SUBMISSION TO THE HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON REGIONAL AUSTRALIA'S INQUIRY ON "CERTAIN MATTERS RELATING TO THE PROPOSED MURRAY-DARLING BASIN PLAN": GROUNDWATER SDLS

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1. Executive summary

In his second reading speech for the Water Act 2007, Malcolm Turnbull, MP, referred to "seriously overallocated and overused" aquifers, called attention to the need for better metering and monitoring of groundwater resources, and referred to "a sustainable and integrated cap on groundwater and surface water diversions". Much of the public attention to the proposed Basin Plan for the Murray-Darling Basin (MDB)—and indeed, the water reforms that preceded it—has focused on surface water systems. However, groundwater, groundwater-dependent ecosystems (GDEs) and rivers that depend on groundwater were intended to be important beneficiaries of the Basin Plan.

Sustainable diversion limits (SDLs) are the main measure that the Water Act provides for the sustainable management of groundwater resources under the Basin Plan. SDLs must be set at a level that satisfies environmental requirements set out in the Water Act, such as not compromising key groundwater-dependent environmental assets, ecosystem functions, and biodiversity. However, the processes used to set the groundwater SDLs under the revised draft of the proposed Basin Plan are not adequate to ensure that these requirements are met.

In summary, the groundwater SDLs have two key deficiencies, which stem from the process by which they were developed, and have not been cured by the recent revision to the proposed Basin Plan. First, the proposed SDLs overlook, in large part, the ecological role of groundwater, which has been the subject of a large body of government policy and scientific

[1] I am grateful to Moya Tomlinson for her insights into the topic of groundwater-dependent ecosystems. All errors remain my own. This submission does not constitute legal advice.

work. Ironically, that scientific work has been funded by millions of dollars of federal government funding. Second, the groundwater SDLs fail adequately to reflect the integrated nature of groundwater and surface water.

In particular, the following key omissions and over-simplifications were made in formulating the groundwater SDLs:

- The way that the groundwater SDLs are expressed as coarse, large-scale volumetric limits mirrors surface water SDLs but ignores the different nature of groundwater systems. Groundwater SDLs need to take into account groundwater flux, levels, and multiple quality parameters. In their current form, the groundwater SDLs cannot guarantee that groundwater extraction will be environmentally sustainable in the manner required by the Water Act.

- The formulation of groundwater SDLs did not consider:
  - the full range of GDEs, particularly those that do not involve the surface expression of groundwater, like terrestrial vegetation and aquifer ecosystems;
  - the full range of ecosystem functions and environmental outcomes associated with groundwater, focusing narrowly on groundwater contributions to surface waters, and the impacts of saline groundwater discharges; and
  - the effect of time lags between pumping and responses of physical systems, and the spatial distribution of groundwater pumps, on rivers and GDEs.

- The formulation of groundwater SDLs uses too high a threshold for recognizing connectivity between groundwater and surface water systems, omitting many connected systems from the formal “connected sources” category. As a result, groundwater SDLs are set at much higher levels that would have been the case if the proposed Basin Plan had adopted a more realistic approach to recognizing aquifer-stream connections.

These omissions and over-simplifications could well result in the reversal of some of the gains obtained by buying back water for the environment, since taking groundwater from connected resources effectively depletes rivers “through the back door”. It could also result in damage to sensitive and valuable GDEs, the importance of which is underscored by the significant and concerted federal and state science and policy-building effort over the past decade. The proposed groundwater SDLs must be revised to better address these issues, and to meet the spirit and the letter of the Water Act in relation to groundwater resources. The recommendations included in this submission sets out approaches that could be adopted to do so.

2. Background: Groundwater-dependent ecosystems

The environmental water requirements of groundwater-dependent ecosystems (GDEs) are central to the determination of groundwater SDLs under the Water Act. This section provides background on the nature of GDEs and examples of GDEs in the MDB, and outlines how the Water Act provides for groundwater SDLs to protect GDEs and associated ecological processes and outcomes.

2.1 Groundwater-dependent ecosystems in the Murray-Darling Basin

Although much of the public focus on providing water for ecosystems has concentrated on surface waters, to be ecologically sustainable, a water regime must also provide water for ecosystems that depend on groundwater (GDEs)—like floodplain forests, wetlands, and wildlife that depends on low flows in rivers. Groundwater and GDEs provide a broad variety of ecosystem functions: they provide habitats for microorganisms that sustain biochemical processes, artesian or other pressure, thermal water supply, and nutrient supply;[2] and support ecological refugia, including during drought to allow for subsequent recolonisation beyond the refugia.[3] GDEs also represent a key component of biodiversity. Scientific work suggests that aquifer ecosystems—only one type of GDE—represent "the most extended array of freshwater ecosystems across the entire planet … [with] high levels of endemism and high proportions of relictual species compared with surface environments".[4]

Column 1 of Table 1, below, sets out key types of GDEs; Column 2 sets out selected examples of those types of ecosystems in the MDB.[5]

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[2] Matthias Brunke and Tom Gonser, 'The ecological significance of exchange processes between rivers and groundwater' (1997) 37(1) *Freshwater Biology* 1; S Richardson et al, *Australian Groundwater-Dependent Ecosystems Toolbox: Part 1: Assessment Framework,* Waterlines Report Series No 69 (National Water Commission 2011) 34.

[3] A. J. Boulton and P. J. Hancock, 'Rivers as groundwater-dependent ecosystems: a review of degrees of dependency, riverine processes and management implications' (2006) 54(2) *Australian Journal of Botany* 133, 136.

[4] Sinclair Knight Merz Pty Ltd, *Environmental Water Requirements to Maintain Groundwater Dependent Ecosystems,* National River Health Program Environmental Flows Initiative Technical Report Number 2 (Environment Australia, 2001).

[5] Sources of information for the table: Sinclair Knight Merz Pty Ltd, *Environmental Water Requirements to Maintain Groundwater Dependent Ecosystems,* National River Health Program Environmental Flows Initiative Technical Report Number 2 (Environment Australia, 2001); Moya Tomlinson, *Ecological Water Requirements of Groundwater Systems: A Knowledge and Policy Review,* Waterlines Report Series No 68, National Water Commission (National Water Commission, 2011); Alison Curtin, *Information Sheet on Ramsar Wetlands (RIS): Paroo River Wetlands (Nocoleche Nature Reserve and Peery and Mandalay Blocks (to be referred to as "Peery") in Paroo-Darling National Park)*, 10 ("the Peery Lake mound springs form the largest active spring complex in NSW"). Note that although the mound springs are fed by groundwater from the Great Artesian Basin, they fall under the Basin Plan as surface water, in the form of "water flowing over or lying on land after having risen to the surface naturally from underground": Water Act 2007 (Cth) s 4(1) ("surface water"); Tim Wilson, *Information Sheet on Ramsar Wetlands (RIS): The Coorong, and Lakes Alexandrina and Albert Wetland, South Australia*, prepared March 2006, 5 ("… there are groundwater inputs and inflows into the South Lagoon from the Upper South East drainage scheme via Salt Creek."); Rhonda Butcher, *Information Sheet on Ramsar Wetlands (RIS): Banrock Station Wetland Complex*, prepared November 2009, 6 ("The wetland is believed to influence the local expression of groundwater, however the degree to which the wetland operates as a recharge versus a discharge site (depending on inundation levels) is still being investigated."); Marcus Cooling, *Information Sheet on Ramsar Wetlands (RIS): Hattah-Kulkyne Lakes, Victoria*, prepared 7 April 2005, 5 (Lake Kramen … potentially has a

Table 1: Categories of GDEs and MDB examples

Category of GDE	**Example of GDE, or suspected GDE, in the MDB**
Terrestrial vegetation	Eucalypt woodlands along the floodplain of the Murray River
River baseflow systems	Baseflow-dependent ecosystems, such as those supported by the Peel Valley Alluvium, and the Mid-Murrumbidgee Alluvium; various fauna, e.g. platypus, across at least some of its range, where groundwater is required to sustain the flow or pools in which it feeds.
Aquifer and cave ecosystems	Karst ecosystems, such as those associated with Wellington Caves and Abercrombie Caves in NSW.
Wetlands	Swamp sclerophyll forests and woodlands, including “a wide range of mostly eucalypt species that occupy the riparian corridors of ephemeral or baseflow dependent streams. The group includes species such as *E.ovata*, *E.viminalis* and *E.leucoxylon* communities in South Australia, *E.camaldulensis* and *E.largiflorens* woodlands of the Murray and Darling River floodplain…” “chenopod shrublands of the heavy-textured, periodically inundated plains country of western New South Wales and Queensland and northern South Australia” Sedgelands in the coastal, floodplain and valley floor environments of eastern Australia, e.g. *Eleocharis sphacelata* sedgelands in lagoons of the Murray River and tributaries, and *Baumea sedgelands* of the Coorong and south-east of South Australia…” Swamp grasslands, particularly *Phragmites* and *Typha* grasslands associated with groundwater dependent semi-permanent water features, and swamp herblands Mound spring ecosystems, as in the Paroo Ramsar site in the MDB. The Ramsar Information Sheets for several other Ramsar wetlands in the MDB disclose that the respective wetlands depend, or may depend, on groundwater, namely those for the Coorong, and Lakes Alexandrina and Albert Wetland (SA), the Banrock Station Wetland Complex (SA), and the Hattah-Kulkyne Lakes (Vic).
Terrestrial fauna	Various—relying on groundwater as drinking water, or groundwater-dependent terrestrial and riparian vegetation as drought refuges.
Estuarine and near-shore marine ecosystems	Ecosystems of the Coorong.

significant hydraulic connection to the aquifer and may receive groundwater discharge when the lake is dry and River Murray levels are low”).

2.2 The science and policy of GDEs

A significant body of scientific and policy work has developed to deal with the water requirements of GDEs, though uncertainty in this area remains. Many ecosystems depend on groundwater to varying degrees, from total dependence, to high dependence, to proportional dependence, to limited or opportunistic dependence.[6] Ecosystems that are more dependent on groundwater are more sensitive to slight changes in groundwater attributes (flux or flow, pressure/level, and quality).[7]

GDEs are threatened by groundwater extraction. A federally-commissioned report on GDEs has found that consumptive use of groundwater and surface water is a key threatening process in relation to GDEs:

> Consumptive use of water resources poses a major threat to groundwater dependent ecosystems in many landscapes across Australia (and internationally). This is particularly true in the more intensively developed landscapes of eastern and south-western Australia … Consumptive uses of groundwater and surface water resources potentially impact on ecological processes in groundwater dependent ecosystems.[8]

Reduced groundwater levels can:[9]

(i) reduce the access of GDEs to groundwater, “resulting in changes to species composition or greater vulnerability to environmental stresses”;

(ii) reduce river baseflows, which may “reduce or eliminate habitat for in-stream aquatic communities at certain times of year and result in a shift in species composition or even collapse of the ecosystem”;

(iii) cause a loss of habitat “at particular levels in [a] cave system or aquifer and potentially the loss of species dependent on that particular niche”; and

(iv) (predominantly in estuarine and coastal areas) activate acid-sulphate soils, making soils acidic, impairing or killing plant growth; releasing toxic contaminants that may harm or kill aquatic organisms and impair ecosystem function (particularly, recruitment).

GDEs are not just the obscure domain of a few scientists—they have been the subject of a concerted federal and state policy effort. A suite of federal and state policy documents adopted over the past decade emphasizes the need for water regimes to consider the water needs of GDEs. These documents include the *National Water Initiative* (2004), the *NSW State Groundwater Dependent Ecosystems Policy* (2002), and myriad regional and local water allocation plans and state legislative provisions across the country.[10]

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[6] Sinclair Knight Merz Pty Ltd, above note 5, 5-7.
[7] Ibid 2, 5-7.
[8] Ibid 18.
[9] Ibid 19, 23.
[10] See, for example, Moya Tomlinson, *Ecological Water Requirements of Groundwater Systems: A Knowledge and Policy Review,* Waterlines Report Series No 68, National Water Commission (National Water Commission, 2011); National Water Commission, *The National Water Initiative - Securing Australia's Water Future: 2011 Assessment* (National Water Commission (Australia), 2011) 98; Rebecca Nelson,

In addition, as a concrete expression of the policy statements that urge attention to GDEs, a substantial portion of the Australian work on GDEs has been commissioned or funded by Australian federal agencies, for example, the former Environment Australia and, more recently, the National Water Commission. Key works, and the investments required to develop them, follow:[11]

(b) An Australian Groundwater-Dependent Ecosystems Toolbox, which is directed towards identifying GDEs and determining the impact of changes in groundwater availability on GDEs ($499,121);[12]

(c) A new approach to accounting for groundwater-dependent ecosystems and surface water systems ($300,000);

(d) A National Atlas of groundwater-dependent ecosystems ($5,545,000);

(e) A scientific study on NSW groundwater quality and coastal groundwater dependent ecosystems ($960,000); and

(f) A scientific study on groundwater-dependent ecosystem vulnerability in the Mid-West of Western Australia ($2,460,000).

Judging from the Basin Plan Knowledge and Information Directory, which lists scientific information that has been considered in the preparation of the proposed Basin Plan,[13] the substantial body of scientific and policy work on GDEs, described above, appears to have been entirely overlooked. In addition, the consultation report on the proposed Basin Plan[14] does not mention any of this work. This scientific information should be considered in relation to the wide variety of GDEs that are found in the MDB.

2.3 GDEs and the Basin Plan

Many provisions of the Water Act require that GDEs be considered in connection with the Basin Plan. These are set out below, with key elements in bold.

(a) The objects of the Water Act include:

> to protect, restore and provide for the ecological values and ecosystem services of the Murray-Darling Basin (taking into account, in particular, the **impact that the taking of water has on** the watercourses, lakes, wetlands, **ground water and water-dependent ecosystems** that are part of the **Basin water resources and on associated biodiversity**)

Under the Water Act, the terms “water resources” and “Basin water resources” include groundwater, aquifers, and “organisms and other components and

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'Groundwater Dependent Ecosystems in Law: Troubled Waters?' (2007) 10 *Asia Pacific Journal of Environmental Law* 99.

[11] See National Groundwater Action Plan projects - Vulnerability of Groundwater Dependent Ecosystems, available at http://www.nwc.gov.au/ngap/groundwater-projects.

[12] S Richardson et al, above note 2.

[13] BP-KID, available at http://www.mdba.gov.au/bpkid/.

[14] Murray-Darling Basin Authority, *Proposed Basin Plan: Consultation Report* (2012), available at http://www.mdba.gov.au/proposed-basin-plan/consultation-report.

ecosystems that contribute to the physical state and environmental value" of a groundwater resource.[15] This clearly includes GDEs.

The purpose of the Basin Plan is to "provide for the integrated management of the Basin water resources in a way that promotes the objects" of the Water Act, including the object set out above.

(b) A purpose of the Basin Plan is to provide for Basin-wide environmental objectives for water-dependent ecosystems of the MDB.[16] A "water-dependent ecosystem" is defined to include "**a ground water ecosystem, and its natural components and processes … that depends on … significant inputs of water for its ecological integrity and includes an ecosystem associated with" wetlands, streams, lakes, salt marshes, estuaries, a karst system, or a ground water system**; and "a reference to a water-dependent ecosystem includes a reference to the **biodiversity** of the ecosystem".[17]

(c) The Basin Plan must be prepared having regard to "the fact that the use of the Basin water resources [which includes groundwater, as set out in (a) above] has had, and is likely to have, significant adverse impacts on the conservation and sustainable use of biodiversity" and "the fact that the Basin water resources require, as a result, special measures to manage their use to **conserve biodiversity**".[18]

(d) The Basin Plan must "promote sustainable use of the Basin water resources to **protect and restore the ecosystems, natural habitats and species** that are reliant on the Basin water resources and to conserve biodiversity".[19]

(e) The Basin Plan must be prepared having regard to the National Water Initiative,[20] which includes the need to consider **interconnections between groundwater and surface water,[21] and GDEs**.[22]

(f) In preparing the Basin Plan, the MDB Authority (MDBA) must act on the basis of "the **best available scientific knowledge**".[23] Accordingly, it must consider and act on the basis of the best available scientific information about GDEs. It appears that much of this information has been overlooked.

(g) In preparing the Basin Plan, the MDBA must have regard to "the diversity and variability of the Basin water resources and the need to adapt management approaches to that diversity and variability".[24] Groundwater systems differ from

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[15] *Water Act 2007* (Cth) s 4(1) "water resource".
[16] *Water Act 2007* (Cth) s 20(c).
[17] *Water Act 2007* (Cth) s 4(1) "water-dependent ecosystem".
[18] *Water Act 2007* (Cth) s 21(2)(a).
[19] *Water Act 2007* (Cth) s 21(2)(b).
[20] *Water Act 2007* (Cth) s 21(4)(c)(i).
[21] Intergovernmental Agreement on a National Water Initiative Between the Commonwealth of Australia and the Governments of New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and the Northern Territory, 2004, cll 4, 23(x), 79(i)(c), 82(iii)(b), 83, 98.
[22] Ibid, cll 25(ii), 25(x), 79(i)(f).
[23] *Water Act 2007* (Cth) s 21(4)(b).
[24] *Water Act 2007* (Cth) s 21(4)(c)(iii).

surface water systems, and the ecological water requirements of GDEs differ from those of surface water systems. As this submission outlines, the proposed Basin Plan often does not take into account the full diversity of GDEs, considering only those that involve the surface expression of groundwater, and it often fails to adapt its management elements to suit groundwater systems—for example, considering time lags between pumping and effects, the consequences of the spatial distribution of pumps, and appropriate ways of expressing groundwater SDLs.

The remainder of this submission shows how the elements of the revised draft of the proposed Basin Plan (for simplicity, referred to here as the "proposed Basin Plan") that relate to groundwater SDLs fall short of meeting these requirements, and suggests approaches to rectify this. Unless otherwise specified, references to sections are to sections of the revised draft of the proposed Basin Plan.

3. Legal requirements in relation to groundwater SDLs

The following provisions of the Water Act apply to setting SDLs for Basin water resources, whether surface water or groundwater:

(a) A SDL must reflect an environmentally sustainable level of take (ESLT).[25]

(b) The ESLT is the level at which water can be taken from a water resource which, if exceeded, would compromise:
  (a) key environmental assets of the water resource; or
  (b) key ecosystem functions of the water resource; or
  (c) the productive base of the water resource; or
  (d) key environmental outcomes for the water resource.[26]

(c) The term "environmental assets" includes water-dependent ecosystems, ecosystem services, and sites with ecological significance.[27] No process is specified for determining which environmental assets are "key" environmental assets. The term "water-dependent ecosystems" is not qualified, indicating that any water-dependent ecosystem can be an environmental asset.

(d) The term "environmental outcomes" includes ecosystem function, biodiversity, water quality; and water resource health.[28] No process is specified for determining which environmental outcomes are "key" environmental outcomes.

(e) The terms "productive base" and "ecosystem functions" are not defined.

Since "water resources" are defined to include groundwater, aquifers, and GDEs, the provisions outlined above require that groundwater SDLs be set at a level that does not compromise the environmental elements outlined above in relation to GDEs, to the extent that they have been determined to be "key". As suggested at part 2.2, above, the high level of science and policy attention to GDEs suggests that some GDEs are likely to fall into these

[25] *Water Act 2007* (Cth) s 23(1).
[26] *Water Act 2007* (Cth) s 4(1).
[27] *Water Act 2007* (Cth) s 4(1).
[28] *Water Act 2007* (Cth) s 4(1).

categories. At minimum, it suggests that a full range of GDEs should be considered and assessed for whether they fall into these categories. The Water Act provisions outlined above also clearly require this.

4. Groundwater SDLs are not expressed in a form that is appropriate for protecting ESLT characteristics

The first major problem with the proposed groundwater SDLs relates to how they are expressed. In short, expressed as large-scale volumes, the groundwater SDLs cannot guarantee that groundwater extraction will be environmentally sustainable in the manner required by the Water Act, because many GDEs occur on a local scale.

All groundwater SDLs in the proposed Basin Plan are expressed as a *volume* of extraction that is allowable over a large area. However, a large-scale, volumetric limit is unlikely to protect key environmental assets that take the form of GDEs and sites of ecological significance that depend on groundwater, particularly those that do not involve the surface expression of groundwater. These assets can occur at a very local scale, and can be highly sensitive to even small decreases in groundwater levels (see part 2 of this submission). The volume-based approach to SDLs mirrors the form of SDLs for surface water systems, as opposed to a form that is more appropriate for groundwater systems, which would relate to groundwater levels or pressure, as well as flux, and perhaps quality.[29]

The MDBA's scientific advice acknowledges that a volumetric limit on extraction is insufficient to protect the ESLT characteristics of groundwater resources. One report states that there may be "localised unacceptable impacts" as a result of "the spatial pattern of extraction", which are not accounted for in the way that groundwater SDLs were set.[30] In order to protect against these localised impacts that could compromise local ESLT characteristics, the MDBA's scientific advisers developed the valuable concept of "resource condition limits" ("RCLs") and principles to guide the application of these limits. Indicators used for the purposes of the RCLs are expressed generally as groundwater levels, and sometimes as groundwater fluxes, or quality. This reflects the scientific reality that the "key ecologically relevant attributes of the groundwater regime have been identified as flux or flow, level (in unconfined aquifers), pressure (in confined aquifers) and water quality".[31] Indeed, existing extraction limits set by the states to protect GDEs tend to refer to groundwater levels more commonly than they refer to volumes, as for example, a "maximum variation in water level at a GDE from a reference point; maximum rate of water level change for selected wetlands and terrestrial vegetation; and minimum flows and/or river stage heights for selected river systems".[32]

Unfortunately, the proposed RCLs were not adopted in determining groundwater SDLs, because "within the scope of this work there was insufficient time for a consensus to be

[29] Tomlinson, above note 5, 29, citing Sinclair Knight Merz Pty Ltd, above note 5, 5.
[30] CSIRO and SKM, *The Groundwater SDL Methodology for the Murray-Darling Basin Plan,* Water for a Healthy Country Flagship Report Series (CSIRO, 2011) 12.
[31] Ibid 29.
[32] N L Hyde, 'A summary of investigations into ecological water requirements of groundwater-dependent ecosystems in the South West groundwater areas' (Department of Water, Western Australia, 2006) <http://www.water.wa.gov.au/PublicationStore/first/70982.pdf> 3.

achieved with the jurisdictions … to arrive at a widely accepted position on RCLs".[33] Without the more localised type of assessment involved in RCLs, volumetric limits are not able to guarantee an ESLT. As a result, large-scale, volume-based SDLs are unable to safeguard individual environmental assets or ecosystem functions, since these assets and functions often require groundwater to be available at a local scale. The Water Act recognizes this by explicitly providing that SDLs may be set in ways *other than* a quantity of water.[34]

5. The process used by the MDBA to set many groundwater SDLs overlooked the ecological value of GDEs

The MDBA used two different approaches to determining "preliminary extraction limits"—the first step towards determining a groundwater SDL. Where a numerical groundwater model was available, that was used. For areas lacking such a numerical model, the MDBA used the "recharge risk assessment method" (RRAM) to establish a preliminary extraction limit, before finally determining the groundwater SDLs.[35] The basic concept behind RRAM is that a sustainable level of extraction is "some set fraction of the recharge based on ESLT concepts".[36]

Unfortunately, the RRAM process adopted an overly narrow view of what is meant by an ESLT in relation to groundwater—a fatal flaw that means that the process of setting groundwater SDLs did not assess whether they would be adequate to meet the environmental requirements of the Water Act. In particular:

(a) **The RRAM process overlooked important environmental assets dependent on groundwater, because the process used to identify key environmental assets involved assessing groundwater systems only in terms of how they contribute to surface water assets.** That is, the process did not consider any GDEs, other than GDEs that involve the surface expression of groundwater.[37] No comprehensive review of the water-dependent ecosystems, ecosystem services, or sites with ecological significance was undertaken, specifically in relation to groundwater, in order to identify key environmental assets.

(b) **The RRAM process overlooked important ecosystem functions dependent on groundwater**, because it sought to maintain only groundwater discharge to streams and springs,[38] overlooking the ecosystem functions of a large number of GDE types that do not involve the surface expression of groundwater, and overlooking the much broader range of ecosystem functions provided by GDEs, outlined at part 2 of this submission.

(c) **The RRAM process overlooked important environmental outcomes in relation to groundwater**, because it sought only narrowly to prevent "water quality

[33] CSIRO and SKM, above note 30, 13.
[34] *Water Act 2007* (Cth) s 23(2).
[35] Murray-Darling Basin Authority, 'The Proposed Groundwater Baseline and Sustainable Diversion Limits: Methods Report' (2012) <http://download.mdba.gov.au/proposed/Proposed-BP-GW-BDL-SDL.pdf> 10.
[36] CSIRO and SKM, above note 30, 3. This report describes the RRAM process in detail.
[37] Tomlinson, above note 5, 23.
[38] I note that the scientific information provided does not outline how springs were considered—only how baseflow to rivers was considered: CSIRO and SKM, above note 30, 3, 15-16.

degradation through groundwater salinisation", even though the concept of environmental outcomes for groundwater embraces "a combination of ecosystem function, biodiversity, water quality and water resource health".[39] In particular, biodiversity in relation to GDEs is thought to be very high (see part 2 of this submission).

While the types of ecosystem functions, environmental outcomes, and even environmental assets connected to GDEs may be the subject of some scientific uncertainty, the materials accompanying the proposed Basin Plan do not indicate that even the available scientific information on GDEs has been considered. Further, state policies on GDEs provide examples of methods of protecting important GDEs even in the presence of some uncertainty. In short, uncertainty is no excuse for failing to consider a comprehensive range of GDEs.

Scientific advice commissioned for the purposes of the Basin Plan took a much wider view of the role of groundwater and GDEs, compared to that ultimately adopted in the proposed Basin Plan. In addition to the matters adopted by the final RRAM process, the RCL concept, described above, focused also on avoiding land subsidence and irrecoverable aquifer compaction; preventing fundamental changes to the aquifer structure (for example, changing from a confined to an unconfined aquifer); preventing situations in which flows of saline groundwater would move laterally or vertically to fresh aquifers, and protecting GDEs from significant impacts;.[40] This expands somewhat the much narrower view of factors that were ultimately adopted as relevant to the ESLT.

6. Deficiencies in relation to groundwater SDLs for particular categories of groundwater resources

With the preliminary volumetric extraction limits in hand, the MDBA determined groundwater SDLs based on various categories of resources, which were treated in different ways.[41] In addition to the general comments about groundwater SDLs and the RRAM process set out above, this part sets out further concerns related to selected categories of groundwater resources.

(a) An inappropriately short time-frame was used for assessing groundwater SDLs for non-renewable resources. Although it is not explicit in the proposed Basin Plan, the accompanying technical material suggests that groundwater SDLs are based on overly short timeframes. For example, the MDBA adopted the extraction limits set by states for non-renewable resources, on the basis that these limits "would not compromise the ESLT characteristics within the time frame of the Basin Plan".[42] This presumably refers to the 10-year period before the Basin Plan is required to be reviewed. This period is not appropriate for protecting ESLT characteristics in relation to groundwater: the slow movement of groundwater means that pumping permitted over a decade could "lock in" undesirable outcomes that would manifest only in the future. These outcomes would be irreversible for non-renewable resources. A much

[39] Ibid 3, 16-17.
[40] Ibid 13.
[41] Murray-Darling Basin Authority, above note 35, 13.
[42] Ibid 18.

longer planning horizon should be selected for assessing ESLT with respect to non-renewable resources, the "diversity and variability"[43] of which calls for a different assessment approach.

(b) **The categorisation of groundwater resources as "connected" or "unconnected" uses an inappropriately high threshold for determining connection, allowing unacceptable river depletion to occur**. Groundwater SDLs were set more conservatively for connected resources than for other categories of groundwater resources. For connected resources, the SDL was set equal to current ("baseline") levels of diversion.[44] Accordingly, determining which resources are considered connected for policy purposes has a significant impact on SDLs, as demonstrated by the number of large fractured rock aquifers that were initially classified by the MDBA as "highly connected", then subsequently re-categorised as suitable for unassigned water assessment, which led to much higher groundwater SDLs:[45] the Lachlan, Macquarie-Castlereagh, Murray and Murrumbidgee resource units.[46]

A groundwater SDL unit was categorised as a "connected resource" if
(1) groundwater provided baseflow to an unregulated stream reach; or,
(2) groundwater provided baseflow to a regulated stream reach that was "highly connected" to the aquifer. A river was deemed to be "highly connected" if more than 50 percent of the pumped groundwater volume would be derived from the river flow, and the river depletion would occur within a 50-year time frame (the "50/50 policy"). On the other hand, a system was not considered to be a connected resource if a regulated or unregulated river in the SDL resource unit had a "low to moderate" connection with the groundwater system, in other words, if it fell below the 50/50 policy threshold, for example, if 45 percent of the pumped groundwater volume was derived from a regulated river over 50 years.

The 50/50 policy permits too great an impact on surface water resources, by leading too many groundwater resources that are connected in fact, to fall below the policy threshold. Indeed, the National Water Commission and others have long argued in favour of the assumption that groundwater and surface water are connected until proven otherwise.[47] Such an approach would result in much lower groundwater SDLs—set at the "baseline diversion limit" unless the systems were clearly unconnected to surface waters.

(c) **The setting of groundwater SDLs for connected resources over-simplifies the concept of connectivity, using purely volumetric terms, in a way that may under-estimate the ecological seriousness of pumping groundwater on connected rivers.** The 50/50 policy does not adequately reflect the ecological

[43] *Water Act 2007* (Cth) s 21(4)(b).
[44] Murray-Darling Basin Authority, above note 35, 20.
[45] Ibid 20-21.
[46] Ibid 33.
[47] Peter Cullen, 'Flying Blind: The Disconnect between Groundwater and Policy' (2006) (19 September 2006) *10th Murray-Darling Basin Groundwater Workshop* 4; National Water Commission, above note 10, 100; I Fullagar, *Rivers & Aquifers: Towards Conjunctive Water Management (Workshop proceedings)* (Bureau of Rural Sciences, 2004) 2.

consequences of river depletion, which may differ widely in different places and at different times, for the same volume of depletion. For example, depleting the flow of a river during a low-flow period would have a much greater ecological impact than the same volume of depletion during a very high-flow period. Indeed, the MDBA appears to acknowledge this situation in a 2010 report entitled "Assessing the Impacts of Groundwater Development on Low Flows in Rivers Using Resource Indicators" that it commissioned from the CSIRO. Two years after the report was delivered, it has not yet been publicly released, but rather the MDBA is noted as still being "in the process of finalising the resource for public release".[48] The Basin Plan should adopt a more nuanced approach that estimates connectivity in terms of "the timing, direction and volume of interaction, its spatial and temporal scale, and an understanding of its ecological relevance",[49] in accordance with current science.

(d) **The 50/50 policy may under-estimate the impacts of pumping groundwater on rivers by ignoring the spatial element of pumping (i.e. where bores are located, and the volumes of pumping from distributed points).** This will not protect baseflow to the extent anticipated if many high-capacity pumps are located very close to a river, even where the aquifer characteristics are such that groundwater moves relatively slowly.

(e) **The process used for setting groundwater SDLs overlooks the potentially increasing future impacts of current levels of groundwater extraction on connected rivers.** Time lags between groundwater pumping and river depletion mean that recently commenced pumping (or the activation of "sleeper" or "dozer" licences) will result in increased future depletion of rivers, compared to the impacts that we see today, within what the MDBA terms the "baseline diversion limit". In setting groundwater SDLs at the baseline diversion limit for resources that it classifies as "connected resources", the proposed Basin Plan overlooks these facts, appearing to assume that limiting groundwater pumping to today's levels will maintain current levels of river depletion, and will be sufficient to protect Basin water resources. This is not necessarily the case.

(f) **Foreign groundwater laws provide examples of more nuanced, but practical approaches to assessing stream-aquifer connectivity, which go some way to dealing with the problems outlined above.** For example, in the United States, Kansas, Colorado and Oregon use concepts like "zones of influence" or "baseflow nodes" to consider the effects of the spatial distribution of bores, and their capacity, when determining impacts on streamflow.[50] In addition, the timeframes used for assessing depletion can be considerably more stringent than those set out in the proposed Basin Plan. Even in the setting of a highly negotiated interjurisdictional

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[48] See Basin Plan Knowledge and Information Directory: http://www.mdba.gov.au/bpkid/bpkid-view.php?key=TBXtNCwuO//YirczesJSoykEzAyAPDErYwjj86i4XaQ=.

[49] Tomlinson, above note 5, 38.

[50] Sarah Bates, 'Blueprint for a Ground Water Mitigation Exchange Pilot Project in Montana: A Report to the Montana Water Project of Trout Unlimited' (2009) <http://www.tu.org/sites/www.tu.org/files/documents/GroundwaterBlueprintSept2009.pdf> 15-21; JC Peck, 'Groundwater management in Kansas: a brief history and assessment' (2005) 15 *Kansas Journal of Law & Public Policy* 441, 446.

basin, a more stringent concept of connectivity is used. The Platte River Recovery and Implementation Program involves Nebraska, Wyoming, Colorado, and the US federal government, and requires that a state offset groundwater depletion to the Platte River if pumping from a bore would deplete the river by 28% of the pumped volume within 40 years (a "28/40 rule").[51] The US has advanced further than Australia in the area of recognizing groundwater-surface water connectivity in water policy, and further attention to these policies would be valuable.[52] These examples demonstrate that it is possible for sophisticated legal and policy instruments to better reflect the nature of connected groundwater-surface water resources.

(g) **The special treatment of resources categorised as "existing reduction programs" allows unsustainable levels of extraction to continue.** In relation to four of seven alluvial groundwater systems that fall under an ongoing NSW-Commonwealth buyout of groundwater rights (Achieving Sustainable Groundwater Entitlements program), the preliminary extraction limit calculated using numerical modelling was lower than the baseline diversion limit. However, the SDL was set at the baseline diversion limit[53] rather than the lower levels of use that were determined by considering ESLT requirements using complex numerical models (even though level of reductions pursued by the buyout program was not set at a level that meets Water Act requirements). The main reasons offered for this are: first, uncertainty associated with the outcomes of the buyout program; second, the large nature of the groundwater storages ("a minimum of 200 years at current levels of use"); and third, the "low risk of depleting the volume of groundwater stored in these aquifers within the period of the first Basin Plan".[54] These reasons do not justify raising the calculated SDL. The Commonwealth's buyout program for surface water is also an ongoing program, which is not expressed to be a reason for deviating from determinations of flows required to meet ESLT requirements. In addition, large groundwater storages do not necessarily safeguard ecosystems that depend on them, purely by virtue of their size. As outlined above, the period of the Basin Plan is not an appropriate period of time over which to assess impacts in relation to groundwater pumping.

(h) **Revisions to the treatment of "unassigned groundwater" do not cure the flaws inherent in the groundwater SDLs, even though they reduce the total volume of groundwater take.** The category of "unassigned water" describes groundwater systems with "potential to increase extraction without compromising ESLT characteristics".[55] The MDBA specifies an unassigned groundwater "factor" that is used in the formula to determine the groundwater that can be made available for consumptive use above the baseline diversion limit. The main groundwater-related revision adopted in the revised draft of the proposed Basin Plan was to change this factor from the previous levels of 0.5 or 1 (which varied depending on the particular

[51] Rebecca Nelson, 'Instituting Integration: Findings of the Comparative Groundwater Law and Policy Program's Workshop 1' (Stanford University, 2012), available at http://www.stanford.edu/group/waterinthewest/cgi-bin/web/sites/default/files/RNelsonWorkingPaper3.pdf.
[52] See generally ibid.
[53] Murray-Darling Basin Authority, above note 35, 23.
[54] Ibid 22.
[55] Murray-Darling Basin Authority, above note 35, 31.

area), to a "more precautionary" level of 0.25. This resulted in reducing the total of the groundwater SDLs by 1,000GL. The large size of this cut in response to the tweaking of a "factor" underscores the coarseness of the methods used to calculate groundwater SDLs—the factor could equally, subjectively, have been changed to a different level. Most importantly, these modifications do nothing to cure the fundamental flaws inherent in the processes used to set groundwater SDLs outlined in this submission.

7. Determining non-compliance with groundwater SDLs

Under the proposed Basin Plan, non-compliance with a groundwater SDL occurs if the "annual actual take" is 20 percent or greater than the "annual permitted take", and the Basin State does not have "a reasonable excuse for the excess" (s 6.13). Since any level of take above the ESLT will, by definition, compromise key environmental assets, key ecosystem functions, the productive base, or key environmental outcomes for the water resource, this submission strongly suggests that any excess not be deemed to comply with the SDL. This should be the case *especially* for groundwater resources, since some GDEs are very sensitive to changes in groundwater levels (for example, at certain threshold levels, e.g. levels below the root zone of groundwater-dependent terrestrial vegetation), which can be caused by relatively moderate volumetric increases in extractions.[56] The proposed Basin Plan's environmental objectives are already modest, since only "key" ESLT elements are protected.

8. Recommendations

(a) Review all groundwater SDLs after taking account of the best available scientific information about a full range of GDEs and their environmental water requirements, and after determining which of this full range of GDEs, associated groundwater-dependent ecological functions and environmental outcomes, are relevant to the ESLT.

(b) Express groundwater SDLs not as coarse, large-scale volumetric limits on extraction, but as limits that relate to groundwater levels or pressure, and express them in a way that connects with the more localised scale of the matters which must be protected so that groundwater SDLs reflect the ESLT.

(c) In determining whether to deem groundwater and surface water resources to be connected for policy purposes:

  (i) assume connectivity unless proven otherwise;

  (ii) consider the *ecological* relevance of depletions to rivers caused by groundwater pumping;

  (iii) consider how the spatial distribution of bores and their capacity affects river depletion; and

[56] Sinclair Knight Merz Pty Ltd, above note 4, 5, 36 ("There may be a threshold response in some cases, whereby an ecosystem collapses completely if a certain attribute value [e.g. groundwater level] is exceeded.")

(iv) recognize the time lags involved in groundwater systems by reducing SDLs to below baseline diversion limits if the impacts of baseline levels of pumping will increase in the future, and this will compromise ESLT.

(d) Use a longer timeframe for assessing groundwater SDLs in relation to non-renewable resources.

(e) Set groundwater SDLs for the alluvial basins covered by the Achieving Sustainable Groundwater Entitlements program using methods that are consistent with other groundwater basins for which the preliminary extraction limit is lower than the baseline diversion limit.

(f) Define non-compliance with SDLs as any exceedence of the actual annual take relative to the annual permitted take, except in case of emergencies.