Government of **Western Australia**
Department of **Water**

Water resource considerations when controlling groundwater levels in urban development

April 2013

Looking after all our water needs

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Department of Water
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This document will be reviewed within three years on the basis of experience with its use, feedback and potential changes to technical references.

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Foreword

The Department of Water has prepared this document to help state and local government and the land development industry identify water resource factors recommended for consideration in relation to assessing the need for and setting controlled groundwater levels to manage groundwater in urban development.

Integrated land and water planning is based on the principle of total water cycle management as outlined in *State planning policy 2.9: water resources* (WAPC 2006a) and *Better urban water management* (WAPC 2008). This document supports the land planning process and defines what investigation and analysis need to be undertaken and reported. Addressing its recommendations and including them in the land planning process is part of an integrated approach to land use and water management.

In the same way as *Better urban water management*, this document acknowledges the need for a flexible approach. The scale of investigation and analysis will depend on the presence of local water resources, the availability of existing data, the proposed urban form and any associated risks.

Implementation of guidance provided in this document will promote a more consistent approach to assessing the need for and when required setting a controlled groundwater level in urban development across Western Australia. The Department of Water will periodically review and update this document to reflect current issues.

Maree De Lacey
Director General
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1 Document purpose

This document provides a process for state and local government and the land development industry to identify water resource factors recommended to be considered when assessing the need for and setting the controlled groundwater level (CGL).

The need for groundwater management is based on a number of factors including the groundwater regime and an assessment of the risk this poses to the proposed urban form. This document only provides advice on determining an understanding of the groundwater regime.

The CGL is defined as the controlled (i.e. modified) groundwater level at which the Department of Water will permit groundwater drainage inverts to be set (DoW 2009a). This document details the considerations required when setting the CGL.

To ensure local and regional environmental impacts are managed (DoW 2009a) and the continued operation of groundwater drainage systems this document discusses management of discharged groundwater and maintenance considerations.

The detail provided in this document is laid out to enable the level of investigation and analysis required at the regional, district, local and subdivision planning stages to be easily identified.

1.1 Why is this document needed?

There is currently no documented process for identifying the groundwater regime in relation to urban development or what water resource considerations are required when setting the CGL. This document addresses this gap by providing guidance on the timing and level of information required to make these decisions.

1.2 Using this document

This document presents four groundwater management components (supported by tabulated criteria and flowcharts):

- Assessing the need for groundwater management (Section 2).
- Setting the CGL of groundwater management systems (Section 3).
- Detailed design for subsoil drainage (Section 4).
- Information required at each stage of the planning process (Section 5).

The information required as presented in this document may be needed to support other water resource decisions. When the information is required to support other water resource decisions the timing and level of information required should be conducted in line with *Better urban water management* (WAPC 2008).

1.3 What risks and considerations need to be addressed at each planning stage?

This document has been developed to ensure the relevant risks and considerations are appropriately addressed and managed at the right planning stage.

District level planning

The district level planning question to ask is whether the land is capable of supporting urban development. If the land is capable, the land required for water management should be identified. Proponents need to consider whether groundwater poses a risk to the proposed urban form and if so show that groundwater management can be effectively implemented within the catchment constraints.

This document provides advice on how to determine the groundwater regime, which should consider and be based on investigation and analysis of:

- seasonal and long-term pre-development groundwater observations including contributing factors, like seasonal and long-term climate variations and local and regional groundwater abstraction
- post-development changes of water balance components that affect groundwater levels; for example, changed hydrology, decreased evapotranspiration, altered topography.

In line with *Better urban water management* (WAPC 2008) a flexible approach is supported. At the district level of planning a preliminary assessment of the groundwater regime may be made using available information. More detailed assessment of the groundwater regime can be made using site-specific investigation and analysis at the local level of planning. However, more detailed investigations and analysis may be required to be able to make an informed district level planning decision when:

- there is insufficient information
- groundwater and catchment constraints are significant.

Once the groundwater regime has been established the risk to the proposed urban form should be assessed by the proponent, taking into account:

- the vertical separation required between groundwater and each component of the proposed urban form
- the groundwater level from which the vertical separation should be measured.

The Department of Water is not the relevant approval agency for determining the vertical separation required between groundwater and each component of the proposed urban form. This detail is therefore not covered in this document.

To determine the groundwater level from which the vertical separation is to be measured requires an understanding of the factors taken into account within the required vertical separations for each component of the urban form. This detail is therefore not covered in this document.

In determining the required vertical separation and groundwater level from which this is to be measured the department encourages and supports innovative designs and proposals to reduce or negate the need to manage groundwater, such as alternative construction methods and materials.

Local level planning

The local level planning question is to ask how the proposed urban form will address water use and management. Where groundwater poses a risk to the proposed urban form, the proponents need to develop management strategies to mitigate the risk. Traditionally groundwater has been managed by installing drainage systems to control groundwater rise. These systems often comprised a combination of subsoil and open channel drainage.

The invert level of the drainage system sets the discharge control level for groundwater and is referred to as the controlled groundwater level (CGL). When setting the CGL a range of risks to protect catchment values (e.g. water-dependent ecosystems – WDEs) must be considered. Continued operation of the system must also be considered; for instance, appropriate outlet levels.

To assess constraints and appropriately mitigate or manage the risks, detailed investigation and analysis may be required to gain an understanding of:

- pre-defined criteria within existing management plans
- physical factors that may limit the drainage system outlet locations and levels, including environmental assets, topography, seasonal and event-based inundation and winter baseflow levels
- soil and groundwater contaminants that if mobilised may reduce the efficiency or integrity of the drainage system and/or result in detrimental impacts to the receiving environment
- adjacent environmental assets and land uses and their dependence on groundwater availability such as water-dependent ecosystems, agriculture and private bores.

It is important to remember that groundwater may rise higher than the CGL, due to groundwater mounding between drainage lines. The extent of rise depends on factors including the soil permeability, rainfall events and where the CGL is set relative to natural groundwater variations. These factors need to be considered when assessing the risk to the proposed urban form but are not covered in this document.

Subdivision planning

The subdivision planning question to ask is how the final urban form will use and manage water. This requires detailed design of the groundwater management methods proposed for use at the local level of planning; for example, subsoil and open channel drainage and associated infrastructure that may have been identified.

This document provides advice on the detail required for managing the quantity and quality of discharged groundwater, maintenance of the drainage systems and planning requirements. They do not cover material specifications and installation criteria for subsoil drainage, which should be based on industry standards.

The department recommends and encourages the adoption of water sensitive urban design principles when designing open channel drainage, which should ideally be incorporated into the urban forms landscape as living streams. Design requirements for these systems are provided in Chapter 9, Section 4.3 of the *Stormwater management manual for Western Australia* (DoW 2004–07) and more detailed information on natural streams is also provided in the *River Restoration Manual* (WRC 1999–2003).The above detail is summarised in Figure 1 which provides links to the *Better Urban Water Management* water and land planning processes diagram (WAPC 2008). A flowchart of the required steps is provided in Figure 2.

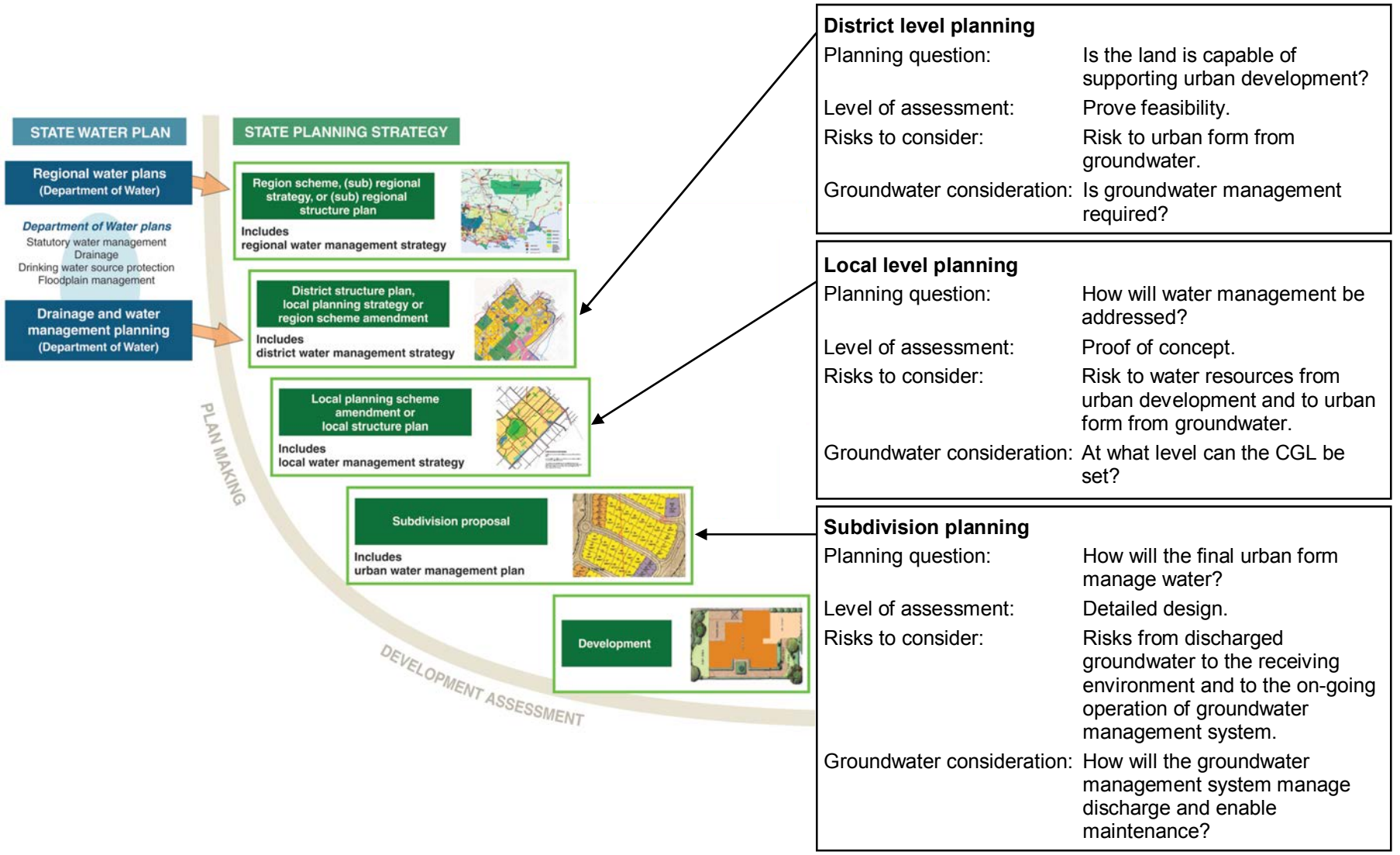

Figure 1 Risks and considerations to be addressed at each planning stage (Source: Adapted from: Better Urban Water Management, WAPC 2008*)*

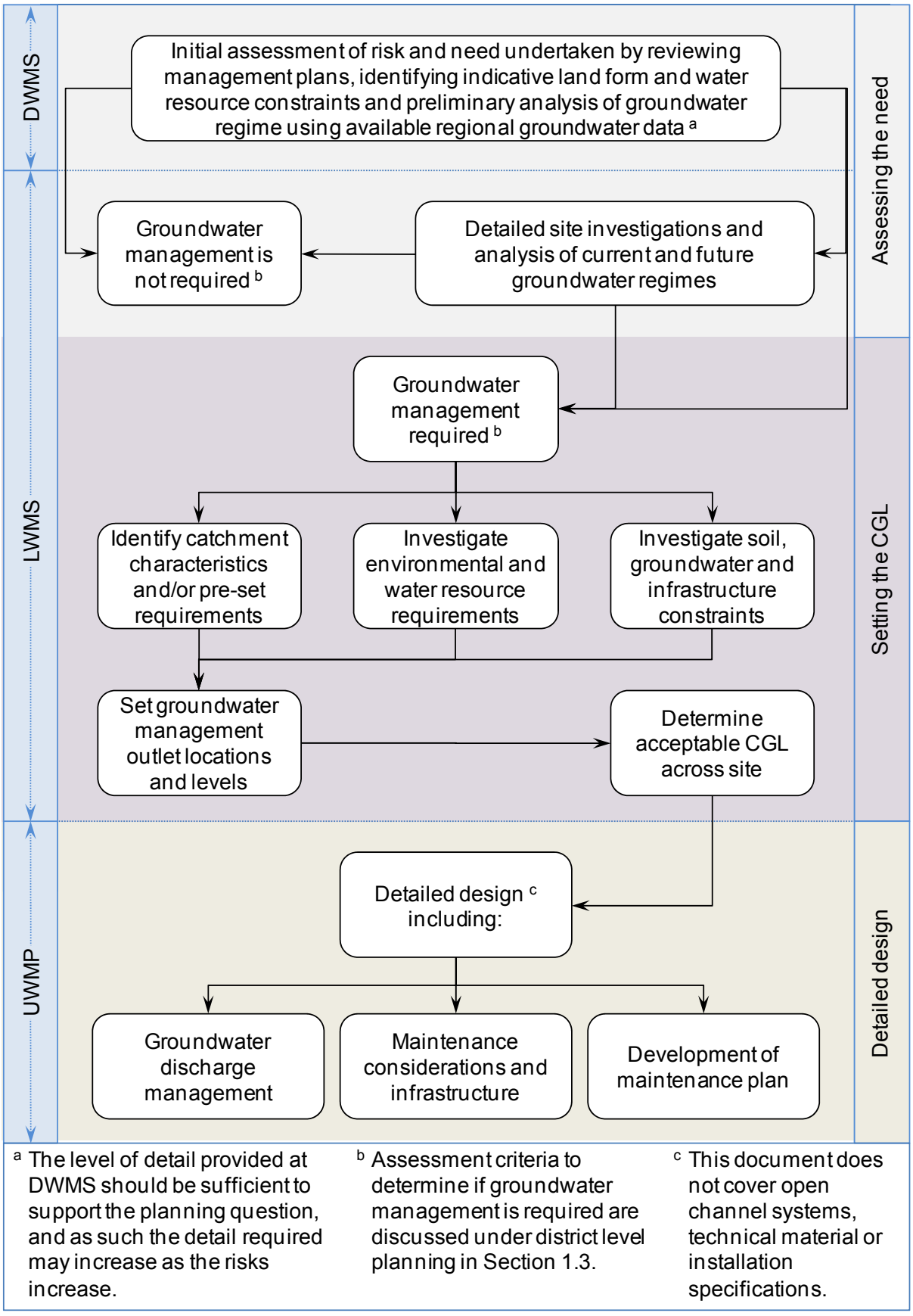

Figure 2 Groundwater management assessment and design flowchart

2 Assessing the need for groundwater management

As detailed under district level planning in Section 1.3 the Department of Water is not the relevant approval agency for determining the vertical separation or the groundwater level from which the vertical separation is to be measured. This detail is therefore not covered in this document and this section only covers the level of investigation and analysis recommended to gain an understanding of the groundwater regime.

Progressively more detailed investigation and analysis of the groundwater regime are recommended. This process is outlined in Figure 3, with more detail provided in Table 1.

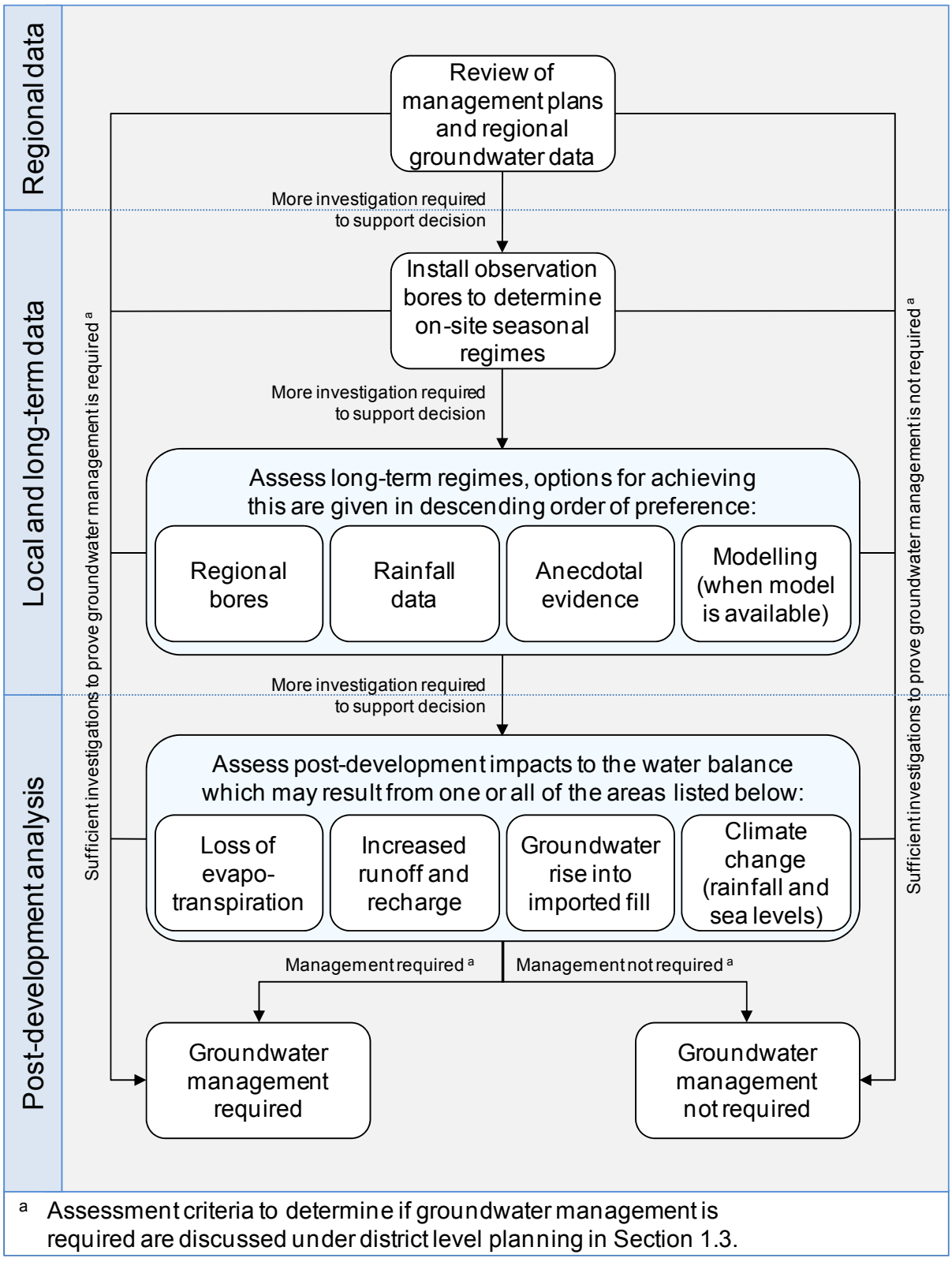

Figure 3 Assessing the need for groundwater management flowchart

Table 1 Criteria for assessing the need for groundwater management

Design consideration	Consideration need/question	Requirements	Further information
Groundwater regime	Assess whether groundwater management is required.	Initial assessment, usually presented in a district water management strategy: • Review of existing management plans and their recommendations and requirements to: – use groundwater management – restrict management approaches • Preliminary assessment of the groundwater regime based on available data (e.g. regional groundwater data) to identify if groundwater management is required • Initial assessment of the pre-development landform and the constraints this may present to viable groundwater management options including: – WDEs including waterways and their foreshore areas and wetlands and their buffers – presence and depth of perched groundwater system – areas of seasonal inundation – regional and local hydrology data – sufficient catchment gradient for a groundwater drainage system, if required, to function effectively Detailed assessment, usually presented in a local water management strategy, should include the following works. At any stage during this assessment if it is determined that groundwater management is required there is no need to further assess the groundwater regime. However, it should be noted that further investigation and analysis of the groundwater regime may be required to set the CGL as outlined in Section 3.	• Management plans that may provide groundwater management requirements include: • Drainage and water management plans • Water allocation plans <www.water.wa.gov.au → Managing water → Allocation planning> • Drinking water source protection reports <www.water.wa.gov.au → Managing water → Drinking water → Water source protection plans> • For available water resource data: • *Water resource information catalogue* for details of available water resource data <www.water.wa.gov.au → Tools & data → Monitoring and data> • Data request form to request relevant water resource data <www.water.wa.gov.au → Tools & data → Monitoring and data> • Other useful documents: • *Water monitoring guidelines for better urban water management strategies/plans* (DoW 2012) • *Plantation forestry and water management guideline* (DoW 2009b) • *Effect of urban development on water balance in the Southern River catchment* (Barron & Barr 2009) • *Murray hydrological studies: surface water, groundwater and environmental water – land development, drainage and climate scenario report* (Hall et al. 2010)

Design consideration	Consideration need/question	Requirements	Further information
		• Installation and monitoring of on-site observation bores to further determine site based groundwater regime, noting: – the required duration for monitoring on-site observation bores depends on the identified risks – the use of continuous dataloggers, while not a requirement, can provide a more detailed data set and decrease costs by reducing the number of site visits • Analysis of regional bores including: – ensuring location has similar topography and hydrological features/connectivity to bores on-site – comparing regional and on-site bore construction (e.g. screen depth, lithology) – comparing regional and on-site bore data seasonal and event based response • For regional bores that provide data deemed suitable to assist in extrapolating on-site observations, identify and investigate: – the magnitude of change and duration of seasonal peaks – trends such as increasing or decreasing seasonal peaks – links between trends and regional/local events such as successive above and/or below years rainfall, groundwater abstractions and durations – whether regional/local events are long or short term (e.g. abstraction to support a mining operation) – what period of data from regional bores is relevant to be used	

Design consideration	Consideration need/question	Requirements	Further information
		• When there are no regional bores the following data may be useful in extrapolating on-site observations: – Rainfall data may be used, noting total annual rainfall is not directly linked to seasonal peak groundwater levels and an assessment of local recharge conditions and rainfall patterns is required. – Anecdotal evidence may be used, including photographs, aerial imagery, vegetation composition, wet areas and/or on-site waterbody levels. – Where a groundwater model has been developed to support a drainage and water management plan, the model will be made available to enable site-specific modelling when required and/or requested. – The Perth Groundwater Atlas provides information to assist in the installation of groundwater abstraction bores and is **not** intended to define groundwater regime for urban development. • Post-development changes in groundwater regime should also be considered, including: – climate change (changes in rainfall and sea level) – reduced evapotranspiration – increased localised recharge – potential of groundwater rise into imported fill	

3 Setting the controlled groundwater level of groundwater management systems

Where groundwater management is needed the Department of Water requires the setting of the CGL to take account of:

- catchment constraints and requirements
- adjacent land uses and infrastructure
- impacts to local and regional water-dependent ecosystems and water resources
- contaminants that may be mobilised with released groundwater
- the system needing to be hydraulically sound and having a free-flowing outlet.

Figure 4 provides a recommended order for considering these factors, with more detail in Tables 2–5.

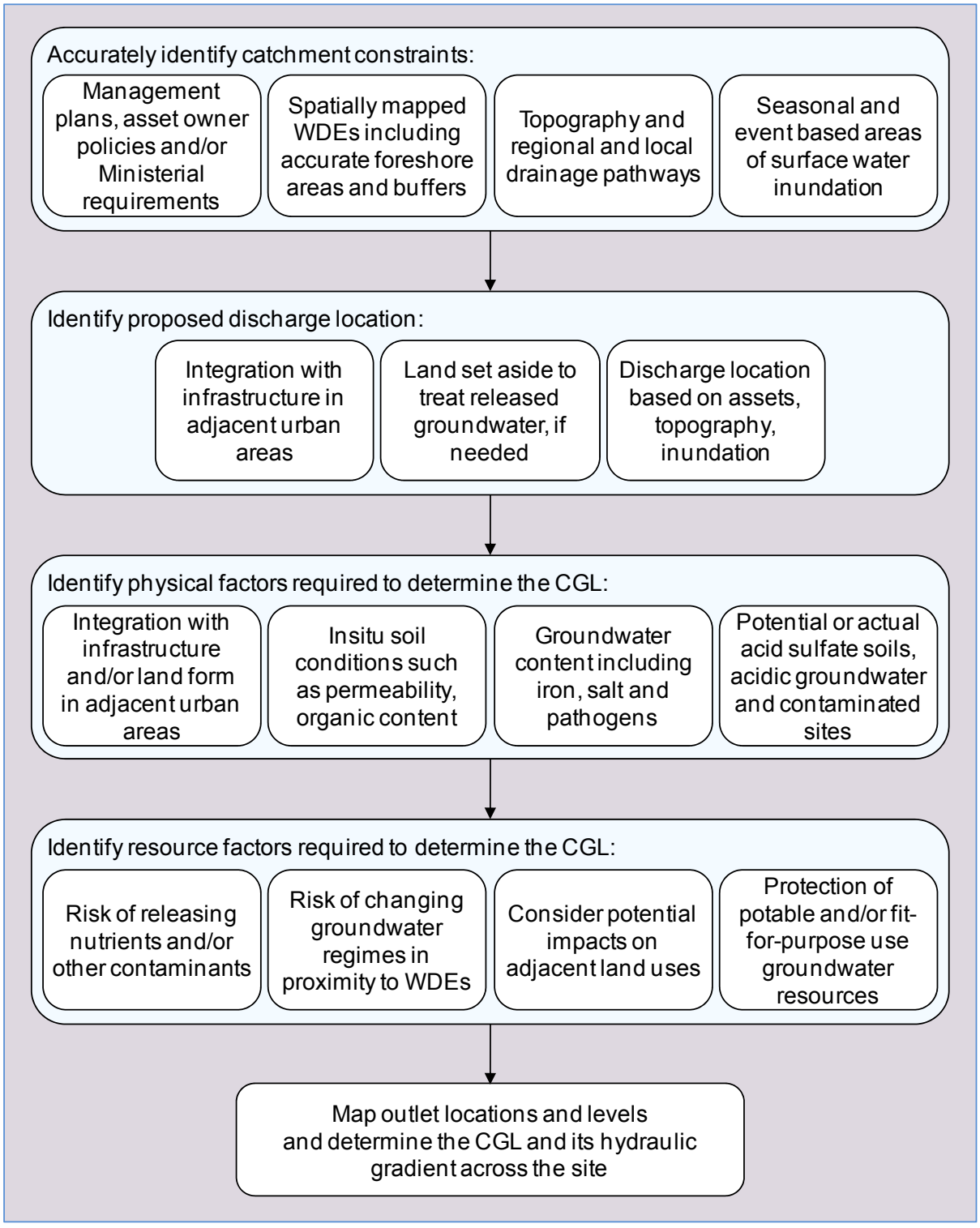

Figure 4 Setting the controlled groundwater level (CGL) flowchart

Table 2 Catchment investigations to support the discharge location and CGL

Design consideration	Consideration need/question	Requirements	Further information
Existing requirements	Apply criteria consistent with existing requirements.	• Investigate and identify the requirements of management plans (e.g. Ministerial requirements on the Jandakot Mound). • Identify the owner/manager of the receiving environment (e.g. land owner, LGA or Water Corporation) and investigate their requirements.	• Water quality improvement plans • Drainage and water management plans • Water allocation plans <www.water.wa.gov.au → Managing water → Allocation planning> • Drinking water source protection reports <www.water.wa.gov.au → Managing water → Drinking water → Water source protection plans>
Water-dependent ecosystems	Location and level of protection required for water-dependent ecosystems and their protection areas	• Identify and map water-dependent ecosystems including exact waterways, their foreshore areas and wetlands, and their buffers and assets to which discharge of mobilised groundwater may be restricted, unless approved by the Department of Water and the Department of Environment and Conservation. • Identify the level of protection required for each asset as required by the asset owner and/or manager in relation to water-dependent ecosystem sensitivity to changes in the seasonal and long-term groundwater regime and/or quality.	• *Operational policy 4.3: Identifying and establishing waterways foreshore areas* (DoW 2012a) • Chapter B4 & B5 of *Environmental guidance for planning and development – guidance statement no. 33* (Environmental Protection Authority 2008) • *Decision process for stormwater management in Western Australia* (DoW 2009a) • *Better Urban Water Management Guidance Note No. 7– managing the hydrology and hydrogeology of water-dependent ecosystems in urban development* (DOW 2012c) • *Environmental water provisions policy for Western Australia* (Water and Rivers Commission 2000) • *Ecological water requirements of selected wetlands in the Murray drainage and water management plan area* (GHD 2010)

Design consideration	Consideration need/question	Requirements	Further information
Catchment hydrology	How to use the catchment's natural drainage and landform	• Map the site's topography and how this integrates with the natural drainage pathways in the catchments. • Identify the winter/wet season baseflow level of the natural drainage pathways in the catchments. • Identify and map areas seasonally inundated, including the level of inundation. • Determine event-based levels of inundation and the duration required to return to winter/wet season baseflow levels.	

Table 3 Criteria to consider when setting the discharge location

Design consideration	Consideration need/question	Requirements	Further information
Existing infrastructure	Will the groundwater management integrate with an existing system?	• Identify if the proposed groundwater management will integrate with an existing system in adjacent urban areas. • Identify criteria requirements of the asset owner, and prove to the satisfaction of the asset owner that these can be met.	
Contaminated groundwater	Does the discharged groundwater need to be treated?	• Investigate potential groundwater contaminants and determine what level of treatment may be required prior to release. • Set aside sufficient land to achieve the required level of treatment. • Assess what modification may be required to achieve the level of treatment required when the proposed groundwater management system connects into and discharges via an existing system.	• *Decision process for stormwater management in Western Australia* (DoW 2009a) • *Better Urban Water Management Guidance Note No. 7 – managing the hydrology and hydrogeology of water dependent ecosystems in urban development* (DoW 2012c) • *Determining the effectiveness of best management practices to reduce nutrient flows in urban drains managed by the Water Corporation: Part 2 Literature Review* (Barron & Donn 2009) • *Best management practices: Investigation of mineral-based by-products for the attenuation of nutrients and DOC in surface waters from the Swan Coastal Plain (Wendling et al. 2009)* • *SRT/D4 - Stormwater Management* (Swan River Trust 2012) • Department of Environment and Conservation <www.dec.wa.gov.au → Management and protection → Land → Acid sulfate soils> • Department of Environment and Conservation <www.dec.wa.gov.au → Pollution prevention → Contaminated sites>

Design consideration	Consideration need/question	Requirements	Further information
Setting the discharge location	How to use natural site attributes and manage risks to the receiving environment.	• Identify the connection point where direct connection to an existing urban groundwater or stormwater management system is acceptable. • Where discharge is proposed to a natural drainage feature: – Identify water-dependent ecosystems to which direct discharge is not permitted. – Construct new groundwater infrastructure so that it is not located within waterways and their foreshore areas or wetlands and their buffer foreshore areas unless approved by the responsible agency (e.g. Department of Environment and Conservation, Office of the Environmental Protection Authority, Department of Water and/or Swan River Trust). – Set outlet locations and levels outside and above the receiving environment's winter/wet season baseflow level and extent to make sure the system has a free-flowing outlet. – Ensure outlets are not inundated for periods longer than one week during major events. • Where discharge is proposed to a stormwater system: – the outlet invert should be a minimum of 100 mm higher than the invert level of stormwater pipes – the level should be 100 mm higher than the predicted or measured winter/wet season level for back-flooded stormwater systems.	• *Decision process for stormwater management in Western Australia* (DoW 2009a) • *Better Urban Water Management Guidance Note No. 7 – managing the hydrology and hydrogeology of water dependent ecosystems in urban development* (DoW 2012c) • *Murray drainage and water management plan* (DoW 2010) • *SRT/D4 – Stormwater Management* (Swan River Trust 2012) • *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)

Table 4 Physical criteria to consider when setting the CGL

Design consideration	Consideration need/question	Requirements	Further information
Existing infrastructure	Will the groundwater management integrate with an existing system?	• Identify the invert level of the existing receiving groundwater management system.	
Geotechnical conditions	Soil profile is appropriate for groundwater management	• Where groundwater management is proposed to be placed below pre-development ground level consider the: – ability to practically manage groundwater in the proposed soil horizons (e.g. soil permeability, soil dispersiveness, potential for capillary rise) – risks of managing groundwater in the proposed soil horizons (e.g. differential subsidence can occur in peaty or other organic soils). • Where localised perched groundwater exists due to impermeable substrata, such as clay, the CGL may be set at the top of the impermeable layer. This is acceptable as long as other physical and resource considerations can be managed.	• *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)
Avoid clogging	Accumulation of bacterial bioslime, iron biofouling and/or salt precipitation is avoided	• Test groundwater for pathogens, iron and salt content where site conditions indicate the risk may exist. • Avoid mobilisation of identified contaminants that may reduce the system efficiency and increase maintenance requirements.	• *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)

Design consideration	Consideration need/question	Requirements	Further information
Potential acid sulfate soil/acid sulfate soil and contaminated sites	Assess the risk of releasing acidity and/or contaminants.	• Investigate the presence of potential acid sulfate soil/acid sulfate soil. • Monitor seasonal groundwater quality variation to identify existing acidic groundwater. • Identify the presence of contaminated sites. • Avoid: – exposure of potential acid sulfate soil/acid sulfate soil and/or mobilisation of acidic groundwater, to protect the groundwater management infrastructure and receiving environment – use of groundwater management in proximity to contaminated sites.	• Department of Environment and Conservation <www.dec.wa.gov.au → Management and protection → Land → Acid sulfate soils> • Department of Environment and Conservation <www.dec.wa.gov.au → Pollution prevention → Contaminated sites> • *Decision process for stormwater management in Western Australia* (DoW 2009a)

Table 5 Resource criteria to consider when setting the CGL

Design consideration	Consideration need/question	Requirements	Further information
Minimise water quality impacts to water-dependent ecosystems.	Avoid mobilisation of nutrients and contaminants.	• Maintain or improve the physical condition and ecological health of the WDE by ensuring the quality of groundwater discharged is in accordance with: – *Decision process for stormwater management in Western Australia* (DOW 2009a) – Water quality improvement plans – Drainage and water management plans – Drinking water source protection reports – *Australian water quality guidelines for fresh and marine waters* (ANZECC 2000) – any other relevant catchment or asset-specific plan (including references listed under further information). • When groundwater discharge quality requirements cannot be met, demonstrate to the satisfaction of the responsible agency (e.g. Department of Environment and Conservation, Office of the Environmental Protection Authority, Department of Water and/or Swan River Trust) that the physical condition and ecological health of the water-dependent ecosystem will be maintained or improved. This may require an ecological water requirement study.	• *Decision process for stormwater management in Western Australia* (DoW 2009a) • *Better Urban Water Management Guidance Note No. 7 – managing the hydrology and hydrogeology of water dependent ecosystems in urban development* (DoW 2012c) • *Environmental water provisions policy for Western Australia* (Water and Rivers Commission 2000) • *Ecological water requirements of selected wetlands in the Murray drainage and water management plan area* (GHD 2010) • *Determining the effectiveness of best management practices to reduce nutrient flows in urban drains managed by the Water Corporation: Part 2 Literature Review* (Barron & Donn 2009) • *Best management practices: Investigation of mineral-based by-products for the attenuation of nutrients and DOC in surface waters from the Swan Coastal Plain (Wendling et al. 2009)* • *Australian water quality guidelines for fresh and marine waters* (ANZECC 2000) • Water quality improvement plans • Drainage and water management plans • Water allocation plans <www.water.wa.gov.au → Managing water → Allocation planning> • Drinking water source protection reports <www.water.wa.gov.au → Managing water → Drinking water → Water source protection plans>

Design consideration	Consideration need/question	Requirements	Further information
Minimise groundwater regime impacts to water-dependent ecosystems.	Avoid altering the groundwater regime.	• Maintain or improve the physical condition and ecological health of the water-dependent ecosystem by not altering the groundwater regime within the WDE and its protection zone by greater than normal climatic variances. • If it is proposed to alter the groundwater regime by greater than normal climatic variances, demonstrate to the satisfaction of the responsible agency (e.g. Department of Environment and Conservation, Office of the Environmental Protection Authority, Department of Water and/or Swan River Trust) that the physical condition and ecological health of the water-dependent ecosystem will be maintained or improved. This may require an assessment of its monthly catchment water balances, taking into account: – the pre- and post-development total water balances of the WDE including surface water, groundwater and climatic inputs and outputs, such as direct rainfall and evapotranspiration – changes resulting from proposed surface water management approaches (e.g. altered surface water discharge locations and flow rates) – changes resulting from proposed groundwater management approaches, considering: o depth of the CGL relative to pre-development groundwater regimes o horizontal distance between the CGL and water-dependent ecosystem and its protection zone o aquifer characteristics o discharge capacity of the proposed groundwater drainage system.	• *Better Urban Water Management Guidance Note No. 7 – managing the hydrology and hydrogeology of water dependent ecosystems in urban development* (DoW 2012c) • *Environmental water provisions policy for Western Australia* (Water and Rivers Commission 2000) • *Ecological water requirements of selected wetlands in the Murray drainage and water management plan area* (GHD 2010) • Drainage and water management plans • Water allocation plans <www.water.wa.gov.au → Managing water → Allocation planning> • Drinking water source protection reports <www.water.wa.gov.au → Managing water → Drinking water → Water source protection plans>

Design consideration	Consideration need/question	Requirements	Further information
Maintaining adjacent land uses	Protect adjacent economic and social activities.	• Investigate uses of adjacent land and the reliance on groundwater of associated activities (e.g. agriculture, recreational water bodies). • Prove the proposed groundwater management will not lower the groundwater in adjacent land such that existing economic and/or social activities cannot be maintained.	
Maintaining potable and fit-for-purpose use groundwater resources	Provide the required level of protection and do not reduce the availability of potable and fit-for-purpose use groundwater resources.	• Where present ensure the management of potable and fit-for-purpose use groundwater resource is in accordance with: – Water allocation plans – Drinking water source protection reports – any other relevant catchment or asset-specific plan. • This may include a requirement to: – limit land use activities in wellhead protection zones – provide a minimum vertical separation for groundwater from specific land use activities – minimise mobilisation of allocated fit-for-purpose groundwater resources.	• Water allocation plans <www.water.wa.gov.au → Managing water → *Allocation* planning> • Drinking water source protection reports <www.water.wa.gov.au → Managing water → Drinking water → Water source protection plans>

4 Detailed design for subsoil drainage

This document only provides detailed design advice related to:

- management of groundwater discharged via the system
- maintenance systems and planning.

Tables 6–9 provide detailed design considerations. These should be taken into account in conjunction with other industry standard detailed design requirements (e.g. standard material and installation specifications and local government polices).

Table 6 Criteria for managing subsoil drainage discharge

Design consideration	Consideration need/question	Requirements	Further information
Treatment of released groundwater (if required)	Protect and where possible enhance the quality of discharged groundwater.	• Treat poor quality groundwater (e.g. high total nitrogen/total phosphorus) released by the subsoil drainage to the appropriate level as determined based on the requirements for the receiving environment (e.g. conservation category wetland). • Treatment may be achieved by using a suitably selected filter material to treat the groundwater (and infiltrated stormwater) prior to entry into the subsoil drainage pipe or by construction of a treatment system at the subsoil drainage system outlet.	• *State Planning Policy 2.10 Swan Canning River system* (WAPC 2006b) • *Decision process for stormwater management in Western Australia* (DOW 2009a) • *Stormwater management manual for Western Australia* (DOW 2004–07) *Determining the effectiveness of best management practices to reduce nutrient flows in urban drains managed by the Water Corporation: Part 2 Literature Review* (Barron & Donn 2009) *Best management practices: Investigation of mineral-based by-products for the attenuation of nutrients and DOC in surface waters from the Swan Coastal Plain* (Wendling et al. 2009) • *Australian water quality guidelines for fresh and marine waters* (ANZECC 2000) Local water quality improvement plans and/or other catchment management plans
Management of disease vector and nuisance insects	Minimise the risk of wet areas during mosquito breeding periods.	• Design outlets to avoid the creation of wet areas, especially near residential areas. • Areas for infiltration or treatment should not hold immobile water for periods longer than 96 hours between November and May.	• *Decision process for stormwater management in Western Australia* (DOW 2009a) • *Chironomid midge and mosquito risk assessment guide for constructed water bodies* (Midge Research Group 2007) • *Guidance statement for management of mosquitoes by land developers – guidance statement no. 40* (EPA 2008)

Design consideration	Consideration need/question	Requirements	Further information
Managing erosion	Prevent erosion of soils at the discharge location.	• Protect soil of an erodible nature by installing a headwall, concrete apron and/or rock protection at and/or downstream of the outlet. • Place a geotextile under rock protection where soils are highly mobile or terrain is steep.	• *Decision process for stormwater management in Western Australia* (DOW 2009a) • *Stormwater management manual for Western Australia* (DOW 2004–07) • *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)

Table 7 Criteria for subsoil drainage maintenance systems

Design consideration	Consideration need/question	Requirements	Further information
Maintenance access	Provide access for maintenance.	• Align groundwater drainage to coincide with other subsurface infrastructure within the road reserve to reduce installation costs. • Avoid placement within private property and especially under building envelopes. • Establish easements to provide long term maintenance access where drainage lines need to be located within private lots.	
Access inlets	Provide ability to maintain the system.	• Place access inlets at the head of all subsoil drainage lines and at 60 metre spacings until the outlet is reached or at abrupt changes of grade and alignment. • Locate access inlets so they remain accessible post-development. • Include watertight caps on access inlets.	• *Subsoil drainage – detailed design* (Main Roads WA 2011) • *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)
Outlets	Reduce risk of sedimentation and blockages.	• Protect exposed/visible subsoil drainage outlets with a wire plug/netting. • Ensure the last 6 m of pipe is rigid with no slots and of sufficient strength to withstand maintenance vehicle loadings.	• *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)
Imported fill material	Ensure imported fill material meets specified criteria.	• Test imported fill before delivery to site to ensure filter specification criteria used in the drainage system design are met.	

Table 8 Criteria for subsoil drainage maintenance plan

Design consideration	Consideration need/question	Requirements	Further information
Post construction	Prove the system operates effectively and is free of sediments.	• Flush drainage lines immediately after construction.	• *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)
Maintenance period	Prove the system continues to operate effectively.	• Retain or install strategically placed groundwater observation bores to allow post-development monitoring. • Monitor mobilised groundwater when treatment of discharged groundwater is required. • Inspect infrastructure access inlets and outlets.	• *Water monitoring guidelines for better urban water management strategies/plans* (DoW 2012) • *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)
Pre-handover inspections	Prove the system operates effectively and is free of sediments.	• Review post-development monitoring data to prove: – groundwater is being managed as proposed – treatment of mobilised groundwater is effective. • Inspect system outlets for: – signs of erosion – outlet blockage (due to vegetation or silt accumulation) – mobilisation of pollutants (discolouration) – nuisance insect build up. • Do a flush test to ensure the system is operating effectively.	• *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)

Design consideration	Consideration need/question	Requirements	Further information
Ongoing maintenance	Ensure the system remains effective.	• Prepare a maintenance plan to include in the local government asset register. The plan should cover: – roles and responsibilities – frequency of inspections of access inlets and outlets – frequency of clearing of vegetation and silt accumulation from outlets – frequency of testing of subsoil drainage to check for blockages – frequency of monitoring observation bores and discharge groundwater treatment systems – methods for managing blockages. It is recommended to use rodding and flushing, starting from the inspection access inlet closest to the blockage and working upstream (specify that high pressure jetting is not recommended due to risk of opening joints).	• *Guide to pavement technology part 10: subsurface drainage* (Austroads 2009)

5 Information required at each stage of the planning process

The following tables summarise the timing and level of information required for assessing the need for and setting a CGL[1] to be presented in the urban water management reports as specified by *Better urban water management* (WAPC 2008), as identified in Figure 2. A flexible approach is required at each planning stage and the level of detail required will vary based on the risks associated with the proposed development, associated infrastructure and local and regional water resources.

If the water management report(s) required at the previous land use planning stage(s) has/have not been completed, the information to support the former stage(s) needs/need to be collated and considered as part of the current planning stage.

Table 9 Regional water management strategy

Planning question	Engineering consideration	Information requirements for the assessment and design of groundwater management
What are likely areas for land use change in the future that impact the use and management of water resources?	Issues	Additional investigations into the need for groundwater management will not be required to support this planning decision, as sufficient information should exist in studies undertaken by relevant state government agencies. Where additional information is required this will be identified for future studies in later planning stages.

Table 10 District water management strategy

Planning question	Engineering consideration	Information requirements for the assessment and design of groundwater management
Is this area capable of supporting urban development and, if so, what areas are required for water management?	Capability	The following information must be presented to prove the land is capable of supporting the proposed land use change: • A review of recommendations and requirements in existing management plans • Preliminary assessment of the groundwater regime based on available regional and local data to identify if groundwater management is required* • Initial assessment of the pre-development landform and the constraints this may present to viable groundwater management options* • Preliminary assessment of whether groundwater management is required

* *Sufficient information is required to enable an informed planning decision on whether the land is capable of supporting the proposed land use change. Where a significant portion of the land is constrained by environmental assets, seasonally high groundwater, inundation and/or low relief more detailed monitoring and analysis to prove capability may be required.*

[1] The Department of Water has produced guidelines for the preparation and assessment of urban water management reports which cover the detail required for other water management aspects. These are available on our website <www.water.wa.gov.au → Managing water → Water and land use planning>.

Table 11 Local water management strategy

Planning question	Engineering consideration	Information requirements for the assessment and design of groundwater management
How will the proposed urban form address water use and management?	Proof of concept	If the preliminary assessment of the groundwater regime indicates the site, or portions thereof, to be constrained by groundwater, detail to support option A or B must be presented: Option A consists of a more detailed assessment of the groundwater regime to prove that groundwater management is not required and is to be supported by: • Seasonal groundwater level and quality variations from on-site monitoring • Correlation of short-term regimes identified from on-site monitoring with available long-term data • Consideration of post-development impacts on groundwater regime due to: – decreased evapotranspiration from clearing of pre-development vegetation – increased recharge due to infiltration of increased runoff from impervious areas – groundwater rising into imported fill – climate change (e.g. rainfall and sea levels) Option B consists of applying groundwater management and providing a detailed assessment to appropriately set the CGL. Option B requires: • An understanding of catchment features and constraints including: – catchment plans and requirements – water-dependent ecosystems and accurate foreshore areas and buffers – hydrology including natural drainage and inundation • Details of the proposed outlet location including: – interaction with existing infrastructure – ensuring land is available for treatment – proving the outlet will be free flowing • Investigation of physical factors that limit the CGL including: – interaction with existing infrastructure – insitu soil conditions – risk of clogging due to contaminants – potential of acidic discharge – identifying contaminated site • Investigation of resource factors that limit the CGL including: – preventing or managing the release of nutrients – ensuring groundwater remains available for WDEs – maintaining the physical health of WDEs – protecting adjacent land uses that rely on groundwater – preserving proclaimed groundwater resources

Table 12 Urban water management plan

Planning question	Engineering consideration	Information requirements specifically for the assessment and design of subsoil drainage
How will the final urban form use and manage water?	Final design	When groundwater management is required the following information must be presented: • Details of discharge set-up including treatment systems for discharged groundwater and management of mosquito and midge risk • Plans showing pre- and post-development topography and groundwater contours • Plans showing subsoil and open channel groundwater drainage alignments, spacing, inverts, size, grade, access inlets and outlets • Maintenance, monitoring and responsibility plan

Shortened forms

ANZECC	Australian and New Zealand Environment and Conservation Council
CGL	controlled groundwater level
DoW	Department of Water
EPA	Environmental Protection Authority
SRT	Swan River Trust
WAPC	Western Australian Planning Commission
WDE	water-dependent ecosystem

Glossary

Acid sulfate soils (ASS)	The common name given to soils and sediments containing iron sulfides, the most common being pyrite. When exposed to air following drainage or disturbance, these soils produce sulfuric acid, often releasing toxic quantities of iron, aluminium and heavy metals.
Baseflow level	The at-rest or steady state level of a waterbody between rainfall events.
Wetland buffer	An interface adjoining a wetland designated to assist in protecting the wetland's natural values from the threats posed by surrounding land use(s) or an area endorsed by the Department of Environment and Conservation.
Climate change	Changes in climate (such as temperature, precipitation, wind) that differ significantly from previous average conditions and are seen to endure, bringing about corresponding changes in ecosystems and socioeconomic activity.
Controlled groundwater level (CGL)	The invert level of a groundwater management conduit such as a drain or channel in metres Australian Height Datum.
Ecological water requirement	The water regime needed to maintain ecological values of water-dependent ecosystems at a low level of risk. A water regime is a prevailing pattern of water flow over a given time – the components of which include depth, rate of rise and duration.
Evapotranspiration	The combined loss of water by evaporation and transpiration. It includes water evaporated from the soil surface and water transpired by plants.
Foreshore areas	The land that adjoins or directly influences a waterway. It is the area of transition between the edge of the waterway and the furthest extent of riparian vegetation, the floodplain and riverine landforms, or a negotiated area endorsed by the Department of Water.
Groundwater	Water that occupies the pores and crevices of rock or soil beneath the land surface. Specifically for this document this relates to unconfined shallow groundwater that may be encountered during, or adversely affected by, urban development.
Invert level	The level of the lowest portion at any given section of a conduit, such as a drain or channel.

Land development proponent	The person or organisation initiating a change in land use, subdivision or development activity. In the land planning process, this is the initiator of the planning proposal. For other approval processes, it is the initiator of the application or development proposal.
Subsoil drainage	Artificial piped system that enables groundwater to flow out of the surrounding soil and away from the site.
Urban development	Change of land use to enable residential, commercial and industrial expansion (excluding heavy industrial).
Urban form	The physical layout and design of an urban area and the arrangement of land uses including density, street layout, transportation and service infrastructure, social requirements (e.g. public open space and recreation areas) and environmental considerations (e.g. retention of remnant native vegetation and considering the natural topography).
Water-dependent ecosystem (WDE)	Those parts of the environment where the species composition and natural ecological processes are determined by the permanent or temporary presence of water, including flowing or standing water and water within aquifers.
Water resources	Water in all states within the hydrologic cycle that has economic, environmental, social or cultural significance.
Water sensitive urban design (WSUD)	The philosophy of achieving better water resource management outcomes in an urban context by using an integrated approach to planning and incorporating total water cycle management objectives into the planning process. The key elements of this design include protection from flooding; management of water quantity and quality to achieve ecological objectives; and water conservation, efficiency and re-use.
Wellhead protection zones	A wellhead protection zone is usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination threats in the nearby area.

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