Plain English summary of the Proposed Basin Plan (28 November 2011)

Appendix A—Outline of the scientific knowledge

Appendix A responds to subsection 43(2) of the *Water Act 2007* , which requires an outline of the scientific knowledge on which the proposed Basin Plan is based to be included in the plain English summary. More detailed information about this scientific knowledge is available on MDBA's website at mdba.gov.au

Note: Appendix B provides an outline of the socioeconomic analysis on which the proposed Basin Plan is based.

Overview

The Murray–Darling Basin Authority (MDBA) has aimed to develop a proposed Basin Plan that will deliver a healthy working Murray–Darling Basin. The *Water Act 2007* (Cwlth) requires MDBA to act on the best available scientific knowledge when developing the Basin Plan (subsection 21(4)(b)). The knowledge used by MDBA has been incorporated into the key elements of the Basin Plan, notably the **environmentally sustainable levels of take** for surface water and groundwater on which the **long-term average sustainable diversion limits** (SDLs) are based, the Environmental Watering Plan, Water Quality and Salinity Management Plan and risk assessment. Climate science has also been considered in developing the proposed plan, and will be further taken into account when the Basin Plan is reviewed.

Using the best available science has involved examining existing scientific knowledge and data, as well as capturing the expertise of national and international scientists to undertake studies and provide peer review. The MDBA has also considered more than 1,500 scientific reports, peer-reviewed journal articles and current datasets.

While the proposed Basin Plan is based on the best available science, it must take into account the principle that lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation where there are threats of serious or irreversible environmental damage.

Taking these considerations into account, MDBA has not just applied science in developing the proposed Basin Plan, it has applied an appropriate mix of the best available science and the best available socioeconomic analysis and, on this basis, has made what it considers are appropriate judgements to deliver a healthy working Basin.

A range of information inputs have been used to inform the proposed Basin Plan. A core strength of the proposed plan is the balanced judgements the MDBA has made acting on this information. A framework of robust and defensible science, socioeconomic analysis, consultation and verification has allowed MDBA to develop a proposed Basin Plan that provides for the use and management of Basin water resources in a way that optimises economic, social and environmental outcomes.

The following sections of Appendix A explain the science underpinning each of the key elements of the proposed Basin Plan, as well as how this information has been tested and used.

The scientific basis of the proposed Basin Plan

Surface-water resources

The long-term average sustainable diversion limits (SDLs) set out in Schedule 2 to the proposed Basin Plan have been informed by multiple lines of evidence, including an assessment of the environmental water requirements of the Murray–Darling Basin. Scientifically assessing the environmental requirements of a system as large as the Basin is a significant challenge. No equivalent study has ever been carried out on such a large scale. The Murray–Darling Basin Authority (MDBA) process has been to provide multiple lines of evidence to inform the intrinsic judgement required to set an SDL for surface water in the Basin. The process, and therefore the available lines of evidence, has evolved during the development of the proposed Basin Plan.

Initially, work focused on identifying all of the Basin's **key environmental assets** and **key ecosystem functions**. More than 2,400 named key environmental assets and four key supporting ecosystem functions were identified. In analysing the datasets used, it became apparent that only a small subset of the environmental assets had been extensively studied. It was also recognised that the scientific knowledge required to fully determine the environmental water requirements for the set of assets was not currently available. Given this, a detailed site-by-site approach, where the environmental water requirements for the whole Basin are based on assessing the requirements of each individual asset, was considered unfeasible.

Accordingly, the initial work by MDBA to determine a new balance for the Basin was based on the approach of identifying water needs at a subset of key environmental assets and key ecosystem function sites in the Basin (known as **hydrologic indicator sites**). The water needs at these sites were considered a reasonable approximation of the environmental water requirements of the broader Basin environment. Determining the environmental water requirements through this method involved an assessment of known water needs of species, communities and areas of biodiversity, in particular those that are recognised under international agreements such as the **Ramsar** Convention and Commonwealth legislation such as the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

In 2010, as the Guide to the proposed Basin Plan was being finalised, the modelling to estimate water needs based on the hydrologic indicator sites approach (based on assets and functions) was still under way. This method was described in the Guide, but a simpler estimation of environmental requirements based on an end-of-system flow analysis, also described in the Guide, was used to derive the SDL numbers in the Guide. While this method can be applied relatively quickly, and can show the likely level of change required to improve the hydrology of the Basin, the shortcomings of this method were, however, that the end-of-system flow analysis does not take account of physical system constraints (channel capacity, flood risk to infrastructure and so on) or any of the rules that constrain the use of environmental water (such as capacity to call water from storages). Further, it does not consider specific environmental water requirements of assets or ecosystem functions.

In 2011, MDBA continued the work, commenced before the Guide, to model water requirements based on an assessment of flows at hydrologic indicator sites; this method is used to inform the proposed Basin Plan.

The hydrologic indicator sites method is a more robust way of examining environmental water requirements than the process used to estimate the numbers in the Guide, because it has a stronger link between flows and ecological responses, and caters for the particular characteristics of Basin ecosystems as they vary spatially and temporally. It also allows consideration of the physical characteristics of the Basin's river systems.

The hydrological models used are predominantly those developed and used by the **Basin states**. There are models for most rivers in the Basin, and these operate on different software platforms and in a wide variety of ways. These models have been partly integrated to give a Basin-wide perspective on water resources and use. This Basin-wide modelling was built on work that had been done for the CSIRO Sustainable Yields Project. In this case, MDBA's own data from river operations in the River Murray system has also been invaluable and, combined with data from the states, has been used to put together a framework for surface-water modelling. These models allow MDBA to take account of system constraints and explore different approaches to environmental flow delivery.

The hydrologic indicator sites method has focused on determining the environmental water needs for a number of indicator sites, with the assumption that if these are met, the environmental water needs of the broader suite of key environmental asset functions and ecosystem services will also be met. The MDBA's understanding of the river systems suggests that as the water for these indicator sites flows down the rivers, it will also flow through and meet the needs of other key environmental areas. The assets used are large floodplain and wetland complexes that are well understood, and in many cases are also listed as being of national or international significance. Using all available information, environmental water requirements have been determined for these assets as well as for ecologically important **in-channel flows** across the Basin. The improvement made through meeting these environmental water requirements was then assessed at 122 indicator sites across the Basin.

These site-by-site environmental water requirements have been determined based on ecological targets, a detailed analysis of all available literature, discussion with a broad range of stakeholders, an assessment of the current hydrology against **without-development flow conditions**, and with reference to the significant feedback received.

Acting on all this information, the MDBA has determined there are three main groups of flow type targeted by the environmental water requirements. These are bankfull and overbank flows; freshes; and base or low flows. Depending on what has changed in any given location, one or more of these

flow groupings may need to be increased or restored. In order to determine the volumetric requirements, the ecological need for a flow is described based on the desired flow rate, the duration this flow is required for and how often this flow needs to occur.

Once all of these flow requirements are specified in this manner, hydrologic models and other supporting tools are used to determine how the requirements interact and how successfully they can be delivered for any given reduction in diversions.

Groundwater resources

The SDLs for groundwater have been determined on the basis of an understanding of the environmentally sustainable level of take. This includes:

- maintaining base flow groundwater contributions to rivers and streams
- accounting for groundwater-induced recharge from surface water streams
- considering the long time it takes for the impact of groundwater extraction to be fully realised and for the effects to be felt by the environment
- protecting against the continued drawdown of groundwater levels, so that groundwater levels are stabilised, within a 50-year period, to a level that protects the integrity of the groundwater resource
- maintaining key environmental assets that depend on groundwater
- protecting against the salinisation of the groundwater resource.

The scientific knowledge that underpins the proposed groundwater SDLs varies significantly across the Murray–Darling Basin. The amount and quality of information varies for each groundwater system, and because of this a number of different approaches were used to deal with this data variability.

Where available, groundwater modelling was used to inform the groundwater SDLs set out in Schedule 4 to the proposed Basin Plan. Eleven models were used in determining the groundwater SDLs. These models were developed or modified in the CSIRO Sustainable Yields Project, and covered 73% of the Basin's 2007–08 extraction volume. Before being used for the proposed Basin Plan, the models were upgraded to include the most recent available data.

Where there were no groundwater models available, a method known as the recharge risk assessment method (RRAM) was applied. This risk based assessment method was developed by MDBA in partnership with the CSIRO, SKM and the Basin states, and was used to work out the proportion of recharge that could be taken without compromising the key environmental assets, key ecosystem functions, productive base of the resource or key environmental outcomes. The higher the risk there is to compromising these needs, the lower the percentage of recharge that can be extracted for consumption.

Within the scope of SDLs reflecting an environmentally sustainable level of take, MDBA then further refined the numbers suggested by the modelling and RRAM by applying a series of policies. These include:

- where a reduction program is already in operation, the final extraction limit will be adopted as the SDL; this affects the groundwater areas in New South Wales where the Achieving Sustainable Groundwater Entitlements program is in place
- where information on sustainable extraction was provided by the Basin states, this was considered, and implemented if approved by MDBA
- where a groundwater area is considered highly connected to streams and rivers, the SDL will be set at current entitlement to ensure there are no further impacts on surface water resources
- where there is little or no recharge, the relevant state management arrangements will be adopted
- where the RRAM analysis indicated an additional volume of water that could be sustainably taken above the **baseline diversion limit** (BDL), a proportion of this will be made available.

The Basin states supplied groundwater maps, extraction levels, models and other information, which were then used by MDBA to help develop the SDLs. Consultation with the states has greatly helped MDBA to understand the individual systems and the information on the state management of these systems.

This whole-of-Basin view of groundwater had never previously been achieved and it will be further refined over the coming years through additional modelling, improved information from groundwater metering and monitoring and greater understanding of the connectivity between surface water and groundwater.

Environmental Watering Plan

The Environmental Watering Plan provides the management framework for environmental watering across the Basin, setting out processes to coordinate the use of environmental water held by various parties, including the **Commonwealth Environmental Water Holder**. The framework assists in identifying priorities and making decisions on how environmental watering is planned and environmental water is used.

The design of this framework draws on existing approaches and the knowledge base behind current environmental water delivery and management. This includes scientific methods used to determine the environmentally sustainable level of take.

The Environmental Watering Plan also sets out overall objectives for the water-dependent ecosystems of the Basin, and targets to measure progress towards achieving them. These objectives and targets were developed with technical input from sources including the Independent Sustainable Rivers Audit Group and Basin states. The proposed policy also underwent a peer-review process by recognised scientific experts and a high-level review by an international panel of eminent scientists.

In implementing the Environmental Watering Plan, local knowledge, in particular governments partnering with local and regional communities and organisations, will also play a key role in how environmental water is planned and managed.

Water Quality and Salinity Management Plan

The Water Quality and Salinity Management Plan uses water science to identify threats to **water quality**. It also sets water quality objectives and targets. Water quality targets were informed by scientific reviews conducted by state and Australian Government experts, independent consultants, and the Murray–Darling Freshwater Research Centre.

These reviews investigated:

- the biological effects of poor water quality on water-dependent ecosystems, and the extent to which ecosystems are resistant and **resilient** to poor water quality
- the effect of salinity on irrigated crops
- water quality requirements for drinking water
- risks associated with the recreational use of Basin waters
- salinity management.

While some of the work on which the Water Quality and Salinity Management Plan is based was conducted specifically for MDBA, much of the science relevant to water quality has been developed nationally and internationally. This work has been thoroughly reviewed by professionals in the field, and is readily accessible. The MDBA has made use of this material in developing the proposed Basin Plan. Key references include:

- the *Australian and New Zealand guidelines for fresh and marine water quality*, published in 2000 by the Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ), available at mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality
- ecological character descriptions of Ramsar wetlands. For more information, see environment.gov.au/water/topics/wetlands/ramsar-convention/implementation-of-framework.html
- technical documents on irrigation and drainage from the United Nations Food and Agriculture Organization, available at fao.org/docrep/T0231E/t0231e0c.htm
- the *Australian drinking water guidelines*, prepared in 2004 by the National Health and Medical Research Council & National Resource Management Ministerial Council (NHMRC & NRMMC), available at nhmrc.gov.au/_files_nhmrc/file/publications/synopses/adwg_11_06.pdf
- *Management strategies for cyanobacteria (blue-green algae) and their toxins: a guide for water utilities*, a research report published by Water Quality Research Australia and available at wqra.com.au/publications/document-search/?download=106
- *Guidelines for managing risks in recreational water*, published in 2008 by the National Health and Medical Research Council (NHMRC), available at nhmrc.gov.au/publications/synopses/eh38.htm
- Schedule B (*Basin salinity management*) to the Murray–Darling Basin Agreement, which is Schedule 1 to the Water Act 2007 (Cwlth).

Salt export targets were built on previous water quality and salinity management strategies. The MDBA investigated groundwater salt movement and surface-water salinity records at end-of-valley salinity monitoring stations. This data identified the source of salt contributions to the rivers, and the impact and risk of surface-water salinity to the system as a whole. Together, the data informed the salt export targets.

Risk assessment and management strategies

To assess future risks to the Basin's water resources once the Basin Plan is in place, the MDBA conducted a risk assessment using the Australian/New Zealand standard AS/NZS ISO 31000:2009 Risk Management — Principles and Guidelines. This included identification of the risks that could arise and the factors that contribute to the risks. As the purpose of the assessment was to identify and evaluate the risks that will remain when the Basin Plan is in operation, a 10-year time frame was chosen to correspond with the Water Act's requirement to review the Basin Plan at least every 10 years.

The Basin Plan's risk assessment was undertaken at a Basin scale. The MDBA identified approximately 140 contributing factors, which were grouped into three risks:

- insufficient water for the environment
- water quality unsuitable for use
- poor health of water-dependent ecosystems.

These risks were analysed to identify the contributing factors for each and to assign a rating. This analysis was completed using a purpose-made Bayesian network, a modelling tool that is used to analyse and manage the linkages between the factors that contribute to the likelihood of a risk arising, and to transparently incorporate both qualitative and quantitative information from a variety of sources (Pollino, CA, Dyer, F, Herron, N, Harrison, W and White, A 2010, *Risk assessment of water resources for the Murray–Darling Basin*, ANU Enterprise, Canberra). The model identified significant links between the contributing factors across these three categories of risk, with central factors being lack of knowledge and lack of compliance.

Each of the three risks was assigned a rating according to its likelihood of occurrence, on a scale from low (less than 40%) to moderate (40–80%) to high (greater than 80%). The risk likelihood and the contributing factors were then used to identify the risk management strategies.

Consideration of climate change

The MDBA has considered a range of climate change studies applicable to the Basin in developing SDLs for the proposed Basin Plan. Climate studies considered by MDBA included the CSIRO Murray–Darling Basin Sustainable Yields Project and the findings from Phase 1 of the South Eastern Australia Climate Initiative. While there is uncertainty over the potential impacts of climate change, the evidence suggests that across the Basin, surface water availability is much more likely to decline than to increase.

For example, a recent update of the CSIRO Murray–Darling Basin Sustainable Yields Project suggests that under a median climate change scenario, average annual surface water availability is likely to reduce by 10% by 2030. The impact of the reduction in surface water availability is expected to be greater in the south of the Basin, and the projections are also more reliable in the south. The projected impacts of climate change on groundwater are somewhat different. Modelling of the impact of the 2030 median climate change scenario on groundwater recharge shows no strong deviation from historical median recharge.

The studies indicate that the Basin climate is likely to become more variable as well as drier. So in addition to more extreme droughts, there may also be more extreme flood events. The research indicates that the rainfall decline during the recent millennium drought (1997–2009) is linked to changes in large-scale atmospheric circulation. There is evidence that these changes in atmospheric circulation are at least partly due to greenhouse gas emissions resulting from human activity.

The South Eastern Australian Climate Initiative also found that the millennium drought in the southern Murray–Darling Basin was unprecedented — the reduction in streamflow during the drought was significantly greater than occurred in other prolonged droughts, it was largely constrained to the southern region, and there were no 'wet' years during the period. The millennium drought was also distinctive because around two thirds of the rainfall deficit occurred in autumn.

Because the median projected climate change impacts on streamflow are currently within the range of natural variability, MDBA selected the historical 1895–2009 climate as the climate baseline in

preparing the proposed Basin Plan. This climatic record offers an appropriate sequence for hydrological and environmental system modelling and planning purposes, as it takes into account extremes of climate, including three prolonged droughts (the 'Federation' drought of about 1900, the 'World War Two' drought of around 1940, and the recent millennium drought), and has similar average annual rainfall and average annual run-off to the past 30 years.

This climate baseline is the major climate scenario used for analysing and defining the SDLs. Median, wet and dry climate scenarios were used for assessing the impacts of climate change on water availability for both environmental and consumptive use under current water planning arrangements.

The Basin Plan will help manage the impacts of future climate change because:

- the reduction in consumptive diversions in the Basin Plan will provide buffering for the environment of potential reductions in water availability until a more detailed exploration of the implications of climate change can be carried out
- the median projected impact of climate change is within the range of water availability being considered in the Basin Plan; the water resource plans accredited under the Basin Plan are therefore expected to adequately deal with reduced water availability due to climate change.

Revisions of the Basin Plan, including the review of SDLs in 2015, will further be able to take into account the impacts of climate change, and MDBA's proposed research program will help build the information base needed to do this.

Data and information compilation

Many lines of evidence have guided the Murray–Darling Basin Authority in setting the policy behind the proposed Basin Plan. Evidence has come from commissioned and internal scientific and socioeconomic studies such as the Sustainable Rivers Audit and CSIRO Murray–Darling Basin Sustainable Yields Project reports, external reports, outcomes of science forums, academic papers and parliamentary inquiries. Many Australian Government agencies have also contributed data and expert knowledge in the form of databases, reports and workshops. These include CSIRO, the Bureau of Meteorology, the Australian Bureau of Statistics, the Bureau of Rural Science (BRS) and the Australian Bureau of Agricultural and Resource Economics (ABARE) (the last two having merged in 2010 to form ABARES).

The MDBA has been progressively publishing these underpinning technical documents, and the majority are available in the Basin Plan Knowledge and Information Directory (BP-KID). BP-KID is accessible from the MDBA website at mdba.gov.au, and it acts as a portal allowing anyone to locate information used in the development of the proposed Basin Plan.

Some of the central scientific studies and programs were:

- the Sustainable Rivers Audit, which analyses the condition of each catchment's hydrology and its fish and macroinvertebrate populations
- the CSIRO Murray–Darling Basin Sustainable Yields Project, which assessed current and future water availability in the Murray–Darling Basin
- a major river restoration program, The Living Murray, which aims to achieve a healthy working River Murray system, including returning water to the environment
- *Key ecosystem functions and their environmental water requirements*, which identifies the key ecosystem functions in the Murray–Darling Basin and describes the characteristics of the flow regime required to drive those functions
- flow regimes to achieve the Basin Plan objectives and targets for the 18 key indicator assets, which were estimated by drawing on existing literature (including scientific papers and project reports, management plans, ecological character descriptions and environmental flow reports) and expert advice (typically from local experts and state government agencies)
- several studies of groundwater flow and recharge patterns
- the database of Threatened species and ecological communities, Department of Sustainability, Environment, Water, Population and Communities, which guided the selection of key environmental assets
- the *Directory of Wetlands in Australia*, Department of Sustainability, Environment, Water, Population and Communities, which also guided the selection of key environmental assets
- the *Directory of Wetlands of International Importance*, which contains wetlands listed under the Ramsar Convention and also guided the selection of key environmental assets.

Testing the science through peer review

The MDBA has relied heavily on both nationally and internationally peer-reviewed science, and the peer review process has played an integral part in the development of the proposed Basin Plan. Throughout the proposed plan's development, MDBA has commissioned a number of peer reviews to check that it has used the best available science that represents a good basis for future water reform in the Basin.

Peer review has involved leading water scientists, international and local water planners, environmental scientists, economists and hydrologists, who were external to MDBA and had no previous involvement in the development of the proposed Basin Plan. Reviewers have independently examined MDBA's methods and process, reviewed the technical data on which much of the plan's proposed management settings are based, and discussed the interpretation and validity of science used. The MDBA's engagement in peer review is an ongoing process that will continue beyond the release of the proposed Basin Plan as more data and new research comes to light.

Peer review during the development of the proposed Basin Plan supported the integration of science into policy, and confirmed that the best available science was used in the context of the proposed Basin Plan.

While peer review has indicated use of the best available science, there is scope for improvement in the knowledge that underpins the adaptive nature of the proposed Basin Plan. The Authority will seek to use the best possible tools, resources and science to underpin future amendments to the Basin Plan, requiring investments in research to increase our knowledge on the ecology, hydrology and socioeconomic circumstances of the Basin. The Monitoring and Evaluation Plan of the Basin Plan establishes critical indicators to measure change in the Basin and will allow MDBA to understand how changes to water rules, the impacts of infrastructure works and measures, and the ecologically sustainable level of take affect both the environment and the people of the Basin.

The peer review reports are publicly available via the Publications page on the Murray–Darling Basin Authority website.