Western Davenport Background Report 2024-2034

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Front page photo: Growing irrigated hay using a centre pivot

Acknowledgement of Country

The Department of Lands, Planning and Environment respectfully and proudly acknowledges the Northern Territory's Aboriginal people and their rich cultures. We pay respect to Elders past and present.

We acknowledge Alyawarr, Kaytetye, Warumungu and Warlpiri peoples as the Traditional Owners and custodians of the lands and waters of the Western Davenport Water Control District.

We recognise the intrinsic connection of Traditional Owners to Country and value their ongoing contribution to managing the lands and waters. We support the need for genuine and lasting partnerships with Traditional Owners to better understand cultural connections, and we will work to establish lasting partnerships to manage water together, now and into the future.

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1. Overview

About the water allocation process

Water allocation is the process of determining how much water must stay in the environment to protect ecological functions and environmental requirements and how much is available for drinking and regional economic priorities. Water allocation in the Northern Territory is undertaken at a regional level within defined areas known as water control districts, which are declared by the Minister for Water Resources (Minister) by *Gazette* notice.

About the Western Davenport water control district

The Western Davenport water control district (the district), an area of about 24,500 km² located approximately 150 km south of Tennant Creek (Schedule C). The district was first identified for its potential as a commercial horticultural precinct in 2007 through a soil and land suitability assessment for irrigated agriculture. The assessment identified more than 43,830 hectares of land suitable for a range of irrigated agricultural cropping uses, and has been supplemented by investigative water studies, the declarations of the previous water allocation plans, and more recently through the studies undertaken as part of Mapping the Future program, which investigated land, biodiversity and water resources across the region.

About this document

This document is one of three core documents prepared as part of the water allocation process for the plan area. This document references other documents and guidelines that may relate to the plan area, but which do not form part of the core documents. The three core documents are:

Western Davenport Water Allocation Plan 2024–2034 (the plan). The plan is declared by the Minister under section 22B(1) of the *Water Act 1992* (the Act)[1]. The plan describes the estimated sustainable yield for the water resources of the plan area in three water management zones (Schedule D). The estimated sustainable yield is the volume of water that can be taken sustainably from the water resources to which the plan applies. The plan allocates that water amongst declared beneficial uses and provides for the trading of water. The plan takes effect from the date in the *Gazette* by the Minister and will remain in force for a period of ten years.

Western Davenport Background Report 2024–2034 (this document, the report) provides details on the information and processes that informed the plan, including available data and research on the surface and groundwater water resources of the plan area. It also describes the key environmental values of the plan area and their dependency on water resources, and the social and developmental context of the region, including existing water use and projections of future water demand. The report collates the information and knowledge regarding the plan area at the time of its preparation.

Western Davenport Implementation Actions 2024–2034 (the implementation actions) details how the requirements in section 34 of the Act with respect to the water resources of the plan area are fulfilled. It defines a continuous program for the assessment of water resources in the plan area, including the investigation, collection and analysis of data concerning the occurrence, volume, flow, characteristics, quality and use of water resources. That program is described within the document as a series of implementation actions which includes a body of research, monitoring and analytical work.

The Controller of Water Resources must consider any water allocation plan applying to the area in question when making a decision referred to in s 90(1) of the Act. The Western Davenport 2024-2034 background report and implementation actions and other factors may be taken into account, where relevant to the decision.

[1] https://legislation.nt.gov.au/en/Legislation/WATER-ACT-1992

2. Summary

Overview

This section provides an overview of the development of the water allocation plan and the planning processes used in the district.

Planning is an iterative process and this is the fourth replacement of the plan for the district.

The plan is comprised of three water management zones: Davenport Range, Central Plains and Southern Ranges aligned to different hydrogeologically distinct environments. The district is situated approximately 150 km south of Tennant Creek and covers an area of about 24,500 km^2.

The purpose of this document is to reference and summarise the foundational information and knowledge that informed the development of the Western Davenport Water Allocation Plan 2024–2034 and the Western Davenport Implementation Actions 2024–2034.

The dictionary in Schedule A defines particular words used in this report and acronyms are provided in Schedule B.

Unless otherwise stated, terms defined in the Act have the same meaning when used in this report.

2.1 Water planning process

Information on the department's approach to water allocation planning is available on the department's website[2].

As part of the department's commitment to the National Water Initiative the department is continuously improving water management across the Territory. The department has restructured the Territory's water allocation plans into a series of three public documents to more clearly present the statutory requirements, supported by applicable documents relevant to respective water control districts and plan areas. The new structure will be applied to new plans under development and progressively applied to existing plans as they are reviewed and replaced over the coming years.

2.1.1 Western Davenport water control district

Under section 22 of the Act, the Western Davenport water control district (the district) was first declared on 15 July 2009.

A map of the district is shown in Schedule C.

2.1.2 Water management zones

Three water management zones are recognised within the district. These are the Davenport Range, the Central Plains and the Southern Ranges as shown in Schedule D.

2.1.3 Previous Western Davenport water allocation plans

The Western Davenport region was first identified for its potential as a commercial horticultural development in 2007 through the soil and land suitability assessment for irrigated agriculture, which identified more than 43,830 hectares of land suitable for a range of irrigated agricultural cropping uses.

[2] About water allocation planning | Department of Environment, Parks and Water Security

The first water allocation plan in the district was declared in 2011. The plan was subject to a substantial review from 2016–2018 and a further plan was declared in 2018 for three years. A report on the community engagement undertaken prior to the declaration 2018-2021 plan is available[3].

That plan expired in 2021 and a new plan declared for 2021-2022 with limited changes to ensure compliance with legislative amendments in the Act since the previous plan. The changes were to ensure compliance with legislative amendments in the Act since the previous plan, namely the establishment of an Aboriginal water reserve through legislation and the inclusion of new beneficial uses of water. An explanation of the changes is available[4]. The department also released a factsheet to provide an overview of key issues raised through a variety of channels[5]. That plan expired on 6 December 2022.

A new draft water allocation plan for the period 2023-2033 (the draft plan) was released for public consultation between March and May 2023. The draft plan was developed with input from the Western Davenport and Ti Tree water advisory committee (the committee). This statutory committee has diverse membership representing Aboriginal, horticultural, environmental, remote community water supply and community interests and included, NT Farmers Association and the Central Land Council.

2.2 Population and land uses

The pastoral industry has a long history in the district and is a major land user. Five pastoral leases overlap the district (Stirling, Murray Downs, Elkedra, Neutral Junction and Singleton stations). The district also supports a number of tourism enterprises, as well as an established horticultural industry. There is strong interest in increasing agricultural and horticultural development in the district, and some mining exploration is occurring in the general area.

The amount of water used for agricultural purposes in the Central Plains water management zone over the last five years has been about 5 per cent of the consumptive pool. In 2021-22 the reported water use was less than 5,000 ML per year.

Two proposed mines will take water from water resources in the district. Mount Peake Mine proposes to take water from the Hanson River palaeochannel in the southwest of the district in the Southern Ranges water management zone. The Ammaroo Phosphate Mine proposes to take water from a bore field outside the district, however modelling presented in the environmental impact statement indicates drawdown from the proposed bore field will occur in the district within the eastern part of the Central Plains water management zone.

Figure 1 shows places and land use.

[3] Report on community engagement: Western Davenport Water allocation plan review 2017

[4] Summary of changes to the Western Davenport Water Allocation Plan 2018-2021 to declare the Western Davenport Water Allocation Plan 2021-2022

[5] Western Davenport Water Allocation Plan - Fact sheet 2021

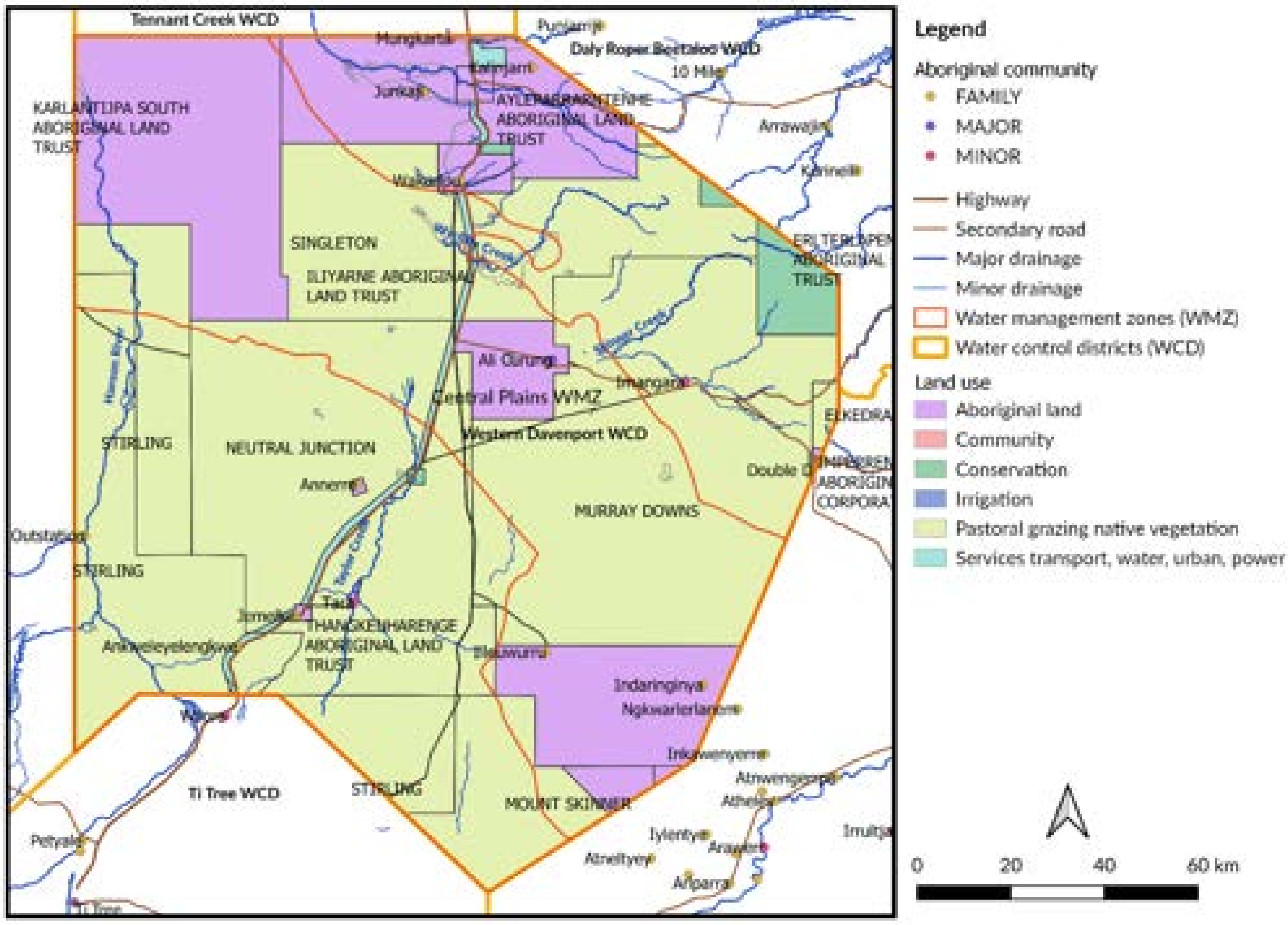


Figure 1. Places and land use

3. Water resources

Overview

This section outlines the foundational information and knowledge on the water resources in the plan area. The scientific understanding of the water resources is underpinned by water monitoring, assessments and modelling.

The groundwater resources managed through the plan comprise the:

- Central Plains: a extensive regional aquifer that is high yielding and better quality (lower salinity) than other aquifers in the district. The primary water holding formations include the Lake Surprise Sandstone, Arrinthrunga Formation, Chabalowe Formation and Dulcie Sandstone aquifers. Potential bore yields are typically around 30 litres per second. These formations store extensive volumes of water, currently with a minimum volume of 137,986,000 ML.
- Davenport Range and Southern Ranges many small local fractured rock aquifers, with little or no connectivity to the regional aquifer of the Central Plains, that occur unreliably, often with poor water quality. Water resources are limited and expected to be primarily used for stock purposes. Potential yields are typically less than 2.5 litres per second.

Two major surface water features, namely the Hanson River and Taylor Creek, originate in the Southern Ranges and flow north towards the Central Plains region.

The understanding of the resources was improved through a number of key investigations conducted during 2018-2022 by the department, Geoscience Australia, the National Water Grid Authority (NWGA) and other private companies. Data acquisition for these investigations included:

- an airborne electromagnetic geophysical survey
- 3D geological modelling
- landform mapping
- water bore drilling and construction
- downhole geophysical surveys
- groundwater level monitoring
- groundwater quality sampling events.

3.1 Topography

While the district has predominantly flat terrain, the northeast boundary straddles the Davenport Range and the southern boundary includes the Forster and Spring Ranges. Between these ranges, the area mainly consists of: a lightly wooded red aeolian sand plain (sand transported and deposited by wind) covered with spinifex, dense mulga shrub land, with intermittent low sand dunes; large patches of alluvial flood out country; ephemeral swamps and clay pans; and some small areas of colluvial foot slopes adjacent to the ranges.

3.2 Climate and rainfall

The district has an arid climate with highly variable and episodic rainfall. It is hot in the summer months between October and March, and relatively mild and dry for the remainder of the year. Daily temperature, rainfall and evaporation data for Ali Curung and Barrow Creek have been extracted from the SILO[6] database, which is based on regional observations made by the Bureau of Meteorology (BoM) (Jeffrey et al., 2001).

[6] https://www.longpaddock.qld.gov.au/silo/point-data/

The area is hot year round (Figure 2). Average daily maximum temperatures can reach up to 37°C from November to March. Average daily minimum temperatures rarely fall below 8°C from April to September, and 21°C from November to March. July is usually the coldest month of the year.

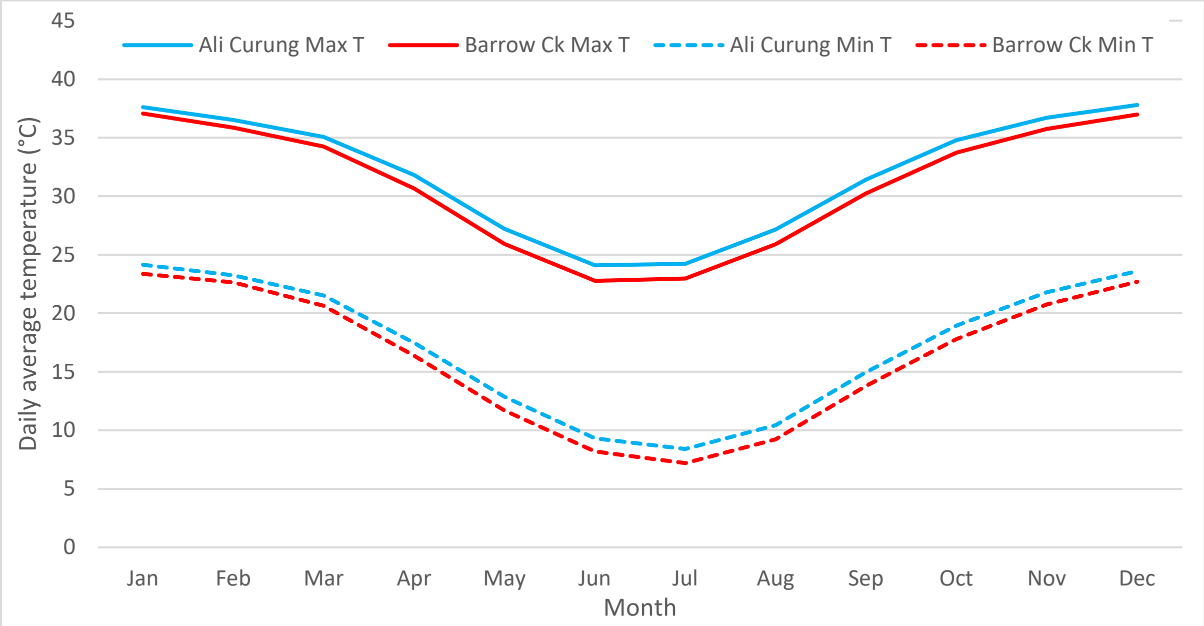


Figure 2. Average daily minimum and maximum temperature (T)

Rainfall occurs predominantly between November and March primarily associated with intense thunderstorms or widespread monsoonal depressions originating in the north (Figure 3). From April to October, very little, if any, rainfall occurs.

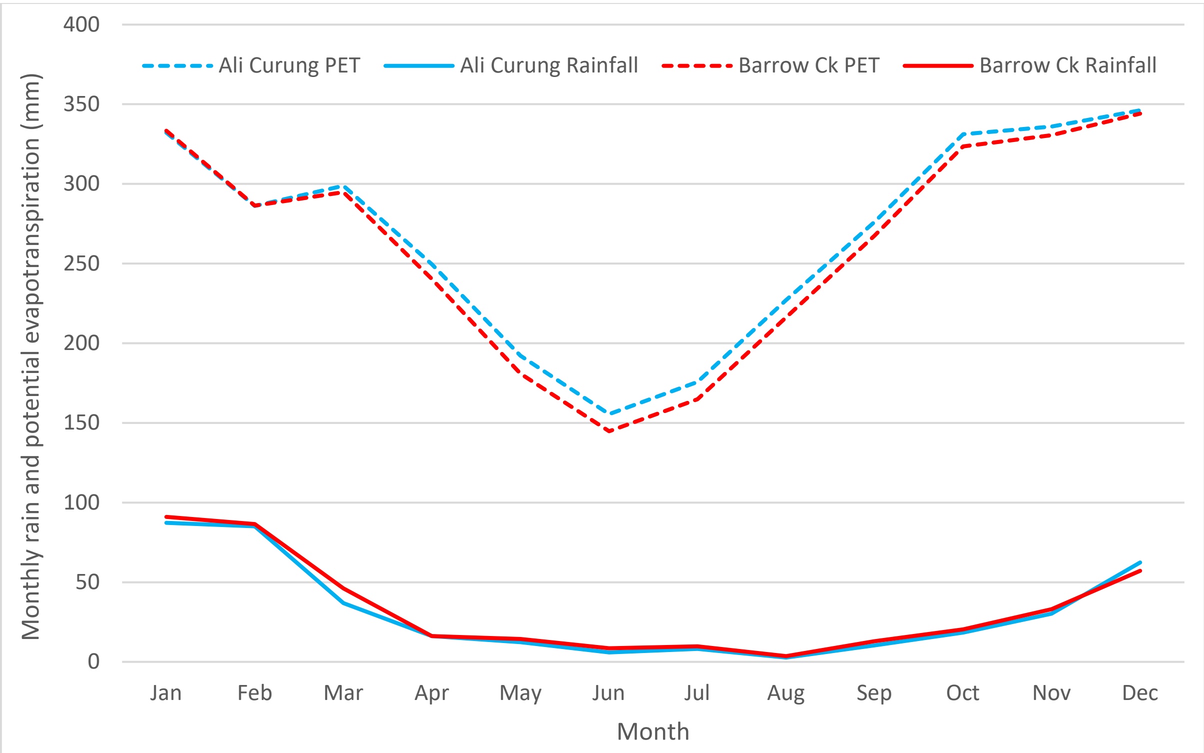


Figure 3. Average monthly rainfall and evapotranspiration (PET)

Generally, potential evapotranspiration exceeds rainfall throughout the year (Figure 3). Average monthly potential evapotranspiration is highest in the high temperature months of November to January at approximately 355 mm, and rarely drops below 160 mm in June.

3.2.1 Rainfall variability

Rain observations from the SILO database (Jeffrey et al., 2001) 1900 to 2021 for Ali Curung and Barrow Creek are shown in Figure 4 and Figure 5. The average annual rainfall for these locations is 307 mm and 325 mm respectively however there is significant variability over time, the highest annual rainfall on record at Ali Curung was 975 mm in 2011 and the lowest was 50 mm in 1900. At Barrow Creek the highest annual rainfall was 1,136 mm in 2011 and the lowest was 46 mm in 1900. The climate period trend can be observed from the cumulative deviation from average annual rainfall. The cumulative deviation show a decreasing rainfall trend from 1900 to the mid 1960’s and an increasing trend in rainfall in the plan area since 1973.

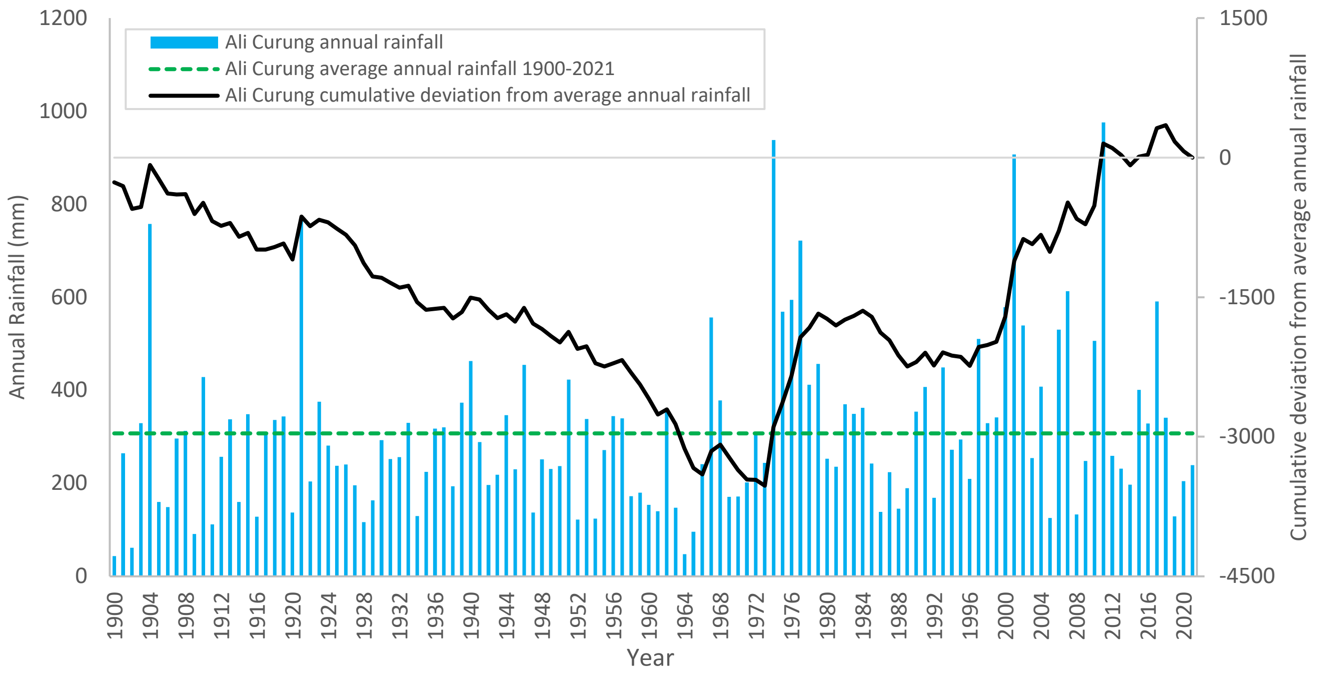


Figure 4. Cumulative residual rainfall (mm) measured at Ali Curung (BoM Station ID 015502)

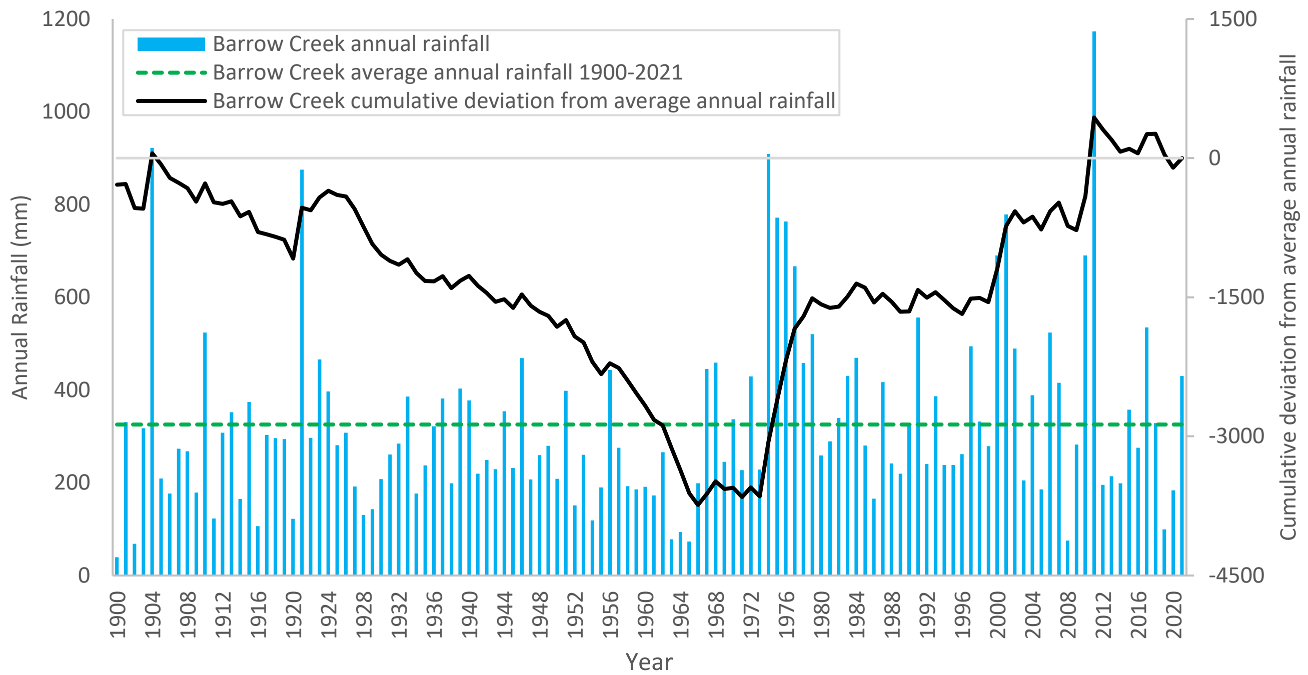


Figure 5. Cumulative residual rainfall (mm) measured at Barrow Creek (BoM Station ID 015525)

The potential effects of climate change on water resources around Australia can be assessed using climate outlooks, which draw on the latest climate research, encompassing observations, analyses and projections to describe variability in the recent past and to predict long term changes across Australia. The most recent climate outlook produced by the BoM and CSIRO is the State of the climate 2020 report (BoM and CSIRO, 2022).

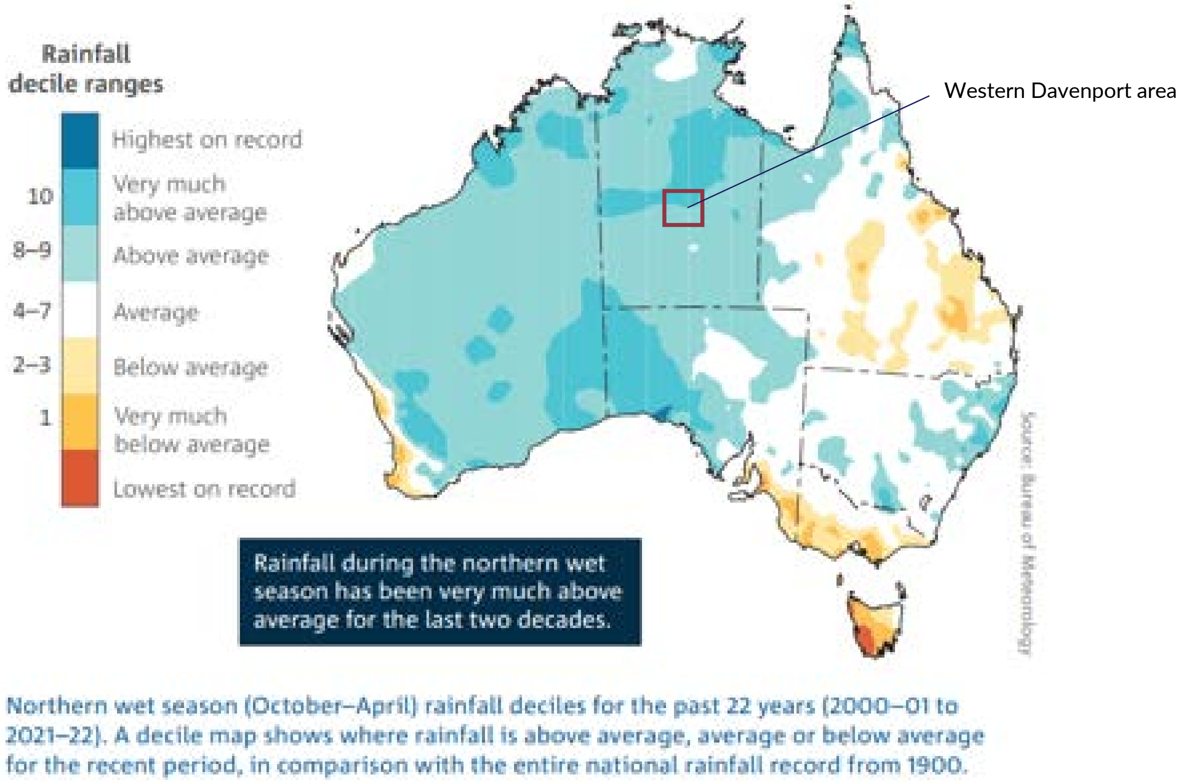


Figure 6. Northern wet season rainfall decile map (BoM and CSIRO, 2022)

Observed climate data acquired for the district supports the State of the Climate Report, which shows an increasing trend in rainfall over the previous decades (Figure 6). In the Tanami–Timor Sea Coast drainage division in northern Australia, which includes the district, there has been an increasing trend in annual median stream flows at about 51 per cent of the gauges since 1975. This is consistent with the observed increase in rainfall since the 1970s in the region (BoM and CSIRO, 2022).

Additionally, a long term climate change prediction is presented by Northey et al. (2020), which is based on modelled classifications of environment proposed by the Intergovernmental panel on climate change scenario A1F1 for 2076 to 2100 (Rubel and Kottek, 2010). Northey et al. suggests that an increasing proportion of the district will be classified as Arid Steppe Hot as opposed to Arid Desert Hot by the year 2100, implying that the region may experience an increase in rainfall and/or a decrease in temperature.

It is important to note that climate change modelling used for the assessment of impacts to groundwater resources is underlain by inherent uncertainty due to environmental variability and the complexity of natural systems. Crosbie et al. (2013) states that results from such models should be presented using a risk analysis framework, which "incorporates the uncertainty associated with differences between Global Climate Models, thus [acknowledging] this inherent and possibly irreducible uncertainty". Therefore, climate data used in the modelling for the district has not been altered or adjusted to fit variable climate change scenarios.

Instead, to account for climate change it is considered practical to use rainfall and evaporation data post 1970. This data inherently allows for other trends such as a decrease in the number of tropical cyclones in the Australian region since 1982, high variability of rainfall in northern Australia, and a continuing trend of more frequent compound extreme events (BoM and CSIRO, 2022). Further to this, a lack of regional scale observations of pan evaporation and/or meteorological observations were available to derive synthetic data for evaporation prior to 1970.

The daily evaporation data for the SILO datasets obtained at Ali Curung (BoM Station ID 015502) and Barrow Creek (BoM Station ID 015525) are displayed in Figure 7 and Figure 8. These figures clearly highlight the difference between artificially simulated potential evaporation for the period 1900-1970 and observed or derived potential evaporation for the period 1970 to 2021.

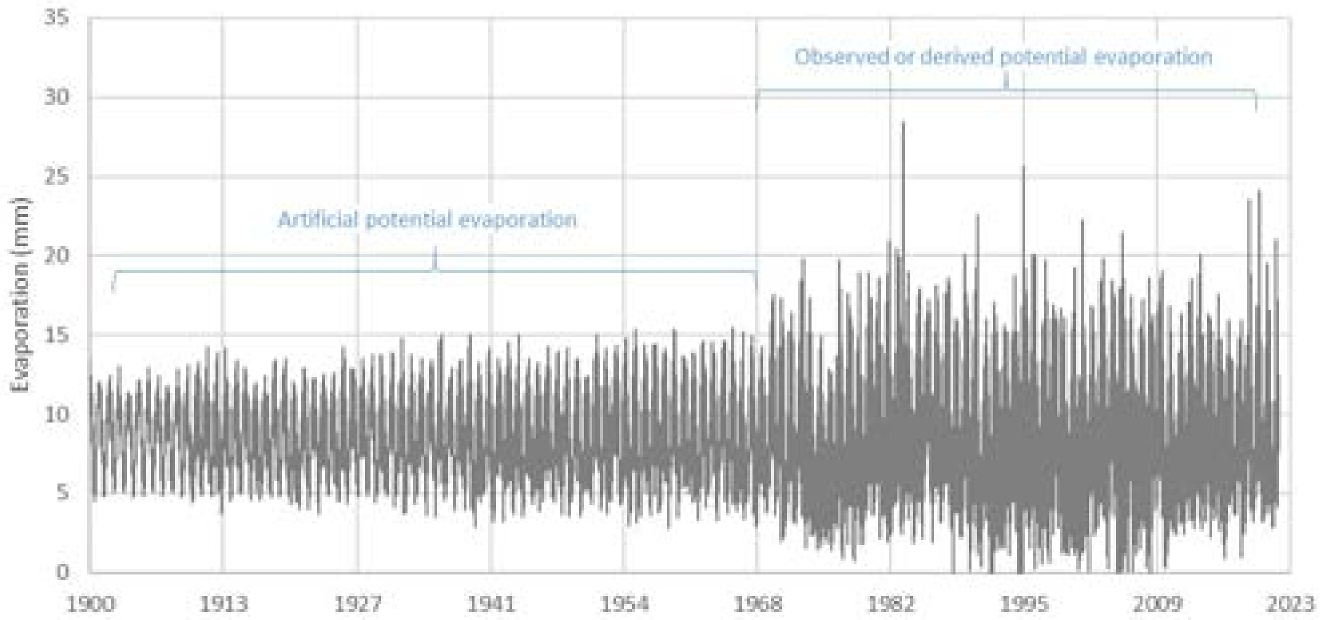


Figure 7. Daily evaporation (mm) data for Ali Curung (BoM Station ID 015502) 1900-2021

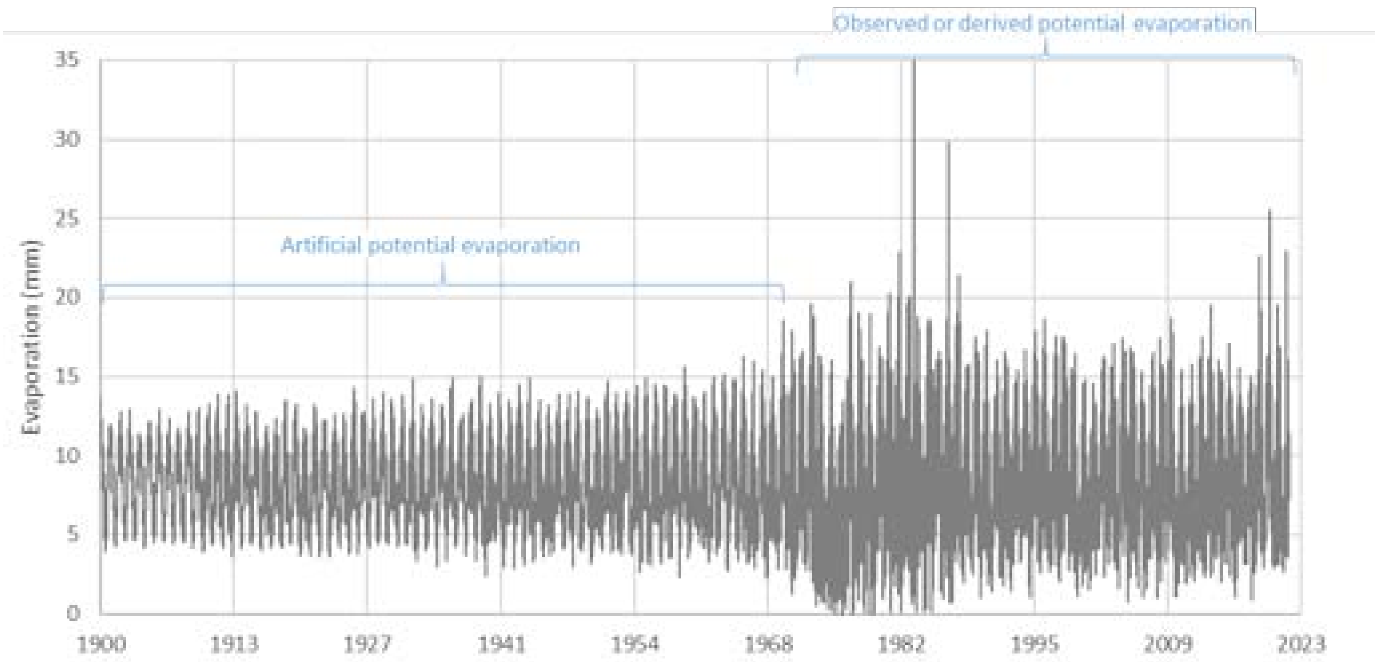


Figure 8. Daily evaporation (mm) for Barrow Creek (BoM Station ID 015525) 1900-2021

3.3 Key water resource investigations

3.3.1 Exploring for the Future

Exploring for the Future (EFTF) is an Australian Government program led by Geoscience Australia. The program's aim is to drive investment in the resource and agricultural sectors by providing industry, land and water managers with precompetitive data about potential mineral, energy and groundwater resources. As part of the EFTF program, Geoscience Australia undertook a geological and hydrogeological study in the Western Davenport region undertaken in partnership with the department and Power and Water Corporation (PWC).

The EFTF program included acquisition of helicopter airborne electromagnetic data, water bore drilling, hydrogeology and hydrochemistry data, and landscape assessment. Analysis of new and existing data allowed for the correlation of hydrostratigraphic units in the plan area with hydrostratigraphic units in the neighbouring Wiso and Georgina Basins.

Hydrochemistry data acquired as part of the study identified zones of potentially higher recharge, including floodouts associated with Skinner Creek and Taylor Creek, and along ephemeral streams. Hydrochemistry data also revealed that the Central Plains of the district is characterised by good quality groundwater, suggesting irrigated agriculture could be supported in this area. Groundwater stable isotope data suggested that minimal evaporation of water was occurring prior to recharge taking place, and that recharge only occurs following heavy rainfall events. This indicates that recharge is dominated by episodic recharge from floodouts and creeks, rather than direct infiltration across the area. However, it was flagged that more data is required to better define the role of floodouts to recharge (Northey et al., 2020).

The improved understanding of geology and hydrogeology gained from Northey et al., (2020) provides new information to support groundwater management in the Western Davenport area. Data and information related to this work are accessible via the EFTF portal[7].

3.3.2 Mapping the Future

Mapping the Future (MtF) is a five year (2018-22) NTG funded initiative undertaking integrated water, land, soil and biodiversity assessments in areas of high development potential around the Northern Territory. The goal is to provide an evidence based tool that will directly inform government and local decision making around land use planning, and identify economic opportunities to encourage the private sector to do business in the Northern Territory.

The Western Davenport area was identified as one of the program's priority areas, and was included in the 2018-19 MtF program. Part of the suite of work included in the MtF program focusses on the assessment of water resources. The water resources assessment component of the MtF Western Davenport project includes the following studies:

- establish interconnectivity between groundwater and surface water, including delineation of recharge zones and mechanisms within the area and
- hydrogeological conceptualisation of groundwater resources in the area.

3.3.3 National Water Grid Authority

The National Water Grid Authority (NWGA) Science Program is aimed at disseminating scientific information to inform water infrastructure investment decisions across Australia. The main themes of the Science Program include water resource analysis, alternative and emerging options, and communicating science. Cook and Keane's (2021) report was completed under the theme of water resource analysis. The report provides a desktop assessment of the potential regional scale risk of aquifer salinisation as a result of large scale irrigated agriculture projects for the Central Plains water management zone.

The assessment included an evaluation of salinisation risk to the unconfined aquifer under two scenarios:

1. Scenario 1: no recycling of irrigation water. The source of groundwater used for irrigation is distinct and does not include the recharge that occurs beneath the irrigated crop (e.g. use of a confined aquifer).
2. Scenario 2: recycled water is used for irrigation. The irrigation drainage water is reused for irrigation as soon as it reaches the aquifer, for example use of an unconfined aquifer.

[7] https://portal.ga.gov.au/

Salinity implications of the two scenarios were summarised using a salinity risk map, which classified areas as high, moderate and low risk. Risks were predominantly determined by soil and groundwater salinity, and the timeframe for water movement through the soil profile. The resulting risk map was predominantly a reflection of groundwater depth and salinity distribution rather than water movement, likely due to the lack of information on soil salinity and soil type in the Central Plains area.

This desktop work has identified that further soil and water testing are the most critical elements to refining salinity risk. The department is currently undertaking the collection of field data to fulfil this requirement.

3.4 Surface water resources

The district includes a surface water catchment of 15,000 km² and is primarily within the Wiso surface water management area, also referred to as the Wiso Drainage Basin. Surface water resources within the district are ephemeral and poorly defined, and therefore not a reliable source of water for consumptive purposes. However, these systems are highly important and interconnected with groundwater resources in the district.

Surface water features (Figure 9) in the district include the following:

- two major ephemeral rivers (Hanson River and Taylor Creek) which flow north, into or towards the Tanami Desert
- ephemeral rivers and creeks, such as Wycliffe Creek, which flow off the Davenport Range in a south westerly direction and join to flow along a northwest flood path
- significant ephemeral swamps, claypans, and floodouts, including Thring Swamp (a floodout of Wycliffe Creek), Warrabri Swamp, the floodouts from Skinner Creek, Bonney Creek, Taylor Creek and McLaren Creek.

Most rivers and creeks originate from the rocky ranges in the northeast and southwest of the district, where there is high runoff, and often terminate in floodouts in the Central Plains region. Given that regional surface water resources are not permanent, baseflow contributions to watercourses sourced from groundwater are likely negligible.

Most creeks that originate in the Davenport Range, situated in the northeast of the district, initially flow to the west or southwest into floodouts, swamps, ephemeral lakes and sandplains, which eventually coalesce to form a northwest flowpath. During large rain events, this flowpath continues beyond the regional boundary; however, for most of the year flow terminates within the Central Plains region. Some creeks, such as Kurundi Creek and Lenner Creek, flow off the Davenport Range to the northeast, terminating outside of the district.

Two major surface water features, namely the Hanson River and Taylor Creek, originate in the Southern Ranges and flow north towards the Central Plains region. The Hanson River flows along the western boundary of the district, while Taylor Creek is situated centrally in the district and flows towards the discharge flowpath emanating from the Davenport Range, merging with it during periods of intense rainfall.

The wetlands of the district include a number of significant semi-permanent and seasonal waterholes, claypans and floodouts. The deeper waterholes in major channels hold water the longest in the district, although few, if any, are permanent. Most of the larger wetlands are associated with the river floodouts where water spreads out from a defined channel. These wetlands can be filled from rain that has fallen many kilometres away and travelled down the river channels before flooding out. They can also be filled from more localised rainfall and flooding events (Duguid, 2009). These may be more prominent in shallow groundwater areas. Smaller wetlands, such as swamps and claypans that are not connected by flood ways or channels, are generally filled intermittently via local rainfall, runoff from nearby rocky ranges, or from sheet-flow across the surrounding landscape (Figure 9).

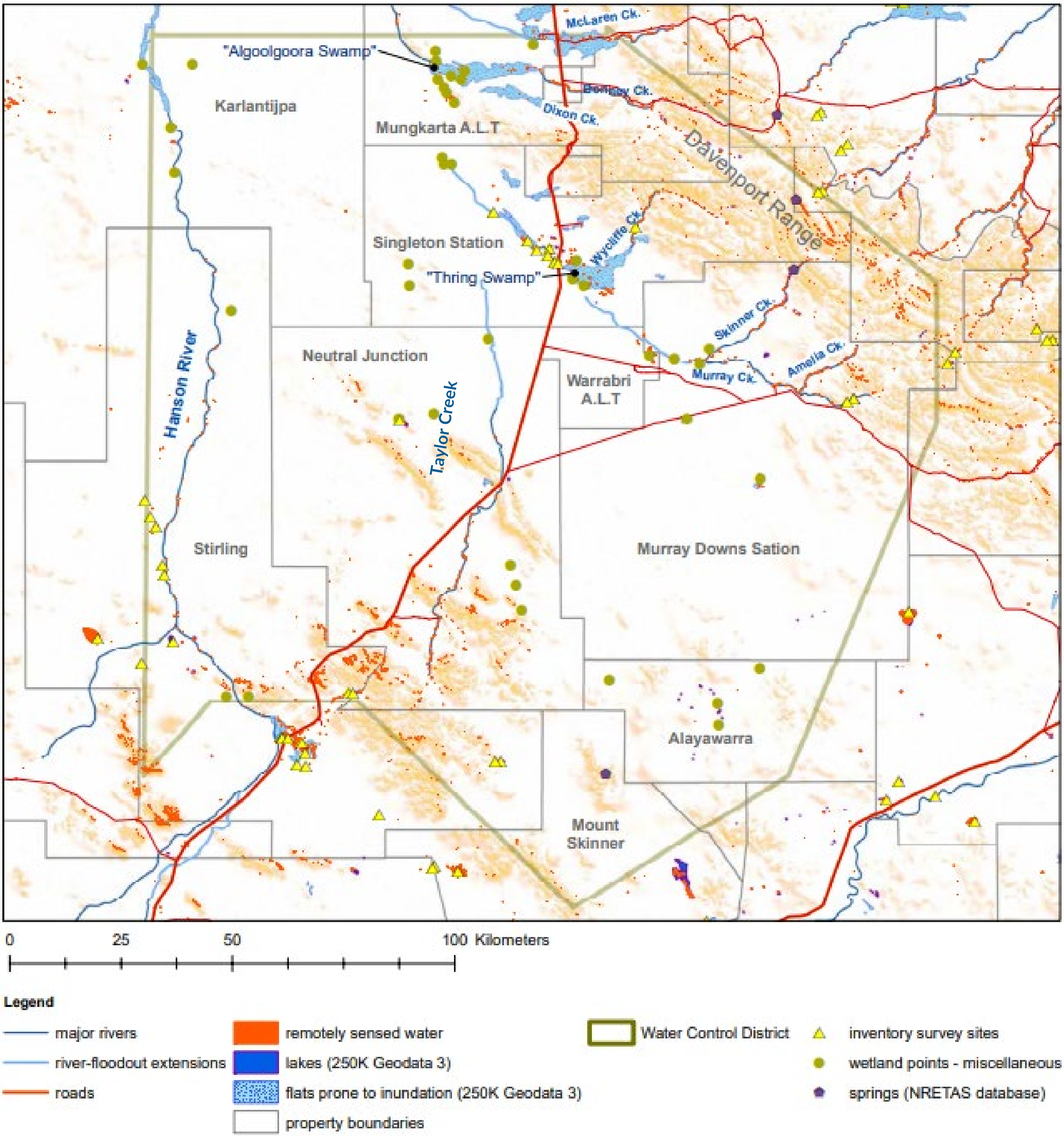


Figure 9. Wetlands in the Western Davenport water control district (Duguid, 2009)

3.5 Groundwater resources

There are three groups of groundwater resources in the district. They are the fractured rock aquifers associated with the Davenport Range, high yielding regional scale aquifers in the Central Plain between the Davenport Range and the Southern Ranges and the fractured rock aquifers of the Southern Ranges (Figure 17). The Hanson River Palaeochannel runs along the western side of the district from the Southern Ranges into the Central Plains and has not been assessed as part of the groundwater resources of the district.

3.5.1 Hydrogeological setting

The district is positioned across three distinct geological environments, including the folded Paleoproterozoic strata and intrusive of the Tennant Region in the Davenport Province to the northeast and the Aileron Province to the southwest. Between these features lies a series of northwest trending troughs, where the Paleoproterozoic strata of the Davenport and Aileron Provinces are unconformably overlain by relatively flat lying Palaeozoic strata associated with the Wiso and Georgina Basins (Northey et al. 2020).

Each of the geological environments hosts a series of hydrostratigraphic units that inform the hydrogeological setting of the district and form the foundation for the three water management zones (Schedule D). The main productive aquifers occur in the Central Plains water management zone. The Davenport Range and Southern Ranges water management zones host primarily local scale fractured and weathered rock aquifers, which are considered unreliable as a groundwater resource.

The Cambrian stratigraphic units in the Central Plains have been grouped into two main aquifers, which along with the overlying Cenozoic sediments form the primary regional aquifers of the district. The Arrinthrunga and Chabalowe Formations comprise the primary aquifer bearing units in the Georgina Basin, while the Hooker Creek Formation and Montejinni Limestone comprise the primary aquifer bearing units in the Wiso Basin see Figure 17. Subregional aquifers in the district include the Devonian aged sediments of the Dulcie Sandstone in the Wiso Basin and the Lake Surprise Sandstone the Georgina Basin. Ordovician/Devonian aged sediments of the Tomahawk Formation in the Georgina Basin and the Hanson River Beds in the Wiso Basin are also subregional aquifers in the area.

More information on the regional surface geology, major hydrogeological units and corresponding cross sections is available in Tickell and Zaar (2022).

3.5.2 Hydrogeological conceptualisation

Tickell and Zaar (2022) provide the most up to date understanding of hydrogeology in the Western Davenport region in Groundwater resources of the western davenport area, completed as part of the MtF project. The report provides a comprehensive hydrogeological conceptualisation of the Western Davenport area based on the most recent data collected from the region. The report also includes a groundwater resource risk map, which categorises the Central Plains aquifer system into risk categories associated with development of irrigated agriculture. The risks are based on aquifer properties including the capability of the aquifer to supply water, the depth of the water table and groundwater salinity.

The MtF project included a drilling campaign in the Western Davenport area, completed between 2018 and 2020, to aid in the hydrogeological understanding of the region. Eight bores were drilled, one in the Wiso Basin (RN019810) on NT Portion 653 (Singleton Station), approximately 17 km west of Wycliffe Well, and the remaining seven within the Georgina Basin, in the south eastern part of the Central Plains area. The drilling in the Georgina Basin was partly oriented to assist with the calibration of airborne electromagnetic data surveys undertaken for the EFTF program. The drilling campaign added to the stratigraphic, hydrochemical, and aquifer connectivity understanding of the Central Plains.

The deep bores (more than 100 m deep) drilled as part of the MtF project and the EFTF program shed new light on the hydrogeological understanding of the Central Plains area. Conceptual understanding of regional groundwater flow patterns, aquifer yield, and delineation of hydrostratigraphic units has been improved.

Measured standing water level in bores screened within the Chabalowe Sandstone, at depths over 200 m, were over 9 m lower than adjacent bores screened in the Cenozoic sediments. Preliminary construction of a flow net based on this data indicates that piezometric head generally decreases with depth and groundwater flows downwards vertically and horizontally in a north westerly direction. A similar finding was observed at two close bores in the northwest of the Wiso Basin.

Hydrochemical data collected from newly drilled bores included carbon-14 dating of groundwater in various hydrostratigraphic units. Measured carbon-14 ages are generally in agreeance with the conceptual flow net i.e. older water is situated further along the flowpath.

Recent airlift yields acquired during the MtF drilling campaign indicate that yields greater than 8 L/s are associated with both the Cenozoic and Cambrian aquifers in the Central Plains area. Lower yields (less than 3 L/s) were encountered in bores within the Arrinthrunga Formation and Chabalowe Sandstone aquifers after screening, however airlift yields during drilling were often much higher.

Within the Central Plains , 46 water bores have been drilled to a depth greater than 100 m. Ten of these air lifted greater than 10 L/s from strata below 100 m whilst drilling, indicating that productive yields at depth is not uncommon. However, regional data indicates that overall lower yields are associated with depths greater than 150 metres below ground level (mBGL) in the Central Plains area. These lower yields may suggest that the practical extraction depth in this part of the area is around 150 mBGL.

Recent hydrogeological investigations in the area have produced additional knowledge surrounding the connection of the Wiso and Georgina Basins in the Central Plains area, however the location and character of the boundary between the two basins requires further refinement. Recent investigations provided some indication that at least a portion of the Cambrian sediments within these basins may be separated by a basement high which may cause a groundwater flow divide (Figure 16). Targeted drilling near the suggested boundary would be useful in determining its significance.

3.5.3 Groundwater recharge

Recharge to the aquifer system in the Western Davenport area is dominated by event based episodic recharge from floodouts and creeks during high intensity rainfall events. These episodic events are dependent on runoff, which is a function of rainfall intensity and ground conditions. The watertable fluctuation method (Nimmo et al. 2015) was used to determine potential recharge to aquifers in the Central Plains aquifer system. Groundwater bores that show a rise in groundwater level following rainfall events were used to determine a rainfall threshold for recharge to occur. The analysis shows that aquifers in the Central Plains typically experience recharge (determined by a rise in groundwater level) following rainfall events in excess of 50 mm.

The size and frequency of rainfall events over the past 100 years has been compiled from the SILO database to investigate long term patterns and potential future trends associated with recharge events within the Western Davenport area (data collected from SILO[8]; Jeffrey et al., 2001).

A rainfall event has been defined as a single day in which total rainfall exceeds a prescribed amount. The number of historic rainfall events in excess of 50 mm, 100 mm, 150 mm and 200 mm have been plotted using the SILO dataset for Ali Curung and Barrow Creek (Figure 10 and Figure 11).

Data from these areas indicate that the size and occurrence of groundwater recharge episodes have increased since the 1970s. Groundwater monitoring confirms that over the past 50 years there have been three significant recharge events, occurring in 1975-1976, 2000-2001 and 2010-2011.

[8] https://www.longpaddock.qld.gov.au/silo/point-data/

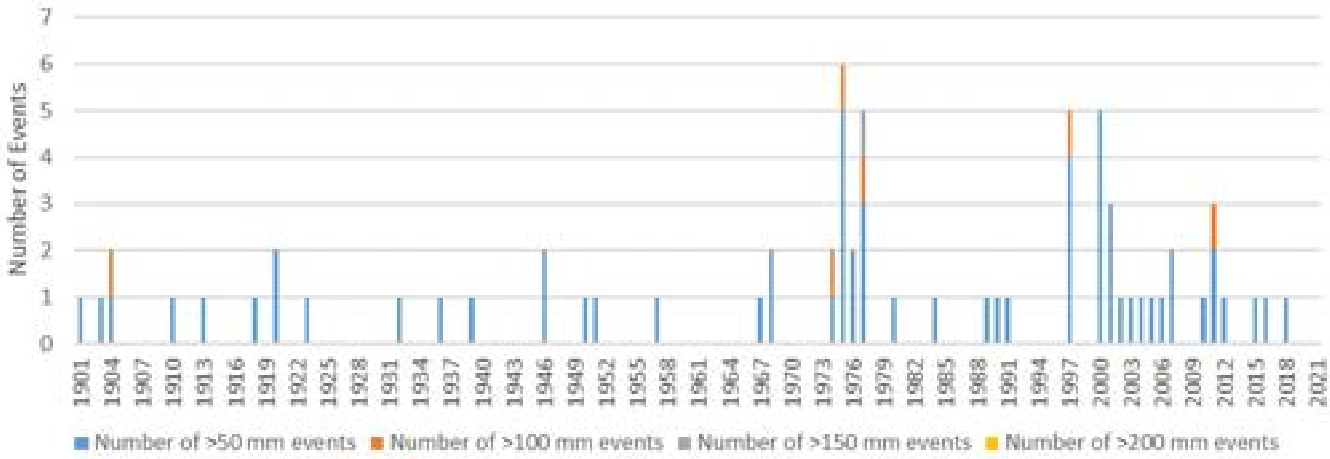


Figure 10. Number of rainfall events in excess of 50 mm, 100 mm, 150 mm and 200 mm per year at Ali Curung (BoM Station ID 015502)

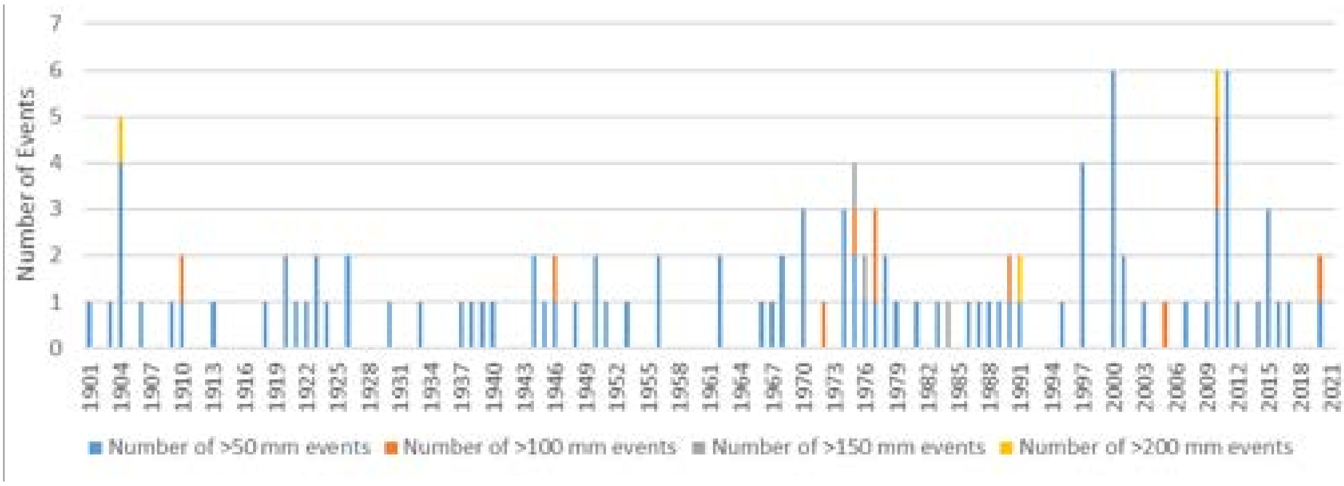


Figure 11. Number of rainfall events in excess of 50 mm, 100 mm, 150 mm and 200 mm per year at Barrow Creek (BoM Station ID 015525)

Tickell and Zaar (2022) identify two main recharge zones and several minor areas (Figure 12). One is located south of the northern boundary of Neutral Junction and is directly underlain by the Lake Surprise aquifer. The relatively large area covered by this recharge zone suggests that diffuse recharge may be an important mechanism in addition to direct recharge along the channel and at the terminal flood out of Taylor Creek. The other main recharge zone is east and southeast of Ali Curung. The Chabalowe aquifer is the main aquifer however in some areas it is overlain by Cenozoic deposits in others it is close to or at ground level. Tickell and Zaar provide further explanation of recharge processes as part of the Western Davenport MtF project.

Measured groundwater response to recharge processes varies widely across the basin, depending on the location of the borehole and the lithology which is screened. Figure 13 and Figure 14 show the relationship between groundwater level and rainfall. Groundwater level is represented as elevation i.e. metres above the Australian Height Datum (mAHD).

Monitoring bore RN005427 has the longest record of groundwater level monitoring data in the district (1966 to present). The bore is screened in the (shallow) Cenozoic sediments of the Central Plains aquifer system near Skinner Creek floodout and the community of Ali Curung. Due to its location the bore is highly responsive to rainfall runoff events. Over the 50 year period there have been rapid increases in groundwater level in response to intermittent recharge events, followed by a characteristic recession gradient as the water level mound dissipates into surrounding sediments.

The largest of these events occurred during the early to mid 1970s with almost a nine metre rise in groundwater levels. The cumulative effect of regular recharge events show a net increase of minimum groundwater levels over the monitoring period depicted by the trend line in Figure 13.

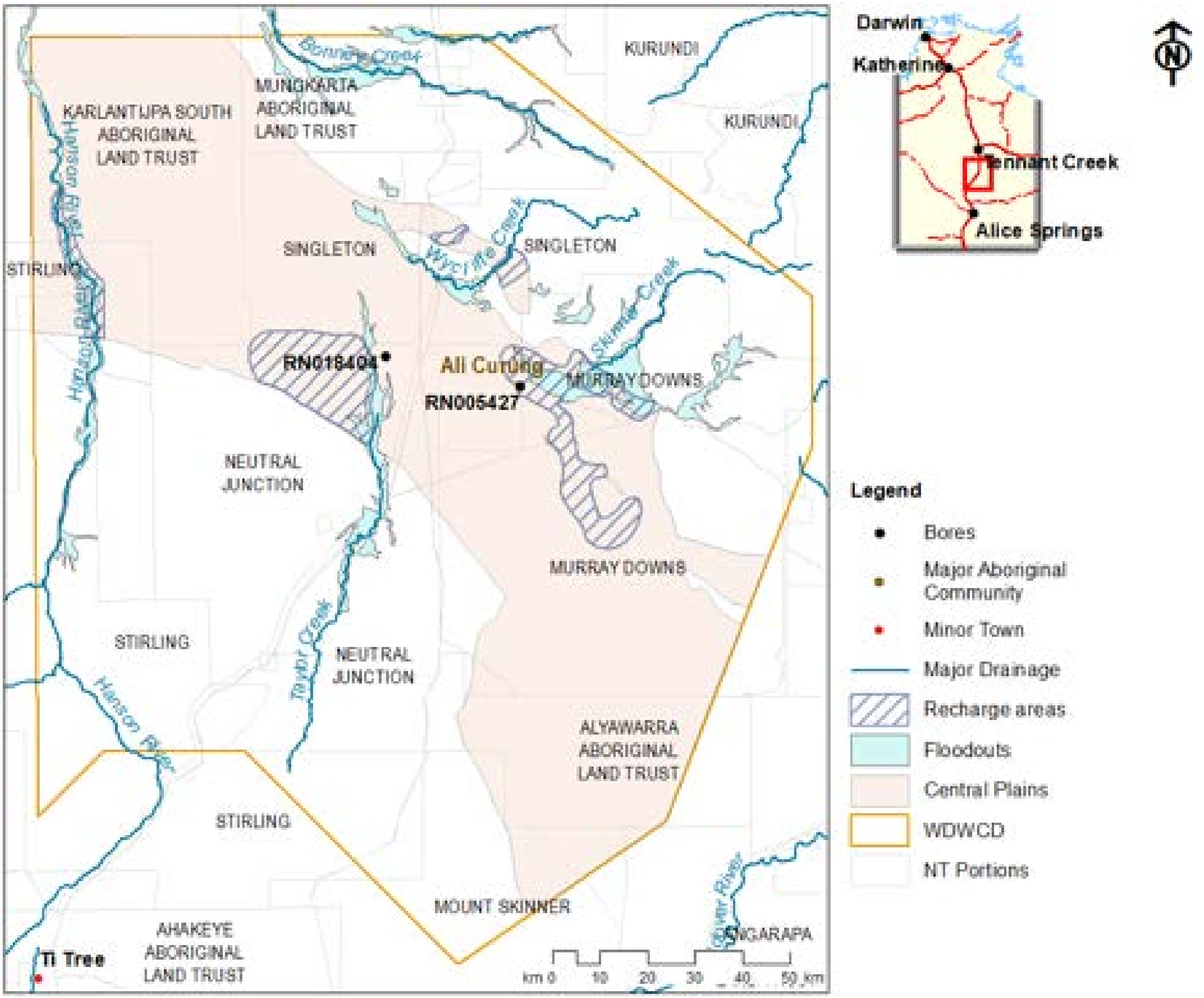


Figure 12. Recharge areas across the Central Plains (Tickell and Zaar, 2022)

Figure 13. Time series of groundwater level at bore RN005427 and response to rainfall recharge events

Bore RN018404, shown in Figure 14, also shows the episodic response to recharge events. The bore is screened in the Cenozoic sediments near the Taylor Creek floodout on Neutral Junction Station. Similar to RN005427, RN018404 shows rises in groundwater level due to recharge events with a two metre rise in response to the 2011 wet season.

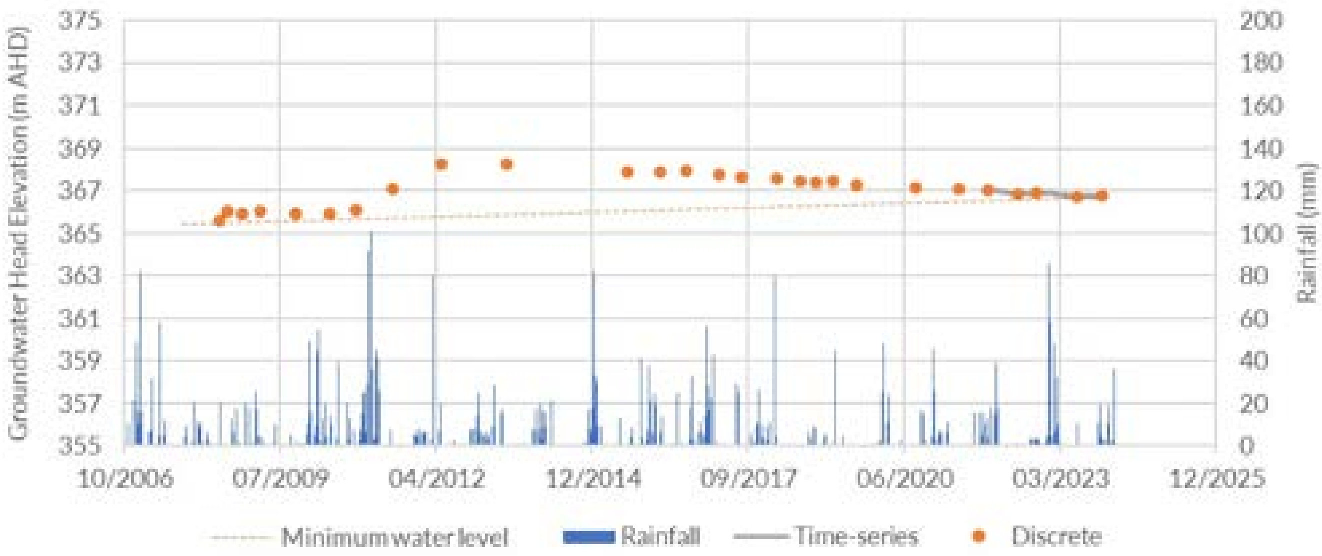


Figure 14. Time series of groundwater level at bore RN018404 and response to rainfall recharge events

3.5.4 Groundwater storage

Storage with the Central Plains aquifer system is substantial, estimated at approximately 137,986 GL based on the thickness of the formations that overlie the basement rocks (refer to section 3.6.2 of this document). Groundwater storage changes in response to recharge, discharge and throughflow with groundwater level data providing an overview of the seasonal and long term variability of the system. Due to the extensive area of the basin, groundwater levels that rise in one location may take years to dissipate out into the surrounding aquifer. Monitoring groundwater levels allow for continued assessment and insight into the relationship between rainfall, which results in recharge, and groundwater level trends. The current groundwater monitoring network includes a series of monitoring bores with long data records (some over 50 years), which can be used to analyse historical trends.

3.5.5 Groundwater discharge

Groundwater flows through aquifers under gravity from recharge zones to areas in the landscape which are lower and may discharge to surface during wet periods. Two mechanisms of groundwater discharge from the Central Plains aquifer include:

- direct outflow in springs or stream bed seepage and
- indirect outflow via evapotranspiration (ET).

There are no known permanent discharge features, such as springs or stream bed seepages, however it is likely that the latter may occur in some low lying areas during and for a short time after major rainfall events (Tickell and Zaar 2022). The main form of groundwater discharge taking place is through ET (evaporation combined with tree water use) in areas where water tables are shallow enough to be available to tree roots and susceptible to evaporation of soil moisture.

3.5.6 Groundwater quality

Groundwater salinity concentrations across the Central Plains aquifer system are generally less than 1,000 mg/L total dissolved solids (TDS), however can vary from less than 200 mg/L to greater than 3,000 mg/L (Figure 15 showing the Central Plains). While data is generally confined to the Central Plains, salinity has been recorded higher in the ranges, particularly within the Southern Ranges, where some bores indicate TDS values more than 10,000 mg/L (Northey et al., 2020).

With the exception of a pocket near the Stuart Highway, west of Ali Curung, and the area to the northwest in a remote part of the district, salinity values are generally less than 1,200 mg/L (exceedance threshold for palatability) according to the Australian drinking water guidelines (NHMRC, NRMMC, 2011). In terms of beef cattle livestock, where less than 5,000 mg/L (ANZG, 2023) is considered the threshold for production loss, there areas with the Davenport Ranges and Southern Ranges where these values are exceeded.

The hydrogeological investigation undertaken by Geoscience Australia (Northey et al., 2020), determined that groundwater salinity does not correlate to bore depth, which is consistent with the current conceptualisation that aquifer systems are connected, with no hydraulic boundaries between stratigraphic units across the region.

Baseline water quality sampling was established in the Central Plains district in 2016. Twelve bores were included in the suite however some years did not permit sampling due to circumstances encountered in the field (limited access, unfavourable weather conditions, etc.). The sampling takes place annually with a data gap between 2019 and 2021.

Major ions present in groundwater include sodium, potassium, calcium, magnesium, chloride, sulphate and bicarbonate. Data indicates four dominant water types, listed here in order of abundance: sodium chloride (58%), sodium bicarbonate (31%), magnesium bicarbonate (8%) and calcium bicarbonate (3%) (Tickell and Zaar, 2022). Fresher sodium bicarbonate waters are associated with areas of higher recharge, while higher salinity groundwater sodium chloride has likely experienced greater evaporative concentration (Northey et al., 2020).

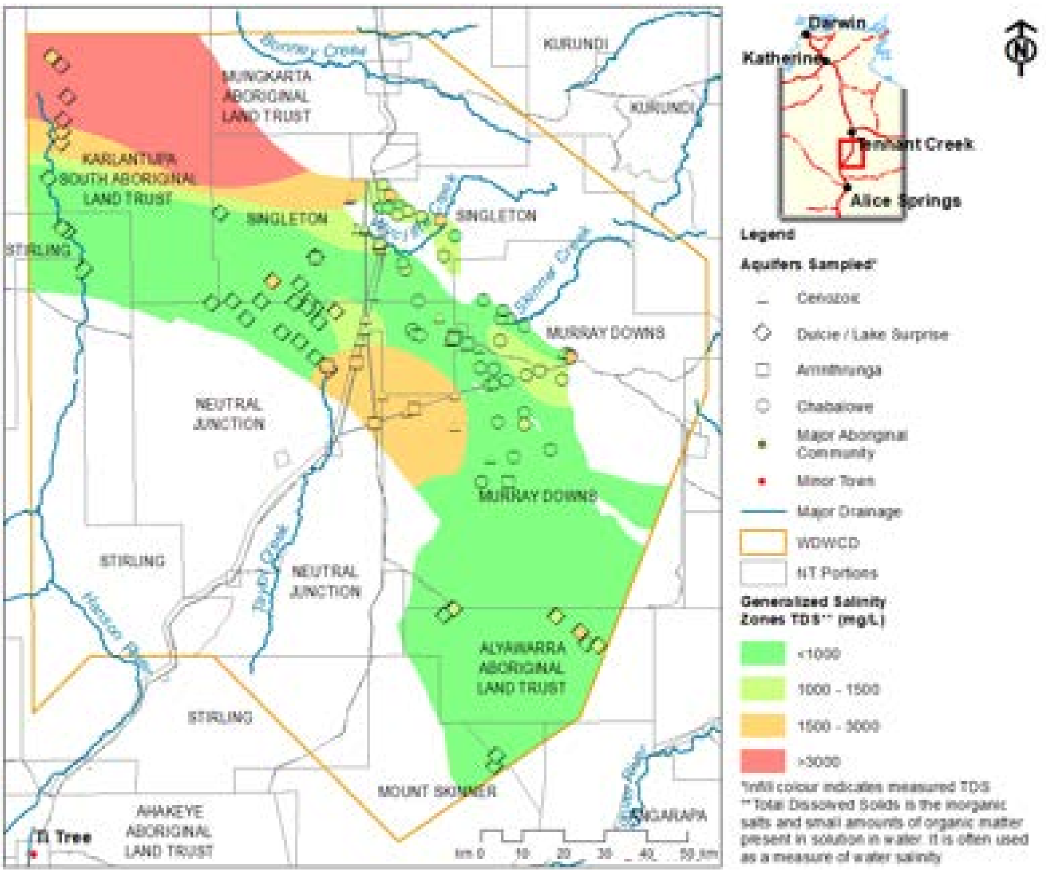


Figure 15. Regional groundwater salinity across the Central Plains (adapted from Tickell and Zaar, 2022)

3.5.7 Groundwater flow

Groundwater elevation within the district is highest in the southeast, falling progressively to the northwest. The water table generally mimics the slope of the plains and becomes shallower towards the northwest and adjacent to the foothills of the Davenport Range. The water table is deeper along the southern part of the plain adjacent to the Southern Ranges The water table is a dynamic feature, which can rise and fall depending on available recharge or lack thereof (Tickell and Zaar, 2022).

Regional groundwater flow is from the south southeast towards the north-northwest. Current conceptualisation infers that aquifers of the Wiso Basin and Georgina Basin are vertically connected and laterally continuous at the regional scale. This is evidenced by a strong correlation in groundwater levels and geological composition across the Georgina and Wiso Basins. Additionally, there is limited evidence regarding localised constraint of regional groundwater flow due to the aquitards or structural features (Tickell, 2014; Knapton, 2017).

Figure 16 shows the baseline established groundwater head elevation (mAHD) across the Central Plains aquifers and the generalised regional groundwater flow direction. The depth to groundwater can range from 0 to more than 50 metres, and where shallower than 15 metres below ground it may be accessible by vegetation (Cook and Eamus, 2018).

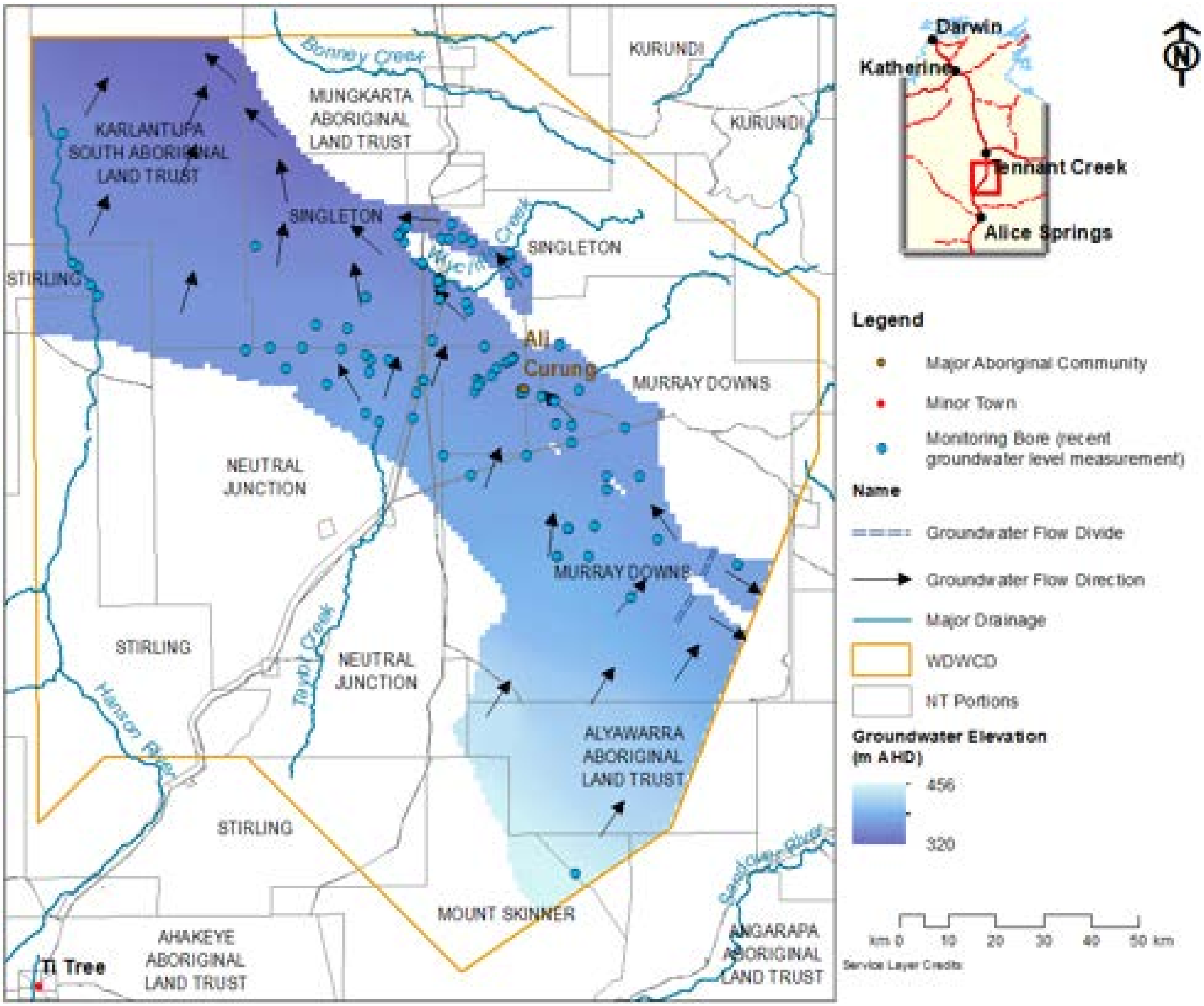


Figure 16. Groundwater elevation (mAHD) and flow direction across the Central Plains (Tickell and Zaar, 2022)

3.6 Groundwater modelling

Numerical models of natural systems are used to help humans better understand their environments, and can be used to find sustainable ways of living in them.

A groundwater model is a numerical method to represent how water flows or is stored underground. It comprises mathematical equations that simulate the movement of groundwater using the principles of physics. Scientific data is analysed to build a conceptual model of the region’s geology and underground water storages (aquifers). The model simulates all the components of the groundwater resources including groundwater flows and directions, aquifer recharge and discharges, evapotranspiration, and throughflow. The computer software simulates the effects of pumping to extract water from bores, which can also be used to ‘test’ future water use options. The Western Davenport numerical model has informed allocating water to benefical uses in the district through water allocation plans by assessing the impacts of taking water.

3.6.1 Model development

In 2016, the department engaged CloudGMS to develop a hydrogeological conceptualisation and numerical groundwater model (the model) using MIKE SHE proprietary software for the district (Knapton, 2017). The model domain is shown in Figure 17.The model boundary was based upon the watershed boundaries on the basis that rainfall occurring in the Davenport and Southern Ranges will shed runoff into the Central Plains basin. The model does not extend fully towards the Tennant Creek water control district and Tanami district to the northwest, where there is a paucity of field data and accessibility at the outlet of the basin.

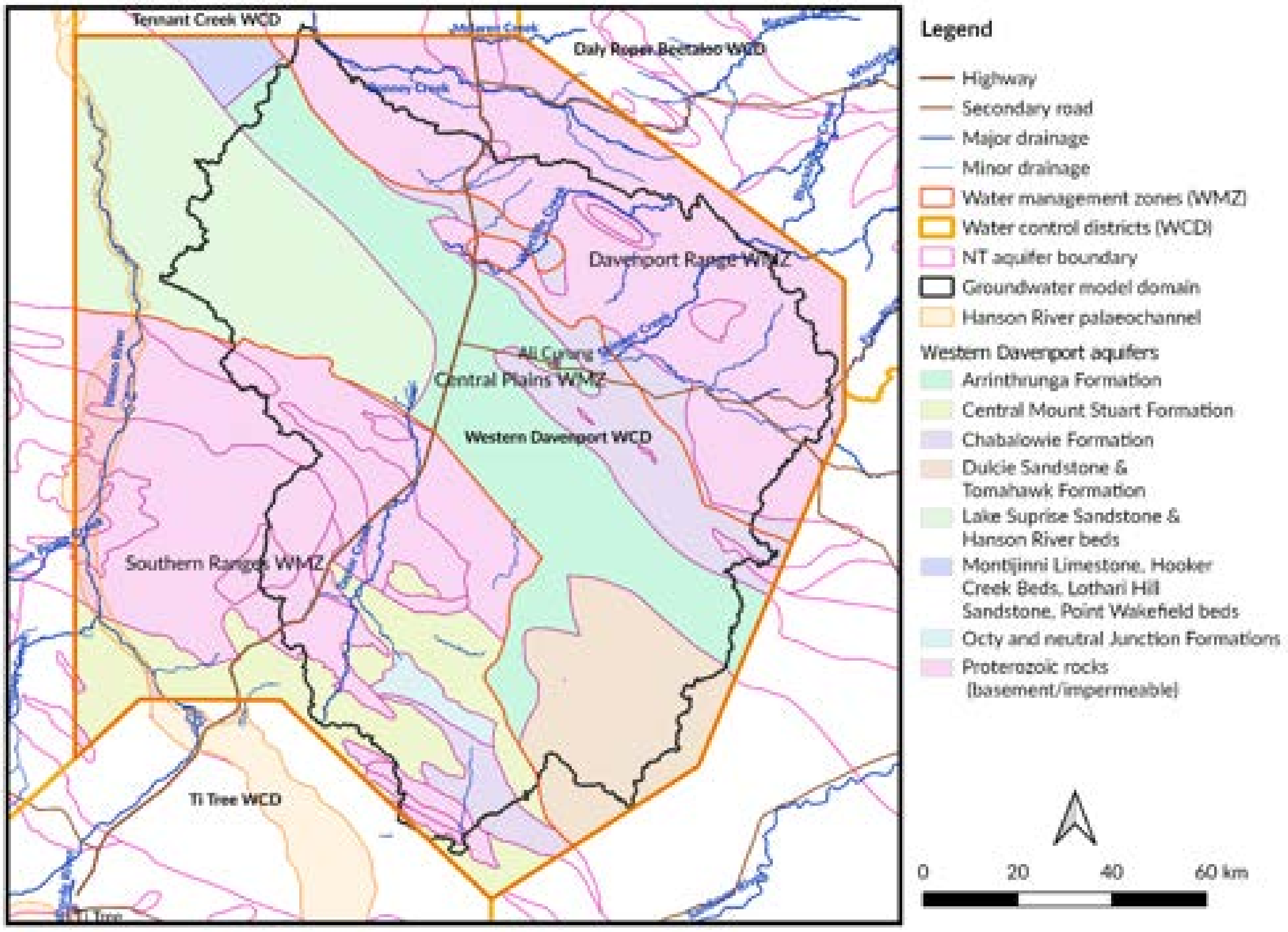


Figure 17. Aquifers, palaeochannels and model domain

The model provides the department with knowledge about aquifer yields and performance under various pumping scenarios to assist in the water planning process. It has been designed specifically to examine the groundwater resources of the Central Plains water management zone in the district, as this is the area with the greatest potential for intensive development. The active model area is approximately 16,146 km^2, with boundaries designed to include the saturated areas of the Western Davenport aquifers and the surface water catchment (Knapton, 2017).

Various data was collected and compiled to construct the groundwater model, including:

- radar data from the Shuttle Radar Topography Mission, used to determine the ground surface (i.e. topography) for the region covered by the model
- climate data, obtained from rainfall gauges at Tennant Creek (outside but close to the district), Ali Curung and Barrow Creek, as well as national climate data to increase continuity of rainfall and evaporation records
- measurements of groundwater levels at 176 bores
- continuous measurements of groundwater monitoring data for 48 bores showing changes in groundwater level over time
- borehole drilling logs at all available bores, which mapped the top and bottom of each formation within the Central Plains aquifer system
- pumping tests at 50 bores to identify the range of aquifer parameters in the Central Plains aquifer system
- vegetation data sets obtained from the national vegetation information system Moderate Resolution Imaging Spectroradiometer satellite imagery.

The groundwater model was calibrated using history matching, a method commonly used to check that a computer model satisfactorily predicts past conditions. Because no suitable evaporation data was available for the Western Davenport area from the BoM prior to 1970, the 45 year period from 1970 to 2015 was chosen to calibrate the model and to estimate key model parameters. Modelled groundwater levels were compared with approximately 20,000 recorded groundwater level measurements available for the calibration period. In general, modelled groundwater levels were found to be in good agreement with recorded levels as they followed long term trends and reproduced observed recharge events.

The model was also graded for reliability and sophistication using a classification system developed under the Australian groundwater modelling guidelines 2012 (Barnett et al., 2012). The classifications range from Class 1 (lowest) to Class 3 (highest). While many characteristics of groundwater model were graded Class 3, the model was ultimately graded Class 2 owing to the limited availability of information to the southeast and northwest of the main (Central Plains) aquifer system. The model classification (or 'Class') indicates how the model rates for complexity, internal calculation errors, rigour of calibration, availability and time period of field data, and other factors. The model is deemed sufficient for use in the water planning process.

The model uses the DHI MIKE SHE 2016 platform, which applies a finite-difference code to simulate processes associated with episodic recharge and three-dimensional groundwater flow. Five layers are used to represent the hydrostratigrapic units within the plan area shown in Figure 17.

These layers are:

- layer 1: Cenozoic (Quaternary/Tertiary)
- layer 2: Devonian, including the Dulcie Formation and Lake Surprise Sandstone
- layer 3: Cambro-Ordivician, including the Hanson River Beds and Hooker Creek Formation in the Wiso Basin and the Tomahawk Formation and Arrinthrunga Formation in the Georgina Basin
- layer 4: Middle Cambrian, including the Chabalowe Formation (Georgina Basin)
- layer 5: Basement, including the Archean granites, Hatches Creek Group and Mount Stuart.

Model parameter estimation, or calibration, was completed following the model design and construction to ensure the model was acceptable as a good representation of the physical system. Model calibration was undertaken using a combination of a manual trial and error and automated methods. The calibration process included both steady state and transient model parameter estimation. Sensitivity and uncertainty analyses (extended in 2021) were also performed to quantify the response of the model's output to incremental variations in model parameters, stresses and boundary conditions.

Independent reviews are conducted as part of ongoing scientific advancement within the department. Most recently, considerable work was carried out to test the model parameters by running over 1,000 simulations. This testing confirmed the model was fit for purpose. The model was able to simulate actual data sets collected from several bore sites in the Central Plains management zone to acceptable levels of accuracy. The paucity of bore data in the remaining zones and the far eastern and western parts of the Central Plains management zone is acknowledged.

An uncertainty analysis of the model concluded that the model parameters are within the acceptable range of precalibration data (Knapton 2023). The independent review found that the model meets industry standards as a Class 2 model at the basin scale with some individual parameters considered to be at Class 3 level. Based on this, the model is considered adequate for water allocation planning. Improvements, including data from new monitoring sites and recommendations from an independent review of the model, will be included in the next update of the model scheduled prior to the review of the plan.

3.6.2 Natural water balance

The natural water balance is an important concept in water resource management that refers to the inflow and outflow of water in a given area, and the resulting change in the water storage in that area over time. The natural water balance can be expressed using a simple flux equation:

Inflow = outflow +/- change in storage

The water balance is used to assess water availability in a given area and to plan the sustainable use of water resources. The natural water balance has been produced using the MIKE SHE model (Knapton, 2017) for each of the three water management zones. The modelled results are based on 50 years of climate data (1970-2020). Inflow parameters are recharge and throughflow in; outflow parameters are evapotranspiration and throughflow out.

The flux equation is a general expression of the water balance. Fluxes vary in space and time so the equation may not provide an exact balance at all times and all locations within the model domain. The value of the individual flux components is likely to contain errors due to spatial lumping, parameter estimation and calculation assumptions (Knapton, 2020). In addition, the flux components have been averaged from daily values to long term annual averages.

Groundwater throughflow represents lateral inflow through the saturated zone from the Davenport Range and the Southern Ranges, into the Central Plains water management zone which lies down gradient of the adjacent Ranges.

Storage change is the net increase/decrease of water within the aquifer. The average annual storage change in all three management zones is increasing (ie +ve change) for the modelled time period. This corresponds broadly to the increasing frequency of rainfall events shown in Figure 13 and Figure 14.

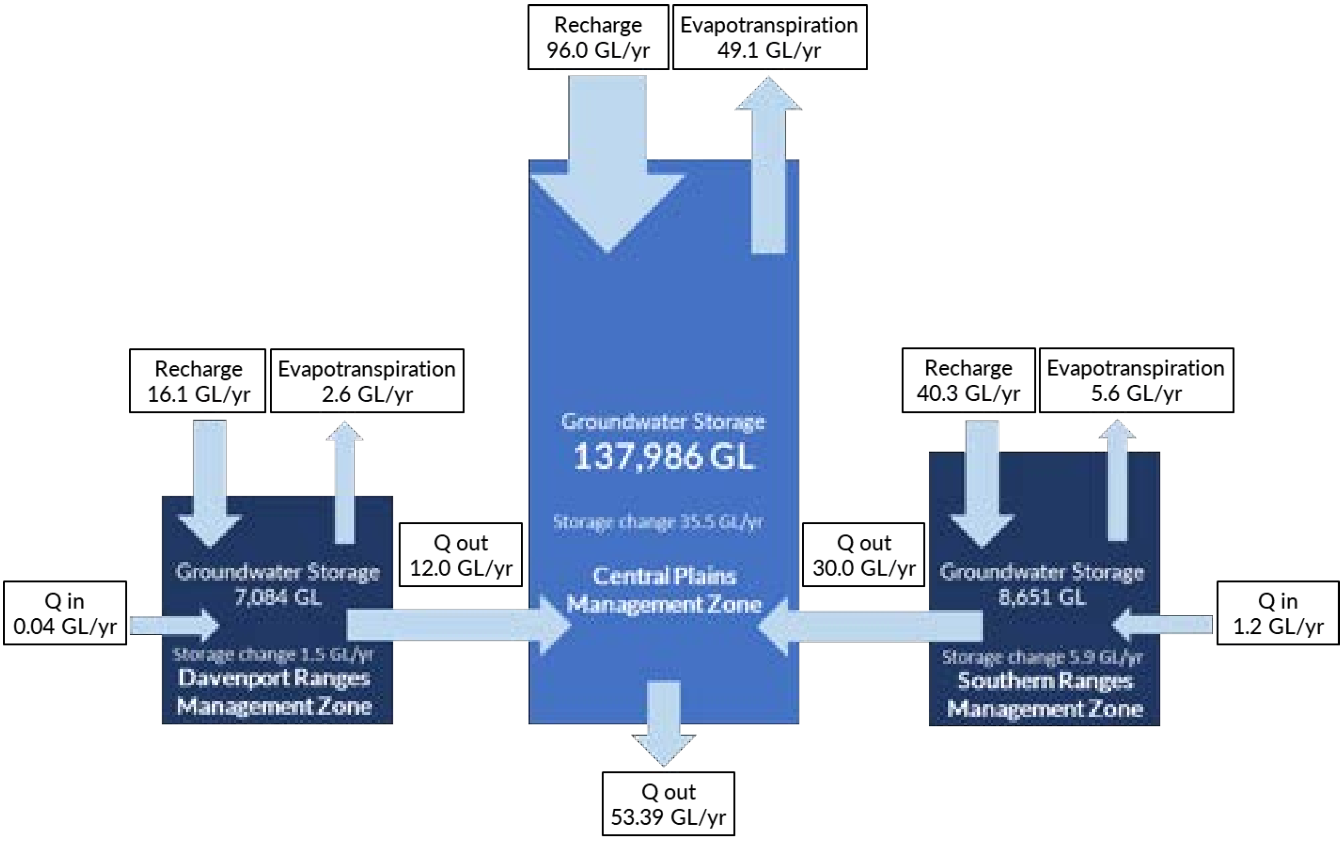


Figure 18. Natural water balance for the Western Davenport water management zones

Evapotranspiration is determined using actual evaporation values combined with transpiration from major vegetation classes and associated rooting depths in the groundwater model.

Figure 18 shows the natural water balance in each of the water management zones. All components of the water balance flux equation are annualised averages for the period 1970 to 2020. The volume of storage presented in the water balance was estimated using saturated zone storage as at 31 December 2020, and includes all lithological layers occurring above the underlying basement rocks in model layers 1 through 4 (refer section 3.5.1 of this document).

The maximum aquifer thickness in the Central Plains water management zone is estimated to be greater than 800 mBGL while the average thickness is around 300 m. The volume of water held in storage is estimated to be 137,986 GL with a net increase of approximately 35.5 GL/year over the 1970-2020 period. The maximum aquifer thickness in the Davenport Range and Southern Ranges water management zones is approximately 71 mBGL and 114 mBGL, respectively. The total volume of water in storage is 7,084 GL and 8,651 GL, for the Davenport Range and Southern Ranges respectively; these are also increasing over the period. The full volume of storage for these zones is deemed a reasonable estimate for productive use due to the relatively small aquifer thicknesses.

3.7 Interconnectivity of groundwater and surface water

A combination of satellite observations, groundwater and hydrological modelling, and analysis of composite runoff data and hydrochemical data were used to establish an understanding of the interconnectivity between surface water and groundwater within the district. Satellite observations from water observations from space and Terra/AQIS MODIS (moderate resolution imaging spectro-radiometer) were used to inform the mapping of inundation areas. Observations confirm that streams discharge into low lying areas where soils are mapped predominantly as alluvial. Simulations from the model suggests that runoff is generated from rocky catchments in the ranges situated north and south of the district. Analysis of runoff data shows that the majority of runoff occurs in March due to antecedent catchment wetness provided by rainfall in the preceding months.

Modelling indicates that recharge is dependent on runoff, which is reliant upon rainfall intensity and ground conditions. This is common in arid environments. Data analysis shows that recharge is not spatially uniform and is likely to be localised near floodouts and along creeks. To improve understanding of these recharge mechanisms monitoring should be undertaken in areas close to mapped floodouts and creeks to assist in delineation of recharge contribution. The department is currently embarking on drilling programs to investigate and monitor these processes.

4. Environmental water

Overview

This section outlines the natural ecosystems related to the water resources managed through the plan.

The first priority of the plan is to ensure the majority of water in the plan area is retained for ecological and environmental functions and cultural water requirements.

Knowledge of environmental water values and requirements within the district have been significantly improved through the department's extensive work to establish the extent and potential location of groundwater dependent ecosystems that require access to groundwater to meet all or some of their water requirements.

There are also a range of values associated with surface water in the district.

Environmental water considers the water needs required to maintain natural ecosystems over time. In the district natural ecosystems have evolved to meet their water requirements from rainfall, surface water flows and accessing groundwater. These ecosystems have adapted to the variability of water being available from these three sources.

In the arid zone rainfall occurs mostly in the period from October to April each year, however as described in the climate section rainfall can be quite variable. As the larger rainfall events lead to groundwater recharge ecosystems accessing groundwater have access to water more often than ecosystems accessing surface water. Losing access to water has the potential to have greater impact on groundwater dependent ecosystems than other ecosystems.

4.1 Groundwater dependent ecosystems

The Norther Territory Government uses the definition of groundwater dependent ecosystems (GDEs) in Schedule A.

In general, GDEs in Australia are diverse. Eamus et al. (2006) classified GDEs into three major categories:

1. Terrestrial groundwater dependent ecosystems that rely on the presence of groundwater within the rooting depth, especially during drought.
2. Subterranean groundwater dependent ecosystems such as caves, aquifers and the hyporheic zones of rivers - areas where stygofauna may exist.
3. Aquatic groundwater dependent ecosystems such as springs, baseflow rivers, streams and wetlands that rely on an influx of groundwater to maintain water levels and functionality.

All three categories of GDEs are known to occur or are likely to occur within the district.

The type of GDE is strongly influenced by depth to groundwater, which is outlined in Schedule F within the district.

4.1.1 Terrestrial groundwater dependent ecosystems

The previous Western Davenport Water Allocation Plan 2018-2021 created a GDE protection area where depth to groundwater was expected to be less than 20 m, which was set when understanding of the distribution and occurrence of GDEs was limited. The boundary was based on the information provided in a report (Cook and Eamus, 2018) regarding the depth at which different plant species access groundwater in the arid zone. Using 60 site inspections Nano et al. (2021) identified different types of GDEs based on floristic groupings on sandplain and alluvial landscapes with varying depths to groundwater. This work provides information about the types of plants likely to be associated with GDEs with in alluvial and sandplain landscapes and depth to groundwater changes.

During 2018-20, further scientific investigation resulted in significant advances in the understanding of GDEs in the Western Davenport area. To map the probable occurrence of GDEs, Brim Box et al. (2022) applied singular value decomposition to a time series of vegetation indices derived from Landsat-8 data. In-situ field data from 442 sites were used to validate the logistic regression and neural network models, to determine whether sites could be correctly classified as GDEs. These results were used to produce a probability map of GDE occurrence across the plan area. The GDE map shown in Schedule F depicts the potential distribution of GDE sites using a model probability threshold of 50 per cent. An analysis of GDE model performance (Stokeld et al., 2022) has shown that use of a 50 per cent probability threshold provides the greatest level of accuracy for distinguishing GDE sites from non GDE sites, compared to higher (70 per cent) and lower (30 per cent) probability thresholds, which are more likely to misclassify sites.

These investigations show that the majority of GDEs in the Central Plains area occur in the shallowest groundwater areas (<10 m) and include features such as Thring Swamp and the Wycliffe Creek floodout. These areas have high environmental and cultural importance and their significance has been well documented in previous plans and reports.

In order to improve understanding of the ecological attributes of GDEs and their relationship to groundwater depth, the department undertook extensive on ground sampling within the Central Plains (Stokeld et al., 2022). Terrestrial vegetation was sampled at 60 sites along a groundwater depth gradient in the two dominant landscapes of the study area; sandplains and alluvial plains. Sampling included full floristic inventory at each site and morphometric measurements for focal tree species. Most sites were sampled twice to help partition rainfall from groundwater effects, and landscape and disturbance variables were scored to help determine the importance of groundwater relative to other drivers of vegetation patterns.

Stokeld et al. (2022) also highlight the importance of large aggregations of terrestrial GDEs for maintaining connectivity across the landscape, and which likely contain a greater variety of flora, fauna and habitats than smaller and more isolated GDEs. A proximity analysis was undertaken, utilising the GDE model at a 50 per cent probability threshold, to identify and map aggregations of terrestrial GDEs in the landscape, including areas where sparse groves of large groundwater-dependent trees are likely to occur. The map at Schedule F identifies where large aggregations of GDEs, at varying densities, are likely to occur in the Central Plains area.

The 50 per cent GDE probability map at Schedule F provides a reliable baseline for this water allocation plan and will be used to guide further targeted ground surveys during plan implementation. This mapping should be used in concert with the terrestrial GDE aggregation map at Schedule F when considering the potential impacts of proposed water extraction.

A guideline was developed that sets an overall threshold of acceptable change for GDEs. The guideline states that 70 per cent of the current extent of GDEs should be protected from the negative impact of groundwater extraction. When applying the guideline, the 50 per cent GDE probability map at Schedule F should be used as the baseline for GDE extent, including any future refinement and extension of this mapping during the implementation of this water allocation plan.

4.1.2 Subterranean groundwater dependent ecosystems

Stygofauna (small aquatic invertebrate animals) have been found in groundwater in some parts of central Australia. Aquifers containing stygofauna are also considered GDEs. The district covers the southern part of the Wiso Basin, which is identified as having high potential for stygofauna (Moulds and Bannink, 2012). More recently Rees et al. (2020) and Biota (2022) found a high diversity of stygofauna in the Daly Basin and northern part of the Georgina Basin and Wiso Basin. Stygofauna are likely to be present in alluvial, karstic and some fractured rock aquifers at depths of less than 100 mBGL (Hose et al. 2015).

While this information indicates the potential for stygofauna to occur in the district, there are no records. It is likely that sampling for stygofauna will find specimens. Biota (2002) reported recent bore sampling in the Daly Basin, Georgina Basin and Wiso Basin that about 30 per cent of bores had stygofauna.

Stygofauna communities are reliant on recharge to maintain water quality, groundwater levels and provide tropic level inputs to subterranean food webs. Desaturation of suitable habitat is the biggest threat to stygofauna communities. Changes in water quality could also impact stygofauna. Where depth to groundwater is less than 50 metres there is increased probability of stygofauna occurring.

4.1.3 Aquatic groundwater dependent ecosystems

A small number of springs are known in the ranges, as well as waterholes sustained by groundwater discharge, and several are recognised as sites of conservation and botanical significance. These wetland features are not well documented but are thought to mainly occur in and near the ranges. Stokeld et al. (2022) reports that these and other areas where the depth to groundwater is shallow (less than 15 m), are heavily impacted by grazing, and are also susceptible to exotic plant invasions (e.g. buffel grass) and altered fire regimes. The areas where springs and waterholes associated with the ranges are located within water resources that have poor yields and groundwater quality, and consequently the risk to these types of GDEs is limited.

Several springs occur in areas underlain by Dulcie Sandstone adjacent to the south eastern boundary of the Central Plains water management zone. There are currently no springs recorded or evident from satellite imagery within the eastern extent of the water control district, however this area is underlain by the Dulcie Sandstone may also host localised springs, or springs that flow during rainfall events similar to those outside of the water control district boundary.

Schedule G shows the areas where depth to groundwater is less than 5 metres where there is increased probability of interaction with surface water and aquatic GDEs.

4.2 Aquatic ecosystems

The district contains large floodouts where water spills across adjacent alluvial land systems during intermittent events. Flooding doesn't last very long but occurs regularly (about every other year). The clay rich soils of flood out areas and associated claypans provide vegetation longer term access to water (Duguid, 2009). Floodouts are generally considered inflow dependent ecosystems rather than GDEs, because vegetation accesses floodwater stored in the unsaturated zone or in perched aquifers, rather than a deeper, regional aquifers.

Stokeld et al. (2022) identify a number of vegetation communities associated with surface water flows and floodouts in the district.

- River channels and creek lines supporting narrow corridors of river red gum (*Eucalyptus camaldulensis* subsp. *Arida*) low open woodland - a vegetation community which provides suitable nesting opportunities for Grey falcon (*Falco hypoleucos*, Vulnerable, *Environment Protection and Biodiversity Conservation Act 1999* and *Territory Parks and Wildlife Conservation Act 1976* (TPWC Act).
- Melaleuca shrub lands dominated by sandhill tea tree (*Melaleuca lasiandra*) which occurs in a narrow discontinuous band from the northern end of the Taylor Creek floodout and eventually connecting with Wycliffe Creek.
- Coolibah low open woodlands which dominate the floodouts associated with Thring Swamp, Wycliffe, Hurst, Skinner, Sutherland and Taylor creeks. Coolibah swamps are also present as discrete units away from creek lines, occurring in hardpan depressions where inundation occurs after heavy rainfalls.

There are a number of plants associated with wetlands that are rare, threatened or have limited distribution. Thring Swamp provides suitable habitat for several uncommon or highly restricted plant species, such as water lily *Nymphaea immutabilis subsp immutabilis* (Data Deficient, TPWC Act) and yellow fringed water lily *Nymphoides indica* (Least Concern, TPWC Act). The study area also supports one of only three known populations of the fern *Marsilea cryptocarpa* (Data Deficient, TPWC Act).

Several sites of conservation and botanical significance occur in the district. The nationally significant Davenport and Murchison Ranges Site of conservation significance, an area with long lasting waterholes, relatively high fish diversity and habitat for threatened fauna, overlaps the north eastern boundary of the district.

White et al. (2000) identified four sites of botanical significance associated with creeks and waterways. The most significant is the Thring Swamp site associated with the Wycliffe Creek system, which supports an extensive area of GDEs and other wetlands and suitable habitat for several uncommon or highly restricted plant species as reported above. The other sites of botanical significance are Algoolgoora Swamp, Watt Range floodouts and fringing sandplains, and Barrow Creek.

5. Cultural water

Overview

This section outlines the current understanding of the water needs of key cultural sites related to the water resources managed through the plan.

The first priority of the plan is to ensure the majority of water in the plan area is retained for ecological and environmental functions and cultural water requirements.

Better reflection and understanding of Aboriginal cultural water knowledge and associated requirements in the plan area will continue through the implementation actions. As this information is considered, the water resources related to key cultural values can be appropriately managed through the plan.

5.1 Cultural values

5.1.1 Aboriginal cultural values

Aboriginal people within the district have a strong connection to country. The cultural landscape of this area includes physical (e.g. sacred sites, ancestor trees and other features such as stone arrangements) and non physical cultural values (e.g. knowledge, practices, songs, and ceremony). All water sources such as soaks, rock holes, springs and rivers play a major role in the social, spiritual and customary values of the Traditional Owners of the district.

In addition to cultural values, Traditional Owners are subject to the rules and institutions associated with customary law. It is important to recognise Traditional Owners as being central to the interpretation of customary law as it relates to the management of cultural values. This includes obligations for managing country, managing access to sites, and passing on knowledge and law, which are key aspects of cultural identity. Hence the use of a water resource is not only physical, but extends to other cultural values through activities such as visiting and maintaining sites, sharing and teaching cultural knowledge, conducting ceremony, or participating in management decisions.

Dreaming lines which run throughout this area as part of the cultural landscape often relate to surface water ecosystems. The continuing importance of these water related sites and their cultural associations is emphasised by activities such as the “Walking and Sharing Stories from Bonney Creek to Barrow Creek” in June 2008 when about 65 Kaytetye, Warumungu, Warlpiri and Alyawarra people took 15 days to walk 140 km between some 30 soaks near the central northsouth axis of the district, with Traditional Owners working to maintain the health of the soaks along the way (Central Land Council, 2008).

The significance of water for Traditional Owners is not limited to surface water and GDEs as water is found throughout the country and in all living things. Water availability also affects many activities, like hunting for and harvesting bush tucker, bush medicine, and tool and craft making.

Soaks are considered one of the most important sources of water in the desert. Knowledge of where to find water, and how to source it, is vital information passed down from generation to generation. Hunting and harvesting are regularly conducted in these environments and habitats. Significant drying or lowering of the water table could adversely affect the availability of water in soaks and the health of culturally important GDEs.

The floodouts and associated vegetation are culturally important to the Traditional Owners, particularly in relation to the large trees they support (such as *Eucalyptus sp.* and *Corymbia sp.)* and the high importance of these areas to Aboriginal cultural practices and land use. Floodouts are generally important hunting areas, and also often have ceremonial importance.

Further details regarding Aboriginal cultural values are documented in a cultural values assessment prepared for the Central Land Council (Donaldson, 2021). The assessment involved a literature review and consultations with 80 Traditional Owners in June 2021, which identified a complex Aboriginal cultural landscape across the area including important cultural values directly associated with GDEs. The assessment documented the Traditional Owners' belief in the Altyerre (Dreaming) Law, and the need to follow the Law as the cornerstone cultural value arising from this assessment and the foundation of all other identified cultural values.

Taking care of country into the future according to ancient laws and customs appeases the creator spirits residing at important places. If traditional roles and responsibilities are not carried out by Traditional Owners, and if country is damaged as a result of the actions of Traditional Owners or others, punishment is imposed on senior Traditional Owners by Altyerre forces resulting in sickness, injury and even death. Spiritual punishment can lead to psychological stress and guilt linked to people's sense of internal moral failure associated with being responsible for damaging the country belonging to their spiritual ancestors, their actual ancestors, and the current generation of kin and their descendants. Social sanctions may also result; Traditional Owners can be forced into temporary or permanent isolation from their group.

The assessment also revealed the strong spiritual connection between Traditional Owners and sacred sites, the places embodying the Altyerre (Dreaming). Background research combined with consultations with Traditional Owners identified 40 sacred sites associated with 20 Altyerre mythologies within the drawdown area. Each of the 40 sacred sites identified have features associated with GDE: soakages, bean trees, orange trees, coolibah trees, creeks, swamps, supplejack trees, ghost gums, and bloodwood trees.

Many of the Altyerre tracks traversing the drawdown area interlink with places across the broader cultural landscape. Whilst all of the mythologies across the drawdown area relate to the Altyerre creation of the land and water, a number of mythologies specifically relate to water, such as ancestors carrying and digging for water, ancestors teaching others how to sing for rain, and groups attending large rain ceremonies. These mythological episodes continue to be re-enacted by Traditional Owners today in ritual, through song, dance, paint, storytelling and by visiting the spiritual ancestors residing at sacred places. Damage to sacred sites can impact Traditional Owners' spiritual connection to country.

5.2 Considerations for protection of cultural uses

The development of policies relating to the protection of cultural values that will inform decision making is required for a range of sites, places and practices, including but not limited to family trees, soaks where animals gather and vegetation complexes relying on access to groundwater which support cultural practices.

The policies for environmental protections should be relevant to the protection of cultural values that coincide with GDEs. It is recognised that there are additional areas of cultural value which may not be GDEs, and some cultural values which relate to GDEs which will have additional requirements for cultural use protection such as soaks, ceremonial areas and hunting grounds. Further work is required to ensure that these requirements are understood. Ongoing monitoring is needed to identify any changes or threats to the protection of these values.

The ongoing involvement of Aboriginal people in the district is important as they hold immense knowledge of the region, and are custodians for water places and places relying on water. Access to groundwater for consumptive use offers a pathway for regional economic development. This is being actively progressed by the department through the establishment of an Aboriginal reference group for the region under the Act or a similar appropriate mechanism agreed with Aboriginal representatives. This will provide the opportunity to work in partnership with local Aboriginal representatives to document cultural water values and to protect key cultural assets associated with water.

6. Water use

Overview

This section outlines the key considerations to determine the amount of water that may be taken from the water resources managed under the plan. This includes an overview of the policy and processes to establish the estimated sustainable yield and Aboriginal water reserve allocations. Information is also presented on existing water use and water licence entitlements in the plan area.

The first priority of the plan is to ensure the majority of water in the plan area is retained to ensure ecological and environmental functions and requirements of the resource. It defines the water available for allocation and for stock and domestic take by establishing the take of water that is sustainable, known as the estimated sustainable yield.

The estimated sustainable yield 87,700 ML per year is informed by scientific understanding of the water resources, underpinned by water monitoring, assessments and modelling:

- maintains the vast majority of the water in storage, over 100 years 94 per cent remains, which does not account for recharge events that will also occur
- relies on stored water to meet the continuous demand for water that can be accurately measured, as recharge in the region doesn't occur regularly.

The largest and most productive groundwater resource is the Central Plains, which averages 300 metres thick and holds an estimated 138,000,000 ML:

- naturally groundwater depths range from near surface to 50 metres below ground level
- the extensive understanding of ground water dependant ecosystems and where the water is taken is moderated through water licences that must protect 70 per cent from development in the area.

Drinking water will always be protected, so towns and communities have enough safe water.

Within the estimated sustainable yield 25,677 ML per year is available for the Aboriginal water reserve, which is in proportion to the percentage of eligible land in the district with access to the groundwater resources for each water management zone.

Current water use is very limited and water licence entitlements are primarily for agriculture activities.

The Act provides that a water allocation plan is to ensure that water is allocated within the estimated sustainable yield (ESY) to beneficial uses. The ESY determines the proportion of water from a water resource within the district that can be sustainably allocated to beneficial uses. This includes an allocation to the environment, and to an Aboriginal water reserve for future Aboriginal economic development.

In broad terms, Northern Territory Water allocation planning framework[9] (framework) sets the approach to water allocations in the Northern Territory. All available scientific research directly related to environmental and other public benefit requirements for the water resource will be applied in setting water allocations for non-consumptive use as the first priority, with allocations for consumptive use made subsequently within the remaining available water resource. The framework recognises that the characteristics of water resources varies significantly between the north and south of the Territory and defines water allocation principles for the Top End Zone and Arid Zone. More recently, criteria have been defined to assess whether water resources behave like Top End or Arid Zone water resources to consistently inform allocation volumes and licence decisions (Short and Bond, 2021).

The water resources in the district are characterised as Arid Zone (Short and Bond, 2021) and the plan sets a tailored ESY that is based on the water planning process undertaken in the region.

[9] https://nt.gov.au/environment/water/management-security/water-allocation/water-allocation-framework

In arid regions like Western Davenport where rainfall is low, unpredictable and recharge to water resources doesn't occur reliably every year, underground aquifers must be relied upon to sustain life.

It is necessary to use aquifer storage to meet the continuous demand for water. Relying on actual stored water is a more precautious as it does not rely on uncertainty of climate variability.

6.1 Current water entitlements and use

Understanding existing water entitlements and how much water is reported used is important when determining allocations to beneficial uses within the ESY. Water entitlements can be categorised by those that require a licence and those that do not require a licence.

6.1.2 Unlicensed entitlements

Rural stock and domestic water use does not require licensing.

Section 11 of the Act provides that, the owner or occupier of land on or immediately adjacent to which there is a waterway may take water from that waterway for:

a) the use of the owner or occupier or the owner's or occupier's family and employees, for domestic purposes on the land or

b) drinking water for grazing stock on the land or

c) irrigating a garden, not exceeding 0.5 hectares, which is part of the land and used solely in connection with a dwelling.

Rural domestic use is the water used by outstations not supplied by Power and Water Corporation as a public water supply, and water used for domestic use on pastoral properties.

Outstation water use has been estimated by comparing domestic water consumption rates for the communities of Ali Curung, Tara and Imangara, who do have a metered public water supply, relative to the community population and applying a similar rate of water use per person to population statistics.

Rural domestic water use on pastoral properties has been estimated by applying an average water use based on Power and Water Corporation Water Smart consumption rates to the number of homesteads within each management zone.

Estimates of rural stock and domestic use for groundwater is provided in Table 1.

Table 1. Rural stock and domestic water use estimates (ML per year) for each water management zone

Estimated water use (ML per year)	Davenport Range	Central Plains	Southern Ranges	Total
Domestic water use – outstations	29	10.2	5.5	**44.7**
Domestic water use – pastoral	5	9.8	19.5	**34.3**
Stock water use	215	259	430	**904**
Total	**249**	**279**	**455**	**983**

Estimates for stock water use are based on the methodology provided by Meat and Livestock Australia's best practice guidelines[10] that determine water consumption based on animal carrying capacity per unit of land.

[10] Meat and Livestock Australia's Cattle and land management best practices guide: https://industry.nt.gov.au/__data/assets/pdf_file/0010/227827/kbp_apr09_web_96dpi.pdf

6.1.3 Licensed entitlements

Section 45 and 60 of the Act provides that the Controller of Water Resources may grant to a person a water extraction licence to take groundwater from a bore or to take surface water. The licence permits a maximum annual water entitlement to be taken for a nominated beneficial use or uses. Existing water licence entitlements to each beneficial use are summarised in Table 2.

Table 2. Total water licence entitlements by for the district (ML per year)

Groundwater (ML per year)	Davenport Range	Central Plains	Southern Ranges	Total
Beneficial uses:				
Public water supply	30	500	35	**565**
Agriculture	0	50,604	0	**50,604**
Industry	10	300	0	**310**
Aquaculture, cultural, mining activity, petroleum activity	0	0	0	**0**
Total	**40**	**51,404**	**35**	**51,479**

6.1.4 Public water supply

Public water supply is delivered through community water supply systems.

In the Northern Territory the Chief Health Officer provides directions related to safe drinking water and has a key role in the protection of public health.

The *Public and Environmental Health Act 2011*, *Water Supply and Sewerage Services Act 2000*, and *Power and Water Corporation Act 2002* provides the regulatory framework for service delivery of public drinking water in urban centres and by agreement with the Northern Territory Government for remote centres.

In the district, public water supply applies to the communities of Imangara, Tara, and Ali Curung (Figure 1). A water licence is issued to PWC for each of these communities based on existing average demand and forecasted 30 year demand estimates. The existing licence entitlements for each community includes a significant buffer for expansion of the community or emergency provision.

A licence to take water on Singleton Station for public water supply has been granted for a maximum entitlement of 100 ML per year. A summary of licensed public water supply is provided in Table 3.

Table 3. Current licensed entitlements for public water supply (ML per year) at January 2024

Groundwater (ML per year)	Davenport Range	Central Plains	Southern Ranges	Total
Location	Imangara	Ali Curung, Singleton	Tara	
Forecast 30 year demand	13	135	14	
Licensed entitlements	30	400,100	35	**565**
Licensed entitlement relative to forecast 30 year demand (%)	230	296	250	
Total ML per year	**30**	**500**	**35**	**565**

Details of water quality results are provide by PWC in an annual drinking water quality report accessible via the publications[11].

Northern Territory desert communities are reliant on the local groundwater for drinking water. The local groundwater can be hard, taste salty, and may have other naturally occurring contaminants including nitrate, fluoride and uranium. PWC is continuing to research and develop efficiencies with the desalination of brackish groundwater, such as in a membrane Capacitive Deionisation (mCDI) trial that is underway in Ali Curung. At the completion of the trial, key operation and performance indicators, as well as cost will be used to compare the mCDI to other available technologies to aid in the selection of appropriate treatment solutions for desert communities. The technology may also support improved public health outcomes elsewhere, for towns where salty groundwater leads to lower rates of tap water consumption.

6.1.5 Agriculture water use

The main use of water in the plan area is for agricultural purposes, with 99.6 per cent of all entitlements held by 6 licensees in the Central Plains water management zone.

The region already produces significant food and fodder crops from irrigation. In addition to well established and developing irrigated farming enterprises, there are several proposals for new and expanded enterprises. A farm training center has been established at Ali Curung to support educational outcomes and workforce development.

6.1.6 Industry, cultural, mining and petroleum water use

There are 2 licences for industry and currently no licences or water used by the beneficial uses of aquaculture, cultural, mining activities and petroleum activities.

6.2 Future water use

The climate and natural resources of this region have been identified by the Territory Government as highly suitable for horticultural development because there is a large amount of good quality groundwater in areas with suitable soils. Other advantages of the region include proximity to major transport routes, abundant sunshine, cool winters, low frost risk, low humidity, different harvest times from more established farming regions and low levels of pests. Research by the Territory Government and its partners has identified potential for production of a diverse range of crops, including stone fruit, nuts, temperate and subtropical fruits, and ornamental flowers.

There is potential for the region to be a significant agriculture precinct, with opportunity for up to 10,000 hectares under irrigation to be developed over the next 10 to 15 years. This strategic agricultural expansion will be beneficial to regional development, supply chain opportunities in the Territory and strengthen existing communities and services. Future growth will be supported through health, education, accommodation and social infrastructure, along with significant economic and business opportunities and attract new workforce to the region. Future development of the area would also increase potential prospects for agribusiness that is led by Indigenous communities and on Indigenous land. Future agricultural development within district will continue to be underpinned by a robust regulatory framework.

This includes opportunities for economic growth through agribusiness in Aboriginal communities, economic growth and resilience of a region, regional development regional growth in support services and to strengthen supply chain opportunities along the Stuart Highway.

[11] https://www.powerwater.com.au/__data/assets/pdf_file/0029/115985/Annual-Drinking-Water-Quality-Report-2021-FINAL.pdf

6.3 Estimated sustainable yield

The estimated sustainable yield (ESY) means the amount of water that can be allocated from the water resource to support declared beneficial uses that is sustainable as defined in section 3.1 of the water allocation plan.

The process for determining the ESY follows accepted practices that begins with revisiting its understanding the water resource, identifying the environmental values associated with the water resource (including cultural where described), considering the limits of acceptable change to natural water requirements, and finally, determining how much water can be taken from a water resource for beneficial uses set for the region.

The ESY is determined after prioritising water for non-consumptive uses. That is, the majority of the water is retained in the environment to maintain important ecological functions and for cultural purposes and values of water in the region. A comparatively low proportion of the water is allocated to the ESY for drinking and sustainable development.

This approach is the reverse of most other jurisdictions, ensuring the Territory is able to be precautionary as it develops water resources to support the growth of its communities and economy in regional and remote areas.

6.3.2 Surface water

Surface water in the district is ephemeral and unreliable. Generally, it is not a practical source of water for consumptive use, except for rural stock and domestic purposes, which does not require a licence to be taken.

Surface water flows during wet periods contribute to recharging the groundwater and wetting of the soil profile. Surface water may form pools in low lying areas for days to weeks after rainfall and supports natural ecosystems along with associated sites of cultural significance for Aboriginal people. Further investigations to better quantify overland flow and recharge are underway.

Overall, setting an ESY for surface water through the plan has not been included due to the ephemeral nature of the resources, to ensure protection of replenishment processes of the groundwater resources, and noting that its use is limited to rural stock and domestic purposes when surface standing water occurs.

6.3.3 Groundwater

The natural water account (Figure 17) based on long term historical data indicates the expansive storage in volumes of 153,721,000 ML which has been increasing since the 1970s. The Central Plains water management zone is the most significant and extensive resource in the region.

In arid regions like Georgina Wiso where rainfall is low, unpredictable and recharge to water resources is infrequent, underground aquifers must be relied upon to sustain life. It is necessary to use aquifer storage to balance infrequent recharge with a continuous demand for water. Relying on actual stored water available is a more precautious approach than relying recharge, as it does not rely on uncertainty of climate variability.

The ESY for groundwater in the plan is based on the following considerations:

- stored volumes of water
- the sustainability of current water allocations (currently up to a maximum of 51,479 ML/year) and existing and prospective development opportunities in the region
- protecting groundwater dependent ecosystems within the limits of acceptable change and
- modelled impact of different extraction scenarios against all of these.

Without taking into account any changes in the water balance that may occur over time, the direct application of the framework to the Central Plains water management zone stored volume provides a maximum potential extraction of 1,106,573 ML/year. However applying the framework to determine the ESY was dismissed during the planning process.

6.3.4 Modelling extraction scenarios

Modelling is a useful tool to assess the potential and relative impact for a range of management decisions. Modelling results show how the system responds to extraction and, when assessed against limits of acceptable change, inform options for the determination of an ESY.

In developing the plan a number of groundwater extraction scenarios were modelled to assess the relative impact of extraction on groundwater levels across the plan area, including the acceptable limits of change for GDE's mapped within the plan area.

Six scenarios ranging from 61,000 to 307,000 ML/year, were modelled for impact. These scenarios included c existing entitlements, likely potential development areas and representative use of the Aboriginal water reserve. The relative impact of groundwater drawdown were compared against the acceptable limits of change to GDEs and impacts on other uses.

The model was run to simulate the impacts for 10 years of the plan and assuming that this would continue for 50 years to provide an indicative long term impact of each water extraction scenario.

The impact of the extraction scenarios were compared with the proposed limits of acceptable change on GDEs using GDE probability mapping in the Central Plains water management zone. It should be noted, however, that these extraction scenarios represent indicative regional scale impacts; detailed specific assessments of water extraction impacts at a local scale are completed during the water extraction licence decision process.

In summary the model results indicate the impact of extraction on drawdown or extent does not significantly change between scenarios with a maximum total extraction of 61,000 ML/year to 97,000 ML/year. The impact becomes more evident at scenarios of 116,000 ML/year and greater.

Following the scenario modelling assessment, 87,700 ML/year was selected as the ESY for the plan, which represents an ESY for the Central Plains water management zone of 81,500 ML/year. Schedule G shows the modelled impact of 87,700 ML/year continuous extraction after 10 years and 50 years respectively. The selection of the ESY is consistent with the Committees advice to be precautionary.

For the Central Plains water management zone, taking an ESY of 81,500 ML every year for 100 years, means that 94 per cent of the current water holding remains stored underground without relying on any recharge.

More important than the ESY total volume is the location from where the water is taken, as the resource is spatially variable and impacts will depend on proximity to receptors such as GDEs and other users. This is appropriately managed through licence decisions and conditions that are assessed and set based on the specific amount and location of water extraction i.e. point of take.

The entire ESY volume cannot be taken at once due to staged licence conditions, the actual volume of water that can be taken each year is much less (i.e. a portion of the entitlement) and can only increase if the licence conditions are met and the Controller approves the next stage.

Staged release of water under current licences means that over the next five years of the plan, less than 50 per cent of the ESY will be allowed to be taken before the next review process. In addition, a review of the plan will be triggered if 70 per cent of the water is used, including considerations of different beneficial use categories outlined in the plan.

This staging of water licences in the district provides:

- a tool to manage how much of the ESY may be taken at any given time
- ensures sufficient time to establish regional monitoring as well as site specific monitoring of the resource before more water is released
- ensures the effects of actual water use are clearly understood before the next level of extraction is approved.

The allocation of the groundwater ESY to each of the beneficial uses for each water management zone is set out in the water allocation plan.

The selection of the ESY, resulted in a reduction in the ESY for the Central Plains water management zone from the previous plan from 87,720 ML/year to 81,500 ML/year. Consequently as the Aboriginal water reserve allocations are proportional to the ESY, these allocations will be reduced by from 26,091 ML/year to 24,225 ML/year for the Central Plains water management zone.

6.4 Protection of environmental and cultural values

A key outcome of this plan is that environmental values are appropriately accounted for in water planning and licensing. The following sections identify how this will be achieved.

6.4.2 Monitoring and assessment

The department conducts an ongoing monitoring and assessment program focussed on groundwater levels, groundwater discharge and water quality in areas of possible extraction impact. The implementation actions include details of the monitoring program which is frequently evaluated to ensure that data is fit for purpose and knowledge gaps are addressed. The monitoring program focuses on regional groundwater levels and water quality.

Water licence conditions require licence holders to meter and report water take which allows the department to assess how the system is responding to extraction. Significant licences may contain additional monitoring requirements as part of a risk management process such as water quality.

Bore drilling logs provide valuable detail of lithology, aquifer parameters, depth to groundwater and water quality data. Additional drilling and monitoring is being conducted to improve understanding of recharge mechanisms and lithology ultimately informing recalibration of the groundwater model.

Recently collected LiDAR (light detecting and ranging) data for the plan area will significantly improve accuracy of digital elevation models, depth to groundwater datasets and the next generation of the model.

6.5 Aboriginal water reserve

In 2017, the Northern Territory Government approved the Strategic Aboriginal water reserves policy framework to provide Aboriginal people with an increased opportunity to access water resources for their economic benefit, and in doing so, seeks to address the disadvantages faced by Aboriginal people in relation to economic opportunities and development. The first Aboriginal water reserve in the Northern Territory was allocated in the Western Davenport Water Allocation Plan 2018-2021.

Under the Act, Aboriginal water reserves (AWR) are created in the Northern Territory by the Minister declaring a water allocation plan for a water resource. Specifically section 4B of the Act provides a meaning for eligible land and section 22C(2) requires land to be designated in a water allocation plan only after the Minister has consulted with the relevant land councils. An Aboriginal water reserve is only created where there is a water allocation that relates to eligible land.

A detailed report was prepared for consultation with the Central Land Council detailing the methodology to determine the eligible land, eligible land holders, and the volumes of water allocated to the AWR for each water management zone in the plan area. An indication of the percentage of water that should be allocated to the AWR and each management zone is presented in Table 4. The land to be designated eligible land will be described in the water allocation plan.

Table 4. The Aboriginal water reserve (%)

Groundwater (ML per year)	Davenport Ranges (%)	Central Plains (%)	Southern Ranges (%)
Aboriginal water reserve	30.00	30.00	10.00

Schedule A: Dictionary

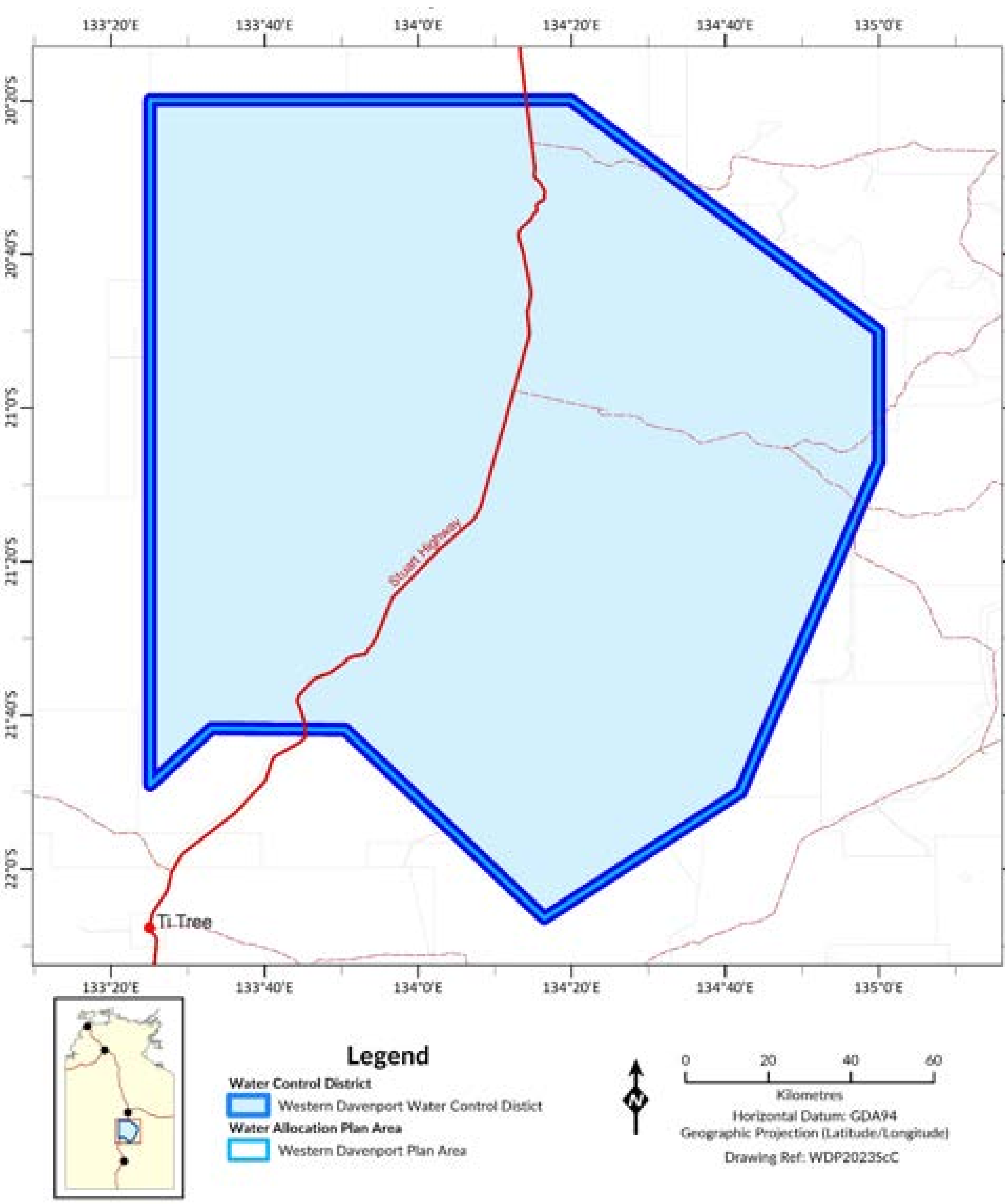
Term	Definition or reference
Aboriginal water reserve	see *Water Act 1992*, section 4(1)
Act	the *Water Act 1992*
beneficial uses	the beneficial uses for the Western Davenport water control district declared by Gazette notice dated 3 December 2021. A copy of the declaration is included in Schedule E of the plan
committee	the Western Davenport and Ti Tree water advisory committee
department	the department with responsibility for administering the *Water Act 1992*, according to the Northern Territory of Australia Administration Arrangements Order
district	the Western Davenport water control district
eligible land	see *Water Act 1992*, section 4B
estimated sustainable yield	the amount of water that can be allocated from the water resource to support declared beneficial uses that is sustainable, section 3 of the plan refers
groundwater	*see Water Act 1992*, section 4(1)
groundwater dependent ecosystem	an ecosystem that requires access to groundwater to meet all or some of their water requirements
implementation actions	Western Davenport Implementation Actions 2024–2034, as amended from time to time
licence entitlement	the maximum volume of water authorised to be taken in a water extraction licence
licence holder	the person granted a licence to take water under section 45 or 60 of the *Water Act 1992*
Minister	the Minister[12] responsible for the *Water Act 1992*
plan	Western Davenport Water Allocation Plan 2024–2034
TPWC Act	*Territory Parks and Wildlife Conservation Act 1976*
water control district	the Western Davenport water control district, declared by Gazette notice dated 15 July 2009 under section 22 of the Act. A copy of the declaration is included in Schedule E of the plan
water licence	a licence to take water granted under section 45 or section 60 of the *Water Act 1992*
water management zone	those areas of land within the plan separated for management purposes as depicted in Schedule D
waterway	see *Water Act 1992*, section 4(1)

[12] Currently the Minister for Water Resources

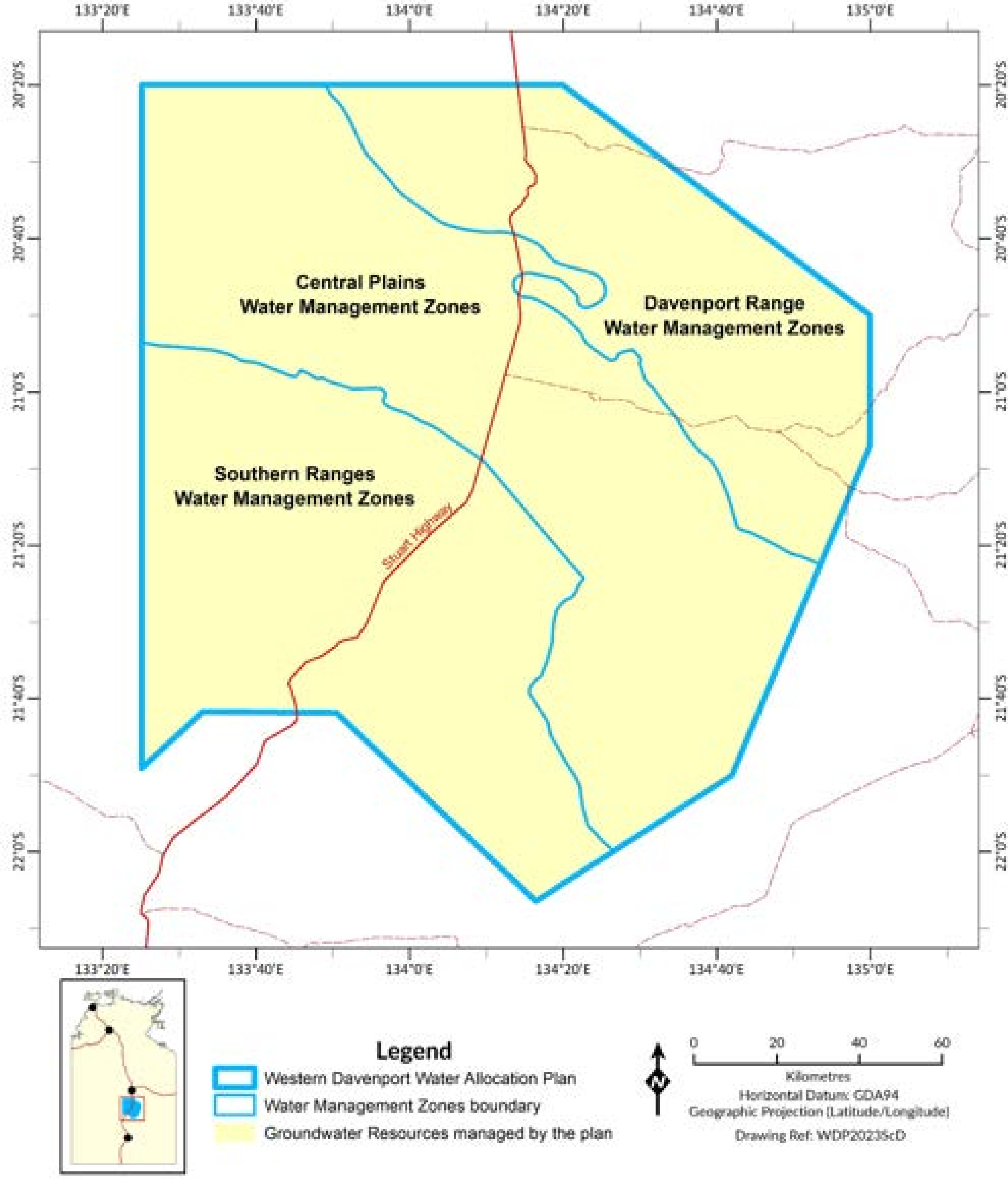
Schedule B: Acronyms

Acronyms	Full form
AWR	Aboriginal water reserve
BoM	Bureau of Meteorology
CSIRO	Commonwealth Scientific Investigation and Research Organisation
DEPWS	Department Environment, Parks and Water Security
DHI MIKE SHE	integrated hydrological modelling software for analysing groundwater, surface water, recharge and evapotranspiration processes
EFTF	Exploring for the Future
ESY	estimated sustainable yield
GDE	groundwater dependent ecosystem
GL	gigalitre
km	kilometre
L	litre
L/s	litres per second
m	metre
m^2	square metres
mAHD	meters above Australian Height Datum
mBGL	metres below ground level
mCDI	membrane Capacitive Deionisation
mg	milligram
mg/L	Milligram per litre
ML	megalitre
mm	millimetre
MtF	Mapping the Future
NT	Northern Territory
NTG	Northern Territory Government
NWGA	National Water Grid Authority
PWC	Power and Water Corporation
SILO	Scientific Information for Land Owners
TDS	total dissolved solids
WOFS	water observations from space

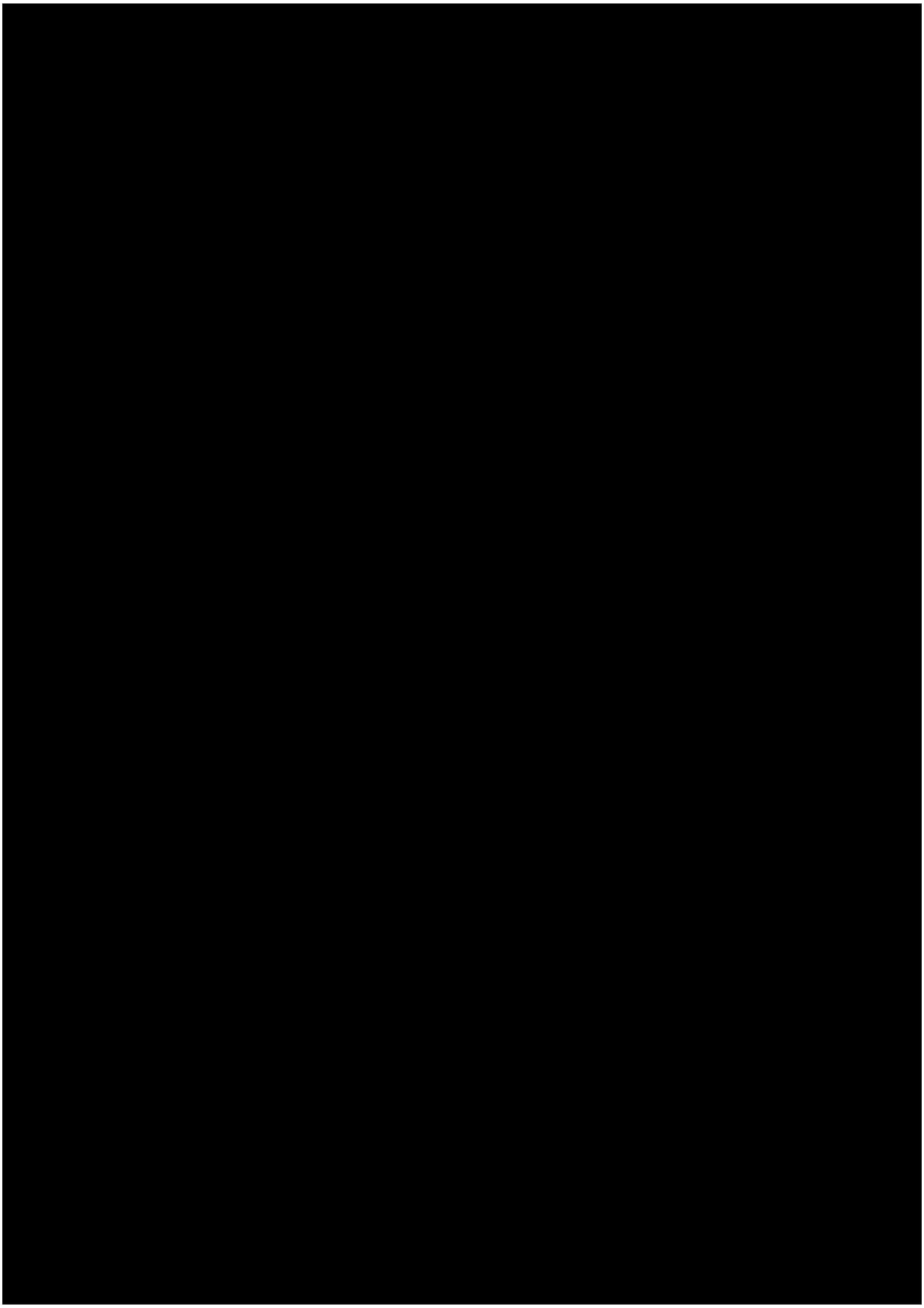
Schedule C: Western Davenport water control district



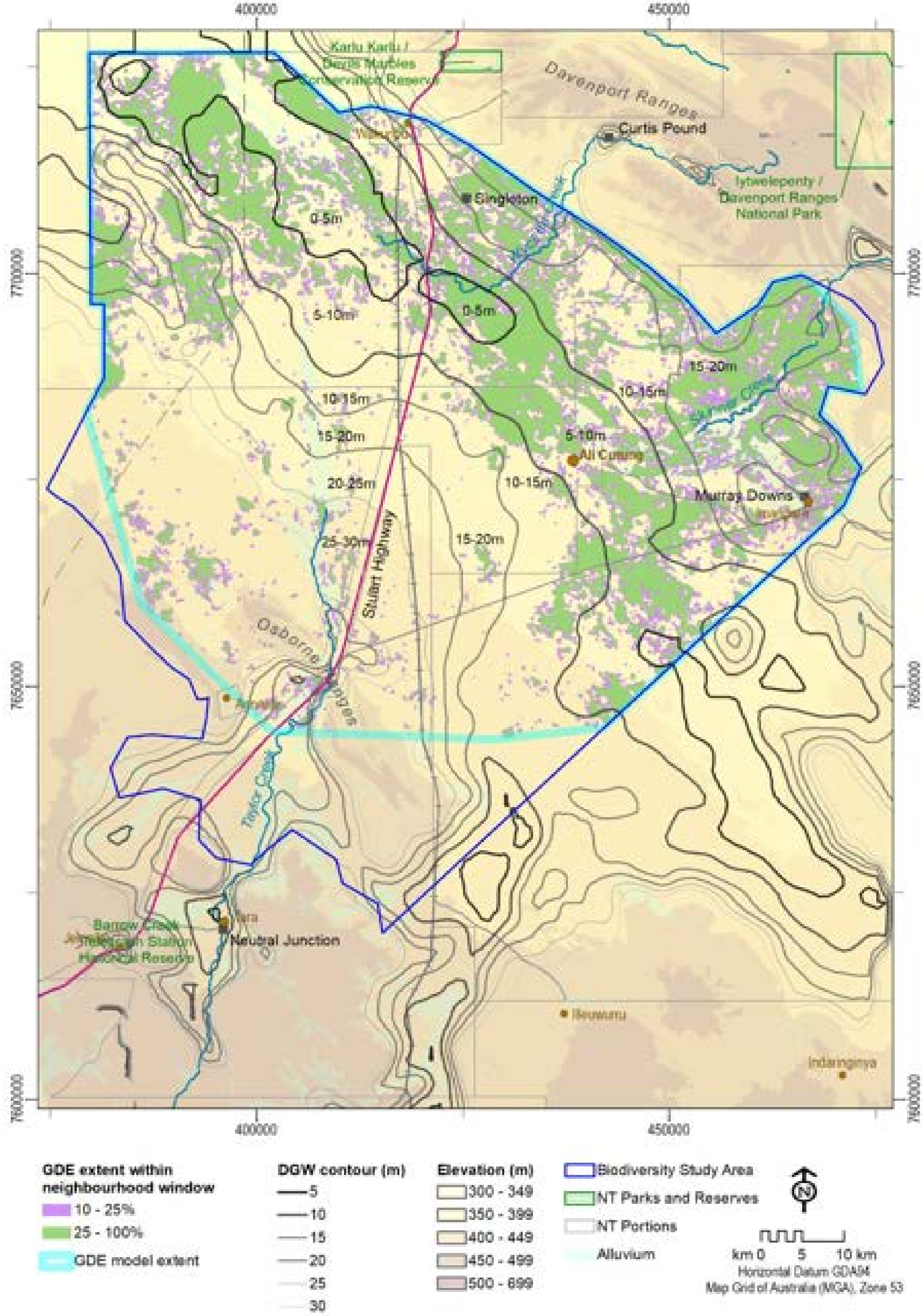
Schedule D: Western Davenport water management zones



Schedule E: Hydrogeology of the district



Schedule F: Probability map of potential groundwater dependent ecosystems distribution



Schedule G: Scenario modelling drawdown contours

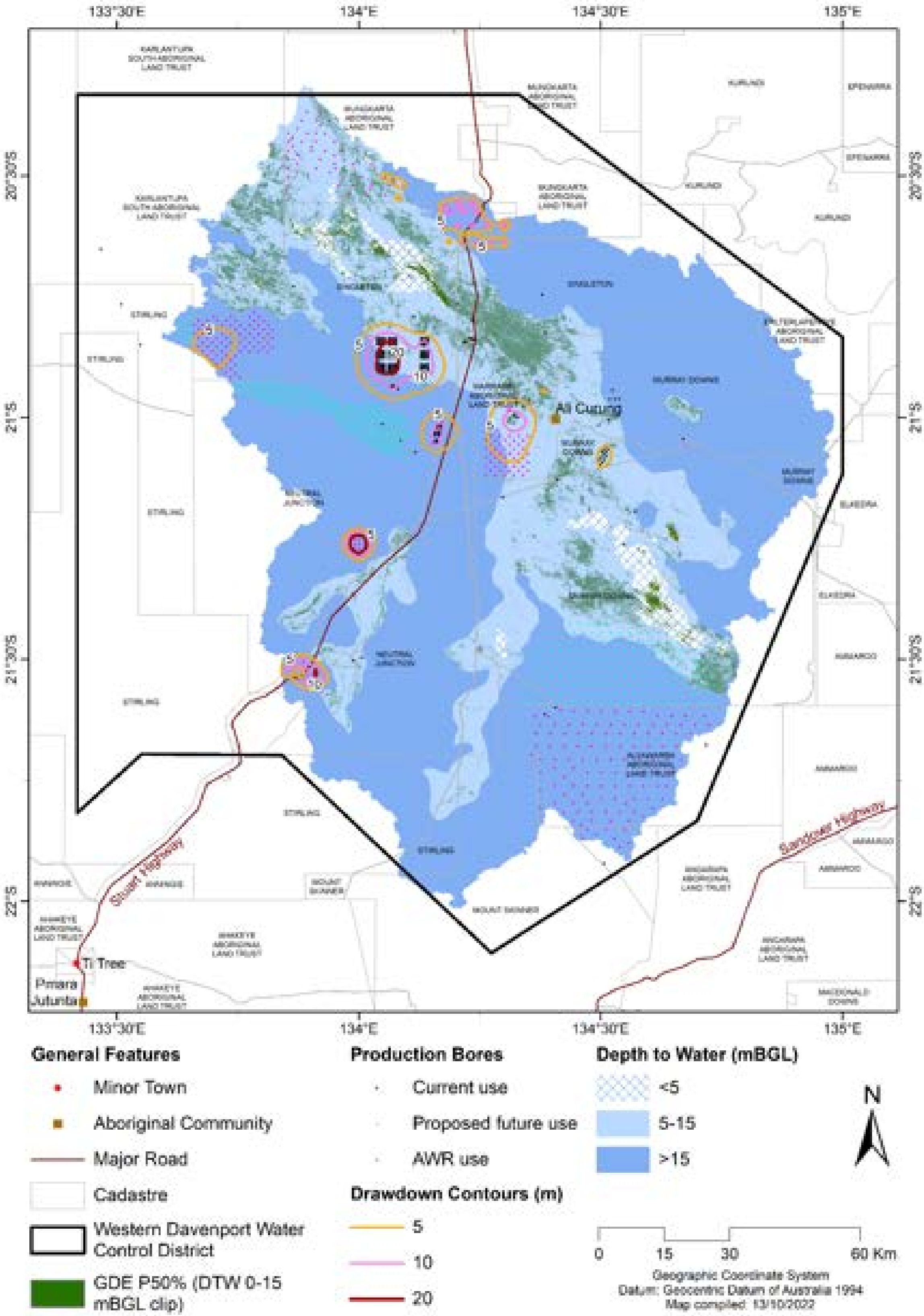


Figure 19. Groundwater extraction of 87,700 ML/year after 10 years continuous pumping (note: depth to water at 1 November 2020)

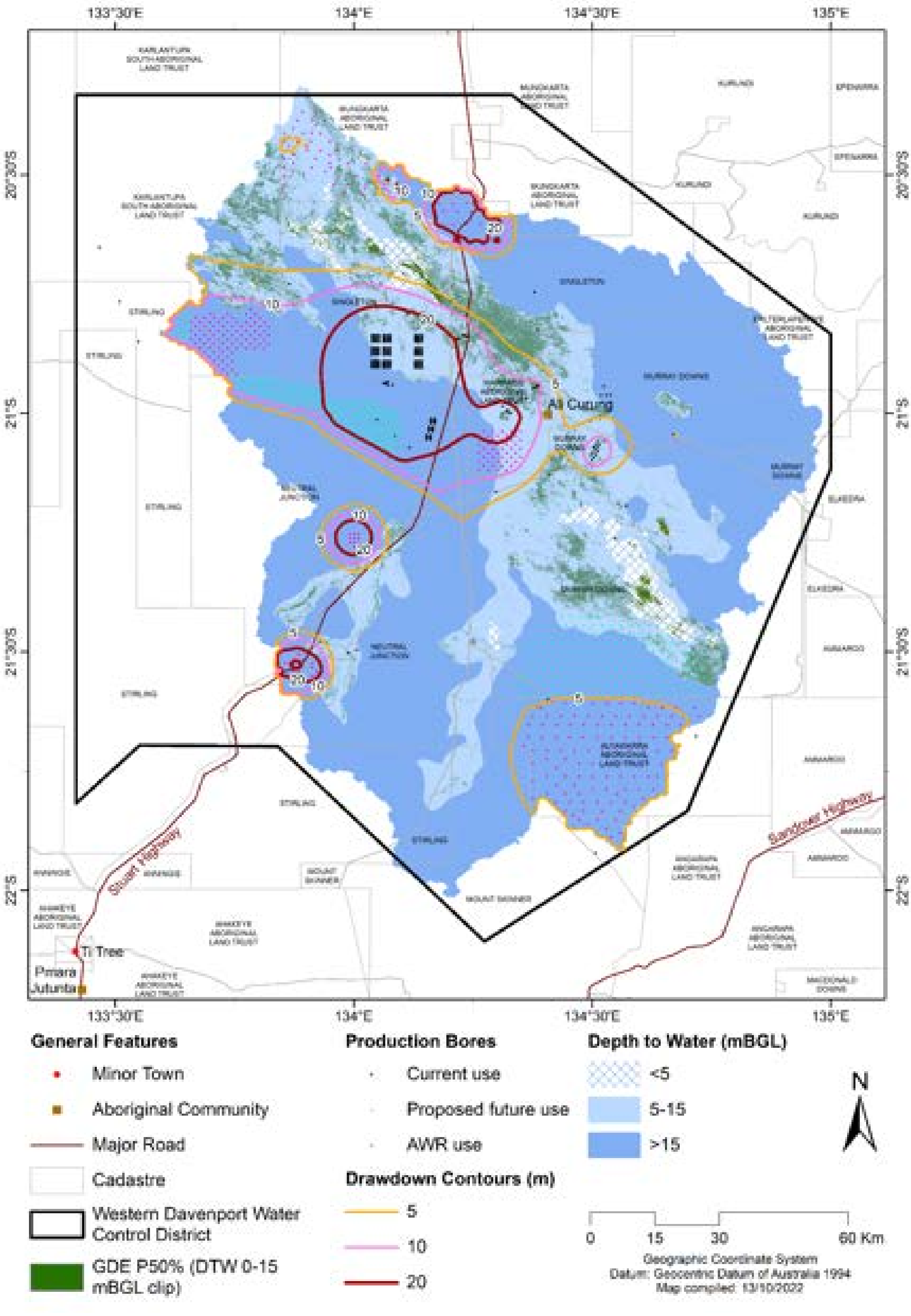


Figure 20. Groundwater extraction of 87,700 ML/year after 50 years continuous pumping (note: depth to water at 1 November 2020)

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