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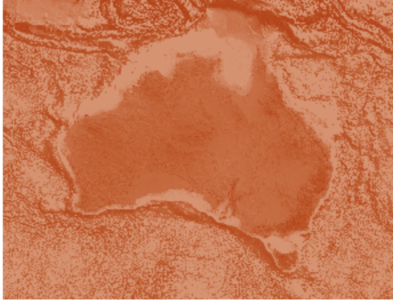

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A national-scale vulnerability assessment of seawater intrusion

Seawater intrusion vulnerability indexing – quantitative

Leanne K. Morgan, Adrian D. Werner, Hashim Carey

National Centre for Groundwater Research and Training
sustaining a vital water resource

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GEOSCIENCE AUSTRALIA
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Executive Summary

Fresh groundwater stored in Australian coastal aquifers constitutes an important resource for humans and the natural environment. However, many Australian coastal aquifers are vulnerable to seawater intrusion (SWI) – the landward encroachment of seawater into coastal aquifers. SWI can significantly degrade water quality and reduce freshwater availability. The increasing demands for freshwater in coastal areas and the anticipated impacts of climate change (such as sea-level rise and variations in rainfall recharge) may result in increases in the incidence and severity of SWI. Despite these threats, comprehensive investigations of SWI are relatively uncommon and the extent of monitoring and investigations specific to SWI are highly variable across the nation (Werner 2010).

In response to the threat posed by SWI, Geoscience Australia (GA) and the National Centre for Groundwater Research and Training (NCGRT), in collaboration with state and territory water agencies, have undertaken a national scale assessment of the vulnerability of coastal aquifers to SWI. This assessment aims to identify the coastal groundwater resources that are most vulnerable to SWI, including future consequences of over-extraction, sea-level rise, and recharge–discharge variations associated with climate change. The current study focuses on assessing the vulnerability of coastal aquifers, rather than that of surface waterbodies, to the landward migration of the freshwater–saltwater interface. Project funding was provided through the Raising National Water Standards program, which is administered by the National Water Commission.

In order to achieve the project aims, the study comprised five technical assessments to analyse factors contributing to the vulnerability of coastal aquifers: (i) vulnerability factor analysis (VFA); (ii) coastal aquifer typology; (iii) mathematical analysis; (iv) SWI quantitative and qualitative vulnerability indexing; and, (v) future land surface inundation and population growth analysis.

This report describes the SWI quantitative vulnerability indexing component of the project and should be considered as a complement to the report by Norman et al. (2012), which describes the qualitative indexing.

1. Introduction

The current project entitled “A national scale vulnerability assessment of seawater intrusion” has been completed by Geoscience Australia (GA) and the National Centre for Groundwater Research and Training (NCGRT) in collaboration with State and Territory agencies. The aim of this project is to identify Australian coastal groundwater resources currently vulnerable to seawater intrusion (SWI), and potentially at risk in the future as a consequence of over-extraction, sea-level rise and/or recharge-discharge variations associated with climate change.

The introduction to this report provides background information on SWI and provides a motivating context for the development of the project. In this chapter the concept of vulnerability is introduced; the aims and objectives of the project are listed; the quantitative vulnerability indexing methodology and application to 28 case study areas (CSAs) is also described.

The project has included five technical assessments in order to analyse factors contributing to the vulnerability of coastal aquifers: (i) vulnerability factor analysis (VFA); (ii) coastal aquifer typology; (iii) mathematical analysis; (iv) SWI quantitative and qualitative vulnerability indexing; and, (v) future land surface inundation and population growth analysis. This report addresses the quantitative vulnerability indexing component of the project. A summary of this report can be found in Chapter 4.5 of the project summary report (Ivkovic et al., 2012c).

1.1. Background to a National Scale Vulnerability Assessment of Seawater Intrusion

Fresh groundwater stored in Australian coastal aquifers is an important resource for the natural environment, as well as for urban, agricultural, rural residential and industrial activities. These aquifers may be vulnerable to seawater intrusion (SWI), which is the landward encroachment of seawater into fresh coastal aquifers. SWI can be caused by hydrologic changes, such as groundwater extraction, groundwater recharge variations, sea-level rise, or modifications to coastal surface water features. SWI poses a threat to the groundwater resources in all of Australia’s states and the Northern Territory. Yet despite this existing threat, comprehensive investigations of SWI are relatively uncommon and the extent of monitoring and investigations specific to SWI is highly variable across the nation (Werner, 2010). SWI investigation is a problematic and resource intensive business and the current scientific challenges of coastal aquifer management in Australia are as complex and diverse as the systems themselves.

The vulnerability of Australia’s coastal aquifers to SWI is not only an area of current concern but also an area of increasing future concern. The increasing demands for freshwater in coastal areas and the anticipated impacts of climate change, such as sea-level rise and variations in rainfall recharge, may result in increases in the incidence and severity of SWI. An assessment is needed to address the paucity of knowledge of SWI vulnerability at the national scale that considers the extensive and diverse aquifer systems of Australia’s coastal fringe (Werner, 2010). An improved awareness and understanding of the key drivers for SWI, the current and emerging SWI vulnerable areas and possible future trends in SWI, will benefit decision makers and groundwater stakeholders across local, state and national levels. Development of a consistent approach for the assessment of SWI vulnerability will assist national, state and regional planning and management strategies.

The national vulnerability assessment of SWI was developed to address the issues highlighted above. The broader project includes a number of technical reports focussing on various factors contributing to SWI vulnerability. The increased stresses being placed upon Australia's freshwater coastal aquifer systems and the reported threats of SWI within the states and the Northern Territory were strong motivating factors for development of the current project. It was funded by the National Water Commission under the Groundwater Action Plan, and implemented by Geoscience Australia and the National Centre for Groundwater Research and Training (NCGRT) in partnership with state and territory agencies. The project commenced in November 2009 and finished in May 2012.

1.2. Vulnerability Concept Clarification

The principal focus of this project is assessing the vulnerability of Australian coastal aquifers to SWI, and accordingly a discussion of the concept of vulnerability and its meaning are provided. Vulnerability has numerous definitions, conceptualisations and assessment methods in the literature found both across and within disciplines (Füssel, 2007). This project has utilised several vulnerability definitions that are appropriate for the multiple components of this national vulnerability assessment of SWI.

Füssel (2007) reviewed vulnerability definitions and found that four dimensions were fundamental to describe any vulnerable situation. These four dimensions included:

- The **System** undergoing analysis;
- The **Valued Attribute**(s) of the vulnerable (susceptible) system that is threatened by its exposure to a hazard;
- **Hazard**: A potentially damaging influence on the system of analysis; and
- **Temporal Reference**: The point in time or period of interest (current, future, number of years into future etc.).

Using these terms, this project can be described as an assessment of the vulnerability of Australian freshwater coastal aquifers (system and attribute of concern) to SWI as a consequence of over-extraction and sea-level rise and/or recharge-discharge variations associated with climate change (hazards) in the present, and future (temporal reference). This is consistent with the fact that SWI vulnerability is a function of the intrinsic characteristics of the aquifer and the management of the water balance in that aquifer.

The Intergovernmental Panel on Climate Change (IPCC) has defined vulnerability in the specific context of climate change as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change" (IPCC, 2007). Barnett et al. (2007), notes that "While there is no consensus on the best approach to vulnerability assessment, in general they entail considering one or more of: exposure to climate risks, susceptibility to damage, and capacity to recover". The essence of these definitions is captured by (Voice et al., 2006) who states "vulnerability is a function of exposure, sensitivity and adaptive capacity".

By combining the above vulnerability definitions for the purposes of the current study, this report assesses the system of aquifer SWI vulnerability as a function of:

- Exposure to hazards (SWI as a result of groundwater extraction and climate change);

- Sensitivity of the system (coastal aquifers) for attribute of concern (position of the freshwater-seawater interface);
- Time (current and future vulnerability); and,
- Adaptive capacity (monitoring and management specific to SWI).

1.3. Project Aim and Objectives

The aim of 'A national scale vulnerability assessment of seawater intrusion' is to undertake a national assessment of coastal groundwater resources currently vulnerable to SWI, and potentially vulnerable in the future, as a consequence of over-extraction, sea-level rise and recharge-discharge variations associated with climate change.

The project has three principal objectives:

Objective 1: Provide a baseline assessment of the current status and knowledge of SWI around Australia

Objective 2: Provide conceptualisations and assessments of a range of factors contributing to the SWI vulnerability of Australian coastal aquifers, including the influences of over-extraction, sea-level rise and recharge-discharge variations associated with climate change

Objective 3: Provide an integrated assessment of the vulnerability of coastal aquifers in Australia to SWI.

The methodologies employed to meet the above objectives are outlined below.

1.4. Project Methodology

In order meet the project objectives and to achieve a national scale assessment of aquifer vulnerability to SWI for current and future scenarios, the project adopted a methodology comprising four work phases. These are:

Phase 1: Literature and data reviews to provide a baseline assessment of the state of SWI investigations in Australia and informed the development of the project methodology (Ivkovic et al., 2012a).

Phase 2: Five technical assessment components to analyse key factors contributing to the overall vulnerability of coastal aquifers to SWI. The five technical assessments included:

Vulnerability Factor Analysis (Cook et al., 2012)

Coastal Aquifer Typology (Ivkovic et al., 2012b)

Mathematical Analysis (Morgan et al., 2012b)

Quantitative and Qualitative Indexing (Morgan and Werner (2012) and Norman et al. (2012) respectively)

Future land surface inundation and population growth analysis (contained within the Ivkovic et al. (2012c) project summary report)

Phase 3: The five technical components in phase 2 are integrated to provide an overall SWI vulnerability assessment (Marshall et al., 2012)

Phase 4: A national summary of SWI vulnerability (Ivkovic et al., 2012c) provides an overview of the project findings.

The following general approaches to analysis were adopted throughout this project:

1. SWI vulnerability analysis was restricted to areas within 15 kilometres of the coast, including a limited selection of off-shore islands; areas further than 15 kilometres inland were not considered likely to be vulnerable to SWI.
2. The areas of interest for detailed analysis within the CSAs are those where the groundwater management units or equivalent groundwater management areas intersect the 15 kilometre buffer zone and are connected to the coast.
3. The project focus is on SWI of coastal aquifer systems and there is limited emphasis on investigating the impacts of inundation to coastal environments and communities (human, ecological, infrastructure etc.).
4. Surface water processes are not specifically considered in any detail.
5. The project has been restricted to the synthesis, analysis and interpretation of existing data and there has not been any new field data collection, local mapping or drilling.

1.5. Quantitative Indexing Aims and Objectives

The Vulnerability Indexing methodology involves vulnerability ratings and weightings to combine both theoretical and subjective elements associated with SWI. As such, the indexing methodology is made up of two components: 1. Quantitative Indexing, which uses results from the Mathematical Analysis of case study areas, and 2. Qualitative Indexing, which uses results from the Coastal Aquifer Typology and Vulnerability Factor Analysis. This document describes the Quantitative Indexing methodology, as well as its application to 28 case study areas. The Qualitative Indexing methodology has been described in Norman et al. (2012), and includes application to the same case study areas. The indexing approach developed as part of the NSWI project improves on existing methods through the use of theoretically robust quantitative factors as well as a range of qualitative factors, which are able to capture various SWI vulnerability complexities, not captured by the Mathematical Analysis.

Existing indexing methods used to characterise SWI vulnerability, such as GALDIT (Lobo-Ferreira et al. 2007) and CVI (Ozyurt, 2007), apply a range of SWI vulnerability indicators that are presumed to control SWI. The GALDIT approach, for example, considers aquifer type, distance from the coast, hydraulic conductivity, groundwater level, previous occurrence of SWI and aquifer thickness. While the simplicity of these methods makes them useful for large-scale SWI vulnerability assessments, they lack a theoretical basis because only subjective elements associated with SWI are considered. Also, aquifer fluxes are not accounted for, and SWI vulnerability arising from changes in sea-level, recharge or extraction is not captured directly, if at all.

The Mathematical Analysis methodology is based on the commonly applied approach to the rapid assessment of SWI in coastal aquifers. That approach involves a steady state, sharp-interface approximation to the freshwater-saltwater transition zone, combined with the Ghyben-Herzberg relation. While the Mathematical Analysis methodology relies heavily on the theory developed by Strack (1976), there are mathematical extensions to Strack's (1976) analytical solutions that have been devised specifically for the purposes of the current project. A detailed description of the method can be found in Werner et al. (2012) as well as this project's Milestone 5 Report (Morgan et al., 2012). Mathematical analyses of 28 case study areas have been completed as part of the NSWI project, with unconfined, confined and freshwater lens systems considered. Results from these analyses are reported in Morgan et al. (2012) and are used for the quantitative SWI vulnerability indexing described in this document.

2. Method

The Quantitative SWI Vulnerability Indexing employs a matrix-style approach to systematically categorise the SWI vulnerability of selected case study areas. The mathematical analysis considered unconfined aquifers, confined aquifers and freshwater lens systems. Separate indexing matrices were developed for each of these aquifer systems. The range of potential indexing scores is consistent across the different indexing matrices, allowing for comparison between the different systems.

The factors used for each of the unconfined, confined and freshwater lens system indexing matrices are taken directly from results of the Mathematical Analysis. The Mathematical Analysis results that were used included: a) the calculated theoretical steady-state extent of SWI under current conditions (i.e., scaled wedge toe (unconfined aquifers), wedge toe (confined aquifers), and maximum freshwater thickness (freshwater lenses)), b) the location of the wedge toe relative to extraction bores (for unconfined and confined aquifers), and c) the propensity for change in SWI extent under future stresses (sea-level rise, recharge change and changes in flows at the inland boundary, as might occur under increased extraction). Morgan et al. (2012) provide further details of the Mathematical Analysis results and the key tables of results are provided in Appendix B of this document.

Ratings for each factor were characterised by subdividing possible values (determined using results for all case studies considered in the Mathematical Analysis) into classes. The different classes are given a rating score. The rating is used to determine the relative significance of the factor on SWI at each site.

Weightings assigned to each factor are a fixed value, which represent the (subjectively determined) relative importance of the factor in terms of SWI vulnerability. Here, the selection of weightings was also guided by the need to have consistent minimum and maximum indexing scores across the different indexing matrices. The minimum indexing score is 5 and the maximum indexing score is 50. An indexing score is obtained by summing the product of the rating and weighting for each factor. A large indexing score is presumed to indicate high vulnerability.

2.1. Unconfined Aquifers

The indexing matrix developed for unconfined aquifers is shown in Table 1.

Table 1. *Indexing matrix for unconfined aquifers*

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

$$\textbf{Score} = \sum_{\text{factors}} \textbf{weighting} \times \textbf{rating}$$

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

2.2. Confined Aquifers

The indexing matrix developed for confined aquifers is shown in Table 2.

Table 2. *Indexing matrix for confined aquifers*

	Inland extent of wedge toe, x_T	**Wedge toe relative to extraction bores** [1]	**Propensity for change in SWI extent due to sea-level rise** [2]	**Propensity for change in SWI extent due to change in flows at the inland boundary** [2]
Weighting → Rating ↓	2	1	1	1
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

$$\textbf{Score} = \sum_{\text{factors}} \textbf{weighting} \times \textbf{rating}$$

[1] This is the ratio of toe location to distance of extraction bores from the coast

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

2.3. Freshwater Lens Systems

The indexing matrix developed for freshwater lenses is shown in Table 3.

Table 3. *Indexing matrix for freshwater lenses*

	Maximum freshwater thickness, h_{max} (m)	**Propensity for change in SWI extent due to recharge change** [1]
Weighting → Rating ↓	**3**	**2**
1	$h_{max} > 100$ m	In lowest quarter of ranked results
2		
3		
4	$100 \text{ m} \geq h_{max} \geq 50$ m	In lower-mid quarter of ranked results
5		
6		
7	$50 \text{ m} > h_{max} > 20$ m	In upper-mid quarter of ranked results
8		
9		
10	$h_{max} \leq 20$ m	In highest quarter of ranked results

$$\textbf{Score} = \sum_{\text{factors}} \textbf{weighting} \times \textbf{rating}$$

[1] Derivatives for all lens systems that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

3. Limitations

The Quantitative Indexing used outputs from the Mathematical Analysis and, as such, is subject to the limitations of the Mathematical Analysis, as reported by Morgan et al. (2012). These limitations arise from the simplification of the conceptual system and the assumptions inherent in the analytical models. These include assumptions of steady-state conditions, a sharp interface, homogeneous aquifer properties and uniform hydrologic stresses. It has also been assumed that all aquifers discharge at the coast. Further, wells are not directly simulated and tidal impacts are not accounted for.

It is also important to consider that the effectiveness of the Mathematical Analysis is heavily reliant on the conceptualisation of the coastal system as well as the availability of data for parameterisation. In this regard, a challenge for the project was the development of conceptual models for a large number of case study areas, in such a way that the key parameters for SWI vulnerability are discernible. That is, the Mathematical Approach was heavily dependent on parameters obtained from aquifer characterisation assessments.

In light of the limitations listed above, it is important to appreciate that the Quantitative Indexing is complemented by the Qualitative Indexing, as described by Norman et al. (2012). The Qualitative Indexing considers subjective elements associated with SWI vulnerability, not accounted for by the Mathematical Analysis. Ranking of aquifers and case study areas using both the Quantitative and Qualitative Indexing will be used to inform the final assessment of vulnerability, which will consider all project components.

Additional limitations arise from the need to develop separate indexing matrices for unconfined, confined and freshwater lens systems, because the Mathematical Analysis produced different outputs for these systems. The ability of the indexing matrices to effectively compare the potential vulnerability of the different systems requires further detailed assessment.

4. Results

The Quantitative Indexing was applied to 28 case study areas, shown in Figure 1. The resulting indexing matrices are provided in this section and a summary of the indexing results is provided at the end of this section. Maps showing the location of case study areas, as well as extraction bore locations are provided in Appendix A. Please refer to the Milestone 5 Math Analysis report (Morgan et al., 2012) for values used to determine the ratings for the different factors for each aquifer.

Figure 1. *Indexed case study areas*

4.1. Uley South, Eyre Peninsula, South Australia

4.1.1. Bridgewater Formation - Unconfined aquifer

	Scaled wedge toe, x_T'	**Wedge toe relative to extraction bores** [1]	**Propensity for change in SWI extent due to sea-level rise** [2]	**Propensity for change in SWI extent due to recharge change** [2]	**Propensity for change in SWI extent due to change in flows at the inland boundary** [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 25

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.1.2. Wanilla Sands - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 10

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.2. Willunga, South Australia

4.2.1. Quarternary - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 25

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.2.2. Port Willunga Formation - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 35

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.2.3. Maslin Sands - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.3. Port Macdonnell

4.3.1. Tertiary Limestone - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 47

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.3.2. Tertiary Sands - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 20

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.4. Le Fevre

4.4.1. Semaphore Sands - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 16

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.4.2. T1 - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.4.3. T2 - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.5. Adelaide Metropolitan, South Australia

4.5.1. T1 - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.5.2. T2 - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.6. Werribee, Victoria

4.6.1. Alluvium/Fractured rock - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 20

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.7. Point Nepean, Victoria

4.7.1. Freshwater lens system

Weighting → Rating ↓	**Maximum freshwater thickness, h_{max} (m)**	**Propensity for change in SWI extent due to recharge change** [1]
	3	**2**
1	h_{max} > 100 m	In lowest quarter of ranked results
2		
3		
4	100 m ≥ h_{max} ≥ 50 m	In lower-mid quarter of ranked results
5		
6		
7	50 m > h_{max} > 20 m	In upper-mid quarter of ranked results
8		
9		
10	h_{max} ≤ 20 m	In highest quarter of ranked results

Score = 26

[1] Derivatives for all lens systems that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating.

4.8. Bowen, Queensland

4.8.1. Unconfined aquifer

	Scaled wedge toe, x_T'	**Wedge toe relative to extraction bores [1]**	**Propensity for change in SWI extent due to sea-level rise [2]**	**Propensity for change in SWI extent due to recharge change [2]**	**Propensity for change in SWI extent due to change in flows at the inland boundary [2]**
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 30

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.9. North Stradbroke Island (East & West), Queensland

4.9.1. Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 10

[1] This is the ratio of toe location to distance of extraction bores from the coast. Extraction bore locations not available for this site however and therefore average rating applied.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.10. Pioneer Valley

4.10.1. Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	1	1	1	1	1
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 16

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.11. Burdekin, Queensland

4.11.1. Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	1	1	1	1	1
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.12. Burnett (Moore Park) Queensland

4.12.1. Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 36

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.13. Burnett (Bargara) Queensland

4.13.1. Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 16

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.14. Perth (Whitfords) Western Australia

4.14.1. Superficial - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 31

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.14.2. Leederville - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 32

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.14.3. Yarragadee - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 32

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.15. Perth (Cottesloe), Western Australia

4.15.1. Freshwater lens system

	Maximum freshwater thickness, h_{max} (m)	Propensity for change in SWI extent due to recharge change [1]
Weighting → Rating ↓	**3**	**2**
1	h_{max} > 100 m	In lowest quarter of ranked results
2		
3		
4	100 m ≥ h_{max} ≥ 50 m	In lower-mid quarter of ranked results
5		
6		
7	50 m > h_{max} > 20 m	In upper-mid quarter of ranked results
8		
9		
10	h_{max} ≤ 20 m	In highest quarter of ranked results

Score = 38

[1] Derivatives for all lens systems that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating.

4.16. Rottnest Island, Western Australia

4.16.1. Freshwater lens system

	Maximum freshwater thickness, h_{max} (m)	Propensity for change in SWI extent due to recharge change [1]
Weighting → Rating ↓	**3**	**2**
1	h_{max} > 100 m	In lowest quarter of ranked results
2		
3		
4	100 m ≥ h_{max} ≥ 50 m	In lower-mid quarter of ranked results
5		
6		
7	50 m > h_{max} > 20 m	In upper-mid quarter of ranked results
8		
9		
10	h_{max} ≤ 20 m	In highest quarter of ranked results

Score = 38

[1] Derivatives for all lens systems that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating.

4.16.2. Esperance, Western Australia

4.16.3. Superficial/Pallinup – Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 43

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.16.4. Werillup - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.17. Albany (Ocean Side), Western Australia

4.17.1. Werillup Formation Sand – Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 7

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.18. Albany (Harbour Side), Western Australia

4.18.1. Superficial – Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 7

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.18.2. Pallinup/Werillup - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 7

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.19. Busselton, Western Australia

4.19.1. Superficial – Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 13

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.19.2. Leederville - Confined aquifer

Weighting → Rating ↓	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
	2	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 10

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.20. Bunbury, Western Australia

4.20.1. Superficial – Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 16

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.20.2. Yarragadee - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 38

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.21. Carnarvon, Western Australia

4.21.1. River bed sand – Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 25

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.21.2. Alluvium - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 29

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.22. Exmouth (Cape Range), Western Australia

4.22.1. Cape Range Group – Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.22.2. Cape Range Group – Freshwater Lens

	Maximum freshwater thickness, h_{max} (m)	Propensity for change in SWI extent due to recharge change [1]
Weighting → Rating ↓	**3**	**2**
1	h_{max} > 100 m	In lowest quarter of ranked results
2		
3		
4	100 m ≥ h_{max} ≥ 50 m	In lower-mid quarter of ranked results
5		
6		
7	50 m > h_{max} > 20 m	In upper-mid quarter of ranked results
8		
9		
10	h_{max} ≤ 20 m	In highest quarter of ranked results

Score = 41

[1] Derivatives for all lens systems that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating.

4.23. Broome (Coconut Wells & Cable Beach), Western Australia

4.23.1. Broome Sandstone - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 47

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.24. Derby, Western Australia

4.24.1. Wallal/Erskine Sandstone - Unconfined aquifer

	Scaled wedge toe, x_T'	**Wedge toe relative to extraction bores [1]**	**Propensity for change in SWI extent due to sea-level rise [2]**	**Propensity for change in SWI extent due to recharge change [2]**	**Propensity for change in SWI extent due to change in flows at the inland boundary [2]**
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 50

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.25. Botany Sands, New South Wales

4.25.1. Botany Sand Beds - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 28

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.26. Stuarts Point, New South Wales

4.26.1. Coastal Sands - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \leq x_T' \leq 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 10

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.27. Hat Head, New South Wales

4.27.1. Coastal Sands - Unconfined aquifer

	Scaled wedge toe, x_T'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 13

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.28. Stockton, New South Wales

4.28.1. Stockton Sand Beds - Unconfined aquifer

	Scaled wedge toe, xT'	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to recharge change [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**1**	**1**	**1**	**1**	**1**
1	$x_T' < 0.05$	0	In lowest quarter of ranked results	In lowest quarter of ranked results	In lowest quarter of ranked results
2					
3		0 to 0.25			
4	$0.05 \le x_T' \le 0.1$		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5					
6		0.25 to 0.5			
7	$0.1 < x_T' < 1$		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75			
9					
10	$x_T' = 1$	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results	In highest quarter of ranked results

Score = 16

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all unconfined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

4.29. Howard Springs, Northern Territory

4.29.1. Koolpinyah/Coomalie dolomite - Confined aquifer

	Inland extent of wedge toe, x_T	Wedge toe relative to extraction bores [1]	Propensity for change in SWI extent due to sea-level rise [2]	Propensity for change in SWI extent due to change in flows at the inland boundary [2]
Weighting → Rating ↓	**2**	**1**	**1**	**1**
1	$x_T < 2$ km	0	In lowest quarter of ranked results	In lowest quarter of ranked results
2				
3		0 to 0.25		
4	2 km ≤ x_T ≤ 10 km		In lower-mid quarter of ranked results	In lower-mid quarter of ranked results
5				
6		0.25 to 0.5		
7	$x_T > 10$ km		In upper-mid quarter of ranked results	In upper-mid quarter of ranked results
8		0.5 to 0.75		
9				
10	Unstable	≥0.75	In highest quarter of ranked results	In highest quarter of ranked results

Score = 14

[1] This is the ratio of toe location to distance of extraction bores from the coast.

[2] Derivatives for all confined aquifers that were assessed as part of the Math Analysis component of the NSWI project were ranked by magnitude. The ranking is used to determine the rating in the above indexing table.

5. Results summary

The Quantitative Indexing in Section 4.0 was used to rank aquifers in the 28 case study areas. Results are shown in Table 1. The method outlined in this report was presented to stakeholders at a workshop on 26 March 2012 and comments and suggestions were considered and incorporated, where applicable. The 28 case study areas indexed within this report were also indexed using the Qualitative Indexing methods. The rankings were used to inform the final assessment of SWI vulnerability, which considered all project components, as outlined in the final project summary report (Ivkovic et al., 2012c).

Table 4. *Ranking of aquifers based on quantitative indexing results*

Case study area	Aquifer	Indexing score
Le Fevre, SA	T1 - Confined	50
Le Fevre, SA	T2 - Confined	50
Adelaide Metropolitan, SA	T1 - Confined	50
Adelaide Metropolitan, SA	T2 - Confined	50
Willunga, SA	Maslin Sands - Confined	50
Burdekin, QLD	Unconfined	50
Esperance, WA	Werillup - Confined	50
Exmouth, WA	Cape Range Group - Unconfined	50
Derby, WA	Wallal/ Erskine Sandstone - Unconfined	50
Broome (Coconut Wells and Cable Beach), WA	Broome Sandstone -Unconfined	47
Port MacDonnell, SA	Tertiary Limestone - Unconfined	47
Esperance, WA	Superficial/ Pallinup - Unconfined	43
Exmouth, WA	Cape Range Group – Freshwater lens	41
Perth (Cottesloe), WA	Freshwater lens	38
Rottnest Island, WA	Freshwater lens	38
Bunbury, WA	Yarragadee - Confined	38
Burnett (Moore Park), QLD	Unconfined	36
Willunga, SA	Port Willunga Formation - Confined	35
Perth (Whitford), WA	Yarragadee - Confined	32
Perth (Whitford), WA	Leederville - Confined	32
Perth (Whitford), WA	Superficial - Unconfined	31
Bowen, QLD	Unconfined	30
Carnarvon, WA	Alluvium - Confined	29
Botany Sands, NSW	Botany Sand Beds - Unconfined	28
Point Nepean, VIC	Freshwater lens	26
Carnarvon, WA	Riverbed Sand - Unconfined	25
Uley South, SA	Bridgewater Formation	25
Willunga, SA	Quarternary - Unconfined	25
Port MacDonnell, SA	Tertiary Sands - Confined	20
Werribee, VIC	Unconfined	20
Pioneer Valley, QLD	Unconfined	16
Le Fevre, SA	Semaphore Sands - Unconfined	16

Case study area	Aquifer	Indexing score
Burnett (Bargara), QLD	Unconfined	16
Bunbury, WA	Superficial - Unconfined	16
Stockton, NSW	Stockton Sand Beds - Unconfined	16
Howard Springs, NT	Koolpinyah/ Coomalie - Confined	14
Busselton, WA	Superficial - Unconfined	13
Hat Head, NSW	Coastal Sands - Unconfined	13
Busselton, WA	Leederville - Confined	10
Stuarts Point, NSW	Coastal Sands - Unconfined	10
North Stradbroke Island, QLD	Unconfined	10
Uley South, SA	Wanilla Sands	10
Albany (Ocean side), WA	Werillup Formation Sand - Unconfined	7
Albany (Harbour Side), WA	Superficial - Unconfined	7
Albany (Harbour Side), WA	Pallinup/ Werillup - Confined	7

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Appendix A. Case study area location maps

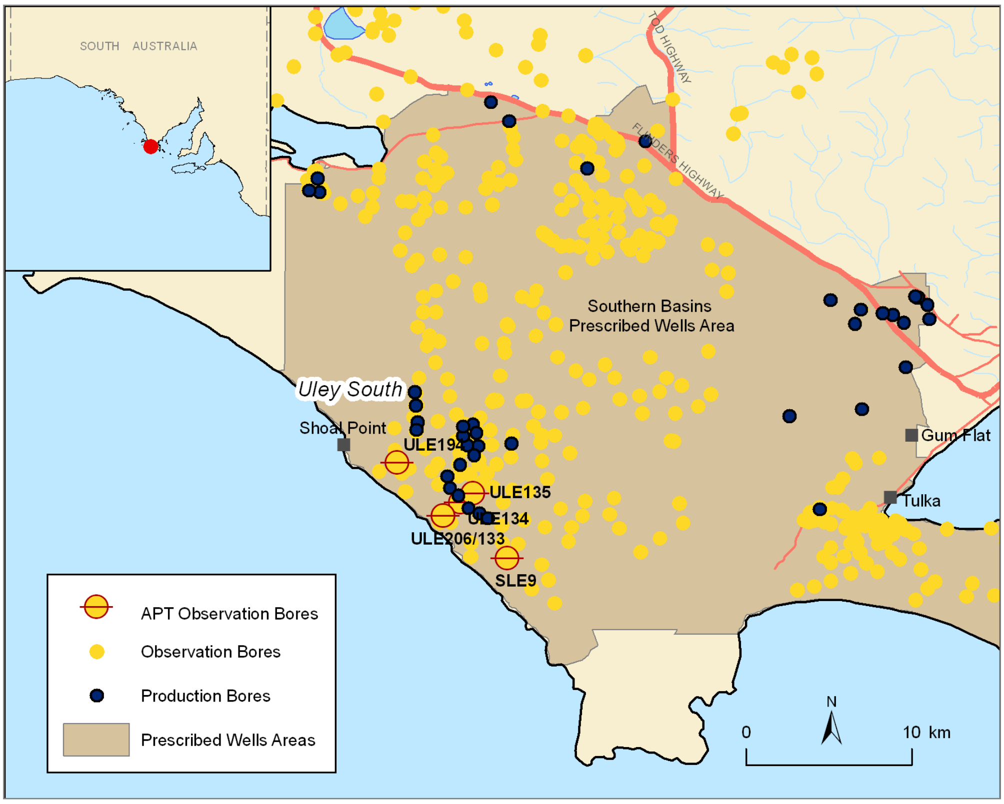

Figure 2. *Location map and associated features of the Uley South, SA case study area*

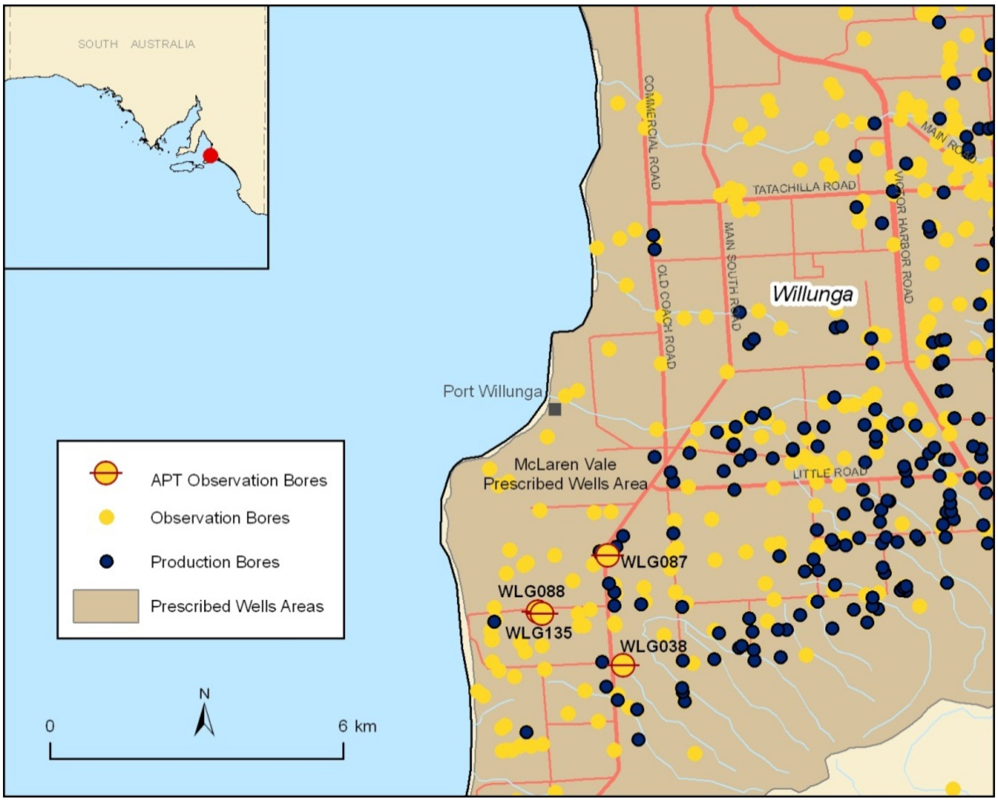

Figure 3. *Location map and associated features of the Willunga, SA case study area*

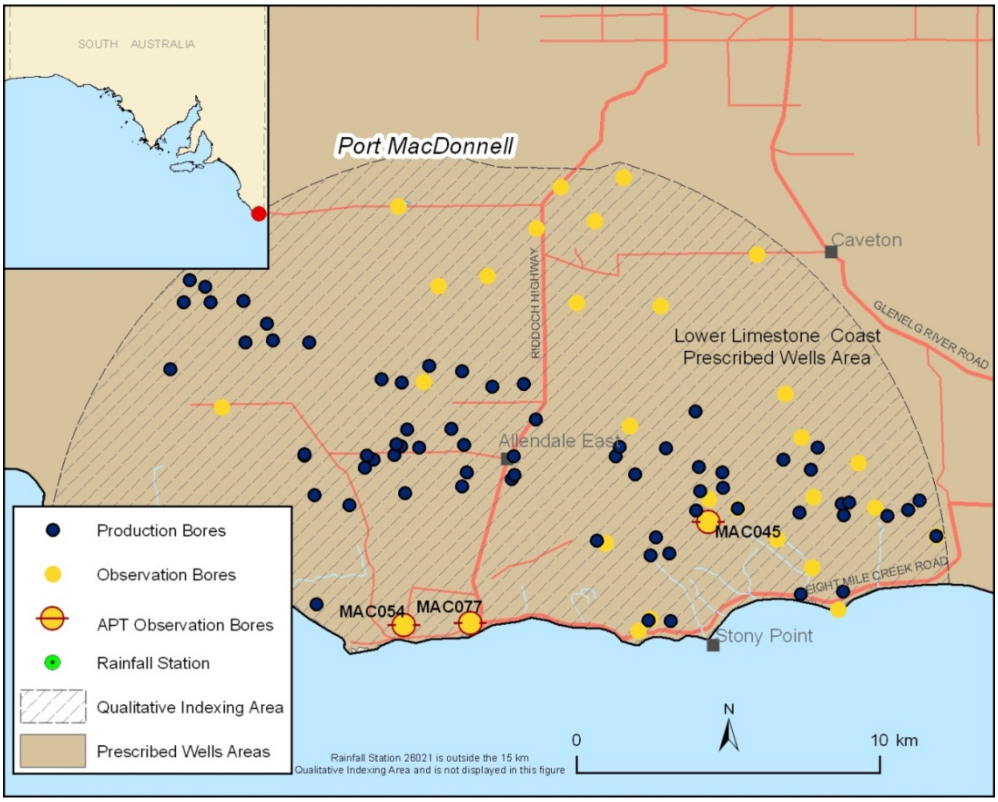

Figure 4. *Location map and associated features of the Port MacDonnell, SA case study area*

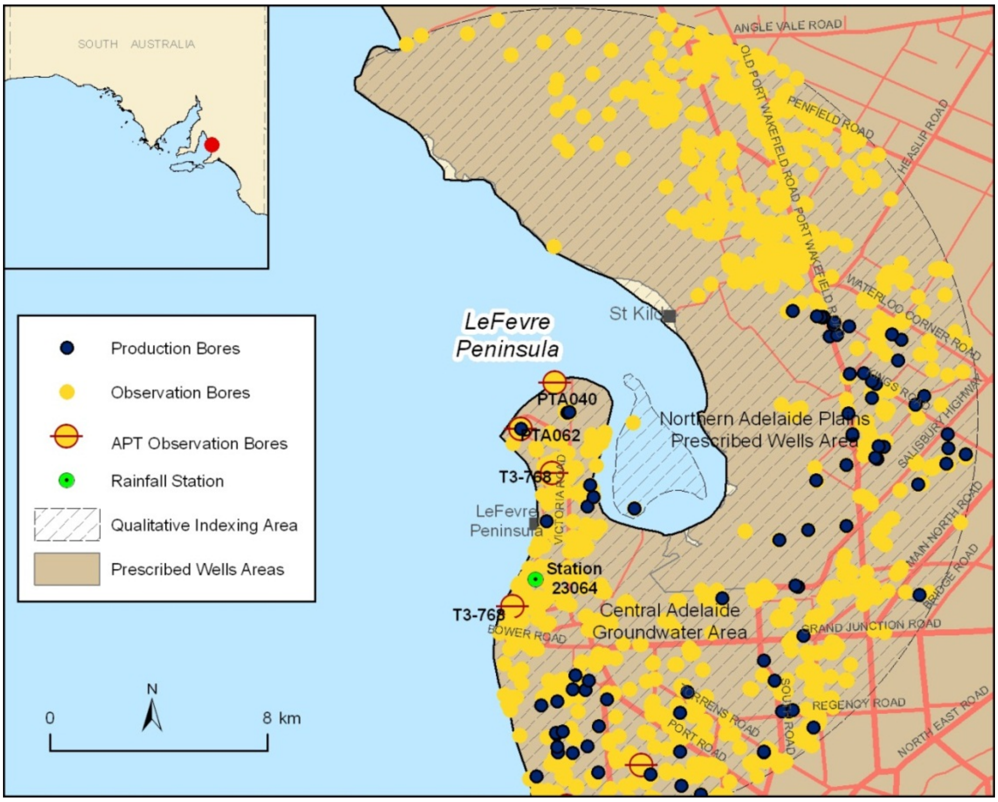

Figure 5. *Location map and associated features of the LeFevre, SA case study area*

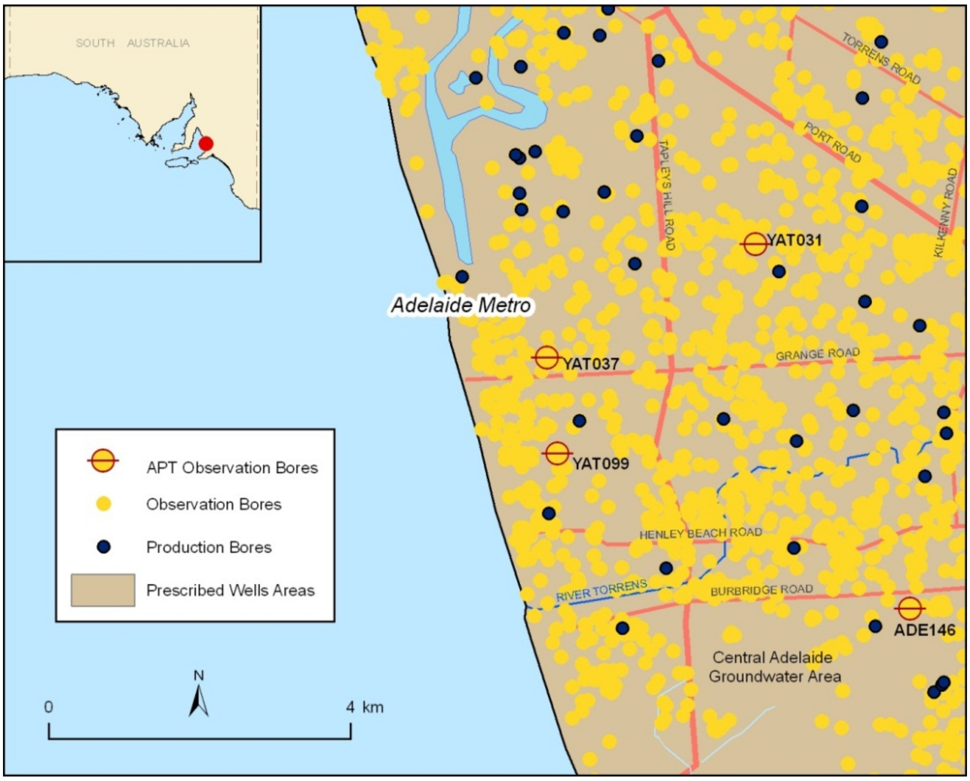

Figure 6. *Location map and associated features of the Adelaide Metropolitan, SA case study area*

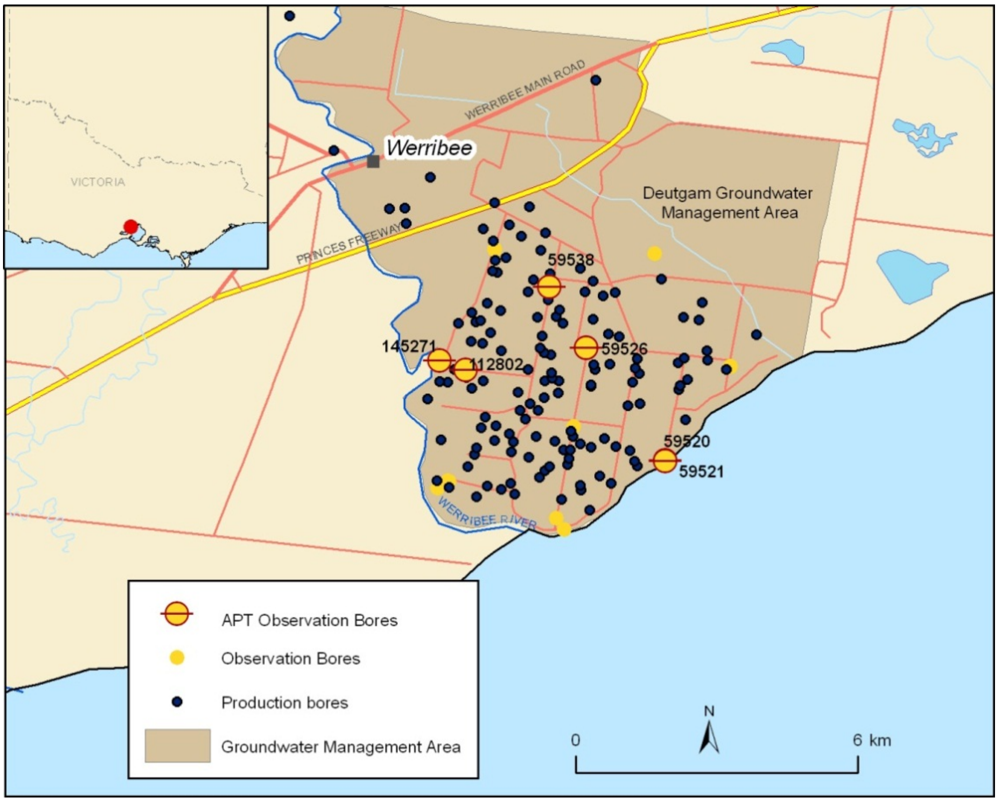

__Figure 7.__ Location map and associated features of the Werribee, VIC case study area

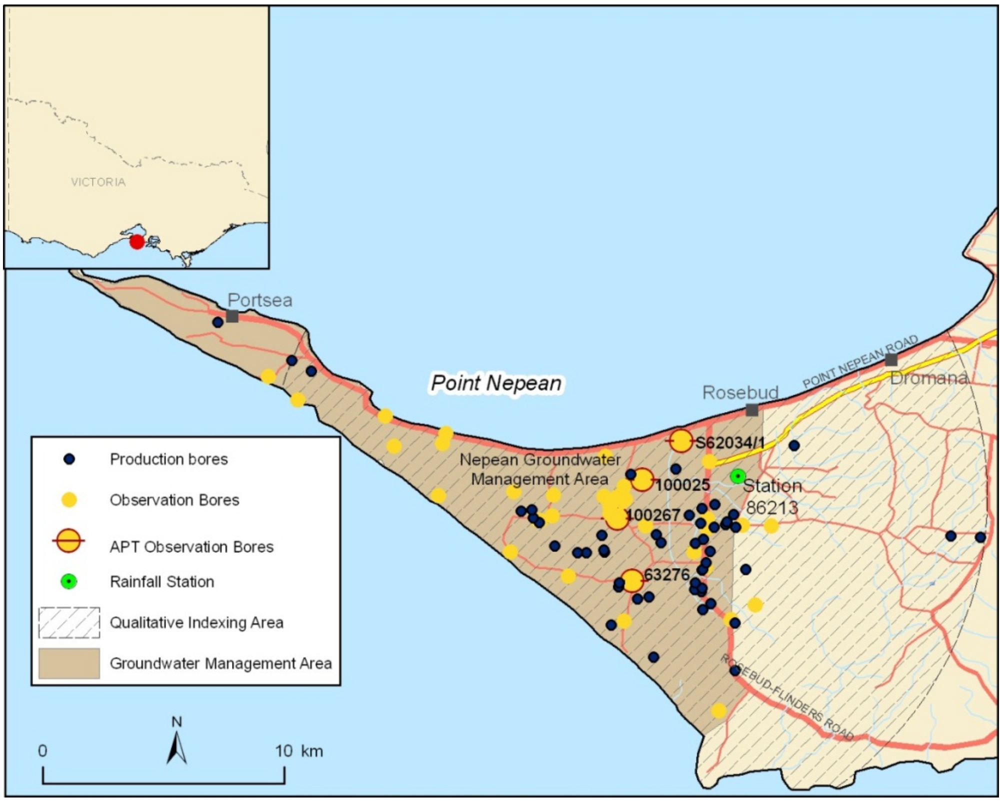

__Figure 8.__ Location map and associated features of the Point Nepean, VIC case study area

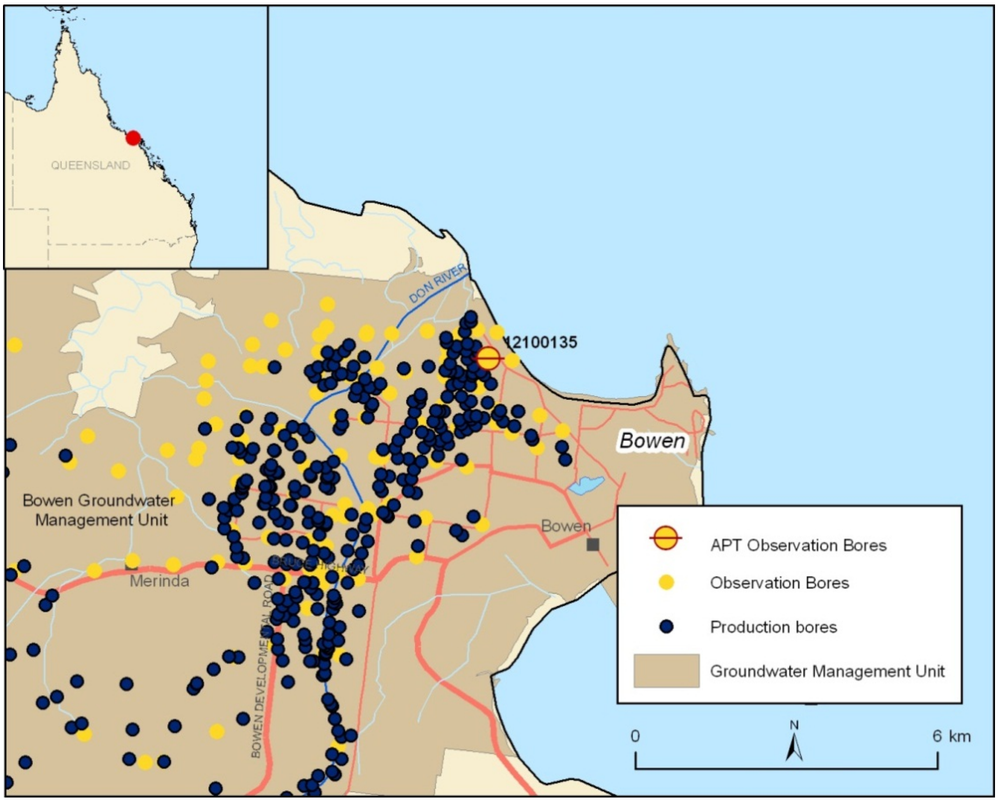

Figure 9. *Location map and associated features of the Bowen, QLD case study area*

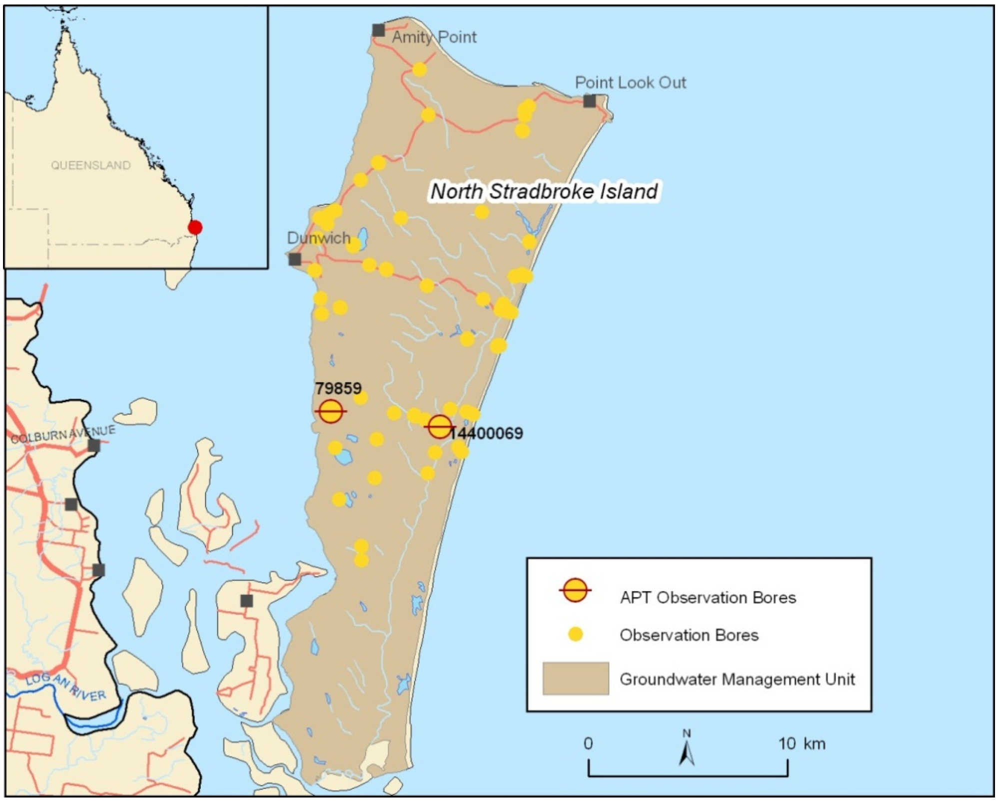

Figure 10. *Location map and associated features of the North Stradbroke Island, QLD case study area*

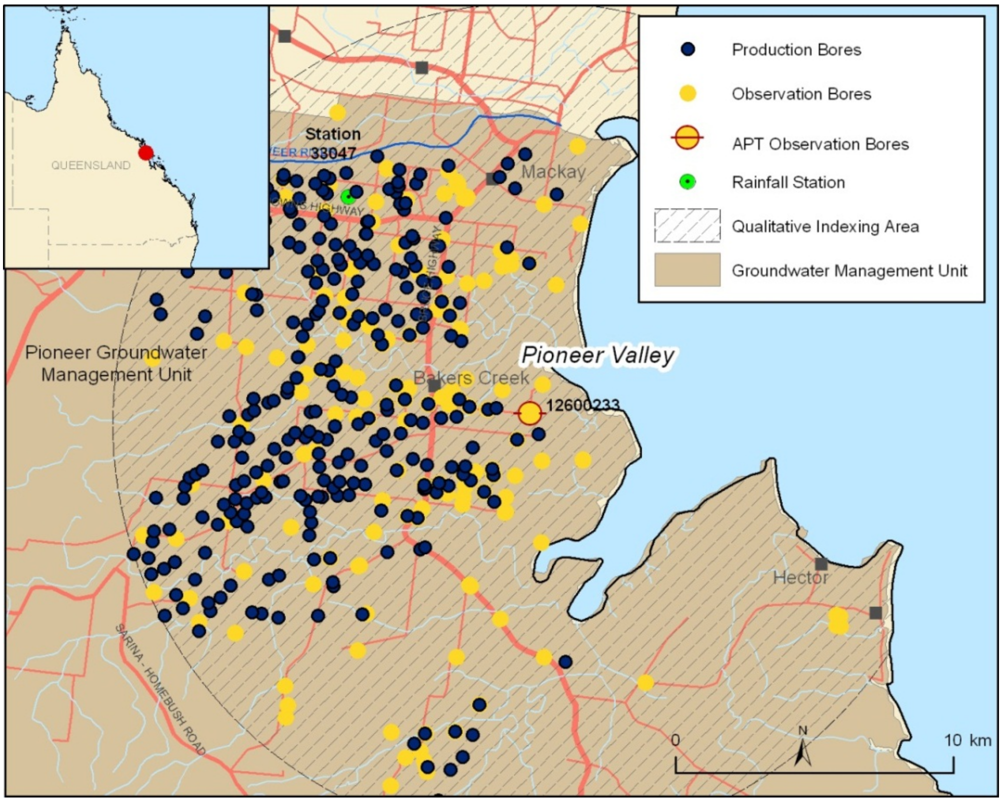

Figure 11. *Location map and associated features of the Pioneer Valley, QLD case study area*

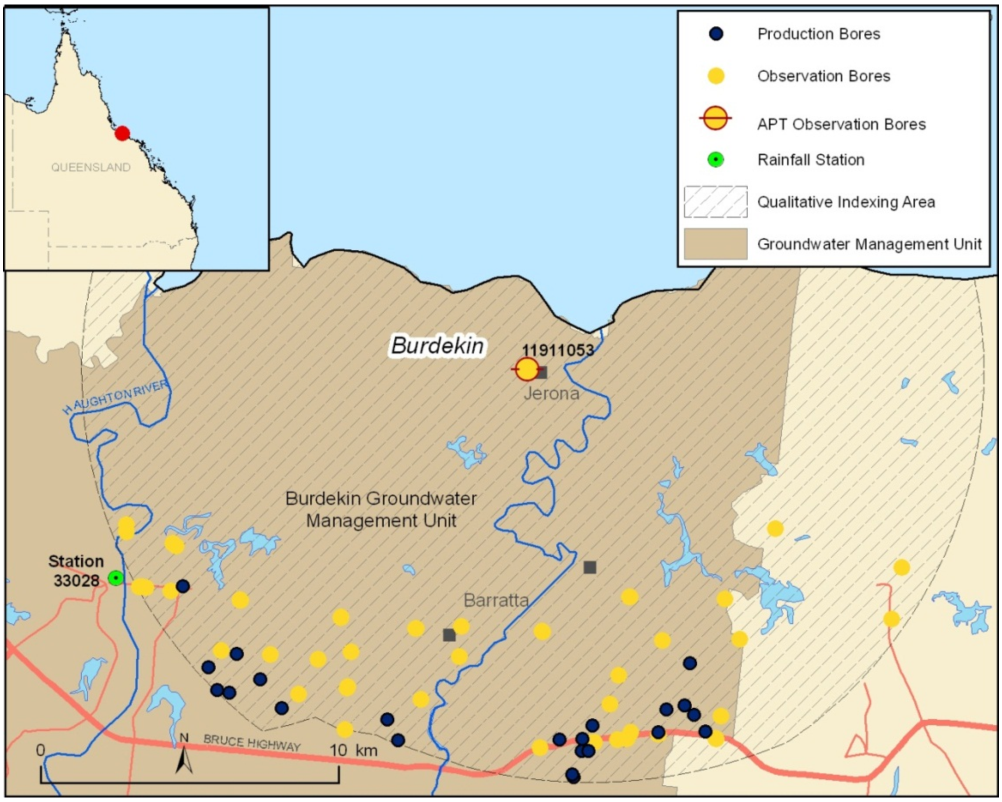

Figure 12. *Location map and associated features of the Burdekin, QLD case study area*

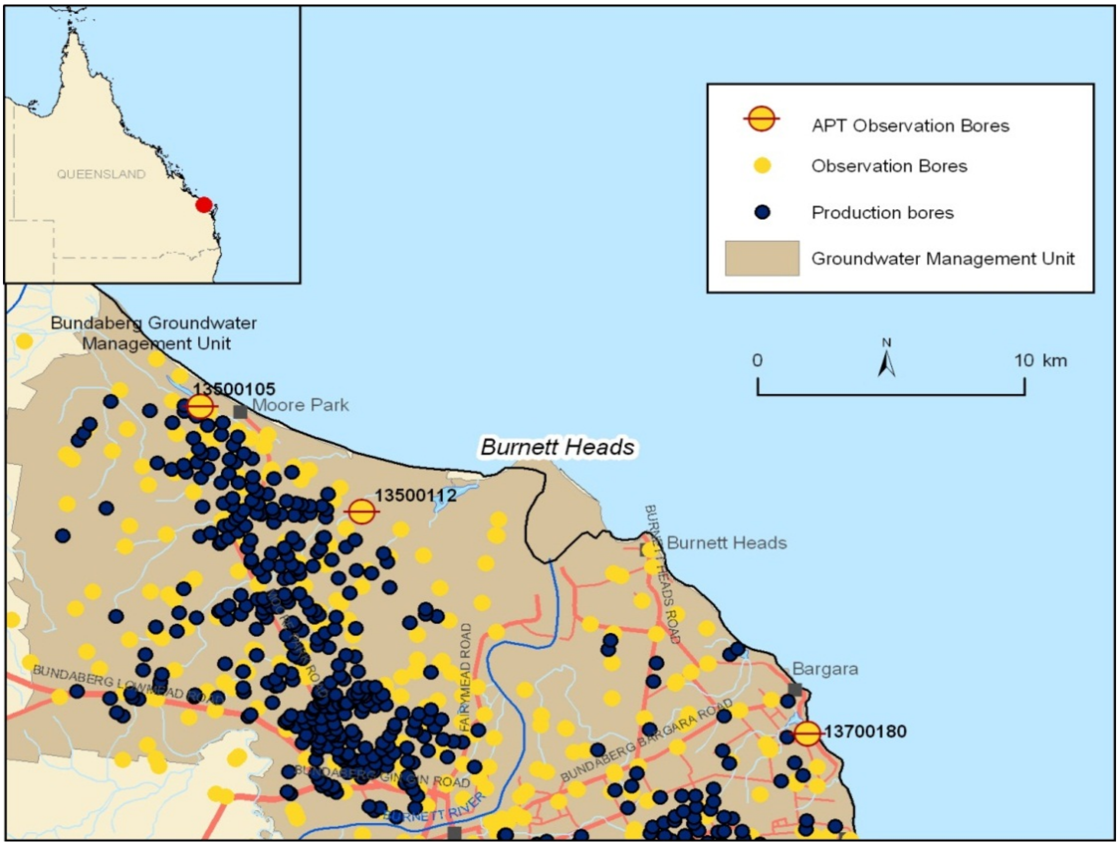

Figure 13. *Location map and associated features of the Burnett, QLD case study areas*

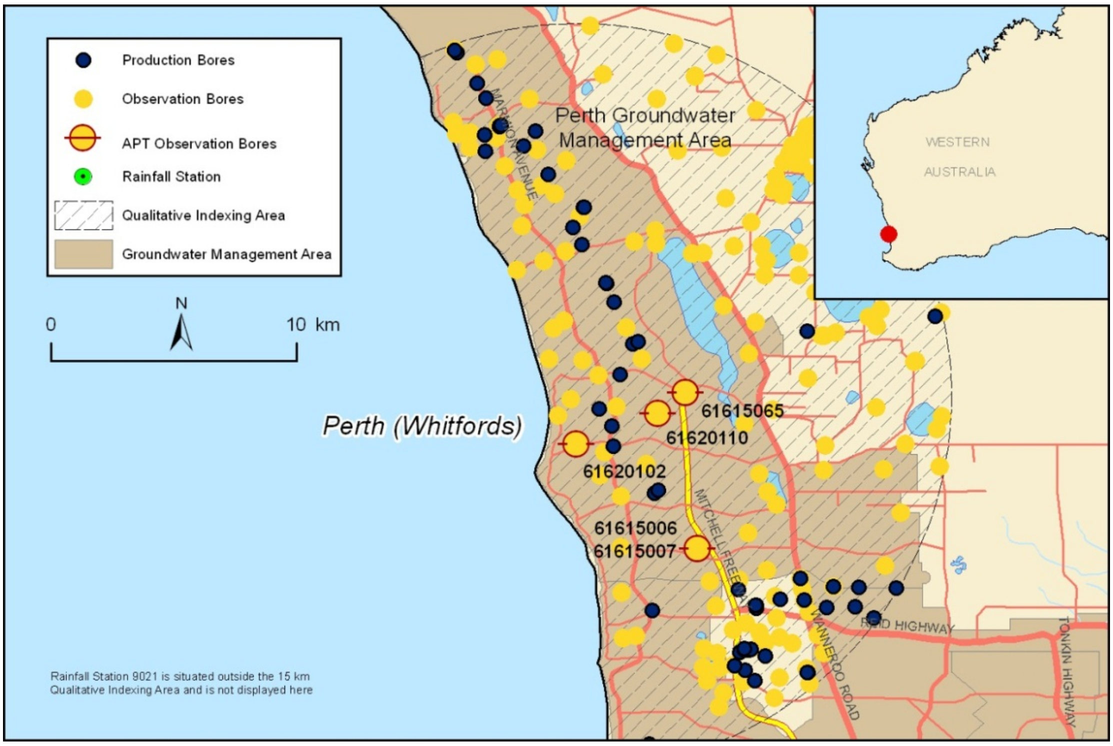

Figure 14. *Location map and associated features of the Perth (Whitfords), WA case study area*

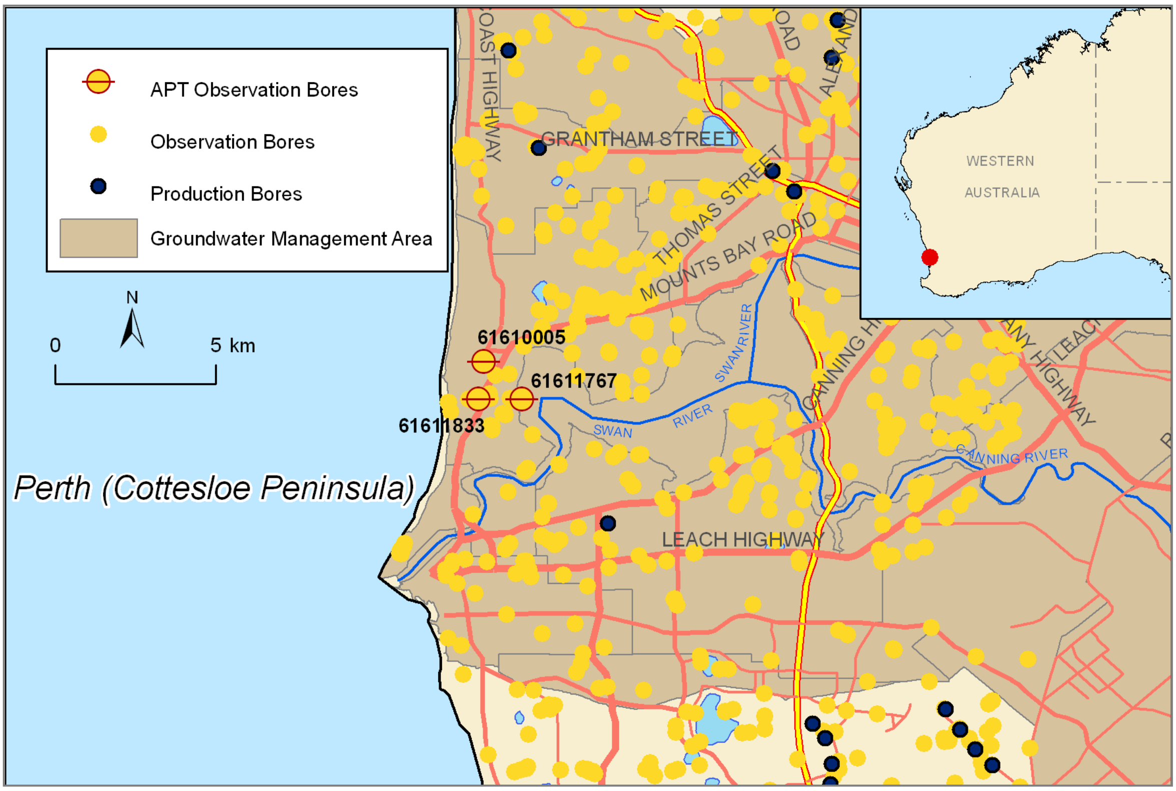

Figure 15. *Location map and associated features of the Perth (Cottesloe), WA case study area*

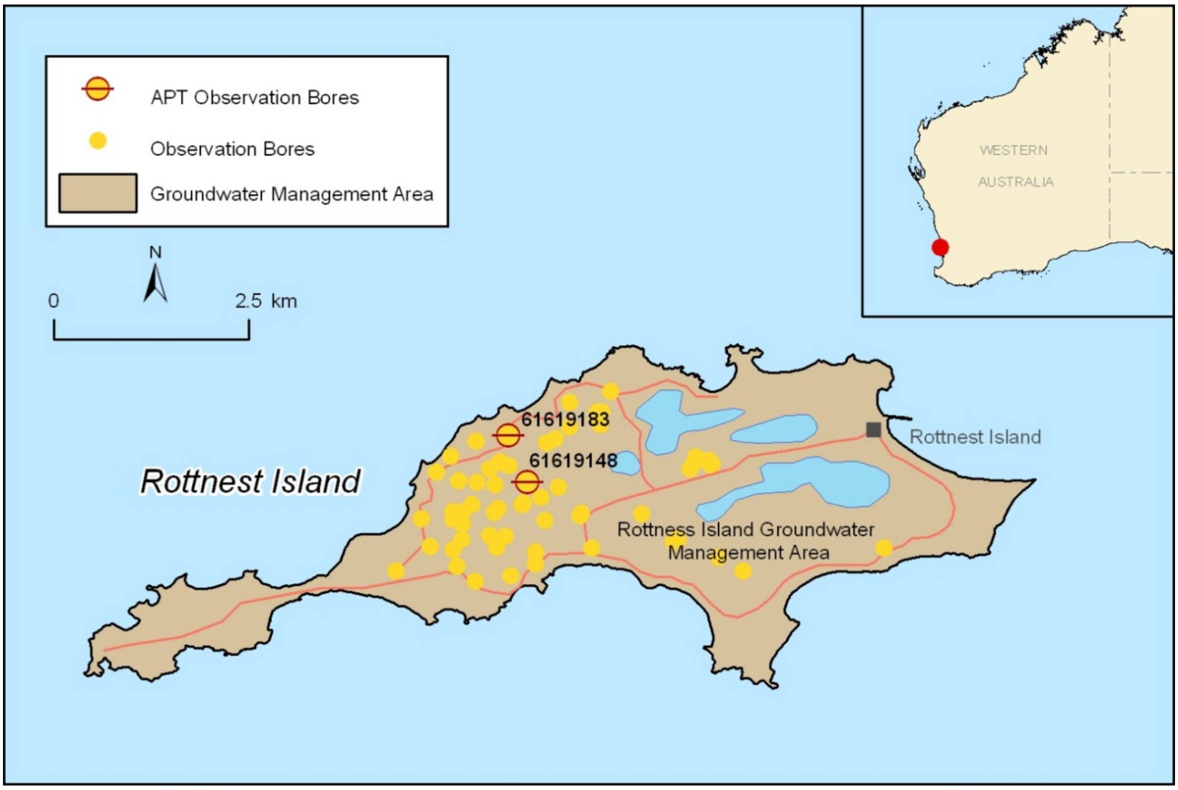

Figure 16. *Location map and associated features of the Rottnest Island, WA case study area*

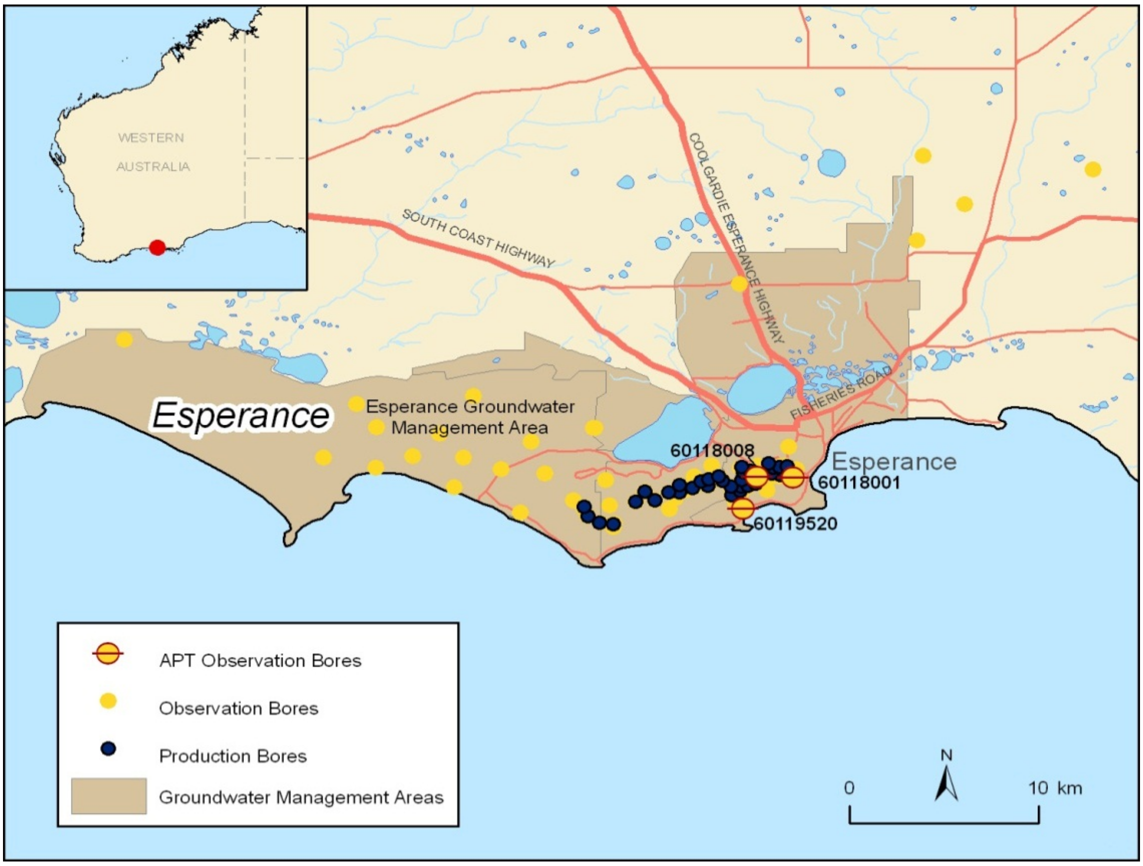

Figure 17. *Location map and associated features of the Esperance, WA case study*

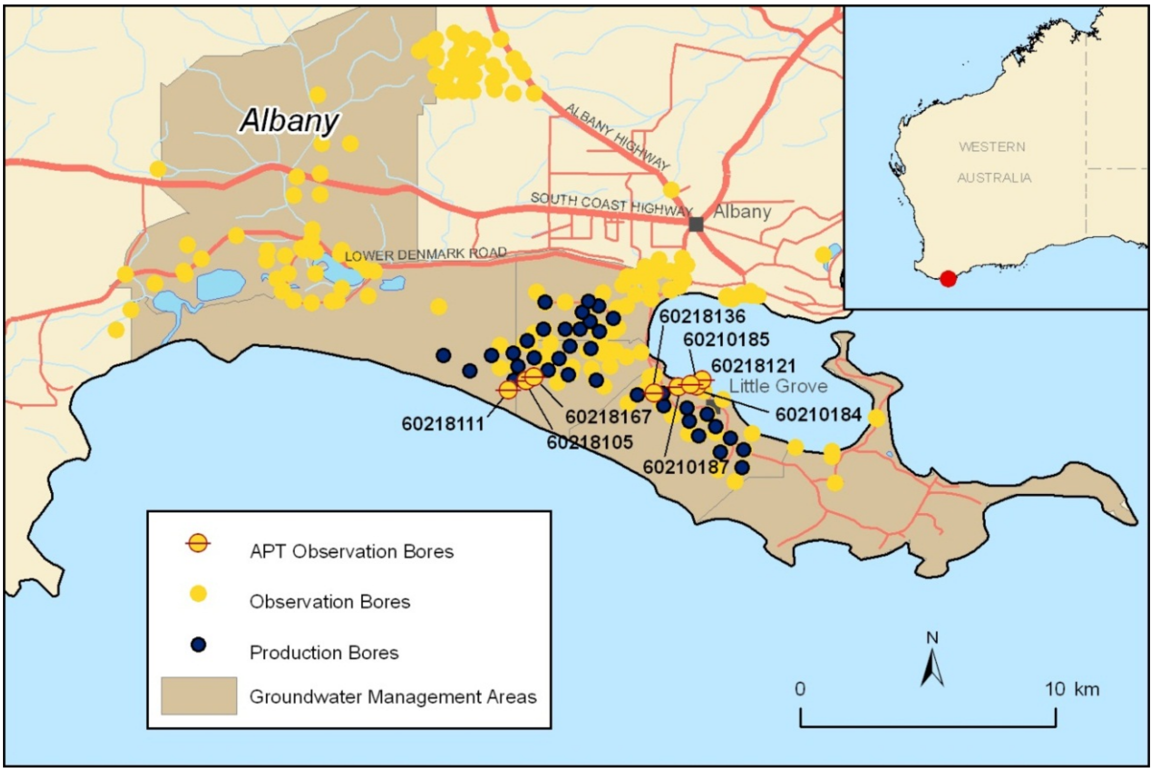

Figure 18. *Location map and associated features of the Albany, WA case study area*

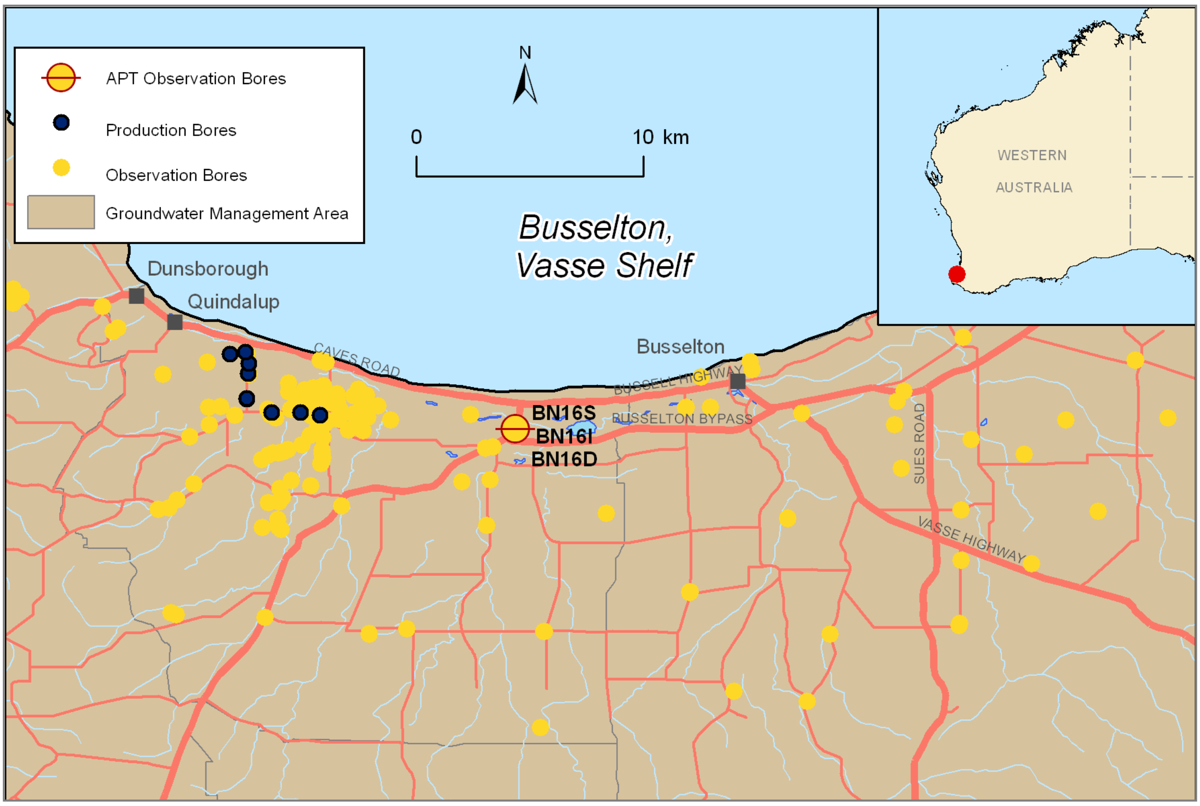

Figure 19. *Location map and associated features of the Busselton, WA case study area*

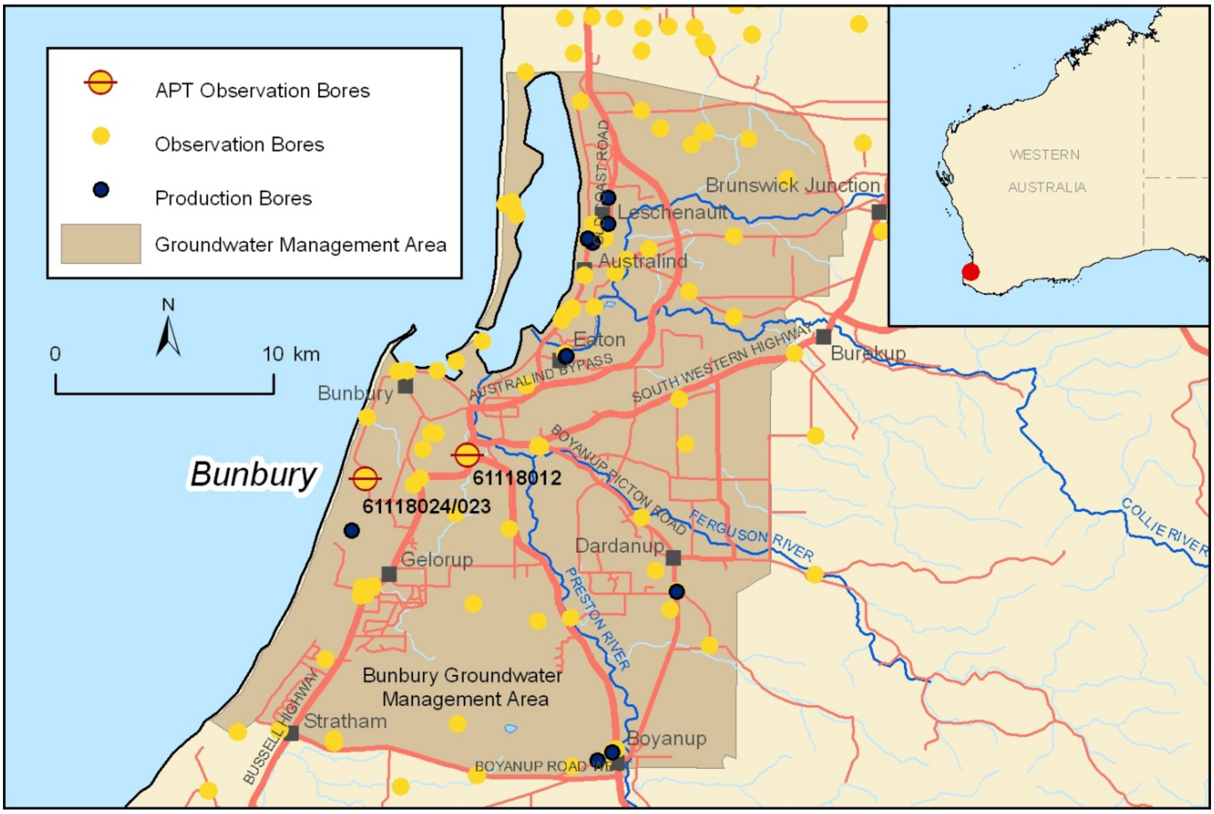

Figure 20. *Location map and associated features of the Bunbury, WA case study area*

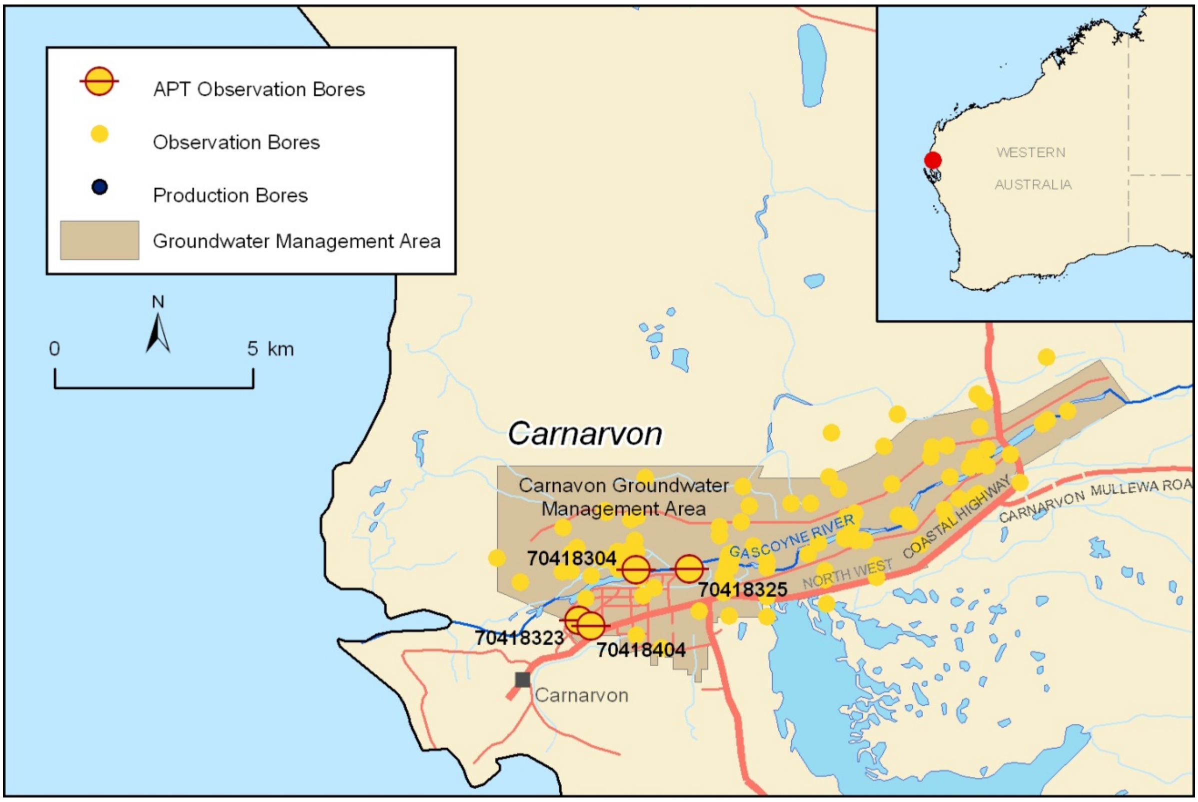

Figure 21. *Location map and associated features of the Carnarvon, WA case study area*

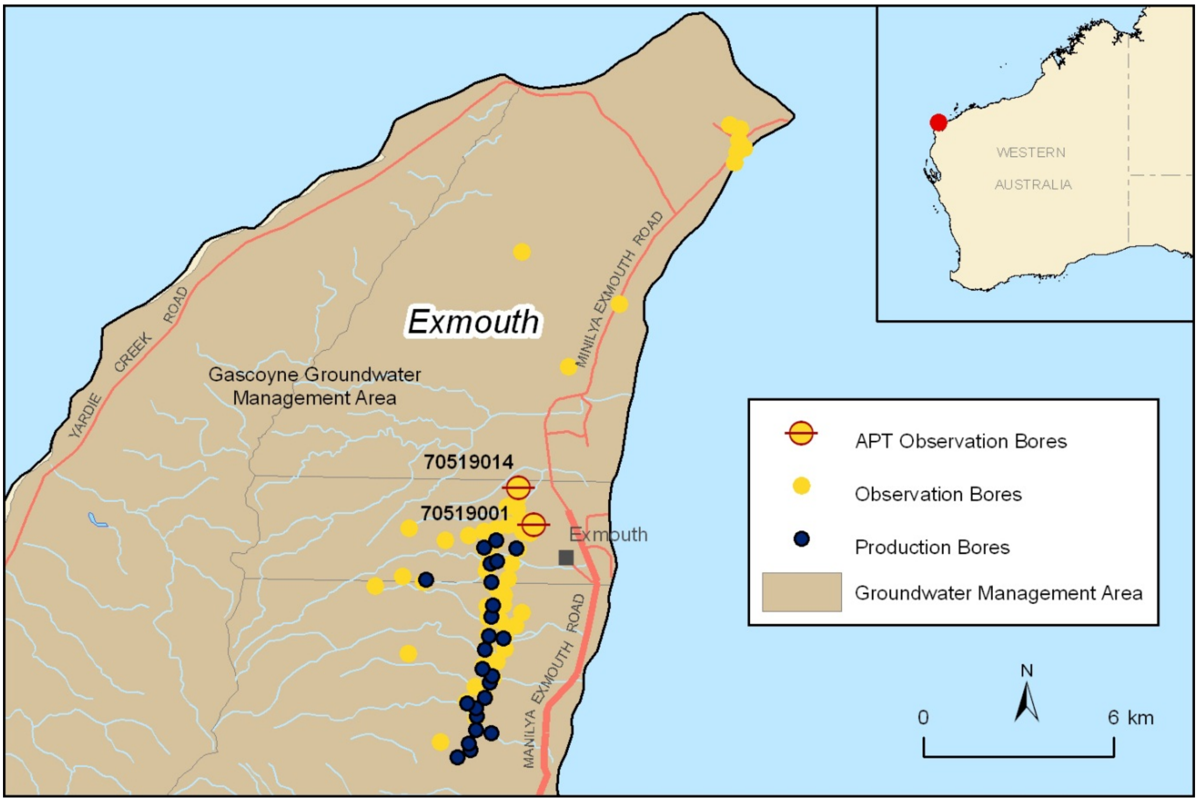

Figure 22*. Location map and associated features of the Exmouth, WA case study area*

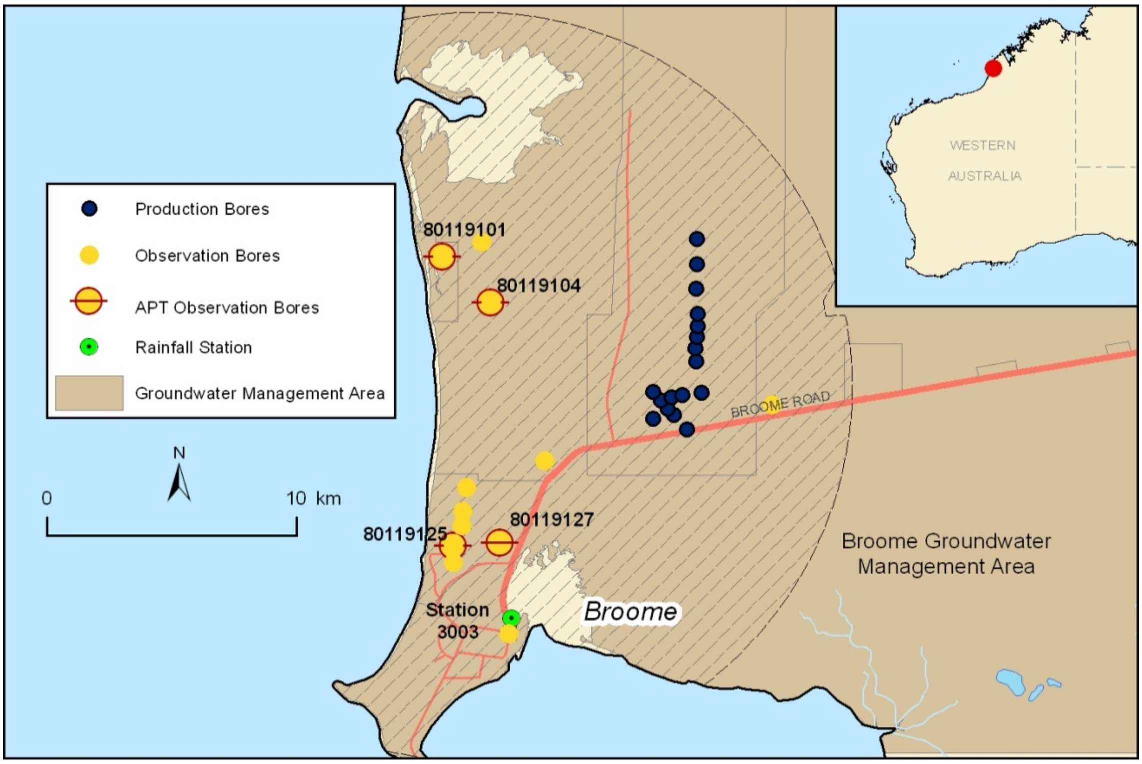

Figure 23. *Location map and associated features of the Broome, WA case study area*

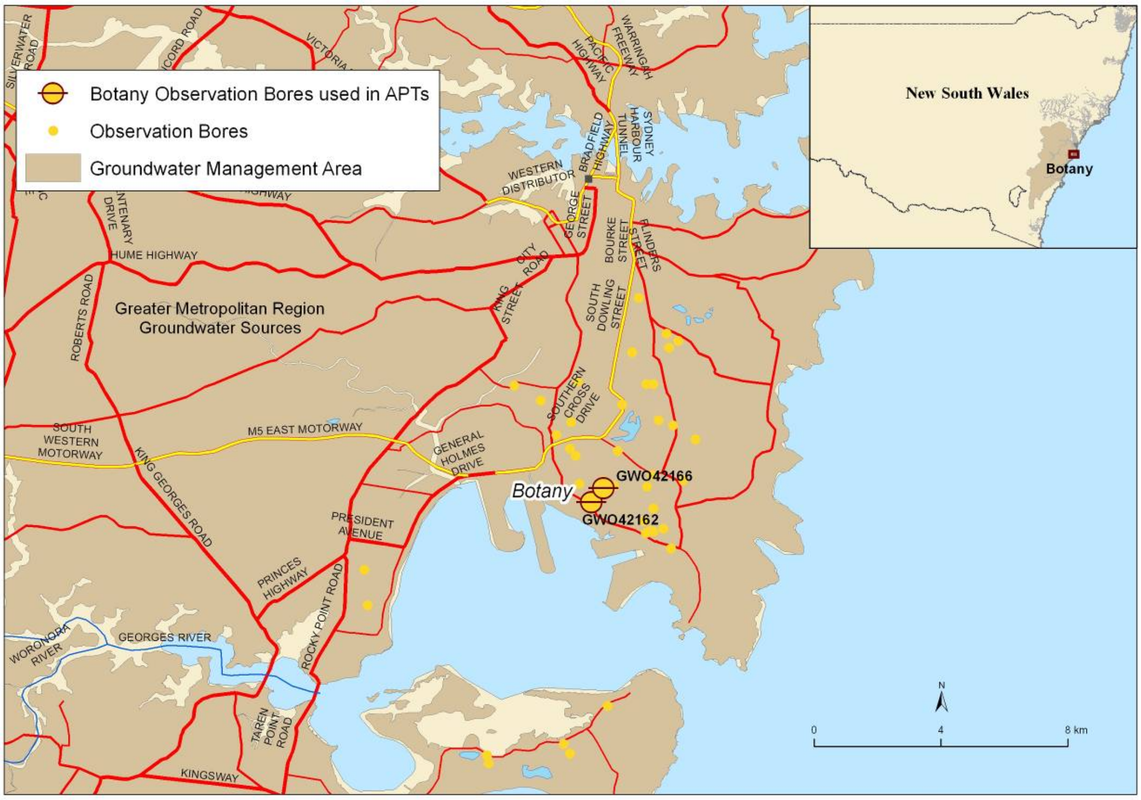

Figure 24. *Location map and associated features of the Botany, NSW case study area*

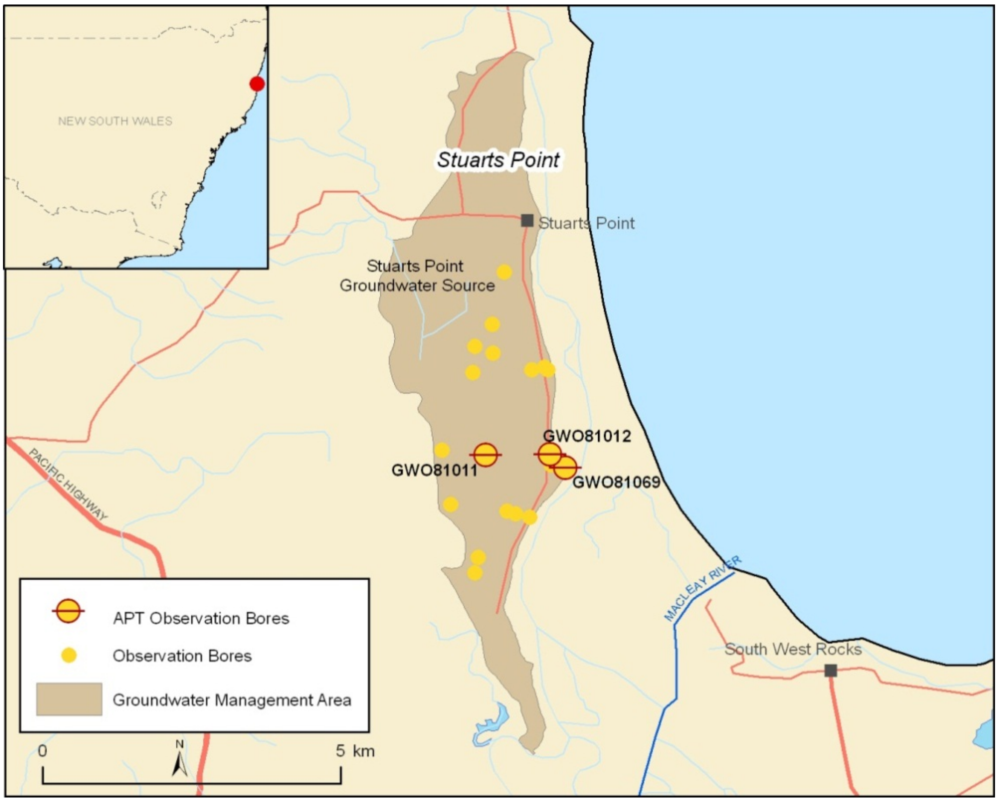

Figure 25. *Location map and associated features of the Stuarts Point, NSW case study area*

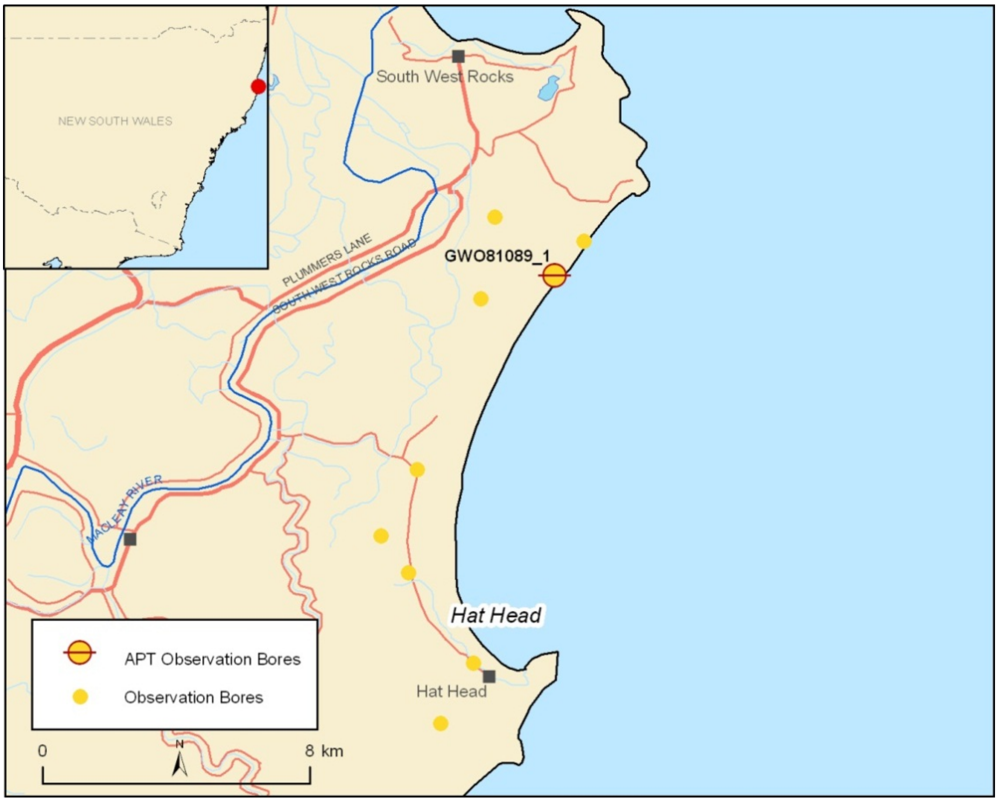

Figure 26. *Location map and associated features of the Hat Head, NSW case study area*

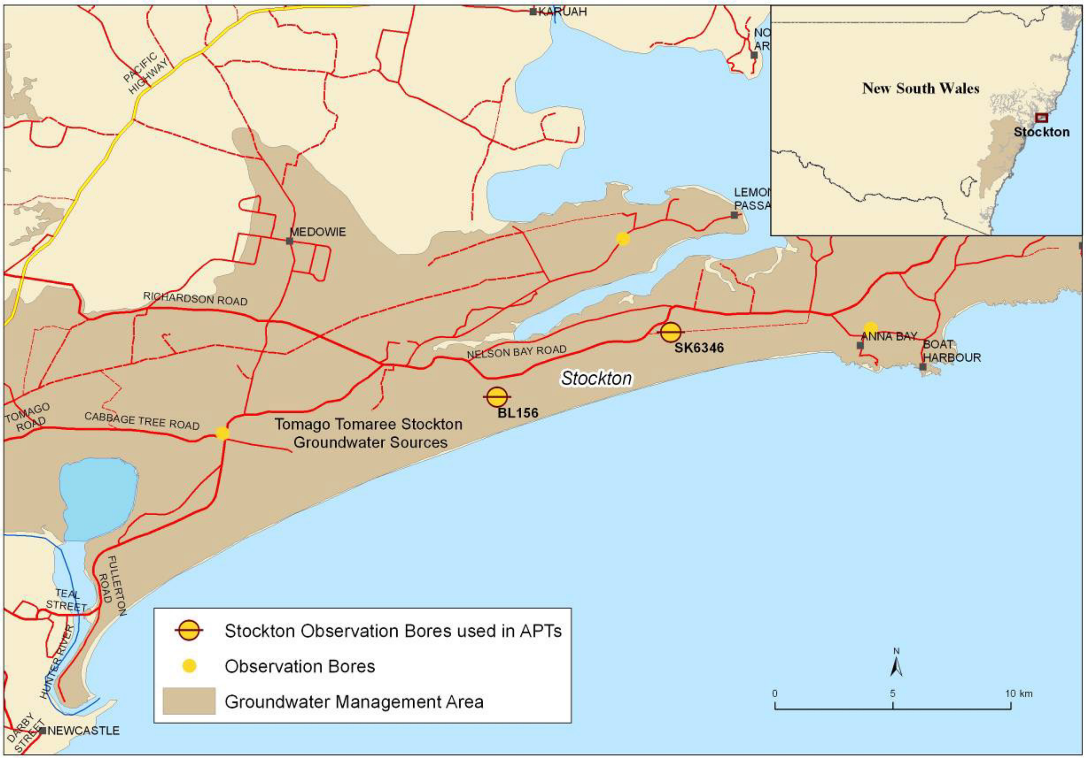

Figure 27. *Location map and associated features of the Stockton, NSW case study area*

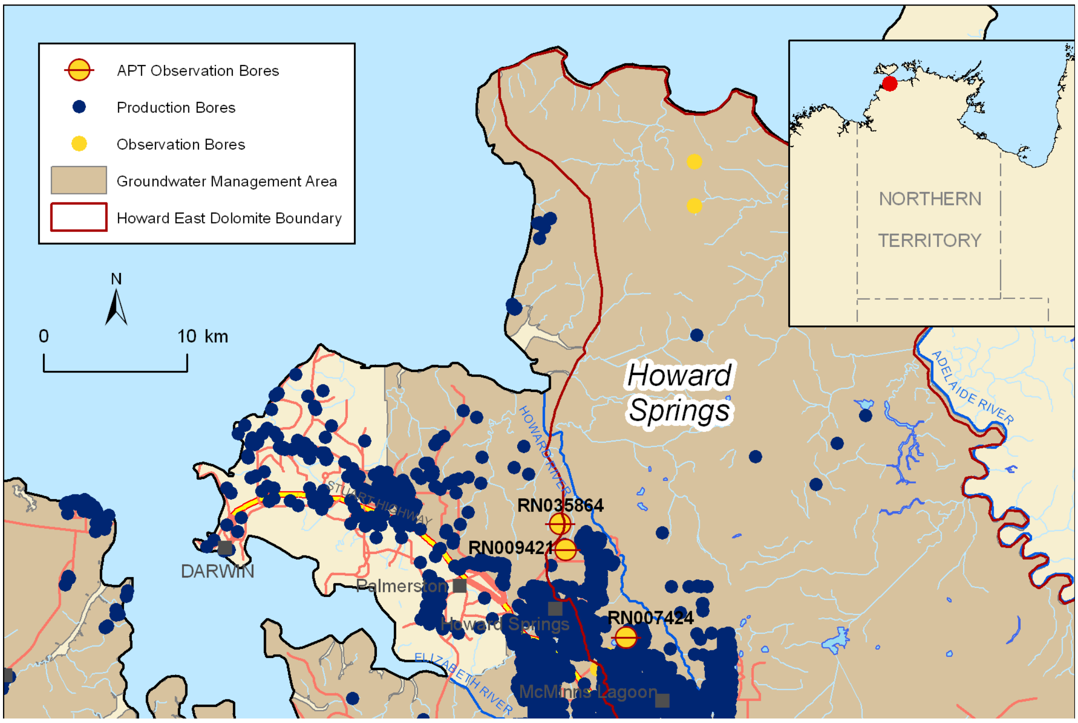

Figure 28. *Location map and associated features of the Howard Springs, NT case study area*

Appendix B. Math analysis results used for the indexing

Table 5. *Wedge toe and scaled wedge toe values for unconfined aquifers*

Case study	Aquifer	x_T (m)	x_T' (-)
Derby (WA)	Wallal/Erskine Sandstone	Unstable	1.00
Exmouth (WA)	Cape Range Group	Unstable	1.00
Burdekin (QLD)	Unconfined	Unstable	1.00
Broome, Cable Beach (WA)	Broome Sandstone	7676	0.42
Port MacDonnell (SA)	Tertiary Limestone	14679	0.30
Broome, Coconut Wells (WA)	Broome Sandstone	5471	0.24
Burnett Heads, Moore Park (QLD)	Elliott Formation	392	0.23
Botany Sands (NSW)	Botany Sand Beds	208	0.19
Esperance (WA)	Superficial/ Pallinup	635	0.15
Perth, Whitfords (WA)	Superficial	1138	0.10
Uley South (SA)	Bridgewater Formation/Wanilla Sands	1044	0.07
Bowen (QLD)	Unconfined	441	0.04
Le Fevre (SA)	Semaphore Sands	42	0.04
Willunga (SA)	Quarternary	197	0.04
Stockton (NSW)	Stockton Sand Beds	55	0.04
Hat Head (NSW)	Coastal Sands	122	0.03
Uley South (SA)	Bridgewater Formation	224	0.03
Stuarts Point (NSW)	Coastal Sands	112	0.03
Nth Stradbroke, East (QLD)	Unconfined	37	0.02
Albany, Ocean side (WA)	Werrillup Formation Sand	34	0.02
Werribee (VIC)	Alluvium/ Fractured Rock	42	0.02
Burnett Heads, Bargara (QLD)	Elliott Formation	90	0.01
Carnarvon (WA)	Riverbed Sand	89	0.01
Bunbury (WA)	Superficial	59	0.01
Albany, Harbour side (WA)	Superficial	6	0.01
Busselton (WA)	Superficial	16	0.01
Pioneer Valley (QLD)	Unconfined	201	0.01

Case study	Aquifer	x_T (m)	x_T' (-)
Nth Stradbroke, West (QLD)	Unconfined	9	0.00

Table 6. *Unconfined aquifers ranked using propensity for change in SWI extent for sea-level rise*

Case study	Aquifer	Flux-controlled $\partial x_T/\partial z_0$ (-)	Head-controlled $\partial x_T/\partial z_0$ (-)
Derby, WA	Wallal/Erskine Sandstone	Unstable	Unstable
Burdekin, QLD	Unconfined	Unstable	Unstable
Exmouth, WA	Cape Range Group	Unstable	Unstable
Port MacDonnell, SA	Tertiary Limestone	123	1598
Broome (Cable Beach), WA	Broome Sandstone	104	1834
Esperance, WA	Superficial/ Pallinup	69	483
Broome (Coconut Wells), WA	Broome Sandstone	63	657
Burnett Heads (Moore Park), QLD	Elliott Formation	60	620
Uley South, SA	Bridgewater Formation/Wanilla Sands	48	191
Bowen, QLD	Unconfined	45	118
Carnarvon, WA	Riverbed Sand	36	52
Perth (Whitfords), WA	Superficial	32	156
Uley South, SA	Bridgewater Formation	30	69
Willunga, SA	Quarternary	20	53
Botany Sands, NSW	Botany Sand Beds	19	160
Pioneer Valley, QLD	Unconfined	13	17
Burnett Heads (Bargara), QLD	Elliott Formation	12	19
Le Fevre, SA	Semaphore Sands	8	22
Bunbury, WA	Superficial	8	11
Stockton, NSW	Stockton Sand Beds	7	19
Hat Head, NSW	Coastal Sands	7	17
Stuarts Point, NSW	Coastal Sands	6	14
Werribee, VIC	Alluvium/ Fractured Rock	4	7
Albany (Ocean side), WA	Werrillup Formation Sand	3	6
Busselton, WA	Superficial	3	4
Albany (Harbour side), WA	Superficial	2	3
Nth Stradbroke (East), QLD	Unconfined	2	3
Nth Stradbroke (West), QLD	Unconfined	0	0

Table 7. *Unconfined aquifers ranked using propensity for change in SWI extent for recharge change*

Case study	Aquifer	Flux-controlled $\partial x T / \partial W net$ (d)	Head-controlled $\partial x T / \partial W net$ (d)
Derby, WA	Wallal/Erskine Sandstone	Unstable	Unstable
Burdekin, QLD	Unconfined	Unstable	Unstable
Exmouth, WA	Cape Range Group	Unstable	Unstable
Port MacDonnell, SA	Tertiary Limestone	-2.2.E+08	-9.2.E+07
Broome (Cable Beach), WA	Broome Sandstone	-1.5.E+08	-5.6.E+07
Broome (Coconut Wells), WA	Broome Sandstone	-9.2.E+07	-4.0.E+07
Esperance, WA	Superficial/ Pallinup	-1.7.E+07	-7.7.E+06
Perth (Whitfords), WA	Superficial	-1.4.E+07	-6.7.E+06
Bowen, QLD	Unconfined	-4.1.E+06	-2.0.E+06
Uley South, SA	Bridgewater Formation/Wanilla Sands	-4.0.E+06	-1.9.E+06
Willunga, SA	Quarternary	-3.7.E+06	-1.8.E+06
Burnett Heads (Moore Park), QLD	Elliott Formation	-1.8.E+06	-8.0.E+05
Carnarvon, WA	Riverbed Sand	-1.3.E+06	-6.5.E+05
Uley South, SA	Bridgewater Formation	-8.3.E+05	-4.1.E+05
Bunbury, WA	Superficial	-7.3.E+05	-3.6.E+05
Pioneer Valley, QLD	Unconfined	-6.7.E+05	-3.3.E+05
Burnett Heads (Bargara), QLD	Elliott Formation	-3.7.E+05	-1.8.E+05
Botany Sands, NSW	Botany Sand Beds	-2.0.E+05	-8.8.E+04
Busselton, WA	Superficial	-1.9.E+05	-9.6.E+04
Werribee, VIC	Alluvium/ Fractured Rock	-1.8.E+05	-9.1.E+04
Le Fevre, SA	Semaphore Sands	-1.7.E+05	-8.4.E+04
Hat Head, NSW	Coastal Sands	-1.7.E+05	-8.3.E+04
Stuarts Point, NSW	Coastal Sands	-1.5.E+05	-7.6.E+04
Albany (Ocean side), WA	Werrillup Formation Sand	-7.7.E+04	-3.8.E+04
Stockton, NSW	Stockton Sand Beds	-7.3.E+04	-3.6.E+04
Nth Stradbroke (East), QLD	Unconfined	-4.1.E+04	-2.0.E+04
Albany (Harbour side), WA	Superficial	-1.3.E+04	-6.5.E+03
Nth Stradbroke (West), QLD	Unconfined	-1.0.E+04	-5.0.E+03

Table 8. *Unconfined aquifers ranked using propensity for change in SWI extent for change in flows at the inland boundary*

Case study	Aquifer	$\partial x_T/\partial q_i$ (d/m)
Derby, WA	Wallal/Erskine Sandstone	Unstable
Burdekin, QLD	Unconfined	Unstable
Exmouth, WA	Cape Range Group	Unstable
Broome (Cable Beach), WA	Broome Sandstone	-10389
Port MacDonnell, SA	Tertiary Limestone	-5396
Broome (Coconut Wells), WA	Broome Sandstone	-4493
Esperance, WA	Superficial/ Pallinup	-4286
Perth (Whitfords), WA	Superficial	-1262
Burnett Heads (Moore Park), QLD	Elliott Formation	-1229
Willunga, SA	Quarternary	-772
Bowen, QLD	Unconfined	-387
Uley South, SA	Bridgewater Formation/Wanilla Sands	-291
Botany Sands, NSW	Botany Sand Beds	-201
Le Fevre, SA	Semaphore Sands	-173
Carnarvon, WA	Riverbed Sand	-166
Bunbury, WA	Superficial	-123
Uley South, SA	Bridgewater Formation	-118
Busselton, WA	Superficial	-96
Werribee, VIC	Alluvium/ Fractured Rock	-71
Burnett Heads (Bargara), QLD	Elliott Formation	-56
Stockton, NSW	Stockton Sand Beds	-53
Hat Head, NSW	Coastal Sands	-48
Albany (Ocean side), WA	Werrillup Formation Sand	-44
Stuarts Point, NSW	Coastal Sands	-41
Nth Stradbroke (East), QLD	Unconfined	-23
Pioneer Valley, QLD	Unconfined	-22
Albany (Harbour side), WA	Superficial	-20
Nth Stradbroke (West), QLD	Unconfined	0

Table 9. *Wedge toe values for confined aquifers*

Case study	Aquifer	x_T (m)
Le Fevre (SA)	T1	Unstable
Le Fevre (SA)	T2	Unstable
Adelaide Metro (SA)	T1	Unstable
Adelaide Metro (SA)	T2	Unstable
Willunga (SA)	Maslin Sands	Unstable
Burnett Heads, Bargara (QLD)	Fairymead Beds	Unstable
Esperance (WA)	Werillup	Unstable
Bunbury (WA)	Yarragadee	675000
Perth, Whitfords (WA)	Yarragadee	54759
Willunga (SA)	Port Willunga Formation	31500
Perth, Whitfords (WA)	Leederville	23181
Carnarvon (WA)	Older Alluvium	9450
Port MacDonnell (SA)	Tertiary Sands	4167
Busselton (WA)	Leederville	601
Uley South (SA)	Wanilla Sands	600
Albany, Harbour side (WA)	Pallinup/ Werrilup	140
Howard Springs (NT)	Koolpinyah/Coomalie dolomite	80

Table 10. *Confined aquifers ranked using propensity for change in SWI extent for sea-level rise*

Case study	Aquifer	Flux-controlled $\partial x_T/\partial z_0$ (-)	Head-controlled $\partial x_T/\partial z_0$ (-)
Le Fevre (SA)	T1	0	Unstable
Le Fevre (SA)	T2	0	Unstable
Adelaide Metro (SA)	T1	0	Unstable
Adelaide Metro (SA)	T2	0	Unstable
Willunga (SA)	Maslin Sands	0	Unstable
Burnett Heads, Bargara (QLD)	Fairymead Beds	0	Unstable
Esperance (WA)	Werillup	0	Unstable
Bunbury (WA)	Yarragadee	0	41512500
Willunga (SA)	Port Willunga Formation	0	258300
Perth, Whitfords (WA)	Leederville	0	71938
Carnarvon (WA)	Older Alluvium	0	38745
Perth, Whitfords (WA)	Yarragadee	0	36427
Port MacDonnell (SA)	Tertiary Sands	0	712
Uley South (SA)	Wanilla Sands	0	351
Busselton (WA)	Leederville	0	106
Albany, Harbour side (WA)	Pallinup/ Werrilup	0	101
Howard Springs (NT)	Koolpinyah/Coomalie	0	10

Table 11. *Confined aquifers ranked using propensity for change in SWI extent for change in inflows at the inland boundary*

Case study	Aquifer	$\partial x_T / \partial q_i$ (d/m)
Le Fevre, SA	T1	Unstable
Le Fevre, SA	T2	Unstable
Adelaide Metro, SA	T1	Unstable
Adelaide Metro, SA	T2	Unstable
Willunga, SA	Maslin Sands	Unstable
Burnett Heads (Bargara), QLD	Fairymead Beds	Unstable
Esperance, WA	Werillup	Unstable
Bunbury, WA	Yarragadee	-20250000
Carnarvon, WA	Older Alluvium	-3528000
Perth (Whitfords), WA	Leederville	-1403675
Willunga, SA	Port Willunga Formation	-980000
Perth (Whitfords), WA	Yarragadee	-53308
Busselton, WA	Leederville	-6841
Port MacDonnell, SA	Tertiary Sands	-868
Albany (Harbour side), WA	Pallinup/ Werrilup	-788
Uley South, SA	Wanilla Sands	-356
Howard Springs, NT	Koolpinyah/Coomalie dolomite	-20

Table 12. *Maximum freshwater thickness for freshwater lenses*

Case study	Aquifer	h_{max} (m)
Perth, Cottesloe (WA)	Tamala Limestone	5
Rottnest (WA)	Tamala Limestone	17
Exmouth (WA)	Cape Range Group	43
Point Nepean (Vic)	Quaternary	67

Table 13. *Freshwater lenses ranked using propensity for change in SWI extent for recharge change*

Case study	Aquifer	Flux-controlled $\partial h_{max}/\partial W_{net}$ (d)	Head-controlled $\partial h_{max}/\partial W_{net}$ (d)
Exmouth, WA	Cape Range Group	3.16E+05	0.00E+00
Point Nepean, Vic	Quaternary	3.08E+05	0.00E+00
Perth (Cottesloe), WA	Tamala Limestone	2.67E+04	0.00E+00
Rottnest, WA	Tamala Limestone	2.65E+05	0.00E+00