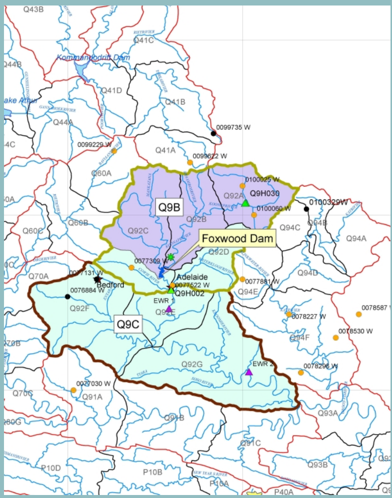

Feasibility Study for Foxwood Dam (WP10580)

Geotechnical Reconnaissance

Final Issue

DWA Report Number: **P WMA 15/Q92/00/2113/4**

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SIGNATURE PAGE

Project name:	***Feasibility Study for Foxwood Dam***
Report Title:	***Preliminary Study Geotechnical Reconnaissance Report***
Author:	***Terreco Geotechnical cc and Arup (Pty) Limited***
Arup project reference no.:	***225739-00***
DWA Report no.:	***P WMA 15/Q92/00/2113/4***
Status of report:	***Final***
First issue:	***2013/05/02***
Final issue:	***2013/07/10***

CONSULTANTS: Arup (Pty) Limited in association with Terreco Geotechnical cc

Approved for Consultants:

James Bristow	*James Hampton*
Project Manager	*Project Director*

DEPARTMENT OF WATER AFFAIRS (DWA): Directorate: Options Analysis

Approved for DWA:

S. v Jaarsveld

S. van Jaarsveld	***PD Pyke***
Project Engineer: Options Analysis (South)	***Acting Director: Options Analysis***

REPORT STRUCTURE

Feasibility Study for Foxwood Dam: Inception Report

P WMA 15/Q92/00/2113/1

Feasibility Study for Foxwood Dam: Preliminary Study Report

P WMA 15/Q92/00/2113/2

Preliminary Hydrology Review & Desktop Reserve

Feasibility Study for Foxwood Dam: Alternative Water Supply Options
P WMA 15/Q92/00/2113/5

Feasibility Study for Foxwood Dam: Geotechnical Reconnaissance
P WMA 15/Q92/00/2113/4

Stakeholder Engagement

Feasibility Study for Foxwood Dam: Environmental Screening
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Feasibility Study for Foxwood Dam: Feasibility Study Main Report

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Feasibility Study for Foxwood Dam: Topographical Survey
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Feasibility Study for Foxwood Dam: Dam Feasibility Design
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Foxwood Dam
ENVIRONMENTAL IMPACT ASSESSMENT

(THE EIA DOES NOT FORM PART OF THE FEASIBILITY STUDY)

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1 LIST OF ACRONYMS

ACV	Aggregate Crushing Value
CFRD	Concrete-Face Rock-Fill
FACT	Fines Aggregate Crushing Test
OMC	Optimum Moisture Content
PLSI	Point Load Strength Index
RCC	Roller Compacted Concrete
SAIEG	The South African Institute for Engineering and Environmental Geologists
UCS	Unconfined Compressive Strength
XRD	X-Ray Diffraction

2 INTRODUCTION

2.1 General

Terreco Geotechnical cc was, on 28th August 2012, appointed by Arup (Pty) Ltd to undertake geotechnical investigations for the proposed Foxwood Dam on the Koonap River, approximately 5 kilometres north of Adelaide in the Eastern Cape Province (Figure 1 Locality Plan).

This after Dr GV Price of Terreco Geotechnical cc had on 10th June 2011 provided Arup with a Proposal and Cost for the work in terms of the Department of Water Affairs Terms of Reference BID WP 10580 ‘Appointment of a Professional Service Provider to undertake the Feasibility Study for Foxwood Dam’.

This report provides the findings of the initial reconnaissance investigation.

2.2 Terms of Reference

The Scope of Work for the reconnaissance aspect is not a request of the original bid: suffice to say that the reconnaissance work follows on from the earlier Inception Report submitted towards the end of 2012. Reconnaissance investigations would comprise:

- Collate and assess all geotechnical information recovered from geological plans; topography sheets; and geohydrological maps
- Retrieve information from the Inception Report for use in the reconnaissance field appraisal
- Review data from earlier geological investigations of 1962 including a review of borehole drilling undertaken for the centreline and a proposed spillway on the left flank
- Undertake field inspections of the dam centreline and spillway areas including a detailed walkover survey
- Undertake prospecting for a hard rock source and for borrow materials to construct the dam with
- Meet with the design and project engineers in Adelaide and undertake an inspection of the proposed dam, and indicate potential core and embankment shell borrow pit prospects already discovered.
- Collate field data on completion of the field activities and compile the reconnaissance report.

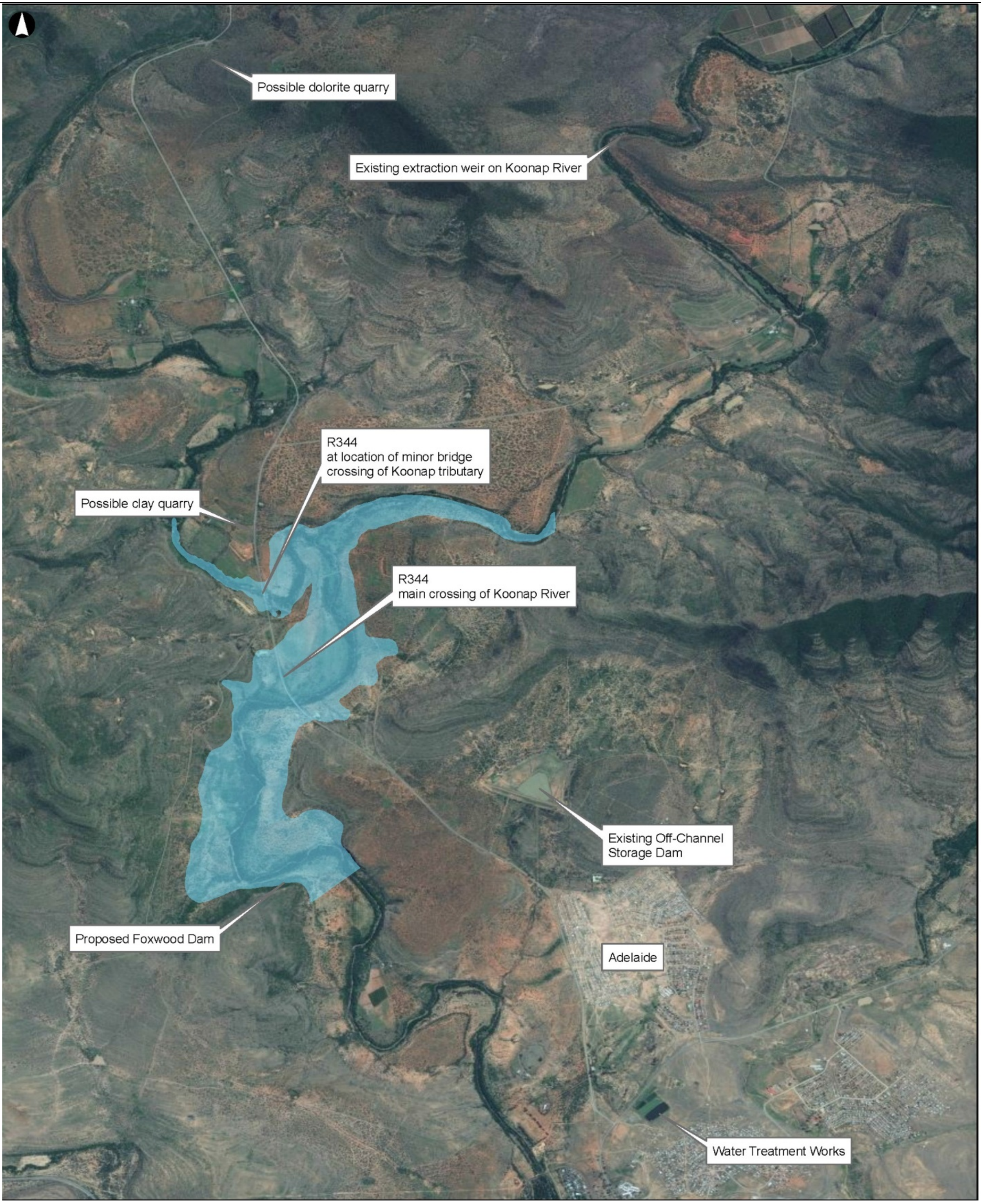


Figure 1: Foxwood Dam Locality Plan

2.3 Aim of this Report

The investigation is aimed at providing reconnaissance geotechnical information to enable a plan of action for the detailed geotechnical investigation.

3 METHOD OF INVESTIGATION

Reconnaissance investigations comprised:

- Retrieving geological; topographical and geohydrological data from published information and copying of relevant field data onto maps destined for field use
- Retrieving previously compiled information for the Inception Report for use in the field.
- Study of the geological report as compiled by the Geological Survey of the Department of Mines by JAH Marais titled "Foundation conditions of the Foxwood site; Koonap River; Adelaide District; CP" and dated 20 November 1962. This report has some invaluable information with respect to dam and spillway founding conditions and will be discussed in more detail in Section 5 of the report
- Field reconnaissance investigations were undertaken over three days during mid-December 2012. Dr GV Price, on completion of an initial dam site appraisal and materials prospecting, met with the Project Director and Dam Designer Mr James Hampton, and with the Project Manager/ Engineer Mr James Bristow of Arup (Pty) Ltd. Further inspection of various aspects of the dam followed, culminating in discussion of various geotechnical aspects for the project, and including aspects of the detailed geotechnical investigation requirements.
- Additional field investigations centred on attempts to locate zones of more clayey material for an earth embankment core - in relatively short supply due to the arenaceous nature of the unconsolidated soils - plus locations of a natural sand source.
- All the field and desk top data has been compiled into this the reconnaissance geotechnical report.

4 GEOLOGY

The dam site and reservoir basin is underlain by sedimentary rocks of the Balfour Formation; Adelaide Subgroup; Beaufort Group; Karoo Supergroup. Rocks consist mainly of grey mudstone and shale with subordinate grey and buff-coloured sandstone. A Geological plan, as extracted from the Council for Geoscience 1: 250 000 King William's Town Sheet 3226, of the dam site and surrounds, is presented as Figure 2.

In Figure 2 the red colouration depicts the dolerite intrusives and the green "Pub" the sedimentary units of the Balfour Formation.

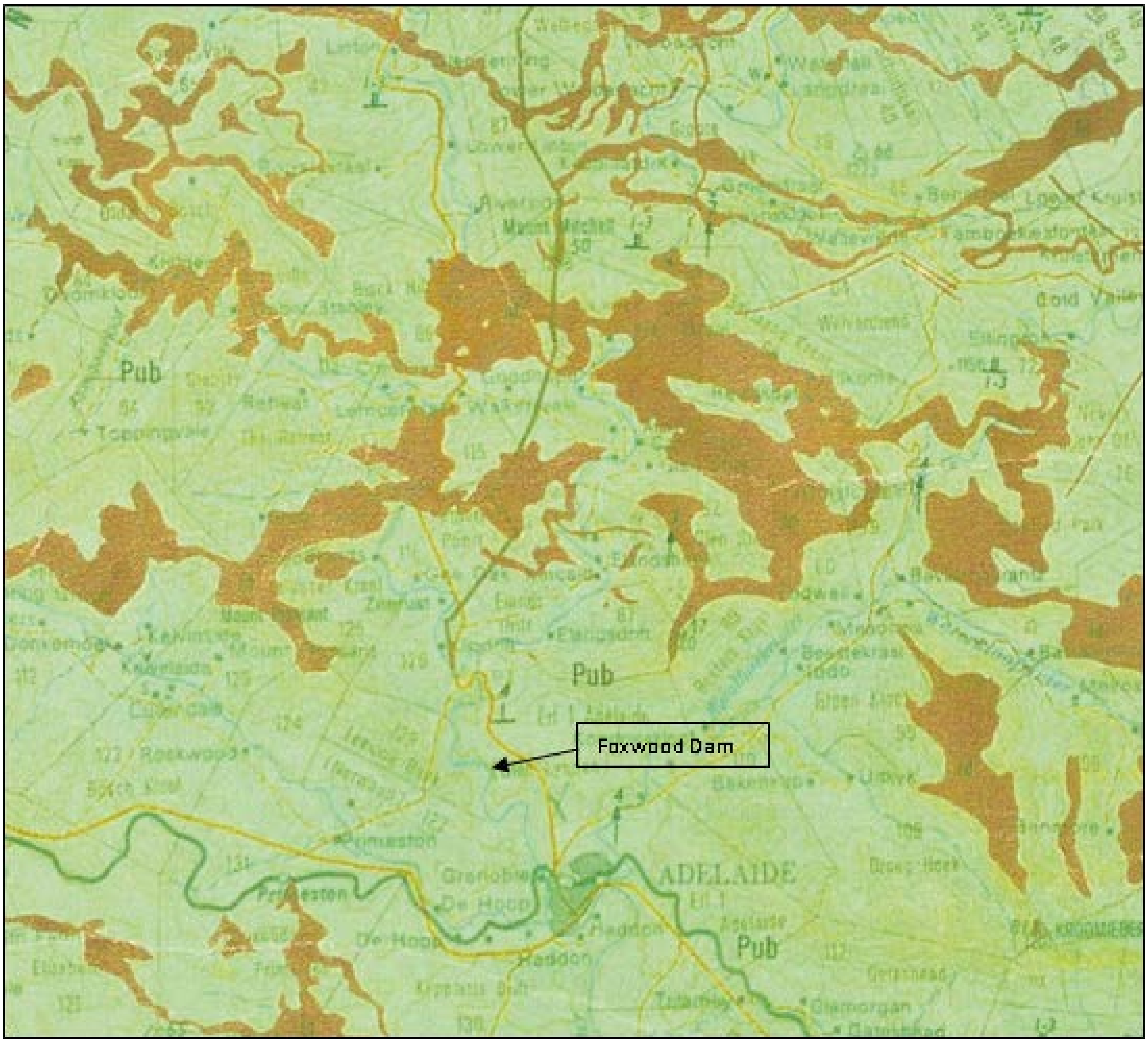


Figure 1 Geological Plan

The sedimentary mudrocks consist mostly of olive and grey mudstone, with a high silt component at times approaching siltstone classification. The mudrocks alternate with sandstone units less than a metre up to tens of metres thick consisting of buff/ grey, fine grained, ultra-lithofeldspathic sandstone (approximately 20%) and mudstone (80%) as described.

The sandstone displays flat-bedding, through cross-bedding and micro-crosslamination. Sandstone rock is mostly massive. Relatively rapid refusal of excavation will occur in areas underlain by slightly weathered or unweathered sandstone or siltstone.

The mudstone is poorly stratified or massive. Cut and fill structures within the mudstone are common. Near-surface rock generally comprises relatively softer or medium hard rock which quickly hardens with depth to rock that is hard and difficult to excavate. Sandstone and mudstone are the major rock types on site.

Post-Karoo dolerite occurs in the area as large sheets; sills and dykes. Dolerite deposits are extensive starting approximately 5 kilometres north of the dam site. In its unweathered state it is a dark grey, hard, hypabyssal igneous rock intruded into the host sedimentary rock. Dolerite is a sought after material as hard rock aggregate when unweathered.

The valley floors have a covering of colluvial and alluvial soils which vary in depth and type as determined by factors such as geological parentage; distance from source; river gradient, and deposition period. Early indications are that both the alluvial and colluvial deposits at the dam site are mostly arenaceous with a relatively minor clay content.

5 DAM AND SPILLWAY FOUNDATIONS

This section of the report provides a summary of expected geotechnical conditions at the proposed dam site and spillway areas.

5.1 General

Foxwood dam site is located on the Koonap River approximately 5km north of the town of Adelaide in the Eastern Cape Province (see previous Figure 2). The dam site is located in a near-symmetrical portion of the Koonap River valley as orientated across a wide centreline approaching 500m.

5.2 1962 Geological Report

An important document for the Foxwood Dam is the original geological foundation report by JAH Marais previously referenced in Section 5: Method of Investigation of this report. Important in the sense that it contains invaluable drilling information with respect to both unconsolidated materials; rockhead contact depths, and nature of the underlying rock. It also means, besides the important information it provides, a reduction in geotechnical costs in that the amount of drilling required along the centreline and along the spillway alignment on the left flank can be reduced.

The report provides important geological information as summarised below.

5.2.1 Centreline

- Both dam flanks comprise sandstone overlying mudstone with mudstone beneath the sandstone capping on the right flank apparently not as hard as its counterpart on the left flank.
- Drilling on the flanks and exposures in the slope indicate a thick capping of light grey, medium grained, feldspathic sandstone overlying fine grained, massive, dark grey mudstone. The comment that mudstone is found to be "more arenaceous and indurated than the average mudstone" is a trait common to the Adelaide Formation. Terreco Geotechnical cc experience indicates that mudstones in this formation are hard and siliceous tending even towards siltstone classification.
- Two boreholes in the river/ alluvial plain section of the centreline indicate alluvial sandy silt overlying coarse alluvial gravels/ cobbles/ boulders, in turn overlying dark grey mudstone.
- Water losses have been experienced during drilling on sandstone and in the mudstone. It is not clear whether they are derived from controlled water pressure tests but it is expected, rather, that these are simply water losses recorded at various positions during the drilling itself.

5.2.2 Left Flank Spillway

- The report indicates that due consideration had been given to a side-channel spillway on the left flank approximately 100m east of the dam's left flank abutment. The three boreholes drilled along the spillway alignment all intersected only sandstone.
- Additional information from the foundation geological report applicable to this reconnaissance investigation and its findings have been included as and where appropriate in the text of the report.

5.3 Anticipated Founding Conditions

5.3.1 Left Flank

The left flank is characterised by a steep sandstone scarp, or cliff, overlying a gentler lower slope of exposed mudstone, followed lower down by a pediment of sandstone fragments and block - combined with alluvial detritus - overlying mudstone. Borehole 1 drilled at the scarp summit intersected 22,6m of hard, massive, or bedded/ cross-bedded sandstone. The borehole did not extend down to the underlying mudstone which is unfortunate, since this could have provided important information with respect to the contact zone between the two rock types.

Central and lower parts of the flank slope consist of mudstone which disintegrates on exposure. This has resulted in undermining of the sandstone capping resulting in sandstone debris - both small fragments and large blocks - littering the lower parts of both abutment slopes.

Figure 2 Left Flank Slope

5.3.2 River Section

The wide river section has a gentle rise from the river channel on the extreme left side towards higher ground on the right flank. Fine grained silt blankets the exposed surface and the two boreholes drilled in this section in 1962 - one next to the river channel and one midway along the centreline - indicate an upper layer of alluvial silty sand 3m to 9m thick overlying gravel; cobbles, and boulders (borehole logs indicate boulders but the report text suggests gravels) 2m to 3m thick, overlying unweathered mudstone with thin siltstone and sandstone intercalations.

Depth to the rockhead contact is 5,8m in the borehole adjacent to the river channel and 10,8m midway along the centreline.

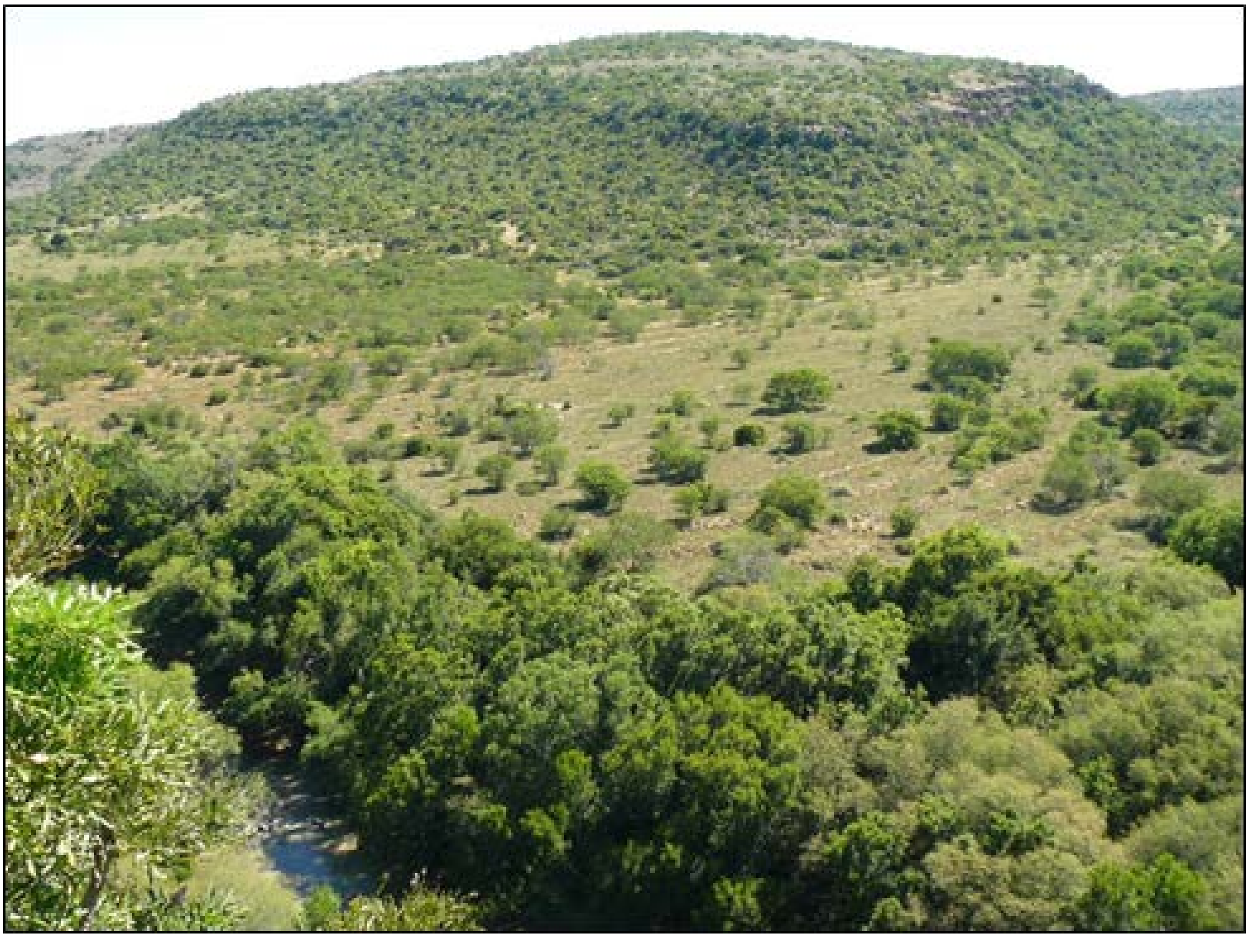


Figure 3 River Section

5.3.3 Right Flank

The right flank is not as steep as the left and has a greater proportion of slope debris. The sandstone capping in prominent at the top of the flank but most of the central and lower slope geology is hidden by a layer or colluvium; bush and grass. One borehole drilled slightly downslope of the flank summit indicates 9,1m of massive feldspathic sandstone overlying green to grey mudstone. The contact zone has a 75mm layer of 'clay with secondary lime'. Mudstone is reportedly of lower strength than on the left flank but this will require confirmation via rock core testing of still to be drilled borehole cores.

The 1962 report suggests that the 'right flank consists practically entirely of mudstone being capped at its crest by a sandstone layer of 35 feet (10,7m) thickness only'.

Figure 4 Right Flank

5.4 Spillway Options

It would appear, from discussions on site, that the dam position lends itself to an earthwall structure with a side-channel spillway through the sandstone capping on the left flank (as originally proposed), or as a composite structure with a concrete spillway in the river section.

Three boreholes drilled along the original spillway position on the left flank all intersected sandstone from 13,3m on the north side to 18,6m on the south side. None of the boreholes intersected the full depth to intersection with the underlying mudstone, and it therefore remains unknown how much deeper the contact zone is, or nature of geotechnical conditions along the contact. This therefore requires additional investigation. One problem with having a side-channel spillway is that nearer its outlet it has to cross steep terrain, over erodable disintegrating mudstone, and will therefore probably require a lined concrete channel with concomitant costs.

A concrete structure with spillway in the river section will require relatively deep founding on the underlying mudstone, with a stilling basin on the downstream side to prevent scour and headward erosion towards the structure. This solution too could therefore prove relatively costly. It will also require additional borehole drilling to determine rockhead depths downstream of the centreline, and to provide information with respect to type and quality of the underlying rock.

6 CONSTRUCTION MATERIALS

6.1 General

Indication from the design engineer is that a dam at the Foxwood site will probably comprise an earthwall structure. Reconnaissance investigations have therefore been concentrated in this area. However, other options too, such as RCC and CFRD, have also been considered and are discussed in the sections following.

6.2 Rock Aggregate for Concrete and Riprap

The 1962 report suggests that either unweathered dolerite or sandstone could be used as a hard rock aggregate or as riprap. This would not, however, be advisable since recent studies indicate that certain sandstones of the Beaufort Group - and notably the Adelaide Subgroup - undergo conchoidal fracturing over time which results in initially hard unweathered rock cracking and breaking apart after long periods of exposure. The process is not entirely understood but with net result that riprap disintegrates over time and its use for that purpose must therefore be avoided.

Hard, unweathered dolerite is therefore the material of choice as hard rock aggregate for concrete; rollcrete and riprap. Reconnaissance prospecting investigations reveal good quality dolerite quarry opportunities approximately 5 kilometres north of the dam site: two of which have been identified as possible quarry sites. These are marked Q1 and Q2 in Figure 6 below, with Figure 7: Potential Quarry and Borrow Pits Locality Plan over page providing a general locality plan for all recognised material opportunities. Figure 6 provides a closer locality plan view for the two quarry sites.

Figure 5 Quarry Sites Q1 and Q2 Locations

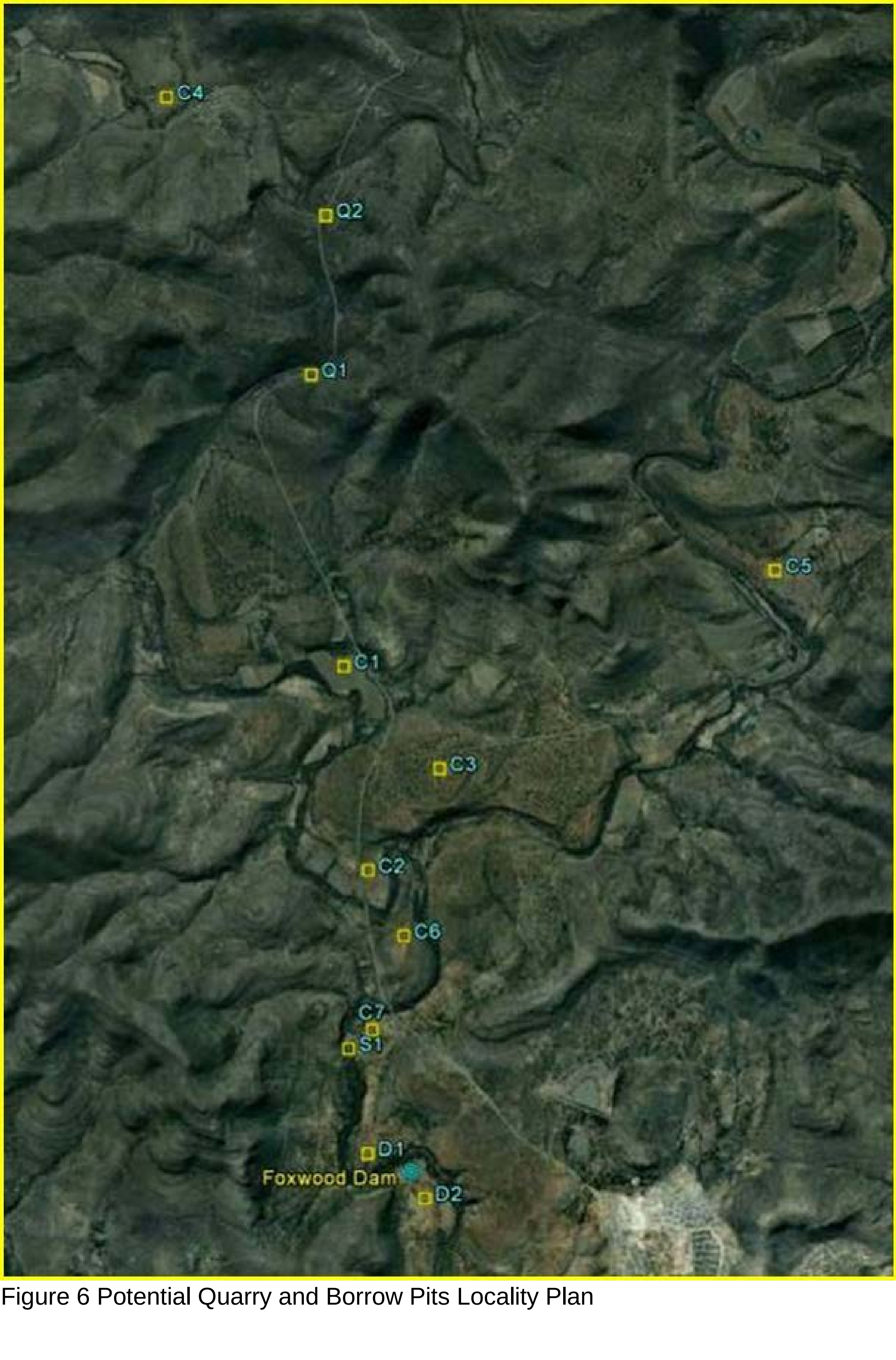


Figure 6 Potential Quarry and Borrow Pits Locality Plan

Potential quarry site Q1 is located alongside and east of the Adelaide/ Tarkastad road where unweathered, massive, domed dolerite outcrops at surface. Figure 6 below provides a photograph of the site where quarrying alongside the length of road in the narrow cutting between road and river could also improve the road alignment, and with it, safety of road users. It is therefore an attractive prospect.

Potential Quarry Q2 comprises similar domed, massive dolerite at surface with location on the same dolerite sill. It has a gentler slope thereby requiring a lower cutface but is further from the dam site with greater haulage distance. Both sites have telephone/ electricity poles requiring relocation.

Figure 8 Quarry Q1
S 32° 36’ 48.60” / E 26° 15’

Figure 7 Quarry Q2
S 32° 36’ 04.79” / E 26° 15’ 48.53”

Quarry Q1 appears to be the better option. The preferred site will require as minimum 3 boreholes - preferably 5 - to determine available reserves; allow removal of samples for strength and durability testing, and most importantly: the drilling of boreholes is a mandatory requirement for permitting/ licensing of the quarry as required by the Department of Minerals & Energy.

6.3 Earthdam Core Materials

6.3.1 Introduction

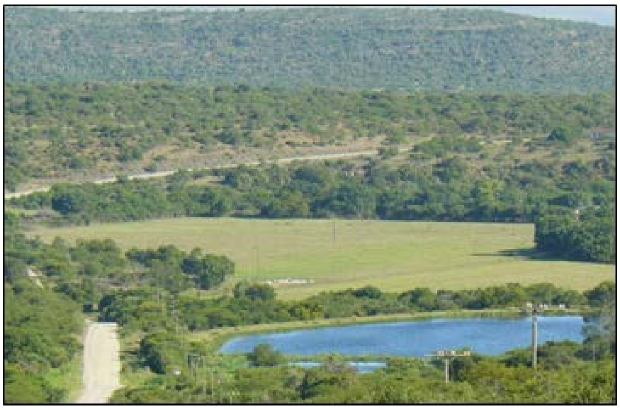
Prospecting has been undertaken for material that will be required for the dam's clay core. An earlier report of September 1992 titled “Water Supply: Proposed Foxwood Dam” by Ninham Shand Consulting Engineers reflects on reddish-brown clayey silt materials encountered in trial hole excavations for a De Beersdrift dam site. The suggestion by Ninham Shand is that this material could be suitable for an earth embankment dam. The location of this dam is not stipulated but is presumably upstream of the Foxwood Dam site since a red residual/ colluvial soil is generally associated with a dolerite parentage and dolerite outcrops are located upstream? Dolerite, owing to its igneous origin, can have substantial clay quantities

The sedimentary rock derived soils nearer Foxwood Dam are more siliceous and arenaceous and prospecting for core materials has therefore been concentrated upstream of the dam where investigations reveal - in all but one prospective borrow pit: namely C1 - a reddish brown slightly clayey sandy silt which could possibly provide core material. All the potential 'core' sites have been denoted the letter 'C' as indicated in Figure 7. These are described in more detail in the sections following.

6.3.2 Borrow Pit C1

Borrow Pit C1, as indicated in the Google Earth image Figure 10 Material comprises of dark grey, possibly slightly clayey silts and sands and gravels. This site does have some potential but detracting from it is location within pristine cultivated agricultural lands alongside the Koonap

River and the fact that alluvial materials highly variable as a result of their river born depositional history.



The remaining potential 'core' material borrow pits all comprise a similar material, namely a colluvial reddish/ brown slightly clayey silt with varying quantities of sand or gravel. This material does appear to have some plasticity - as suggested in the field via thin surface shrinkage cracks; red colouration, and texture - but this will require laboratory testing to determine whether or not it ascribes to the requirements of a dam core material. Individual sites have therefore not been individually described, but have been individually demarcated via the generalised lay-out of Figure 7, and via individual locality plans and photographs as indicated in the sections following.

6.3.3 Borrow Pit C2

Red brown slightly clayey silt on east side of road. The nearby dam east of the road has been constructed of this material.

Figure 10 Borrow Pit C2
S 32° 39’ 08.25” / E 26° 16’ 01.36”

6.3.4 Borrow Pit C3

Borrow Pit C3 comprises of the same ubiquitous red brown slightly clayey silt but in this case is located alongside an easterly orientated road leading off the main Tarkastad / Adelaide Road.


Figure 11: Borrow Pit C3 : S 32° 38’ 39.56” / E 26° 16’ 25.47”

6.3.5 Borrow Pit C4

Borrow Pit C4 consists of red brown slightly clayey silt as located in cultivated lands far to the north along a westward orientated branch road.


Figure 12: Borrow Pit C4 : S 32° 35’ 31.93” / E 26° 14’ 55.90”

6.3.6 Borrow Pit C5

Borrow Pit C5 - red brown slightly clayey silt - has material borrow opportunities either side of the local district roads. It is a fairly long distance from Foxwood dam.

Figure 13: Borrow Pit C5 : S 32° 37’ 43.69” /E 26° 18’ 17.40”

6.3.7 Borrow Pit C6

Borrow Pit C6 also comprises red brown slightly clayey silt as located east of the Tarkastad/ Adelaide road, and importantly, in close proximity to Foxwood dam site.

Figure 14: Borrow Pit C6 : S 32° 39’ 26.59” / E 26° 16’ 13.51”

6.3.8 Borrow Pit C7

Borrow Pit C7 is the closest 'core' borrow location to Foxwood dam site. Its location is immediately upstream of the dam and west of the main road.

Also indicated in the locality plan, Figure 16, is borrow area S1 which is an old 'sand' borrow pit source as discussed in 8.5 Homogenous Dam Materials.

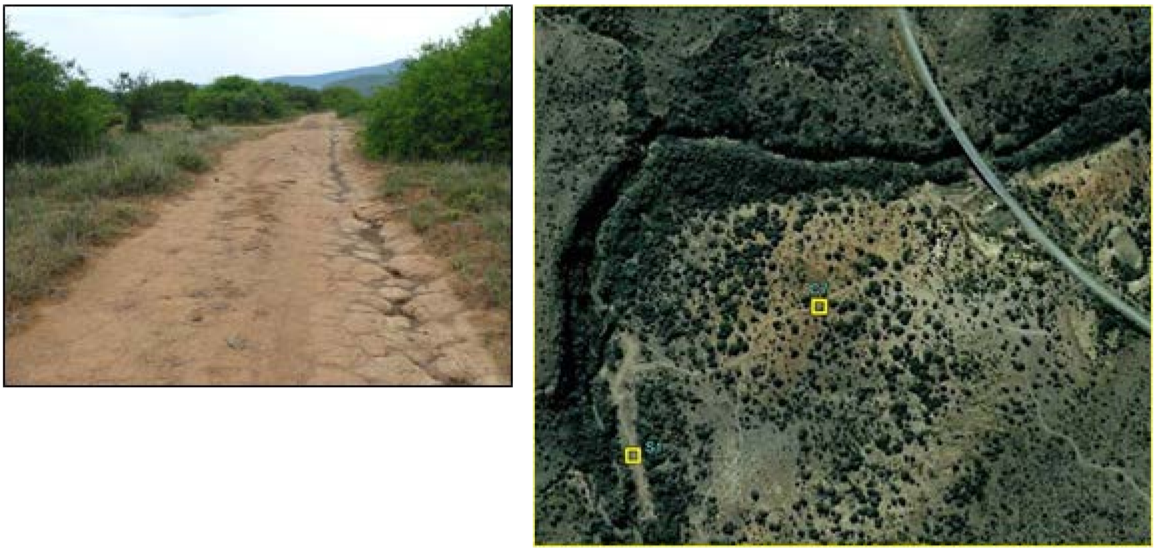


Figure 15: Borrow Pit C7 : S 32° 39’ 53.18” / E 26° 16’ 02.71”

6.4 Earthdam Shell Materials

Extensive alluvial deposits occur both immediately upstream and downstream of the dam site. Care with respect to both hydraulic gradient and proximity to the centreline will need to be taken into account but is an item that can be accommodated. Earlier 1962 drilling indicates that these deposits are quite deep as described, suggesting possibly sufficient quantities for construction for the dam shells.

More permeable materials are required for the upstream and downstream shells where the arenaceous/ siliceous alluvial and colluvial soils available could meet material design requirements for the earthdam. Extensive borrow investigations and testing will be required to determine this. One advantage of having large dam shell reserves is that if core materials prove unsuitable then consideration could be given to a homogenous dam wall structure.

Additionally, materials upstream of the bridge over the Koonap River and east of the Tarkastad/ Adelaide Road, but still within the reservoir basin, could also be considered.

Figure 16 Borrow Pits D1 and D2

Figure 17
Borrow Pit D1
S 32° 40’ 28.01” / E 26° 16’ 01.19”

Borrow Pit D2
S 32° 40’ 40.59” / E 26° 16’ 20.33”

Figure 18 Potential additional dam shell material upstream of the site on the left flank above the Koonap River Bridge

6.5 Homogenous Dam Materials

The option of an homogenous earthdam has been briefly alluded to previously in Section 5.4. Fortunately there appear to be quite extensive unconsolidated material opportunities within the dam basin which, although still requiring testing for both quality and quantity, could prove suited for homogenous dam construction. Especially so given the expected arenaceous nature of these materials.

6.6 Roller Compacted Concrete (RCC) Dam Materials

An RCC Dam could also be considered given the extensive potentially excellent quality hard rock dolerite available nearby. Either dolerite quarry sites, or both of them, could be expanded to provide the necessary aggregate quantities. This will though require extensive additional rotary cored drilling and laboratory testing to ensure both quality and available reserves.

6.7 Concrete Faced Rockfill Dam (CFRD) Materials

A CFRD would attract even greater hard rock quantities but could, as for the RCC option, be considered given the extensive reserves of hard rock dolerite available.

6.8 Fine Aggregate

Natural occurring river sand sources are in short supply along the relatively immature Koonap River system. There is an old 'sand' borrow pit alongside the river at position S1 (see Figure 19) where material has been borrowed presumably for local building purposes: possibly plaster 'sand'. The material though is a too fine grained silt, with an unacceptably high organic content, to be of use as a fine grained aggregate source for the dam project. It is suggested rather that fine grained aggregate be crushed from rock sourced at the proposed dolerite quarry.

Figure 19: Very Fine Grained Sand/Silt Borrow Pit and “Sand” Borrow Pit
S 32° 39’ 58.41” / E 26° 15’ 54.96”

6.9 Materials Conclusion

The overall conclusion reached regarding material sources is that dam materials do appear available but will require further field and laboratory testing to confirm quality and therefore potential use in dam construction.

7 RECOMMENDATIONS FOR DETAILED INVESTIGATIONS

7.1 General Geotechnical Investigation

General geotechnical investigations should comprise the following:

- Geophysical investigations along the dam centreline and in certain of the borrow pits
- Drilling of boreholes with core acquisition for testing to determine rock quality and allow water pressure permeability testing
- Excavation of trial holes to determine depth and engineering characteristics of unconsolidated material for the dam and borrow pits
- Seismic risk evaluation for potential for dam induced seismicity, and analysis of the likelihood - or otherwise - of local seismic activity.

7.2 Dam Centreline and Spillway Investigations

It is recommended that detailed geotechnical investigations for the dam centreline and spillway should comprise:

- Excavation of 15X trial holes along the dam centreline; within the structure footprint, and in the spillway area. This will require hiring of an excavator plus conveyance to the site using a lowbed. An excavator would be required since it will allow deeper subsurface penetration and simulate the size of machine used during construction of the dam
- Terreco Geotechnical cc will undertake soil profiling; removal of samples for laboratory testing; supervise excavations; interpret laboratory data; undertake analyses and report on the findings
- Seismic traverses should be undertaken as a relevant but inexpensive method of determining depth to rockhead. It is recommended 4 traverses be undertaken along the centreline; another 3 in borrow pits upstream and downstream of the dam site, and 2 along the spillway alignment. This work will be sub-contracted to a firm specialising in geophysics and paid for by the client

- Laboratory testing should comprise:

  - 20X Grading; Atterberg Limits; and Proctor Density of centreline soils
  - 3X Permeability tests on samples compacted to 85% Proctor Density (to simulate in situ density)
  - 5X Shear Box Strength testing of soils to provide shear strength characteristics to enable the design engineer to undertake dam slope stability assessments
  - 3X each of Double Hydrometer; Pin Hole and Crumb tests for dispersion.

7.3 Drilling Investigations

Rotary drilling of N-size boreholes will be required to establish depth of unconsolidated soils; rockhead depths; removal of core samples for laboratory testing; and for Lugeon water pressure permeability testing. It is recommended drilling be undertaken as follows:

- One borehole at both abutments and three along the centreline to augment previous drilling from 1962. Boreholes should be drilled to an equivalent depth to the dam embankment's height, and definitely to below the sandstone/ mudstone contact on both flanks. Two if the three river section boreholes should be inclined 45° to intersect steeply dipping joints to test permeability along these sub-vertical joints
- Another 3 boreholes should be allowed for to determine any anomalies picked up by the geophysics, e.g. any perceived deeper palaeo channels, etc.
- Lugeon water pressure permeability tests should be undertaken on the centreline boreholes using down-the-hole testing with one packer at 5m intervals: but within the rock formations only. Water rest levels are to be recorded for each borehole
- 3X Boreholes along the preferred spillway alignment. All boreholes to be drilled to below the sandstone/ mudstone contact should the side-channel on the left flank be the preferred structure, or at least 4m into the underlying mudstone should a central spillway be chosen
- 3X Boreholes at the preferred quarry site. These should be drilled a minimum of 15m each, one of which should be inclined at 45° to intersect the conjugate joint set

- Drilling tender and supervision will require:

  - Compilation of a drilling contract document
  - Distribution of tender documents to drilling companies
  - Compilation of an adjudication tender report and recommendations for drilling contractor appointment
  - Setting out of boreholes and logging of borehole core according to SAIEG standards
  - Determination of Lugeon permeability testing together with estimates of water pressure requirements; supervision and analysis of results
  - Drilling supervision
  - The Client will be directly responsible for appointment and payment of the successful drilling company. There will be no constant on site drilling supervision. This in order to minimise costs and because a check on the drilling can be accomplished remotely via phone calls. ‘Supervision’ will therefore consist only of setting out boreholes and logging of these on completion of the drilling with one interim field site supervision visit.

- Remove of rock core samples for laboratory testing of strength and rock substance durability. These tests will comprise:

  - Strength:
    2X 10% FACT - Quarry
    2X ACV - Quarry
    10X Point Load Strength Index (PLSI) - Dam & Spillway
    6X Unconfined Compressive Strength (UCS) - Dam & Spillway

  - Durability:
    10X Ethylene glycol submersion - Quarry & Dam
    5X Slake durability - Quarry & Dam
    1X Petrographic analysis - Quarry
    1X XRD to determine presence or absence of smectite materials - Quarry

7.4 Materials Investigations

Detailed materials investigations will be undertaken for an earthdam.

7.4.1 Core Material Investigations

It is recommended, for clay core borrow pits, that investigations begin with two trial holes in each one of the 'core' borrow pits nearest the dam, namely C2, C3, C5, C6 & C7. C5 is distant but included because it seems to be a good prospect. C1 and C4 should for the time being be excluded: C1 has good agriculture prospects as described, and C4 is very distant. They could again be considered should the others prove unsatisfactory. It is recommended 1X Grading and Atterberg Limit test be undertaken for each of the 5 borrow pits, viz 5 in total.

Thereafter 12 trial holes should be excavated on the preferred core borrow pit with laboratory testing as follows:

- 15X Grading; Atterberg Limit & Hydrometer tests
- 15X Proctor density tests
- 3X Falling head permeability tests
- 3X of each of Double Hydrometer; Pin Hole and Crumb test for dispersion
- 3X Triaxial tests on materials compacted to 95% Proctor density at OMC

7.4.2 Dam Shell Material Investigations

25X Excavator excavated trial holes in shell borrow areas upstream of the dam site (Borrow Pit D1 and areas further upstream above the Koonap River road bridge).

15X Excavator excavated trial holes in D2 borrow pit immediately downstream of the dam centerline.

Laboratory testing:

- 20X Grading; Atterberg Limit & Hydrometer tests
- 20X Proctor density tests
- 3X Falling head permeability tests
- 3X of each of Double Hydrometer; Pin Hole and Crumb test for dispersion
- 3X Triaxial tests on materials compacted to 95% Proctor density at OMC

Every effort will be made during the investigation to meet the dam project engineer's programme.