DEPARTMENT OF **ENVIRONMENT AND NATURAL RESOURCES**

DRAFT
Ti Tree Water Allocation Plan 2019 - 2029

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NORTHERN TERRITORY GOVERNMENT

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Front page: Table grapes at the Territory Grape Farm

Photo: Stuart Smith

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Release for public consultation

The Ti Tree Water Allocation Plan 2019-2029 is a draft water allocation plan that has been released for public consultation for a six-week period closing on 20 May 2019.

A water advisory committee of community members, stakeholders and Traditional Owners has provided advice on the content of the draft plan. A dedicated webpage (see below) contains information about the Ti Tree Water Advisory Committee (TTWAC) and its meetings.

The Minister for Environment and Natural Resources is now seeking your input on the best way to manage waterways and groundwater in the Ti Tree Water Control District to protect what you value that is associated with these important water resources. Commenting on this draft water allocation plan is a good opportunity for you to influence the management of the water resource to maximise sustainable beneficial use.

If you represent a group of interested people, a representative of the Department of Environment and Natural Resources (DENR) can attend a meeting with your group to talk about the draft plan and your opportunity to make a submission. Please request a meeting using the email address listed below.

Community and stakeholders are invited to make a submission. To make a submission you can either:

- Fill in the online submission form available at: denr.nt.gov.au/open-for-consultation
- Post or email a submission to:

  Draft Ti Tree WAP Submission
  Water Resources Division
  Department of Environment and Natural Resources
  PO Box 496
  PALMERSTON NT 0831

  or waterresources@nt.gov.au

More information about the draft plan and the water resources of the Ti Tree Water Control District is available from: www.denr.nt.gov.au/titreewaterplan. The web page contains publications related to Ti Tree, a digital copy of the draft plan and information about upcoming engagement activities to seek input on the draft plan.

Your input on the draft plan will be appreciated. It is recognised that a fair commitment of time is required to read, consider and make a written submission on the draft plan. Contributions to the final plan will be recognised in a public consultation report, published online following declaration of a final plan by the Minister for Environment and Natural Resources.

Thank you for your contribution.

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Key points

- The Ti Tree Aquifer is comprised of two primary groundwater management zones (GMZ), as identified in this plan: the Southern GMZ (where demand is focused); and the Northern GMZ (less demand).
- A third zone, named the Low Yield GMZ is not described nor dealt with as a discrete aquifer, as it incorporates small low-yielding and disconnected fractured rock aquifers with limited commercial potential.
- The total estimated sustainable yield of the Ti Tree Aquifer is 15,840 ML/yr, of which 10,140 ML/yr is allocated for consumptive use. For non-consumptive use (to support environmental and cultural values), 5,700 ML/yr is allocated, reflecting the volume that should not be extracted.
- In the Northern GMZ, 80 ML/yr has been assigned to the consumptive pool based on meeting minimum essential requirements for public water supply and rural stock and domestic use. This allocation will protect sensitive environmental and cultural values which are dependent upon shallow groundwater.
- In the Southern GMZ, 7,240 ML/yr has been assigned to the consumptive pool based on 100 per cent of annual average recharge of the aquifer. This is to ensure the productive base of the resource is maintained and to reduce risks to groundwater dependent ecosystems and cultural values.
- The Low Yield GMZ is not considered suitable for most productive uses due to low permeability and transmissivity. However, 2,820 ML/yr has been assigned to the consumptive pool based on meeting expected demand for mining activity (mine pit dewatering) and rural stock and domestic use. Water in the Low Yield GMZ is allocated to the environment and to support cultural values.
- At January 2019, the sum of existing licensed and unlicensed water entitlements exceeded water allocations for consumptive use under this plan. However, there is a consistent pattern of under use of licensed entitlements in the Ti Tree Water Control District (TTWCD).
- Water can become available for new applicants through trade or return of unused water entitlements.
- This plan sets the guidelines for trading of water. Trading of water, including from a Strategic Aboriginal Water Reserve, can enable access to water for new developments.
- A Strategic Aboriginal Water Reserve (SWR) is established at plan commencement as a subclass of agriculture, industry, mining activity and petroleum activity beneficial uses. This will remain a notional (empty) reserve until water becomes available. Distribution of returned entitlements will be based on the established hierarchy of priority (public water supply and rural stock and domestic uses are prioritised) and may not immediately support provision to the SWR.
- Guidelines for protection of environmental and cultural values are established that propose limits to allowable change in groundwater levels in areas where groundwater dependent ecosystems are expected to occur.

Allocations in this plan to consumptive beneficial uses and the environment beneficial use are shown in Table 1, below.

Table 1. Allocations (ML/yr) in the ESY to beneficial uses[1]

Beneficial uses	Groundwater Management Zone			Total (ML/yr)
	Southern	Northern	Low Yield	
Public water supply	250	40	0	290
Rural stock and domestic	147	40	350	537
Other consumptive beneficial use pool	6,843	0	2,470	9,313
Notional allocation				
Agriculture	5,218	0	20	5,238
Industry	80	0	20	100
Mining activity	20	0	2,410	2,430
Petroleum activity	20	0	20	40
Subclass of other beneficial uses				
Strategic Aboriginal Water Reserve[2]	1,505	0	0	1,505
Total consumptive pool	**7,240**	**80**	**2,820**	**10,140**
Environment	2,350	2,250	1,100	5,700
Estimated sustainable yield	**9,590**	**2,330**	**3,920**	**15,840**

1 Beneficial uses for the Ti Tree Water Control District will be revoked and remade when this water allocation plan is declared, to provide for allocations to new Beneficial Uses, in line with recent changes to the *Water Act* 1992.

2 SWR is expected to be established as a Beneficial Use under the *Water Act* 1992 during the term of this plan. In the interim, the plan establishes SWR as a subclass of water allocated for agriculture, mining activity, petroleum activity and industry beneficial uses.

Summary

Water allocation plans are established under section 22B of the *Water Act* 1992, which states (in part) that water resource management in a water control district is to be in accordance with the water allocation plan declared in respect of the district.

The Draft Ti Tree Water Allocation Plan 2019-2029 applies to all surface water and groundwater within the Ti Tree Water Control District (TTWCD). It establishes an adaptive management framework for the allocation of water resources and the regulation of licensed water use. Its purpose is to ensure water resources are managed in a way that recognises and maintains environmental and cultural values while allowing water to be sustainably used for productive consumptive beneficial uses.

This plan's principal objectives are to:

- Avoid detrimental impacts to water dependent ecosystems as a consequence of consumptive water use.
- Avoid negative impacts to cultural values of places reliant upon surface or groundwater as a consequence of consumptive water use.
- Secure domestic and public water supply for current and future population.
- Ensure fair access to water for economic activities for current users and future generations.
- Enhance opportunities for Aboriginal people to benefit from consumptive use and management of water.

This plan draws upon new and innovative research methodologies to identify water requirements and distribution of groundwater dependent ecosystems. This plan aims to protect cultural sites and water dependent ecosystems by establishing guidelines that seek to ensure water extraction will not impact detrimentally on environmental and cultural assets and values. In practice this means that the potential impact of proposed extraction on cultural and environmental sites will be assessed through modelling, and licences may not be granted if unacceptable impacts are predicted.

The estimated sustainable yield (ESY) is based on 100% of recharge into the Southern GMZ and 10% of recharge from the Northern GMZ and Low Yield GMZ. In accordance with sections 22B(5)(a) and (6) of the *Water Act* 1992, an allocation is made from within the ESY to the environment. Allocations of water for public water supply and rural stock and domestic uses are prioritised and provisioned before other consumptive uses. The largest portion of the consumptive pool is allocated to agriculture, and a small allocation is made for mining activity.

Previous Ti Tree water allocation plans (the Ti Tree Region Water Allocation Plan 2009 and the Ti Tree Region Water Resource Strategy 2002) allowed for (in theory) the productive base of the Ti Tree Aquifer to be depleted over time. Notwithstanding this, historical water use has never exceeded the average annual recharge.

This plan sets guidelines for trading of water. Trading of water can enable access to water for new developments.

In accordance with the Northern Territory Government *Strategic Aboriginal Water Reserves Policy Framework* (October 2017), an SWR is established in this plan, to enable future opportunities for eligible Aboriginal rights holders, in this case the Anmatyerr tyerrty (people), to access water for commercial use or trade. The SWR will be a notional (empty) reserve at plan commencement. The SWR can only contain water within the plan period if the current volume of licensed entitlements is reduced.

Water may be returned to the consumptive pool through the return of unused licence entitlements, which aims to return unused water for economic development.

Management strategies, performance indicators and a monitoring matrix are provided to guide implementation and assess the effectiveness of this plan. Research priorities to improve scientific knowledge of the water resources in the TTWCD are indicated.

In accordance with the *Water Act* 1992, this plan must be reviewed at intervals not longer than five years and is made for a period not longer than ten years.

1 Introduction

1.1 Title

This is the Draft Ti Tree Water Allocation Plan 2019-2029.

1.2 Plan area

Figure 1 shows the location and extent of the Ti Tree Water Control District (TTWCD) in the Northern Territory. Alice Springs is 200 km south of the District and Darwin is 1,300 km north.

The TTWCD is over 14,000 square kilometres and includes all of the Ti Tree Aquifer and its surface water catchments. The Ti Tree Water Allocation Plan area is equivalent to the TTWCD.

The TTWCD's population of around 2,000 is well dispersed over its area, in small communities and outstations including: Ti Tree, Nturiya, Pmara Jutunta, Wilora, Alyuen, Adelaide Bore and Mulga Bore (Angula); on irrigation farms including Ti Tree Farms and Territory Table Grapes; at Aileron, Pine Hill, Woodgreen and Stirling Station pastoral properties; and on the Ahakeye Aboriginal Land Trust.

1.3 Date of effect

This plan takes effect as declared by the Minister for Environment and Natural Resources by notice in the Northern Territory Government *Gazette*.

1.4 Period of effect

The Northern Territory's water management framework is established by the *Water Act* 1992. This plan has a maximum life of ten years and must be reviewed in intervals no longer than five years. The review is a formal process that ensures that a water allocation plan meets the needs of beneficial uses into the future, within the sustainable yield.

The objective of a five-yearly review is to determine if:

- Knowledge assumptions on which the plan is based (e.g. as a result of implementation of research identified under the plan) have changed.
- The strategies in the plan have been effective in achieving the plan's objectives.

A water allocation plan can only be in effect for 10 years. This invites a fundamental rethink of the desired outcomes and objectives of the plan, in particular the balance between economic uses and risks to environmental and cultural assets and the social equity of how benefits and costs associated with the resource are shared.

The development of a new water allocation plan will include:

- a review of progress in achieving original objectives and outcomes;
- renewed community consultation and input;
- incorporation of new information and research;
- review of modelling and subsequent review of the estimated sustainable yield;
- review of current gaps in understanding, to inform updated monitoring and research; and
- priorities for the next five years (a new implementation plan).

1.5 Plan context

The Northern Territory Government has committed to the long-term sustainable management of the Territory's water resources.

This plan is entirely new. It follows the Ti Tree Region Water Resource Strategy (DIPE, 2002) and the Ti Tree Region Water Allocation Plan (NRETAS, 2009) (a revision of the 2002 strategy). The consumptive uses of water and the environmental and cultural assets supported by water in the Ti Tree region, as described in the 2002 strategy and the 2009 plan, remain relevant for this plan.

The Central Anmatyerr people of Central Australia (Anmatyerr tyerrty) continue to maintain a close association with the country of their ancestors, including the District, as they have for millennia. While it is recognised that Anmatyerr tyerrty relationships with country and water have not changed, a significant research project undertaken through Land and Water Australia by Rea (2008) described the cultural and economic significance of water to Anmatyerr tyerrty and provided various insights that are considered in this plan.

The significance of environmental assets in the District was further acknowledged in 2014 through the establishment of the Woodgreen Conservation Reserve. This reserve features a significant portion of the Burt Bioregion, which is not represented elsewhere in the Northern Territory reserve system. This plan continues to recognise other water dependent environmental assets, such as wetlands, waterways and groundwater dependent ecosystems that occur within the plan area but outside of reserves.

Section 4.1 provides further information regarding water requirements for cultural and environmental values in the TTWCD.

With respect to consumptive water uses there remains ongoing demand for water for public water supply and rural stock and domestic uses, including from Ti Tree, Nturiya, Pmara Jutunta, Wilora, Alyuen, and Mulga Bore and Angula communities.

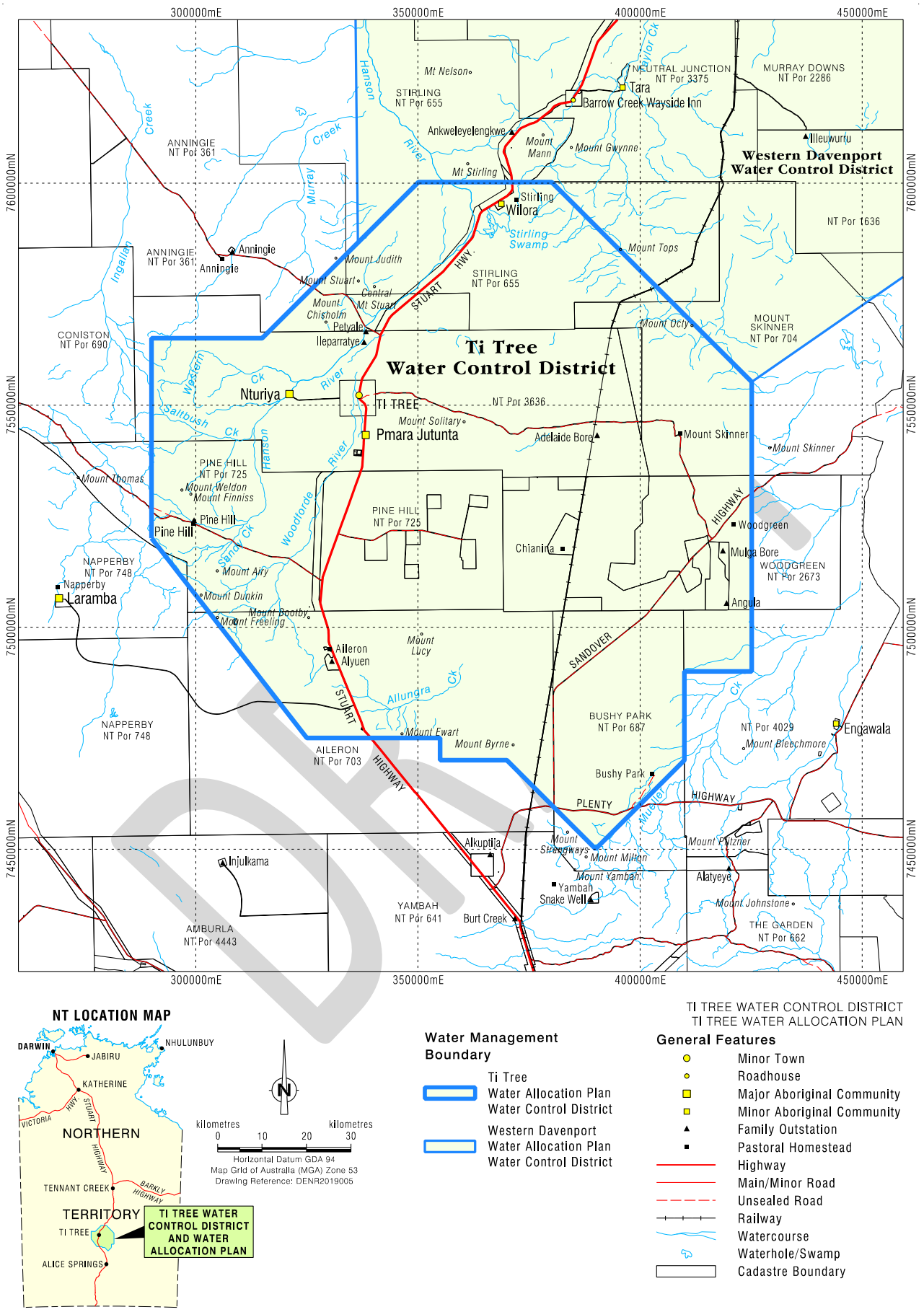


Figure 1. Ti Tree Water Allocation Plan Area and Water Control District

1.5.1 Legislative Framework

Section 22B of the *Water Act* 1992 provides for a water allocation plan to be declared for a water control district, to provide for the management of its water resources. The WAP is to ensure that water is allocated to beneficial uses within the estimated sustainable yield, licensing and trading guidelines and cost-recovery. The *Water Act* 1992 mandates an allocation of water to the environment.

The beneficial uses described in section 4(3) of the *Water Act* 1992 are listed in Table 2.

Table 2. Beneficial uses under the *Water Act* 1992

Non-consumptive
Environment
Cultural

Consumptive
Public water supply
Rural stock and domestic
Agriculture
Aquaculture
Mining activity
Petroleum activity
Industry
Cultural

1.5.2 Water allocation plans

Water allocation plans are statutory documents which take their legal force from the *Water Act* 1992, which remains the main source of legal rights and obligations affecting water resource management in the Northern Territory. Although this plan contains summaries of the effect of certain provisions of the Act, those summaries are provided for information only. The plan should be read in conjunction with the Act, and will be subject to any amendments which may be made to the Act after commencement.

Water allocation plans establish a framework to share water between human and environmental needs. Water resource management in a water allocation planning area is to be in accordance with such a plan. A plan is declared to ensure that water is allocated within the estimated sustainable yield to beneficial uses, as defined in section 4(3) of the *Water Act* 1992. The beneficial uses of water defined in the Act include agriculture, public water supply, the environment, cultural, mining activity, petroleum activity, industry, aquaculture and to provide water for rural stock and domestic purposes.

1.5.3 NT Water Allocation Planning Framework

The Northern Territory Government's *Northern Territory Water Allocation Planning Framework* (NT Government 2000) establishes the principles for water allocation decisions. This is reproduced in part below, insofar as it relates to the arid zone.

> *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.*
>
> *In the absence of directly-related research, contingent allocations are made for environmental and other public benefit water provisions and consumptive use. These are explained below.*
>
> …
>
> *Within the Arid Zone (southern two thirds of the Northern Territory):*
>
> ***Rivers***
>
> *At least 95 per cent of flow at any time in any part of a river is allocated as environmental and other public benefit water provision, and extraction for consumptive uses will not exceed the threshold level equivalent to five per cent of flow at any time in any part of a river.*
>
> *In the event that current and/ or projected consumptive use exceeds the threshold levels of five per cent for river flow, new surface water Licences will not be granted unless supported by directly-related scientific research into environmental and other public benefit requirements.*
>
> ***Aquifers***
>
> *There will be no deleterious change in groundwater discharges to dependent ecosystems, and total extraction over a period of at least 100 years will not exceed 80 per cent of the total aquifer storage at start of extraction.*
>
> *In the event that current and/ or projected consumptive use exceeds the threshold levels of 80 per cent of the consumptive pool for aquifers, or groundwater discharges to groundwater dependent ecosystems are impacted, new groundwater Licences will not be granted unless supported by directly-related scientific research into groundwater dependent ecosystem/cultural requirements.*

The *NT Water Allocation Planning Framework* states that allocations (extraction) should not exceed 80 per cent of total available storage.

1.6 Plan development pathway

Water allocation plans are developed through a detailed technical and scientific assessment, and community consultation to determine an appropriate balance between competing uses for water.

The following steps (Figure 2) were taken in developing this plan.

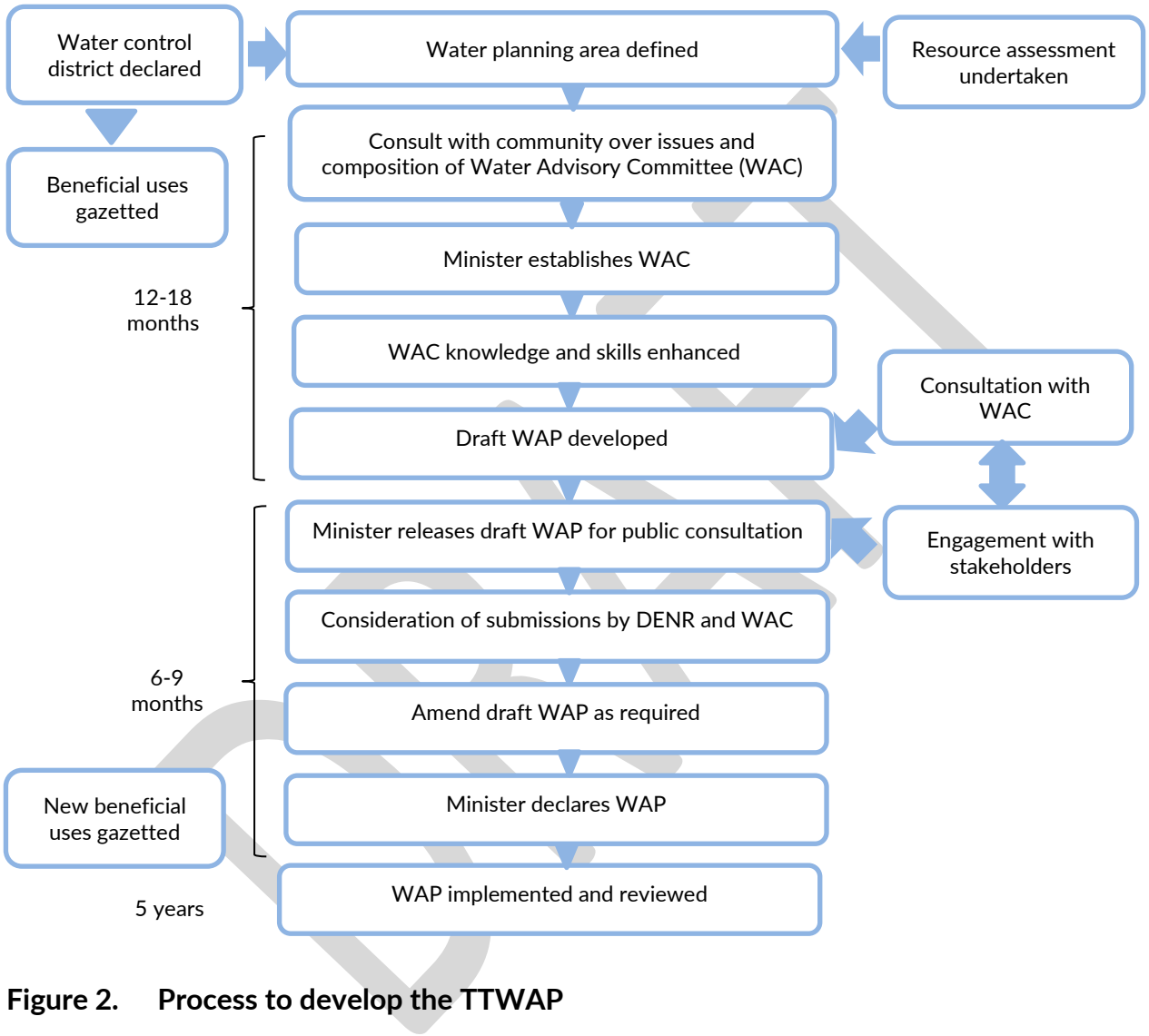


Figure 2. Process to develop the TTWAP

Schedule A outlines the stakeholder engagement and community consultation that has occurred in the development of this plan. During participation, stakeholders were informed of the scope of their participation and the level of influence or control they had over planning outcomes.

N.B.: Schedule A will be added to the final plan (when consultation is completed) and is not included in this draft.

2 Purpose and objectives

The purpose of this plan is to ensure water resources in the TTWCD are managed in a manner that protects and maintains environmental and cultural values while providing a sustainable volume of water for consumptive beneficial use. The objectives (below) support and provide further detail to this plan's purpose. The objectives also form the basis of the water management arrangements detailed in Section 6.

1. Avoid detrimental impacts to water dependent ecosystems as a consequence of consumptive water use.
2. Avoid negative impacts to the cultural values of places reliant upon surface or groundwater as a consequence of consumptive water use.
3. Provide water of suitable quality is available for domestic and public water supplies in perpetuity.
4. Enable fair access to water for economic activities for current potential users and future generations.
5. Enhance opportunities for Aboriginal people to benefit from consumptive use and management of water.

2.1 Beneficial uses

The proposed beneficial uses[3] for waters in the TTWCD, as per section 4(3) of the *Water Act* 1992, are listed in Table 3, below. Beneficial uses are declared by the Administrator by notice in the *Gazette*.

Table 3. Ti Tree Water Control District – beneficial uses

GMZ/area specified	Beneficial uses	
	Non-consumptive	Consumptive
Surface water		
Waterways in all zones	environment and cultural	rural stock and domestic
Groundwater		
Southern GMZ	environment and cultural	public water supply, aquaculture, agriculture, industry, petroleum activity, mining activity and rural stock and domestic
Northern GMZ	environment and cultural	public water supply, aquaculture, agriculture, industry, petroleum activity, mining activity and rural stock and domestic
Low Yield GMZ	environment and cultural	public water supply, aquaculture, agriculture, industry, petroleum activity, mining activity and rural stock and domestic

[3] At plan commencement, the NT Government has proposed amendments to the *Water Act* 1992 to create a new beneficial use of Strategic Aboriginal Water Reserve. (In this plan, this is currently captured as a subclass of other consumptive beneficial uses).

3 Water resources (availability and condition)

3.1 Climate and rainfall

Information on climate and rainfall used in this plan has been sourced from the Australian Bureau of Meteorology.

The TTWCD falls within the 'hot dry summer, mild winter' climatic zone. The average July and December maximum temperatures are 23°C and 38°C respectively, with minimums of 8°C and 24°C.

The average annual rainfall is around 300 mm, with high variability. A continuous record of daily rainfall is available for several locations across the District including:

- Aileron Station between 1949 and 2002
- Stirling Station between 1965 and 2002
- Woodgreen Station between 1946 and 1973, and between 1998 and 2003.

The average annual rainfall at Aileron is 288 mm, 335 mm at Stirling Station and 246 mm at Woodgreen Station (all figures are approximate).

Monthly total rainfalls of around 100 mm or more are of specific interest as there is a strong correlation between this threshold being reached and regional rivers flowing. Over the 118 years between 1900 and 2017, records indicate that 65 years had at least one month in which the 100 mm monthly threshold was reached or exceeded. In the past 20 years of recorded flow there have been 30 significant flow events and 24 instances where this monthly rainfall threshold has been met or exceeded.

The rainfall and groundwater recharge relationship for the main aquifer varies across the landscape and is dependent on a complex relationship involving the landforms, geology and soil conditions at each location. However, correlation of monitoring bore data (RN005507) and rainfall over the bore's monitored period suggests that a groundwater recharge response occurs after at least 600 to 700 mm of rainfall in a season (Figure 3).

Figure 4 shows rainfall and recharge events for the past 118 years.

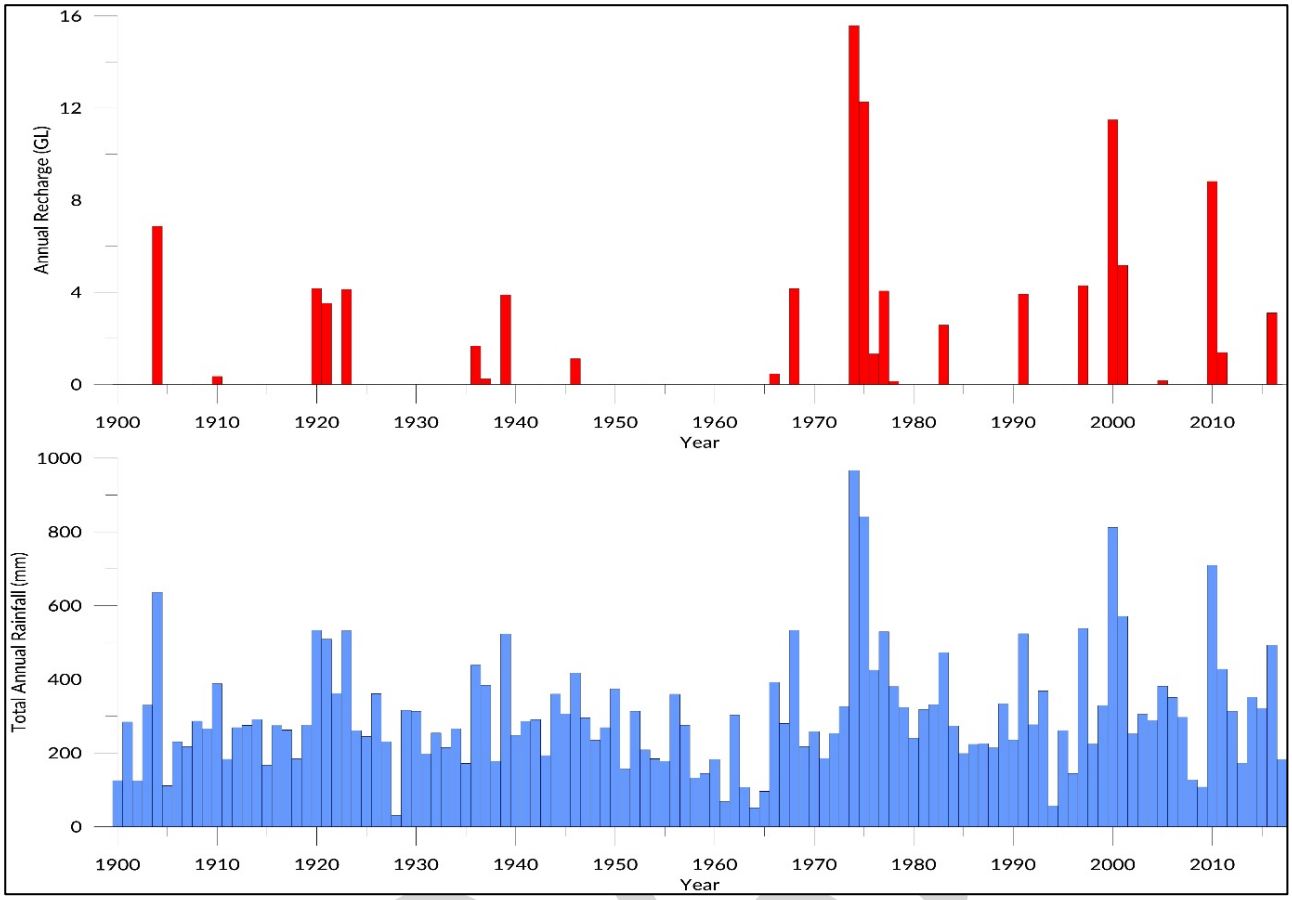


Figure 3. Rainfall and groundwater recharge

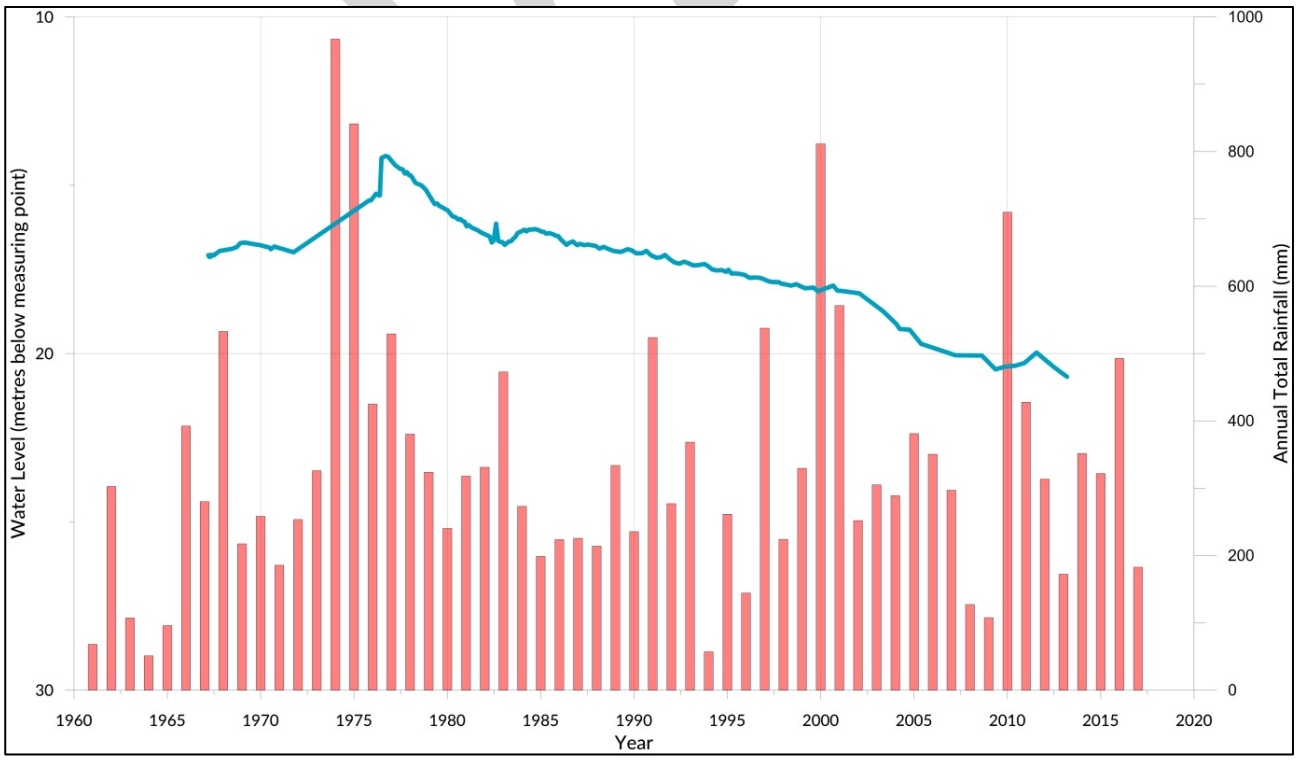


Figure 4. Relationship between monitoring bore data (RN005507) and rainfall

3.2 Surface water resources

The TTWCD contains several creeks with associated flood outs that are an important source of recharge for the Ti Tree Aquifer. However, with the exception of Anna's Reservoir, most natural surface water bodies in the plan area are relatively short lasting (weeks to months) after rains, and creek flows are not a reliable source of water for consumptive use.

The potential evapotranspiration is approximately 3600 mm annually. It exceeds rainfall by a factor of four in the winter months and more than a factor of ten during summer months. This suggests that open water storages would not be an efficient way of storing water in the longer term.

The TTWCD contains much of the Hanson River catchment south of Mount Stirling (located northwest of Wilora). Its largest tributary is the Woodforde River, which flows across the western part of the Ti Tree Aquifer. Water monitoring data shows the Woodforde River flowed 18 out of 22 years from 1997 to 2017. The gauging station for Allungra Creek (G0280004), situated at Allungra Waterhole, has been recording river levels intermittently since 1996. Assessment of flows in Allungra Creek is limited by data quality issues – only the data records from 2002 to 2007, and 2010 to 2017 are suitable for analysis. Still, the collected data shows flows in at least twelve out of the fifteen years (Figure 5).

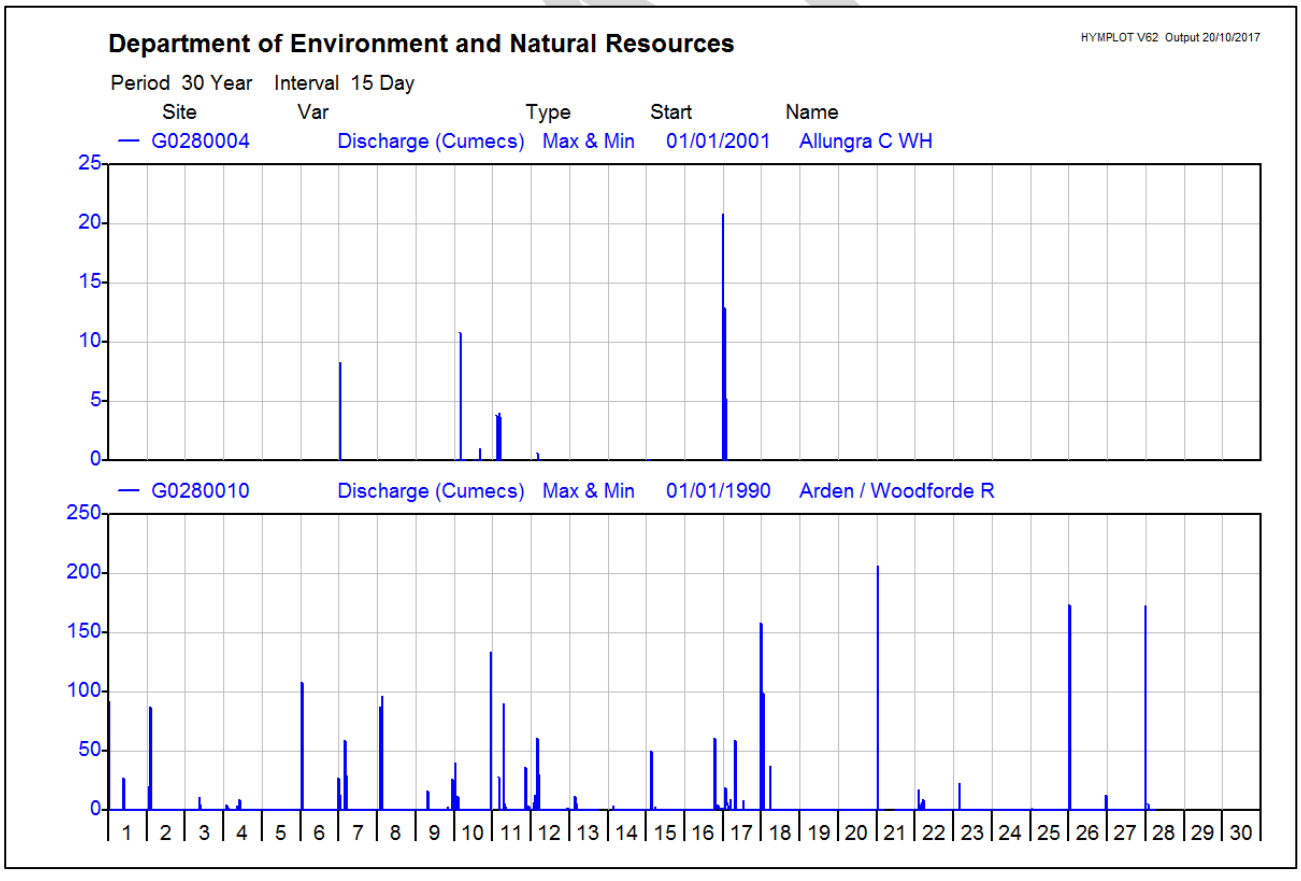


Figure 5. Recorded flows in Allungra Creek (top) and the Woodforde River (bottom)

There are several ephemeral surface water bodies in the region. Stirling Swamp, located north of the Ti Tree Basin, is a large complex of ephemeral wetlands with areas of bare claypan, lignum swamp, semi-saline samphire and temporary open water. Stirling Swamp collects flood overflow from the Hanson River to the west and run-off from uplands to the east. Anna's Reservoir is a long lasting natural rock hole on Wickstead Creek in the south-western part of the TTWCD. Allungra Waterhole is non-permanent waterhole on Allungra Creek in the central/southern part of the TTWCD.

3.3 Groundwater resources

The Ti Tree Aquifer is one of the best studied systems in the world. It is part of TERN, Australia's land ecosystem observatory program to observe, record and measure critical terrestrial ecosystem parameters and conditions for Australia over time from continental scale to field sites at hundreds of representative locations. This information is standardised, integrated and transformed into model-ready data, enabling researchers to discern and interpret changes in land ecosystems. Work commenced in 2010 at Ti Tree, including groundwater observations and interactions with terrestrial flora.

The plan area is divided into three GMZs: the Northern GMZ and Southern GMZ constitute the Ti Tree Aquifer and Basin boundary and the Low Yield GMZ refers to all other areas. A map of GMZs is at Figure 6.

The boundary of the Ti Tree Basin outlines the extent of potential water-bearing sediments and rocks in the region, mainly sandstone but also siltstone, claystone and brown coal. The main Ti Tree Aquifer is represented by the saturated sandier sediments of old river deposits which are believed to be largely continuous across the basin to a depth of approximately 40 to 50 metres. The rate at which the Ti Tree Aquifer delivers water to bores varies with some areas experiencing moderately high yields of 5 to 15 litres per second.

Low-yielding bores will occur in the less sandy sediments of the Basin as bore yields vary according to the amount of clay and silt in the sand, and the thickness of the aquifer. These low-yielding bores will not provide sufficient yield for irrigation or public water supply. Further, minor aquifers of limited extent and thickness may occur beneath the main aquifer to about 100 m but they are of limited extent and thickness.

Figure 7 shows a geological cross-section of the Ti Tree Basin including the location of the Ti Tree Aquifer in relation to the two main sedimentary layers. The location of this cross-section A-B in the Ti Tree Basin is indicated on the map in Figure 6.

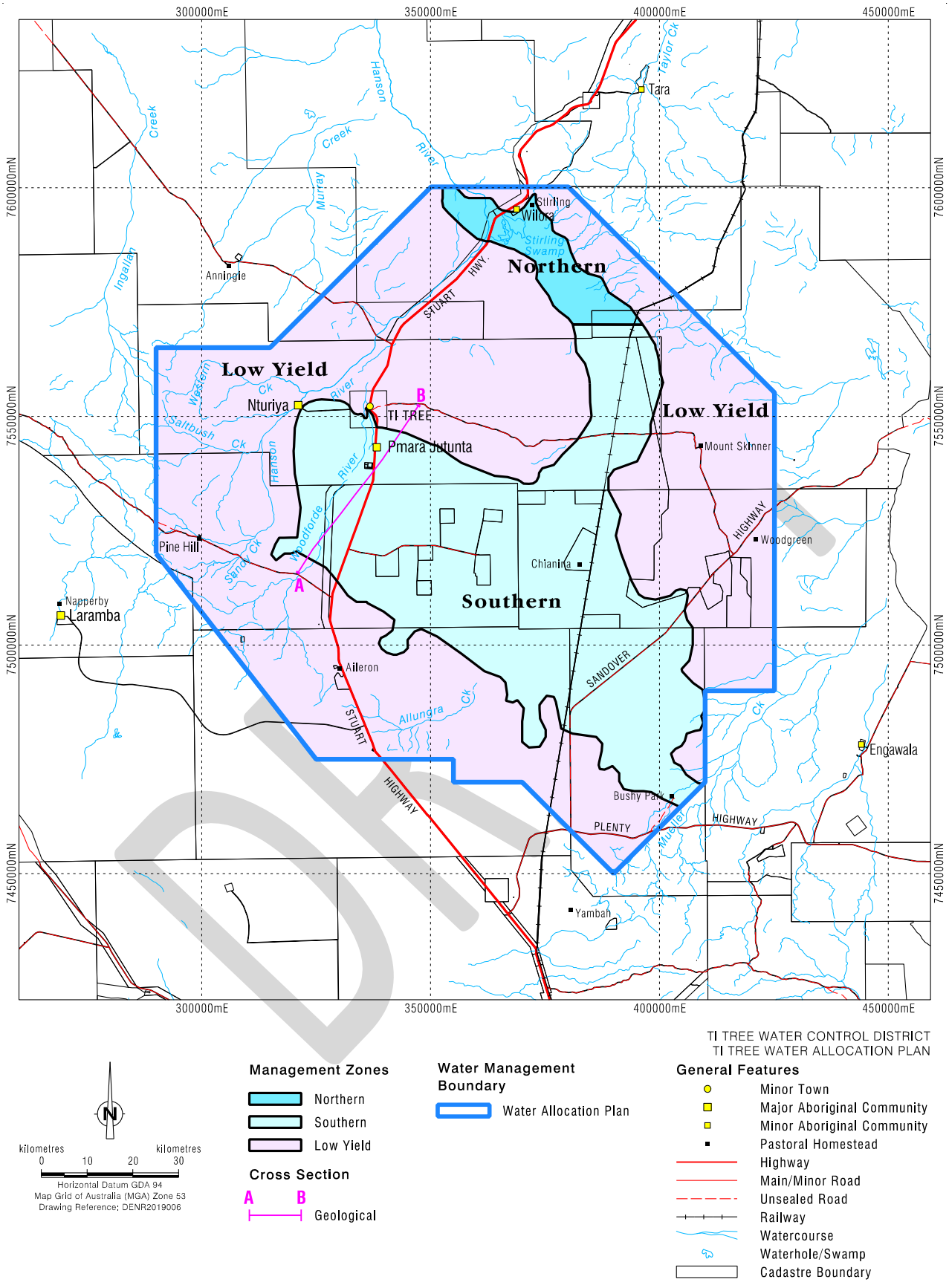


Figure 6. Groundwater management zones

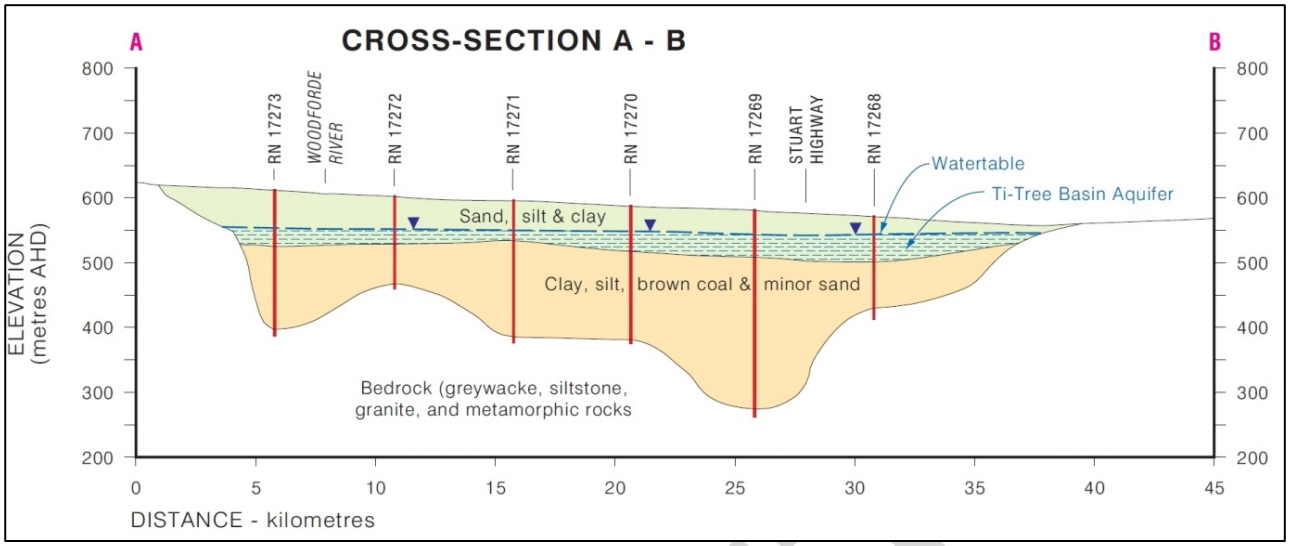


Figure 7. Geological cross-section of the Ti Tree Aquifer

Groundwater in the Ti Tree Aquifer is represented relative to sea level. Water levels are higher in the southern parts of the Ti Tree Basin and lower in the northern parts, causing water to generally flow from south to north. Depth below ground level to the water table also varies; the water table lies less than 10 m below ground level in the northern parts of the Ti Tree Aquifer, and up to 60 m below ground level in the southern parts.

The map at Figure 6 also shows the extent of the Ti Tree Aquifer (as defined by the Southern and Northern GMZ boundaries) and Figure 8 overleaf shows depth to groundwater (below ground surface).

Bedrock comprising greywacke, siltstone, granite and metamorphic rocks occurs outside of the Ti Tree Basin in the Low Yield GMZ and also outcrops within the basin (particularly in the east). Aquifers in this surrounding environment are developed in faults and structural features and are generally low-yielding and not widespread.

Wischusen et al. (2012) reported that the Ti Tree Basin is some 300 m in depth with groundwater resources within sandy sediments at its base. However, little is known of the quality and quantity of this groundwater.

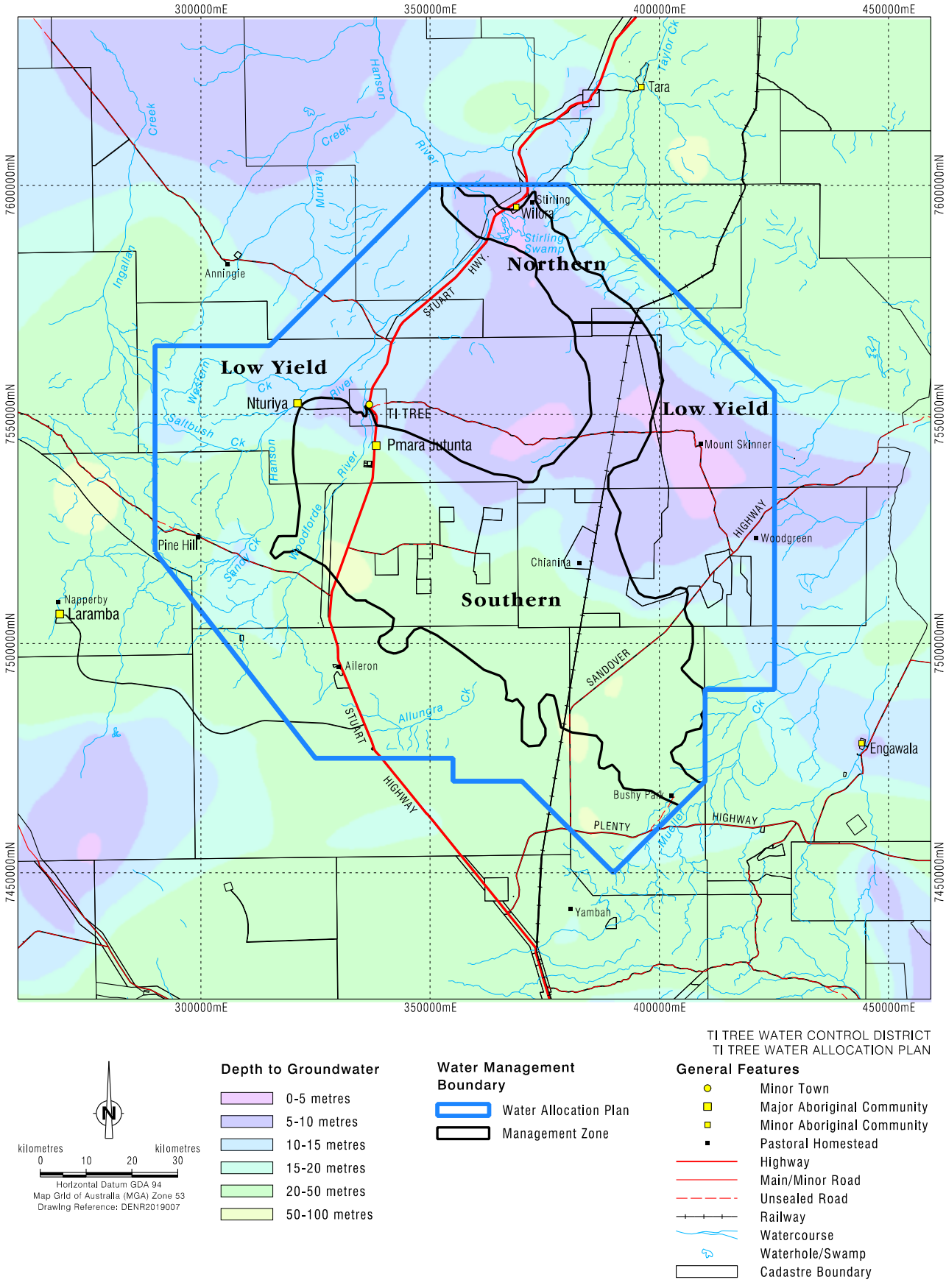


Figure 8. Groundwater depth below surface

3.3.1 Groundwater recharge

Wood (2015) determined that there is significant spatial variability in recharge across the Ti Tree Basin which is dominated by 'mountain front' and ephemeral stream 'flood-out' mechanisms. These mechanisms are a consequence of the landscape and geology and respectively refer to infiltration occurring adjacent to the basin edge and that which occurs as a result of significant flow events in the local streams. Diffuse recharge through rainfall infiltration of the unsaturated profile (i.e. through the soils) also occurs across the TTWCD. This was quantified by Harrington et al. (2002) and in volumetric terms, accounts for a small proportion of recharge.

Groundwater monitoring of the Ti Tree Basin dates from 1967. During the past 50 years, the groundwater hydrographs represented from the local bore monitoring network indicate that recharge occurs on an episodic basis. Gough (2011) observed that on average, there was a significant recharge event approximately once every decade, correlated to significant rainfall events during that period. Gough (2011) also undertook a trend analysis and observed variation in recharge across the landscape - noting the western and central parts of the Ti Tree Basin were experiencing a downward trend in water levels, while in other areas, such as the southern margin, water levels were increasing.

3.3.2 Groundwater monitoring

This plan requires ongoing monitoring of groundwater resources and sets out a strategic monitoring plan that will provide data for continuous assessment informing the performance of the resource in terms of the various plan objectives.

3.3.3 Groundwater quality

Groundwater quality in the TTWCD (both salinity and trace element concentrations) varies both spatially and with depth. There is wide variation in salinity with total dissolved solids (TDS) from 420 to over 10,000 mg/L.

Harrington et al. (2002) determined the processes resulting in the variable chemical composition within the shallow Ti Tree groundwater system.

The area of freshest groundwater (TDS<1,000 mg/L) is located in the central part of the Ti Tree Basin. McDonald (1998) attributed this central fresher zone to recharge from the floodplain of Allungra Creek after major rainfall events.

Nitrate levels in the TTWCD generally range from 70 to 350 mg/L. Therefore, the National Health and Medical Research Council, *Australian Drinking Water Guidelines* (2011) limits of 50 and 100 mg/L for nitrate applicable to bottle-fed infants under three months of age and adults respectively, are mostly exceeded. Potable groundwater supplies (where TDS<1,500 mg/L and nitrate <45 mg/L) only occur in the north-west part of the Ti Tree Basin.

A groundwater quality map showing salinity is at Figure 9.

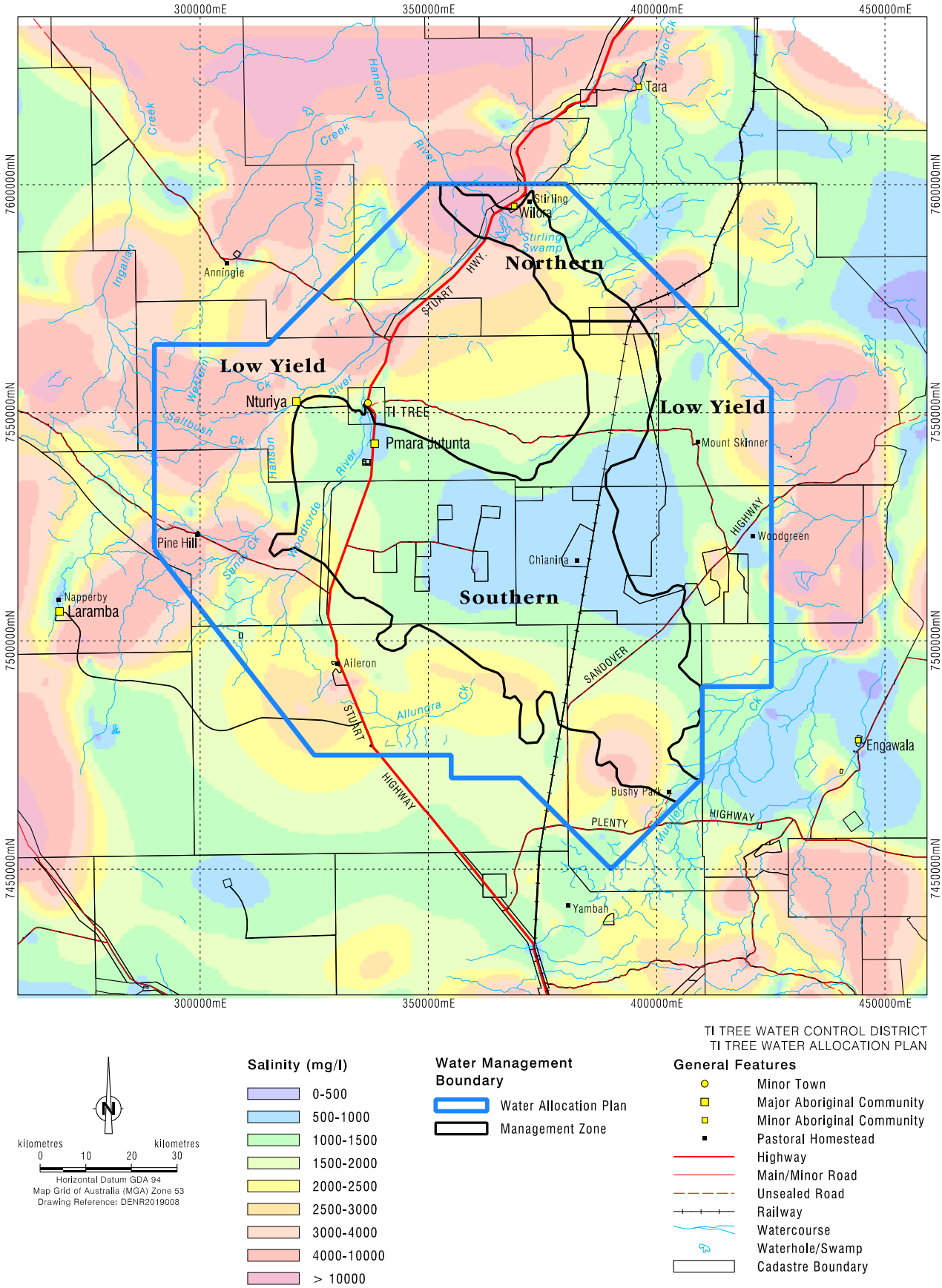


Figure 9. Groundwater quality

3.4 Hydrologic modelling

Hydrologic or groundwater modelling is an important tool used to affirm the understanding of a hydrogeological system as well as to quantify the resource and the level of impact that groundwater extraction is having on that system. For the Ti Tree Basin, a model was used to determine the water natural balance provided in Table 4 which is based on no groundwater pumping occurring in the Basin (i.e. under natural system behaviour). The Ti Tree Aquifer water balance is divided into GMZs which are shown in Figure 10. This 'baseline' water balance provides a basis to measure the level of impact that present day and future pumping regimes may have on groundwater resources.

The subsequent modelling applies different scenarios, or pumping regimes, for example an increase in pumping based upon anticipated demand or pending licence applications. The cumulative impact of these scenarios on the volume of water in the aquifer, water table level and on the groundwater dependent ecosystem protection area, are then predicted. When compared to the no-pumping scenario, decisions regarding whether the impact is acceptable or not, can then be made.

The model has assisted in determining the estimated sustainable yield of the Ti Tree Aquifer. By modelling hypothetical pumping scenarios, the limits that should apply to groundwater extraction to avoid potential deleterious impacts to identified groundwater dependent ecosystems (GDEs) and culturally significant areas may be established.

The model may be used in licensing assessment, to test the positioning of new production bores and bore fields by predicting the effects of different extraction rates within the modelled aquifer areas, such as changes to water table depth in areas where GDEs are assumed or are known to occur.

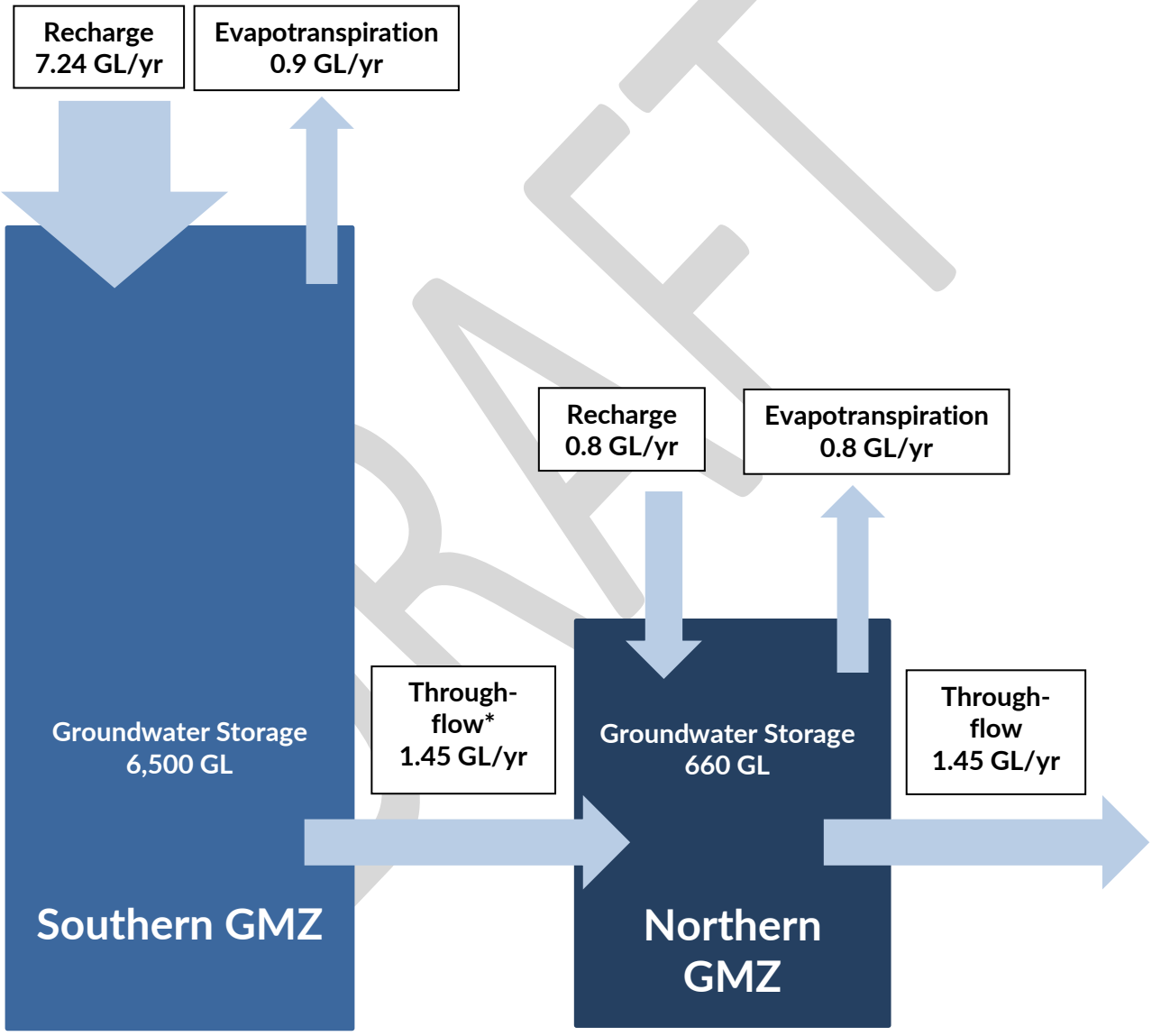
3.4.1 Natural water balance

The natural water balance for the Southern and Northern GMZs (Table 4) is based on modelling the past 100 years of climate data. Estimates beyond 100 years have not been undertaken. However, in modelling future scenarios, a necessary assumption is that the climate of the next 100 years will be similar to that which has been experienced in the past. The water balance for the Low Yield GMZ is estimated from empirical data and has less relevance for water management purposes as it is generally not available for extractive use.

The natural water balance for the groundwater resources includes the volumes of water in storage, combined with the inputs (recharge; through-flow) and outputs (discharge; through-flow).

Table 4. Natural water balance

Component	Northern GMZ	Southern GMZ	Low Yield GMZ	Total
Through-flow GL/yr	1.45	1.45	0	**2.9**
Groundwater Recharge GL/yr	0.8	7.24	28.2	**36.2**
Groundwater Storage GL	660	6,500	120.0	**7,280**
Evapotranspiration GL/yr	0.8	0.9	1.1	**2.8**



*Through-flow from the Southern GMZ to the Northern GMZ does not change significantly over time. This results in an increase in groundwater storage over time as evidenced by an increase in groundwater levels in the Southern GMZ.

Figure 10. Natural water balance of the Ti Tree Aquifer system

4 Water use

Water uses are described in terms of beneficial use categories under the *Water Act* 1992, including consumptive and non-consumptive uses. The beneficial uses applying to this plan will be declared in the Government *Gazette*. The full list of beneficial uses available under the *Water Act* 1992 is in Table 2, and those selected for allocation of water under this plan are in Table 3.

4.1 Non-consumptive use

4.1.1 Environmental water requirements

The surface water features in the TTWCD, including the semi-permanent Anna's Reservoir (Mer Ngwurla) and Allungra waterhole, and rock holes are utilised by native animals such as kangaroos, numerous species of birds (e.g. emus), reptiles, native frogs, and macro-invertebrates, including insects and crustaceans. The surface water features are dependent upon natural and highly variable surface water flows that occur after significant rainfall events. The surface water features are not dependent on the main Ti Tree Aquifer, meaning groundwater extraction will not affect their long-term health.

Stock watering points also provide additional access to water for native birds and mammals. The semi-permanent nature of some of the natural surface water features allows them to act as refuges supporting the persistence of water dependent species and ecosystems in the TTWCD. The most significant risk to surface water health and environmental values is due to access by cattle and camels. These animals compete with native animals for water and damage water based ecosystems and degrade water quality.

The dominant landform within the TTWCD is red sand plains comprising open woodlands, where bloodwood (*Corymbia opaca*), ghost gum (*Corymbia apparrerinja*) or smooth-barked coolibah (*Eucalyptus victrix*) are commonly the dominant tree species over a sparse grassy understorey.

GDEs are 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 (Richardson et al. 2011). Several plant species and vegetation communities in the TTWCD are known GDEs.

It is reasonable to assume occurrence of GDEs within the extent of the Ti Tree Aquifer where depth to groundwater is 15 m or less, and where vegetation species present include those found to be capable of accessing groundwater. Depth to groundwater is 15 m or less for most of the northern half of the Ti Tree Aquifer (see Figure 8 showing groundwater depth below surface).

Cook and Eamus (2018) examined groundwater use by vegetation in central Australia, much of which was derived from studies undertaken in the TTWCD. These studies demonstrated significant groundwater use in areas with water tables from 8-12 m with some evidence of groundwater use to depths of 20 m.

Bloodwood was found to be capable of accessing groundwater to 15 m. Species found accessing groundwater at shallower depths (<12 m) included the river red gum (*Eucalyptus camaldulensis*), dogwood hakea (*Hakea macrocarpa*), scented wax wattle (*Acacia melleodora*) and crimson turkey bush (*Eremophila latrobei*). Other species such as ghost gum and smooth-barked coolabah are also likely to access groundwater.

Stirling Swamp, located in the Northern GMZ of the TTWCD was identified by Cook and Eamus (2018) as a groundwater dependent ecosystem which exhibits complex interactions between surface water and groundwater. The swamp is recognised within the *Anmatyerr North Site of Conservation Significance* (Harrison et al. 2009) as a significant wetland and habitat for a nationally threatened small sedge species, *Eleocharis papillosa* (conservation status: vulnerable). The swamp is comprised of a large wetland complex of claypans, lignum swamp, semi-saline samphire and temporary open water. Groundwater levels near Stirling Swamp are close to the ground level and groundwater is discharged (lost) through evaporation.

River red gums line river banks in the region and are likely to depend on underlying groundwater that is recharged by creek flows. This species has been found to tap into perched aquifers that occur beneath the rivers and the riparian zone, for example along the Woodforde River and Allungra Creek. A perched aquifer is an aquifer that sits above the regional water table, for example on top of an impermeable layer of sediment or rock. Perched aquifers are separate from and therefore not impacted by extraction from the main Ti Tree Aquifer.

There is insufficient directly-related research to accurately predict the impact of declining groundwater levels on vegetation communities in the TTWCD (e.g. due to water extraction). However, a number of studies have observed significant impacts on vegetation from water table decline at other locations, such as Pfautsch et al. (2014) and Adams et al. (2005).

Maximum rooting depths can differ between different species, and so ecosystems can be affected when a declining water table exceeds the maximum rooting depth of species within that ecosystem. However, there can also be limits on root growth rates, so that vegetation may no longer have access to groundwater if the rate of water table decline exceeds the rate of root growth.

4.1.2 Cultural water requirements

The TTWCD is part of a living cultural landscape which extends beyond its boundaries.

The Anmatyerr tyerrty (people) are the Traditional Owners of the land within the TTWCD. The importance of water for Anmatyerr tyerrty is found throughout the country and all living things; it is not limited to surface water and groundwater dependent ecosystems. Anmatyerr cultural values are associated with physical (e.g. sacred sites and other features such as stone arrangements) and non-physical expressions of culture (e.g. knowledge, songs, ceremony).

In addition to cultural values, Anmatyerr Traditional Owners are subject to the rules and institutions associated with customary law. It is important to recognise Anmatyerr people as being central to the interpretation of customary law as it relates to the management of cultural values. For these reasons, Anmatyerr Traditional Owners have been engaged in the development of this plan and are proposed to have an ongoing role in its implementation.

Within the Anmatyerr region, all people and country have a 'skin.' The Skin System determines identity, ownership of country and place, as well as who a person can (or cannot) marry. Further, this system conveys a connection to ancestors and more importantly to ancestral beings who travel the landscape via Dreaming lines. Skin, descent and ancestral relationships dictate who the Merekartwey (traditional owner) and Kwertengwerl (traditional manager or caretaker) is for land and water within the region. Merekartwey and Kwertengwerl are the individuals who possess knowledge and have the right to speak for a particular area. It is important to recognise that Aboriginal cultural water use 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 and 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.

Water availability also affects many activities, like hunting and harvesting, tool and craft making. There are a number of important cultural sites and features in the TTWCD which depend on surface and/or groundwater. Cultural water requirements include provision of flows required by physical cultural features (e.g. vegetation or soaks) to maintain their health and amenity. Cultural water requirements are usually categorised as non-consumptive; however, could include consumptive uses, if identified.

Cultural water requirements may include manipulation of water systems by Aboriginal people for various outcomes (e.g. excavation of soaks), and traditional rights to manage and make decisions about water (e.g. controlling access) and are not limited to the maintenance of natural flows from which Aboriginal people derive a cultural benefit. Anmatyerr tyerrty have traditional methods for maintaining and protecting water sources. Soaks are closed after use and sometimes marked by putting a long stick into the hole before backfilling; this prevents contamination by dead animals and stops evaporation. Stone lids are used to cap small rock holes. Permanent wells have been created in more recent times by lining a soak with a flour drum; the base cut out and lid placed on top.

The Anmatyerr Water Story (Rea 2008) outlined some of the ways in which water is valued by the local Anmatyerr people who live in the Ti Tree region and includes recommendations as to how Anmatyerr cultural water values could be provided for in the Ti Tree Water Allocation Plan. According to the study, many water places, including more permanent springs in the mountain ranges, are linked to the journey of the Rainbow Serpent through Anmatyerr country; these are sacred places which people must avoid. Water is not only embedded within the Dreaming lines which run throughout Anmatyerr country, it is entrenched within the fabric of Anmatyerr society. Kwaty or Rain Dreaming is one of the most sacred Dreaming lines in the region. Related dreamings' include Hail Stone Dreaming and Lightning Dreaming.

Non-Aboriginal development in the region has seen many important water places turned into dams, wells and bores. Other surface water sites have been degraded by cattle and camels. Most surface water features within the TTWCD are not connected to the main Ti Tree Aquifer and will not be affected by the large-scale horticultural groundwater extractions. However, cultural values of surface waters can be impacted by access from domestic stock and feral animals (e.g. horses, camels).

Due to the variable arid zone climate and insufficiency of information, it is not currently practical to use the instrument of volumetric flow allocations to the diversity of cultural uses and sites where water is culturally valued. However, it is a reasonable assumption that avoiding deleterious impacts to environmental values will contribute to protection of cultural values of water sites. Provision of Aboriginal non-consumptive values for water can also be enhanced through use of Anmatyerr language names for water places, developing protocols to enhance Anmatyerr tyerrty participation in planning and management decisions, and enabling Anmatyerr tyerrty to access and manage access to culturally significant water sites.

Further to the information provided above, the Aboriginal Areas Protection Authority has identified Stirling Swamp as a registered sacred site in accordance with the *Northern Territory Aboriginal Sacred Sites Act* 1989 *and* has 'noted' the Woodroffe River (near Arden Soak bore) as being of significance to Aboriginal people.

4.2 Consumptive use

Since the inception of water allocation planning in the TTWCD (see Ti Tree Region Water Resource Strategy 2002) all consumptive groundwater has been within the beneficial use categories of agriculture, public water supply, industry and rural stock and domestic use. Pumping for agriculture, industry and public water supply is licensed and extraction volumes are reported. Rural stock and domestic use is not required to be licensed and licensees are not required to provide pumping data.

Amendments to the *Water Act* 1992 to include mining activity and petroleum activity as beneficial uses were made on 31 December 2018.There is currently no use of groundwater by mines in exploration, development and production; however, at plan commencement such use would not require licensing.

The Northern Territory Government's *Strategic Aboriginal Water Reserves Policy Framework* (NT Government 2017) applies to this plan. The SWR is a portion of the consumptive pool reserved for Aboriginal access to use or trade to third parties. There is no historic SWR use; however, future demand considers the volume reserved for SWR (refer to Section 5.1.5).

4.2.1 Current surface water use

At January 2019, there were no surface water extraction licences within the TTWCD.

4.2.2 Current licensed groundwater entitlements

At January 2019, there were 15 groundwater extraction licences for agriculture (totalling 7,104 ML/yr) and three public water supply licences (totalling 290 ML/yr) within the TTWCD. Agricultural water uses include growing crops, such as mangoes, table grapes, melons and citrus, and production of fodder crops such as lucerne for cattle. The majority (88%) of water extracted for consumptive use since 2002 has been for agriculture (see Figure 11).

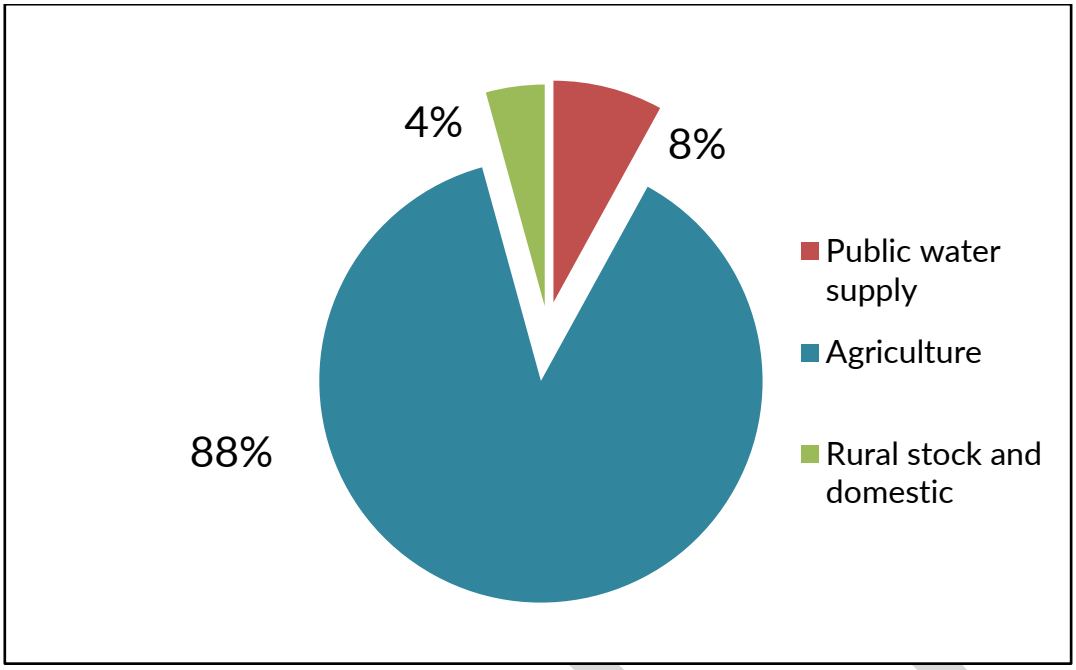


Figure 11. Percentage of water used per consumptive beneficial use in the TTWCD (2007-2017)

4.2.3 Licensed groundwater use

As at June 2018 there was a consistent pattern of underutilisation of licensed water entitlements in the TTWCD.

The volume of groundwater extracted for agriculture has declined since a peak extraction of 2,823 ML in 2006. Total agricultural use was 824 ML in 2017, which was the lowest annual extraction volume since 2002. In 2018, agricultural extraction increased to 1,997 ML (Figure 12).

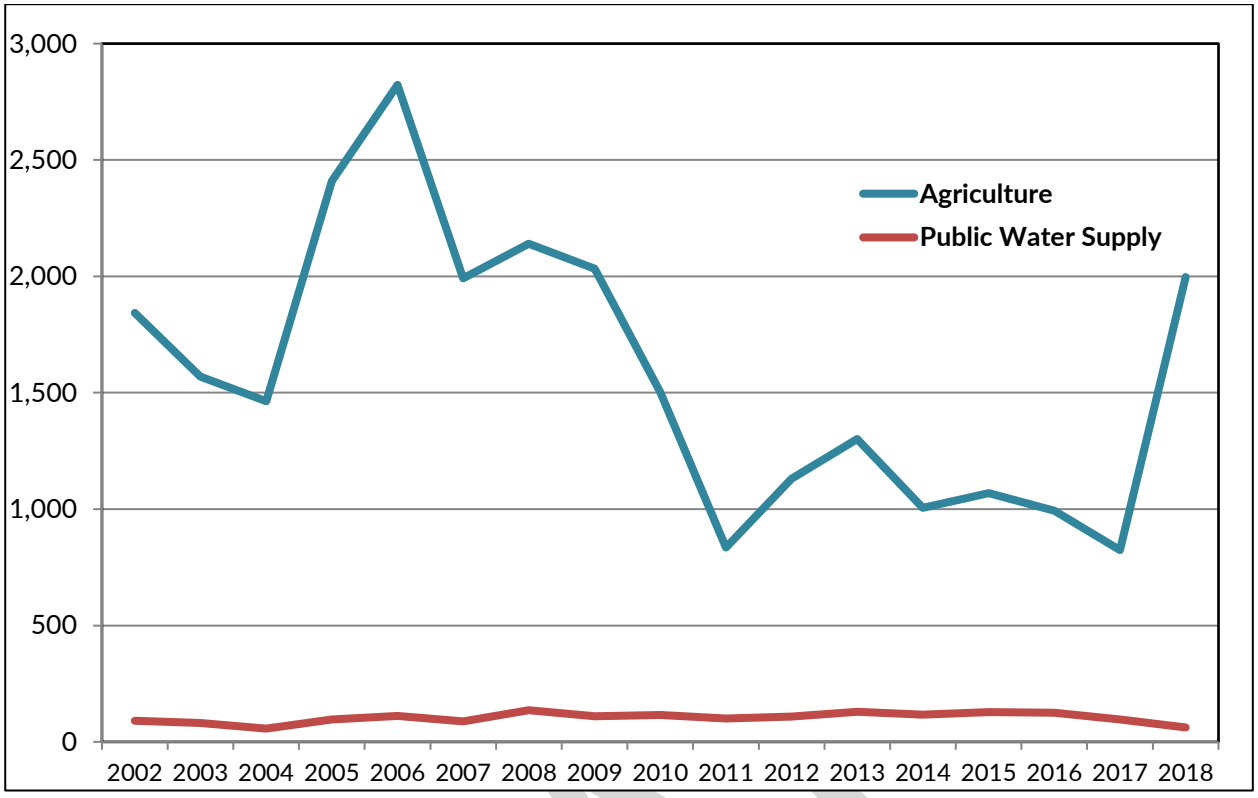


Figure 12. Total water use (ML) in the TTWCD for consumptive beneficial use (YE 2002-2018)

The 7,104 ML/yr licensed for extraction for agriculture in the water accounting year ending June 2018 was significantly higher than actual extraction of 1,997 ML in the same period, representing utilisation of only 28.1% of licensed water entitlements (Figure 13). During the previous TTWAP, the total water allocated for agriculture was 13,100 ML/yr. The allocation to agriculture of 10,000 ML/yr in the Ti Tree Water Resource Strategy 2002 was increased in the 2009 plan due to an anticipated increase in demand at the time; however, actual use decreased between 2009 and 2018.

The underutilisation of licensed water entitlements during the period 2009 to 2018 was likely due to a range of social, economic and environmental factors (including plant diseases and fire), which impacted on development plans or viability of farms in the TTWCD. Some licensees also implemented efficient irrigation practices that further reduced volume of water use per irrigated hectare compared with the volumes conservatively estimated in licence applications.

Average extraction for public water supply was 103 ML/yr for the period 2002-2018 and consumption was 63 ML for the year ending June 2018 (Figure 13). However, overall, public water supply extraction showed a slight upward trend between 2002 and 2018.

As at January 2018, a single licence for industrial water use was held by the Northern Territory Government Department of Infrastructure, Planning and Logistic's Construction Division for annual extraction up to 72 ML/yr.

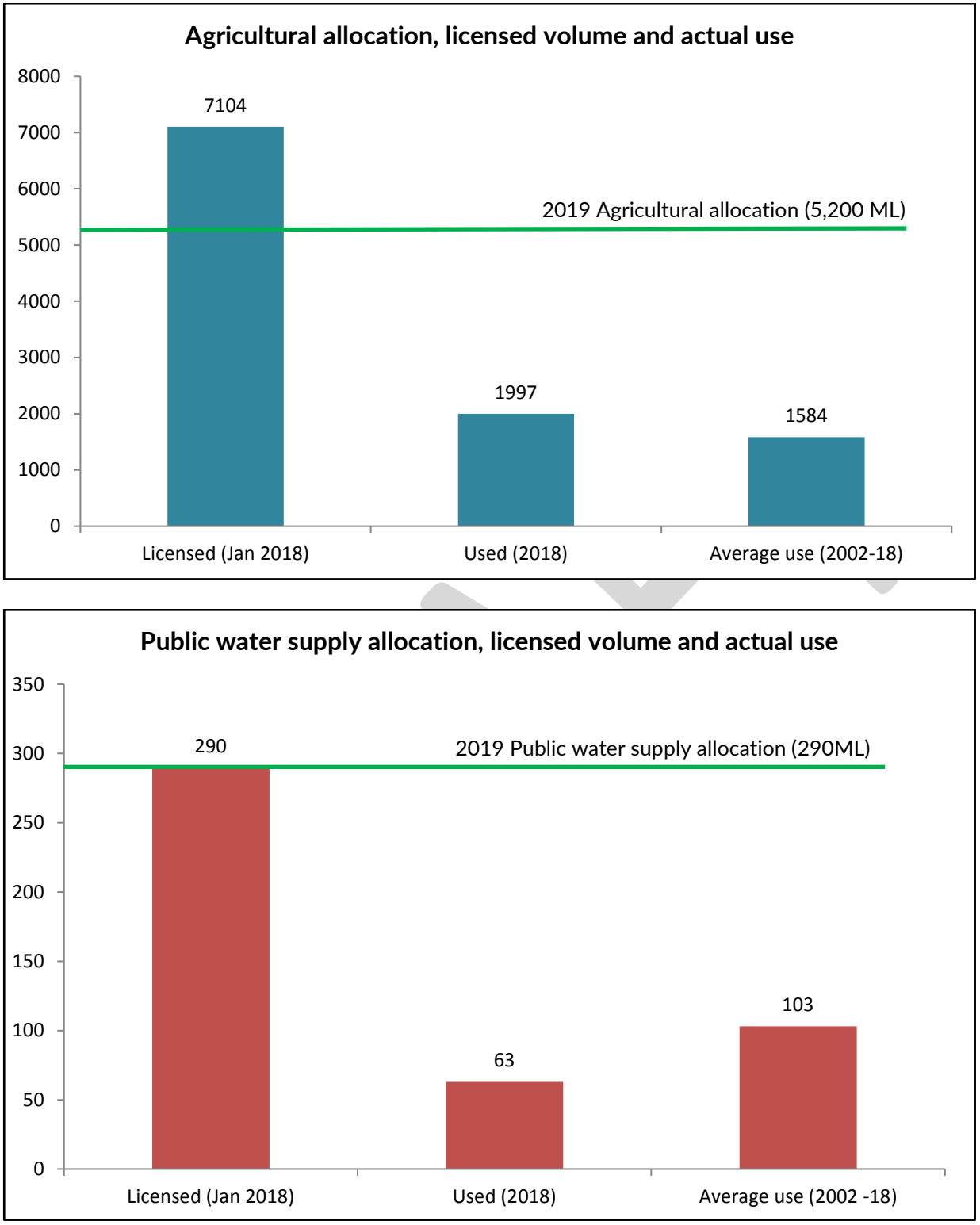


Figure 13. Comparison of water allocated (consumptive pool) with volume licensed and used for (a) agriculture and (b) public water supply.

The volume of consumptive water use varied between GMZs. This was because of the differing allocations and licences granted in each zone, but also reflected a pattern of underutilisation of licensed water entitlements (see Table 5).

Table 5. Comparison of volume (ML/yr and percentage) allocated, licensed and extracted for each GMZ to end June 2018 from the consumptive pool of the estimated sustainable yield.

Zone	Consumptive pool of the ESY	Licensed entitlements	Actual	Percentage of entitlements used	Percentage of consumptive pool-ESY used
			Extraction YE 2018		
Southern GMZ	7,240	7,354	2,040	27.7	28.2
Northern GMZ	80	40	19	47.5	23.8
Whole aquifer	**7,320**	**7,394**	**2,059**	**27.8**	**28.1**

4.2.4 Unlicensed groundwater use

Rural stock and domestic use is not required to be licensed and is unmetered. This includes pastoral property water use for homestead and stock drinking water.

Domestic water use

Domestic use includes homesteads and farm occupiers and employees and has been estimated as:

annual water use = number of households X 2.7 kL X 365

(approximately 1000 L/person/day permanent and 500 L/person/day transient population) or approximately 36 ML/year (Table 6).

Table 6. Estimated current domestic water use (unlicensed)

Type of Household	Water use (ML/yr)			
	TTWCD	Southern GMZ	Northern GMZ	Low Yield GMZ
Homesteads (1000 L/person/day)	6	2	1	3
Farms (permanent) 1000 L/person/day)	20	20	0	0
Farms (transient population) (500 L/person/day)	10	10	0	0
Total	**36**	**32**	**1**	**3**

Rural stock and domestic use

Rural stock water use can be estimated based on area grazed (water use per km²) or carrying capacity (water used per head of cattle). Using carrying capacity, annual rural stock water use is estimated to be 377 ML/yr for the whole TTWCD, comprising 115.4 ML/yr for the Southern GMZ, 15 ML/yr for the Northern GMZ and 246.3 ML/yr (Table 7) for the Low Yield GMZ. It is not known how many stock watering points exist that make use of surface water, but it has been assumed that the total volume of surface water used is less than 5% of the total flows in any one catchment area and that the majority of stock water is supplied by groundwater.

Table 7. Estimated rural stock water use (not licensed)[4]

Property	Estimated stock water use Southern GMZ (ML/yr)	Estimated stock water use Northern GMZ (ML/yr)	Estimated stock water use Low Yield GMZ (ML/yr)
Aileron	9.16	-	*Low Yield GMZ stock water use calculated as a single unit using the average stocking rate from the combined pastoral properties*
Bushy Park	23.12	-	
Mount Skinner	1.32	0.35	
Woodgreen	1.13	-	
Ahakeye	28.45	-	
Pine Hill	51.56	-	
Stirling	0.48	14.6	
TOTAL	**115.4**	**15.0**	**246.3**

Industry

Previously licensed industrial water use was 72 ML/yr associated with road construction and maintenance. The licence expired in February 2018 and was not extended because road works are exempt from licensing requirements (*Gazette* S60 of 28 November 2008).

[4] Assumes stock consumption @ 50L/head per day formulated from Corbett et al. (1990); Estimated stock density calculated from carrying capacity estimated from NT Department of Primary Industry and Resources (September 2016). Actual stocking rates as reported by pastoral stations (unpublished).

4.3 Demand projections

4.3.1 Consumptive uses

Agriculture

Demand for agricultural use is difficult to estimate (Table 8) because it is influenced by a relatively small number of groundwater extraction licence (GWEL) holders (15 licences operating in March 2019). The extent to which existing licensees use their entitlement will have a significant impact on the volume of water actually used, noting that for the water accounting year ending 30 June 2018, usage records indicated that 28.1 per cent of the volume licensed for extraction was utilised.

At March 2019, existing licences (assuming full utilisation), will contribute 7,108 ML/year to future demand. No applications for new or increased agricultural licences were held by the Department of Environment and Natural Resources, as at March 2019.

Table 8. Estimate of future agricultural demand for water in the TTWCD

Description	Total (ML/year)
Existing agricultural GWELs, March 2019 *Assumes full use of current licences and renewals to be assessed*	7,108
Applications for renewal, new or increased agricultural GWELs, July 2018	100
Anticipated demand for agricultural GWELs from NT Portions 6108, 6109 and 6110	3,000
Total demand *Assumes 100% use of GWELs but does not include an additional Strategic Aboriginal Water Reserve*	**10,208**

Public water supply

There is insufficient ABS data available to accurately determine population growth (and subsequent growth in potable water demand) at the scale of the TTWCD, and estimates are further complicated by variation in population due to high mobility of residents in Aboriginal communities.

An estimate of growth in demand for public water supply obtained by applying a linear regression analysis (line of best fit) to volumes extracted between 2002 and 2018 (average 103 ML/yr) results in estimated demand of 125 ML/yr after 10 years and 241 ML/yr after 100 years.

Power and Water Corporation applies a demand growth forecast of 0.4 per cent resulting in estimated demand of 130 ML/yr after 10 years and 186 ML/yr after 100 years.

In the next 10 years, potential development of a new 25 km^2 Ywel Community Living Area on a land portion excised from Pine Hill Station may result in an additional demand of 20 ML/yr. Given the importance of public water supply, the plan uses the highest demand scenario after ten years (based on 0.4 % growth + Ywel community) of 150 ML/yr after 10 years.

Power and Water Corporation already holds licences for public water supply totalling 290 ML/yr in the TTWCD, which provides a satisfactory buffer against unexpected growth in demand.

Industry

The demand for water use for road works is estimated to continue at current levels of extraction of less than 100 ML/yr.

Mining activity

Mining activity was included as a beneficial use category in the *Water Act* 1992 in 2018.

Arafura Resources proposes to develop the Nolan's Project rare earth mineral mine approximately 10 km north-west of Aileron Roadhouse. If developed, the mine would use approximately 1,450 ML/yr (at peak operation) through open pit mine dewatering in the Low Yield Zone of the TTWCD (Arafura Resources 2016). The proposed mine location sits outside of the Ti Tree Basin and hence the dewatering activities are not expected to impact on the Ti Tree Aquifer. The main water take for the proposed mine is for a processing plant that would source water from a separate aquifer and is located outside of the TTWCD.

Rural stock and domestic

Rural stock and domestic use is estimated to remain at current estimated levels (36 ML/yr domestic and 377 ML/yr stock) for the TTWCD. Of this use, 65 per cent occurs in the Low Yield GMZ.

Strategic Aboriginal Water Reserve

There is a notional amount of water available for the SWR in the Southern GMZ of 1,505 ML that could be used as a subclass of a number of beneficial uses. If eligible Aboriginal rights holders seek to utilise the maximum volume of their SWR allocation for agriculture (and assuming this is additional to the above demand) the additional demand would be 22% of the available consumptive pool (consumptive pool available remaining after public water supply and rural stock and domestic are kept aside). However, it should be noted that SWR allocation is not necessarily mutually exclusive from other demand in that developers may negotiate for SWR access from eligible Aboriginal rights holders for a number of different beneficial uses.

5 Estimated sustainable yield

Under section 22B(5)(a) of the *Water Act* 1992, water is allocated to beneficial uses within the estimated sustainable yield (ESY). The estimated sustainable yield is the amount of water that can be allocated from the water resource to support declared beneficial uses without compromising key cultural and environmental values, or ecosystem functions or the productive base of the resource or declared water quality standards, criteria or objectives.

Environmental values include groundwater dependent ecosystems (GDEs), which refers to vegetation that accesses groundwater. Cultural values include physical features within the landscape that often include but are not limited to GDEs, and are significant to Aboriginal Traditional Owners. The productive base of the resource refers to the volume of water stored within the aquifer (aquifer storage).

The total estimated sustainable yield for the Ti Tree Aquifer water resource is 15,840 ML/yr, of which 10,140 ML/yr is allocated for consumptive use (Table 9). The consumptive pool for groundwater extraction is based on 100% of recharge in the Southern GMZ, and 10% of recharge from the Northern GMZ. Modelling shows the estimated sustainable yield for the Southern GMZ at a volume that would maintain aquifer storage at current levels. If the consumptive component of the estimated sustainable yield was extracted every year, the resource in the Southern GMZ could theoretically be available for consumptive use in perpetuity. The Northern GMZ ESY is established at a relatively low level to protect sensitive groundwater dependent environmental and cultural values present in this zone.

The Low Yield GMZ has an ESY of 3,920 ML/yr. The consumptive pool is based on allocating 10% of the median annual recharge; however, most of the zone overlies bedrock that has insufficient permeability or transmissivity for water extraction. Water may be available in limited quantities from small localised aquifers (e.g. perched aquifers) that are distinct from the Ti Tree Aquifer. The allocation to the beneficial use of mining activity recognises potential demand for water through mine pit dewatering that is not constrained by flow rates that would be required for a typical production bore.

Within the ESY for groundwater, the allocation to the environment is based on maintaining through-flow and meeting the evapotranspiration needs of vegetation accessing groundwater.

This plan considers the ESY for waterways (surface water) to equal 100% of instantaneous flow at any point in time. However, flow is highly variable and usually zero in dry conditions. Ninety-five per cent (95%) of the ESY (flow at any time) is allocated to non-consumptive beneficial uses of environment and cultural. Due to irregular flows and the temporary nature of surface water in the TTWCD, it is not practical to assign a volumetric allocation to the non-consumptive beneficial uses (which do not require licensing).

Table 9. Estimated sustainable yield (ML/yr) for the Ti Tree Aquifer

Groundwater management zone	ESY	Consumptive pool	Environment allocation	Main basis
Northern GMZ (Ti Tree Aquifer)	2,330	80	2,250	ESY based on provisioning environmental flows and protecting sensitive environmental and cultural values. Consumptive pool is based on 10% of recharge
Southern GMZ (Ti Tree Aquifer)	9,590	7,240	2,350	Consumptive pool is based on 100% of recharge
Subtotal (above)	**11,920**	**7,320**	**4,600**	
Low Yield Zone (outside of the Ti Tree Aquifer boundary)	3,920	2,820	1,100	Zone predominantly low-yielding bedrock and not a continuous connected resource. Consumptive pool is based on 10% of recharge.
Total	**15,840**	**10,140**	**5,700**	See above

5.1 Allocation of water to beneficial uses

5.1.1 Water allocations

Water allocations to beneficial uses in the consumptive and non-consumptive pool are provided in Table 10. The sum of these allocations, including to the environment, form the estimated sustainable yield.

In this plan, the estimated sustainable yield for groundwater includes an allocation to the environment that comprises evapotranspiration and through-flow (as described in Table 9).

Table 10. Allocations (ML/yr) in the ESY to beneficial uses[5]

Beneficial uses	Groundwater Management Zone			Total (ML/yr)
	Southern	Northern	Low Yield	
Public water supply	250	40	0	290
Rural stock and domestic	147	40	350	537
Other consumptive beneficial use pool	6,843	0	2,470	9,313
Notional allocations:				
Agriculture	5,218	0	20	5,238
Industry	80	0	20	100
Mining activity	20	0	2,410	2,430
Petroleum activity	20	0	20	40
Subclass of other beneficial uses:				
Strategic Aboriginal Water Reserve[6]	1,505	0	0	1,505
Total consumptive pool	**7,240**	**80**	**2,820**	**10,140**
Environment	2,350	2,250	1,100	5,700
Estimated sustainable yield	**9,590**	**2,330**	**3,920**	**15,840**

5.1.2 Environmental water

In accordance with section 22B(6) of the *Water Act* 1992, an allocation must be made to the beneficial use of Environment.

Under this plan, 95% of natural surface water flows is maintained for environmental beneficial use and associated cultural values. There are currently no known diversions into dams or reservoirs.

This plan allocates all water estimated to leave the Ti Tree Aquifer in the baseline (natural) water balance scenario due to evapotranspiration and through-flow to the Environment beneficial use. This equates to 2,350 ML/yr in the Southern GMZ and 2,250 ML/yr in the Northern GMZ. The allocation to environment in the Low Yield GMZ is 1,100 ML/yr is based on estimated evapotranspiration only, due to negligible through-flow.

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5 Beneficial uses for the Ti Tree Water Control District will be revoked and remade when this water allocation plan is declared, to provide for allocations to new beneficial uses, in line with recent changes to the *Water Act* 1992.

6 Strategic Aboriginal Water Reserve (SWR) is expected to be established as a Beneficial Use under the *Water Act* 1992 during the term of this plan; in the interim, the plan establishes SWR as a subclass of water allocated for Agriculture, Mining Activity, Petroleum Activity and Industry beneficial uses.

Environmental water requirements are further provisioned by ensuring consumptive allocations do not cause drawdown rate and absolute drawdown level (groundwater depth) that would adversely impact on ecosystem health.

5.1.3 Water for Aboriginal cultural use

Maintenance of cultural values requires that water dependent cultural assets (such as significant vegetation) have access to sufficient water of suitable quality. Protecting groundwater dependent ecosystems (including terrestrial vegetation) from the impact of consumptive water use, will protect cultural values of these sites, where such values exist.

Cultural values are also provided through non-flow related considerations such as Aboriginal participation in water management and planning, and by activities aiming to protect culturally important places from degradation.

Non-Aboriginal cultural uses were not identified during the development of this plan.

5.1.4 Water for consumptive use

The ESY for the Ti Tree Aquifer in the Northern and Southern GMZs is 11,920 ML/yr, of which 7,320 ML/yr is allocated for consumptive use (refer Table 9). The consumptive pool of the Northern GMZ is limited to 10% of average annual recharge. The volume allocated is equal to the sum of existing demand for public water supply and rural stock and domestic use. The rationale for this approach is to protect the sensitive groundwater dependent ecosystems and cultural sites (e.g. Stirling Swamp) situated in this GMZ. Groundwater salinity of the Northern GMZ is generally above 1,500 mg/L, which further constrains its value for agricultural uses. The main water resource in the TTWCD is the consumptive pool of the Southern GMZ which is set at 100% of annual average recharge.

The consumptive pool in the Low Yield GMZ (outside the Ti Tree Aquifer) is based on 10% of the average annual recharge to meet estimated demand from mining activity (mine pit dewatering), notional allocations to agriculture and petroleum activity, and rural stock and domestic use. Consumptive use allocations are limited because aquifers or water resources within the Low Yield GMZ are likely to be localised and bores would generally produce low yields that are mostly suitable for unlicensed rural stock and domestic use. Mine pit dewatering is a water use, but does not require an extractive water licence when pumped from an open pit.

This plan recommends applications for licensed extraction from the Low Yield GMZ be considered on a case-by-case basis, subject to the *Water Act* 1992 and:

1. an assessment of the characteristics of the local aquifer system identified within the Low Yield GMZ;
2. limiting annual extraction to no more than 10% of the annual average recharge to the applicable local aquifer or resource within the Low Yield GMZ; and
3. guidelines for protection of environmental and cultural values outlined in Section 6.2.

5.1.5 Strategic Aboriginal water reserve

The SWR is a reserved percentage of water from the consumptive pool exclusively accessible by eligible Aboriginal people to use, or trade. The SWR is calculated based on the percentage of eligible land area in a water management zone and in accordance with the Northern Territory Government's *Strategic Aboriginal Water Reserves Policy Framework*: www.denr.nt.gov.au/swrpolicy. SWR is expected to be established as a beneficial use under the *Water Act* 1992 during the term of this plan; in the interim the plan considers SWR as a subclass of water allocated for agriculture, mining activity, petroleum activity and industry.

There is no SWR in the Northern GMZ where consumptive use is limited to public water supply and rural stock and domestic. There is no SWR in the Low Yield GMZ because there is no eligible Aboriginal land that overlies or with direct access to a productive resource in this zone.

In the Southern GMZ, 22% of the consumptive pool remaining after public water supply and rural stock and domestic use is set aside, is reserved in the SWR. The percentage for SWR is based on the percentage eligible land area. Consistent with the Northern Territory Government's *Strategic Aboriginal Water Reserve Policy Framework* (October 2017), the SWR identified in this plan is 'notional' at plan commencement because existing licensed entitlements in the Southern GMZ result in insufficient unallocated water to provision the SWR. Water may become available in the future (e.g. through surrendered, amended or cancelled licences). Table 11 establishes the allocations to SWR, and indicates how the SWR is assigned to eligible Aboriginal rights holders.

Table 11. Allocation and assignment of Strategic Aboriginal Water Reserve (SWR)

Eligible group	Zone	Share of SWR
Ahakeye ALT	Northern GMZ	No SWR
	Southern GMZ	100%
	Low Yield Zone	No SWR

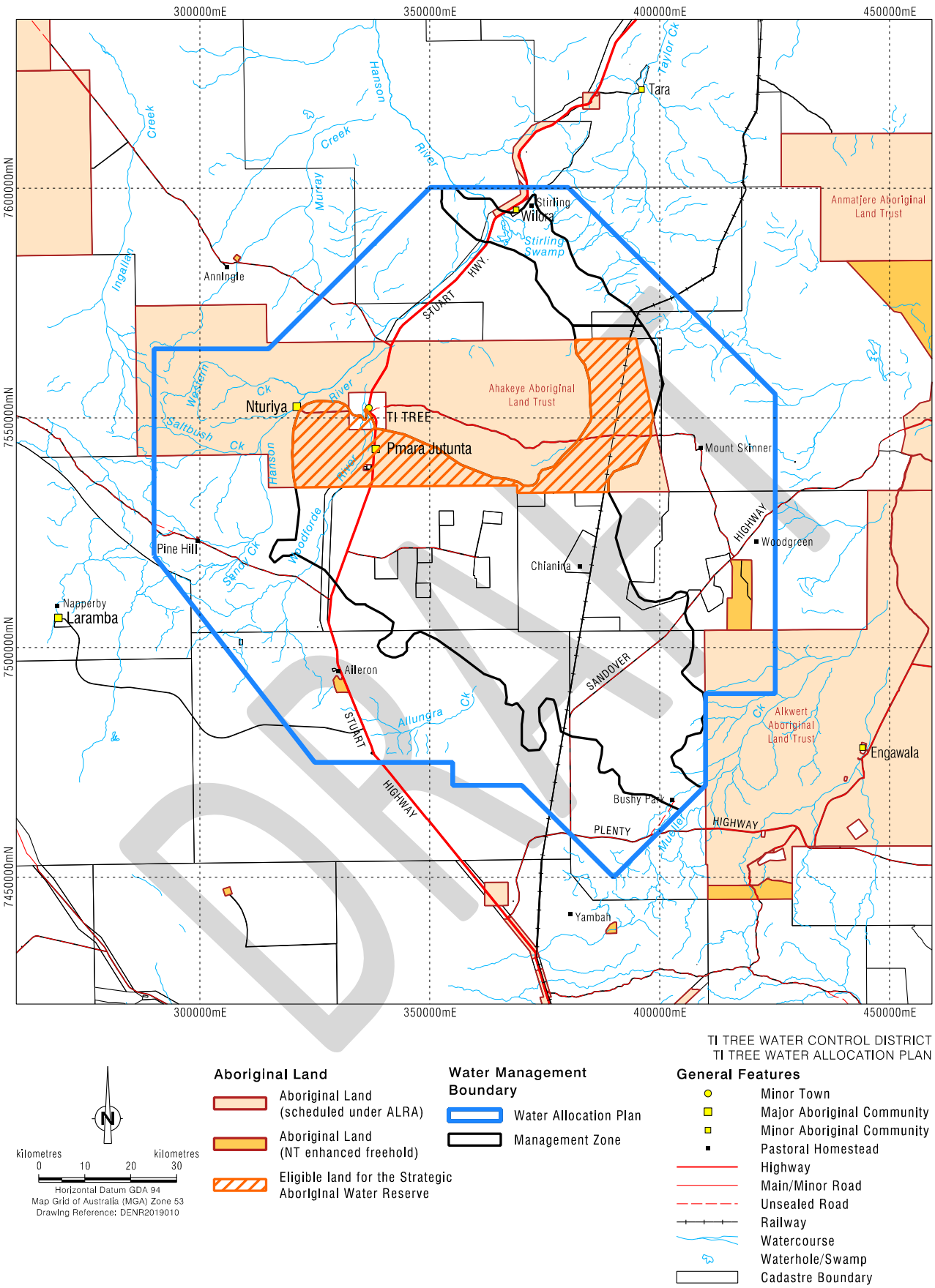

Figure 14. Eligible land for Strategic Aboriginal Water Reserve

6 Water management arrangements

6.1 Water management framework

Table 12. Water management framework

Purpose		**Indicators of achievement (date references are from plan commencement)**	
To ensure water resources in the Ti Tree Water Control District are managed in a manner that protects and maintains environmental and cultural values while providing a sustainable volume of water for consumptive beneficial use		See indicators related to each plan objective (below).	
Output/result	**Activities**	**Indicators of achievement**	**Lead responsibility**
P1. Estimated Sustainable Yield (ESY) and allocations to beneficial uses.	P1. Water modelling and TTWAP development process	P1. Productive base of the resource maintained; ESY established under TTWAP (reviewed in five years).	DENR Water Planning and Engagement
P2. Water licences: sum of licensed entitlements and estimates of other uses not requiring licences, does not exceed ESY.	P2(a). Implement management of unused water policy [see 6.4.3] P2(b). Observe ESY limits to allocations and entitlements	P2(a). Unused water not required for further development within licence period, returned to the consumptive pool/redistributed in 18 months. P2(b). Sum of licensed entitlements (should be equal to or less than the ESY) in ten years.	DENR Water Licensing and Regulation
P3. Compliance checks and follow up extension & enforcement activities (as required).	P3. Licensee visits / inspections, data collection, extension activities	P3. Compliance check (risk-based assessment) of licensees annually. Target 100% compliance with licence conditions.	DENR Water Licensing and Regulation
P4. Ti Tree water monitoring plan.	P4. Develop water monitoring plan	P4. Water monitoring plan is strategic; monitoring activities are sufficient to support TTWAP objectives; include licence condition triggers; completed and resourced in 12 months.	DENR Water Monitoring

P5. Water monitoring plan implemented.	P5. Implement water monitoring; rapid reporting against licence condition triggers.	P5. Monitoring implemented in accordance the monitoring plan; exceedance of licence condition parameters reported to Water Licensing and Regulation as identified.	DENR Water Monitoring
P6. Water monitoring report	P6. Analyse monitoring data and interpret results.	P6. Monitoring 'report card' incorporated into 5-yearly assessment report (for plan review and new plan).	DENR Water Assessment
Objective 1		**Indicators of achievement**	
Avoid detrimental impacts to water dependent ecosystems as a consequence of consumptive water use		Water monitoring at key reference sites shows that sufficient water is available to maintain condition of water dependent ecosystems	
Output/result	**Activities**	**Indicators of achievement**	**Lead responsibility**
1.1 GDE and surface water ecosystem distribution map, including protection area (Figure 14) in the TTWAP	1.1 GDE and water dependent cultural site research project: remote sensing and field study	1.1 Map produced and interim reference sites identified in 6 months.	DENR Water Planning and Engagement – (GDE scientist)
1.2 Accurate water table depth map	1.2 Field work (1-2 weeks) & water modelling	1.2 Map produced in 12 months.	DENR Water Assessment
1.3 GDE assessment report	[See 4.1.1]	1.3 Technical report published in 12 months.	DENR Water Planning and Engagement – (GDE scientist)
1.4 Parameters that describe limits to change in water availability to GDEs	1.4 Commission study into potential for groundwater use by vegetation at Ti Tree. Establish parameters based on study recommendations.	1.4 Parameters (limits to change in groundwater availability to GDEs) established under TTWAP (reviewed in five years).	DENR Water Planning and Engagement

1.5 Applications in the GDE zone accompanied by GDE impact assessment for consideration in licence decisions.	1.5 Model groundwater drawdown and provide assessment report for assessment of relevant licence applications.	1.5 Modelling undertaken to assess all applications potentially effecting areas where water table is <15 mbgl.	DENR Water Assessment (modeller)
1.6 Specific licence conditions for protection of GDEs (recommended to Controller of Water Resources for consideration).	1.6 Develop recommended conditions for water extraction licences related to GDEs and surface water ecosystem protection.	1.6 From plan commencement, special conditions related to GDEs protection recommended and considered by the Controller of Water Resources for all relevant licences.	DENR Water Planning and Engagement with reference to Water Licensing and Regulation
1.7 Change in water availability to GDEs monitored for compliance with licence conditions.	1.7 Develop and implement water monitoring plan [see P4 & P5.]	1.7 GDE-related monitoring included in water monitoring plan; From plan commencement, monitoring undertaken at GDE relevant reference sites.	DENR Water Monitoring
Objective 2		**Indicators of achievement**	
Avoid negative impact to cultural values of places reliant upon surface or groundwater as a consequence of consumptive water use		Water monitoring at key reference sites shows that sufficient water is available to maintain cultural values of places reliant upon surface or groundwater	
Output/result	**Activities**	**Indicators of achievement**	**Lead responsibility**
2.1 Cultural site / value map & data sharing agreement (including conditions relating to the de-identification, use and distribution of a cultural values map/information)	2.1 Cultural site research / field work & TO consultation, development of data sharing agreement	2.1 Map produced and interim reference sites identified in 6 months; data sharing agreement in 12 months.	DENR Water Planning and Engagement assisted by CLC / Anmatyerr Rangers
2.2 Guidelines / protocols for monitoring and access to culturally significant sites	2.2 Development of monitoring and access protocol	2.2 Protocol approved by DENR/CLC in 18 months.	DENR Water Planning and Engagement CLC/Anmatyerr Rangers

2.3 Process for assessing acceptable limits to change in water availability to water dependent cultural sites.	2.3 Consultation with CLC / Traditional Owners to design assessment process.	2.3 Process established / approved by CLC/DENR by Aug 2019. Includes assigning limits to drawdown depth and rate for relevant cultural sites.	DENR Water Planning and Engagement CLC/Anmatyerr Rangers
2.4 CLC informed of all licence applications when notice of intention is advertised.	2.4 Email copy of water extraction licence NOI advertisement to CLC.	2.4 CLC informed of all NOIs (at the same time as others are informed).	DENR Water Licensing and Regulation
2.5 Assessment of change in water availability in proximity to cultural values for consideration in licence decisions.	2.5 Apply system for assessing impact on cultural values; including modelling groundwater drawdown and report for relevant licence applications	2.5 From 2019, assess all applications potentially affecting areas where water dependent cultural values are identified.	DENR Water Assessment – modeller
2.6 Specific licence conditions for water dependent cultural value protection (recommended to Controller of Water Resources for consideration).	2.6 Develop recommended conditions for licences related to water dependent cultural value protection	2.6 From plan commencement, conditions related to water dependent cultural values protection recommended and considered by the Controller of Water Resources for all relevant licences.	DENR Water Planning and Engagement (consult with CLC and TOs)
2.7 Monitor change in water availability to water dependent cultural values to monitor compliance with licence conditions.	2.7 Develop and implement water monitoring plan	2.7 Water dependent cultural values related monitoring included in water monitoring plan; Monitoring undertaken at relevant reference sites.	DENR water planning and water monitoring
2.8 Guidelines for minimal impact unlicensed water use.	2.8 Develop guidelines and promote to land holders.	2.8 All Ti Tree land holders are aware of guidelines within two years of their development.	DENR Water Planning and Engagement CLC/Anmatyerr Rangers

Objective 3		**Indicators of achievement**	
Water of suitable quality available for domestic public water supply in perpetuity		No decrease in quality and quantity of water available for public water supply	
Output/result	**Activities**	**Indicators of achievement**	**Lead responsibility**
3.1 Allocations prioritise domestic and public water supply above other consumptive uses	3.1 TTWAP development process	3.1 Allocations established in TTWAP.	DENR Water Planning and Engagement
3.2 Assessment of future domestic and public water supply demand	3.2 Consultation with Power & Water and stakeholders	3.2 Forecast demand reported in TTWAP.	DENR Water Planning and Engagement
3.3 Technical report: salinity distribution in soil profile	3.3 Field work & Geoscience Australia mapping	3.3 Completion of technical report by in three years.	DENR Water Assessment
3.4 Technical report: potential water quality changes due to consumptive use (include solute transport model)	3.3 Develop / implement solute transport model. May require additional water quality monitoring (see Activity P4 & P5)	3.3 Report completed by in two years.	DENR Water Assessment
Objective 4		**Indicators of achievement**	
Fair access to water for economic activities for current potential users and future generations		Stakeholder satisfaction with consistency, clarity and transparency of allocation and licensing process No decrease in availability of water for consumptive use for potential future users	
Output/result	**Activities**	**Indicators of achievement**	**Lead responsibility**
4.1 Licence applications assessed through clear and transparent process	4.1 Licence information published on the NT Government's Water Licensing Portal.	4.1 Compliance with the *Water Act* 1992/policy and licensing procedures; all Ti Tree licences available publicly on the NT Government's Water Licensing Portal.	DENR Water Licensing and Regulation

4.2 Water Trading	4.2 Implement trading guidelines and other improvements to facilitate trading.	4.2 Trading guidelines implemented.	DENR Water Licensing and Regulation
4.3 Unused licensed water entitlement procedures	4.3 Implement return of unused licensed water entitlement procedures	4.3 Decisions made on unused water by the Controller of Water Resources as per unused licensed water entitlement procedures and the *Water Act* 1992.	DENR Water Licensing and Regulation
Objective 5		**Indicators of achievement**	
Enhance opportunities for Aboriginal people to benefit from consumptive use and management of water		Water available from the SWR for eligible Aboriginal rights holders by 2023.	
Outputs	Activities	Indicators of achievement	Lead responsibility
5.1 Implement Strategic Aboriginal Water Reserve (SWR) Policy Framework in TTWAP.	5.1(a) TTWAP development process. 5.1(b) Establish SWR notional allocation.	5.1 TTWAP includes notional SWR.	DENR Water Planning and Engagement
5.2 Anmatyerr Kwatj (water) advisory committee (AKAC) or similar.	5.2 Collaborate with CLC to coordinate AKAC meetings.	5.2 Target: From plan commencement, equivalent number of AKAC meetings to TTWAC meetings or similar consultation process.	DENR Water Planning and Engagement and CLC
5.3 Monitoring data collected by Anmatyerr Rangers/monitoring reports.	5.3(a) Develop Ranger monitoring plan (see activity P4 & P5). 5.3(b) Implementing monitoring and reporting activities (include capacity-building).	5.3 Quality-assured monitoring data collected by Anmatyerr Rangers integrated into DENR data management and reporting systems.	DENR Water Planning and Engagement CLC/Anmatyerr Rangers

6.2 Water accounting period

The water accounting period for the TTWAP is 12 months from 1 July to 30 June in the following year.

6.3 Protection of environmental and cultural values

6.3.1 Terrestrial vegetation groundwater dependent ecosystems

It is recommended that water extraction should not result in change to groundwater conditions beyond the following limits to change within the GDE protection area (Figure 15) unless it can be shown that the vegetation is not accessing groundwater. Assessment of compliance with these criteria should be based on groundwater modelling giving consideration to the cumulative effect of all extraction.

The following limits to change in groundwater levels within the GDE protection area are recommended:

- Modelled extraction should not cause maximum depth to water table to exceed 15 metres below ground level.
- Modelled extraction should not result in the maximum depth to water table declining by more than 50% below the levels that would be expected under a natural baseline scenario (no pumping scenario).
- Modelled extraction should not result in a rate of groundwater drawdown that exceeds 0.2 m/year.

6.3.2 Aboriginal cultural values

Groundwater modelling (on cumulative consideration of all licensed extraction) should be undertaken to determine if proposed water extraction (i.e. licence applications) will unacceptably impact on groundwater dependent Aboriginal cultural values. Modelling should demonstrate that extraction would not result in a change to groundwater conditions that would result in loss or decline of cultural values.

The Central Land Council will maintain a record of relevant places and cultural values reliant on groundwater access. The record will not be publicly available in order to protect culturally sensitive information and cultural rights. The CLC may update the record of cultural values from time to time including between WAP reviews (e.g. as knowledge of cultural site location improves). Furthermore, where justified CLC may recommend additional cultural values for assessment of potential impact, noting the statutory timeframes for licence assessment within sections 71B and 71C of the *Water Act* 1992.

Cultural values protection also requires the participation of local Aboriginal people in water management and planning, education of regulators about protection requirements, site monitoring and by activities to protect culturally important values from degradation. A Traditional Owner advisory committee (or a different approach that achieves the same outcomes) to meet at the time of water advisory committee meetings is recommended along with the involvement of the Ranger program in cultural site condition assessment.

Demonstration of appropriate consultation with the Traditional Owners and commitments to protect cultural values from the impacts of groundwater extraction that can be enforced though licence conditions is recommended for the Controller of Water Resource's consideration of licence applications.

6.3.3 Monitoring triggers

The plan recommends monitoring conditions and corrective actions for licences that have potential to impact terrestrial vegetation GDEs or groundwater dependent cultural values.

Licence conditions should identify specific monitoring sites and monitoring parameters that determine limits to change at the sites. Licences should contain specific clauses that allow the Controller of Water Resources to request corrective actions (e.g. changed pumping regimes) be employed, or to otherwise amend, modify or revoke a licence where monitoring suggests unexpected and unacceptable impacts.

Monitoring sites should be:

- proximate to groundwater dependent cultural sites or ecosystems that may be impacted by groundwater extraction; or
- located between extraction sites and location of important GDE or cultural assets, in order to provide early warning of potential changes in groundwater levels.

Trigger levels should be specified for these or other sites to identify thresholds at which changes in pumping regimes are required.

6.4 Licensing and other relevant regulation, policy and procedures

6.4.1 Groundwater licences

Groundwater extraction is subject to the requirements of the *Water Act* 1992. In accordance with section 60 of the Act, a person is not permitted to take water except in accordance with a licence. Under the *Water Act* 1992, there is no licence requirement for the beneficial use 'Rural Stock and Domestic Use,' and general exemptions to take water from an aquifer from all bores on the parcel of land not exceeding 5 megalitres per year for combined beneficial uses (refer *Gazette* S109 of 20 December 2018) and for road works (refer *Gazette* S60 of 28 November 2008).

6.4.2 Surface water licences

Surface water in the district is ephemeral and unreliable and is not a practical or reliable source of water for consumptive use. Surface waters (e.g. rivers and wetlands) are recognised for their primary role in supporting natural ecosystems and are typically associated with sites of high cultural significance for Aboriginal people. In accordance with the *NT Water Allocation Planning Framework*, 95 per cent of surface water resources are allocated for environmental and cultural use and no more than 5 per cent of surface water is allocated to the consumptive beneficial use for rural stock and domestic use.

Dams are generally considered to be an unreliable source of water given the annual average pan evaporation rate in the TTWCD is around 3,000 mm. Under the *Water Act* 1992, a permit is generally required to construct a dam. However, rural dams with a bank height less than 3 metres and a catchment area of less than 5 km^2 are exempt from permit and licence requirements (*Gazette* S63 of 6 July 2016).

Regardless of these exemptions, any construction of dams or water-intercepting/diverting works may require a permit under other legislation (particularly the *Sacred Sites Act*). As such it is the land owner's responsibility to ensure all appropriate permits and approvals have been granted under all relevant legislation before any construction begins.

6.4.3 Return of unused water

Licence conditions require licensees to use their licensed water entitlements. The overarching intent of the Northern Territory Government's return of unused licensed water entitlements policy is to return water to the consumptive pool for redistribution and economic benefit. As a general rule, if a licence holder cannot demonstrate the need to retain an entitlement for use during the term of the licence, and the capacity to use the water, then the entitlement may be returned to the consumptive pool by the Controller of Water Resources, through licence amendments.

6.4.4 Water trading

The following water trading guidelines are established by this plan:

1. Trade should only occur within the same water resource, which is within the same GMZ.
2. Trade should only occur within or between the beneficial use categories of agriculture, mining activity, petroleum activity, industry and Strategic Aboriginal Water Reserve (either as a subclass of other beneficial uses or as a beneficial use in its own category, subject to amendments to the *Water Act* 1992).
3. Trade of water that results in an increase in extraction from within the GDE protection area should trigger assessment as per Section 6.2 *Protection of environmental and cultural values*.
4. Trade of water from the Strategic Aboriginal Water Reserve will be in accordance with the relevant policy framework.

General water trading guidelines may also be established by Northern Territory Government policy, which may be updated from time to time independently of this plan.

6.4.5 Licensed use from SWR allocations

Access to an SWR will be consistent with the Northern Territory Government's *Strategic Aboriginal Water Reserves Policy Framework* (NT Government 2017). As for any NT Government Policy, this may be updated from time to time independently of this plan.

The eligible rights holders for the SWR or their authorised representatives can provide consent for access to the Strategic Aboriginal Water Reserve. The Ahakeye Aboriginal Land Trust can be contacted via the Central Land Council www.clc.org.au.

6.4.6 Other relevant polices

The Department of Environment and Natural Resources undertakes water management and regulation under a range of NT Government policies which may be updated from time to time independently of this plan. For updates on water resource management policies go to www.nt.gov.au/water.

7 Risk identification and mitigation strategies

7.1 Risk and uncertainty

7.1.1 Climate variability and change

Estimated sustainable yield and allocations to beneficial uses have been determined based on historic climatic data only and do not consider the possible effect of climate change on the long-term availability of water.

There is no standard for projecting future climate patterns. Different climate scenarios invariably result in different rainfall and recharge estimates and predict differing impacts on the estimated sustainable yield and GDEs. For the purpose of this plan, the past 100 years has been assumed to represent the next 100 years, and has been selected for modelling purposes. Figure 3 shows the relationship between rainfall and recharge for the past 100 years.

Alternative climate scenarios will be considered at the review stage of the plan (within 5 years) and for future plans (after 10 years). Presently available climate projections do not provide sufficient certainty, particularly with respect to rainfall, to be applied with confidence.

The Rangelands Cluster Report of Climate Change in Australia (Watterson et al. 2015) projected climate change in the rangelands region based upon a set of 40 global climate models. The report projected that average temperatures will continue to increase in all seasons (with very high confidence) and hence the Ti Tree region is likely to experience more hot days and warm spells, and fewer frosts. Changes to summer rainfall are possible but unclear and it is likely the intensity of extreme daily rainfall events, when they occur, will increase. Time spent in drought is projected to increase over the course of the century (with medium confidence). However, the cluster report also recognised that over periods of years or decades, the natural variability in the climate system can mask or enhance any long-term human-induced trend, particularly in the next 20 years.

7.1.2 Proposed development and land use change

The majority of land within the TTWCD is held under pastoral lease or by Aboriginal Land Trusts. There may be some future applications for non-pastoral use for the purpose of irrigated agriculture on some properties. The *Pastoral Land Act* 1992 enables diversification of activities on pastoral lease land, where authorised.

Arafura Resources has proposed development of the Nolan's Bore mine in the south-west of the TTWCD, outside of the Ti Tree Basin. If the development goes ahead it will consist of a large open pit that overlies tributaries of the Woodforde River in the south-west of the TTWCD, located in the Low Yield GMZ.

7.1.3 Caveats or limitations on the underpinning science

Distribution of GDEs and impacts of extraction

There is some species-level knowledge of GDEs within the TTWCD, focused on the Ti Tree Basin; however, the focus of research to date has been on identifying species which are groundwater dependent, rather than their distribution across the region. Understanding of the distribution of groundwater dependent ecosystems within the Ti Tree region is limited.

Distribution of terrestrial GDEs has been surmised using depth to water table and remote sensing techniques that identify persistent green woody vegetation overlying shallow groundwater areas; it has not been confirmed by field measurement. Shallow groundwater areas are mapped in Figure 8. GDEs may occur anywhere within the areas where depth to groundwater is less than 15 metres. Remote sensing is unlikely to detect sparse occurrences of trees that access groundwater due to limited resolution of satellite imagery. It is also difficult to determine if persistent green woody vegetation is a result of surface water inflow, shallow groundwater (i.e. a GDE) or a combination.

A GDE protection area is shown in Figure 15. The protection area overlays the Ti Tree Aquifer where the depth to groundwater is less than or equal to 20 metres below ground level (mbgl). This level was chosen as the depth to water table is mapped from a limited data set and is assumed to contain a margin of error.

The assumption that declining water levels would impact vegetation is based on significant impacts on vegetation from water table decline observed from studies conducted in other locations. There are no published experimental data available for Australian species that examine the impact of different rates of increase in depth-to-groundwater.

The risk to groundwater dependent ecosystems within the TTWCD, uncertainty about distribution of GDEs and the relationship of drawdown to impacts justifies applying the 'precautionary principle.' Water management guidelines have been developed to protect vegetation communities that have a high probability of being groundwater dependent (see Section 6.2). It is noted that GDEs may coincide with sites of high cultural value to Traditional Owners, and while cultural value mapping is underway, a comprehensive map has not been completed.

Groundwater assessment

Although the Ti Tree Aquifer is one of the most well studied arid zone aquifer systems in the world, the underpinning science is limited by the availability of data (e.g. number and distribution of monitoring sites) and the time over which the system has been studied. Scientific observations of parameters such as aquifer depth, thickness, porosity, transmissivity, salinity etc. are made at point locations, and extrapolated between monitoring points through modelling.

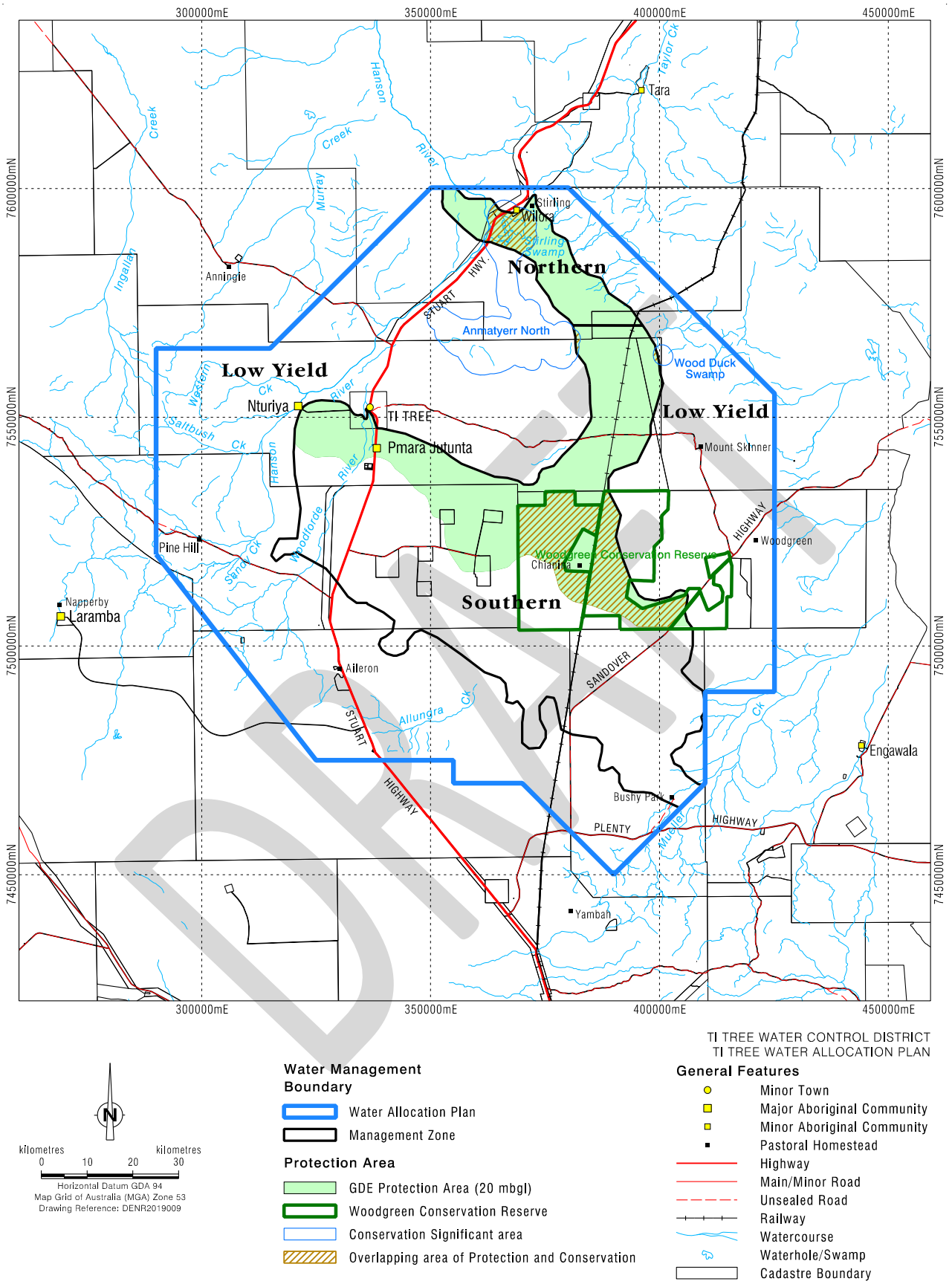

Figure 15. Groundwater dependent ecosystem protection area

Groundwater modelling

This plan assumes that steady state modelling for the Ti Tree Aquifer provides an accurate estimate of water in storage, recharge and an accurate estimate of how the aquifer responds to extraction, however models have limitations. Steady state models are limited in their use in the arid environment because of the large variation in rainfall and recharge from year to year. Any model depends on current and accurate input data and parameters.

Despite the Ti Tree Aquifer being one the best studied arid zone hydrological systems, it is a large and complex system and the understanding of groundwater dependent ecosystems (GDEs), recharge mechanisms and other Ti Tree Basin characteristics is far from complete. It is important that the differences between observed and predicted groundwater levels are monitored and the model is adjusted accordingly.

7.2 Risk assignment

It must be understood by all water users in the Northern Territory that:

1. Their rights to extract and use water, whether under *Water Act* 1992 (for example for rural stock and domestic purposes) or under a licence, are not, and cannot be, guaranteed by the Northern Territory Government.
2. They bear the risks of any reductions to water availability under their licence resulting from seasonal or long-term changes in climate, and from periodic natural events such as drought or contamination.
3. They bear the risk of reduced water availability under a water licence arising because of *bona fide* improvements in the knowledge about the water resource's capacity to sustain particular extraction levels.

7.3 Mitigation Strategies

Proposed mitigation (management) strategies for the risks associated with this plan are outlined in Table 13, following.

Table 13. Summary of risks associated with the plan and proposed mitigation strategies

(See Schedule B. Description of qualitative measures of likelihood, consequence and risk rating categories)

Risk	Likelihood	Consequence	Initial Risk Rating	Management strategy in the plan [linked outputs/actions]	Risk Rating following mitigation
Modelling under/over estimates extraction impact on groundwater drawdown and/or water quality, and subsequent impact on groundwater dependent environmental and cultural values	Likely: Models use limited samples, approximations & historical data to make predictions; they are not exact and are only indicative of future 'real world' responses.	Moderate: (If drawdown under estimated): impacts to groundwater dependent environmental & cultural values in the future (If drawdown over estimated): Consumptive allocations may be over conservative.	High	Monitor actual drawdown at reference sites. Consider modelled drawdown rate and limits in licence decisions. Review allocations within every 5-year period to account for improved knowledge of GDE requirements, modelling and observations. Implement strategic monitoring and research program to improve modelling and knowledge of the aquifer. [1.4, 1.5, P1 & P3]	Moderate
Extraction limits exceeded	Unlikely: Overall compliance with licensed limits is high and extraction has historically remained well below allocations	Minor: Long term non-compliance may mean extraction is greater than sustainable yield; may impact environmental or cultural values	Low	Continue to monitor extraction and compliance with licence conditions. Independently and with other agencies (e.g. DPIR) educate users about water efficiency. Where appropriate, pursue breaches with legal action as per the *Water Act* 1992. [P2 & P3]	Low

Risk	Likelihood	Consequence	Initial Risk Rating	Management strategy in the plan [linked outputs/actions]	Risk Rating following mitigation
Uncertainty about estimated sustainable yield / consumptive pool impedes investment	Possible: Models use limited samples, approximations & historical data to make predictions; they are not exact and are only indicative of future 'real world' responses.	Moderate: Unfavourable risk profile for business; Reduced confidence / investment in agricultural or industry development	High	Ensure that model inputs are conservative (e.g. assume highest scenario extraction, assume realistic recharge volumes). Increase certainty by applying the precautionary principle when determining sustainable yield; this will reduce risks of ESY being reduced in future iterations of the plan. [P1]	Low
Impact on water quality through contamination from agricultural chemicals or mobilisation of saline groundwater	Possible: Extraction will change the flow of groundwater and could draw more saline water into new locations. Farm chemicals can cause contamination if not used responsibly	Minor: Impacts (if they occur) expected to occur slowly	Moderate	Investigate salinity within soil profile. Develop solute transport model. Implement monitoring and research program to improve modelling and knowledge of the aquifer. Bore construction inspections/compliance. [3.3, 3.4, P4, P5]	Moderate
Licence holders fail to utilise or under utilise their entitlement	Likely: There has been a consistent pattern of underutilisation (approx. 20% of entitlements actually used)	Minor: Failure to maximise development potential, loss of opportunities for new development if water is locked-up in unused entitlements	High	Application of management of unused water policy. Trade in water entitlements (once resource fully allocated). [P2, 4.2, 4.3]]	Moderate

Risk	Likelihood	Consequence	Initial Risk Rating	Management strategy in the plan [linked outputs/actions]	Risk Rating following mitigation
Aboriginal cultural values threatened by stock water use.	Likely: Already occurring and expected to continue without intervention	Moderate: Negative impacts to cultural values reliant upon surface water	High	Foster partnerships between CLC Anmatyerr Ranger Group, TOs and pastoralists to enhance management of water dependent cultural values [2.8]	High
Aboriginal cultural values threatened by inadequate Aboriginal participation in water planning and governance	Likely: Historically low levels of participation and low capacity within DENR to effectively facilitate Aboriginal participation	Moderate: Cultural values unknown to DENR, unrecognised therefore increased risk that they are not protected	High	Collaborate with CLC to establish an Anmatyerr Kwatj (water) advisory committee (AKAC) Work with AKAC and CLC Anmatyerr Rangers to improve management and understanding of cultural values associated with water [5.2]	Moderate
Entitlements fully allocated before Aboriginal land owners have capacity to participate in development that requires water	Almost certain: Existing licences for agriculture have locked up the water that would have been allocated to the SWR. The SWR will commence as a notional reserve.	Moderate: Aboriginal land owners disadvantaged / unable to attain economic benefit from consumptive use of water	Extreme	Establish SWR – initially as a notional reserve. Ensure an allocation is provided to the SWR before new licence applications are provisioned at the commencement of the planning period Develop and implement unused water policy [5.1, 4.3]	Moderate
Pressure on water resources from mining and petroleum	Possible: There is potential for future extraction of water for mining and petroleum purposes. Proposed mine would not use water from Ti Tree Aquifer.	Minor: Future mining and petroleum activities will be subject to the *Water Act* 1992 and the WAP	Moderate	Current demand for water for mining considered in the plan and allocations Extraction of water for mining and petroleum regulated under the *Water Act* 1992 [P1]	Low

8 Implementation, monitoring and review

This section describes the roles and responsibilities of the various parties to implement, monitor, review and update the plan, including adapting the plan where necessary.

8.1 Adaptive management

Adaptive management is an iterative process to assist decision making when there is uncertainty. It aims to reduce uncertainty by monitoring resources and responses to management actions and using this information to improve future management actions to meet the water management objectives.

As outlined in the risk management table (Table 13), there is uncertainty regarding:

- Model assumptions and interpretation - the estimated sustainable yield (volume of water) available because of long term climate variability and unpredictability of recharge events, and the density of data regarding depth to groundwater, aquifer properties and salinity
- Groundwater dependent ecosystems – their distribution and significance, environmental water requirements and response to increased extraction
- Cultural sites and values - the full extent of cultural and practices and their water requirements and responses to increased extraction.
- Demand for water resources - the pace and type of development that occurs and the response of the aquifer.

Adaptive management is undertaken at the whole of plan scale (whole plan review and development of a new plan) and is also applied to management decisions within the plan.

8.1.1 Plan review

Continuous improvement is required at the whole of plan scale. In accordance with section 22B(4) of the *Water Act* 1992, the Minister must ensure that a review of a water allocation plan is conducted at intervals not longer than 5 years. A revision of this plan will be required in 2024, and it will be subsequently replaced by a new plan in 2029. These process will capture improved knowledge and will be generally informed by the outcomes of the monitoring program, research findings, and community consultation. If appropriate, the allocations within the plan may also be adjusted to align with the improved understanding. All public submissions, as well as any Northern Territory or regional policies or agreements coming into force after the initial declaration and with relevance to this plan, will be considered. Under limited circumstances, such as those relating to level of development or risk to the resources, then a new plan may be declared prior to 2029.

8.1.2 Adaptive management framework - licensing

Figure 16 illustrates the process for adaptive management through licensing, which recommends establishing licence conditions that can require change in pumping regimes in response to monitoring of important parameters, such as groundwater drawdown or tree health.

Table 14 recommends the adaptive response to changes in conditions in the TTWCD at the whole of water allocation plan level.

Licences will be reviewed against licence conditions and water use annually and reviewed at the end of their ten-year term before renewal.

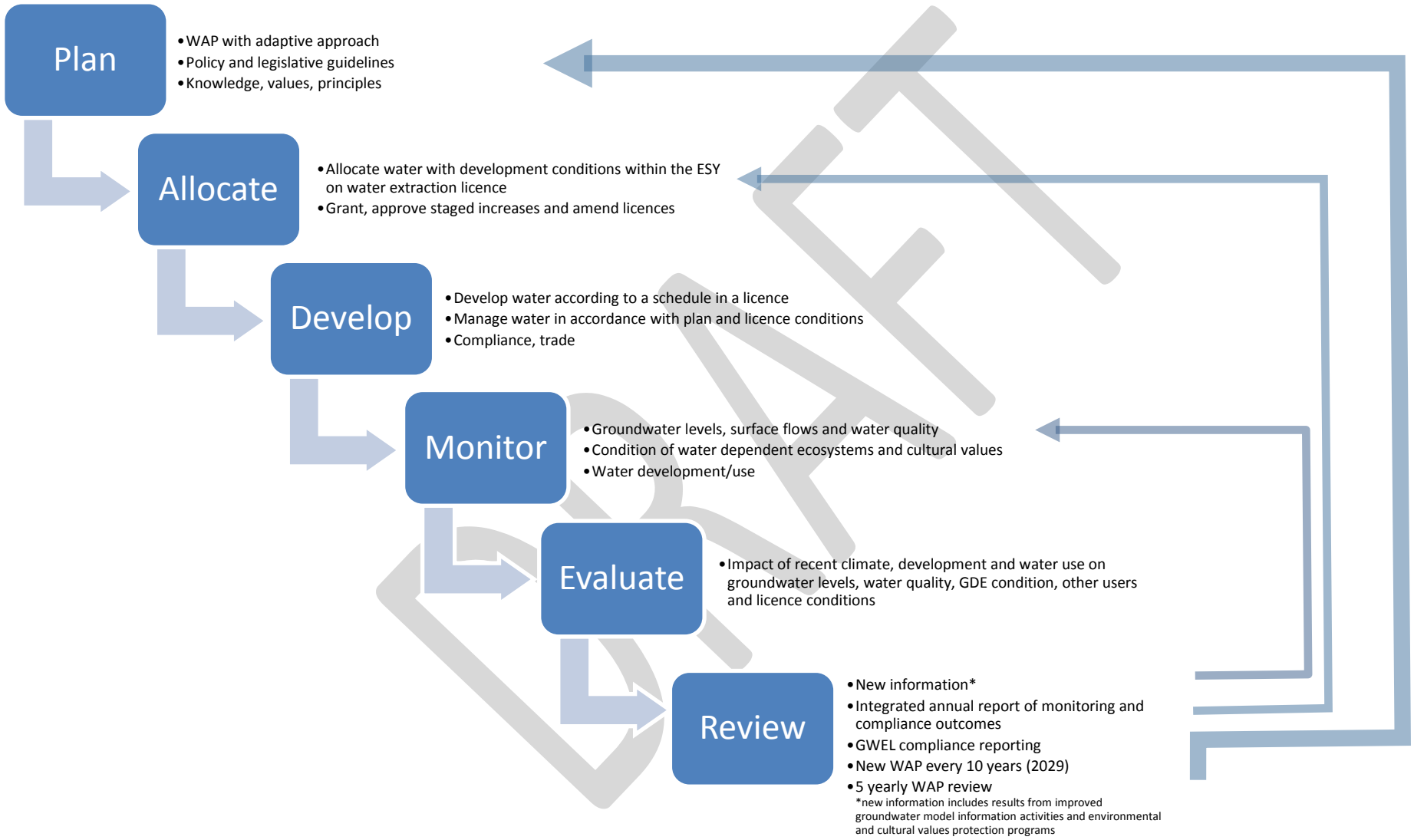

Figure 16. Adaptive management diagram

Table 14. Adaptive management framework

Note: Risks identified in this table correspond with relevant risks also identified in Table 13 (Summary of risks associated with the plan and proposed mitigation strategies)

Risk	Monitoring	Effect	Treatment	Related WAP outputs
Modelling under estimates impact of extraction on groundwater drawdown and/or water quality.	• Water table depth below ground level • Rate of water table drawdown • Condition of cultural values • Condition / extent of GDEs • Water quality.	Negative impact on groundwater dependent environmental and cultural values.	• Monitoring may trigger change in extraction regime (specified in licence condition); e.g. pumping schedule, bore location, volume.	1.6, 1.7, P4, P5
Modelling over estimates impact of extraction on groundwater drawdown and/or water quality.	• As above	Consumptive allocations overly conservative.	• Monitoring data included in future iterations of the water model. ESY / Allocations may be increased at plan review.	1.6, 1.7, P4, P5
Licence holders fail to utilise or underutilise their entitlement.	• Monthly/annual extraction volumes via pumping data and inspections	Loss of opportunities for new development if water is locked-up in unused entitlements.	• Implement unused water policy - return of unused water to consumptive pool.	4.3
Entitlements fully allocated before eligible Aboriginal rights holders have capacity to participate in development that requires water.	• Total volume of entitlements	No water available within SWR.	• Return unused water to consumptive pool. Provision SWR based on hierarchy of priority for returned water.	4.3

8.2 Implementation

The plan will be implemented in accordance with the *Water Act* 1992:

1. Consistent with section 23(1B)(a) of the Act, the Minister may ask a water advisory committee to advise on the effectiveness of the water allocation plan in maximising economic and social benefits within ecological restraints.
2. Consistent with section 34 of the Act, the Controller of Water Resources must ensure, as far as possible, that a continuous assessment of water resources of the Northern Territory is carried out.
3. Consistent with section 46 of the Act, licence holders must use water consistent with the terms specified on the licence and the management arrangements outlined in the plan.

The Territory Government maintains a network of monitoring bores and surface water gauging stations and is responsible for water resource investigation studies and water resource modelling. The monitoring program for the TTWCD was not implemented in 2012 and 2018; however, the monitoring program will be further developed and reinstated upon commencement of this new plan.

The overall implementation of the plan will be guided by the management strategies identified in Table 12 in Section 6.1.

8.3 Monitoring implementation

A 'project management' approach will be taken to monitor and support implementation of this plan. Implementation progress will be monitored against the target outputs / results and indicators as described in Table 15, Section 8.5.

DENR Water Resources Division will coordinate a TTWAP project team that will meet quarterly or as required, to plan and track implementation progress.

A Ti Tree Water Advisory Committee should meet at least twice a year to provide external oversight of plan implementation.

8.4 Reporting

The Northern Territory Government maintains an up to date, public and transparent record of all water allocations, entitlements and licences on its Water Licensing Portal at: www.waterresources.nt.gov.au/licenceportal.

The overall performance of this plan will be assessed at the time of review or new plan development. The reviewed or new plans will contain records of performance over the past period and will summarise data associated with performance indicators, such as licensed volume and actual pumping for each zone and beneficial use category. An updated Ti Tree Water Assessment report will also be produced upon the 5-yearly review and 10-year new plan development. The assessment will document any changes in the condition of the resources that have occurred because of plan implementation.

8.5 Evaluating achievement of plan objectives

Monitoring will be undertaken to evaluate achievement of the plan objectives against the indicators in Table 15.

Table 15. Monitoring matrix

Plan objective	Indicators	Output/Activity	Timing	Responsibility
Avoid detrimental impacts to water dependent ecosystems as a consequence of consumptive water use	Water monitoring at key reference sites shows that sufficient water is available to maintain condition of water dependent ecosystems	P4. – P6. Ti Tree water monitoring plan, implementation & reporting	Ongoing monitoring Annual report (Dec)	DENR Water Assessment; Monitoring and Planning
Avoid negative impact to cultural values reliant upon surface or groundwater as a consequence of consumptive water use	Water monitoring at key reference sites shows that sufficient water is available to maintain cultural values reliant upon surface or groundwater	P4. – P6. Ti Tree water monitoring plan, implementation & reporting	Ongoing monitoring Annual report card (Dec)	DENR Water Assessment; Monitoring and Planning
Water of suitable quality available for domestic public water supply in perpetuity	No decrease in quality and quantity of water available for public water supply	P4. – P6. Ti Tree water monitoring plan, implementation & reporting	Ongoing monitoring Annual report (Dec)	DENR Water Assessment; Monitoring and Planning
Fair access to water for economic activities for current potential users and future generations	Stakeholder satisfaction with consistency, clarity and transparency of allocation and licensing process No decrease in availability of water for consumptive use for potential future users	Stakeholder survey P4. – P6. Ti Tree water monitoring plan, implementation & reporting	Annual survey (Dec) Ongoing monitoring Annual report (Dec)	DENR Water Planning DENR Water Assessment; Monitoring and Planning

Plan objective	Indicators	Output/Activity	Timing	Responsibility
Enhance opportunities for Aboriginal people to benefit from consumptive use and management of water	Water available from the SWR for eligible Aboriginal rights holders by 2023. Number and type of water management activities undertaken by Traditional Owners or the Anmatyerr Ranger Program.	Assessment of SWR availability Annual activity report (Dec)	Ongoing Commence 2019; ongoing	DENR Water Planning and Engagement
Deliver TTWAP outputs; refer Table 12	Refer to indicators in Table 12	Annual report on TTWAP implementation presented to TTWAC.	Annually	DENR Water Planning and Engagement

Schedule A: Stakeholder and community consultation

This schedule will be completed for the final version of the TTWAP (after stakeholder and community consultation has concluded).

Table 16. Level of stakeholder participation in water allocation planning

Water allocation planning stage	Engagement goal	Promise to stakeholders[7]
Problem definition	• Identify stakeholders • Confirm beneficial uses for water	• CONSULT: We will keep you informed, listen to and acknowledge your views and provide feedback
Information	• Improve understanding of consumptive demand, and water related environmental and cultural assets • Inform stakeholder about water resource characteristics	• CONSULT: We will keep you informed, listen to and acknowledge your ideas and knowledge, and provide feedback
Alternatives	• Formulate different planning options (e.g. alternative allocations)	• INVOLVE: We will work with you to ensure your ideas, needs and concerns are reflected in planning options identified
Assessment	• Obtain stakeholder feedback on plan options (e.g. alternative allocations)	• CONSULT: We will keep you informed, listen to and acknowledge your views, and provide feedback
Decision	• Inform stakeholders of planning decisions	• INFORM: We will keep you informed and provide feedback on how participant input influenced the planning decision

[7] Adapted from International Association for Public Participation Australasia, IAP2 Public Participation Spectrum; https://www.iap2.org.au/resources/public-participation-spectrum

Schedule B: Risk definition and classification

1. Likelihood of occurrence

Descriptor	Description
Almost certain	Is expected to happen in most situations
Likely	Will probably happen in most situations
Possible	May happen at some time
Unlikely	Could happen at some time
Rare	May happen only in exceptional situations

2. Consequence (impact)

Descriptor	Detailed description
Insignificant	Immaterial impact to environmental and/or cultural values; and/or inconsequential financial impact and reputational damage
Minor	Material but low impact on environmental and/or cultural values; and/or low financial impact and reputational damage
Moderate	High impact on environmental and/or cultural values; and/or moderate financial impact and reputational damage
Major	Extensive impact to environmental and/or cultural values; and/or high financial impact and reputational damage
Catastrophic	Severe, irreversible impact to environmental and/or cultural values; and/or huge financial loss and reputational damage

3. Risk rating (Matrix)

Likelihood of occurrence	**Consequence (impact)**				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	M	H	E	E	E
Likely	M	H	H	E	E
Possible	L	M	H	E	E
Unlikely	L	L	M	H	E
Rare	L	L	M	H	H

Legend:
Extreme (E): urgent intervention / correction required
High (H): matter requiring ongoing / systematic action to manage
Moderate (M): identify responsibility and actions to address
Low (L): manage by routine policy and procedures.

Glossary

Environmental water requirements	Water (e.g. flow, volume, depth, timing, seasonality, duration) required to sustain the ecological values of water dependent ecosystems, including their processes and biological diversity.
Ephemeral	Not permanent.
Estimated sustainable yield (ESY)	To meet the requirements of section 22B of *Water Act* 1992, the ESY is the amount of water that can be taken from the water resource to support beneficial uses without compromising key cultural and environmental values, or ecosystem functions or the productive base of the resource or or declared water quality standards, criteria or objectives.
Fractured rock	Rock with linear gaps of varying direction, length and width.
Groundwater	Water occurring or obtained from below the surface of the ground (other than water contained in works, not being a bore, for the distribution, reticulation, transportation, storage or treatment of water or waste) and includes water occurring in or obtained from a bore or aquifer.
Groundwater dependent ecosystem (GDE)	Ecosystem that requires access to groundwater to meet all or some of its water requirements to maintain communities of plants and animals, ecological processes and ecosystems services.
Hydrogeological	Study of the interrelationship between geology and water, particularly groundwater.
Hydrographs	A graph showing the properties of water.
Licence	A licence granted by the Controller of Water Resources under section 45 of the *Water Act* 1992 to take water from a waterway; or A licence granted by the Controller of Water Resources under section 60 of the *Water Act 1992* to take water from a bore.
Licensed entitlement	The volume of water that may be taken under a licence in accordance with the conditions of that licence.
Minister	Minister with portfolio responsibility for the *Water Act 1992*under the Administrative Arrangements Order.
Quaternary	A period of geological time dating back from the present to 2 million years ago.
Surface water	Under the *Water Act 1992*, surface water means water flowing or contained in a waterway. In this plan, it includes water found in rock holes, rivers, creeks and flood-outs. Sometimes surface water is called free water to distinguish it from water in soil. Springs are places where discharging groundwater becomes surface water.

Through-flow	Water that infiltrates the soil surface and then moves laterally through the upper soil horizon, often as shallow perched saturated flow above the main groundwater table.
Ti Tree Water Allocation Plan area	Equivalent to the Ti Tree Water Control District – see description in Section 1.2.
Transmissivity	The rate at which water is transmitted horizontally through an aquifer.
Unused water	Refer to relevant NT Government policy.
Water Licensing Portal	Available from: www.waterresources.nt.gov.au/licenceportal

Abbreviations

AKAC	Anmatyerr Kwaty Advisory Committee (Traditional Owner (TO) committee established by CLC to provide input into the TTWAP and support TO members of TTWAC).
CLC	Central Land Council
DENR	NT Department of Environment and Natural Resources
DPIR	NT Department of Primary Industry and Resources
ESY	Estimated sustainable yield
GDE	Groundwater dependent ecosystem
GL	Gigalitre or 1,000ML or 1,000,000kL or 1,000,000,000 litres
GMZ	Groundwater management zone.
GWEL	Groundwater extraction licence
kL	Kilolitre or 1000 litres
mbgl	Metres below ground level.
ML	Megalitre or 1,000 kL or 1,000,000 litres
NOI	Notice of intent
NRETAS	Natural Resources, Environment, Tourism, the Arts and Sport
SWEL	Surface water extraction licence
SWR	Strategic Aboriginal Water Reserve
TO	Traditional owner
TTWAC	Ti Tree Water Advisory Committee
TTWAP	Ti Tree Water Allocation Plan
TTWCD	Ti Tree Water Control District
WAC	Water advisory committee
WAP	Water allocation plan
WCD	Water control district

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