Independent Competition and Regulatory Commission

Enlarged Cotter Dam Water Security Project Investigation

Final Report

March 2010

Halcrow Pacific Pty Ltd

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Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Prepared by	Checked by	Authorised by
1	0	Preliminary Final Report	04/03/2010	DF/DS		
1	1	Final Report	17/03/2010	DF	AMD/JOS	JOS
1	2	Final Report + expanded findings	22/03/2010	DF	JOS	JOS
1	3	Final Report with response to ACTEW comments	28/04/2010	DF	DF	JOS

Contents

1 Introduction

1.1 *Background*

The ACT Government has released a Terms of Reference (TOR) to the Independent Competition and Regulatory Commission (the Commission) to undertake a review of matters relating to the cost estimates for the Enlarged Cotter Dam water security project (the ECD project). The TOR require the Commission to consider the prudency and the efficiency of the current cost estimates in terms of meeting the additional water security requirements contained in ACTEW's service delivery obligations.

The ECD project is one of a number of major projects being implemented by ACTEW Corporation (ACTEW) as part of its Water Security Program. The enlargement of the Cotter Dam on the Cotter River is an integral feature of the ACT Government's suite of initiatives designed to deliver water security for the ACT and region.

The ECD involves the construction of a Roller Compacted Concrete (RCC) dam approximately 80 metres in height, and located approximately 125 metres downstream of the existing Cotter Dam. When complete, the ECD will increase storage capacity of the Cotter Reservoir from the existing 4 gigalitres to 78 gigalitres. The ECD will also involve the construction of two saddle dams.

1.2 *Review Objectives*

The objective of this review is to fulfil the requirements of the TOR, that is, for the Commission to examine and report on:

1. whether the projected costs of the ECD project are prudent and efficient in terms of meeting the water security standards required of ACTEW;
2. the approach taken to put into place an alliance arrangement with contractors for the construction of the project's capital works;
3. the process undertaken to develop and test the costing of the ECD project;
4. the potential for any new cost variations to be incurred under the contractual arrangement;
5. the scope for cost savings to be passed on to ACTEW to the benefit of ACT and regional water users; and
6. any other matter the Commission considers relevant.

1.3 *Scope of Review*

The Commission engaged Halcrow, a consultant with experience in dam construction, construction costing and hydrological modelling, to assist with the conduct of this review. In particular, Halcrow was engaged to undertake the following tasks:

1. Investigate the projected costs of the project through a review of all relevant documents and determine whether the costs are prudent in terms of meeting the water security standards required of ACTEW, in particular providing expert advice as to whether the upgraded dam design is optimised and fit-for-purpose and whether the hydrological data supporting the design is valid and takes into account the impacts of climate change.
2. Determine whether the costs are efficient in terms of meeting the water security standards required of ACTEW, including providing advice on whether the scope of work in the approved design is accurately costed and assessing the risk of significant, unfavourable cost variations.
3. Investigate the contractual and alliance arrangement for delivery of the project through the review of relevant documents and provision of expert advice on:
    a. whether the approach taken for the alliance arrangement was prudent and consistent with best practice;
    b. the process to develop and test the costings of the project at all stages from 2005 to November 2009 and whether this process is consistent with best practice for major capital works design and implementation;
    c. whether there is potential for new cost variations under the alliance contract; and
    d. the scope for cost savings to be passed on to ACTEW and whether these will then be passed through to the benefit of the ACT and regional water users.
4. Any other matters arising from the investigations that are undertaken and considered to require further investigation.

   Following issue of the draft report, the Commission requested that Halcrow undertake a further assessment of the prudence of the original drivers of the ECD project.

2 Project Approach

2.1 *Overview*

This section outlines the approach adopted in undertaking this review. It has involved the following steps/phases:

- Project initiation;
- Initial review of data;
- Detailed interviews;
- Detailed analysis;
- Preparation of a Draft Report; and
- Preparation of a Final Report (this report).

An overview of each of these steps/phases is provided in the following sections.

2.2 *Project Initiation*

2.2.1 *Overview*

This phase of the review involved our preparations to undertake this project, including project inception meetings and implementation of provisions to ensure the security/confidentiality of information provided for review.

2.2.2 *Project inception meeting*

Project inception meetings were held with the Commission and with ACTEW on Friday, 18 December 2009 to confirm the scope of the review, and to discuss confidentiality provisions and our approach to keeping information provided by ACTEW appropriately secured.

2.2.3 *Confidentiality*

All members of the review team were required to sign confidentiality agreements prior to commencing work on the project, copies of which are held by the Commission.

2.3 Initial Review of Data

2.3.1 *Overview*

This phase comprised our initial review of the data initially provided by ACTEW for the purposes of this review. The information was reviewed and a set of key issues were identified for further discussion during the detailed interviews.

2.3.2 *Review of documents*

ACTEW provided a substantial amount of information related to the project. This information was reviewed to identify any potential data gaps including any additional information that appeared necessary to prepare for the interviews.

This initial review identified a number of key issues that required discussion during our detailed interviews with ACTEW personnel. These issues were categorised under the three key tasks that comprised the scope of the review, that is:

1. Prudence of proposed solution;
2. Cost efficiency; and
3. Contractual/alliance arrangements.

2.3.3 *Development of interview questions*

An Issues Report highlighting the key areas requiring discussion during the interviews was prepared. This report, a copy of which is provided in **Appendix A**, formed the basis of our interviews; it was submitted to ACTEW prior to the interviews to allow time for preparation.

2.4 Detailed Interviews

2.4.1 *Overview*

This phase comprised the conduct of detailed interviews with ACTEW and other project related personnel.

2.4.2 *Interviews with ACTEW*

Detailed interviews covering the areas identified in the issues report were held with relevant ACTEW personnel over the period from 12 January 2010 to 14 January 2010 at ACTEW's Water Security Projects office at Mount Stromlo. **Table 2.1** following lists the personnel interviewed while the agenda contained in **Appendix A** provides details of the topics in respect of which the individual staff were interviewed.

Table 2.1: Personnel Interviewed

Name	Title	Company
Ian Carmody	Director, Water Security Operations	ACTEW
John Dymke	Bulk Water Alliance Chief Engineer	ACTEW
Peter Buchanan	ECD Design Manager	GHD
Maurice Bell	Bulk Water Alliance Operations Delivery Manager	ActewAGL
Richard Frost	Bulk Water Alliance Program Design Manager	GHD
Tim Purves	Planning Options Computer Modeller	ActewAGL
Chris Allen	Director	Project Support
Ray Hezkial	Bulk Water Alliance ECD Manager	ActewAGL
Allan Roberts	Bulk Water Alliance ECD TOC Manager	Abigroup
Paul Gallagher	Bulk Water Alliance Program Director	Abigroup
Brigitte Kuhn	Bulk Water Alliance, ECD Fish Studies Program Director	ACTEW
Ray Sloan	Bulk Water Alliance ECD Fish Studies Project Manager	GHD
Mark Sullivan	CEO	ACTEW

2.5 Detailed Analysis

2.5.1 *Overview*

This phase of the review comprised the detailed analysis of the ECD project. The analysis has focussed on the three key areas that comprised the scope of the review, that is:

1. Prudence of the proposed solution;
2. Cost efficiency; and
3. Contractual/alliance arrangements.

2.5.2 *Prudence of proposed solution*

This involved investigating the project to determine whether the upgraded dam design is optimised and fit-for-purpose and whether the hydrological data supporting the design is valid and takes into account the impacts of climate change.

It has involved a review of:

- development of the Water Security Program and the inclusion of the ECD project as part of the Program;
- the validity of the dam design; and
- the validity of the hydrological analysis supporting ACTEW's decision making process.

2.5.3 *Cost efficiency*

This involved determining whether the costs of the ECD project are efficient in terms of meeting the water security standards required of ACTEW. It has involved a review of:

- development of the cost estimates for the ECD project, from initial planning to the Target Outturn Cost (TOC) estimate;
- unit rates used to develop the cost estimates; and
- independent verification of the cost estimates.

2.5.4 *Contractual/alliance arrangements*

This involved investigation of the contractual and alliance arrangement for delivery of the project through the review of relevant documents including a review of:

- decisions to implement an alliance based delivery model;
- the process used to build up the TOC estimate;
- provisions for incentivisation under the Alliance contract, including the pain-share/gain-share mechanism and Quality Pool;
- terms and conditions in the Alliance contract that deal with changes to the ECD project;
- and
- ACTEW's process for dealing with changes arising over the ECD project.

2.6 Draft Report

2.6.1 *Overview*

This phase of the review comprised preparation of the Draft Report which was submitted to ICRC and to ACTEW for comment on 12 February 2010.

2.6.2 *Draft report*

The preparation of the Draft Report involved collation of the outcomes of the detailed analysis based on the information supplied during and after the interviews. It documented the information reviewed, the analysis undertaken, and the basis upon which findings/conclusions were drawn.

2.6.3 *Discussions with ICRC and ACTEW*

A workshop was held with the Commission and ACTEW on 24 February 2010 to discuss the findings of the review. The workshop provided ACTEW with the opportunity to highlight any factual errors and to comment on and seek clarification on the review findings.

2.7 ***Final Report***

The Draft Report has been updated to form this Final Report. In preparing this report, comments received from the Commission and ACTEW and the outcomes of our further discussions have been taken into account.

3 Prudence of the Proposed Solution

3.1 *Overview*

The TOR require that an assessment be made as to whether the costs of the ECD project are prudent in terms of meeting the water security standards required of ACTEW. This assessment required a review of whether the ECD project design is optimised and fit-for-purpose, and whether the hydrological data supporting the design is valid for a future involving climate change.

This section presents a discussion of the key technical issues that impact on that assessment. Relevant cost issues are discussed in **Section 4**.

Specifically, the following section provides an overview of the underlying investment drivers that provided the foundation for the original planning and strategy studies that led to the adoption of the ECD project as part of the suite of projects that together comprise the Water Security Program. Establishing the drivers set as the criteria for original planning and strategy studies provides a baseline from which to assess the prudence of the options identified and in particular the ECD project. The next sections then provide a chronological summary of the options selection and assessment process leading to the identification of the ECD project as one of the preferred options. Finally, the technical aspects of the dam design and the hydrological analyses supporting the design are reviewed.

3.2 *Prudence Framework*

3.2.1 *Definition of prudence*

The assessment of prudence typically involves an assessment as to whether, based on the circumstances existing at the time, the decision to invest in an asset is one that the proponent (in this case ACTEW) would be expected to make. A prudence test will usually assess both: the prudence of how the decision was made to invest; and, the prudence of how the investment was executed (that is, the construction or delivery and operation of the asset), having regard to information available at the time.[1]

[1] IPART 2009, *Review of the Department of Water and Energy's Water Management Expenditure*, Request for Quote No. W03/2009, Schedule 1, p.3.

Expenditure is generally deemed prudent if it is required as a result of a legal obligation, new growth, renewal of existing infrastructure, or it achieves an increase in the reliability or the quality of supply that is explicitly endorsed or desired by customers. Put more simply, expenditure is prudent if there is a demonstrated need for it, or it is deemed necessary.[2]

With regard to the ECD project, the requirement for this assessment of prudence has been driven by the significant variance in cost estimates between the time of Government endorsement in July 2007 and preparation of final detailed costings in August 2009. The original total ECD project cost estimate put forward by ACTEW to (and endorsed by) the ACT Government in July 2007 was $145 million; the final detailed total project cost estimate, put forward by ACTEW in August 2009, is $363 million.

In particular, an assessment of prudence is required in respect to:

- Does the ECD project (in conjunction with other currently proposed measures) remain the most appropriate measure to secure water supply to the ACT; and
- Assuming that the ECD project is considered to be prudent, does the proposed design represent the most appropriate form of the dam.

3.3 Development of the ECD Project

3.3.1 *Background*

This section provides a brief overview of the historical development of the current Water Security Program and specifically how the development (and justification) of the ECD project has progressed over this period. The history of the program has been addressed at various levels in a number of previous documents including Halcrow's review[3] of the Water Security Program completed for the Commission in early 2008, an independent review report[4] completed for ACTEW in mid 2009.

3.3.2 *The Water Security Program*

ACTEW has undertaken an extensive body of work spanning several years to develop the program of water security measures, including the ECD project that has been identified for implementation. The development/planning process was undertaken in a number of key stages, including:

[2] ICRC 2008, *Water and Wastewater Price Review Final Report and Price Determination*, April 2008.

[3] Halcrow, *Review of Capital and Operating Expenditure associated with ACT Water Security Measures – Review Report*, April 2008.

[4] Deloitte, *Independent review of the design and estimate process for the Enlarged Cotter Dam Project*, 24 August 2009.

- *Think water, act water* Strategy (April 2004);
- *Future Water Options* Process (August 2004 – April 2005);
- Review of Future Water Options Assumptions (June 2006);
- *Water2Water* Proposal (January 2007);
- Future Water Options Review (July 2007);
- Water Security Recommendations (July 2007);
- Water Security Taskforce Response (September 2007); and
- Project delivery process.

A brief overview of each of these stages of the program development is provided in the following sections, primarily with a view to assessing the robustness of the development process.

Think water, act water Strategy (April 2004)

In April 2004, the ACT Government released *Think water, act water* – a water resources management strategy which defined actions to achieve sustainable water use in the ACT to the year 2050.

Supply augmentation options were identified in an options report produced in April 2004[5]. Following an initial assessment of some thirty options and more detailed assessment of eleven short listed options, the following three were identified for further investigation:

- building a new dam near Mount Tennent;
- enlarging the existing Cotter Dam; and
- transferring water from Tantangara Dam (in NSW) to the Cotter catchment.

Other options considered, but not short listed for further consideration at that stage, include:

- water farm (advanced water reclamation plant at the Lower Molonglo Water Quality Control Centre);
- cross border supplies (other than the Tantangara to Cotter option);
- groundwater;
- stormwater reuse;
- enlargement of the existing Corin, Bendora or Googong Dams; and
- construction of new dams at various alternative locations.

[5] ActewAGL,*Options for the next ACT Water Source*, April 2004.

The three options identified for further investigation were then considered in detail as part of the *Future Water Options* process discussed below.

Future Water Options **(December 2004 – April 2005)**

The *Future Water Options* process involved a review of the need and required timing for augmentation of the ACT water supply. This was followed by a detailed assessment of the options identified under the *Think water, act water* strategy for provision of a long-term reliable source of water for the ACT Region. The review of the need and required timing for augmentation of the ACT water supply was documented in a report[6] produced in December 2004.

Detailed assessment of the three primary long-term water source options identified under the *Think water, act water* strategy is documented in the *Future Water Options* report[7] from April 2005. The report assessed a total of twenty five variations based around the three identified options, and recommended the following:

- that implementation of the option to pump water from the Murrumbidgee River near Angle Crossing to Googong Reservoir commence immediately. (This option was identified during the assessment process as the Virtual Tennent Option. This option effectively secures the yield associated with the Tennent Dam option without the need to build a new dam);
- that:
  - the remaining options of an enlarged Cotter Dam (78GL), a small (43GL) or a large (159GL) Tennent Dam and transferring water from Tantangara Dam down the Murrumbidgee River into the ACT be retained as future viable options; and
  - ACTEW be ready to implement one of these options without delay, if required, through the development of a work program, implementation of formal processes for regularly reviewing the six assumptions, and completing analysis, design and other relevant technical studies for an approval process; and
- that additional technical analysis be undertaken for each of the dam options, including refining the dam design, further detailed examination of pipeline routes and additional examination of the benefits of building a new water treatment plant near the Tennent Dam versus transferring water from the Tennent Dam into the Mt Stromlo Water Treatment Plant.

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[6] ACTEW, *An Assessment of the Need to Increase the ACT's Water Storage*, December 2004.

[7] ACTEW, *Future Water Options for the ACT Region- Implementation Plan: A Recommended Strategy to Increase the ACT's Water Supply*, April 2005.

Concurrent to the *Future Water Options* investigations for long-term water security, work was also undertaken to implement works aimed at securing water supply in the short term (primarily in response to bushfire and drought).

These included:

- construction of the Mt Stromlo Water Treatment Plant to adequately treat water harvested in the Cotter catchment following the 2003 bushfires;
- optimisation of use of "current water". Water, which would previously be spilled from Bendora Reservoir, was transferred via the Mt Stromlo Water Treatment Plant and the distribution system to Googong Reservoir (the so-called Stromlo to Googong Reticulation Transfer);
- upgrade of the Cotter Pumping Station to transfer flows directly to the Mt Stromlo Water Treatment Plant (which facilitated the so-called Cotter to Googong Bulk Transfer system); and
- extraction of water from the Murrumbidgee River. This led to an arrangement comprising extraction from downstream of Cotter Reservoir and pumping, via the Cotter Pumping Station, to the upgraded Mt Stromlo Water Treatment Plant.

Further analysis carried out in 2006 resulted in the deferral of the Angle Crossing to Googong Reservoir Transfer option and the implementation of the Extended Cotter to Googong Bulk Transfer option, which was able to be implemented earlier and at a lower cost. The Extended Cotter to Googong Bulk Transfer option involved pumping water from the Murrumbidgee River, near the Cotter Pumping Station, to the Mount Stromlo Water Treatment Plant to supplement supply to Canberra. Any excess water could be pumped to Googong Reservoir for storage via the water reticulation system.

The Angle Crossing to Googong Reservoir Transfer option, which involved the extraction of water from the Murrumbidgee River at Angle Crossing, was deferred as pumping from the Cotter Pumping Station was possible by the end of 2007, whereas pumping from Angle Crossing could not be implemented within this timeframe.

Review of Future Water Options Assumptions (June 2006)

A review[8] of the assumptions made in respect to planning variables and demand assessments in the *Future Water Options* process was undertaken and reported in June 2006. The primary findings were that:

[8] ActewAGL, *2006 Annual Review of Planning Variables for Water Supply and Demand Assessment*, June 2006.

- the assumptions with respect to climate change and variability, and bushfire impacts, had not changed over the last twelve months in such a way as to change the judgements made in *Future Water Options* and subsequent advice;
- minor changes had been identified for trends in water demand reduction targets and population projections and with the new 2006 environmental flow guidelines; and
- further work was identified and initiated with respect to reviewing system performance criteria (time in restrictions), particularly in response to new Permanent Water Conservation Measures.

Water2Water Proposal (January 2007)

In January 2007, the Board of ACTEW committed in principle to enlarging the Lower Cotter Dam to increase its storage capacity from 4 gigalitres to 78 gigalitres.

The Board also committed in principle to investigating the further purification of water discharged from the Lower Molonglo Water Quality Control Centre to drinking water standard. The purified water would be pumped to a stream in the Lower Cotter catchment from where it would flow into the Cotter Reservoir. The water would then be further treated at Mt Stromlo Water Treatment Plant before supply to consumers. The Water Purification Scheme would only proceed if ACTEW could provide assurance that the quality of water produced would be of a standard at least equal to, and most likely higher than, the water currently available.

The ECD project and implementation of the Water Purification Scheme were subsequently identified as the *Water2Water* proposal.

Future Water Options Review (July 2007)

A detailed review[9] of the *Future Water Options* program was undertaken and reported in July 2007 in response to extremely low inflows to water supply storages during 2006. It is understood that this review may have been preceded by the annual review of planning assumptions which was documented in early 2007.[10]

The review of the *Future Water Options* program identified some fundamental changes to the assumptions underlying the original *Future Water Options* assessment. These changes included changed climate scenarios that indicated significant reductions in runoff, scenario modelling using actual storage levels rather than

[9] ActewAGL, *Future Water Options Review; Water Security Program*, July 2007.

[10] ActewAGL, *2007 Annual Review of Planning Variables for Water Supply and Demand Assessment (Internal Draft)*, 2007.

assumed full levels as the modelling starting point, and revised planning guidelines published by the Water Services Association of Australia.

The review identified and assessed a total of nine individual and eight combinations of the individual options that would (potentially) form part of the water security program. The assessment resulted in a series of recommended actions, the *Water Security Recommendations* (refer below), which were dependent upon a variety of climate scenarios.

Water Security Recommendations (July 2007)

In July 2007, ACTEW presented a series of recommendations for ensuring the long-term security of water supply to the ACT Government. These recommendations were documented in a report dated July 2007.[11]

ACTEW's recommendations, which were based primarily on the observed change and variability of climate in recent years, included the following:

- immediately commence the detailed planning and construction of an enlarged Cotter Dam to 78 gigalitre capacity;
- add to the capacity and operational flexibility to extract water from the Murrumbidgee River by undertaking the work necessary to proceed to construction of a pumping capability near Angle Crossing, which could also be used to transfer additional flows released from Tantangara Dam if such flows become available; and
- obtain additional water from a source not largely dependent on rainfall within the ACT catchments through either;
    - the Tantangara transfer option; or
    - the Water Purification Scheme.

ACTEW indicated that it would advise the ACT Government on which option was preferred for the future by December 2007 after determining whether satisfactory legal and commercial arrangements could be made to transfer water to the ACT via the Tantangara Dam, including the establishment of an ACT Water Cap, and after more detailed examination of the Water Purification Scheme, especially further analysis of salt management options.

[11] ACTEW, *Water Security for the ACT and Region; Recommendations to ACT Government*, July 2007.

Water Security Taskforce Response (September 2007)

A Water Security Taskforce and Advisory Panel was engaged by the ACT Government to review the options identified in ACTEW's *Water2Water* program and its July 2007 recommendations to Government in respect to securing the ACT's water supply into the future.

In September 2007, the Taskforce recommended a series of actions to the ACT Government and ACTEW.[12] Recommended actions in respect to water supply security included:

- enlargement of the Cotter Reservoir by 2011;
- progression of (undertake design and obtain approvals) the Murrumbidgee to Googong Transfer;
- progress arrangements for the Tantangara Transfer option (commercial negotiations and assessment of transfer alternatives);
- not progressing the proposed Water Purification Scheme, subject to further extensive analysis (detailed design of the Water Purification Plant to be progressed, and a review of the need for additional infrastructure undertaken before a decision is made to progress to construction); and
- construction and monitoring of a Demonstration Water Purification Plant.

Actions recommended in respect to demand management included improvement of the metering of water in the ACT, with ACTEW/ActewAGL being requested to implement a pilot Smart Metering Program, for commencement in 2008/09.

Project Delivery Process (August 2007 – current)

In August 2007 the ACTEW Board considered a proposal to use an alliance approach for the ECD project along with the Murrumbidgee to Googong Bulk Water Transfer System and the proposed Water Purification Scheme, however, a decision was deferred until further information was provided. At the October 2007 Board meeting it was decided to adopt an alliance model for each of these projects. In November 2007 it was further decided to undertake the projects through a single alliance structure, which has become known as the Bulk Water Alliance.

The Bulk Water Alliance was developed over the period from September 2007 to May 2008 after a competitive tendering process for both the designer and constructor roles with the formal alliance agreement executed in May 2008.

[12] Water Security Taskforce, *Next Steps to Ensure Water Security for the ACT Region*, Water Security Taskforce and Water Security Advisory Panel, September 2007.

Development of the ECD project design was subsequently undertaken by the Alliance.

3.3.3 *Approval of the ECD Project*

The key events and approvals regarding the ECD project can be summarised as follows:[13]

- On 31 July 2007, ACTEW provided its Report, *Water Security for the ACT and Region – Recommendations to the ACT Government*, to the ACT Government. The report called for the ACT Government to "immediately commence the detailed planning and construction of an enlarged Cotter Dam to 78 gigalitres capacity".[14]

  The report stated that the "approximate capital cost of the enlarged Cotter Dam is $145 million with an operating cost of around $1 million each year."[15] This figure included $119 million for the dam and associated works, $4 million for clearing and site preparation, $2 million for pipelines, $15 million for the upgrade of the existing Cotter Pumping Station, and $5 million for miscellaneous works.

  The report provided no additional detail regarding the cost estimates of the ECD project, and no detailed breakdown or costings analysis was provided to Government in this particular report.

- On 4 October 2007, the ACTEW Board (based on recommendations presented by ACTEW) agreed that work commence on a Progressive Alliance for procuring the ECD.

- On 23 October 2007, in response to ACTEW's recommendations, the ACT Government formally approved the enlarging of the Cotter Dam from 4 gigalitres to 78 gigalitres, "with planning and design work to commence immediately and work expected to be completed within three to five years, at a capital cost of about $145 million."[16]

- In April 2008, ICRC estimated that costs for the ECD project could result in a final cost of up to 30 percent greater than the $145 million estimate.

- In July 2008, ACTEW confirmed the possibility of a 30 percent increase in the final ECD project cost.

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[13] ACTEW submission to ACT Legislative Assembly, *Tabling of Information Motion put by Mrs Dunne regarding information on Water Security Major Projects*, 17 September 2009.

[14] ACTEW 2007. *Water Security for the ACT and Region – Recommendations to the ACT Government*, p. x.

[15] Ibid, p. 9.

[16] ACT Government, *Media Release, Enlarged Cotter Dam, Murrumbidgee Extraction and Pilot Purification Plant Highlights of Water Plan*, 23 October 2007.

- In December 2008, ACTEW provided a Progress Report to the ACT Government stating that it expected that the final ECD project cost could increase in the order of 50 to 70 percent due to significant increases in the cost of labour, cement and other materials.
- In March 2009, the ACTEW Board was advised that costs for the ECD project may exceed $250 million.
- In July 2009, the ACTEW Board was advised that the preliminary TOC estimate for the ECD project was "significantly over expectations"[17] and that the Alliance was working towards bringing the TOC to within $300 million.
- On 26 August 2009, ACTEW formally advised ACT Treasury and the Chief Minister's Department that the final TOC of the ECD project would be $299 million and a total project cost of $363 million.
- The ACT Government considered the ECD project on 31 August 2009 including a briefing from ACT Treasury and a presentation on the final cost estimate of the ECD project by ACTEW.
- On 1 September 2009, the ACTEW Board approved the $299 million TOC and total project cost of $363 million.

As outlined above, there was a dramatic increase in cost estimates of the ECD project from October 2007 to the time of ACTEW Board approval in September 2009. This report has provided a breakdown and reconciliation of the various ECD project cost estimates in **Section 4**, which also discusses the ACTEW Board approval processes in relation to the increase in ECD project cost estimates.

In March 2009, ACTEW advised the Board for the first time that the cost of the ECD project may exceed $250 million. According to ACTEW Board minutes, the Board noted the progress on the ECD project, however, it is not apparent whether the Board sought additional information or advice in relation to the new estimate. Halcrow notes that, within a period of only four months, a preliminary TOC estimate presented by ACTEW to the Board in July 2009 was significantly exceeded, and it was flagged that significant work was required to bring the TOC estimate within $300 million.

The significant shift in cost estimates within a short period of time would require efficient financial management and communication processes within ACTEW and the Alliance. Halcrow would expect a project of this scale to have sufficient

[17] ACTEW 2009, *Submission to Legislation Assembly for the ACT*, p.12.

processes in place whereby significant movements in cost estimates would be captured by financial modelling and expediently communicated to all relevant parties, including the ACTEW Board, as they occur. Such processes would avoid unnecessary surprises and ensure relevant decision makers have the most relevant and up-to-date information.

3.3.4 *Previous reviews*

Halcrow was commissioned by the Commission in March 2008 to undertake a brief, high level review of proposed expenditure associated with the implementation of a number of water security measures including the ECD project. The review examined the processes used to identify the ECD project as one of the preferred options and the processes behind the development of the reported cost estimate.

On the basis of the information available at the time, Halcrow reported[18] the following conclusions in relation to the ECD project:

- *"ACTEW have followed an extensive, robust process for the identification of prudent and efficient options aimed at ensuring the long-term security of water supply for the ACT;*
- *the Enlargement of Cotter Dam project option appears to have been well justified and is considered prudent; and*
- *the process followed in developing the estimated capital costs associated with the ECD project ($145 million, plus up to 30 percent) is considered to be robust, and there can be confidence that it allows for the efficient implementation of the project".*

The report noted that the process involved in developing the reported cost estimate involved two key stages with the original estimate developed in 2005 while the estimate was revised in 2007 and subject to an independent review.

3.3.5 *Updated options analysis*

In December 2008, ACTEW commissioned the independent estimator for the ECD project to undertake a review of the comparative cost estimate contained in the *Future Water Options* report with respect to the Tennent Dam option.[19] The purpose of the independent review was to update the estimate for Tennent Dam in line with the delivery of the project via an Alliance and in line with the estimation processes and rates being used for the ECD project cost estimate.

[18] Halcrow, *Review of Capital and Operating Expenditure associated with ACT Water Security Measures – Review Report*, April 2008.

[19] Project Support, *Tennent Dam and Associated Facilities Capital Cost Estimate Report at Options Stage*, 2 December 2008.

The findings of the independent estimator were that the total cost of the Tennent Dam option would be least $606 million (in November 2008 dollars), significantly more than the estimate at the time for the ECD project.

The review undertaken by the independent estimator provides some comparative analysis of one of the options originally considered as part of the *Future Water Options* studies based on updated prices and methodologies. While this assessment is not comprehensive, the outcomes provide some support to retention of the ECD project as part of the suite of projects that together comprise the Water Security Program.

3.4 Underlying Investment Drivers

3.4.1 *Background*

This section provides an overview of the key drivers that underpin the planning and options analysis processes that lead to adoption of the ECD project as part of the Water Security Program now being implemented. These drivers form the basis for the reasoning behind the need for the project and are therefore important to consider in the assessment of prudence.

3.4.2 *Legislative drivers*

Think water, act water

The ACT Government's *Think water, act water* (2004) strategy outlines a long-term approach for the management of ACT water resources. *Think water, act water* states that securing water for future growth can be achieved by increasing water supply capacity and/or reducing per capita water use. However, *Think water, act water* acknowledges that "…the most effective option, taking account of costs to the entire ACT community, is to implement water efficiency measures first."[20]

Accordingly, the ACT Government has implemented water use targets of a reduction in per capita consumption of mains water by 12 percent by 2013, and 25 percent reduction by 2023, on 2003 levels.

In the event that "water use efficiency measures are not able to save enough water to avoid the need to construct further water supply infrastructure"[21] *Think water, act water* identified three water infrastructure projects for future consideration. They were:

[20] ACT Government, *Think water, act water*, *Volume 1: Strategy for sustainable water resource management in the ACT*, April 2004, p.3.

[21] ACT Government, *Think water, act water, Volume 1: Strategy for sustainable water resource management in the ACT*, April 2004, p.4.

- construction of a new dam near Mount Tennent;
- enlarging the existing Cotter Dam; and
- transferring water from Tantangara Dam to the Cotter catchment.

Water Resources Act 2007

The *Water Resources Act 2007* aims to:

- ensure that management and use of the water resources of the Territory sustain the physical, economic and social wellbeing of the people of the ACT while protecting the ecosystems that depend on those resources;
- protect aquatic ecosystems and aquifers from damage and, where practicable, to reverse damage that has already happened; and
- ensure that the water resources are able to meet the reasonably foreseeable needs of future generations.

Apart from the broad requirements outlined above, there are no specific requirements in the *Water Resources Act 2007* relating to minimum levels of service standards, avoidance of water restrictions or maintaining minimum levels of storages.

National Urban Water Planning Principles

The National Urban Water Planning Principles (the Principles) resulted from the 2008 Council of Australian Governments (COAG) Work Program, and are designed to achieve optimal urban water planning outcomes.

The Principles do not set specific requirements on levels of service for water authorities or councils. Rather, the Principles state that "The service level for each water supply system should specify the minimum service in terms of water quantity, water quality and service provision (such as reliability and safety)."[22] That is, levels of service should not be applied uniformly across jurisdictions or supply systems, but rather should be set for each supply system and potentially for different parts of an individual supply system.

The Principles also require water authorities and councils to consider the full portfolio of water demand and supply options so as to "optimise the economic, social and environmental outcomes and reduce system reliability risks, recognising that in most cases there is no one option that will provide a total solution."[23]

[22] See: http://www.environment.gov.au/water/policy-programs/urban-reform/nuw-planning-principles.html

[23] Ibid

Water Supply and Sewerage Services Standards Code

The Water Supply and Sewerage Services Standards Code (made under the *Utilities Act 2000*) also does not make explicit reference to minimum levels of service standards. Rather, in discussing customer water supply, clause 4.1 states "A Water Utility [in this case ACTEW] is required to ensure that the customer has a water supply that meets the Customer's reasonable needs…"[24] subject to events or circumstances beyond the control of the water utility.

Summary

Halcrow's review of relevant ACT legislation and national water policies indicates that there is no explicit requirement for ACTEW in respect to the avoidance of water restrictions or maintaining minimum levels of storages as part of its minimum levels of service standards.

Under various forms of ACT legislation and national urban water policies, it could be interpreted that there is a requirement for ACTEW to ensure that the management and use of ACT water resources sustain the physical, economic and social wellbeing of the people of the ACT, while also ensuring that water resources are able to meet the reasonably foreseeable needs of future generations.

However, in doing so, there is also a requirement for ACTEW to consider the full portfolio of water demand and supply options to optimise economic, social and environmental outcomes and reduce system reliability risks.

3.4.3 ACTEW's service level standard

ACTEW's current planning framework is consistent with the Water Services Association of Australia's (WSAA) framework as outlined in the *Framework for Urban Water Resource Planning*[25]. ACTEW adopted the WSAA framework in 2005. The approach of maintaining security of supply adopted by ACTEW involves the traditional approach of maintaining a minimum level of storage without the need for water restrictions at any level, supplemented by the setting of level of service objectives for frequency, duration and severity of drought response. In essence, this approach recognises that due to the variability of rainfall in Australia, restrictions will be required from time to time unless water supply systems are "gold plated" with highly conservative buffer supplies that incur high economic and environmental costs.

[24] ACT Government, *Water Supply and Sewerage Service Standards*, December 2000, p. 1.

[25] WSAA, 2005, *Framework for Urban Water Resource Planning*, Water Services Association of Australia

The inclusion of drought response service level objectives in water resource planning generally allows for a more economic and environmentally appropriate risk based approach, when adopted correctly. If adopted correctly, the WSAA framework ensures that augmentation to the water supply system is based on optimising the cost of additional water supply against the cost of water restrictions.

While ACTEW has adopted the WSAA framework when assessing whether to augment its water supply system, Halcrow notes that the ACT Government still considers the time in restrictions (notably one year in 20) as a requirement to be met. Indeed, in addressing the ACT Legislative Assembly on 26 March 2009, Minister Corbell stated[26]:

> "…*The cost of time in water restrictions can be gauged against the cost of future capital expenditure to ensure water supply. The parameters being used by the government draw upon those being used elsewhere in Australia and are based around one year in 20 in temporary water restrictions. The use of this parameter enables the government to gauge supply and supply augmentation proposals against climate change scenarios.*"

Accordingly, ACTEW's service level standard in relation to restrictions appears to be a hybrid framework whereby consideration is given to optimising the cost of additional water supply against the cost of water restrictions, supplemented by an ACT Government planning guideline based around a maximum of one year in 20 in temporary water restrictions.

A review of other jurisdictions' service level standards indicates that the ACT Government's one year in 20 in temporary water restrictions service standard is generally consistent with the 'time in restrictions' criteria adopted by other jurisdictions. Overall, these policies should probably be viewed as 'aspirational' in nature, that is, they are not set by legislation, and could be considered conservative. These are outlined in **Table 3.1**.

[26] See: http://www.hansard.act.gov.au/hansard/2009/week04/1434.htm

Table 3.1: Service Level Standards by Jurisdiction

Jurisdiction	Service level standard
NSW	• Reliability: estimates that, on average, restrictions due to drought will not need to be applied more often than 3.6 months in 10 years (that is, less than 3% of the time). This is often expressed as '97% reliability'. • Robustness: estimates that, on average, not more than 10 years in 100 years will be affected by restrictions due to drought (where a year is considered to be affected by restrictions if restrictions are applied on any one day in that year). This is expressed as '90% robustness'. • Security: requires that the dams must not approach emptiness (less than 5% of total storage) more than 0.001% of the time. That is, in a period of 8333 years, only in one month should the combined level of the operating storages approach emptiness.
QLD	• Sufficient investment will occur in the water supply system with the objective of ensuring that medium-level restrictions: o will not occur more than once every 25 years, on average; o will last longer than six months no more than once every 50 years, on average; and o will achieve a targeted reduction in consumption of 15% below the total consumption volume in normal operations. • Combined regional storage reserves will reach levels of 10% of capacity not more than once every 1000 years. • Regional water storages must not be permitted to reach minimum operating levels.
SA	• SA Water uses, as a guide, 1:100 as the measure of reliability for its major water resources. For the metropolitan water supply system, SA Water has a licence to use Murray River water to a maximum of 650GL over five years. This licence was determined at the time the Murray–Darling Basin cap was being established, by using water-use modelling (based on 2001 levels of development) indicating that the full 650GL would be exceeded once in 100 years.
	• On this basis, there is an obligation for SA Water to base its planning on a 1 in 100 level of reliability. (This has been defined for recent studies as being the need to go to Level 3 restrictions or higher in only one year in 100 years.) This standard would apply to all of SA Water's metropolitan system, which includes both the Mount Lofty Ranges and Murray River supplies.
VIC	In Melbourne, requirements are that restrictions should only occur as a 1 in 20 year event.
WA	In Perth, the Water Corporation has planned on the basis of needing a total sprinkler ban in only 0.5% of years (or 1 in 200 years).

Source: Nation Water Commission[27].

[27] See: http://www.nwc.gov.au/resources/documents/2009_BA_chapter_11_urban_water.pdf, page 228 & 229

Prior to the adoption of the WSAA framework, ACTEW maintained 'time in restrictions' criteria when setting service level standards. The service level standard adopted by ACTEW in 2005 was based on:

- minimum storages of 5 percent;
- 5 percent of time in restrictions;
- frequency of restrictions being one in 10 years;
- 1 percent of time in Stage 3 or higher restrictions; and
- frequency of Stage 3 or higher restrictions of one in 25 years.[28]

ACTEW has stated anecdotally during interviews that, at the time the *Future Water Options* were being prepared by ACTEW (2004-05), there was a general consensus among Australian water authorities that water restrictions at any level should not occur more than once in ten years on average.

While the 'time in restrictions' and 'frequency of restrictions' targets provide a basis for water authorities to plan for future water requirements; the National Water Commission notes that extra security always comes at a cost and that 100 percent security may only be attainable by constructing an unaffordable water supply system.[29]

3.4.4 Population growth

Population growth is a significant driver in determining the water requirements of a region. To assist in determining the water requirements of the ACT, *Think water, act water* made use of two common population projections in the development of planning scenarios:

- **median level population projections:** median population of Canberra, Queanbeyan and the adjacent region of 460,000 by 2050, reflecting the most likely scenario of future regional population growth; and
- **upper level population projections:** upper-range population projection of 500,000 by 2032, to allow for contingency planning should higher-than-expected population growth in the region eventuate.

At the time of the publication of *Think water, act water*, the ACT used approximately 65 gigalitres of water per annum, out of a total approximately 494 gigalitres of ACT-controlled water resources (including water entitlements not currently used).

[28] See: http://www.nwc.gov.au/resources/documents/2009_BA_chapter_11_urban_water.pdf, page 228 & 229

[29] Ibid

This equates to an average water use of 180 megalitres per day, with summer peak demand reaching as high as 450 megalitres.[30]

Think water, act water states that if no action was taken (either demand or supply-side), existing water supply headworks are expected to meet demand until the ACT reaches a population of approximately 405,000, anticipated around 2017. This projection was based on population growth rates and per capita water consumption at the time.

It should be noted that *Think water, act water* states that if the targets for reducing mains water use (refer **Section 3.4.2**) are achieved, it is possible that the ACT can meet the water requirements for a population of 460,000 "without constructing further water supply infrastructure."[31] While it was further noted that the impact of bushfires, climate change and other factors could result in demand reduction measures being insufficient on their own, *Think water, act water* was clear in stating that "more efficient water use should be put in place first, given its lower cost."[32]

In planning for future water options, ACTEW adopted what it deemed to be a "prudent" planning scenario that incorporated: [33]

- the high population growth projections; and
- a 12 percent reduction in mains water use by 2012, and 25 percent reduction by 2023, from 2003 levels.

In Halcrow's opinion, this planning approach is not inconsistent with the approaches generally used in the water industry. The water industry is, by its nature, a conservative industry given that the potential impact of not providing basic water supply and sewage collection services can be significant.

3.4.5 Economic drivers[34]

ACTEW has indicated that augmentation of its water supply system is based on optimising the cost of additional water supply against the cost of water restrictions.[35] The initial investigation and assessment of the cost of additional

[30] ACTEW, *ACT Future Water Options: Water Resources Modelling Report – Volume 1*, April 2005, p.5.

[31] ACT Government, *Think water, act water, Volume 1: Strategy for sustainable water resource management in the ACT*, April 2004, p.15.

[32] Ibid, p.15.

[33] ACTEW, *ACT Future Water Options: Water Resources Modelling Report – Volume 1*, April 2005, p.19.

[34] This assessment of economic drivers was requested by the ICRC as an addition to the scope of the review as detailed in section 1.3. The review was undertaken on the basis of information previously supplied by ACTEW and no specific engagement of ACTEW was undertaken during the review. We note that the ICRC has undertaken a full review of economic drivers and issues and their review takes precedence over our brief review.

[35] ACTEW, *Issues/comments regarding the draft Halcrow report*, 23 February 2010.

water supply against the cost of water restrictions was undertaken by the Centre for International Economics (CIE) on behalf of ACTEW in 2005.

The outcome of the analysis identified the best option (in net present value terms) as a combination of two options; the Virtual Tennent option and Cotter 78 gigalitre option. The outcome of the CIE assessment formed an important driver for ACTEW to proceed with the ECD option.

The CIE report and analysis, *Economic benefit-cost analysis of new water supply options for the ACT,* included:[36]

- Identification of the various costs of water restrictions. Seven main costs of water restrictions were identified and estimated including costs to households, commercial costs, recreation costs, tourism and urban environment costs, transaction costs, reductions in ACTEW profits, and costs to the ACT government.[37]
- An assessment of two baselines (do nothing scenarios) under which the costs of water restrictions was projected to increase over time. The two scenarios included the 'medium growth' scenario and the 'prudent planning' scenario.
- Identification of the performance and costs of the new water supply options, where performance of options was defined in terms of the extent to which they reduced the estimated time in restrictions relative to the relevant 'do nothing' scenario. Nine separate new water supply options were investigated as part of the CIE assessment, including:
  1. Cotter 78 gigalitre (capital cost $120 million);
  2. Tennent 43 gigalitre (capital cost $185 million);
  3. Tennent 159 gigalitre (capital cost $250 million);
  4. Tantangara tunnel (capital cost $141 million);
  5. Virtual dam (capital cost $40 million);
  6. Tantangara down river (capital cost $70 million);
  7. Cotter plus virtual dam (capital cost $160 million);
  8. Small Tennent plus virtual (capital cost $225 million); and
  9. Large Tennent plus Cotter (capital cost $370 million).
- An assessment of the benefit to cost comparison of the options, and some sensitivity analysis of key assumptions.

[36] Centre for International Economics, *Economic benefit-cost analysis of new water supply options for the ACT*, 18 April 2005, p.1.

[37] CIE estimated the lower and upper bound cost of restrictions for the five different levels of restrictions. The cost of restrictions ranged from $3.5 million (lower bound) to $9.4 million (upper bound) per year for stage 1 restrictions, up to $162.8 million (lower bound) to $428.9 million (upper bound) per year for stage 5 restrictions.

- An analysis of the major options under alternative assumptions in relation to environmental flows.
- An analysis of the staging of the highest ranked option (the combined Cotter 78 gigalitre and Virtual Tennent option) in combination with the Cotter to Googong reticulation development.

The CIE analysis found that, while delaying the introduction of the Cotter 78 gigalitre from 2011 to 2023 involved a loss of gross benefits (restrictions in place over a longer period), it resulted in a financial gain (deferred expenditure), with a net overall gain of $29 million.

While the detailed analysis supporting the CIE report has not been made available for this review, Halcrow has undertaken a high level review of the report to review the estimation of the cost of water restrictions (which provides the primary benefit streams for the cost benefit analysis), as well as the key structural elements of the cost benefit analysis (discount rate, period of evaluation, etc).

Overall, Halcrow has noted that the CIE report lacks sufficient detail to substantiate the assumptions and analysis included in report. The CIE report does not include any significant sensitivity analysis, and the robustness of the results was not presented. The range of probable results for each project scenario and the extent to which the results were clustered around a low-value or high-value result could not be assessed.

Furthermore, key factors driving the result were not identified. For example, it is not clear the extent to which individual cost or benefit elements affected the net present value results reported in the study. Consequently, it has been difficult to determine whether sufficient analysis of the relevant benefit and cost streams was undertaken.

At a more sophisticated level, Monte Carlo simulation of the expected water efficiencies between 2005 and 2025 for each category of demand identified in the report might have provided a clearer profile of the expected level of benefits. The CIE report presented only two levels of expected water efficiency by 2025, a 12 percent saving and a 25 percent saving. Key arising from Halcrow's review of the reported economic cost benefit analysis assumptions are included in **Appendix B**.

Some additional criticisms of the CIE analysis were also identified by the Institute of Sustainable Futures (ISF) and ACIL Tasman[38] in their review of water

[38] Institute for Sustainable Futures and ACIL Tasman, *Review of Water Restrictions, Final Report*, 2009.

restrictions on behalf of the NWC in 2009. The report for the NWC included a critique of the 2005 CIE analysis, and was critical of the methodology adopted by CIE to determine the cost of restrictions. In particular, it was critical of the "choice of upper bounds to calibrate costs and the lack of sensitivity testing of key assumptions (such as elasticity of demand)."

These criticisms of the CIE report highlight a number of potential issues with the identification in 2005 of the ECD project as a preferred option on the basis that it represented the optimised cost of additional water supply against the cost of water restrictions.

In its 2007 *Future Water Options Review,*[39] ACTEW updated its economic assessment. The update took account of the new water restriction scheme, updated prices and incomes, as well as the introduction of Permanent Water Conservation Measures. In addition, ACTEW reported that it '*sought to improve the calculation of the total cost of restrictions to reflect a risk aversion to Stage 4 Water Restrictions*'[40]. It reported that informal community feedback, together with a formal analysis conducted within ACTEW, indicated that there was a strong aversion to Stage 4 restrictions. To this effect, it applied a 'risk aversion factor' of 3.5 to the Stage 4 component of the total cost of restrictions. The report does not include the basis for this factor, or any sensitivity analysis surrounding its application. The estimated community costs of water restrictions are shown in **Table 3.2**.

Table 3.2: Estimate costs of water restrictions

Water Restriction Stage	ICE Report (2005) $2005	ACTEW Update (2007) $2007
Stage 1	3.5	5.6
Stage 2	16.1	44.9
Stage 3	60.1	62.1
Stage 4	81.0	139.6
Stage 4 (ACTEW Adjusted)	-	488.6
Stage 5	162.8	-

[39] ACTEW Corporation, *Future Water Options Review: Water Security Program*, July 2007.

[40] Ibid, p.9.

The updated estimates of the costs of water restrictions, together with updated capital costs for the options under review, were used by ACTEW to review the 2005 *Future Water Options* project recommendations. A key finding of this 2007 review was that immediately building an enlarged Cotter Dam would provide the best water supply security over the longer-term. The review also found that the ECD project provided the greatest net economic benefit of the dam options when combined with the Murrumbidgee pumping options.

In 2008, CIE updated its 2005 CIE benefit cost analysis.[41] Halcrow notes that the ICRC has undertaken a more detailed review of the 2005 and 2008 CIE report, together with the related updates made by ACTEW in relation to the cost of water restrictions. Further assessment of prudence in relation to the economic assessment of the ECD project has been undertaken by the ICRC.

Halcrow has undertaken an examination of the economic basis upon which the 78 gigalitre ECD option was selected in 2005. The results of Halcrow's examination of CIE's 2005 study suggest that the net present value is very sensitive to the discount rate applied. Net present value ranges from -$14 million at 10 percent real discount rate, to $310.9 million at a 4 percent real discount rate.

Halcrow's analysis also demonstrates that an increase in project capital costs from $120 million to $363 million, excluding any increase in other project related costs, will produce a negative net present value of $13.6 million at a real discount rate of 5 percent. Halcrow's full examination of CIE's 2005 study is outlined in **Appendix C**.

3.5 Validity of the Dam Design

3.5.1 Background

The selection of a roller compacted concrete (RCC) dam as the preferred option for the ECD project was first identified in April 2005 in a review of water supply options completed under the *Future Water Options* program[42]. The review considered four types of dam, namely, a roller compacted concrete dam, a mass concrete dam, a concrete faced rockfill dam and an earth core rockfill dam.

The water supply options identified in April 2005 were reviewed again in July 2007, however, the scope of the review primarily involved an escalation of the costs for the options, not a further review of feasible options. The outcomes of this review

[41] CIE, *Updated estimates of the cost of water restrictions in the ACT*, September 2008.

[42] GHD, *Future Water Options Study – Cotter, Tennent, Coree Dam and Murrumbidgee Transfer Options*, April 2005.

confirmed that the RCC dam option was still the preferred option and an independent review completed in July 2007[43], confirmed that the RCC dam option was the lowest comparative cost option.

The choice of the RCC dam was, as indicated in the August 2009 independent review[44], based on the comparative cost estimate completed for the dam and the relative speed of construction. The process by which the RCC dam was selected as the preferred option was assessed in Halcrow's 2008 review[45] for the Commission. The findings of this review indicated that the process used for the options analysis was, on the basis of the documentation reviewed and the findings of the independent review[46], considered to be appropriate.

3.5.2 *Review of dam design process*

The level of design completed for the RCC dam prior to the commencement of the Bulk Water Alliance can only be regarded as a preliminary concept suitable only for comparative purposes and the April 2005 options review stated this quite clearly.[47]

The level of geotechnical assessment completed prior to the formation of the Alliance was also quite limited. The options developed in the April 2005 *Future Water Options* report were based on site inspections and a desktop assessment of geological maps and surface topography. Further geotechnical investigations were commenced in January 2007, with the results reported in September 2007.[48] The scope of works for this study comprised field mapping; aerial photo interpretation; inclined boreholes at the top of each abutment and in the valley floor; packer testing; groundwater level monitoring; three seismic traverses; two boreholes, two seismic traverses and four test pits at the proposed quarry site; laboratory testing on rock cores; and, petrographic analysis.

The 2007 review of the *Future Water Options* report did not involve any additional design work, however, in the review of cost estimates for the options, the scope of works involved was generally confirmed.

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[43] Rider Levett Bucknall, *Enlarged Cotter Dam – Cost Estimates Review*, July 2007.

[44] Deloitte, *Independent review of the design and estimate process for the Enlarged Cotter Dam Project*, 24 August 2009.

[45] Halcrow, *Review of Capital and Operating Expenditure associated with ACT Water Security Measures Review Report*, April 2008.

[46] Rider Levett Bucknall, op. cit.

[47] GHD, *Future Water Options Study Cotter, Tennent, Coree Dam and Murrumbidgee Transfer Options*, April 2005.

[48] URS, *Future Water Options Stage 2 New Cotter Dam Geotechnical Studies*, September 2007.

Once the Alliance design partner was engaged in April 2008, work began in earnest on the design and associated studies required for the development of the ECD project's Target Outturn Cost (TOC). In April 2008, more detailed geotechnical investigations were commenced at the main dam site, the saddle dams and at the two proposed quarry sites (quarry 2 and quarry 3).

In July 2008, a report[49] was produced which outlined the findings of an initial review and development of options for the ECD project. This involved the review of the different dam types available and covered essentially the four dam types identified in the *Future Water Options* review from April 2005, with some minor variations or options investigated.

In October 2008, an optimisation study was completed and a report[50] produced which detailed an assessment of the options identified in the initial review and development of options report from July 2008. The optimisation was undertaken on the basis of maximising the Net Economic Benefit of each option considered. The outcomes of this report were that a RCC dam with earth and rockfill saddle dams was the preferred option that should be progressed to detailed design.

During the period from November 2008 to March 2009, the results of the geotechnical studies commenced in April 2008 were released leading to the production of a combined geotechnical assessment report in April 2009[51] for input into the development process for the TOC estimate.

In July 2009 a report[52] was prepared to define the design basis/criteria for the ECD project, and in August 2009 two design reports were released which provided details of the design process to date. The first report[53] provided details of the preliminary design works completed up to the initial 'design freeze' point on 15 April 2009.

The second report[54] provided details of the changes that were made to the preliminary design during the development of the TOC and particularly after the Value for Money (VFM) process that was undertaken during the process.

[49] Bulk Water Alliance, *Report for Enlarged Cotter Dam Initial Review and Development of Options*, July 2008.

[50] Bulk Water Alliance, *Enlarged Cotter Dam Optimisation Study Report*, 8 October 2008.

[51] Bulk Water Alliance, *Enlarged Cotter Dam Geotechnical Assessment Report for TOC Design*, April 2009.

[52] Bulk Water Alliance, *Enlarged Cotter Dam Design Criteria Report*, July 2009.

[53] Bulk Water Alliance, *Enlarged Cotter Dam TOC Design Report*, August 2009.

[54] Bulk Water Alliance, *Enlarged Cotter Dam TOC Design Report Addendum No. 1*, August 2009.

The culmination of the design reports and studies to date is the ECD project TOC report[55] which was also released in August 2009. The TOC report includes a summary of the design basis for the ECD project and a listing of the key design documents delivered as part of the design process. The TOC report also includes descriptive methodologies for undertaking the construction of the works. The methodologies include consideration of all the required stages of construction and the key issues to be considered including heritage, rock anchors and stabilisation, RCC placement at the dam, and environmental management.

The TOC report states that the design phase for the ECD project is currently around 30 percent complete with the detailed design phase expected to be completed by April 2010.

3.5.3 *Technical review of dam design*

As part of this review, Halcrow has undertaken a technical review of the dam design and has identified some minor issues. The full review findings are presented in **Appendix D** while key findings are summarised in the following.

Timeline for construction

The proposed RCC average placement rate of 50,000 cubic metres per month is at the high end of benchmark rates but should be achievable. Sufficient mixing and placing plant located onsite, stockpiling of aggregate, and uninterrupted supply of cement and fly ash will be critical factors.

Foundation excavations

The lack of site investigation work looking at the geological conditions and the resulting uncertainty over excavation quantities may have had a significant influence in the variance of cost estimates between the initial planning estimates and subsequent TOC estimates.

Dam site alternatives

The location of the ECD appears to be close to the optimum point in the valley.

Construction methodology

Abutment excavation

[55] Bulk Water Alliance, *Target Outturn Cost (TOC) Report – Enlarged Cotter Dam Project*, 4 August 2009.

In general the minimum excavation line appears to be reasonable. There may be some areas where, subject to further confirmation, potential reductions in excavation might be achieved:

- High on the left abutment, where the access road cuts deeply into the abutment, it appears that the foundation slope could be steepened locally, thereby reducing the road cut width by approximately seven metres (assuming that the minimum excavation line is the same upstream and downstream of the dam). This would slightly increase the gradient of the top section of the side spillway chute, resulting in a limited saving in excavation, although would not result in a significant savings in RCC, as the dam section at this elevation is narrow. One problem with steepening the upper section of the excavated slope would be drilling at the base of this slope for pre-splitting the flatter slope below, and this may be the reason for adopting the arrangement shown. The blue lines on **Figure 3.1** (extract from Figure 1.3.10, section 1.3 of the TOC report[56]) show a possible alternative.

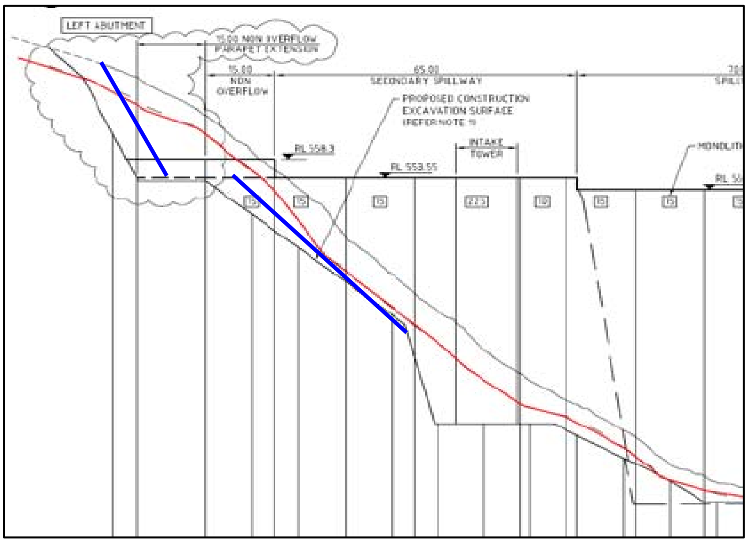

Figure 3.1: Possible Alternative to Left Abutment Excavation

- The approximately 35 metre wide bench on the left abutment, connecting to the intake tower, appears that it might be wider than potentially necessary for

[56] Bulk Water Alliance, *Target Outturn Cost (TOC) Report – Enlarged Cotter Dam Project*, 4 August 2009, p.16 of section 1.3.

the outlet. It might be worth reviewing this in more detail as part of the optimisation process as it would potentially save both excavation and RCC infill costs.

- "Excavation extents" (refer section 1.3 of the TOC report[57]) notes that the upstream batters are set between two to three metres back from the dam faces to allow room for placing formwork. While used on some dams, this is not the only approach. The alternative is to end the batter approximately one metre back from the upstream face line and on the downstream face line and fill against the rock batter with RCC until there is room to place formwork; refer to **Figure 3.2** for a suggested sketch. This would reduce the excavation volume, but marginally increase the RCC volume.

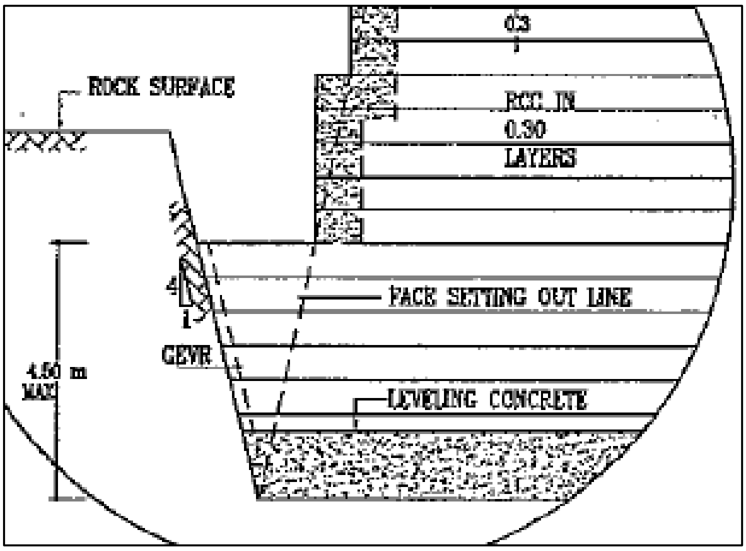

Figure 3.2: Possible Alternative Approach to Upstream Batter

- Section 1.3 of the TOC report also notes that the excavation has been started 6.5 metres inside the minimum excavation line to avoid the risk of having to go back to remove unsuitable material. Assuming that this is 6.5 metres horizontally, at a 45 degree slope, this is an extra excavation depth of 4.6 metres normal to the minimum excavation line, but less on flatter slopes. This seems slightly high, but will depend on the confidence and conservatism of the geological assessment for the minimum excavation line.

  An initial estimate suggests that, if this is applied over the whole dam and spillway chute excavation area, it is equivalent to some 50,000 cubic metres of

[57] Bulk Water Alliance, *Target Outturn Cost (TOC) Report – Enlarged Cotter Dam Project*, 4 August 2009, p.19 of section 1.3.

excavation and 35,000 cubic metres of RCC under the dam body, but not the spillway chute. A comparison of the cost of this with the risk cost of dealing with any unsuitable foundation material left below the excavation line would be useful.

Concrete production

A one hour maximum practical output trial of the RCC batcher plant would be required to test the proposed peak output of 300 cubic metres per hour. Halcrow is of the opinion that the peak RCC placement rate of 91,000 cubic metres per month will be a challenge to the work teams over the relatively short construction period envisaged.

It is common practice that a significant proportion of the aggregate required be stockpiled before RCC placement commences. We would expect that approximately 50 percent of all aggregate sizes be stockpiled to meet the placement rates.

The proposed cement and fly ash mix of 190 kilograms per cubic metre is a reasonable mix for a high paste RCC.

The aggregate and RCC delivery conveyor systems appear appropriate to meet the planned speed of placement.

3.5.4 *Review of environmental and social factors*

A significant volume of work investigating environmental and social factors has been completed over the period from 2004/2005 to the present including:

- Fish impact study;
- Terrestrial flora, fauna and vegetation study;
- Cultural heritage assessment;
- Land ownership study;
- Catchment and landscape analysis of the future water source options for the ACT;
- Stage 1 social impact appraisal;
- Cotter options water quality report;
- Risk assessment and management report for the use of Cotter Reservoir water in the Canberra drinking water supply system;
- Sustainability framework and assessment plan;
- Technical advice on ACT reservoir recreational water use options;
- Ecological risk assessment of ACT water source options;
- Aquatic ecology study, April 2005; and

- Enlargement of the Cotter Reservoir and associated works environmental impact statement.

The sustainability plan[58] completed in April 2005 provides details of the triple bottom line/sustainability assessment that was undertaken for the major options identified in the *Future Water Options* report. The assessment provides equal weighting to environmental, social and economic factors and appears relatively consistent with acceptable standards for sustainability assessments.

The preferred option for the ECD project was chosen in part due to the consideration of potential environmental impacts. Primarily, this consideration related to the presence of the endangered Macquarie Perch within the existing dam and upstream river sections. The selection of the 78 gigalitre dam option, as opposed to the smaller 45 gigalitre dam option, was made in part to reduce the potential impact on the habitat of the Macquarie Perch.

The construction of the ECD raises environmental issues regarding the management of five threatened aquatic species; Macquarie Perch, Trout Cod, Two-spined Blackfish, Murray Cod, and Murray River Crayfish. The Macquarie Perch is the key species of concern as the population in the existing Cotter Reservoir is the only sustainable population in the ACT.

The presence of Macquarie Perch, Trout Cod and Murray Cod within the broader upstream and downstream catchment area and the potential for environmental impacts during the construction and operation of the ECD triggers the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The presence of the above threatened species also triggers the ACT *Nature Conservation Act 1980*. The Macquarie Perch and Trout Cod are currently listed as endangered under the EPBC Act.

In order to obtain the relevant licences and approvals, ACTEW was required to demonstrate that the appropriate measures to protect the above aquatic species would be taken. To this end, fish studies and habitat works have been developed to provide artificial habitat and shelter for the Macquarie Perch during the filling and operation of the ECD, and a range of fish research studies.

[58] ACTEW, *Sustainability Framework and Assessment Plan*, April 2005.

3.6 Validity of the Hydrological Investigations

3.6.1 *Background*

A number of hydrological investigations have been undertaken for the ECD project and as part of the various planning and strategy studies completed between 2004 and the present. The following lists a number of the studies while further details of particular studies are provided in the following sections.

- Update of Water Resources Strategy for Canberra and Queanbeyan (ACTEW Corp. Doc. No. 3959) (July 2004);
- ACT Future Water Options Water Resources Modelling Report – Volume 1 (2005);
- Hydrological investigations (January 2006);
- 2006 Annual Review of Planning Variables for Water Supply And Demand Assessment: A review of the changes in demand assumptions for Future Water Options for the ACT (June 2006);
- Flood hydrology investigations (January 2007);
- Future Water Source Options - Stage 2 Assessment: Assessment of Different Models for Stochastic Data Generation (13 April 2007);
- Performance Of Existing SimHyd Models During Recent Drought Flows (ActewAGL Document No. 322867) (October 2007);
- Update of Canberra Water Resources Model Assumptions: Change 1: Impact of Googong Inflow Review and Murrumbidgee Water Quality Rule (ActewAGL Document No. 322706) (October 2007);
- Update of Canberra Water Resources Model Assumptions: Change 2: Murrumbidgee Environmental Flow Assumptions Review (ActewAGL Document No. 326573) (December 2007);
- Future Water Source Options - Stage 2 Assessment: Proposal for Stochastic Generation of Climate Data Under "Current" and "2030" Conditions, (27 February 2008);
- Enlargement of Cotter Dam: Additional Hydrology Design Criteria Report (28 July 2008);
- How long will the Enlarged Cotter Dam take to fill after construction? (ActewAGL Advice to ACTEW Reference No. WA0809_028) (9 February 2009); and
- 2009 Review of Planning Variables for Water Supply and Demand Assessment, (July 2009).

3.6.2 *Key Planning Assumptions and Scenarios*

The water resource modelling undertaken for the assessment of *Future Water Options* and concept design of the ECD has been based on the following assumptions:

- ACT population (Canberra and Queanbeyan) will grow to around 570,000 persons (representing the highest growth scenario) by 2032 as defined in the most recent Australian Bureau of Statistics population projection in 2008[59] (Note: this is a significant increase over the 500,000 persons forecast provided in the Canberra *Spatial Plan*[60] high population growth scenario);
- Water efficiency targets established in the *Think water, act water* strategy will result in a reduction in per person water consumption of 25 percent by 2023 with a linear reduction of 8 percent in 2005. The range of measures to be implemented to meet these targets include education and awareness programs, increased water pricing, rebates for toilets, showerheads and rain water tanks, indoor and outdoor water "tune ups", audits and retrofits for the commercial and government sectors, increased recycling and use of grey water;
- CSIRO 2030 climate model, representing increases in the frequency and duration of droughts, as well as a tendency towards higher temperatures and lower annual rainfall, has been used to inform the options assessment. In addition to this, further worst-case climate models have been developed assuming a repeat (over the 50 year planning horizon) of the 2006 drought year and 2000-2006 drought years;
- Bushfires in the Cotter catchment will result in reduced inflow to existing reservoirs and the ECD due to regrowth. This will occur whenever pre-2003 bushfire climate conditions occur; and
- Compliance with the ACT Government's 2006 *Environmental Flow Guidelines*.[61]

These assumptions, which were most recently reviewed during 2009[62], are considered conservative and offer a suitably prudent planning approach to the estimate of yield and demand for each modelled option, and performance against other key measures including the likelihood of water restrictions and expected Net Economic Benefit. Further detail surrounding these assumptions is provided in **Sections 3.6.4** and **3.6.5**.

[59] ACTEW, *REALM Base System File Assumptions and Operating Rules*, August 2009.

[60] ACTPLA 2004.

[61] *Environment ACT 2006*.

[62] ACTEW, *2009 Review of Planning Variables for Water Supply and Demand Assessment*, July 2009.

3.6.3 *System Modelling*

A sophisticated water resource model has been developed using the industry-accepted REsource ALlocation Model ('REALM') software to predict the response of the existing, and possible future, water supplies to long sequences of future climate (rainfall, temperature, evaporation and stream flow), water efficiency and demand scenarios (municipal, agricultural, industrial water use, and environmental flow).

The model represents the interconnection of all ACT storages and their complex operating rules. The model iterates on a monthly basis and is capable of using a range of climate scenarios against which the performance of the system can be assessed (including the 137 years of historical climate record, the CSIRO 2030 10,000-year synthetic climate record and other worst case scenarios including repeat cycles of the 2000-2006 inflow and demand). A key model output and performance criteria against which options were assessed is the probability that a certain water restriction will be imposed.

In support of this review, ACTEW has provided a report[63] which fully documents the key assumptions and operating rules for the entire water supply system and is found to be in accordance with the information presented in the *Future Water Options* report (refer **Sections 3.6.4** and **3.6.5**). It is understood that this report is updated on a regular basis, thereby providing a clear and transparent means of cataloguing the evolution of the model and noting significant model changes.

The water resource model has undergone independent reviews by a leading hydrological modelling firm and a copy of the review report has been provided by ACTEW[64].

3.6.4 *Yield Calculation*

Rainfall-Runoff Model

The SIMHYD rainfall-runoff model has been adopted to represent inflows from the Googong, Corin, Bendora and Cotter sub-catchments. Rainfall-runoff parameters have been calibrated against observed monthly stream flow and then validated against independent observed monthly streamflow periods to assess the accuracy of the model. Following this, various climate sequences (including the representation of bushfires in terms of reduction in runoff) have been passed through the model to provide the inflows to the various storages.

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[63] ACTEW, *REALM: Base System File Assumptions and Operating Rules*, August 2009.

[64] SKM, *Peer Review of Water Resource Modelling*, 29 March 2007.

SIMHYD is a conceptual hydrological model which represents inputs (rainfall), storage (soil moisture store, groundwater store), transfers (infiltration excess, interflow and baseflow) and losses (evapotranspiration) on a daily time step basis. Streamflow is calculated as the sum of the infiltration excess, interflow and baseflow components. Separate models were developed for each sub-catchment and calibration was performed against monthly observed flows.

In summary, it was found that the calibration models for Corin, Bendora and Cotter Dams offer a good level of fit with coefficients of determination ranging from 0.65 to 0.8.[65] Furthermore, the observed versus estimated mean flows are considered to be within acceptable limits, at around ±5 percent. The general process of configuring the models, preparing the rainfall and evaporation data, and selecting time periods for calibration and validation is all in accordance with accepted best practice and so the inflow estimates to these storages can be considered reasonable.

Googong Dam, however, has presented more technical problems, and whilst outside of the ECD catchment, is still an important determinant in the effectiveness of the overall water supply system. The SIMHYD model for this storage significantly overestimated flows experienced during the recent drought. ACTEW revised the model in 2006/7, resulting in a 20GL/year reduction in inflows. Following the revision, whilst the average Googong inflows are well represented, the model still significantly overestimates flows for 2005-2009. ACTEW is aware of this issue and has tried other rainfall-runoff models to improve the representation of actual conditions. Further improvements are, however, required.

Given the importance of the rainfall-runoff parameters in determining inflows to the storages, it is suggested that further calibration is undertaken periodically (every 2 to 5 years) to ensure that the latest climate data is fully included.

Climate Variability and Climate Change

Climate is the biggest driver and in some respects the greatest unknown within the *Future Water Options* assessment. Advice on the likely impact of the greenhouse effect on local rainfall, temperature and evaporation rates was sought from CSIRO, a world leader in this scientific field, in 2003.

[65] ACTEW, *Catchment Rainfall Runoff Modelling*, November 2004.

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

- decreases in ACT annual run-off of up to 20 percent in 2030 and 50 percent by 2070;
- changes in summer/autumn run-off (relative to 1990) of –20 to +5 percent, and –50 to +10 percent by 2030 and 2070 respectively;
- changes in winter/spring run-off (relative to 1990) of –20 to –5 percent and -50 to –10 percent by 2030 and 2070 respectively; and
- per capita ACT water demand will increase by 1 to 5 percent (3 percent for mid-range scenarios) by 2030 and 1 to 16 percent (9 percent for mid-range scenarios) by 2070.

These figures are forecasts only and represent likely limits of change. The clear message, however, is that a reduction in rainfall and higher evaporation are expected to occur. In order to represent these expected changes in the hydrological model, the original 10,000 year stochastic climate sequence (used in the 2005 *Future Water Options* modelling) was updated using the 2003 CSIRO report estimates for the climate in the ACT in the year 2030. The 2003 CSIRO report gave a range of decrease in annual average rainfall of around 5 to 11 percent and increase in annual average evaporation by 8 to 11 percent. The 2003 CSIRO report also supplied seasonal variations in rainfall and evaporation. ACTEW used the maximum in the annual averages (9 percent increase in evaporation and 9 percent reduction in rainfall), and distributed these seasonally by scaling the CSIRO seasonal predictions. ACTEW also assumed that there had been a step change to 2030 climate, not that the climate would gradually shift from its current state to the 2030 prediction by 2030. This approach gave a "worst case" 2030 climate sequence for the ACT.

In order to represent the variability in these climate predictions ACTEW took the 10,000 years of "2030 climate" and divided it up into 200 sets of 50 year projections. This provided 200 samples of what the ACT may experience in the next 50 years, based the assumption that the ACT has already moved to the 2003 CSIRO prediction of 2030 climate. This allows a probabilistic measure of the chance of being in restrictions, and also allows the Net Economic Benefit of various schemes to be presented probabilistically (that is, showing a range of outcomes and their probability).

This approach results in a 45 percent reduction in inflows to the dams relative to the long term historical average, and consequently more prolonged and frequent periods of drought (with a return interval of 1 in 19 years compared to 1 in 136 years for the historical data set.) The average dam inflow of this "2030 climate scenario" aligns well with the average actual inflows experienced in the last 15 years. However the 2030 climate scenario is less severe than the average inflows of the last seven years or particularly the last four years.

ACTEW considers that this approach offers a suitable conservative estimate of future climate for use in planning, however, notes that inflows experienced in the last four years have averaged 75 percent below the long term average which, it suggests, indicates that the approach may not be conservative enough.

In order to represent further worst case scenarios, ACTEW has modelled ongoing repetition of the drought period from 2000-2006 and the ongoing repetition of the 2006 climate over the 50 year planning horizon. Whilst these are statistically unlikely scenarios, they do serve to test and, in this case, support the robustness of the proposed options, including the ECD. The results show that, in the severe case of a repetition of 2006 climate, the current suite of projects (that is, the ECD, the Murrumbidgee to Googong transfer and the Tantangara transfer) need to be supplemented by the Water Purification Plant in order for the ACT to fully recover from and remain out of water restrictions. In the less severe repetition of the 2000-2006 scenario, the ECD, by itself, just keeps the ACT out of restrictions.

In summary, it is considered that the allowance for future climate variability and climate change within the water resource model has been undertaken appropriately and with sufficient rigour to ensure that the options selected are robust and sustainable in the long term. However, given the inherent uncertainty in our understanding of climate change and its sensitivity on the performance of the water supply system, it is suggested that as improved estimates become available they are fully incorporated into future modelling.

Bushfires

Bushfires are likely to occur in the ACT water catchment in future years, with the most recent event occurring in 2003. Following this event, modelling was undertaken in conjunction with the 2003/04 *Future Water Options* project to quantify the impact of the severe bush fires on catchment hydrology. An immediate impact of bushfires includes increased runoff and enhanced streamflow due to vegetation loss (loss of interception and evapotranspiration functions), coupled with poor water quality.

In the medium term, streamflows are likely to be reduced by up to 15 percent (with impacts lasting up to 50 years) due to increased evapotranspiration during the vegetation recovery phase. To account for this significant impact on catchment hydrological processes, bushfire yield reduction has been incorporated into the stochastic climate inflow sequences by applying a bushfire trigger model which tests antecedent conditions (fuel load and catchment dryness) and time of year and then determines whether a bushfire would be initiated. Comparisons with and without the bushfire trigger model show that over the long term there is around a 4 percent reduction in dam inflows.

The inclusion of the bushfire trigger model is considered both innovative and highly appropriate given recent history, and again serves to support the robustness of the options selection process and concept design of the ECD. Further sensitivity testing reveals that by not accounting for the occurrence of future bushfires the future population that can be served would be over-estimated by approximately 5 percent.

Time to Fill Assessment

Further modelling was undertaken in February 2009 to determine the likely time it would take to fill the reservoir. Three option combinations were modelled:

- the ECD;
- the ECD plus 100 megalitre per day pipeline from Murrumbidgee River to Googong Dam; and
- the ECD plus the Murrumbidgee River to Googong Dam transfer and a 20 gigalitre General Security Allocation from Tantangara Reservoir in NSW.

Each of these three options was modelled with three climate sequence scenarios:

- CSIRO 2030 climate;
- repeat of 6 year inflows and demands from 2000-2006; and
- the 133 year historical climate data set.

Assuming an initial volume of 50 percent in all of the dams (representing conditions at 1 February 2009), the model was run to determine the time to fill the reservoir to Full Supply Level. The results indicated that under the historical climate, the ECD would fill in around eight months; with the CSIRO 2030 climate sequence, the ECD would fill in around 17-21 months; and, with the repeating climate from 2000-2006, the ECD would fill in around 44 months with the ECD alone but just nine months when combined with other options, that is, the Murrumbidgee River to Googong Dam transfer and the Tantangara Reservoir allocation.

The methodology used to determine this is considered suitable and robust, and offers a range of planning scenarios, depending on the assumed climate sequence and initial dam volume.

3.6.5 *Demand Assessment*

Population Growth and Demand Management

Three future water demand scenarios were investigated during the *Future Water Options* assessment in 2005, comprising:

- High population growth as outlined in the ACT Government's Spatial Plan coinciding with no reduction in water demand (assumed a Canberra-Queanbeyan population of 500,000 persons by 2050);
- High population growth with a 25 percent reduction in demand for water through meeting the water efficiency targets of *Think water, act water*; and
- Moderate population growth and a 12 percent reduction in water demand.

In 2008, the Australian Bureau of Statistics (ABS) released new population projections for the ACT resulting in an uplift compared to the 2005 figures, to 500,000 by 2023 and 570,000 by 2032. The revised upper bound ABS population forecast has been used in the water resources model.

REALM has been used to determine the unrestricted demand (assuming that no water restrictions are put in place) by taking into account antecedent climate, the latest population growth scenario and the *Think water, act water* demand management targets. The 'prudent planning' approach combines high population growth with a 25 percent reduction in demand by 2023 and the CSIRO 2030 climate to provide a conservative estimate of future unrestricted water demand.

These estimates range from around 71 gigalitres per annum for an average (ie. 50th percentile) 2030 climate to 76 gigalitres per annum for an extremely dry (ie. 90th percentile) 2030 climate.[66]

The model has also been run for the worst case climate scenario comprising the repetition of 2006 inflows and demands. This results in an unrestricted demand of around 79 gigalitres, which is considered an upper bound. It should be noted that, if no improvements were made in water efficiency, more than 110 gigalitres would be required to supply the high population growth identified in the latest ABS forecast. This would be significantly beyond the capacity of the proposed system.

[66] ACTEW, *Future Water Options Review*, July 2007.

This clearly underlines the importance of the continued implementation of the *Think water, act water* objectives.

It is also noted that, whilst the high population growth scenario has been adopted, the actual population growth within the ACT region since 2006/2007 has exceeded this forecast population growth estimate.[67] This could potentially compromise the effectiveness of the proposed option combination in achieving the desired performance targets. However, to date the actual differences are relatively small and, over the long term, the adoption of the high population growth model scenario is still expected to offer a conservative assessment of demand.

It is understood that ACTEW is in the process of calibrating a decision support tool, called the End Use Model (developed by the Institute of Sustainable Futures), which is capable of including the impacts of seasonality, climate change and climate variability on potable water demand.[68] This could provide a far more realistic means of determining per capita water consumption over time, compared with a fixed (albeit adjusted for water efficiency measures) water use.

Given the potential for large errors in the population forecast, it is suggested that as future trends become apparent and/or the outcomes from the End Use Model become available, the model assessment should be updated accordingly.

Environmental Flows

The water abstraction licence issued by ACT Environment to ACTEW specifies the environmental flows to be released from the water storages to maintain the flow regime, river morphology (pool and riffle sequences) and dependent ecosystems. The water resources model includes the environmental flows from the 2006 Environmental Flow Guidelines, including specific guidance for each dam under normal, Stage 1 and Stage 2 or higher water restrictions.

During the *Future Water Options* 2005 assessment, this was a significant source of uncertainty (resulting in two modified environmental flow scenarios being assessed with differing implications on system performance). With the publication of the 2006 guidelines, this source of uncertainty was largely removed.

[67] ACTEW, *2009 Review of Planning Variables for Water Supply and Demand Assessment*, July 2009.

[68] Ibid.

It is, however, noted that the environmental flows associated with the planned new infrastructure (ECD and Murrumbidgee River to Googong Dam pipeline) had not been formally agreed as of July 2009.[69] This could have a significant affect on water supply security; consequently it is essential that this is resolved as soon as practically possible. It is suggested that future updates to the Environmental Flow Guidelines are incorporated immediately into the water resource model to determine their impact on system performance.

3.6.6 *Flood Hydrology*

Overview

The design of the ECD spillway and stilling basin follows the NSW Dam Safety Committee Guidelines, which is adapted from the Australian National Committee on Large Dams (ANCOLD) risk assessment process.

The return period of the design flood during operation depends on the hazard rating of the dam which is a measure of the severity of the consequences of failure of the dam under flood conditions. Although a preliminary assessment suggested that a lower Consequence Category may be appropriate, ACTEW has nominated the Probable Maximum Flood (PMF) as the design basis for the spillway and stilling basin design in order to be conservative. As reported in the Design Criteria Report[70], the hazard rating was due to be confirmed by undertaking a dam break consequences assessment for the ECD in accordance with the latest ANCOLD guidelines (the outcomes of this assessment are not known and have not been reviewed). Irrespective of the outcome, it is understood that the PMF will most likely remain the design flood.

The 2007 hydrology study re-evaluated earlier estimates of the design flood using latest guidelines from the Bureau of Meteorology. The PMF inflow estimate for the *existing* Cotter Dam had been estimated as 5,670 cubic metres per second. This was revised slightly to take into account the additional storage effects of the ECD which results in a minor attenuation of the peak flow (by 1.4 percent). The PMF inflow assessment assumes that the catchment is saturated and that all storages are at capacity prior to the onset of the Probable Maximum Precipitation (PMP) event. The assumptions are consistent with NSW Dam Safety Committee and ANCOLD Guidelines and are considered good practice.

[69] ACTEW, *2009 Review of Planning Variables for Water Supply and Demand Assessment*, July 2009.

[70] Bulk Water Alliance, *Enlarged Cotter Dam Design Criteria Report*, July 2009.

Approach

The approach taken to deriving the series of return period flood hydrographs was to develop a RORB[71] model that incorporated a Monte Carlo framework to represent variations and uncertainties in loss parameters, rainfall temporal pattern, rainfall areal distribution, ground initial and continuous perviousness (losses) and drawdown of the three dams (Corin, Bendora and Cotter). The drawdown exceedance curves were derived from the water resources model (REALM) for the existing water supply system (for the current configuration of the Cotter Dam, not taking into account the proposed enlargement or other proposed water supply options).

The coupled Monte Carlo-RORB joint probability approach allows the simulation of many combinations of different flood-causing factors to be assessed and enables uncertainties to be fully quantified (thereby informing levels of acceptable risk within the design). This represents an innovative and good practice approach.

The RORB model was then calibrated against an existing RAFTS[72] model and verified against local stream flow gauges, prior to running the model to derive inflow and outflow. Flood frequency curves were derived on both an annual basis and across two seasons, ie. December through March (summer) and April through November (rest of the year).

A full review of the flood studies from 1 in 50 years Annual Exceedance Probability (AEP) to the PMF for the three dams in the catchment is presented in the 2007 hydrology peer review report[73]. From the information provided, it is apparent that the procedures used to represent the catchment and drainage network within the RORB model are appropriate for the existing and proposed ECD.

As mentioned, the original RORB model has recently been updated to include the storage effects of the proposed ECD. With this inclusion, the PMF peak discharge is predicted to be attenuated by 1.4 percent, resulting in a design PMF of approximately 5,590 cubic metres per second. As expected, the degree of attenuation increases for higher AEP's (up to 70 percent for the AEP 1 in 5 event).

[71] RORB is a general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs.

[72] RAFTS is a runoff routing program (Australia and the Asia Pacific region) for hydrologic and hydraulic analysis of drainage and conveyance systems.

[73] SKM, *Peer Review of Water Resource Modelling*, 29 March 2007.

Key assumptions

The key assumptions behind the hydrological model are as follows:

- The hazard rating is high (Consequence Category A) and therefore the PMF has been selected as the design flood event;
- All dams are assumed to be at full supply level and the catchment is assumed to be saturated at the onset of the PMF event (no losses and limited attenuation);
- The PMF peak inflow values are the maximum inflows to the dams for the current spillway configurations, assuming that any upstream dams overtop without failing;
- Joint probability modelling (using the Monte Carlo framework) is appropriate for all other flood events (taking into account variations in temporal and areal rainfall distributions, loss parameters and initial dam volumes); and
- The design inflow and outflow hydrographs for Bendora and existing Cotter Dam assume that there was no failure of upstream dams.

The assumptions are consistent with current dam guidelines and good practice.

Future Reviews

The following points relate to the need for ongoing review of the hydrological model during the early design of the ECD process (in line with model recommendations provided in Appendix B of the Design Criteria Report[74]):

- Joint probability of revised drawdown – the addition of the ECD will alter the way in which the ACT water supply system is operated and therefore alter the drawdown exceedance curves for all three dams in the Cotter catchment. If not already assessed, this could result in changes to the inflow and outflow flood frequency curves for all events except the PMF (which assumes that all dams are at full supply level). The new drawdown exceedance curves should be derived using the latest version of the water resource planning model (REALM), with inclusion of all planned improvements to the water supply system.
- Design rainfall – Design growth factors and areal reduction factors from the rainfall database for Northern Victoria have been adopted for the design rainfall estimates. Whilst the rainfall database method is considered suitable for application to extreme design rainfall estimation in other regions of Australia, specific areal reduction factors and growth factors are currently being derived for NSW and ACT, which will likely yield different and more

[74] Bulk Water Alliance, *Enlarged Cotter Dam – Design Criteria Report*, Appendix B, July 2009.

realistic results. As such, it is suggested that a review of the design rainfall estimates is undertaken once this becomes available.

- Revised calibration and verification – The RORB model has been calibrated and verified against stream flow data from 1968 and 2006. It is understood that since this time there have been no significant flood events and therefore updated calibration would not improve the RORB model any further. Periodic re-calibration and verification should be undertaken, however, if and when large AEP flood events (>1 in 5 to 10 years) occur, to ensure that the best available datasets are used to inform the flood frequency curves.
- Climate change – Changes to the Probable Maximum Precipitation (PMP) under climate change are highly uncertain at present and currently the Bureau of Meteorology is not planning to revise PMP estimates. On this basis, the existing analysis undertaken in the 2007 hydrology peer review report[75] is in accordance with best practice. Furthermore, whilst design rainfall depths for lower probability events (up to AEP 1 in 40) of up to 24 hour duration are expected to increase by around 5 percent, the applicable flood events used to inform the design of the spillway and stilling basins are significantly larger than this and consequently such changes will not impact the design. This is an area of rapidly evolving science and as further evidence becomes available, particularly relating to potential increases in the PMP, additional updates may be necessary.

[75] SKM, *Peer Review of Water Resource Modelling*, 29 March 2007.

4 Cost Efficiency

4.1 *Overview*

This section provides a detailed discussion on the cost efficiency of the ECD project. It provides a brief overview of the historical development of the total project cost, and specifically an analysis of total project costs including a breakdown of the Alliance Target Outturn Cost (TOC) and non-TOC costs. The accuracy of the Alliance cost estimates is considered with analysis of escalation provided, and a review of the benchmarking and independent advice undertaken by the Alliance in developing the cost estimates.

4.2 *Development of Enlarged Cotter Dam Project Cost*

4.2.1 *General*

Since the initial consideration of value for money, there have been a number of changes in the expected total cost of the ECD project. An initial project estimate was developed by GHD in 2005, reviewed by GHD and peer reviewed by Rider Levett Bucknall[76] in 2007, and a final project estimate was developed by the Bulk Water Alliance in 2009. **Table 4.1** outlines the various publicly reported ECD project estimates over time.

Table 4.1: Publicly reported ECD project estimates over time

Year	Author	ECD project estimate	Gross increase
April 2005	GHD	$120 million	
July 2007	ACTEW (based on estimates provided by GHD and RBL)	$145 million	$25 million 21% increase
August 2009	Bulk Water Alliance	$363 million	$218 million 150% increase

<u>Note::</u> *The above figures are presented in nominal dollars, and involve different scope of services, as outlined in the following sections. The July 2007 estimate includes the Cotter Pumping Station upgrade at an estimated $15 million. The April 2005 and August 2009 estimates exclude the Cotter Pumping Station upgrade.*

[76] Deloitte, *Independent Review of the design and estimate process for the Enlarged Cotter Dam Project*, August 2009, p.13.

The estimate for the ECD project has increased significantly over time. This section provides an overview of the history of the development of the ECD project cost estimate, and a reconciliation of the early estimates with the final ECD project estimate. It also discusses issues that have arisen during the development, and subsequent communication, of the ECD project estimates and attempts to capture lessons for ACTEW for future projects of this nature.

4.2.2 *2005 Enlarged Cotter Dam project estimate*

In April 2005, in order to allow a cost comparison of different water security measures being considered for the ACT, ACTEW engaged GHD to provide preliminary engineering cost estimates for the variety of measures. As noted in **Section 3**, these measures included Murrumbidgee to Googong transfer (virtual Tennent option), Enlarged Cotter Dam and a new Tennent Dam.

It was estimated by GHD that a 78 gigalitre roller compacted concrete (RCC) Enlarged Cotter Dam would cost approximately $98 million[77] in 2005-06 dollars. This estimate excluded the Cotter Pumping Station upgrade, owner's costs, land purchase costs, permitting costs, financing costs, and costs associated with government liaison. At the time, this estimate was deemed to have an error factor of ±30 percent. It is important to note that the 2005 GHD options study for the Enlarged Cotter Dam was presented as being "a preliminary cost estimate" for comparison between options. It was clearly stated that these estimates should be used for "*the purposes of preliminary budgeting*" and not be used "*for any other purpose*". It also stated that "*a functional design is recommended for budget setting purposes*".[78]

Project Support, engaged by ACTEW as an independent estimator to review project cost estimates from 2005 to 2009, noted that a limitation of the 2005 estimate involved the lack of contingency in relation to a "Fatal Flaw Analysis" which identified the existence of 10 potential Category C issues affecting the RCC option. Each issue had a potential impact on construction costs of between zero and $10 million dollars. Assuming an average outcome across all of these risk issues, the necessary contingency required based on the Fatal Flaw Analysis could be in the order of $50 million for those risks alone.

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[77] This estimate excludes the cost of clearing, pipelines, power and pump stations. The inclusion of these items would result in an estimate of $120 million.

[78] GHD, *Future Water Options Study: Cotter, Tennent, Coree Dams and Murrumbidgee Transfer Options*, April 2005, p.98.

4.2.3 *2007 Enlarged Cotter Dam project estimate*

In July 2007, ACTEW engaged GHD to review and update the ECD estimates and option comparison. The review only involved a re-evaluation by GHD of the unit rates used in the 2005 estimates. The dam concept or quantities were not reconsidered. The revised estimate was $124 million, compared to $98 million in 2005. It should be noted that the GHD review focused on the dam construction costs; related costs were not re-estimated.

At the same time, ACTEW commissioned Rider Levett Bucknall to review the GHD 2005 cost estimates and also review the preliminary scope provided by GHD. Based on the review of rates adopted by GHD, Rider Levett Bucknall estimated the cost of the ECD project at $107 million ($124 million after escalation to expected completion date December 2011).

As noted in ACTEW's *Enlarged Cotter Dam Update Report* in July 2007, a comparison of the common items in the GHD and Rider Levett Bucknall estimates led to a best estimate of $119 million for the ECD project. This was supported by ACTEW's recommendation to the ACT Government, also in July 2007, in a report entitled *Water Security for the ACT and Region – Recommendations to ACT Government.* ACTEW recommended to the ACT Government that an ECD would cost approximately $145 million in 2006-07 dollars. This figure included $119 million for the dam and associated works, $4 million for clearing and site preparation, $2 million for pipelines, $15 million for the upgrade of the existing Cotter Pumping Station, and $5 million for miscellaneous works.

There were, however, a number of significant issues relating to the cost estimate communicated to the ACT Government. As noted by Project Support[79], no allowance appeared to have been made anywhere in ACTEW's July 2007 *Enlarged Cotter Dam Update Report* for owner's costs relating to the ECD project. The 2007 GHD review, which was used to derive the ACTEW July 2007 estimate, was limited to a review only of the unit rates from 2005 and was clear in stating that "*no reviews of the concepts or quantities has been undertaken in this (further 2007) study*". It went further in again stipulating that the "*preliminary cost estimates presented*" were for the "*purposes of comparing options only*" and "*may be used for preliminary budgeting*". The accuracy was stated as "*about ±30%*" and "*a functional design is recommended for more definitive budget setting purposes*".[80]

[79] Project Support, *Independent Estimator Review of Proposed Cotter Dam 2005 and 2007 Estimates*, August 2009, p.7.

[80] GHD, *Enlarged Cotter Dam – Review and update of cost estimates and comparisons*, July 2007, p.12.

Additionally, the contingency adopted in the 2007 estimates was $29.2 million, representing approximately 33 percent of the then proposed direct costs. As stated by Project Support[81], the generally accepted guidance for contingencies at this stage of estimate development is a range of 30 to 50 percent, with the adoption of the 50 percent value (or more if a lack of detail warrants) more likely in this case given the nature of the project and lack of detail in the work breakdown structure.

On the basis of information now available, Halcrow considers that the July 2007 estimate prepared by ACTEW, while sufficient for comparative purposes, was not suitable as a formal recommendation to Government for anything other than the presentation of the process for selecting the preferred option.

4.2.4 2009 Enlarged Cotter Dam project estimate

Following the establishment of the Bulk Water Alliance in early 2008, a detailed work breakdown of the ECD project was established with significant time undertaken to quantify the work to be done. A tendering process was then undertaken with sub-contractors to develop cost estimates for the range of works involved in the ECD project. These costs were then used in the development and preparation of the Target Outturn Cost (TOC) for the ECD project. To ensure the costs tendered by sub-contractors were appropriate, sub-contractors were interrogated by ECD project managers to ensure the work could be delivered to the quality and quantity required by the Bulk Water Alliance. Sub-contractors were also asked by the Bulk Water Alliance if the tendered price incorporated the requirements of the Alliance; if the sub-contractor indicated that the costs did not reflect the requirements of the Bulk Water Alliance they were asked to re-submit their tender.

On 26 August 2009, following extensive project reviews and challenges to the design and cost estimates which included review of the following[82], the Bulk Water Alliance estimated the TOC for the Enlarged Cotter Dam at $310.9 million (inclusive of fees):

- appropriateness of the (then) current selected dam type;
- suitability of the dam design;
- optimisation of the construction methodology for the dam type; and
- the value for money of the current design and construction plans.

[81] Project Support, *Independent Estimator Review of Proposed Cotter Dam 2005 and 2007 Estimates*, August 2009, p.10.

[82] ACTEW Decision Paper, *Enlarged Cotter Dam*, 1 July 2009.

The Alliance Leadership Group (ALG), when presented with the TOC of $310.9 million on 27 August 2009, took a commercial decision to reduce the TOC to $299 million together with a modified pain-share/gain-share model.

A summary of the final TOC of $299 million is outlined in **Table 4.2**.

Table 4.2: Final Enlarged Cotter Dam TOC

Item	Cost
Direct costs	$224,292,261
Total Direct Costs	**$224,292,261**
Escalation	$15,404,734
Risk allocation	$21,958,287
Direct costs plus escalation and risk	**$261,655,282**
IT and management fees	$1,772,844
Fee costs	$35,571,874
Target Outturn Cost	**$299,000,000**

Source: Adapted from Enlarged Cotter Dam Target Outturn Cost Report.

The final TOC of $299 million comprises $261,655,282 (including allowances for escalation and risk allocation) for the direct construction costs of the dam and $37,344,718 in fees to the Bulk Water Alliance partners.

It is recognised that the Bulk Water Alliance expects final tendered prices for the work packages to move in both directions. It was noted by ACTEW during detailed interviews that, for those items of work where machinery is to be imported or work packages are dependent on exchange rates, there is an expectation that prices will move in the favour of the Bulk Water Alliance. Where the scope and definition of work packages was relatively less developed in August 2009, there is a known risk that prices may move against the Bulk Water Alliance.

In addition to the TOC of $299 million, there are a range of non-TOC costs totalling $64.118 million. Non-TOC costs include pre-TOC costs (for example, project inception, planning, preliminary design, approvals etc), owner's costs, fish studies and habitat protection costs, and the Cotter Precinct mitigation works. A breakdown of these costs has been outlined below in **Section 4.3**. With the inclusion of the non-TOC costs, the estimated total cost of the ECD project is $363.118 million. **Table 4.3** provides a summary of the total ECD project cost.

Table 4.3: Total Enlarged Cotter Dam Project Cost

Item	Cost
Target Outturn Cost	$299,000,000
Non-TOC costs	$64,118,000
Total Enlarged Cotter Dam project cost	**$363,118,000**

4.2.5 *Reconciliation of estimates*

In response to the significant increase in project costs reported in 2009, Project Support was engaged by ACTEW as an independent estimator to undertake a review of the project cost estimates to compare the previous 2005 and 2007 estimates with the August TOC estimate of $310.9 million. It was the intention of the review to provide a basis for a re-evaluation of the completeness of the project estimates made in July 2007 and to assist in explaining movements in the final estimated cost of delivering the ECD project. **Table 4.4** below provides a headline comparison of the estimates reviewed by Project Support. It should be noted that the owner's costs were omitted from both of the estimates shown in **Table 4.4**.

Table 4.4: Comparison of 2007 and 2009 Estimates undertaken by Project Support

ACTEW Enlarged Cotter Dam Update Report July 2007	July 2009 BWA TOC Estimate
$120 million[83]	$310.92 million
Gross Estimate Difference	
As Dollar Value	As Percentage Increase
$190.92 million	159 percent

Source: Independent Estimator Review of Proposed Cotter Dam 2005 and 2007 Estimates.

The findings from Project Support's review are summarised in **Table 4.5**.

[83] Represents the best estimate of $119 million for the ECD project derived by ACTEW from the 2007 GHD and RBL estimates, rounded up to $120 million by Project Support.

Table 4.5: Differences in Respective Estimate Values

Difference Item	Review Value	Caused By
Comparison uplift for 'like' items	$82.10 million	Scope growth – increases in design cost, quantities, rates and scope additions.
Missing estimate placeholders		
• Contractors indirect costs and margin	$76.12 million	Not included in 2007 Work Breakdown Structure
• Unallocated direct cost items	$17.29 million	Not included in 2007 Work Breakdown Structure
• Escalation	$15.41 million	Not included anywhere
Reconciled total	**$190.92 million**	

Source: *Independent Estimator Review of Proposed Cotter Dam 2005 and 2007 Estimates.*

It was noted by Project Support that the uplift in like items of $82.10 million "*is largely a product of the increase in design costs and general scope growth (manifested as increases in quantities and rates) that has occurred in developing the estimate to its current level of detail.*"[84] Project Support determined that the majority of the increases in quantities resulted from increased RCC volumes and, to a lesser extent, increases in dam excavation quantities and reinforced concrete for the tower and spillway.

In relation to the missing estimate placeholder components, Project Support identified the following items as missing from the estimate schedules of both the GHD and RLB July 2007 Estimate Update Report:

- Contractors allowance for site overheads (indirects), offsite overhead and corporate margin (fee). The Alliance value for these items based on the July 2009 TOC was $76.12 million;
- Unallocated Direct Cost Items – these were current estimate items that were either not found in the initial estimates or could not be reasonably allocated to any of the 2005 or 2007 Work Breakdown Structure estimate items. The value of these unallocated items based on the July 2009 TOC was assessed as $17.29 million; and
- Escalation – the July 2009 TOC estimate value for this was $15.41 million. There was no provision made anywhere in the reviewed estimate schedules for escalation.

[84] Project Support, *Independent Estimator Review of Proposed Cotter Dam 2005 and 2007 Estimates*, August 2009, p.8.

In relation to the 2005 and 2007 cost estimates, Project Support concluded in its August 2009 report that the "*initial estimates needed to have significantly more contingency provided at that stage of their development.*"[85]

4.3 Analysis of Total Project Costs

4.3.1 *Breakdown of Target Outturn Cost*

Table 4.6 provides a detailed breakdown of the TOC costs for the ECD project. They include risk allocation and escalation, construction of the saddle dams, quarry and crushing operations, metalwork and pipework, rehabilitation of the site, RCC batch plant and materials, placement of the RCC and design works.

Table 4.6: Breakdown of Target Outturn Costs

Item	Cost
Non-recurring overheads (excl. risk and escalation)	$4,190,274
Risk Allocation	$21,958,287
Escalation	$15,404,734
Recurring Indirect Items	$79,518,106
Craneage	[redacted]
Structural concrete supply	
Reinforcing steel	
Gallery	
Spillways	
Intake tower	
Stilling basin	
Outlet works	
Metalwork, pipework and valves	
Mechanical and electrical works, and instruments	
Decommissioning of existing dam	
Saddle dams	
Grouting	
Quarry operations	

[85] Project Support, *Independent Estimator Review of Proposed Cotter Dam 2005 and 2007 Estimates*, August 2009, p.10.

Item	Cost
Crushing operations	[redacted]
Rehabilitation of site	
Heritage and approvals	
Site establishment and civil works	
Rockfall protection	
Construction and maintenance of environmental controls	
Workshop	
Construction services	
Diversion	
Excavation of abutments and foundation	
RCC batch plant	
RCC materials	
Placement of RCC	
Detailed design	
Design construction phase services	
Total Target Outturn Costs	**$299,000,301**

Source: ACTEW[86]. Note: this table contains Commercial and In Confidence information related to works packages which are yet to be tendered. To facilitate best market pricing for these packages, the specific values of each item have been removed.

It is important to note that the above expenditure items are inclusive of Alliance fees, and IT and management fees.

4.3.2 *Breakdown of non-TOC costs*

Table 4.7 provides a breakdown of the non-TOC costs for the ECD project. They include pre-Alliance costs (such as project inception, preliminary design, approvals, etc), Alliance quality pool, fish and habitat protection, precinct mitigation works, and owner's costs.

[86] Email ACTEW, Revised ECD TOC Budget, $299m, January 22, 2010

Table 4.7: Breakdown of non-TOC costs

Expenditure Item	Cost
Pre-Alliance / Pre-TOC costs – includes project inception, planning, preliminary design, approvals, construction plans and estimates, and program management costs	$36,575,000
Maximum quality pool	$4,000,000
Fish and habitat protection (not to exceed)	$5,681,000
Cotter precinct mitigation works	$7,447,000
Owner's costs: • Direct costs for community engagement and stakeholder management, electricity works and supply, equipment, and network services • Water security major projects program costs	 $5,568,000 $4,847,000
Sub total Owner's costs	$10,415,000
Total non-TOC costs	**$64,118,000**

Source: ACTEW[87]

The pre-Alliance / pre-TOC costs reflect project related costs incurred by ACTEW prior to the establishment of the Bulk Water Alliance and prior to the development of the TOC. The main activities undertaken include project inception and options analysis, planning, preliminary design, seeking and gaining relevant approvals, construction plans, estimates and related program management costs.

Based on the information provided, we are of the opinion that there is no evidence to suggest that the level of expenditure on pre-Alliance costs is inappropriate for a project of this size and complexity. It is currently unclear, however, whether any proportion of the pre-Alliance costs have already been included in capital and operating expenditure submissions for previous price reviews. We understand that the Commission is investigating this issue.

Quality pool

An allowance of $4 million has been set aside in relation to the quality pool available to the Bulk Water Alliance. The conditions and nature of the quality pool are discussed in **Section 5.4.4**.

[87] ACTEW, *Total Costs for Water Security Major Projects – Total ECD Project Costs.*

Fish Studies and Habitat Works

While the Fish Studies and Habitat works and the Cotter Precinct mitigation works are to be developed in conjunction with the ECD project, it was decided by the Bulk Water Alliance to keep these costs separate from the TOC. This decision was based on the view that "*these costs are not specifically part of the dam construction*".[88] Given that ACTEW has committed to delivering these works (which are in accord with the needs of the community and requirements of protecting an endangered fish species) in conjunction with the ECD project, it is appropriate that the associated costs are included as part of the total cost of delivering the ECD project. The cost breakdown of the works is outlined in **Table 4.8** below.

Table 4.8: Fish Studies and Habitat Expenditure

Expenditure Item	Cost
Direct Costs	
• Artificial fish habitat	[redacted]
• Fish research and studies	
Total Direct Costs	**$4,910,671**
IT and management fees	[redacted]
Agreed Alliance fees	
Total Fish Studies and Habitat Cost	**$5,681,459**

Source: Adapted from Enlarged Cotter Dam Target Outturn Cost Report. Note: this table contains Commercial and In Confidence information related to works packages which are yet to be tendered. To facilitate best market pricing for these packages, the specific values of each item have been removed.

With the presence of a number of endangered and threatened aquatic species, including the only sustainable population of Macquarie Perch in the ACT, in the broader upstream and downstream catchments, the Fish Studies and Habitat works to be undertaken by the Alliance are a critical and necessary component of the broader ECD project.

Cotter Recreational Precinct

The Cotter Recreational Precinct incorporates the areas encompassing the dam and a number of locations immediately downstream of the dam site extending to Casuarina Sands. The precinct includes picnic and recreational areas, camping grounds and walking trails. At a minimum, the ECD project will be required to

88 Bulk Water Alliance, *Enlarged Cotter Dam Target Outturn Cost Report*, August 2009, Section 1.1.

reinstate the level of service that previously existed in the precinct, and ameliorate the impacts of construction within the recreational area.

As a result of community and Government stakeholder engagement, it was identified that there is an opportunity to enhance the precinct area.

The Cotter Precinct mitigation works involve the upgrading of the Casuarina Sands recreational area, construction of a lookout and Cotter Dam Discovery Trail on the slopes of Moores Hill, and the upgrading of facilities along Cotter Avenue. The upgrading of Casuarina Sands was carried out expeditiously to enable Cotter Avenue to be closed prior to the planned commencement of the diversion works. **Table 4.9** below provides a summary of the works to be undertaken by the Alliance as mitigation measures directly associated with the construction of the ECD.

Table 4.9: Cotter Precinct Mitigation Measures

Mitigation measure	Description of works
Signage	Development and partial implementation of signage master plan. Includes regulatory, way finding and interpretive signage throughout the precinct.
Art & Culture master-plan	Development of a master plan as a positive legacy document. No implementation.
Landscape strategy	To provide a strategy that links current and future landscape works at the Cotter through a common design approach. Partial implementation only.
Above dam recreation area	Determining final construction ground levels to govern completed landscape works within construction footprint.
Upgrading of facilities	Selective repair, upgrade and replacement of existing recreational furniture and facilities.
Walking trails	Development of a walking trail master plan and partial implementation to improve connectivity of existing track network.
Cotter River amenity	Design and construction of a new walking bridge over the Cotter River and improved walking path along river edge within Cotter Avenue.
Upgrading of Casuarina Sands	Upgrading and reconfiguration of existing Casuarina Sands and Charlie's Point recreational areas as an alternate destination to Cotter Avenue.
Moores Hill viewing platform	Design and construction of new viewing platform to permit public viewing of construction activity and completed dam structure.

Source: Enlarged Cotter Dam Target Outturn Cost Report

The total cost of the Cotter Precinct mitigation works is summarised in **Table 4.10**.

Table 4.10: Cotter Precinct Mitigation Works Expenditure

Expenditure Item	Cost
Direct Costs	
• Design	[redacted]
• Signage	
• Facilities	
• Walking tracks	
• Cotter River walk	
• Casurina Sands	
• Viewing platforms	
Total Direct Costs	**$6,457,895**
IT and Management fees	[redacted]
Agreed Alliance fees	
Total Cotter Precinct Mitigation costs	**$7,446,762**

Source: Adapted from Enlarged Cotter Dam Target Outturn Cost Report. *Note: this table contains Commercial and In Confidence information related to works packages which are yet to be tendered. To facilitate best market pricing for these packages, the specific values of each item have been removed.*

Halcrow notes that it a requirement of the ECD project to reinstate (at a minimum) the level of service that previously existed in the precinct, and ameliorate the impacts of construction within the recreational area. After considering the planned works and expenditure, Halcrow has found no evidence to suggest that the proposed Cotter Precinct mitigation works are inappropriate.

Owner's costs

Owner's costs for the construction and commissioning of the ECD project from 1 July 2009 to project completion are budgeted at $10.415 million. As identified in **Table 4.7**, this is separated into direct costs for community engagement and stakeholder management, electricity works and supply, equipment monitoring and network services ($5.568 million) and Water Security Major Projects Program costs ($4.847 million).

4.3.3 *Analysis of exclusions*

The *Cotter Dam and Reservoir Management Plan* (CDRMP) currently being developed by ACTEW outlines and guides the management of the Cotter Dam and Reservoir for the first 10 years following the completion of the ECD project. During detailed interviews with ACTEW, it was indicated to Halcrow that the CDRMP would cover a range of capital works projects required post ECD construction that were not included in either the TOC of non-TOC costs.

As part of this review, Halcrow was provided with a draft outline of the CDRMP by ACTEW. This outline suggests that the following projects, not covered in the TOC or non-TOC costs for the ECD project, will be required in the future:

- Water quality planning and management, including hydrodynamic model development and management, and water quality sampling.
- Dam safety and surveillance.
- Enlarged Cotter Dam asset management, including reservoir inundation area tree and vegetation clearing, operations and maintenance plans for the ECD and saddle dams, and intake and outlet works.
- Residual Environmental Impact Statements and Development Approval responsibilities.
- Ongoing capital works program, including the installation of mixers.

While the majority of the above works relate to the ongoing operation and maintenance of the ECD project, Halcrow has concerns regarding the apparent exclusion of reservoir inundation area tree and vegetation clearing from the total ECD costs. It is, however, understood that a provisional sum of $1.5 million has been included in the TOC for the purchase and installation of log booms and to clear the inundation area. It is also understood that the final extent of clearing that will be required is the subject of ongoing studies and has not yet been determined.

Halcrow also believes that the purchase and installation of mixers should also be included in the total ECD project cost estimate. It is noted that the provision of power supply and associated control systems has been included in the TOC, however, the need to purchase new mixers (existing mixers will be used initially) has not yet been confirmed.

In addition to the above works, costs associated with a major flooding event over and above $1.42 million and over and above the recovery from insurance are also not covered in the TOC or non-TOC costs. Halcrow notes, however, the difficulty in attempting to quantify in monetary terms the impact of such a risk. Consequently, at this stage it is considered reasonable for such a risk to be excluded from the TOC and non-TOC costs unless a suitable risk allowance can be determined. It should be noted that contract works for the ECD project are indemnified against major storms, floods, cyclones and earthquakes.

4.4 Accuracy of Cost Estimates

4.4.1 *Analysis of unit rates*

Development of the TOC estimate has been based on two key inputs:

- Unit rates provided through a competitive tendering process for specific components of the works required for the ECD project; and
- Unit rates adopted on the basis of the Alliance partners' experience, which have been used to complete cost estimates for the remaining components of the ECD project.

As discussed in **Section 4.2.4**, a tendering process was undertaken with sub-contractors to develop cost estimates for the range of works involved in the ECD project. These costs were then used in the development and preparation of the TOC.

Cost estimates have been extensively reviewed commencing with detailed financial audits as part of the alliance tender evaluation process (which challenged cost rates, margins and billing practices) through to the independent estimator engaged by ACTEW to assess the TOC figure. It is important to note that the independent estimator had no comments on either the direct or indirect cost components of the TOC. There were, however, some minor points of difference related primarily to escalation and contingency (risk and opportunity) allocations.

4.4.2 *Analysis of escalation factors*

Table 4.11 outlines the escalation assumptions adopted by the Alliance in the development of the TOC.

Using the rates and assumptions in **Table 4.11**, the escalation calculated by the Alliance is $15,404,734. On total direct costs of $224,292,261, calculated escalation represents 6.87 percent of direct costs over two years. It should be noted that, when the Alliance revised the TOC from $310.9 million to $299 million, no change was made to the risk allocation or escalation. While the level of escalation would ideally be recalculated as part of the revised TOC, it is noted that any adjustment to the previously calculated escalation would likely be in the order of $0.5 million, and is therefore not significant in terms of the overall TOC.

Table 4.11: Escalation Assumptions Adopted by the Alliance

Item	Assumption
Project completion	December 2011
Purchases before 2010	No escalation applied
Timing	The majority of construction materials will be purchased in 2010
Direct staff costs	3% p.a.
Direct labour costs	4% p.a.
Materials	2.5% p.a.
Metal work, reinforcing bar, pipe work	5% p.a.
Major plant	6% p.a. assuming fuel increasing $0.40 p.a. (less $0.19 for fuel rebate)
Minor plant	10% p.a.
Consultants	5% p.a.
Major sub-contractors	5% p.a.
Cement and fly ash	5% p.a.

Source: Enlarged Cotter Dam Target Outturn Cost Report

The proposed escalation rates were reviewed by Project Support as part of its independent review of the TOC. As a result of its analysis, Project Support had a point of difference of -$3.65 million compared to that proposed by the Bulk Water Alliance. The main basis for the difference was the plant escalation rate adopted; the Bulk Water Alliance has proposed a rate of 6 percent per annum, whereas Project Support believes that a rate of 3.5 percent per annum is more appropriate.

In its response to Project Support's review, the Bulk Water Alliance countered that an escalation rate of 3.5 percent per annum was inappropriate for plant rates. The Bulk Water Alliance claimed that the lower rate did not sufficiently take into account the impact of fuel prices, and did not adequately recognise the practical difficulty in purchasing permanent materials, such as cement, early on due to the detailed design phase not yet being completed. Despite the views of the Bulk Water Alliance, Project Support's view remained unchanged, claiming that it had seen similar outcomes in "*far more escalation unfriendly times*".[89]

[89] Project Support, *Independent Estimator Review of Enlarged Cotter Dam Alliance TOC2 Estimate*, August 2009.

During the detailed interviews conducted as part of this review, it was noted by both ACTEW and Project Support that the development of escalation rates is highly subjective with a high degree of uncertainty.

The global financial crisis has been seen to have had a significant effect on the prices of some materials, the construction industry in general and the financial sector. However, anecdotal evidence from similar reviews conducted by Halcrow indicates that the effects of the crisis on particularly relevant input items can be variable and the costs of some materials have not dropped as deeply as expected.

While the point of difference remains, Halcrow notes that the difference of $3.65 million represents only approximately 1.4 percent of total direct costs (including escalation and risk allocation). Given the relative size of the point of difference, and the highly subjective and uncertain nature of determining accurate escalation rates, it is likely that the actual escalation rate would lie somewhere between the two figures quoted.

In relation to the remaining escalation assumptions outlined in **Table 4.11** above, Halcrow does not consider the proposed rates to be inappropriate.

4.4.3 Benchmarking and independent review processes

It is noted by the Bulk Water Alliance in the TOC Report[90] that, throughout the development of the TOC, there was a process of continual detailed and comprehensive review of the design and construction methodology by the Bulk Water Alliance. In addition to this, ACTEW and the Bulk Water Alliance has sought the input of independent experts and an independent estimator (Project Support) to add an additional level of rigour and robustness to the budget estimates. Indeed, it has been claimed by the Bulk Water Alliance that "*Value management was a primary focus and as a result the TOC development phase was extended by eight weeks to allow more development of cost saving ideas.*"[91]

As part of the overall checks and balances established as part of the Alliance Agreement, a range of external reviews, internal reviews and mixed reviews were undertaken. These reviews are summarised in **Table 4.12**.

[90] Bulk Water Alliance, *Enlarged Cotter Dam Target Outturn Cost Report*, August 2009.

[91] Bulk Water Alliance, *Enlarged Cotter Dam Target Outturn Cost Report*, August 2009, Section 1.0, p.3.

Table 4.12: Review processes adopted by the Alliance

Type of review	Description
External	An independent estimator (Project Support) was engaged by ACTEW to review all project estimates throughout the project lifecycle and before the TOC was submitted to the ACTEW Board. The aim of the independent estimator was to review the rates for the different cost items as stated by the Alliance and report on their reasonableness. A Technical Review Panel (TRP) was also established by ACTEW. It consisted of independent experts from the design and construction areas with the task of independently reviewing the design of the ECD.
Internal	Value for Money workshops were held throughout the concept design phase. The workshops were attended by owner, designer and constructor representatives with the goal of reducing the costs of the proposed design. Various deliverables were discussed and the appropriateness of assumptions and the design and construction methodology were questioned. As part of Risk and Opportunity workshops, each deliverable was allocated a probability that the expected cost of delivery will be lower (opportunity) or higher (risk) than the TOC estimate. The Risk and Opportunity workshops were attended by the designer and constructor representatives as well as the Owner's Representatives.
Mixed	Challenge Panels were created as an additional layer of review and were tasked to criticise the proposed solution. Separate Challenge Panels exist for design and construction methodology. GHD (Alliance Design Partner) also has an internal process that requires the proposed design to go through a GHD challenge panel.

Source: *Adopted from Independent review of the design and estimate process for the ECD Project.*[92]

Overall, Halcrow considers the approach undertaken to review the design and construction methodology and costings for the ECD project to be detailed, comprehensive and robust. The roles of the independent estimator and value for money workshops are discussed in greater detail in the following section.

Role of Independent Estimator

Project Support was engaged by ACTEW as an independent estimator to review all project estimates throughout the project lifecycle and report on their reasonableness.

[92] Deloitte, *Independent review of the design and estimate process for the ECD Project,* August 2009, p.15.

Project Support reviewed the direct costs, risk allocation and escalation outlined in the July 2009 TOC estimate of $310.92 million. Combined, the direct costs, risk allocation and escalation totalled $272.09 million. Project Support's final assessment resulted in a total point of difference (POD) with the Alliance's estimate of $5.91 million in a project with direct costs of $272.09 million. This represents a point of difference of approximately 2.2 percent.

In the experience of Project Support, where a single point of estimate price differs within a range of ±2.5 percent, the price is considered to be within a realistic level of accuracy. The major points of difference between the review undertaken by Project Support and the Alliance estimates are outlined in **Table 4.13**.

Table 4.13: Independent Estimator Difference Summary

Point of Difference	Difference	Project Support finding
Risk & Opportunity Contingency	-$1.80 million	The modelling by Project Support produced a contingency (P50) amount of $20.16 million which represents 10.8% of the Project Support reconciled 'true' direct costs of $187.2 million. The Alliance has proposed an amount of $21.96 million which represents 11.7% of 'true' direct costs. A POD of -$1.80 million was raised based on adopting the Project Support modelling P50 amount.
Escalation	-$3.65 million	Project Support's analysis indicated an escalation amount $3.65 million less than that proposed by the Alliance. The difference is largely around the plant rate escalation adopted – the Alliance proposed 6% whereas Project Support's view is 3.5%.
Design	-$0.46 million	The POD amount relates to disbursements and the assumed numbers of some engineering disciplines engaged on project design. Project Support noted the seemingly large numbers of geotech resource days allowed and the relatively large allowances for HydroTas design in comparison to the other Alliance design work and their respective work section values. The final POD raised here is -$0.46 million.
Total POD	**-$5.91 million**	

Source: Adapted from Independent Estimator Review of Enlarged Cotter Dam Alliance TOC2 Estimate.

Halcrow is satisfied with the approach taken by ACTEW to engage an independent estimator to review all project estimates throughout the project lifecycle and report on their reasonableness.

Halcrow notes that the review returned no recorded points of difference with the Alliance direct and indirect costs. These costs were considered to be "*on the money*" by Project Support[93]. Points of difference totalling -$5.91 million remained against risk, escalation and design, areas which are more 'subjective' components of the estimate (risk and escalation).

A more detailed discussion on the level of contingency adopted as part of the TOC is presented in **Section 4.4.1**, whilst **Section 4.4.2** provides a discussion on the level of escalation proposed by the Alliance and the key issues raised by Project Support.

Value for Money Workshops

As noted above, value management has been a stated focus of the Alliance throughout the TOC development phase. To this end, value for money workshops were held throughout the concept design phase and were attended by owner, designer and constructor representatives with the goal of reducing the costs of the proposed design.

As part of this process, design coordination meetings were held in the lead up to the TOC design freeze on 15 April 2009. The intent of these meetings was to formally review the concept design in a forum including representatives of all members of the Alliance. As noted in the TOC report[94], the drawings for each design lot were reviewed for errors, consistency and safety, and with respect to value for money, innovations and cost savings. The drawings were then updated and taken forward to the TOC design freeze.

A two day value for money workshop was held from 21-22 April 2009 after the TOC design freeze to review the design and proposed construction methodologies.

[93] Project Support, *Independent Estimator Review of Enlarged Cotter Dam Alliance TOC2 Estimate*, August 2009, p.9.

[94] Bulk Water Alliance, *Target Outturn Cost (TOC) Report – Enlarged Cotter Dam Project*, 4 August 2009.

Following preparation and review of the TOC estimate on 28 May 2009, a value management meeting was convened with all key ECD Alliance participants to discuss ways and ideas to improve value for money in the project. All aspects of the design, construction methodology and owner's scope were challenged in order to identify areas where significant savings could be made.

Halcrow notes that, as a result of the value for money workshops, a total of fifty seven ideas were documented. A champion was then assigned to each item to develop them. A follow up value for money meeting was held from 15-16 June 2009 where each of the champions presented reports from their respective items to the Alliance. Each item was discussed and the group decided which items would be progressed onto concept design and into the final TOC estimate.

Halcrow is satisfied with the value for money workshops undertaken by ACTEW and the Alliance. Halcrow is of the opinion that the value for money workshops, and the corresponding value for money outcomes reports[95], contributed to the Alliance ensuring that value management remained a focus throughout the development of the TOC.

4.5 Risk of Cost Variations

4.5.1 *Analysis of risk assessments and contingency allowances*

An analysis of the risk assessment and contingency allowances made for the ECD project is presented in **Section 5.4.1**.

4.5.2 *Analysis of response to scope variations*

An analysis of the process by which changes to the scope of the ECD project are assessed is presented in **Section 5.4.5**.

[95] Bulk Water Alliance, *Target Outturn Cost (TOC) Report – Enlarged Cotter Dam Project*, August 2009.

5 Contractual/Alliance Arrangements

5.1 Overview

This section provides a detailed discussion on the contractual and Alliance arrangements of the ECD project. It provides a detailed overview of the selection of the Alliance project delivery method, a discussion on the process used to develop cost estimates, and a review of the potential for cost variations and the pain-share/gain-share arrangements. Finally, the scope and treatment of savings is discussed.

5.2 Selection of an Alliance Project Delivery Methodology

5.2.1 *Analysis of project delivery methods*

For any project there exist a number of procurement or project delivery models/methodologies, all of which have strengths and weaknesses depending on the priorities of the project and the priorities of the project proponent. Accordingly, careful and detailed evaluation of the project drivers and priorities together with an assessment of the strengths and weaknesses of available project delivery methodologies should enable the selection of the most appropriate project delivery methodology which should then result in the most effective project delivery outcomes.

Halcrow finds that in this instance, ACTEW has followed this discipline.

ACTEW engaged IDSM Pty Ltd (IDSM), one of three or four companies with significant 'transaction evaluation and facilitation' capability, to assist in the identification of the most appropriate project delivery model for the ECD project.

ACTEW, with the assistance of IDSM, undertook the evaluation of a wide range of project delivery methodologies. The design delivery methodologies evaluated included:

- **Design.Bid.Build** – the more traditional form of procurement methodology whereby the works are designed and then contracted for construction.
- **EPCM** (Engineering, Procurement and Construction Management) - commonly used in the mining sector.

- **Alliance** – an increasingly utilised (within the water infrastructure construction arena) cooperative procurement methodology that is based on equitable risk sharing and gain-share/pain-share outcomes.
- **Managing Contractor** – commonly used in the building construction sector.
- **Design.Build** (also known as D&C or Design and Construct) – a combined design and construction methodology very commonly utilised for infrastructure delivery.
- **Progressive Engagement Design Build** – a variant of the Design.Build methodology where the designer is appointed prior to the constructor.
- **DBFO** (Design, Build, Finance and Operate) – a methodology that requires the works to be privately financed and subsequently privately operated for a defined period of time.

A Project Delivery Workshop was held to determine the most appropriate project delivery methodology. Representation at this workshop included ACTEW Water Security Program personnel and capital works personnel, and ActewAGL project and capital works personnel.

The foregoing project delivery methodologies were subsequently evaluated against the following objectives and issues raised during the course of the Project Delivery Workshop:

<u>Corporate & Stakeholder Objectives & Issues:</u>

- **Economic Development:**
  - Manage contracts to give local/regional business opportunities.
  - Ensure local/regional businesses can bid civil works.
  - Ensure local/regional engineering consultants can bid design.
- **Community:**
  - Agency wants a direct relationship with the local (site) community.

<u>Project Performance & Physical Delivery Objectives & Issues:</u>

- **Project Cost:**
  - Agency to tender detail design work, based on fee competition.
  - Particular objective to minimise capital cost.
  - Lowest Net Present Value the key financial determinant.
  - Want certainty on capital cost after tender award.
  - Want certainty on O&M (Operations and Maintenance) cost after tender award.
  - Want all feasible construction techniques available to get best value.
  - Contractor to accept or share geotechnical risk.

- **Changes in Physical & Operation Scope:**
  - Need flexibility to make major facility/system changes during contract.
  - Need to commence work before scope is fully defined.
  - Only limited EPA/DA approval available, major changes likely.
  - Maintain flexibility in project scope until costs known.
  - Competitively tender future augmentation works for facilities.
- **Design & Quality:**
  - Agency to maintain close control on design.
  - Agency has design & operations skills to benefit design & skills transfer.
  - Access to widest range of specialist technologies.
  - Detail design work to be bid on the basis of technology competition.
  - Engage designers in best-for-project in each field.
  - Relevant agency staff actively engaged in Design Phase.
  - Relevant agency staff actively engaged in commissioning phase.
- **Construction & Interface Risks:**
  - Engage contractors in best-in-field basis for the project.
  - Focus on maximising the scope for construction innovation.
  - Optimise performance of existing facilities as a priority.
  - 'Commissioning Guarantee' of facilities required.
  - Have only a single contract interface for project delivery.
  - Minimise the number of contract interfaces.
  - Commissioning to be carried out by the designer.
  - Commissioning to be carried out by the head contractor.
  - Agency wants to reduce its risk pricing of flood events.
  - Agency to have best management capacity to limit flood event risks.
  - Agency wants to hold risk pricing of flood events.
- **Controlling Time & Time Related Costs:**
  - Need to minimise the project delivery time.
  - Maintain flexibility on time & cost rate of project delivery.
  - Want certainty on cash flow after tender award.
  - Certainty of meeting scheduled delivery date.

Using a scoring system (IDSM's 3DM Model), the workshop concluded that an Alliance project delivery methodology was the most favoured. Further sensitivity analysis was undertaken, but the Alliance methodology remained the most favourable.

While Halcrow was not privy to the detail of the proprietary IDSM 3DM Model, it is understood from the documentation sighted that the model is substantially a "comparative" model. As such, it is likely to generate the most appropriate option dependent on the use of appropriate "criteria" on the one hand and "weightings" applied to the criteria on the other. In Halcrow's view, the criteria used appear appropriate. The weightings used, however, appear to be more a result of the priority accorded to the criteria by the adjudicators. The sensitivity analysis undertaken was also a "comparative" analysis whereby the weightings for the criteria were amended, both upwards and downwards, and the corresponding outcomes observed. This sensitivity analysis appears to be appropriate.

The assessment factors with which an Alliance project delivery methodology most closely aligned included:

- Engage designers in best-for-project in each field.
- Focus on maximising the scope for construction innovation.
- Only limited EPA/DA approval available, major changes likely.
- Agency wants a direct relationship with the local (site) community.
- Certainty of meeting scheduled delivery date.
- Engage contractors in best-in-field basis for the project.
- Want all feasible construction techniques available to get best value.

To gain higher alignment with the issue of 'engagement of designers in best-for-project in each field' a 'progressive alliance engagement' model was ultimately recommended. In this instance, the designer is selected first, from a field of designers only, prior to the selection of a contractor engaged for the construction of the works.

To further pursue 'value for money', it was proposed that a mechanism be adopted that maintained 'competitive tension' throughout the Bulk Water Alliance selection process. The proposal was that the full finalisation of the commercial terms be conducted prior to the conclusion of the non-financial evaluation process.

5.2.2 *Appropriateness of selection of an Alliance project delivery methodology*

Halcrow considers that the process for the selection of a project delivery methodology was systematic and rigorous. The project delivery methodologies under consideration were broad ranging and inclusive of those commonly utilised by similar agencies. Likewise, the objectives and issues used to evaluate the project delivery methodologies are those of common concern to similar agencies for the delivery of substantial infrastructure projects.

With respect to the identified objectives and issues, a number resonate with Halcrow's understanding of commonly experienced project implementation issues, particularly in the recent and continuing climate of skills shortage in the water infrastructure sector. The resonating objectives and issues include:

- Managing contracts to maximise local/regional business opportunities, including the opportunity for local/regional businesses to be able to bid for civil works and the opportunity for local/regional engineering consultants to be able to bid for the design work.
- Tendering the detail design work on a competitive basis.
- Minimisation of capital cost; certainty of capital cost and certainty of Operations and Maintenance costs, after tender award.
- Flexibility of construction techniques to get best value.
- The need to commence work before the project scope is fully defined, coupled with limited approval in hand prior to project commencement, thus requiring contractual flexibility to make changes during contract.
- The engagement of relevant agency staff during the design stage of the project to maximise the knowledge transfer of agency staff and to maintain control over the design.
- The engagement of the best available designers for the project.
- The engagement of the best available constructors for the project.
- Maximising the scope for construction innovation during both the design phase of the project and during construction.
- Minimisation of the project delivery time and certainty of meeting scheduled delivery dates.

As alluded to in the above paragraphs, the Alliance project delivery methodology is well regarded throughout the infrastructure construction industry in general, to achieve the engagement of the best available designers and the best available constructors for projects. Alliances have been used for some significant time for infrastructure delivery projects, especially in the road construction arena. Alliances have also been used for some significant time in long term operations and/or maintenance contracts. Alliance delivery is observed to be an increasingly used delivery methodology for water related infrastructure delivery projects.

The engagement of the best available designers and the best available constructors was a highly valued criterion used for the selection of an Alliance project delivery methodology over and above other methodologies.

ACTEW has (anecdotally) advised, during the course of the interviews, that some difficulties were encountered early in the formative stages of the Bulk Water Alliance with respect to the active engagement of the specific personnel nominated in the tenders and subsequent tender evaluation. Halcrow understands that these difficulties have been successfully resolved to ACTEW's satisfaction; an indication of the strength of an Alliance project delivery methodology.

5.2.3 *Description of the tendering process*

Consistent with ACTEW's decision to undertake the project utilising Alliance delivery, ACTEW proceeded to tender the project. Just prior to the release of the Request for Proposal (RFP), ACTEW tendered for and appointed a Financial Auditor and a Probity Auditor to assist during the project tender and award process.

The tendering process for the Bulk Water Alliance partners used was consistent with the practice of similar agencies throughout Australia. It comprised an industry briefing, followed by the submission of a proposal, followed by assessment, financial audit, and finally resultant commercial closure.

This process was substantially similar for both the appointment of the design participant and the construction participant except that the preferred design participant (identified prior to the selection of the construction participant) was included in the selection process for the construction participant albeit in a non-voting role.

For the design role, two proposals were received by ACTEW with both proposals fully conforming. The fact that there were only two tenderers to the design aspect of the project meant that there was limited scope to maintain 'competitive tension' throughout the remainder of the selection process.

Both ACTEW and IDSM inform (anecdotally) that the competitive tension remained throughout the process, citing progressively keener pricing by the ultimately successful participant by the end of the commercial stage of the process. This occurred partly through a detailed commercial and financial audit of the participants which assessed and challenged cost rates, margins, and billing procedures to facilitate a value for money outcome. ACTEW has provided details of the financial audits, however, a full review of these was not able to be completed at the time of preparing this report.

For the construction role, five proposals were received by ACTEW. Of these, only four proposals were fully conforming, that is, a technical and a commercial proposal was submitted. All four conforming bids went on to be evaluated by ACTEW.

Again, both ACTEW and IDSM inform (anecdotally) that the competitive tension remained throughout the process, citing progressively keener pricing by the ultimately successful participant by the end of the commercial stage of the process. As above, this occurred partly through a detailed commercial and financial audit of the participants which assessed and challenged cost rates, margins and billing procedures to facilitate a value for money outcome. ACTEW has provided details of the financial audits, however, a full review of these was not able to be completed at the time of preparing this report.

In both evaluation processes, extreme care was taken to avoid the possibility of participants determining their relative competitive position in the evaluation process. There were no changes to the proposed evaluation program and, in the case of the design consultant evaluation, the participants were not notified of their success or otherwise until the final decision had been approved. In the case of the contractor evaluation, two of the participants were notified, however, the remaining two participants were unaware of this. In particular, the second placed participant was deliberately kept in the process to facilitate some competitive tension. It is unclear, however, exactly how this process affected the outcomes.

5.2.4 *Appropriateness of the tendering process*

Halcrow is substantially satisfied with the tendering and evaluation process undertaken by ACTEW, leading to the ultimate appointment of both the design and construction participants to the Alliance.

A minor misgiving, however, was the lack of competing participants for the designer evaluation; a lack of participants that was beyond the control of ACTEW. ACTEW may have been able to re-tender the project in order to gain greater participation by potential design companies; alternatively, they might have invited specific responses from a selection of the large number of interested parties who attended the initial briefing sessions for the project.

It is recognised, however, that this tender occurred during, arguably, the height of the skills shortage in the design capability area of the water industry; a skills shortage that has adversely affected many water related projects throughout Australia, especially with respect to the availability of designers and thus high competition for projects.

Halcrow's observation is that it is unlikely that the situation would have been significantly different in the last 12 months, especially in the water sector. The water sector (and the transport infrastructure sector) has not been immune from the global financial crisis but has been (by observation and experience in the market) significantly less effected than in other infrastructure sectors. There is still an observed skills shortage (especially in consulting engineering) and some difficulty in attracting contractors for water infrastructure projects due to the prevalence of other large infrastructure projects.

5.3 Process to Develop Cost Estimates

5.3.1 *TOC development*

For Alliance delivered projects, the cost estimate is called the Target Outturn Cost (TOC). The TOC is usually a sophisticated and robust estimate compiled by the Alliance participants in parallel with the design process (ie. prior to the commencement of construction); a process that includes early contractor involvement to assist the development of cost effective designs, and value management workshops to further refine designs and hence costs, etc. The TOC requires the sign-off of the Alliance Leadership Group (the ALG) and the client entity (in this case, the Board of ACTEW).

The process followed by the Bulk Water Alliance for the development of the TOC for the ECD project follows normal industry practice, albeit with two substantial differences from other Alliance agreements known to our team.

These differences are that, per the Bulk Water Alliance contract, the Program Alliance Agreement (the PAA):

- The development of the TOC is time and expense limited. That is, the Alliance participants are required to undertake all of the work required to develop the TOC to a predetermined budget.
- Should the TOC fail to be accepted by the ACTEW Board, the commercial participants will only be paid their costs in the development of the TOC (ie. no profit payment will be made to the commercial participants).

These differences only serve to add commercial pressure to the TOC development phase of the Alliance, serving to add rigour to the TOC development and hence, theoretically, giving rise to a more competitive TOC.

5.3.2 *Analysis of the TOC*

An analysis of the TOC, including a breakdown of the key TOC components has been provided in **Section 4.3**.

5.4 Potential for Cost Variations

5.4.1 Analysis of risk assessments

As noted in **Section 4.4.3**, Risk and Opportunity workshops were held as part of the development of the final TOC. During these Risk and Opportunity workshops, each deliverable was allocated a probability that the expected cost of delivery will be lower (opportunity) or higher (risk) than the TOC estimate. The Risk and Opportunity workshops were attended by the designer and constructor representatives as well as the Owner's Representatives.

In developing the level of risk allocation (contingency) during the Risk and Opportunity workshops, the predicted variability of each deliverable was analysed. This involved estimating:

- the percentage under run;
- the best case outcome;
- the most likely outcome;
- the percentage over run; and
- the worst case outcome.

The outputs from the workshops were then input into 'Crystal Ball', a spreadsheet-based software suite used for predictive modelling, forecasting and Monte Carlo simulation. The Monte Carlo simulation undertaken by the Bulk Water Alliance returned a P50 result of $267.027 million compared to a TOC estimate (at the time of the Monte Carlo analysis) of $245.068 million. The risk allocation was then calculated from the difference between the P50 result and the TOC estimate with the difference being approximately $21.960 million.

The risk allocation adopted by the Bulk Water Alliance represents approximately nine percent of total direct costs. For a project of similar complexity and level of detailed design it could be reasonably expected that the risk allocation be in the order of 15 to 20 percent. However, Halcrow notes that the process by which the risk allocation was developed, that is estimating the variability of each deliverable and inputting the outcomes into a Monte Carlo simulation, is considerably superior to the application of an arbitrary percentage. As such, Halcrow is satisfied with the process by which the Bulk Water Alliance has estimated the level of risk allocation for the ECD project.

Additionally, Halcrow has reviewed the individual allowances for the underrun/over run of quantities. It is the view of this review that there is potential for some reduction in the over run of some elements in the TOC (refer to **Appendix C** for further analysis).

As noted in **Section 4.4.2** above, when the Bulk Water Alliance revised the TOC from $310.9 million to $299 million, no change was made to the risk allocation.

The independent estimator engaged by ACTEW in August 2009 modelled the Alliance risks using @risk software. The modelling produced a risk allocation of $20.16 million. This resulted in a point of difference between the risk allocation adopted by the Bulk Water Alliance and that modelled by Project Support of -$1.80 million.

Despite the point of difference, Halcrow notes that the two independent Monte Carlo simulations returned risk allocations in the same order of magnitude. Halcrow also considers the point of difference of -$1.80 million to be relatively minor in a total project budget of $363 million.

On the basis of a review of the development of the risk allocation adopted by the Alliance, and a review of the independent estimator's report[96], Halcrow is satisfied with the level of risk allocation adopted by the Bulk Water Alliance for the ECD project.

5.4.2 *Analysis of performance incentives*

As is the case for most, if not all, Alliance agreements, the performance of the parties to the Alliance is incentivised. The incentives are essentially in two parts; one for cost outcomes and one for quality outcomes, with both being independent.

The cost incentive is a gain-share/pain-share mechanism whereby, if the final cost is less than that estimated, the cost savings (the project cost underrun), up to a predetermined limit, are shared between the commercial participants (ACTEW, the designer, and the constructor). The obverse also applies whereby, if the final cost is greater than that estimated, the additional costs, up to a predetermined limit are shared between the commercial participants.

The quality incentive is a share for each of the commercial participants in a predetermined Quality Pool. In this instance the Quality Pool has been contributed to by ACTEW to the sum of $4 million.

5.4.3 *Gain Share/Pain Share mechanism*

This mechanism is designed to incentivise the Alliance participants to complete the works for lower than estimated costs.

[96] Project Support, *Independent Estimator Review of Enlarged Cotter Dam Alliance TOC2 Estimate*, August 2009.

As outlined previously in **Section 5.3**, for Alliance delivered projects, the cost estimate is called the TOC. The TOC requires the sign-off of the Alliance Leadership Group (the ALG) and the client entity (in this case, the Board of ACTEW).

Similarly, the final capital cost is called the AOC (the Actual Outturn Cost).

The gain-share / pain-share mechanism to incentivise cost underruns and disincentivise cost overruns, as outlined in the original alliance contract, was as follows:

- Should the AOC be less than the TOC, 50 percent of the cost saving will be paid to the commercial participants (the designer and the constructor) up to a cap determined by the quantum of the project fee at risk by the commercial participant. ACTEW gets the other 50 percent of the cost saving up to the cap and then gets all of the cost savings beyond the cap.
- Likewise, should the AOC be more than the TOC, 50 percent of the additional costs will be paid by the commercial participants (the designer and the constructor) up to a cap determined by the quantum of the project fee at risk by the commercial participant. ACTEW has to pay the other 50 percent of the cost increase up to the cap and then has to pay all of the remaining increased costs.

In general terms this is a well used, and well understood, Alliance cost incentive mechanism, albeit with some very minor variations from contract to contract.

However, the gain-share/pain-share regime was amended at some time after the signing of the contract. Halcrow understands that this took place at about the same time as the finalisation of the TOC. It is understood that during the resolution of the TOC it was agreed to reduce the accepted TOC from $272,087,113 (corresponding to the total of $310.9 million) to $261,856,282 (corresponding to the revised total of $299 million. Halcrow has been advised that the NOPs (the Non-Owner Participants) identified that the reduction in the TOC would result in a loss of $1,488,882 from their respective total agreed fees. In return for the NOPs’ acceptance of the reduced TOC and in recognition of the reduction in the agreed fees, the ALG (the Alliance Leadership Group) agreed to adjust the pain-share formula such that there is no pain-share until such time as this “lost” Project Fee component was recovered by the NOPs.

The amended gain-share/pain-share regime is now as follows:

- Should the AOC be less than the TOC (now $261,655,282) and less than $251,223,452 (i.e. more than $10,431,830 less than the TOC) all of the cost saving between the TOC and $251,223,452 (i.e. $10,431,830) plus 50 per cent of the difference between the AOC and $251,223,452 will be paid to the commercial participants (the designer and the constructor) up to a cap determined by the quantum of the project fee at risk by the commercial participant.. ACTEW will in effect forego its share of the initial cost under-run amount of $10,431,830 but will benefit from 50 per cent of the cost underrun for an AOC less than $251,223,452.
- Should the AOC be less than the TOC but more than $251,223,452, all of the cost saving will be paid to the commercial participants (the designer and the constructor). ACTEW will in effect forego its share of the cost underrun amount between the TOC and the AOC.
- Should the AOC be equal to the TOC, the commercial participants (the designer and the constructor) will get zero gain-share/pain-share.
- Should the AOC be more than the TOC but less than $275,064,875, the commercial participants (the designer and the constructor) will get zero gain-share/pain-share (that is, also not have to pay any pain-share for that component of the cost over-run). In effect ACTEW will have to pay 100 per cent of the cost over-run to a maximum of $275,064,875.
- Should the AOC be more than the TOC and more than $275,064,875, the commercial participants (the designer and the constructor) will have to pay 50 per cent of the cost over-run greater than $275,064,875. ACTEW will have to pay 100 per cent of the cost overrun to $275,064,875 and then 50 per cent of the cost over-run value thereafter.

While similar gain-share/pain-share regimes (per the original contract) have been seen by Halcrow previously, a gain-share/pain-share regime such as has been agreed by the Alliance's ALG (and thereafter ACTEW) has not.

The existing (amended) gain-share/pain-share regime as outlined above in effect gives the first $10,431,830 of cost savings to the commercial participants; ACTEW foregoes all of this saving. ACTEW will only realise savings (and only 50 per cent at that) on the project should the TOC be under-run by more than $10,431,830.

With respect to pain-share, ACTEW will have to carry all of any cost over-runs to a maximum value of $275,064,875 (or the first $13,409,593). ACTEW will then have to carry all of the initial cost over-run (up to a maximum of $13,409,593) plus 50 per cent of any cost overrun in excess of $275,064,875.

In Halcrow's view, this amended gain-share/pain-share regime is skewed in favour of the commercial participants. While it creates a greater incentive to the commercial participants to attain an AOC much better than the TOC (by more than $10,431,830) it has reduced the disincentive for cost overruns because the TOC can be exceeded by up to $13,409,593 without penalty to the commercial participants.

5.4.4 *Quality Pool*

To incentivise the Bulk Water Alliance participants to deliver outstanding performance on non-directly cost related criteria, a Quality Pool has been established. This Quality Pool has been 'seed funded' by ACTEW to $4 million.

The establishment of a Quality Pool or Performance Incentive Bonus Pool is common practice in Alliance frameworks/contracts and generally follows a consistent theme in its application.

In this instance, the Quality Pool is available for outstanding performance by the Bulk Water Alliance participants in a number of predetermined Key Result Areas (KRAs) indicated by a number of measurable Key Performance Indicators (KPIs).

The KRAs in this instance comprise:

- Safety;
- Environment;
- Cost;
- Time;
- Operability;
- Legacy;
- CESM (Community Engagement and Stakeholder Management); and
- Quality.

For each of these KRAs there are a number of KPIs. Each of the KPIs are scored and aggregated throughout the term of the Alliance to determine the ultimate share of the Quality Pool available to the Bulk Water Alliance participants.

However, this share of the Quality Pool can be adversely affected should any of the Program Modifiers, factors that can override the aggregated performance of the Alliance for its KRAs, come into play. The Program Modifiers in this instance relate to Safety and Environmental performance. The Program Modifiers refer to specific events (eg. a safety related prosecution) and, once initiated serve to proportionally reduce the amount of the overall Quality Pool available to the Bulk Water Alliance participants.

It should be noted that the Quality Pool is available to the Bulk Water Alliance participants for outstanding performance as identified in the set KPIs and not 'business as usual' performance. While it is not possible to definitively say that the quality pool will be sufficient to drive the necessary behaviours of the contractors, the quality pool is considered to give a strong stimulus to drive the necessary behaviours of the contractors to achieve the performance desired by ACTEW.

Halcrow has sighted the Bulk Water Alliance – Performance Measurement specification that identifies the KRAs, quantifies the KPIs, identifies the Program Modifiers and quantifies the effect(s) on the Quality Pool should a Program Modifier event occur.

For any Alliance, the selection of the KRAs and their relevant KPIs should vary from project to project and from client to client, depending on the critical factors associated with each project and client circumstance. Accordingly, comparison of KRAs and KPIs are not readily transferable between projects and, indeed, should be somewhat unique to each project. Notwithstanding, there does exist some commonality of KRAs and KPIs from Alliance project to Alliance project.

For the Bulk Water Alliance, Halcrow finds that the KRAs and KPIs accord with industry practice and are sufficiently well defined.

Unlike the KRAs and their relevant KPIs, Program Modifiers (also known as Commercial Modifiers in other Alliances) do not appear to vary from Alliance project to Alliance project to any great extent, especially with respect to the subject matter of the Modifiers, usually Safety Performance and Environmental Performance. The application of the Modifiers and the effect of their application on the Quality Pool do, however, vary somewhat.

For the Bulk Water Alliance, Halcrow finds that the basis of the Program Modifiers meets industry practice but their application does not. This is exemplified by the negative scoring applicable to both Major Safety events and Major Environmental events as presented in Tables 5.1 and 5.2.

Preliminary assessment of the scoring system for the Program Modifiers indicates that this system is not consistent with those in place in other Alliances with which Halcrow's team members are familiar. In these cases, penalties were significantly more severe.

Table 5.1: Scoring of Major Safety Events

Event Type	Number of Events		
	1	2	3
Safety related prosecution	10%	25%	50%
Injury relating in permanent injury	10%	25%	50%
Fatal event caused by the Alliance	25%	50%	100%

Table 5.2: Scoring of Major Environmental Events

Event Type	Number of Events		
	1	2	3
Prosecution	10%	25%	50%
Irreversible or catastrophic environmental incident	20%	50%	100%
Death of threatened fish in the ECD	25%	50%	100%

5.4.5 *Treatment of design variations and scope variations*

The treatment of design variations and scope variations is well covered in the Bulk Water Alliance contract, that is, the PAA.

In the Bulk Water Alliance context, design changes and scope changes are substantially different.

The definition of a Scope Change in accordance with the PAA's Clause 1.1 - Definitions is as follows:

"*Scope Change means:*

(a) *a* change *that has a significant impact on:*
   (i) *the extent and nature of the Works as described in the Program Brief or applicable Project Brief or as otherwise required by this Agreement; and*
   (ii) *the AOC or the ability to meet a Target Date or KPIs: or*

(b) *an event which the Alliance is unable to avoid, remedy or abate and which has a significant impact on the ability to meet a Target date; or*

(c) *any other event which is stated in this Agreement to be a Scope Change.*"

Accordingly, a design change could be defined as a change to the design that may or may not affect the resultant construction methodology, etc but that does not change the "*extent and nature of the Works as described in the Program Brief or applicable Project Brief*". Design changes could result, in a minor way, in increases or decreases to the AOC during the course of the project.

Regardless, as stated above, the process for dealing with either design changes or scope changes is well documented in the PAA.

Additionally, ACTEW has supplied Halcrow with:

- a copy of BWA-2-002-Design Change Procedure – the procedure required to be followed in the event of the identification of a potential design change; and
- a small number of examples of design changes undertaken for other projects within the Bulk Water Alliance (no design changes have been forthcoming for the ECD project of the Alliance to date).

Halcrow is satisfied that:

- The contract (the PAA) sufficiently allows for design changes and scope changes, the latter requiring significant rigour;
- ACTEW has in place a Design Change procedure to be followed by the Alliance for this project; and
- The Bulk Water Alliance has successfully followed this process for its other projects.

All of the foregoing leads to the conclusion that the TOC will not be altered except for significant change to the scope of the project and only following significant governance rigour.

5.5 Scope and Treatment of Cost Savings

The process by which changes to costs are assessed has been discussed in **Section 5.4.5**, while the process by which the gain-share/pain-share arrangements are assessed has been discussed in **Sections 5.4.2** and **5.4.3**.

Cost savings for the ECD project can accrue in one of two ways, or both. Scope changes that result in cost savings serve to reduce the TOC. Cost savings made throughout the course of the project, not as a result of scope changes, effect the AOC (but not the TOC).

Accordingly, ACTEW can accrue cost savings either from the reduced TOC, in which case it gains 100 percent of the cost saving, or from the AOC bettering the TOC, whereby it gains 50 percent of the cost underrun (but only after the first $10,431,830 that goes to the commercial participants) up to the cap for the other commercial participants and 100 percent of the cost underrun thereafter.

In our view, these savings might be used to fund other projects related to the ECD project. The expected benefit of any cost savings to the ACT community might be manifested in a reduction in the need for additional capital and/or operating expenditure to fund projects, which affect water prices, thereby reducing (slightly) the burden on the community.

6 Findings

6.1 *Background*

This section provides a summary of Halcrow's key findings in relation to the three key areas upon which this review was focussed. Our findings respond to specific requirements outlined in the review objectives and the key tasks listed in the scope of services.

6.2 *Prudence of the Proposed Solution*

6.2.1 *Development of the ECD project*

An assessment of options to meet the water security needs of the ACT was first undertaken in the *Think water, act water* strategy in 2004 and the *Future Water Options* project in 2005. Planning was then updated in a review of the *Future Water Options* project in 2007.

The first regulatory review of the ECD project occurred in 2008 as part of a wider, high level review of the Water Security Program of works. The findings of that review in respect to the ECD project were as follows:

- *"ACTEW have followed an extensive, robust process for the identification of prudent and efficient options aimed at ensuring the long-term security of water supply for the ACT;*
- *the Enlargement of Cotter Dam project option appears to have been well justified and is considered prudent; and*
- *the process followed in developing the estimated capital costs associated with the ECD project ($145 million, plus up to 30 percent) is considered to be robust, and there can be confidence that it allows for the efficient implementation of the project".*

6.2.2 *Underlying investment drivers*

A detailed review of the various drivers that led to the development of the *Think water, act water* strategy and the subsequent *Future Water Options* report has been undertaken. We identified and assessed the basis of the following drivers:

- Legislative drivers – *Think water, act water* strategy, *Water Resources Act 2007*, *National Urban Water Planning Principles*, and the *Water Supply and Sewerage Services Standards Code* (as referenced in ACTEW's Utility Services Licence);
- ACTEW's service level standards – set standard of restrictions occurring no more than once in every 20 years (that is, no more than 5 percent time in restrictions);

- Population growth – allowance for population growth projections to 2032; and
- Economic drivers – Net Economic Benefit analysis process.

The review of legislative drivers found that there are various requirements for ACTEW to ensure that the management and use of ACT water resources sustain the physical, economic and social wellbeing of the people of the ACT, while also ensuring that water resources are able to meet the reasonably foreseeable needs of future generations.

Review of ACTEW's proposed level of service standard found that, while there is no legislative requirement for ACTEW to comply with this standard, the level of service set is not inconsistent with the service level targets adopted by other water authorities around Australia. These targets are considered to be aspirational targets and, by their nature, could be deemed to reflect a conservative approach to water security. Halcrow notes, however, that the 1 in 20 year service level standard has been indirectly endorsed by the ACT Government and could potentially be considered to be ACT Government policy.

Review of population growth as a driver for investment found that in their initial planning and strategy studies, ACTEW used both medium level and upper level population projections. The impact of potential population growth was, to a certain extent, offset by the implementation of demand reduction strategies including a target of up to 25 percent reduction (over 2003 levels) in mains water use by 2023. The achievement of these targets would enable the existing water supply system to meet the requirements of a population of up to 460,000 people.

In planning for future water options, however, ACTEW has adopted its "prudent planning scenario" comprising the upper level population growth projections, a 12 percent reduction in mains water use by 2012 and a 25 percent reduction by 2023 (based on 2003 levels).

In Halcrow's opinion, this planning approach is not inconsistent with the general approach used within the water industry. As a whole, the industry tends to take a relatively conservative approach to planning; Halcrow considers this to be a suitable approach given that the potential impacts of not providing basic water supply and sewerage services can be significant.

The review of economic drivers found that there is some significant overlap with this driver and the level of service standard driver. ACTEW's various drivers are considered under a hybrid framework whereby consideration is given to optimising the cost of additional water supply against the cost of water restrictions, supplemented by an ACT Government planning guideline based around a one year in 20 in temporary water restrictions.

ACTEW has indicated that its decisions in respect to augmentation of its water supply system are based on optimising the cost of additional water supply against the cost of water restrictions. To this effect, a number of economic cost benefit assessments have been undertaken on the cost of additional water supply against the cost of water restrictions, the first of which was undertaken by the Centre for International Economics (CIE) in 2005.

The outcomes of the cost benefit assessments have formed an important driver for ACTEW to proceed with the ECD option. Halcrow's high level review of the 2005 CIE report noted that the net present value is very sensitive to the discount rate applied. Net present value ranges from -$14 million at 10 percent real discount rate, to $310.9 million at a 4 percent real discount rate. Analysis also demonstrates that an increase in project capital costs from $120 million to $363 million, excluding any increase in other project related costs, will produce a net present value of -$13.6 million at a real discount rate of 5 percent.

It is noted that subsequent updates to the 2005 CIE analysis were undertaken in 2007 (an options analysis by ACTEW) and in 2008 (a full review of the original report by CIE). A copy of the 2008 CIE report was requested, however, it was not provided in sufficient time to be reviewed prior to completion of this report. It is also noted that the ICRC has undertaken a more detailed review of the 2005 and 2008 CIE reports, together with the related updates made by ACTEW in relation to the cost of water restrictions. Further assessment of prudence in relation to the economic assessment of the ECD project will therefore be made by the ICRC.

6.2.3 Validity of dam design

A technical review of the dam design has confirmed the selection of a Roller Compacted Concrete (RCC) dam as the most appropriate dam type. Whilst the technical review has identified some potential minor adjustments to excavation extents, it has confirmed that the primary components of the construction methodology appear appropriate.

Some minor adjustments to the risk and contingency allowances for some components of the project have also been identified; these adjustments result in a decrease to the allowances. Given some uncertainty over whether the contingency allowances made are sufficient, and the immaterial value of the potential adjustments relative to the total project value, take-up of these adjustments is not recommended.

6.2.4 *Validity of hydrological investigations*

A review of the hydrological models used to support the options analysis and assessment process has been undertaken. It was found that, based on the publications made available for the review, extensive effort and investment has been made in developing a robust water resources model taking into account the latest science in both yield and demand estimation techniques, as well as the long term effects of climate variability and climate change. ACTEW are clearly committed to the ongoing review and continuous improvement of the water resources model, and have developed links to key organisations, including CSIRO, to help achieve this.

Halcrow assessed the basis of the hydrological models, the assumptions made regarding rainfall and runoff, and specifically, how the impacts of climate change were incorporated into the modelling.

The hydrological investigations undertaken appear to support the ECD project as one of the preferred options. The investigations have tested the ability of the ECD, as part of the suite of water security options, to provide the required yield, even under various climate change scenarios. The modelling has also tested the ability of the ECD to successfully withstand major flooding events.

The extent to which the hydrological performance of alternative options was analysed during development of the *Think water, act water* strategy is not, however, apparent.

6.3 Cost Efficiency

Halcrow considers that the process, by which the final total ECD project estimate ($363.118 million) was developed, comprised a detailed, comprehensive and robust review of design and construction methodologies and cost estimates.

The estimate developed by GHD in 2005 was based on preliminary engineering cost estimates and explicitly excluded a range of significant cost items, including owner's costs, land purchase costs, permitting costs, financing costs, and government liaison.

The 2007 estimate, prepared by ACTEW on the basis of GHD and Rider Levett Bucknall estimates, again did not take account of owner's costs relating to the ECD project. Critically, GHD's 2007 estimate was limited to a review of unit rates from 2005 and did not include a review of concepts or quantities; the Rider Levett Bucknall review did, however, review the preliminary scope of work identified by GHD.

The 2007 GHD estimates, which were incorporated into the 2007 ACTEW estimate, were explicitly stated as preliminary cost estimates for the purposes of comparing options only. It was noted by GHD that a functional design was required for a more definitive budget setting exercise.

On the basis of information now available, it is clear that the 2007 estimate prepared by ACTEW, while sufficient for comparative purposes, was not suitable as a formal recommendation to Government for anything other than the presentation of the process for selecting the preferred option.

In relation to the Target Outturn Cost (TOC), a competitive tendering process was undertaken with sub-contractors to determine unit rates and develop cost estimates for the range of works involved in the ECD project. These costs were then used in the development and preparation of the TOC.

Halcrow has found that the TOC estimate has been extensively reviewed, commencing with detailed financial audits as part of the alliance tender evaluation process (which challenged cost rates, margins and billing practices) through to the review by the independent estimator engaged by ACTEW to assess the TOC figure. It is important to note that the independent estimator had no comments on either the direct or indirect cost components of the TOC. There were, however, some minor points of difference related primarily to escalation and contingency (risk and opportunity) allocations.

In relation to escalation, the independent estimator engaged by ACTEW indicated an escalation amount $3.65 million less than that proposed by the Alliance. The difference was primarily related to the plant rate escalation adopted; the Alliance proposed six percent whereas the independent estimator's view was three percent. Given the relative size of the point of difference, and the highly subjective and uncertain nature of determining accurate escalation rates, it is likely that the actual escalation rate would lie somewhere between the two figures quoted.

Throughout the development of the TOC, there was a process of continual detailed and comprehensive review of the design and construction methodology by the Alliance. A range of external reviews, internal reviews, and mixed reviews formed part of the overall checks and balances established as part of the Alliance Agreement. Overall, Halcrow considers the approach undertaken to review the design and construction methodology and costings for the ECD project to be detailed, comprehensive and robust.

Halcrow has concerns regarding the exclusion of some identified items of work from the total ECD project cost estimate, including inundation area vegetation clearing and the purchase and installation of mixers. It is noted, however, that the need for and scope of these items is still subject to the outcomes of further investigations.

Further investigations are also ongoing as to the current level of actual expenditure related to the project and the degree to which some of this expenditure has already been allowed for in previous pricing determinations. These investigations are being undertaken by ICRC and will be reported by ICRC when completed.

6.4 Contractual/Alliance Arrangements

Careful and detailed evaluation of the project drivers and priorities together with an assessment of the strengths and weaknesses of available project delivery methodologies should enable the selection of the most appropriate project delivery methodology which should then result in the most effective project delivery outcomes. Halcrow has found that, in this instance, ACTEW has followed this discipline.

The process followed by the Alliance for the development of the TOC for the ECD project follows normal industry practice, albeit with two substantial differences from other Alliance agreements known to our team:

- The development of the TOC is time and expense limited. That is, the Alliance participants are required to undertake all of the work required to develop the TOC to a predetermined budget.
- Should the TOC fail to be accepted by the ACTEW Board, the commercial participants will only be paid their costs in the development of the TOC (ie. no profit payment will be made to the commercial participants).

These differences only serve to add commercial pressure to the TOC development phase of the Alliance, serving to add rigour to the TOC development and hence, theoretically, giving rise to a more competitive TOC.

In relation to the level of contingency adopted by the Alliance, Halcrow notes that the process by which the risk allocation was developed, that is estimating the variability of each deliverable and inputting the outcomes into a Monte Carlo simulation, is considerably superior to the application of an arbitrary percentage. Halcrow is, consequently, satisfied with the process by which the Alliance has estimated the level of risk allocation for the ECD project.

On the basis of a review of the development of the risk allocation adopted by the Alliance, and a review of the independent estimator's report, Halcrow is satisfied with the level of risk allocation adopted by the Alliance for the ECD project.

The potential for any increases or decreases to total ECD project costs arise principally through change of scope or the incentivisation allowances under the Alliance Agreement. It is expected that any variances in the total cost will result in a variation to ACTEW's future capital requirements, which would be reflected in prices to consumers through the next pricing review.

6.5 Concluding Comments

On the basis of the information provided for review, the analysis undertaken and the findings presented in the preceding sections, Halcrow finds (in summary) that:

- The do nothing approach is not prudent given the extended drought experienced in the ACT and the long term, high level restrictions that would be required to ensure the continued provision of potable water.
- The decision to identify options to increase the level of security for the water supply in the ACT is a prudent decision based on both the circumstances that existed at the time (2004/2005) and the circumstances that exist now.
- Based on our investigations for this review, it has not been possible to definitively determine whether selection of the Enlarged Cotter Dam, as part of a suite of works that together comprise the adopted Water Security Program, was (or remains) prudent, particularly given the significant increase in its estimated cost in comparison to estimates used in the original decision making process.

  This review has identified a number of inadequacies in the decision making process, the impacts of which are not entirely apparent. These include:
  - the assumptions underlying the net economic benefit analysis, which was used as a key element of the decision making process;
  - the extent to which the hydrological performance of alternative options/combinations of options has been analysed; and
  - the limited additional costing of alternative options/combinations of options in light of the significant increase in estimated project cost.

- It is, however, acknowledged that the rigour involved in estimating the current total project cost, particularly the Target Outturn Cost, has led to a contracted cost for the Enlarged Cotter Dam which can be deemed efficient.
- There remains a question in respect of the timing of construction of the Enlarged Cotter Dam. Whilst it is acknowledged that timing is dependent on the relative progression of other projects that comprise the Water Security Program, the required timing for completion of the first water security measure (whichever project that may be) has not been clearly demonstrated by the information assessed as part of this review.

Appendix A Key Issues for Interviews

A.1 Background

This Appendix presents the outcomes from our initial review of the information provided by ACTEW leading to the identification of a number of key issues that were discussed during our detailed interviews with ACTEW personnel. These issues are presented below, categorised under the three key tasks described in the scope of services, that is:

1. Prudence of proposed solution
2. Cost efficiency
3. Contractual/Alliance arrangements

A.2 Prudence of Proposed Solution

A.2.1 Validity of dam design

1. Is the current dam proposal still the most prudent option, taking into account the latest cost estimates, compared to the water security measures previously investigated?
    a. Are the other water security measures already under construction able to provide sufficient supply if augmented further?
    b. Have you investigated whether the other measures represent a more prudent option now given the significant increases in costs for the dam enlargement?
    c. The proposed RCC dam is forecast to be completed in record time compared to international examples – how is this to be achieved?
2. What is the proposed project's ranking/priority compared to the other water security measures currently being implemented? We understand that the dam might be considered a "last resort" option.
    a. Where does the enlargement project sit within the ranking/ priority of the other options? When does it need to be completed?
3. Is the current dam design the most appropriate (type, location, capacity)? Has there been an independent review of the design?
    a. Could you provide a timeline of the design process from preliminary to detailed design including what stages have been completed under the Alliance?

   b. Our expert review indicates that the placement rate for the dam is at the higher end of benchmark rates for other RCC dams. Could you explain how you are planning to achieve this? (Details of mixing and placing equipment capacity – investment or hire, stockpiling of aggregate, supply of materials).

   c. Could you provide some details on the level of geotechnical (site investigation) information available to the 2005 and 2007 design reports?

4. What is the impact of the dam capacity on fish protection measures? Are there limits on the operation of the dam required for fish protection? Has the dam been sized to facilitate fish protection?

5. Has the current dam design been subject to a full triple bottom line analysis?

A.2.2 Validity of hydrological assessment

6. Is the dam capacity still the optimal size given the current estimates of yield and demand? When is the dam forecast to fill?

   a. Have the original hydrology investigations (2005, 2006) been updated to take account of more recent climatic conditions and predictions?

   b. Has the time take to fill the dam been revised more recently than 2005?

   c. Have the population forecasts/demand curves been updated recently?

   d. Have the demand curves been updated to account for any changes to restrictions/average water use?

7. Could you detail the various allowances made for the impacts of climate change?

   a. What reduction in potential yield/rainfall is expected for the dam catchment?

8. Could you explain the timing of yield relative to demand (that is, the total water balance for the ACT)? Will the dam provide sufficient storage to meet water security requirements in the time required?

A.3 Cost Efficiency

A.3.1 Optimal project scope

9. Provide a detailed cost breakdown categorised by the key project elements

   a. Provide details for earthworks, materials, dam, associated infrastructure, operational costs, environmental works (temporary and permanent), community consultation programs, etc.

10. Provide details of scope changes from earlier cost estimates and the specific cost impacts from these changes including the proportion of the total cost increase attributable to scope changes.
    a. Provide a detailed breakdown of the cost increases from the original figure of $145 million to the current figure of $363 million?
    b. Provide specific details of what makes up the costs increases (eg. scope changes, escalation in materials costs, risk/contingency allowances, etc)
11. Provide details, including a specific breakdown, of all elements of the implementation phase in the cost estimates including environmental (including fish protection), community/social and economic factors.
12. Provide details of TOC versus non-TOC cost elements including what is included in each estimate.
    a. Provide specific details on what makes up the difference between the TOC and the total project cost?

A.3.2 Accurate cost estimates

13. Provide specific details of the basis of the cost estimates including unit rates.
    a. When were the cost estimates used for the project last calculated from scratch (as opposed to escalating previously used figures)?
    b. What are the unit rates based on? Are the unit rates regularly updated?
    c. What was the purpose and intended outcomes of the Value for Money workshops held during the concept design? Who attended these workshops?
14. Provide details of any benchmarking of rates used.
    a. What has been used as the benchmark for the rates?
    b. How have different factors been applied to the rates to ensure their suitability for use on this project?
15. Provide details of any independent peer review of cost estimates undertaken.
    a. When were the cost estimates last independently reviewed? Who undertook the review?
    b. What was the scope of this last review (preliminary design, concept design or detailed design)?
    c. What is the role of the Technical Review Panel (TRP)?
    d. Who has been appointed to the TRP?

16. Provide more specific details on the basis for the final adopted TOC of $299 versus the TOC2 estimate of $310.9 million including identification of where the proposed reduction has been taken from.
    a. Which elements of the original TOC2 estimate have been reduced to meet the final adopted TOC value?
17. Provide details of the allowances made for the gain-share/pain-share and quality pool components of the cost estimates.
    a. What is the basis of the $4 million allowance for quality pool (maximum allowable pool is approx $5.8 million)?
    b. Has any allowance been made specifically for pain-share/gain-share payments in the total project cost?

A.3.3 *Risk of cost variations*

18. Provide details of risk assessments completed for the cost estimates and what cost allowance has been made for risks
    a. Has a risk assessment been completed?
    b. What level of risk allowance has been included in the total project cost?
19. Provide details of any sensitivity analysis completed for the cost estimates, eg. Monte Carlo analysis, and what allowance has been made as a result of the analysis.
20. Provide specific details on gain-share/pain-share and quality pool allowances made and the level of confidence in these allowances.
21. Provide details of escalation factors used in the cost estimates and the level of confidence in these factors.

A.4 *Contractual/Alliance Arrangements*

A.4.1 *Approach to Alliance*

22. Provide more specific details on the tendering and evaluation process including scoring sheets for the various stages of the process and further details of decisions made during the evaluation.
    a. For the design role, one of the two proponents was excluded early in the process – why was this done?
    b. Provide the scoring sheets used in the first rounds of evaluation.
23. Provide details of probity procedures?
    a. What was the scope of work for the probity auditor?

24. Provide further details on the financial auditor / probity auditor
    a. Why was the probity auditor also engaged as the financial auditor?
25. Provide details of any benchmarking undertaken for the alliance model used.
26. Provide further details on the process leading to the selection of the delivery model.
27. Provide further details of recent reviews of the delivery model and the results of these reviews.
28. Provide details of the scope of work covered by the Alliance (inclusions and exclusions).

A.4.2 Process used to develop cost estimates

29. Provide further details on the process used by the Alliance to develop the current cost estimates (refer also **Section A.3.2** above).

A.4.3 Potential for new cost variations

30. Provide details of risk assessments undertaken relating to potential cost variations.
31. Provide specific details on gain-share/pain-share and quality pool allowances made and the level of confidence in these allowances.
32. Provide details on the contractual provisions for cost variations (eg. rise and fall).
33. Provide details on the contractual provisions for scope variations.

A.4.4 Scope for and treatment of cost savings

34. Provide specific details on gain-share/pain-share and quality pool allowances made and the level of confidence in these allowances.
35. Provide details on the contractual provisions for cost savings.
36. Provide details on the contractual provisions for scope variations.

Appendix B Review of Economic Benefit-Cost Analysis Assumptions

B.1 *Introduction*

This section has been completed by Craig Lawrence, an Associate Director in Halcrow's Economic and Business Solutions team.

The following paragraphs contain an overview of the cost of water restrictions (which provides the primary benefit streams for the cost benefit analysis), as well as the key structural elements of the cost benefit analysis (discount rate, period of evaluation, etc). The specification of project options and baseline are not discussed, as a new baseline and project case would need to be developed if a cost benefit analysis is required to address the current dam extension.

B.2 *Cost of Water Restrictions*

As noted above, CIE identified seven main costs of water restrictions. These were identified in terms of types of use and impacts on ACTEW and the ACT government. This classification set does not appear unreasonable; however the CIE report did not include any consideration of whether these costs had been double counted. This is important as these costs formed the major set of benefits in CIE's study. Double-counting would overstate the benefit stream and, consequently, the net present value results. While our review of the report indicates that this was not a major issue, as there do not appear to be major cost overlaps, it appears that there may have been some overlap between transaction costs and cost to the ACT Government in CIE's analysis.

B.3 *Cost to Households*

CIE's estimate of the cost to households of water restrictions was based on its analysis of the household demand for water. This was estimated in two ways: estimation of a household demand function for water use; and the use of survey techniques. A range of prior studies were examined by CIE, however, no specific demand analysis was developed specifically for CIE's study. From the information provided in the report, it has not been possible to assess whether the underlying studies were robust.

B.4 Commercial Costs

CIE split the commercial costs of water restrictions between water using activities by commercial entities and the impact on sales of water related products. This covered both the cost of inputs into production processes as well as consumer responsiveness to goods and services that have significant water consumption content.

Economy wide modelling was used to estimate water input cost impacts. However the information provided in the CIE report was insufficient to assess this effect. Specifically, key information about the shock and which sectors of the input-output table that shock was applied to were not provided. Substitution effects were not considered. Also, there was no baseline against which project case results could be compared. Consequently, it has not possible for this review to assess whether the figures presented in CIE's report are valid or appropriate.

The effect on water related products was largely modelled around the impact on retail nurseries. Mention was made of a CRUSOE model being used to assess changes to consumer spending patterns; however, no details were provided in the report. Also, assumptions regarding impacts of different levels of water restrictions were no specified. Neither was the opportunity to switch to drought tolerant plants. Consequently, the impacts of the higher level restrictions, while within the overall level of expenditure on nurseries, could not be confirmed from the information in CIE's report.

B.5 Recreation Costs

The approach adopted by CIE in relation to recreation costs of water restrictions does not appear unreasonable. However, we note that in other jurisdictions exemptions are approved for sports fields. For example, in Queensland sports fields can be designated as approved playing surfaces and provide with an allowance to maintain those surfaces. Furthermore, the calculation of recreation costs appears to be based on arbitrary assumptions about the reduction of sport playing time and the replacement cost of playing fields.

B.6 Tourism and Urban Environment Costs

A review of the CIE report indicates that arbitrary assumptions were applied regarding the loss of tourism associated with higher level water restrictions. This was modelled on the basis of effectively losing two tourism events. This appears to be a conservative assumption. The apparent use of an unspecified impact multiplier suggests a larger loss in real household welfare than the gross state product numbers suggest. Again, this could not be calculated from the information in the report.

Environmental costs were based on information from Canberra Urban Parks, together with an estimate of value per tree based on the benefit transfer method. This does not appear unreasonable.

B.7 *Transaction Costs*

The CIE analysis based transaction costs on costs incurred by the ACT Government to inform and educate the general public about water restrictions. These were developed from costs incurred by the ACT Government for water restrictions up to Level 3. The approach seems reasonable, however, it does not consider the proportion of these costs that would still be incurred in low probability water restriction situations. The avoided cost may be a proportion of these costs, however, we recognise that this would have been difficult to estimate.

B.8 *Cost to ACTEW Profits*

CIE appears to have adopted a commercial transaction approach to estimating the reduction in ACTEW profits resulting from water restrictions, including consideration of a growing customer base. This does not appear unreasonable.

B.9 *ACT Government Costs*

Some aspects of the ACT Government costs may have overlapped with community transaction costs identified above. However, this was not identified in the CIE report. The basis on which these figures were calculated, including the assumptions, were not set out in the report.

B.10 *Assumptions*

Period of analysis

No period of analysis was explicitly stated however from the charts presented in CIE's report, it appears to be 50 years. Normally the period of analysis is related to the expected life of the assets. This has not been addressed in the report. The effect of using long evaluation periods is simply to add additional out year benefits into the analysis, albeit at heavily discounted values.

Discount rate

A 5 per cent real discount rate appears to have been used. However, the basis for adopting this rate was not discussed in the report. Current guidelines issued by

Infrastructure Australia suggest that a 7 per cent real discount rate should be used with sensitivity tests at 4 per cent and 10 per cent, otherwise a rationale for selecting another discount rate. Increasing the discount rate would have the effect of reducing the net present value results in the study.

Residual value

The asset lives of significant elements of the capital expenditure were not identified in CIE's appraisal. No residual values were calculated. To the extent that asset lives are long lived, this would offset part of the capital cost. This would be appropriate where the service potential of the proposed project is likely to include additional benefit streams outside the evaluation period.

B.11 *Sensitivity Analysis*

There is no significant sensitivity analysis in the CIE report. The robustness of the results was not presented. The range of probable results for each project scenario and the extent to which results may be clustered around a low-value or high value result could not be assessed. Furthermore, key factors driving the result were not identified. For example, a tornado diagram would show the extent to which individual cost or benefit elements affected the net present value results reported in the study. Consequently, it is difficult to determine whether sufficient analysis of the relevant benefit and cost streams has been undertaken. At a more sophisticated level, Monte Carlo simulation of the expected water efficiencies expected between 2005 and 2025 for each category of demand identified in the report would provide a clearer profile of the expected level of benefits. The CIE report presented only two levels of expected water efficiency by 2025, a 12 per cent saving and a 25 per cent saving.

B.12 *Conclusions*

The level of capital costs presented in the CIE analysis is significantly lower than the latest project estimate for the ECD project. Net present value results would, therefore, be expected to be lower than estimated in the CIE report, all other things being the same. While key benefit streams identified in the study appear reasonable, the basis for calculating them and the resultant values obtained should be reviewed in detail.

There are several methodology issues which need to be addressed regarding the parameter assumptions for the CIE study, in order to bring it up to date. Also, a detailed sensitivity analysis would reveal both which assumptions are significant to the result and the extent to which the results obtained in the study are robust.

Appendix C Review of Economic Benefit-Cost Analysis of Water Supply Options

C.1 Introduction

This section has been completed by Craig Lawrence, an Associate Director in Halcrow's Economic and Business Solutions team. It includes an examination of the basis on which the 78 gigalitre dam option was selected in 2005. Specifically, an assessment has been undertaken of the 2005 CIE study *Economic benefit-cost analysis of new water supply options for the ACT*.

C.2 Approach

This review of the CBA study has several objectives:

- Replication of the CBA results in a simple stand alone spreadsheet analysis;
- Implications of applying a higher capital expenditure figure of $363 million, reflecting costs now anticipated for the ECD; and
- Analysis of applying an arbitrary benefit escalation factor of 3.5.

CIE did not publish the full, detailed set of data used in its cost benefit analysis study. Some data was presented in chart form, which meant that use of that information was based on the accuracy with which those charts could be read. Further, the study alluded to some assumptions but did not set out explicit values. This made independent assessment of the cost benefit results reported in the study difficult.

C.3 Data and Assumptions

C.3.1 Benefits

The CIE report estimated a series of costs arising from the imposition of different levels of water restrictions. The robustness of these estimates has been previously considered. Information in a 2008 update report prepared by CIE was not provided in time to be considered in this analysis.

The economic benefit ascribed to the dam comes from the degree to which these costs are avoided at each level of water restriction. In the first instance these costs are estimated by CIE on an annual basis for each level of water restriction. That is, the annual cost of imposing a particular level of restrictions. Most categories of costs were clearly identified in tables, however. some costs were not.

Table C.1 reports the estimated costs together with costs Halcrow has surmised from references in the cost benefit analysis study.

Table C.1: CIE Estimate of Annual Full Year Cost of Water Restrictions by Level (2005)

	Level 1	Level 2	Level 3	Level 4	Level 5
Household – High	2.5	12.0	36.2	41.3	76.7
Household – Low	1.8	8.1	20.1	22.8	40.1
Commercial and Industry	0.5	1.9	6.1	9.9	4.5
Recreational	-	-	8.0	13.7	27.7
Tourism and Environment	-	-	3.0	19.5	37.0
Transaction	0.5	1.0	1.8	2.7	3.6
ACTEW-AGL	0.1	0.9	3.8	7.1	8.4
Government	0.0	0.3	1.3	2.5	2.9
Total	**3.6**	**16.1**	**60.2**	**96.7**	**60.8**

However, the actual cost in any year is the weighted average of the percent of time in each year that each restriction applies. The study identifies these levels for 2005 and 2055. However, the water restrictions do not smoothly increase over time. There is a significant increase in Stage 1 restrictions in the middle of the evaluation period which reduces in the final years. **Table C.2** identifies the values for time under restrictions explicitly identified by CIE together with Halcrow's estimates of within evaluation period values based on the discussion in the CIE study.

Table C.2 shows the prudent baseline identified by CIE, which included assumptions about stronger than average population growth as well as higher level of water savings in future years.

Table C.2: Estimate of Time Under Water Restrictions Each Year - Prudent Baseline

Year	Level 1	Level 2	Level 3	Level 4	Level 5
2010	17%	5%	4%	2%	1%
2034	48%	15%	11%	8%	5%
2055	28%	23%	21%	14%	14%

In order to generate year-to-year figures, the changes in percentages between 2010 and 2034, and between 2034 and 2055 were interpolated. This was done in the absence of detailed information around the hydrological modelling and also in the absence of the specific data points that support the charts in the CIE study.

Similarly the reduction in time spent in water restrictions as a result of the project were set out by CIE as shown in **Table C.3**.

Table C.3: CIE Estimate of Time Under Water Restrictions Each Year - Project Case

Year	All Levels	Level 3 & above	Level 5
2010	22%	6%	1%
2020	37%	10%	2%
2030	44%	13%	3%
2040	40%	17%	6%
2050	19%	21%	8%

In order to map these against individual water restriction levels, Halcrow examined this data together with the charts in the CIE study. **Table C.4** was developed, which is consistent with **Table C.3**.

Table C.4: Halcrow Estimate of Time Under Water Restrictions Each Year by Individual Water Restriction Level – Project Case

Year	Level 1	Level 2	Level 3	Level 4	Level 5
2010	10.0%	5.0%	3.0%	2.0%	1.0%
2020	18.0%	7.0%	5.0%	3.0%	2.0%
2030	20.0%	8.0%	6.0%	4.0%	3.0%
2040	10.0%	7.0%	6.0%	5.0%	6.0%
2050	-1.0%	-1.0%	7.0%	6.0%	8.0%

In order to generate year-to-year figures, the changes in percentages between each ten-year period were interpolated. Again, this was done in the absence of detailed information around the hydrological modelling and also in the absence of the specific data points that support the charts in the CIE study.

C.3.2 *Costs*

Project costs were drawn from the CIE study. These are set out in **Table C.5**.

Table C.5: CIE Estimate of Project Costs for 78GL Extension to the Cotter Dam

	2005	2006	2007	2008	2009	2010	2011 and onwards
Capital Costs	-	-	60.00	60.00	-	-	-
Annual Costs	-	-	-	-		1.40	1.40
Environmental Costs	-	-	1.25	1.25	1.25	1.25	1.25
Land Costs	-	-	0.80	0.80	0.80	0.80	0.80
Option for Water from Snowy	-	-	0.80	0.80	0.80	0.80	0.80

C.4 *Results*

Present values of the costs, benefits and net benefits are set out in **Table C.6** for a range of real discount rates. A 5 per cent real discount rate was used in the CIE analysis. Current guidelines issued by Infrastructure Australia recommend a pro forma 7 per cent real discount rate, with sensitivity analysis at the 4 percent and 10 per cent levels. These are included for comparison. The internal rate of return is also estimated.

Table C.6: Net Present Value, Benefit Cost ratio and Internal Rate of Return Results (2005 base year)

	4%	5%	7%	10%
Net Present Costs ($M)	192.3	176.2	152.6	129.8
Net Present Benefits ($M)	503.2	377.7	224.2	115.8
Net Present Value ($M)	310.9	201.6	71.6	-14.0
Benefit Cost Ratio	2.62	2.14	1.47	0.89
Internal Rate of Return	9%			

At a 5 per cent real discount rate, the net present value reported in the above analysis of $201.6 million is not very different to the result obtained by CIE in its study. The Benefit Cost Ratio of 2.14 appears robust. The results obtain indicate that the simple spreadsheet model developed in this analysis provides a good proxy for the modelling undertaken by CIE.

Given the long period of analysis, the net present value is very sensitive to the discount rate applied. NPV ranges from -$14 million at a 10 per cent real discount rate to $310.9 million at a 4 per cent rate.

C.5 *Sensitivity Analysis*

The sensitivity analysis examined several different situations using the model developed above:

- Sensitivity A: The increase in project costs at which net present value is zero for the estimated stream of benefits at the 5 per cent discount rate.
- Sensitivity B: The reduction in estimated project benefits at which net present value is zero for the estimated stream of costs at the 5 per cent discount rate.

- Sensitivity C: The net present value result when capital costs are increased from $120 million to $363 million at the 5 per cent discount rate.
- Sensitivity D: The net represent value result when capital costs are increased from $120 million to $363 million and each estimated benefit stream is arbitrarily increased by a factor of 3.5 at the 5 per cent discount rate.
- Sensitivity E: The arbitrary benefit factor required to ensure that at least a net present value of zero is achieved when capital costs are increased from $120 million to $363 million at the 5 per cent discount rate.

The results of these sensitivity tests are set out in the following tables (**Table C.7** to **Table C.11**).

Table C.7: Sensitivity A - Increase in project capital costs

	4%	5%	7%	10%
Net Present Costs ($M)	398.7	377.7	345.0	309.4
Net Present Benefits ($M)	503.2	377.7	224.2	115.8
Net Present Value ($M)	104.5	0.0	-120.8	-193.6
Benefit Cost Ratio	1.26	1.00	0.65	0.37
Internal Rate of Return	5%			

The above analysis suggests that at the 5 per cent discount rate, the project will return a zero net present value if project capital costs increase 2.9 times, rising from $120 million to $348 million. This assumes that there is no change in the benefits estimated. Further, there is no increase in operating, maintenance or other costs.

Table C.8: Sensitivity B - Reduction in project benefits

	4%	5%	7%	10%
Net Present Costs ($M)	192.3	176.2	152.6	129.8
Net Present Benefits ($M)	234.7	176.2	104.6	54.0
Net Present Value ($M)	42.4	0.0	-48.1	-75.8
Benefit Cost Ratio	1.22	1.00	0.69	0.42
Internal Rate of Return	5%			

This result shows that if benefits fall by 53 per cent or greater the project will fail to produce a positive net present value given capital costs of $120 million for the dam and other related project costs.

Table C.9: Sensitivity C - Increase in project capital costs to $363 million

	4%	5%	7%	10%
Net Present Costs ($M)	412.6	391.3	357.9	321.5
Net Present Benefits ($M)	503.2	377.7	224.2	115.8
Net Present Value ($M)	90.6	-13.6	-133.7	-205.7
Benefit Cost Ratio	1.22	0.97	0.63	0.36
Internal Rate of Return	5%			

This result shows that an increase in project capital costs from $120 million to $363 million, excluding any increase in other project related costs, will produce a negative net present value of $13.6 million at a real discount rate of 5 per cent. However, this is significantly higher when out year benefits over the 50 year evaluation period are more heavily discounted.

Table C.10: Sensitivity D - Increase in project capital costs to $363 million and arbitrary increase in benefits by a factor of 3.5

	4%	**5%**	**7%**	**10%**
Net Present Costs ($M)	412.6	391.3	357.9	321.5
Net Present Benefits ($M)	1,761.2	1,322.0	784.7	405.3
Net Present Value ($M)	1,348.6	930.7	426.7	83.8
Benefit Cost Ratio	4.27	3.38	2.19	1.26
Internal Rate of Return	11%			

In this result the apparent project economics are improved compared, with NPV increasing from $201.5 million to $930.7 million. This is mainly because the arbitrary factor of 3.5 to increase benefits is significantly greater than the multiple on the increase in project capital costs which was identified above as 2.9.

Table C.11: Sensitivity E - Arbitrary break even factor if project capital costs increase to $363 million

	4%	5%	7%	10%
Net Present Costs ($M)	412.6	391.3	357.9	321.5
Net Present Benefits ($M)	521.3	391.3	232.3	120.0
Net Present Value ($M)	108.7	0.0	-125.7	-201.5
Benefit Cost Ratio	1.26	1.00	0.65	0.37
Internal Rate of Return	5%			

Given an assumption project capital costs increase from $120 million to $363 million it is possible to identify the arbitrary level of increase in benefits required to produce a zero net present value result. This factor is 1.04, which in effect means that any increase above 4 per cent in the level of benefits estimated in the 2005 study would produce a positive net present value if project capital costs increase.

Appendix D Technical Review of Dam Design

D.1 *Background*

This section presents a detailed technical review and analysis of the RCC dam design by Halcrow's RCC dam expert Tony Morison.

D.2 *Timeline for Construction*

The Enlarged Cotter Dam is a traditional gravity dam (minimal outlets, limited galleries and a simple stepped overflow spillway) with an RCC volume of about 300,000m^3. A faster speed of construction was one reason RCC was selected and it is acknowledged among dam engineers as usually the fastest method of construction.

It is proposed to place the RCC over 6 months. The RCC is therefore being placed at an average rate of 50,000m^3 per month. This is towards the higher end of placement rates for RCC dams, but is well within that achieved elsewhere (over 200,000m^3 per month in some cases, but on larger volume dams).

The placement rate is largely a question of:

1. investing in the mixer and placing equipment capacity (or hiring if possible);
2. preparing and stockpiling much of the aggregate in advance; and
3. supply of cement and fly ash from suppliers.

There appears to be no reason why the placement rate proposed by the Alliance could not be achieved, however, it may require a major capital investment in mixing and placing plant. If this can be hired, re-used or sold on (which should be possible in Australia) this is not such an issue.

D.3 Foundation Excavation

Of particular note is the suggestion (as in "proposed" boreholes) that no borehole data was available in 2007. Deloitte[97] notes a URS site investigation was reported in September 2007. If the 2005 and updated July 2007 cost estimates were made prior to any sub-surface geology knowledge being available for the dam foundation, then it is not unreasonable for the cost estimates to increase significantly in respect of foundation excavation. Even if Boreholes 1 to 4 were available, this is a very light investigation for the foundations for a dam of this size. Deloitte[98] notes that the combined geological assessment by GHD was prepared in April 2009 (why it took so long from the SI results reported by URS in September 2008 is not clear, but this could have been due to the need to wait for laboratory results). The optimised excavation methodology was developed by late July 2009.[99]

It is not uncommon that the first assumption for outline foundation design of concrete dams on a rock foundation, without hard data, is that only the weathered surface material beneath the dam footprint needs to be excavated. It is only when data is available (eg. the foundation excavation is looked at in 3D) and the practical problems of safe access for excavation equipment and working benches on steep side slopes (as here) are taken into account (in an excavation methodology) that reality sets in. If there were no borehole records available when the estimate was done, it may well be that it was all regarded as too early in the process for accuracy in the foundation assessment, and was then all overtaken by the unexpected speed of scheme development in response to the drought.

Halcrow has concerns regarding the level of available ground information available in 2005 and 2007 for estimating the foundation. From a review of the available information, it appears that the 2005 and 2007 cost estimates were made without the benefit of any site investigation data. If this was indeed the case, Halcrow notes that it is a major source of risk for such a scheme to be developed to this stage without site investigation. It is Halcrow's experience that at least a limited site investigation is carried out at feasibility design stage.

[97] Deloitte, *Independent review of the design and estimate process for the ECD Project,* August 2009, p.16.

[98] Ibid, p.19.

[99] Ibid, p.16.

D.4 Dam Site Alternatives

From the shape of the reservoir and topography of the dam site, Cotter Dam is located close to the optimum location in the valley, everywhere else being significantly wider. In addition, it is just downstream of the existing dam, which can act as a cofferdam to control flow through the new dam construction (to some extent). Based on the information available, Halcrow has no concerns regarding the proposed site of the ECD.

D.5 Construction Methodology

D.5.1 TOC Section 1.3

Section 1.3.3 - Site Access

Figure 1.3.2[100] gives some indication of the extent of access roads required to the dam right abutment. Figure 1.3.3[101] shows, as an example, the left abutment access roads. However the details of the dam construction access roads are largely given in the section of dam abutment excavation. Figure 1.3.18[102] gives a rather different layout of access roads and benches on the dam left abutment. Multiple contoured access roads are shown in the final approaches to the dam footprint.

Section 1.3.7 - Abutment Excavation

The design criterion for the excavation appears reasonable. In particular, the 12.5 metre general bench width and 8.5 metre local minimum width should allow plant to pass and work safely around itself on the loose broken rockfill surface of the bench without working too close to the potentially unstable edge. This point is particularly critical to the excavation quantity.

Where the natural slope of the ground is steeper than about 40 degrees, this is steeper than the natural angle of repose of the excavated rock material. Where this is the case, it is not possible to extend the working bench beyond the original ground surface on embanked excavated material, as it would be on a flatter slope, except at the base of the valley. This applies to the entire left abutment and some of the lower slopes of the right abutment. The only places where the bench could be extended on spoil fill area are the top of the left abutment and the lower parts of both slopes, where the base of the valley could be used to collect and retain a stable spoil extension to the bench.

[100] Bulk Water Alliance, *Enlarged Cotter Dam Target Outturn Cost Report*, August 2009, Section 1.3, p.5.

[101] Ibid, Section 1.3, p.6.

[102] Ibid, Section 1.3, p.25.

Taking the above two points together, more than the minimum excavation is likely to be required on any slope where the sound rock is close to ground level and the valley slope is more than about 40 degrees.

Figure 1.3.10[103] shows the minimum excavation line from geological considerations and the proposed excavation line. Over most of the excavation section shown, the proposed excavation line is only a short way below the minimum line. In general, the excavation line smoothes out the slopes of the foundations, as would be expected in practice, particularly as the downstream extension of the excavation forms the slope for the secondary spillway chute, and sharp changes in gradient would be detrimental to this. Halcrow notes that the proposed excavation line could be considered generally reasonable, however, to review this fully it is necessary to understand any variation in minimum foundation level across the width of the dam body, which is not provided here.

Looking closely at the details for possible places to reduce excavation, these are:

- High on the left abutment, where the access road cuts deeply into the abutment. It looks as though the foundation slope here could have been steepened locally, thereby reducing the road cut width by about 7 metres, assuming that the minimum excavation line is the same upstream and downstream of the dam. This would increase the gradient of the top section of the side spillway chute, but not excessively. This would provide a limited saving in excavation, but not much in RCC, as the dam section at this elevation is narrow. One problem with steepening the upper section of the excavated slope would be drilling at the base of this slope for pre-splitting the flatter slope below, and this may be the reason for adopting the arrangement shown. The blue lines on **Figure D.1** (derived from Figure 1.3.10 of the TOC report) identify a possible alternative.

[103] Ibid, Section 1.3, p.16.

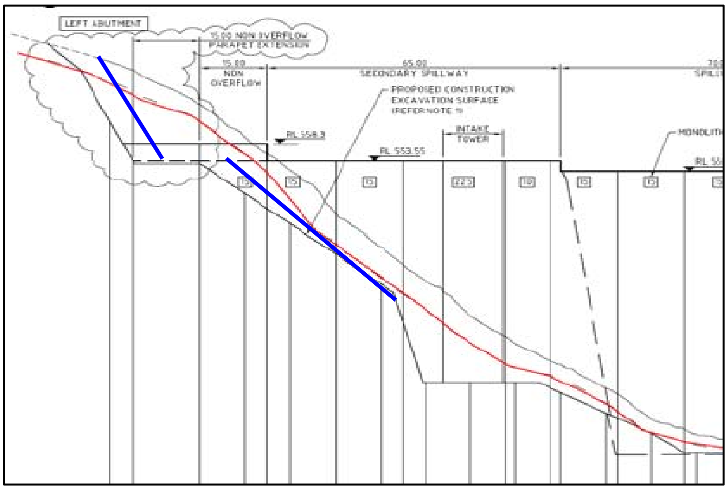

Figure D.1: Possible Alternative to Left Abutment Excavation

- The approximately 35 metre wide bench on the left abutment connecting to the intake tower seems wider than necessary for the outlet. In optimisation, Halcrow would want to look closely at this, as it would both save excavation and RCC infill.

The section "*Excavation Extents*"[104] notes that the upstream batters are set 2 and 3 metres back from the dam faces to allow room for placing formwork. While done on some dams, this is not the only way.

The alternative approach is to end the batter approximately 1 metre back from the upstream face line and on the downstream face line and fill against the rock batter with RCC until there is room to place formwork, as shown on **Figure D.2**. This would reduce the excavation volume, but marginally increase the RCC volume.

[104] Ibid, Section 1.3, p.19.

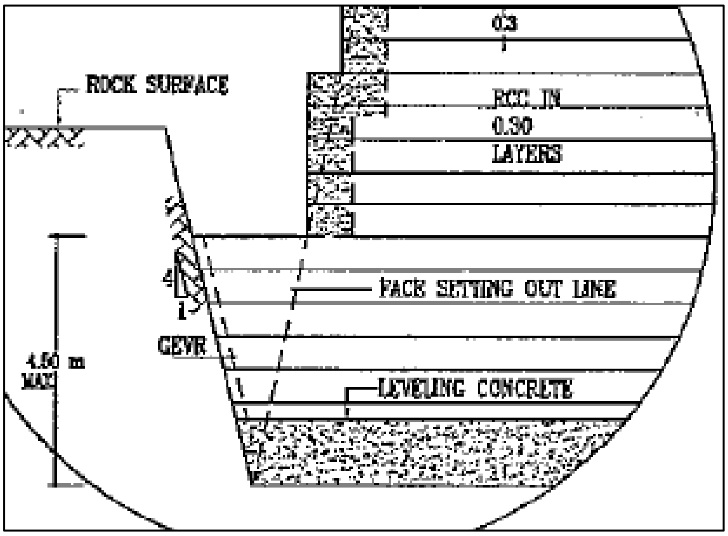

Figure D.2: Possible Alternative Approach to Upstream Batter

The same section notes that the excavation has been started 6.5 metres inside the minimum excavation line to avoid the risk of having to go back to remove unsuitable material. Assuming that this is 6.5 metres horizontally, at a 45 degree slope, this is an extra excavation depth of 4.6 metres normal to the minimum excavation line, but less on flatter slopes. This seems high, but will depend on the confidence and conservatism of the geological assessment for the minimum excavation line. Halcrow's first approximate estimate suggests that if this is applied over the whole dam and spillway chute excavation area, it is equivalent to some 50,000m^3 of excavation and 35,000m^3 of RCC under the dam body, but not spillway chute. Ideally, Halcrow would want to see justification for this, comparing the cost of this with the risk cost of dealing with any unsuitable foundation material left below the excavation line.

The TOC report[105] refers to a ground model, however, Halcrow has not seen details of this.

<u>Section 1.3.11 - Concrete Production</u>

The TOC is based on 300m^3 per hour RCC mixing capacity over a 20 hour day to meet a maximum planned daily output of 5,000m^3 per day[106] and around 91,000m^3 in the peak month (refer Figure 1.3.99[107],).

[105] Ibid, Section 1.3, p.22.

[106] Ibid, Section 1.3, p.43.

Note that Table 1.3.10[108] refers to a peak hourly RCC output of 350m^3 per hour. However, there is also a separate CVC batching plant with a 50m^3 per hour capacity mentioned[109], and it may be intended to operate both for RCC at peak production.

At 300m^3 per hour over 20 hours, the theoretical maximum daily output of the batchers is 6000m^3 per day. To achieve batcher productivity to actually deliver 5000m^3 from the plant in any day will be a challenge, which will only be met if the 300m^3 per hour is a tried and tested output for RCC in practice, rather than a theoretical manufacturer's output. Being dry, RCC is usually harder and takes longer to mix than conventional concrete. Ideally, a one hour maximum practical output trial of the batcher should be included in the RCC trials or early in production, before peak output is required.

At 5,000m^3 per day the theoretical maximum monthly output is 150,000m^3 per month, compared to the peak 91,000m^3/month placing planned. Alternatively, the monthly output can be achieved in 19 days of peak production. This is realistic.

The total volume of RCC in the dam is some 377,000m^3 (refer Table 1.3.9[110]) (Note, however, that the Direct Cost Estimates[111] indicate 386,000m^3), to be placed over 7 months, or an average of 53,800m^3 per month. This is high by the standards of RCC dams of this volume, but has been exceeded elsewhere. It will, however, be a challenge to work new teams up to the planned peak RCC placing over the relatively short construction period envisaged.

Neither the sections on the Quarry[112] or Aggregate Conveying System[113] refer to the quantity of aggregates being stockpiled. It is a common problem on RCC dam that one size of aggregate is in shorter supply that the others and runs out. RCC placement will use aggregate faster than the aggregate can be produced. It is common practice on RCC dams to specify that a significant proportion of aggregate should be already stockpiled before RCC placement starts. Given the short RCC placing time and peak placing rate, Halcrow would expect that approximately 50 percent of all sizes of aggregate to be in stockpiles.

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[107] Ibid, Section 1.3, p.83.

[108] Ibid, Section 1.3, p.77.

[109] Ibid, Section 1.3, p.43.

[110] Ibid, Section 1.3, p.76.

[111] Ibid, Section 2.5, p.89.

[112] Ibid, Section 1.3, p.37.

[113] Ibid, Section 1.3, p.45.

The RCC mix for cooling (refer Table 1.3.6[114]) includes 190kg per m^3 of cement and fly ash, and is a reasonable mix for high-paste RCC. The aggregate and RCC delivery conveyor systems appear appropriate for the planned speed of placement.

Section 1.3.12 - RCC Full Scale Trial

This is standard practice on most RCC dams and is intended both as a check of all equipment and a training program for staff. Halcrow notes that the provision appears reasonable.

Section 1.3.13 - RCC Placement

The general RCC placement methodology set out, including bedding mortars for warm but not hot joints and GERCC facings are as would be expected from an experienced design and construction team on a modern high-paste RCC dam.

It should be noted that the RCC methodology outlined in the TOC report differs significantly from the low paste methodology described in Sections 4.4 to 5.3 of the Technical Review Report by Arup[115], which refer to practices common some 20 years ago and which are rarely adopted on recent RCC dams.

The Alliance TOC methodology is clear and consistent for a high paste (190kg per m^3 cement and fly ash) RCC mix. High paste is the way to go for rapid construction, and the methodology outlined is what Halcrow would expect from the Alliance partners, who have designed and built a number of RCC dams recently.

The Technical Review Report by Arup[116], however, refers to a completely different and, in Halcrow's experience, an out-of-date method of RCC construction. This report therefore needs to be regarded with some caution in respect of the RCC. In particular the argument that lower fly ash content in the RCC means a cheaper dam is very dubious, because a mix of this type requires both facing concrete and bedding mixes at every lift, slowing the entire RCC placement process down. Many of these dams also have an upstream face PVC membrane to reduce leakage; such a membrane would be susceptible to fire and would (presumably) not rate well in a risk assessment for this installation.

[114] Ibid, Section 1.3, p.50-51.

[115] Deloitte, *Independent review of the design and estimate process for the ECD Project,* August 2009, Appendix C.

[116] Ibid.

The factors likely to cause delay and down-time to RCC placement are factors that would be expected. The learning curve delays are already included in the reduced placement rate assumed in the number of productive shifts. There are also questions about the extra time allowed in Table 1.3.12[117], referring back to Figure 1.3.97[118], for downstream formwork in Zone 4 of the dam, because of the change in type of forms at the ogee spillway and abutments in this zone.

On the basis of Halcrow's experience, the plant proposed for RCC placement appears reasonable, although it is normal to require all key plant to have a back-up on site, and it is noted that this is not the case with the grout truck and joint cutting excavator. Halcrow notes, however, that there may be other ways of providing back-up for these tasks.

Staffing levels take no account of labour moving between jobs and could be viewed as high overall. In practice, Halcrow would expect that at times when RCC placement was less than maximum output, some work gangs would be able to cover more than one task.

<u>Section 1.3.14 - Galleries</u>

Halcrow notes that the general methodology proposed for construction of the gallery is sound, however, the practicality of removing and raising the formwork for the walls of the sloping gallery may pose some difficulties in practice. Formwork in galleries is generally constructed because of the cross-bracing, and moving one set of forms past another will be difficult.

Halcrow notes that some of the early sections for the dam included both upstream and downstream low level foundation galleries. Only an upstream gallery is shown in the TOC methodology, and a downstream gallery would further restrict movement of equipment while the galleries are placed.

D.5.2 Drawings

As shown, the abutment crest parapet walls would fall over unless the reinforcement is continuous between the parapet walls and crest slab. (refer Drawing: *Spillway - Primary, Secondary & Abutment Crests - Reinforcement & Anchorage Details*[119]).

[117] Bulk Water Alliance, *Enlarged Cotter Dam Target Outturn Cost Report*, August 2009, Section 1.3, p.82.

[118] Ibid, Section 1.3, p.80.

[119] Ibid, Section 4.1, Drawing GHD-ECD-SPL-CI-DRG-0301.

D.6 TOC Monte Carlo Risk Assessment Review

D.6.1 *General*

From examination of table of risks presented in the TOC report[120], the highest value risk items are outlined in the following table:

Pay Item	Description	% Overrun	Value
1.0	Alliance Cost	Worst case + 36%	$8.14m
2.0	Design Cost	Worst case + 21%	$19.6m
3.4	Construct & maintain haul roads	Worst case + 32%	$8.19m
3.5	Rock fall protection	Worst case + 82%	$5.26m
3.10	Tower Cranes	Worst case + 81%	$5.13m
3.15	Material Testing	Worst case + 54%	$6.23m
6b 1&2	Excavate abutment foundation	Worst case + 82%	$19.7m
6e 8	Place RCC in dam	Worst case + 60%	$34.6m

In addition, the highest potential variability items are outlined as follows:

Pay Item	Description	% Overrun	Value
5a	Curtain Grouting	Worst case +200%	$1.48m
6c	Foundation Grouting	Worst case +200%	$2.26m

Details of the background assumptions to some of these are given in notes of meetings (*Risk and Opportunity Review*, 22/07/2009 and *R&O – Monte Carlo Analysis*, 24/07/2009) in the TOC report.[121]

D.6.2 *Haul Roads*

Halcrow notes that the haul roads are a significant aspect of the project. Both quarry materials and excavated spoil have to be hauled significant distances within the site, and some of these roads are excavated in rock on steep side slopes.

[120] Ibid, Section 3.0, *Monte Carlo Analysis of Schedule and Non-Schedule Risks.*

[121] Ibid, Section 3.0.

The project involves fast track dam construction, and delays due to access road problems are generally unacceptable. Good quality and well maintained haul roads are required for the project.

Halcrow notes that 15 per cent of the risk is in the quantities and 15 per cent in rate. Risks include areas of unsuitable foundations, rock excavation, potential ground instability and weather risks, requiring remedial maintenance. In Halcrow's experience the worst case risk allowances do not appear unreasonable.

D.6.3 *Rock fall Protection*

The steep sides of the valley upstream of the dam include significant areas with potentially unstable rock surface. These will be disturbed by excavation and haul roads, increasing the health and safety risks to both temporary and permanent areas of the site from rock falls and boulders.

The TOC report[122] outlines a wide range of cost-effective approaches to dealing with this including scaling, rock bolting, shotcrete, netting and catch fences. The choice of approach and quantity required will depend on circumstances, which cannot be assessed in advance of excavation. The 40 per cent risk allowance for quantity therefore seems reasonable.

There seems less justification for the 30 per cent risk allowance for rates, although this may relate to uncertain installation and access costs on the steep slopes.

D.6.4 *Tower Cranes*

Tower cranes are proposed primarily for servicing the conventional concrete works on the dam crest, spillway, training walls and draw-off facilities, but can also assist in provisioning the RCC placement. The TOC report[123] includes allowance for two major cranes on the downstream face abutments and a mobile crane on the dam right abutment at crest level. The cranes will be in place throughout the dam construction period.

The TOC proposals look well defined, and the major cost risk seems likely to be an overrun on the time that the cranes are required. From the notes, the worst case quantity increase is based on a four month extension of the RCC, presumably on about a nine month assumed program for the cranes. There is a stated 26 per cent cost risk to having to use a different crane supplier. In Halcrow's experience this appears to be high and could be questioned.

[122] Ibid, Section 1.3.8.

[123] Ibid, Section 1.3.9.

D.6.5 *Materials testing*

Materials testing is required to confirm the construction materials, to develop the RCC mix and provide quality control during construction. The requirements for this can usually be reasonably well defined, and the 43 per cent risk allowance for increase in quantities seems large. This could only relate to major production and placing problems with the initial RCC design mix and the need to develop a radically different RCC mix with new materials. This seems very unlikely.

D.6.6 *Excavate abutment foundation*

The TOC report[124] looks in great detail at the dam abutment excavations, and includes mitigation for many of the risks envisaged in the design. The main remaining risk is geotechnical, that is, the minimum excavation line developed from site investigations and shown on Figure 1.3.10[125] still leaves unsatisfactory material in the foundation, which has to be excavated, causing additional work and delay to the whole job. The variations in both quantity and rate used in the Monte Carlo analysis are mentioned in this section of the TOC report, and are reported to have been derived by the geotechnical team in a Risk and Opportunity workshop. The increase in rate relates to an assumed four month increase on a twelve month excavation program. Given Halcrow's experience, these conclusions appear reasonable based on the extent of this review. One question Halcrow raises is whether the 40 per cent additional excavation quantity advised by the geotechnical team is beyond the minimum excavation line or the excavation line proposed in the TOC report, which already includes additional excavation to reduce the risk of leaving unacceptable material.

D.6.7 *Place RCC in the dam*

Halcrow notes that the item for placing RCC in the dam includes a 60 per cent risk item for the rate, but nothing for the quantity. The rate for RCC in the TOC report already appears high by industry standards, reflecting the planned speed of placement (as discussed above). It is Halcrow's view that an increase of 60 per cent on this seems unrealistic. The major risk is probably extended time for placing the RCC, which could be considered an increase in the unit rate, but an extra four months on a planned seven month construction period, already including weather and breakdown stoppage allowances, would appear to be excessive. Given the significant risk of an increase in excavation quantity, it is surprising not to see a risk allowance for an increase in the RCC quantity.

[124] Ibid, Section 1.3.7.

[125] Ibid, Section 1.3, p.16.

However, this may be an error. The TOC notes[126] suggest allowing a 25 per cent worst case increase in RCC quantity.

D.6.8 *Foundation & Curtain Grouting*

The total value for grouting is not a major part of the dam total cost, but the risk assessment includes a worst case 200 per cent increase in most items. The geotechnical assessment is that major parts of the foundation are sufficiently impermeable already and that only limited grouting is required in particular areas. The cost estimate includes 100 per cent of primary and secondary holes (leaving a 6 metre spacing); 60 per cent of infilling to tertiary (3 metre spacing); and 30 per cent infilling to quaternary (1.5 metre spacing). Parts of the tertiary and quaternary grouting will be for grouting of water test holes to confirm that the previous phase of grouting has been effective.

The TOC notes[127] show that the worst case was taken to be grouting of 100 per cent of all tertiary and quaternary holes. If this is 100 per cent coverage, 50 per cent of the total is quaternary, 25 per cent is tertiary and 25 per cent is primary and secondary. The quantities assumed in the TOC (as noted above) indicate a total 55 per cent coverage, so the worst case overrun should be 82 per cent, not 200 per cent. This appears to be an arithmetic error. Overall, Halcrow notes that the higher percentage increase for grouting materials is considered to be reasonable.

From Halcrow's review of the TOC drawings, the tertiary and quaternary foundation grout holes are shown as 18 metres deep rather than 40 metres for the primary and secondary grouting. If all holes fully grouted to 40 metres length represents 100 per cent coverage, a worst case assumption is that the primary and secondary holes represent 25 per cent, the tertiary holes represent 25 per cent, and the quaternary holes represent 50 per cent of the works required. The design assumption with tertiary and quaternary holes being 18 metres long would be equal to 38.5 per cent of the total (25 percent + 6.75 per cent + 6.75 per cent). Therefore the worst case scenario is 2.6 times the design assumption (100/38.5). This represents a 160 per cent increase on the design assumption. Given the test results reported to date, it is Halcrow's view that this assumption is extremely unlikely to occur.

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[126] Ibid, Section 3.0, *Meeting Minutes; R&O – Monte Carlo Analysis*, 24/07/2009, Item 2.3.

[127] Ibid, Section 3.0, *Meeting Minutes; R&O – Monte Carlo Analysis*, 24/07/2009, Item 2.5.

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