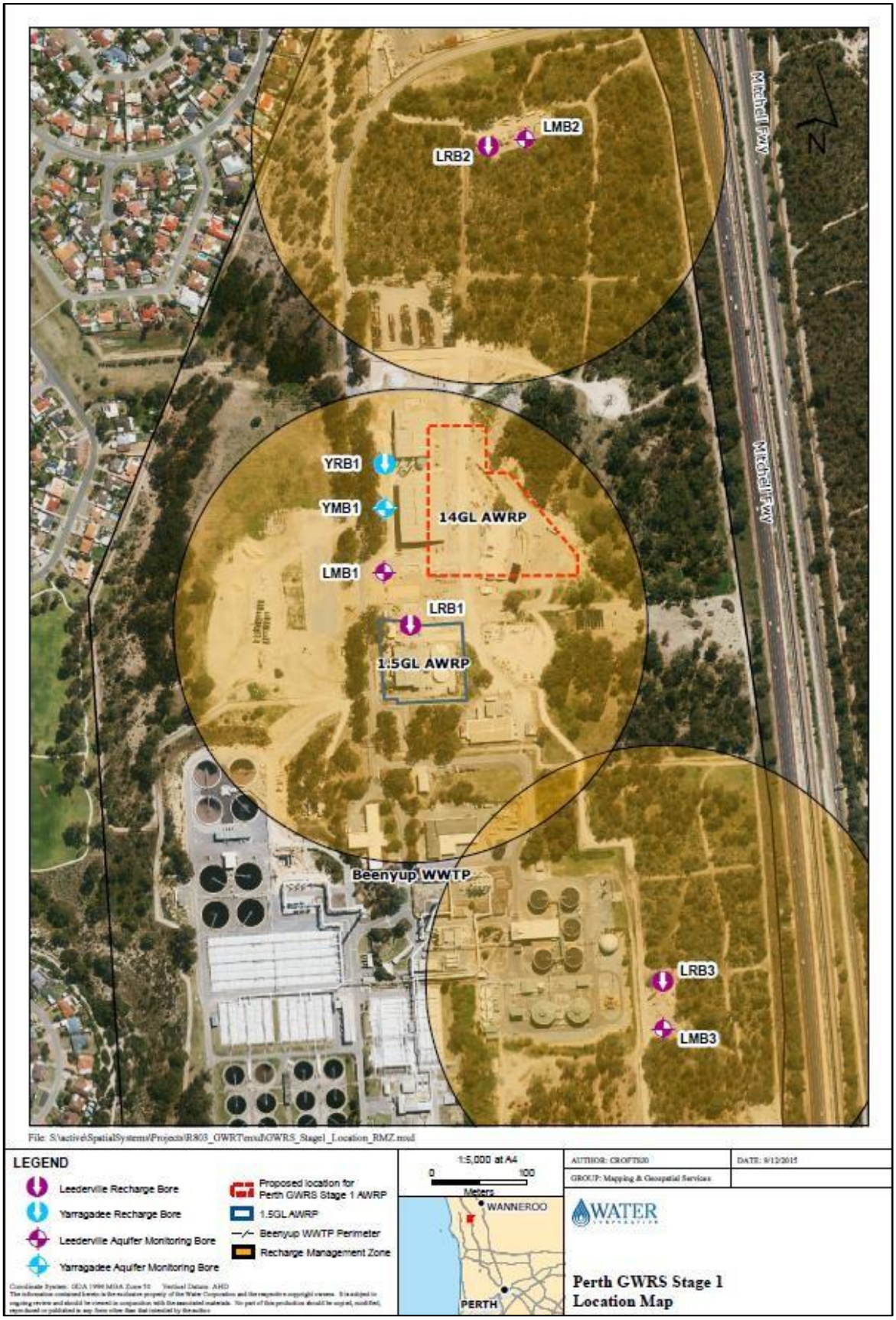

Figure 5-2: Perth GWRS Stage 1 – recharge and monitoring bores and RMZ

5.2 Perth GWRS Stage 2

In order to maintain supply against a background of drying climate, the State Government announced Stage 2 of the Perth GWRS in July 2016.

Stage 2 includes construction of an additional AWRP which can produce approximately 14GL using the same technology utilised in Stage 1. Recharge will be into the Leederville and Yarragadee aquifers at two offsite locations referred to as the 'northern recharge site' and the 'southern recharge site' located approximately 8.5km and 6.5km north of the Beenyup site respectively (Figure 5-1). They are located outside the PDWSA.

The location of recharge bores and abstraction bores were determined collaboratively between the DoW and Water Corporation to optimise recharge and abstraction rates and locations to maximise recovery of groundwater for public water supply and enhanced management of the Perth groundwater system. In addition, the recharge sites were chosen to meet the following criteria:

- Similar characteristics to the Beenyup site, where extensive characterisation and research has occurred.
- Available land access for the recycled water pipeline route and recharge sites (recharge bore, monitoring bore, storage tank, pump housing).

Preliminary aquifer investigations were required at the northern recharge site to confirm the thickness of the confining layer between the Leederville and Superficial aquifers. This assessment confirmed the similarity of aquifer confinement of the proposed recharge locations to the Beenyup site. Drilling for core collection, petrophysical and geophysical analysis was completed in July – August 2016, allowing characterisation of the aquifer for the EV identification process.

The Groundwater TRG defined a RMZ for each recharge bore at a radial distance of 250m from the point of recharge, each with an early indication monitoring bore located between 50 to 100m from recharge (which is the same as Stage 1).

The recharge volumes are planned to be distributed across the Leederville (approx. 8GL/yr) and Yarragadee aquifers (approx. 6GL/yr) and across the two sites (approx. 7GL/yr per site). The final recharge volumes will be guided by information gathered from recharge achieved at Stage 1. However, to allow future operational flexibility, the process of identifying the EVs will consider a maximum recharge volume (14GL/yr) to each aquifer at each site.

6 Characterising the aquifer to allow identification of Environmental Values

This section provides information required to support the identification of the EVs. It will:

- Present a general description of the aquifer composition at different intervals (hydrostratigraphy) to provide a background understanding and indicate presence and depths of aquicludes and aquitards (confining layers) and aquifers (recharge layers).
- Provide an assessment of the vertical travel time of water from the Leederville to the Superficial aquifer, to allow the IAWG to determine if the Superficial aquifer should be considered.
- Define the conditions required to support stygofauna in the Leederville and Yarragadee aquifers and assess the likelihood of their presence.
- Provide a description of other groundwater users in the proximity of recharge.

The hydrostratigraphy interpreted from investigative drilling at the northern recharge site (LRB5) by the Corporation and historic drilling completed by the DoW and the Corporation has been reviewed. This review shows that the Superficial aquifer, Leederville aquifer and the Yarragadee aquifer are present at the northern and southern recharge sites and that the site is consistent with other sites in the Gnangara Groundwater System. This similarity will be confirmed with further investigations at both the northern and southern recharge sites, including lithological, geophysical, and mineralogical analysis, surface seismic surveys and aquifer pumping tests.

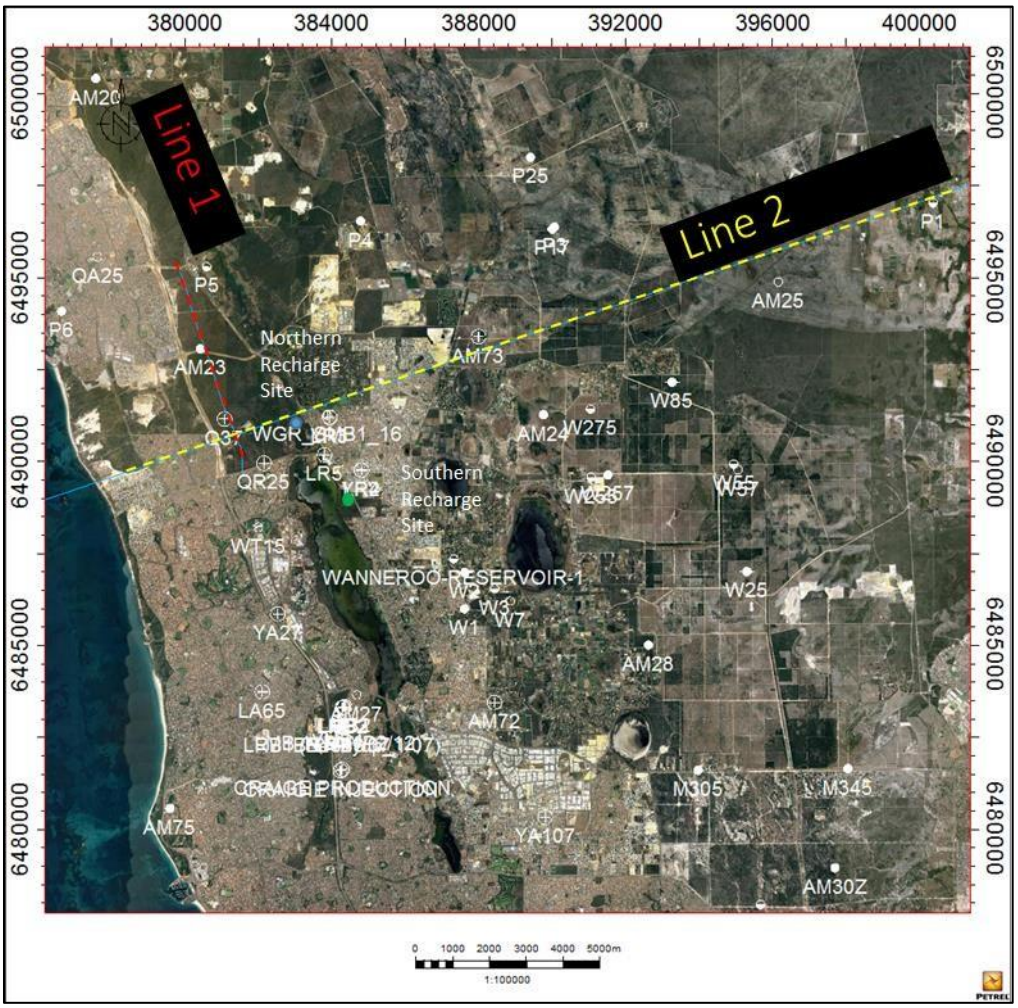

Figure 6-1: Hydrostratigraphic transects for Perth GWRS Stage 2

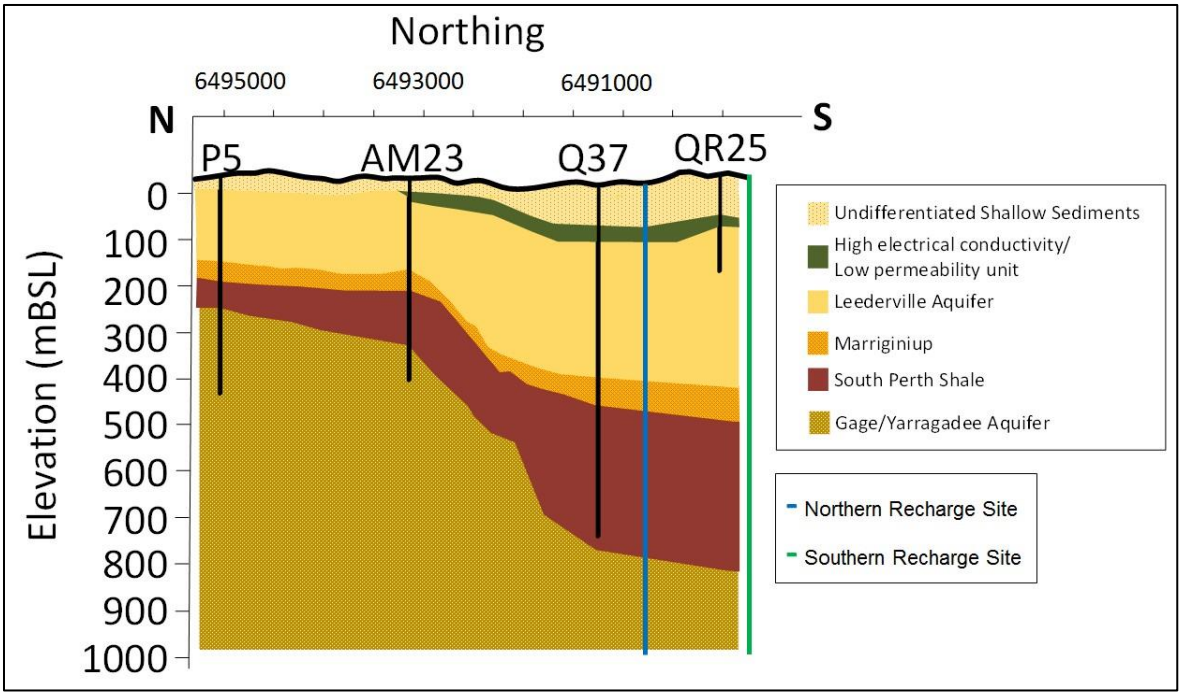

Figure 6-2: North-South Hydrostratigraphic Transect for Perth GWRS Stage 2

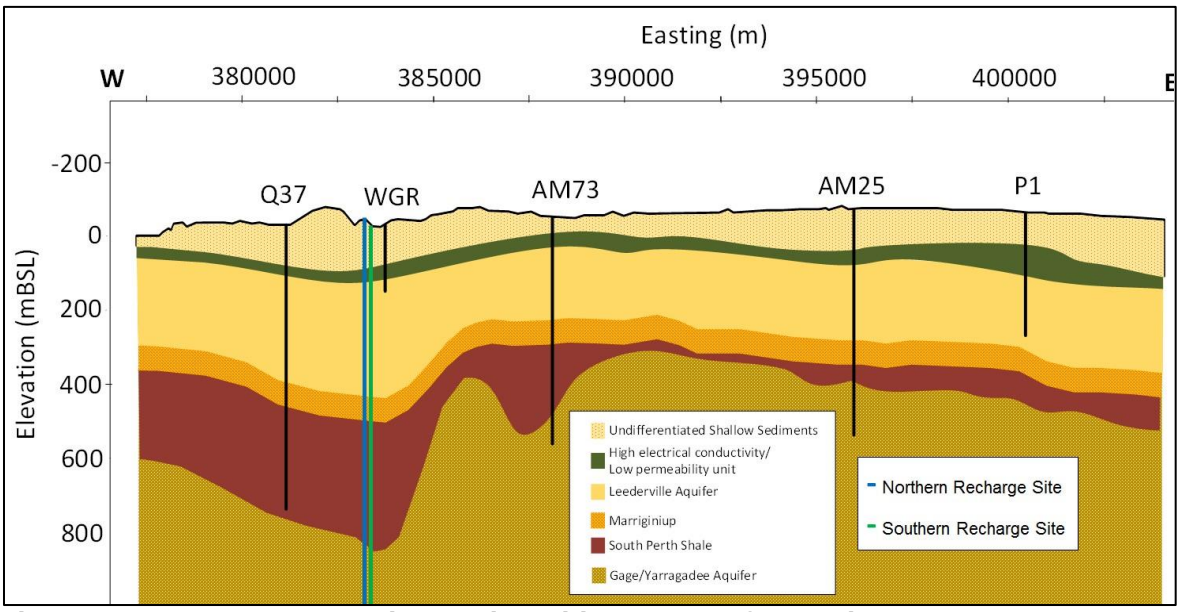

Figure 6-3: West-East Hydrostratigraphic Transect for Perth GWRS Stage 2

Table 6-1: Interpreted hydrostratigraphy of the Stage 2 recharge sites

Average Depth (m)		Description,	Stratigraphic Unit	Hydrogeology
From	To			
0	46	SAND: fine to coarse grained quartz	Bassendean Sand	Superficial
UNCOMFORMITY				
46	71	SAND: grey to pale green, fine to very course quartz with minor green staining (glauconite)	Osborne Formation	Mirrabooka Aquifer
71	81.5	SANDSTONE: greyish brown, fine to very course grained, poorly sorted, weakly consolidated		
81.5	108	SANDSTONE: grey very fine to very course grained with occasional granules, with minor clay		
UNCOMFORMITY				
108	117	SILTSTONE: Dark grey, moderately to well consolidated, interbedded with fine to course grained sand	Leederville Formation	Wanneroo Member (Aquitard) *Referred to as in previous GWR documentation the Pinjar Member (Depicted as the low permeability unit in Figures 6-2 and 6-3)*
117	140	SILTSTONE, MUDSTONE: Dark grey to black, very well consolidate, interbedded with fine to medium grained quartz sandstone		
140	178	SANSTONE: Grey to dark grey, fine to coarse grain with some siltstone and clays.		Wanneroo Member (Aquifer)
178*	404*	SANDSTONE/SILTSTONE: fine to coarse grained quartz with some siltstone and shale beds.		
404*	474*	SILTSTONE AND SHALE		Mariginiup Member (Aquitard/Seal)
474*	776*	SILTSTONE AND SHALE	South Perth Shale	Aquiclude
>776*		SANDSTONE: light grey to grey, interbedded fine to medium grained well sorted quartz with fine to coarse grained poorly sorted beds. Few siltstone/shale beds. Garnet and heavy minerals occur throughout.	Yarragadee Formation	Yarragadee (Aquifer)

**Depths interpreted from PRAMS 3.5.2 from Beenyup interpretation. Water Corporation, 2016a*

6.1 Leederville Aquifer

Sections 6.1.1 to 6.1.4 describe the aquifer characteristics for the Leederville aquifer. The characteristics of the Yarragadee aquifer are described in Section 6.2.

6.1.1 Aquifer description

The Leederville Formation hosts a major regional aquifer composed of discontinuous interbedded sandstones, siltstones and shales. The level of confinement varies regionally across the Swan Coastal Plain.

The Leederville Formation has recently been re-interpreted as described in Leyland (2012), the Pinjar Member previously referred to in GWR hydrostratigraphic descriptions has been determined as absent over much of the western region of the Gnangara Groundwater System. This low permeability interval has been re-interpreted as the top of the Wanneroo Member and will be referred to here as the Wanneroo Member (aquitard).

Approximately 30m of siltstones, mudstones and clays were intersected at the northern recharge site between 108 and 140mbgl, separating the Superficial aquifer and the recharge interval of the Wanneroo Member (aquifer). The lithology of the Wanneroo Member (aquitard) at this site is predominantly dark grey siltstones and mudstones with minor very fine to coarse grained quartz sands. There is some minor interbedding of sandstones within this sequence. The significant siltstone and mudstone horizons within the Wanneroo Member (aquitard) constitute a low permeability barrier, effectively confining the Wanneroo Member at this location.

Prior to drilling at the northern recharge site the Wanneroo Member (aquifer) was expected to be overlain by the Wanneroo Member (aquitard) of the Leederville formation which, in turn may be overlain by the Kardinya Member of the Osborne Formation. However, the northern recharge site is close to where the Kardinya Shale is known to pinch out, therefore its presence was speculative only. The investigative drilling did not observe the presence of the Kardinya Shale Member.

Investigative drilling at the northern recharge site intersected the Wanneroo Member (aquifer) of the Leederville formation at a depth of 140m. Lithology from the investigation bore describes the Wanneroo Member (aquifer) from 140 to 178m. This zone consists predominantly of fine to coarse grained sub-angular sands with minor clay. A discrete sandy clay horizon was observed from 148 to 158m. This description and interbedding is consistent with descriptions of the Wanneroo Member (aquifer) from other locations and is expected at the southern recharge site.

It is likely that drilling at the southern recharge site, ~2.5km to the south of the northern site will encounter the Kardinya Shale confining unit as its presence becomes more extensive to the south.

6.1.2 Upward flow into the Superficial aquifer

The likelihood of recycled water moving upwards into the Superficial aquifer is a key consideration of this assessment. If water is shown to flow from the recharged aquifer, specifically from the Leederville aquifer to the Superficial aquifer then the EVs relevant to the Superficial aquifer must also be identified.

The Water Corporation investigated the likelihood of vertical flow from the Leederville aquifer to the Superficial aquifer based on information gained from the GWRT, drilling for Stage 1, coring activities at the Stage 2 northern recharge site, and utilised the same

modelling processes as used for Stage 1 to estimate travel times into the overlying Superficial aquifer.

As described in Table 6-1, there is an effective seal between the recharge interval of the Leederville aquifer and the overlying Superficial aquifer. The presence of this seal is known or inferred from multiple well logs across the basin, and in particular bores drilled at Beenyup and the northern recharge location. The likelihood of upward flow is directly related to the degree of confinement, recharge rates, and aquifer pressure.

As the rate of recharge increases, there is a corresponding increase in aquifer pressure; that increase is greatest at the point of recharge. The increase in pressure can challenge the integrity of the aquifer confining layer, and with increased pressure, the risk of upwards flow through the confining layer also increases.

An analytic model was developed by the Groundwater TRG to predict travel times of upward flow to the base of the Superficial aquifer from the Leederville recharge interval. This model is applicable for a range of potential recharge rates (Figure 6-4). The model has been refined based on observed strata from diamond coring at the northern site, and permeability values derived from petrophysical testing of core samples and down hole geophysics (nuclear magnetic resonance and density). The model provides a conservative prediction (underestimate) of travel time as it only considers vertical flow and does not take into account lateral flow from the recharge bore.

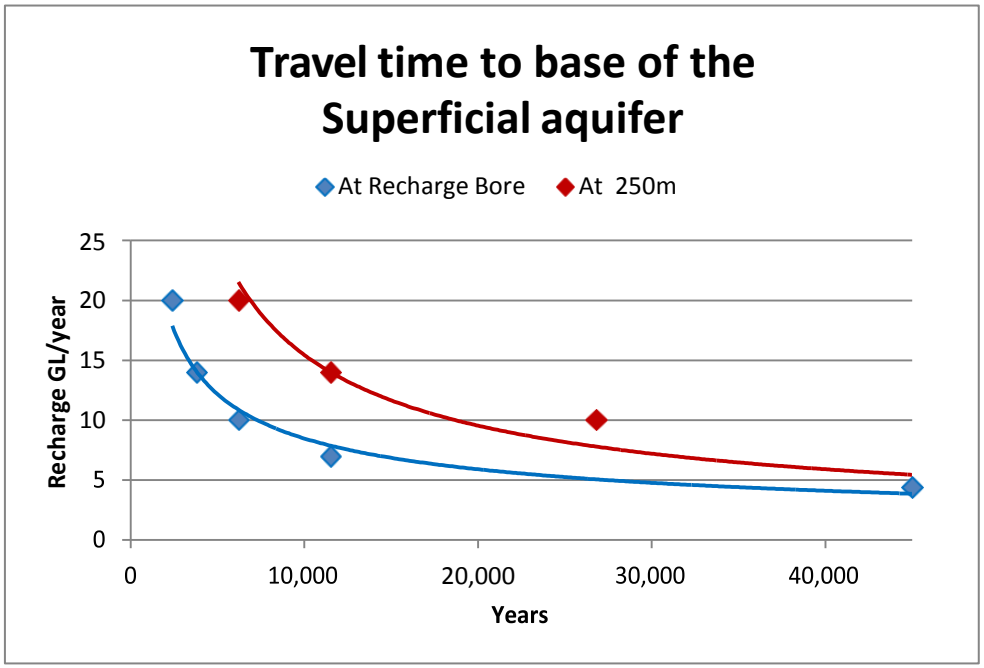

Figure 6-4: Travel Time for upward flow into the Superficial aquifer

The Groundwater TRG considered a number of Leederville aquifer recharge rates up to 20GL/yr. In this approach the entire additional AWRP production volume associated with Stage 2 was recharged at a single point at the top of the Wanneroo Member (aquifer), directly below the confining layer. Evaluation of the 20GL/year recharge ensures a scenario with the greatest pressure with respect to upward flow is assessed. However, this is considered to be conservative and highly unlikely to occur for the following reasons:

- It is not possible to recharge 14GL in one aquifer at one site.
- Recharge will occur over an interval of approximately 100m (to be determined once drilling occurs) to provide the best opportunity for recharge.
- The preferential water flow is horizontal, through the aquifer.

The travel times for recycled water to reach the Superficial aquifer were predicted by applying the recharge scenarios to the analytic model presented in Figure 6-4. The predicted travel times are summarised in Table 6-2.

Table 6-2: Predicted travel times for water recharged to move to the base of the Superficial aquifer

GWR Scheme	Recharge to the Leederville aquifer		Travel Time (years)	
	GL/yr	ML/day	At Recharge Bore	At RMZ boundary (250m)
Stage 2 Northern and Southern recharge sites	3.5	9.6	1,500,000	n/a
	4.4	12	45,000	n/a
	7	19.2	11,500	1,500,000
	10	27.4	6,200	26,800
	14	38.4	3,800	11,500
	20	54.8	2,400	6,200

Specific to Stage 2 where recharge into the Leederville aquifer could reach up to 14 GL/yr, the travel time for the recycled water to reach the base of the Superficial aquifer is estimated to be greater than 3,000 years.

While there is a possibility for vertical flow further from the recharge bore, this is mitigated by the reduced head difference with distance from the bore, the horizontal travel time within the aquifer, and the extent and thickness of sediments overlying the recharge zone. At a distance of 250m – 500m from the recharge bore, vertical movement is very unlikely. The potential for regional movement of recharged water to the Superficial aquifer will be confirmed using the PRAMS model and documented as part of the Perth GWRS Stage 2 aquifer preliminary risk assessment.

Hydrogeological modelling undertaken using PRAMS version 3.5.2 estimate the impacts of recharge and abstraction an additional 14GL/yr of water into the Gnangara confined aquifer system over a 30 year period (2013-2043) (Water Corporation, 2016b). Outputs from this modelling demonstrated that recycled water is extremely unlikely to reach the base of the Superficial aquifer or enter nearby wetlands as hydraulic heads are likely to remain downward (Neerabup Lake Example - Figure 6-5).

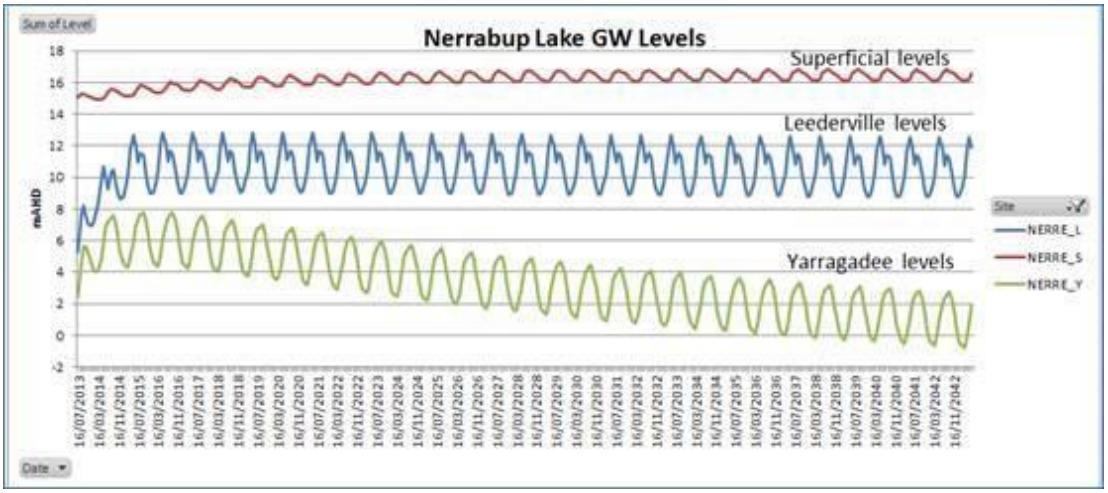

Figure 6-5: Hydraulic heads at Neerabup Lake after 30 year of recharge and abstraction

In order for recycled water recharged into the confined aquifer to reach the Superficial aquifer or the surface (wetland), two conditions must be met;

1. There must be no confining geology between the confined aquifers (Leederville and Yarragadee) and the Superficial aquifer, and
2. The groundwater pressure (head) in the confined aquifers must be greater than the groundwater level in the Superficial aquifer.

For Stage 1 and Stage 2, the confinement provided by the low permeability aquitard (Wanneroo Member/Pinjar Member) is sufficient to prevent recycled water moving into the overlying aquifer, and regionally, heads in the confined will remain below the groundwater level in the Superficial aquifer therefore it is very unlikely that recycled water will reach the surface.

Investigations will occur at all recharge locations to ensure suitable confinement between the Wanneroo Member (aquifer) and the Superficial aquifer is present.

6.1.3 Subterranean Fauna (Stygofauna)

The Corporation engaged Bennelongia Environmental Consultants to investigate the likelihood of stygofauna existing in the confined Leederville and Yarragadee aquifers at the new recharge sites (**Bennelongia Environmental Consultants, 2016**). Given that recharge will occur at depths from greater than 140m below ground, in an environment with very low level of carbon and nutrients, it was considered extremely unlikely that stygofauna are present. As the recharge locations are confined and the risk of vertical movement into the overlying aquifer is very low, no impact on stygofauna conservation values is anticipated from Perth GWRS Stage 2.

6.1.4 Uses of the Leederville aquifer

The Leederville aquifer is a major groundwater resource for Perth. Groundwater from the Leederville aquifer is currently used by the Water Corporation for public water supply, by local government for irrigation of parks and gardens and by private suppliers for horticultural and industrial purposes. These uses are expected to continue into the future.

6.2 Yarragadee Aquifer

As described in Table 6-1, there is a regionally extensive layer that separates the Leederville and Yarragadee aquifers (Davidson W.A. & Yu X., 2008). This layer consists of the Mariginiup aquitard and South Perth Shale aquitard and is estimated to be more than 350m thick at the northern and southern recharge sites, based on current understanding of the Perth Basin. This understanding will be confirmed upon drilling of a pilot hole and geophysical logging to the Yarragadee aquifer.

6.2.1 Upward flow into the Superficial aquifer

Due to the thick and extensive nature of the low permeability sediments that overlie the Yarragadee aquifer, it is considered that upward flow of recharge water across this layer is unlikely.

If conditions allowed for recharged water from the Yarragadee to flow upwards, it would have to first flow through the South Perth Shale (aquiclude) and Mariginiup Member, into the Leederville aquifer, through the Wanneroo member (aquitard) and overlying aquifers before reaching the base of the Superficial aquifer. Travel times even under extreme head conditions will be in the order of tens of thousands of years.

6.2.2 Subterranean Fauna (Stygofauna)

The Water Corporation engaged Bennelongia Environmental Consultants to investigate the likelihood of stygofauna existing in the confined Leederville and Yarragadee aquifers at the new recharge sites (Bennelongia Environmental Consultants, 2016). Given that recharge will occur at a depth from 1000m below ground, in an environment with very low level of carbon and nutrients, there is an extremely low likelihood of stygofauna being present. As the recharge locations are confined and there is a low risk of vertical movement into the overlying aquifer, no impact on stygofauna conservation values is anticipated from Perth GWRS Stage 2.

6.2.3 Uses of the Yarragadee aquifer

Groundwater from the Yarragadee aquifer is used by the Water Corporation, and to a lesser extent industry and local government. Uses include public water supplies, irrigation and heating public swimming pools (geothermal bores). Whilst further development of water from this aquifer for horticulture and industry may be currently constrained due to cost, water quality and availability of groundwater allocation, maintaining water quality that is adequate for these uses is required.

7 Environmental Values, Management Objectives and Water Quality Guidelines

7.1 Step 2a: Identify Environmental Values of the receiving environment (Leederville and Yarragadee aquifers)

In summary, an assessment of the aquifers at the recharge sites has confirmed that:

- There is an effective confining layer present between the Leederville aquifer and Superficial aquifer at the northern recharge site.
- Assessment of the northern recharge site has verified that the aquitard characteristics at both the northern and southern recharge sites is similar to the Beenyup Stage 1 site.
- Vertical flow will take thousands of years for recycled water to travel from the Leederville aquifer to the Superficial aquifer at the point of recharge and at the boundary of the RMZ. As a result the EVs of the Superficial aquifer do not need to be considered for the Stage 2.

The following section considers each value described in the ANZECC Guidelines and assesses its relevance for the Leederville and Yarragadee aquifers in the vicinity of the Perth GWRS Stage 2 recharge locations.

7.1.1 Drinking Water

The ANZECC guideline references the Australian National Health and Medical Research Council *Australian Drinking Water* Guidelines (NHMRC, NRMMC, 2011) to provide guidance on what constitutes good quality drinking water (ANZECC and ARMCANZ, 2000a).

Guidance on producing drinking water using recycled water as a source is provided in the *Australian Guidelines for Water Recycling: Managed Aquifer Recharge (Phase 2) (AGWR Phase 2)* (NRMMC-EPHC- NHRMC, 2009).

Further to this and specific to groundwater replenishment in Western Australia, the DoH required that the recycled water meets the Recycled Water Quality Parameters (RWQP) and Recycled Water Quality Indicators (RWQI) as defined by the WSW/GWR MoU 2014 at the:

- Point of recharge if the aquifer is used for public drinking water supplies;
- At the boundary of the RMZ.

The Water Corporation currently uses the Leederville and Yarragadee aquifers as a raw source of drinking water. While the Stage 2 Leederville and Yarragadee recharge sites are outside the P3 PDWSA, the existing and future use of both aquifers for the purpose of providing a raw drinking water resource should be maintained.

The IAWG has determined that the Drinking Water EV is applicable and must therefore be protected.

7.1.2 Primary Industries

The ANZECC Guidelines have amalgamated agriculture, aquaculture and human consumption of aquatic foods into one environmental value called ‘Primary Industries’. Both the quality and the quantity of water resources are critical issues for agriculture and aquaculture in Australia. Water quality is also of major importance for the protection of human consumers of food products. Growth of these major primary industries, together with expanding urbanisation and other industrial development, has increased the demand

for good quality water but at the same time exerted escalating pressures on the quality of the water resources that are available. Therefore, to assess water for primary industries, not only must productivity issues be considered but also the possible adverse effects of these enterprises on downstream water quality and activities (ANZECC and ARMCANZ, 2000).

There are a number of bores currently used for the purpose of primary industry in the Leederville aquifer and there is potential for future bores to be licensed for this purpose. Therefore the IAWG has determined that the Primary Industry EV should be maintained for the Leederville aquifer.

There is currently one licenced Yarragadee bore in the vicinity of the Perth GWRS Stage 2 recharge sites providing water for primary industry, located approximately 10km north. However with a growing population and increasing pressures to gain access to this water source for the purpose of Primary Industry, current constraints may be overcome and future additional use for primary industry is possible. Therefore the IAWG has determined that the Primary Industry EV should apply to the Yarragadee aquifer.

7.1.3 Industrial Water

The ANZECC guidelines recognise that water for industrial use is an environmental value that has a high economic benefit to the community.

There are bores present in the Leederville and Yarragadee aquifers that provide water for industrial water purposes therefore the IAWG has determined that the Industrial Water EV must be maintained.

7.1.4 Cultural and Spiritual Values

The ANZECC Guidelines recognise cultural and spiritual values are important, particularly for indigenous people. No specific guidance for protection of these values is provided but the ANZECC Guidelines indicates that planning and management must consider cultural issues.

The Water Corporation will continue consultation with members of the indigenous community.

7.1.5 Aquatic Ecosystems

The objective of the Aquatic Ecosystem environmental value adopted by the ANZECC Guidelines is “to maintain and enhance the ‘ecological integrity’ of freshwater and marine ecosystems, including biological diversity, relative abundance and ecological processes”.

The Groundwater TRG has estimated that upward flow from the Leederville aquifer to the Superficial aquifer will take more than 3,800 years at the point of recharge or 11,500 years at boundary of the RMZ under conservative (and unlikely) recharge conditions, indicating virtually no connectivity to the Superficial aquifer in the vicinity of recharge, and hence virtually no risk of impact to the aquatic ecosystems in the Superficial aquifer.

The likelihood of freshwater ecosystems surviving in each aquifer in the vicinity of recharge was assessed. In a report assessing the presence of stygofauna in the Leederville and Yarragadee aquifers in the vicinity of recharge, stygofauna experts Bennelongia Environmental Consultants, advised the following (full report provided as Appendix 3).

The geology within the Leederville and Yarragadee aquifers is transmissive and the water is fresh (<500mg/L); thus both aquifers may provide suitable habitat for stygofauna where they are unconfined. However stygofauna are unlikely to occur naturally at the actual point of injection of recycled water, which will be at depths of 140 – 400 m (Leederville) or ~ 1350 m (Yarragadee) and about because levels of carbon and nutrients will be very low.

Based on this information, the IAWG has confirmed that the Aquatic Ecosystems EV will not be considered for the Leederville or Yarragadee aquifers.

7.1.6 Recreation and Aesthetics (a social value)

Irrigation of public open spaces for the purpose of recreation or aesthetics is considered in the Primary Industries EV (section 7.1.2).

The recharge interval of the Leederville aquifer at the northern recharge site commences below 140m depth and the Yarragadee aquifer is estimated to commence below 770 m, with no connectivity to the Superficial aquifer or ornamental lakes in the vicinity of recharge, therefore both these aquifers are not accessible for recreation purposes.

Local governments in Perth often abstract groundwater to maintain water levels in ornamental lakes for aesthetic purposes. It is possible that water can be sourced from the Leederville and Yarragadee aquifers for these purposes. There are no users within the vicinity of the Stage 2 recharge sites using water for these purposes.

There are also a number of users with geothermal bores in the Yarragadee aquifer, including the Craigie Leisure Centre located approximately 1km south of the Stage 1 recharge sites. In this situation, changes to water temperature caused by recharge of recycled water must be considered. This has been reviewed in the aquifer risk assessment for Stage 1 and is adequately mitigated. It is not considered to be a relevant risk for Stage 2 due to the distance of the geothermal bore from the Stage 2 recharge sites.

The IAWG has determined that the Recreation and Aesthetics EV does not apply to the Leederville and Yarragadee aquifers.

7.2 Step 2b: Establish a broad management objective for the relevant EVs

The establishment of a management objective is to reflect the desired state of the EVs identified as relevant to the receiving environment.

The IAWG has determined the management objectives of the EVs defined in Table 8-2 will be “to maintain the water quality in the receiving aquifer to facilitate current and future use”.

7.3 Step 2c: Determine Appropriate Water Quality Guidelines

The IAWG has agreed that the water quality guidelines required to protect the identified EVs must be met at the point of recharge. The water quality guidelines applied to the Leederville and Yarragadee aquifers will be the same at the boundary of the RMZ. In the event that the background groundwater quality is higher than the set guideline, it is the background groundwater level that shall be met at the boundary of the RMZ.

7.3.1 Drinking Water EV

The DoH has confirmed the water quality guidelines required to protect human health and the drinking water resource as part of the Stage 2 are the same as Stage 1 and defined in the WWS/GWR MoU 2014 (Schedule 1.)

The RWQP and RWQI values are based on health guidelines provided in the ADWG, AGWR Phase 2, GWRT and results from the Premiers Collaborative Research Project (DoH et al, 2009) and tailored to the Beenyup wastewater catchment. They are subject to ongoing review by the DoH, the Water Corporation, technical peer review experts and government agencies and may be varied from time to time in accordance with strict change control processes. Changes to guidelines may be a result of, but aren't limited to, amendment of the Australian Drinking Water Guidelines and Australian Guidelines for Recycled Water (from which the RWQP and RWQI are derived), assessment of emerging chemicals, perceived chemical of concern or new research all of which are identified in the environment scan processes.

The RWQP and RWQI defined in the WWS/GWR MoU 2014 (as amended from time to time) will be applied at the point of recharge and at the boundary of the RMZ to protect the Drinking Water EV.

7.3.2 Primary Industry EV and Industrial Water EV

There is a wide range of uses of water in the EVs of Primary Industries and Industrial Water; given that there is unrestricted access to potable (drinking) water for the purpose of Primary Industry and Industrial Water, the Drinking Water EV water quality guidelines will be applied for these two EVs.

7.3.3 Cultural and Spiritual EV

There is no specific guidance for the protection of the Cultural and Spiritual EVs however the Water Corporation will continue to liaise with the relevant stakeholders in the Indigenous Community to discuss any cultural issues with respect to recharging into the Leederville and Yarragadee aquifers.

8 Conclusion

The IAWG has established the relevant EVs and water quality guidelines for the Stage 2, recharging to the Leederville and Yarragadee aquifers based on:

- Advice on the characteristics of the Leederville and Yarragadee aquifers provided by the Groundwater TRG; and
- Evaluation of the six environmental values described in the ANZECC guidelines.

In summary, the EVs that are applicable to the Leederville and Yarragadee aquifers in the vicinity of the GWRS Stage 2 recharge sites are listed in **Table 8-1**.

Table 8-1: Assessment of the relevant EVs for Perth GWRS Stage 2

Environmental Value	Yarragadee aquifer	Leederville aquifer	Superficial aquifer
Drinking Water	✔	✔	✕
Primary Industries	✔	✔	✕
Industrial Water	✔	✔	✕
Cultural and Spiritual	✔	✔	✕
Aquatic ecosystems	✕	✕	✕
Recreation and Aesthetics	✕	✕	✕

A lack of connectivity to the Superficial aquifer from the Leederville or Yarragadee aquifer means that the IAWG do not need to consider the EVs applicable to the Superficial aquifer.

The management objectives and water quality guidelines applicable to the relevant EVs are listed in Table 8-2.

Table 8-2: EVs and Water Quality Guidelines Relevant to the Perth GWRS Stage 2

<table>
<tr><th rowspan="2">Environmental Value</th><th rowspan="2">Management Objective</th><th colspan="2">Water Quality Guideline</th></tr>
<tr><th>Leederville aquifer</th><th>Yarragadee aquifer</th></tr>
<tr><td>Drinking Water</td><td rowspan="4">To maintain the water quality in the receiving aquifer to facilitate current and future use</td><td colspan="2">• Recycled Water Quality Indicators
• Recycled Water Quality Parameters
As defined by the WWS/GWR MoU</td></tr>
<tr><td>Primary Industries</td><td colspan="2">• As per Drinking Water EV</td></tr>
<tr><td>Industrial Water</td><td colspan="2">• As per Drinking Water EV</td></tr>
<tr><td>Cultural and Spiritual</td><td colspan="2">• Consultation with Indigenous Community</td></tr>
</table>

Identification of the relevant EVs, Management Objectives and Water Quality Guidelines completes the activities required for Step 2 of the GWR Regulatory Framework.

The Water Corporation will now proceed with Step 3 “Conduct a risk assessment for treatment processes and aquifer response to ensure protection of EVs.”

Following completion of this step, the IAWG will reconvene to review the risk assessment and approve as appropriate.

References

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Appendix 1:

IAWG Workshop to define the EVs -

List of Attendees

Perth Groundwater Replenishment Scheme - Stage 2

IAWG Workshop to define the Environmental Values

Meeting Attendance Register

DATE: 22 August 2016
TIME: 10:30- 12:00pm,
LOCATION: Shannon Room, Water Corporation

Name	Title	Organisation	Signature
MATTHEW AWANG	A/DIRECTOR REGULATION	DoW	[illegible]
Ben Drew	Branch Manager WAP	DoW	[illegible]
Simon Higginson	Senior MAR Advisor	WC	[illegible]
Tanya McKenna	Environmental Consultant	WC	[illegible]
Clemencia Rodriguez	Senior Project Of	DoH	MCRodriguez
Nick Turner	Manager TWCP	WC	[illegible]
Richard Theobald	Manag. Water	DoH.	[illegible]
Vanessa Moscovis	Manager Dry Season Response	WC	[illegible]

Appendix 2: Extract of Groundwater TRG Meeting Minutes - Defining the Recharge Management Zone

WATER CORPORATION

Groundwater Replenishment – Technical Reference Group

Extract from Meeting Outcomes

to define the Recharge Management Zone (RMZ) boundary and monitoring bore location

ATTENDEES: **DATE:** 17 August 2016

Curtin University - Brett Harris, CSIRO - Henning Prommer, Bradley Patterson, Michael Donn
Rockwater Consultant Hydrogeologists - Karen Johnston, Department of Water - Jon-Phillippe Pigois, Robert Karelse, Water Corporation - Andrew Jones, Simon Higginson (Chair)

APOLOGIES: Robert Woods **(**WC**)**

No.	Agenda Item	Meeting Outcomes
3.	Stage 2 GWR	• Review Scope *SH advised on recharge/abstraction locations and AWRP duplication. Advised the final CCP will be located at the end of the AWRP process at Beenyup, with PCP to be located at recharge bores*
4.	GWR Regulatory Framework	*SH reiterated the GWR Regulatory Framework and the process to gain approvals for Stage 2GWR and where the TRG have key deliverables* • Pilot hole *SH summarised the drilling that occurred at the northern recharge site (coring, petrophysics, geophysics) to determine thickness of confinement, permeabilities between Leederville and Superficial aquifers.* • Environmental Values *SH summarised the Recharge Management Zone (RMZ), Environmental Values, management objective and monitoring for Stage 1 GWR. SH reaffirmed that Stage 1 will be used to validate the RMZ using the compliance monitoring bores with additional research sampling at the GWRT 240N site and modelling by the CSIRO.* • Management – Monitoring Bore, Recharge Management Zone *The TRG agreed a RMZ of 250m for the Stage 2 recharge sites was appropriate, and would be confirmed through Stage 1 monitoring, modelling and future assessment by the TRG. If the TRG were to recommend a change in the RMZ (smaller or greater) the IAWG would be informed.* *SH identified the investigations occurring to optimise drilling and operating of recharge at the new sites, which included investigating the option of multiple bores into the same aquifer at the same site. The TRG discussed the monitoring requirement and concluded that one monitoring bore per aquifer, screened over the recharge interval is appropriate. This would be located 50-100m radial distance from the recharge bore/s.*

7.	Summary of outcomes	***Recharge Management Zone*** *– The Technical Reference Group agreed that a RMZ of 250m was appropriate for new recharge sites, subject to validation of the RMZ during Stage 1 GWR at Beenyup. The results will be presented to the TRG and addressed through the iterative risk assessment process.* ***Monitoring Bores*** *– The TRG agreed that one monitoring bore per aquifer at each recharge site was sufficient to verify recycled water recharged and to provide early warning to implement a management response if required. This bore would be located 50-100m away from the recharge bore/s, screened over the same recharge interval.*

Appendix 3:
Stygofauna Report

Bennelongia Environmental Consultants

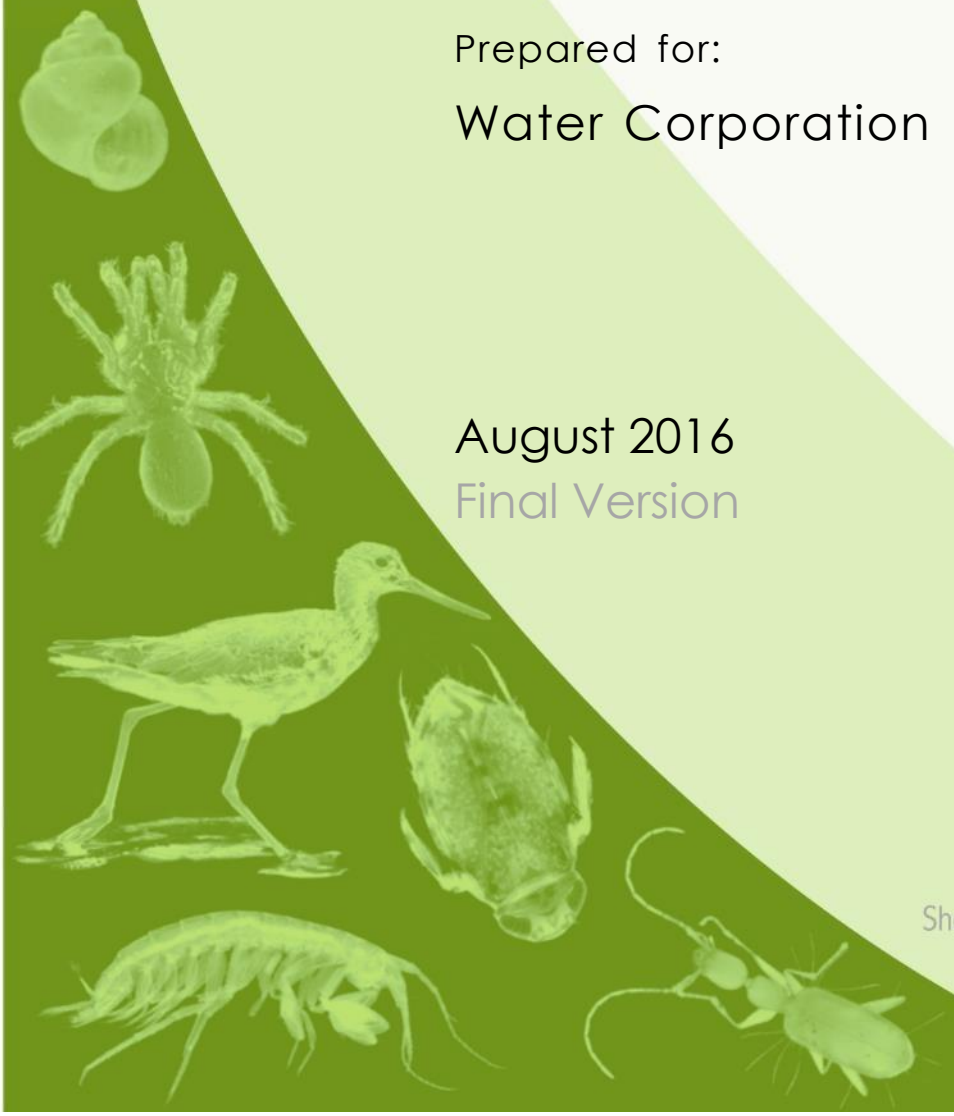
Groundwater Replenishment Scheme Stage 2: Subterranean Fauna Desktop Assessment

Prepared for:

Water Corporation

August 2016

Final Version



Short-Range Endemics I Subterranean Fauna

Waterbirds I Wetlands

Groundwater Replenishment Scheme Stage 2: Stygofauna Desktop Assessment

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ACN: 124 110 167

Report Number: 280

Report Version	Prepared by	Reviewed by	Submitted to Client	
			Method	Date
Draft	Renee Young	Stuart Halse	email	17 August 2016
Final	Renee Young	Stuart Halse	email	31 August 2016

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EXECUTIVE SUMMARY

The Water Corporation is proposing to implement an expansion of the Groundwater Replenishment Scheme (Stage 2) including off-site recharge of the confined aquifers. Duplication of the existing Advanced Water Recycling Plant (AWRP) located at the Beenyup Wastewater Treatment Plant (WWTP) and the construction of additional water recharge and conveyance infrastructure will increase the capacity of the project to recharge on average 77 ML/day of recycled water into the Leederville and Yarragadee aquifers. The water will meet drinking water standards prior to being recharged. This report assesses the likelihood of stygofauna being present within the Leederville or Yarragadee aquifers at, or immediately adjacent to, the proposed recharge locations.

Stygofauna are animals that live in groundwater and arid areas of Western Australia are particularly rich in stygofauna. However, knowledge of the subterranean fauna of the Swan Coastal Plain is relatively limited. An unpublished review of stygofauna occurrence in the Gnangara groundwater system suggested that the more frequently recorded groups are copepods, amphipods, syncarids, ostracods and oligochaetes.

Stygofauna may occur in an array of different groundwater habitats including porous, karstic and fractured-rock aquifers, springs and the hyporheos of streams. The groundwater habitats on the Swan Coastal Plain that are likely to support stygofauna include porous alluvium and colluvium, limestone karst, springs and the hyporheos of rivers and streams. In these habitats, both lateral and vertical connectivity of fissures and voids are important for the occurrence of stygofauna. Lateral connectivity enables animals to move about underground, while vertical connectivity through to the surface enables recharge of carbon and nutrients to the stygofauna community. Stygofauna have mostly been recorded in fresh to brackish groundwater but may occur in salinities (expressed as conductivity) of up to 55,000 µS/cm. Irrespective of the prospectivity of the geology, few species and only low numbers of individuals are expected to occur where depth to the watertable is much more than 30 m.

Three regional aquifers occur in the Perth Region: the unconfined superficial aquifer; the confined Leederville aquifer; and the confined Yarragadee aquifer. The superficial aquifer is located close to the surface and is often expressed as wetlands or lakes in low lying areas of land. The Leederville and Yarragadee are mostly confined aquifers that occur much deeper, and are separated from the superficial aquifer and each other by confining materials such as clay and shale. There are small areas north of Perth (and also extensive areas off-shore) where these aquifers come to the surface. Locally, the Mirrabooka aquifer is also used for public supply and was intersected when Bore BNYP 1/07 was drilled in 2007 near near Beenyup and when the pilot hole at the northern recharge site was drilled in 2016.

The geology within the Leederville and Yarragadee aquifers is transmissive and the water is fresh (<500 mg/L TDS); thus both aquifers may provide suitable habitat for stygofauna in this local area where they are unconfined. However, stygofauna are unlikely to occur naturally at the actual point of injection of recycled water, which will be at depths of 140 – 400 m (Leederville) or ~ 1350 m (Yarragadee) and about because levels of carbon and nutrients will be very low. Farther afield, the aquifers quickly become confined with an impermeable layer between the Superficial and the Leederville aquifer (and again between the Leederville and Yarragadee aquifers). In areas where the Leederville and Yarragadee aquifers are confined there is no vertical connectivity with the surface to provide input of carbon and nutrients to the aquifers and stygofauna are very unlikely to occur.

In theory, recharge might have an impact on stygofauna if injection into the underlying Leederville and Yarragadee aquifers leads to upwards movement of the recycled water into the superficial aquifer, where stygofauna are likely to be present. However, owing to mixing of water after injection, it is considered unlikely that there would be any impact on stygofauna in the superficial aquifer from changes in water quality should upward movement of recycled water occur. Furthermore, most species in the Gnangara Mound, where the scheme will operate, appear to have ranges that extend beyond the Mound and the likely extent of any possible water quality changes.

Given that stygofauna are unlikely to occur in the vicinity of reinjection points of recycled water because injection is occurring deep in confined parts of the Leederville and Yarragadee aquifers and that the likelihood of water quality changes in the superficial aquifer appears to very low, no impact on stygofauna conservation values would be expected from Stage 2 of the Groundwater Replenishment Scheme.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

The Water Corporation is proposing to implement an expansion of the Groundwater Replenishment Scheme (Stage 2) including off-site recharge of the confined aquifers from which scheme water is drawn. Duplication of the existing Advanced Water Recycling Plant (AWRP) located at the Beenyup Wastewater Treatment Plant (WWTP) and the construction of additional water recharge and conveyance infrastructure will increase the capacity of the scheme to recharge into the Leederville and Yarragadee aquifers, on average, 77 ML/day of recycled water. The recycled water will meet drinking water standards.

Recharge of the confined aquifers in specific locations (Figure 1) has potential ecological benefits in aiding the recovery of some sensitive wetlands and groundwater dependent ecosystems (GDEs). The proposed recharge locations have been placed where increase in pressure within the deep aquifer as a result of injecting recycled water will result in upwards water pressure from the deeper aquifers to the superficial aquifer.

This report assesses the likelihood of stygofauna being present within the Leederville or Yarragadee aquifers at, or immediately adjacent to, the proposed recharge locations. It also examines the likelihood of recharge affecting stygofauna in the superficial aquifer but does not consider in detail whether stygofauna communities that may occur near the recharge sites. It takes account of:

- Pre-existing datasets and relevant reference materials;
- Information on the current understanding of aquifers within the Perth Metropolitan area (including conceptual models);
- Site-specific geological data derived from a pilot hole at the proposed northern recharge site; and
- The consultant's experience regarding the likely distribution of stygofauna within the confined aquifers of the Perth Metropolitan area.

2. OVERVIEW OF PERTH'S MAJOR AQUIFERS

Three regional aquifers occur in the Perth Region in the vicinity of the proposed recharge sites. These are the:

- unconfined superficial aquifer;
- confined Leederville aquifer; and
- confined Yarragadee aquifer.

The superficial aquifer is located relatively close to the ground surface and is often expressed as wetlands or lakes in low-lying parts of the landscape. The Leederville and Yarragadee aquifers are confined aquifers that occur much deeper, and are separated from the superficial aquifer and each other by confining materials such as siltstone and shale (Figure 2). Locally, the Mirrabooka aquifer is also used for public supply (Commander 2003) and was intersected when Bore BNYP 1/07 was drilled in 2007, and when the pilot hole at the northern recharge site was drilled in 2016, in addition to the three aforementioned aquifers (Rockwater 2008). Thus, the Mirrabooka aquifer is also described in this report.

2.1 Superficial Aquifer

The superficial aquifer is a complex, unconfined multilayered aquifer which extends throughout the Swan Coastal Plain, west of Gingin and the Darling Scarps. It supports a mix of ephemeral, seasonal and perennial wetlands, and in areas of urban development with shallow water tables much of it has

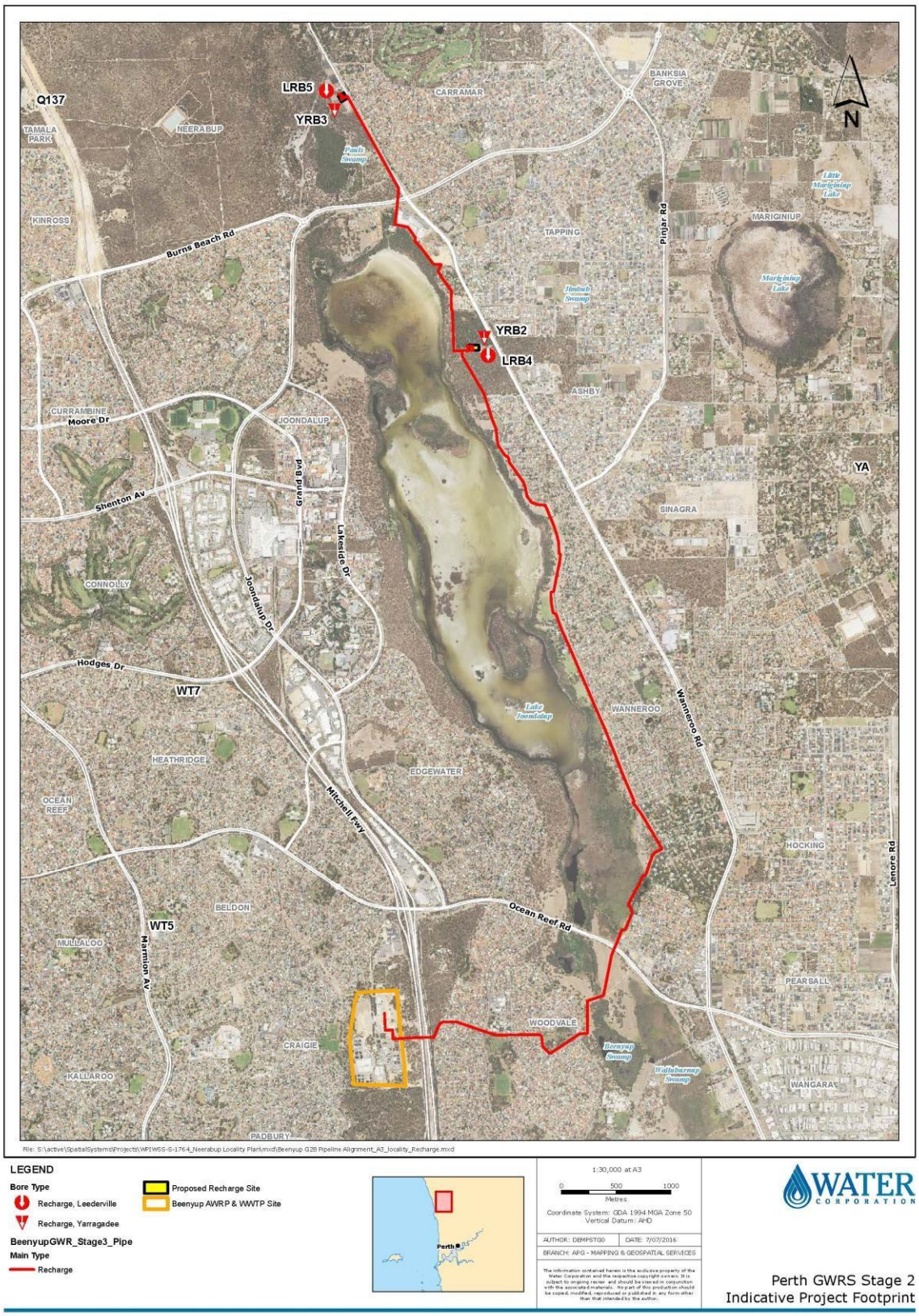

Figure 1. Perth GWRS Stage 2 Indicative Project Footprint.

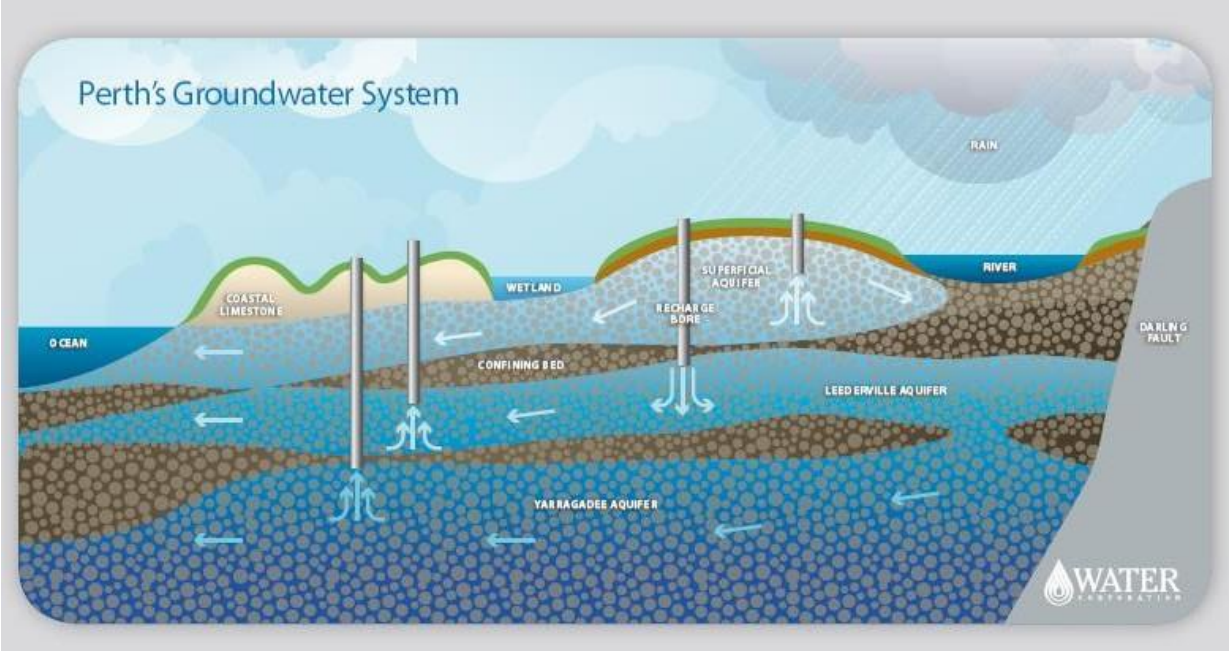

Figure 2. Schematic diagram of Perth's groundwater system (Water Corporation).

been drained (Halse 1989). The sediments which constitute the superficial aquifer range from predominantly clayey (Guildford Clay) in the east adjacent to the Darling Fault, through a sandy succession (Bassendean Sand and Gnangara Sand) in the central coastal plain area, to sand and limestone (Safety Bay Sand, Becher Sand and Tamala Limestone) within the coastal belt. The superficial aquifer has a maximum thickness of about 70 m, but average thicknesses of 45 and 20 m in the northern and southern Perth Region respectively (Davidson 1995).

Groundwater recharge occurs mostly from winter rainfall and is highest in the central and western parts of the coastal plain where the superficial formations are sandy and runoff is minimal. Seasonal water table fluctuations range from less than 0.5 m in the Tamala Limestone, 1-1.5 m in the Bassendean Sand and 3 m in the Guildford Clay, reflecting transmissivity of the sediments (Commander 2003).

The groundwater salinity is less than 250 mg/L in the Gnangara and Jandakot Mounds and typically rises to 600–800 mg/L along the coast (Davidson, 1995). Pockets of high salinity occur in groundwater discharge areas (Maddington, Serpentine Flats). Lakes Coogee, Cooloongup and Walyungup in coastal areas south of Perth are fed by groundwater and are saline.

2.2 Mirrabooka aquifer

The Mirrabooka aquifer is a semi-confined, or locally confined, aquifer that exists only in the northern Perth area. It is a predominantly sandy, major semi-confined aquifer and comprises the Poison Hill Greensand, Gingin Chalk, Molecap Greensand, and Mirrabooka Member. The extent of the Mirrabooka aquifer is quite widespread in the northern Perth area, where it is in hydraulic continuity with the superficial aquifer (Davidson 2005).

Groundwater from the Mirrabooka aquifer ranges in salinity from 130 to 350 mg/L TDS. The lowest salinity water is generally found in the recharge area and at the top of the aquifer, where it is in direct hydraulic contact with the groundwater in the superficial aquifer.

2.3 Leederville aquifer

The Leederville Aquifer is located between the superficial aquifer and the Yarragadee aquifer. While smaller than the Perth Yarragadee, it is still very large and in some areas it connects with the surface.

The Leederville aquifer is a major confined aquifer spanning the Perth Region. It overlaps the Darling Fault south of the Dandaragan Plateau and extends both north and south of the area. This aquifer is present beneath the entire coastal plain except near the Swan Estuary, where it has been eroded out prior to deposition of the Kings Park Formation, and in the southeast corner where the superficial formations rest directly on the Cattamarra Coal Measures. The Leederville aquifer is a multilayer groundwater-flow system consisting of discontinuous interbedded sandstones, siltstones and shales of the Henley Sandstone Member (Osborne Formation) and the Wanneroo and Mariginiup Members (Leederville Formation) (Davidson 2005).

The Leederville aquifer has a maximum thickness of more than 550 m in the Yanchep Syncline. In the northern part of the Swan Syncline and in the Wanneroo area it is about 500 and 400 m thick, respectively. Across the Pinjar Anticline the aquifer has a minimum thickness of about 50 m. South of Perth, the Leederville aquifer ranges in thickness from about 50 m in the southeast to about 300 m in the Jandakot area.

Groundwater salinity is less than 500 mg/L north of the Swan River and in areas near the Darling Scarp to the south east. The salinity exceeds 1,000 mg/L around the contact with the Kings Park Formation; in the eastern Swan Valley, the Kwinana Rockingham area, Serpentine, and in the Maddington area (where it is greater than 3,000 mg/L) (Davidson 2005).

The aquifer is unconfined at natural recharge locations where it directly underlies the superficial aquifer, but over short distances it becomes confined by discontinuous interbedding of siltstone and shale (Davidson 2005).

2.4 Yarragadee aquifer

The Yarragadee aquifer is a major confined aquifer, located below the Leederville aquifer and underlying the entire Perth Region and extending to the north and south within the Perth Basin. It is a multilayer aquifer, more than 2,000 m thick, consisting of interbedded sandstones, siltstones and shales of the Gage Formation, Parmelia Formation, Yarragadee Formation and Cattamarra Coal Measures. Over most of the area, the Yarragadee Formation is the major component of the aquifer, but in the northeastern and southern areas, the Parmelia Formation and the Cattamarra Coal Measures are, respectively, the major components. Only about the upper 500 m of the aquifer have been investigated by drilling (Davidson 2005).

Groundwater flow is from the north, with the addition of recharge in a comparatively small area in the north of the Gnangara Mound by leakage through the Wanneroo Member of the Leederville Formation. This recharge is low in salinity, less than 500 mg/L, and flows southwards to cross the coast between City Beach and Whitfords. Groundwater elsewhere in the aquifer is brackish, reaching over 3,000 mg/L in the Swan Valley.

3. PROJECT SITE: HYDRO-STRATIGRAPHIC SUMMARY

The results from drilling at a site near to the proposed northern reinjection location is described below and summarised in Table 1. It provides a good overview of the depths of the aquifers and geological layers.

Closest to the surface is the superficial aquifer, which is 46 m thick and consists of unconsolidated Bassendean Sand consisting of fine to coarse-grained quartz. Below this, the Mirrabooka aquifer occurs at a depth of 46 m and 108 m. It includes the Osbourne Formation and Henley Sandstone. The Osbourne Formation is comprised of two layers, an overlying sand layer comprised of fine to very coarse grained quartz and an underlying layer of sandstone that is weakly consolidated.

The Leederville Formation, which lies below the Mirrabooka aquifer, extends from 108 – 474 m and contains an upper siltstone and mudstone aquitard layer (a layer that separates aquifers and partially disconnects the flow of water) and lower sandstone and siltstone aquifer layer, both within the Wanneroo Member. Below these layers, there is approximately 30 m of siltstone and shale aquitard (in the Mariginiup Member).

The Leederville and Yarragadee Formations are separated by a 300 m thick siltstone and shale aquiclude (a layer that separates aquifers where there is zero flow) in the South Perth Shale. The Yarragadee Formation itself consists of a deep sandstone aquifer.

Groundwater salinity in the superficial and Mirrabooka aquifer in the vicinity of the drilling site is fresh and less than 500 mg/L TDS. Groundwater salinity gradually increases from about 250 mg/L at the top to about 800 mg/L TDS at the base of the Leederville aquifer.

Table 1. Hydro-Stratigraphic summary.

Average Depth (m)		Description	Stratigraphic Unit	Hydrogeology
From	To			
0	46	SAND: fine to coarse grained quartz	Bassendean Sand	Superficial
UNCOMFORMITY				
46	71	SAND: grey to pale green, fine to very course quartz with minor green staining (glauconite)	Osborne Formation	Mirrabooka Aquifer
71	81.5	SANDSTONE: greyish brown, fine to very course grained, poorly sorted, weakly consolidated		
81.5	108	SANDSTONE: grey very fine to very course grained with occasional granules, with minor clay	Henley Sandstone	
UNCOMFORMITY				
108	117	SILTSTONE: Dark grey, moderately to well consolidated, interbedded with fine to course grained sand	Leederville Formation	Wanneroo Member (Aquitard)
117	140	SILTSTONE, MUDSTONE: Dark grey to black, very well consolidate, interbedded with fine to medium grained quartz sandstone		
140	178	SANSTONE: Grey to dark grey, fine to coarse grain with some siltstone and clays.		Wanneroo Member (Aquifer)
178*	404*	SANDSTONE/SILTSTONE: fine to coarse grained quartz with some siltstone and shale beds.		
404*	474*	SILTSTONE AND SHALE		Mariginiup Member (Aquitard/Seal)
474*	776*	SILTSTONE AND SHALE	South Perth Shale	Aquiclude
>776*		SANDSTONE: light grey to grey, interbedded fine to medium grained well sorted quartz with fine to coarse grained poorly sorted beds. Few siltstone/shale beds. Garnet and heavy minerals occur throughout.	Yarragadee Formation	Yarragadee (Aquifer)

*Depths taken from PRAMS3.5 and interpretation from Beenyup lithology.

4. HYDROGEOLOGICAL MODELLING OF THE GWS

Hydrogeological modelling of the effects of GWR Stage 1 and Stage 2 which includes recharge and subsequent abstraction from new and existing assets for the Integrated Water Supply System (IWSS) was undertaken by Water Corporation in 2016. The assessment compares the net effect on the three main aquifers of the Gnangara groundwater system of recharge and abstraction of GWR Stage 1 and Stage 2 against the currently licenced IWSS Baseline abstraction plan. These effects were modelled over 30 years and Option 17 for GWR Stage 2 provides the preferred distribution of impacts relative to site specific environmental sensitivity and provides an operationally feasible option in terms of water quality, site access and IWSS capacity (see Water Corporation 2016).

The development of off-site recharge options has determined the balance of planned recharge between the Leederville and Yarragadee aquifers. This balance has evolved into the proposed recharge of 14 GL/year through a mix of two Leederville bores delivering 4 GL/year each and two Yarragadee bores delivering 3 GL/year each (Water Corporation 2016).

It is anticipated that an increase in pressure in the Leederville aquifer can help to reverse the historic de-pressurisation of the Leederville aquifer and decrease, or reverse, the existing downward vertical hydraulic gradient between the superficial and Leederville aquifers in some areas. Where the Leederville aquifer is unconfined, a significant change in vertical gradient can provide a mechanism to aid recovery of groundwater levels in the superficial aquifer. However, at the recharge sites in the Leederville aquifer some confinement of that aquifer is required to prevent the direct vertical movement of recharge water into the superficial aquifer where aquatic ecosystems might be impacted. Consequently Leederville recharge locations have been selected based on sites near where a confining layer (Wanneroo Member) pinches out to provide maximum pressure benefit but prevent direct vertical flux to the superficial aquifer (Water Corporation 2016).

5. OVERVIEW OF STYGOFAUNA AND PREFERRED HABITATS

5.1 Stygofauna

Stygofauna are animals that live in groundwater and arid Western Australia appears to be particularly rich in stygofauna. Nearly all stygofauna are invertebrates, mostly crustaceans, although stygofaunal fish have been found on around Exmouth Cape (e.g. Whitely 1945). Various terminologies have been applied to describe the relationship between stygofaunal species and groundwater. The most common scheme is that stygoxenes are surface species that use groundwater facultatively, stygophiles are species with most life stages completed in groundwater or some populations entirely dependent on groundwater, and stygobionts are obligate users of groundwater throughout their life cycle. In this document, however, all species using groundwater will be referred to as stygofauna. In general, stygofauna are characterised by the loss of eyes and skin pigmentation and the development of a vermiform body shape and more elongated appendages than surface relatives, although some species retain reduced eyes and not all have a vermiform shape.

The main concentrations of stygofauna in Western Australia appear to be in the Pilbara (Eberhard et al. 2005a, Halse et al. 2014) and the Yilgarn (Cooper et al. 2007) but they have also been found in the Kimberley (Hancock & Bennison 2005), Nullarbor and south-western Australia in lower abundance. Historically, intensive study of stygofauna in Western Australia began at Cape Range (Knott 1993) and then expanded to Barrow Island and the Pilbara before the Yilgarn was explored (see Humphreys

2001). There has been less survey effort in the South-West than in central and northern Western Australia.

A high proportion of stygofauna have restricted distributions (Gibert and Deharveng, 2002). According to Eberhard et al. (2009), about 70 % of Pilbara stygofauna species are likely to be short range endemics (SREs) as defined by Harvey (2002), with many of them having much smaller ranges than Harvey's criterion of 10,000 km^2. Species with restricted ranges are vulnerable to extinction following habitat destruction or environmental changes (Ponder and Colgan 2002; Fontaine et al. 2007).

5.1.1 Stygofauna of the Swan Coastal Plain

Knowledge of the subterranean fauna of the Swan Coastal Plain is relatively limited. An unpublished review of stygofauna occurrence in the Gnangara groundwater system suggested that the more frequently recorded groups are copepods, amphipods, syncarids, ostracods and oligochaetes (Bennelongia 2008).

More recently, Bennelongia has conducted monitoring in shallow bores at Kensington, with 59 samples collected from 12 bores over three years to 2015. Twenty-one species were collected and of these, at least 13 are true stygofauna including six copepods, three syncarids, three oligochaetes and one aphanoneuran species. The assemblage is typical of that found in alluvial/colluvial aquifers and is similar in higher-level taxonomic composition to the assemblages found in eastern Australian alluvial aquifers (Hancock and Boulton 2008). All of the species were collected at very low abundance.

The Western Australian Museum has undertaken ad-hoc stygofauna surveys of the subterranean fauna of the Swan Coastal Plain. Both unconfined (superficial) and confined (Leederville, Yarragadee) aquifers have been sampled. The surveys also revealed that stygofauna occur within the superficial aquifer but species richness is low. There were only 24 records of 11 species from a moderately extensive sampling program (Table 2) (Bennelongia 2008). The occurrence of stygofauna in the confined aquifers has not been confirmed.

Other sampling along the Swan Coastal Plain has been undertaken around the Yanchep area by Brenton Knott of the University of Western Australia, who has taken hundreds of samples to find only copepods, amphipods and a few ostracods (pers. comm. 2008). Results of other studies in the South-West are similar to those of the Museum and University, providing added confidence that the area does not support stygofauna communities as diverse as those in arid areas. Schmidt (2005) found relatively few species in groundwater associated with Marbling Brook on the eastern edge of the Darling Scarp in the Chittering catchment, 60 km north-east of Perth. The total yield from seven groundwater bores sampled 12 times was about 21 species, with most being copepods (Table 3). All animals collected were very small, with the exception of two species of amphipod, and only two of the 21 species were considered to be stygobionts. Other animals are either known, or likely to be, widespread. Another moderately diverse fauna was found on the eastern side of the Harvey Estuary, where 18 species were collected from 19 samples. All but four of the species were known to have a wider distribution than the study area (Bennelongia 2009).

With few stygobionts and extensive aquifers systems, few species on the Swan Coastal Plain would be expected to have highly restricted distributions. This has been confirmed when Swan Coastal Plain species have identified by morphological studies, with most stygobionts appearing to be wide-ranging. For example, the copepod *Kinnecaris eberhardi* has been recorded from both the Leeuwin-Naturaliste and Yanchep karsts (Tang and Knott, 2009). However, not all groups show this pattern, and

regional endemism has been recorded in the worm fauna, with two congeneric species known only from Leeuwin-Naturaliste and Nambung north of Perth, respectively (Pinder *et al.* 2006). It should also be noted that taxonomic concepts are primarily based on morphology and no genetic studies have been carried out to test for cryptic speciation.

Table 2. Results of sampling in bores by the Western Australian Museum on the Swan Coastal Plain within the rectangle defined by 31° 30'S 115° 30'E and 32° 12'S 116° 00'E. Note that the number of stygobionts is uncertain but likely to be few. Data supplied by W.F. Humphreys

Taxon	No. records	Comments
Protozoa		
'Paramecium'	1	
Rotifera		
rotifer	1	few rotifers other than bdelloids are stygobionts
Oligochaeta		
Antarctodrilus WA3	1	
Enchytraeidae spp	1	usually widespread
Crustacea		
Ostracoda		
ostracod	5	prob. 2 species
Cyclopoida		
Paracyclops fimbriatus	7	=*P. chiltoni*, widespread surface species
cyclopoid	1	2nd species of cyclopoid
Harpacticoida		
harpacticoid	2	
Syncarida		
Bathynellidae	1	bathynellids usually stygobionts
Decapoda		
shrimp	1	atyid?
crustacea larvae	3	Order unknown but perhaps decapods

Table 3. Results of sampling seven groundwater bores 12 times for stygofauna at Marbling Brook (Schmidt, 2005)

Higher Taxon	No. bores present	Comments
Nematoda	6	
Oligochaeta	6	
Ostracoda	2	1+ species of candonid
Copepoda	5	4+ species of cyclopoid, 5+ of harpacticoid
Syncarida	2	2 secies, 1 bathynellid, 1 parabathynellid
Amphipoda	4	2+ species
Acariformes	6	5+ species, 4+ oribatids

5.2 Stygofauna Habitat

Stygofauna occur in an array of different groundwater habitats including porous, karstic and fractured-rock aquifers, springs and the hyporheos of streams (Eberhard *et al.* 2005). Calcrete and alluvium are typically considered to be productive habitats for stygofauna, although mafic volcanics support rich stygofauna communities compared with the moderate abundance of communities in banded iron formation (Halse *et al.* 2014). The groundwater habitats on the Swan Coastal Plain that are likely to support stygofauna includee porous alluvium and colluvium, limestone karst, springs and the hyporheos of rivers and streams.

In these habitats, both lateral and vertical connectivity of fissures and voids are important for the occurrence of stygofauna. Lateral connectivity enables animals to move about underground, while vertical connectivity through to the surface enables recharge of carbon and nutrients to the

stygofauna community. There is a clear correlation between transmissivity of an aquifer and its suitability for stygofauna.

Stygofauna have mostly been recorded in fresh to brackish groundwater but may occur in salinities (expressed as conductivity) of up to 55,000 µS/cm (ca. 35,000 mg/L) (Watts and Humphreys 2006; Schulz *et al*. 2013). Apart from salinity, the physicochemical tolerance of stygofauna to different groundwater parameters, especially in the Pilbara, has been poorly defined (see Halse *et al.* 2014).

Irrespective of the prospectivity of the geology, few species and only low numbers of individuals are expected to occur where depth to the water table is much more than 30 m (Halse *et al.* 2014). Similarly few species will occur at large depths below the water table because of the attenuation of carbon and nutrient inputs with depth, so that productivity is reliant on chemosynthesis (Porter *et al*. 2009)

6. LIKELIHOOD OF IMPACT ON STYGOFAUNA

The geology within the Leederville and Yarragadee Aquifers is likely to be suitably transmissive for stygofauna and the water is fresh (<500 mg/L TDS), so that it might be considered to provide suitable habitat for stygofauna. Injection of recharge water is proposed to occur at depths of 140 m – 400 m and ~1350 m (Rockwater 2008), so that it is unlikely stygofauna will occur in the zone of recharge owing to the presence of confining layers and the attenuation of carbon and nutrient inputs with depth. Accordingly, there is unlikely to be any conservation impact on stygofauna as a direct consequence of recharge.

There might, theoretically, be an impact on stygofauna if recharge of the underlying Leederville and Yarragadee Aquifers led to upwards movement of recharged water into the superficial aquifer, where stygofauna are likely to be present. In this regard, it should be noted that recycled water is required to meet only drinking water guidelines (Water Corporation 2015), which are less stringent than ecological guidelines for parameters such as nitrogen (ANZEEC 2000). With that caveat and without detailed analysis of water flows, mixing and likely realised water quality after injection, it is considered unlikely that there will actually be an impact on stygofauna for four reasons:

- The salinity of groundwater in all aquifers and the recharge water has similar magnitude (approximately 250 – 500 mg/L in the superficial aquifer on the Gnangara Mound, 150 – 350 in the Mirrabooka aquifer, <500 in the Leederville aquifer, <500 in the Yarragadee aquifer and <600 in recharge) (Davidson 1995).
- The Leederville recharge locations have been selected such that they are where the Wanneroo Member pinches out to provide maximum pressure benefit but prevent direct vertical flux to the superficial aquifer.
- Aquatic invertebrate species in south-western Australia, including stygofauna species, have evolved in a relatively saline landscape and have relatively high salinity tolerances. The differences in salinity levels in the different aquifers and recharge water are unlikely to be ecologically meaningful below 600 mg/L (Pinder *et al*. 2005).
- Most species occurring in the superficial aquifer are likely to be relatively widespread at the scale of water management operations (about 13 km). It is likely that most stygofauna species with restricted distributions occur in association with landscape features, such as the Yanchep caves, approximately 20 km north of the scheme (Jasinska and Knott 2000), rather than in more hydrogeologically uniform parts of the Swan Coastal Plain. For example, Tang and Knott (2009) recorded 14 groundwater copepod species from the Gnangara Mound, of which only two species were restricted to the Mound: *Eucyclops edytea* which occurs in springs and caves, and *Paranitocrella bastiani* which occurs only in caves.

7. SUMMARY AND CONCLUSIONS

The Water Corporation is proposing to implement an expansion of the Groundwater Replenishment Scheme (Stage 2) including off-site recharge of the confined aquifers. Water is proposed to be reinjected to the Leederville or Yarragadee aquifers where the superficial aquifer is disconnected from the deeper aquifers, but close enough to where the deeper aquifers are unconfined and this report assesses the likelihood of stygofauna being present at, or immediately adjacent to, the proposed recharge locations.

Reinjection to the aquifer is proposed to occur at depths of 140 m – 400 m and ~1,350 m. The density of stygofauna is usually inversely proportional to depth because carbon and nutrient inputs decline with depth. In theory, there might be an impact on stygofauna if recharge of the underlying Leederville and Yarragadee aquifers leads to upwards movement of recycled water into the superficial aquifer where stygofauna are likely to occur. In practice, however, owing to mixing of recycled water with surrounding aquifer water after injection, it is considered unlikely that there will be any changes in water quality that are sufficient to impact on stygofauna in the superficial aquifer. Furthermore, most species in the Gnangara Mound, where the scheme will operate, appear to have ranges that extend beyond the Mound and any possible extent of water quality changes.

Given that stygofauna are unlikely to occur in the vicinity of reinjection points of recycled water because injection is occurring deep in confined parts of the Leederville and Yarragadee aquifers and that the likelihood of water quality changes in the superficial aquifer appears to very low, no impact on stygofauna conservation values would be expected from Stage 2 of the Groundwater Replenishment Scheme.

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Groundwater Replenishment Regulatory Framework

December 2012

Prepared by the Groundwater Replenishment Trial Interagency Working Group:

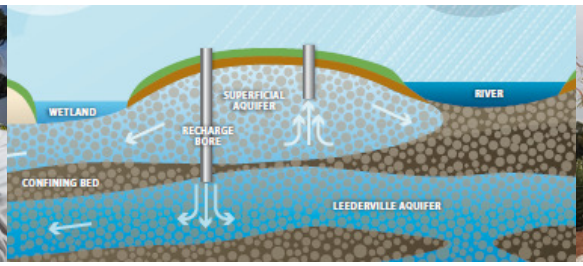
Government of Western Australia Department of Health

Department of Environment and Conservation Our environment, our future

Government of Western Australia Department of Water

and

WATER CORPORATION



Revision History

Version	Prepared By	Date Issued	Issued to	Comments Received
Final Draft v1	Adrian Parker, Ruth Dowd, Richard Theobald, Clemencia Rodriguez, Nick Turner, Vanessa Moscovis and Tran Huynh	05/12/12	GWRT IAWG	Comments received from Alan Sands, Director Environmental Regulation.
Final Draft v1A	Tran Huynh	10/12/12	GWRT IAWG and Signatories for endorsement.	

Status

The Groundwater Replenishment Framework is "Draft" untill all signatories have signed it off for final release.

A "Draft" document should not be used for any purpose other than to be reviewed with the intention of generating a "Final" version

Table of Contents

Endorsement

This document was developed by the Groundwater Replenishment Trial Interagency Working Group which consisted of:

1. **Department of Health** of 189 Royal Street, East Perth, Western Australia

2. **Department of Environment and Conservation**, of 168 St Georges Terrace, Perth, Western Australia

3. **Department of Water**, of 168 St Georges Terrace, Perth, Western Australia

4. **Water Corporation**, a statutory body corporate established under the Water Corporation Act 1995, of 629 Newcastle Street, Leederville, Western Australia

In endorsing this document, the Department of Health (DoH), Department of Environment and Conservation (DEC), Department of Water (DoW) and the Water Corporation agree to comply with the Groundwater Replenishment Regulatory Framework.

This document will be reviewed by the DoH, DEC, DoW and Water Corporation, five (5) yearly from the commencement date.

Signed for
Department of Health

19th December, 2012

Dr Tarun Weeramanthri
Executive Director
Public Health and Clinical Services Division

Date

Signed for
Department of Environment and Conservation

13 December 2012

Mr Keiran McNamara
Director General

Date

Signed for
Department of Water

17 December 2012

Ms Maree De Lacey
Director General

Date

Signed for
Water Corporation

17 December 2012

Ms Sue Murphy
Chief Executive Officer

Date

Definitions

Advance Water Recycling Plant (AWRP) is a multi-step treatment process which produces recycled water for the purpose of Groundwater Replenishment.

ANZECC Guidelines means the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000a).

Australian Guidelines for Water Recycling (AGWR) Guidelines means the Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (Phase 1) (2006), the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Augmentation of Drinking Water Supplies (2008) and the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Managed Aquifer Recharge (2009) published by the National Health and Medical Research Council.

Commencement Date means the date on which the last party signs the GWR Regulatory Framework.

Drinking Water means water intended primarily for human consumption, which also has other domestic uses.

Environmental Values is the term applied to particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health.

Groundwater Replenishment process by which secondary treated wastewater undergoes advanced treatment to produce water which meets Australian guidelines for Drinking Water prior to being recharged to an aquifer for later use as a Drinking Water source.

Groundwater Replenishment Regulatory Framework defines the approvals pathway required to develop, approve and provide ongoing regulation for a Groundwater Replenishment Scheme.

GWR MoU means the Groundwater Replenishment Memorandum of Understanding between the DoH and the Water Corporation.

GWRT MoU means the Groundwater Replenishment Trial Memorandum of Understanding between the Department of Health and the Water Corporation. *The GWRT MoU will be superseded by the GWR MoU*.

Interagency Working Group (IAWG) comprising of Departments of Health, Environment and Conservation and Water and the Water Corporation to oversee the Groundwater Replenishment Trial.

Point of recharge is where recycled water has met all the critical control points i.e., a step or procedure at which controls can be applied and a hazard can be prevented, eliminated or reduced to acceptable (critical) levels and is ready to be recharged to the aquifer.

Public Drinking Water Source Areas (PDWSA's) are underground pollution control areas, water reserves and catchment areas that have been identified as current or future sources of Drinking Water.

Recharge Management Zone (RMZ) defines the minimum distance between recharge of recycled water and abstraction of groundwater for public Drinking Water supplies.

Recycled Water in the case of GWR is produced by further treatment of secondary treated wastewater by the Advanced Water Recycling Plant (AWRP) to meet Drinking Water quality standards before being recharged into an aquifer.

Wastewater Catchment means the wastewater collection system that delivers inflows to wastewater treatment plants.

1 Introduction

Groundwater replenishment (GWR) is the process by which secondary treated wastewater undergoes advanced treatment to produce recycled water which meets Australian guidelines for Drinking Water prior to being recharged to an aquifer for later use as a Drinking Water source.

The Water Corporation intends on implementing Groundwater Replenishment to provide a public Drinking Water source for Perth, Western Australia.

The Water Corporation has been working with the Department of Health (DoH), Department of Environment and Conservation (DEC), Department of Water (DoW) to assess the viability of Groundwater Replenishment.

2 Background

Groundwater Replenishment was initially considered as a viable recycled water option for Western Australia in 2005. Successful GWR Schemes for Drinking Water sources (indirect potable reuse) occurred internationally, however, there was a lack of National and State guidance for the planning, design, commissioning, operation, use and regulation of these schemes.

Under Section 16(e) of the *Environmental Protection Act (1986)*, the Environmental Protection Authority (EPA) advises the Minister for the Environment on strategic environmental matters. Advice provided under Section 16(e) also guides the proponent on the type and extent of further work that will be required for environmental approval.

In 2005 the EPA assessed the potential for Groundwater Replenishment to be conducted in the Perth metropolitan area. The EPA supported further investigation of the approach on a staged basis "*starting with trials and projects of low risk*" (EPA, 2005).

Based on this advice, the Water Corporation developed the Groundwater Replenishment Trial. The DoH, DEC, DoW and the Water Corporation entered into a Groundwater Replenishment Trial Interagency Agreement in March 2007 (IAWG, 2007) and formed the Interagency Working Group (IAWG). The Objectives of this Agreement were to allow:

1. The Water Corporation to conduct the Groundwater Replenishment Trial to assess technical feasibility and gauge community support for Groundwater Replenishment; and
2. The DoH, DEC and DoW to review information from the Water Corporation's Groundwater Replenishment Trial in order to:
    a) Develop a GWR Regulatory Framework.
    b) Inform government policy relating to Groundwater Replenishment, specifically by addressing issues identified by the IAWG in April 2008 (IAWG, 2008).
    c) Assess Groundwater Replenishment as a Drinking Water source for Perth, Western Australia.

By December 2012 the IAWG will have successfully achieved objectives 2a and 2b through the delivery of the GWR Regulatory Framework document and addressed the gaps in Policy and Regulation, which will have informed the GWR Regulatory Framework.

Assessment of Groundwater Replenishment as a Drinking Water source for Perth (Objectives 1 and 2c) will be complete in early 2013.

3 Scope of the Document

This document outlines the GWR Regulatory Framework.

It is important to note that Groundwater Replenishment will be used as a Drinking Water source. Therefore this document only addresses the indirect potable reuse of water and does not address any other use for recycled water.

This document is not intended and does not affect any of the statutory responsibilities of the DoH, DEC, DoW or the Water Corporation.

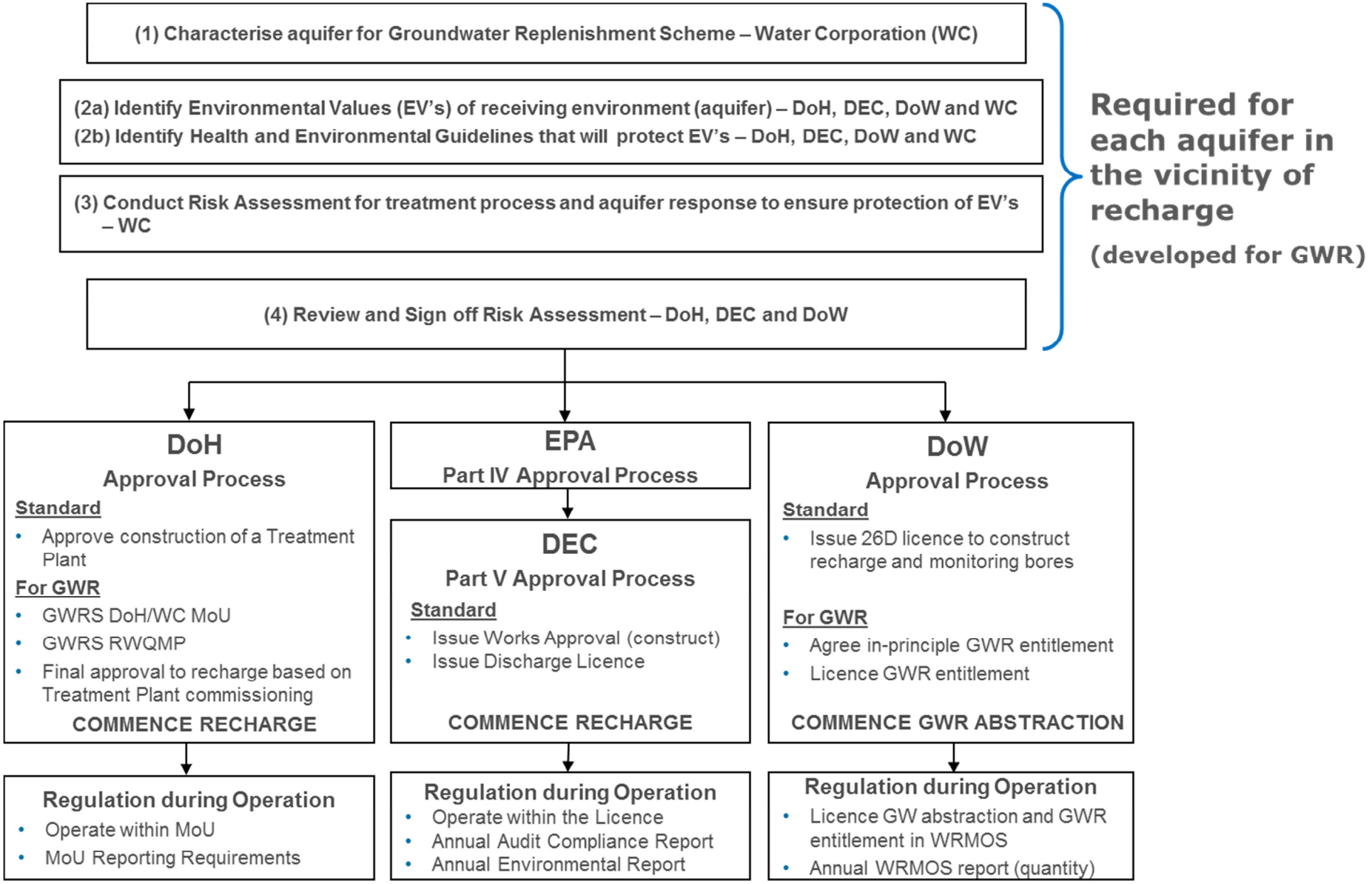
4 Purpose of the Regulatory Framework

The GWR Regulatory Framework defines the approvals pathway required to develop, approve commencement of recharge and provide ongoing regulation for a Groundwater Replenishment Scheme.

The GWR Regulatory Framework was developed utilising existing legislation, AGWR Guidelines and ANZECC Guidelines and a directive from the Western Australian Environmental Protection Authority (EPA) to implement a risk-based approach.

Figure 4-1 illustrates the GWR Regulatory Framework.

Figure 4-1: Groundwater Replenishment Framework



5 Roles and responsibilities

The government agencies that have a role in providing initial assessment, approval and ongoing regulation of a GWR Scheme are as follows:

5.1 Department of Health

The DoH is responsible for administering the legislation concerning health regulation in Western Australia under the *Health Act 1911*.

The DoH's role is to:

i. Minimise human exposure to environmental health hazards that pose or have the potential to pose a health risk.
ii. Reduce the incidence and impact of communicable disease.
iii. Guide, assess and approve all water recycling schemes to safeguard public health.

5.2 Department of Environment and Conservation

DEC is responsible for administering the legislation concerning environmental regulation in Western Australia under the *Environmental Protection Act 1986* (the EP Act). Under Part V of the EP Act*,* DEC regulates emissions and discharges from prescribed premises.

DEC will consider Groundwater Replenishment under Part V of the *EP Act.*

5.3 Department of Water

The DoW manages water quality issues by using powers provided through the *Metropolitan Water Supply, Sewerage and Drainage Act 1909 (WA)* and the *Country Areas Water Supply Act 1947 (WA)* and associated By-laws under these Acts.

The DoW also manages abstraction of groundwater under the *Rights in Water and Irrigation Act (RIWI Act) 1914.*

5.4 Water Corporation

The Water Corporation provides water services across Western Australia, under the *Water Corporation Act 1995* and administers the *Water Agencies (Powers) Act 1984.*

The Water Corporation will seek approval for construction and operation of future Groundwater Replenishment Schemes in accordance with this Groundwater Replenishment Regulatory Framework.

6 Definition of Recycled Water and Waste

Recycled water is usually treated wastewater which is further treated to varying qualities that is "fit for purpose" for its intended use. In the case of GWR, recycled water is produced by further treatment of secondary treated wastewater by an Advanced Water Recycling Plant (AWRP) to meet Drinking Water quality standards before being recharged into an aquifer.

Current legislation does not adequately define recycled water for the purposes of Groundwater Replenishment. The DoH, DEC, and DoW were required to consider the definition of recycled water produced by an AWRP for the purposes of Groundwater Replenishment as part of the Trial. The definitions are as follows:

Department of Health
The DoH considers *recycled water as "sewage" until it is appropriately treated to a level considered to be Drinking Water quality or above. The water passing through the AWRP is sewage up until the point of recharge*.

Department of Environment and Conservation
For the purposes of DEC's regulation of the AWRP and Groundwater Replenishment as a prescribed premises category 54, recycled water from the AWRP will always be considered to be treated sewage irrespective of the recycled water quality achieved.

The Trial has demonstrated that DEC is able to effectively manage the recharge of treated sewage from the Beenyup AWRP into the Leederville aquifer, by regulating the AWRP and confirming the specification of recycled water quality prior to it entering the recharge bore, so as to achieve the objectives and purposes of the EP Act.

In relation to the above circumstances, DEC has considered the extent to which 'matter', as referred to in the definition of 'waste' under section 3(1) of the EP Act - being in this case treated sewage (recycled water) arising from the Beenyup AWRP - ought to be regulated under the EP Act. DEC has concluded that recycled water meeting the Drinking Water specification ceases to be 'waste'.

An 'emission' under section 3(1) of the EP Act is defined to include a discharge of waste. Under section 56(1) of the EP Act, an occupier of prescribed premises who, among other things, causes an emission from the premises commits an offence unless having done so in accordance with a licence issued in relation to the premises. In view of DEC's conclusion above, the recharge of recycled water meeting the Drinking Water specification to groundwater does not meet the definition of an emission under the EP Act.

Department of Water
The DoW has taken advice from the DoH and consider *recycled water as "sewage" until it is appropriately treated to a level considered to be Drinking Water quality or above. The water passing through the AWRP is*

sewage up until the point of recharge. DoW will adopt this definition in the administration of their relevant acts, regulation and by-laws.

7 Purpose of the Recharge Management Zone

A Recharge Management Zone (RMZ) defines the minimum distance between recharge of recycled water and abstraction of groundwater for public Drinking Water supplies. It also defines the boundary at which groundwater must meet the water quality guidelines required to protect the identified environmental values. Environmental values are always preserved and the recharged water becomes part of the environment beyond the RMZ boundary.

The IAWG have agreed that a RMZ is a requirement of any GWR Scheme. They have defined that:

- A RMZ should be applied to all Groundwater Replenishment Schemes recharging into the confined aquifers in Perth.
- The RMZ boundary is a radial distance of 250m from the recharge bore for all confined aquifers at the Beenyup site, subject to final assessment of the Yarragadee aquifer.
- The principles for a groundwater monitoring plan within the RMZ. A groundwater monitoring plan should demonstrate protection of the environmental values of the receiving groundwater environment and be derived from the groundwater risk assessment (section 8.1.3).

In addition to defining the RMZ, the DoH, DEC, and DoW were required to consider their Agency's ongoing role in regulating the RMZ as an output of the Trial. This is summarised as follows:

Department of Health
DoH will regulate the RMZ within the GWR MoU. The DoH requires that the groundwater quality meets the Recycled Water Quality Parameters and Recycled Water Quality Indicators as defined in the GWR MoU at the RMZ boundary.

Department of Environment and Conservation
DEC has an interest in the RMZ in so far as it is the receiving environment for the discharge of treated sewage (recycled water) from the prescribed premises (AWRP).

DEC may require the on-going monitoring of groundwater quality within the RMZ, as part of licencing conditions. This is to ensure that the regulatory controls applied to the prescribed premises are effectively preventing pollution and environmental harm occurring as a result of the discharge of treated sewage (recycled water) and that the environmental values of the groundwater are being protected.

Department of Water

DoW have advised that the appropriate mechanism to manage groundwater quality is through the GWR MoU which is administered by the DoH.

The DoW's Operational Policy 1.01 – Managed aquifer recharge in Western Australia (DoW, 2011) makes reference to the establishment of "managed aquifer recharge management zones" (MAR management zones) to facilitate the management of groundwater quality and quantity in the vicinity of MAR schemes. These zones are used as an internal management tool by the DoW to ensure the location of MAR schemes is considered in the processing of other groundwater abstraction licence applications in the area.

The RMZ meets the DoW requirement for this internal management tool and will be mapped on the DoW's geographical information system (GIS) for internal use.

8 Groundwater Replenishment Regulatory Framework

The purpose of the GWR Regulatory framework is defined in section 3.

8.1 Initial Assessment of a Groundwater Replenishment Scheme

The first four steps of the GWR Regulatory Framework involve collaboration between the DoH, DEC, DoW and Water Corporation to conduct an initial assessment of the GWR scheme prior to entering into each Agency's formal approval process.

This approach was developed for Groundwater Replenishment utilising a risk management approach recommended by the AGWR Guidelines ((NRMMC-EPHC-AHMC, 2006) (NRMMC-EPHC-NHRMC, 2008) (NRMMC-EPHC- NHRMC, 2009) and the ANZECC Guidelines (ANZECC and ARMCANZ, 2000a). This approach recognises and protects water quality to maintain or enhance an environment which will support an ecosystem or use for public benefit, welfare, safety or health.

The benefits of applying this approach are:

- To gain agreement between the three regulating agencies and the Water Corporation of the values of the receiving groundwater environment.
- To gain agreement between the three regulating agencies and the Water Corporation of the water quality guidelines that will protect the values of the receiving groundwater environment early in the development of the GWR scheme.

- Support the EPA's environmental impact assessment of the proposed GWR Scheme under Part IV for the EP Act 1986[1].

Prior to commencing the Initial Assessment of a Groundwater Replenishment Scheme, the Water Corporation must undertake Planning of a GWR scheme. Planning must consider the scale and location of the scheme and suitability of source water quality and the receiving groundwater environment.

This information can then be used to undertake the initial assessment.

8.1.1 Step One: Aquifer Characterisation

This step requires the Water Corporation to characterise the receiving groundwater environment such that appropriate environmental values can be defined.

Information used to characterise the aquifer can be derived from, but is not limited to, existing knowledge of groundwater systems and models that can predict pressure, fate and solute transport. Site investigations may also be carried out to inform this step. The extent of the investigations will depend on the amount of background knowledge that is available to the receiving groundwater environment at the vicinity of recharge.

The Water Corporation will obtain all approvals necessary to undertake site investigations.

Previous experience with the Groundwater Replenishment Trial, subsequent schemes and Table 4.2 in chapter 4 of the Australian Guidelines for Water Recycling: Managed Aquifer Recharge (Phase 2) (NRMMC-EPHC- NHRMC, 2009) will define the key issues to consider at this stage of project development.

8.1.2 Step Two: Environmental Values, Management Objectives and Water Quality Guidelines

This step involves:

1. Defining the Environmental Values (EV) for the receiving groundwater environment in the vicinity of recharge.
2. Establishing a set of broad management objectives for the relevant environmental values.
3. Determining appropriate water quality guidelines or criteria.

[1] The Water Corporation will refer all GWR Schemes to the EPA for assessment under Part IV of the EP Act.

Environmental Values
'Environmental values' is the term applied to particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health. The ANZECC Guidelines recognise six environmental values:

- Aquatic ecosystems
- Primary industries (irrigation and general water uses, stock Drinking Water, aquaculture and human consumers of aquatic foods)
- Recreation and aesthetics
- Drinking water resource
- Industrial water
- Cultural and spiritual value

The DoH, DEC, DoW and Water Corporation will convene to identify the EVs relevant to the receiving groundwater environment.

Management Objectives
The environmental management objectives reflect the desired state for EV's identified as relevant to the receiving groundwater environment, such as "maintain for current and future use".

The DoH, DEC, DoW and Water Corporation will convene to identify the management objectives for the relevant EV's.

Water Quality Guidelines
Associated with each environmental value are 'guidelines' or 'trigger values' for substances that might potentially impair water quality (e.g. pesticides, metals or nutrients). If these values are exceeded, they may be used to trigger an investigation or initiate a management response. Where two or more agreed environmental values apply to a water body, the more conservative, or stringent, of the associated guidelines should be selected as the water quality guideline.

Determining the EV's and associated water quality guidelines provides a clear pathway for assigning Agency responsibilities where multiple agencies can regulate a GWR Scheme. Water quality guidelines appropriate for the protection of EVs are described in Table 9.1.

Table 8-1: Water quality guidelines appropriate for the protection of EVs

Environmental Value	Water Quality Guideline that will protect the Environmental Value
Aquatic Ecosystems	DEC to establish water quality criteria[2] which will be applied with assistance from DoW and DoH.
Primary Industries	Given the unrestricted access to potable (drinking) water for the purpose of primary industry, the Drinking Water Resource EV water quality guidelines will be applied.
Recreation and Aesthetics	DoH and DEC to establish water quality criteria[2] with assistance from DoW.
Drinking Water Resource	*Recycled Water Quality Parameters* and *Recycled Water Quality Indicators* identified by the DoH and defined in the GWR MoU.
Industrial Water	Given the unrestricted access to potable (drinking) water for the use in industrial processes, the Drinking Water Resource EV water quality guidelines will be applied.
Cultural and spiritual values	No water quality guidelines are provided for this environmental value. Water Corporation to continue to engage with Indigenous stakeholders.

Representatives from the DoH, DEC, DoW and Water Corporation will convene to identify the water quality guidelines required to protect the relevant EV's.

8.1.3 Step Three: Risk Assessment

The Water Corporation will undertake a risk assessment from the wastewater catchment to the boundary of the Recharge Management Zone by applying the process described in the AGWR Guidelines to evaluate whether the GWR Scheme is able to protect the EVs. The risk assessment will consider whether the:

1. Management approaches in wastewater catchments are adequate to mitigate risks to feed quality for the treatment process.
2. Recycled water produced by the treatment process meets the required water quality guidelines at the point of recharge.
3. Potential aquifer risks to ensure that water quality continues to meet the water quality guidelines at the boundary of the Recharge Management Zone.

[2] Water quality guidelines may be derived from existing guidelines where appropriate.

8.1.4 Step Four: Agency Evaluation

The Water Corporation will present the GWR Scheme risk assessment to the Agencies, including risk mitigation strategies.

The DoH, DEC and DoW will evaluate and provide written advice regarding the acceptability of the risk assessment process and resultants risks.

8.2 Approvals Process

8.2.1 Environment Protection Authority

The Environment Protection Authority (EPA) undertakes the environmental impact assessment (EIA) of proposals and schemes referred to it under Part IV of the Environmental Protection Act 1986 (EP Act). EIA is a systematic and orderly evaluation of a proposal and its impact on the environment. This evaluation includes considering ways in which the proposal, if implemented, could avoid or reduce any impact on the environment.

Further details on submitting a proposal can be found on the EPA website.

The Water Corporation will refer a proposal under Part IV of the EP Act for a GWR scheme to the EPA.

The EPA will make its decision on whether or not to assess a GWR Scheme based on the potential impact(s) to the environment. It will advise the Water Corporation and relevant Decision Making Authority (DMA) of its decision on whether or not to assess the GWR Scheme, once all requests for information have been met to the EPA's satisfaction.

If the EPA determines a formal level of assessment, the GWR Scheme project proposal will then be assessed by the EPA under Part IV of the EP Act and managed according to the Ministerial Conditions applied to it. Further approvals will also be required under Part V of the EP Act. If the EPA finds the proposal does not require assessment, the Part V approvals will still be required. Approvals under Part V are administered by the Department of Environment and Conservation.

8.2.2 Department of Environment and Conservation

8.2.2.1 Works Approval

To meet the requirements of Part V of the EP Act, Water Corporation is required to undertake any work or construction in relation to an AWRP and GWR scheme (that will cause the premises to become or capable of being a prescribed premises) in accordance with a works approval issued by DEC.

Water Corporation will be required to make an application for a works approval to DEC and provide supporting information to allow DEC to determine whether all necessary measures to protect the environment will be taken to ensure emissions and discharges from the prescribed premises do not present an unacceptable risk.

A key area of interest for DEC will be the treatment processes and process controls including measurement, critical control and feedback systems that will be used to manage the performance of the AWRP and GWR process, to the extent that they impact on recycled water quality and emissions and discharges from the Premises.

DEC assesses works approval applications in accordance with all relevant principles and objectives of the EP Act and will, where a decision is made to issue a works approval, impose conditions on the works approval in accordance with Section 62A of the EP Act, to prevent, control, abate or mitigate pollution or environmental harm.

Following completion of the works authorised by the works approval, Water Corporation will be required to submit a compliance document to DEC. This compliance document is required to verify that the works have been completed in accordance with the conditions of works approval and that commissioning has demonstrated that the AWRP is operating to its design specification. Section 57 (3)(b) of the EP Act, prevents DEC issuing a licence where works have not been completed as per the conditions of a works approval.

8.2.2.2 Licence

Water Corporation will require a licence under Part V of the EP Act to operate an AWRP and GWR scheme. DEC will impose conditions on any licence issued in accordance with Section 62A of the EP Act, to prevent, control, abate or mitigate pollution or environmental harm.

The extent to which DEC may impose conditions on Part V licences for GWR Schemes will depend on the circumstances and facts of each GWR proposal. For most schemes, conditions relating to the specification of the treated sewage (recycled water quality) and monitoring of the receiving groundwater are likely to be appropriate.

8.2.3 Department of Health

The following requirements must be addressed by the Water Corporation in gaining approval for a GWR Scheme.

8.2.3.1 Approve construction of a Treatment Plant

According to the *Health Act* 1911, recycled water is considered to be sewage, until such time it appropriately treated to a level considered to be Drinking Water quality or above. Therefore, an Advanced Water Recycling Plant (AWRP) is considered to be an infrastructure

which treats sewage and *requires an application to construct or install an apparatus for the treatment of sewage* in accordance with the *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974*.

8.2.3.2 Memorandum of Understanding

The DoH will enter into a Memorandum of Understanding (MoU) with the Water Corporation to describe requirements for water quality, monitoring, review, notification, compliance and audit. A MoU enables the DoH to assess and scrutinise recycled water quality to ensure protection of public health and the Drinking Water resource.

8.2.3.3 Recycled Water Quality Management Plan

The Recycled Water Quality Management Plan is designed to manage recycled water quality from catchment to tap by incorporating an integrated quality assurance framework. A 12 element risk management framework for the management of recycled water quality describes a process for developing and implementing preventative risk management systems for recycled water use. This management framework is referenced in the AGWR Guidelines.

A GWR Scheme will be managed through the implementation of a Recycled Water Quality Management Plan. The Plan together with details of a monitoring plan for the Scheme must be endorsed by the DoH prior to commencing recharge.

8.2.3.4 Treatment Plant Commissioning

The DoH will review AWRP commissioning data prior to providing final approval to commence recharge.

8.2.4 Department of Water

The DoW have developed a new policy, *Operational Policy 1.01 – Managed aquifer recharge in Western Australia* (DoW, 2011) to aid the approval of socially and environmentally acceptable managed Aquifer Recharge (MAR) proposals under the *RIWI Act 1914*. Policy 1.01 was utilised to provide guidance in the development of the following DoW approvals required for a GWR Scheme:

8.2.4.1 26D licence to construct recharge and monitoring bores

Construction of recharge bores will need to be licensed under Section 26D of the *RIWI Act 1914*. The license when issued will contain terms and conditions specific to the construction requirements of the bore. The Water Corporation must apply for a 26D licence prior to commencing construction.

8.2.4.2 In-principle GWR entitlement

As noted in Section 6.2 of the DoW Operational Policy 1.01, *water that is recharged into the natural groundwater system is vested in the Crown (i.e. when the recharge water enters the groundwater*

system, the proponent does not retain ownership of that water). Therefore the proponent of a GWR Scheme has the same rights as other licence holders and must apply for a licence to recover the recharge water. Typically, DoW will grant licence entitlement to abstract water to the proponent undertaking recharge operations.

The DoW have granted the Water Corporation a 1:1 recharge and recovery ratio of a GWR Scheme (i.e., 7 GL/yr, Stage 1). An annual licence to recoup GWR recharged water is outlined below.

8.2.4.3 Licence GWR entitlement

The DoW manages annual groundwater abstraction via a five (5) yearly Water Resource Management Operating Strategy (WRMOS) for the Integrated Water Supply Scheme (IWSS) (Water Corporation, 2012). The process by which GWR water is recouped aligns with established operating procedures detailed in the IWSS WRMOS.

Prior to the commencement of each water year, the Water Corporation will submit a 5C application to abstract water that will specify the anticipated groundwater abstraction and proposed location (including GWR water). As the licence will be issued for a limited tenure, an addendum to the IWSS WRMOS will be prepared.

The GWR entitlement of the 5C licence will be based on the forecast recharge for that year. The location of abstraction will be determined in accordance with the operating rules for groundwater abstraction that include the environmental sensitivity principles described in the IWSS WRMOS.

Matters relating to water quality can be submitted as an addendum to the IWSS WRMOS, once the results of the Trial have been analysed against the identified environmental values within the defined management zone and the level of protection achieved.

8.2.4.4 Permission and exemption of By-Laws under the EP Act

The DoW is responsible for protecting Public Drinking Water Source Areas (PDWSA's) under the *Metropolitan Water Supply, Sewerage and Drainage (MWSSD) Act 1909.* There is currently no differentiation with regards to recharging into an unconfined or confined PDWSA and therefore, all associated By-laws under the *MWSSD Act 1909* apply.

Specifically, there are two By-laws under *MWSSD Act 1909* that relate to the approval of a GWR Scheme proposal. These By-laws are administered by the DoW, and are as follows;

By-law 5.4.6
In a pollution area or a part of a pollution area, a person shall not dispose of or discharge onto or into the ground, or into any lake, swamp or drain industrial wastes, chemicals, radioactive material, petroleum or petroleum products, polluted water, or refuse unless that person has been granted permission in writing by the Commission to do so.

By-law 5.4.7
A person shall not discharge into any well or observation well any chemical, industrial waste, treated or untreated sewage, effluent or other matter which in the opinion of the Commission may pollute the underground water.

Based on the definition of recycled water (section 6), GWR recycled water is not considered to be *polluted water, or refuse* or *untreated sewage, effluent or other matter* pertaining to the above By-laws. The DoW will not require the administration of these Bylaws for the approval of a GWR Scheme. Therefore, the Water Corporation will not be required to seek permission or exemption from these By-laws for a GWR Scheme.

8.3 Regulating an Operational Scheme

8.3.1 Department of Health

The DoH provides protection of public and the Drinking Water resource by regulating the recycled water quality in a GWR Scheme. This is managed via a GWR MoU (section 8.2.3.2).

The Health Advisory Committee, consisting of the DoH and Water Corporation was established for the GWR Trial and will remain in place after the Trial. The Committee, chaired by the Water Corporation, meets monthly to review treatment performance and recycled water quality to ensure protection of public health and the Drinking Water resource. Both organisations are committed to the ongoing work of this Committee to ensure safe Recycled Water.

8.3.2 Department of Environment and Conservation

Water Corporation must manage, operate, monitor, report and undertake any relevant actions in relation to an operational GWR scheme in accordance with the conditions of the EP Act licence. The licence will require Water Corporation to produce an Annual Audit Compliance Report (AACR) that sets out the extent to which licence conditions have been complied with over the previous year and an Annual Environmental Report (AER). The licence will require the AER to include information relating to any complaints and/or incidents at the premises together with a summary of relevant process/operational data, monitoring data and an assessment of monitoring results against any targets or limits in the licence.

DEC will regulate operational GWR Schemes through a series of inspections and audits and by the review and assessment of AACRs, AERs and other submissions that may be required by the licence.

8.3.3 Department of Water

The DoW will manage the annual groundwater recharge and abstraction quantities via the IWSS WRMOS. The GWR abstraction will be negotiated annually in addition to a baseline groundwater allocation.

For water accounting purposes, the Water Corporation will add water replenishment volumes to standard monthly and annual reporting. The overall "banked" volume will also be reported. This is the cumulative difference between recharge and abstraction calculated over the life of the scheme.

9 Conclusion

The IAWG have developed the GWR Regulatory Framework which defines the initial assessments pathway required to develop, approve commencement of recharge and provide ongoing regulation for a Groundwater Replenishment Scheme.

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Instrument No. CAW183044(1)

LICENCE TO CONSTRUCT OR ALTER WELL

Granted by the Minister under section 26D of the Rights in Water and Irrigation Act 1914

Licensee(s)	Water Corporation
Description of Water Resource	Perth Perth - Leederville.
Location of Well(s)	Lot 9472 On Plan 11393 - Volume/Folio Lr3047/494 - Lot 9472 Gradient Way Beldon Lot 500 On Plan 64576 - Volume/Folio Lr3159/411 - Lot 500 Wanneroo Rd Wanneroo Lot 800 On Plan 52636 - Volume/Folio 2719/728 - Lot 800 Wanneroo Rd Neerabup

Authorised Activities	**Activity**	**Location of Activity**
	Construct 1 artesian well(s). Construct 1 monitoring well(s).	Lot 500 On Plan 64576 - Volume/Folio Lr3159/411 - Lot 500 Wanneroo Rd Wanneroo
	Construct 1 artesian well(s). Construct 1 monitoring well(s).	Lot 800 On Plan 52636 - Volume/Folio 2719/728 - Lot 800 Wanneroo Rd Neerabup
	Construct 1 artesian well(s).	Lot 9472 On Plan 11393 - Volume/Folio Lr3047/494 - Lot 9472 Gradient Way Beldon
Duration of Licence	From 12 July 2016 to 11 July 2018	

This Licence is subject to the following terms, limitations and conditions:

1 The well must be constructed by a driller having a current class 3 water well drillers certificate issued by the Western Australian branch of the Australian Drilling Industry Association or equivalent certification recognised nationally by the Australian Drilling Industry Association.

2 The licensee shall construct the well(s) to the specifications provided with the application for this licence dated 21 June 2016.

End of terms, limitations and conditions

Instrument No. CAW183059(1)

LICENCE TO CONSTRUCT OR ALTER WELL

Granted by the Minister under section 26D of the Rights in Water and Irrigation Act 1914

Licensee(s)	Water Corporation	
Description of Water Resource	Perth Perth - Yarragadee North.	
Location of Well(s)	Lot 500 On Plan 64576 - Volume/Folio Lr3159/411 - Lot 500 Wanneroo Rd Wanneroo Lot 800 On Plan 52636 - Volume/Folio 2719/728 - Lot 800 Wanneroo Rd Neerabup Lot 10284 On Plan 13529 - Volume/Folio Lr3048/732 - Lot 10284 Lysander Dr Heathridge Lot 12520 On Plan 192531 - Volume/Folio Lr3086/993 - Lot 12520 Connolly Dr Tamala Park	
Authorised Activities	**Activity**	**Location of Activity**
	Construct 1 artesian well(s).	Lot 10284 On Plan 13529 - Volume/Folio Lr3048/732 - Lot 10284 Lysander Dr Heathridge
	Construct 1 artesian well(s).	Lot 12520 On Plan 192531 - Volume/Folio Lr3086/993 - Lot 12520 Connolly Dr Tamala Park
	Construct 1 artesian well(s). Construct 1 monitoring well(s).	Lot 500 On Plan 64576 - Volume/Folio Lr3159/411 - Lot 500 Wanneroo Rd Wanneroo
	Construct 1 artesian well(s). Construct 1 monitoring well(s).	Lot 800 On Plan 52636 - Volume/Folio 2719/728 - Lot 800 Wanneroo Rd Neerabup
Duration of Licence	From 12 July 2016 to 11 July 2018	

This Licence is subject to the following terms, limitations and conditions:

1 The well must be constructed by a driller having a current class 3 water well drillers certificate issued by the Western Australian branch of the Australian Drilling Industry Association or equivalent certification recognised nationally by the Australian Drilling Industry Association.

2 The licensee shall construct the well(s) to the specifications provided with the application for this licence dated 2 June 2016.

End of terms, limitations and conditions

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000.

21 September 2016

YOUR REF
OUR REF P9474/42075
ENQUIRIES Janine Symons (08) 6552 4167

Mr Daniel Stevens
Water Corporation

By email: Daniel.Stevens@watercorporation.com.au

Dear Daniel

PERRY'S PADDOCK, COTTAGE AND STABLES
New underground pipe

Thank you for your correspondence of 9 September 2016 regarding the proposed development at *Perry's Paddock, Cottage and Stables*.

We received the following:

2 aerial images showing location of proposed subterranean pipeline

The proposed development has been considered in the context of the identified cultural significance of the place and the following comments are given:

Findings

- *Perry's Paddock, Cottage and Stables* has cultural heritage significance as the first land grant in Wanneroo, largely retaining its original spatial and functional characteristics.
- The proposal is for a Ground Water Replenishment Scheme project, which comprises an underground pipeline which will run from Beenyup wastewater treatment plant to a ground water injection site in the City of Wanneroo. The proposed pipe will traverse the northern portion of *Perry's Paddock, Cottage and Stables,* and travel near P2674 *Buckingham House,* which is on the State Register of Heritage Places.
- On the basis that the proposed pipe will follow an existing sewer main, it is unlikely that it will impact negatively on the archaeological significance of the place.

Comments

1. If the proposed route of the pipe changes, the proposal will need to be reconsidered by the State Heritage Office.
2. If archaeological artefacts are discovered, work is to stop, and the State Heritage Office is to be contacted for advice.
3. Disturbed landscape to be returned to condition prior to excavation, or as close as is possible.

Please note that these comments are provided to assist the owner in its application to the decision-making authority and are not provided under the provisions of Section 11 of the *Heritage of Western Australia Act 1990*. These comments do not replace the need for any required approvals from the decision-making authority.

Should you have any queries regarding this advice please contact Janine Symons at janine.symons@stateheritage.wa.gov.au or on 6552 4167.

Yours sincerely

Harriet Wyatt
A/DIRECTOR DEVELOPMENT & INCENTIVES

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

looking after all our water needs

Your ref:
Our ref: WT2419-04
Enquiries: John Connolly, 6364 6640

Mrs Sue Murphy
Chief Executive Officer
Water Corporation
PO Box 100
LEEDERVILLE WA 6902

ATTENTION: Vanessa Moscovis

Dear Sue

PERTH GROUNDWATER REPLENISHMENT SCHEME, STAGE 2 – AQUIFER RISK ASSESSMENT EVALUATION, OCTOBER 2016

The Department of Water understands that the Water Corporation intends to refer the above proposal to recharge up to 28GL/yr of highly treated recycled water into the confined Leederville and Yarragadee aquifers to the Office of the Environmental Protection Authority in accordance with Section 38 of the *Environmental Protection Act (1986).*

The purpose of this letter is to confirm the Department's position regarding the scheme, and to advise the adequacy of the assessment information provided by the Water Corporation. The Department's key consideration in this regard is to ensure that the identified environmental and resource values of the aquifers are maintained.

Consistent with the *Groundwater Regulatory Framework (December 2012)*, the Department has assisted the Water Corporation to establish the environmental values and conduct the risk assessment for the expanded groundwater replenishment scheme.

The Department is satisfied the proposed water recycling and recharge management systems and procedures will adequately protect the agreed environmental values of the target aquifers.

Furthermore, the Department is able to effectively manage groundwater resource impacts and abstraction under the water licensing provisions of the *Rights in Water and Irrigation Act 1914.*

If you have any enquiries regarding this matter please John Connolly on telephone 6364 6640.

Yours sincerely

Mike Rowe
DIRECTOR GENERAL

18 October 2016

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

Your ref:
Our ref: WT12660
Enquiries: Matt Viskovich, 6364 6869

Securing Western Australia's water future

Water Corporation
PO Box 100
LEEDERVILLE WA 6902
ATTENTION: Deanne McDonald

Dear Deanne,

Perth Groundwater Replenishment Scheme - Stage 2 Hydrogeological Report modified, June 2016

The Department of Water has reviewed the Water Corporation's *Perth Groundwater Replenishment Scheme - Stage 2 Hydrogeological Report modified, June 2016* (GWRS Stage 2) received on 4 July 2016.

The Department confirms that it is satisfied with the technical content of the report for proposed off-site locations of new recharge and abstraction bores for the reinjection and recovery of up to 28 Gigalitres from the Leederville and Yarragadee aquifers based on Perth Regional Aquifer Modelling System (PRAMS) scenarios.

I also confirm the Department's in-principle support for a 1:1 allocation ratio for GWRS Stage 2 based on the recharge and recovery scenario identified through the above mentioned technical report and acknowledge that Water Corporation will use this confirmation to initiate the project.

However, while recognising the preliminary scientific studies undertaken to date, it is important to note that further technical work may be necessary to allow the Department to complete an assessment of future applications for a 5C water licence, this may include but are not limited to the following:

- A hydrogeological report with the additional scientific information for precise aquifer characteristics and management at the selected locations.
- Preparation and submission of an enhanced IWSS monitoring program that includes GWRS Stage 2.
- Revisions to the IWSS Water Resource Management Operating Strategy where appropriate (eg. Revision to the IWSS bore abstraction plan to include GWRS Stage 2 recharge bores and water accounting).

It should be noted that when GWRS Stage 2 is commissioned both the recharge and recovery of groundwater will be re-evaluated each year consistent with requirements of the IWSS Water Resource Management Operation Strategy. A yearly review is essential as it will allow for an adaptive management approach that considers IWSS system constraints, adjustments to volumes and pattern of abstraction to limit impacts on environmentally sensitive areas and other users. This evaluation will be part of the joint annual review of the IWSS bore abstraction plan.

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This evaluation will be part of the joint annual review of the IWSS bore abstraction plan.

GWRS Stage 2 will also need to be included in the triennial IWSS Water Monitoring Reviews to evaluate performance against the modelled scenarios presented in the report using latest monitoring data. Re-evaluation builds our understanding of the groundwater resources whilst aiding refinement and optimisation of the IWSS recharge and abstraction plan to mitigate potential impacts to environmentally sensitive areas and other users.

I look forward to continued collaboration to ensure groundwater remains a viable, sustainable part of the IWSS supply mix and I would also like to confirm that the Department is fully committed towards meeting its obligations of the Interagency Technical Working Group as part of developing the regulatory approvals pathway for Stage 2 GWRS.

Should you have any further enquires on this matter please contact Matt Viskovich on telephone 6364 6869.

Yours sincerely

Paul Brown

Paul Brown
Executive Director, Regional Delivery & Regulation
13 July 2016