ENVIRONMENT ACT

Environmental Flow Guidelines

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ACT GOVERNMENT

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INTRODUCTION

1.1 Background

Increasing demands for the allocation of water for off-stream uses has resulted in substantial changes in the streamflow regimes in many streams across Australia. These changes in streamflow have contributed to major impacts on aquatic habitats and ecology.

In some Australian streams allocation of water for off-stream uses can exceed flow resulting in patterns of flow that reflect the rights of water users rather than the requirements of the streams and their ecological processes. Consumptive uses are often given priority with water rights, entitlements, and licences having legal and commercial status. With the growing use of market forces as the basis of resource allocation, there is a need to ensure that environmental quality and ecological requirements are not disadvantaged.

Recently, there has been an acceptance of the need to give explicit recognition to an environmental flow allocation through the establishment of water entitlements for the environment. Similarly, it is accepted that there is a relationship between surface and ground water and that ground water abstraction can impact on base flows of surface streams. These environmental entitlements should be based on the best available scientific information to protect the health and viability of the river systems and groundwater basins.

Environmental flows are defined as the streamflow necessary to sustain habitats (including channel morphology and substrate), encourage spawning and the migration of fauna species to previously unpopulated habitats, enable the processes upon which succession and biodiversity depend, and maintain the desired nutrient structure within lakes, streams, wetlands and riparian areas. Environmental flows may comprise elements from the full range of flow conditions which describe long term average flows, variability of flows including low flows and irregular flooding events.

Many aquatic ecosystems in the ACT are highly modified as a result of changes in land use, changes to river channels and floodplains, streamflow diversion, discharges to streams, introduction of flora and fauna, and recreational fishing. Some of these systems, particularly urban lakes and streams, are created ecosystems. Some of these created ecosystems are valued more highly by some than those that existed in the same places before development. Other aquatic ecosystems are in a condition close to that prior to European settlement.

Depending on the condition of a stream and the environmental values specified for that stream, the planning and management issues in respect to environmental flows might be:

- to manage streamflow diversion and discharges so as to maintain the current status of the aquatic ecosystems; or
- to manage streamflow diversion and discharges so as to restore aquatic ecosystems to a standard to meet the community's environmental values.

It should be recognised that the guidelines for environmental flows in this document are based upon the best scientific knowledge available at the time they were drafted. The determination of environmental flows is an active research field and this document will be refined and amended as the knowledge base grows.

1.2 Purpose of the Guidelines

These Guidelines are an administrative document that sets out a methodology for the calculation of environmental flows to be used as the basis of a Water Resource Management Plan for the ACT. While the Guidelines have been developed using the most up to date scientific information available, some pragmatic assumptions have been made.

1.3 Ecologically Sustainable Development

The *InterGovernment Agreement on the Environment (1992)* sets out clear guidance on land use decision and approval processes to ensure development is ecologically sustainable. *The National Strategy for Ecologically Sustainable Development (1992)* sets the goal of Ecologically Sustainable Development (ESD) as 'development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends'. When applied to ecosystems this core objective is expressed as 'protection of biological diversity and the maintenance of essential ecological processes and life support systems'. These guidelines have been prepared with these principles in mind.

In line with the ESD precautionary principle, the guidelines for natural systems, modified systems and created systems are conservative and may need to be reassessed in light of further knowledge and experience.

1.4 Statutory basis for Environmental Flows in the ACT

1.4.1 Water Resources Act

The preparation of environmental flow guidelines is a requirement of the *Water Resources Act 1998*. This act has the objectives of:

- ensuring the use and management of water resources sustain the physical, economic and social wellbeing of the people of the Territory while protecting the ecosystems that depend on those resources;

- protection of waterways and aquifers from damage and, where possible, to reverse damage that has already occurred; and
- ensuring that water resources are able to meet the reasonably foreseeable needs of future generations.

To achieve these objectives the *Water Resources Act* sets out a process for the sustainable allocation of water to environmental and human uses. The Act requires that Environmental Flow Guidelines be prepared to set out the flows necessary to ensure environmental values in ACT waterways. The Act also requires a Water Resource Management Plan, which describes the water resources of the ACT and actions to be taken by the Environment Management Authority to manage those resources, be prepared. The Act further provides that the Environment Management Authority may make allocations, of both surface and groundwater, for off-stream use as provided for in the Water Resource Management Plan.

1.4.2 Territory Plan

Implementation of the *Water Resources Act* needs to be consistent with the Territory Plan. Three types of water use catchments are identified in the Territory Plan; "conservation", "water supply", and "drainage and open space". Part C2 of the Territory Plan specifies the primary environmental and use values of water bodies in the ACT for each of these types of catchment.

Within each of these catchments, secondary environmental and use values are also specified and include provision of recreational amenity, supply of potable or second class water, provision of aquatic habitat, and remediation of low quality urban stormwater (Part C2, Schedules 1 to 6 of the Plan). Where several secondary uses are specified for a water body, that water body should be managed to achieve the use with the most stringent requirements so that no uses are compromised by relaxation of standards.

Under the general principles and policies, the Territory Plan requires that planning be guided by the principles of ecological sustainability and exclude catchment land and water uses which impact on the sustainability of identified environmental or water use values. It is therefore necessary that appropriate flows be provided to protect the environmental and use values of ACT water bodies.

The Territory Plan explicitly requires that environmental flows be maintained to ensure that the stream-flow and quality of discharges from all catchments protect environmental values of downstream waters.

Three policies are elaborated to achieve this objective:

- land use and management practice shall be cognisant of streamflow and water quality impacts downstream;

- stream-flow diversions shall be restricted to authorised diversions; and
- lake and reservoir releases shall be consistent with the protection of downstream ecology and water uses.

Implementing these policies necessitates defining quantitative environmental flow guidelines for all streams, rivers and lakes in the ACT and the control of abstraction to flows not required by the environment.

1.4.3 Supporting Legislation and Strategies

The objectives of the Territory Plan and the *Water Resources Act* are supported by the provisions and strategies contained in the *Environment Protection Act 1997*, the *Nature Conservation Act 1980* and the ACT Nature Conservation Strategy 1998. The *Environment Protection Act* provides support by the enforcement of water quality and chemical use standards. The *Nature Conservation Act* and ACT Nature Conservation Strategy support the conservation of native species, communities and habitats essential to the protection of the wellbeing of aquatic habitats.

1.4.4 National Waters

These Guidelines include environmental flows for Lake Burley Griffin and releases from Scrivener Dam, the management of which are Commonwealth responsibilities. This approach has been taken in light of the ACT's responsibility for water resources under the *Australian Capital Territory (Self-Government) Act* and to ensure consistency across the ACT, given the impracticality of considering the management of Lake Burley Griffin in isolation. The role of these Guidelines is explicitly recognised in the Lake Burley Griffin Management Plan (National Capital Planning Authority 1995). The Guidelines therefore specify environmental flows for all waterways lying within the ACT.

1.4.5 Paramount Rights to Queanbeyan and Molonglo Waters

By the Agreement between the Commonwealth and NSW for the surrender of territory by NSW for the Seat of Government, the Commonwealth gained paramount rights to the waters of the Queanbeyan and Molonglo Rivers and their tributaries for all the purposes of the Territory. The Commonwealth developed the waters of the Queanbeyan River for the purposes of the ACT and through self-government legislation, the Territory Executive exercises the rights to these waters. The Council of Australian Governments' agreement on water reform, and the Commonwealth *Canberra Water Supply (Googong Dam) Act 1974*, require that environmental needs are taken into account in water resources management.

In this context, these guidelines also specify the environmental flows, which are seen by the ACT as appropriate downstream of Googong Dam and on

other parts of the Queanbeyan and Molonglo Rivers. These guidelines are not legally enforceable for NSW waters. Rather, they provide ACT's view on how it considers NSW should manage these waters which are of interest to the ACT. In addition, they assist in providing a basis to assess whether the Commonwealth's paramount rights to the waters of the Molonglo and Queanbeyan Rivers are being protected.

1.5 Review of the Guidelines

Actual flows and their effect on stream structure and ecology will be the subject of an ongoing monitoring and evaluation program. The program will be used to evaluate the effectiveness of the Guidelines. The Guidelines will be reviewed after the initial five years of operation to determine if targets and thresholds chosen are the most appropriate for individual water bodies. The review may be conducted earlier if evidence indicates it is warranted.

2 DETERMINATION OF ENVIRONMENTAL FLOWS

2.1 Basis for Determination of Environmental Flows

The concept of environmental flow is based on the recognition that stream biota is adapted to certain flow conditions and modification of the flow regime will impact on the ecosystem. Additionally, the structure of streams is strongly influenced by flow regimes producing secondary effects on stream biota in terms of substrate type, available habitat, etc. Flow regime refers not only to average flows but also to the variability of flow and incidence of flood events. For long term viability of some ecosystems there may be a need for 'stressing' flows, low flows that stress the aquatic ecosystem and allow succession. In practice it may be difficult to consider an 'environmental flow' component in isolation from other flows and from water quality.

The environmental flows have been determined by bringing together the Territory Plan requirements to protect specific environmental values associated with aquatic ecosystems, and the scientific basis for sustaining significant ecosystems or species.

2.2 Water Quality Issues

Both water quality and water quantity characteristics have effects on ecosystems, and in some areas these are strongly interrelated. Although these environmental flow guidelines focus on water quantity, some water quality factors should not be ignored in this discussion. In particular, water quality problems can arise when water is released from impoundments to meet downstream environmental flow requirements. Water from the lower layers of deep, stratified reservoirs can have a much lower temperature and oxygen content than surface waters. If this bottom water is released to meet

environmental flow requirements, its quality may compromise its value in the maintenance of aquatic ecosystems. For example most native fish species use both water temperature and flow as cues for reproduction, and the temperature of water released to meet an environmental flow requirement may severely disrupt spawning migrations and reproductive activity.

The algal biomass (and potential for nuisance blue-green algal blooms) of lakes is a function of the nutrient loading on the lakes and the residence time of water in the lake. Consequently, a diminution of inflow as a result of water abstraction, for example, can result in extended residence time and associated elevation in algal biomass levels. The sustainable nutrient loads on each lake identified in the ACT Water Quality Guidelines are premised on the existing inflow regimes. Any decision which leads to a reduction in inflow would need to consider the impact of altered nutrient loadings.

2.3 Modification of Water Control Structures

Many water control structures were built before environmental flows were identified and as presently constructed cannot be operated to meet the environmental flow requirements of these guidelines. In particular this relates to the temperature and flow variations to mimic natural conditions.

The major water storage structures, Corin, Bendora and Googong Dams all have the capacity to draw water from a variety of depths. However, each has only one water release structure. The depth from which water is drawn is determined by the quality requirements for water supply which are not always the same as the temperature requirements of special purpose environmental flows critical to fish reproduction during spring and early summer. The natural filling of the dams during spring often leads to over spillway flows removing the need for specific releases. Googong is only used during peak summer demand periods reducing the possibility of conflict between water supply and environmental flow requirements. It is expected that existing infrastructure will be managed so as to comply as closely as possible with the Guidelines.

Cotter Dam also has a multi-level off-take but as currently operated is not used for water supply. Any change to the use or method of operation of Cotter Dam should not adversely affect the quality of future environmental flows.

Scrivener and Captains Flat Dams on the Molonglo River do not have multi-level off-takes but are able to release water from the base of the dam wall. To comply with these guidelines, multi-level off-takes should be retrofitted to these dams. The priority for this work should be to Scrivener Dam and the work should be undertaken within a reasonable time. Urban lakes and ponds only have the capacity to release water by spilling.

Where minor changes to the infrastructure will produce a significantly better environmental outcome, it is expected that changes will be undertaken within an appropriate time. In the future as opportunities arise to modify any of these structures, through maintenance or redevelopment, it is expected that modifications will be undertaken so as to maximise possible improvements in environmental flows. It is not expected that major structural changes will be undertaken specifically to meet these guidelines.

2.4 Consideration of Return Flows

In urban situations flows returning to natural streams from sewage treatment, increased stormwater flows and other impacts can significantly increase flow volume and change flow variability, particularly at the lower end of the scale. These changes can be detrimental to the environment and it is appropriate to encourage the net abstraction of water to more closely approximate the flow prior to urbanisation. At the same time it needs to be recognised that part of the value of some created ecosystems in urban areas arises from flows which are higher than they would have been in natural conditions

Currently, the ACT diverts an average of 65 GL a year for urban water supply. Of the 65 GL around 55% is returned as treated waste water. Increased run-off resulting from lower infiltration rates in urban areas provides an additional 30% to 45% of the volume abstracted for water supply back to streams. The sum of returns to stream and additional run-off results in net abstraction of around 15% of the 65 GL originally abstracted. This is less than 2% of the mean annual flow at Burrinjuck Reservoir.

While the overall loss of flow in the system in the longer term is low, the changes in the median to low flow regimes on rivers downstream of water supply diversion dams and Scrivener Dam, is significant. Conversely, downstream of the sewerage treatment works on the Molonglo River there is a significant increase in base flows as a result of the return of treated wastewater to the stream.

The Guidelines address these changes in two ways:

- by managing further abstraction from streams so as to minimise impacts on the flow regime within this median to low flow band; and
- by requiring releases from Water Supply Reservoirs to protect low flows downstream.

Separately, the re-use of stormwater and treated waste water is being promoted as a means of reducing the return flows during low flow periods, thus restoring in part a more natural flow regime downstream of the treated waste water discharge point. Reuse also reduces the diversion from existing dams and defers the need for the construction of additional water supply dams.

2.5 Relationship to Groundwater

Aquifers in the ACT fall into two types, aquifers in fractured rock and aquifers in alluvium. Abstraction of groundwater from both types of aquifers will ultimately affect surface water flows and consequently such systems should be considered as integrated systems. With aquifers in alluvium there is often a direct connection with surface waters and the importance of a joint consideration of surface and groundwater in such systems is clear.

With fractured rock aquifers the connection between surface and groundwater may be less direct. The boundaries of such aquifers may not be related to the catchments which overlie them and the transit time of water through such aquifers may be so slow that it is not relevant to surface processes. Further work needs to be done to establish the importance of this type of aquifer in sustaining base flows, and of their recharge rates. Until further work is done, environmental flow requirements and allocations from fractured rock aquifers will be conservative.

2.6 Type of Ecosystems

There has been extensive changes to land use in some parts of the ACT resulting in substantial changes to stream flow. Restoration of natural aquatic ecosystems is no longer practical. In recognition of this situation, aquatic ecosystems have been categorised into four broad types in order to clarify differences in management goals and techniques that can be used to arrive at these goals (Table 1).

Table 1. - Types of aquatic ecosystems and their location

Type of Aquatic Ecosystem	Description	Management goal	Water bodies in this category
Natural ecosystems	Ecosystems that have persisted from a period prior to European settlement.	Primary goal: Maintain ecosystems in their pristine state, Secondary goal: recreation.	Water bodies in Namadgi National Park, excepting the Cotter River catchment
Modified ecosystems	Ecosystems modified by catchment activities (land use change, discharges) or by changes to the flow regime.	Should meet a range of functions; recreation, conservation.	Rivers, lakes and streams outside Namadgi and the Canberra urban area including Molonglo (except Lake Burley Griffin) and Queanbeyan Rivers.
Water supply ecosystems	Ecosystems in catchments that provide the ACT water supply.	Primary goal: Provide water supply, Secondary goal: conservation.	Cotter River catchment.
Created ecosystems	Ecosystems in urban lakes, ponds and streams that have developed since urbanisation	Should meet a range of functions; recreation, conservation, irrigation.	All urban lakes and streams.

Different approaches were used to set environmental flow guidelines for each of the types of ecosystem referred to in Table 1, natural, modified, water supply and created. These approaches are discussed in detail in Section 3. For the purpose of setting environmental flow guidelines, major rivers and streams are divided into reaches delineated by major confluences, lakes or reservoirs. This procedure assumes that a degree of homogeneity applies within reaches. It also acknowledges that there are links between reaches of a river. Specific environmental flow requirements can then be determined for each reach. This procedure is applied to all river reaches.

These guidelines also establish water levels at which lakes in the ACT should be maintained. Excessive draw down of lakes may result in an impact on ecosystems as does changing flow regimes in rivers. The approaches used to set environmental flow guidelines for lakes and reservoirs in the four types of aquatic ecosystems are discussed in Section 3.

3 ENVIRONMENTAL FLOW APPROACH ADOPTED

A holistic approach has been used for the setting of environmental flow guidelines in the ACT. This approach aims to consider the complete river ecosystem including catchment, channels, storages, riparian zone ground water and wetlands to maintain integrity, natural seasonality and variability of flows (see Figure 1).

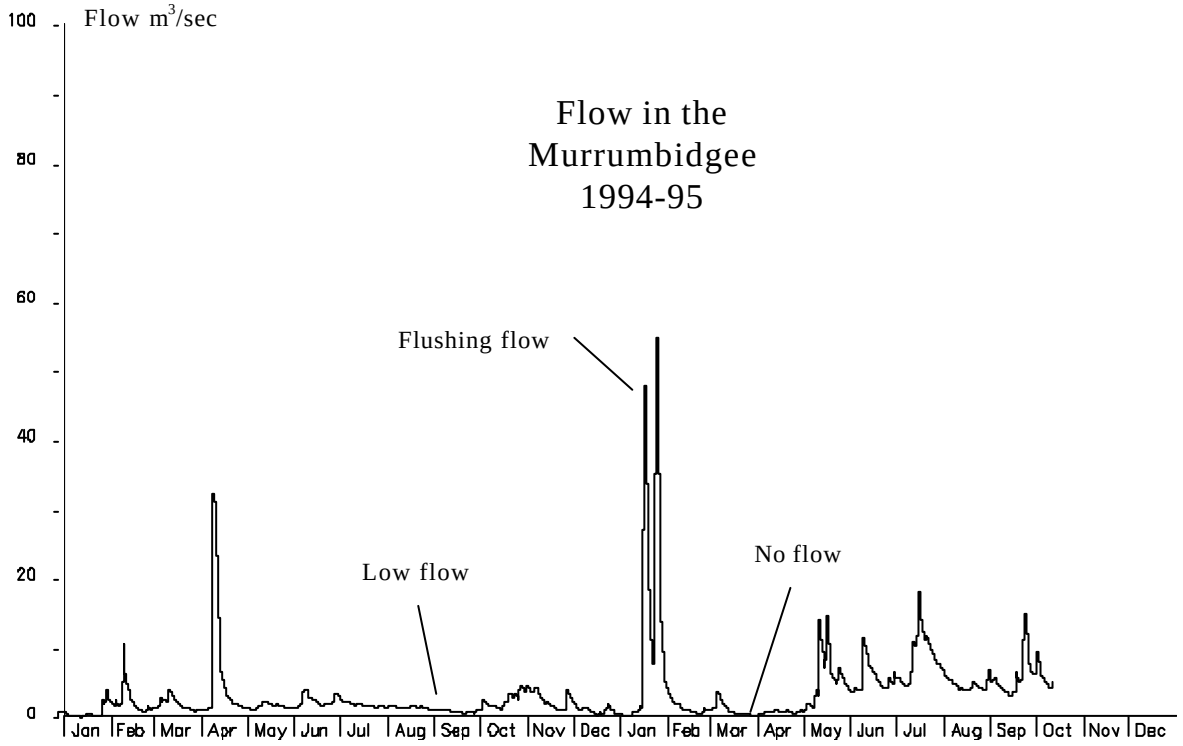

Figure 1 Flow at Lobbs Hole in the Murrumbidgee over 1994-95 illustrating flow variability and flow elements to be considered in an environmental flow.

A holistic approach has the following advantages;

- the philosophy underlying this technique is the maintenance of the aquatic ecosystem as a whole, rather than some selected component, eg. fish;
- this approach makes explicit provision for natural variability in river flow including seasonal variation and flood flow; and
- when more information on flow requirements of particular ecosystem components becomes available, eg. fish diversity, it can be readily incorporated into the approach.

3.1 Determination of Environmental Flows

For the purpose of these Guidelines, the following methods shall be adopted as the basis for determining flows. The method selected for a catchment will depend on the availability of data, its reliability and relevance. In determining flows percentile flows will be based on "time weighted" recorded flows and gauged data should be of a suitable length of record (preferably 10 years), have no significant dams or other flow modifications, and should be stable catchment conditions.

Cumulative gauged flow based method

Where an abstraction point is located upstream or downstream of a gauging station, the flow can be calculated on the basis of the gauged flow for the nearest appropriate station, multiplied by a catchment area ratio raised to the power 0.7 to account for flows from tributaries; that is: $Flow_{abstr} = Flow_{gauge} \times (A_{abstr}/A_{gauge})^{0.7}$

Paired catchment based method

Where gauging is not available on a stream, and a calibrated 'paired catchment' station exists for the stream, the flow can be calculated on the basis of the flow for the paired stream multiplied by the calibrated flow coefficients for the abstraction stream. If no calibration factor is available, the closest hydrologically similar catchment will be selected and the flows determined by the Cumulative gauged flow based method above.

Regional rainfall-run-off model based estimates

Flow can also be calculated on the basis of the application of rainfall data for the catchment of the stream to a Rainfall-Run-off Model calibrated to regional parameters.

3.2 Components of Environmental Flows

For ACT waterbodies there are four elements that should be built into any environmental flow, these are:

- low flows,
- flushing flows,
- special purpose flows, and
- maintenance of impoundment levels.

3.2.1 Low Flows

Aquatic ecosystems in ACT rivers are assumed to be adapted to periods of low flow or no flow. Such conditions are presumed to have occurred before European settlement and still occur in pristine catchments. It has been argued that natural low or no flow periods play an important role in stressing ecosystems, permitting re-colonisation and succession. However, this stress should not be exacerbated by unnatural long periods of low or no flow. Ecosystems are particularly sensitive to impact when stressed and further stress will result in harmful impacts. Low flows need to be maintained as close to natural levels as possible.

A critical decision in determination of any flow, including low flows, is the period over which it is calculated. If a low flow guideline were based on a statistic calculated for the entire year, it would ignore the natural seasonal variability in river flow; ACT flows are naturally higher in winter. Calculation of a percentile flow for each week better reflects natural variability, but if this flow forms the basis for the environmental flow, administration of environmental flows could become impractical. As a pragmatic compromise, statistics based on the monthly flow are used in these guidelines as the measure of low flow component of the environmental flow.

Selection of a threshold that appropriately defines low flows has generated significant debate. For simplicity of calculation a single threshold is preferred. A pragmatic approach has led to the selection of the 80^{th} percentile as the threshold of low flows. The 80^{th}[1] percentile flows will be calculated on periods of not more than a month. The collection of flow data from continual monitoring will provide additional information as to the appropriateness of this threshold. Similarly, 10% of flows above the 80^{th} percentile has been selected as a suitable portion of water for abstraction. These thresholds will be subject to the review outlined in Section 1.5. Actual guidelines for protection of low flows are discussed in detail in Section 4.

[1] The 80^{th} percentile flow is the flow which is exceeded 80% of the time. (also see Glossary)

3.2.2 Flushing flows

These are flushes of fresh water following storm events, which are necessary for maintenance of aquatic ecosystems and channel structure. Flushing flows are of particular importance in streams downstream of water supply dams. Water supply requirements often drastically change natural flow regimes, causing damage to downstream aquatic communities and stream structure. An example of this is the riffle - pool structure of the Murrumbidgee River in the ACT, which would evolve to a system without deep pools and associated aquatic communities if flushing flows did not occur.

The discharge that research elsewhere has found to be the most critical at determining the width, depth and meander frequency of channels is the 1 in 1.5 to 2.5 years annual recurrence interval flood event. Flood events of this size should be protected to ensure that channel structure and the dependent ecological processes are maintained.

In ACT rivers, other than water supply catchments, the short duration of high volume flows and a limit on abstraction of 10% of flows over the 80^{th} percentile will ensure that flushing flows occur with this frequency. This 10% threshold has been selected using the best available scientific advice on the provision of habitat diversity and quality, nutrient and sediment cycling, movement of biota and connectivity between aquatic and terrestrial habitats. For simplicity of calculation a single threshold has been selected. The collection of flow data from continual monitoring will provide additional information as to the suitability of this threshold. The threshold will be subject to the review discussed in Section 1.5.

3.2.3 Special purpose flows

These are flood flows for specific ecosystem requirements, for example the inundation of a wetland. The ecological requirements for special purpose flows in ACT rivers are not well understood. Except for the requirement of spawning flows in the Cotter River, explicit special purpose components of environmental flows have not been set at this stage.

3.2.4 Maintenance of impoundment levels

The stability of water levels in lakes, ponds and reservoirs determines success of submerged and emergent macrophytes. Macrophyte stands are a significant component of aquatic habitat, and their destruction affects dependent biota and associated ecosystem processes. If the water level of urban lakes and ponds is lowered too far below spillway level for a significant period, macrophytes will be damaged or killed, compromising the ecological values of those water bodies and their capacity to support other environmental functions.

4 ENVIRONMENTAL FLOWS FOR PARTICULAR ECOSYSTEMS

4.1 Water Supply Ecosystems

The Cotter River catchment from its headwaters to the wall of the Cotter Dam is the only catchment in this category.

The primary use of waterbodies in water supply catchments is provision of a potable water supply. Although protection of aquatic habitat is a designated secondary goal in these areas, their primary function may require substantial drawdown of reservoirs and abstraction from streams. No guidelines are set for maximum drawdown of reservoirs in water supply ecosystems.

The specific objective of environmental flows in water supply catchments is to ensure that existing downstream ecological values are retained. Environmental flow guidelines for river flow in this catchment also acknowledge the primary water supply role of the catchment. Nevertheless, as a consequence of the protected nature of the Cotter catchment, this system contains valuable aquatic ecosystems. For example, the Cotter River has the highest number of threatened fish species of any stream in the ACT or surrounding region.

Guidelines have been set for three categories of river reach in the water supply catchment;

Category A - river reaches above all impoundments in the catchment (eg. above Corin Dam);

Category B - river reaches between impoundments used as a conduit for water intended for water supply (eg. between Corin and Bendora Dams - water in Corin Dam intended for domestic supply is not pumped directly from there, but is allowed to flow downstream to Bendora Dam and from there gravitated to Canberra); and

Category C - river reaches below impoundments not used as a conduit for water intended for water supply (eg below Bendora and Cotter Dams).

Category A (above Corin Dam)
Within this region there is to be no interruption to natural flows.

Category B (Corin Dam to Bendora Dam)
The approach taken has been to base guidelines on the minimum flow requirements for maintenance of viable native fish populations in these regions. The health of native fish is considered a good indicator for typical aquatic ecosystems. A critical period for native fish is the breeding season in the spring months. At other times of the year lower flows will suffice to maintain fish populations. A flow adequate for spawning has been defined as

the 50th percentile[2] monthly flow during the spring months (September, October and November) and the 80th percentile monthly flow for the months August and December to March.

- In two out of every five years flows are to be at or above the spawning level for each month in the August-to-March period.
- In addition, in all months in all years the defined low flow is to be protected. The low flow is defined as the 80th percentile of water flowing into the reservoir. That is, flows entering the reservoir, up to and including the 80th percentile, are to be released. Where the water supply service provider can demonstrate the need for further supplies, the Environment Management Authority may reduce this level of protection. Where the level of protection is reduced flow should not be permitted to fall below 50% of the inflow when flows are below the 80th percentile, except as specified under drought conditions.
- Reservoir releases to meet environmental flow requirements should mimic natural flows as far as possible.
- Temperature of released water should approximate as closely as possible temperature of water flowing into reservoirs.

Once flow requirements are met, all other water is available for abstraction.

Drought is defined for the purpose of these Guidelines as occurring when in nine of the preceding 12 months flows into Corin Dam and Googong Dam were less than the median monthly inflows, and the total amount of water in ACT water supply reservoirs is less than 50% of total storage capacity. It is accepted that during a period of drought, specified environmental flow guidelines may need to be modified by the Environment Management Authority, subject to appropriate consultation, to ensure security of Canberra's water supply. Parties involved in such consultation should at least include the service provider, and the Government agencies responsible for water resource planning and regulation.

Category C (below Bendora Dam)

There is recognition that releases of water below impoundments to meet environmental flows may conflict with the water supply function of the catchment. Nevertheless the Territory Plan explicitly states that reservoir releases in this and other water supply regions shall be consistent with maintenance of the downstream ecology.

- In all months in all years the defined low flow is to be protected. The low flow is defined as the 80th percentile of water, which would have flowed into the reservoir prior to the development of upstream impoundments. That is, flows entering the reservoir, up to and including the 80th percentile, are to be released. Where the water

[2] The 50th percentile flow is the flow which is exceeded 50% of the time. (also see Glossary)

supply service provider can demonstrate the need for further supplies, the Environment Management Authority may reduce this level of protection but flow should not be permitted to fall below 50% of the inflow when flows are below the 80th percentile, except as specified under drought conditions (see Category B).

Once flow requirements are met, all other water is available for abstraction.

Implementation

Environmental flows below impoundments should be met by releases from the impoundments. Water released to achieve environmental flow targets should be at a temperature approximating as closely as possible that of inflow water. If inflow water temperature is unknown, surface water should be used to meet environmental flow requirements. Percentile flows should be calculated on not more than a monthly basis but releases should be made to mimic natural short term, daily or within month variability as much as possible.

100th Percentile Flows

Flows close to the 100 percentile flow should be allowed to occur at some time and this approach provides a mechanism to approximate their natural frequency of occurrence. Abstraction or diversion that would reduce flows below the 100 percentile flow would not be permitted. This mechanism enables the water supply service provider to access more than 50 percent of the flow below the 80 percentile flow in extreme circumstances. In such circumstances, significant water use restrictions would be expected to apply.

4.2 Natural Ecosystems

Rivers, lakes and streams whose catchments are wholly in Namadgi National Park, with the exception of the Cotter catchment, fall into this category.

Protection of low flows;

- For rivers and streams the flows below the 80th percentile flows are to be protected from abstraction;
- Abstraction from rivers and streams shall never exceed flow rate; and
- No abstraction is permitted from lakes and ponds in which natural ecosystems are to be maintained.

Protection of flushing flows:

- for rivers and streams, 10% of the flow volume in events above the 80th percentile is available for abstraction.

Implementation

Restrictions on abstraction are the major strategy adopted to maintain streamflow. In practical terms, abstracters would not be permitted to use

their water allocation during a period of low flow, but would be able to pump or divert water in other parts of the flow regime. Percentile flows should be calculated on not more than a monthly basis.

4.3 Modified Ecosystems

Rivers, lakes and streams outside Namadgi National Park and the Canberra urban area fall into this category. Lake Burley Griffin and the Molonglo and Queanbeyan Rivers are included here even though the major use of the Queanbeyan River is for water supply purposes. This recognises the established uses in the catchment before the construction of Googong Dam.

The guidelines for these ecosystems aims to manage of flows and abstraction from streams, so as to maintain modified ecosystems in as natural state as possible. The objective acknowledges recreation related ecosystem attributes including recreational fishery and the absence of algal scums and odours. Modified Ecosystems fall into three categories "Water Supply Reaches", "the Murrumbidgee River" and "Other Reaches". Some guidelines are common for all three categories.

Protection of low flows;

- For rivers and streams the flows below the 80th percentile flows should be protected from abstraction except for stock and domestic needs; and
- Abstraction from rivers and streams should never exceed flow rate.

Protection of flushing flows:

- for rivers and streams, 10% of the flow volume in events above the 80th percentile is available for abstraction.

4.3.1 Water Supply Reaches

The Queanbeyan River at Googong Dam and the Molonglo River at Captains Flat Dam fall into in this category. The defined low flow should be protected. The low flow is defined as the 80th percentile of water flowing into the reservoir. That is, flows entering the reservoir, up to and including the 80th percentile, are to be released. For Googong Dam, where the water service provider can demonstrate the need for further supplies, the Environment Management Authority may reduce this level of protection after consultation with the Commonwealth, NSW and local authorities. Where the level of protection is reduced flow should not be permitted to fall below 50% of the inflow when flows are below the 80th percentile except as specified under drought conditions (see Section 4.1).

Reservoir releases to meet environmental requirements should mimic natural flows as far as possible. Once flow requirements are met, all other water is available for abstraction.

4.3.2 Murrumbidgee River Environmental Flows

For the Murrumbidgee River in the ACT, percentile flows are calculated from gauged data taken subsequent to construction of the Tantangara Dam. This is an interim approach and may be modified as more information becomes available or the pattern of releases from Tantangara Dam is changed. An agreement between the former NSW Water Conservation and Irrigation Commission and the Snowy Mountains Hydro-electric Authority (1961) on releases from Tantangara provided for a base flow of 0.20 cumecs at the Cotter Crossing in the ACT. However, there is no requirement to release more than 0.96 cumecs at the dam, or more than is flowing into the dam. This agreement and abstractions in NSW result in flows which are often well below 80 percentile monthly flows in the ACT section of the Murrumbidgee River.

Environmental flows for the Murrumbidgee River consist of the sum of the Murrumbidgee flow entering the ACT and the end of valley environmental flows from all tributaries that join the river within the ACT including those

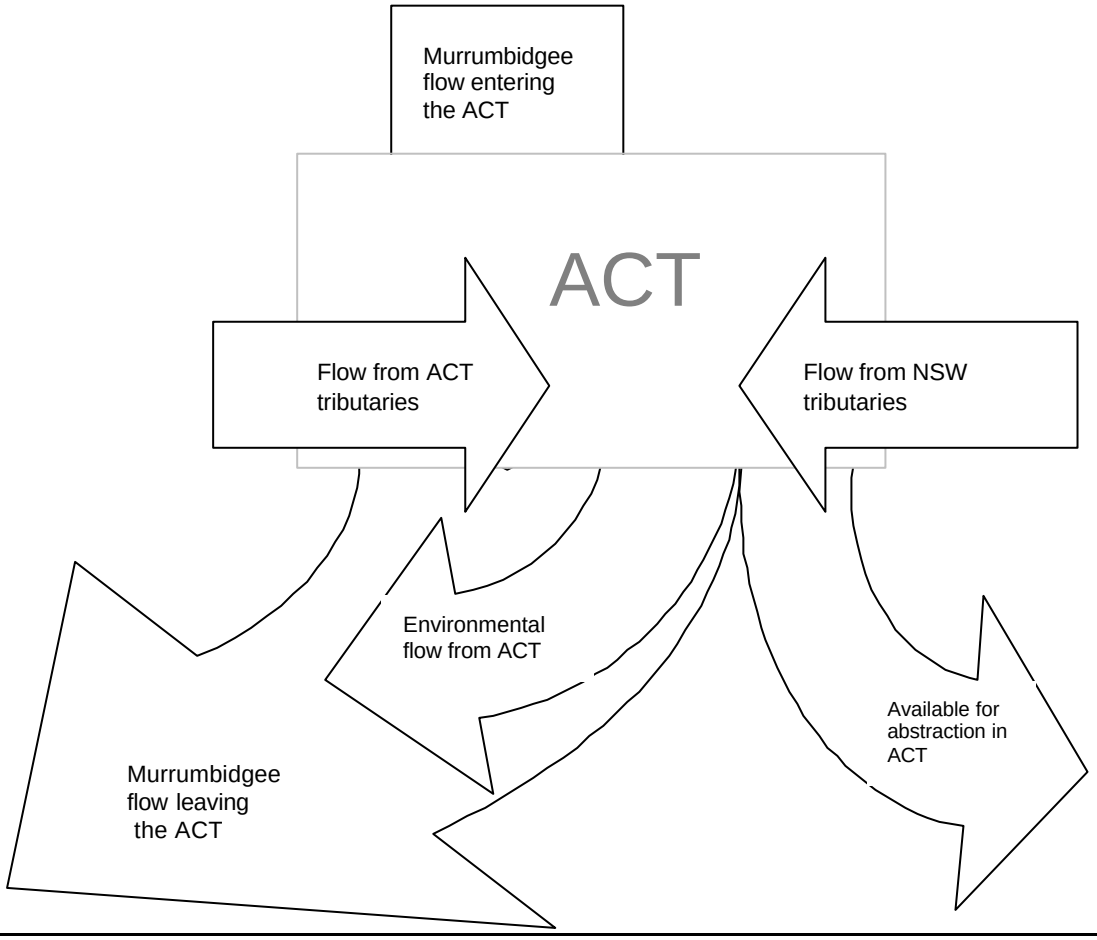

Figure 2: Components of Murrumbidgee RiverFlow

that originate in NSW. This is illustrated in Figure 2.

4.3.3 Other Reaches

All other waterbodies including the Queanbeyan River above Googong Dam and the Molonglo River above Captains Flat Dam fall into in this category. The guidelines for these reaches are:

- Abstraction or diversion of water above Googong and Captains Flat Dams should be limited to that permitted as a riparian right;
- For lakes and ponds in modified ecosystems the maximum drawdown is 0.2 m below spillway level; and
- Temperature of water released from reservoirs should approximate as closely as possible the temperature of water flowing into reservoirs.

Implementation

For river reaches immediately downstream of reservoirs, controls on abstraction together with low flow releases from the reservoirs are seen as the appropriate mechanism for achieving guideline environmental flows. Water released from reservoirs should be at a temperature approximating as close as possible that of inflow water. If inflow water temperature is unknown, surface water should be used to meet environmental flow requirements.

For other river reaches, controls on abstraction are seen as the appropriate mechanism for achieving guideline environmental flows. In practical terms abstracters would not be permitted to withdraw their water allocation during a period of low flow, except for stock and domestic needs, but would be able to pump or divert water in other parts of the flow regime.

Storages, including Captains Flat, Googong and Lake Burley Griffin, should not be required to make releases to provide flushing flows as tributary inflow will provide adequate flushing and the frequency and volume of spills from Lake Burley Griffin will provide an acceptable replication of pre-urban flushing flows.

Lake and pond water levels should be maintained principally by controls on abstraction. Abstraction should be permitted only if the lake level is above the maximum drawdown specified in these guidelines.

Percentile flows should be calculated on not more than a monthly basis but releases should be made to mimic natural short term, daily or within month, variability as much as possible.

100th Percentile Flows

It is recognised that flows close to the 100 percentile flow should be allowed to occur at some time and this approach provides a mechanism to approximate their natural frequency of occurrence. Abstraction or diversion

that would reduce flows below the 100 percentile flow should not be permitted. This approach enables the water supply service provider to access more than 50 percent of the flow below the 80thpercentile flow in extreme circumstances. In such circumstances, significant water use restrictions would be expected to apply.

4.4 Created Ecosystems

All streams, lakes and ponds within the urban area excluding the Molonglo River and Lake Burley Griffin fall into this category.

The specific objective of for created ecosystems is the management of stream flows, and constructed water features, to maintain a range of urban aquatic ecosystems.

Protection of low flows;

- For rivers and streams the flows below the 80th percentile flow are to be protected from abstraction, except for stock and domestic needs;
- Abstraction from rivers and streams shall never exceed flow rate; and
- For urban lakes and ponds the maximum drawdown as a result of abstraction is 0.20 m below spillway level. The limit acknowledges that there will be further losses through evaporation in dry seasons. Lake edges are sloped at approximately 1 in 10 for stability, safety and public health. A draw down of 0.2 m represents a band of some 2 metres, within which macrophytes could be lost, if draw down was sustained for long periods. There will be a need to monitor the impact of this guideline on lake and pond macrophytes, and to review it over time.

Protection of flushing flows:

- for rivers and streams, 10% of the flow volume in events above the 80th percentile is available for abstraction.

Implementation

In the absence of upstream ponds and lakes, control of abstraction is seen as the appropriate mechanism for achieving guideline environmental flows. In practical terms abstracters would not be permitted to withdraw their water allocation during a period of low flow but would be able to pump or divert water in other parts of the flow regime.

While some storages do not have the capacity to make releases without inflow, the frequency and volume of spills from those storages is considered to provide an acceptable replication of pre-urbanisation streamflow. Lake and pond water levels would be maintained principally by controls on abstraction. Abstraction would be permitted only if the lake level were above the maximum drawdown specified in these guidelines. There is

already a significant demand for use of water from these waterbodies from the ACT Government for irrigation of parklands and playing fields, and for irrigation of golf courses. If increased demands were accommodated without consideration of environmental requirements, they could impact severely on other functions of the waterbodies. Absolute drawdown levels are considered to be the most effective form of guideline for the protection of urban lakes and ponds.

5 FUTURE WORK

Further investigation is needed to confirm the flow requirements of local aquatic biota. The holistic approach, recommended here as the soundest available procedure on which to base environmental flow guidelines, requires the identification of different riverine ecosystems and the flows necessary to maintain their biota and processes. This is a major task. Furthermore, in Australia we cannot rely heavily on approaches pioneered on very different northern hemisphere ecosystems, or on approaches focusing exclusively on maintenance of fish habitat. Of particular importance in our streams with highly variable flows is an understanding of the impact of daily, seasonal, annual and event based flow variability to long-term health of and changes in aquatic ecosystems.

There is a significant amount of research currently being undertaken into environmental flows in the Australian context. The expanding knowledge base resulting from the research and increased quantity of data obtained from monitoring of stream flows will both influence and impact on the review of these Guidelines.

An ongoing monitoring and evaluation program of actual flows is required to determine if targets and thresholds nominated in the Guidelines are the most appropriate for individual water bodies. Future review of the Guidelines must be based on information gathered from the monitoring and evaluation program.

In addition, investigations are needed into ACT groundwater resources to establish the impact of increasing groundwater abstraction on river and streamflow, particularly base flows, the distribution of groundwater resources in the ACT, the vulnerability of these resources, and the sustainable yield. It is recognised that controls on surface water abstraction alone cannot guarantee base flow requirements in the medium to longer term.

GLOSSARY

Abstracter

An abstracter is a person or corporation that abstracts water from a waterway, dam or bore.

Abstraction

Abstraction refers to the removal of water from a natural waterway, dam or bore.

Aquatic Ecosystem

For the purposes of these guidelines, an aquatic ecosystem is an ecosystem bounded by the riparian zone.

Aquifer

An aquifer is a layer of rock or soil that is permeable and has the capacity to convey significant amounts of groundwater.

Baseflow

Baseflow describes the quantity of flow in a waterway that exists purely as a result of seepage into the upstream channel from groundwater. Practically, baseflow is determined from either field investigation after a prolonged period without precipitation or one of several quantitative baseflow separation models.

Biota

Biota is a general term describing the animal or plant life of an area.

Created Ecosystem

A created ecosystem is an ecosystem that has been significantly altered.

Discharge

Discharge refers to the release of water from a detention structure into a waterway.

Diversion

See abstraction.

Drawdown

Drawdown refers to the change in water surface elevation in a dam during a certain time period.

Ecosystem

An ecosystem is a biological community of interacting organisms and their physical environment.

Ephemeral Streams

Ephemeral streams are waterways that are temporary in nature. That is, waterways that exist for a relatively short period of time, usually a matter of days, after a storm event.

Flow Regime

Flow regime commonly describes the distribution of flow rate magnitudes over time for a particular waterway. In this capacity it is similar to a unit hydrograph.

Flushing Flows

Flushing Flows are flows, resulting from storm events, which typically comprise high flow rates over a relatively short duration. Flushing flows are crucial to establishment and maintenance of channel structure.

Fractured Rock Aquifer

A fractured rock aquifer is an aquifer that exists where the geological structure is characteristically impervious rock with sediment filled fractures. These fractures allow the conveyance of groundwater.

Macrophytes

Macrophytes are large water plants. Emergent macrophytes are plants that are rooted in the riverbeds or lakebeds, and protrude from the water surface. Submerged macrophytes are plants that are rooted in the riverbeds or lakebeds, but do not protrude from the water surface.

Modified Ecosystem

In the context of this document a modified ecosystem is an ecosystem that has been somewhat altered by direct or indirect human influence.

Multi-level Off-takes

Multi-level Off-takes are structures that allow the release of a controlled quantity of water from a variety of depths in a dam thus allowing water of a desired temperature to be released.

Natural Ecosystem

A natural ecosystem is an ecosystem on which there is minimal human impact.

Percentile

A percentile is a value between 0 and 100 that indicates the proportion of measurements that fall above the percentile value. In this document the range of stream flows are expressed in percentiles. The 80^{th} percentile is that flow that is exceeded 80% of the time, that is it is those commonly occurring (low) levels of flow. The 50^{th} percentile, or median is that flow that is exceeded only half of the time, the less common and higher flows. Percentile flows are represented graphically in Figure I.

Percentage

Where a percentage is used in conjunction with a percentile such as 10% of the flow above the 80^{th} percentile, this refers to the portion of the water available for abstraction (10%) when certain flow conditions prevail (the flow exceeds the 80^{th} percentile). It refers only to a portion of the water above the threshold level, not a portion of all water flowing at the time.

Riparian vegetation

Riparian vegetation is terrestrial vegetation that is influenced by its proximity to a body of water.

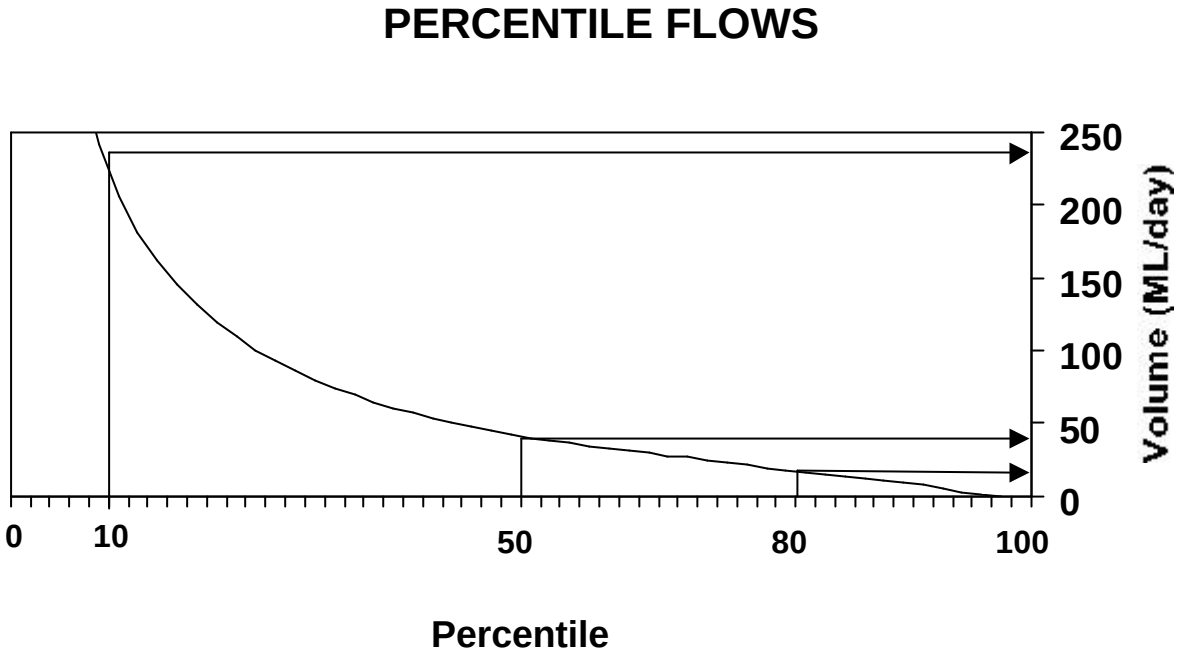

Figure I A graphical representation of percentile flows.

Special Purpose Flows

A special purpose flow refers to a particular flow regime that is required to meet a specified purpose. For example, some fish require a relatively unique flow regime, in terms of flow and temperature, to occur before spawning is initiated.

Stratified Reservoir

A reservoir becomes stratified when the water forms a layered structure, each layer having a distinct temperature and water quality.

Stressed Stream

A stressed stream is a stream that has endured a prolonged period of low flow. These conditions are often detrimental to stream health yet are a necessary component of the flow regime because they improve the resistance of local organisms to periods of low flow or drought conditions.

A stressed stream may also refer to a stream that is suffering from pollution.

Sustainable Yield

Sustainable yield refers to the quantity of water that may be diverted without having an adverse effect on dependent ecosystems.

Territory Plan

The Territory Plan is the primary planning document that implements the *Land (Planning and Environment) Act* and provides a framework for the sustainable growth of the ACT region. It provides specific guidelines and restrictions on land use.

Urban Lake or Pond

An urban lake or pond is a dam that was constructed for the purposes of recreation, pollution control and minimisation of peak storm flows. In the ACT they are Point Hut pond, Isabella pond, Upper Stranger pond, Lower Stranger pond, Lake Tuggeranong, Lake Ginninderra, Gungahlin pond, Yerrabi pond.

Water Supply Ecosystem

A water supply ecosystem is an ecosystem in a catchment, which is primarily used as a water supply catchment.

Water Use Restrictions

Water use restrictions are rules that are put in place during periods of drought or near-drought to prevent the excessive drawdown of water supply reservoirs. Examples of water use restrictions include limited sprinkler hours and prohibition of outdoor watering.

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