5. THE DESIGN PROCESS

This section outlines the calculations that are undertaken to determine the OSD parameters. In view of the added complexity that can arise if rainwater tanks are included as part of the development and if not all of the site area is discharged to the OSD storage, an On-Site Detention Calculation spreadsheet has been prepared to ensure that calculations are undertaken in a manner consistent with the procedures described in Section 4.2 by all OSD designers.

The OSD Calculation spreadsheet:

- calculates the extended detention storage volume and the overall storage volume based on the total site area;
- calculates the volume of dedicated and dynamic airspace that can be credited against the required extended detention storage volume and the overall detention storage volume (based on a rainwater tank being installed for each dwelling);
- calculates the nett extended detention storage volume and the overall storage volume based on the total site area; and
- calculates the primary and secondary outlet discharges (based on the adjusted SRDs);

This OSD Calculation spreadsheet can be downloaded from the Trust’s website at: www.uprct.nsw.gov.au

5.1 The OSD design process

The OSD design process encapsulated in the OSD Calculation spreadsheet is outlined as follows (refer also Figures 5.1, 5.2 and 5.3):

5.1.1 Site data

The site data to be entered by the OSD designer includes the:

- total site area (in ha);
- total roof area (in ha);
- area of the site draining to the OSD storage (in ha); and
- number of proposed dwellings on the site (to allow for multi-dwelling developments)

The OSD Calculation spreadsheet:

- calculates the residual site area – Total site area less total roof area (in ha). It is assumed that all roof runoff is directed to the OSD storage;
- calculates the area of the site bypassing the storage;
- checks that the area of the site bypassing the storage is less than 30% of the residual site area (bypasses greater than 30% are not allowed)\(^1\);
- calculates the equivalent site area per dwelling (in ha); and
- calculates the average roof area per dwelling (in ha).

\(^1\) Councils will still require a justification to allow any part of a site to bypass the OSD system.
Figure 5.1  Key Parameters for an On-Site Detention System

Figure 5.2  Key Parameters of a Rainwater Tank
5.1.2 Basic OSD parameters

The basic OSD parameters are reported in Sections 2.3.2, 3.5.1 and 3.5.2, namely

\[
\begin{align*}
SRD_L &= 40 \, \text{L/s/ha} \\
SSR_L &= 300 \, \text{m}^3/\text{ha} \\
SRD_U &= 150 \, \text{L/s/ha} \\
SSR_T &= 455 \, \text{m}^3/\text{ha}
\end{align*}
\]

5.1.3 OSD storage bypass

The OSD Calculation spreadsheet:

- calculates the adjusted SRDs based on the calculated percentage of the residual lot area draining to the OSD storage and the tabulation given in Section 4.2.9.

5.1.4 OSD calculations

The OSD Calculation spreadsheet:

- calculates the extended detention storage volume and the overall storage volume based on the total site area;
- calculates the volume of dedicated and dynamic airspace that can be credited against the required extended detention storage volume and the overall detention storage volume (based on a rainwater tank being installed for each dwelling);
- calculates the nett extended detention storage volume and the overall storage volume based on the total site area; and
- calculates the primary and secondary outlet discharges (based on the adjusted SRDs);

The OSD designer enters:

- the RL of the top water level in the extended detention storage and the detention storage (in m);
- the RL of the orifice centre-line of the primary and secondary orifices
- selects the number of orifices to be installed (primary and/or secondary) ie. in the majority of cases a single primary and a single secondary orifice will be sufficient however it may be advantageous to install multiple orifices where the diameter of a single orifice is a significant proportion of the storage depth to ensure that efficient orifice flow occurs.

The OSD Calculation spreadsheet:

- calculates the maximum heads to the centre-lines of the orifices;
- calculates the required diameter of the primary orifice and checks that it is greater than a minimum 25 mm; and
• calculates the required diameter of the secondary orifice (based on the assumption that head adopted for calculation purposes is the RL of the top water level of the extended detention storage ie. the level at which spill into the secondary DCP occurs less the RL of the centre-line of the secondary orifice and that a HED of 150 L/s/ha is achieved soon after spill into the DCP commences) (see Figure 5.4).

5.1.5 Rainwater tank calculations (Optional)

Rainwater tank data is only entered if the OSD designer is claiming an airspace “credit” against the required OSD storage volumes. When claiming an airspace “credit” the rainwater tank data to be entered by the OSD designer includes (refer Figure 5.2):

• percentage of the roof area draining to a rainwater tank (ie. can include cases where not all of the roof can be drained to a rainwater tank) (Note: the percentage that is entered must be greater than the calculated minimum percentage – the calculated minimum percentage changes if the maximum dynamic rainwater storage is changed);

• the total volume of the rainwater tank volume (in kL); and

• the minimum volume in the rainwater tank at which top-up commences (in kL);

The OSD Calculation spreadsheet:

• calculates the minimum percentage of roof that must drain to the rainwater tank compatible with the maximum dynamic rainwater storage that is available; and

• calculates the rainwater tank volume less the minimum volume in the rainwater tank at which top-up commences (the minimum volume in the rainwater tank at which top-up commences can be set equal to 0 kL).

Dedicated Airspace

If part of the rainwater tank is to be dedicated to detention (by installing an orifice outlet in the side of the tank) then the OSD designer enters the:

• volume of airspace to be dedicated to detention (in kL) (Enter 0 if there is no dedicated airspace); and

• maximum head to the centre of the tank orifice outlet (in m).

The OSD Calculation spreadsheet:

• calculates the volume of dedicated airspace that could be credited against the required extended detention storage volume and the overall detention storage volume (in accordance with Section 4.2.8);

• calculates the maximum tank discharge for the dedicated airspace based on the maximum rainwater tank PSD of 40 L/s/ha and the site area per dwelling; and

• calculates the required orifice diameter (in mm) and checks that it is greater than a minimum 25 mm.
Dynamic Airspace

Dynamic airspace is created in a rainwater tank by the usage of stored water for external and/or internal uses. The OSD designer enters:

- the daily demand for water stored in the rainwater tank (in kL/day). Section 4.2.8 gives a method for the calculation of this daily demand.

The OSD Calculation spreadsheet:

- calculates the maximum available dynamic airspace ie. the rainwater tank volume less the minimum volume in the rainwater tank at which top-up commences less any volume of dedicated airspace;
- calculates the dynamic airspace at the start of a storm (based on the procedure given in Section 4.2.8);
- calculates the volume of dynamic airspace that could be credited against the required extended detention storage volume and the overall detention storage volume (in accordance with Section 4.2.8);
- calculates the overall volume of dedicated and dynamic airspace that could be credited against the required extended detention storage volume and the overall detention storage volume;
- calculates the maximum volume of rainwater tank airspace that can be credited against the required extended detention storage volume and the overall detention storage volume. This maximum is equal to the SSR times the roof area draining to the rainwater tank; and
- adopts the rainwater tank airspace credit as the smaller of the calculated combined credit or the maximum volume credit; and
- calculates the rainwater tank airspace credits for the site.

5.2 Worked example

The design process described in the previous section is illustrated in the following example. The calculations are presented in Figure 5.3.

Four units are to be constructed on a 0.24 hectare site. A grassed area at the rear comprising 10% of the site (0.024 hectares) falls steeply to the rear and cannot be drained to the OSD storage. Each unit will have a 5 kL rainwater tank that will collect runoff from 80% of each 150 m² roof with rainwater to be used for outdoor, toilet flushing and laundry in each 4 person household. An airspace “credit” is to be claimed against the OSD storage requirements. There will be no dedicated airspace. The minimum volume in the rainwater tank at which top-up commences is 0 kL ie. when it is empty.
### Figure 5.3 On-Site Detention Calculation Sheet

#### On-Site Detention Calculation Sheet for Upper Parramatta River Catchment

**HED Secondary Outlet**

---

**Site Data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.O.A</td>
<td>Upper Parramatta River Catchment Parramatta City Council</td>
</tr>
<tr>
<td>Site Area</td>
<td>0.24 ha</td>
</tr>
<tr>
<td>Total Roof Area</td>
<td>0.06 ha</td>
</tr>
<tr>
<td>Area of Site draining to OSD Storage</td>
<td>0.216 ha</td>
</tr>
<tr>
<td>Residual Site Area (Lot Area - Roof Area)</td>
<td>0.180 ha</td>
</tr>
<tr>
<td>Area Repassing Storage</td>
<td>0.024 ha</td>
</tr>
<tr>
<td>Area Bypassing / Residual Site Area</td>
<td>13.3%</td>
</tr>
<tr>
<td>No. of Dwellings on Site</td>
<td>4</td>
</tr>
<tr>
<td>Site Area per Dwelling</td>
<td>0.060 ha</td>
</tr>
<tr>
<td>Roof Area per Dwelling</td>
<td>0.015 ha</td>
</tr>
</tbody>
</table>

---

**Basic OSD Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic SDR Vols.</td>
<td>300 m³/ha</td>
</tr>
<tr>
<td>Basic SDRs</td>
<td>40 L/ha</td>
</tr>
<tr>
<td>Detention</td>
<td>Total Storage 450 m³/ha</td>
</tr>
<tr>
<td>Detention</td>
<td>Secondary Outlet 150 L/ha</td>
</tr>
</tbody>
</table>

---

**CSD Tank Bypass**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual Lot Capture in CSD Tank</td>
<td>87%</td>
</tr>
<tr>
<td>Adjusted SDRs</td>
<td>36 L/ha</td>
</tr>
<tr>
<td>Adjusted SDRs</td>
<td>123 L/ha</td>
</tr>
</tbody>
</table>

---

**OSD Calculations**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic SDR Volume</td>
<td>72.00 m³</td>
</tr>
<tr>
<td>Total Rainwater Tank Credits</td>
<td>5.60 m³</td>
</tr>
<tr>
<td>Storage Volume</td>
<td>Total 103.04 m³</td>
</tr>
<tr>
<td>Storage Volume</td>
<td>66.40 m³</td>
</tr>
<tr>
<td>OSD Discharges</td>
<td>Primary Outlet 8.04 L/s</td>
</tr>
<tr>
<td></td>
<td>Secondary Outlet 29.00 L/s</td>
</tr>
<tr>
<td>PL of Top Water Level of Storage</td>
<td>10.100 m</td>
</tr>
<tr>
<td>PL of Office Centre-line</td>
<td>9.100 m</td>
</tr>
<tr>
<td>Number of Orifices</td>
<td>1</td>
</tr>
<tr>
<td>Estimated Downstream Flood Level</td>
<td>9.00 100 yr ARI</td>
</tr>
<tr>
<td>Downstream FL - PL of Office Centre-line</td>
<td>-0.40 Satisfactory</td>
</tr>
<tr>
<td>Design Head to Office Centre</td>
<td>1.000 m</td>
</tr>
<tr>
<td>Calculated Office Diameter</td>
<td>64 mm Satisfactory</td>
</tr>
<tr>
<td>Calculated Office Diameter</td>
<td>116 mm Satisfactory</td>
</tr>
</tbody>
</table>

---

**Overflow Weir & Freeboard Calculation**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL of Minimum Habitable Floor Level</td>
<td>10.600 m</td>
</tr>
<tr>
<td>PL of Minimum Garage Floor Level</td>
<td>10.500 m</td>
</tr>
<tr>
<td>Length of Overflow Weir</td>
<td>2.00 m</td>
</tr>
<tr>
<td>Site Runoff Coefficient</td>
<td>0.75</td>
</tr>
<tr>
<td>Storm Intensity (5 min 100 yr ARI)</td>
<td>206 mm³</td>
</tr>
<tr>
<td>Peak Flow over Weir</td>
<td>92.7 L/s</td>
</tr>
<tr>
<td>Depth of Flow over Weir</td>
<td>93 mm</td>
</tr>
<tr>
<td>Freeboard to Habitable Floor</td>
<td>207 mm Satisfactory</td>
</tr>
<tr>
<td>Freeboard to Garage Floor</td>
<td>107 mm Satisfactory</td>
</tr>
</tbody>
</table>
Figure 5.4  Non-dimensional Outlet Rating Curve for OSD Systems
6. TECHNICAL DISCUSSION

6.1 Frequency Staged Storage

Generally the most challenging task of the OSD designer is locating and distributing the storage (s) in the face of the following competing demands:

- making sure the system costs no more than necessary;
- creating storages that are attractive and complementary to the architectural design;
- avoiding unnecessary maintenance problems for future property owners;
- minimising personal inconvenience for property owners/residents.

These demands can be balanced by providing storage in accordance with a frequency staged storage approach. Under this approach, the depth of inundation and extent of area inundated increase with the storm magnitude so that the greatest inconvenience to owners/occupiers occurs very infrequently. The approach recognises that people are generally prepared to accept flooding which causes inconvenience, but no damage provided it does not happen too often. Conversely, the less the personal inconvenience the more frequently the inundation can be tolerated. Where use of private courtyards for storage is unavoidable, safety issues must be addressed and provision should be made to warn occupants and also to maintain a dry area for sheds or similar structures. Private courtyards that are less than 25 m$^2$ in area are not to be used for OSD storage nor flood storage on flood prone sites.

Table 6.1  Suggested Flood Frequencies for Storage Areas

<table>
<thead>
<tr>
<th>Storage Area</th>
<th>Suggested Depth</th>
<th>Frequency of Inundation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian areas</td>
<td>beginning to pond 50 mm</td>
<td>once in 20 years, once in 100 years</td>
</tr>
<tr>
<td>Parking &amp; driveways</td>
<td>beginning to pond 100 mm, 200 mm</td>
<td>once in 10 years, once in 20 years, once in 100 years</td>
</tr>
<tr>
<td>Gardens</td>
<td>beginning to pond 200 mm, 400 mm, 600 mm</td>
<td>once a year, once in 2 years, once in 10 years, once in 100 years</td>
</tr>
<tr>
<td>Private courtyards (where the area is between 25 m$^2$ - 60 m$^2$)</td>
<td>beginning to pond 300 mm, 600 mm</td>
<td>once in 5 years, once in 20 years, once in 100 years</td>
</tr>
<tr>
<td>Paved recreation in common areas</td>
<td>beginning to pond</td>
<td>6 times per year</td>
</tr>
</tbody>
</table>
Recommendations for depth and frequency for inundation of different classes of storages are given in the Table 6.1 above. It is emphasised that these are provided for guidance only and should not be considered prescriptive. The maximum depth of ponding for above ground storages should be limited to 600 mm, and appropriate safety precautions should be made. This should include the provision of warning signs and fencing where depths exceed 600 mm near pedestrian traffic areas.

The indicative frequency of inundation can be estimated from Figure 6.1.

6.2 Site drainage techniques

A number of simple techniques can be employed to increase the efficiency of the OSD system, whilst reducing the impact on the site.

- Grade the site for surface drainage so that when the pipe system fails no serious consequences will occur. The surface flows on many sites are so small that there is no need for any underground drainage system, except for the roof drainage;
- Avoid filling the site with pits that are not needed. Pits rarely get any maintenance. As well, increased pit head loss through the drainage system can cause drainage failure due to blockage;
- Direct as much of the site as possible to the storage. A frequent failing of storage systems is that the driveways either discharge directly to the street or a grated drain on the boundary. These drains rarely perform adequately. A better approach is to introduce a speed hump or threshold that will more effectively divert surface flows to a storage or contain flows when the driveway forms part of the storage system. Figure 6.1 shows three profiles suitable for diverting driveway flows to a storage;
- When OSD storage is provided in a garden area, avoid placing the DCP in the centre where it will be an eyesore. Alterations to the grading of the floor of the storage will generally allow the DCP to be located unobtrusively in a corner next to shrubbery or some garden furniture. Allow for future garden sheds in determining the area available or storage; and
- Try to retain some informality in garden areas used for storage. Rectangular steep-sided basins unbroken by any features maximise the volume, but detract from the appearance of the landscaping. Steep sided basins also require safety issues to be addressed (see Section 3.5.5).

6.3 Common problems to avoid in OSD systems

Early OSD Systems

A field study of over 150 OSD systems throughout Sydney built between 1991 and 1994, when the OSD policy was quite new, revealed a high proportion with features that detracted from their effectiveness. The most commonly encountered problems are set out below.

- Deficient Storage Volume – this was particularly common in landscaped storages, and is often the result of incompetent construction, deficiencies or volume losses associated with landscape finishing, or furniture;
- Uncertain Discharge Control – a wide variety of discharge control devices were in use. The discharge rates from many outlets were impossible to predict with any confidence. Drowned outlets, skewed inlets and crudely fabricated outlets in unsuitable material were common;
Figure 6.1  Indicative Storage Frequency Curve
Figure 6.2  Driveway Profiles to Divert Stormwater to Storage
• Less than half the inspected systems had screens. When provided, screening was often poorly fabricated in corrosible material. Also, the screen area was often small in relation to the size of the orifice;

• Decomposing organic material in unvented structural storages was causing odour problems;

• Often costly structural storages had been constructed on sites where opportunities for low cost driveway and landscaped storage had not been used;

• The design of some storages had neglected the loadings of a full or partially full storage, and some walls were structurally deficient.

More Recent OSD Systems

Field inspections by Councils and the Trust and the OSD audits carried out by consultants on behalf of the Trust revealed the following deficiencies in OSD systems built from 1994 to 2004:

• Screens placed vertically in DCPs but not to the top of the DCP allowed debris to float over screen and obstruct the orifice. Other screens left gaps around the edges large enough to let debris through;

• Access to pits or underground storage was difficult because of the use of concrete lids or jammed grates;

• OSD systems did not cater sufficiently for inflow from off-site with the result that storages would be surcharge in large events less than the 100-year ARI event;

• Insufficient care was taken to grade surface of site to storage or DCP resulting in flows bypassing OSD system in larger events when roof gutters overflow or internal drainage lines surcharge;

• Deep pits constructed without safe access to underground storages;

• Failure to install subsurface drainage in landscaped surface storages;

6.4 Drowned outlets

Even when care has been taken to ensure that the outlet pipe from the outlet is large enough, the assumption of free discharge from the outlets may be invalid if the outlets are drowned by the downstream drainage system.

An OSD system is designed to control flows in all storms up to and including the 100-year ARI event, while the downstream drainage system is often only able to cater for smaller storms (typically 5-year or 20-year ARI) without surcharging. The effect of this surcharging on the outlets of an in-ground OSD storage is shown in greater detail in Figure 6.3.

In the case of in-ground extended detention storage it is expected that the primary outlet that controls runoff in events up to a 1.5 yr ARI event will not be drowned by water levels in the downstream drainage system. If the downstream drainage system drowns the primary outlet in even small storms less than 1.5 yr ARI then above ground extended detention needs to be considered or the merits of developing a site subject to adverse downstream flooding in even small storms needs to be re-considered.
Figure 6.3  Effects of Downstream Drainage on Outlets

(a) Discharge Independent of Downstream Drainage
The primary and secondary outlets are sufficiently above the downstream water level to remain free outlets.

(b) Discharge Dependant on Downstream Drainage
The primary and secondary orifices are submerged for some part of the storm. As the water level in the street drainage system rises the discharge from the outlets is reduced and the amount of water stored is increased. The OSD storages need to be re-configured to minimise the impact of the downstream conditions.

(c) Discharge Dependant on Downstream Drainage and Storage below Surcharged Water Level
The primary and secondary outlets are affected by downstream water levels over a wide range of storm events. The OSD storages need to be re-configured to overcome the adverse downstream conditions.
Figure 6.3 (a) shows a drainage system where the primary and secondary outlets are above the downstream water levels. The orifices will discharge freely, even in a severe storm event. This outlet arrangement gives the designer the most certain form of discharge control.

Figure 6.3 (b) shows a system where, due to site drainage constraints, the preferred location of the secondary outlet is below the surcharged water level downstream and the outlet is submerged. In this case the secondary orifice needs to be raised to a level where it is not submerged in severe storm events while still maintaining high early discharge (HED). If it is not possible to achieve high early discharge with a raised secondary outlet then a non-HED orifice outlet needs to be installed. Under conditions where a non-HED secondary outlet is installed the SSR needs to be increased to 520 m$^3$/ha to compensate for a less efficient secondary outlet.

Figure 6.3 (c) shows an in-ground storage located below the downstream water level. The outflow from the outlets is highly dependent on the water level in the downstream drainage system and the discharge is likely to vary over a wide range of storm events. In this case it is expected that it is not possible to achieve high early discharge with a raised secondary outlet. Consequently at the least above ground flood detention and a non-HED secondary orifice outlet needs to be installed. Under conditions where a non-HED secondary outlet is installed the SSR needs to be increased to 520 m$^3$/ha to compensate for a less efficient secondary outlet. Alternatively it may be possible to implement both extended detention and flood detention above ground and to construct an above ground HED secondary outlet.

In the case of non-HED secondary outlets a separate Non-HED Outlet OSD Calculation Sheet needs to be completed. This calculation sheet accounts for the adjusted SSR and the head over the secondary orifice outlet based on the overall water level in the flood detention storage (see example given in Figure 7.5).

6.5 Designing for maintenance

OSD systems are intended to regulate flows over the entire life of the development. This cannot be achieved without some regular maintenance. Councils are ultimately responsible for ensuring these systems are maintained through field inspections and enforcing the terms of the positive covenant covering OSD systems. The designer’s task is to minimise the frequency of maintenance and make the job as simple as possible. The following points are suggestions. Site constraints will mean that they will not always be feasible.

- Surface storages are generally easier to maintain and should be specified where possible. If extended detention storage is to be provided on the surface then it should be in little used areas where inundation will not cause amenity problems;

- Attempt to locate access points to underground storages away from heavily trafficked areas. Manholes in the entrance driveway to a large villa and townhouse development can discourage property owners from regularly inspecting and maintaining the system;

- Use light duty covers and consider locating access points in areas not subject to vehicle traffic. Several manufacturers produce lightweight access covers that can be easily lifted by one person;

- Try to locate your outlet(s) in an accessible location, often a slight regrading of the storage floor will allow you to move an outlet from a private courtyard into a common open space. Common areas are more readily accessible to council inspectors or persons doing maintenance and help ensure the responsibility for maintenance lies with the joint owners rather than an individual.
• Every attempt should be made to locate primary storage in common open space because this is the storage most frequently filled and hence most likely to need maintenance;

• Manholes should be fitted with the same industry-standard lifting/keying system throughout the project to assist future property owners to replace missing keys;

• Consider using circular manholes, as they are often easier to remove and more difficult to drop into the storage when being replaced; and

• Use a guide channel inside the storage or DCP to fix the screen and put a handle on the screen to assist removal. The guide channel prevents debris from being forced between the wall of the pit and the screen, and allows the screen to be easily removed and replaced in the correct position.

6.6 Sumps

A sump below the invert of the orifice outlet has been previously encouraged to:

• avoid turbulence near the pit floor affecting the hydraulic performance of the orifice;

• allow simple installation of orifice plates and outlet pipes; and

• prevent silt and debris blocking the orifice outlet.

Hydraulic model studies have shown that the proximity of the pit floor does not significantly affect the discharge coefficient of any orifice tested. In addition, field studies of OSD systems have revealed that where a fine mesh screen is securely fitted to the walls and floor of the storage or DCP, (to prevent material being carried under or around the screen), any silt or sediment carried through the screen is carried through the orifice.

Various combinations of the following factors have led to odour and mosquito problems in the sumps of some DCPs:

• Excessively deep sumps;

• Poorly constructed underlying aggregate beds of insufficient depth;

• Poor infiltration rates of surrounding sub-soil;

• DCPs with underground storages founded on rock or shale; and

• Construction debris, (typically concrete slurry), blocking weep holes in the pit floor.

The requirement to install sumps at the outlets varies between Councils as follows:

• Parramatta City Council requires 2 x 90 mm diameter pipes to be installed through the base of each sump (refer Figures 4.3 and 4.4);

• Holroyd City Council requires 2 x 90 mm diameter pipes to be installed through the base of each sump (refer Figures 4.3 and 4.4);

• Baulkham Hills Shire Council requires that sumps be filled with a mortar mix to the invert of the orifice; while

• Blacktown City Council does not require sumps to be installed.
6.7 Multiple storages

In terms of construction and recurrent maintenance costs, it is preferable to provide fewer larger storages than a larger number of smaller storages. Multiple storages should be carefully treated when preparing a detailed design. The storages need to be designed separately with the catchment draining to each storage defined. When establishing the catchments draining to each storage, it is important to remember that flows up to and including the 100 year storm need to be directed to the storage. This will mean that, in addition to the piped drainage, surface gradings will need to be checked to ensure that overflows from roof gutters or pipes are directed to the appropriate storage.

In the case of rainwater tanks the overflows from any rainwater tank(s) must be discharged to the OSD system.

6.8 Construction tolerances

Because of the importance of OSD systems in protecting downstream areas from flooding, every effort should be made to avoid, or at least to minimise, construction errors. Whilst an OSD system with slightly less than the specified storage volume will mitigate flooding in most storm events, it will not be fully effective in a major storm. For this reason, the design should allow for a potential reduction in the storage volume due to common post-construction activities such as landscaping, top dressing and garden furniture.

Notwithstanding this, it is recognised that achieving precise levels and dimensions may not always be possible in practice. It is therefore considered that an OSD system could be certified as meeting the design intent where:

- the storage volume is at least 95% of the specified volume; and
- the discharges are within plus or minus 5% of the design SRDs.