# Chapter 3
# Stormwater management concepts

## 3.1 Introduction

This chapter presents a guide to the following stormwater management concepts of:

> site design,
> contamination control and treatment;
> common structural stormwater management practices and
> a summary of treatment mechanisms that they utilise.

## 3.2 Stormwater management concepts

### 3.2.1 Overview

As we saw in Chapter Two; water is in a constant dynamic cycle between the land, water bodies and the atmosphere. Development alters the rate of water's progress through the cycle, resulting in hydrological and water quality effects. The most effective forms of stormwater management try to redress this disruption by avoiding it as much as possible in the design phase. Where this is not possible, stormwater effects must be managed by constructed mitigative methods such as detention ponds and water quality treatment devices. Unfortunately, attempts at mitigation are usually only partially successful, as they control a limited proportion of contaminants and are restricted by technical and financial constraints.

Prevention is better than cure. Stormwater management solutions that fundamentally reduce the risk of stormwater effects are more successful as the potential effects are never generated. Even partial prevention is more useful than mitigation, in that the scale of mitigation required is reduced. Prevention is best achieved by integrating careful site design and contamination control measures.

The RMA outlines the multi- faceted, integrated approach to managing effects; Section 17 states: "*Every person has a duty to* ***avoid, remedy or mitigate*** *any adverse effect on the environment arising from an activity* ..." In the context of stormwater management, the 'avoid, remedy or mitigate' concept matches three stormwater management concepts -

'Avoid' - Site design - practices which prevent stormwater becoming contaminated by reducing runoff or removing contaminant sources, e.g., use of non-zinc roofing materials, reduction of impervious area by porous paving.

'Remedy' - Contamination control

*Source control* - practices which contain contaminants or prevent them from contacting stormwater runoff, e.g. separation of stormwater and oil spills by bunding.

*Management practices* - work practices that avoid or reduce the potential for runoff to become contaminated, e.g. improved street sweeping practices, training staff in chemical handling procedures.

'Mitigate' - Treatment devices - constructed practices to reduce the quantity of contaminants in stormwater or retard the volume of flow e.g. constructed wetlands, detention ponds.

The purpose of this manual is to provide design guidance for treatment devices, and therefore primarily deals with the mitigative section of stormwater management tools. However, avoiding effects by careful site design and remedying effects by source control and management practices is a vital tool in the control of contaminants. Any one stormwater management tool, on it's own, is unlikely to achieve the stormwater management objectives for any given development. For this reason it is necessary to consider the objectives early in the design process while competing demands can be carefully balanced and an integrated solution achieved. The need for, and size of, treatment devices is then minimised as is their installation and maintenance costs. The combination of a number of different tools or practices to achieve an overall stormwater management objective is called "The Treatment Train" and is discussed further in Chapter Four: Choosing of a stormwater management device.

Many of the effects of stormwater are, by themselves, very small. However when considered on a catchment basis, their cumulative effect is substantial - such as in the case of flooding due to gradual increases in upstream impervious areas. To manage these effects, we need to understand them on a catchment basis, where the effects are discernible, but prevent them on an individual site basis, where the physical changes to the hydrological cycle are made. This is the role of catchment management plans. They are a key tool for integrated stormwater management and are a range of the above approaches to achieve overall catchment objectives.

### 3.2.2 Site design

Site design, or runoff control practices, aim to fundamentally reduce the impact of development on the hydrological cycle by attempting to mimic pre-development rates of runoff, infiltration, and evapo-transpiration. To achieve this, we must carefully evaluate the components of a development proposal and identify how they will change the existing hydrological regime. Reduced infiltration, increased runoff and reduced evapotranspiration will result from the development. But, with careful design and control of construction processes, we can minimise the changes.

To manage the effect of development on runoff hydrographs, several defining rainfall events need to be considered to approximate predevelopment conditions as closely as possible to those post development. The 50%, 10% and 1% AEP events have been chosen for this purpose. The ARC considers that changes to the hydrological cycle are minimised by matching the pre and post development peak flow rates and minimising changes to the volume and duration for these events. This usually requires a mixture of site design practices and structural treatment practices.

Four techniques for runoff control are outlined below- further detail is contained in the Auckland Regional Council Technical Publication No. 124 : Low impact design manual for the Auckland Region.

### 3.2.3 Existing site features

A natural site contains an existing drainage network with features such as watercourses, depressions, floodplains, wetlands, vegetation and permeable areas that contribute to the current balance in the hydrological cycle. By identifying, preserving, and integrating these features with the development where appropriate, changes to the cycle are minimised. the residual changes are thus easier (and cheaper) to manage.

### 3.2.4 Reduce imperviousness

Impervious surfaces affect water cycle processes by reducing infiltration and increasing runoff. By reducing imperviousness, the overall percentage of hard surfaces can be reduced and the permeability of the required hard surfaces increased. Using pervious channels or infiltration practices at the start of the treatment train for onsite infiltration or to collect and transfer stormwater to a downstream treatment practice reduces the effective impervious area of the development. In either case, the amount of runoff is reduced, which will subsequently reduce the necessary volume of stormwater treatment devices on site.

Some methods to reduce impervious areas:
- Reduce road widths to suit actual traffic densities instead of generic minimum widths
- Make lots closer to the main roading network to minimise accessway lengths
- Use grass swales for drainage to reduce concentration times and encourage infiltration
- Use porous pavements, gravel or grass for low density accessways and parking areas
- Place footpaths on only one side of a street
- Reduce parking requirements to a minimum

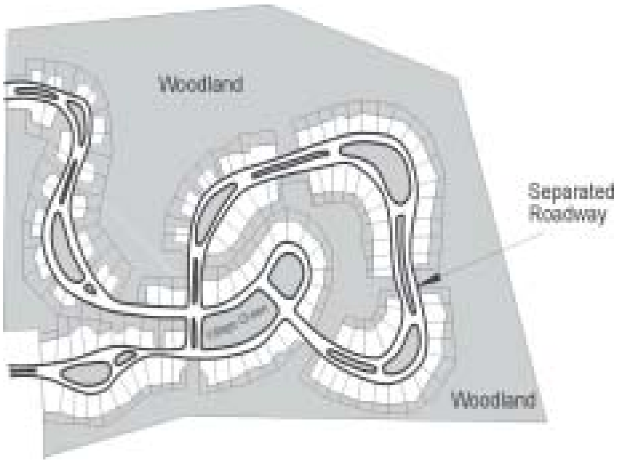



**Figure 3-1 Cluster development**

3.2.5 Clustering/lot configuration

Subdivisions traditionally require significant amount of earthworks to produce flat sites with house lots of very similar sizes. Typically, each will have a house, front yard, back yard and separate access to the road. All streams, vegetation and site features are lost to maximise the number of lots. However, by clustering houses, as shown in Figure 3-1, together with smaller lot sizes, existing site features may become common recreational resources. Overall site imperviousness is then reduced and the existing stormwater channels are retained.

Some methods to change the lot configuration include using:
- Smaller lot densities with common recreational areas
- Duplex or terrace housing configurations instead of single family lots
- The same accessways to service multiple lots

3.2.6 Minimise site disturbance

Earthworks compaction produces high strength but high density soil with reduced permeability. Even when not sealed with impervious surfaces, this reduces infiltration and increases runoff. To prevent changes to the hydrological cycle, it is therefore very important to avoid earthworks on areas that are to be retained as permeable.

Existing vegetation also plays an important role in maximising infiltration and promoting evapotranspiration. Organic litter beneath trees and smaller vegetation acts a sponge by capturing rainfall and holding it while it slowly infiltrates into the ground. By analysing the existing topography and natural site features and carefully planning around them, it is possible to integrate the development with the environment and minimise the areas of vegetation and earthworks disturbance.

Some methods to minimise site disturbance include:
- Minimise bulk earthwork areas during construction
- Avoid earthworks on future permeable areas
- Maintain riparian margins of watercourses
- Maintain vegetated areas to promote long term infiltration
- Replant vegetation on slopes

3.2.7 Contamination control

Source control and management procedures attempt to reduce or avoid contaminants getting entrained in stormwater runoff. These practices assume that the contaminant source is necessary for the successful operation of the business or activity, and seek to control the release of contaminants or remove them before they come into contact with stormwater. For example, service stations inherently use trade oils and petrol as their main business activity, but, they are required to cover the service area and shut off stormwater pipes during tanker deliveries to prevent the discharge of petroleum products to the environment via stormwater drains.

The ARC advocates that businesses that handle chemicals or produce wastewater carry out an environmental self audit to identify actual and potential contaminant sources. An action plan should then be developed to eliminate any actual pollution and minimise the risk of potential pollution. The reduction of potential pollution sources is set out in 3.2.8 or 3.2.9. Further information is available in the ARC's "Environmental Operations Plan" manual.

Plate 3-1: Chemical roof and bunding

### 3.2.8 Source control

Source control practices identify contaminant sources and construct physical works to prevent them coming into contact with stormwater. The classic example is the above ground storage tank with a bund constructed around the tank. The bund volume is slightly greater than the volume of the storage tank.

Other examples include:
- Physical control structures such as bunding, spill containment
- Covering stockpiles of soil, waste products
- Directing washwater to sanitary sewer
- Covering "dirty" work areas such as truck washes or oil changing bays

### 3.2.9 Management practices

Numerous procedures can be designated as management practices, from council initiatives to regularly remove gutter dusts before they get entrained in stormwater to industrial protocols for handling chemicals. The common factor is that there is a process to be followed that minimises the risk of contaminant transfer to stormwater.

Council initiatives include:
- Street vacuuming
- Education initiatives
- Recycling

Industry initiatives include:
- Refuelling procedures
- Chemical handling procedures
- Staff training re proper disposal areas for wastes, chemicals etc.
- Proper storage for chemicals, fuel etc. i.e. not outside, forgotten

### 3.2.10 Treatment

Treatment practices attempt a difficult task; the removal of contaminants entrained in stormwater flows. Significant proportions of contaminants are dissolved in stormwater, and many others are attached to fine particles of silt which do not easily settle. Removing these contaminants needs a complex combination of processes such as sedimentation, adsorption, and filtration. When site size constraints and limited financial resources to implement treatment are also considered, the complete removal of contaminants from stormwater is basically not achievable. This is why the ARC emphasizes that opportunities for good site design practices and contamination control must be incorporated as a necessary precursor to effective treatment practices. This will produce a better overall result for treating the effects of stormwater.

The time of installation and the maintenance of treatment devices are important issues. Much of the impact of development occurs in the early stages of construction when the significant changes occur to the hydrological regime and large quantities of sediment are discharged during earthworks. The early installation of stormwater management facilities is the best defence to these changes and also provides a backup to earthworks controls. After development, stormwater devices require ongoing maintenance to ensure that inlets and outlets are not blocked and the full treatment volume is available to remove contaminants.

The remainder of this section provides an introduction to the different types of treatment practices. Following the section, a number of photographs illustrate the various types of stormwater management practices.

(a) <u>Sedimentation</u>

Most particles suspended in stormwater are less than 120 *u*m diameter. Coarser fractions, above 120 *u*m tend to remain in gutters or get caught in catchpits. However, contaminants attach to particles less than 20 *u*m in disproportionately high numbers, meaning that effective removal devices must target these very small clay particles.

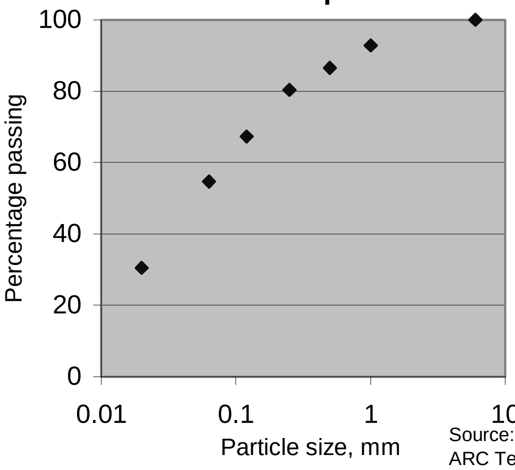
Sediment coarser than <u>medium silt</u> (approx. 20 *u*m) settles rapidly, but much longer settling times are required for finer particles to settle. Particles less than 10 *u*m tend not to settle discretely according to Stokes Law but must flocculate before settling. The particle shape, density, water viscosity, electrostatic forces and flow characteristics affect settling rates.

Particle size distribution and laboratory settling rates for residential stormwater in Pakuranga are presented in Figure 3-2.

The proportion of sediment and contaminated sediment removed can be improved by the following measures:
- longer detention times
- larger surface area for settling
- promoting laminar flow and reducing turbulence
- promotion of coagulation

**Figure 3-2**

**Stormwater suspended solids**




Source: Table A2.5: ARC Tech Pub 5

(b) <u>Aerobic and anaerobic decomposition</u>

Microorganisms reduce soluble BOD (biological oxygen demand) and break down nutrients and organic compounds by aerobic and anaerobic oxidation. Once the aerobic microorganisms have taken up contaminants they die, and settle to the bottom of ponds where further anaerobic oxidation may take place. In anaerobic conditions, microorganisms can remove nitrogen by de-nitrification. This is an importance process in constructed wetland function.

*<u>Aerobic:</u>*
Organic matter + bacteria + $O_2$ => new cells + $CO_2$ + $NH_3$ + $H_2O$

*<u>Anaerobic:</u>*
Organic matter + bacteria => new cells + alcohols/acids + bacteria =>
new cells + $CH_4$ + $H_2S$ + $NH_3$ + $CO_2$ + $H_2O$

(c) <u>Filtration and adsorption to filter material</u>

As sediment particles pass through a filter bed or through soil, they may be removed by the following filtration processes:
- settling into crevices
- enmeshment in interstices (sieving)

- impingement onto filter particles followed by sticking onto particles (by electrostatic or other bonding)

Adsorption is the accumulation of dissolved substances on the surface of a media such as plants or filters. Dissolved substances can also be removed by adsorption to filter material and biological uptake by microorganisms living among the filter material.

(d) Biological uptake

Plants take up nutrients or metals from stormwater via absorption processes. However they may also re-release them to the water column when they die and decay.

(e) Biofiltration

A variation to the filtration mechanism is to use plants as the filter media. Contaminants adhere to plant surfaces or are absorbed into vegetation. This mechanism is a combination of filtering, reduced settling time and adhesion.

(f) Precipitation

Colloidal particles may, under the right physical-chemical conditions, flocculate and settle out, enabling sedimentation devices to sometimes remove apparently dissolved trace metals. The precipitation process may be slow, requiring large detention times, but may be assisted by mechanical flocculation or chemical additives.

## 3.3 Typical stormwater management practices

### 3.3.1 Water quality ponds

Ponds detain stormwater inflows to allow suspended solids to settle. There are two main types; wet ponds and detention ponds. Wet ponds as shown in Plate 3-2 have a permanent pool with very slow flow through the pond. Detention ponds have a temporary pool formed by capturing and releasing stormwater at a slow rate. Sedimentation is promoted by slow flows which give longer detention times and minimise turbulence. Aerobic decomposition and adsorption of contaminants on to plants provide secondary treatment benefits by removing some nutrients and further sediment.

Plate 3-2

### 3.3.2 Wetlands

Wetlands, as shown in Plate 3-3, detain flows to allow sediments to settle, but also remove a significant proportion of contaminants by adhesion to vegetation and aerobic decomposition. Vegetation is an integral component of the wetland system and assists each of the treatment mechanisms. It reduces velocities and turbulence, provides significant surface area for silt adhesion and reduces dissolved metals and nutrients through biological uptake. Wetlands also have the potential to provide hydrological benefits in a similar fashion to detention ponds.

Plate 3-3

Plate 3-4

### 3.3.3 Detention practices

Detention ponds and tanks intercept stormwater flows, store it and release it at a reduced rate. Their volume is determined according to flood routing principles for a range of rainfall events. Plate 3-4 shows a dry detention pond that functions only during or jsut after rainfall/runoff.

Their primary function is to reducing flooding and erosion of the downstream channel, but they also contribute to water quality by retaining water, thereby giving silt particles some opportunity to settle out of suspension.

Plate 3-5

### 3.3.4 Filtration

Sand, topsoil or even compost are filter media that can remove contaminants when stormwater is passed through them. Coarse sediment particles are generally removed by sedimentation (right hand chamber in Plate 3-5) and then silt and attached contaminants are removed by sieving and adhesion to filter media (large left hand chamber). Underdrains collect water at the base of the filter media and discharge to the outlet. Filters generally only service a small catchment area and therefore only give limited hydrological benefit from flow attenuation on a catchment basis.

Plate 3-6

### 3.3.5 Infiltration

Infiltration practices collect and hold water below ground for disposal to the groundwater table. Sediments are removed by filtering in the stone reservoir or by in situ soils adjacent to the excavation where the stormwater is stored. Practices include infiltration trenches, soakage pits and porous block pavements. Soils must be permeable enough to disperse stormwater in a reasonable time and ensure the practice is ready to receive further inflow. Consequently, infiltration practices are more often used in areas with volcanic soils. Infiltration practices can have significant hydrological benefits by assisting groundwater recharge.

Plate 3-7

3.3.6 Rain gardens

Rain gardens, as shown in Plate 3-7, are a combination of an infiltration and filtration device. Water is directed to a local hollow where it soaks into a organic filter medium such as topsoil or compost. Some water soaks into the ground while the remainder is collected and piped to the stormwater drainage system.

Plate 3-8

3.3.7 Biofiltration

Passing stormwater through vegetation removes sediment particles by adhesion to the plants and organic material as it filters through them. Dense vegetation, low water velocity and a long exposure time through the vegetation are required to ensure reasonable effectiveness. Biofiltration practices may have multiple benefits by reducing impermeable area, assisting groundwater recharge and increasing hydrological response times.

Vegetative swales such as that in Plate 3-8 are well suited to collecting and treating non-point source flows from long impermeable surfaces such as roads and carparks.

Plate 3-9

3.3.8 Vegetative filters

Vegetative filter strips are another biofiltration practice. They rely on distributed flow to produce a thin layer of water passing through the vegetation to ensure reasonable treatment. They are generally only used in conjunction with another stormwater treatment practice (both upstream and down).

Plate 3-10

3.3.9 Gross pollutant traps

GPTs are often placed at the inlets to stormwater practices to catch large pieces of litter and vegetation. Collection of litter at a single point allows easier maintenance and better performance of downstream stormwater management devices.

## 3.4 Design basis of treatment practices

The following design concepts form the basis for the stormwater management practices in the rest of this manual. Specific regulatory and technical objectives are set out in Chapter Four

3.4.1 Resource consent applications

The ARC advocates that applications for resource consents for the diversion and discharge of stormwater made from the beginning of the year 2000 should be supported by calculations of peak flows, volumes and hydrographs using ARC's TP108, "Guidelines for stormwater runoff modelling in the Auckland Region", April 1999. The ARC recommends HEC-HMS as a suitable model for doing such calculations. HEC-HMS is available as freeware, and may be downloaded from the Internet.

The ARC suggests that there are advantages in continuing to use TP108 in undertaking calculations associated with stormwater quality treatment. The following sections relate to the use of TP108 in design. If a HEC-HMS model has been set up with pervious and impervious areas separately modelled, it can also be used for stormwater quality treatment calculations. Otherwise hand calculations are required.

3.4.2 Water quality design

This manual describes the required sizing of various stormwater treatment devices to achieve the required level of suspended solids removal. Compliance with the Water Quality Volume, WQV, and the checklist requirements set out in the practice chapters is deemed to produce a design that will achieve the water quality objective.

Water quality treatment practices in this manual are sized on the Water Quality Volume (WQV). This is an empirical measure based on the stormwater quality design storm, $S_d$ and the Areas of Development (be they impervious and/or pervious), draining to the water quality treatment device and the associated Curve Numbers relating to those contributing areas.

The Areas of Development contributing to the Water Quality Treatment Practice are those areas, be they impervious or pervious, that contribute runoff whether or not it needs to be treated.

The Curve Numbers represent runoff from various surfaces or land uses overlying various soil types and are obtained from TP108 Table 3.2 "Hydrological Soil Classifications for prevalent Auckland Soils" and Table 3.3 "Curve Numbers for typical Auckland Conditions".

TP108 provides rainfall charts and worksheets. The use of HEC-HMS or similar mathematical model is recommended, especially as the use of this method and models will have already been set up and used in the prediction of peak flows and volumes of stormwater runoff from the proposed development.

Section 3.4.3 and 3.4.4 outline how to use TP108 for obtaining the Water Quality Volume, WQV.

### 3.4.3 Stormwater quality design storm, $S_d$

ARC TP4's analysis of rainfall from the rain gauge at the Botanic Gardens at Manurewa arrived at a rainfall depth of 25 mm for $S_d$. In order to make allowance for the differences in location, the rainfall depth corresponding to the site location is obtained from Figure 3-3, the 2 Year ARI Daily Rainfall Depth.

$S_d$ = (2 year 24-hour rainfall depth at site) /3

This rainfall depth is to be applied on a 24-hour event using TP 108 (with the temporal rainfall pattern set out in Section 2 of TP 108).

### 3.4.4 Water Quality Volume, WQV

The Stormwater Quality Design Storm, $S_d$, is the rainfall depth chosen from hydrological analysis of a rain gauge located in the Auckland Region that enables 80% of the runoff volume of all storms to be captured and treated. This gives 75% removal of total suspended solids on a long term average basis. The choice of this objective is justified in ARC Technical Publication No. 4 "Selection of Stormwater Treatment Volumes for Auckland". This study found that the removal of 75% TSS is at the marginal point of return for sediment removal versus device size, i.e. aiming for a higher degree of removal would require an undue increase in treatment device size and therefore cost.

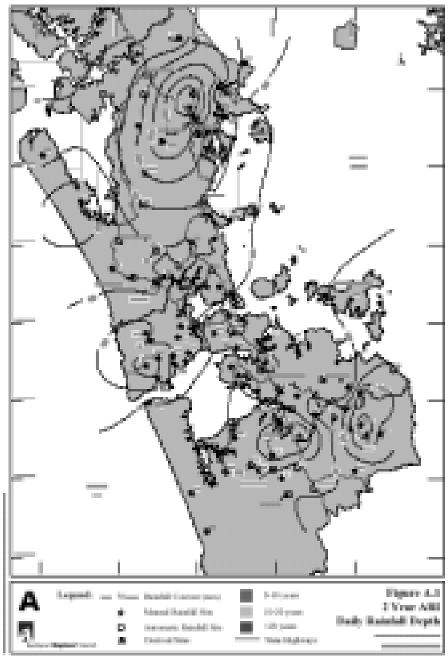


**Figure 3-3**
**2 year rainfall depth image**

Section 3.5 shows how to calculate the water quality volume WQV. Two methods are described below:

> The first (Modelling Method) being based on the assumption that the designer has already undertaken calculations for the development using TP108 Guidelines for Stormwater Runoff Modelling in the Auckland Region, and
> The second (Manual Method) being based on the manual method of TP108. It is recommended that designers hold a copy of TP108 Guidelines for Stormwater Runoff Modelling in the Auckland Region.

It is important, regardless of which method is used (modelling or manual) that calculations be done separately for pervious surfaces and impervious surfaces to calculate the total volumes associated with water quality and extended detention (34.5 mm). This approach provides a more accurate and more consistent calculation for volume. Grouping them together for the analysis tends to under-predict volumes associated with those storms. On the other hand, peak discharges for the 2, 10, and possibly 100 year events can be grouped for consideration of timing and peak discharges.

## 3.5 Modelling Method

When modelling for water quality, extended detention, 2, and 10 year peak control, consider the catchment (or site) to be heterogeneous. Heterogeneous catchments should be modelled by division into separate homogeneous sub-catchments, connected by hydraulic elements.

For the water quality and extended detention storms, issues such as timing or response time are not important as for most devices. Vegetated swales and filter strips are designed for a peak flow rate, but because they serve very small catchments the catchment response time can be ignored and the peak 10 minute rainfall rate used (minus losses).

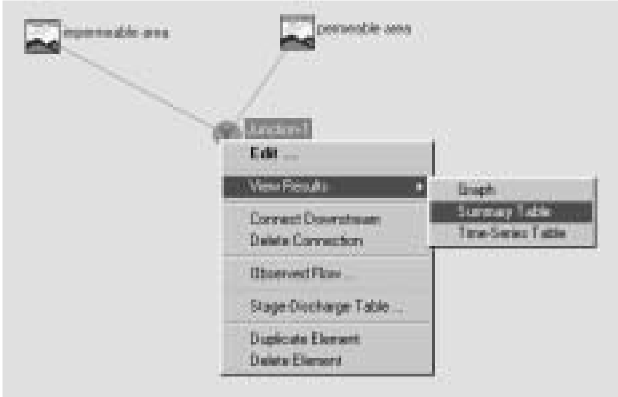



**Figure 3-4**
**Summary of results**

For 2 and 10 year peak determination timing is important. The procedure outlined in TP 108 should then be used to complete the analysis.

WQV is the "Total Outflow" obtained from the Summary of Results screen for the point of interest. An example of the output screens is presented in Figure 3-4.

### 3.5.1 Manual Method

This may be the easier approach for determining the water quality and extended detention volumes. It is directly based on using TP108 and the designer is referred to that document.

Rainfall

Use TP108 Figure A.1 to obtain the rainfall depth associated with the 2 year event being studied.

Stormwater Quality Design Storm, $S_d$

Use TP108 Figure A.1 - 2 Year ARI Daily Rainfall Depth
Find rainfall depth for the site location,
$S_d$ = rainfall for site / 3

Runoff Curve Numbers

Identify the soil type for the site and its associated land cover to select the associated curve number.
Use TP108 Table 3.3 for Curve Numbers
Impervious coverage has a curve number of 98.

Initial Abstraction

$I_a$ = 5 mm for pervious areas
$I_a$ = 0 for impervious area

Calculate storage individually for both the pervious and impervious area

$S = ((1000/CN) - 10)25.4 =$ mm
calculate separately for pervious and impervious areas

Runoff depth

Runoff depth, $Q_{24} = (P_{24} - I_a)^2/((P_{24} - I_a) + S)$
this is done separately for pervious and impervious areas

Runoff Volume

Runoff volume, $V_{24} = 1000Q_{24}A =$ $m^3$

Calculate this separately for pervious and impervious areas

Water quality volume is the summation of both $V_{24}$'s

Designers are also referred to ARCs TP108: for worked examples:

- > Section 5. Worked Example for setting up a model and undertaking the calculations using HEC-HMS, and
- > Section 6. Graphical Method for Peak Flow Rate

## 3.6 Alternative methods of design

The ARC prefers designers to use TP108 methodology for design calculations. The ARC also prefers the use of mathematical models such as HEC-HMS because it reduces chance of mathematical error. The use of TP108 will also ensure that comparative results are obtained by the use of the standard input parameters. It will also ensure consistency in analyses within a catchment.

Whilst the ARC does not encourage the use of other methods for calculations, we recognise that there are other methods of calculation and other sources of data. If these are used, the applications need to be well supported with full sources of alternative data, full copies of calculations and all appropriate references to support the application.

The primary situation where alternative methods of design may be used, with ARC concurrence, is when catchment-wide analyses are done. This may be the situation where characteristics of the catchment or management approach may be better considered through a modelling technique that is more appropriate for that specific catchment. Situations where that could occur include enclosed system analysis or continuous simulation (where adequate rainfall data exists). Communication between the individual proposing an alternative method of design and the ARC should be done prior to modelling being initiated to ensure there are no disagreements on the methods of analysis.

## 3.7 Relative levels of removal efficiencies

In some situations where the treatment device to achieve the required removal cannot fit within a specific site, a lower level of treatment will result. Similarly, if additional land and volume is available, improved efficiency can also be provided. Table 3-1indicates approximate levels of treatment achieved by devices having greater or less volumes than those detailed in Section 3.4.

**Table 3-1**
**Relative levels of removal efficiency**

| Practice Volume | Efficiency |
|---|---|
| 150% of WQV | 82% |
| 100% of WQV | 75% |
| 75% of WQV | 70% |
| 50% of WQV | 60% |
| 25% of WQV | 50% |
| 10% of WQV | 40% |
| 5% of WQV | 30% |

The expected removal efficiency is simply the available WQV divided by the WQV detailed in Section 3.4. If that analysis indicates that the required WQV is 2,000 $m^3$, and the available volume is 1,500 $m^3$, then the practice efficiency will be approximately 70%.

## 3.8 Use of rainfall station data

Where more extensive site rainfall is available, e.g. long term instantaneous data, that data may be analysed independently to give a more accurate estimate of the 2 year ARI daily rainfall depth at that location, or a long term part of the record may be used directly as input into a routing model. Such an approach will need full justification for that approach and the results obtained will need to be fully supported by calculations, identification of the rainfall station and results of the statistical analysis of the rainfall data.

### 3.8.1 Rainfall depth for stream bank protection

The ARC is concerned about erosion in watercourses. A study "Stream Erosion – A Hydrological Basis for Management" has been undertaken by BCHF. The report has two main recommendations for the protection of streams, one for stable streams and the second for unstable streams.

The recommendation for stable streams is that post development peak flows should not exceed predevelopment peak flows. This recommendation requires a stringent analysis relating bankfull flow to shear stress. If the stream has frittering of banks, landslides, bank collapse or streambed undermining then the stream is not considered as being stable. Since almost all streams in the Auckland Region have one or more of the conditions mentioned, this scenario is not being pursued, especially in an urban or urbanising environment. We are therefore considering all streams as unstable.

For unstable streams the interim recommendation is for detention ponds to be designed for the discharges from a 2 year ARI 24 hour storm from post development conditions, such that no more than 30 mm of runoff occurs over the 24 hour period, or that the maximum peak outflow is 7.5 l/s per hectare of the site.

The initial BCHF information has been modified for greater consistency with the design approach used in TP 10 which aims to store and release the first 34.5 mm of rainfall over a 24 hour period.

## 3.9 Water quantity design

Controlling water quantity control requires matching the post and predevelopment hydrological conditions as closely as possible. Stormwater management practices are often sized to match peak flows for the 1%, 10% and 100% AEP events. The outflow conditions and required storage volumes are then determined by hydrological routing for these events.

Hydrological modelling should be carried out in accordance with ARC Technical Publication 108: Guidelines for Stormwater Runoff Modelling in the Auckland Region.

## 3.10 Summary

Minimising the effects of stormwater requires an integrated, catchment wide approach to stormwater management. Site design, contamination control and treatment practices all have a role to play. This chapter has provided an introduction to site design and contamination control concepts, but other ARC publications such as the Environmental Operating Procedures manual and the Low Impact Design approach deal with these in more detail.

Water quality treatment is based on the Water Quality volume defined in Section 3.4 and the specific requirements for each practice outlined in chapters 5-14. Water quantity control requires control practices also defined in those chapters. Both of these methodologies are developed in the following chapter, Choosing of a Stormwater Management Devices.

## 3.11 Good practice guidelines

When implementing the stormwater management concepts outlined in this chapter, the following guidelines for designing and implementing stormwater management practices will be helpful and cost effective:

1) Prevention is better than cure, so implement source control as much as possible.
2) Consider the site in the context of the catchment management plan.
3) Consider stormwater management objectives early in the design process to achieve an integrated approach within the site constraints.
4) Consider the treatment train concept and incorporate a suite of practices to achieve the stormwater management objectives.
5) Preserve natural watercourses and minimise works in and around watercourses to preserve aquatic resources.
6) Maintain riparian margins and vegetative buffers around watercourses and wetlands to preserve stream health and encourage natural processes to remove contaminants.
7) Minimise the impervious area of the development and maximise infiltration on site storage/detention to minimise changes to the water cycle.
8) Separate discrete pollution sources from the general stormwater system. Provide additional treatment or dispose of wastes from those sources to the sanitary sewer if necessary.
9) Develop management practices to reduce the risk of contamination during hazardous operations.
10) Institute earthworks controls before starting construction.
11) Institute stormwater management practices before development so they are working from Day One. This also acts a backstop for sediment control during earthworks.

## 3.12 Bibliography

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