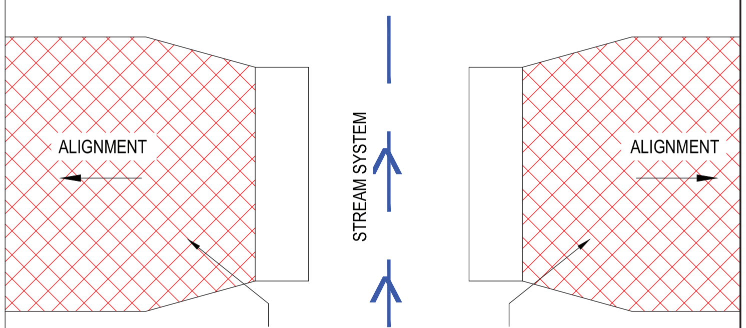
Appendix H.H
Stone Column Drawing: Refer to Drawing CV-CM-245, Management Plan Appendices, Appendix H, Volume 5

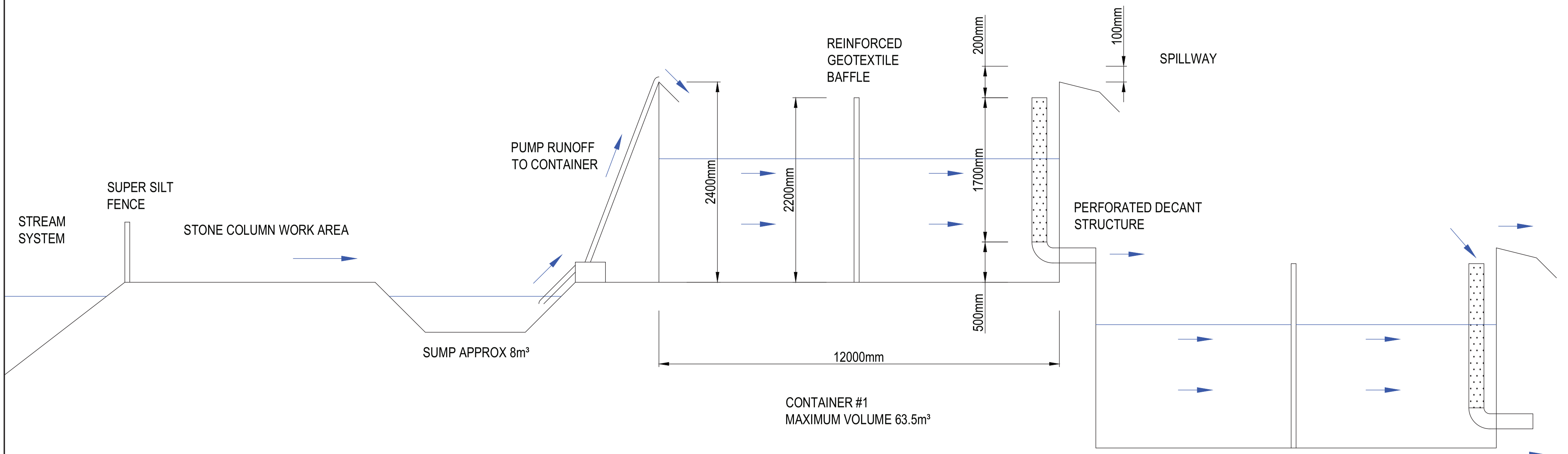
NOTES

1. DRAWING NOT TO SCALE. SCHEMATIC ONLY.
2. BAFFLE DESIGNED FROM REINFORCED GEOTEXTILE TO ALLOW FLOWS TO PASS.
3. STRUCTURAL INTEGRITY OF CONTAINERS WOULD REMAIN
4. CONTAINER #1 WILL BE POSITIONED 1.9m HIGHER THAN CONTAINER #2. IF CONTOURS DO NOW ALLOW THIS THEN CONTAINER #1 WILL BE ARTIFICIALLY RAISED BY 1.9m.
5. WATER CLARITY CAN BE CHECKED IN CONTAINER #2 AND FLOCCULANT UTILISED IF NECESSARY TO ACHIEVE WATER CLARITY.
6. RECYCLING OF WATER BACK TO WORKS AREA WILL OCCUR.

SCHEMATIC OF LOCATION



PEAT REMOVAL AND STONE COLUMN INSTALLATION AT BRIDGE ABUTMENTS APPROXIMATELY 3000m² EACH



NOTES:	Original Scale (A3)

Revision.	Amendment.	Approved.	Date.
+			

NZ TRANSPORT AGENCY
WAKA KOTAHI

Project: MACKAYS TO PEKA PEKA EXPRESSWAY

Title: EROSION & SEDIMENT CONTROL
STONE COLUMN WATER MANAGEMENT

UNDER REVISION

Status: -
Document ID: M2PP-AEE-DWG
Drawing No: CV-CM-245
Rev. +

Document No. M2PP-AEE-DWG-CV-CM-245.DWG

Document created for NZTA by M2PP Alliance, Level 2, 17-21 Whitmore St, WELLINGTON

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Appendix H.I
ESCP Design Drawings: Refer to Drawings
CV-CM-248 - CV-CM-251, Management Plan Appendices,
Appendix H, Volume 5

Appendix H.J
Greater Wellington Regional Council and NZTA ESCP Principles

4. Erosion and sediment control concepts

4.1 Key principle of erosion and sediment control

The overarching principle of erosion and sediment control on earthworks sites is to limit sediment transport and deposition. As a number of factors (e.g. rainfall intensity, soil composition) are beyond our control, it therefore falls to applying the most appropriate solution for the circumstances. As there are numerous devices at our disposal, the integration of as many concepts as possible provides the most effective erosion and sediment control on site (Georgetown County, 2006).

These concepts are typically formalised through the use of erosion and sediment control practices detailed in an Erosion and Sediment Control Plan (ESCP) prepared for the land disturbing activity.

4.2 Advantages of erosion and sediment control

With careful pre-planning, erosion and sediment controls usually result in many on-site advantages in addition to protecting the environment.

Environmental benefits include:

- Reduced risk of damage to aquatic ecosystems,
- Improved appearance of the site and downstream waters,
- Reduced water treatment costs,
- Reduced blockage of drains, and
- Less mud dropped or washed onto roads.

On-site benefits can typically include:

- Improved drainage and reduced site wetness as a result,
- Less dust problems,
- Improved working conditions,
- Reduced downtime after rain,
- Less stockpile losses,
- Reduced clean-up costs,
- Earlier works completion, and
- Less chance of public complaints.

4.3 Concepts and principles of erosion and sediment control

Implementation of erosion and sediment controls is required to avoid, remedy or mitigate the effects of earthworks on the receiving environment. To ensure that erosion and sediment controls are effective and cost efficient, an understanding of the basic principles of erosion and sediment control is required, as is ensuring that erosion and sediment control practices are considered and carefully managed throughout the project's planning, design and construction phases (Environment Canterbury, 2007).

State highway project's construction timeframes may take longer to construct than other types of construction projects, and the resulting longer operational life of many erosion and sediment controls, requires a stronger emphasis on some management concepts (Department of Environment and Climate Change NSW, June 2008), particularly:

- The control of upper catchment water,
- Separation of clean from dirty water,
- Protecting the land surface from erosion, and
- Preventing sediment from leaving the site.

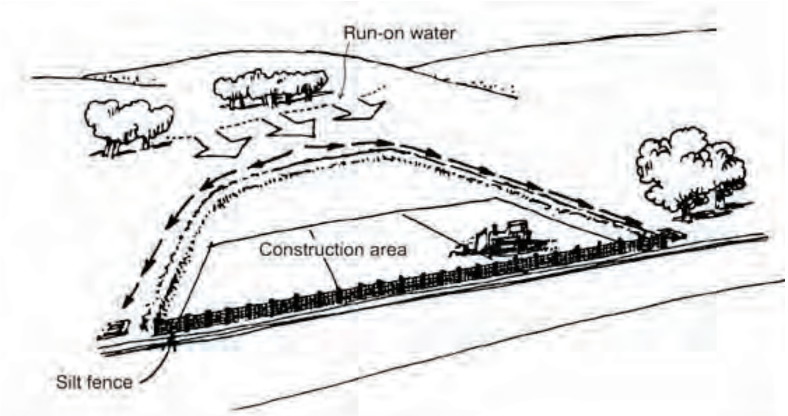
The following concepts are therefore relevant when designing an erosion and sediment control plan for a state highway project site.

4.3.1 Control upper catchment water

Upper catchment water is runoff from above the area of disturbance that would normally flow through the site. The key consideration in reducing the contributing catchment is to control this clean water by interception, diversion and safe disposal to a location below the area of disturbance as shown in Figure 4.1.

Reducing the area of the catchment contributing to water flowing through the site will reduce the volume of water to be treated thereby minimising the sizing of any controls.

Figure 4.1
Diversion of clean water from above the site (Goldman et al 1986)



Diversion separating the clean water from the dirty water

4.3.2 Separate clean from dirty

Clean water is water that has not flowed through disturbed areas whilst discharges from disturbed areas are considered to be dirty water. Minimising the volume of water that is required to be treated by a sediment control device saves space and money. Furthermore clean water (upper catchment water that does not flow through the disturbed area) has not been contaminated by sediment, therefore does not require treatment. Practices to achieve this are outlined in Section 7 of this standard.

4.3.3 Reduce the area available for erosion

To minimise the rates of soil loss, techniques as outlined in section 8 of this standard will assist however, protecting the land surface from erosion can be as simple as:

- Project design taking into account terrain limitations,
- Project scheduling to known climatic and soil variations,
- Minimising land clearance,
- Limiting areas of disturbance, and
- Progressively stabilising disturbed areas (e.g. grassing and mulching)

Erosion Control – Mulching

4.3.4 Minimise sediment from leaving the site

Sediment laden water (dirty water), as discussed in previous sections, can have a variety of impacts if not managed in accordance with best practice. Therefore it is imperative that a suite of controls are used on state highway construction projects. Sediment controls should be selected taking into account the site constraints and receiving environment, and steps should be taken to ensure that the controls are integrated with the permanent features of the project. Refer to the practices outlined in section 8.

Sediment Control Practices

4.4 The role of erosion and sediment controls

Erosion and sediment controls have different roles on an earthworks site. Erosion controls seek to minimise any sediment from being mobilised whilst sediment controls attempt to remove sediment from suspension once entrained. The analogy of erosion controls (fence at the top of the cliff) whilst sediment controls (ambulance at the bottom of the cliff) is applicable in describing their roles.

Any ESCP should place initial emphasis on erosion control although in many circumstances this may not be achievable.

4.4.1 Efficiency vs effectiveness of practices

The ability of an erosion and sediment control practice to prevent sediment from being transported or to remove sediment once entrained is a measure of its efficiency. This efficiency (as a %) can be represented as the volume removed when measured against the volume of sediment that arrives at the practice. Depending on a range of factors the removal efficiency can range from 50% to 75%.

Efficiency should not be confused with effectiveness. The effectiveness of a specific practice takes into consideration other factors such as the timing, cost, sensitivity of receiving environment and placement location of the device. For example, a sediment retention pond placed in an area that receives little or no water is still an efficient practice but is not an effective measure for that particular site.

4.5 The treatment train

A treatment train comprises a series of best management practices and/or natural features, each planned to treat a different aspect of pollution prevention, that are implemented in a linear fashion to maximise pollutant removal. This approach is directly applicable to the control of sediment on state highway projects.

Erosion and sediment control measures should generally be planned to link functionally to form a "treatment train" with each measure having a specific role within the framework of surface water management, soil protection and stabilisation, and sediment capture. This approach can be a combination of structural (e.g. sediment ponds, hydroseeding) and non-structural (e.g. earthworking season) practices.

This approach needs to be considered during the early phases of project planning, and followed through to the completion of the project. Section 5 of this document will detail how to select the appropriate tools to ensure that this approach occurs.

4.6 Principles to follow

These ten principles (best practice principles) build upon the previous concepts and provide guidance for erosion and sediment control through the planning, construction and maintenance phase of a project

4.6.1 Minimise disturbance

Fit earthworks, construction techniques and methodologies to land sensitivity. This may be difficult from a state highway perspective where space is limited but the concept should always be considered.

Some parts of a site should never be worked and others need very careful working. Watch out for and, if practicable, avoid areas that are wet (streams, wetlands and springs), have steep or fragile soils or are conservation sites or features.

Bear in mind a minimum earthworks strategy and only clear areas required for structures or access.

Show all limits of disturbance on the ESCP. On site, clearly show the limits of disturbance using fences, signs and flags.

Highway Construction Site – Minimising Disturbance

4.6.2 Stage construction

Carrying out bulk earthworks over the whole site maximises the time and area that soil is exposed and prone to erosion. "Construction staging", where the site has earthworks undertaken in small units over time with progressive revegetation, limits erosion.

Careful planning is needed. Temporary stockpiles, access and utility service installation all need to be planned. Construction staging differs from sequencing. Sequencing sets out the order of construction to contractors. Detail both construction staging and sequencing in the ESCP.

4.6.3 Protect Steep Slopes

Where possible avoid existing steep slopes. If clearing of steep slopes is necessary, runoff from above the site can be diverted away from the exposed slope to minimise erosion. If steep slopes are worked and need stabilisation, traditional vegetative covers like

Flume Installed to Protect Steep Slope

topsoiling and seeding may not be enough - special protection is often needed.
Highlight steep areas on the ESCP showing limits of disturbance and any works and areas for special protection.

4.6.4 Protect watercourses

Existing streams and watercourses, and proposed drainage patterns need to be mapped. Resource consent may be required for clearance works adjacent to a watercourse.

Map all watercourses and show all limits of disturbance and protection measures in the ESCP. Also, the ESCP should show all practices to be used to protect new drainage channels. Indicate crossing or disturbances and associated construction methods in the ESCP.

Sediment Discharge as a Result of Not Protecting the Watercourse

4.6.5 Stabilise exposed areas rapidly

An important objective is to fully stabilise disturbed soils with vegetation after each stage and at specific milestones within stages. Methods are site specific and can range from conventional sowing through to straw mulching. Mulching is the most effective instant protection.

In the ESCP clearly define time limits for grass or mulch application, outline grass rates and species and define conditions for temporary cover in the case of severe erosion or poor germination.

Rapid Stabilisation

4.6.6 Install perimeter controls

Perimeter controls above the site keep clean runoff out of the worked area - a critical factor for effective erosion control. Perimeter controls can also retain or direct sediment laden runoff within the site. Common perimeter controls are diversion drains, silt fences and earth bunds.

Detail the type and extent of perimeter controls in the ESCP along with the design parameters for those controls.

Types of Perimeter Controls

4.6.7 Employ detention devices

Sediment Retention Pond

Even with the best erosion and sediment practices, earthworks will discharge sediment laden runoff during storms. Along with erosion control measures, sediment retention structures are needed to capture runoff so sediment generated can settle out. Sediment retention ponds are often not highly effective in areas with fine grained soils. In those areas it is necessary to ensure the other control measures used are appropriate for the project and adequately protect the receiving environment.

Include sediment retention structure design specifications; detailed inspection and maintenance schedules of structures and conversion plans for permanent structures, in the ESCP.

4.6.8 Experience and training

A trained and experienced contractor is an important element of an ESCP. Contractors are individuals responsible for installing, maintaining and decommissioning erosion and sediment control practices.

Critical on-site staff should go through an erosion and sediment control training programme that may be available either locally or elsewhere in New Zealand. The NZTA also has an e-learning module on erosion and sediment control in development. Better knowledge can save project time and money, by allowing for identification of threatened areas early on and putting into place correct practices.

Making arrangements for a pre-construction meeting, regular inspection visits, and final inspection is also important.

4.6.9 Make sure the plan evolves

An effective ESCP is modified as the project progresses from bulk earthworks to permanent drainage and stabilisation. Factors such as weather, changes to grade and altered drainage can all mean changes to planned erosion and sediment control practices.

Update the ESCP to suit site adjustments in time for the pre-construction meeting and initial inspection of installed erosion and sediment controls, and make sure it is regularly referred to and available on site.

4.6.10 Assess and adjust

Inspect, monitor and maintain control measures.

Undertaking Maintenance of a Sediment Retention Pond

Assessment of controls is especially important following a storm. A large or intense storm will leave erosion and sediment controls in need of repair, reinforcement or cleaning out. Repairing without delay reduces further soil loss and environmental damage.

Assessment and adjustment is an important erosion and sediment control practice -make sure it figures prominently in the ESCP.

Assign responsibility for implementing the ESCP and monitoring control measures as the project progresses.

The ESCP should also be integrated with the Contractor's Social and Environmental Management Plan, therefore, reducing duplication in the site specific environmental aspect management plans.

4.7 Bibliography

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Department of Environment and Climate Change NSW, Managing Urban Stormwater - Soils and Construction, Volume 2D Main Road construction, June 2008

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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.

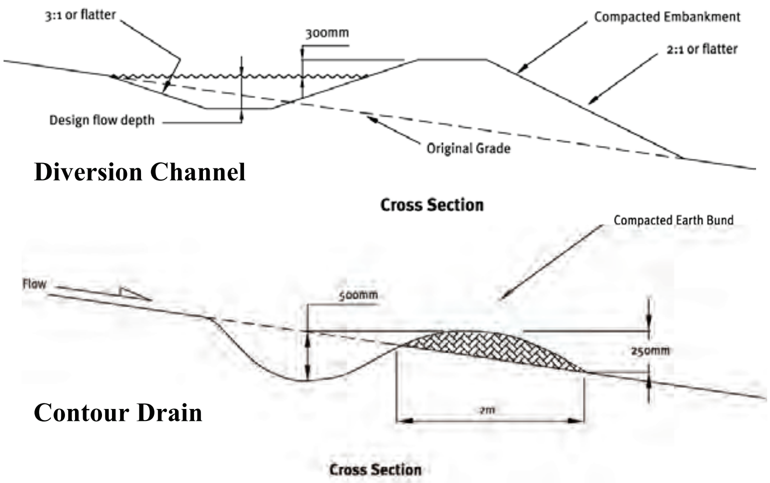
Georgetown County, Storm Water Management Design Manual, November 2006.

Goldman S J, Jackson K and Bursztynsky T, Erosion and Sediment Control Handbook, 1986.

Appendix H.K
NZTA ESCP Checklists

Erosion and Sediment Control Inspection Checklist

Check List for Contour Drains and Diversions



Contractor: Inspector:	Date: Time:	Consent #:	Site:

Site Inspection of Erosion and Sediment Control Practices

Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Contour drains				
Minimum compacted height is 250 mm				
Minimum depth of 500 mm				
Longitudinal grade < 2% w/out lining				
Catchment area < 0.5 ha				
Parabolic flow area and not V shaped				
Diversion channels and bunds				
Choose a route that avoids trees, services, fence lines or other natural or built features				
Channels shall be trapezoidal or parabolic in shape.				
Internal side slopes no steeper than 3:1 External side slopes no steeper than 2:1				
Bunds shall be well compacted				

Outlets shall be stable and protected as needed				
Diversions shall be stabilised to prevent erosion				
Maintenance				
Contour drains				
Repair or reinstate drains if destroyed by equipment				
Inspect contour drains after rainfall and repair as necessary				
Check outfall for erosion and repair as needed				
Diversion channels and bunds				
Inspect weekly and after every rainfall and repair immediately				
Remove accumulated sediment				
Check inlets and outlets to ensure that these remain scour and erosion free				
Look for low spots where water can pond, formation of tunnel gullies and debris blockage				
Check for stabilisation cover				
Protect bunds from equipment damage				
Decommissioning				
Contour drains				
Spread bunded area and stablise				
Diversion channels and bunds				
Fill in channels and spread bunded area and stabilise				

	Erosion and Sediment Control Inspection Checklist
Check List for Dust Suppression	

Contractor: Inspector:	Date: Time:	Consent #:	Site:

Site Inspection of Erosion and Sediment Control Practices

Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Has issue been considered at project initiation				
What method of suppression has been selected (water, adhesives, barriers, mulches)				
Maintenance				
Periodically inspect areas to ensure dust is kept to a minimum				
Decommissioning				
Ensure good stabilisation occurs				

NZ TRANSPORT AGENCY WAKA KOTAHI	Erosion and Sediment Control Inspection Checklist
Check List for Mulching	

Contractor: Inspector:	Date: Time:	Consent #:	Site:

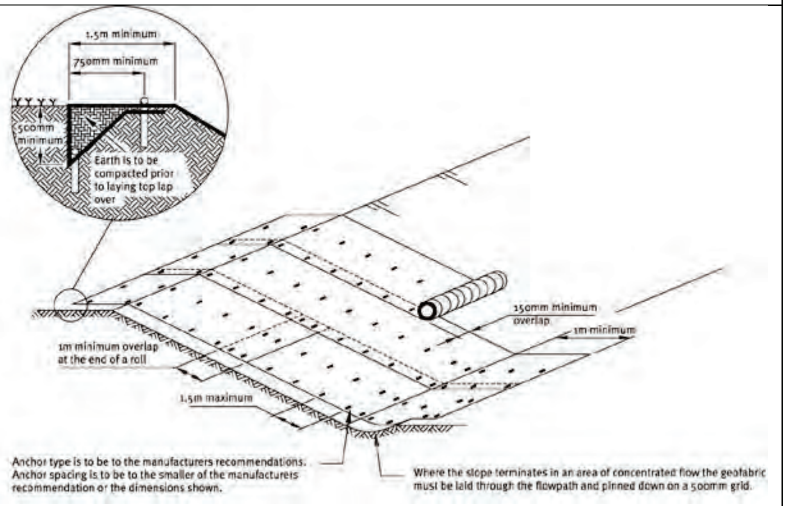
Site Inspection of Erosion and Sediment Control Practices

Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Straw or hay shall be unrotted material and applied at a rate of 6,000 kg/ha				
If wind is a problem mulch should be either crimped or bound to prevent blowing				
Hydro mulch must contain a minimum of 80% virgin or recycled wood, be in accordance with manufacturers specifications and from 2,200 kg/ha – 2,800 kg/ha and slope length < 150 m				
Wood chip can be applied at rates of 10,000 kg/ha – 13,000 kg/ha				
Maintenance				
Inspect after each rainfall or after strong winds and repair or replace as needed				
Decommissioning				
Ensure good stabilisation occurs				

NZ TRANSPORT AGENCY
WAKA KOTAHI

Erosion and Sediment Control Inspection Checklist

Check List for Geotextiles



Contractor: Inspector:	Date: Time:	Consent #:	Site:

Site Inspection of Erosion and Sediment Control Practices

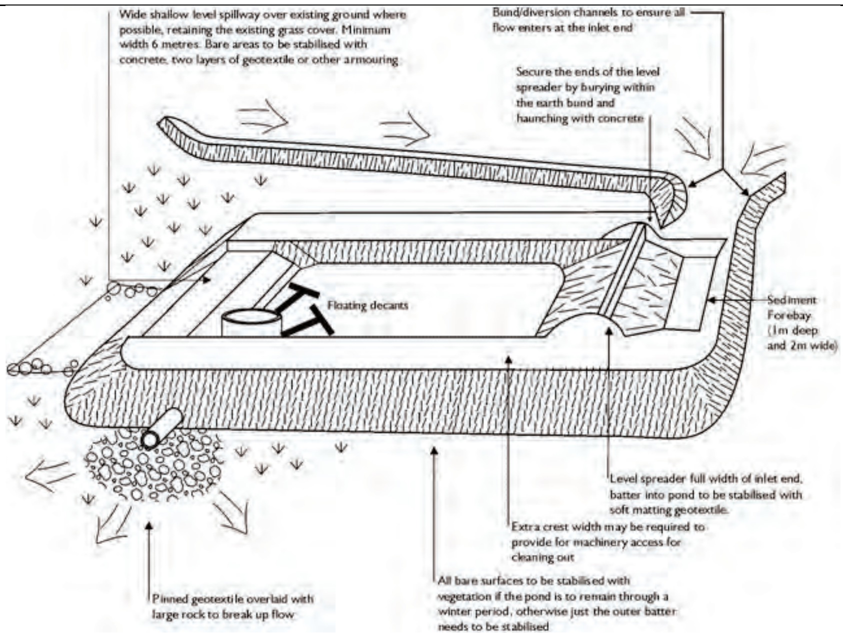
Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Has the site been prepared to ensure complete contact of the blanket or matting with the soil				
Area graded and shaped for installation				
All rocks, clods, vegetation or other obstructions removed				
Seedbed prepared by loosening 50 mm to 75 mm of topsoil				
Area seeded prior to blanket installation unless specified otherwise				
Wire staples, stake pins or wooden stakes have been placed to anchor mats and blankets to the ground. Propoer sized anchoring materials have been used				
On slopes, has the blanket started at the top of the slope and rolled downslope				
Are blanket edges overlapped				

In channels is there an anchor trench >300 mm deep x 150 mm across at the lower end of the project				
Intermittent check slots at 8-10 m intervals				
Are side fabric edges keyed in at least 100 mm deep x 100 mm wide				
Channel fabric begun at the downstream end with upstream geotextile overlapping < 75 mm				
Upstream end keyed in >300 mm x 150 mm wide				
Geotextile anchored securely with appropriate anchors				
Seed and fill turf reinforcement matting with soil if specified				
Maintenance				
Inspected daily and after each rain				
All rills, tears, missing pins or other damage repaired immediately				
Decommissioning				
If geotextile is temporary, remove it and stabilise the area				
If geotextile is permanent, ensure good stabilisation exists				

Erosion and Sediment Control Inspection Checklist

NZ TRANSPORT AGENCY
WAKA KOTAHI

Check List for Sediment Retention Ponds



Contractor: Inspector:	Date: Time:	Consent #:	Site:

Site Inspection of Erosion and Sediment Control Practices

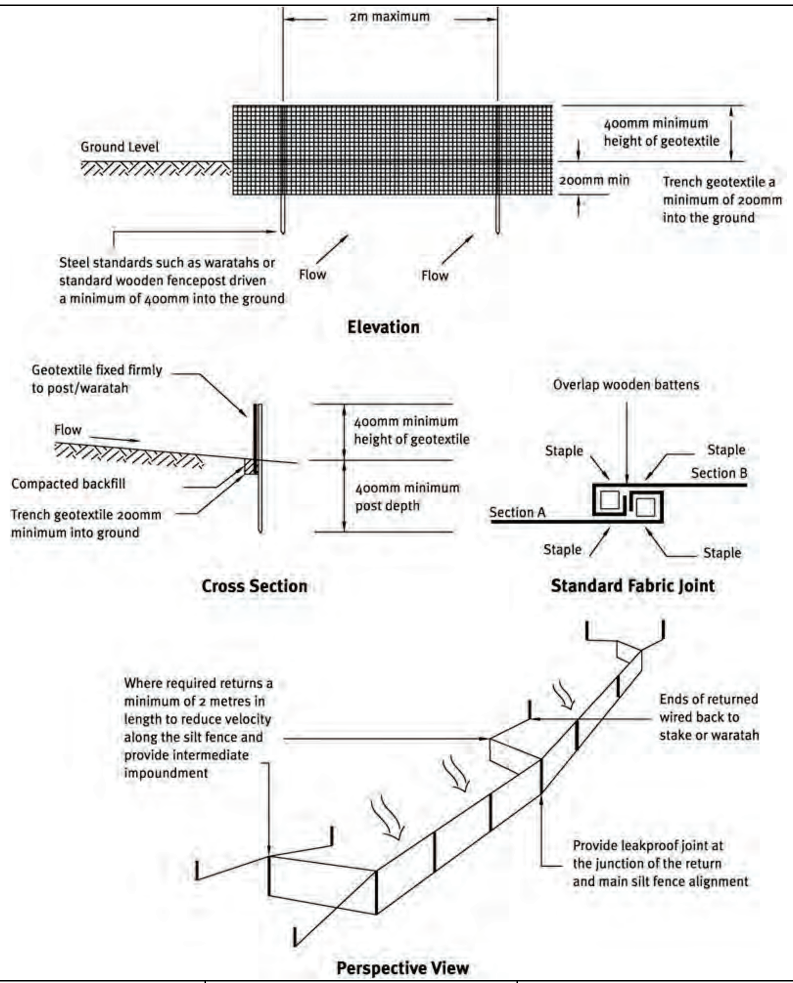
Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Implement sediment control downslope of the proposed sediment retention pond				
Clear areas of proposed fill of topsoil or other suitable material down to competent material.				
If the pond is to be converted to a permanent stormwater management pond ensure that a key trench is constructed				
Use only approved fill material.				
Place and compact fill in layers per the engineering recommendations				
Construct fill embankment 10% higher than the design height to allow for settlement				

Install pipework and anti-seep collars or filter collars during construction of the embankment and ensure good compaction around pipes				
Construct the emergency spillway				
Install and stabilise the level spreader				
Securely attach the decant system to the horizontal pipework. Make all connections watertight. Place any manhole riser on a firm foundation of concrete or compacted soil				
Protect inlet and outlet with fabric				
Install baffles when the pond's length to width ratio < 3:1				
Provide an all weather access track for maintenance				
Check all elevations to ensure proper function and rectify any inaccuracies				
Stabilise both internal and external batters with vegetation and the emergency spillway in accordance with the approved erosion and sediment control plan				
Undertake an As Built assessment at the completion of consruction and rectify any discrepancies with the design				
Maintenance				
Clean out pond before the volume of accumulated sediment reaches 20% of the total pond volume. A staff gauge would assist in this determination				
Clean out ponds with high capacity sludge pumps or with excavators loading the material onto sealed tip trucks to an area that will not discharge sediment off-site				
Clean out forebay after each runoff event if there is any evidence of sediment deposition				
Inspect pond every day and before every forecasted rainfall event				
Inspect for correct operation after every runoff event				
Immediately repair any damage caused by erosion or construction equipment				
Decommissioning				
Install a silt fence or other device downhill from the pond				
Dewater pond				
Remove and correctly dispose of all accumulated sediment				
Backfill the pond and compact soil. Regrade as required				
Stabilise all exposed surfaces				

NZ TRANSPORT AGENCY
WAKA KOTAHI

Erosion and Sediment Control Inspection Checklist

Check List for Silt Fence



Contractor: Inspector:	Date: Time:	Consent #:	Site:

Site Inspection of Erosion and Sediment Control Practices

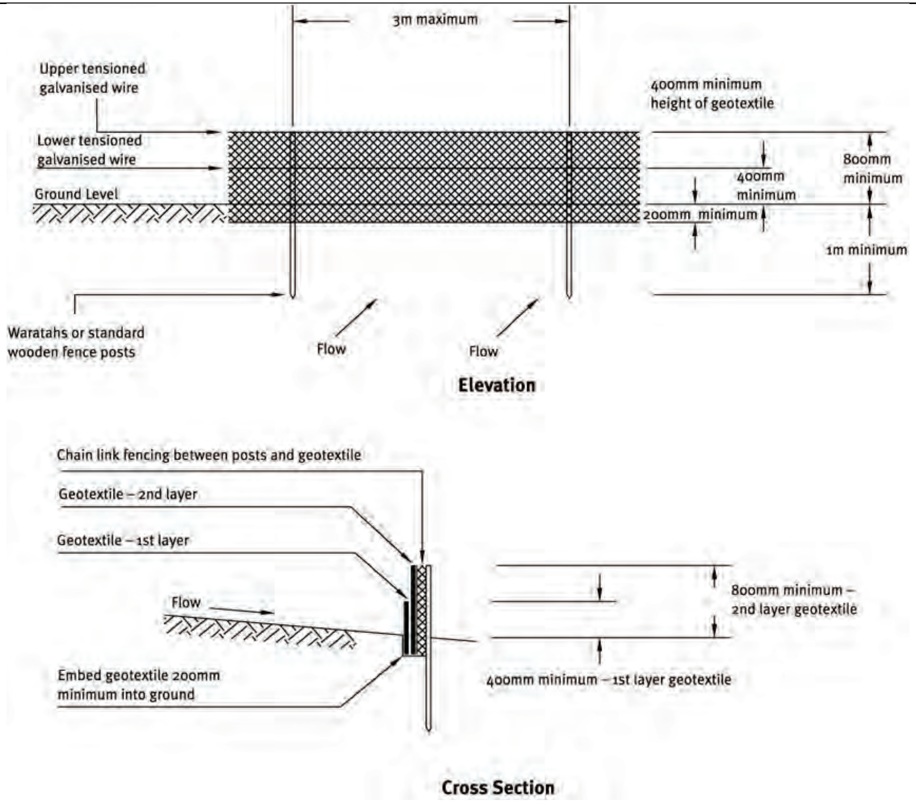
Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Use silt fence material appropriate to the site conditions and in accordance with the manufacturer's specifications				
Always install silt fences along the contour				

Excavate a trench a minimum of 100 mm wide and 200 mm deep along the proposed line of the silt fence				
Use supporting posts of tantalised timber a minimum of 50 mm square or steel waratahs at least 1.5 m length				
Install the support posts/waratahs on the downslope edge of the trench and silt fence fabric on the upslope side of the support posts to the full depth of the trench and then backfill the trench with compacted soil				
Reinforce the top of the silt fence fabric with a support made of high tensile 2.5 mm diameter galvanised wire. Tension the wire using permanent wire streainers attached to angled waratahs at the end of the silt fence				
Where ends of silt fence fabric come together, ensure they are overlapped, folded and stapled/screwed to prevent sediment bypass				
Maintenance				
Inspect silt fences at least once a week and after each rainfall				
Check for damage including rips, tears, bulges in the fabric, broken support wires, loose posts/waratahs, overtopping, outflanking, undercutting and leaking joins in the fabric				
Make any necessary repairs as soon as they are identified				
Remove sediment when bulges occur or when sediment accumulation reaches 50% of the fabric height				
Remove sediment deposits as necessary (prior to 50% level) to continue to allow for adequate sediment storage and reduce pressure on the silt fence				
Dispose of the sediment to an area where sediment cannot be transported downstream				
Decommissioning				
Do not remove silt fence and accumulated sediment until the catchment area has been appropriately stabilised				
Remove and dispose of accumulated sediment				
Backfill trench, regrade and stabilise the disturbed area				

NZ TRANSPORT AGENCY
WAKA KOTAHI

Erosion and Sediment Control Inspection Checklist

Check List for Super Silt Fence



Contractor: Inspector:	Date: Time:	Consent #:	Site:

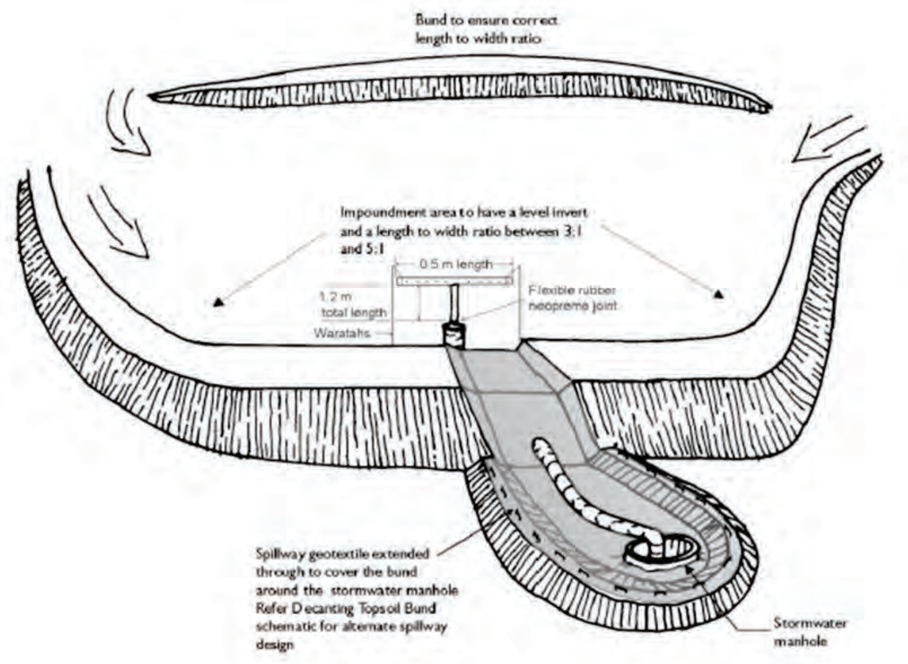
Site Inspection of Erosion and Sediment Control Practices

Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Use super silt fence material appropriate to the site conditions and in accordance with the manufacturer’s specifications				
Always install super silt fences along the contour				
Excavate a trench a minimum of 100 mm deep along the proposed line of the super silt fence				

Use supporting posts of tantalised timber (No. 3 rounds, No. 2 half rounds) or steel waratahs at least 1.8 m in length				
While there is no need to set the posts in concrete, ensure the 1.8 m long posts are driven in > 1 m				
Install tensioned galvanised wire (2.5 mmHT) at 400 mm and again at 800 mm above ground. Tension the wire using permanent wire strainers attached to angled waratahs at the end of the super silt fence				
Secure chain link fence to the fence posts with wire ties or staples, ensuring the chain link fence goes to the base of the trench				
Fasten two layers of geotextile fabric to the base of the trench (a minimum of 200 mm into the ground) and place compacted backfill back to the original ground level				
When two sections of geotextile fabric adjoin each other, ensure that they are doubled over a minimum of 300 mm, wrapped around a batten and fastened at 75 mm spacings to prevent sediment bypass				
Maintenance				
Inspect fences at least once/week and after each rainfall				
Check for damage including rips, tears, bulges in the fabric, broken support wires, loose posts/waratahs, overtopping, outflanking, undercutting and leaking joins in fabric				
Make repairs as soon as identified				
Remove sediment when bulges occur or when sediment accumulation reaches 50% of the fabric height				
Remove sediment deposits as necessary (prior to 50% level) to continue to allow for adequate sediment storage and reduce pressure on the super silt fence				
Dispose of the sediment to an area where sediment cannot be transported downstream				
Decommissioning				
Do not remove super silt fence and accumulated sediment until the catchment area has been appropriately stabilised				
Remove and dispose of accumulated sediment				
Backfill trench, regrade and stabilise the disturbed area				

Erosion and Sediment Control Inspection Checklist

Check List for Decanting Earth Bund



Contractor: Inspector:	Date: Time:	Consent #:	Site:

Site Inspection of Erosion and Sediment Control Practices

Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Build Decanting Earth Bunds along the contour to obtain required volumes				
Remove all organic/ vegetation before construction				
The Decanting Earth Bund is to be keyed into the existing ground to a minimum depth of 0.3 m				

The Decanting Earth Bund is to be made with a clay-silt mix of suitable moisture content to achieve a reasonable compaction standard (90%). It is considered that this can be achieved, in most instances, by track rolling at 150 - 200 mm lifts. Particular care is required to achieve good compaction around the outlet pipe that passes through the bund to avoid seepage and potential failure				
Install a 150 mm diameter non-perforated outlet pipe through the bund and this is to discharge to a stable erosion proofed area or stormwater system				
A T-Bar decant is attached by way of a standard 100 mm tee joint (glued and screwed). The decant is 100 mm dia. PVC pipe 0.5 metres long with 20 equally spaced holes of 10 mm diameter and fixed firmly to a waratah standard to achieve 3 litres/second/ha of contributing catchment				
A sealed PVC pipe (with endcaps) is placed on top of the decant to provide buoyancy				
Use a flexible thick rubber coupling to provide a connection between the decant arm and the discharge pipe. To provide sufficient flexibility (such as is required for the lower decant arm) install two couplings. Fasten the flexible coupling using strap clamps, glue and screws				
The decant is fastened to two waratahs by way of a nylon cord to the correct height				
Provide an emergency spillway to a stabilised outfall 150 mm above the level of the top of the decanting novacoil pipe. This can be a trapezoidal spillway with a minimum invert length of 2 m which is smooth, has no voids and is lined with a soft needle punched geotextile to the stabilised outfall. Ensure the geotextile is pinned at 0.5m centres				
The emergency spillway is to have a minimum freeboard of 250 mm, i.e. between the invert of the spillway to the lowest point of the top of the bund				
Undertake an As Built assessment at the completion of construction to check against design. If there are discrepancies rectify immediately				
Maintenance				
Inspect decanting earth bunds at least once/week and after each rainfall				

Check for damage including • Spillway • Outlet erosion • Decant or fitting damage • Embankment seepage or along outlet pipe • Blockages to holes in decants				
Make any necessary repairs as soon as identified				
Remove sediment when sediment accumulation reaches 20% of volume				
Dispose of the sediment to an area where sediment cannot be transported downstream				
Decommissioning				
Do not remove Decanting Earth Bund and accumulated sediment until the catchment area has been appropriately stabilised				
Dewater bund area				
Remove and dispose of accumulated sediment				
Remove pipes, fabric and other construction materials				
Backfill, regrade and stabilise the disturbed area				

NZ TRANSPORT AGENCY WAKA KOTAHI	Erosion and Sediment Control Inspection Checklist
Check List for Dewatering	

Contractor: Inspector:	Date: Time:	Consent #:	Site:

Site Inspection of Erosion and Sediment Control Practices

Erosion and Sediment Control Practice	Yes	No	N/A	Corrective Action
General Information				
Do you know what receiving system the project drains into				
Are you aware of local rainfall patterns during various times of the year				
Soil types and erosion potential for site				
Is a copy of the erosion and sediment control plan on site				
Is temporary fencing placed in areas where no construction is to take place				
Construction				
Always dewater the cleaner water at the top first then pump the residual sediment laden water to a tank/truck				
Small volumes of sediment laden water can be pumped to a silt fence or decanting earth bund but do not overwhelm these practices				
Larger volumes can be pumped to a sediment forebay of a sediment retention pond				
Maintenance				
Ensure that the area being pumped to provides effective sediment removal				

Check for any leakage or flow bypass of practices				
Decommissioning				
Remove when the need no longer exists				

Appendix H.L
Chemical Treatment Plans

Safety Data Sheet

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product Name: **CRYSTALFLOC B600 SERIES**

Other name(s): Crystalfloc grades: B610, B610H, B620, B630 KOS, B630L, B630 LVM, B630H, B640H, B660, B660H, B660 LVM, B670, B680 LVM, B600 PWG, B680 LVM-S, B690, B630KPWG, B640; Crystalfloc Anionic Powder; B680PWG.

Recommended Use: Flocculant/coagulant for water and waste water treatment.

Supplier: Orica New Zealand Limited
Street Address: Orica Chemnet House
Level four, 123 Carlton Gore Road
Newmarket, Auckland
New Zealand
Telephone Number: +64 9 368 2700
Facsimile: +64 9 368 2710
Emergency Telephone: 0 800 734 607 (ALL HOURS)

2. HAZARDS IDENTIFICATION

Not classified as a Dangerous Good under NZS 5433:2007 Transport of Dangerous Goods on Land.

Based on available information, not classified as hazardous according to criteria in the HS (Minimum Degrees of Hazard) Regulations 2001.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Components	CAS Number	Proportion	Risk Phrases
Acrylamide/Sodium acrylate copolymer	-	90%	-
Water	7732-18-5	10%	-

4. FIRST AID MEASURES

For advice, contact a Poisons Information Centre (e.g. phone Australia 131 126; New Zealand 0800 764 766) or a doctor.

Inhalation:
Remove victim from area of exposure - avoid becoming a casualty. Seek medical advice if effects persist.

Skin Contact:
If skin contact occurs, remove contaminated clothing and wash skin with running water. If irritation occurs seek medical advice.

Eye Contact:
If in eyes, wash out immediately with water. In all cases of eye contamination it is a sensible precaution to seek medical advice.

Ingestion:
Rinse mouth with water. If swallowed, give a glass of water to drink. If vomiting occurs give further water. Seek medical advice.

Medical attention and special treatment:
Treat symptomatically.

5. FIRE FIGHTING MEASURES

Hazards from combustion products:
Combustible solid. On burning will emit toxic fumes, including those of oxides of carbon , and oxides of nitrogen .

Precautions for fire fighters and special protective equipment:
Fire fighters to wear self-contained breathing apparatus and suitable protective clothing if risk of exposure to vapour or products of combustion.

Suitable Extinguishing Media:
Normal foam, dry agent (carbon dioxide, dry chemical powder). Avoid water if possible as the product is slippery when wet.

Unsuitable Extinguishing Media:
Water jets, water fog. Product is extremely slippery when wet.

6. ACCIDENTAL RELEASE MEASURES

Emergency procedures:
Avoid skin and eye contact. Avoid breathing in dust. Wear protective equipment to prevent skin and eye contact and inhalation of vapours/dusts.

Methods and materials for containment and clean up:
Wet material is slippery when spilt. Cover with damp absorbent (inert material, sand or soil). Sweep or vacuum up, but avoid generating dust. Collect in properly labelled containers for disposal. Wash area down with excess water.

7. HANDLING AND STORAGE

Precautions for safe handling: Avoid skin and eye contact and breathing in dust. Avoid handling which leads to dust formation. In common with many organic chemicals, may form flammable dust clouds in air. For precautions necessary refer to Safety Data Sheet "Dust Explosion Hazards".

Conditions for safe storage: Store in a cool, dry, well ventilated place and out of direct sunlight. Store below 30°C. Store away from incompatible materials described in Section 10. Keep containers closed when not in use - check regularly for spills.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits: No value assigned for this specific material by the New Zealand Occupational Safety and Health Service (OSH). However, Workplace Exposure Standard(s) for particulates:

Particulates not otherwise classified: 8hr WES-TWA 10 mg/m^3 (inhalable dust) or 3 mg/m^3 (respirable dust)

As published by the New Zealand Occupational Safety and Health Service (OSH).

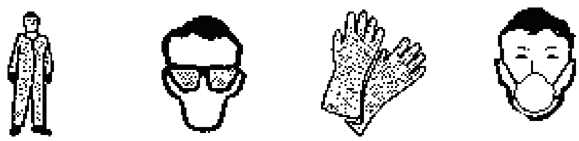
WES - TWA (Workplace Exposure Standard - Time Weighted Average) - The eight-hour, time-weighted average exposure standard is designed to protect the worker from the effects of long-term exposure.

These Exposure Standards are guides to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. These exposure standards should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity.

Engineering controls:
Ensure ventilation is adequate to maintain air concentrations below Exposure Standards. Keep containers closed when not in use.

Personal Protective Equipment:
The selection of PPE is dependant on a detailed risk assessment. The risk assessment should consider the work situation, the physical form of the chemical, the handling methods, and environmental factors.

Orica Personal Protection Guide No. 1, 1998: E - OVERALLS, SAFETY SHOES, SAFETY GLASSES, GLOVES, DUST MASK.



Wear overalls, safety glasses and impervious gloves. Avoid generating and inhaling dusts. If excessive dust exists, wear dust mask/respirator meeting the requirements of AS/NZS 1715 and AS/NZS 1716. Always wash hands before smoking, eating, drinking or using the toilet. Wash contaminated clothing and other protective equipment before storage or re-use.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Granular Solid
Colour:	White
Odour:	Slightly Ammoniacal
Solubility:	Slightly soluble in water.
Specific Gravity:	1.25
Flash Point (°C):	Not available
Flammability Limits (%):	Not available
Melting Point/Range (°C):	Not available
pH:	4-9 @5 g/L

10. STABILITY AND REACTIVITY

Chemical stability:	Stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.
Conditions to avoid:	Avoid dust generation. Avoid contact with water. Wet product renders surfaces extremely slippery.
Incompatible materials:	Incompatible with oxidising agents. Incompatible with water.
Hazardous decomposition products:	Oxides of carbon. Oxides of nitrogen.
Hazardous reactions:	Hazardous polymerisation will not occur. Slippery on contact with water.

11. TOXICOLOGICAL INFORMATION

No adverse health effects expected if the product is handled in accordance with this Safety Data Sheet and the product label. Symptoms or effects that may arise if the product is mishandled and overexposure occurs are:

Ingestion:	Swallowing may result in irritation of the gastrointestinal tract.

Eye contact:	May be an eye irritant. Exposure to the dust may cause discomfort due to particulate nature. May cause physical irritation to the eyes.
Skin contact:	Not expected to be a skin irritant.
Inhalation:	Material may be irritant to the mucous membranes of the respiratory tract (airways).

Long Term Effects:
A two year feeding study on rats and a one year feeding study on dogs did not reveal adverse health effects. (1)

Toxicological Data:
Oral LD50 (rat): >5000 mg/kg.
SKIN: Non-irritant (rabbit). Not a skin sensitiser (guinea pig).
EYES: Slight irritant (rabbit).

12. ECOLOGICAL INFORMATION

Ecotoxicity	Avoid contaminating waterways.
Persistence/degradability and mobility	Not readily biodegradable. Does not bioaccumulate. (1)
48hr EC50 (Daphnia magna):	>100 mg/L (1)
96hr LC50 (fish):	>100 mg/L (Danio rerio) (1)

13. DISPOSAL CONSIDERATIONS

Disposal methods:
Refer to Waste Management Authority. Dispose of material through a licensed waste contractor. Normally suitable for disposal at approved land waste site.

14. TRANSPORT INFORMATION

Road and Rail Transport
Not classified as a Dangerous Good under NZS 5433:2007 Transport of Dangerous Goods on Land.

Marine Transport
Not classified as Dangerous Goods by the criteria of the International Maritime Dangerous Goods Code (IMDG Code) for transport by sea; NON-DANGEROUS GOODS.

Air Transport
Not classified as Dangerous Goods by the criteria of the International Air Transport Association (IATA) Dangerous Goods Regulations for transport by air; NON-DANGEROUS GOODS.

15. REGULATORY INFORMATION

Classification:
Based on available information, not classified as hazardous according to criteria in the HS (Minimum Degrees of Hazard) Regulations 2001.

16. OTHER INFORMATION

(1) Supplier Material Safety Data Sheet;

Safety Data Sheet

This safety data sheet has been prepared by SH&E Shared Services, Orica.

Reason(s) for Issue:
5 Yearly Revised Primary SDS

This SDS summarises to our best knowledge at the date of issue, the chemical health and safety hazards of the material and general guidance on how to safely handle the material in the workplace. Since Orica Limited cannot anticipate or control the conditions under which the product may be used, each user must, prior to usage, assess and control the risks arising from its use of the material.

If clarification or further information is needed, the user should contact their Orica representative or Orica Limited at the contact details on page 1.

Orica Limited's responsibility for the material as sold is subject to the terms and conditions of sale, a copy of which is available upon request.

MACKAYS TO PEKAPEKA SH1 REALIGNMENT

SEDIMENTATION TESTS INCLUDING CHEMICALLY ASSISTED SEDIMENTATION

Settling analysis on soil samples provided by Ridley Dunphy Environmental Limited from the Mackays to PekaPeka Project

(June 2011)

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.
10 mL of Crystalfloc L3RC (PolyDADMAC 40%) as supplied was diluted with 1L of tap water to give 1% solution as L3RC supplied.

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

Both of the the samples provided had a very mobile clay/organic or very fine colloidal particles which remained in suspension long enough to potentially create settling issues in an earthworks/roading project (Samples J487 and J489).

The pH of the samples tested namely J487 and J489 both have a potential to be an issue as the untreated sample pH was 4.09 and 4.01 respectively.

Discussion

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 Summary

Given the potential issue with the low pH of both samples from this project we recommend some investigation of the typical receiving waters and determine what risks (if any) are involved with the discharge of settled water with low pH and also the levels of dissolved metals or other contaminants potentially present at relative ambient low pH.

Given that the area to be “worked” has a relatively high organic component it is likely that the receiving waters may be similar in “background components” so this must be taken into account when prescribing a sediment management plan for prospective clients. For example if the receiving water from said earthworks project has an initial/typical noticeable/significant organic/suspended solids loading this should be taken into account.
Provision for deviation from initial basis for consent should be in place to allow local authorities to amend the consent if suspended/organics loading in earthworks discharge are deemed to be detrimental to receiving water/environment.

The optimal dose rate of coagulant Crystalfloc L3RC (PolyDADMAC) for sample J487 and also J489 had a relatively wide range and coagulation started at what could be typically described as mid range dose rates for organic laden suspended solids/colloids.

The optimal dose rate of Flocculent Crystalfloc B610 (Polyacrylamide) for sample J487 and also J489 had a relatively wide range and coagulation started at what could be typically described as low to mid range dose rates for organic laden suspended solids/colloids.

We would not recommend the use of an aluminium based coagulant (such as Poly Aluminium Chloride or Aluminium sulphate) for the type of sediment found in suspended solids for this project as given relatively low starting point pH and relatively high dose rates followed by post treatment pH correction, or pre treatment pH adjustment and then subsequent treatment would be very difficult to manage and also result in very high cost of compliance.

Recommendations Sample J487

This sample had a relatively high mobile organic/colloidal component which remained in suspension long enough to be an issue in a sediment pond. PolyDADMAC (L3RC/B3H powder alternative) gave the lowest settled water turbidity, however the polyacrylamide alternative appeared to be more cost effective for this application.

The sample required a relatively high dose of flocculant to create a floc which would easily settle in a sediment pond.
B610 (Polyacrylamide) also performed well on this sample (~6 to 12ppm) with relatively low settled water and no effect on pH.
B610 can be dosed via a “floc sock” where sediment laden water is passed over the sock to dissolve product and the floc sock size/number is customised for the flow rates entering the sediment pond.

The sample required a relatively high dose of coagulant to create a floc which would easily settle in a sediment pond.
L3RC/B3H (PolyDADMAC) also performed well on this sample (~30 to 50ppm) with relatively low settled water and no effect on pH.
L3RC can be dosed via a displacement dosing system but is not suitable for shock or broadcast dosing.
B3H can be dosed via a “floc sock” where sediment laden water is passed over the sock to dissolve product and the floc sock size/number is customised for the flow rates entering the sediment pond.

Of note polyDADMAC powder dissolution rate is faster than polyacrylamide powder so this may be a factor in considering the best option for sediment control on this project.
If sufficient mixing energy can be engineered into the dosing regime the polyacrylamide option will be the preferred option, however if mixing energy is limited/compromised the polyDADMAC option may work more efficiently so suggest some preliminary tests are undertaken to determine best product fit if deemed necessary.

Recommendations Sample J489

This sample had a relatively high mobile organic/colloidal component which remained in suspension long enough to be an issue in a sediment pond.
PolyDADMAC (L3RC/B3H powder alternative) gave the lowest settled water turbidity, however the polyacrylamide alternative appeared to be more cost effective for this application.

The sample required a relatively high dose of flocculant to create a floc which would easily settle in a sediment pond.
B610 (Polyacrylamide) also performed well on this sample (~3 to 9ppm) with relatively low settled water and no effect on pH.
B610 can be dosed via a “floc sock” where sediment laden water is passed over the sock to dissolve product and the floc sock size/number is customised for the flow rates entering the sediment pond.

The sample required a relatively high dose of coagulant to create a floc which would easily settle in a sediment pond.
L3RC/B3H (PolyDADMAC) also performed well on this sample (~20 to 40ppm) with relatively low settled water and no effect on pH.
L3RC can be dosed via a displacement dosing system but is not suitable for shock or broadcast dosing.
B3H can be dosed via a “floc sock” where sediment laden water is passed over the sock to dissolve product and the floc sock size/number is customised for the flow rates entering the sediment pond.

Of note polyDADMAC powder dissolution rate is faster than polyacrylamide powder so this may be a factor in considering the best option for sediment control on this project.
If sufficient mixing energy can be engineered into the dosing regime the polyacrylamide option will be the preferred option, however if mixing energy is limited/compromised the polyDADMAC option may work more efficiently so suggest some preliminary tests are undertaken to determine best product fit if deemed necessary.

Unassisted Settling Test Data

Time	Sample J487	Sample J489
Start	>1000	>1000
1 hour	>1000	486
3 hours	>1000	482
5 hours	926	451
15 hours	683	386
24 hours (1 day)	615	298
48 hours (2 days)	498	230
72 hours (3 days)	384	158
96 hours (4 days)	343	128
192 hours (8 days)	323	122

Discussion of Unassisted Settling Test Data for "Raumati straights" samples

The table above shows sample J487 had the highest risk in terms of settled water turbidity vs time and appeared to contain a very fine colloidal/organic component which gave the settled water a dark colouration even after an extended period of settling.
This sample was tested for optimal coagulation chemical(s) on the basis it would be an issue in a sediment pond.

The table above shows sample J489 also had a high risk in terms of settled water turbidity vs time and appeared to contain a very fine colloidal/organic component which gave the settled water a dark colouration even after an extended period of settling, however was noticeably lighter colour and had better settling quality than sample J487.
This sample was tested for optimal coagulation chemical(s) on the basis it would be an issue in a sediment pond.

Chemically Assisted Settling Test Data
Raumati Straights samples

Best of test results shown but other data available if required.
Notes….
Some other polyacrylamides (similar compounds to Crystalfloc 610) appeared to flocculate the samples, but best of products tested was Crystalfloc 610 by a considerable margin.
Aluminium salt results did not appear to be cost effective for these samples and also lowered the pH to well below desirable levels to even be considered an option.

Note
This fill colour denotes optimum dose rate/range

Sample J487

L3RC ppm	pH	NTU at 10 min
0	4.09	>1000
5	4.08	>1000
10	4.07	987
20	4.05	709
30	4.01	516
40	3.98	4.57
50	3.97	2.42
60	3.96	2.67
70	3.96	2.71

610 ppm	pH	NTU at 10 min
0	4.09	>1000
3	4.09	>1000
6	4.09	486
9	4.09	43.7
12	4.09	39.2
15	4.09	69.5
18	4.09	129

Sample J489

L3RC ppm	pH	NTU at 10 min
0	4.01	>1000
5	4.00	>1000
10	4.00	846
20	3.98	493
30	3.97	86.1
40	3.96	8.79
50	3.96	1.66
60	3.94	5.69
70	3.92	29.7

610 ppm	pH	NTU at 10 min
0	4.01	>1000
3	4.01	512
6	4.01	99.6
9	4.01	22.3
12	4.01	14.6
15	4.01	87.4
18	4.01	216

Appendix H.M
Dirty Water Diversion Calculations

MacKays to PekaPeka Dirty Water Diversion Calculations

		20 yr ARI	100 yr ARI
Catchment Area	ha	0.5	0.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.0820**	**0.1124**
Q24 (Runoff Depth)	mm	90	126
V24	m3	452	630

		20 yr ARI	100 yr ARI
Catchment Area	ha	1	1
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.1639**	**0.2248**
Q24 (Runoff Depth)	mm	90	126
V24	m3	903	1260

		20 yr ARI	100 yr ARI
Catchment Area	ha	1.5	1.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.2459**	**0.3372**
Q24 (Runoff Depth)	mm	90	126
V24	m3	1355	1890

		20 yr ARI	100 yr ARI
Catchment Area	ha	2	2
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.3279**	**0.4496**
Q24 (Runoff Depth)	mm	90	126
V24	m3	1807	2520

		20 yr ARI	100 yr ARI
Catchment Area	ha	2.5	2.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.4098**	**0.5620**
Q24 (Runoff Depth)	mm	90	126
V24	m3	2258	3150

		20 yr ARI	100 yr ARI
Catchment Area	ha	3	3
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.4918**	**0.6744**
Q24 (Runoff Depth)	mm	90	126
V24	m3	2710	3779

		20 yr ARI	100 yr ARI
Catchment Area	ha	3.5	3.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.5737**	**0.7867**
Q24 (Runoff Depth)	mm	90	126
V24	m3	3162	4409

		20 yr ARI	100 yr ARI
Catchment Area	ha	4	4
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.6557**	**0.8991**
Q24 (Runoff Depth)	mm	90	126
V24	m3	3614	5039

		20 yr ARI	100 yr ARI
Catchment Area	ha	4.5	4.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.7377**	**1.0115**
Q24 (Runoff Depth)	mm	90	126
V24	m3	4065	5669

		20 yr ARI	100 yr ARI
Catchment Area	ha	5	5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.8196**	**1.1239**
Q24 (Runoff Depth)	mm	90	126
V24	m3	4517	6299

		20 yr ARI	100 yr ARI
Catchment Area	ha	5.5	5.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.9016**	**1.2363**
Q24 (Runoff Depth)	mm	90	126
V24	m3	4969	6929

		20 yr ARI	100 yr ARI
Catchment Area	ha	6	6
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**0.9836**	**1.3487**
Q24 (Runoff Depth)	mm	90	126
V24	m3	5420	7559

		20 yr ARI	100 yr ARI
Catchment Area	ha	6.5	6.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**1.0655**	**1.4611**
Q24 (Runoff Depth)	mm	90	126
V24	m3	5872	8189

		20 yr ARI	100 yr ARI
Catchment Area	ha	7	7
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**1.1475**	**1.5735**
Q24 (Runoff Depth)	mm	90	126
V24	m3	6324	8819

		20 yr ARI	100 yr ARI
Catchment Area	ha	7.5	7.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**1.2295**	**1.6859**
Q24 (Runoff Depth)	mm	90	126
V24	m3	6775	9449

		20 yr ARI	100 yr ARI
Catchment Area	ha	8	8
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**1.3114**	**1.7983**
Q24 (Runoff Depth)	mm	90	126
V24	m3	7227	10078

		20 yr ARI	100 yr ARI
Catchment Area	ha	8.5	8.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**1.3934**	**1.9107**
Q24 (Runoff Depth)	mm	90	126
V24	m3	7679	10708

		20 yr ARI	100 yr ARI
Catchment Area	ha	9	9
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**1.4753**	**2.0231**
Q24 (Runoff Depth)	mm	90	126
V24	m3	8130	11338

		20 yr ARI	100 yr ARI
Catchment Area	ha	9.5	9.5
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**1.5573**	**2.1354**
Q24 (Runoff Depth)	mm	90	126
V24	m3	8582	11968

		20 yr ARI	100 yr ARI
Catchment Area	ha	10	10
Catchment slope		0.05	0.05
Channel factor		1	1
Imperviousness		0%	0%
SCS Curve Number		89	89
24-hour rainfall	mm	120	157
Weighted curve number		89	89
Ia weighted	mm	5	5
tc	hours	0.17	0.17
tp	hours	0.11	0.11
Storage S	mm	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.637	0.701
q* (from Fig. 6.1)	Approx!!	0.137	0.143
q peak	**m3/s**	**1.6393**	**2.2478**
Q24 (Runoff Depth)	mm	90	126
V24	m3	9034	12598

MacKays to PekaPeka Dirty Water Diversion Channel Sizing

RATIONAL METHOD FOR CALCULATING STORMWATER FLOWS

Q Discharge
A Area
c run-off coefficient
i rainfall intensity

$Q = c*i*A/360$ where A = ha & i = mm/hr

20 year ARI

c	0.5
tc	0.17
i	81.6
A	1
Q	**0.113**

c	0.5
tc	0.17
i	81.6
A	2
Q	**0.227**

c	0.5
tc	0.17
i	81.6
A	3
Q	**0.340**

c	0.5
tc	0.17
i	81.6
A	4
Q	**0.453**

c	0.5
tc	0.17
i	81.6
A	5
Q	**0.567**

c	0.5
tc	0.17
i	81.6
A	6
Q	**0.680**

100 year ARI

c	0.5
tc	0.17
i	114.6
A	1
Q	**0.159**

c	0.5
tc	0.17
i	114.6
A	2
Q	**0.318**

c	0.5
tc	0.17
i	114.6
A	3
Q	**0.478**

c	0.5
tc	0.17
i	114.6
A	4
Q	**0.637**

c	0.5
tc	0.17
i	114.6
A	5
Q	**0.796**

c	0.5
tc	0.17
i	114.6
A	6
Q	**0.955**

c	0.5
tc	0.17
i	81.6
A	7
Q	**0.793**

c	0.5
tc	0.17
i	114.6
A	7
Q	**1.114**

c	0.5
tc	0.17
i	81.6
A	8
Q	**0.907**

c	0.5
tc	0.17
i	114.6
A	8
Q	**1.273**

c	0.5
tc	0.17
i	81.6
A	9
Q	**1.020**

c	0.5
tc	0.17
i	114.6
A	9
Q	**1.433**

c	0.5
tc	0.17
i	81.6
A	10
Q	**1.133**

c	0.5
tc	0.17
i	114.6
A	10
Q	**1.592**