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

Skuthorpe allocation limit review methods report

Background information and method used to review allocation limit for the Skuthorpe subarea, Broome groundwater area.

May 2016

Securing Western Australia's water future

Skuthorpe Allocation Limit Review

Methods report

Background Information and method used to review allocation limit for the Skuthorpe subarea, Broome Groundwater area.

Securing Western Australia's water future

Department of Water

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For more information about this report, contact
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What is this report?

This report explains how the Department of Water developed the allocation limits for the Broome Sandstone aquifer as part of the *Skuthorpe groundwater allocation statement* (Department of Water 2015a). It provides further detail on the hydrogeological and environmental information available for the Skuthorpe area, and on the decision-making process.

The allocation statement details the allocation limits, water licensing arrangements and resource monitoring specific to the plan area.

What does this report include?

This report is split into three main chapters which follow the department's water allocation planning process for plan development set out in *Water allocation planning in Western Australia: a guide to our process* (Department of Water 2011):

- Chapter 2 – Part A describes the information used in refining the precision of the allocation limits, particularly our current understanding of the groundwater resource, including current use of water and future demands.
- Chapter 3 – Part B outlines how we set the management and resource objectives and the methodology for making the allocation limit decisions.
- Chapter 4 – Part C describes the role of policy and licence conditions in local resource management and the broader water management approach to support the use of the allocation limit in the statement.

The following reports also supported the planning process and provide key reference material for groundwater management in and adjacent to the plan area:

- *Skuthorpe Yield Assessment, Broome Groundwater Area Western Australia. Final Report to Department of Water. GCS Project Number: DOW011. June 2015* (Groundwater Consulting Services 2015)
- *Skuthorpe – Environmental scan of groundwater-dependent values.* (Department of Water 2015c, provided as Appendix 2).
- *Relevant internal reports and advice on regional hydrogeology.*

Further information on the statement area can be obtained by contacting the Kununurra regional office.

1 Introduction

This report explains how the Department of Water developed the allocation limit for the Broome Sandstone aquifer as part of the *Skuthorpe groundwater allocation statement* (Department of Water 2015).

This report is designed to be read in conjunction with the *Skuthorpe groundwater allocation statement* (Department of Water 2015).

1.1 Skuthorpe statement area

Skuthorpe is a subarea of the Broome groundwater area and is approximately 20 km east of the Broome town centre along Broome Road and covers approximately 323 km^2. Skuthorpe is in the local government boundary for the Shire of Broome.

The Broome groundwater area consists of seven subareas (see Figure 1):

- Townsite
- Cable Beach
- Coconut Wells
- Roebuck
- Town Water Reserve
- 12 Mile
- Skuthorpe.

An allocation plan was developed for the Broome groundwater area in 1994 (Water Authority of Western Australia 1994). Allocation limits for the Broome groundwater areas were revised in 2013. At this time, the Department of Water identified that additional hydrogeological investigations were required to support further review of allocation limits. This work has now been completed and is summarised as part of this review.

In 2014 the Government of Western Australia announced the Water for Food initiative, aimed at increasing economic growth and regional employment. The existing Skuthorpe horticultural precinct was identified as a suitable location for expanded horticultural activity based on:

- land available for release in the short term
- the availability of low salinity, easily accessible groundwater in the underlying, unconfined Broome aquifer system.

For the purposes of this document, the term Skuthorpe refers to the Skuthorpe subarea.

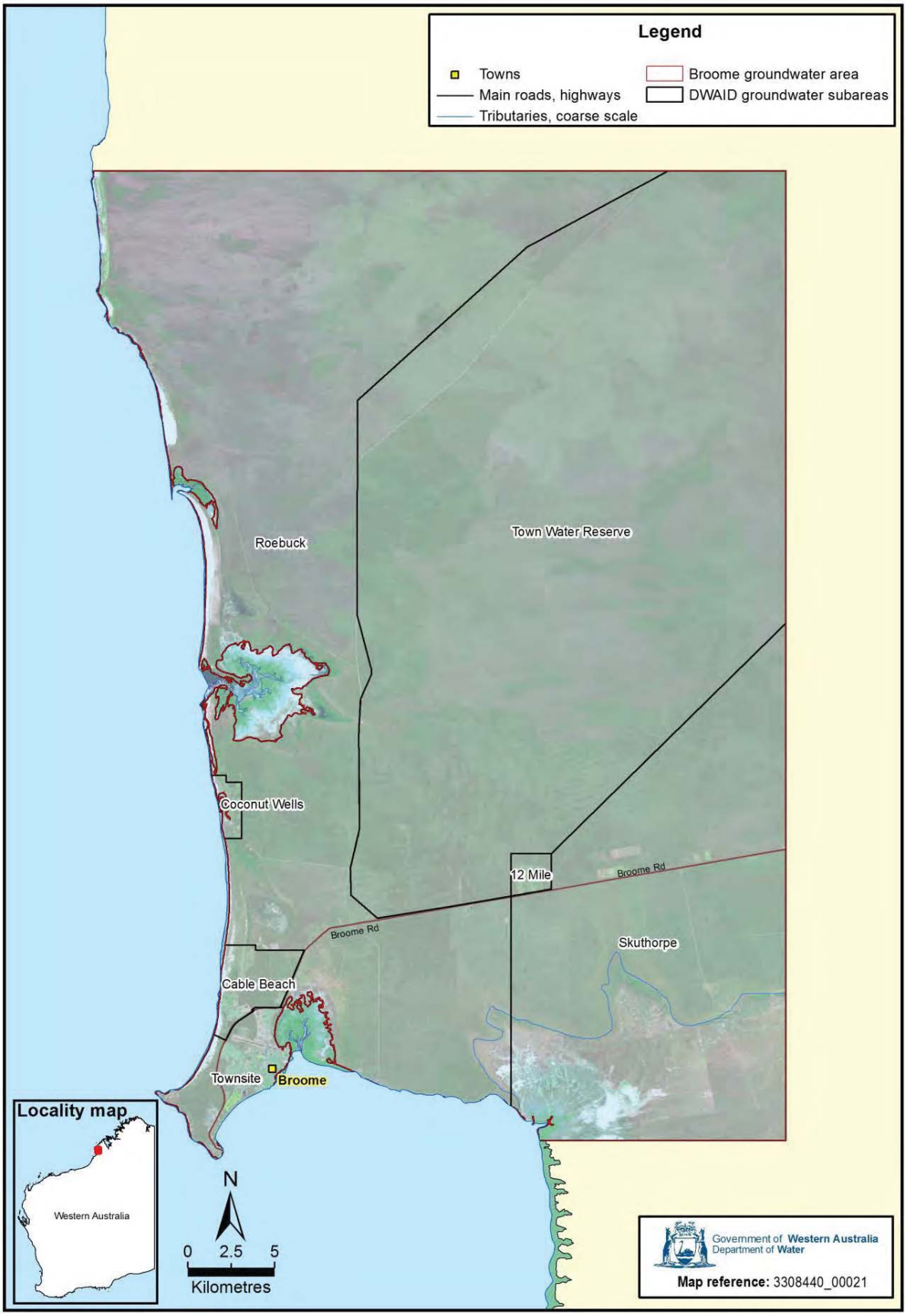


Figure 1: Location of the Skuthorpe subarea, Broome groundwater area

1.2 Our process for allocation planning and resource management

The *Skuthorpe groundwater allocation statement* (Department of Water 2015a) was developed using the department's process for water allocation plans: *Water allocation planning in Western Australia: a guide to our process* (Department of Water 2011; Figure 2).

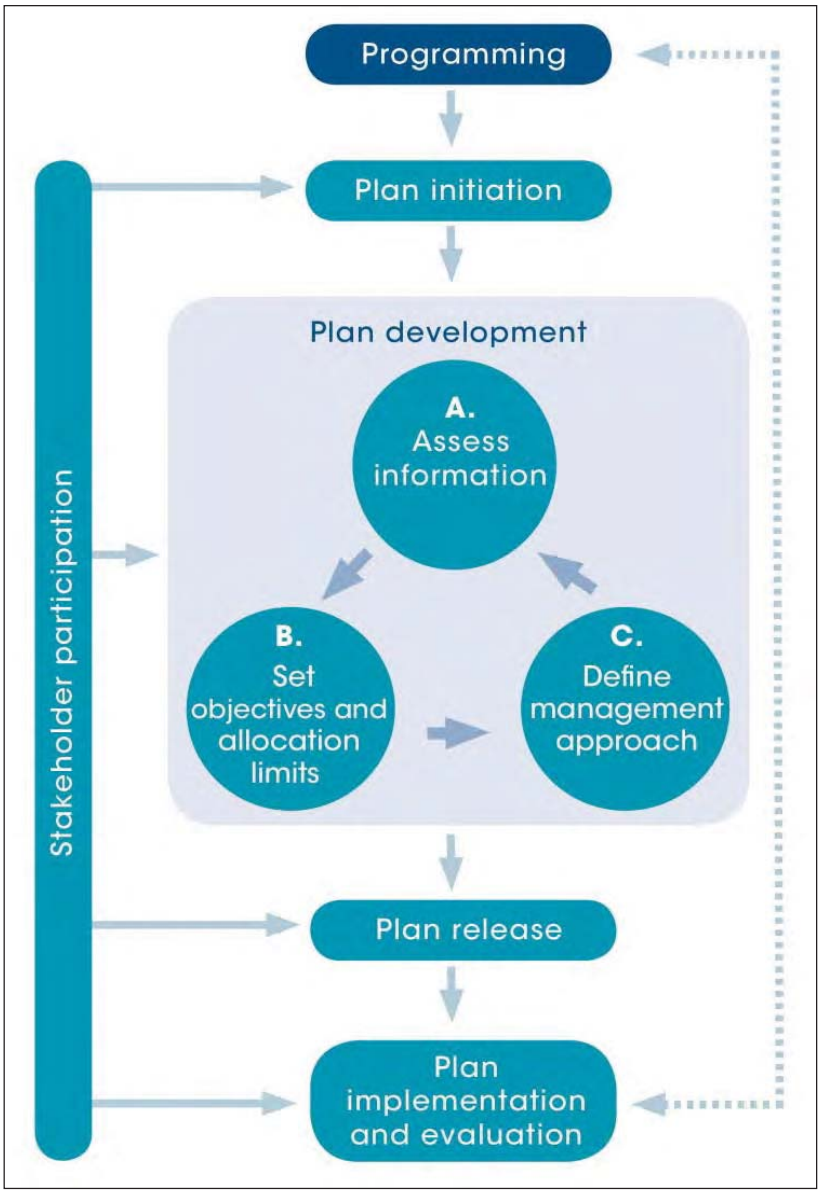


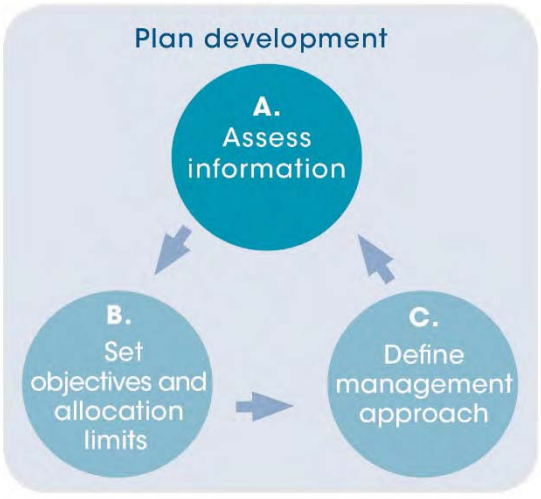
Figure 2: The Department of Water's standard water allocation planning process (Department of Water 2011)

As a full plan document was not being produced, an appropriately scaled version of the process was adopted. This report is set out to follow the three stages of plan development and provides the information and methodology used to complete each stage (Table 1). Each stage corresponds to a chapter in this report:

Table 1: Report alignment with the allocation planning process

Chapter 2 - Part A Investigate and assess the water resource.	• Assess the area's hydrogeology and climate (Sections 2.1-2.4). • Consider the ecological and social values (Sections 2.4–2.5). • Assess the level of water use and future water demands (Section 2.6).
Chapter 3 - Part B Set management objectives and allocation limits for the resource.	• Set resource objectives (Section 3.1). • Consider allocation options (Section 3.2). • Set allocation limits (Section 3.2).
Chapter 4 - Part C Define the management approach for the resource.	• Identify the water licensing approach to meet plan outcomes and objectives (Section 4.1). • Identify any specific local licensing policies required other than state-wide policies (Section 4.1). • Develop a monitoring and evaluation process to monitor performance against specific resource objectives (Section 4.2).

2 Part A: Assessing information



In Part A of the allocation planning process, we assess:

- the hydrogeology of the resource
- how much water needs to be left in the system (environmental water)
- current water use and future demand for groundwater.

This information is used to set objectives, allocation limits and define the water licensing approach for the plan area.

Key points from this section:

- The key groundwater resource in Skuthorpe is the Broome Sandstone aquifer. No water is abstracted from the Wallal aquifer in this area is because it is deeper and of poorer quality.
- Groundwater levels in the Broome Sandstone aquifer are strongly correlated to infrequent, consecutive high rainfall years. These episodes raise the water levels in the aquifer and offset the drawdown effects for a number of years.
- The risks to the Broome Sandstone aquifer are movement of the seawater interface, the cumulative impacts of abstraction by current users (particularly for public water supply in an adjacent subarea), and potential reductions in freshwater throughflow.
- There are high-value environmental features in the Skuthorpe area which are groundwater-dependent, such as Roebuck Bay (Ramsar) and ecosystems of the Roebuck Plains (Directory of Important Wetlands).
- Currently 54% of allocation at Skuthorpe is licensed or allocated to exempt use (stock and domestic). Actual use of licensed entitlements is estimated at 28%. Proponents are required to meet the terms and conditions of licences to maintain existing entitlements. Further land releases for

horticultural production at Skuthorpe will increase water demand in the near future.

2.1 Understanding the water resource

There are two main aquifers in Skuthorpe subarea; the shallow Broome Sandstone aquifer and the deep Wallal aquifer. The local extent of the Broome Sandstone aquifer is shown in Figure 3 and its properties are summarised in Table 2.

The Wallal aquifer is not covered here or in the allocation statement. This aquifer is in low demand, primarily because it is deep (> 250 m) and therefore expensive to access. Additionally, at Skuthorpe, the water quality is poor (brackish) and so unsuitable for horticulture.

Table 2: Description of the Broome Sandstone aquifer (Canning-Broome)

Aquifer	Description
Broome Sandstone (Canning Broome)	• Large, unconfined aquifer system which predominates on the Dampier Peninsula • Sandstone dominated • Generally fresh groundwater (< 400 mg/L TDS) • Generally small bore yields (< 100 kL/day) • Connected directly with the Indian Ocean via a seawater interface • Supports groundwater-dependent ecosystems

Hydrogeology of the Broome Sandstone aquifer at Skuthorpe

The Broome Sandstone aquifer forms a large, unconfined aquifer system across the Dampier Peninsula. It is separated from the deeper Wallal aquifer by the Jarlemai Siltstone.

The Broome Sandstone aquifer is recharged by throughflow and rainfall, and discharges over a saline interface near the coast. Where the groundwater is shallow, the Broome Sandstone aquifer supports groundwater-dependent ecosystems.

The Skuthorpe subarea flanks the gently domed Dampier Peninsula and ground elevations range from 30 to 50 m AHD near the Broome Road. The land drains to the south, and ground levels undulate and rise to the east.

The land drains only after intensive rain exceeds the infiltration capacity of the sandy soil, and water discharges through poorly defined broad drainage paths to the coastal plain mudflats and ultimately to the Indian Ocean in Roebuck Bay (Groundwater Consulting Services 2015).

At Skuthorpe, the Broome Sandstone is approximately 152 m thick and comprises approximately 15 m of red sandy clay and silty sand (Pindan sand) overlying approximately 137 m of coarse sand interbedded with white clay layers and fine sandstone (Searle 2011). Below this the Jarlemai Siltstone is estimated at between 118 m and 214 m thick in this area.

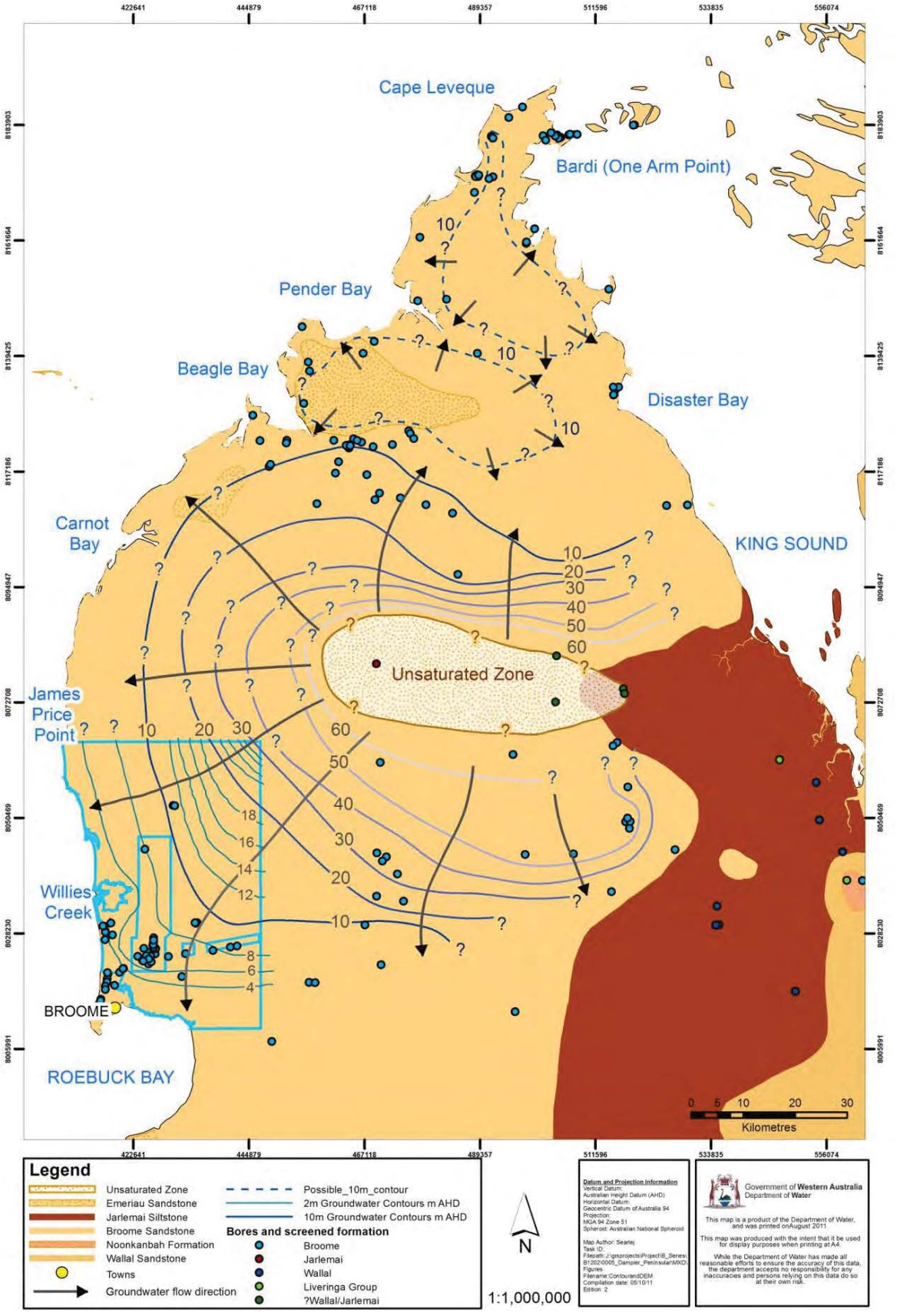


Figure 3: Location of aquifers and regional groundwater flow, Dampier Peninsula (note: contours use maximum water levels; Searle 2011)

A shallow hydrogeological cross-section across the 12 Mile subarea drawn from records in 1994 is reproduced here as Figure 4. Given its proximity to Skuthorpe it provides a representation of the likely hydrogeology at Skuthorpe.

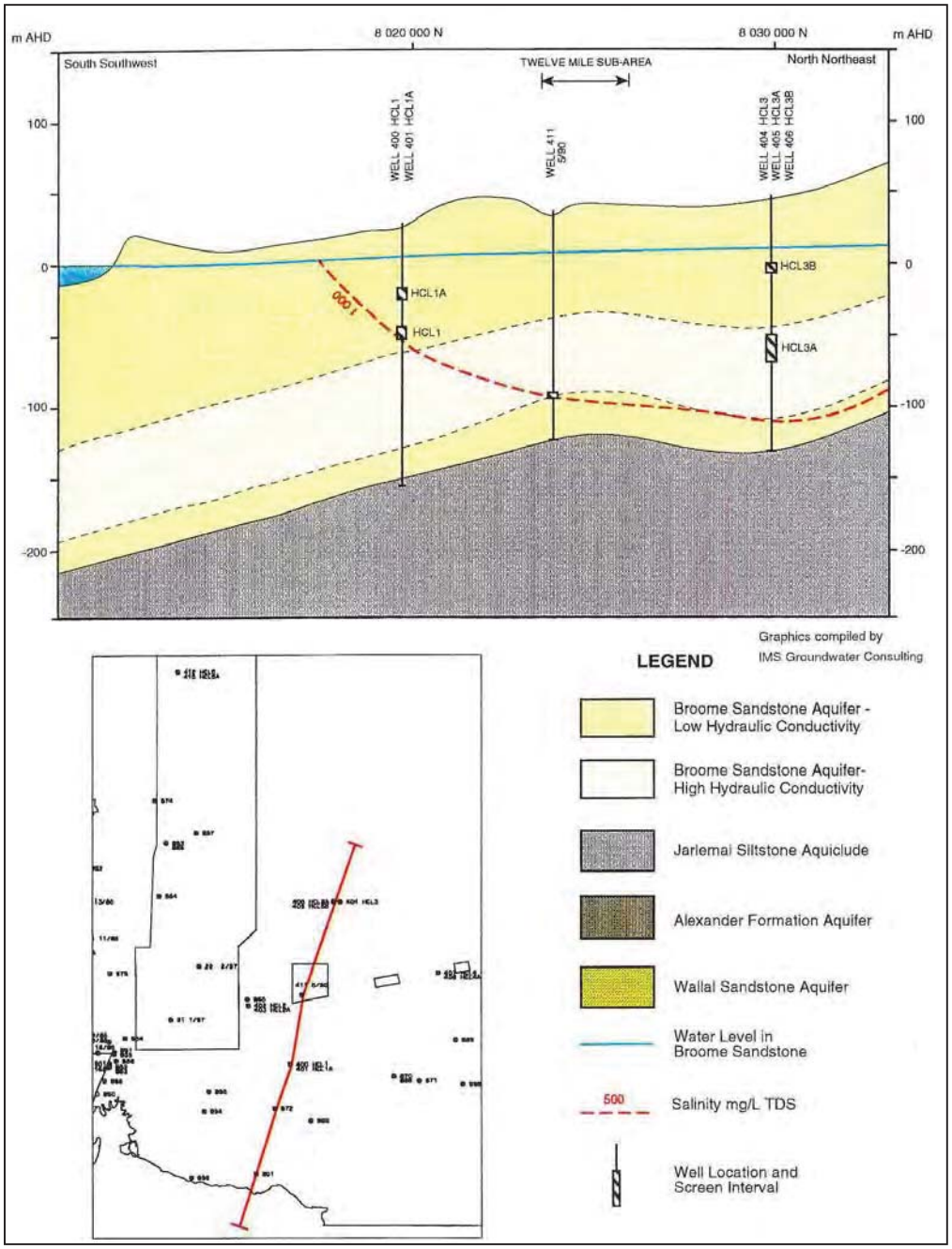


Figure 4: Shallow hydrogeological cross-section of 12 Mile subarea (WAWA 1994)

Groundwater flow and discharge

Groundwater in the Broome Sandstone flows radially from the centre of the peninsula towards the coast. At Skuthorpe, groundwater flows roughly from north–north-east to south–south-west with a shallow (horizontal) hydraulic gradient across the subarea. While there is generally good vertical connectivity throughout the Broome Sandstone aquifer, some hydraulic disconnection is suggested (Searle 2011).

Recharge

At Skuthorpe, recharge into the Broome Sandstone is by throughflow from the centre of the peninsula, passing through the Canning-Pender and Town Water Reserve subareas. A roughly equal volume of water also recharges the aquifer from direct rainfall infiltration.

Groundwater quality

Groundwater in the Skuthorpe Broome Sandstone aquifer is fresh (generally < 400 mg/L TDS) and neutral (pH 6.29–6.8; Searle 2011). Analysis of salinity data at Skuthorpe suggests a vertical variation in salinity.

At certain locations in the subarea, the shallower water is fresher than the deeper (near HCL1A and 3/90), while in other locations the opposite is true (near HCL2, HCL3, and HCL4), and the westernmost bores have a shallow and a deep fresh zone, with the mid-depths in the aquifer having the highest salinity (near 4/90). Figures 5 and 6 provide outlines of aquifer salinity charts in the region.

Groundwater salinity in the Broome Sandstone aquifer is measured by licensees and the Department at the following frequencies:

- monthly in production bores located in the Town Water Reserve subarea – conducted by the Water Corporation
- annually by downhole geophysical logging in saltwater interface monitoring bores (SWIM) located in the Town Water Reserve sub area – conducted by the Water Corporation
- quarterly in production bores on some properties in Skuthorpe – conducted by large volume licence holders
- twice a year in water samples from bores in Skuthorpe provided by licence holders to the Department
- twice a year in water samples collected from monitoring bores in Skuthorpe by the Department.

The results of airborne electromagnetic surveys (AEM) of the Dampier Peninsula by the Department of Water in 2013 and by the Department of Agriculture and Food Western Australia in 2014 indicate the general shape and depth of the saline interface at Skuthorpe. The AEM data correlates with downhole geophysical data. A hydrogeological and geophysical cross-section produced from AEM data is shown as Figure 7.

Groundwater levels

Groundwater levels are measured twice a year as part of the regional monitoring bore network maintained by the Department of Water. Additional groundwater level measurements were taken by the Department as a result of further investigations into the Dampier peninsula in 2013. Larger licence holders and the Water Corporation also collect water level data. Groundwater level data are provided in Figure 8 as hydrographs.

Resource and subarea boundaries

The Broome Sandstone subarea boundaries divide the aquifer into individual resources primarily for licensing purposes and to reflect groundwater flow systems as discretely as possible to allow area-specific management strategies. Further details on the hydrogeology of Skuthorpe may be found in Searle (2011) and Searle (2012).

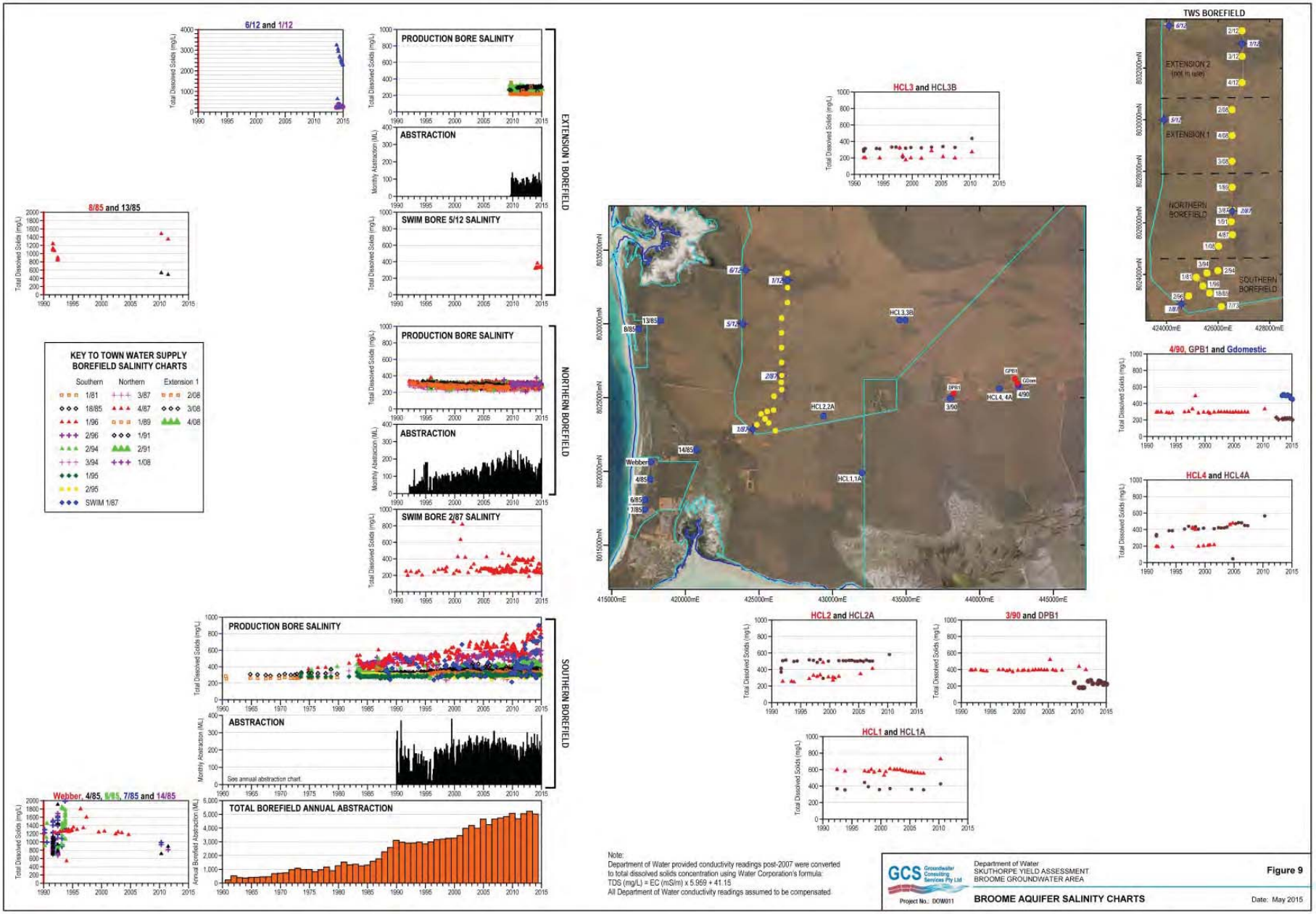
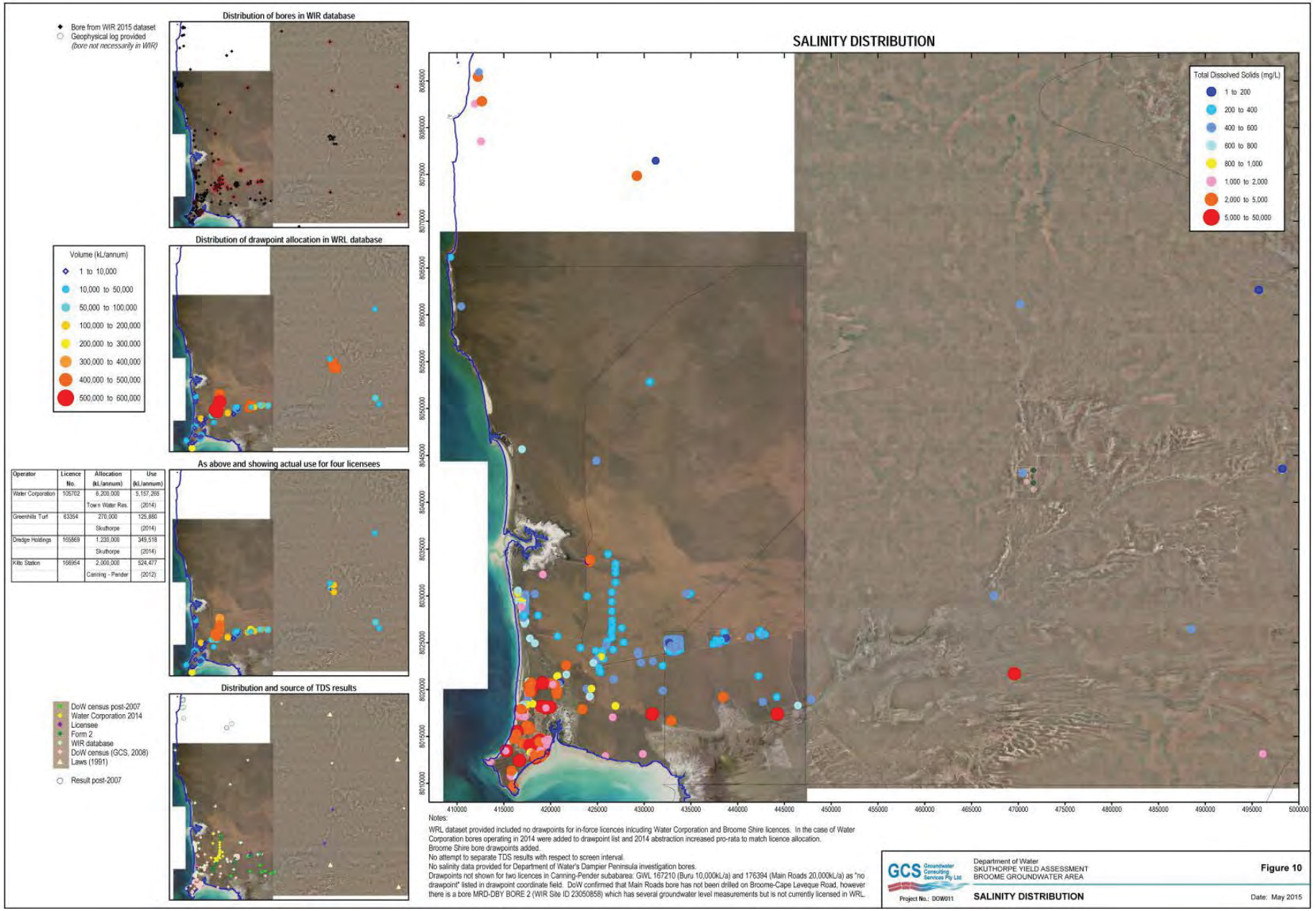


Figure 5: Broome Sandstone aquifer salinity charts (Source: GCS 2015)



Operator	Licence No.	Allocation (kL/annum)	Use (kL/annum)
Water Corporation	105702	8,200,000	5,157,265
		Town Water Res.	(2014)
Greenhills Turf	63354	270,000	125,880
		Skuthorpe	(2014)
Dredge Holdings	155869	1,230,000	349,518
		Skuthorpe	(2014)
Kiln Station	156954	2,000,000	524,477
		Canning - Pender	(2012)

Figure 6: Broome Sandstone aquifer salinity distribution (Source: GCS 2015)

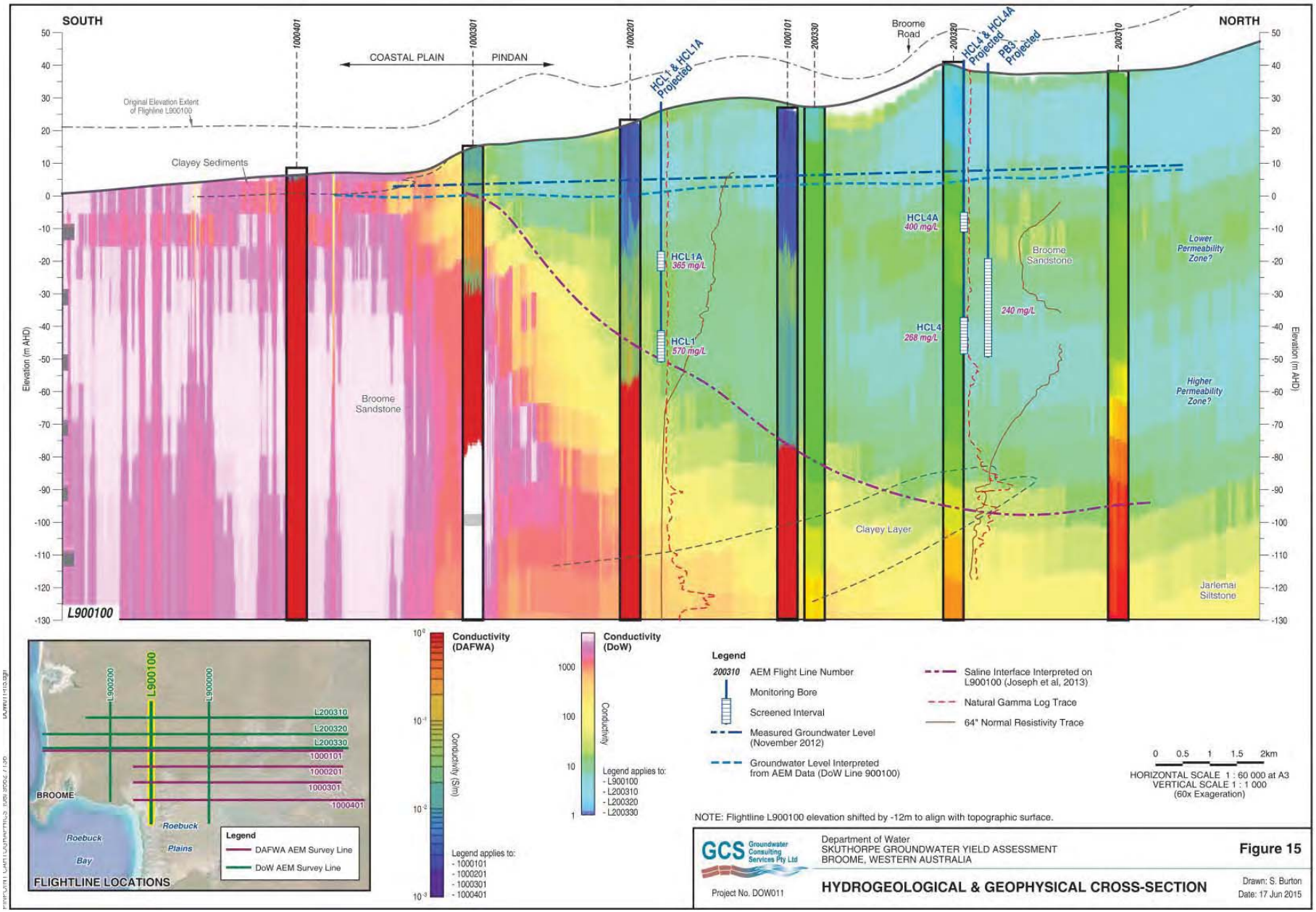


Figure 7: Hydrogeological and geophysical cross-section of Skuthorpe based on AEM data (Source: GCS 2015)

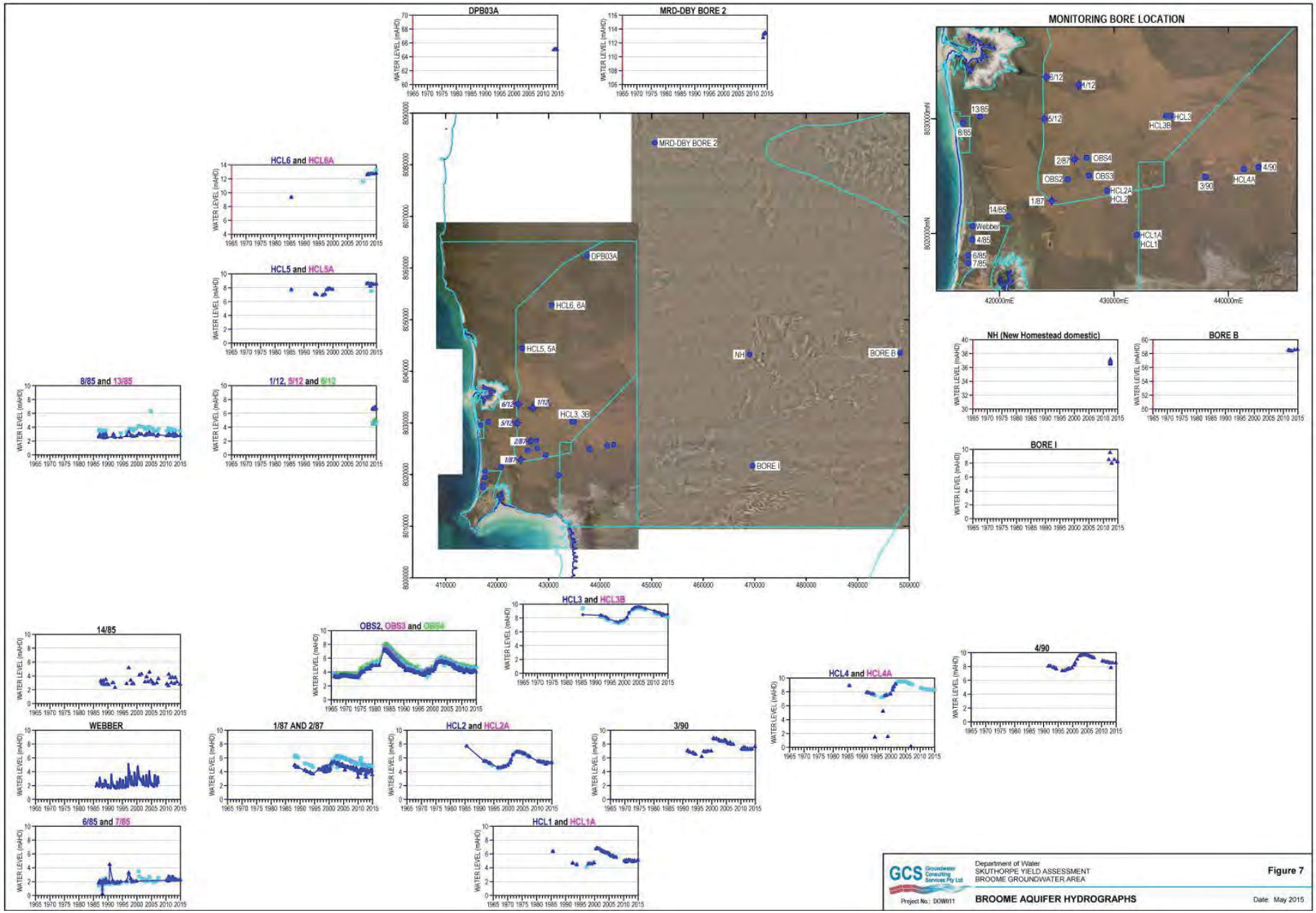


Figure 8: Broome aquifer hydrographs (Source: GCS 2015)

2.2 Climate and rainfall

The climate at Broome has a distinct ‘wet’ season from December to March and a ‘dry’ season for the remainder of the year. Rainfall during the wet season is variable as it is associated with thunderstorms, tropical lows and cyclones. These wet season weather systems generate approximately three-quarters of the average annual rainfall. Average monthly rainfall data recorded at Broome Airport demonstrate this seasonality and are provided in Table 3.

Rainfall records collected from across the region show that typically there is higher rainfall to the north of Broome than to the south. This is supported by rainfall records at Country Downs Station (approx. 95 km north of Broome), and is most probably due to an orographic effect. The townsite of Broome is located on a peninsula and considered to be in a rain shadow. It is likely that at Skuthorpe rainfall is higher than that recorded for Broome Airport.

Annual rainfall data for stations close to Skuthorpe are presented in Table 4. Synthetic rainfall records, provided by the Queensland Government’s Department of Information, Science and Innovation, were used to provide interpolated data to ‘patch’ data sets for stations or to provide interpolated data in the absence of a station.

The rainfall data in Table 4 were recalculated from calendar year (January to December) to financial year (July to June) so that each wet season could be considered in isolation.

The groundwater levels in the Broome Sandstone aquifer are strongly correlated to infrequent consecutive high rainfall years. These events raise the water levels in the aquifer and offset the drawdown impacts for a number of years. Comparative hydrographs and rainfall data provided in Figure 9 illustrate this trend.

The Department of Water has developed standard climate scenarios for five broad climatic regions based on Global Circulation Models (GCM). The scenarios are based on information from the World Climate Research Program and Intergovernmental Panel on Climate Change (IPCC 2007).

The GCM for northern Western Australia project a hotter future, but are less definitive on rainfall. Around half of them project that it will be wetter and half that it will be drier (Department of Water 2015b).

Because of the uncertainty associated with rainfall projections for the north, the department uses a long-term historical sequence of rainfall that captures variability to make decisions on water availability.

Long-term historical rainfall data for Skuthorpe was used in groundwater assessment work outlined in Section 2.4 of this report.

Table 3: Average monthly rainfall data Broome Airport (Source: GCS 2015)

Period (1940–2014)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average rainfall (mm)	181.6	178.8	100.1	26.2	26.7	19.6	7	1.7	1.4	1.5	9.3	57.7	613.5

Rainfall records provided by Bureau of Meteorology (www.bom.gov.au)

Note: long-term average is provided (1940–2014).

Table 4: Annual rainfall data (mm) at stations in proximity to Skuthorpe, recalculated to financial year (July to June: source: GCS 2015)

Station	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	10 year average	Average (1940-2014)
Skuthorpe	583	928	836	635	673	606	965	829	940	667	766	650
Roebuck Plains Station	629	849	684	557	666	501	893	793	880	668	712	633
Broome Airport	345	1032	663	557	700	544	832	688	963	710	703	614
Kilto Station	700	921	911	700	777	656	1036	922	1096	690	841	680
Thangoo Station	491	809	651	629	523	494	743	776	806	735	666	583
Country Downs	503	1232	1272	1041	1023	872	1383	1114	1707	841	1099	873

Note: rainfall records supplied by Queensland Government Department of Science Information technology and Innovation (https://www.longpaddock.qld.gov.au/silo/)

Patched data for Roebuck Plains, Thangoo and Country Downs. "Data drill' synthetic interpolation used for Skuthorpe and Kilto.

Broome Airport rainfall record was complete and data from Bureau of Meteorology are provided.

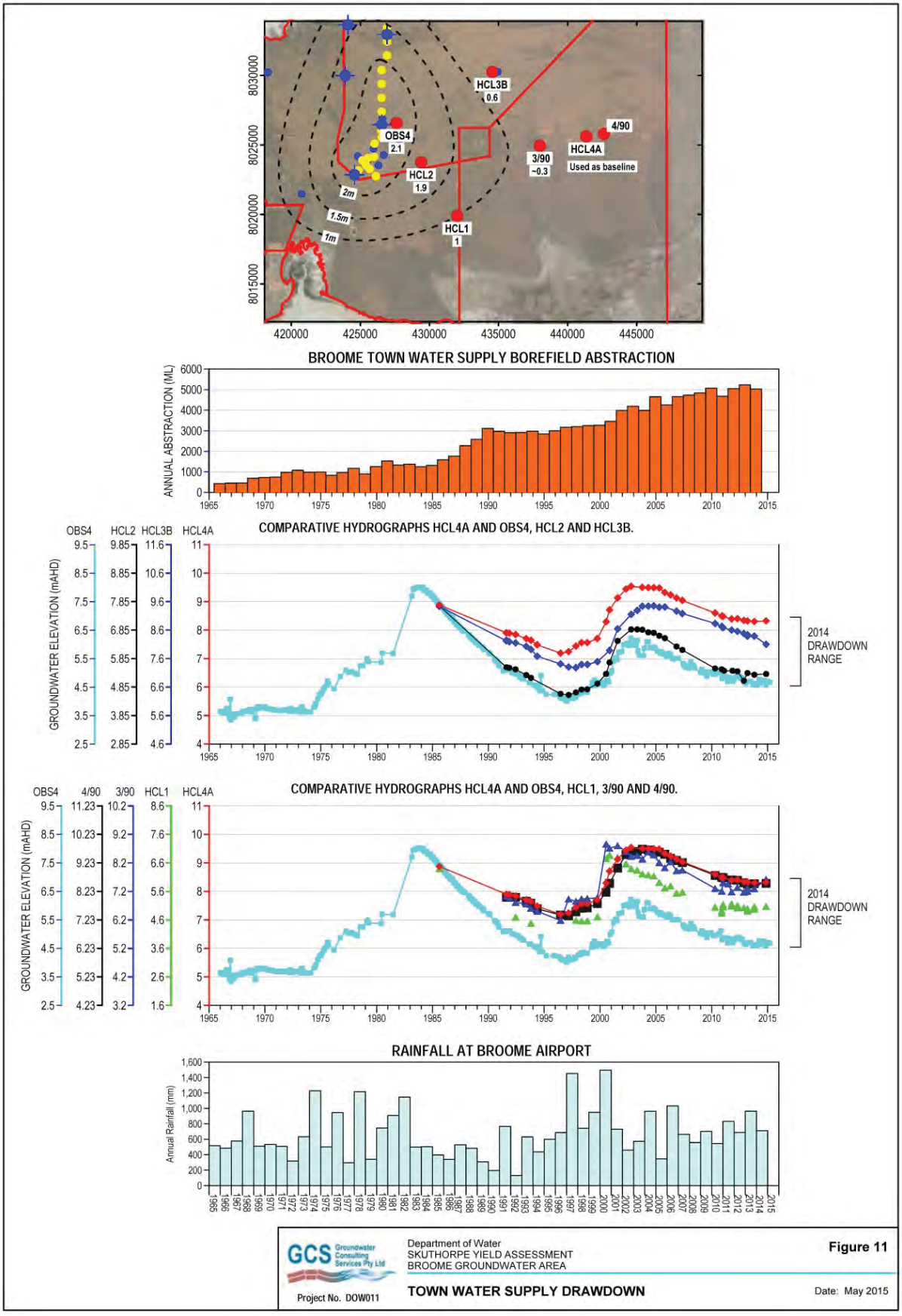


Figure 9: Broome aquifer hydrographs (Source: GCS 2015)

2.3 Groundwater assessment

To investigate the potential for increased water availability to support horticultural production, the department (through the Water for Food program) contracted GCS Consulting Pty Ltd to undertake an assessment of the Broome Sandstone aquifer in the Skuthorpe subarea. The study focused on:

- observations from monitoring data on the behaviour of the aquifer based on existing use (presented in Section 2.2)
- groundwater throughflow analysis in the Skuthorpe subarea
- rainfall recharge calculations.

The study did not:

- evaluate the storage capacity of the aquifer
- assess potential effects on groundwater levels, movement of the salt water interface, implications for other groundwater users or the environment
- set allocation limits and licensing policies required to support expansion of horticultural production.

A base case and extended scenario were considered for both groundwater throughflow and rainfall recharge calculations. The area considered for base and extended cases is presented as Figure 10.

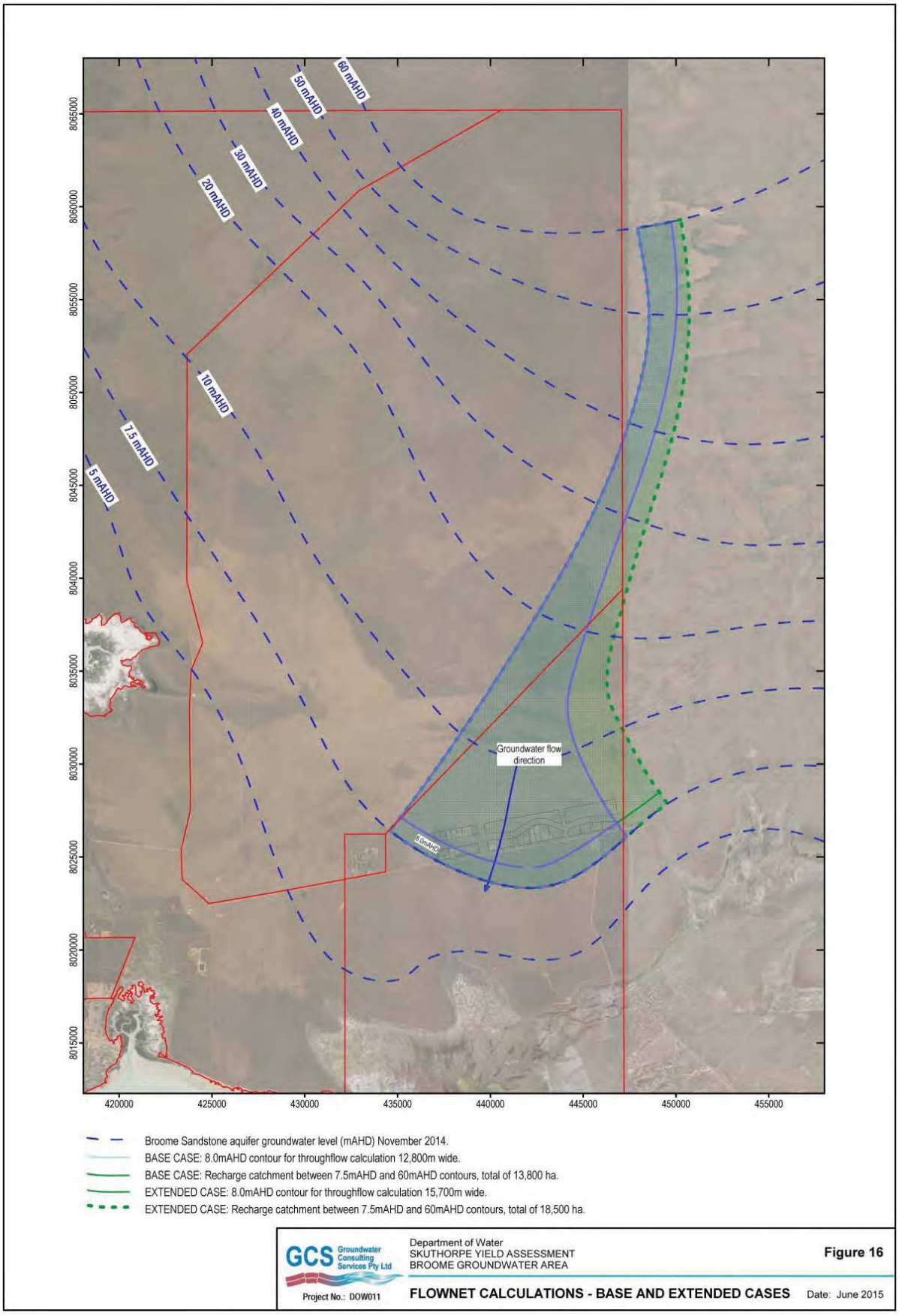


Figure 10: Flow-net calculations for base and extended scenarios

Groundwater throughflow

Groundwater throughflow can be considered as part of the renewable water budget for an aquifer. The volume of water flowing through the Broome Sandstone aquifer in the Skuthorpe subarea was calculated using Darcy's Law. The hydraulic conductivity, aquifer thickness and hydraulic gradient were based on local data. The width assigned to the groundwater flow was limited to the Skuthorpe subarea boundary for the base case. An extended case was also provided as pumping will draw on groundwater from neighbouring areas as well as the base case area.

The throughflow methodology used by Laws (1984) was adopted. A sensitivity analysis for hydraulic conductivity and the hydraulic gradient was included in calculations. Analysis results for the base case and the extended case are presented in Table 5 and Table 6 respectively.

Table 5: Groundwater throughflow analysis – base case (Source: GCS 2015)

Parameter	Low	Adopted	High	Units	Source
Hydraulic conductivity	15	30	40	m/day	Local pumping test
Aquifer width	12 800	12 800	12 800	m	Flow-net analysis – 8 m AHD contour
Aquifer thickness	80	80	80	m	Drilling & geophysical data
Hydraulic gradient	0.00036	0.004	0.00044	-	Flow-net analysis
Daily throughflow	5530	12 288	18 022	kL/day	Calculated
Annual throughflow	**2 018 304**	**4 485 120**	**6 578 176**	**kL/yr**	**Calculated**

When considering the results of throughflow calculations, the department noted the following:

- Hydraulic conductivity: A value of 30 m/day was high but justified as it is consistent with work completed by the department for the Dampier Peninsula.
- Aquifer thickness: A value of 80 m represents the full saturated thickness of the aquifer which is the potential best case.
- Hydraulic gradient: This was calculated from contours and considers a range of values.

Rainfall recharge

Aquifer recharge estimates are a useful indicator of potential groundwater availability. Two methods were used to estimate recharge and the results and limitations of each approach were considered when reviewing the allocation limit for Skuthorpe.

Table 6: Groundwater throughflow analysis – extended case (Source: GCS 2015)

Parameter	Low	Adopted	High	Units	Source
Hydraulic conductivity	15	30	40	m/day	Local pumping test
Aquifer width	15 700	15 700	15 700	m	Flow-net analysis – 8 m AHD contour
Aquifer thickness	80	80	80	m	Drilling & geophysical data
Hydraulic gradient	0.00036	0.0004	0.00044	-	Flow-net analysis
Daily throughflow	6782	15 072	22 106	kL/day	Calculated
Annual throughflow	**2 475 576**	**5 501 280**	**8 068 544**	**kL/yr**	**Calculated**

The long-term average rainfall, 650 mm/yr, for Skuthorpe was used in calculations. Estimates of rainfall recharge were set at 5% and 7.5% based on previous work in the region. The results of rainfall recharge calculations for both the base case and extended case are presented in Table 7.

Table 7: Rainfall recharge calculations (Source: GCS 2015)

Item	Base case		Extended case		Unit	Source
Catchment area	13 800	13 800	18 500	18 500	ha	Digitised area of the flow-net between 7.5 and 60 m AHD contours
Rainfall	650	650	650	650	mm/yr	SILO data drill for Skuthorpe
Recharge coefficient	0.05	0.075	0.05	0.075	-	Commonly used values in the range 5–7.5%
Annual recharge	4 485 000	6 727 500	6 012 500	9 018 750	kL/yr	Calculated

General comments

Estimates of rainfall recharge were similar to the groundwater throughflow calculation results. Results of both methods were used in the allocation limit review process. We used a risk-based approach for setting allocation limits. Further explanation of why and how this was carried out is outlined in Section 3.2.

2.4 Factors that may limit groundwater abstraction

In Skuthorpe there are risks to water levels and water quality from over-abstraction. Declines in groundwater levels in the Broome Sandstone aquifer will affect the maintenance of the salt water interface and therefore the reliability of the supply of fresh water. Water quality may be altered through landward movement of the seawater interface and localised saline upconing.

Public water supply

Abstraction of groundwater for public water supply predominates in the region. The Water Corporation is licensed to draw up to 6.2 GL/yr from the Broome Sandstone aquifer from its borefield in the Town Water Reserve subarea. The Water Corporation implements a monitoring program in line with licence conditions. Monitoring results are submitted to the department annually.

As the Town Water Reserve subarea is located immediately adjacent to the Skuthorpe subarea, it is important to consider the cumulative impacts of abstraction on the Broome Sandstone aquifer. This will be particularly important as use by all licensed users in the region increases.

Seawater interface

The seawater interface is the boundary between the fresh water throughflow of the aquifer and the denser, saline waters of Roebuck Bay. Over-abstraction from areas near the coast will increase the draw of saline water into the freshwater aquifer.

Over-abstraction and changes in rainfall events and recharge will cause landward movement of the saline waters from Roebuck Bay, posing a risk to existing users in Skuthorpe.

The GCS study (2015) concluded that the saline interface is just inland of monitoring bores located south of Broome Road and approximates the 5 m AHD groundwater contour. The study recommended that a groundwater level of 5 m AHD in bore HCL1/HCL1A is set as the critical elevation for the Broome Sandstone aquifer in the Skuthorpe area (GCS 2015). Previously, the department has set a level of 7 m AHD in monitoring bore 3/90 (on Broome Road) as a precautionary trigger level for management of the seawater interface.

The potential for movement of the seawater interface and risk of salinisation of the aquifer is described in Section 3.2.

Groundwater-dependent ecosystems

In administering the *Rights in Water and Irrigation Act 1914*, the Department of Water must provide for the sustainable use and development of water resources as well as the protection of ecosystems associated with those water resources.

The department undertook a desktop review to identify any groundwater-dependent ecosystems (GDE) that may be associated with the Broome Sandstone aquifer in and around Skuthorpe. The review used spatial datasets and existing mapping to:

- identify and describe the possible types of GDE
- map their likely distribution
- consider the conservation significance of GDE.

A full description of the work done and the results are provided as Appendix A.

Groundwater-dependent ecosystems occur along the edge of the pindan sand outcrop where it meets the coastal plain sediments. These GDE comprise wetlands and seepage zones supported by shallow groundwater. Key GDE in and adjacent to the Skuthorpe subarea is:

- Roebuck Bay: a Ramsar wetland and also listed in the *Directory of Important Wetlands of Australia*.
- Roebuck Bay Plains: wetlands are listed in the *Directory of Important Wetlands of Australia* (Environment Australia 2001).
- Willie Creek: listed in the *Directory of Important Wetlands of Australia* (Environment Australia 2001).

Further work is planned to define the scale, extent and condition of these GDE. This will be used to define the ecological water requirements for these systems. This was noted as an information gap during the allocation limit review process and identified as an implementation action, which is scheduled to be completed in 2016.

2.5 Social and cultural water values

The *Environmental water provisions policy for Western Australia* (Water and Rivers Commission 2000) identifies the following as the social values that require consideration in planning:

- Aboriginal cultural values
- Australian heritage values
- recreational and tourism pursuits
- landscape and aesthetic aspects
- educational and scientific aspects.

Social values relate to water found in its natural place, not water consumed for social benefit (Beckwith 2009).

Although specific studies to describe or quantify the social values associated with groundwater were not completed as part of developing this statement, some clear assumptions can be made. The presence of culturally important Aboriginal heritage sites is commonly linked to the availability of fresh water. Aboriginal peoples have always lived in and around the Broome area, hence the region has very high cultural values. Aboriginal heritage sites, if they exist, occur at the edge of the pindan (Yawuru 2013 cited in GCS 2015).

There are two registered Aboriginal sites in the Skuthorpe subarea and many more in the wider area, especially along the coast. An Aboriginal site is one that is of

significance according to Aboriginal tradition, archaeology, anthropology or history. There are also a number of 'other heritage places' registered in the wider area.

The Skuthorpe subarea, excluding the current precinct and the vast majority of the wider area are in the Jawru Native title area.

Roebuck Bay and surrounding waters are important for recreational fishing and general boating. Camping and bird watching are also common in the area. The Broome Bird Observatory is located on Roebuck Bay, adjacent to the subarea boundary.

2.6 Demand for water

We take into account both current and future demand for groundwater when setting allocation limits. Section 3.2 describes our assumptions for future demands in the plan area.

Current groundwater use

The department accounts for all types of groundwater use when determining allocation limits. All water extracted from the Canning-Broome (Broome Sandstone) aquifer in the Skuthorpe subarea is for either private licensing or exempt use. Table 8 provides a breakdown of how water is currently accounted for.

Stock, garden and domestic bore use (exempt from licensing) was estimated for Skuthorpe and represents 79 755 kL/yr or 1.6% of the total allocation. A figure of 30 000 kL/yr has been determined for garden and domestic bores for this review. This figure (based on the assumption that 2500 kL/yr is used across 12 properties for domestic purposes) was derived from the 10 000 kL/ha of water used to account for stock and domestic use in the north of the state. This is higher than the 1500 kL/yr used in the south of the state to account for the increased water needed to maintain gardens. Volumes allocated for domestic use are 2500 kL/yr with 2000 kL/yr for lawns and gardens and 500 kL/yr for household use.

Exempt use for stock was estimated for this review at 49 755 kL/yr. This figure was decided by calculating the area of the Roebuck Plains Station that falls in the Skuthorpe subarea. Cattle stocking rates and water use per head per year were provided by the Department of Agriculture and Food WA and cross checked with the Manager, Roebuck Plains Station. Stock bores are located on Roebuck Plains Station south of Broome Road. Ongoing supply of fit-for-purpose water in stock bores in the Skuthorpe subarea was a consideration in selecting the allocation limit.

Water at Skuthorpe is predominantly licensed for use for agricultural (horticulture) purposes and includes other uses such as turf farming, caravan and campsite, stock and product processing, commercial, recreation and nursery production. The volume of licensed water used by different land uses is summarised in Table 9.

Currently a total of 2 284 999 kL is licensed at Skuthorpe which represents 53% of the total allocation. Licensing information suggests that as little as 28% of licensed

entitlements are currently used. The predominant reason is that most licensees are in their first two years of a staged development and so have not yet reached full use.

Proponents are required to meet the terms and conditions of staged developments to maintain licensed entitlements. The level of use of licensed entitlements was considered when reviewing the allocation limit.

Table 8: Allocation of water in Skuthorpe in October 2015 (Source: WRL)

Groundwater resource (subarea and aquifer)	Allocation limit components (kL/yr)					
	Allocation limit	Licensable		Total Licensed	Unlicensable	Reserved water
		General	*Public water supply*		*Exempt*	*Public water supply*
Skuthorpe, Canning - Broome	5 000 000	4 920 245	0	2 284 999	79 755*	0

**No exempt component set prior to review, these figures are based on estimates as described above for domestic and stock use.*

Table 9: Total licensed water entitlements categorised by use in Skuthorpe October 2015 (Source: WRL)

Usage category	Total licensed entitlement volume (kL/yr)	Percentage of total entitlement volume (%)
Agriculture	2 046 399	89
Licensed domestic use	150 500	7
Commercial and institutional	88 100	4
Parks, gardens and recreation	2 000	0
TOTAL	**2 284 999**	**100**

Future groundwater use

Much of Skuthorpe area is undeveloped and covered with native vegetation. Existing agricultural production is located on lots along the Broome Road. Current production is based on irrigation of fodder crops (Rhodes grass, sorghum etc.) and horticulture crops (asparagus, melons, market gardens, mangos, bananas).

The Water for Food program is progressing an expansion of the Skuthorpe horticultural area with approximately 1000 hectares (ha) of land available between 12 Mile rural residential area and the Roebuck Plains Roadhouse. The 1000 ha land package is divided into two parts with 683 ha available for irrigation and currently vested with the State through the Department of Lands (DoL) in multiple holdings.

Native Title was extinguished on this land in 1998 as part of the Skuthorpe Land Agreement. The development area has a cultural and environmental corridor dividing the southern and northern areas.

The area has direct highway frontage and is in close proximity to the Broome international airport, service and port facilities. Mains power is established to the start of the proposed precinct.

The Department of Lands, through the Water for Food program, released the 683 ha land parcel to market in December 2015. While the development area is currently divided into multiple holdings, the Departments of Water's preference is for a single proponent to undertake the development to maximise the land and water opportunities and minimise risks to the environment.

An additional 450 ha is vested in the Yawuru Native Title Holders Aboriginal Corporation (Corporation) through Roebuck Plains Station. Exclusive Native Title exists over this land as part of the Rubibi native title claim.

The Shire of Broome, Department of Water and Department of Lands have had some preliminary discussions with Nyamba Buru Yawuru (NBY) regarding the potential development of this land as part of land release package or as a separate development.

Under the *Rights in Water and Irrigation Act 1914* a water licence is not automatically transferred or split between properties when land changes ownership or is sub-divided. Licensees need to contact the department before the sale or transfer of the land to ensure that the water licence is transferred to the new owner.

Figure 11 shows the existing land use with proposed land use changes highlighted in blue.

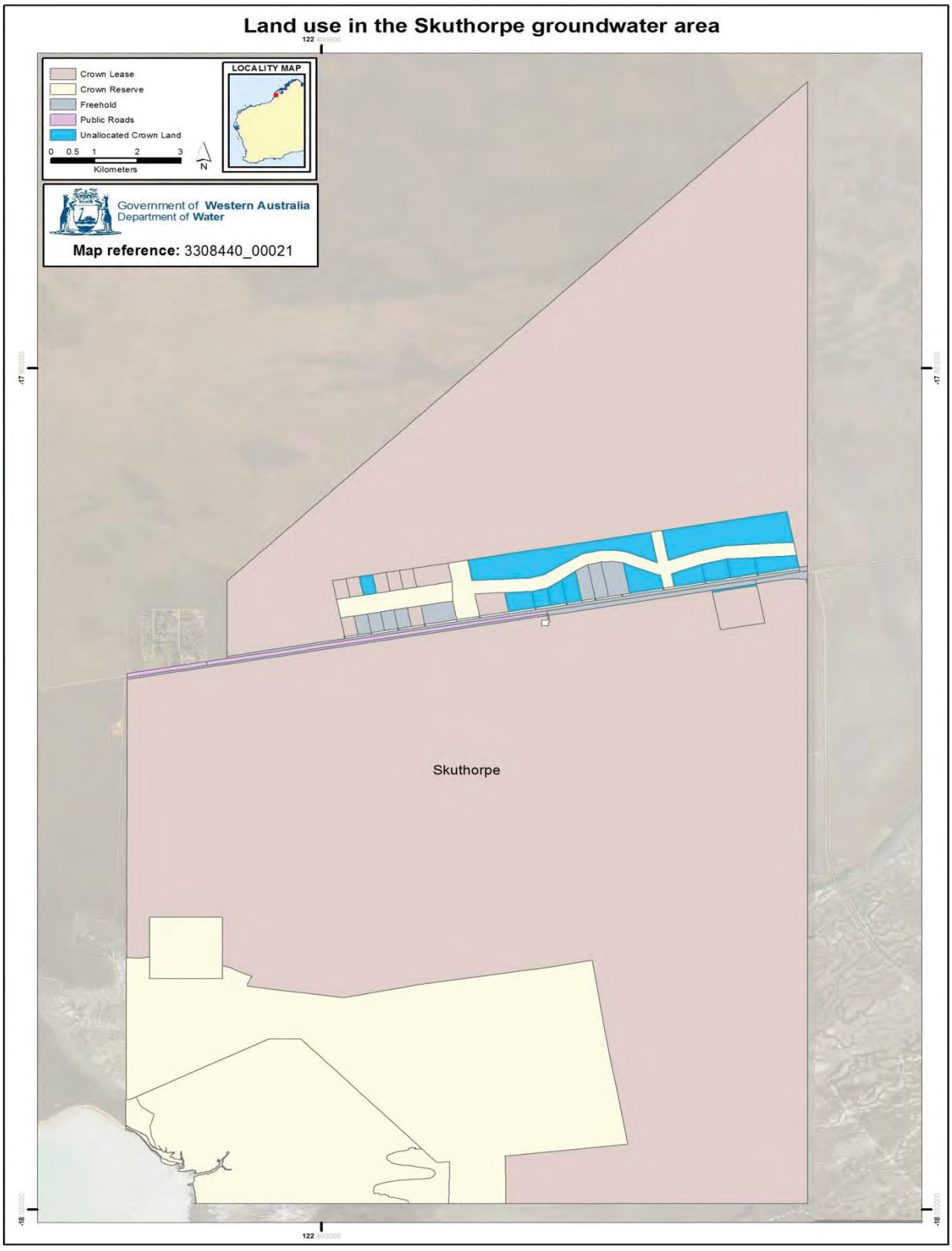
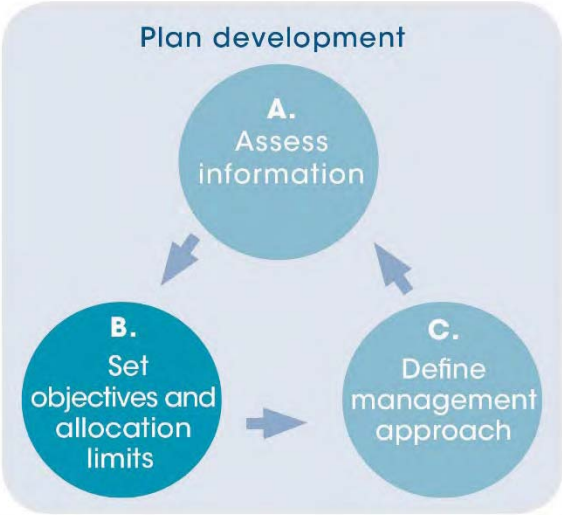


Figure 11: Land use in the Skuthorpe subarea, Broome groundwater area

3 Part B: Setting plan objectives and allocation limits



In Part B of the allocation planning process we:

- set objectives for our management of the area
- outline the methodology selected
- assess allocation options
- decide allocation limits.

Key points for this section:

- We developed measurable resource objectives to achieve the plan outcomes:
  - Abstraction does not cause inland movement of the seawater interface or saline upconing.
  - The supply of fit-for-purpose water is maintained for existing users.
  - Groundwater levels and quality are sufficient to minimise risks to groundwater-dependent ecosystems.
- A risk-based approach was used to set allocation limits and consider water demand for future land release.
- In setting the allocation limits we used the following to inform our decisions:
  - our understanding of groundwater-dependent ecosystems and significant environmental assets
  - trends in groundwater levels, estimates of groundwater throughflow and rainfall recharge, and assessment of the risk of taking more, less or the same volume of water
  - current licensed and exempt-from-licensing water use
  - future demand for water based on land use planning.

3.1 Setting objectives

The process of setting allocation limits, developing licensing approaches and policies, and setting up our monitoring and evaluation program are guided by the outcomes and resource objectives described below. They will also continue to inform our management as we implement the statement.

Outcome

To support the state government's Water for Food initiative by locating a long-term, reliable source of water from the unconfined Broome Sandstone aquifer at Skuthorpe

Resource objectives

To support the plan outcomes, our management is directed towards meeting specific water resource objectives. These must be measurable and relate directly to maintaining, increasing, improving, restoring, reducing or decreasing surface water flow, groundwater levels or water quality. They are measurable so that progress against them can be assessed during regular plan evaluations.

The 2013 review of allocation limits for the Broome Groundwater area identified the resource objectives for the Skuthorpe subarea. These objectives were reviewed based on new information and are summarised in Table 10:

- Abstraction does not cause inland movement of the seawater interface or saline upconing.
- The supply of fit-for-purpose water is maintained for existing users.
- Groundwater levels and quality are sufficient to minimise risks to groundwater-dependent ecosystems.

Key water resource risks identified in 2013 were also revised and amended to reflect discussion around objectives.

The key water resource risks were identified as:

- Seawater interface
- Impacts on other users
- Effects on environmental values.

Table 10: Developing the resource objectives and water management framework for Skuthorpe

Resource objectives	Main factors considered in developing the resource objective
Abstraction does not cause the inward movement of the seawater interface or saline upconing.	Preventing significant seawater intrusion into the aquifer as a result of abstraction will contribute to maintain the reliability of freshwater supply for existing users and the environment. Groundwater users and any groundwater-dependent ecosystems located along the coast are likely to be harmed if the seawater interface moves further inland.
The supply of fit-for-purpose water is maintained for existing users.	Reliability of supply to existing users will be maintained by managing abstraction of water to ensure groundwater levels remain within an acceptable range. Groundwater users along, and south of, Broome Road are likely to be affected by lowering of the water table if abstraction rates are higher than recharge. We aim to minimise this risk by licensing water within the allocation limit and reviewing monitoring data. Skuthorpe is adjacent to the Town Water Supply subarea. Water supply for Broome is drawn from a series of bores in the Broome Sandstone aquifer approximately 10–20 km from Skuthorpe. The cumulative impacts on regional groundwater levels from abstraction for horticulture and town water supply will be monitored to help future planning processes.
Groundwater levels and quality are sufficient to minimise risks to groundwater-dependent ecosystems.	Roebuck Bay and the Roebuck Bay Plains wetlands are highly valued environmental assets which require annual fresh groundwater discharge to maintain their ecological state. We expect that as abstraction in Skuthorpe increases there may be some changes in the volume of freshwater discharged at these sites. We aim to minimise this risk by how we manage groundwater abstraction in the statement area.

3.2 Setting allocation limits

What is an allocation limit?

An allocation limit is the annual volume of water set aside from a water resource for consumptive use. Allocation limits are the main tool that the Department of Water uses to ensure sustainable take and security of supply at the resource scale. The limit does not include water allocated to remain in the aquifer.

The allocation limit decision represents a balance between current and future groundwater use, and the volume of water that needs to be retained in the aquifer for environmental and resource protection purposes.

Selecting the best method to set allocation limits

Due to the relatively low use of groundwater (compared to other areas of the state) the department does not have an extensive groundwater monitoring program at

Skuthorpe. As a result, the extensive data needed to support quantitative methods for setting allocation limits, such as a numerical model, was not available.

Due to the timelines of the Water for Food program an update to allocation limits could not be postponed until more information was available. Additional work would have delayed the statement and the release of land for horticulture.

So, as in other areas of the state with limited monitoring data, we used a risk-based approach to set allocation limits. This typically involves understanding how water use (current and future) could affect the resource and decide whether more or less water can be allocated while still achieving the water resource outcomes and objectives.

How we set an allocation limit in the Broome Sandstone aquifer

Allocation setting framework

To assist our decisions about the allocation limits and licensing rules for further horticultural expansion in Skuthorpe, we developed four allocation scenarios. These build on the previous allocation limit decisions using current information about the aquifer and assumptions about the potential demands for groundwater. This approach does not depend on numerical modelling or additional yield calculations that can take account of seawater interface movement and effects on GDE. Each of these scenarios is outlined in Table 11.

Previous allocation of groundwater at Skuthorpe

Allocation limits for the Skuthorpe subarea were originally set through the development of the Broome Groundwater Management Plan (WAWA 1994). Water was allocated on the basis of 135 000 kL per 15 ha lot.

The allocation limit and subarea boundary for Skuthorpe was amended in 2013 as part of a review of allocation limits for the Broome Groundwater Area. Through this review, the allocation limit at Skuthorpe was raised from 2.1 to 5 GL/yr and the subarea boundary was expanded significantly. At the time of the 2013 review there were two large licence applications under assessment by the department. Allocation limit amendments at this time were based on meeting increased demand for water for horticulture in the area.

2015 Allocation limit decision for Skuthorpe

Table 12 below provides the rationale for the allocation limit decision for the Broome Sandstone aquifer at Skuthorpe.

Table 11: Allocation limit setting scenarios considered for Skuthorpe

Allocation scenario	Detail	Outcome
Scenario 1: Follow the Groundwater risk-based allocation planning process methodology (2011) to set allocation limit.	This method was developed for use in areas of limited knowledge and limited competing demands for water. As there is some knowledge of the Broome Sandstone aquifer, abstraction and potential impacts this scenario was not progressed further.	This method was assessed as unsuitable for this area as there was sufficient information to apply a more precise methodology.
Scenario 2: Retain the existing allocation limit of 5 000 000 kL/yr.	This scenario provided a review of the current management approach and licensing rules for abstraction. Updated hydrogeological information was reviewed to assess the effects of current abstraction and the effectiveness of existing licensing rules and management approaches. This review helped in deciding whether additional allocation to support expanded horticultural production could be endorsed. As the volume used is significantly lower than the licensed entitlements, the resource was not tested at full allocation and this was a key consideration in decision making.	More recent scientific data from the study completed by GCS in 2015 supported the current allocation limit of 5 000 000 kL/yr.

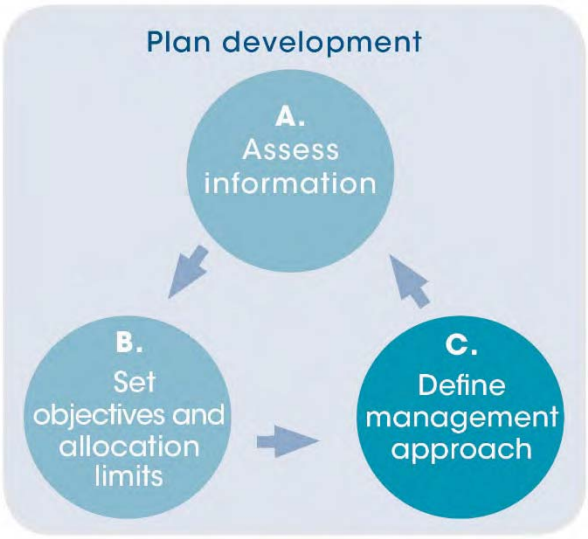
Allocation scenario	Detail	Outcome
Scenario 3: Proposed allocation limit of 7 000 000 kL/yr	An allocation limit of 7 000 000 kL/yr was considered. This figure was based on releasing an additional volume of water to support the expansion of the horticultural industry. After considering the available information and after discussion around Scenario 2, increasing the allocation limit to 7 000 000 kL/yr could not be supported at this time, as: • There is insufficient scientific data to support the higher volume. • There is potential to affect existing users, including the Broome town water supply. Without the scientific data to support this decision, the department's capacity to manage the resource at this level of allocation is reduced. So, in the absence of sufficient information, specifically as the resource was not tested even at an allocation of 5 000 000 kL/yr, the risk to existing users and the resource was too high.	There was insufficient evidence to support a limit of 7 000 000 kL/yr, but targeted management and monitoring could potentially identify additional water so Scenario 4 was developed.
Scenario 4: Consideration of a 'staged water development' above the current allocation limit of 5 000 000 kL/yr.	Building on Scenarios 2 and 3, it was decided that it was appropriate for the allocation limit to remain at 5 000 000 kL/yr. Licensing rules and management of the resource were reviewed and amended. Hydrogeological information used by the department in decision making suggests that up to an additional 2 000 000 kL/yr may be available for allocation. Proponents applying for water in excess of the allocation limit will be required to submit hydrogeological assessments to support their applications. More detailed assessment may identify that this volume cannot be abstracted sustainably.	Allocation limit set at 5 000 000 kL/yr. Review of hydrogeological assessments and precise management through licensing may support the release of additional water to support the expansion of horticultural production at Skuthorpe. Any decision to release additional water will ensure that existing users, the environment and resource integrity are not impaired.

Table 12: Allocation limits for the Broome Sandstone in Skuthorpe

Resource (subarea & aquifer)	Previous allocation limit (kL)	New allocation limit (kL)	Risk assessment and allocation limit decision
Skuthorpe – Broome Sandstone	5 000 000	5 000 000	**1. Groundwater trend assessment** • Measurement data (hydrographs) indicate that water levels in the Broome Sandstone aquifer are correlated with consecutive high rainfall years. Increased frequency and intensity of rain events are likely to offset the impacts of abstraction. However, the GCM for northern Western Australia are not definitive on rainfall – around half of them project that the climate will be wetter, and half that it will be drier (Department of Water 2015b). • Previous internal advice from Regional Hydrogeologists supports an allocation limit of 5 000 000 kL with management triggers.
			2. Current and future use • Most water is currently used for horticulture. It is estimated that only 28% of licensed entitlements are currently used. As the level of use is low (54% allocated), the resource is yet to be tested at full use. • Some domestic use is licensed, the remainder is estimated at 30 000 kL/yr. Unlicensed stock use is estimated at 49 755kL/yr. All unlicensed use will be accounted for. • Through the state government's Water for Food program, 650 ha of new land will to be released for horticultural development at Skuthorpe. Demand for water above the allocation limit is anticipated.
			3. Allocation limit decision *Allocation limit set at 5 000 000 kL/yr. Review of hydrogeological assessments and precise management through licensing may support the release of additional water to support the expansion of horticultural production at Skuthorpe. Any decision to release additional water will ensure that existing users, the environment and resource integrity are not impaired.* • Based on current knowledge, the level of risk to groundwater-dependent ecosystems and saltwater intrusion at Skuthorpe is likely to be low. Additional monitoring will be put in place to inform future

Resource (subarea & aquifer)	Previous allocation limit (kL)	New allocation limit (kL)	Risk assessment and allocation limit decision
			management. Further work is required to better understand the effects of abstraction on groundwater-dependent ecosystems, seawater interface and existing users. • Estimates of throughflow and rainfall recharge (GCS 2015) suggest an allocation limit of 5 000 000 kL is appropriate. Allocation above this will require a greater level of rigour around yield determination. • To meet objectives of the Water for Food program, future revision of allocation limits will be considered where sufficient evidence is presented to the department. This work will be done at the cost of proponents and undertaken in consultation with departmental representatives.

4 Part C: Defining the management approach



In Part C of the allocation planning process, we define the management approach in meeting the outcomes and objectives of the plan.

Key points from this section:

- The department has put in place a suite of management arrangements that complement our allocation limit decisions.
- The water licensing approach described in Chapter 4 aims to allocate water to enable development, achieve improvements to water use efficiency to optimise water use, facilitate water trading to maximise water availability and carry out hydrogeological work to work out if additional volumes can be taken sustainably.
- The local licensing rules set out in the allocation statement are designed to:
  - protect the integrity of the resource and groundwater-dependent ecosystems and establish the effects of licensed abstraction
  - prevent licensees from affecting each other's ability to take groundwater in accordance with a licence.
- The monitoring and evaluation outlined in Section 4.1 have been developed to support adaptive management of groundwater resources at Skuthorpe.

4.1 Water licensing in the plan area

A water licence issued under the provisions of the *Rights in Water and Irrigation Act 1914* provides legal and secure access to water. For Skuthorpe, the allocation statement outlines our water licensing approach and local licensing policies. These replace those in the Broome groundwater management plan (WAWA 1994).

Water licensing approach

Proponents can apply for water in three ways:

- Apply for water available now within the allocation limit;
- Trade with existing licence; and
- Apply for new water above the allocation limit.

Preliminary calculations for groundwater throughflow and rainfall recharge for Skuthorpe outlined in Section 2.4 indicate that up to an additional 2 000 000 kL/yr may be available if proponents are interested in more groundwater than is currently available in the allocation limit or through trading opportunities with existing users.

To access this additional water the proponent will need to submit a detailed hydrogeological assessment and demonstrate that the water can be taken without significantly affecting other users, the ongoing productivity of the resource or important environmental values. The assessment will likely include investigative drilling, monitoring, and groundwater modelling.

Local licensing policies

Local licensing policies outlined in the allocation statement are used to address resource management issues where they are not addressed by state-wide policy. They help us achieve the outcomes and resource objectives in the plan.

Local licensing policies will be applied to all new licence applications:

- if water becomes available through the relinquishment or trading of licensed volumes
- from departmental recouping
- when a licence is renewed

or

- if monitoring of the water resource indicates there is a need to amend a licence.

Table 13 describes the intent of each local licensing policy.

Table 13: The intent of the local licensing policies

Local licensing policy	Intent of local licensing policy
Requirements for hydrogeological assessment: • Licenses requiring hydrogeological assessment	The intent of these policies is to identify baseline information and any potential impacts to the groundwater through the assessment phase of the licensing process. Baseline data provides a benchmark for monitoring programs. Identifying the potential impacts early ensures that they are adequately considered and addressed before a licence is issued. Each proponent will be provided with guidance on what we require to complete our assessment of the licence application by the regional office. The department applies a consistent approach across the state to requesting hydrogeological information. Further details can be found in *Operational Policy no 5.12 – Hydrogeological reporting associated with a groundwater well licence* (Department of Water 2009). Assessment may identify that specific management strategies are required or that the water cannot be taken sustainably.
Water use efficiency: • Promoting efficient use of water	The intent of this policy is to maximise water availability at Skuthorpe by promoting the efficient use of water. It is anticipated that the demand for water will be greater than the current allocation limit. To help meet demand, the department promotes the use of irrigation techniques and equipment that will ensure efficient use of water. It is expected that increased efficiency will enable more produce to be grown with less water.
Metering conditions: • Requirements for metering	Meters are the most accurate tool for measuring the volume of water abstracted from a bore. The metering requirements for this policy are designed to document use, particularly linking local groundwater use with groundwater levels (cumulative impacts on the resource). Metering will also help the department assess applications for trading entitlements.
Monitoring conditions: • Requirements for monitoring	Monitoring provides knowledge of localised and regional impacts on water resources. The monitoring requirements for this policy are designed to recognise the impacts of abstraction on local and regional groundwater levels as well as groundwater quality. Monitoring will provide information on the effectiveness of licensing policy and will be used to decide when action is needed to prevent impacts on the resource and hence reliability of the supply of fit-for-purpose water. Monitoring will also be used to assess if additional water can be made available in the future.

Details of the local licensing policy developed for Skuthorpe are provided in Table 14.

Table 14: Local licensing policies for Skuthorpe groundwater area

Rule	Action
Requirements for hydrogeological assessment	
1	New and replacement production, investigation and monitoring bores may require down-hole geophysical logging (including gamma and resistivity) to be carried out at the time of drilling to establish baseline water quality and geology.
2	Applicants for a water licence requiring a hydrogeological assessment may be required to install one or more monitoring bores and carry out water level and quality monitoring for a period before the department issues a licence to take water.
Water use efficiency	
3	Applicants for a water licence will need to demonstrate how they will maximise their water use efficiency.
Metering conditions	
4	New groundwater licences, renewals and amendments > 50 000 kL/yr will likely require a meter.
5	New groundwater licences, renewals and amendments < 50 000 kL/yr will be dealt with on a case-by-case basis.
6	Communal bores used by multiple licensees will likely require metering at each point of off-take.
Monitoring conditions	
7	The department may include as a condition of the licence a requirement to: take monthly meter readings; measure electrical conductivity and water levels; and regularly collect water samples for salinity and major component analysis.
8	The department may include as a condition of the licence the need to take specified actions if water quality in the well exceeds a prescribed salinity trigger. This may include restrictions on take until water quality stabilises.

4.2 Monitoring and evaluation

Monitoring

Through monitoring groundwater resources, we will understand how the Broome Sandstone aquifer performs over time in response to abstraction and changes in groundwater recharge. This will help us assess how well the allocation limits, licensing approach and local licensing policies described above are helping us to meet the plan's outcomes and resource objectives.

Critically, it will inform our adaptive management approach for Skuthorpe.

The following details the monitoring we will carry out and the performance indicators we will use to assess how well we are meeting the specific resource objectives of the

plan. The monitoring program will also be important in understanding how rain events and the cumulative impacts of abstraction for town water supply are affecting groundwater resources. Ecological values will be defined and baseline monitoring will be used to set trigger levels for managing groundwater resources.

As outlined in Section 2.1 several monitoring programs are used in water resource management at Skuthorpe and Table 15 lists these.

Table 15: Monitoring activities at Skuthorpe

Item	Description
Licensee monitoring	Monitoring required under license conditions
Department monitoring	North West Broome Groundwater Monitoring Program
Ecological monitoring	Provide baseline data and Detailed program is provided as Appendix B

Through the allocation planning process the need for extra monitoring to provide a better overview of the impacts of abstraction was identified. We will be actioning this in 2015–16 as part of the Water for Food program and the North West Broome Groundwater Monitoring Program.

Table 16 outlines how monitoring activities relate to the resource objectives set for management at Skuthorpe.

As well as monitoring data relating to abstraction, any new information about climate, abstraction and land-use changes will be assessed during the licence renewal process. This will be used in our management response if significant issues with water levels or quality are detected. Our response could include further assessment work if the causes are not clear, increased compliance activity or, where necessary, changes to abstraction.

Table 16: Monitoring program for Skuthorpe

	Resource objective	Monitoring sites	Performance indicator	Frequency of data collection
1	Abstraction does not cause the inland movement of the seawater interface or saline upconing.	To be set through a review of the current monitoring program – Implementation item 6	Assess water level trends using water level monitoring triggers for management action. Water levels recorded at: • m AHD in bore HCL1/HCL1A; & • m AHD in bore 3/90 These will be reviewed once the saltwater interface monitoring (SWIM) bores are installed.	Bi-annually/twice a year
2	Supply of fit-for-purpose water is maintained for existing users.	To be set through a review of the current monitoring program – Implementation item 6	Water quality in existing bores is maintained. Salinity range to be decided.	Annually – data from loggers downloaded and reviewed annually.
3	Groundwater levels and quality are sufficient to minimise risks to groundwater-dependent ecosystems.	Groundwater-dependent vegetation monitoring sites: • Sites to be set through Implementation item 3 • Trigger levels to be set through Implementation item 4	Groundwater levels at groundwater-dependent ecosystem target sites remain above trigger set for water level and quality. To be set once baseline data collected.	Monthly – data from loggers downloaded and reviewed annually. To be decided by review of the current monitoring program – Implementation item 6

Evaluation

Evaluation is part of the department's adaptive management approach and helps us to continually improve our management of water resources. It is applied to all allocation plans and statements across the state.

We will evaluate the effectiveness of the management approach by comparing measured data to plan objectives once a year. The evaluation statement will be published at least every three years.

To support management of water resources at Skuthorpe and the potential expansion of the horticultural precinct, there are a number of actions that need to be addressed. These are in addition to managing to the allocation limit, licensing policy and monitoring and are outlined in Table 17.

Table 17: Actions for implementation

Action		Responsibility	Timeline
Resource assessment			
1	Assess the condition and trend of the groundwater resources.	North West Region, Water Information and Water Resource Assessment	Annually
2	Review current bores: • Potentially replace monitoring bore 5/90 at 12 Mile • Install a saltwater interface monitoring (SWIM) bore south of Broome Road	Water for Food	2015–16
Allocation planning			
3	Survey to establish the location & extent of groundwater-dependent ecosystems.	Environmental Water Planning	Quarter 2, 2016
4	Select water level triggers for groundwater-dependent ecosystems.	Environmental Water Planning	Quarter 2, 2016
Licence compliance			
5	Ensure compliance with licence conditions to maximise water available for use.	North West Region	2016
Monitoring			
6	Review, and where appropriate, amend the North West Broome Groundwater Monitoring Program.	Water Resource Assessment, Water Allocation Planning, North West Region	2016
Communication and evaluation statement			
7	We will publish a comprehensive evaluation statement at least every three years to ensure that all stakeholders are informed of how the	Water Allocation Planning	2019

	resource and management framework is performing.

Appendices

Appendix A — Environmental scan

Background

The Water for Food initiative is a key state government investment designed to increase economic growth and employment in regional communities by defining water resource availability and land tenure pathways to facilitate new irrigation areas and increase the size and water efficiency of existing irrigation districts.

The Skuthorpe horticultural precinct, which is located between 22 km and 32 km east-northeast of Broome, is a potential development area. It was selected based on the availability of land that can be released in the short term and the availability of low salinity, easily accessible groundwater within the underlying, unconfined Broome sandstone aquifer.

The Skuthorpe horticultural precinct is located within the Skuthorpe subarea of the Broome groundwater area. The department has recently reviewed the Broome groundwater area subarea boundaries and allocation limits. In 2014 the Skuthorpe subarea was extended to run from 12 Mile (west) to the Roebuck Plains roadhouse (east) as well as upstream and downstream (north and south) to simplify groundwater resource management (Groundwater Consulting Services 2015).

Approach

This document describes the groundwater-dependent values of the subarea and the risks of further development of the resource. It follows on from a recent study to estimate groundwater through-flow in the Broome sandstone aquifer at Skuthorpe (Groundwater Consulting Services 2015).

We conducted a desktop scan with limited field visits in July and October 2015, to identify any groundwater-dependent ecosystems that may be associated with the Broome aquifer in and around the Skuthorpe subarea.

The review:

- identified and described the possible types of groundwater-dependent ecosystems
- mapped the likely distribution of groundwater-dependent ecosystems
- considered the conservation significance of groundwater-dependent ecosystems
- assessed the risk to values from water resource development.

Spatial datasets (DoW, other state agencies and Commonwealth Department of Environment) were used to overlay the sub-area and development area with aerial photographs and existing mapping of groundwater-dependent ecosystems, wetlands and other hydrographical features (e.g. rivers, creeks, springs). This allowed us to identify known or potential groundwater-dependent ecosystems. Other layers were

then used to describe the ecological and cultural values of groundwater-dependent ecosystems and the wider sub-area and to identify high priority ecosystems.

Environmental and social values

Wetlands of International or national importance

- Roebuck Bay

Roebuck Bay is a Ramsar wetland and is also listed in the Directory of Important Wetlands of Australia (Environment Australia 2001). It extends into the south-eastern corner of the sub-area and is 13 km south of Skuthorpe development area. As a Ramsar wetland it may support up to 38 migratory bird species (Department of Environment 2000). A further eight threatened fauna species are listed in the area.

The site receives tidal seawater as well as fresh surface and groundwater (Bennelongia 2009) from a major paleoriver system associated with the Fitzroy River (Vogwill 2003; Bennelongia 2009) and from the Broome sandstone. It is the balance between the two influences the residual groundwater salinity and the distribution of plants and animals. An unusual freshwater sponge community has been noted from within the Bay (Graham 2001).

The freshwater-dependent components of the system could be threatened from regional water use or pollution (Graham 2001; Bennelongia 2009).

- Roebuck Bay Plains

Roebuck Bay Plains wetlands are listed in the Directory of Important Wetlands of Australia (Environment Australia 2001). Two wetlands occur to the east of the sub-area boundary. However, during the 2015 site visit these wetlands were completely dry and heavily disturbed by cattle (Figure 2). Lake Eda is approximately 15 km from the eastern boundary of the development.

Groundwater discharge from the Broome aquifer can be seen as surface expressions of the freshwater in the plains north of Crab Creek (Bennelongia 2009). This may create freshwater dependant ecological niches which could be threatened by regional water use or pollution. Crab Creek discharges into Roebuck Bay.

- Willie Creek

Willie Creek is listed in the Directory of Important Wetlands of Australia (Environment Australia 2001). It is 13 km northwest of the Skuthorpe sub-area and development area boundary. Here are two freshwater spring-fed wetlands, Nimalaica Swamp and an unnamed lake. These are vegetated with spike rush (*Eleocharis dulcis*) sedgelands, *Melaleuca cajuputi*, *Timonius timon* and *Pandanus spiralis* forest. Many of the species found here are at their southern range limits or are disjunct populations (DPaW 2014).

Willie Creek and associated wetlands - including the Nimalaica clay pan community - are within 5 km of the existing Broome town water-supply borefield. Graham (2001) and Groundwater Consulting Services (2015) note this system is potentially at threat from groundwater abstraction associated with the expansion of Broome.

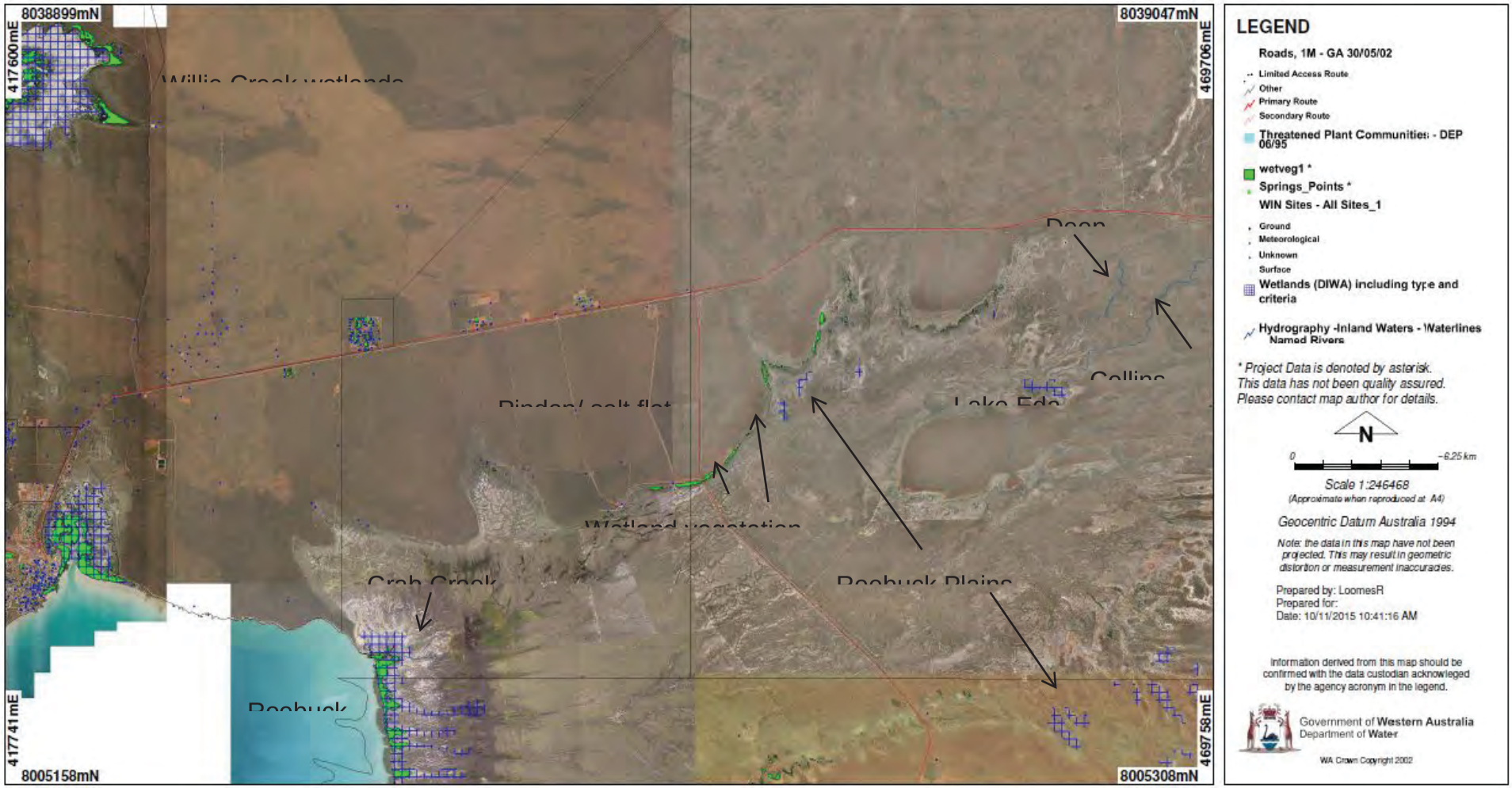


Figure A1 *Ramsar and DIWA wetlands and* potential groundwater-dependent ecosystems *within and adjacent to the Skuthorpe sub-area*

Figure A2 A heavily grazed Roebuck Plain wetland in Skuthorpe sub-area

Threatened ecological communities

- Monsoon vine thickets

Monsoon vine thickets of the Dampier Peninsula are listed by the Department of Environment and Conservation (now DEPaW) as a threatened ecological community (TEC) and recently nominated for listing under the Commonwealth EPBC Act. They occur 15 km south-west of the Skuthorpe subarea boundary and 20 km southwest of the Skuthorpe development area.

Many Kimberley vine thickets occur near freshwater springs or shallow groundwater and support species including *Terminalia* sp., *Pandanus spiralis, Melaleuca dealbata* and *Lophostemon grandiflorus* also associated with shallow groundwater (English 2010).

The vine thickets of the Dampier Peninsula represent the most southern occurrences of rainforest in Western Australia and their vegetation assemblages are distinct from other rainforest communities found throughout the Kimberley and northern Australia (English 2010).

Native vegetation

Native vegetation currently covers upwards of 95% of the sub-area and wider region.

In addition to groundwater-dependent vegetation associated with the Willie Creek wetlands and the monsoon vine thickets, there are a number of species likely to occur near springs/ seepages or in areas of shallow groundwater. These include *Corymbia bella* and *Melaleuca alsophila,* both know from freshwater wetlands on the Dampier Peninsula, and *Eucalyptus camaldulensis* common to many riparian ecosystem of the Kimberley (Graham 2001).

There are at least two potential groundwater-dependent vegetation communities that are poorly represented within reserve systems in the region – 'medium woodland *Eucalyptus camaldulensis* and *Terminalia* spp.' and 'medium woodland of *E. camaldulensis* and *Terminalia* spp. mixed with coolibah and *C. bella.'* (Graham 2001).

Threatened flora and fauna

Eight EPBC listed threatened fauna species are likely to occur in the area surrounding Skuthorpe - four birds, three mammals and a reptile. The habitat requirements of the four birds - *Erythrotriorchis radiates* (red goshawk), *Erythrura gouldiae* (Gouldian Finch), *Rostratula australis* (Australian Painted Snipe), *Tyto novaehollandiae kimberli* (Masked Owl (northern)) – include permanent freshwater and/or fringing woodlands along watercourses and *Melaleuca* swamps (Department of Environment 2000).

A P3 flora species has been recorded within the current extent of the Skuthorpe development precinct. There are 20 other recorded occurrences of P1, P3, P4 and threatened flora species within the surrounding area.

Conservation reserves

Parts of Waterbank Station, adjacent to the northern boundary of the sub-area – have been recommended for included in the Coulomb Point Nature Reserve.

Other GDE

Areas of permanently green vegetation across the Dampier Peninsula were mapped using satellite imagery (Boggs 2011). Although some areas identified were mangroves, there were other areas of freshwater vegetation. Some of these occur in seepages along the interface of pindan soils and Roebuck Plains.

Areas along the interface within and adjacent to the eastern boundary of the Skuthorpe sub-area were visited in July and October 2015. *Sesbania formosa* (white dragon tree) and *M. nervosa* - both freshwater species - were identified in various patches (Figure A3), along with *M. alsophila* – a saltwater tolerant species. The presence of these species supports the supposition that fresh groundwater discharges along the pindan/ salt flat interface.

Figure A3 Sesbania formosa (left) and Melaleuca alsophila (right) along the pindan/ salt flat interface

Collins and Deep creeks occur beyond the eastern boundary of the sub-area. Both flow north-west across Roebuck Plains and alongside DIWA listed wetlands to discharge into Lake Eda. During the October 2015 site visit both saltwater and freshwater Melaleucas were noted – *M. dealbata* and *M. alsophila* (Figure A4). A small, muddy pool was also noted on Collins Creek (Figure A5). The presence of freshwater species and a permanent pool (still present at the end of the dry season) suggests groundwater inputs.

Figure A4 Melaleuca dealbata at Deep Creek

Figure A5 Muddy, permanent pool on Collins Creek

Cultural values

Aboriginal peoples have always lived in and around the Broome area, hence the region has very high cultural values. There are two registered Aboriginal sites within the Skuthorpe sub-area and many more within the wider area, especially along the coast. An Aboriginal site is one that is of significance according to Aboriginal tradition, archaeology, anthropology or history. In addition a number of 'other heritage places' are also registered within the wider area.

The Skuthorpe sub-area, excluding the current precinct, and the vast majority of the wider area are within the Jawru native title area.

Social values

The West Kimberley, in its entirety, is on the Commonwealth Heritage List (Environment Australia 2001).

Roebuck Bay and surrounding waters are important for recreational fishing and general boating. Camping and bird watching are also common in the area. The Broome Bird Observatory is located on Roebuck Bay, adjacent to the sub-area boundary.

Environmental and cultural values checklist

Values	Sub-area	Wider area
1. Native vegetation and fauna		
Conservation reserves and land recommended for conservation reserves	-	*
Listed WA threatened ecological community	-	*
Habitat for WA threatened fauna or flora	*	*
Nationally listed threatened ecological community	-	*
Any native vegetation not associated with a wetland or watercourse	*	*
Habitat for nationally threatened fauna	*	*
2. Wetlands and watercourses		
Wetlands and watercourses that are listed as of national importance	*	*
Wetlands and watercourses to which an international agreement applies (e.g. Ramsar)	*	*
Wetlands or water courses where management category has not been assigned but may be of high conservation priority for any reason.	*	*
3. Sites of heritage, cultural or social significance		
Aboriginal heritage sites associated with any of the above categories	*	*
Heritage sites associated with any of the above categories	-	*
Recreation or tourism sites associated with any of the above categories	-	*
4. Matters of National Environmental Significance		
World heritage properties	-	-
National heritage places	*	*
Wetlands of international importance (listed under the Ramsar Convention)	*	*
Listed threatened species and ecological communities	*	*
Habitat for migratory species protected under international agreements (JAMBA, CAMBA, ROKAMBA)	*	*

Appendix B — Ecological Monitoring Program

Monitoring water resources and their dependent ecosystems is a requirement of licences under the *Rights in Water and Irrigation Act 1914*. The department will require licensees to monitor groundwater-dependent ecosystems in the Skuthorpe subarea and those dependent on throughflow from the Skuthorpe subarea.

Ecological monitoring by licensees of the department itself has often focused on the vegetation component of groundwater-dependent ecosystems but we may also require monitoring of other groundwater-dependent ecosystems components including fauna.

We have developed a general approach to monitoring vegetation in areas with few or no previous groundwater-dependent ecosystems investigations. The department will use this approach to identify and describe groundwater-dependent ecosystems in the area, define their likely level of groundwater dependence and assess their current, pre-development or baseline condition. Then we will define a series of groundwater performance indicators or trigger levels that licensees must either adhere to or, if breached, take management actions to address. Licensees will also be required to commit to monitoring vegetation in key areas.

Several potentially groundwater-dependent wetlands and associated vegetation were identified in the Skuthorpe Environmental Scan:

- Roebuck Bay Plain wetlands including Lake Eda
- vegetation associated with freshwater seepages along pindan/Roebuck Bay Plains salt-flat interface
- Crab Creek which flows into Roebuck Bay
- other groundwater-dependent ecosystems dependent upon through flow from the Skuthorpe subarea including freshwater wetlands of Willie Creek System (Directory of Important Wetlands listed).

The department will arrange field visits to verify the location of these groundwater-dependent ecosystems and make the following assessments:

1. Describe vegetation community types/key species trees and fauna in areas most likely to be affected by drawdown (there are a suite of species known to be groundwater-dependent).
2. Define level of dependence according to:
    a. Depth to groundwater – < 10 m deep usually indicates groundwater-dependent ecosystems
    b. Canopy condition (3 point scale or canopy photography) – dense, healthy canopies are an indicator of good water availability
    c. Species distribution/range across the site
3. Assess ‘wetland’ vegetation condition and health:

   a. Assess baseline (pre-development) condition assessment at the end of the dry season when vegetation is most dependent on groundwater.
   b. Describe the age class structure (tree size) – a good range of age classes is an indicator of a healthy, viable vegetation community.
   c. Steps 2b and 2c above will also help define vegetation condition.

4. Monitoring by licensee:
   a. Ecological annual vegetation condition assessment (as for baseline).
   b. Hydrological – salinity, saltwater interface and groundwater depth at existing and/or new bores along pindan/salt flat interface and other groundwater-dependent ecosystems locations.

Glossary

Terms commonly used in reference to water resource management in the Skuthorpe statement area.

Abstraction	Withdrawal of water from any surface water or groundwater source of supply.
Allocation limit	Annual volume of water set aside for use from a water resource.
Consumptive use	Water used for consumptive purposes considered as a private benefit including irrigation, industry, urban and stock and domestic use.
Ecological values	The natural ecological processes occurring in water-dependent ecosystems and the biodiversity of these systems.
Ecological water requirement	The water regime needed to maintain the current ecological values (including assets, functions and processes) of water-dependent ecosystems consistent with the objectives of an ecological water requirements study.
Fit-for-purpose water	Water that is of quality suitable for the intended end purpose. It implies that the quality is not higher than needed.
Groundwater area	The boundaries proclaimed under the *Rights in Water and Irrigation Act 1914* and used for water allocation planning and management.
Groundwater-dependent ecosystem	An ecosystem that is at least partially dependent on groundwater for its existence and health.
Groundwater-dependent social value	An in-situ quality, attribute or use associated with a groundwater resource (or dependent on a groundwater resource) that is important for public benefit, welfare, state or health.
Licence (or licensed entitlement)	A formal permit which entitles the licence holder to take water from a watercourse, wetland or underground source under the *Rights in Water and Irrigation Act 1914.*
Ramsar-listed wetland	Wetlands recognised as internationally significant and registered on the list of Convention of Wetlands of Importance (Ramsar 1971).
Reliability	The frequency with which a water licence holder can obtain their full licensed volume.
Seawater or saltwater intrusion	The inland or upgradient intrusion of salt water into a layer of fresh groundwater, from the sea or from the edges of the aquifer.
Saltwater upconing	The upward movement of saline water resulting from excessive pumping, affecting fresh groundwater resources above.
Subarea	A subdivision, in a surface or groundwater area, defined to better manage water allocation. Subarea boundaries are not proclaimed and can therefore be amended without being gazetted.

Shortened forms

AEM	Airborne electromagnetic surveying
AHD	Australian height datum
CSIRO	Commonwealth Scientific and Industrial Research Organisation
GCM	Global circulation models
GDE	Groundwater dependent ecosystems
IPCC	Intergovernmental Panel on Climate Change
SWIM	Salt water interface monitoring
TDS	Total dissolved solids

Volumes of water

One litre	1 litre	1 litre	(L)
One thousand litres	1000 litres	1 kilolitre	(kL)
One million litres	1 000 000 litres	1 Megalitre	(ML)
One thousand million litres	1 000 000 000 litres	1 Gigalitre	(GL)

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Databases

Water Resource Licensing database, Department of Water

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