# Georgina Wiso

## Background Report 2023–2031

NORTHERN TERRITORY GOVERNMENT

**Further information:**

Please contact the Water Resources Division at:

Department of Environment, Parks and Water Security
Level 3, Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0830
Email: waterresources@nt.gov.au
Phone: 08 8999 4455
Web: www.depws.nt.gov.au/water

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Front page photo: Cattle grazing at sunset.

## Acknowledgement of Country

The Department of Environment, Parks and Water Security proudly acknowledges the Northern Territory's Aboriginal communities and their rich culture, and pays respect to the Elders past and present.

We acknowledge Aboriginal peoples as the Traditional Owners and custodians of the lands and waters on which we all rely.

We recognise the intrinsic connection of Traditional Owners to Country and value their contribution to managing the lands, waters and landscapes. We support the need for genuine and lasting partnerships with Traditional Owners to understand their culture and connections to Country in the way we plan and manage the water resources of the Daly Roper Beetaloo Water Control District.

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# 1 Overview

**About the water allocation process**

Water allocation is the process of determining how much water is available in the water resource to share between consumptive uses and non-consumptive uses. 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 Environment, Climate Change and Water Security (Minister) by gazette notice.

**About the Georgina Wiso plan area**

The Georgina Wiso plan is within the Daly Roper Beetaloo Water Control District (the district), an area of 330,000 km$^2$. The district includes a number of basins and aquifers. Separate water allocation plans have been declared or are in draft for different parts of the district. In addition to this plan, water in the district is managed under the Katherine Tindall Limestone Aquifer Plan 2019–2024 (declared), Oolloo Dolostone Aquifer Plan 2019–2029 (declared), Flora Plan (draft), the Mataranka Plan (draft), and this Georgina Wiso plan.

The Georgina Wiso plan applies to an area approximately 155,000 km$^2$ extending about 600 km from north to south, and 500 km east to west (the plan area). The plan area includes the towns of Daly Waters, Elliott and Newcastle Waters and smaller communities of Jangirulu, Likkaparta, Marlinja, Murranji and Wutunugurra. Pastoral leases cover about 85 per cent of the land with approximately 13 per cent of the plan area recognised as Aboriginal land. Although there is currently very limited water use in the plan area, the primary driver for development of the plan is the final report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory. The report recommended that water allocation plans be developed for the Beetaloo Sub-basin as part of any onshore shale gas production. Petroleum activities are prohibited from using surface water under section 45A of the *Water Act 1992*. Consequently, to the extent that water is required, such activities only have the option to use groundwater.

**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 that may provide some guidance in the plan area. The three core documents are:

***Georgina Wiso Water Allocation Plan 2023–2031***. The Georgina Wiso Water Allocation Plan 2023–2031 (the plan) is declared by the Minister under section 22B(1) of the *Water Act 1992* (Act). The plan describes the estimated sustainable yield for the groundwater resources of the plan area in the two management zones (Schedule D), as defined at 2.6. The estimated sustainable yield is the volume of water that can be taken sustainably from the water resources to which this plan applies. The plan allocates that water amongst declared beneficial uses and provides for trading of water. The plan takes effect from the date of its gazette by the Minister and will remain in force for a period of eight years.

***Georgina Wiso 2023–2031 Background Report*** (this document). The Georgina Wiso 2023–2031 Background Report provides details on the information and processes that informed the plan, including available data and research on the water resources of the plan area. It also describes the key environmental values and their dependency on water resources, and the social and developmental context of the region, including current water use and projections of future water demand. This report collates the information and knowledge regarding the plan area at the time of its preparation.

***Georgina Wiso 2023–2031 Implementation Actions***. The Georgina Wiso 2023–2031 Implementation Actions details how section 34 of the *Water Act 1992* with respect to the water resources of the plan area is fulfilled. It defines a continuous program for the management 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.

The Controller must take into account any water allocation plan applying to the area in question when making a decision referred to in s 90(1) of the *Water Act 1992*. The Georgina Wiso 2023-2031 Background Report, Implementation Actions and other factors may be taken into account, where relevant to the decision.

# 2 Summary

**Overview**

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

The purpose of the background report is to reference and summarise the foundational data and knowledge that informed the development of the Georgina Wiso Water Allocation Plan 2023-2031 and the Georgina Wiso Implementation Actions 2023–2031.

On 16 April 2018, the Northern Territory Government accepted all recommendations from the Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory (the inquiry). The inquiry made specific recommendations to manage the potential impact and risks associated with hydraulic fracturing of onshore unconventional shale gas reservoirs on water resources. The inquiry recommended that the Daly Roper Water Control District be extended south to include all of the Beetaloo Sub-basin, and that water allocation plans be developed for the regions of the Beetaloo Sub-basin.

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

## 2.1. Planning processes

Information on the department's approach to water allocation planning is available on the Northern Territory Government's water allocation internet page[1].

As part of the department's commitment to the National Water Initiative the department is continuously improving water management across the Territory[2]. The department has recently 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 due for review and or replacement over the coming years.

### 2.1.1. Daly Roper Beetaloo Water Control District and plan area

Under section 22 of the *Water Act 1992* (the Act) the Daly Roper Beetaloo Water Control District (the district) was first declared by gazette S58 on 20 July 2018, and extended by gazette G41 on 19 October 2022.

A map of the district is set out in Schedule C.

This report relates to the water allocation plan area for the Georgina Wiso Water Allocation Plan 2023-2031 (plan area). The plan area forms part of the district. Other water allocation plans apply to other parts of the district.

### 2.1.2. Water management zones

Two water management zones have been recognised within the plan area based on hydrogeologically distinct environments. These are the Georgina Basin and Wiso Basin, set out in Schedule D.

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[1] https://nt.gov.au/environment/water/management-security/water-allocation
[2] https://nt.gov.au/environment/water/management-security

### 2.1.3. First Georgina Wiso water allocation plan

This is the first water allocation plan for the Georgina and Wiso Basins.

## 2.2. Population and land uses

Approximately 1200 people live in the Georgina Basin, including around 290 people in the township of Elliot. The plan area also includes the smaller communities of Wutunugurra and Likkaparta, and 24 homelands or family outstations.

The Wiso Basin water management zone (WMZ) area is sparsely populated. It includes the townships of Newcastle Waters which has a population of 65, the Aboriginal community of Marlinja with a population of 36 and the Aboriginal community living areas of Murranji and Jangirulu.

The pastoral industry has a long history in the plan area and is a major land user. Sixty-five pastoral leases overlap the plan area. There is strong interest in diversifying pastoral land use, and some mining and petroleum exploration is occurring in the general area. The plan area overlays the majority of the Beetaloo Sub-basin which has a very large unconventional gas resource which is a target for exploration and potentially production activities.

# 3 Water resources

**Overview**

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

The groundwater resource managed through the plan is the Cambrian Limestone Aquifer (CLA). The CLA is an extensive regional aquifer that occurs within a number of geological basins within the district, including the Georgina Basin and Wiso Basin. The CLA overlies basement rock formed by a thick layer of basalt and shale of very low conductance. The primary water holding formations of the CLA are:

- the Montejinni Limestone in the Wiso Basin, which is up to 130 m thick
- the Anthony Lagoon and Gum Ridge Formation in the Georgina Basin, which is up to 250 m thick, with a possible increase to over 300 m along the Barkly Highway.

The gas bearing geological layers within the Beetaloo Sub-basin are located at great depths, in excess of approximately 1000 m. The groundwater resources of the area overlay the Beetaloo Sub-basin and are much shallower and more extensive than the Beetaloo Sub-basin set out in Schedule E.

The Georgina and Wiso Basins are very extensive, covering nearly 12 per cent of the Northern Territory, with a modelled stored volume of 740,000,000 ML. This is over double the land area of all other current plans in the Territory combined and approximately five times more water than the next largest plan area, in the Western Davenport area.

Recent studies based on monitoring and modelling data demonstrate that gains to the system from recharge exceed losses from throughflow resulting in groundwater storage steadily increasing over the past 50 years.

There are no perennially flowing waterways within the plan area.

Understanding of the water resources has improved through analyses of bores drilled since the 1970's, a groundwater monitoring program since the 1990's and previous investigations under the following programs:

- impact assessment for the Beetaloo Geological and Bioregional Assessment
- Gas Industry Social and Environmental Research Alliance, a collaboration between CSIRO, Commonwealth, state and territory governments, and industry to undertake independent research in the public interest around the social and environmental impacts of the gas industry
- CSIRO's Roper River Water Resource Assessment to investigate opportunities for water and agriculture development in the Roper River catchment
- Geoscience Australia's Exploring for the Future Program.

Most recently, the Beetaloo Strategic Regional Environmental and Baseline Assessment (SREBA) included a number of water quality and quantity studies:

- an extensive drilling program delivering 19 bores over 9 site locations
- two pumping tests and re-interpretation of another 17 historical pumping tests
- deployment of 25 loggers to capture time series groundwater level data
- groundwater sampling and laboratory analysis, general parameters, metals, hydrocarbons, radiological and nutrients, of 21 bores over three sampling events.

## 3.1. Topography

The land elevation in the Georgina Basin water management zone ranges from approximately 165 to 600 mAHD. Features include isolated higher ridges and plateaus of the Sturt Plateau in the northern region, where elevation is about 250 to 325 mAHD.

In the southern region of the water management zone, elevated areas are represented by the Short and Ashburton Ranges and the north-eastern margins of the Davenport Murchison Ranges. The lower elevation areas are along drainage lines and tributaries, such as Newcastle Creek, and associated lakes, for example Tarrabool Lake and Lake Sylvester.

Topography in the Wiso Basin water management zone ranges from approximately 184 to 321 mAHD. The area includes isolated ridges and plateaus of the Sturt Plateau to the east of Top Springs where elevation is about 250–321 mAHD. The lower elevation areas are along drainage lines that feed into the Armstrong River and Lake Woods.

## 3.2. Climate and rainfall

The climate of the plan area is predominately semi-arid, with potential evapotranspiration greater than total annual rainfall in most years. Described using Köppen climate classifications (Köppen, 1884) the area is hot desert for small areas in the south, adjacent to Barkley Homestead and Tennant Creek, and hot grassland for the remainder of the area, as per Schedule F.

Across the extent of the plan area, rainfall varies markedly geographically, reducing from north to south. Median annual rainfall ranges from approximately 750 mm in the north near Daly Waters, to approximately 375 mm in the south near Tennant Creek (**Figure 1** and Schedule D:Georgina Wiso water management zones G). Rainfall variability is moderate in the north to very high in the south. Rainfall occurs predominantly between November and March, and is primarily associated with intense thunderstorms or widespread monsoonal depressions originating in the north. From April to October, very little, if any, rainfall occurs.

Generally, potential evapotranspiration (PET) exceeds rainfall throughout the year (Figure **1**). Average monthly PET for the area increases from the north, approximately 215 mm, to the south, approximately 355 mm, and rarely drops below 160 mm.

The area is hot year round (Figure **2**). Average daily maximum temperatures can reach up to 39°C from November to March. Average daily minimum temperatures rarely fall below 9°C from April to September, and 21°C from November to March. July is usually the coldest month of the year.

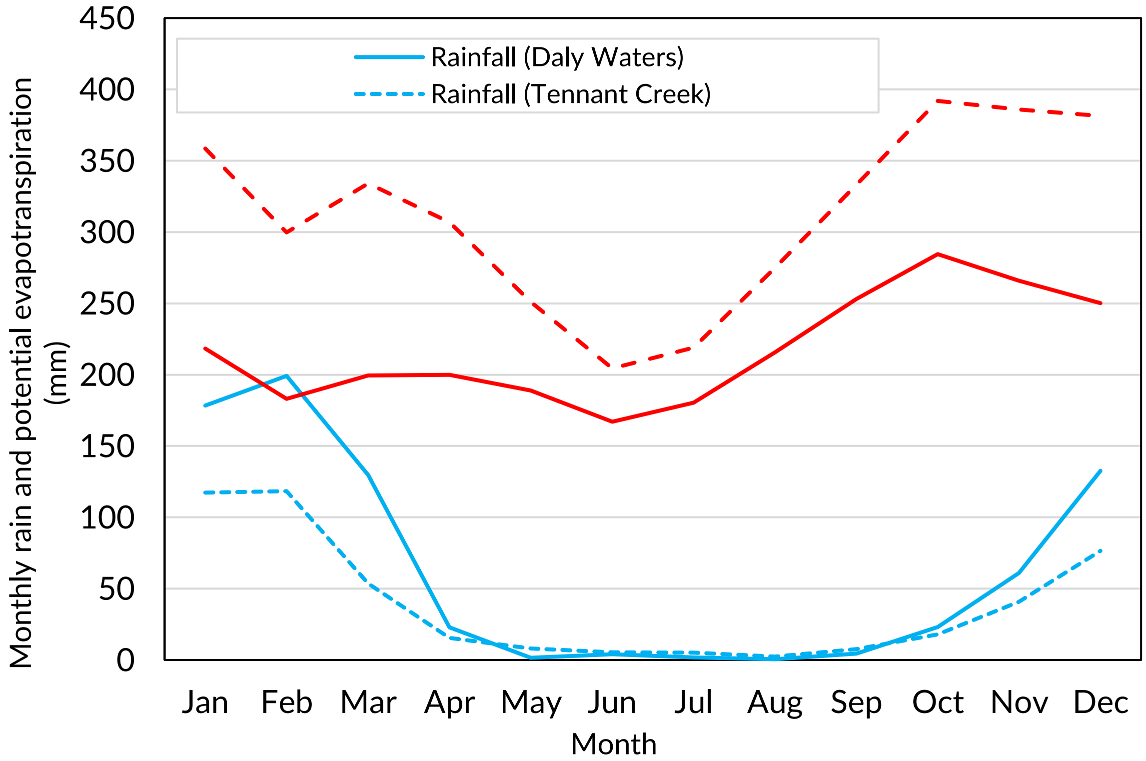



Figure 1 Daly Waters and Tennant Creek average monthly rainfall and evapotranspiration (PET)

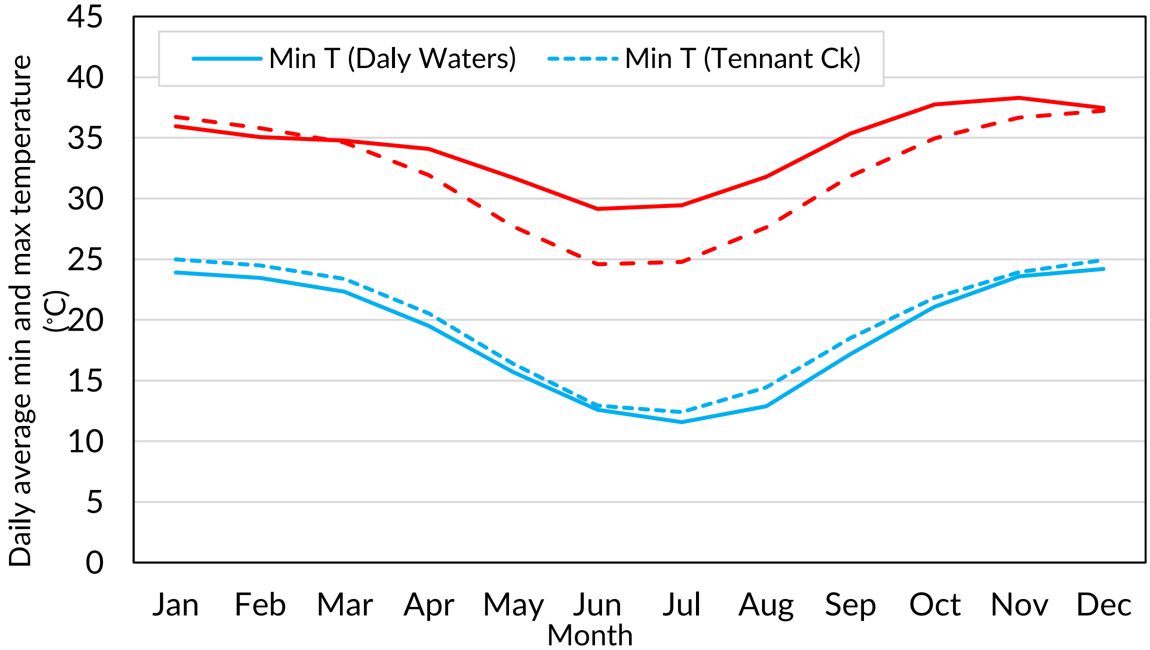



Figure 2 Daly Waters and Tennant Creek average daily minimum and maximum temperature (T)

### 3.2.1. Rainfall variability

Rain observations from the SILO database (Jeffrey et al., 2001) 1900 to 2021 for Daly Waters and Tennant Creek are shown in Figure **3** and **Figure 4**. The average annual rainfall for the period of record at Daly Waters is 650 mm and 390 mm at Tennant Creek. The climate period trend can be observed from the cumulative deviation from average annual rainfall. The cumulative deviation show an increasing trend in rainfall in the plan area since approximately 1970.

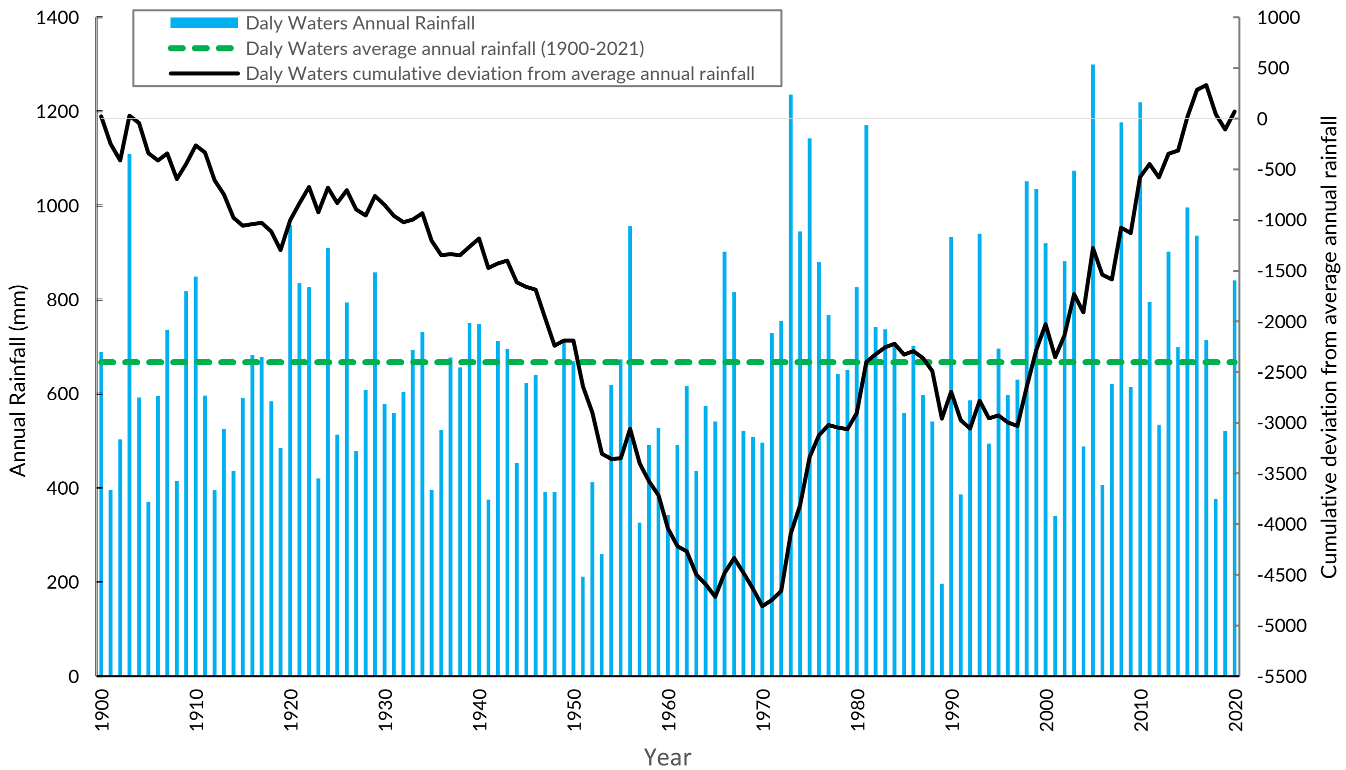



Figure 3 Daly Waters annual rainfall and cumulative deviation.

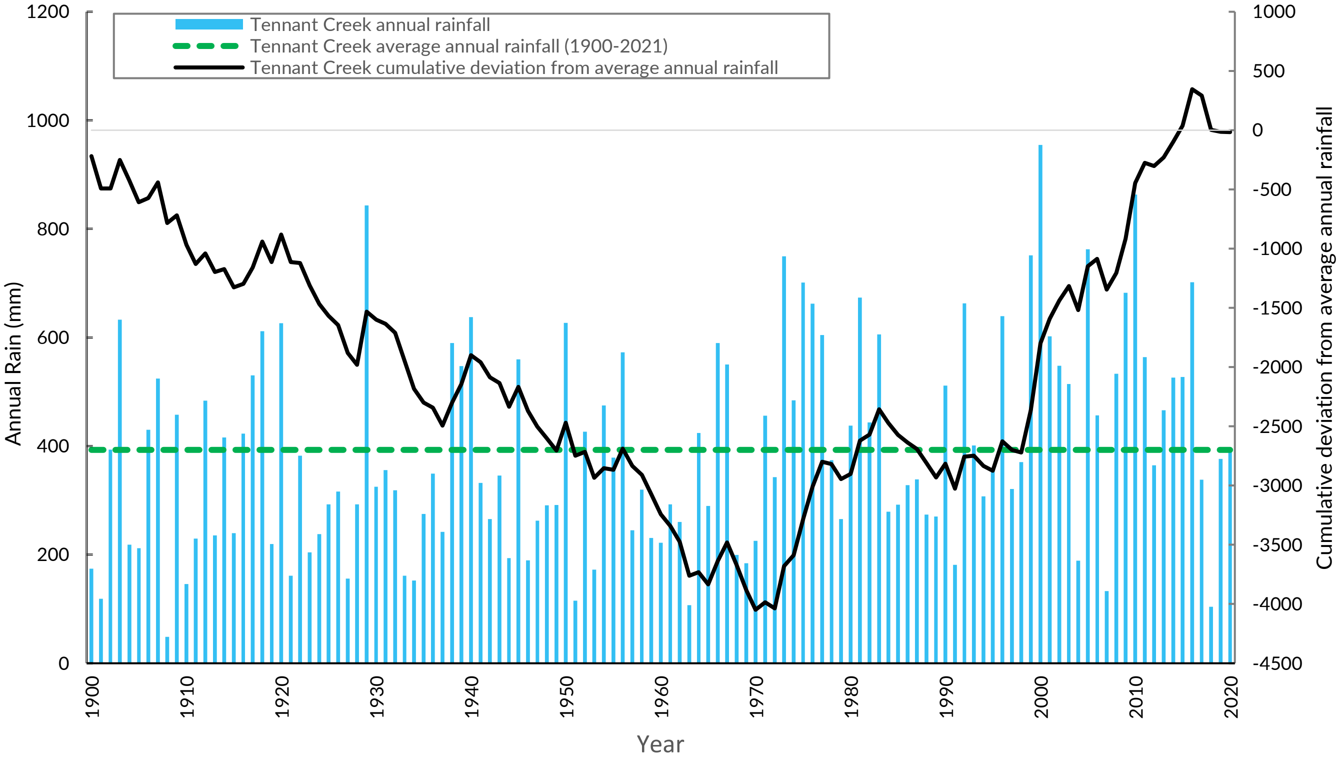



Figure 4 Tennant Creek annual rainfall and cumulative deviation.

Recent concern over future climate scenarios and the potential effects on water resources around Australia have resulted in several scientific studies addressing this topic. The most comprehensive investigation on the effect of a wide range of potential future climate scenarios on recharge in the proposed plan area was undertaken by CSIRO during the Northern Australia Sustainable Yields (NASY) project (Crosbie et al., 2009, 2015). In this work, the researchers modelled diffuse recharge across north Australia under the baseline climate conditions of 1930-2009 and atmospheric carbon dioxide concentration in 1990. The results for future climate change conditions of 15 global climate models were then compared to the baseline period to develop the recharge scaling factor (where 1 is no change, <1 is lower recharge rates, and >1 is higher recharge rates) and assess the potential variability in diffuse groundwater recharge as a result of changing climate. The results of the CSIRO NASY work have subsequently been synthesised by the department to summarise the range of projected future climate impacts on diffuse recharge across the Territory (Short, 2018).

Based on Crosbie et al. (2013), recharge in the proposed plan area is projected to change in the order of 0.8–1.5 times recharge, that is, most projections predict an increase in recharge. The median projection of climate models suggests that the majority of the plan area may experience minor increase in diffuse recharge in the future, except a small area to the south of Elliott. Therefore, the best available information for the impact of climate change on groundwater availability in the proposed plan area suggests that recharge will stay the same or will show some variability from north to south. It is important to note that climate change modelling used for assessment of impacts to groundwater resources is underlain by inherent uncertainty due to environmental variability and complexity of natural systems. Additionally, the results of the aforementioned models were only applicable to diffuse groundwater recharge; other recharge mechanisms, including karstic point sources and episodic streamflow recharge, were not considered.

## 3.3. Key water resource investigations

### 3.3.1. Strategic Regional Environmental and Baseline Assessment

The need for robust baseline data was identified in the inquiry. The Beetaloo Strategical Regional Environmental and Baseline Assessment (SREBA) provides the baseline information necessary for appropriate decisions to be made about the development of any onshore shale gas industry in the Northern Territory. While the Beetaloo SREBA focused on the Beetaloo Sub-basin, individual projects including the SREBA Water Quality and Quantity Baseline Study covered a broader area to provide regional context and inform this plan.

The Water Quality and Quantity Baseline Summary Report (ELA, 2022) provides an update to other significant contributions to the baseline characterisation of the water resources for the region that have been produced as part of the Commonwealth Government's Geological and Bioregional Assessment and Gas Industry Social and Environmental Research Alliance programs, and the Northern Territory Government Department of Environment, Parks and Water Security's water resource assessments.

Collectively these studies provide a strong understanding of:

- regional hydrology conceptualisation
- the hydraulic characteristics of each aquifer, including the identification of key geologic features that may control groundwater movement and connectivity
- mapping of aquifer depths and properties, and potentiometric surfaces
- identification of key recharge and discharge areas, and characterisation of mechanisms
- quantification of recharge, discharge and groundwater flow
- presentation of water quality data and how it may relate to water movement, such as resource extent
- identification of the location and source for springs and potential groundwater dependent ecosystems.

Recommendations for further studies by ELA (2022) have been included in the implementation actions for this plan, noting these are not required in order to develop a robust plan informed by a detailed scientific understanding of the groundwater resources.

## 3.4. Surface water resources

The plan area overlies a key topographic divide, partially covering numerous surface water catchments within two drainage divisions: Carpentaria Coast and Tanami–Timor Sea Coast, see Schedule H.

Most of the plan area contains endorheic (inland draining) waterways within the Tanami–Timor Sea Coast division, however the northern and north eastern boundaries of the plan area intersect the upper reaches of several waterways within the Carpentaria Coast. This results in some surface water discharge from the plan area into the Gulf of Carpentaria to the northeast. The majority of surface water drainage terminates in large inland storage features such as lakes and swamps within the Barkly Tableland region.

No perennially flowing waterways exist within the plan area, although some large perennial waterholes do occur particularly in the Newcastle Waters region. No significant groundwater discharges occur in the plan area due to the depth of groundwater resources below the surface. Surface water flows coincide with the northern summer wet season, with monitoring stations typically recording flows commencing in December/January and rarely continuing beyond May. The relatively rapid cessation of flows after the end of wet season rainfall further demonstrates no ongoing groundwater discharge or drainage through the dry season from significant storage features such as lakes and swamps.

Waterholes, some permanent, are documented throughout the plan area, while some terminus features including lakes and swamps may persist well into the dry season, or even perennially in high rainfall years. These include Lake Woods, Tarrabool Lake, Lake Sylvester, Lake Du Burgh and Corella Lake, as well as floodouts and wetland features including Eva Downs Swamp and the Frew River Floodout swamps.

When surface water is present, most surface water features in the plan area contribute to recharge of underlying groundwater.

## 3.5. Groundwater resources

The information presented in this section is compiled from the Water Resources of the Georgina Basin and Wiso Basin Technical Reports (DEPWS 2022a and 2022b).

### 3.5.1. Hydrogeological setting

Five hydrogeological provinces underlie the plan area (see Schedule I, noting that only the first major aquifer intercepted is shown). These are:

- Cretaceous sediments
- Cambrian Limestone Aquifer:
  - Anthony Lagoon Formation
  - Gum Ridge Formation
  - Montejinni Limestone
- Antrim Plateau Volcanics and equivalents
- Bukalara Sandstone
- Local scale aquifers (Proterozoic rocks).

Of these provinces, the Cambrian Limestone Aquifer (CLA) is the most productive and reliable groundwater resource and therefore the water subject to the plan.

The CLA is an extensive regional aquifer and covers a vast area of at least 200,000 km$^2$, which includes the Daly Basin, Wiso Basin and Georgina Basin. It is hydrogeologically complex with multiple aquifer layers, varying recharge rates/mechanisms, and groundwater flow regimes (Evans et al. 2020). The CLA is a sequence of sedimentary formations deposited during the Cambrian period, with karstic limestone as the primary rock type hosting aquifers. The Georgina Basin consists of the Gum Ridge Formation and Anthony Lagoon Formation and the Wiso Basin mainly consists of Montejinni Limestone.

A small area of the southeast Georgina Basin contains the Wonarah Formation and Thorntonia Limestone which are part of the CLA and are a major part of a separate groundwater flow system that discharges to Lawn Hill Creek and the Gregory River in Queensland.

A variety of other formations underlie the CLA and some of these contain aquifers including the Bukalara Sandstone. With only a very small number of bores in the plan area intercepting the Bukalara Sandstone, its hydrogeological characteristics are poorly known and consequently the Bukalara Sandstone has not been considered within the estimated sustainable yield of the plan.

### 3.5.2. Groundwater recharge

Recharge across the plan area varies significantly with precipitation, topography, karstic features, overlying rock and sediment formations. There are four main recharge mechanisms for aquifers within the CLA system (Fulton and Knapton 2015):

- diffuse (direct) recharge

- macropores recharge
- localised discrete (indirect) recharge
- mountain-front recharge.

Measuring recharge to any groundwater system is extremely difficult, especially where there are a number of recharge mechanisms. A number of models from several sources have been used to quantify recharge within the plan area:

1. DR2 (2020). The 3-D coupled surface water and groundwater model for the CLA, Roper River and Daly River systems is known as the 'DR2' (Knapton, 2020) calibrated to groundwater levels and river flows in the Flora River and Daly River. Recharge was extracted for the period 1970-2022.
2. Constrained chloride mass balance method (Crosbie and Rachakonda, 2021). Data represents no specific time period but represents long term average recharge.
3. Chloride mass balance method adopted by Tickell and Bruwer (2017 and 2019). This method calculated recharge rates for different recharge zones in the Georgina Basin in 2017 and updated in 2019.
4. BoM landscape water balance model (AWRA-L; Frost et al., 2018). Data extracted for the period 1989-2018.
5. National-scale diffuse recharge using CSIRO WAVES model for the period 1930-2009 (Crosbie et al., 2009).
6. Chloride mass balance method adopted by Yin Foo and Matthews (2000). This method calculated recharge rates to be approximately 1% to 3% of rainfall.

Estimates of average recharge using each of the above approaches are set out in Table **1**.

Table 1 Average recharge estimates (ML/year) for the Georgina and Wiso Basins.

| Estimates and methods of recharge in the region | Georgina Basin[1] | Wiso Basin[1] |
|---|---:|---:|
| 1. NTG region specific model DR2 | 585,000 | 46,000 |
| 2. CSIRO constrained chloride mass balance | 1,000,000 | 1,300,000 |
| 3. NTG chloride mass balance using recharge | 70,000 – 230,000[2]<br>(120,000 – 280,000) [3] | N/A |
| 4. BoM landscape model | 4,900,000 | 2,800,000 |
| 5. CSIRO national scale diffuse | 2,700,000 | 1,700,000 |
| 6. NTG chloride mass balance using rainfall | NA | 190,000 – 570,000[4]<br>(80,000-220,000)[5] |

[1]Values rounded down to nearest whole number
[2]Calculated using recharge areas from Tickell & Bruwer (2019)
[3]Calculated using updated recharge areas from Tickell (2022)
[4]Calculated using recharge rate from Yin Foo and Matthews (2001)
[5]Calculated using site-specific rainfall, groundwater chloride concentration and study area

While recharge estimates vary considerably, those from the department's regional coupled groundwater-surface water flow model (DR2) are considered the most reliable because they are based on site-specific research, and calibrated to over 50 years of observational data using groundwater levels from 136 bores and gauged river flows from 3 gauging sites. The results of all other methods represent potential recharge over the geographical extent of the entire CLA and are based on regional-scale datasets that are not calibrated to resource-specific data. Notably, the estimated recharge from DR2 is significantly lower than from most other methods.

DR2 allows for recharge based on the various recharge mechanisms and the hydrogeologic features within the plan area, providing an estimated annual recharge value for each of the preceding 50 years. While rainfall data is available for over 100 years, a 50 year dataset is used because the model is very sensitive to evaporation and measured evaporation data is only available post 1970.

Figure **5** and Figure **6** present the spatial and temporal recharge variation for the plan area based on DR2s average annual recharge over the modelled period. The high variability in annual recharge is a function of the variability in annual rainfall, which ranges from 200 to over 1,200 mm (Figure **3** and Figure **4**), which results in significant recharge during some years and low to no recharge in others.

Irrespective of the magnitude and frequency of recharge, groundwater monitoring for the same period shows that groundwater storage is increasing over time (section 3.5.3).

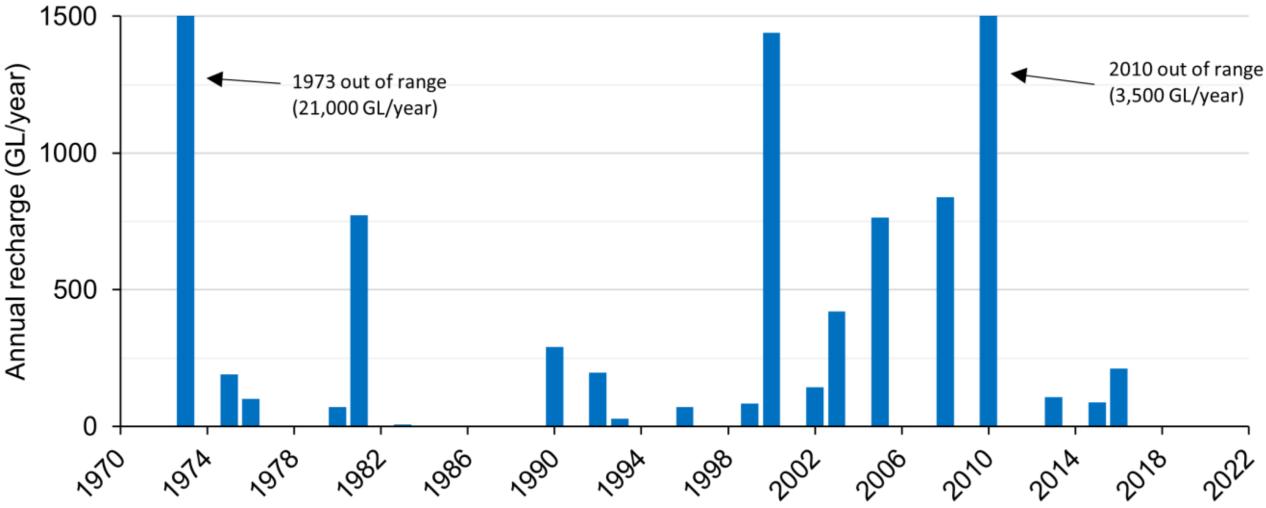



Figure 5 Modelled recharge to the CLA in the Georgina Basin

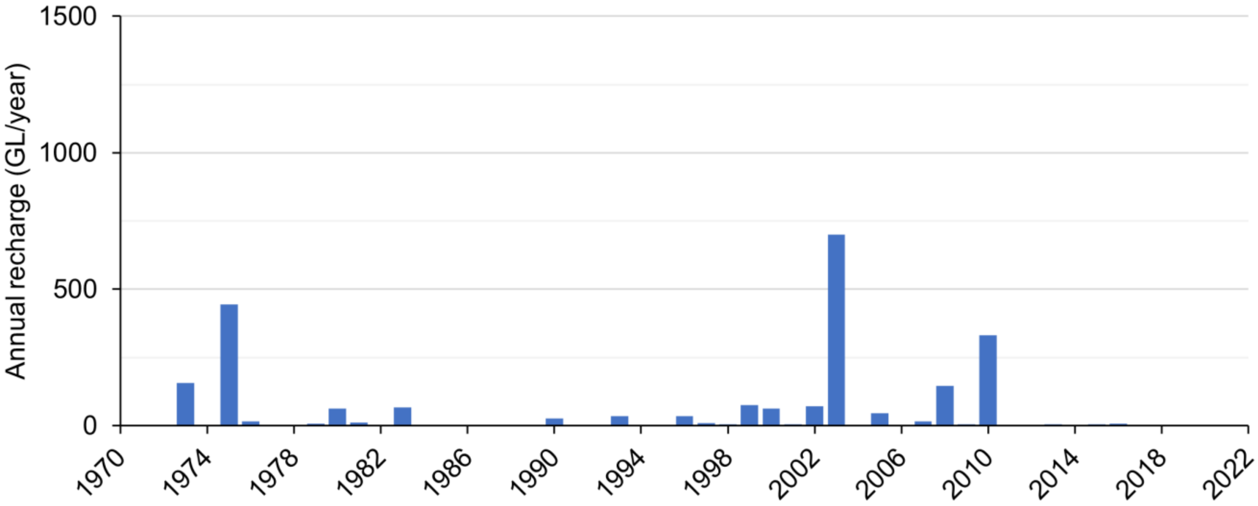



Figure 6 Modelled recharge to the CLA in the Wiso Basin

### 3.5.3. Groundwater storage

As at 1 November 2021 the modelled groundwater storage volume is approximately 660,000,000 ML in the Georgina Basin and 80,000,000 ML in the Wiso Basin. Irrespective of the variability in recharge since 1970, long term recharge is exceeding the rate at which throughflow out of the system occurs. The DR2 model natural water balance estimates that groundwater storage for the Georgina Basin and Wiso Basin is increasing at a rate of approximately 581,500 ML/year and 45,700 ML/year respectively.

In Figure **7**, modelled natural groundwater level traces (SC0) for locations in the Wiso Basin and north, mid and south Georgina Basin have been combined with long term measured groundwater level records from bores within the region, Tarlee Station (RN028087) and Maryfield Station (RN029013). These traces show a sustained period of increasing groundwater levels and aquifer storage since the 1970's, which is indicative that the aquifer is generally in a 'filling' phase in response to increasing rainfall as shown in Figure **3** and **Figure 4**.

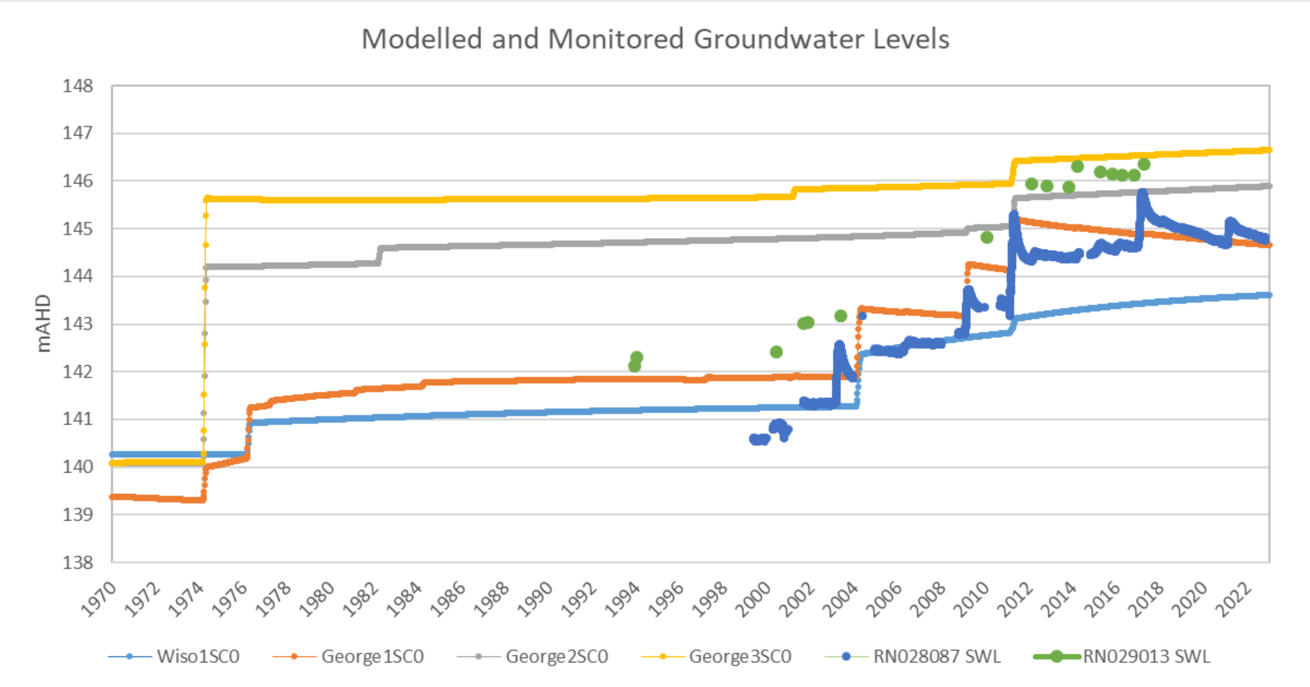



Figure 7 Increasing groundwater storage as a result of recharge, from models and monitoring data.

### 3.5.4. Groundwater discharge

Natural groundwater discharge from the CLA to the surface is considered to be via three dominant mechanisms (ELA, 2022):

- discrete springs where geological features allow for discharge from artesian portions of the aquifer and
- diffusely through riverbeds where the water table is intercepted
- discharge via diffuse or discrete areas of evapotranspiration where vegetation utilises groundwater or water tables are shallow.

Groundwater discharge from the CLA is limited within the plan area to a succession of separate springs at Top Springs (see Schedule J). Although the source of discharge at Top Springs along the western end of the Wiso Basin is unknown, the springs appear to be seasonal and low flowing. Because the depth to groundwater in the neighbourhood is less than 15 m below ground level, the area may contain groundwater dependent vegetation; nevertheless, due to its small size, the area is unlikely to provide any considerable discharge via evapotranspiration.

The discharge from Helen Springs, which is located inside the plan area, is sourced from local scale aquifers, but the discharge from Hot Springs Valley, which is outside the plan area, is sourced from Mesoproterozoic formations. Discharge from spring flow or evapotranspiration from these systems does not reflect CLA discharge and will be unaffected by extraction from the Georgina Basin.

Discharge through riverbeds is unlikely to occur as stream flow ceases soon after rainfall.

Throughout the plan area depth to groundwater is too great for vegetation to access the CLA, see Schedule K, therefore discharge from evapotranspiration is primarily derived from surface water evaporation and not related to the CLA.

### 3.5.5. Groundwater quality

As part of the SREBA Water Studies (ELA, 2022), a groundwater quality dataset was compiled from historic data as well as data collected as part of recent Commonwealth Government and other programmes. These include the Geological and Bioregional Assessment (GBA), Gas Industry Social and Environmental Research Alliance (GISERA), Geoscience Australia's Exploring for the Future programme, petroleum industry monitoring, and ongoing town water supply monitoring by Power and Water Corporation (PWC).

The Environmental Health Studies assessment of water quality in the Beetaloo Sub-basin region, undertaken as part of the SREBA Environmental Health Studies report (Tetra Tech Coffey, 2022) has assessed the human health implications of the existing water quality in the area, and the potential for anthropogenic features such as petrol stations and airstrips to be legacy sources of pollutants.

The National Centre for Groundwater Research and Training reviewed the groundwater quality dataset and discovered that, while it has some significant limitations for detailed hydrogeochemical analysis due to the ad hoc nature and limited analytical suite of early sampling (i.e. prior to 2015), it is useful for providing a broad-scale overview of water quality trends across the CLA (Shand et al., 2022).

The location of water quality sampling points and the aquifers associated with the water quality dataset are mapped in Schedules L. Assessment of the key water quality parameters found that:

- groundwater salinity varies between fresh to brackish, see Schedule M. The most prominent areas of elevated salinity are between Daly Waters and Larrimah and north-northwest of Newcastle Waters/Lake Woods
- pH generally ranges from lower neutral to a slightly acidic
- metal concentrations are generally low and remain below the health and aesthetic guidelines
- dissolved methane concentrations are very low in groundwater across the SREBA Water Studies area and are typically below standard limits of reporting (<10 µg/Litre). However, dissolved methane concentrations of 10-500 µg/Litre are not uncommon and have been observed on several occasions during the GISERA, industry and SREBA monitoring programs.

In relation to drinking water, data is available from routine groundwater quality monitoring carried out by PWC for water supplies at serviced townships, Daly Waters, Elliott, Larrimah, Mataranka and Newcastle Waters and Marlinja and the Aboriginal community of Jilkminggan.

The SREBA Water Studies groundwater quality dataset is extensive and continues to grow as new data are provided by ongoing DEPWS and PWC monitoring programs, as well as petroleum exploration companies that are active in the region.

### 3.5.6. Groundwater flow

The pattern of regional groundwater flow has been deduced from the watertable elevation map, see Schedule N. The map shows the height above sea level of the watertable in the CLA. Groundwater moves under the action of gravity from higher to lower elevations, so flow is at right angles to the contours. The arrows shown on the map indicate the generalised flow pattern. There are notable gaps in the monitoring bore network that was used to construct the map, in particular the area west of Elliott. Flow directions are poorly understood in that area.

Water elevation is typically higher in the southern areas of the plan area, the Barkly Tablelands and northern Tanami, becoming lower towards the northwest. Regional flow direction follows the same trend, however in the north the regional flow system is divided by a geological feature called the Birdum Fault which runs parallel to the Stuart Highway. The fault directs groundwater flows from the Wiso Basin towards the Flora River and from the Georgina Basin towards the Roper River.

In many places flows are from the basin margins towards the centre of the basins which reflects the presence of recharge areas along the margins. Widely spaced contours indicate a very low watertable gradient which implies low groundwater velocities. More closely spaced contours seen in parts of the Wiso Basin are due to the aquifer being thinner, such as just east of Top Springs.

The time groundwater would take to travel from the southern boundary of the Georgina Plan area to the outlet at the Roper River would be of the order of millions of years. Note however that watertable gradients are considerably steeper in the immediate vicinity of the Roper and Flora Rivers, and groundwater velocities are greater.

## 3.6. Groundwater modelling

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 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

The plan area is covered by the Daly-Roper coupled groundwater/surface water model (version 2) which is known as DR2 (Knapton, 2020). DR2 covers 196,000 $km^2$ extending across the southern Daly Basin to the southern Georgina Basin and west into the northern Wiso Basin. The development of this model commenced in 2004 as a regional 3-D groundwater model of the CLA and has undergone several extensions and upgrades. The most recent update occurred in 2020 where revisions were made to aquifer geometry and calibration undertaken to include an additional 10 year's field data.

The model is calibrated to groundwater level and streamflow gauging measurements where the CLA discharges to riverine systems (section 3.5.4). Based on the classification scheme outlined in Australian Groundwater Modelling Guideline (Barnett et al. 2012), this model is deemed to be class 2 with many components including spatial and temporal observations adequately defining groundwater behaviour and calibration statistics, prediction period and stresses all meeting class 3 criteria.

An upgrade of the model is in progress and expected to be completed in 2024. As the model already reflects basin performance from known field measurements, for example monitoring boreholes and spring discharge rates, the recalibration will not result in significant overall changes to the water balance.

### 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 equation:

**Inflow = outflow +/- change in storage**

Understanding the inflows and outflows of water in a system is important for managing water resources, as it is used to assess the water availability in a given area and to plan the sustainable use of water resources. The natural water balance for the plan area has been developed using the DR2 model.

The water balance for the plan area includes the volumes of water in storage, combined with the inputs (recharge, inflow) and outputs (discharge, outflow and evapotranspiration). Figure **8** shows the natural water balance for the Georgina Basin and Wiso Basin management zones as at November 2021.

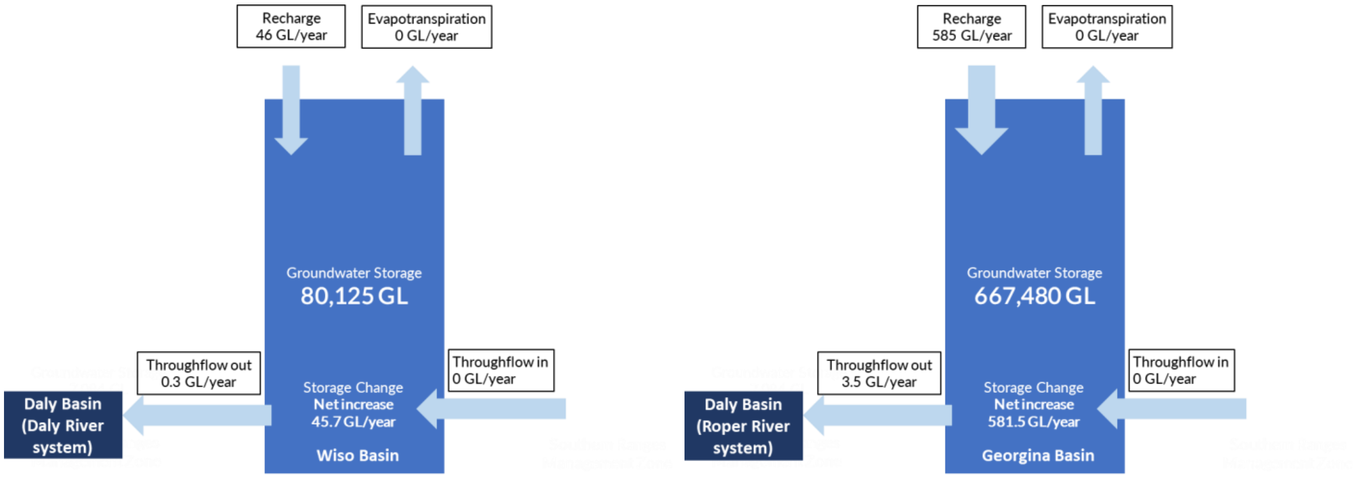



Figure 8 Natural water balance for the Wiso Basin and Georgina Basin water management zones

DR2 quantifies the inputs, outputs and storage for the system as follows:

**System Inputs**

- Groundwater inflow (throughflow in) to the plan area was modelled as 0 GL/year. The exposed Proterozoic rocks along the margins of the plan area and a groundwater divide in the southeast restricts groundwater inflow from other areas.
- Average annual recharge for the period 1970-2022 is estimated at approximately 46,000 ML/year into the Wiso Basin and 585,000 ML/year into the Georgina Basin.

**System outputs**

- Groundwater discharge (throughflow out) from the plan area into the adjacent Daly Basin (Roper River system) is estimated to be 3500 ML/year and 300 ML/year to the adjacent Daly Basin (Flora River system) for the period 1970-2022. A small unquantified proportion of groundwater in the southeast flows towards Lawn Hill Creek and the Gregory River in Queensland and forms a separate groundwater flow system.
- Evapotranspiration losses from groundwater associated with the plan are considered to be negligible as the depth to groundwater is predominantly beyond that available to vegetation, see section 4.1 and Schedule K.

**Groundwater storage**

- Storage in the Wiso Basin is estimated at approximately 80,000,000 ML and 660,000,000 ML in the Georgina Basin. These are increasing at an average of approximately 45,700 ML/year and 581,500 ML/year respectively for the period 1970-2022.

The natural water balance indicates that the inputs into each Basin exceed the outputs and consequently the storage volume is increasing, as evidenced by increasing groundwater levels (Figure **7**).

## 3.7. Interconnectivity of groundwater and surface water

### 3.7.1. Georgina Basin

Throughflow from the Georgina Basin predominantly flows in a northerly direction into the Mataranka Tindall Limestone, ultimately discharging to the Roper River near the community of Mataranka, approximately 100 km north of the Georgina Basin boundary.

The recent environmental tracer studies undertaken by CSIRO as part of the GBA and GISERA programs (Deslandes et al. 2019; Lamontagne et al. 2021) supports the long-held assumption that groundwater discharge at the Roper River is overwhelmingly derived from the local CLA. Evidence indicates that groundwater discharge at the Roper River is likely to be sourced from groundwater within approximately 100 km of the Roper River and that groundwater originating from deeper formations or from the Georgina Basin are likely to be only a very minor portion of the total discharge at the Roper River (ELA, 2022).

DR2 estimates throughflow from the Georgina Basin at 3530 ML/year.

Annual groundwater discharge to the Roper River is estimated at 63,000 to 252,000 ML/year, based on gauged dry season flows at the Elsey Homestead gauging station. Concurrent flow measurements undertaken upstream of the discharge zone enables the net discharge into the Roper River to be calculated. Conducting these gaugings at the end of the dry season ensures flow values are not affected by rainfall or surface water runoff (river flow).

Based on the above discharge estimates, the throughflow from the Georgina Basin represents up to five per cent of total discharge to the Roper River.

The importance of spring flow and groundwater discharge to the Roper River is recognised. The impact of extraction from the Mataranka Tindall groundwater system and measures necessary to protect environmental and cultural values will be presented in the Mataranka Tindall water allocation plan, currently under development.

### 3.7.2. Wiso Basin

Throughflow from the Wiso Basin predominantly flows in a northerly direction into the Tindall Limestone (Daly Basin) and ultimately discharges into the Flora River downstream of Djarrung and the confluence of the Flora River and Matherson Creek, approximately 100 km north of the plan boundary.

As part of the SREBA Water Studies, DEPWS commissioned Charles Darwin University to undertake an environmental tracer study of the Flora River and nearby CLA groundwater flow system (Irvine and Duvert, 2022). The study identified that the majority of water discharging to the Flora River is recharged locally but that there were indications of a minor portion of groundwater older than that expected. This suggests that the source for this water was more likely the result of throughflow from upgradient areas of the Flora River flowpath.

DR2 estimates throughflow from the Wiso Basin at 300 ML/year.

Annual groundwater discharge to the Flora River is typically 110,000 to 174,000 ML/year, based on gauged dry season flows at the Stoney Creek gauging station. As per the Roper River, concurrent flow measurements undertaken upstream of the discharge zone enables the net discharge into the Flora River to be calculated. Based on the above discharge estimates, the throughflow from the Wiso Basin represents less than one per cent of total discharge to the Roper River.

Groundwater discharge maintains dry season flow into the Flora River and provides a significant contribution to the Daly River system. While there is currently very little use from local groundwater in the Flora catchment, the potential impact of extraction and measures necessary to protect environmental and cultural values will be presented in the Flora water allocation plan, currently under development.

# 4 Environmental water

**Overview**

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

First and foremost the majority of water is retained and maintained for non-consumptive uses, including environmental water values and their water requirements.

Knowledge of environmental water values and requirements within the plan area and the broader region has been significantly improved through the SREBA studies and will continue to grow through the implementation actions.

Depth to groundwater mapping combined with an analysis of vegetation indices derived from a time series of Landsat satellite imagery identifies that the extent of terrestrial groundwater dependent ecosystems in the plan area is very limited. The groundwater resources in the plan area are generally greater than 30 m below the ground and beyond the depth accessible by groundwater dependent vegetation. While further field verification to establish GDE probability mapping will occur during implementation of the plan existing studies verify that there is limited interdependency between the CLA and water dependent ecosystems on the surface.

Surface water bodies such as Lake Woods and the Barkly lakes may contribute recharge to the CLA however there is no direct connectivity between them which means that water levels in the lakes are not maintained by the groundwater resource.

Environmental water considers the water needs required to maintain natural ecosystems over time. In the plan area, natural ecosystems 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.

## 4.1. Groundwater dependent ecosystems

The NTG uses the definition of groundwater dependent ecosystems (GDEs) in Schedule A. Eamus et al. (2006) classified GDEs in Australia 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.

Depth to groundwater mapping has been undertaken for the regional CLA system within the Beetaloo SREBA water study area, see Schedule K. Where this mapping aligns with the plan area it shows that the depth to groundwater is generally greater than 30 m below ground level. Terrestrial vegetation is unlikely to be accessing groundwater where it occurs at depths greater than 15 to 20m. In the vicinity of large ephemeral surface water bodies such as Lake Woods and the Barkly lakes, groundwater is 15-30 m below ground level and this “mounding” is potentially a result of recharge occurring from the lakes.

### 4.1.1. Terrestrial groundwater dependent ecosystems

A uniform vegetation map has been developed for the Beetaloo SREBA study area, and vegetation communities described based on extensive field sampling (Young et al. 2022; DEPWS 2022c). This mapping covers northern and eastern portions of the Wiso Basin Management Zone and northern portions of the Georgina Basin Management Zone (north of Lake Woods and the Barkly Tableland. Based on vegetation characteristics, seven vegetation communities and three map units (broad vegetation groups) were identified as potential groundwater dependent ecosystems. The majority of their extent was around the northerly edges of the study area (and outside the plan area), where groundwater was shallow and/or associated with springs and riparian zones. In more southerly areas mapped as potential groundwater-dependent ecosystems where depth to regional aquifers is relatively deep, vegetation may be accessing a shallower perched groundwater system or be in an area of increased soil moisture due to inflow of surface water from adjacent areas, and with soils of higher water-holding capacity.

The implementation actions include further work to develop a probability map for groundwater dependent vegetation across the plan area, based on an analysis of vegetation indices derived from a time series of Landsat satellite imagery (Brim Box et al. 2022) supported by ground validation.

Given the relatively large depth to the Cambrian Limestone Aquifer across most of the plan area, there is a low risk that groundwater extraction from the CLA, within the limits set by this plan, will have impacts on terrestrial groundwater dependent ecosystems.

### 4.1.2. Subterranean groundwater dependent ecosystems

A baseline assessment of stygofauna was undertaken as part of the Beetaloo SREBA (Humphreys et al. 2022, DEPWS 2022c), including field surveys conducted in October 2021 and May 2022 which sampled a total of 66 water bores into various formations of the CLA. This added to a study undertaken by CSIRO in collaboration with Charles Darwin University and Latrobe University during 2019 (Rees et al. 2020). These study areas overlap the northern part of the plan area.

The SREBA stygofauna study showed that species richness and relative frequency of stygofauna in the northern part of the plan area is low compared to samples in the Tindall Limestone portion of the CLA to the north of the plan area, where depth to groundwater is less. Of the 38 species level taxa currently known from the Beetaloo Sub-basin, only a single widespread stygofauna species was recorded from bores in the Wiso basin, while five species were recorded from the Georgina Basin, with four of these recorded only within that Basin. However, these two Basins were relatively poorly sampled compared to the Tindall Limestone. The stygofauna report considered that real total species richness for stygofauna in the study area was likely about twice that currently know.

The Tindall Limestone to the north of the plan area is a Top End aquifer system with its widely-connected and highly transmissive habitat space for fauna below the water table, and significant annual recharge from the surface through sinkholes and other surface karst features. The stygofauna report noted that maintaining recharge regimes, maintaining groundwater quality and avoiding desaturation of stygofauna habitat were important to minimise impacts on the stygofauna community.

In the Arid Zone systems of the Georgina and Wiso Basins, seasonal or decadal variations in groundwater level is minimal due to the magnitude of storage and episodic recharge patterns. On the basis of available information, the potential threat to stygofauna communities from groundwater extraction, within the limits set by this plan, is considered to be minimal and any impacts are likely to be limited to localised areas subject to significant drawdown during pumping.

# 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 and maintained for non-consumptive uses, including to maintain cultural values.

In the region overlaying the Beetaloo Sub-basin, work to identify cultural values and sites has started through SREBA and will continue through the implementation actions. When completed, the key cultural sites related to the water resources can be managed through the plan, if required.

## 5.1. Cultural values

The following information has been collated from a review of submissions provided to the scientific inquiry into hydraulic fracturing in the Northern Territory[3]. Important values associated with water were also recognised during the social-cultural baselines studies for the SREBA (Witt et al. 2023, DEPWS 2022c).

Cultural knowledge and values are at the core of the Aboriginal way of life that preceded European contact by many millennia. Some degree of cultural evolution across time is inevitable, but industrialisation of the Northern Territory has the potential to lead to rapid and significant loss of traditional Aboriginal ecological and cultural information. Overall spiritual values of the landscape will be lost if individual sites become isolated, cultural values of water will be damaged if it becomes contaminated and the wider traditional ecological and cultural knowledge that constitutes the unique Aboriginal body of science will eventually become diminished once traditional practices are no longer followed.

According to Aboriginal tradition, the aquifers underlying country which may give rise to springs and other naturally occurring water sources can be associated with the travels of ancestral beings and link neighbouring Aboriginal groups, connecting people across the landscape. In the area surrounding the Beetaloo Sub-basin, for example, these connections find expression in the kujika song cycles. Kujika are central to the major ceremonies linking Aboriginal groups across the region. The songs link people with sites in the landscape, celebrating the exploits of ancestral beings as they travelled above and below the ground.

The kujika reinforce the concept of mangalalgal, or “the way of the dreaming”, which is an explicit imperative to honour and maintain cultural traditions. Traditional Aboriginal owners have submitted that they are connected with neighbouring Aboriginal groups by “underground culture.”

## 5.2. Considerations for protection of cultural values

The ongoing involvement of Aboriginal people in the plan area 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 will be 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.

[3] https://frackinginquiry.nt.gov.au/

# 6 Water use

**Overview**

This section outlines the key considerations to determine the amount of water to be taken from the water resources managed through the plan. This includes an overview of the policy and processes to establish the estimated sustainable yield (ESY) and Aboriginal water reserve allocations. There is also information on current water use and cumulative water licence entitlements in the plan area.

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 and therefore available to take for drinking and sustainable development.

The ESY is informed by scientific understanding of the water resources, underpinned by water monitoring, assessments and modelling.

In arid regions like Georgina Wiso it is necessary to rely on the actual stored water available, to balance the continuous demand for water with recharge that may only occur every ten years or longer.

The Georgina and Wiso Basins are very extensive, with a stored volume of 740,000,000 ML. Taking the ESY of 210,000 ML/year for 100 years means 97% of the current water remains stored. This percentage does not account for recharge events that will also occur during this period. Relying on actual stored water is a more precautionary approach as it does not rely on highly variable recharge or uncertainties about climate change.

The Aboriginal water reserve of 20,251 ML/year is calculated in proportion to the percentage of eligible land for each water management zone with access to the water resources.

Petroleum activities have been allocated 10,000 ML/year, which represents less than eight per cent of the total allocation to all beneficial uses and is less than half of the estimated water use for rural stock and domestic purposes in the plan area.

Current water use in the region is very limited and predominately used for rural stock and domestic purposes.

The Act requires a water allocation plan to set the ESY within a water control district and allocate the volume of water taken by beneficial use category. The ESY establishes the amount of water from a water resource within the district that can be sustainably allocated for drinking water and for a range of commercial uses and reserved for future Aboriginal economic development.

Broadly, the Northern Territory Water Allocation Planning Framework (NTG, 2000) 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 the characteristics of water resources vary 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 CLA in this plan area meets the criteria of an Arid Zone groundwater resource (Short and Bond 2021). Median annual rainfall ranges from 750 mm in the north to approximately 375 mm in the south. Recharge is generally low and is highly variable across the plan area and from year to year. Rivers and creeks do not flow every year, sometimes not flowing for several years. This is evidenced by groundwater level monitoring data that shows no discernible seasonal response to rainfall (Figure **7**), unlike Top End systems where there is a distinct annual recharge and discharge signature related to seasonal rainfall patterns.

The water resources in the plan area are considered to be Arid Zone (Short and Bond, 2021) and the plan sets an ESY that is based on the water planning process undertaken in the region.

It is necessary to use aquifer storage to balance infrequent recharge with a continuous demand for water. Relying on actual stored water is a more precautionary approach as it does not rely on highly variable recharge or uncertainties about climate change.

## 6.1. Current water use

Understanding current use is important when determining allocations to beneficial uses within the ESY. The approach to allocating to beneficial uses ensures that allocations take into account current use.

Presently the current use is limited to rural stock and domestic purposes, public water supply and petroleum activities as per Table **2**.

Table 2 Estimated current water use (licenced and unlicensed) for each water management zone

| Beneficial uses (ML/year) | Georgina Basin | Wiso Basin | Total |
|---|---|---|---|
| Rural Stock and Domestic | 9,921 | 3,666 | **13,587** |
| Public Water Supply | 360 | 100 | **460** |
| Agriculture, Aquaculture, Cultural, Industry, Mining activity | 0 | 0 | **0** |
| Petroleum activity | 948 | 0 | **948** |
| **Total** | **11,228** | **3,766** | **14,994** |

The extension in October 2022 of the water control district to include all of the plan area means that current water users (above 5 ML/year) will require a licence, except for water for rural stock and domestic use.

### 6.1.1. Rural stock and domestic

Under section 14 of the Act, owners of land are authorised to take groundwater for:

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

b) drinking water for grazing stock on the land or

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

Estimations of the rural stock and domestic water use is provided in Table **3**.

Table 3 Rural stock and domestic water use estimates (ML/year) for each water management zone

| Estimated water use (ML/year) | Georgina Basin | Wiso Basin | Total |
|---|---|---|---|
| Domestic | 208 | 29 | **237** |
| Rural stock | 9,713 | 3,637 | **13,350** |
| **Total** | **9,921** | **3,666** | **13,578** |

Rural domestic use is that water used by minor communities and outstations not supplied by Power Water Corporation (PWC) and water used for domestic use on pastoral properties. Minor community use has been estimated by comparing domestic water consumption rates for the communities of Elliott and Daly Waters, who do have a metered public water supply, relative to the community population and applying similar rate of water use per person to population statistics for each minor community.

Rural domestic use on pastoral properties has been estimated by applying an average water use based on PWC Water Smart consumption rates to the number of homesteads within the plan area.

Stock water use is calculated using Meat and Livestock Australia's industry guidelines[4]. Stock water use estimates do not account for potential stock holdings on Aboriginal land as land use mapping for Aboriginal land is not available within this region.

### 6.1.2. Public water supply

Public water supply is defined as the source water for drinking purposes delivered through community water supply systems. Allocation of water to public water supply requires a water extraction licence.

In the Northern Territory the Department of Health is the regulator of safe drinking water and has a key role in the protection of public health. This responsibility is established under the *Public and Environmental Health Act 2011*, *Water Supply and Sewerage Services Act 2000*, *Power and Water Corporation Act 2002*, the *Government Owned Corporations Act 2001* for urban centres and by agreement with the Northern Territory Government for remote centres.

In the plan area this service applies to the communities of Daly Waters, Marlinja and Elliot. A water licence is issued to PWC for each of these communities based on existing average demand and forecasted 30-year bulk demand estimates. The existing licence entitlements for each community includes a significant buffer for expansion of the community or emergency provision. A summary of licensed public water supply is provided in Table **4** Licensed public water supply (ML/yr) from groundwater Table **4**.

Table 4 Licensed public water supply (ML/yr) from groundwater

| Groundwater (ML/year) | | Georgina Basin | Wiso Basin | Total |
|---|---|---|---|---|
| Location | Daly Waters | Elliott | Marlinja | |
| Forecast 30 year bulk demand | 60 | 250 | 60 | **370** |
| Licensed entitlement | 60 | 300 | 100 | **460** |
| Licensed entitlement relative to forecast 30 year bulk demand (%) | 100 | 120 | 167 | |
| **Total** | **60** | **300** | **100** | **460** |

Details of water quality data are provided by PWC in an annual drinking water quality report accessible via the Power and Water Corporations publications[5].

### 6.1.3. Other consumptive use

Other consumptive use refers to the water being used by beneficial uses of agriculture, aquaculture, cultural, industry, mining activities and petroleum activities. Current water licence entitlements to each beneficial use are summarised in Table **5.**

[4] Meat and Livestock Australia's – Cattle and land management best practices guide

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

Table 5 Total licence entitlements (ML/year) by beneficial use at January 2023

| Beneficial uses (ML/year) | Georgina Basin | Wiso Basin | Total |
|---|---|---|---|
| Agriculture, Aquaculture, Cultural, Industry and Mining activity | 0 | 0 | **0** |
| Petroleum activity | 948 | 0 | **948** |
| **Total** | **948** | **0** | **948** |

## 6.2. Future water use

Future demand for water within the life of the plan is expected to come from the agricultural, mining and petroleum industries summarised in Table **6**.

Table 6 Projected future use in plan area (ML/Year)

| Potential Future Use (ML/Year) | Georgina Basin | Wiso Basin | Total |
|---|---|---|---|
| Agriculture | 128,160 | 20,000 | 148,160 |
| Industry | 600 | 400 | 1,000 |
| Mining activity | 8,000 | 2,000 | 10,000 |
| Petroleum activity | 8,000 | 2,000 | 10,000 |
| **Potential future use** | **144,760** | **24,400** | **169,160** |

### 6.2.1. Agriculture

Estimates of water use for agricultural purposes within the life of the plan are based on potential irrigated agriculture development opportunities identified through soil and land assessments for the Barkly North and Dunmarra areas and Kurnturlparla and Warumungu Aboriginal Land Trust land. These detailed studies identified approximately 52,000 ha of versatile lands suited to a range of broad-acre irrigated agricultural cropping systems and a further 25,000 ha of land with marginal irrigation development capability. Water use will depend on a range of factors including crop selection, irrigation method and seasonal climatic conditions.

Estimated future use assumes an average water use of 5 ML/ha and that half of the lands most suited to irrigated development are developed within the life of the plan.

The Barkly area has significant existing capability within the pastoral industry. Diversification of the agricultural sector within the Georgina Wiso plan area could support economic growth opportunities with other benefits including regional development and supply chain opportunities, as well as strengthen existing communities and services within the region. Future development of the area would also increase potential prospects for agribusiness that is led by Aboriginal communities and on Aboriginal land. Future agricultural development within the plan area will continue to be underpinned by a robust regulatory framework.

### 6.2.2. Mining activity

According to the Spatial Territory Resource Information Kit for Exploration (STRIKE; the Northern Territory Government web-mapping application for geoscientific data and minerals and energy tenure information), as of October 2022 there are three mining activities located within the Georgina WMZ and no activities within the Wiso WMZ. Of those in the Georgina, Mauretania Mine and Buccaneer Mine are classified as being assessed for feasibility and Bootu Creek is under care and maintenance. Estimated future water use volumes are based on water usage in similar areas of the Territory.

### 6.2.3. Petroleum activity

The Beetaloo Sub-basin is a focus for onshore gas exploration and potential major development. There have been a number of estimates on the amount of water required for these activities, which depends on the scale of development in the area. The inquiry estimated between 1000 and 1150 wells being developed in the Beetaloo Sub-basin with a total water use of 2500 to 5000 ML/year. A more recent report on infrastructure and logistics requirements for the development of an onshore gas industry in the Northern Territory (KPMG, 2019) estimates 375 - 2225 wells with a total water requirement ranging from 1156 ML/year under a low development scenario to 6610 ML/year for a high development scenario.

Based on current development progress, water use projections for petroleum activities in the plan area are based on a medium production scenario for the Georgina WMZ and a low use scenario for the Wiso WMZ, with additional capacity provided for further expansion as the industry develops over time. Schedule E provides an overview of petroleum titles and current exploration wells within the plan area.

### 6.2.4. Industry

Associated industry development is likely to be required to support workforce development and expansion associated with the projected mining and petroleum activities. These future demand requirements are notional and will be refined as development progresses.

## 6.3. Estimated sustainable yield

The estimated sustainable yield 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 plan.

The process for determining the ESY follows accepted practices that begins with revisiting understanding of the water resource, identifying the environmental values associated with water (including cultural values 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.

First and foremost, 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 and therefore available to take 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.

### 6.3.1. Surface water

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

Surface water flows during wet periods contribute to recharging groundwater and supporting natural ecosystems along with associated sites of cultural significance for Aboriginal people. Further investigations to better quantify overland flow and recharge are underway.

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 because consumptive use is limited to rural stock and domestic purposes.

### 6.3.2. Groundwater

The natural water balance (Figure **8**) based on long-term historical data, shows a total storage volume of 740,000,000 ML for the Georgina and Wiso management zones, with stored volume increasing by an average of 627,200 ML/year since the 1970's.

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 stored water volumes is a more precautionary approach than relying on recharge, as it does not rely on highly variable recharge or uncertainties about climate change.

The determination of the ESY for the CLA in the plan is based on the following key considerations:

- maintaining stored volumes of water in the Georgina and Wiso Basins to ensure minimal impact on environmental and cultural values
- limiting allocations for development purposes to the capacity for development of the region
- maintaining current and future rural stock and domestic take, and ensuring availability of public water supplies
- ensuring specified, limited allocations of water for consumptive use for petroleum activities over the life of the plan.

Without taking into account any changes in the water balance that may occur over time, the direct application of the framework yields a maximum potential ESY of 5,920,000 ML/year. However applying the framework to determine the ESY was dismissed during the planning process.

Estimates of unlicensed water take, development potential, and modelling results (Section 3.5.3) guided the determination of the ESY for the area's first plan.

Following feedback from public consultation, an ESY of 210,000 ML per year was selected for the plan.

### 6.3.3. Modelling extraction scenarios

Modelling is a useful tool to assess the potential and relative impact for a range of management decisions. Outputs demonstrate how the system responds to extraction and can inform what an estimated sustainable yield could look like.

In developing the draft plan a number of groundwater extraction scenarios were modelled to assess the relative impact of extraction on groundwater levels across the plan area and discharge to the Roper River.

Four water extraction scenarios (SC1 – SC4) for volumes ranging from 18,466 ML per year to 262,560 ML per year were formulated to test potential ESYs against natural conditions (SC0), as presented in Table **7**.

Table 7 Modelling scenarios

| Scenario | Description | Georgina Volume (ML/year) | Wiso Volume (ML/year) | Total Volume (ML/year) |
|---|---|---:|---:|---:|
| **SC0** | Natural – no extraction | | | |
| **SC1** | Current use | 13,343 | 5,123 | **18,466** |
| **SC2** | Current and future use | 243,360 | 19,200 | **262,560** |
| **SC3** | Current and future use | 186,154 | 23,846 | **210,000** |
| **SC4** | Current and future use | 120,150 | 14,850 | **135,000** |

A number of assumptions were made to derive appropriate pumping scenarios for the extractive volumes of each beneficial use. Water extraction bores for agricultural use were located towards the north of the Georgina and Wiso Basins near areas of current horticultural suitability. Water extraction bores for petroleum purposes were located in the vicinity of existing exploration wells. Extraction bores representing the Aboriginal water reserve were allocated proportionally to land eligible for the Aboriginal water reserve. The pumping schedule was implemented at full pumpage for 50 years. Only extraction within the plan area was included in the pumping files, in order to isolate the impacts of the above scenarios from the effects of usage beyond the plan boundaries.

All scenarios were modelled from 1970 to 2022 using a daily timestamp with results reported on a weekly basis. The commencement date of 1970 was chosen based on availability of measured evaporation data. Reporting nodes for northern Wiso, northern, mid and southern Georgina were selected at random but the model outputs are considered representative of each region, see Schedule O.

Model results should be considered indicative rather than absolute based on the assumptions used, however the model provides a reasonable depiction of natural situations, as illustrated in Figure **7**. This increases confidence in the model's ability to depict the relative implications of the various scenarios.

Modelled impact of extraction in the Wiso Basin for scenario 1 to 4 is plotted against the modelled natural groundwater levels (Scenario 0) in Figure **9**. After 52 years of extraction groundwater levels increase by approximately 3.2 m and the difference between scenario 0, where no extraction occurs, and scenario 3 (ESY of 23,846 ML/year) is a relative reduction in groundwater level of approximately 0.11 m.

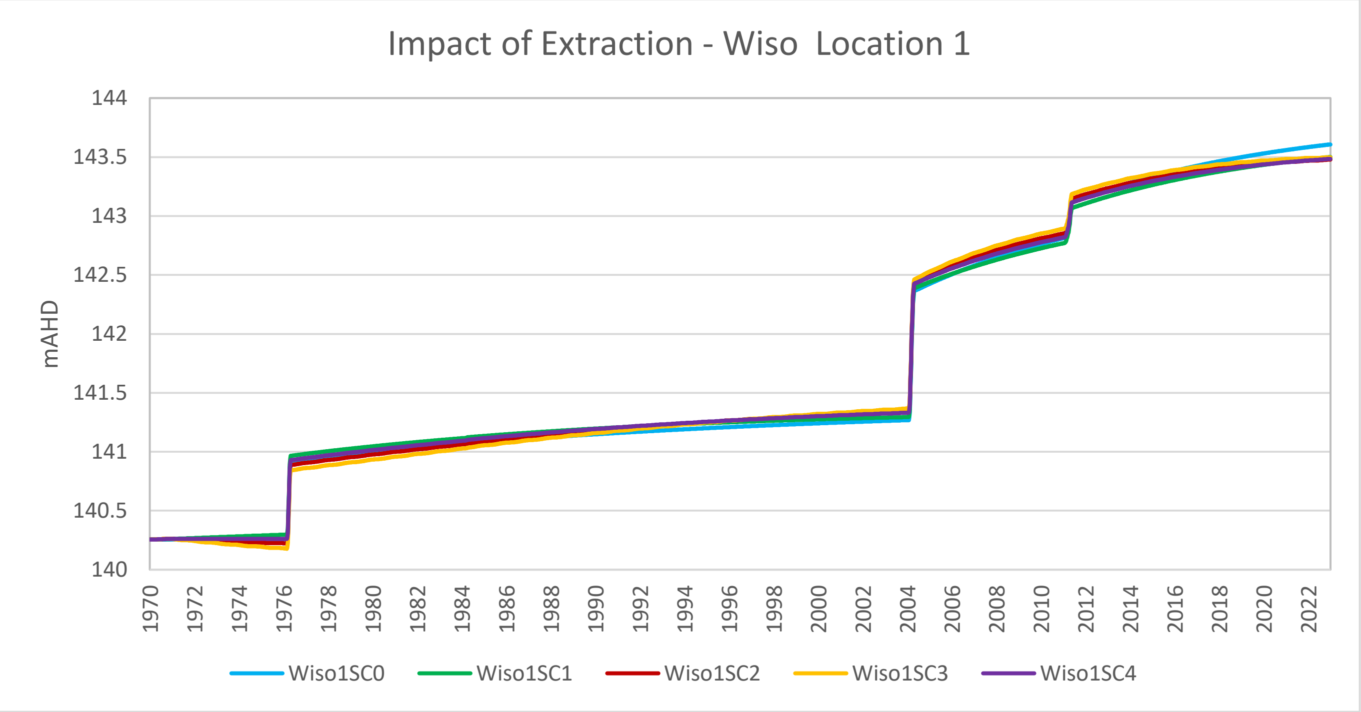



Figure 9 Modelled impact of extraction, Wiso Basin location 1

Figure **10**, Figure **11** and Figure **12** show the modelled impact of extraction in the Georgina Basin at each of the three reporting nodes. Regardless of the ESY scenario, groundwater levels continue to rise in all three locations after 52 years of extraction. Under scenario 3, applying an ESY of 186,154ML/year, groundwater levels rise by approximately 3.2 m at location one, 3.8 m at position two, and 4.6 m at location three.

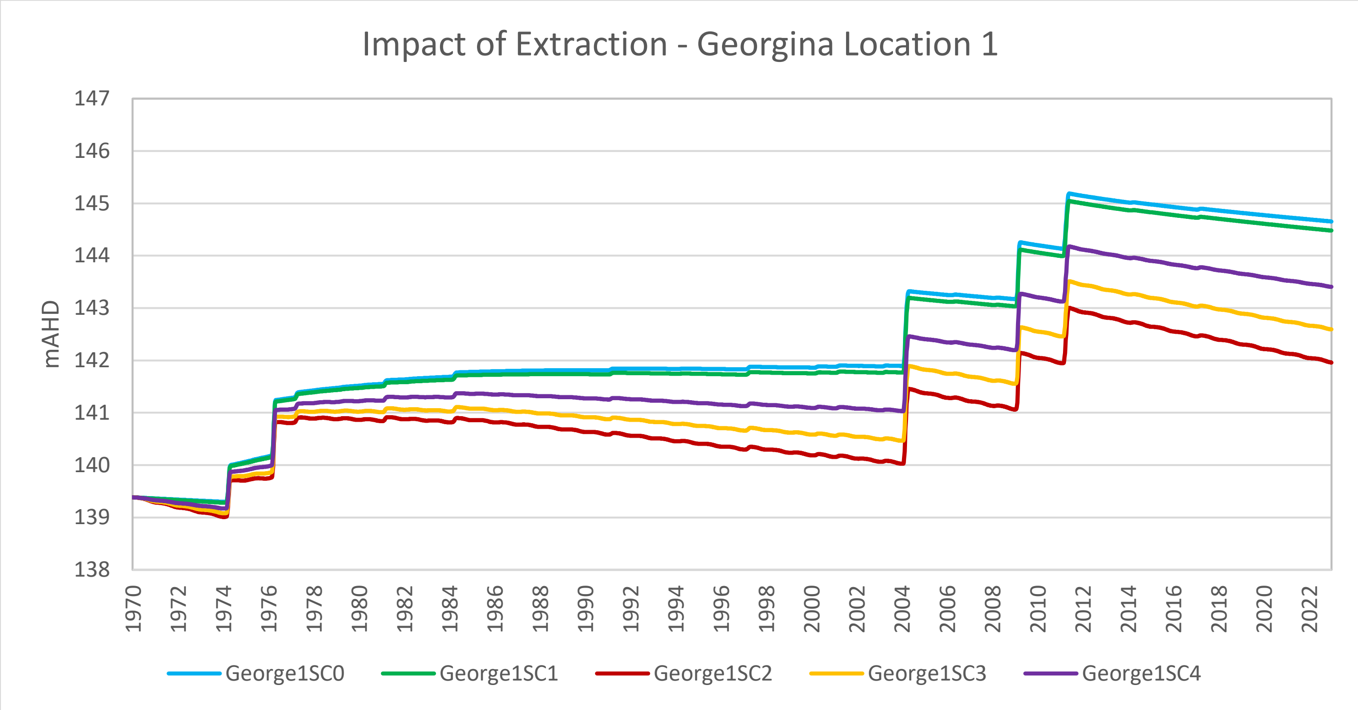



Figure 10 Modelled impact of extraction, Georgina Basin location 1

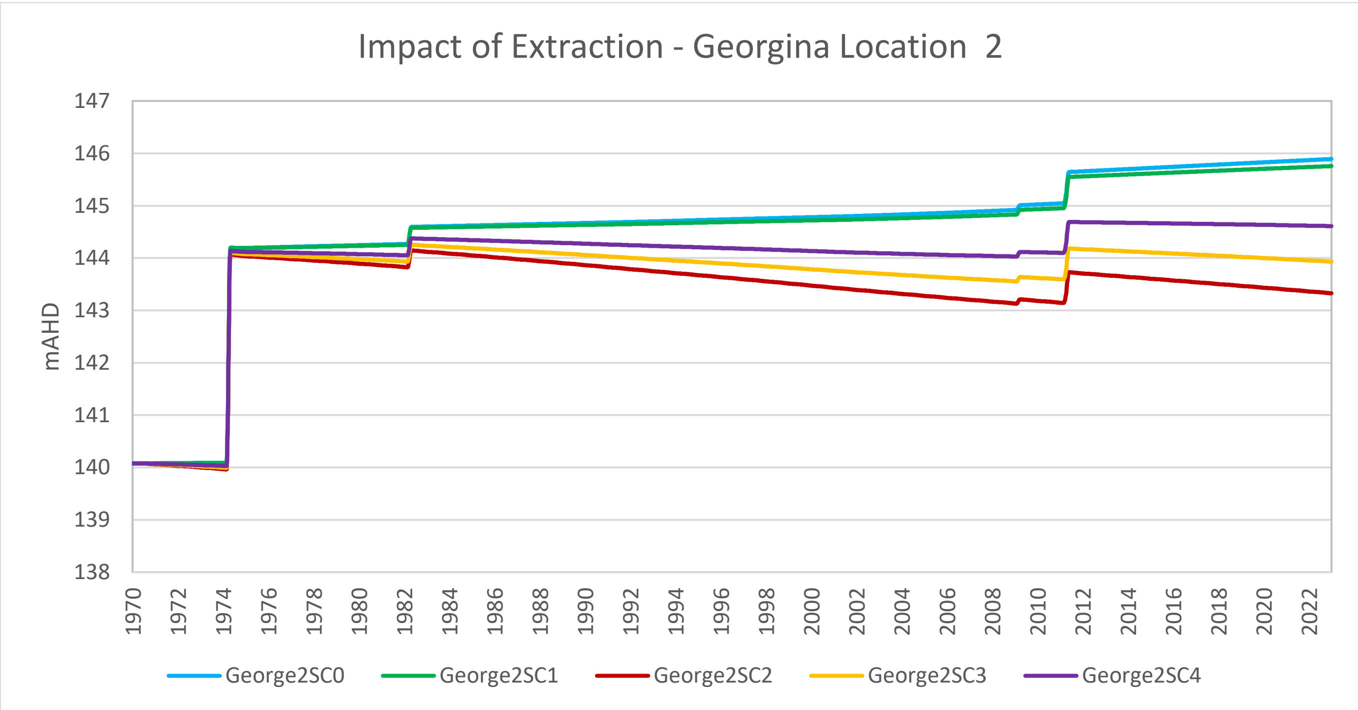



Figure 11 Modelled impact of extraction, Georgina Basin location 2

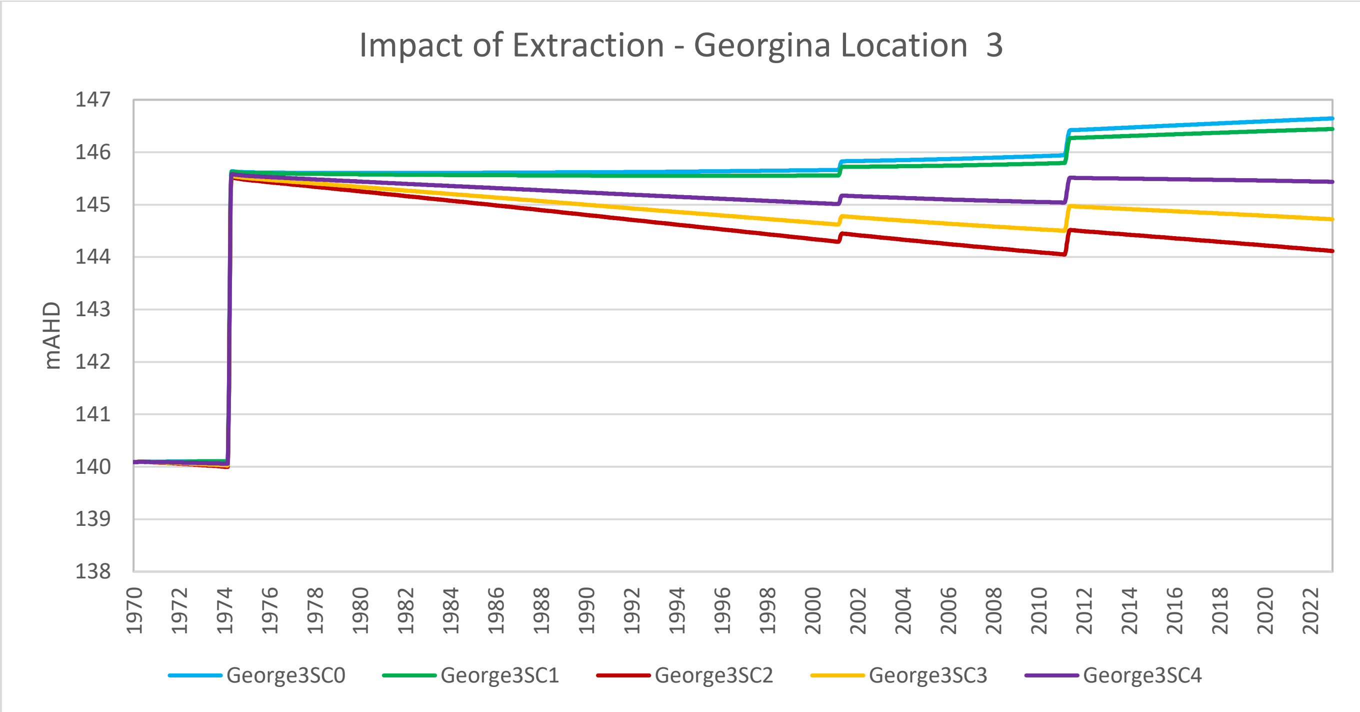



Figure 12 Modelled impact of extraction, Georgina Basin location 3

For each scenario, the impacts of extraction from the Georgina Basin on discharge to the Roper River was also modelled, as was the impact of extraction from the Wiso Basin on discharge to the Flora River. During the modelling period, the decline in flow for all years and scenarios was almost imperceptible. It should be noted that this modelling exercise did not include extraction from the CLA outside of the plan area so as to demonstrate the impact of extraction from the Georgina and Wiso Basins.

## 6.4. Aboriginal water reserve

In 2017 the Northern Territory Government approved the Strategic Aboriginal Water Reserve Policy Framework (NTG, 2017) to provide Aboriginal people with increased opportunity to access water resources for their economic benefit, and in doing so seek to address the disadvantage faced by Aboriginal people in relation to economic opportunities and development.

Under the Act, an Aboriginal water reserves (AWR) is 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 AWR is only created where there is a water allocation that relates to eligible land.

Detailed reports (NTG, 2022 a and b) on the eligible land for the Georgina Basin and Wiso Basin AWR have been prepared for Central Land Council and Northern Land Council. The reports detail the methodology to determine the eligible land, identify eligible land holders, shares of the AWR and the volumes of water allocated to the AWR for each water management zone in the plan. The plan provides detail on how the AWR is shared between the eligible lands. A summary of the AWR is presented in Table **8**.

Table 8 Allocation (ML/year) to the Aboriginal water reserve for each water management zone

| Groundwater (ML/year) | Georgina Basin | Wiso Basin | Total |
|---|---|---|---|
| Estimated sustainable yield | 186,154 | 23,846 | **210,000** |
| Available consumptive pool[6] | 171,090 | 18,320 | **189,410** |
| AWR per cent of available | 10.00% | 17.15% | |
| Total | **17,109** | **3,142** | **20,251** |

[6] The available consumptive pool is the ESY less the allocation to public water supply, environment, and rural stock and domestic use

# Schedule A: Dictionary

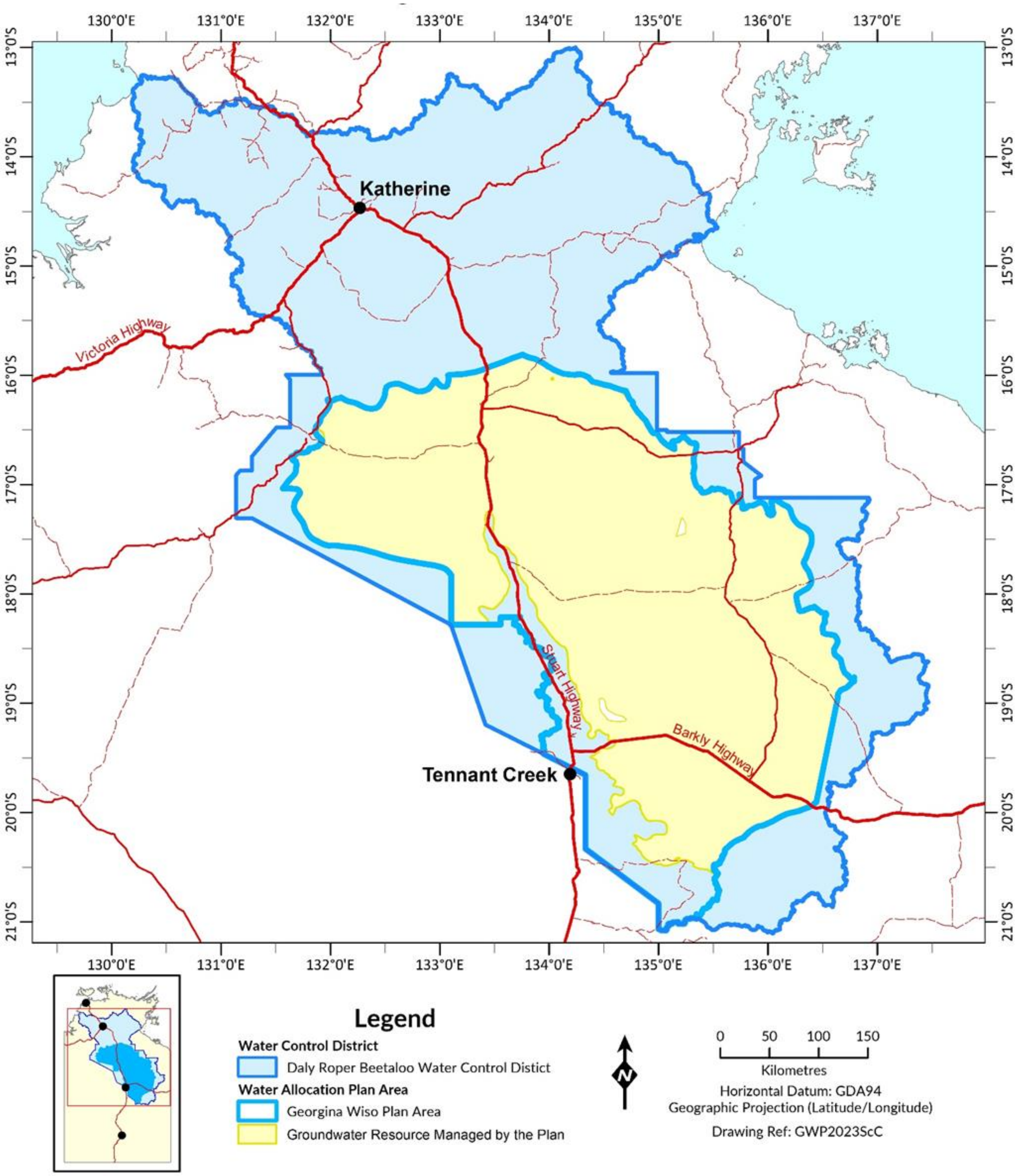
| Term | Definition or reference |
|---|---|
| Aboriginal water reserve | Section 4(1) of the Act |
| Act | *Water Act 1992*[7] |
| Beneficial uses | The beneficial uses for the Daly Roper Beetaloo Water Control District declared by gazette on 19 October 2022. A copy of the declaration is included in Schedule E of the plan |
| Cambrian Limestone Aquifer | The Cambrian Limestone Aquifer (CLA) is a collective term for an extensive groundwater system covering 570,000km2 straddling the NT and QLD border. The CLA comprises the geological basins of the Daly, Georgina and Wiso. The aquifer consists primarily of limestone. |
| Controller | Controller of Water Resources appointed under section 18 of the *Water Act 1992* |
| Department | Northern Territory Government department with administrative responsibility for the Act, currently the Department of Environment, Parks and Water Security |
| Eligible land | Section 4B of the Act |
| Estimated sustainable yield | Amount of water that can be allocated from the water resource to support declared beneficial uses that is sustainable. Section 6.3 of this report |
| Groundwater | Section 4(1) of the Act |
| Groundwater dependent ecosystem or GDE | Ecosystems that require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services |
| Implementation Actions | Georgina Wiso Implementation Actions 2023-2031, as amended from time to time |
| Licence entitlement | Maximum volume of water listed on a water extraction licence and which may be taken in water year |
| Plan area | Section 1 and Schedule C of this report |
| Water control district | Daly Roper Beetaloo Water Control District, declared on 19 October 2022 under section 22 of the Act and in Schedule C of this report |
| Water licence | A water extraction licence granted under section 45 or section 60 of the Act |
| Water management zone | Areas of land within the plan separated for management purposes as depicted in Schedule D of this report |
| Waterway | Section 4(1) of the Act |

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

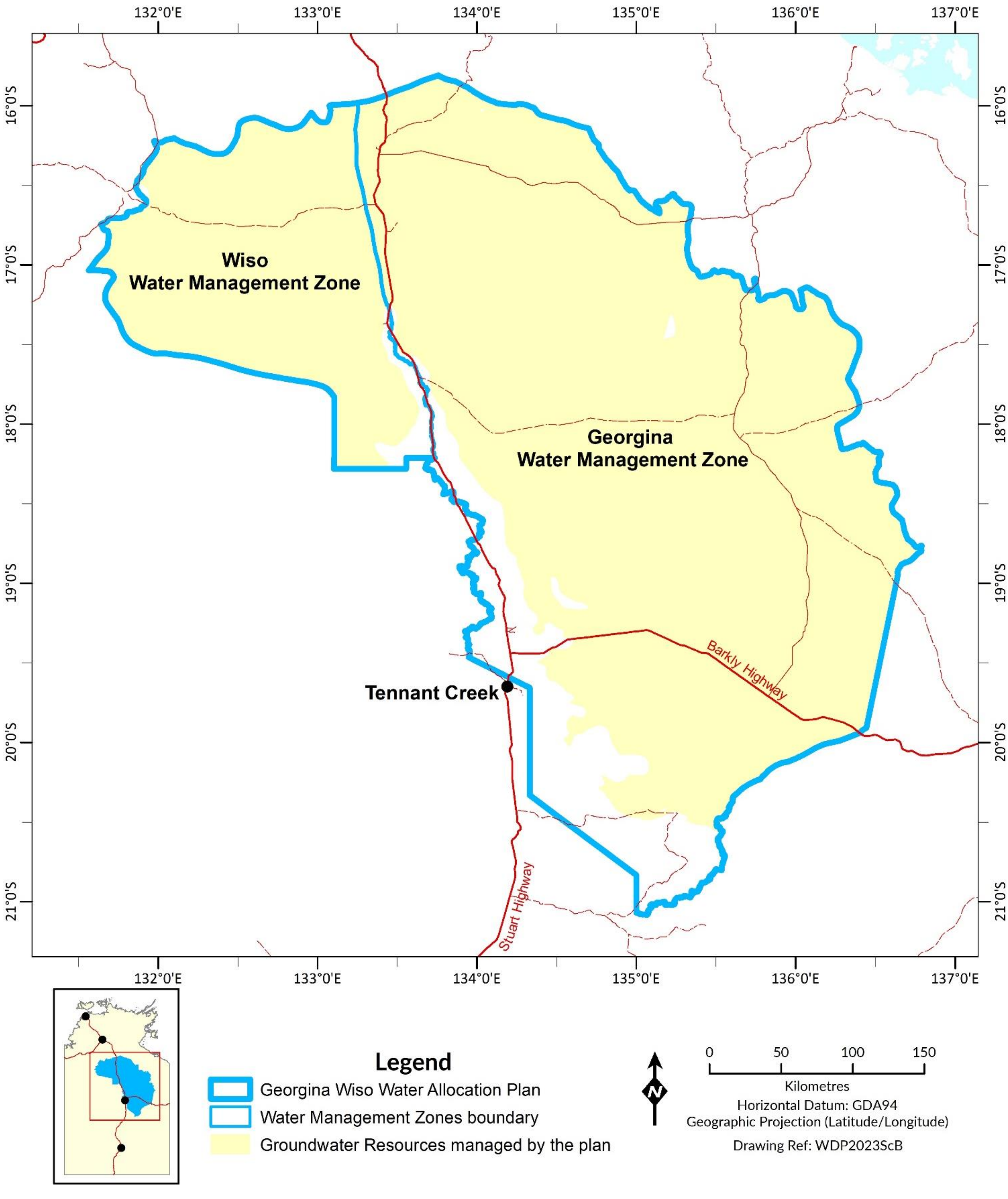
# Schedule B: Abbreviations and acronyms

| Abbreviations and acronym | Full form |
|---|---|
| AAPA | Aboriginal Areas Protection Authority |
| Act | *Water Act 1992* |
| CLA | Cambrian Limestone Aquifer |
| CLC | Central Land Council |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DEPWS | Department Environment, Parks and Water Security |
| DITT | Department Industry, Tourism and Trade |
| ESY | Estimated sustainable yield |
| FFD | Flora and Fauna Division, DEPWS |
| GL | Giga Litres |
| GBA | Geological and Bioregional Assessment |
| GDE | Groundwater dependent ecosystems |
| GDV | Groundwater dependent vegetation |
| GISERA | Gas Industry Social and Environmental Research Alliance |
| KPI | Key performance indicator |
| Licence holders | Water extraction licence holders |
| mAHD | Metres with respect to the Australian height datum |
| ML | Mega litres |
| NASY | Northern Australia Sustainable Yields |
| NLC | Northern Land Council |
| NTG | Northern Territory Government |
| OWS | Office of Water Security, DEPWS |
| PET | Potential evapotranspiration |
| PWC | Power and Water Corporation |
| SREBA | Strategic Regional Environmental and Baseline Assessment |
| STRIKE | Spatial Territory Resource Information Kit for Exploration |
| WAC | Water Advisory Committee |
| WMZ | Water Management Zone |
| WRD | Water Resources Division, DEPWS |

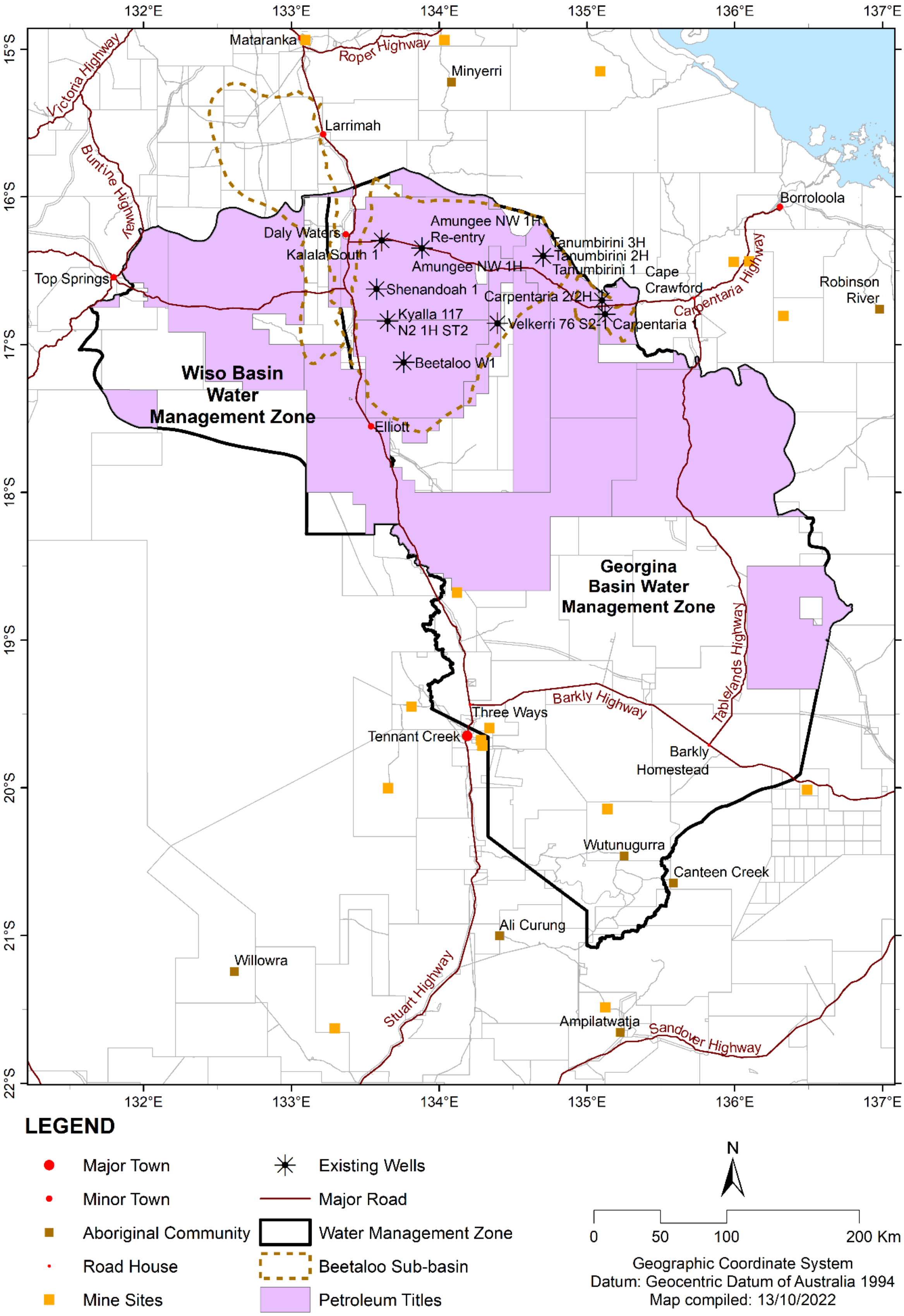
# Schedule C: Daly Roper Beetaloo water control district and Georgina Wiso plan area



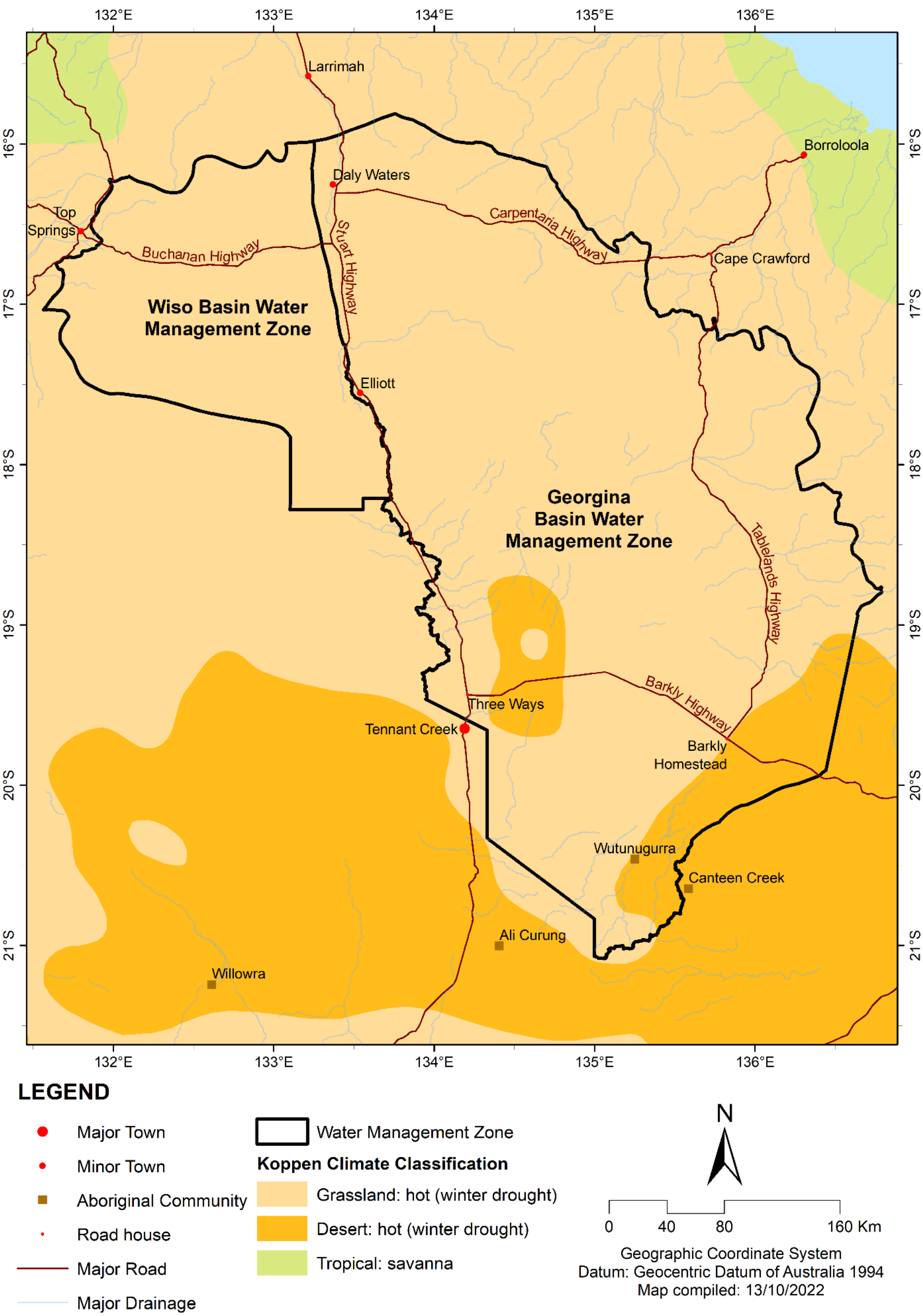
# Schedule D: Georgina Wiso water management zones



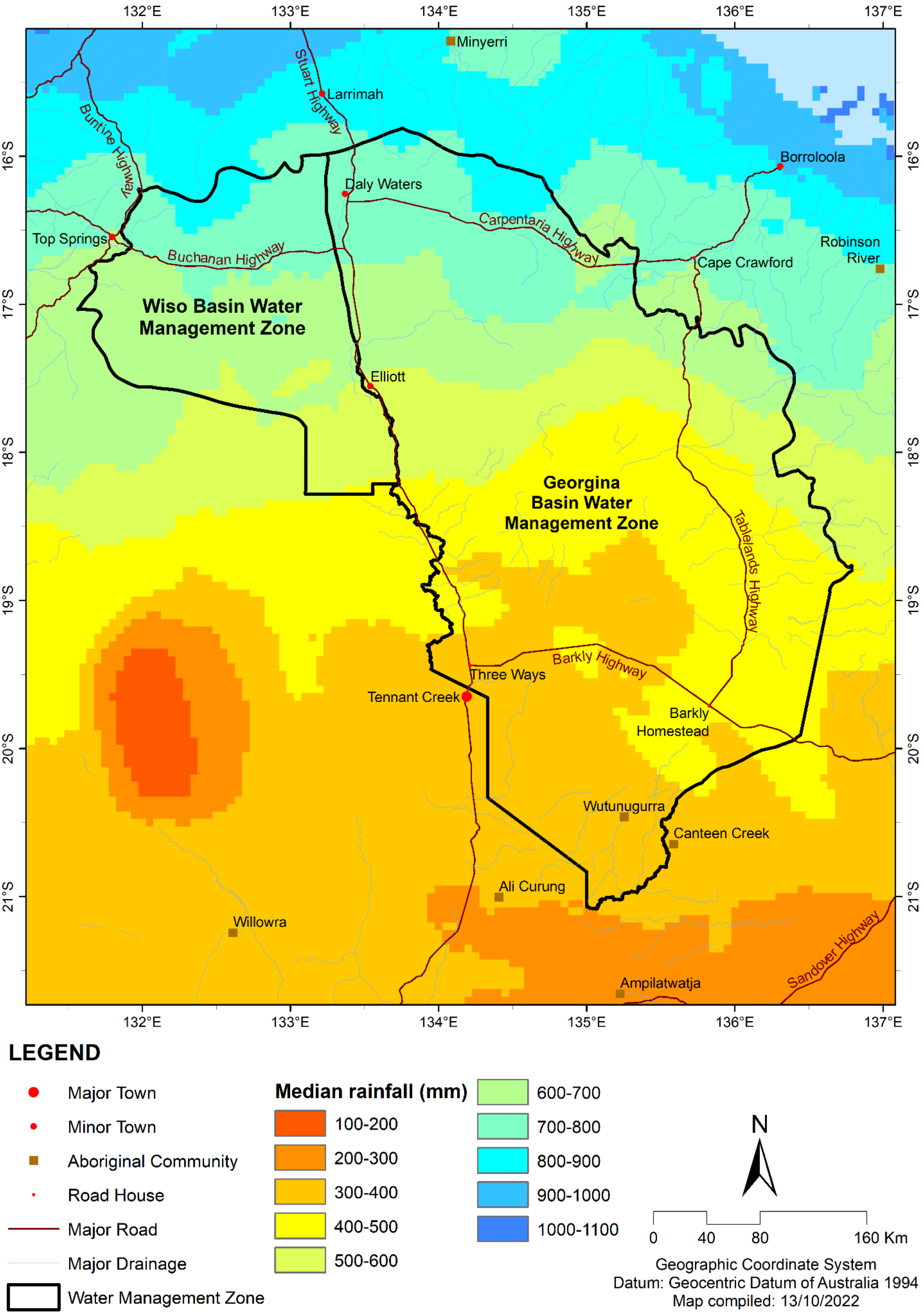
# Schedule E: Petroleum titles



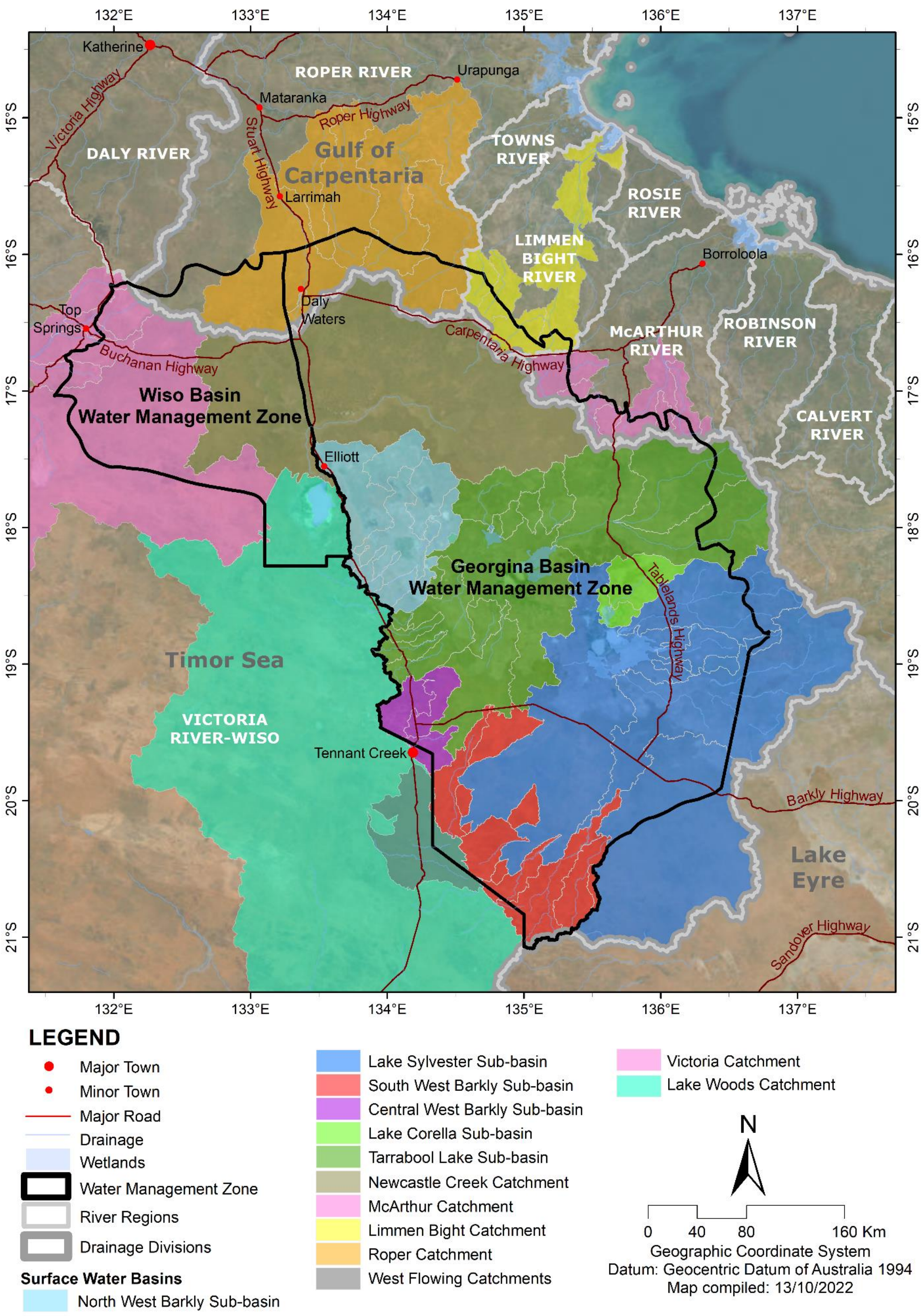
# Schedule F: Climate



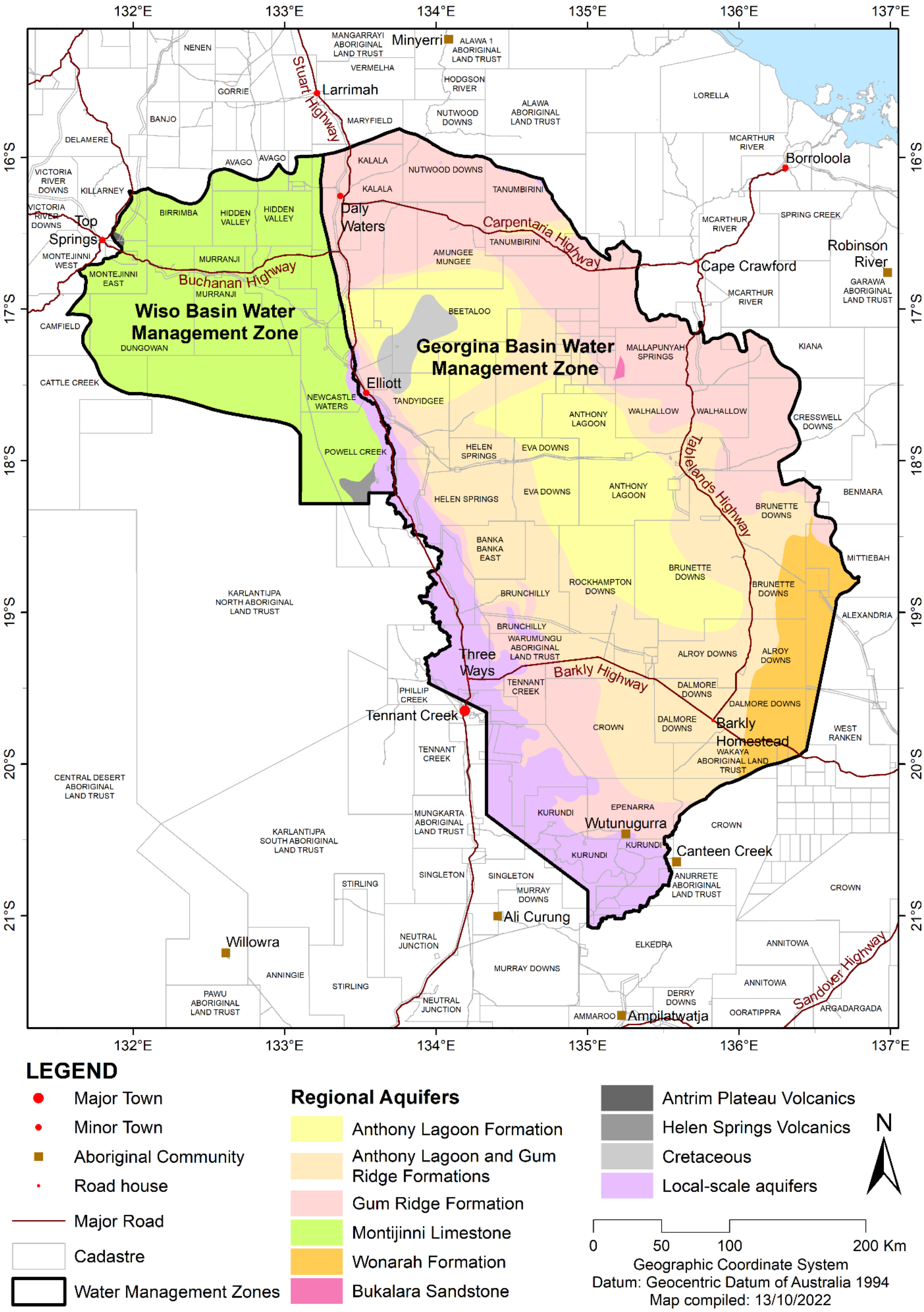
# Schedule G: Rainfall



# Schedule H: Surface water drainage divisions



# Schedule I: Hydrogeological provinces



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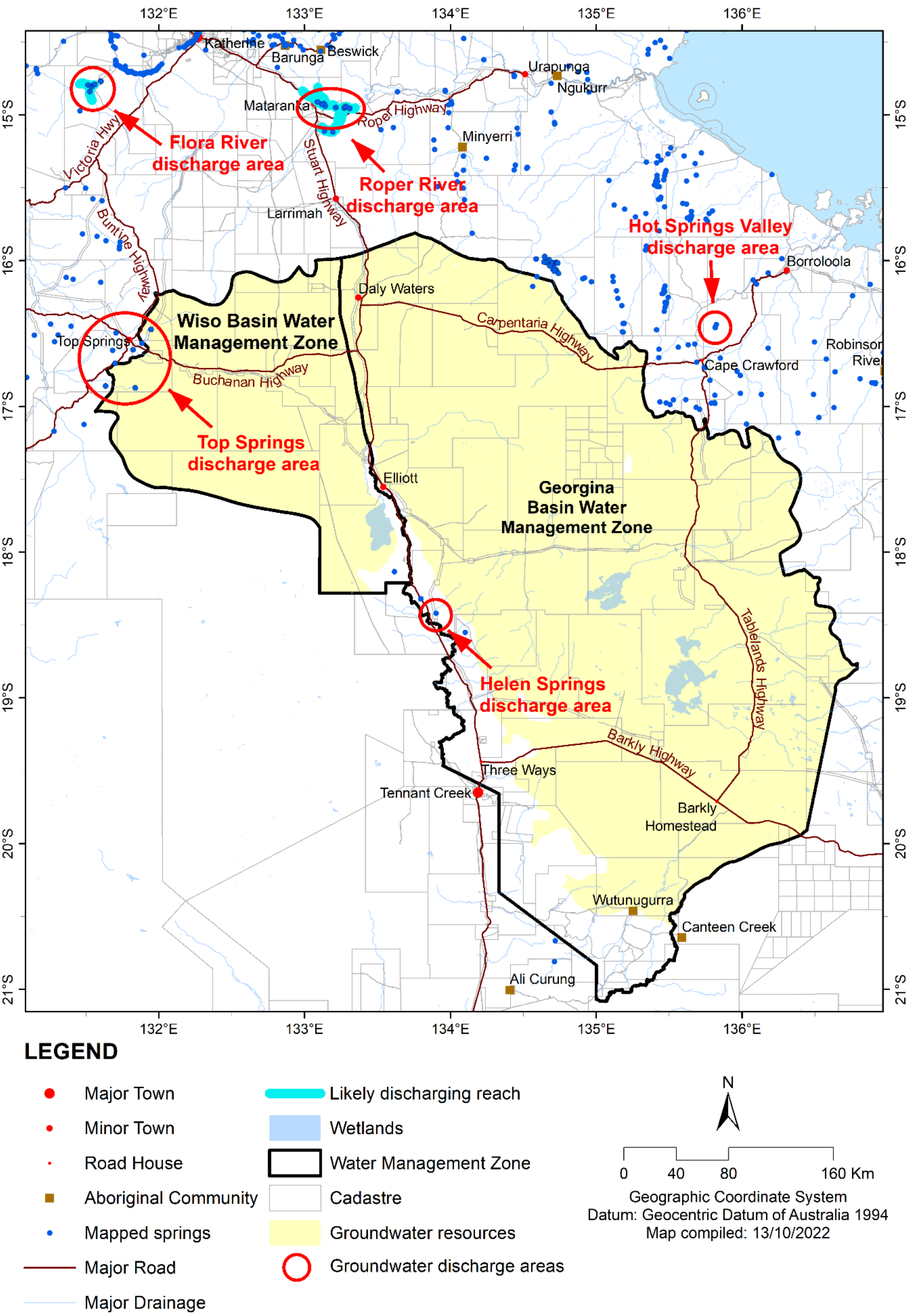

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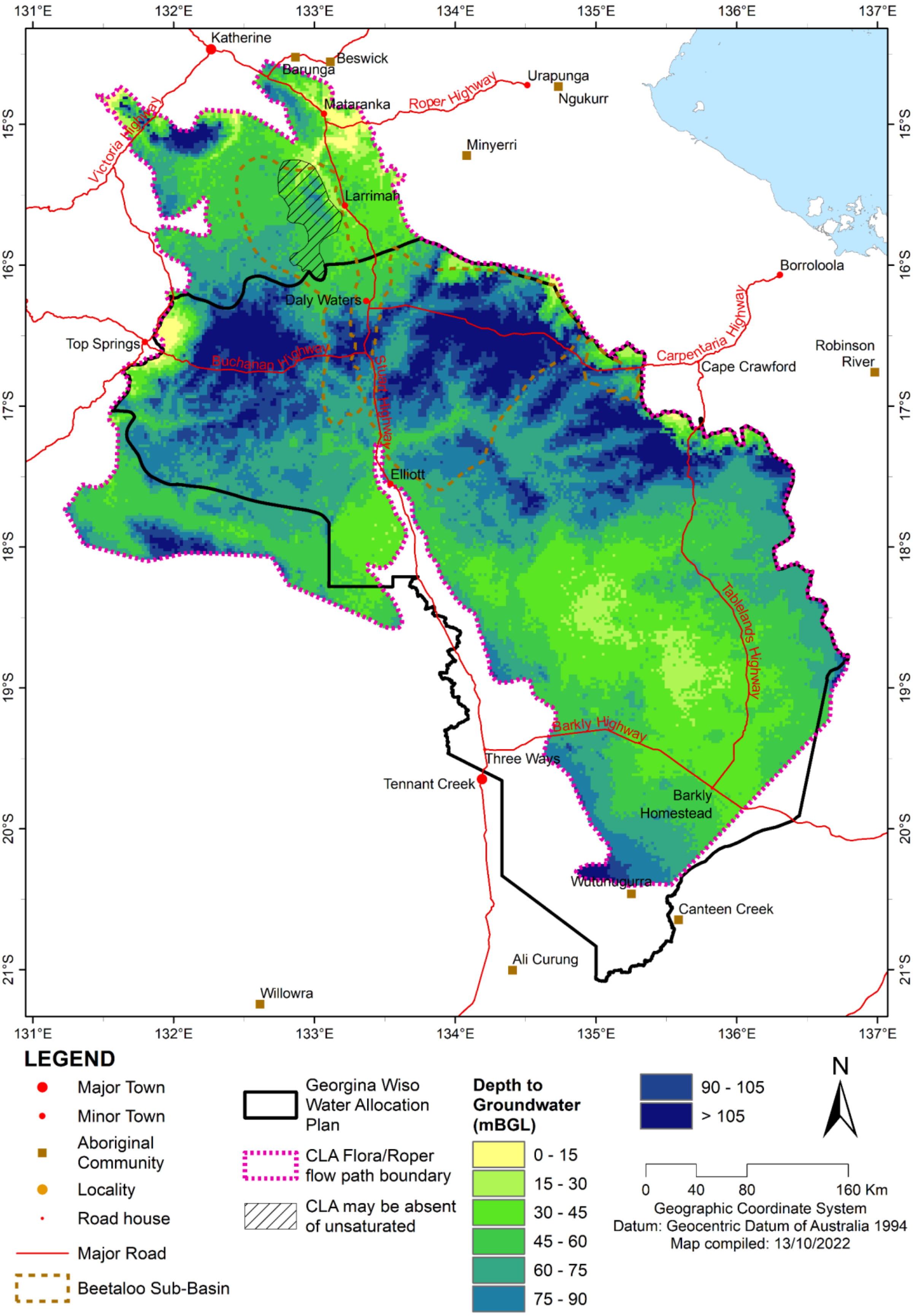
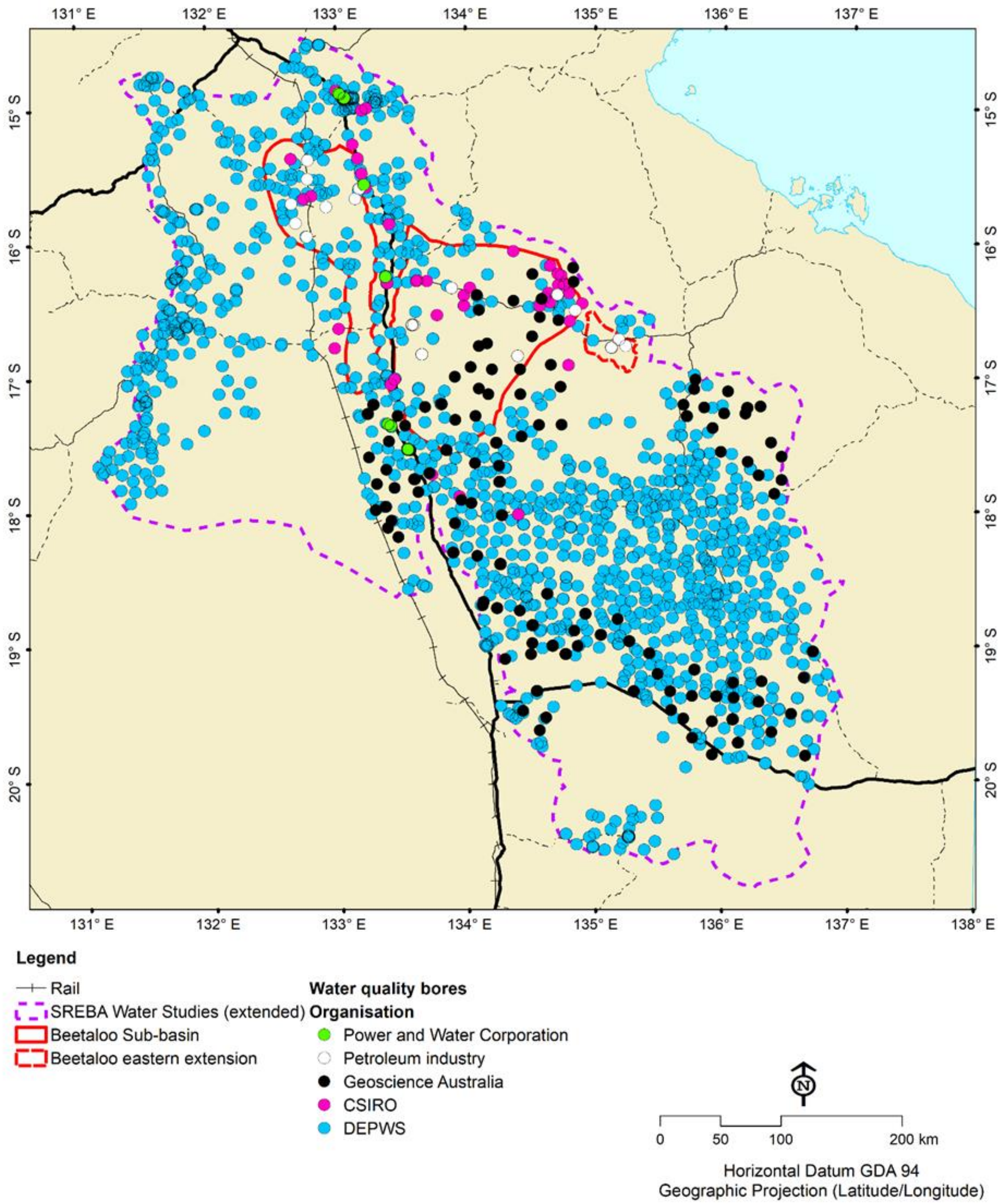
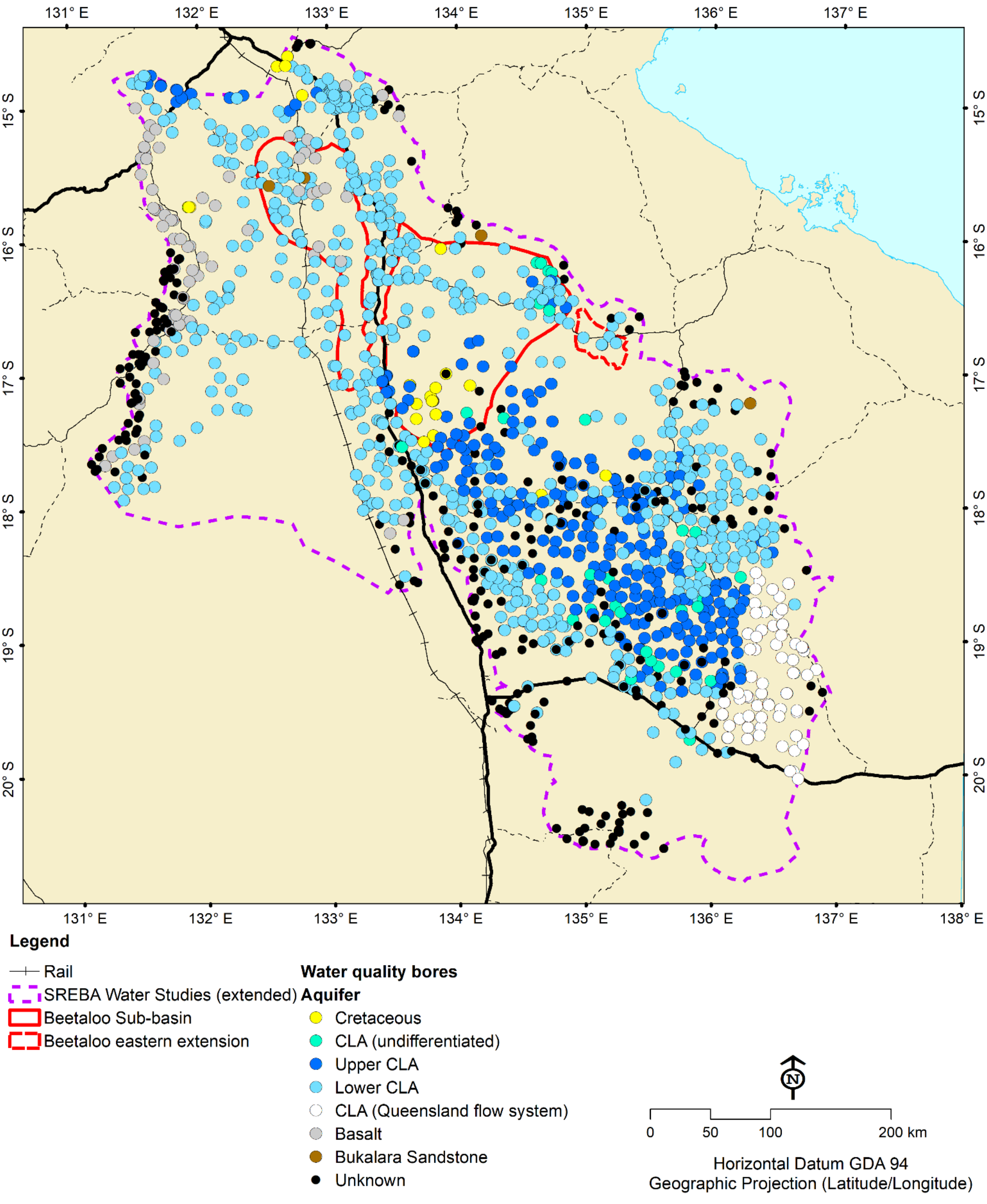
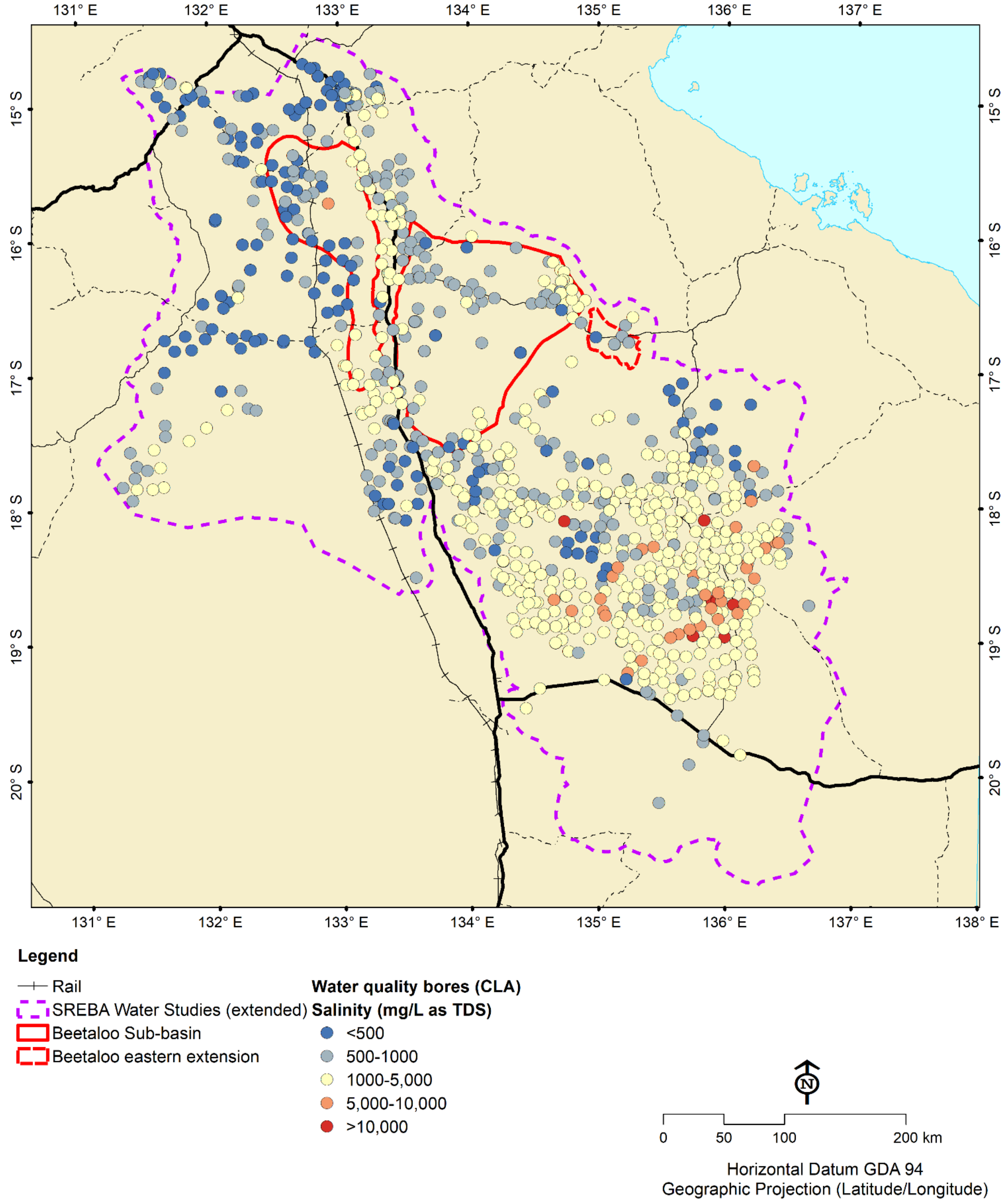


# Schedule L: Water quality bores: location and aquifer

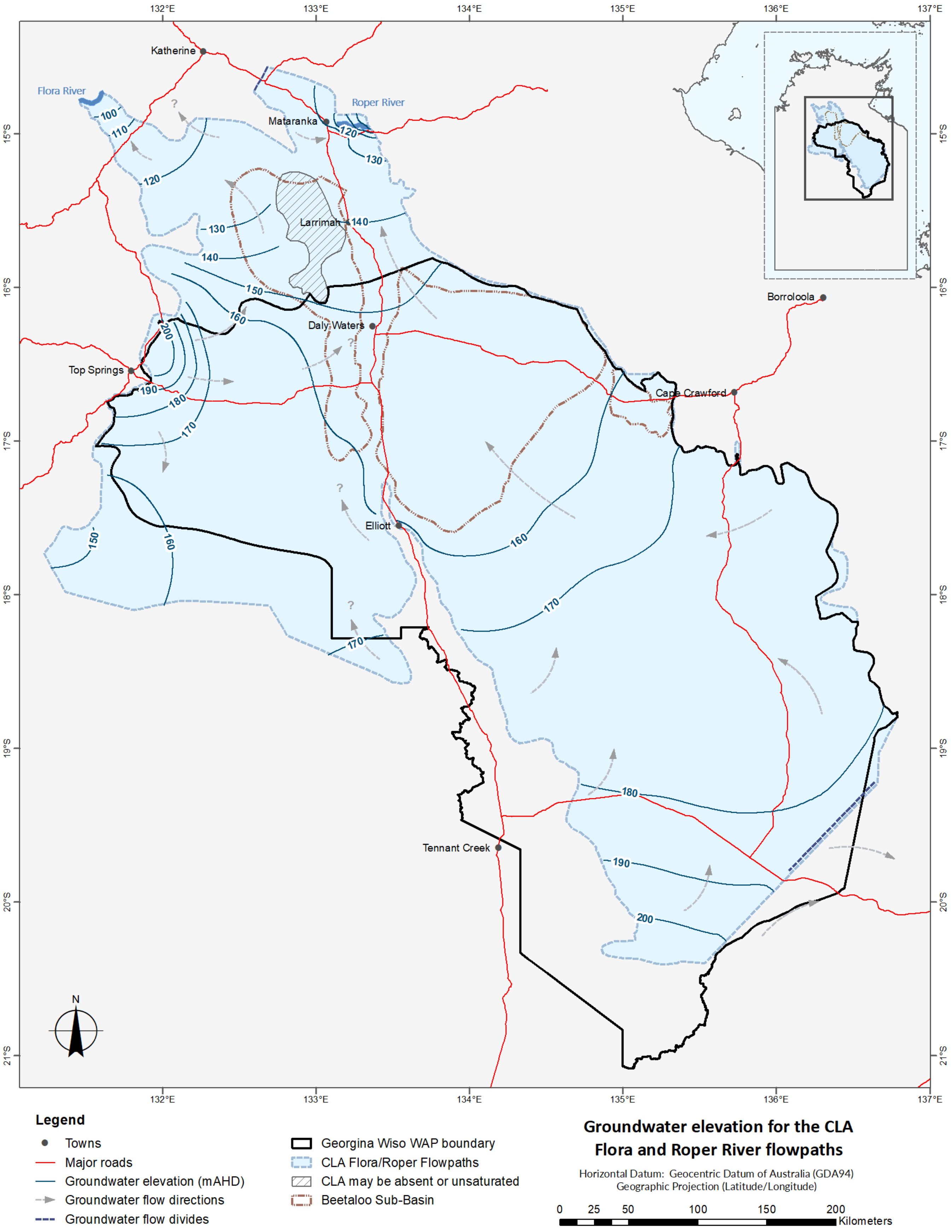



131° E
132° E
133° E
134° E
135° E
136° E
137° E
138° E
15° S
16° S
17° S
18° S
19° S
20° S
Legend
Rail
SREBA Water Studies (extended)
Beetaloo Sub-basin
Beetaloo eastern extension
Water quality bores
Aquifer
Cretaceous
CLA (undifferentiated)
Upper CLA
Lower CLA
CLA (Queensland flow system)
Basalt
Bukalara Sandstone
Unknown
N
0
50
100
200 km
Horizontal Datum GDA 94
Geographic Projection (Latitude/Longitude)

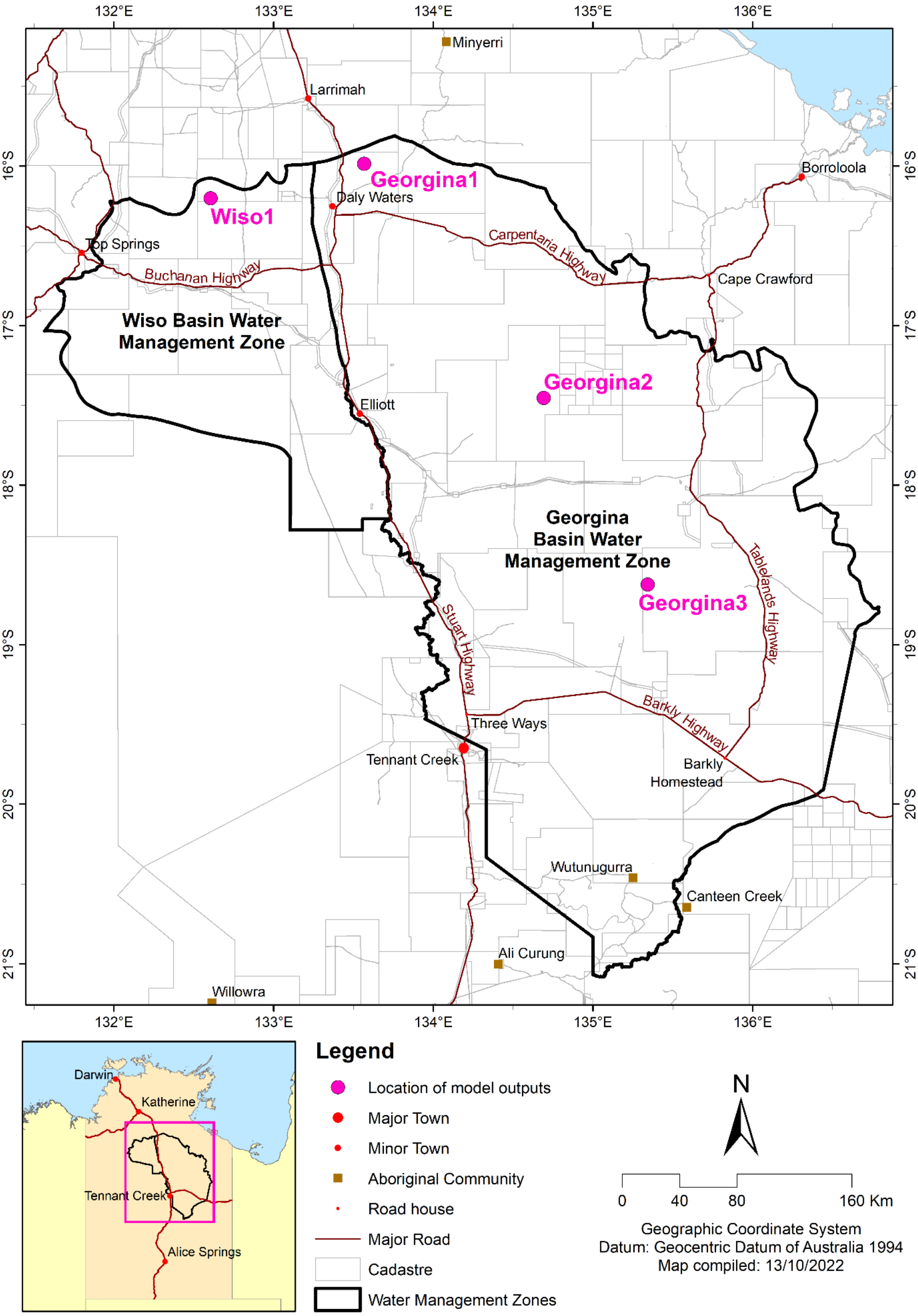
# Schedule M: Groundwater salinity



# Schedule N: Groundwater flow



# Schedule O: Model reporting nodes



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