Guidelines for the Design and Assessment of Flood Retarding Basins

1. Introduction

Melbourne Water currently manages over 200 flood retarding basins within the drainage system. These basins have been constructed over many years by various authorities including the Melbourne and Metropolitan Board of Works, Dandenong Valley Authority, local councils and land developers.

These guidelines aim to formalise Melbourne Water’s requirements for the general design, construction, operation and maintenance of retarding basins. Where designers believe that a departure from the normal requirements set out in this guideline is warranted, Melbourne Water will assess each proposal on its own merits.

Melbourne Water is currently undertaking adequacy reviews of its existing retarding basins to develop a prioritised program of upgrades. This program aims to bring existing retarding basins progressively into line with current policy.

2. Background

Flood retarding basins are urban holding ponds, which temporarily store stormwater runoff from a drainage catchment from small to moderate flood events and allow the downstream flow rates to be kept within the design capacity of the drainage system. Such basins are constructed to reduce downstream flooding impacts, reduce the need for downstream drainage works and protect natural waterways. These basins are usually designed to mitigate floods up to a 1 in 100 Annual Exceedance Probability (AEP) flood level.

These basins also provide considerable benefits, other than flood control, for the community (e.g. stormwater quality, recreational areas, pollution control etc).

When these basins store water they act as dams, storing significant volumes of stormwater, and therefore they may pose a potential threat to communities downstream. As a result, the design must have regard for ANCOLD (Australian National Committee on Large Dams) guidelines, comply with Melbourne Water’s ‘Statement of Obligations’ to the Essential Service Commission (ESC) and comply with Melbourne Water’s ‘Dam Safety Management Policy’.
3. Design Requirements

Melbourne Water requires that retarding basins are designed by suitably qualified persons (i.e. dam engineers or urban drainage engineers with suitable experience) and that appropriate dam design concepts are employed. Melbourne Water relies on the knowledge, skill and diligence of the designer for aspects of detailed analysis, design and conformance with current practice. However Melbourne Water may require further assessment of any aspect of design to ensure adequate protection of the community and environment. The following areas, in particular, require detailed consideration by designers:

3.1 Flood Capacity

The consequences of a storm exceeding the Dam Crest Flood should be considered in the design of a retarding basin. Although such an occurrence may be unusual, it is still possible, and the consequences of the sudden failure of a basin could be catastrophic because of their proximity to residential areas.

Accordingly, Melbourne Water requires that basins be designed to pass appropriate extreme storms safely in accordance with the Hazard Category of the basin as defined by ANCOLD, as is the case for conventional dams.

Melbourne Water requires that an “Initial Assessment”, as defined by ANCOLD’s guidelines within the ‘Assessment of the Consequence of Dam Failure’ (2000) be undertaken on all proposed retarding basins to determine the hazard category of the structure. If the basin has no embankment or if the consequences of failure of the embankment are considered very low, then a letter stating the assumed hazard category must be submitted supported by detailed reasons an ANCOLD assessment was not undertaken.

The “Initial Assessment” should include but is not limited to:-

- Determining the potential downstream inundation extent, using Method 1 - Approximate determination (definition provided in Appendix C of the ANCOLD “Guidelines on Assessment of the Consequences of Dam Failure” 2000), the associated Population at Risk (PAR) and the Severity of Damage and Loss.
- Determining the Hazard Category for the basin based on existing conditions, and for the proposed future ‘ultimate development' scenario.
- Determining the required flood capacity (Spillway Design Flood) to satisfy the “Fallback” design flood criteria defined in ANCOLD “Guidelines on Selection of Acceptable Flood Capacity of Dams” (2000)
- Preparing a report detailing the study and the findings, and summarising the ANCOLD requirements for the basin.

Depending on the findings of the “Initial assessment” a more detailed assessment (Intermediate or Comprehensive Assessment as defined under Consequence Assessment within ANCOLD “Guidelines on Assessment of the
Consequences of Dam Failure” 2000) including a Dam Break analysis for both ‘flood failure’ and ‘sunny day’ scenarios may be required. Melbourne Water will determine if this is required following the review of the ‘Initial Assessment’ report.

3.2 Downstream Development
The extent of existing and future development in an urban catchment should be considered during design of a retarding basin, as future extensive development within the catchment could significantly alter catchment inflow response at the basin. In addition, future development downstream of the basin could significantly increase the hazard presented by the basin (affecting Melbourne Water’s requirements) and affect Melbourne Water’s risk profile. It is possible that the construction of a new retarding basin may require subsequent upgrades of downstream basins.

The flood capacity of a basin should be designed to take into account future downstream development based on the expected density of population.

3.3 Multiple Basins within a Catchment
With increasing urbanisation there are now many catchments in Melbourne Water’s drainage area which contain a series of retarding basins. This introduces two further aspects which must be considered. The consequences of one basin failure cascading downstream into lower basins should be evaluated. In addition the effect of long period releases from upper basins superimposing on flows through lower basins may require a revision of the basins’ operation throughout the catchment. Overall each basin within a catchment should be investigated, not only individually, but also collectively within the catchment, including all basins modelled as a whole.

4. The Design Process

4.1 Site Investigation
Site investigations must be undertaken as part of the overall design process of such investigation shall include but not be limited to:

- Geological assessment of the site;
- A program of bore holes to assess the retarding basin and spillway, foundations and any preferred borrow pits;
- Laboratory testing;
- Desiccation fissuring present
- Shear strength testing of the overall design.

4.2 Embankment Design
The embankments forming retarding basins are to be designed as dams using appropriate stability analyses and practices. In particular appropriate foundation treatment should be specified. For embankments suitable compaction levels should be specified and protection provided to cater for cracking or dispersive soils. Impervious zones of the embankment should take the form of a centrally
located ‘core’ rather than an upstream face zone to reduce the effects of drying which may lead to cracking. Chimney Intercept filters and filter/drainage blankets must be used for all high and extreme hazard category retarding basins. Such filters may also be required for lower hazard category retarding basins. All embankments constructed from dispersion soils must have a chimney filter and downstream filter/drain. For design of filters and drainage pipes, see Fell et al, 2005.

Embankment slopes and their protection should take into account long term maintenance of the structure. Trees should not be planted on embankments. Preferably, embankments should be protected by a uniform, robust grass cover that can be routinely mown and inspected for defects.

If the earthfill for any embankment is to be taken from borrow areas, these areas must be kept as far away from the embankment(s) as practicable. Should the borrow area penetrate any alluvial sand layers or lenses, the embankment’s cut-offs should be taken to at least 1m below the estimated depth of such sand layers/lenses at the retarding basin floor.

4.3 Spillway Design
Melbourne Water does not usually permit designs that envisage the overtopping of earthen embankments at flood peaks less than the “Fallback Spillway ARI required by ANCOLD unless a full risk assessment as defined by ANCOLD is undertaken.

In general, the spillway capacity should be based on the hazard rating of the structure as defined by the ANCOLD seven level rating system. The hazard rating defines the required “Fallback Design Flood. In some cases where the required “Fallback Design Flood is considered to be impractical, a full risk assessment of the basin may allow a lesser capacity spillway in line with ALARP (As Low As Reasonably Practicable) principles.

The design capacity of spillways should be set assuming NO contribution to flood capacity from any outlets that have the potential to become blocked during an event. Unless it can be clearly shown that the outlet would remain fully or partially functional during the inundation the outlet must be assumed to be blocked. A sensitivity analysis of impacts of outlet blocking or being partially blocked can be used as part of designing the spillway capacity.

Where the spillway is a grass depression excavated into the abutment of an embankment, the spillway crest level should be defined by a concrete control weir. Spillway flows should be directed such that they do not impact upon the integrity of the embankment and minimise the affect on surrounding property and other assets. Flow velocities must be within recognised limits to avoid erosion on the floor and sides of the grassed channel.

4.4 Conduits below or through embankment
All conduits below or through embankment must be designed as pipes fully encased in reinforced concrete. Cut-off collars will be required, but an intercept filter collar extending around the conduit structure by at least 2m must be included. If a chimney filter is to be built into the embankment that filter should be extended below the conduit structure to act as the intercept filter collar. The outer sides of the conduit structure should be sloped at not steeper than 1(H) to 10(V). The structure must be designed to resist all applied loads including overburden with a 20% increase in the calculated load, and internal and external water pressures.

4.5 Outlet Structures and Gratings
Outlet structures and gratings should be designed such that they inhibit the accumulation of debris and allow maximum outlet flow to continue for as long as possible during a storm event. Grates directly on the pipe should be avoided where possible and other means to provide public safety—such as pools at inlet and outlets to deter entry to the pipe.

4.6 Underground Pipelines
Designers should also be aware of the effects of any service conduits (gas, power, water, sewer etc) that penetrate retarding basin embankments in respect of initiating potential piping failures. Gas and high pressure water lines should be re-routed. Sewers and similar pipelines must be treated as conduits through or below the embankment and have appropriate defensive measures such as intercept filter zones, to guard against piping (see section 4.4)

4.7 Vegetation
Vegetation cover on embankments should be limited to grass. This grass cover should be able to be mown easily and safety. Vegetation can be undesirable on retarding basin embankments for structural integrity, surveillance and maintenance reasons. Vegetation around structures such as pits, spillways and pipelines should be chosen such that the structure will not be damaged by roots and access for maintenance is available. Trees must not be planted on any embankment (see also section 4.2). Any trees that do appear should be quickly removed before the lateral and tap roots develop too far.
5. **Construction Supervision**

Construction supervision, design advice and other activities during the construction of the works must be supervised by an experienced team with knowledge of dam construction. That team must include at least a construction engineer and an inspector. Input from an appropriate geologist/geotechnical engineer will be required to assess and map the foundation. The designer must have access at all times to inspect the works so that he or she can see that the design intent is being met. It would be appropriate for the designer, the geologist/geotechnical engineer and the construction engineer to be involved in the acceptance or rejection of the foundations at various times during the works. The work-as-executed drawings must be prepared, preferably progressively during the works. An updated design report, complete with detail of changes made and the reasons for them, plus broad information on the construction process, must be presented after construction.

6. **Maintenance**

Regular maintenance is a critical factor to ensure the long-term safe operation of basins. Therefore, the design of any retarding basin structure should take into account the ease of maintenance with respect to:-

- Safe access to the structure and assets within for
  - clearing of debris
  - vegetation management including grass cutting
  - de-silting of sediment/wetland ponds
- Outlet blockages
  - design grille to reduce blockages
- Vegetation management
  - uniform grass coverage
  - tree planting - location and type
  - removal of small trees from embankments (see section 4.7)

7. **Engineering Information**

Melbourne Water requires that all information relevant to the design and proposed construction supervision of the retarding basin be presented in the form of a design report. The design report needs to cover all aspects of the retarding basin (Appendix A – Retarding Basin Requirements Guide) included in the above Guidelines as well as any other relevant information related specifically to the basin in question.
Glossary

**Dam Crest Flood** – The flood event which when routed through the reservoir, results in a still water level in the reservoir, excluding wave effects, which:
- For an embankment is the lowest point of the embankment crest.
- For a concrete dam is the uppermost level of the crest, excluding handrails, and normally parapets, unless the parapet is capable of supporting the flood surcharge load.

**Spillway Design Flood** – is the flow stage selected from site and economic considerations for the hydraulic design of the spillway structure, chute and dissipater, under operational conditions, as distinct from potential, but low probability extreme floods selected for overall dam safety.

“**Fallback**” **Design Flood** – Refers to the use of the ANCOLD guidelines as a simplified method for the determination of spillway design flood as opposed to a risk management approach.

Reference


ANCOLD “Guidelines on Assessment of the Consequences of Dam Failure” (2000)

“Geotechnical engineering of dams”, Balkema
APPENDIX A

Retarding Basin
Requirements Guide

Location & Background
Location
Date of Practical Completion / Final Completion
Melways Map reference
Design Intent

Catchment Details (assume fully developed)
Watercourse Name
Total Catchment (ha)
5 Year Flow at Outlet (cumecs)
100 Year Flow at Outlet (cumecs)
RORB Model parameters (kc, m etc)

Physical Details
Land Ownership
Maximum Length of Basin (m)
Maximum Width of Basin (m)
Maximum Embankment Crest Height (m)
Maximum Embankment Crest Height above NSL (m)
Embarkment Crest Level (AHD)
Top Water Level to Spillway Crest (AHD)
Capacity to Spillway Crest (ML)
Capacity to Spillway Crest above NSL (ML)
Capacity at Embankment Crest Level (ML)
Capacity at Embankment Crest Level above NSL (ML)
Water Surface Area at Spillway Level (ha)

Normal Outlet
Normal Outlet Type
Normal Outlet Invert Level (AHD)
Normal Outlet Size (mm)
Low Flow or Bypass System Capacity (m3/s)
Discharge with water at Spillway Crest (m3/s)
Discharge with water at Embankment Crest Level (without spillway) (m3/s)

Spillway
Spillway Type
Spillway Crest Level (AHD)
Spillway Crest Length / diameter (m)
Spillway Capacity with water at Embankment Crest Level (m3/s)
Outlet Pipe Size (mm)
Additional Spillway/s
- Spillway Type
- Spillway Crest Level (AHD)
- Spillway Crest Length (m)
- Spillway Capacity at Embankment Crest Level (m³/s)

Probability of Dam Crest Flood
- Average Recurrence Interval
- Average Recurrence Interval Assuming 50% Normal Outlet Blockage
- Average Recurrence Interval Assuming 90% Normal Outlet Blockage

Risk Assessment
- Dam Break Analysis Type
- Downstream Assessment Distance
- Total Population at Risk
- Incremental Population at Risk
- Severity of Damage and Loss
- ANCOLD ‘fallback’ required spillway AEP (if VL, L or S)
- ANCOLD Hazard Category

Design Requirements
- Embankment Type
- Soil test results
- Compaction requirements
- Embankment stability information
- Embankment design characteristics (core & drainage barrier details)

Operational and Maintenance Information
- Land Ownership
- Security Provision (fencing, appropriate prohibition signage, secure access points etc)
- Agreements / Licenses / Leases
- Monitoring Requirements (e.g. an indication of silt, litter and debris build up monitoring, High risk fire prone area monitoring)
- Final Asset Inspection Details (signage, safety, quality of work etc)

Asset Information
- As constructed information provided

Please note the above requirements are a guide and some parameters may not be applicable to all sites.