Draft Specification
Separation distances for groundwater controlled urban development

Prepared by the
Land development in groundwater constrained landscapes Steering Group

Version 2: February 2016

Contents

1 General requirements

The objective of the groundwater separation distance guidelines is to provide criteria (specifications) for groundwater separations appropriate to acceptable levels of risk and amenity for critical elements of built form and infrastructure and provide guidance regarding appropriate methodology (design) for assessment and approval of groundwater levels and separations.

The following guidance applies to controlled (engineered) groundwater systems in urban areas.

To satisfy conditions of subdivision relating to urban water management, developers should liaise with local government and refer to the Department of Water's *Water resource considerations when controlling groundwater levels in urban development* (DoW, 2013a).

1.1 Assessment

The performance of this draft specification will be assessed over the next 2 years. Consideration will be given to the outcomes in terms of approval requirements and timelines: and development and maintenance costs of approved subdivisions, with the aim of achieving good urban form outcomes which optimise infrastructure performance whilst balancing the shared costs and risks of the development to the home owner (i.e. development costs) and the community (i.e. maintenance costs).

2 Policies, standards and guidelines

2.1 Policies

- State Water Plan (Department of the Premier and Cabinet, Perth Western Australia, 2007).
- State Water Strategy (Department of the Premier and Cabinet, Perth Western Australia, 2003).
- State Planning Policy 1 – State Planning Framework Policy (WAPC, Perth Western Australia, 2006).
- State Planning Policy 2 – Environment and Natural Resources (WAPC, Perth Western Australia, 2003).
- State Planning Policy 2.9 – Water Resources Policy (WAPC, Perth Western Australia)
- State Planning Policy 2.10 – Swan Canning River System (WAPC, Perth Western Australia, 2006.

2.2 Standards and Guidelines

- *Australian groundwater modelling guidelines,* Sinclair Knight Merz and National Centre for Groundwater Research and Training, Waterlines Report Series No. 82, June 2012.
- *Better urban water management*, Western Australian Planning Commission, Perth, 2008.
- *Classification Framework for Public Open Space*, Department of Sport and Recreation, Perth, 2012.

- *Decision process for stormwater management in Western Australia*, Department of Water, Perth, WA, 2009.
- *Guidelines for district water management strategies: Guidelines for preparing a district water management strategy to support a region scheme amendment or district structure plan*, Department of Water, Perth, WA, 2013.
- *Interim: Developing a local water management strategy*, Department of Water, Perth, WA, 2008.
- *Liveable Neighbourhoods: A Western Australian government sustainable cities initiative*, 4th edition, Western Australian Planning Commission, Perth, WA, 2009.
- *Model Subdivision Conditions Schedule,* Western Australian Planning Commission, Perth, WA.
- *National Construction Code Series 2015 Volume 1; Building Code of Australia Class 2-9 Buildings,* Australian Building Codes Board, 2015.
- *National Construction Code Series 2015 Volume 2; Building Code of Australia Class 1 and 10 Building,* Australian Building Codes Board, 2015.
- *Planning and Development (Local Planning Schemes) Regulations 2015, Structure Plan Framework*, Western Australian Planning Commission, Perth, WA, 2015.
- *Selection of future climate projections for Western Australia*, Water Science Technical Series, report no. 72, Department of Water, Perth, WA, 2015.
- *Urban water management plan: Guidelines for preparing plans and complying with subdivision conditions*. Department of Water, Perth, WA, 2008.
- *Water resource considerations when controlling groundwater levels in urban development*, Department of Water, Perth, WA, 2013.

3 Design

3.1 General

Designing of groundwater drainage systems requires modelling to predict the performance of the proposed system under probable future climate, site and land use conditions.

Modelling is required to assess a series of representative cross sections through any specified development area. This should include at least one typical street-to-street section and sections through turfed public open spaces.

Modelling is also required to provide average and peak discharge flow rates from the designed subsoil drainage system to facilitate sizing of infrastructure including subsoil pipes and (when required) water quality treatment systems.

The design of groundwater management systems should be undertaken in the context of a broader development planning and design process which includes:

- Structure planning including road layouts and dimensions;
- Subdivision design including lot sizes and streetscapes;
- Earthworks design and catchment definition;

- Civil design of roads and services including subsoil drainage; and
- Landscape design and integration of public open space with drainage and water quality treatment systems

The design process should be undertaken as an iterative process including opportunities to inform other aspects of design and test options for innovative approaches. In particular, the performance of a proposed groundwater management system may have implications for the use of fill and the selection of building materials and methodologies.

Consistent with the requirements of *Better Urban Water Management* (WAPC 2008), urban water management documents are required to be prepared at each stage of the development process. The requirements for each stage, provided in greater detail than in *Better Urban Water Management,* are provided in Table 1.

Table 1: Summary of groundwater modelling requirements

Planning stage	Requirement
District water management strategy	Modelling of groundwater mounding is not required. . The DWMS should identify if groundwater management may be necessary based on a review of available regional bore data available from the Department of Water's Water Information Network and consider key defining factors including key receiving environments; complexity and connectivity of groundwater resources/aquifers; and groundwater dependent ecosystems.
Local water management strategy	Define appropriate controlled groundwater level and describe the implications for any identified groundwater dependent ecosystems. Include ground-truthed desktop investigations with sufficient detail to provide a conceptual understanding of the site conditions. This includes establishing if the site is part of the regional system or a local aquitard. Preliminary modelling to consider fill implications for the potential drainage system layout (spacing of road reserves) is required and should provide 'proof of concept' for the proposed design. Design parameters (eg for imported fill) may be specified generically.
Urban water management plan	Modelling to develop and test the subsoil drainage system is required and should incorporate the following level of detail: • Designed urban form; • Investigated and/or designed geotechnical conditions; • Measured and/or specified parameterisation; and • Designed drainage system. Detailed geotechnical investigations with sufficient coverage to provide a detailed understanding of the site conditions are required. Design parameters (eg for imported fill) applied in modelling should be identified as a part of construction specifications. In-situ testing for key parameters may be required during construction as part of quality control and/or following construction prior to practical completion.

The key aspects of this design process include model selection; definition of model inputs; and required model outputs. The model outputs will need to address the specifications in section 4.

3.2 Model selection

A variety of modelling methodologies are currently applied to this process by industry, generally with the principal aim of demonstrating a satisfactory separation of the proposed development from groundwater. The various broad model types which are considered appropriate are:

- Steady state calculations – typically spreadsheet based. To be used only for broad assessment for concept planning or where the depth of fill proposed is driven by other factors;
- Dynamic 1-dimensional models – can also be spreadsheet based but a number of Graphic User Interface based models are commercially available; and
- Detailed 2-dimensional or 3-dimensional models.

Different model types may be used at different stages of assessment to provide a level of information that is appropriate for the planning and design tasks being undertaken. More detailed models are likely to require more detailed and accurate information. This may need to be considered when designing monitoring programs.

Steady state modelling assumes that the magnitude and direction of flow is constant with time throughout the entire domain. This does not mean that in a steady state system there is no movement, it simply means that the amount of water within the domain remains the same, and that the amount of water that flows into the system, is the same amount as flows out.

The most common steady state models applied to groundwater mounding use modified versions of the Houghoudt equation which can be written as:

$$Q\,L^2 = 8\,Kb\,d\,(Di - Dd)\,(Dd - Dw) + 4\,Ka\,(Dd - Dw)^2$$

where:

Q = steady state drainage discharge rate (m/day)
Ka = hydraulic conductivity of the soil above drain level (m/day)
Kb = hydraulic conductivity of the soil below drain level (m/day)
Di = depth of the impermeable layer below drain level (m)
Dd = depth of the drains (m)
Dw = steady state depth of the watertable midway between the drains (m)
L = spacing between the drains (m)
d = equivalent depth, a function of L, (Di-Dd), and r
r = drain radius (m)

3.3 Boundary/initial conditions

Where a simplified 1-dimensional model has been identified as appropriate it is reasonable to fix an initial boundary condition at the invert level (or half full level) of the subsoil drain and assume a free discharge from the drain, provided that the invert level is suitably elevated in relation to the ultimate discharge point to provide a reasonable grade. The ultimate discharge invert level should be located at or above the higher of the winter baseflow or AAMGL at the point of discharge where possible. Where a cross section extends into an 'undrained' area it might be necessary to consider a variable groundwater level at the boundary which could be derived from available monitoring data or larger scale modelling where available.

For more complex systems or environments where 2-dimensional or 3-dimensional modelling is required it will be necessary to establish fixed or variable boundary conditions using regional or district scale modelling and/or monitoring where available consistent with the *Australian groundwater modelling guidelines* (Sinclair Knight Merz and National Centre for Groundwater Research and Training, Waterlines Report Series No. 82, June 2012).

Where it is proposed to use a regional scale model to develop a boundary condition, monitoring of local conditions will need to consider the on-site soil types to determine if the local conditions are different to those represented regionally (i.e. is the system perched?).

Where the local conditions reflect regional characteristics, the boundary conditions may be able to be obtained from existing modelling by the Department of Water. Models which are available for use in this way include:

- The Perth Regional Aquifer Modelling System (PRAMS) which covers the Northern Perth basin extending from Moora to Mandurah and including the Perth metropolitan region.
- The Peel-Harvey Regional Aquifer Modelling System (PHRAMS), which was developed for the Peel-Harvey Area and includes Mandurah and the northern extent of Bunbury.
- The South West Regional Aquifer Modelling System (SWAMS) which covers the Southern Perth Basin from Bunbury to Scott River East.
- The Collie Basin model.

3.4 Rainfall

A 30 year daily timestep rainfall record is to be used to develop a probability density function from which the required level of service can be selected. This data should be sourced from the Department of Water.

Rainfall predictions to be used as modelling inputs should be based on the Department of Water's future median scenario, as outlined in the S*election of future climate projections for Western Australia* (DoW, 2015).

For steady state calculations, additional conservatism is necessary to account for the coarse methodology. A 50% AEP 72 hour rainfall event averaged over 24 hours to provide mm/day is to be applied.

3.5 Geotechnical and hydrological parameters

The following parameters to be applied when undertaking conceptual planning:

- Specific yield for imported fill ('yellow sand')– 0.2
- Hydraulic conductivity for imported fill ('yellow sand')– 5 m/day

Table2 proposes recommended net recharge ranges for different scales of groundwater investigation. These rates are not applicable for stormwater modelling.

Table 2: Summary of recommended recharge rates

Land use	Net recharge range
Lot scale 1D modelling:	
Roof/hardstand (with soakage)	80-90%
Roof/hardstand (with pipe connections)	0-10%
Vegetation	10-20%
Turf	40-50%
Street scale 1D or small scale 2D/3D modelling:	
Lots (R10-30 with soakage)	50-60%
Lots (R10-30 without soakage)	10-20%
Lots (30 and above with soakage)	70-90%
Lots (R30 and above without soakage)	10-15%
Road reserves (with soakage)	80-90%
Road reserves (without soakage)	0-20%
Public open space	10-50%
District/regional scale 2D/3D modelling:	
Urban residential (soakage areas)	60-90%
Urban residential (non-soakage areas)	10-20%

The ranges in Table 2 are based on an analysis of various back to back lot cross sections (street to street – including road reserve and setback to setback – excluding road reserve). Each cross section was assessed by assigning a 'catchment' and 'recharge' rate to each land use element with catchments adjusted to account for provision of soakage devices in lots and verges. Recharge assumptions for the individual land use elements used for this general analysis were:

- Hardstand (road pavement, paved verges & setbacks) – 0% recharge
- Street soakage (raingarden) – 90% recharge
- Turf – 50% recharge
- Mixed turf/vegetation – 30% recharge
- Lot soakage (soakwell) – 100% recharge, resulting in:

- Small backyards with soakwells – 80% recharge (mix of 100% for connected roof and 50% for surrounding turf)
- Large backyards with soakwells - 60% recharge (mix of 100% for connected roof and 30% for surrounding turf & vegetation)

The rates in Table2 should be revised as further research is undertaken.

4 Specifications

This section provides specifications for groundwater separations appropriate to acceptable levels of risk and amenity for the following critical elements of built form and infrastructure:

- Buildings;
- Roads;
- Services;
- Drainage infrastructure (infiltration systems and devices);
- Private spaces; and
- Public open space – recreation, sport and nature.

The criteria may be applied through a "deemed to comply" or acceptable solution approach. An alternative performance measure is also permitted which allows the acceptable solution to be modified as long as the identified objectives can be met. Use of the performance approach will require the proposed solution to be substantiated by sufficient technical investigation and justification.

4.1 Buildings

The *Building Code of Australia Volume 2 – Class 1 and 10 buildings* (2015) (BCA) contains performance requirements for dwellings. Detailed guidance is provided in the document for design and construction of suitable drainage and damp-proofing systems. The underlying objective is that water should be kept out of habitable spaces and structures should be appropriately designed to accommodate the prevalent site conditions.

The BCA specifies that buildings must "*perform adequately under all reasonably expected design actions*" and "*withstand extreme or frequently repeated design actions*". Groundwater and rainwater (including ponding) action are specified 'actions' under the BCA.

The BCA also specifies that:

> "*A building is to be constructed to provide resistance to moisture from the outside and moisture rising from the ground*".

And:

> "*Moisture from the ground must be prevented from causing:*
>
> (a) *unhealthy or dangerous conditions, or loss of amenity for occupants; and*
> (b) *undue dampness or deterioration of building elements.*"

Deemed to comply criteria

Meet the requirements of the *Building Code of Australia Volume 2*.

Performance measures

None required as this is addressed through the BCA.

4.2 Roads and pavements

Roads and pavements are recognised as key infrastructure in development areas that are prone to water damage. Alternative materials and construction methods are available to provide more robust surfaces which may have a substantially increased lifespan. These surface types may be more costly to install but when considered in relation to the increasing cost of fill and future repair costs may become more cost effective in future such that they should not be excluded from consideration.

Deemed to comply criteria

Meet the requirements of Module 8 of the IPWEA *Local Government Guidelines for Subdivisional Development* (the 'IPWEA Guidelines') for materials selection and testing, design and construction, and Module 4 of the IPWEA Guidelines, relating to drainage design and construction, in accordance with the WAPC's model subdivision conditions schedule.

Performance measures

None

4.3 Services

It is recognised that connections to services often impact on the fill use strategy; however this is generally in relation to the need for integration with existing services and/or optimisation of the efficiency of provision of the services.

Deemed to comply criteria

None. Services may be located within the groundwater.

Performance measures

None required.

4.4 Drainage infrastructure (infiltration systems and devices)

Drainage systems are provided in developments to manage both stormwater and groundwater. The effect of a drainage system that is located at or below groundwater will be to locally control the groundwater level to some extent.

Deemed to comply criteria

Drainage infrastructure should be designed in accordance with Module 8 of this guideline. In addition, the separation distances in Table 3 apply.

Table 3: Separation criteria for drainage infrastructure

Type of drainage infrastructure	Specification
Underground infiltration systems	0mm from the 50% AEP phreatic surface
Surface infiltration systems (vegetated)	300mm from the 50% AEP phreatic surface
Surface infiltration systems (duel function turf)	Default to Recreation POS standards

Performance measures

Underground infiltration systems – demonstration of acceptable volumetric capacity when groundwater is elevated above base of system and that the groundwater recedes below the invert of the system during mosquito breeding seasons (grated or partially open systems).

Surface infiltration systems – None.

4.5 Private spaces

In areas where groundwater is shallow, land that is waterlogged during winter can become muddy and/or inaccessible depending on the amount and type of traffic (pedestrian, vehicular). Development in these landscapes should consider the amenity requirements of the specific urban form proposed.

Deemed to comply criteria

The separation distances in Table 4 apply in the design of private spaces.

Table 4: Separation criteria for private spaces

Type of drainage infrastructure	Specification
Residential lots > 800 m2	No criteria. It is expected that design of lots will include site specific consideration of appropriate levels of amenity.
Residential lots 400 m2 to 800 m2	300mm of coarse sand applied to anticipated garden areas in the rear of lots above the 50% AEP phreatic surface
Residential lots <400 m2	150mm of coarse sand applied to anticipated garden areas in the rear of lots above the 50% AEP phreatic surface

Performance measures

The following performance measures may be applied for Residential lots below 800 m2 where it has been demonstrated that lot purchasers have been provided with sufficient educational material and landscape design advice to facilitate a suitably informed decision to purchase.

- 0mm from the 50% AEP phreatic crest level

No performance measures are proposed for Residential lots > 800 m2.

4.6 Public open space – recreation, sport and nature

The *Classification Framework for Public Open Space* developed by the Department of Sport and Recreation (2012), categorises different types of parkland by primary function: recreation, sport and nature space; and by expected catchment: local, neighbourhood, district or regional open space.

Nature spaces should be landscaped in a way that is consistent with the natural environment and its ecological water requirements. Plant selection should address the local hydrological conditions public access to low-lying wet parts of the space should be limited. No separation criteria are therefore required for these spaces.

Recreation and sport spaces should also address the local environment, providing adequately drained hard spaces and vegetation that is appropriate to the local hydrological conditions. Where open parkland or turfed areas are proposed, an unsaturated root zone should be provided so that plant (grass) health can be maintained. This requires an understanding of the capillary fringe thickness of the soil.

Deemed to comply criteria

The separation distances from the engineered phreatic surface for turfed open space on a range of soil types are provided in Table 5. This incorporates a 150 mm allowance for root zone depth. It is not recommended that turf is laid directly on silt or clay soils.

Table 5: Separation distance for turfed open space based on typical soil types*

Soil type	Separation distance
Gravel:	
Coarse	150 mm
Medium	150 mm
Fine	200 mm
Sand	
Coarse	300 mm
Medium	450 mm
Fine	650 mm

* Classification of soils types is based on Table A1 of AS 1726-1993 Geotechnical site investigations.

The approach for design of groundwater drainage systems under turfed open space based on the various function and catchment categories is presented in Table 6 and Figure 1. It requires calculation of the appropriate AEP engineered phreatic surface, on top of which the separation distances in Table 5 are to be added.

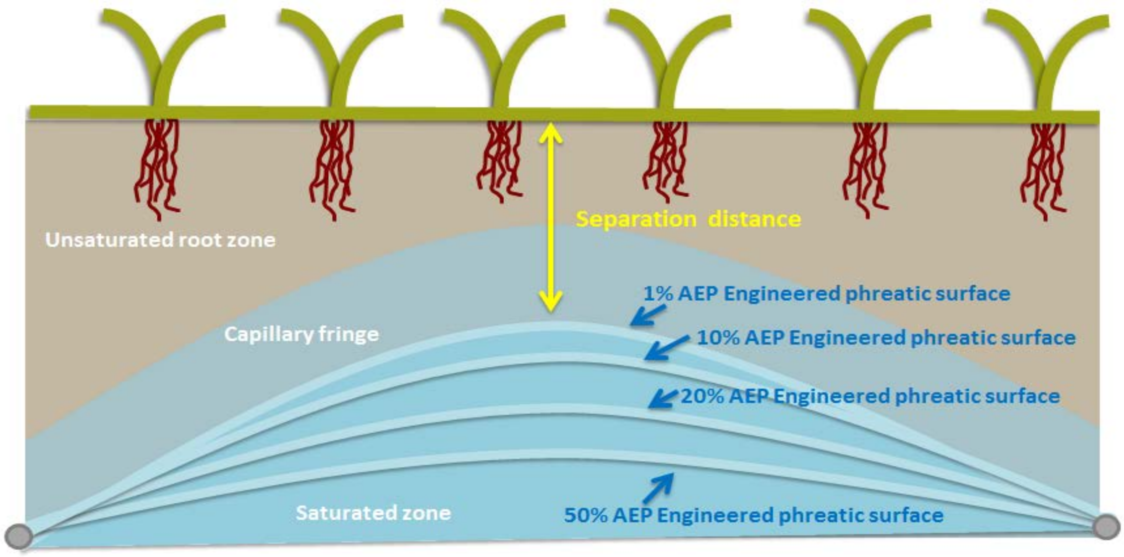

Figure 1: Designing groundwater drainage under turfed open space

Table 6: Designing groundwater drainage for turfed open space based on function and catchment

Function	Catchment	Deemed-to comply criteria
Multi-function areas (drainage and recreation)		Where turf is proposed as a landscape treatment, the approach appropriate to its public open space function and catchment is to be applied.
Nature	local	The requirement for nature spaces is dependent on its characteristics and ecological water requirements. For example a wetland should be maintained as wet, whilst dryland vegetation should to be maintained as dry (with access to groundwater at a consistent depth).
	neighbourhood	
	district	
	regional	
Recreation	local	The turf surface should be separated from the 50% AEP phreatic surface consistent with Table 5.
	neighbourhood	The turf surface should be separated from the 50% AEP phreatic surface consistent with Table 5.
	district	The turf surface should be separated from the 20% AEP phreatic surface consistent with Table 5.
	regional	The turf surface should be separated from the 20% AEP phreatic surface consistent with Table 5.
Sport	local	The turf surface should be separated from the 50% AEP phreatic surface consistent with Table 5.
	neighbourhood	The turf surface should be separated from the 20% AEP phreatic surface consistent with Table 5.
	district	The turf surface should be separated from the 20% AEP phreatic surface consistent with Table 5.

Function	Catchment	Deemed-to comply criteria
	regional	The turf surface should be separated from the 10% AEP phreatic surface consistent with Table 5.

Performance measures

Turf for recreation or sports use should be planted with a well-drained layer of underlying soil no less than 300 mm deep to provide ideal growing conditions and surface performance. The characteristics of the underlying soil layer should be specified to ensure that the thickness of the capillary fringe will not exceed around half of the thickness of the soil layer (typically: hydraulic conductivity/infiltration rate and grain diameter).

For sites where a design process is undertaken for the public open space which includes detailed specification and testing of underlying soils such that a more accurate assessment of capillary fringe thickness can be made the default separations presented in Table 5 can be replaced with a site specific calculation.

Glossary of terms

Annual exceedance probability (% AEP)	The probability that a given event will occur or be exceeded in any year
Capillary fringe	Part of the unsaturated zone, where soil voids are filled (or almost filled) with water due to capillary rise
Controlled groundwater system	A groundwater system that is subject to control or management through the provision of drainage infrastructure
Controlled groundwater level (CGL)	The invert level of groundwater controlling infrastructure
Groundwater	Water in the soil voids of the saturated zone
Groundwater level	The non-static top of the saturated zone (can include locally perched groundwater)
Perched groundwater	Groundwater that occurs above the regional water table, as a distinct saturated zone embedded within the unsaturated zone due to the presence of an aquiclude or aquitard
Engineered phreatic surface	The non-static top of the saturated zone in a controlled groundwater system
Engineered phreatic crest level	The highest point on the controlled phreatic surface
50% AEP phreatic surface	The phreatic surface that will be exceeded in 50% of years (50% chance each year).
20% AEP phreatic surface	The phreatic surface that will be exceeded in 20% of years (20% chance each year).
Saturated zone	The part of the soil profile where voids are completely filled with water.
Seasonally perched groundwater	Perched groundwater that is seasonally connected to the underlying water table
Unsaturated zone	The part of the soil profile where voids are only partially filled with water.
Water table	The non-static top of the saturated zone (generally does not include locally perched groundwater)

Land development in groundwater constrained landscapes Steering Group: Development of guidance for groundwater separation distances –

Agency engagement

Steering Group	Methodology Reference Group
IPWEA	Local Government - Gosnells
City of Rockingham	Local Government - Armadale
City of Gosnells	Department of Water
City of Swan	SIA WA
City of Armadale	Consulting industry – Calibre
Town of Kwinana	Consulting industry – JDA
City of Cockburn	Consulting industry – Emerge
Shire of Murray	Consulting industry – Coterra
Serpentine-Jarrahdale Shire	
Department of Planning	Separations Technical Working group
Department of Water	City of Gosnells
LandCorp	City of Armadale
HIA	Department of Planning
Hydraulic Services Consultants	Office of Land and Housing Supply
UDIA	LandCorp
WALGA	CMW Geosciences
	Essential Environmental