Erosion and Sediment Control Guidelines for Land Disturbing Activities

Guideline 2010/01

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NEW ZEALAND

Working with our communities for a better environment
E mahi ngatahi e pai ake ai te taiao

Environment Bay of Plenty REGIONAL COUNCIL

Erosion and Sediment Control Guidelines for Land Disturbing Activities

June 2010

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Cover Photo:
Tauriko Earthworks Development, Tauranga.
Photo by Dudley Clemens

Acknowledgements

The material in this Guideline has been drawn from the project manager's experience and excellent resources already prepared by the Auckland Regional Council, Sunshine Coast Regional Council, Environment Waikato and Environment Canterbury. The use of their material is gratefully acknowledged. Where images and/or information have been sourced from other individuals, this has also been identified.

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1.1 Structure and purpose of this Guideline

Environment Bay of Plenty wants to ensure that people who disturb land understand concerns, plan their developments appropriately and then manage their sites using best practice erosion and sediment control methods to protect the environment. This guideline describes the requirements and outcomes to be achieved when land is disturbed to comply with overall environmental objectives.

The primary purpose of this Guideline is to set out and clarify the acceptable measures, standards, and design processes to be adopted for erosion and sediment control in achieving the necessary environmental objectives.

The Guideline also aims to:

- Provide reference material on erosion and sediment control which can be used for a number of purposes, including education, regulation and continuing environmental improvement.
- Provide land users with comprehensive guidelines on erosion and sediment control which:
  - outline the principles of erosion and sediment control,
  - provide guidelines on particular land management activities to minimise erosion and sedimentation and
  - provide specifications and standards for particular erosion and sediment control practices.
- To detail the rules in the Bay of Plenty Regional Water and Land Plan, which defines when resource consent is required to disturb land and the Council's expectations when applying for a consent.

The Guideline provides information on how to minimise environmental effects from sediment yields and land disturbing activities by:

- promoting understanding of the principles of erosion and sediment control;
- providing a comprehensive set of erosion and sediment control practices and procedures and guiding users on how to use these during project design, construction, operation, maintenance and decommissioning; and
- providing criteria and measures as minimum standards when disturbing land.

This Guideline is not a statutory document, however it will be used when applying for consents for land disturbing activities and will help in ensuring effects are less than minor.

Target readership is personnel involved in the planning, design, construction, maintenance and decommissioning of erosion and sediment control practices. Decisions made at the planning and design stage of a project can have a significant impact on water quality once the project reaches the construction stage.

The Guideline specifically targets:

- clients/promoters;
- designers;
- environmental consultants;
- construction project managers;
- site engineers and site agents;
- site environmental managers; and
- regulators.

It replaces the Environment Bay of Plenty Erosion and Sediment Control Guidelines for Land Disturbing Operations – 2001/03 and previous editions.

The Guideline is divided into principles and practices. The principles sections outline factors that influence erosion and sedimentation, and the factors that should be considered at all times when disturbing land, as well as a risk assessment process.

The practices section provides details of onsite practices when disturbing land in a step-by-step way for design, implementation, maintenance and decommissioning.

1.2 Background

This Guideline has been drafted as a result of a review of current erosion and sediment control guidelines (Erosion and Sediment Control Guidelines for Land Disturbing Activities dated 2001/03) used within the Bay of Plenty region. Existing guidelines and the implementation of them is proving ineffective in some circumstances, with inappropriate design and implementation causing problems.

The Guideline has been collated with the assistance of a team of people and a range of resources and experience with the appropriate acknowledgements detailed above. It will be referred to as the Erosion and Sediment Control Guidelines for Land Disturbing Activities 2010/01 (the Guideline) and replaces all other previous erosion and sediment control guideline documents.

Erosion and sediment control practices and procedures in this Guideline apply to temporary land disturbing activities usually associated with:

- residential, commercial and industrial subdivisions;
- tracking and roading development;
- clean fills and landfills;
- quarries;
- stream works; and
- utility installation.

The Guideline does not specifically address forestry activities or storm water discharges, however aspects of this guideline can be used for these activities. Quarry activities are addressed in Section 9: of this Guideline.

Reference should also be made to the following documents:

- Environment Bay of Plenty Hydrological and Hydraulic Guideline 2001/04.
- Guidelines for the Design, Construction, Maintenance and Safety of Small Flood Detention Dams.

1.3 Issues and effects

There is wide diversity of land uses in the Bay of Plenty region. Without appropriate erosion and sediment control, many soils of the Bay of Plenty region are very susceptible to fluvial erosion (erosion caused by flowing water), particularly from poorly controlled runoff. The receiving environments, including Tauranga and Ohiwa Harbours, are valued for their high water quality, ecological values and wide range of potential uses options, including recreational activities. It is important to ensure that accelerated erosion is minimised and that sediment yields do not adversely affect our receiving environments.

This table indicates potential sediment discharge from different types of land use.

Table 1 Representative rates of erosion from various land uses.

Land Use	Erosion Rates	
	Tonnes per km^2 per year	Relative to Forest
Natural Forest	8.5	1
Grassland	85	10
Abandoned Surface Mines	850	100
Cropland	1,700	200
Harvested Forest	4,250	500
Active Surface mines	17,000	2,000
Earthworks (uncontrolled sites)	17,000	2,000

(Source: ARC Technical Publication No. 69)

Key findings from a recent study undertaken for the southern Tauranga Harbour (Tauranga Harbour Sediment Study: Catchment Model Results) (Elliot et al, 2009), demonstrate that the sediment yield from uncontrolled earthworks are modelled to be one of the highest sources of sediment to the harbour, via transport through waterways. If appropriate erosion and sediment controls are implemented, this yield is demonstrated to reduce dramatically.

While no specific “protection zones” are identified within Environment Bay of Plenty statutory documents, the wider receiving environments of both the Tauranga and the Ohiwa Harbours require particular care to ensure their values are not compromised in any way.

Specific sub catchments identified as key contributors of sediment in the southern Tauranga Harbour, where reduction in sediment loads could be made, include the following in rank of importance (Elliot et al, 2009). (Note the numbering in brackets which relates to the sub catchment as detailed below in Figure 1).

1 Waitao (4);

2 Kaitemako (5);

3 Waimapu (6);

4 Kopurererua (7);

5 Oturu (9).

6 Te Puna (10).

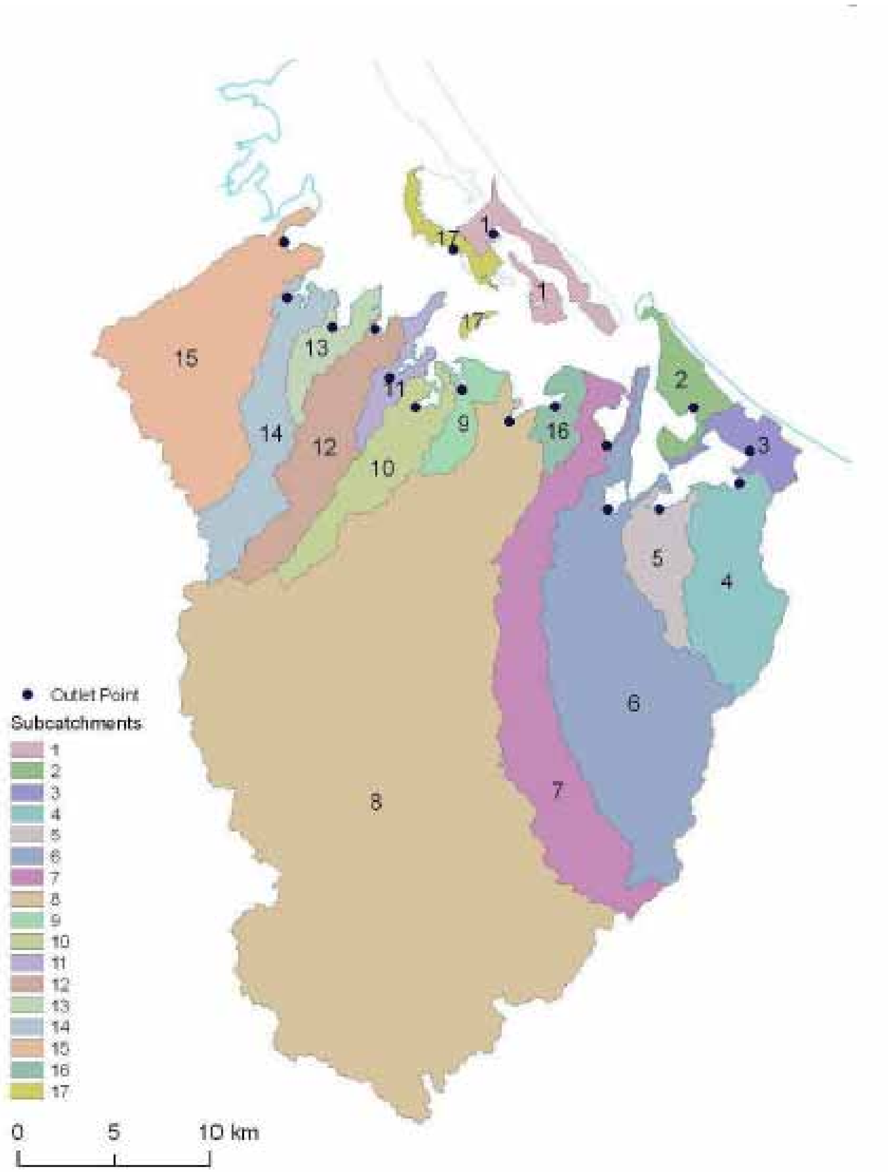


Figure 1 Locations of sub catchments draining to the southern Tauranga Harbour (Elliot et al, 2010).

Additional site analysis and sediment controls are required for earth working activities within these catchments to provide an integrated management approach for the southern Tauranga Harbour to help control sediment generation at its source.

Where earthworks are proposed that require resource consent, depending on site characteristics, additional controls may include:

- Risk assessment, taking into account slope, soils and rainfall; and/or
- Additional controls at the source of sediment, including additional storm water management; and/or
- Increased staging and more frequent site stabilisation requirements; and/or
- Use of treatment chemicals to treat sediment-contaminated storm water.

1.3.1 Effects of sediment

The main effect of land development on the erosion process consists of exposing disturbed soils to rainfall, resulting in surface runoff. Land development changes the vegetative cover and soil exposed to rainfall, and can lead to detrimental effects on site drainage and runoff patterns, and eventually the off-site receiving systems.

Irrespective of erosion and sediment controls employed, construction activities lead to the generation of sediment and a subsequent sediment discharge, affecting visual, recreational and ecological factors. These activities can be appropriately managed using a range of tools including both regulatory and educational initiatives. One of the key tools in the educational component is a specific guideline which typically provides a comprehensive approach to erosion and sediment control, details the specific policies and rules which apply to the site in question, and essentially work towards minimisation of adverse environmental effects of sediment discharge through appropriate use and design of specific measures. These Guidelines are designed to assist in this manner.

The following is a summary of effects from sediment discharges.

Table 2 Effects of sediment.

Physical	Chemical	On People
Aquatic life can be physically smothered by a build-up of sediment in the stream bed. Animals not actually covered by deposits of silt can sustain damage to their gill and mouthparts due to the abrasive nature of silt. Juvenile stages of many species are particularly vulnerable	Sediment transports other pollutants such as lead, hydrocarbons, agricultural nutrients and toxic substances into streams and harbours which can accumulate and affect aquatic life. Control of pollutants transported by sediment is simply achieved by controlling the generation and movement of sediment itself.	High loadings of suspended solids affect the use of water for irrigation, stock and domestic water supplies. Sediment in irrigation water clogs pump filters and sprinkler nozzles, and in domestic and stock water supplies sediment can lead to unacceptable drinking quality. Removing sediment from drinking water can be an expensive operation. Sediment can also threaten the useful life of dams.

Physical	Chemical	On People
Sedimentation may significantly alter habitats, for example by destroying spawning grounds.	Direct toxicity from high turbidity and sediment contaminants	Sediment discharges into streams, lakes or coastal waters detracts from their aesthetic qualities. Clean, clear water is perceived as being much more conducive to recreation than “dirty” sediment-laden water. The purely scenic value of water bodies, such as key harbour areas, are enhanced by the degree of clarity that exists.
Algae, the major food supply for stream life, can be scoured off the rocks in the stream bed by sediment. Other links in the food chain may also be affected, and the surviving animals forced to migrate elsewhere if they can.	Low dissolved oxygen (especially in depositional areas) and change in temperature of the water column.	Construction activities can inundate lower lying properties or roadways with sediment if adequate control measures are not in place.
Turbidity (cloudiness of the water) from suspended solids in the water may stop animals feeding because they can’t see their prey. It can also increase heat absorption and therefore the temperature of the water, affecting aquatic life. It also stops light penetrating the water, slowing down photosynthetic activity and subsequent plant and algae growth.		Construction activities often disturb items and matters of cultural and archaeological importance. The effects can vary from significant destruction or alteration of a physical site through to a more indirect effect such as impacts on cultural values.
Sediment deposition can lead to infilling of affected water bodies. This reduces their hydraulic efficiency, increases susceptibility to flooding and restricts access. While such sediment deposition has environmental impacts, removal works also have potential serious environmental effects.		

Key message: Remember the effects of sediment are wide-ranging and need to be understood to ensure appropriate actions can be followed.

Recovery time for in-stream communities can be long-term, from months to years, and there is also the potential problem of damage to assets such as pumps and water supplies. Injecting sediment into a stream system can initiate an erosion cycle which can be difficult to control. Localised flooding may result from sediment discharge, as well as unsightly damage in the form of debris and sediment. Suspended sediment can also be a carrier for other contaminants such as pathogens.

It is well recognised that a background level of sediment occurs naturally, but elevated levels are disruptive to the natural environment. By following the principles and practices in this Guideline, land developers should be able to substantially reduce the adverse effects of land disturbance activities on water resources.

1.3.2 Characteristics of soils in the Bay of Plenty

Soils of the Bay of Plenty region are influenced by the volcanic parent material, particularly in the central and western areas. Many of the soils are formed from volcanic eruptions and some are relatively young, with limited time for any substantial soil development. Often, the physical nature of the soils means that they are non-cohesive, friable and easily worked.

Soil characteristics, including texture, organic matter content, structure and permeability are all important when understanding sediment generation and yields. Sand, silts and clays are the major soil particle classes and it is critical to understand the soils you are working with so that the erodibility of these different particles can be assessed. Organic matter is critical in improving soil structure and increasing its permeability and water-holding capacity. Soil permeability in itself is important, with soils with higher permeability producing less runoff than soils with a low permeability.

Soil compaction is also a major issue to consider. Soil compaction during construction and use are likely to cause most of the reduced infiltration capacity of urban soils. This aspect of construction activities is often not given due attention however the reduced infiltration is known to result in increased runoff and associated effects. (Pitt, et al, 2002).

Eroded soil materials can be classified according to their grain sizes into clay, silt, and sand fractions. Different soil types have different proportions of these particles. Clay particles are generally considered to be less than 0.002 mm in size, silt particles range from 0.002 to 0.063 mm, and sand particles have a diameter range of 0.063 to 2.0 mm.

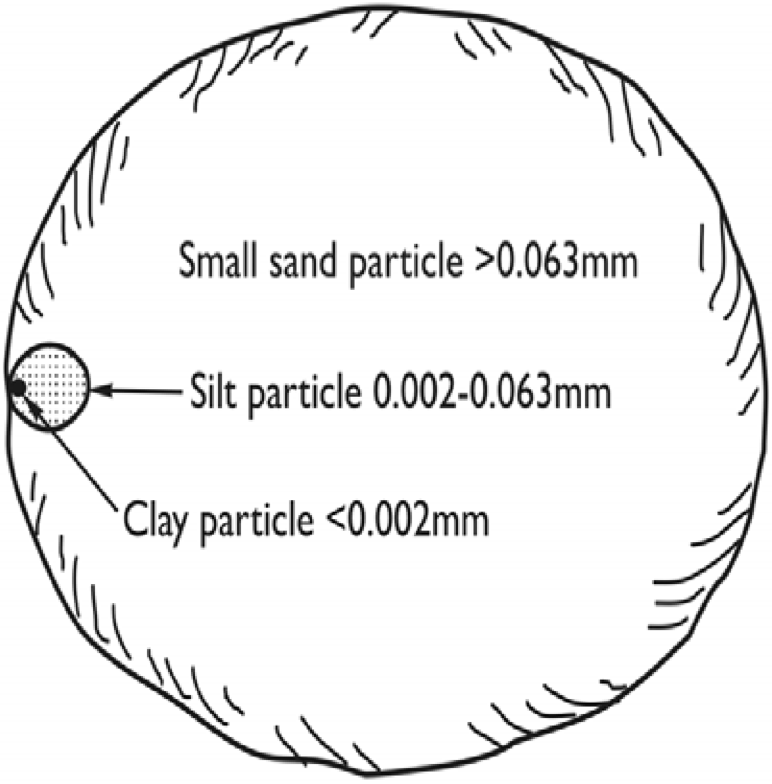


Figure 2 Soil Particle Size (Source: Auckland Regional Council 1997)

Soils dominated by sands are generally non-cohesive and are more susceptible to erosion than silts and clays. However, sands settle out easily and can be controlled using simple management practices on site. Once they have been mobilised, clays and fine silts are more difficult to control as they can be held in suspension and may require other methods (such as flocculation) to settle the particles out.

In the Bay of Plenty, soil texture tends to be dominated by sand and silt, rather than clay. These soils are often able to be worked and disturbed, using relatively simple erosion and sediment controls to reduce adverse off-site effects. The Bay of Plenty geology however also means that there may be a deep mantle of volcanic ash showers with a range of different characteristics. Any land disturbance involving deeper excavation through different tephra layers in the soil profile may disturb materials with a higher clay content. Soils derived from tephra are very easily broken down and lose their structure when worked through the land disturbance process.

Within the Bay of Plenty region four main orders of soils are encountered where major earthworks generally occur and include Allophanic soils, Podzols, Pumices and Organics. From a range of representative soil samples it is concluded that within suspension Tarawera ash, Rotomahana mud and Kaharoa ash all have an acceptable settling period, while Taupo pumice contains very fine clay and silt particles which take longer to settle. However there will be significant variations within these soils over the region.

It is critical that prior to undertaking any works on your site you understand the soils through analysis and treat them accordingly. For example it is known that while Rotomahana mud demonstrated acceptable settling through the sampling undertaken that this soil type does contain high clay content and will react differently from different samples collected.

1.3.3 Erosion and sediment control

Erosion and sediment control should be considered whenever land disturbing activities are undertaken, and should be in place before any earthworks commence. Once earthworks are completed, erosion and sediment controls should be maintained until the area is fully stabilised.

It is important that all land disturbing activities undertake a risk based approach whereby those activities with a higher risk of sediment effects (such as sites with high sediment generation, steeper sites and discharges into sensitive receiving environments) are managed according to this risk. See Section 3: of this Guideline.

In addition to erosion and sediment control it is vital that that the following critical factors are considered when undertaking development projects. They all have an impact on the quality of the receiving environment and need to be considered in an integrated fashion.

- Hydrological processes.
- Minimising changes to the natural hydrological characteristics of a catchment, including percentage imperviousness, channel geometry, frequency of runoff events and base flows.
- Natural vegetation and riparian zones.
- Maximising ground surface and channel protection by preserving a natural vegetative cover.
- Aquatic habitat and ecosystems, by maintaining natural stream substrates.
- Water quality – minimising the amount of pollution, such as sediment and soil nutrients entrained in storm water runoff through appropriate erosion controls. These entrained pollutants should be captured by implementing appropriate storm water controls.

Key message: Erosion and sediment controls to minimise off-site sediment discharges should be in place before land-disturbing activities start and only removed when the site is stabilised.

Regardless of whether or not consent from Environment Bay of Plenty is required, erosion and sediment control principles and practices in this Guideline provide a good guide for what to consider to minimise potential for environmental effects.

1.4 Statutory provisions

Environment Bay of Plenty has a number of regional plans prepared under the Resource Management Act (RMA) to improve and maintain the quality of our natural resources. From issues and policies within these plans, rules are set out that govern the environmental effects of various activities. Depending on the nature and scale of effect, your activity may be permitted, prohibited or need resource consent to ensure that environmental effects are avoided or minimised.

Relevant policies in plans include:

The Operative Bay of Plenty Regional Policy Statement (1999) identifies issues as follows:

- 6.2.5 - Land use and management practices may adversely affect water yield, flow, quality and aquatic ecosystems;
- 6.2.5 - High sediment and nutrient loads resulting from inappropriate land use practices can adversely affect water quality and use, and aquatic species and habitats.

Policies of specific relevance include:

- 6.3.1(b)(iii) - To avoid remedy or mitigate the adverse effects on the environment associated with inappropriate subdivision, use, and development of land.
- 6.3.1(b)(viii) - To manage the use and development of land resources which enables people and communities to provide for their social, economic and cultural well being.
- 6.3.1(b)(xiv) - To protect water quality from the adverse effects of land use.
- 6.3.1(b)(xvi) - To promote the integrated management of mineral resources including aggregates.

The Operative Bay of Plenty Regional Water and Land Plan 2008 (Water and Land Plan) identifies the following issues:

Issue 10 – Land use and management practices that are inappropriate to the specific characteristics of the site, (including soil type) may cause adverse effects on the environment. Adverse effects may include the following:

(a) Erosion of land and the banks of rivers, streams, lakes, and wetlands.

(b) Reduction of the life-supporting capacity of soil over time either from a loss of soil, the deposition of erosion detritus down-slope or in down-stream areas, or by reducing soil health.

(c) Increased sediment levels in rivers, streams, lakes, land drainage canals and wetlands, which may reduce water quality; adversely affect aquatic habitat values; reduce the flood flow capacity of rivers, streams and land drainage canals; lead to unstable river and stream systems; and lead to the infilling of wetlands and coastal estuaries and harbours.

(d) Reduced protective function of coastal sand dune systems.

(e) Adverse effects on ecological values, cultural values, natural character and landscapes. Such values may be modified, damaged or destroyed by inappropriate use and development activities. High natural character contributes to recreational values. The maintenance or enhancement of terrestrial and aquatic ecological values is important to indigenous biodiversity.

Para 2 – The major land use activities and areas of concern in the Bay of Plenty are:

1 Land use and land management practices that are not suited to the characteristics of the site. Site characteristics include soil type, slope, receiving environment, assimilative capacity of the environment, and climatic conditions.

2 Land disturbance activities that are not undertaken in accordance with standards required to avoid, remedy or mitigate adverse effects on the environment. These include earthworks, vegetation disturbance, and cultivation where there is a discharge of sediment to water. Sediment from land disturbance activities is of concern around Tauranga Harbour (resulting from inappropriate developments and earthworks), and the Ohiwa Harbour (where areas of kaimoana [sea food] are affected).

3 Damage to the protective functions of coastal sand dunes, which increases the risk of erosion and flooding from storm events along the Bay of Plenty coast, in particular from Waihi Beach to Opape.

4 Inappropriate use and development in riparian management areas, including soil disturbance, vegetation clearance, and inappropriate grazing practices, that lead to erosion and the discharge of sediment to water.

- Issue 12 – Water quality in some streams, rivers, lakes, estuaries, harbours and coastal margins in the Bay of Plenty can be adversely affected as a result of use and development activities.

- Issue 23 – There is the potential for storm water to transport contaminants, which adversely affect receiving environments.

Para 1 – The source of storm water influences the types of contaminants that may be present in the discharge:

3 <u>Land Disturbance Activities</u> (e.g. earthworks, vegetation disturbance, and quarries). Sediment is the major contaminant present in discharges from land disturbance activities, which can degrade water quality and aquatic habitats, change instream characteristics, and increase sedimentation in receiving environments such as lakes, harbours and estuaries. Sediment from earthworks is a particular concern in the Tauranga Harbour catchment. Earthworks and quarries present different risks to the environment, earthworks are generally short-term activities carried out during the development stage of a project, whereas quarries are of a longer duration.

Policies of specific relevance include:

- Policy 21 – To manage land and water resources in the Bay of Plenty within an integrated catchment management framework to:

  (k) Promote and encourage the adoption of sustainable land management practices that are appropriate to the environmental characteristics and limitations of the site to:

    (i) Protect the soil and avoid, remedy or mitigate the adverse effects of erosion.

    (ii) Maintain the health of the region’s soil resources for future generations.

    (iv) Avoid, remedy or mitigate adverse effects on water quality in the receiving environment.

    (v) Take into account the assimilative capacity of the soil.

    (viii) Control sediment entering estuaries and harbours from use and development activities.

    (l) Manage land and water resources according to realistic management goals that are appropriate to the existing environmental quality and heritage values (including ecosystem values) of the location.

- Policy 27 – To use a range of mechanisms, including education, and regulation where necessary and appropriate, to avoid, remedy or mitigate the adverse effects of land use activities on water quality, or for soil conservation purposes, in order to achieve stated environmental objectives. Areas of particular concern in the Bay of Plenty are riparian margins, steep slopes, erosion-prone soils, the recharge areas of potable groundwater supplies, and the catchments of the Rotorua lakes.
- Policy 51 – To require the appropriate management of storm water quality, including:

  (a) The use of source controls to avoid the contamination of storm water.

  (b) The use of best practicable options.

  (c) Treatment of storm water to prevent the contamination of receiving environments.

The Operative Bay of Plenty Regional Coastal Environment Plan (2003) identifies the following issues:

- 9.2.1 – Coastal water resources and ecosystems and their Mauri are being adversely affected by direct and indirect discharges of contaminants into coastal water.

Policies of specific relevance include:

- 9.2.3(a) – To integrate the management of water quality in the coastal marine area with the management of land use and freshwater.
- 9.2.3(b) – Discharges must not have significant adverse effects on aquatic life, habitats, feeding grounds, ecosystems or amenity values in the coastal marine area. This policy applies whether or not the actual point of discharge is in the coastal marine area.

This Guideline helps to fulfil the requirements of these issues and policies.

1.4.1 Earthworks and consent requirements

The Regional Water and Land Plan sets out a number of rules to manage the effects of earthworks, such as erosion and discharges of sediment-laden water to rivers, streams, lakes and wetlands. Whether a resource consent is required or not depends on a number of factors including land slope, distance to water bodies, volume of earthworks and area of exposed soil.

Generally a resource consent **will** be needed to work in any river, stream, lake or wetland.

You **may** need a resource consent:

- for works near watercourses (riparian areas), depending on the scale of works and the slope of the area;
- depending on the slope of the land. Works on steep slopes (>35°) is more likely to cause erosion and sediment discharge to water;
- for work near coastal areas, depending on scale of works and if on sand dunes; and
- for work in ephemeral flowpaths, depending on scale of works.

Appendix 1 of the Guideline provides a copy of the earthworks rules within the Bay of Plenty Regional Water and Land Plan (Water and Land Plan) to help you decide which rule applies to your activity. Flow charts are also provided.

All permitted earthworks must meet a number of conditions, including:

- avoid discharging untreated storm water to vegetation or watercourses. Treated discharges shall achieve the minimum requirement of 150 g/m^3 suspended solids except where a 10 minute duration 10% AEP storm event (10 year return period storm) is exceeded.
- the activity must not block river or stream flows.
- machinery must be kept out of streambeds, except for unavoidable crossings of streams (check extra requirements for earthworks for stream crossings).
- manage storm water to avoid areas of exposed soil.
- avoid causing erosion.
- avoid damage to wetlands.
- avoid causing a dust nuisance off site.

It is important to note that all conditions under the permitted rules must be able to be met, otherwise resource consent will be needed.

1.4.2 Earthworks limits

In sensitive areas, only small volume earthworks are permitted. These areas are:

- in the riparian areas of streams, rivers, lakes and wetlands.
- on the margins of estuaries, harbours and the coast.
- in ephemeral flowpaths.

On land away from watercourses and sand dunes, the permitted limits are:

- slope 0-15° – 1 ha exposed area and 5,000 m^3 volume.
- slope >15-25° – 5,000 m^2 exposed area and 5,000 m^3 volume.
- slope >25-35° – 500 m^2 exposed area and 500 m^3 volume.

Refer to Table 28 in Appendix 1 for a full list of these earthworks limits.

Land disturbance activities are also governed by provisions in district plans. City and district councils look at subdivision and other aspects of earthworks, including matters relating to the land use, landscape, amenity values and protection of heritage sites.

1.4.3 Dust Limits

The Bay of Plenty Regional Air Plan governs any discharges to air within the Bay of Plenty Region, including the discharge of dust. Discharge of dust from earthworks is a permitted activity, provided specified standards are complied with. In particular the discharge must not result in objectionable or offensive particulates beyond the boundary of the subject property or into water.

Appendix 2 provides a copy of the Regional Air Plan permitted rules which are relevant for the control of dust.

1.4.4 What other types of activities may require consent?

Other activities may be subject to rules within the Water and Land Plan. These include:

- De-watering of building and construction sites.
- Discharge of untreated or treated (using flocculants and coagulants) storm water to land or water.
- Activities in the bed of streams or rivers, such as the placement of bridges or culverts as well as the removal of plans.
- Modification of wetlands.
- The take of water from stream(s) for dust control.

Key message: Ensure you are aware of the statutory responsibilities that apply to your activity. This can include earthworks, dewatering, dust control and use of flocculants. Always talk to your Environment Bay of Plenty representative to obtain accurate and up-to-date advice.

If you are unsure about whether your activity is permitted or requires resource consent from Environment Bay of Plenty, contact us on 0800 ENVBOP, or 0800 368 267. You should also contact the relevant city or district council to ensure that all requirements, especially relating to earthworks activities, are met.

1.5 Winter earthworks in the Bay of Plenty

When consents are required for earthworks, Environment Bay of Plenty uses a "best practicable option" (BPO) approach to regulate earthworks. This approach recognises that earthworks can be well controlled by undertaking best management practices on site to control erosion and any resultant sediment yields.

It is recognised however that there is a degree of risk associated with accepting a BPO approach and in accepting this risk, Environment Bay of Plenty has a policy (known as the "Winter Earthworks Policy") that has been confirmed through Environment Bay of Plenty resolution (2001). This policy states that a winter period applies whereby earthwork sites over this period are subject to a reduced earthwork scope and the inclusion of a water quality discharge standard. This is primarily due to the increased risk of effects over this period in particular with soils containing higher percentages of clay and fine silts (for example some pumice soils), or when the slopes are steeper on the site. In setting this Winter Earthworks Policy, Environment Bay of Plenty recognise that it is site specific and, as an example, if your site contains only sandy soils then the winter exclusion will not apply. In all circumstances reference should be made to your resource consent to check conditions and details of the assessment undertaken.

Key message: Remember that winter is the wettest time of year and therefore presents the greatest risk of an environmental hazard.

To further understand the Environment Bay of Plenty Winter Earthworks Policy it is important to understand the reasons why the Winter Earthworks Policy is applied which includes:

- Wetter soils during the winter period;
- Less daylight hours and sun hours for drying during the winter period;
- Fewer drying days between rain events during the winter period;
- Colder temperatures which leads to difficulty with vegetation establishment during the winter period;
- Problems with access during the winter period;
- More difficult conditions for achieving suitable compaction conditions during the winter period; and
- Difficulty in achieving a soil stabilisation during the winter period.

It is important to recognise that the Winter Earthworks Policy does allow for undertaking earthworks in winter with Environment Bay of Plenty consent, but there are strict prerequisites to this approval in relation to soil type, assessment of effects, and performance standards on any discharge.

In order to further support the Winter Earthworks Policy regional rainfall analysis and the variability has been re-analysed. The weather systems that the Bay of Plenty experiences are well known, including the pattern of rainfall variability over the region, which largely reflects the regions exposure to the main rain-bearing north-easterly fronts and the variations in elevation of the land. The highest rainfalls generally occur in the months of April to August and as the region is sheltered and depends on northerly airstreams for much of its rainfall, there is considerable variability from season to season with many short duration high-intensity events. There is considerably greater rainfall variability in the western Bay of Plenty than in the east and southeast where rainfall occurs under a wider range of conditions.

The analysis of the regional rainfall variability is summarised in Table 3 below.

Table 3 Data results of rainfall analysis.

Site	Highest Monthly rainfall occurrence Note 1.	Months with high intensity 24 hour occurrence Note2.
Tuapiro at Woodlands (Katikati)	July, April, June	December (2), February (2), April (1), January (1), July(1)
Tauranga at Omokoroa	July, April, June	April (2), December (1)
Tauranga at Airport	April, July, June	April (4), May (2), January (1), February (1), July (1), November (1), December (1).
Kaituna at Te Matai	July, June, August	April (2), May (1), December (1)
Rotorua at Whakarewarewa	July, June, December	April (1), September (1), May (1)
Pongakawa	July, May, June	February (1), April (1), May(1)
Rangitaiki at Te Teko	July, April, June	February (3), May (1), April (1)
Otara at Town Wharf (Opotiki)	July, August, December	February (1), July (1), August (1)

Note 1 The three months that have the highest occurrence of high monthly rainfall totals.

Note 2 The months that have an occurrence of rainfall exceeding the 50% AEP (two year return period) 24 hour rainfall. The number of occurrences for a particular month is provided in the (#). AEP figures are based upon HIRDs Version 1.50b.

It can be seen that a significant portion of the high intensity 24 hour rainfalls occur in the summer and autumn months however, when considering rainfall alone, the trigger for an appropriate or series of appropriate winter periods, is more justifiably based around the longer scale saturated soil conditions over longer periods. This is due to the majority of erosion and subsequent discharges likely to occur when the site is exposed and the number of rainfall events being higher therefore leading to larger rates of flow from any sediment retention devices.

In accordance with the existing Environment Bay of Plenty Winter Earthworks Policy and from the further rainfall data detailed above the Environment Bay of Plenty Winter Earthworks Policy and associated winter period remains as 1 May to 15 September. While there will be exceptions to this period it is considered that the winter shutdown period is a practical approach and clearly forms part of the BPO. If your site is subject to the Winter Earthworks Policy then you need to be aware of the requirements and if you wish to work over the winter period then you must only do so in accordance with the Winter Earthworks Policy and the specific conditions of your consent.

1.5.1 Works within the winter shutdown period

Earthworks may only be undertaken during the winter period with Environment Bay of Plenty approval and in accordance with consent conditions over this time. Through your consent you may apply for an exemption (variation to consent conditions) to the winter period and Environment Bay of Plenty may grant such a variation. Variations should be applied for at the outset of a consent application to avoid future delays due to the consent application process. Exemptions are limited as detailed below:

- The site is located on sandy soils with good ground infiltration and terrain is not too steep. Note that it is preferable that earthworks be undertaken in the winter period in sandy soils as this lowers the risk of dust during the drier summer months; and/or
- When there is no discharge off site; and/or
- If a discharge is proposed, that the discharge meet a water quality limit that is matched to the receiving environment and any sensitivities of this receiving environment as identified under an Assessment of Environmental Effects (AEE); and/or
- If a discharge is proposed, an appropriate monitoring regime is in place to confirm that the water quality standards on any discharge have been complied with; and/or
- Erosion and sediment controls including Sediment Retention Ponds, must be sized appropriately for storage capacity on site. Consideration should be given to providing an increased storage capacity within Sediment Retention Ponds and providing storage for the 100 year 24 hour storm event at the location of the site for the entire winter duration.

Due to the changing nature of the earthworks undertaken on sites and the risk during the winter period, provision for earthworks to proceed during the winter period under the processing of a resource consent, or variation to resource consent conditions, will be considered only on a year-by-year basis.

Some specific works are allowed within the winter exclusion period without requiring a specific exemption. These works however are limited and only include:

- If earthworks are to excavate and backfill trenching for the installation of services including storm water infrastructure and telecommunication or other cabling; and/or
- If earthworks are to maintain and/or create new erosion and sediment controls.

1.5.2 Process of works over the winter shutdown period:

Environment Bay of Plenty recognise that once earthworks are completed on your site that it may take a period of time to achieve full stabilisation. Environment Bay of Plenty requires this stabilisation to be achieved by the 1st June of each year and achieve this by:

(i) Top soiling and grassing your site by the 30^{th} April of each year; or

(ii) Hydro seeding (or by use of a comparably effective method) by the 15^{th} May of each year; or

(iii) Using hay or straw mulching (or by use of a comparably effective method) by the 31^{st} May of each year.

Environment Bay of Plenty requires your site to be fully stabilised by the 1^{st} June of each year and if the above methodologies do not achieve this then your site will be required to apply an instant stabilisation technique immediately prior to that date. This includes, but may not be limited to, the use of mulching and geotextiles over exposed areas of the site. This requirement should form part of your site risk assessment.

Key message: The winter earthworks policy means no earthworks between 1 May and 15 September in each year unless Environment Bay of Plenty approval and consent conditions allow.

Key message: If you do not obtain approval to work over the winter period you must not work your site after 1 May in each year and your site must be fully stabilised by 1 June in each year.

At all times, and until Environment Bay of Plenty approval is obtained to remove them, your erosion and sediment control measures must remain in place and operational.

If works are approved to continue through the winter period, and changes to erosion and sediment controls are required, these controls should be in place and functioning before the commencement of the winter period.

During the winter period you must undertake regular inspections and maintenance of erosion and sediment controls in order to ensure that they continue to function correctly. If you have approval to work through this period you will need to ensure that you comply with the conditions of your consent and subsequent approval which will include testing, analysis and reporting for offsite discharges. If your site is subject to the Winter Earthworks Policy and no approval is in place to work over this period you will still need to check your erosion and sediment control measures and maintain them as necessary.

Prior to commencing works after the winter period it is again critical that you ensure that erosion and sediment controls are functioning correctly.

Key Guidance

ARC Technical Publication No 69 http://www.arc.govt.nz

Tauranga Harbour Sediment Study: Catchment Model Results. NIWA Client Report for Environment Bay of Plenty HAM2009-046

Environment Bay of Plenty Winter Earthworks Policy 2001

Section 2: Principles of erosion and sediment control

Chapter objectives

1. **To understand the processes of erosion and sedimentation on an earthworks site.**
2. **To understand the factors that influence erosion.**
3. **To highlight the key principles of erosion and sediment control.**

2.1 The erosion and sedimentation process

When considering erosion and sediment management it must always be thought of as two separate components, erosion control and sediment control.

Erosion is the process where the land surface is worn away by the action of water, wind, ice or other geological processes. The resultant displaced material is known as sediment, with 'sediment yield' consisting of the amount of sediment which leaves a sediment control measure. Sedimentation is the process of deposition of this eroded material. Accelerated erosion is primarily caused by human activities and is a much more rapid process then natural erosion.

Through the erosion process, soil particles are dislodged, generally by rainfall. As rain falls, water droplets concentrate and form small flows. The combined energy of the rain droplets and the concentrated flows can dislodge soil particles. The amount of sediment generated depends on the erodibility of the soil, the amount of energy created by the intensity of the rainfall event and site conditions, for example the slope and the slope length of the site. In general, the steeper the site and the longer the flow lengths, the more energy will be created. Any reduction of erosion will reduce the erosion and sediment generation.

Erosion and sediment control measures are used to minimise the effects of earthworks on receiving environments. Erosion control acts to limit the amount of sediment generated and sediment control acts to remove sediment once mobilised. Both types of controls are critical as part of any land disturbing activities, although the emphasis should always be on erosion control to minimise the mobilisation of sediment in the first instance. A significant reduction in erosion on a site will lead to far less sediment being generated, treated and ultimately lost through control measures. Full reliance on sediment control measures alone is not recommended.

Key message: Erosion control limits the amount of sediment generated while sediment control removes sediment when mobilised. In general, all sites will require a combination of both controls.

When considering erosion there are seven main types that need to be considered as follows.

- Splash erosion is commonly caused by raindrop impact, which can break up the soil surface, moving soil particles down the slope.

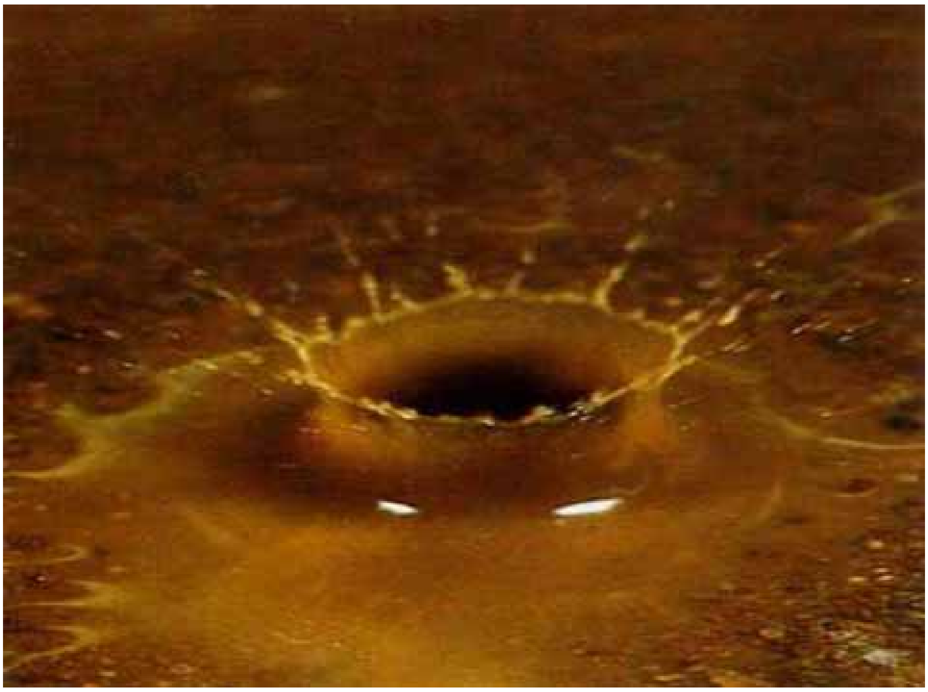


Figure 3 Splash erosion - photo courtesy of Auckland Regional Council.

- Sheet erosion occurs when intensity of rainfall exceeds the infiltration rate. Sheet erosion refers to the uniform removal of soil in thin layers by the forces of raindrops and overland flow.
- Rill erosion is the removal of soil by runoff moving in concentrated flows. Velocity and turbulence of the flow increases in these concentrated flow paths, with the resultant energy detaching and transporting soil particles.

Figure 4 Rill erosion - photo courtesy of Environment Bay of Plenty

- Gully erosion is the next step from rill erosion, where gullies form which are usually greater than 300 mm in depth. The potential for gullies to transport significant amounts of sediment is large, and these should be avoided as part of the erosion control philosophy.

Figure 5 Gully erosion - photo courtesy of Ridley Dunphy Environmental Limited.

- Tunnel erosion is the removal of subsurface soil by subsurface water while the surface soil remains intact. This produces large cavities beneath the ground surface which eventually can lead to the collapse of surface material.
- Channel erosion occurs once the water in concentrated flow reaches the stream system. This erosion is essentially caused when the water velocity increases such that scouring or undercutting of the stream banks occurs. Channel erosion has a direct relationship with watershed urbanisation, with increased flows and increased erosion occurring once a watershed is urbanised.
- Mass movement is the erosion of soil or rock by gravity or other movement-induced collapse. It can be triggered by heavy rainfall and increased groundwater pressure or by streams undercutting the base of a slope where works are occurring.

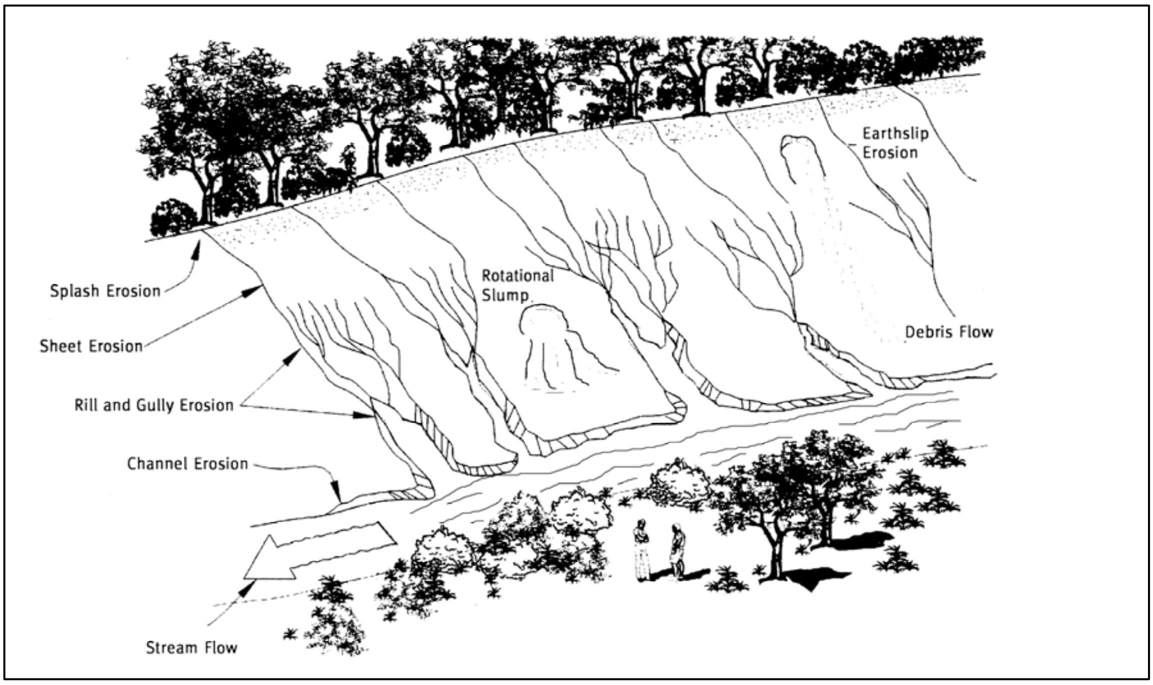


Figure 6 Types of erosion - Source: Auckland Regional Council 1999.

The rate of sedimentation depends primarily on particle size and velocity of runoff. Heavier particles, such as gravel and sand settle out sooner than the finer particles such as silt and clay. Clay particles can also become electro-statically charged due to turbulence, and can stay suspended in water for long periods, causing water to become cloudy or discoloured.

Key message: Heavier particles such as silts, sands and gravels are easier to "drop out" once in suspension than clay or fine particles. In some instances, chemical treatment will be required to treat clay-rich or fine particle areas.

Runoff from the site should be managed to minimise the volume and velocity of overland flows. This reduces the amount of erosion (and hence the amount of sediment mobilised) and the flow path through which it has to travel. To reduce water energy, the gradients of runoff controls should be kept as flat as possible. Contour drains should be installed to break up slope lengths with gradients as flat as possible to help to keep velocities low. This will, in turn, reduce the potential for erosion, creates less turbulence so larger particles being carried in suspension will not be broken down as readily.

In the Bay of Plenty, movement of pumice gives particular problems, because pumice is more buoyant than other materials. Sizeable pumice fragments may travel further downstream before settling, and may also cause blockages in smaller diameter culverts.

2.2 Factors that influence the erosion process

It is also important to understand factors that influence erosion - climate, soil characteristics, topography, ground cover, evaporation and transpiration. Four of these six factors also form the basis of the Universal Soil Loss Equation.

2.2.1 Climate

Climate is a key factor, with rain being the driving force of erosion. The erosive power of rain is determined by rainfall intensity and the droplet size. The annual pattern of rainfall and temperature change is also critical because it determines the extent and growth rate of vegetative cover - the key tool in prevention of erosion. The pattern of rainfall over the Bay of Plenty region largely reflects the region's exposure to the main rain-bearing north-easterly winds and also variations in elevation.

Annual rainfall distribution rises from approximately 1400 mm in the coastal area to 2500 mm in the Kaimai and Mamaku Ranges (Source: New Zealand Meteorological Service – The Climate and Weather of the Bay of Plenty Region, A.M Quayle, 1984). Table 3 in section 1.5 of this Guideline provides some further analysis of rainfall distribution and variability.

2.2.2 Soil characteristics

Soil characteristics, including texture, organic matter content, structure and permeability are all important. Sand, silts and clays are the major soil particle classes and it is critical to understand the soils you are working with so the erodibility of these different particles can be assessed. Organic matter is critical in improving soil structure and increasing the permeability and water holding capacity of the soil. Soil permeability in itself is important, with soils with higher permeability producing less runoff than soils with a low permeability. Soil structure is also important because if the soil is compacted, runoff will occur as opposed to infiltration.

The most important physical property of a soil particle is its size, which can be determined in a number of ways. The nominal diameter refers to the diameter of a sphere of the same volume as the particle and the sieve diameter is the minimum length of the square sieve opening through which a particle will fall. Recognising the size of material on an earthworks site can increase awareness of how easy or difficult it can be to remove sediment once it is in suspension. This helps target erosion and sediment controls. While sands and silts are more erodible than clays, they settle easier. However clays, being a cohesive material that can form quite strong bonds once in suspension, are very difficult to trap with sediment control mechanisms. Sites with dominant clay soils will require erosion control methods.

2.2.3 Topography

Topography is important, primarily from a slope length and slope angle perspective. The shape of the slope also plays an important part as the base of the slope is typically more susceptible to erosion than the top, due to runoff arriving at a faster, more concentrated rate.

2.2.4 Groundcover

Groundcover includes vegetation and surface treatment, such as mulches and geotextiles, which is the most important and effective form of long-term erosion control. Good ground cover provides direct instant protection, slows runoff and maintains the soil's ability to absorb water.

2.2.5 Evaporation and transpiration

Evaporation and transpiration are often not often considered. In some areas they are a critical factor as minimal rainfall and high evaporation and transpiration rates in the summer can lead to soil moisture deficit. This becomes a critical factor when considering establishing vegetative cover for erosion control, and alternative methods may need to be considered to establish a vegetative cover.

Evaporation and transpiration rates over the Bay of Plenty Region vary, and typically are in the order of 100 to 150 mm (combined) over the months of January and February, corresponding to a deficit of between 50 to 70 mm over the same period. May to September have the lowest rates of evaporation and transpiration with no evaporatrion and transpiration deficit *(Source: New Zealand Meteorological Service – The Climate and Weather of the Bay of Plenty Region, A.M Quayle, 1984)*.

Key message: With all other factors remaining equal, slope has the most influence on the generation of sediment. If slope angle is doubled you generate three times the sediment and if slope length is doubled you generate 1.5 times the sediment.

Once the principles of erosion and sedimentation are understood it is much easier to understand the importance of erosion control and sediment control.

Erosion control is based around preventing erosion and includes controls such as revegetation, contour slope drains, project phasing and time frame limitations. The specific designs of some erosion control mechanisms are discussed later in this chapter.

Sediment Control is based around preventing sedimentation and preventing sediment leaving the site. Sediment control is never 100% effective, but with effective erosion control can move a long way towards minimising downstream effects of sediment discharge.

When assessing construction operations the emphasis must always be on first preventing erosion. Only after this has been fully assessed should you consider sediment control options for the site.

2.3 The key principles of erosion and sediment control

The principles set out below provide guidance on matters that should be considered on every land disturbing activity in controlling erosion and sedimentation. Control is based firstly on protecting the soil surface from erosion and secondly on capturing sediment generated on-site. Because finer particles can be difficult to capture once they are moving, the best way to control generation of sediment is to prevent erosion.

The following principles effectively reduce both erosion and sedimentation, and should be implemented on every land disturbing activity and included, where necessary, in erosion and sediment control plans. The four main elements are: methodology, on-site erosion control, on-site sediment control and first/last line of control.

1 <u>Methodology</u>

- **Principle 1: Minimise disturbance / time of exposure.** Match land development to land sensitivity. Some parts of a site should never be worked and others may need careful working. Watch out for and avoid areas that are wet or sensitive, and only work on the land needed to be cleared.

- **Principle 2: Protect critical areas.** Steep slopes and watercourses should be avoided where practicable. If earth working in these areas is absolutely necessary, runoff from above the site can be diverted away from exposed slopes to minimise erosion. If steep slopes are worked and need stabilisation, traditional vegetative covers like top-soiling and seeding may not be sufficient and special protection is often required. Consideration should be given to retaining as much existing vegetation as possible to assist in erosion and sediment control.
- **Principle 3: Stage construction.** Plan construction activities to minimise the extent and duration that bare soils are exposed. Any land disturbance operations should take into account the season, and, in the case of short-term sensitive operations, the weather forecast. This includes planning operations to stage construction works, and limit the construction area of each stage.
- **Principle 4: Separate Clean water from dirty water.** Clean water is water that has not flowed through disturbed areas while discharges from disturbed areas are considered dirty water. Minimising the volume of water that is required to be treated by a sediment control device saves time and money. Furthermore clean water (upper catchment water that does not flow through the disturbed area) has also not been contaminated by sediment and therefore does not require treatment.
- **Principle 5: Make sure the Erosion and Sediment Control Plan evolves.** An effective Erosion and Sediment Control Plan needs to be modified as the project progresses over time. Factors such as weather, changes to grade and altered drainage can all mean changes to planned erosion and sediment control practices. Update the Erosion and Sediment Control Plan to suit site adjustments and at key project milestones. Make sure the Erosion and Sediment Control Plan is regularly referred to and available on site.

When undertaking earthworks operations, it is important to understand the difference between temporary and permanent erosion and sediment control measures. Temporary controls are a very short-term measure such as overnight or for a few days, during a public holiday period or wet weather. Permanent controls are installed for weeks or months, and may last for the duration of earthworks operations. Permanent controls are not removed until the site is stabilised. Even though temporary controls are only in place for a brief time, their design should be conservative enough to allow for reasonably foreseeable circumstances.

For example, temporary contour drains could be constructed on exposed sloping ground, immediately prior to wet weather. They would divert any runoff (that occurred during the wet period) into permanent diversion channels and into permanent sediment retention ponds. When earthworks operations recommence, temporary contour drains on exposed sloping ground are no longer needed.

2 On-site Erosion Control (Source Control)

- **Principle 6: Control erosion at source.** Preventing erosion may avoid the need for more expensive sediment control measures. Methods include contour drains, bunds and revegetation. Erosion controls should ensure water velocities are low and mobilisation of sediment is minimised.
- **Principle 7: Progressively stabilise disturbed areas.** Disturbed areas should be stabilised quickly. Regardless of seasonal influence, look at revegetation as each stage is completed. If required, revegetation can be repeated in autumn or spring.

3 On-site Sediment Control (Source Control)

- **Principle 8: Retain sediment on site.** Some erosion is unavoidable. Ensure that every effort is made to minimise potential discharge of sediment off site. Sediment control measures are critical before the disturbance of land . For large scale earthworks, sediment control systems will require design input to ensure that they can cope with critical storm flows. Make sure all control measures used are appropriate for the project.

4 Perimeter Controls (First and last line of control)

- **Principle 9: Install perimeter controls.** It is important to ensure that the disturbed area is isolated so that on site problems can be contained and controlled. This often involves keeping the works site divided into discrete catchment areas so that clean runoff water (from undisturbed upslope areas) is kept separate from sediment laden runoff (draining the disturbed areas). The boundary of the working area should be marked using fences, flags, signs, high visibility tape etc to help ensure that machinery doesn't encroach into undisturbed areas.

- **Principle 10: Inspect and maintain control measures.** Specialist skills are required to install and monitor erosion and sediment control measures. Adopt a flexible approach, and continually assess your operations. Monitoring of controls in long-term will ultimately result in improvements to design, and fine tuning of construction practices. Have one person on-site responsible for construction and monitoring of the erosion and sediment controls. Ensure all weather access for inspections and maintenance operations. Inspect the works during wet weather, so you can be sure that the storm water runoff controls are functioning properly. Always consider the potential effects of operations on the receiving environment. Continue to monitor the erosion and sediment control systems, making necessary changes to ensure that effects are minimised.

Key Guidance

Erosion and Sediment Control Handbook. Steven J Goldman, Katharine Jackson, Taras A Bursztynsky. McGraw and Hill 1986

ARC Technical Publication No 90 www.arc.govt.nz/guidelines

Section 3: Site assessment and risk

Chapter objectives

1. **To understand risk assessment and risk management for land disturbing activities.**
2. **To provide an overview of a typical work sequence on site including implementing erosion and sediment controls.**
3. **To understand and utilise the Universal Soil Loss Equation (USLE) for estimating soil loss for proposed developments.**

3.1 Adopting a risk assessment approach for your site

All developments, irrespective of size, nature and location, need to undertake an appropriate risk assessment for hazard and risk.

Risk assessment is linked directly with the concepts of both hazard and risk. Hazard is the potential for something to cause harm while risk is the likelihood that harm will actually be done. Overall environmental risk is defined as hazard versus exposure.

With respect to environmental risk (including erosion and sediment control), risk assessment has the following key stages.

1 Hazard identification - identifying the problem or opportunity and associated risk.

2 Identifying consequences if the hazard was to occur.

3 Estimating the magnitude of the consequences and when they could occur.

4 Estimating the probability of the consequences.

5 Evaluating the significance of a risk - the likelihood of the hazard being realised and the severity of the consequences.

Source: Royal Society of Chemistry Environment, Health and Safety Committee note, April 2008.

Table 3 Risk assessment process.

Probability of Receiving Environments being Exposed					
	High	Medium Risk	Medium Risk	High Risk	Very High Risk
	Medium	Low Risk	Medium Risk	Medium Risk	High Risk
	Low	Low Risk	Low Risk	Medium Risk	Medium Risk
	Very Low	Very Low Risk	Low Risk	Low Risk	Medium Risk
		Very Low	**Low**	**Medium**	**High**
		Consequences of Hazard being realised			

In the context of erosion and sediment control and potential effects, the effects can be considered on a qualitative scale as:

- **nil effects:** no effects at all.
- **minor adverse effects:** adverse effects that are noticeable but that will not cause any significant adverse impacts.
- **significant adverse effects that could be remedied or mitigated:** an effect that is noticeable and will have a serious adverse impact on the environment, but could potentially be mitigated or remedied.
- **unacceptable adverse effects:** extensive adverse effects that you cannot avoid, remedy or mitigate.

Source: The quality planning website (www.qualityplanning.org.nz).

It may also be relevant when assessing whether effects are minor to consider:

- the cumulative nature of any effect over time, or in combination with other effects;
- the probability of it occurring;
- temporary effects, including adverse effects associated with construction work;
- the scale and consequences of the effect (high potential impact?);
- the duration of the effect;
- the Resource Management Act permitted baseline concepts;
- the frequency or timing of any effect;
- whether the effect is a Resource Management Act section 6 or 7 matter;
- the area affected (is it an effect on neighbours or the wider environment?);
- the sensitivity of surrounding uses;
- reverse sensitivity issues;
- whether the effect is to be mitigated or avoided by a condition contained in the application or offered by the applicant in the application, which the applicant has agreed to.

Before undertaking any earthworks on the site and before finalising the erosion and sediment control measures to be used, all relevant parties need to understand the risks with the proposal. This involves ensuring that the land to be developed is understood from a from a physical perspective (slope, geology etc), the receiving environment is understood with and specific values clearly identified. Earthworks cut to fill balances, contours and general site details all need to be discussed and methodologies confirmed.

Once these are finalised then a matrix will be developed which can split the site into logical areas of risk. Table 4 can be used in this regard. Management of the site can then be developed around this risk matrix.

When assessing and managing risk on a site, use the following steps:

Step 1: Assess the potential sediment yield

Assess the potential sediment yield from the earthworks area, with tools such as the USLE, against the pre-developed (pastoral) sediment generation. If the site could discharge a large volume of sediment, it would be considered to have a high potential risk. This would primarily be determined through the slope of the site but also distance from the receiving environment, type of earthworks operation and the duration of earthworks.

Step 2: Determine the risk of the earthworks

Take into account variables, including stage of development, competency and performance of earthmoving contractor, seasonal timing and duration of works and the quality of the erosion and sediment controls. Weather forecasting is critical.

Key message: Weather forecasting is a critical component of risk management for earth working sites. A number of websites can assist with forecasting.

Step 3: Develop the risk profile for the operation

An overall risk profile should be developed based on potential and actual risk, allowing the team to focus on aspects of the earthworks programme, giving confidence that the site is appropriately managed.

Step 4: Risk management techniques

Some key management techniques used to help address risk are:

<u>Site Management Plans</u>

1 Site Management Plans for all earthworks areas should include any management plan requirements within the various consents and:

- (i) How the proposed erosion and sediment control measures meet, and where necessary, exceed Guideline design standards;
- (ii) An assessment of risk factors including erosion and sediment control management measures;
- (iii) Management measures including organisational responsibilities, for implementing, monitoring, reporting and maintenance of erosion and sediment control measures; and
- (iv) Proposed monitoring and reporting methods.

<u>Team Approach</u>

1 Development of a Team Approach to will ensure effective implementation and foster a compliance culture. The “Team” should consist of representatives of the contractor, client and council.

2 Team meetings should be integrated into regular site meetings. The contractor and client will take a proactive approach, and will have the responsibility for initial risk assessment, implementation programming, reviewing monitoring data and incorporating outcomes into erosion and sediment control measures. From this analysis ongoing assessment and adjustment may need to occur.

3 The team should meet regularly to identify activities and/or areas of high risk for sediment generation and discharge to the receiving environment, and identify risk mitigation measures, as well as being responsible for identifying appropriate control of high risk activities.

4 A team approach ensures that adequate resources, commitment and expertise are provided to the erosion and sediment control aspects from beginning to end of the development.

Site Personnel Requirements

1 Select site personnel carefully to ensure the success of any erosion and sediment management programme.

2 Site personnel should be part of an active educational programme, including regular briefings on erosion and sediment control principles and practices.

Guideline Implementation

1 Implementation of the Guidelines through both consented and permitted activities will be required.

2 All erosion and sediment control measures will need to be in place before any site works or subdivision activities are undertaken.

3 All erosion and sediment control measures will need to be retained and maintained in good working order until all site works and subdivision activities have been completed, the site secured to prevent erosion and any further discharges of sediment from the site.

Implementation

For all earthworks operations attention will need to be given to:

1 Stripping vegetation and topsoil only when earthworks will immediately follow.

2 Staging of earthworks should be decided not only for completing within a reasonable economic timeframe, but also for optimising earthworks efficiency with available resources.

3 Progressive stabilisation (including stockpiles) rather than leaving stabilisation until the end of the earthworks operation. Setting timeframes for areas to be open before stabilisation is required should be established.

4 Preparation of earthworks areas to minimise erosion when heavy rain is forecast.

5 Minimising activities that could exacerbate erosion or have adverse effects on the receiving environment's water quality.

Monitoring

1 Development of a site performance monitoring programme. This will include a regular site walkover after rain and /or high risk areas.

2 Development of an environmental monitoring programme. This could involve an ongoing water quality monitoring programme in the receiving environments (fresh water and marine). This should be linked to the base line programme. Quantitative sampling could occur prior to any earthworks activity so it is clearly understood what the base line conditions are. Ideally this should be undertaken during periods of fine weather and also during storms events of various magnitudes. For example this can include stream water and discharge water quality sampling.

This will lead to improved response and a proactive approach to avoiding adverse effects, will optimise existing controls, will add new/additional controls if required and will better manage risk.

Works Sequence

1 To ensure that the correct sequence of earthworks is followed. from an erosion and sediment control perspective this sequence will generally be:

(i) install perimeter controls such as clean water diversions;

(ii) install key sediment controls;

(iii) install diversion channels to ensure all “dirty” water runoff flows to sediment control devices;

(iv) install long term storm water controls if applicable;

(v) undertake as built plans for sediment ponds to confirm that sizing and design of controls is appropriate;

(vi) undertake main earthworks;

(vii) ongoing assessment and adjustment of control measures;

(viii) removal of impounded sediment from the control measures when necessary;

(ix) completion and progressive stabilisation; and

(x) removal of erosion and sediment controls once full vegetative cover is achieved.

Key message: Risk assessment should be considered in all circumstances. It is the engine that will drive all of the decisions and will illustrate how erosion and sediment controls are being linked to receiving environments. The risk steps should be followed for the most effective and efficient erosion and sediment control plan.

3.2 Universal soil loss equation

A tool that can be utilised to assist with determination of risk is the Universal Soil Loss Equation (USLE).

While assessment of storm water runoff is common in the development process, estimating possible soil loss is not. Nonetheless, estimates of soil loss have three important applications to soil and water management:

- assess the erosion risk at a site;
- identify suitable measures to overcome the erosion risk; and
- compare the effectiveness of various erosion control measures.

As part of a risk management approach you can optimise erosion and sediment control measures to each part of any development site.

The USLE is a simple model originally developed for agricultural practices in the USA. It is a suitable sediment yield estimation tool for activities such as earth working operations.

Rather than providing an accurate estimate of actual total sediment yield the most beneficial use of the USLE is to help identify variations of sediment yields across a particular site. It is critical that a site is divided up into logical sectors based on gradient, slope length and surface cover. Other factors are the proximity and nature of the receiving environment. Once completed the USLE will then allow the erosion and sediment control methodology to be tailored to suit the site's variations.

The USLE is based on the following factors:

Rainfall Erosion Index (R)

This factor is a measure of the erosive force and intensity of rain in a normal year, based on the energy and maximum 30 minute intensity for all major storms in an area during an average year. It is derived from probability statistics resulting from analyzing rainfall records of individual storms.

Soil Erodibility Factor (K)

This represents the ability of the surface to resist the erosive energy of rain. Texture is the principle factor affecting K but structure, organic matter and permeability also contribute. Adjustments are made to the K factor as the site works progress which reflects the percentage of clay, silts and sands within a soil structure. An allowance is also made for the percentage of organic matter that is contained within the soil.

Length-Slope Factor (LS)

This is a numeric representation of the length and slope angle of a site. It is the ratio of soil loss per unit area on a site to the corresponding loss from a 22.1 meter long experimental site with a 9% slope. Representative slope length and gradients are assessed for the separate sediment sources and are depicted in a table. It should be noted that the potential sediment generation on a site increases geometrically with an increase in gradient. Thus it is essential that bare area and slope length are minimised on steeper gradients. This may be achieved by staging works, progressively stabilising completed areas and installing contour drains to reduce slope lengths.

Ground Cover Factor (C)

Is the ratio of soil loss under specified conditions to that of a bare site. Where the soil is protected against erosion then the C Factor will reduce the soil loss estimate. This factor also takes into account the effectiveness of the vegetation and mulch at preventing the detachment and transport of soil particles.

Erosion Control Factor (P)

This factor reflects the roughness of the earthworks surface with those practices (such as contour plowing) that reduce the velocity of runoff and the tendency of runoff to flow directly down slope reduce the P factor.

Once the values for R, K, LS, C and P have been derived, the value for estimated sediment generated can be calculated. To estimate the quantity of sediment likely to be discharged to the receiving environment it is necessary to multiply this result by areas of exposure, sediment delivery ratio, sediment control measure efficiency and duration of exposure to determine the amount of sediment likely to be yielded. Areas of the site, or the entire site that are demonstrated to exhibit high sediment yields can then be managed accordingly.

It is important to also be aware that the sediment that is generated will be mobilised as either bed load or as suspended sediment. Bed load is moved at or near the bottom of the stream while suspended sediment is mixed with the waters of the receiving environment.

Key message: Only ever use the USLE as a risk assessment tool. While it can be mentioned within a supporting Assessment of Environmental Effects and associated risk profile, the actual sediment yields determined should be treated with significant caution.

For further detail of the USLE factors and determination of the values to be utilised contact should be made to Environment Bay of Plenty staff. Reference can be made to Appendix 5 of this guideline which outlines the process for undertaking a USLE calculation for an earthworks site.

Key Guidance

USLE Estimating Sediment Yield – Auckland Regional Council Land Facts

Erosion and Sediment Control Handbook. Steven J Goldman, Katharine Jackson, Taras A Bursztynsky. McGraw and Hill 1986

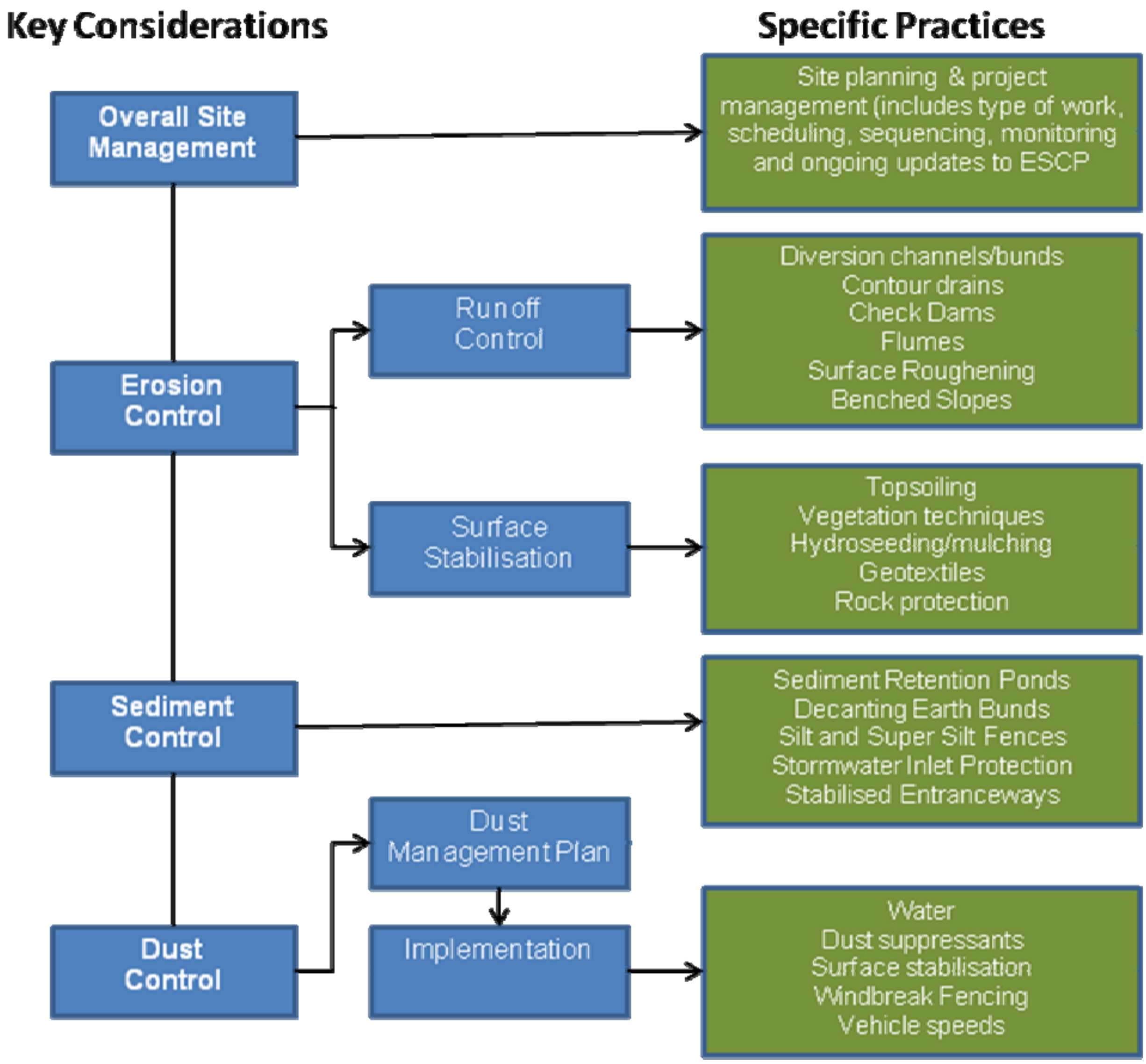
Section 4: Plan preparation and choosing the correct erosion and sediment control measure

Chapter objectives

1. **To ensure that development is undertaken with appropriate planning and implementation which is reflected in erosion and sediment control plans.**
2. **To understand the differences and benefits of both erosion control and sediment control.**
3. **To provide an overview of dust management considerations.**

The Erosion and Sediment Control Plan is the key documentation of successful project implementation. Erosion and sediment control implementation will not work unless the erosion and sediment control plan has been thoroughly and properly prepared.

The Erosion and Sediment Control Plan can be thought of in four main steps as shown below:



4.1 Overall site management

Erosion and sediment control needs to be effectively integrated into the works programme.

A key aspect of this is in the forward planning stage prior to works commencing on-site. Where erosion and sediment control measures have been well designed and are incorporated into contract documents, contractors are able to appropriately price and get paid for implementation and maintenance of the control works.

This is preferable to having unspecified erosion and sediment control as a lump sum, where control measures will generally involve minimal controls.

One person should be responsible for erosion and sediment control measures on the site, This person needs to have access to materials, machinery and labour so that they can respond to problems quickly. Ideally, this person should oversee the construction of all erosion and sediment controls, as well as be responsible for the monitoring and maintenance.

Overall site management covers matters such as:

- Programming the project;
- Specifying and scheduling of erosion and sediment control measures in contract documents;
- Timing of works in specific high risk areas;
- Limiting exposed or disturbed areas though forward planning of operations, staging of works, progressive stabilisation etc;
- Ensuring work methodologies are followed to minimise erosion and sediment problems (for example keeping machines out of watercourses);
- Scheduling when erosion and sediment controls are constructed in relation to the bulk earthworks;
- Setting out responsibilities for erosion and sediment control construction standards, inspection and maintenance; and
- Covering contingency measures such as end-of day protection works, close-up prior to public holidays, weather watch, storm damage assessment and response.

Planning for soil and water management needs to be based on an assessment of the physical constraints present at the site. Preparation of an erosion and sediment control plan should offer solutions that ensure that any development is sustainable, being considerate of the immediate and eventual effect of development on:

- the quality and quantity of both surface water and ground water;
- biodiversity and riparian ecosystems;
- consider the cumulative effect of each particular development program on other developments within the catchment area;
- enable a choice of soil and water management strategies that consider aspects other than just capital outlays such as environmental and maintenance; and
- be undertaken in concept before and at the development application stage.

4.2 Erosion control

Erosion control can be broken into two main elements:

- Runoff control
- Surface stabilisation

Erosion control relies on avoiding erosion as early as possible, before soil particles become dislodged and mobilised. Effective erosion control techniques result in reduced sediment generation and less reliance on sediment control measures. While most of the erosion control techniques are relatively low-tech and simple to implement, they require a high degree of attention to detail to be effective. Erosion control measures target rain drop impact splash erosion, sheet-flow erosion and rill erosion.

4.2.1 Runoff control

One of the most important and effective methods of control is ensuring that storm water runoff is controlled both on site as well above the site.

Key principles are.

- Clean storm water should be separated from dirty (sediment contaminated) storm water at all times. Keep clean water clean and only treat your dirty water.
- All sediment contaminated storm water should flow through some form of sediment treatment system prior to discharge off site or into a reticulated storm water system.
- To ensure that on-site velocities are kept low, runoff channels controlling storm water flow off disturbed areas should be constructed on grades that are as flat as possible.
- Where channel slopes exceed 2% grade, channels should be stabilised to control erosive velocities (e.g. line with geosynthetic fabric, use check dams etc).
- Runoff control channels should be of sufficient capacity to carry 20% AEP flows.

4.2.2 Surface stabilisation

Surface stabilisation can be temporary or permanent. Temporary stabilisation includes temporary vegetative covers, mulching or using erosion control blankets while permanent stabilisation includes permanent grassing and aggregate cover. It is important to recognise that while top soiling is a critical part of any revegetation programme, top soiling in itself is not considered a stabilised surface.

Studies in Auckland have shown that sediment reductions (using temporary surface stabilisation) when placed directly on clay subsoils can reduce sediment generation as follows:

- 48% reduction with topsoil alone.
- 85% reduction with the application of mulch.
- 93% reduction with established grass.
- 97% reduction with mulch and topsoil.

This demonstrates the importance of achieving appropriate surface stabilisation as part of your erosion and sediment control plan.

4.3 Sediment control

The primary purpose of sediment control systems is to retain sediment on site and therefore minimise off site sedimentation. These structures can also:

- Retain sediment on site and minimise sedimentation off site;
- Provide a degree of storage volume for storm water prior to discharging off site;
- Reduce the velocity of storm water runoff from the activity site to allow sediment to settle out; and
- Discharge storm water at a controlled rate.

Sediment control systems include practices such as sediment retention ponds, silt fences and storm water inlet controls. Most sediment control systems rely on detaining storm water for a long enough period to allow for sediment settling and to retain that sediment.

Do not rely on sediment controls alone. While they can be very efficient, their effectiveness relies on the amount of sediment being generated on-site. Ultimately, effective sediment control relies on good erosion controls on site, matched with efficient sediment controls.

Effectiveness of sediment control systems will depend on a number of factors. These include:

- Sites with steeper slopes have a potential to generate more sediment;
- Sediments from soils with higher fractions of fine silts and clays are more difficult to control;
- Attention to detail and strict maintenance of sediment control systems can improve their effectiveness; and
- Silt fences should only be used to control sediment runoff from sheet flow. Sediment retention ponds should be used to control runoff from channels or flow paths.
- Storage volume is important. Sediment ponds with larger storage volumes are likely to be more effective than smaller ponds.
- Select the most appropriate type of sediment control system to match the particular site requirements.

The sediment retention pond design adopted by Environment Bay of Plenty is based on a design which takes into account the design storm event and also the various soils' ability to settle.

Key message: Ensure both erosion control (prevention of sediment generation) and sediment control (trapping sediment in devices on the site of works) is implemented for all developments. Incorporate these aspects into the overall site management planning and implementation.

4.4 Dust control

Dust is the product of wind erosion, as sediment is the product of water erosion. Dust can be generated when soil that is repeatedly disturbed and broken down into finer particle size is then subjected to windy conditions. On some susceptible soils (such as some volcanic ashes) dust problems from earthworks can be severe and difficult to control. Repeated tracking of soils with machinery not only breaks down the soil particles but also aerates the soils so that they become quite "fluffy" and suspended as particulate material in the air.

Small soil particles are susceptible to suspension by wind, and capable of causing dust problems off site. As the strength of the wind increases, the potential for dust problems increases exponentially. (The rate of soil movement is proportional to the cube of the wind velocity).

On high-risk sites that have had no dust management, fine soil on the ground can be very dry and aerated, and roll in waves as machines pass, even when there is no wind to exacerbate the problem. Once the site is subject to any wind, the dust problem is very difficult to control. Dust from problem sites can travel for kilometres and cause a range of health and property problems.

4.5 Identifying and using correct procedure and practices

Prior to developing an Erosion and Sediment Control Plan it is important to have minimised the areas of disturbed soils and duration of exposure. It is also imperative to control water from above the site, control water on-site, control sediment on-site and control sediment discharge from the site.

Before developing an Erosion and Sediment Control Plan the planning process begins with data collection. This then flows through to assessment, understanding, construction methodology and only then a final Erosion and Sediment Control Plan

4.5.1 Assessment of environmental values and risks

This involves understanding site conditions, receiving environments and their values and risks. This step will involve a range of expertise to ensure that an appropriate Assessment of Environmental Effects supports the Erosion and Sediment Control Plan. Details include:

- Location
- Present land use
- Proposed land use
- Surrounding land use
- Relevant catchment information
- Climate
- Geology
- Elevation/slopes
- Soils
- Vegetation
- Cultural heritage issues
- Planning requirements
- Site limitations
- Protected areas/wetlands/vegetation
- Stream corridors
- Existing utilities

4.5.2 Construction methodology

Based on the values identified and the risk assessment the construction methodology can be determined.

The methodology should focus on avoiding, remedying and mitigation of any effects. It will provide for elements of staging works, sequencing activities and also consider seasonal requirements with respect to the expected activities.

4.5.3 Preparing an Erosion and Sediment Control Plan

Your erosion and sediment control plan is the key tool in effective site management and ensuring all the aspects identified in the site assessment and construction methodology are appropriately managed.

4.5.4 Contract process

It is well recognised that the type of contract implemented as part of an earthworks activity tender process can influence the ability to implement erosion and sediment control measures. The three key contract types are either lump sum, measure and value or cost reimbursement.

Under lump sum pricing, the contractor carries out work described in the contract documentation with the principal paying the contract price. A schedule of prices is often included in these contracts but should only be used as a basis for computing payment schedules and valuing variations and for no other purpose.

Key aspects of lump sum contracts are:

- client perception - they know the cost of the works.
- good for well defined rigid portions of work that won't change.
- risk to the contractor makes it likely to generate a higher price.
- it doesn't remove the likelihood of variations and contingencies should be provided for.
- it removes the basis for valuation of variations.
- it provides an increased risk of contractor cutting corners to fit budget.
- it increases liability for client, consultant and contractor.
- provides for the possibility of overlaps between temporary and permanent works.

The erosion and sediment control component of a Measure and Value Contract sees the contractor carry out the work described in the contract documents to fulfil its obligations.

The principal pays the contractor for the measured quantity (as determined by the engineer) of each item of work carried out at the rate set out in the schedule of prices. The contractor is required to have allowed in its price to cover the whole range of work included within those items.

Any quantities given in the schedule of prices are provided for the purpose of evaluating tenders and may be taken as a reasonable assessment of the quantities involved in the contract works. Where the actual quantity of any single item differs from that given in the schedule of prices to such an extent as to make the scheduled price for that item unreasonable, then the change in quantity shall be treated as if it were a variation.

Key aspects of consideration of measure and value contracts are:

- it provides a clear indication of works necessary if scheduled correctly.
- it provides a flexible basis for varying works and valuing variations as works progress.
- it reduces the likelihood of higher pricing by contractor due to reduced risk.
- it reduces the likelihood of the contractor cutting corners – lower liability.
- it can be of concern to the developer re uncertainty in costs.
- it can result in cost blowouts if scheduled poorly.

Under cost reimbursement, the contractor carries out the work described in the contract documentation. The principal reimburses the contractor for costs and makes an allowance for profit in accordance with the method set out in special conditions.

Key aspects of consideration of cost reimbursement contracts are:

- It reduces the likelihood of higher pricing by contractor due to risk.
- It reduces the likelihood of contractor cutting corners and provides for lower liability.
- It can provide client concerns in that final costs may be uncertain.

- It can be difficult in tender analysis to compare 'like for like' as there is not a price but a margin.

Consider the options available for tendering and associated pricing. Environment Bay of Plenty prefers a measure and value contract for erosion and sediment control and encourages this. However it is critical that these key steps are followed:

- develop a standard, unambiguous schedule and contract specification for erosion and sediment control.
- put the necessary time and forethought into each design.
- consider a "sub-contingency" in the erosion and sediment control schedule to cover the need for minor, unforeseen items of work that are not easy to predict.

4.6 Erosion and Sediment Control Plan requirements

The erosion and sediment control plan is a working tool that helps you and Environment Bay of Plenty make sure that your selected practices and procedures are pulled together to address the values and risks of the site and its broader environmental and community context.

Key message: Keep it simple - use a small number of robust practices to treat water once and get it off site.

The erosion and sediment control plan will outline how the fundamental principles of erosion and sediment control have led you to select certain project methodologies, erosion and sediment control practices and site management procedures. This plan will be considered as part of the resource consent process but can also be undertaken when permitted activity works are being undertaken.

You need to demonstrate that you have considered, addressed and planned the management at all stages of the project's planning, design and construction phases, to:

- control water running onto the site;
- separate 'clean' from 'dirty' water;
- protect the land surface from erosion; and
- prevent sediment from leaving the site.

Key message: Use available expertise and resources to select and design your controls.

Your erosion and sediment control plan needs to include a map and a narrative that describes an integrated suite of practices from the top of the site, through it and down to the foot of the site, deploying a range of erosion and sediment control practices that support each other.

The plan must include at least the following information:

- a description of the proposed development and the site, including:

  (i) total area of bare ground on site (cumulative total through development period);

  (ii) total length of exposed roads, trenches, tracks; and

  (iii) volume of proposed earthworks.

- a management plan that reflects the AEE you have prepared as part of project consenting. The level of detail should be appropriate to the scale of the operation, but should generally include:

  (i) detailed location map with a north point and a bar scale as well as a ratio scale, showing roads, boundaries, location of surface water bodies, any existing storm water reticulation and outfalls, directions of groundwater flow;

  (ii) be at a suitable scale for the size of the project; and

  (iii) site description, including land type, climate, topography, vegetation, soils, watercourses, site boundaries, contour maps, existing and protected vegetation, location of site access and other impervious areas and existing and proposed drainage pathways with discharge points;

- a map of the site with a scale bar of the practices that reflect:

  (i) erosion controls proposed to prevent detachment and transport of soil particles;

  (ii) sediment controls proposed to avoid or minimise sediment discharge;

  (iii) drawings for different stages of the seasonal works associated with the development;

  (iv) details of any stream crossing and measures taken to avoid or minimise sediment impacts;

  (v) programme of works containing details on the nature and specific location of works (revegetation, cut and fills, run-off diversions, stockpile management, access protection), timing of measures to be implemented and maintenance requirements;

  (vi) copies of the selected controls so that people onsite can follow them;

  (vii) risk assessment details;

  (viii) environmental compensation details;

  (ix) provide details of any chemical treatment proposed;

  (x) details of proposed monitoring to assess the effectiveness of the control measures;

  (xi) details of any other measures designed to reduce impact on the environment; and

(xii) supporting text and calculations detailing:

- a project planning/work programme and description of all procedures and control practices, staging, timing and sequencing of works, design and methodology;
- erosion controls, including run-off water control and site stabilisation and revegetation;
- sediment controls; and
- supporting calculations for dimensions, depth, volumes, capacity, gradient, flow and other key design parameters for each practice.

Key message: Put practices where you can get at them for maintenance, including during and after heavy rain.

Appendix 4 of the Guideline provides a schematic of an erosion and sediment control plan.

Key Guidance

Erosion and Sediment Control Handbook. Steven J Goldman, Katharine Jackson, Taras A Bursztynsky. McGraw and Hill 1986

ARC Technical Publication No 90 www.arc.govt.nz/guidelines

Section 5: Revegetation

Chapter objectives

1. **To provide an overview of revegetation practices that are available following land disturbance activities.**
2. **Each practice outlines the:**
   - **Purpose**
   - **Conditions where practice applies**
   - **Design**
   - **Construction specifications**
   - **Maintenance; and**
   - **Limitations**

5.1 Top soiling and seeding

Top soiling 

Temporary Seeding 

Permanent Seeding 

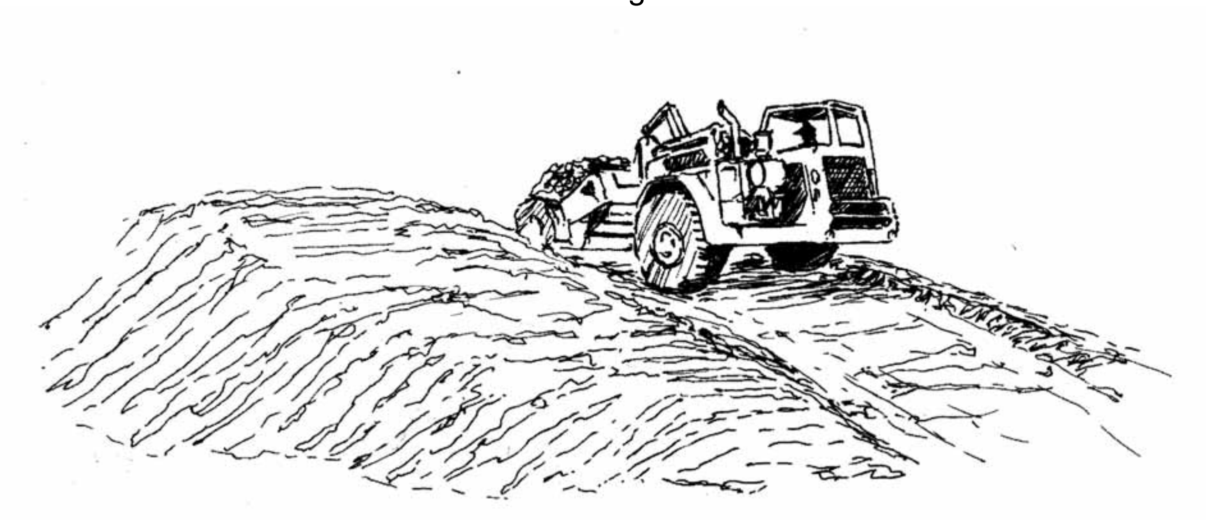


Figure 7 Topsoil storage schematic.

<u>Definition</u>

Top soiling involves placing topsoil over a prepared subsoil prior to the establishment of vegetation.

Seeding involves planting and establishment of quick growing and/or perennial vegetation to provide temporary and/or permanent stabilisation on exposed areas.

Purpose

The key purpose of top soiling is to provide a suitable soil medium for vegetative growth for erosion control while providing some protection of the subsoil layer, and also increasing absorption capacity of the soil. Once established, vegetation protects exposed soils from raindrop impact, reduces runoff velocity and volume, binds soil particles together and can also inhibit weed growth.

Temporary grassing involves planting rapid-growing annual grasses to provide initial, short-term cover for erosion control on disturbed areas. This is usually needed where areas are not yet at final grades, and further works are not planned for an extended period. Typically temporary grassing is undertaken on identified risk areas of the site for the winter period.

Permanent grassing involves planting perennial grasses to provide permanent erosion protection to disturbed areas following completion of the earthworks activity. Wherever practicable, permanent grassing should be done progressively throughout the construction sequence as areas are finalised and are brought to final grade.

Topsoil is a valuable resource. When placing topsoil in stockpiles ensure that it is isolated by the upslope diversion of clean water runoff, stabilised appropriately and not stored in stockpiles greater than two metres in height to maintain soil structure and integrity.

Conditions where practice applies

Topsoil provides the major zone for root development and biological activities as well as having greater available water holding capacity than clay subsoil layers.

Top soiling is recommended for sites where:

- the texture and/or the organic component of the exposed subsoil or parent material cannot produce adequate vegetative growth;
- the soil material is so shallow that the rooting zone is not deep enough to support plants or furnish continuing supplies of moisture and plant nutrients; and
- high quality vegetative cover is required to be established.

Top soiling is combined with vegetation establishment and is not seen as an erosion control measure in itself. When staging within an earthworks operation, top soiling as a treatment in itself is not acceptable and other means of stabilisation such as revegetation will also be required.

Key message: Top soiling is not considered to provide a stabilised surface. Top soiling simply provides a media within which vegetation can be established and maintained.

Temporary seeding

Use on any cleared or unvegetated areas which are subject to erosion and will not be earthworked for a period of 30 days up to a maximum of 12 months. Temporary stabilisation is normally practised where the vegetative cover is required to be in place for less than one year. In some circumstances mulching may be used as an alternative.

Permanent seeding

This practice applies to any site where establishing permanent vegetation is important to protect bare earth. It may also be used on rough graded areas that will not be brought to final grade for a year or more.

Key items

Utilise temporary seeding on short to medium-term stockpiles, the outside of pond embankments, on cut and fill slopes, access/haul road embankments and any other disturbed area that is likely to remain exposed and unworked for less than 12 months. Where the exposed area is likely to remain exposed for period of 12 months or greater (even if works are proposed in the future after this time) then permanent seeding should be implemented.

It is recommended that soil surface mulching should be undertaken as part of an integral component of a seeding programme during dry or cold periods. This will protect both seed and soil, while providing a better microclimate for germination and growth of grasses.

Fertiliser, from both an establishment and maintenance perspective, needs to be applied at the same time as sowing grass seed.

Ensure that site conditions, and the time of the year are appropriate for germination and vegetation establishment prior to undertaking this activity. This may involve the placement of mulch and / or, irrigation of the area.

Design

- To maximise germination and growth rates, the preferred seeding windows for both temporary and permanent grassing are in autumn and spring Using mulch or geotextiles to maintain soil temperatures and irrigation to supply moisture, grassing may be done throughout summer.
- If irrigation is to be utilised, a volume at least equal to the evaporation and transpiration rates is required. This should continue until natural rainfall provides the necessary soil moisture levels for plant survival.
- Environment Bay of Plenty considers that 80 percent ground cover over the entire subject area is necessary to achieve a stabilised surface.

Figure 8 *Example of 80% strike over entire site - photo courtesy of Environment Bay of Plenty*

When choosing the appropriate seed and fertiliser mix for your site to achieve the necessary erosion control function it is recommended that you use the Options (O), Alternatives (A) together with the Essential Species (E) below in Table 5.

Seed mixes should be comprised of the following proportions and applied at 270kg/ha, however site specific seed and fertiliser requirements should be determined based on site soil analysis.

- Perennial Ryegrass E or + O / A 70%
- Fescues / Cocksfoot E or + O / A 20%
- Clover / Lotus E or + O / A 5%
- Other e.g. Browntop or O / A 5%

Application rate: 270kg/Ha

Fertiliser Application - 15:10:10 @ 250kg/Ha

Maintenance - 15:10:10 (6 to 12 weeks after seeding and as required) @ 250kg/Ha

Table 4 Example Seed and fertiliser application.

Seed species recommendations for Erosion and Sediment Control

Key : E = essential, **AE** = alternative & essential, **O** = optional, **I** = requires inoculants

	Batters/Cuttings (A, B & C Horizon)	Topsoiled Earthworks	Subsoil Earthworks	Coastal High Sand Content	Wetlands and Saline
Perennial Ryegrass – select cultivar for low DM production and deep rooting persistence such as Pacific	E	E	E	O	O
Winter Active Perennial Ryegrass – requires reasonable fertility. Active in temperatures from 5ºC. Sports turf cultivars such as "Sports Oval".	O	Temporary O	Temporary O	Temporary O	-
Annual Ryegrass – fast establishment, high DM production, requires med + fertility – generally lower temp tolerant. Cultivars – most Italian Ryegrasses such as Tama, H1.	O	O	O	O	O
Fescue Creeping Red – drought & low fertility & saline tolerant. Spreads readily.	E	AE	AE	E	E
Tall Fescue – persistent, drought & fertility tolerant.	AE	AE	AE	O	O
Cocksfoot – drought, low fertility and acid (low pH) tolerant. Cultivars – NZ prostrate habit such as "Tekapo".	O	O	O	O	O
Browntop – low fert requirement, low DM production. Drought tolerant. Prolific self-seeding. Persistent in low pH soils.	E	O	O	O	O
White Clover – persistent "Huia" cultivar is the highest N fixing clover in NZ.	E, I	E, I	E, I	E, I	E, I
Lotus – very low fertility tolerant, drought & wet tolerant also. High N fixing. Spreads persistently in most situations.	E, I	-	AE, I	E, I	AE, I
Subterranean Clover – very drought tolerant, low fertility.	O, I	O, I	O, I	-	-
Couch Grass or Kikuyu – saline tolerant, low fertility in wet & dry conditions. Spreads profusely. Will grow where most other grasses won't.	O	O	O	E	E
Other species for consideration include: - Yarrow - Plantain - Red Clovers - Native Grasses - Other Natives - Cereals	O, A	O, A	O, A	O, A	O, A

NB: In all circumstances ensure that the seed and fertiliser application rates and mix is appropriate for your site. Always discuss with your seed and fertiliser supplier prior to application.

Construction specifications

The following flow chart should be followed when undertaking top soiling and seeding.

Step One – Install all required erosion and sediment control measures. Prepare a good surface clear of all large rocks, clods and unsuitable material.

Step Two - Evenly spread a minimum of 100 mm of topsoil before re-vegetating. On steeper sites over 25 percent, scarify the subsoils to a depth of a least 100 mm to ensure bonding between topsoil and subsoil before applying topsoil.

Step Three - On slopes greater than 25% compact the topsoil to avoid slumping and incorporate surface roughening into all top soiling operations in accordance with these guidelines

Step Four – Apply seed and fertiliser. Utilise Table 5 of these Guidelines as a guide however seek specialist advice for your site. For large or "out of the ordinary" sites undertake a fertility test to ensure appropriate seed and fertiliser application.

Step Five - Seed applied via broadcasting must be raked in to ensure adequate coverage of the seed is achieved.

Step Six – Irrigate, fertilise and maintain as necessary.

Use only fresh, certified seed with a high purity and germination percentage preferably from local reputable suppliers. Species selection must consider the project's ecological context and if permanent, seeding must consider final landscape plans.

Hydroseeding is recommended for establishing seed. Reference should be made to 5.2 of this Guideline.

Traditional agricultural techniques such as drill seeding, broadcast seeding or no tillage are appropriate for establishing grass on areas flatter than 25%. Ensure the methodology achieves a good seed-to-soil contact, enhancing seed survival and germination rates. For small areas hand-broadcasting and raking may also be used to apply seed and fertiliser.

Maintenance

- Check the condition of the topsoil on a regular basis and re-grade and/or replace where necessary to always maintain a 100 mm minimum depth of topsoil and appropriate surface roughening.
- Reseed where seed germination is unsatisfactory or where areas of erosion occur. If germination is unsatisfactory during the winter months the area will also require the application of mulch in accordance with 5.3 of these Guidelines.
- Protect all revegetated areas from traffic flows and other activities such as the installation of drainage lines and utilities. If required, erect temporary barrier fencing and/or signage.
- Apply additional fertilisers where further plant nutrition is required.

Limitations

- Establishing a protective vegetative sward is difficult during periods of low rainfall or temperature extremes. Develop construction sequencing so top soiling and seeding occurs during optimum periods for vegetation establishment.
- Topsoil in itself is not considered stabilised and as a result the downstream sediment control measures will need to remain in place throughout the operation until vegetation achieves this criteria. Other stabilisation methods such as mulching may be able to be implemented.

5.2 Hydroseeding

HS

Figure 9 Hydro seeding schematic.

Definition

The application of seed, fertiliser and paper or wood pulp with water in the form of a slurry, sprayed over an area for re-vegetation.

Purpose

Hydroseeding will provide some protection from raindrop impact for a limited period and primarily is designed to rapidly establish vegetation as a stabilised surface, quickly and effectively. Hydroseeding is typically used to establish grass and other vegetation on steep and/or inaccessible areas.

Conditions where practice applies

This practice applies to any site where vegetation establishment is important for stabilisation. Typically it is used on:

- Critical areas such as steep slopes or batters and exposed areas near watercourses that require rapid stabilisation.
- Critical areas that may be difficult to establish by conventional sowing methods.
- Around or on runoff diversion channels/bunds, where rapid establishment of a protective vegetation cover is required before introducing water flow.

Key message: As with top soiling, hydroseeding is not considered stabilised as a practice in itself, however it will quickly provide an effective vegetative cover of exposed earthwork areas.

Design

Figure 10 Hydro seeding Operation - photo courtesy of Erosion Control Limited.

- As a minimum, hydroseed mix must contain appropriate seed and fertiliser mix as detailed in 5.1 of these Guidelines. Various hydroseed mixes exist, utilising soil ameliorants, paper or wood pulp and in some circumstances a binder to help seeds adhere to the soil surface. Hydroseed slurry should be applied at a rate in accordance with the specialist applicators specifications.
- Apply the hydroseed mix using a specialised vehicle-mounted cannon, or, for inaccessible areas, a hand-held hose and nozzle. Additional use of a mulch (as per 5.3 of these Guidelines) over the hydroseed to protect the seed and soil will enhance seed survival and germination rates.
- Environment Bay of Plenty considers that 80 percent ground cover over the entire subject area following the growth of seed within the hydroseed mix is necessary to achieve a stabilised surface.

Construction specifications

The following flow chart should be followed when undertaking hydroseeding:

Step One - Before hydroseeding, install any needed erosion and sediment control practices such as runoff diversion channels.

Step Two - Scarify any steep or smooth clay surfaces to improve retention of the hydroseeding slurry.

Step Three - Apply hydroseed with specialist supplier and with seed and fertiliser mix as per 5.1 of this guideline.

Step Four - Hydroseeding requires moisture for germination and growth. Because hydroseeding is often used for difficult sites, the timing of the application to get favourable growing conditions is an important factor.

Step Five - Check that steep pumice slopes are not so dry that they will crumble as the hydroseeding is applied.

Step Six – Maintain moisture and ensure growth achieves the necessary stabilisation.

Figure 11 Recently applied hydroseed showing emergent grass growth – photo courtesy of Ridley Dunphy Environmental Limited.

Maintenance

- Heavy rainfall can wash new hydroseeding away before establishment, particularly from smoother hard surfaces and overland flow paths. Where vegetation establishment is unsatisfactory, the area will require hydroseeding again or consideration will need to be given to other stabilisation techniques.
- Protect all re-vegetated areas from construction traffic and other activities such as the installation of drainage and utility services.

Limitations

- Always use local knowledge, and experienced contractors to ensure that the seed mix is appropriate for the site.

5.3 Mulching and Metalling

Figure 12 Mulching schematic.

Definition:

The application of a protective layer of straw or other suitable material to the soil surface.

Soil surface mulching puts a protective layer of material over the soil to protect it from the erosive forces of wind and water. Mulching for erosion control is usually a short to medium-term treatment. It can be used as a stand-alone surface cover or in conjunction with a seed and fertiliser grassing programme.

While straw and hay are the commonly used materials, mulching can also include the application of bark, wood residue and wood pulp spread over the surface of disturbed flatter ground.

The application of graded rock over the soil surface in order to provide an immediately stabilised surface. The use of graded rock is considered a long-term stabilisation method over the applied areas.

Figure 13 *Specialist application of hay mulch - photo courtesy of Auckland Regional Council.*

Purpose

To protect the soil surface from the erosive forces of raindrop impact and erosion that forms from overland flow. Mulching and gravelling provides an instantaneous layer of protection in the form of a surface cover.

Mulching also helps conserve moisture during dry periods of moisture deficit, can help control weed growth and will assist with maintaining a higher soil temperature through providing a microclimate. This microclimate will assist seed germination to establish the seed and a vegetative cover. Mulch also provides a source of organic matter

Straw mulches can include wheat or barley straw, while hay is used in circumstances where straw is unavailable. Hay can contain weed seeds and care needs to be taken to prevent weed infestation of the mulched area.

Soil surface mulches can also include inorganic materials such as crushed rock or gravel which also provides an immediate stabilised surface. Where rock is used, it is typically used in conjunction with other site practices such as achieving a stabilised contractors yard, lay down area or tracks.

*Figure 14	Well applied mulch and vegetative cover - photo courtesy of Ridley Dunphy Environmental Limited.*

Conditions where practice applies

- Use in circumstances where it is critical to achieve an immediate stabilised surface cover and to maintain this cover for the short or medium-term. This includes stabilising areas that have not been worked for some time but may be worked in future development stages.

- Mulching provides a microclimate by maintaining soil temperatures and avoiding soil temperature fluctuations. A consistent ground temperature provides for appropriate conditions for seed germination, and enables establishment of vegetation at most times of the year.

- Mulching can be used at any time where instant erosion protection is needed.

- Where straw is used as a mulch material it can achieve a maximum of five months' stabilised surface cover before the straw becomes part of the overall soil matrix and effective surface cover is lost.

- Where hay is used as a mulch material it can achieve a maximum of three months' of stabilised surface cover before the hay becomes part of the overall soil matrix and effective surface cover is lost.

- Wood chips, gravels or other heavier material are only to be applied on flatter slopes where the risk of the placed material will not erode. Slopes that are less than 20% are considered appropriate.

Key message: Always focus on erosion control first. Mulching is the key erosion control methodology; it provides immediate soil protection, helps establish vegetation and allows successful staging and sequencing of earthworks operations.

- As an alternative to straw or hay mulch, Bonded Fibre Matrix products (which consist of an application of a specialist wood fibre) can be utilised. These are available from specific stabilisation specialists, however it is important to recognise that this surface cover treatment is not considered stabilised as a treatment in itself. They are typically used on steeper slope areas greater than 50%.
- Never use mulch in or immediately adjacent to areas of concentrated flow paths or in stream channel systems.

Design

- Straw or hay is the most commonly used mulching material, based on weed-free materials. A specialised machine is used to shred and distribute the material over the area to be treated. The application rate is 6000 kilograms per hectare, however it is recommended that the application rate be “measured” based on the full cover of the soil surface with no exposed soils. A 30 mm loose thickness measured at the time of application is the required coverage. This is considered to be fully stabilised in this state.
- If the site conditions are windy and, there are difficulties with the mulch material remaining on site, binders or tackifiers can be applied directly as the mulch is being distributed. The binders or tackifiers should be applied at an application rate that matches the manufactures specifications for that specific product. If the mulch is applied during rain drizzle this may in itself act as an adequate mulch binder and help enable the mulch to remain on the site.
- Hydro mulch applications, an alternative to mulching, should only be undertaken in accordance with the manufacturer’s specifications and will need to be applied with an approved methodology.
- Wood chip can be used and has the advantage of being generally slow to deteriorate, but it can “lock up” large amounts of soil nitrogen, making it unavailable to plants. Saps and tannins leaching from bark material can cause a low pH discharge, therefore care is required when applying wood chip near or adjacent to watercourses.
- The application of graded rock over surfaces within internal areas of the site should have a minimum thickness of no less than 50 mm, spread evenly with no visible soil seen through the rock matrix.

Figure 15 Recently applied mulch - photo courtesy of Environment Bay of Plenty

Construction specifications

The following flow chart should be followed when utilising mulch:

Step One – Plan in advance and ensure staging and sequencing methods are conducive to mulching.

Step Two - Before mulching or gravelling install any erosion and sediment control practices such as Runoff Diversion Channels and sediment retention structures.

Step Three - Mulch at a minimum rate of 6000 kg per ha or to achieve a 30 mm loose thickness (measured at time of application) or gravelling at 50mm thickness. Hand application of mulch will require a higher rate as the application is not as uniform. Apply seed and fertiliser as necessary to mulch.

Step Four - Mulch or graded rock needs to be spread uniformly and no soil surface should be left exposed.

Step Five - With mulch, anchor in place immediately after application to avoid or minimise loss by wind or water. The mulch is typically 'settled' in place by the first rainfall.

Step Six – Always consider mulching options and continue to maintain the stabilised surface as necessary.

Maintenance

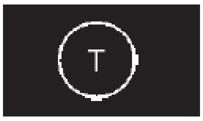
- Inspect after each rainfall event or periods of strong winds, and repair or replace any areas of damaged cover.
- Construction equipment can disturb the stabilised areas. If required, erect temporary barrier fencing and/or signage to restrict movement of equipment and vehicles to direct vehicles away from mulched areas.

Limitations

- Most mulching needs specialised application equipment to ensure uniform coverage. Hand mulching can be done on smaller sites. Plan your mulching programme and book mulching contractors well ahead if you will be needing them during peak seeding requirements.
- Gravelling does not require specialist equipment. However in most cases it is not practical to cover large areas in graded rock.
- Access to some areas can be difficult as sites are developed, so develop a progressive mulching programme to ensure that all disturbed areas can be treated as they are completed and before moving on. Gravelled areas can be a good solution for access around stabilised sites.
- Mulch can be dislodged by intense rain or very high winds. For optimal protection, one hundred percent surface cover must be maintained, so inspect mulch for damage and reapply when needed.

Figure 16 Good and inadequate mulch surface cover - photo courtesy of Ridley Dunphy Environmental Limited.

5.4 Turfing



Definition

The establishment and permanent stabilisation of disturbed areas by laying a continuous cover of grass turf.

Purpose

To provide immediate vegetative cover to stabilise exposed areas. Turfing, or laying instant lawn may establish an instant vegetative 'filter' or buffer along footpaths, driveways, kerbs and channels. It provides instant results in both visual and erosion control terms.

Conditions where practice applies

Turfing options include:

- Critical erosion-prone areas on the site that cannot be stabilised by conventional sowing or other stabilisation methods.
- Runoff diversion channels and other areas of concentrated flow where velocities will not exceed the specifications for a grass lining.
- Areas around grass storm water inlets
- Residential or commercial lawns for immediate use and aesthetic reasons.

Key message: When considering the options for achieving stabilisation on your site ensure that the full suite of tools are considered. Turfing is one of those tools.

Design

While there are no specific design criteria for turfing, care needs to taken to ensure that the velocities of flow that will travel over the area of turfing will not cause erosion. In steeper areas, turf reinforced with geotextiles should be considered. Refer to Section 6.1 of this Guideline for geotextile options.

Construction specifications

The following flow chart should be followed when undertaking turfing.

Step One - Before turfing, properly prepare the site to ensure successful establishment of vegetation - applying fertiliser, uniformly grading the area, clearing all debris, removing stones and clods and scarifying hard packed surfaces.

→

Step Two - During periods of high soil temperatures, lightly irrigate soil immediately before laying turf. Lay the first row of turf in a straight line, with subsequent rows placed parallel to and tightly wedged against each other.

→

Step Three - Stagger lateral joints in a brick-like pattern. Do not stretch or overlap turf and make sure all joints are butted tight to prevent voids, which can cause drying of the grass roots.

↓

Step Four - On sloping areas or channels where turfing is proposed, lay turf downslope with the ends of the material overlapped so the upslope turf overlaps the downslope turf by at least 100 mm.

→

Step Five - Secure the turf with pegs or staples. Ensure turf at the top of the slope is appropriately trenched in to prevent runoff moving underneath it.

→

Step Six - As turfing is completed in one area, roll or tamp the entire area to ensure solid contact of the grass roots with the soil surface. After rolling, immediately water the turf until the underside and soil surface below are thoroughly wet.

Maintain with moisture and fertiliser as necessary.

Figure 17 Laying turf next to drainage channel - photo courtesy of Auckland Regional Council.

Maintenance

- Water daily during the first week of laying the turf unless there is adequate rainfall.
- Ensure that the turf is firmly rooted to the original ground surface. Do not mow until the turf is firmly rooted.
- Apply fertiliser as required in accordance with supplier's specifications.

Limitations

Turfing can be a relatively expensive option to achieve a stabilised surface, however provides immediate protection.

Section 6: Erosion control

Chapter objectives

1. To provide an overview of erosion control practices that are available for use where land disturbance activities occur.
2. Each practice outlines the:
   - Definition
   - Purpose
   - Conditions where practice applies
   - Design
   - Construction specifications
   - Maintenance; and
   - Limitations

6.1 Geotextiles

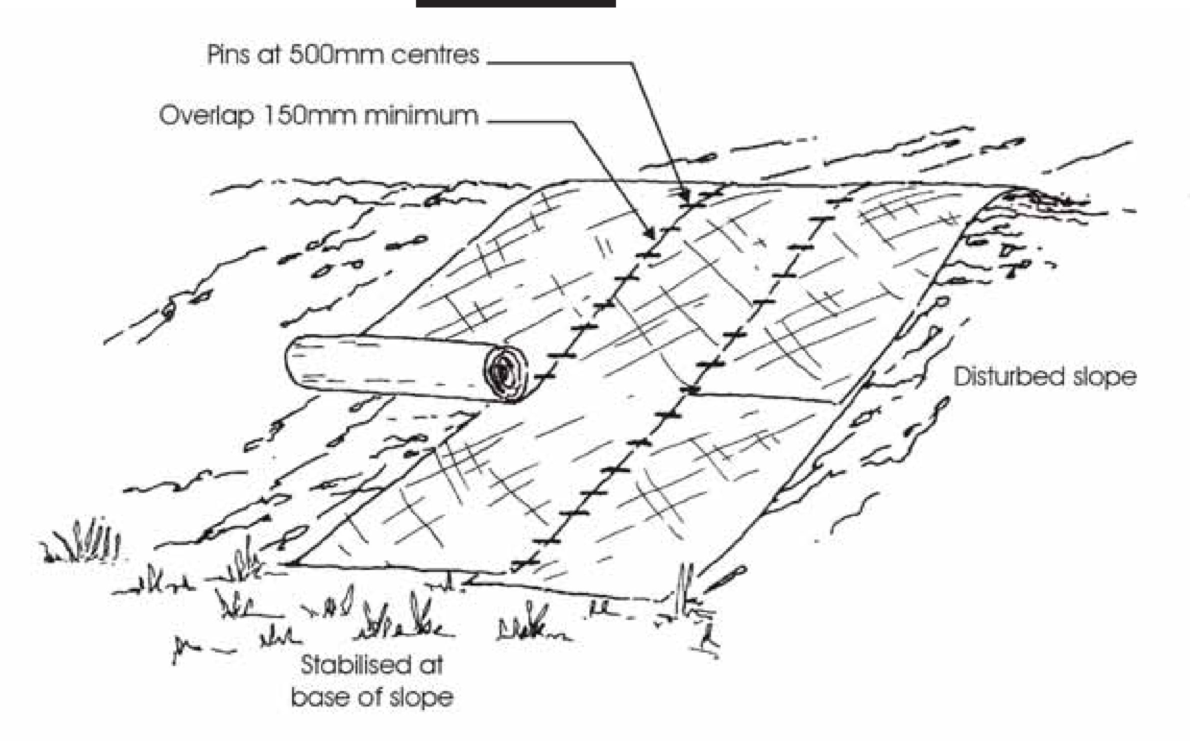


Figure 18 Geotextile schematic.

Definition

The protection of channel systems and erodible slopes using artificial erosion control material such as geosynthetic matting, geotextiles or erosion matting. The use of geotextile is typically categorised into temporary degradable geotextiles and permanent non degradable geotextiles.

Erosion control batter blankets are a specific group of proprietary rolled erosion control products commonly made from biodegradable materials. They provide a quick, short to medium-term protective cover of the soil surface, shielding it from the erosive forces of wind, raindrop impact and sheet flows until a vegetative sward can be established or an alternative stabilisation methodology is used.

The blankets are securely pegged to the soil surface, making them suitable for use on steep slopes, in areas inaccessible to machinery or on areas where a temporary and relatively quick stabilisation measure is required.

There are many products available, including:

- Vegetation promotion blankets - relatively thin materials used to encourage grasses to grow up through them.
- Vegetation suppression blankets - much thicker and generally used for soil protection and weed-control purposes and where pre-grown or potted plant material is planted down through the blanket into the topsoil (generally in a landscaping context).
- Erosion control mats - mainly high shear strength synthetic products used as soft armour channel liners in areas of concentrated flow, such as channels and drains. Needle-punched geotextile fabric or even builder's plastic may be used as a temporary blanket to cover stockpiles or high-risk areas.

Purpose

To immediately reduce the erosion potential of disturbed areas and/or to reduce or eliminate erosion on critical sites while long-term vegetation is being established.

Figure 19 Geotextile showing overlap and top key support. Not appropriately pinned to slope - photo courtesy of Ridley Dunphy Environmental Limited.

Conditions where practice applies

Geotextiles should only be used:

- In critical erosion-prone areas, such as sediment retention pond outlets and inlet points.
- In channels (both perennial and ephemeral) where the design flow produces tractive shear forces greater than existing soils can withstand, which leads to erosion of the soil surface. It is important to note that in pumice soils, due to their erodibility, any diversion channel greater than 2% in grade should be fully lined with an appropriate geotextile.
- Temporarily where there is not enough room to install adequate sediment controls.
- In areas that may be slow to establish an adequate permanent vegetative cover, with the geotextile providing an initial protective layer as well as assisting in maintaining higher soil temperature.
- On short steep slopes, on batters or stockpiles during periods of inactivity on the site.
- In situations where tensile and shear strength characteristics of conventional mulches limit their effectiveness in runoff velocities.
- In areas where the downstream environment is of high value and rapid stabilisation is needed.

Key message: Always check that the geotextile material to be utilised is the correct product for use. Do not accept or use products outside the manufacturer's specifications.

Geotextiles can be an alternative to mulch for stabilisation where dust from traditional mulching equipment has the potential to cause environmental harm or create public nuisance.

Design

Figure 20 Geotextile covering of stockpiles - photo courtesy of Site Specific Limited.

There are two categories of geotextiles - temporary degradable and permanent non-degradable.

Temporary Degradable Geotextiles

These are used to prevent loss of seedbed and promote vegetation establishment where vegetation alone will be sufficient for site protection, once established. Common temporary geotextiles are erosion control blankets, open weave meshes/matting and organic erosion control netting (fibre mats factory-bonded to synthetic netting).

Permanent Non-Degradable Geotextiles

These are used to extend erosion control limits of vegetation, soil, rock or other materials. Common permanent geotextiles are three-dimensional erosion control and revegetation mats, geocellular confinement systems, reno mattresses and gabions.

The selection of an appropriate geotextile is a complex balancing exercise of the of the following requirements.

Endurance durability, degree of resistance to deformation over time, ultra violet radiation and chemicals (natural chemicals and contaminants).

Physical thickness, weight, specific gravity and degree of light penetration. Generally, a thicker, heavier material will provide better protection over a longer period of time.

Hydraulic ability of the system to resist tractive shear strength and protect against channel erosion, erosion of underlying soils or slope erosion from rainfall impact. When working in pumice soils ensure this is clearly identified and addressed within the erosion and sediment control plan. The design velocity of the geotextile needs careful consideration, ensuring that the geotextile chosen is appropriate for the intended use.

Mechanical deformation and strength behaviour. Tensile strength and elongation, stiffness (how well it will conform to the sub grade), and how well it will resist tractive shear forces.

When a geotextile is to be used for temporary channel or spillway protection, consider combining a high strength low permeability cloth over a soft pliable needle punch cloth, pinned to ensure the cloth is in contact with the entire soil surface.

Trench and pin all flow entry points such that the upslope geotextile edge overlaps the down slope geotextile mat. Toe in the upslope end of the down slope mat as per Figure 24 below.

In all circumstances pin geotextiles down on a 500 mm grid. This is critical in ensuring an appropriate number of contact points with the underlying soil and ensuring that wind does not cause the geotextile to lift from the slope it is protecting.

There are a large number of products available for all situations and depending on the purpose of the geotextile and the degree of protection needed. A product or combination of products will be available to suit most situations. It is vital that the product is designed for the intended use, and installed and maintained according to its specifications.

Figure 21 Matting utilised to assist with vegetation establishment in channel – photo courtesy of Ridley Dunphy Environmental Limited.

Construction Specifications

In all circumstances for specific construction specifications refer to the product information sheets supplied by the manufacturer. Where these are not available, follow this flow chart:

Step One – Prepare slope and soil adding fertiliser and seed if necessary. Remove rocks and other larger material.

Step Two – Begin at the top of the slope. Trench in the top of the geotextile a minimum of 500mm (“double over” and secure in high risk circumstances).

Step Three - Roll geotextile down the slope and ensure there is a minimum of 150mm overlap. At the end of the roll provide for a minimum of 1000mm layer at the end of the slope.

Step Four - Pin at 500mm centres utilising geotextile pins that are a minimum of 150mm in length.

Step Five - Where used in channels ensure that the geotextile is suitable for that use and overlap a minimum of 150mm in all cases.

Step Six – Where used in channels always pin across the full width of the channel.

Maintenance

Inspect daily and after each rainfall event and look for:

- Lifting geotextile caused by vegetation growing up under the fabric.
- Rilling caused by water flowing beneath the geotextile.
- Torn geotextile, missing pins or other damage caused by high winds, machinery or vandalism.

Repair or replace any areas of geotextile damaged or dislodged in any way. If required, erect a temporary barrier and/or signage fencing to restrict uncontrolled movement of equipment and vehicles onto treated areas.

Limitations

- Cost of installation can be relatively high compared with traditional mulching methodologies.
- Geotextiles do not generally benefit soil quality as much as many traditional mulches.
- Most geotextiles have a limited working life of generally no more than six to nine months, and some materials may be prone to UV degradation.
- Geotextile material can be flammable and can be subject to vandalism.
- Some geotextile may contain a fine synthetic mesh or netting that can pose a threat to a number of aquatic species.

Figure 22 Geotextile with fine mesh on stream bank causing potential damage to wildlife through trapping in mesh system – photo courtesy of Ridley Dunphy Environmental Limited.

Design Details

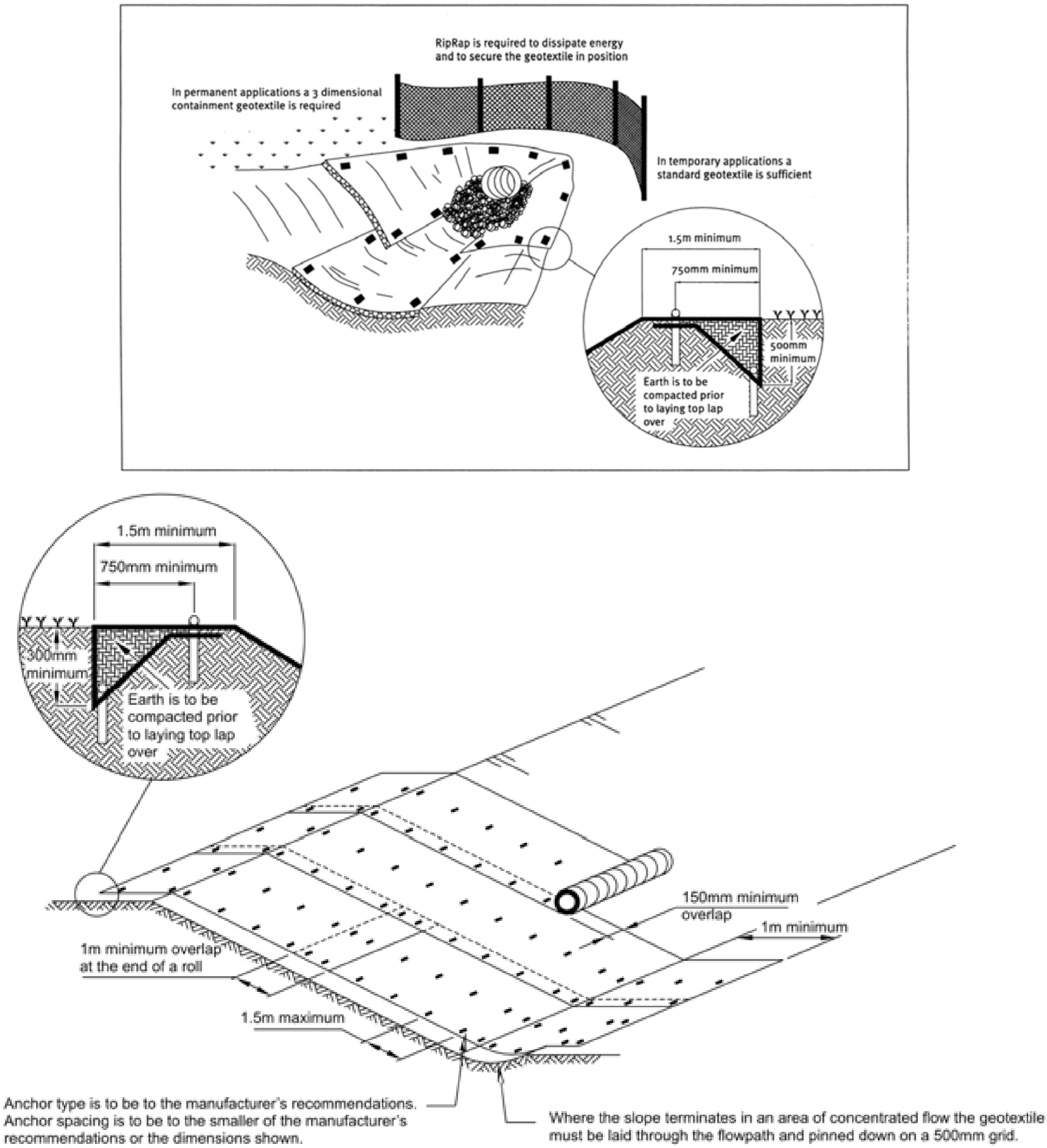
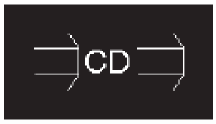


Figure 23 Geotextile design – image courtesy of Auckland Regional Council 1999.

6.2 Contour drains



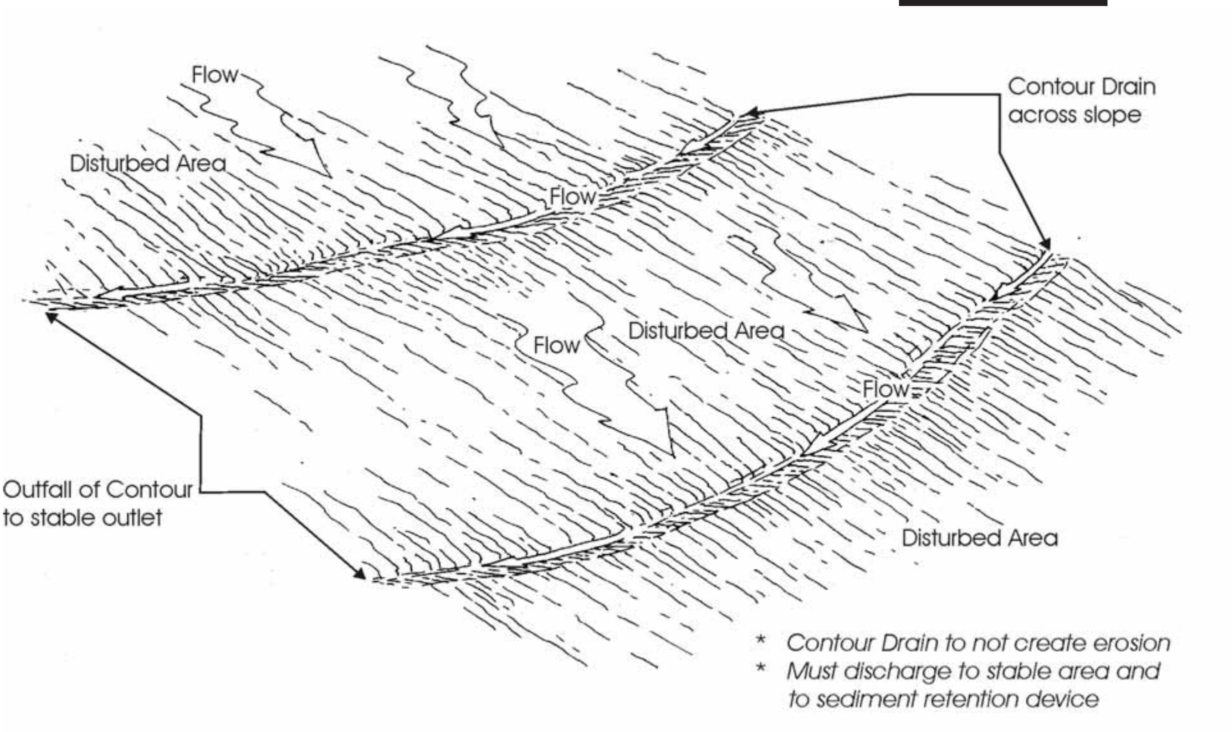


Figure 24 Contour drain schematic.

Definition

These are either temporary excavated channels or ridges or a combination of both, constructed on a slope to reduce slope length and intercept and divert potentially erodible flows of runoff to erosion-proof outlets. Once the area that they are draining has been stabilised, they may not be required.

Purpose

To break overland flow down disturbed slopes by reducing slope length and thus the erosive power of runoff, and divert sediment-laden water to appropriate controls through stable outlets.

Key message: As a rule of thumb; for every doubling of slope length a 1.5x increase in sediment generation will result. Contour drains are a simple and very effective method of reducing slope lengths and the sediment generation potential.

Mid-slope contour banks and/or drains are short-term, temporary structures placed across unprotected slopes within the working area at the end of each day's work, before site closedown or when rain is imminent. They may also be placed across other disturbed areas that are likely to remain exposed and unworked for a period of time. Although commonly called contour drains, this term is misleading as they need to be constructed slightly off the contour to ensure they drain appropriately.

Conditions where practice applies

Contour Drains should be promoted on nearly all earthworks sites, especially where there are large areas of exposed ground and long steep slopes. The specific scenarios for their application include the following:

- To reduce the overall contributing catchment and to segment slopes so that the water flows are reduced, limiting the erosion potential of the water. They should be used at mid to lower slopes on all exposed areas;
- To assist with diverting dirty water flows towards sediment retention devices (sediment retention pond, decanting earth bund). They do not form the same function as a Dirty Water Diversion;
- As cut-offs on tracking activities to direct water into a stable water table and/or outfall structure.

Key message: As contour drains are temporary measures they can be easily forgotten. Be vigilant and ensure that they are installed at the end of the day's work and/or before rain interrupts work.

Design

Although formal design of the contour drains is generally not required due to their temporary nature, they should nevertheless adhere to the following design principles:

- Temporary Contour Drains should have a minimum compacted bank height of 250 millimetres.
- Temporary Contour Drains must have a minimum depth of 500 millimetres.
- Contour Drains should ideally be broad enough to create a low-profile bank (like a very broad speed bump) that trucks and/or other large equipment can safely go over. If this is not achievable, a dedicated crossing using a removal culvert can be used.
- Avoid construction with a "V" profile instead use a parabolic ("flat "U") or a square shape.
- Build all Contour Drains with longitudinal gradients not exceeding 2%.
- Indicative maximum catchment slope lengths are provided in Table 6 below.

Table 5 Positioning of contour drains.

Slope of site (%)	Spacing of contour drains (m)
5	50
10	40
15	30
30	20

Construction specifications

The following flow chart should be followed when installing contour drains:

Step One – Identify the outlet point of the Contour Drain. Ensure that outlet is stable. You may need to line with geotextile or other materials if there is a chance of erosion.

Step Two – Work back up the slope from the stable outlet by excavating a channel of 0.5m deep. Deposit the spoil on the downslope side of the Contour Drain. Compact it.

Step Three - Ensure that longitudinal gradients within the Contour Drains do not exceed 2% (otherwise erosion may occur).

Step Four – Install the contour drains at spacings as outlined in Table 6. Avoid 'V' shaped drains (instead shape with a parabolic "U" or a square profile).

Step Five - Reinstate Contour Drains before the end of the day or when rain is forecast.

Step Six – Maintain Contour Drains as necessary. Repair breached areas immediately. Remove any accumulated sediment in Contour Drains.

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Key message: Contour drains should never be a source of sediment, so do not construct drains with a longitudinal gradient greater than 2%, otherwise some form of geotextile lining will be required.

Figure 25 Contour drain - photo courtesy of Ridley Dunphy Environmental Limited (Note that contour drain base could be better shaped to avoid erosion).

Figure 26 Contour drain – overtopping and short-circuiting of contour drain has reduced its water control ability - photo courtesy of Environment Bay of Plenty

Maintenance

Key items to check as part of the regular inspection includes:

- Repair or reinstate contour drains if destroyed by machinery movement.
- Inspect contour drains after rainfall or storms and repair as necessary.
- Check the outfall for erosion and repair if required. It may be necessary to install a temporary flume or provide geotextile.
- Use sandbags during rainfall events if extra height is needed on the ridges of contour drains.

Limitations

Contour Drains will concentrate sheet flows, increasing erosion potential. This is of most concern on any steep slope and in any vulnerable soils such as un-compacted fills and weak strength soils. Their informal design means the contour drains (including the down slope bund) has the potential to overtop during high intensity rainfall events.

Steep contour drain grades will increase flow velocities and cause additional scour therefore may need to be lined. Excessively flat Contour Drain grades mean sediment deposition is likely to occur, reducing capacity and resulting in overtopping.

Design drawings

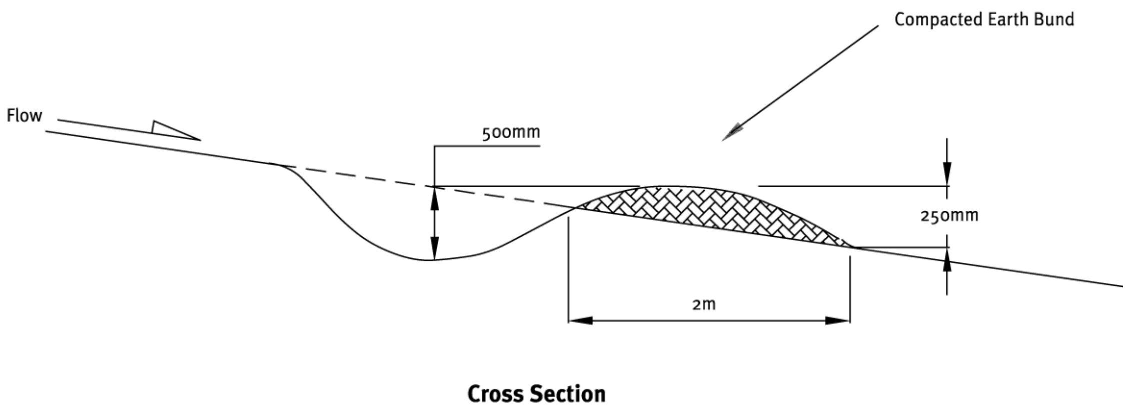


Figure 27 Contour drains - image courtesy of Auckland Regional Council 1999.

6.3 Runoff diversion channels

Definition

A non-erodible channel and bund for the conveyance of runoff, constructed to a site-specific cross section and design. Runoff diversion channels can be thought of as clean water runoff diversion channels or dirty water runoff diversion channels.

Clean water runoff diversion channels intercept 'clean' water from above the earthworks site (not contaminated by sediment from the site itself) and prevents it from entering work areas.

Dirty Water Runoff Diversion Channels collect sediment-laden runoff from disturbed areas on the subject site and direct it to sediment retention facilities for treatment.

Purpose

Clean Water Runoff Diversion Channels intercept clean runoff from above a construction site and divert around the works area. They minimise potential for erosion damage to the site by reducing the volume of water flowing over the site and the associated sediment generation. They allow earthworks sites to manage water from within the site and reduce sizes of control measures required. By diverting all upslope water away from the site they reduce the time and cost needed to repair, maintain and/or rework the site and any associated drainage infrastructure.

Clean Water Runoff Diversion Channels may be installed as permanent drainage works, but as a minimum are installed throughout the duration of the earthworks programme. They divert sediment-laden water to an appropriate sediment retention structure and can take the form of short or long-term temporary structures maintained for the duration of the disturbance in the contributing catchment.

All dirty water runoff diversion channels must remain in place until the contributing catchment area is stabilised against erosion.

Conditions where practice applies

Runoff Diversion Channels are used in the following situations:

- To divert clean runoff water above the works site, and divert to safe outlet(s).
- In either temporary or permanent situations.
- Around the perimeter of an earthworks activity site, to isolate the site and prevent sediment from leaving the area.
- Along the lower perimeter of a works site, to divert sediment laden water to an approved sediment retention device (such as a sediment retention pond).
- Always construct clean water runoff diversion channels prior to undertaking any other earthworks.
- Always use dirty water runoff diversion channels on your site to collect and convey sediment-laden runoff to sediment retention devices
- When working in pumice soils always take care with development of runoff diversion channels and stabilise runoff diversion channels with appropriate geotextile to ensure no erosion results.
- Never discharge diversions onto unstable soils, unconsolidated fill slopes or in concentrated flows over the bank of a stream.

Key message: Always keep the clean water (above your site) clean – never allow this water to flow over your site. Only capture the water from your site, treat and discharge as required. Clean stays clean. Dirty needs treatment.

Figure 28 Clean water diversion channel diverting water away from site (on left) and dirty water diversion channel directing sediment flows to retention structure (on right). Photos courtesy of Ridley Dunphy Environmental Limited.

Design

There are many designs for runoff diversion channels, however the following points cover the main design criteria.

- Design to carry the flow for at least a 20 year return period storm, allowing for a minimum 300mm freeboard. Figure 31 below provides the design bund height (including freeboard) based on various catchment areas and slope categories based on Bay of Plenty region rainfall figures. At all times the specific sizing should be checked on site.

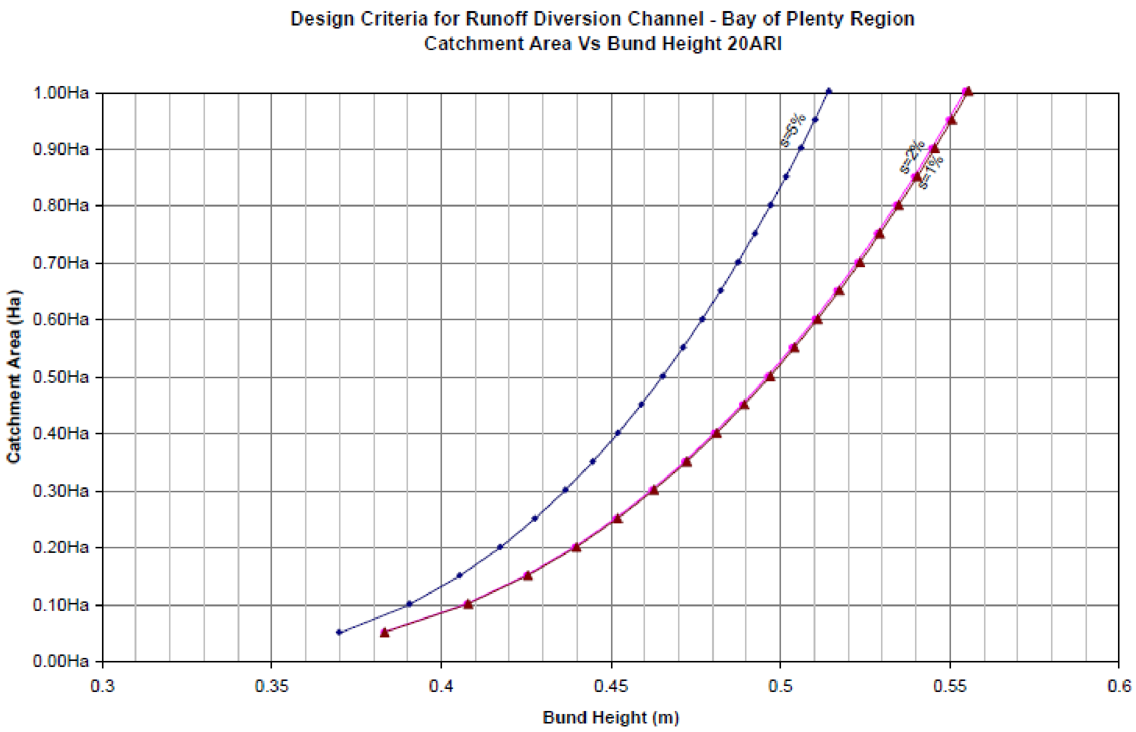


Figure 29 Design criteria for runoff diversion channel graph.

- Where catchments of either clean or dirty water runoff diversion channels exceed 5.0 hectares in size then formal design (sizing, shape and outfall) is required.
- For dirty water runoff diversion channels, restrict longitudinal grades to no more than 2%, unless the channel is armoured with aggregate, or protected with geotextile cloth. Note that for pumice soils, armouring is likely to be required in most circumstances. If grades are greater than 2% then erosion can occur and increased and unnecessary sediment generation can result.
- For clean water runoff diversion channels, longitudinal grades should be managed to ensure, where practicable, grades do not exceed 2%. However to ensure they do not become a source of erosion they all need to be armoured with aggregate, or protected with geotextile. Ensure geotextile is always secured into the ground on the upper slope where water flows. Methods such as placing a grass sward in the form of a turf strip can be used successfully for stabilising, however alternative methods of stabilising clean water runoff diversion channels may only be used if Environment Bay of Plenty approval has been obtained.

Figure 30 Example of stabilised clean water diversion channel – stabilised with grass sward. Photo courtesy of Ridley Dunphy Environmental Limited.

- Ensure that the runoff diversion channels discharge into a stable erosion-proof outfall.
- Ensure the bunds associated with the Runoff Diversion Channels are well compacted, and stabilised.
- Construct runoff diversion channels with a trapezoidal cross-sectional shape for the channel. Ensure the internal sides of the bund associated with the Runoff Diversion Channels are no steeper than 3:1, and the external sides no steeper than 2:1.
- Consider designing an emergency overflow section or bypass area to limit damage from storms that exceed the design storm.
- Avoid abrupt changes in grade which can lead to sediment deposits and overtopping or erosion.
- Include all calculations, design notes, drawings, etc. in the site erosion and sediment control plan.
- Where practicable, choose a route for permanent structures that avoids trees, existing or proposed service infrastructure, existing or proposed fence lines and other natural or built features.

Runoff diversion channels may take the form of catch drains (usually lined with an erosion-resistant material such as needle-punched fabric), existing or new storm water reticulation systems, combination bank or bund with excavated upslope channel or earthen bank (often made from compacted topsoil).

Construction specifications

The following flow chart should be followed when installing Runoff Diversion Channels

Step One - Plan the construction of all runoff diversion channels as part of the initial site establishment.

Step Two - Prioritise the works and install all clean water runoff diversion channels first. Remove and correctly dispose of vegetation and obstacles along the diversion alignment.

Step Three - Build runoff diversion channels with a uniform grade along the invert to avoid scour or accumulate, causing the bank to overtop. Always build the channel from the outlet end.

Step Four - Thoroughly compact all embankments by tracking with construction equipment.

Step Five - Take particular care to ensure that the channel does not erode. A fully geotextile lined or stabilised channel will be necessary for all clean water runoff diversion channels and dirty water runoff diversion channels over a 2% grade.

Step Six - Ensure finished runoff diversion channels cross section meets all design requirements. Survey all runoff diversion channels and provide the necessary as-built plans to support the design details.

Runoff diversion channels/bunds need regular maintenance to keep functioning throughout their life. Regular maintenance consists of the following:

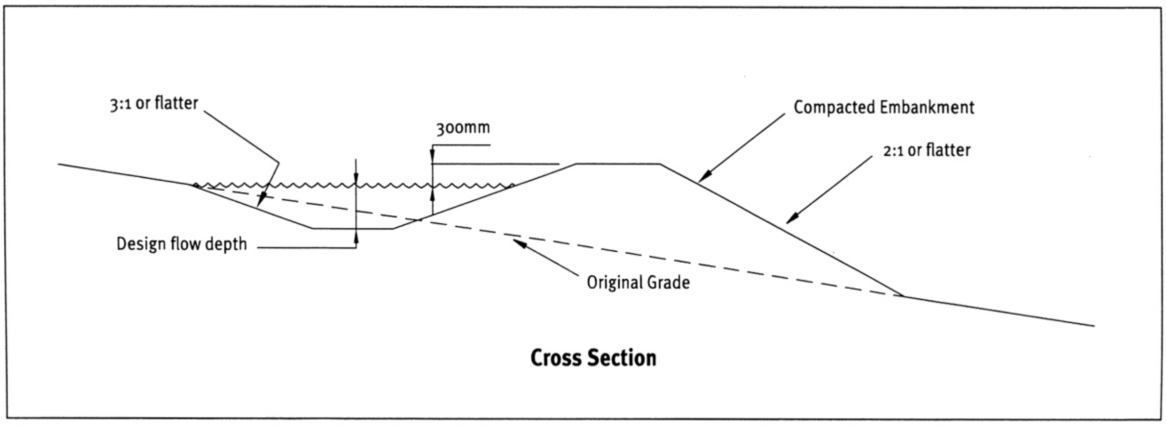
- Inspect weekly and after every rainfall and during periods of prolonged rainfall for scour and areas where they may breach.
- Repair immediately if required to ensure that design capacity is maintained.
- Remove any accumulated sediment deposited in the runoff diversion channel/bund due to low gradients and velocities.
- Carefully check invert and outlets to ensure that these remain free from scour and erosion.
- Look for low spots, areas of water ponding, formation of tunnel gullies, sediment deposition and debris blockage.
- Check for stabilisation cover and ensure full stabilisation cover remains. where required
- When the earthworks site is stabilised and approval of Environment Bay of Plenty is obtained, fill, compact, shape and stabilise all disturbed areas around the runoff diversion channels to blend in with the finished landform. In some circumstances the runoff diversion channel may provide a longer term function and can remain in place with Environment Bay of Plenty approval.

Figure 31 Good asphalt clean water diversion and bad geotextile example - photos courtesy of Ridley Dunphy Environmental Limited.

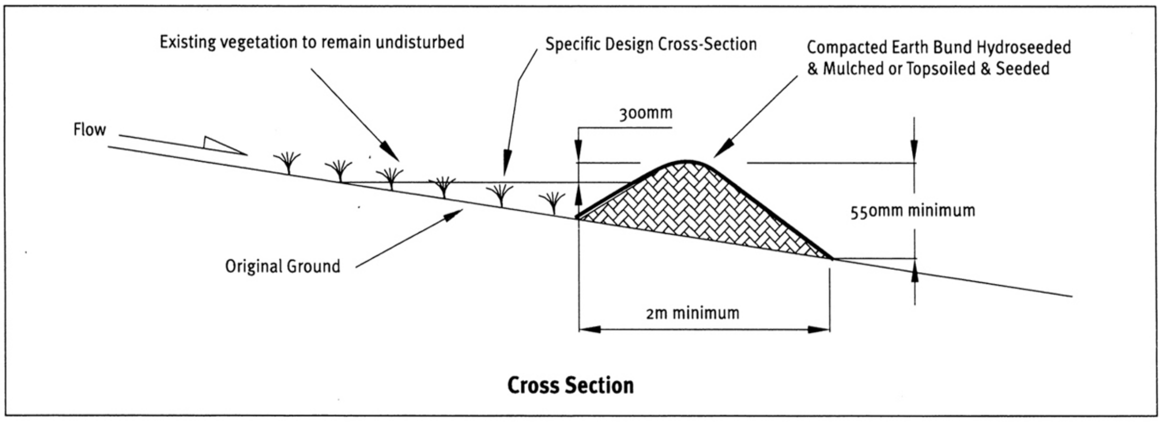
Limitations

- Clean water runoff diversion channels should be constructed using material from within the earthworks site, minimising disturbance to existing ground cover where the clean runoff water will flow.
- Consider where excess runoff will drain to, if the design storm is exceeded and the runoff diversion channel is overtopped. Allow for a safety overflow in the most appropriate location.
- Bunds need particular care to protect against damage from earthmoving operations and should be reinstated if damaged.
- It is often difficult to construct a channel bank or drain with the required channel capacity on steep slopes. Consider all options and in particular the location of the sediment retention device to which the dirty water runoff diversion channels will flow.
- Access for maintenance can be difficult once construction activities have commenced.

Design drawings



Dirty Water Runoff Diversion Channel Design Details



Clean Water Runoff Diversion Channel Design Details

Figure 32 Runoff diversion channels - image courtesy of Auckland Regional Council 1999.

6.4 Pipe drop structure/flume

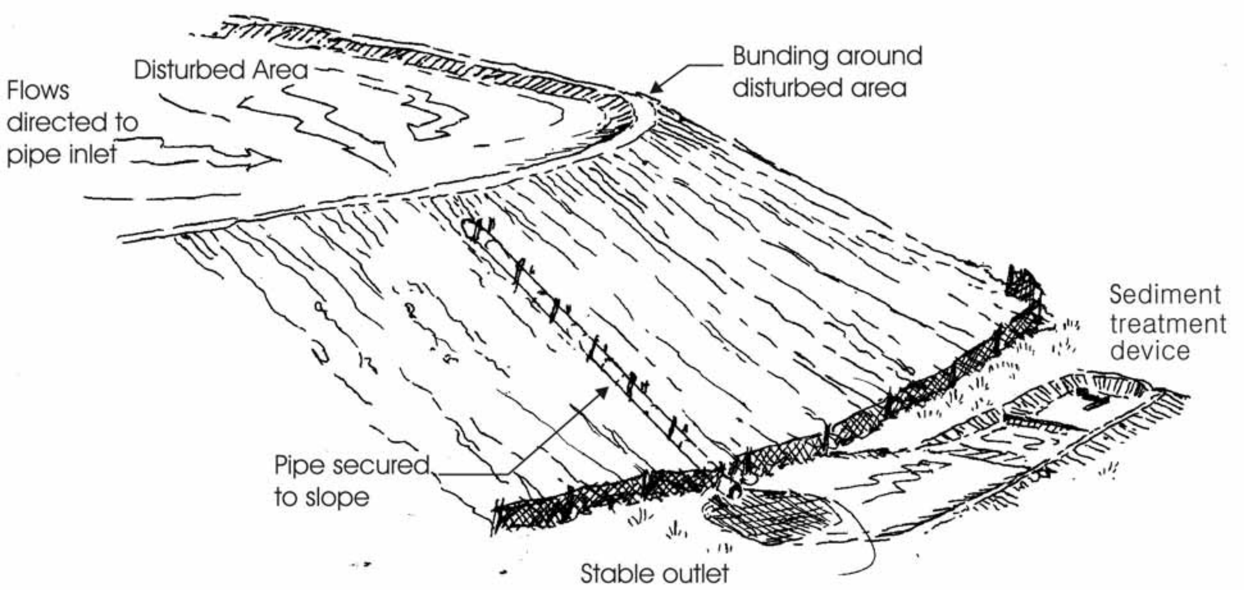


Figure 33 Pipe drop structure schematic.

Definition

A temporary pipe structure or constructed flume placed from the top of a slope to the bottom.

Purpose

A pipe drop structure conveys either clean or dirty surface runoff from an elevated area down the face of a slope (either stabilised or unstabilised) to minimise erosion on the slope face. Temporary flumes achieve the same purpose and may be designed to carry clean or dirty water, depending on where they are in the site's overall water management system. If designed to carry dirty water down the slope, care needs to be taken to ensure that they discharge into an approved treatment device.

Flumes may be used at the inlet to Sediment Retention Ponds and also at the final point of discharge into receiving environments. Flumes may also be used to stabilise an active gully head.

Both pipe drop structures and flumes are commonly used in association with diversion channels, which act to collect and direct surface water into the structure.

Flumes which are used within channels for the purpose of establishing a series of grade-stabilising structures are not part of this Guideline, and if implemented as part of a project should be designed in accordance with appropriate criteria for that site.

Conditions where practice applies

Figure 34 Stabilised flume down a slope - photo courtesy of Ridley Dunphy Environmental Limited.

Key message: Never allow concentrated flows to flow down slopes where they will cause erosion of the slope. Use pipe drop structures and flumes to convey this flow, ensuring that the flow is appropriately managed at the base through a treatment device (dirty water) or a stable outfall (clean water).

Pipe drop structures and flumes are used in conjunction with runoff diversion channels and bunds. The runoff diversion channels direct surface runoff to the pipe drop structure or flume, which then conveys flow in a concentrated manner down the face of a slope. If other forms of drop structures are being considered on your site, approval of those structures may be necessary on a case-by-case basis.

- Always use flumes where slopes are steeper than 3:1 and where channelised water flows must be conveyed down the slopes.
- Always make sure that the inlet is well secured to avoid undercutting.

Design

- Always construct pipe drop structures and flumes from watertight materials.
- Extend the pipe drop structure and flume beyond the toe of the slope and adequately protect the outlet from erosion using riprap over a geotextile apron.

- Use the following design criteria for pipe drop structures and flumes as shown in Figure 37 below. This details design flume sizing based on various catchment areas and diversion embankment heights based on Bay of Plenty region rainfall figures. At all times the specific sizing should be checked on site.

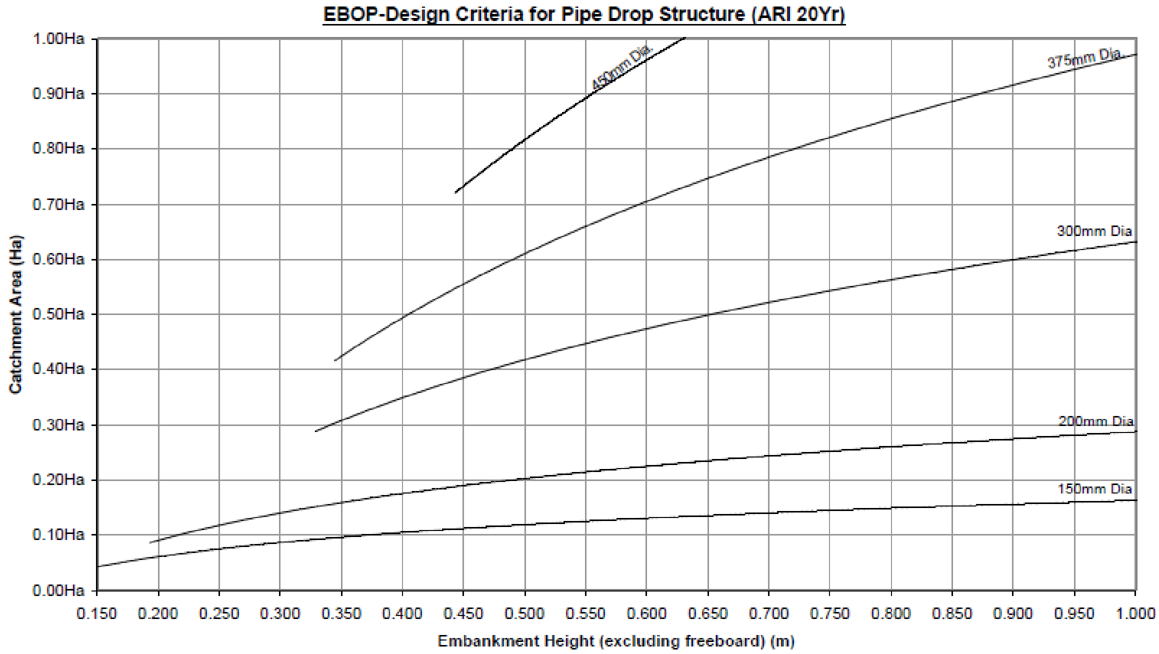


Figure 35 Design criteria for pipe drop structure graph.

Note:

(i) Rainfall intensities are based on OPUS International Consultants analysis of Tauranga City Councils rainfall data (October 2005) which incorporates climate projections to 2055,

(ii) Peak flow calculations are based on Rational Formulae with run-off coefficient, C = 0.7 (bare impermeable clay)

(iii) Open channel flow based on Mannings equation

(iv) Pipe drop structure flow based on orifice discharge equation

- Specific design is required for catchments exceeding 1 ha in area.
- Ensure that the runoff diversion channel/bund used to divert flows to the pipe drop structure or flume is at least twice the pipe diameter or height of the pipe drop structure or flume as measured from the invert.
- Install a flared entrance section of compacted earth. To prevent erosion, place impermeable geotextile fabric into the inlet extended a minimum of 1.0 m in front of and to the side of the inlet and up the sides of the flared entrance. Ensure this geotextile is keyed into the ground and pinned as required under section 6.1 of this Guideline.
- When the catchment area is disturbed, ensure the pipe drop structure or flume discharges into a sediment retention device or a stable conveyance system that leads to such a device.

- When the catchment area is stabilised, ensure the pipe drop structure or flume outlets onto a stabilised area at a non-erosive velocity. The point of discharge may be protected by rock riprap.
- Ensure the pipe drop structure or flume has a minimum slope of 3% (percent) to avoid sediment deposition within the structure.

Pipe drop structures or flumes may be either temporary or permanent structures. Temporary structures may be fabricated from needle-punched geotextile fabric, concrete, steel or plastic half-round pipes, rock, sandbags, construction ply or even builder's plastic, Any number of products can be used, provided they can convey water safely over exposed soils or unstable slopes. Ensure that Environment Bay of Plenty approval is obtained prior to implementing such materials.

Figure 36 Diversion channel leading to structure and pipe taking flows down slope - photos courtesy of Ridley Dunphy Environmental Limited.

Construction Specifications

The following flow chart should be followed when installing Pipe Drop Structures or Flumes.

Step One – Confirm the material with which the structure will be made. Confirm the sizing requirements based on Figure 31 above.

Step Two – Construct the structure from the base of the slope to the top of the slope. Ensure that it contains no leaks and fasten the structure securely to the slope using stakes at a maximum of 4m centres.

Step Three – Ensure the outlet of the structure is extended beyond the slope base. If it is discharging dirty water ensure this is discharged to and treated through an approved device.

Step Four - Construct an appropriate Diversion Channel at the top of the slope to direct flows to the structure inlet. Ensure no outflanking or scour can occur at this point.

Step Five - Provide a stabilised apron 1 metre in width at the top of the structure to ensure no "draw down" scour occurs.

Step Six – Provide for ongoing maintenance and ensure that no leakage, scour or failure occurs. If a temporary device only, remove once approval is obtained from Environment Bay of Plenty.

Figure 37 Flume discharging to appropriate sediment retention pond with no slope scour. Photo courtesy of Auckland Regional Council.

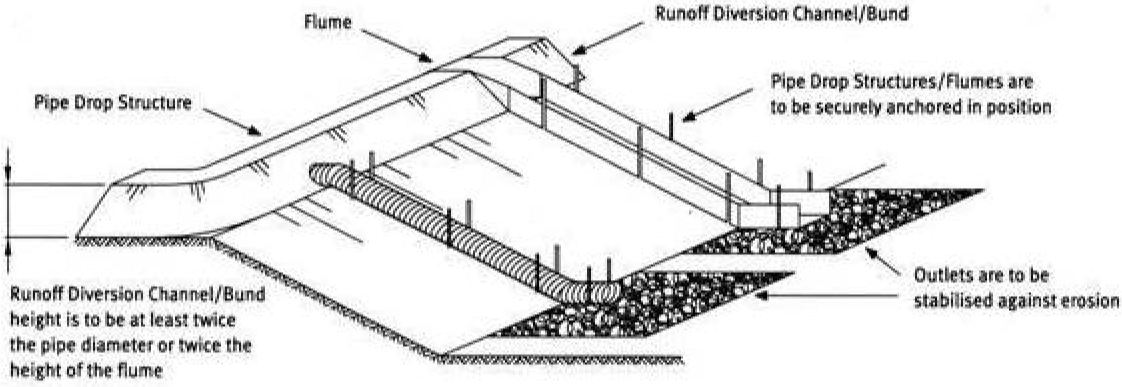
Maintenance

- Inspect the pipe drop structure or flume weekly and after each rain event. Carry out any maintenance immediately if required. Keep the inlet open at all times.
- Check for evidence of water bypassing the pipe drop structure or flume, water undermining it or water overtopping or outflanking it. Check for scour at the base of the structure or in the receiving downstream area
- Extend the length of the pipe drop structure or flume as earthworks progress and repair and/or modify as required.
- Keep pipe drop structures or flumes in place until runoff has been controlled and all disturbed areas have been stabilised, or until permanent storm water systems have been commissioned.
- Remove temporary materials and where possible re-use or recycle them into future works.
- Stabilise all areas disturbed as part of the removal process and apply seed, fertiliser and mulch as necessary.

Limitations

- The pipe drop structure or flume should be impervious and must prevent water from flowing under the structure.
- Energy dissipation is usually always needed at the bottom of a pipe drop structure or flume to avoid scour of this area. Damage may result from slippage or slumping caused by unstable foundation material.
- Don’t install pipe drop structures or flumes unless there is a good maintenance system onsite. They require ongoing inspection and possible remedial action.

Design drawings



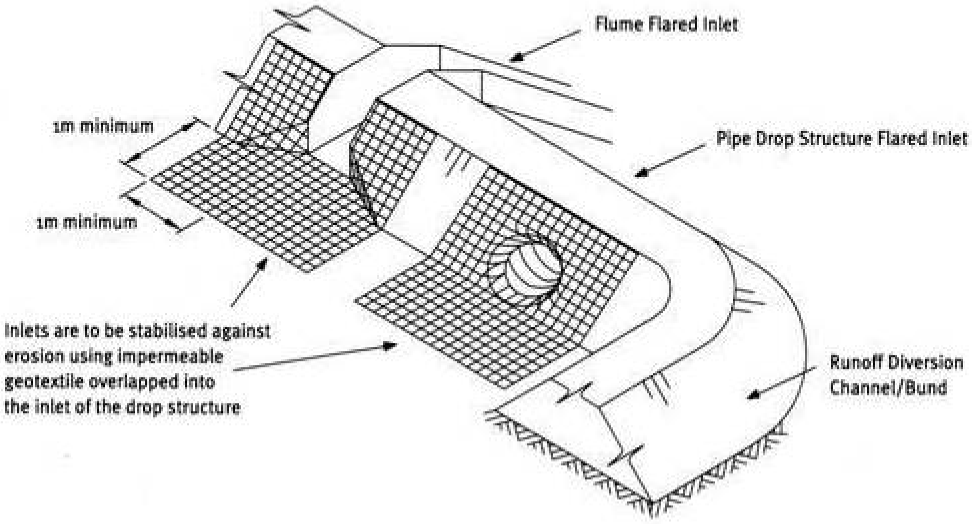


Figure 38 Flume design - image courtesy of Environment Bay of Plenty.

6.5 Check dams

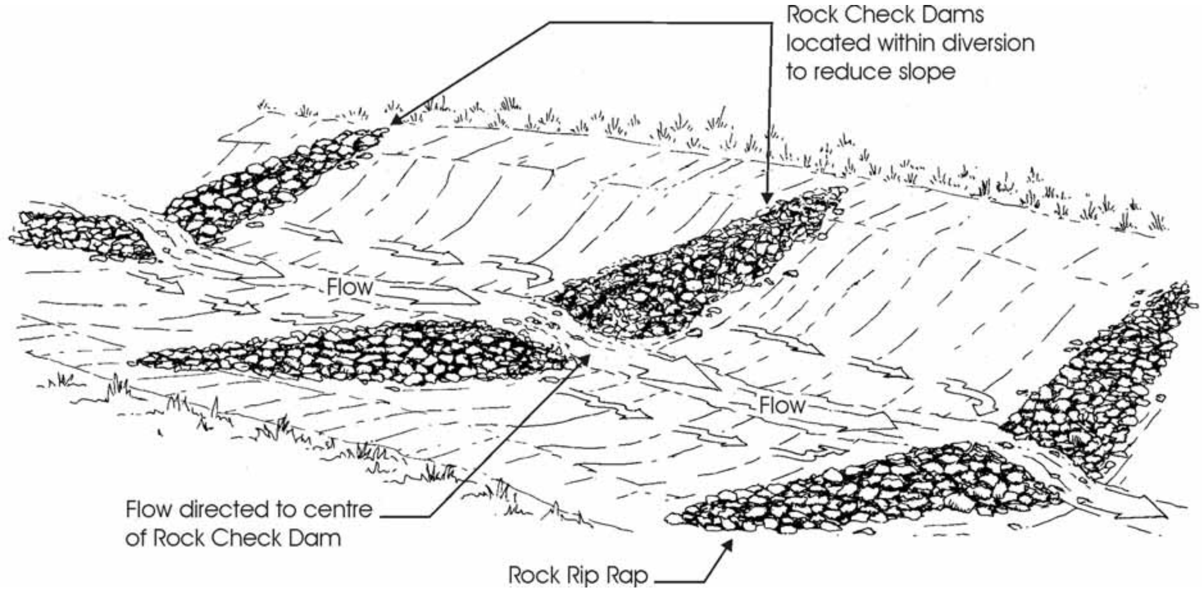


Figure 39 Check dams schematic.

Definition

Small dams made of rock rip-rap constructed across a swale or channel which act as grade control structures.

Purpose

To reduce the velocity of concentrated flows, in order to reduce erosion of the swale or channel. They are often placed in series down the channel and used during construction to reduce invert scour in drains or channels that will be reworked, filled, grassed or otherwise stabilised.

Although this practice may trap small amounts of sediment generated in the swale or channel, it is not intended to be a sediment trapping practice and should not be used as one. They work by temporarily ponding the water and then naturally releasing the impounded water at a more controlled rate.

Conditions where practice applies

Limited for use in small open channels (not perennial watercourses) where it is necessary to slow the velocity of flows to prevent erosion occurring. They may be installed as temporary structures during the construction phase or may remain as permanent storm water management structures. The specific scenarios for their application include the following:

- Temporary swales or channels which, because of their short length of service, are not suitable for a non-erodible lining (geotextile) but still need some protection to reduce erosion;
- Permanent swales or channels which for some reason cannot receive a permanent non-erodible lining for an extended period of time;
- Either temporary or permanent swales/channels which need protection during the establishment of vegetative linings or other materials.

Key message: To be effective, rock check dams need to be installed at spacings so that the dammed water level extends from the foot of the upper dam to the head of the lower check dam. The spacing between dams will depend on the longitudinal slope.

Design

Temporary check dams are typically constructed of loose rock (rip-rap) or sandbags. Prefabricated and re-useable triangular plastic material is now also available, and reinforced fabric dams can also be used. The following table may be used to determine the approximate spacing of check dams for channel slopes within indicated ranges.

Table 6 Positioning of check dams.

Slope of site (%)	Spacing (m) between Dams with a 450mm Centre Height	Spacing (m) between Dams with a 600mm Centre Height
Less than 2%	24	30
2 – 4%	12	15
4 – 7%	8	11
7 – 10%	5	6
>10%	Unsuitable – use stabilised channel	Unsuitable – use stabilised channel

- The maximum height of a check dam depends on the depth of the drain into which it is being placed, although as a general rule the centre height (spillway level) should be no higher than 600mm.
- All check dams must incorporate a spillway to direct flows over the centre of the structure, with the spillway elevation at least 150mm to 200mm lower than the crest of the structure.
- To be effective, place check dams so that the toe of the upstream dam is at the same elevation as the crest of the downstream dam. Spacing between dams is outlined in Table 7.
- When used on highly erodible soils, check dams should be placed on a needle-punched geotextile fabric to minimise the chance of water undermining the structure.

Key message: The limitations of check dam spacings on steep slopes may exclude their use as a practical solution for erosion control and alternative options (geotextile-lined channel) may need to be explored.

Construction specifications

The flow chart outlined below should be followed when installing check dams

Step One – Confirm required spacing and location of check dams relative to channel gradient. Start from the bottom and work up the channel.

Step Two – Place rocks or similar non-erodible material in channel. Build structure up to a maximum height of 600mm so that ponding of water will occur.

Step Three – Ensure that the centre of the check dam is approximately 150mm to 200mm lower than the outside edges to form a well-defined spillway.

Step Four – The placement of the dam and the spillway depth may need to be confirmed with a spirit level or similar device.

Step Five – Continue building the next dam upslope in series using the spacing outlined in Table 7.

Step Six – Maintain as necessary and remove any accumulated sediment behind the check dams.

Figure 40 *Check dam using rock rip rap. Good spacing of check dams and fabric lining of channel however rock should be shaped to provide a spillway - photo courtesy of Environment Canterbury.*

Figure 41 Check dam in highly erodible soils. Problems with excessive spacing, unsuitable location and insufficient up turn resulting in water outflanking the structure - photo courtesy of Environment Canterbury.

Maintenance

Key items to check as part of the regular inspection:

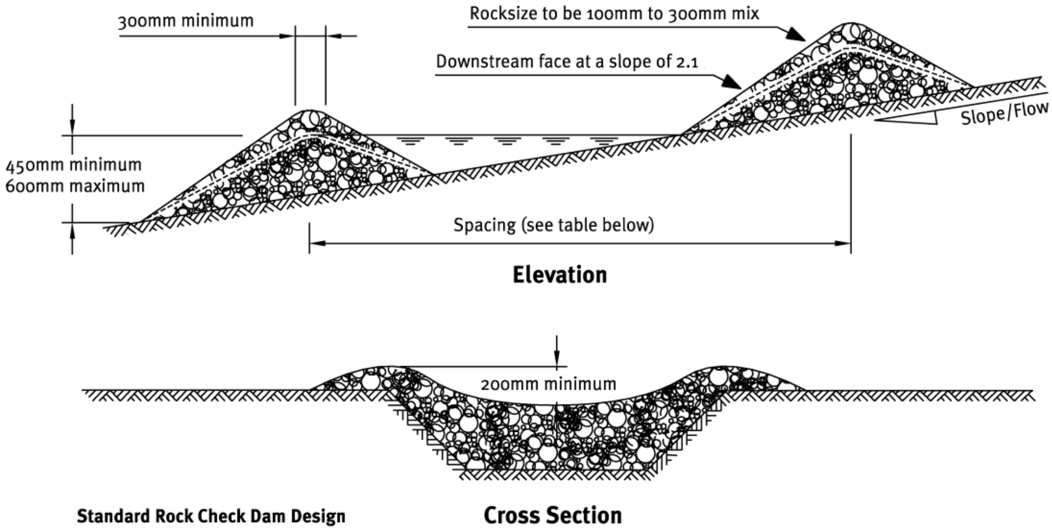
- Repair or reinstate the check dams if destroyed by machinery movement.
- Inspect the check dams after rainfall or storms and repair as necessary.
- Check if water is outflanking the structure and look for scouring around the edges of the check dam: if so – increase the spillway depth, crest height and/or turn up edges of structure.
- If scour is occurring between check dams then additional structures may need to be provided.
- Check dams should be inspected for sediment accumulation after each significant rain event. Sediment should be removed when it reaches 40% of the original height or before this occurs.

Limitations

- The contributing catchments for a complete series of check dams should not exceed 3.0ha for slopes less than 10%. However, formal engineering design is required when catchment areas exceed this and should be formalised through an approved erosion and sediment control plan.
- Check dams are not intended to be a sediment trapping practice and should not be used as such.
- They have a limited contributing catchment area and the channels will erode if the dams are spaced too far apart (especially on highly erodible soils).

- In order to be effective, on steep slopes the check dams will need to be placed very close to each other. If their placement is to a stage where they are impractical (too close together), lining the channel (with needle-punched geotextile or fine-weave coir mesh) may be a better approach.
- Check dams can be time consuming to construct (especially on steep slopes).
- They may not be a suitable option to provide erosion protection when highly erodible soils, susceptible to tunnel erosion are prevalent.

Design drawings



Standard Rock Check Dam Design

Slope	Spacing (m) Between Dams (450mm centre height)	Spacing (m) Between Dams (600mm centre height)
2% or less	24	30
2% to 4%	12	15
4% to 7%	8	11
7% to 10%	5	6
over 10%	Use Stabilised Channel	Use Stabilised Channel

Figure 42 Rock check dams - image courtesy of Auckland Regional Council 1999.

6.6 Stabilised entrance way (SEW)

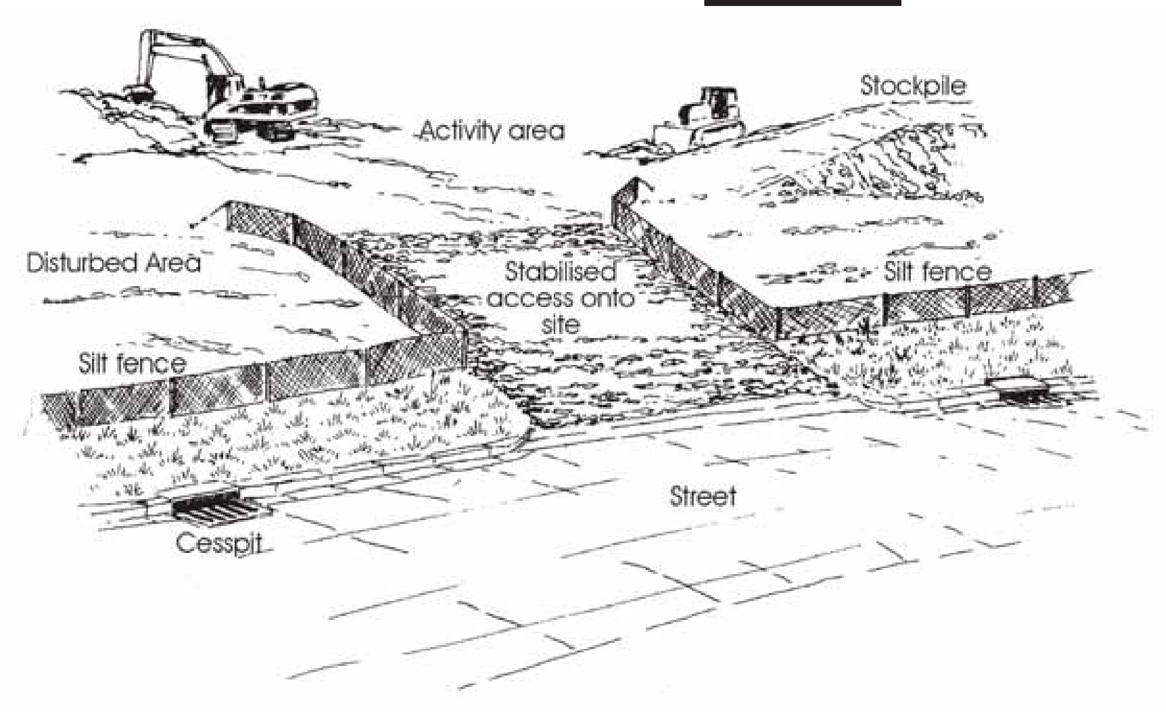


Figure 43 Stabilised entrance schematic.

Definition

A stabilised pad of aggregate on a filter cloth base located at any entry or exit point of a construction site.

Entry or exit points include all points where construction traffic leaves disturbed areas and enters sealed roadways or public streets.

Purpose

To prevent site access points from becoming sediment sources and to prevent transport of sediment from the site onto the stabilised road surface. Stabilised entrance ways also assist in minimising dust generation and disturbance of areas adjacent to the road frontage by providing a defined entry and exit point.

While stabilised entrance ways are installed in some circumstances to remove mud or soil from vehicle tyres as vehicles leave the site, care needs to be taken as they are often ineffective unless supported by a formal wheel wash or a vibrating cattle grate system (shaker ramps).

Conditions where practice applies

- Use a stabilised entrance way at all points of construction site entry and exit with a view to limit traffic to these entrances only. They are particularly useful on small construction sites but can be used for all projects.
- Where necessary install stabilised entrance ways along with shaker ramps or wheel wash facilities as close as possible to the boundary of the works area. Ensure that a water collection and disposal method (can include water recirculation) is provided.

- If wheel wash runoff cannot be disposed of appropriately in the immediate vicinity then all overflow should be directed to a sediment retention facility within the site.
- Do not locate stabilised entrance ways on steep slopes, in areas of concentrated flows or next to watercourses or storm water cesspits.
- Supplementary street sweeping on adjacent roads at regular intervals may still be required.

Key message: Install stabilised entrance ways at all ingress and egress points from a site and always assess the need for additional controls such as wheel wash facilities, shaker ramps and/or street sweeping.

Design

- Clear the location of the stabilised entrance way site of all vegetation, roots and other unsuitable material and grade the base to a smooth finish.
- Lay woven geotextile over the area, ensuring this is appropriately pinned and overlapped as necessary.
- Place aggregate to the edge of the sealed pavement and contour to suit the entrance point. Note that contouring can include a highpoint on the grade to act as a barrier to water flowing out of the site.

Table 7 Stabilised entrance way specifications.

Aggregate Size	50-75 mm washed aggregate
Thickness	150 mm minimum
Length Width	10 m minimum 4 m minimum

- Provide drainage from the stabilised entrance way to an appropriate location which typically will involve a site sediment retention measure.

Figure 44 Sediment on road – no stabilised entrance way - photo source unknown.

- Stabilised entrance ways do not necessarily need to be at the permanent site entry/exit point, however consideration needs to be given to minimising the number of site entry and exit points.
- Locate all stabilised entrance ways so that vehicles cannot bypass them. Use in association with silt fences. Show the location and discuss management of all stabilised entrance ways in the erosion and sediment control plan.
- If a shaker ramp is to be used this could be in the form of a prefabricated cattle stop and must be a minimum of 5 metres long to allow at least one full revolution of a truck tyre.
  - (i) Two cattle stops should be placed one in front of the other to provide enough length. Stabilise the section of access road between the shaker ramp and the sealed pavement with rock.
  - (ii) Ensure the runoff from the shaker ramp area and/or wheel wash systems passes through an appropriate sediment retention device.

Construction specifications

The following flow chart should be followed when installing stabilised entrance ways.

Step One – Determine the most appropriate location for the stabilised entrance way(s) away from watercourses, stormwater cesspits and most likely entry and exit points to the site.

→

Step Two – Clear the location of the stabilised entrance way.

→

Step Three - Lay geotextile to manufactures specifications and overlap and pin as necessary.

↓

Step Four – Place aggregate to the specifications as in Table 8.

←

Step Five - Ensure all drainage and surface water flowing towards stabilised entrance way is installed.

Figure 45 Stabilised entrance way as part of a small site development – photo courtesy of Auckland Regional Council.

Maintenance

- Inspect weekly and after each rainfall event for general maintenance requirements
- Maintain the stabilised entrance way to prevent sediment from leaving the construction site.
- After each rainfall inspect any structure used to trap runoff from the stabilised entrance way and clean out as necessary.
- When wheel washing is also required, ensure this is done on an area stabilised with aggregate which drains to an approved sediment retention facility. Add further aggregate as necessary when mud blockage becomes evident or when aggregate thickness is not to specification
- Remove sediments from sealed pavements by sweeping or vacuuming as necessary. Do not wash any sediment into the storm water system or any adjoining watercourse.

Limitations

- Stabilised entrance ways will reduce sediment movement, but will not eliminate it completely. Care needs to be taken to implement other management techniques to reduce the potential for vehicles to transport sediment on to road surfaces.
- Operation and maintenance of wheel wash systems can be expensive, but will provide much higher efficiencies in terms of sediment removal.

Design drawings

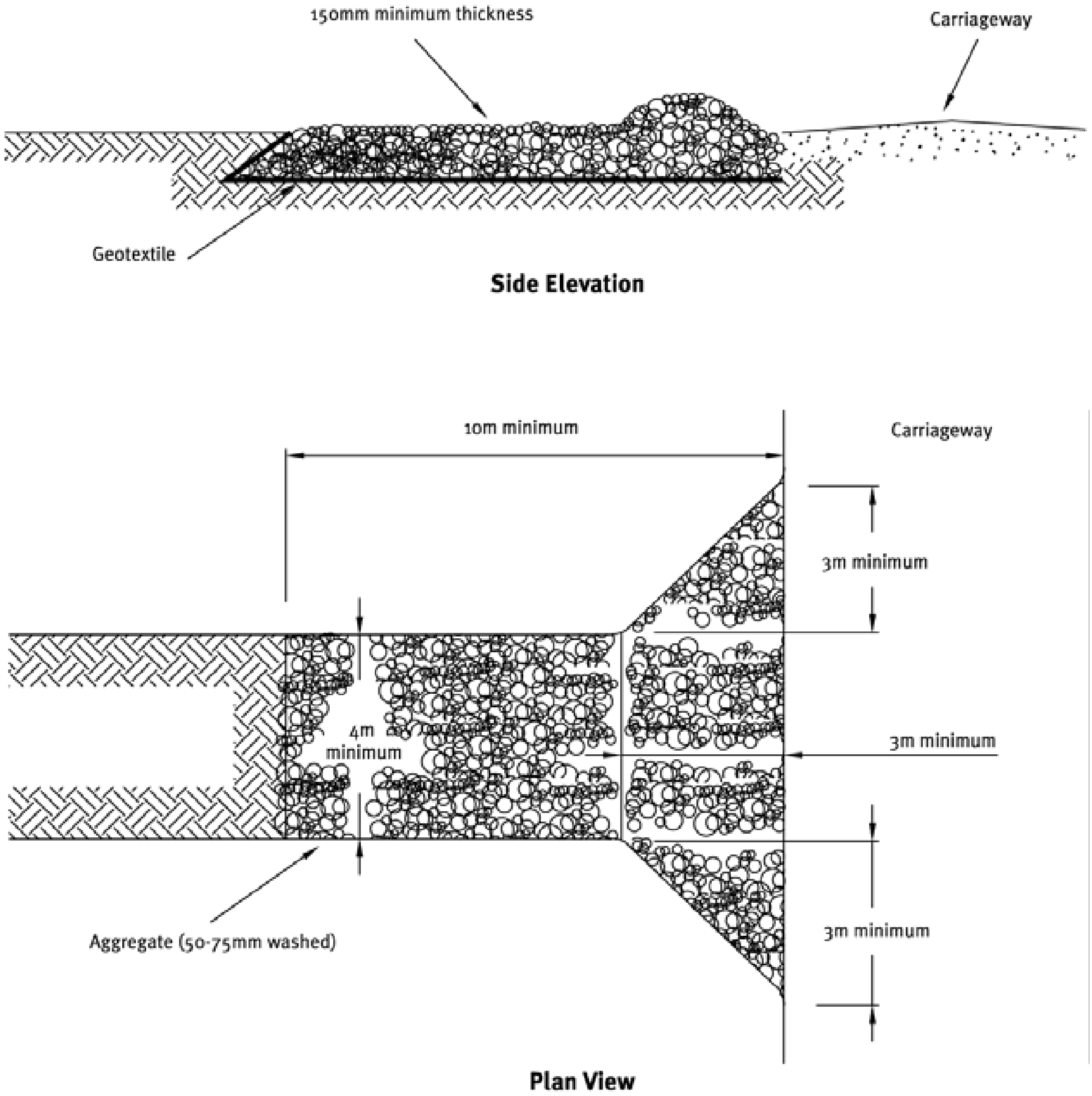


Figure 46 Stabilised entrance way - image courtesy of Auckland Regional Council 1999.

6.7 Surface roughening

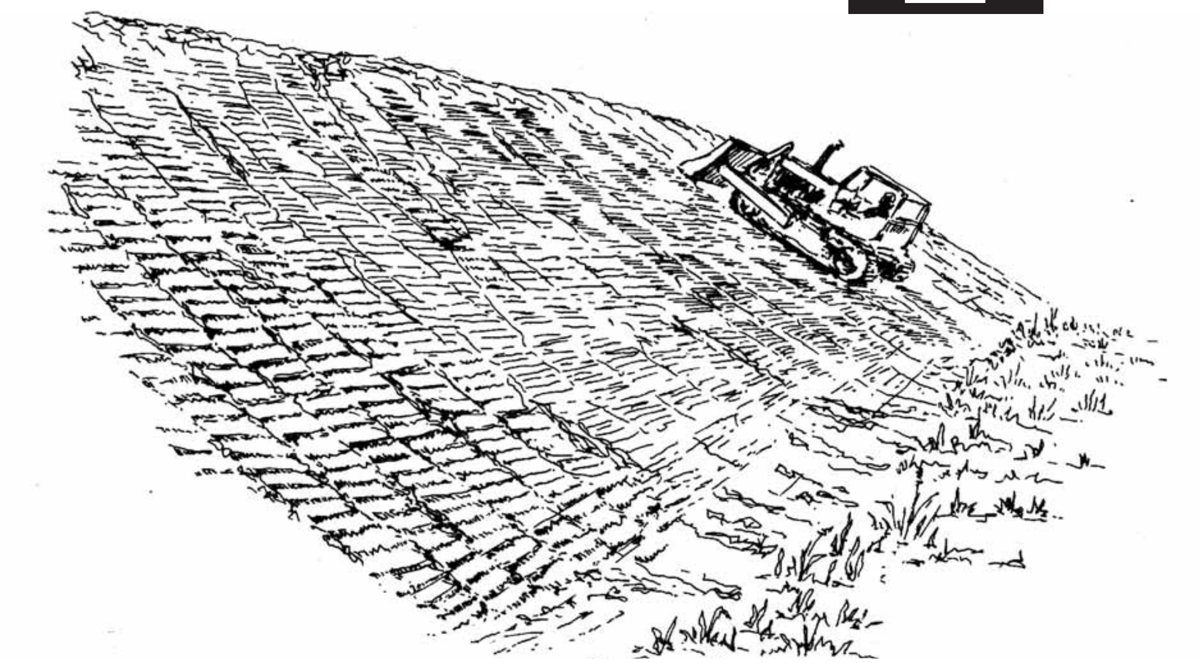


Figure 47 Surface roughening schematic.

Definition

Roughening the surface of unstabilised (bare soil) earth surface with horizontal grooves extending across the slope, or by tracking with construction equipment.

Purpose

The technique is a temporary erosion control procedure that significantly reduces runoff velocity, promotes infiltration, delays formation of rills and can significantly reduce short-term soil losses. It may also help capture small quantities of sediment. Roughening can also reduce wind velocities at ground level, making a soil less prone to wind erosion.

Ripping or scarification may also break up hard or compacted surfaces before seeding for either temporary or permanent revegetation programmes.

Conditions where practice applies

Surface roughening is a simple and effective method to reduce soil erosion. It should be used where possible on any slopes that have the potential to generate sediment discharges.

Design

There is no formal design for the construction of surface roughening, although the following principles apply:

- Intercept run-on water and divert it away from the area(s) to be roughened prior to undertaking the works.
- Fill existing rills before roughening or track-walking a batter face. Roughening must be done on the contour and in a direction perpendicular to surface water flows.

- Track-walking must leave well-defined cleat impressions in the soil, parallel to the contour. This is necessary in order for the creation of a series of mound and hollow features to act as micro sediment traps.
- When track-walking topsoil material, take care not to compact it.

Key message: If done correctly, surface roughening is an inexpensive and effective method of reducing soil erosion on earthworks sites. It should be automatically used when working these sites.

Construction Specifications

- Prior to undertaking surface roughening, the disturbed areas should be protected during clearing and construction in accordance with an approved erosion and sediment control plan until they are permanently stabilised.
- Roughening of flatter areas is usually done with rubber-tyred agricultural or earthmoving equipment fitted with scarifier or ripper tines. Steeper areas are generally roughened using a general-purpose bucket on an excavator (preferably with a hydraulic tilting head) or by continually walking a tracked machine up and down the slope.
- Ripping or scarification with conventional rubber-tyred equipment is usually limited to slopes 3:1 or flatter. Steeper areas can be safely scarified using the teeth of a general purpose bucket on an excavator or backhoe.
- Wherever possible, all ripping or scarification operations must be undertaken on the contour and perpendicular to the direction of surface water flows. Excavator or backhoe buckets must not be used to scarify a batter face in the vertical axis.
- Contour scarification may also be used across the face of hard cut slopes to provide a key for topsoil, making it less likely to slip. Scarification will also encourage deep root penetration later in the revegetation programme.
- Track-walking can be safely done on most slopes up to 2:1 and is suited to the generally looser surfaces found on fill slopes and soil stockpiles. Walking a tracked machine up and down the slope leaves horizontal cleat impressions perpendicular to the direction of surface water flows, effectively providing a series of micro sediment traps.

Figure 48 *Slope with surface roughening undertaken. Note the fine grained-sediment caught in the hollowed areas behind the mounds caused by the tracks. These have acted as micro sediment traps - photo courtesy of Auckland Regional Council.*

Maintenance

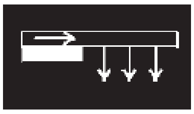
Periodically check the slopes for rills and washes. Rework and/or reseed the area as necessary.

- Repair or reinstate contour drains if destroyed by machinery movement. Inspect Contour Drains after rainfall or storms and repair as necessary.

Limitations

- Surface roughening will not generally provide a satisfactory level of erosion control during high-intensity or long-duration rainfall events. Therefore the technique cannot be relied upon as the only form of control and may require other devices such as diversion channels, contour drains or sediment ponds.
- Ripping or scarification may allow water to enter dispersible soils or soils that are vulnerable to tunnelling thereby exacerbating erosion.
- Do not roughen cut batters in highly erodible soils (pumice soils), so that scarification lines are likely to collect water.
- Do not surface roughen very dry, fine-textured soils as they may be prone to pulverisation, making them more susceptible to detachment and transport by either wind or water.

6.8 Level spreader



Definition

A device that transforms concentrated runoff by dispersing flows uniformly across a slope.

Purpose

To convert concentrated (channelised) flow to sheet flow and release it uniformly over a stabilised area to prevent erosion. The level spreader provides a relatively low cost option, which can release concentrated flow where site conditions are suitable. These devices are typically used as inflow devices (at the inlet) to impoundment devices such as Decanting Earth Bunds or Sediment Retention Ponds.

Conditions where practice applies

This practice is typically used where:

- sediment-free storm runoff can be released in a sheet flow over a stabilised slope without causing erosion.
- sediment-laden overland flow can be released in sheet flow across the inlet to a sediment retention pond, decanting earth bund or similar impoundment device.
- the area below the level spreader lip is uniform with the slope of 10 percent or less and/or is stable for the anticipated flow conditions.

Key message: For a level spreader to be effective in producing sheet flow it needs to be level and remain in this state. Concrete haunching of the spreader bar may assist in this regard.

Design

A level spreader is used at the inlet to the pond to spread inflow, reduce velocity, transform the erosive force of turbulent flow into laminar flow and maximise the full capacity of the pond. A level spreader consists of a 200 by 50 millimetre straight timber plank laid on its edge (or similar material), levelled and fastened into place with concrete, bolted through warratahs or other secure fastening systems. Timber stakes are not recommended, as they usually move and allow spreader deformation.

The following design criteria are important when establishing level spreaders on an earthworks site:

- Determine the capacity of the level spreader by estimating peak flow from the 20 year storm.
- Where possible, choose a site for the level spreader that has a natural contour that will allow for the rapid spreading of flows, for example, at the end of a knoll or ridge.
- Select the appropriate length, width and depth of the spreader from the table below. When using the device for a pond, make the length of the spreader the same as the base width of the pond.

- Construct a 6m long transition section in the runoff diversion channel leading up to the level spreader so the width of the runoff diversion channel will smoothly meet the width of the level spreader to ensure uniform outflow. The level spreader trench tapers down to 1 m at the end of the level spreader.

Key message: Do not use timber stakes to secure the level spreader as they will move and deform the spreader.

- Maintain a minimum inlet width of 3 m. It is imperative that the grade of the level spreader is 0%.
- Construct the level spreader lip on undisturbed soil, incorporating a 50 x 150 mm board (spreader beam) levelled and positioned edge on as shown below. An alternative is to armour the level spreader to a uniform height and zero grade over the length of the level spreader. For the spreader bar to remain in a level position, it may be necessary to haunch around the plank with concrete.
- Use geotextile and ensure the disturbed area is seeded and fertilised for vegetation establishment.

The following table may be used to determine the sizing of the level spreader.

Table 8 Level spreader design criteria.

Design Flow (m^3/sec)	Inlet Width (m)	Depth (mm)	Length (m)
0.0 – 0.3	3	150	3
0.3 – 0.6	5	180	7
0.6 – 0.9	7	220	10

Maintenance

Key items to check as part of the regular inspection includes:

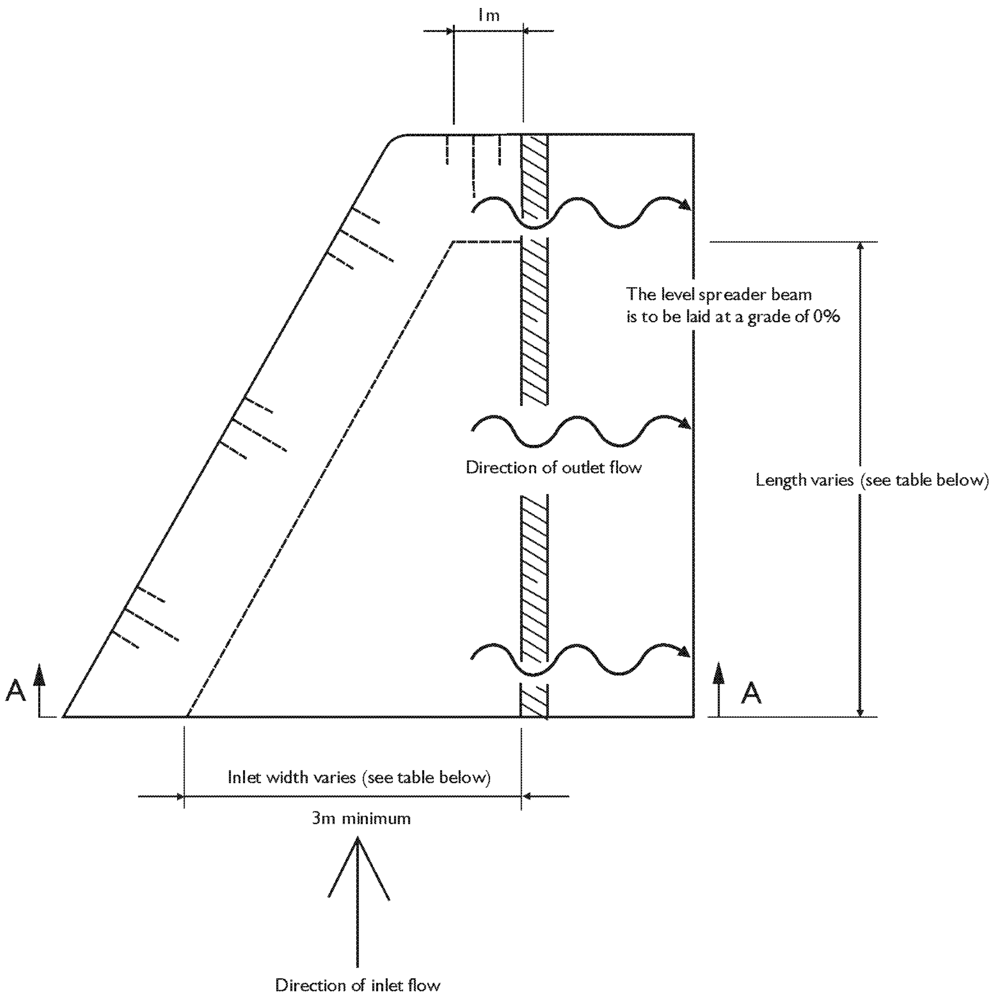
- Repair or reinstate the level spreaders if destroyed by machinery movement.
- Inspect the level spreaders after rain events and repair as necessary.

Limitations

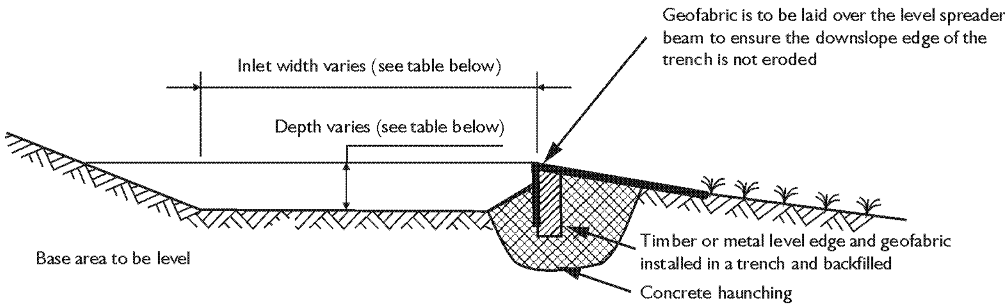
- The sizing of these level spreaders are for a maximum catchment of 5ha. In site conditions where a level spreader is required for a catchment greater than 5ha, specific engineering design will be required.
- For a level spreader to be effective in creating sheet flow, it must remain level. Therefore:
  - (i) Take care to ensure the level spreader outlet lip is completely level and is in stable, undisturbed soil or is well armoured. Any depressions in the level spreader lip will re-concentrate flows, resulting in further erosion.
  - (ii) Ensure that there will be no traffic over the level spreader.

Figure 49 *Level spreader construction - photo courtesy of Ridley Dunphy Environmental Limited.*

<u>Design drawings</u>



Plan View



Section A-A

Design Flow (m^3/sec)	Inlet Width (m)	Depth (mm)	End Width (m)	Length (m)
0-0.3	3	150	1	3
0.3-0.6	5	180	1	7
0.6-0.9	7	220	1	10

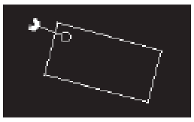
Figure 50 Level spreader detail - image courtesy of Auckland Regional Council 1999.

Section 7: Sediment control

Chapter objectives

1. **To provide an overview of sediment control practices where land disturbance activities occur.**
2. **Each practice outlines the:**
   - **Definition**
   - **Purpose**
   - **Conditions where practice applies**
   - **Design**
   - **Construction specifications**
   - **Maintenance; and**
   - **Limitations**

7.1 Sediment Retention Pond (SRP)



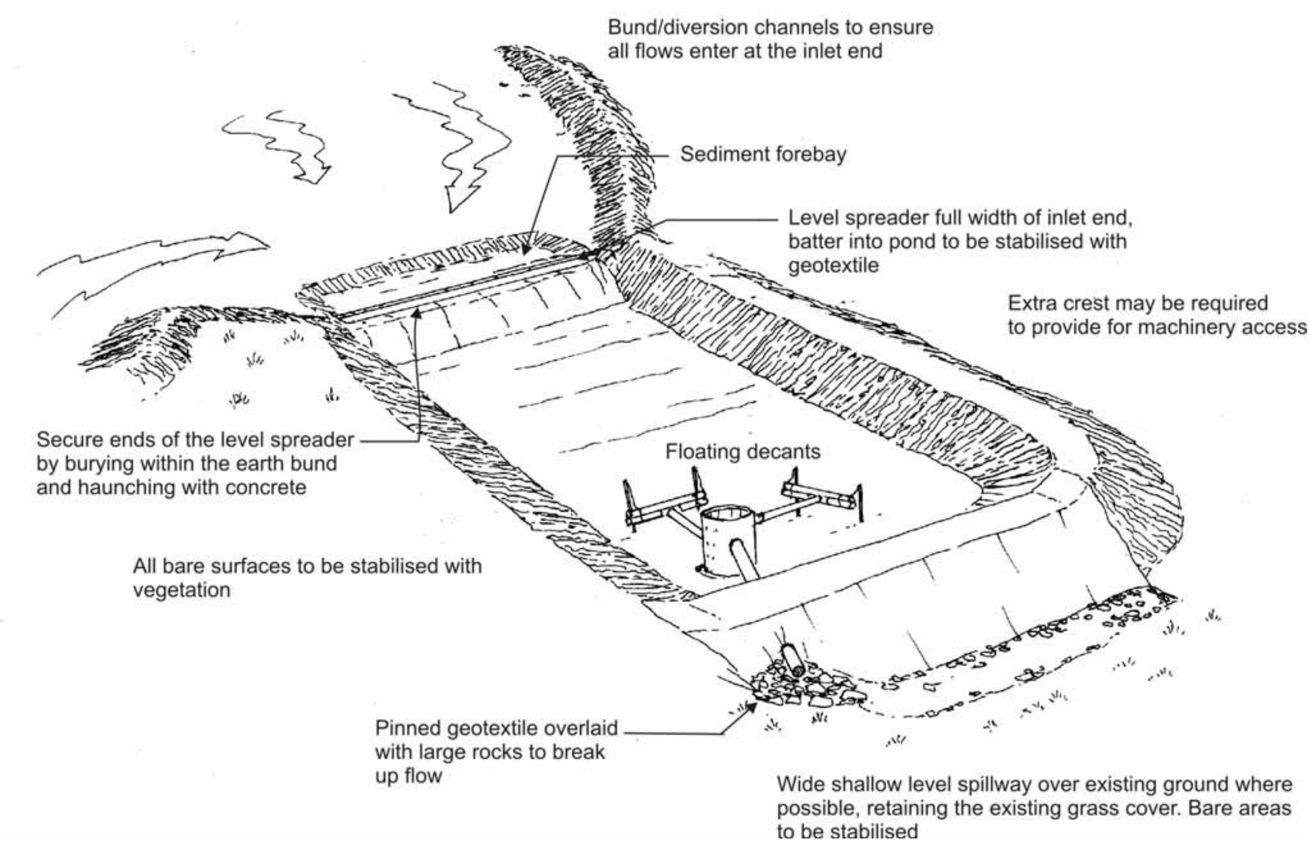


Figure 51 Sediment retention pond schematic.

<u>Definition</u>

A temporary pond formed by excavation into natural ground or by the excavation or the construction of an embankment, and incorporating a decant device to dewater the pond at a rate that will allow a proportion of the suspended sediment to settle out.

Sediment retention ponds have a permanent pool of water (Dead Storage) which reduces re-suspension of retained sediments by inflow, an operational volume (Live Storage) through which storm flows can be temporarily detained and decant devices that skim clearer water from the top of the water column to minimise discharge of suspended sediment.

Purpose

To treat sediment-laden runoff from earthworks sites and reduce the volume of sediment leaving a site. Sediment retention ponds do not capture all sediment entering the structure, however they are designed to capture enough sediment that downstream environments are protected from water quality degradation.

Key message: Sediment retention ponds are one of the most robust sediment control measures available. They should always be considered in this way on earthworks sites and should be a priority measure on large construction sites.

Conditions where practice applies

- Sediment retention ponds are appropriate for contributing catchments of more than 0.3 ha. Contributing catchment areas should be kept to less than 5.0 hectares. In all circumstances sediment retention ponds must be installed at the beginning of earth working (or phases for staged development) and need to be maintained until the disturbed area is fully protected against erosion by stabilisation. Robust runoff diversion channels will be necessary to convey sediment-laden runoff to the sediment retention ponds and it may be easier to construct several ponds for larger catchments.
- The location of sediment retention ponds needs to be carefully considered in terms of the overall project, available room for construction and importantly access and provision for maintenance. Consider also the location of any proposed permanent storm water retention facilities that may be constructed at a later stage of the development.
- Consider drainage and utility installation works that may be located in the same position as the Sediment Retention Pond and will cause sequencing and construction difficulties. You should also consider drainage reticulation that can be routed to the sediment retention pond until such a time as the site is fully stabilised. This reduces the requirement to install and maintain storm water inlet protection throughout the latter stages of a development.
- Sediment retention ponds should never be located within permanent watercourses. Clean water from above the contributing catchment needs to be diverted away from the sediment retention ponds contributing catchment by cleanwater runoff diversion channels.
- Always site sediment retention ponds where the primary and/or emergency spillway will discharge over undisturbed, well vegetated ground. Do not place sediment retention ponds on unstable slopes. This may apply to pumice soils in some locations and in this circumstance geotechnical consideration needs to be applied.
- Always put sediment retention ponds as close as possible to the sediment source. Make sure that site runoff can be conveyed to the sediment retention pond.

Design

Figure 52 Sediment retention pond - photo courtesy of Auckland Regional Council.

The general design approach is to create a sufficient volume to capture a significant proportion of the design runoff event, and to provide quiescent (stilling) conditions, which promote settling of suspended sediment. The sediment retention pond design is such that very large runoff events will receive at least partial treatment and smaller runoff events will receive a high level of treatment.

- Energy of the inlet water into the sediment retention pond needs to be low to minimise re-suspension of sediment, and the decant rate of the outlet also needs to be low to minimise water currents and to allow sufficient detention time for the suspended sediment to settle out.
- Always use erosion control to minimise sediment generating and therefore the amount of sediment entering the sediment retention pond. This will minimise the need to clean it out.
- Always place a sediment retention device such as a silt fence or decanting earth bund around the area of construction while the sediment retention pond is being constructed.
- A sediment retention pond's life should generally be limited to no more than two earthworks seasons. Ponds installed for longer periods require care to ensure their stability and effectiveness. This should include consideration of geotechnical stabilisation of pond embankments.
- It is noted that at the completion of construction an as-built assessment of each sediment ponds shall be undertaken by a suitably qualified engineer. Deviation from this requirement shall only occur in exceptional circumstances in discussion with Environment Bay of Plenty.

Sediment Retention Pond Volume Analysis

- Turbidity of water discharging from sediment retention ponds is not likely to be reduced by volume alone, and it is critical that "treatment' be provided through the pond design.
- Particle size distribution of soils is extremely variable, therefore the sizing of sediment retention ponds alone on the basis of particle size is complex.
- Environment Bay of Plenty analysed the preferred approach to sizing of sediment retention ponds in July 2001 and concluded that in addition to soil particle size analysis, the hydrology of the catchment contributing to the sediment retention pond is critical. This study has been reviewed further as part of this Guideline review and is considered to be largely still relevant.
- The study was based on the "design storm" which was defined as the two year storm event (50% AEP) for a range of storm durations. Utilising the runoff data available within the Bay of Plenty region design hydrographs were produced and storage volumes to capture this storm event were calculated, as shown in the table below:

Design Storm Duration Hours	Storage Required (m^3/ha)	Minimum decant rate to leave storage buffer litres/sec/ha
1	94	20
2	137	14
3	180	10
6	288	5
12	366	3.2
24	486	1.8
48	608	1.1

The study concluded that during the design storm, and assuming a 12 hour storm duration, that 366 m3 of storage would be required to capture this storm and with a decant rate of approximately 3.2 litres per second per hectare sediment laden water would be detained for approximately 24 hours in total (with some volume obviously detained for a lesser period) and with an average of 12 hours detention achieved.

It was recommended through this study that Sediment Retention Pond volume should therefore be based on 3% of the contributing catchment as an absolute minimum with 4% as a recommended approach.

In 2009, soil settling tests were undertaken, including the settling with assistance of chemical treatment options. The results of this study are in Appendix 3 of this Guideline and are summarised as follows:

- Four soil types which generally were thought to represent the Bay of Plenty region were assessed including Taupo pumice (Pumice Soil), Kaharoa ash (Podzol), Tarawera ash (Recent Soil) and Rotomahana mud (Recent Soil). These were assessed with both unassisted and chemically assisted settling.
- Taupo pumice sample had the highest risk in terms of settled water turbidity versus time and appeared to contain very fine clay or colloidal component which gave settled water a pale pink or white colouration even after an extended period of settling.

- Kaharoa ash sample settled well over a relatively short time frame but could potentially remain in suspension or be drawn into suspension if Sediment Retention Pond design does not allow for adequate settling area.
- The results, while representing only one set of soil samples, showed that Tarawera ash and Rotomahana mud samples settled very well and would be relatively easily retained in a suitable size Sediment Retention Pond.
- Taupo pumice and Kaharoa ash were tested with low dose rates of either PAC or L3RC to assist with settling of the soil particles. The Taupo pumice sample highlighted the potential risk of overdosing the chemical as settled water turbidity results deteriorated as the chemical doses increased however overall PAC was the most cost effective and environmental acceptable option of the products tested.
- It is concluded therefore that when taking into account the above assessment and catchment differences (and the knowledge that as slope angle and slope length increases erosion potential also increases significantly) that a volume criteria should be based on both slope angle and length with the sizing criteria detailed below. This criteria is also noted to achieve similar volumes as outlined within the original Environment Bay of Plenty 2001 study.
- Further it is concluded that if earthworks are to be undertaken on site that predominantly include Taupo pumice and Kaharoa ash that chemical assistance (using PAC) needs to be considered for use on site with site specific justification provided if it is not to be utilised. Where other soil types (or a mix of soil types) are encountered then specific soil sampling and chemical settling assistance analysis should be undertaken to determine the need for chemicals to be utilised. If soil types are predominantly Tarawera ash or Rotomahana mud it is expected that no chemical assistance would be required.

Sediment Retention Pond Volume Design

It is recognised that the treatment of suspended solids and turbidity of water in discharge from Sediment Retention Ponds is not solely dependent on pond volume alone and it is critical that other features of the pond are designed to optimise treatment.

It is further recognised that particle size distribution of soils across the region is extremely variable, which leads to the fact that sizing of Sediment Retention Ponds adds to the complexity of pond sizing.

Analysis of the sizing of Sediment Retention Ponds indicates that both soil particle size analysis and the hydrology of the catchment contributing to the Sediment Retention Pond are both critical factors. The following table should be used for calculating the storage per hectare.

Table 9 Sizing requirements for sediment retention pond design.

Slope Angle or Length of Slope	Minimum Percentage of Contributing Catchment	Storage Volume per Hectare of Contributing Catchment
≤ 10 % and/or≤ 200 m	2%	200 m^3/ ha
> 10% and/or> 200 m	3%	300 m^3/ha

Note: For the purposes of calculating Sediment Retention Pond volume the slope is determined by the slope immediately above the Sediment Retention Pond or by the average slope angle over the pond's contributing catchment, whichever is the greatest.

- Calculate the volume of the sediment retention pond using the depth measured from the base of the pond to the top of the primary spillway (manhole riser). In the case of a pond which does not incorporate a manhole riser measure the depth from the base of the pond to the invert of the emergency spillway is used to calculate volume.
- If a lesser pond volume is proposed, detailed analysis of the volume, catchment area and soil types (particle size analysis) is required to provide justification. Environment Bay of Plenty approval will be required in these situations.
- The forebay is the main component of the sediment retention pond that will be used for trapping sediment and will also be the component of the pond subject to the most significant maintenance. An additional 10 percent of the total pond volume is to be used as a sediment forebay.
- When calculating the volume of sediment retention ponds, incorporate the side slope angles, ensure that the volume accounts for these areas and measure the volume at mid slope. Clearly show the pond dimensions necessary to obtain the required volume on the site's Erosion and Sediment Control Plan(s).
- Always undertake an as-built assessment at the completion of construction of the pond to ensure it is built as designed and has the correct catchment area.

Key message: Sediment Retention Pond design details should be clearly shown on the sites Erosion and Sediment Control Plan, with details of volumes, sizing and specific design criteria.

Dead Storage Volume

Dead storage is the component of impoundment volume that does not decant and remains in the sediment retention pond.

- Dead storage is important in that it dissipates the energy of inflows. For all sediment retention ponds ensure that the dead storage is based on 30 percent of the total pond volume.
- To achieve dead storage volume position the lowest decant at a level that equates to 30% of the height to the primary spillway.
- It is important that if sediment deposition occurs within the main body of the pond that this is removed as soon as is possible to ensure that dead storage volume is maintained.

Live Storage Volume

Live storage is the volume between the lowest decant outlet level and the level of the primary spillway.

- For ponds with no primary spillway the live storage volume is from the floating decant to the invert of the emergency spillway.
- Ensure that the live storage volume capacity is 70 percent of the total pond volume.

Shape of Sediment Retention Pond

Ensure the length to width ratio of the sediment retention pond is no less than 3:1 and no greater than 5:1 to avoid creation of short circuiting or increased flow velocities. The length of the pond is measured as the distance between the inlet and the outlet decant. Always maximise the distance between the inlet and the outlet (including the emergency spillway location) to reduce the risk of short circuiting and to promote quiescent conditions.

- If this cannot be achieved by correctly positioning the inlet and outlets, install baffles to achieve the appropriate length to width ratio design. Care needs to be taken to ensure that currents are not created.
- Always ensure that the sediment retention pond has a level invert to promote the even and gradual dissipation of the heavier inflow water across the full area of the pond.

Depth of Pond

Sediment retention pond depths may be between 1 and 2 metres deep with a 1.5 metre depth the desired measurement. Deeper ponds are more likely to cause short circuiting problems during larger storm events and shallow ponds lead to mixing of the sediment stored within the dead storage.

- It is important to note that the decant design in these Guidelines operates through a maximum live storage range of 1.4 metres (from the dead storage level to the top of the primary spillway) which is suitable for ponds up to 2 metres in depth.

Primary Spillway

For catchments greater than 1.0 ha the sediment retention pond requires a primary piped spillway and typically a manhole is used.

The table below illustrates the correct type and sizing of primary spillways.

Table 10 Sizing requirements for primary spillways.

Catchment Size	Primary Spillway Type	Primary Spillway Size
≤ 1.0 ha	n/a	n/a
1.0 ha to 2.0 ha	Vertical PVC Pipe	150 mm diameter minimum
> 2.0 ha to 5 ha	Vertical Concrete Manhole Riser to accommodate the 5% AEP rainfall event.	300 mm diameter minimum

- Ensure the riser and the discharge pipe connections are all completely watertight.
- Where a primary spillway upstand riser is used, place the top of the riser a minimum 500 mm lower than the top of the sediment retention pond embankment and a minimum 200 mm lower than the emergency spillway invert.

Emergency/Secondary Spillway

An emergency spillway is essential for all sediment retention ponds and must be capable of accommodating the 1 % AEP rainfall event without eroding.

- The emergency spillway must be located at the outlet end of the Pond behind or beside the decant system and must discharge onto stabilised ground.
- The emergency spillway construction and outer batter require a very high standard of compaction during construction in order to prevent erosion.
- Construct the emergency spillway as a stabilised trapezoidal cross section with a minimum length equal to the width of the pond. The maximum length of the spill way should be no greater than 8 m. The trapezoidal cross sections to be continued down the outside batter to avoid flows outflanking the geotextile.
- If geotextile is used to stabilise the spillway, a strong woven low permeability geotextile is laid first and then covered with a soft non-woven needle punched geotextile. Ensure the geotextile is pinned at 500 mm centres over the full area of the emergency spillway. Contact your geotextile supplier for specific manufacturer's geotextile specifications and recommendations.
- If the emergency spillway is constructed on exposed soil, provide complete erosion protection which can include the provision of grouted riprap, erosion matting/geotextile or concrete.
- Construct the emergency spillway with a minimum of 200 mm freeboard height above the primary spillway invert and a 300mm freeboard to the crest of the Sediment Retention Pond.

Forebay Design

Construct a forebay with a volume equal to a minimum 5 percent of the pond design volume. Details of the sizing requirements are shown below in the following table.

Table 11 Sizing requirements for forebay construction.

Slope Angle or Length of Slope	Minimum Percentage of Contributing Catchment	Forebay Volume per Hectare of Contributing Catchment
≤ 10 % or ≤ 200 m	2%	$10m^3$/ha
> 10% or > 200 m	3%	$15m^3$/ha

- The forebay is to extend the full width of the sediment retention pond and is to be excavated 1 m deep.
- Water will enter the forebay via dirty water runoff diversion channels and access needs to be maintained at all times to allow easy and frequent removal of accumulated sediments by an excavator. Sediment should be removed after every large storm event.

Figure 53   Forebay and level spreader - courtesy of Environment Waikato.

<u>Level Spreader</u>

Always install a level spreader between the forebay and the main sediment retention pond to spread inflow velocities, reducing energy and thereby allowing rapid dissipation of all inflow energies. Ensure that the pond level spreader has a well compacted and smoothed batter into the pond with a maximum grade of 3:1 gradient. This batter needs to be stabilised over its entire area.

- The essential design feature is to ensure the pond level spreader is completely level, non-erodible and spans the full width of the pond.
- Construct the level spreader from 150 mm x 50 mm H4 treated timber or equivalent across the full width of the pond inlet. This critical construction feature needs to be trenched into the surface and haunched with site concrete along the length of the level spreader and at the ends of the level spreader to ensure that no undercutting or outflanking occurs.
- Position the top of the level spreader weir 200 mm above the invert of the emergency spillway.
- Stabilise the level spreader and pond embankment to the base of the pond with a layer of strong woven low permeability geotextile overlaid with a layer of soft nonwoven needle punched geotextile. Seek advice from your geotextile manufacturer about the most appropriate product.
- Pin all geotextiles at 500 mm centres.

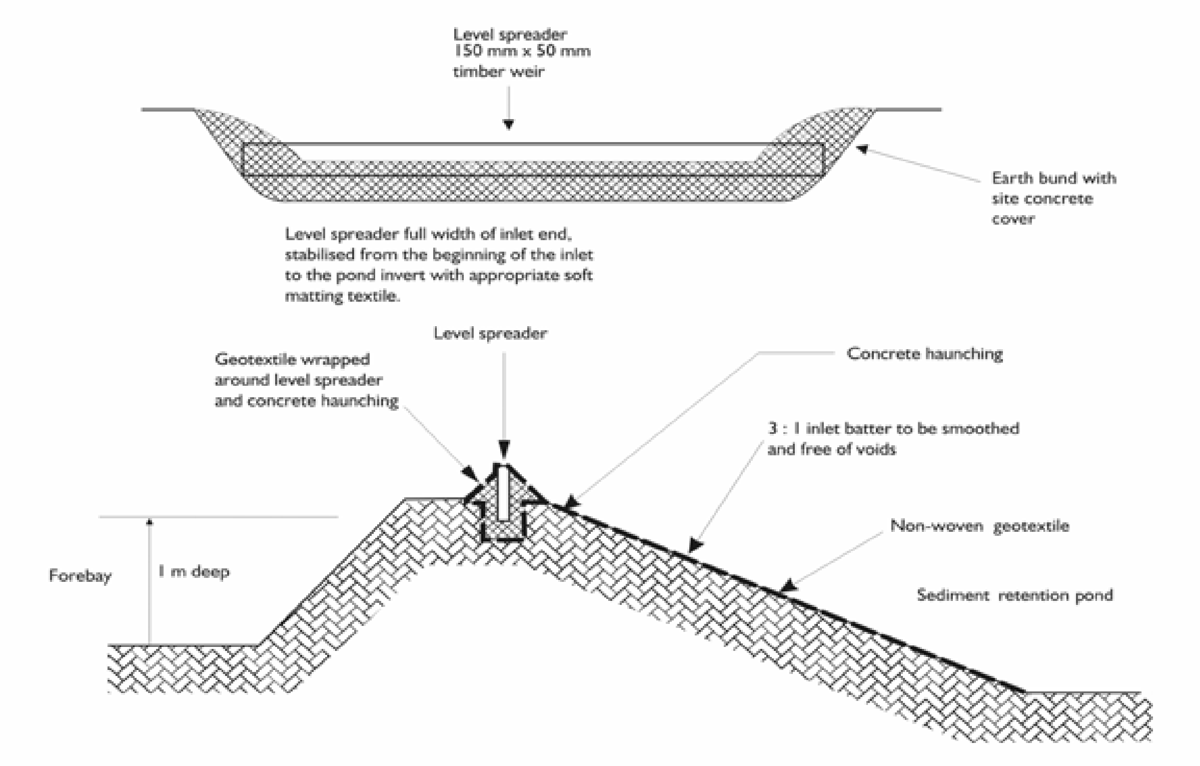


Figure 54 Level spreader detail – courtesy of Auckland Regional Council.

Figure 55 Level spreader showing concrete haunching - courtesy of Ridley Dunphy Environmental Limited.

Figure 56 Installation of level spreader and concrete haunching - Courtesy of HEB Construction Limited.

Embankment and Outlet

- If the sediment retention pond is constructed through an embankment then low permeability soils should be used and thoroughly compacted, with material laid in 150 mm layers and compacted to engineering standards. If the pond is to be near a watercourse or made from less suitable material, it is recommended that geotechnical supervision and checking of the embankment occurs. Refer to Environment Bay of Plenty "Guidelines for the Design, Construction, Maintenance and Safety of Small Flood Detention Dams"
- The crest width should be a minimum of 2.0 metres and be sufficient to ensure structural stability and allow for clearing of sediment where necessary;
- Before building a sediment retention pond always install sediment controls such as silt fences or decanting earth bunds below the construction area and maintain them to a functional standard for the full life of the pond or until the pond batters and lower area are fully stabilised.
- Where possible, install the discharge pipes through the embankment as the embankment is being constructed and ensure anti-seep collars are in place.
- Filter collars need to be incorporated to increase the seepage length and ensure that no embankment failure occurs. Filter collar design will be specific to the pond as detailed in Figure 59 below.
- If the pond is to remain in place over the winter months, ensure all bare areas associated with the pond are stabilised to minimise the sediment generation potential.

- Ensure that the outlet from the pond is in a position to minimise scour and that the outlet also incorporates erosion protection as necessary. This is typically an appropriate geotextile placed under the outlet and beyond the discharge point to a stable location.

Figure 57 Approved antiseep collar design - Courtesy of Wai Ora Soil Conservation Limited.

Figure 58 Collapsing sediment retention pond embankment - Courtesy of Ridley Dunphy Environmental Limited.

Decant Device

Always use a floating T-bar de-watering device, which allows for decanting of the cleaner surface water from the top of the water column. These devices have specific design criteria and if a different design is proposed then you will need to submit a substantiated performance design for the decant systems.

- The recommended decant rate from a sediment retention pond is a maximum of 3 litres/second/ha of contributing catchment – an average over the design storm event. This ensures that optimal detention times are achieved to ensure settling of sediment particles.
- A standard T-bar design is detailed in Figure 61 which provides for a decant that is less prone to blockage due to mulch or floating debris, such as pumice. For simplicity, installing a standard T-bar decant that provides a maximum discharge rate of 4.5 litres/second per decant is appropriate and these can be added in discrete increments to accommodate various sized catchments.
- To achieve a decant rate of 4.5 litres/second per decant, drill 6 rows of 10mm diameter holes at 60mm spacings along the 2m decant arm.

Single T-bar decants must be able to operate through the full live storage of the pond. If two decant systems are required, the lower T-bar decant continues to operate through the full live storage depth of the pond with the higher decant also operating to that same top level through the upper 50 percent of the live storage volume.

If three decant systems are to be used, then the lower T-bar decant operates through the full live storage volume, the second T-bar decant through the upper two thirds of the live storage volume the upper T-bar decant operates through the upper one third of live storage volume.

To build and secure the decant(s):

- Secure a T-bar decant float with steel strapping directly on top of the decant arm and weight it to keep the arm submerged just below the surface through all stages of the decant cycle. You can use a warratah placed between the float and the decant, which needs to be securely fastened to ensure that the weight does not "favour" a particular side and result in an unbalanced and uneven decant. By adjusting this weight the decant should sit immediately below the water surface and will also reduce potential for blockage through floating material.
- Position the T-bar decant at the correct height by supporting the decant arm between warratahs and a support wire, and positioning the decant discharge pipe at a flat grade to the primary spillway manhole. Where a concrete riser decant system is used, the lower decant connection can be positioned on an angle upwards from the horizontal to reduce the operational angle that the decant works through, reducing the deformation force on the couplings used.
- The discharge pipe from the manhole structure to the outer side of the pond embankment should be placed at a grade of 2% and should have compacted fill placed around it using a compactor.
- Use a flexible thick rubber coupling to provide a connection between the decant arm and the primary spillway or discharge pipe. To provide sufficient flexibility (particularly for the lower decant arm which has the greatest travel distance) use two couplings. In all circumstances the coupling needs to be secured with strap clamps, self taping screws and glue.

In addition to the decant, a boom can be placed across the pond immediately up-pond from the decant device to provide a physical barrier to debris. This boom floats on the water surface and up and down with fluctuating water levels in the pond and prevents floating debris from blocking the decants which reduces their function. Booms can be made from a non-punched 160 mm novacoil pipe and tied to both sides of the pond embankment.

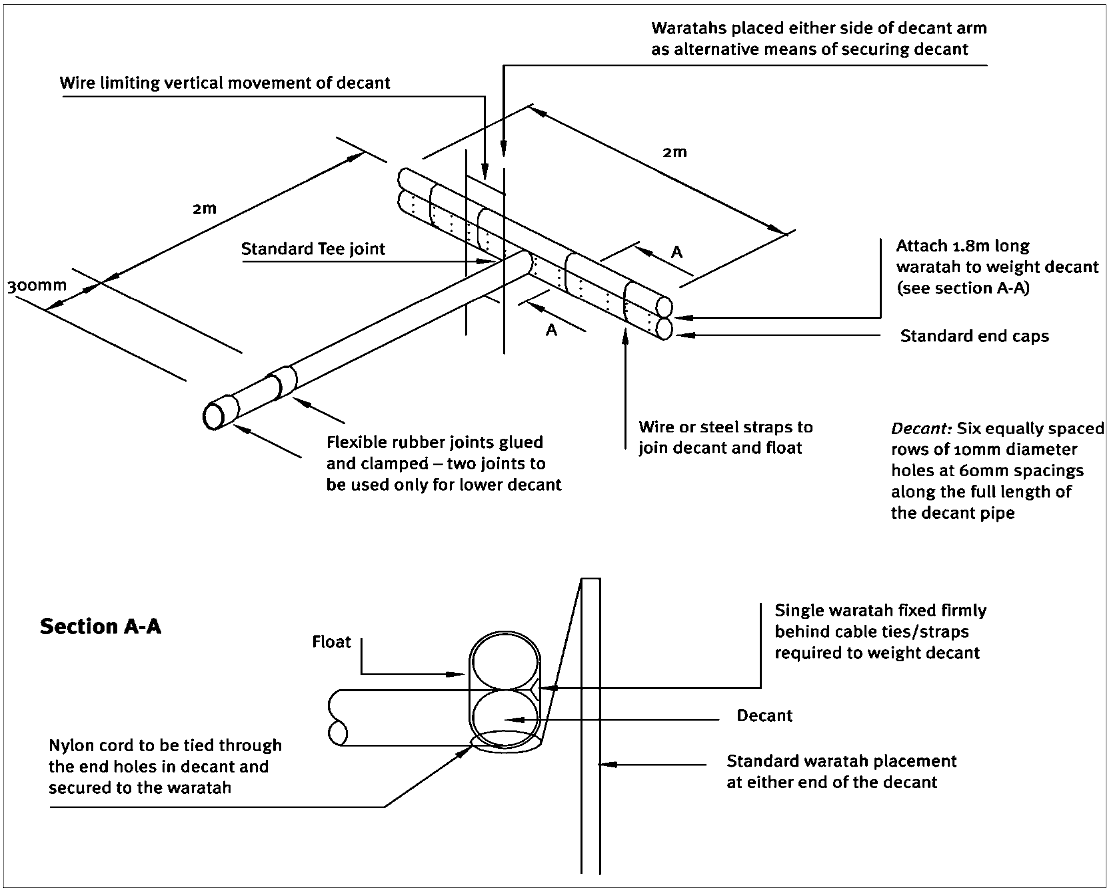


Figure 59 Decant detail for sediment retention pond.

Baffle Installation

Incorporate baffles into sediment retention ponds where the recommended pond shape cannot be achieved to provide a longer, artificial flow length.

- Baffles need to be designed on a site-by-site basis and require specific approval of Environment Bay of Plenty prior to installation. It is important that the baffles do not create currents or re-suspension of sediments within the pond, and design will need to take this into account.
- Extend baffles the full depth of the pond and place them to maximise dissipation of flow energy. The concept is to divert flows away from the outlet decant device and to maximise the stilling zone. Baffles can also be placed immediately up-pond from the decant devices to act as a further barrier to sediment entering these decants and leaving the pond.
- Baffles may be constructed from various materials ranging from solid plywood to braced geotextile curtains.

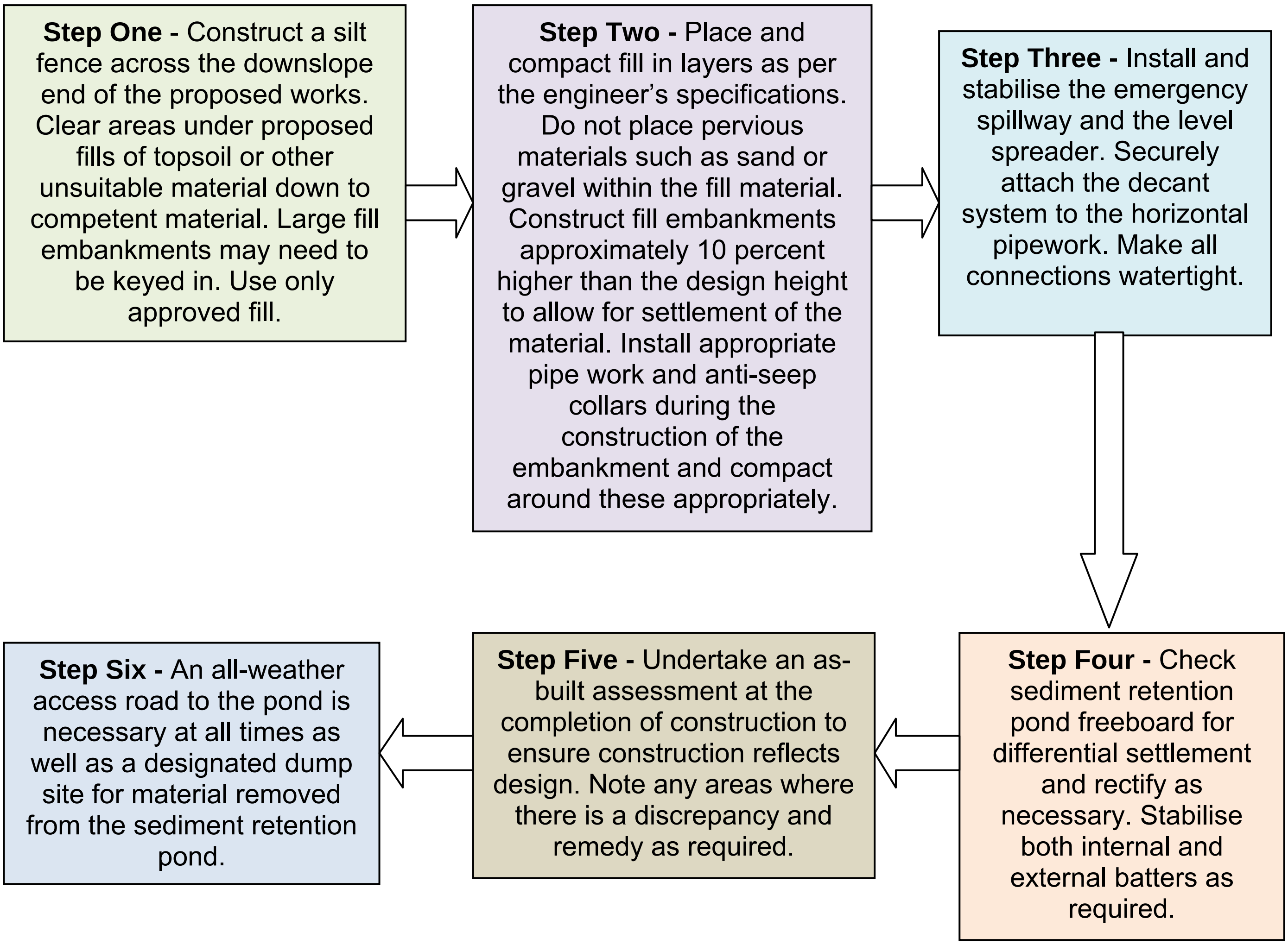
Chemical Treatment

Some chemicals can be used successfully to promote flocculation of suspended solids, to increase the particle mass and speed the rate of settling. Chemical dosing systems may be used where the design sediment retention pond volume cannot be achieved because of site constraints and/or where a high level of treatment is required because of the sensitivity of the receiving environment. Chemical treatment is more likely to be required where the clay component of the soil is high.

When considering chemical treatment refer to Section 7.7 of this Guideline.

Construction specifications

The following flow chart should be followed when installing sediment retention ponds. This is a summary construction process only and specific design and construction specifications should be sourced from the text within this Guideline.



The operating condition of sediment retention ponds specified in these Guidelines should be achieved at start of development and after inspection and maintenance routines.

Consider general health and safety issues regarding sediment retention ponds. In most circumstances it will be necessary to use safety fencing and/or signage. Check the safety requirements of the appropriate authority.

Maintenance

Clean out sediment retention ponds before the volume of accumulated sediment reaches 20 percent of the total volume. Typically most of the maintenance will be within the forebay and provided this is maintained after every storm event the sediment entering the main pond body will be minimised.

- To assist in gauging sediment loads, clearly mark the 20 % volume height on the decant riser.

- Clean out ponds with excavators loading onto sealed tip trucks or to a secure area, ideally immediately adjacent to the pond. Sludge pumps can be used in some situations.
- The forebay should be cleaned of sediment once it contains 20% by volume of sediment.
- The Erosion and Sediment Control Plan should identify disposal locations for the sediment removed from ponds.
- Inspect ponds daily and before every forecasted rainfall event. Inspect for correct operation and repair any damage caused by erosion or construction equipment.
- Also check for damage caused by settlement and/or seepage through embankments, leaking joints, decant systems not working correctly or blocked, 'unlevel' level spreader, outflanking of inlet/outlet systems, pond short-circuiting, erosion at outlets and any other signs of weakness or failure.

Figure 60 Sediment retention pond forebay requiring maintenance - courtesy of Ridley Dunphy Environmental Limited.

Limitations

- A sediment retention pond with the associated side slopes and surrounding bunds can take up a considerable area. This must be allowed for when setting out erosion and sediment controls. Consider drainage and utility installation locations. Batter slopes will also need to be considered to ensure that there is available room for stable batters.
- Sediment retention ponds are the priority sediment control measure, and often the last control measures to be removed when works are complete. They should be retained until the catchment is stable against erosion. Sediment retention ponds therefore often have to be worked around up to the last stages of the development.
- The outlet pipe-work through the embankment and the embankment itself is usually the weakest point of a pond. Construct these and monitor carefully.
- Decant systems can be easily blocked with floating debris, and need regular cleaning.

Design drawings

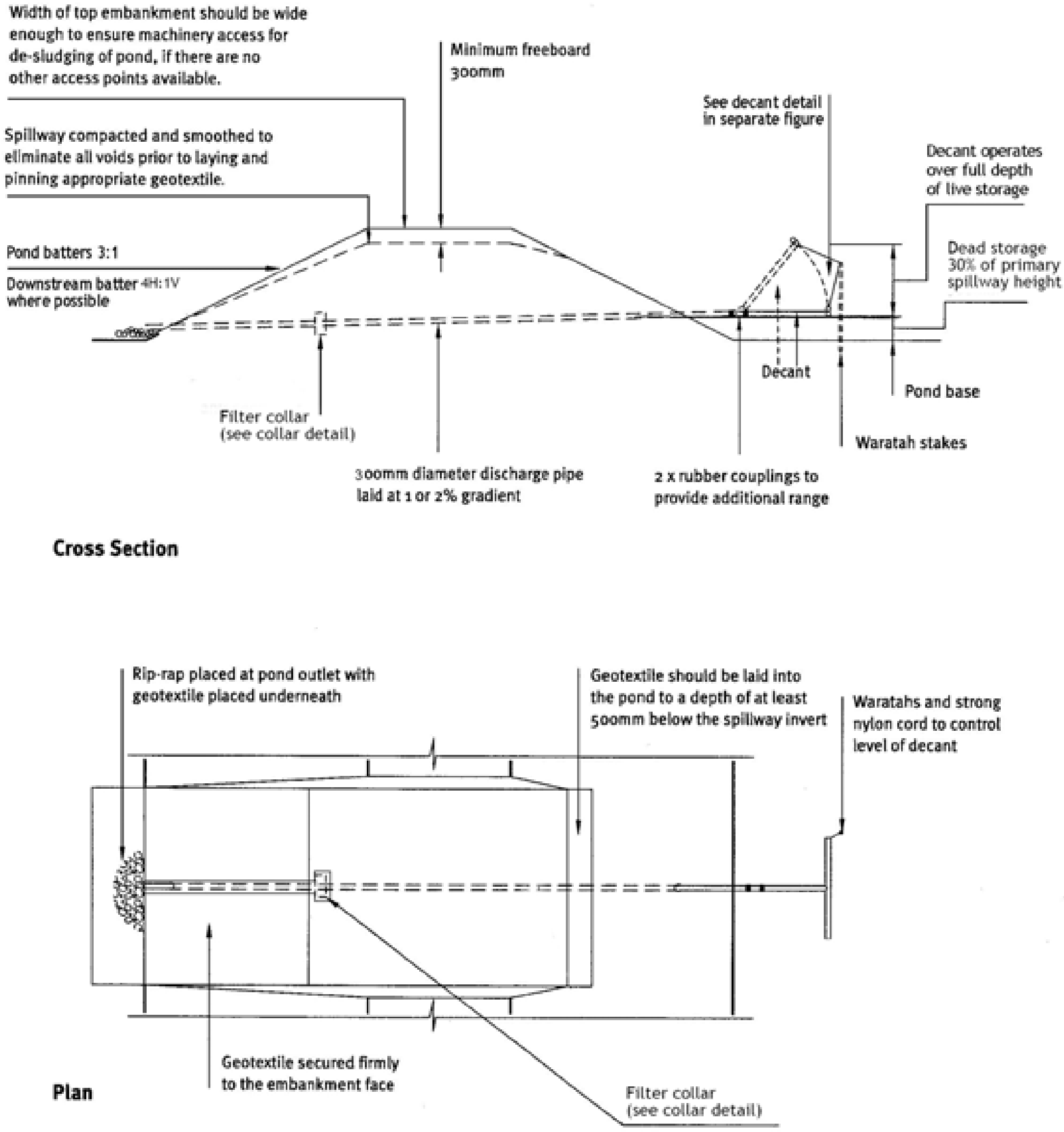


Figure 61 Sediment retention pond for contributing catchments up to 1.0 ha.

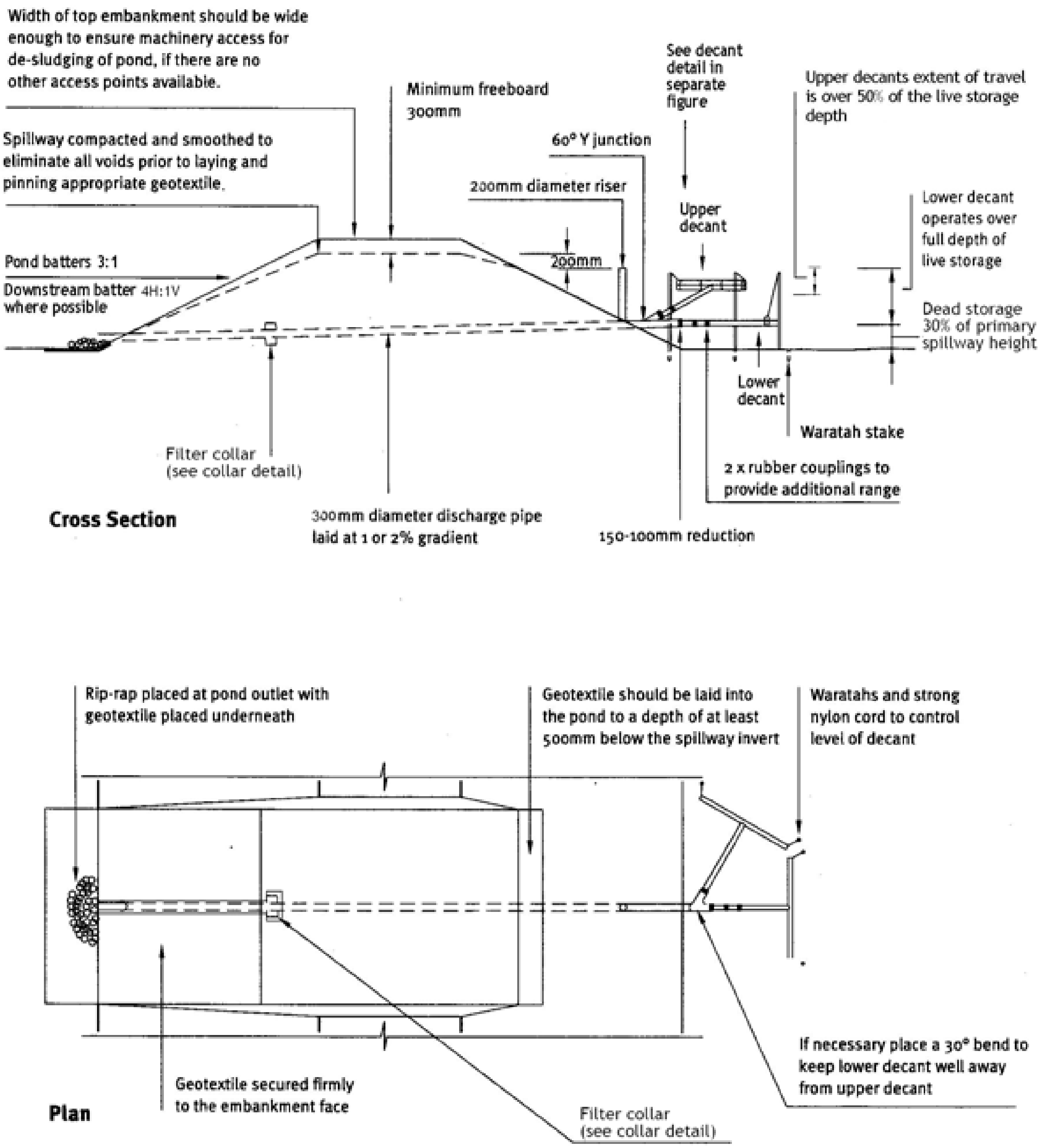


Figure 62 Sediment retention pond for contributing catchments between 1.0 and 2.0 ha.

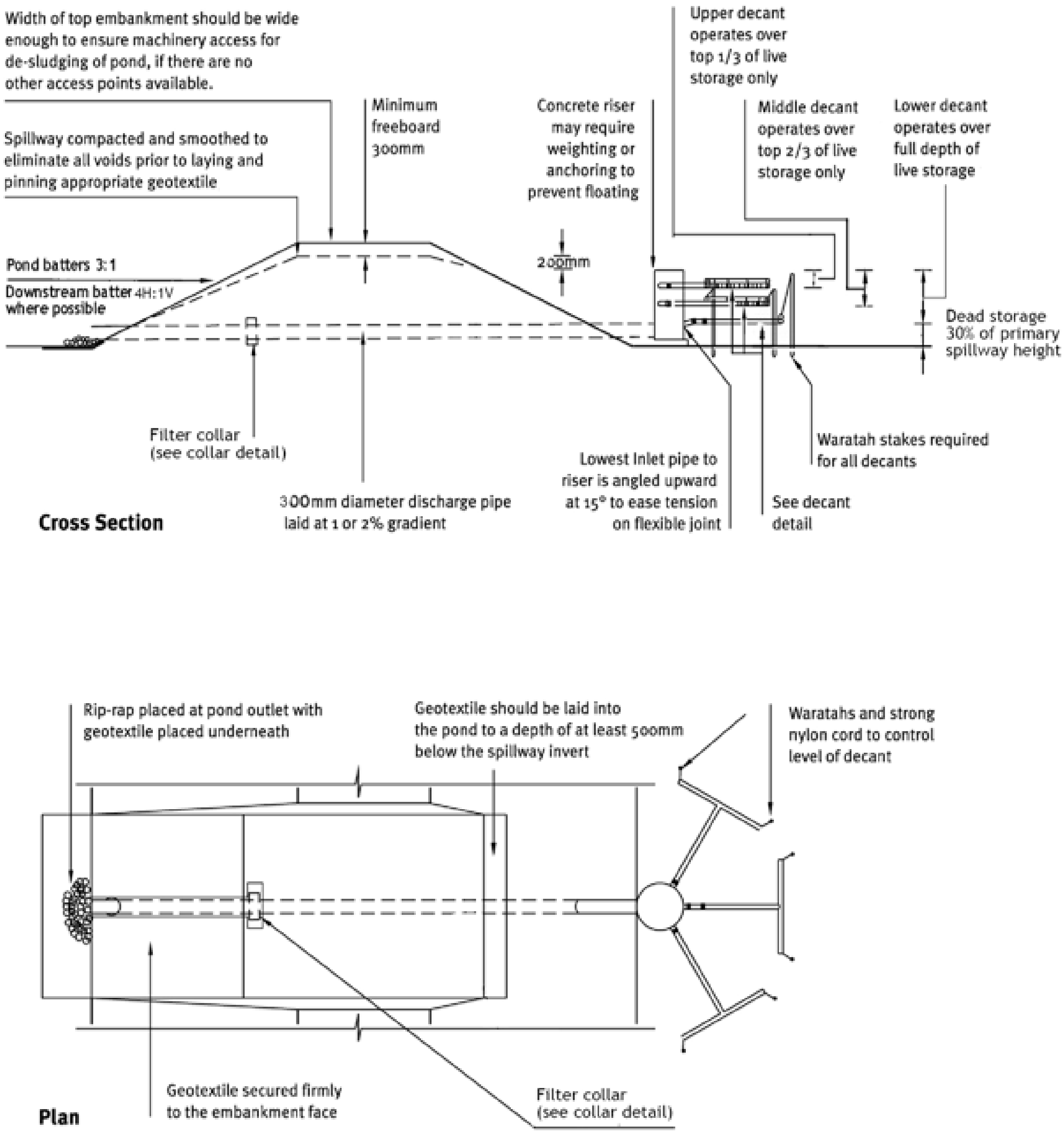


Figure 63 *Sediment retention pond for contributing catchments between 2.0 and 5.0 ha. Sediment retention pond design - images courtesy of Environmental Waikato and Auckland Regional Council 1999.*

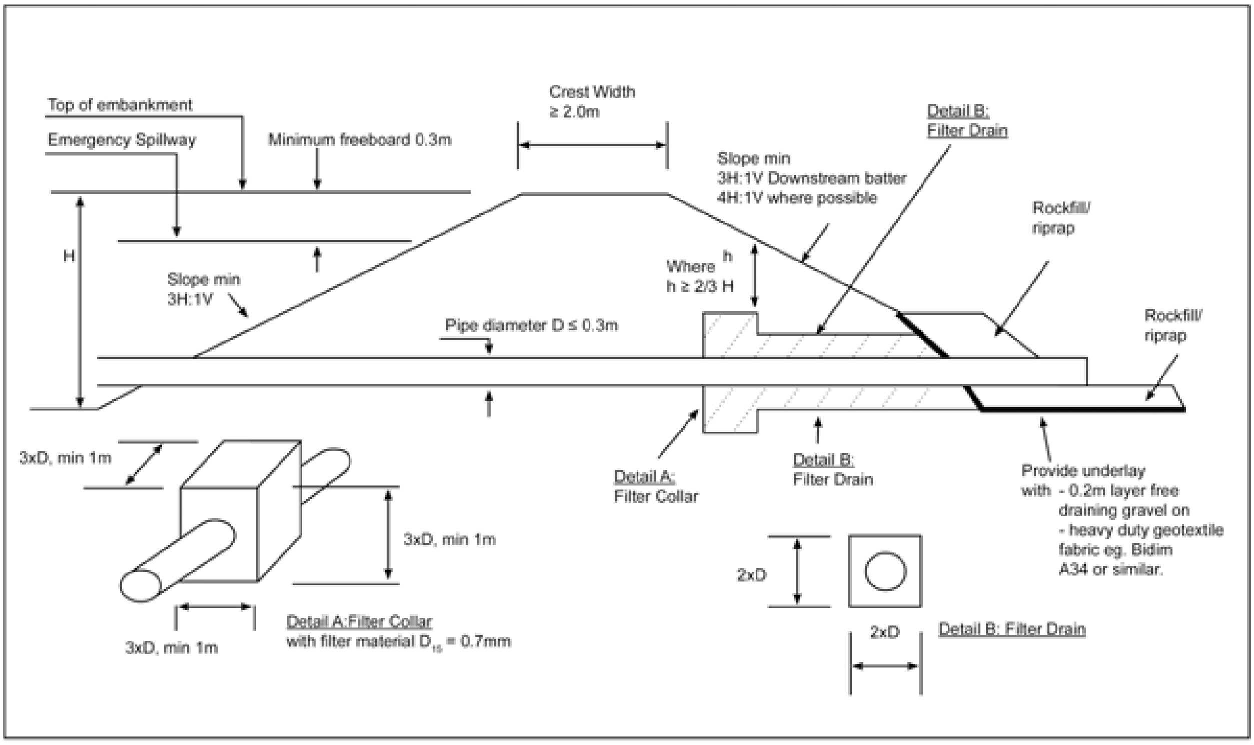


Figure 64 Sediment retention pond filter collar design.

7.2 Decanting earth bunds (DEB)

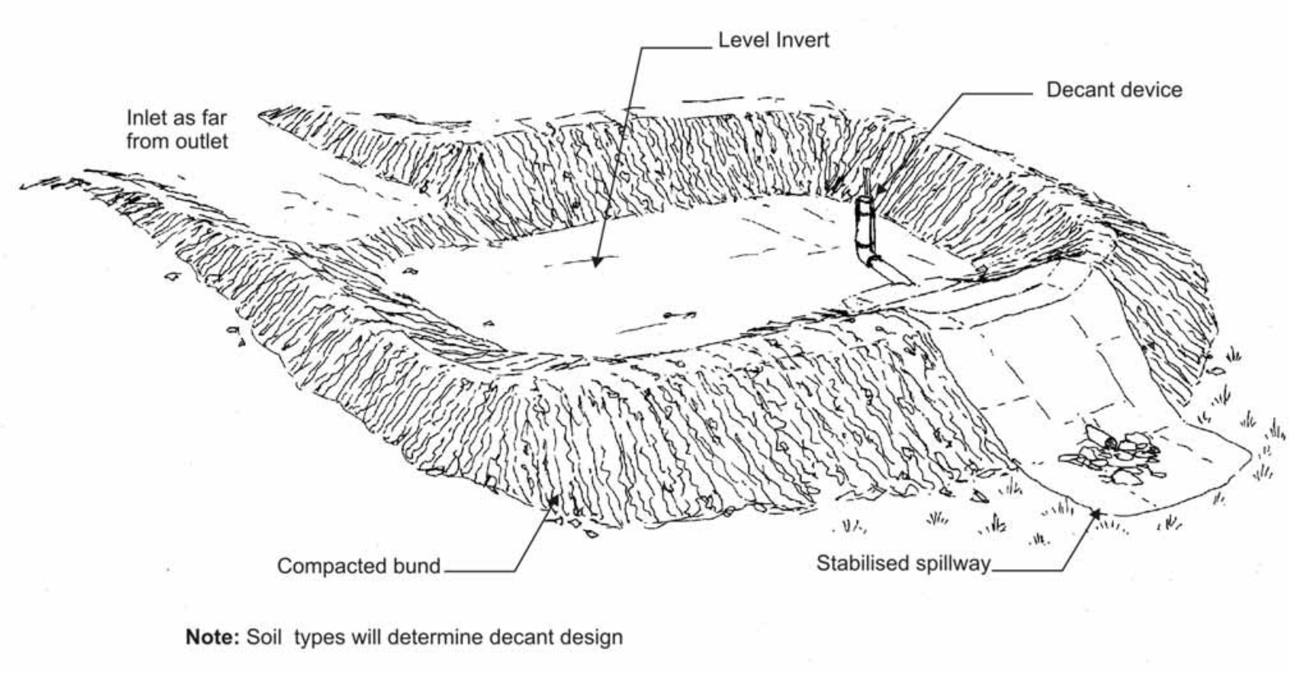


Figure 65 Decanting earth bund schematic.

Definition

A temporary ridge of compacted soil in a bund, or an excavated area, constructed to create an impoundment where ponding of runoff can occur, and suspended material can settle before runoff is discharged via a decant device.

Figure 66 Decanting earth bund installed with "T"-bar decant.

Purpose

The purpose of a decanting earth bund is to intercept sediment-laden runoff and reduce the amount of sediment leaving the site by detaining the runoff long enough to allow coarser particles of sediment to drop out within the impoundment area. They differ from a sediment retention pond in that, while having an ideal length to width ratio of 3:1, they do not always have a standardised shape and are applicable for much smaller catchments.

Conditions where practice applies

They are typically used in temporary situations where flexibility is required and space prohibits the use of a sediment retention pond. Accordingly they can be constructed in a variety of shapes, linear continuous bunds installed parallel to the site contour, 'U'-shaped bunds to treat a discrete catchment as well as more regular shaped ponds. In a number of situations they can be used as a pre-treatment device to throttle flows before discharge into a sediment retention pond or similar device.

Their application is similar to the principles outlined for a sediment retention pond however decanting earth bunds are suitable for small catchments only. They can be used in numerous situations, including;

- In a "tight" area where there is insufficient space to install a sediment retention pond or other sediment control;
- Instead of super silt fences or silt fences as they are more robust;
- Using topsoil on the cut to fill line to form a bund to throttle flows as a pre-treatment device before discharge into another form of sediment control such as a sediment retention pond;

Figure 67 Decanting earth bund installed along the contour.

- Decanting earth bunds are particularly useful for controlling runoff after top soiling and grassing before vegetation becomes established.

Key message: DEBs are relatively quick to install and can be use in a variety of situations. They are however, not a substitute for a sediment retention pond and the option of using a sediment retention pond should be explored first.

Design

Decanting earth bunds can be constructed from topsoil or clay (or other suitable soils), but as the bund must be 'waterproof', material that may allow seepage through the bund must not be used. The bund has a permanent pool of water to reduce re-suspension of retained sediments and an operational volume through which storm flows can be temporarily detained. A decanting earth bund can be almost any shape, provided the key performance characteristics (volume, configuration of decant and position of inlet) are met.

A decant device is needed and a "T-bar" arrangement is required in clay to silty soils (Taupo pumice and Kaharoa ash) where a greater surface area of the water column is being decanted. A snorkel-type decant is appropriate for coarser grained soils (Tarawera ash and Rotomahana mud). Decanting earth bunds are sized in a similar way to sediment retention ponds, except that their maximum capacity is limited to $90m^3$.

The following characteristics are important in the design of Decanting Earth Bunds:

- Work out how the bund will fit in/work for the site. Identify the catchment area and avoid placing the bund where damage is likely, for example, from construction machinery. Maximum catchment areas for bunds is 3,000 m^2.
- Always put the bunds as close as possible to the sediment source. Make sure that site runoff can be conveyed to the bund.
- Always use erosion control to minimise generation of sediment and therefore the amount of sediment entering the bund. This will minimise the need to clean it out.
- Measure the bund's volume from the invert to the top of the outlet riser.
- On earthwork sites with slopes less than 10 percent and less than 200 m in length, construct a bund with a minimum volume of 2 percent of the contributing catchment (20 m^3 for each 1000 m^2 of contributing catchment).
- On sites with slopes greater than 10 percent and/or more than 200 m in length, construct bunds with a minimum volume of 3 percent of the contributing catchment (30 m^3 capacity for each 1000 m^2 of contributing catchment).
- If a lesser bund volume is proposed, detailed analysis of the volume, the catchment area and the soil types (particle size analysis) is required to provide justification. Environment Bay of Plenty approval will be required in these situations.
- Depending on the catchment, more than one bund may be needed.
- A bund should have a minimum compacted earth bund height of 1.15 metres at the lowest point. This is made up of 0.75 metres for the height of the riser, 0.15 metres elevation to the spillway and a further 0.25 metres spillway depth. A level invert of the decanting earth bund must be provided.
- Ensure that all bund embankments are compacted appropriately, particularly around the outlet pipe. If there is sand, pumice or other erodible material in the embankment, an anti-seep collar must be installed during construction of the embankment.

Figure 68 T-bar decant.

- Inlet points must be located as far as possible away from the outlet to optimise sediment deposition. The bund should be three times longer than it is wide with inflow at one end and outlet at the other. A baffle may be able to be installed to achieve this.
- Put a 160 millimetre diameter non-perforated drainage pipe through the bund at the low point and compact soil firmly around the pipe.
- The pipe needs to discharge to an erosion-proof outlet, such as a natural depression. Do not discharge over bare land, fill or unstable ground. If necessary, flume the outflow to an erosion-proof outlet.
- Install a decanting device as shown in either Figure 70 or Figure 71 below depending on soil types. Position the decant inlet to provide 70 percent live storage volume with a minimum distance of 5 m of flat ground from the inlet. If a flat level invert cannot be achieved, raise the inlet so the dead storage level extends out at least this far. Ensure that the section of pipe within the impoundment area is supported by a rigid post, allowing for filtration to occur.

Figure 69 Snorkel upstand decant.

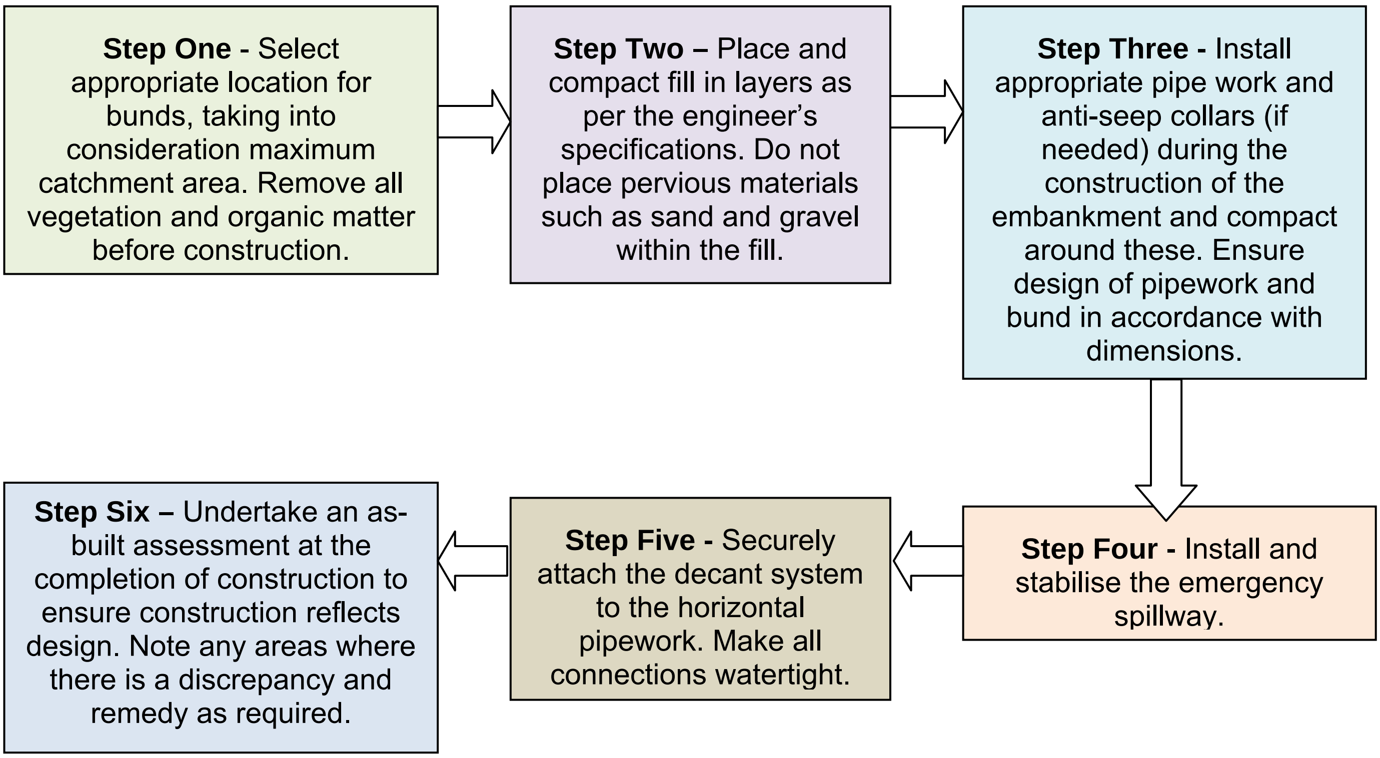
- In some cases, chemical treatment may be required to improve sediment removal efficiencies and guidance on this is outlined in Section 7.7 of this Guideline.

Key message: The capacity of a decanting earth bund should never exceed 90m^3. This therefore governs the upper catchment size for a DEB to be used on a site.

- Build a two metre-wide trapezoidal spillway over the bund embankment (preferably to spill to undisturbed land). The spillway must always be at the lowest point of the bund, and level across its width, 150 millimetres above the invert of the upstand and at least 250 millimetres deep. Stabilise the surface of the spillway against erosion with appropriate geotextile, rock or concrete.

Construction specifications

The following flow chart should be followed when installing decanting earth bunds. This is a summary construction process only and specific design and construction specifications should be sourced from the text within this Guideline.



Maintenance

Inspect and maintain decanting earth bunds regularly and after each rainfall event to check for accumulated sediment, which may cause overtopping. Check any discharge points for signs of scouring and install further armouring or other stabilisation if scouring is evident.

Inspect regularly, and before and after every major storm, to look for any changes in the structure. Important details to check on are:

- that runoff is not outflanking the bunds;
- that the spillway is the lowest point over the embankment wall, that it is functional and protected against erosion. Repair any damage;
- whether there is erosion at the outfall and remedy if required. This could include redirecting flow to a new outlet or installing a flume;
- whether there is any damage to the pipe drainage systems and repair as necessary;
- whether there is seepage through the embankment, or along the outlet pipe and remedy as necessary;

Figure 70 Decanting earth bund which needs maintenance (removal of accumulated sediment) otherwise good length:width ratio and appropriate decant. Photo courtesy of Auckland Regional Council.

- Repair any blockages, such as to the holes in the upstand and other parts of the device;
- Remove accumulated sediment when the bund is 20% full. Place the material so it cannot wash back into the bund or into surface water; and repair the bund immediately where damaged;
- The Erosion and Sediment Control Plan should identify disposal locations for the sediment removed from decanting earth bunds.

Limitations

- Decanting earth bunds capture slightly finer soil particles than super silt fences or silt fences but are not as effective as sediment retention ponds. Where defined inlets are not provided they can lead to short-circuiting, although baffles can overcome this. They are usually more effective on flatter land where runoff velocities are less. They can be outflanked unless well constructed.
- They can only be used to treat small catchment areas.
- The small drainage holes in the perforated drainage coil often become blocked with floating debris. Regular cleaning of these is usually necessary. Consider placing chicken mesh or similar around the perforated upstand to keep material away from blocking the drainage holes in the upstand.
- The upstand is often wrongly constructed higher than the emergency spillway, so review the completed structure carefully and rectify as required.

- Like silt fences, decanting earth bunds are usually used to supplement other sediment retention measures on larger sites.

Design drawings

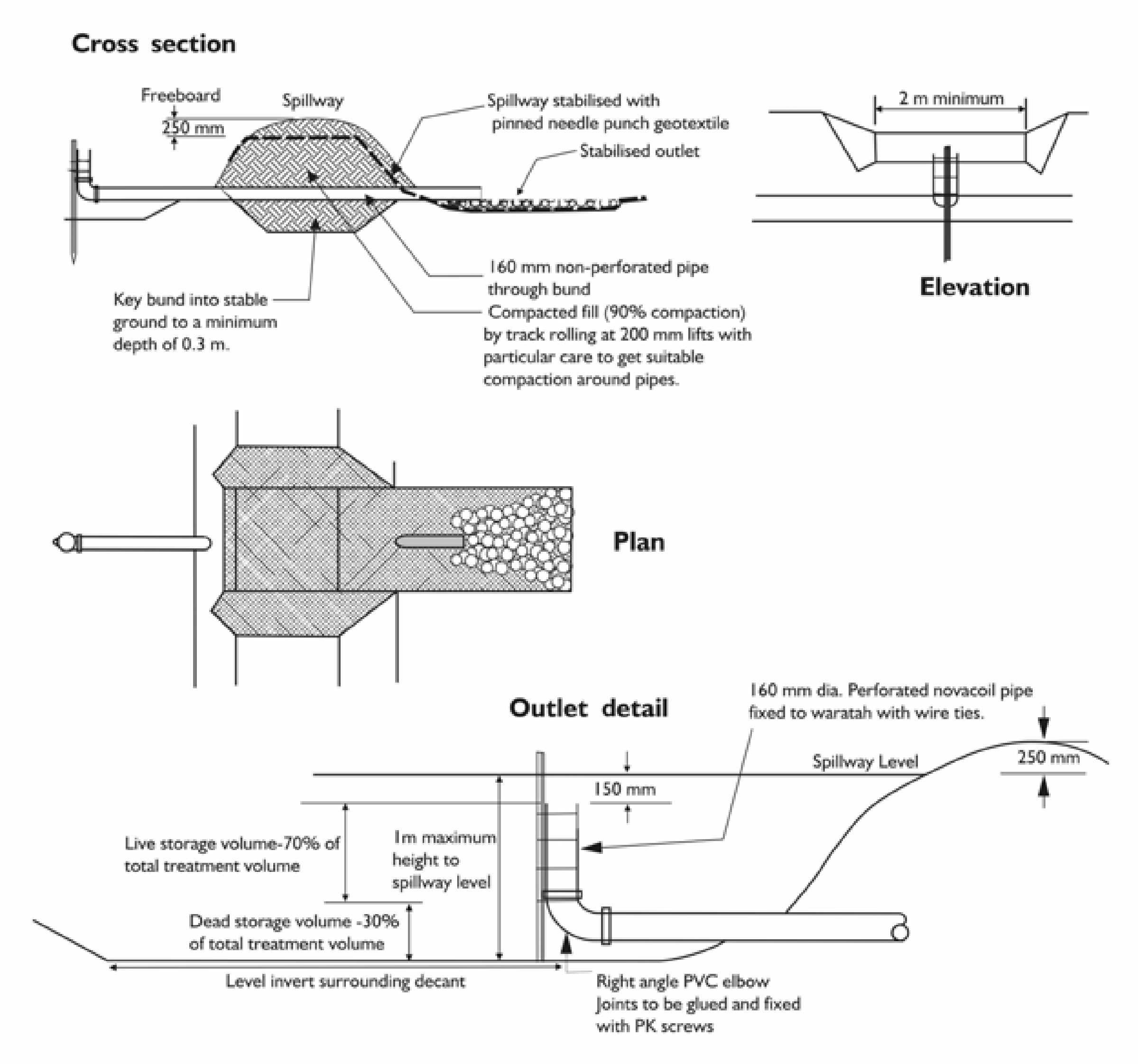


Figure 71 Decanting earth bund and snorkel upstand - image courtesy of Auckland Regional Council 1999.

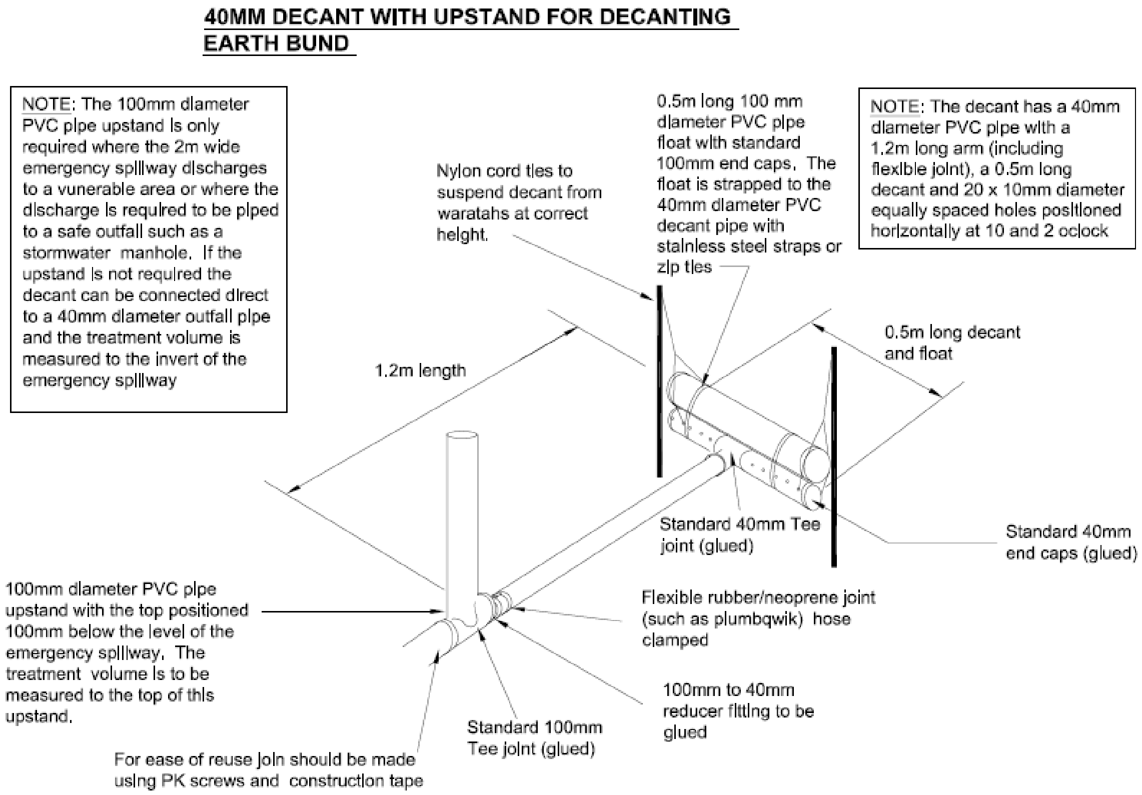


Figure 72 Detail on T-bar decant for Taupo pumice and Kaharoa ash related soils and high clay content soils - image courtesy of Auckland Regional Council 1999.

7.3 Super silt fence (SSF)

SSF

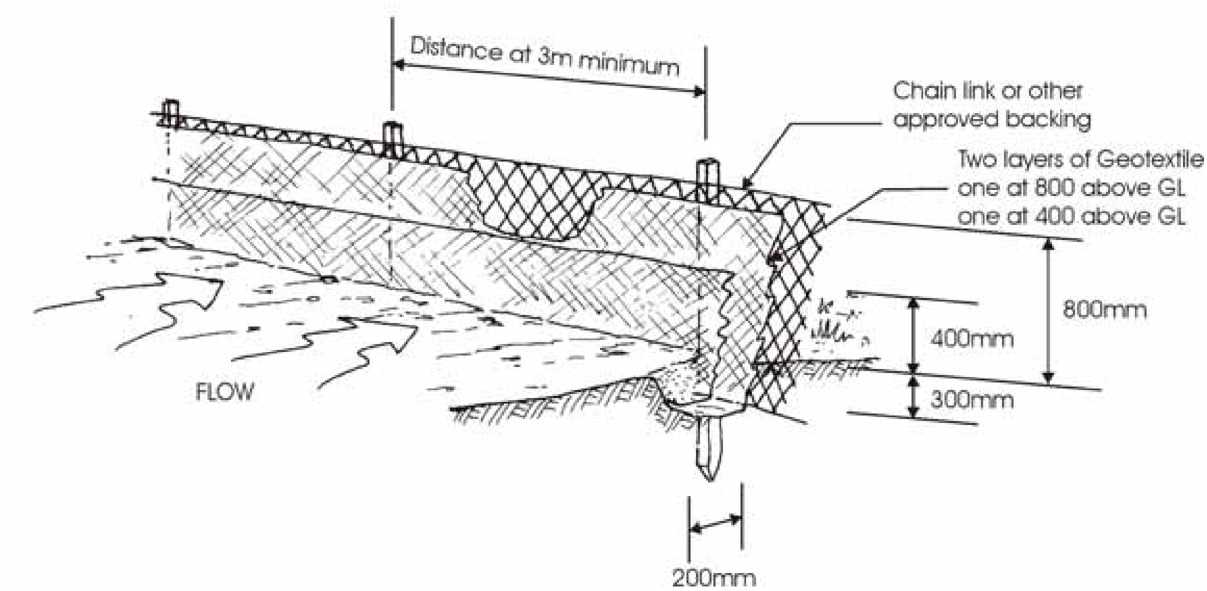


Figure 73 Super silt fence schematic.

Definition

A temporary barrier of geotextile fabric layers backed with chain link fence, or other Environment Bay of Plenty-approved product, used to intercept sediment laden flows, to reduce the velocity of the runoff, to allow the runoff to pool behind the super silt fence and to impound any sediment that settles out of the water column.

Purpose

To detain and pond sediment-laden runoff to allow for deposition of sediment to occur through settlement. The ponded water decants through the woven geotextile fabric and will leave the settled sediment captured behind the super silt fence.

A super silt fence provides a much more robust sediment control measure than a standard silt fence and allows for a larger catchment area to be treated. A super silt fence can have a secondary purpose to act as a clear delineation of a work area from an undisturbed area.

Conditions where practice applies

Key message: Never use super silt fences within concentrated flow paths. They should always be placed as close as practicable to the contour of the land.

- Provides a barrier that can prevent or minimise sediment from entering sensitive environments, critical areas and watercourses. They should not be used as retaining walls, and they require maintenance to ensure material does not build up against the fence.

Figure 74 Super silt fence used to retain material - photo courtesy of Ridley Dunphy Environmental Limited.

- Can be used where alternatives such as an earth or topsoil bund would destroy sensitive areas, such as vegetation and wetlands.
- Should be placed as close to the contour as possible. No section of the fence should exceed a grade of 5% for a distance of more than 15 metres.
- Only used in situations where the criteria in Table 13 below can be achieved and only where there is no concentration of water flowing to the silt fence.
- Only where soil conditions allow proper keying of the fence “skirt” into the ground surface or an alternative Environment Bay of Plenty-approved method is provided.
- Only where the impounded runoff cannot flow around the fence ends. To help avoid this, “returns” can be installed along the fence and also at the fence ends.

When considering super silt fence installation for catchments greater than 0.5 ha, carefully consider the specific site conditions and other alternative control measures available. The length of the fence is unlimited, however maximum slope lengths apply and need to be carefully followed. Refer to Table 13 below.

Table 12 Super silt fence design criteria.

Slope %	**Slope Length (m) (Maximum)**
0 - 10	Unlimited
10 - 20	60
20 - 33	30
> 33	20

Figure 75 *Super silt fence clearly delineating disturbed area and protected vegetation - photo courtesy of Ridley Dunphy Environmental Limited.*

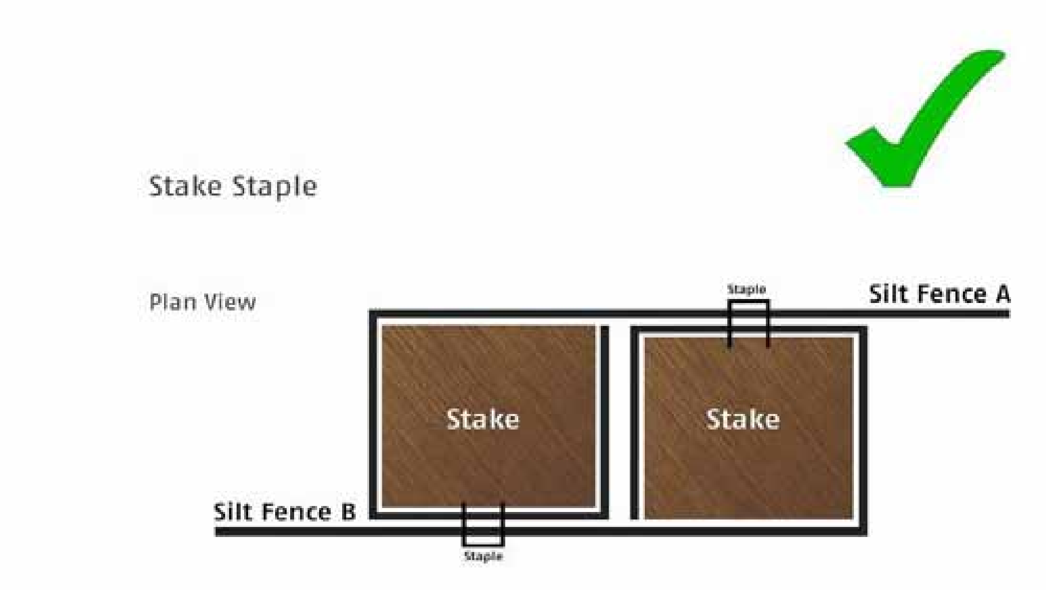
Design

There are no specific design computations needed for design of super silt fences, however the following design aspects are considered important;

- The geotextile fabric must be in two layers and meet the following requirements:

Grab Tensile Strength	> 440 N (ASTM D4632)
Apparent Opening Size	0.1 to 0.5 mm (ASTM D4751)

- Ensure total fence height is 800 mm above ground level
- Place supporting tantalised timber posts (50mm by 50mm) or steel warratah posts no more than 3m apart. Additional support is required by tensioned wire (2.5 mm) at 400mm and 800mm above the ground will support the top of the two layers of geotextile.
- Ensure supporting posts or warratahs are 800mm above the ground and are embedded a minimum of 800 mm into the ground.
- Secure the chain link fence to the posts with wire ties and fasten the two layers of geotextile to the fence with cloth fastening clips at 150 mm spacing. Compact soil back within the trench.
- The filter fabric should be set a minimum of 300mm buried into the ground, with a further 200mm of the material upslope within the excavated trench.
- Super silt fence returns can be installed a minimum of 2m in length and are constructed by continuing the fence fabric around the return and doubling back, to eliminate “gaps”, to avoid weak sections and unnecessary joins.
- Install wings at either end of the fence projecting upslope to a sufficient height to prevent outflanking.
- Join lengths of fence by doubling fabric ends around a wooden post or stake and turning, or by stapling the fabric ends to a batten and butting the two battens together as shown in Figure 78 below.



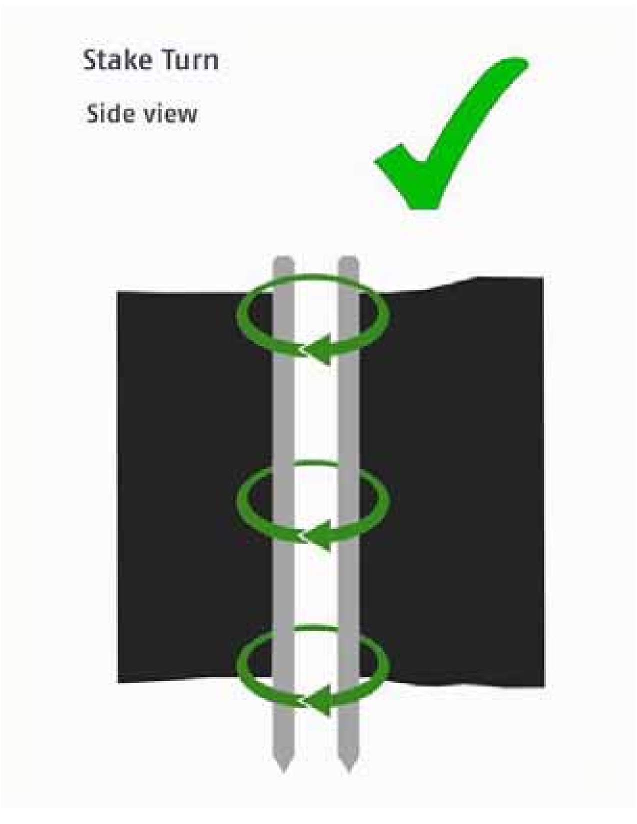


Figure 76 Super silt fence joins - courtesy of Fletcher Construction Company Limited.

Ultraviolet light can affect the life and stability of the geotextile fabric and will dictate the maximum period that a super silt fence may be used.

Figure 77 *Super silt fence example showing well constructed fence - photo courtesy of Ridley Dunphy Environmental Limited.*

<u>Construction specifications</u>

The following flow chart should be followed when manually installing Super Silt Fences.

Step One - Select correct fabric from supplier. Ensure that the fabric is in accordance with the appropriate manufacturer's specifications. If possible source fabric that is pre sewn to make installation easier and more robust.

→

Step Two - Excavate a trench a minimum of 200 mm wide and 300 mm deep along the proposed line of the fence. This is easily achieved with a small digger.

→

Step Three - Install the supporting posts in accordance with the design criteria.

↓

Step Four - Install high tensile wire at 400mm and 800mm above the ground. Tension the wire as necessary. Secure the chain link fence to the fence posts with ties or staples with the chain link to be placed from the bottom of the trench.

←

Step Five - Secure the two layers of geotextile fabric to the wire and supporting posts with clips at 150mm spacings.

←

Step Six - Back fill and compact the trench in a manner which secures the base of the fence. Compaction is critical.

Figure 78 Super silt fence no upslope water control (maintenance required) - photo courtesy of Environment Bay of Plenty.

<u>Maintenance</u>

- Inspect super silt fences at least once a week and after each rainfall. Make any necessary repairs. Fences should also be periodically checked for wind damage.
- Remove sediment when accumulation reaches 50 percent of the fabric height to reduce pressure and to allow for adequate sediment storage. Check for isolated areas of sediment build up and consequential “bulging” of the material. Sediment removed must be taken to a secure area.
- Any areas of collapse, decomposition or ineffectiveness need to be immediately replaced with appropriate super silt fence joins.
- The fence should remain in place until the catchment area has been appropriately stabilised. If installed properly at the commencement of works, they will easily last for a full season with minimal repair.
- Where water ponds behind the fence, provide extra support with tie backs from the fence to a central stable point on the upward side.

<u>Limitations</u>

- Fence efficiency is limited by the large pore size of most fabrics, which allow some water to flow through the fabric. Fine clay particles may not entirely captured behind super silt fences and in high risk situations (see Chapter 4) other measures may be necessary.
- With two layers of geotextile the pores in the geotextile fabric can become quickly blocked with sediment. This can lead to extra pressure on the fence and sometimes failure. Maintenance is critical.
- Damage can be caused by earthmoving equipment, delivery vehicles, fill and construction debris. On sites with space constraints, in some circumstances, further physical barriers such as concrete barriers or safety fences may be necessary to protect and avoid ongoing damage to the fence.

- Do not use super silt fences in channels, drains or streams as this will most likely to lead to failure, including undercutting and bypassing of the fence.

Design drawings

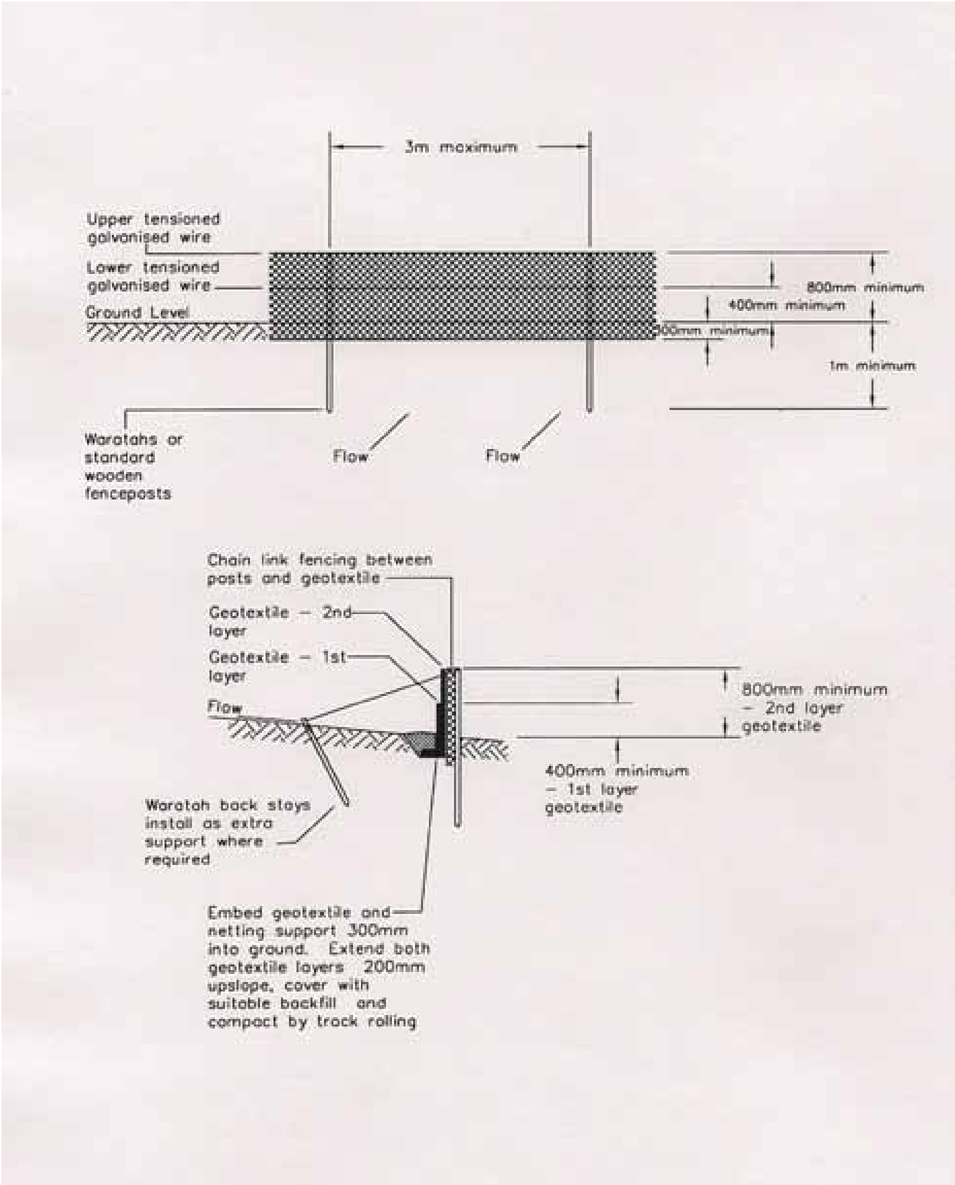


Figure 79 Super silt fence design - image courtesy of Auckland Regional Council 1999.

7.4 Silt fence (SF)

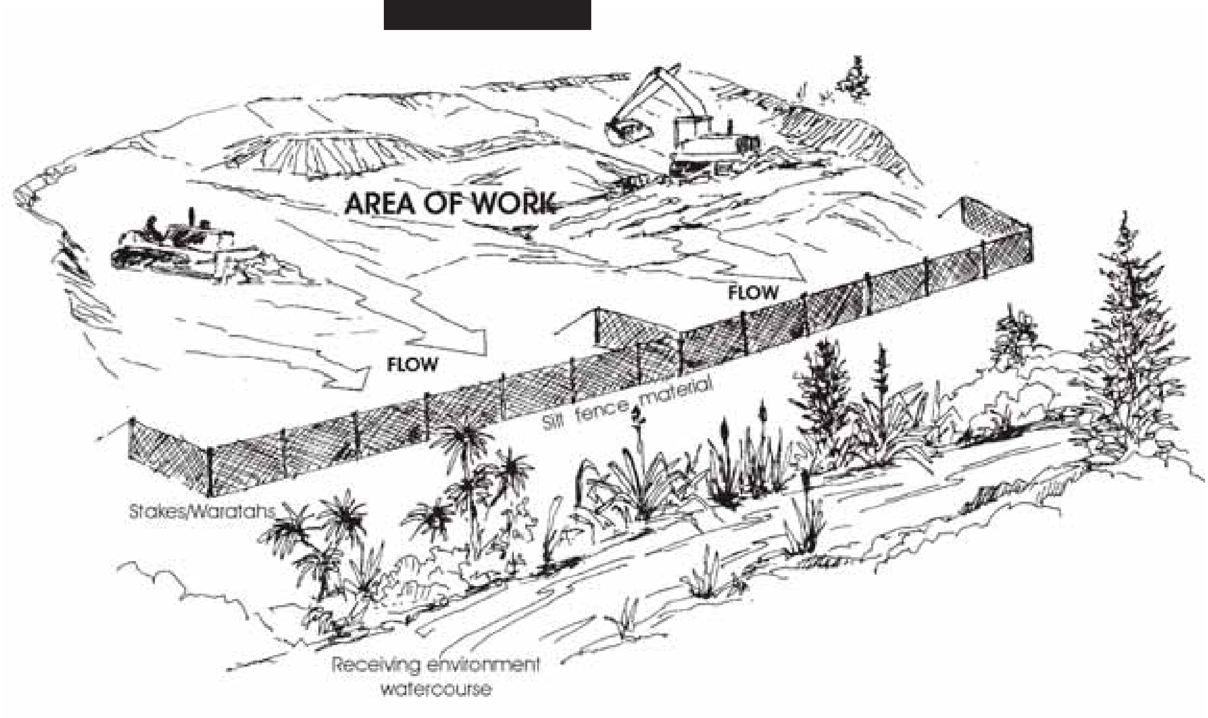


Figure 80 Silt fence schematic.

Definition

A temporary barrier of woven geotextile fabric used to intercept sediment laden runoff to reduce the velocity of the runoff, temporarily allow runoff to pool behind the fence and to impound any sediment that settles out of the water column.

Purpose

To detain and pond sediment-laden runoff to allow for deposition of sediment through settlement. The ponded water decants through the woven geotextile fabric and leave settled sediment captured behind the fence.

A silt fence can have a secondary purpose to act as a clear delineation of a work area from an area that is not to be earthworked or disturbed.

Conditions where practice applies

- Preferable on low gradient sites or confined areas where the contributing catchment is small.
- Only in situations where the criteria in Table 14 below can be achieved.
- Only where there is no concentration of water flowing to the fence.
- Only where soil conditions allow proper keying of the silt fence “skirt” into the ground surface.
- Only where the impounded runoff cannot flow around the fence ends. To help avoid this, “returns” can be installed along the fence and also at the ends.

Key message: Never use silt fences as check dams or within concentrated flow paths. They should only be used to capture sheet flow and should always be placed on the contour of the land.

Table 13 Silt fence application.

Soil Type and Slope	Maximum Slope Length to Silt Fence (Metres)	Spacing of Returns (metres)
Any soil type with a slope less than 5%	100	50
All soil types with a soil composition of **less than** 40% (by volume) of particle size less than 0.063mm (Small or fine sand). * Slope greater than 5%	75	40
All soil types with a soil composition of **greater than** 40% (by volume) of particle size less than 0.063mm (Small or fine sand). * Slope greater than 5%	50	30

* Particle size analysis can be determined by specific on site samples and site specific geotechnical reports.

Design

- The geotextile fabric must meet the following requirements

  Grab Tensile Strength > 440 N (ASTM D4632)

  Apparent Opening Size 0.1 to 0.5 mm (ASTM D4751)
- Ensure silt fence height is a minimum of 400 mm above ground level and a minimum of 200mm buried into the ground.
- Place supporting tantalised timber posts (50mm by 50mm) or steel warratah posts no more than 2m apart, unless additional support is provided by tensioned wire (2.5mm) along the top and middle of the silt fence. Where these wire supports are provided, the distance between posts can be extended up to 4m.
- Ensure supporting posts or warratahs are a minimum of 800mm in length and are embedded a minimum of 400 mm into the ground.
- Double the silt fence fabric over and fasten to the wire and posts with wire ties or cloth fastening clips at 150 mm spacing.
- Where silt fences cannot be installed along the contour, and are the most appropriate control measure, install short returns, projecting upslope from the fence to minimise concentration of flows.
- Silt fence returns are a minimum of 2m in length and are constructed by continuing the fabric around the return and doubling back, to eliminate “gaps” to avoid weak sections within the fence, and unnecessary joins.

- Install wings at either end of the fence projecting upslope to a sufficient height to prevent outflanking.
- Join lengths of fence by doubling fabric ends around a wooden post or stake and turning or by stapling the fabric ends to a batten and butting the two battens together as shown in Figure 83 below.

Figure 81 Silt fence join - photo courtesy of McConnell Consultancy Limited.

Construction Specifications

The following flow chart should be followed when manually installing Silt Fences. Silt fence ploughs can undertake steps in this process automatically.

Step One - Select correct fabric from supplier. Ensure that the fabric is in accordance with the appropriate manufacturer's specifications.

Step Two - Excavate a trench a minimum of 200 mm wide and 200 mm deep along the proposed line of the fence. This is easily achieved with a small digger.

Step Three - Install the supporting posts in accordance with the design criteria.

Step Four - Install high tensile wire at top and middle of stakes and tension the wire at 50metre intervals.

Step Five - Secure the geotextile fabric to the wire and supporting posts.

Step Six - Back fill and compact the trench in a manner which secures the base of the silt fence. Compaction is critical.

Figure 82 Silt fence example - photos courtesy of Environment Bay of Plenty

Maintenance

- Inspect fences at least once a week and after rain event. Fences should also be periodically checked for wind damage.
- Remove accumulated sediment to a secure area when it reaches 50 percent of the fabric height to reduce pressure and to allow for adequate sediment storage.
- Any areas of collapse, decomposition or ineffectiveness need to be immediately replaced with appropriate silt fence joins.
- Silt fence should remain in place until the catchment area has been appropriately stabilised.
- Where water ponds behind the fence, provide extra support with tie backs from the fence to a central stable point on the upward side.

Limitations

- Silt fence efficiency is limited by the large pore size of most fabrics, which allow some water to flow through. Fine clay particles may not entirely be captured behind fences and in high risk situations (see Chapter 4 of this Guideline) other measures may be necessary.
- The pores in the geotextile fabric can become quickly blocked with sediment. This can lead to extra pressure on the fence fabric and in some cases leads to failure. Maintenance is critical.
- Do not use silt fences in channels, drains or streams as this will most likely to lead to failure, including undercutting and bypassing of the fence.

Design drawings

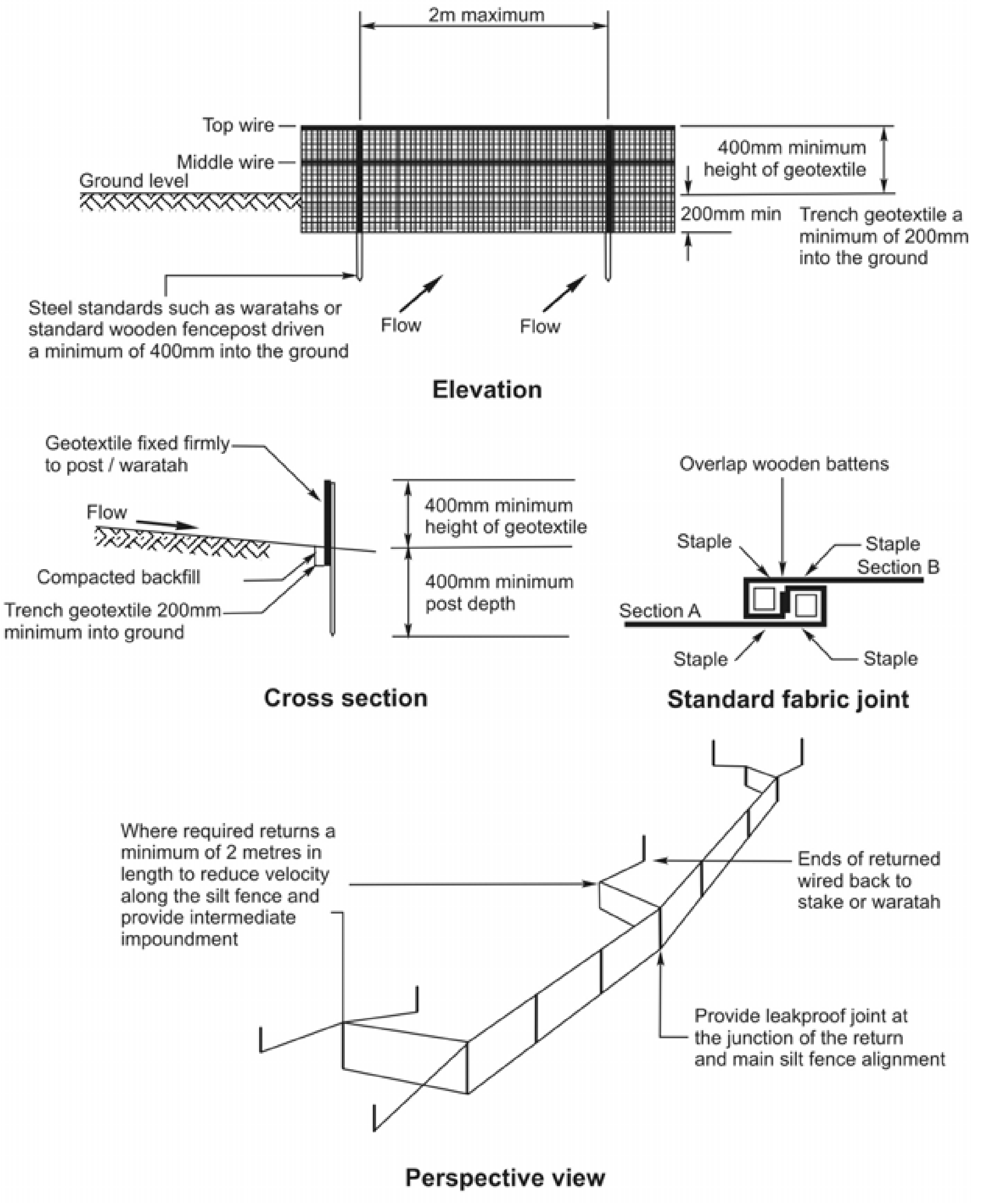
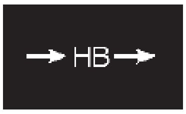


Figure 83 Silt fence design - image courtesy of Auckland Regional Council 1999.

7.5 Hay bale barrier (HBB)



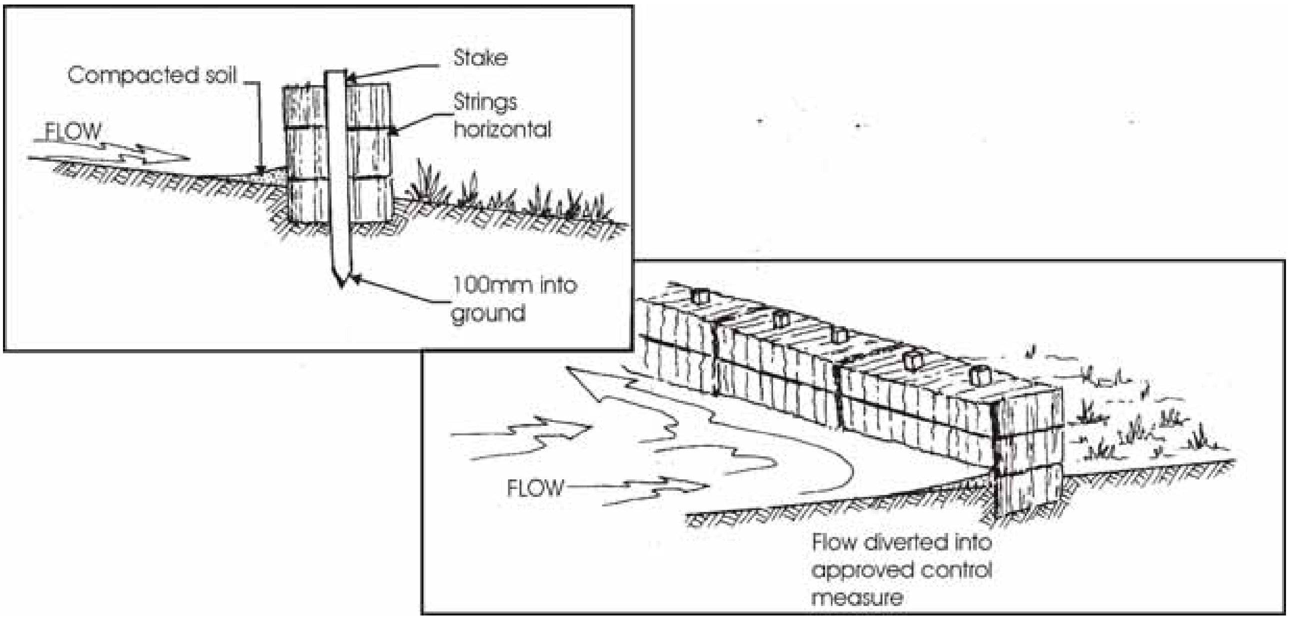


Figure 84 Hay bale schematic.

<u>Definition</u>

A temporary barrier of hay bales used to intercept sediment laden sheet flow runoff from small surface areas and to direct this surface runoff to appropriate locations.

<u>Purpose</u>

Hay bale barriers can temporarily pool sediment-laden runoff, slowing the velocity and allowing enough time for most sediments to settle out of the water.

The upstream face of a straw bale barrier may be lined with an appropriate geotextile fabric pegged to the barrier to improve rigidity of the structure, however in most circumstances using super silt fences or a silt fences as a preferred alternative.

Key message: Hay bale barriers do not filter sediment. They should only ever be used for diverting runoff. Never use them as check dams or within concentrated flow paths.

<u>Conditions where practice applies</u>

<u>The uses of hay bale barriers is very limited.</u> In particular, they are not primary sediment control measures. Specific applications include:

- For short-term needs (A maximum of one month).
- Only use barriers to intercept sheet flow, not concentrated flow. Because they do not act as filters, they can be easily overtopped or scoured out. Only use them where sheet erosion would occur.
- Do not use with a catchment area of more than 0.25 ha.

- Do not use barriers on slopes exceeding 20% as the risk of concentrated flow is too great.
- Place the barrier as close as possible to the sediment source, with the active length along the contour to allow a storage pool to form behind the structure.
- Always place with the cut edge of the bale on ground level and the bale string horizontal off the ground to allow for a reduction in short circuiting of runoff

Design

There is no specific design criteria. They should always be placed along the contour and be used only to divert flows for short duration periods to appropriate sediment retention devices as outlined in this Guideline.

Figure 85 Hay bale barrier – Good use of stakes however in concentrated flow path - photo courtesy of Auckland Regional Council.

Construction specifications

The following flow chart should be followed when installing Hay Bale Barriers.

Step One – Place hay bale barriers at the toe of a slope or on the contour (use a laser level if required) in a row with ends tightly abutting the adjacent bales.

Step Two - Excavate a trench bale width wide and a minimum of 100mm deep. This is easily achieved with a small digger or by hand.

Step Three - Install the hay bales within the trench with the strings horizontal and tightly abut the bales, together. Do not place the Hay Bales more than one bale high.

Step Four – Secure the bales in place with two warratah posts. The first warratah should be driven toward the previously laid bale at an angle to force the bales together.

Step Five - Ensure that all waratahs are flush with the top of the bales.

Step Six – Maintain as necessary and only use for periods of less than one month.

Figure 86 Hay bale barrier – on contour however placed wrong way with no stakes - photos courtesy of Environment Canterbury.

Maintenance

- Inspect hay bale barriers frequently, and after rain event. Undertake maintenance as necessary. Check to ensure that the catchment area draining into the barrier is less than 0.25 hectares at all times.

- Remove all bales when the site has been fully stabilised or when an alternative measure has been installed. Stabilise the trench where the Hay Bales were located and grade so the ground level is flush.

Key items to check as part of the regular inspection:

- Loose stakes and/or loose, damaged or degraded bales;
- Damage caused by earthmoving equipment, machinery, string degradation and potential vandalism;
- Undercutting caused by water flowing under the structure or leaking between bales or scour caused by overtopping or outflanking.
- If sediment deposits behind the hay bale barrier remove deposited sediment when the depth exceeds 30 percent of the height and dispose of removed sediment to an area where it cannot be washed into or onto receiving environments.

Limitations

- Hay bale barriers are used far more often than they should be used and in all circumstances alternatives should be considered in the first instance.

Key message: Hay bale barriers deteriorate quickly and are easily damaged. They should only be considered as part of a wider comprehensive approach to managing erosion and sediment on a development site.

- Hay bale barriers can introduce weed species, and depending on the location, care needs to be taken to ensure this is not an issue.

Design drawings

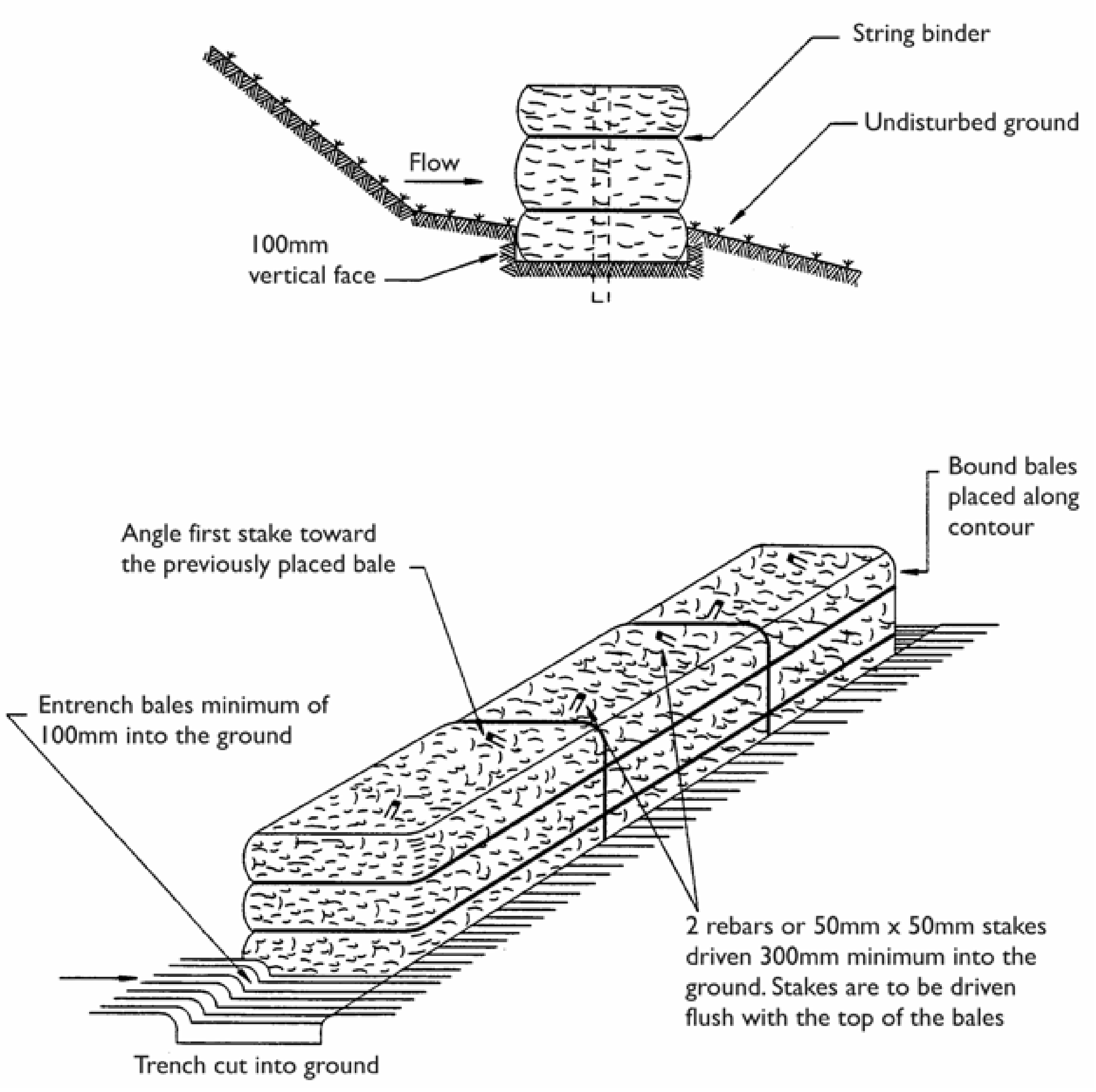


Figure 87 Hay bale barrier - image courtesy of Auckland Regional Council 1999.

7.6 Storm water inlet protection

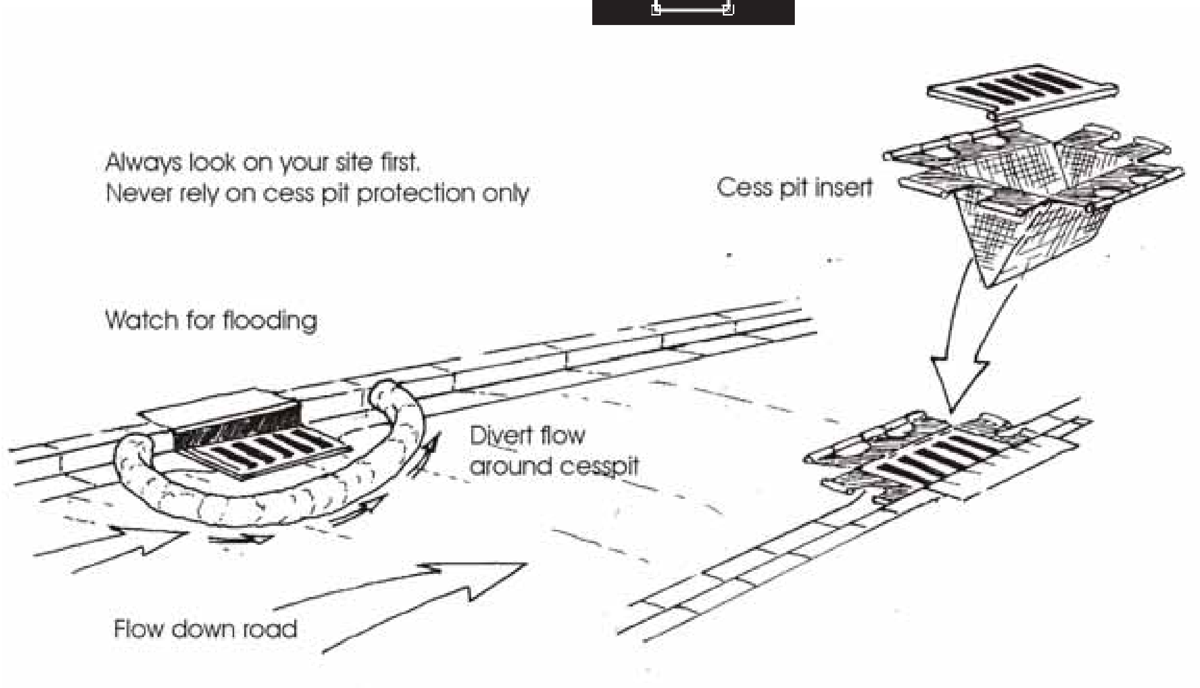


Figure 88 Storm water inlet schematic.

Definition

A barrier across, within or around a storm water inlet used to intercept sediment-laden runoff before it enters a reticulated storm water system. Storm water inlet protection may take various forms, depending on the type of storm water inlet to be protected.

Storm water inlet protection is by nature installed in areas of concentrated flow, such as the roadside kerb and channel and will usually have to contend with significant flow velocities. Sediment retention efficiency is typically low and storm water inlet protection should always be a secondary or supplementary sediment control measure, and should never be used as a stand-alone technique.

Purpose

To intercept and filter as much as possible sediment-laden runoff before it enters a reticulated storm water system. Storm water inlet protection also prevents sediment and other material from the road surface from entering the storm water inlet during dry weather.

Storm water inlet protection must be used in conjunction with a full range of other erosion and sediment control management practices that have been implemented in an integrated approach on the subject site.

The design does not typically take into account runoff volume or turbidity capture and installation is a decision for the site manager on a day-to-day basis.

Conditions where practice applies

Key message: If appropriate and well maintained erosion and sediment control measures are in place, storm water inlet protection requirements are greatly reduced and may not be required at all.

- Do not use storm water inlet protection as a primary method of treatment.
- Always consider temporarily diverting the storm water reticulation outfall into a sediment retention facility.

Storm water inlet protection only offers limited treatment of sediment-laden water because of the nature of the concentrated flows entering these areas. Storm water systems are, by design, very efficient at conducting flows towards storm water inlets, and once any sediment enters into the storm water system, it will be discharged to the receiving environment.

Storm water inlets must be able to convey flow from the site to prevent large concentrated highly erosive flows from building up and causing washouts in secondary overland paths. Take care that a full blockage of the storm water inlet does not occur so storm flows can escape. If full blockage occurs then you need to consider the downstream catchment (typically a road surface) to ensure that increased flows will not create flooding or scouring issues.

- Use storm water inlet protection as an integral component of a much broader and more comprehensive erosion and sediment control system.
- Never completely block the storm water inlet and if you do always include a stable bypass arrangement.

Figure 89 Storm water inlet protection (filter media with silt fence protection from grass/disturbed surface) - photo courtesy of Ridley Dunphy Environmental Limited.

Design

There are three key design options.

Silt Fence Design

A silt fence can be erected around the storm water inlet. This method is appropriate where inlets have been connected to a storm water system and are collecting runoff from disturbed soil surfaces.

Filter Media Design

Geotextile and scoria or gravel can be used to treat sediment-laden flows. All points where runoff can enter the storm water inlet must be protected with suitable geotextile fabric. Note that this type of protection can lead to a direct blockage of the cess pit.

- Wrap geotextile fabric around the cesspit grate as a barrier to flow directly from the roadside gutter. Care must be taken to secure the fabric to the grate or independent device such as a frame to ensure that the material does not come loose. Pay special attention to the inlet above the grate back of the storm water inlet where a geotextile fabric sock filled with gravel must be placed to intercept runoff;
- Lay coarse geotextile fabric over the cesspit and up onto the kerb with a layer of aggregate material to act as a primary filter and hold the fabric in place.

Filter Bags

Many proprietary products can be used as cess pit inserts, providing partial treatment for flows entering the storm water inlet. These products should be used where road or parking surfaces are established and some form of storm water inlet protection is required. They typically allow for high flow bypass and can also be relatively easily lifted from the storm water inlet and cleaned as required before reinstalling. Refer to Section 8: of this Guideline to understand Environment Bay of Plenty's approach to new and innovative practices.

- Do not completely block the storm water inlet, and ensure an appropriate stable bypass arrangement is provided.
- Storm water inlet protection must not divert water over cut or fill slopes.
- A "silt fence design" must be kept to less than 300 millimetres in height so that runoff does not cause local flooding and/or is not directed into adjacent catchments.

Hay bales are not considered appropriate as storm water inlet protection.

Construction Specifications

Construction methods and detail will vary according to the type of storm water inlet protection.

- Always ensure an emergency spillway or bypass facility is included on all cess pits.
- Ensure the location and/or operation of the device will not be unsafe.
- Keep all stockpiles or loose sediments away from roadside water tables.

Key message: Where a proprietary product is to be used ensure this has been endorsed by Environment Bay of Plenty as appropriate for the activity and area where it is proposed to be used.

Maintenance

Maintenance requirements for storm water inlet protection measures are high because they block easily. Prior to blockage occurring they should have the accumulated sediment removed, the device cleaned and any geotextile fabric, filter bag or aggregate replaced as necessary.

Inspect all storm water inlet protection measures following any rainfall event and maintain to ensure they operate effectively.

- Inspect daily and during and after every rainfall event. Check for leaks which may affect performance;
- Check to see that the device has not directed water away to cause localised flooding;
- Repair and/or modify the device as necessary.

Limitations

Storm water inlet protection provides at best limited sediment retention. Do not use it as a primary method of sediment control. At all time inlets must remain able to convey flow from the site to prevent large, concentrated highly erosive flows from building up and causing washouts in secondary overland paths.

Storm water Inlet Protection

- Should never be used as a stand-alone technique. It has very limited sediment storage capacity and as a result extremely high maintenance requirements;
- May partially block the storm water system, increasing the likelihood of localised flooding;
- May cause storm water and sediments to pond on footpaths, carriageways or newly constructed pavements;
- Is easily damaged by vehicles and/or construction equipment.

Key message: Even if you have storm water inlet protection in place, a lot of sediment entering a storm water inlet downstream from your site, suggests there is a problem on the site itself. Erosion and sediment control measures will need reassessment.

Figure 90 Storm water inlet fully blocked leading to downstream flooding - Photo courtesy of Ridley Dunphy Environmental Limited.

Design drawings

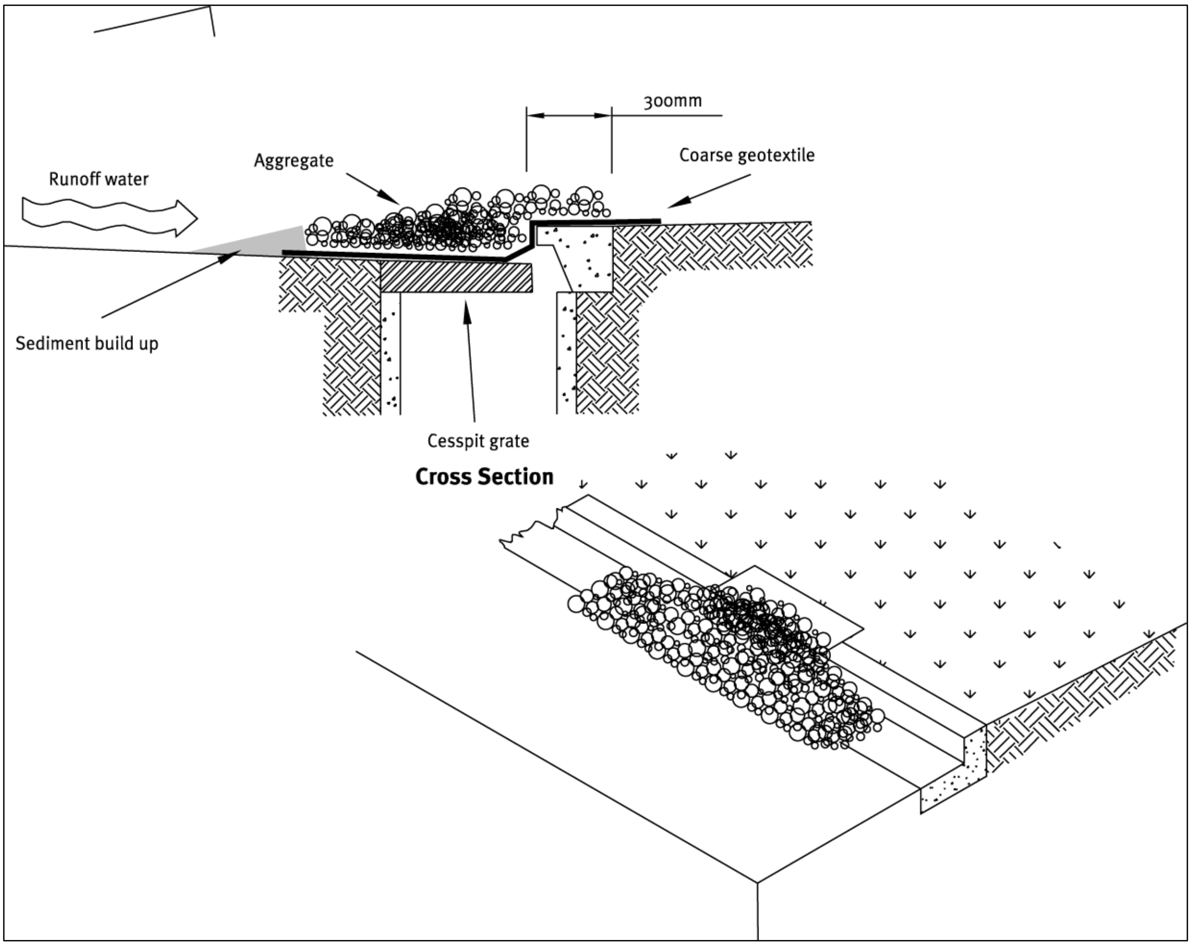


Figure 91 Storm water inlet protection (filter media design) - image courtesy of Auckland Regional Council 1999.

7.7 Chemical treatment

Figure 92 Operation chemical treatment system – image courtesy of Auckland Regional Council.

Definition

The use of chemicals to help treat sediment-contaminated storm water generated from earthworks sites. The chemical used will be dependent on site characteristics, including soils, with the chemical being used to enhance settlement of sediment from the water column.

Coagulation

Colloidal particles are particles that fall into a general category of very fine material that has electrostatic surface charges. In general, most colloidal material has a negative charge. Particles with like charges tend to repel each other, preventing coagulated particles forming. These characteristics cause colloidal particles to remain in suspension. Destabilising colloidal material to allow coagulation and settlement is achieved by adding reagents that develop positive charges. Positively charged ions in the solution act to destabilise the colloidal matter and allow settlement of coagulated material.

Flocculation

Flocculation occurs after the addition of a chemical to destabilise charges on colloidal particles in suspension. The particles adhere to each other via flocculations on the surface of the particles. These charged ions provide an opportunity for charged particles in a system to adhere together, merging individual particles and resulting in larger, denser particles which settle more rapidly.

Purpose

To provide an additional method of treatment to sediment contaminated storm water, over and above typical mechanical methods, provided correct application is achieved.

Key message: Ensure that correct application of chemical is undertaken to avoid overdoses. Overdosing is most likely to result in significant negative changes to receiving environments.

Condition where practice applies

Treatment chemicals should be used in conjunction with other sediment controls, most notably sediment retention ponds. Sediment retention ponds are considered one of the easiest and most reliable locations to use chemical treatment, as the ponds provide still conditions which promote settlement.

Key message: Discharging chemicals to water requires resource consent, which needs to be considered as part of planning for your project.

Aluminium Coagulants

Aluminium coagulants are commonly used for potable water treatment and removing sediment from storm water. Overseas the direct dosing of eutrophic lakes with Aluminium based coagulants has achieved major reductions in suspended solids, phosphorus, nitrogen, biochemical oxygen demanding substances, chlorophyll ‘a’ and turbidity for long periods.

Previous studies have shown that both Aluminium and Polyaluminium Chloride (PAC) achieved encouraging results in settling suspended solids in sediment-laden runoff, with recent bench testing undertaken in the Bay of Plenty region further confirming this outcome. Results from this testing are included in Appendix 3.

Aluminium coagulants contain high concentrations of the toxic ionic form of aluminium. The USEPA freshwater ambient water quality criteria for dissolved aluminium at a pH between 6.5 and 9.0 are as follows:

- Chronic: 0.087mg/L (4 day average not to be exceeded)
- Acute: 0.750mg/L (1 hour average not to be exceeded)

It is generally accepted that dissolved aluminium at a concentration between 0.050 and 0.100mg/L and a pH between 6.5 –and 8.0 presents little threat of toxicity. However, at lower pH, toxicity increases with the effect major concern being the coagulation of mucus on the gills of fish species.

After the addition of aluminium coagulants to water containing dissolved and/or suspended matter, dissolved aluminium ions are rapidly incorporated into microscopic aluminium hydroxide and aluminium phosphate precipitates. As they form these precipitates, they combine with phosphorus, suspended solids, metals and other dissolved and suspended matter. The insoluble precipitates formed are considered stable. The toxic aluminium derived from the coagulant dose is very rapidly reduced by precipitation and coagulation reactions. Even if coagulant is added at a higher dose rate than required for effective removal of solids and nutrients, the dissolved aluminium is still reduced very rapidly to a low concentration with no serious toxicity.

- The primary method used to add PAC is an automatic rainfall-driven system used to treat sediment-laden runoff which drains to sediment retention ponds and decanting earth bunds.
- It is acknowledged that the application of PAC can affect the pH levels of marine and freshwater receiving environments. Native freshwater fish species are sensitive to pH changes therefore it is recommended that discharges from sediment control devices should not reduce the downstream pH to less than 5.5. This will also ensure that the aluminium in the PAC does not become toxic to fish species.

To ensure that the risk of overdosing, Environment Bay of Plenty requires all chemical treatment to be undertaken in accordance with Chemical Treatment Plans. Employ appropriate specialist expertise to prepare your plan. Environment Bay of Plenty can advise where to find this expertise.

As different conditions are encountered and earthworks progress on site changes may be required to the chemical treatment plan. Any changes of this nature should be discussed with Environment Bay of Plenty directly prior to implementation.

Soil Settlement Bench Testing

Settlement analysis has been undertaken with representative soils to assist in the correct application of treatment chemicals. This does not preclude the requirement for site-specific analyses to ensure correct chemical and application.

Four soil types are generally thought to represent the Bay of Plenty region in areas where earthworks are undertaken -Taupo pumice, Kaharoa ash, Tarawera ash and Rotomahana mud.

Results of both unassisted and chemically-assisted settlement are detailed below.

- Taupo pumice sample had the highest risk in terms of settled water turbidity versus time, and appeared to contain very fine clay or colloidal component. This gave the settled water a pale pink or white colouration even after an extended period of settling.
- Kaharoa ash sample settled well over a relatively short time frame but could potentially remain in suspension or be drawn into suspension if, for example, sediment retention pond design does not allow for adequate settling area.
- Tarawera ash and Rotomahana mud samples settled very well and would be relatively easily retained in a suitable size sediment retention pond.
- With a potential risk of overdosing with chemical (PAC), the Taupo pumice sample settled water turbidity results deteriorated as the chemical doses increased.
- If earthworks are to be undertaken on site(s) that predominantly include Taupo pumice and Kaharoa ash then chemical assistance (using PAC) is an option to be utilised for parties to utilise. This should not be considered as a primary option however or a reduction in reliance on other mechanical treatment methods.
- Overall PAC was the most cost-effective and environmentally acceptable option of the products tested.
- For other soil types (or a mix of soil types) specific soil sampling and chemical settling assistance analysis should be undertaken to determine the need for and type of chemicals appropriate for the site.
- If soil types are predominantly Tarawera ash or Rotomahana mud, chemical assistance may not be required.

Design

Automatic Rainfall-Driven System and Batch Dosing

The typical chemical treatment system is a standard rainfall-driven PAC dosing system developed specifically for earthworks sites. The system uses a rainfall catchment tray with the size of the tray determined by the required PAC dose and land catchment size. Typically the rainfall-driven dosing system will be connected to treat water contained within a sediment retention pond.

- Rainwater caught by the catchment tray is piped into a header tank, and then into a 400 L displacement tank which floats in a larger tank containing PAC. This larger tank is filled to the level of an outlet pipe leading to the sediment retention pond inlet diversion channel located approximately 5 metres upstream of the sediment retention pond.
- The greater the rate of rainwater flow into the displacement tank, the greater the flow of PAC into the storm water channel.
- The header tank is designed to provide for no dosing during initial rainfall under dry conditions, and for attenuation of the PAC flow during the initial stages of a storm and after rain has ceased.

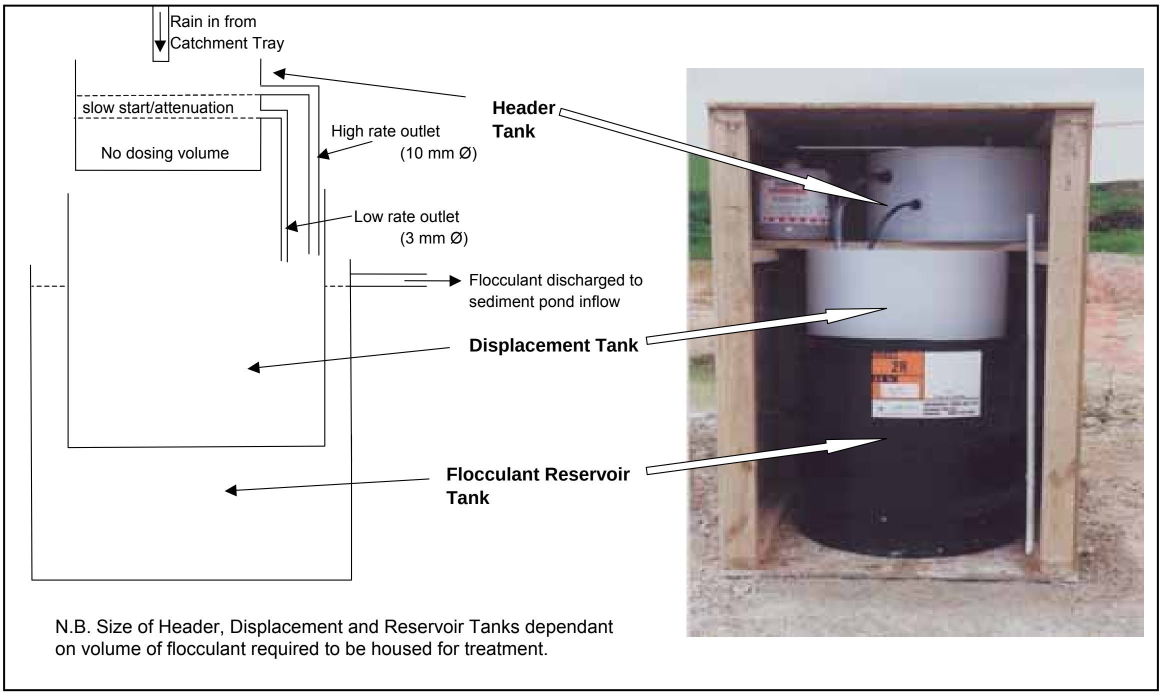


Figure 93 Basic design of the rainfall activated system.

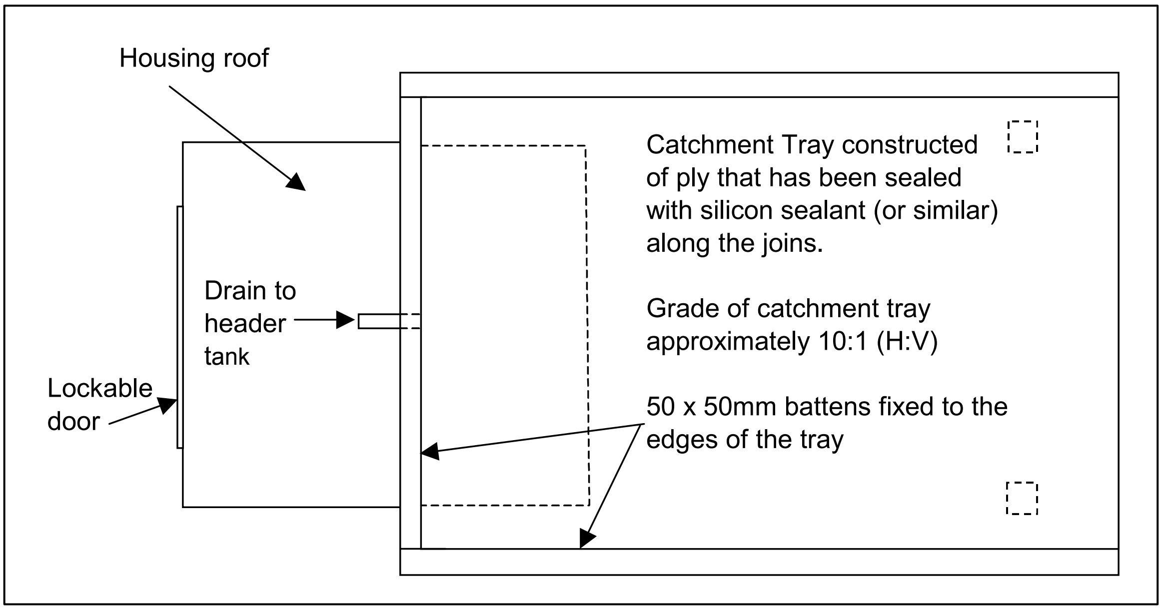


Figure 94 Basic design of an automatic rainfall driven dosing system.

Determining Dosage Rates

The PAC dose required to achieve satisfactory removal of suspended solids from sediment laden runoff depends on physical and chemical characteristics of the soil. On site soil samples will need to be taken and bench tests performed to determine optimum dosage rates.

Batch Dosing

Manual batch dosing can occur using a knapsack pressurized spray unit and applied until the following morning after a significant rain event. Where batch dosing occurs there needs to be the ability to block all flows from the sediment retention structure. This is typically achieved through raising the decant arms through a series of pulleys, or using an expandable plug in the outlet discharge pipe. Once water clarity is achieved the decant arms can be lowered, or the plug removed, to allow normal operation of the detention structure.

Design Criteria

- The area of the rainwater catchment tray and the levels of the high and low flow pipes are critical and will be determined through the Chemical Treatment Plan.
- All water flowing into the pond needs to be treated, and the rainwater catchment tray size is determined by the total land catchment area draining to the pond. If the catchment area draining to the pond is changed, the catchment tray size should also be changed proportionally.

Key message: Chemical treatment can significantly increase efficiency of sediment detention facilities. Chemical treatment should not be relied on solely and used only in addition to other erosion and sediment controls.

Storm water Channel and Dosing Point

- PAC needs to be added to the sediment-laden diversion channel to mix with the storm water runoff before it reaches the ponded water in the forebay or the pond itself. The chemical treatment facility should be established so all runoff from the catchment flows into a single channel before it reaches the ponded water. This method allows for the PAC to be mixed with the total storm water flow(s).

- The dosing point should be at a location where the chemical will fall into the overland runoff flow during periods of low flow. The end of the dosing tube should be only a few centimetres above the sediment laden diversion channel to ensure that the chemical falls into the overland runoff, and is not blown away during periods of strong wind.

Monitoring and Maintenance Requirements

If the treated water in the pond is consistently very clear it could indicate overdosing and the possibility of lowered pH which can present a risk to receiving waters because of elevated free aluminium concentration in the discharge.

- As part of the use of chemicals for treatment on sites, testing will be required for the water quality characteristics of both the treated water and the receiving environment. Depending on site characteristics, the parameters to be tested for include, but are not limited to:
  1 clarity;
  2 pH
  3 The concentrations of the chemical being applied.
- Consult with Environment Bay of Plenty about contingencies such as poor treatment performance or consistently very clear treated water (potential overdosing).
- Maintenance of the chemical treatment system should be recorded, with a copy kept on site. This will include details of the drainage or otherwise of the header tank and testing records under the site's Chemical Treatment Plan.
- The integrity of the treatment system should be checked weekly during both dry and wet weather. This check should include a quick check of the plumbing, that header tank hoses are clear and the dosing point to ensure that the chemical will drop into the storm water flow.
- Bulk PAC which is supplied by the manufacturer in 200L polyethylene drums should be kept in secure storage, in a locked shed or container, or the chemical treatment system shed. Wash empty PAC drums out with water, and pour the wash water onto dry soil well away from any watercourse. Drums can be disposed of to a drum recycling company.
- If there is a PAC spill onto the ground it should be immediately contained using earth bunds to prevent it entering water. The spilt PAC should be recovered if possible and placed in polyethylene containers.
- Routine monitoring and maintenance of the system and appropriate record keeping needs to be done by a trained site supervisor. Only trained staff and/or consultants with appropriate expertise should undertake planning and implementation of the flocculation management system.

An example of a Flocculation Management Plan is provided in Appendix 6 of this Guideline.

Section 8: Innovative practices

Chapter objective

1. To provide an overview of the process for Environment Bay of Plenty endorsement of innovative practices for erosion and sediment control.

8.1 Innovative practices

In the context of land disturbing activities Environment Bay of Plenty's goal is to minimise sediment discharges to receiving environments using erosion and sediment controls as outlined within this Guideline. These practices provide a comprehensive selection of available and known techniques with demonstrated effectiveness established over a long period of time.

Environment Bay of Plenty acknowledges that new products have been, and continue to be, developed which may provide an acceptable alternative while also providing expected environmental performance. Alternative technologies will continue to be proposed. These products and alternative practices are referred to within this Guideline as Innovative Practices.

Environment Bay of Plenty encourages the development of innovative, cost-effective erosion and sediment controls and management technologies. Subject to Environment Bay of Plenty endorsement, these new controls, practices and technologies will be able to be used on site.

Endorsement by Environment Bay of Plenty will depend on a number of factors including largely objective, verifiable data that supports the efficiency and effectiveness of the measure.

To ensure consistency, Environment Bay of Plenty requires the following basic information to be submitted with any request for approval for any given measure. This can be provided as part of a consent application process or from a specific product supplier seeking endorsement for their product. This process is designed to ensure a consistent, verifiable approach and provides surety for product manufacturer, consent applicant and the public.

Comparing the performance of different products and techniques can be difficult as test procedures and protocols are not always consistent. For a given measure the test procedures and results will be considered on a case by case basis.

The following product information for product endorsement should be provided:

- A representative product sample (if practicable).
- Product specifications, literature, installation references, field performance data and lab test data (how does the device work under a particular storm? Has the device been compared to other existing devices? What soil type was the product tested with?)
- Proposed monitoring data (this may be necessary if field data is limited) to include:
  - (i) Soil conditions
  - (ii) Slope
  - (iii) Storm event analysis

(iv) Field data (not lab)

(v) Composite samples (inlet and outlet)

(vi) Expected sediment removal efficiencies

(vii) Protocols/standards

(viii) Laboratory analysis

- Names of any other companies/agencies testing the product, and notifications of completed tests and/or product approval.
- Documentation and/or discussion of potential causes of poor performance or failure of the practice.
- Key design, installation and maintenance specifications or considerations.
- Health and safety considerations.
- Estimated cost.

Environment Bay of Plenty will assess the details seek further information as required and determine the practice's appropriateness. If fully approved a letter of endorsement will be sent to the supplier for future reference. Environment Bay of Plenty will retain a database of endorsements for people undertaking land disturbing activities in the future.

Key message: Innovative practices are encouraged, however Environment Bay of Plenty requires confirmation and certainty that new measures and practices are appropriate. Always seek Environment Bay of Plenty's endorsement prior to implementing innovative practices.

Section 9: Quarries

Chapter objectives

1. **To provide an overview of practices that can be used within quarry operations.**
2. **To provide links back to specific erosion and sediment control measures as outlined within sections 6, 7, and Chapter 5 of this Guideline.**

9.1 Quarries

Figure 95 Overview of a quarry operation– image courtesy of Ridley Dunphy Environmental Limited.

9.1.1 Overview

Quarries are potentially a major source of sediment, with activities such as overburden removal identified as the key high risk component of the operation. Quarries are often long-term operations which usually means that site conditions continually change. Careful planning is required to ensure that operations are carried out with minimal environmental impact.

This section of the Guidelines is designed to help quarry operators understand and assess options for erosion and sediment control. It should be read and implemented with sections 6 and 7, and chapter 5 of these Guidelines, which detail specific erosion and sediment control practices.

Quarries are typically required to produce management plans covering various operational aspects. These Guidelines will help in the production of such plans.

Specific issues include:

- Road establishment and access
- Storm water management
- Overburden disposal
- Stockpile areas
- Rehabilitation of worked out areas
- Riparian protection areas
- Maintenance schedule for erosion and sediment control treatment structures

9.1.2 Road access

Many quarries are serviced by metal roads used in all weather. Both establishing these roads and ongoing vehicle movements during rain can generate a lot of sediment. These roads are not always within the designated quarry area and are not covered by the Quarry Management Plan. However it is important that erosion and sediment control measures are used for both road establishment and ongoing road use.

Road catchments can typically be reticulated (through water table drainage or overland flow) back to the main sediment retention pond on the quarry site. This needs to be fully considered from both a catchment size and also a soil or rock type perspective. Where possible, incorporate road access into the Quarry Management Plan, ensuring all measures are put in place to protect receiving environments.

Figure 96 Quarry road access and water table drain leading to control measure – image courtesy of Ridley Dunphy Environmental Limited.

Storm water Management

In all circumstances prior to before implementing erosion and sediment control on your quarry site refer to the key principles outlined in section 2.3 of these Guidelines.

As far as possible, divert clean water away from working and bare areas to prevent them from becoming contaminated by sediment. This helps reduce the volume of contaminated runoff needing to be controlled and treated and results in smaller sized sediment retention ponds with less maintenance. Cleanwater runoff diversion channels around the working site, as outlined in Section 6.3 are the simplest way to deal with clean runoff.

Any runoff from bare areas, including from rock processing, will collect sediment and become contaminated. This contaminated runoff, which includes runoff from aggregate wash processes, must be managed and treated appropriately before being discharged to the receiving environment. The Quarry Management Plan must detail the methods for sediment control, referring to section 6.3 of this Guideline. Particular attention should be given to sensitive areas such as permanent watercourses, watercourse crossings and steep areas. Because of the long-term nature of quarry operations, always design your erosion and sediment control measures for the 5% AEP rainfall event.

Chemical treatment to assist with sediment settling (section 7.7 of these Guidelines) will generally be required due to the small particle size typically encountered in quarries. Due to the long-term nature of quarries and fine particles generated, chemical treatment is likely to the most successfully method of storm water treatment. This can include an automated system with specific design for the catchment size and storm water flows. Other options such as automatic water clarification systems may also be considered based on soil sampling analysis. It is important that chemical treatment soil analysis be undertaken for all quarries prior to implementation.

Sediment retention ponds will likely be employed on most quarry sites and in view of their long-term nature, specific design will be required which takes into account whether there is any colloidal material within the storm water runoff. It is also critical that greater emphasis be placed on structural elements of the pond(s), in particular compaction and structural integrity of pond walls and spillway. It is recommended that these sediment retention pond features be fully assessed through geotechnical investigation to ensure the long-term structural integrity of the pond will remain throughout the life of the quarry.

If sediment retention ponds are used ensure the following is considered:

- Year around operation;
- Nature of quarry material;
- How storm water runoff will be managed within the quarry;
- Whether discharge is to ground/or surface water
- Size of operation, and;
- Contributing catchment

9.1.3 **Overburden disposal**

Methods of overburden disposal vary for each quarry operation. Overburden removal and disposal sites can be a major source of erosion and sediment discharges from quarries, particularly if the disposal site is not properly located and managed. The Quarry Management Plan is the key document for the site and should give a reasonable indication of:

- Selection of disposal site;
- Stability of the site and subsequent overburden fill (batter slopes, safety factors, benching, underlying material, and drainage). If fill material is to be imported onto the quarry site as part of a rehabilitation programme it is important that the source of this fill is understood, material is classified as clean fill and transportation and haul road options are fully considered
- The timing and extent of overburden stripping, which will be related to an expected volume and area of extraction.
- The methods for disposing the overburden.
- Erosion and sediment control measures.
- Ongoing management of disposal sites, including provision for regular maintenance of erosion and sediment control measures.
- Rehabilitation of disposal site (re-vegetation, contouring).

Figure 97 Quarry overburden removal – image courtesy of Google images.

9.1.4 Stockpile areas

Stockpile areas include those used for stockpiling both raw and finished quarry products prior to further processing or final despatch. These areas can be a major source of sediment-laden runoff if not properly controlled. Position stockpiles well away from any watercourses and clean water runoff flow paths. It is often feasible to incorporate the stockpile areas into the wider erosion and sediment control systems and provide a comprehensive treatment system such as a sediment retention pond.

9.1.5 Rehabilitation of worked out areas

Planning for rehabilitation must be an integral part of all quarry operations. A properly planned and implemented rehabilitation programme, as outlined within your Quarry Management Plan, will reduce the need for expensive ongoing erosion and sediment control. Reference should be made to the revegetation techniques outlined in chapter 5 of this Guideline. The aim of site rehabilitation, whether temporary or permanent, is to maintain the specific part of the site so that erosion is minimised to an acceptable level and clean water diverted away from the sediment control measures. Key considerations are:

- Establishing suitable final ground contours.
- Establishing a suitable ground conditions and environment for vegetation growth.
- Re-vegetating the site with suitable vegetation cover.

9.1.6 Riparian protection areas

Riparian protection areas refer to those areas immediately adjacent to permanent watercourses or wetlands and should always be identified within the Quarry Management Plan. These areas rely on an undisturbed and vegetated area to provide a buffer between the quarry operations and a watercourse or wetland. These margins act as a physical barrier to keep machines away from sensitive areas as well as being a last-resort sediment treatment area for diffuse runoff. The width of the riparian protection area should be discussed within the Quarry Management Plan and should be agreed with Environment Bay of Plenty. Never rely on riparian protection as a primary sediment control mechanism.

9.1.7 Maintenance schedule for erosion and sediment controls

Because quarry operations can continue over a long time frame, it is important to develop a maintenance schedule for all erosion and sediment control measures. Money spent on designing and constructing control /measures will be wasted if these structures are not adequately maintained.

Properly maintained measures will provide optimum performance at all times, thereby minimising adverse environmental effects of the quarry operation. Conversely, poorly maintained structures are likely to result in unsatisfactory environmental protection, despite being initially well designed and constructed.

Develop a maintenance schedule for the site that clearly indicates what is to be done in terms of visual inspections and maintenance works. It is also particularly important that all measures are inspected after significant rainfall events, or during prolonged rainfall, in addition to any regular scheduled inspections. In the maintenance schedule include a procedure for immediately repairing and remedying any damage to control measures from daily quarry activities. Always place a high priority on the inspection and maintenance of control measures.

Ensure every person involved in the quarry operation is familiar with all aspects of erosion and sediment control on the site, including any special consent conditions, for example, specific water quality sampling requirements. For all aspects of quarry operations where erosion and sediment controls are required, install the practices specified in these Guidelines or those outlined in the approved Quarry Management Plan.

Key message: Erosion and sediment control requirements for each quarrying operation should be considered individually. In all circumstances a Quarry Management Plan should clearly outline erosion and sediment control measures to be implemented.

Section 10: Streamworks

Chapter objectives

1. To provide an overview of the practices for stream works.

2. To provide links to specific erosion and sediment control measures outlined in chapter 5 of this Guideline.

10.1.1 Streamworks

Works in or around watercourses can directly impact on watercourse habitat, such as physical disturbance or destruction, and affect watercourse ecology through sediment discharge and temperature-related changes. The loss of watercourse values and direct loss of watercourses through works such as piping can have permanent adverse ecological effects. Environment Bay of Plenty should always be contacted prior to undertaking these works to ensure that consent requirements are fully addressed.

Large quantities of sediment can potentially be generated by works in watercourses through the physical works themselves and also by storm scour through construction areas. Sediment in the receiving environment and can result in significant effects at the specific location and immediately downstream. Flowing water causes ongoing scour and provides the transport mechanism that allows sediment to be dispersed downstream of the works. This ends up ultimately into the receiving environment such as estuaries and harbours.

Environment Bay of Plenty's approach is to avoid works in and immediately adjacent to watercourses wherever possible. Where works are required it is expected that a full assessment will be undertaken to ensure that all viable alternatives have been addressed.

When constructing watercourse crossings the order of preference, from a long-term environmental perspective is:

- Bridges;
- Arch culverts;
- Box culverts; then
- Round culverts.

Any instream structures, such as a culvert or a weir, need to avoid creating fish passage barriers as well as allow for future bed re-grading. Consult with Environment Bay of Plenty to determine the most appropriate form of fish passage requirements. Dependent upon the requirements for fish passage the order of preference as listed above may change.

Key aspects for provision of fish passage with stream works are both design and construction method.

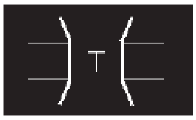
Never construct erosion and sediment control measures within permanent flowing watercourses as this will dramatically reduce their effectiveness. The measures themselves can also impede fish passage and cause their own adverse effects because of construction disturbance.

Actual construction of such work as culverts should be carried out "off-line" - in a work zone away from stream flows. Typically a watercourse diversion will be necessary which can take the form of a specific designed diversion channel or in some circumstances a short term pumping regime. In some situations, the issue can be resolved through careful construction methods, for example, by bridging instead of culverting a watercourse, or by realigning a road or track to avoid the need for any kind of watercourse crossing.

Once it is decided that streamworks will be undertaken, the <u>works method</u> becomes the most important factor in minimising adverse effects.

Key message: For in-stream works, a well planned construction method is the key to minimising adverse downstream effects

The following erosion and sediment control methods and techniques are specific to temporary watercourse works only associated with crossings and diversions. Such works may also require a range of other control measures. These are described in other sections of these Guidelines and include both erosion control and sediment control techniques. Where other streamworks activities are required, such as rock outlet protection or culvert headwall installation, it is vital to consider Environment Bay of Plenty's design expectations and this Guideline's principles and practices. For details of engineering standards and design expectations, contact Environment Bay of Plenty.



10.1.2 Temporary watercourse crossings

Figure 98 Temporary watercourse crossing – image courtesy of Auckland Regional Council.

<u>Definition</u>

A bridge or temporary structure installed across a watercourse for short-term use by construction vehicles.

Purpose

To provide a means for construction vehicles to cross watercourses without discharging sediment into the watercourse, directly damaging the bed or channel or causing flooding during construction, operation, maintenance or removal of the structure.

Condition where practice applies

Where heavy equipment is required to be moved from one side of a watercourse to the other, or where traffic must cross the watercourse frequently for a short period of time. Note that these structures are considered short term only and typically will have a maximum life of two years.

Design

Careful planning can minimise the need for watercourse crossings. Wherever possible, avoid crossing watercourses by completing the development, such as cut and fills, separately on each side of the channel, leaving the watercourse in its natural state.

If no other option exists and a watercourse crossing is required, select a location where the potential effects of the crossing (including construction) are minimised. Plan watercourse crossings well before you need them and always construct them during periods of fine weather. Complete construction as rapidly as possible and stabilise all disturbed areas immediately during and following construction using the practices in chapter 5 of these Guidelines.

Do not build a watercourse crossing during the fish migration period for the watercourse. Environment Bay of Plenty can help identify these periods for specific watercourses.

There are two main types of crossings, bridges and culverts.

Bridges

Where available materials and designs are adequate to bear the expected loadings, bridges are the preferred temporary watercourse crossing method. They provide the least obstruction to flow and fish migration, cause little or no modification of the bed or banks and generally require little maintenance.

Always ensure that the placement of the bridge is not creating a flood flow path restriction. Further take particular care that the approaches to the bridge do not become a source of sediment that leads to runoff and discharges at the bridge location.

Culvert Crossings

Culverts are the most commonly used type of temporary watercourse crossing, and can be easily adapted to most site conditions. Installing and removing culverts, however, causes considerable damage to watercourses and can also creates the greatest obstruction to flood flows. While the culverts need to be designed to allow for a 20% AEP storm event to pass through them a stabilised overland flow path also needs to be provided to ensure that larger storm events can safely pass the site of the culvert with no effects.

Maintenance and Overview

As well as erosion and sediment control measures, structural stability, utility and safety must also be taken into account when designing temporary watercourse crossings. These details must be supplied to Environment Bay of Plenty for approval before construction and for any consents required.

Inspect temporary watercourse crossings after rain to check for blockage in the watercourse, erosion of the banks, channel scour or signs of instability and repair immediately. Permanent crossings need to be inspected following major storm events.

If the structure is no longer needed, remove the structure and all material from the site. Immediately stabilise all areas disturbed during the process of removal as outlined in chapter 5 of this Guideline. Keep machinery clear of the watercourse while removing the structure.

10.1.3 Temporary watercourse diversion

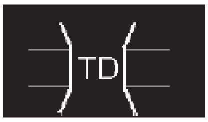


Figure 99 Temporary watercourse diversion – image courtesy of Auckland Regional Council.

Definition

A short-term watercourse diversion to allow for works to occur within an area of the diverted watercourse under dry conditions.

Purpose

To enable watercourse works to be undertaken without working in water flows and without creating sediment generation and discharge into the watercourse.

Condition where practice applies

Temporary watercourse diversions are used as temporary measures to allow any works to be undertaken within permanent and intermittent watercourses.

This flow can be pumped around a site (when works are for short durations only), conveyed through temporary drainage coil or plastic flumes or similar or diverted into a specifically designed, constructed and stabilised diversion channel. Some of the disadvantages to pumping and/or small pipes is their lack of capacity should flows increase, running out of fuel if the pump is unattended and fish passage constraints.

Where works in a watercourse will take place over a period of time, it is usual to construct a separate diversion channel. This will be stabilised followed by flow diverted into the channel isolating flows from the work area. This makes construction easier and enables a better environmental outcome

Design

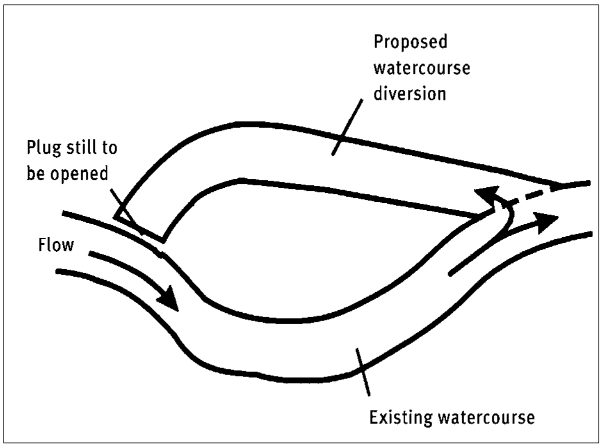
Divert all flow via a stabilised system around the area of proposed works and discharge it back into the channel below the works to avoid scour of the watercourse bed and banks.

The diversion system needs to be capable of conveying flow from a 5% AEP storm event with the ability for larger flows to safely pass through the site works. Always use weather forecasting to ensure that the site is in a safe and stable state during periods of heavy rain with large watercourse flows avoided.

The recommended steps for a watercourse diversion are:

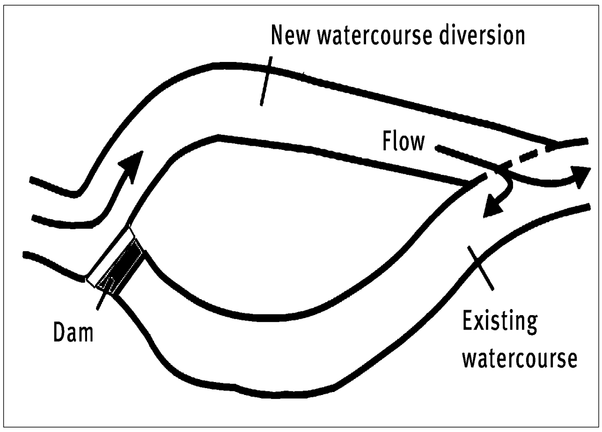
Step 1

Excavate the diversion channel leaving a plug at each end so that the watercourse does not breach the diversion. Size the diversion channel to allow for a 20% AEP rain event. Stabilise the channel to ensure it does not become a source of sediment. Contact Environment Bay of Plenty to ensure that the diversion is approved prior to allowing water to flow down the diversion. Open the downstream plug and allow water to flow up the channel, keeping some water within the channel to reduce problems when the upstream plug is excavated. Open the upstream plug and allow water to flow into the channel.



Step 2

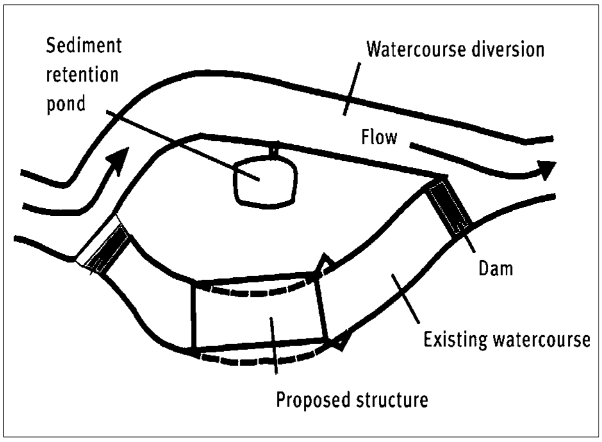
Immediately place a non-erodible dam in the upstream end of the existing channel. This dam should be constructed as in Figure 102 below. Contact Environment Bay of Plenty to discuss alternative forms of the dams, which could include forming a sand bag barrier with a impermeable lining to avoid seepage.



Step 3

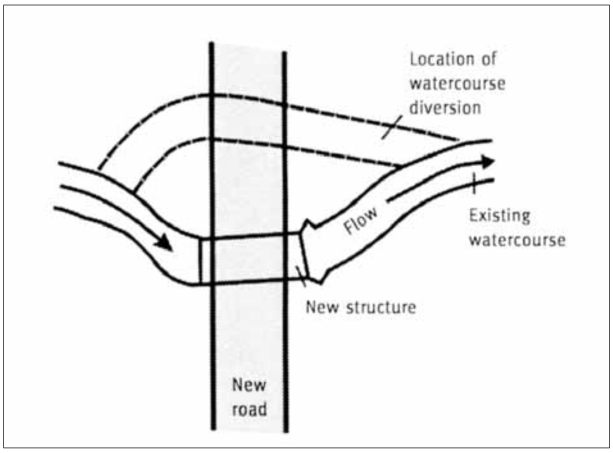
Immediately install a non-erodible downstream dam to prevent backflow into the construction area. Drain the existing watercourse by pumping to a sediment retention pond or a detention device to treat ponded water before discharging to the receiving environment.

Works on the proposed structure can now commence.



Step 4

On completion of the works remove the downstream dam first, allowing water to flood back into the original channel. Remove the upstream dam and fill in both ends of the diversion channel with non-erodible material. Pump any sediment laden water to a sediment retention pond. Fill in the watercourse remainder of the diversion and stabilise.



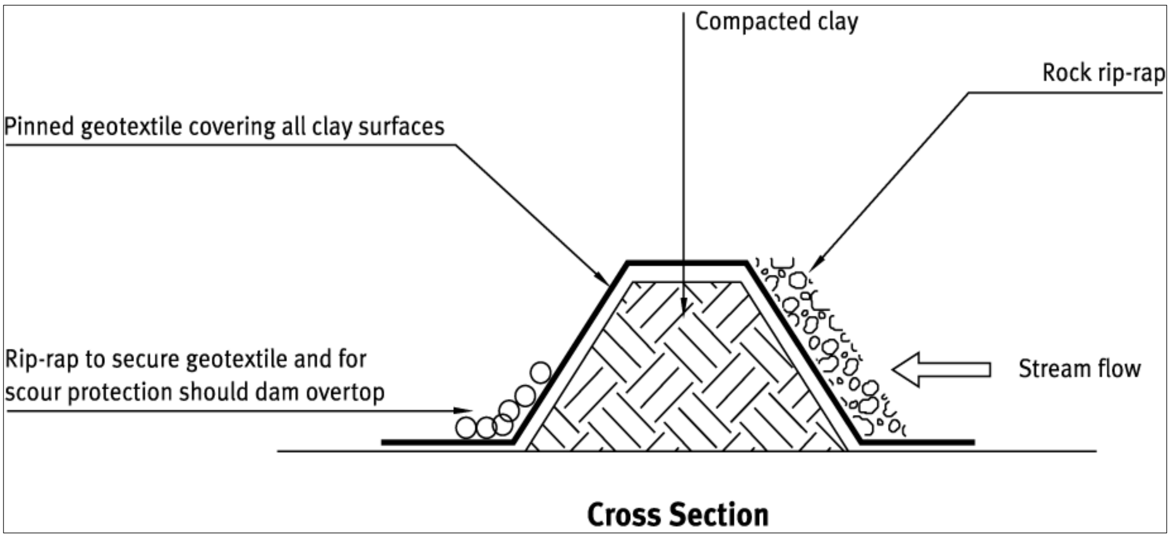


Figure 100 Temporary watercourse diversion dam detail – image courtesy of Auckland Regional Council.

Maintenance

Any works within a watercourse will require ongoing and vigilant maintenance to minimise sediment generation. To achieve this, identify and correct any erosion or issues that may indicate a potential problems. Take particular notice of the following signs.

- The geotextile lining ripping.
- Scour occurring where the flow re-enters the channel.
- Undercutting of the diversion lining.
- Pinning protective fabric is often poorly done. Make sure that it is carried out in accordance with the manufacturer's specifications. If the material is ripped, repair it.

Key message: Works within a watercourse can do significant environmental damage. Avoid the works first, consider all alternatives and if they are required then ensure a dry work environment and appropriate methods are used.

Section 11: Dust control

Chapter objectives

1. **To provide an overview of the practices available for use to manage dust from earthworks.**
2. **To provide links to specific erosion and sediment control measures outlined in chapter 5 of this Guideline.**

11.1 Dust control

11.1.1 Planning for dust control

Dust management should be considered early in the planning stages of any earthworks project. Forward planning and management to minimise dust problems provide the best control options. If dust management is only addressed after it has become a problem, it is almost impossible to bring under effective control.

A Dust Management Plan should be prepared prior to any works being undertaken. A Dust Management Plan is a necessary part of a resource consent application.

On earthworks sites the main practice used to control dust is the application of water to keep soil moisture high enough to prevent dust generation. A Dust Management Plan should include:

- Potential effects of a dust nuisance off site.
- Soil characteristics of the site and whether timing operations will help or hinder dust control.
- Consideration of reducing dust problems. Including restricting the amount of bare ground exposed, staging of works etc
- Type of controls to be used. If water is used, the plan should also detail the water source, capacity and availability. If the source is marginal, on-site storage may be necessary. If water is sourced from a municipal-reticulated water supply, written confirmation from the territorial authority can be required for consent purposes.
- Other types of control can include the use of dust suppressants, soil binding agents and tackifiers. Site stabilisation with aggregate or established vegetation can also be successful.
- Contingency plans (for severe wind problems). These will outline other options if the primary method of control is ineffectual and usually involves machinery stopping works until dust is under control.
- A Dust Management Plan normally also provides for signage at an earthworks site giving a 24 hour contact number for dealing with dust complaints that may arise from the operations. This ensures that the contractor has a management plan operating to deal with dust control.

Timing of works can be crucial for dust management. If the earthworks can be carried out during the wetter winter season with minimal erosion and sediment control problems, then dust control will be less of a problem. This may be an option if the works are on coastal sand country with little off site erosion or sedimentation effects.

The application of water to control dust on earthworks sites is usually achieved by water cart or a sprinkler system. Either system requires a minimum amount of water to achieve effective dust control over an open earthworks site.

- In the Bay of Plenty, the minimum amount of water required to control potential dust problems is 5 mm/day.
- Water carts can carry from 3,000 to 10,000 litres. The use of water carts is limited by the ability of the vehicle to access areas that require wetting down.
- A sprinkler system may be used on earthworks sites where there are large open areas, or where the terrain may be too steep for water carts.
- Sprinkler systems are also commonly used on sites where some irrigation may be useful to establish vegetation following completion of earthworks.
- A reliable source of water is required, from an authorised water take such as bore, stream, lake or municipal water supply.
- Water from a municipal water supply will require written confirmation from the Territorial Authority.
- A reservoir can be used to ensure that sufficient water will be available.
- If water is taken from a surface water body, the site of the water take should be stabilised to prevent adverse effects on the stream/water body.

Limitations often involve the availability of sufficient water during mid-summer when water supply may be limited. When the water is taken from municipal water supplies, alternatives may be required. Using a groundwater bore specifically for the operation is a common practice.

Key message: Effective dust control requires forward planning and ongoing monitoring of site conditions to control soil moisture and avoid the site becoming dry.

Section 12: Key References

Auckland Regional Authority, Review, Sediments of the Upper Waitemata Harbour, Upper Waitemata Harbour Catchment Study, 1983.

Auckland Regional Council, Erosion & Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region, Technical Publication No. 90, March 1999.

Auckland Regional Council, Low Impact Design Manual for the Auckland Region, Technical Publication No. 124, April 2000.

Auckland Regional Council. 1996: The Environmental Impacts of Accelerated Erosion and Sedimentation. TP 69.

Babington and Associates Ltd., Decanting Earth Bund Efficiency Trial, April 2008 with amendments September 2008.

CIRIA C648. Control of Water Pollution from Linear Construction Projects. Technical Guidance dated 2006.

Delaware Erosion and Sediment Control Handbook.

Elliot, S, Parshotam, A, Wadhwa, S. Tauranga Harbour Sediment Study: Catchment Model Results. Prepared for Environment Bay of Plenty NIWA March 2009.

Environment Bay of Plenty, Erosion and Sediment Control Guidelines for Land Disturbing Activities, September 2001.

Environment Canterbury, Erosion and Sediment Control Guidelines, 2007

Environment Waikato, Erosion and Sediment Control - Guidelines for Soil Disturbing Activities" (Technical Report No.2002/01), January 2009.

Goldman, S.J., Jackson, K., Bursztynsky, T.A., Erosion and Sediment Control Handbook, McGraw-Hill Book Company, 1986.

Greater Wellington Regional Council, Erosion and Sediment Control Guidelines for the Wellington Region, September 2002.

Hicks, Murray, Storm Sediment Yields from Basins with Various Lanuses in Auckland Area, prepared for Auckland Regional Council, NIWA, July 1994.

Moores, J., Pattinson, P., Performance of a Sediment Retention Pond Receiving Chemical Treatment, prepared for Auckland Regional Council, NIWA, July 2008.

Sunshine Coast Regional Council, Manual for Erosion and Sediment Control (Version 1.2), November 2008.

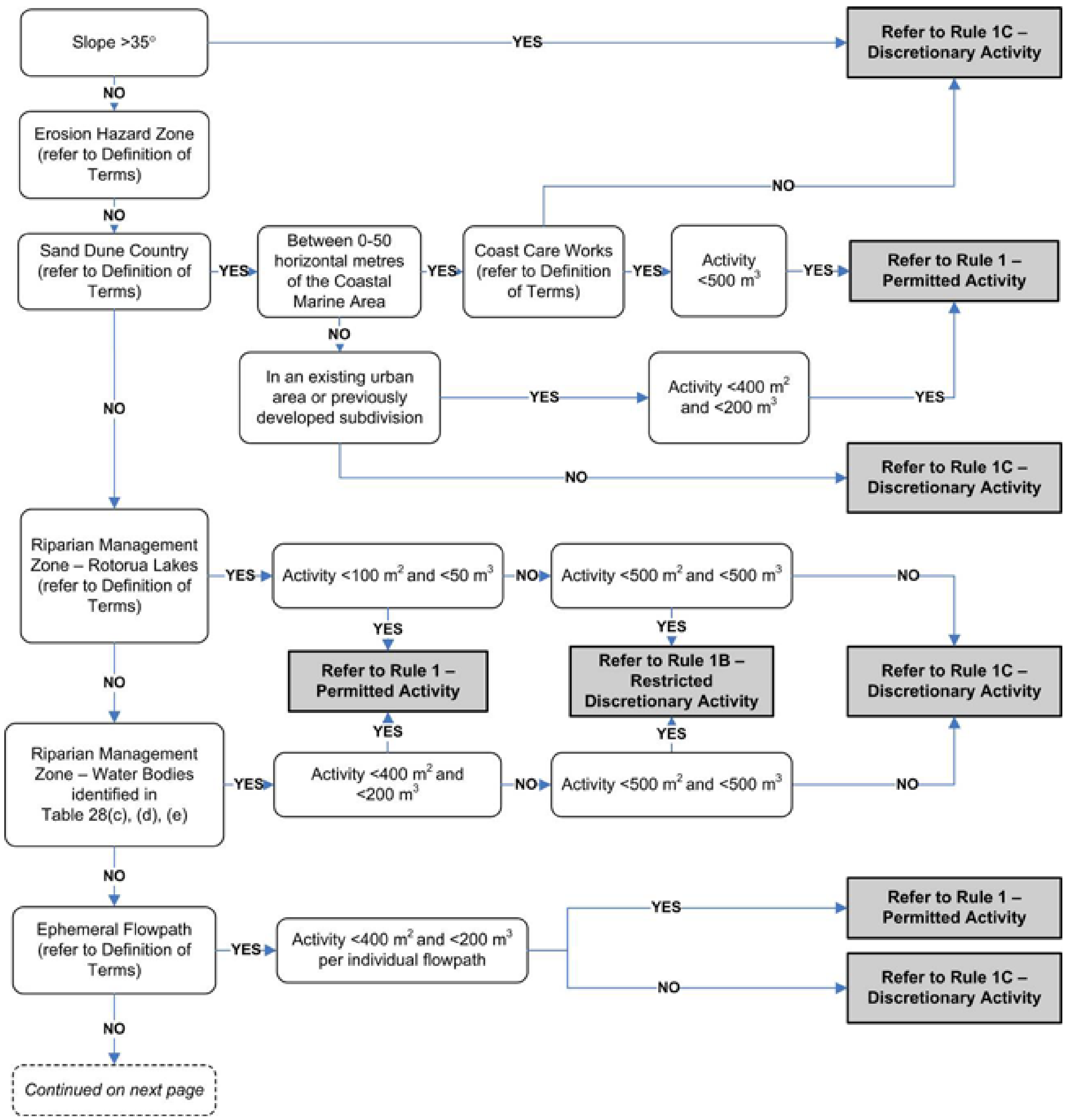
Williamson, B. 1993. Urban runoff data book: a manual for preliminary evaluation of stormwater impacts. NIWA, Water Quality Centre publication; 1993 (2nd Edition).

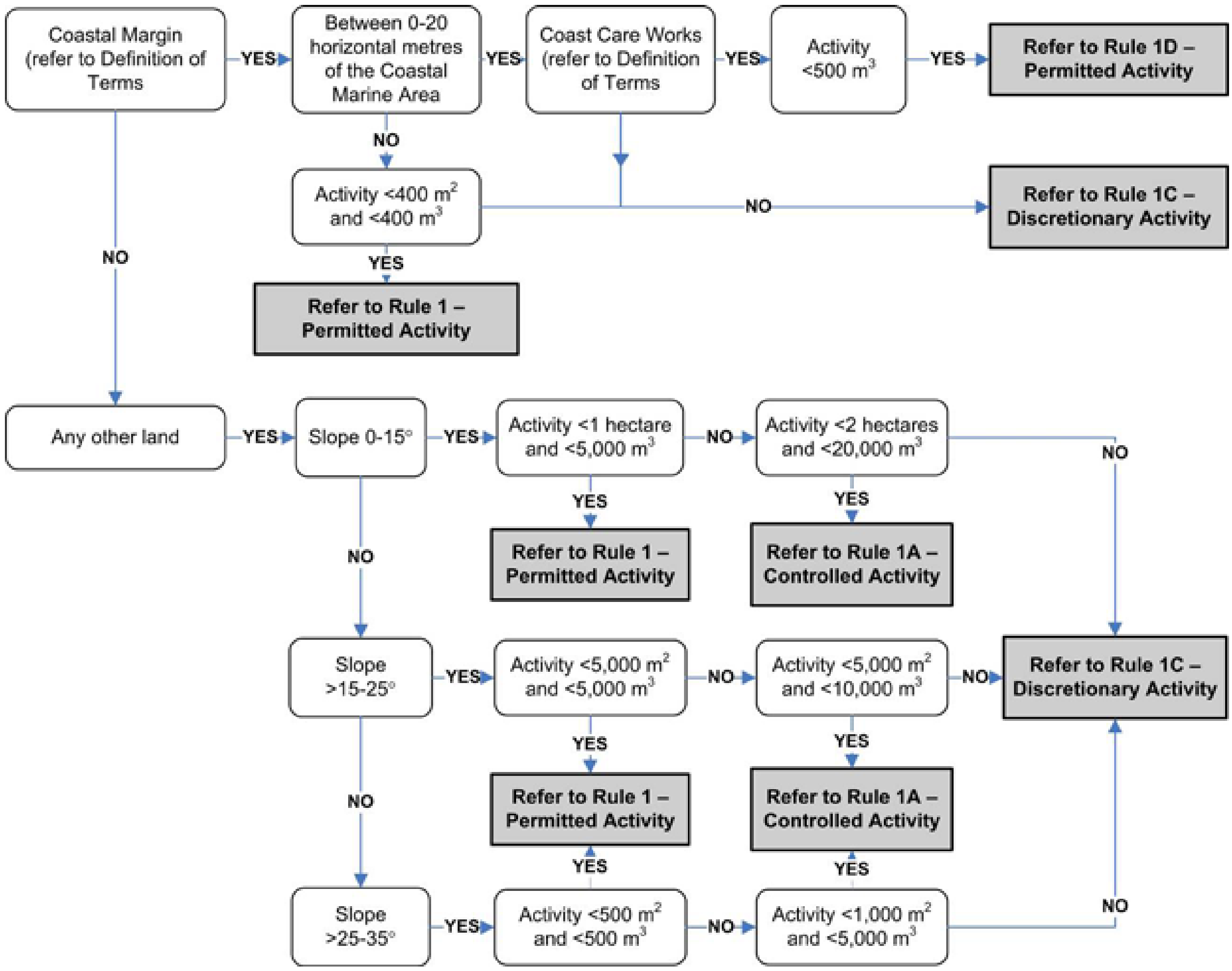
Winter, R, 1998: Predicting Sediment Yield During the Earthworks Development Stage of a Subdivision, Auckland and Assessment of the Efficiency of a Sediment Retention Pond. MSc Thesis, University of Waikato

Appendices

Appendix 1 – Relevant Regional Water and Land Plan Rules

Flow diagram 1 – Earthworks and Quarries





Advisory Note

1 This flow diagram is to assist working out which rules apply, but does not constitute a part of the rules. If there is any inconsistency between the flow diagram and the rules in the regional plan it refers to, the criteria in the rules prevail.

Rule 1 Permitted – Earthworks and Quarries

The disturbance of land and soil as a result of earthworks or a quarry, where the activity does not exceed the limits in Table 28 within any 12 month period is a permitted activity subject to the following conditions:

Table 28 – Permitted Limits for Earthworks and Quarries

<table>
<tr><th></th><th>General Area</th><th>Land Slope</th><th>Distance from Water Body</th><th>Permitted Limits within any 12 month period</th></tr>
<tr><td>(a)</td><td>Urban areas on sand dune country, and previously developed subdivisions on sand dune country</td><td>No greater than 35º</td><td>Coastal land between 50 metres landward of the Coastal Marine Area and either:
(i) 150 horizontal metres landward of the Coastal Marine Area; or
(ii) the point where land changes from sand dune country to another soil type;
whichever is the lesser distance.</td><td>Exposed area no greater than 400 m² and volume no greater than 200 m³.</td></tr>
<tr><td rowspan="3">(b)</td><td rowspan="3">Riparian Management Zone – Rotorua Lakes</td><td>0 to 15º</td><td>Between 0-20 horizontal metres from the edge of the lake</td><td rowspan="3">Exposed area no greater than 100 m² and volume no greater than 50 m³.</td></tr>
<tr><td>>15 to 25º</td><td>Between 0-25 horizontal metres from the edge of the lake</td></tr>
<tr><td>>25 to 35º</td><td>Between 0-40 horizontal metres from the edge of the lake</td></tr>
<tr><td rowspan="4">(c)</td><td rowspan="4">Riparian Management Zone - other lake not specified in (b), wetland or the bed of any river or stream, excluding streams and rivers with water supply water quality classification and Schedule 1 streams</td><td>0 to 7º</td><td>Between 0-5 horizontal metres from the edge of the water body</td><td rowspan="4">Earthworks excluding stream crossings - Exposed area no greater than 400 m² and volume no greater than 200 m³
Earthworks for stream crossing purposes – exposed area no greater than 1,000 m² per crossing.</td></tr>
<tr><td>>7 to 15º</td><td>Between 0-10 horizontal metres from the edge of the water body</td></tr>
<tr><td>>15 to 25º</td><td>Between 0-20 horizontal metres from the edge of the water body</td></tr>
<tr><td>>25 to 35º</td><td>Between 0-25 horizontal metres from the edge of the water body</td></tr>
<tr><td rowspan="2">(d)</td><td rowspan="2">Riparian Management Zone – streams and rivers with water supply water quality classification</td><td>0 to 15º</td><td>Between 0-20 horizontal metres from the edge of the water body</td><td rowspan="2">Earthworks excluding stream crossings – Exposed area no greater than 400 m² and volume no greater than 200 m³.</td></tr>
<tr><td>>15 to 25º</td><td>Between 0-25 horizontal metres from the edge of the water body</td></tr>
</table>

	General Area	Land Slope	Distance from Water Body	Permitted Limits within any 12 month period
		>25 to 35º	Between 0-40 horizontal metres from the edge of the water body	Earthworks for stream crossing purposes – exposed area no greater than 1000 m² per crossing.
(e)	Riparian Management Zone – Schedule 1 streams	0 to 7º	Between 0-5 horizontal metres from the edge of the water body	Earthworks excluding stream crossings - Exposed area no greater than 400 m² and volume no greater than 200 m³. Earthworks for stream crossing purposes – exposed area no greater than 600m² per crossing.
		>7 to 15º	Between 0-10 horizontal metres from the edge of the water body	
		>15 to 25º	Between 0-20 horizontal metres from the edge of the water body	
		>25 to 35º	Between 0-25 horizontal metres from the edge of the water body	
(f)	Ephemeral Flowpath not in the Erosion Hazard Zone	No greater than 35º	N/A	Earthworks excluding roading crossings - Exposed area no greater than 100 m² and volume no greater than 50 m³ per individual flowpath. Earthworks outside urban areas for roading crossing purposes – exposed area no greater than 400 m² per crossing.
(g)	Coastal Margin	No greater than 35º	Land between 20-40 horizontal metres as measured from the Coastal Marine Area on the edge of an estuary, harbour, or the open rocky coast.	Exposed area no greater than 400 m² and volume no greater than 200 m³.
(h)	Land not in areas covered by (a) to (e), and not in the Erosion Hazard Zone	0 to 15º	N/A	Exposed area no greater than 1 hectare and volume no greater than 5,000 m³.
		>15 to 25º	N/A	Exposed area no greater than 5,000 m² and volume no greater than 5,000 m³.
		>25 to 35º	N/A	Exposed area no greater than 500 m² and volume no greater than 500 m³.

	General Area	Land Slope	Distance from Water Body	Permitted Limits within any 12 month period

Notes:

1 Any earthworks:

(a) In the Erosion Hazard Zone, or
(b) On slopes greater than 35 degrees; or
(c) On coastal land between 0-50 metres of the Coastal Marine Area on Sand Dune Country; or
(d) On coastal land between 0-20 metres of the Coastal Marine Area on the Coastal Margin;

are discretionary activities under Rule 1C.

2 The area covered by Table 28(a) will be interpreted to be modified or stabilised Sand Dune Country which has a vegetative cover, sealed or compacted soil, and a previously modified or flattened topography. This excludes unmodified or natural dune systems.

3 Any earthworks in the Coastal Margin between 0 to 20 horizontal metres as measured from the Coastal Marine Area on the edge of an estuary, harbour, or the open rocky coast are a discretionary activity under Rule 1C.

(a) There shall be no point source discharge of sediment contaminated stormwater to surface water from the activity.

(b) The diffuse discharge of sediment contaminated storm water to surface water from the activity shall not cause the following effects, except where a 20% AEP flood event is exceeded:

(i) The production of any conspicuous oil, grease films, scums or foams, or floatable or suspended solids.

(ii) Any conspicuous change in colour or visual clarity.

(iii) Any emission of objectionable odour.

(iv) The rendering of fresh water unsuitable for consumption by farm animals.

(v) Any more than minor adverse effects on aquatic life.

(c) The activity shall not cause or induce erosion to land or to the bed or banks of any surface water body, where the erosion is persistent or requires active erosion control measures to bring it under control. Erosion includes:

(i) Instability of land or the banks of the surface water body.

(ii) Scour to the bed of the surface water body.

(d) Fill from the earthwork activity shall not be deposited in overland or secondary flow paths that convey stormwater during rainfall events.

(e) The activity shall not obstruct or divert the flow of water in such a manner that it results in damming, flooding or erosion.

(f) The activity shall not disturb vegetation in a wetland; or change the water flow or quantity, or water quality in a wetland.

(g) Where an activity is a cleanfill site, the activity shall comply with the Ministry for the Environment's Cleanfill Guidelines (2001)[1].

(h) The activity shall not disturb an identified contaminated site.

(i) No machinery refuelling or fuel storage shall occur at a location where fuel can enter any water body.

(j) No contaminants (including, but not limited to, oil, hydraulic fluids, petrol, diesel, other fuels, paint, solvents or anti-fouling paints), excluding sediment, shall be discharged to water, or discharged to land in circumstances where the contaminant may enter water, from the activity.

(k) All practicable measures shall be taken to avoid vegetation, soil, slash or any other debris being deposited into a water body or placed in a position where it could readily enter or be carried into a water body.

[33] Ministry for the Environment, 2001. Guide to the Management of Cleanfills. Wellington, New Zealand.

(l) The activity shall be staged, managed and completed, and the activity site closed-off, in a manner that ensures compliance with conditions (a) to (k) inclusive.

(m) Any stormwater from outside the exposed area shall be kept separate from the earthworks area.

(n) Where the earthworks are for stream crossing purposes, the activity shall also comply with the following conditions:

(i) The crossing shall be made at, or near to, right angles to the flow of the water in the river or stream, ensuring minimal roading in the Riparian Management Zone.

(ii) The area shall be stabilised as soon as practicable, but no later than 3 months from the end of the activity.

(iii) All practicable steps shall be taken to keep stormwater away from the stream crossing approach.

Advisory Note

1 Clean fill sites that do not produce leachate are included in the definition of 'earthworks'.

2 In relation to condition (a), where there is a point source discharge of sediment contaminated storm water to surface water from earthworks, then a resource consent is required under Rule 37. Discharges to land soakage are permitted under Rule 30B.

3 In relation to condition (g), the disturbance of a contaminated site is addressed by Rules 34 and 35.

4 Volume of earthworks is measured as the following:

(a) The volume as 'cut' where the material is taken away from the activity site; or

(b) The volume as 'fill' where the material is received from an area which is not the activity site; or

(c) The volume as 'cut to fill' within an activity site. This means that up to maximum permitted volume can be moved within one activity site (e.g. in relation to Table 28 (f), 5,000 m³ can be moved within an activity site).

5 Best management practices shall be used to avoid or mitigate the discharge of sediment contaminated storm water to water. In selecting the best management practices appropriate to the activity site, the following should be considered:

(a) The water quality classification of the receiving water body.

(b) Aquatic ecosystem values of the receiving water body.

(c) Soil type and slope.

(d) Proximity to surface water bodies.

Explanation/Intent of Rule

To allow earthworks and quarries that are located in low risk areas. Earthworks and quarries that do not comply with all the required conditions require consent. Refer to Flow Diagram 1 to assist reading of this rule. In relation to condition (a), it is unlikely that discharges of sediment contaminated stormwater from earthworks will meet the requirements of Rule 30 (permitted discharges of stormwater to surface water). Discharges from earthworks need to comply with Rule 30B (permitted discharge of stormwater to land).

Rule 1A Controlled – Earthworks and Quarries

The disturbance of land and soil as a result of earthworks or a quarry, where the activity is;

1 Not in the Riparian Management Zone;
2 Not in the Coastal Margin;
3 Not in the Erosion Hazard Zone;

and does not exceed the limits in Table 29 within any 12 month period is a controlled activity, subject to the following terms and conditions:

Table 29 – Controlled Earthworks

	General Area	Land Slope	Controlled Limits
(a)	Ephemeral Flowpath not in the Erosion Hazard Zone	0 to 25º	Exposed area no greater than 1,000 m² and volume no greater than 500 m³ per individual flowpath
(b)	Land not in the Riparian Management Zone, an ephemeral flowpath, the Coastal Margin, or the Erosion Hazard Zone	0 to 15º	2 hectare and 20,000 m³
		>15 to 25º	5,000 m² and 10,000 m³
		>25 to 35º	1,000 m² and 5,000 m³

(a) There shall be no point source discharge of sediment contaminated stormwater to surface water from the activity.

(b) The diffuse discharge of sediment contaminated stormwater to surface water from the activity shall not cause the following effects, except where a 20% AEP flood event is exceeded:

- (i) The production of any conspicuous oil, grease films, scums or foams, or floatable or suspended solids.
- (ii) Any conspicuous change in colour or visual clarity.
- (iii) Any emission of objectionable odour.
- (iv) The rendering of fresh water unsuitable for consumption by farm animals.
- (v) Any more than minor adverse effects on aquatic life.

(c) The activity shall not cause or induce erosion to land or to the bed or banks of any surface water body, where the erosion is persistent or requires active erosion control measures to bring it under control. Erosion includes:

- (i) Instability of land or the banks of the surface water body.
- (ii) Scour to the bed of the surface water body.

(d) Fill from the earthwork activity shall not be deposited in overland or secondary flow paths that convey stormwater during rainfall events.

(e) The activity shall not obstruct or divert the flow of water in such a manner that it results in damming, flooding or erosion.

(f) The activity shall not disturb vegetation in a wetland; or change the water flow or quantity, or quality in a wetland.

(g) Where an activity is a cleanfill site, the activity shall comply with the Ministry for the Environment's Cleanfill Guidelines (2001).

(h) The activity shall not disturb an identified contaminated site.

(i) No machinery refuelling or fuel storage shall occur at a location where fuel can enter any water body.

(j) No contaminants (including, but not limited to, oil, hydraulic fluids, petrol, diesel, other fuels, paint, solvents or anti-fouling paints), excluding sediment, shall be discharged to water, or discharged to land in circumstances where the contaminant may enter water, from the activity.

(k) All practicable measures shall be taken to avoid vegetation, soil, slash or any other debris being deposited into a water body or placed in a position where it could readily enter or be carried into a water body.

Environment Bay of Plenty reserves its control over the following matters:

(a) Measures to manage discharges of contaminants from the activity, including discharges of sediment contaminated stormwater.

(b) Measures to avoid, remedy or mitigate erosion.

(c) Timing and duration of the activity.

(d) Effect on water flows, including overland or secondary flow paths that convey storm water during rainfall events.

(e) Measures to avoid, remedy or mitigate adverse effects on sites of significance to tangata whenua, indigenous biodiversity, and areas of significant indigenous vegetation and significant habitats of indigenous fauna.

(f) Measures to protect and replace topsoil where the activity is re-contouring.

(g) Information and monitoring requirements.

(h) The administration charges under section 36 of the Act.

Notification

Applications for controlled activities under this Rule do not require the written approval of affected persons, and shall not be publicly notified, except where Environment Bay of Plenty considers special circumstances exist in accordance with Section 94C of the Act.

Advisory Note

1 Volume of earthworks is measured as the following:

 (a) The volume as 'cut' where the material is taken away from the activity site; or

 (b) The volume as 'fill' where the material is received from an area which is not the activity site; or

 (c) The volume as 'cut to fill' within an activity site. This means that up to maximum permitted volume can be moved within one activity site (e.g. in relation to Table 29(b) slope 0-15º, 20,000 m^3 can be moved within an activity site).

Explanation/Intent of Rule

To control earthworks and quarries that present some risk to the environment, and where it is appropriate to assess the effects of the activity within the resource consent application process.

Rule 1B Restricted Discretionary – Earthworks and Quarries

The disturbance of land and soil as a result of earthworks or a quarry, where the activity does not exceed limits in Table 30 within any 12 month period is a restricted discretionary activity.

Table 30 – Restricted Discretionary Earthworks and Quarries

	General Area	Land Slope	Distance from Water body	Restricted Discretionary Limits
(a)	Riparian Management Zone – Rotorua Lakes	0 to 15º	Between 0-20 horizontal metres of the lake	500 m² and 500 m³
		>15 to 25º	Between 0-25 horizontal metres of the lake	
		>25 to 35º	Between 0-40 horizontal metres of the lake	
(b)	Riparian Management Zone – other lake not specified in (a), wetland or the bed of any river or stream, excluding streams and rivers with Water Supply water quality classification	0 to 7º	Between 0-5 horizontal metres of the water body	Earthworks excluding stream crossings – 500 m² and 500 m³ Earthworks for stream crossing purposes – all earthworks not permitted by Rule 1
		>7 to 15º	Between 0-10 horizontal metres of the water body	
		>15 to 25º	Between 0-20 horizontal metres of the water body	
		>25 to 35º	Between 0-25 horizontal metres of the water body	
(c)	Riparian Management Zone – streams and rivers with Water Supply water quality classification	0 to 15º	Between 0-20 horizontal metres from the edge of the water body	Earthworks excluding stream crossings – 500 m² and 500 m³. Earthworks for stream crossing purposes – all earthworks not permitted by Rule 1.
		>15 to 25º	Between 0-25 horizontal metres from the edge of the water body	
		>25 to 35º	Between 0-40 horizontal metres from the edge of the water body	
(d)	Ephemeral Flowpath not in the Erosion Hazard Zone	No greater than 35º	N/A	Any activity not otherwise permitted by Rule 1 or controlled by Rule 1A.

Environment Bay of Plenty restricts its discretion to the following matters:

(a) Measures to manage discharges of contaminants from the activity, including discharges of sediment contaminated stormwater.

(b) Measures to avoid, remedy or mitigate erosion.

(c) Timing and duration of the activity.

(d) Effect on water flows, including overland or secondary flow paths that convey storm water during rainfall events.

(e) Measures to avoid, remedy or mitigate adverse effects on: natural character of the coastal environment, wetlands, lakes, rivers and their margins; amenity values; legal public access; sites of significance to tangata whenua; aquatic ecosystems; indigenous biodiversity; and areas of significant indigenous vegetation and significant habitats of indigenous fauna.

(f) Measures to protect and replace topsoil where the activity is re-contouring.

(g) Information and monitoring requirements.

(h) The administration charges under section 36 of the Act.

Explanation/Intent of Rule

To control earthworks and quarries that present a higher risk to the environment, and where it is appropriate to assess specific adverse effects of the activity on the environment within the resource consent application process.

Rule 1C Discretionary – Earthworks and Quarries

The disturbance of land and soil as a result of earthworks or a quarry, where the activity:

1 Is not permitted by a rule in this regional plan; and
2 Is not a controlled activity under a rule in this regional plan, and
3 Is not a restricted discretionary activity under a rule in this regional plan;

Is a discretionary activity.

Assessment Criteria

When assessing resource consent applications under this rule, Environment Bay of Plenty will have particular regard to, but not be limited to, the following provisions:

Objective *4, 5, 9, 17, 19, 21, 31, 32, 34*
Policy *5, 14, 15, 17, 18, 20, 21, 51, 54*
Method *12, 19, 20, 56, 60, 124*

Explanation/Intent of Rule

To control earthworks and quarries that present a high risk to the environment, and where it is appropriate to assess the effects of the activity within the resource consent application process.

Rule 30 Permitted – Discharge of Storm water to Surface Water

The discharge of storm water to surface water, or to land where the discharge enters surface water, is a permitted activity, subject to the following conditions:

(a) The suspended solids concentration of the discharge shall not be greater than 150 g/m^3, except where a 10 minute duration 10% AEP storm event (10 year return period storm) is exceeded.

(b) The discharge shall not be to a surface water body in an area otherwise covered by a Comprehensive Catchment Discharge Consent.

(c) The discharge shall not cause the production of conspicuous oil or grease films, scums or foams, or floatable materials.

(d) The rate of discharge shall not exceed 125 litres per second for a 10 minute duration 10% AEP storm event (10 year return period storm).

(d) The discharge shall not contain any storm water from a timber preservation site, timber treatment site, or a site where chemically treated timber is stored.

(f) The discharge shall not cause or induce erosion to the bed or banks of any surface water body, or to land, where the erosion is persistent or requires active erosion control measures to bring it under control. Erosion includes:

   (i) Instability of land or the banks of the surface water body.

   (ii) Scour to the bed of the surface water body.

   (iii) Damage to the margins or banks of the surface water body.

(g) The discharge shall not cause nor contribute to flooding or ponding on any land or property owned or occupied by another person.

(h) The discharge shall not contain hazardous substances, or substances that are toxic to aquatic ecosystems (as measured relative to the ANZECC Guidelines for Fresh and Marine Water Quality, 2000).[1]

(i) The discharge shall not contain any wastes (including, but not limited to, wastewater or condensates) from a trade or industrial process.

(j) The discharge shall not cause a conspicuous change in the colour of the receiving waters.

(k) Where the discharge is to a part of a receiving water body that is classified as Water Supply, the discharge shall not contain any substance that renders the water unsuitable for treatment (equivalent to coagulation, filtration, disinfection or micro-infiltration) for human consumption.

This activity is also subject to the requirements of the rules in section 9.4.

Advisory Note

1 If a resource user wishes to discharge storm water to water at a greater rate or suspended solid concentration than permitted under Rule 30, they must apply for a resource consent and the effects of the discharge will be assessed on a case by case basis. Environment Bay of Plenty will assess the effects of a proposed higher suspended solids limit providing the results of appropriate investigations are in the Assessment of Environmental Effects for a resource consent application.

2 In relation to the application of condition (d), storm water management systems for State Highways and other roads may be designed to allow multiple discharges along a length of roadway, providing each individual discharge does not exceed the stated rate.

3 In relation to condition (c), the term ‘conspicuous’ refers to a visually evident effect.

Explanation/Intent of Rule

To allow point sources discharges of clean storm water to surface water, and to land where the discharge flows over land to surface water. The rule applies to discharges of storm water from roofs, roads outside urban areas, and point source discharges of rural storm water. Such discharges present a low risk to the environment, and would generally not be covered by a Comprehensive Catchment Discharge Consent. Discharges of sediment contaminated storm water from land disturbance activities are addressed by rules in section 9.2. Any discharge of storm water that does not comply with all conditions of Rule 30 requires a resource consent. Where the discharge of storm water to surface water does not comply with Rule 30, and is not a restricted discretionary activity under Rule 30A, it is a discretionary activity under Rule 37. Water passing through a culvert that crosses a stream (i.e. the culvert is a stream crossing structure) is not considered to be a discharge, and is not subject to rules in section 9.5, including Rule 30. If a resource user wishes to discharge storm water to water at a greater rate or suspended solid concentration that permitted under Rule 30, they must apply for a resource consent and the effects of the discharge will be assessed on a case by case basis. Refer to Flow Diagram 9 to assist reading of this rule.

Rule 31 Permitted – Discharge of Storm water to Land Soakage

The discharge of contaminated storm water to land soakage is a permitted activity, subject to the following conditions:

(a) The rate of discharge shall not exceed 125 litres per second for a 10 minute duration 10% AEP storm event (10 year return period storm).

(b) The discharge shall not cause the production of conspicuous oil or grease films, scums or foams, or floatable materials.

(c) The discharge shall not contain any wastes (including, but not limited to, wastewater or condensates) from a trade or industrial process.

(d) The discharge shall not contain any storm water from a timber preservation site, timber treatment site, or a site where chemically treated timber is stored.

[1] Australian and New Zealand Environment and Conservation Council, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, New Zealand.

(e) The discharge shall not cause or induce erosion to the bed or banks of any surface water body, or to land, where the erosion is persistent or requires active erosion control measures to bring it under control. Erosion includes:

  (i) Instability of land or the banks of the surface water body.

  (ii) Scour to the bed of the surface water body.

  (iii) Damage to the margins or banks of the surface water body.

(f) The discharge shall not cause nor contribute to flooding or ponding on any land or property owned or occupied by another person.

This activity is also subject to the requirements of the rules in section 9.4.

Explanation/Intent of Rule

To allow point sources discharges of clean storm water and encourage the discharge to land soakage, where this is appropriate. Such discharges present a low risk to the environment. Rule 31 is consistent with Objective 35, Policy 57, and Method 140. Refer to Flow Diagram 9 to assist reading of this rule.

Rule 42 Permitted – Take of Water and Discharge of Sediment Contaminated Water from the Dewatering of Building and Construction Sites

The:

1 Take of water, and

2 Temporary discharge of sediment contaminated water to water or to land where the contaminant may enter water,

for the purposes of dewatering of building and construction sites is a permitted activity subject to compliance with the following conditions:

(a) The discharge shall not be water taken from contaminated land (refer to Definition of Terms and Advisory Note (3), or a trade or industrial site.

(b) There shall be no direct discharge of water to water in Lake Rotorua, Rotoiti, Rotoehu, Rotoma, Okataina, Okareka, Tikitapu, Rotokakahi, Tarawera, Okaro, Rotomahana, or Rerewhakaaitu. Discharge to these lakes shall pass through a filter system or a land soakage pond prior to overland flow, and the suspended solids concentration shall comply with condition (g).

(c) The discharge shall not contain any wastes (including, but not limited to, wastewater or condensates) from a trade or industrial process.

(d) The discharge shall not cause a conspicuous change in the colour of the receiving waters as measured at a downstream distance of three (3) times the width of the stream or river at the point of discharge.

(e) Where the discharge is to a receiving water body that is classified as Water Supply, the discharge shall not contain any substance that renders the water unsuitable for treatment (equivalent to coagulation, filtration, disinfection or micro-filtration) for human consumption.

(f) The discharge shall not contaminate an authorised water take (refer to Advisory Note 4).

(g) Where the discharge is to a surface water body, the suspended solids concentration of the discharge shall not be greater than 80g/m³.

(h) Where the discharge is to land soakage where there is overland flow to a surface water body, the suspended solids concentration of the discharge shall not be greater than 150g/m³.

(i) The volume of discharge from the activity site shall not be greater than 80 litres per second.

(j) The discharge shall not damage or destroy aquatic ecosystems. This includes, but is not limited to, the smothering of flora and fauna by sedimentation of aquatic habitats.

(k) The take of water, or the discharge, shall not cause or induce subsidence, erosion to the bed or banks of any surface water body, or to land, where the erosion is persistent or requires active erosion control measures to bring it under control. Erosion includes:

  (i) Instability of land or the banks of the surface water body.

  (ii) Scour to the bed of the surface water body.

(l) The discharge shall not cause flooding or ponding on any land or property owned or occupied by another person, unless the written approval of the affected person(s) has been obtained.

(m) Where the activity prevents the normal use of any existing bore or well in the vicinity due to draw-down, the activity shall be halted immediately.

Advisory Note

1 Where the discharge is made to a closed/piped storm water system, permission for the discharge shall be obtained from the city or district council.

2 For the purposes of Rule 42, 'building or construction site' means an activity for the construction or maintenance of a building, structure, or infrastructure.

3 In relation to condition (a), contact Environment Bay of Plenty for more information on the location of contaminated land.

4 It is recognised that there are natural geothermal inflows or volcanic soils in the Bay of Plenty region that have high natural background levels of metals above those in New Zealand drinking water standards. These metals are part of the ambient environment, and naturally enter water bodies.

Explanation/Intent of Rule

To allow the dewatering of building and construction sites, where it may be necessary to undertake such activities at short notice. It would not be practicable or efficient to require a resource consent in these circumstances.

Definition of Terms:

Ephemeral flowpath – An ephemeral flowpath is where any one of the following criteria are met:

(a) The flow path is an entrenched dry gully greater than 1 metre deep.

(b) There is clear evidence of a channel within the valley system where overland flow occurs from time to time.

(c) There is clear evidence of erosion (such as gullying or headward gully erosion) associated with short term water flow from time to time within the valley system.

Erosion Hazard Zone – Land that has very severe to extreme erosion hazards. For the purposes of rules in section 9.2 of this regional plan, the Erosion Hazard Zone is:

(a) Any Sand Dune Country; excluding sand dune country within urban areas or already developed subdivisions that are on land between 50-150 metres from the Coastal Marine Area.

(b) Any land in the upper Rangitaiki River catchment above the confluence of the Otangimoana Stream and Rangitaiki River, including the Otamatea River catchment, in the following areas:

  (i) On the margins of erosion susceptible permanent streams and rivers; or (ii) In the beds and margins of ephemeral flowpaths; or

  (iii) On steep terrace edges;

  as shown in Environment Bay of Plenty Plan Series M1009[2].

[2] Note: The photomap plan series M1009 prepared by Environment Bay of Plenty at a scale of 1:25,000 shows the location of the beds and margins of the relevant land areas and ephemeral flowpaths that are covered by definition points (b) (i) to (iii).

Riparian Management Zone – the area of land that covers a specified horizontal distance from any wetland, or from the bed of any permanently or intermittently flowing river, stream or a lake. Areas of land adjacent to ephemeral flowpaths are excluded from the Riparian Management Zone. Land on the margins of estuaries, harbours and the open rocky coast is covered by the definition of “Coastal Margin”. Land on the margins of coastal dune systems is covered by the definition of “Sand Dune Country”. The horizontal width of a Riparian Management Zone, as measured from the edge of the surface water body to the width stated, is as follows:

1 For land adjacent to Rotorua Lakes:

Land Slope	**Land Disturbance Activity**			
	Vegetation Clearance	***Earthworks***	**Clearance of Vegetation by Burning**	**Cultivation**
0 to 7°	10 metres	20 metres	20 metres	5 metres
>7 to 15°				10 metres
>15 to 25°	20 metres	25 metres	25 metres	10 metres
>25 to 35°	25 metres	40 metres	40 metres	40 metres
>35°	40 metres	40 metres	40 metres	40 metres

2 For land adjacent to any other lake not specified in 1, or wetland or the bed of any river or stream, excluding land adjacent to streams and rivers with Water Supply water quality classification in relation to earthworks and vegetation clearance:

Land Slope	**Land Disturbance Activity**			
	Vegetation Clearance	**Earthworks**	**Clearance of Vegetation by Burning**	**Cultivation**
0 to 7°	5 metres	5 metres	5 metres	2 metres
>7 to 15°	5 metres	10 metres	10 metres	5 metres
>15 to 25°	20 metres	20 metres	20 metres	10 metres
>25 to 35°	25 metres	25 metres	25 metres	25 metres
>35°	40 metres	40 metres	40 metres	40 metres

3 For land adjacent to streams and rivers with Water Supply water quality classification in relation to earthworks and vegetation clearance:

Land Slope	**Land Disturbance Activity**	
	Vegetation Clearance	**Earthworks**
0 to 7°	10 metres	20 metres
> 7 to 15°		
> 15 to 25°	20 metres	25 metres
> 25 to 35°	25 metres	40 metres
> 35°	40 metres	40 metres

Sand Dune Country – coastal dune systems with sand soils, which are characterised by low amounts of organic matter and low cohesiveness. Includes areas with Land Use Capability of VIIe and VIIIe, and Land Management Suite of LMS 3 or LMS 4. For the purposes of the rules in section 9.2 of this regional plan, it is coastal land measured horizontally from the Coastal Marine Area to either:

(i) 150 metres landward of the Coastal Marine Area; or

(ii) the point where land changes from sand dune country to another soil type; whichever is the lesser distance.

These are the definitive maps used to assess compliance. Copies of these maps are available from or may be viewed at any Environment Bay of Plenty office or found on the website (www.envbop.govt.nz)

Appendix 2 – Relevant Bay of Plenty Regional Air Plan Rules

Rule 18 Permitted Activity - General Activities

All other discharges of contaminants into air which are not subject to an express rule in this regional air plan shall be a permitted activity subject to compliance with the following conditions. If the conditions cannot be complied with the activity shall be a discretionary activity.

(b) The discharge must not result in objectionable or offensive odour or particulates beyond the boundary of the subject property or into water;

(c) There must be no harmful concentrations of contaminants beyond the boundary of the subject property or into water;

(d) Any dust arising from an activity should meet the requirements of 6.6.4(a)(ii)4.

6.6.5(a) Offensive, Objectionable

"Offensive" is defined as "…giving or meant to give offence…disgusting, foul smelling, nauseous, repulsive…". "Objectionable" is defined as "open to objection, unpleasant, offensive". Case law has established that what may be offensive or objectionable under the Resource Management Act 1991 cannot be defined or prescribed except in the most general of terms. Each case will depend upon its own circumstances. Key considerations include:

1 *Location of an activity and sensitivity of the receiving environment* – What may be considered offensive or objectionable in an urban area may not necessarily be considered offensive or objectionable in a rural area;

2 *Reasonableness* – Whether or not an activity is offensive or objectionable should be determined by an ordinary person who is representative of the community at large, deciding whether the activity is disgusting, nauseous, repulsive or otherwise objectionable. This assessment will mainly involve Council Officers;

3 *Existing uses* – It is important to consider what lawfully established activities exist in the area, i.e. if a new activity requires a permit, the effect of existing discharges of contaminants into air should be considered (sensitivity or reverse sensitivity).

Each investigation of a complaint concerning offensive or objectionable discharges will depend upon the specific circumstances.

6.6.5(a)(ii) Particulate Matter

Particulate matter effects relate to the size of particles. Smaller particles stay suspended for longer periods than larger particles. The smaller particles can be inhaled and possibly cause health effects whereas the larger particles tend to fall out close to the source and deposition on surfaces. The techniques for measuring particulate concentrations change for the two particle size groupings. Environment Bay of Plenty has chosen to use total suspended particulate as this covers more of the health effects. The nuisance guideline for deposition has an averaging period of a month that does not take account of peak discharges, which are likely to cause offensive and objectionable levels of particulate beyond the source boundary. Deposition measurements may be used at times for assessing peak discharges of deposited material.

For particulate matter, the approach will be as follows:

1 A Council Officer who has experience in particulate complaints will make an assessment of the situation. This assessment will take into account the FIDOL factors which are:

- **Frequency** of the occurrence;

Note: The rules apply to the discharge of contaminants into air from activities on land as well as in the coastal marine area.

- **Intensity** of the particulate matter event;
- **Duration** of exposure to the particulate matter;
- **Offensiveness** of the particulate matter; and
- **Location** of the discharge (refer 6.6.4(a)1).

2 If the discharge is deemed to be offensive or objectionable by the Council Officer, the discharger will be asked to take whatever action is necessary to avoid, remedy or mitigate the effects of the discharge on the environment.

3 If the discharger disputes the Council Officer's assessment or the problem is ongoing, then further evaluation may be required. This evaluation could include:

- An assessment by another Council Officer;
- Monitoring of particulate matter beyond the boundary will be compared with the following standard. Discharges into air in excess of the following standards will be considered to be objectionable, offensive or harmful.

4 Any particulate matter arising from the activity should not result in levels of suspended particulate matter greater than 350 µg/m3 averaged over 10 minutes or 250 µg/m3 over 1 hour or 150 µg/m3 averaged over 24 hours, at any point beyond the boundary of the subject property. (Derived from the USEPA (United States Environmental Protection Agency) National Ambient Air Quality Standards).

If the discharge into air continues to be offensive or objectionable, then enforcement action may be taken. This could be in the form of an abatement notice, enforcement order or prosecution, pursuant to the Resource Management Act 1991. In the case of a permitted activity, failure to comply with the conditions could result in enforcement and would also mean that the activity was no longer permitted and would thus require a resource consent application to be lodged if the person wished to continue with an activity.

ENVIRONMENT BOP

SEDIMENT ANALYSIS

SEDIMENTATION TESTS INCLUDING CHEMICALLY ASSISTED SEDIMENTATION

Settling analysis on soil samples provided by Environment Bay of Plenty

(July 2009)

Prepared by: Danny Williams
Orica Chemnet – Water Chemicals

Introduction

Sediment control from earthworks sites has recently been highlighted as a potential source of environmental pollution and a risk to New Zealand native species and habitats in waterways.

Particle size, soil chemistry and rainfall intensity are the main factors influencing the settling rate of suspended particles in a rain event.

Bench testing of soil types likely to be encountered in an earthworks project and highlighting potential problematic soil types has been beneficial in alerting consent issuing authorities to aid in enforcing guidelines or regulations to minimise and for the most part eliminate sediment effects on ecosystems and waterways around or potentially affected by recent projects in New Zealand.

When required the use of chemicals to assist coagulation and/or flocculation, and subsequently reduce settled water turbidity exiting a sediment pond has shown to be very beneficial in reducing or eliminating effects on receiving waters.

The aim of the tests performed on the samples provided was to determine the settling rates of suspended solids mobilised by rainfall events, and if deemed necessary the optimum treatment chemical(s) and approximate dose rate(s) to effectively settle and compact the colloidal or very fine sediment in a retention pond.

Unassisted settling, coagulation and/or flocculation, settled water turbidity and pH was observed and recorded for each jar test and the results used to determine the optimum chemical and approximate dose rate (if any) for each type of soil/sediment provided.

Methodology

Unassisted settling tests

~1L volume of sample was suspended via agitation in ~20L of town supply tap water.

The unassisted settling tests were performed first where samples were drawn from the surface of the settling sample, followed by further agitation of the sample prior to each chemically assisted test.

Each test sample was prepared in 20L plastic pails which were subsequently settled indoors and were not subjected to wind action or significant changes in temperature other than ambient.

Turbidity (NTU) measurement was used to determine the level of clay or colloidal contamination in the sample.

Chemically assisted settling tests

Each settling test was performed on 500mL samples of the suspension as used for the unassisted settling tests.

Each sample was dosed with chemical, then agitated in a “Boltac” coagulation simulator for 10 seconds at 150rpm (to imitate chemical addition prior to the sediment pond fore bay and subsequent mixing in the fore bay and overflow to the pond), followed by 2 minutes at 30rpm (to imitate slow agitation and minimal mixing in the sediment pond), followed by 10 minutes of settling before sampling from the surface of the treated sample.

In an actual sediment pond we would believe this type of test regime to be indicative of the worst case scenario and in working ponds there is likely to be considerably more settling time. However if there is the potential for significant wind action across the pond then this type of test regime will be more likely indicative of actual settling achieved in practice.

To allow distinct measureable doses to be added to the bench tests it is generally accepted that the concentrated chemicals be diluted before addition.

The dilution of chemicals used for the bench testing was based on the following detail as normally specified as water/waste water industry standards…

24 mL of LiquiPAC (Poly aluminium chloride 33.7% or 10.1% as Al_2O_3) as supplied was diluted with 1L of tap water to give 1% solution as PAC.

16 mL of Alum (Aluminium sulphate 47% or 8% as Al_2O_3) as supplied was diluted with 1L of tap water to give 1% solution as Alum.

10 mL of Crystalfloc L3RC (PolyDADMAC 40%) as supplied was diluted with 1L of tap water to give 1% solution as L3RC supplied.

1g of Crystalfloc Polyacrylamide powder as supplied was diluted with 1L of tap water to give 0.1% solution.

Given the above dilutions the samples were tested on the basis that 1mL of the 1% solutions per litre of testing sample/suspension is equivalent to 10 parts per million or 1 mL of the 0.1% solution is equivalent to 1 part per million (ppm or g/m^3).

Summary

Environment Bay of Plenty

Soil samples provided had in general sufficient particle size to allow self settling given relevant time frames as highlighted.

The only clear exception to this was the “Taupo pumice” sample which has a very mobile clay component and/or very fine clay/colloidal particles which remained in suspension long enough to potentially create settling issues in an earthworks project.

The pH of the samples tested did not appear to be an issue even after addition of the optimum dose of coagulant.

Discussion

If low pH proves to be an issue and the aluminium based coagulants are preferred it would be wise to investigate the use of an alkaline chemical post coagulation to increase the pH to an acceptable level. Products such as lime or soda ash could potentially be used to increase pH before discharge. This does not appear to be a significant issue for Environment Bay of Plenty soils tested.

Another option would be to use the organic coagulant Crystalfloc L3RC (PolyDADMAC) which has little or no impact on pH.

One of the downsides of the use of L3RC is due to the SG being close to that of water we have not found it to be suitable for broadcast dosing on the surface of a sediment pond.

The use of town supply tap water (as used in this testing) will add a small amount of alkalinity to the test sample, which in general will tend to give slightly higher settled water pH than tests performed with rain water or actual results in practice.

Recommendations

Environment Bay of Plenty

Low dose rates of either PAC or L3RC are suitable for the two clay types identified in the settling tests to potentially require chemical treatment (Taupo pumice and Kaharoa ash).

The Taupo pumice sample highlighted the potential risk of overdosing the chemical as settled water turbidity results deteriorated as the chemical doses increased.

PAC was the most cost effective option of the products tested.

If the receiving waters are vulnerable and require the site discharge to have very low turbidity the use of Polyacrylamides as highlighted below can give better quality settled water than the coagulants tested.

Unassisted Settling Test Data ENVIRONMENT BAY OF PLENTY

Unassisted settling tests ENVIRONMENT BAY OF PLENTY

	Sample NTU			
Time	**Tarawera ash**	**Rotomahana mud**	**Kaharoa ash**	**Taupo pumice**
10 min	55.6	162	>1000	>1000
20 min	28.8	73	657	>1000
30 min	22.5	61.5	510	>1000
1 hour	16.1	34.3	272	>1000
2 hours		21.8	178	>1000
3 hours			163	>1000
4 hours			150	>1000
12 hours			24.8	759
24 hours				689
48 hours				548
72 hours				502

Discussion of Unassisted Settling Test Data for ENVIRONMENT BAY OF PLENTY samples

The Taupo pumice sample had the highest risk in terms of settled water turbidity vs time and appeared to contain very fine clay or colloidal component which gave settled water a pale pink or white colouration even after an extended period of settling.

This sample was tested for optimal coagulation chemical(s) on the basis it would most likely be an issue in a sediment pond.

Orica was involved in the storm water relief sewer which was recently instated in Otumoetai, which had a high level of this Taupo pumice type material throughout the project. We identified at the time that a polyacrylamide product (Crystalfloc B570LPWG) gave significant improvements to the contractors settling and dewatering processes allowing them to comply with the consents issued for the project so this type of chemical was included in the chemically assisted testing.

The Kaharoa ash sample settled well over a relatively short time frame but could potentially remain in suspension or be drawn into suspension if pond design does not allow for adequate settling area.

This sample was tested for optimal coagulation chemical on the basis it could potentially be an issue.

The table above shows the Tarawera ash and Rotomahana mud samples settled very well and we would expect that these types of soil would be easily retained in a suitable size sediment retention pond. These samples were not tested for optimal coagulation chemical based on the unassisted settling test results.

Chemically Assisted Settling Test Data ENVIRONMENT BAY OF PLENTY

Taupo pumice					
PAC ppm	pH	NTU at 10 min	Alum ppm	pH	NTU at 10 min
0	6.65		0	6.63	
2	6.63	550	4	6.46	>1000
4	6.6	508	8	6.3	>1000
6	6.56	518	12	6.2	>1000
8	6.52	534	16	6.08	>1000
10	6.27	770	20	5.84	883
20	6.16	863	24	5.69	831
30	6.1	>1000	28	5.43	950
40	5.95	>1000	32	5.36	>1000
L3RC ppm	pH	NTU at 10 min	Polymers	NTU at 10 min	
0	6.62		610H 0.6ppm	386	
1	6.62	997	630H 0.6ppm	>1000	
2	6.62	767	490H 1.0ppm	482	
3	6.62	>1000	610H 1.0ppm	312	
4	6.62	>1000	570L 1ppm	527	
8	6.62	>1000	570L 2ppm	87.2	
12	6.62	>1000	610H 2.0ppm	280	
16	6.62	>1000			
Kaharoa ash					
PAC ppm	pH	NTU at 10 min	Alum ppm	pH	NTU at 10 min
0	6.68		0	6.69	

10	6.55	132	10	6.42	687
20	6.44	137	20	6.18	183
30	6.4	161	30	6.02	106
40	6.36	194	40	5.94	90.9
L3RC ppm	pH	NTU at 10 min			
0	6.69				
2	6.69	241			
4	6.69	261			
6	6.69	336			
8	6.69	357			

Indicative Chemical Costs

LiquiPAC (Poly aluminium chloride) single item

1000L pods $1500 each, 200L drums $450 each, 20L jerrycan $125 each

Alum (Aluminium sulphate) single item

1000L pods $900 each, 200L drums $300 each, 20L jerrycan $90 each

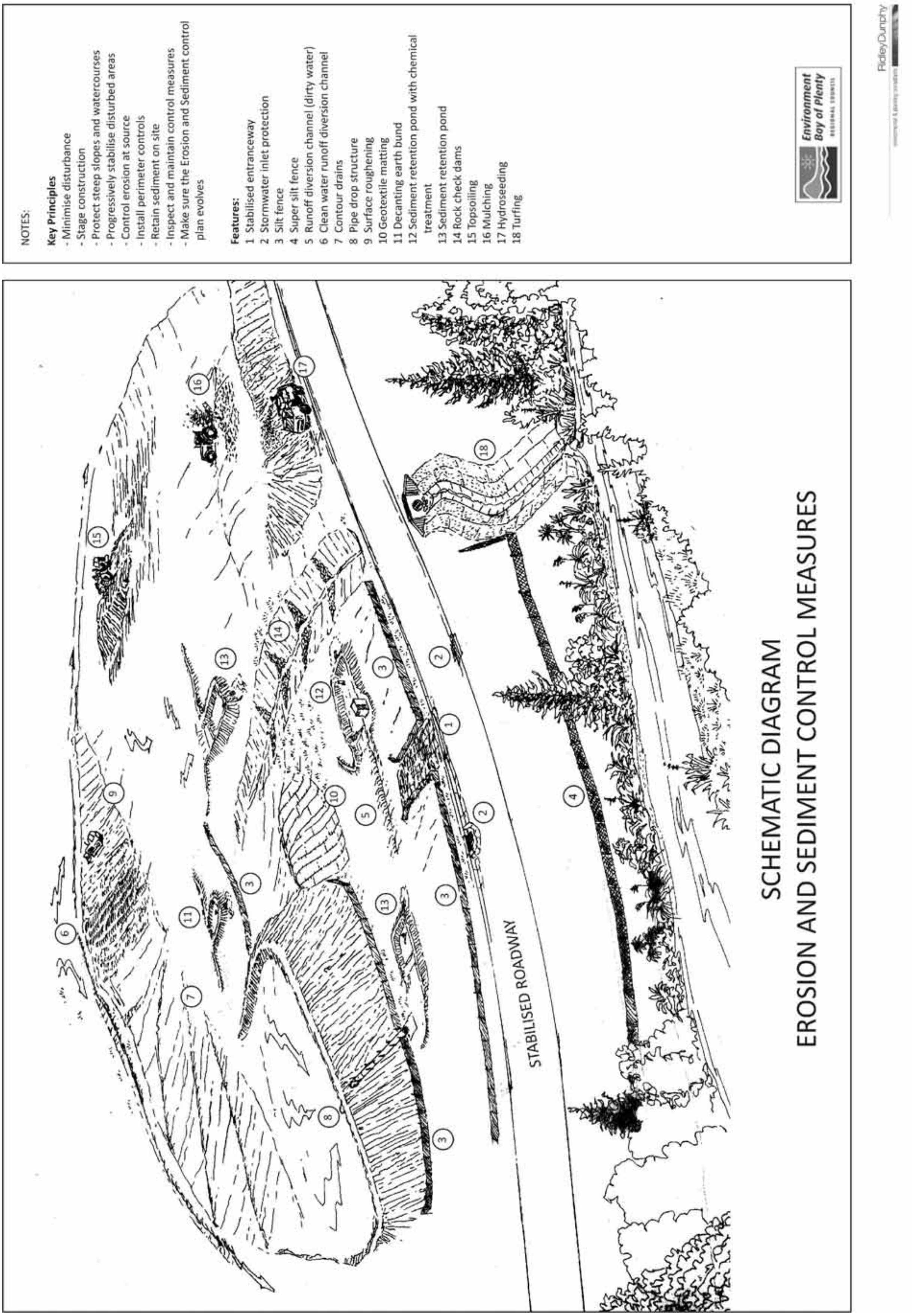
Crystalfloc L3RC (PolyDADMAC) single item

1000L pods $7.50/kg, 200L drums $8.50/kg, 20L jerrycan $9.50/kg

Crystalfloc Polyacrylamides B570L (or similar product) single item

25kg bags $13.50/kg

Appendix 4 – Schematic Diagram



Appendix 5 – Universal Soil Loss Equation Information

When utilising USLE on your site ensure you contact Environment Bay of Plenty to obtain details of site conditions including rainfall and soils. Please note that the USLE is designed to provide guidance only and indicative figures for the various components of the USLE equation.

Estimating Sediment Yield in the Bay of Plenty using the Universal Soil Loss Equation (USLE)

When preparing an application for a resource consent for land disturbance, it is often beneficial to provide an estimate of the sediment yield likely to be discharged from various parts of the subject site during the course of the proposed works. This estimate allows both the applicant and Environment Bay of Plenty to identify areas of high potential sediment yield, and consequent risk, and allows the applicant to develop an appropriate erosion and sediment control methodology for the site that reflects this risk.

The USLE is a relatively simple model which was originally developed in the USA, primarily for agricultural practices. However, it is suitable as a sediment yield estimation tool for a range of land disturbing activities, including earthworks. The USLE method should only be used to identify variation in potential sediment yield across a site, rather than providing a numerically accurate estimate of actual total sediment yield. While the overall estimate of yield is indicative of the magnitude of sediment likely to be discharged, the range of assumptions required in the USLE calculation means that it should not be relied on as an accurate assessment of actual total yield.

It is critical that a site is divided into logical sectors based on variations in slope angle, slope length, soil type and surface cover. Other factors to consider are the proximity and nature of any watercourse in relation to the site. Once the sectors have been determined, a USLE calculation should be completed for each so that variations in sediment generation potential between sectors can be identified. This allows higher risk sectors to be identified and the erosion and sediment control methodology to be tailored to suit variations across the site.

The Universal Soil Loss Equation (USLE)

The following equation provides an estimate of sediment generation (A) in tonnes/ha/yr for a given site:

$A = R*K*LS*C*P$ Where:

R = Rainfall Erosion Index

K = Soil Erodibility Factor

LS = Slope Length and Steepness Factor

C = Ground Cover Factor

P = Roughness Factor

Once the estimate of sediment yield has been determined, the sediment yield from the site is estimated by multiplying A by the area of exposure, the sediment delivery ratio, the sediment control measure efficiency and the duration of exposure.

How to use the USLE

The following provides definitions and guidance on using the USLE to estimate sediment yield from an area of land disturbance.

<u>A Estimated Quantity of Sediment Generated (tonnes/ha/yr)</u>

This is the <u>average annual</u> quantity of sediment generated (eroded) from a particular site or part of a site.

<u>R Rainfall Erosion Index (J/hectare)</u>

R is calculated by the formula $0.00828*p^{2.2}*1.7$; where p is the rainfall for the 6 hour duration 2 year storm event for the subject site. The value of p can be derived from Environment Bay of Plenty hydrological data.

The multiplier of 1.7 converts the R value from imperial to metric units.

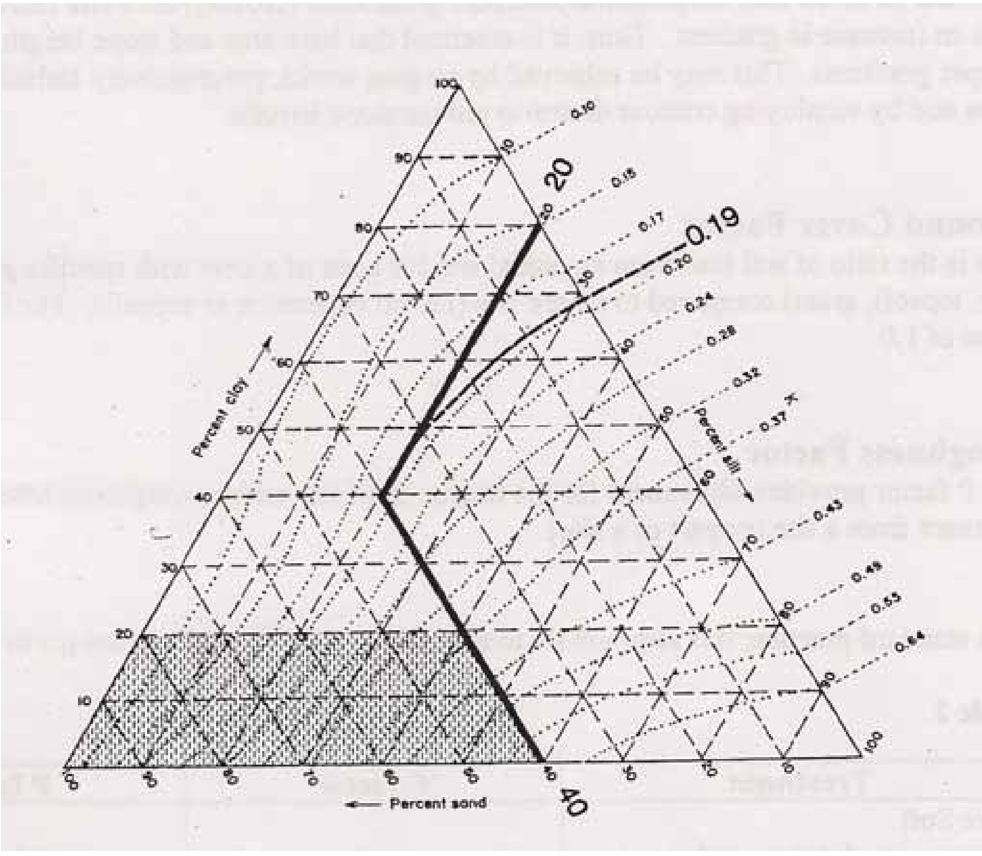
<u>K Soil Erodibility Factor (tonnes/unit of R)</u>

To calculate K, the percentage of sand, silt and clay must be known for each dominant soil type within a site. For the purposes of calculation, the soil type is usually taken as being uniform across the site however, this is not always the case and soil analysis should be undertaken to determine if significant variations occur within the site.

Once the soil type is known, K is calculated as follows:

1 Using the Figure 1 below, estimate the K value for the basic soil type from the following nomograph. The example shown in the nomograph is based on a soil containing 40% sand / 40% clay and 20% silt.

Figure 1 Nomograph for Estimating K Values



2 Correct for organic content using Table 1 below (the nomograph assumes 2% organic matter)

Table 1 K Value Correction Factor

	Correction factor when percent organic matter is:				
K Value	**0% (clay)**	**1%**	**2%**	**3%**	**4% (topsoil)**
Greater than 0.40	+0.14	+0.07	0	- 0.07	-0.14
0.20 – 0.40	+0.10	+0.05	0	-0.05	-0.10
Less than 0.2	+0.06	+0.03	0	-0.03	-0.06

In this table exposed clay is considered 0% organic, topsoil 4% organic. In the above example, for an exposed site, the value would be corrected by 0.06 giving a value of 0.25.

3 Multiply the corrected K Value by 1.32 to convert from imperial to metric. The above example would from a K value of 0.33.

LS Slope Length and Steepness Factor (dimensionless)

To determine the LS factor, slope length and slope gradient must be known. Using these parameters, the LS factor for a particular slope is read from Appendix A of this document. In developing the USLE methodology, a standardised slope was used to determine soil loss. The LS factor derived from Appendix A provides correction for variation in the actual slope gradient and length compared to the standardised slope.

It should be noted that the potential sediment generation on a site increases with an increase in both slope angle and slope length. Thus, it is essential that bare area, slope length and where possible slope angle are minimised. This may be achieved by staging works, progressively stabilising completed areas and by employing contour drains to reduce slope lengths.

C Ground Cover Factor

This is the ratio of soil loss from an actual site (or parts of a site) with specific ground cover (e.g. clay, topsoil, grass) compared to a bare site (i.e. no vegetation or topsoil). A bare site is given a C value of 1.0.

P Roughness Factor

The P factor provides adjustment for the degree to which surface roughness affects the erosion of sediment from a site (or part of a site).

As a standard practice, it is appropriate to use the range of C and P values given in Table 2 below.

Table 2 USLE C and P Factors

Treatment	C Factor	P Factor
Bare Soil		
- compacted and smooth	1.0	1.32
- track walked on contour	1.0	1.2
- rough irregular surface	1.0	0.9
- disked to 250 mm depth	1.0	0.8
Native vegetation (undisturbed)	0.01	1.0
Pasture (undisturbed)	0.02	1.0
Establishing grass	0.1	1.0
Mulch – on subsoil	0.15 (3 month period only)	1.0
Mulch – on topsoil	0.05 (3 month period only)	1.0

Estimating Sediment Yield

Once the values for R, K, LS, C and P have been derived, the value for A (estimated quantity of sediment generated) can be calculated. This represents sediment generation only (tonnes/ha/yr). To estimate the quantity of sediment likely to be discharged to the receiving environment (sediment yield), it is necessary to multiply A by the area of exposure, the sediment delivery ratio, the sediment control measure efficiency and the duration of exposure.

Area of Exposure (ha)

The value for A is given in tonnes/ha/yr. To derive an estimate of sediment yield from a particular site (or part of a site), the actual area of exposed ground must be taken into account.

Sediment Delivery Ratio (0.0 – 1.0)

In general, some of the sediment that is initially entrained (eroded) within a site will not be transported to the sediment control measures, or even to the bottom of the slope. This sediment will be retained within depressions, rough surfaces and vegetation. The sediment delivery ratio takes into account the likely ratio of sediment retained on the site, or part there of, compared to the gross amount of sediment generated (eroded). In general, a sediment delivery ratio of 0.5 is accepted however, if slopes are steep and/or immediately adjacent to the receiving environment, the sediment delivery ratio may be considerably higher. For concave slopes, the sediment delivery ratio may be somewhat lower.

Sediment Control Measure Efficiency (%)

The efficiency of sediment control measures must be taken into account when estimating net sediment yield. For coarse grained soils or with the use of chemical flocculation systems, the efficiency may be higher while conversely, for fine grained soils, including those with a high clay content, this efficiency may be lower. Environment Bay of Plenty should be consulted to determine any recent research results with respect to efficiency of particular control measures.

Duration of Exposure (yrs)

The USLE provides an estimate of average annual soil loss. As most consented sites will only be exposed for part of the year, the duration of the works and the time for which the site will be under various land covers must be taken into account.

Example

Table 3 below gives an example of how all of the above factors can be used to provide an estimate of sediment yield (tonnes) from a particular site that has been assessed in three separate areas. In the example, R is derived to be 67.2, the slope length and gradients are as per Table 3, soil type is 32% clay / 20% sand and 48% silt. The site will be worked for four months with the example for the construction period only.

Table 3 Example USLE Calculation

Section of Site	Area (ha)	R	K	LS	C	P	Duration (yrs)	Sediment Generation	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Net Sediment Yields (tonnes)
Area A	3.3	67.2	0.62	1.19	1.0	1.32	0.33	71.3	0.5	75	**8.9**
Area B	5.0	67.2	0.62	3.51	1.0	1.32	0.33	318.5	0.5	75	**39.8**
Area C	1.0	67.2	0.62	7.39	1.0	1.32	0.33	134.1	0.5	75	**16.8**
Total								523.9			**65.5**

Soil Type

32% Clay / 20 % sand / 48% Silt

Slope Length and Angle

Area A 150m slope length 5% slope

Area B 200m slope length 10% slope

Area C 100m slope length 20% slope

Points to Note

The USLE should always be carried out for each part of a site where slope, soil type and/or surface cover vary.

It is clear that an exposed clay surface will generate considerably more sediment than stabilised or partially stabilised surfaces. This highlights the benefit of staging works and minimising bare areas.

The value used for the sediment delivery ratio has a big impact on the estimated yield. As this is difficult to assess, it is more conservative to use a higher value, especially for steeper slopes.

If the sediment control efficiency is 75%, multiply the previous product by 0.25 i.e. only 25% of the sediment passes through the control measure.

It is essential to maintain all erosion and sediment control measures in accordance with Environment Bay of Plenty Guidelines. This will maximise their efficiency and minimise the volume of sediment discharged from the site (sediment yield).

Bibliography

Estimating Sediment Yield using the Universal Soil Loss Equation – Auckland Regional Council Landfacts.

Goldman SJ, Jackson K and Bursztynsky T, 1986. Erosion and sediment Control Handbook. McGraw Hill.

Appendix A

Slope Ratio s,%	Slope Length, m 10.00	25.00	50.00	75.00	100.00	125.00	150.00	175.00	200.00	225.00	250.00	275.00	300.00
0.50	0.08	0.09	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15
1.00	0.09	0.12	0.15	0.17	0.18	0.20	0.21	0.22	0.23	0.23	0.24	0.25	0.26
2.00	0.14	0.19	0.23	0.26	0.29	0.31	0.32	0.34	0.35	0.37	0.38	0.39	0.40
3.00	0.21	0.27	0.33	0.38	0.41	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.57
4.00	0.26	0.37	0.49	0.57	0.64	0.70	0.76	0.80	0.85	0.89	0.93	0.96	1.00
5.00	0.31	0.48	0.69	0.84	0.97	1.08	1.19	1.28	1.37	1.45	1.53	1.61	1.68
6.00	0.39	0.61	0.86	1.06	1.22	1.36	1.49	1.61	1.72	1.83	1.93	2.02	2.11
7.00	0.47	0.75	1.06	1.29	1.49	1.67	1.83	1.98	2.11	2.24	2.36	2.48	2.59
8.00	0.57	0.90	1.27	1.56	1.80	2.01	2.20	2.38	2.54	2.70	2.84	2.98	3.11
9.00	0.67	1.06	1.50	1.84	2.13	2.38	2.60	2.81	3.01	3.19	3.36	3.53	3.68
10.00	0.78	1.24	1.75	2.15	2.48	2.77	3.04	3.28	3.51	3.72	3.92	4.11	4.30
11.00	0.91	1.43	2.02	2.48	2.86	3.20	3.51	3.79	4.05	4.29	4.53	4.75	4.96
12.50	1.10	1.74	2.46	3.02	3.48	3.89	4.26	4.61	4.92	5.22	5.51	5.77	6.03
15.00	1.47	2.32	3.28	4.02	4.64	5.19	5.68	6.14	6.56	6.96	7.34	7.69	8.04
16.70	1.74	2.76	3.90	4.77	5.51	6.16	6.75	7.29	7.79	8.27	8.71	9.14	9.55
20.00	2.34	3.70	5.23	6.40	7.39	8.26	9.05	9.78	10.45	11.09	11.69	12.26	12.80
22.00	2.73	4.32	6.11	7.49	8.65	9.67	10.59	11.44	12.23	12.97	13.67	14.34	14.98
25.00	3.38	5.34	7.55	9.25	10.68	11.94	13.08	14.12	15.10	16.01	16.88	17.70	18.49
30.00	4.56	7.21	10.19	12.48	14.41	16.12	17.65	19.07	20.39	21.62	22.79	23.90	24.97
33.30	5.41	8.55	12.09	14.80	17.09	19.11	20.93	22.61	24.17	25.64	27.03	28.34	29.61
35.00	5.86	9.26	13.10	16.05	18.53	20.71	22.69	24.51	26.20	27.79	29.30	30.73	32.09
40.00	7.25	11.47	16.22	19.86	22.93	25.64	28.09	30.34	32.43	34.40	36.26	38.03	39.72
45.00	8.71	13.78	19.48	23.86	27.55	30.80	33.74	36.45	38.96	41.33	43.56	45.69	47.72
50.00	10.22	16.15	22.84	27.98	32.31	36.12	39.57	42.74	45.69	48.46	51.08	53.57	55.95
55.00	11.74	18.56	26.25	32.15	37.13	41.51	45.47	49.12	52.51	55.69	58.71	61.57	64.31
57.00	12.35	19.53	27.62	33.83	39.06	43.67	47.84	51.68	55.24	58.60	61.77	64.78	67.66
60.00	13.27	20.98	29.67	36.34	41.96	46.91	51.39	55.51	59.34	62.94	66.35	69.59	72.68
66.70	15.29	24.18	34.20	41.88	48.36	54.07	59.23	63.98	68.40	72.55	76.47	80.20	83.77
70.00	16.27	25.73	36.39	44.57	51.46	57.53	63.03	68.08	72.78	77.19	81.37	85.34	89.13
75.00	17.72	28.03	39.63	48.54	56.05	62.67	68.65	74.15	79.27	84.08	88.62	92.95	97.08
80.00	19.13	30.25	42.78	52.39	60.50	67.64	74.10	80.03	85.56	90.75	95.66	100.33	104.79
85.00	20.49	32.39	45.81	56.11	64.78	72.43	79.34	85.70	91.62	97.18	102.43	107.43	112.21
90.00	21.79	34.45	48.72	59.67	68.90	77.03	84.38	91.14	97.43	103.35	108.94	114.25	119.33
95.00	23.03	36.41	51.50	63.07	72.83	81.42	89.19	96.34	102.99	109.24	115.15	120.77	126.14
100.00	24.21	38.28	54.14	66.31	76.57	85.61	93.78	101.29	108.29	114.85	121.07	126.98	132.62

Calculated From:

$$LS = \left(\frac{65.41 \times s^2}{s^2 + 10{,}000} + \frac{4.56 \times s}{\sqrt{s^2 + 10{,}000}} + 0.065\right) \times \left(\frac{l}{72.5}\right)^m$$

LS= topographic factor
l = Slope length, m
s = Slope steepness
m = Exponent dependent on slope steepness
0.2 for slopes<1%, 0.3 for slopes 1-3%, 0.4 for slopes 3.5-4.5%, and 0.5 for slopes > 5%)

Appendix 6 – Example Chemical Treatment Management Plan

Project Name

Earthworks

Example Chemical Treatment Management Plan

1 Introduction

[Introduction to project and details of consent conditions related to chemical treatment requirements. Include discussion on the requirement for obtaining any further discharge consents for chemical use.]

It is acknowledged that the application of polyaluminium chloride (PAC) has the potential to affect the receiving environments pH levels. Native freshwater fish species are sensitive to pH changes and accordingly it is recommended that the discharges from the sediment control devices should not cause a reduction in the downstream pH of less than 5.5. This will also ensure that the aluminium in the PAC does not become toxic to fish species.

[Note other flocculants may have other contaminant issues that need to be addressed]

The methods of reducing the risk of overdosing and ensuring an appropriate management or quality assurance of implementing this Chemical Treatment Management Plan is also discussed within this Plan.

[Details of soil samples taken and an outline of the process of collecting the samples.]

2 Automatic rainfall driven system

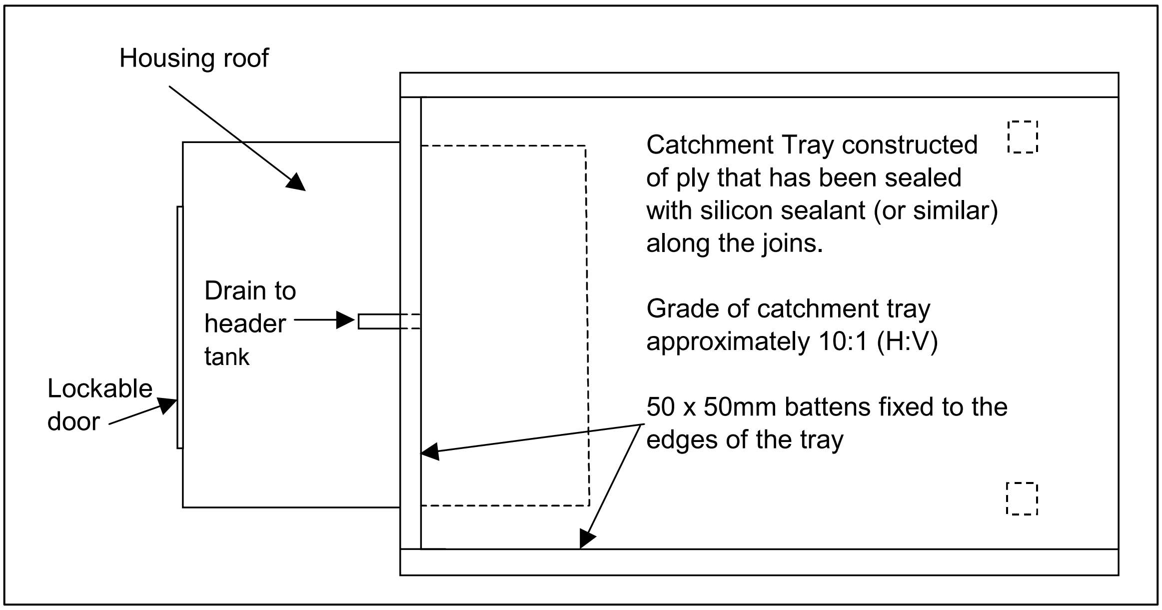
2.1 Introduction

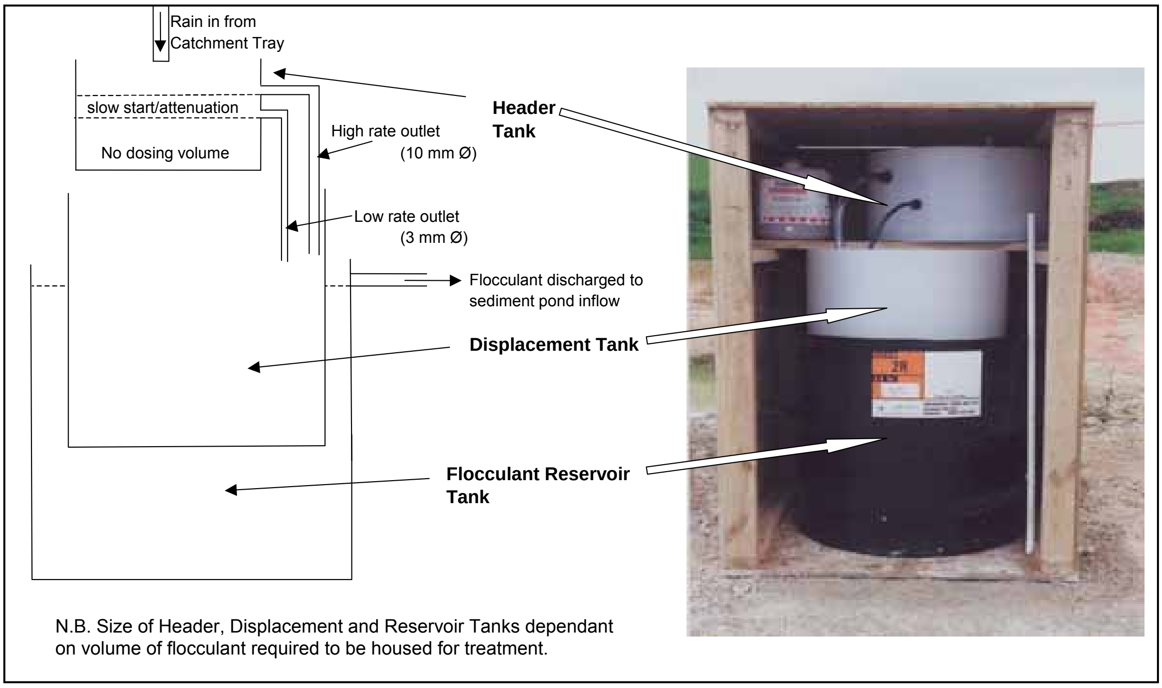
The proposed chemical treatment system is a standard rainfall driven chemical dosing system / manual batch dosing *[describe system to be utilised].*

The system uses a rainfall catchment tray to capture rainfall with the size of the tray determined by the required chemical dose and the land catchment size.

Rainwater caught by the catchment tray is piped into a header tank, and then into a 400L displacement tank which floats in a larger tank containing chemical filled to the level of an outlet pipe leading to the Sediment Retention Pond Inlet Diversion Channel located approximately 5m upstream of the Sediment Retention Pond. The greater the rate of rainwater flow into the displacement tank the greater the flow of chemical into the stormwater channel. The header tank is designed to provide for no dosing during initial rainfall under dry conditions, and for attenuation of the chemical flow during the initial stages of a storm and after rain has ceased at the end of a storm.

Below is the basic design of the rainfall activated system.





2.2 Determination of Dosage Rates

The chemical dose required to achieve satisfactory removal of suspended solids from sediment laden runoff depends on physical and chemical characteristics of the soil.

[Further details of soil sample location and visual observations.]

2.3 Results of Bench Tests

[Include discussion of the results of bench testing including clarity and also pH measurements

Provide details of recommended dosage rates.]

2.4 Area of Rainwater Catchment Tray Required

[Provide details of catchment tray size.]

All water flowing into the pond needs to be treated, and the rainwater catchment tray size is determined by the total land catchment area draining to the pond. If the catchment area draining to the pond is changed, then the catchment tray size should also be changed in proportion. Reduction of the tray size is easily achieved by placing a piece of plywood on top of the upstand over the lower end of the tray, thereby allowing the rain which falls on the plywood to run to waste.

2.5 Header Tank Low Flow and High Flow Pipe

[Provide details of header tank levels – below detail is ideal for PAC.]

The low flow pipe will be constructed from a 10mm internal diameter pipe with a 3mm diameter hole and will be located at a level based on a volume of 12 litres per square meter of roof area. The high flow pipe will have a 10mm internal diameter pipe and will also be located at a level based on a volume of 12 litres per square meter of roof area which will be measured above the low flow pipe. 50mm of freeboard will be provided above the top of the high flow pipe.

2.6 Stormwater Channel and Dosing Point

The chemical needs to be added to the sediment laden diversion channel to provide mixing with the overland runoff before it reaches the area of ponded water in the forebay or the pond itself.

The chemical treatment facility shall be established such that all runoff from the catchment flows into a single channel at least before it reaches the ponded water so the chemical can be added to and mixed with the total storm flows.

The dosing point should be at a location where the chemical will fall into the overland runoff flow during periods of low flow. The end of the dosing tube should be only a few centimetres above the sediment laden diversion channel to ensure that the chemical falls into the overland runoff, and is not blown away during periods of strong wind.

2.7 Monitoring and Maintenance Requirements

2.7.1 Routine management and maintenance

Instructions for routine management and maintenance of the chemical treatment system are attached. A copy of this table will be placed in the chemical treatment system shed.

All monitoring records and maintenance checks and actions should be recorded on the monthly record sheet provided.

2.7.2 Contingency Management

Contingencies could include poor performance of the treatment system, or effects of other influences on stormwater quality.

If the treated water in the pond is consistently very clear it could indicate overdosing and the possibility of lowered pH which can present a risk to receiving waters as a result of elevated free aluminium concentration in the discharge. If the treated water is consistently clear the pH of the water in the pond will be tested.

Contingencies such as poor treatment performance or consistently very clear treated water should be dealt with by consultation with Environment Bay of Plenty.

2.8 Record Keeping and Reporting to Environment Bay of Plenty

A copy of the maintenance record for the chemical treatment system will be kept in the treatment system shed.

The integrity of the treatment system should be checked weekly during both dry and wet weather. This check should include a quick check of the plumbing, a check that the header tank hoses are clear, and a check of the dosing point to ensure that the chemical would drop into the stormwater flow from the site.

After rain, draining of the header tank is required at least on the 3^{rd} day and 6^{th} day following rain, and possibly more frequently if the treated water in the pond is consistently clear.

After moderate or heavy rain the dosing point should be checked to ensure that the chemical is being delivered into the storm flows during low flow conditions.

The integrity of the catchment tray, particularly the seal between the tray and the upstand should be checked monthly.

A copy of the maintenance record for the chemical treatment system for each calendar month will be kept and supplied to Environment Bay of Plenty on request.

2.9 Storage of Chemical on Site

[secure storage, either in a locked shed or container, or in the chemical treatment system shed]

Empty chemical drums will be washed out with water, and the wash water poured onto dry soil well away from any watercourse. Drums can be disposed of to a drum recycling company.

2.10 Chemical Spill Contingency Plan

If there is a spill of chemical onto the ground it should be immediately contained using earth bunds to prevent it entering water. The spilt chemical should be recovered if possible and placed in polyethylene containers.

If there is a spill of chemical into ponded water, discharge from the pond to natural water should be prevented.

If there is a spill of chemical into flowing water:

1 Environment Bay of Plenty should be advised immediately.

2 The volume of the spill should be recorded.

3 If possible the water and spilt chemical should be pumped into a bund or pond until all the spilt chemical has been removed from the watercourse.

4 If the chemical cannot be removed from the watercourse any downstream users should be identified and advised. In association with Environment Bay of Plenty an action plan will be developed.

2.11 Chain of Responsibility for Monitoring and Maintaining the Chemical Treatment Systems

The site supervisor will have primary responsibility for maintenance and monitoring the effectiveness of the chemical treatment system.

2.12 Training of Person Responsible for Monitoring and Maintenance of Chemical Treatment System

Training of the site supervisor will occur to ensure that routine monitoring and maintenance of the system is undertaken and appropriate records kept.

Chemical Treatment System Monitoring and Maintenance Record

Site:
Month:
Pond Reference:
Maintenance Person:

Date	Visual check	Chemical Volume Added	Pond Clarity (cm)	pH in Pond	pH in Receiving Environment	Notes on maintenance required or additional information	Initial

Glossary

AEP (Annual exceedance probability): a statistical term defining the probability of an event occurring annually. Expressed as a percentage and generally used in hydrology to define rainstorm intensity and frequency. For example, a five percent AEP event has a five percent chance of being exceeded in any one year. A five percent AEP event expresses the twenty year return period in more probability terms.

Filter collar/Filter Drain: a drainage filter collar and drainage filter, constructed within the zone of saturation, along the conduit of a primary outlet pipe to increase the seepage length along the conduit and, thereby prevent piping or seepage in the compacted fill material along the outside of the pipe.

Area of disturbance: the area of soil exposed as a result of land disturbance.

Baffles: semi-permeable or solid barriers placed in a Sediment Retention Pond to regulate flow and effect a more uniform distribution of velocities and increase flow path length hence creating better settling conditions.

BPO: best practicable option. In relation to a discharge of a sediment, BPO means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to the nature of the discharge, the sensitivity of the receiving environment, the financial implications and the current state of technical knowledge and the likelihood that the option can be successfully applied.

Bulk earthworks: this term is generally used to describe the cut to fill earthworks associated with larger-scale earthworks.

Clay: a mineral soil consisting of particles less than 0.002mm in equivalent diameter.

Clean water: any water that has not been contaminated by earthworks activities. Includes both on and offsite clean water.

Cohesive soil: a soil that, when unconfined, has considerable strength when air-dried and significant cohesion when submerged.

Compaction: for construction work in soils, engineering compaction is any process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing their shear and bearing strength and reducing permeability.

Concentrated flow: the accumulation of sheet flow into discrete rills, gullies or channels, which in turn significantly increases erosive forces.

Contour: a line across a slope connecting points of the same elevation.

Crimping: the embedding of straw mulch into the soil surface by using implements such as a disc cultivator set at zero cut.

Deposition: the accumulation of material that has settled because of reduced velocity of the transporting agent (water or wind).

Di-ammonium phosphate (DAP): a high-percentage nitrogen and phosphate fertiliser suitable for the rapid establishment of grass.

Diversion: a channel or bund constructed to convey concentrated flow.

Erosion: The process whereby the land surface is worn away by the action of water, wind, ice or other geological processes. The resultant displaced material is known as sediment with sediment yields being the sediment which leaves a particular control measure. Sedimentation is the deposition of this eroded material. Accelerated erosion is primarily caused by human activities and is a much more rapid process then natural erosion.

Flocculation: The process whereby fine particles suspended in the water column clump together and settle. In some instances this can occur naturally, such as when fresh clay-laden flows mix with saline water, as occurs in estuaries. Flocculation can be used to promote rapid settling in Sediment Retention Ponds by the addition of flocculating chemicals (flocculants).

Hydrology: the science of the behaviour of water in the atmosphere, on the surface of the earth and underground.

Hydroseeding: the pressure-spraying of a slurry of water, seed, fertiliser and paper or wood pulp over a surface to be revegetated.

Impervious area: an area with a surface cover that does not allowing infiltration of water.

Level spreader: a device used to convert concentrated flow into sheet flow.

Mulch: covering on surface of soil to protect it and enhance certain characteristics, such as protection from raindrop impact and improving germination.

Perennial (or permanent) stream: a stream that maintains water in its channel throughout the year or maintains a viable aquatic ecosystem.

Permeability (soil): the rate at which water will move through a saturated soil.

Permitted activities: activities described in the Resource Management Act, regulations, or a plan or proposed plan that does not require a resource consent if it complies with the standards, terms, or conditions specified.

Poly aluminum chloride (PAC): an inorganic coagulant that is used as a flocculant.

Return period: the statistical interpretation of the frequency of a given intensity and duration of a rainstorm event. Refer AEP.

Sediment: solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below water.

Sediment delivery ratio: the proportion of the soil eroded from within a catchment area that actually reaches sediment treatment controls or water bodies.

Sediment texture: the relative proportions of different sizes of sediment and soil particles that can be separated by screening.

Sediment yield: the quantity of sediment discharged from a particular site or catchment in a given time, measured in dry weight or by volume. When erosion and sediment control measures are in place, sediment yield is the sediment discharged from the site after passing through those measures.

Silt: a soil consisting of particles between 0.05 and 0.002 millimetres in equivalent diameter.

Slope: degree of deviation of a surface from the horizontal, measured as a numerical ratio, as a percent, or in degrees. Note that a 1:1 slope equates to 45 degrees, 2:1 slope equates to 26.5 degrees and 3:1 equates to 18 degrees.

Degrees	Percent
5	8
10	18
15	27
20	36
30	58
40	84
45	100

Stabilisation: providing adequate measures, vegetative and/or structural that will protect exposed soil to prevent erosion.

Stabilised area: an area sufficiently covered by erosion-resistant material such as a good cover of grass, or paving by asphalt, concrete or aggregate, in order to prevent erosion of the underlying soil. Environment Bay of Plenty consider 80% ground cover as adequate stabilisation.

Staging of construction: the completion of bulk earthworks in successive time phases to minimise the area of bare earth exposed at any one time.

Surface runoff: rain that runs off rather than being infiltrated into or retained on the surface on which it falls.

Suspended solids: solids either floating or suspended in water.

Tackifier: A compound that is added to straw or hay mulch to bind it together and prevent it being blown around by the wind.

Time of concentration: the time for runoff to flow from the most remote part of the drainage area to the outlet.

Turbidity: the cloudiness of a fluid caused by individual particles. Measured in Nephelometric Turbidity Units (NTU).

Universal soil loss equation: an equation used for the design of a water erosion control system:

A = RKLSCP where:

A = the soil loss in tonnes per ha per annum;

R = the rainfall factor;

K = the soil erodibility factor;

LS = the slope length and gradient factor

C = the vegetation factor;

P = the surface roughness factor.

Water table: the upper surface of the free groundwater in a zone of saturation.

Winter earthworks period: the period defined as 1 May to 15 September where the risk of erosion and sediment yield is higher and more stringent control measures are required on earthworks sites with Environment Bay of Plenty approval required for sites to operate.