Enlarged Cotter Dam

Update report

July 2007

ACTEW
CORPORATION

WATER security program
safe • secure • sustainable

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Abbreviations

ACT	***Australian Capital Territory***
AEP	***Annual Exceedence Probability***
BOM	***Bureau of Meteorology***
CFRD	***Concrete Faced Rockfill Dam***
DRB	***Dispute Resolution Board***
ECD	***Enlarged Cotter Dam***
ECGBT	***Extended Cotter to Googong Bulk Transfer project***
EIS	***Environmental Impact Statement***
FSL	***Full Supply Level***
GL	***Gigalitre***
m	***metre***
m^3/s	***Cubic metres per second***
ML	***Megalitre***
ML/d	***Megalitre per day***
Mt	***Mount***
PMF	***Probable Maximum Flood***
PMP	***Probable Maximum Precipitation***
PMPDF	***Probable Maximum Precipitation Design Flood***
RCC	***Roller Compacted Concrete***
RL	***Level relative to the Australian Height Datum***
SD1	***Saddle Dam No 1***
SD2	***Saddle Dam No 2***
SKM	***Sinclair Knight Mertz***
URS	***URS Corporation Asia Pacific***

Executive Summary

Context

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

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

The options were studied in 2004 with the Cotter Option recommended in The Cotter Dam Option ***(ACTEW 2005). The report used the conclusions from a technical study reported in*** Future Water Options, Cotter, Tennent, Coree and Murrumbidgee Transfer Options (Engineering) ***(GHD 2005). This latter report also compared different dam types at the Cotter site recommending a Roller Compacted Concrete (RCC) gravity dam as the most appropriate for the site from both programming and cost considerations. Between that time and now a number of studies have been carried out and are ongoing which require*** The Cotter Dam Option ***(ACTEW 2005) report to be updated in content.***

Site Investigations

Hydrological and geotechnical investigations have been commissioned for the project in 2006 and 2007 respectively.

The hydrological investigations reviewed previous estimates for the Probable Maximum Flood (PMF) that could be expected at the dam site and the magnitudes of the more common floods. The report concluded that as a result of some changes in the methodology of flood estimation recommended by the Bureau of Meteorology (BOM), that the magnitude of the PMF should be increased by 34%. However, the peak inflows for the return period floods have been reduced. All the flood studies were undertaken on the basis of the existing Cotter Reservoir and therefore, will have to be rerun for the much enlarged reservoir, an increase in the volume of water stored from 3.68 GL to 78 GL with consequent increase in the reservoir area.

A contract for preliminary geotechnical investigations was let in late February 2007. The site program is ongoing and is scheduled to finish in September 2007.

Drilling results so far have confirmed that the sites chosen for the main dam and the two saddle dams are suitable for the structures envisaged. The rock at the site is typically hard dacite with a number of joint sets, lineaments and geological structures that will need further investigation to allow accurate geological models of each of the dam sites, essential for a successful project, to be prepared.

Suitable construction materials are available at the site to construct most of the works, with cement and pozzolans being the major materials that will need to be imported from elsewhere. The investigations have indicated that there may not be sufficient earthfill for the proposed saddle dams. Therefore, the search for suitable material will have to be extended. In any case, alternative dam types such as RCC structures, utilising the equipment that would probably be used for the main dam, would be satisfactory.

Proposed Structures

Based on current data the structures proposed for the development are most suitable for the sites and for the materials available. GHD (GHD 2005) reported that the RCC option was some 35% cheaper than suitable alternative dam types. This result was confirmed by Rider Levett Bucknall (RLB 2007). Potential exists for an arch RCC dam which may provide some aesthetic appeal in such a tourist area.

The gravity type dam allows the intake tower to be attached to the face of the dam, removing cantilever type loads that would be caused by earthquake loadings, resulting in an economical and safe intake. Energy dissipation at the foot of the spillway and its effect on the lineament, evident along the river bed under the dam, will need careful consideration in the design phase.

Geotechnical investigations have located an anticline in the left abutment of the main dam. This must be considered in the ongoing drilling and mapping exercises to determine the permeability of joints and the best position to site the axis of the dam.

Approval process

Studies and submissions required for approvals have continued to be developed since the 2005 option report. The status of the submissions in early 2007 is reported in Planning Approvals ***(CBRE 2007). A new Planning and Development bill for the ACT, expected to be implemented in late 2007, is not expected to pose any particular challenges to the project.***

As part of the approval process, an Environmental Impact Statement (EIS) may be required. Background studies are underway to provide the necessary data for the EIS. It is noted that a critical factor in the development schedule for the Enlarged Cotter Dam is the potential for delays caused by extended studies in the approvals process. Currently there are no issues that are considered serious enough to delay the project.

Environmental Studies

Environmental studies to prepare data for the EIS are continuing. The EIS approval process is scheduled to be completed by mid May 2009. The study of the aquatic flora and fauna focusing on the Macquarie Perch, Trout Cod and the Two Spine Blackfish is the major activity controlling this date.

Other impacts that have been identified and are being evaluated include the effect of the reservoir on aquatic ecology, Aboriginal and European heritage sites and terrestrial flora and fauna. There are no issues in these areas that are seen as having a serious impact on the project, or where the issues cannot be dealt with by suitable mitigation measures.

Contract Delivery Options

ACTEW is currently reviewing options for project delivery. Appropriate contract delivery options were reviewed as part of this report. ACTEW is yet to resolve the delivery mechanism for the project.

Estimated Cost

The cost of the dam was estimated in 2005 and again, by two consultants, in 2007. The estimated costs in 2007 dollars were $107 million and $123 million. A comparison of the common items in the estimates; some of which were significant and subjective led to a best estimate of $119 million. The estimators differed on the accuracy of these estimates quoting ±15% and ±30%. A figure of +20% to -10% is recommended for budget purposes. The works at the Cotter site include pipeline replacement and upgrades at the Cotter Pumping Station. A budget price of $20 million for these works has been allocated and is subject to revision when the full extent of the works at the pumping station is known. Thus the budget price for the works at the Cotter area is $140 million with an accuracy range of +20% to -10%.

Construction Program

A 16 month period has been allowed for the construction of the dam. As this program focuses only on the dam and does not allow for any other of the project activities, it would be prudent to allow 24 months in the overall project implementation program. It is recommended that a comprehensive implementation program including all works be prepared to confirm the online service date for the dam, new pipelines and modifications and extensions to the Cotter Pumping Station.

Risk Assessment

An assessment of the risks associated with the construction of the three dams in the project is necessary before calling for bids for construction. This assessment would focus on the geotechnical, hydrological, procurement, program and completion risks.

1 Introduction and Background

Development of an enlarged dam on the Cotter River is a significant and important option for the future water supply for Canberra. The selection of this option was reported in ACTEW 2005. The option was studied to a pre-feasibility level as reported in GHD 2005.

The purpose of this report is to provide comment on investigations and other work carried out on developing the Cotter Dam Option between 2005 and 2007 and to draw attention to any changes which might have occurred in the meantime. Where gaps in information needed for the final consolidated report are identified, these have been noted. This report provides an update to ***The Cotter Dam Option*** report (ACTEW 2005).

There are three dams on the Cotter River. These are Corin, Bendora and Cotter Dams.

The existing Cotter Dam was constructed in two stage: Stage I from 1912 to 1915 and Stage II from 1948 to 1951. A post tensioning exercise to ensure the dam met safety requirements for stability was completed in 1999. The dam has performed well with only some minor seeps over its 92 year lifespan.

The Cotter Dam Option report (ACTEW 2005) proposed the construction of a new dam approximately 125 m downstream of the existing Cotter Dam. The height of the dam was optimised to provide a reservoir volume that will ensure a risk of failure of supply of 1 in 25 years. As planned the new dam would submerge the existing dam which is on the Register of the National Estate.

The report proposed the Enlarged Cotter Dam be a 76 m high RCC dam with a two stage free overfall spillway. Diversion of river flows during construction would be through a low level culvert to be plugged at the end of the construction period. The outlet works design proposed included an intake tower attached to the upstream face of the proposed dam feeding a system of outlet pipes that direct flows to either the Cotter Pumping Station or discharge them into the river downstream to provide environmental flows.

Studies at the time confirmed that the selection of a Roller Compacted Concrete (RCC) type dam was appropriate for the new dam. In comparative studies against other types of dams the estimated cost of the RCC was found to be 35% cheaper than the nearest alternative. Suggestions that an arch dam should be considered for aesthetic reasons, given the position of the dam in a recreation area, although being a more expensive option, have been made.

2 Project Location and Layout

2.1 Project Location

The project is located on the Cotter River approximately 125 m downstream of the existing Cotter Dam.

Figure 2-1 shows the location of the proposed dam, its position relative to the existing Cotter Dam and the extent of the old and new reservoirs.

2.2 Project Layout

The project includes the main dam on the Cotter River, with two saddle dams to the west of the right abutment.

The design layout for the dam is for a conventional RCC dam with a straight axis, vertical upstream face and downstream face slope of 0.75 Horizontal to 1.0 Vertical. A two stage strategy has been adopted for the spillway with a 50 m wide lower central section that passes floods up to the 1 in 1,000 annual exceedence probability (AEP) with the full crest of the dam acting as a spillway crest for floods in excess of 1 in 1000 AEP up to the PMF. A stepped slab constructed at the toe of the dam directs the spillway floods back into the river, protecting the toe of the dam from erosion.

The outlet works incorporate a wet well intake tower constructed on the face of the dam with provision for drawing water from different levels in the reservoir, providing operators with some control of the temperature of the water releases into the river system and for selection of best quality water for input to the water supply for Canberra. The tower is considered simple and practical.

Diversion of flows in the river during construction would be through a 4 m by 4 m culvert section included in the base of the dam. The culvert will be plugged at the completion of construction when filling of the reservoir commences.

Figure 2-2 shows the Enlarged Cotter Dam project layout.

Figure 2-1 – Existing and Proposed Cotter Dams

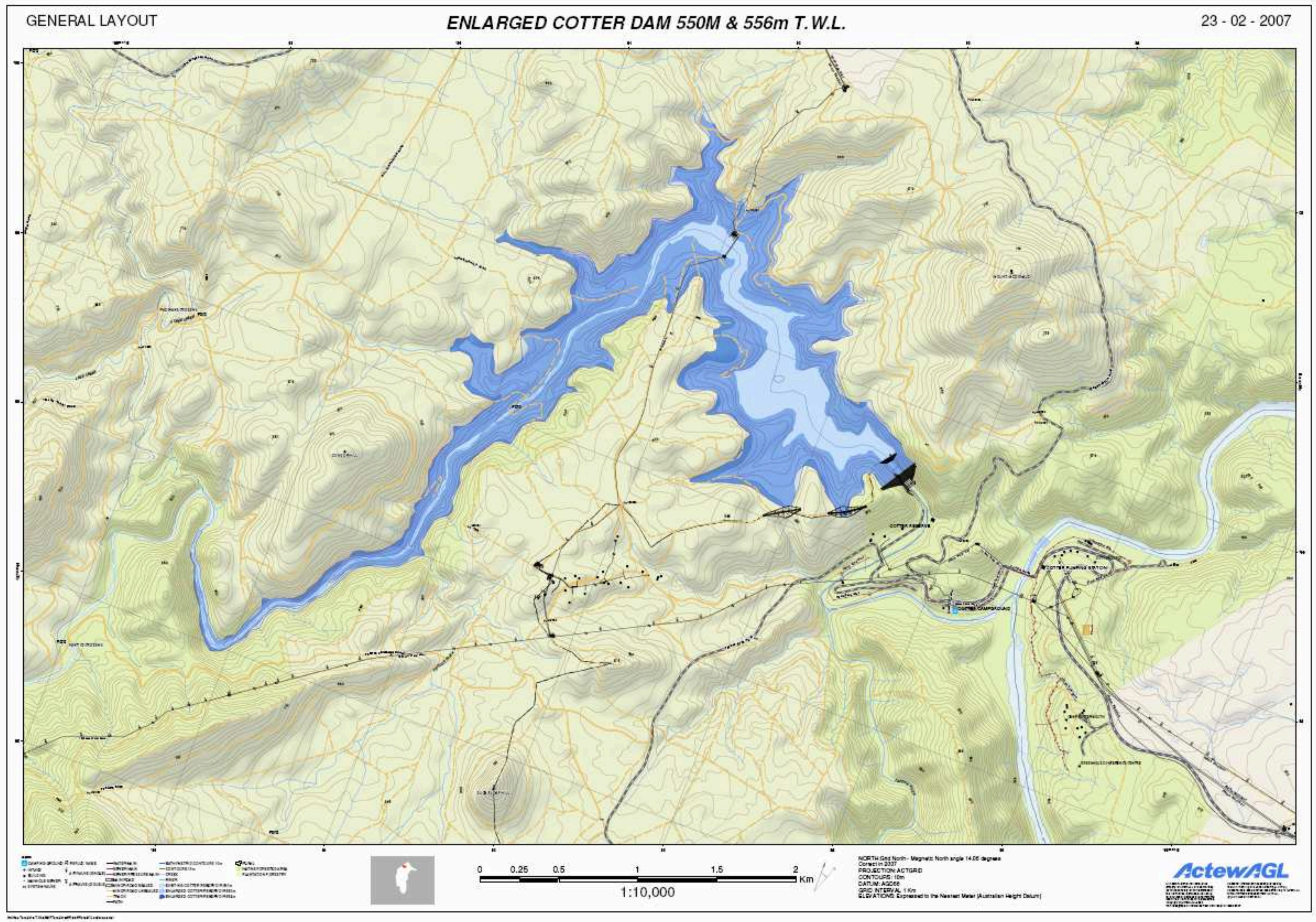
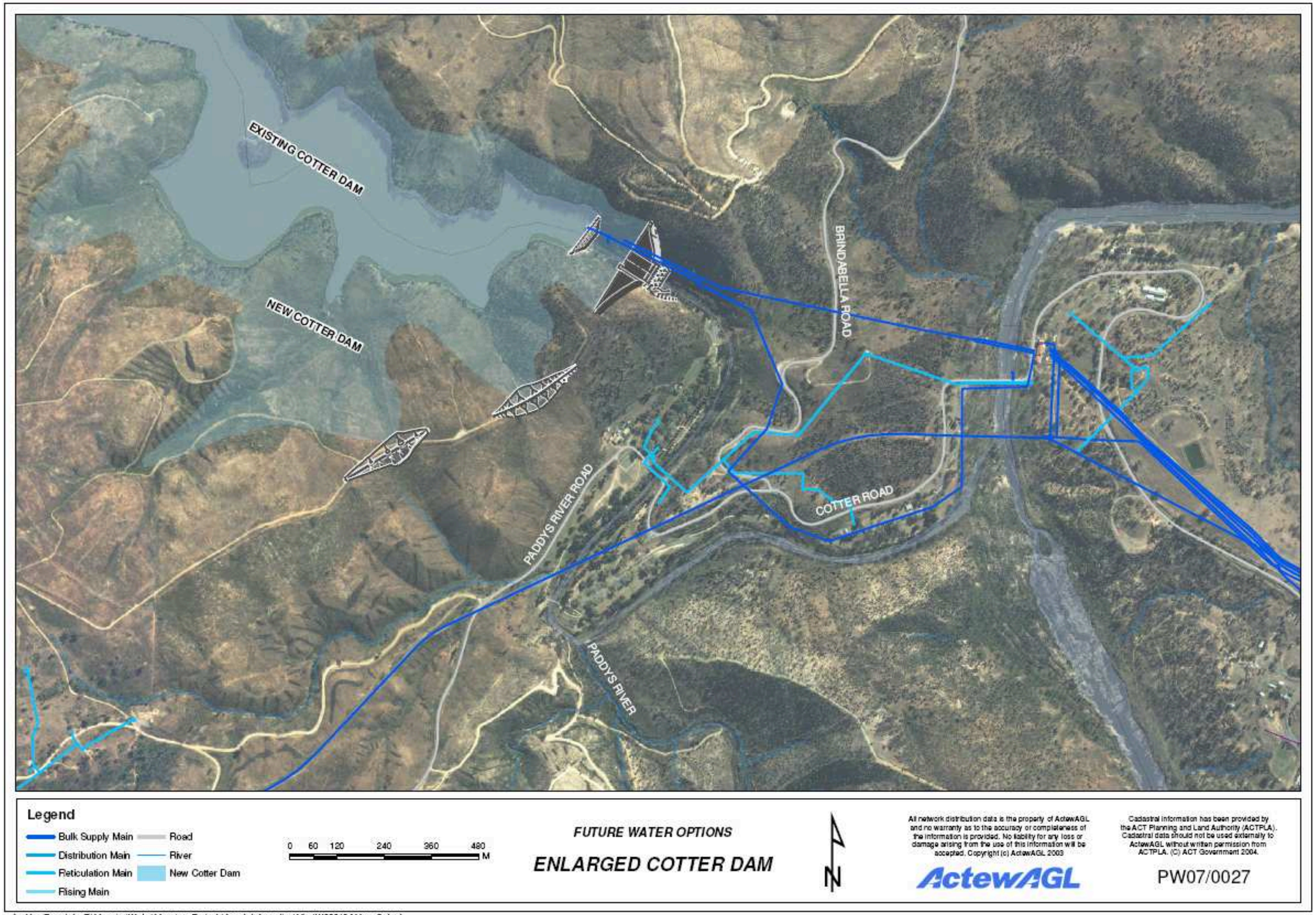


Figure 2-2 - Enlarged Cotter Dam Project



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3 Geotechnical Studies

3.1 General

Previous geotechnical investigations at the dam site have been restricted to walkover inspections by the ACT Water Administration (1988) and by GHD (2004). A drilling exercise at the existing Cotter Dam by Coffey Partners was completed in 1988. The need for further geological investigations was recognized by ActewAGL and subsequently URS were commissioned in late February 2007 to undertake preliminary geotechnical investigations for the Enlarged Cotter Dam.

3.2 Scope

The scope of the current geotechnical investigations includes:

- a geological review;
- surface geological mapping;
- site investigations (including test pitting, seismic traverses and diamond drilling);
- laboratory testing of materials in the foundations of the proposed dams; and
- materials proposed for construction.

URS 2007 summarised the preliminary findings from the field geological mapping noting that they may need to be revised when subsurface investigations were completed.

3.3 Progress of Investigations

Investigations to date include:

- interpretation of geological features from aerial photography;
- drilling and test pitting at the proposed quarry and borrow area and at the two saddle dams, Saddle Dam 1 (SD1) and Saddle Dam 2 (SD2);
- seismic traverses at each site (including the quarry and borrow area); and
- drilling on the upper right abutment of the main dam (this was underway as this report was being prepared).

The location of drill holes and test pits is shown in Figure 3-1, Figure 3-2 and Figure 3-3. Preliminary copies of logs for test pits and drilling for the quarry, borrow area and saddle dams have been sighted.

This program of investigations is preliminary and will provide an overall picture of the geological model of the site. The results will guide the geologists in conjunction with the design engineers as to the type, location and extent of more detailed investigations that will be necessary if construction of the Enlarged Cotter Dam proceeds.

3.4 Surface Mapping

Surface mapping has confirmed a number of lineaments and faults at and near the proposed dam sites and at the existing site. None of these features appear to be of a serious enough nature to render the proposed dams unfeasible. Further information on the characteristics of these features will be provided by the ongoing and future drilling programs. Observations of the slopes in the quarry used for the existing dam and of the stability of the slopes above the proposed dam indicate that care will have to be taken in design and construction activities, relating to excavation in the quarry and in areas above the dam, to prevent rock falls during and after construction.

The potential for instability in the reservoir, once it has been filled and during operation as the water levels rise and fall will need to be assessed during detail design.

3.5 Test Pitting and Core Drilling

The program of test pits has been completed. Depth to refusal in the test pits averaged about 1.5 m with a maximum depth of 2.5 m, which were dug using an excavator. The results confirm that the overburden at the quarry site and at each dam site is relatively shallow.

Core drilling is complete at SD1, SD2 and at the quarry site. Until the drill reached sound material the holes were not cored. To date the maximum depth of non cored hole is 2.5 m, confirming the results from the test pitting. Typically, the rock encountered is high strength dacite, with some very high strength and some medium strength rock. Depth to fresh rock is deeper at the low point of each saddle. Water tests confirm that the rock is tight.

3.6 Seismic Traverses

Seismic traverses have been completed at the saddle dams, quarry and the borrow area. Velocities confirm a relatively shallow overburden across all sites, with a mixed zone a few metres deep before fresh rock is reached. In the quarry the overburden that may need stripping is shallow varying from 2 to 5 m in depth. At the nominated borrow area the overburden consists of silty sand before an impervious material is reached.

3.7 Laboratory Testing

A full set of laboratory tests is to be run on the foundation, quarry and borrow area materials.

3.8 Quarry Site

Drilling is complete at the quarry site confirming the existence of a consistent body of generally high strength dacite, overlain by about 2 to 5 m of overburden. There appears to be adequate quantities of good quality rock in the proposed quarry. Based on results from core drilling and seismic traverses, some 850,000 m^3 of suitable rock, sufficient for construction of the proposed RCC dam, is available.

The rock type in the quarry site is the same dacite as that used in the original dam which shows little signs of deterioration, after nearly 100 years in service. This result confirms the quality of the quarry material. However, RCC mix trials and a series of tests on the suitability of the aggregate must be completed during design investigations.

3.9 Borrow Area and Saddle Dams

Based on an initial review of the proposed borrow area for clay material for the saddle dams, the surface colluvial materials in this area were typically mapped as silty sand. This assessment will need to be confirmed during further investigation works, however it is likely that there may not be sufficient suitable low permeability materials in this area and that additional borrow area sites may need to be investigated.

3.10 Recommendations for Further Investigation Work

Quality geotechnical data is a necessary ingredient for a successful project, as geotechnical risk is often the major risk in projects such as the Enlarged Cotter Dam. The risk can be greatly reduced by a thorough and complete investigation program. The envisaged development program allows time for such an investigation program.

Further drilling will be required before the project proceeds to construction. Given that the approval process is not expected to be complete until mid 2009, ACTEW should plan to move quickly into the design phase with the designer, specifying that further drilling and other investigations found to be necessary are to be carried out as investigation and design proceeds. Further drilling would follow on from the preliminary investigation now ongoing and be aimed at answering any geological and geotechnical queries that the present program poses. Drilling would finally focus on features of the project such as the stilling basin downstream of the spillway to confirm the competence of the rock in the energy dissipater.

A series of tests on alternative RCC mix designs to select the best combination of materials, such as the cement and pozzolan content, using rock from the proposed quarry, will be necessary during the design phase. The designer must provide personnel with experience in this critical area.

Once the mix design is selected, a trial embankment should be constructed and tested to confirm the performance of the mix.

An investigation to locate suitable pozzolanic material should also be undertaken.

Figure 3-1 - Plan of Preliminary Investigations

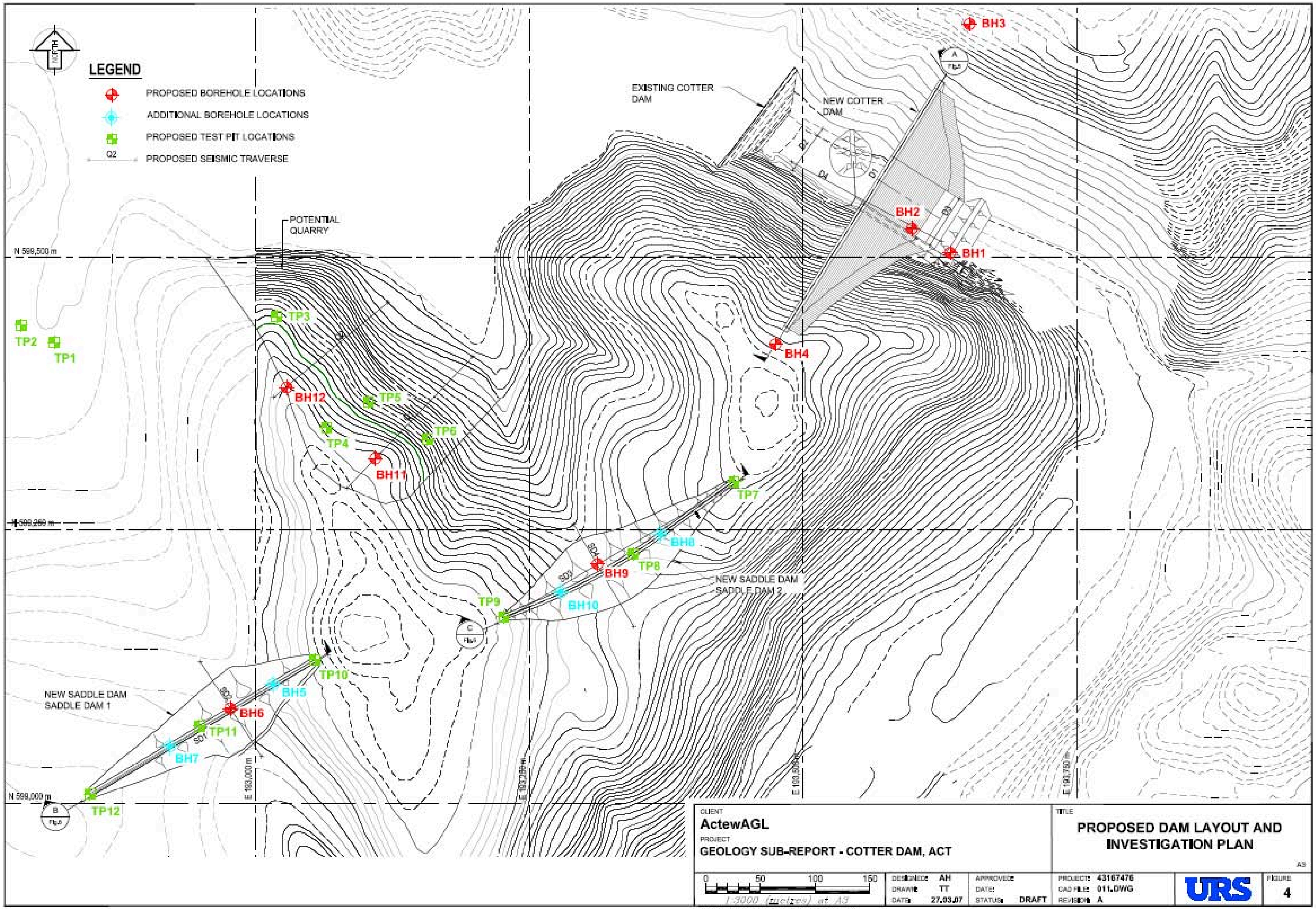


Figure 3-2 - Main Dam – Borehole Locations

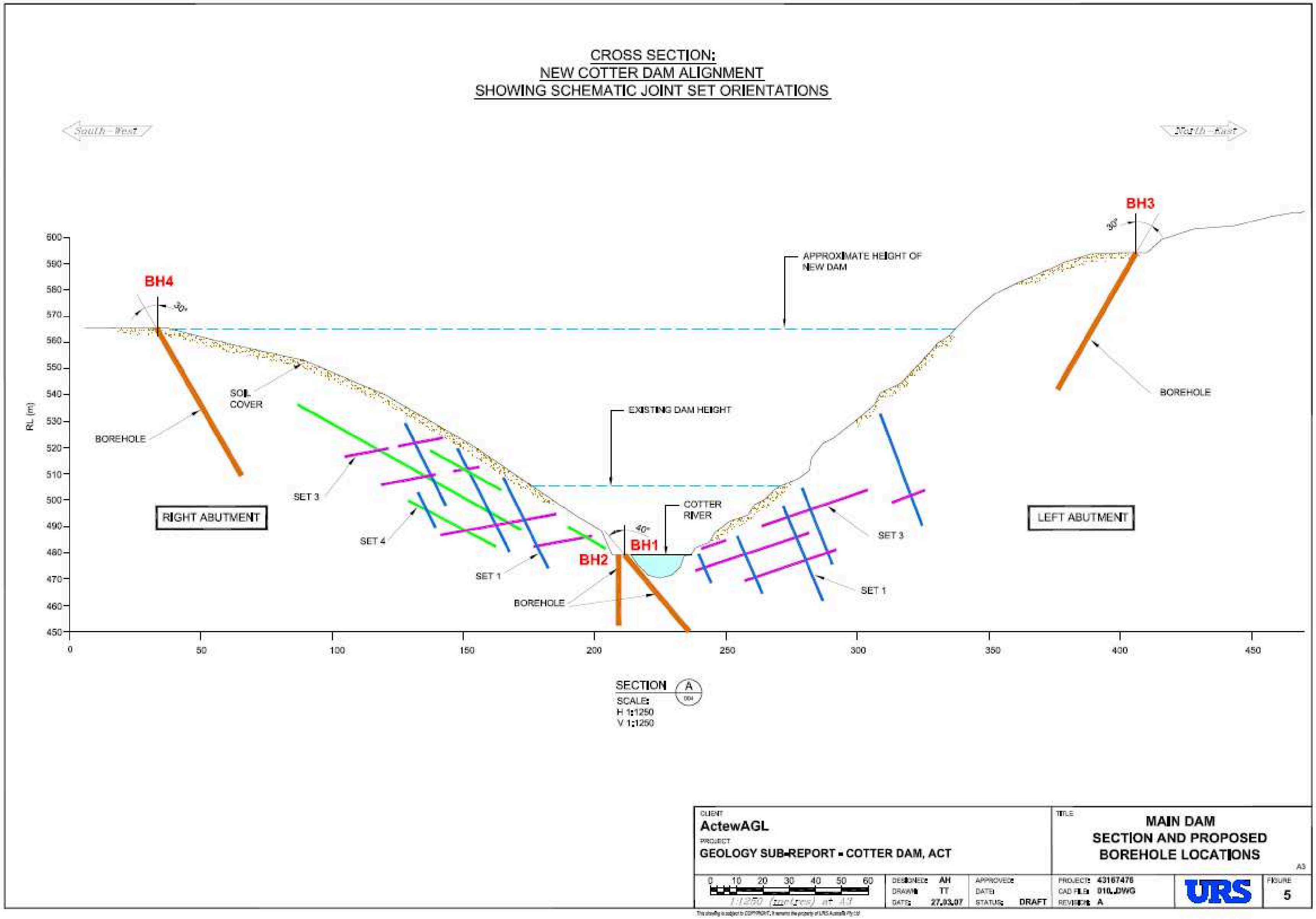
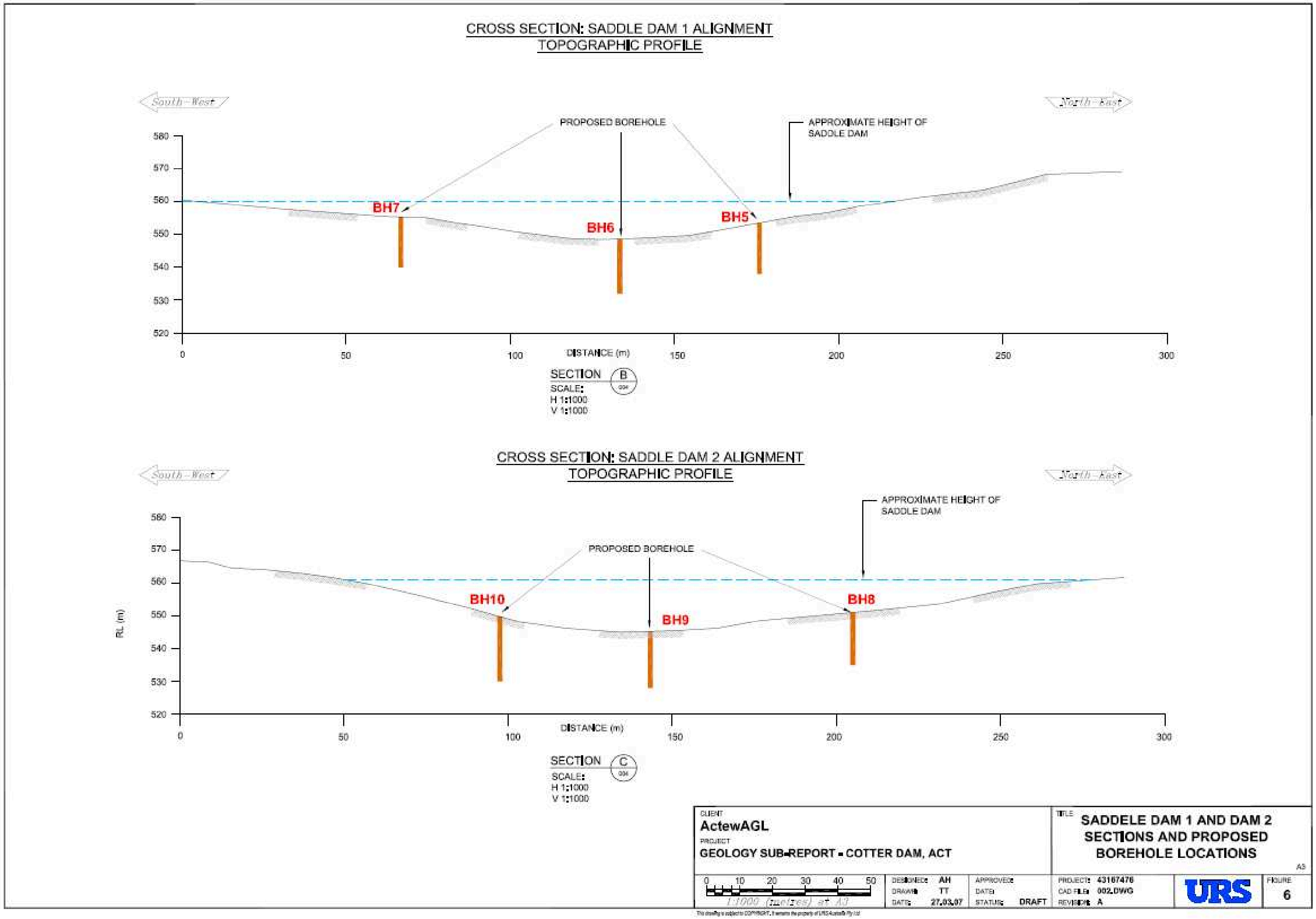


Figure 3-3 - Saddle Dams I and 2 – Sections - Borehole Locations



4 Hydrological Studies

4.1 General

The hydrology of the Cotter River catchment has been the subject of studies since before construction of the present Cotter Dam in 1912. Hydrological studies have been used to determine not only the yield of the catchment for each of the existing dams and for the proposed new dam, but also the magnitude of floods up to the PMF and the quantity of sediment that is likely to be deposited in the reservoir over the life of the structure.

4.2 Yield

The estimated yield of the Enlarged Cotter Dam is reported in ActewAGL 2005. This has been revised using the flow series associated with the current drought and the CSIRO assessment (Bates et al, 2003) of the effects of climate change on rainfall and temperature on the Cotter catchment by 2030. This is considered a prudent approach and is reported in ACTEW 2007. The estimated yield determines the full supply level (FSL) of the reservoir which was set at RL 550 m.

4.3 Flood Hydrology

4.3.1 General

In the design and construction planning for dams, return period floods are used to determine the risk of flooding of a site during construction. The return period of the design flood during operation depends on the hazard rating of the dam, essentially a marker of the severity of the consequences of failure of the dam under flood conditions. In the case of the Enlarged Cotter Dam, which will become one of the key storage dams for the ACT, the hazard rating is high and the design flood would be the PMF. Therefore, the PMF has been used to size the spillway in previous studies.

4.3.2 Recent Flood Studies

Recent flood studies have been conducted by the Hydrology and Water Resources Unit (HWR) of the ACT Water Administration (HWR 1988) and by Ecowise Environmental (Ecowise 2001). The HWR study estimated outflow flood frequency curves for each of the three dams in the Cotter catchment, for events with an AEP of 1 in 2 up to the PMF event. Ecowise Environmental produced revised estimates of only the PMF inflow and outflow floods for each of the three dams in February 2001. A full review of flood studies from 1 in 50 years AEP to the PMF for the three dams in the catchment is presented in SKM 2007.

4.3.3 Probable Maximum Flood

The 2007 SKM study re-evaluated the floods following the latest guidelines from the BOM. The PMF inflow estimate for the existing Cotter Dam produced by the study at 5,670 m^3/s, is 34% larger than the estimate labelled as the Probable Maximum Precipitation Design Flood (PMPDF) by Ecowise (2001). The PMPDF is a design flood calculated using the Probable Maximum Precipitation (PMP) with mean catchment conditions. The PMF is computed assuming that the PMP falls on a fully saturated catchment and is therefore, a more conservative approach. However, these assumptions are not the main reason for the considerable increase in the peak

PMF inflow. This is a result of the new method, as per the revised BOM guidelines (BOM 2003), used to apply the spatial pattern of design rainfall to the catchment. The result is a 48% increase in the catchment average rainfall depth for modelling the PMP event.

The effect of storage at the Cotter site on the analysis was based on the existing Cotter Dam which has a capacity of 3.86 GL, substantially smaller than the 78 GL proposed for the Enlarged Cotter Dam. Because the larger reservoir may change some of the parameters used in the estimate of the PMF inflows and outflows, it is recommended that results from the 2007 study be reviewed.

4.3.4 Return Period Floods

The return period floods will also be affected by the larger storage volume available in the new reservoir with the maximum effect on the smaller, more frequent floods. Therefore, the 2007 return period flood estimates should be revised. Note that the return period floods to be used for construction planning, in particular for design of the diversion strategy, will not be affected as the existing Cotter Dam will still be in use until the enlarged dam is completed.

A comparison of the return period floods, on a seasonal basis for December to March and April to November, showed that peak outflows for the latter period were 75% of the former. This is not considered to be a significant enough difference to warrant other diversion strategies for the two seasons.

4.3.5 Recommendations

The 2007 PMF and return period floods study should be reviewed to allow for the effect of the larger reservoir on the PMF and return period inflow hydrographs.

5 Main Dam

5.1 General

The cross section of the dam as presented is considered typical and safe, for a dam of this type and height. Figure 5-1, Figure 5-2 and Figure 5-3 (copied from GHD 2005) show the layout of proposed structures and a cross section of the proposed dam.

The main feature at the site is the presence of an open anticline clearly visible in the left abutment slope. Four joint sets were identified in the right abutment, three in the left. Two randomly oriented sets were measured along the valley axis. The excavations for the quarry used for the existing dam show evidence of large planar slide failures. These aspects will need to be studied in the design phase to ensure that any potential for failure is recognised.

Stability problems due to unfavourable orientation of joints may exist in the reservoir area as well as around the dam site. Considering that areas adjacent to the dam may be used for recreation, the designer will need to identify areas that may be suspect to instability and determine what, if any, measures would be needed to ensure stability of the reservoir slopes where there may be danger to the general public.

As part of the present geotechnical investigations, four cored holes are proposed for the Main Dam. The purpose of these holes is to:

- better define the lineament running along the river valley floor under the dam (BH1);
- clarify the structure of the rock below the foundation in the river bed under the maximum section of the dam (BH2); and
- investigate the materials forming the left and right abutments (BH3 & BH4).

The designer will have to specify the follow on program of drilling after review of the results of the present program. This operation needs to continue as soon as practicable after completion of the preliminary drilling exercise, so that sufficient time is available for detailed design.

5.2 Type of Dam

Four types of dam were compared in GHD 2005. The four alternatives included two gravity dams (one roller compacted concrete (RCC) and the other conventional concrete) and two rockfill dams (one a concrete faced rockfill dam and the other a rockfill dam with an earth core). Subsequent investigations show that there may not be sufficient material in the vicinity to construct an earth cored rockfill dam. An RCC type of dam was selected on the basis of cost and a considerably shorter construction program than any of the alternatives. The selected alternative is a straight axis dam. An arch RCC could be considered as having aesthetic appeal in the Cotter area which is a popular recreation area.

5.3 Alignment

The present alignment of the dam has been located downstream of the suspected shear zone running across the gorge. An anticline forms the foundation of the left abutment of the dam. The anticline in the left abutment dips at 65^0 downstream and 25^0 upstream. The dam may be best sited on the upstream arm of the anticline.

Both the shear zone and the anticline must be investigated thoroughly during design drilling before the alignment is finalised.

5.4 Results from Geotechnical Investigations

Study of the aerial photographs and geological surface mapping has shown a number of joint sequences where the majority of joints are clean and dry. Drilling in the right abutment has intersected fresh dacite over most of its length, recording high leakage rates some 4 m below the crest of the proposed dam. The jointing, lineaments and faults would be expected to be open in some cases and will require grouting for water tightness.

Greater detail on the status of current geotechnical investigations is provided in Section 3.

5.5 Diversion Strategy

5.5.1 General

The proposed diversion strategy uses a 4 m by 4 m culvert constructed in the base of the dam, together with a small coffer dam, to pass short term floods of 1 in 2 AEP (46 m^3/s) with a capacity to pass a 1 in 10 AEP (180 m^3/s) generally. This needs to be reviewed during design.

The drawings included in the report show an energy dissipater at the downstream end of the diversion culvert. The need for this in an area where the foundation rock is expected to be sound is questioned. The function of training the flows away from construction of the dam may be served by a simpler training wall type structure. However, if the existing Cotter Dam can be used for flood control during construction the need for a dissipater is further reduced. The dissipater is regarded as a conservative approach and needs review in the design phase.

5.5.2 Role of Existing Cotter Dam

There is some suggestion that the existing Cotter Dam be used as a coffer dam by drawing the reservoir down, therefore supplying flood storage for floods during construction. This would not necessarily allow the diversion conduit or the coffer dam to be deleted from the project, but, in a dry period, could provide completely dry conditions at the site for the period the reservoir was drawn down. Therefore, some of the construction risk, to the contractor, or to the partnership or alliance, depending on what contract option is taken, is reduced.

It is recommended that ACTEW continue to investigate the possibility of reservoir drawdown for the duration of construction of the Enlarged Cotter Dam, noting that the reservoir was drawn down during the 1999 post tensioning exercise.

5.6 Spillway

5.6.1 Spillway Design Flood

The design flood for the Enlarged Cotter Dam as presented in GHD 2005 has been taken as the PMF, the magnitude of which has since been updated by SKM 2007. The update was based on the storage volume of the existing Cotter Dam with a 3.86 GL storage, compared to the 78 GL in the enlarged dam and therefore needed updating. The new inflow floods calculated by SKM will have to be rerouted, by the designer, through the reservoir to determine the change in the outflows and what changes may need to be made to the spillway design. It is likely that the outflow floods would be reduced as a result of the greater routing capacity of the larger reservoir.

As stated in Section 4.3 the inflow floods computed by SKM 2007 need to be reviewed before the design proceeds, to confirm whether the larger reservoir has any effect on their magnitude.

5.6.2 Overtopping Strategy and Risks

The dam is designed to be overtopped across the full crest width of the dam during floods in excess of 1 in 1000 AEP. Such practice is common for gravity type dams where sound rock foundations are available in the abutments. The quality of the rock and its resistance to erosion, in the region of spillway discharge, requires knowledge of its jointing and bedding planes. This will have to be confirmed during further geotechnical investigations.

5.6.3 Energy dissipation

A roller bucket energy dissipater is included in the spillway design, together with a 15 m stepped apron at the downstream toe of each abutment of the dam.

The roller bucket is a conservative approach. An economic alternative that is often used in locations where competent rock exists is a flip bucket spillway, where the spillway discharge is flipped directly onto the rock avoiding the construction of an energy dissipater. In this case the presence of a lineament running along the river bed may provide a weakness that could lead to excessive erosion if a flip is used. The present drilling program includes provision for investigating the lineament. Once the results from the drilling are received, the dissipater design may be reviewed.

The option of a physical hydraulic model study for the spillway, to investigate the potential for cost saving using a flip bucket design should be considered during the design.

5.7 Outlet Works

A simple and effective arrangement has been designed for the outlet works. The intake tower is planned to be integrally constructed with the upstream face of the dam. The tower has been designed as a multiple draw off wet well type intake tower. An outlet pipe leads from the base of the tower to outlet valves for environmental releases and to the Cotter Pumping Station.

The ultimate capacity of the outlet works assumed by GHD 2005 was 580 ML/day made up of:

- 400 ML/d for environmental releases; and
- 180 ML/d for water supply.

These figures need to be confirmed before detailed design commences.

A single 1.4 m diameter pipe with two cone valves to supply environmental releases was allowed and is of the right order. This must be designed to ensure that the releases required can be provided at minimum operating level of the reservoir.

Consideration needs to be given during design for separate outlet pipes for water supply and environmental flows. Provision of two outlet pipes instead of one would provide the operator with more flexibility in controlling releases and separate the water supply outlet which would be connected to the Cotter Pumping Station hydraulic system from the environmental releases which discharge to the river. Environmental flows could be released and metered through one system, water supply through the other.

Provision must be made for accurate metering over the range of environmental flows. Options such as multiple outlet valves with different diameters, with magnetic flow meters and V-notch weirs need to be considered. The maximum environmental flow may be around 4.6 m^3/s, starting from a low base. The low flows could be metered by magnetic flow meters with the larger flows using a combination of V-notch and concrete weirs.

To allow releases to be made when water levels in the reservoir fall below the FSL of the existing dam the designer must investigate options to allow the remaining water upstream of the existing dam to be accessed. There are two possible options:

- remove a section of the existing outlet pipe in the lower left abutment of the dam, and remove the upstream gates in the intake structure allowing free flow of water through the outlet works; and
- leave the existing downstream bypass cone valve open.

The right abutment conduit that was included in the existing dam to allow installation of a hydropower plant has been plugged and is not usable. An option would be to blast a slot through the dam, this would require approvals from Heritage agencies, but would be the cleanest method operationally as there is no chance of a blockage.

Consideration needs to be given to the option of replacing the existing pipeline connecting the outlet works to the Cotter Pumping Station. This option and the upgrade works for the Cotter Pumping Station are the subject of separate studies and must be revisited during the design period.

Proposals for the outlet works include provision for a small hydropower station which would generate energy using environmental flows. Studies into the viability of hydropower are to be included in the design brief. The option could be preserved for later inclusion by provision of a suitable offtake in the outlet works pipework.

5.8 Construction Materials

Based on an initial review of the quarry site area the depth to fresh rock is estimated to be of the order of 2 to 5 m. Therefore a suitable quarry could be opened without a great degree of effort and cost. The history of the existing quarry and the jointing patterns in the rock will need to be kept in mind when opening the quarry to ensure safe operation.

Drilling in the quarry area confirms that there is ample high strength dacite available for coarse and fine aggregate for the RCC alternative. A preliminary estimate of the available quantity of rock in the quarry indicates some 850,000 m^3 available to supply about 300,000 m^3 of rock for aggregate for the dam. The quality of rock will need to be confirmed by laboratory testing.

Sand sizes may have be crushed at site or imported. Cement and pozzolan would also be imported.

5.9 Recreation Aspects

The dam will be a central feature of the Cotter River Valley and could provide various lookouts and picnic facilities around the reservoir. Discussion of the recreation issues is given in Section 9 and in CBRE 2007a.

Figure 5-1 - RCC Dam – Layout (ex GHD 2005)

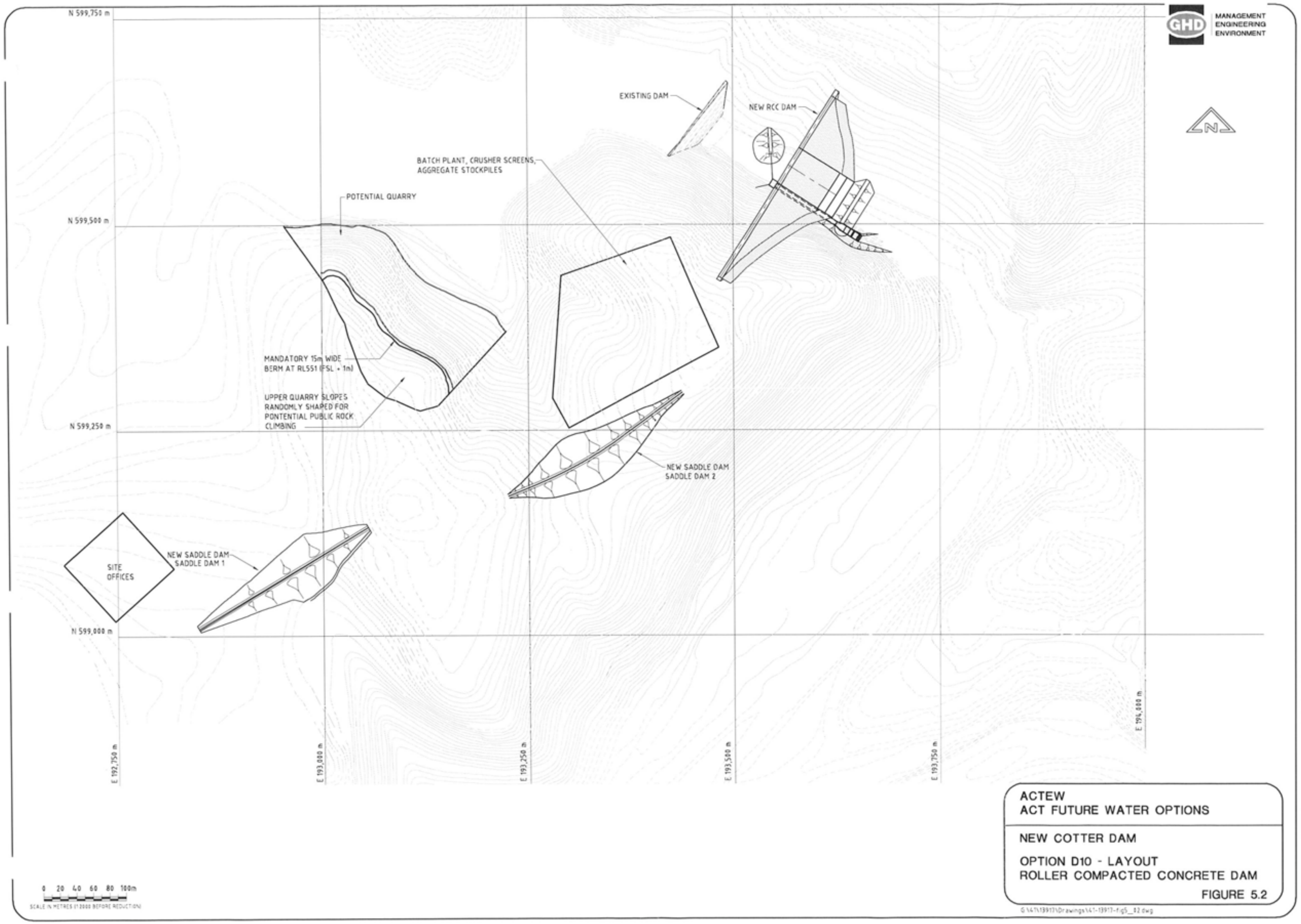


Figure 5-2 - RCC Dam – Plan (ex GHD 2005)

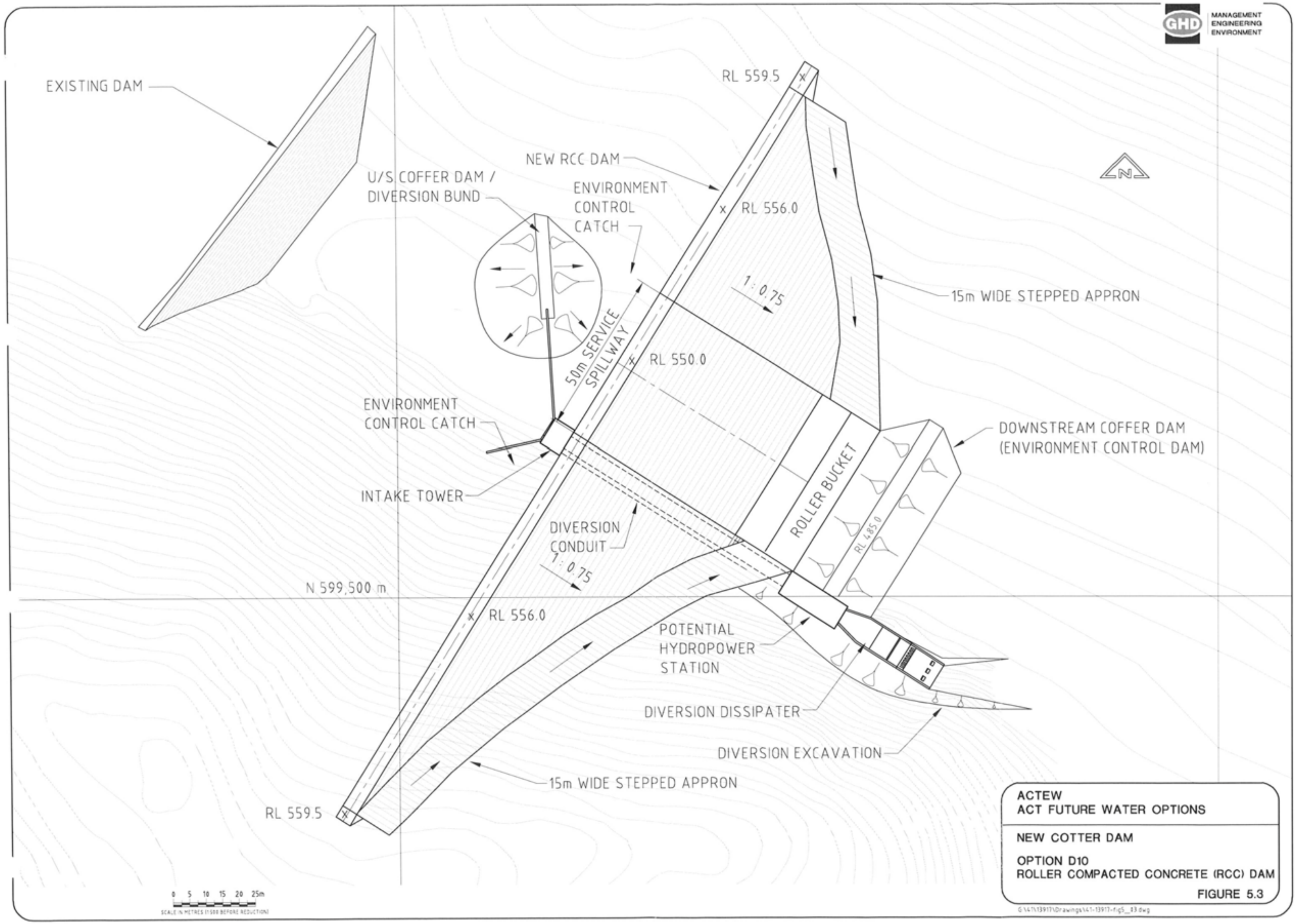
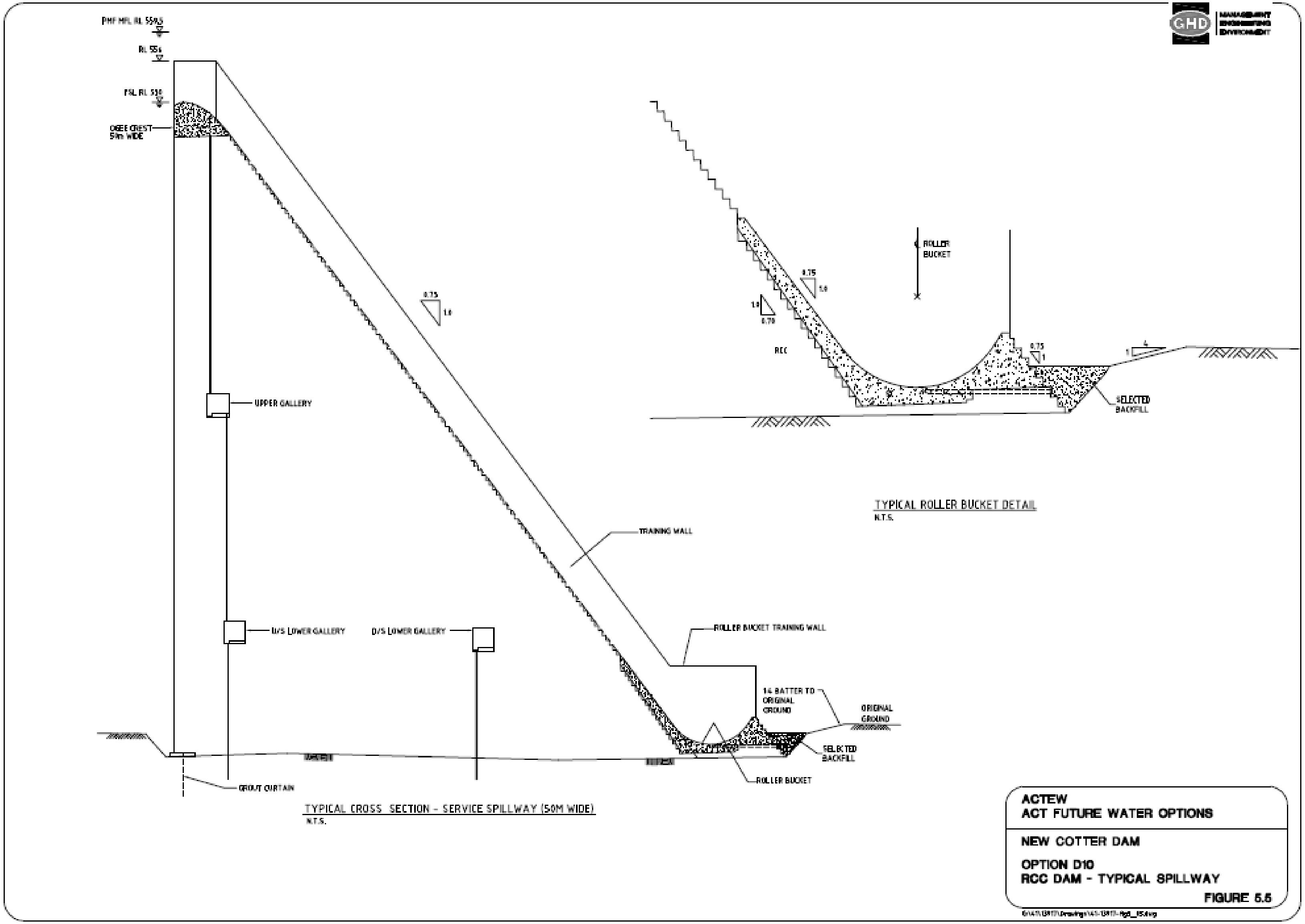


Figure 5-3 - RCC Dam – Section (ex GHD 2005)



6 Saddle Dams

6.1 General

Two saddle dams, SD1 and SD2, at approximately 16 m and 11 m height above existing ground level, are required. These are significant structures when compared to the long term reservoir Full Supply Level (FSL) which will be about 5 m and 1 m above the bases of SD1 and SD2 respectively. The saddle dams mainly provide flood storage. Investigations to date indicate that the sites for each saddle dam are underlain by competent rock, with low leakage rates once into the fresh rock. The sites chosen are suitable for the heights of the dams proposed. Figure 6-1 shows the location, plan and a typical cross section of the saddle dams.

6.2 Geology

Although there is limited exposure of outcrop at the saddle dam sites, core drilling at each site indicates that a sound foundation is available at depths varying across the site from around 1.5 m to 2.5 m, with the maximum depths recorded at the low point in each saddle.

Lineament features were noted at the location of the two saddle dams which transect the alignments of each dam. Possible minor shearing was noted parallel to these features which may impact on the permeability of the surrounding rock. The drilling stage of the project should be used to target specific points along the saddle dam alignments to determine the permeability of the foundation rock, and estimate the extent of foundation grouting in these areas.

6.3 Type of Dam

Rockfill dams with an earth core and filters will be included in the design. The rockfill is to be sourced from required excavation. To date, sufficient quantities of earthfill have not been proved in the nominated borrow area. However, the quantities required are not large, so other borrow areas will have to be located during the design investigation phase. Investigations need to be extended to locate a suitable borrow area. In fact, low RCC type structures could be constructed utilizing the equipment for RCC that may be employed on the Main Dam. Such RCC structures may consist of a trapezoidal cross section with slopes of 0.5 H to 1.0 V upstream and downstream.

Present designs include a 5 m deep cut off under the core. However, the drilling results at the saddle dams have shown sound, competent rock close to the surface. The need for such a substantial cut off will need reviewing during design.

6.4 Quantity Balance

The quantities for the saddle dams as computed require 138 000 m^3 rockfill, designated as Zone 3A. The volume of excavation of rock from the main dam and diversion conduit suitable for use in the saddle dams totals about 125,000 m^3. Of this volume a percentage would be rejected as unsatisfactory for inclusion in the saddle dams and a percentage would be wasted. Allowing a bulking factor of 25%, wastage of 20% and 10% rejected there is a shortfall of 30 000 m^3 that would have to be supplied from the quarry. This shortfall could have a $500,000 impact on the project cost estimate. This is within the range of sensitivities for the cost estimate quoted in Section 11.

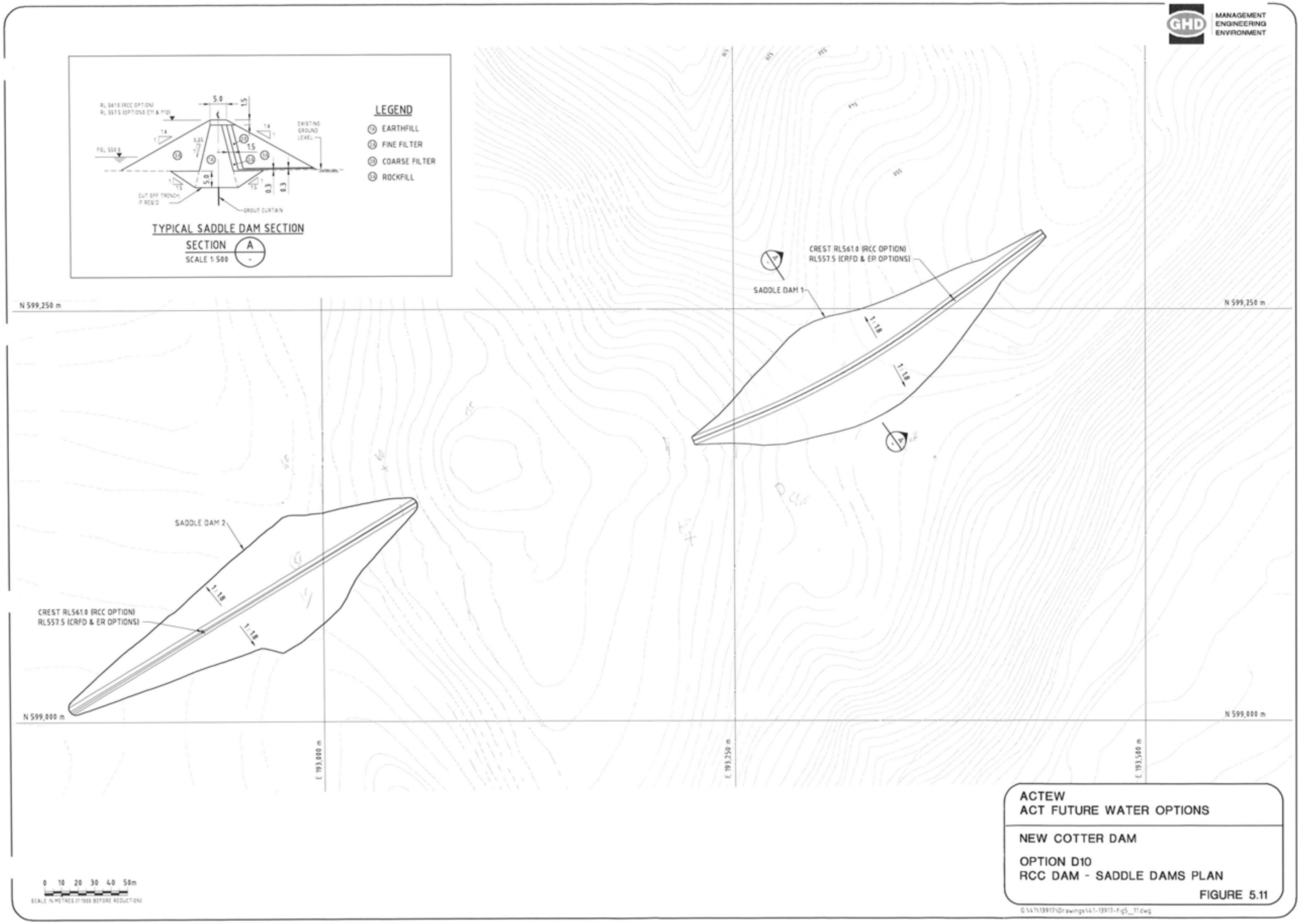
A material flow analysis to confirm the sources and quantity of all materials must be included in the design phase.

6.5 Summary

The saddle dams are significant structures, and the sites chosen are well suited for the dam types chosen. Issues to be addressed are:

- borrow areas for earthfill to be identified;
- dam type i.e. rock and earthfill or RCC to be confirmed;
- cut off provisions to be confirmed; and
- material flow analysis for saddle dams.

Figure 6-1 - Saddle Dams – Plan and Typical Section (ex GHD 2005)



7 Planning Approvals

7.1 Background

The approvals required and the status of existing submissions to relevant authorities to obtain approval for the development of the Dam, were detailed in ACTEW 2005. Since then studies and submissions required for approvals have continued, their status is reported in CBRE 2007b.

On the assumption that construction of the dam would proceed, the ACTEW Board has provided an 'in principal' approval for the project which allows funds to be allocated to further the design and to enable the necessary background studies to continue. Design has proceeded in the form of preliminary geological mapping, subsurface investigations and laboratory testing and updated cost estimates. Background studies into planning, European and indigenous heritage, terrestrial and aquatic flora and fauna are continuing.

It is significant to note that a new Planning and Development bill for the ACT is expected to be implemented in late 2007. The provisions expected to be included in the new bill are known to ACTEW and are reported to be not greatly different from the present Act. Therefore the new provisions are not expected to pose any particular challenges to the project. However, there is potential that implementation of the new Act and associated regulations, could lead to delays.

7.2 Timing

The critical factor in the development schedule for the Enlarged Cotter Dam is the potential for delays caused by extended technical and environmental assessments in the approvals process.

A copy of the indicative project timeline is shown in Figure 11-1. This shows the best estimate of the timing. The approval date could be earlier or delayed depending on circumstances. Where there are statutory timelines for tasks, maximum times are shown. However, investigations and design for the new dam, which are on the critical path for preparation of bidding documents, should continue on the assumed timeline.

7.3 Approval Process

The approval process is outlined in CRBE 2007b. The process requires an EIS and will come under the new Planning and Development Act which will be accompanied by a rewritten Territory Plan. As assessed in ACTEW 2005, the dam enlargement is not inconsistent with the present Territory Plan. It is expected that this situation will continue.

Other ACT approvals relating to Flora and Fauna, ACT Health, Emergency Services, Environment Protection and Heritage will be required. The Commonwealth ***Environment Protection Biodiversity and Conservation Act 1999*** will be triggered by any potential to impact on the Trout Cod and Macquarie Perch.

7.4 Background Studies

There are certain technical questions that will have to be answered during the approval process. The accepted method to answer such questions is to commission specific studies into technical aspects as supporting documentation.

For the Cotter Dam project, desktop studies have already been completed on subjects including:

- cultural heritage;
- fish impacts;
- flora and fauna;
- catchment and landscape analysis; and
- social impacts.

This body of work provides important references and also the confidence that there are no critical constraints on the project proceeding.

In anticipation of the projects proceeding, background studies have commenced with initially a gap analysis and briefing for completion of detailed reports.

It is noted that cloud seeding is considered an economically viable option. However, because of the uncertain nature of this exercise no account should be taken of it in the development of the new storage.

7.5 Recommendations

The following recommendations, made in CBRE 2007b relating to the Cotter Dam, have or are now been implemented:

- an ongoing review of the Planning and Development bill, regulations and implementation progress;
- confirmation be sought from ACTPLA that Cotter Dam enlargement does not require a Territory Plan variation;
- map the approval path for the Cotter Dam enlargement using the existing ***Land (Planning and Environment) Act 1988***, to compare with the path presented in this report, looking for possible time savings and potential areas for delays;
- seek advice from ACTPLA regarding early scoping of an EIS for the Cotter Dam enlargement in advance of the new Act being implemented; and
- undertake a detailed gap analysis on the background studies completed for the Cotter Dam on heritage, fish impact and flora.

For the development to have the best chance of an early completion, ACTEW should continue to fast track the completion of these actions.

8 Environmental Studies

8.1 General

As outlined in CBRE 2007b, the Planning and Development Bill 2006 requires the environmental impact of the Cotter Dam development to be assessed under the third of the three assessment streams; the Impact Track. All projects assessed under this track require an EIS, unless specifically exempted by the minister, which is considered unlikely given the public profile of this project.

The EIS is an essential part of the process of design for a major water supply storage project. The recent history of water storage projects in Australia and elsewhere warns of projects that have suffered extensive delays and, in extreme cases, cancellation after the full impact of the project on the environment, together with possible mitigating measures, has been assessed.

8.2 Process

ACTEW has a number of studies and community consultation initiatives underway to meet the requirements of the ACT planning regulations for approval to be obtained for the dam. Details of the process are outlined in ACTEW 2005 and CBRE 2007.

8.3 Sedimentation

Sediment inflows into the reservoir either:

- remain in solution and have to be removed from the water at the water treatment plant; or
- are deposited in the reservoir therefore reducing the available storage.

Sediment that has remained in solution in the past has caused turbidity problems, requiring more investment into treatment works, which resulted in increased maintenance on pumps due to increased wear on impellers. The enlarged reservoir would reduce the amount of sediment that would reach the pumping station due to greater dilution, increased time for settling of sediment in the reservoir and slower drift velocities through the reservoir. Combined with the comprehensive erosion control measures such as wetlands and structures implemented in the catchment by ACTEW, sediment inflows will be minimised into the reservoir. Due to the destruction of vegetation cover by the recent bushfires, rates of sediment inflow to the reservoir are expected to be high in the mid term until the forest cover is re-established.

Estimates of sediment deposition in the existing Cotter Dam were made in 1966, and again in 2006, by Ecowise (Ecowise 2006). The deposition volumes calculated were:

- 600 000 m^3 between 1915 and 1966, equal to 13% of the reservoir volume in 41 years, or 15,000 m^3 per annum; and
- 830,000 m^3 by 2006, with an accelerated rate of sedimentation after the 2003 bush fires.

These sedimentation rates are small when compared with the storage volume in the enlarged reservoir. On the basis of these figures, the reservoir is in a low sedimentation area, so in relation to current planning, this will not be an issue for the lifespan of the dam.

8.4 Riverine Habitat

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

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

While these changes would be permanent, they would be restricted to the dam location and would therefore be generally marginal in the total scheme of things.

The best mitigating measures would come from a flow regime that closely mirrors natural low flows over summer and seasonal peaks during spring. Management actions that would assist the downstream habitat include:

- taking water for release at varying depths;
- thermal destratification; and
- a scheme to recirculate water from the Murrumbidgee River near the Cotter Pumping Station using the existing 600 mm pipeline discharging water into the energy dissipater at the base of the spillway (reducing the need for making releases from the reservoir).

Such options need to be discussed with the designer with close liaison maintained between the design group and the environmental agencies.

8.5 Effects on Fish

Enlargement of the Cotter Dam to 78 GL capacity, was rated by Environment ACT as having the lowest impact on fish among the various Cotter options initially under consideration. This is because it provides opportunities for active enhancement of endangered fish habitats and populations in the lower Cotter catchment.

Four species (three fish and one crayfish) have been declared as endangered or vulnerable under ACT or Commonwealth legislation and are potentially affected by the Cotter Dam enlargement:

- Macquarie Perch (***Macquaria australasica***),
- Two Spined Blackfish (***Gadopsis bispinosus***)
- Trout Cod (***Maccullochella macquariensis***), and
- Murray River Crayfish (***Euastacus armatus***)

Further study and field work, which is seasonally dependant, is underway to close a series of knowledge gaps in relation to these aquatic species. The fish study is on the critical path and is seen as a major risk.

8.6 Environmental Flows

The outlet works for the environmental flows for the Enlarged Cotter Dam will be designed to release water from selected levels of the reservoir to avoid releases of cold water in the wrong season, as it may stress animals downstream. The outlet works have the controls to release the quantity at the required rate to represent the hydrological cycle in the catchment at any time.

8.7 Terrestrial Flora and Fauna

There are no endangered plant species that would be affected by the Cotter Dam enlargement and the potential occurrence of significant animal species is low. Against criteria of native vegetation clearing and habitat loss, Cotter Dam enlargement is the most benign of the three options. Whilst it would flood considerable areas of existing amphibian habitat, larger areas of equivalent habitat will be created.

8.8 Other Impacts

Other impacts that have been identified and are being evaluated include the effect of the reservoir on:

- aquatic ecology;
- European and indigenous heritage sites; and
- terrestrial flora and fauna.

There are no issues in these areas that are seen as having a serious impact on the project, or where the impact cannot be dealt with by suitable mitigating measures.

Additional fieldwork has been identified and is being carried out for ACTEW. Again, any results that impact on the dam must be given to the design team.

9 Recreational Issues

9.1 Background

The Cotter Dam precinct downstream of the existing dam has long been a popular recreation area for Canberra's residents. Both ACTEW and the ACT Government recognise this and are committed to ensuring the value of the area is maintained and enhanced into the future.

In recent times there have been many significant changes in the Cotter Area and many ideas have been put forward to improve the level of service and amenity that it offers.

The bushfires of January 2003 had a dramatic impact, which has permanently changed some areas. Most of the popular picnic sites have recovered, but many still bear some scars.

If the ACT Government makes a decision to enlarge the Cotter Dam there is potential for another significant change in the area including, disturbance during construction. However, there is also the potential for a positive legacy into the future.

A brief summary of the current status of the Cotter and the issues that should be considered during the dam construction project to ensure the outcome of the disturbance is positive follows.

9.2 Definition

For the purposes of this report, 'the Cotter' includes everything from Pierces Creek to the Dam Wall and along the river from the Cotter Avenue, past the camp ground to Casuarina Sands. It also includes the areas visited by walking trails in the vicinity. Refer to Figure 9.1.

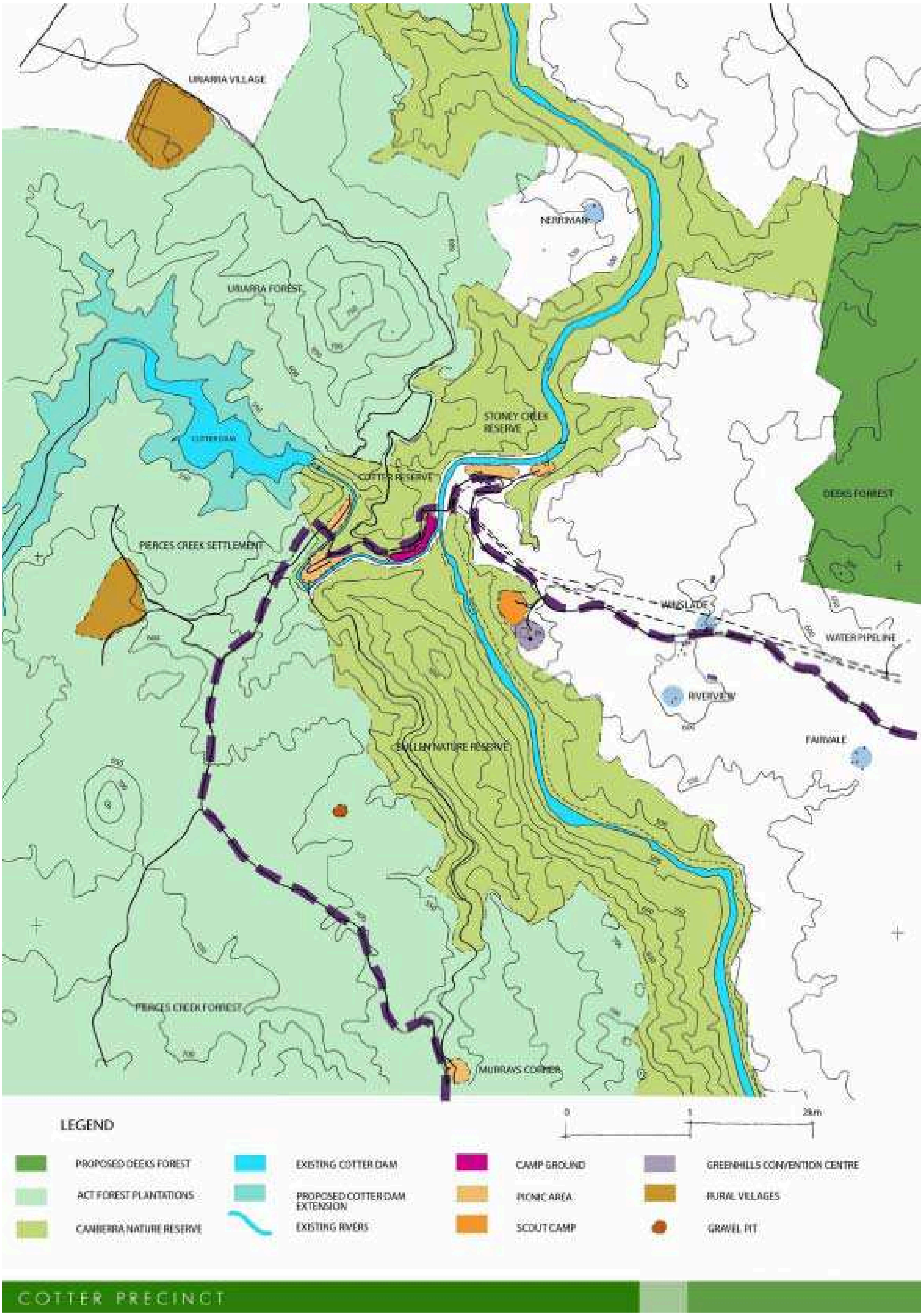
9.3 History

The Cotter area has a long history of Aboriginal occupation and early settler activity. The original Cotter Dam provided Canberra's water supply and recreational use as a swimming and picnic area for Canberra families. At its best, the popularity was strong enough to support a kiosk at Casuarina Sands and a Pub/Restaurant at the Cotter Avenue. In recent times there have been dramatic changes, precipitated by the bushfires of January 2003.

The bushfires destroyed the Pub, the suspension bridge near the dam wall, twelve of the thirteen houses at Pierces Creek Settlement, several of the ranger's cottages at the Cotter and many of the mature trees along the river. There are now only three families living in the immediate vicinity rather than nearly twenty. The loss of the pub and the suspension bridge has removed some of attraction of the area.

The loss of vegetation has also led to instability of the valley walls near the Cotter Dam wall, resulting in access being closed to the public. The loss of mature Casuarina trees in the vicinity of Casuarina Sands has resulted in a loss of general amenity.

Figure 9-1 - Cotter Precinct



9.4 Recent Studies

Revitalising the Cotter has been the subject of a number of studies and reports in recent years particularly since the 2003 bushfires.

The first study ***Shaping Our Territory – Opportunities for Non-Urban ACT*** (ACT Government 2004a) floated a number of ideas ranging from very passive recreation to major commercial development. The overwhelming community reaction was the desire to maintain the free family barbecue atmosphere and the capacity for recreation in the surrounding forests. Major commercial development was generally not supported, although some development to replace the previous amenity would have been acceptable.

At the time, it was also envisaged that the nearby Uriarra Village would be reconstructed and enlarged to 100 dwellings and that the Pierces Creek Settlement would also be reconstructed with 40 dwellings. These developments would bring additional population to the area and make commercial developments at the Cotter potentially viable.

The Uriarra Village is going ahead, but due to an inability to reach agreement between the ACT Government and the National Capital Authority, Pierces Creek Settlement is not currently planned to be rebuilt.

A second study by the Shaping Our Territory Group looked more specifically at the opportunities at the Cotter (ACT Government 2004b). This study looked at recreation and development opportunities and consulted with interested parties. It became apparent that the needs of recreational user groups were relatively simple, as they tended to use the area as a meeting and staging point for activities further into the forests. The likelihood of commercial development remained unquantified and hence it was decided to test the market by seeking expressions of interest.

The conclusions drawn were that while the Cotter is highly valued by the community as a place of recreation, there is not sufficient activity in the area to warrant commercial investment. The number of visitors to the Cotter is still recovering after the bushfires and until it stabilises and is predictable, the risks of investment are too high.

A campground strategy for the ACT, was also prepared during the same period. It looked at the Cotter Campground and drew attention to several deficiencies in the current set-up, due to; a growing demand for camping and cabins in a bush setting and to meet the needs of domestic tourism.

The Cotter Precinct has been extensively studied, however it has been subject to limited investment, pending a decision about the enlargement of the Cotter Dam.

It is therefore essential that, if the enlargement of the Cotter Dam proceeds, the latent desire for improvements to recreational facilities at the Cotter is catered for.

Unfortunately, the pending decision about whether the dam would be built has made it almost impossible to measure the value of that latent desire over the past few years.

9.5 Recreation Master Plan

A master plan for the redevelopment of the Cotter will be required in the long term planning and development. To take advantage of the construction of the dam when there will be opportunity for construction of viewing areas, tracks, cabins and camping areas, it would be ideal if such a master plan was prepared before construction starts.

It is noted that ACTEW has decided that because the Enlarged Cotter Dam's main purpose is for water supply and to ensure an unpolluted source, the use of the reservoir itself for recreational activities will not be permitted. Also due to safety reasons, access to the proposed dam will be restricted to maintenance staff only.

9.6 Construction of the Enlarged Cotter Dam

Construction of the new dam will create opportunities for consequential benefits one of which is the potential to redevelop the Cotter as a recreational area for Canberrans. All of the recommendations in ACT Government 2004b recognised the possibility of the Cotter Dam being enlarged and the need to work within the realm of this potential project. However, the possible construction of the Enlarged Cotter Dam could close access to visitors to some areas during the two year construction period.

In order to maintain public support for the project, it would be ideal for many of the current recreational opportunities to be maintained during construction. However, the mix of construction activities and traffic for a project of the size of the Enlarged Cotter Dam with visitors, picnickers and the like would not create a relaxing atmosphere and potentially create a dangerous environment for visitors. To overcome this issue, ACTEW could use the construction process as a tourist attraction as has been done for many infrastructure projects such as the Snowy Mountains Scheme where a very successful publicity campaign was based on the construction phase of the project. Clear directions to areas set aside from construction would enable visitors, particularly schools, to view the project from a number of different, preferably elevated, locations. The viewing areas would be equipped with sign boards explaining the construction process and progress and fixed binoculars. In addition, the vision for the future recreational use of the Cotter could also be displayed.

Construction of recreational facilities that are in the Cotter precinct could be included in the construction package, provided a master plan and designs are in place before bids are called for construction.

9.7 Post Construction

Once construction is completed there may be an opportunity for the ACT Government to purchase buildings from the contractor. Alternatively the tender documents could include a specification for the construction of cabins that could be used by the contractor, the owner and designer during construction and then revert back to the ACT Government on completion of works. The type and quality of dwelling would then be suitable for campers, holiday makers and outdoor groups.

As the type of construction relating to the recreation features will not be compatible with that needed for the dam, it may be appropriate that a separate contract be let for the detailed completion of the precinct facilities.

9.8 Stakeholder Communication

In preparing the ***Shaping Our Territory Revitalising the Cotter*** (ACT Government 2004b) report, telephone conversations were held with many of the stakeholder groups interested in active outdoor recreation in the Cotter Area. Groups interested in Horse Riding, Mountain Biking, Road

Cycling, Car Rallies, Orienteering, Rock Climbing, Four wheel Driving, Motor Cycling and Fishing were all consulted.

These groups are generally interested in having locations from which to stage events rather than needing infrastructure for their recreation.

9.9 Recommendations

It is recommended that:

- a master plan be prepared for recreational development of the Cotter;
- ACTEW include relevant aspects of the master plan, such as holiday cabins, in the scope of the construction contract for the Enlarged Cotter Dam; and
- ACTEW consider a publicity program to be undertaken during construction to involve the Canberra community in the progress of construction of the dam.

10 Contract Delivery Options

10.1 General

Over the past two decades the implementation of large civil engineering projects has seen a number of new forms for contract delivery. The traditional method, called conventional contracting, in which the owner employs an engineer to develop a design, then prepare a specification and tender documents for bidding by a contractor has, in many instances, been replaced by one or another of the following alternative methods of project delivery.

- relationship contracting, including alliancing and partnering – the owner (ACTEW), contractor and an engineer (designer) form a team, or an alliance, to implement the project;
- progressive partnering, where other parties such as the designer and contractor are introduced into the development, either by direct appointment or as a result of competitive bidding, by the owner as the process proceeds. This can be a variation on the conventional contracting approach; and
- design and construct – the owner employs a group to prepare the design and construct the project. Given the type of project and planning strategy for the new dam, where there are decisions affecting the schedule, quality and difficulty of work to be made during construction, as well as the contractors profit, this is not considered an appropriate model for the enlarged Cotter dam.

Alternatives such as Build, Own, Operate and Transfer (BOOT) where ownership by others is involved, are not appropriate for this project where the asset will be developed, owned and operated by ACTEW and not by a private consortium nor in a private/public partnership.

Another feature introduced into contract delivery in recent years, is the Dispute Resolution Board which is outlined in Section 10.6.

10.2 Implementation Plan for Enlarged Cotter Dam

Current planning for the future ACT water supply for the Enlarged Cotter Dam anticipates that the approval process for construction of the dam will be completed in the second quarter of 2009. Construction of the dam is expected to take less than two years. Present programs allow 16 months for the construction period, however, this must be confirmed when design is further advanced. For the purposes of this discussion, a six month period for the bidding and award of contracts, followed by a two year construction program has been assumed, resulting in a 2011 commissioning for the enlarged dam.

To meet the 2011 date it will be necessary for investigations and design work to proceed in parallel with the approval process. Preliminary geotechnical investigations have already commenced, with drilling at the saddle dams and quarry completed. Designs are to a concept design level. The implication of this is that a method of contract delivery that allows for design work to start as soon as possible and when well advanced to be followed by construction. Therefore a design and construct approach is not applicable.

The program suits a conventional contracting or alliance/partnering approach.

10.3 Conventional Contracting

Conventional contracting is a delivery method that only involves construction. Design development, contract documentation, tendering and contract supervision are all undertaken by the owner, or the owner's project manager, which could be ActewAGL in this case, or by designers and other consultants directly contracted to the owner or the project manager.

The construction contract is based on competitive tendering on a bill of quantities, sometimes with a fixed price (cap) and a fixed completion date with penalties applied for late completion. Risks for cost overrun, delay and technology are generally passed onto the contractor providing a basis for disputes. Traditionally, disputes have been handled in an adversarial approach often with associated high court costs and legal fees.

Conventional contracting is popular where the owner needs to control the design and have flexibility in it throughout the implementation process. This applies particularly in the case of dam construction where foundation preparation and treatment are unknown quantities until the foundation is exposed for inspection.

Properly structured and administered, it is a fair and competitive process which should result in best value-for-money. Clear statements of procedures to be adopted, evaluation procedures and assessment criteria in the tender documents and a consistent and firm application of these procedures and criteria are necessary.

The disadvantages of this delivery method are:

- allocation of most risk to the contractor which encourages an adversarial relationship between owner and contractor;
- contracts need to be tight and therefore must be prepared thoroughly and there are many examples that can be used as models in the case of the Enlarged Cotter Dam;
- competitive tendering is a cost impute to contractors and this is generally passed on in the bid price;
- there is little mechanism for the contractor to influence build-ability; and
- legal complexities.

A variation on this approach is to call tenders for construction on the basis that the successful contractor would then negotiate with the project manager to join with the owner and designer in a risk sharing partnership removing the adversarial nature of the relationship.

10.4 Partnering

Partnering requires a commitment by those involved in the project to work to a common goal. It is not a contractual agreement, nor does it create any legally enforceable rights or duties. Its success requires commitment and relies on trust, respect and good faith rather than suspicion, contempt and scepticism.

Partnering has been widely used in Australia, including in conjunction with the conventional contract for delivery of the LMWQCC Bypass Storage Dam. Reported pitfalls in partnering include:

- an over-reliance on others skills due to lack of in-house skills;

- the cost of involvement as it requires the investment of significant management and staff time, effort and money;
- the perception that close knit working relationships over a long period erode competition. However in this case the contractor can be selected via a transparent, competitive bidding process based on quality and price; and
- introducing partnering too late in the process and not sufficiently far down the chain of workers, contractors, sub-contractors, suppliers and union.

10.5 Alliance Contracting

10.5.1 General

In broad terms, alliance contracting involves the commitment of all parties to agreed principles, to assume equal responsibility for delivery of the project and to jointly assume the risks and rewards of delivery. It seeks to embrace a 'no-blame' and best for project culture. Alliance contracting is often described as a 'risk embrace' culture under which parties seek to better manage risks by working together within a flexible project delivery environment. There are unique legal issues which arise out of an alliance relationship. A concept of 'no litigation' is generally included in the principles unless there is wilful default.

Alliance contracting requires a high level of mutual respect and trust between alliance team members and is based on a framework of cooperation and mutual adhesion to agreed principles and outcomes particularly in relation to risk and risk sharing, quality, timing, cost and profit.

Key elements of successful alliance contracting include:

- having the right people in the project team;
- a joint view on risk and risk management;
- a shared and accepted view on remuneration consistent with the joint view on risk management;
- an acceptable methodology for dispute resolution; and
- there is a 'pain share / gain share' model within an alliance where all parties share in profit (gain) or loss (pain), although the Non-Owner Participants pain is usually limited to overheads (including profit). All alliance transactions are fully 'open-book' to help facilitate this.

Alliance contracting is generally considered for water infrastructure projects with the following characteristics:

- high risk, complex projects without clearly defined scope;
- projects where the outcome is clearly defined but method of delivery is not; and
- projects where exceptional outcomes are required in terms of schedule achievement, cost reduction, technical innovation, public interest, continuous improvement and/or complex integration.

There is a recommended process for confirming the appropriateness of project alliance contracting. If not undertaken correctly there could be some Trade Practices Act (TPA) issues regarding competition in alliance contracting. A probity auditor is often included for public sector alliance projects.

Organising an alliance usually takes some six to nine months which may not fit the ECD timetable.

10.5.2 Alternative Forms of Alliance Contracting

Two alternative methods of alliance contracting are:

a) Non-Competitive (or 'Pure' form of) Alliance Contracting

This is the 'classic' form of alliance contracting and was used at Awoonga Dam in Queensland. It generally takes the following form:

- selection of the alliance contractor and if required other designer/contractors on non-financial grounds;
- creating the legal entity, the Alliance, which includes client, designer, contractors and others with associated interests;
- negotiating a contract price/rates which are generally on a cost plus overhead basis as well as the construction timetable within the alliance; and
- final design documentation within the alliance.

b) Competitive (or Commercial) Alliance Contracting

This alliance contracting approach tries to put some competitive tension into the tender process. It generally takes the following form:

- design development outside of the alliance;
- competitive tender by prospective alliance contractors and, if required, other designer/contractors including a form of financial offer;
- creating the legal entity, the Alliance, which includes client, designer, contractors and others with associated interests; and
- final design documentation including target cost within the alliance.

For the ECD, option b) would be a better fit as the design could be documented before an alliance is formed.

10.6 Dispute Resolution Board

Dispute Resolution Boards (DRB), are a standard feature in most types of contractual arrangement both in Australia and Internationally. Australian Standard AS4608-2004, 'Dispute Management Systems', (Standards Australia 2004) applies.

DRB's comprise a panel of 3 independent technical experts jointly selected by the client/principal and the contractor, or the members of an alliance partnering arrangement. Issues not resolved by negotiation between the owner/principal and the contractor are formally referred to the DRB for a recommendation which is non-binding, but discoverable in any subsequent legal proceedings.

10.7 Discussion

10.7.1 General

Either Conventional or Alliance contracting models are suitable for the design and construction of the ECD, as its construction is considered to be non-complex, relatively straight forward project with clearly defined outcomes where the major cost is in supplying and placing Roller Compacted Concrete.

10.7.2 Conventional Contracting

The conventional approach provides some strong advantages that affect the quality and control of the development. They are:

- the development process commencing with investigations and design can commence as soon ACTEW obtains the relevant planning approvals;
- allowing the designer sufficient time to properly investigate the project and interact with environmentalists and planners in areas where their inputs may affect the design;
- the owner has control over the design, specifications and tender documentation and can settle most technical issues before the contractor is selected and construction commences;
- the ability to initiate early, the prequalification and tendering process for selection of a suitable contractor providing transparency and a competitive price;
- the ability to use the option of a progressive partnership to provide a better spread of risk, including a clause in the bidding documents that states that the successful contractor may be asked to join a progressive partnership with the owner and designer which should reduce the provisions that bidders would normally include for risk;
- the opportunities for inclusion of recreation facilities around the new dam and reservoir in the Cotter Valley would be able to be studied and included in the project; and
- the ability to use a progressive partnership to allow the owner to add recreation facilities to the works after letting of the contract. Inclusion of provisional sums would allow for addition of extra works as the project progresses.

10.7.3 Alliance Contracting

Many of the advantages of a conventional contract with progressive partnering also apply to alliance contracting. As the design function could commence before the alliance is formed, the Competitive Alliance Contracting model could apply.

The reduction of risk to the contractor is the major advantage for the contractor allowing them to enter the project without the risk that they could lose heavily if they have misinterpreted the difficulty of the works. The final price for the works is then developed in discussion between the contractor, the owner and the designer.

10.8 Conclusions

The following conclusions have been made:

- A Dispute Resolution Board should be appointed.

- Construction of the ECD could be undertaken using either an alliance or conventional contracting system. Each has its advantages and disadvantages.
- Alliance contracting is contractor selective and is based on a bidding process with the target cost, and the agreed time negotiated with the selected contractor. In the case of the ECD extra time would be required to set up an alliance in accordance with proper legal principals. In regards to planning, the alliance team could be set up in parallel with the design; although if the design proceeds quickly it would be largely completed by the time alliance discussions would take place.
- The conventional contract is competitive, adversarial oriented, self interested with risk allocation, whereas alliance contracting is cooperative, relationship oriented, outcome focussed with distribution of risk. Conventional contracting is fair to all tendering contractors and is based on a fixed price / fixed time.
- Progressive partnering could be imposed on either contract system to allow the inclusion of the designer as well as the owner and the construction contractor in the team responsible for project delivery.

ACTEW is presently reviewing contract delivery options and to date no decisions have been made of the approach to be applied for this project.

11 Cost Estimates and Construction Program

11.1 General

Cost estimates for the new dam were included in the GHD 2005. They were reviewed separately by GHD 2007 and RLB 2007***.*** The estimates were prepared using typical rates obtained from industry publications, data from contractors engaged on similar works and escalation factors included in the Consumer Price Index for Non-building construction. GHD 2007 compared the rate of increase of construction costs in Canberra to the national average and found it to be generally in line allowing 6% escalation between 2005 and 2007.

The construction program for the dam allows a 16 month period for completion of the dam. This will need a more detailed study, but it has been indicated that if all approvals are obtained early enough to start work in mid 2009, the 2011 date could be met. The 16 month program is focussed on the dam only.

11.2 Cost Estimates - Comparison

GHD and RLB estimated the cost of the RCC alternative in 2007 dollars as $124 and $107 million respectively. Table 11.1 major items of difference in $millions are:

Table 11.1 Cost Estimates – Major items of difference ($ millions)

Item	GHD	RLB	Difference
RCC Construction	53.5	46	+7.3
Unestimated items	11.3	2.5	+8.8
Contingency	18	11.3	+6.7
Engineering	6	9.7	-3.7

The differences are due to:

- different rates used for RCC, $160/m^3$ (GHD 2007) and $130/m^3$ (RLB 2007);
- varying assessments of unestimated items and contingency which are subjective at this stage; and
- engineering, the cost will vary depending on the scope of works.

A check on the basis of 6% inflation since the 2005 estimate of $98 million, suggests a price of $112 million. A review of the rates for RCC in other projects in Australia suggests that the GHD rate for RCC is well founded. For instance, current rates for Meander Dam in Tasmania are $200/m^3$ for a fill quantity of 84,000 m^3. Then, averaging the amounts for unestimated, contingency and engineering items, the subjective items, from each estimate results in a project cost estimate of $119 million, which is considered the current estimate for the dam.

The total works at the Cotter River precinct will include:

- the upgrade of the pipelines between the dam and the pumping station; and
- the refurbishment of the pumps and electrical works at the Cotter Pumping Station or the construction of a new pumping station.

Options for the pumping station upgrade are presently being studied as a separate exercise to the Enlarged Cotter Dam. Until the optimum arrangement is determined, the cost for the upgrade is treated as a separate item with a budget price assessed to be $20 million. Therefore, the total work in the Cotter River precinct is estimated to be $140 million.

The 2007 estimators differed on the accuracy of these estimates; one quoting ±15% and the other ±30%. On the basis of the averaging of the subjective items an accuracy range of +20% to -10% is recommended for budget purposes.

Placing RCC is the major single element of the cost. For example, an increase in cost of RCC placement to $200/m^3$, would add $12.4 million to the cost of the dam, which is within the +20% range.

The estimates exclude costs for the owner's project team, land acquisition costs, permitting costs, finance costs, Government liaison and operational staff training.

It will be necessary for an engineer's estimate to be prepared when the design is well advanced and is in sufficient detail for un-estimated items to be minimised allowing a tighter estimate to be made. Such estimate would be used by ACTEW for budgeting purposes and as a comparator when evaluating bids.

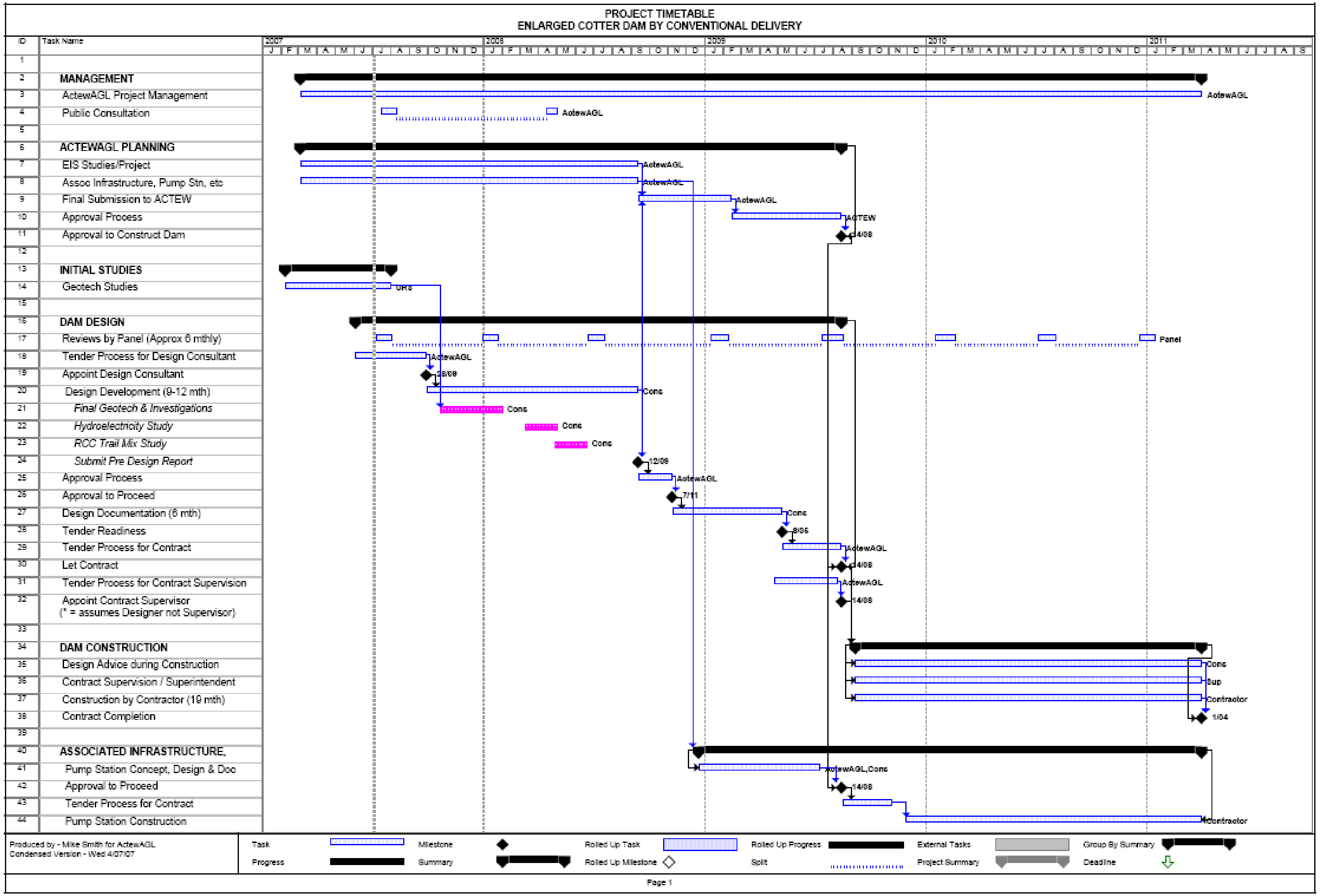
11.3 Construction Program

Sixteen months has been allowed for the construction of the dam in the 2005 report. This period is for the dam and outlet works alone. No time has been included for preparatory works, construction of pipelines to the Cotter Pumping Station and providing water passages through the existing dam. It is suggested that ACTEW take a conservative approach and budget for a two year construction period to allow for preliminary activities and provide some float.

Figure 11-1 shows an indicative construction schedule for the project.

The construction program is a major step in the planning for the dam however it is one of a number of items that need to be included. A comprehensive implementation program including all works and studies necessary before the dam, new pipelines and modifications and extensions to the Cotter Pumping Station are commissioned, must be prepared. The program should allow for the master plans and designs for developing the recreational facilities in the Cotter Valley to proceed in parallel with the detailed design of the dam.

Figure 11-1 - Indicative Enlarged Cotter Dam Project Schedule



12 Cotter Pumping Station

The Cotter Pumping Station is heritage listed and is to be preserved. At present, the pumping capacity is being upgraded as part of the Extended Cotter to Googong Bulk Transfer Project (ECBGT).

The increased flows that will have to be pumped by the station will need an increase in capacity that dictates that an extension be constructed. The characteristics of the existing pumps fit the existing Cotter Dam where the head results from the 30 m high dam. The decrease in pump duty head, due to the higher FSL in the new reservoir means that consideration must be given to either new pumps in the existing station, or new motors and impellers on the existing equipment or other modification to match the pumps to the changed duty, if this is practicable.

13 Conclusions and Recommendations

13.1 Conclusions

After a review of the investigations between 2005 and mid 2007 into the proposed Enlarged Cotter Dam, the following general conclusions have been made:

- the studies undertaken between 2005 and 2007 have reinforced the findings of previous reports confirming that the proposed dam site is suitable for construction of the Enlarged Cotter Dam;
- preliminary geotechnical investigations have confirmed that the site is suitable for an RCC type or concrete gravity type dam;
- ACTEW must 'fast track' the technical investigations and design work to be able to commission the dam as planned in 2011/2012;
- it is essential that a thorough geotechnical investigation is undertaken and to minimize the geotechnical risk during construction, which is a major risk, the current investigations program will have to be extended;
- studies into the potential environmental impacts of the project indicate that there are no major issues that would prevent the construction of the dam;
- ActewAGL should continue to pursue the possibility of reservoir drawdown for the duration of construction of the Enlarged Cotter Dam;
- evidence of the presence of the Macquarie Perch and the Two-spined Blackfish upstream of the existing Cotter Reservoir has allayed concerns that the larger dam would prevent their migration upstream. Further studies are underway to confirm this;
- the total cost of the proposed dam and Cotter Pumping Station upgrades is estimated to be $140 million in 2007 dollars;
- the overall comprehensive implementation program must be updated to include all project activities;
- the estimates of the PMF and return period floods at the dam site are to be reviewed allowing for the effect of the larger storage of the Enlarged Cotter Dam; and
- a Dispute Resolution Board should be imposed in either contractual case.

A summary of conclusions from the report is provided in Appendix A.

13.2 Recommendations

It is recommended that;

- ACTEW fast track the technical investigations and designs as soon as the ACT Government approves the project (assumed to be in September 2007) which may require the process of appointing a designer to commence shortly ensuring continuing direction for the geotechnical investigations;
- geotechnical investigations continue, which may require the present contract to be extended and an interim dam engineer to direct the drilling in the absence of a designer;

- a comprehensive implementation program be prepared to allow detailed program management of the project;
- flood estimates be reviewed;
- consideration be given to the type of contract delivery method best suited to the project. ACTEW has appointed a transaction advisor and is looking into this aspect; and
- some thought be given to the make up of a Dispute Resolution Board. This board could be in place as the design process commences to ensure continuity.

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APPENDICES

Appendix A – Summary Conclusions

APPENDIX A

SUMMARY CONCLUSIONS

Geotechnical

Further drilling will be required at all dam sites before the project proceeds to construction.

A series of tests on alternative RCC mix designs must be included in the testing program with experienced personnel required to be in charge of the process.

An investigation to locate suitable pozzolanic material should be undertaken.

Additional borrow area sites may need to be investigated.

A trial mix design to be prepared in the investigation program.

Hydrology

The 2007 PMF and return period floods study be reviewed to allow for the effect of the larger reservoir on the estimated PMF inflow hydrograph.

Main dam

That an RCC dam is the economic choice and is suitable for the site as geotechnical conditions are now known.

An arch dam may have a more aesthetic appeal.

Both the shear zone and the anticline features across the gorge and in the left abutment respectively must be investigated thoroughly during design drilling, before the alignment of the dam is finalised.

Diversion Works

The ACTEW/ActewAGL should continue to pursue the possibility of the existing reservoir drawdown for the duration of construction of the Enlarged Cotter Dam.

The need for a dissipater is to be reviewed.

Spillway

Flood routing needs to be redone after inflow hydrographs have been revised.

Dissipater design should be reviewed when results to hand from the drilling program.

Outlet Works

The design of the outlet works including the complete hydraulic circuit from the dam to the inlets to the pumps in the pump station needs to be revised once the pump station upgrade design is completed.

The designer needs to consider dual outlet pipes, for multiple outlets and metering to provide accurate metering over the full range of environmental flows.

Construction materials

The quality of rock proposed for the RCC will need to be confirmed by laboratory testing.

Saddle dams

The type of dam needs to be confirmed during design.

A material flow analysis to confirm the sources, quality and quantity of all materials must be included in the design exercise.

Borrow areas for earthfill to be identified.

Review cut off design.

Approvals

To keep the program on schedule, investigations and design for the new dam, which are on the critical path for preparation of bidding documents, should continue on the present fast track timeline.

For the development to have the best chance of an early completion ACTEW should continue to fast track the technical aspects which it can control best.

Environmental Impact

The ACTEW/ActewAGL coordinator will have a key role to play managing the environmental interfaces.

The fish study is on the critical path and is seen as a major risk.

Recreational Issues

A master plan prepared for the recreational development of the Cotter.

ACTEW should consider including relevant aspects of the master plan, such as cabins, in the scope of the construction contract for the Enlarged Cotter Dam.

ACTEW should consider a publicity exercise to be undertaken during construction of the dam to involve the Canberra populace in the progress of construction.

Contract Delivery Options

A Dispute Resolution Board should be imposed.

Construction of the Enlarged Cotter Dam could be undertaken by either a conventional contracting or alliance contracting system. Each has its advantages and disadvantages.

Cost Estimates and Construction program

The project cost estimate for the dam is $119 million in 2007 dollars.

The cost of the total work in the Cotter River precinct as at June 2007, including pipework and pump station upgrades, is estimated to be $140 million.

The accuracy of the estimate is in the range +20% to -10%.

An engineer's estimate for all works is to be prepared towards the end of the design period.

The construction program needs to be revised when design is further advanced.

The preparation of a comprehensive construction program covering all tasks from now to commissioning of the project is necessary.