futurewateroptions

FOR THE ACT REGION IN THE 21ST CENTURY

ACTEW CORPORATION

THE COTTER DAM OPTION

A report assessing various alternatives for the use of Cotter Dam for future ACT water supply

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ACT Future Water Options
Integrated Project Team
TransACT House
470 Northbourne Avenue
CANBERRA ACT 2602

ACTEW Project No. 800845

Prepared By

ACIL Tasman
Economics Policy Strategy

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Context and purpose

When the ACT Government released "Think water, act water – a strategy for sustainable water resource management" in April 2004, a Future Water Options project was established to identify how best to provide a long-term reliable source of water for the ACT region. Three options were selected for detailed assessment:

- *enlargement of the existing Cotter Dam;*
- *construction of a new dam on the Gudgenby River (the Tennent Dam); and;*
- *transfer of water to the ACT from Tantangara Dam in NSW on the Murrumbidgee River.*

Within each option a number of alternatives were included, as were combinations of options. This report assesses the Cotter Dam enlargement option.

Despite far-reaching action to implement a range of water efficiency measures, designed to reduce per capita mains water consumption by 12 per cent (by 2013) and 25 per cent (by 2025), it seems likely, given present population growth forecasts, that a major new water source will be required. In ACTEW's view, this will be so "unless the ACT is willing to accept the regular occurrence of water restrictions of a severity and frequency unprecedented in planning elsewhere in Australia."

Canberra's water cycle

The amount of water historically available from ACT controlled catchments (that is, excluding water in the Murrumbidgee River as it flows into the southern ACT from NSW) has averaged 494 GL per year. Of this, 272 GL are designated as environmental flows, leaving 222 GL potentially available for human consumption. Hydrological modelling conducted as part of this study assumes somewhat lower stream flows, due to climate change and the possibility of droughts even worse than experienced over the past 100 years.

The ACT's actual water consumption in recent years has averaged about 66 GL, with around half of this (31 GL) being subsequently returned to the Murrumbidgee River after treatment at the Lower Molonglo Water Quality Control Centre.

A further 386 GL per year enters the ACT from the south via the Murrumbidgee River. Thus a total of 845 GL in an average year flows out of the ACT into Burrinjuck Dam and beyond, supporting economic activity including the Murrumbidgee Irrigation Area, the towns along or close to the river, and contributing to environmental flow levels.

The ACT is a significant net water exporter to NSW and would remain so if an additional water storage facility were constructed.

Cotter alternatives

Initially, four alternatives involving the Cotter catchment were under consideration:

- *existing dam, plus greater use of environmental flow releases from Bendora Dam;*
- *new 45 GL Cotter Dam;*
- *new 78 GL Cotter Dam; and*
- *new 68 GL Coree Dam, upstream from the existing Cotter Dam.*

The Coree Dam was only in contention in the event that geological assessment rendered enlargement of the Cotter Dam impractical or impossible. Once that issue was resolved, the Coree alternative was *discarded. The small (45 GL) Cotter Dam option was discarded on the basis of hydrological assessment – that is, it did not add sufficiently to future water yield – and also because of a potential fish passage threat to the existing Macquarie Perch population (not a problem with the 78 GL option).*

The existing Cotter Dam has recently been brought back into service now that the upgraded Mt Stromlo water treatment plant enables treatment of its water. This contributes up to 50 ML per day and Cotter is once again a permanent component of the ACT's water supply system.

In addition, an opportunity exists to increase available supply using the existing infrastructure by capturing "surplus" water from the Cotter catchment and diverting it to Googong Reservoir. This is referred to as the Stromlo to Googong Reticulation Transfer. There are significant spills from the Bendora and Cotter Reservoirs each year, even during the drought year of 2004. The option involves capturing a proportion of these spills from Bendora Reservoir, via the gravity main to Mt Stromlo treatment plant, supplemented with water from the Cotter Reservoir and also from the Murrumbidgee River (when available). It is being pursued by ACTEW separately to the analysis described in this report.

Prior to the January 2003 bushfires, water quality from Bendora and Corin Dams was such that it only required disinfection and fluoride addition before reticulation to Canberra's consumers. This water had the additional (cost) advantage of being gravity fed to Mt Stromlo. However, sediment and ash contamination after the bushfires meant that Corin and Bendora water could not be used, forcing reliance on Googong water. Unfortunately Googong has not yet been replenished because of the continuing drought.

Planning and approvals

The statutory framework within which a future water supply option must be planned and implemented involves a complex array of legislation across three tiers of government, including water resource management policies, sustainability strategies, regional development policies (and their economic, social and spatial dimensions), and environmental, land management and development control policies.

Should a new dam be constructed, the principal planning instrument would be a development application submitted under the Land (Planning and Environment) Act to the ACT Planning and Land Authority. This would trigger a number of other processes that would need positive resolution before the Authority could grant approval. The Commonwealth would also be involved via several of its agencies. Unlike some of the Tennent and Tantangara options, Cotter at least has the advantage of not involving the NSW Government or NSW legislation to any significant degree.

A sustainability framework

The ACT Government's document, "People, Place, Prosperity", commits the Government to embed sustainability within its decision-making processes. This means recognising the interdependence of social, economic and environmental well-being, the effects of decisions on others, and that meeting today's needs must not be at the expense of future generations. For example, the social impact study (undertaken as part of the Future Water Options project) noted that damage to the ACT, and especially to those at lower income levels, would result if water supply levels and uncertainty inhibited future population growth and employment. Similarly, it noted that high cost regulatory measures and subsidies are likely to be regressive.

The "Economic White Paper", "Social Plan" and "Spatial Plan" state that reliability, availability and quality of supply, along with economy of use and environmental responsibility, are core water-related community values – not water use minimisation to the point where it would inhibit natural population growth of Canberra and the region.

Recent focus group discussions (carried out by ACTEW in November 2004) confirmed that 72 per cent of participants were willing to pay more for water, both to reduce demand and increase supply, if doing so reduced water restrictions. The most important water criteria are protection of public health, reliability of water supply, and effects on the aquatic environment.

Steps to enlarging the Cotter Dam

There are no privately held leases in the catchments affected by enlargement of the Cotter Dam – all is unleased Territory land and no variation to the Territory Plan would be required. Four categories of land, as defined by the Territory Plan, are involved: water feature, plantation forestry, mountains and bushlands, and river corridors. A "major utility installation" (such as a dam) is permitted in each of these categories.

Drawing on the recent Mt Stromlo water treatment plant upgrading experience, early and full consultation with all relevant parties is the key to a smooth planning and approvals process. After a development application is lodged with the Planning and Land Authority, an environmental assessment would be conducted, referrals would occur to the Conservator of Wildlife, the ACT and Australian Heritage Councils, the National Capital Authority, the Murray-Darling Basin Commission, other ACT Government agencies, and the Commonwealth Environment Minister, and an application made for a new abstraction licence pursuant to the Water Resources Act.

Water resources and quality

A total of 108 GL per annum is potentially available for human consumption from the Cotter catchment (over and above environmental flows); 27 GL of this is from the Cotter Dam and the balance from Bendora and Corin. About half this total has already been allocated, another 15 GL has been provisionally allocated (including 12 GL from Cotter Dam), while nearly 45 GL is "reserved".

Turbidity has been a problem with Cotter Dam water for many years, reflecting the fragile soils in the catchment, especially in the Pierces Creek area, and subsequent sediment discharge. As water temperatures increase during the summer months, the reservoir becomes stratified, with warmer (less dense) water at the top. Sediment microorganisms become more active, decreasing dissolved oxygen that in turn releases nutrients (such as nitrogen and phosphorus) and metals (iron and manganese) into the water column. Nutrients can result in algal blooms, while metals lead to water discoloration. Around April-May, surface water temperatures cool quickly and the now cooler heavier surface water sinks to the bottom, distributing the previously released material throughout the reservoir.

Despite this problem, projected key water quality characteristics are generally treatable by the recently upgraded Mt Stromlo water treatment plant, although mechanical de-stratification of the reservoir may be cost effective and preferable to additional treatment at the Stromlo facility.

Climate change

CSIRO, in a recent report for ACTEW Corporation, has predicted that likely changes to the region's climate in coming decades – temperature, rainfall and evaporation – have the potential to reduce water yields relative to historic patterns, by up to 20 percent by 2030 and by up to 50 per cent by 2070. At the same time, per capita demand could rise in response to the warmer temperatures by up to 5 and 16 percent by 2030 and 2070 respectively. Such projections have serious implications for future water supply decisions.

Reliable water supply and the need for future storage

"Water supply reliability" means having sufficient water in storage to supply the ACT and region's urban areas without the risk of running out of water. ACTEW has determined that this equates to water restrictions being imposed for up to 5 per cent of the time, with Stage 3 restrictions, where sprinklers are not permitted, could occur about one summer every 25 years. The water supply system would be said to be "failing" if restrictions needed to be imposed more frequently.

The point at which failure occurs depends on both the available supply and the demand. Demand increases over time as the population grows, moderated by the achievement of efficiency targets set by the ACT Government. It therefore reflects future population growth, which in turn can be converted into a year at which a given supply structure would "fail". From one standpoint, the "best" option will be the one where system failure occurs furthest into the future; however, other factors need to be considered, such as risk, cost and other components of sustainability.

With the introduction of environmental flows, assessment of climate change, and climatic variability, and the impact of post bushfire vegetation recovery on water runoff – none of which were contemplated prior to the 1990s – the existing water supply system technically reached failure point in 1999. In this context the long current water restriction period does not come as a surprise, although it has been exacerbated by the impact of the 2003 bushfires on the Cotter catchment.

Infrastructure issues

Engineering studies have indicated that the proposed site for Cotter Dam enlargement (125 m downstream from the existing dam) is suitable. The preferred dam type would be roller compacted concrete and the crest level would be 50 m higher than the existing dam and 76 m above the riverbed level. Two saddle dams (16 and 11 m high) would also be required in lower saddles of the reservoir catchment to hold water back. A new 750 mm pipeline would cross under the Murrumbidgee River to a new pump station just south of the existing building. Hydropower generation would be possible, utilising daily environmental water releases.

The overall cost would be approximately $98 million for the dam, and associated works, $4 million for clearing/site preparation, $2 million for pipelines, and $15 million for the pump station, a total of approximately $120 million.

The construction period would be 20 months, with the majority of material coming from a nearby quarry site. Suitable environmental controls would be implemented during construction, the main risks being sediment discharge and alkaline water from the dam wall.

The dam would supply up to 180 ML per day to the Mt Stromlo water treatment plant, and may operate in lieu of, or in conjunction with, water from Bendora Dam.

Environmental issues

A number of technical reports have reviewed the future water options against relevant environmental considerations.

While there are no landscape constraints that would prevent construction of a new Cotter Dam, the pine plantation land adjacent to the dam constitutes a major constraint to effective management of the catchment and a long-term impediment to water quality. The soils are particularly prone to erosion, producing highly turbid water. While pines may be relatively stable during their growth phase, periodic instability associated with harvesting and preparation for planting appears to be a direct cause of sediment mobilisation. ACT Forests has implemented sweeping changes to its operational procedures since the bushfires, designed to reduce sediment movement, but their effectiveness is still being assessed. Further work on catchment remediation will be required, regardless of whether Cotter Dam enlargement proceeds.

There are four threatened fish or crayfish species in the streams of the Cotter catchment that are potentially affected by future water supply options, Macquarie Perch, Trout Cod, Two-spined Blackfish and Murray River Crayfish. Cotter Dam enlargement has a relatively low impact on fish because it provides opportunities for active enhancement of threatened fish habitats and populations. However, any new dam would require operating rules to minimise potential impacts on threatened fish.

Environmental flows in the Cotter River have been closely managed under the guidelines, and this management has markedly improved the ecological condition of the river. Further improvements may be achieved through variation in base flows and smart management of water releases. An enlarged Cotter Dam would need to facilitate environmental flow releases and manage water quality. While it would flood considerable areas of existing amphibian habitat, larger areas of equivalent habitat will be created. Releases of cold water should be avoided because they may stress animals downstream. There will be a trade-off between the time taken to fill the dam and its impact on the aquatic ecosystem; even at a maximum rate filling a new Cotter Dam under average inflow conditions will take approximately twelve months.

There are no threatened plant species that would be affected by Cotter Dam enlargement, and the potential occurrence of significant animal species is low. Against criteria of native vegetation clearing and habitat loss, Cotter Dam enlargement is the most benign of the three options.

Human environment

There do not appear to be any major Aboriginal cultural heritage constraints to the Cotter Dam enlargement option. The existing Cotter Dam appears on the Register of the National Estate and would be covered by a new dam; other registered sites (the Cotter Pumping Station, the Upper Cotter catchment, the Murrumbidgee corridor and the Murrumbidgee River) would be largely unaffected.

There are increasing demands for recreation use at the Cotter precinct and in the catchment (including a wider range of recreation pursuits), issues that have been addressed in work commissioned by the (post bushfire) Shaping Our Territory Working Group and elsewhere. Conversely, the CRC for Water Quality and Treatment has cautioned about potential negative effects of recreation on the Cotter Reservoir's water quality. Prior to any decision to construct an enlarged Cotter Dam, these issues will require careful assessment, with an agreed position determined, if only because of the opportunity to incorporate some recreation design features into a new dam.

Public health protection is a paramount requirement of water supply planning, and is explicitly recognised in Think water, act water, as well as in the Australian Drinking Water Guidelines. One of the main principles is to retain multiple barriers to prevent the transmission of microbiological or chemical contaminants.

The ACT Government has a guiding objective to ensure the prudent use of resources, including minimisation of energy consumption and greenhouse gas emissions. A new water storage reservoir consumes energy and produces greenhouse gas emissions in three ways: in construction, including materials used; in operation; and via the decomposition of organic matter in reservoirs, both aerobic and anaerobic. Equally, the beneficial greenhouse effects of a reliable water supply to Canberra's parks, gardens and streetscapes, need to be recognised. Quantification of these energy and greenhouse effects is difficult but the conclusion is that they do not constitute a major impediment to proceeding with Cotter Dam enlargement.

Economic assessment

The economic framework for assessing the various future water options involves quantifying the benefits (measured as the value of having less time under water restrictions) and costs (both construction and operational), all discounted back to a net present value, and measured against one of two "do nothing" options (one based on medium population growth and the other described as the prudent planning scenario).

Water restrictions impose costs on households, businesses, recreation facilities, tourism, monitoring and compliance, ACTEW, and the ACT Government. Costs to households range between $20 and $36 million per year for stage 3 restrictions, rising to $40-77 million for stage 5 restrictions. In total, the costs of spending one year in restrictions is $60 million for stage 3 restrictions, and $163 million for stage 5 restrictions. The "benefits" of each water option are then calculated by relating these costs to the extent to which it reduces the expected time in restrictions in future, relative to the appropriate baseline scenario.

Of three alternatives involving the enlarged Cotter Dam, the Cotter plus Virtual Tennent option is the preferred option (of a total of nine modelled), the Cotter Dam on its own ranks fourth or fifth, and the Cotter plus large Tennent, while it produces the most water storage, is ranked ninth because of what today appears to be a prohibitive cost.

Risk assessment

The risk assessment conducted as part of the Future Water Options project involved the standard approach of determining the degree of risk – multiplying the likelihood of an event occurring by its consequence. This involved assessing inherent risks, as well as residual risks once control actions have been identified.

For Cotter Dam enlargement, the major risks (categorised as very high on a scale from low to extreme) are:

- *on its own, an occasional need for stage 4 or 5 water restrictions and frequent need for stage 3 restrictions – that is, a new Cotter Dam alone would not provide sufficient water to meet Canberra's future water needs;*
- *the condition of the catchment following the January 2003 bushfires exacerbating turbidity and water quality problems;*
- *poor catchment management practices continuing to affect water quality; and*
- *management of the recreational use of the Cotter catchment.*

The reliability of supply risk can only be mitigated by combining the Cotter option in with others. The risks relating to water quality will require intensive catchment remediation – indeed, regardless of whether the Cotter Dam is enlarged or not – and improved catchment management practices such as erosion controls. Risks relating to recreation will require the development of a recreation management plan.

With the implementation of adequate control measures the risks associated with the Cotter Dam enlargement option are considered to be manageable and would not preclude a decision to proceed.

Sustainability assessment

Consistent with the ACT's sustainability framework, noted earlier, the Future Water Options project team identified twelve criteria against which water options should be assessed. These were:

- *environment: effect on aquatic ecology, terrestrial ecology, greenhouse gas emissions and intrinsic value;*

- *social: risk to public health, heritage and cultural values, landscape and amenity values, and recreational opportunities; and*
- *cost and affordability, reliability, employment creation, and distribution of costs and benefits.*

A series of workshops, involving respectively project team members, selected community representatives, and ACT Government agency representatives, evaluated six options (Cotter Dam enlargement, large and small Tennent, Tantangara tunnel, Tantangara via Murrumbidgee River, and Virtual Tennent). The Cotter Dam was ranked first at both the project team workshop and the Community representatives workshop, and second (to large Tennent) by the ACT Government agency workshop.

1 Introduction

1.1 Purpose of Report

In April 2004, the ACT Government released the planning document *Think water, act water - a strategy for sustainable water resources management*[1]*.* The strategy defined actions to achieve sustainability objectives for water use in the ACT out to 2050*. Future Water Options* was initiated to respond to one of the objectives in the strategy: *to provide a long-term reliable source of water for the ACT region.*

Prior to this, nearly 30 possible options for boosting Canberra's water supply had been investigated in a report commissioned by ACTEW for *Think water, act water*[2]*.* That report identified three principal options for more detailed assessment:

- building a new dam on the Cotter River, just downstream of, and thus effectively enlarging, the existing Cotter Dam;
- building a new dam on the Gudgenby River near Mt Tennent, south of Tharwa (the Tennent Dam); and
- transferring water from Tantangara Dam in NSW to the ACT.

Within each option, several alternatives were analysed. A number of other options were discarded. As the analysis became more detailed, other variants and ideas came into focus, including options within the existing infrastructure for immediate implementation pending construction of a major water storage facility.

As part of *Think water, act water,* the ACT Government asked ACTEW Corporation to produce a final report on the preferred approach. This report assesses the Cotter Dam enlargement option. Companion reports assess the other two options and a summary report provides a final recommendation to the ACT Government on future water options for the ACT.

1.2 Water Supply in the ACT

Two catchments currently supply Canberra's water (see Figure 1.1):

- the Cotter catchment with three storage dams (Cotter, Bendora and Corin) and Mt Stromlo water treatment plant supplies about 60 per cent of Canberra-Queanbeyan's water needs; and
- the Googong Dam (on the Queanbeyan River) and water treatment plant supplies the balance.

Historically, water supply has been managed to maximise use of the Cotter catchment of Bendora and Corin Dams. Water from Bendora (in part fed by Corin) can be delivered by gravity through the Bendora Gravity Main direct to Stromlo. In the past this water has required only disinfection and fluoride addition before reticulation to Canberra's consumers.

The high water quality was due to the protected nature of the Cotter catchment in Namadgi National Park. Not having to pump the water reduces energy costs; indeed the availability of some residual

[1] ACT Government (2004), *Think water, act water,* Vol 1 "Strategy for sustainable water resource management in the ACT;" Vol 2 "Explanatory document;" Vol 3 "State of the ACT's water resources and catchments," April 2004.
[2] ActewAGL (2004), *Options for the Next ACT Water Source*, report for ACTEW Corporation by Technical and Consulting Services Branch, ActewAGL Water Division, April 2004.

energy can be used to generate hydroelectricity. This minimises water production costs while yielding environmental gains through greenhouse gas reductions and renewable energy production.

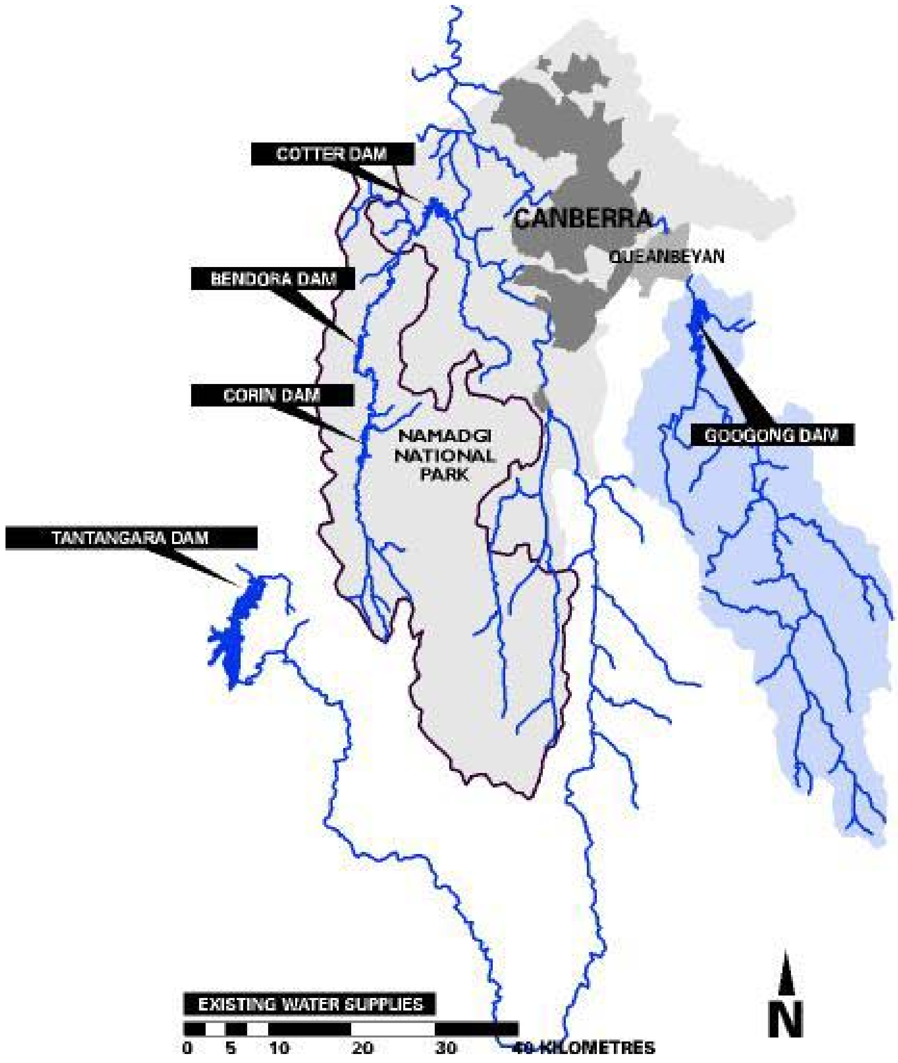


Figure 1.1: Canberra's water supply

Cotter Dam has not been used for water supply for the past 20 years for several reasons. The water quality from the lower part of the Cotter catchment was poor due to turbidity, in turn a consequence of erodible soils, historic forestry practices and associated forestry infrastructure. Prior to the new treatment plant, there was no facility available to treat this water. In addition, the need to elevate the water more than 150 m to Mt Stromlo and the small capacity of the storage reduced its attractiveness.

The Cotter catchment receives relatively high rainfall, particularly the section above Bendora Dam in the Brindabella Mountains (approximately 950 mm per year, compared with 600 mm at Canberra Airport).

In the January 2003 bushfires, the Cotter catchment was severely burnt, resulting in long-term water quality damage until vegetation regenerates and exposed soils stablise once again. Post bushfire storms washed large amounts of sediment into the Bendora and Corin Dams, meaning that water from the entire Cotter catchment required treatment. Accordingly, ACTEW commissioned a water treatment plant at Mt Stromlo with a capacity to purify 250 ML per day; this facility became operational in late 2004.

Googong Dam lies in NSW about 20 km southeast of Canberra on the Queanbeyan River.[3] The Queanbeyan River water flows through forests, grazing land, and rural residential areas and requires treatment for water supply. Although it is triple the size of the Cotter catchment, the Googong catchment receives much less rainfall (650 mm) and also has higher evaporation, so its yield is less than that of the Cotter catchment. The Googong Water Treatment Plant, which processes water before distribution, has recently been upgraded from 180 ML per day to 270 ML per day. Googong water must be elevated 50 m to the treatment plant and fully treated before distribution. Treatment and pumping mean that water from Googong was historically more expensive to supply than from Corin and Bendora.

Figure 1.1 also shows Tantangara Dam on the Upper Murrumbidgee River in NSW. While this dam does not form part of the ACT's present water supply, its inclusion is to indicate its relative proximity (as the crow flies) to the Cotter catchment dams. Tantangara has delivered water to the ACT in the past to supplement dwindling supplies, was captured via a temporary weir on the Murrumbidgee River and an associated pumping station.

Historically, water from ACT controlled catchments (that is, excluding water in the Murrumbidgee River as it flows into southern ACT from NSW) has averaged 494 GL annually.[4] Of this, 272 GL is designated by the Environmental Flow Guidelines as environmental flows (see section 4.2), leaving 222 GL potentially available for human consumption. The actual consumption in recent years has averaged about 63 GL, with around half this (31 GL) being subsequently returned to the Murrumbidgee River after treatment at the Lower Molonglo Water Quality Control Centre.

A further 386 GL per year enters the ACT from the south via the Murrumbidgee River; this water is not used by the ACT and flows along the Murrumbidgee to the north and back into NSW. A total of 845 GL in an average year flows out of the ACT into Burrinjuck Dam, supporting downstream economic activity including the Murrumbidgee Irrigation Area, the towns along or close to the river, and contributing to environmental flows.

These water flow data are based on historical stream flow records collected over time across the various river catchments. The hydrological modelling discussed in Chapter 4, which has been used as a basis for determining future water needs, has shown that when factors such as climate change and allowance for droughts even worse than experienced over the past 100 years are taken into account, future water flows are likely to be less than the historical average.

With that proviso, the main historical water aggregates (based on 2001-02) for the ACT are depicted diagrammatically in Figure 1.2.

[3] Under the *Seat of Government Acceptance Act 1909,* the Commonwealth was granted the rights to use water from the Molonglo and Queanbeyan Rivers for Canberra's water supply.
[4] ACT Government (2004), *Think water, act water, Vol 1, op cit,* p 21.

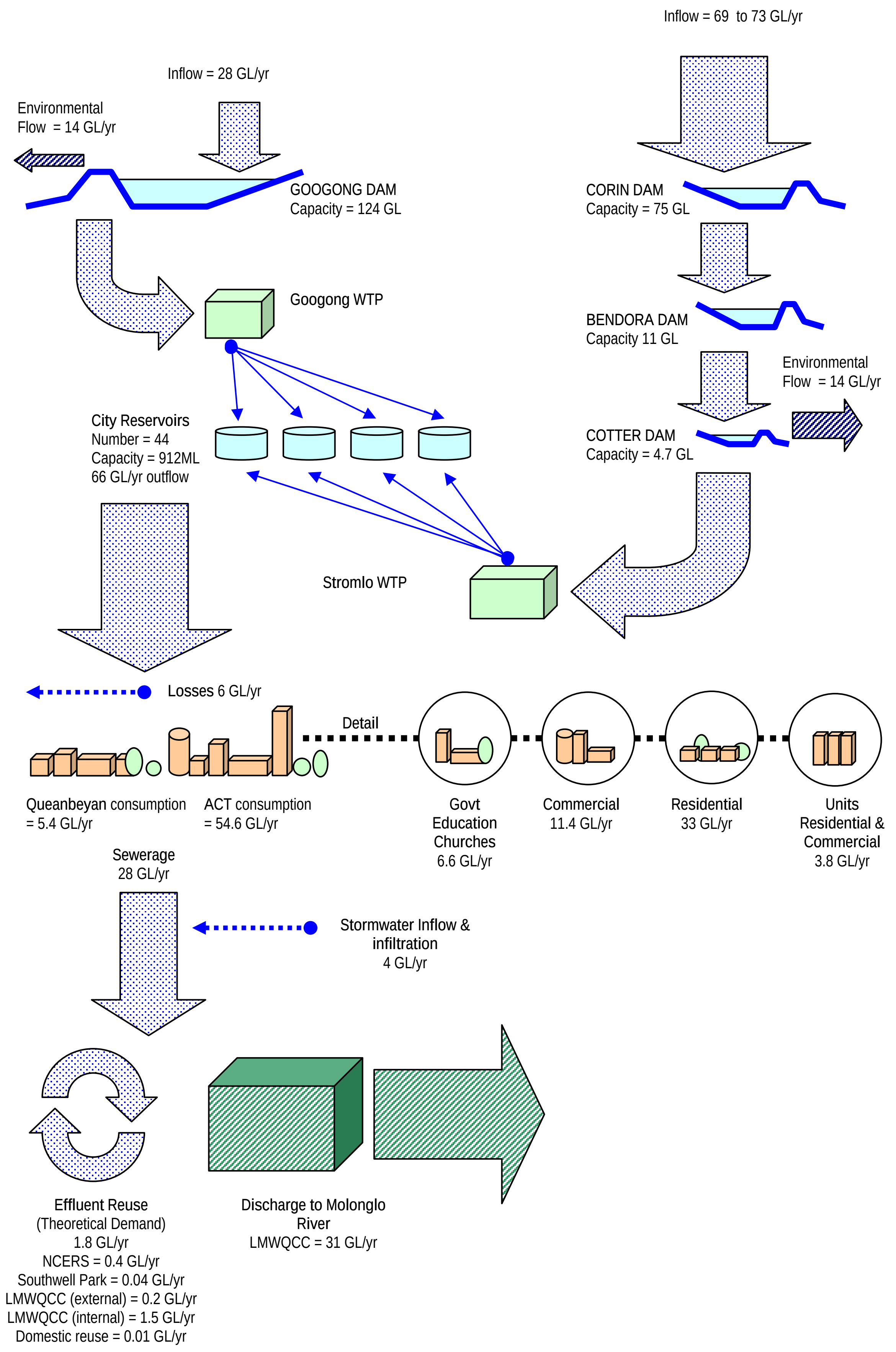


Figure 1.2: The ACT's water cycle (2001-02)

1.3 Think Water, Act Water Context

Following extensive community involvement and input from a range of specialists, the ACT Government released *Think water, act water* on 28 April 2004. This document constitutes the ACT's Water Resources Management Plan, pursuant to the *Water Resources Act 1988*, and replaces a previous version published in August 1999. *Think water, act water* is designed to achieve the following objectives:

- provide a long-term, reliable source of water for the ACT and region;
- increase the efficiency of water usage;
- promote development and implementation of an integrated regional approach to ACT/New South Wales cross-border water supply and management;
- protect the water quality in ACT rivers, lakes and aquifers, so as to maintain and enhance environmental, amenity, recreational and designated use values and to protect the health of people in the ACT and down river;
- facilitate the incorporation of water sensitive urban design principles into urban, commercial and industrial development; and
- promote and provide for community involvement and partnership in the management of the ACT Water Resources Strategy.

Future water management depends on:

- population growth and per capita demand;
- the continuing impact of 2003 bushfire damage;
- possible climate change associated with global warming; and
- 'urban water cycle' management.

Increasing water demand could be satisfied by:

- increasing supplies from existing or proposed reservoirs or other water sources;
- reducing per capita mains water use; or
- a combination of both.

The most cost effective short-term option is to implement water efficiency measures. It is for this reason that the ACT Government has set targets to reduce per capita mains water consumption by 12 per cent by 2013 and 25 per cent by 2023. The cost to the community to reduce water consumption by 25 per cent has been estimated in *Think water, act water* at $300-$400 million, the bulk of it to achieve the last few percentage point reductions. These targets will require:

- water efficiency actions;
- sustainable water recycling;
- enhanced use of stormwater and rainwater; and
- an increase in the re-use of reclaimed water, from the present 5 per cent to 20 per cent.

Even with these efficiencies taken into account, it seems most likely, given current official forecasts of population growth, that a new major water source will be required. This was confirmed with the release in December 2004 of a report by ACTEW Corporation, which concluded that:

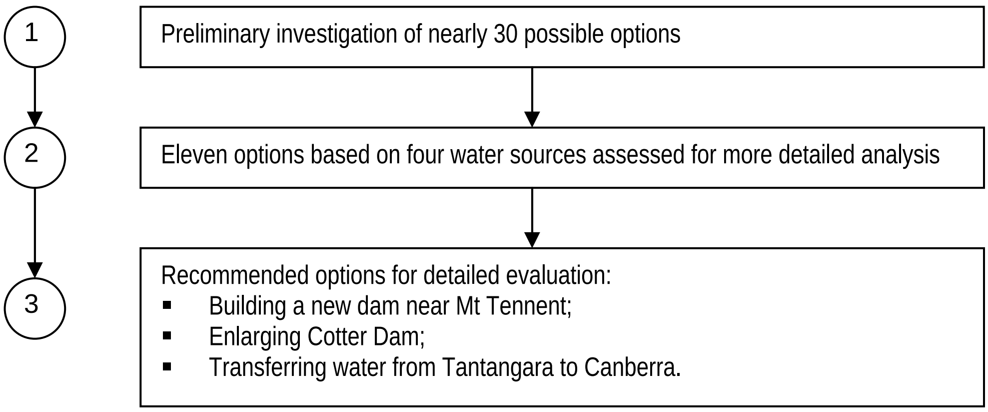
> "*unless the ACT is willing to accept the regular recurrence of water restrictions of a severity and frequency unprecedented in planning elsewhere in Australia, then additional water storage will be needed in the ACT*." [5]

This report, and its companions analysing other future water options for the ACT, take the next step in the *Think water, act water* strategy. Making further use of the Cotter catchment is logical given that it was identified as Canberra's main water supply at the time of Canberra's settlement, is designated as such in the relevant planning documents and legislation, and has a high and reliable rainfall. There are some drawbacks and these are discussed later in this report.

1.4 Study of Future Water Options

The 2004 *Options* report identified new water supply options as well as contingency planning for a continuing drought.[6] It re-assessed previously proposed schemes and developed new options in a three-staged approach depicted in Figure 1.3.

Figure 1.3: Assessing options for the next ACT water source



Following preliminary investigation, eleven alternatives were short-listed covering the three main options of Cotter, Tennent and Tantangara.

Figure 1.4 shows the location of the three main water supply options. The initial conclusions of the *Options* report with respect to each of these options were:

- *"1. Whilst Tennent Dam has a large capital cost, it would provide significant storage and the options of feeding water to either a new water treatment plant at Tuggeranong or to the new Stromlo treatment plant.*
- *2. Enlarging Cotter Dam also has a number of advantages that should be examined in detail. These include that it is an existing dam that would be enlarged, it is in a high rainfall catchment area, and the river is already regulated.*
- *3. The Tantangara option is attractive enough to warrant further investigation. From an engineering perspective the Yaouk Valley pipeline route, discharging into Porcupine Creek, should be examined in more detail. The other three pipeline options could be*

[5] ACTEW Corporation (2004), *An Assessment of the Need to Increase the ACT's Water Storage*, December 2004, p 20.
[6] ActewAGL (2004), *Options for the Next ACT Water Source*, *op cit*.

discarded because of their high operating cost (pumped option) or capital cost (tunnel option), but further examination of the social and environmental factors need to be considered." [7]

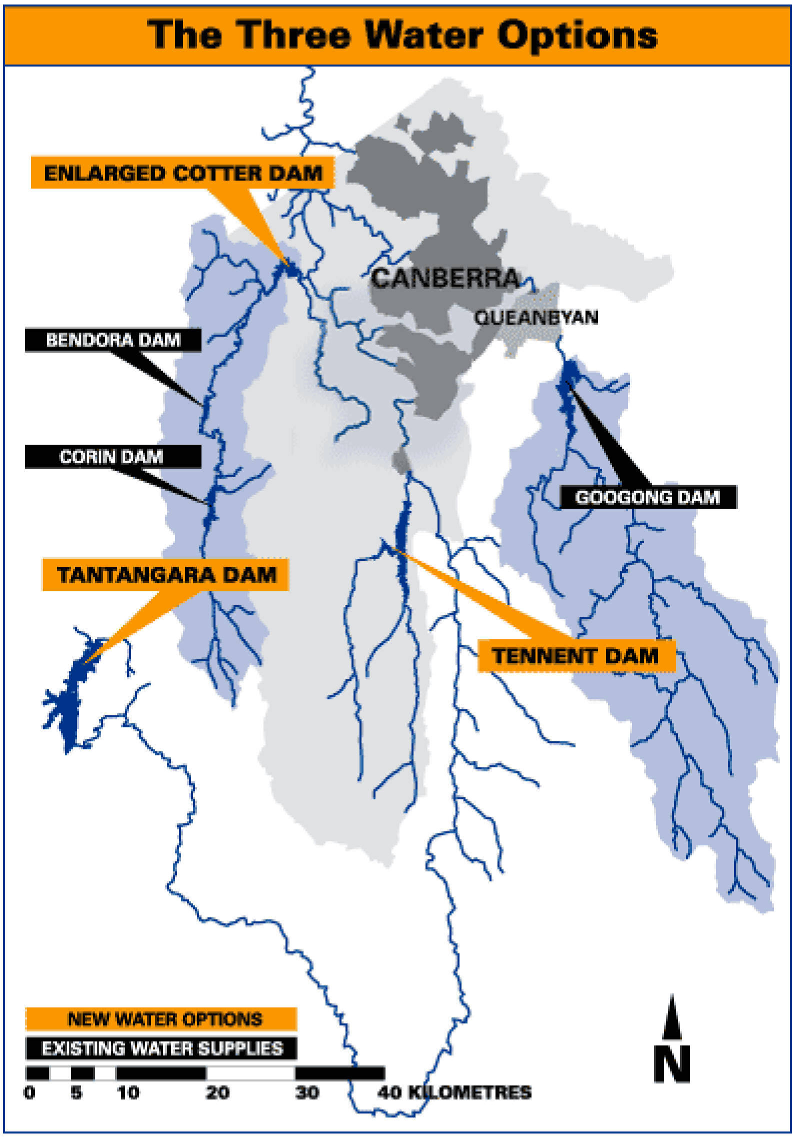


Figure 1.4: Options for the next ACT water source - main supply options

Other water sources assessed, but then discarded (for reasons set out in the *Options* report), include:

- a water farm (advanced effluent treatment);
- cross border supplies (other than Tantangara);
- groundwater;
- stormwater reuse;

[7] *Ibid,* p 27.

- using existing urban lakes to supplement supply;
- enlarging other existing storages in the ACT;
- raising spillways on existing storages thus increasing effective capacity;
- transferring water from existing storages in NSW;
- potential dam sites within the ACT; and
- potential dam sites in NSW near the ACT[8].

As the analysis became more focused and comprehensive, including in terms of the timetable for providing additional water for ACT consumers, additional variants to the initial eleven were assessed. Table 1.1 provides a summary of what at one stage were 25 variants.

Table 1.1: Summary of new water supply options examined

		Option	Alternative	Variant	Features
Cotter	1	Cotter 78 GL			Large new reservoir over existing Cotter Dam. Capacity of 180 ML per day, pumped to Mt Stromlo WTP
	2	Cotter 45 GL			New reservoir over existing Cotter dam. Capacity of 180 ML per day, pumped to Mt Stromlo WTP
	3	Cotter 5 GL			The existing reservoir, with additional capture of Bendora Reservoir environmental flows.
	4	Coree			Large new reservoir at Coree, alternative to new Cotter Dam options
Tennent	5	Tennent 159 GL	Pipe to Mt Stromlo WTP		Large new Tennent Reservoir
	6		WTP at Tennent and pipe to Tuggeranong mains supply		
	7	Tennent 78 GL	Pipe to Mt Stromlo WTP		Medium new Tennent Reservoir
	8		WTP at Tennent and pipe to Tuggeranong mains supply		
	9	Tennent 43 GL	Pipe to Mt Stromlo WTP		Relatively small new Tennent Reservoir
	10		WTP at Tennent and pipe to Tuggeranong mains supply		
	11	Tennent virtual dam	Weir at Angle Crossing	Pipe from Angle Crossing to Burra Creek (thence gravity flow to Googong Reservoir)	Water pumped from Murrumbidgee River weir at Angle Crossing, 60 ML per day. Abstraction rate equal to agreed proportion of Gudgenby River flow (which replaces the water taken from Murrumbidgee River)
	12			Pipe from Angle Crossing to Googong Reservoir	As for 11
	13		Weir at Tharwa	Pipe from Angle Crossing to Burra Creek (thence gravity flow to Googong Reservoir)	As for 11 but weir at Tharwa, pipe to Angle Crossing.
	14			Pipe from Angle Crossing to Googong Reservoir	As for 11 but weir at Tharwa, pipe to Angle Crossing
anga	15	Tantangara 20 km tunnel			Water from Tantangara Reservoir into Murrumbidgee River then through a tunnel into Cotter River above Corin Reservoir.

8 *Ibid,* pp 30-35.

	16	Tantangara 20 km pipeline			Release water from Tantangara Reservoir via pipeline to Cotter River above Corin Reservoir
	17	Tantangara 10 km tunnel plus pipe			Combination of 15 and 16
	18	Tantangara flow down river to ACT	Weir at Angle Crossing	Pipe from Angle Crossing to Burra Creek (thence gravity flow to Googong Reservoir)	Water stored at Tantangara Reservoir, released as required, pumped from Murrumbidgee River to Googong Reservoir
	19			Pipe from Angle Crossing to Googong Reservoir	As for 18
	20		Weir at Tharwa	Pipe from Angle Crossing to Burra Creek (thence gravity flow to Googong Reservoir)	As for 18
	21			Pipe from Angle Crossing to Googong Reservoir	As for 18
	22		Same as drought contingency Scheme	Pump directly from Murrumbidgee River	Pumping from Murrumbidgee River at Cotter pump station to Mt Stromlo WTP (either purchased Murrumbidgee River water or proportion of Gudgenby River flow as per 11)
	23			Construct weir and pump from weir	As for 22
	24	Drought contingency Scheme	Pump directly from Murrumbidgee River using ACT owned water (i.e. not from Tantangara)		Pumping from Murrumbidgee River at Cotter pump station to Mt Stromlo WTP (either purchased Murrumbidgee River water or proportion of Gudgenby River flow as per 11)
	25		Construct weir and pump from weir		As for 24

1.5 Study Procedure

The approach taken to this phase of the future water options study has been to:

- conduct a set of wide-ranging, comprehensive and robust technical studies and consultations into all relevant aspects of each of the options under investigation;
- investigate and report on the need for, and likely timing of, a new ACT water supply – this was ACTEW Corporation's December 2004 report[9];
- prepare a report on each of the three options under investigation, drawing on the results of the technical and consultation work and objectively setting out all aspects of the option; this report is the Cotter option report; and
- prepare a combined report that summarises the costs, benefits and impacts of each option so that they can be compared and contrasted, leading to the selection of the recommended option, or combinations of options.

The technical studies that have provided input to this part of the work include the following reports:

- Fish Impact Study, by Environment ACT;
- Murrumbidgee Transmission Losses Report, by Marsden Jacob Associates;
- Ecological Risk Assessment, by the CRC for Freshwater Ecology;

[9] ACTEW Corporation (2004), *op cit*.

- Aquatic Ecology, by the CRC for Freshwater Ecology;
- Flora and Fauna, by Biosis Research;
- Cultural Heritage, by Navin Officer;
- Land Ownership, by KMR Consulting and Guildin Consultants;
- Catchment and Landscape Analysis, by Ecowise Environmental/Barry Starr;
- Water Quality (six studies), by ActewAGL/Ecowise Environmental;
- Technical Advice on ACT Reservoir Recreational Water Use Options, by ActewAGL and Water Futures;
- Infrastructure Reports, by GHD and SMEC;
- Geotechnical Investigation, by Coffey Geosciences;
- Social Impact Analysis, by Tania Parkes/Ernst and Young;
- Economic Impact, by the Centre for International Economics;
- Hydrology, by ActewAGL;
- Greenhouse Gas Emissions, by ActewAGL;
- Consultation Framework, by Purdon and Associates, Clarity Communications and Swell Design;
- Community Values and Sustainability Assessment, by Consulting Environmental Engineers; and
- Sustainability Assessment, by the Institute of Sustainable Futures/University of Technology, Sydney.

These technical studies are summarised and cited as appropriate throughout this report.

1.6 Contents of Report

The next chapter provides background description of the Cotter catchment, including its past history, the alternatives examined within the overall Cotter option and the basis for preferring the 78 GL Cotter Dam enlargement option.

Chapter 3 contains background material on planning process, both ACT and nationally. Specific legislative instruments are described and their implications in terms of approvals. Canberra's broader planning policies, starting with the approach to sustainability *People, Place, Prosperity* and the *Social Plan, Spatial Plan,* and *Economic White Paper,* are outlined.

Chapter 4 describes aspects of water resource use: historic river flows in the Cotter catchment, how the environmental flow regime operates, water quality, climate change, and water supply outcomes.

Chapter 5 summarises the geotechnical and engineering report. The dam site is described, as is the construction procedure, timelines and operation of the dam.

Chapter 6 contains detailed information on a range of environmental factors including sediment transport, the effect of the dam on the riverine habitat, fish, aquatic ecology, and flora and fauna.

Chapter 7 considers the human environment, covering such aspects as cultural heritage, recreation, public health, energy and greenhouse gas emissions and the effects on leaseholders.

In Chapter 8, the results of a comprehensive economic benefit cost study are reported. The economic framework is described, where the benefits from building a new water storage are measured in terms of willingness to pay – variously by households, businesses and other users – in order to avoid (or lessen the prevalence of) water restrictions.

Chapter 9 presents the results of a technical risk assessment, while Chapter 10 reports the results of a sustainability assessment.

2 Cotter River Alternatives

2.1 Existing Water Storages in Cotter Catchment

The existing Cotter Dam site was the most suitable of six sites on the Cotter River selected by surveyors in 1908 for storing Canberra's water supply. The dam was completed in 1915, when it was designed to serve a population of 25,000; in 1951 the wall was raised by 7.5 m. Cotter provided Canberra's water until 1961 when the Bendora Dam was constructed (Cotter Dam water has not been used for Canberra drinking water since then, apart from a brief period during the 1982 drought). In the 1960s and 1970s, Canberra's population was increasing at an annual rate of 12 per cent and so the Corin and Googong Dams were constructed in quick succession.

Corin Dam, another of the short listed sites from 1908, was selected for construction in late 1963. A feasibility study was completed in January 1964, the decision to construct was made in November 1964, construction commenced in April 1966 and filling commenced in April 1968, five months ahead of schedule.[10] This short lead-time reflected the clear need for enhanced storage facilities at this time.

Details of the three Cotter River water storages are shown in Table 2.1.

Table 2.1: Cotter catchment dams

Dam	Commissioned	Catchment (km^{2})	Capacity (GL)	Mean inflow (GL/yr)	Type	Wall ht (m)
Corin	1968	197	76	76	Rock fill	76
Bendora	1961	91	11	34	Concrete arch	47
Cotter	1915/1951	193	4.7	36	Concrete gravity	31
Total		**482**	**92**	**146**		

Associated with the Cotter Dam is a range of associated works. These include a tunnel under the Murrumbidgee River, a 450 mm diameter main pipeline to the pumping station, the pumping station itself and a 450 mm cast iron main to a reservoir on Mt Stromlo, from where water could gravitate to Canberra's reticulation system.

Following construction of Bendora Dam in 1961, the benefits of having a gravity main to the city (feasible because of Bendora's elevation) became increasingly apparent. The cost of maintaining and operating the Cotter Pumping Station continued to rise, while it struggled to meet peak demands due to Canberra's growing population. Accordingly, a 20 km long, 1500 mm diameter pipeline was constructed and, following commissioning in 1968, resulted in Cotter Dam water and the Cotter Pumping Station being bypassed. The pipeline has a capacity to deliver 320 ML of water to Canberra each day, nearly equivalent to Canberra's mid summer maximum (350 ML) and well above the average daily consumption of around 180 ML.

[10] *Ibid*, pp 1-2.

2.2 Possible Additional Storages

For the purposes of analysis, four alternatives involving the Cotter catchment were initially under consideration. These were:

- retaining the existing Cotter Dam and pumping the water to the Mt Stromlo water treatment plant; this is the baseline Cotter option and may include any changes to environmental flow release requirements from Cotter Dam to allow harvesting of the environmental flows released from Bendora Dam, thus increasing the effective yield from the entire Cotter catchment;
- constructing a new Cotter Dam adjacent to the existing dam to provide a storage volume of 45 GL and pumping water to the Mt Stromlo water treatment plant;
- constructing a new Cotter Dam adjacent to the existing dam to provide a storage volume of 78 GL and pumping water to the Mt Stromlo water treatment plant; and
- retaining existing Cotter Dam, constructing a new Coree Dam (68 GL capacity) on the Cotter River upstream of the existing Cotter Dam, and pumping water from Coree and Cotter Dams to the Mt Stromlo water treatment plant.

The four Cotter alternatives are shown diagrammatically in Figure 2.1.

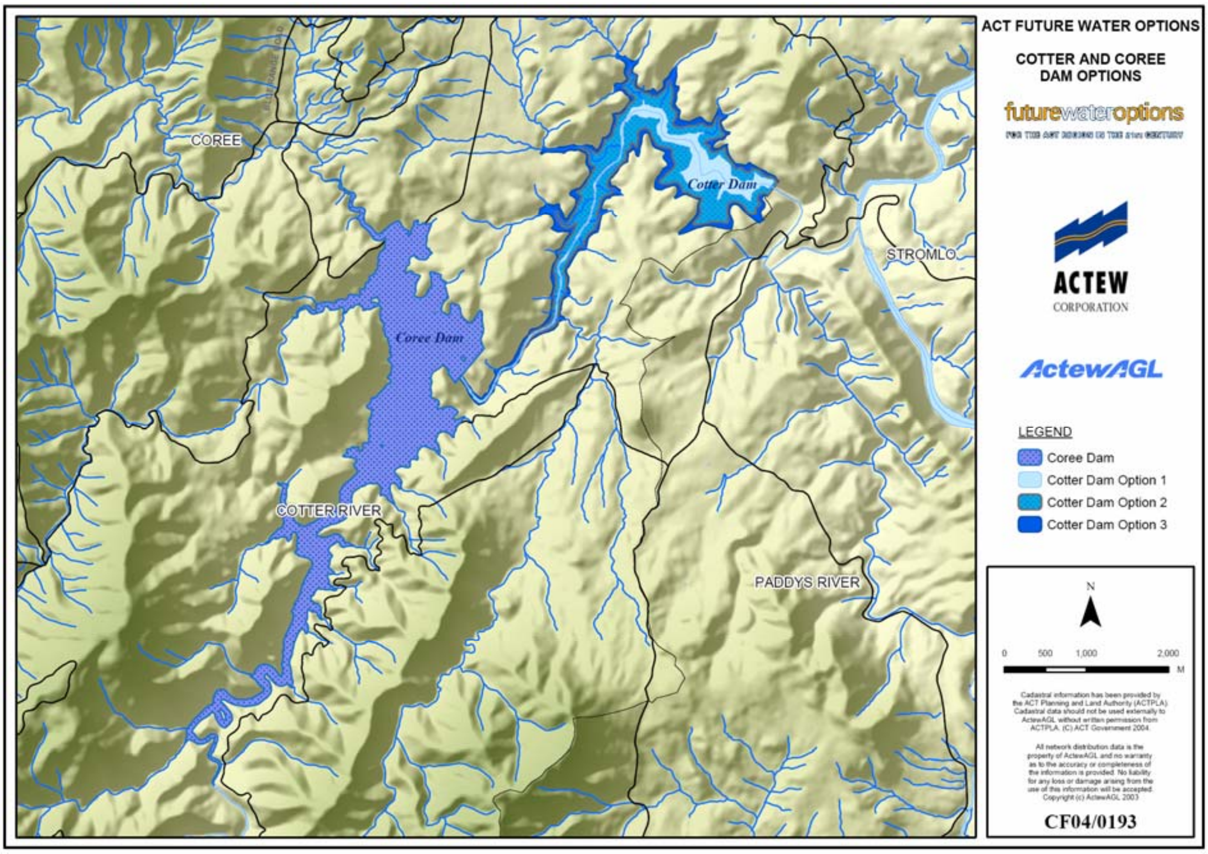


Figure 2.1: Alternatives involving Cotter catchment

2.3 Description and History of the Region

2.3.1 Area and topography

The entire Cotter River catchment is approximately 48,200 ha (or 482 km^2) on the western extremity of the ACT[11]. The Cotter River flows in a northerly direction before joining the Murrumbidgee River, its path largely determined by the Cotter fault, a high angle reverse fault extending for about 40 km. The catchment is bound by the Tidbinbilla range in the east and the Brindabella range in the west. Downstream, the river flows in a "narrow youthful valley with overlapping spurs and deep river sides, whereas upstream from Kangaroo Creek, the valley floor is considerably wider and contains extensive alluvial flats."[12] From the existing Cotter Dam, the catchment extends for about 55 km in a southerly direction and averages about 13 km in width (see Figure 2.2).

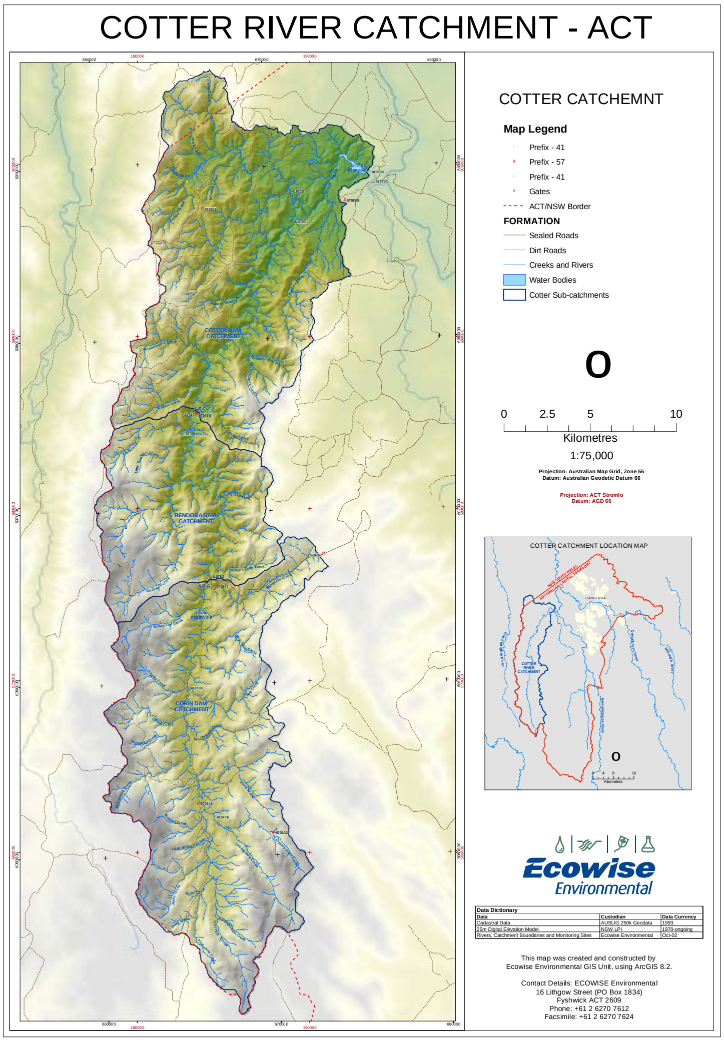


Figure 2.2: Cotter catchment

[11] All but 10 km^2 is within the ACT; the balance is in NSW.
[12] EJ Best (1969), "Geological report on site investigation and construction of Corin Dam," Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, report 1969/111, p 2.

The lowest point of the catchment (where the Cotter River joins the Murrumbidgee River) is 500 m above sea level. It rises to an elevation of about 1900 m at Mt Bimberi. Over half the catchment is located within the Namadgi National Park.

The Cotter River is described as "an upland boulder, cobble, and gravel-bed river, with highly heterogeneous bed topography, including bedrock outcrops".[13] The upper Cotter catchment (above Corin Dam) is rugged and virtually unmodified by human activity. There is some localised soil erosion along tracks and firebreaks. Native fauna is abundant and recreation is limited by the need to protect water quality.

The lower section of the catchment, near Cotter Reservoir, previously contained large areas of pine plantations. The remnants of these plantations have been cleared since the bushfires and a replanting program, involving both pines and native revegetation (especially in more sensitive riparian areas), is underway. The state of the lower Cotter catchment has been subject to detailed assessment and a major remediation program is required. This is discussed in section 4.4 on water quality. The terrain of the lower catchment is hilly with some steep slopes. Sandy topsoils overlay thick clay subsoils, and there is some localised soil erosion from logged areas, tracks and firebreaks.

The catchment comprises sharply dissected terrain with a mixture of sub-alpine, wet and dry schlerophyl forests, perched swamps and valley floor grasslands. Climate and terrain have a dominating influence on the hydrology of the catchment: higher elevations are associated with increased rainfall, wetter forests – except on ridge tops – and lower temperatures. Three major river reaches feed respectively into the Cotter, Bendora and Corin Dams. These reaches are:

- lower northern landscape with extensive undulating terrain surrounded by mountainous ranges to the west;
- a central deeply incised valley system flanked by steep ranges to the east and west; and
- an upper river landscape characterised by a series of alluvial valley flats, surrounded by mountainous ranges.

Away from valley floor systems, the terrain is precipitous with slopes averaging more than 20 degrees.

2.3.2 History and land use

Apart from water supply, other land uses within the catchment over the years have included grazing, forestry, mining and recreational activities.

Pioneer settler Gareth Cotter first introduced cattle grazing into the upper catchment in the 1830s. Clearing of parts of the catchment for pasture development occurred; however, due to the fragile soils, overgrazing and introduced rabbits, major erosion soon followed. There has been virtually no grazing within the total catchment since its acquisition by the Commonwealth.

Prospecting and mining for precious minerals was initiated in the late 1800s via shallow pits and trenches at Mt Blundell. Exploration identified lead and zinc with minor copper deposits. Extraction activities occurred spasmodically until the late 1920s. Quarrying occurred during the construction of the Corin Dam adjacent to the existing dam wall. Minor gravel pits were also created for construction and servicing of the existing roads and tracks.

Softwood pine plantation developments were introduced to the northern parts of the catchment, around Cotter Dam, as a response to soil erosion. The initial plantings occurred during 1926 and planting extended throughout the Uriarra and Pierces Creek areas. Selective hardwood logging of

[13] Ecowise Environmental and Starr (2005), Catchment & Landscape Analysis of the Future Water Options for the ACT, April 2005, ACTEW Corp Doc No. 4656.

Alpine Ash and Brown Barrel in the northern catchment from around Piccadilly Circus to Mt Franklin, above Bendora Dam, occurred in the periods 1930 to 1938 and 1947 to 1967.

Recreation is mostly limited to the lower catchment and along the Brindabella range as far south as Mt Ginini. Recreation activities include pleasure driving, trail bike riding, picnicking, snow sight seeing, skiing, and bushwalking, with much of the upper catchment restricted to walking. Camping occurs to a minor degree, subject to permits being obtained.

The catchment is used extensively for research, including vegetation, fauna, fire ecology, nutrient cycling and hydrological and water quality studies.

The following water uses are permitted:

- head waters to Corin: waters are to be used for scenic values and mountain stream aquatic habitat;
- Corin Dam: waters are to be used for domestic water supply, scenic values and as a mountain reservoir aquatic habitat;
- Corin Dam to Bendora Dam (including reservoir): waters are to be used for domestic water supply, scenic values, as mountain stream and mountain reservoir aquatic habitat;
- Bendora Dam to Cotter Dam: waters are to be used for domestic water supply, scenic values, as mountain reservoir aquatic habitat; and
- Cotter Dam: waters are to be used for domestic water supply, scenic values and mountain reservoir aquatic habitat.

2.4 Refinement of Alternatives

The Coree Dam option was included in the event that engineering and geological studies detected a fatal flaw, preventing enlargement of the Cotter Dam. These possibilities were investigated by GHD as part of a study commissioned by ACTEW Corporation.[14] As GHD explained, "the intent of the fatal flaw analysis is to identify items that may prohibit construction of either dam in terms of geology and reasonable costs."[15]

The analysis involved an evaluation of the geological, geotechnical, hydrological and design options at each dam site, the identification of the potential issues that could develop based on the information available, and an assessment of the possible impact of those issues. A "fatal flaw" would make the dam unconstructable. Lesser problems may allow construction, albeit at a higher cost.

GHD studied a range of prior reports undertaken in relation to the Cotter catchment from the late 1950s to the late 1990s, supplemented with site inspections (but no new drilling or detailed field work). It concluded: "the assessment did not identify any fatal flaws associated with the site. The issues identified relate to geotechnical conditions that may exist and require design solutions that may involve increased construction costs."[16]

Accordingly, the Coree Dam option has not been taken further. As the water options report explained:

[14] GHD (2005), Cotter, Tennent and Coree Options (Engineering) Report, April 2005.
[15] *Ibid,* p 14.
[16] *Ibid,* p 16.

"Coree options are marginally attractive. However, Coree and an enlarged Cotter Dam are mutually exclusive (ie once one is built the other would never be built) as their catchments overlap. Other factors also more strongly favour the Cotter Dam. These include that it has greater catchment and hence more yield, and it has less environmental issues. While Coree had better water quality than lower Cotter prior to the bushfires, this is not such a strong factor now that a larger water treatment plant is being built at Stromlo. On balance, it is hard to see a case for continued examination of the Coree site."[17]

In regard to the Cotter Dam, the GHD report observed that:

"(a)lthough the site already hosts a concrete gravity dam, detailed geological and geotechnical investigations will be required to fully understand the geological structure of the proposed 'new' embankment area downstream of the existing dam. There is sufficient structure identifiable in the existing outcrop to warrant a detailed geological and geotechnical study prior to selection of this site for construction of a new dam."[18]

As to the other alternatives, the existing Cotter Dam has recently been brought back into service now that the upgraded Mt Stromlo Water Treatment Plant enables treatment of its water. This contributes up to 50 ML per day and Cotter is once again a permanent component of the ACT's water supply system.

In addition, an opportunity exists to increase available supply using the existing infrastructure by capturing "surplus" water from the Cotter catchment and diverting it to Googong Reservoir. This is referred to as the Stromlo to Googong Reticulation Transfer. There are significant spills from the Bendora and Cotter Reservoirs each year, even during the drought year of 2004. The option involves capturing a proportion of these spills from Bendora Reservoir, via the gravity main to Mt Stromlo treatment plant, supplemented with water from the Cotter Reservoir and also from the Murrumbidgee River (when available). It is being pursued by ACTEW separately to the analysis described in this report.

The 45 GL Cotter Dam enlargement alternative rated poorly on a cost per GL stored basis. It is also deficient from a native fish perspective in that fish passage difficulties at the upstream limit of the impounded waters (not a problem with the 78 GL option), would potentially threaten the existing Macquarie Perch population (see section 6.4). For these reasons, the 45 GL option has not been further assessed.

Most of the remainder of this report focuses on the 78 GL enlargement option.

[17] ActewAGL (2004), *Options for the Next ACT Water Source*, *op cit*, p 26.
[18] GHD (2005), *op cit,* Appendix "Report on Geological Inspections for Cotter, Tennent and Coree Sites,"

3 Planning Requirements and Approvals Processes

3.1 Statutory Planning and Legislation

The statutory framework within which a future water option must be planned and implemented involves a complex array of legislation of the Commonwealth, NSW, and ACT Governments. Implementation of a preferred option will also be informed and influenced by:

- water resource management policies;
- sustainability strategies, including greenhouse abatement;
- economic, social and spatial dimensions of regional development strategies; and
- environment, land management and development control policies and regimes established to control land use, and manage environmental impacts and water quality.

The responsibilities of the various tiers of government and intergovernmental agreement obligations further delineate the framework within which the *Future Water Options* study has developed. The simultaneous involvement and interaction of Commonwealth, NSW and ACT legislation (especially for the Tennent and Tantangara options) increases the complexity of the planning, investigation, assessment, review and approval process.

Indeed, given the interest of Queanbeyan in future water option decisions, and the fact that pipelines may traverse land in NSW (whether from Tantangara or to Googong), it is logical that relevant local government bodies (such as the Queanbeyan City Council) be consulted at the appropriate stages. This is so even if a pipeline proposal were to be declared a “project of state significance”, putting the formal development approval process in state rather than local government hands. Of the three options under consideration, the Cotter Dam enlargement would be least likely to involve local government, as there would be no pipeline proposal in NSW.

The main pieces of legislation that impact on a future water option are briefly described in this section, with Table 3.1 summarising the main legislative instruments that must be considered in the context of Cotter Dam enlargement.

3.2 Commonwealth Legislation and Policy

3.2.1 Water

Canberra’s national capital function is supported by Commonwealth legislation, which (among other things) establishes arrangements to secure long-term water supplies.[19] As noted in section 1.2, the legislation creating the ACT provides control over water resources totaling 494 GL in an average rainfall year (from ACT rivers and streams, exclusive of the Murrumbidgee River, plus the Queanbeyan and Molonglo Rivers).

National objectives for improving natural resource management, water distribution, asset management and financial arrangements for the Murray-Darling Basin were agreed in 1992, and ratified by the *Murray-Darling Basin Act 1993;* subsequent reforms and agreements set parameters that impact on ACT water planning.

[19] *Commonwealth Seat of Government Acceptance Act 1909* established paramount water right of the Commonwealth for the purposes of the ACT. NSW retains rights to the reasonable use of the Murrumbidgee River for conservation or irrigation. The *ACT Self Government (Consequential Provisions) Act 1988* transferred water functions to the ACT.

Table 3.1: Legislative instruments relevant to enlargement of Cotter Dam[20]

X – Potentially Relevant **XX** – Definitely Relevant	Cotter Dam	Comment
Commonwealth		
ACT Self-Government (Consequential Provisions) Act 1988	**XX**	Water rights devolved to ACT Government from the Commonwealth
Murray-Darling Basin Act 1993	**XX**	Improves natural resource management and water distribution; caps on diversions; National Water Initiative
ACT (Planning and Land Management) Act 1988	**XX**	Establishes National Capital Plan ensuring ACT water supplies are directed to ACT needs; protects catchments
Environment Protection and Biodiversity Conservation Act 1999	**XX**	Provides for management of conservation issues of national significance
Australian Heritage Commission Act 1975/ Heritage Council Act 2003	**XX**	Provides management of heritage issues of national significance via the Register of the National Estate; includes existing Cotter Dam
ACT		
Land (Planning and Environment) Act 1991	**XX**	Establishes Territory Plan and provides mechanisms for development and environmental assessments
Nature Conservation Act 1980	**XX**	Provides mechanisms and controls for nature conservation including threatened/endangered species action plans; specifies role of the Conservator of wildlife; prohibits construction in certain areas
Environment Protection Act 1997	**XX**	Provides mechanisms for pollution control, including during construction
Water Resources Act 1998	**XX**	Provides water management in the ACT including environmental flows and the preparation of a Water Management Strategy
Planning and Land Act 2002	**X**	Planning Advisory Council advises Planning and land Authority and Minister for Planning on Territory Plan variations and major projects
Lands Acquisition Act 1994	**X**	Enables compulsory acquisition of land needed for public purposes
Heritage Act 2004	**XX**	Empowers Heritage Council to assess impact of proposals and advise Planning and Land Authority

The ACT formalised its participation in the Murray-Darling Basin initiative in 1998, committing to a cap on diversions. In consultation with other members of the Murray-Darling Basin Commission, the ACT is in the process of quantifying the appropriate cap. The ACT Government has said it will complete a Memorandum of Understanding with the NSW and Commonwealth Governments by the end of 2005 that will include provision for a water cap.

A Murray-Darling Basin Water Agreement in 2003 incorporated a five-year strategy for the implementation of water recovery measures, with 500 GL to be set-aside for environmental purposes across the Basin. The ACT will contribute $5 million to increase water recovery by 2 GL per annum as part of this agreement.

The Council of Australian Governments (COAG) agreed in June 2004 to a National Water Initiative to achieve environmental outcomes, involving:

- expansion of permanent trading in water entitlements;

[20] Adapted from McCann Property and Planning Pty Ltd and ACTEW (2004), *New Water Source for the ACT, Planning and Development Controls*, June 2004.

- improved water management arrangements;
- more sophisticated, transparent and comprehensive water planning;
- a commitment to address over allocated systems; and
- better and more efficient management of water in urban environments. [21]

The National Water Commission has recently been established, together with an Australian Water Fund.[22] The $2 billion fund will assist projects that improve river flows, encourage on-farm water use efficiency measures, recycle and reuse storm water and grey water, provide more efficient storage facilities (such as underground aquifers), and other initiatives.

Particular implications of Commonwealth water legislation and policy initiatives for Cotter Dam enlargement option are:

- the concurrence of the Murray-Darling Basin Commission may be required for any major additional diversion of water, or establishment of additional storage capacity; and
- the Commonwealth has set a pre-condition – the development of an integrated water supply strategy for the region – before any expansion of regional water supply beyond the ACT and Queanbeyan will be approved. The ACT has established outcomes that it will seek within an integrated regional water supply strategy.[23]

3.2.2 Planning

Whilst the ACT, in accordance with the *Land (Planning and Environment) Act*, would grant approval for Cotter Dam works, the National Capital Plan controls the management and future development of land in the ACT. [24] The Territory Plan, which is given effect by the *Land (Planning and Environment) Act*, must be consistent with the National Capital Plan.

The Cotter catchment forms part of the Mountains and Bushland land use category in the National Capital Plan. This area is to be "maintained as an important visual background to the National Capital; to protect both its nature conservation values and Canberra's existing and future water supply."[25] Supporting policies include:

- "the Cotter catchment should be managed to protect the water supply to the National Capital in a manner consistent with its nature conservation values; the quality of water supply is to be assured primarily by controls over catchment uses;
- the North Cotter area should be planned and managed in a manner consistent with Namadgi National Park in terms of protection for nature conservation and water supply requirements, with the additional potential of use for low to medium density recreation particularly in the pine plantations and adjacent Uriarra rural area; and
- native vegetation in pine plantations should be retained particularly along plantation edges, public roads and rivers and creeks to preserve wildlife corridors and habitats."[26]

In addition, Appendix G of the National Capital Plan, states, in respect of the Cotter catchment:

[21] See http://www.pmc.gov.au/nwi/index.cfm
[22] See http://www.aph.gov.au/library/pubs/bd/2004-05/05bd072.htm
[23] ACT Government (2004), *Think water, act water*, Vol 1, *op cit,* p 38.
[24] *Australian Capital Territory (Planning and Land Management) Act 1988* established the National Capital Authority and National Capital Plan, which set out special requirements for development in selected areas.
[25] National Capital Authority (2002), *Consolidated National Capital Plan, including amendments*, February 2002, p 118, available at http://downloads.nationalcapital.gov.au/plan/ncp/feb2002_ncp.pdf
[26] *Ibid.*

> *"the protection of the Cotter catchment so as to maintain a water supply yield in terms of quality, quantity and reliability to Canberra, requires controls on land uses and appropriate management practices. The lower catchment exhibits run-off having turbidity and bacteriological concentrations such that water treatment is required prior to the delivery of water to the distribution system. The efficiency of the treatment process will be dependent on limitations on turbidity, iron and nutrient levels in the raw water. A restricted access policy is essential when the reservoir is in use, including for a short period prior to use."*[27]

And:

> *"Use of the reservoir to be reserved for Canberra water supply specifically as a secondary storage for use either in the event of a failure of the Bendora or Googong systems or to augment the primary water supply during periods of peak demand. Access to the dam would be permitted for sightseeing purposes. When water is not being drawn from the reservoir, access for fishing and manually and electrically powered boats may be considered subject to the maintenance of water quality and protection of the environment. Swimming and other body contact activities not to be permitted."*[28]

The existing Cotter Dam and any future Cotter Dam enlargement are located within the Murrumbidgee River Corridor. Appendix F of the National Capital Plan, which deals with the Murrumbidgee River Corridor, states that recreation is the key land use of the corridor, with the key water use in low intensity areas being preservation of aquatic habitat. Appendix E (Water Quality Policies) lists a number of approved water use designations, but power generation, for example, from a mini hydro scheme, is not one of these. This has implications for any future mini hydro scheme and is discussed later in this report.

3.2.3 Environment

Under the provisions of the *Environment Protection and Biodiversity Conservation Act*, actions that are likely to have a *significant impact* on a matter of national environmental significance are subject to a rigorous assessment and approval process. An "action" includes a project, development, undertaking, activity, or series of activities.

The Act identifies seven matters of national environmental significance, one of which is nationally listed threatened species and ecological communities. As discussed in section 6.5 below, two of the fish species present in the Cotter catchment are listed as nationally threatened (Macquarie Perch and Trout Cod) and so the provisions of the *Environment Protection and Biodiversity Conservation Act* are expected to apply.

An action will require approval from the Commonwealth Environment Minister if it has, will have, or is likely to have, a significant impact on a species listed in any of the following categories:

- extinct in the wild;
- critically endangered;
- endangered; or
- vulnerable.

Administrative guidelines for determining whether or not an action will fall into the *Environment Protection and Biodiversity Conservation Act* net can be used to assess what is a "significant

[27] *Ibid,* Appendix G, p 97.
[28] *Ibid,* Appendix G, p 103.

impact".[29] The guidelines outline criteria affecting significant impacts on critically endangered and endangered species if the proposed action will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species´ habitat[30]; or
- interfere with the recovery of the species.

It would be expected that the Cotter Dam option, if proposed for implementation, would be formally reviewed under the provisions of the Act.

3.2.4 Heritage

The *Australian Heritage Council Act 2003* has replaced the *Australian Heritage Commission Act 1975*, although final administrative arrangements have not been completed.

As discussed in section 7.1 below, the existing Cotter Dam, the Cotter Pumping Station, the Upper Cotter catchment, the Murrumbidgee River corridor and the Murrumbidgee River itself are all listed in the Register of the National Estate pursuant to this legislation. Such places or sites cannot be damaged unless there are no feasible or prudent alternatives and Australian Heritage Council advice must be sought before any action that might affect such areas is taken. Cotter Dam enlargement, especially the inevitable inundation of the existing Cotter Dam, would require clearance under this legislation prior to proceeding.

3.3 NSW Legislation and Policy

Because the Cotter catchment is entirely within the ACT (with the minor exception of 10 km^2 as noted earlier) and because there are no proposed weirs or pipelines extending across the border, NSW legislation does not impact on the Cotter Dam enlargement option as it does with the other two options. Indeed, this is one of the advantages enjoyed by the Cotter Dam enlargement option. However, for the sake of completeness and consistency with the companion reports, the main features of relevant NSW legislation are briefly noted here.

The *Environmental Planning and Assessment Act 1979* establishes the development assessment system for NSW. Any major water infrastructure project may be a designated development or an integrated development requiring approval under multiple enactments. Options that impact on the environment in both NSW and the ACT may have to proceed in an integrated and concurrent manner under a formal NSW/ACT agreement covering integrated environmental assessment.

[29] See http://www.deh.gov.au/epbc/assessmentsapprovals/guidelines/administrative/index.html#threatened

[30] Introducing an invasive species into a habitat may result in that species becoming established. An invasive species may harm a critically endangered or endangered species by direct competition, modification of habitat, or predation.

The *Environment Operations Act 1997* allocates responsibilities between the Environment Protection Authority (part of the Department of Environment and Conservation), local councils and other public authorities, authorises protection of the environment policies, and establishes licences for activities that may impact on the environment.

A development application cannot be made on land within a wilderness area unless consent to the development has been obtained under the *Wilderness Act 1987*. The *National Parks and Wildlife Act 1974* defines responsibilities and management arrangements.

The *Fisheries Management Act 1994* requires fish passage arrangements for a dam, weir or reservoir constructed on a waterway. The *Water Act 1912* provides for the granting of water licences and allocations and the subsequent transfer or sale of allocations.

NSW and the ACT have a shared interest in management of the resources of the Murrumbidgee River since it underpins regional economic development. The development of a regional integrated water supply strategy and a cap on ACT diversions will require inter-governmental agreement.

3.4 ACT Legislation and Policy Framework

The *Water Resources Act 1998* vests to the ACT under Section 13, the right to the use, flow and control of all water of the ACT, and allows:

- the preparation of environmental flow guidelines to maintain aquatic ecosystems (s5)[31];
- subordinate law in the form of the Water Resources Management Plan[32] to describe the water resources of the ACT, including the flows required for environmental needs and other water allocations, such as urban water supply;
- the creation and transfer of water allocations (Part 6), licensing water use (Part 7), and permits to construct water control structures (s69); and
- a fee (currently $492.90 per ML) to be paid for additional water allocations.

Any of the future water supply options that sourced water within the ACT or ACT controlled catchments would be subject to these provisions.

As discussed in section 4.2 below, the *Environmental Flow Guidelines* set out a methodology for the calculation of environmental flows to be used to support the *Water Resources Act* and the Territory Plan, and as the basis of the *Water Resource Management Plan* for the ACT. The Act requires that environmental flows must be provided for, before any other use.

The *Water Resource Management Plan* determines the allocations available on a sub-catchment basis, taking into account climate, environmental values, land use, stream flow and environmental flow considerations. ACTEW Corporation has a rolling average annual allocation of 62.7 GL limited to the Cotter and Queanbeyan River catchments, and a licence which authorises abstractions.[33] Implementation of the preferred option will require adjustments to the management plan, and amendment of allocations and licence conditions.[34]

The *Land (Planning and Environment) Act 1991* (the Land Act) sets a framework for the assessment and approval (or refusal) of development proposals, including infrastructure projects. It includes a number of components:

[31] Environment ACT (1999), *Environmental Flow Guidelines*, 27 May 1999.
[32] ACT Government (2004), *Think water, act water*, *op cit,* is the Water Resource Management Plan presented to the ACT Legislative Assembly, and now a Disallowable Instrument.
[33] Water use in 2003-04 was 54.4 GL.
[34] Allocations and licences are sub-catchment specific and require detailed analysis.

- establishes the Territory Plan that in turn determines permissible land uses for land in the ACT (excluding designated land covered by the National Capital Plan) and processes for variations to the Plan;
- specifies procedures for development application approvals, review of decisions, and consultation requirements;
- provides for referrals to the Heritage Council on matters of heritage significance;
- establishes procedures and requirements for environmental assessments and inquiries; and
- establishes procedures for land administration, including leasing and land management.

The future water supply options would fall within the definition of a "major utility installation" in the Territory Plan. "Major utility installation" is permissible within the "mountains and bushland", "river corridor" and "plantation forestry" land use policy areas of the Territory Plan, and consequently implementation would not require a variation to the Territory Plan.

Appendix 1 of the Territory Plan sets out "water use and catchment policies" that define permitted uses of water within catchment areas. The permitted uses in the Cotter catchment include use of the water for water supply purposes. An enlarged dam is, of course, compatible with this. It also appears that the generation of hydropower would be permitted under the Territory Plan, although, as noted earlier (section 3.2.2), the position is less clear-cut under the National Capital Plan. The latter takes precedence over the former if there is a difference and, in view of the ambiguity, further investigation will be required should the Cotter option proceed.

Environmental assessment is subject to part 4 of the Land Act. A Development Application will be required for the preferred option, which will trigger a mandatory Preliminary Assessment and probably lead to a requirement to prepare a full Public Environment Report or Environmental Impact Statement, including a formal inquiry. To date, the administration of this part of the Land Act has been such that, even for major proposals, only a Preliminary Assessment (albeit sometimes a substantial piece of work) has been required. More recent practice has been to proceed to the further levels of assessment for significant projects. This means that while a future water option would probably be subjected to either an Environmental Impact Statement or a Public Environment Report, this report (or its companions examining the Tennent and Tantangara options) will serve as an appropriate document for a Preliminary Assessment. This is a practical approach that will save both time and money, without any diminution in the rigour of the assessment and approvals process.

The *Planning and Land Act 2002* sits beside the *Land (Planning and Environment) Act*. Referral of Territory Plan Variations and major development proposals (such as dams or pipelines) to the Planning and Land Council is mandated by regulations under this Act. The Planning and Land Council provides advice to the Planning and Land Authority and the Planning Minister on major planning matters.

The *Heritage Act 2004*:

- establishes a register for the recognition and conservation of natural and cultural heritage places and objects, including Aboriginal places and objects;
- establishes the Heritage Council;
- provides for heritage agreements to encourage the conservation of heritage places and objects;

- establishes enforcement and offence provisions to provide greater protection for heritage places and objects; and
- provides a system integrated with land planning and development to consider development applications having regard to the heritage significance of places and heritage guidelines.

The Planning and Land Authority must give the Heritage Council a copy of any development application that relates to a place or object registered, or nominated for provisional registration, under this Act. New water supply options would require such a referral.

The Council provides advice to the Planning and Land Authority about the effect of development on heritage issues. The Authority must consider its advice.

It is therefore likely that, in respect of the Cotter Dam enlargement option at least, simultaneous and somewhat overlapping review of the heritage implications will occur pursuant to both Commonwealth and ACT legislation.

The *Nature Conservation Act 1980* provides for the protection and conservation of native animals and plants and for the reservation of areas for these purposes, and for special protection status. Declaration of a threatened fish or invertebrate under the Act confers on it the status of "animal", meaning that the provisions of the Act also apply. The two fish species listed as endangered under the *Nature Conservation Act* (Macquarie Perch and Trout Cod – see section 6.5) are automatically given special protection status, the highest level of statutory protection that can be conferred.

Under the legislation, any action affecting an endangered species is subject to special scrutiny. Conservation requirements are a paramount consideration and only activities relevant to conservation of the species or serving a special purpose are permissible. The Conservator of Flora and Fauna may only grant a licence for activities affecting a species with special protection status where satisfied that the act specified in the licence meets a range of stringent conditions.

It is also an offence under the Act to disturb or destroy a nest of an animal, which would extend to the destruction of spawning sites of threatened fish. The Act provides for the preparation of Action Plans for the conservation of threatened or endangered species or ecological communities.

There are prohibitions on the Conservator approving certain work in wilderness areas, including Namadgi National Park. *Plans of Management* are developed for public land by the Conservator, approved by the Minister and presented as disallowable instruments to the ACT Legislative Assembly. Any of the future water options will require referral to the Conservator.

The *Environment Protection Act 1997* specifies environmental management and pollution control measures that will impact on detailed design and management, particularly during the construction phase of a major infrastructure project.

The *Lands Acquisition Act 1994* provides for the compulsory resumption of land for "public purposes".

The *Independent Competition and Regulatory Commission* is a statutory body set up to regulate prices, access to infrastructure services and other matters in relation to regulated industries. The Commission will have a role in examining pricing changes generated by increased costs to ACTEW Corporation through the financing of infrastructure required for a preferred water option.

3.5 ACT Planning Policies

The ACT Government has adopted an overarching policy on sustainability, *People, Place, Prosperity.*[35] The policy is discussed in Chapter 10.

Establishing the core values of the Canberra community has been integral to decision-making over the years on Canberra's future direction. These core values have guided the development and coherence of successive iterations of the *Canberra Plan* and its components, the *Social Plan*, *Spatial Plan* and *Economic White Paper*.[36] The community also had the opportunity in 2003 to express its views about non-urban values, issues and aspirations through consultation afforded as part of the major post bushfire report, *Shaping Our Territory: Opportunities for Non-Urban ACT*.[37]

Tania Parkes Consulting and Ernst and Young reviewed the social impact of water supply planning and proposals for securing a new water source, for the Future Water Options Project Team.[38] Their report noted that the expression "the Canberra community" extends well beyond the borders of Canberra and the ACT, and beyond its population, because of Canberra's national capital status. It is in this context that the National Capital Authority has the role of fostering the national capital interests of the city.

For example, the Authority considers there is a risk to the heritage landscape within the Parliamentary Triangle as a result of both current and potentially escalated water restrictions. It has advised that many of the trees in the heritage landscape are particularly sensitive to longer-term irrigation reduction.[39]

Another important observation of the social impact study was that:

> *"the greatest damage to the ACT, and especially those at lower income levels, will occur where water supply levels and uncertainty inhibit future population growth … and employment opportunities. High cost government measures such as extensive reticulation of recycled water, high cost regulatory design measures and subsidies for high cost items such as rainwater tanks, are also likely to have regressive impacts on the community (with) least benefit to those on lower incomes and through reducing government financial capacity for providing essential, affordable services."*[40]

The *Economic White Paper*, *Social Plan*, and *Spatial Plan* recognise that Canberra's water resources are integral to supporting the community's goals for sustainability:

- there is an understanding within the *Economic White Paper* of the importance of water for regional economic development;
- there are commitments in the *Social Plan* to ensure that a reliable source of high quality water is maintained; and
- there is recognition in the *Spatial Plan* of water resources management as a key sustainability issue, including a metropolitan urban form that protects existing and future potable water catchment areas and riparian zones and committing the ACT to working

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[35] ACT Government (2003), *People, Place, Prosperity: a policy for sustainability in the ACT,* March 2003.
[36] ACT Government (2003), *The Economic White Paper for the ACT,* December 2003; ACT Government (2004), *Building Our Community: the Canberra Social Plan,* February 2004; ACT Government (2004), *The Canberra Spatial Plan,* March 2004.
[37] Non-Urban Study Steering Committee (2003), *Shaping Our Territory: Final Report: Opportunities for Non-Urban ACT,* November 2003.
[38] Tania Parkes Consulting and Ernst & Young (2005), Stage 1 Social Impact Appraisal, An overview of the social impact of the Future Water Options Project, April 2005, ACTEW Corp Doc No. 4657.
[39] *Ibid.*
[40] *Ibid,* p ix.

with the NSW Government and local councils to ensure coordinated land uses which encourage sustainable development and catchment protection.

Reliability, availability and quality of supply, along with economy in use and environmental responsibility, are thus core water-related community values. They do not suggest that water use minimisation is an overriding goal to the point where it would inhibit natural population growth of Canberra and its region. Neither do they restrict opportunities for livelihood and diversity of activity and participation that underpin the achievement of a fair and equitable society.

As part of the future water options research, four community values meetings were held in late 2004. Each meeting consisted of 15-20 people, with participants having responded to advertisements and registered their interest.[41] The discussions focused on five questions:

- how concerned is the Canberra community about water restrictions?;
- should any additional funds being spent improving the ACT's water supply security focus on reducing demand, increasing supply or a combination of both?;
- what issues are important in comparing the Cotter and Tennent water storage options?;
- what issues are important in considering the Tantangara water transfer options?; and
- how does the community feel about buying and selling (trading) the ACT's water allocation?

While the answers to these questions were varied, and while there is no guarantee that the participants were fully representative of the whole community, the following were the main outcomes:

- 72 per cent were willing to pay more for water per household to reduce restrictions, with similar proportions selecting $40, $80 and $150 additional per year, while 28 per cent considered stage 3 restrictions were not a concern or that they were willing to accept restrictions one year in six;
- two-thirds of participants preferred to spend the additional funds on reducing water demand, and one-third on increasing supply; comments were quite varied, for example, some welcoming increased recycling of grey water on parks and nature strips, other expressing concern about potential public health risks associated with it;
- the most important sustainability criteria in comparing various options were seen to be: protection of public health; maintaining a reliable water supply; and effects on the aquatic environment;
- the least important were recreation uses; national capital lawns, areas near Lake Burley Griffin, and buildings; and impacts during construction; and
- only 33 per cent were in favour of the ACT purchasing water from NSW, but 66 per cent supported selling part of what was seen as surplus ACT water to NSW; there were concerns raised about the perceived risk if the ACT had to purchase water from interstate.

3.6 Land Use in the Cotter Catchment

The Commonwealth compulsorily acquired all remaining freehold land in the ACT in the early 1970s. Rights to use and occupy land are granted under a leasehold system. Under the provisions of the

[41] The results are described ACTEW (2005), Consultation Report, A report on the consultation process undertaken as part of the Future Water Options Project, April 2005, ACTEW Corp Doc No. 4668 and 4669.

Australian Capital Territory (Planning and Land Management) Act 1989 (Commonwealth), management of the leasehold estate is vested in the ACT Government.

Leasehold tenure was adopted so that speculation in undeveloped land could be avoided, and future increases in the value of land remain in the public purse. The leasehold system also has planning advantages in that the ACT Government, being responsible for development decisions, can ensure that planning and development policies are implemented in an orderly and efficient manner.

As far as Cotter Dam enlargement and the Cotter catchment are concerned (unlike Tennent for example), there are no privately held leases that would require negotiations/surrendering. All the land that would be inundated by the Cotter Dam enlargement, or covered by a foreshore buffer, is unleased Territory land. According to the Catchment and Landscape report, "an expansion of the Cotter Dam will not change any of the policies that are currently applicable to the existing dam catchment"[42], meaning that no variation to the Territory Plan would be required. However, as shown in , there are four existing land use types defined in the Territory Plan relevant to Cotter Dam enlargement:

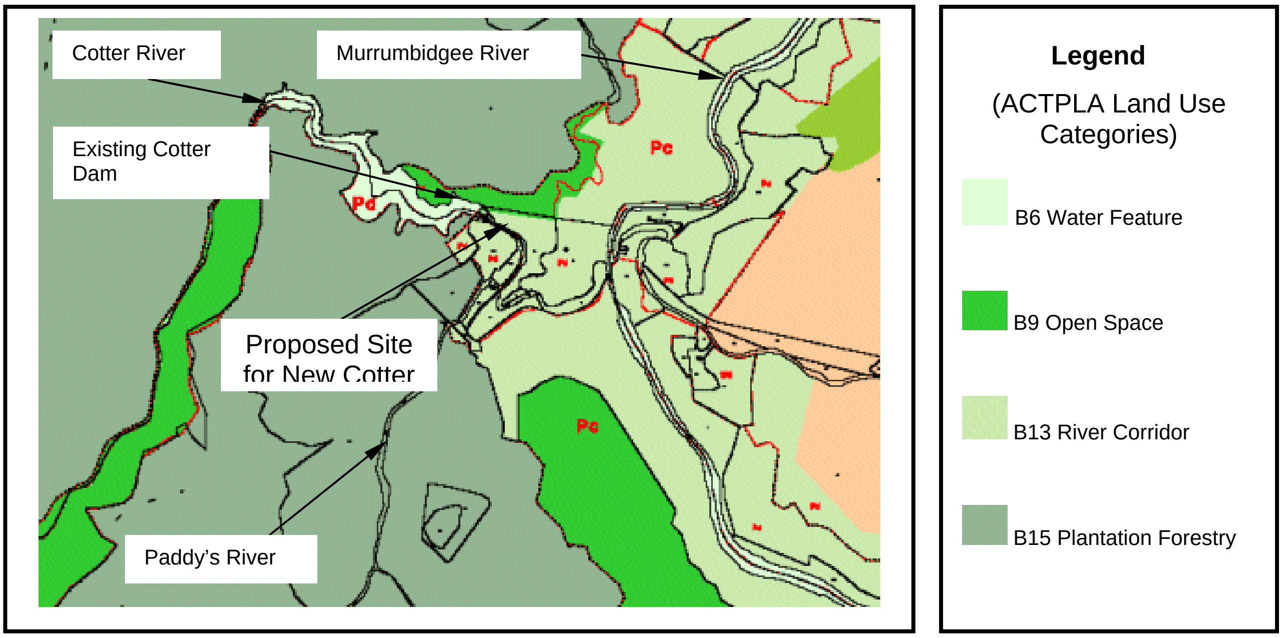

Figure 3.1: Existing Territory Plan land uses for Cotter Dam enlargement area

Source: ACT Planning and Land Authority, *Territory Plan.*[43]

- **water feature**: the area of the existing Cotter Reservoir; according to the Territory Plan, it is inappropriate to allow intensive recreational activities in waterways that form part of Canberra's domestic water supply;
- **plantation forestry**: most of the area behind the existing reservoir; the intention is "to maintain a balance between the various uses to ensure a viable commercial enterprise while also protecting both soil and water quality and quantity, providing recreational opportunities and enhancing the landscape"; an approved land use for plantation forestry land includes "major utility installation"; this would cover Cotter Dam enlargement;
- **mountains and bushlands**: portions of land immediately north of the lower part of the existing reservoir, and upstream of it; the land is intended to be "used primarily for

[42] Ecowise Environmental and Barry Starr Pty Ltd (2005), *Op cit,* p 8.
[43] See www.actpla.act.gov.au/tplan/gridmaps/f188591.htm

nature conservation and as a water supply catchment area, for recreation purposes, scientific study and education whilst ensuring that water quality and the natural environment are preserved"; this category includes "major utility installation" as an approved use, so no change to the Territory Plan would be required; and

- **river corridors**: land between the existing and the new dam; river corridors "provide diverse ecological, scenic, cultural and recreational resources, (where) conservation is the primary goal in a system in which recreation is the key use"; as with plantation forestry, an approved land use is "major utility installation".[44]

In the case of the plantation forestry land, which is presently managed by ACT Forests, its consent would be needed to withdraw involvement in favour of ACTEW.

A somewhat analogous situation arose recently in the course of construction of the Mt Stromlo Water Treatment Plant.[45] In that case, ACTEW needed to acquire a small parcel of land previously under the control of ACT Forests. This was fairly straightforward in that ACT Forests readily agreed to the transfer of the land and an exchange of letters to that effect occurred. However, a full-scale Preliminary Assessment for the upgrading project at Mt Stromlo was required, necessitating extensive consultation with relevant parties – ranging from the National Capital Authority and the ACT Planning and Land Authority, to ACT Roads, Environment ACT, the Heritage Unit, ACT Housing, the ANU (in connection with illumination risks to the Mt Stromlo observatory and potential damage to sensitive instruments during blasting) and the Land Titles Office.

A draft Preliminary Assessment was prepared and discussed with the ACT Planning and Land Authority, so that as many errors and gaps as possible could be identified and corrected before the document was submitted formally. Then, a land application was made by ACTEW to the Land Development Agency for the sale of a land lease, and this application triggered the process that called for the Preliminary Assessment to be submitted. At about the same time, the Chairman of ACTEW wrote to the Chief Minister noting that it was seeking the transfer of unleased land, and describing the processes being followed. Over about a three-month period, various meetings and correspondence took place between the parties, before the ACT Government offered the lease to ACTEW.

The National Capital Authority's consent was required before a sub-division of an existing parcel of land falling under its control could occur; at one point it rejected the transfer of some of ACT Forest's land to ACTEW (for use during the construction phase and as a fire buffer) but allowed occupancy during construction.

ACT Planning and Land Authority, acting as the delegate of the Minister for Planning, evaluated the Preliminary Assessment and concluded that no further assessments were required.

The main lesson from this case study is the desirability of maximum early consultation with all relevant parties, so that they know what is proposed and have the opportunity to assist with the preparation of the formal planning documents.

3.7 Approvals Processes

The approval processes for the Cotter Dam options are as follows. The principal instrument would be a development application submitted under the *Land (Planning and Environment) Act* (the Land Act) to the ACT Planning and Land Authority. This would trigger a number of other processes that would need resolution before the Authority could grant approval:

[44] See http://www.actpla.act.gov.au/tplan/web/default.htm Part B, sections B6, B15, B14 and B13 respectively.
[45] Information on this case study was assisted by discussions with ACTEW officer Simon Webber and perusal of relevant documentation.

- environmental assessment under Part IV of the Land Act;
- referral to the Conservator of Wildlife in accordance with the provisions of the *Nature Conservation Act*;
- referral to the Planning Advisory Council;
- referral to the ACT Heritage Council, in accordance with the *Heritage Act*; the Heritage Council would also take into consideration national heritage interests;
- referral to the National Capital Authority, in part to clarify whether a variation to the National Capital Plan would be needed to accommodate a mini hydro scheme associated with the enlarged Cotter Dam;
- application for a water abstraction license under the provisions of the *Water Resources Act*;
- referral to the Murray-Darling Basin Commission (while this may be advisory only, given that the Commission does not have statutory power and no constraining agreements – for a cap – have as yet been entered into by the ACT Government, the Commission's involvement and concurrence with the proposed water diversion is logical);
- referral to other relevant ACT Government Agencies (advice only) such as ACT Roads, Housing and Community Services and Environment ACT;
- referral to the Commonwealth Minister of Environment and Heritage for assessment of significant environmental impacts; and
- referral to the Australian Heritage Council for assessment of places listed on the Register of the National Estate, especially inundation of the existing Cotter Dam.

Several of the above processes, in addition to the development application itself, include provision for community consultation. The practice of the ACT Planning and Land Authority is to ensure that, in addition to statutory requirements for consultation, substantial opportunities are provided for public input to major development proposals.

4 Water Resources

4.1 Historical River Flows

Volume 3 of *Think water, act water* contains data on the river flows and allocation provisions for each of the ACT's catchments and sub-catchments. For the Cotter catchment, the key data are shown in Table 4.1.[46]

Table 4.1: Historical average river flows and water allocations, Cotter catchment (GL)

	Corin	Bendora	Cotter	Total
Average annual flow	75.8	33.9	36.0	145.7
Environmental allocation	19.3	9.5	9.3	38.1
Available for use	56.5	24.4[1]	26.7	107.6
* already allocated	29.7	21.0	0	50.7
* provision for allocation	1.8	1.2	12.0	15.0
* reserved	25.0	5.1	14.7	44.8

Source: Think water, act water, Vol 3. Note: 1: there is an error in the *Think water, act water* calculations for Bendora in that the components of the "available for use" category add up to more than the total (by 2.9 GL).

Of a total of 107.6 GL per annum from the three sub-catchments potentially available for human consumption, only 50.7 GL has been allocated to date, although provision has been made in the existing Water Resources Management Plan (which is what *Think water, act water* constitutes) for a further 15 GL to be allocated, the bulk of it from the Cotter Reservoir. Additional allocations over and above this level (that is, the presently "reserved" category) would require a new iteration of the Water Resources Management Plan before they could be reclassified.

Think water, act water also contains data on monthly river flows. For the lower Cotter catchment (that is, excluding Corin and Bendora) the historical average monthly flows are shown in Table 4.2. The table shows that around 58 per cent of the annual flow occurs in the four months from August to November.

Table 4.2: Historical average monthly river flows in the lower Cotter catchment (GL)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Monthly Flow	2.0	1.5	0.9	1.1	1.3	1.9	2.7	4.4	5.6	5.8	5.1	3.6
% avge Annual Flow	6	4	3	3	4	5	8	12	16	16	14	10

[46] ACT Government (2004), *Think water, act water, Vol 3, op cit,* pp 30-35.

4.2 Environmental Flows

The *Water Resources Act 1998* requires that Environment ACT produce a Water Resources Management Plan as one component of the management of the ACT's water resources. The plan is to specify water set aside for environmental flows, and document how the Government intends to manage the remaining water resources. A key part of the plan is to make provision for water allocations (over a ten year period). Allocations cannot be created or licenses to take water granted unless they are provided for by the plan.

The environmental flow guidelines came into operation in 1999. They are defined as the "*stream flows 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.*"[47]

ACTEW has calculated that the water accounted for by current environmental flows in the Cotter and Googong catchments is equivalent to the requirements of 75,000 residents – implying that, other things being equal, a new water storage facility will be required somewhat earlier than if the environmental guidelines did not exist.

There are four elements of environmental flows:

- **Low flows** are based on the 80th percentile flows calculated on periods of not more than a month. The 80th percentile flow is the flow that is exceeded 80 per cent of the time. Water flows below the 80th percentile are all required for environmental purposes, although the guidelines enable Environment ACT, as the administering agency, to reduce the low flow definition (but not below the 50th percentile) if the water service provider (ACTEW) can demonstrate the need for additional supply.
- **Flushing flows** are required to ensure that water channel structures and ecological processes dependent on them are maintained. The discharge that has been found to be most critical is the 1 in 1.5 to 2.5 years recurrence interval flood event. In the ACT's rivers, other than water supply catchments, the short duration of high volume flows and a limit on abstraction of 10 per cent of flows above the 80th percentile will ensure that flushing flows occur with this frequency.
- **Special purpose flows** include a requirement for spawning flows in the Cotter River. A flow adequate for spawning has been defined as the 50th percentile monthly flow during the spring months (September, October and November) and the 80th percentile monthly flow for the months of August and December to March inclusive. 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, regardless of prevailing seasonal conditions. ACTEW would prefer to have this requirement conditional on the previous 12 months flow into Corin Dam being in excess of 60 GL.
- **Maintenance of impoundment levels** is required to protect macrophytes. For urban lakes and ponds the maximum drawdown as a result of abstraction is 0.20 m below spillway level. This requirement is not relevant to the Cotter River.[48]

While most sub-catchments are restricted to having no more than 10 per cent of flows above the 80th percentile abstracted, "water supply catchments" (which include the Cotter) are able to have 100 per cent of flows above the 80th percentile utilised.

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[47] Environment ACT (1999), *Environment Flow Guidelines*, 27 May 1999, p 3.
[48] ACT Government (2004), *Think water, act water,* Vol 3, *op cit,* p 6.

Under its water licence (number WU67), ACTEW is required to have its reservoir releases for environmental flows mimic natural flows as far as possible. This particularly applies to water temperature, especially from Corin Reservoir in summer months, where the licence conditions state: “rapid changes in temperature of releases should always be avoided if practicable”.

A clause exists within the environmental flow guidelines to reduce releases based on drought conditions to ensure security of water supply. “Drought” is defined for the purpose of the guidelines as occurring when the nine months of the preceding 12 months flows into Corin and Googong were less than the median monthly inflows and the total amount of storage is less than 50 per cent. If these conditions are met, application for drought flows can be made to the Environment Management Authority of Environment ACT to reduce releases down to but not below the 50^{th} percentile flows.

The Environment Management Authority of Environment ACT is responsible for establishing and reviewing the environmental flow guidelines. Currently (2004-05) the guidelines are being reviewed and may result in changes. However, the final outcomes of this review will not be known before mid 2005. To assess the ability of new water options to meet demand, assumptions have to be made on the environmental flows to be released in the future. Advice was sought from the Environment Management Authority on potential scenarios for environmental flows for the purposes of assessing future water options. Three scenarios were identified to provide a realistic basis for assessing the future water options[49]. These are:

- Scenario 1 – Current environmental flow guidelines;
- Scenario 2 – Preliminary modified environmental flow guidelines; and
- Scenario 3 – Modified environmental flow guidelines.

The minimum scenario is considered to be the least amount needed to sustain ecosystems. The relevant assumptions for the current and modified guidelines are set out in Table 4.3 below.

[49] ActewAGL (2004), *Environmental Flow Scenarios*, Environment ACT personal communication, file note

Table 4.3: Current and "modified" environmental flow releases

Storage	Current	Modified
Normal releases		
Corin and Bendora	80th percentile	80th percentile
Cotter	80th percentile	5 ML/day
Drought releases		
Corin and Bendora	20 ML/day + 2 monthly flush	20 ML/day + 2 monthly flush
Cotter	20 ML/day	5 ML/day
Demonstrated need releases		
Corin and Bendora	50% of 80th percentile	50% of 80th percentile
Cotter	50% of 80th percentile	5 ML/day
Spawning flows	2 in 5 years	none

Notes: a) 80th percentile is the flow that is exceeded 80 per cent of the time.
b) "drought" is defined as a period when the storage volume is less than 50 per cent and 9 of the previous 12 months have received less than "average" inflow.
c) "demonstrated need" begins when reservoir levels fall to 55 per cent of capacity.
d) spawning flows are high spring flows designed to trigger fish spawning.
Source: ActewAGL (2004), ACT Water Supply Augmentation Timing, volume 1,Technical report, December 2004, p 41.

4.3 Water Quality

A comprehensive water quality review was prepared as part of the Future Water Options project by ActewAGL.[50] It notes that key water quality characteristics relative to drinking water are:

- turbidity, measured in Nephelometric Turbidity Units (NTU), represents the amount of suspended material in the water column; values above 1 NTU in drinking water can shield some micro-organisms from disinfection, whereas above 5 NTU can be noticeable in a glass of water;
- colour, measured in platinum-cobalt units (Pt-Co Units), represents the colour of the water after any suspended particles have been removed;
- iron and manganese, measured in mg/L, can give water a brown or black colour and in high (iron) or moderate (manganese) concentrations can stain laundry;
- pH, which measures the hydrogen ion concentration (acidity) of water, can affect treatment processes, the efficiency of disinfection, and the conditions of pipe work.
- algae, measured as cells per mL, can influence the amount of organic material in water, impacting on the disinfection processes, formation of potentially harmful disinfection by-products, as well as producing taste, odour and sometimes toxin problems;
- chlorophyll-a, measured in µg/L, is another measure of algal prevalence; and
- coliforms, measured in colony forming units per 100mL (CFU/100mL), are bacteria that indicate the presence of recent human faecal contamination, and are important for assessing the water quality of reservoirs (and other raw water sources).

By 1930, just fifteen years after the completion of Cotter Dam, turbidity had become a concern to Canberra's water users. Apart from intrinsically fragile soils in the catchment, rabbit infestation had become a major factor by the early twentieth century, adding to erosion and sediment discharge into streams and ultimately the dam itself.

[50] ActewAGL (2005), Cotter Options Water Quality Report, April 2005, ACTEW Corp Doc No. 4661.

A comprehensive report prepared in 1966 for the National Capital Development Commission (predecessor of the National Capital Authority) noted several factors affecting turbidity and concluded that:

- turbidity in the Cotter catchment derives largely downstream of Vanitys Crossing;
- stream bank erosion, for example in Pierces Creek, is a major contributor to the problem;
- there is also pick up of previously deposited silt in stream channels;
- sediment discharge can be heavy from roads, firebreaks, borrow pits and powerline clearings;
- land surface erosion from erodible soils with poor vegetative cover, for example, Pierces Creek and Coree Creek, adds to the sediment load;
- disturbed land following pine planting or harvesting (for up to about a year) can contribute to soil discharge; and
- turbulence within the dam itself after heavy inflows can increase turbidity levels. [51]

Of these causes, the first three were seen as the most important.

Other relevant observations made in the report were the following:

- an estimate was made that since 1915 approximately 600,000 m^3 of sediment had been deposited into Cotter Reservoir, equivalent to 13 percent of the dam's capacity; extrapolation to 2004 implies that sediment now comprises nearly one quarter of the reservoir's existing capacity;
- possibly as much as 90 percent of sediment discharge occurs during periods of high water flow (floods); and
- controlled burning should aim to retain at least 7.5 tonnes of dry matter per hectare.

Considerable additional information has been collected on the water quality of the Cotter catchment over the past 30 years:

- Cotter Reservoir was sampled regularly up to the early 1980s, and irregularly between 1982 and 2002; since August 2002, water has been sampled monthly, at 3 m depth intervals at the off take tower;
- Bendora Reservoir has been sampled about twice a month since the early 1970s, at 3 m intervals at the off take tower; and
- Corin Reservoir has been sampled approximately monthly, but at a lower level of intensity than Bendora.[52]

The available information can be used to help understand the main factors that influence water quality changes including:

- water temperature and dissolved oxygen;
- organic content of the sediment;
- inflows from rainfall and environmental flow releases; and

[51] LJH Teakle (1966), *Canberra water supply – Cotter River catchment: catchment control related to river quality*, report to NCDC, February 1966, p 14.
[52] ActewAGL (2005), *Cotter Option Water Quality Report*, *op cit,* p 2.

- the January 2003 bushfires (which have made the impacts of the above factors more pronounced, partly because of increased erosion, and increased nutrient loads into the reservoirs).

In the Cotter River reservoirs, surface water temperatures range from a low of about 5 - 7°C in July, to a high of about 20 - 24°C in January. As water temperatures increase each spring and summer, the reservoir becomes stratified with colder (and denser) water at the bottom, and warmer (and less dense) water at the top. Sediment microorganisms become more active, decreasing dissolved oxygen concentrations immediately above them and resulting in chemical stratification, with dissolved nutrients (such as nitrogen and phosphorus) and metals (such as iron and manganese) being released into the water column.

Around April–May, surface waters cool down quickly and the reservoir experiences an overturn, with the now cooler heavier surface water sinking to the bottom. This distributes the previously released material throughout the reservoir and can result in elevated levels of turbidity, colour, iron, manganese, phosphorus and nitrogen.

Rainfall, which is generally highest during the months of August to November, and the subsequent run-off can partly disrupt reservoir stratification as well as introduce suspended material into the water column. In some cases, environmental flow releases can also disrupt the otherwise predictable pattern provided by temperature, dissolved oxygen and the organic content of the sediment.

The three existing Cotter catchment reservoirs show similar water quality patterns over the course of the year (although they are more pronounced in Cotter Reservoir). From a water supply perspective, the best water quality is at the 3 – 6 m level below the reservoir surface, because:

- water at the surface can contain significant concentrations of algae, or some floating matter form rainfall run-off; and
- water in the bottom half of the reservoir can have elevated levels of nutrients and metals, particularly between November and April.

An enlarged Cotter Reservoir will have some of the water quality characteristics of the existing Cotter and Bendora Reservoirs. Consequently, the predicted values at the 90 and 95 percentile distributions for key water quality characteristics at 3 – 6 m below the surface are as shown in Table 4.4.[53]

These figures are generally treatable by the Mt Stromlo water treatment plant (with or without blending with water from Bendora Reservoir).[54]

[53] That is, on 90 or 95 per cent of occasions, the measurements are at, or less than, those appearing in the table.
[54] For example, turbidity at up to 8 NTU (at a treatment rate of 250 ML per day) and 15 NTU (at 150 ML per day) can be handled by the treatment plant, see ActewAGL (2004), *Cotter Option Water Quality Report, op cit,* p 8.

Table 4.4: Projected water quality characteristics at enlarged Cotter Reservoir.

Water quality characteristics	Projected 90% of value	Projected 95% of value
Turbidity (NTU)	5.2	10
True Colour (Pt-Co Units)	26	32
Total Iron (mg/L)	0.36	0.56
Total Manganese (mg/L)	0.11	0.19
pH (pH units)	7.5	7.7
Total algae (cells/mL)	5,891	8,601
Chlorophyll – a (µg/L)	7.2	10
Faecal coliforms (CFU/100 mL)	3	4

However, a continuing problem may be the release of iron and manganese during summer stratification, and the mixing of these metals throughout the reservoir during the autumn turnover. This would be similar to the current situation observed in Bendora Reservoir, which experiences a mild deterioration in water quality as a result of destratification and turnover. Total iron and manganese releases by sediments in an enlarged Cotter Reservoir may make it cost effective to de-stratify the reservoir by mechanical means. This would reduce iron and manganese in the reservoir, and may cost less than additional treatment at the Mt Stromlo facility.

Based on recovery rates for other south-east Australian catchments following a major bushfire, it is expected that by the time a new Cotter Dam would be completed, the catchment will be in substantially better shape than at the present time and erosion rates may be substantially lower.

A decrease in the long-term average rainfall for the Canberra area would marginally decrease (that is, improve) the projected values for key water quality characteristics. This is largely because reduced total rainfall would result in reduced erosion and amounts of suspended matter in dams. However, an increase in rainfall variability could increase the projected values for key water quality characteristics.

4.4 Influence of Climate Change

As part of its assessment of the need for a new water storage in the ACT, ACTEW commissioned CSIRO to analyse possible climate changes for Canberra over the next 70 years.[55] CSIRO has conducted similar analyses for at least NSW and Victoria and its ACT results draw heavily on its earlier research.

ACTEW commented:

> *"with only 90 years of record of ACT climate (available) … the climate (rainfall, evaporation, temperature) records for the ACT (clearly do not) reflect the range of floods and droughts that might be experienced in the future. … The current drought is now the worst on record and would have been difficult to predict even a few years ago. … There are uncertainties in projections and new information continues to give a better understanding of the possible impacts of climate change."*[56]

[55] CSIRO (2003), *Climate Change Projections and the Effects on Water Yield and Water Demand for the Australian Capital Territory,* report commissioned by ACTEW Corporation and the Future Water Options Project Team, October 2003, available at http://www.thinkwater.act.gov.au/climate_change_report.shtml The report involved the CSIRO Divisions of Land and Water (Canberra and Perth), Atmospheric Research and Sustainable Ecosystems.

[56] ACTEW Corporation (2004), *Assessment of the Need to Increase the ACT's Water Storage, op cit,* pp 6-7.

The CSIRO results indicate that there will be significant implications for water yield in the ACT catchments and water demand in the region. Regional temperature, rainfall and potential evaporation projections from global climate models imply that:

- mean annual temperatures might increase by 0.4 to 1.6 °C by 2030 and by 1.0 to 4.8 °C by 2070, with slight seasonal variations;
- temperature increases will change the frequency of extreme temperatures in the ACT region;
- potential evaporation resulting from increased temperatures might increase by up to 10 per cent by 2030;
- mean annual rainfall might change by between –9 per cent and +2 per cent by 2030, and by –29 per cent and +7 per cent by 2070, largely over winter and spring;
- rainfall changes might influence extreme dry and wet year frequencies (with rainfall effectiveness during wet years reduced by higher evaporation); and
- extreme rainfall events (in both frequency and intensity) might increase.

Although the evidence is not definitive, the CSIRO analysis also indicates that atmospheric circulation patterns over the Murrumbidgee Basin have changed over the past 40 years with the following implications:

- there has been a rainfall decline over the ACT region, with lower inter-annual variability since the 1980s and a change in rainfall seasonality (increased winter and decreased summer rainfall); and
- there may be about a 6 - 8 per cent rainfall decrease between 2035 and 2065.

CSIRO projections of water yield in the Cotter and Googong catchments and water demand within the ACT indicate:

- decreases in ACT annual run-off of up to 20 per cent in 2030 and 50 per cent by 2070;
- changes in summer/autumn run-off (relative to 1990) of –20 to +5 per cent, and –50 to +10 per cent by 2030 and 2070 respectively;
- changes in winter/spring run-off (relative to 1990) of –20 to –5 per cent and –50 to –10 per cent by 2030 and 2070 respectively.
- the projected percentage changes appear higher in the Queanbeyan River catchment than the Cotter River catchment;
- climate change, expressed as an increase in mean temperatures, predicts per capita ACT water demand will increase by 1 to 5 per cent (3 per cent for mid-range scenarios) by 2030 and 1 to 16 per cent (9 per cent for mid-range scenarios) by 2070; and
- climate change, expressed as an increase in the frequency of “hot periods”, implies that the increase in demand could be approximately twice this level, 1.4 to 14 per cent by 2030 and 9 to 38 per cent by 2070.

These figures represent estimations produced by complex models that should be considered as forecasts limited by the vagaries of climate prediction. Nevertheless, they imply that rainfall decline and higher evaporation are distinct possibilities for the region and water supply models for the ACT have been adjusted accordingly.

4.5 Cotter Options Water Supply Outcomes

4.5.1 Reliable Water Supply

Water supply reliability is clearly an important consideration in the selection of a preferred future water option. While guaranteeing unlimited supply is technically possible, it would be financially prohibitive. In practice the objective must be to achieve reasonable water availability within reasonable financial, environmental and social cost parameters, with the proviso that a certain minimum supply must be guaranteed at all times.

The term “water supply reliability” means having sufficient water in storage to supply the ACT and region’s urban areas without the risk of running out of water. As the water supplier, ACTEW must be able to provide customers with water for reasonable household and commercial use, and to maintain public parks and gardens in reasonable condition.

Water restrictions may need to be imposed in prolonged droughts so that consumption is reduced. ACTEW has determined that a “reliable water supply” means that water restrictions might be expected to be imposed up to 5 per cent of the time. This implies restrictions of some sort (stage 1 or stage 2) would be imposed for about one summer every five years, or perhaps one full year each twenty years. Stage 3 restrictions, where sprinklers are not permitted, could occur about one summer every 25 years. Ideally, stage 4 or stage 5 restrictions would not be required, but of course they may be needed in an absolutely catastrophic drought.

A corollary of this definition is that the water supply system would be said to be “failing” if restrictions need to be imposed more frequently.

4.5.2 Population Growth and Other Assumptions

The task of this water supply options project is to select an option (or a combination of options) that will ensure that system failure does not occur.

The point at which failure occurs is dependent on both the available supply of water and the demand. Demand increases over time as the population grows, moderated by the achievement of demand efficiency targets set by the ACT Government (12 per cent reduction in per capita consumption by 2013 and 25 per cent by 2023). The point at which a particular option will fail is therefore dependent on the rate at which the population grows.

For precautionary water supply planning purposes, the ACT Government’s “high” population forecast, which assumes a total Canberra-Queanbeyan population of a total of 500,000 persons by 2050, has been adopted.

Calculation of the population level at which the various options will fail has involved a sophisticated hydrology model. [57] The model has been tailor-made for Canberra conditions and is leading edge for water supply planning in Australia. It predicts the response of the existing and possible future water storages to long sequences of rainfall, stream flow, temperature, water conservation and water demand scenarios.

Because existing rainfall and stream flow records for the catchments are available for only a relatively short period (a maximum of 130 years), which may not be representative of longer term climatic conditions, the model uses a 10,000 year synthetic record to examine in more detail the effects of climatic variability and possible climatic change scenarios. This approach has found, for example, that whilst the current drought is certainly severe and possibly the “worst on record”, it may not be the “worst ever”. The modeling suggests droughts have occurred in the past that were twice as bad as

[57] ActewAGL (2005), ACT Future Water Options Water Resources Modelling report – Volume 1, April 2005, ACTEW Corp Doc No. 4644.

the current drought, lasting longer or being more severe. Such extreme events may also be expected to occur in the future, albeit only very rarely, and must be provided for in the planning process.

The modeling has indicated that the water resources thought to be available to the ACT when the *Think water, act water* reports were published may have been optimistic. They were based on stream flow data from gauging stations throughout the ACT that in some cases extended over long periods but did not encompass a "worst ever" drought event, yet did apparently include some reasonably heavy rainfall periods. The modeling has calculated lower catchment inflow levels than those in *Think water, act water*. This approach may turn out to be overly conservative but it is considered prudent for major infrastructure planning purposes.

Canberra's existing water supply is sourced from local rivers and streams. These waterways are a vital part of the natural environment and need to continue to function as elements in natural ecological systems. The concept of environmental flows (discussed in Section 4.2 above) has been developed to ensure that a minimum amount of flow is maintained in rivers and streams to ensure that they remain ecologically "healthy". It generally requires that flows be maintained at a minimum 85th percentile of natural levels. This means that certain volumes of water must be constantly released from all dams whenever they are not overtopping. The volumes involved can be substantial and obviously reduce the amount of water remaining in the dams and available for human consumption. Environment ACT is currently reviewing the environmental flow regime in consultation with relevant parties, including ACTEW. Environment ACT has foreshadowed the possibility that the flow levels may be modified and in some cases reduced. The modeling has assessed water supply outcomes under the current environmental flow regime and, in addition, modeling runs have been conducted for the various options under a modified environmental flow regime agreed by Environment ACT for this purpose.

4.5.3 Analysis of the Options

The water supply options study initially focused on three options for future water supply – Cotter, Tennent and Tantangara. Closer examination of these options has revealed that within them is a range of alternatives and combinations and, as shown in Table 1.1, some 25 alternatives and combinations have been analysed.

The outcome of the modeling analysis is best presented by identifying the population level at which the system being analysed will reach its failure point as discussed above. Assuming a population growth rate enables the year in which system failure will occur to be calculated. This is the year beyond which the likelihood is that restrictions will be imposed for more than 5 per cent of the time.

From one standpoint, the best option will be the one where system failure occurs furthest into the future (following which further infrastructure will be required) or not at all. However, in addition other factors must also be considered in the selection of the "best" option, such as risk, cost and other components of sustainability. These are discussed later in this report.

With the introduction of environmental flows, assessment of climate change and climatic variability, and the impact of post bushfire vegetation recovery on water runoff, none of which were contemplated prior to the 1990s, the existing water supply system technically reached failure point in 1999[58]. In this context, the long current water restriction period does not come as a surprise, although it has been exacerbated by the impacts of the January 2003 bushfires on the Cotter catchment.

The relative results of the hydrology analysis, expressed in terms of projected failure points, are set out in Figure 4.1. Key features of the results relevant to the Cotter alternatives are:

[58] Based on the hydrology output table, 10 per cent time in restrictions, and 25 per cent per capita demand reduction, with water use optimised in accordance with ACTEW's operating rules for operational costs and other factors.

- the reintroduction of the existing lower Cotter Dam brings the (notional) failure point forward from the 1980s to 1999;
- the enlarged Cotter Dam would enable water system reliability to be provided until about 2024;
- in conjunction with the Virtual Tennent option, the enlarged Cotter Dam would not fail until 2035; and
- the combination of the enlarged Cotter Dam and the large Tennent Dam would provide a reliable water supply until well beyond 2050.

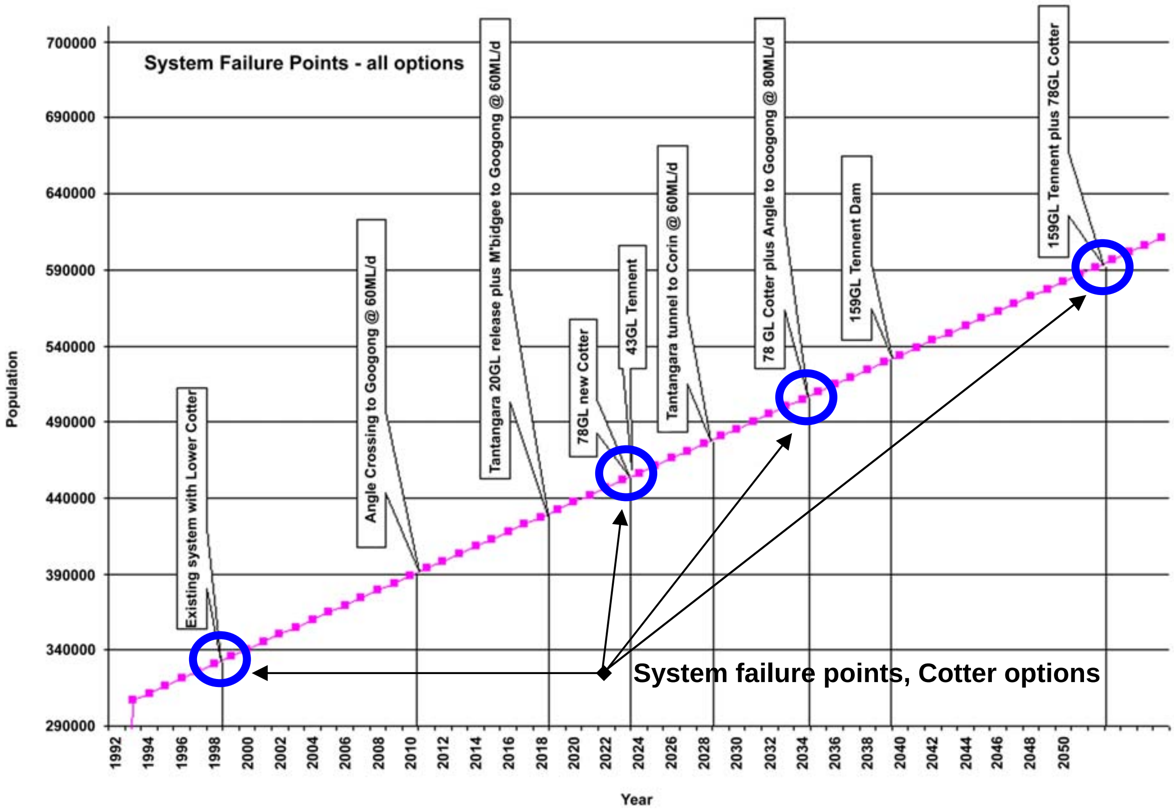

Figure 4.1: Water supply system failure points, including future options

** Note – The graph above shows the relative ranking of options to meet a reliability of supply for no more than 10 per cent time in restrictions. To achieve a reliability of supply of no more than 5 per cent time in restrictions, the line above would shift to the left, maintaining the same relative ranking*

5 Infrastructure

5.1 Site and Geotechnical Conditions

According to GHD, the foundation for the proposed Cotter Dam enlargement is considered to be adequate for the construction of the proposed dam with appropriate dam axis selection [59]. The rock exposed at the surface is of high to very high strength. A small fault occurs along the left abutment of the existing Cotter Dam and a shear zone is also suspected about 100 m downstream of the dam, but neither is likely to pose significant difficulties. The area immediately downstream of the existing spillway does not show signs of significant erosion.

Little is known about the permeability of the foundations. A number of relatively minor seepages exist but no significant problems are expected given a program of foundation grouting would occur during construction. Detailed investigations will be required prior to detailed design, which should also include investigation of the saddle dams to the right of the main dam (see below).

Although the site already hosts a concrete gravity dam, detailed geological and geotechnical investigations will be required to understand fully the geological structure of the proposed new embankment area downstream of the existing dam.

5.2 Development Description

The proposed Cotter Dam enlargement would provide a storage volume of 78 GL. The dam would have a crest level approximately 50 m higher than the existing dam and 76 m above the riverbed level. The new dam would be of roller compacted concrete construction and located 125 m downstream of the existing dam.

A multi-level intake tower with separate inlets for water supply and environmental releases would be located on the upstream face of the dam.

Associated works include: foundation treatment (including grouting), spillway and roller bucket energy dissipator, diversion works for the river during construction, and outlet works (for water supply, environmental flow releases and to enable the reservoir to be emptied for safety or inspection reasons).

Two saddle dams would be required to the right of the main dam (to hold back water in lower saddles of the reservoir catchment). These would be approximately 16 m and 11 m high and constructed of zoned earth and rockfill, or zoned earthfill embankments.

Figure 5.1 is an engineering diagram of the dam while Figure 5.2 provides a schematic view of what the new dam would look like.

[59] GHD (2005), *op cit,* p 63.

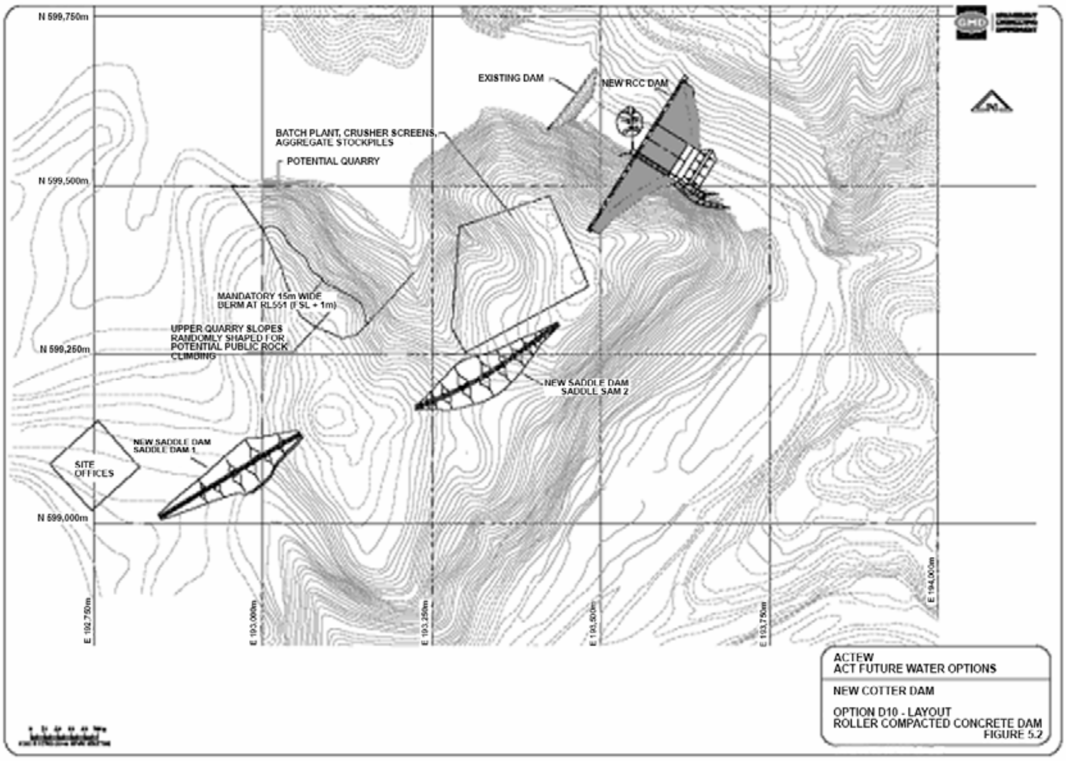

Figure 5.1: Engineering drawing of enlarged Cotter Dam, showing saddle dams

Figure 5.2: Schematic diagram of enlarged Cotter Dam

GHD considered four dam construction types: roller compacted concrete, conventional mass concrete, earthcore and rockfill shoulders, and concrete faced rockfill. The roller compacted concrete design emerged as easily the least cost (approximately $98 million, including allowances for contingencies and design). Conventional mass concrete construction would be easily the highest cost ($165 million), with the other two options costing around $132 million.[60] These preliminary cost estimates were developed to enable comparison and evaluation, rather than budgeting, as some elements were not fully scoped.

The existing 750 mm and 600 mm diameter suction mains from the Cotter Dam to the Cotter Pump Station would be utilised. These have adequate hydraulic capacity to carry the maximum supply of 180 ML/day except at very low dam storage levels. A new 750 mm diameter pipeline crossing under the Murrumbidgee River would be required to replace the existing twin 450 mm diameter mains located in a tunnel under the Murrumbidgee River.

A new pump station would be sited adjacent to, and south of, the existing pump station. Architectural treatment to the façade would be required to be consistent with the existing building which is heritage listed. The pump station would have a capacity of 180 ML/day.

The pump station would connect to the existing 600 mm and 900 mm diameter pipelines that run from the existing Cotter Pump Station to the Mt Stromlo water treatment plant.

The new dam would enable hydropower generation, with up to 1950 kW being generated, or 17 million kWh per year, assuming a daily environmental water release of 300 ML. The cost would be about $1.2 million, plus $0.2 million for transmission and sub-station costs.[61] As noted in Chapter 3, the status of hydropower generation *vis a vis* the National capital Plan and Territory Plan, needs to be clarified.

Total cost estimates for the new Cotter Dam project are $98 million for the dam, $3.5 million for land clearing/site preparation, $1.5 million for pipelines, and $14.9 million for the pump station, which, when a small contingency is included, amounts to a total of $120 million.

5.3 Construction Procedure

A construction period of approximately 20 months would be required, of which 16 months would be for the building of the dam itself. The controlling factor would be the construction of the pump station, due to the long lead-time for the supply of pumps, motors and valves. If a decision were made in 2005 to build the enlarged Cotter Dam, 2006 and 2007 would be required to undertake Environmental Impact Studies, allowing construction to start about the middle of 2008. Filling would take most of 2010 and 2011, with the Dam being ready for use by the beginning of 2012.

The dam would be constructed using 320,000 m^3 of roller compacted concrete. Roller compacted concrete dams are gravity dams constructed in layers using a “low cementitious” concrete mix. Each layer of concrete would be spread by a dozer and compacted by a smooth drum roller. Typical layer thickness is 300 mm.

The majority of material for the dam would come from a local quarry to be established about 350 m northwest of the dam, near the rim of the new reservoir. The quarry would be expected to provide 75 per cent of the fine aggregate for the roller compacted concrete, as well as for the concrete, coarse aggregate and saddle dam core, filters and rockfill. Cement, flyash and 25 per cent of the fine aggregate requirement would need to be imported. The roller compacted concrete would be delivered from the batch plant to the dam via a high-speed conveyor belt system.

[60] *Ibid.,* p 92.
[61] *Ibid,* p 96.

It is proposed that the bulk of the construction facilities would be located above the right abutment of the main dam, relatively close to the quarry. Facilities required during construction would include:

- an office;
- workshop and plant compound;
- concrete batch plants for both roller compacted concrete and conventional concrete;
- storage silos for cement and flyash;
- storage bins for aggregate and bulk aggregate stockpile areas;
- a crushing system capable of handling 400 tonnes/hour;
- an impact crusher for producing sand;
- a screening system to size aggregate;
- a high speed conveyor belt system to transport material to the dam site, including down steep gorge walls; and
- appropriate access tracks.

The new 750 mm diameter pipeline crossing of the Murrumbidgee River would be installed via directional drilling under the riverbed.

Suitable environmental controls would need to be established to handle the construction phase, in which the main risks would be sediment discharge and alkaline water from the dam wall. GHD envisages that a full-time environmental officer would be present on site throughout the construction period. The cost of environmental control and monitoring has been assessed at $2 million.

An area of 213 ha would need to be cleared as part of the construction phase. Based on a cost of $13,000 per ha, plus allowances for design and contingencies, this cost would approximate $3.5 million.[62]

5.4 Operations

The Cotter Dam system would supply water to the 250 ML/day capacity Mt Stromlo Water Treatment Plant at a rate up to 180 ML/day via the existing pipelines linking Cotter and Bendora to Stromlo. The intake structure at the dam would allow water of differing quality to be extracted for water supply and environmental flow releases. To open the required inlet on the tower for each supply, a hoist would lift shutters. The proposed Cotter Dam system may operate in lieu of, or in conjunction with, supply from the Bendora Dam.

[62] *Ibid,* p 116.

6 Environmental Considerations

This chapter reviews the key environmental considerations that may potentially affect enlargement of the Cotter Reservoir. For the most part, the text draws on technical reports prepared for ACTEW Corporation and the Future Water Options Project Team, which are referenced as appropriate.

6.1 Sediment Transport

Rivers carry substantial loads of eroded material from upstream catchment areas that are deposited as sediment downstream. Possible changes in sedimentation patterns are a common consequence of the construction of water impoundments such as dams or weirs. The Catchment and Landscape Report contained a detailed description of the effects of soil erosion and sediment discharge into the rivers and streams of the ACT, including as a result of the January 2003 bushfires.[63] In regard to the enlarged Cotter option, the report stated that:

> *"There are no landscape constraints that would prevent implementation of the enlarged Cotter Dam option. There is, however, a major constraint to effective management of the immediate catchment and a long-term impediment to water quality. That constraint and impediment is the pine plantation land use within the immediate catchment."*
>
> *"While the steep lands within Namadgi National Park, downstream of Bendora Dam, will always be subject to episodic erosion events, there will be a limited ability to control the impact of these events. Within ACT Forests lands, however, there are land use and management activities that are contributing substantially to water quality impairment. The soils within the plantations are particularly prone to erosion, producing highly turbid water. There is substantial evidence of past, massive erosion that may be the direct result of the pine plantation land use. While pine plantations may be relatively stable during growth, periodic instability associated with harvesting and preparation for planting appear to be a direct cause of sediment mobilisation. An association with pines, fire and erosion has mobilised sediment at rates that may approach or exceed peak rates since European settlement."*[64]

Among other comments in the Catchment and Landscape report were the following:

- *"ACT Forests lands are currently highly prone to erosion due to soil type, disturbance, lack of recovery of vegetation and the impact of internal management roads";*
- *"overall … it will take between five and ten years before the erosion risk of the pine forests will be substantially reduced; given the 60-70 per cent probability of storms in any year, it is likely that there will be erosion initiated in some parts of the ACT Forests during the next five to ten years";*
- *"erosion is currently occurring across the Pierces Creek landscape, with the exception of the main drainage lines; the bed of Pierces Creek and main tributaries are well vegetated; that vegetation is acting as a trap for coarse sediment that has recently eroded into the channels; current erosion comprises rilling of steep land, gullying of depressions and sheet and rill erosion in areas that have been ripped";*
- *"there is one certainty: turbidity will continue for as long as it takes for the lower Cotter catchment to stabilise"; and*

[63] Ecowise Environmental and Barry Starr Pty Ltd (2005), *op cit,* pp 40-54 and 64.
[64] *Ibid,* p 64.

- *"while all of the lower Cotter catchment is at risk of erosion, particularly during sporadic storm events, the ACT Forests lands are certain to yield sediment at the highest rate for the longest period of time; given the proximity to Cotter Dam, it is also certain that water quality in Cotter will be impacted for decades, and possibly storage capacity reduced".*[65]

The report recommends that if the Cotter Dam enlargement option proceeds, priority should be given to reservoir and immediate catchment studies, plus an analysis of land management methods applied to pine plantations, with particular reference to urban water supply catchment values. The Future Water Options Project Team agrees that high priority will need to be given to remediation in the lower Cotter catchment, regardless of whether the Cotter Dam enlargement option proceeds.

6.2 Effects on Riverine Habitat

Enlargement of the Cotter Dam would have both immediate and long-term effects on riverine habitats due to:

- direct displacement from structures and plant;
- vegetation drowning;
- flow changes;
- sedimentation within the reservoir; and
- erosion immediately downstream of the dam.

While these changes would be permanent, they would be restricted to the dam location and would therefore be generally marginal in the total scheme of things. The main long-term impacts on riverine habitat are likely to result from bank and channel erosion and deposition. Areas with bedrock controls are unlikely to experience any significant riverine habitat changes. Changes in flow patterns would increase the extent and duration of wet and drying cycles with substantial benefits to riparian vegetation and its attendant habitat. While short-term instability could result in some negative impacts, the long-term benefits could be significant, depending on water release strategies. The best results would come from a flow regime that as closely as possible mirrors natural low flows over summer and seasonal peaks during spring.

Water quality (dissolved oxygen, iron, manganese and possibly hydrocarbons – as discussed in section 4.3) and temperature may also be significant in altering habitat, both in the Cotter Reservoir and downstream of the dam. Management actions that would assist the downstream habitat include taking water for release at varying depths, and thermal stratification.

6.3 Effects on Fish

The Wildlife Research and Monitoring Unit of Environment ACT has provided advice on the impacts of future water supply options on fish and crayfish populations.[66] As far as the Cotter is concerned, the report notes "there are few published studies on the fish fauna of the Cotter River catchment that can be considered primary sources of information."[67] It makes reference, *inter alia,* to a study of Mountain Galaxias that have been shown to spawn in Pierces Creek, an unpublished 1990 survey on sites in the lower Cotter catchment, and a nine year research project on Two-spined Blackfish, mostly conducted within the Cotter catchment.

Four species (three fish and one crayfish) have been declared as threatened and are potentially affected by Cotter Dam enlargement:

[65] *Ibid,* pp 40-54.
[66] Environment ACT (2005), Fish Impact Study, April 2005, ACTEW Corp Doc No. 4548..
[67] *Ibid,* p 12.

- *Macquarie Perch* *Macquaria australasica*
- *Trout Cod* *Maccullochella macquariensis*
- *Two-spined Blackfish* *Gadopsis bispinosus*
- Murray River Crayfish *Euastacus armatus*

Of these, Macquarie Perch and Trout Cod are listed as endangered at both ACT and national levels, as shown in Table 6.1, whereas Two-spined Blackfish and Murray River Crayfish are listed as merely vulnerable in the ACT.[68]

Table 6.1: Status of threatened fish/crayfish species from the Cotter catchment

Species	ACT	NSW	National	International
Listing instrument	*Nature Conservation Act (1980)*	*Fisheries Management Act (1984)*	*Environment Protection and Biodiversity Act (1999)*	IUCN Red list (2004)
Macquarie Perch	Endangered		Endangered	Data deficient
Two-spined Blackfish	Vulnerable			
Trout Cod	Endangered	Endangered	Endangered	Critically Endangered
Murray River Crayfish	Vulnerable			Vulnerable

Source: Lintermans, op cit, p 16.

The only native species known to make regular river-reach or larger migrations is the Macquarie Perch. It spawns in flowing waters, in late spring/summer, when water temperatures reach approximately 16.5°C. The eggs are washed downstream where they lodge in gravel or rocky areas until hatching.

As discussed in section 3.1.6, the ACT *Nature Conservation Act* encourages the protection of native species, the identification of threatened species and communities, and the management of public land reserved for nature conservation purposes. The threats to native fish species are outlined in ACT Action Plans and can be summarised as: habitat destruction or modification (including the effects of dams and weirs), introduction of alien species, and over fishing.

Habitat destruction or modification is one of the most important causes of native fish declines in Australia. The major types of habitat modification are:

- barriers to fish passage (including from dams and weirs);
- alteration to flow or thermal regimes below dams and weirs;
- reduction in floodplain habitat or access to floodplains;
- reduction of instream habitat; and
- reduction in water quality.

The introduction of alien species is often cited as a cause of native fish declines in Australia although much of the evidence is anecdotal. However, there is evidence of Mountain Galaxias and Two-spined Blackfish being adversely affected by Brown Trout and Rainbow Trout, both predation and competition for feeding, spawning or territory. Another potential impact of alien species is their ability to introduce or spread diseases and parasites to native fish species, principally the disease Epizootic Haematopoietic Necrosis (EHN) virus. Brown Trout are located throughout the lower Cotter

[68] Trout Cod in the Cotter are the result of a stocked population in Bendora Dam that has bred naturally in the Dam (regarded as a nationally significant achievement). Two-spined Blackfish still occur naturally throughout the Cotter system (above Cotter Dam) and this is the only ACT river system where they persist. The judgement is that blackfish have a better chance of maintaining a self-sustaining population in that they are starting from a more secure base (healthy numbers and regular reproduction). *Source*: Mark Lintermans, *pers com*.

catchment, while Eastern Gambusia, Oriental Weatherloach and Goldfish are confined to the Cotter Dam and the river immediately upstream from it.

Overfishing has been important in the decline of several freshwater native fish species in the Murray-Darling Basin, such as Trout Cod, Macquarie Perch, Murray Cod, Murray River Crayfish and blackfish.

The Wildlife Research and Monitoring report assessed the Cotter options from a fish perspective using seven components:

1. **Threatened fish impacts in storage**: includes issues such as loss of cover, increased trout and cormorant predation, water quality concerns, loss of important habitats, entrainment of fish into pumps/pipelines etc.
2. **Introduction of alien species or diseases**: includes potential transfer of alien species through inter-valley water transfer, introduction of alien species via recreational fishing, potential for transferring the EHN virus.
3. **Other alien species issues**: includes expansion or enhancement of existing alien species populations, impacts of enhanced alien populations on native fish and crayfish.
4. **Construction and maintenance impacts**: includes impacts at and downstream of the site from sedimentation from dam/weir construction, sedimentation from weir maintenance.
5. **Fish passage/fragmentation**: includes fish passage issues for new infrastructure, potential fish passage issues with natural barriers upstream of impoundments, additional fragmentation of aquatic corridors.
6. **Long-term downstream impacts**: issues related to reduction in flows downstream of structures, increases in flows from water transfers, increased sedimentation, and reduction in habitat diversity (hydraulic and bed structure).
7. **Positive impacts**: includes potential for habitat or existing native fish population enhancement, potential for establishment of new populations of threatened fish, benefits to native fish populations of increased flow.[69]

Enlargement of the Cotter Dam to 78 GL capacity was rated by Environment ACT as having the lowest impact on fish among the various Cotter options initially under consideration because it provides opportunities for active enhancement of threatened fish habitats and populations in the lower Cotter catchment. For example, the 45 GL Cotter option was not rated as highly because of potential fish passage issues at the upstream limit of the impounded waters, which would threaten the viability of the existing Macquarie Perch population. These would be covered by the 78 GL Cotter Dam, meaning that the barrier to fish movement would be removed. The Coree Dam option, which is not being investigated further, would have posed significant fish passage constraints.

Comparing all options, the Cotter 78 GL option was rated similarly to the Virtual Tennent option and the Tantangara pipeline option. However, the Tantangara option of releasing water down the Murrumbidgee and collecting it within the ACT (at Angle Crossing) was the most desirable from a fish perspective, producing a net improvement.

Environment ACT recommends that any new dam on the Cotter would require the development of an agreed suite of operating rules to minimise potential impacts on threatened fish.

[69] *Ibid,* p 69.

6.4 Effects on Aquatic Ecology

The Water Research Centre of the University of Canberra undertook a review of aquatic ecology in the Cotter River catchment.[70] The report is comprehensive and, as well as focusing on factors specific to the three options, contains a detailed literature review of relevant, mainly broader, aquatic ecology issues.

The Water Research Centre report follows the approach of the National Land and Water Resources Audit and the Murray-Darling Basin Sustainable Rivers Audit, evaluating the major components of the aquatic ecosystems (Figure 6.1). The following elements were included: hydrology, habitat, water quality, and aquatic biota. Where possible assessments were made relative to a reference condition, that is, measuring change, rather than just providing absolute values. This enables some evaluation of the change to ecological condition that may occur because of the proposed developments.

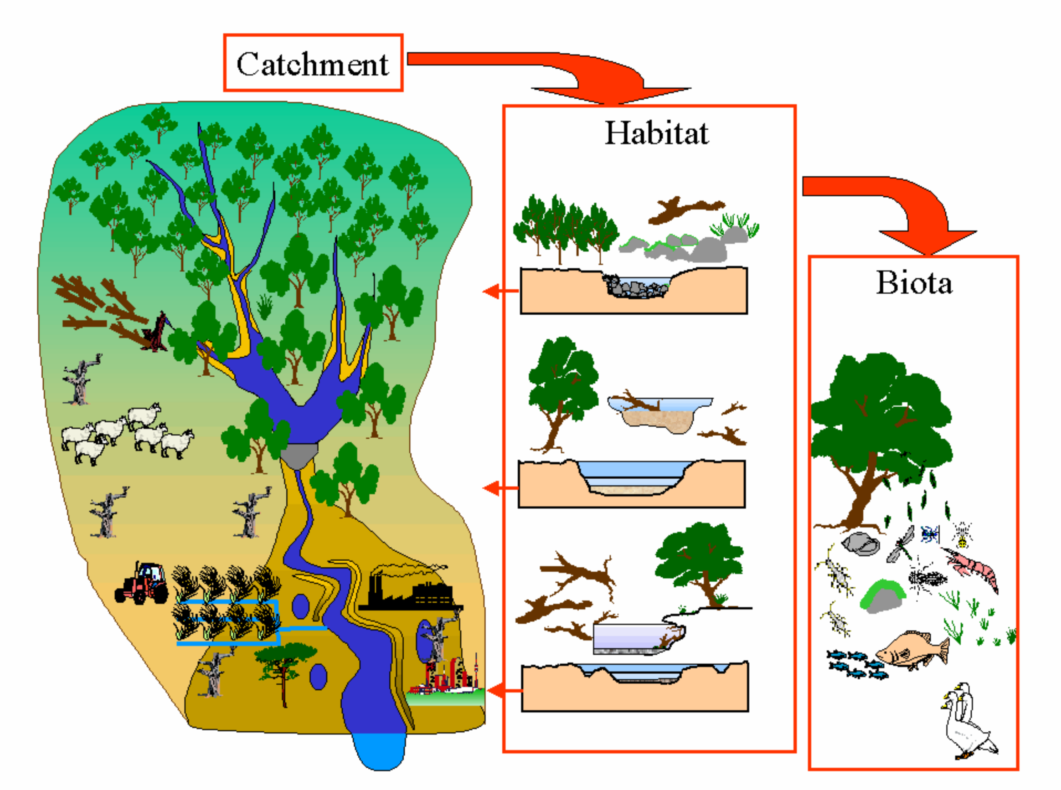

Figure 6.1 Model of factors related to river condition

6.4.1 Overall response of the Cotter River to flow management

Flows in the Cotter River have been closely managed under environmental flow guidelines (see section 2.4). This regime has markedly improved and subsequently maintained the ecological condition of the Cotter River, relative to local unregulated streams, even taking into account stress from drought and the January 2003 bushfires. Habitat reduction, sediment and algal accumulation, and negative effects on the food chain are all still seen in the Cotter River. Further improvement may

[70] Water Research Centre, University of Canberra (2005), Aquatic Ecology Study, April 2005, ACTEW Corp Doc No. 4682.

be achieved through variation in base flows and smart management of water releases to benefit both the river ecology and drinking water quality.

Operation of the dams has had obvious but short-term effects on water quality, such as low water temperatures downstream of Corin and Bendora Dams and turbid water releases from Bendora Reservoir. The release of "drought flows" (average base flow of 20 ML per day and two flushing flows) has been largely effective in maintaining the biota in the Cotter River in a condition similar to tributaries and the nearby Goodradigbee River.

Flushing of fine sediment was more frequent in 2003-04 because of the managed flushing flows, especially immediately downstream of Bendora Dam. Such flushing flows are particularly important in maintaining the condition of the riverbed for aquatic biota.

According to the aquatic ecology report, temperature variation in deep pools resulting from the "drought flow" regime was unlikely to cause significant stress to fish because mixing occurred each day irrespective of flow conditions. Careful management resulted in a strategy to release turbid water from Bendora Reservoir to maintain drinking water quality and to benefit the environment. It is likely that the sediment levels were less than that in water derived from the recently burnt catchment. This release can be seen as an example of using sound scientific knowledge for management to benefit both the environment and water supply.

Variation in base flows from 10-30 ML per day, whilst maintaining an average of 20 ML per day from Bendora Reservoir, was introduced in January 2003. This strategy holds promise to further improve the ecological condition of the Cotter River.

The aquatic ecology study concluded is that it is possible to manage river flows to benefit the environment and water supply. A larger dam on the lower Cotter River would need to be designed to facilitate environmental flow releases and manage water quality to ensure adequate dissolved oxygen, and avoid low temperatures and metals such as iron and manganese.

6.4.2 Biota

Enlarging the storage capacity of the Cotter Reservoir will flood considerable areas of existing amphibian habitat, both in the bed of the river, and in adjacent riparian areas. The main species affected will be the Rocky Stream Frog, the Eastern Banjo Frog and the Common Eastern Froglet, all common species in the ACT region. Equally, it will create similar forms of habitat for these species, on a larger scale commensurate with the size of the reservoir.

Macro invertebrate communities (animals without backbones that can be seen with the naked eye) are impaired downstream of the three dams on the Cotter River, particularly below Corin Dam. Dam release procedures that provide flow variability assist in maintaining healthy populations. Water temperature is also an important influence, so there is a need for a new dam to have a multi-level off take to allow alteration in the level of flow releases.

Platypuses are relatively common in the Cotter River, having been recorded in all three reservoirs. They have also been seen in the Cotter River immediately below the Cotter Dam wall and at the campground. An enlarged Cotter Dam may affect platypus populations through changes to food availability, and upstream increases in water levels that change relatively shallow and productive river environments into deep, less productive lake-like ones. Cold-water releases from the dams should be avoided because this may impose additional stress on animals inhabiting waters downstream.

6.4.3 Habitat

No significant wetlands would be affected by enlargement of the Cotter Dam.

The current dam traps all coarse sediment, so changes to sediment transport capacity caused by an enlarged dam will have little impact. The effects on silting will depend on dam operation and maintenance of a medium/low flow regime, because the system is already regulated.

The report concludes: "provided it is designed carefully, Cotter Dam enlargement appears to have much less impact on stream geomorphology and sediment movement than the Tantangara Options"[71].

For the lower Cotter River the proposed options do not change the hydrologic disturbance category, which is currently described as 'moderately modified'.

6.4.4 Environmental impacts/ benefits of the Cotter options

One issue surrounding Cotter Dam enlargement is the potential effect on aquatic ecosystems during the filling phase of the dam. There will be a trade-off between the time taken to fill the dam and its impact on the aquatic ecosystem. The dam will be filled most quickly if only the minimum environmental flow requirement (currently the 80 percentile of natural flows) is released from the dam, with remaining inflows captured. Even under this scenario, for average inflows it will take approximately 12 months to fill a 78 GL dam. However, a constant low flow release during the filling period is likely to have detrimental effects on the aquatic biota that rely heavily on seasonal flows.

Environmental impacts during construction can be mitigated with proper planning and implementation of best management practices. During construction, water would have to be controlled and provisions for run-off and erosion control developed and implemented. A spill control plan would be needed to control any construction-related fuels, lubricants, and other materials.

6.5 Effects on Terrestrial Flora and Fauna

An assessment of flora and fauna on potential future water option sites was conducted by Biosis Research.[72] The purpose was to establish whether there is a major constraint or impediment to implementation due to significant flora and vegetation issues. The study identified threatened species, or species habitat, that may be affected by an enlarged Cotter Dam, compared them with the requirements of the *Nature Conservation Act 1980* and the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999,* and detailed issues needing further examination via a preliminary assessment/ environmental impact assessment.

Most of the areas under native forests within the Cotter catchment are relatively undisturbed, apart from the obvious recent bushfire damage. These areas are mainly in the upper catchment. While only a small proportion of the total Cotter catchment is affected by grazing, softwood plantations, harvesting of native timbers and engineering works, a high proportion of the lower Cotter catchment is affected by these land uses. Slopes near the Cotter Reservoir were planted with exotic conifers in the 1920s and there has been infestation of blackberries and other weeds in these areas.

Downstream of Cotter Dam areas have been cleared for recreation purposes, although native *Casuarina* trees are still the main riparian species. Surveys following the 2003 bushfires have found that many riparian species are demonstrating signs of recovery and re-growth, although there is a loss of shrub species that trap sediments and stabilise steep banks.

[71] *Ibid,* p 12.
[72] Biosis Research (2005), Terrestrial Flora and Fauna and Vegetation Study, April 2005, ACTEW Corp Doc No. 4649.

Enlargement of the Cotter Dam to 78 GL would increase the total area inundated by about 260 ha. In addition, another 120 ha of buffer zone would be created, assuming a buffer of 50 lineal metres from the water edge, or 230 ha if the buffer was 100 lineal metres.[73]

As to plant species affected by Cotter Dam enlargement, the report concluded: "no threatened species have been previously recorded…and none were recorded during this assessment."[74] It noted that there is potential habitat for two threatened species under the *Environment Protection and Biodiversity Conservation Act*, *Pomaderris pallida* and *Thesium australe.* The report stated that few native animals were observed during field inspections – just two frog, 18 bird and one mammal species – and that the potential occurrence of significant animal species is expected to be low.

The report then ranked each of the option areas against seven criteria: connectivity of habitat to surrounding areas; presence of significant species; presence of significant vegetation communities and/or threatened species habitats; presence of conservation reserves; condition of ecological integrity of habitats; species richness and diversity; and the national, regional or local significance of the site. On this basis, the Cotter site produced a ranking of 2-5 with a conservation significance of "generally low", compared with 4-8 ("low to moderate") for Tantangara, and 12 ("high") for Tennent.[75]

The options were also assessed against criteria of native vegetation clearing and habitat loss; significant species; potential weed invasion; road, track creation or widening; vehicle movements (construction and operation phases); erosion and siltation; and effect of wave splash on lower slopes (erosion and vegetation loss). Again on these criteria, Cotter Dam enlargement was the most benign of the three options under investigation, with an impact rank of 6 ("low"), compared with 14 ("moderate") for Tantangara and 16-18 ("high") for Tennent.[76]

[73] These measurements were derived by Ecowise, as a one-off exercise for the Future Water Options Project Team.
[74] *Ibid,* p 20.
[75] *Ibid,* pp 50-51.
[76] *Ibid,* p 54.

7 Human Environment

7.1 Effects on Cultural Heritage

A desktop Cultural Heritage Study was commissioned by ACTEW to establish whether there may be a major constraint or impediment to implementation of the any of the three possible water options due to the impact of significant Aboriginal sites and non-Aboriginal heritage.[77]

As part of this process, the consultant liaised with the three local Aboriginal community groups that have an interest in cultural heritage issues and are registered with the ACT Heritage Unit: the Ngunnawal ACT and District Indigenous Peoples Association, based at Yass; the Ngunnawal Elders Council Incorporated/Ngunnawal Local Aboriginal Land Council, based at Queanbeyan; and the Buru Ngunnawal Aboriginal Corporation, based at Dunlop, ACT.

These groups indicated that, at face value, there did not appear to be any major Aboriginal cultural heritage constraints to the Cotter Dam enlargement option. However, they also noted that there was insufficient information available for them to make considered comments and reserved their right to comment further when more specific information became available on a preferred option.

The consultants rated Tantangara as having the least number of Aboriginal recorded sites, followed by Cotter, and with Tennent having the highest number. As far as Cotter is concerned, the study concluded that there is likely to be a "low to medium probability of containing additional culturally significant Aboriginal sites" within areas affected by the dam construction and inundation of the reservoir.

Navin Officer assessed that eight Aboriginal sites would be directly affected by enlargement of the Cotter Dam, with possibly an additional 89 indirectly affected. The latter are those sites located within about 1 km of the dam or water body, and therefore potentially vulnerable to being affected by construction activities, roads or inundation. All the sites directly or indirectly affected are described as being open scatters, artifacts, isolated finds or, in one case, a rock shelter. Only one of the directly impacted sites was assigned a significance rating: "low" (based on an earlier investigation, given that the present study was desktop only); no details are available for the remainder. Of the sites potentially indirectly affected, ten received a low significance rating, with again no details being available for the remainder.

In terms of non-Aboriginal heritage, the existing Cotter Dam appears on the Register of the National Estate. A further five sites would be indirectly affected: a disused mine site, the Cotter Pumping Station, the Upper Cotter catchment, the Murrumbidgee corridor and the Murrumbidgee River itself. Apart from the mine site, the other four locations are also listed on the Register of the National Estate.

The consultants reported there was a low probability of the area containing additional non-Aboriginal heritage sites, such as huts, stock enclosures, fence lines, and bridle tracks.

On this basis, it can be concluded that the effects of Cotter Dam enlargement on the heritage of the area would be minimal, apart from the obvious inundation of the original Cotter Dam, given that a new dam would be located barely a hundred metres downstream from it.

[77] Navin Officer Heritage Consultants (2005), Cultural Heritage Assessment, April 2005, ACTEW Corp Doc No. 4651.

7.2 Effects on Recreation

Following the January 2003 bushfires, the ACT Government released an interim recreation strategy for the natural areas of the ACT, pending other planning and consultation processes that will influence the final strategy.[78] Other work, much of which forms part of the post bushfire *Shaping Our Territory* reports, includes:

- a management review of the Namadgi Plan;
- the Tidbinbilla Nature Reserve Business Case and Masterplan;
- the Cotter Precinct Masterplan;
- reports on proposed reconstruction of Pierces Creek and Uriarra villages;
- Stromlo/Deeks Forest Park; and
- the International Gardens and Arboretum.[79]

The interim recreation strategy discusses a wide range of recreation activities pursued by ACT residents, including walking, mountain bike riding, organised cycling, horse riding, four wheel driving, organised vehicular events, dog sledding, field archery, organised running and walking, orienteering, and night events. It recommends "key directions" in a number of areas that relate to the Cotter Dam enlargement option, including:

- Corin Dam area, a popular day use area and starting point for walks, should continue to serve this purpose;
- Cotter-Uriarra area provides the first impression for visitors travelling along Tourist Drive 5 which, together with the Cotter precinct itself, should be considered as the primary vehicle for enhancing the tourism and recreation opportunities within non-urban ACT;
- Cotter recreation activities should retain family values including day use, walking, cycling, and adventure activities, with consideration of adventure activity infrastructure located near or associated with the Cotter Dam;
- ACT Forests lands (Uriarra and Pierces Creek) play a leading role in offering opportunities for recreation including broad scale and high impact activities such as four wheel driving, cycling, horse riding, rallies as well as the broad range of outdoor pursuits; the integration of forest areas and forest park with the urban area will continue to enable the community to use the forest areas for everyday recreation including walking, horse and cycle riding and dog walking; future re-establishment of forestry areas should, consistent with bushfire management and protection of water quality, continue to provide areas for motorised recreation; and
- improved facilities for high-impact recreation activities, such as spectator viewing and tracks for car rallies/mountain bike events, should be established prior to pine replanting, particularly in areas close to the Cotter precinct.[80]

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[78] Janet Mackay (2004), *Interim Recreation Strategy for the Natural Areas of the ACT*, prepared for Environment ACT, April 2004; available at: http://www.environment.act.gov.au/Files/interimrecreationstrategy0804.pdf

[79] The various *Shaping Our Territory* reports have been published by the Shaping Our Territory Working Group and can be see at: http://www.cmd.act.gov.au/nonurban/index.shtml. The titles are: *Tidbinbilla Nature Reserve: Business Case and Master Plan* (August 2004); *Revitalising the Cotter: Action to date and future possibilities* (September 2004); *Sustainability Study: Uriarra Village* (May 2004); *Sustainability Study: Pierces Creek Settlement* (May 2004); and *Deeks Forest Park: Masterplan* (July 2004). Details on the 2003 management review of the Namadgi plan can be seen at:
http://www.environment.act.gov.au/bushparksandreserves/namadgimgtreview.html

Future growth of the Canberra population means there is a need for a broader range of recreation opportunities than have been available historically, from remote settings and adventure activities, through to developed sites and more passive recreation, including facilities for disabled people. An enlarged Cotter Dam could provide significant opportunities for the development of active recreation to meet a growing community demand.

The original *Shaping Our Territory* report identified a wide range of development options that would enhance the Cotter as an adventure recreation precinct, the primary focus being on family recreation within the natural environment.[81] As *Revitalising the Cotter* noted:

> *"infrastructure that could enhance the recreational capabilities of the Cotter could be created by the dam construction phase (such as improved roads, residual cabins/site office, a quarry/amphitheatre, and additional walking tracks). Also, the additional recreation possibilities from enlargement of the dam may in turn influence the specifics of the dam (eg, a road across the dam wall)."* [82]

Potential recreational activities for the Cotter area identified in *Revitalising the Cotter* (some of them below the dam wall, others on the wall, in the dam water or in the catchment) included:

- specialised mountain bike downhill courses;
- zip line flying or high tension cables with flying foxes;
- zorbing (rolling down a hill in a large 3-4 m plastic ball);
- 2 and 4WD drive tracks;
- paintballing;
- motorcross;
- land-based luges;
- tracks for horses, mountain biking and dirt biking;
- orienteering;
- bouldering;
- abseiling;
- rock climbing;
- swimming;
- outrigger canoes or dragon boat racing;
- dinghy sailing and windsurfing;
- rowing;
- scout boating;
- passive water recreation instruction courses;
- fishing; and

[80] Janet Mackay (2004), *op cit,* pp 67-76.
[81] Shaping Our Territory Working Group (2004), *Revitalising the Cotter, op cit,* p 1.
[82] *Ibid,* p 6.

- various events, such as triathlons, regattas, car clubs, "hash house harriers" and multi sport events.[83]

The GHD engineering report also highlighted a number of potential opportunities associated with an enlarged Cotter Dam, several of which had been identified in *Shaping Our Territory.*[84] These included:

- abseiling, water slides and rock climbing on the right abutment of the dam;
- picnic areas, lookout and barbecue area with a view of the dam from the left abutment;
- constructed rock pools and a swimming lagoon downstream from the dam;
- retaining the construction flying fox or constructing a suspension bridge near the spillway; and
- a cliff top and tree canopy walk.

The GHD report put forward some additional possibilities:

- canoeing and kayaking in the reservoir and use by non-powered watercraft;
- use of the dam structure by the YMCA for recreational activities;
- the possibility of retaining the construction camp/office and converting it into use by community groups, such as schools and scouts; and
- community bushwalks around the foreshore, as at Googong Dam.[85]

Finally, a recent submission to the Shaping Our Territory Implementation Group from ACT Fly Fishers Inc proposed, and gave arguments in support of, greater access to the Cotter catchment (dams and rivers) for fly and lure fishing (not bait fishing).[86] It proposed a trial to enable the evaluation of fishing upstream of Corin Dam, in the upstream half of Corin Dam itself, and on Cotter Dam (similar to that allowed on Googong Dam). The submission noted that such fishing was allowed in other water catchments around the world (in Europe, Yellowstone National park in the United States, and indeed Kosciusko National Park).

All this, of course, is predicated on there being no unacceptable threat to environmental values or to the water quality of Cotter Dam water for potable use, either from recreation in the dam water or in the immediate catchment. On the one hand, as water from Cotter Dam will require treatment for other reasons prior to human consumption (discussed previously in section 4.4), water quality concerns may be less of an impediment to some recreational pursuits than would be the case in a pristine catchment, even if the problem of greater turbidity may make treatment more difficult. There are various examples in Australia and overseas (for example, Googong Dam) of appropriate recreational activities co-existing with water supply storage.

On the other hand, concerns still exist regarding potential threats to water quality and environmental values as a result of nearby recreational activities. In 1997, the ACT's Environment Advisory Committee was asked to review the existing prohibition of public recreation access to the Cotter Dam. Having received a number of submissions from interested groups, the committee considered fishing, jet skis, sailing and swimming. On the question of fishing, the committee concluded that "even if the fishing community could be educated to catch and return Macquarie Perch," some anglers would be tempted to use live bait, principally carp, despite it being illegal. As the evidence to the committee was

[83] *Ibid,* p 25.
[84] Non-Urban Study Steering Committee (2003), *op cit,* p 200.
[85] GHD (2005), *op cit,* p 135.
[86] Hena Power (2005), *Submission to Shaping Our Territory Implementation Group,* ACT Fly Fishers Inc., February 2005.

not strong that Cotter Dam could become a high-class recreational trout fishery, the committee did not support fishing in the dam.

Similarly, the committee opposed conventional power boating for the same reason it is precluded on Googong Dam – a risk of escaping exhaust oil that could react with chlorine during subsequent treatment to form a potential carcinogen. While jet skis were claimed to avoid this risk, and while there may be some mild aeration advantages from water agitation, the committee recommended that the existing prohibitions should be maintained, mainly to protect the endangered Macquarie Perch.[87]

As part of the current assessment, ActewAGL and Water Futures were commissioned to provide technical advice on recreation issues.[88] This report focused mainly on the potential for contamination of the water supply by human pathogens, which might then not be fully removed or treated prior to consumption. The report concluded that:

> *"the primary function of ACTEW's source water reservoirs is the provision of safe, high quality, reliable drinking water. Any form of recreational access should be considered a secondary use and should only be permitted if there is a clear and demonstrated need (both demand and a lack of alternative facilities), and where risks to the primary function can be shown to be fully and reliably mitigated.*
>
> *It is unlikely that ACTEW would be supported in permitting additional access to the Cotter Dam or its surrounding catchment. Even though additional treatment is now in place, the combination of threatened fish species of national significance, the fragile and fire-prone ecosystem and restrictions on comparable systems in other metropolitan capitals means that it is likely that there will be strong opposition to recreational access in these protected systems. It is likely that ACTEW will need to maintain at least its current level of recreational access in the Googong system since it has been generally found that once provided, it is not possible to gain support for reducing this level of access."*[89]

The report listed six types of access to water supply reservoirs and their catchments, from which contamination may occur:

- primary contact recreation (eg swimming and wind surfing) in which direct faecal smear shedding, pathogen release and riparian disturbance is inevitable;
- secondary contact recreation (eg canoeing, sailing, fishing from boats and boating with low powered electric motors) in which direct faecal smear shedding and pathogen release is less likely, although riparian disturbance is inevitable;
- motorised recreation (eg boats with petrol motors, jet skis and water skiing) in which direct faecal smear shedding and pathogen release is possible, and significant riparian and benthic disturbance is inevitable;
- shore-based activities (eg fishing with or without live bait) in which direct faecal smear shedding is unlikely, if properly policed, some riparian disturbance will take place and ecological impacts may arise;
- inner catchment low contact weight activities (eg walking, cycling and camping) in which indirect faecal release via runoff is possible and some riparian disturbance and ecological impacts, including fire, may arise; and

[87] ACT Environment Advisory Committee (1998), *Cotter Reservoir – Review of Recreational Use,* May 1998.
[88] ActewAGL and Water Futures (2005), *Technical Advice on ACT Reservoir Recreational Water Use Options,* report prepared for ActewAGL, April 2005.
[89] *Ibid,* p 5.

- inner catchment high contact weight activities (eg horse riding and four wheel driving) in which indirect faecal release via runoff is possible, and catchment, riparian disturbance and ecological impacts, including fire, are likely.[90]

The report noted that while proving cause (recreational activity) and effect (water quality or ecological damage) can be difficult, predictions are possible. It stated that permitting additional recreation at water supply reservoirs would be expected to lead to additional, albeit sporadic, infections in the community supplied by that water. Whether that was considered significant or acceptable would need to be determined on a case-by-case basis, measured against the cost of mitigation. Mitigation measures include: buffer distances to separate recreation activities from the outlet point; additional water treatment; allowing certain recreation activities only; providing alternative activities; providing facilities (such as toilets and litter collection); active policing; and education. Some indicative costs of mitigation measures were provided, with a capital cost of approximately $1 million and annual operating costs of around $0.5 million.

In conjunction with this report, ACTEW received a letter from the chief executive of the CRC for Water Treatment and Quality, summarising the main arguments in the recreation/potable water quality interface. The main points were:

- with increased urbanisation, the need for recreational opportunities in natural environments has increased; urban water utilities are under increasing pressure to open up these areas for a range of recreation activities;
- the report prepared for ACTEW is accurate in concluding that increased recreation would be expected to have a negative impact on water quality, with some mitigation activity required to manage the risks; the protection of public health must remain the prime focus;
- once decisions to liberalise recreation have been made, they are difficult to overturn, even when evidence of unacceptable risks emerge;
- the importance of multiple barriers is a fundamental principle of the Australian Drinking Water Guidelines and their international equivalents; it is more important to maximise the reduction in public health risk than approve recreational access that can meet existing guidelines; and
- the level of access currently allowed is somewhat on the high side of what is normal practice nationally; therefore alternatives should be sought, such as providing facilities outside or downstream of water catchments.[91]

Clearly, there is a conflict between some of the pro recreation arguments advanced in recent ACT Government reports and the more restrictive stance of the CRC for Water Treatment and Quality – and indeed of ACTEW itself. If an enlarged Cotter Dam is to be built, these issues will need to be resolved and an agreed position developed, if only because of the opportunity to incorporate some recreation design features into a new dam.

7.3 Effects on Public Health

The ACT Water Resources Management Plan, collectively encompassed by *Think water, act water,*[92] clearly sets out the need to "ensure water supply and management practices are consistent with protecting public health". In essence, the legislation requires that:

[90] *Ibid,* pp 15-16.
[91] Prof D Bursill (2004), letter to ACTEW 15 December 2004, commenting on the ActewAGL and Treatment and Water Futures report, *Technical Advice on ACT Reservoir Recreational Water Use Options, op cit.*

- a triple bottom line (environment, economic and social) approach be used in decision-making;
- water management occur within an ecologically sustainable, healthy, attractive, safe and efficient environment, ensuring provision for the needs of future generations;
- the reduction of source pollution be promoted;
- water quality protection generally receive higher priority than recreational access;
- waterways and aquifers be protected from damage; and
- secondary uses of designated catchments be permitted provided they do not compromise primary environmental values as water supply catchments. [93]

This means that an enlarged water supply at Cotter would need to be managed, as with existing supplies, with public health as the principal consideration. As noted in section 4.4, the water quality outcomes likely to be achieved at Cotter have been found to be within the range that can be utilised for human consumption, following appropriate treatment. However, human access to the catchment will need to be carefully managed, in order to keep microbiological contamination at a low level (for the reasons discussed in section 7.2). The management of such access will be particularly important for future recreational opportunities and facilities near Cotter Reservoir.

In the ACT, drinking water management follows the requirements of the following two key documents:

- *Drinking Water Quality Code of Practice,* published in 2000 by the ACT Department of Health and Community Care; and
- *Australian Drinking Water Guidelines*, published by the National Health and Medical Research Council and the Agriculture and Resource Management Council of Australia and New Zealand in 1996.

These documents emphasise the importance of a catchment to consumers and the need to retain multiple barriers to prevent the transmission of microbiological or chemical contaminants.

From quite a different public health perspective, one of the important dimensions is the stress and anxiety that residents suffer during prolonged periods of drought, and accompanying water shortages and restrictions. The time required to water established and valuable gardens by hand during higher level restrictions can be significant, encroaching into the available time for other pursuits. It is partly for this reason that ACTEW has reliability explicitly in its charter of service delivery.

Similarly, recreational activities for Canberra residents, and others dependent on ACT water, are constrained during periods of water shortage and restrictions because of their effects on sports grounds and public parks and gardens. In some circumstances there may also be a higher risk of injury from sports grounds whose conditions are well below optimal.

7.4 Energy Impacts

The ACT Government has a guiding objective to ensure the prudent use of resources.[94] This includes the minimisation of energy consumption and greenhouse gas emissions. Accordingly, as part of the evaluation of future water options, ACTEW commissioned an assessment of the energy implications of each of the options.[95] While the report stresses that the results should be only a guide due to the lack

[92] ACT Government (2004), *Think water act water*, *op cit*
[93] ActewAGL and Water Futures (2005), *op cit.*
[94] ACT Government (2003), *People, Place, Prosperity, op cit.*
[95] ActewAGL (2005), Greenhouse Gas Emissions, April 2005, ACTEW Corp Doc No. 4670.

of previous case studies and unknown variables, the following points summarise the analytical framework and the quantitative estimates for the Cotter Dam system.

A new water storage reservoir consumes energy and produces greenhouse gas emissions in three ways:

- construction energy and embodied energy of the materials used;
- energy and chemicals used in the operation of the system following construction; and
- decomposition of organic matter within reservoirs, both aerobic (where oxygen is readily available, and carbon dioxide is released) and anaerobic (where oxygen is absent and methane is released, methane having about 20 times the greenhouse impact of carbon dioxide).

All reservoirs (as well as natural lakes) release some greenhouse gases. The scale reflects:

- the amount of uncleared vegetation allowed to remain in a reservoir after the construction and flooding process;
- the amount of nutrients and organic matter entering the reservoir as catchment run-off after construction;
- the organic content of sediment;
- the depth of the reservoir;
- the temperature of the water; and
- the dissolved oxygen in the water column and at the sediment surface, which will determine whether carbon is decomposed aerobically or anaerobically.

Various management procedures can significantly reduce emissions, for example:

- removing trees and other large organic material during construction;
- maintaining good catchment health, thereby reducing organic material run-off; and
- destratifying the reservoir during warmer months to promote aerobic decomposition.

Energy is used during construction of any large infrastructure project, and is influenced by factors including:

- sourcing of materials: materials sourced locally tend to use less transport energy than those sourced from further away;
- the transport mode: mass transport options, such as rail, tend to use less transport energy than more tailor made options;
- the existence of waste minimisation programs on the construction site; and
- the balance of cut and fill: avoiding the import or export of soil will decrease the amount of transportation energy.

In addition, tunneling options requiring blasting and drilling will use more energy than the construction of dams, which in turn will use more energy than pipelines. The precise quantification of these construction energy costs is difficult and accurate estimates have not been able to be calculated.

Embodied energy is the amount of energy used to make a particular piece of material. Once again, quantification is difficult, given there can be large differences in:

- transport distances for raw materials;

- energy used on site for building or assembling;
- upstream energy inputs for manufacturing the material; and
- recycling of materials after their intended use.

In addition, the direct conversion of embodied energy into greenhouse gas emissions (in terms of carbon dioxide equivalent) depends on upstream energy sources, such as coal-fired power stations or hydropower, and whether methane was incorporated.

Against this background, the following calculations were made for the enlarged Cotter Dam option:

- embodied energy: 2,700 tonnes per year as CO_2 equivalent (assuming a 100 year life);
- operating energy (assuming 11 GL per year pumped from Cotter to Stromlo water treatment plant): 25,000 tonnes per year as CO_2 equivalent;
- sediment releases (based on overseas data): 220 tonnes per year as CO_2 equivalent (assuming best management practices are employed); and
- a total of 358 tonnes per year (CO_2 equivalent) per GL of dam capacity.

Measured on a CO_2 equivalent per GL stored, the large Tennent Dam option ranks best of the various new water supply options. This reflects high energy consumption in other activities such as tunneling for some of the Tantangara options or high pumping costs for the virtual dam alternatives pumping to Googong. The calculations have not factored in some elements of these proposals such as mini hydro power stations that would have a mitigating effect.

Energy estimates require further investigation to make a reliable comparison between options. The absence of virtual dam possible hydropower contributions to renewable energy has already been discussed but the use of existing reservoirs (at Tantangara and Corin) and their embodied energy also requires further consideration.

Finally, the beneficial greenhouse effects of a reliable water supply to Canberra's parks, gardens, and streetscape and their consequent microclimate effects are significant. Energy savings from these microclimate effects (through reduced air-conditioning and cooling) – and the threat to them from frequent water restrictions – should also be considered when comparing greenhouse gas emissions.

A recently published Tree Management and Protection Policy for the ACT noted, as some of the benefits of a well tree-ed and shady landscape, the fact that:

- urban trees mitigate the impact of human-induced urban heat islands, and reduce pollution (through the absorption of ozone, sulphur dioxide and nitrogen dioxide, the interception of particulate matter, and the release of oxygen);
- trees lower urban temperatures and reduce the rate of ozone formation;
- urban trees in car parks help lower the temperature of parked vehicles and reduce vehicle hydrocarbon emission;
- tree shade over roads protects weathering and reduces the need for frequent road sealing;
- urban trees reduce greenhouse gases (by storing carbon); and
- shading, wind shielding, evapo-transpirative cooling of air temperatures and modification of solar radiation reduce energy consumption for summer air conditioning

and winter heating – saving energy costs, reducing carbon dioxide emissions and power utility investments.[96]

These effects have not been quantified, although the impact of public area street trees that have died due to water restrictions has been factored in to the benefit cost analysis discussed in the next chapter.

7.5 Effects on Leaseholders

KMR Consulting was engaged to analyse the current arrangements of land ownership and leasing, and land use in the Cotter area.[97] As far as the Cotter Dam enlargement option is concerned, the areas of land affected are all unleased and owned by the ACT Government. Some is public land, managed by Environment ACT, and some is occupied by ACT Forests.

The Government would be required to comply with planning restrictions and any environmental conditions applied within Plans of Management gazetted for public land areas such as Namadgi National Park of the Murrumbidgee River Corridor. Generally, no formal acquisition would be necessary and ACT Forests could claim reimbursement for actual trees lost, but no compensation for land forfeited.

From a tenure point of view there is little impediment with the Cotter option, although some additional requirements may be imposed on any lessees within the re-established Pierce's Creek Forestry Settlement.

For the three levels of application (top water level, foreshore area and catchment) arrangements for catchment management are already in place. The existing co-operative arrangements across government agencies would be able to satisfy any increased environmental requirements.

If additional pipelines were required from Cotter Dam to the pump station or from the pump station to the Mt Stromlo treatment plant, they would follow the route of the existing pipeline. Affected rural leases contain a pipeline clause that would allow for the construction of such pipelines.

[96] Environment ACT (2001), *A Tree Management and Protection Policy for the ACT,* September 2001.
[97] KMR Consulting (2005), Land Ownership Study, April 2005, ACTEW Corp Doc No. 4652.

8 Economic Implications

8.1 Economic Framework

The Centre for International Economics (CIE) undertook a benefit cost analysis of future water options, using data and key assumptions provided by the Future Water Options Project Team.[98] Each future water option produces benefits in terms of a lower likelihood of restrictions than "do nothing", and hence a lower cost of restrictions. The basis of the benefit cost analysis is to compare the reduction in the expected costs of restrictions associated with a new water option (the benefit side of the equation) with the costs (both construction and operational) of providing it.

Behind this relatively simple economic framework, a number of quite complex variables need to be taken into account, for example:

- the stage of restrictions (there are five stages, each with a different target for reduction in water demand);
- impact of restrictions on different categories of water user;
- timing issues, requiring the discounting of future costs and benefits back to the present using an agreed discount rate (5 per cent real), to produce a net present value which can then be compared across different options; in addition a crucial timing consideration is the time at which a new water storage facility would be constructed;
- cost components, including construction costs, environmental costs and social costs, associated with each future water option; and
- the make-up of the do nothing options, including population growth, income growth, climate change, and demand management.

The outcome of the benefit cost analysis is to identify the option with the highest net present value (of benefits less costs).

Seven main costs of water restrictions have been identified:

- cost to households of dealing with restrictions;
- cost to business and industry of restrictions, including lost surpluses from plant based industries;
- cost of changed outside recreation options as a result of restrictions affecting parks and playing fields;
- cost of reduced outside tourism to the ACT resulting from restrictions affecting attractions such as Floriade, plus the impact on the urban environment such as street trees;
- cost of monitoring and enforcing restrictions;
- impact on ACTEW profits from reduced water sales; and
- impact on the ACT Government from reduced water extraction charge revenue while incurring fixed costs for water related activities.[99]

[98] Centre for International Economics (2005), Economic benefit-cost analysis of new water supply options, April 2005, ACTEW Corp Doc No. 4674.
[99] *Ibid,* p 6.

The starting point is two "do nothing" options, one based on medium population growth and one described as the prudent planning scenario. Under the medium growth scenario, Canberra's population would grow according to the medium projections of the ACT Demographer, demand management would result in a 12 per cent per capita reduction in water use by 2025, existing environmental flow assumptions apply and climate change is as predicted by CSIRO. Under the prudent planning scenario, population is assumed to grow according to the high projections by the ACT Demographer, while demand management would result in a 25 per cent per capita reduction in water use by 2025.

8.2 Costs to Households

Households are the main users of water in the ACT (see) and bear a significant proportion of the cost of water restrictions. Almost 90 per cent of ACT households have a garden, a figure that has not changed significantly over time.

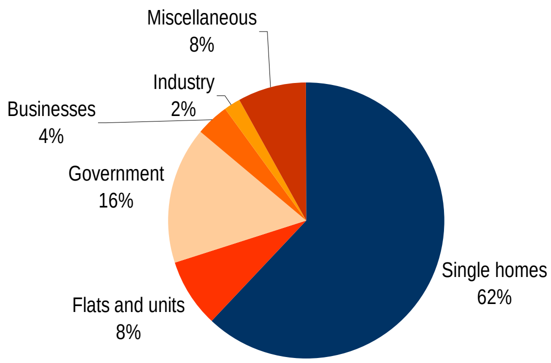

Figure 8.1: Water use in the ACT

Source: CIE report and ActewAGL

While, in theory, households could offset most of the impact of the way water restrictions are currently applied (eg by engaging sufficient numbers of "volunteers" to use many hoses), in practice restrictions limit water use and dictate behavioural change. Householders' costs of water restrictions include the inconvenience (and time taken) of hand-watering gardens, the cost of restoring gardens after restrictions have been lifted, and the cost of installing rainwater tanks or water efficient devices to "live with" restrictions. To estimate these costs, it is necessary to quantify householders' willingness to pay to obtain a reliable supply of water, free from restrictions on its use.

Household demand for water reflects several factors, not least its price. Some uses (for example, cooking and personal hygiene) are relatively insensitive to price (referred to as inelastic demand), whereas others (such as outdoor use) are more price sensitive (more demand elastic). The latter uses comprise around 55 per cent of total household water use, as shown in Figure 8.2.

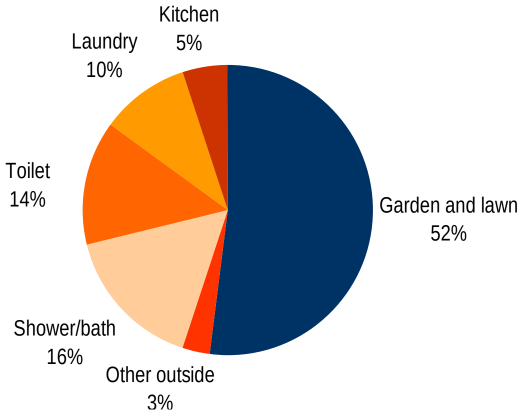

Figure 8.2: ACT Household use of water

Source: CIE report and ActewAGL

Other factors relevant to household water demand include the number of people in the household, property size, weather conditions, existing appliances and investments (dishwashers, spas, swimming pools, lawns etc), the cost of changing over to appliances that use less water, the cost and availability of grey water recycling systems, and so on.

The ACT has employed a mix of price-based and quantity-based measures, along with community education programs, in an attempt to influence water demand. The Government provides subsidies for the installation of water saving appliances, and the basis of water pricing has been modified over time to reflect user pays principles more closely[100]. In addition, consumer preferences change over time, with factors such as an increase in higher density/apartment living, individual responses to the recent water restrictions (such as replacing exotic garden plants with natives), and the wider availability of water saving technology, being examples.

The CIE report discussed an earlier study undertaken for ACTEW Corporation and ActewAGL by NERA and ACNielsen that examined households' willingness to pay for reliability of water supply.[101] While the study was not specifically targeted at future water supply options, and was conducted before participants had had extensive experience in dealing with water restrictions – after which arguably their willingness to pay for water reliability and avoid the inconvenience of restrictions may well have increased further – it provides useful information about the costs that restrictions impose on households. A total of 211 Canberra households participated in the survey, conducted in March 2003, that is, just after the January 2003 bushfires. At this time stage 1 restrictions (sprinklers to be used only between 6pm and 8am) were in place.

The results indicated that:

[100] Prior to 1991-92 households had a "free" allowance of 455kl and were charged for water use above this; between 1991-92 and 1993-94 the free allowance was 350kl. Since 1994-95, the free allowance has been 1kl, with usage up to 350kl being charged at 28c per kl, and 64c per kl above it. An assessment showed that many households, especially among middle-class households in older established suburbs, reduced water usage (there were no restrictions operating at the time) from 350kl to 300kl. See CIE, *op cit,* p 13.

[101] NERA and ACNielsen Research (2003), *Willingness to Pay Research Study,* a report for ACTEW Corporation and ActewAGL, September 2003.

- respondents were only willing to pay to avoid restrictions that were stage 3 or above, that lasted all year and that applied every day;
- on average, households were willing to pay $237 (31 per cent of the average water and sewerage bill) to reduce the frequency of these restrictions from every year to never; and
- respondents were not willing to pay to avoid brown lawns in public areas.

The CIE report also noted the results of the community consultation meetings, conducted as part of the Future Water Options project, in which participants were asked explicitly how much they would be prepared to pay to reduce the frequency of water restrictions. Twenty-eight per cent said nothing, and that they were happy with restrictions one year in six; 28 per cent said $40 per year to reduce the frequency from one year in six to one year in 12; 23 per cent said $80 per year to reduce the frequency from one year in six to one year in 25, and 21 per cent said $150 per cent to reduce the frequency from one year in six to one year in 70.

These answers are equivalent to saying the cost of restrictions is $480 (for the $40 willingness to pay group), $632 (for the $80 willingness to pay group), and $984 (for the $150 willingness to pay group), or $486 on average per household (inclusive of the 28 per cent who were not willing to pay to have the frequency of restrictions lessened).

From this study and other data and analyses, CIE produced a range of estimates for household costs of water restrictions, reproduced in Table 8.1. These data are in turn used in the calculations reported below.

Table 8.1: Estimates of household cost of water restrictions (based on 2005 prices and incomes)

	Lower estimates	Higher estimates
Per household estimates		
	$	$
Stage 1	18	24
Stage 2	80	118
Stage 3	198	360
Stage 4	224	411
Stage 5	396	769
Average for stage 3 and above	*273*	*513*

Source: CIE estimates based on water use data, a range of elasticity estimates and NERA/ACNeilson.

In aggregate household terms, the cost of stage 3 restrictions ranges between $20 and $36 million, rising to $40 - $77 million for stage 5 restrictions.

8.3 Other Costs of Restrictions

There are at least two effects of water restrictions on commercial and industrial activities in the ACT: the effects on businesses that use water themselves, and reduced sales by firms that sell products that require water for their ultimate use.[102]

[102] A possible third effect – reduced demand for goods and services because people are hand watering when they could be eating at restaurants, going to the movies etc – has not been taken into account in the CIE analysis. Tracing out the full effects of restrictions is complex, for example, the ACT economy may receive a "boost" to the

As to the first category, the CIE's economy-wide model of the ACT/Queanbeyan region assessed the cost of stage 3 and above water restrictions per average commercial water user at $1560, a broadly similar figure to the NERA/ACNielsen's willingness to pay estimate for commercial customers of $1104.

The second category includes nurseries and businesses selling lawn, and other water intensive, products. The overall effect here is complex, both because demand for native or water hardy plants may increase, and that consumers who do not spend money on these products will tend to spend similar amounts elsewhere, with similar overall output, employment and consumption effects. In the case of nurseries, the capital tied up in existing stocks of plants for which demand has declined cannot easily be transformed to other plants. However, there is evidence of significant sales declines by nurseries due to the recent stage 3 restrictions. Taking all these factors into account, the CIE's cost estimate of stage 3 restrictions on nursery businesses was put at $2.9 million, rising to $8.6 million for stage 5 restrictions.[103]

The cost of water restrictions on recreation activities was estimated by noting that ACT residents spend around 164 hours per year on outdoor recreation, an implicit value of around $1600. Assuming that 15 per cent of this time needs to be reallocated under stage 3 restrictions, and adding a cost to restore the recreation activities after restrictions have been lifted (such as replanting of lawn), produces a total cost estimate of $8 million for stage 3 restrictions, rising to $21 million for stage 5 restrictions.

The impact of water restrictions on tourism in the ACT is difficult to determine, although tourism is a major activity, contributing about $690 million to the ACT's gross state product each year. The CIE's assumption is that stage 5 water restrictions would reduce tourism by 10 per cent, relative to what it otherwise would be, implying a $31 million reduction in real household welfare, using the economy-wide model.

There is anecdotal evidence that some of the existing decline in tourism numbers to the ACT is in response to the combined impact of drought and water restrictions. However, there is no hard quantitative evidence to support this and CIE has not factored it in to its calculations, which may therefore be on the conservative side.

As noted in section 7.4, the benefits of Canberra's "garden city" status, especially the impacts of street trees and other trees in the urban environment, are significant. Canberra Urban Parks and Places has estimated that around half of the 6000 street trees lost as a result of the drought, could have been saved in the absence of water restrictions.[104] Attributing a conservative value of $1000 for each tree, including the cost of its removal, the cost of stage 3 restrictions on street trees is $3 million.[105]

The imposition of water restrictions imposes a range of transactions costs, such as advertising material to inform the community, monitoring compliance with restrictions, and prosecuting breaches. These costs have been estimated at $1.8 million for stage 3 restrictions.

Stage 3 restrictions have been estimated to reduce ACTEW's profits by $3.8 million, rising to $8.4 million at stage 5, and the ACT Government will experience an additional revenue loss of $1.3 million at stage 3, rising to $2.9 million at stage 5.

extent that fewer residents choose to go to the coast at weekends because they are staying at home to keep their gardens alive. And so on.

[103] These estimates drew in part on confidential sales data from a number of representative nurseries.

[104] This section has been assisted by discussions with staff of Canberra Urban Parks and Places, part of the Department of Urban Services.

[105] There is an established methodology that values such specimen trees, with outstanding examples being attributed a value of up to $100,000 each in some circumstances.

8.4 Overall Costs

The total costs of restrictions for stages 3 and 5, drawing together the material from the previous two sections, and assuming one year in restrictions at the stage indicated, are as shown in Table 8.2. The estimates for 2055 are based on assumed population and income growth, expressed in today's dollar terms.

Table 8.2: Total costs of spending one year in restrictions ($ million)

Category of cost	Stage 3	Stage 5
Household (upper estimate)	36.2	76.7
Commercial	6.3	13.1
Recreation	8.0	20.8
Tourism/street trees	3.0	37.0
Transactions costs	1.8	3.6
ACTEW profits	3.8	8.4
ACT Government	1.3	2.9
Total	**60.3**	**162.8**
Projected to 2055 (2005 $s)	**157.6**	**428.9**

Source: CIE analysis.

Under either of the do nothing options, the probability of water restrictions increases over time in line with population growth and water demand, net of demand management efficiencies. With the medium growth scenario, the expected time in restrictions rises from 26 per cent now, to 54 per cent by 2055, with around 15 per cent of the time being in stage 3 restrictions or above, as shown in Figure 8.3. Under the prudent planning scenario, the proportion of time in restrictions hits 100 percent by 2043; by 2055 the probability of stage 3 restrictions or above is 50 per cent, as shown in Figure 8.4.

In order to estimate the costs of restrictions in the do nothing options, the cost data associated with restrictions need to be multiplied by the expected time in restrictions. This is shown in Figure 8.5 for the medium growth option and Figure 8.5: Expected cost of restrictions, medium growth scenario

for the prudent planning option.

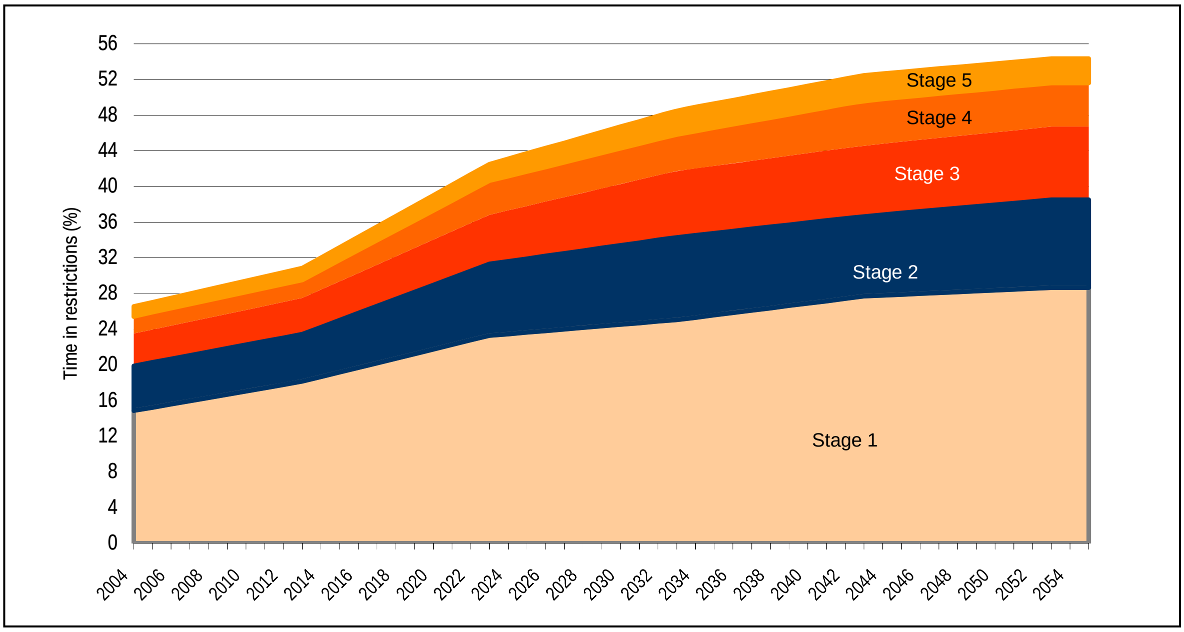

Figure 8.3: Cumulative time in restrictions (medium growth scenario)

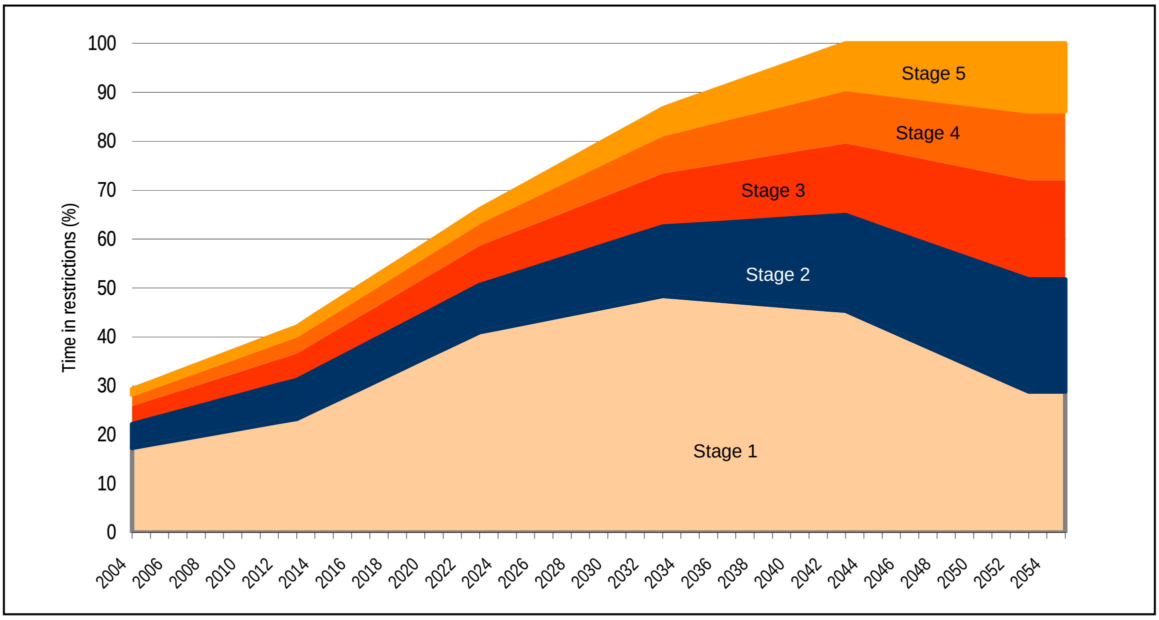

Figure 8.4: Cumulative time in restrictions (prudent planning scenario)

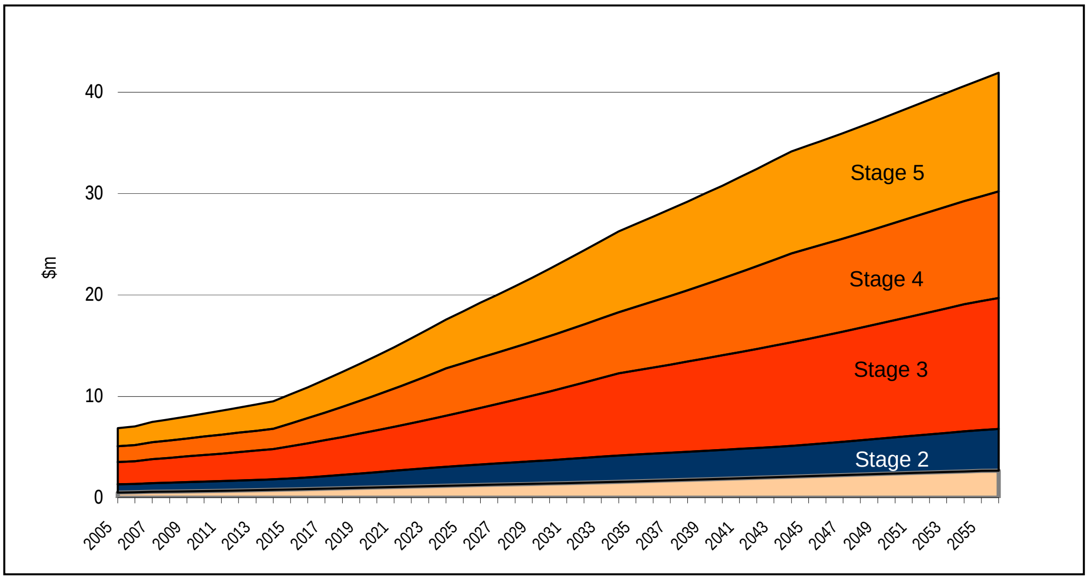

Figure 8.5: Expected cost of restrictions, medium growth scenario

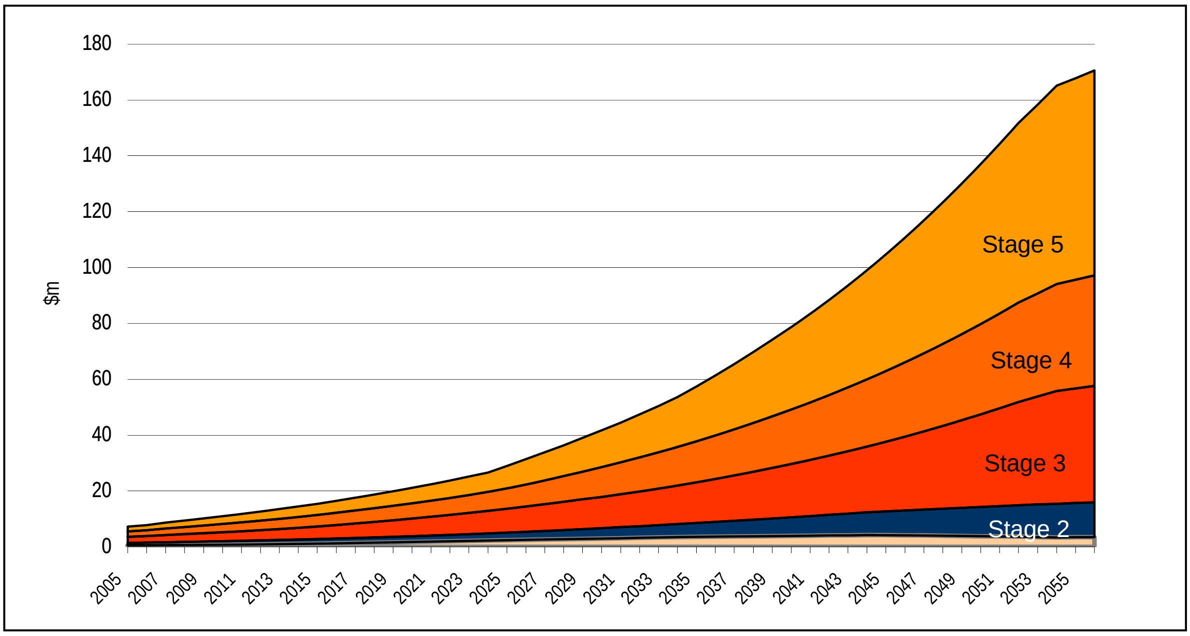

Figure 8.6: Expected cost of restrictions, prudent planning scenario

In the medium growth scenario, the total expected cost of restrictions increases from $7 million in 2005 to $42 million by 2055, with most of the costs arising because of stage 3 or above restrictions. In line with the much higher expected time in restrictions associated with the prudent planning scenario, the expected costs are also much higher, rising to $170 million by 2055, with the bulk being associated with stage 4 or 5 water restrictions.

8.5 Implications for Cotter Dam Enlargement

The performance of each water supply option can be measured by the extent to which it decreases the expected time at each stage of restrictions relative to the do nothing options. In other words, the "benefits" of each option is equivalent to the reduction of costs as discussed in previous sections.

As far as Cotter Dam enlargement is concerned, CIE modeled three alternatives: Cotter Dam on its own, Cotter Dam in conjunction with the Virtual Tennent option, and Cotter Dam in conjunction with the large Tennent Dam. Other alternatives not involving Cotter were also modeled. The results relating to Cotter Dam are in Table 8.3 which shows the percentage point reduction of expected time in restrictions, at the stages specified, and for the years out to 2050, for both the medium growth and prudent planning scenarios. For example, for the enlarged Cotter Dam alone in 2020 and the medium growth do nothing option, the expected time in any level of water restrictions would fall by 21 percentage points (from 39 percent of the time to 18 percent of the time[106]

Table 8.3: Performance of Cotter Dam enlargement, relative to do nothing options (percentage point reduction of expected time in restrictions)

		2010	2020	2030	2040	2050
Cotter Dam alone						
	Medium growth					
	All stages	18	21	23	24	25
	Stage 3 + above	5	6	8	9	9
	Prudent planning					
	All stages	22	37	44	40	19
	Stage 3 + above	6	10	13	17	21
Cotter + Virtual Tennent						
	Medium growth					
	All stages	26	32	37	39	41
	Stage 3 + above	6	9	11	13	13
	Prudent planning					
	All stages	32	52	65	67	56
	Stage 3 + above	8	13	18	26	35
Cotter + large Tennent						
	Medium growth					
	All stages	27	36	42	45	47
	Stage 3 + above	7	9	12	14	14
	Prudent planning					
	All stages	35	55	72	78	71
	Stage 3 + above	9	13	20	28	38

Source: CIE analysis

The costs associated with the three alternatives involving Cotter Dam enlargement are shown in Table 8.4. Thus for Cotter Dam alone, there is the capital cost ($120 million – see Chapter 5), an allowance for environmental management ($5 million) and annual operational (including energy) costs ($1.2 million for the medium growth baseline or $1.4 million for the prudent planning baseline). These costs are then brought back to a net present value (using a 5 per cent real discount rate), resulting in $124 million for the medium growth scenario and $127 million for the prudent planning scenario.[107]

Table 8.4: Costs of Cotter Dam alternatives ($m)

[106] See CIE (2005), *op cit,* p 45.

[107] Assuming capital costs are incurred in 2007 and 2008, environmental costs are incurred over the four years 2007 – 2010 and operational costs commence in 2010. In addition, Cotter Dam enlargement entails an opportunity cost of foregone forestry production associated with land that would be inundated or otherwise converted to a buffer zone by the new dam, and an estimate is made of the value of "lost" water for downstream users in the Murrumbidgee Valley.

Option	**Capex**	**Environ Mngt**	**Annual costs**		**Present Value of costs (in 2005)**	
			MG	**PP**	**MG**	**PP**
Cotter alone	120	5	1.2	1.4	124	127
Cotter + Virtual Tennent	160	7	2.6	3.5	179	192
Cotter + large Tennent	370	8	4.1	4.6	392	396

The CIE report then calculates the net benefits associated with each of the alternatives analysed, and against both baseline assumptions. It also provides the results against a combined baseline. The data assume the "best" timing to build the various dams, noting that delaying construction until demand warrants it provides a better outcome because of the way the discounting (net present value) arithmetic operates on up front capital costs versus delayed benefits from reduced time in restrictions. The results for the alternatives involving Cotter Dam enlargement are shown in Table 8.5.

Table 8.5: Net benefits associated with Cotter Dam enlargement ($m)

Option	Medium growth	Prudent planning	Combined
Cotter alone	37	205	121
Cotter + Virtual Tennent	54	290	172
Cotter + large Tennent	-94	168	37

Cotter plus Virtual Tennent is the preferred option under the prudent planning baselines, and second under the medium growth baseline. It remains the preferred option under the combined baseline. The Cotter Dam by itself ranks either fourth or fifth, and the combined Cotter and large Tennent Dam option ranks seventh or ninth (out of nine analysed). The Cotter Dam by itself is more costly option relative to the improved water performance than Virtual Tennent, whereas the combination of Cotter and large Tennent, while producing the best performance (in terms of reduction in expected time in water restrictions) does so at what today is a prohibitive cost.

Various sensitivity tests – higher discount rate, lower/higher economic growth, and lower estimates of household costs of water restrictions – do not greatly change the ranking of options. Cotter plus Virtual Tennent is ranked first or second in all cases (Virtual Tennent ranks ahead of it in some circumstances), Cotter fifth or fourth, and Cotter plus large Tennent ninth or eighth. These results indicate that the rankings are fairly robust against changes in key model assumptions.

Finally, the CIE report describes changes to the outcomes of the model when modified environmental flow assumptions are used. The values for net benefits decline somewhat in each case – because more water presently required for environmental flows would be available for potable water consumption, thus implying a reduced need for additional water storage – but the rankings remain largely unchanged (although Cotter on its own rises from fifth to fourth rank). Cotter plus Virtual Tennent remains the preferred option.

9 Risk Assessment

9.1 Approach

The risk assessment process employed workshops to identify and measure the degree of risk by multiplying the ***likelihood*** of an event occurring and its ***consequence***. The approach is consistent with the Australian Risk Management Guidelines (AS/NZS 4360) and the US Environment Protection Agency framework.

Despite its subjectivity, this approach generates reasonable risk analyses when experienced workshop participants provide knowledge on the risk events and their characteristics. Figure 9.1below shows the approach.[108]

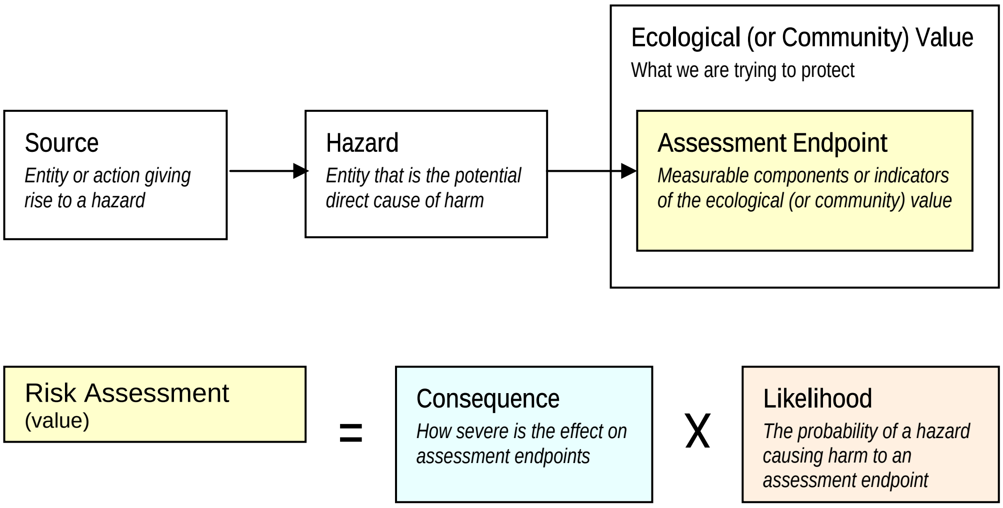

Figure 9.1: Risk Assessment Approach

A qualitative risk assessment of the potential future water options has been conducted in accordance with the Australian/New Zealand Standard for Risk Management[109]. The risk assessment identifies risk sources associated with the implementation of each of the option alternatives, assesses the level of risk involved and establishes control measures or actions to reduce the level of risk.[110]

The methodology for risk assessment involves two stages. The first is to determine the 'inherent risk', or the risk that exists before control actions are applied. The second stage is to determine the 'residual risk', or that level of risk that still remains after control actions have been implemented. In both stages the level of risk has been assessed as the *likelihood* (in a numeric scale) of an event occurring multiplied by its *consequence* (also scaled numerically).

Based on the inherent risk level, the acceptability and required action for each risk source has been determined according to Table 9.1below.

[108] CRC for Freshwater Ecology (2004); Ecological Risk Assessment, October 2004, ACTEW Corp Doc No. 4676 p 5.
[109] Australian/New Zealand Standard 4360: 2004 (Risk Management)
[110] The risk assessment work is described in more detail in URS and ACTEW (2005), Future Water Options Risk Assessment, April 2005, ACTEW Corp Doc No. 4650.

Table 9.1: Level of Risk and Required Actions

Description	Required Action
Extreme	Shall be brought to the immediate attention of senior management (including Quality, Health Safety and Environment management) and the task must not be commenced until sufficient risk reduction has been undertaken.
Very High	Shall be brought to the immediate attention of senior management (including Quality, Health Safety and Environment management) so consideration can be given to immediate interim controls until the risk has been reduced/mitigated. Any decision to proceed must come from senior management and must involve extraordinary care and contingency planning.
High	Shall receive attention as soon as possible and with some priority. The risk must be closely and continuously monitored to ensure it does not occur. Interim measures may be adopted such as isolation of the risk.
Moderate	Shall be dealt with as soon as practicable but the situation is not urgent. However, the situation should be monitored to ensure circumstances do not change and people are aware of the risk.
Low	The risk would normally be acceptable. However, the situation should be monitored to ensure circumstances do not change.

The following risk reduction methods have been applied for all risks:

- avoid the risk;
- reduce the likelihood of occurrence; safety, health and environmental risks are a specific type in which a hierarchy of controls are applied to the originating hazard to reduce the chance of an incident occurring;
- reduce the consequences;
- transfer to another party, normally better equipped to manage the risk; and
- retain and manage the risk.

9.2 Results

A risk assessment of the Cotter Dam enlargement option identified a large number of potential risk sources. Those that pose the greatest risk are listed below and outlined in the risk assessment report:

- very high risk that, on its own, an occasional need for stage 4 or 5 water restrictions in Canberra and frequent need for stage 3 restrictions – that is, a new Cotter Dam alone would not provide sufficient water to meet Canberra's future water needs;
- very high risk of the condition of the catchment following the January 2003 bushfires exacerbating turbidity and water quality problems;
- very high risk of poor catchment management practices continuing to affect water quality; and
- very high risk associated with management of the recreational use of the Cotter catchment. [111]

None of the risks were judged as extreme, unlike the case with some of the other future water options.

[111] *Ibid*.

9.3 Control Measures

The risk that the reliability of supply provided by the Cotter option would lead to an unacceptable amount of time in stage 3 water restrictions or worse, can only be mitigated by implementing the Cotter option in combination with other options.

The risks relating to water quality require intensive catchment remediation – indeed, regardless of whether the Cotter Dam is enlarged or not – and improved catchment management practices such as erosion controls.

Risks relating to recreation will require the development of a recreation management plan, as discussed in section 7.2 above.

With the implementation of adequate control measures the risks associated with the Cotter Dam enlargement option are considered to be manageable and would not preclude a decision to proceed.

10 Sustainability Assessment

10.1 Sustainability Framework

The sustainability framework sets out the regulatory requirements and policy guidelines that define how ACTEW should proceed with a sustainability assessment.[112]

The concept of sustainability:

- recognises that effective environmental solutions must achieve a balance with economic and social issues;
- reflects ecologically sustainable development as defined in the *1992 National Strategy for Ecologically Sustainable Development* as "development which aims to meet the needs of Australians today, while conserving ecosystems for the benefit of future generations"; and
- means maintaining or enhancing total resources without reducing any one type of natural, human, social, physical or financial capital below a point of irreversibility.

ACTEW's objectives now include ecologically sustainable development principles:

- the precautionary principle, whereby a lack of scientific certainty should not be used to postpone taking action to prevent environmental degradation;
- the inter-generational equity principle, whereby the present generation should ensure health diversity and productivity of the environment for the benefit of future generations;
- conservation of biological diversity and ecological integrity; and
- improved valuation and pricing of environmental resources.

10.2 Environmental, Social and Economic Parameters

Analyses conducted for the Future Water Options project used environmental, social and economic assessments similar to those used by other water agencies in Australia and overseas. The assessment criteria were developed from *People Place Prosperity*.[113] In turn, twelve sustainability criteria – four relating to each of environmental, social and economic factors – were developed with expert input, and in consultation with the community, for the evaluation of the future water options (see Table 10.1. These assessment criteria are designed so that:

- there is equal consideration of economic, environmental and social factors;
- they encompass the key issues involved in the comparison of Future Water Options as identified in public and agency consultation, and can be measured for the different options;
- they are able to show a difference for the various options;
- they do not overlap, in order to avoid the problems of double counting;
- they reflect local, regional, basin-wide, national and worldwide concerns and interests; and

[112] This chapter draws on Consulting Environmental Engineers and Institute of Sustainable Futures (2005), Sustainability Framework and Assessment, April 2005, ACTEW Corp Doc No. 4666.
[113] ACT Government (2003), *People, Place, Prosperity, op cit.*

- they provide a direct measure of inter-generational equity.

Table 10.1: Sustainability Criteria for Evaluation of Future Water Options

Criteria	Sector
Effect on aquatic ecology	Environment
Effect on terrestrial ecology	Environment
Greenhouse gas emissions	Environment
Intrinsic value	Environment
Risk to public health	Social
Heritage and cultural values	Social
Landscape and amenity values	Social
Recreational opportunities	Social
Cost and affordability	Economic
Reliability	Economic
Employment creation	Economic
Distribution of costs and benefits	Economic

An initial set of criteria was developed in scoping workshops involving project team members, specialist consultants and representatives of government agencies. A series of refinements occurred involving discussions with the ACT Office of Sustainability and the Sustainability Expert Reference Group; four community and community group workshops; the Institute for Sustainable Futures; and the project team.

10.3 Assessment Procedure

The procedure followed to assess the various options was as follows:

- a summary of the key environmental, social and economic issues relating to the construction and operation of each of the six options being assessed was prepared;
- a scoring sheet was prepared, with the effects, levels or attributes of the options in terms of each criterion being quantified;
- at the workshops, the criteria were discussed sequentially;
- participants scored each option for each criterion, using an eleven point scale: - 5 (worst) to 0 (no change) to + 5 (best);
- participants then weighted the criteria, providing a judgment of how important each criteria is relative to the others;
- the average score and average weighting for each criterion were calculated;
- average scores were multiplied by average weightings to derive normalised average scores for each group of criteria, and the rank of the options calculated for each group of criteria (the option with the highest normalised average score was ranked first, and so on); and
- the overall rank of the options was derived by calculating the normalised average score for all 12 criteria.

10.4 Results from Project Team Workshop

The first workshop involved the project team, as it was considered that members would have a good understanding of the characteristics and issues relating to the options and could provide comment on the documentation of issues as well as 'test run' the scoring and weighting procedure. There were 12 project team members present, and the workshop was independently facilitated. The rankings for the three groups of criteria and the overall ranking for the options are shown in Table 10.2.

Table 10.2: Sustainability Ranking of Major Options by Project Team

Option	Overall ranking	Environment	Social	Economic
Large Cotter Dam	1	1	2	4
Tantangara – via river	2	3	1	3
Tantangara tunnel	3	5	3	1
Virtual Tennent Dam	4	2	4	2
Small Tennent Dam	5	4	5	5
Large Tennent Dam	6	6	6	6

The outcome was that the Cotter option was ranked best on the basis of least environmental impacts, and little social impact. These considerations outweighed the lower ranking of the Cotter option in terms of economic criteria.

10.5 Results from Community Perspective

The second workshop involved 12 community representatives, three from each of four groups (Conservation Council, Engineers Australia, commercial interests and 'concerned citizens'). These representatives had previously attended a briefing on the project, so were reasonably informed about the options and their implications. However, they should not necessarily be seen as representing the whole community.

The results were somewhat bi-polar, with half clearly favouring the large Tennent option and the other half clearly favouring the Tantangara via the river option. Nonetheless, the procedure of averaging scores and weights mutes these preferences, leading to the overall rankings as shown in Table 10.3.

Table 10.3: Sustainability Ranking of Options by Community Representatives

Option	Overall ranking	Environment	Social	Economic
Large Cotter Dam	1	1	3	4
Large Tennent Dam	2	4	1	1
Small Tennent Dam	3	5	2	3
Tantangara – via river	4	2	5	6
Tantangara tunnel	5	6	4	5
Virtual Tennent Dam	6	3	6	2

Once again, the Cotter option was ranked best on the basis of least environmental impacts, and this outweighed the lower social and economic rankings for this option.

10.6 ACT Government Agency Perspective

The third workshop involved representatives of ACT Government agencies. The rankings for the three groups of criteria and the overall ranking are shown in Table 10.4.

Table 10.4: Sustainability Ranking of Options by ACT Agency Representatives

Option	Overall ranking	Environment	Social	Economic
Large Tennent Dam	1	1	1	1
Large Cotter Dam	2	2	2	2
Small Tennent Dam	3	3	4	3
Tantangara tunnel	4	6	3	4
Tantangara – via river	5	4	5	6
Virtual Tennent Dam	6	5	6	5

The outcome was that the large Tennent option was ranked best. The Cotter option was also well regarded. Most participants saw the Tantangara options as having a lower benefit than additional storage of water in the ACT.

10.7 Overall Assessment

The preferences and rankings developed in the sustainability workshops reflect the views of a small number of participants of generally informed people. The community has not been surveyed as a whole if only because it would be impossible to obtain a single answer that represented the view of "the community".

Indeed, the results of the three workshops show there is a range of views as to the best option. No single option was favoured in all workshops although, overall, there was a slight preference for the Cotter option. The Tennent options ranked highly in one workshop and poorly in another. Similarly, the Tantangara options ranked highly in one workshop and poorly in others.

11 Abbreviations

°C	degress Celsius
$m	Million Dollars (Australian)
µg/L	Microgram per liter (equivalent to parts per billion (ppb) or one millionth of a gram per litre)
ACT	Australian Captial Territory
ANU	Australian National University
AS/NZS	Australian and New Zealand Standards
CFU	colony forming units
CO2	Carbon Dioxide
COAG	Council of Australian Governments'
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EHN	Epizootic Haematopoietic Necrosis (Fish Virus)
GL	Gigalitres (1 gigalitre = 1 000 000 000 litres)
GL/yr	Gigalitres per year
ha	hectares (equals 10,000 square meters)
km	kilometres
km2	square kilometres (equal to one million square meters (m2), 100 hectares (ha))
kW	kilowatts (1,000 watts)
kWh	kilowatt hours (1,000 watts for one hour)
m	metres
m3	cubic metres
mg/L	milligrams per litre
ML	Megalitres (1 megalitre = 1 000 000 litres)
mL	millilitre
ML/day	Megalitres per day
mm	millimetres
Mt	Mount
NSW	New South Wales
NTU	Nephelometric Turbidity Units
Pt-Co	platinum-cobalt units
WTP	Water Treatment Plant

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