Manukau City Council

Stormwater Ponds

Te Kaunihera o
MANUKAU
City Council

Contents

		Page Number
1.	Design of Stormwater Ponds	1-1
1.1	Definition	1-1
1.2	General	1-1
1.3	Purposes of Stormwater Ponds	1-1
1.4	General Approach	1-2
1.5	Design Procedures	1-2
1.6	Geotechnical Investigation	17
1.7	Planting proposals for bank stability and water quality improvements.	18
1.8	Relationship with Catchment Management Plan	19
1.9	Amenity Features	19
1.10	Erosion and Sediment Control Plans	19
1.11	Preliminary Operation and Maintenance Manual	19
1.12	Cost Estimates	20
1.13	Stormwater Pond Safety Guidelines	20
1.14	Concept plans	20
1.15	Checklist for Applications for Resource Consents	20
2.	Operation and Maintenance of Stormwater Ponds	22
2.1	General	22
2.2	Maintenance Requirements	22
2.3	Maintenance Inspection Checklist	25
2.4	Special Inspections	32
2.5	Water Quality Monitoring	32

List of Tables

Table 1.1 Techniques to Enhance Pond Performance
Table 1.2 Estimation of Runoff and Peak Discharges

Table 2.1 Requirements of Erosion and Sediment Control Measures
Table 2.2 Stormwater Pond Inspection Checklist

Table 3.1 Maintenance Requirements for Stormwater Ponds
Table 3.2 Maintenance Inspection Checklist for Stormwater Ponds

List of Figures

Figure 1.1 Design Chart for Water Quality Volumes
Figure 1.2 Design Chart for Extended Detention Volumes
Figure 1.3 Cross Section of a Stormwater Pond Involving Quality and Quantity Controls

List of Photographs

Photograph 1.1 A Typical Stormwater Pond
Photograph 1.2 Metal Plate for Debris Control at Outlet Manhole
Photograph 1.3 Pond Leakage
Photograph1.4 Pond Lining
Photograph 1.5 Fish Passage

Appendices

Appendix A Water Balance Calculations for Barry Curtis Park Stormwater Pond

1. Design of Stormwater Ponds

1.1 Definition

Stormwater ponds are created by constructing either an embankment or a structural barrier across the flow or by excavating a pit. The removal of contaminants occurs through a settling process while the stormwater is detained in the pond.

1.2 General

Stormwater ponds are the preferred option to mitigate the environmental effects of stormwater runoff to streams and receiving environments. However, the effectiveness of retrofitting stormwater ponds in fully developed urban areas is limited unless the ponds are designed and constructed to take account of the characteristics of each particular catchment.

Table 1.1 shows summary of useful techniques to enhance the performance of stormwater ponds in particular situations.

Table 1.1 Techniques to Enhance Pond Performance

Desired Outcomes	Recommended Pond Fingerprinting Techniques
Avoiding existing wetland(s)	Define boundary of existing wetland before selecting the location of new pond. Select pond system with minimal permanent pool
Preserving a mature forest or habitat area Taking into account tree/bush protection rules in Operative District Plan.	Configure pond to minimise the removal of trees Limit the area of disturbance Adopt tree protection measures during construction Plant native trees and shrubs to replicate lost habitat Refer to Operative District Plan and riparian guidelines.
Consider the implications of upstream development on stormwater treatment measures.	Install parallel pipe system along the upstream to convey excessive storm flows Install plunge- pools at outlet of storm drains to reduce flow velocities Use bio-engineering techniques and check dams to stabilise the stream reach.
Consider possible variations in water temperature of the pond on the downstream environment.	Minimise the use of concrete, metal or riprap.

1.3 Purposes of Stormwater Ponds

The primary purposes of stormwater ponds are to:

- Improve water quality
- Reduce potential for downstream flooding.

- Minimise risk of downstream channel erosion.

Photograph 1.1 shows a typical stormwater treatment pond constructed in a golf Course.

Photograph 1.1: A Typical Stormwater Treatment Pond

1.4 General Approach

- Dry ponds are not usually approved because they generally have higher maintenance costs and poorer performance than wet ponds.
- A series of ponds may be constructed instead of a single pond, provided that the total surface area will be the similar, and the treatment volume is 20% higher than that of a single pond.
- Offline ponds are preferred to online ponds.
- Consider all areas (pervious and impervious) of development as contributing to stormwater runoff.

1.5 Design Procedures

Stormwater ponds are to be designed in accordance with the following:

- ARC TP10 "Stormwater Treatment Devices: Design Guideline Manual"
- ARC TP108 "Guidelines for Stormwater Runoff Modelling in the Auckland Region" should be used for estimating peak discharges and runoff volumes.

1.5.1 Water Quality Volume:

The water quality treatment ponds must be of a capacity to achieve the removal of 75 % of Total Suspended Solids on a long-term average. The volume of stormwater be treated is calculated as runoff from 1/3rd of the one in two years ARI 24 hour rainfall event.

Calculations of the water quality and peak discharges should be based on the work sheet provided in TP108 using the following procedure:

- Use contour maps to define the catchment area which drains to the pond site.
- Calculate the pervious and impervious areas in the catchment from aerial photographs and other information on development in the catchment such as catchment management plans.
- Use Table 4.2 of TP108 (page 13) to select channelisation factor C. (C= 0.6 for piped stormwater system, C= 1 for natural channels)
- Determine catchment slope by using the equal area method. (Refer to TP108: Worked Example 5.1).
- Determine the hydrologic soil group (A, B or C) based on soil investigations within the catchment.
- Use Table 2 .2 of TP108 to select Curve Number (CN) for the proposed land use. (CN = 74 for lawns and parks in good condition in Waitemata Clay: Class C and CN= 98 for impervious areas).
- Determine the design storm using the pond catchment shown on Figure A.1 of TP108 and the 2-year ARI daily rainfall depth. Design storm = 1/3rd of the 2 year ARI 24 hour rainfall depth.
- Identify the specific peak flow, q*, for calculated T_c.and c* based on figure 5.1 of TP108
- The calculated runoff volume V_{24} is the volume considered for stormwater quality.
- Determine the pre-developed and developed scenarios peak discharges for 2, 10 and 100-year ARI events.

Note: The volume of permanent water considered for stormwater quality should be reduced by 50% for ponds with extended detention.

Table 1.2 provides an example for calculating the volume considered for stormwater quality for a stormwater pond in the Flat Bush area of Manukau.

Table 1.2 Estimation of Runoff Volumes and Peak Discharges

A Catchment Area and Main Channel

Project: Flat Bush Stormwater Treatment Devices	Total Area (ha) Pervious Area (ha) Impervious Area (ha) Channelisation factor (C) Catchment Length L (km) Catchment Slope Sc (%)	51.30 23.6 27.7 0.6 1.35 0.008
Location : Pond B11B		
Status: Developed		

B Curve Number and Initial Abstraction

Soil name and classification	Cover description (cover type, treatment and hydrological condition)	Curve Number (CN)	Area	Product CN x Area
C	Impervious Area	98	27.7	2715
	Pervious Area	74	23.6	1746
Total			51.3	4461
CN (weighted)	(Total CN x Area)/Total Area	= (4461)/51.3	=	87
Ian (Weighted)	(5 x Pervious Area)/ Total Area	= 118/51/3	=	2.3

C Time of Concentration

Runoff Factor = CN/(200-CN) tc= 0.14 C x L $^{0.66}$ x [CN/(200-CN)] $^{-0.55}$ x Sc $^{-0.30}$ SCS Lag for HEC-HMS "tp" = 2/3 tc	= 0.77 = 0.5 hrs = 0.34 hrs

D Storage

Catchment Area (km2)	= 0.513
Calculate storage S = 25.4 x[(1000/CN-10)]	= 38.09

E Runoff Volumes and Peak Discharges

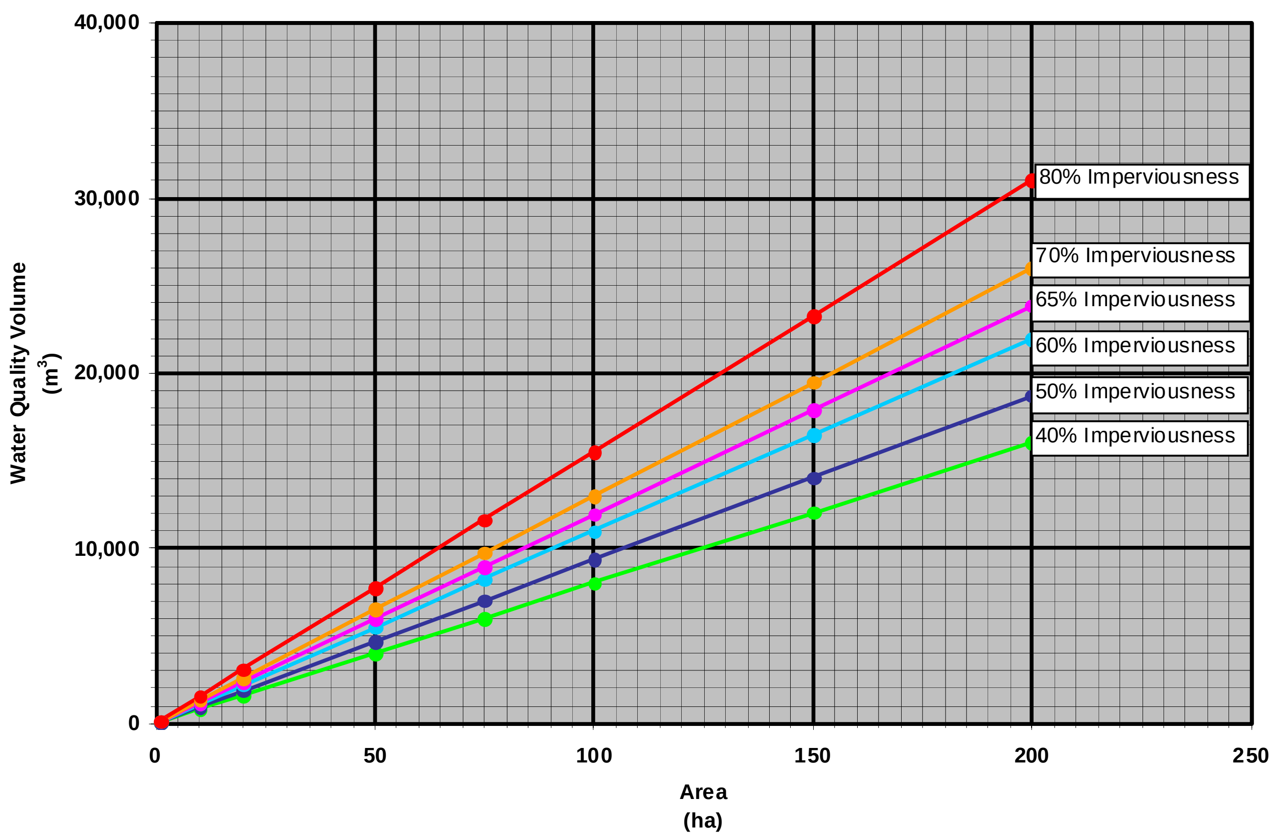
Description	Storm #1	Storm # 2	Storm#3
Average Recurrence Interval/WQV	2 yr ARI	10 yr ARI	100 yr ARI
24 hr rainfall depth, P_{24} (mm)	26.67	150	230
Compute c* = $(P_{24} - 2\,Ia)/(P_{24} - 2Ia + 2S)$ (mm)	0.225	0.666	0.747
Specific flow rate q * (from Fig. 6.1)	0.045	0.1	0.107
Peak flowrate q_P = $q^* A P_{24}$ (m^3/sec)	0.62	7.70	12.62
Runoff depth Q_{24} = $(P_{24}-Ia)^2/(P_{24}-Ia)+S$ (mm)	9.5	117.4	195.10
Runoff Volume V_{24} = 1000 x Q_{24} A (m^3)	4878	60,235	100,070

Note:

2 year 24 hr rainfall = 80mm

1/3 2 yr 24 hr rainfall = 26.67 mm

Figure 1.1 Design Chart for Water Quality Volume



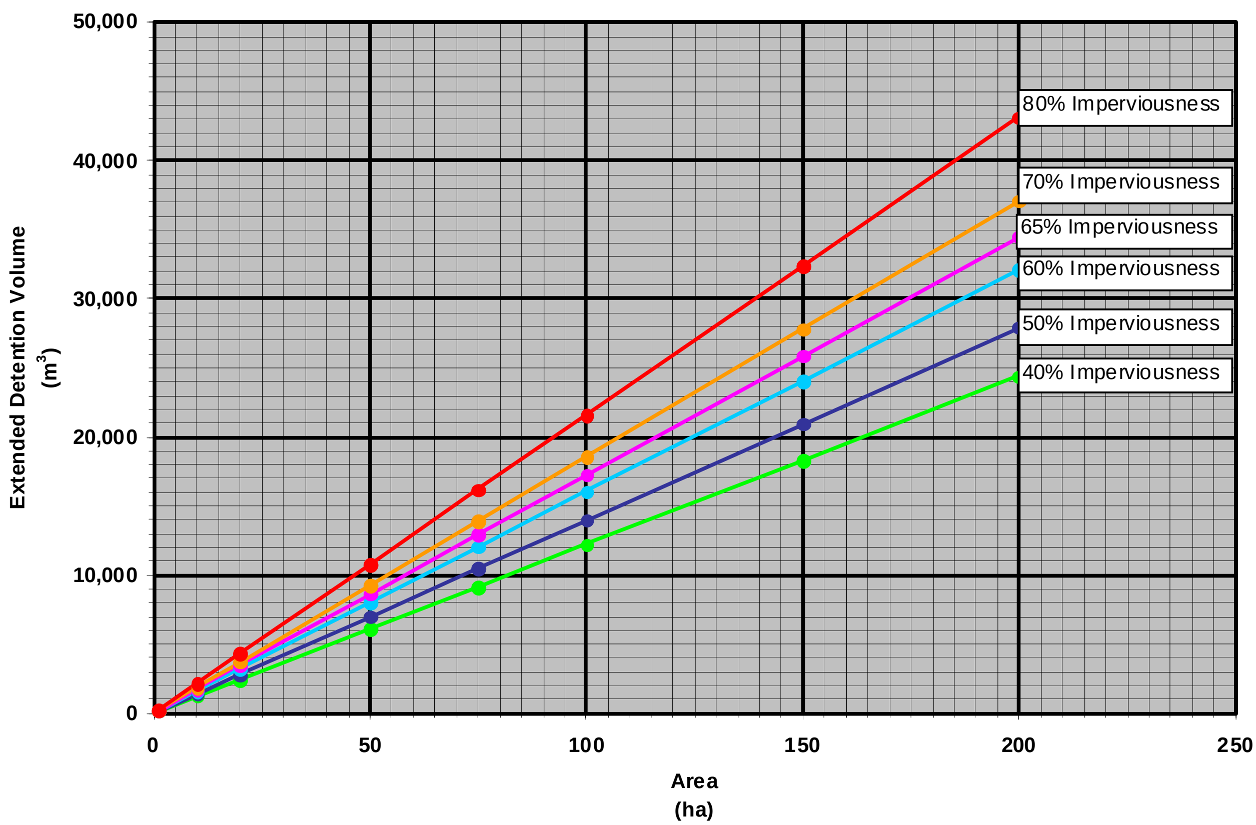
1.5.2 Requirements for Extended Detention

If a pond discharges into a channel of a natural perennial stream, then the runoff from a rainfall event of 34.5mm is to be stored and released over 24 hour period to minimise the potential for downstream erosion. The outlet device is to be designed to cater for twice the average rate of release for 24 hours. There may also be a requirement to control peak rates of runoff. Controls for managing the quantity of stormwater runoff are not necessary where the receiving environment is either an enclosed storm drainage system with adequate capacity for the increased runoff or is tidal (either estuarine or marine).

The extended detention volume for 34.5mm rainfall is calculated by repeating the procedure of section 1.4.1 for Water Quality Volume and using the 34.5mm rainfall depth in place of 1/3 of the 2 yr 24 hr rainfall (This example shows that 7567 m^3 is required to be stored and released over a 24 hour period)

Figure 1 shows a design chart for extended detention volume for Flat Bush catchment.

Figure 1.2 Design Chart for Extended Detention Volume



1.5.3 Flood Control

Quantity control is achieved by limiting the post development peak discharges for the two and 10-year floods to their predevelopment peak discharge rates.

If downstream flooding is documented, the quantity control is to limit the post development peak discharge rate for the 100-year flood to 80% of the predevelopment rate for that rainfall event. The 80% peak discharge rate reduces potential coincidence of flow downstream as a result of the extended detention and release of the 100 year ARI flow.

The simplest way to calculate the flood volume that will be required to be stored in the pond would be to repeat the steps of section 1.5.1 and use the TP108 worksheet for 2yr, 10 yr or 100 yr ARI rainfalls for pre and post development scenarios. The difference in the calculated runoff volumes V_{24} between the post and pre predevelopment flows would be the flood volumes required to be stored in the pond. The rates of release from the pond are then calculated as required. The invert level of the 2 year control device is set at the top level of the extended detention and the invert level of the control device for the 10 yr flow is set at the top of the 10 year flood storage volume and so on.

Figure 1.3 shows typical cross section of a stormwater pond in Flat Bush dealing with both detention and water quality treatment. This pond was designed for the catchment, which is yet to be developed. The flood detention requirement for this pond was to limit the post development 100 yr ARI peak rate to 80% of the pre-development peak rate.

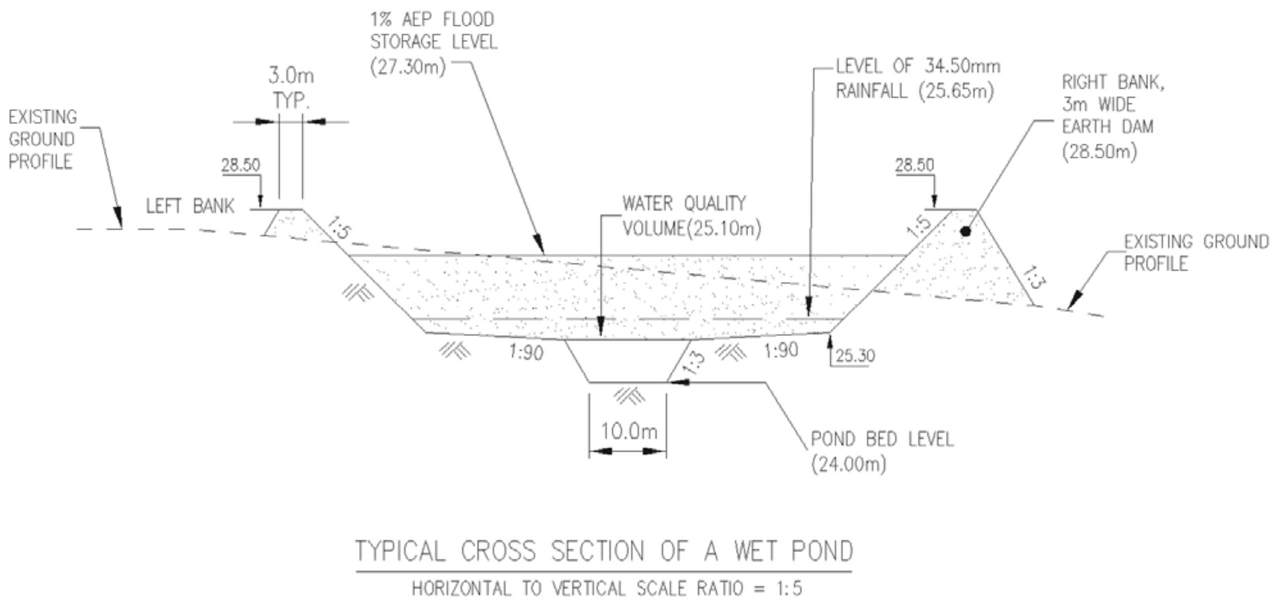
Total Pond Capacity
= **50% of WQV** (from 1/3rd of the 2 yr ARI 24 hr rainfall) + Flood volume required to be stored to limit the peak rates.

Out of the volume of stormwater required to be stored to limit the peaks of stormwater runoff, the extended detention volume is released over a period of 24 hours and the balance is released in accordance with the two year, 10 year or 100 year ARI peak rates.

Note: If extended detention is not required, 100% WQV should be used instead of 50%.

Compare the total volume required to be stored in the pond to the available volume from physical layouts and set levels for each storage.

Figure 1.3 Cross Section of a Pond involving Quality and Quantity Controls



1.5.4 Water Balance

A permanent pool of water should be maintained by rainfall and the base flow to ensure an ecologically healthy pond, avoid bad smells and minimise breeding of mosquitoes.

A water balance assessment was been carried out for a wet pond at Barry Curtis Park in Flat Bush, which is presented below. This pond serves 60.5 hectares of the catchment, and future development in the catchment will direct primary and secondary flows into this pond. The pond has a capacity of 19,000m^3 at permanent water level and occupies approximately 14,000m^2 area at this level. The pond is designed for stormwater treatment as well as for recreational purposes. A wetland has been incorporated in the design for aesthetics and is located below the wet pond. An Education Centre building is proposed near the pond inlet structure.

The water balance analysis was calculated on the following basis.

(a) Rainfall

Monthly rainfall data recorded for the Pakuranga Station (C64983) between 1971 and 2002 was used in the calculations.

(b) Volumetric Runoff Coefficient

The following volumetric runoff coefficients (Cv) for Otara (Station No. 8204) were used, as recommended by ARC TP19:

Summer	Winter
0.25	0.34

(c) Monthly Catchment Runoff

Catchment runoffs for summer and winter (from 1971 to 2002) were calculated by multiplying the monthly rainfalls with the corresponding volumetric coefficients. The initial depression storages were considered negligible for the monthly assessment.

(d) Monthly Base Flow

There is no record of monthly base flow for the Flat Bush catchment. Stormwater Runoff Volumes prepared by Beca Steven (2000) for Auckland Regional Council for Pakuranga Catchment allows 0.20m annual depth for base flow out of the total annual precipitation of 1.15m. 17% of the monthly rainfall was allowed for monthly base flow in the water balance exercise for Barry Curtis Park Pond,.

(e) Monthly Pond Water Evaporation

The average monthly pan evaporation data for Otara Station was used. These observed values of pan evaporation were multiplied by a pan factor of 0.70 (Chow et. al., 1988) to convert them to equivalent open water evaporation values from the pond. The monthly equivalent open water evaporation values were multiplied by the pond surface area to give a figure for monthly loss from evaporation.

(f) Monthly Water Balance

The monthly volume of water that will be available to the pond is equal to:

Monthly runoff from the catchment

\+ Monthly base flow from the catchment

– Monthly evaporation loss from the pond.

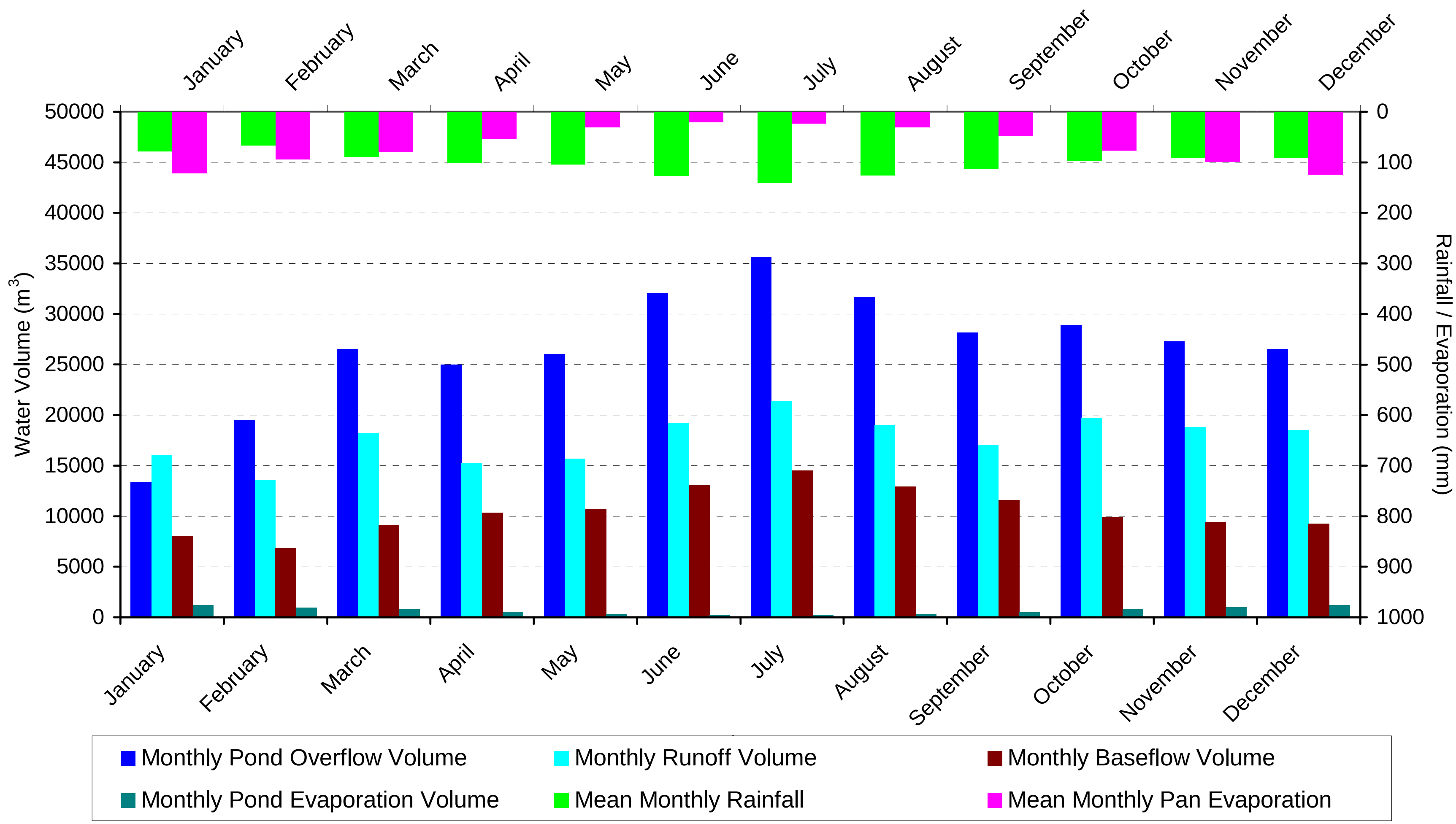
This monthly water balance equation was used for winter and summer for the period between 1971 and 2002 and these parameters are plotted on Figure 1.4.

Figure 1.4 shows that the water availability at the pond from rainfall and base flow for each month is greater than the loss from evaporation, suggesting that the permanent water level will be maintained on a monthly basis. The surplus water will flow out of the pond through the service outlet which is provided at permanent water level. February 1973 and January 1974 were the two driest months in the record. February 1973 had a total of 5.8 mm rainfall and January 1974 had 9.9mm.

The Otara Station (close to the site) February 1973 did not have rainfall for 12 consecutive days and January 1974 did not have rainfall for 14 consecutive days, suggesting that if the rainfall pattern of 1974 is repeated, the pond may remain stagnant for a maximum period of 14 days.

Based on calculations that after a period of seven days without rainfall, the stagnant pond may start to give off an unpleasant smell, the pond should be supplied with extra water to raise the lower water level to the permanent water level. Taking both the 1973 draught into account, and calculations that the inflow from the base flow is $21m^3$ per day and loss from pond evaporation is $33m^3$ per day, it is considered that an extra $84m^3$ of water will be required for seven days. This additional supply of water will help to prevent any unpleasant smells from the pond, which are related to the water quality of the pond.

Figure 1.4 Mean Monthly Water Balance for Barry Curtis Park Stormwater Pond, MCC



1.5.5 Other Pond Features

The physical parameters are determined after calculating the hydraulics of the pond.

- Sediment forebay capacity is 15% of the WQV.
- Flow velocity exiting the sediment forebay should not be more than 0.25m/s for 10-year flow.
- Length: width ratio should be 3:1 or greater.
- Permanent water depth in the pond should range from 1m to 2m.
- Pond side slopes should not be steeper than 1(V): 5(H). A planted shelf with slope of not exceeding 1:15 shall be provided around the perimeter of the pond at WQV level. The shelf shall be a minimum of four metres wide, extending for two metres above and below the normal water level of the pond
- Dead zones should be avoided to improve performance of the ponds.

1.5.6 Service Outlet

As a minimum, the service outlet should be designed to:

- Accommodate the five-year storm flows from the primary drainage system entering the pond.
- Convey the flow from the extended detention orifice for the two-year storm and ten-year storm events.
- To be not less than 150mm in diameter for extended detention.

The impacts of possible blockages should be considered on all outlet devices.

The outlet structure shall be designed to achieve the following:

- Minimal outlet velocity to minimise downstream scour
- Provide a flow pattern that will not cause bank erosion downstream
- Have access for maintenance and cleaning
- Provide for fish passage where necessary

1.5.7 Emergency Spillway

The emergency spillway is to convey flows beyond the capacity of the service outlet and should be designed to convey at least the 100-year storm with a freeboard of at least 300mm. The risk for a potential dam break should be considered and managed. In situations where embankment failure may lead to loss of life or extensive property damage, the emergency spillway should be designed to pass a minimum of 3 times the 1 in 100 ARI flood.

Wherever possible the emergency spillway should be located in natural ground. If placed on fill material, adequate erosion protection measures should be included. A site-specific design incorporating one of the following types of linings for emergency spillways would be acceptable:

- **Reno mattress** - the voids on top of the spillway are to be filled with 20/7 scoria for ease of pedestrian movement on the bank. The scoria may be washed during passage of the flood over the spillway and will need to be replaced after a flood.
- **Gabion** - the voids on top of the spillway to be filled with 20/7 scoria for ease of pedestrian movement on the bank. Scoria will need to be replaced after a flood.
- **Rocks** –these must be large enough so they will not be at risk of being washed away by flooding.

Note: it is not acceptable to use concrete linings on a spillway

1.5.8 Pond Dewatering Pipes

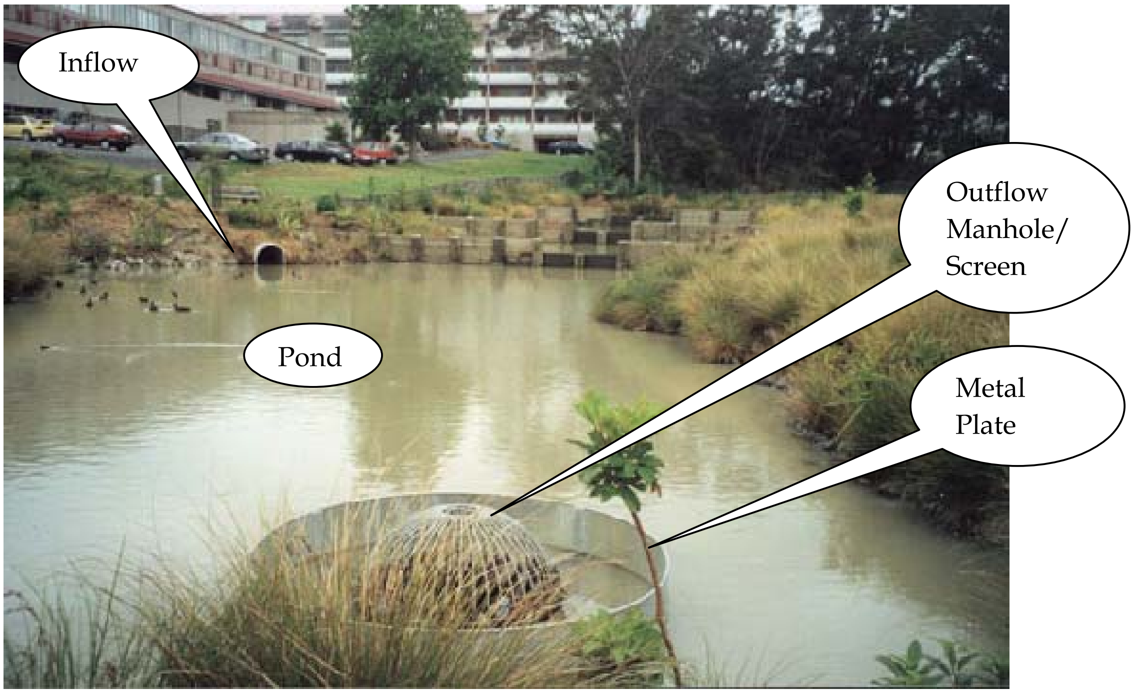
The outflow structures shall be fitted with a pond-dewatering pipe with a minimum diameter of 150mm.

1.5.9 Debris control

One of the following debris control devices should be included to avoid any blockages of outflow devices:

- A screen device
- A metal plate installed around outflow debris control screen (Photograph 1.1
- An unperforated drain coil fixed around/in front of outflow system. The drain coil should be fixed to the bank with chains to allow pipe movement as the water level fluctuates.

Photograph 1.2 Metal Plate for Debris Control



1.5.10 Pond Safety and Signage

Manukau City Council does not require fencing of stormwater treatment ponds. A preferred option is to manage the contours of the pond to eliminate drop offs and other safety hazards. The internal side slope should not be steeper than 1:5. Slopes steeper than 1:5 should terminate on a safety bench. Both safety bench and aquatic bench may be densely planted to prevent access to the pond. This bench requirement may be waived for slopes are more flat than 1:5

Signs shall be erected at all defined access points to the pond providing information and warnings. Where available, a running board shall be added to the bottom of an existing park sign. A stand-alone sign shall be designed and approved by Council.

Signage at entry locations should identify potential hazards and prohibit swimming. Swimming will not be permitted for the following reasons:
- Potential to stir sediment from the pond edges and bottom.
- Likelihood to damage wetland plants.
- Potential for contaminants to cause significant health and safety risks.

1.5.11 Access and maintenance

Sediment forebay, pond and pond outflow structures must be kept accessible for operation and maintenance purposes.

1.5.12 Inflow Pipes

The inflow pipes to the pond should be graded so that the flow velocity does not exceed 2m/sec. The inlet velocity should be dissipated in the sediment forebay. The exit velocity form the forebay should not exceed 0.25m/sec for 10-year flow to avoid re-suspension of sediments in the pond.

1.5.13 Pond Linings

Any requirements for pond linings and selection of the type of lining shall be determined at an early stage based on geotechnical investigations. The installation of the lining shall be in accordance with the requirements of the suppliers and the manufacturers of the particular product.

The following lining materials may be used subject to approval from Manukau City Council on a case by case basis:

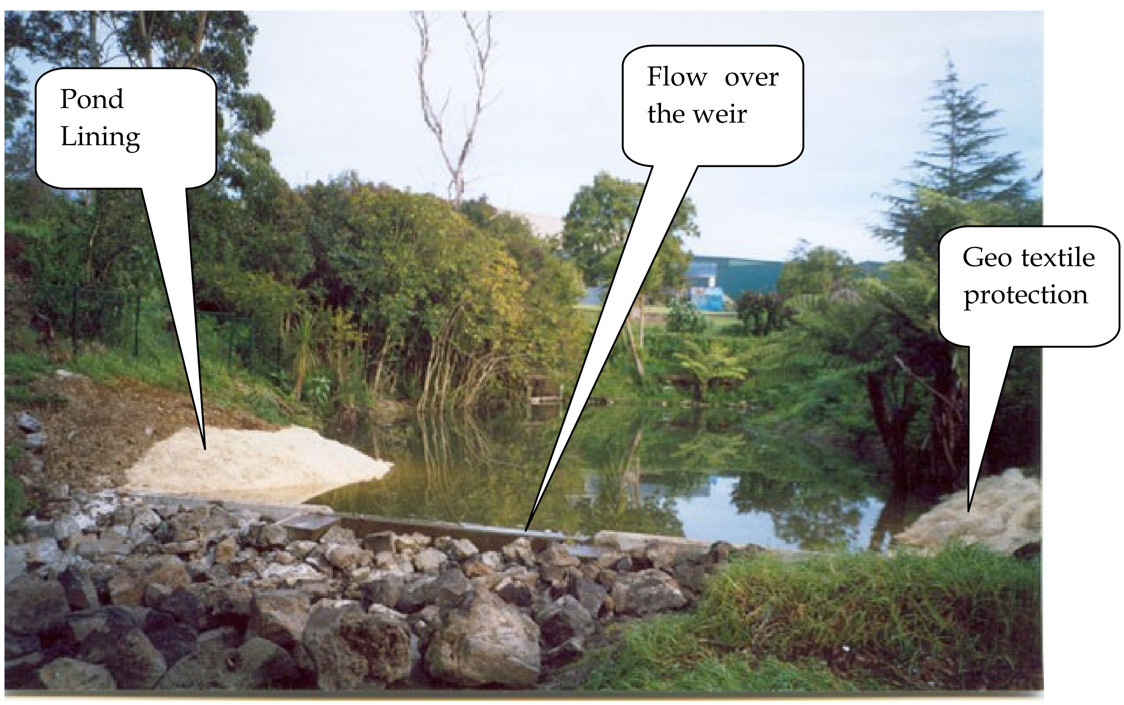
- A mixture of clay and bentonite powder
- Proprietary products (e.g. Geosynthetic clay liner, polypropylene alloy pond liner).

Note: Concrete linings will only be approved in exceptional circumstances.

Photograph 1.3 shows leakage from a pond and Photograph 1.4 shows the same pond after lining with geo-synthetic clay liner.

Photograph 1.3 Pond Leakage

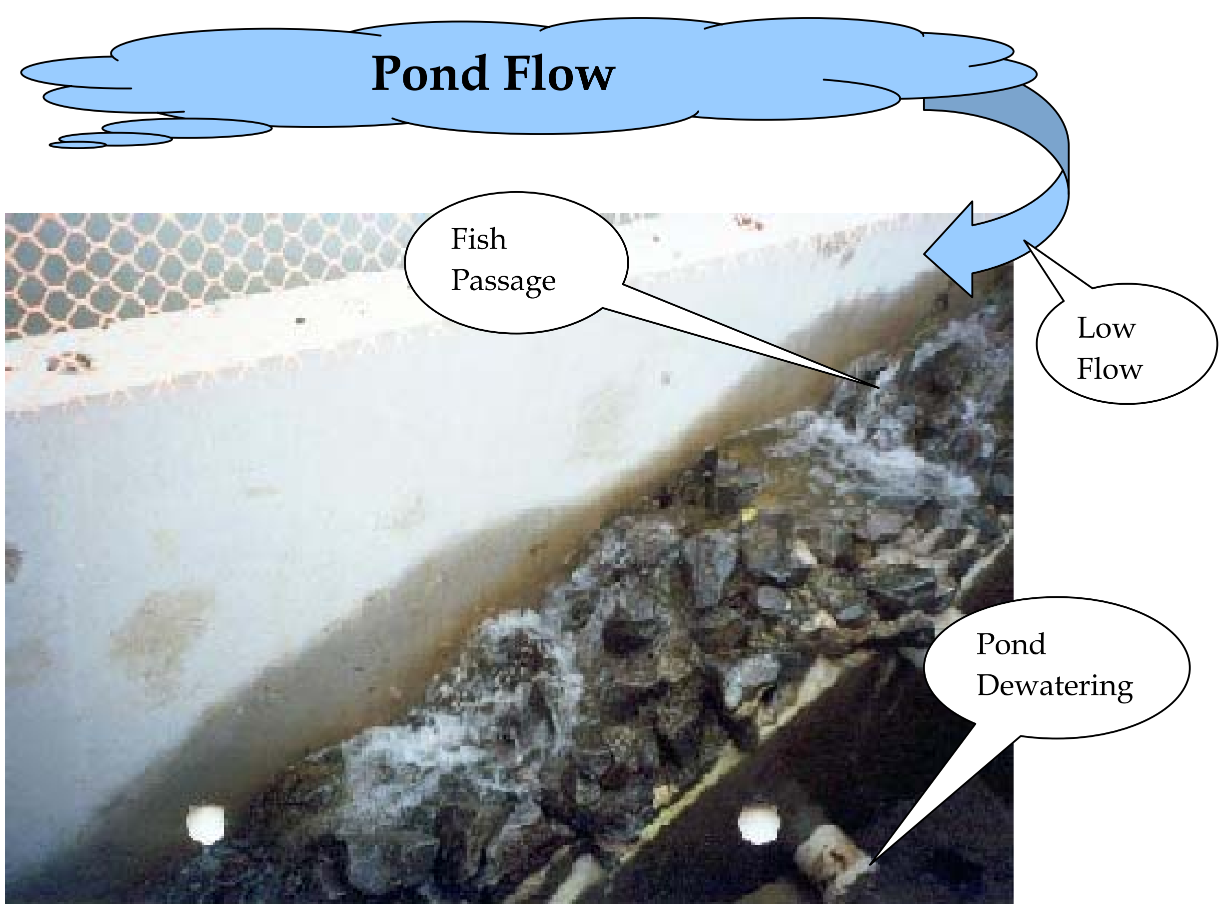
Photograph 1.4 Pond Lining with Geosynthetic Clay Liner



1.5.14 Fish Passage

If the pond is situated online on a perennial watercourse, a fish passage will be required at the outflow structure to provide for fish migration. A typical fish passage at outflow concrete chamber can be constructed by creating a series of water pools on a concrete ramp as shown on photograph 1.5. Fish passage in outflow culverts may be provided by fixing PE pipes on a bed and creating a series of baffles along the flow. For further information on the design of fish passage, , refer ARC TP 131(2000) and Fish Passage at Culverts (NIWA, 1999).

Photograph 1.5 Fish Passage



1.6 Geotechnical Investigation

A preliminary geotechnical investigation is required at the concept design stage to gain an initial understanding of a site. A detailed investigation must be carried out at the detailed design stage. As a minimum requirement, the following matters must be addressed in a geotechnical report:

- General geology and soil characteristics of the area and its influence on foundation conditions
- Evaluation of the foundation requirements
- Identification of the existence of the previous filling activities on the site
- Slope stability at the site
- Earthworks quality assurance and controls
- Fill materials
- Subgrade for filling
- Assessment for settlement of filling
- Requirement for pond lining
- Potential for downstream erosion and proposed methods to avoid or mitigate
- Stability report for access track for use of machinery and vehicle access if required machine

  Likely risks and risk management procedures.

1.7 Planting proposals for bank stability and water quality improvements.

Detailed site specific landscaping and planting plans and specifications must be approved by Manukau City Council. The planting plans should take into account the need to minimise long term maintenance. As a minimum, the landscaping and planting plans shall include the following matters:

- Common and botanical names of plants proposed for various locations of the pond project
- Timing of planting and staging
- Density of planting
- Planting and maintenance methodology
- Plant replacement during maintenance period
- Water level control for the maintenance/establishment period
- Protection of plants against pests
- Weed control methodology including aquatic plant management

The plants shall be sourced locally where practicable, and shall be suitable to the conditions of the particular site.

All clay that is not suitable for planting shall be ripped to a depth of 300mm before the application of 300mm of topsoil prior to planting.

A variety of native plants shall be used in the planting plan. No single plant species shall comprise more than 30% of the total plant mix.

1.8 Relationship with Catchment Management Plan

Site-specific assessment of the environmental effects (AEE) should be carried out in accordance with the catchment management plan and the presence of any sensitive habitat in the vicinity of the pond site must be identified. Recommendations must include measures to minimise any adverse effects of pond construction to the receiving environment.

1.9 Amenity Features

The design of ponds should include amenity features such as walking tracks, boardwalks, picnic tables and benches, landscaping and riparian planting where appropriate.

1.10 Erosion and Sediment Control Plans

Erosion and sediment control plans for pond construction shall be prepared in accordance with ARC TP90.

1.11 Preliminary Operation and Maintenance Manual

A draft operation and maintenance manual shall be submitted to Manukau City Council, together with the final design for approval. The draft Operation and Maintenance Manual shall address the following matters listed under each subheading:

(i) Plans:

- Location plan
- Site plan
- Site access
- Construction plan
- Planting plan
- Maintenance plan

(ii) General information:

- Pond data summary
- Pond design calculation summary
- Resource consents to be obtained
- Pond survey designated title plan status
- Geotechnical investigation report
- List of assets such as parks furniture, benches, signs

(iii) Maintenance requirements:

- Maintenance activities and frequency
- History of maintenance to be prepared
- Pond - dewatering method
- Pond cleaning and disposal method
- Plant maintenance
- Weed control method
- Structural maintenance method
- Method of pest application

1.12 Cost Estimates

The detailed design report shall include an estimated cost for construction and a projected cost for maintenance for the next twenty years after construction.

In accordance with Manukau City Council's Stormwater Asset Management Plan, the life of the pond is considered to be indefinite. However, the 20 years is the planning period within the Asset Management Plan.

1.13 Stormwater Pond Safety Guidelines

The design of stormwater treatment ponds must include consideration of public safety as well as the safety of operations and maintenance staff. In terms of addressing the structural safety of the pond it is necessary to refer to ARC TP109, Dam Safety Guidelines.

1.14 Concept plans

It is recommended that the developer discusses concept plans with appropriate Council Officers at an early stage to ensure that mutually acceptable solutions are derived prior to the lodgement of applications for resource consent.

1.15 Checklist for Applications for Resource Consents

In addition to the standard requirements for lodging a resource consent an application to construct a stormwater treatment pond shall include the following information:

- Design calculations for water quality volume, extended detention volume and flood storage volume including outflow controls. (Refer to spreadsheets in ARC TP 108 and TP 10).
- Design report
- Geotechnical investigation report

- Preliminary operation and maintenance manual
- Design drawings
- Erosion and sediment control plans
- Site specific assessment of the environmental effects
- Application fee
- Application Form.

Council may also request additional information relating to any application once the application has been lodged, pursuant to Section 92 of the Resource Management Act 1991.

2. Operation and Maintenance of Stormwater Ponds

2.1 General

Ponds are normally associated with other works such as walking tracks, boardwalks, park benches, picnic tables riparian planting etc, that all contribute towards the amenity value of the pond sites.

A maintenance plan is required to ensure effective operation and functioning of the pond, and would include activities such as regular inspections; regular removal of litter and debris; preventing blockages of outflow structures; maintaining aesthetic values of the site; and removing weeds on vegetated buffers around ponds. Pond maintenance is very critical in summer when the potential for unpleasant smells and mosquito problems is high.

Based on international experience, the annual cost of routine maintenance typically ranges from 3% to 5% of the construction cost.

2.2 Maintenance Requirements

Table 2.1 shows the maintenance requirements for pond access, entrance, areas, embankment and spillway, and outflow structures.

Table2.1 Maintenance Requirements for Stormwater Ponds

Pond Components	Wet Season Inspection	Annual Inspection	Condition when Maintenance Required	Action Required
1. POND ACCESS				
1. Pond access	Y	Y	Eroded, cannot be driven in	Repair
2. POND ENTRANCE GATE				
2. Entrance gate	Y	Y	Lock damaged/ rusted or lock missing	Replace
3. POND AREAS				
a) Trash/ Waste	Y	Y	More than 0.03 m^3	Remove/dispos e
b) Sediment	Y	Y	Accumulated sediment exceeds 0.30m	Remove/restore
c) Pollution	Y	Y	Any visible accumulation of oil, gas or other contaminant	Remove/Dispos e
d) Noxious weeds	N	Y	Any nuisance or noxious vegetation.	Remove and dispose cuttings
e) Grass/ ground cover	N	Y	Residential Area: mow when grass height reaches 450mm. In other areas, match adjacent ground	Mow 50mm height. Remove cuttings and dispose.

Pond Components	Wet Season Inspection	Annual Inspection	Condition when Maintenance Required	Action Required
			cover/terrain as long as there is no interference with facility function	
f) Insects	N	Y	Wasp, hornets interfere with operations	Remove
g) Tree/brush growth	N	Y	Growth does not allow access, interferes with future maintenance activity or reduces storage capacity. Otherwise leave alone.	Remove and restore pond bottom.
h) Fence	N	Y	Damage to gate/fence, posts out of plumb, or frames bent more than 150mm	Repair/Replace
	N	Y	Brush/weeds along fence line	Remove and dispose
	N	Y	Erosion /settlement causing opening under the fence greater than 100mm and 300-450mm wide or openings along fence line greater than 200mm diameter	Repair
4. EMBANKMENT AND SPILLWAY				
a) Spillway	N	Y	Rock lining down to 1 layer of rock	Add rock to design conditions
	N	Y	Brush, tree growth on spillway	Remove and dispose
b) Embankment	N	Y	Downstream face wet, seeps or leaks evident	Plug holes. Contact geotechnical Engineer ASAP
	N	Y	Any evidence of rodent holes or water piping around holes if facility acts as dam or berm	Eradicate rodents/repair holes (fill and compact)
	N	Y	Erosion/rills greater than 50mm around inlets, outlet and along side slopes. Note evidence of	Eliminate source of erosion and stabilise

Pond Components	Wet Season Inspection	Annual Inspection	Condition when Maintenance Required	Action Required
	     N	 Y	leakage through embankment Settlement greater than 100mm (relative to undisturbed sections of berm)	damaged area (regrade, rock, vegetation, erosion control blanket) Restore to design height
5. OUTFLOW STRUCTURE				
a) Concrete Outflow Chamber/Manhole	N Y N	Y Y Y	Outflow debris control screen damaged Outflow debris control screen blocked Debris control screen cannot be opened for access into the chamber for inspection	Repair/Replace Clear debris Repair/replace
b) Orifice plate(s)	N	Y	Bent, rusted or missing	Replace
c) Pond drainage pipe	N	Y	Screw damaged /leaking	Replace screw
d) Structural integrity at the outflow chamber/manhole	N N	Y Y	Ladder rungs damaged, missing or misaligned Cracks wider than 12mm and longer than 1m, any evidence of leakage	Repair/replace Repair
f) Outlet pipe	N N	Y Y	Submerged or partially submerges Root intrusion greater than150mm in length or less than 150mm apart	Check obstruction down stream and clear Root saw pipes
6. Permanent Pool				
a) Undesirable or excessive vegetation	N	Y	Undesirable plants	Remove and replant with native wetland plants
b) Sediment	N	Y	Accumulated sediment greater than depth of the sedimentation zone in forebay (typically 300mm) plus 150mm	Remove, regrade and replant pond bottom

Pond Components	Wet Season Inspection	Annual Inspection	Condition when Maintenance Required	Action Required
c) Receiving water	Y	Y	Erosion damage along banks	Regrade /Armour below outlet

Note:: Y = Yes (or required) ; N= No (or not required).

Wet Season inspection: Inspect the items that are checked once in the early part of the wet season (June) and gain near the end of the wet season (September).

Annual inspection: Inspect the items that are checked once each year. To avoid interference caused by rainfall, the annual inspection should be conducted during the dry season (November – December).

2.3 Maintenance Inspection Checklist

Table 2.2 shows a typical maintenance inspection checklist for a stormwater pond. Inspections should be carried out in accordance with Table 2.1 as a minimum and more frequently when required. The investigating officer should have a copy of "Operation and Maintenance Procedure" while inspecting the pond. Refer to Appendix B for example of issues covered in preconstruction meetings.

Table 2.2 Maintenance Inspection Checklist for Stormwater Ponds

Name of Pond: Location: Inspecting Officer: Date: Time: Weather:	

Description of pond features	**Items Inspected**	**Maintenance needed/Not needed**	**Frequency of Maintenance**	**Comments**
1 Access track			A,S	
2 Embankment and Emergency spillway a) Is the Spillway level? b) Is there adequate vegetation and ground cover? c) Is there adequate freeboard? d) Do plants need weeding? e) Are there any unwanted plants f) Is there any evidence erosion in the embankment? g) Is there any sign of Cracking, bulging or sliding of the embankment? Upstream face Downstream face At or beyond toe upstream At or beyond downstream toe Emergency spillway h) Are the pond and toe drains clear and functioning? i) Is there any evidence			A,S	

Description of pond features	Items Inspected	Maintenance needed/Not needed	Frequency of Maintenance	Comments
of animal burrows? j) Is there any seepage/leakage on downstream face? k) Are vertical and horizontal alignments of embankment as per As-Builts? l) The Emergency spillway clear of obstruction and debris? m) What provision of access is made for maintenance? By hand? Machine operation? Other?				
3 Riser and service spillway Type: RCC chamber RCC manhole Other a) Is the low flow orifice obstructed? b) Is the low flow trash rack blocked with debris? Is debris removal necessary? Is corrosion evident in the low flow trash rack?				

Description of pond features	Items Inspected	Maintenance needed/Not needed	Frequency of Maintenance	Comments
c) Does the weir trash rack need maintenance? Debris removal required? Corrosion evident? d) Is there evidence of excessive sediment accumulation inside the riser? e) What is the metal Pipe condition? f) Is outfall channel functioning?			A	
4 Conditions of Concrete risers and barrels a) Are there cracks or displacement? b) Is it a minor spalling (0.25mm)? c) Are reinforcing bars exposed? d) Are there joint failures? e) Is there adequate water tightness? f) Is the pond drainage pipe screw operational /exercised? Chained and locked?			A	
5 Are there any slope protection or riprap failures?			A	

Description of pond features	**Items Inspected**	**Maintenance needed/Not needed**	**Frequency of Maintenance**	**Comments**
Other				
6 Permanent Pool of Wet Pond a) Is there unwanted vegetative growth? b) Removal of floating debris required? c) Is there visible pollution? d) Evidence of "edge erosion"? e) Other?			M	
7 Dry Pond a) Is there adequate vegetation cover? b) Any unwanted vegetative growth? c) Standing water or wet spots? d) Sediment/trash accumulation? e) Low flow channels unobstructed?			M	
8 Sediment Forebays a) Any Sedimentation noted? b) What provision for access maintenance is allowed? By hand? For machinery?			A	
9 Pond inlets:			A,S	

Description of pond features	Items Inspected	Maintenance needed/Not needed	Frequency of Maintenance	Comments
a) Riprap failures? b) Condition of head and wing walls c) Evidence of erosion at inlet? d) Slope erosion? e) Condition of inflow pipes? f) Other?				
10 Miscellaneous a) Encroachment on pond/easement area? b) Complaints from residents? Smell? Mosquitoes? Dying of birds? c) Aesthetics? Is the grass mowing required? Graffiti removal needed? d) Any public hazard (specify) e) Vegetation healthy and growing? f) Is there evidence of invasive species? g) Is there excessive sedimentation in the wetland areas?			A	

Note: A = Annual, M= Monthly, S= After storm

General Comments on the following:
Aesthetics of the pond/Site safety/Overall condition of the facility

2.4 Special Inspections

Special inspections will be required to be conducted after the following:

- When any problems are reported from routine or maintenance inspections
- After extreme events such as earthquake, cyclones or severe winds
- In the events of significant rainfall in the previous 24 hours (more than 50mm)

2.5 Water Quality Monitoring

MCC operates and maintains a number of stormwater ponds. A system of monitoring should be set up for regular monitoring of stormwater quality in the ponds.

Reference

1 Auckland Regional Council(2003) "Stormwater Management Devices: Design Guidelines Manual", Revision to Technical Publication No.10.

2 Auckland Regional Council(2000) " Stormwater Runoff Volumes".

3 Auckland Regional Council(1999) " Erosion and Sediment Control, Guidelines for Land Disturbing Activities", Technical Publication No. 90.

4 Auckland Regional Council(1999) " Guidelines for Stormwater Runoff Modelling in the Auckland Region" Technical Publication No. 108.

5 Auckland Regional Council(1992) " Guidelines for the Estimation of Flood Flows in the Auckland Region". Technical Publication No. 19.

6 Applied Hydrology, Ven Te Chow, David R Maidment and Larry W. Mays, 1988

Appendix A

Water Balance Calculations for Barry Curtis Park Stormwater Pond

Table A1 Water Balance Calculations for Barry Curtis Park Pond

Month & Year	Monthly Rainfall (mm)	Mean Monthly Pan Evaporation (mm)	Monthly Runoff (m3)	Monthly Base Flow (m3)	Monthly Evaporation (m3)	Monthly Spills (m3)	Pond Storage (m3)
Monthly Average	**102**	**67**	**17696**	**10459**	**652**	**26712**	
Annual Average	**1220**	**798**	**212349**	**125513**	**7820**	**320541**	
January	77.96	122	16036	8018	1196	13359	19000
February	66.19	94	13615	6808	921	19502	19000
March	88.49	79	18202	9101	774	26529	19000
April	100.41	53	15187	10327	519	24995	19000
May	103.64	30	15676	10659	294	26041	19000
June	126.82	20	19182	13043	196	32029	19000
July	141.14	23	21347	14516	225	35638	19000
August	125.71	30	19014	12929	294	31649	19000
September	112.61	48	17032	11582	470	28144	19000
October	95.96	76	19739	9869	745	28864	19000
November	91.55	99	18832	9416	970	27278	19000
December	89.87	124	18486	9243	1215	26514	19000