VERSION 3.0

WCC - Countryside and Foothills Stormwater Management Code of Practice

RDC – Management of Stormwater in Countryside Living Zones – (rural and town) – A toolbox of methods

Part B – Stormwater Management Device Design Details

Prepared for

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1.1 Design Information

Part B of the Code presents design information for a range of stormwater management devices.

The design information provided in the Code has been developed to provide the flexibility to select the various stormwater management options and combination of options that are most appropriate for a site. Property owners may wish to develop sites using different methods that are applicable to the site conditions and the style of development. Part A should be read before proceeding with use of information in Part B.

Sections 2 to 9 outline various stormwater management options, and provide appropriate design detail to select combinations of stormwater management techniques. Table 1-1 summarises the methods that are acceptable for compliance with Flood Protection and Stream Channel Protection approaches. Stormwater quality measures must also be provided.

Table 1-1 - Compliance Measures for Both Approaches

Methods for Meeting Design Approach	Flood Protection Approach	Stream Channel Protection Approach	Stormwater Quality
Minimising impervious areas	✓	✓	
Planting of bush vegetation	✓	✓	✓
Rainwater tanks	✓ (1)	✓	
Rain gardens		✓	✓
Permeable Pavement	✓	✓	✓
Wetland areas (2)		✓	✓
Detention Ponds (2)		✓	✓
Dispersal Devices		✓ (3)	
Swales		✓ (3)	✓
Green Roofs		✓	✓

(1) Where reuse of stormwater applies.

(2) See ARC TP-10 for design details.

(3) Swales and Dispersal Devices are not used to mitigate impervious surfaces. These devices are used to minimise effects of concentrated flows from impervious surfaces and treatment devices. Swales also provide treatment.

The design details in this document are based on managing flows and runoff volumes for the 50 % AEP rainfall event and 1% AEP rainfall event. Appendix B outlines the analysis inputs relevant to developing the Code.

2.1 Introduction

Impervious surfaces (roads, roofs, and footpaths) prevent the passage of water through the surface into the ground. Water must then be transported across the surface to the point of discharge. Minimising impervious areas is the most effective way to preserve a site's predevelopment runoff characteristics.

If developers proposed to develop more than 600 m^2 impervious surface, WCC, and RDC will expect to see a more detailed application and explanation of mitigation methods.

2.2 Description

Techniques to minimise impervious surface areas include:

- Reducing the area/extent of roof area (two stories for additional space);
- Construction of a Green Roof (refer to Section 9)
- The use of pervious surfaces around buildings (e.g. open slated decks rather than concrete);
- Clustering of structures (placing the house, garage and additional structures in close proximity) to reduce the impervious hardstand areas between structures; and
- Reducing impervious surface areas of accessways and driveways by the following methods: -
  - The use of dual strip driveways with a grassed central strip;
  - Reducing drive and accessway length (locating the house closer to the road); and,
  - Providing shared accessways to serve several houses.

The design of the driveway is the responsibility of the property owner. It is important that precast paving materials are used strictly in accordance with manufacturers specifications that take into account the bedding material and basecourse requirements applicable for the site conditions.

Reducing the amount of impervious surface reduces the amount of stormwater generated. Non structural and alternative approaches to stormwater management are more easily applied and successful when the amount of stormwater generated is reduced.

2.3 What to do?

Consider the amount of impervious area you realistically need to meet your requirements. Apply some or all of the methods listed above to minimise the area required. The stormwater effects generated by the area that you decide on will have to be managed by application of the stormwater management techniques that you choose to apply from the following pages.

The total impervious surface area allowed should generally not exceed 600 m^2 for each site, including private driveways, paths and all roof areas (including garages). This impervious area should be used in the stormwater management technique calculations that follow on subsequent worksheets.

3.1 Introduction

Development usually results in the need for more roads and an associated increase in road runoff.

In designing and locating new roads developers will be expected to take account of the general objectives set by WCC and RDC to minimise stormwater flow increases associated with development and provide ongoing stormwater treatment.

General guidelines applicable to new roads include:

- Roads should be located where practicable away from watercourses and existing areas of established bush;
- Roads should be aligned to minimise cut and fill;
- Road and pavement widths should be kept to a minimum;
- Houses should be sited to minimise the length of access road needed and the opportunity for shared access should be explored.

The runoff from roads carries contaminants, and treatment of this runoff in accordance with ARC TP10 requirements applies.

Treatment for small scale developments can be provided using bush planting and rain gardens as described in this document. For bush planting, where possible the bush should be planted around natural watercourses to create riparian margins

For road construction in excess of 1,000 m^2 of impervious cover TP10 should be referenced for other options and in particular wetlands, which can provide aesthetic and ecological benefits.

3.2 Driveways

The design of the driveway is the responsibility of the property owner.

The general principles identified above for access roads also apply to driveways.

Options to consider for driveways include:

- The use of dual strip driveways with a grassed central strip; and
- Shared driveways serving several houses.

Figure 3-1 shows typical cross-sections of a driveway. It is important that the driveway design takes into account the ground conditions under the driveway. Figure 3-2 shows the detail for a strip driveway.

4.1 Introduction

Land development generally increases stormwater runoff by increasing site imperviousness through construction of hard surfaces such as roofs, driveways, garages, footpaths, etc. At the same time it is recognised that previous rural uses of land has also increased stormwater runoff by removal of bush, vegetation and underbrush, and replacing that vegetation with grasses for stock grazing. In terms of stormwater runoff, existing bush areas generate less runoff than does grass which in turn produces less runoff than impervious surfaces.

4.2 Description

On a property that has significant areas of pasture, the establishment of bush vegetation has the effect of reducing site stormwater runoff. A relationship may be drawn between the increase in the area imperviousness on a site and corresponding percentages on site of bush planting required to partially or, in some cases, fully eliminate increases in site runoff peak rates and volumes.

This section provides guidance on how much bush vegetation should be planted during site design to mitigate the increase in site imperviousness. It is assumed that impervious surfaces will be replacing existing pasture.

4.3 Benefits

Bush revegetation is one of the few stormwater management practices that can reduce the total volume of stormwater runoff. In addition, bush planting provides other ecological benefits that more conventional approaches to stormwater management do not. Bush revegetation also provides landscape and visual amenity benefits.

Another major benefit of bush planting relates to long term maintenance. Conventional stormwater management techniques, in the form of ponds or other structural approaches, generally requires increased maintenance over time to maintain water quantity/water quality performance.

Once established bush revegetation should require less maintenance over time, which is a significant strength of the approach.

4.4 Considerations

1. This stormwater management design approach applies to large lot rural residential developments where the following situations apply:

   - New lot sizes are no less than 4,000m^2.
   - A single home and accessory structures only are constructed on each lot.

- The total imperviousness of the site, which includes all impervious surfaces including driveways, footpaths, and all roof areas (house and ancillary structures) is not greater than 600 m^2 per lot.

2. At this stage this approach does not provide for, or include:

   - Other types of development or densities;
   - Other wider resource management issues such as effects on landscape qualities, rural character and amenity, provision of infrastructure etc. The relevant district plan and structure plan must be consulted to identify compatibility (if any) with this approach; and
   - Design guidelines for catchment wide development, rather the main focus is on individual lot development and small subdivisions. Catchment management plans are still necessary to manage cumulative effects.

3. Bush planting will be subject to the following controls:

   - Areas to be re-vegetated and the plant species and densities must be detailed on appropriate site plans. A permanent ground coverage in excess of 75% is required to mitigate increases in stormwater runoff.
   - Plants should be placed at a minimum of 1 m centres and selected to achieve full canopy closure in 3 years.
   - Limitations will apply to total site imperviousness to ensure that the original design assumptions for bush revegetation remain adequate. Increases in site imperviousness above those approved will be considered on an individual basis and may require additional stormwater management devices.
   - Re-vegetated areas are likely to be protected through the use of legal covenants on property titles to ensure the ongoing preservation of planted areas
   - Planting will be required to be in place at the time of the issue of 224c. The maintenance period for planting shall be twenty four months. This maintenance may be transferred to the incoming owner subject to the matter being an agreed condition of the sale and purchase for the property a copy of which is forwarded to Council for lodgement on the property file.
   - Implementation of maintenance and monitoring conditions will be set by WCC or RDC to ensure the proper planting and protection of planted areas (refer Section 11).

4.5 What to do?

Where bush revegetation is proposed, the location of where it is to be done must be considered carefully. Preferred locations are either adjacent to:

- Existing bush areas;

- Linking existing bush areas;
- Streams;
- Springs;
- Wetlands;

or appropriately located on:

- Steep slopes;
- Unstable slopes.

In selecting the location of the bush vegetation it should also be noted that a minimum planting width of 20 m is required for the bush planting to be effective.

Having determined the impervious area on site, the required area of bush replanting is derived from Table 4-1. Table 4-1 summarises the area of bush replanting required to offset impervious areas of 100 to 600 m^2. The table provided applies to sites currently in pasture.

Replacement of existing bush area with impervious surface is not encouraged. Where bush is disturbed, the area removed must be replaced in total, in addition to the areas required in Table 4–1.

Equivalent areas apply for application in both the Flood Protection Approach and Stream Channel Protection approach.

Table 4-1 - Bush Planting Requirements

Proposed Impervious Area on Site (m^2)	Area of Bush Required (m^2)
100	400
200	700
300	1050
400	1400
500	1750
600	2000

If the impervious area being developed falls in between the impervious areas provided in Table 4-1, then proportion the area of bush required appropriately. For example, if you are looking at bush planting for 250 m^2 of impervious area, you will need to plant 875 m^2 of bush.

Where the proposed site water management system incorporates rainwater recycling from rain water tanks or other forms of on site storage, bush planting areas can be reduced by 70 m^2 for full recycling or 40 m^2 for partial recycling. The water recycling volumes adopted for the Code of Practice are shown in Appendix B. For this reduction to apply WCC/RDC must be provided with details of the proposed water recycling system.

Plants should be selected from the plant list provided in Appendix C.

5.1 Introduction

The use of rain water tanks to collect stormwater runoff for domestic use applies in areas where there is no reticulated water supply system. Using roof rainwater rather than importing reticulated water reduces the total runoff volume from the site. The rain water tank system can be modified to provide additional temporary storage to attenuate stormwater flows. The Code assumes that construction of a rain water tank mitigates 50 % of the roof area drained. A maximum of 100 m^2 of impervious area (draining 200 m^2 of roof area) can be mitigated with rain water tanks.

5.2 Description

Stormwater detention is achieved by the provision of rain water tank storage and an orifice outlet to throttle flows to the pre-development flow rate. The rain water tank volume and the orifice outlet diameter depend on the area of the roof. Depending on the size of roof and whether rain water is relied on for domestic supply, more than one tank may be required.

The maximum roof area to be mitigated with a roof tank is 200 m^2, which equates to an impervious area mitigation of 100 m^2. Roof areas not mitigated with rain water tanks will require an alternative method for mitigation. For houses using the rain water tank for water supply, the entire roof can be connected to the tank. However, special consideration for outlets and erosion protection needs to be made for discharging the excess water from the rain water tank.

5.3 Considerations

The typical tank volume normally required for domestic household use is in the order of 22.7 m^3 (5,000 gallons), which is a standard tank size available for rural water supply. Other tank volumes may be used depending on household requirements. Extra volume may be needed for irrigating gardens or for stock watering.

Part C of the Code provides detail on the special considerations applicable to rain water tank design if it is intended to use the water for drinking.

Other buildings such as garages and sheds should be located as close as possible to the tank to minimise piping. Also consider the visual impacts if the building platform and tank is located in a visually sensitive area or on a ridgeline.

Runoff from other impervious surfaces, such as driveways or paving will need to be managed by other stormwater management methods.

5.4 What to do?

5.4.1 Flood Protection Approach (1% AEP)

The rain water tank for the house is sized to accommodate the 100-year event with a maximum discharge not exceeding the pre-development 2-year flood. Storage above the tank orifice outlet is available for temporary storage of rain water. Storage below the tank orifice outlet is available for domestic use.

The orifice diameter and the detention storage head and size required for roof areas up to 200 m^2 are shown in Table 5-1.

Table 5-1 - Orifice Diameter and Detention Storage Size for the Flood Protection Approach

Diameter. (mm)	897-910		1600-1785		2180		3555	
Vol. (litres)	450-1138		2499-4420		8475		25210	
Area (m^2)	d (mm)	H (mm)	d (mm)	H (mm)	d (mm)	H (mm)	d (mm)	H (mm)
<25	15	800	15	400	15	275	25	150
26-50	-	-	20	650	20	450	20	250
51-75	-	-	20	825	20	640	20	347.5
76-100	-	-	25	1000	25	830	25	445
101-150	-	-	25	1190	25	1115	25	642.5
151-200	-	-	25	1200	25	1400	25	840

All roof tank overflows should discharge to a flow dispersion system. Multiple tanks may apply when larger volumes for water supply are required. Typical rain water tank arrangements are shown on Figure 5-1 and 5-2.

5.4.2 Stream Channel Protection Approach (50% AEP)

The flood detention volumes required for the 50 % AEP are significantly less than those required for the 1% AEP. In the 1% AEP sizing, the water reuse is less than the storage required for flood attenuation and therefore has less of an impact on the size of the tank. For the 50 % AEP event, the water reuse volume may be greater than the required detention storage.

The level of water reuse and the projected water use thus needs to be evaluated closely. A system that operates as the sole source of water for a dwelling will require a larger tank than a system where the water is used for "non potable" uses only.

If no water reuse is proposed, a tank size less than 9,500 litres (2,500 gallons) could be used. Where an alternative tank size is proposed (with a smaller diameter), the max detention storage head and orifice diameter will need to be checked.

Table 5-2 - Orifice Diameter and Detention Storage Size for Stream Channel Protection Approach

Diameter. (mm)	897-910		1600-1785		2180		3555	
Vol. (litres)	450-1138		2499-4420		8475		25210	
Area (m^2)	d (mm)	H (mm)	d (mm)	H (mm)	d (mm)	H (mm)	d (mm)	H (mm)
<25	15	200	15	140	15	100	25	40
26-50	15	600	15	300	20	150	25	70
51-75	-	-	20	400	25	200	25	100
76-100	-	-	20	500	25	250	30	120
101-150	-	-	25	600	25	420	30	200
151-200	-	-	25	700	25	600	30	300

Figure 5-1

Conceptual Layout of Rain Water Tank

Figure 5-2

Rain water Tank orifice detail

6.1 Introduction

A rain garden is used to attenuate peak flows and to provide stormwater treatment. Rain gardens use the concept of bioretention, a water quality practice in which plants and soils remove contaminants. Rain gardens are created in low-lying areas, with specific layers of soil, sand and organic mulch. These layers naturally filter the stormwater. During the inter-event dry period, the soil stores the rainwater and nourishes the garden's vegetation, promoting degradation, uptake and metabolism of contaminants. Some storage can be designed into the rain garden by allowing some temporary ponding to occur above the filter layers.

6.2 Description

Rain gardens look and function like any other garden except they treat runoff and are specifically designed with a number of components to suit site conditions.

6.2.1 Vegetation

Vegetation identified for use in rain gardens includes grasses and shrubs, with a preference for native species. Plants suitable for use in rain gardens are listed in Appendix C.

6.2.2 Mulch

A thin (up to 75mm) layer of mulch is recommended on the surface of the planting soil to maintain soil moisture and biota. This can be landscape-type shredded wood mulch or chips.

6.2.3 Planting soil

The layer of planting soil should be 1 metre or greater in depth. The soil composition must be permeable enough to allow runoff to filter through the media. The planting soil should be a sandy loam, loamy sand, loam, or a loam/sand mix (35-60% sand). The clay content should be less than 25% and the permeability should be at least 0.3 metres per day. The soil should be free of stones, stumps, roots or other woody material over 25 mm in diameter. Brush or seeds from noxious plants should not be present in the soils.

Placement of the soil should be in lifts of 300 - 400 mm and loosely compacted (tamped lightly with a backhoe bucket).

6.2.4 Sand bed (optional)

A sand bed may be used immediately below the planting soil to prevent the migration of particles into the underdrain material. The sand layer should be 300 mm deep and, if present, is included in the minimum 400 mm underdrain depth.

6.2.5 Underdrain system

All rain gardens must include an underdrain system to collect treated runoff from the base of the system. This usually consists of a 100-150 mm perforated pipe system embedded in a gravel layer with at least 50 mm gravel cover over the pipe. In unstable or heavy soils the pipe can be positioned at the base of the underdrain to prevent water standing in the bottom of the system. In soils with high permeability, groundwater recharge may be encouraged by the infiltration of the treated runoff. This is achieved by elevating the piping system above the base of the gravel layer.

The combined depth of the sand bed and gravel underdrain layers should be at least 400 mm, depending on the diameter of piping used.

6.2.6 Filter fabric or impervious liner

Filter fabric is not recommended for use between the mulch, planting soil, sand bed or underdrain layers as it may clog with fine particles and reduce the overall permeability of the system. However, filter fabric should be used on the side walls and in some situations also the base of the system to prevent the migration of adjacent soil into the planting soil or the underdrain material. In stable soils the filter fabric can be a pervious, open-weave cloth, whereas unstable soils will require an impervious liner.

6.3 Considerations

The main issue on the long-term performance of rain gardens is adequate maintenance. Over time, the planting soil permeability may reduce which will increase surface ponding time. Another issue relates to maintenance of the rain garden vegetation. During dry periods the underdrain may cause the rain garden to dry out, which may necessitate watering of the vegetation on an as-needed basis to ensure vegetation remains healthy and viable.

Runoff from areas such as lawns and gardens should not require treatment. Overland flow from these areas located within the raingarden catchment may be diverted around raingarden by the use of a low diversion bund. Raingardens should be designed as off-line systems and situated in areas of the property that are not required for other purposes.

The maximum ponded depth on the surface of the raingarden is 220 mm. Provision of a maximum ponded water depth of 220 mm above the rain garden surface provides for storm events to be caught and treated. An overflow provision should be allowed for storm events that exceed the 220 mm freeboard.

Figure 6-1 illustrates a typical layout of a rain garden.

Figures 6-2 and 6-3 show the detailed design for an "in lawn" rain garden constructed by Ecowater Solutions. This design provides for dispersal of roof runoff over the rain garden area without surface ponding. The design shown is for treatment of roof runoff up to 200 m^2. The details provided on Figures 6-2 and 6-3 should be checked and customised by a Chartered Engineer prior to adoption for a particular site.

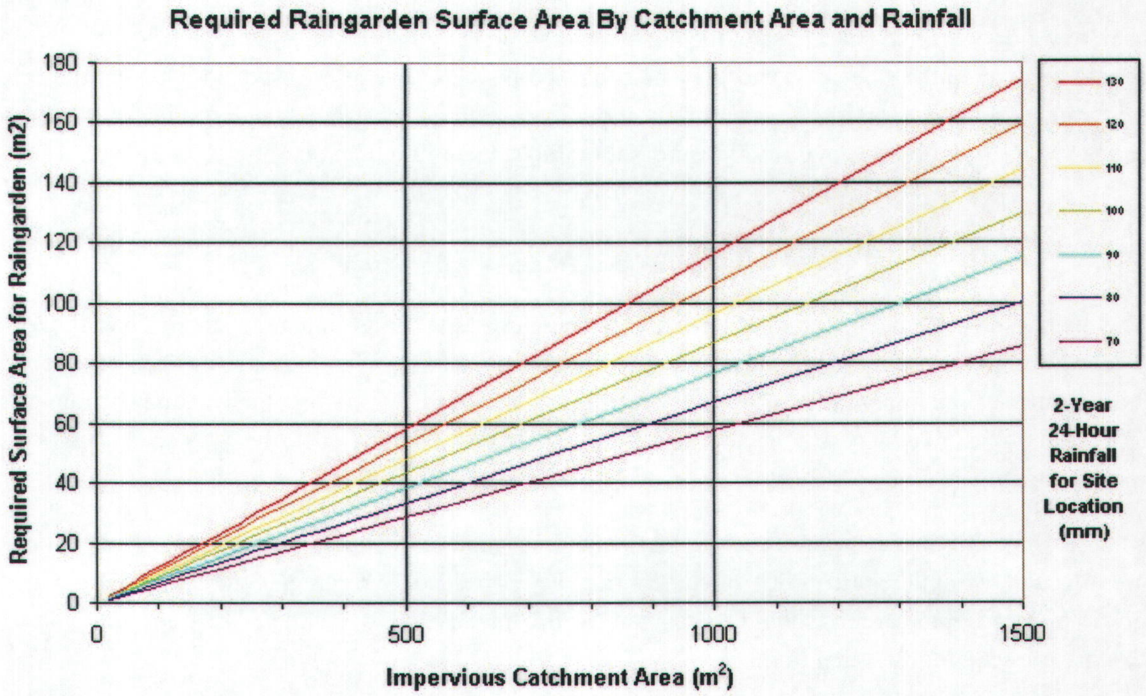
6.4 What to do?

The size of the rain garden depends on the area that drains into the rain garden. The area may include pervious areas as well as impervious areas. For entirely impervious catchments the graph presented in section 6.4.1 can be used.

These areas need to be calculated to determine the volume of runoff that can be expected from these areas in a 2 return period year storm.

The rainfall depth associated with a 24 hour period for a 2 year return period event is needed for input to design. Map A.1 from the ARC TP108 report has been reproduced in this section for this purpose.

6.4.1 Impervious catchments



The above graph can be used to obtain a conservative estimate of the required surface area of the rain garden for various impervious catchment sizes and rainfall and has been produced using the following 'worst case' assumptions:

Depth of planting soil	d = 1 m
Initial abstraction	Ia = 0 mm
Coefficient of permeability of planting soil	k = 0.3 m/day

Hydraulic retention time $t = 1$ day

Average depth of ponded water on surface of garden during storm $h = 0.11$ m

Impervious Area Curve Number $CN = 98$

6.4.2 Mixed catchments

1) Calculate Required Surface Area of Rain garden

$$SurfaceArea = \frac{d * A * \left(\frac{R}{3} - Ia\right)^2}{1000 * k * t * (h + d)\left(\frac{R}{3} - Ia + \left[25.4 * \left(\frac{1000}{CN} - 10\right)\right]\right)}$$

Where: d = Depth of planting soil [= 1 or greater] (m)

A = Catchment Area Contributing to Rain Garden (m^2)

R = Rainfall 2-year 24-hour (mm)

Ia = Initial Abstraction [= 0 for impervious surfaces] (mm)

k = Permeability of planting soil [= 0.3 or greater] (m/day)

t = Hydraulic retention time [= 1 (residential) to 1.5 (non-residential)] (days)

h = Average depth of ponded water on surface of garden during storm [= 0.11 (half maximum pond depth 0.22m)] (m)

CN = Curve Number [= 98 for impervious surfaces]

S = Storage [= 0 for impervious areas] (mm)

WQV = Water Quality Volume (m^3)

The above formula can be used by substituting site-specific values as calculated in the step-by-step worksheet example shown below:

2) Step-by-step Worksheet

1. Calculate pervious and impervious areas of the catchment separately (m^2)

- Impervious area (**Area**$_{impervious}$) may include roof, deck, patio, driveways or carpark.
- Pervious area (**Area**$_{pervious}$) may include lawns, gardens, bush.

2. Assume Initial Abstraction (**Ia**) values

- Impervious area Ia = 0mm
- Pervious areas Ia = 5mm

3. Assume Curve Numbers for the pervious and impervious areas
   - Impervious area, CN = 98
   - Pervious areas, CN=74 (grass)
4. Calculate a weighted Curve Number (**CN**) for the catchment

$$CN = \frac{(98 * Area_{impervious}) + (CN_{pervious} * Area_{pervious})}{(Area_{impervious} + Area_{pervious})}$$

5. Find the 2-year 24-hour rainfall (in mm) at the site using Map A.1 in TP108
   - Identify site location on map
   - Interpolate between isohyetal lines to obtain rainfall (**R**) in millimetres (mm).
6. Choose a depth (**d**) for the planting soil to be used (1m or more)
7. Obtain or estimate the coefficient of permeability (**k**) for the planting soil (m/day) (the soil selected must have a coefficient of permeability greater than 0.3 m/day).
8. The hydraulic retention time (**t**) for a residential site is 1 day
9. Estimate the maximum depth of water that could pond on the surface of the raingarden (metres). 0.22m is used as a rough guide. The average depth of water (**h**) is found by halving the maximum depth (i.e 0.11m).

The values can be directly substituted into the equation above to obtain the required surface area for the raingarden.

6.5 Construction Inspections

The construction of a rain garden will require two inspections. The first inspection will be conducted after the installation of the under drain pipe and drainage layer. The trench for the pipe connecting the rain garden and dispersal device should remain open for the inspection. The final inspection will be conducted upon completion of the rain garden, including planting of vegetation. Figure 6-4 shows the two inspection stages.

Figure 6-1

Conceptual Layout of Rain Garden

Figure 6-2

'In-Lawn' Rain Garden Plan and Section

Figure 6-3

'In-Lawn' Rain Garden Details

7.1 Introduction

When existing grassed or vegetated areas are developed and corresponding impermeable areas are created a resulting increase in stormwater flow, volume and sometimes a decrease in the time of concentration results. Stormwater detention is one method of controlling peak flows and times of concentration. The release of flow from the stormwater detention system requires a dispersal device to distribute the flow to avoid concentration and possible scour downstream.

7.2 Description

Two alternative dispersal devices are a trench or a sump. The intended function of these devices is to spread any discharges from the system over a sufficiently large area to avoid concentrations of flow. In this way it attempts to mimic the predevelopment conditions on site. The dispersal trench or sump perimeter length determined from the Code guidelines may require confirmation based on site conditions.

Where disposal is to bush and trench construction is not practicable an over ground system may be appropriate, providing the dispersion device is adequately protected from damage and deterioration from UV. Design proposals for such a system should be submitted to Council for review.

7.3 Application

Dispersal devices are the preferred means to disperse the concentrated outflow from impervious surfaces and stormwater treatment devices. Figures 7-1 to 7-4 show conceptual details for the design of dispersal devices.

7.4 Considerations

- Dispersal devices should be sited clear of any effluent disposal fields, or areas where water tables are high i.e. springs.
- In areas that are geotechnically sensitive to increases in water table, the opinion of an engineer should be sought.
- The dispersal length should be designed such that there is no more than a 20% increase in runoff over the area to which the trench discharges.
- The dispersal area should be sited such that flows will not concentrate for a distance of at least 30 metres past the outlet.
- The dispersal device should be designed so that minimal maintenance is required.

- The dispersal device design should give due regard to any potential conflict that may occur with any proposed activity on the site. In this respect fencing or isolation from other activities may be required.

8.1 Introduction

Swales can assist in preserving a site's predevelopment runoff characteristics by retarding flow and providing some infiltration especially from larger areas of impervious surface like driveways and carpark areas. Swales also provide treatment of stormwater.

8.2 Description

Swales are vegetated channels that convey runoff to a collection point or further drainage system. Swales can range in length and are generally vegetated with grass.

8.3 Application

Swales can have visual appeal as they are easily incorporated into the overall landscape design especially if they are considered as an integral part of a development. They also offer some water quality treatment. Shared driveways and roads longer than 30 meters will require a swale with an underdrain.

8.4 Considerations

- Swales are generally suitable for gradients between 1 and 4 percent. On steeper slopes check dams may be required within the swales to prevent high velocities and subsequent erosion. A piped underdrain can also be incorporated to the design.
- Vegetative cover of swales generally consists of a dense and continuous cover of relatively long grass. The grass should be maintained at a height of not less than 35 mm and typically 150 mm. Owners must be advised of proper maintenance requirements, swales should not be mown too short, or too frequently.
- Stock should be excluded from these areas.
- The swale size should be based on the dimensions provided on Figure 8-1. The dimensions shown are for effective catchment areas of up to 1000 m^2. The effective catchment area is equal to the impervious area plus 0.72 times the pervious area. For larger drainage areas the swales should be designed in accordance with ARC TP No. 10.
- Typical check dam details for the swales on Figure 8-1, are shown on Figure 8-2

9.1 Introduction

A green roof is a roof system that incorporates soil and plants to minimize the impacts of the covered structure. The idea of the green roof is to mimic the natural environment by filtering precipitation through the soil while capturing some to be evapotranspired later. The infiltration and filtering of precipitation helps to limit the decreases in the time of concentration that normally occur when a roof structure is built.

9.2 Description

A green roof is a roof system consisting of waterproofing material covered with a thin protective layer of soil and vegetation. A green roof, also known as a "eco-roof", can be used in place of a traditional roof. It is capable of capturing and evaporating between 10 and 100% of precipitation. The effectiveness is dependant on the soil type, soil thickness and vegetation. The season can also have an impact on the performance.

Figure 9-1 shows the conceptual design of a green roof. Green roof designs must be specific to the structure being considered. This detail is provided to illustrate the green roof option only.

9.3 Considerations

Adequate plant coverage needs to be established and maintained. Irrigation may be required during the summer months and to aid in establishment.

The additional weight of the soil and water needs to be considered in the structural design of the roof.

The slope of the roof should not exceed 25% unless additional runoff control measures are incorporated.

A chartered Professional Engineer should be consulted in the design and construction of a green roof system.

Maintenance and Monitoring Requirements

SECTION 10

The monitoring and maintenance requirements anticipated by WCC/RDC for the devices described in this document are listed in Table 10-1. It is anticipated that maintenance works will be carried out by property owners. Monitoring is also the responsibility of property owners. Formal inspection requirements by Council inspectors will be indicated in Building Consent conditions.

Table 10-1 - Summary of maintenance and monitoring requirements

Practice	Monitoring	Frequency	Maintenance	Frequency
ALL	Inspection by a Certified professional	5 years		
Bush Plantings	Independent Inspection by Council to check: • Bush area not reduced (GIS) • Bush health	5 years	Plant replacement as required. Pest control (weeds and possums)	As needed during establishment and long term
Rain Water Tanks	Check orifice openings for trapped or floating debris	3 months	Remove floating debris from tank	3 months
	Inspect all piping for restrictions or failures	1 year		
Rain Gardens	Check vegetation condition	6 months	Prune and clear excess vegetation. Irrigate as required	Varies depending on the type of vegetation
	Check for overflow due to clogging	6 months	Remove accumulated sediments	5 year
Wetlands	As per Approved Maintenance Plan	Varies	Erosion and weed control	As needed during establishment and then on an annual basis
			Remove accumulated sediments	5 year
Dispersal Devices	Check for downstream scour and uneven discharge	6 months	Repair areas indicating erosion	3 month
			Remove accumulated sediments	annual

Practice	Monitoring	Frequency	Maintenance	Frequency
Swales	Check for scour	6 months	Remove trash or debris	As needed
			Clear excessive vegetation	As needed
			Repair damaged areas	As needed
Green Roof	Design Specific		Design Specific	
Detention Ponds	As per Approved Maintenance Manual	Varies	Remove accumulated sediments	5 years
			Remove debris and excess vegetation	annual

Appendix A
Checklists

Checklist 1: Pre-Development Site Assessment

Pre-Development Site Assessment (include all parent titles)	**Please tick to indicate that the required information and detail is attached**
1. Size of site	
2. Topography and site contours	
3. Extent of existing vegetation, land cover and land uses	
4. Existing drainage patterns, streams, wetlands and springs	
5. Where the site is in relation to the catchment area	

Checklist 2: Development Proposal Assessment

Development Proposal (include all site information)	**Please tick to indicate that the required information and detail is attached**
1. Number and size of proposed lots	
2. Roading pattern (if required)	
3. Assessment of the proposed location, extent and material type for impervious areas on all proposed lots: - Roof area of all buildings, including farm buildings etc - Driveways, accessways, turning and parking areas - All paved areas, including patios, tennis courts etc.	
4. Total impervious area (m^2) from 3 above.	
5. State potential flow increase due to increase in impervious area using Appendix B.	
6. Proposed Roof Material	
7. Water supply on all lots.	
8. Identification of interference with existing drainage patterns (drains and overland flow paths)	

Appendix A
Checklists

Checklist 3A: Flood Protection Approach - Balance Sheet to Assess Mitigation Measures

Item	Mitigation Measure	Design Detail		Impervious Area to be Attenuated (m^2)
1	Planting of bush vegetation	Area of bush planting (m^2):		
2	Rain water tanks	Flood detention storage (m^3): Orifice diameter (mm): Max detention head (m): Mitigated Area: Roof Area (m^2) * 0.5 (Maximum of $100m^2$)		

Item		Area (m^2)
4	Total increase in on-site impervious area that needs to be attenuated (from Checklist 2, point 4):	
5	Total impervious area that has been attenuated [Add up the 'Impervious Area to be Attenuated' for Items 1, 2, 3 above]:	
6	Mitigation balance (Item 5 – Item 4):	

⇨ If Item 6 is positive then more than sufficient mitigation measures have been provided.
⇨ If Item 6 is zero then sufficient mitigation measures have been provided.
⇨ If Item 6 is negative then insufficient mitigation measures have been provided.

Item		Yes/No
7	Have swales been used to convey stormwater flow where appropriate:	
8	Have dispersion devices been used where appropriate:	
9	Has the area of driveways or accessways been minimised using techniques outlined in Section 3?	
10	Has stormwater treatment and/or source control been provided in the design	

Checklist 3B: Stream Channel Protection Approach - Balance Sheet to Assess Mitigation Measures

Item	Mitigation Measure	Design Detail		Impervious Area to be Attenuated (m^2)
1	Planting of bush vegetation	Area of bush planting (m^2):		
2	Rain water tanks	Flood detention storage (m^3): Orifice diameter (mm): Max Detention Head (m): Mitigated Area: Roof Area (m^2) * 0.5 (Maximum of 100m^2)		
3	Raingarden	Effective catchment area (m^2): Surface area of raingarden (m^2):		
4	Wetland Areas	Effective catchment area (m^2) Area of wetland (m^2): Orifice Diameter (mm):		
5	Detention Ponds	Effective Catchment Area (m^2) Surface Area of Pond (m^2) Orifice Diameter (mm)		
6	Green Roofs	Roof Area (m^2)		

Item		Area (m^2)
7	Total increase in on-site impervious area that needs to be attenuated (from Checklist 2, point 4):	
8	Total impervious area that has been attenuated [Add up the 'Impervious Area to be Attenuated' for Items 1, 2, 3, 4, 5, 6 and 7 above]:	
9	Mitigation balance (Item 9 – Item 8):	

⇨ If Item 10 is positive then more than sufficient mitigation measures have been provided.
⇨ If Item 10 is zero then sufficient mitigation measures have been provided.
⇨ If Item 10 is negative then insufficient mitigation measures have been provided.

Item		Yes/No
10	Have swales been used to convey stormwater flow where appropriate:	
11	Have dispersion devices been used where appropriate:	
12	Has the area of driveways or accessways been minimised using techniques outlined in Section 3?	
13	Has stormwater treatment and/or source control been provided in the design	

Appendix B
Summary of Analyses

Appendix B
Summary of Analyses

B1.0 Stormwater Runoff Modelling Overview

All analysis requiring estimates of stormwater runoff volumes or peak flows were based on the ARC Guidelines for Stormwater Runoff Modelling in the Auckland Region (TP 108).

Analysis was undertaken for the 1 % AEP and 50% AEP with rainfall depths estimated at 210 mm and 100 mm respectively, over 24 hours.

The soil cover was assumed to be weathered mudstone and sandstone (clay) and the SCS Hydrological Soil Group C was used to develop curve numbers.

The SCS curve numbers used were: -

Bush	CN = 65 (assumes >75% ground cover)
Pasture	CN = 74
Impervious	CN = 98

A series of hydrological models were developed to assess the effect of change in slope on the peak flow generated. Changes in slope were found to have minimal impact on the peak flows, hence, a constant slope of 15% was used for all analysis.

Analysis was undertaken using 100 m^2 units of impervious area to provide design information that allows the flexibility to select the various stormwater management options and combination of options that are most appropriate for a site. Pre and post development flows were generated for 100, 200, 300, 400, 500 and 600 square metre unit areas of impervious surface. Flows were assessed for up to a 600 m^2.

TP108 stipulates that time of concentration should be a minimum of 10 min. However in analysing very small catchments (600 m^2 and less), lag times are more likely to be in the order of minutes. For these small impervious units a lag time of 2 min was assumed. For 1-hectare sites a 0.5 km length of flow was assumed.

Table B-1 shows the difference in peak flows calculated between a pasture surface and an impervious surface.

The following table summarises the potential peak flow increase if a site is developed for 50%, and 1 % AEP events, depending on the impervious area.

Appendix B
Summary of Analyses

Table B-1 Potential Peak Flow Increase from Pasture to Impervious Surface (l/s)

	100 m²	200 m²	300 m²	400 m²	500 m²	600 m²
50% AEP	0.9	1.7	2.6	3.5	4.3	5.2
1 % AEP	1.0	1.9	2.9	3.8	4.8	5.8

For analysis of bush planting requirements lot sizes were assumed to be 1 ha. It was also assumed that all bush planting would replace pasture.

B2.0 Rain Water Tank Design

Water Recycling

Rain water tank water recycling is effective when no additional water is being imported onto the site for household use. This Code adopts the following volumes based on RDC/WCC data, either for full recycling or for partial recycling, for properties in a rural environment:

Table 1 Water Recycling Volumes

Water Use	Full Recycling Volume Used (l/day/person)	Partial Recycling Volume Used (l/day/person)
Toilet	47	47
Shower and bath	59	-
Laundry	38	30
Dishwashing	11	-
Taps (indoor & outdoor)	25	15
Total	180	92

Allowing for 3.8 people per dwelling gives water reuse volumes of 680 l/day/dwelling for full recycling, or 350 l/day/dwelling for partial recycling. This assumes that a storage volume of either 680 or 350 litres/dwelling is available in the rainwater storage component of the tank at the time of the design storm.

Appendix B
Summary of Analyses

The 680 litres is a volumetric reduction in the 100-year runoff during a 24-hour storm. TP 108 gives a reduction in runoff between a grass and bush cover over a 24 hour period of approximately 9 mm. This represents approximately 76 m^2 of additional bush cover that can be saved if full water recycling is used. In the Code a figure of 70 m^2 is adopted.

Similarly, partial recycling would provide a reduction of 350 litres during a 24-hour storm, which would represent approximately 40 m^2 of additional bush cover that can be saved if partial water recycling were used.

Derivation of orifice diameter and the detention storage head and size

1. Orifice sizes and detention volumes were calculated such that peak flows associated with pre-development conditions would be maintained.
2. The storage versus orifice size and the outflow verus orifice size curves are computed for the 1 % AEP design flood on each roof area, and routed through various tank sizes using HEC-HMS.
3. From the outflow versus orifice size curve, the 50% AEP inflow for each roof area provides an estimate of the actual orifice size needed. The next lowest standard PVC pipe diameter is selected for each roof area.
4. From the storage versus orifice size curve, the PVC pipe diameter determined from 3 above is used to determine the storage size needed.
5. For the storage size needed, the detention head is determined from the tank dimensions.

Appendix C
Recommended Plant Species

Appendix C
Recommended Plant Species

Plants listed below are preferred by WCC and RDC for any activities requiring revegetation. Please refer to the key at the base of the table for Location and Preference Rating information.

Location	Preference Rating	[1]TREES/LARGE SHRUBS	
OSE	*	Agathis australis	kauri
SE	*	Aristotelia serrata	makomako, wineberry
SE	*	Coprosma arborea	mamangi
SE	*	Coprosma grandifolia	kanono
EOS	*	Coprosma lucida	shining karamu
OSE	**	Coprosma robusta	karamu
BSOE	**	Cordyline australis	ti kouka, cabbage tree
BESO	**	Dacrycarpus dacrydioides	Kahikatea
ESO	*	Dacrydium cupressinum	Rimu
SE	*	Geniostoma repestre var.ligustrifolium	hangehange
O	*	Griselinia lucida	puka
E	*	Hebe macrocarpa	koromiko
EO	*	Hebe stricta	koromiko
S	*	Hedycarya arborea	pigeonwood
OS	**	Hoheria populnea	houhere, lacebark
SE	*	Knightia excelsa	rewarewa
O	*	Kunzea ericoides	kanuka
O	*	Leptospermum scoparium	manuka
E	*	Melicope simplex	poataniwha
EOS	**	Melicytus ramiflorus	mahoe
C	*	Metrosideros excelsa	pohutukawa
OS	*	Myrsine australis	mapou, red matipo

Appendix C
Recommended Plant Species

BOE	**	Phormium tenax	harakeke, flax
ESO	*	Pittosporum eugenoides	lemonwood
ESO	*	Pittosporum tenuifolium	kohuhu
ESO	*	Podocarpus totara	Totara
ES	**	Pseudopanax arboreus	whauwhaupaku, five finger
ES	*	Pseudopanax crassifolius	horoeka, lancewood
ES	**	Schefflera digitata	pate
C	*	Sophora microphylla	kowhai

		OTHER SPECIES FOR GENERAL USE FROM WAITAKERE/RODNEY ECOSYSTEMS	
B		Carex dipsaceae	NZ Sedge
B	*	C.flagellifera	NZ Sedge
B	*	C.lessoniana	NZ Sedge
B		C.maorica	NZ Sedge
B	*	C.secta	NZ Sedge
B		C.virgata	NZ Sedge
BEOS	**	Cortaderia fulvida	NZ toetoe
B		Cyperus ustulatus	giant umbrella sedge
SE		[1]Entelea arborescens	Whau
E		[1]Gahnia lacera	cutty grass
E		[1]G setifolia	cutty grass
SE	*	[1]G.xanthocarpa	cutty grass

Table Key :

Appendix C
Recommended Plant Species

[1] Not applicable for rain gardens.

* Recommended Species

** Most Recommended Species

C = Coastal margins

B = Immediate stream bank or swamp edge

E = Forest edge or gaps in bush

S = Sheltered, shady, moist

O = Open, dry, sunny