

UPPER PARRAMATTA RIVER



CATCHMENT TRUST

On-site Stormwater Detention Handbook



Third Edition
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This Handbook is published in accordance with the Upper Parramatta River Catchment Trust's On-site Stormwater Detention Policy. This policy was developed in conjunction with the four local councils in the catchment:

- . Baulkham Hills Shire Council
- . Blacktown City Council
- . Holroyd City Council
- . Parramatta City Council

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Note for Third Edition Revisions 1 and 2.

Where appropriate, changes from the second edition dated November 1994, the third edition dated December 1999 and the first revision of the third edition dated January 2001 have been indicated with footnotes.

Upper Parramatta River Catchment Trust
PO Box 3720
PARRAMATTA NSW 2124
AUSTRALIA
Telephone: +61 (02) 9891 4633
Facsimile: +61 (02) 9689 2537
E-mail: uprct@uprct.nsw.gov.au
Web Site: www.uprct.nsw.gov.au

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PARRAMATTA NSW 2124

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ⁱ Amended to include GST in third edition

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ⁱⁱ New section 2.7 added in third edition

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ⁱⁱⁱ New section 4.9 added in third edition.

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List of Revisions to the Third Edition

Date	Page	Changes
Jan 2001	i	Revision 1 added
Jan 2001	viii	New page with revisions table
Jan 2001	3-4	Clarified OSD requirements for residual lots and rural areas
Jan 2001	4-13	Fig 4.5 amended
Jan 2001	4-14	Private courtyard area clarified, clarification of design parameters added
Jan 2001	4-15	Private courtyard definition added, clarification of design parameters added
Jan 2001	4-16	Note added regarding free standing timber walls, confined space requirements added
Jan 2001	6-1	Private courtyards defined in Table 6.1
Jan 2001	7-29 to 7-33	Fig 7.9 added and following pages renumbered
Jan 2001	7-32	Dwelling 1 summary sheet added
Jan 2001	B3-6	Deleted repeated page
Jan 2001	C1	Title changed and notes on confined space warning sign added
Jan 2001	C3	Confined space warning sign added
Jan 2001	D-2 to D-6	Amendments to structural details
Jan 2001	E-1 to E-3	Revised lists of manufacturers and maintenance contractors
Jan 2001	I-1	Winner and highly commended for 2000 added
Jun 2004	i	Revision 2 added
Jun 2004	ii	Note adjusted for revision 2
Jun 2004	iii	GST added to price of Handbook
Jun 2004	iv	New 2.7 added to contents
Jun 2004	v	New 4.2.9 added to contents and numbering changed
Jun 2004	vi	Checklists added to Appendices B8-10
Jun 2004	viii-x	Revisions table extended
Jun 2004	1-1	Introductory comment about WSUD added
Jun 2004	1-2	Rainwater tank section added to relevant groups
Jun 2004	1-2	Comment about WSUD added
Jun 2004	1-3	Revision 2 major changes listed
Jun 2004	1-5 to 1-7	New words added to glossary
Jun 2004	2-4	New section 2.7 on Water Sensitive Urban Design
Jun 2004	3-1	Link between Water Sensitive Urban Design (WSUD) and OSD noted in policy
Jun 2004	3-1	Need for integration of OSD and WSUD
Jun 2004	3-3	Clarification of application of OSD policy with WSUD
Jun 2004	3-6	Mainstream flood storage in lieu of OSD added
Jun 2004	3-7	Holroyd City Council position on SCP
Jun 2004	3-7	Deferral of OSD in subdivisions clarified
Jun 2004	3-9 & 3-10	Holroyd City Council position on SCP
Jun 2004	3-10	Approved plans to be sent to designer
Jun 2004	4-1 to 4-29	All pages renumbered as new material added
Jun 2004	4-1	Deferral of OSD in subdivisions clarified
Jun 2004	4-1	Holroyd City Council position on SCP clarified
Jun 2004	4-1	OSD and site water management including WSUD

Date	Page	Changes
Jun 2004	4-2	Links between OSD & WSUD added
Jun 2004	4-3	WSUD and water management added to flow chart
Jun 2004	4-4	Relationship between OSD and WSUD required
Jun 2004	4-5	Change to minimum allowed to by pass OSD facility
Jun 2004	4-6 to 4-8 & 4-10	Providing designers with an approved copy of plans
Jun 2004	4-6	OSD to complement WSUD
Jun 2004	4-7	Integration of OSD and WSUD
Jun 2004	4-7	Weir calculations required
Jun 2004	4-7	Storages wholly within the property
Jun 2004	4-10	Weir calculations
Jun 2004	4-12 & 4-13	Changed mesh code
Jun 2004	4-15	OSD deferral for small subdivisions
Jun 2004	4-15	Storages within property
Jun 2004	4-16	Freeboard
Jun 2004	4-16	Storages within property
Jun 2004	4-17	Pool fencing of storages in play areast
Jun 2004	4-18	Storages within property
Jun 2004	4-19	Clarification of grate spacing
Jun 2004	4-20	New section 4.2.9 on rainwater tanks
Jun 2004	4-21	Renumbered Overflow
Jun 2004	4-21	Renumbered Maintenance Schedule
Jun 2004	4-23	Designer supervision of construction
Jun 2004	4-25	Rainwater tank issues
Jun 2004	4-26	Clarification of top water level
Jun 2004	4-26	Confirmation required when rainwater tanks used as part of OSD storage
Jun 2004	4-26	Certification of maintainability
Jun 2004	4-28	Freeboard on weir flow
Jun 2004	4-29	Deferral of OSD in small subdivisions cross referenced
Jun 2004	5-1	Change to minimum allowed to by pass OSD facility
Jun 2004	5-8	Note regarding bypass area added above Design Summary Sheet
Jun 2004	6-1	No OSD storage in small courtyards
Jun 2004	7-7,7-13,7-20,7-23,7-32,7-33	Note regarding bypass area added above Design Summary Sheet
Jun 2004	8-1	Additional references added
Jun 2004	B1-1	Design Summary Sheet altered
Jun 2004	B4-1	New sub appendices created & chapter renumbered
Jun 2004	B4-2	Plan reference on restriction on title
Jun 2004	B4-4 & B4-5	Blacktown City Council recital added in new sub appendix
Jun 2004	B5-3	Plan reference on restriction on title
Jun 2004	B7-1	Deferral for small subdivisions clarified
Jun 2004	B8-1	Additional notes on initial page
Jun 2004	B8-1 to B8-4	New front page, new SCP checklist and following pages renumbered
Jun 2004	B8-3	References to new SCP checklist on original SCP checklist
Jun 2004	B8-4	Change in undrained portion of site
Jun 2004	B9-1 to B9-7	New front page, new Detailed Design checklist and following pages renumbered

Date	Page	Changes
Jun 2004	B9-4	References to new design checklist on original design checklist & weir calculations clarified
Jun 2004	B9-5	Change in undrained portion of site
Jun 2004	B9-7	Overflow depth calculation requirement clarified
Jun 2004	B10-1 to B10-7	New front page, new WAE checklist and following pages renumbered
Jun 2004	B10-2 to B10-7	New WAE checklist added and following pages renumbered
Jun 2004	B10-4	References to new WAE checklist on original WAE checklist
Jun 2004	B11-1	Maintainability added to hydraulic compliance certificate
Jun 2004	B12-1	Maintainability added to list of outstanding works
Jun 2004	C-1	New OSD sign
Jun 2004	C-4	OSD sign details added
Jun 2004	E-1	Signs added to two suppliers
Jun 2004	E-2 & E-3	Revised list of maintenance contractors added
Jun 2004	F-1	Clarification of contact s at Blacktown City Council
Jun 2004	I-1 & I-2	Award winners for 2001 to 2004 added
Jun 2004	J-1 & J-2	Additional entries in index

1.0 Introduction

On-site Stormwater Detention (OSD) involves the temporary storage and controlled release of stormwater generated within a site. Without adversely affecting the property, it relies on thoughtful design and passive engineering during site development to achieve significant reductions in downstream flooding. OSD is required to ensure that the change in stormwater runoff from a site due to development does not increase flooding problems downstream except in very severe events. OSD systems must be properly maintained to make sure that stormwater flows from the site are regulated for the life of the development.

OSD is only one aspect of the management of the water cycle on a site. In recent years the Trust has begun to broaden its focus to include the complete water cycle affecting developments. Under the heading of Water Sensitive Urban Design (WSUD), water management now needs to consider the opportunities to better mimic the natural water cycle by addressing issues such as the potable water supply, re-use of grey water, the installation of rainwater tanks, the use of infiltration (where appropriate), the quality of stormwater runoff and the impact of more frequent storms on natural creeks and watercourses.

The Trust and the four catchment councils support the philosophy of WSUD and are currently working with a range of other groups to better understand the processes involved and the opportunities to implement better water management as part of the development process. Nonetheless, the role of OSD in ensuring that new developments do not worsen existing flooding problems remains critical. While sympathetic consideration will be given to WSUD features, these cannot be treated as a trade off against the requirement to provide OSD. In many cases more research will be required to demonstrate whether WSUD proposals such as water retention (eg. for infiltration or rain gardens) can be partly, or completely, offset against the volume of OSD storage required. In the case of rainwater tanks, for example, the Trust has had research undertaken by the University of Newcastle based on local rainfall data and predictive usage rates which now allows part of the volume of rainwater tanks to be offset against the OSD storage required. (See section 4.2.9 for more details)ⁱ

This Handbook has been principally prepared for experienced OSD designers. In the upper Parramatta River catchment design and certification of OSD systems will only be accepted from persons having acceptable professional accreditation. The following are considered to be acceptable accreditation for the purpose of OSD design and certification:

- NPER in Civil Engineering (Institution of Engineers, Australia);
- Surveyors Certificate of Accreditation in On Site Detention and Drainage Design (Institution of Surveyors NSW and the Association of Consulting Surveyors NSW);
- Stormwater Register (Association of Hydraulic Services Consultants Australia)
- Accreditation as a certifier under the Environmental Planning and Assessment Act 1979 in the relevant discipline.ⁱⁱ

OSD can be provided most efficiently and effectively when it is considered as early as possible in the development process. The system is most easily maintained when owners have a clear idea of the location and function of the components of the system. For these reasons, this Handbook has wider application for architects, engineers, builders, developers, property owners and managers, local government officials or staff and concerned citizens who each have a role to play in the successful application of OSD in the Upper Parramatta River Catchment.

ⁱ Introduction of WSUD added for third edition

ⁱⁱ Professional accreditation requirements added for third edition.

The format of the Handbook is set out in Section 1.2, but the following table provides a guide to those areas of the Handbook likely to be of most use to different groups within the community.ⁱ

PROFESSION/GROUP	RELEVANT SECTIONS OF HANDBOOK
OSD Designers	Sections 3 - 7 and Appendices
Architects	Sections 1, 3 and 4
Solicitors and Conveyancers	Sections 1.3, 2.5, 4.3.6, Appendices B2-B7
Developers	Sections 1-3, 4.1 and 4.3.6
Owner Builders	Sections 1-3, 4.1, 4.3.6, 4.2.9-11 ⁱⁱ , 6.6, Appendices B2-B7
Owners/Tenants/Property Managers	Sections 1, 4.2.1, 4.3.6, Appendix B2
Local Council Officials	Sections 1-3, 4.2.9, 4.3.6, Appendix B2
Local Council Staff	Sections 1-7 and Appendices
Concerned Citizens	Sections 1, 2, 3.4, 4.2.7, 4.3.6 and 6.2

The OSD policy and the Handbook are primarily intended for use within the upper Parramatta River catchment. However, the catchment councils generally require OSD in other catchments too. Appendix F provides the relevant parameters for those areas while Appendix G shows how the methodology can be adapted to other areas. The application of WSUD principles is dependent on a range of local factors, such as soil types, rainfall intensities and land uses, and reference should be made to the local council for advice in other catchmentsⁱⁱⁱ.

1.1 General

There are two key components to the Upper Parramatta River Catchment Trust's flood mitigation effort. The first aims to reduce and eventually eliminate the present flood threat. This will involve public expenditure of more than \$50M on projects such as retarding basins, channel improvements and levees to protect some 2200 properties threatened by mainstream and trunk drainage flooding.

The second component aims to prevent growth of the already substantial flooding problem caused by increasing development of the catchment. This is achieved through planning and development controls of which OSD is the most important element.

Since the publication of the first edition in September 1991, the Handbook has been purchased by over 500 OSD practitioners. The second edition in November 1994 was released to take advantage of the considerable body of practical experience which had been developed, as well as including the results of several Trust-sponsored research projects.

The second edition incorporated:

- a reorganisation of the Handbook to better reflect the development process
- a requirement for OSD designers to be involved in the initial site layout through the preparation of the Stormwater Concept Plan
- an increased emphasis on designer supervision of the construction of OSD systems.
- generic dimensions for in-situ and precast discharge control pits

ⁱ Quick reference guide added for third edition.

ⁱⁱ Section on rainwater tanks added where appropriate in third edition.

ⁱⁱⁱ Comment on WSUD added for third edition

- a reduction in the minimum orifice diameter of discharge control pits
- increased attention to construction practices.

The third edition^{iv} reflects the experience gained by council staff and consultants in the practical application of OSD. The format has been retained as closely as possible to provide continuity for both council staff and designers. The changes focus on improvements to make the policy and its application more robust, and include:

Revision 1:

- revised covenants;
- an index;
- references for all three editions;
- revised discharge control pit;
- accreditation of designers;
- alterations to suit new planning legislation;
- promoting larger common storages;
- removing deferral of OSD;
- change in minimum development area;
- freeboard specified;
- access covers;
- authority to release plans to future owners;
- limiting storage in private courtyards;
- safety fences and
- check lists.

Revision 2:^v

- simpler checklists added;
- reduction in the area of site not draining to the OSD storage;
- the use of rainwater tanks;
- consideration of Water Sensitive Urban Design;
- clarification of freeboard;
- calculations required for weirs and other overflows;
- clarification of deferral of OSD in small subdivisions;
- clarification of Holroyd City Council's position on Stormwater Concept Plans;
- providing OSD designers with an approved copy of the plans;
- OSD storages including wall footings to be wholly within property;
- Pool fencing of storages in play areas;
- Clarification of spacing of entry grates to underground storages;
- Maintainability added to Hydraulic Compliance certificate;
- Additional references added;
- Design Summary Sheet altered to address flow from off site;
- Reference to plan numbers added to restrictions on title;
- Copy of Blacktown City Council's recitals for covenants and restrictions on use;
- List of maintenance contractors revised; and
- OSD Award winners updated.

Using commercially available products to reduce the number of items that have to be purpose-built is the key to reducing OSD costs. To assist designers, this revision includes details of manufactured products that are available to meet OSD requirements on development sites. (See Appendix E)^{vi}

^{iv} List of changes added for third edition.

^v Major changes in revision 2 of third edition listed

^{vi} Appendix E added for third edition.

To continue the improvement of OSD, the Trust welcomes suggestions, comments, design hints and examples of successful OSD designs for inclusion in subsequent editions of the Handbook.

1.2 Handbook format

The Handbook is divided into seven main sections and seven appendices. The first two sections contain background information on the general principles of OSD. The next two sections cover policy and application of the policy. The final three sections provide the technical information required to prepare an effective and functional OSD system

Section 1 - outlines the development and format of the Handbook and includes a glossary of terms and abbreviations used.

Section 2 - presents the concepts and principles of a catchment-based OSD policy.

Section 3 - defines the policy, the catchment area, the developments to which it applies and the method of implementation.

Section 4 - details the approval process, the minimum information required at each stage and important issues to be considered.

Section 5 - covers the hydrologic and hydraulic design of the storage and discharge control pit.

Section 6 - provides technical advice on the integration of the storage into a site, effective site drainage techniques and related issues.

Section 7 - presents a number of case studies.

1.3 Glossary of terms

AEP - Annual Exceedance Probability - probability of a given discharge or rainfall being equalled or exceeded within a period of one year.

ARI - Average Recurrence Interval - average or expected value of the period between exceedances of a given discharge or rainfall.

Certificate of Hydraulic Compliance - a certificate prepared by the OSD designer and submitted to the relevant council on completion of the OSD system. The certificate verifies that the works have been carried out in accordance with the approved design.

DCP - Discharge Control Pit - a chamber that receives the majority of stormwater from the site and discharges it to the gutter or drain at a controlled rate not exceeding the PSD.

Development Area - the area of a property to be affected by the construction/reconstruction of buildings, structures, sealed surfaces, landscaping, driveways and car-parks.

Floodways - surface drainage systems that cater for major concentrated flows from upstream catchments.

Flowpath – See Overland Flowpath.

Grey Water – Waste water from non-toilet plumbing systems such as handbasins, washing machines, showers and baths. Grey water is differentiated from black water, which is wastewater from toilets^{vii}

HED - High Early Discharge - method for ensuring that the discharge from a DCP approaches the PSD early in the storm event. Also, the discharge from a DCP when overflow first occurs to the storage.

Infiltration – the vertical movement of water through a permeable substance, such as sand or soil. The rate at which the flow occurs is dependent on the properties of the substance and the relative volume of voids (air spaces) it contains. In the case of the clay soils typical of Western Sydney, infiltration rates are extremely slow whereas in sandy soils or fissured rock the rate of infiltration may be much faster^{viii}.

Maintenance Schedule - set of operating instructions for prospective property owners or occupiers setting out the routine maintenance necessary to keep the OSD system working properly.

Orifice – A circular hole with sharp edges machined to 0.5 mm accuracy in a corrosion resistant steel plate which controls the rate of discharge from the Discharge Control Pit.^{ix}

OSD - On-site Stormwater Detention - temporary storage of stormwater generated within the site so as to restrict the discharge leaving the site to a pre-determined rate.

Outlet – The pipe conveying the stormwater discharge from the Discharge Control Pit downstream of the orifice.^x

^{vii} Definition added for third edition

^{viii} Definition added for third edition

^{ix} Definition added for third edition.

^x Definition added for third edition

Overland Flowpath – surface drainage system that caters for minor flow from an upstream catchment. Also the drainage system that caters for surcharges from the OSD storage in events larger than the 100 year ARI flow or when a blockage occurs.

Permeable – a property of a porous material that allows a liquid to flow through it^{xi}.

Positive Covenant/Restriction-as-to-use - legal protection placed on a property title requiring owners to repair and maintain the OSD systems.

Potable – fit for drinking. Potable water may be used, without further treatment, for drinking. Kitchen sinks, basins, showers and baths are considered to be potable uses because of the chance of water being ingested, especially by the young.^{xii}

PSD - Permissible Site Discharge - the maximum allowable discharge leaving the site in litres/sec/hectare (l/s/ha), or in litres/sec (l/s) when applied to a specific site.

Rain Garden — 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. Components of a rain garden include a grass pre-treatment area, temporary ponding, planting soil, sand mixing with the soil, an organic layer, and plant material. Infiltration can be a component depending on soil conditions)^{xiii}

Retention – (as defined by Argue, 1986) refers to procedures and schemes whereby stormwater is held for considerable periods causing water to continue in the hydrological cycle via infiltration, percolation, evapotranspiration, and not via direct discharge to watercourses. This description can be expanded to include rainwater tanks of various types^{xiv}

SCP - Stormwater Concept Plan - conceptual layout of the OSD system submitted with the development or subdivision application. **Note:** Holroyd City Council do not accept SCPs (See Section 4.1)^{xv}

SSR - Site Storage Requirement - the minimum volume (in m³/hectare or in m³ when applied to a specific site) required for a storage to ensure that spillage will not occur when the outflow is restricted to the PSD.

Storage – an area where water is stored temporarily to achieve OSD. The area may be divided into Primary, Secondary or Tertiary Storage. Primary storage caters for frequent storm events, Secondary storage caters for intermediate events and Tertiary storage caters for major events.^{xvi}

Structural Storage - a storage system, generally below ground level, where the volume is contained within a closed structure.

Sump - space between the DCP invert and the outlet, used to prevent silt and debris blocking the outlet.

Surface Storage – a storage system, generally above ground, where the volume is contained within an open area.^{xvii}

Sustainable – capable of being maintained at length without interruption, weakening, or loss of power or quality.^{xviii}

^{xi} Definition added for third edition

^{xii} Definition added for third edition

^{xiii} Definition added for third edition

^{xiv} Definition added for third edition

^{xv} Clarification of HCC position in third edition

^{xvi} Definition added for third edition.

^{xvii} Definition added for third edition

Water Cycle – the natural cyclical process whereby atmospheric water falls as rain, flows as stormwater or groundwater to receiving waters and is then evaporated back into the atmosphere. At various stages of the process, water may also be released into the atmosphere (transpired) by living things^{xix}.

Water Sensitive Urban Design – a process of urban design for development or re-development that seeks to mimic the natural water cycle so as to create a sustainable development in terms of its treatment of water, wastewater and stormwater^{xx}.

Work-as-Executed Plans – plans showing the levels, dimensions and location of what is constructed. In the context of this Handbook the plans refer to the OSD system and must be prepared by a Registered Surveyor or the OSD designer.

WSUD – See Water Sensitive Urban Design

^{xviii} Definition added for third edition

^{xix} Definition added for third edition

^{xx} Definition added for third edition

2.0 Concepts

2.1 The problems

In many parts of the Sydney metropolitan area, the drainage system has become increasingly inadequate. This is shown by the growing frequency and severity of stormwater surcharge and flooding. At the same time, there are doubts about the capacity of local authorities to fund upgrades to the drainage system or, indeed, the wisdom of doing so. Many of today's flooding problems are the result of well-intentioned improvements to the drainage systems which simply transferred and compounded the overall problem.

Until relatively recently, the objective of urban stormwater drainage was to get rid of stormwater as quickly as possible. To that end, pits and drains were built, roads were sealed and drained, swamps were filled, surfaces were 'smoothed' and stream channels were lined and straightened. Although successful in reducing the local nuisance of stormwater, no thought was given to the effect these measures may have on flooding elsewhere in the catchment. It was not sufficiently appreciated that if stormwater leaves one area more quickly, it must arrive somewhere else equally quickly!

Around 1970 it became evident that increased downstream flooding (caused by urban development and a more efficient drainage system) could be mitigated by temporarily holding back some of the stormwater in flood retarding or detention basins. Retarding basins could be built either to reduce the increased stormwater runoff from existing developments or to offset the expected increase when a rural catchment is urbanised. Since the mid 1970s, most new-release estates in Australian cities have incorporated a series of flood retarding basins intended to maintain the pre-development flood peak discharges.

Today there are hundreds of these basins in areas where there has been extensive land development over the past 20 years. In general, these basins performed satisfactorily during the series of major storms in Sydney in the late 1980s.

The most severe flooding occurred in older middle distance suburbs of western Sydney which had been developed without retarding basins. Over the last two decades, governments and local councils have spent tens of millions of dollars constructing large retarding basins on whatever large publicly-owned sites could be found in these areas. Inevitably their cost was greater, and their effectiveness less, than had the basins been built at the time the areas were first urbanised.

2.2 Development and redevelopment

Sydney's middle distance suburbs are now undergoing redevelopment. Considerable design and construction of dual occupancies, townhouses, villas, duplexes, and semi-detached residences is under-way. These medium density developments mean more intensive site usage and more efficient stormwater drainage systems. Without some compensating measures, they will progressively and cumulatively increase the amount of stormwater run-off and decrease the available flood storage, causing local and downstream flooding, and negating the benefits of the large flood retarding basins.

Further developments and redevelopments in Sydney's middle distance suburbs pose considerable difficulties for local authorities. The random and unpredictable nature of individually-small developments makes it difficult to design, fund and construct further public retarding basins to compensate for the anticipated loss of flood storage. Sites for these basins are scarce (the best publicly-owned sites already have basins) and acquiring private land is prohibitively expensive. The alternative of further improving the efficiency of the drains and creeks would merely transfer a larger stormwater problem to downstream areas, and repeat the mistakes of the past.

2.3 The OSD solution

The Trust's catchment OSD policy, developed in conjunction with the four local councils in the catchment - Baulkham Hills, Blacktown, Holroyd and Parramatta - is the result of an extensive series of computer simulations using a detailed hydrologic model of the catchment. Since late 1991, all four councils have been applying the same OSD policy to their portion of the catchment.

The catchment OSD policy aims to ensure that subsequent developments will not increase flooding or stormwater flows at any downstream locations, in all flood events up to and including 100 year average recurrence interval (ARI) events.

OSD is more likely to be successful than previous approaches because it addresses the fundamental reason for our present and growing urban stormwater flooding problems - loss of flood storage.

In the Trust's computer simulations, OSD storages were represented as small flood retarding basins. The flood peak discharges were calculated throughout the 110 km² catchment both under current conditions, with the catchment redeveloped to different degrees.

The simulations compared the catchment without any OSD and with OSD systems on all development sites, limiting runoff to different rates ranging from 60 to 150 litres per second per hectare (l/s/ha). The simulations were repeated for a range of storm durations and storm frequencies.

Comparing post-development flood peak discharges with existing-condition discharges, the Trust found that run-off from development sites must be limited to 80 l/s/ha to ensure there is no increase in flood discharges anywhere in the catchment under all storm frequencies and durations. This is called the permissible site discharge (PSD). It was shown that, in this catchment, if the PSD is achieved early in the storm event ('high early discharge') and the stormwater storage is off-line (rather than in line with the discharge control pit), 470 cubic metres per hectare (m³/ha) of storage is required to control runoff in all storms up to and including 100 year ARI events. This is called the site storage requirement (SSR).

The use of these two simple parameters avoids the need for complex calculations by the designer. This is particularly handy when making preliminary estimates of the cost of an OSD system, as would be required when evaluating several sites for purchase and development.

2.4 Why so much storage is required

The 470 m³ /ha of storage required under the upper Parramatta River catchment OSD policy is approximately three times greater than the volumes required under former council policies. While this volume may at first appear excessive, the former policies only aimed at controlling 5 year or 20 year storm flows for one particular storm duration.

However, the flood standard adopted in this catchment, and generally throughout New South Wales, is the one in 100 year event. This standard is widely used for both the design of flood mitigation schemes and for defining flood plain limits. (Even though the draft Floodplain Management Manual redefines as floodprone all land below the Probable Maximum Flood level, development constraints are likely to apply mostly to land below the 100 year ARI event.)ⁱ

As the catchment OSD policy deals with storms of all durations up to 100 year ARI events, it must detain much greater volumes of runoff. If the policy aimed only at controlling, say, the 30 minute - 20 year ARI storm, only 260 m³ /ha would be required.

Another point of concern is that the 80 l/s/ha corresponds to the 5 year ARI - 2 hour storm duration runoff from a fully developed site calculated using the Rational Method. For longer duration storms the runoff is even less. Is it reasonable, some have asked, to limit the 100 year ARI runoff to the 5 year magnitude or less?

The confusion is understandable because early OSD policies focussed only on the peak discharge. It needs to be appreciated that, even if OSD limits the post-development peak discharge to the pre-development rate, the overall post-development volume of runoff is still greater. As a result the post-development stormwater discharge after the peak (on the hydrograph 'tail') will be greater. Moreover, by maintaining outflow at the PSD rate for some time, OSD further increases these discharges.

The Rational Method OSD procedures necessarily ignore the cumulative downstream implications of these increased 'tail' discharges. However, with a catchment hydrologic model, it is seen that the accumulation of increased 'tail' discharges can (and does) result in greater flood discharges at some points further downstream. It is to avoid this that the PSD must be less than that required merely to avoid increasing peak discharges at some specific site.

2.5 Legal basis of the Policy

Legal advice obtained by the Upper Parramatta River Catchment Trust states that local councils have the power to impose a condition on development consent or building approval requiring the construction of OSD systems on the development site.

OSD also satisfies the test of 'reasonableness'. New developments should not be allowed to add to downstream flooding and drainage problems. Without OSD or other compensatory flood storage, the cost of dealing with additional stormwater runoff from a new development is passed onto downstream residents in the form of increased flood damage and distress, or onto the local authorities which must upgrade the drainage system or construct additional flood mitigation works.

OSD is also consistent with, and supports, urban consolidation. One of the principal arguments against urban consolidation is that the stormwater drainage system cannot cope with the increased stormwater runoff. By ensuring there is no increase in peak runoff from urban consolidation sites under all circumstances, OSD completely overcomes this objection.

ⁱ Reference added for third edition.

2.6 Better water quality

The primary function of an OSD system is to control runoff quantity. However, downstream water quality is also improved as a result of storage outlet screening which:

- traps visible pollution such as trash and litter and prevents it being discharged into receiving waters
- prevents leaves and grass clippings and other organic matter from entering receiving waters where decomposition decreases dissolved oxygen levels and threatens aquatic life.

2.7 Water Sensitive Urban Design

Current trends in urban development seek to address the issue of creating a more sustainable urban environment. Global warming and climate change are now seen as issues to be addressed in the present not just the future. Droughts and dry land salinity have highlighted the need to review our national approach to water usage, while the increasing population in major cities has focussed attention on the supply of potable water and the disposal of wastewater. Water supply authorities are reviewing the appropriateness and cost implications of using treated, potable water for domestic or industrial uses which are predominantly non-potable.

As the driest continent in the world, Australia must conserve water, which is one of its most precious resources, if the country is to prosper in the long term. Action now will give future generations an opportunity to enjoy the quality of life we currently enjoy. Failure to act could create enormous problems within the next generation.

Water Sensitive Urban Design (WSUD) is a process by which a development is designed so as to mimic the natural pre-development water cycle. In an undeveloped site rainwater may fall on vegetation or pervious ground surfaces. Typically there will be some infiltration into the topsoil, ponding on flat areas from where the water may evaporate and absorption by vegetation. Any overland flow that results is likely to be sheet flow over a vegetated surface which means that velocities are low and the stormwater may take a considerable time to reach the nearest watercourse. This extended period of flow to watercourses reduces the risk of flooding because a significant portion of the rainfall takes a long time to reach the watercourse. Rainwater which has infiltrated into the topsoil may also find its way to local watercourses but this takes much longer again. This water may also flow into ground water if the subsoil is sufficiently pervious.

After development however there is less vegetation, more impervious area and a more efficient means of collecting and transporting flows off site. This increases the volume of flow into the watercourses and reduces the time taken to reach the waterway. This leads to greater flow depths in the creek and the likelihood of flooding. OSD is one way that stormwater can be temporarily detained close to where the rain falls to help overcome the quickening of flows to the creek systems. The same volume of stormwater will reach the waterway but at least it takes several hours longer which, in this catchment, helps reduce the risk of flooding downstreamⁱ.

ⁱ Water Sensitive Urban Design note added in third edition

3.0 On-site Stormwater Detention Policy

3.1 Policy statement

The overall aim of the catchment OSD policy is to ensure that new developments and redevelopments do not increase peak stormwater flows in any downstream area during major storms up to and including 100 year ARI (1% AEP) events.

The OSD solution should create a sustainable solution for peak stormwater flow management, which complements any WSUD aspects of the development. However, there should be no reduction in the volume of storage provided, nor increase in the site discharge to the downstream drainage system. (Section 4.2.9 details the volumes of rainwater tanks which can be offset against the OSD storage.)ⁱ

3.2 Objectives

The objectives of the OSD policy are to:

- prevent any increase in downstream peak flows resulting from new developments or redevelopments by temporarily storing on-site the additional and quicker runoff generated
- prevent increases in downstream flooding and drainage problems that could:
 - increase flood losses
 - damage public assets
 - reduce property values
 - require additional expenditure on flood mitigation
 - drainage works.
- encourage integration of OSD systems into the architectural design and layout of the development so that adequate storage areas are included in the initial stages of the site design
- encourage integration of the OSD facilities into a sustainable overall water management plan for the siteⁱⁱ
- require construction supervision of OSD systems by the OSD designer to improve construction standards.

3.3 The Catchment area

The policy, control standards, procedures and approval processes detailed in this Handbook apply throughout the 110 km² of the upper Parramatta River catchment. The four local councils, Baulkham Hills, Blacktown, Holroyd and Parramatta have adopted the common OSD policy for those areas within the catchment. The catchment boundaries are shown in Figure 3.1.

For areas outside the catchment, interested parties should contact the relevant local council. An approximate procedure for applying the methodology outside the catchment is given in Appendix Gⁱⁱⁱ and the parameters for the design of OSD systems in other catchments within the four councils are given in Appendix F^{iv}.

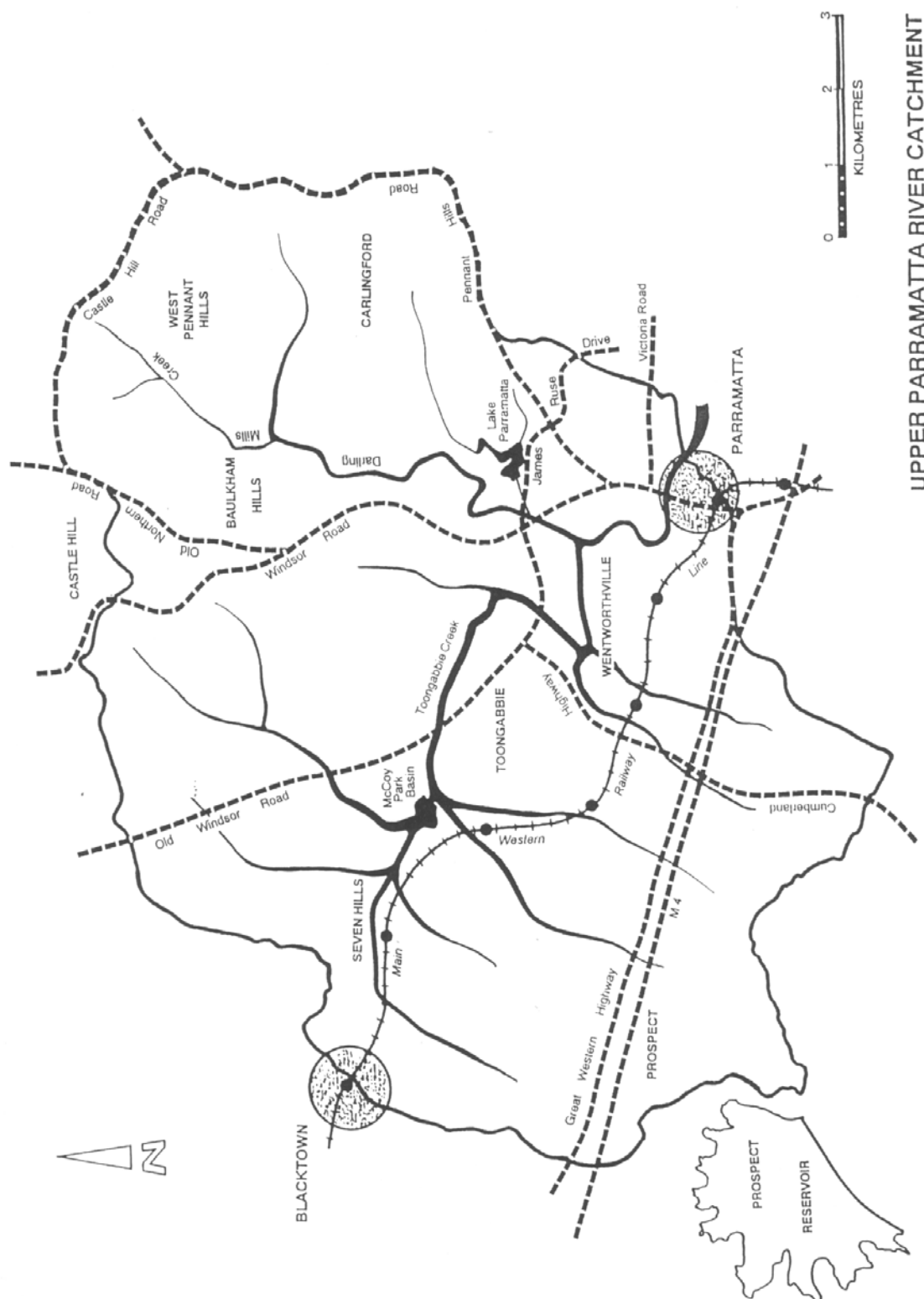
ⁱ Impact of WSUD added in third edition

ⁱⁱ Need for integration added in third edition

ⁱⁱⁱ Previously Appendix C.

^{iv} Appendix F added for third edition.

Figure 3.1



UPPER PARRAMATTA RIVER CATCHMENT

3.4 Policy application

On-site Stormwater Detention (OSD) systems temporarily detain stormwater on a site, in order to limit the discharge leaving the property to a pre-determined rate which will ensure that the development does not increase downstream flood discharges for storms up to the 100 year ARI event.^v

OSD is applied as a condition of development consent by Council under the Environmental Planning and Assessment Act 1979. Any existing obligation to provide and maintain an OSD system will be found in the development consent applicable to the property or on the property title itself. In the case of a proposed development, the guidelines given below in sections 3.4.1 and 3.4.2 show whether OSD will be necessary.

For residential subdivisions, OSD was not generally required on lots created by subdivision until 1991 when the common OSD policy was adopted by the four councils in the upper Parramatta River catchment. However, all lots created after that date have a requirement for OSD applied as a condition of development consent for the subdivision.

3.4.1 Developments to which OSD applies

OSD requirements generally apply to all types of development and redevelopment on both flood liable and flood-free sites. These include the following:

- subdivisions (including residential) approved after 1991;
- single dwellings on lots created by a subdivision approved after 1991, unless a communal OSD system was constructed as part of the subdivision;
- all commercial, industrial and special-use developments and buildings;
- town houses, villas, home units, duplexes;
- dual occupancies;
- semi-detached residential/commercial and residential/industrial properties;
- tennis courts;
- roads, car parks, paths and other sealed areas;
- public buildings;
- buildings, car parks and other sealed areas of public sport and recreational facilities;
- single dwellings, extensions and additions (in the Parramatta City Council area only) where the proposed development involves an increase in impervious area greater than 150m² and the land is designated as Grey or Grey Hatched on Council's Flood Prone Land Map;
- sites which include WSUD and water re-use. Consideration will be given to variations to the PSD or SSR only where it has been proved conclusively that infiltration/recycling or reuse will invariably reduce the site stormwater discharge for the full range of storm events.^{vi}

^v Definition added for third edition.

^{vi} Integration with WSUD added to third edition

3.4.2 Developments to which OSD does not apply

OSD policy does not apply to:

- single dwellings, extensions, additions and improvements on single residential lots created before November 1991 (when the OSD policy was adopted), except where OSD is required as a restriction on the property title or in the case of local drainage problems in the City of Parramatta as noted in Section 3.4.1;
- the residual lot containing an existing dwelling which is excised as part of a subdivision of a lot created prior to 1991, provided that flows from the excised portion are directed away from the OSD system; (**Note:** OSD is required for the new lots created.) Subsequent single residential building/additions on the residual lot will also not be required to provide OSD;
- the residual lot containing an existing industrial or commercial development which is excised as part of a subdivision of a lot created prior to 1991, provided that there is no significant development proposed on the residual lot and that flows from the residual lot are directed away from the OSD system; (**Note:** OSD is required for the new lots created.);
- dual occupancy residences on a lot with an existing residence involving less than 150ⁱ m² of development area;
- sub-divisions of existing dual occupancies where no changes to the buildings or site are proposed;
- boundary adjustments and consolidations of allotments where no additional lots are created;
- one-off minor developments, minor additions and repairs where the proposed development area is less than 150 m² (subsequent minor developments or additions shall require OSD). This exclusion is aimed principally at small areas within large commercial or industrial sites. It does not apply to any developments where the development area is greater than 150 m² nor to dual occupanciesⁱⁱ;
- change of use where no physical changes to the outside of the property are proposed;
- areas within large properties (usually commercial or industrial but may be residential) not covered by the development application or construction certificate;
- new developments in subdivisions where OSD has already been provided for the entire subdivision;
- buildings in Rural/Non-urban areas;
- the grassed playing field and vegetated area of public sports and recreational facilities which are not part of a development.

ⁱ Minimum area increased for third edition.

ⁱⁱ Explanation added for third edition.

3.4.3 Area of the site to which OSD applies (Previously Section 4.1.5)ⁱ

Generally, OSD applies to the entire site, but there may be exceptions in certain circumstances.

Additions & extensions

On an already-developed property, the OSD requirements apply only to the area of the new development, provided runoff from previously developed areas can be excluded from the OSD storage.

Dual occupancies

Where an additional dwelling is proposed on a lot with an existing dwelling, the OSD requirements will relate to the additional dwelling and a curtilage for anticipated paths, driveways and paved areas. In the absence of details on the plans, the curtilage will be taken as 10% of the area of the proposed second dwelling. Where two or more dwellings are constructed on the same lot at the same time, the OSD requirements will be applied to the entire site.

Subdivision of an existing residential property

When an existing residential property is subdivided to create a single additional lotⁱⁱ, the OSD requirements will relate only to the area of the new allotment. The OSD storage facilities may be located on the remainder of the original property, provided the combined peak discharge (from both lots) is no greater than if the OSD systems were located on the new lot.

Subdivisions creating new public or private roads and paths

The OSD requirements apply to the whole development area including roads and paths, not just the individual lots. The best solution will normally be for the detention storage to be located on one lot for the whole subdivision. However, if individual storages are provided on each lot, the discharges should be adjusted to provide the equivalent storage for the area of roads or paths.

Undeveloped portions of a lot

Portions of large lots which are unaffected by the development may be excluded from the area to be controlled by the OSD systems, provided flows from these areas can be diverted around the OSD system. Council approval must be obtained before excluding portions of a lot from the OSD requirements.

Floodways (See Section 4.1.3)

Creeks, waterways and drainage swales that carry major concentrated flows around the storage area are defined as floodways. The area of the floodway can be excluded from the site area for the purpose of calculating the site storage requirements, provided that the area is protected from development by an appropriate covenant or easement.

Note: Overland flowpaths, which cater for minor flows cannot be excluded from the site area for the calculation of OSD.

ⁱ Section number changed for third edition.

ⁱⁱ Clarification added for third edition.

New development or redevelopment

Where the proposed development is of a vacant site or a complete redevelopment of an already-developed property, the OSD requirement will relate to the whole property.

Battle-axe blocks

The access driveway to battle-axe blocks shall be included in the site area used for calculation of the site storage requirements.

3.4.4 Policy variations (Previously Section 3.4.3)

Each council will, in consultation with the Trust, consider requests to vary control standards or provide/contribute to alternative storage facilities in accordance with the procedures outlined in Appendix A. For equity reasons, where OSD is waived for a particular site, an equivalent expenditure on measures providing environmental and/or community benefits from the development, such as water quality improvements, will be required.ⁱ

In some situations, where the site is flood prone and the watercourse flows through the site, the council may accept the provision of additional mainstream flood storage in lieu of OSD. In these cases, the storage must be available over the full range of storm events and allow for the fact that mainstream flood levels will tend to decrease over time. As the storage is on-line and the site discharge has not been restricted, the additional storage required is a minimum of 25% greater than the site's OSD storage requirement.ⁱⁱ

3.5 Control standards

3.5.1 Permissible Site Discharge (PSD)

The maximum PSD is 80 l/s/ha. This will need to be adjusted in accordance with the procedures set out in Section 5.1 when the entire site cannot be drained to the storage.

3.5.2 Site Storage Requirements (SSR)

The minimum SSR for an off-line OSD storage that has a DCP which achieves the full PSD early in the storm event is 470 m³/ha. This will need to be adjusted where either full high early discharge (HED) is not achieved or the permissible site discharge is reduced according to Section 5.1.

3.5.3 Minimum outlet size

To reduce the likelihood of the DCP outlet being blocked by debris, the outlet opening shall have a minimum internal diameter or width of at least 25 mm and shall be protected by an approved mesh screen.

3.5.4 Ponding depths

Guidelines to assist in determining depths and frequencies of ponding for different classes of storages are given in Table 6.1. It is emphasised that these are general guidelines that will be varied according to the nature of the development and the location of the storage. The maximum depth of ponding in above ground storages is 600 mm. Council may approve deeper ponding in individual cases where the applicant demonstrates that safety issues have been adequately addressed. For example warning signs and or fencing should be installed where the depth exceeds 600 mm or adjacent to pedestrian traffic areas.

ⁱ Community benefit requirement formalised in third edition.

ⁱⁱ Mainstream storage equivalent defined in third edition.

3.5.5 Safety Fencesⁱⁱⁱ

Surface storages should be constructed so as to be easily accessible, with gentle side slopes permitting walking in or out. A maximum gradient of 1:4 (ie 1 vertical to 4 horizontal) will be required on at least one side to permit safe egress in an emergency. Where steep or vertical sides are unavoidable, due consideration should be given to safety aspects such as the need for fencing, both when the storage is full and empty.

Balustrades (fences) must comply with the Building Code of Australia (See Section D2.16 of the Code), while safety fences should comply with the Swimming Pool Act 1992.

3.5.6 Internal drainage system (Previously Section 3.5.5)^{iv}

The stormwater drainage system (including surface gradings, gutters, pipes, surface drains and overland flowpaths) for the property must::

- be able to collectively convey all runoff to the OSD system in a 100 year ARI (1% AEP) rainfall event with a duration equal to the time of concentration of the site
- ensure that the OSD storage is by-passed by all runoff from neighbouring properties and any part of the site not being directed to the OSD storage, for storms up to and including the 100 year ARI event.

3.6 Policy implementation

3.6.1 Development approvals for Subdivisions.^v

In general, the OSD requirements are imposed at the subdivision stage, in the following manner:

- Development Application - submission and approval of a conceptual layout of the OSD system. (Stormwater Concept Plan) Except at Holroyd City Council where detailed design required with development application^{vi}.
- submission of Engineering Plans - submission and approval of the detailed design, including calculations and construction plans and details
- release of Subdivision Certificate/Linen Plans - submission and approval of work-as-executed drawings, certificates of hydraulic compliance^{vii}, and legal instruments on property titles protecting the OSD system.

Note: The OSD system must be constructed at the time of subdivision and not deferred until the construction of the individual dwellings except where the subdivision is up to seven lots, if it is proven there are site restrictions. (See Section 4.0)^{viii}

Refer to Figure 3.2.

ⁱⁱⁱ New section added in third edition.

^{iv} Numbering altered for third edition.

^v Wording changed in third edition to reflect changes to Environmental Planning & Assessment Act 1979.

^{vi} Holroyd City Council position clarified in third edition.

^{vii} "Hydraulic" added to clarify certificate terminology in third edition.

^{viii} Deferral of OSD clarified for small subdivisions in third edition.

3.6.2 Development approvals and construction certificates^{ix}

When the OSD requirements are implemented through the development approval and construction certificate process, the approval is in three stages:

- Development Application - submission and approval of a conceptual layout of the OSD system (Stormwater Concept Plan) Except at Holroyd City Council where detailed design required with development application;^x
- Construction certificate - submission and approval of the detailed design, including calculations and construction plans and details;
- Final Approval - submission and approval of work-as-executed drawings, certificates of hydraulic (and structural, if required) compliance and legal instruments protecting the OSD system.

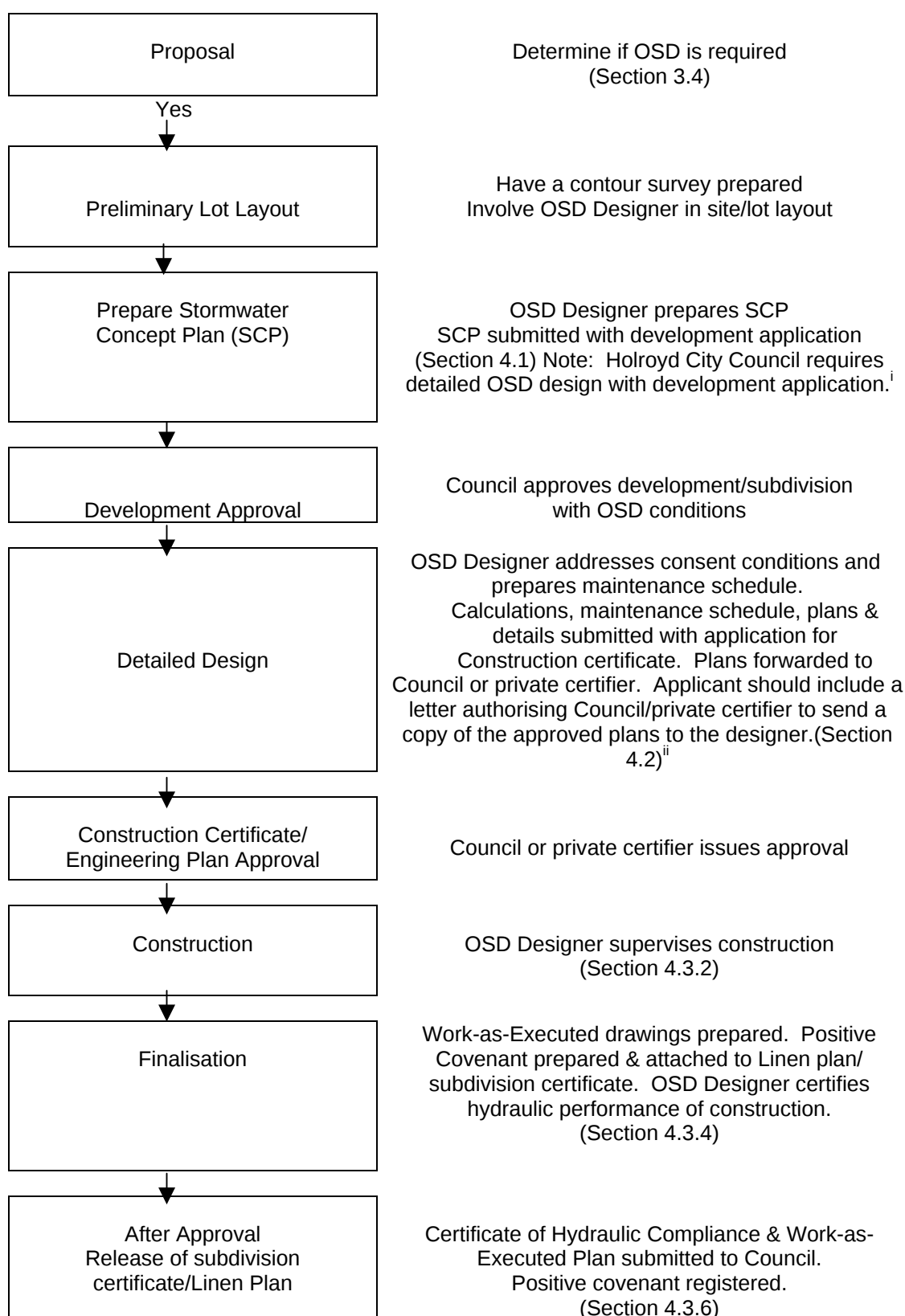
Note: If the OSD system was constructed at the subdivision stage, the system may need to be re-certified at final approval to ensure it will still function as designed.

The various steps involved are set out in Figure 3.2.

^{ix}Wording changed in third edition to reflect changes to Environmental Planning & Assessment Act 1979.

^x Holroyd City Council position clarified in third edition

Figure 3.2
OSD APPROVAL PROCESS



ⁱ Holroyd City Council position clarified in third edition

ⁱⁱ Copy of plans to designer added to third edition

4.0 The approval process

This sectionⁱ sets out the steps in the approval process from the Stormwater Concept Plan through the detailed design to the construction and final approval.

OSD is best considered as early as possible in the development process, particularly where the proposal includes WSUD principlesⁱⁱ, so that the most efficient and effective system can be designed and installed. There are a number of issues to be addressed at the conceptual stage which will have a significant impact on the final solution:

- in multi lot subdivisions, a common OSD system should be constructed on one lot rather than a separate system on each individual lot;
- every attempt should be made to use surface storage for the OSD system. Underground storages should be the option of last resort. The use of surface storage reduces the cost of the system and improves accessibility for maintenance (See Section 4.2.6 and Appendix H);
- overland flows from upstream must be diverted past the OSD storage unless the storage volume is increased to cater for the upstream catchment;
- the OSD system is to be constructed at the time of subdivision and not to be deferred until the building is constructed without specific Council approval. Council approval will only be considered for subdivisions of up to 7 lots where there are demonstrable site restrictions. Any easements or inter allotment drainage cannot be deferred and must be created/installed at the time of subdivision.ⁱⁱⁱ
- the site should be shaped to ensure all flows are directed to the storage even if blockages or larger storm events occur;
- development of flood prone sites must be carried out without any net loss of flood storage.

4.1 The Stormwater Concept Plan

A Stormwater Concept Plan (SCP) is required to support all development applications covered by the OSD Policy (see 3.4.1). The purpose of a SCP is not to provide a detailed design, but to identify the drainage constraints and to demonstrate that the OSD system can be integrated into the site's overall water management and proposed layout. The steps involved in preparing a SCP are summarised in Figure 4.1. It should be noted however, that Holroyd City Council no longer accept SCPs in conjunction with the development application and require a detailed OSD design because in many parts of the City, detailed levels are required to show that the OSD facility will function correctly.^{iv}

An OSD system is an integral part of the entire development and can be expensive to retro-fit once the site layout has been established. The control of stormwater flows through the OSD facility may facilitate the provision of water quality improvements on sites where these are required by the development consent. Treatment of the stormwater will often be easier once the discharge has been controlled by the OSD facility. Developers and architects should involve their OSD and WSUD designer(s) in developing the initial site layout.

ⁱ Key considerations compiled for third edition.

ⁱⁱ Reference to WSUD added in third edition

ⁱⁱⁱ Deferral of OSD clarified in third edition

^{iv} Clarification of Holroyd City Council's position on SCPs added to third edition

4.1.1 Objectives

The objectives of the Stormwater Concept Plan are to:

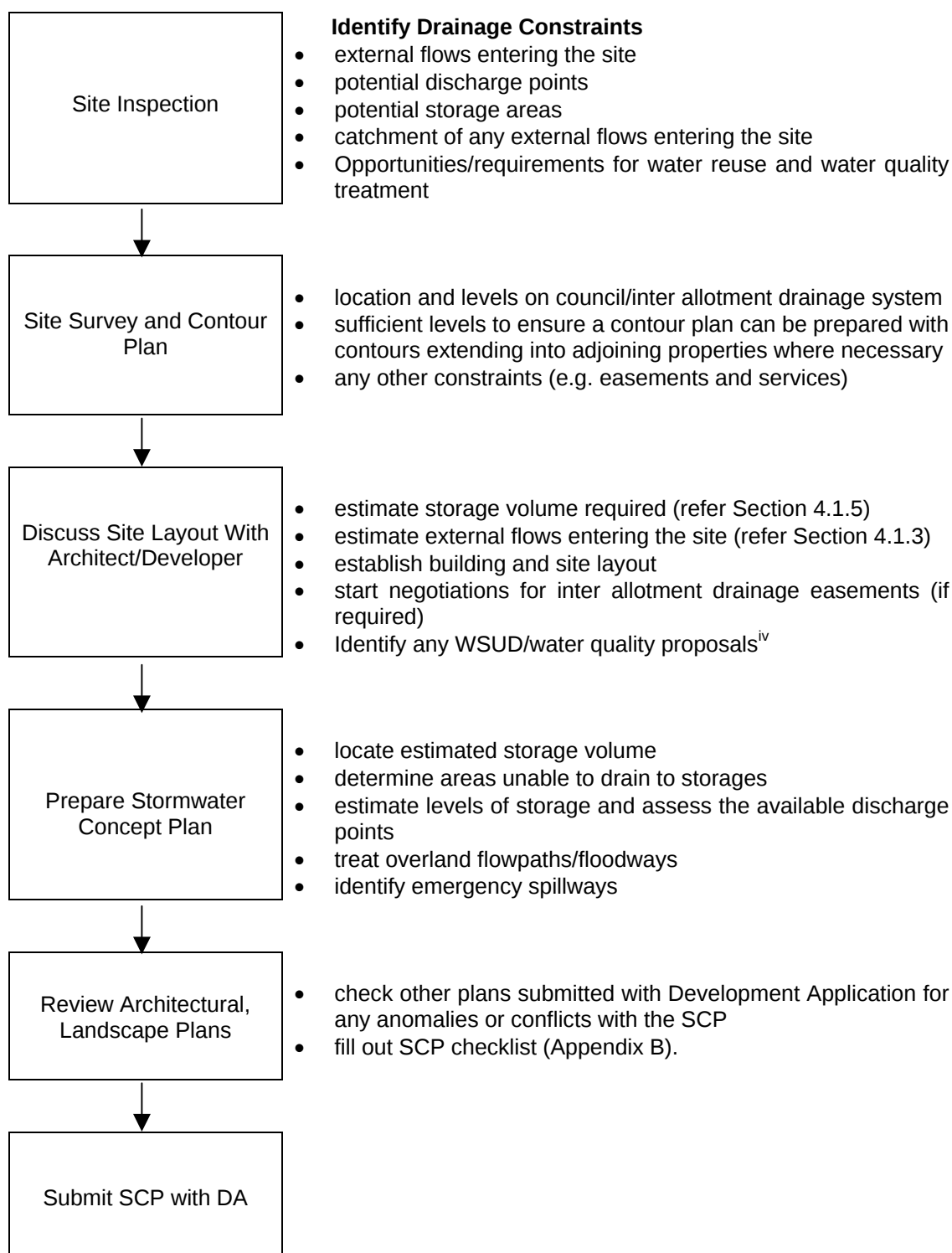
- emphasise that the OSD and drainage requirements need to be considered, as part of an overall site water management plan,ⁱ in the initial planning stages of the development
- simplify the detailed design by identifying adequate storage areas in the planning stage and showing how the OSD design complements the WSUD components of the proposalⁱⁱ
- reduce project costs by maximising the use of proposed landscape and architectural features as part of the OSD system
- allow the cost of development consent conditions relating to OSD to be determined at the planning stage
- assist in addressing the concerns of local residents regarding drainage and flooding issues.

ⁱ Reference to site stormwater management added to third edition

ⁱⁱ Relationship to WSUD added to third edition

Figure 4.1 Preparation of typical Stormwater Concept Plan

Note: Holroyd City Council do not accept SCPs with development applicationsⁱⁱⁱ



ⁱⁱⁱ Holroyd City Council position clarified in third edition

^{iv} Reference to WSUD and water quality added to third edition

4.1.2 Minimum data requirements

The minimum information to be included in a SCP is:

- an estimate of the volume of OSD storage required
- the relationship between OSD and any WSUD proposals for the site^v
- calculations of the maximum 100 year ARI flow rate for flowpaths and floodways
- a plan which includes:
 - the development/site boundaries and area
 - contours and spot levels (which reflect the site gradings and extend into adjoining properties)
 - the extent and area of any upstream catchment for external flows entering the site
 - the location and extent of detention storages
 - the location and levels of discharge points for the storages
 - the layout of the site, including location of all buildings, roadways and landscaped areas
 - the location and approximate extent of any floodways or flowpaths through the site
 - the location and area of any portion of the site unable to drain to the storages.

An SCP Checklist is provided in Appendix B.8^{vi}

4.1.3 Assessment of external flows

An OSD storage is designed to deal with stormwater runoff from only a particular area. If external flows enter the storage, it will fill more quickly, causing a greater nuisance to occupiers and it will become ineffective in terms of reducing stormwater flows leaving the site. The OSD design must therefore cater for external flows which can enter the storage. This is done by either increasing the size of the storage, or by diverting the external flows around the storage.

If upstream flows cannot be diverted around the storage, the storage size must be increased to cater for the additional catchment with the PSD remaining at 80 l/s/ha.^{vii}

Where the storage is not sized to detain runoff from the entire upstream catchment, a floodway/overland flowpath must be provided to ensure that the 100 year ARI runoff from outside the site by-passes the OSD storage. It is important to ensure that the by-pass flow is directed to a suitable outlet point and not directed onto an adjoining property.^{viii} The diversion drainage should be designed to cater for the 100 year ARI flow for the upstream catchment, which may well have a longer time of concentration than the site. It is preferable if the diversion drainage can be designed to avoid unnecessarily concentrating the flow and in some instances it may be possible to respread the flow to sheet flow. The diversion may be achieved with a grass swale or raised garden bed in many instances. This will provide a

^v Relationship to WSUD added in third edition

^{vi} Checklist added for third edition.

^{vii} Clarification added for third edition.

^{viii} Design hint added for third edition.

softer solution than a concrete drain or piped system and may be easier to respread to sheet flow. In addition, the use of a landscaped solution will often be more attractive and cheaper.

For the purposes of the OSD policy, the external flows can be divided into two categories: overland flowpaths and floodways.

Overland Flowpaths

These are surface drainage systems which cater for relatively minor sheet flow from upstream properties and convey it around the storage or allow it to pass across the site without interference (eg. dish drain, grass swale). The area of the flowpath must be included in the site area when determining the site storage requirements.

Floodways

These surface drainage systems convey relatively major concentrated mainstream, surface or surcharge flows from an upstream catchment around the storages (eg. overbank flow, natural gully or surcharge path for a drainage line). The area of the floodway can be excluded from the site area for the purpose of calculating the site storage requirements, provided that the area is protected from development by an appropriate covenant or easement. Where an existing easement is insufficient to cater for the 100 year ARI flow from the upstream catchment, it may need to be widened to cater for the flow. This would reduce the area for calculating the storage requirements.^{ix}

There are a small number of situations where part of the external flow would not enter the storage. This portion of the flow need not be collected nor diverted. For example:

- dual occupancies where a second dwelling is proposed on a lot with an existing dwelling;
- (OSD is required for the area of the additional dwelling plus a curtilage to cover paths and paved areas. Runoff from the remainder of the lot need not be directed to the OSD storage nor is it necessary to divert external flows affecting this portion of the lot.)
- large properties where only a small area is being developed.
- (OSD applies only to the area covered by the development application, generally the building/paved area plus curtilage. Here again external flows affecting the undeveloped areas need not be diverted.)

4.1.4 Areas not directed to the OSD storages

(See also Section 3.4.3 where the development affects only part of a site)^x

Where possible, the drainage system should be designed to direct runoff from the entire site to the OSD system. Sometimes, because of ground levels, the receiving drainage system or because of other circumstances, this will not be feasible. In these cases up to 15% of the site area may be permitted to bypass the OSD systems, provided that as much as possible of the runoff from impervious site areas is drained to the OSD system. Calculations based on the standard design storm for this catchment, indicate that 15% of the site without OSD will generate a site discharge of 80 l/s/ha which means that no runoff at all could be permitted from the remaining 85% of the site.^{xi}

For areas not draining to an OSD storage, the storage volume is still calculated on the entire site area while the PSD is adjusted downwards according to procedures in Section 5. This makes sure the storage is fully used in the design storm.

4.1.5 (This section has now become Section 3.4.3)

^{ix} Clarification added for third edition.

^x Cross-reference added for third edition.

^{xi} Bypass area reduced in third edition

4.1.6 Estimating storage volumes

The Site Storage Requirement (SSR) will vary depending on the efficiency of the discharge control device. It can be shown that if an OSD storage has a discharge control pit that achieves the PSD immediately flow is generated from the site, the SSR is 470 m³/ha. In practice this does not occur and an adjustment to the storage volumes is necessary after the discharge characteristics have been fixed.

It is not necessary to select the discharge control device or accurately determine the SSR for the SCP. A storage rate of 500 m³/ha can be used to approximate the required storage volume. This approximate volume is refined at the detailed design stage.

4.2 Detailed design

From 1 May 1999^{xii}, design and certification will only be accepted from persons having acceptable professional accreditation. The following are considered to be acceptable accreditation for the purpose of OSD design and certification:

- NPER in Civil Engineering (Institution of Engineers, Australia);
- Surveyors Certificate of Accreditation in On Site Detention and Drainage Design (Institution of Surveyors NSW and the Association of Consulting Surveyors NSW);
- Stormwater Register (Association of Hydraulic Services Consultants Australia)
- Accreditation as a certifier under the Environmental Planning and Assessment Act 1979 in the relevant discipline.

A detailed design submission is required to support an application for a construction certificate or the engineering plans of a development. The specific site drainage constraints will have been identified and addressed conceptually in the SCP, thereby simplifying the detailed design.

The purpose of the detailed design submission is to finalise the design of all components of the OSD system, provide a set of plans and details for construction of the system, and detail the maintenance procedures necessary to ensure the long-term effectiveness of the system. The steps involved in a typical detailed design submission are outlined in Figure 4.2.

One of the concerns raised by OSD designers is that they may not see the approved OSD plans if they are not the applicant. Council may not be entitled to send a copy to the designer unless the applicant gives permission. If the applicant authorises release of a copy of the plans, this will allow designers to adjust future designs to better suit the council's requirements. It will also ensure that the designer has the approved plans if engaged to provide the hydraulic certification for the OSD facility^{xiii}.

4.2.1 Objectives

The objectives of a detailed OSD design are to:

- ensure that all components of the OSD system are functional
- ensure that the OSD design complements the WSUD proposals for the site
- simplify construction of OSD systems by providing detailed design plans
- increase owner awareness and improve maintenance standards by simply outlining the necessary maintenance practices
- encourage consideration of accessibility and maintainability of storages.

^{xii} Accreditation requirement added in third edition.

^{xiii} Plans to designer added to third edition

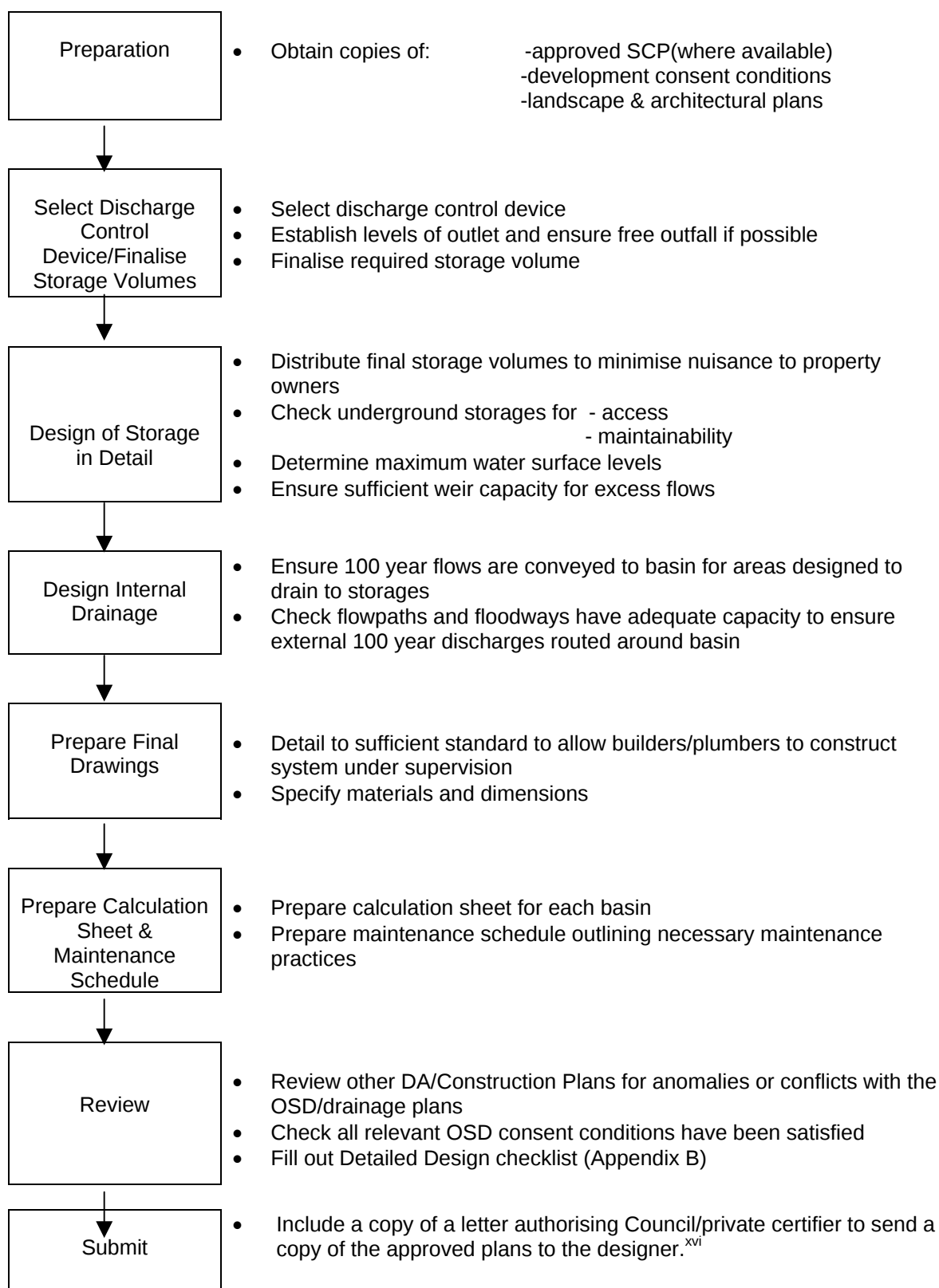
4.2.2. Minimum data requirements

The following information must be included in a detailed design submission:

- calculations for each storage, finalising the storage volumes and discharge
- Where WSUD components are proposed, calculations and details of both the OSD and WSUD components are required which clearly demonstrate that the designer has integrated the systems so as to allow for the impact of each on the design of the other. For further information on the details to be submitted for the WSUD components please contact the local council. Additional information is also available in the Final Draft Water Sensitive Urban Design Technical Guidelines dated October 2003 prepared for the Trust by URS Australia Pty Ltd. Copies of the report or the final report which supersedes it) will be available from the Trust web site (www.uprct.nsw.gov.au) and the Water Sensitive Urban Design in the Sydney Region website (www.wsud.org).^{xiv}
- rates in accordance with procedures in Section 5
- calculations verifying that the overflow from the DCP to the storage, flowpaths/floodways, internal drainage systems and any overflow weirs have sufficient capacity
- design plans and details which include the:
 - location and extent of each storage with each storage wholly within the property.
 - locations and details of each discharge control device
 - catchment area draining to each storage
 - maximum water surface levels in each storage
 - overflow structures and surcharge paths
 - levels and location of the discharge points for each storage
 - internal drainage system
 - existing contours and final design levels
 - final site/lot layout
 - location and extent of any floodway/flowpath
- cross-sections through the storages
- a maintenance schedule that simply sets out:
 - what maintenance is required
 - how will the maintenance be done
 - who should carry out the maintenance
 - when the maintenance will be done
- structural certification for components of the OSD system (if necessary).
- completed Detailed Design checklist (See Appendix B.9)^{xv}
- a letter authorising Council to forward a copy of the approved plans to the designer

^{xiv} Clarification of relationship between OSD and WSUD clarified in third edition

^{xv} Checklist added in third edition.

Figure 4.2 PREPARATION OF A TYPICAL DETAILED DESIGN SUBMISSION

^{xvi} Plans to be available for designer added in third edition

4.2.3 Discharge Control Pit (DCP)

The DCP is the key feature in regulating discharge from the site. Hydraulic model tests conducted on behalf of the Trust by Manly Hydraulics Laboratory established a set of generic design parameters for DCPs incorporating HED, screens and orifice control.

Proprietary products or in-situ devices meeting these guidelines are not required to provide a laboratory-determined head-discharge relationship. Other forms of discharge control are commercially available and can be used in the catchment provided that:

- the hydraulic characteristics of a prototype have been determined and certified by a recognised hydraulics laboratory
- the risk of the device becoming blocked by debris is minimal
- the device can be readily inspected
- the device can be accessed for cleaning
- there is minimal risk of the system being tampered with.

Orifice Controlled High Early Discharge Pits

A typical discharge control pit with an orifice control is shown in Figure 4.3. The minimum orifice diameter is 25 mm.

The following minimum pit dimensions will achieve predictable hydraulic characteristics:

- minimum width = $3d$ (symmetrical about the orifice)
- minimum design head = $2d$ (centre of orifice to top of overflow)
- minimum screen clearance = $1.5d$ (orifice to upstream face of screen)

where d is the internal diameter of the orifice.

These dimensions can be increased to allow greater screen sizes or improve access.

Orifice plates are to have the following characteristics:

- orifice plates are to be manufactured in corrosion-resistant 3 mm thick stainless steel plate, or 5 mm thick plate where the orifice exceeds 150 mm, with a circular hole machined to 0.5 mm accuracy.
- orifices fashioned in material other than stainless steel will be subject to the specific approval of the Trust. In determining whether an orifice is suitable, it will be necessary to demonstrate:
 - the discharge characteristics are constant and predictable
 - the material is durable
 - the machined hole is to retain a sharp edge
 - the plate is to be permanently fixed to the pit wall with no gaps between the plate and the wall.

High early discharge (HED) is important in minimising the storage volume required. In order that HED can be assumed:

- the discharge to the storage is to commence at a minimum of 75% of the PSD;
- the overflow structure from the DCP to the storage (weir, pipe, grate etc.) must be able to convey the maximum 100 year flow to the DCP less the initial HED through the orifice and sufficient calculations are to be provided to demonstrate this;ⁱ
- the majority of the site drainage system is to be connected to the DCP; and
- the volume of the DCP is to be small in comparison to the volume of the storage.

The Discharge Control Pit will need to be maintained regularly. To assist with inspecting and cleaning, the minimum internal dimensions of the DCP should beⁱⁱ:

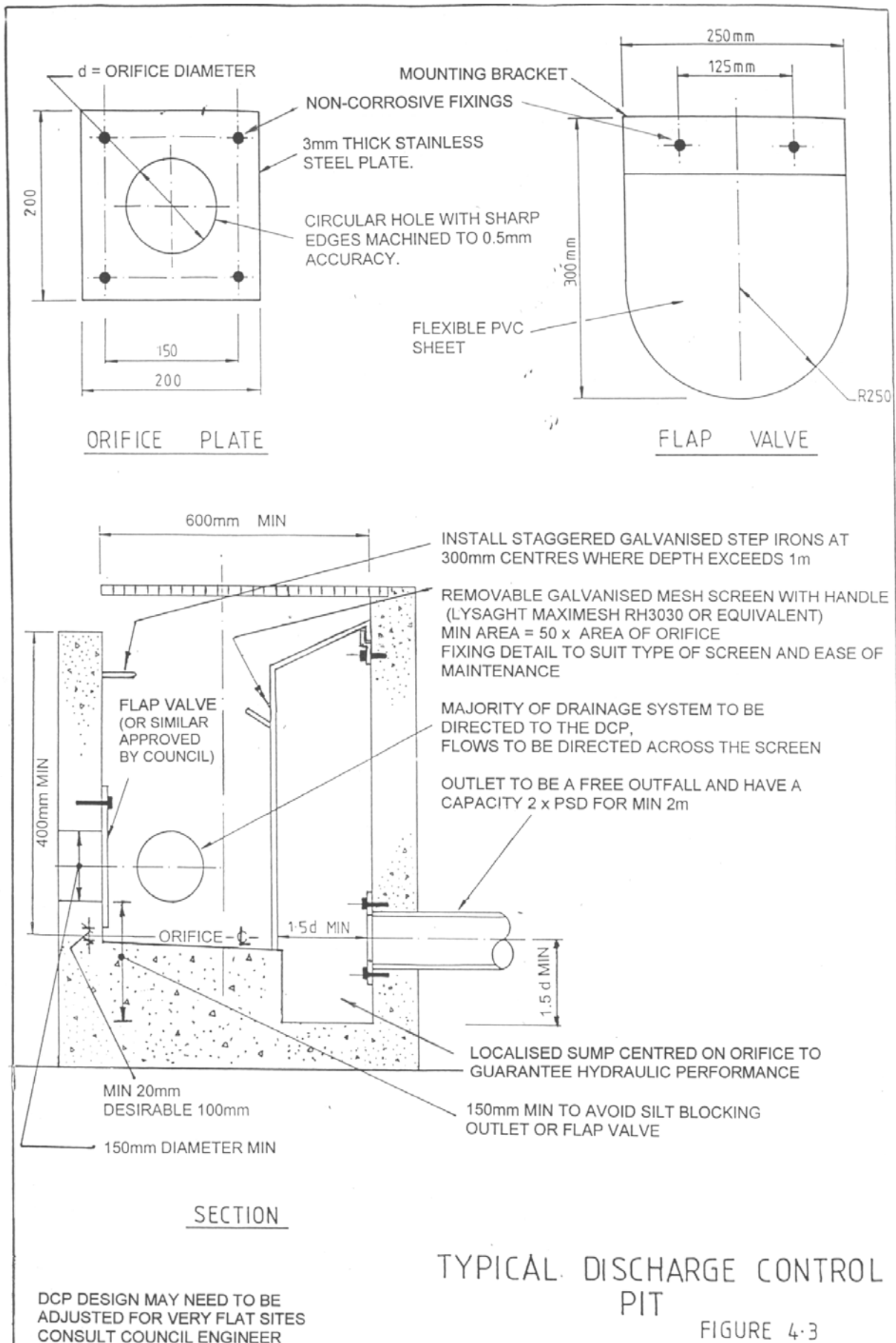
- 600x600 mm for up to 600 mm deep
- 900x900 mm for greater than 600 mm deep

For sites with multiple owners/tenants the DCP, and as much of the storage as possible, should be contained in the common areas rather than on private lots. This means that inspections and maintenance are simpler and remain the responsibility of the joint owners rather than an individual.ⁱⁱⁱ

ⁱ Calculations for weir flow spelled out in third edition

ⁱⁱ Pit dimensions altered for third edition.

ⁱⁱⁱ Use of common areas added in third edition.



4.2.4 Free discharge from a DCP

The orifice discharge equation is:

$$Q = CA (2gh)^{1/2}$$

where Q is the discharge in m³/sec

C is the coefficient of discharge

A is the orifice area in m²

g is the acceleration due to gravity

h is the depth of water above the centre of the orifice in metres.

This equation relies on:

- a circular sharp-edged orifice and
- free discharge from the orifice.

To ensure that free discharge is maintained the outlet needs to be well ventilated and the outlet pipe needs to be large enough to prevent submergence. As a guide, designers should try to ensure that the outlet from the DCP has a just-full capacity of twice the PSD. The orifice should be centred in the outlet pipe to avoid edge effects.ⁱ Free discharge is not achieved when the outlet from the DCP is affected by tailwater levels in the downstream drainage system. See Section 6.5.

4.2.5 Screens

DCPs must be fitted with an internal screen. The screen needs to:

- protect the orifice from blockage
- create static conditions around the orifice which helps to achieve predictable discharge co-efficients
- retain litter and debris which would degrade downstream waterways.

Screen type

A small aperture-expanded steel mesh, such as Maximesh Rh3030, is recommended for orifices less than 150 mm in diameter. This type of screen retains relatively fine material (eg. cigarette butts and grass clippings) while maintaining the performance of the orifice under heavy debris loading. For orifices larger than 150 mm, the screen area necessary for a fine mesh screen can make it difficult to fit in a DCP.

A grid mesh, such as Weldlok A40/203,ⁱⁱ may be used for these larger orifices. Where the grid mesh is used, a fine mesh screen should be installed upstream of the DCP, for areas likely to collect litter or debris.

ⁱ Design hint added in third edition.

ⁱⁱ Code number of mesh updated in third edition

Screen area

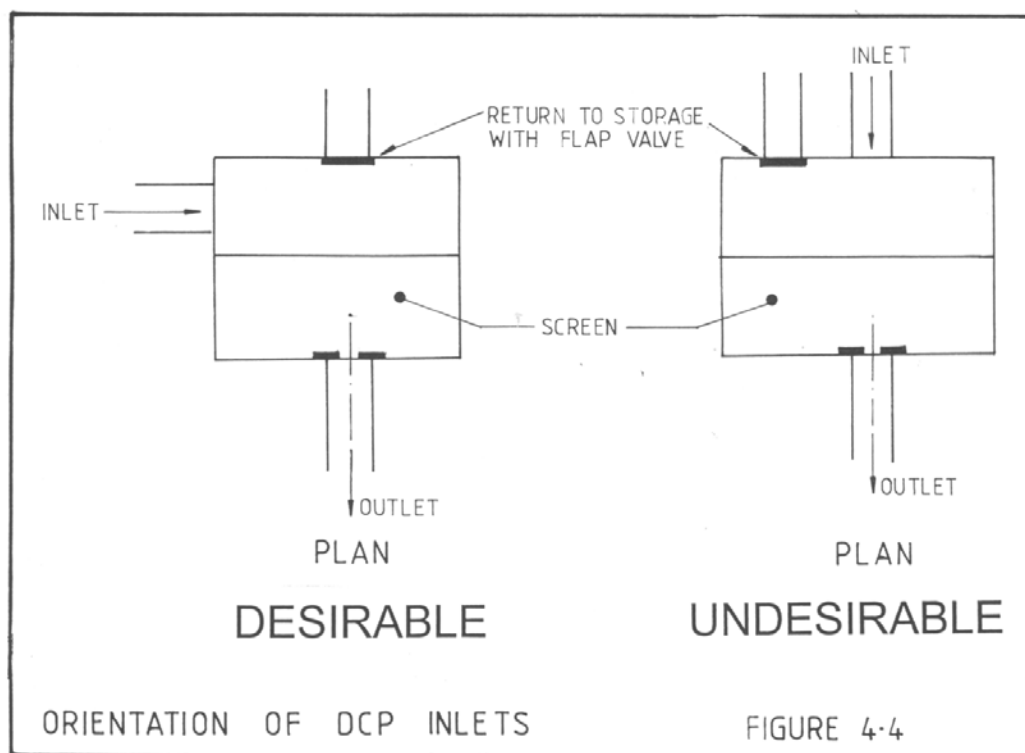
The minimum recommended area (including blocked area) for an internal screen in a DCP is:

- 50 times the orifice area where a fine mesh screen is used (eg. Maximesh Rh3030)
- 20 times the orifice area where a grid mesh is used (eg. Weldlok A40/203).

Screen orientation

The inlet pipe to a DCP should direct inflows parallel (or at a small angle) to the screen. Perpendicular inflows drive debris into a mesh screen making it difficult to dislodge. When inflows are directed parallel to the screen, the debris is layered on the screen but is blown off when the inflow exceeds approximately 2-3 times the PSD. This arrangement is illustrated in Figure 4.4. The performance of the orifice and screen is influenced by the orientation of the screen.

To assist in shedding debris, the screen should be positioned as close to vertical as possible. This allows debris to fall off once the water level in the DCP drops. However, the screen must fit securely to the pit to avoid debris floating over or around the screen and blocking the orifice.ⁱⁱⁱ The screen should be placed no less than 60 degrees to the horizontal.



General

ⁱⁱⁱ Design hint added in third edition.

To prevent blockages, Maximesh screens must be positioned so that the long axis of the oval shaped holes is horizontal, the protruding lip is uppermost and above the hole and the screen is tilted downstream. (See Figure 4.5)ⁱ. Blockages can occur if the screen is accidentally placed upside down. Fitting a handle to the screen not only reduces the chance of incorrect placement but also makes removal for cleaning easier. Fixings need to be selected to suit the screen and to promote easy removal for maintenance.

Reducing the screen size also facilitates cleaning by reducing the weight. Proprietary screens may be considered to achieve this end. A list of current suppliers of screens (and other OSD products) is given in Appendix E.

After being cut to size, Maximesh screens need to be 'hot dipped' galvanised to prevent corrosion.

All mesh screens deflect under high inflows and heavy debris loading and should be braced to stop debris being carried around the screen.

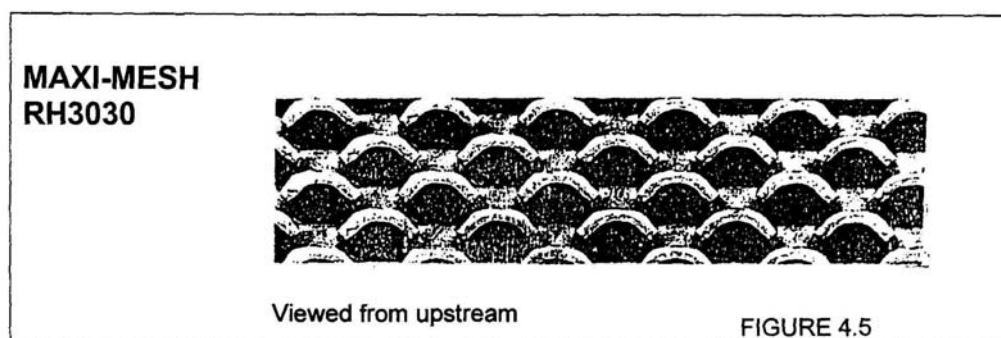


FIGURE 4.5

4.2.6 Storagesⁱⁱ

The selection of the most appropriate type of storage for the site is critical to the quality, effectiveness and cost of the OSD design. Every attempt should be made to provide the majority of the volume as surface storage rather than below ground. Not only will this be generally cheaper to construct (savings of \$100-150/m³ for storages between 20m³ and 100m³ were identified by a survey commissioned by the Trust and the NSW Department of Housing in 1996)ⁱⁱⁱ, but greater flexibility is usually achieved in siting the storage. Also, maintenance is simpler and generally safer. Designers should be aware, however, of the increased risk of subsequent alteration to the storage by future occupants and should try to provide a finished landscaping product which needs no further improvement. It may be necessary to provide primary storage below ground to reduce the chance of ponded water causing problems for occupiers of the site. However, innovative design can reduce the volume of below ground storage required.

ⁱ Clarification and Fig 4.5 added in third edition.

ⁱⁱ Additional comments added in third edition.

ⁱⁱⁱ *On-Site Stormwater Detention System Cost Survey* dated January 1997 prepared by Bewsher Consulting Pty Ltd. (See Appendix H for further details).

Designers should also seek to provide larger common storages in multi-owner developments or subdivisions. This removes the need for a large number of smaller storages which will have increased design, construction and maintenance costs. Particular problems have been experienced in multi-lot subdivisions where OSD storages on individual lots have proved to be considerably more costly to install than a single OSD storage would have been. Care should also be taken with the use of private courtyards (considered to be yards less than 60 m² in area) for storage for safety reasons. OSD storage in these courtyards will not be permitted if the area is less than 25m² and Council's specific approval will be required for courtyards whose area is

between 25 and 60m². Recommendations for allowable depths and the frequency of ponding are given in Table 6.1.^{iv}

OSD storages for subdivisions must be constructed prior to the release of the Linen Plan rather than deferred until the construction of the dwelling because of the problems faced by owners in deferred construction.^v The only exception to this requirement is the case of a subdivision of up to 7 lots where there are demonstrable site restrictions. Deferral still requires the written approval of Council.^{vi} The construction of a single storage provides more flexibility in the design and siting of houses on the individual lots.

The walls of each storage must be entirely within the property so as to avoid possible disputes with adjoining land holders if the common boundary fence was used as part of the storage.^{vii}

Off-line – On-line storages

The relative location of the DCP and the storage is an important design consideration. As shown in Figure 4.6, an OSD system with the storage and the DCP in series is defined as an on-line system. In this case, the discharge from the DCP is dependant on the characteristics of both the DCP and the storage. The design processes outlined in section 5 of this Handbook are generally not applicable for on-line storages. On-line systems will need to be designed using a calibrated hydrologic/hydraulic model.

There are some specialised discharge control devices, such as float controlled discharge regulators that have different discharge characteristics. These may be used on-line and still achieve HED and discharge rates independent of the shape of the storage. The characteristics of these devices should be checked with the manufacturer and verified with the Trust prior to preparation of a detailed design.

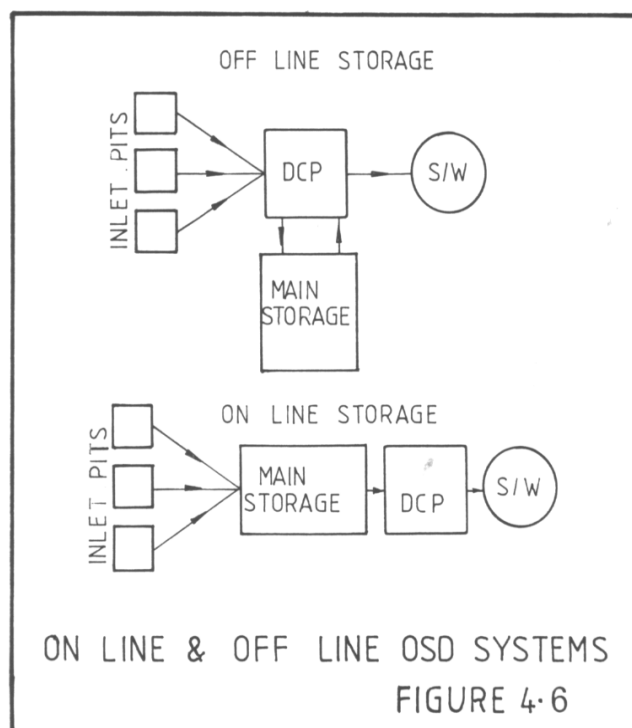
Where the majority of the stormwater passes directly to the DCP, and the storage fills by spillage from the top of the DCP, the OSD system is defined as off-line (See Figure 4.6). Here the DCP discharge and the storage volume is independent of each other. On-line storage systems require more storage volume than off-line storages. In the upper Parramatta River catchment, the difference can be in the range of 10-20%.

^{iv} Design requirement added in third edition.

^v Design requirement added in third edition.

^{vi} Deferral of OSD clarified for small subdivisions in third edition

^{vii} Boundary issue added to third edition



4.2.7 Surface storage systems

There are few absolute requirements when designing a surface storage. These guidelines have been framed to allow the designer maximum flexibility when integrating the storage in the site layout. A discussion of the general principles of storage design is included in Section 6. However the desirable minimum design parameters for surface storage systems are set out below.

General

The floor levels of buildings adjacent to surface storage areas should have a suitable freeboard to avoid the risk of water entering the building in storms more severe than the design storm or in the event of system blockage. The free board is to be calculated from the top water level including the depth of flow over the overflow weir. (See Section 4.2.9).^{viii} The required freeboard is:

- 200 mm for habitable buildings
- 100 mm for garages.

A similar freeboard should be provided for flowpaths adjacent to buildings.

The walls creating each storage must be entirely within the property so as to avoid possible disputes with adjoining land holders if the common boundary fence was used as part of the storage.^{ix}

^{viii} Freeboard requirement clarified in third edition

^{ix} Boundary issue added to third edition

Landscaped storages

- The desirable minimum surface slope is 1.5% for the base.
The absolute minimum surface slope is 1.0% for the base.
- Side slopes should be a maximum of 1V to 6H where possible. (See also Section 3.5.5)
- Sub-soil drainage should be provided around the outlet to prevent the ground becoming saturated during prolonged wet weather.
- Where the above ground storage is located in the same area as the children's play equipment, pool type fencing, including a child proof gate, must be provided to ensure that young children can only enter the area under supervision. Water levels can rise quickly in the basin and pictorial signage such as that shown in Appendix C must be installed to reinforce the need to leave the area when it rains.ⁱ
- Where the storage is located in an area where frequent ponding could create maintenance problems or personal inconvenience to property owners, the first 10%-20% of the storage should be provided in an area able to tolerate frequent inundation such as:
 - a paved outdoor entertainment area
 - a small underground tank
 - a permanent water feature
 - a rockery or rock garden.
- If using private courtyards for OSD storage, the area of courtyard must be between 25 and 60m² and specific Council approval must be obtained. In this Handbook, private courtyards are considered to have an area of 60 m² or less. Areas greater than that are treated as gardens. The storage should generally not commence ponding more frequently than once every 5 years. Provision should also be made for the future installation of garden sheds and the like by leaving an area of the courtyard above the storage depth.ⁱⁱ Refer to Table 6.1 for depths and frequency of ponding.
- The maximum depth of storage should be limited to 600 mm unless otherwise approved by Council and the area must be designed to allow safe egress as the storage fills with waterⁱⁱⁱ.
- The structural adequacy of retaining walls must be checked, including the hydrostatic loads caused by a full storage.
- Free standing timber log retaining walls should not be used to create a storage, but timber can be satisfactory as part of an earth retaining wall which prevents any significant leakage.

ⁱ Fencing of OSD storage in playgrounds added in third edition

ⁱⁱ Design requirement added for third edition.

ⁱⁱⁱ Maximum ponding depth added in third edition.

Driveway and car-park storages

- To avoid damage to vehicles, depths of ponding on driveways and car-parks should not exceed 200 mm under design conditions.
- Transverse paving slopes within storages areas should not be less than 0.7%.
- Where the storage is to be provided in a commonly used area where ponding will cause inconvenience (eg. a car-park), the area should only flood once every year, on average. This will require approximately the first 15% of the storage to be provided in a non-sensitive area.

4.2.8 Structural/underground storages

The use of underground storages for total storage volumes should be avoided where at all possibleⁱ. However, locating a small proportion of the required storage underground can often enhance a development by limiting the frequency of inundation of an open storage area. In very difficult topography, the only feasible solution may be to provide all or most of the storage volume underground. However the designer should recognise that underground storages:

- are more expensive to construct than surface storage systems
- are difficult to inspect for silt and debris accumulation
- are difficult to maintain
- can be dangerous to work in and may be unsafe for property owners to maintain.

The optimal solution will generally be a system where the property owner is able to carry out the routine maintenance. Where the structure cannot be maintained by the property owner or occupier, this must be clearly identified in the maintenance schedule. When preparing a design for underground storage, designers should be aware of the provisions of AS 2865-1995 *Safe Working in a Confined Space*. Where practicable, the design should eliminate the need to enter the confined space for maintenance or other purposesⁱⁱ. A sign indicating that the storage is a confined space and that entry should be restricted to trained personnel should be fixed to each opening into the underground storage. A typical sign is included in Appendix C.

The walls of each storage must be entirely within the property so as to avoid possible disputes with adjoining land holders if the tank or underground storage encroaches onto their land.ⁱⁱⁱ

ⁱ Design requirement added for third edition.

ⁱⁱ Design hint added for third edition.

ⁱⁱⁱ Boundary issue added to third edition

Important design considerations

- Residents/owners must be able to inspect critical parts of the storage from the surface without having to remove heavy access covers. Concrete covers are to be avoided for this reasonⁱ.
- Openings must be wide enough to allow easy entry to a storageⁱⁱ, ie:
 - 600 x 600 (storages up to 600 mm deep)
 - 900 x 900 (storages greater than 600 mm deep)
- A continuous fall on the floor of the storage of at least 1% must be provided to the storage outlet to minimise ponding in the storage.
- The minimum clearance height for accessible tanks is 900 mmⁱⁱⁱ. Where this cannot be achieved due to level or other constraints, the following internal heights can be considered:

• Commercial/Industrial developments	750 mm
• Residential developments	500 mm.

provided that :

 - All grates accessing the tank shall be a minimum of 900 mm x 900 mm, and a maximum lifting weight of 20kg;
 - Grates to be placed at the extremities of the tank with a maximum distance of 3m from any point in the tank to the edge of the nearest grate. This should allow any point in the tank to be reached with a broom or similar implement without the need to enter the tank;^{iv}
 - The base of the tank is shaped with a 2% crossfall to a V drain and with a 2% longitudinal slope along the V drain;
 - Tanks less than 750 mm high must be precast to avoid difficulties with removing formwork.
- To minimise the risk of silt and debris blocking the storage outlet or flap valve, the floor of the DCP should be a minimum of 150 mm below the return pipe to the storage, and the return pipe to the storage should be at least 150 mm in diameter.
- Where all the storage is provided in an underground structure, a large storm could be stored even with a totally blocked outlet. The storage should be designed to overflow and pond in a very visible part of the property so that the ponding will be noticed and the outlet blockage cleared before another storm event.
- All surface inlet drains upstream of the DCP and the storage must be designed so that there is no overflow before the storage is full.
- The build-up of noxious odour in storages without a grated access can create problems. If the storage is sealed, vents should be provided.
- In addition to checking that the storage is structurally adequate for the normal earth, traffic and hydrostatic loads generated by a full storage, the structure should be checked for flotation. Depending on the surrounding soil conditions, the soil around the tank can become saturated during a storm. The underground tank will empty soon after the storm is finished, while the soil will remain saturated for much longer. Sub-soil drainage, weep-holes and wall drainage may be needed to equalise hydrostatic pressures.

ⁱ Design hint added for third edition.

ⁱⁱ Pit dimensions changed for third edition.

ⁱⁱⁱ Design requirements added in third edition.

^{iv} Cleaning requirement clarified in third edition

4.2.9 Rainwater Tanks^v

In the past the four local councils and the Trust have always refused to allow rainwater tanks to be considered as part of an OSD facility because of the probability that the tank would be full at the start of a major rainfall event. In recent years it has been argued, however, that a rainwater tank will not always be full at the start of a storm if its water is used inside and outside the dwelling for non-potable purposes - toilet flushing, hot water, garden watering.

To resolve this matter, the Trust engaged Peter Coombes and Associate Professor George Kuczera of the University of Newcastle to carry out a study to find what proportion of the volume of a rainwater tank can be counted as part of the site's OSD volume – assuming its water was used both inside and outside the dwelling. A 1000-year rainfall record was generated based on a 53-year pluviograph record at West Ryde. This was applied to water-use models of different types of residences - a single dwelling, a duplex, a town house and an apartment building. The results of repeated simulations with different typical sizes of rainwater tanks (5, 10 and 15 m³) showed that the average percentage of rainwater tank volume that can be counted as part of the site's OSD volume ranges from 32% to 50% if the tank has no air space, and 51% to 72% if there is 50% air space. The full set of percentages is set out in the table below.

These results should be considered as an interim answer. The study only looked at individual sites and it will be necessary to also investigate the cumulative impact on peak discharges from groups of dwellings with rainwater tanks. (This is the subject of a separate study for the Trust being undertaken by Dr Allan Goyen of Cardno Willing. The results of that study will be available at the next revision of this Handbook.) The West Ryde 100-year rainfall intensities are significantly higher than corresponding intensities in the middle of the upper Parramatta River catchment, so the study results may understate the effectiveness of rainwater tanks for OSD. It should also be noted that, in this catchment at least, with rainwater tanks typically 5 or 10 m³ in capacity, the volume allowed (1.5 m³ to 7 m³) would be quite small relative to the total OSD volume required on most developments.

The specified percentages of a rainwater tank's volume shown in the table below can be counted as part of a site's OSD storage (the Site Storage Requirement) provided that:

- the development is residential, or its water usage can be considered to approximate that of a residence;
- the rainwater tank volume is between 5 and 15 m³ (or 20 m³ for apartment blocks);
- the rainwater tank is plumbed into the household water supply system so that its water is automatically used for non-potable purposes;
- the design is in accordance with Section 3.5 of the study report by Coombes et al and AS/NZS 3500.1.2: *Water Supply – Acceptable Solutions* (provides guidance for the design of rainwater tanks with dual water supply (rainwater and mains water)); and
- all overflows from the rainwater tanks are directed into the OSD discharge control pit.

The average percentage of rainwater tank volume that can be counted as OSD site storage is in the table below for each allotment scenario.

Scenario	Volume of rainwater tank counting as OSD storage (%)	
	No airspace in tank	50% airspace in tank
Allotment	42	65
Duplex	50	72
Townhouses	40	53
Walk up apartments	32	51

The report by Coombes et al can be viewed and downloaded from the Trust's web site at:

http://www.uprct.nsw.gov.au/sustainable_water/publications/list.htm

^v New section 4.2.9 added in third edition

4.2.10 Overflowⁱ

Provision needs to be made in the design of a storage for storms more severe than the design storm or for blockages in the system. With most storages, it is relatively easy to provide a weir capable of passing the entire discharge from a very large storm event with only a few centimetres depth of water over the weir.

The following design method should be used to check the adequacy of overflow structures, such as weirs or spillways, and freeboards to finished floor levels. Overflow and weir flow calculations must be included in the detailed design information submitted to the consent authority.

- Assume the outlet is blocked and the storage full.
- Calculate the approximate maximum 100 year ARI event discharge to the storage (a Rational Method approximation will be adequate).
- Calculate the maximum depth over the spillway/weir assuming the entire 100 year ARI event discharge passes over the spillway/weir.
- Check the floor levels of any buildings upstream of the storage to ensure that these buildings are not inundated. (Refer 4.2.7 for suitable freeboards)
- Overflows should be directed to a flowpath through the development so that buildings are not inundated nor are flows concentrated on an adjoining property.

4.2.11 Maintenance scheduleⁱⁱ

As part of the detailed design submission, a maintenance schedule is to be prepared. The maintenance schedule is a simple set of operating instructions for future property owners and occupiers. It should be clearly and simply set out and should be accompanied by a simplified plan showing the layout of the OSD system. (See sample plan in Figure B2.2) The designer's consent to release of this plan to subsequent owners/occupiers should be provided to facilitate long term maintenance of the facility.ⁱⁱⁱ

What must be done?

The maintenance schedule needs to set out simply and clearly the routine maintenance necessary to keep the OSD system working. Some of the issues that will need to be addressed are:

- where the storages are located
- which parts of the system need to be accessed for cleaning and how access is obtained
- a description of any equipment needed (such as keys and lifting devices) and where they can be obtained
- the location of screens and how they can be removed for cleaning.

ⁱ Section renumbered in third edition

ⁱⁱ Section renumbered in third edition

ⁱⁱⁱ Plan and release requirements added in third edition

Who should do the maintenance?

The majority of OSD systems, particularly those where a large proportion of the storage is located above ground, will be able to be maintained by property owners, residents or handymen. Larger underground systems, particularly those with limited access and/or substantial depth, may require the owner to engage commercial cleaning companies with specialised equipment.

How often should it be done?

The owner should be provided with advice on how frequently the system needs to be inspected and approximately how often it will require cleaning. The frequencies of both inspections and maintenance will be highly dependant on the nature of the development, location of the storage and the occurrence of major storms. Suggested frequencies are:

- Residential
 - inspect system every six months and after heavy rainfall
 - clean system as required, generally at least once a year.
- Commercial/Industrial
 - inspect system every three months and after heavy rainfall.
 - clean system as required, generally at least once every six months.

4.3 Construction/final approval

The last stage in the approval process involves making sure that the system has been built correctly and that appropriate legal protection is in place to ensure long-term performance of the system. The design effort involved in preparing a concept plan or a detailed design submission is wasted unless the OSD system is built correctly and maintained. The constructed system should conform exactly to the approved design plans and particular attention is required to ensure that all critical levels are achieved.^{iv} Figure 4.7 summarises the procedure for supervising and constructing and certifying an OSD system.

4.3.1 Objectives

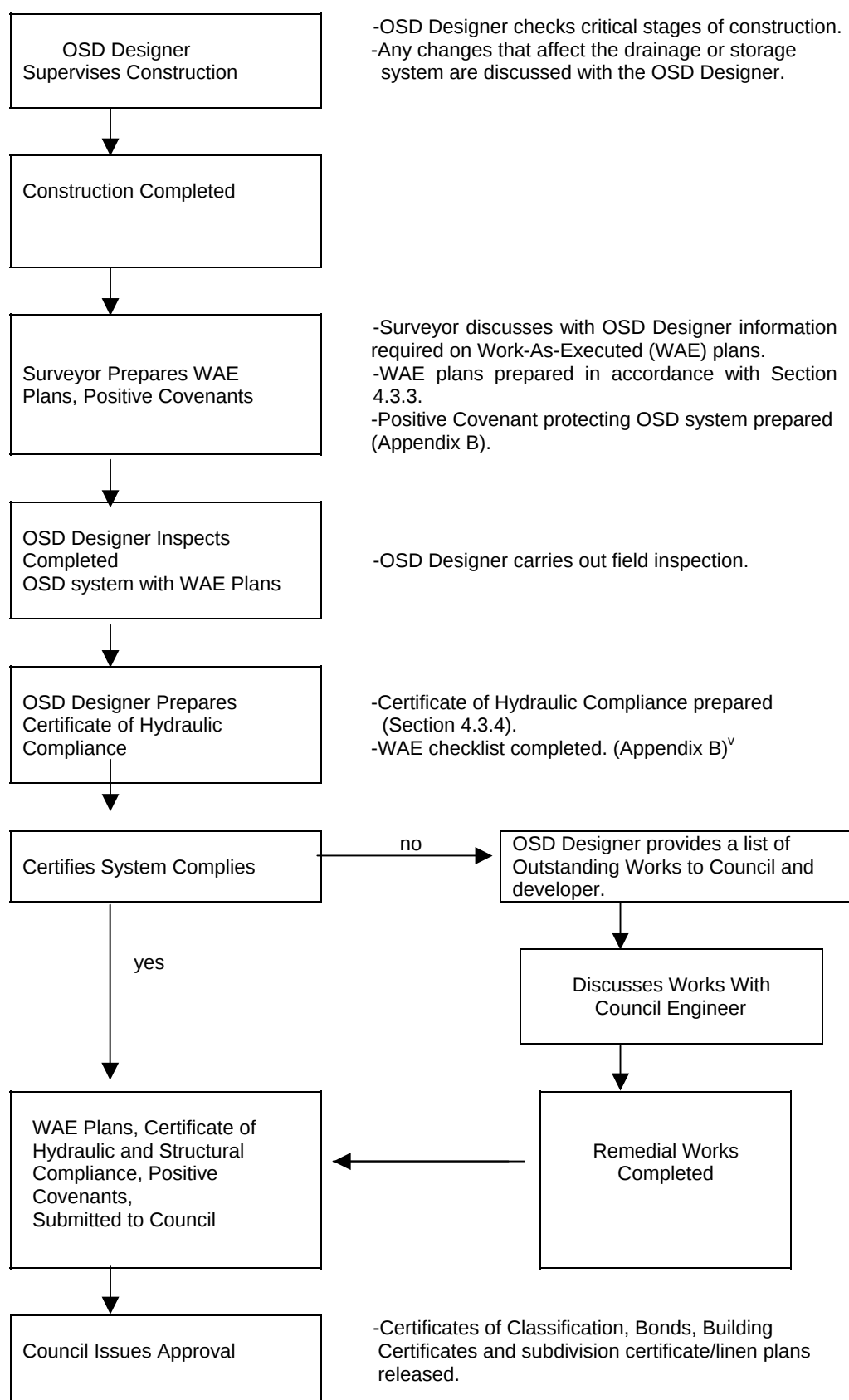
The objectives of the construction supervision and certification arrangements are to:

- encourage supervision of critical stages of construction by the OSD designer to improve construction standards,
- minimise delays and additional expenditure on rectification works by ensuring adequate construction supervision,
- increase community acceptance of OSD by eliminating nuisances created by poor construction, and
- enable local Councils to inspect and insist on essential maintenance of the system.

^{iv} Design requirement added in third edition.

4.3.2 Construction supervision

Construction supervision is essential in achieving a properly working OSD system. OSD construction is often multi-disciplined with many tradesmen (such as bricklayers, landscapers and concrete finishers,) who may be unfamiliar with stormwater drainage, being responsible for constructing critical features of the system. OSD systems require closer attention to set-out and levels than a conventional drainage system. Without adequate supervision during construction (preferably by the designer or someone very familiar with the design intent), expensive and time consuming rectification works are often necessary before a Certificate of Hydraulic Compliance can be issued by the OSD designer.

Figure 4.7 Construction, certification and final approval^v Checklist added in third edition.

4.3.3 Work-as-Executed Plans

Work-as-Executed (WAE) plans prepared by a Registered Surveyor or the OSD designer must be submitted. A general set of guidelines for preparation of WAE plans is provided below. However in some projects there will be site-specific features which will require additional details. The OSD designer should therefore be consulted before preparing these plans. It is important that the WAE plans provide the OSD designer with sufficient information to certify that the as-constructed system will function in accordance with the approved design. Note that any changes to the top water level in the storage or depth of storage may alter the required orifice diameter. Calculations should be submitted to show that the orifice diameter is correct if the approved design water level has been changed.^{vi}

Discharge Control Pit

The following information on the discharge control pit (DCP) should be included:

- internal pit dimensions
- the diameter of the orifice plate and verification that it has been fitted correctly
- verification that a screen has been fitted, as well as its location, dimensions and the minimum distance from the orifice
- verification that an appropriate flap valve has been fitted (if specified)
- levels on the top and invert of the pit
- internal diameter of the outlet pipe.

Storage

The following details of the OSD storage should be provided:

- type of storage - roof, above ground, below ground, rainwater tank^{vii} or combination
- detailed calculations of the actual volume achieved for each storage
- level and location of any overflow structures (eg. spillways, weirs)
- sufficient levels and dimensions to verify storage volumes – as a minimum, WAE plans should give the constructed level of all design levels shown on approved plans.^{viii}
- any changes to storage depth or top water level and whether the orifice size is affected.^{ix}
- Where rainwater tanks have been installed as part of the OSD storage, the volume of the tank and the % used for OSD with certification that the tank is plumbed in for non-potable internal and external uses.^x

^{vi} Design requirement added in third edition.

^{vii} Rainwater tank added in third edition

^{viii} Design requirement added in third edition.

^{ix} Design requirement added in third edition.

^x Certification of rainwater tank characteristics added in third edition

Internal drainage

The following information on the internal drainage system is to be included:

- pit surface levels
- invert levels and diameters of pipes
- location and levels of any floodways and/or overland flowpaths
- sufficient spot levels to show site gradings and extent of areas not draining to the storage(s).

Freeboards

The finished floor levels of adjacent structures on the property, such as garages and dwellings, are to be shown to ensure they are sufficiently above the maximum storage water surface levels and overland flowpaths. As stated in Section 4.2.7, a freeboard of 200 mm should be provided for habitable dwellings and a freeboard 100 mm for garages. The top water level should take into account the depth of water over the overflow weir. (Section 4.2.9).^{xi}

4.3.4 Certificates of Hydraulic Compliance

Certificates of Hydraulic Compliance are required by all councils within the catchment to confirm that the drainage and On-site Stormwater Detention (OSD) works have been carried out in accordance with the approved design. From 1 May 1999,^{xii} design and certification will only be accepted from persons having acceptable professional accreditation. The following are considered to be acceptable accreditation for the purpose of OSD design and certification:

- NPER in Civil Engineering (Institution of Engineers, Australia);
- Surveyors Certificate of Accreditation in On Site Detention and Drainage Design (Institution of Surveyors NSW and the Association of Consulting Surveyors NSW);
- Accreditation as a certifier under the Environmental Planning and Assessment Act 1979 in the relevant discipline; and
- Stormwater Register (Association of Hydraulic Services Consultants Australia)

To avoid delays in obtaining certification, developers and builders are encouraged to have the OSD designer supervise the construction of these systems. Defects are expensive to repair once the development is completed.

Certificates of Hydraulic Compliance are to be attached to the Work-As-Executed plans and submitted to council prior to the release of linen plans, certificates of occupation and/or final approval. A separate structural certification will be required for any structural elements. The Certificate of Hydraulic Compliance needs to:

- state that the system will function and can be maintained^{xiii} in accordance with the approved designs, subject to satisfactory maintenance;
- state what percentage of any rainwater tank contributes to the OSD storage and document that tank has been plumbed for non-potable uses inside and outside^{xiv}.
- identify any variations from the approved design, and state that these variations will not impair the performance of the OSD system.

^{xi} Weir calculations clarified in third edition

^{xii} Accreditation requirements added in third edition.

^{xiii} Maintainability added in third edition

^{xiv} Certification of rainwater tank characteristics added in third edition

Alternatively, where variations are identified that impair the performance of the OSD system, the OSD designer will need to complete an Outstanding Works form. This form lists the variations from the approved design and the required remedial works. Where significant remedial works are necessary, discussions should be held with the relevant council officers and arrangements made to have these works carried out prior to the issue of a Certificate of Hydraulic Compliance by the OSD designer or final approval by council.

The Certificate of Hydraulic Compliance is the principal means by which adequate construction standards are ensured and certification needs to be conducted in a professional manner. Whilst the Certificate will be based on the work-as-executed plans, the OSD designer will need to inspect the site to check critical design features.

Some of the important considerations to be addressed when certifying hydraulic compliance are that for:

Discharge Control Pits:

- a plate with a sharp-edged orifice of the correct diameter and the specified material has been securely fitted;
- the discharge control pit (DCP) dimensions satisfy minimum parameters, eg. width, design head, and clearance from screen;
- the orifice is screened and the screen is properly fixed, located and able to be removed for cleaning;
- outlet pipes from the DCP are the correct size, level and grade to ensure there is free discharge through the orifice;
- the levels of the top water surface, storage invert and DCP are such that the design discharge from the storage is achieved;
- where the design assumes 'high early discharge', runoff from sufficient areas of the site is directed to the DCP to ensure that the design PSD is achieved soon after the commencement of heavy rainfall; and
- the flap valve, if specified, is fitted correctly.

Storage:

- actual storage volumes achieved are adequate;
- the actual top water surface level of the storage will not cause either unintended surcharge of the internal drainage system or inundation of/or inadequate freeboards to finished floor levels; nor will it alter the storage depth sufficiently to impact on the required orifice size;
- the base of the storage is well graded and drains to the DCP; and
- spillways and overflow paths are the correct level and free from obstructions.

Internal drainage

- site gradings are correct;
- the internal drainage lines are of a sufficient size, level and grade to convey flows to the storage;
- if a blockage occurs or the internal drainage lines cannot convey all runoff in a 100 year rainfall event, the site is graded to direct surcharging flows to the storages;
- storages cannot be by-passed by overflows from the internal drainage system or by overflows from any surface area designed to drain to the storages;
- flowpaths designed to divert upstream flows around the basin have been properly constructed and will function as designed; and
- general workmanship is adequate to prevent long-term failure of the system.

Freeboards

- the levels of structures (such as garages, factories, offices and dwellings) are sufficiently above the as-constructed maximum water surface levels in the storage (including the calculated depth of any weir overflow) and flowpaths; and
- an emergency spillway or overflow path is provided to ensure that surcharge of the drainage system and storage (even in the event of an extreme storm or accidental blockage of pits, pipes etc.) will not cause stormwater to enter buildings where significant damage would occur.

Standard Certificate of Hydraulic Compliance Forms and Outstanding Works forms are included in Appendix B.

4.3.5 Structural certification

Due to loadings, certain OSD storage components may require specific structural certification for design and construction. The following list is typical but not exhaustive. This certification should be provided by a qualified, practising structural engineer, except where the components match the standard designs provided in Appendix E.^{xv}

Free standing walls

These are subject to hydrostatic loads when a storage is full or filling. The significance will depend on the maximum ponding depth.

Retaining walls

In addition to the normal earth and hydrostatic loadings, it may be necessary to consider the possibility of saturated sub-soil conditions.

Underground storages

These may be subject to a combination of earth pressures, hydrostatic loadings, traffic loadings and buoyancy forces.

^{xv} Certification requirement clarified in third edition.

4.3.6 Legal protection of OSD systems^{xvi}

OSD systems are structures intended to control site discharges over the entire life of the development. To guarantee the system's continued operation, it needs to be protected from alteration and regularly maintained.

Prior to the issue of final approval (eg. Building Certificate under Section 149 of the Environmental Planning and Assessment Act 1979 and/or the release of any subdivision certificate/line plan) the OSD system and associated floodways and flowpaths need to be legally protected. This is achieved by applying a restriction on the use of the land and a positive covenant over the lot in favour of the local council. These can be imposed either by submitting a suitable Request Form to the Land Titles Office or in conjunction with the registration of a plan showing the new lots to be created. An explanation of the process involved, sample instruments, standard terms and conditions, a copy of the Land Titles Office Information Bulletin 14 and sample forms 13PC and 13RPA, are included in Appendix B, and as listed below.

- B.2 Explanatory notes on the preparation and registration of Positive Covenants and Restrictions on Use of Land.
- B.3 Forms for use under Section 88E(3) of the Conveyancing Act where there is no subdivision of land involved and the covenant and restriction on use are being imposed on an existing parcel of land.
- B.4 Terms and conditions for Restriction on Use of Land and Positive Covenant.
- B.5 Sample Restriction on Use of Land and Covenant where a deposited plan is being registered together with a Section 88B instrument.
- B.6 A copy of Information Bulletin No 14 (dated September 1998), prepared by the Land Titles Office, *A Guide to the Preparation of a Section 88B Instrument to:*
 - *Create Easements, Profits à Prendre, Restrictions on the Use of Land or Positive Covenants*
 - *Release Easements or Profits à Prendre*
- B.7 Sample Covenant used where a deposited plan is being registered together with a Section 88B instrument and construction of the OSD system is being deferred.
Note: Council will only permit deferral of the construction of the OSD systems in exceptional circumstances. (See Section 4.0)^{xvii}

^{xvi} Section expanded to include current Land Titles Office information and clarify process.

^{xvii} Cross reference added in third edition

5.0 The Design Process

This section explains the calculations which will normally be undertaken to determine the OSD parameters. (Reference should also be made to Section 4.0 for issues which affect the design concept.)

A simplified hydraulic/hydrological design method has been prepared for use within the catchment provided that the OSD system has:

- high early discharge (HED), and
- off-line storage.

Where this is not the case, the discharge will be dependant on the shape of the storage and the design will need to be prepared using a calibrated hydraulic/hydrological model acceptable to the Trust. It will be necessary to discuss the project with the relevant council before preparing a design on this basis.

5.1 The OSD design process

5.1.1 Determination of basic parameters

Assuming the proposed OSD system will have HED and an off-line storage:

- measure the total site area (where exclusions apply refer 4.1.3 & 4.1.5);
- calculate the preliminary storage requirement based on a rate of 470 m³/ha; and
- determine the preliminary PSD assuming a rate of 80 l/s/ha.

5.1.2 Adjustment for areas unable to drain to storage

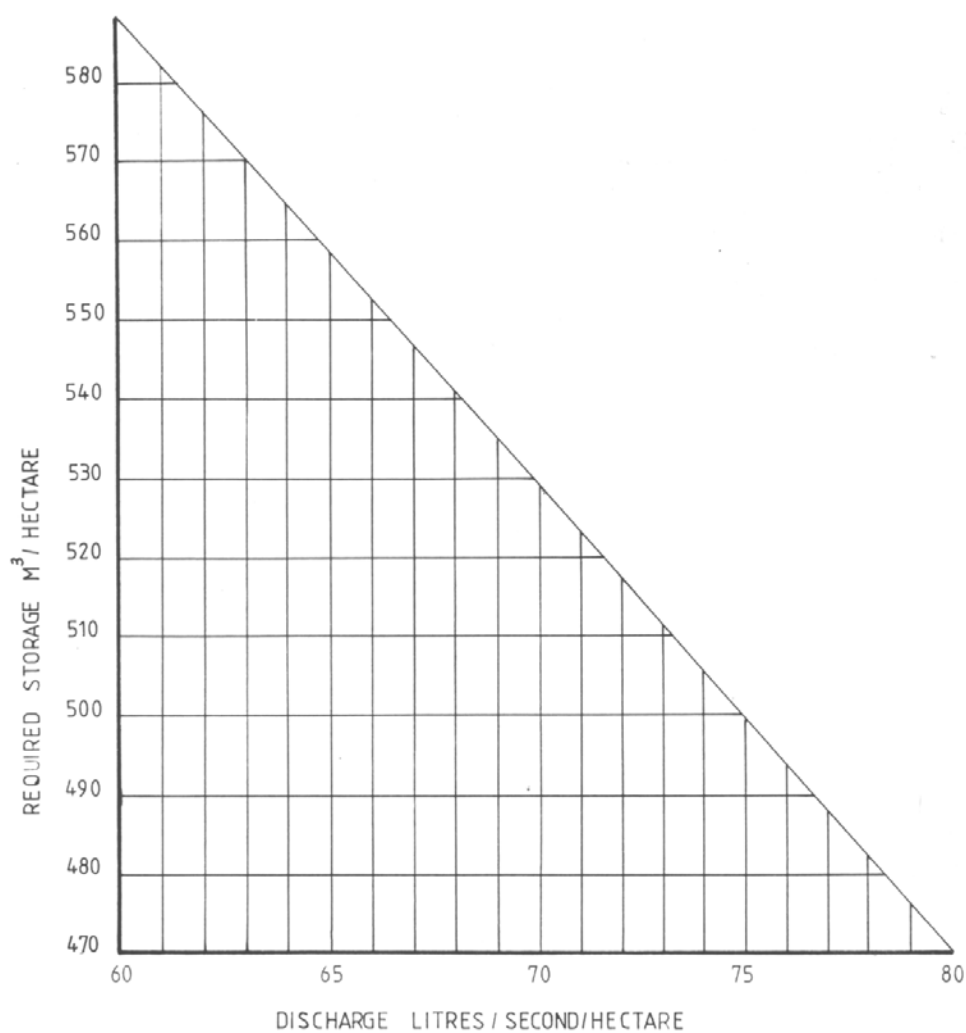
In some cases, it will be impractical for runoff from all of the development site to drain to the OSD storage. In these cases the PSD is adjusted as follows:

- measure the area of the site unable to drain to the storages;
- check that this amount does not exceed 15%ⁱ of the total site area, and
- maintain the basic storage requirement, but adjust the PSD downwards according to the volume/PSD adjustment chart (Figure 5.1). This adjustment ensures the storage is fully utilised during the 100 year ARI event.

Where the area of site unable to be drained is greater than 15%, the rate of site discharge from that area will exceed the PSD of 80 l/s/ha for the standard design storm. This means that no discharge would be permitted from the remainder of the site. As this is not feasible, designers should discuss the possible options with council to reduce the area not drained through the OSD facility.ⁱⁱ

ⁱ Percentage bypassing OSD reduced to 15% in third edition

ⁱⁱ Explanation of reduced bypass area added in third edition



The graph is a straight line approximation of the equation

$$SSR = 74.66 \times PSD^{-0.731}$$

Where: SSR is the Site Storage Requirement in m³/ha

PSD is the Permissible Site Discharge in m³/s/ha

UPPER PARRAMATTA RIVER CATCHMENT TRUST

VOLUME / PSD ADJUSTMENT CHART

FIG. 5.1

5.1.3 Adjustment for HED

Following the design of the DCP, it is necessary to adjust the preliminary storage requirement to account for the fact that the PSD is not achieved until the storage is full. As the average discharge is less than the PSD, more storage is required to prevent surcharge of the storage. The procedure for calculating the additional storage is:

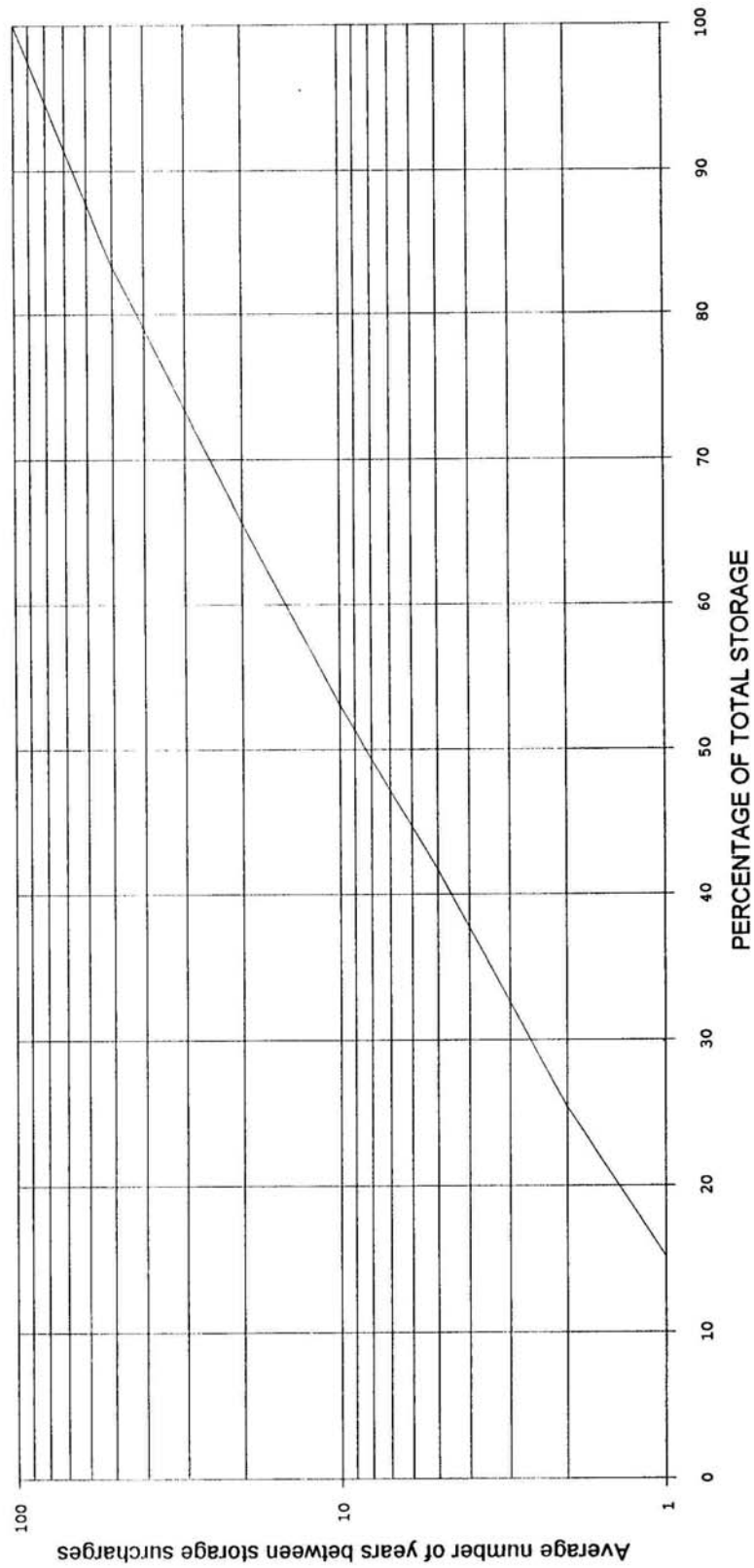
- determine the HED; (ie. the discharge through the orifice when the DCP first overflows to the storage);
- average the adjusted PSD and the HED to determine the average discharge per hectare;
- enter the Volume/PSD Adjustment Chart (Figure 5.1) with the average discharge per hectare and read off the new SSR; and
- apply the above rate to the area draining to the storage to calculate the final site storage volume in m³.

5.1.4 Distribution of storage to minimise inconvenience

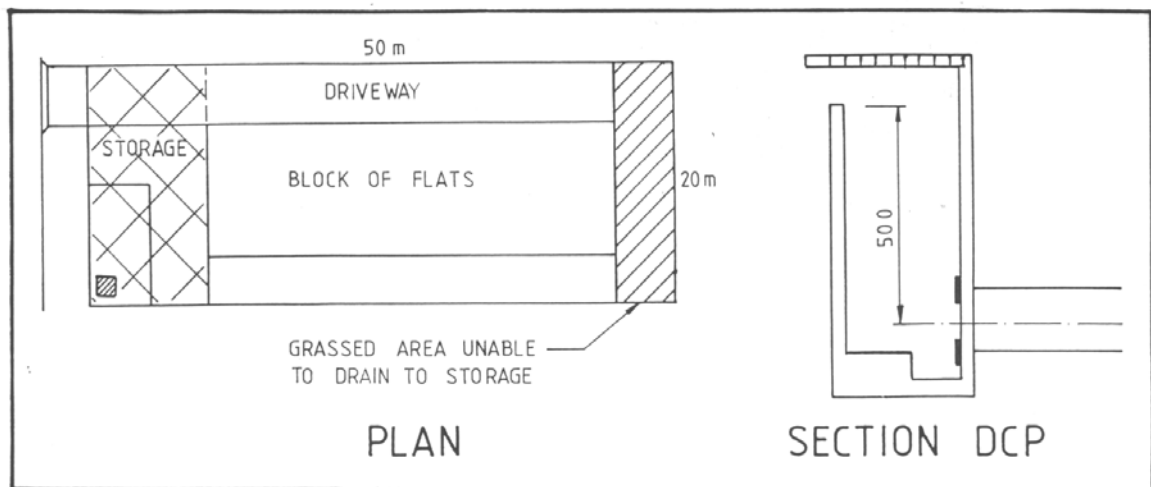
Having determined the required storage volume an estimate can be made of the proportion of storage required to accommodate more frequent storms, and the frequency of inundation of sensitive areas of the site. The Storage Frequency Selection Chart (Figure 5.2) is used for this purpose.

Figure 5.2

STORAGE FREQUENCY SELECTION CHART



5.2 Example



The basic design process described in the previous section is illustrated in the following example.

A block of flats is to be constructed on a 0.1 hectare site. A grassed area at the rear comprising 10% of the site (0.01 hectares) falls steeply to the rear and cannot be drained to the front landscaped and driveway storage.

Calculations

Adjustment for area unable to drain to storage

- | | | | |
|---|--------------------|---|------------------------------|
| • preliminary storage requirement | 470×0.1 | = | 47 m^3 |
| • basic PSD | 0.08×0.1 | = | $0.008 \text{ m}^3/\text{s}$ |
| • area of site draining to storage | | = | 0.09 ha |
| • storage per hectare of contributing area | $47/0.09$ | = | $522 \text{ m}^3/\text{ha}$ |
| • adjusted PSD (enter Volume\PSD adjustment chart Figure 5.1 with $522 \text{ m}^3/\text{ha}$) | | = | 70.6 l/s/ha |
| • final PSD | 70.6×0.09 | = | 6.35 l/s |

Calculation of orifice size

0.07 hectares of the site drains directly to the discharge control pit. The remaining 0.02 hectares is graded to the storage. The overflow weir from the DCP to the storage has been set above the maximum water level in the storage. The length of the weir is 900 mm and the weir is 500 mm above the centreline of the orifice. Accordingly it is necessary to calculate the maximum water depth over the weir before sizing the orifice.

- calculate the peak discharge to the DCP using the Rational Method.

$$Q = CIA/360$$

$$= 1.0 \times 235 \times 0.07/360$$

$$= 0.046 \text{ m}^3/\text{s}$$

$$= 46 \text{ l/s}$$

where Q = discharge in m^3/s

C = coefficient of runoff

I = 100 year rainfall intensity in mm/hr for the time of concentration of the site.

A = area of site draining to storage in hectares.

- the peak flow over the weir to the storage (ie. inflow to the DCP less the PSD).

$$Q^{\text{Weir}} = 0.046 - 0.00635$$

$$= 0.0397 \text{ m}^3/\text{s}$$

$$Q^{\text{Weir}} = CL H^{3/2}$$

$$0.0397 = 1.6 \times 0.9 \times H^{3/2}$$

$$H = 0.091 \text{ m}$$

where C = coefficient of weir discharge

H = depth of flow over the weir in metres

L = length of weir in metres

- required orifice diameter (d)

$$Q = CA\sqrt{2gh}$$

rearrange equation

$$d = (0.464 \times Q / \sqrt{h})^{0.5}$$

$$= (0.464 \times 0.00635 / \sqrt{0.591})^{0.5}$$

$$= 0.062 \text{ m}$$

where C = coefficient of orifice discharge (0.62)

A = area of orifice in m^2

g = acceleration due to gravity
= 9.81 m/s^2

h = depth of water above the centre of the orifice in metres.

d = diameter of orifice in metres.

a 62 mm diameter orifice is necessary.

Adjustment for HED

- $$\text{HED} = \text{PSD} \times \sqrt{h^{\min}/h^{\max}}$$

$$= 6.35 \times \sqrt{(0.5/0.591)}$$

$$= 5.84 \text{ l/s}$$

where HED= discharge in l/s when first flow to storage occurs
 PSD= final PSD in l/s
 $h^{\min}$ = height above centre of orifice at first flow to storage
 $h^{\max}$ = maximum height above centre of orifice
- check this exceeds 75% of the PSD
- mean discharge = $(5.84 + 6.35)/2$
 $= 6.1 \text{ l/s}$
- mean discharge per hectare $= 6.1/0.09 = 67.8 \text{ l/s/ha}$
- calculate SSR (read off value from PSD\Volume Adjustment chart using PSD of 67.8 l/s/ha)
 $\text{SSR} = 540 \text{ m}^3/\text{ha}$
- calculate storage volume needed

$$\text{Final SSR} = 540 \times 0.09$$

$$= 48.6 \text{ m}^3$$

Distribute Storage to Minimise Nuisance

A paved outdoor seating area is to be provided for storms up to the 1 year frequency to prevent the landscaped storage becoming saturated frequently. The storage volume required to meet this criteria is set out below:

- using (Figure 5.2) the storage frequency selection chart enter the graph at 1 year ARI and read off the percentage of the total storage

$$0.16 \times 48.6 = 7.8 \text{ m}^3.$$

The architect and property owner have asked that the frequency of ponding on the driveway be specified, 40m³ of storage has been provided in the landscaped and paved outdoor seating area and 8.2m³ over the driveway.

- percentage of total storage in the outdoor paved and landscaped area

$$40/48.6 = 0.83$$

ie. 83%

- enter Figure 5.2 with 83% of total storage and read off frequency as 1 in 45 years. Therefore ponding will occur on the driveway on average once every 45 years.

Note: Area drained to site storage must now be 85% not 75% as shown in this example.ⁱ

DRAINAGE DESIGN SUMMARY		SUB/DA No. _____
Project: <u>WORKED EXAMPLE</u> Location: _____		
Designed by: _____ Company: _____ Phone: _____		
SITE AREA <u>0.1</u> ha [A]		
*See Section 4.1.5 for dual occupancy		
Basic storage volume	$470 \times [A] \times \underline{0.1}$	= <u>47</u> m ³ [B]
Basic discharge	= $0.08 \times [A] \times \underline{0.1}$	= <u>.008</u> m ³ /s [C]
Area of site drained to storage (Must be as much as possible and not be less than 75% of the total site without written Council approval).		= <u>.09</u> ha [D]
$[D] / [A] + [\underline{0.09}] / [\underline{0.1}] \times 100$		= <u>90</u> % [E]
Storage per ha. of contributing area = $[B] / [D]$	<u>47 / 0.09</u>	= <u>522</u> [F]
Enter volume/PSD adjustment chart (Fig 5.1) using [F], and Read new PSD in litres/second/ha.		= <u>70.6</u> l/s/ha [G]
Determine PSD = $[G] \times [D]$	<u>70.6 \times 0.09</u>	= <u>6.35</u> l/s [H]
Maximum head to orifice centre		= <u>0.591</u> m [K]
Weir flow to storage	$Q^{Weir} = CL(H^{Weir})^{1.5} \therefore H^{Weir}$	= <u>0.091</u> m [I]
Selected orifice diameter: $d = (0.464 \times Q / \sqrt{h})^{0.5} = (0.464 \times [H] / \sqrt{[K]})^{0.5}$		= <u>0.062</u> m [J]
Maximum discharge		= <u>6.35</u> l/s [L]
Head for high early discharge		= <u>0.50</u> m [M]
High early discharge $\{ [L] \times \sqrt{[M] / [K]} \}$ (min 75% of [L])		= <u>5.84</u> l/s [N]
Approximate mean discharge = $([L] + [N]) / 2$		= <u>6.1</u> l/s [P]
Average discharge/ha = $[P] / [D]$	<u>6.1 / 0.09</u>	= <u>67.8</u> l/s/ha [Q]
Enter volume/P.S.D. adjustment chart (Fig 5.1) using [Q] And read off final storage volume per hectare		= <u>540</u> m ³ /ha [R]
Determine final SSR = $[R] \times [D]$	<u>540 \times 0.09</u>	= <u>48.6</u> m ³ [S]
Primary storage proportion = $[S] \times \underline{16}$ %		= <u>7.8</u> m ³ [T]
Secondary storage proportion = $[S] \times \underline{67}$ %		= <u>32.6</u> m ³ [U]
Tertiary storage proportion $[S] \times \underline{17}$ %		= <u>8.2</u> m ³ [V]
Check $[T] + [U] + [V] = [S]$		= <u>48.6</u> m ³

SIGNATURE: _____ DATE: _____

ⁱ Area draining changed in revision 2 of third edition

6.0 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 the 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 which are less than 25 m² in area are not to be used for OSD storage nor for flood storage on flood prone sites.ⁱ

Recommendations for depth and frequency for inundation of different classes of storages are given in the Table below. 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.ⁱⁱ This should include the provision of warning signs and fencing where depths exceed 600 mm near pedestrian traffic areas.

Table 6.1 SUGGESTED FLOOD FREQUENCIES FOR STORAGE AREAS

STORAGE AREA	SUGGESTED DEPTH	FREQUENCY OF INUNDATION
pedestrian areas	50 mm beginning to pond	once in 100 years once in 20 years
parking & driveways	200 mm 100 mm beginning to pond	once in 100 years once in 20 years once in 10 years
gardens	600 mm 400 mm 200 mm beginning to pond	once in 100 years once in 10 years once in 2 years once a year
Private courtyards ⁱⁱⁱ (where the area is between 25 and 60 m ²)	600 mm 300 mm beginning to pond	once in 100 years once in 20 years once in 5 years
Paved recreation in common areas	beginning to pond	6 times per year

ⁱ Design requirements added in third edition.

ⁱⁱ Maximum storage depth specified in third edition.

ⁱⁱⁱ Private courtyards added in third edition

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.

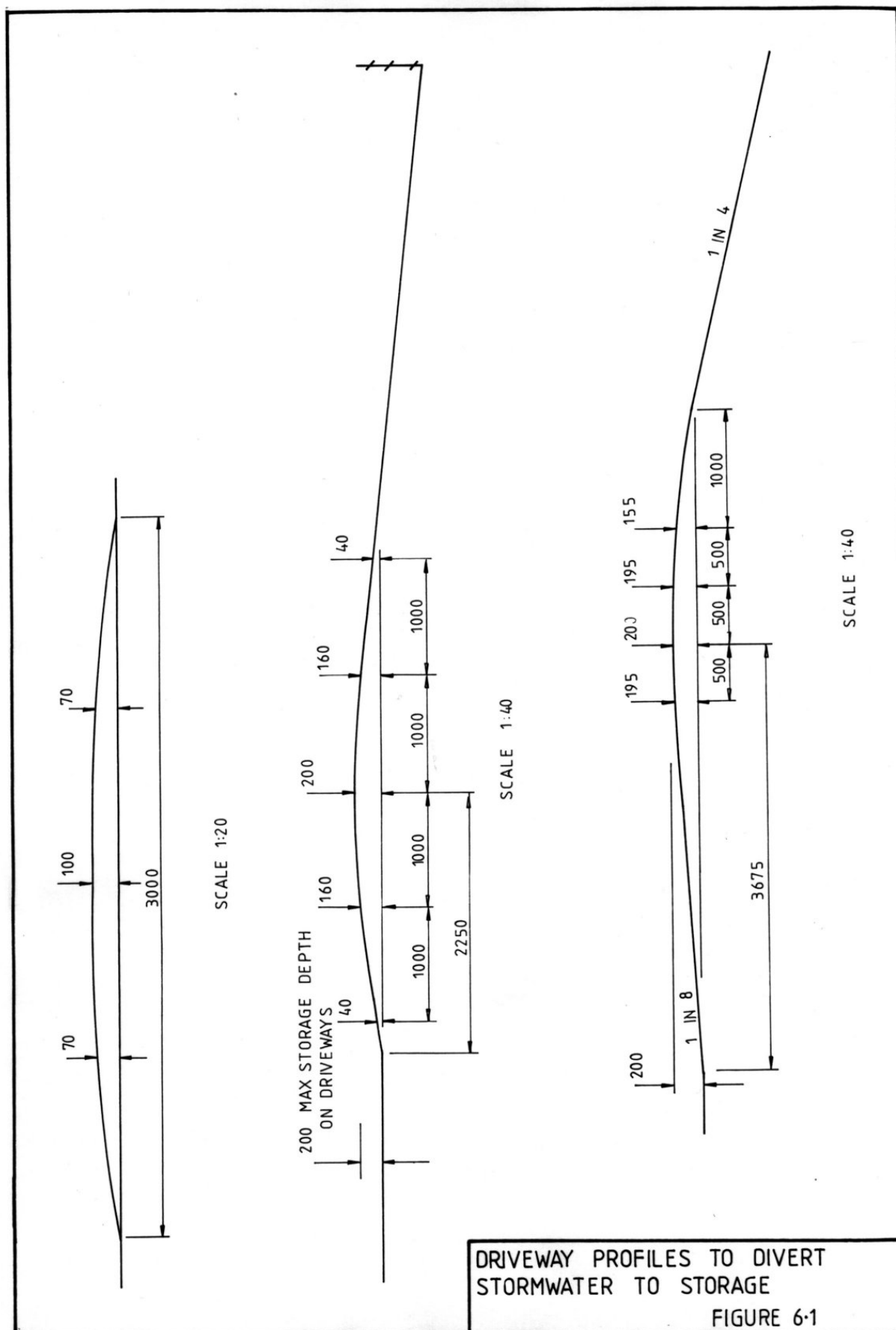
- Grade the site for surface drainage so that when the pipe system fails no serious consequences will occur. The surface flows on many sites are so small that there is no need for any underground drainage system, except for the roof drainage.
- Avoid filling the site with pits that are not needed. Pits 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 which 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 for storage.ⁱ
- 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)ⁱⁱ

6.3 Overflows to a structural storage

Several OSD systems recently examined have had the overflow weir to the structural storage screened to prevent the accumulation of litter and debris in the storage. Screening the overflow weir greatly increases potential for blockage. When the screen becomes blocked, the DCP surcharges and the OSD system fails. Screening the overflow weir is generally impractical because the screen area necessary to maintain the full discharge over the weir is so large. A better solution is shown in Figure 6.2. In this DCP, a basket is provided within the structural storage to collect litter and debris without interfering with flows into the storage.

ⁱ Allowance for sheds added in third edition.

ⁱⁱ Cross-reference added in third edition.



6.4 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 which detract from their effectiveness. The most commonly encountered problems are set out below.

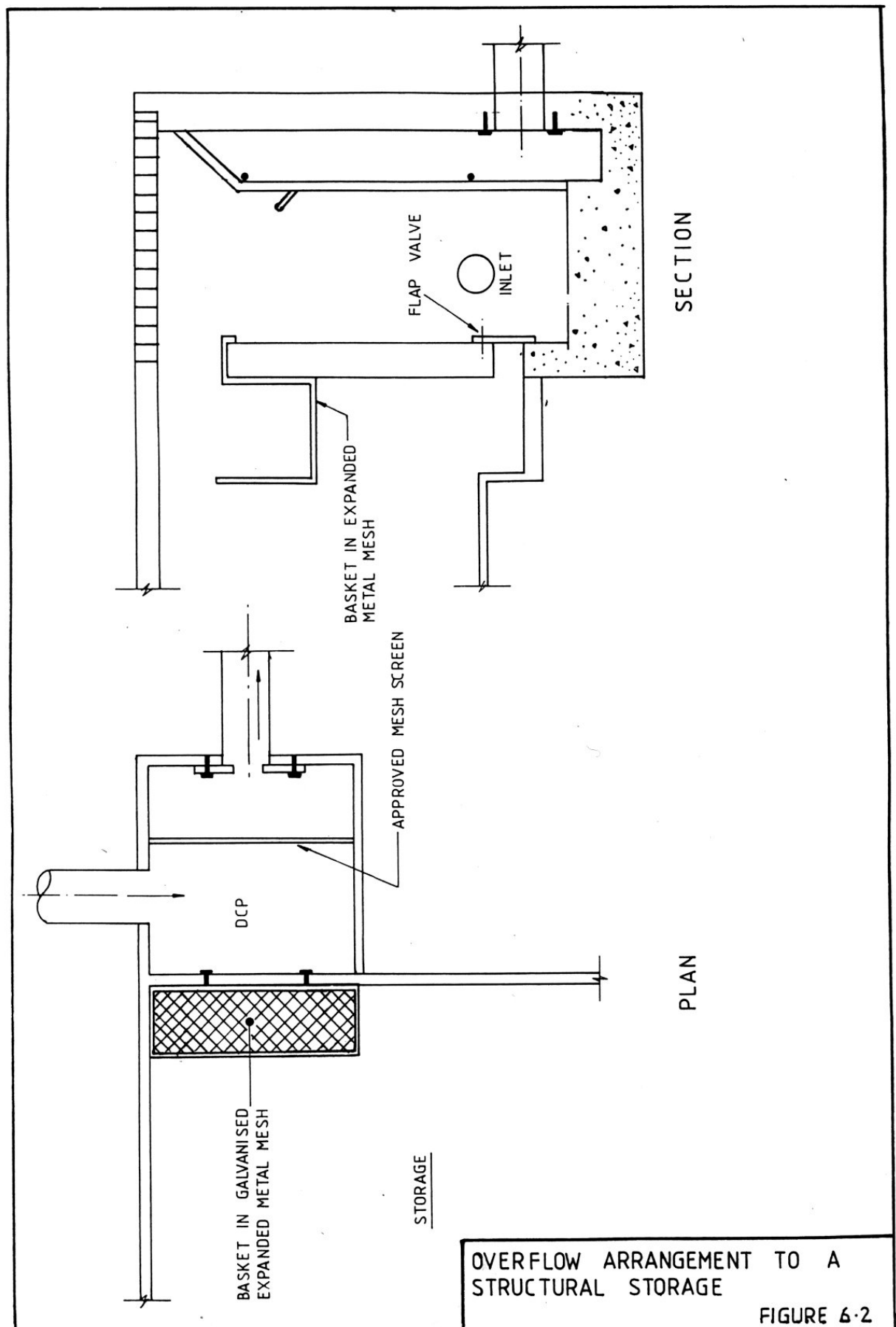
- Deficient Storage Volume - this was particularly common in landscaped storages, and is often the result of incompetent construction, deficiencies or volume losses associated with landscape finishing, or furniture.
- Uncertain Discharge Control - a wide variety of discharge control devices were in use. 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.
- Less than half the inspected systems had screens. When provided, screening was often poorly fabricated in corrodible 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 Systemsⁱⁱⁱ

Field inspections by Council and Trust and the OSD audits carried out by consultants on behalf of the Trust revealed the following deficiencies in OSD systems built since 1994:

- Screens placed vertically in DCPs but not to the top of the DCP allowed debris to float over screen and obstruct 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.

ⁱⁱⁱ Recent experience added in third edition.



6.5 Drowned Outlets

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

An OSD system is designed to control flows in all storms up to and including the 1 in 100 year event, while the downstream drainage system is often only able to cater for smaller storms (typically 1 in 5 year or 1 in 20 year) without surcharging. The effect of this surcharging on the outlet of a DCP is shown in greater detail in Figure 6.3.

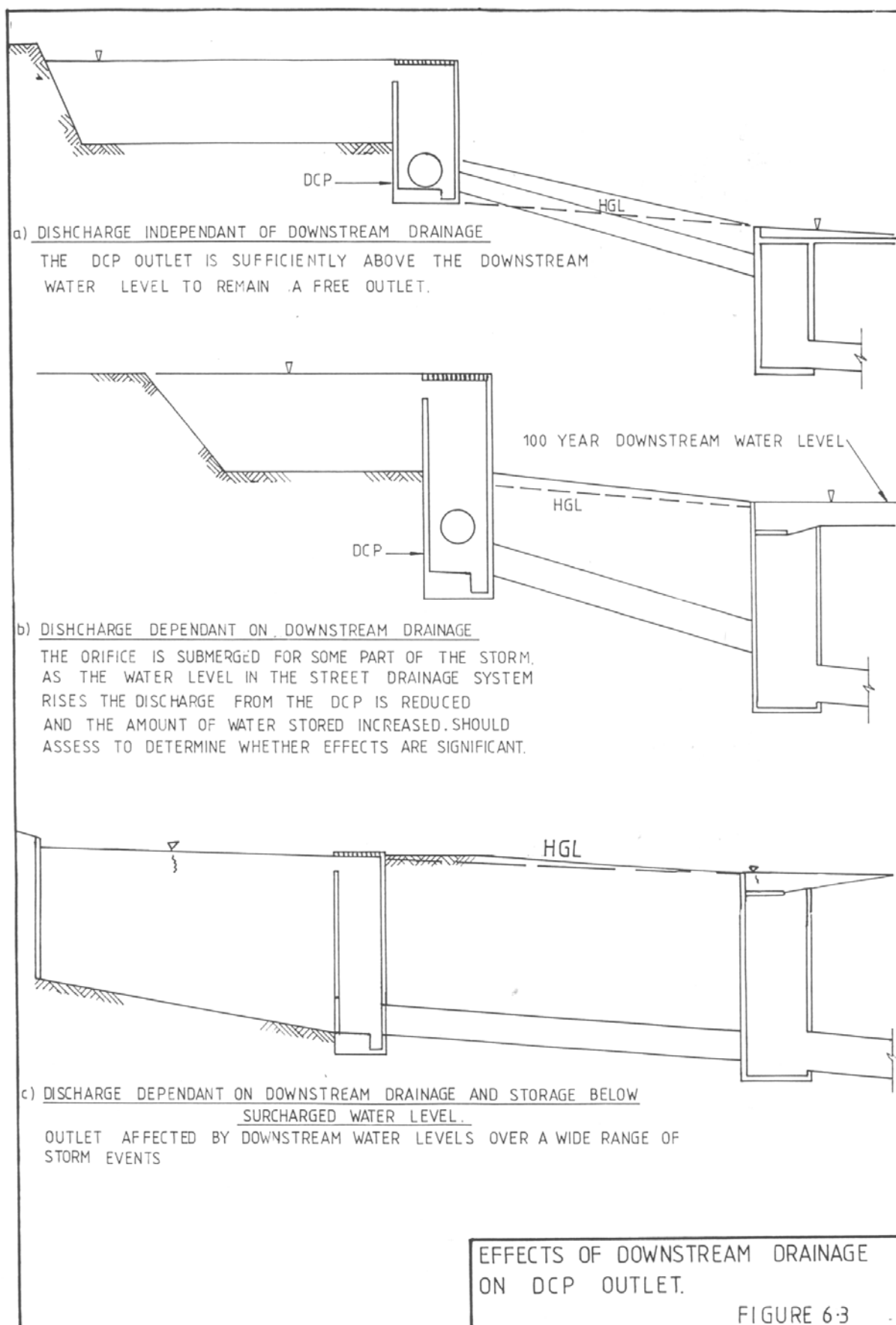
Figure 6.3 (a) shows a drainage system where the outlet to the DCP is above the downstream water level. The orifice will discharge freely, even in a severe storm event. This outlet arrangement gives the designer the most certain form of discharge control.

Figure 6.3 (b) shows a system where, due to site drainage constraints, it has not been possible to locate the DCP outlet above the surcharged water level downstream and the outlet is submerged. In this case, it will be necessary to assess whether the submergence is significant.

When the outlet is submerged, the effective head becomes less and the discharge from the DCP is reduced, causing the storage to fill more quickly. OSD storages are designed to fill in longer storm events than will generally cause the street drainage system to surcharge. Therefore the additional storage in these shorter events may not cause the OSD system to spill. The HED feature also reduces the effects of downstream submergence and assists in preventing flows from the street drainage system entering the storage.

Figure 6.3 (c) shows a storage located below the downstream water level. The outlet from the DCP 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 more severe events, there is a possibility of flows from the street drainage system entering the OSD storage. Consideration should be given to raising the storage and DCP or using a tailwater discharge compensator.

A tailwater discharge compensator has been successfully trialed in the laboratory (refer to Manly Hydraulics Laboratory report MHL657). The purpose of such a device is to allow drainage from a storage to a receiving stream or pipe which has its invert below that of the storage but a potential water level above the primary orifice. The device would not be used in the case of trivial outlet submergence. However on projects, with more difficult downstream drainage conditions, it may be worth considering.



6.6 Designing for maintenance^{iv}

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 designers 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. Primary storage should be underground or in little used areas.
- 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 DCP in an accessible location, often a slight regrading of the storage floor will allow you to move a DCP 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. This should 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.
- Use a guide channel inside the 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.

6.7 DCP 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
- 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

^{iv} Additional design hints added in third edition.

of OSD systems have revealed that where a fine mesh screen is securely fitted to the walls and floor of the 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
- construction debris, (typically concrete slurry), blocking weep holes in the pit floor.

For these reasons the suggested design for the Discharge Control Pit^v no longer has a sump over the whole floor. A localised sump is provided adjacent to the orifice.

6.8 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 addition the outlet pipe from a storage needs to be connected downstream of the outlet of the DCP of any other storage.

6.9 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 design discharge is within plus or minus 5% of the PSD.

^v Standard DCP altered for practicality in third edition. (See Figure 4.3)

7.0 Case studies

7.1 A unit site with standard coverage

A residential flat development of 12 units on a site with 4% diagonal fall to the rear of the property discharges to an existing piped easement. The total site area is 1,350 m².

The design has placed the buildings as low as possible, possibly in response to height limitations, and garage floors are only 200 mm above the ground level at the lowest corner of the block.

This makes any form of drainage difficult but makes an OSD solution a more reliable one in protecting the garages than conventional drainage would be. OSD is much less dependent on the condition of the downstream pipe system and will normally continue to protect the property during periods when the downstream system is full while a fully piped system, denied a free outlet, instantly backs up and fails at the entry points.

See Figure 7.1 for the layout, Figure 7.2 for the discharge control pit connections and Figure 7.3 for the storage calculations. A completed Drainage Design Summary sheet also follows.

The solution

Primary storage is provided in a shallow tank beneath a section of the parking area to take the once in 1 year storm. 8.5 m³ is required here. When this storage fills, it overflows through its surface entry grate and cascades to the adjoining garden area, where it gradually builds to the level at which the visitor car-park begins to flood. This will occur about once every 10 years on average. Water will also back-up into the drying and play areas, but only in very severe rainfall when there is little likelihood of these areas being in use.

Outlet control

PSD = 0.1350 x 0.08 l/sec.

PSD = 10.8 l/s. No adjustment is needed as every part of the site falls to the storage.

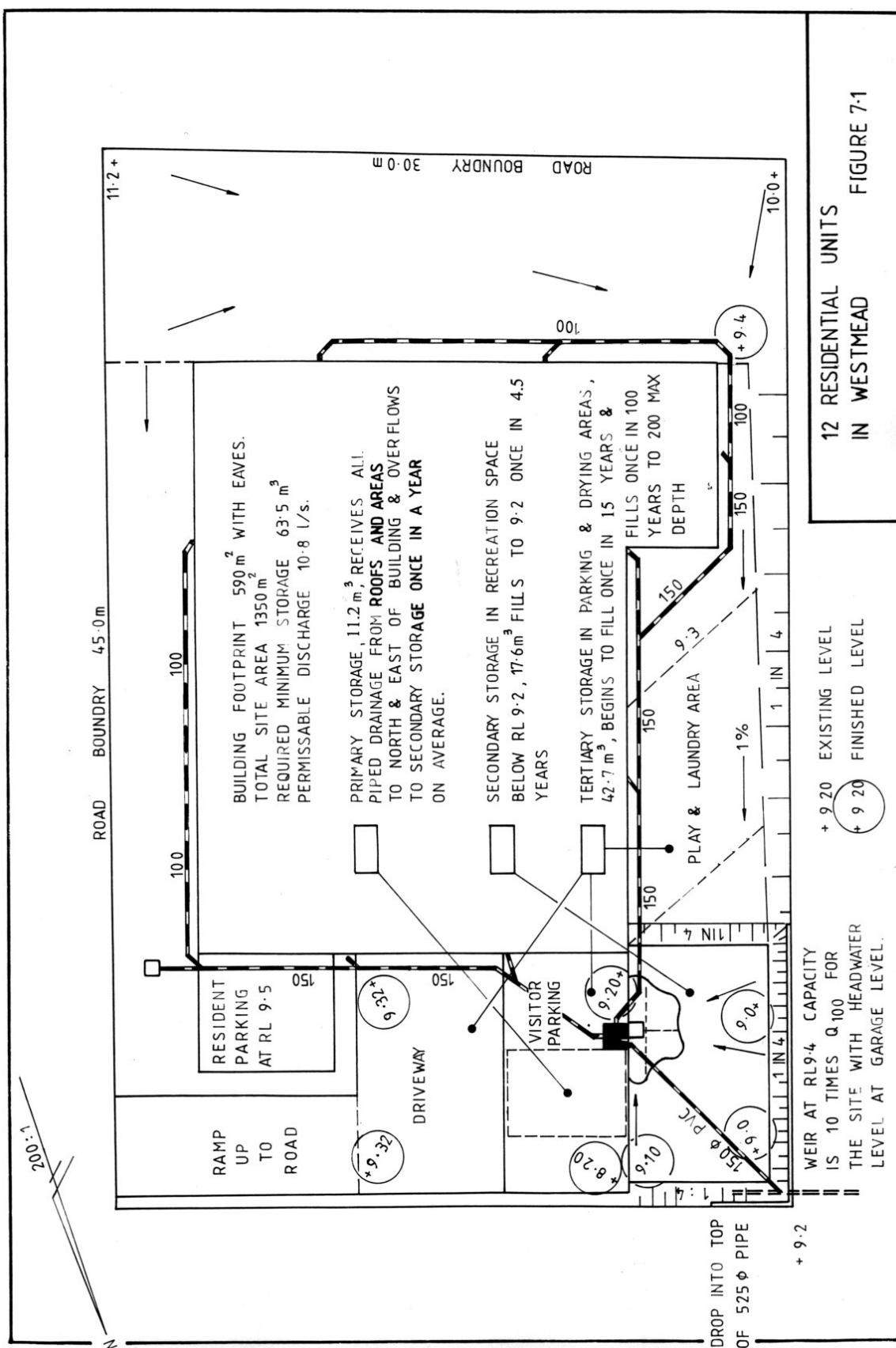
The council stormwater pipe is steep graded and will run part-full for most flows, allowing a free discharge.

Maximum outflow occurs with the storage level is at R.L. 9.4 m.

Maximum head to orifice is therefore 0.925 m.

Calculate orifice diameter for outflow of 10.8 l/s.

$$\begin{aligned}
 d &= (0.464Q / \sqrt{h})^{0.5} \\
 &= \frac{(0.464 \times 0.0108)^{0.5}}{\sqrt{0.925}} \\
 d &= 72 \text{ mm}
 \end{aligned}$$



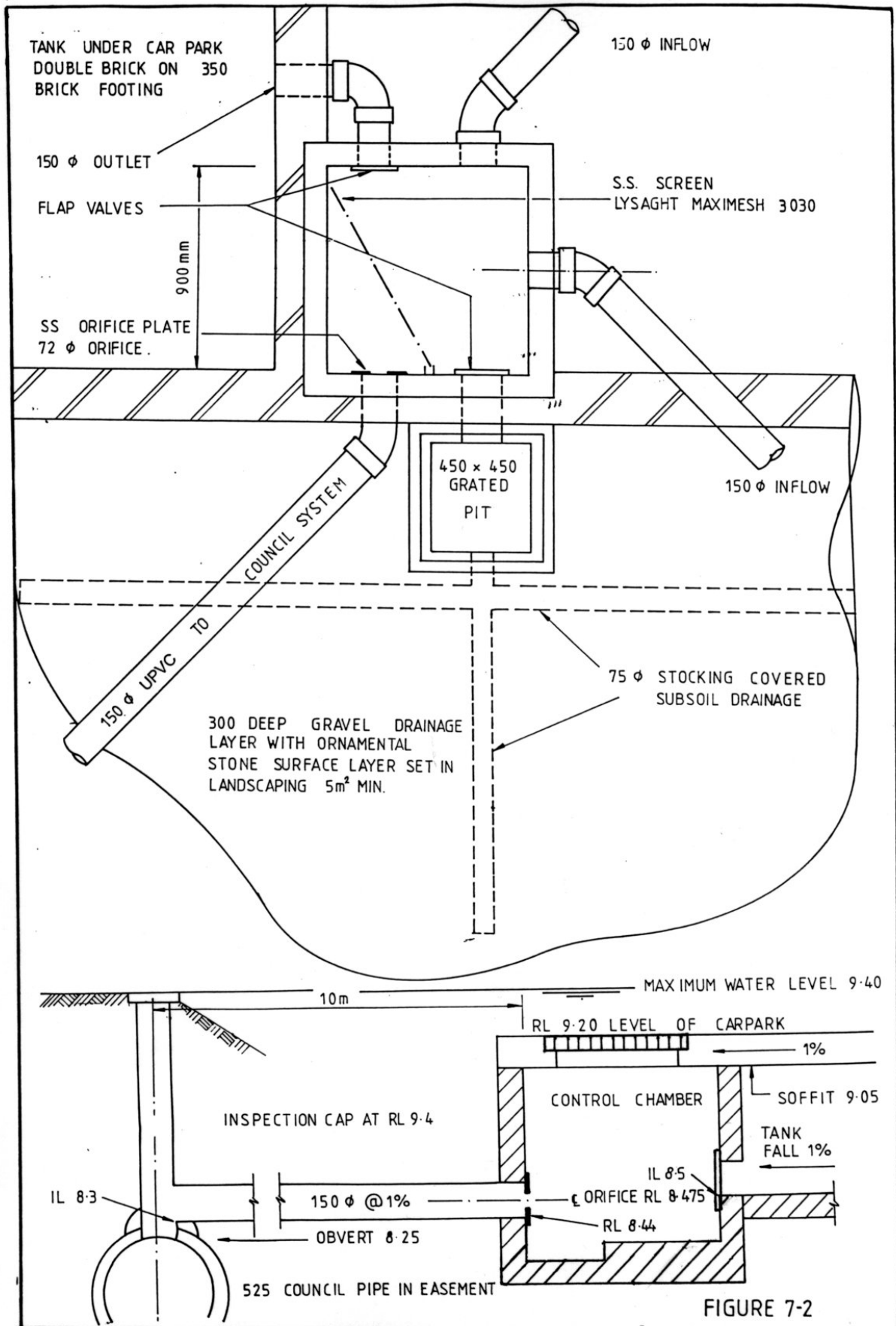


FIGURE 7-2

High early discharge will occur as the pit overflows to the storage chamber through the 0.9m long overflow weir. If the storage is to protect the garden from surcharges for the once in one year storm, the overflow needs to pass the once in one year flow before the pit grate level is reached.

The area drained to the outlet pit during severe storms includes the building, the car-park and all land to the east of these, some 900 m². Runoff from other areas cannot pass the flap valve controlling the garden sump while the outlet pit is full. Assuming a 5 minute response time:

$$\begin{aligned} Q_2 &= FCIA \\ &= 0.00278 \times 0.95 \times 83.8 \times .09 \\ &= 0.020 \text{ m}^3/\text{s} \end{aligned}$$

Calculating the depth of flow over the weir:

$$\begin{aligned} Q &= CLH^{3/2} \\ H &= (Q/CL)^{2/3} \\ &= (0.02/1.6 \times 0.9)^{2/3} \\ &= 0.058 \text{ m} \end{aligned}$$

To ensure that the grate does not interfere with the weir flow, a 58 mm clearance to the underside of the grate is needed, placing the weir level 150 mm below the top of the grate.

$$\begin{aligned} \text{Weir level} &= 9.2 - 0.15 = 9.05 \text{ m.} \\ H_{\min} &= 9.05 - 8.475 = 0.575 \text{ m.} \end{aligned}$$

Orifice discharge is in the ratio of $\sqrt{h}$.

$$\begin{aligned} \text{So HED} &= \text{PSD} \times \sqrt{h_{\min}/h_{\max}} \\ &= 10.8 \times \sqrt{0.575/0.925} \\ &= 8.5 \text{ l/s.} \end{aligned}$$

$$\begin{aligned} \text{Average discharge} &= 0.5 (8.5 + 10.8) \\ &= 9.65 \text{ l/s.} \end{aligned}$$

Figure 5.1 is now used to estimate the final storage volume following the example in Section 5.2.

$$\begin{aligned} \text{Average discharge per hectare} &= 9.65 \times 10,000/1350 \\ &= 71.5 \text{ l/s/ha} \end{aligned}$$

Enter the chart with 71.5 l/s/ha and read off the adjusted required storage as 520 m³/ha.

$$\text{So the final SSR becomes } 520 \times 0.1350 = 70.2 \text{ m}^3.$$

This additional storage results from a relatively less efficient outlet. It could probably be reduced with an alternative pit detail. The outlet is probably not worth reworking as the extra storage volume can be provided at very little cost because it represents less than 5 mm of depth increase over the full storage in the most severe storm.

Volumes

Primary storage

The tank beneath the parking area is to store the one in one year storm. Figure 5.2 shows that 16% of the SSR is needed to do this.

$$0.16 \times 70.2 = 11.2 \text{ m}^3$$

The maximum storage depth on the tank is 0.55m (see outlet arrangement).

Using the length of a parking bay as 5.5 metres and with 150 mm block walls surrounding the tank, the width required becomes:

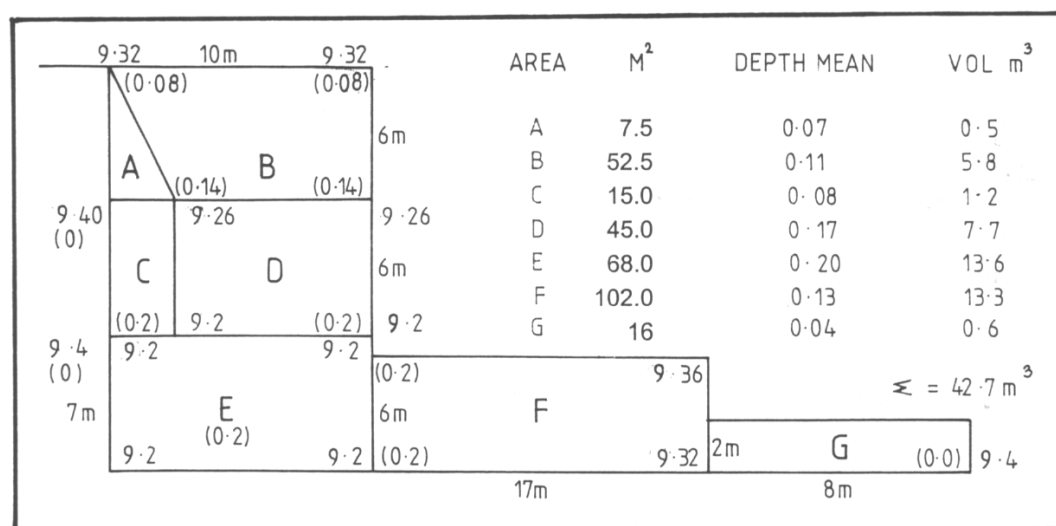
$$w = \frac{11.5}{(5.5 - 0.3) \times 0.55} = 3.91, \text{ say } 4 \text{ m}$$

Tertiary storage

Flooding of the parking, laundry and play areas is restricted to a maximum 200 mm depth, except in the landscaped area designated for secondary storage.

The volume of water stored between R.L.9.4 and 9.2 extends over all areas and is computed as follows:

Figure 7.3 Storage Volume Calculations



The volume of secondary storage needed:

$$\begin{aligned} \text{Secondary Storage} &= \text{SSR} - \text{Primary Storage} - \text{Tertiary Storage} \\ &= 70.2 - 11.2 - 42.7 \\ &= 16.3 \text{ m}^3 \end{aligned}$$

This area will be provided in area E below RL 9.2.

Lower, the edges to the storage area by 0.2m to RL 9.0 m. Then grade evenly to the collection pit, adjusting the surface levels to suit the volume required.

If the grate level of collection pit is 8.88 m, then:

$$\begin{aligned} \text{Secondary Storage} &= (6.8 \times 0.2 + 6.8 \times 0.12/3) \times 10 \\ &= 16.3 \text{ m}^3 \end{aligned}$$

Check return flow from collection pit to DCP

The lowest invert level for a pipe from the collection pit to the DCP which will still drain the collection pit is at the orifice invert of RL 8.44 m. This is only 440 mm below the pit surface, allowing a 10 mm fall across the pit gives a maximum pit depth of 430 mm.

Check frequency of ponding on the parking and drying areas

(Using Figure 5.2)

Total Storage below RL 9.2 is 27.5 m^3 i.e. 39% of the SSR.

From Figure 5.2 it can be seen that the parking and drying areas will have water ponding on them on average once in every 4.5 years.

Check Overflow Weir

A kerb is required on the western and northern boundaries to set the storage level at RL 9.40 m, a little above downstream properties. Fencing in this location should be built leaving 75 mm clearance to the kerb.

$$\begin{aligned} Q_{\text{weir}} &= CLH^{3/2} \\ &= 1.6 \times 15.5 \times (0.1)^{3/2} \\ &= 0.784 \text{ m}^3/\text{s} \end{aligned}$$

$$\begin{aligned} Q_{100} &= FCIA \\ &= .00278 \times 0.95 \times 217 \times 0.135 \\ &= 0.077 \text{ m}^3/\text{s} \end{aligned}$$

Weir capacity is 10 times the 100 year flow from the site by the time water builds to garage floor level.

In summary

Originally this project had been designed to provide on-site detention of 20 m^3 with a SSR lower than the Trust's requirement and a cost comparison has been prepared.

Total construction costs for the Trust proposal showed a saving on the earlier proposal, while providing more than three times the storage volume. The all-up costs of drainage should be about \$1,500 per unit, including an allowance for effective engineering supervision. This estimate does not include ancillary work not directly involved in drainage such as final trimming of excavation to finished levels on landscaping works. A slightly higher basement would have been an advantage gaining head for the outlet works. As well, the long level driveway within the building could have been set 150 mm below the garage floors and allowed to flood (say) once in 50 years without causing serious alarm.

Such opportunities to create considerable volumes of storage at no cost, where only marginal level adjustments are needed, can often be found. With early input into the level and layout of this job, an OSD designer could have worked with the landscape designer to produce an OSD arrangement costing no more than a conventional piped drainage solution and with rather better security of operation.

Note: Area drained to site storage must now be 85% not 75% as shown in this exampleⁱ

DRAINAGE DESIGN SUMMARY		SUB/DA No. _____
Project: <u>CASE STUDY 7.1</u> Location: _____		
Designed by: _____ Company: _____ Phone: _____		
SITE AREA <u>0.135</u> ha [A]		
*See Section 4.1.5 for dual occupancy		
Basic storage volume	$470 \times [A] \times \underline{0.135}$	= <u>63.5</u> m ³ [B]
Basic discharge	= $0.08 \times [A] \times \underline{0.135}$	= <u>0.0108</u> m ³ /s [C]
Area of site drained to storage (Must be as much as possible and not be less than 75% of the total site without written Council approval).		= <u>0.135</u> ha [D]
$[D] / [A] \times 100$	$[\underline{0.135}] / [\underline{0.135}] \times 100$	= <u>100</u> % [E]
Storage per ha. of contributing area = [B]/[D]		= <u>470</u> [F]
Enter volume/PSD adjustment chart (Fig 5.1) using [F], and Read new PSD in litres/second/ha.		= <u>80</u> l/s/ha [G]
Determine PSD = [G] x [D]	<u>80</u> x <u>0.135</u>	= <u>10.8</u> l/s [H]
Maximum head to orifice centre		= <u>0.925</u> m [K]
Weir flow to storage $Q^{Weir} = CL(H^{Weir})^{1.5}$ $\therefore H^{Weir}$		= <u>0.058</u> m [I]
Selected orifice diameter: $d = (0.464 \times Q / \sqrt{h})^{0.5} = (0.464 \times [H] / \sqrt{[K]})^{0.5}$		= <u>0.072</u> m [J]
Maximum discharge		= <u>10.8</u> l/s [L]
Head for high early discharge		= <u>0.575</u> m [M]
High early discharge $\{[L] \times \sqrt{[M] / [K]}\}$ (min 75% of [L])		= <u>8.5</u> l/s [N]
Approximate mean discharge = ([L]) + [N] / 2		= <u>9.65</u> l/s [P]
Average discharge/ha = [P] / [D]	<u>9.65</u> / <u>0.135</u>	= <u>71.5</u> l/s/ha [Q]
Enter volume/P.S.D. adjustment chart (Fig 5.1) using [Q] And read off final storage volume per hectare		= <u>520</u> m ³ /ha [R]
Determine final SSR = [R] x [D]	<u>520</u> x <u>0.135</u>	= <u>70.2</u> m ³ [S]
Primary storage proportion = [S] x <u>16</u> %		= <u>11.2</u> m ³ [T]
Secondary storage proportion = [S] x <u>23</u> %		= <u>16.3</u> m ³ [U]
Tertiary storage proportion [S] x <u>61</u> %		= <u>42.7</u> m ³ [V]
Check [T] + [U] + [V] = [S]		= <u>70.2</u> m ³

SIGNATURE: _____ DATE: _____

ⁱ Area draining changed in revision 2 of third edition

7.2 A site with full coverage and no spare floor space

The proposed office development is on a very tight remnant site from which the maximum utility has been achieved without prior consideration being given to OSD. The site falls to the street where there is immediately adjacent drainage. Conventional drainage from the pitched roof would deliver runoff from the entire catchment to the street system in under two and a half minutes at essentially 100% runoff.

See Figure 7.4 for the site layout and storage calculations. A completed Drainage Design Summary sheet also follows.

Solution

Primary storage is to be provided in a galvanised steel tank suspended beneath the ceiling of the upper parking level, hard against the rear boundary. The provision of 8m³ is needed to limit ponding frequency of the secondary storage to slightly in excess of 1 in 5 years.

Secondary storage is to be provided on a deck which is lowered between upstanding beams to retain general clearance on this part of the upper parking level at the proposed under beam clearance under beams shown on architectural.

Overflow can be provided by setting the edge beam adjacent to the residential driveway 75 mm below the office threshold level. With the weir length available, this would allow many times Q₁₀₀ to overflow without affecting the offices.

Volumes

Tank: 8m³ required.

Building with inside structure 9.4 m, so 9.3 m long tank is feasible.

Tank width say 1.2 m.

$$\text{so depth} = 8.0 / (9.3 \times 1.2) = 0.72 \text{ m.}$$

The tank can use airspace at the extreme rear of the building where suspended services are not a problem. Clearances for the tank need to be checked against the Australian Standard AS 2890.1 *Parking Facilities - Off-Street Parking*.ⁱⁱ There is no problem in this case although there is a minor nuisance in that access to the boot (or bonnet) of cars using the four spaces affected would not be possible without moving the vehicles.

Deck: 9.9 m³ required.

Upturning of edge-beams and depressing the deck provides a potential pond 300 mm deep below office floor level with a surface area of 9.4 x 5.7 metres.

$$\text{So depth for 1\% AEP storm} = 9.9 / (9.4 \times 5.7) = 0.185 \text{ m.}$$

Slab will require surfacing as a recreation space and the provision of some fall to drainage. 'Fullgoes' on a line just inside the suspended tank at 3m centres will allow a general 0.5% fall with only 20 mm level variation over the deck area. A further 20 mm is allowed for surfacing the slab.

$$\begin{aligned} \text{so freeboard to office floor} &= 0.300 - 0.185 - 0.040 \\ &= 0.075 \text{ m} \end{aligned}$$

ⁱⁱ Reference to standard added in third edition.

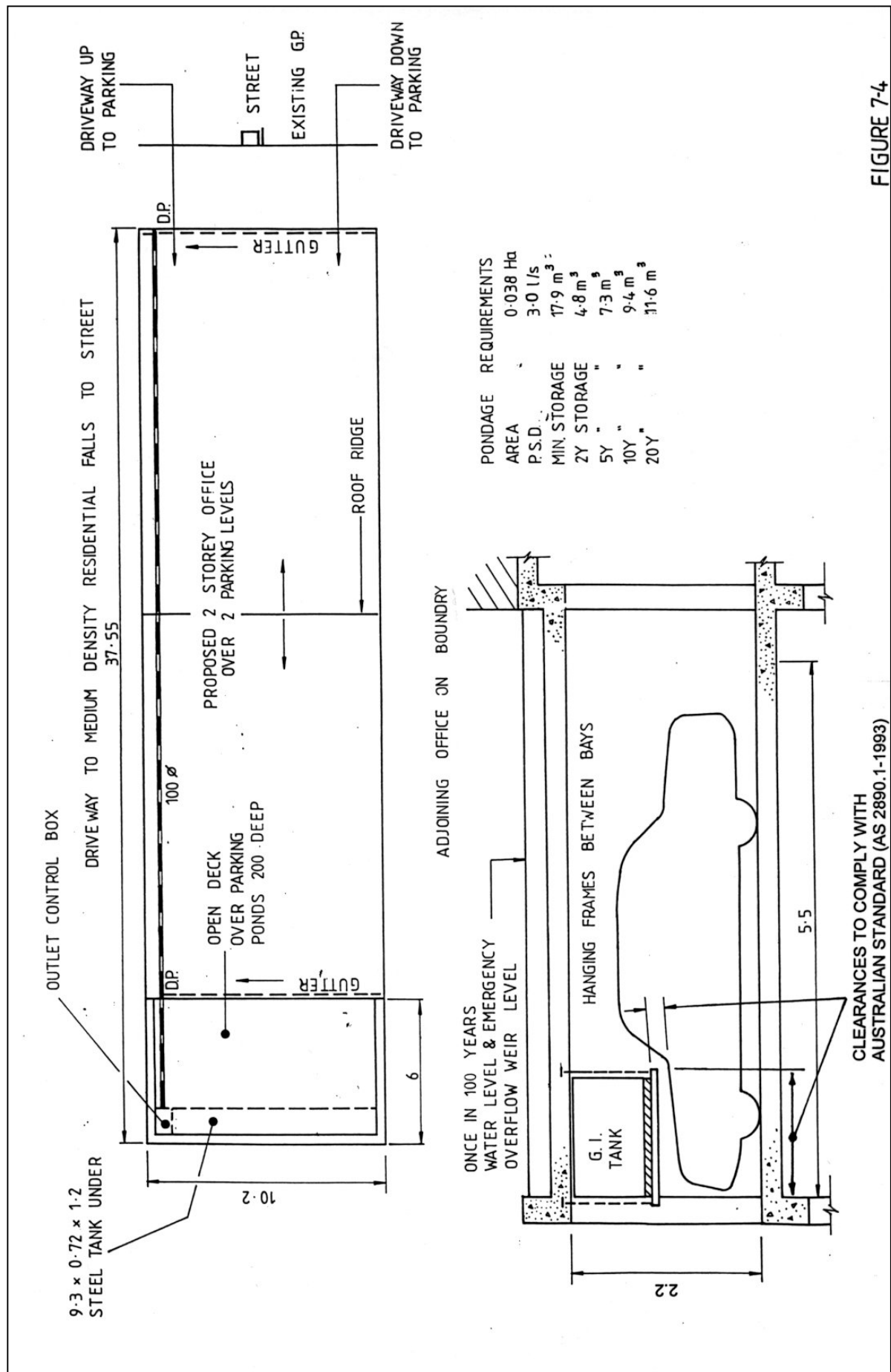


FIGURE 7-4

If overflow weir is set as this level (i.e. top of one side beam) the weir length is 6.0m.

$$\begin{aligned}
 Q &= CLH^{3/2} \\
 &= 1.6 \times 6 \times (0.075)^{3/2} \\
 &= 0.197 \text{ m}^3/\text{s} \\
 &= F C I A
 \end{aligned}$$

$$\begin{aligned}
 Q_{100} &= 0.0278 \times 0.038 \times 0.95 \times 230 \\
 &= 0.023 \text{ m}^3/\text{s} \quad \ll \text{ overflow capacity.}
 \end{aligned}$$

Outlet control

- Maximum outflow occurs with about 200 mm of water stored at the lowest point of the deck.
- Assume 200 mm slab thickness.
- Nominal tank depth is 720 mm, but allow 1% fall to outlet over 9 metres to make maximum depth 810 mm.
- A small drop is needed into the discharge chamber to facilitate flap valve operation, say 40 mm.
- No sump is proposed as there is no source of silt and the orifice will be horizontal in the base of the chamber to allow complete drying and minimise corrosion.

Maximum head to orifice is therefore 1.25 m.

Determine diameter d from:

$$Q = CA \sqrt{2gh} \quad \text{where } C = 0.62$$

$$d = (0.464 \times Q / \sqrt{h})^{0.5}$$

$$d = \frac{(0.464 \times 0.003)^{0.5}}{\sqrt{1.25}}$$

$$\text{so } d = 35 \text{ mm.}$$

Check high early discharge

All stormwater is directed to the outlet control chamber which substantially fills early in the event before outflow into the primary storage begins.

Assuming the outflow chamber to be the same width as the tank, 1.2 m

$$\begin{aligned} Q &= F C I A \\ &= .00278 \times 0.95 \times .038 \times 137.6 \\ &= 14 \text{ l/s} \end{aligned}$$

$$Q = CLH^{3/2}$$

$$\text{so } H = \left(\frac{0.014}{1.6 \times 1.2} \right)^{2/3}$$

$$H = 0.038 \text{ m}$$

With weir depth below tank soffit, the head for high early discharge becomes
 $1.25 - 0.40 = 0.85 \text{ m}$.

Orifice discharge is in the ratio of $\sqrt{h}$

$$\begin{aligned} \text{so, High Early Discharge} &= \text{PSD} \times \sqrt{(0.85 / 1.25)} \\ &= 2.5 \text{ l/s} \end{aligned}$$

$$\begin{aligned} \text{Average discharge} &= (\text{PSD} + \text{HED})/2 \\ &= (3.0 + 2.5)/2 \\ &= 2.75 \text{ l/s} \end{aligned}$$

Check Additional Storage.

$$\begin{aligned} \text{Average discharge per hectare} &= 2.75/0.038 \\ &= 72.4 \text{ l/s/ha} \end{aligned}$$

Using Figure 5.1 with a discharge of 72.4 l/s/ha

$$\begin{aligned} \text{SSR} &= 512 \text{ m}^3/\text{ha} \\ \text{required storage} &= 512 \times 0.038 \\ &= 19.5 \text{ m}^3 \end{aligned}$$

$$\text{Increased ponding on deck } 19.5 - 17.9 = 1.6 \text{ m}^3$$

$$\begin{aligned} \text{increased depth} &= 1.61 / (5.7 \times 9.4) \\ &= 0.03 \text{ m} \end{aligned}$$

Check freeboard to office floor with extra 30 mm water depth

$$\begin{aligned} Q &= CLH^{3/2} \\ Q &= 1.6 \times 6 \times 0.045^{3/2} \\ &= 0.092 \text{ m}^3/\text{s} \\ &= 92 \text{ l/s (overflow capacity } 4 \times Q_{100} \text{ before office} \\ &\quad \text{floor level reached.)} \end{aligned}$$

Check Loading

Water on deck has average depth of 0.21 m representing a live load of 2.1 kPa. The deck must be designed for 4.0 kPa as a balcony or public area and coincidence of crowd loading and flooding would not occur. There remains the linear loading of the tank, about 1 tonne/m if fully suspended. This roughly equates to another 1.7 kPa distributed over the full slab indicating that the slab and the three non-adjacent beams need not be any larger than for the non-OSD condition. The immediately adjacent beam may require slight enlargement.

In Summary

This is a fairly typical job. All available space has been allocated and there is a temptation to delete a parking space to build a tank. OSD will be better accepted if it does not limit legitimate land use and there is often a way to do this.

The additional costs, in this case result from the tank construction, about \$4,000, and the drainage line from the tank to the street. A line to bring stormwater to the tank from the front section of the roof will cost the same as the line which would have been needed to bring water from the rear to the street. The extra line, for only 3 l/s, protected from blockage as it is, need only be 65 mm diameter and \$1,000 should be allowed. There was no time to rework this after cost assessment. The rear deck has to be waterproofed to protect parking areas below, so no additional cost should be involved here. But the upturning of beams will involve some additional formworking and upstands may have to be included with a later pour. Allow \$2,000 to bring the total OSD cost for the site to \$7,000.

Note: Area drained to site storage must now be 85% not 75% as shown in this exampleⁱ

DRAINAGE DESIGN SUMMARY		SUB/DA No. _____
Project: <u>CASE STUDY 7.2</u> Location: _____		
Designed by: _____ Company: _____ Phone: _____		
SITE AREA <u>0.038</u> ha [A] *See Section 4.1.5 for dual occupancy Basic storage volume $470 \times [A] \times \underline{0.038} = \underline{17.9} \text{ m}^3$ [B] Basic discharge $= 0.08 \times [A] \times \underline{0.038} = \underline{3.0} \text{ m}^3/\text{s}$ [C] Area of site drained to storage $= \underline{0.038} \text{ ha}$ [D] (Must be as much as possible and not be less than 75% of the total site without written Council approval). $[D] / [A] + [\underline{0.038}] / [\underline{0.038}] \times 100 = \underline{100} \%$ [E] Storage per ha. of contributing area $= [B] / [D] = \underline{470}$ [F] Enter volume/PSD adjustment chart (Fig 5.1) using [F], and Read new PSD in litres/second/ha. $= \underline{80} \text{ l/s/ha}$ [G] Determine PSD $= [G] \times [D] \times \underline{0.038} = \underline{3.0} \text{ l/s}$ [H] Maximum head to orifice centre $= \underline{1.25} \text{ m}$ [K] Weir flow to storage $Q^{\text{Weir}} = CL(H^{\text{Weir}})^{1.5} \therefore H^{\text{Weir}} = \underline{0.038} \text{ m}$ [I] Selected orifice diameter: $d = (0.464 \times Q / \sqrt{h})^{0.5} = (0.464 \times [H] / \sqrt{[K]})^{0.5} = \underline{0.035} \text{ m}$ [J] Maximum discharge $= \underline{3.0} \text{ l/s}$ [L] Head for high early discharge $= \underline{0.85} \text{ m}$ [M] High early discharge $\{ [L] \times \sqrt{[M] / [K]} \}$ (min 75% of [L]) $= \underline{2.5} \text{ l/s}$ [N] Approximate mean discharge $= ([L] + [N]) / 2 = \underline{2.75} \text{ l/s}$ [P] Average discharge/ha $= [P] / [D] = \underline{2.75} / \underline{0.038} = \underline{72.4} \text{ l/s/ha}$ [Q] Enter volume/P.S.D. adjustment chart (Fig 5.1) using [Q] And read off final storage volume per hectare $= \underline{512} \text{ m}^3/\text{ha}$ [R] Determine final SSR $= [R] \times [D] = \underline{512} \times \underline{0.038} = \underline{19.5} \text{ m}^3$ [S] Primary storage proportion $= [S] \times \underline{41} \% = \underline{8} \text{ m}^3$ [T] Secondary storage proportion $= [S] \times \underline{59} \% = \underline{9.9} \text{ m}^3$ [U] Tertiary storage proportion $[S] \times \underline{\quad} \% = \underline{\quad} \text{ m}^3$ [V] Check $[T] + [U] + [V] = [S] = \underline{17.9} \text{ m}^3$		

SIGNATURE: _____ DATE: _____

ⁱ Area draining changed in revision 2 of third edition

7.3 A flat site

The site is assumed to have no fall, but the adjacent council road has normal crossfall and is drained in a way which allows free discharge to the kerb. Although underground drainage may be present, it is assumed to be fully charged with the hydraulic grade line at the surface level.

As a starting condition for the assessment of OSD the proposal must be arranged so that it can be effectively drained by conventional methods and rendered flood free to normal standards (5%AEP).

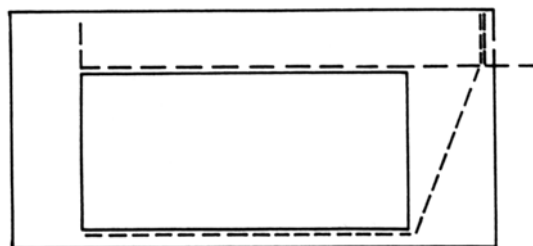
The site has an area of 0.1 ha and a residential development is proposed to cover 50% of the land exclusive of driveways, parking and a paved drying area. Two significant sections of garden space are proposed.

The site layout and discharge control pit details are shown in Figure 7.5.

Conventional drainage

With such a flat site, it would be preferable to use two stormwater drains running from the rear corners of the building to the kerb. However, Council insists upon a single discharge point. Therefore, allow the network suggested below.

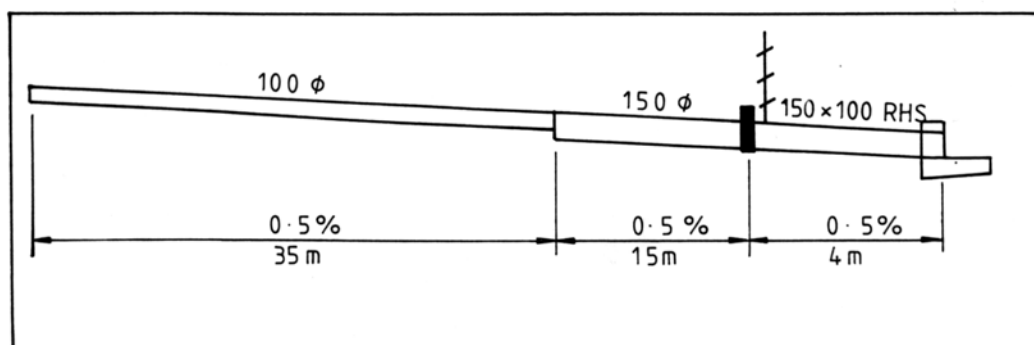
The driveway is collected only at a grated drain just inside the boundary.



Discharge in each line is from half roof. For the whole roof:
 $A = 36.2 \times 14.3 = .052 \text{ ha.}$

$$Q_{20} = FCIA = .00278 \times 0.95 \times 180 \times .052 = 0.025 \text{ m}^3/\text{s}$$

Using sewer grade uPVC the last section of pipe in each run upstream of the grated drain must be 150 mm diameter for gravity flow, as shown in the schematic long section below.



Ignoring junction losses, the pipe crown at the rear of the building is $0.16 + 54 \times 0.005 = 0.43$ m above gutter invert.

Allowing 0.025 m sand cover beneath, 0.125 m thick concrete paving and providing 0.15 m clearance to floor level above finished ground gives a floor level 0.73 m above the gutter invert, providing a good level of flood protection.

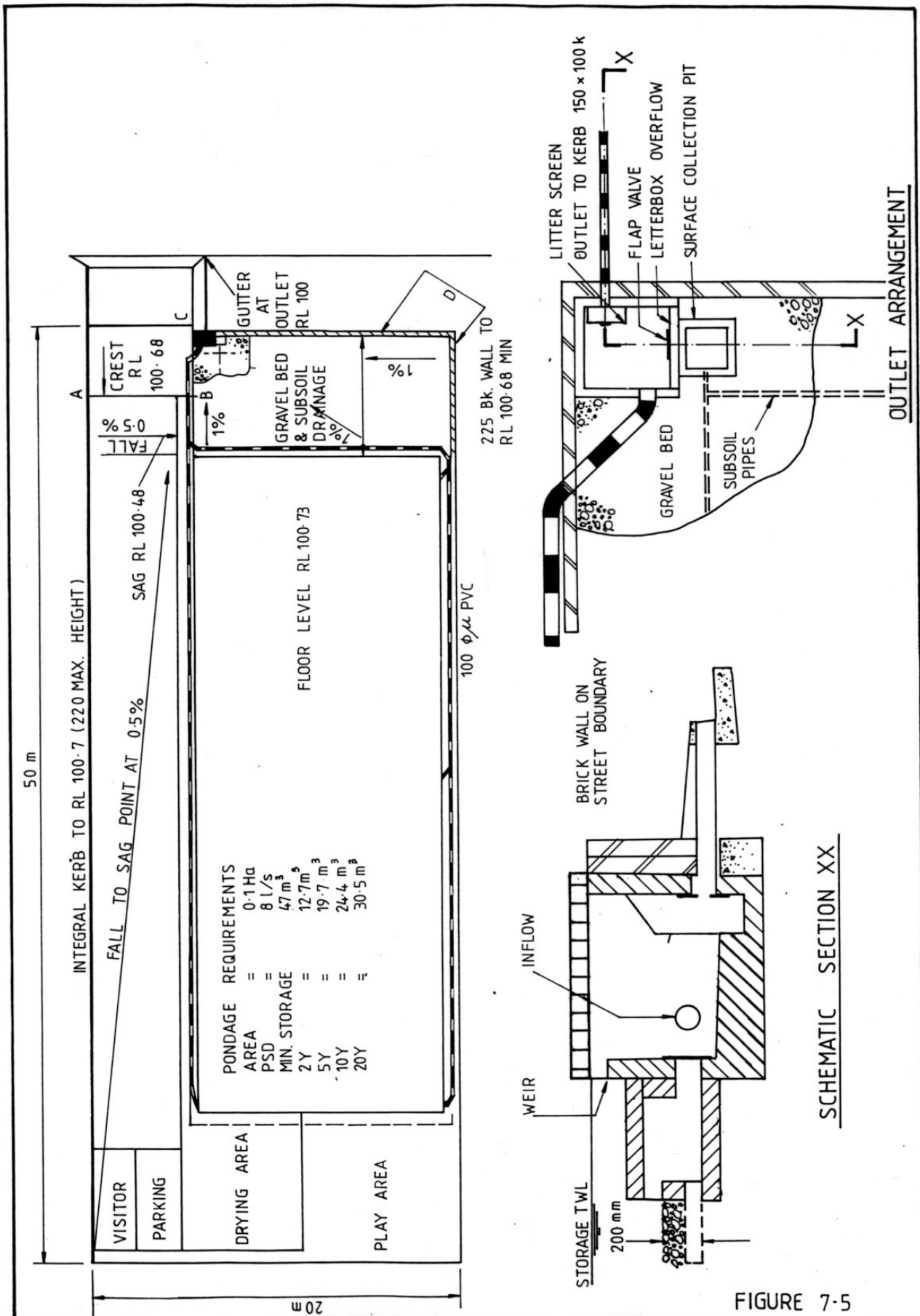


FIGURE 7-5

OSD solution

Primary storage is provided in the landscaping at the front of the land where about 20% of the SSR can be stored before significant ponding begins on the driveway, suggesting that flood frequency on the driveway, would be about once a year.

Runoff from the driveway and the drying area flows to the front of the property down the driveway and is diverted to the storage by a crest on the driveway into the landscaped primary storage, which lies a little below the driveway sag point. All roof water is delivered to the discharge pit to establish high early discharge, with the excess surcharging by weir to the primary storage.

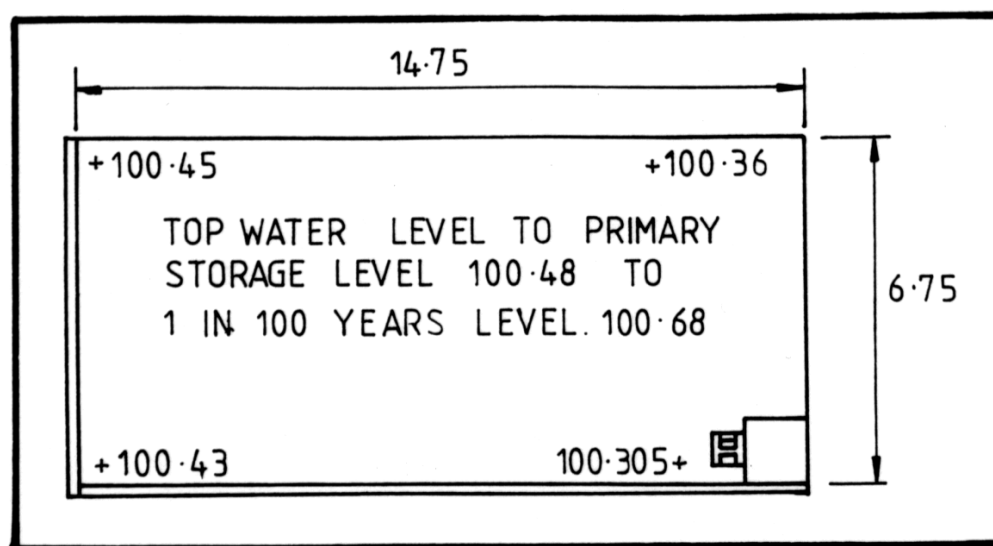
When the primary storage is full, continuing flow in excess of PSD backs up onto the driveway to an increasing extent dependent on storm severity. The whole driveway is flooded once in 100 years.

In more extreme events than the 100 year storm or when blockage causes the system to fail, overflows occur over the driveway crest and the front brick fence.

$$Q_{WEIR} = CLH^{3/2} = 1.6 \times 23.4 \times .05 = 0.17 \text{ m}^3/\text{s}$$

$$Q_{100}(\text{Site}) = FCIA = .00278 \times 0.95 \times 230 \times 0.1 = 0.06 \text{ m}^3/\text{s}$$

Outlet calculations indicate a lowest practicable water storage level 305 mm above the street gutter to allow the garden to drain freely. Maximum storage depth on the driveway should not exceed 200 mm, so with a top water level of 100.68 the top level of primary storage before driveway flooding begins is R.L. 100.48.

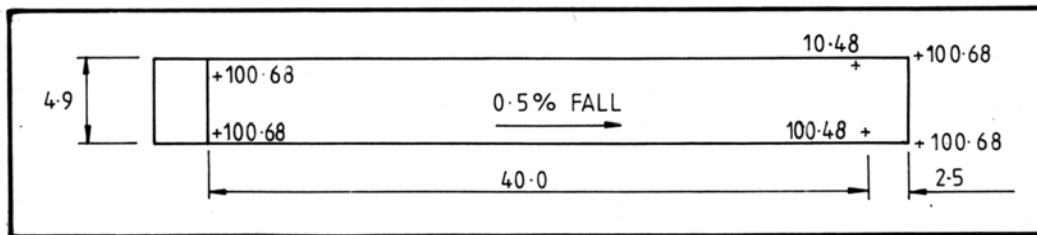


Allowing 1% fall to the garden surface inlet, the dimensions of the primary storage become:

$$\begin{aligned} \text{Mean storage depth as primary storage} &= 0.093 \text{ m} \\ \text{so volume} &= 9.25 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Mean storage depth to 100 year level} &= 0.293 \text{ m} \\ \text{so volume} &= 27.2 \text{ m}^3 \end{aligned}$$

Driveway dimensions are as shown below:



$$\text{Mean depth} = 0.100 \text{ m.}$$

$$\text{Potential volume} = 42.5 \times 4.9 \times 0.1 = 20.8 \text{ m}^3$$

$$\text{So, total available storage} = 48 \text{ m}^3.$$

Outlet design

$$\text{Orifice centre level} = 100.10$$

$$\text{Top water level} = 100.68 \quad \text{So } h_{\max} = 0.58$$

Weir must allow pit to discharge the 1% AEP flow from the roof area.

$$Q_{100} = FCIA$$

$$= .00278 \times 0.95 \times 230 \times .052 = 0.032 \text{ m}^3/\text{s}$$

$$\text{Weir is length of pit side internally} = 0.9 \text{ m}$$

$$\text{Outflow includes } 0.008 \text{ m}^3/\text{s} \text{ to street so weir flow is } 0.024 \text{ m}^3/\text{s}$$

$$Q_w = CLH^{3/2}$$

$$H = (Q / CL)^{2/3}$$

$$= [0.024 / (1.6 \times 0.9)]^{2/3}$$

$$= 0.065 \text{ m}$$

Therefore, the range of head between full discharge and the point at which the pit just begins to surcharge to primary storage is 65 mm.

Calculate orifice diameter.

$$d = (0.464 \times Q / \sqrt{h})^{0.5}$$

$$\frac{(0.464 \times 0.0008)^{0.5}}{\sqrt{0.58}}$$

$$= 0.070 \text{ m}$$

$$\text{High early discharge} = 8 \times \sqrt{h_{\min} / h_{\max}}$$

$$= 8 \times \sqrt{0.515 / 0.58}$$

$$= 7.54 \text{ l/s}$$

So, Q_{mean} is 7.77 l/s or 77.7 l/s/ha.

Enter Volume Adjustment Chart (Figure 5.1) with 77.7 l/s/ha and read off required volume as 484 m³/ha.

For 0.1 ha site volume is 48.4 m³.

The available 48 m³ is therefore acceptable.

In summary

Sites are rarely this flat and there is usually a little fall to work with. Fall had to be created here by raising the block levels to provide a notional grade of 0.5% to the street. There is nearly always some fall available so the exercise will normally be a little easier.

Costing is interesting. The driveway must be built anyway, whether it is for water storage or not. The landscaping at the front of the property costs approximately the same per m² whatever level it is put at, and the trivial quantity of earthwork would not be identifiable in site costs. The brick wall, common enough for such a development, needs no special attention provided it is heavy enough to function as a gravity wall. It should cost no more than the usual fencing cost.

There remains only the outlet arrangement. The footpath crossing can be smaller than that normally required and the discharge control pit cost is comparable to that of the grated drain and junction pit normally located at the boundary. The only additional cost of OSD in a case like this probably lies in supervising the work to make sure the plans are understood and the levels specified are achieved. Even this cost is one which should already be put into making sure conventional drainage is installed so that it will work and ensure the owner gets value.

Note: Area drained to site storage must now be 85% not 75% as shown in this exampleⁱ

DRAINAGE DESIGN SUMMARY		SUB/DA No. _____
Project: <u>CASE STUDY 7.3</u> Location: _____		
Designed by: _____ Company: _____ Phone: _____		
SITE AREA <u>0.1</u> ha [A] *See Section 4.1.5 for dual occupancy Basic storage volume $470 \times [A] \text{ } \underline{0.1} = \underline{47} \text{ m}^3$ [B] Basic discharge $= 0.08 \times [A] \text{ } \underline{0.1} = \underline{0.008} \text{ m}^3/\text{s}$ [C] Area of site drained to storage $= \underline{0.1} \text{ ha}$ [D] (Must be as much as possible and not be less than 75% of the total site without written Council approval). $[D]/[A] + [\text{ } \underline{0.1} \text{ }]/[\text{ } \underline{0.1} \text{ }] \times 100 = \underline{100} \%$ [E] Storage per ha. of contributing area $= [B]/[D] = \underline{470}$ [F] Enter <i>volume/PSD adjustment chart</i> (Fig 5.1) using [F], and Read new PSD in litres/second/ha. $= \underline{80} \text{ l/s/ha}$ [G] Determine PSD $= [G] \times [D] \text{ } \underline{80} \times \underline{0.1} = \underline{8} \text{ l/s}$ [H] Maximum head to orifice centre $= \underline{0.58} \text{ m}$ [K] Weir flow to storage $Q^{\text{Weir}} = CL(H^{\text{Weir}})^{1.5} \therefore H^{\text{Weir}} = \underline{0.065} \text{ m}$ [I] Selected orifice diameter: $d = (0.464 \times Q / \sqrt{h})^{0.5} = (0.464 \times [H] / \sqrt{[K]})^{0.5} = \underline{0.070} \text{ m}$ [J] Maximum discharge $= \underline{8} \text{ l/s}$ [L] Head for high early discharge $= \underline{0.515} \text{ m}$ [M] High early discharge $\{ [L] \times \sqrt{[M] / [K]} \}$ (min 75% of [L]) $= \underline{7.54} \text{ l/s}$ [N] Approximate mean discharge $= ([L] + [N]) / 2 = \underline{7.77} \text{ l/s}$ [P] Average discharge/ha $= [P] / [D] = \underline{7.77} / \underline{0.1} = \underline{77.7} \text{ l/s/ha}$ [Q] Enter <i>volume/P.S.D. adjustment chart</i> (Fig 5.1) using [Q] And read off final storage volume per hectare $= \underline{484} \text{ m}^3/\text{ha}$ [R] Determine final SSR $= [R] \times [D] = \underline{484} \times \underline{0.1} = \underline{48.4} \text{ m}^3$ [S] Primary storage proportion $= [S] \times \underline{19.3} \% = \underline{9.25} \text{ m}^3$ [T] Secondary storage proportion $= [S] \times \underline{37.5} \% = \underline{18.0} \text{ m}^3$ [U] Tertiary storage proportion $[S] \times \underline{43.2} \% = \underline{20.8} \text{ m}^3$ [V] Check $[T] + [U] + [V] = [S] = \underline{48} \text{ m}^3$		

SIGNATURE: _____ DATE: _____

ⁱ Area draining changed in revision 2 of third edition

7.4 A flat roof with membrane waterproofing

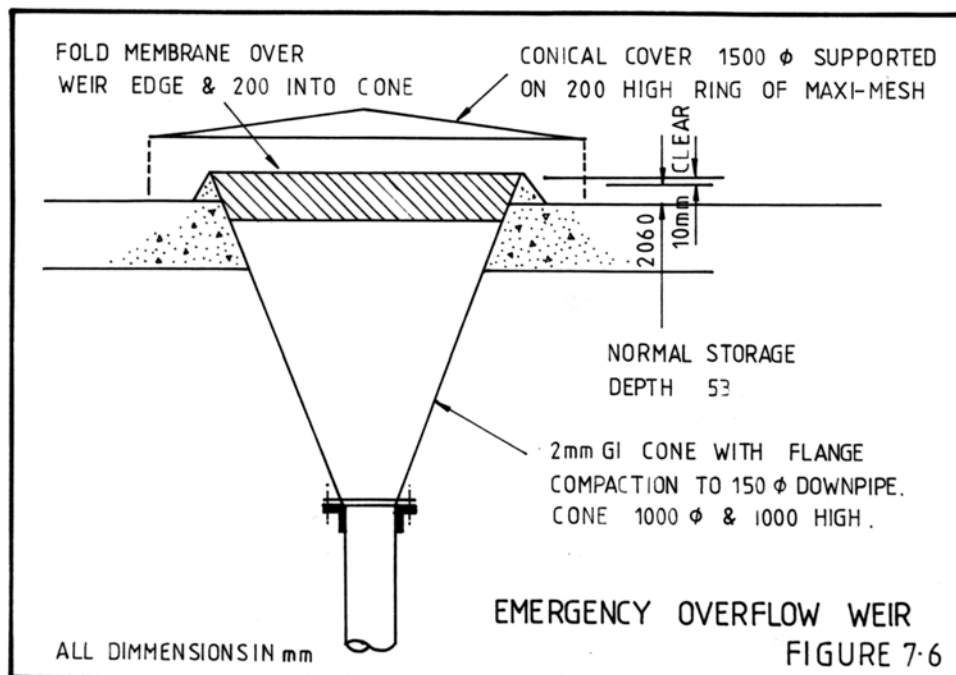
Site conditions in this case are irrelevant as the building covers the entire property. No sketch is provided because the layout, is also unimportant to the calculations. The only data needed is the proportion of roof surface which is unobstructed. In this case, a lift wall plant room occupies 48 m^2 and has a steel roof shedding water to the main roof. The cover over the stair well occupies a further 12 m^2 . Sundry vents and supports for air conditioning apparatus occupy a further 5 m^2 and the parapet wall reduces the storage area by 26 m^2 . The total roof area of 900 m^2 therefore has an effective storage area of 809 m^2 .

The solution

The Trust standard SSR of $470 \text{ m}^3/\text{ha}$ is satisfied by providing 47 mm of storage over the whole catchment, if it is near enough to level and can all be used for storage. With only 90% of the area available in this instance the storage depth must be increased to 52.2 mm to maintain the volume.

There remains only to design the outlet. Using an outlet pit with its orifice 900 mm below deck level, the head range is from 953 mm to 900 mm. The high early discharge with this range is 97% of maximum, giving an average discharge of 78.9 l/s/ha and an adjusted SSR of $477 \text{ m}^3/\text{ha}$ read from Figure 5.1. This requires an increase in storage depth to 53 mm. This orifice should be protected by two screens in series and needs only a 65 mm diameter pipe down to ground level where it discharges into a 100 mm square galvanised steel pipe under the footpath.

As with all systems, an overflow provision is essential. This is achieved as sketched below by placing a 1m diameter sharp crested weir 10 mm above the nominal top water level as a feed for an emergency drain pipe.



The required depth above the weir level to pass the once in 100 years storm is 45 mm. In the unlikely event that a storm of this severity occurred with the water storage full, the total depth of water on the deck would reach 108 mm. The second pipe should also be screened outside of the weir and roofed to ensure that nothing can fall into it and cause blockage. A 150 mm diameter pipe is required to street level where it should not discharge into the kerb, (where its operation would go unnoticed), but onto the footpath near the building entrance where its operation will cause comment and prompt maintenance.

In summary

Use of this technique for flat, membrane-tanked roofs will normally offer savings over conventional drainage. Apart from the controlled outlet box there is no additional cost at roof level as the overflow device, or something similar, should be provided for all installations. The water loading is less than the SAA loading code requires for live loading and the tanking depth needed is less than the normal allowance for build-up of water depth during a hail storm.

Conduits falling through the building can be smaller with OSD, as can conduits under the footpath. One Parramatta CBD office building has five 100 mm diameter cast iron pipes crossing a 10 metre footway. One such pipe, with an emergency branch able to discharge at the boundary, in the event of breakage or blockage of the footpath conduit, would have been sufficient with OSD. Designers should always consider the potential of a vehicle tyre, hard against a kerb outlet, to disrupt discharge and provide for it.

Note: Area drained to site storage must now be 85% not 75% as shown in this exampleⁱ

DRAINAGE DESIGN SUMMARY		SUB/DA No. _____
Project: <u>CASE STUDY 7.4</u>	Location: <u>FLAT ROOF TOWER</u>	
Designed by: _____	Phone: _____	

SITE AREA <u>0.09</u> ha	[A]
*See Section 4.1.5 for dual occupancy	
Basic storage volume $470 \times [A]$ <u>0.09</u>	= <u>42.3</u> m ³ [B]
Basic discharge $= 0.08 \times [A]$ <u>0.09</u>	= <u>0.0072</u> m ³ /s [C]
Area of site drained to storage (Must be as much as possible and not be less than 75% of the total site without written Council approval.)	= <u>-</u> ha [D]
$[D] / [A] = [\quad] / [\quad] \times 100$	= <u>100</u> % [E]
Storage per ha. of contributing area $= [B] / [D]$	= <u>-</u> [F]
Enter volume/PSD. adjustment chart (Fig 5.1) using [F], and read new PSD in litres/second/ha.	= <u>-</u> l/s/ha [G]
Determine PSD $= [G] \times [D]$ _____ $\times$ _____	= <u>7.2</u> l/s [H]
Maximum head to orifice centre	= <u>0.255</u> m [K]
Selected orifice diameter $d = (0.464 \times Q / \sqrt{h})^{0.5}$	= <u>0.0385</u> m [J]
Maximum discharge	= <u>7.2</u> l/s [L]
Head for high early discharge	= <u>0.200</u> m [M]
High early discharge. $\{ [L] \times \sqrt{[M] / [K]} \}$ (min 75% of [L])	= <u>7.0</u> l/s [N]
Approximate mean discharge $= ([L] + [N]) / 2$	= <u>7.1</u> l/s [P]
Average discharge/ha $= [P] / [D] =$ <u>71</u> / <u>0.09</u>	= <u>789</u> l/s/ha [Q]
Enter volume/P.S.D. adjustment chart (Fig 5.1) using [Q], and read off final storage volume per hectare	= <u>477</u> m ³ /ha [R]
Determine final SSR $= [R] \times [D] =$ <u>477</u> $\times$ <u>0.09</u>	= <u>42.9</u> m ³ [S]
Primary storage proportion $= [S] \times$ _____ %	= _____ m ³ [T]
Secondary storage proportion $= [S] \times$ _____ %	= _____ m ³ [U]
Tertiary storage proportion $= [S] \times$ _____ %	= _____ m ³ [V]
Check $[T] + [U] + [V] = [S]$	= _____ m ³

SIGNATURE: _____ DATE: _____

COMPANY: _____

ⁱ Area draining changed in revision 2 of third edition

7.5 Duplex Site

Total site area = 841.2 m²

dwelling No. 1 - 502.2 m² dwelling No. 2 – 339 m².

A storage for each dwelling is proposed. The storage area available for dwelling No. 2 is limited, but the grassed rear boundary and side landscaping are being used as an overland flowpath and will not drain to the storage. These areas therefore can be added to the storage area for dwelling No. 1. Overland flowpaths are needed to drain 0.03 ha of upstream catchment flowing across the rear boundary and 0.1 ha across the side boundary.

Cross sections of the proposed water storage are shown in the following details. (Figures 7.8 and 7.9)

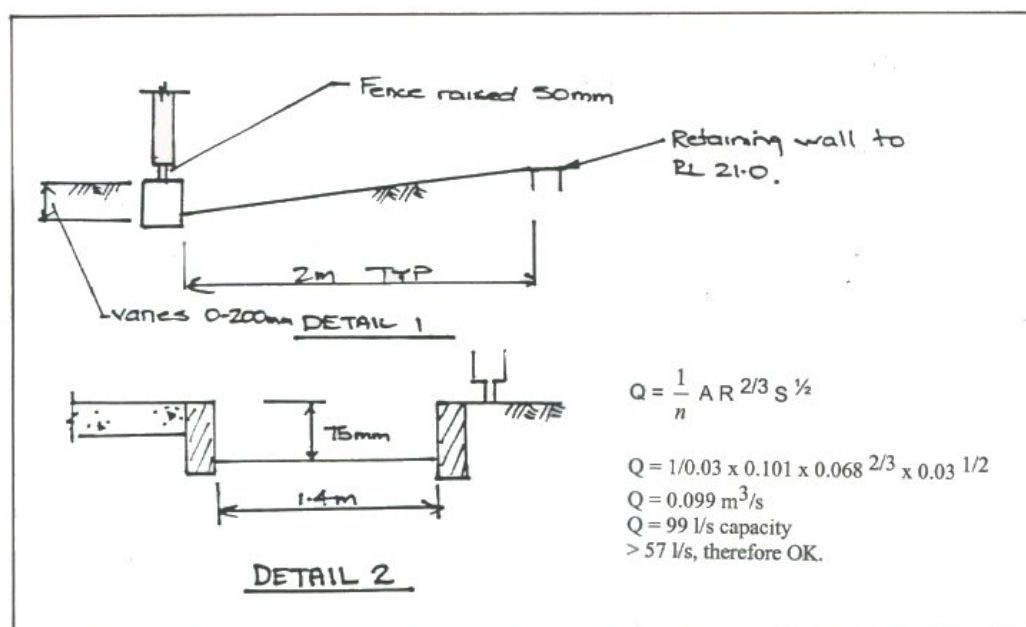
Details of the 2 discharge control pits are also shown in Figures 7.10 and 7.11.

Treating overland flow

Calculate total overland flow

$$\begin{aligned} Q &= CIA/360 \\ &= 0.7 \times 227.3 \times 0.13/360 \\ &= 0.057 \text{ m}^3/\text{s} \\ Q &= 57 \text{ l/s} \end{aligned}$$

The rear of dwelling No. 2 and the courtyard are in cut and even small catchments can cause flooding if the area is not properly graded. A sensible precaution would be to raise the retaining wall above the existing surface and regrade the rear yard to fall to the north-east. As the rear boundary is essentially flat, it will be necessary to create a fall. This could simply be achieved using railway sleepers on some other garden edging, as shown below. This will serve as the flowpath.



The driveway downstream of the speed hump will need to be shaped to discharge the overland flowpath via the driveway to the street.

Storage area No. 2

As the landscaped storage is at the front of dwelling No. 2 and will be rarely used as recreation space, it was decided not to provide any protection from frequent inundation. To prevent this area from becoming a maintenance problem, a 1% fall is maintained and sub-soil drainage lines have been placed underneath the area. Ponding does not start over the driveway and parking areas until a 1 in 5 year ARI storm.

See drainage design summary sheet for storage calculations; and see plans and details Figure 7.7 for storage volumes.

Overflow spillway before garage flooded

$$\begin{aligned}
 Q &= CLH^{3/2} & H &= 19.5 - 19.35 \\
 &= 1.6 \times 3 \times 0.15^{3/2} & &= 0.15 \text{ m} \\
 &= 0.28 \text{ m}^3/\text{s}
 \end{aligned}$$

Maximum discharge to storage area

$$\begin{aligned}
 &= FCIA \\
 Q_{100} &= 1.2 \times 227.3 \times 0.02708/360 \\
 &= 0.021 \text{ m}^3/\text{s}
 \end{aligned}$$

Therefore spillway capacity = 13 x Q₁₀₀.

Check DCP design

$$\begin{aligned}
 \text{Minimum screen area } A &= 50 \times \pi d^2 \\
 &= 50 \times \pi \times \frac{0.035^4}{4} \\
 &= 0.048 \text{ m}^2
 \end{aligned}$$

Therefore minimum screen area is 200 mm x 200 mm whilst actual screen is 700 mm x 900 mm. Hence area is OK.

Size DCP outlet try 90 mm

$$\text{Grade} = 1.1\% \quad A = 0.0064 \quad R = 0.090/4 \quad n = 0.010$$

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$Q = \frac{1}{0.01} \times 0.0064 \times 0.0225^{2/3} \times 0.011^{1/2}$$

$$\begin{aligned}
 &= 0.0054 \text{ m}^3/\text{s} \\
 &= 5.4 \text{ l/s}
 \end{aligned}$$

$$\begin{aligned}
 \text{Minimum capacity} &= 2 \times \text{PSD} \\
 &= 2 \times 2.2 \\
 &= 4.4 \text{ l/s}
 \end{aligned}$$

Therefore outlet pipe is large enough to prevent submergence.

Storage No. 1

$$\begin{aligned}\text{Storage Area} &= 502.2 \text{ m}^2 + 339 - 270.8 \\ &= 570.4 \text{ m}^2\end{aligned}$$

- for storage calculations see summary sheet.
- for storage volumes see plans and details at Figure 7.7.

Determine maximum height over orifice (See detail Figure 7.8)

$$\begin{aligned}\text{Total flow } Q &= CIA/360 \\ &= 1.2 \times 227.3 \times 0.015/360 \\ &= 0.0114 \text{ m}^3/\text{s}\end{aligned}$$

Depth over weir

$$\begin{aligned}Q &= CLH^{3/2} \\ 0.0114 &= 1.6 \times 0.9 \times H^{3/2} \\ H &= 0.04 \text{ m}\end{aligned}$$

$$\begin{aligned}\text{Maximum height} &= 19.35 + 0.04 - 18.6 \\ &= 0.79 \text{ m}\end{aligned}$$

Check spillway capacity to garage floor

$$\begin{aligned}\text{Clearance} &= 19.5 - 19.35 \\ &= 0.15 \text{ m} \\ L &= 16 \text{ m} \quad C = 1.6 \\ Q &= 1.6 \times 16 \times 0.15^{1.5} \\ &= 1.48 \text{ m}^3/\text{s}\end{aligned}$$

Maximum flow to storage

$$\begin{aligned}Q &= 1.0 \times 227.3 \times 0.0436/360 \\ &= 0.028 \text{ m}^3/\text{s}\end{aligned}$$

- Therefore spillway has in excess 50 x Q₁₀₀ capacity
- Screen area satisfactory as for Storage 2.

Check Outlet Capacity

$$\begin{aligned}S &= 0.029 \quad A = 0.0064 \quad R = 0.0225 \quad n = 0.010 \\ Q &= (1 / 0.01) \times 0.0064 \times 0.0225^{0.66} \times 0.029^{1/2} \\ &= 0.008 \text{ m}^3/\text{s} \quad \text{Greater than } 2 \times \text{PSD, therefore O.K.}\end{aligned}$$

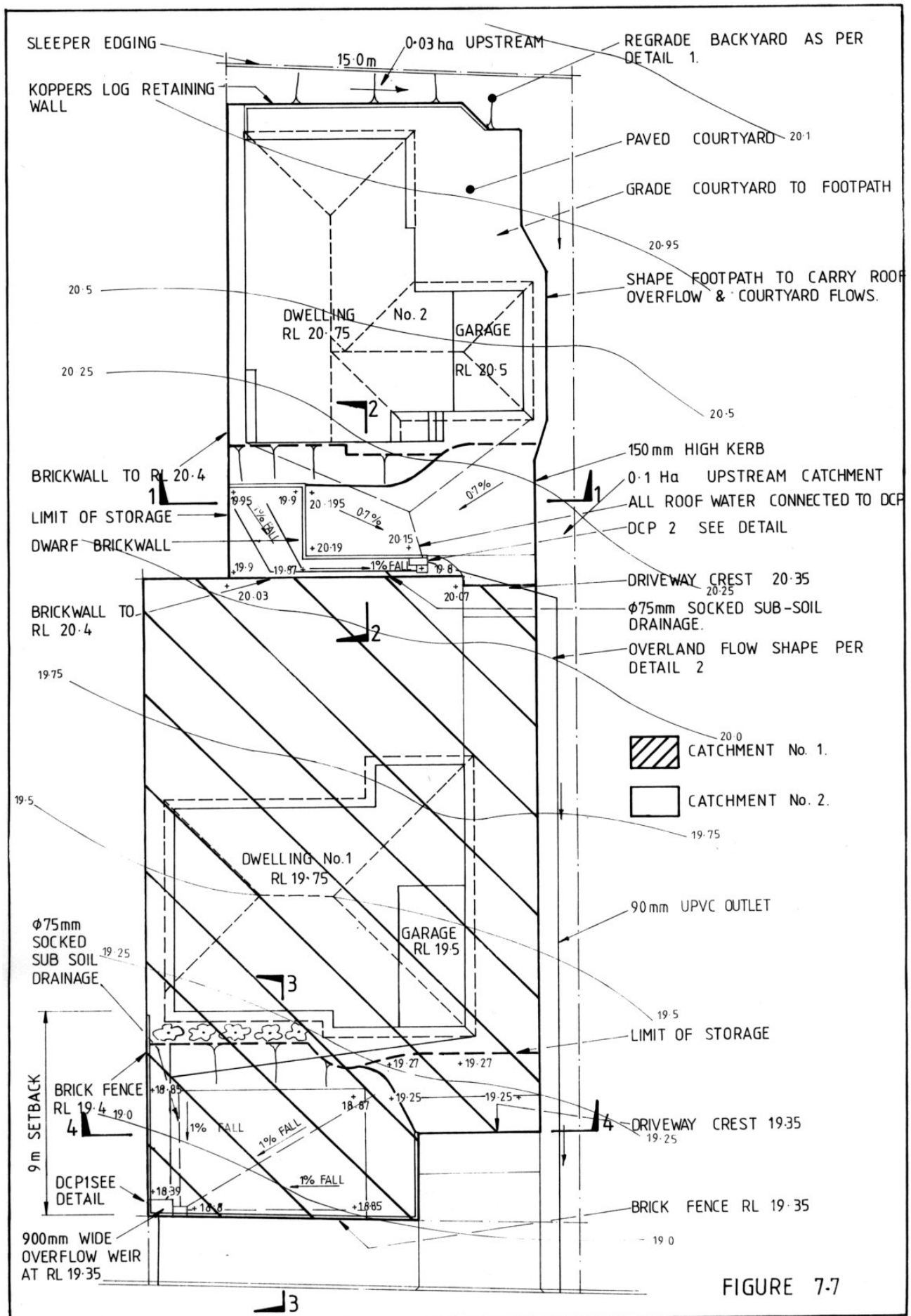


FIGURE 7-7

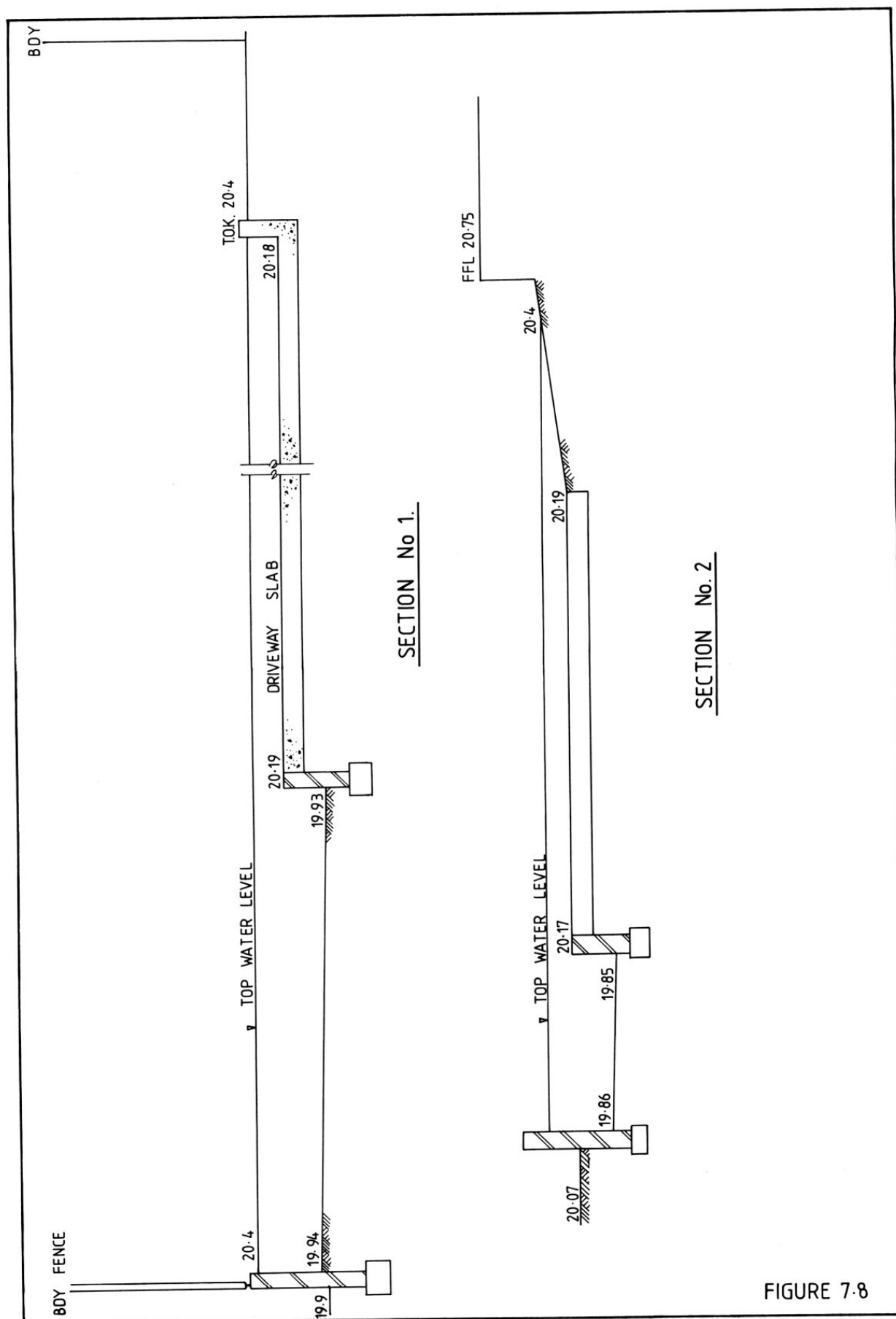


FIGURE 7.8

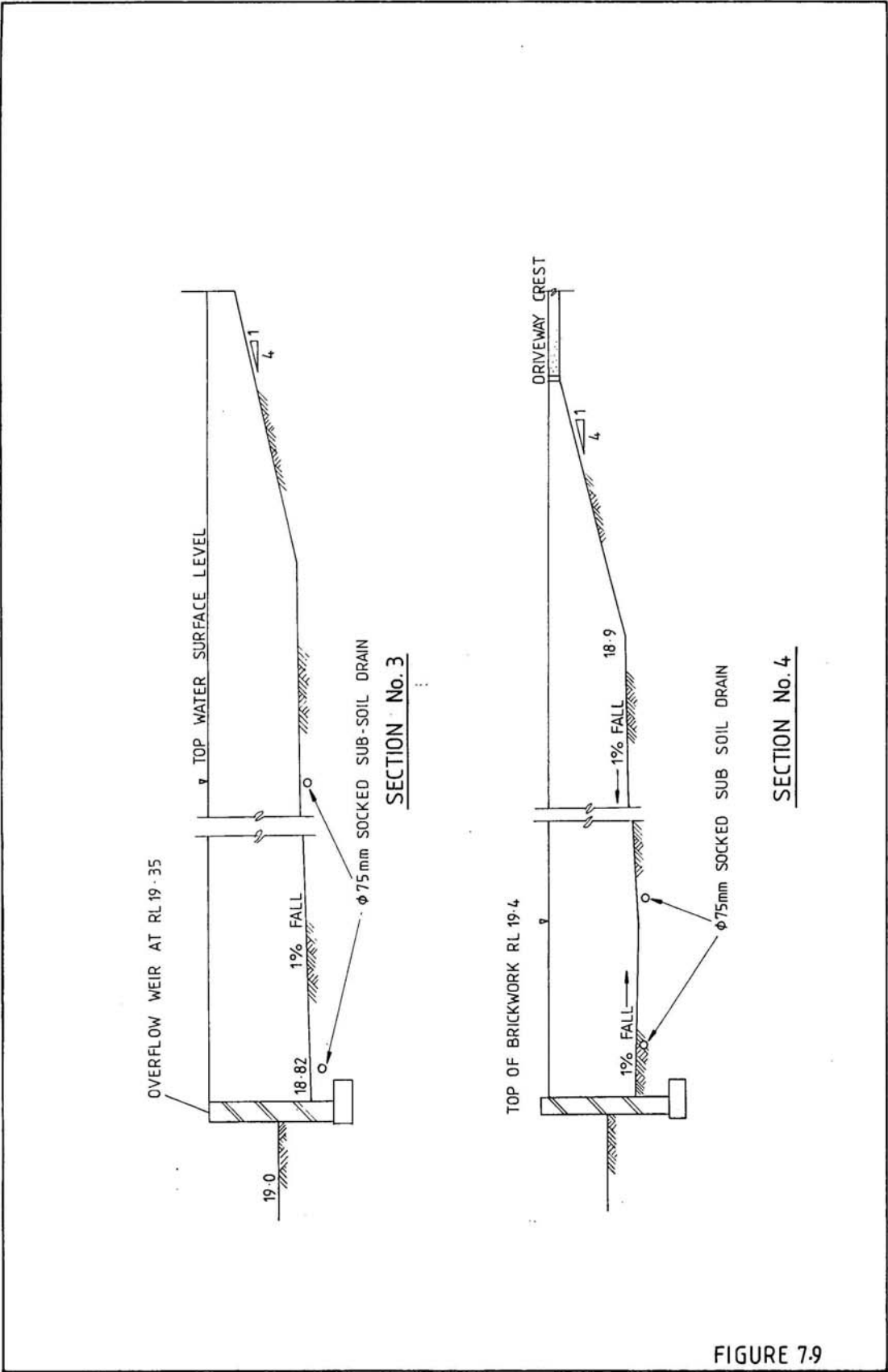
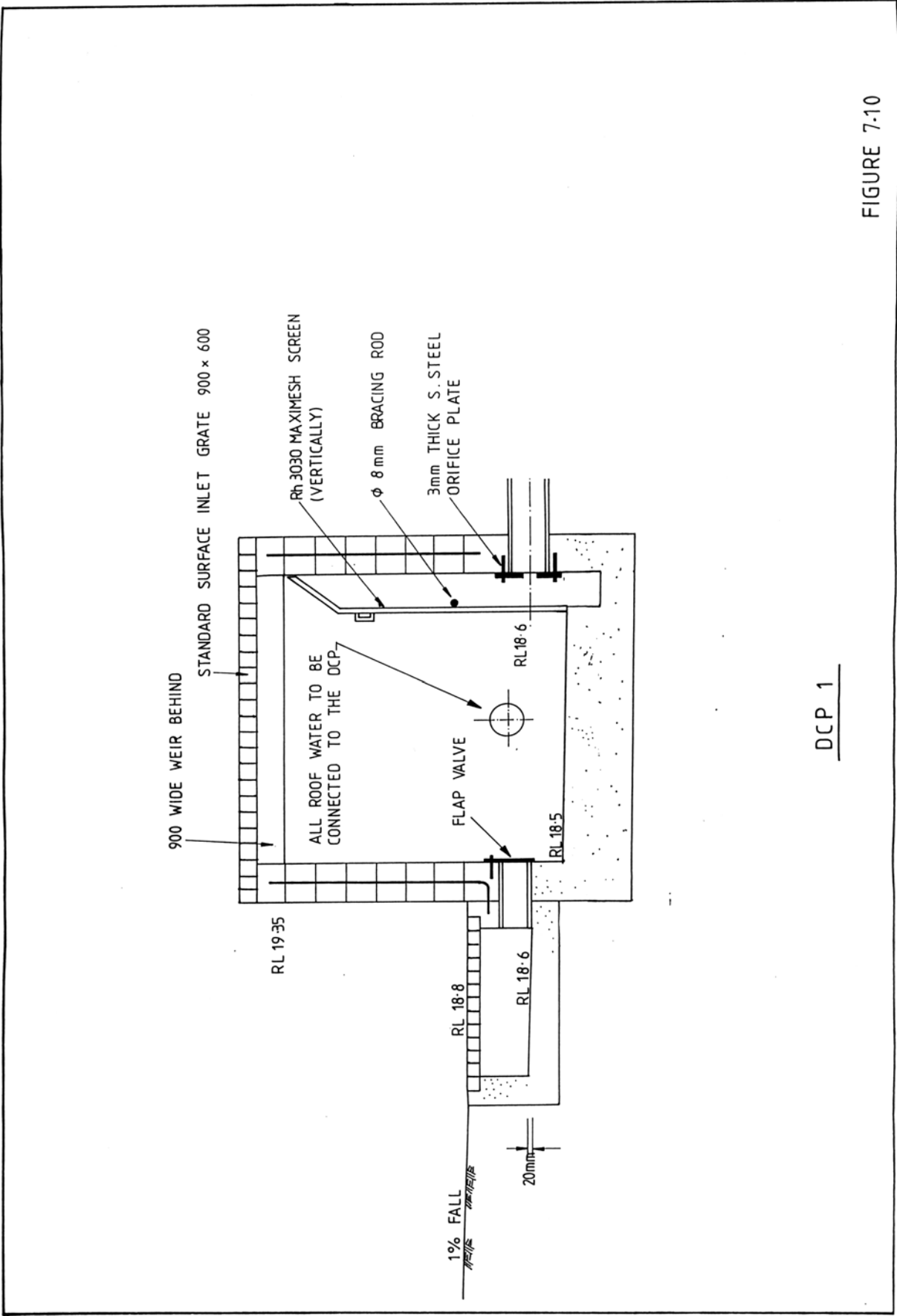
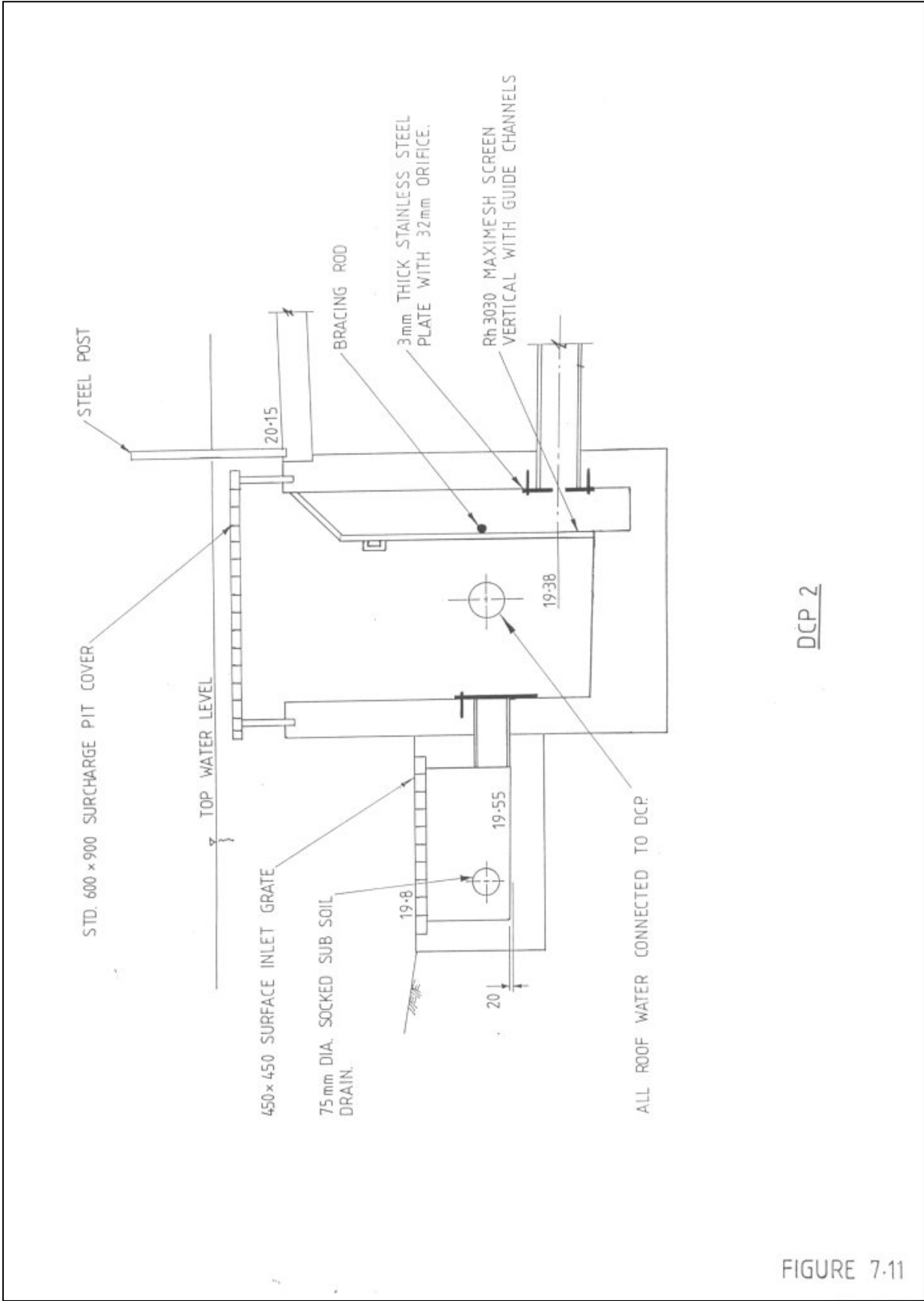


FIGURE 7.9





Note: Area drained to site storage must now be 85% not 75% as shown in this exampleⁱ

DRAINAGE DESIGN SUMMARY		SUB/DA No. _____
Project: <u>CASE STUDY 7.5</u>		Location: <u>DWELLING N9.1</u>
Designed by: _____		Phone: _____

CAT		
SITE AREA	<u>0.0574</u> ha	[A]
*See Section 4.1.5 for dual occupancy		
Basic storage volume	$470 \times [A] \underline{0.0574} = \underline{27.0}$ m ³	[B]
Basic discharge	$= 0.08 \times [A] \underline{0.0574} = \underline{0.0046}$ m ³ /s	[C]
Area of site drained to storage (Must be as much as possible and not be less than 75% of the total site without written Council approval.)	$= \underline{0.0436}$ ha	[D]
$[D] / [A] = [\underline{436} / [\underline{574}] \times 100$	$= \underline{76}$ %	[E]
Storage per ha. of contributing area = $[B] / [D]$	$= \underline{619}$	[F]
Enter volume/PSD. adjustment chart (Fig 5.1) using [F], and read new PSD in litres/second/ha. <i>- extended using eq'n</i>	$= \underline{55.5}$ l/s/ha	[G]
Determine PSD = $[G] \times [D]$	$\underline{55.5} \times \underline{0.0436} = \underline{2.4}$ l/s	[H]
Maximum head to orifice centre	$= \underline{0.79}$ m	[K]
Selected orifice diameter	$d = (0.464 \times Q / \sqrt{h})^{0.5} = \underline{0.035}$ m	[J]
Maximum discharge	$= \underline{2.3}$ l/s	[L]
Head for high early discharge	$= \underline{0.75}$ m	[M]
High early discharge. $\{ [L] \times \sqrt{[M] / [K]} \}$ (min 75% of [L])	$= \underline{2.2}$ l/s	[N]
Approximate mean discharge = $([L] + [N]) / 2$	$= \underline{2.25}$ l/s	[P]
Average discharge/ha = $[P] / [D]$	$\underline{2.25} / \underline{0.0436} = \underline{51.4}$ l/s/ha	[Q]
Enter volume/P.S.D. adjustment chart (Fig 5.1) using [Q], and read off final storage volume per hectare <i>- extended using eq'n</i>	$= \underline{654}$ m ³ /ha	[R]
Determine final SSR = $[R] \times [D]$	$\underline{654} \times \underline{0.0436} = \underline{28.5}$ m ³	[S]
Primary storage proportion = $[S] \times \underline{77\%}$ <i>1 in 25y</i>	$= \underline{21.8}$ m ³	[T]
Secondary storage proportion = $[S] \times \underline{\quad\quad\quad}\%$	$= \underline{6.9}$ m ³	[U]
Tertiary storage proportion = $[S] \times \underline{\quad\quad\quad}\%$	$= \underline{\quad\quad\quad}$ m ³	[V]
Check $[T] + [U] + [V] = [S]$	$= \underline{28.7}$ m ³	

SIGNATURE: _____ DATE: _____

COMPANY: _____

ⁱ Area draining changed in revision 2 of third edition

Note: Area drained to site storage must now be 85% not 75% as shown in this exampleⁱ

DRAINAGE DESIGN SUMMARY		SUB/DA No. _____
Project: <u>CASE STUDY 7-5</u>		Location: <u>DWELLING H92</u>
Designed by: _____		Phone: _____

CAT SITE AREA <u>0.02708</u> ha *See Section 4.1.5 for dual occupancy		[A]
Basic storage volume	$470 \times [A] \underline{0.02708} = \underline{12.7} \text{ m}^3$	[B]
Basic discharge	$= 0.08 \times [A] \underline{0.02708} = \underline{0.0022} \text{ m}^3/\text{s}$	[C]
Area of site drained to storage (Must be as much as possible and not be less than 75% of the total site without written Council approval.)	$= \underline{\quad} \text{ ha}$	[D]
$[D] / [A] = [\quad] / [\quad] \times 100$	$= \underline{100} \%$	[E]
Storage per ha. of contributing area = $[B] / [D]$	$= \underline{\quad}$	[F]
Enter volume/PSD. adjustment chart (Fig 5.1) using [F], and read new PSD in litres/second/ha.	$= \underline{\quad} \text{ l/s/ha}$	[G]
Determine PSD = $[G] \times [D]$	$= \underline{2.2} \text{ l/s}$	[H]
Maximum head to orifice centre	$= \underline{0.970} \text{ m}$	[K]
Selected orifice diameter	$d = (0.464 \times Q / \sqrt{h})^{0.5} = \underline{0.032} \text{ m}$	[J]
Maximum discharge	$= \underline{2.2} \text{ l/s}$	[L]
Head for high early discharge	$= \underline{0.710} \text{ m}$	[M]
High early discharge. $\{[L] \times \sqrt{[M] / [K]}\}$ (min 75% of [L])	$= \underline{2.0} \text{ l/s}$	[N]
Approximate mean discharge = $([L] + [N]) / 2$	$= \underline{2.1} \text{ l/s}$	[P]
Average discharge/ha = $[P] / [D] = \underline{2.1} / \underline{0.02708} = \underline{75.7} \text{ l/s/ha}$		[Q]
Enter volume/P.S.D. adjustment chart (Fig 5.1) using [Q], and read off final storage volume per hectare	$= \underline{495} \text{ m}^3/\text{ha}$	[R]
Determine final SSR = $[R] \times [D] = \underline{495} \times \underline{0.02708} = \underline{13.4} \text{ m}^3$		[S]
Primary storage proportion = $[S] \times \underline{41} \%$ in 5y	$= \underline{5.5} \text{ m}^3$	[T]
Secondary storage proportion = $[S] \times \underline{\quad} \%$	$= \underline{8.5} \text{ m}^3$	[U]
Tertiary storage proportion = $[S] \times \underline{\quad} \%$	$= \underline{\quad} \text{ m}^3$	[V]
Check $[T] + [U] + [V] = [S]$	$= \underline{14} \text{ m}^3$	

SIGNATURE: _____ DATE: _____

COMPANY: _____

ⁱ Area draining changed in revision 2 of third edition

8.0 Referencesⁱ

Argue, J.R. (1986). Storm drainage design in small urban catchments : a handbook for Australian practice. ARRB Special Report, SR 34, Melbourne
Bewsher Consulting Pty Ltd. (1997). <i>On-site Stormwater Detention System Cost Survey.</i> January 1997.
Bewsher Consulting Pty Ltd. (1999). <i>OSD Checklists.</i> November 1999.
Bilton, H.J.I. (1908). <i>Coefficients of Discharge Through Circular orifices.</i> Extracts from paper to the Victorian Institute of Engineers in Engineering News (N.Y) July 1908, pp49-50.
Boyd, M..J. (1980). <i>Evaluation of Simplified Methods for Design of Retarding Basins.</i> I E Aust Hydrology and Water Resources Symposium, National Conference Publications 80/9, pp182-183, Canberra.
Coombes, P, Frost, A, & Kuczera, G. (2001) <i>Impact of Rainwater Tank and On-site Detention Options on Stormwater Management in the Upper Parramatta River Catchment.</i>
Institution of Engineers, Australia (1987). <i>Australian Rainfall and Runoff. A Guide to Flood Estimation.</i>
Institution of Engineers, Australia. Sydney Division, Water Resources Panel. (1989). <i>On-site Stormwater Detention Systems Seminar, Sydney.</i>
Institution of Engineers, Australia. Western Sydney and Sydney Water Engineering Panels. (1992). <i>On-site Stormwater Detention Systems.</i> One Day Seminar, Parramatta.
Lucas Consulting Engineers (1999). <i>Study of Upstream Flows into OSD Systems</i> dated October 1999. Report No 2181/98 prepared for UPRCT.
Lees, S.J. & Lynch, S.J. (1992). <i>Development of a Catchment On-Site Stormwater Detention Policy.</i> International Symposium on Urban Stormwater Management, Sydney, February 1992.
Medaugh, F.W. & Johnson, G.D. (1940). <i>Investigation of the Discharge and Coefficients of Small Circular Orifices.</i> Civil Engineering, July 1940, Vol 10. No 7, pp 422-424.
Mein, R.G. & Goyen A.G. (1988). <i>Urban Runoff,</i> Civil Eng Trans., I E Aust., pp 225-238, Canberra.
Nicholas Civil Engineering (1995). <i>Holroyd City Council – On-site Stormwater Detention Audit.</i>
NSW Public Works Department, Manly Hydraulics Laboratory (1993). <i>Orifice discharge Control for On-site Stormwater Detention Systems - Hydraulic Model Study.</i> Report MHL657, October 1993.
Phillips, D.I., Boyd, M.J. & Cann, D.M. (1990). <i>Seminar on On-site Stormwater Detention,</i> Swinburne Institute of Technology, November, Melbourne.
Smith, D & Walker, W.J. (1923). <i>Orifice Flow.</i> Journal of the Institute of Mechanical Engineers (Great Britain), January 1923, pp 23-36.
Thomas, A.J. & Mcleod, P., (1992). <i>Australian Research Priorities in the Urban Water Services and Utilities Area</i> (draft). CSIRO Division of Water Resources, Perth.
Upper Parramatta River Catchment Trust (1991). <i>On-Site Detention Handbook.</i> First Edition.
Upper Parramatta River Catchment Trust (1992). <i>Hydraulic Testing of Discharge Control Pits for On-site Stormwater Detention.</i>
Upper Parramatta River Catchment Trust (1994). <i>On-site Stormwater Detention Handbook.</i> Second Edition.
Upper Parramatta River Catchment Trust (1999). <i>On-site Stormwater Detention Handbook. Third Edition Revision 1</i>

ⁱ Additional references added in third edition

Appendix A - Variations To OSD Policy

A.1 Varying control standards

Requests to change OSD parameters or to exclude particular developments will be considered by the relevant council in consultation with the Trust. These requests will need to be supported by a report endorsed by a suitably qualified and experienced chartered engineer. The study needs to:

- use a calibrated hydrologic model acceptable to the Trust
- assume development and/or redevelopment of a significant portion of the principal catchment containing the subject site
- consider a range of storm durations and frequencies for all flood events up to and including the 100 year (1% AEP) storm event
- show that the flood peak discharges at all downstream locations are not increased.

For equity reasons, where OSD is waived for a particular site, an equivalent expenditure on measures providing environmental and/or community benefits from the development, such as water quality improvements, will be required.ⁱ

A.2 Alternative application

When Council considers it impractical, or not in the community interest, to provide the required site storage within the property, Council may allow a developer to contribute to the cost of off-site flood storage works nearby. In these cases the volume of flood storage required will be greater than for on-site OSD because there will be no discharge control device to maximise outflows. Contributions may be used for works and/or land purchase to create additional flood storage by means of retarding basins, off-stream storages, channel enlargements or channel improvements between the development site and the downstream off-site flood storage.

A.3 Tradeable On-site Stormwater Detention permits

A study of the feasibility of tradeable discharge control permits has been completed. (Feasibility Assessment of Tradeable On-site Stormwater Detention Permits, Willing and Partners 1993). The study concluded that it was possible for the owner of a development property, which could discharge at less than the PSD, to sell the unused discharge capacity to a nearby developer, but subject to strict limitations. These limitations are that the trading of excess discharge capacity can only occur in the downstream direction along the same drainage/creek line and over a distance of no more than 5km; and not across a flood retarding basin.

To date there has been no trading of discharge permits. Should developers wish to investigate this option, further discussion would be required with the relevant council and the Trust.

ⁱ Requirement for equivalent works in lieu formalised in third edition.

Appendix B – Standard Forms and Accompanying Notes

- B.1 Drainage Design Summary sheet.
- B.2 Explanatory notes on the preparation and registration of Positive Covenants and Restrictions on Use of Land.
- B.3 Blank copy of form 13PC for a Positive Covenant and form 13RPA for a Restriction on Use of land with instructions, for use when there is no subdivision of land involved.
- B.4 Terms and conditions for Restriction on Use of Land and Positive Covenant.
- B.5 Sample Restriction on Use of Land and Covenant where a deposited plan is being registered together with a Section 88B instrument.
- B.6 A copy of Information Bulletin No 14 (dated September 1998) *A Guide to the Preparation of a Section 88B Instrument to:*
 - . *Create Easements, profits à Prendre, Restrictions on the Use of Land or Positive Covenants*
 - . *Release Easements or Profits à Prendre*prepared by the Land Titles Office.
- B.7 Sample Covenant used where a deposited plan is being registered together with a Section 88B instrument and construction of the OSD system is being deferred.
Note: Council will only permit deferral of the construction of the OSD systems in exceptional circumstances.
- B.8 Checklist for Stormwater Control Plan.
- B.9 Checklist for Detailed Design.
- B.10 Checklist for Work-As-Executed Plans.
- B.11 Standard Certificate of Hydraulic Compliance.
- B.12 List of Outstanding Works.

Form B1ⁱ**DRAINAGE DESIGN SUMMARY****SUB/DA****No.** _____

Project: _____ Location: _____

Designed by: _____ Company: _____ Phone: _____

SITE AREA _____ ha *See Section 3.4.3 for dual occupancy [A]

Upstream catchment draining through site = _____ ha [AA]

See Section 4.1.3 for assessment of external flows.

Basic storage volume 470 x [A] _____ = _____ m³ [B]Basic discharge = 0.08 x [A] _____ = _____ m³/s [C]

Area of site drained to storage = _____ ha [D]

(Must be as much as possible and not be less than 85% of the total site without written Council approval).

[D] / [A] + [_____] / [_____] x 100 = _____ % [E]

Storage per ha. of contributing area = [B] / [D] = _____ [F]

Enter *volume/PSD adjustment chart* (Fig 5.1) using [F], and Read new PSD in litres/second/ha (l/s/ha). = _____ l/s/ha [G]

Determine PSD = [G] x [D] _____ x _____ = _____ l/s [H]

Maximum head to orifice centre = _____ m [K]

Weir flow to storage $Q^{Weir} = CL(H^{Weir})^{1.5} \therefore H^{Weir} = \text{_____} \text{ m}$ [I]Selected orifice diameter: $d = (0.464 \times Q / \sqrt{h})^{0.5} = (0.464 \times [H] / \sqrt{[K]})^{0.5} = \text{_____} \text{ m}$ [J]

Maximum discharge = _____ l/s [L]

Head for high early discharge = _____ m [M]

High early discharge $\{[L] \times \sqrt{[M] / [K]}\}$ (min 75% of [L]) = _____ l/s [N]

Approximate mean discharge = ([L]) + [N] / 2 = _____ l/s [P]

Average discharge/ha = [P] / [D] = _____ / _____ = _____ l/s/ha [Q]

Enter *volume/P.S.D. adjustment chart* (Fig 5.1) using [Q] And read off final storage volume per hectare = _____ m³/ha [R]Determine final SSR = [R] x [D] = _____ x _____ = _____ m³ [S]Primary storage proportion = [S] x _____ % = _____ m³ [T]Secondary storage proportion = [S] x _____ % = _____ m³ [U]Tertiary storage proportion [S] x _____ % = _____ m³ [V]Check [T] + [U] + [V] = [S] = _____ m³ⁱ Revised for third edition to include flow from upstream and revised by pass flows

SIGNATURE: _____ DATE: _____

B.2 Explanatory notes on the preparation and registration of Restrictions on Use of Land and Positive Covenants.ⁱ

Private developers within the upper Parramatta River catchment are required to construct On-site Stormwater Detention (OSD) facilities as part of their development consent to make sure that the development does not increase downstream flooding at any point for all storms up to the 100year ARI event. OSD systems consist of a Discharge Control Pit (DCP), a storage area and a collection network. The collection network directs stormwater flow to the DCP or the storage. The collection network includes those surfaces which are sloped so as to direct flow to the DCP or storage, as well as the more obvious devices such as roof gutters, downpipes, drainage lines and pits. In effect, the whole lot is part of the OSD system.

All the components of an OSD system need to be kept intact and maintained so that the overall system continues to function as it was intended for the life of the development. To ensure that the OSD system is not altered during the life of the development, a Restriction on Use of the land is created. This prevents owners making changes to any of the site drainage components which would alter the way the facility works, without the permission of their local council. To ensure that the OSD system is adequately maintained, a Positive Covenant is registered on the title of the property which places the responsibility for this maintenance on the owner of the land. By registering the covenant and restriction on the property title, the obligations can be transferred to future owners. The Positive Covenant will be stated to benefit the local Council.

A sketch plan showing the location of the different components of the OSD system and a copy of the Maintenance Schedule must be included as attachments to the Positive Covenant. This will ensure future owners are aware of their maintenance obligation. Figure B.2.2 shows a sample sketch plan of an OSD system for a residential development.

In a multi-lot development, there are a number of ways OSD can be provided. A complete OSD system can be installed on each lot; a single OSD system can be constructed to cater for all lots; or multiple facilities can be constructed catering for different lots. Whatever method is chosen for a development, it is important to ensure that the appropriate restrictions and covenants are applied. The storage and the DCP may be the most obvious components to protect, but each lot draining to those components is also important. If the stormwater flow from any lot is diverted away from the storage, part of the value of the OSD system is lost and additional flooding may occur.

Figure B.2.1 shows the steps to be followed to determine the appropriate statutory requirements for OSD systems.

If no new lot is being created, the cheapest and quickest way to register the Positive Covenant and Restriction on Use on the title of Torrens Title land is through:

Form 13PC for a Positive Covenant, and

Form 13RPA for a Restriction on Use,

For Old System land the covenant and restriction should be imposed with a suitable deed.

ⁱ Appendices added in third edition to include current Land Titles Office information and clarify process.

The covenant and restriction on use may also be imposed under Section 88B of the Conveyancing Act, 1919 in conjunction with the creation of a new lot or lots. The Positive Covenant will be in favour of the local council but, because the land is privately owned, the covenant and restriction will be imposed through Section 88E of the Act.

A copy of Information Bulletin No 14, prepared by the Land Titles Office (LTO), *A Guide to the Preparation of a Section 88B Instrument to:*

- *Create Easements, Profits à Prendre, Restrictions on the Use of Land or Positive Covenants*
 - *Release Easements or Profits à Prendre*
- is included in Appendix B6.

The terms and conditions of the covenant and restriction must be shown in part 2 of the Section 88B Instrument or be attached to the forms 13PC and 13RPA. A copy of suitable wording for the terms and conditions is included in Appendix B4. The local Council has the right to release, vary or modify the terms and conditions of the covenant and restriction.

Figure B.2.1 STEPS TO BE FOLLOWED TO CREATE LEGAL PROTECTION FOR OSD SYSTEMS

1. Are any new lots created by the development?

YES Draw Plan with 88B Instrument. Go to **2**.

NO Create Restriction on Use of Land with Form 13RPA
Create Positive Covenant with Form 13PC. Go to **5**

2. Do any of the new lots require a right to drain across other new or existing lots (including the common property in a Strata Title or Association property in a Community Title)?

YES Use 88B instrument to create appropriate easements for drainage for each lot and Go to **3**.

NO Go to **3**.

3. Use 88B instrument to:
Create Restriction on Use of Land for each lot
Create positive Covenant on each lot. Go to **4**.

4. Are owners required to contribute to the maintenance costs of OSD systems on lots in which they do not have an interest?

YES Add appropriate terms to the easement for drainage under the 88B instrument. Go to **5**.

NO Go to **5**.

5. End.

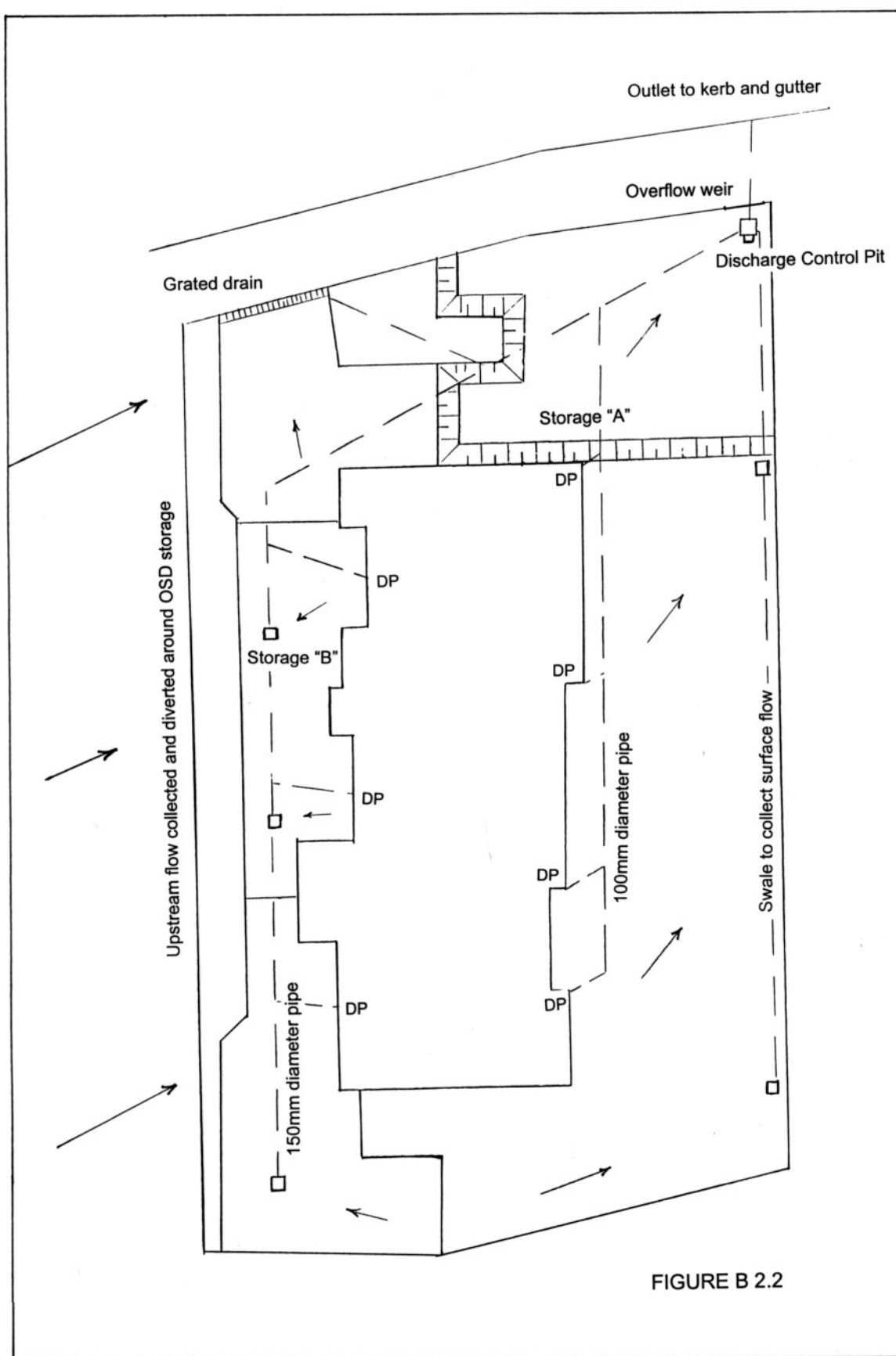


FIGURE B 2.2

Sample OSD Maintenance Schedule

The On-Site Stormwater Detention (OSD) system is designed to temporarily store water during significant rainfall so that stormwater runoff from this property does not worsen flooding downstream. Ponding of water will occur but should not last for more than two hours in most storms. If ponding persists, it is likely that maintenance attention is required.

The following schedule (Figure B2.3) provides a guide to the timing of typical maintenance actions for an On-Site Stormwater Detention (OSD) system as well as defining the person responsible and describing the actions required. It is only intended as a guide and should be tailored to suit the needs of each site. Although the schedule appears very detailed, there are similar actions detailed for the individual components of the OSD system. Most components of the system should be checked for blockages after each significant storm to ensure that they continue to function effectively. The build up of sludge and debris depends on the individual site and more frequent maintenance may be required where there are many trees, especially after windy conditions.

In general, owners could often maintain OSD systems where the depth of pits is less than 1.2 m. For deeper pits or where there are other confined spaces, such as tanks, experienced personnel should be used to ensure that the system is safely maintained. The maintenance schedule should include appropriate notes on the hazards of confined space entry where this is required.

Note: The schedule should be accompanied a sketch plan of the system such as that shown in Figure B 2.2.

Figure B.2.3

MAINTENANCE ACTION	FREQUENCY	RESPONSIBILITY	PROCEDURE
Discharge Control Pit (DCP)			
Inspect & remove any blockage of orifice	Six monthly	Owner	Remove grate & screen to inspect orifice. See plan for location of DCP
Check attachment of orifice plate to wall of pit (gaps less than 5 mm)	Annually	Maintenance Contractor	Remove grate and screen. Ensure plate mounted securely, tighten fixings if required. Seal gaps as required.
Check orifice diameter correct and retains sharp edge	Five yearly	Maintenance Contractor	Compare diameter to design (see Work-as-Executed) and ensure edge is not pitted or damaged.
Inspect screen and clean	Six monthly	Owner	Remove grate and screen if required to clean it.
Check attachment of screen to wall of pit	Annually	Maintenance Contractor	Remove grate and screen. Ensure screen fixings secure. Repair as required.
Check screen for corrosion	Annually	Maintenance Contractor	Remove grate and examine screen for rust or corrosion, especially at corners or welds.
Inspect flap valve & remove any blockage	Six monthly	Owner	Remove grate. Ensure flap valve moves freely and remove any blockages or debris.
Check attachment of flap valve to wall of pit	Annually	Maintenance Contractor	Remove grate. Ensure fixings of valve are secure.
Check flap valve seals against wall of pit	Annually	Maintenance Contractor	Remove grate. Fill pit with water and check that flap seals against side of pit with minimal leakage.
Check any hinges of flap valve move freely	Six monthly	Maintenance Contractor	Remove grate. Test valve hinge by moving flap to full extent.
Inspect overflow weir & remove any blockage	Six monthly	Maintenance Contractor	Remove grate and open cover to ventilate underground storage if present. Ensure weir clear of blockages.
Empty basket at overflow weir (if present)	Six monthly	Maintenance Contractor	Remove grate and ventilate underground storage chamber if present. Empty basket, check fixings secure and not corroded.

MAINTENANCE ACTION	FREQUENCY	RESPONSIBILITY	PROCEDURE
Inspect DCP walls (internal and external, if appropriate) for cracks or spalling	Annually	Maintenance Contractor	Remove grate to inspect internal walls. Repair as required. Clear vegetation from external walls if necessary and repair as required.
Inspect DCP sump & remove any sediment/sludge	Six monthly	Owner	Remove grate and screen. Remove sediment/sludge build-up and check orifice and flap valve clear.
Inspect grate for damage or blockage	Six monthly	Owner	Check both sides of grate for corrosion, (especially corners and welds) damage or blockage.
Inspect return pipe from storage & remove any blockage	Six monthly	Owner	Remove grate and screen. Ventilate underground storage if present. Open flap valve and remove any blockages in return line. Check for sludge/debris on upstream side of return line.
Inspect outlet pipe & remove any blockage	Six monthly	Maintenance Contractor	Remove grate and screen. Ventilate underground storage if present. Check orifice and remove any blockages in outlet pipe. Flush outlet pipe to confirm it drains freely. Check for sludge/debris on upstream side of return line.
Check step irons for corrosion	Annually	Maintenance Contractor	Remove grate. Examine step irons and repair any corrosion or damage.
Check fixing of step irons is secure	Six monthly	Maintenance Contractor	Remove grate and ensure fixings secure prior to placing weight on step iron.
Storage			
Inspect return pit & remove any sediment/sludge in pit	Six monthly	Owner	Remove grate and screen. Remove sediment/sludge build-up.
Inspect internal walls of return pit (and external, if appropriate) for cracks or spalling	Annually	Maintenance Contractor	Remove grate to inspect internal walls. Repair as required. Clear vegetation from external walls if necessary and repair as required.
Inspect & remove any debris/litter/mulch etc blocking grates of return pit	Six monthly	Owner	Remove blockages from grate and check if pit blocked.

MAINTENANCE ACTION	FREQUENCY	RESPONSIBILITY	PROCEDURE
Inspect storage areas & remove debris/mulch/litter etc likely to block screens/grates	Six monthly	Owner	Remove debris and floatable material likely to be carried to grates.
Compare storage volume to volume approved. (Rectify if loss > 5%)	Annually	Maintenance Contractor	Compare actual storage available with Work-as Executed plans. If volume loss is greater than 5%, arrange for reconstruction to replace the volume lost. Council to be notified of the proposal.
Inspect storages for subsidence near pits	Annually	Maintenance Contractor	Check along drainage lines and at pits for subsidence likely to indicate leakages.

B3 Blank Copy of Forms 13RPA AND 13PC

These forms for a Restriction on Use of Land and Positive Covenant are required by the Lands Titles Office where there is no subdivision of land, and the covenant and restriction are being imposed on an existing parcel of land.

A plan should be attached showing the location and various components of the On-site Stormwater Detention system. This should be accompanied by the Maintenance Schedule. (See Appendix B.2)

Form: 13RPA
Licence: 98M111
Edition: 9906

**RESTRICTION ON THE
USE OF LAND BY A
PRESCRIBED AUTHORITY**

New South Wales
Section 88E(3) Conveyancing Act 1919

Land Titles Office use only

Do not affix additional pages
here: use the left-hand corner

(A) TORRENS TITLE			
(B) LODGED BY	LTO Box	Name, Address or DX and Telephone Reference (optional):	CODE R
(C) REGISTERED PROPRIETOR	Of the above land		
(D) LESSEE MORTGAGEE or CHARGE	Of the above land agreeing to be bound by this restriction on land		
	Nature of Interest	Number of Instrument	Name
(E) APPLICANT	A prescribed authority		

- The applicant, being a prescribed authority within the meaning of section 88E(1) of the Conveyancing Act 1919, imposes on the above
- (F) land a restriction on the use of land in the terms set out in annexure hereto, applies to have it recorded in the Register and
- (G) certifies this application correct for the purposes of the Real Property Act 1900. **DATE:**

Signed in my presence by the an **authorised officer of the prescribed authority** who is personally known to me.

Signature of witness:

Signature of authorised officer:

Name of witness:

Name of authorised officer:

Address of witness:

Position of authorised officer:

Signed in my presence by the **registered proprietor of the land** who is personally known to me.

Signature of witness:

Signature of registered proprietor:

Name of witness:

Address of witness:

- (H) I, the **lessee/mortgagee/chargee** under lease/mortgage/charge No. _____, agree to be bound by this restriction.

Signed in my presence by the above lessee/mortgagee/chargee who is personally known to me.

Signature of witness:

Signature of lessee/mortgagee/chargee:

Name of witness:

Address of witness:

All handwriting must be in block capitals.
A set of notes on this form (13RPA-2)
is available from the Land Titles Office.

Page 1 of _____

Checked by (LTO use):

13RPA-2 (9909)

Restriction on the Use of Land by a Prescribed Authority form 13RPA: Instructions for Completion

Note: This form is to be used only where the restriction is imposed by a prescribed authority on land in private ownership.

1. Complete the form in dense black or dark blue ink. If handwriting, use block capitals only.
2. Do not use an eraser or correction fluid to make alterations: rule through rejected material and initial the left-hand margin.
3. If the space provided at any point is insufficient, insert "See Annexure" at that point and include the required material on sheets of white A4 paper at least 80gsm (ordinary copier paper satisfies these requirements) using one side only. Insert a heading beginning "Annexure to ..." and specifying the type of form, the date and the parties to the transaction. Identify the material included, where possible by referring to the relevant marginal heading on the form. In the case of signatures which could not be fitted in the space provided, reproduce the text and layout used on the form. Number all pages in sequence with the form using the format "Page ... of ...", the number to be placed at the foot of the form in the centre. The first and last pages must be signed by the parties and any witness. Securely attach the additional pages to the upper left-hand corner of the form: a Nalclip is preferred; stapling should be avoided.
4. Insert the total number of pages, including any additional pages (see above), in the space provided at the foot of the form.
5. Lodge the completed form by hand at the Land Titles Office, Queens Square, Sydney (adjacent to Hyde Park Barracks). Lodgment of the certificate of title is optional.
6. The following instructions relate to the marginal letters on the form.

(A) TORRENS TITLE

Insert the number of the folio of the Register for the property affected. If the restriction affects only part of the land, add a description of the part, for example, "... part formerly comprised in Lot 1 in DP123456".

(B) LODGED BY

This section must be completed by the person or firm lodging the form at the Land Titles Office. If the party lodging does not have a Land Titles Office delivery box, leave this panel blank. Provision of a reference is optional.

(C) REGISTERED PROPRIETOR

Insert the full name of the registered proprietor of the land subject to the restriction. Address and occupation are not required.

(D) LESSEE, MORTGAGEE or CHARGE

Insert the details of any lessee, mortgagee or chargee who agrees to be bound by the restriction.

(E) APPLICANT

The applicant must be a prescribed authority within the meaning of section 88E(1) of the Conveyancing Act 1919.

(F) Specify the annexure containing the terms of the restriction.

(G) EXECUTION

The completed form must be executed by an authorised officer of the prescribed authority, and by or on behalf of the registered proprietor of the land and any lessee, mortgagee or chargee who agrees to be bound by the restriction. Any witness must be an adult who is not a party to the application and knows the person executing. Where the form is executed—

By an individual on his/her own behalf The signature must be witnessed.

By an attorney The power of attorney must be registered at the Land Titles Office. In addition to the attorney's signature, a statement in the following format must be added: "John Smith by his attorney Jane Smith pursuant to power of attorney Book 1234 No. 567". The signature must be witnessed.

By a receiver or delegate Use the format given in "By an attorney" suitably modified. The signature must be witnessed.

By a corporation The form of execution must include reference to the power or authority relied on by the signatories, for example, "Executed by ABC Pty Ltd ACN 123456 by a director and secretary".

Note The application may not be executed by a solicitor or licensed conveyancer on behalf of the registered proprietor of the land or any lessee, mortgagee or chargee who agrees to be bound by the restriction.

(H) Rule through the inapplicable words and insert the number of the relevant instrument. If this section of the form does not apply rule it through.

If you have any questions, please call Land Titles Office Client Services on 02 9228 6713.

Form: 13PC
Licence: 98M111
Edition: 9909

POSITIVE COVENANT

New South Wales
Section 88E(3) Conveyancing Act 1919

Land Titles Office use only

*Do not affix additional pages
here: use the left-hand corner*

(A) TORRENS TITLE			
(B) LODGED BY	LTO Box	Name, Address or DX and Telephone Reference (optional):	CODE PC
(C) REGISTERED PROPRIETOR	Of the above land		
(D) LESSEE MORTGAGEE or CHARGE	Of the above land agreeing to be bound by this positive covenant		
	Nature of Interest	Number of Instrument	Name
(E) APPLICANT	A prescribed authority		

- The applicant, being a prescribed authority within the meaning of section 88E(1) of the Conveyancing Act 1919, imposes on the
- (F) above land a positive covenant in the terms set out in annexure hereto, applies to have it recorded in the Register and
- (G) certifies this application correct for the purposes of the Real Property Act 1900. **DATE:**

Signed in my presence by the **authorised officer of the prescribed authority** who is personally known to me.

Signature of witness:

Signature of authorised officer:

Name of witness:

Name of authorised officer:

Address of witness:

Position of authorised officer:

Signed in my presence by the **registered proprietor of the land** who is personally known to me.

Signature of witness:

Signature of registered proprietor:

Name of witness:

Address of witness:

- (H) I, the **lessee/mortgagee/chargee** under lease/mortgage/charge No. , agree to be bound by this positive covenant.

Signed in my presence by the above lessee/mortgagee/chargee who is personally known to me.

Signature of witness:

Signature of lessee/mortgagee/chargee:

Name of witness:

Address of witness:

All handwriting must be in block capitals.

A set of notes on this form (13PC-2)
is available from the Land Titles Office.

Page 1 of ____

Checked by (LTO use):

13PC-2 (9909)

Positive Covenant form 13PC: Instructions for Completion

1. Complete the form in dense black or dark blue ink. If handwriting, use block capitals only.
2. Do not use an eraser or correction fluid to make alterations: rule through rejected material and initial the left-hand margin.
3. If the space provided at any point is insufficient, insert "See Annexure" at that point and include the required material on sheets of white A4 paper at least 80gsm (ordinary copier paper satisfies these requirements) using one side only. Insert a heading beginning "Annexure to ..." and specifying the type of form, the date and the parties to the transaction. Identify the material included, where possible by referring to the relevant marginal heading on the form. In the case of signatures which could not be fitted in the space provided, reproduce the text and layout used on the form. Number all pages in sequence with the form using the format "Page ... of ...", the number to be placed at the foot of the form in the centre. The first and last pages must be signed by the parties and any witness. Securely attach the additional pages to the upper left-hand corner of the form: a Nalclip is preferred; stapling should be avoided.
4. Insert the total number of pages, including any additional pages (see above), in the space provided at the foot of the form.
5. Lodge the completed form by hand at the Land Titles Office, Queens Square, Sydney (adjacent to Hyde Park Barracks). Lodgment of the certificate of title is optional.
6. The following instructions relate to the marginal letters on the form.

(A) TORRENS TITLE

Insert the number of the folio of the Register for the property affected. If the positive covenant affects only part of the land, add a description of the part, for example, "... part formerly comprised in Lot 1 in DP123456".

(B) LODGED BY

This section must be completed by the person or firm lodging the form at the Land Titles Office. If the party lodging does not have a Land Titles Office delivery box, leave this panel blank. Provision of a reference is optional.

(C) REGISTERED PROPRIETOR

Insert the full name of the registered proprietor of the land subject to the positive covenant. Address and occupation are not required.

(D) LESSEE, MORTGAGEE or CHARGE

Insert the details of any lessee, mortgagee or chargee who agrees to be bound by the positive covenant.

(E) APPLICANT

The applicant must be a prescribed authority within the meaning of section 88E(1) of the Conveyancing Act 1919.

(F) Specify the annexure containing the terms of the positive covenant.**(G) EXECUTION**

The completed form must be executed by an authorised officer of the prescribed authority, and by or on behalf of the registered proprietor of the land and any lessee, mortgagee or chargee who agrees to be bound by the positive covenant. Any witness must be an adult who is not a party to the application and knows the person executing. Where the form is executed—

By an individual on his/her own behalf The signature must be witnessed.

By an attorney The power of attorney must be registered at the Land Titles Office. In addition to the attorney's signature, a statement in the following format must be added: "John Smith by his attorney Jane Smith pursuant to power of attorney Book 1234 No. 567". The signature must be witnessed.

By a receiver or delegate Use the format given in "By an attorney" suitably modified. The signature must be witnessed.

By of a corporation The form of execution must include reference to the power or authority relied on by the signatories, for example, "Executed by ABC Pty Ltd ACN 123456 by a director and secretary".

Note The application may not be executed by a solicitor or licensed conveyancer on behalf of the registered proprietor of the land or any lessee, mortgagee or chargee who agrees to be bound by the positive covenant.

(H) Rule through the inapplicable words and insert the number of the relevant instrument. If this section of the form does not apply rule it through.

If you have any questions, please call Land Titles Office Client Services on 02 9228 6713.

B4 Terms and conditions for Restriction on Use of Land and Positive Covenantⁱ

Appendix B4A contains standard recitals for the Terms and Conditions to be applied in Restrictions on Use of Land and or Positive Covenants in relation to OSD systems. Appendix B.5 contains a sample instrument which shows how these terms and conditions are applied.

Both the Restriction on Use and the Positive Covenant will normally be required, however in cases where only the Positive Covenant is used, the definition of the OSD system and the details of the Council file number (given in clause 1 of the Restriction on Use) should be included in the Positive Covenant.

Appendix B4B contains the OSD related recitals for use in the City of Blacktown. Council also has a booklet of Standard Recitals for Terms of Easements, Covenants and Restrictions Commonly Imposed by Instrument under Section 88B of the Conveyancing Act, 1919 as Amended.

ⁱ Council file number and Blacktown City Council recitals added for third edition.
Upper Parramatta River Catchment Trust

B4Aⁱⁱ Restrictions on Use of Land for OSD Systems

1. The registered proprietor shall not make or permit or suffer the making of any alterations to any on-site stormwater detention system which is, or shall be, constructed on the lot(s) burdened without the prior consent in writing of(*Insert name of Council*) . The expression “on-site stormwater detention system” shall include all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater as well as all surfaces graded to direct stormwater to the temporary storageⁱⁱⁱ. The on-site stormwater detention system is detailed on the plans approved by as Construction Certificate No..... on (Include the following for privately certified Construction Certificates only:) A copy of this Construction Certificate is held on Council file No.

Any on-site stormwater detention system constructed on the lot(s) burdened is hereafter referred to as “the system”.

Name of Authority having the power to release, vary or modify the Restriction referred to is(*Insert name of Council*).

2. The registered proprietor shall not erect or suffer the erection of any dwelling house or other structure on the lot(s) hereby burdened unless the registered proprietor has first constructed or has made provision for the construction of an on site stormwater detention system on the said lot(s), in accordance with the design, construction and/or provision requirements of the(*Insert name of Council*) and to the satisfaction of the (*Insert name of Council*). The expression “on-site stormwater detention system” shall include all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater as well as all surfaces graded to direct stormwater to the temporary storage.

Note: Clause 2 is only necessary when construction of the OSD system is being deferred, which will only be permitted by Council in exceptional circumstances.

Positive Covenants

1. The registered proprietor of the lot(s) hereby burdened will in respect of the system:
 - (a) keep the system clean and free from silt, rubbish and debris
 - (b) maintain and repair at the sole expense of the registered proprietors the whole of the system so that it functions in a safe and efficient manner
 - (c) permit the Council or its authorised agents from time to time and upon giving reasonable notice (but at any time and without notice in the case of an emergency) to enter and inspect the land for the compliance with the requirements of this covenant
 - (d) comply with the terms of any written notice issued by the Council in respect of the requirements of this covenant within the time stated in the notice.

ⁱⁱ Space for Council file number added in third edition

ⁱⁱⁱ Surface grading requirement added in third edition.

2. Pursuant to Section 88F(3) of the Conveyancing Act 1919 the Council shall have the following additional powers:
- (a) in the event that the registered proprietor fails to comply with the terms of any written notice issued by the Council as set out above the Council or its authorised agents may enter the land with all necessary materials and equipment and carry out any work which the Council in its discretion considers reasonable to comply with the said notice referred to in part 1(d) above
 - (b) the Council may recover from the registered proprietor in a Court of competent jurisdiction:
 - (i) any expense reasonably incurred by it in exercising its powers under sub-paragraph (i) hereof. Such expense shall include reasonable wages for the Council's employees engaged in effecting the work referred to in (i) above, supervising and administering the said work together with costs, reasonably estimated by the Council, for the use of materials, machinery, tools and equipment in conjunction with the said work.
 - (ii) legal costs on an indemnity basis for issue of the said notices and recovery of the said costs and expenses together with the costs and expenses of registration of a covenant charge pursuant to section 88F of the Act or providing any certificate required pursuant to section 88G of the Act or obtaining any injunction pursuant to section 88H of the Act.

Name of Authority having the power to release vary or modify the Positive Covenant
..... referred to is(*Insert name of Council*).

B4B Standard recital for Use in the City of Blacktown^{iv}**Terms of Restriction on Use of Land****1. For constructed works**

The registered proprietor(s) covenant as follows with the Authority benefited in respect to the on-site stormwater detention system (hereinafter referred to as “the system”) constructed on the burdened lot(s) that they will not, without the prior and express written consent of the Authority benefited:

- a. Do any act, matter or thing which would prevent the system from operating in a safe and efficient manner.
- b. Make or permit or suffer the making of any alterations or additions to the system.
- c. Allow any development within the meaning of the Environmental Planning and Assessment Act 1979 to encroach upon the system.

This restriction shall bind all persons who are or claim under the registered proprietor(s) as stipulated in Section 88E(5) of the Conveyancing Act 1919.

For the purposes of this restriction, “the system” means the on-site stormwater detention system constructed on the land as detailed on the plans approved by as Construction Certificate No. on, including all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater, as well as all surfaces graded to direct stormwater to the temporary storage. *(Include the following for Private CC's only)* A copy of this Construction Certificate is held on Council File No.

2. For deferred works

This following version is only used when construction of the OSD system is being deferred, which will only be permitted by Council in **exceptional** circumstances.

“The registered proprietor shall not erect or suffer the erection of any dwelling house or other structure on the lot(s) hereby burdened unless the registered proprietor has first constructed or has made provision for the construction of an on site stormwater detention system on the said lot(s), in accordance with the design, construction and/or provision requirements of, and to the satisfaction of Blacktown City Council.

The expression “on-site stormwater detention system” shall include all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater as well as all surfaces graded to direct stormwater to the temporary storage.”

^{iv} Blacktown City Council recital added for third edition.

Terms of Positive Covenant.....

1. The registered proprietor(s) covenant as follows with the Authority benefited in respect to the on-site stormwater detention system (hereinafter referred to as "the system") constructed on the burdened lot(s), that they will:
 - a) Keep the system clean and free from silt, rubbish and debris
 - b) Maintain and repair at the sole expense of the registered proprietor(s) that part of the system contained within the registered proprietor's own lot, so that it functions in a safe and efficient manner, in accordance with the "On-Site Detention Maintenance Schedule" as approved by on, a copy of which is held on Council File A copy of this Schedule is available to all owners and occupiers of the burdened lot(s)
 - c) For the purpose of ensuring observance of this covenant, permit Blacktown City Council or its authorised agents (hereinafter referred to as "the Council") from time to time and upon giving reasonable notice (but at any time and without notice in the case of an emergency) to enter the land and inspect the condition of the system and the state of construction, maintenance or repair of the system, for compliance with the requirements of this covenant
 - d) Comply with the terms of any written notice issued by the Council to attend to any matter and carry out such work within the time stated in the notice, to ensure the proper and efficient performance of the system and to that extent Section 88F(2)(a) of the Conveyancing Act 1919 (hereinafter referred to as "the Act") is hereby agreed to be amended accordingly.
2. Pursuant to Section 88F (3) of the Act the Council shall have the following additional powers pursuant to this covenant:
 - a) In the event that the registered proprietor fails to comply with the terms of any written notice issued by the Council as set out above, the Council may enter the land with all necessary equipment and carry out any work considered by Council to be reasonable to comply with the said notice referred to in 1(d) above.
 - b) The Council may recover from the registered proprietor in a court of competent jurisdiction:
 - I. Any expense reasonably incurred by it in exercising its powers in subparagraph 2(a) above. Such expense shall include reasonable wages for employees engaged in effecting, supervising and administering the said work, together with costs, reasonably estimated by Council, for the use of materials, machinery, tools and equipment used in conjunction with the said work.
 - II. Legal costs on an indemnity basis for issue of the said notices and recovery of the said costs and expenses together with the costs, charges, and expenses of registration of a covenant charge pursuant to Section 88F of the Act or providing any certificate required pursuant to Section 88G of the Act or obtaining any injunction pursuant to Section 88H of the Act.
3. This covenant shall bind all persons who are or claim under the registered proprietor(s) as stipulated in Section 88E(5) of the Act.

For the purposes of this covenant, "the system" means the on-site stormwater detention system constructed on the land as detailed on the plans approved by as Construction Certificate No. on, including all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater, as well as all surfaces graded to direct stormwater to the temporary storage. *(Include the following for Private CC's only)* A copy of this Construction Certificate is held on Council File No.

B5 Sample Restriction on Use of Land and Covenant where a Deposited plan is being registered together with a Section 88B instrument.

In this case the On-Site Detention system is provided with Development Approval involving subdivision of land.

A copy of the Maintenance Schedule should be attached to the Instrument.

(ON-SITE DETENTION SYSTEM PROVIDED WITH DEVELOPMENT APPROVAL INVOLVING SUBDIVISION)INSTRUMENT SETTING OUT TERMS OF RESTRICTION ON THE USE OF LAND AND POSITIVE COVENANT INTENDED TO BE CREATED PURSUANT TO SECTION 88E OF THE CONVEYANCING ACT 1919.

(Sheet .. of ... sheets)

Plan:

Subdivision of LotD.P.....
 Covered by Council Clerk's
 Certificate No.
 Of

Full name and address
Of proprietor of the land

.....

PART 1

- () Identity of restriction..... Restriction on use under Section 88E of the
referred to in abovementioned plan Conveyancing Act 1919

SCHEDULE OF LOT(S), ETC. AFFECTEDLot(s) BurdenedAuthority Benefited

.....

Insert name of Council

- () Identity of Positive Covenant
..... referred to in
above-mentioned plan

Positive Covenant under
 Section 88E of the
 Conveyancing Act 1919

SCHEDULE OF LOT(S), ETC. AFFECTEDLot(s) BurdenedAuthority Benefited

.....

*Insert name of Council*INSTRUMENT SETTING OUT TERMS OF RESTRICTION ON THE USE OF LAND AND POSITIVE COVENANT INTENDED TO BE CREATED PURSUANT TO SECTION 88E OF THE CONVEYANCING ACT 1919.

(Sheet .. of ... sheets)

Plan:

Subdivision of LotD.P.....
 Covered by Council Clerk's
 Certificate No.
 Of

Full name and address
Of proprietor of the land

.....

PART 2ⁱTERMS OF RESTRICTION ON USE REFERRED TO IN
THE ABOVE-MENTIONED PLAN

The registered proprietor shall not make or permit or suffer the making of any alterations to the on-site stormwater detention system which is constructed on the lot(s) burdened without the prior consent in writing of(Insert name of Council). The expression "on-site stormwater detention system" shall include all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater as well as all surfaces graded to direct stormwater to the temporary storageⁱⁱ. Any on-site stormwater detention system constructed on the lot(s) burdened is hereafter referred to as "the system". The on-site stormwater detention system is detailed on the plans approved by as Construction Certificate No..... on (Include the following for privately certified Construction Certificates only:) A copy of this Construction Certificate is held on Council file No.

Name of Authority having the power to release, vary or modify the Restriction referred to is(Insert name of Council).

PART 2 (Continued)TERMS OF POSITIVE COVENANTREFERRED TO IN
THE ABOVE-MENTIONED PLAN

1. The registered proprietor of the lot(s) hereby burdened will in respect of the system:
 - (a) keep the system clean and free from silt, rubbish and debris
 - (b) maintain and repair at the sole expense of the registered proprietors the whole of the system so that it functions in a safe and efficient manner
 - (c) permit the Council or its authorised agents from time to time and upon giving reasonable notice (but at any time and without notice in the case of an emergency) to enter and inspect the land for the compliance with the requirements of this covenant
 - (d) comply with the terms of any written notice issued by the Council in respect of the requirements of this covenant within the time stated in the notice.

ⁱ Space for council file number added to third edition.

ⁱⁱ Surface grading requirement added in third edition.

INSTRUMENT SETTING OUT TERMS OF RESTRICTION ON THE USE OF LAND AND POSITIVE COVENANT INTENDED TO BE CREATED PURSUANT TO SECTION 88E OF THE CONVEYANCING ACT 1919.

(Sheet .. of ... sheets)

Plan:

Subdivision of LotD.P.....
Covered by Council Clerk's
Certificate No.
Of

Full name and address

Of proprietor of the land

.....
.....

2. Pursuant to Section 88F(3) of the Conveyancing Act 1919 the Council shall have the following additional powers:

- (i) in the event that the registered proprietor fails to comply with the terms of any written notice issued by the Council as set out above the Council or its authorised agents may enter the land with all necessary materials and equipment and carry out any work which the Council in its discretion considers reasonable to comply with the said notice referred to in part 1(d) above
- (ii) The Council may recover from the registered proprietor in a Court of competent jurisdiction:
 - (a) any expense reasonably incurred by it in exercising its powers under subparagraph (i) hereof. Such expense shall include reasonable wages for the Council's employees engaged in effecting the work referred to in (i) above, supervising and administering the said work together with costs, reasonably estimated by the Council, for the use of materials, machinery, tools and equipment in conjunction with the said work.
 - (b) legal costs on an indemnity basis for issue of the said notices and recovery of the said costs and expenses together with the costs and expenses of registration of a covenant charge pursuant to section 88F of the Act or providing any certificate required pursuant to section 88G of the Act or obtaining any injunction pursuant to section 88H of the Act.

Name of Authority having the power to release vary or modify the Positive Covenant referred to is(Insert name of Council).

B.6

Land Titles Office

Information Bulletin

September 1998

Number: 14

A Guide to the preparation of a Section 88B Instrument to:

- **Create Easements, Profits à Prendre, Restrictions on the Use of Land or Positive Covenants**
- **Release Easements or Profits à Prendre**

Note: This bulletin should be read in conjunction with the following:

- **Information Bulletin No. 43** - 'Creating an Easement over a Track in Use'
- **Information Bulletin No. 56** - 'Property Legislation (Easements) Amendment Act 1995.'

1. Introduction:

A Section 88B Instrument is the part of a deposited plan which upon registration

- creates Easements, Profit à Prendre, Restrictions on the Use of Land, and Positive Covenants [clause 27 Conveyancing (General) Regulation 1998]
- releases Easements and Profits à Prendre [clause 28 Conveyancing (General) Regulation 1998]

Note: Restrictions on the use of land and Positive Covenants cannot be varied or released by a Section 88B instrument.

The Instrument must be drawn in accordance with Approved Form 10 (**Annexures 2 and 3**).

The original instrument must be lodged as part of the plan. Stamp Duty is not payable.

Identification of easements:

Easements must be identified on the face of the plan using 'alpha' symbols. A specimen plan is attached as **Annexure 1**.

It is necessary to identify easements with the same expression:

- in the statements of intention panel on the plan
- in the Section 88B Instrument and
- on the face of the plan

Note: Where a Section 88B Instrument, includes height limitations to define the stratum of an easement, profit à prendre, restriction or positive covenant, the accompanying deposited plan must comply with clause 47 of the Surveyors (Practice) Regulation 1996.

2. Preparation of a Section 88B Instrument:

A Section 88B instrument comprises three parts:

- **Part 1:** Identifies each easement, profit à prendre, restriction or positive covenant to be created.
- **Part 1A:** Identifies each easement or profit à prendre to be released.
Examples of the Schedules of lots burdened and benefited in Parts 1 and 1A are shown in **Annexure 4**
- **Part 2:** Sets out the terms and conditions of easements profits à prendre, restrictions or positive covenants referred to in Part 1)

Part 2 may not be required see **Para.3.1**

3. Creating easements:

Easements may be created with or without terms and conditions shown in Part 2 of the section 88B instrument.

3.1 Terms and conditions not required:

In order to simplify the creation of easements, the statutory form of easements may be used. Statutory easements adopt the terms and conditions specified in Schedule 4A (easements in gross) and Schedule 8 (easements having a dominant tenement) Conveyancing Act 1919.

The terms and conditions of an easement cannot refer to persons empowered to release vary or modify the easement. (see sec. 88[1](c) Conveyancing Act 1919).

Following is a list of statutory easements (referred to as short form easements) set out in the Schedules that do not require terms and conditions to be included in Part 2 of the instrument:

- Right of Carriage Way
- Right of Foot Way
- Easement to Drain Water
- Easement to Drain Sewage
- Easement for Repairs
- Easement for Batter
- Easement for Drainage of Sewage
- Easement for Drainage of Water
- Easement for Electricity Purposes
- Easement for Overhang
- Easement for Services
- Easement for Water Supply
- Easement to permit Encroaching Structure to remain
- Right of Access

Note: The use of these expressions does not prevent the inclusion in Part 2 of variations of the terms and conditions referred to in the Schedules. Such variations may be by way of addition, exception, qualification or omission.

3.2 Terms and conditions required

Alternatively, an easement may be created for another purpose. In this case relevant terms and conditions must be shown in Part 2 of the instrument

4. Creating Profits à Prendre, Restrictions on Use of Land.

Terms and conditions of profits à prendre and restrictions on the use of land must always be shown in Part 2 of the instrument.

The terms and conditions of a Restriction on the Use of Land may state the person(s) empowered to release, vary or modify the restriction. (sec. 88[1](c) Conveyancing Act 1919)

Note: The sites of Restrictions and Profits à Prendre and are only identified on the face of the plan if they affect part of a lot.

5. Creating Positive Covenants

Terms and conditions of Positive Covenants must always be shown in Part 2 of the instrument. They may be created in favour of:

- prescribed authorities (sections 88D & 88E Conveyancing Act 1919) or
- privately owned land, where the covenant relates to maintenance or repair of an easement to be created by the instrument.

The site of the Positive Covenant is only shown on the face of the plan if it affects part of a lot.

Note:

A Section 88B Instrument cannot be used to create a Positive Covenant over an existing easement

To record an interest relating to maintenance and repair of the site of an **existing easement** over:

- Torrens title land, a Request (97-11R) should be registered containing the terms of the covenant or
- Old System land, a deed containing the terms of the covenant should be registered in the General Register of Deeds.

6. Releasing Easements or Profits à Prendre

Section 88B Conveyancing Act 1919 provides for the release of easements and profits à prendre by the registration of a plan.

The identity of easements and Profits à Prendre to be released must be set out in:

- Part 1A of the instrument and
- the statement of intention panel of the plan.

An example is shown in **Annexure 3**.

7. Signatures and Consents

Where an easement, profit à prendre, restriction or positive covenant is being created the plan and Section 88B instrument must be signed by:

- the registered proprietor
- mortgagee
- chargee or
- covenant chargee and

Written consents must be furnished by any

- caveator,
- lessee, or
- judgement creditor under any writ

in accordance with Section 195D Conveyancing Act 1919.

Note: Written consents may be dispensed with if the caveator, lessee or judgement creditor signs the plan and instrument.

Where an Easement or Profit à Prendre is being released:

The signatures and consents of all the parties relating to the dominant tenement should be furnished.

Inquiries on all matters related to plans and associated dealings should initially be made in person at Customer Services Branch, second level, Land Titles Office, Queens Square, Sydney or by contacting the Telephone Inquiry Service on (02) 9228 6713.

David Mulcahy
Director of Land Titles and Registrar General

First issued July 1987

Annexure 1

PLAN FORM 2 (APPROVED FORM 3) SIGNATURES, AND SEALS ONLY	Plan Drawing only to appear in this space NOTE THIS PLAN HAS BEEN PREPARED FOR SAMPLE PURPOSES ONLY BEARINGS AND OTHER SURVEY INFORMATION HAVE BEEN OMITTED D P 3 0 4 7 9 D P 2 9 7 4 3
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| **PLAN FORM 2 (APPROVED FORM 3)** **SIGNATURES, AND SEALS ONLY** | Plan Drawing only to appear in this space NOTE THIS PLAN HAS BEEN PREPARED FOR SAMPLE PURPOSES ONLY BEARINGS AND OTHER SURVEY INFORMATION HAVE BEEN OMITTED D P 3 0 4 7 9 D P 2 9 7 4 3 |

Annexure 2

Instrument setting out Terms of Easements/Profits à Prendre intended to be created or released and of Restrictions on the Use of Land and Positive Covenants intended to be created pursuant to Section 88B of the Conveyancing Act 1919.

Plan: Subdivision of Lot 8 D.P.29743 covered by Subdivision Certificate No. 98/200 of 9/7/1998

Full name and address of the owner of the land Grace Mary Brothers
4 Crane Avenue
Fine NSW 2775

Part 1

- | | |
|---|--|
| 1. Identity of easement, profit à prendre, restriction or positive covenant to be created and firstly referred to in the plan | Right of Carriage Way and Easement for Services 2.7 wide |
|---|--|

Schedule of Lots etc. Affected**Lots Burdened**

82

Lots Benefited

81

- | | |
|--|--|
| 2. Identity of easement to be created and secondly referred to in the plan | Right of Way 2.1 wide and variable width |
|--|--|

Schedule of Lots etc. Affected**Lots Burdened**

81

Lots Benefited

82

- | | |
|--|-------------------|
| 3. Identity of positive covenant thirdly referred to in the plan | Positive Covenant |
|--|-------------------|

Schedule of Lots etc. Affected**Lots Burdened**

81

Lots Benefited

Goodarea Council

- | | |
|---|--------------------------------|
| 4. Identity of restriction fourthly referred to in the plan | Restriction on the Use of Land |
|---|--------------------------------|

Schedule of Lots etc. Affected**Lots Burdened**

81

Lots Benefited

Goodarea Council

82

Goodarea Council

Annexure 2

This page last updated December 1999 B.6-7 *On-site Stormwater Detention Handbook*
Instrument setting out Terms of Easements/Profits à Prendre intended to be created or released, and of Restrictions on the Use of Land and Positive Covenants intended to be created pursuant to Section 88B of the Conveyancing Act 1919.

Plan: Subdivision of Lot 8 D.P.29743 covered by
Subdivision Certificate No. 98/200 of
9/7/1998

Part 1A

- 1. Identity of easement to be released and** Easement to Drain Water 2 wide
firstly referred to in the plan (DP 840601)

Schedule of Lots etc. Affected

Lots Burdened	Lots Benefited
8/29743	9/29743

Part 2

Note: The terms for the positive covenant and restriction on the use of land, set out in Part 2, are included for the purposes of illustration only.

- 1. Terms of Right of Way 2.1 wide and variable secondly referred to in the plan.**

(Insert terms and conditions).

- 2. Terms of Positive Covenant thirdly referred to in the plan**

The Proprietor of the land hereby burdened (herein called 'the Proprietor') shall at all times in respect of the land hereby burdened, identified on the plan as 'stormwater retention basin' (herein called 'the basin'): (Insert terms and conditions).

- 3. Terms of Restriction on the Use of Land fourthly referred to in the plan**

- a. Not to erect or suffer to permit any building, structure or erection on the whole or in part of the land hereby burdened identified on the plan as 'stormwater retention basin' (herein called 'the basin') except: (Insert terms of restrictions).
- b. No alteration is to be made to the retention levels (Insert terms of restrictions).

Name of authority empowered to release, vary or modify positive covenant and restriction thirdly and fourthly referred to in the plan.

Goodarea Council.

Annexure 2

Instrument setting out Terms of Easements/Profits à Prendre intended to be created or released, and of Restrictions on the Use of Land and Positive Covenants intended to be created pursuant to Section 88B of the Conveyancing Act 1919.

Plan: Subdivision of Lot 8 D.P.29743 covered by
Subdivision Certificate No. 98/200 of
9/7/1998

Signed in my presence by Grace Mary
Brothers who is personally known to me.

Signature of witness

Grace Mary Brothers

Name of Witness (Block Letters)

Address and Occupation of Witness

Signed in my presence by Francis Richard
Drake (registered proprietor of dominant
tenement 9/29743) who is personally known
to me.

Signature of Witness

Francis Richard Drake

Name of Witness (Block Letters)

Address and occupation of Witness

Annexure 3

Copy of Approved Form 10

Instrument setting out Terms of Easements/Profits à Prendre intended to be created or released and of Restrictions on the Use of Land and Positive Covenants intended to be created pursuant to Section 88B of the Conveyancing Act 1919.

Plan: *(Please leave 26 mm to allow for
plan number and heading of plan)* Plan of (heading of plan) covered by
Subdivision Certificate No. (add reference
as appropriate)

Full name and address of the owner of the land:

Part 1

- | | |
|---|---|
| 1. Identity of easement, profit à prendre, restriction or positive covenant to be created and firstly referred to in the plan. | <i>(Brief description in same terms as used in relevant statement in the plan).</i> |
|---|---|

Schedule of Lots etc. affected**Lots burdened****Lots, relevant roads, bodies or prescribed authorities benefited.**

(Set out vertically in numerical sequence of lot numbers. Title details should be added if the land referred to is outside the plan).

(Continue above pattern until all easements, profits à prendre, restrictions, or positive covenants to be created and referred to in the plan have been dealt with).

Part 1A

- | | |
|--|---|
| 1. Identity of easement, profit à prendre to be released and firstly referred to in the plan. | <i>(Brief description in same terms as used in relevant statement in the plan).</i> |
|--|---|

Lots burdened by existing easement, , profit à prendre**Lots, relevant roads, bodies or prescribed authorities benefited by existing easement.**

(Set out vertically in numerical sequence of lot numbers. Title details should be added if the land referred to is outside the plan).

(Continue above pattern until all easements or profits à prendre to be released and referred to in the plan have been dealt with).

Annexure 3**Part 2**

Terms of easement, profit à prendre, restrictions or positive covenant("firstly", or as the case may be) referred to in the plan

(Continue the above pattern until all easements, profits à prendre, restrictions or positive covenants to be created and referred to in the plan have been dealt with)

Instrument setting out Terms of Easements/ profits à prendre intended to be created or released and of Restrictions on the Use of Land and Positive Covenants intended to be created pursuant to Section 88B of the Conveyancing Act 1919.

Plan: (Please leave 26 mm to allow for number and plan heading)

Plan of (heading of plan) covered by Subdivision Certificate No. (add reference as appropriate)

Name of person empowered to release, vary or modify restriction or positive covenant ("firstly", or as the case may be) referred to in the plan:

(Not required where it is intended that the restriction may only be released, varied or modified by the owners for the time being of all lots benefited, or by order of the Supreme Court)

Annexure 4

Examples of the Schedule of Lots Burdened and Benefited

The following examples show recommended formats for the scheduling of lots burdened and benefited in Parts 1 and 1A of a Section 88B Instrument.

Lots burdened	Lots benefited
1	2, 3 & 4
2	3 & 4
3 or Each lot except lot 6 (see note)	4 or Every other lot except lot 6 (see note)
or Each of the lots 1 to 4 inclusive the part of lot 5 designated (A) in the plan and lot 6	or Every other lot and the Council of
or Each lot	or Any prescribed authority

Note: This format should be used only for Restrictions on the Use of Land.

The current title details and parcel identity must be shown for each lot or parcel of land burdened and/or benefited by the easement, profit à prendre, restriction, or positive covenant. The reference to title need only be referred to once throughout the instrument.

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B.7 Sample instrument when OSD is deferred

Sample 88B Instrument for use when the On-Site Detention system is not provided at the time of subdivision but is deferred until construction of a building development on the land.

This situation has caused considerable difficulties for new home builders in the past and will only be permitted by Council in exceptional circumstances. The provision of OSD can be deferred for subdivisions of up to 7 lots, if it is proven there are site restrictions. Note however, that any easements or inter allotment drainage must be created/installed at the time of subdivision and cannot be deferred.ⁱ

ⁱ Clarification of deferral of OSD added for third edition

(NO ON-SITE DETENTION SYSTEM PROVIDED AT DEVELOPMENT APPLICATION STAGE)

INSTRUMENT SETTING OUT TERMS OF RESTRICTION ON THE USE OF LAND INTENDED TO BE CREATED PURSUANT TO SECTION 88E OF THE CONVEYANCING ACT 1919.

(Sheet .. of ... sheets)

Plan:

Subdivision of LotD.P.....
Covered by Council Clerk's
Certificate No.
Of

Full name and address
Of proprietor of the land

.....
.....
.....

PART 1

- () Identity of restriction..... Restriction on use under Section 88E of the
referred to in abovementioned plan Conveyancing Act 1919

SCHEDULE OF LOT(S), ETC. AFFECTED

Lot(s) Burdened

Authority Benefited

.....

Insert name of Council

- () Identity of Positive Covenant Positive Covenant under
..... referred to in Section 88E of the
above-mentioned plan Conveyancing Act 1919

SCHEDULE OF LOT(S), ETC. AFFECTED

Lot(s) Burdened

Authority Benefited

.....

Insert name of Council

PART 2

TERMS OF RESTRICTION ON USE.....REFERRED TO IN THE
ABOVE-MENTIONED PLAN

- (i) The registered proprietor shall not erect or suffer the erection of any dwelling house or other structure on the lot(s) hereby burdened unless the registered proprietor has first constructed or has made provision for the construction of an on site stormwater detention system on the said lot(s), in accordance with the design, construction and/or provision requirements of the(*Insert name of Council*) and to the satisfaction of the (*Insert name of Council*). The expression "on-site stormwater detention system" shall include all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater as well as all surfaces graded to direct stormwater to the temporary storageⁱ.

ⁱ Surface grading requirement added in third edition.

INSTRUMENT SETTING OUT TERMS OF RESTRICTION ON THE USE OF LAND INTENDED TO BE CREATED PURSUANT TO SECTION 88E OF THE CONVEYANCING ACT 1919.

(Sheet .. of ... sheets)

Plan:

Subdivision of LotD.P.....
Covered by Council Clerk's
Certificate No.
Of

Full name and address
Of proprietor of the land

.....
.....
.....

PART 2 (Continued)

- (ii) The registered proprietor shall not make or permit or suffer the making of any alterations to any on-site stormwater detention system which is, or shall be, constructed on the lot(s) burdened without the prior consent in writing of(*Insert name of Council*) . The expression "on-site stormwater detention system" shall include all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater as well as all surfaces graded to direct stormwater to the temporary storageⁱⁱ. Any on-site stormwater detention system constructed on the lot(s) burdened is hereafter referred to as "the system".

Name of Authority having the power to release, vary or modify the Restriction
referred to is(*Insert name of Council*).

TERMS OF POSITIVE COVENANTREFERRED TO IN THE
ABOVE-MENTIONED PLAN

.1.1

1. The registered proprietor of the lot(s) hereby burdened will in respect of the system:
 - (a) keep the system clean and free from silt, rubbish and debris
 - (b) maintain and repair at the sole expense of the registered proprietors the whole of the system so that it functions in a safe and efficient manner
 - (c) permit the Council or its authorised agents from time to time and upon giving reasonable notice (but at any time and without notice in the case of an emergency) to enter and inspect the land for the compliance with the requirements of this covenant
 - (d) comply with the terms of any written notice issued by the Council in respect of the requirements of this covenant within the time stated in the notice.
2. Pursuant to Section 88F(3) of the Conveyancing Act 1919 the Council shall have the following additional powers:
 - (i) in the event that the registered proprietor fails to comply with the terms of any written notice issued by the Council as set out above the Council or its authorised agents may enter the land with all necessary materials and equipment and carry out any work which the Council in its discretion considers reasonable to comply with the said notice referred to in part 1(d) above

ⁱⁱ Surface grading requirement added in third edition.

INSTRUMENT SETTING OUT TERMS OF RESTRICTION ON THE USE OF LAND INTENDED TO BE CREATED PURSUANT TO SECTION 88E OF THE CONVEYANCING ACT 1919.

(Sheet .. of ... sheets)

Plan:

Subdivision of LotD.P.....
Covered by Council Clerk's
Certificate No.
Of

Full name and address
Of proprietor of the land

.....
.....
.....

PART 2 (Continued)

(ii) The Council may recover from the registered proprietor in a Court of competent jurisdiction:

- (a) any expense reasonably incurred by it in exercising its powers under sub-paragraph (i) hereof. Such expense shall include reasonable wages for the Council's employees engaged in effecting the work referred to in (i) above, supervising and administering the said work together with costs, reasonably estimated by the Council, for the use of materials, machinery, tools and equipment in conjunction with the said work.
- (b) legal costs on an indemnity basis for issue of the said notices and recovery of the said costs and expenses together with the costs and expenses of registration of a covenant charge pursuant to section 88F of the Act or providing any certificate required pursuant to section 88G of the Act or obtaining any injunction pursuant to section 88H of the Act.

Name of Authority having the power to release vary or modify the Positive Covenant
..... referred to is(Insert name of Council).

B8 STORMWATER CONCEPT PLAN SUBMISSIONⁱ

The following checklists have been provided to assist designers to confirm that all necessary issues have been addressed. The first Stormwater Concept Plan (SCP) checklist (B8A) is a shorter version of the second. The first list is to be completed by the stormwater consultant and submitted to Council together with the plan/s and any necessary attachments.

The second more comprehensive checklist (B8B) may be used by less experienced designers as an aid to ensure that all relevant information has been provided. It may be submitted to Council instead of the shorter form if desired.

Note:

Holroyd City Council does not accept SCPs and a detailed OSD design is to be submitted with the development application. Council also requires consultants to complete a detailed design checklist, which is available from Council, which incorporates both the SCP checklist (Appendix B8A) and the Detailed Design checklist (Appendix B9A).

ⁱ Shorter SCP checklist added in third edition

B8A OSD STORMWATER CONCEPT PLAN SUBMISSION

This form is to be completed by the stormwater designer and submitted to Council together with the plan/s and any necessary attachments.

PROJECT ADDRESS: _____

OSD DESIGNER DETAILS:

Company Name: _____

Address: _____

Telephone No.: _____ **Fax No:** _____

Accreditation Organisation: _____ **Accreditation Reference:** _____

Name of designer: _____ **Date:** _____
(Print Name)

Council Reviewer's Name: _____ **Date:** _____

CHECKLIST

1. Flooding:

Is the site (whole or partly) below the 1 in 100 year flood level?

If yes, does the OSD system reflect the flood affectation?

Have floodplain issues been addressed (eg storage, obstructed flow etc)?

2. External catchment: (refer section 4.1.3)

Is there an external catchment draining into the site?

If Yes, have calculations of 100 year ARI flow been submitted & full area of catchment shown?

3. OSD Storage : (refer Sections 4.1.4, 4.1.6 & 6.5)

The storage volume has been estimated with calculations

The area to be drained has been shown on plan and is more than 85%?

Is there free discharge at the outlet or provision made for drowned outlet?

Has the storage been located at the lowest point of the site to collect surface & roof gutter overflow?

4. Site information:

The following information has been shown on the plans:

- scaled site layout showing all buildings, roadways and landscaped areas

- spot levels and contours (including adjoining properties)

- location, dimensions and extent of detention storages

- location of any floodways or flowpaths through the site

- location of any other constraints, e.g. easements, sewer & other services or Water Sensitive Urban Design (WSUD) features

Complies with Handbook		Council agrees	
Yes	No	Yes	No
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐

B8B STORMWATER CONCEPT PLAN SUBMISSIONⁱⁱ

This form may be completed by the stormwater consultant and submitted to Council together with the plan/s and any-necessary attachments if form B8A is not used.

PROJECT ADDRESS: _____

PROJECT APPLICANT: _____

STORMWATER DESIGNER DETAILS:

Company Name: _____

Address: _____

Telephone No.: _____ **Fax No:** _____

Accreditation Organisation: _____

Accreditation Reference: _____

Name and signature of designer: _____

(Print Name)

Date: _____

(Signature)

Items submitted: **

Stormwater Concept Plan	Yes / No
-------------------------	----------

Stormwater Concept Plan Checklist	Yes / No
-----------------------------------	----------

– Attachment A: Flood Affection Information	Yes / No
---	----------

– Attachment B: External Catchment Assessment	Yes / No
---	----------

– Attachment C: OSD Value Assessment	Yes / No
--------------------------------------	----------

– Attachment D: Outlet Hydraulic Assessment	Yes / No
---	----------

COUNCIL REVIEW DETAILS:

Council Review Officer's Name: _____

Review officer's comments: _____

Signature of Review Officer: _____ **Date:** _____

** The above items are to be submitted in a single bound form — a 'loose leaf' format is unacceptable.

ⁱⁱ Form number changed to reflect new shorter checklist in third edition.

STORMWATER CONCEPT PLAN CHECKLIST

ITEM	DESIGNER		COUNCIL REVIEW	
	YES	NO	YES	NO
1. Is the site (whole or partly) defined as floodprone?				
If YES, see Plan No and reference flood level information in Attachment A.				
2. Is there an external catchment draining into the site?				
If YES, see Plan No and calculations of 100 year ARI flow in Attachment B				
2. Plan No has been prepared in accordance with Section 4.1.2 showing:				
- site layout showing all buildings, roadways and landscaped areas				
- site spot levels and contours (with extensions into adjoining properties)				
- location, levels and extent of detention storages				
- location and levels at collecting stormwater system				
- location and approximate extent of any floodways or flowpaths through the site (based on flows defined in Attachment B)				
- location and area of any portion of the site unable to drain to the storages				
- location of any other constraints, e.g. easements and services				
- datum and scale				
4. The storage volume has been estimated (refer Section 4.1.6)				
If YES, see calculations in Attachment C.				
5. The area of the site to be drained has been determined, (refer Section 4.1.4)				
If YES, see Plan No				
If YES, the undrained percentage is% (to be not more than 15% ⁱⁱⁱ , refer Section 4.1.4).				
6. The approximate dimensions of the storage area, including invert level, are provided				
If YES, see Plan No.				
7. Invert level of storage is not less than ground level (or top of kerb) at point of connection to external stormwater system, (refer Section 6.5)				
If YES, see Plan No.				
If NO, see calculations in Attachment D				

ⁱⁱⁱ Undrained percentage of site reduced in third edition

B9 OSD DETAILED DESIGN SUBMISSIONⁱ

The following checklists have been provided to assist designers to confirm that all necessary issues have been addressed. The first detailed Design checklist (B9A) is a shorter version of the second. The first list is to be completed by the stormwater consultant and submitted to Council together with the plan/s and any necessary attachments.

The second more comprehensive checklist (B9B) may be used by less experienced designers as an aid to ensure that all relevant information has been provided. It may be submitted to Council instead of the shorter form if desired.

Note:

Holroyd City Council requires consultants to complete a detailed design checklist which is available from Council and which incorporates both the SCP Checklist (Appendix B8A) and the Detailed Design Checklist (Appendix B9A).

ⁱ Shorter detailed design checklist added in third edition

B9A**OSD DETAILED DESIGN SUBMISSIONⁱⁱ**

This form is to be completed by the stormwater consultant and submitted to Council/Principal Certifying Authority (PCA) together with the plan/s and any necessary attachments.

PROJECT ADDRESS: _____

STORMWATER DESIGNER DETAILS:

Company Name: _____

Address: _____

Telephone No.: _____ **Fax No:** _____

Accreditation Organisation: _____ **Accreditation Reference:** _____

Name of designer: _____

(Print Name)

Reviewer's Name: _____ **Date:** _____

ⁱⁱ Shorter checklist added in third edition

DETAILED DESIGN SUMMARY CHECKLIST			COUNCIL AGREES:	
	Yes	No	Yes	No
1. Stormwater Concept Plan (SCP): (refer Section 4.1)				
Has a SCP been approved previously? If not please submit SCP checklist	☐	☐	☐	☐
Is the detailed design consistent with the approved SCP?	☐	☐	☐	☐
Is this design consistent with all conditions of development consent affecting the OSD design (eg trees to be retained)?	☐	☐	☐	☐
2. Design information:	☐	☐	☐	☐
Do the plans show all information required by Section 4.2.2 of the Handbook? (Including calculations for weir and by-pass flows, final site/lot layout, etc)	☐	☐	☐	☐
Does the entire drained area grade to the storage, including roof gutter overflows?	☐	☐	☐	☐
If No, do drainage all components have 100 year ARI capacities?	☐	☐	☐	☐
3. OSD System:	☐	☐	☐	☐
Is the catchment for each OSD storage clearly shown on the plans?	☐	☐	☐	☐
Has a drainage design summary sheet (Form B1) been submitted for each OSD system?	☐	☐	☐	☐
Is the Discharge Control Pit consistent with the principles in section 4.2, Fig. 4.3 and Council's design standards?	☐	☐	☐	☐
4. OSD Storage:	☐	☐	☐	☐
Does depth of storages comply with Table 6.1 & Section 4.2.6 to 4.2.10?	☐	☐	☐	☐
Has a cross-section of the storage been provided?	☐	☐	☐	☐
Is there the required freeboard for all buildings on site?	☐	☐	☐	☐
Have structural details been provided?	☐	☐	☐	☐
Have access/ maintenance issues been addressed (eg. Section 4.2.8)?	☐	☐	☐	☐
) Are any walls and footings of the storage completely within the property? (Section 4.2.6 to 4.2.8	☐	☐	☐	☐

B9B. OSD DETAILED DESIGN SUBMISSIONⁱⁱⁱ

This form may be completed by the stormwater designer and submitted to Council/Principal Certifying Authority (PCA) together with the design plan/s and any necessary attachments if form B9A is not used.

PROJECT ADDRESS: _____

PROJECT APPLICANT: _____

OSD DESIGNER DETAILS:

Company Name: _____

Address: _____

Telephone No.: _____ **Fax No:** _____

Accreditation organisation: _____

Accreditation Reference: _____

Name and signature of designer: _____

(Print Name)

Date: _____

(Signature)

Items submitted: **

- | | |
|---|----------|
| • OSD Design Plan/s | Yes / No |
| • OSD Detailed Design Checklist | Yes / No |
| – Attachment A: Flood Affection Information | Yes / No |
| – Attachment B: External Catchment Assessment | Yes / No |
| – Attachment C: On-line System Calculations | Yes / No |
| – Attachment D: Weir, Overflow and Surge Pathway Calculations | Yes / No |
| – Attachment E: Site Drainage Calculations | Yes / No |
| – Attachment F: Outlet Hydraulic Assessment | Yes / No |
| – Attachment G: Site Storage Details | Yes / No |
| – Attachment H: Drainage Design Summary Sheet | Yes / No |

COUNCIL REVIEW DETAILS:

Council Review Officer's Name: _____

Review officer's comments: _____

Signature of Review Officer: _____ **Date:** _____

** The above items are to be submitted in a single bound form — a 'loose leaf' format is unacceptable.

ⁱⁱⁱ Form number changed to reflect new shorter checklist in third edition

OSD DETAILED DESIGN CHECKLIST

ITEM	DESIGNER		COUNCIL REVIEW	
	YES	NO	YES	NO
1. A Stormwater Concept Plan (SCP) has been approved previously (refer Section 4.1)				
2. The site (whole or partly) is defined as floodprone in a 100 year event				
If YES, see Plan No in Attachment A				
2(a) Has any floodplain storage been lost?				
If YES, see Plan No in Attachment A				
2(b) Has the floodprone area been excluded from the OSD calculations?				
2(c) Is the OSD system performance adversely affected by the 100 year flood level?				
3. Is there an external catchment draining into the site?				
If YES, see Plan No and calculations of 100 year ARI flow in Attachment B				
4. The location and extent of any floodway/flowpath has been determined, (refer Sections 4.1.3 & 4.2.2)				
If YES, see Plan Noand accompanying 100 year event hydraulic calculations in Attachment B. Buildings are not inundated (and have the required freeboard) nor are flows concentrated on an adjoining property (refer Sections 4.1.3, 4.2.7 & 4.2.9)				
5. The detailed design submission is consistent with the approved SCP				
6. Are there any conditions on the development approval that may affect the drainage design (for example, trees to be retained)?				
7. The detailed design submission addresses the drainage-related conditions of the development approval				
8. A site layout plan with accompanying ground levels/contours which extend into adjoining properties is submitted				
If YES, see Plan No.				
9. Have other constraints, e.g. easements, services, been defined?				
If YES, see Plan No.				
10. How many OSD storage systems are there?.....				
-				
11. Are the storage system/s off-line (refer Section 4.2.6)?				
If NO, see alternative calculations included in Attachment C				
12. State the type of discharge control device (i.e. orifice or.....? Where the device is not an orifice, has specific Trust approval been obtained?				
13. The area of the site to be drained by each OSD storage has been determined, (refer Section 4.2.2)				
If YES, see Plan No.				
If YES, the uncommanded site percentage is% (to be less than 15%, refer Section 4.1.4 unless specific approval has been granted).				
14. The plan/s identify the maximum water levels, and the levels and locations of each storage's discharge point (refer Section 4.2.2)				
If YES, see Plan No.				
15. The location of overflow structures and surcharge pathways have been determined, (refer Sections 4.2.2 & 4.2.9)				
If YES, see Plan No and calculations in Attachment D				
Buildings are not inundated nor are flows concentrated on an adjoining property (refer Sections 4.2.7 & 4.2.9)				
16. The drainage plans have been checked for consistency against the Architectural and landscaping plans				
17. A maintenance schedule has been prepared (ref Section 4.2.10)				

Where there is more than one OSD system, Questions 18 to 26 are to be answered separately for each OSD storage system.

OSD Storage system identifier.....

ITEM	DESIGNER		COUNCIL REVIEW	
	YES	NO	YES	NO
18. The design explicitly shows how all the drained area grades to the storage, including roof gutter overflows (refer Section 6.2)				
If YES, see Plan No				
If NO, see calculations in Attachment E showing how all drainage system components (including all roof gutters, downpipes, collecting pits and pipe systems, etc) have 100 year ARI capacities with 50% blockage factor				
19. The invert level of storage is not less than ground level (or top of kerb) at point of connection to external stormwater system				
If YES, see Plan No.				
If NO, see explanatory notes in Attachment F				
20. The discharge control pit design is consistent with the principles shown in Figures 4.3, 7.10 and/or 7.11				
20(a) The DCP has an open grating type lid (for ease of inspection)				
20(b) The DCP minimum dimensions are consistent with Section 4.2.3				
20(c) The floor of the DCP has a localised sump adjacent to the orifice with level at least 150 mm below the return pipe, (refer Section 4.2.8)				
20(d) The return pipe from the storage is at least 150 mm in diameter (refer Section 4.2.8)				
20(e) The return pipe flap valve is consistent with Figure 4.3				
20(f) If an orifice control is specified, is it consistent with the requirements set out in Section 4.2.3?				
If YES, see: Plan No. for stainless steel plate specification, thickness and fixing to pit wall				
20(g) The overflow weir is fitted with a basket (refer Section 6.3). There is a surface grate above the basket to facilitate inspection and maintenance				
20(h) The high early discharge (HED) characteristics are consistent with the requirements set out in Section 4.2.3 including calculations for overflow depth to storage ^{iv} .				
If YES, see: Plan No. for height of discharge to storage relative to permissible site discharge (PSD)				
Accompanying weir calculations in Attachment E				
Plan No. showing majority of site drainage system connecting to the DCP & the volume of the DCP is small compared to the volume of the storage				
20(i) The screen design is consistent with Section 4.2.5				
If YES, see: Plan No. for screen type, area and orientation				
Plan No. for fabrication note re aperture orientation				
Plan No. for fixing and handle details				
Plan No. showing how all inflows to the DCP are on the upstream side of the screen protecting the orifice				
20(j) The outlet pipe from the DCP has a capacity at least twice the PSD (refer Section 4.2.4)				
If YES, see calculations in Attachment E				

^{iv} Weir calculations clarified

ITEM	DESIGNER		COUNCIL REVIEW	
	YES	NO	YES	NO
21. If an above ground/landscaped storage is specified, answer Q21(a) to Q21(g), otherwise move to Q22.				
21(a) The first 10%-20% of storage is provided in an area able to tolerate frequent inundation(refer Section 4.2.7)				
21(b) Where the depth of ponding exceeds 600 mm, consideration has been given to whether there are steep drops, and/or a need for steps or 'walk-in' 'walk-out' batters, etc. when deciding if fencing and/or warning signs are required (Refer Sections 4.2.7 & 6.2)				
21(c) The landscaping treatment within the storage area is such that it does not limit storage volumes or provide a significant source of debris loading				
21(d) The minimum surface slope is consistent with Section 4.2.7				
21(e) Subsoil drainage is provided in areas subject to frequent ponding and around the outlet (refer Section 4.2.7)				
21(f) If the design includes a retaining wall, has it been structurally checked ?				
21(g) Does the system have the correct storage?				
If YES, see stage-storage calculations in Attachment G				
22. If a driveway/car-park storage is specified, answer Q22(a) to Q22(c), otherwise move to Q23				
22(a) The maximum depth is less than or equal to 200mm (refer Section 4.2.7)				
22(b) The minimum transverse slope is 0.7% (refer Section 4.2.7)				
22(c) The system has the correct storage				
If YES, see stage-storage calculations in Attachment G				
23. If a structural/underground storage is specified, answer Q 23(a) to Q 23(f), otherwise move to Q24				
23(a) The dimensions of openings are consistent with Section 4.2.8				
23(b) The storage floor has a minimum slope of 0.7% (refer Section 4.2.8)				
23(c) There are sufficient access points for flushing purposes (refer Section 4.2.8)				
23(d) There are sufficient grated openings for ventilation purposes (refer Section 4.2.8)				
23(e) All access points have light weight covers				
23(f) The system has the correct storage				
If YES, see stage-storage calculations in Attachment G				
24. The distribution of storage minimises inconvenience (refer Section 5.1.4)				
25. The Drainage Design Summary sheet has been completed (refer Appendix B1)				
If YES, see completed sheet in Attachment H				
26. The Drainage Design Summary sheet details are consistent with the design plans				

B10. OSD WAE SURVEY AND CERTIFICATION SUBMISSIONⁱⁱ

The following checklists have been provided to assist designers/surveyors to confirm that all necessary information has been provided to confirm the as built OSD facility complies with the design. The first WAE checklist is a shorter version of the second. The first list (B10A) is to be completed by the stormwater consultant and submitted to Council together with the plan/s and any necessary attachments.

The second more comprehensive checklist (B10B) may be used as an aid to ensure that all relevant information has been provided. It may also be submitted to Council instead of the shorter form if desired.

ⁱ Shorter checklist added in third edition

B10A**OSD WAE SURVEY AND CERTIFICATION
SUBMISSIONⁱⁱ**

This form is to be completed and submitted to Council/Principal Certifying Authority (PCA) together with the plan/s and any necessary attachments.

PROJECT ADDRESS: _____

WAE PLAN DETAILS:

Company

Name: _____

Name of surveyor: _____ **Date of WAE Plan:** _____

Telephone No.: _____ **Fax No:** _____

Items submitted:

- Signed WAE Plans
- Certificate of Hydraulic Compliance (Form B11)
- Certificate of Structural Compliance
- OSD WAE Volume Calculations

Yes No NA

☐	☐	
☐	☐	
☐	☐	☐
☐	☐	

COUNCIL REVIEW DETAILS:

Reviewer's Name: _____ **Date:** _____

ⁱⁱ Form number changed to reflect new shorter checklist in third edition
Upper Parramatta River Catchment Trust

OSD WAE & CERTIFICATION CHECKLIST			COUNCIL AGREES	
	Yes	No	Yes	No
1. WAE Plans: (Section 4.3.3)				
Are there any major variations from the approved plans?	☐	☐	☐	☐
If so, is a Section 96 (EP&A Act) modification required?	☐	☐	☐	☐
Is the WAE plan superimposed on an approved design plan in red ink?	☐	☐	☐	☐
Has a WAE level boxed in red ink been shown at each design level?	☐	☐	☐	☐
Have WAE dimensions been shown adjacent to design dimensions?	☐	☐	☐	☐
Do the WAE plans show the following information:	☐	☐	☐	☐
• finished floor levels of dwellings and garages	☐	☐	☐	☐
• levels of overland flow paths	☐	☐	☐	☐
• area and flows from external catchment or reason why its ignoredt	☐	☐	☐	☐
For the Discharge Control Pit (DCP):	☐	☐	☐	☐
• internal pit dimensions	☐	☐	☐	☐
• diameter and centre line of orifice	☐	☐	☐	☐
• location, dimensions, distance from orifice for fitted screen	☐	☐	☐	☐
• levels of top and invert of pit	☐	☐	☐	☐
• levels of maximum water level and water level at HED	☐	☐	☐	☐
• Internal diameter of outlet pipe	☐	☐	☐	☐
For each storage:	☐	☐	☐	☐
• type of storage (roof, above ground, below ground, etc.)	☐	☐	☐	☐
• sufficient levels and dimensions to verify storage volumes	☐	☐	☐	☐
• calculations of actual volume achieved	☐	☐	☐	☐
• level, dimensions and location of overflow between DCP and storage	☐	☐	☐	☐
• site gradings and areas draining to or bypassing the storage(s)	☐	☐	☐	☐
2. Certification: (Section 4.3.4 & 4.3.5)	☐	☐	☐	☐
Has revised design summary sheet (Form B1) based on WAE been submitted?	☐	☐	☐	☐
Have upstream flows been ignored, and if so Why?	☐	☐	☐	☐
Are WAE calculations sufficient to show storage & PSD are satisfactory?	☐	☐	☐	☐
Does the WAE volume agree with design volume for each storage?	☐	☐	☐	☐
Does OSD system function correctly?	☐	☐	☐	☐
Have structural certificates been submitted?	☐	☐	☐	☐

B10B. OSD WAE SURVEY AND CERTIFICATION SUBMISSIONⁱⁱⁱ

This form may to be completed by the stormwater designer and submitted to Council/Principal Certifying Authority (PCA) if Form B10A is not used.

PROJECT ADDRESS: _____

DEVELOPER: _____

OSD DESIGNER DETAILS:

Company Name: _____

Address:

Telephone No.: _____ **Fax No:** _____

Accreditation Organisation: _____

Accreditation Reference: _____

Name and signature of designer: _____

(Print Name)

Date: _____

(Signature)

Items submitted: **

- | | |
|---|---------------|
| • WAE Plan/s | Yes / No |
| • Certificate of Hydraulic Compliance | Yes / No |
| • Certificate of Structural Compliance | Yes / No / NA |
| • WAE Survey and Certification Checklist | Yes / No |
| -- Attachment A: OSD Volume Calculations | Yes / No |
| -- Attachment B: OSD WAE Dimensions, etc. | Yes / No |

COUNCIL REVIEW DETAILS:

Council Review Officer's Name: _____

Review officer's comments: _____

Signature of Review Officer: _____ **Date:** _____

** The above items are to be submitted in a single bound form — a 'loose leaf' format is unacceptable.

ⁱⁱⁱ Form altered to reflect shorter checklist in third edition

OSD WAE &**CERTIFICATION****CHECKLIST**

ITEM	DESIGNER		COUNCIL REVIEW	
	YES	NO	YES	NO
1. The WAE plan/s has/have been prepared				
If YES, see Plan No/Nos prepared by and dated				
1(a) The WAE plan or Attachment B provides the following information about each discharge control pit, DCP (refer Section 4.3.3)				
- internal pit dimensions				
- diameter of fitted orifice plate				
- location, dimensions, distance from orifice for fitted screen				
- levels of top and invert of pit				
- Internal diameter of outlet pipe				
1(b) The WAE survey provides the following information about each storage (ref Section 4.3.3)				
- type of storage (roof, above ground, below ground, etc.)				
- sufficient levels and dimensions to verify storage volumes				
- calculations of actual volume achieved, see Attachment A				
- level, dimensions and location of overflow structure between DCP and storage				
1(c) The WAE plans provide the following information on internal drainage (ref Section 4.3.3)				
- pit lid types and surface levels				
- invert levels and diameters of pipes				
- location, dimensions and levels of any floodways and/or overland flowpaths				
- sufficient spot levels to show site gradings and extent of areas draining and not draining to the storage(s)				
1(d) The WAE plan provides finished floor levels of dwellings and garages (refer Section 4.3.3)				
2. The following drainage-related structural elements have been constructed in accordance with the design (refer Section 4.3.5)				
2(a) Free standing walls (see certificate of structural compliance)				
2(b) Retaining walls (see certificate of structural compliance)				
2(c) Underground storages (see certificate of structural compliance)				

Final site inspection details: By.....Date:.....

ITEM	DESIGNER		COUNCIL REVIEW	
	YES	NO	YES	NO
3(a) Each discharge control pit complies with the following requirements (refer Section 4.3.4). See also Attachment B				
- DCP dimensions and levels comply with design parameters				
- material, thickness, diameter and sharp edge of fitted orifice plate				
- the orifice plate is securely fitted				
- the orifice is screened and the screen is properly fixed, located and able to be easily removed				
- outlet pipe is the correct diameter, level and grade (to ensure there is free discharge through the orifice)				
- the levels of the top water surface, storage invert and DCP are such that the design discharge from the storage is achieved				
- in design cases of 'high early discharge', runoff from sufficient areas of the site is directed to the DCP				
- the specified flap valve is fitted correctly				
3(b) Each storage complies with the following requirements (refer Section 4.3.4), see also Attachment B				
- the actual volume achieved is adequate				
- the actual top water level will not result in either unintended surcharge of the internal drainage system and/or inundation or inadequate freeboard to finished floor levels				
- the base of the storage is well graded and drains to the DCP				
- Spillways and overflow paths are constructed to the correct levels and are free from obstructions				
3(c) The internal drainage complies with the following requirements (refer Section 4.3.4)				
- site gradings are in accordance with the design expectation (regarding areas to be commanded by each storage)				
- the internal drainage lines are of a sufficient size, level and grade to convey the flows to the storage				
- storages cannot be by-passed by overflows from the internal system or by overflows from any surface area designed to drain to the storages				
- floodways and/or overland flowpaths designed to divert flows around the basin have been properly constructed and will function as designed				
- general workmanship is adequate to prevent long-term failure of the system				
3(d) The finished levels of structures (e.g. dwellings, garages) are sufficiently above the as-constructed maximum water surface levels in the storage and flowpaths (refer Section 4.3.4)				
3(e) An emergency spillway or overflow path has been provided so that surcharge will not cause stormwater to enter buildings where significant damage would occur				
3(f) All drainage pits, pipes, storages are in a clean condition and free of building materials,				

ATTACHMENT B: OSD WAE DIMENSIONS, ETC.

DESCRIPTION	APPROVED	WAE	CERTIFIER'S COMMENTS
DISCHARGE CONTROL PIT:			
(a) Orifice diameter (mm)			
(b) Orifice plate material			
(c) Pit width (m)			
(d) Pit breadth (m)			
WEIR:			
(a) Reduced level			
(b) Width			
(c) Height (mm)			
DCP invert level			
Access grate dimensions			
STORAGE:			
(a) Top water level			
(b) Storage volume (m ³)			
(c) Freeboard to F.F.L. (mm)			
(i) Habitable area			
(ii) Garage			
Maximum depth of water (mm)			

CERTIFIER'S NAME:

SIGNATURE:

DATE:

FORM B.11
UPPER PARRAMATTA RIVER CATCHMENT TRUST
ON-SITE STORMWATER DETENTION SYSTEM
CERTIFICATE OF HYDRAULIC COMPLIANCE

**BAULKHAM HILLS/BLACKTOWN CITY/HOLROYD CITY/PARRAMATTA CITY
COUNCIL**
(delete not applicable)

JOB NO: _____ **DA NO:** _____ **BA NO:** _____

PROJECT: _____

LOCATION: _____

DESIGNED BY: _____

CONSTRUCTION

CERTIFIED BY: _____

QUALIFICATIONS: _____

TELEPHONE: _____

1.0 WORKS CONSTRUCTED IN ACCORDANCE WITH DESIGN. (Delete if not applicable)

I _____ of _____ (accredited professional being competent to practice in the field of stormwater drainage design) have inspected the above on-site stormwater detention system and certify that the works have been constructed and can be maintainedⁱ in accordance with the approved design details for the above mentioned project.

Signature: _____ **Date:** _____

2.0 CONSTRUCTION VARIATIONS NOT AFFECTING DESIGN PERFORMANCE. (Delete if not applicable)

I _____ of _____ (accredited professional being competent to practice in the field of stormwater drainage design) have inspected the above on-site stormwater detention system and certify that the works have been constructed and can be maintained in accordance with the approved design details for the above mentioned project, except for the variations listed below which do not affect the performance of the system, subject to satisfactory maintenance.

Variations:

Signature: _____ **Date:** _____

3.0 AUTHORITY TO RELEASE PLANS TO FUTURE OWNERS OF THE PROPERTY

As the copyright owner of the drainage plans, I hereby authorise release of the approved plans/attached sketch plan to future owners of the property to assist in the maintenance of the On-site Stormwater Detention system.

Signature: _____ **Date:** _____

Name: _____ (Print)

ⁱ Maintainability added for third edition

Appendix C - Signs

OSD Warning Signⁱ

Signs are only required for OSD systems where deemed necessary by Council because of the depth and/or location of the storage.

The size of the sign will depend on the individual situation. The following guidelines are suggested:

- 600 mm x 450 mm Open areas or large developments.
- 400 mm x 300 mm Restricted areas.

Confined Space Sign

Signs are required at each entry into confined spaces, such as deep pits or underground storages. Signs may be made of metal or a durable synthetic material.

The size of the sign will depend on the individual situation, but the following sizes are suggested as a guide:

- 300 mm x 450 mm Large entries (such as doors)
- 187.5 mm x 250mm Small entries (such as manholes)

OSD Signⁱⁱ

These signs should be located in or near the OSD facility to alert future owners of their obligations to maintain the facility.

ⁱ Sign name changed in third edition

ⁱⁱ New sign added in third edition

OSD Warning Sign



Colours:

Triangle and "WARNING"	Red
Water	Blue
Figure and other lettering	Black

Confined Space Warning Sign

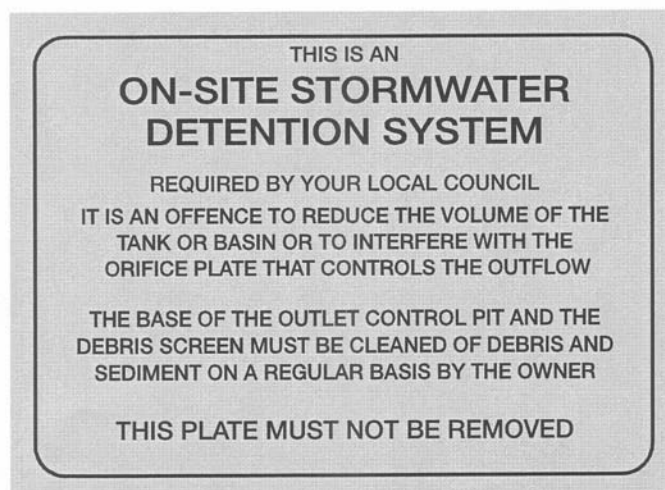


Colours:

"DANGER" and background
Elliptical area
Rectangle containing ellipse
Other lettering and border

White
Red
Black
Black

OSD Sign



SIZE: 110 mm x 80 mm
CORNERS: Square
COLOUR: Etched and filled Black Legend on Natural Silver Background
MATERIAL: Aluminium 0.9mm Mill

Appendix D - Structural walls for surface storage

Typical structural details for storages

Free standing

- | | | |
|-----|------------|-----------------|
| E.1 | Brick Wall | - 500 mm |
| E.2 | Brick Wall | - 588 - 1000 mm |
| E.3 | Block Wall | 1100 mm |

Earth retaining

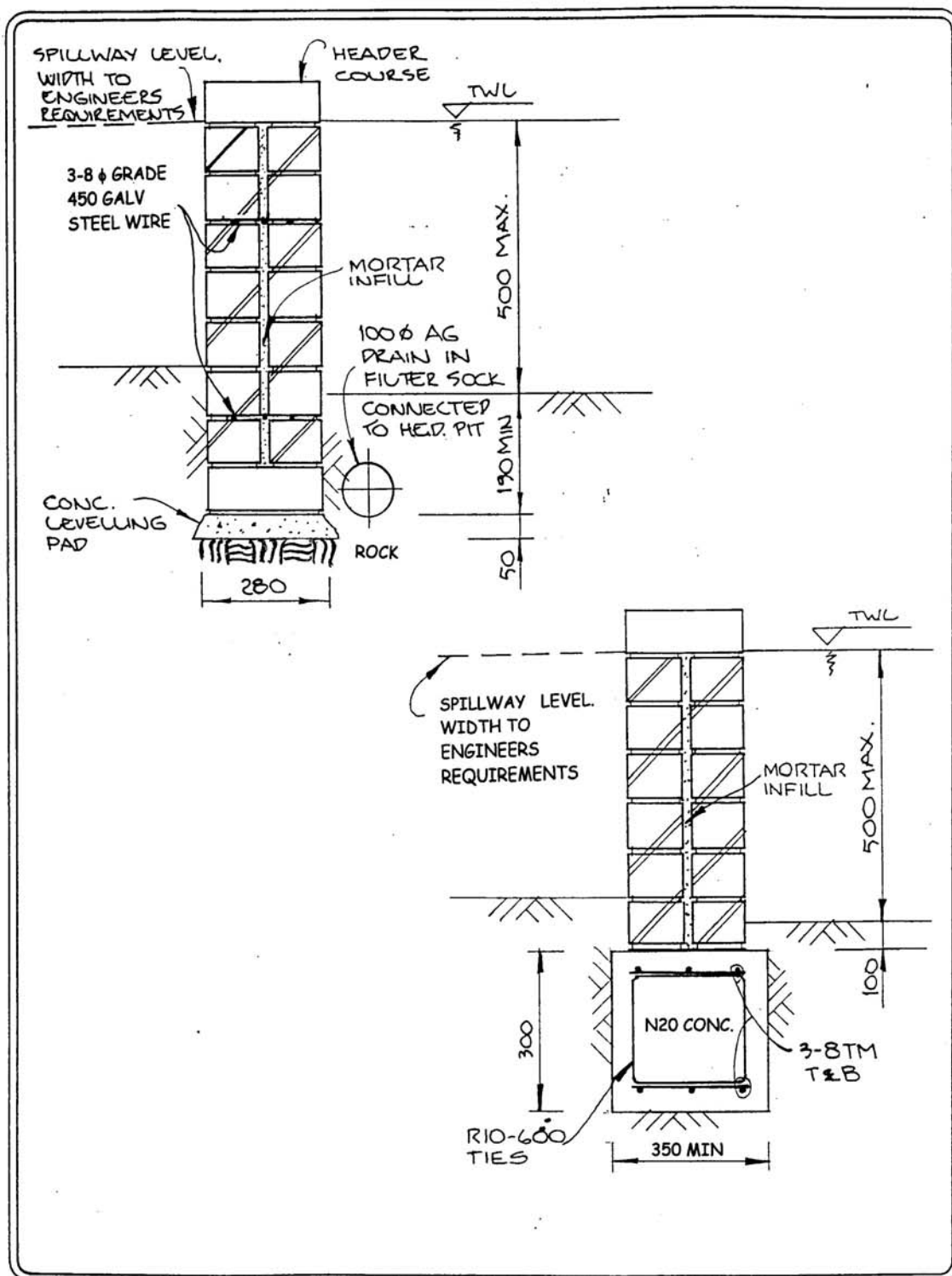
- | | |
|-----|------------|
| E.4 | Brick Wall |
| E.5 | Block Wall |

Structural Walls for Surface Storage Systems

A set of typical structural details have been included to demonstrate the need to consider loadings from both soil and water pressures in the design of an OSD system. These designs have been prepared on the basis of a site with homogenous soil condition, and the following characteristics:

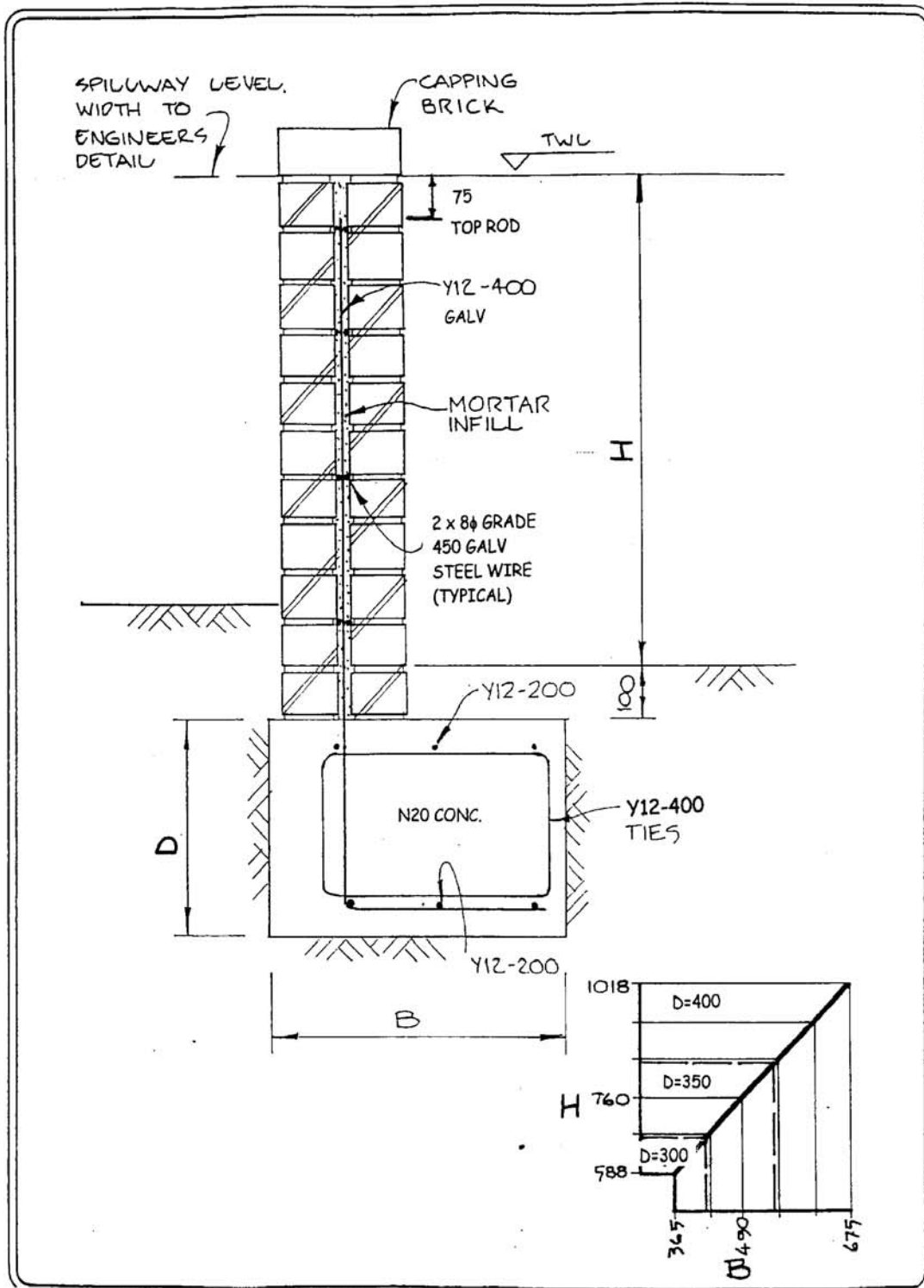
- a clay soil with a density of 19kN/m^3 and friction angle of 20 degrees
- saturated soil conditions behind the retaining walls
- footings are generally designed to be adjacent to property boundaries
- free standing walls are designed for water pressure loadings and
- retaining walls have been designed for both soil and water pressure loadings.

The designer will need to take these factors into account when determining whether these details are applicable to their particular site.



U P R C T
 OSD ABOVE GROUND STORAGE
 TYPICAL WATER RETAINING WALL
 BRICK WALL UP TO
 500mm HIGH

SCALE
 1:10
 REFERENCE N9
 W01



UP RCT

OSD ABOVE GROUND STORAGE
TYPICAL WATER RETAINING WALL

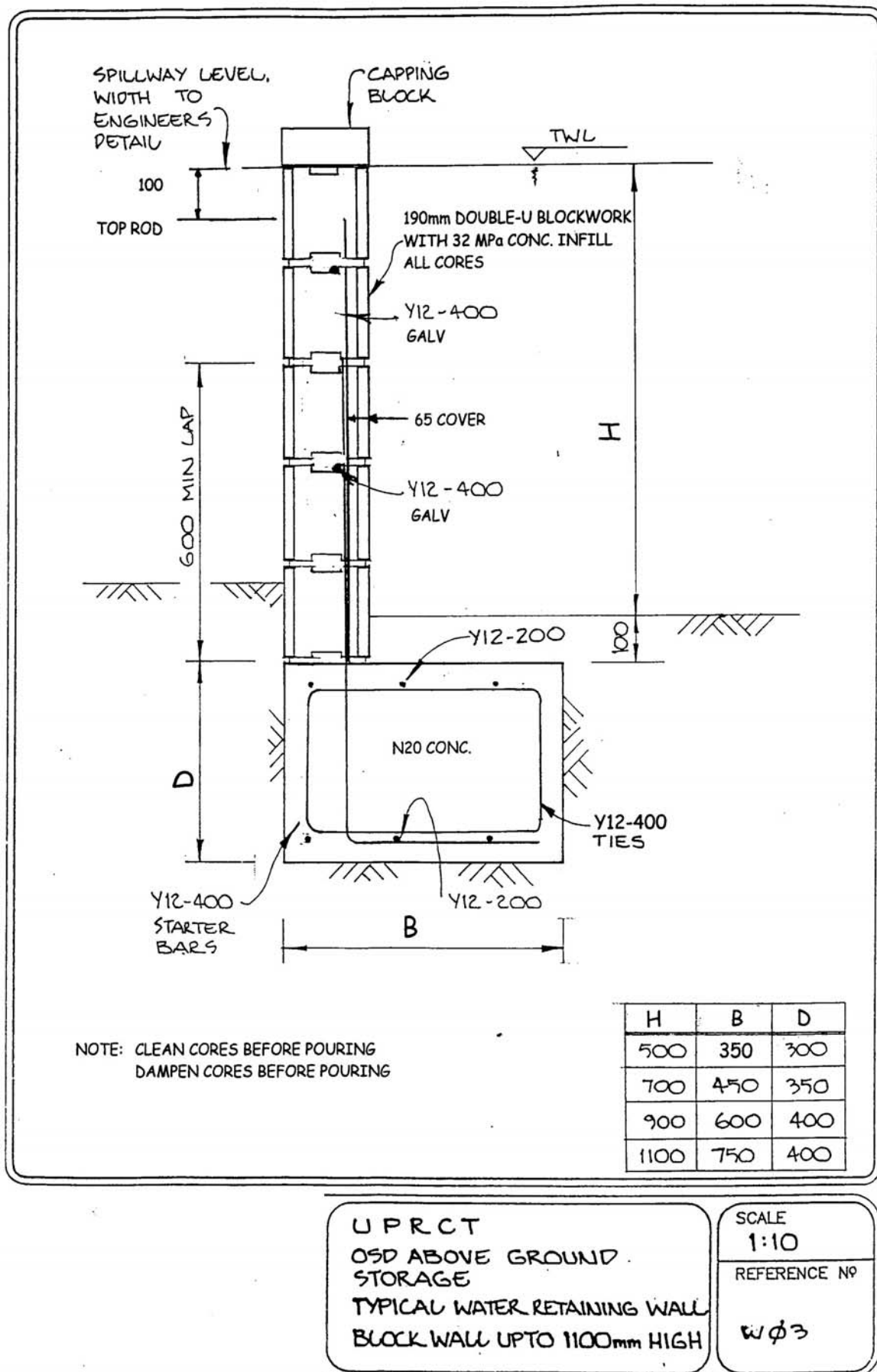
BRICKWALL 588 - 1000mm
HIGH

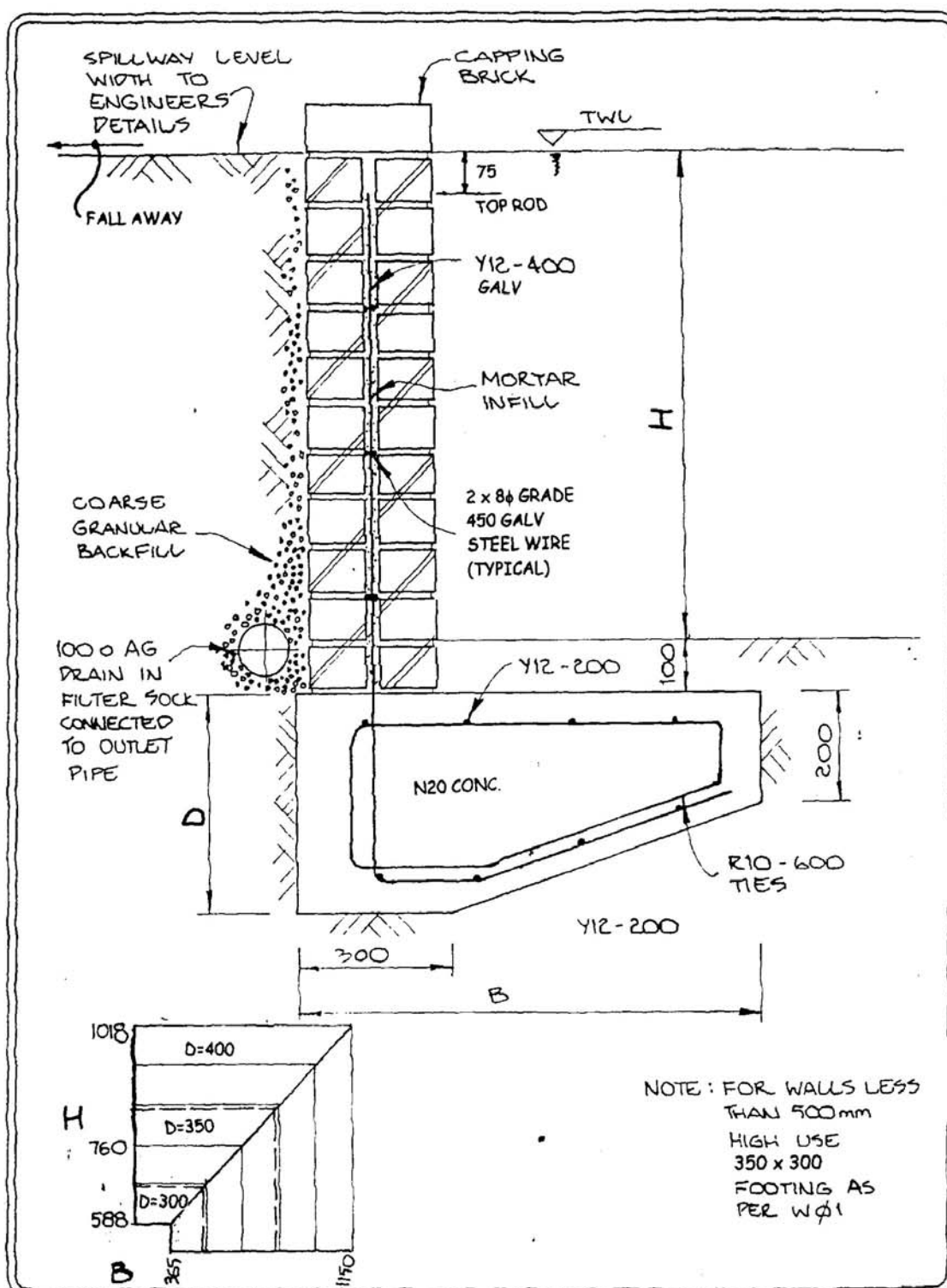
SCALE

1:10

REFERENCE NO

WØ2



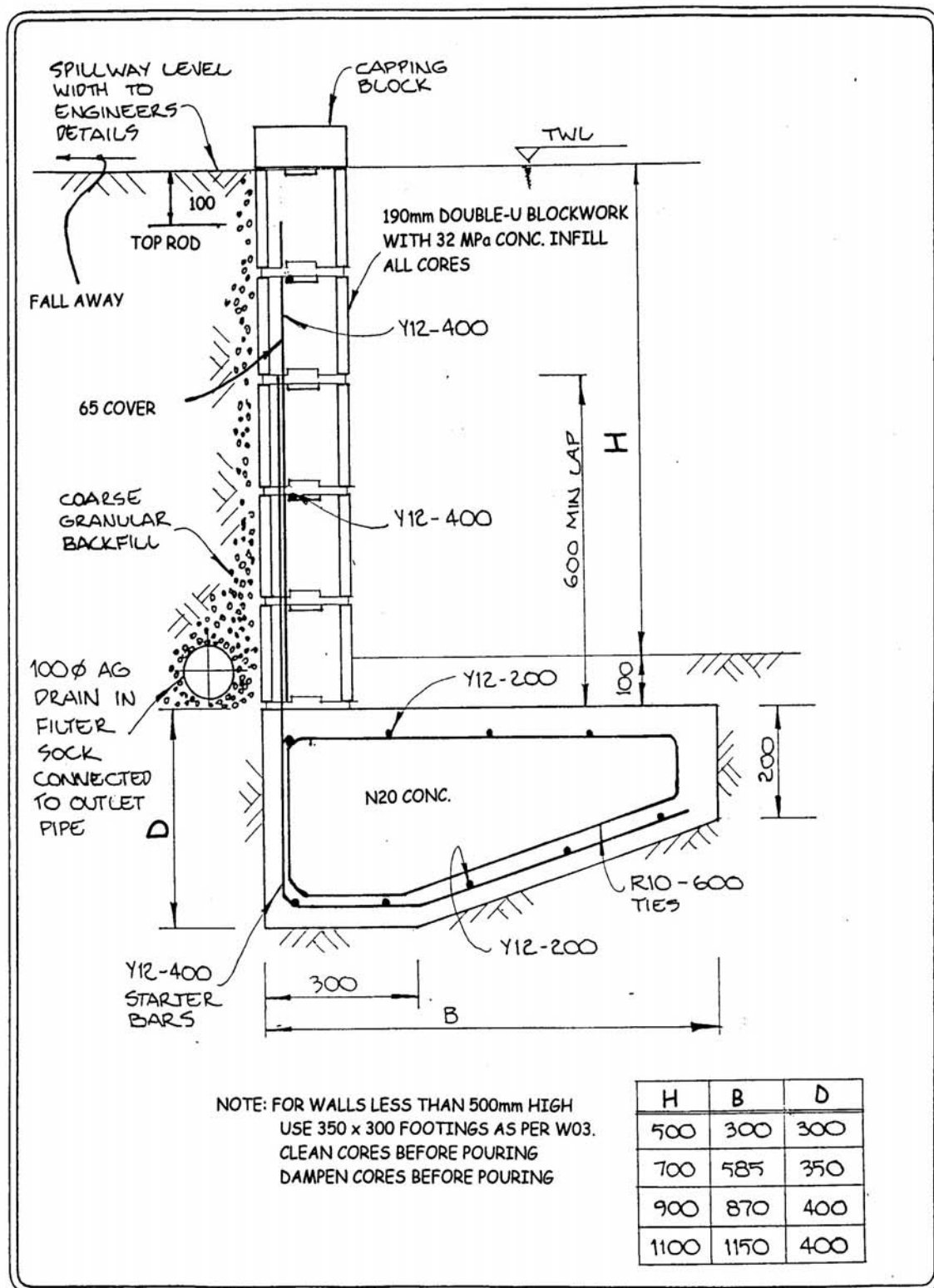


UP RCT
OSD ABOVE GROUND STORAGE
TYPICAL DUAL FUNCTION
SOIL/WATER RETAINING WALL
BRICK WALL UP TO 1000 HIGH

SCALE
1:10

REFERENCE NO

WØ4



UP RCT
OSD ABOVE GROUND STORAGE
TYPICAL DUAL FUNCTION
SOIL/WATER RETAINING WALL
BLOCKWALL UPTO 1100mm HIGH

SCALE
1:10

REFERENCE NO

WØ5

Appendix E – Lists of Manufacturers of Proprietary and Other OSD Products and Maintenance Contractors

Manufacturer	Address	Products
ACO-Polycrete Australia	185 Briens Road NORTHMEAD 2152 Tel: (02)9630 2788	Precast discharge pits.
Barrys Signs	180 Targo Rd GIRRAWEE NSW 2145 Tel: (02)9631 1351	Warning signs
BCP Precast Pty Ltd	Pacific Highway CHARMHAVEN 2263 Tel: (0243) 923 300	Reinforced concrete storage and precast discharge control pits.
De Neefe Signs Pty Ltd	13 James Ruse Drive GRANVILLE NSW 2142 Tel: (02)9637 0218	Warning signs
Everhard Industries	3 Jumal Place SMITHFIELD 2164 Tel: (02)9604 5955	Screens, flap valves, orifice plates, concrete and plastic discharge control pits, concrete storages.
Hu-Tech Metal Products	37 Anzac Street GREENACRE 2190 Tel: (02)9790 0100	Screens, flap valves, orifice plates and tailwater discharge compensators, confined space sign and OSD sign ⁱ .
Ingal Civil Products	127-141 Bath Road SUTHERLAND 2232 TEL: (02)9521 2711	Buffa-tank storage systems.
Mascot Engineering Group	45-51 Clapham Road REGENTS PARK 2143 Tel: (02)9644 1044	Discharge control pits, light weight lids, screens, orifice plates.
Signs Of Safety	74 Fitzwilliam Road TOONGABBIE 2146 Tel: (02)9636 8813	Warning signs.
Wilmac Pty Ltd	40 Burrabogee Road PENDLE HILL 2145 Tel: (02)9631 0957	Screens, flap valves, precast pits, orifice plates, confined space sign and OSD sign ⁱⁱ .
RMS Roadsigns	2 Cawarra Road TAREN POINT NSW 2229 Tel: (02)9540 4400	Warning Signs
Safetyman Signs Pty Ltd	17 Commercial Road KINGSGROVE NSW 2208 Tel: (02) 9502 2300	Warning Signs

ⁱ Additional products added in third edition

ⁱⁱ Additional products added in third edition

OSD Maintenance Contractors

The Trust sought updated expressions of interest in April 2004ⁱ from companies or individuals able to maintain OSD facilities. The following companies responded and have provided details of their maintenance capability. The list is provided to assist owners to maintain OSD facilities on their properties. No attempt has been made to check the credentials of the listed firms, nor are any specifically recommended by the Trust.

The selection of a suitable maintenance contractor and agreement on the works to be undertaken are matters for individual owners. The Trust will not be liable for any losses incurred by either the owner or the contractor.

COMPANY	CONTACT DETAILS	STATED MAINTENANCE CAPABILITY
Australian Wastewater Management Strategies Pty Ltd Suite 1/191 Blues Point Road, NORTH SYDNEY NSW 2060	Mr Armen Mesrobian (02) 9460 2020 (ph) (02) 9460 2121 (fax) AWMS1@bigpond.com (email)	-General repair and maintenance -Envirocell Sewage treatment systems
Beachs Fencing 82 Ulundri Drive CASTLE HILL NSW 2154	Mr Robert Beach (02) 9680 3247 (ph) 0408 470 783 (mob)	-General maintenance
Collex Industrial Services PO Box 4574 MILPERRA DC NSW 1891	Ms Carol Smith (02) 9709 3011 (ph) (02) 9709 3411 (fax)	-Stormwater, Gross Pollution Traps and Sewer maintenance services -Confined space trained staff
D-CO Plumbing and Drainage P/L PO Box 3350 ROUSE HILL NSW 2155	Mr Keenan Di Francesco (02) 9836 5654 (ph) 0419 126 166 (mob) (02) 9636 3120 (fax)	-Plumbing and Draining -General cleaning and maintenance
BR Durham& Son Pty Ltd Lot 103, Curtis Road MULGRAVE NSW 2756	Mr Denis Durham, Mr Charles Durham (02) 4587 7011 (ph) (02) 4587 7069 0418 861 977 (Denis) 0418 202 094 (Charles) sales@durham.com.au	-Suppliers of civil drainage products -Maintenance of drainage systems including Full Vacuum Pump cleanout (for road use)
Ecosol Wastewater Filtration Systems Unit 29/56 O'Riordan Street ALEXANDRIA NSW 2015	Mr Andrew Middleton (02) 9669 6000 (ph) (02) 9669 6100 (fax) 0427 013 355 (mob) info@ecosol.com.au (email)	-Design, supply, installation, cleaning and maintenance of solid pollutant filters.
Envirocivil (NSW) P/L PO Box 158 LANE COVE NSW 1595	Mr Peter Day (02) 9418 9601 (ph) (02) 9418 3498 (fax) 0412 232 859 (mob) peterday@netspace.net.au (email)	-General cleaning and maintenance

ⁱ Revised list added for third edition

COMPANY	CONTACT DETAILS	STATED MAINTENANCE CAPABILITY
James Plumbing Services 7/143 Coreen Avenue PENRITH NSW 2750	Mr Steve James, (02) 4722 9698 (ph) (02) 4722 8481 (fax)	-Plumbing and drainage installation, repair and maintenance
Storm Water Systems PO Box 96 PYRMONT NSW 2009	Mr Anto Pratten (02) 9555 8744 (ph) (02) 9555 8766 (fax) 0419 419 478 (mob) antopratten@stormwater.com.au (email)	-Supply and install floating booms, end of line traps and pit inserts -Vacuum eductor truck -Cleaning and maintenance of pits and pollution devices
Sydney Wide Pipe Cleaning Pty Ltd PO Box 506 BLACKTOWN NSW 2148	Mr Jeff Field (02) 9627 7133 (ph) (02) 9627 7144 (fax) 0417 924 993 (mob) sydwide@bigpond.com.au (email)	-OSD cleaning & maintenance -High velocity water jetting -CCTV pipeline inspections -Rootcutting -Grease trap cleansing -Liquid waste transport
Transpacific Industrial Solutions Pty Ltd PO Box 20 CARRINGTON NSW 2294	Mr Ian Wellsmore (02) 4967 6600 (ph) (02) 4967 3337 (fax)	-maintenance, cleaning and service of stormwater and waste water infrastructure -facilities maintenance -drain cleaning -CCTV inspections

Appendix F – OSD Parameters Outside Upper Parramatta River Catchmentⁱ

Baulkham Hills Shire Council (BHSC), Holroyd City Council (HCC) and Parramatta City Council (PCC) have adopted the principles of the Trust policy for other catchments in their local government areas. The parameters to be used for the other catchments are given in the table below.

Blacktown City Council (BCC) requires OSD in identified drainage problem areas outside the upper Parramatta River catchment. Contact Council's Drainageⁱⁱ Engineers for further information

Local Government Area	Catchment	Site Slope *BHSC only	PSD (l/s/ha)	SSR (m3/ha)
BHSC	Hawkesbury River	>15%	136	298
BHSC	Hawkesbury River	10% to 15%	115	336
BHSC	Hawkesbury River	6% to 10%	104	362
BHSC	Hawkesbury River	3% to 6%	92	396
BHSC	Hawkesbury River	0% to 3%	87	412
HCC	A'Becketts Creek		140	300
HCC	Duck Creek		140	300
HCC	Prospect Creek		140	300
PCC	A'Becketts and Duck River/Creek		80	470
PCC	Claycliff Creek		235	215
PCC	Devlins Creek		210	250
PCC	Parramatta River – North Side - Charles St to Vineyard Creek		208	235
PCC	Parramatta River – North Side - East of Vineyard Creek		280	190
PCC	Parramatta River –South Side -		80	470
PCC	Ponds/Subiaco Creek		130	330
PCC	Terrys Creek		210	250
PCC	Vineyard Creek		160	285

Additional notes for BHSC

The OSD policy applies to the Hawkesbury River catchment within the shire except in :

- the Rouse Hill Development Area (including Norwest Business Park) defined as the gazetted River Management Area.
- Bingara Drainage Catchment and Barina Downs North Precinct as defined in Section 94 Contribution Plan No 3 – Crestwood.

ⁱ Parameters for other areas of catchment councils added in third edition.

ⁱⁱ Clarification of contact point at BCC added in third edition

Appendix G -Procedure For Applying Methodology Outside Catchment

The studies undertaken by the Upper Parramatta River Catchment Trust which lead to the catchment OSD policy took an experienced engineer six months and made use of a sophisticated runoff routing model which has taken several years to develop. Clearly, local councils wishing to apply the catchment OSD policy to other areas would find it difficult to duplicate such an exercise. Fortunately, the Trust's analysis suggests a relatively simple procedure for determining the PSD and SSR values applicable in other areas, for use on an interim basis. The procedure is set out below:

Step 1 Select the flood standard (say 100 years ARI)

Step 2 Develop and calibrate a runoff routing model and compute the critical (largest) flood peak discharge for the standard flood frequency at all locations in the catchment where no further increase in flood discharges can be tolerated.

Step 3 Compute the 100 year peak runoff rate, which is the critical 100 year peak discharge divided by the contributing catchment area, and express in litres/sec/ha.

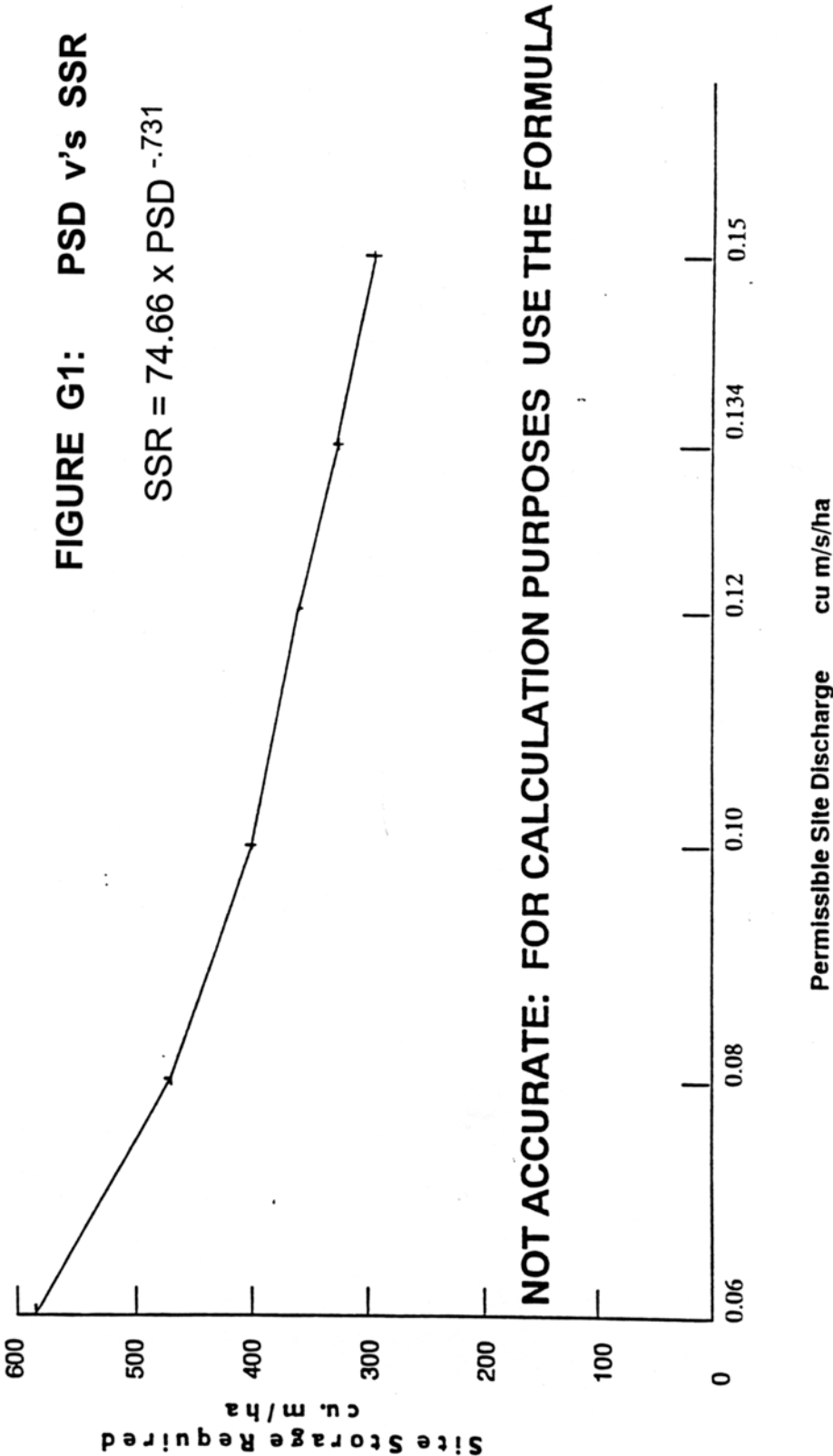
Step 4 Select the smallest peak runoff rate and reduce by 15% to obtain the PSD.

Step 5 Compute SSR using the following regression equation:

$$SSR = 74.66 \times (PSD/1000)^{-0.731} \text{ (provided } 60 < PSD < 150 \text{ l/sec/ha.)}$$

Step 6 Scale the SSR to the subject catchment on the basis of the average 100 year-2 hour rainfall intensity for the upper Parramatta River catchment (48.3 mm/hr) and the local equivalent, or other storm duration if appropriate.

A list of PSD and SSR values for other nearby catchments is given in Appendix F.



Appendix H. On-site Stormwater Detention System Costsⁱ

In 1996, Bewsher Consulting Pty Ltd was commissioned jointly by the Upper Parramatta River Catchment Trust and the NSW Department of Housing to report on the costs associated with the design, approval, installation of OSD systemsⁱⁱ. The consultant's report was completed in January 1997 and provided indicative costs of OSD although no data was available for on-going maintenance costs.

Table 2 of the report provided the following costs associated with the design and approval of OSD systems.

ITEM	INDICATIVE COSTS (\$)
Concept design	500-2,000
Detailed design	500-2,000
Council charges	200-400
Certification	350-550

For construction costs, the consultant had a qualified quantity surveyor estimate the additional costs of installing OSD systems from design plans which had been submitted to the four catchment councils for a range of types of development. The study found a *"consistent trend whereby the fully or majority above ground storage systems are cheaper per cubic metre than the below ground systems."* For storage volumes between 20m³ and 100m³, a saving of between \$100 and \$150 per m³ of storage was identified. Figure H.1 is a copy of Figure 1 of the consultant's report which shows the unit costs of different types of storage.

The report made the following conclusions:

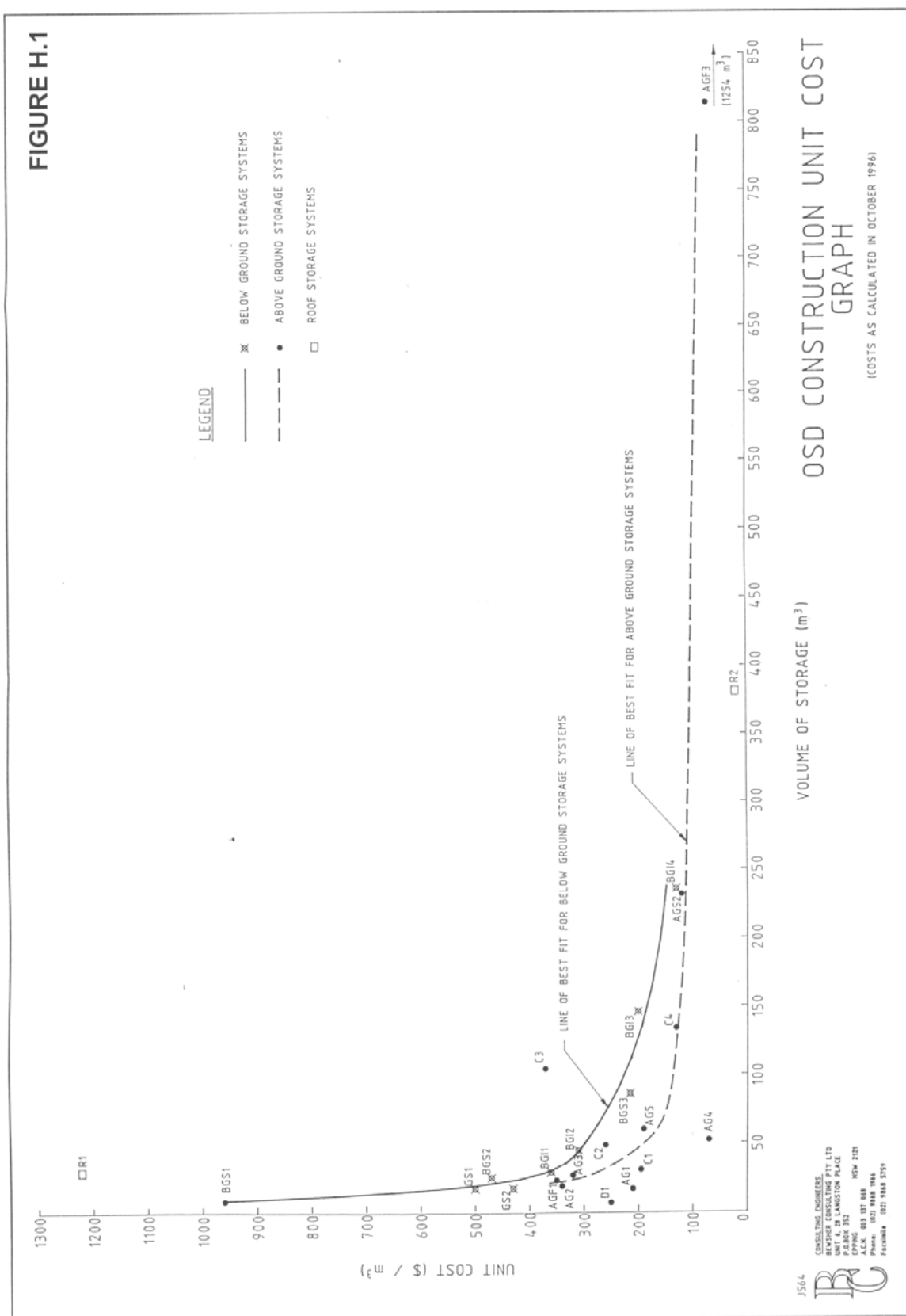
- *"the total costs associated with installation of OSD systems – being the combination of design, Council review, construction and certification costs are very substantial. (To this should be added the long term maintenance costs however at this point in time there is no data available regarding system maintenance.);"*
- *for smaller site developments there are definite cost advantages in providing the OSD storage by using above ground systems. Given that advantage it is obviously important that site layouts should make adequate provision for such systems at an early stage of site planning;*
- *for larger site developments there would still appear to be advantages in making allowance within the site for an above ground system. However based on the limited number (6) of large scale (ie. greater than 100m³) storage systems analysed during this survey the cost advantages for above ground systems compared with below ground (in-situ) tanks are not as clear cut as for smaller sites;*
- *based on an assessment of other costs – such as design, approval and certification – the costs associated with constructing the storages are easily the greatest single cost associated with OSD systems. It therefore follows that it would be prudent to spend additional effort (and cost) at the investigation and design stages so that the overall cost of providing an OSD system is minimised;*

ⁱ OSD costings added in third edition.

ⁱⁱ Bewsher Consulting Pty Ltd. (1997). *On-Site Stormwater Detention System Cost Survey*. January 1997.

- *given the relatively small sample of sites that were sampled in this survey it is recommended that additional sites be costed so that the initial trends identified in this report can be confirmed. The additional sites should ideally include the following:*
 - a) *those that have storage volumes larger than 100m³;*
 - b) *those that include innovative solutions for difficult sites (including those that utilise roof top systems to achieve storage)."*

FIGURE H.1



Appendix I. Stormwater Industry Association On-site Stormwater Detention Excellence Award Winners And On-site Stormwater Detention Regional Environment Award Winnersⁱ

Note: The Trust sponsored the national Stormwater Industry Association (SIA) OSD Excellence Awards in 1999-2001. That sponsorship was refocussed on the SIA's Educational Excellence Award from 2002, and the Award for OSD Excellence for design or construction was incorporated into the Regional Environment Awards sponsored by the Trust and the four catchment councils. Projects for the Regional Environment Awards must be located within one of the Cities of Blacktown, Holroyd or Parramatta or the Shire of Baulkham Hills.

Year	Winner	Highly Commended
1999	Haddad Khaicy Partners 80 Weston Street, Harris Park NSW Tel: 9687 9222	
2000	D S Agencies Pty Ltd PO Box 7027 Cloisters Square WA 6850 Tel: (08) 9322 3090	- Haddad Khaicy Partners 80 Weston Street, Harris Park NSW Tel: 9687 9222 - Rammy Associates PO Box 280, Pendle Hill NSW 2145 Tel: 9896 6116
2001	Tweed Shire Council Tumbulgum Road Murwillumbah NSW 2484 Tel: (02) 6670 2400	
2002	Messrs Steve Arraj and Giorgio Bucci of Dincel & Associates Level 3, 7K Parkes Street, Parramatta NSW 2150	
2003		Mr Steve Arraj of Haddad Khaicy Mance Arraj Partners 1/142 James Ruse Drive Rosehill NSW 2150
2004	Messrs Steve Arraj and Giorgio Bucci Of Haddad Khalil Mance Arraj Partners 1/142 James Ruse Drive Rosehill NSW 2150	

ⁱ Winners names updated in third edition

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