Estimation of groundwater resource capacity and recommended extraction limits for the Adelaide Plains Water Allocation Plan: Addendum 2020

Department for Environment and Water

September, 2020

DEW Technical report 2020/17

Government of South Australia
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September 2020

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DEW-TR-2020-17
ISBN 978-1-925964-41-7

Preferred way to cite this publication

Department for Environment and Water (DEW), 2020. *Estimation of groundwater resource capacity and recommended extraction limits for the Adelaide Plains Water Allocation Plan: Addendum 2020*, DEW Technical report 2020/17, Government of South Australia, Adelaide.

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1 Introduction

This addendum amends DEWNR Technical Report 2017/03, *Estimation of groundwater resource capacity and recommended extraction limits for the Adelaide Plains Water Allocation Plan*.

It is to be referred to when reading that report. The amendments relate to:

- the boundaries of the groundwater management zones proposed in that report and the subsequent recommended extraction limits.
- the separation of the recommended extraction limits presented in DEWNR Technical Report 2017/03 solely for the Central Adelaide (CA) Prescribed Wells Area (PWA), as part of the existing user process.
- the resource capacity and recommended extraction limit for the Quaternary aquifers groundwater management zone (GMZ).

The addendum does not alter the intent or purpose of DEWNR Technical Report 2017/03. The report remains valid as a supporting document to the WAP in combination with this addendum. The documentation of amendments is directed at maintaining transparency in the water allocation plan development process.

2 Amendments to groundwater management zones

During the drafting of the WAP, it became apparent that amendments needed to be made to some of the groundwater management zones proposed earlier in DEWNR Technical Report 2017/03. These changes are summarised in Table 2.1.

Table 2.1. Amendments made to the groundwater management zones

Proposed GMZ as in DEWNR Technical Report 2017/03	New proposed GMZ
Quaternary aquifers	No change
T1 NAP	Top right boundary cropped
T1 Dry Creek	T1 Regional
T1 Grange	
T1 Thebarton	
T1 Central Adelaide	
T2 NAP	The two separate GMZs remain, but there is a small change to the shared boundary
T2 Kangaroo Flat	
T2 Virginia	No change
T2 Regional	T2 Regional
T2 Osborne	
T2 Regency Park	
T1 and T2 GGE	T1, T2 & FRA GGE
FRA GGE	
T3 and T4 aquifers	No change
FRA Northern	Northern FRA
FRA Torrens	
FRA Patawalonga	Southern FRA
FRA Southern	
Noarlunga Embayment	No change

NAP = Northern Adelaide Plains
GGE = Golden Grove Embayment
FRA = Fractured rock aquifer

2.1 T1 aquifer GMZs

The new T1 Regional GMZ was created by combining the T1 Dry Creek, T1 Grange, T1 Thebarton and T1 Central Adelaide GMZs (Figure 2.1). The top right corner of the T1 Regional GMZ was also cropped to the southern boundary of the T2 Kangaroo Flat GMZ as the T1 aquifer is not present in the area.

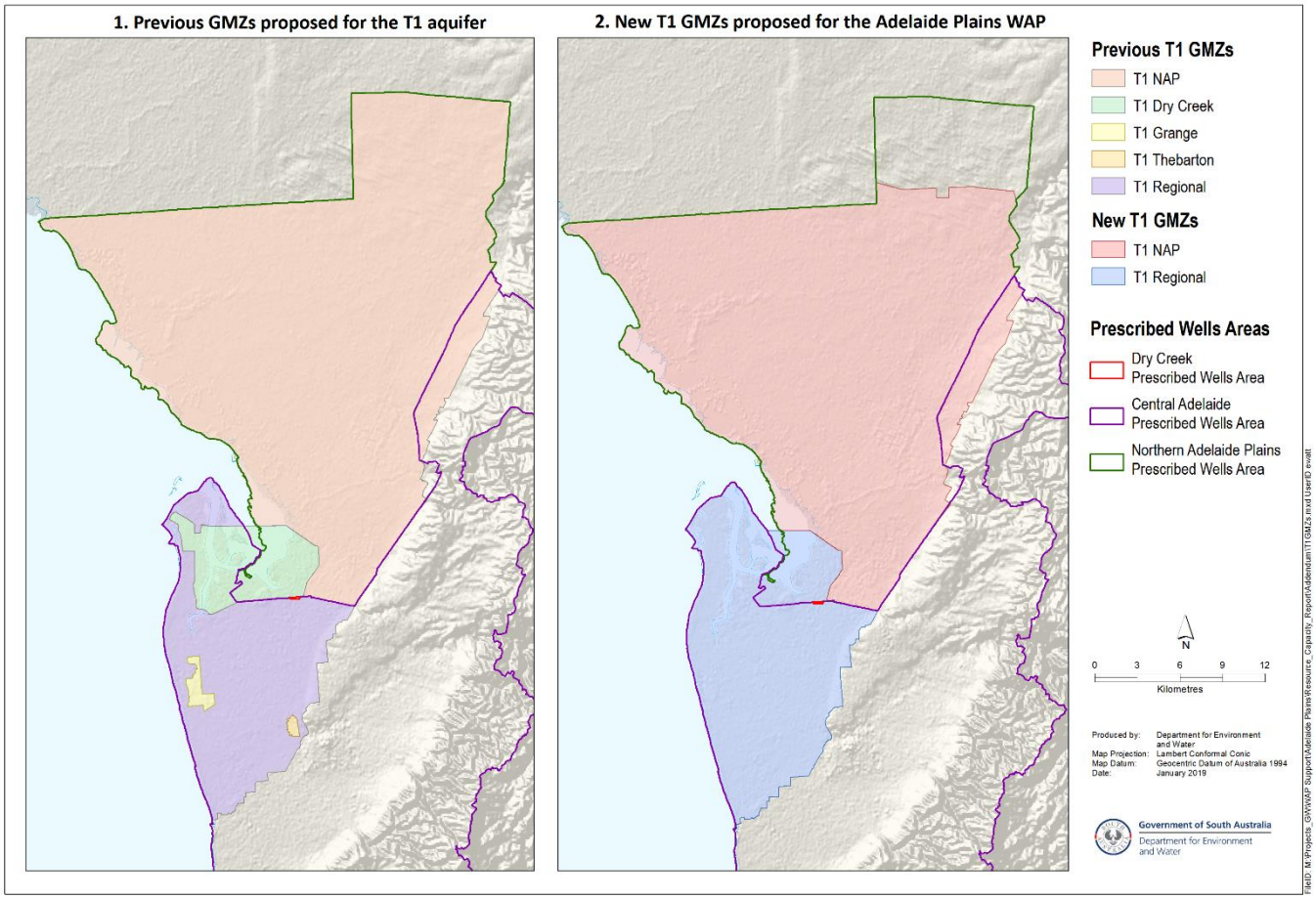

Figure 2.1. Groundwater management zones proposed for the T1 aquifer showing 1) the previous zones as proposed in DEWNR Technical Report 2017/03, and 2) the latest proposed zones

2.2 T2 aquifer GMZs

The new T2 Regional GMZ was created by combining the original T2 Regional GMZ with the T2 Regency Park and T2 Osborne GMZs (Figure 2.2). The top right corner of the T2 Regional GMZ was also amended to accommodate the new southern boundary of the T2 Kangaroo Flat GMZ (Figure 2.2).

2.2.1 T2 Kangaroo Flat GMZ

The current Northern Adelaide Plains WAP was amended to include the Kangaroo Flat area in 2004. The boundary of the T2 Kangaroo Flat GMZ proposed in DEWNR Technical Report 2017/03 was based on this added area. However on closer inspection of the southern boundary of the Kangaroo Flat area and the proposed GMZ, it was discovered that the boundary bisects the property of an irrigator, causing the licence to be split across two different GMZs. An earlier assessment of the T2 aquifer in the Kangaroo Flat region of the NAP PWA (Barnett 2013) confirmed 1500 ML/y as an initial recommended limit for allocations. Therefore, it is important that this licence is contained wholly within the T2 Kangaroo Flat GMZ so it can be managed successfully. Therefore, the southern boundary of the proposed T2 Kangaroo Flat GMZ has been amended to fully include this property (Figure 2.2). This also affects the boundary of the T2 NAP GMZ as they share a common boundary in this area.

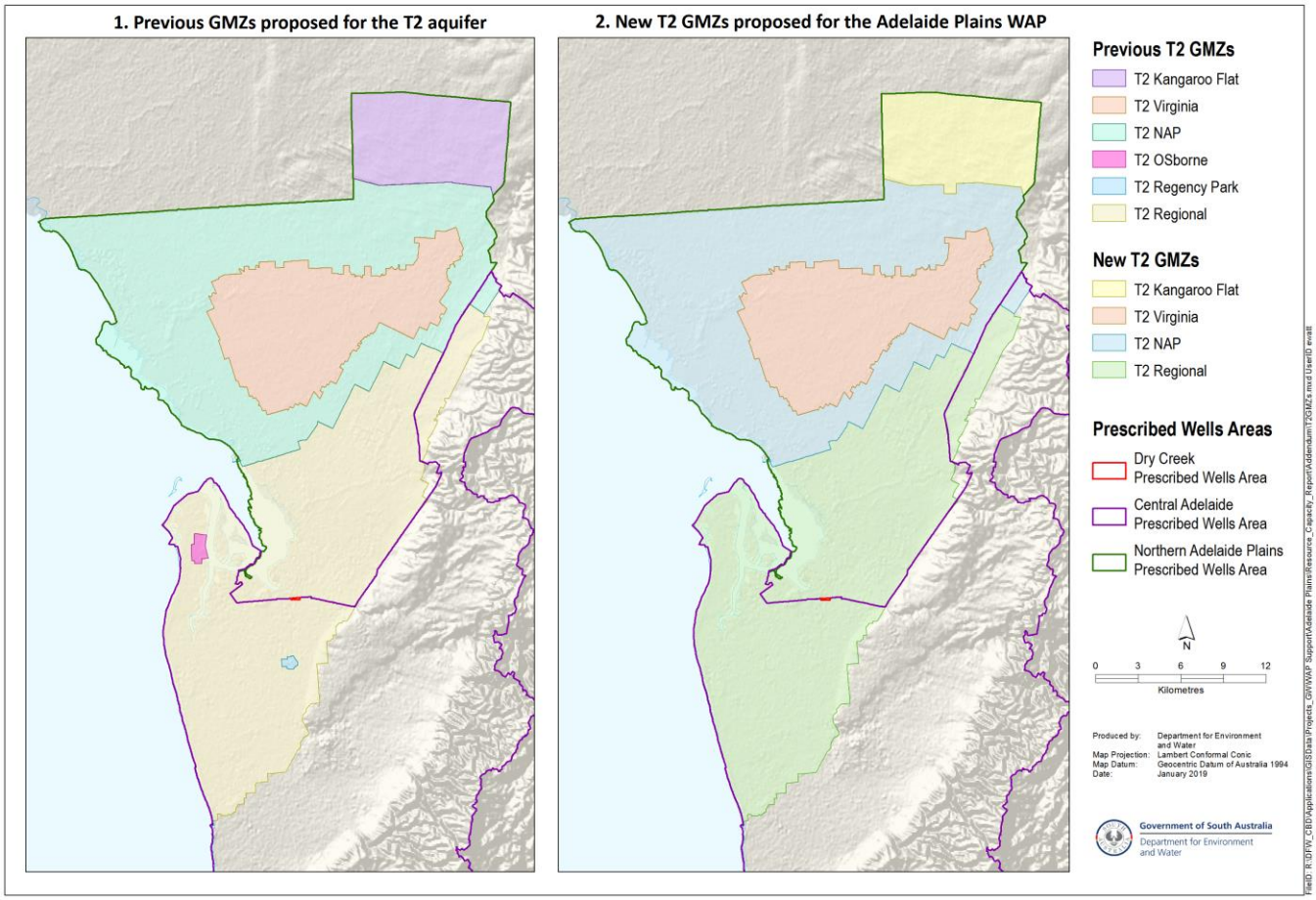

Figure 2.2. Groundwater management zones proposed for the T2 aquifer showing 1) the previous zones as proposed in DEWNR Technical Report 2017/03 and 2) the latest proposed zones

2.3 Golden Grove Embayment

Previously, there were two GMZs proposed for the Golden Grove Embayment (GGE) in DEWNR Technical Report 2017/03. It was decided that the two zones, the T1 & T2 GGE GMZ and the fractured rock aquifer (FRA) GGE GMZ should be combined into the one zone, the GGE GMZ (T1/T2 & FRA) (Figure 2.3). It should be noted that there is a portion of this new GMZ that overlaps the Northern FRA GMZ. Where there is overlap, licences for the fractured rock aquifer will be governed by the conditions relevant to the Northern FRA GMZ, not the GGE GMZ.

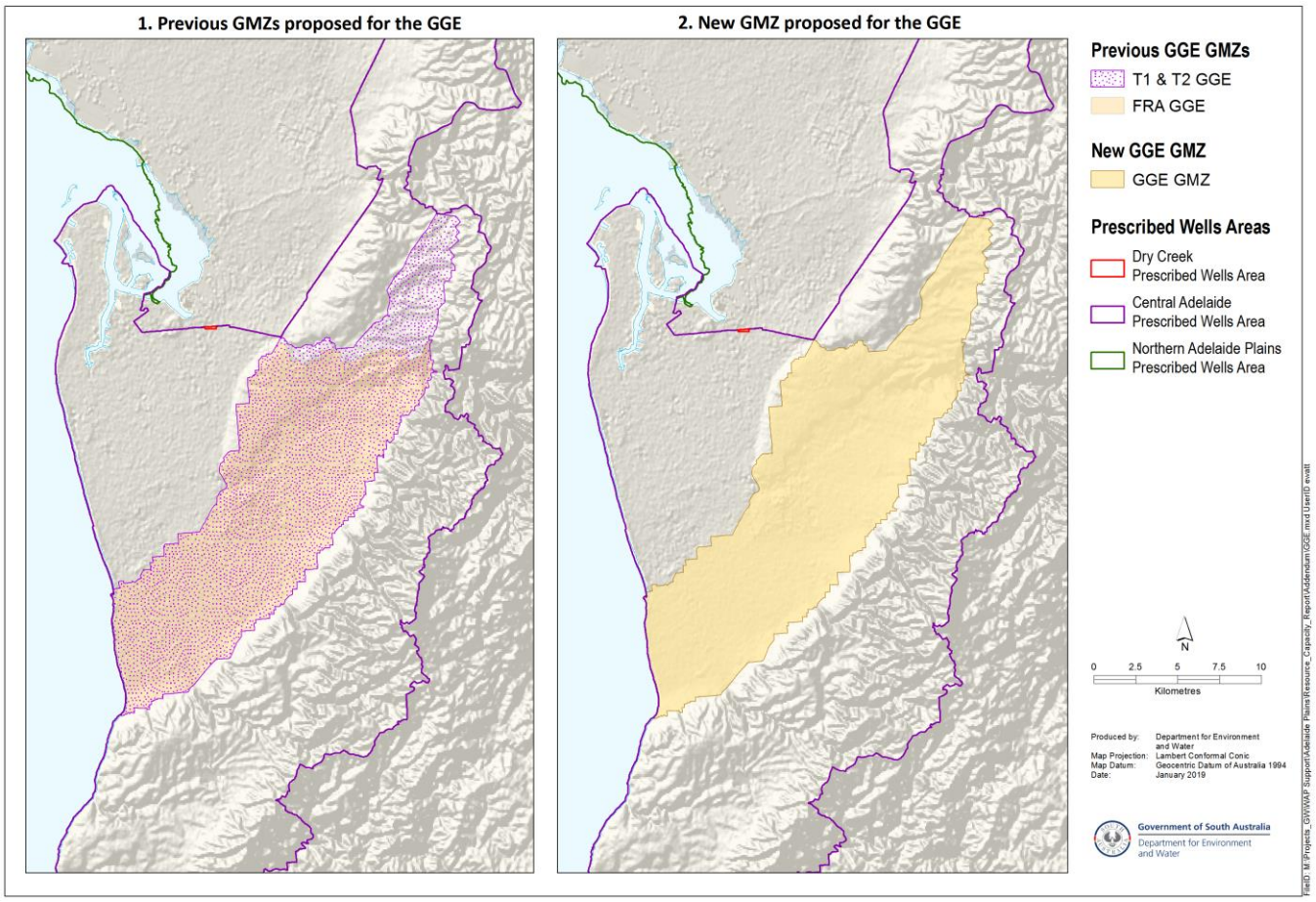

Figure 2.3. Groundwater management zones proposed for the Golden Grove Embayment showing 1) the previous zones as proposed in DEWNR Technical Report 2017/03 and 2) the latest proposed zones

2.4 Fractured rock aquifers GMZs

Previously, there were five GMZs proposed for the fractured rock aquifers (FRA) in DEWNR Technical Report 2017/03. As mentioned in section 2.3, it was decided that the FRA GGE GMZ should be combined with the T1 and T2 GGE GMZ to become the GGE GMZ (T1/T2 & FRA) (Figure 2.3). The other four fractured rock aquifer management zones were delineated using the same criteria as those used by Green and Zulfic (2008), i.e. by surface water sub-catchments and geology. The location of gauging stations with sufficient data recorded to calculate baseflow volumes was also considered. Following the calculation of recommended extraction limits for these four fractured rock aquifer GMZs, it was decided to merge them into two management zones (Figure 2.4). The Northern FRA GMZ combined the original Northern FRA GMZ with the Torrens FRA GMZ (Figure 2.4) as it was possible to calculate a recommended extraction limit for these two zones using the same method, which resulted in an REL that is more than that is currently expected to be allocated under the existing user process for the Central Adelaide PWA.

However, this method highlighted some discrepancies in the Patawalonga and Southern FRA GMZs, wherein the baseflow estimates are almost as high as the recharge estimates. While this situation might be expected in a highly permeable catchment with high rates of throughflow (such as the Tookayerta GMZ in the EMLR, which is infilled with Permian Sands), it is unusual for fractured rock aquifers which typically have a much lower permeability.

In these two cases, the hydrochemical investigations estimated groundwater recharge to be significantly less than the sum of groundwater discharges, and therefore some degree of uncertainty in the accuracy of the hydrochemical methodology must be assumed. This is particularly the case if the available monitoring data indicate that

groundwater levels are not showing any sustained decline, as has been observed in the two southern FRA GMZs. In these instances, the approximation of recharge from the sum of all groundwater discharges (baseflow, non-licensed extraction and existing user demand) is the preferred methodology and was applied to the Patawalonga and Southern FRA GMZs. Therefore, it was decided to combine these two zones to create a new Southern FRA GMZ (Figure 2.4).

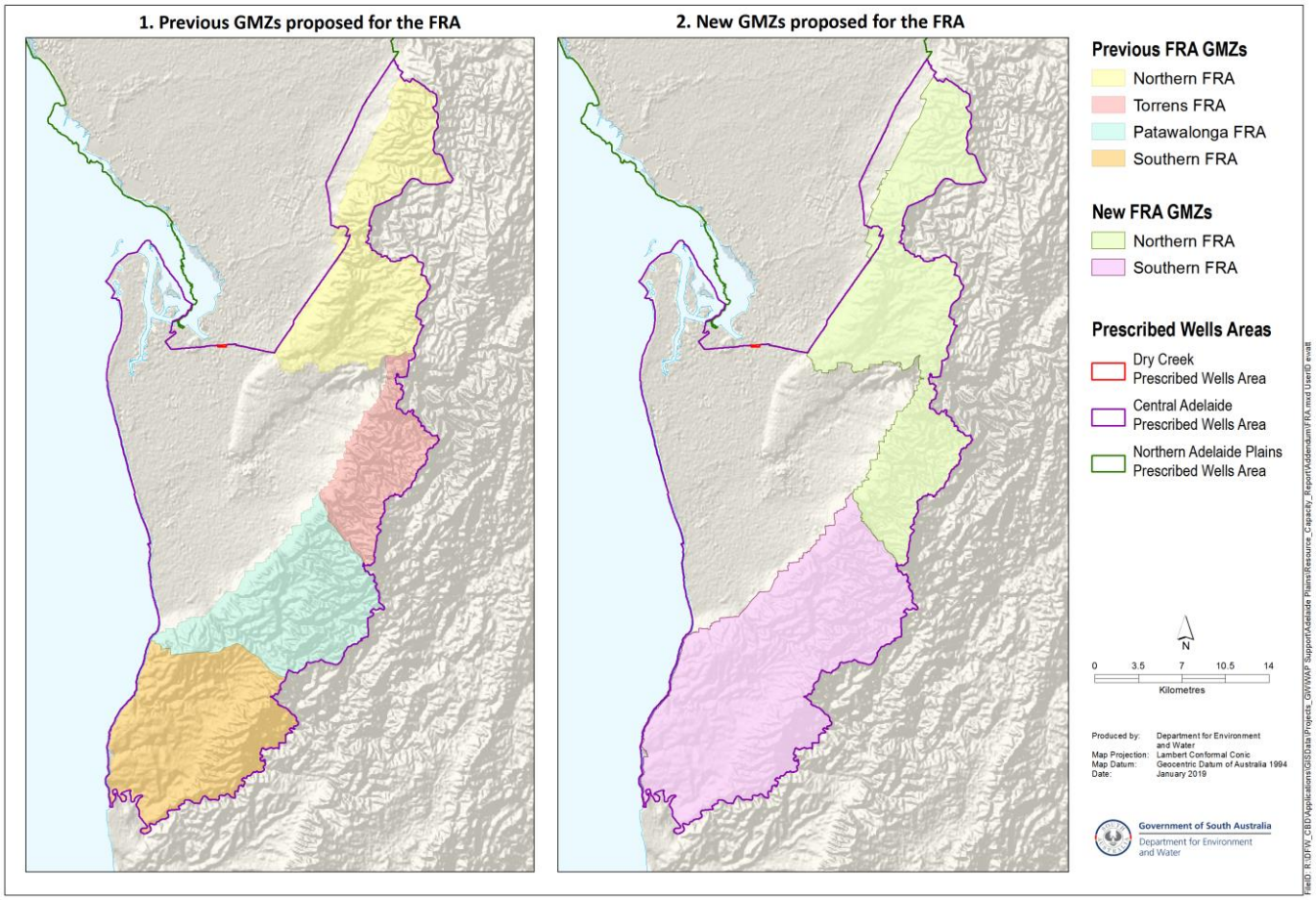

Figure 2.4. Groundwater management zones proposed for the fractured rock aquifers showing 1) the previous zones as proposed in DEWNR Technical Report 2017/03 and 2) the latest proposed zones

3 Separate recommended extraction limits for the Central Adelaide PWA

In 2018, the Department for Environment and Water (DEW) was preparing to issue existing user water licences in the Central Adelaide PWA. Prior to issuing water licences, DEW conducts a process to assesses whether the aggregate of water access entitlements assigned to existing users exceeds the capacity of the resource in order to determine whether reductions of entitlements should be considered; in this case, in accordance with section 164N(3) of the (then) *Natural Resources Management Act 2004* (the Act). DEWNR Technical Report 2017/03 describes the resource capacity and extraction limits for the whole area covered by the Adelaide Plains WAP, not the discrete boundaries of the prescribed wells areas covered by the WAP—Northern Adelaide Plains, Central Adelaide and Dry Creek. Accordingly, some of the GMZs include areas that form part of the Northern Adelaide Plains, Central Adelaide and Dry Creek PWAs. It is therefore not possible to use the current extraction limits to complete the assessment required under section 164N (3) of the Act for the Central Adelaide PWA existing user process. As DEW is issuing existing user licences for only the Central Adelaide PWA, there is a need to determine resource capacity and extraction limits within the bounds of the Central Adelaide PWA.

Separate resource capacities and recommended extraction limits for the proposed GMZs that are either wholly or partly within the boundary of the Central Adelaide PWA (Table 3.1) have been calculated using the methods outlined in DEWNR Technical report 2017/03. The following sections explain how these volumes were obtained.

Table 3.1. Maximum recommended extraction limits for the latest groundwater management zones that lie within the Central Adelaide PWA

Proposed GMZ	Recommended extraction limit (ML/y) for the CA PWA
Quaternary	1708
T1 NAP	130
T1 Regional	8714
T2 Regional	5096
GGE (T1, T2 & FRA)	4552
T3 & T4 aquifers	-
Noarlunga Embayment	1717
Northern FRA	5116
Southern FRA	619

3.1 Quaternary GMZ

A water balance approach was used to determine the resource capacity and recommended extraction limit for the Quaternary aquifers GMZ (Figure 3.1) in DEWNR Technical report 2017/03. The water balance used in that report has been improved and updated based on new information that became available after the original technical report had been written. It should be noted that although DEWNR Technical report 2017/03 was published in 2017, it was completed in 2014.

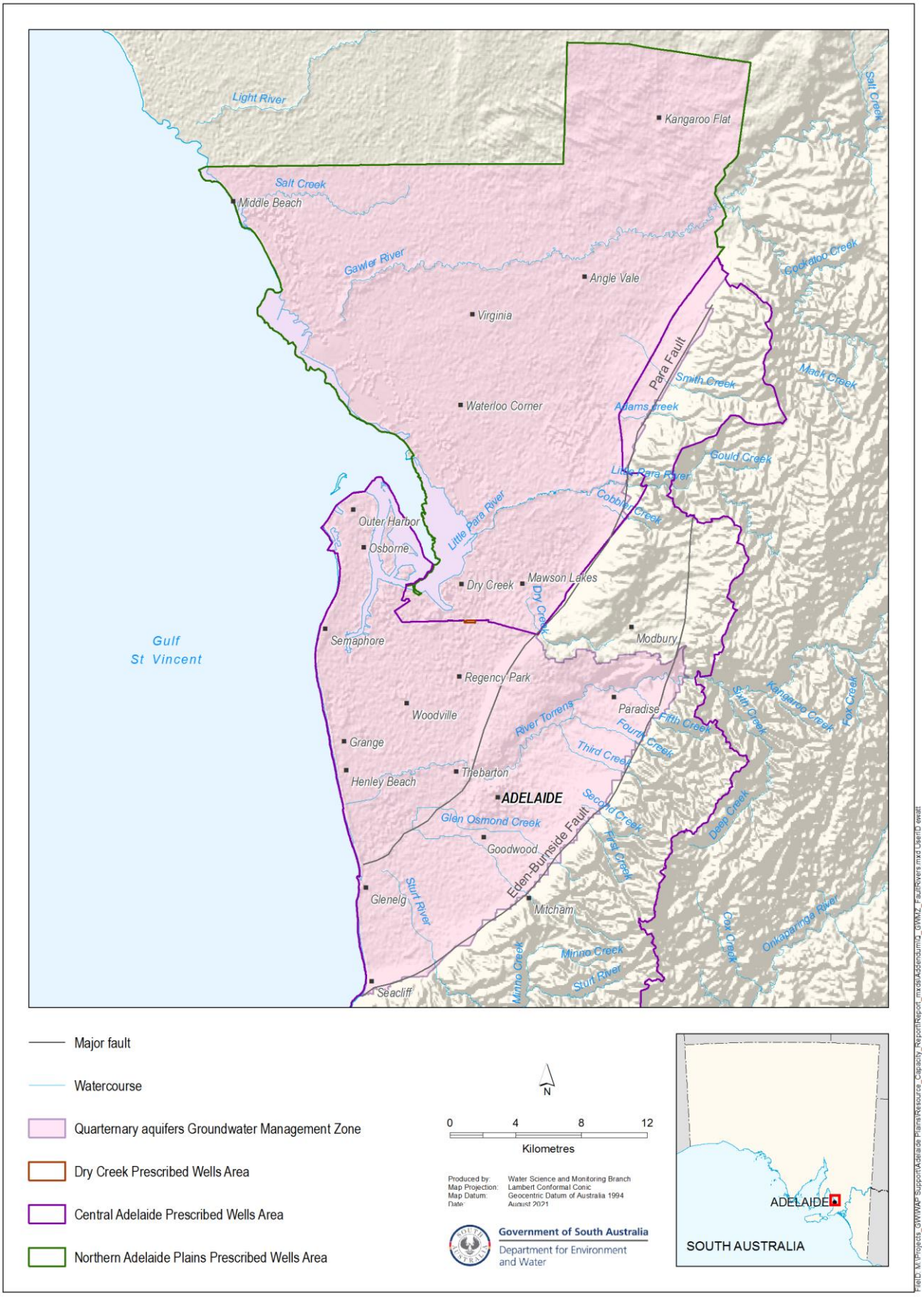

Figure 3.1 Quaternary aquifers Groundwater Management Zone

3.1.1 Water balance

The resource capacity refers to the total volume of groundwater available for all uses. That is, the volume of groundwater available for both consumptive demands (human use) and non-consumptive demands (environmental requirements), or:

Resource capacity = consumptive demand + non-consumptive demand

The volume of water available for consumptive demand is the amount of water (for both licensed and non-licensed purposes) that can be extracted without causing unacceptable long-term declines in groundwater quantity or quality, or unacceptable impacts to GDEs or assets. The water available for licensed demand is calculated as the volume of water available for consumptive demand minus the volume of water represented by non-licensed demand. Therefore, the volume available for consumptive demand would equal the resource capacity minus the non-consumptive demand:

Consumptive demand = resource capacity – non-consumptive demand

or

Licensed extraction + non-licensed extraction = resource capacity – non-consumptive demand

The resource capacity is taken as equal to the recharge to a groundwater system, as the amount of recharge will affect the volume of groundwater held in storage and therefore the volume available for all uses. Therefore, the amount of recharge is explicitly linked to the resource capacity:

Licensed extraction + non-licensed extraction = recharge – non-consumptive demand

Therefore, to find the amount available for licensed extraction:

Licensed extraction = recharge – non-consumptive demand – non-licensed extraction.

Recharge to the Quaternary aquifers occurs from rainfall, but also includes seepage from rivers and creeks.

Licensed extraction = (rainfall recharge + recharge from rivers and creeks) – non-consumptive demand – non-licensed extraction

Non-consumptive demand includes a number of different uses such as: the water used by groundwater dependent ecosystems (GDEs) such as vegetation, springs and permanently-flowing stream reaches, and evapotranspiration. Ecological Associates and SKM (2012) determined that three GDE types in the CA and NAP prescribed areas are relevant to the development of the WAP: fractured rock aquifer springs, groundwater-dependent streams and terrestrial vegetation at the base of the hills. Fractured rock aquifer springs are irrelevant to the Quaternary aquifers of the Central Adelaide PWA. Base flow from groundwater is an important source of flow in the upper reaches of the Torrens River where the river exits the Gorge and spills onto the plains. Shallow groundwater systems in the Quaternary aquifer west of the Eden-Burnside Fault contribute to the water requirements of River Red Gums located along watercourses and drainage lines. The volume of groundwater required by these River Red Gums has not been quantified, but their water needs have been considered in the overall water balance in the evapotranspiration budget to avoid double-accounting.

Licensed extraction = (rainfall recharge + recharge from rivers and creeks) – (discharge to rivers and creeks + evapotranspiration) – non-licensed extraction.

3.1.1.1 Rainfall recharge

The most recent recharge estimates for the Quaternary aquifers of the Adelaide Plains have been calculated by the Goyder Institute report (Bresciani et al. 2015b). Here net recharge (i.e., rainfall minus actual evapotranspiration) was modelled, resulting in:

Licensed extraction = (net rainfall recharge + recharge from rivers and creeks) – discharge to rivers and creeks – non-licensed extraction

The combination of processes leading to net recharge was captured by calculating an effective fraction of the rainfall ($RPMUL$) that was applied uniformly in space and time. Using the Chloride mass balance approach resulted in a median recharge estimate of 0.8% of rainfall given the average rainfall over the model area for the period 1889–2013. The Goyder report documents the limitations and uncertainties associated with this approach.

As such, a recharge rate to the watertable of 0.8% of the average annual rainfall isohyets has been assumed. This gives a total volume of 1490 ML of net rainfall recharge to the Quaternary aquifers in the CA PWA.

3.1.1.2 Recharge from rivers and creeks

The most recent estimate of recharge to the Quaternary aquifers from rivers and creeks is also taken from the Goyder report (Bresciani et al. 2015a) which estimated 1802 ML/y of river recharge from Brownhill Creek and First through Fifth Creeks and Sturt River (Figure 3.1). In the area around the River Torrens west of the Para Fault (Figure 3.1), the higher salinity in Quaternary aquifers (Q5 and Q6) suggests that leakage from surface streams does not reach these aquifers in that area (Gerges 2006). SKM (2011) also found that groundwater levels and stream elevations are very similar along much of the river length and could therefore indicate only minor fluxes to or from the River Torrens to the aquifer across the rest of the plains.

3.1.1.3 Discharge to rivers and creeks

Baseflow from groundwater is an important source of flow in the upper reaches of the Torrens River where the river exits the Gorge and flows onto the plains. With respect to the impact of the taking of groundwater, SKM (2011) suggests that extraction from the Quaternary aquifers has the potential to reduce groundwater discharge to the Torrens River in the upper Golden Grove Embayment. The reduction in baseflow due to groundwater extraction has yet to be quantified, but SKM (2011) estimated streamflow reductions to the Torrens River as a consequence of groundwater extraction to be 190 ML a year. This volume is used in the water balance calculation below as a proxy for the volume of water discharged from the Quaternary aquifers.

3.1.1.4 Non-licensed extraction

AGT (2011) estimated the volume of groundwater extraction by non-licensed users from each major aquifer across the CA and NAP PWAs. The spatial distribution of this information was used to derive a volume of 1394 ML/y for the Quaternary aquifers within the Central Adelaide PWA.

3.1.1.5 Recommended extraction limit

Substituting the available data into the water balance equation gives us:

= (1490 + 1802) – 190 – 1394

= 3292 – 1584

= 1708

This gives a resource capacity of 3292 ML and a recommended extraction limit of 1708 ML available for allocation from the Quaternary aquifers within the Central Adelaide PWA.

3.2 Upper Tertiary aquifers (T1 and T2) GMZs

The resource capacity of the Tertiary aquifers could not be estimated using the water balance approach due to the complexity of the recharge mechanisms of these systems, such as throughflow and vertical leakage, and the uncertainty surrounding the estimation of these volumes. This is why the AP2013 groundwater flow model was used

to calculate the recommended extraction limits for the T1 and T2 aquifers GMZs based on predicted drawdowns in pressure levels. A number of scenarios for groundwater extraction were developed as part of the modelling exercise. The results from Scenario 10 were used as the maximum recommended extraction limits for the T1 and T2 aquifers. Therefore, to determine the limits for the parts of the T1 and T2 aquifers that are only in the Central Adelaide PWA, the results from scenario 10 were mapped and collated accordingly.

3.3 Lower Tertiary aquifers (T3 and T4) GMZ

As there are no licence applications for the T3 or T4 aquifers in the CA PWA, a recommended extraction limit for the T3 and T4 aquifers GMZ has not been estimated. Further development is likely to be limited by the depth of the aquifers and the poor water quality of the resource. The WAP could have provisions to create new consumptive pools or vary the consumptive pool limit for the T3 and T4 aquifers once an applicant has 'proved' up the resource.

3.4 Golden Grove Embayment

The T1 and T2 GGE GMZ and FRA GGE GMZ have been merged (see section 2.3) and their recommended extraction limits combined. A typographic error was discovered in DEWNR Technical report 2017/03, which is why the recommended extraction limit in this addendum is different to the one presented in that report.

3.5 Noarlunga Embayment

The recommended extraction limit for the Noarlunga Embayment has not changed from DEWNR Technical report 2017/03, and remains at 1717 ML/y.

3.6 Fractured rock aquifers

All fractured rock aquifer GMZs are contained within the Central Adelaide PWA. While the extraction limits recommended in DEWNR Technical report 2017/03 have not changed in total, the boundaries of the GMZs have, as outlined in section 2.4. The FRA Northern and FRA Torrens GMZs have been merged and the FRA Patawalonga and FRA Southern GMZs have been merged and the recommended extraction limits have been combined accordingly.

4 Recalculation of the recommended extraction limit for the Quaternary aquifer GMZ for the NAP PWA

Following the resource capacity and recommended extraction limit for the Quaternary aquifer GMZ within the Central Adelaide PWA was calculated using the best available data, the resource capacity and recommended extraction limit has been recalculated for the Northern Adelaide Plains and Dry Creek PWAs.

4.1 Water balance

The resource capacity refers to the total volume of groundwater available for all uses. That is, the volume of groundwater available for both consumptive demands (human use) and non-consumptive demands (environmental requirements), or:

Resource capacity = consumptive demand + non-consumptive demand

The volume of water available for consumptive demand is the amount of water (for both licensed and non-licensed purposes) that can be extracted without causing unacceptable long-term declines in groundwater quantity or quality, or unacceptable impacts to GDEs or assets. The water available for licensed demand is calculated as the volume of water available for consumptive demand minus the volume of water represented by non-licensed demand. Therefore, the volume available for consumptive demand would equal the resource capacity minus the non-consumptive demand:

Consumptive demand = resource capacity – non-consumptive demand

or

Licensed extraction + non-licensed extraction = resource capacity – non-consumptive demand

The resource capacity is taken as equal to the recharge to a groundwater system, as the amount of recharge will affect the volume of groundwater held in storage and therefore the volume available for all uses. Therefore, the amount of recharge is explicitly linked to the resource capacity:

Licensed extraction + non-licensed extraction = recharge – non-consumptive demand

Therefore, to find the amount available for licensed extraction:

Licensed extraction = recharge – non-consumptive demand – non-licensed extraction.

Recharge to the Quaternary aquifers is primarily from rainfall, but also includes seepage from rivers and creeks.

Licensed extraction = (rainfall recharge + recharge from rivers and creeks) – non-consumptive demand – non-licensed extraction

Non-consumptive demand includes a number of different uses such as: the water used by groundwater dependent ecosystems (GDEs) such as vegetation, springs and permanently-flowing stream reaches, and evapotranspiration. In 2012, Ecological Associates and SKM were engaged by the Board to recommend environmental objectives and water requirements for the GDEs of the Adelaide Plains. Of the nine GDEs types proposed in SKM (2011a), Ecological Associates and SKM (2012) excluded those within the Northern Adelaide Plains PWA from the study either because the aquifer was not subject to use, or there is not enough information to adequately define a environmental water requirement, and because the risk to these GDE types was not considered significant.

Licensed extraction = (rainfall recharge + recharge from rivers and creeks) – (discharge to rivers and creeks + evapotranspiration) – non-licensed extraction.

4.1.1 Rainfall recharge

The most recent recharge estimates for the Quaternary aquifers of the Adelaide Plains have been calculated by the Goyder report (Bresciani et al. 2015b). Here net recharge (i.e., rainfall minus actual evapotranspiration) was modelled, resulting in:

Licensed extraction = (net rainfall recharge + recharge from rivers and creeks) – discharge to rivers and creeks – non-licensed extraction

The combination of processes leading to net recharge was captured by calculating an effective fraction of the rainfall ($RPMUL$) that was applied uniformly in space and time. Using the Chloride mass balance approach resulted in a median recharge estimate of 0.8 % of rainfall given the average rainfall over the model area for the period 1889–2013. Please refer to the Goyder report for the limitations and uncertainties associated with this approach.

As such, a recharge rate to the watertable of 0.8% of the average annual rainfall isohyets has been assumed. This gives a total volume of 2180 ML of net rainfall recharge to the Quaternary aquifers in the NAP PWA.

4.1.2 Recharge from rivers and creeks

The most recent estimate of recharge to the Quaternary aquifers from rivers and creeks is also taken from the Goyder report (Bresciani et al. 2015a). They estimate 2898 ML/y of river recharge from the Gawler and Little Para Rivers and represents a conservative estimate of river recharge in the NAP. A volume for Dry Creek is not available.

4.1.3 Discharge to rivers and creeks

Though SKM (2011) concluded that streams throughout the NAP are thought to be predominantly losing, they noted that some groundwater discharge to the Gawler River may occur at times, as some dry season pools were noted by videography surveys. However, flow in the Gawler River is regulated by dam releases, which may support these pools rather than groundwater discharge (SKM 2011) and as such, discharge to rivers and creeks has not been included in this water balance calculation.

4.1.4 Non-licensed extraction

AGT (2011) estimated the volume of groundwater extraction by non-licensed users from each major aquifer across the CA and NAP PWAs. The spatial distribution of this information was used to derive a volume of 24 ML/y for the Quaternary aquifers within the Northern Adelaide Plains PWA. Stock and domestic use is primarily licensed in the NAP PWA, which would account for this small volume of non-licensed extraction.

4.1.5 Recommended extraction limit

Substituting the available data into the water balance equation gives us:

= (2180 + 2898) – 24

= 5078 – 24

= 5054

This gives a resource capacity of 5078 ML and a recommended extraction limit of 5054 ML available for allocation from the Quaternary aquifers within the Northern Adelaide Plains PWA.

5 Updated recommended extraction limits by GMZ

Because of the amendments made to DEWNR Technical Report 2017/03 based on the new GMZ boundaries and the recalculation of the recommended extraction limit (REL) for the Quaternary aquifers GMZ, it is important to clearly state what the REL is for each GMZ (Table 2.2). Where a range of recommended extraction limits were presented in DEWNR Technical Report 2017/03, the maximum recommended limit is presented in Table 5.1 for clarity.

Table 5.1. Maximum recommended extraction limit for the latest groundwater management zones

Groundwater management zone	Recommended extraction limit (ML/y)
Quaternary aquifers	6762
T1 NAP	4159
T1 Regional	10 494
T2 NAP	4483
T2 Kangaroo Flat	1500
T2 Virginia	11 072
T2 Regional	6023
T1, T2 & FRA GGE	4552
T3 and T4 aquifers	2385
FRA Northern	5116
FRA Southern	619
Noarlunga Embayment	1717

As there are no licence applications for the T3 or T4 aquifers in the Central Adelaide PWA, a recommended extraction limit for the T3 and T4 aquifers GMZ in the Central Adelaide PWA was not estimated as part of the existing user process.

It is recommended that the recommended extraction limit of 4000 ML for the T3 and T4 aquifers for the Northern Adelaide Plans WAP proposed in DEWNR Technical Report 2017/03 should be reduced to the existing allocation volume for the Northern Adelaide Plains PWA of 2385 ML. Further development is likely to be limited by the depth of the aquifers and the poor water quality of the resource. The WAP could have provisions to create new consumptive pools or vary the consumptive pool limit for the T3 and T4 aquifers once an applicant has 'proved' up the resource.

6 References

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