The countryside living TOOLBOX

Background

April 2010



Papakura District Council

Waitakere City Council
Te Taiao o Waitakere

Franklin District Council

Rodney District Council

Auckland Regional Council
Te Rauhītanga Taiao

THE COUNTRYSIDE LIVING TOOLBOX:

A GUIDE FOR THE MANAGEMENT OF STORMWATER DISCHARGES IN COUNTRYSIDE LIVING AREAS IN THE AUCKLAND REGION

April 2010

There are 4 publications in this series

The Countryside Living Toolbox: Background

The Countryside Living Toolbox: Site Design and Prevention of Stormwater Effects

The Countryside Living Toolbox: Stormwater Management Device Design Details

The Countryside Living Toolbox: Water Supply Public Health Guidelines and Wastewater Management Considerations

Acknowledgement:

This Toolbox is Version 4.0 of several original documents done by and on behalf of the Rodney District Council and the Waitakere City Council over the past eight years. It has borrowed from the earlier versions where changes were not needed and it supercedes those documents.

Permission was given by Rodney District Council and Waitakere City Council to use information from the earlier documents where use of that information was appropriate.

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Documents in the Series

The Countryside Living Toolbox is divided into 4 publications.

Countryside Living Toolbox: Background and Application – This section defines the applicability of the Toolbox; provides background information on stormwater effects in rural areas; details the regulatory context of this guideline; describes the key stormwater design objectives and approaches; and summarises the different techniques available for use.

Countryside Living Toolbox: Site Design – This section provides information on how site design can affect the volume and rate of stormwater which is discharged as a result of development. This section of the Toolbox will assist developers to “avoid” or “prevent” effects.

Countryside Living Toolbox: Stormwater Management Device Design Details – This section provides design information for structural stormwater practices. Ponds, wetlands, filter strips, swales, rain gardens, infiltration trenches and rain tanks are discussed. This section of the Toolbox will assist developers to “mitigate” effects.

Countryside Living Toolbox: Water Supply and Wastewater Management Considerations – This section of the Toolbox briefly discusses requirements relating to both potable and non-potable water supply. It also provides an overview of the design features and maintenance considerations associated with on-site wastewater treatment and disposal systems.

Disclaimers

Waitakere District Council
In situations where there are differences to the earlier versions and where they have been relied on or embodied into planning documents such as Structure Plans or Resource Consents then the requirements of the earlier versions shall take precedence over Version 4.0.

Rodney District Council
Infiltration in Rodney District Council
Rodney District Council has significant areas of countryside where soil stability is strongly dependent on and particularly sensitive to changes in moisture content and the hydrological cycle in general.
for that reason infiltration as a means of stormwater management is not seen as a viable management tool.
Water Supply for re-use
This section is not applied in Rodney District Council. RDC has its own provisions for re-use. Where a particular re-use application is required RDC can make available a protocol for calculating storage v consumption requirements to estimate tankage against supply.

Papakura District Council
The guideline provides for a number of methods and tools to mitigate the effects of storm water run-off from countryside living areas but the acceptance of any particular method and tool will depend with the respective TLA (PDC) . The extent and sharing of responsibility by TLA, property owners and developers to ensure continued performance from these methods and tools is not covered in this guideline and will depend on the consenting and approval processes of respective TLA.

Countryside Living Toolbox:
Background

Table of Contents

1 INTRODUCTION

1.1 Purpose

The Auckland Regional Council, jointly with Rodney District Council, Waitakere City Council, Manukau City Council, Papakura District Council and Franklin District Council have commissioned a document to provide stormwater design guidance to consultants, developers, landowners and council consenting staff for countryside living areas.

The guideline document (the "Toolbox") is intended to provide the abovementioned groups with a selection of methods and tools to mitigate the effects of stormwater run-off from countryside living areas. All these councils are committed to a policy of avoiding, remedying or mitigating the adverse effects from stormwater discharges on the receiving environment to the greatest extent possible.

1.2 Objectives of these Guidelines

The primary objective of the Toolbox is to outline and demonstrate the preferred approach for stormwater management in rural residential areas in the Auckland Region. It provides a myriad of techniques ranging from stormwater sensitive site design, to guidelines for using natural vegetation to mitigate effects, to the design approach for structural stormwater management practices.

The goals of the Toolbox are:

1. to minimise changes to the hydrological regime in order to protect the physical structure of streams and also to reduce potential downstream flooding; and

2. to reduce sediment discharges resulting from increased stream channel erosion and small scale rural development.

1.3 Previous Document Versions

This document supersedes the following stormwater manuals:

- "Countryside and Foothills Stormwater Management Code of Practice – Version 2" (February 2002). Prepared for Waitakere City Council.

- "Countryside and Foothills Stormwater Management Code of Practice – Version 3" (July 2005). Prepared for Waitakere City Council.

- "Management of Stormwater in Countryside Living Zones (Rural and Town) – A toolbox of methods" Version 3 (July 2005). Prepared for Rodney District Council.

- “The Large Lot Guidelines” Technical Publication 92. (undated). Auckland Regional Council.

- Stormwater Design Manual for Soakage Retention Pits and Detention Tanks. Version 1 (October 1998). Prepared for Franklin District Council [*the Countryside Living Toolbox supersedes this document for the applicable countryside living/ rural residential areas only*].

1.4 Document Structure

The Countryside Living Toolbox is divided into 4 parts.

Countryside Living Toolbox: Background and Application – This section defines the applicability of the Toolbox; provides background information on stormwater effects in rural areas; details the regulatory context of this guideline; describes the key stormwater design objectives and approaches; and summarises the different techniques available for use.

Countryside Living Toolbox: Site Design – This section provides information on how site design can affect the volume and rate of stormwater which is discharged as a result of development. This section of the Toolbox will assist developers to “avoid” or “prevent” effects.

Countryside Living Toolbox: Stormwater Management Device Design Details – This section provides design information for structural stormwater practices. Ponds, wetlands, filter strips, swales, rain gardens, infiltration trenches and rain tanks are discussed. This section of the Toolbox will assist developers to “mitigate” effects.

Countryside Living Toolbox: Water Supply – This section of the Toolbox briefly discusses requirements relating to both potable and non-potable water supply.

Countryside Living Toolbox: Wastewater Management Considerations – This section provides an overview of the design features and maintenance considerations associated with on-site wastewater treatment and disposal systems.

2 APPLICABILITY AND LIMITATIONS

2.1 Applicability

The Countryside Living Toolbox has been developed to provide guidance for the management of stormwater infrastructure and discharges for:

- residential sites with no more than 600m^2 of impervious area per lot (this limit includes driveways, shared accessways, roof areas and any other hardstand areas such as patios or car parking);

- an average rural residential lot size of 2000m^2 and greater (this is to allow clustering of lots and to ensure that there is enough space for on-site management);

- local access roads (this includes all driveways, local roads; footpaths; cycle ways and bridle tracks – it does not include State Highways and main council roads);

- small rural commercial sites (such as the corner dairy or bakery);

- greenhouses with less than 1000m^2 impervious area (greenhouses larger than this may require consent from the Auckland Regional Council).

The stormwater management tools and practices provided in the Toolbox are simple to use and are aimed at providing methods that are most applicable for the conditions encountered. Depending on the scale of the project, consents may be required from the Auckland Regional Council and/or the local city/ district council for stormwater discharges. This is discussed in greater detail in Section 3 of Part A. However, owners, developers and consultants are strongly urged to check with the local and regional council prior to assuming that any proposed development is either a permitted activity or will meet the criteria to allow use of this Toolbox.

2.2 Limitations

Users need to be aware that there are a number of limitations relating to this guidance document:

a) Whilst it is intended that the Toolbox be used as a guide to appropriate on-site management of stormwater, effective implementation of stormwater management is also dependant on good site design, choice of methods, construction and long term operation and maintenance. A proper site assessment needs to be undertaken to assess site constraints such as catchment area (including up and downstream characteristics), slope, bush cover and soil conditions. In addition, careful monitoring of the construction of any device is critical to ensuring that the relevant designs are built correctly. Finally, to ensure that the device functions as intended, regular maintenance of the system is required.

b) The Toolbox is to be used as a “toolbox of methods” for appropriate on-site stormwater management where site imperviousness does not exceed 600m^2 per lot. However, the document in no way sets policy relating to lot size, density or ratio that is in conflict with any district plan requirements for the area. In addition, all councils reserve the right to impose more restrictive requirements than those provided in this guideline.

c) Developers are advised to use the services of a consulting engineer to assist in the development of appropriate on-site stormwater management options. In addition, developers are advised to use the services of a geotechnical engineer to assess the suitability of the underlying soils to receive stormwater (in geotechnically unstable areas disposal over land or to ground may cause further slope instability and failure).

3 THE REGULATORY FRAMEWORK

The Local Government Act (2002) (LGA) and Resource Management Act (1991) (RMA) set the legislative framework for how Councils must function and how the effects on the receiving environment must be managed.

The LGA states the purpose of local government and provides a framework and the necessary power for local authorities to decide which activities they undertake and the manner in which they will undertake them. It promotes a sustainable development approach by allowing councils to take social, economic, environmental and cultural well-being into account during decision making.

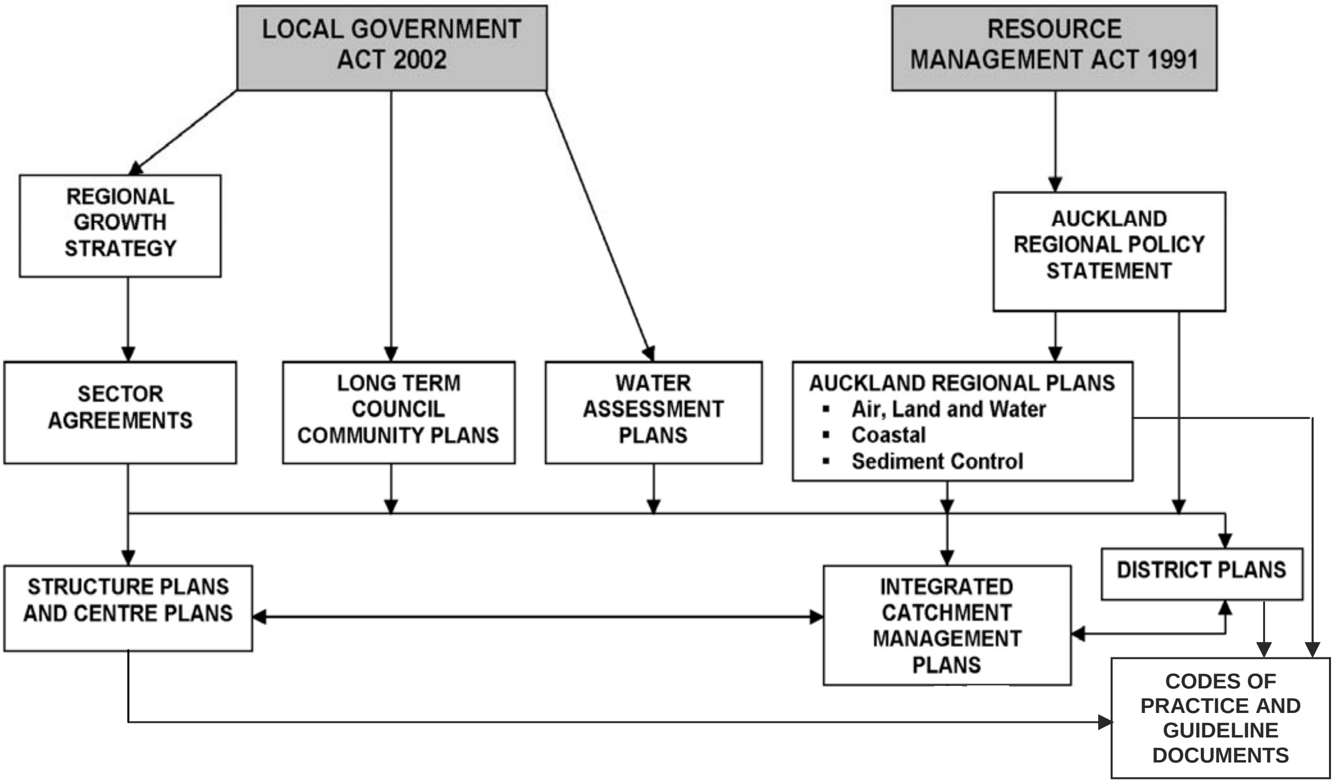
The purpose of the RMA is to "*promote the sustainable management of natural and physical resources*". Sections 14 and 15 of the RMA provide the legislative framework for the management of the diversion and discharge of stormwater. In addition, Section 5 of the RMA requires that rural resources be managed to meet present needs while maintaining options for future generations to meet their social, cultural and economic needs.

Under the LGA and RMA councils are required to prepare a number of planning documents (see Figure A1). Regional councils prepare regional policy statements and regional plans in order to direct the use, development and protection of natural and physical resources within the region. The *Auckland Regional Policy Statement* (ARPS) (ARC, 1999b) sets the strategic direction for the Auckland Region. The Auckland Regional Council (ARC) is responsible for the implementation of these plans in order to control the effects of air and water discharges to land, streams, lakes and the coast. In addition, the ARC is responsible for regulating activities on the land and in the coastal marine area to avoid, remedy or mitigate effects on the Region's receiving environment.

Under the RMA local councils are required to prepare district plans. These district plans need to be consistent with the regional planning documents and, ideally, changes to the district plan need to be supported by structure plans and integrated catchment management plans.

The Toolbox has been developed as a non-statutory guideline under this framework. The methods and tools provided have been developed to ensure that district and regional planning objectives and policies are met, and that stormwater discharges from rural developments have a no more than minor effect on the receiving environment.

Figure A1 Relationship between the different planning documents for the management of stormwater discharges in the Auckland Region (adapted from the ARC's Stormwater Action Plan, 2005)



<u>The Resource Management Act</u>
The RMA requires landowners and developers to avoid, remedy or mitigate; or prevent or minimise the effects of stormwater discharges on the receiving environment. In the context of stormwater management, the concept of "Avoid" or "Prevent" relates to site design practices which reduce runoff or contaminants through a reduction in impervious surfaces and minimization of site disturbance. "Mitigate" or "Minimise" refers to constructed stormwater practices which have the ability to treat or attenuate stormwater runoff generated from impervious surfaces.

The Toolbox has been therefore been divided into an "Avoidance" section (Part B) and "Mitigation" section (Part C).

<u>The Proposed Auckland Regional Plan: Air Land and Water</u>
Chapter 5 of the PARP: ALW (ARC, 2008) provides the objectives, policies and rules for the management of stormwater discharges throughout the Auckland Region. Rule 5.5.1 (2), (3) and (4) is the relevant rule which permits new impervious areas up to 5000m^2 outside urban areas. There are a number of conditions relating to these rules and, although the Toobox is a non-statutory document, it can be used to assist developers in meeting the intent of these conditions.

<u>District Plans</u>
In addition to the PARP:ALW, developers will need to assess their development against the relevant district plan provisions. Again, the Toolbox can be used to meet these district plan requirements.

Regional Stormwater Guidance Documents

The ARC has a number of technical publications which guide stormwater, wastewater and sediment management across the region to assist in the implementation of the rules of the PARP:ALW. Of particular relevance are the following documents:

- Technical Publication 124: Low Impact Design Manual for the Auckland Region (ARC, 2000). (TP124)

- Technical Publication 10: Stormwater Treatment Devices: Design Guideline Manual (ARC, 2003). (TP10)

- Technical Publication 108: Guidelines for Stormwater Runoff Modeling in the Auckland Region (ARC, 1999c). (TP108)

- Technical Publication 90: Erosion and Sediment Control – Guidelines for Land Disturbing Activities in the Auckland Region (ARC, 2007). (TP90)

- Technical Publication 58: On-site Wastewater Systems: Design and Management Manual (ARC, 2004). (TP58)

In addition to these regional documents, each local council has their own engineering code of practice to support their district plan rules.

It is considered that the Toolbox provides both local and regional guidance to developers which will allow them to seek compliance with local and regional planning documents.

4 EFFECTS OF STORMWATER DISCHARGES

4.1 General Effects of Stormwater Discharges

Stormwater is rainwater that flows over land (roads, buildings, etc) into drains, along waterways and eventually discharges to the coast.

Under a natural bush catchment the majority of rainfall infiltrates into the ground or evapotranspires into the atmosphere. Only about 10% of rainfall actually discharges as stormwater runoff (Shaver *et al*., 2007). As the landform changes from bush to farmland so the amount of evapotranspiration decreases and runoff increases. With development and the construction of impervious surfaces (roads, roofs, etc) vegetation is cleared and the ground looses its soakage capacity. As a result infiltration and evapotranspiration decrease, leading to a corresponding increase in the volume of stormwater runoff discharged.

In urban areas, rain that falls onto roofs, roads and other hard surfaces collects in stormwater catchpits and is carried through a system of pipes to our receiving waters. These pipes have been built to protect public safety by directing water away from houses and people to prevent flooding. In rural areas, rain that falls onto roofs and roads is often discharged diffusely or uncontrolled into streams. This increased quantity of water can cause problems downstream. In addition, after stormwater runs over impervious surfaces its quality also deteriorates.

There are 3 key adverse effects of stormwater on the environment which need to be managed. These are:

- **Water quantity effects** – increases in impervious surfaces, coupled with the removal of native bush, cause an increase in stormwater run-off, and this increases the risk of flooding and erosion. Flooding risks for developments which are too close to existing watercourses are also increased.

- **Water quality effects** – impervious surfaces also collect contaminants derived from everyday urban life. This could be anything from litter, dust, decomposing vegetation and sediment to oils, tyre wear and exhaust emission particles. Impervious surfaces themselves can generate contaminants, for example exposed metal roofs can leach zinc or copper. Increases in impervious surfaces therefore decrease the quality of stormwater runoff and increase threats to human health and the receiving waterways.

- **Aquatic habitat effects** – altered hydrology (i.e. increased stormwater flows) and contamination of stormwater may cause a loss of aquatic resources. Increased stormwater flows cause erosion and subsequent sedimentation of streams. Pipes and culverts can cause barriers to fish passage and the creation of irrigation channels (or straightening of streams) can alter hydrology and further exacerbate stream erosion. The removal of bush for pasture land also increases stormwater runoff and destabilises stream banks.

The stormwater management techniques presented in the Toolbox aim to protect human health and safety, as well as ecological values by preventing or mitigating the abovementioned adverse effects.

4.2 *Stormwater Effects in Rural Areas*

4.2.1 Water Quantity Effects

In rural areas the cumulative impact of countryside living subdivisions, access roads and connector roads, and farm buildings (eg, green houses and chicken sheds) causes an increase in peak flow rates and the volume of water which is discharged after storm events. This leads to 2 key effects: flooding and stream erosion.

<u>Flooding</u>

Flooding adjacent to streams is a natural phenomenon, however, impervious surfaces can cause an increase in flood levels as well as the frequency of flooding. The flood level at any given point is determined by how quickly upstream conditions deliver water and how quickly downstream conditions allow it to get away. Since development within a catchment changes these flow rates over time, flood levels will also change. The purpose of stormwater quantity management therefore is to try to 'imitate' the natural flow conditions in order to ensure existing flood levels are not increased. This is sometimes referred to as creating a "hydrologically neutral" development.

Another key contributor to flooding within rural catchments is filling of floodplains. In many instances river floodplains are 'reclaimed' in order to make the land more usable for farming activities. This loss of storage volume further increases the level and extent of flooding.

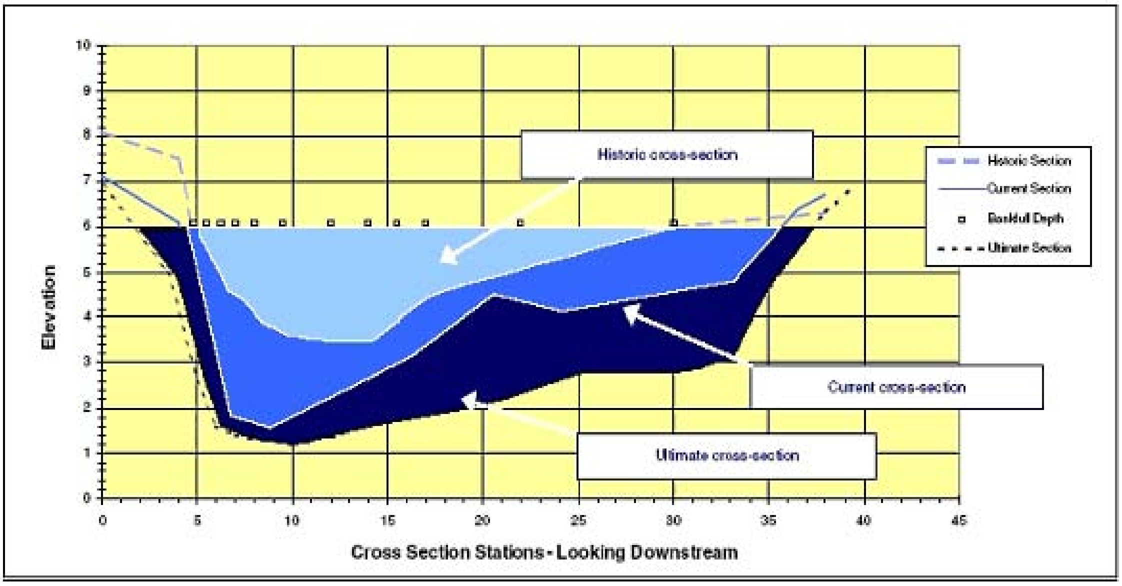
<u>Stream Erosion</u>

Like flooding, stream erosion is a natural process. However, the creation of impervious surfaces reduces the soakage capacity of the ground thereby increasing the volume of runoff during a storm. What this means is that less rainfall generates the same or more runoff during post-development conditions than what was generated under a pre-development scenario. Put another way, in a pre-development scenario a two year Average Recurrence Interval (ARI) rainfall event generates a two year runoff event. In a post-development scenario a two year ARI rainfall event may generate a 4 or 6 month runoff event. This means that streams will run full more frequently than prior to development. More work is therefore done on the stream channel, thereby accelerating stream erosion. One study on stream erosion in the Auckland Region

(Herald, 1989) predicts a three-fold increase in stream channel cross-section when a catchment changes from pastoral to urban land use.

The potential impacts of impervious surfaces on stream boundaries from an increase in the volume, frequency and rate of stormwater discharges is illustrated in Figure A2 (Centre for Watershed Protection, 2003). Figure A2 shows that, between 1950 and 2000, both the depth and width of the cross section have increased significantly. Impervious area within the catchment increased from 2% to 27% during this time (Shaver *et al*., 2007).

Figure A2 Effects of impervious surfaces/ development on stream erosion (Center for Water Shed Protection, 2003)

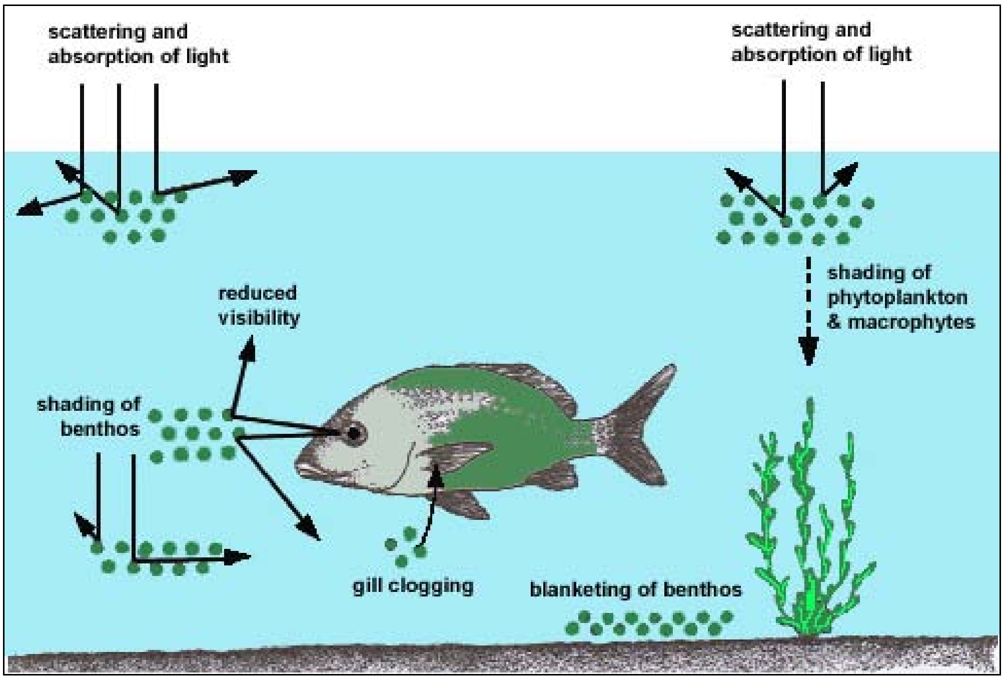


4.2.2 Water Quality Effects

Natural waters (i.e. streams, estuaries, open ocean) contain a variety chemicals and particles (both organic and inorganic) in specific quantities. These waters also have certain physical parameters relating to temperature and colour. As a result, aquatic organisms are adapted to living in waters with particular chemical constituents and physical attributes (Davies and Day, 1998). Pollution is defined as "*the introduction of contaminants into an environment…[that may]…cause instability, disorder, harm or discomfort to the physical systems or living organisms therein*" (Wikipedia, 2008). A contaminant can therefore be defined as something which may be responsible for the pollution of or change in the physical or chemical attributes of water.

Contaminants in stormwater can act in many different ways to cause adverse effects on aquatic biota. Sediments can smother benthic dwelling organisms, clog fish gills and reduce light transmission within the water column (Figure A3). Metals accumulate within benthic dwelling organisms (such as oysters) and can be toxic to them. Nutrients can cause algal blooms and an excess of blue green algae, thereby causing anoxic conditions within the water column (ARC, 2003).

Figure A3 A schematic diagram of some of the effects of sedimentation on aquatic ecosystems and their biota (Davies and Day, 1998).



The types of contaminants discharged in rural areas differ from the 'urban' contaminants which most stormwater programmes are targeted towards removing. In an urban setting the key contaminants of concern include zinc, copper and other metals, and PAHs. In rural areas the key contaminants of concern include nutrients (nitrogen, ammonia, phosphorus) and sediment. Sources of these contaminants are generally from:

(a) overland runoff from pasture areas because such runoff includes faeces and urine from grazing stock, herbicides, pesticides and fertilizers;
(b) sediment discharged from stock trampling activities and access to streams;
(c) sediment discharged from accelerated stream channel erosion as a result of channel modification, increased stormwater flows and clearance of riparian vegetation;
(d) sediment discharged from land modification activities (eg. the creation of building platforms and clearance of vegetation); and
(e) overflows from septic tank systems or where waste has not been treated to the appropriate level and tanks are not operated and maintained effectively.

As can be seen from the above list, the majority of rural contaminants are derived from farming activities rather than countryside living subdivisions. Management of nutrients needs to be undertaken at the source of contamination and are currently legislated through the Auckland Regional Plan: Farm Dairy Discharges (1999a) and the Proposed Auckland Regional Plan: Air, Land and Water (2008) (PARP: ALW).

The Toolbox will focus on the management of sediments from accelerated stream channel erosion and land modification activities resulting from rural residential and small-scale commercial developments.

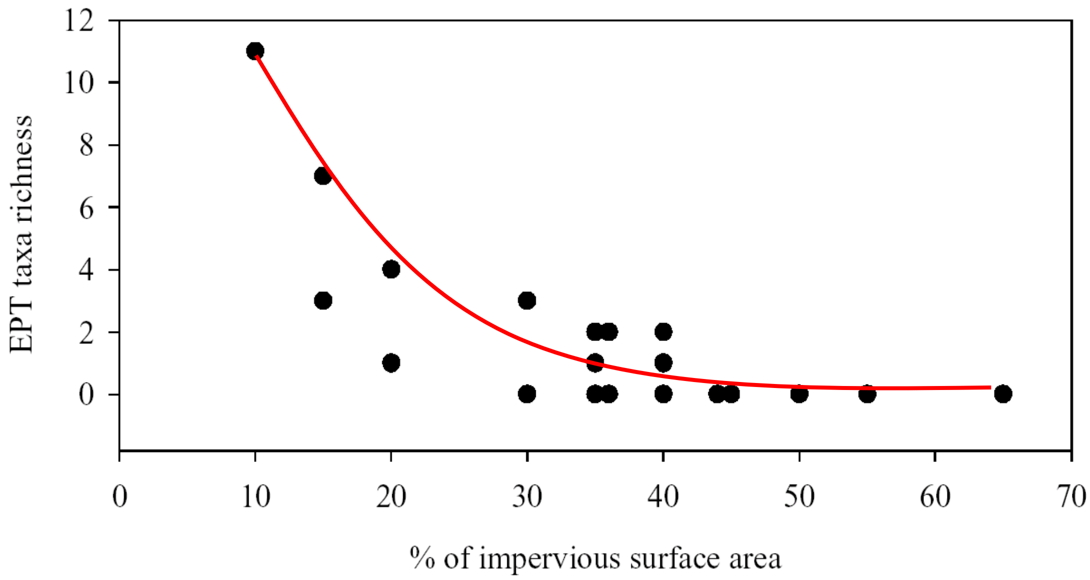
4.2.3 Aquatic Habitat Effects

Stream health is affected by both water quality and water quantity effects. Hydrological factors are thought to be key factors in causing sedimentation and erosion of the physical structure of streams (Auckland Regional Council, 2003). Due to the complexity of stream systems, it is very difficult to identify the combination of factors that cause specific problems in stream health. However, research has shown that stream health is directly linked to the level of imperviousness within a catchment (see Figure A4 below). Once a catchment approaches impervious levels of approximately 15%, effects on the physical structure of streams becomes evident (Allibone et al., 2001). Local studies have also shown that stream health is affected by impervious areas. Herald (1989) investigated the hydrological impacts of urban development in the Albany basin in North Shore. From the study Herald (1989) was able to ascertain that channel enlargement (or accelerated erosion) is closely linked with an increasing percentage of impervious cover. The study indicated that channels can expect to enlarge by as much as three times more than their rural state to a completely urban state.

Other effects of development on stream systems include:

- the destabilisation of stream banks and increased sedimentation from an increased frequency and magnitude of peak flows;
- smothering of stable and productive aquatic habitats such as rocks, logs, and aquatic plants from sedimentation;
- bare soil stream banks from the deliberate removal of vegetation (Auckland Regional Council, 2003).

Figure A4 Relationship between the number of sensitive species living in a stream system and the percentage of impervious cover (Alibone *et al.*, 2001)



Given that the structural stability of the stream channel has a significant effect on the health of the aquatic ecosystem, stormwater management needs to be directed towards maintaining stream channel integrity and minimising accelerated stream channel erosion.

5 DESIGN OBJECTIVES AND APPROACH

5.1 Design Objectives

The focus of stormwater management initiatives in countryside living areas needs to be directed towards flood provision and stream management. It is acknowledged that rural contaminants do cause a decrease in water quality, however, it is considered that the majority of solutions for reducing flooding and managing streams will assist with reducing effects from rural development on water quality. As a result, the objectives of the Toolbox are to:

1. minimise changes to the hydrological regime in order to protect the physical structure of streams and also to reduce potential downstream flooding; and

2. reduce sediment discharges resulting from increased stream channel erosion and small scale rural development.

5.2 Design Approach

5.2.1 Minimising Changes to the Hydrological Regime

The Toolbox recommends three design approaches for the management of stormwater quantity effects:

1. Peak flow control
2. Extended detention
3. Volume reduction

Each of these approaches is discussed in more detail below.

1. Peak Flow Control

The intent of peak flow control is to manage flood flows by preventing or reducing damage caused to property and infrastructure by large, infrequent storm events. By attenuating peak flows, existing flood plain levels and hazards can be maintained and the physical integrity of the associated infrastructure protected (Dillon Consulting, 2006). Furthermore, peak flow control prevents habitat damage and protects the amenity value of streams (Shaver *et al*., 2007). In the Auckland Region, generally one ensures that post development peak discharges for both the 2 and the 10 year ARI storm events are attenuated to predevelopment levels. The intent of peak control for two different frequency storms is to:

- achieve benefits for a range of discharges;
- provide peak control of storms between those intervals; and
- provide a degree of control of peak flows from greater magnitude storms (Auckland Regional Council, 2003).

Depending on the catchment, the number of tributaries and the location of the development in a catchment, timing of flow discharges may be an issue (ARC, 2003). Generally, if a project is in the upper half of a catchment, peak flow control should be provided. Discharges to ground or soakage do not require peak flow control.

If there are downstream flooding issues, peak discharges for the post development 100 year ARI event should also be attenuated to predevelopment levels to ensure that downstream flooding is not increased. Again, timing of flow discharges may be an issue depending on where the development discharges in the catchment. As a result there are two options available to developers:

1. if a catchment wide study has been undertaken then peak flow attenuation should be undertaken in accordance with the approach recommended in the catchment management plan;

2. if there is no catchment wide study, limit the 1% AEP post development peak discharges back to 80% of the predevelopment peak flow rates. This additional attenuation reduces potential for coincidence of elevated flow downstream (ARC, 2003).

2. Extended Detention

The purpose of extended detention is to maintain or improve in-stream channel stability in order to protect ecological values and to reduce sedimentation downstream (ARC, 2003). Extended detention involves attenuating the first 34.5mm of rainfall and releasing it slowly over 24 hours. This method allows for stormwater flows in streams to be kept below erosive velocities, therefore reducing the amount of work done on the stream channel boundaries and reducing accelerated stream channel erosion.

Extended detention should be provided for all discharges to streams. Discharges to ground or soakage, and to tidally influenced streams or the coast do not require extended detention.

3. Volume Control

In addition to peak flow rates increasing with development, the volume or amount of water discharged in a post-development scenario is greater than in a pre-development one. At present there are no defined regional or local guidelines for reducing the volume of water that is discharged, however, many of the techniques presented in this Toolbox will assist with volume reduction. The site design (or low impact design) methods provided in Part B of the Toolbox will assist in reducing the volume of stormwater discharged through source control (i.e. preventing an increase in the volume or peak flow of discharges rather than mitigating it through structural stormwater management practices). In addition, some of the stormwater management practices provided in Part C of the Toolbox will assist with volume reduction. For example, the use of rain tanks for water reuse will reduce the amount of stormwater which is discharged to the receiving environment. Also, the evapotranspiration function of rain gardens has been shown in Australia and in the United States to reduce the amount of stormwater discharged (Hatt *et al.*, in press; Betty).

5.2.2 Reducing Sediment Discharges

The two key sources of sediment discharged to streams and estuaries are from accelerated stream channel erosion and sediment during development.

1. Reducing Accelerated Stream Channel Erosion

The best way of reducing accelerated stream channel erosion is to reduce the impervious surface area. The amount of impervious area is a factor of the site/ subdivision design and is addressed in Part B of the Toolbox.

Accelerated stream channel erosion can be mitigated by minimizing changes to the hydrological regime and by attenuating the first 34.5mm of rainfall and releasing it slowly over 24 hours (as discussed in Section 5.2.1).

2. Reducing Sediment Discharges during Development

In greenfields (or developing) catchments the biggest sources of sediment are from farming and construction activities. The Auckland Regional Council's TP90 provides guidance on appropriate sediment and erosion control measures that should be put in place during land disturbing activities. It's applicability to and further information relating to sediment and erosion control on small sites in rural areas is provided in Part B of the Toolbox.

Sediment and other contaminants (such as metals) are also discharged from existing and new impervious areas once they have been constructed. These contaminants can either be controlled at their source or through stormwater treatment. Source control of contaminants is defined as measures designed to prevent the introduction of contaminants into stormwater runoff (e.g. using an inert roofing material to prevent copper or zinc leaching from an exposed metal roof).

The accepted minimum level of stormwater treatment in the Auckland region (as given in the PARP:ALW) is the removal of 75% total suspended solids over a long term average basis. The practices summarized in Section 6 and discussed in detail in Part C will assist landowners, developers and consultants to meet this minimum standard.

By addressing construction generated sediment, as well as providing long term stormwater treatment, discharges of sediment and other contaminants to the receiving environment can be minimized.

6 SUMMARY OF KEY PRACTICES: CHOOSING THE RIGHT STORMWATER MANAGEMENT PRACTICE(S) FOR YOUR SITE

The purpose of the Toolbox is to provide developers, consultants and individual property owners with a range of stormwater management methods and practices for reducing the effect of impervious surfaces on the receiving environment. Not all the methods provided will be suitable for each site, and thus this section explains the benefits and constraints of different stormwater practices.

It should be remembered that there are a number of site design techniques (often referred to as low impact design) which will prevent effects of stormwater runoff. These are presented in Part B of the Toolbox.

6.1 Description of Practices

Ponds

Ponds attenuate (detain) stormwater flows and treat suspended sediments through settlement. Sedimentation is promoted by slow flows which give longer detention times and allows for settlement of particles.

Wet ponds (as shown in this photograph) have a permanent pool of water and can also be used as water supply ponds for non-potable uses and fire-fighting.

Wetlands

Wetlands also have permanent pools of water and attenuate flows to promote sedimentation. However, wetlands are able to remove a variety of other contaminants (such as nutrients and metals) due to the biological and chemical processes provided by the wetland plants.

Wetlands have the added benefit of being very shallow systems so they are less of a safety hazard in terms of drowning than open water ponds.

Rain Gardens

Rain gardens are filtration practices which capture water and then treat the water as it filters through the plant and soil media. Due to evapotranspiration and the 'wetting and drying' of the plants in rain gardens they are also able to reduce the amount of water actually discharged to a certain degree. Some water will also soak back into the ground.

Rain gardens should only serve small catchment areas and need to be built using a carefully graded filter media. It should be planted with lots of native plants.

Swales

Swales treat stormwater by allowing a shallow film of water to flow through the vegetation. This filtering action removes sediment particles through biological uptake and adhesion of particles to the plant surface.

Swales have multiple benefits by 'breaking up' or reducing impervious areas. They can assist with groundwater recharge and increase hydrological residence times. They are best suited to treating roads or other 'long' sections of impervious areas and on grades of less than 5%.

Filter Strips

Vegetative filter strips are very similar to swales and use the same processes of biofiltration to remove contaminants. They are suitable for flatter areas (<5%) and have the added benefit of ensuring that flows are discharged in a diffuse manner across pasture or bush to the receiving environment, therefore reducing point source, erosive flows.

Filter strips can be planted with grass or using native vegetation as a riparian buffer strip adjacent to streams.

Infiltration Trenches

Infiltration trenches (often capped with permeable paving) collect and hold water for soakage into the ground. They are useful in areas where there are no stability issues and where groundwater recharge is a priority. They are excellent practices to reduce the volume of water discharged to streams.

Infiltration practices use the natural soil media to provide filtering and therefore they can only be used in areas with permeable soils.

Rain Tanks

Rain tanks collect rain water from roof areas. The tanks will store the water for either full or non-potable water reuse. Non-potable water reuse includes activities such as toilet flushing, laundry washing and garden watering. They are therefore a good way of reducing the volume of stormwater discharged to the receiving environment.

Sometimes rain tanks are also used to attenuate stormwater and release it slowly to prevent accelerated stream channel erosion or flooding in downstream areas.

Green Roofs

Green roofs are an innovative way of reducing the amount of water discharged from a roof. They work by effectively changing an impervious surface to a pervious one by using a planting media and plants to “soak up” the rain water. Green roofs are therefore good at reducing the volume of water which is discharged to the receiving environment. They also provide insulation against extreme temperatures.

Bush Revegetation

By replanting pastoral areas back into natural bush areas one is able to off-set the increases in the volume and rate of stormwater discharged as a result of increased impervious surfaces. The only limitation on using this option would be ensuring that there is enough space to be able to meet the planting requirements.

6.2 *Key Considerations/ Constraints*

Stormwater practices are only effective when they are used under the right conditions. Catchment size, slope and soils are the key constraints that the designer needs to be aware of when selecting a stormwater management device. Rain tanks and green roofs are not discussed in this section as they are constrained directly by the size of the roof area.

6.2.1 Catchment Size

Not all practices are able to treat or attenuate stormwater from the same size of catchment area. Filtering and vegetative practices (such as rain gardens, swales and infiltration trenches) can only serve small catchment areas as large quantities of stormwater may overwhelm their ability to treat run-off. Ponds and wetlands, on the other hand, need large catchment areas to maintain the normal pool areas and support wetland plant growth (ARC, 2003). Even if a site has a very large catchment area, it can be divided into a number of smaller catchment areas using more than one practice for treatment and attenuation. Table A1 below shows the catchment area for which various practices are the most effective.

Table A1 The relationship between stormwater management practices and catchment area (adapted from ARC, 2003)

Stormwater Management Practice	0	2	4	6	8	10	12	14	16	18	20	>20	Controlling factor for use
Ponds	Not Recommended	Not Recommended	Marginal	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Catchment area to maintain normal pool of water
Wetlands	Not Recommended	Marginal	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Catchment area to maintain saturated soils
Rain gardens	Feasible	Marginal	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Volume of runoff
Swales	Feasible	Marginal	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Rate of runoff and slope
Filter strips	Feasible	Marginal	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Rate of runoff and slope
Infiltration	Feasible	Marginal	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Soils, slope, stability, groundwater, bedrock
Bush Revegetation	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Land use, available area

Catchment Area Served (in hectares)

KEY

Not Recommended	(yellow)
Marginal	(light green)
Feasible	(blue)

6.2.2 Slope

Slope is another important criteria to be aware of when selecting an appropriate stormwater device for a site. Given that ponds and wetlands impound large quantities of water, it is unwise to utilise them on steep slopes since they could cause slope instability. The same is true for infiltration trenches. Table A2 below provides an indication of the relationship between steep slopes and stormwater practices.

Table A2 The relationship between longitudinal slope and stormwater management practices

Stormwater Management Practice	0	1	2	3	4	5	6	7	8	9	10	>10	Controlling factor for use
Ponds	Feasible	Feasible	Feasible	Feasible	Feasible	Marginal	Marginal	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Difficult to meet storage requirements on steep slopes; slope instability
Wetlands	Feasible	Feasible	Feasible	Feasible	Marginal	Marginal	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Difficult to meet storage requirements on steep slopes; slope instability
Rain gardens	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Marginal	Level of excavation required for steeper areas becomes uneconomic
Swales	Feasible	Feasible	Feasible	Feasible	Feasible	Marginal	Marginal	Marginal	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Rate of runoff from steep slopes. Can use check dams on steeper slopes
Filter strips	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Rate of runoff from steep slopes
Infiltration	Feasible	Feasible	Feasible	Marginal	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Not Recommended	Difficult to meet storage requirements on steep slopes; slope instability
Bush Revegetation	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Not constrained by slope

Longitudinal Slope (%)

KEY

Not Recommended	(yellow)
Marginal	(light green)
Feasible	(blue)

6.2.3 Soils

Soils play an important role when choosing a stormwater management device. More permeable soils enhance the functioning of some practices (eg. infiltration trenches), whilst clay soils support other practices (eg. ponds and wetlands). Table A3 summarises the relationship between soils and stormwater practices.

Table A3 The relationship between soils and stormwater management practices (adapted from ARC, 2003)

Stormwater Management Practice	Sand	Loam Soils	Silty/ Clay	Clay	Controlling factor for use
Ponds	Not Recommended	Not Recommended	Marginal / Feasible	Feasible	Impermeable soils needed to maintain normal pool of water
Wetlands	Not Recommended	Not Recommended	Marginal / Feasible	Feasible	Impermeable soils needed to maintain normal pool of water
Rain gardens	Feasible	Feasible	Feasible	Feasible	Not constrained by soil type but impermeable liners may be needed
Swales	Feasible	Feasible	Feasible	Feasible	Not constrained by soil type
Filter strips	Feasible	Feasible	Feasible	Feasible	Not constrained by soil type
Infiltration	Feasible	Feasible	Marginal / Not Recommended	Not Recommended	Permeable soils needed to allow for groundwater recharge
Bush Revegetation	Feasible	Feasible	Feasible	Feasible	Not constrained by soil type

KEY

Not Recommended	(yellow)
Marginal	(light green)
Feasible	(blue)

6.3 Ability of Practices to meet the Technical Objectives

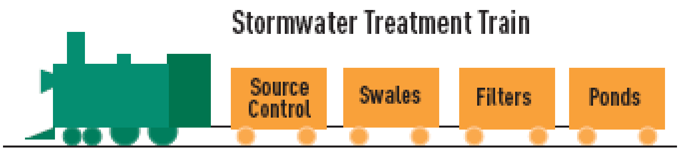
Stormwater practices are not created equally in terms of their ability to provide for attenuation or treatment of stormwater. Table A4 summarises the different practices and their ability to meet the design objectives provided in Section 5.

Table A4 Effectiveness of practices in relation to technical design objectives

Stormwater Practice	Flood Protection	Reduction of Peak Flows	Stream Channel Protection	Volume Reduction	Stormwater Treatment
Ponds	✓	✓	✓		✓
Wetlands	✓	✓	✓	S	✓
Rain Gardens			✓	S	✓
Swales			S	S	✓
Filter Strips			S	S	✓
Infiltration Trenches		S	✓	✓	✓
Bush Restoration	✓	✓	✓	✓	✓
Rain Tanks	S	✓	✓	✓	✓
Green Roofs		S	✓	✓	✓

KEY

Always Provided	✓
Sometimes Provided	S



Because not all practices are able to meet all the water quantity and quality objectives, in some instances more than one device may be needed. When practices are utilised in series or as an integrated stormwater management system it is called as a "Treatment Train" approach (ARC, 2003). If protection of aquatic resources is a priority, then the use of a treatment train approach is an important way to achieve multiple stormwater management objectives on a site.

6.4 Other Considerations

There are a number of other considerations that need to be taken into account when choosing a stormwater management practice. These include, but are not limited to:

- safety issues (eg deep ponds can pose a drowning hazard);
- increased water temperature from open water ponds;
- proximity to bedrock;
- space limitations;
- providing for amenity and aquatic habitat;
- providing for landscape enhancement;
- who is going to own the device in the long term;
- operation and maintenance of the device;
- cost (construction and maintenance costs).

6.5 Summary

Section 6 has provided a summary of the different types of stormwater management practices that are available for use. Whilst all these practices are able to meet one or more of the design objectives given in Section 5, site constraints or practice effectiveness may mean that more than one device is needed on each site (i.e. using the treatment train approach). What becomes clear, however, is that stormwater management is an integral part of site design and needs to be considered up front as part of the design phase.

Part B of the Toolbox provides details on how stormwater effects can be avoided through the use of site design techniques, and Part C of the Toolbox provides design guidance and details on the different practices presented in this Section.

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