TECHNICAL NOTE 2007/08

Department of Water, Land and Biodiversity Conservation

THE PROCESS OF DETERMINING ENVIRONMENTAL WATER REQUIREMENTS FOR THE WESTERN MOUNT LOFTY RANGES

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August 2007

ISBN-978-1-921218-63-7

Preferred way to cite this publication

Bald, M., and Scholz, G. 2007, *The process of determining environmental water requirements for the Western Mount Lofty Ranges,* DWLBC Report 2007/08, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide.

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INTRODUCTION

This Technical Note has been developed as part of the water allocation planning process and it is intended to be a companion document to the discussion paper 'Environmental Water Requirements and Provisions'. It provides an overarching technical background on the methods and processes for defining Environmental Water Requirements (EWR) for the Western Mount Lofty Ranges (WMLR). It also discusses some of the principles and guidelines for determining Environmental Water Provisions (EWP) and how they relate to Water Dependent Ecosystems (WDE).

These are defined as:

- *Water Dependent Ecosystems* - Those parts of the environment, the species composition and natural ecological processes, which are determined by the temporary or permanent presence of flowing or standing water, above or below ground. The in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains, estuaries and lakes are all WDEs".
- *Environmental water requirements* — the water regime needed to sustain the ecological values of aquatic ecosystems, including their processes.
- *Environmental water provisions* — those parts of environmental water requirements that can be met at any given time, considering existing users' rights and social and economic impacts.

ENVIRONMENTAL WATER REQUIREMENTS

The science that underpins 'environmental flows', and in particular the methods used to determine EWR, have gained increased attention in recent times. This has been a direct result of reforms to the water industry and increased awareness of the impact that water resource development has on the health of water-dependant ecosystems (WDE).

EWR are a clear statement of how much water a particular WDE, and the plants and animals within that system, needs to survive. WDE have a complex dependence on water availability and flow. Therefore, EWR cannot simply be a statement of the volume of water these systems require, but also about how and when that water needs to be delivered.

The actual allocation of water that is given to the environment, through a process such as water allocation planning, is known as the EWP.

FLOW REGIME

The natural flow pattern observed in WDE such as rivers, streams and wetlands consists of five basic hydrological components (Poff et al. 1997): The combination of these five components forms the ***flow regime:***

1. Magnitude — volume of water.
2. Frequency — number of times particular flows occur.
3. Duration — how long specific events last.
4. Timing — when flows occur.
5. Rate of change.

Flow regime is considered to be the ‘master variable’ of rivers and streams. It is therefore flow that will largely determine the distribution of flora and fauna, as well as the health of the WDE (Poff et al. 1997).

There is a large body of scientific evidence to show that modifying flow, such as occurs during the development of water resources, will alter the ecology of WDE (Lloyd et al. 2003). However, it is very difficult to predict the exact size and nature of the ecological impacts or stress that may occur as a result of a particular change in flow regime. The nature of the impact will depend on which of the five components of flow regime have been most altered. Even relatively small changes to flow regime have been shown to have large ecological impacts (Lloyd et al. 2003).

The ecological stress caused by changes to flow regime will have consequences not only to the plants and animals and the inherent conservation value of the WDE, but it will also compromise the ‘ecosystem services’ that the WDE provide. Leading water scientists Peter Cullen and Sam Lake (Cullen & Lake1995) said:

‘We have degraded our rivers and wetlands in ways that prevent them from sustaining natural aquatic ecosystems and their high levels of endemicity, and are replacing them with simplified systems of lower diversity and many exotic species that will be much less useful to humans in the future.’

That is to say, as the health of our WDE declines, so does the systems ability to provide useful resources or services to humans (such as good quality water) over the long term.

It is particularly important to understand the relationship between flow regime and ecology in WDE that are subject to high levels of water resource development. By understanding this relationship, we will be able to manage the water resources to ensure that both biodiversity values and ‘ecosystem service’ values are protected.

The four guiding principles developed by Bunn and Arthington (2002) provide a useful framework for understanding the flow–ecology relationship.

Principle 1 — Flow is a major determinant of physical habitat in WDE.

Principle 2 — Aquatic species have evolved life-history strategies primarily in direct response to the natural flow regime.

Principle 3 — Maintenance of natural patterns of longitudinal connectivity (connection along the length of a river or stream) and lateral connectivity (connection to wetlands and floodplains adjacent to the river or stream) is essential to the viability of populations of many riverine species. In addition to this, the links between groundwater systems, hyporheic zones and surface water systems are particularly important in ephemeral systems such as in South Australia (G. Scholz, DWLBC, pers. comm., 2007).

Principle 4 — The invasion and success of exotic and introduced species in WDE is facilitated by the alteration of flow regime.

The next step in the process is to take this broad understanding and general principles and create specific statements and management rules about how, when and how often a particular WDE needs water. This has proven to be a challenging task over which scientists and water managers throughout the world are currently struggling. It is made particularly difficult in areas where we know very little about the specific location and habitat requirements of flora and fauna. It is also difficult when WDE rely on both surface water and groundwater sources, as it is often very difficult to quantify the relative contribution of each source.

METHODOLOGIES FOR DETERMINING EWR

As the need to define EWR has grown, so has the number of methodologies available (over 200 different methods world wide). These methods can be grouped into four main categories — hydrological rules, hydraulic rating, habitat simulation and holistic. The holistic method is increasingly becoming the preferred method for determining EWR. This method recognises the need of all the WDE throughout a catchment (upper catchment to estuary), accounts for a wide range of components (flora and fauna as well as physical habitat) and acknowledges the importance of a variable flow regime to the long-term health of WDE.

The holistic method can be further subdivided into two types:

- *Bottom up* — construct an EWR by 'adding' flow components to an assumed baseline of zero flow.
- *Top down* — poses the question 'how much can we modify the flow regime before the WDE becomes stressed or degraded?'

APPLICATION OF AN EWR METHODOLOGY

The method that will ultimately be used to define EWR will be, in part, determined by the types of WDE we are trying to manage and the type and amount of information we have available.

Given that the task of creating specific management rules for particular WDE can be so daunting, it is tempting to apply simple 'rules of thumb', such as the 'sustainable use' limit of 25% of median annual adjusted catchment yield rule that exists with the current NRM plan. This rule assumes that if 25% is used for consumptive use, the other 75% is available for downstream users, downstream ecosystem processes, estuarine processes, geomorphic processes, evapotranspiration, storage losses and groundwater recharge. However, it must be acknowledged that such simplistic rules do not include a detailed assessment of EWR and as such reliance on these rules can pose an unacceptable risk to the long-term health of WDE (Arthington et al. 2006). Rather than a tool to manage EWP, these rules should be used as an indicator or a trigger to identify potentially stressed areas. This can be used to support the case for more active management, such as prescribing the water resources of a region. Once a resource has been prescribed, an assessment of EWR that explores flow regime must be made.

When trying to define EWR across entire catchments, as will be done in the WAP for the WMLR, compromises will need to be made between the amount and the quality of the information we have available to us (on flow–ecology relationship), the size of the task, time frames within which we need to work and acceptable level of scientific rigour. The 5-year review structure of the WAP process will allow for constant improvement and refinement of the methods and underlying information.

The three-level hierarchy of EWR methods (Arthington 2002) can help to select the appropriate compromise between scientific rigour and available resources:

Level 1 — Generally very simplistic (e.g. very simple hydrological rules). The scientific rigour of these methods is very limited and, as such, these methods should only be applied when time frames, resources and current knowledge of flow–ecology relationships are very poor.

Level 2 — This includes the holistic methods and 'expert scientific panel' approaches. They can be used for catchment-scale assessments and bring together a range of disciplines (including ecology, hydrology, etc.). The degree of scientific rigour can vary enormously and therefore methods need to be carefully selected and appropriately executed to ensure that the recommended EWR are scientifically rigorous.

Level 3 — These methods have very solid scientific foundations. Ideally they will allow for site-specific predictions of how particular WDE will respond to specific types of flow. These predictions (or hypotheses) can be tested by monitoring.

Given the high biodiversity values and the social and/or economic importance of the WMLR region, it could be argued that the EWR assessments should be no less than a Level 2, with a long-term vision of achieving Level 3 assessments across the entire region.

Given current constraints on the time, available information and resources, we can realistically strive for a Level 2 assessment for most regions, with Level 3 assessment in those areas deemed to be 'high priority'.

EWR FOR THE WESTERN MOUNT LOFTY RANGES

The extent and detail of information available on EWR varies enormously across the region. Some important features, such as streams and rivers, the presence of permanent water or pools and location of wetlands, have all been mapped. We also have scattered information on the particular plants and animals that inhabit those environments, and some indications of the current condition and degree of hydrological stress (groundwater and surface water) that these systems may be experiencing. Rigorous EWR studies (Level 3 as described above) have been undertaken in some catchments of the WMLR, whereas in other parts we only have simple hydrological information.

The ecological, hydrological and hydrogeological assessments completed to date have given us a good understanding of the general principles to underpin EWR. Based on these assessments, we have a good appreciation of the particular components of the flow regime that have been most impacted by water resource (surface and groundwater) development and, to some degree, the severity of that impact.

These general principles and broad understanding have been summarised in series of tables below. In order to mange such a large area, WDE have been grouped into categories based on the type of ecosystem and where they are placed in the catchment (e.g. in the headwaters or close to the bottom of the river system). For each WDE type we have described:

- General information on the WDE (i.e. what is it and where does it occur?).
- The EWR principles that summarise the main component of the flow regime that has been impacted.
- The management actions that could mitigate the impact (i.e. potential WAP policies).
- Where this information has come from (i.e. the technical investigations that support the principle).
- The major gaps in our current understanding that could impede our ability to define EWR.

STREAMS IN THE UPPER CATCHMENT — HEADWATERS (1ST AND 2ND ORDER STREAMS)

These systems are mostly ephemeral (i.e. will run dry during summer months). The relative length of time of wet and dry spells is probably one of the most important aspects to manage in headwater environments. Although permanent pools are not a major feature of these environments, they may occur in isolated locations and are crucial refuge points for fish and other fauna and flora. It is important that wet conditions persist for long enough such that aquatic organisms can complete their life cycle before the dry conditions return. Very long periods with little or no flow may also lead to poor water quality and increased predation pressure, making these refuge sites uninhabitable.

EWR Principle — Protecting timing and duration of low flows to ensure that the dry phase and wet isolated phase (where it occurs) are not excessively long (top down approach).

Management action to address EWR principles	Sources of information	Knowledge gaps
Low flows: Assessing the factors that impact on the low flow period in each sub-catchment such as: • type and location of ecosystems • dam volumes, usage and location • land use across the area, including commercial forestry. Determine a range of controls that could address the issues in each sub-catchment including: • timed flow releases from dams • installing low-flow bypasses on new and potentially on existing dams • limit total volume of dam capture • restrictions on commercial forestry.	• Hydrological assessments across WMLR (e.g. Teoh 2002, 2003; Heneker 2003). • EWR of the Onkaparinga Catchment (SKM 2002, 2003). • EWR of the Willunga Basin (Ecological Associates 2005).	• Defining the specific thresholds of 'low flow', i.e. how to quantify (in terms of ML/d) precisely much water should pass any particular point within the catchment. • The importance of other flow bands (e.g. fresh flows and flush flows).

RIVERS AND STREAMS LOWER IN THE CATCHMENT (3^{RD} ORDER AND ABOVE)

Some of these systems are similar to that described above (i.e. will provide important permanent refuge pools). However, these environments further down the catchment are more likely to contain permanent pools and permanent baseflow (which may be groundwater generated), and provide crucial refuge points for fish and other plants and animals. As stated above, it is important to ensure that these systems receive sufficient duration of flow and that dry periods are not excessively long.

EWR Principle — Protecting low flows to ensure that the dry phase and wet isolated phase are not excessively long. Protect groundwater inputs to maintain permanent water and maintain integrity of refuge sites (top down approach). Connecting flows are important to allow the movement of biota between refuge sites.

Management action to address EWR principles	Sources of information	Knowledge gaps
Low flow: As above *Groundwater inputs:* Protect groundwater inputs to rivers and streams by establishing buffers between wells and the river or stream. Buffers may be extended or other controls placed in areas identified as important sites for groundwater – surface water interactions or sites of particular ecological significance. *Flush and fresh flows:* May need active release of these flows from storages.	• Hydrological assessments across WMLR (e.g. Teoh 2002, 2003; Heneker 2003). • EWR of the Onkaparinga Catchment (SKM 2002, 2003). • EWR of the Willunga Basin (Ecological Associates 2005). • Ongoing studies on groundwater – surface water interactions (unpublished). • Mapping of permanent water or pools.	• Defining the specific thresholds of 'low flow', i.e. how to quantify (in terms of ML/d) precisely much water should pass any particular point within the catchment. • Defining and quantifying the actual contribution of groundwater versus surface to these systems. Current work is preliminary, and gives potential locations of groundwater inputs and first indication of relative contribution. • The importance of other flow bands (e.g. fresh flows and flush flows).

RIVERS DOWNSTREAM OF RESERVOIRS

The current condition of these sites varies; some are physically intact (i.e. features such as river bed form and fringing vegetation are in good condition) while others are more highly degraded. However, all of these rivers below reservoirs are severely water stressed.

> *EWR Principle — Severely hydrologically stressed, impact on all components of the flow regime (i.e. high flows, low flows, total volume, timing, duration, etc.). Requires reinstatement of flows (bottom up approach).*

Management action to address EWR principles	Sources of information	Knowledge gaps
Controlled releases: Define a set of specific releases to construct a flow regime to achieve specific ecological objectives.	• Hydrological assessments across WMLR (e.g. Teoh 2002, 2003; Heneker 2003). • EWR of the Onkaparinga Catchment (SKM 2002, 2003). • EWP trial (AMLR NRM Board in prep.).	• Need to test the proposed flow releases to confirm the flow–ecology relationship (i.e. we are still at the 'hypothesis' stage). • We are assuming that the impacts of severe hydrological stress are reversible and that reinstating flow will improve ecological health.

WETLANDS INCLUDING MAN-MADE AND HIGHLY MODIFIED SYSTEMS

The physical form and current condition of wetlands varies considerably across the WMLR region. Wetlands provide important habitat to a range of plants and animals. Fleurieu Peninsula Swamps are considered to be of high conservation status and have been listed under the Australian Government *Environment Protection and Biodiversity Conservation Act 1999*.

EWR Principle — Depending on location and geology, swamps and wetlands depend on surface flow, groundwater inputs or a combination of both (bottom up or top down approaches).

Management action to address EWR principles	Sources of information	Knowledge gaps
Low flows: As above. *Groundwater inputs:* As above.	• Hydrological assessments of Southern Fleurieu Peninsula (DWLBC unpublished). • Groundwater investigation of Southern Fleurieu Peninsula (Barnett and Rix 2006). • Mapping of wetlands across WMLR (DEH database). • Rapid assessments of Fleurieu wetlands (DWLBC unpublished). • EWR of the Willunga Basin (Ecological Associates 2005). • Forestry wetlands water balance method (Greenwood in prep.; Greenwood et al. in prep.). • Studies on groundwater – surface water interactions (DWLBC unpublished).	• May be able to define major source of water and in some cases the total volume of water required by a wetland (e.g. know that peat wetlands must not be allowed to dry out), but still need to review and refine information on the other flow–ecology relationships and the specific regimes required.

ESTUARIES

Estuaries vary considerably in their current condition and form. Estuaries provide important habitat to a range of plants and animals. They also provide a vital link between freshwater and the marine environments (e.g. they allow passage for species of fish that move between marine and freshwater environments in order to complete their life cycle).

EWR Principle — Freshwater flow requirements are not particularly well understood, but they will depend on low flows for maintaining water quality and flushing flows for physical processes At this stage, the default assumption is that if EWR are met immediately upstream of an estuary are met, then the EWR of the estuary will be met (bottom up and top down approaches).

Management action to address EWR principles	Sources of information	Knowledge gaps
Low flows: As above; in addition, may need to release flows from upstream (may link with reservoir releases as above). *Groundwater inputs:* As above.	• Location of estuaries (DEH database). • EWR of the Onkaparinga Catchment (provides EWR immediately upstream of estuary).	• Very little information exists on the specific EWR of the estuaries and the nature of the transition between freshwater and marine environments.

FLOODPLAINS

Floodplains within the WMLR are largely disconnected from the river and fragmented in the landscape, due largely to urban and rural development on or directly adjacent the floodplains. Floodplains provide a unique set of habitats, as well as performing a role in improving the general health of the river itself.

EWR Principle — General floodplain ecology suggests that it is important to maintain a connection between the river and floodplain as these flows are important for breeding cycles, and other ecological processes such as the recycling of nutrients (bottom up and top down approach).

Management action to address EWR principles	Sources of information	Knowledge gaps
Difficult to provide flows for fragmented floodplains and overflows because of urban and rural development. Need to be dealt with on a case-by-case basis.	• Maps of flood zones. • General literature on generic functions of floodplains.	• Do not really know the consequences to river function of the disconnection between floodplain and river. It is known to be important for large rivers like the Murray, but not known how important is it for the smaller (and particularly the ephemeral) rivers of the WMLR. • May be able to apply water to targeted areas of floodplain, but the ecological benefits of such strategies are largely unknown.

These principles give not only give us insight into the potential impacts to WDE in our region, but also point to the management actions that will help mitigate these impacts. However, in order for a WAP to justify any management actions and to be confident that those actions will achieve the desired improvements to WDE health, it is vital that we take these principles and turn them into clear and quantified statements of EWR. From these clear and quantified EWR we will hopefully be able to develop EWP with which all stakeholders will be confident.

The SAMDB NRM Board, AMLR NRM Board and DWLBC are currently undertaking an assessment of EWR based on broad 'reach' or landform types. This method will use the principle outlined above and derive quantified hydrological metrics, linked to specific ecological objectives for each reach type. This methodology for determining EWR will be at least a Level 2 standard and it is anticipated that it will set a foundation for more detailed Level 3 type hypothesis setting and monitoring in the future. This study will form the basis of the Minister's report of the EWR that is required as part of the WAP for both the Western and Eastern Mount Lofty Ranges.

GUIDELINES FOR TURNING EWRS INTO EWPS

The State NRM Plan and National Water Initiative are the two legislative drivers behind EWR and EWP. This legislation sets the criteria and guidelines that must be met when allocating water to the environment. These are 'non-negotiable', that is, they must be met in order for the WAP to meet its legal obligations:

- The environment is a legitimate user of water, and therefore providing EWP within a WAP can no longer be considered an 'optional extra'.
- The EWP should be allocated prior to allocating water to other users.

- EWP must be linked to specific ecological objectives or defined environmental outcomes.
- EWP should match the EWR as close as is practical (given social and environmental constraints). Where EWP do not match EWR, strategies need to be implemented to ensure that over time the EWP more closely match EWR.
- EWP need to be as secure as other water entitlements.

The EWR, as described above, is a statement of what the environment needs, based on science. The EWP is the portion of the EWR that the community is prepared to give the environment (at this point in time) given all the other constraints on the system. Deriving the EWP must be a transparent and rigorous process, not just a failure to deliver EWR based on lack of information. Therefore, the process should be as follows:

1. Determine the ecological values or process that you are targeting, and the ecological objectives you are trying to achieve:

- *Optimum flows* — flows required to provide healthy, self-sustaining populations over the long term (e.g. will ensure that populations are robust and resilient, and are able to endure significant ecosystem disturbance).
- *Sustaining flows* — maintain current populations over the short to medium term, but may not fulfil long-term requirements (e.g. improve conditions for current adult fish population, but not allow for wide-scale successful recruitment).
- *Minimum flows* — ensures short-term survival for current populations; represents a 'holding pattern' (e.g. provision of water to permanent pools during drought or dry spells does not improve significantly upon current conditions, but prevents further loss of fish population).

EWR need to provide for long-term process rather than short-term outcomes. It is recommended that through a consultative process, including water users, managers and scientists, the community generates an agreed flow regime, based on a set of ecological outcomes. In areas of high ecological importance, you may strive for optimum flows for the majority of the time, but accept that sustaining and minimum flows could be delivered in drought years. In areas of lower ecological significance and higher economic importance, it may be agreed that it is appropriate to deliver sustaining or minimum flows in most years, punctuated by targeted optimum flows to encourage breeding and recruitment (or other ecological processes) for specific ecological outcomes. In order to achieve long-term outcomes, rules need to be put in place to ensure accountability and that decisions are not made on an ad hoc basis, an example being rules on how often and for how long less than optimum flows would be accepted (e.g. optimum flow regime must be delivered six out of 10 years, and must occur for at least two successive years).

2. Decide on the best method to determine EWR (based on science) and make clear, quantifiable statements on the EWR.

3. Establish whether or not EWR are being met under the current situation:

   Compare what the environment is currently getting with what the EWR says the environment needs. This needs to be done at an appropriate scale of assessment (i.e. individual WDE, sub-catchment, catchment scale, and consider all relevant parts of the flow regime).

4. If EWR are being met:

   Protect the EWR from future development following the rules set out in the WAP.

5. If EWR <u>are not</u> being met:

- Reclaim water from current users to achieve the EWR, or
- Negotiate an appropriate EWP based on the social and economic constraints on the system, with a clear understanding of what ecological objectives you wish to achieve and a clear acknowledgement of where EWR are not being met and why. Questions that may be used to help guide these decisions include:
- When social and economic values are high, is an ecologically degraded system considered to be as valuable as a pristine or intact system, therefore would you give as much EWP to the degraded system as to the pristine system?
- Do we value systems that are one of the only few of their type left in a region more highly than systems that are well represented (and well protected) throughout the region?
- How do we ensure that the WDE are still linked at a landscape scale (i.e. that plants and animals in good-condition WDE in one part of the catchment can move to another good-condition WDE somewhere else in the catchment) if the systems in between are degraded?

6. Implement a monitoring program or an adaptive management framework to determine whether or not the EWR and EWP are appropriately defined and/or implemented in order to achieve desired objectives. This will then be used to create a feedback loop (i.e. cycle back through steps 1–6 of the process).

CASE STUDIES FROM THE REGION

The principles and methodologies outlined above can be further demonstrated through a series of case studies described below.

DESIGNING EWP TO ACHIEVE TARGETED ECOLOGICAL OUTCOMES — THE ONKAPARINGA RIVER

The 'Determination of environmental water requirements of the Onkaparinga River Catchment' is the most comprehensive study undertaken in the WMLR, representing a Level 2 to Level 3 EWR method within the hierarchy (SKM 2002, 2003).

Eleven sites were selected throughout the catchment, based on the ecological significance and availability of biological and stream flow data. These data were used to link flow and water level height within the river and create hydraulic models. The models were then used to predict ecological responses at each site. This information was used by an expert panel to recommend the EWR that would be required to achieve a series of specific ecological targets. These EWR were in the form of specific volumes of water required per day for different periods of the year. Flows were described as one of three categories — low flows, fresh flows and flush flows. Specific ecological objectives, such as maintaining water quality, facilitating breeding and recruitment, and providing longitudinal connectivity, were linked to the specific flow categories.

These theoretical 'ideal' flows were compared to the current flows at these sites to determine if the requirements were currently being met or not. This analysis found that the flow regime has been partially altered in streams upstream of the Mt Bold Reservoir, with the low-flow period (summer and autumn) of the EWR not being met. This is due primarily to farm dam development. However, downstream of Clarendon Weir (downstream of Mt Bold Reservoir at the off-take to Happy Valley Reservoir), all components of the flow regime (low, fresh and flush flows) have been severely altered. This is due to a combination of the farm dam development and the reservoir, with the reservoir representing the majority of the impact. Despite these massive changes to flow regime and associated decline in ecological health, the physical in-stream habitat and bank vegetation are still relatively intact. Consequently, it is anticipated that there is a good chance that the WDE in this section of river will respond favourably to an EWP.

The particular benefit of providing an EWP to the Onkaparinga River below Clarendon Weir is the improved connection between the river and the estuary, allowing for the movement and breeding of a greater diversity of fish and other aquatic life.

As a result, an environmental flow trial for Clarendon Weir was developed. The economic and social importance of supplying water to metropolitan Adelaide was considered along with the risks to the ecosystem to arrive at a recommended EWP. The final EWP was agreed upon in consultation with DWLBC, AMLR NRMB, SA Water and other stakeholders — designed to achieve specific ecological objectives, some compromises from the originally stated EWR needed to be made.

FOCUSING ON CURRENT ECOLOGICAL OBJECTIVES OR VALUES, NOT NECESSARILY REINSTATING THE 'NATURAL' FLOW REGIME — WILLUNGA BASIN

The coastal lagoons and wetlands that persist today long the Adelaide coastline are a small remanent of what once existed. Therefore, those that remain, such as Washpool Lagoon and Aldinga Scrub in the Willunga Basin area, have particular significance from a conservation perspective. They provide significant habitat for birds and other biota, even despite the fact that they may have been altered from their pre-European state.

As with all regions within the WMLR, the combination of water resource development (both surface water and groundwater) and other upstream catchment pressures may pose a risk to the ecological health of these systems. Two of the region's significant wetlands — Blue Lagoon and Washpool Lagoon — have had their hydrology altered such that they are less permanent now than they once were. Where they once would have provided important habitat for waterfowl such as duck, they now provide important habitat for wader birds. The recommended EWR for these wetlands reflects this change in habitat type and therefore targets the values that currently exist rather than reinstating the 'natural' flow regime.

UNDERSTANDING HOW WATER MANAGEMENT AND ISSUES RELATED TO WATER SUPPLY IMPACT ON THE FLOW REGIME — RIVER TORRENS

As highlighted above, water resource development and extraction of catchment flows for consumptive use can lead to a significant reduction in particular components of the flow regime. However, when rivers are used as part of the water supply infrastructure, it is also possible that rivers can receive too much water.

Sections of the River Torrens are used as an aqueduct. Water is pumped from the River Murray and released into the Torrens at a number of locations including Mt Pleasant and Angus Creek. This water is transferred down the river system into the reservoirs where it is combined with WMLR catchment water to meet the demands of the public water supply.

The use of the river as an aqueduct has a number of negative impacts on the river, including:

- alteration to the timing of flows (i.e. water is pumped during summer when the river would naturally be experiencing low flows)
- the low-flow period the river experiences is consequently reduced
- water of high turbidity and different quality to natural catchment water
- rapid changes in flows within the river channel, exacerbating slumping of the river bank.

The pumping regime from the River Murray is aimed at minimising the pumping costs while maximising the security of supply. This means that significant pumping is undertaken in summer, when the river would naturally have been experiencing low flows, or have been reduced to a series of pools. The WAP provides the opportunity for the community to work with SA Water to improve the timing of pumping and the rapid changes in flow to improve the environmental outcomes.

IMPACT OF OTHER LAND USE ON A CATCHMENT'S ABILITY TO PROVIDE EWR — IMPACT OF FORESTRY ON FLEURIEU PENINSULA SWAMPS AND WETLANDS:

The swamps of Fleurieu Peninsula have been recognised as nationally significant under the Australian Government's environment protection and biodiversity conservation legislation. These swamps and wetlands provide habitat for the endangered Mount Lofty Ranges Southern Emu-wren, and also contain three endangered plants species — the White Beauty Spider-orchid, Maroon Leek-orchid and Osborn's Eyebright.

These swamps and wetlands rely on both underground and surface water flows to varying degrees, depending on their location in the landscape. Many of the systems also contain peat, which must remain moist at all times; swamps that have been allowed to dry out are very difficult to rewet and can become highly susceptible to erosion.

Water resource development, through farm dams, watercourse extractions and wells, can all significantly reduce the amount of water available to swamps and wetlands. However, other changes in land use, such as plantation forestry, can also significantly impact on a wetland receiving its EWR. Impacts from forestry are particularly challenging as it is difficult to impose 'water-taking rules' such as can be used for other consumptive users (e.g. allowing low flows to bypass a dam, or only extracting water from a watercourse after a flow surpasses a pre-defined threshold rate).

A 'Water Balance Method' has been developed within DWLBC (Greenwood in prep.; Greenwood et al. in prep.) to determine the wetland's demand for water and assess the impact of activities such as forestry and farm dam development on that demand. The calculation of water demand for an individual wetland is based on:

- wetland area
- total water use from the wetland, including evapotranspiration
- a flow-through requirement (i.e. water that is allowed to pass downstream of the wetland, based on the 25% catchment yield rule).

This water demand can be used as a preliminary estimate of the EWR. The basis to the 'Water Balance Method' is to maintain ecosystem integrity. By focusing on the critical soil-moisture requirements of a peat soil, the assumption is that you will by default provide the EWR for the other less water sensitive components of the ecosystem (e.g. flora and fauna).

The ‘Water Balance Method’ has been used to develop a set of guidelines that could be incorporated into the WAP, determining buffer distances between swamps or wetlands and the direct impact of forest plantation, as well as recommending that a planting should not exceed a maximum of 30% per unit area (could be applied at property scale, sub-catchment scale or catchment scale) in order to meet sustainable water-use levels.

ACRONYMS USED IN THIS TECHNICAL NOTE

AMLR NRM Board — Adelaide and Mount Lofty Ranges Natural Resource Management Board

DEH — Department for Environment and Heritage

DWLBC — Department of Water, Land and Biodiversity Conservation

EWP — Environmental Water Provisions

EWR — Environmental Water Requirements

NRM — Natural Resource Management

SAMDB NRM Board — South Australian Murray-Darling Basin Natural Resources Management Board

WAP — Water Allocation Plan

WDE — Water-Dependent Ecosystems

WMLR — Western Mount Lofty Ranges

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