Feasibility Study for Foxwood Dam (WP10580)

Main Report

Final

DWS Report Number: **P WMA 15/Q92/00/2113/6**

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STUDY REPORTS

The Feasibility Study Main Report provides a record of the entire study. This report forms one of the suite of reports that make-up the Feasibility Study for Foxwood Dam. The full list of reports is provided below:

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**
Feasibility Study for Foxwood Dam: Environmental Screening	P WMA 15/Q92/00/2113/3
Feasibility Study for Foxwood Dam: Geotechnical Reconnaissance	P WMA 15/Q92/00/2113/4
Feasibility Study for Foxwood Dam: Alternative Water Supply Options	P WMA 15/Q92/00/2113/5
Feasibility Study for Foxwood Dam: Feasibility Study Main Report	**P WMA 15/Q92/00/2113/6**
Feasibility Study for Foxwood Dam: Koonap River Hydrology	P WMA 15/Q92/00/2113/7
Feasibility Study for Foxwood Dam: Water Requirements	P WMA 15/Q92/00/2113/8
Feasibility Study for Foxwood Dam: Agro-Economic Study Report	P WMA 15/Q92/00/2113/9
Feasibility Study for Foxwood Dam: Water Quality	P WMA 15/Q92/00/2113/10
Feasibility Study for Foxwood Dam: Geotechnical Investigation	P WMA 15/Q92/00/2113/11
Feasibility Study for Foxwood Dam: Dam Feasibility Design	P WMA 15/Q92/00/2113/12
Feasibility Study for Foxwood Dam: Project Feasibility Costing	P WMA 15/Q92/00/2113/13
Feasibility Study for Foxwood Dam: Economic Impact Assessment	P WMA 15/Q92/00/2113/14
Feasibility Study for Foxwood Dam: Record of Implementation Decisions	P WMA 15/Q92/00/2113/15
Feasibility Study for Foxwood Dam: Book of Maps	P WMA 15/Q92/00/2113/16
Feasibility Study for Foxwood Dam: Public Participation (Queries & Responses Report)	P WMA 15/Q92/00/2113/17

REPORT REFERENCE

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Feasibility Study Main Report, P WMA 15/Q92/00/2113/6

Note on Departmental name change

In 2014, the Department of Water Affairs (DWA) changed its name to the Department of Water and Sanitation (DWS). This occurred during the course of this study and as a result some reporting which was commenced and/or approved prior to the name change may still refer to DWA. References herein to DWA and DWS should be considered one and the same.

EXECUTIVE SUMMARY

The Department of Water and Sanitation has investigated the feasibility of developing a multi-purpose dam on the Koonap River near Adelaide in the Eastern Cape. The proposed dam site is known as Foxwood and was identified for the development of the water resources of the Koonap River as far back as the 1960’s. The project is again being considered for implementation as a strategic initiative to mobilize the water resources in the area as a stimulus for socio-economic development in this rural, economically depressed region. This initiative would support the objectives of the National Development Plan (NDP) and is consistent with the National Water Resource Strategy 2 (NWRS2).

The feasibility of a major dam on the Koonap River at the Foxwood site for the purpose of supplying water for domestic use and for irrigation has been investigated since the early 1960’s. Previous investigations have taken place to assess the opportunities to augment water supply to Adelaide in the past with particular attention being paid to the option of building a dam at the Foxwood site. The records of these investigations, by the Koonap River Irrigation Board (KRIB), officials of the then Department of Agriculture and the Department of Water Affairs (DWA) and by consulting engineers Ninham Shand, provide valuable information regarding the development proposals (DWAF, 1988; Ninham Shand, 1992; Ninham Shand, 1993). The motivation for the construction of a dam, initially, appears to have been for improved resilience of domestic supply to the town due to acute water shortages suffered historically.

The perceived need for a major dam at the Foxwood site was again raised by the Nxuba Local Municipality at the Eastern Cape Water Indaba in 2009. The then Department of Water Affairs undertook to carry out a detailed feasibility study.

The Feasibility study has covered all technical aspects such as:

- the reasonable future requirements for water by the various user sectors which constitute the ‘need’ for the dam
- the availability of water in the Koonap River taking into account the Environmental Water Requirements (EWR)
- the technical details of constructing a dam at Foxwood and transmitting the water to the intended beneficiaries
- the capital cost of developing the project, including the cost of the land required and the effective management
- expected operating and maintenance costs,
- the economic and social benefits of developing this water resource,
- institutional arrangements for the construction, owning and operating the physical infrastructure,
- compliance with all legal requirements,
- sustainable funding arrangements and the associated cost recovery from water users

1. WATER REQUIREMENTS AND RESOURCES

The main source of domestic water supply to Adelaide is from an abstraction weir to the north of Adelaide which supplies water to Adelaide Dam via a gravity canal. Supplementary supplies come from a municipal borehole with emergency back-up provided by a transfer pipeline from Cookhouse on the Fish River. Adelaide is a town of approximately 25 000 people, with a currently forecast growth rate of -0,9%. Domestic water requriements have conservatively been forecast at a growth rate of 0% giving an annual requirements of approxaimtely 0,78 million m^3/a.

It is apparent the water resources of the towns of Adelaide, Bedford and Fort Beaufort are all sufficient for current domestic requirements and for most future domestic requirements within a

30 year planning horizon. **It is clear that the existing water resources infrastructure are generally in need of improved operation and maintenance and that an increased focus on water conservation and demand management is essential**. This is the responsibility of Amathole District Municipality as the Water Service Provider (WSA) and it is understood that various projects and programmers are underway.

Nevertheless, it is also apparent that there is real potential for the flows of the Koonap River to be regulated in such a way that improved assurance of yield can be achieved that would provide long term assurance of supply for the local towns but that would also, importantly, provide a stimulus for socio-economic development through the growth in the agricultural sector in the Koonap River valley; growth that has been limited historically by, primarily, uncertainty in water supply.

A review was carried out of the potential for development of the Koonap River resource at the Foxwood Dam site to regulate supply to the Great Fish River system. However it was noted that the Koonap River confluence with the Great Fish River is downstream of the main water user abstraction points on the Great Fish River and that existing water allocations within the Great Fish \River are currently not fully utilised. Furthermore, the Foxwood Dam site lies approximately 150 km upstream from the confluence and the expected water losses and quality deterioration over this length would limit the beneficial impact the Koonap River flow would have on the Great Fish System.

Based on this opportunity for agricultural sector growth in the Koonap River valley, and given that there is little apparent benefit to developing the Foxwood Dam to provide a regulated contribution to the great Fish River, this project has focused on the potential for Foxwood Dam as a strategic initiative to mobilize the water resources in the area as a stimulus for socio-economic development in this rural, economically depressed region.

2. KOONAP RIVER HYDROLOGY

The area of the Foxwood Dam catchment is 1 091 km² which is 33% of the total area of the Koonap River catchment (3 334 km²). Important tributaries of the Koonap River include the Braambospruit, Mankazana, Waterkloof and Enyara Rivers. The Foxwood Dam and Lower Koonap River catchments have similar land use in that both catchments are rural in nature with agriculture the dominant activity.

The naturalized stream flows for all catchments were generated and compared with previous studies. The results of the comparison show similar unit runoffs across studies. The naturalized MAR at the proposed Foxwood Dam site is **47,61 million m³/a**.

Water uses within the catchment were assessed and associated streamflow reduction calculated. In terms of the River Reserve Study, the catchment is from Foxwood Dam to the Fish River confluence. The intermediate level Ecological Water Requirements (EWR) study identified the Recommended Ecological Category (REC) as a C-category at both EWR sites, which is the same as the Present Ecological State (PES). The operating rule recommended by the Reserve specialist is that the low flow EWR assurance rule should be implemented at these sites and that the high flow EWRs should be met by spills from Foxwood Dam and that the low flow EWRs can be met by inflows from the incremental catchments downstream of Foxwood Dam. Provision for the EWR requires a discharge of up to 6 m³/s.

In terms of the yield analysis a life-span of 50 years has been assumed for Foxwood Dam and dead storage of 6.11 million m³ for all storage capacities. The estimated average rate of sedimentation in the Upper Koonap catchments is 185 tons\km²\annum based on the Rooseboom methodology (Rooseboom, et al, 1992).

Yield model configuration

The Water Resources Yield Model has been configured to assess the historic, long-term and short-term capability of the Foxwood Dam system for a range of live storage capacities ranging from 23,8 million m^3 to 95,2 million m^3. These live capacities are equivalent to nMAR's (naturalized Mean Annual Runoff) of 0,5 nMAR to 2 nMAR. Analyses were undertaken based on a monthly time-step and at-present day (2011/12) development levels.

Three water requirements scenarios were addressed water resources study (DWS 2015a):

- Scenario 1: Best estimate of present day (2012/13) development levels with Foxwood Dam.
- Scenario 2: Best estimate of present day (2012/13) development levels with Foxwood Dam and **Total Flow EWR** assurance rule implemented.
- Scenario 3: Best estimate of present day (2012/13) development levels with Foxwood Dam and **Low Flow EWR** assurance rule implemented.

The results of the yield analyses (see Figure 1) and the Reserve study indicate that Scenario 3 should be used to determine the final storage capacity of Foxwood Dam. This is primarily because Scenario 3 allows for Total Flow EWR to be provided through natural spilling of the dam. Further to this, the live storage capacity of Foxwood Dam is in the range of 29.9 million m^3 to 53.7 million m^3 with 1:20 yields of 9.7 million m^3/a to 19.1 million m^3/a as it is only within this range that the critical period indicates that natural spilling will occur sufficiently regularly. Scenario 1 was not considered as it did not account for the EWR.

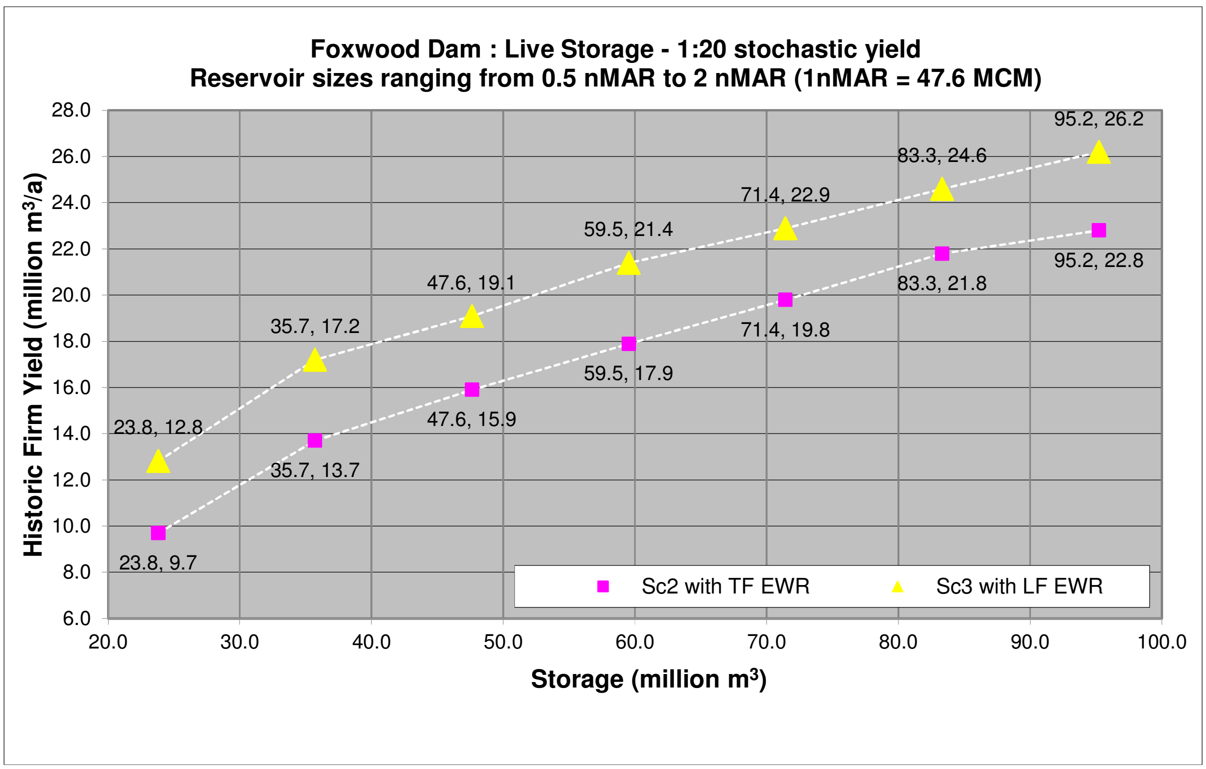

Figure 1: 1:20 year stochastic yield for low flows and total flows EWR requirements

Water Quality

Water from the Koonap River is currently being used both for domestic purposes and irrigation. A review of the Adelaide water treatment works was carried out and numerous shortcomings identified however, the water quality generated appears to be of an acceptable standard. There are limited records of turbidity and suspended solids for the Koonap River and these will need to be generated to allow for detailed consideration of possible future silt loading of the dam.

3. AGRO-ECONOMIC POTENTIAL

Given the order of magnitude difference between the available yield from a dam at the Foxwood site and the current water requirements of Adelaide and surrounding towns, it is clear that development of Foxwood Dam would make available additional water resource at an appropriate level of assurance which could be mobilized, through establishment of an irrigation scheme, to stimulate socio-economic development. Previous studies have confirmed that the irregularity of the Koonap River water resource has been a key factor in the limitation of agriculture development in the Koonap River Valley.

Once allowance is made for high and low flow Reserve requirements as well as existing abstraction rights for farmers downstream of the proposed Foxwood Dam site, the proposed 1 MAR dam would have available yield of approximately 12,5 million m^3/a. An irrigation scheme of 1 250 ha of high value tree crops has been proposed based on a water consumption of 10 000 $m^3/ha/a$ allowing for approximately 20% losses from the dam wall to the field edge.

The locality and extent of irrigable land that can be supplied from releases from the proposed Foxwood Dam has been carried out based on aerial survey, soil depth and type data, minimum slope criteria and verified through consultation with current commercial farmers. Sufficient land for irrigation development has been identified downstream of the proposed Foxwood Dam site, however it is estimated that up to approximately 13 000 ha would need to be purchased to enable 1 250 ha of contiguous land to be combined from separate farms currently held in private ownership. The plan in Figure 2 illustrates the locations of preferred irrigable land downstream of the Foxwood Dam site.

The land on which such a scheme could be developed along the Koonap River is at present owned by individuals who are themselves successful farmers. This land would have to be acquired by the State or the current land owners could become partners in the envisaged development, subject to mutually acceptable contractual arrangements.

Proposed development - farm plot sizes and crop type

Financial models for three high value tree crops (peaches, lemons and macadamias) were developed for three different farming plot sizes (1 ha, 20 ha, 50 ha). The 20 ha scheme was selected for further evaluation within the Economic Impact Assessment of the Foxwood Dam project (DWS, 2015g) to review the potential socio-economic impact that could be expected to result from the Irrigation Scheme.

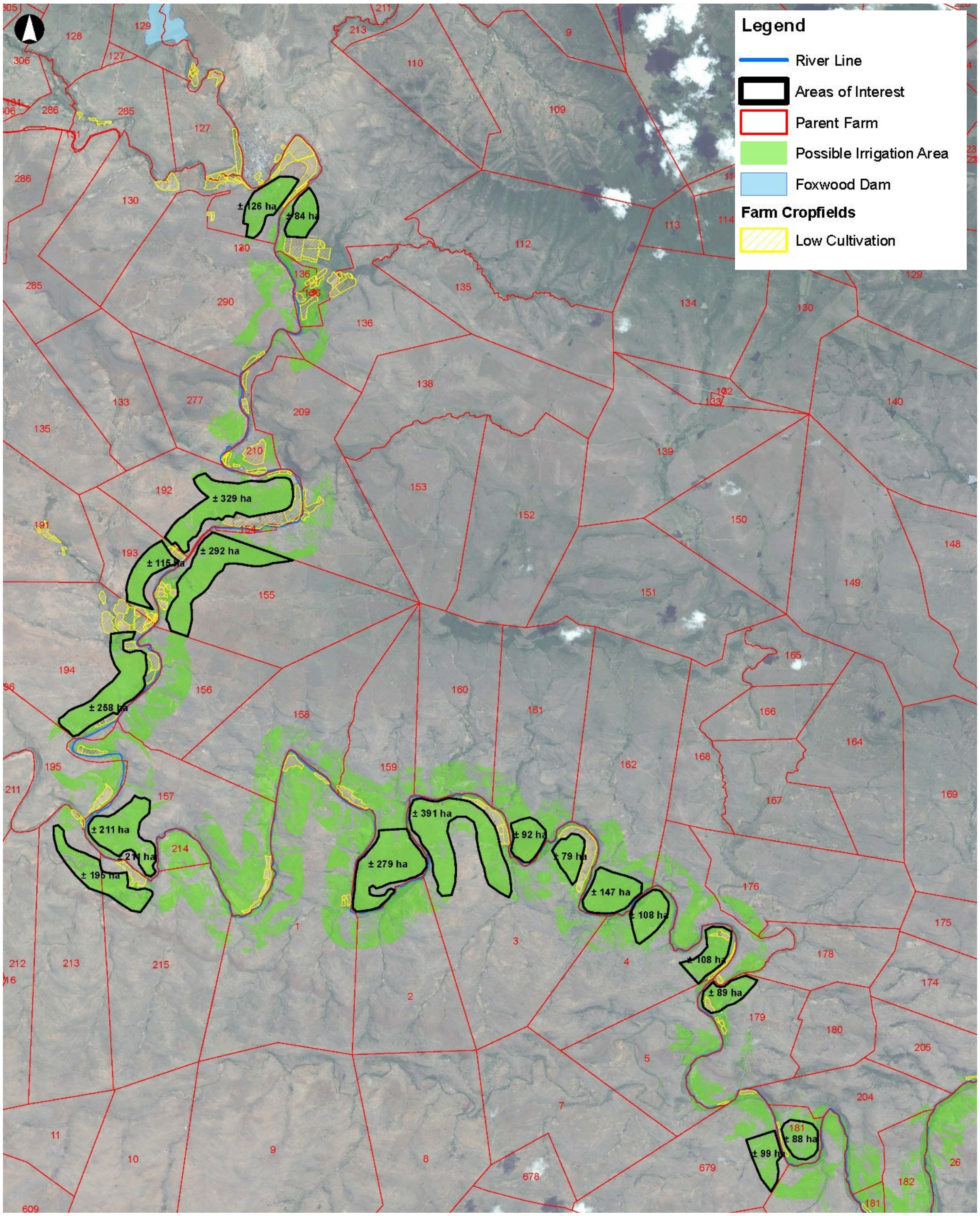

Figure 2: Irrigable soils downstream of the proposed Foxwood Dam site

Financial model - funding investment required

The peak funding is the total cumulative investment required to fund the capital (eg land purchase, farm infrastructure establishment, training and mentoring during establishment) and operational (plant replacement, fuel, electricity, salaries etc) costs of the farm, less revenue earned, up until the time when the farm breaks even and starts to make a profit. For the 20 ha scheme, averaged across all crops, **peak funding of R 437 million** is estimated to be required to develop the

Irrigation Scheme up until it reaches financial sustainability. This investment – expected to be from Government – is estimated to be required over approximately **7 years** from the start of the development of the Irrigation Scheme. Based on the projected cashflow for the different crops, the expected time period for repayment of the peak funding investment has been projected as approximately **5 years**, or 12 years from the start of the development of the Irrigation Scheme. Funding cashflow is illustrated in Figure 3 below.

Key Risks – Institutional Arrangements

The principal risks associated with the development of the Government Irrigation Scheme relate to the dependency of the success of the scheme on the availability of leadership and management from an appropriately mandated and resourced Implementing Agent.

After consultations in Stakeholder Meetings, in the Project Steering Committee and with individual government departments it is concluded that the Eastern Cape Rural Development Agency (ECRDA) is well placed to fulfil the role of Implementing Agent. The availability of the Agency to undertake this responsibility has not been canvassed and the possibility of this happening will be dependent on the commitment by government of the necessary resources, financial and otherwise, for a period of 10 years or until the project is self-sustaining.

NB Consultation with the national Department of Agriculture, Forestry and Fisheries as well as the provincial department of Rural Development and Agrarian Reform has taken place throughout this study. However it is imperative that a thorough and formal feasibility study is carried out for the proposed Irrigation Scheme. DWS has requested that such a study is carried out by DAFF.

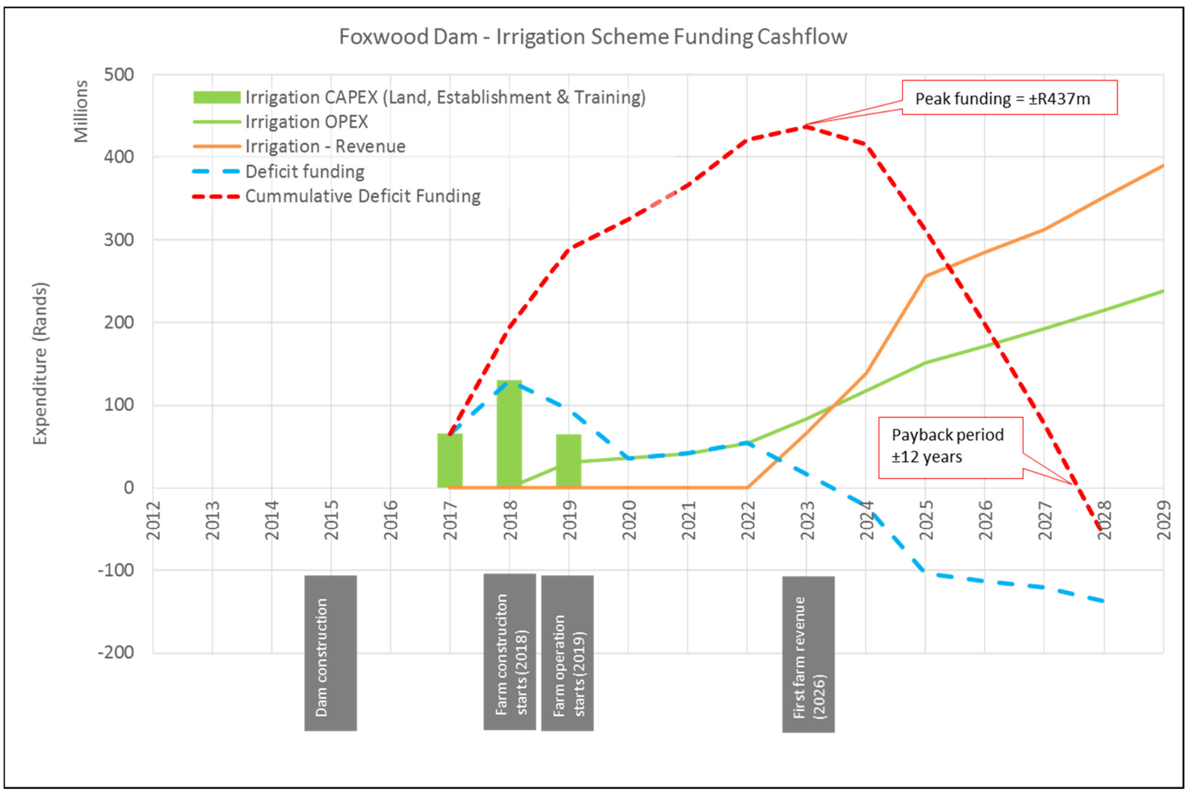

Figure 3: Foxwood Dam Irrigation Scheme Funding / Revenue Cashflow

4. DAM DESIGN

Geology

The geotechnical investigation took cognisance of the findings of a geological report 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" (Marais, 1962). The 1962 investigations include borehole drilling undertaken for the centreline and a proposed spillway on the left flank.

The results of the investigation indicate that it is possible to construct a composite earthfill and concrete gravity dam provided that cognizance is taken of the following certain issues:

- The thick mantle of transported soil on the right hand flank of between 5 and 20 metres implies extensive excavation and backfill operation may be required, with the use of grouting
- Sufficient material suitable for the construction of an embankment has been identified within borrow pits and under the dam centerline. However, it should be noted that there is a wide variability in quality and onsite selection of materials will be necessary during construction with particular attention to dispersion.
- Properly designed and constructed filters adjacent to potentially dispersive material in the embankment is essential to prevent possible piping due to seepage.
- A hard rock source for sand drain filters, concrete aggregate, rip-rap and fine aggregate is available at potential quarry site Q1, some 5 km north of the dam location.
- No natural clean sand was found on site, requiring crushing of dolerite to produce fine aggregate and filter requirements.
- Relatively thin cover of alluvial deposits on the left hand flank, and rock jointing presents a risk of excessive seepage. Grouting of the foundations and abutment of the concrete gravity sections will be required.

Recommended Dam Size and Type

The preferred dam size at the Foxwood site was determined following consultation with DWS. The size of the dam was debated due to the main motivation for the dam being determined to be the potential for socio-economic development in the region which is subject to the establishment of an irrigation scheme. The types of dam construction considered as viable options for analysis were:

1. Zoned Earthfill with a left bank side channel spillway
2. Central Core Rockfill with a left bank side channel spillway
3. Concrete Gravity stepped spillway to Riverbed
4. Composite Concrete Gravity stepped spillway to Riverbed and Earth Embankment

The unit reference value analysis was based on common bills of quantities *(at the time of the options analysis and excluding the total ancillary project values referred to in the final project estimated URV for the selected dam)* and current estimated rates. Refer Figure 4 below. The main differentiator for the various options was the deep left bank spillway cut for the earthfill and rockfill options.

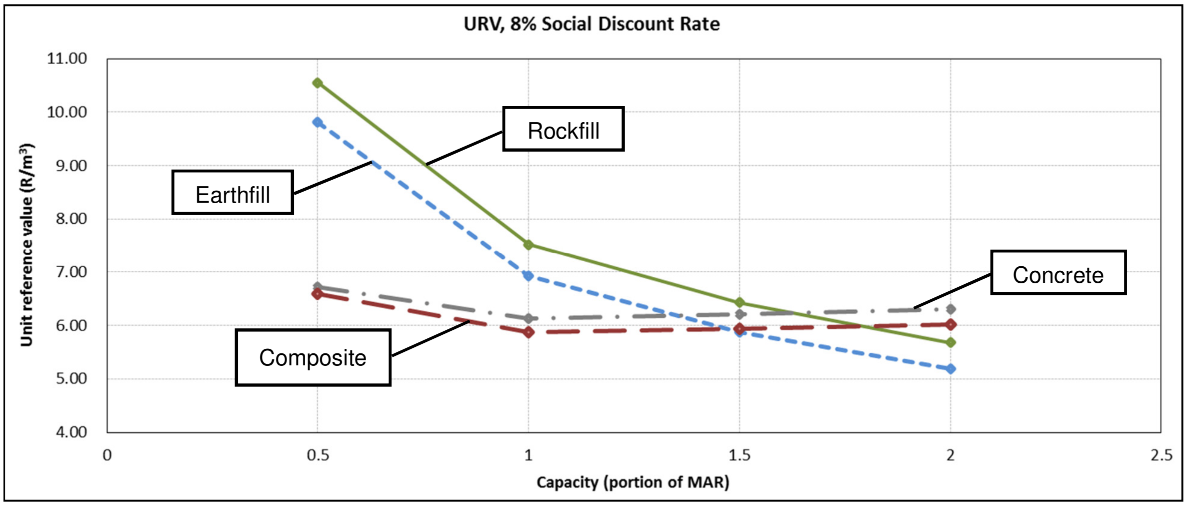

Figure 4: URV Dam Selection

In consultation with DWS, a **1 MAR dam** was determined as the preferred size for developed at the Foxwood Dam site for the following reasons:

- The analysis indicates that the available yields from a new dam are approximately equivalent for 1 MAR storage and 1,5 MAR storage. This is due to releases from dams with larger storage capacities being needed to supply high flow EWRs (1 MAR yield of 19,1 million m^3/a vs 1,5 MAR yield of 19,8 million m^3/a.)
- Providing for the Reserve from natural spillages reduces opportunity for human error. Impounding the Koonap River with a larger dam would impact on the natural ecological system of the river valley.
- It is very unlikely that there will be sufficient domestic or industrial water demand in a regional context to make full use of the yield of dam larger than 1MAR.
- Providing for the development of a 1 250 ha irrigation scheme on irrigable land located on various properties, now in successful production by established commercial farmers, will be a very significant development and will provide the basis for other similar schemes.

A 1 MAR Composite Gravity Dam with Earth Embankment on the right flank is recommended for development at the Foxwood Dam site with the following motivation:

- Lowest URV among the four options for a 1 MAR dam.
- The spillway energy dissipation is more complicated for a side-channel spillway option, with significant changes of direction and the discharge of water into the river.

Spillway design

The dam is categorized as Category III, and as such the basis for the selection of the dam freeboard is the greater of:

- The Recommended Design Flood (RDF) un-routed over the spillway with a dry freeboard contribution or
- The Safety Evaluation Discharge (SED) is the Probable Maximum Flood (PMF) routed with no dry freeboard.

For the purpose of feasibility evaluation this study considered a 250 m spillway with a discharge coefficient of 2,0. The optimisation of the spillway should be carried out during the detailed design stage. In discussion with DWS it was recommended that the spillway design is optimized at detailed design through review of the freeboard requirement with the SEF Kovacks + Δ method.

This study has selected the PMF routed flood for the selection of spillway dimensions:

- Spillway length 250 m
- SEF discharge 5 218 m^3/s
- SEF freeboard requirement 5,5 m

The spillway comprises three distinct elements: the spillway crest, the channel and the stilling basin. The salient design points are highlighted below and an illustration of the wall spillway section is given in Figure 5 below.

Ogee Spillway Crest

The spillway is 267 m long allowing for 21 bridge piers, giving an effective spillway width of 250 m. The bridge was included to provide access to the right bank crest however, following discussion with DWS this will require review during detailed design as it is likely that the bridge will be excluded from the design due to maintenance concerns.

An ogee weir shape with a coefficient of weir discharge of 2,0 has been selected whilst routing flood flows. For the purpose of this feasibility study, the ogee shape is designed to the PMF head of 5,4 m.

Downstream face

Flow over the ogee spillway crest is directed to the stilling basin via a stepped downstream face. Flow energy will be dissipated by the steps in the spillway. The downstream face is sloped at 0,6H:1V (or 59 degrees). This is the maximum steepness determined from the stability analysis. This makes the step length 720 mm. Using the method in Boes (Boes 2012), a side wall height of 2,4 m is recommended to contain the aerated PMF flow. Containing spillway flow is particularly important at the right abutment to protect the embankment dam. This recommended height should be reassessed if aerators are adopted later in the design.

Stilling basin

The toe of the concrete gravity dam has a 15 m long stilling basin block which is stepped to follow the ground level. The return is protected by a cascade system of graded large rocks and rip rap underlain by a crusher graded filter. During the design process the Department reviewed this aspect of the design and considered that the three tier basin was not sustainable and rather than rely on a cascading bolster system to return the flow to the natural river line, excavate out ‘fan’ like return. This will require further geotechnical investigation to determine more precisely the hard formation topography in the area to be considered and the optimal unitary level of the basin.

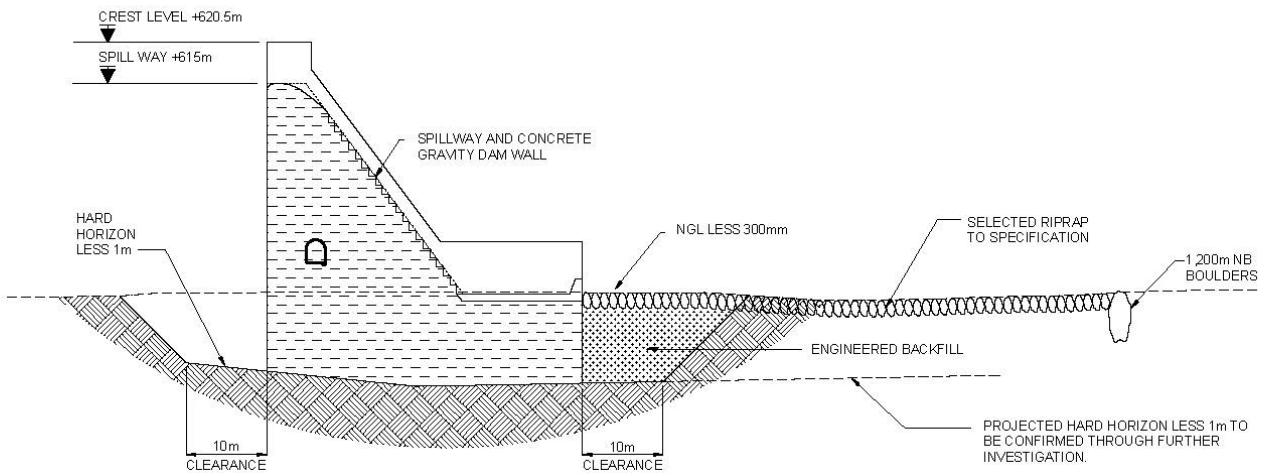

Figure 5: Section through still basin

The concrete gravity dam has been checked for global stability using the load combinations and Factors of Safety recommended in USBR Design of Small Dams. In all cases the dam performs satisfactorily. If, during the next stage of design, and geometric or material amendments are made, the global stability will need to be reassessed. In addition, once the construction technique is confirmed the stability at intermittent stages will also need to be evaluated.

Embankment Design

Analysis of particle size tests indicate that material from proposed borrow pits and beneath the dam alignment is a sandy silt with clay. It is therefore proposed to construct an earthfill embankment using site won alluvial / colluvial material with selection of lower permeability fill in the core and a chimney drain incorporated. Figure 6 below illustrates the key structure of the earthfill embankment section.

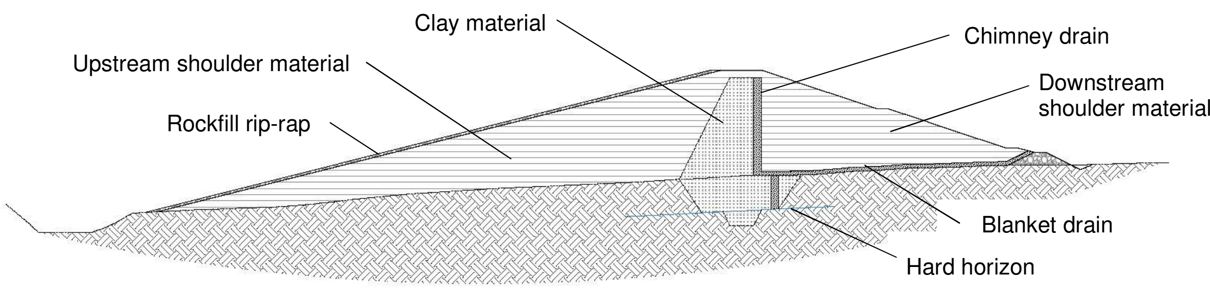

Figure 6: Earthfill embankment section

Seepage analysis has been undertaken in order to establish the amount of seepage which may occur through the embankment dam, and through the embankment and gravity dam foundations, and the extent of grouting works required. The results of seepage analysis show that the following will need to be considered within the design:

- An internal chimney and blanket drain is required to reduce the elevation of seepage through the embankment dam and at the toe
- A cut off trench and grout curtain are likely to be required to reduce the risk of seepage through the alluvial soils and weathered bedrock beneath the embankment dam
- A grout curtain is required to reduce seepage pressures beneath the concrete gravity dam and the left hand side abutment.

Outlet works

The outlet works have been designed to make provision for discharge of the anticipated maximum environmental water requirements (6 m^3/s) and all downstream off takes and to ensure that with multiple level off takes adequate water quality is maintained. The outlet tower is located in the concrete gravity left abutment, which allows for conventional concrete construction methods to be carried out independently of the bulk concrete in the spillway gravity section.

The valve chamber is situated in the toe of the left abutment. The valve chambers are set out such that there is provision for a future pump area sufficiently large to accommodate possible pump sets and possible turbine installation. A preliminary estimate of the hydro potential of Foxwood Dam, based on the projected annual agricultural releases, yielded an estimate 180 kW. This is not considered a viable supply that the Department would be willing to manage within this facility. This can be reviewed in the detailed design stage of this scheme.

5. LAND MATTERS AND EXISTING INFRASTRUCTURE

Construction of the Foxwood Dam would impact on existing lands and infrastructure and would require construction of additional ancillary infrastructure. This section reports on the following land matters and infrastructure requirements resulting from the dam construction:

- Existing bulk water supply to Adelaide and proposed bulk water supply
- Access to the dam site for operation and maintenance
- Inundation of existing roads
- Inundation of existing Eskom infrastructure
- Inundation of existing Telkom infrastructure
- Removal of graves
- Inundation of property and other structures in the dam basin

<u>Existing water supply canal</u>
The proposed Foxwood Dam basin will inundate a portion of the existing gravity canal that supplies Adelaide Dam. The inundated portion will be relocated in a new pipeline to maintain the gravity supply system. Provision has been made in the outlet works of the dam for a pumped pipeline to supply additional domestic water to Adelaide in the event that there is a significant increase in the water requirements.

<u>Access to the dam</u>
Access to the left bank is approximately 4 km outside of Adelaide on the R344 to Tarkastad. Access to the right bank is proposed to be via a bridge across the spillway with a turning circle cut into the crest of the headland.

DWS have noted that it is not preferred to have a bridge over the spillway and that access to the right bank should be provided to the crest through a cutting on the right bank and accessed via the MR00639. The proposed access should be reviewed in the detailed design.

<u>Relocation of R344 and MR00639</u>
The Foxwood Dam basin will inundate a portion of the R344 which links Adelaide and Tarkastad and a portion of the MR00639 which provides a link between the R63 (routed between Adelaide and Bedford) and the R344 and provides a form of bypass of Adelaide for travelers routed between Bedford and Tarkastad. Refer to Figure 7 below.

Consultation regarding the potential relocation of the roads has taken place with the Eastern Cape Department of Roads and Public Works (ECDRPW). Budget allowance has been made for the relocation of the R344 road linking Adelaide to Tarkastad to the same standard as the existing gravel road. The relocated road would include a 91 m long bridge to span the tail water of the dam.

The relocation of the MR00639 was determined but was excluded from the project cost and economic impact assessment due to anecdotal information indicating it is little used and the disproportionately high cost of relocation due to the steep and rocky terrain it would be routed through. A traffic study is to be carried out as part of the Environmental Impact Assessment (EIA) to confirm the actual usage of the road. ECDRPW indicated that the relocation of the MR00639 may not be required depending on actual usage.

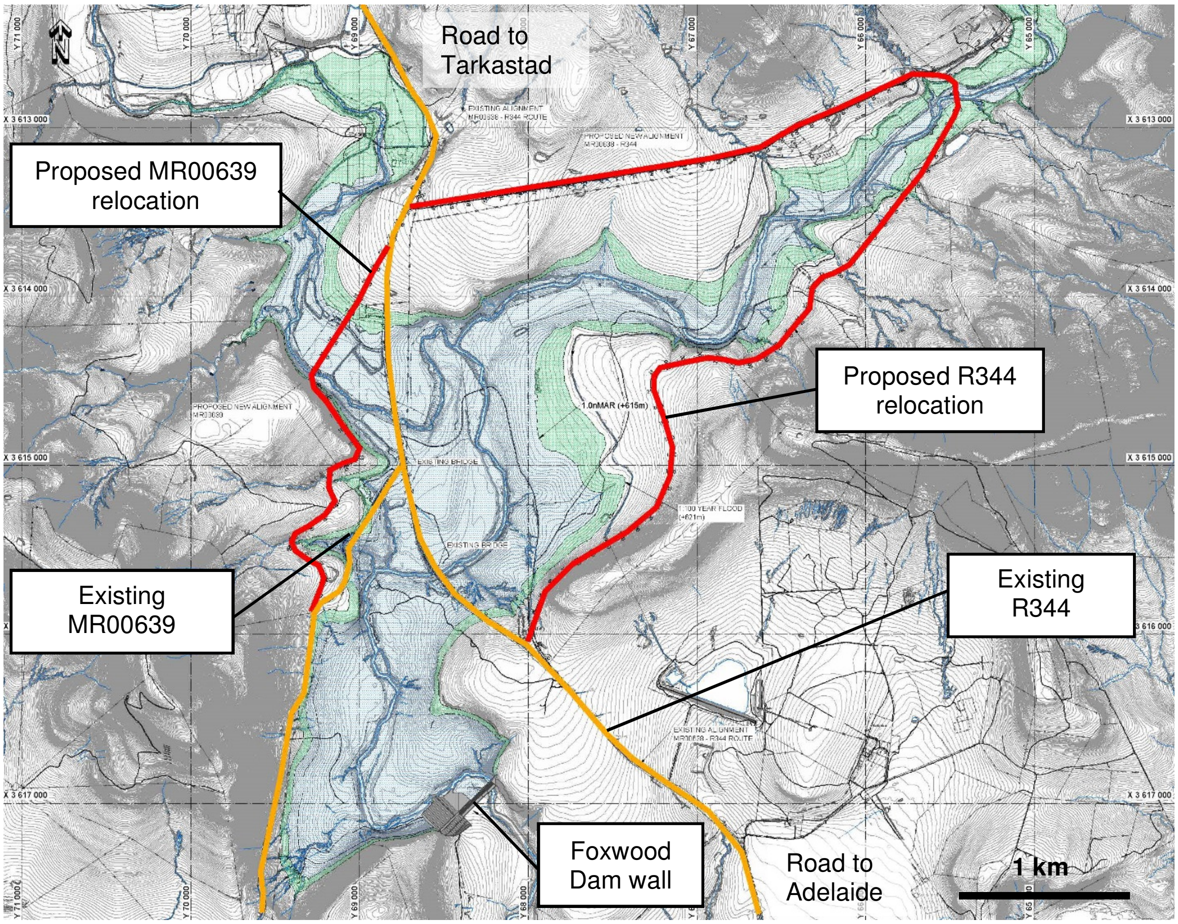

Figure 7: Proposed road relocations

<u>Land Inundation</u>
A preliminary expropriation line, depicting the minimum land purchase requirements for construction of Foxwood Dam, was determined for purposes of the EIA, as background for public consultation processes and for estimating the cost of land acquisition. The backwater line for a 1:100 year flood passing through Foxwood Dam, calculated using existing mapping of the dam basin, with a 15 m horizontal or 1,5 m vertical distance (whichever is worse) is the basis of the preliminary expropriation line.

Properties affected by Foxwood Dam are mostly in private ownership and generally used for commercial farming. The estimated cost of land acquisition is based on a detailed inventory of the affected properties, land uses on those properties and physical improvements. Management of the land acquisition process is time consuming and should commence as early as possible.

There are a number of structures within the dam basin that will be inundated and will be removed subject to the findings of the EIA. Provision for the removal of these structures should be made at detailed design. These structures include:

- Two bridges on the existing R344
- Disused weir immediately upstream of proposed dam wall site
- Inundated portions of MR00639 and R344 roads
- Inundated portions of Eskom and Telkom infrastructure
- Inundated portion of Adelaide canal
- Existing buildings and farming infrastructure such as storage tanks and pipelines

Miscellaneous affected infrastructure
Provision is made for Telkom and Eskom infrastructure which will require relocation due to the inundation. A gravesite was identified in the upper reaches of the proposed reservoir. This will require assessment and possible relocation as part of the wider heritage study being undertaken within the EIA.

Gauging Weir
A gauging weir will be required immediately downstream of the dam. Budget provision has been made for this in accordance with DWS requirements.

6. PROJECT COSTS

For high value or large quantity items related to the dam construction, construction rates have been obtained through consultation with a reputable major contractor currently completing the construction of a similar major composite dam in South Africa for DWS. Costs associated with known measurable other works (eg road construction, power line, Telkom and pipeline construction) have been determined based on recent similar construction project experience by the professional team and in the case of the district road realignments and bridges, these costs were reviewed by the Eastern Cape Department of Roads and Public Works (ECDRPW). The land matters were based on current sale values in the region determined by a property valuing firm. The cost of relocation of graves was based on current (2014) average rate for grave relocation at a large dam (Spring Grove Dam) being completed at the time by DWS.

Contingency and Professional Fees

An estimate of 30% has been used in the dam cost for Preliminary & General. Add-on costs have been allowed for over and above the total project cost to account for the feasibility level of design that has been carried out (15% contingency allowed) and the professional services that will be required for detail design, supervision and implementation of the project (15% for professional services and construction supervision). 14% VAT has been included in the total cost summary for all items.

Project Budget

The estimated capital cost of the proposed works, ***2014 prices including 14% VAT***, are:

Foxwood Dam and associated infrastructure (see Table 2 below for breakdown)	**R 2 084 million**
Estimated peak funding for establishment of a 1 250 ha irrigation scheme*	**R 427 million**

A summary of the dam structure construction costs and the total project costs are provided in Table 1 and Table 2 respectively, below.

**The estimated total funding required to establish a sustainable irrigation scheme is also indicated however this does not form part of the dam construction project and would be subject to further development by the relevant project sponsor, most likely the Department of Agriculture, Forestry and Fisheries.*

Table 1: Summary of dam structure construction costs

Item No	Description	Cost (ZAR) (June 2014 Prices)	Comment
1	PRELIMINARY & GENERAL	239 411 545	*30% of item* 2-15
2	WATER CONTROL-RIVER DIVERSION	5 118 848	
3	DRILLING & GROUTING	65 895 189	
4	Earthfill	5 772 591	
5	Concrete Gravity	60 122 598	
6	GRAVITY SPILLWAY	434 835 032	
7	GRAVITY NOC	26 515 352	
8	EARTHFILL EMBANKMENT	105 196 437	
9	OUTLET WORKS	64 306 681	
10	Concrete Works	21 204 550	
11	Mechanical Equipment	39 102 131	
12	Structural Steelwork	1 750 000	
13	Electrical Equipment	2 250 000	
14	INSTRUMENTATION	7 500 000	*Provisional Sum*
15	Miscellaneous 10% & Landscaping 2.5%	88 670 942	*(12.5% of cost* (excl P&G))
	DAM CONSTRUCTION (excl VAT)	**1 167 651 897**	

Table 2: Summary of total project costs

Foxwood Dam Project Feasibility Cost Estimate	*ZAR (June 2014 prices)*
Foxwood Dam Structure (only)	*1 167 651 897*
Dam Access Road	*9 412 689*
Bulk water pipeline and pumpstation	*8 887 960*
Gauging Weir & other DWS hydrology structures	*5 451 000*
Relocation of R344 (MR00638)	*126 599 941*
Relocation of water supply canal	*20 400 000*
Land matters - land costs	*10 239 625*
Land matters - fixed improvements	*25 764 000*
Graves relocation (estimated 10)	*300 000*
Eskom relocation cost	*2 200 000*
Telkom relocation cost	*500 000*
Environmental management	*5 000 000*
Sub-total (excl VAT)	***1 382 407 112***
Contingencies 15%	*207 361 067*
TOTAL DAM CONSTRUCTION (incl contingency)	***1 589 768 179***
Professional Fees 15%	*238 465 227*
TOTAL COST (incl design fees)	***1 828 233 406***
VAT	*255 952 677*
TOTAL DAM COSTS	***2 084 186 082***

June 2014 rates as priced from a large contractor rates

The capital value of the whole dam project is **R 2 084 186 082,** this generates a Unit Reference Value (URV), at 8% rate, of **R11,77** per cubic meter of water supplied.

7. REGIONAL ECONOMIC IMPACT

The assessment of economic activity of the Foxwood Dam project has focused on the construction and operation of the dam and the construction and operation of the proposed associated Government Irrigation Scheme only. The economic activity of the dam results from the construction of the dam, over a four year period, and then the operation of the dam and sale of water from the dam. A six year period has been estimated until the full take up of water from the dam is achieved, primarily from the development of the Irrigation Scheme. **It is assumed that the capital expenditure for the construction of the dam (estimated at R 2 084 million) will be funded by Treasury with no full recovery of this cost. The construction of the dam will be as enabling infrastructure to support the development of the proposed Irrigation Scheme and the economic activity and job creation that this will stimulate. However, it is assumed that the funding required to establish the irrigation scheme will be repaid over a period of time once the scheme has become financially profitable.**

Assuming a discount rate of 8%, the URV for water yielded by Foxwood Dam would be R11,77 /m^3. However, as it is assumed that the capital funding for Foxwood Dam would be from Treasury, the modelled *price* of water has been calculated based on the URV resulting from the annual maintenance and operation costs (and including major refurbishment) of the dam over the life of the dam, with a value of R 0,60c/m^3. In the event that the project is developed, the price of water must be determined in accordance with the National Water Pricing Strategy and allow for a full review of Water Allocation within the Koonap River catchment.

Economic Impact of Dam Construction and Operation

The Gross Domestic Product for operations and construction of the dam has been modelled, together with peak employment and sustainable employment within the Nxuba municipal area. The rates and utilities which will increase as a result of the project are also calculated, as well as the increase in fiscal revenue due to the payment of corporate taxes by contractors and the wages earned from operations. These metrics are indicated in Table 3 below which illustrates the trend over the first 10 years operation until the dam and irrigation scheme are operating fully and in steady state:

Table 3: Summarised Construction and Operations Economic Impact for Foxwood Dam

Economic Impact and Year:	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	TOTALS
Construction Impacts:											
Project / Construction Costs - Rm	313	521	834	417							2,084
Gross Domestic Product (GDP) Impact - Rm	335	559	894	447							2,235
Direct Employment - Jobs Per Year	474	759	1,166	559							2,958
Operations Impacts:											
Operating Revenue - Rm					6	7	9	10	12	14	59
Gross Value Added (GVA) Impact - Rm					7	9	10	12	15	17	69
Direct Employment - Jobs Per Year					3	3	4	5	5	6	26
Sustained Employment - All - Jobs Per Year					8	9	11	12	14	15	69
Sustained GVA in Municipality - Per Year					6	7	8	10	12	13	56
Construction & Operations Impacts:											
Rates & Utilities Paid to the Munic. - Rm	4.8	8.2	13.3	7.3	1.0	1.0	1.0	1.0	1.0	1.0	40
Taxes Payable to the Fiscus - Rm	23.9	39.8	63.7	31.8	0.6	0.7	0.8	1.0	1.2	1.4	165

Source: Summary of Project Cost Benefit Analysis.

Irrigation Scheme Financial Model

The economic impact study has worked closely with the model assumptions used to perform the agricultural analysis and used the various inputs and operating parameters to establish an economic base case and then evaluate the various scenarios postulated.

There is no standard labour policy or union which regulates wages paid in the agricultural sector. In order to determine what an optimum wage should be for a farm worker and the ideal annual farm profit or Net Farm Income (NFI), various sources have been consulted and an average daily wage of R 104,00 has been used against the national average minimum wage of R 70,00 per day. The NFI has been deemed to be R 300 000 per annum per farm. The average daily wage has been used to estimate job creation from the projected revenue generated by the Irrigation Scheme. The NFI is used as a bench mark to consider the long term financial sustainability of the proposed Irrigation Scheme.

The summary financial output from the agro-economic study, for a total development size of 1 250 ha (using averaged data from all crop types with individual farm sizes of 20 ha) is provided in Table 4 below. Based on a review of the projected IRR for each crop type and farm size as well as the projected employment creation for each scheme, the 20 ha farm model has been used throughout this economic impact analysis, although it is noted that various permutations of proposed Irrigation Scheme could be implemented subject to a detailed Irrigation Scheme investigation. A snapshot of financial indicators at this 10 year stage are provided to indicate the financial performance of the scheme when both have been completely developed and are operating fully. To assess the longer term financial sustainability of the Irrigation Scheme the IRR of the scheme has been assessed after 15 years of establishment of the scheme.

Table 4: Averaged financial performance for 1 250 ha scheme (assuming 20 ha portions)

Financial data (averaged for 1 250 ha scheme for all crops)	1 250 ha irrigation scheme	Comment
Peak funding (ZAR) (4-5 year timeframe)	437 398 862	The total funding that Government would need to provide
Internal Rate of Return (IRR) @ year 15	8,15%	The IRR that would be achieved by year 15
Accumulated retained earnings by year 15 (ZAR)	315 284 832	These earnings indicate whether the business is worth pursuing over the medium to long term
Revenue potential in year 10 (ZAR)	389 531 163	The revenue potential of the farming operation once it is in full production.
Profit earned in year 10 (ZAR)	56 651 682	Substantially more than R300k 'success' benchmark per farm (which equates to R 18 million for all farms within a 1 250 ha scheme)
Wages earned by year 10 (ZAR)	41 830 135	The wages earned by the farm workers.
Total direct employment (including farmer) per scenario in year 10	1 934	Back calculated from wages, based on average daily wage per labourer of R 104.00
Total indirect & induced employment in year 10	728	Based on IDC ratio of 0.38 relative to direct jobs created
Taxation paid in year 10 (ZAR)	25 427 326	The taxes paid to the national fiscus by the farming operation
Potential beneficiation in year 10 (ZAR)	352 237 752	Assumed multiplier of potential beneficiation: 1.75 times
Gross Domestic Product in year 10 (ZAR)	503 196 788	Assumed multiplier of 'All' GDP impact 2.50 times
Export potential in year 10 (ZAR)	150 959 036	Assumed % of revenue exported: 50% Assumed % price improvement of: 150%

Socio-Economic Impact of Irrigation Scheme

A baseline assessment of the agriculture sector in Nxuba was carried out to project the growth of agriculture in Nxuba in the event that the Foxwood Dam in not constructed. This is an assessment of the ‘no-go’ scenario and demonstrates the substantial impact that Foxwood Dam would have on the economic activity in the municipality. Agriculture is responsible for 37% of employment in the municipality, however there has been a 16,5% reduction in employment in Agriculture in the 10 years from 2001 to 2011. Agriculture makes up approximately 14% of Gross Value Added (GVA) contribution within the municipality however this also reduced by 2,2% in the 10 years from 2001 to 2011. In contrast to these trends the projected impact of the proposed Irrigation Scheme on GVA and Employment in Nxuba municipality results in an average overall growth of agricultural sector employment over fifteen years of 5,3% with 1 934 irrigated agriculture employment opportunities created, or 55% of the total 3 488 employment opportunities projected in the agriculture sector Nxuba LM by the year 2028. An average growth of agricultural sector GVA over fifteen years of 12,5% is realised with R 352 million irrigated agriculture economic activity created, or 88,1% of the total of R 396 million agricultural sector GVA for Nxuba LM by the year 2028.

Funding Requirement from Government

Figure 46 below illustrates the estimated required funding from Government to implement the Foxwood Dam project and associated Irrigation Scheme. It is assumed that the capital expenditure for the **dam construction**, approximately R 2 084 million over four years, would be funded by Treasury and not recovered. The total funding required by Government for the **irrigation scheme** is estimated at R 437 million and would be invested over six years. The projected returns from the Irrigation Scheme would allow payback of this investment over five years, or eleven years from the start of investment in the Irrigation Scheme. All prices are benchmarked to 2014 and the start year given in Figure 8, 2015, is illustrative only.

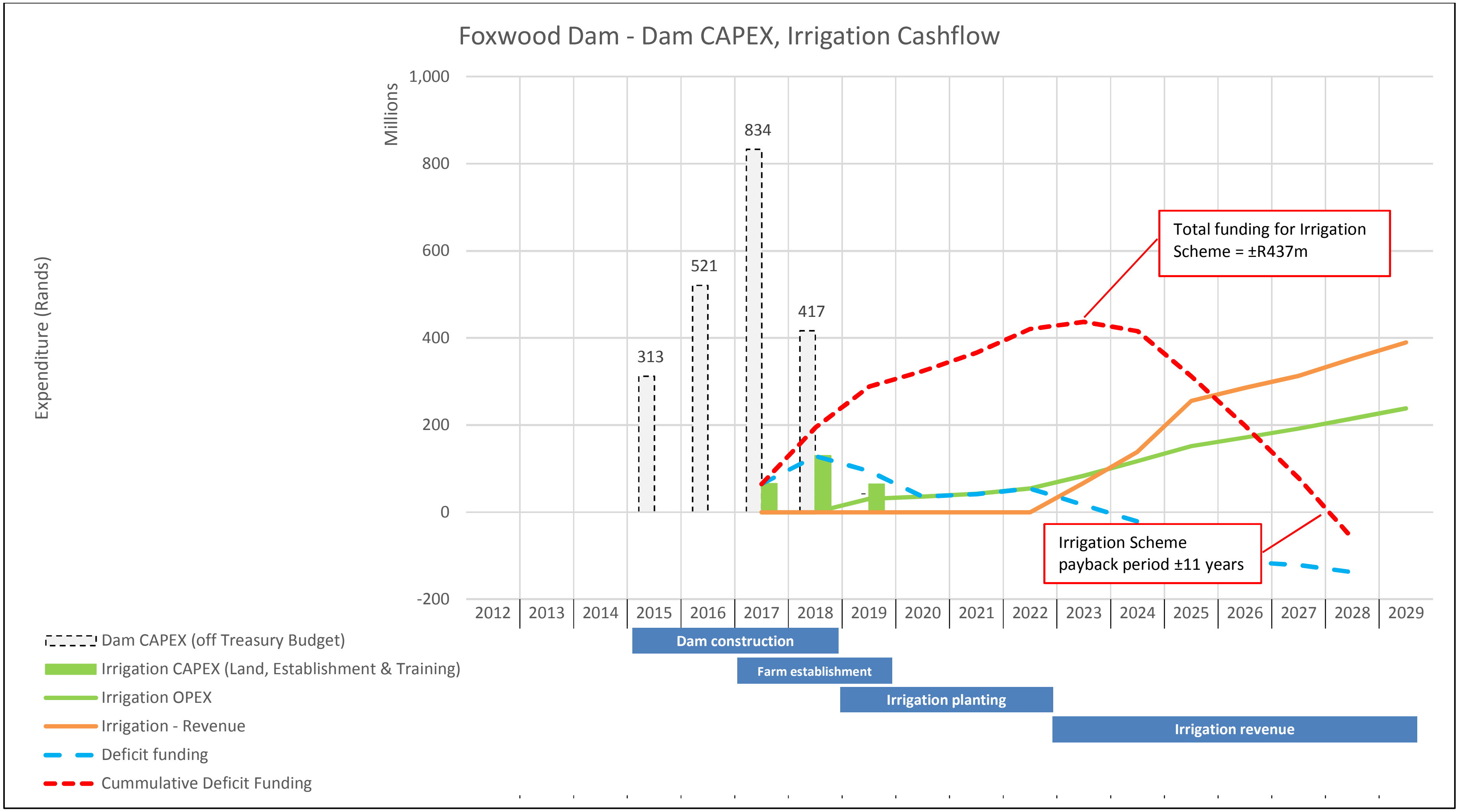

Figure 8: Projected dam CAPEX and Irrigation Scheme establishment cashflow

Legal, Financial and Institutional Arrangements

In the light of the recognition given by Government in the National Development Plan (NDP) to water supply projects as mechanisms for creating employment opportunities and for stimulating and leading socio-economic development, particularly in the rural hinterland, development of the Foxwood Dam could enjoy more than local significance. In view of the relatively high levels of poverty in the Amathole District Municipality, and in the Nxuba Local Municipality in particular, there is a possibility that government would favourably consider making a grant available to finance this project. In this case the DWS would be responsible for owning and for the operation of the dam, at least for a significant time until circumstances in the region change and an alternative responsible authority is able to fulfil these functions.

It is recommended that the proposed Foxwood Dam be developed by the DWS as owner and operator (which may be only as a care-taker until an appropriate institution is identified to take this responsibility over), and that the Amatola Water be considered as Implementing Agent of the DWS. This is motivated by the fact that the dam would be a multi-purpose facility serving objectives of socio-economic development that extend beyond the local context. The dam would, in that sense, be viewed as a component of National Water Resource Infrastructure.

Since beneficiaries of water supplies that can be made available from the dam will not for a very long time, if ever, be in a position to make a meaningful contribution to the redemption of the capital cost of the project, this investment would have to be funded through a grant from Government. This funding should be on the budget of the DWS who also becomes owner of the works on behalf of the State.

The major risk is the time that it will take to obtain the various authorisations, to conclude agreements, and to obtain funding. These include:

- Prepare the application and obtain approval for RBIG funding;
- Prepare the application and obtain approval for water storage, abstraction and affecting the river course licences;
- Complete an environmental impact assessment, including public consultation and obtain environmental authorisation;
- Obtain council and board resolutions for the District Municipality and Amatola Water to enter into a WSP agreement and for the water board to partially fund the project, and to negotiate the details of such an agreement.
- Obtain the necessary land for building the dam wall, the basin and appurtenant works.

A mitigating action would be for the District Municipality, Amatola Water and DWS to take a number of binding decisions/resolutions very early on in the process.

Public Participation

Public Participation was initiated early in the process to establish an interface with the local community. Public Participation during the feasibility study has also formed a solid basis for Public Participation Process which will be undertaken during the EIA. For the purposes of the feasibility study for Foxwood Dam, stakeholder consultation was initiated during the early phases of the study to support and facilitate meaningful Public Participation throughout the study.

No significant objections to the proposed project were registered, however various concerns were raised for consideration during the EIA including:

- Clarity on the institutional arrangement required for development of the project
- Optimisation of the dam size to encourage maximum benefit from the water resource
- Optimisation of opportunities for resource poor farmers

- Compensation to landowners from inundation
- Opportunities for skills development
- Rural and economic development potential including tourism.

Environmental Impact

The environmental screening exercise was carried out as a best practice. At this stage there have been no ‘red flags’ identified which would preclude the project from proceeding subject to the receipt of the relevant authorisations from the competent authorities. The EIA is currently underway and the Scoping Report has been issued. The scoping report addresses the following works of the project:

- Major storage dam (Foxwood Dam);
- Bulk water supply pipeline and pump station;
- Gauging weir;
- Access roads (construction and operational phases);
- Quarry and borrow areas;
- Eskom supply to the dam and gauging weir;
- Relocate existing infrastructure (including water supply canal, R344, MR00639, Telkom telephone line and Eskom power line);
- Construction camp; and
- Permanent offices and accommodation for dam operator.

The Environmental Screening study and the current EIA are not addressing the potential impact of the proposed Irrigation Scheme. The proposed irrigation scheme will be subject to separate authorisation subject to the further development of that scheme.

8. CONCLUSION

- The ‘need’ for the project is driven by the potential for the undeveloped water resource of the Koonap River to be mobilized to stimulate socio-economic development in the region.
- An assessment of the hydrology and geology has been completed and it is recommended that a 1 MAR dam with total storage of 55 million m^3 is developed. This dam will yield approximately 16 million m^3/a at a 1:20 year risk of failure (considered for high value crop irrigation).
- The proposed structure of the dam is a composite earthfill embankment gravity concrete spillway dam. This structure provided the lowest relative URV and also provides some mitigation against observed dispersion in some borrow pit samples as well as avoiding the need to develop a costly side-channel spillway.

- Operational and financial models have been developed for a proposed 1 250 ha Government Irrigation Scheme. Recommendations have been made regarding proposed mentoring, training, minimum employment wages and salaries in an effort to place emphasis on the reasonable long term sustainability of the scheme.
- A socio-economic impact assessment has been carried out considering the potential benefits stimulated by the construction and operation of the dam as well as the establishment of the irrigation scheme. It is recommended that the capital cost of dam construction (R 2 084 billion) is funded by the Treasury. Establishment costs for the irrigation scheme (R 437 million) should be provided as a loan with repayment through generation of revenue by the scheme.

- The overall economic benefit of the total project (dam construction and operation and irrigation scheme development and operation) is positive, however there are in all likelihood additional infrastructure requirements for the establishment of the irrigated agriculture as well as the need for financing and training of the new or emerging farmers. An agricultural options analysis report has been prepared for the various options and provides recommendations as to how the irrigated agriculture could be implemented.

- Certain of the important economic benefits which are realized are as follows:

    - Additional economic activity is stimulated in a region which needs it, with R 532 million of additional economic activity with all of its positive knock-on effects added in year 10 of the development
    - Additional employment opportunities are created – 1 934 sustainable direct employment opportunities
    - Emerging farmers will be established and empowered with financial benefits and skills transfer
    - There is a reasonable return on investment of approximately 8% for the Irrigation Scheme, with payback of the peak funding estimated to be completed within approximately 11 years of commencement of the scheme.
    - The municipality will earn additional rates and charges from the project
    - The national fiscus will receive additional taxation of R 36,6 m in year 10
    - The potential exists for the further beneficiation of the agricultural product, and
    - Potential exists for agricultural product export promotion.

- The ultimate economic benefits of the combined project, the Foxwood Dam and the irrigated agriculture are in favour of the project being implemented based on the prime objectives of socio-economic upliftment. However, it needs to be noted that the implementation of the irrigated agriculture programme as envisaged within this study and the associated agricultural report, assumes that a competent implementation agency will be appointed and will implement the project within the time and financial budgets as contained herein.
- **The most significant risk to the scheme is the need for an implementing agent to be installed to develop the associated Government Irrigation Scheme.**

- The EIA is currently underway and will address all queries and concerns raised during the public participation within this technical feasibility study.
- Table 5 below summarises the key dam statistics.

Table 5: Dam Statistics – Summary Table

LOCALITY	
Province:	Eastern Cape
District Municipality:	Amathole District
Co-ordinates of dam site:	32° 40'30" S 26° 16' 0" E
Nearest town by road:	Adelaide
CATCHMENT	
Drainage Number:	Q92
River:	Koonap
Catchment Area:	3 334 km^2
Mean Annual Precipitation (MAP):	513 mm
Mean Annual Runoff (MAR):	79,6 million m^3/a
STRUCTURAL INFORMATION	
Type of dam:	Composite concrete
Overall length of wall:	485 m
Length of spillway (including piers):	267 m
Total length of left bank NOC:	48 m
Length of earth fill on right bank:	163 m
Length of outlet works:	58,375 m
Non-overspill crest level:	620,5 masl
Spillway crest level:	615,0 masl
Lowest foundation level:	571,6 masl
Maximum height of NOC above foundation:	48,9 m
Recommended Design Discharge (1:200):	2 063 m^3/s
Excavation volume:	234 388 m^3
Earth fill and backfill material volume:	584 820 m^3
Total volume of reinforced concrete:	51 840 m^3
Total volume mass concrete:	220 183 m^3
RESERVOIR INFORMATION	
High Flood Level (HFL)-1:100:	617 m
Design Flood Level (DFL) 1:200:	617,50 m
Safety Evaluation Flood Level:	620,50 m
Full Supply Capacity:	54 995 984 m^3
Lowest Draw Down Level	585,40 m
50 year Silt Volume	6,1 million m^3
Reservoir Surface Area at HFL	4 634 414,49 m^2
DESIGN FLOOD PEAKS	
Return Period (Years)	Discharge
5	176 m^3/s
10	332 m^3/s
20	555 m^3/s
50	985 m^3/s
100	1 457 m^3/s
200	2 063 m^3/s
Recommended Design Flood (PMF)	2 063 m^3/s
Regional Maximum Flood (RMF)	5 218 m^3/s
Safety Evaluation Flood (SEF) (PMF routed)	6 200 m^3/s
OUTLET WORKS	
River Outlet - 2 x Bottom Discharge Sleeve Valves	6 m^3/s
Maximum design pipe velocity	4 m/s
Multiple Intake	4 No

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LIST OF ACRONYMS

ACRONYM	
ADM	Amathole District Municipality
AIP	Alien Invasive Plants
APP	Approved Professional Person
AW	Amatola Water
DAFF	Department of Agriculture, Fisheries and Forestry
ECDRPW	Eastern Cape Department of Roads and Public Works
EPP	Emergency Preparedness Plan
EIA	Environmental Impact Assessment
EIS	Ecological Importance And Sensitivity
EWR	Ecological Water Requirements
DAFF	Department of Agriculture Forestry and Fisheries
DFL	Full Supply Level
DT	Discharge Tables
FSL	Full Supply Level
FRPS	Fish River Pumping Scheme
FSC	Full Supply Capacities
GRA	Groundwater Resources Assessment
HFL	High Flood Level
HFY	Historic Firm Yield
IEI	Integrated Environmental Importance
IRR	Internal Rate of Return
KRIB	Koonap River Irrigation Board
LTY	Long Term Yield
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MCE	Maximum Credible Earthquake
MRU	Management Resource Units
NDP	National Development Plan
NEMA	National Environmental Management Act
NFI	Net Farm Income
NGA	Ground Water Database
nMAR	Natural Mean Annual Runoff
NOC	Non overflow section
NWRS	National Water Resource Strategy
Nxuba	Nxuba Local Municipality
OBE	Operating Basis Earthquake

ACRONYM	
PES	Present Ecological State
PMF	Probable Maximum Flood
PSC	Project Steering Committee
PSP	Professional Service Provider
RDREM	Reserve Estimation Model
REC	Recommended Ecological Category
RID	Record of Implementation Decisions
RMF	Regional Maximum Flood
RTS	Reservoir-Triggered Seismicity
SA	South Africa
SCI	Socio-Cultural Importance
SEF	Safety Evaluation Flood
SMC	Study management Committee
SFR	Streamflow Reduction
StatsSA	Statistics South Africa
STOMSA	Stochastic Model of South Africa
URV	Unit Reference Value
VAPS	Vaal Augmentation Planning Study
WARMS	Water Use Registration Database
WfW	Post Retief Working For Water
WMA	Water Management Area
WARMS	Water Resources Information Management System
WRUI	Water Resource Use Importance
WRYM	Water Resources Yield Model
WSA	Water Service Authority
WSDP	Water Services Development Plan
WSP	Water Service Provider
WTW	Water Treatment Works

LIST OF UNITS

MEASURE	UNIT
Height	m.a.s.l.
Distance	m or km
Dimension	mm, m
Flow rate	l/s or m^3/s
Area	m^2, ha or km^2
Volume (storage)	m^3, million m^3

1 INTRODUCTION

1.1 Background

The Department of Water and Sanitation has investigated the feasibility of developing a multi-purpose dam on the Koonap River near Adelaide in the Eastern Cape. The proposed dam site is known as Foxwood and was identified for the development of the water resources of the Koonap River as far back as the 1960's. The project is again being considered for implementation as a strategic initiative to mobilize the water resources in the area as a stimulus for socio-economic development in this rural, economically depressed region. This initiative would support the objectives of the National Development Plan (NDP) and is consistent with the National Water Resource Strategy 2 (NWRS2).

The feasibility of a major dam on the Koonap River at the Foxwood site for the purpose of supplying water for domestic use and for irrigation has been investigated since the early 1960's. Previous investigations have taken place to assess the opportunities to augment water supply to Adelaide in the past with particular attention being paid to the option of building a dam at the Foxwood site. The records of these investigations, by the Koonap River Irrigation Board (KRIB), officials of the then Department of Agriculture and the Department of Water Affairs (DWA) and by consulting engineers Ninham Shand, provide valuable information regarding the development proposals (DWAF, 1988; Ninham Shand, 1992; Ninham Shand, 1993). The motivation for the construction of a dam, initially, appears to have been for improved resilience of domestic supply to the town due to acute water shortages suffered historically.

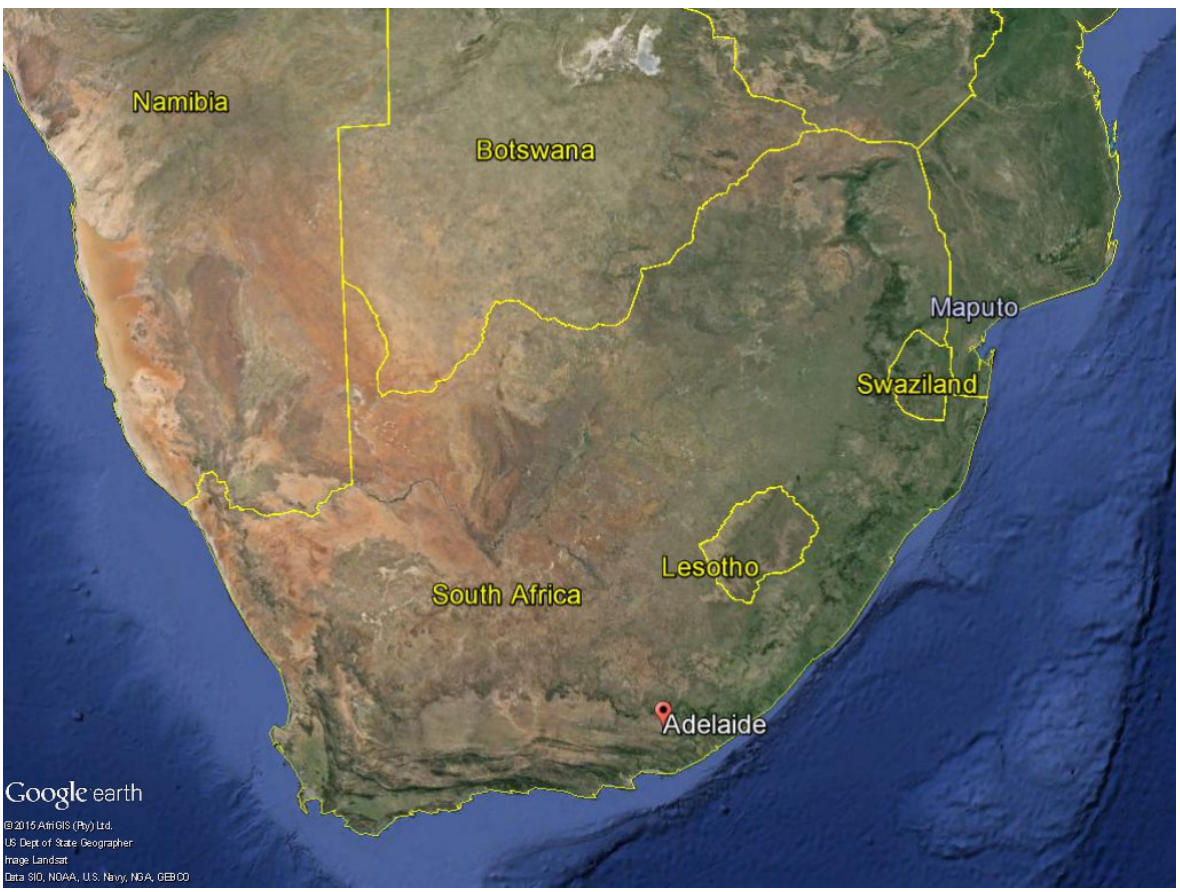

Figure 9: Adelaide location within South Africa

Historical Investigations

The feasibility of a major dam on the Koonap River at the Foxwood site for the purpose of supplying water for domestic use and for irrigation has been investigated since the early 1960's. Previous investigations have taken place to assess the opportunities to augment water supply to Adelaide in the past with particular attention being paid to the option of building a dam at the Foxwood site. Adelaide Municipality commissioned a report in 1992 (ADM, 1992) to investigate the option of building a dam at Foxwood and a subsequent report was commissioned by the Department of Water Affairs and Forestry (DWAF) in 1992 (Ninham Shand, 1992) to consider smaller dam options at the Foxwood site. Amathole District Municipality (ADM) commissioned an investigation into the water and sanitation services in Adelaide in 2008. The records of these investigations, by the Koonap River Irrigation Board (KRIB), officials of the then Department of Agriculture and the Department of Water Affairs (DWA) and by consulting engineers Ninham Shand, provide valuable information regarding the development proposals (DWAF, 1988; Ninham Shand, 1992; Ninham Shand, 1993). These reports either incorporated a bulk water supply to Adelaide with a municipal irrigation scheme or solely as a potable water supply for the town. The motivation for the construction of a dam, initially, appears to have been for improved resilience of domestic supply to the town.

The perceived need for a major dam at the Foxwood site was again raised by the Nxuba Local Municipality at the Eastern Cape Water Indaba in 2009. The then Department of Water Affairs undertook to carry out a detailed feasibility study.

1.1.1 Objectives of the study

The objective of the study was to examine all aspects of the feasibility of constructing a dam at the Foxwood site in the Koonap River for the purpose of augmenting water supplies to Adelaide and to provide reliable water supplies for existing and new irrigation. The study led to motivated recommendations DWS regarding development proposals which, if acceptable, can be submitted to the Minister of Water and Sanitation for approval and to National Treasury for funding.

1.1.2 Scope of the Feasibility Study

The Feasibility study has covered all technical aspects such as:

- the availability of water in the Koonap River taking into account the Environmental Water Requirements (EWR),
- the reasonable future requirements for water by the various user sectors,
- the technical details of constructing a dam at Foxwood and transmitting the water to the intended beneficiaries, at a feasibility level of detail adequate for estimating the construction and operating costs at a reliability suitable for capital budgeting, economic analysis and making financing arrangements,
- the capital cost of developing the project, including the cost of the land required and the effective management in perpetuity of all environmental impacts,
- expected operating and maintenance costs,
- the economic and other benefits of developing this water resource,
- institutional arrangements for the construction, owning and operating of the physical infrastructure,
- compliance with all legal requirements, and
- sustainable funding arrangements and the associated cost recovery from water users

1.1.3 Study team and organisation

Arup (Pty) Ltd were appointed by DWS (Directorate: Options Analysis) as the Professional Service Provider (PSP) to carry out the Feasibility Study. For certain specialist input, Arup engaged the following sub-consultants:

- Public Participation – ACER Africa Ltd
- Agro-Economic Study – Agri-Africa Ltd
- Geotechnical Investigation – Terreco Geotechnical cc
- Economic Impact Assessment – Rand International Capital
- Domestic Water Requirements - Camdekon

Throughout the study Arup engaged formally with DWS's project management team through a Study Management Committee (SMC). Engagement with other Government Departments and key stakeholders was carried out through the Project Steering Committee (PSC) which convened approximately every 6 months during the study. The PSC was responsible for liaison between DWS (through PSP) and other key stakeholders advising the DWS, on the strategic matters relating to the study and for locating and making available information necessary for the investigations.

Representation at the PSC included:

- PSP Study Leader (supported by Task Leaders and support staff when relevant)
- National and Provincial Department of Water and Sanitation
- National Department of Agriculture, Forestry & Fisheries
- National and Provincial Department of Rural Development and Land Reform
- Eastern Cape Office of the Premier
- Provincial Department of Economic Development, Environmental Affairs and Tourism
- Provincial Department of Local Government and Traditional Affairs
- Representatives of the Amathole District Municipality, Nxuba Local Municipality and Amatola Water
- Eastern Cape Rural Development Agency

1.2 Study Area

The Foxwood Dam site is located immediately upstream of Adelaide (coordinates 32˚40'30"S, 26˚16'0"E) in the Koonap River catchment (see Figure 11)

The Koonap River catchment, with an area of 3 334 km², is situated in the Eastern Cape Province and lies within the Fish to Tsitsikamma Water Management Area (WMA). Adelaide is in the Nxuba Local Municipality (Nxuba) within the Amathole District Municipality (ADM). ADM is the Water Service Authority (WSA) in Nxuba Municipality and Amatola Water (AW) is the Water Service Provider (WSP). Adelaide is currently supplied with potable water via an off-channel canal from the Koonap River that feeds an off-channel storage dam (Adelaide Dam) to the north of the town. This system is backed-up by a transfer pipeline from the Fish River (installed as an emergency intervention during historic times of drought) and municipal boreholes.

Adelaide is a town of approximately 25 000 people. Bedford is located approximately 23 km to the west of Adelaide and has a population of approximately 9 000 people. Fort Beaufort is located 37 km to the east of Adelaide and has a population of approximately 26 000 people.

Adelaide is located 170 km West North West from East London which is the nearest large airport. It is on the R63 via King Williams Town. Refer to Figure 10 below.

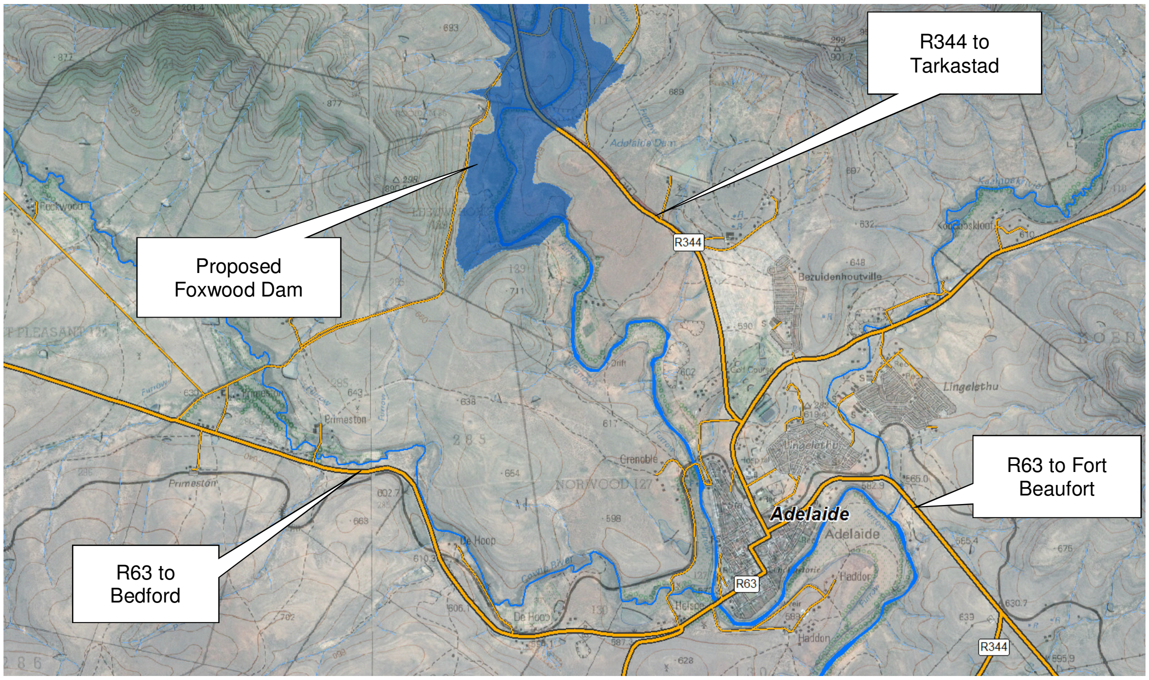

Figure 10: Plan showing regional access to the proposed Foxwood Dam

1.2.1 Aerial Survey & Mapping

Aerial survey was carried out of the dam site and dam basin. Further aerial survey was also carried out along a 2 km wide strip following the route of the Koonap River from the dam site to the confluence with the Great Fish River to assist with the study into the irrigation model.

The deliverables of the aerial survey were provided to the Spatial and Land Information Management team within DWS in printed hard copy and electronic format. It comprised:

- 0,10 m ground sample distance digital colour aerial imagery of the dam basin
- 0,10 m ground sample distance digital colour aerial imagery of the Koonap River from proposed Foxwood site to Koonap River confluence with Great Fish River
- 1/5 000 scale colour Orthophoto maps with 1 m contour interval of the Foxwood Dam Basin
- 1/1 000 scale colour Orthophoto maps with 0,5 m contour interval of the Foxwood Dam Site Area
- 1/5 000 scale colour Orthophoto maps with 1 m contour interval of the Koonap River to the confluence with Great Fish River

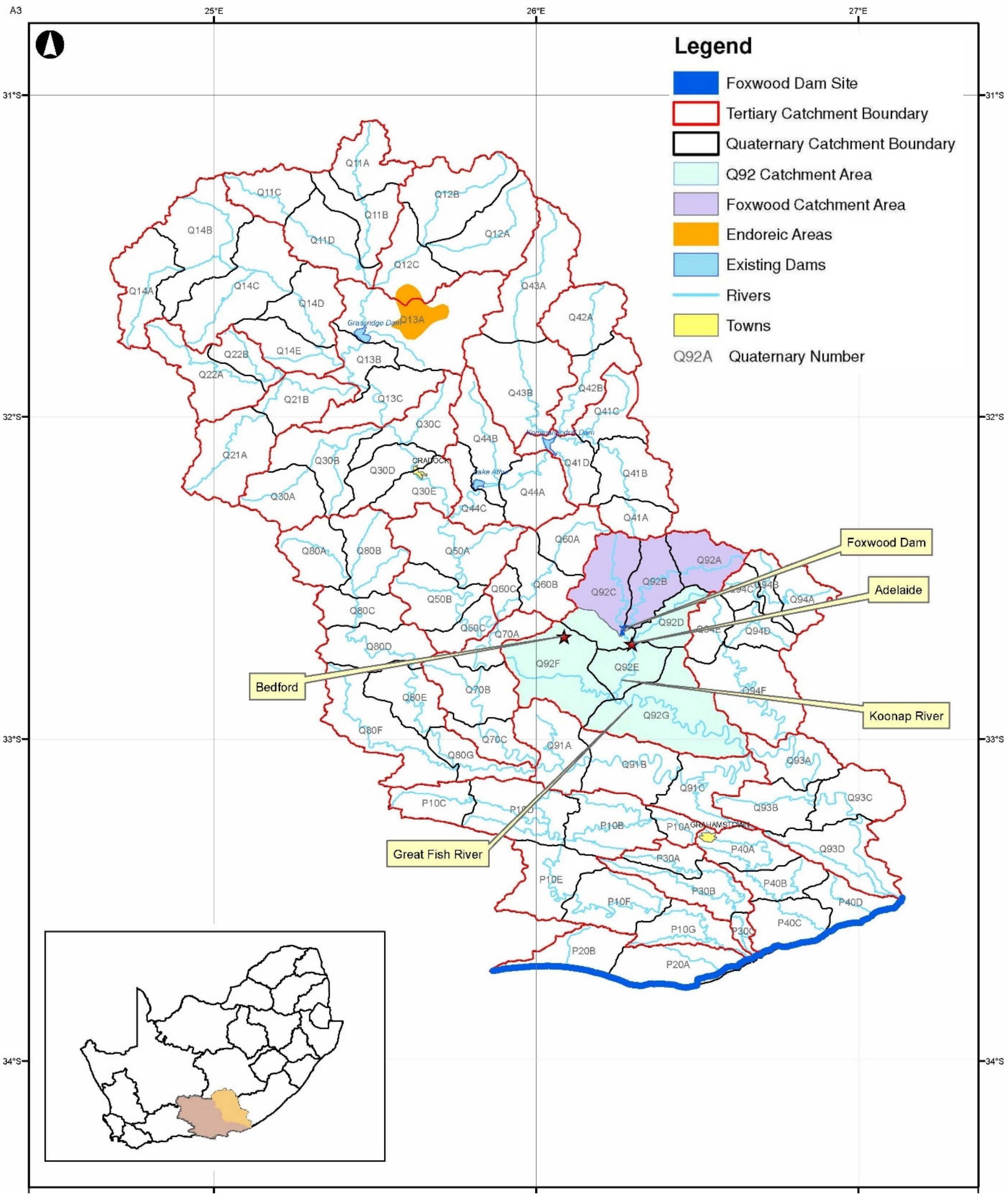

Figure 11: Fish River Catchment with Koonap River Sub-catchment

2 WATER REQUIREMENTS

This section provides summary details of salient information extracted from the main reports on Water Requirements and Water Quality:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Water Requirements, P WMA 15/Q92/00/2113/8

Outcomes of the review of existing water supply infrastructure for Adelaide is contained in the report:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Alternative Water Supply Options, P WMA 15/Q92/00/2113/5

One of the first assessments carried out in the study was a review of the water requirements in Adelaide as well as the wider region. To this end, in the Water Requirements report the requirements for water are assessed in the immediate vicinity of the proposed dam site, around Adelaide, as well as the requirements for water in the wider potential supply area in and around the Koonap River Valley.

A 30-year projection has been used for the estimation of future domestic water requirements for Adelaide. For reference, it is noted that a 1 MAR dam at the proposed Foxwood Dam site would have a yield of 11,3 million m^3/a at a 1:100 year assurance.

2.1 Local domestic water requirements and water resources

The Koonap River catchment is rural in nature with farming the main activity. There is some irrigation, which is mostly run of river abstractions, and some cattle farming. The urban centres of Adelaide and Bedford are located in the catchment. Adelaide's primary source of water is a run-of-river abstraction to an existing off-channel storage dam, supported by groundwater and a transfer scheme from the Fish River (via Bedford). Bedford is supplied via the Andrew Turpin dam with support from Fish River transfers. Fort Beaufort, although located outside of the Koonap River catchment, is a large urban centre which could be considered for supply from a dam at Adelaide should water requirements require. Refer to Figure 12.

The assessment of water requirements and water resources in Bedford and Fort Beaufort have taken into account information from the All Towns Reconciliation Strategies in the first instance along with information from other recently carried out water resource studies. The same approach has been taken for Adelaide along with a new assessment of population trends and associated domestic water requirements.

2.1.1 Domestic water requirements in Adelaide

Adelaide's primary water source is from the Koonap River via the abstraction weir that supplies Adelaide Dam to the north of Adelaide. The existing Adelaide Dam has an estimated historic firm yield of 0,7 million m^3/a based on approximately 90 years of records. The supply from the dam is backed up by a municipal borehole which is estimated to have a yield of 0,1 million m^3/a and an extension of the Fish River transfer pipeline to Bedford. The gravity pipeline from Bedford to Adelaide has a maximum capacity of 0,315 million m^3/a.

The total assumed current available water resource for Adelaide is therefore estimated to be **1,115 million m^3/a.**

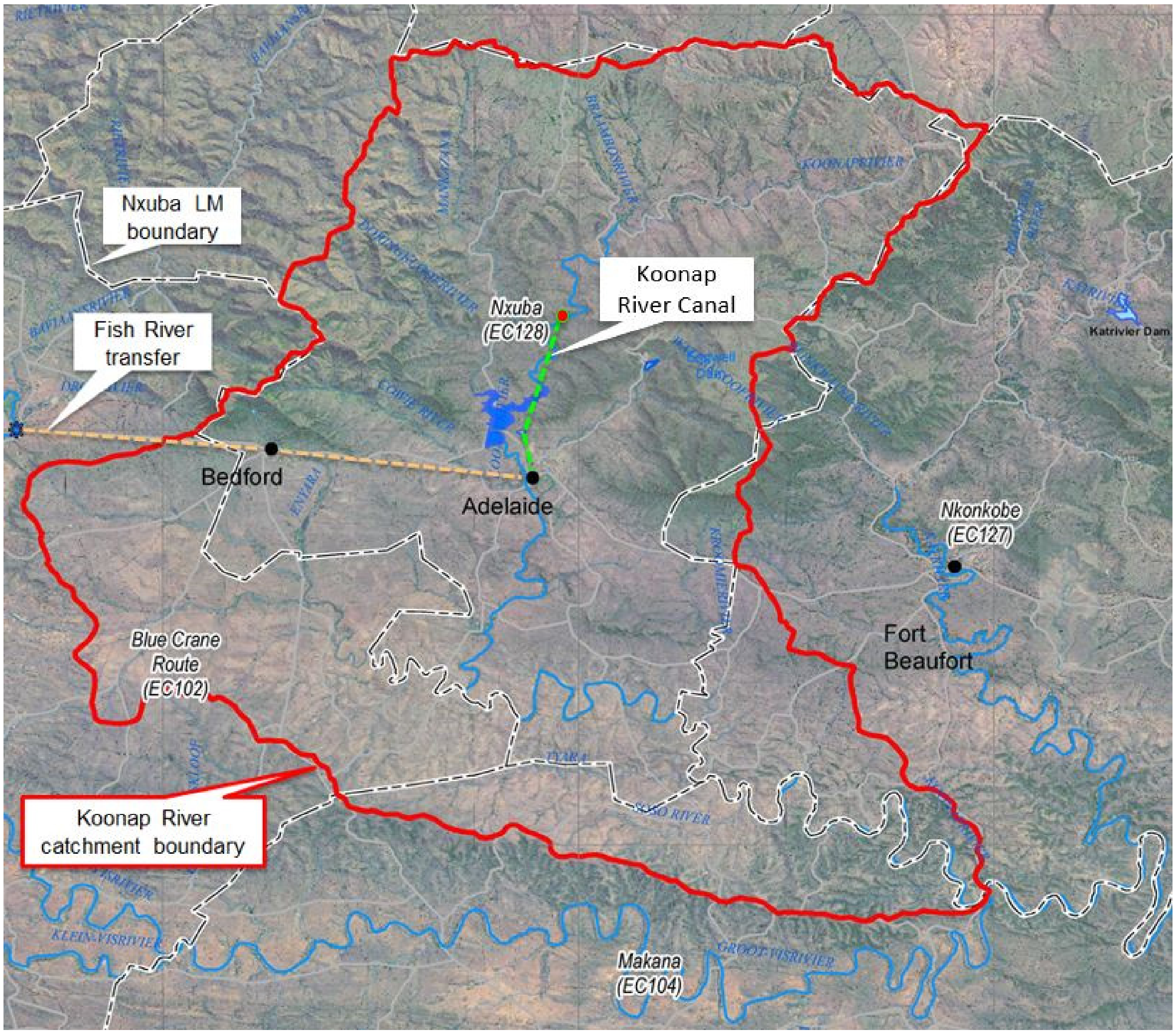

Figure 12: Koonap River Valley showing Adelaide, Bedford and Fort Beaufort

In the Alternative Supplies (DWA 2015) study it is noted that with an increase in capacity of the existing Adelaide dam from 0,7 million m^3 to 1,1 million m^3, the yield of the existing system could be increased by approximately 0,2 million m^3/a. The report also estimates that there is realistic groundwater potential in the Adelaide area of 1,2 million m^3/a.

Projected domestic water requirements

For the purpose of calculating water requirements in the Adelaide area, a review of the urban population in the vicinity of Adelaide was carried out. Existing and projected populations for the town were derived from a comparison of 2001 and 2011 census data. At the time of reporting the historical growth rate of sub-places from the 2011 Census results at a sub-place level have not yet been released, therefore for the purpose of estimating population growth in Adelaide, the average deduced growth rate in Nxuba has been applied to the Adelaide sub-places. Based on Population Census, the following stats for Nxuba are recorded:

Population 2011 = 24 262
Population 2001 = 24 824

This equates to a growth rate of -0,2% between 2001 and 2011 for Nxuba LM. A meeting was held with ADM and Amatola Water (AW, water service provider to ADM) to review these findings and it was agreed that a realistic population growth rate for Adelaide for modelling purposes should be 0%.

For the purpose of context and comparison, water requirements for population growth rates of -0,5%, 1% and 2% were also estimated. A projection period of 30 years from 2018 to 2048 was used. The projection is given in Table 6 below.

Table 6: Projected water requirements for Adelaide based on various growth scenarios.

StatsSA Growth Scenario	Projected Annual Water Requirements (million m^3/a)							
	2013	2018	2023	2028	2033	2038	2043	2048
-0,2% (actual)	0,78	0,77	0,76	0,76	0,75	0,74	0,73	0,73
0,5%	0,78	0,80	0,82	0,84	0,86	0,88	0,91	0,93
1,0%	0,78	0,82	0,86	0,91	0,95	1,00	1,05	1,11
2,0%	0,78	0,86	0,95	1,05	1,16	1,28	1,41	1,56

Due to irregular and inconsistent metering at the Adelaide water treatment works, it has not been possible to determine reliable current water requirements for comparison with the projected requirements based on population and typical consumption. However, in February 2014, ADM published a report including summaries of water flow data at the water treatment works and water storage reservoirs. Although the data is irregular and inconsistent, it is apparent that current end user requirements is approximately 1 600 m^3/day which equates to approximately 0,584 million m^3/a.

For the purpose of design of the water supply infrastructure associated with the proposed Foxwood Dam, a 0% growth projection has been assumed with a resulting water requirement of 0,78 million m^3/a for Adelaide.

2.1.2 Existing domestic water resources in Adelaide

Part of the Alternative Supplies study comprised the investigation into alternative supplies for the provision of potable water to the town of Adelaide as such measures may be required:

- in the event that a large dam at Foxwood is considered unfeasible
- to improve the resilience of the domestic water supply to Adelaide during the implementation period of a possible large dam at Foxwood, or
- to provide increased supply in the future in addition to the development of a large dam at Foxwood.

The report has detailed assessments that were carried out into the three primary existing sources of domestic water to Adelaide. The existing sources are:

- **Koonap River Weir and Off-Channel Storage System**
- **Fish River Pumping Scheme (FRPS) and**
- **Groundwater**

A primary finding was that the design of the existing water supply infrastructure in Adelaide is capable of meeting Adelaide's current and projected domestic water requirements. However, we note that significant portions of the water supply infrastructure is in need of significant maintenance and improved operation procedures. We further note that discussions with ADM confirmed that ADM are very aware of the condition of water supply infrastructure in Adelaide and that there are a number of studies and initiatives underway to improve the situation and resilience of water supply in Adelaide.

Prior to investing further capital expenditure in constructing a possible dam at Foxwood it is important to ensure that maximum use is being made of existing water supply infrastructure. The study also considered **Water Conservation and Water Demand Management** measures in the context of Adelaide. ADM confirmed that the current non-revenue water in Adelaide is estimated at 40%. ADM have commissioned a detailed review of WC&WDM in Adelaide that is currently underway.

The **Koonap River Weir and Off-Channel Storage System** is Adelaide's primary domestic water supply infrastructure. A high level review of the hydrology of this system indicated that with relatively small improvements to the system, such as maintenance to the canal and increased storage in the dam, this system could meet Adelaide's current and projected water requirements at the appropriate level of assurance. The canal capacity is estimated at 100 l/s although the hydrology review of the system indicates an average annual supply of 66 l/s based on the hydrology of the Koonap River.

The **FRPS** was installed as a 'back-up' supply to Adelaide following significant dry periods where water supply to the Adelaide dam was under significant stress. At the time of carrying out the study, it was clear that significant maintenance was required to the system. Subject to appropriate maintenance being carried out, the FRPS is capable of providing a significant contribution to Adelaide's water requirements. The pumped capacity of the pipeline is 30 l/s however it is understood that the gravity section from Bedford to Adelaide can supply at approximately 18 l/s however this source should be secondary to the gravity system of the Koonap River weir.

Groundwater has limited use currently in Adelaide although one municipal borehole is established with a recommended yield of 3,6 l/s (assuming it is pumped constantly). Water supply could be augmented by further wellfield development around Adelaide. The potential yield estimates are in the order of 0,6 million m^3/a to 1,0 million m^3/a. Groundwater should certainly be considered as an option for water resource development particularly as a means of supporting water supply in times of high requirements and water shortage.

It is noted that even with significant growth in population, existing water resource infrastructure is capable of meeting estimated water requirements for a significant time period into the future (refer Figure 13 below). **The status and yield of the existing water supply infrastructure is discussed in detail in the *Feasibility Study for Foxwood Dam Alternative Supplies Report* (DWA, 2015).**

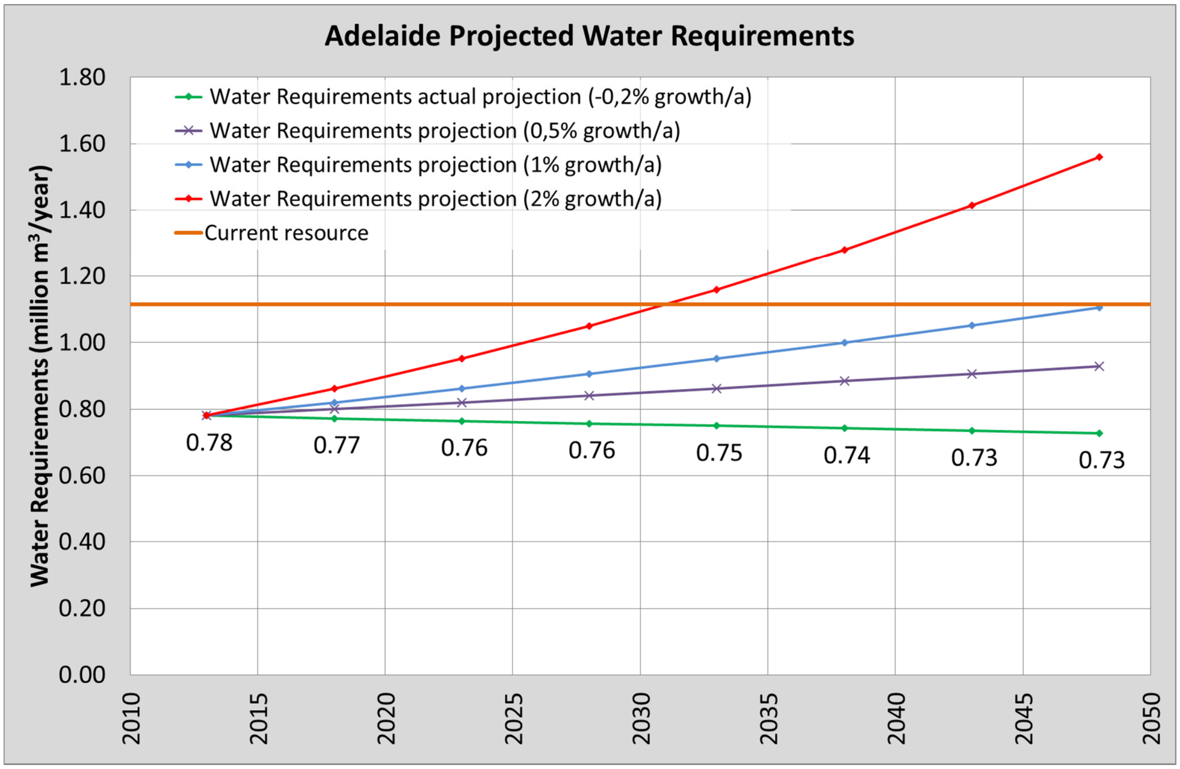

Figure 13: Graph showing projected Adelaide water requirements growth scenarios and existing water resource capacity

2.1.3 Domestic water requirements and water resources in Bedford

Bedford lies approximately 20 km to the west of Adelaide. According to the Reconciliation Strategy for Bedford, Bedford's population was 13 250 in 2007 with a growth rate of -0,29% (derived from the WSDP, based on StatsSA population estimates between 2004 and 2015). The resulting annual bulk water requirement is estimated as **0,526 million m^3/a** with an estimated requirement per capita of 108 l/p/day.

The existing water supply infrastructure has adequate capacity to supply likely future water requirements in Bedford. In line with the objectives of the National Water Resource Strategy, maximum use should be made of existing water supply infrastructure before additional capital expenditure is spent on new infrastructure; the development of a dam at Foxwood is not necessary to meet the likely future water requirements of Bedford. The assessment of the current water resource for Bedford is conservative as it assumes that the full capacity of the gravity pipeline from Bedford to Adelaide is used to transfer water from the Fish River to Adelaide.

In the event that a dam is constructed at Foxwood, there would be no need to transfer water from Bedford to Adelaide, allowing full utilization of the water from the Fish River in Bedford. In addition, it should be noted that, subject to water allocation review and meeting other needs from the yield from the dam, it may be preferable to transfer water from the proposed Foxwood Dam to Bedford in place of the water transfer from the Fish to Bedford. This is primarily due to the probable better quality of the Foxwood Dam water compared to the high silt load of the Fish River water.

2.1.4 Domestic water requirements and water resources in Fort Beaufort

Fort Beaufort is located approximately 35 km to the east of Adelaide, within Nkonkobe Local Municipality. According to the WSDP, Fort Beaufort has a population of 31 700. Fort Beaufort is situated within the Kat River catchment. According to the Reconciliation Strategy for the Kat River Valley the water requirements within the Kat River valley (primarily the towns of Seymour and Fort Beaufort as well as smaller villages) is estimated as **1,2 million m^3/a**. The primary source of water within the Kat River valley is the Kat River Dam located near Seymour. The allocated yield for domestic use from the dam is **1,68 million m^3/a**. However, in a study commissioned by ADM the actual abstractions for domestic use are estimated to be **3,04 million m^3/a**. Allowing for the full irrigation water allocation and the estimated actual domestic water abstraction from the dam, there remains approximately **1,20 million m^3/a** of unallocated water in the dam.

Similarly to Bedford, it can be noted that the existing water resources are greater than current and likely future water requirements. It is unlikely that there will be a requirement in the future to supplement water resources in the Kat River Valley.

2.2 Industrial and commercial water requirements

A review has been carried out of industrial and commercial water requirements in the Koonap River Valley based on the last two records of surface water resources in South Africa (WRC, 1994 and WRC 2008), however none were found. There has been no record of water abstraction for industrial use for the last 25 years and it is considered unlikely that there will be notable future commercial or industrial requirements developed.

Within the most recent Integrated Development Plan issued by Nxuba LM (Nxuba LM, 2013), no reference is made to significant industrial or commercial development.

2.3 Irrigation water requirements

The Koonap River catchment landuse is rural in nature with farming the main activity. There is some irrigation, which is mostly run-off-river abstractions and some cattle farming.

According to the WARMS database (mfeneT@dwa.gov.za; 9 December 2012) a total field area of 21,48 km^2 (2 148 ha) is registered as irrigation in the Koonap River catchment. The irrigation of crops occurs from a number of water sources. Of the total area registered, 93% is registered to surface water sources and 7% to groundwater sources. Most abstractions are from run-of-river sources (88%) with remaining abstractions from farm dams (5%). According to the WARMS database, there is 4,03 million m^3/a of registered allocated abstractions from the Koonap River downstream of the proposed Foxwood Dam site.

Historical information about irrigation was extracted from the WR90 and WR2005 studies (WRC, 1994; WRC, 2008). The declining trend in irrigation area within the Koonap River catchments is not unexpected. It has been noted, anecdotally, by farmers that irrigation development in the Koonap River Valley has been limited by the poor reliability of water supply.

Following consultation with stakeholders an Agricultural Technical Working Group was convened to identify the potential for agriculture development downstream of the proposed Foxwood Dam in the event of the construction of the dam. Out of this consultation, it was clear that there is both willingness and opportunity to develop irrigation downstream of the potential site so long as economically viable agricultural models can be established to pay for the cost of the water. There is sufficient irrigable land that could be developed and irrigated with available yield from an appropriately sized major dam at the Foxwood site.

2.4 Opportunity for regional water resource development - Fish River Context

Considering the limited future opportunities for further water resource development within South Africa, it is important to consider the widest possible opportunities that the Foxwood Dam project can offer.

The Koonap River is a tributary of the Great Fish River (refer Figure 14, an A3 copy is provided in Appendix A), within the Fish-Tsitsikamma Water Management Area (WMA). 575 million m³/a of water is allocated from the Orange River Project for transfer into the Great Fish River to augment the availability of supplies for domestic and irrigation use. The introduction of Orange River water also improves the water quality in the Great Fish River. As the Koonap River is a tributary of the Great Fish River, the study has also considered whether there is potential to regulate flow within the Koonap River to yield additional water to the Great Fish River and possibly relieve some of the burden on the Orange River.

However, at present all of the water available for use along the Great Fish River, mainly the portion intended for new irrigation development, is not yet used in this economic sector. In addition, the potential yield of a proposed new major dam in the Koonap River is small by comparison with the as yet unused resource in the Great Fish River. As a consequence there is no apparent merit in gaining a regional benefit by using the proposed dam in the Koonap River to regulate the flow in that tributary to further increase the availability of water for use in the Lower Great Fish River.

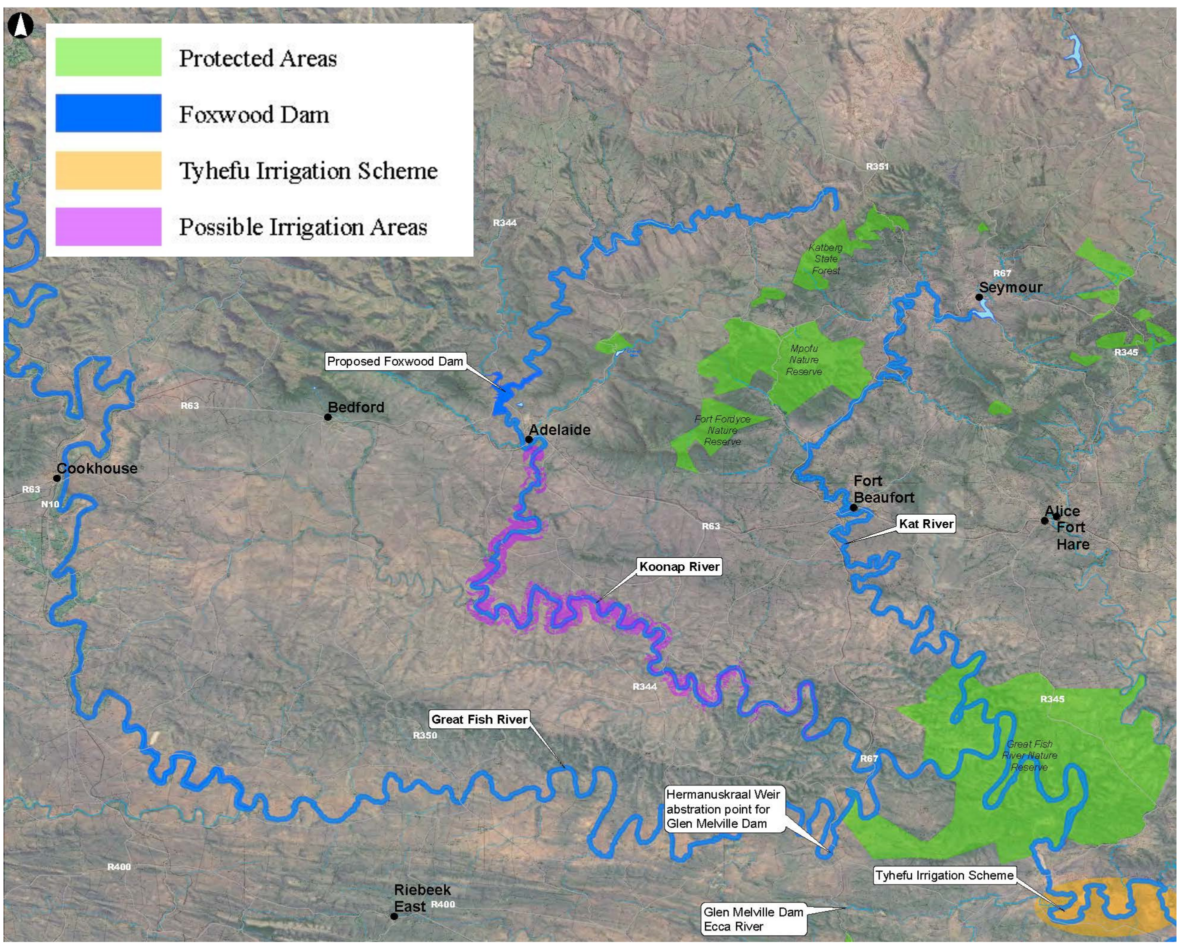

Figure 14: The Koonap River as a tributary of the Great Fish River

From a water resource management and system operation point of view it is important to take cognisance of the following:

- There is a long distance from the proposed Foxwood Dam site to the confluence of the Koonap River with the Fish River, giving rise to significant losses in transmission if the river is used to convey releases from the dam, and
- The confluence of the Koonap River and the Great Fish River is downstream of all points where inter-basin transfers from the Orange River Project are abstracted for use.

From an operational point of view therefore, the opportunity for the Koonap River to add useful water to the Great Fish River is limited. A full memorandum addressing the potential opportunity to use Foxwood Dam to yield water for use in the Great Fish River is provided in Appendix D.

2.5 Conclusion – the ‘need’ for Foxwood Dam

It is apparent that the water resources of the towns of Adelaide, Bedford and Fort Beaufort are all sufficient for current domestic requirements and for most future domestic requirements within a 30 year planning horizon. It is clear that the existing water resources infrastructure is generally in need of improved operation and maintenance and that an increased focus on water conservation and demand management is essential. This is the responsibility of Amathole District Municipality as the WSA and it is understood that various projects and programmers are underway to address this aspect.

Nevertheless, it is also apparent that there is real potential for the flows of the Koonap River to be regulated in such a way that improved assurance of yield can be achieved that would provide long term assurance of supply for the local towns but that would also, importantly, provide a stimulus for socio-economic development through the growth in the agricultural sector in the Koonap River valley. Growth that has been limited historically by, primarily, uncertainty in water supply.

Based on this opportunity for agricultural sector growth in the Koonap River valley, and given that there is little apparent benefit to developing the Foxwood Dam to provide a regulated contribution to the great Fish River, this project has focused on the potential for Foxwood Dam as a strategic initiative to mobilize the water resources in the area as a stimulus for socio-economic development in this rural, economically depressed region.

3 KOONAP RIVER WATER RESOURCE

This section provides summary details of salient information extracted from the comprehensive report on the Koonap River Water Resource:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Koonap River Hydrology, P WMA 15/Q92/00/2113/7

3.1 Introduction

Hydrological and yield analyses were undertaken to assess the impact of current development levels on the availability and reliability of water supply to users in the Koonap River catchment. The following tasks were undertaken as part of the water resources assessment:

- Determining current (2012) land use practices and estimated current water use
- Updating and extending the hydrology of the Koonap River catchment to cover the period from 1920/21 to 2011/12.
- Generating time series of natural monthly streamflows for all sub-catchments within the Koonap River for the selected study period.

The rainfall-runoff modeling for the hydrological analysis was undertaken using version 2.7 of the Pitman model. Outputs from the hydrological analysis served as direct input to the water resources system yield analyses.

The main objectives of the yield analysis included:

- Generating time-series of present day flows at selected Reserve sites.
- Determining the historical firm yields (HFY) and long term stochastic yield of Foxwood Dam.
- Determining the short-term stochastic yield of Foxwood Dam.

The model used for the yield analyses was version 7.5.6.7 of the Water Resources Yield Model (WRYM) which is located within version 3.8.2 of the Water Resources Information Management System (WR-IMS).

Background information
The following studies have information about the Koonap River system:

- Surface Water Resources of South Africa (WRC, 1994)
- Water Resources of South Africa 2005 (WRC, 2008)
- Adelaide Water Supply: Proposed Foxwood Dam (Ninham Shand, 1992).
- The WR2005 hydrology for the Koonap River system (Q92) was used as the basis for this study. The WR2005 system configuration and extended from 2004/5 to 2011/12.
- A copy of the DWS's Water use authorization and registration management system (WARMS) for the Koonap River (Q92) catchment was provided by DWS in the Eastern Cape

The catchment area of Foxwood Dam is 1 091 km² which is 33% of the total area of the Koonap River catchment (3 334 km²) (see Figure 15). Important tributaries of the Koonap River include the Braambospruit, Mankazana, Waterkloof and Enyara Rivers. The Foxwood Dam and Lower Koonap River catchments have similar land use in that both catchments are rural in nature with agriculture the dominant activity.

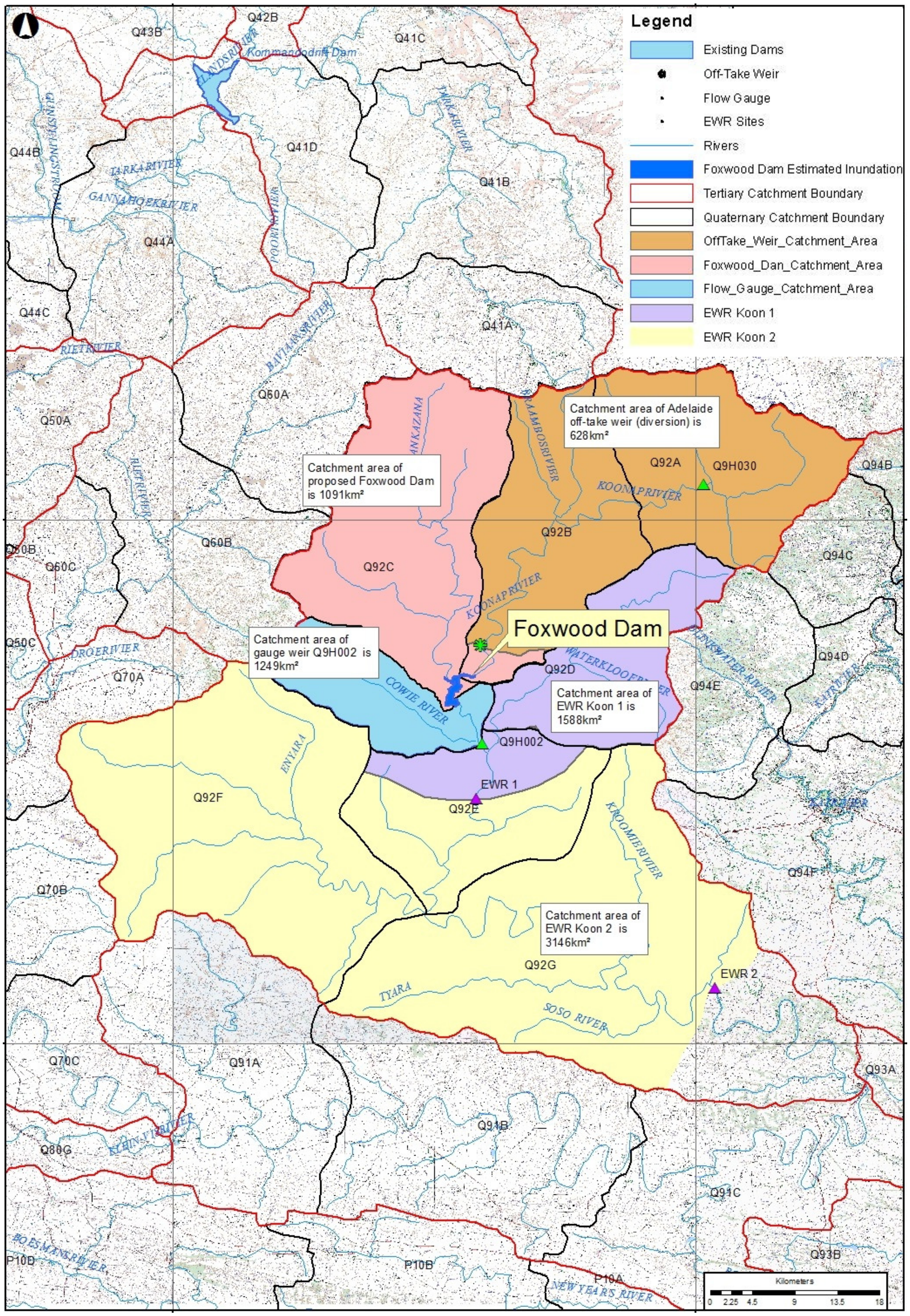

Figure 15: Koonap River and Foxwood Dam catchments and related sub-area

3.2 Water Use

For the purpose of calibrating the Pitman rainfall-runoff model and for calibrating the yield of the proposed Foxwood Dam, all historical and current (2012/12) human interventions that impact on the stream flow generated within the modeled catchments was taken into account. Abstractions and return flows by domestic users and irrigators are assessed. Also considered was the impact on stream flow from commercial forestry, alien invasive plants as well as groundwater abstractions and farm dams. However, the principal water use is for the required Ecological Water flows.

3.3 Ecological Water Requirements

The potential yield at the Foxwood Dam site can only be determined after the Ecological Water Requirements of the Koonap River have been determined and quantified. In terms of the River Reserve Study, the catchment is from Foxwood Dam to the Fish River confluence. The locality of the EWR sites in the Koonap River within the Management Resource Units (MRUs) as identified during this study is provided below in Table 7: EWR Locations. Photos of the sites and the site locations are provided in Figure 16 also their locations are illustrated in Figure 17 below.

Table 7: EWR Locations

EWR site	KOON1	KOON 2
Latitude	32.76671	32.94719
Longitude	26.28989	26.5187
Level II EcoRegion	18.02	18.02
Altitude (masl)	538	340
MRU	MRU Koo A: Foxwood Dam site to the eNyara River.	MRU Koo B: Downstream of MRU 1 to the Great Fish confluence.
Quaternary catchment	Q92E	Q92G
River gauge	Q9H002	None


Figure 16: Photos of EWR 1 (left) and EWR 2 (right)

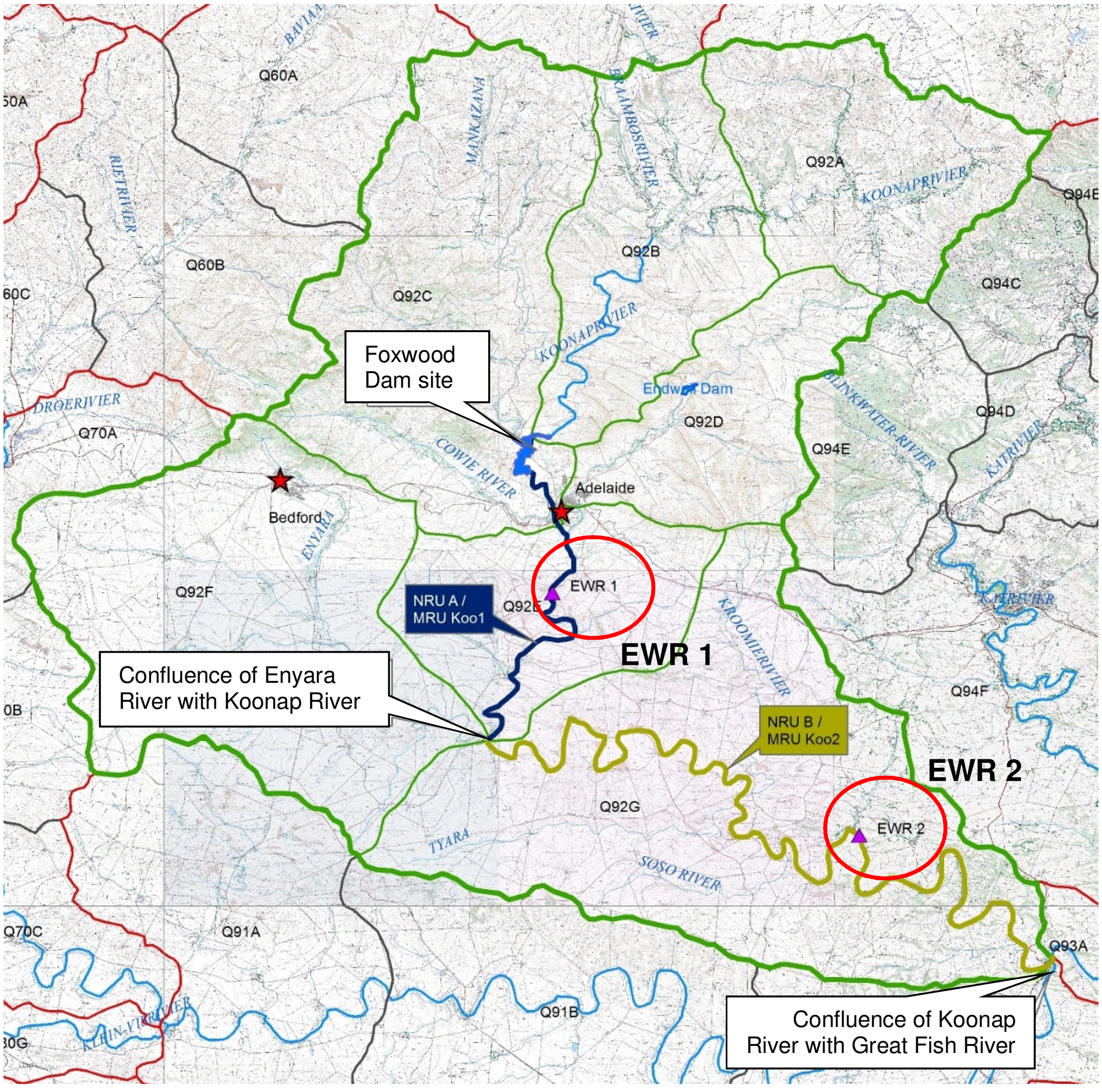

Figure 17: EWR sites locations

3.3.1 EWR quantification

The Intermediate Ecological Reserve Methodology (IERM) was applied to determine the EWR.

The EWR final flow requirements are expressed as a percentage of the natural Mean Annual Runoff (nMAR) and are provided in Table 8 below:

Table 8: Summary EWR as a percentage of the nMAR

					Long term mean					
EWR site	PES	REC	nMAR (million m^3)	pMAR (million m^3)	Low flows (million m^3)	Low flows (%nMAR)	High flows (million m^3)	High flows (%nMAR)	Total flows (million m^3)	TOTAL (%nMAR)
KOON 1	C	C	62,93	52,04	2,997	4,8	7,08	11,25	10,076	16
KOON 2	C	C	77,54	65,30	6,917	8,9	9,624	12,41	16,541	21,33

The intermediate level Ecological Water Requirements (EWR) study identified the Recommended Ecological Category (REC) as a C-category at both EWR sites, which is the same as the Present

Ecological State (PES). The operating rule recommended by the Reserve specialist is that the low flow EWR assurance rule should be implemented at these sites and that that high flow EWRs should be met by spills from Foxwood Dam and that the low flow EWRs can be met by inflows from the incremental catchments downstream of Foxwood Dam. Provision for the EWR requires a discharge of up to 6 m^3/s.

3.3.2 Fish River Estuary

A scoping study was carried out to determine the potential impacts of the Foxwood dam development on the Great Fish River Estuary by applying the results of the EWR assessment of the Foxwood Dam development on the Fish River system.

It was determined that the development of Foxwood Dam would maintain the PES of the Great Fish River Estuary albeit at a slightly reduced condition (1 – 2% reduction in ecological condition), but would not meet the REC of a B/C.

3.4 Hydrological analyses

3.4.1 Storage characteristics of the Foxwood Dam site

below depicts the area-storage relationship for the Foxwood Dam site.

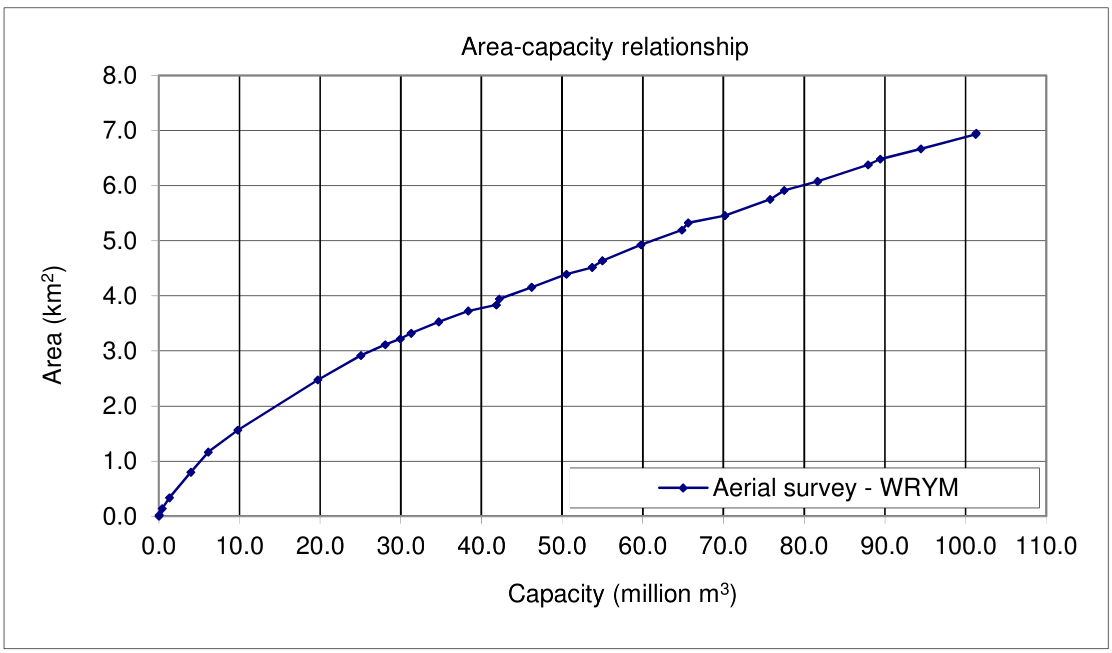

Figure 18: Area-capacity relationship for Foxwood Dam site

3.4.2 Rainfall and stream flow

The Koonap River catchment falls within the summer rainfall zone, but is located adjacent to the year-round zone of coastal catchments, which means rainfall can occur at any time of the year. The Mean Annual Precipitation (MAP) varies from 662 mm in the northern headwater catchments in the Winterberg Mountains to 446 mm in the southern Enyara River catchment.

Information about rainfall was obtained from previous studies and from the DWS in the Eastern Cape. A total of 21 rain gauges in and around the Koonap River catchment were identified and screened using standard validation tests. After screening, 4 gauges were excluded from further analysis. The remaining gauges were used in the patching process to generate catchment rainfall records for the period 1920 to 2011 (92 years). The Mean Annual Symons Pan Evaporation (MAE) in the Foxwood Dam catchment area is in the order of 1 651 mm.

There are two operational flow gauges within the Koonap River catchment. The Q9H030 gauge is located in the headwaters of the Foxwood Dam catchment. The Q9H002 gauge is located just downstream of the proposed site for Foxwood Dam.

3.4.3 Rainfall-runoff calibration and natural flows

The naturalized stream flows for all catchments were generated and compared with previous studies. The results of the comparison show similar unit runoffs across studies. The naturalized MAR at the proposed Foxwood Dam site is 47,61 million m^3/a.

3.4.4 Loss of storage due to sedimentation

The Koonap River catchment falls within Region 9 of the sediment yield potential map of Southern Africa (WR90, Vol. 5, Map 8.2, 1994). The estimated average rate of sedimentation in the Upper Koonap catchments is 185 tons\km^2\annum based on the Rooseboom methodology (Rooseboom, et al, 1992). This region is characterized by medium erodibility indices.

The loss of storage from sedimentation for the proposed Foxwood Dam was determined for various life spans for a reservoir capacity of around 1 nMAR and is summarised in Table 9.

Table 9: Dead storage volumes for Foxwood Dam

Life span	Dead storage volume (million m³)	
(years)	100% trap efficiency	95% trap efficiency
20	4.21	4.00
30	5.19	4.93
40	5.89	5.60
50	6.43	6.11

In terms of the yield analysis a life-span of 50 years has been assumed for Foxwood Dam and dead storage of 6,11 million m^3 for all storage capacities.

3.5 Yield model configuration

The Water Resources Yield Model has been configured to assess the historic, long-term and short-term capability of the Foxwood Dam system for a range of live storage capacities ranging from 23,8 million m^3 to 95,2 million m^3. These live capacities are equivalent to nMAR's (Mean Annual Runoff) of 0,5 nMAR to 2 nMAR. Analyses were undertaken based on a monthly time-step and at-present day (2011/12) development levels.

3.5.1 Scenario development

Three water requirements scenarios have been addressed in previous studies (DWS 2015a):

- Scenario 1: Best estimate of present day (2012/13) development levels with Foxwood Dam.
- Scenario 2: Best estimate of present day (2012/13) development levels with Foxwood Dam and **Total Flow EWR** assurance rule implemented.

- Scenario 3: Best estimate of present day (2012/13) development levels with Foxwood Dam and **Low Flow EWR** assurance rule implemented.

3.5.2 Yield model results

The results of the firm yield, long term and short term stochastic yield assessments for Foxwood Dam for range of storage capacities are provided for scenarios 2 and 3 in Table 10 and Table 11. The critical period (CP) of Foxwood Dam, for the various dam sizes are also noted in Table 10 and Table 11. The length of the CP is a function of the size of reservoir and the degree of variation in the streamflow and allows identification of the start and end of the low flow period over the historical record. The CP's for both scenarios for live storages of 1,5 nMAR and greater are long (greater than 10 years), indicating that the Foxwood Dam at these storage capacities will NOT spill for extended periods thus requiring release gates to support the Koonap River Reserve.

Table 10: WRYM model results - Historic and long term yields of proposed Foxwood Dam for range of storage capacities

Reservoir capacity as a ratio of nMAR	FSL Elevation	Wall height	Live storage	Dead Storage	FSC	EWR KOON1	EWR KOON2	HFY	Critical period		Long term yield ($10^6m^3/a$) at Recurrence Interval		
	(m.a.s.l)	(m)	(10^6m^3)	(10^6m^3)	(10^6m^3)	(million m^3/a)			Start	End	1:20	1:50	1:100
Scenario 2 – Foxwood Dam system with EWR rule supplied for total flows (incl. high flows)													
0,5 nMAR	608,5	33,5	23,81	6,11	29,92	7,86	13,00	6,88	7/1944	4/1948	9,7	7,8	6,7
0,75 nMAR	611,6	36,8	35,71	6,11	41,82	7,86	13,00	9,69	7/1944	3/1950	13,7	11,1	9,3
1,0 nMAR	614,6	39,6	47,61	6.11	53,72	7,86	13,00	12,52	7/1944	4/1950	15,9	13,3	11,3
1,5 nMAR	619,5	44,5	71,42	6.11	77,52	7,86	13,00	17,50	7/1954	9/1970	19,8	16,9	14,9
2,00 nMAR	623,1	48,1	95,22	6.11	101,33	7,86	13,00	18,91	7/1954	12/1970	22,8	19,5	17,2
Scenario 3 – Foxwood Dam system with EWR rule supplied for low flows (excl. high flows)													
0,5 nMAR	608,5	33,5	23,81	6,11	29,92	2,18	5,30	10,23	7/1944	4/1948	12,8	11,0	9,5
0,75 nMAR	611,6	36,8	35,71	6,11	41,82	2,18	5,30	13,36	7/1944	3/1950	17,2	13,8	12,4
1,0 nMAR	614,6	39,6	47,61	6,11	53,72	2,18	5,30	16,56	7/1944	3/1950	19,1	16,4	14,6
1,5 nMAR	619,5	44,5	71,42	6,11	77,52	2,18	5,30	20,47	11/1986	4/1997	22,9	20,3	18,0
2,00 nMAR	623,1	48,1	95,22	6,11	101,33	2,18	5,30	21,88	7/1954	12/1970	26,2	22,8	20,6

Table 11: WRYM model results - Short term yields of proposed Foxwood Dam with live storage capacity of 1nMAR

Recurrence Interval	Short term yields for various starting storages ($10^6m^3/a$)					
	100%	80%	60%	40%	20%	10%
Results for scenario 2 for 1nMAR dam with Total Flow EWR						
1:5	28,7	27,7	25,7	23,5	19,2	14,4
1:10	23,0	21,8	20,2	17,5	12,9	9,3
1:20	19,0	17,6	15,9	13,1	9,0	6,2
1:50	15,4	14,0	11,9	9,4	5,7	3,5
1:100	12,8	11,7	10,4	7,1	4,5	2,3
1:200	11,3	10,6	8,7	5,8	3,6	1,8
Results for scenario 3 for 1nMAR dam with Low Flow EWR						
1:5	32,0	30,6	29,0	26,6	21,6	15,6
1:10	26,3	24,8	23,0	20,4	15,7	11,0
1:20	22,1	21,0	19,1	15,8	11,7	8,0
1:50	18,5	16,9	15,1	12,0	8,4	5,6
1:80	16,4	15,4	12,7	10,8	6,7	4,3
1:100	15,3	13,7	11,1	9,9	5,6	3,3

At live storages of 1,5 nMAR and greater, the yield gained relative to the increased storage capacity is insignificant as shown by the flattening of the curves in Figure 19.

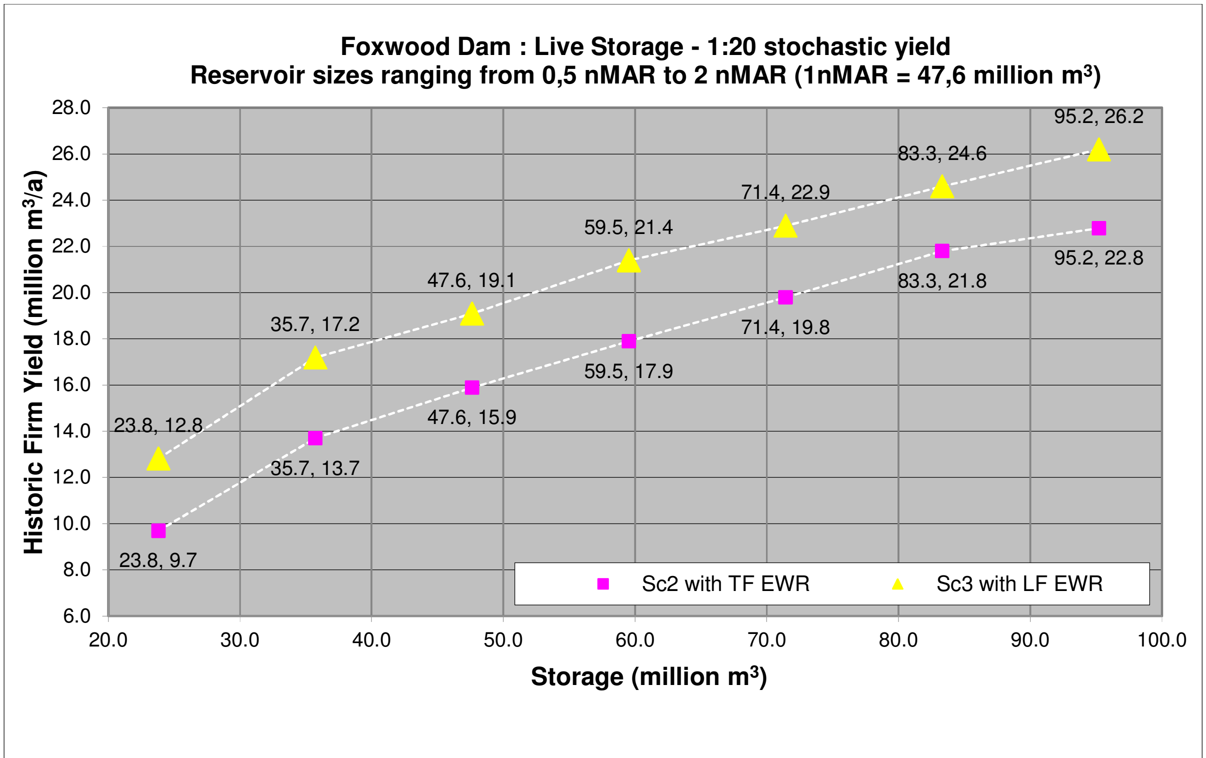

Figure 19: 1:20 year stochastic yield for low flows and total flows EWR requirements

For both scenarios for live storages of 1,5 nMAR and greater the yield gained relative to increased storage capacity is insignificant as shown by a flattening of the storage-yield relationship.

3.6 Hydropower potential

A prefeasibility assessment of installing hydropower generating capacity at the proposed Foxwood Dam was carried out. The hydropower parameters and generating capacity were develop and assessed based on an assumed operating rule implementing Total Flow EWR requirements for the Koon1 and Koon2 EWR sites. Table 12 below summarises the parameters assumed for the modelling of the possible hydropower plant and Table 13 summarises the results from the assessment.

Table 12: Hydro parameters for proposed Foxwood Dam hydropower plant

No.	Description	Hydro parameters
1.	Rated flow	
2.	Flow at maximum efficiency	
3.	Minimum flow	
4.	Elevation of water at intake (full supply level)	614,6 masl
5.	Elevation of water at tailrace (tail water level)	575,0 masl
6.	Elevation / location of turbine (3,5 above TWL)	578,5 masl
7.	Design Head	36,1 m

No.	Description	Hydro parameters
8.	Minimum operating head (65% of Design Head)	23.5 m
9.	Maximum operating head (includes dry free board)	40.1 m
10.	Estimated losses through system at maximum flow conditions (excluding through turbine and draft tube)	0.90
11.	Head loss through plant (m over design head)	5.5%
12.	Turbine generation capacity	150; 200; 250 kW

Table 13: Results of hydropower assessment for proposed Foxwood Dam Hydropower Plant

Generation capacity	Average Energy generated	Ratio	Zero energy months
250 kWh	180 kW/h	0.72	Significant > 10%
200 KW	170 KW	0.85	Around 3%
150 KW	140 KW	0.93	0%

The likely average energy generation that would be achievable at the Foxwood Dam site would not be sufficient for contribution to a local grid. Therefore it is not considered further within the development proposals. However provision is allowed for in the outlet works configuration for installation of a generator in the event that the future dam operator may make use of the power to operate a pump or similar ancillary equipment.

3.7 Hydrology conclusions and recommendations

- The catchment rainfall generated for the Foxwood Dam and Koonap River system for the period 1920 to 2011 is considered acceptable and is appropriate to be used in the rainfall runoff model and in the yield model.
- The hydrology developed during this study produced acceptable calibrations and could be used to setup the yield model (WRYM) to determine the yield of the Foxwood Dam system for a range of reservoir sizes ranging from 29,9 million m^3 to 101,3 million m^3.
- The EWR operating rule recommended for the Foxwood Dam system is that high flow EWRs should be met by spills from Foxwood Dam and that the low flow EWRs can be completely met by inflows from the incremental catchments downstream of Foxwood Dam. This operating rule impacts the storage size of Foxwood Dam as it is important that regular spills can occur.
- The final storage capacity of Foxwood Dam will depend on the requirements that need to be supplied by the dam and the operating rule recommended for the Reserve. The requirements still require clarification while an operating rule has been recommended by the Reserve specialist.
- The results of the yield analyses and the Reserve study indicate that Scenario 3 should be used to determine the final storage capacity of Foxwood Dam.
- The likely storage capacity of Foxwood Dam should be in the range of 29,9 million m^3 to 53,7 million m^3 with 1:20 yields of 9,7 million m3/a to 19,1 million m^3/a.
- All yield results were determined using a ‘constant use’ demand pattern of supply.
- The hydropower generation potential at the site does not warrant development of a hydropower scheme.

The following recommendations will apply if Foxwood Dam is developed:

- All land use information including water abstractions upstream of Foxwood Dam requires verification and confirmation.
- The status of all users in the Foxwood Dam system must be clarified. Including the assurance of supply to users.
- Hydro meteorological and Ecological Water Resources Monitoring Programmes should be initiated as soon as possible and should include:
  1) Weather station to be installed at Foxwood Dam and rain gauges at selected locations in the Upper Koonap River catchment. Currently there are no operational rain gauges in the catchment area of Foxwood Dam.
  2) Flow gauges are required at or near EWR sites to assist in hydraulic modeling of the system.
- Hydraulic modeling of the Foxwood Dam system should be considered to confirm the operating rule for the Reserve. This should be supported by a cost benefit analysis to establish the cost of outlet works for the Reserve.
- The extent of water requirements that will be supported by Foxwood Dam requires confirmation.
- The pattern of supply or abstraction from Foxwood Dam still requires defining. The system yields will have to be reassessed once the pattern of supply is defined.
- The final storage capacity of Foxwood Dam will depend on the requirements that need to be supplied by the dam and whether high flow EWR’s can be met by spills from Foxwood Dam and low flow EWR’s met by inflows from the incremental catchments downstream of Foxwood Dam.
- An Operational model should be setup up of the Foxwood Dam system.

4 KOONAP RIVER WATER QUALITY

This section provides summary details of salient information extracted from the main reports on Water Requirements and Water Quality:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Water Requirements, P WMA 15/Q92/00/2113/8

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Water Quality, P WMA 15/Q92/00/2113/10

To assess any likely required treatment for use of the water for potable or irrigation purposes the quality of water within the Koonap River was reviewed. The condition of the existing water treatment works was also checked and recommendations are made here regarding the dam design to optimize impact on water quality resulting from construction and operation of the dam.

4.1 Review of historic DWS records

Historical water quality data for the period 29 August 1971 to 19 June 2012 were obtained from the DWS water quality database. Three sample locations have been referenced. Their location is shown in Figure 20 below and their details are provided in Table 14 below:

Table 14: Water quality monitoring points on the Koonap River

Monitoring Point Name	Latitude	Longitude	Number of samples
Q9H014Q01 Koonap River at Frisch Gewaagd/Groenkop	-32.4647	26.51083	191
Q9H016Q01 Koonap River at Schurftekop	-32.4992	26.36556	343
Q9H002Q01 Koonap River at Adelaide	-32.7139	26.29667	595

These data sets are readily available from the DWS web site and additional updates (going forward) are made available from time to time. The primary site for the Koonap River at Adelaide is located on the outskirts of the town and has a DWS Reference (or Station) Number of Q9H002Q01 (-32.7139 S, 26.29667 E). Given the length of the data record the information is suitable for determining trends and ranges but often does not provide the detail, or the parameters, that are useful for assessing the treatability of the raw water.

In an attempt to assess the suitability of the Koonap River water for drinking purposes the data set was ranked and the range (minimum and maximum) for each parameter determined. In addition the 25, 50 (median value), and 75 percentile were calculated.

Only the Conductivity and Hardness fall into a Class 1 classification (Class 1 corresponds to the required parameter limits for drinking water, and are 150 mS/m for electrical conductivity and 300 mg/l for total hardness). It is probable that both of these extreme values were recorded during a drought cycle (when salts would be more concentrated), and probably at low flows (or possible at a point where there was no flow in the river). It would be reasonable to conclude that when water flow is present then the raw water (after treatment) has the potential to be classified as a Class 0 drinking water for more than 75% of the time.

In the context of this investigation, the proposal is to establish a dam at the Foxwood site, and the dam would store water during wet cycles. It would therefore be expected that the water quality in the dam would generally be a Class 0. It is also possible that for a significantly greater period of time the incidence of higher conductivity and hardness in the raw water storage reservoir would be limited to extreme drought conditions, and then only when the dam was drawn down to very low levels.

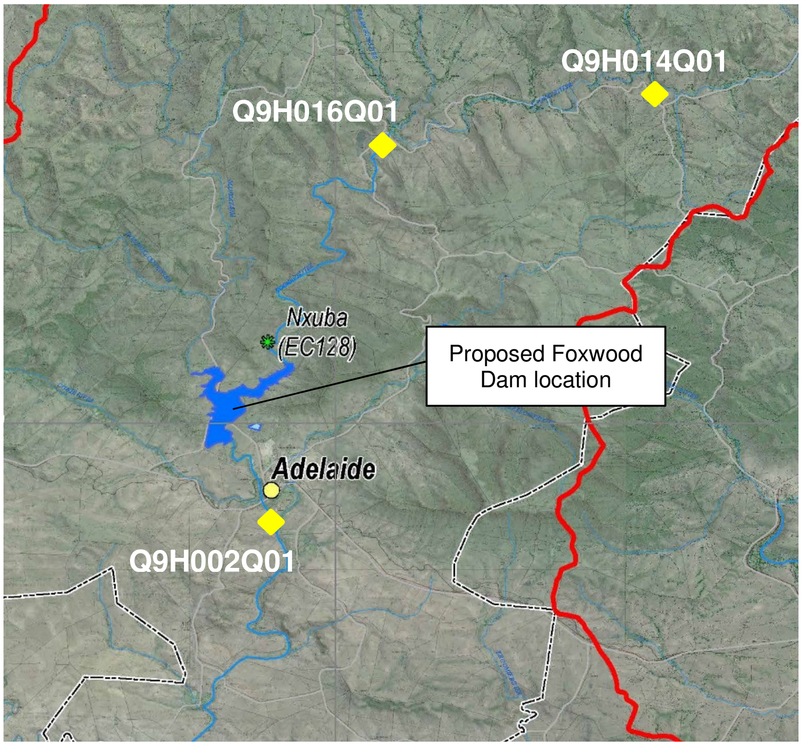

Figure 20: DWS water quality sample locations on the Koonap River

4.2 Water quality for irrigation

With regard to irrigation, the main water quality issues are salinity and total hardness. Many crops cannot tolerate high salt levels and scaling resulting from water hardness impacts on irrigation infrastructure. An initial review of water generally indicates that water quality within the Koonap River is acceptable for irrigation. Calculated from the sodium, calcium and magnesium, Sodium Absorption Ration of the water is within acceptable limits.

Further detailed water quality testing should be carried out in conjunction with soil testing at the specific proposed locations for irrigation development due to the importance of the relationship between water and soil quality in conjunction for crop development. It is noted that the WARMS database has registered abstractions of 12 million m^3/a for irrigation within the Koonap River catchment with the majority of this being from run-of-river.

4.3 Additional sampling and review

One shortcoming of the water quality data is the limited data on the turbidity and suspended solids for the Koonap River. As both parameters can impact on the siltation, storage reduction and treatment requirements it is recommended that, if the project is implemented, consideration be given to weekly sampling of the Koonap River to determine the seasonal silt loads and to confirm water quality upstream of Adelaide.

A concern is that the suspended sediments might negatively impact on the treatability of the raw water. On the other hand the less clear water may reduce light penetration and, as a consequence, algal build-up may be reduced. It is for this reason that we would recommend that weekly samples for sediment and turbidity be collected in the vicinity of the proposed dam for a period of at least 24 months. If such an investigation were to proceed it would be prudent to include additional testing as required.

4.4 Water quality considerations for Foxwood Dam

It is recommended that the off-take structure be provided with draw-offs at regular intervals to 25 m below top water level. The top highest outlet should be 5 – 8 m below full supply level with two further outlets at regular intervals down to a level of approximately 25 m below full supply level.

4.5 Water treatment

The historical water quality data and the confirmatory grab samples and testing conducted during the assessment give no indication that the water from the Koonap River is difficult to treat. The current water treatment works (WTW) appears to be able to produce a potable water from both the Fish and Koonap River supplies with limited equipment and expertise at the water treatment works. No reliable final water quality assessments for the water treatment works were available and grab sampling of the town supply was the only basis for assessing the actual water quality achieved. It is expected that the building of an in-stream dam will result in a more stable raw water quality with smaller seasonal variation.

Based on experience within the general area, and observations at the existing water treatment works, a standard configuration water treatment works would be able to provide a Class 0 quality water for 95% of the time provided that the works was adequately designed, operated and maintained.

The primary components of such a works would require:

- Adequate and consistent water supply and quality
- Flocculant dosing and coagulation
- Sedimentation of flocs
- Removal of sediment
- Filtration of the settled water
- Disinfection and sterilization of the final water
- Safe storage and distribution

In addition such a works will require qualified personnel to operate and maintain the works and to conduct the necessary process control and confirmatory testing.

4.6 Adelaide Water Treatment Works

The existing water treatment works was originally established in about 1957 and has been modified in at least 3 contracts since then. During January 2013 the works was inspected and observations made on the operation and performance of the current works. The water quality assessment was limited to the raw and final water.

The design capacity of the works is the subject of some debate as the District Municipality suggests that the works has a capacity in excess of 7 000 m^3 per day while a KV3 assessment (post 2000) refers to a design capacity of 240 m^3 per hour (5 700 m^3 per day). Current raw water inflows to the WTW suggest that the works is processing 850 000 m^3 per annum (equivalent to 2 330 m^3 per day or 97 m^3 per hour) of raw water.

4.6.1 Configuration of the existing works

The existing works set up conforms to the general requirement to treat the raw water received at the works and the general layout of the works is described in Figure 21 below.

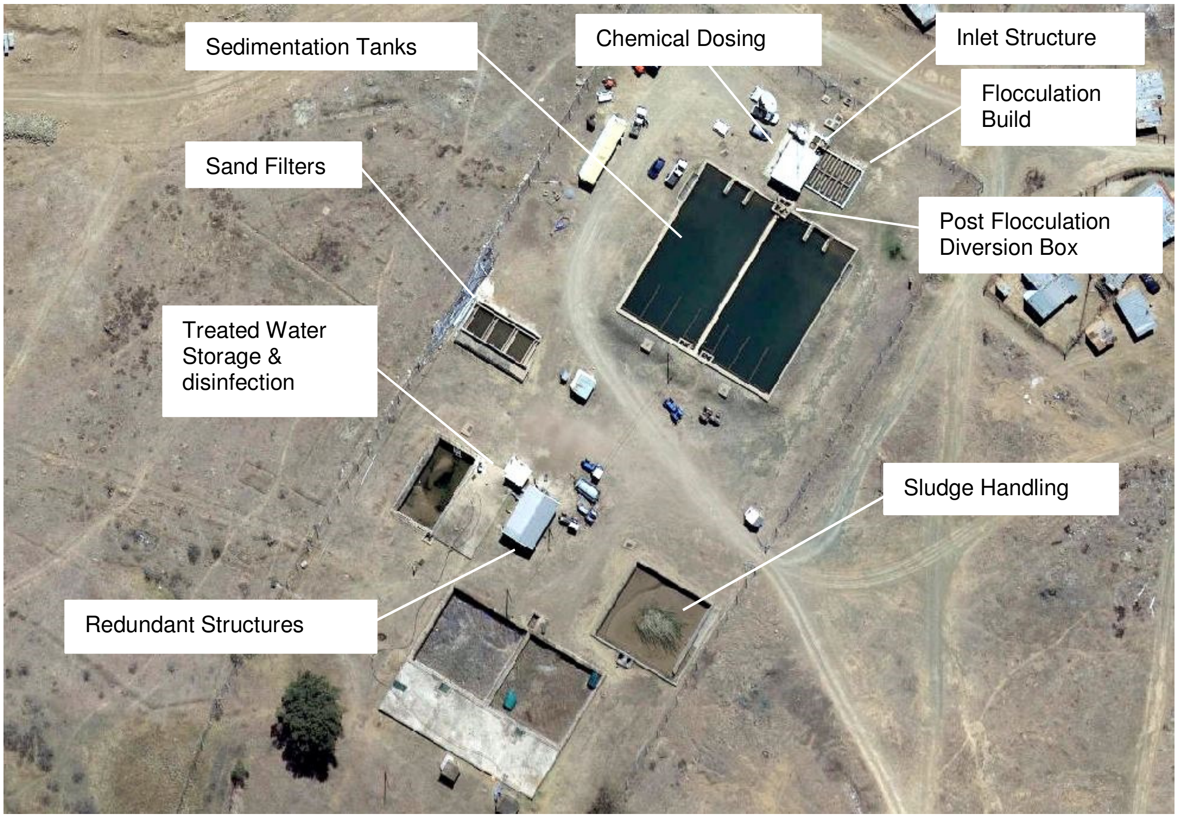

Figure 21: Adelaide Water Treatment Works Layout (October 2013 Aerial Imagery)

There are a number of shortcomings related to almost all aspects of the maintenance and operation of the existing treatment works. There is limited control of chemical dosing, limitations to the effectiveness of flocculation, sedimentation, filtration etc. It is probable that a well trained and experienced operator would be able to maintain operation (and water quality) for the majority of the time. The configuration and current state of the works would not make this an easy task.

On the basis of location and accessibility of the works to competent support, there are real risks to failure at the site, and at the very least the works will need a major overhaul and alteration to consistently be able to produce a compliant potable water quality from the site. Considering the list of identified concerns detailed in the Water Quality Report (DWS, 2015d) it appears difficult for the works to be modified or rehabilitated to reliably produce a fully compliant water quality in terms of SANS 0241- 2011 on a consistent basis. In terms of water production, a revised inlet structure, chemical dosage and storage facilities and improved sedimentation and sludge disposal infrastructure are required. In terms of storage of water the reservoirs need to be secured and the disinfection system operated and maintained on a continuous basis.

4.6.2 Conclusions

In conclusion we note that the Koonap River water has been used for potable use with relatively simple treatment as well as being used for irrigation. Further data sampling is required regarding tubidity of the water to gauge potential siltation. However, with appropriately designed intake levels within the intake tower, no issues with water quality are expected.

5 AGRO-ECONOMIC POTENTIAL

This section provides summary details of salient information extracted from the study module report on the proposed Irrigation Development:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Agro-Economic Study, P WMA 15/Q92/00/2113/9

As concluded in section 2.5, the potential has been identified for the development of Foxwood Dam as a strategic initiative to mobilise the water resources of the Koonap River as a stimulus for socio-economic development. The concept of a Government Irrigation Scheme offers a vehicle for realizing the potential socio-economic value that can be achieved through the development of water, land and human resources in the region in a way that is consistent with the National Development Plan (NDP). Previous investigations of the development potential of the water resources of the Koonap River, the last of which was in 1995 (DA-EC, 1995; de Wet Shand, 1988), revealed that under the circumstances of the time there was no need for a major dam to supply water for irrigation purposes. Reports on previous investigations are clear on the fact that farmers at the time were not in a position to pay the cost of providing additional water for irrigation purposes. Irrigation was developed primarily for lucerne production and pastures in conjunction with stock farming and dairy farming. Other crops were brought under irrigation and, according to existing farmers, the trend now is towards high value, permanent tree crops.

It has been established that historically 2 900 ha have been irrigated along the Koonap River and the Mankazana River from time to time. According to the Water Use Registration Database (WARMS) data base there are at present approximately 340 ha irrigated land along the Koonap River **downstream** of the Foxwood dam site. The irrigation potential in the Koonap River valley has been investigated since 1945 and many reports on this subject have been produced over the years. The main sources of information used in this investigation are listed in the References. The main findings which emerge from the previous investigations are that:

- Some of the soils in the local area are suitable for irrigation (de Wet Shand, 1988)
- Many crop types including lucerne, maize, citrus and other tree fruits and nuts can be successfully produced in the area (DA-EC, 1995)
- Livestock farming is the predominant farming enterprise and irrigation is used primarily for livestock feed (DA-EC, 1995)
- It appears that additional land riparian to the Koonap River, to that currently irrigated, has been irrigated in the past when river flows have permitted (de Wet Shand, 1988).

There is therefore good reason to expect that the present irrigation development can be successfully and sustainably increased if additional water can be made available at an appropriate level of assurance from the proposed Foxwood Dam. Development of a Government Irrigation Scheme as envisaged here calls for the combination of the three resources – water, land and human capital. The Agro-Economic study therefore sought to define in a “business case” the potential to develop such a scheme with reference to at least the following:

- The quantity of water that can be made available from realistically sized dam capacities at an assurance of supply appropriate for irrigation purposes.
- The extent and locality of irrigable land that can be supplied most cost effectively.
- Crops that can be successfully produced in the project area.
- The associated water requirements of the proposed crops.
- A project model that provides for combinations of farm sizes.

- Alternative arrangements for land tenure and the financing of land acquisition for individual emerging farmers.
- An assessment of the economic viability of each unit type, size of unit (gross area and irrigated area) and combination of types considered.
- The conceptual arrangement of bulk water distribution infrastructure necessary to serve the development options.

Further, the Agro-Economic Study has proposed conceptual arrangements for the development of an irrigation scheme along the Koonap River downstream of the Foxwood Dam including:

- An estimate of the capital cost of the infrastructure necessary to supply the water in bulk to the scheme.
- Suggestions for institutional arrangements for developing, owning and operating the bulk water infrastructure.
- An estimate of recurring operating and maintenance costs.
- An estimate of the unit costs of supplying water in bulk, the implications of the current DWS water pricing policy, and of the levels of subsidy that will be necessary to make the irrigation development economically viable.
- A view on the various risks associated with developing such a scheme.
- The level and duration of support from Government necessary to sustain the development.

This study has:

- Considered the available water for irrigation from the proposed Foxwood Dam as well as the water requirements for different potential irrigation types.
- Identified potential lands for irrigation development downstream of the proposed Foxwood Dam site on the Koonap River.
- Consulted regional agricultural stakeholders through the establishment of an Agricultural Technical Working Group (ATWG).
- Developed financial models for potential irrigation schemes to estimate required investments and potential returns from the implementation of a Government Irrigation Scheme.
- Considered institutional matters related to such a proposed irrigation scheme with particular focus on selection and training of possible new farmers and acquisition of lands for possible development.

The outputs from the financial modelling of the irrigation scheme have been assessed within the parallel Economic Impact Assessment (DWS, 2015g) study of both the dam itself and the potential irrigation scheme. This was done to determine the possible impact on the Nxuba Local Municipality and wider region from this development, with particular focus on the agricultural sector.

5.1 Available water and land

Allowing for high and low flow Reserve requirements as well as existing abstraction rights for farmers downstream of the proposed Foxwood Dam site, the proposed 1 MAR dam would supply approximately 12,5 million m^3/a. An irrigation scheme of 1 250 ha of high value tree crops has been proposed based on a water consumption of 10 000 $m^3/ha/a$ allowing for approximately 20% losses from the dam wall to the field edge.

The locality and extent of irrigable land that can be supplied from releases from the proposed Foxwood Dam has been carried out based on aerial survey, soil depth and type data, minimum slope criteria and verified through consultation with current commercial farmers. Sufficient land for irrigation development has been identified downstream of the proposed Foxwood Dam site, however it is estimated that up to approximately 13 000 ha would need to be purchased to enable 1 250 of contiguous land to be combined from separate farms currently held in private ownership. The plan in Figure 22 illustrates the locations of preferred irrigable land downstream of the Foxwood Dam site.

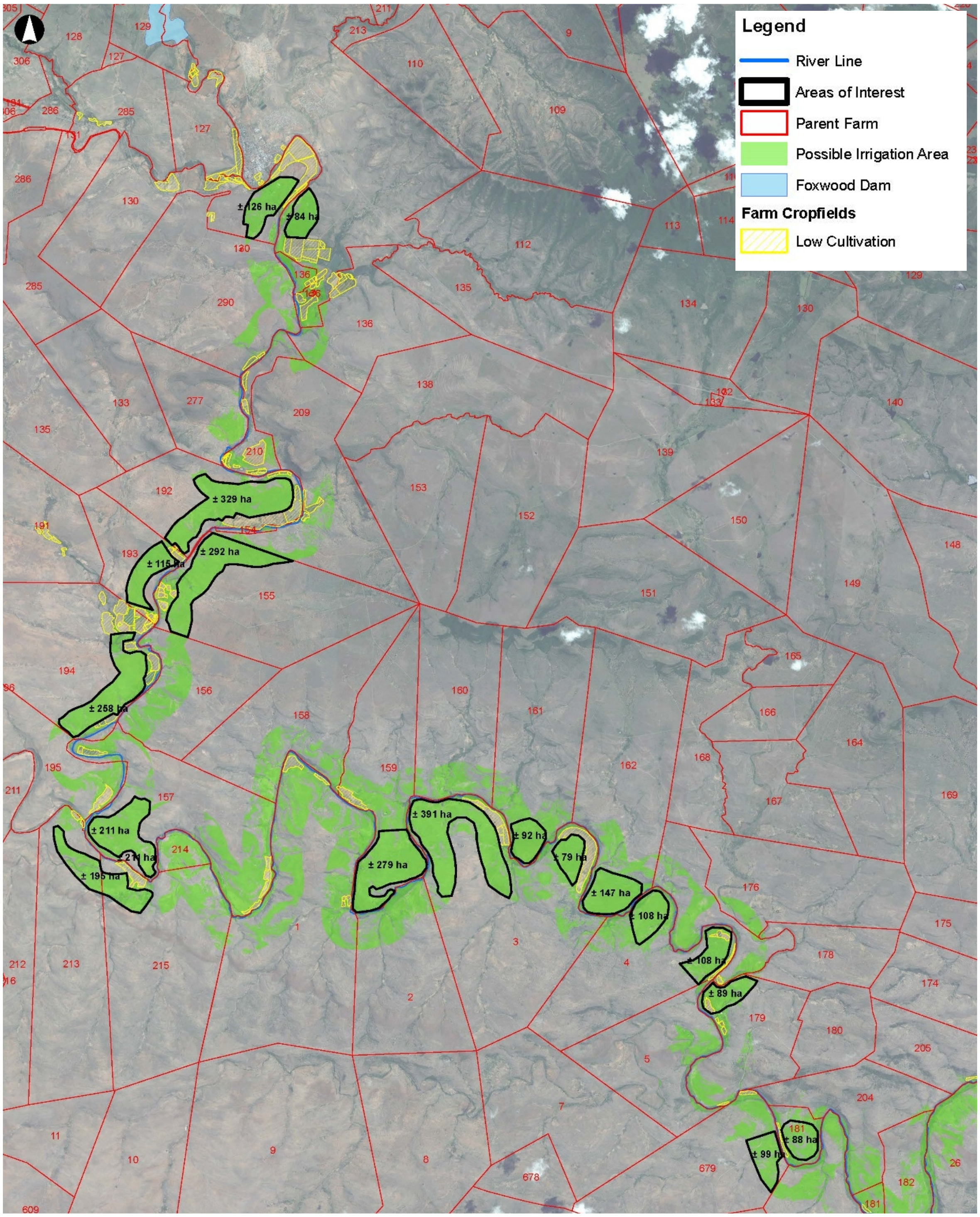

Figure 22: Irrigable soils downstream of the proposed Foxwood Dam site

The land on which such a scheme could be developed along the Koonap River is at present owned by individuals who are themselves successful farmers. This land would have to be acquired by the State or the current land owners could become partners in the envisaged development, subject to mutually acceptable contractual arrangements.

5.2 Cost and price of water

An estimate of the present value cost of water supplied from the proposed Foxwood Dam over its life has been estimated through the calculation of the Unit Reference Value (URV) (see section 9.3). This gives a URV of **R11,77 /m^3** over the life of the dam. If this is used as an indication of the cost of water it is not financially sustainable price of water for the proposed irrigation scheme. It is however, assumed that the capital cost of the dam is funded through Treasury. It is therefore proposed that the price of water applied to the Irrigation Scheme reflects only the operational and maintenance costs incurred for the dam. This present **price** of water has been set at **R0,60 /m^3** over the 50 year lifetime of the dam.

5.3 Proposed development - farm plot sizes and crop type

Financial models for three high value tree crops (peaches, lemons and macadamias) were developed for three different farming plot sizes (1 ha, 20 ha, 50 ha). Cashflow models for the different farm plot sizes and crop types were developed and the financial performance assessed. Table 15 below summarises the key financial performance of the different schemes. Revenue and profit is shown as a snapshot at 10 years to illustrate the financial performance of the model once the farming operations reach full maturity. The Internal Rate of Return (IRR) is shown at 15 years to illustrate the long term bankability of the project. The 20 ha plot sizes were selected for further evaluation within the Economic Impact Assessment of the Foxwood Dam project (DWS, 2015g) to review the potential socio-economic impact that could be expected to result from the Irrigation Scheme.

5.4 Financial model - funding investment required

The peak funding is the total cumulative investment required to fund the capital (eg land purchase, farm infrastructure establishment, training and mentoring during establishment) and operational (plant replacement, fuel, electricity, salaries etc) costs of the farm, less revenue earned, up until the time when the farm breaks even and starts to make a profit. For the 20 ha plot sizes, averaged across all crops, **peak funding of R 437 million** is estimated to be required to develop the Irrigation Scheme up until it reaches financial sustainability. This investment – expected to be from Government – is estimated to be required over approximately **7 years** from the start of the development of the Irrigation Scheme. Based on the projected cashflow for the different crops, the expected time period for repayment of the peak funding investment has been projected as approximately **5 years**, or 12 years from the start of the development of the Irrigation Scheme. Funding cashflow is illustrated in Figure 23 below.

5.5 Key risks – Institutional Arrangements

The principal risks associated with the development of the Government Irrigation Scheme relate to the dependency of the success of the scheme on the availability of leadership and management from an appropriately mandated and resourced Implementing Agent. It will be important for that Agent to fully focus on the socio-economic development of the Eastern Cape and to be available to commit resources to the project for a long period. The emerging farmers will be reliant on the Implementing Agent to provide training and technical support, as well as structured financing and marketing services for a period estimated in the order of 10 years.

After consultations in Stakeholder Meetings, in the Project Steering Committee and with individual government departments it is concluded that the Eastern Cape Rural Development Agency (ECRDA) is well placed to fulfil the role of Implementing Agent of the Government Irrigation Scheme. The availability of the Agency to undertake this responsibility has not been canvassed and the possibility of this happening will be dependent on the commitment by government of the necessary resources, financial and otherwise, for a period of 10 years or until the project is self-sustaining.

NB Consultation with the national Department of Agriculture, Forestry and Fisheries as well as the provincial department of Rural Development and Agrarian Reform has taken place throughout this study. However it is imperative that a thorough and in-depth feasibility study is carried out for the proposed Irrigation Scheme.

Table 15: Financial outputs from farming model

		Peak funding (R)	Total revenue in year 10 (1 250 ha)	Profit as % of revenue in year 10	IRR (@ year 15) %
1 ha	Lemons	749 879 297	R 190 136 584	11%	-9,63
	Peaches	710 676 252	R 212 749 377	36%	4,53
	Macadamias	812 899 635	R 213 346 250	46%	0,79
20 ha	Lemons	405 885 717	R 186 565 322	26%	9,11
	Peaches	423 776 401	R 211 047 382	24%	8,87
	Macadamias	452 534 469	R 206 223 441	35%	6,47
50 ha	Lemons	421 993 876	R 188 069 882	23%	7,33
	Peaches	413 244 219	R 207 488 784	24%	9,31
	Macadamias	439 701 800	R 212 814 214	38%	8,23

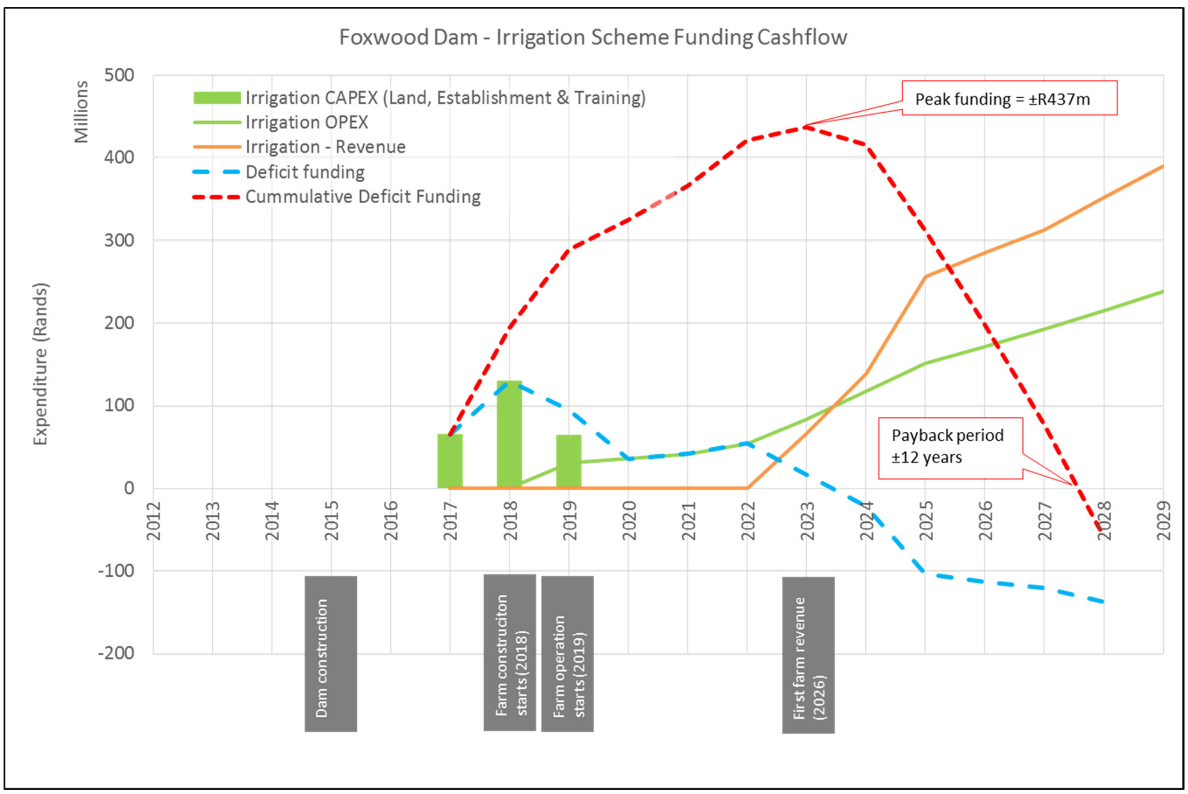

Figure 23: Foxwood Dam Irrigation Scheme Funding / Revenue Cashflow

In conclusion, we considered that there is potential for the further development of irrigated agriculture in the downstream catchment of the Koonap River. This is confirmed by historic intent to further develop expansions of irrigation in the area as well as current engagement from existing commercial and potential emerging farmers to develop future schemes on a commercial basis.

It is proposed that a total scheme of 1 250 ha is developed to achieve most benefit from the available yield from the Foxwood Dam site. It is recommended that the scheme is developed in plot sizes up to approximately 50 ha to achieve a commercial return whilst maximizing job opportunities and reducing operational risks. Financial modelling has been carried out on plot sizes of 1 ha, 20 ha and 50 ha with economic analysis carried out on the 20 ha plot sizes (see section 10. It is anticipated that such an irrigation development could become self-sustaining and profitable after approximately 12 years.

The major risks to the scheme revolve around institutional arrangements related to establishment and operation of the scheme and should be addressed by the Department of Agriculture, Forestry and Fisheries as a priority.

6 GEOLOGY

This section provides summary details of salient information extracted from the main reports on Geotechnical Investigation and material property interpretation contained within the Dam Design Report:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Geotechnical Investigation, P WMA 15/Q92/00/2113/11

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Dam Feasibility Design, P WMA 15/Q92/00/2113/12

6.1 Geological investigations

The geotechnical investigation took cognisance of the findings of a geological report 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" (Marais, 1962). The 1962 investigations include borehole drilling undertaken for the centreline and a proposed spillway on the left flank. The fieldwork for the geotechnical investigation (GI) was carried out during August 2013, and comprised the following:

- Trial hole excavations
- Sampling of unconsolidated soils retrieved from trial holes
- Drilling of boreholes (In addition to the previous 9 holes drilled in 1962 a further 8 holes were drilled on the dam centerline and 3 more at the quarry site.) Core recovery was high and comprehensively recorded. Full photographic and interpretive logs are provided in the Geotechnical Investigation report. The core samples were handed to DWS (Mr Fred van Rensberg) at their Uit Keer facility for storage near Cookhouse.
- In situ testing in boreholes, and
- Geophysics (seismic surveys)

A plan illustrating the locations of the investigations is provided in Appendix A.

6.2 Description of geology

Based on the GI, 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.

It is evident from the desk study and the geotechnical investigation that a significant amount (3,0 m – 14,0 m depth) of alluvial silt, sand and cobbles & boulders overly underlying competent mudstone and/ or siltstone rock. It is clear from the boreholes drilled that the rock immediately underlying the alluvial sediment is weathered to depths as great as 24,8 m; in some cases highly weathered. The rock underlying weathered rock is only slightly weathered to unweathered and persists to the end of each borehole at an approximate depth of 30 m.

The mudrocks, comprising mostly olive and grey mudstone, with a high silt component at times approaching siltstone classification, alternate with sandstone units less than a metre up to tens of metres thick consisting of buff/grey, fine grained ultra-lithofeldspathic sandstone, in the approximate ratio 20% sandstone and 80% mudstone. 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. Sandstone is a much hardier rock and is less prone to weathering on exposure than mudstone.

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 combined with alluvial detritus overlying mudstone.

Central and lower parts of the flank slope consist of mudstone which has disintegrated to some extent over time. This has resulted in undermining of the sandstone capping resulting in sandstone debris - both small fragments and large blocks – forming scree talus on the lower parts of both abutment slopes.

River Section

The wide river section has a gentle rise from the river channel on the left side towards higher ground on the right flank and is flanked immediately by the steep left ridge of the left flank.

Right Flank

The right flank is not as steep as the left and has a greater proportion of slope debris or talus. The sandstone capping is prominent at the top of the flank but most of the central and lower slope geology is concealed by a layer of colluvium; bush and grass.

Figure 24: Photographs and description of the site

The mudstone is poorly stratified or massive. 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. Mudstone undergoes differential weathering on exposure and rapidly fragments into angular pebble to cobble sized rock rubble.

Post-Karoo dolerite occurs in the area as large sheets; sills and dykes. Dolerite deposits are extensive starting approximately 5 km north of the dam site. In its unweathered state dolerite is a dark grey, hard, hypabyssal igneous rock intruded into the host sedimentary rocks. No dolerite was encountered in any of the boreholes drilled along the centreline or spillway, however, boreholes were drilled in dolerite at the target quarry site, Q1, some 5 km distance from the dam itself along the R344 gravel road. Given its rather erratic occurrence dolerite can be expected to occur on a localised scale.

Seismic geophysics conducted at site revealed numerous palaeochannels situated in the mudstone bedrock below the dam centreline and borrow sites C6, D1 and D2. These palaeochannels are mostly aligned parallel to the current Koonap River channel and are inferred as old tributaries that would have once flowed into the river. An inferred fault plane was observed north of the left flank spillway and partially relates to closely to widely jointed sandstone retrieved from boreholes drilled at the site. The geological plan shows no indication of faulting, however, localised faulting is not uncommon and should be expected.

6.2.1 Site Seismic Hazard Appraisal

Foxwood Dam is located on the African Tectonic Plate which, in comparison with other tectonic plates, is stable with low movement - especially so when compared to other inter-plate obduction or subduction zones. Much of the Africa Plate and specifically the South African area can be considered to be a zone of ‘low tectonic activity’. This does not mean that this particular area is totally exempt of any seismic activity but rather that the risk is relatively lower.

The Eastern Cape Province has a general *low* acceleration value of 0,04g with the zone around Adelaide being approximately of 0,06g. This is a particularly low ‘g’ value which indicates that the Foxwood Dam area is in a low risk seismic area and therefore has a *low seismic hazard risk* potential. This is supported by the UNESCO (2007) Earthquake Risk in Africa assessment where this area falls into the lower earthquake intensity modified Mercalli Scale of I – V.

Therefore, the recommended seismic design parameters based on ICOLD Bulletin 72 (Selecting Seismic Parameters for Large Dams) and used in the stability analysis are as follows:

- an Operating Basis Earthquake (OBE) of 0,05g;
- a Maximum Credible Earthquake (MCE) of 0,24g.

6.3 Earthworks construction materials

Figure 25 illustrates the key structure of the earth embankment section.

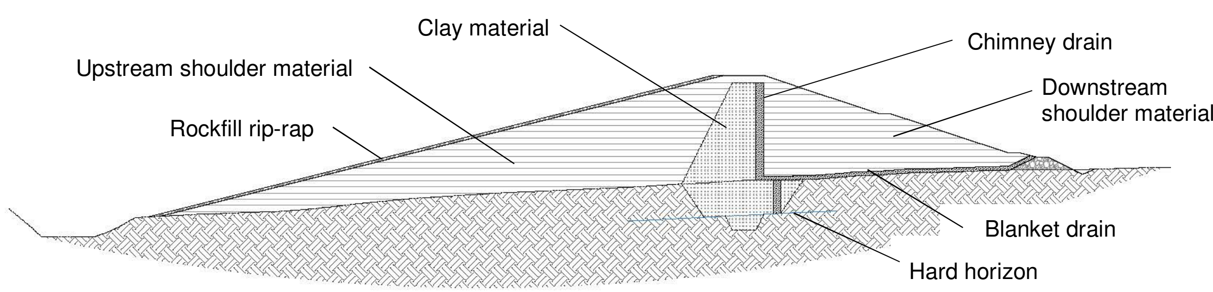

Figure 25: Earth embankment section

The site is underlain by a relatively thick mantle of transported and residual soils overlying succession mudstone, siltstone and intercalated sandstone horizons of the Balfour Formation of the Beaufort Group. The geotechnical investigation revealed the following:

- Earthfill shoulder material is available within the basin.
- Core material within the basin is available but will require careful selection both in terms of permeability and dispersion. There is a suitable borrow area with adequate material properties, however this is further away (±4 km from the dam site) and out of the basin. Further detailed investigations and demarcation of the selected borrow sites will be required. Table 16 below indicates the estimated available materials from selected sites (refer drawing 225739-GEO-0601 in Appendix A).

Table 16: Estimated Available Earthfill Quantities

Borrow Pit	Clay Core (m^3)	Shoulder material (m^3)
D1	275 000	465 000
Centreline	113 000	264 000
D2	101 000	303 000
C7	N/A	144 000
C6	N/A	1 100 000
C2	82 000	175 000
C3	256 000	544 000
Total volume	**827 000**	**3 000 000**

- No suitable filter materials were identified within a commercially viable distance of the site. Filter materials need to be manufactured as part of the plant crushing process.
- No commercial quarry site was identified during the study. A potential quarry site has been investigated ±6 km from the site and borehole investigation confirmed there is significant quantity of good quality dolorite.
- There will be a requirement to carry out a detailed grid investigation on the selected borrow areas to assist in the selection process; as well as to establish excavated material quantities.

Estimated material volume requirements for the earthworks are given in Table 17 below:

Table 17: Estimated Required Quantities

Material Required	Quantity (m^3)
Shell	1 510 000
Clay Core	335 700
Total	**1 845 700**

Quarry site Q1

Located approximately 5 km north of the proposed dam wall site and adjacent to the R244 to Tarkastad.

Figure 26: Photograph of proposed quarry site

6.4 Engineering assessment

The results of the investigation indicate that it is possible to construct a composite earthfill and concrete gravity dam provided that cognizance is taken of the following certain issues:

- The thick mantle of transported soil on the right hand flank of between 5 and 20 metres implies that special consideration will need to be given to foundations for the dam. Extensive excavation and backfill operation may be required, with the use of grouting;
- Material suitable for the construction of an embankment has been identified within borrow pits and under the dam centerline. However, it should be noted that there is a wide variability in quality and onsite selection of materials will be necessary during construction.
- There is an abundance of potential embankment fill material within borrow pits and the dam foundations. Rockfill material can be obtained from the excavation of the mudrocks and sandstone, however, given the depth of these materials the volumes will be limited. Spillway excavations will be the best choice to provide relatively high durability sandstone that will find use as rockfill/ 'dirty' rockfill material. Extensive quantities of earthfill material are available but these are potentially dispersive requiring gypsum stabilization.
- A Hard rock source for sand drain filters, concrete aggregate, rip-rap and fine aggregate is available at potential quarry site Q1, some 5 km north of the dam location.
- No natural clean sand was found on site, requiring crushing of dolerite to produce fine aggregate and filter requirements.
- The earthfill materials encountered within the borrow pits and under the dam centerline show variable potential for dispersive soils which will require detailed assessment during further design stages, if this material is to be used for the core. Properly designed and constructed filters adjacent to potentially dispersive material in the embankment is essential to prevent possible piping due to seepage.
- Thickness of compressible alluvial deposits presents a risk of differential settlement between earthworks and structures founded at different depths. Consideration should be given to construction phasing and / or localized removal of compressible soils.
- Relatively thin cover of alluvial deposits on the left hand flank, and rock jointing presents a risk of excessive seepage. Grouting of the foundations and abutment of the concrete gravity sections will be required.

A summary of the geotechnical design parameters of materials likely to be encountered within the reservoir basin, gravity and embankment dam construction are provided in the tables below.

Table 18: Balfour Mudstone design parameters

Design Parameter	Basis	Value	Unit
Unconfined Compressive Strength (UCS)	6 UCS tests (35,5 MPa to 210 MPa)	40	MPa
Phi'	Assumed from Tomlinson 7th Ed. Table 2.2	27°	
Cohesion, c'	Correlated from UCS & RQD (Tomlinson Section 2.3.6) to 4 MPa. Cripps and Taylor 1981 suggest lower bound of 2 MPa for Coal Measures Mudstone with UCS of 9 to 103 MPa.	2	MPa
Young's Modulus for Settlement	Correlated from UCS & RQD	300	MPa
Permeability	Correlated from Packer test Lugeon Values	3×10^{-6}	m/s
Permeability below 27 m depth	Correlated from Packer test Lugeon Values	1×10^{-7}	m/s
Grouted zone Permeability	Ciria C514, Section 6.3, lower limit permeability of rock mass grouting	1×10^{-7}	m/s
Bulk Density	From 6 UCS tests (25,6 kN/m^3 to 27 kN/m^3)	26	kN/m^3
Allowable bearing capacity	Using Tomlinson table 2.3 for cemented Mudstone.	4	MPa

Table 19: Alluvium design parameters

Design Parameter	Basis	Value	Unit
Undrained shear strength, Cu	Assumed with correlation from LL	90	kPa
Phi'	Correlated from Plasticity Index using BS8002 (c'=0)	31°	
Young's Modulus for Settlement	No data - assumed	5	MPa
Permeability	3 remoulded falling head tests	1×10^{-7}	m/s
Bulk Density	Average proctor compaction from 17 tests at centreline	17,5	kN/m^3

Table 20: Embankment earthfill design parameters

Design Parameter	Basis	Value	Unit
Undrained shear strength, Cu	Assumed with correlation from LL	90	kPa
Phi'	3 Triaxial Test (c' = 0)	32,5°	
Permeability	3 remoulded falling head tests	5×10^{-8}	m/s
Bulk Density	From 3 remoulded falling head tests	18	kN/m^3
Embankment Settlement	BS6031 Code of practice for earthworks	1% of Embankment height	

Table 21: Filter design parameters

Design Parameter	Basis	Value	Unit
Permeability	Requirement for filter design	1 x 10^{-4}	m/s
Bulk Density	Assumed on guidance from BS8002	21	kN/m^3
Phi'	Assumed	30°	

6.5 Recommended Further Investigations for Detailed Design Stage

The investigation undertaken at the site and the material properties described in the section above are believed to be sufficient for the feasibility design stage of the project. Nevertheless as many of the input parameters into this analysis have been assumed or correlated, it is recommended to undertake a complementary ground investigation prior to the detailed design. It is also cautioned that a limited number of samples indicated varying degrees of dispersivity. Due care and site monitoring will be required during the construction phase.

More detailed geotechnical testing of embankment construction materials including strength, settlement characteristics, and dispersivity should be undertaken prior to detailed design. In-situ undrained strength of the colluvium / alluvium have been assumed and may be critical to embankment design and stability. In addition the following recommendations are made:

- Further in-situ permeability testing including falling head tests in the superficial deposits would help refine the seepage analysis and grouting requirements.
- The ground outside the dam centreline is not well defined by boreholes and assumptions have been made for stability analysis models. A wider spread of boreholes should be undertaken particularly at the upstream toe of the embankment where the stability analysis is sensitive to ground conditions. Further drilling of boreholes in a lattice over the spilling footprint and spill basin extent would help define the depth to suitable bearing hard horizon.
- The ground profile for valley stability sections are assumed as trial pits refused at depths less than 3 m. Recommend more boreholes upstream to confirm ground profile in reservoir basin for stability and seepage.
- The thickness of alluvium should be proved in greater detail outside the dam centreline and under the gravity dam section in order to quantify the availability of suitable embankment construction materials in the foundation excavations.
- Settlement analysis undertaken for the feasibility design of the earthwork embankment uses assumptions on settlement characteristics of the soil. Consolidation and / or load tests are recommended to obtain a more accurate estimate of embankment settlement during detailed design.

7 EVALUATION OF THE PROPOSED MAJOR DAM

This section provides summary details of salient information extracted from the study module report on the dam technical design:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Dam Feasibility Design, P WMA 15/Q92/00/2113/12

7.1 Dam sizing and type

The preferred dam size at the Foxwood site was determined following consultation with DWS. The size of the dam was debated due to the main motivation for the dam being determined to be the potential for socio-economic development in the region which is subject to the establishment of an irrigation scheme. The types of dam construction considered as viable options for analysis were:

- Zoned Earthfill with a left bank side channel spillway
- Central Core Rockfill with a left bank side channel spillway
- Concrete Gravity stepped spillway to Riverbed
- Composite Concrete Gravity stepped spillway to Riverbed and Earth Embankment

An arch option was not considered as both the topography and the rock strengths were not considered suitable.

The unit reference value analysis was based on common bills of quantities *(at the time of the option analysis and excluding the total ancillary project values referred to in the final project estimated URV for the selected dam)* and current estimated rates. Refer Figure 27 below. The main differentiator for the various options was the deep left bank spillway cut for the earthfill and rockfill options.

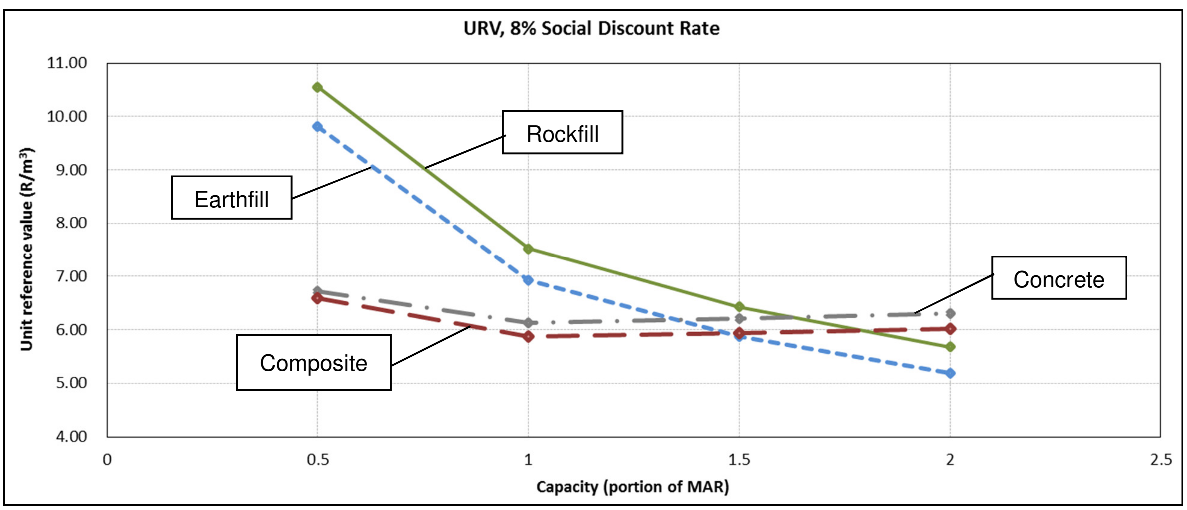

Figure 27: URV Dam Selection

It was recommended that a **1 MAR dam** is developed at the Foxwood Dam site for the following reasons:

- The analysis indicates that the available yields from a new dam are approximately equivalent for 1 MAR storage and 1,5 MAR storage. This is due to releases from dams with larger storage capacities being needed to supply high flow EWRs (1 MAR yield of 19,1 million m³/a vs 1,5 MAR yield of 19,8 million m³/a.)

- Providing for the Reserve from natural spillages reduces opportunity for human error. Impounding the Koonap River with a larger dam would impact on the natural ecological system of the river valley.
- Storage capacities larger than 1 MAR at Foxwood would prejudice further water resource development elsewhere in the catchment.
- It is very unlikely that there will be sufficient domestic or industrial water requirements in a regional context to make full use of the yield of dam larger than 1MAR.
- Providing for the development of a 1 250 ha irrigation scheme on irrigable land located on various properties, now in successful production by established commercial farmers, will be a very significant development and will provide the basis for other similar schemes.

A 1 MAR Composite Gravity Dam with Earth Embankment on the right flank is recommended for development at the Foxwood Dam site with the following motivation:

- Lowest URV among the four options for a 1 MAR dam.
- The spillway energy dissipation is more complicated for a side-channel spillway option, with significant changes of direction and the discharge of water into the river.
- No long term maintenance of a deep spillway excavation cut.
- Reduces the risks of material selection which include some elements of dispersive materials.
- Outlet works are incorporated within the gravity structure to an elevation suitable for effective discharge into the river bed. The other options require free standing towers and tunnels at founding depths similar to the cut off foundation.

A copy of the full Dam Option Selection Memorandum is provided in Appendix B.

7.2 Spillway design

7.2.1 Design criteria and freeboard

The spillway is designed to safely discharge excess flood water from the reservoir whilst maintaining the integrity of the dam and downstream valley. The dam is categorized as Category III, and as such is designed to:

- Pass the Recommended Design Flood (RDF) (1 in 200 year flood event) with dry freeboard.
- Pass the Safety Evaluation Discharge (SED) without freeboard.

7.2.2 Flood Hydrology

Foxwood Dam will be a large dam (>30 m high) with a high hazard potential (due to extensive downstream developments) and will be classified as a Category III dam in terms of the Dam Safety Regulations.

The basis for the selection of the dam freeboard is either:

- The Recommended Design Flood (RDF) un-routed over the spillway with a dry freeboard contribution or
- The Safety Evaluation Discharge (SED) is the Probable Maximum Flood (PMF) routed with no dry freeboard.

Whichever is the greater will constitute the selected freeboard.

For the purpose of feasibility evaluation this study considered a 250 m spillway with a discharge coefficient of 2,0. The optimisation of the spillway should be carried out during the detailed design stage. The final selection will be based on modelling of the spillway and confirming the selected RDF and SED. The flood peaks that were selected during this study are provided below along with their associated required freeboard:

a) Recommended Design Flood (RDF) (1:200 year)

The RDF is the 1:200 flood and is un-routed through the dam with freeboard using SANCOLD 2011 guidelines and the selected dam slope.

- RDF discharge 2 063 m^3/s
- RDF freeboard requirement 5,2 m

b) Safety Evaluation Flood

Safety Evaluation Discharge (SED) is the PMF routed through the dam with no dry freeboard

- SEF discharge 6 200 m^3/s
- SEF freeboard requirement 5,4 m

The SEF was selected due to the more conservative freeboard of 5,4 m.

In discussion with DWS it was recommended that the spillway design is optimized at detailed design through review of the freeboard requirement with the SEF Kovacks + Δ method. This method indicates that the spillway width may be reduced by up to 50 m while maintaining the same freeboard. The key results are:

- Spillway length 200 m
- SEF discharge 5 218 m^3/s
- SEF freeboard requirement 5,5 m

The optimisation and modelling of the spillway configuration will form part of the detailed design. The feasibility design takes in to consideration the conclusions from the flood hydrology study and the recommendations from precedent reports.

This study has selected the PMF routed flood for the selection of spillway dimensions:

- Spillway length 250 m
- SEF discharge 5 218 m^3/s
- SEF freeboard requirement 5,5 m

The freeboard selection was undertaken in accordance with SANCOLD Guidelines on Freeboard for Dams Volume II.

7.2.3 Spillway selection

The dam comprises a central concrete gravity dam, with an earthfill right abutment. The recommended spillway type is therefore a central overtopping section at the location of the concrete gravity dam. Benefits to this selection include:

- Smaller footprint of the dam site
- Reduced excavation of materials

- Greater opportunity for flow energy dissipation
- More economical solution

7.2.4 Proposed Layout

The spillway comprises three distinct elements: the spillway crest, the channel and the stilling basin.

Ogee Spillway Crest

The ogee spillway crest conveys any water above Full Supply Level (FSL) to the downstream face. The hydrology study adopted an ogee spillway crest length of 250 m. However, since that study, a bridge spanning the overflow section has been introduced to the design. The assumed width of bridge pier is 0,6 m and the maximum bridge span is assumed to be 12,0 m (therefore 21 piers). To take account of the pier and abutment effects, as well as the width of the piers, the required length of spillway is 267,0 m. This has been determined using the method in Section 9.11 in *Design of Small Dams (USBR 1987)*, assuming round-nosed piers and square abutments.

An ogee weir shape with a coefficient of weir discharge of 2,0 has been selected whilst routing flood flows. For the purpose of this feasibility study, the ogee shape is designed to the PMF head of 5,4 m. The profile is constructed of compound radii in accordance with Section 9.10 of *Design of Small Dams*. This is acceptable where the height of the ogee spillway crest is greater than one-half the design head. We note that optimisation of the designed flood return period for the ogee may consider the 1:200 year flood versus the PMF.

The ogee spillway crest could be more economic if the profile is designed to a reduced head. The reduced head should be limited to 75% maximum head to avoid cavitation risk. It is recommended that this is explored in further detail in the next stage of design.

Ogee spillway crest details are shown on drawing 225739-DAM-1201 (Appendix A).

Downstream face

Flow over the ogee spillway crest is directed to the stilling basin via a stepped downstream face. Flow energy will be dissipated by the steps in the spillway. A step height of 1 200 mm has been selected for the following reasons:

- A larger step height is preferable for energy dissipation;
- A step height of 1 200 mm is considered a deterrent for persons attempting to climb the dam face.

The slope of the downstream face has been determined as the maximum acceptable steepness from the stability analysis and is sloped at 0,6H:1V (or 59 degrees). It is steeper than the normally accepted 1:0,75 to 0,7 however the opportunity for increased steepness is a function of the large spill basin blocks that were set to the ground level rather than the hard horizon. The resultant step length (from the 0,6H:1V slope) is 720 mm.

Using the method in Boes (Boes 2012), a side wall height of 2,4 m is recommended to contain the aerated PMF flow. Containing spillway flow is particularly important at the right abutment to protect the embankment. This recommended height should be reassessed if aerators are adopted later in the design.

See drawings 225739: -DAM-1201: - DAM-1002 and - DAM-1003 for the layout and details of the downstream face (refer Appendix A).

Stilling basin

Initial calculations indicated that a stilling basin length of 34,5 m was required to contain the hydraulic jump during a 200 year flood event. This would result in a large excavation at the toe of the dam wall. However, upon further investigation of the tailwater it was concluded that the tailwater is of a significant depth so that it greatly contributes to energy dissipation. For example, at the 200 year flood event the water depth would be in the region of 14 m.

It is understood that a rail bridge downstream of the site may contribute to the high tailwater level. A sensitivity analysis was undertaken by removing the bridge and assuming normal depth at the bridge model node. This yields a tailwater depth of 12,3 m during the 200 year event. The predicted tailwater depths are much greater than the theoretical conjugate depth of the hydraulic jump (predicted to be in the region of 5,5 m, in the RDF). Therefore the hydraulic jump in the basin should be contained within the tailwater.

The toe of the concrete gravity dam has a 15 m long stilling basin block which is stepped to follow the ground level. The return is protected by a cascade system of graded large rocks and rip rap underlain by a crusher graded filter. Details of the stilling basin and downstream erosion protection are shown on drawings 225739: -DAM-1002,–DAM-1003 and DAM-1203 respectively. An extract from drawing 225739-DAM-1203 is given in Figure 28.

During the design process the Department reviewed this aspect of the design and considered that the three tier basin was not sustainable and rather than rely on a cascading bolster system to return the flow to the natural river line, excavate out ‘fan’ like return. This will require further geotechnical investigation to determine more precisely the hard formation topography in the area to be considered and the optimal unitary level of the basin.

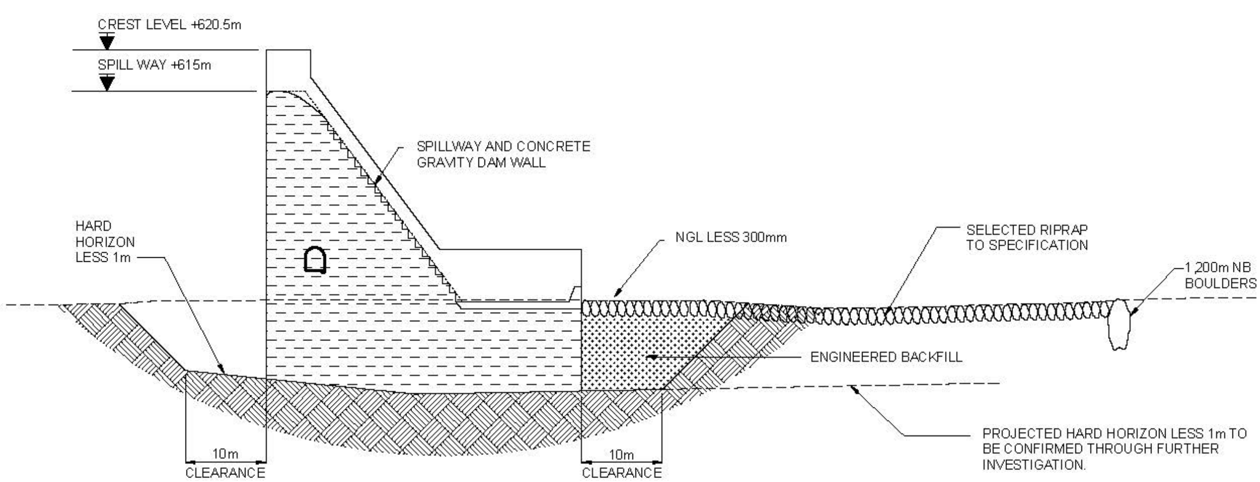

Figure 28: Section through still basin

Right Abutment

The right abutment is an L shaped retaining wall which extends into the embankment as a wrap-around to allow the upstream surface slope to be 2 m below the FSL. The downstream wall extends to allow for retention and protection of the embankment and downstream toe.

During the design process, the Department reviewed this aspect of the design and considered that an L shape retaining wall would be more expensive than a full rap around retaining wall. The rap around retaining wall could be achieved by extension of the gravity wall construction with approximate length 75 m. This will need to be considered in the detailed design phase. This may well lead to considering constructing the wall completely as a concrete gravity structure as opposed to a composite structure.

7.2.5 Recommended future considerations for detailed design

Hydraulic Modelling

Due to the relatively large discharge, sensitivity of the embankment dam to erosion and the high tailwater depths, it is recommended that the spillway is modelled during the next phase of design in order to:

- Confirm the rating curve of the ogee spillway crest
- Determine the performance of the stepped spillway
- Confirm the height of spillway retaining walls
- Ensure the embankment is not subject to turbulent flow from the spillway and/or tailwater
- Determine flow velocity downstream of the dam to confirm the design of erosion protection

Other considerations

It is recommended that the following items be explored further during the next phase of design:

- A reduction in the design head for the ogee crest shape, whilst avoiding the risk of cavitation
- Establish the requirement for a spillway bridge access to the right bank crest
- Confirmation that the bridge design allows free discharge and optimization of span to spillway length
- Requirement for aerators on the spillway steps
- If the cross section of the gravity dam changes, the length of stilling basin should be revisited to ensure stability
- review an alternative stilling basin and river return with more extended excavation to hard horizon for full extent of river return.
- The determination and selection of flood method will need to be reviewed and the spillway length adjusted and optimised accordingly.

7.3 Stability analysis of concrete sections

The concrete gravity section of the dam is shown on Drawings 225739: -DAM-1201 and -DAM-1301 (Appendix A). The stability analysis of this section has been undertaken using the load combinations and Factors of Safety in USBR Design of Small Dams (USBR 1987), presented below.

7.3.1 Loads

The following loads have been considered:

Dead load

Dead weight of the concrete gravity dam. Superstructures such as bridges can be included in the dead load, however, in the absence of a fixed bridge design this has been omitted from the analysis. This is seen as a conservative assumption, and may lead to cost savings later in the project.

The unit weight of concrete is taken to be 24 kN/m^3.

Hydrostatic load (reservoir)

In the usual and extreme load cases (see below) the hydrostatic (water) level is taken to be at Full Supply Level (FSL).

Further to the hydrostatic load, the structure is also subject to uplift pressures across 100% of the base. Considering the foundation rock as fractured mudstone with a permeability of 10^{-6} m/s, the uplift pressure is assumed to respond instantaneously with reservoir level. There is a drainage gallery located near the upstream face. The presence of the drainage gallery (with vertical drains in to the foundation) means that there can be a reduction in uplift near the upstream face. For this stage of the design a drainage effectiveness of 50% will be assumed in accordance with USACE.

Hydrostatic load (tailwater)

A hydraulic jump stilling basin is provided to dissipate the energy of the flow in the spillway. The action of the hydraulic jump will push the tailwater downstream of the dam. Therefore a restoring tailwater hydrostatic load was not considered here.

Hydrostatic load (flood)

In the unusual load case, the hydrostatic (water) level is taken to be at Maximum Water Level (MWL) generated by the PMF. This is noted to be slightly conservative as the water flowing over the ogee spillway crest will be velocity head rather than static head. With water flowing over the section there will be a tailwater. This will be considered for uplift calculations, however it is assumed that the tailwater does not offer a restoring force as it is being used in the energy dissipating process (USBR 1987). Uplift is assumed to respond instantaneously to reservoir level, therefore the uplift pressures are increased. Due to the tailwater the pressure distribution is trapezoidal. The other uplift assumptions are still applicable.

Earth pressure

If there is no significant tension at the downstream toe then the deflections will be sufficiently nominal to not cause additional strain in the downstream soil mass. Therefore at-rest earth pressure coefficient is deemed appropriate. In the unusual case, the soil mass at the downstream toe is assumed to be eroded away due to overtopping of the dam (a conservative assumption considering the provision of riprap).

Silt load

The anticipated accumulation of silt over the design life of the reservoir is 6,11 million m^3 for 50 years. From the reservoir storage curve, this represents a nominal depth. Therefore for the purposes of the stability analysis a greater depth of 1 m is chosen for the assessment of silt loading.

Seismic load

The peak ground acceleration for the Maximum Credible Earthquake (MCE) is taken as 0,24g. In line with Section 6 of BRE An Engineering Guide to Seismic Risk to Dams in the UK (BRE 1991), this has been reduced by 2/3 for the horizontal load, and by a further 1/2 for the vertical load.

Temperature

In the absence of construction/expansion joint details, the stresses generated due to the volumetric change of concrete following temperature rise have not been considered. However, it must be a consideration in future design phases.

Ice

It is anticipated that no ice load shall be present at this site.

7.3.2 Load combinations

Stability assessment has been carried out in accordance with USBR guidance. DWS have noted that additional load cases should be considered during detailed design in accordance with the requirements of Directorate Civil Engineering. The following load combinations have been considered in the feasibility study:

Table 22: Load combinations for concrete section stability analysis

Load	Usual	Unusual	Extreme
Dead load	Yes	Yes	Yes
Hydrostatic load	Yes – FSL	Yes – MWL	Yes – FSL
Silt	Yes	Yes	Yes
Earth	Yes	Yes (not at downstream toe)	Yes
Uplift	Yes	Yes	Yes
Earthquake	No	No	MCE

7.3.3 Stability criteria

The analysis considered the global stability of the structure as a whole. There is no obvious weak point (change in section) or details of construction joints, therefore at this stage of the design intermediate failure plans within the body of the dam were not considered. However, this must be considered in later design stages. It was assumed the dam may fail by sliding (along the concrete-rock interface), overturning (about the downstream toe), or due to insufficient bearing capacity. The compressive strength of the concrete was also checked.

Sliding
The following minimum factors of safety are required against sliding failure:

Table 23: Load combinations for concrete section stability analysis

Material/Interface	Usual	Unusual	Extreme
Concrete/rock interface	3,0	2,0	>1,0

Overturning
No tensile capacity is permitted in the concrete and rock. In order to meet this criterion, the resultant location should be:

Table 24: Required resultant location for overturning

Load combination	Location of resultant force
Usual	Within middle ⅓
Unusual	Within middle ½
Extreme	Within base

Foundation failure
Foundation bearing pressure should be:

Table 25: Required foundation bearing pressure

Load combination	Foundation bearing pressure
Usual	< allowable
Unusual	< allowable
Extreme	< 1,5 allowable

Concrete strength
Allowable compressive stress should be:

Table 26: Allowable concrete compressive strength

Load combination	Allowable compressive stress
Usual	0,33f'c (FoS 3,0)
Unusual	0,5f'c (FoS 2,0)
Extreme	1,0f'c (FoS 1,0)

In the above, f'c is the characteristic compressive strength of the concrete at the section being considered. For this analysis f'c was taken as 40 N/mm^2.

7.3.4 Design parameters

In addition to those discussed above, the following design parameters were also adopted:

Table 27: Concrete dam design parameters

Parameter	Assumption
Dam crest level	620,4 m
Spillway crest level (also FSL)	615,0 m
Silt level	578,0 m
Existing Ground Level	577,0 m
Foundation level	572,5 m
Unit weight of earth fill	18 kN/m^3

Parameter	Assumption
Unit weight of water	10 kN/m³
Angle of friction (fill)	32,5 degrees
Unit weight of silt	17 kN/m³
Angle of friction (silt)	20 degrees
Allowable bearing capacity of rock foundation	4 000 kN/m²

7.3.5 Stress and stability analysis

Limit state analysis was undertaken on the overflow section of the concrete gravity dam, along with the upper part of the non-overflow section (that part greater than 615,0 m).

As discussed, the concrete at the toe of the dam is required for both stability and erosion protection. A minimum length of 15 m is required if the downstream face of the dam is 0,6H:1V.

7.3.6 Results

The results are summarized below:

Table 28: Usual case

	Acceptable	Calculated
Sliding Factor of Safety	3	9,96
Resultant location	Middle third	This is acceptable
Foundation bearing pressure	< allowable	This is acceptable
Maximum compressive stress	0,33f'c	This is acceptable

The base is in compression.

Table 29: Unusual case

	Acceptable	Calculated
Sliding Factor of Safety	2	7,67
Resultant location	Middle half	This is acceptable
Foundation bearing pressure	< allowable	This is acceptable
Maximum compressive stress	0,5f'c	This is acceptable

The base is in compression.

Table 30: Extreme case

	Acceptable	Calculated
Sliding Factor of Safety	1	6,58
Resultant location	Within base	This is acceptable
Foundation bearing pressure	< 1,5 x allowable	This is acceptable
Maximum compressive stress	1,0f'c	This is acceptable

The base is in compression.

Additional load scenarios
Two additional load scenarios were considered:

- Usual with full uplift – simulating blocked drainage. This met the design criteria.
- Unusual with no hydrostatic load – simulating end-of-construction. This met the criteria except the base is not 100% in compression. However in this scenario it is the toe which is in tension which is considered acceptable.

7.3.7 Conclusions

The concrete gravity dam has been checked for global stability using the load combinations and Factors of Safety recommended in USBR Design of Small Dams. In all cases the dam performs satisfactorily. If, during the next stage of design, and geometric or material amendments are made, the global stability will need to be re-assessed. In addition, once the construction technique is confirmed the stability at intermittent stages will also need to be evaluated.

7.4 Stability analysis of embankment sections and settlement

7.4.1 Embankment cross section and details

Analysis of particle size tests indicate that material from proposed borrow pits and beneath the dam alignment is a sandy silt with clay. Recompacted laboratory permeability tests indicate a permeability on the order less than 1 x 10^{-8} m/s can be achieved. It is therefore proposed to construct an earthfill embankment using site won alluvial / colluvial material with selection of lower permeability fill in the core and a chimney drain incorporated (See Drawing No. 225739-DAM-1002). Figure 29 below illustrates the key structure of the earthfill embankment section.

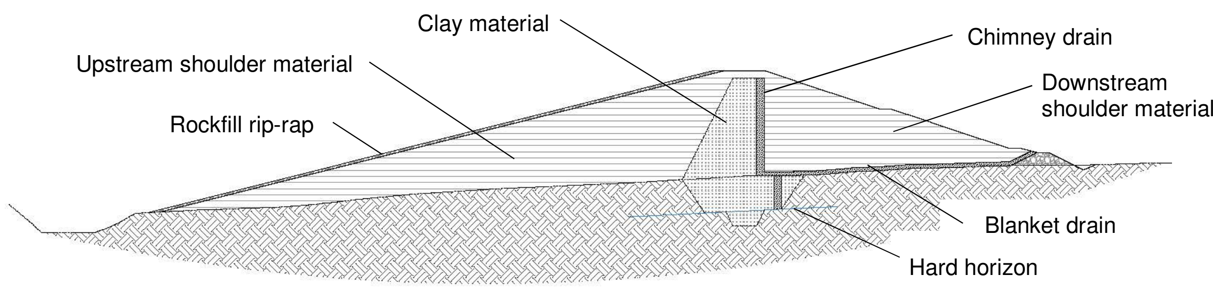

Figure 29: Earthfill embankment section

The embankment can be considered to have the characteristics of an earthfill embankment at this stage. It is recommended that the material properties are re-assessed during the final design stage, and that the material properties used for the purpose of this feasibility design be used and/or accepted with caution. In particular the risk from dispersive soils within borrow pit materials should be investigated fully.

The general cross section details for the embankment are provided in Table 31 below.

Table 31: General embankment cross section details

Detail	Value
Surface strip	300 mm
Crest width	10 m
Crest level	620,5 m

Detail	Value
Upstream slope	1 in 4
Downstream slope	1 in 3 slopes between 3 step berms
Core crest width	6 m
Core slope	1 in 0,5
Main Core Trench depth	To hard horizon (notionally 8 m)
Additional Core Trench depth	4 m below hard horizon
Core Trench slopes	1 in 0,67
Grout curtain depth	27 m below ground level
Filter drain thickness	2 m

7.4.2 Cross sections analysed

The section analysed is the highest embankment section at the interface with the concrete gravity section. Since the analysis, the length of the concrete spillway has increased, and the length of the embankment section has decreased. The height of analysed section is therefore slightly higher than is proposed by the feasibility design, however this difference was considered slightly conservative.

The existing ground level under the centerline of the embankment section analysed is 589,1 m.

7.4.3 Cases investigated and stability criteria

Embankment dam stability of the upstream and downstream slopes has been assessed under the following conditions:

- Maximum Water Level (MWL) at 620,4 masl – steady seepage; u/s and d/s slopes
- Rapid Drawdown from Full Supply Level (FSL) of 615 masl to 580 masl, u/s slope
- End of construction, u/s and d/s.
- Seismic analysis will be carried out at MWL for an Operating Basis Earthquake (OBE) of 0,05g and at FSL for a Maximum Credible Earthquake (MCE) of 0,24g.

The global factors of safety have been adopted in accordance with USBR Guide – Chapter 6, are shown in Table 32.

Table 32: Factors of Safety for embankment design

Loading condition	Minimum Factor of Safety
Steady seepage with reservoir at MWL (u/s and d/s)	1,5
Rapid drawdown (u/s)	1,3
End of construction (u/s and d/s)	1,3
Seismic-OBE (u/s and d/s) Seismic MCE (u/s and d/s)	>1,1 <1, with allowable displacements

7.4.4 Findings and results

The initial embankment geometry analysed included steeper slopes (1 in 3 upstream, and 1 in 2,5 downstream) which failed to meet the required factor of safety under the following conditions:

- Drawdown on the upstream slope FoS 1,24
- Max Credible Earthquake on the downstream slope FoS of 0,97,
- Undrained end of construction on upstream FoS 1,01.
- Undrained end of construction on downstream slope FoS 1,19.

The embankment slopes were subsequently slackened to that shown in design drawings and the following sections discuss this design:

Summary of stability modelling results
A summary of the stability load cases and their results is included in Table 33 below:

Table 33: Factors of Safety achieved in embankment design

Loading condition	Location	Required Factor of Safety	Minimum Factor of Safety Achieved
Steady seepage with reservoir at MWL	u/s	1,5	2,5
	d/s		1,9
Rapid drawdown	u/s embankment	1,3	1,4
	valley slopes		**0,9***
End of construction	u/s	1,3	1,3
	d/s		1,3
Seismic-Operating Basis Earthquake	u/s	>1,1	1,73
	d/s		1,66
Seismic Maximum Credible Earthquake	u/s	1,0 with allowable displacements	**0,74**
	d/s		1,02

* shallow slips in area with poorly defined ground profile – further investigation recommended

The above table shows that the minimum required factors of safety were achieved in all loading conditions apart from the following:

- Stability of the natural valley slopes within the reservoir basin on rapid drawdown. A factor of safety of 0,9 was achieved, however the ground profile was poorly defined in an area of steep ground. It is recommended further investigation is undertaken at the detailed design stage.
- Stability of upstream slope of the embankment during MCE. Factor of Safety of 0,74 was achieved, however the likely displacements were considered tolerable.

7.4.5 Settlement

Settlement analysis has been carried out in order to establish the scale of settlement expected around the embankment and concrete gravity dam interface. Modelling was undertaken in *Oasys pdisp*. The model assumes the following parameters:

- 8,8 m thickness of Alluvial deposits overlying Mudstone
- Alluvial Deposit properties of Cu=90 kPa, Eu=5 MPa

- Mudstone properties of Eu=300 MPa
- Embankment loading associated with height of 31 m of $\gamma = 18$ kN/m^3
- Gravity dam loading associated with height of 31 m of $\gamma = 24$ kN/m^3

The results show that total settlement of foundation soils in the order of 600 mm may be expected due to embankment loading. In addition 1% of internal self-weight settlement of the embankment may be anticipated equating to approximately 900 mm of total embankment and foundation settlement. Approximately 50% of settlement may be anticipated to occur during construction (conservative assumption based on Burland et.al. 1978), and therefore 450 mm of post construction settlement may be anticipated if the alluvium were to remain in place. An additional camber of approximately 450 mm is recommended for design due to anticipated long term settlement.

Settlement of the concrete gravity dam is limited to approximately 50 mm due to its founding at depth within the mudstone.

It should be noted that no consolidation testing of the alluvial deposits is available and settlement characteristics have been estimated. The values of settlement should be properly evaluated during the final design stage and based on sufficient and credible laboratory test results.

7.4.6 Seepage Analysis

Seepage analysis has been undertaken in order to establish the amount of seepage which may occur through the embankment dam, and through the embankment and gravity dam foundations, and the extent of grouting works required. Steady state seepage has been carried out to a steady state analysis at Top Water Level using the Geo-slope software SEEP/W.

The results of seepage analysis show that the following will need to be considered within the design:

- An internal chimney and blanket drain is required to reduce the elevation of seepage through the embankment dam and at the toe
- A cut off trench and grout curtain are likely to be required to reduce the risk of seepage through the alluvial soils and weathered bedrock beneath the embankment dam
- A grout curtain is required to reduce seepage pressures beneath the concrete gravity dam and the left hand side abutment.

The requirement for grouting beneath the embankment section is not shown by the seepage analysis, however it is recommended to include the grout curtain due to high near surface Lugeon values and the risk of connected permeable discontinuities within the rock. Indicative grouting layout is shown on the feasibility design drawings. The full extent and layout must be verified during the detailed design stage.

Toe drainage is required at the downstream toe of the embankment, including a collection drain, access manholes, measuring weirs and a discharge point.

7.5 Outlet works

The outlet works have been designed to make provision for discharge of the anticipated maximum environmental water requirements (6 m^3/s) and all downstream off takes and to ensure that with multiple level off takes adequate the water quality is maintained. The pipe design constraint was set at flow velocities < 8 m/s. Consequently their limit is not generally the hydraulic gradient. The velocity in the system can be increased but there is a concern that the bottom discharge sleeve valves may be subject to vibration at higher velocities.

7.5.1 Layout

The outlet tower is located in the concrete gravity left abutment, which allows for conventional concrete construction methods to be carried out independently of the bulk concrete in the spillway gravity section. Refer to the outlet work drawing in Appendix A.

The outlet works are designed with a twin stack system to allow for 100% redundancy for maintenance purposes and to make provision for discharge of the maximum EWR (6 m^3/s). The outlet works also provide multiple downstream off takes to ensure adequate water quality is maintained in the discharges. Although the individual stacks can discharge the full discharge with a pipe design, a constraint was set at flow velocities < 8 m/s. It is recommended that in order to deliver the EWR that both stacks be used. This will result in < 4 m/s flows.

Irrigation water is released to the river for run-of-river abstraction downstream of the dam. The irrigation peak requirement for the approximate 1 600 ha of downstream irrigators (existing and proposed) should not exceed 2 m^3/s.
Access to the upstream tower is off the wall crest via the main access road to the dam wall. The gate house includes a gantry crane to operate the service gates, screens and facilitate maintenance of isolation valves and pipework.

7.5.2 Intake Tower

There is a dual system pipe work in the intake structure. It includes multi-level intakes at different levels, with butterfly isolation valves at each intake structure for selecting the level at which water is to be drawn off. The minimum operating level will be approximately 590 masl. The intake tower consisting of dry and wet chambers is required for maintenance. The intakes are protected with precast concrete trash racks and fine screens to prevent blockage by floating debris. An emergency gate is required for closure for maintenance purposes at the bell mouth entrances. The tower intake chamber includes a motorised gantry and crane for removal of equipment and the raising and lowering of the emergency gate.

On the recommendations of the water quality report (DWS 2015d) the intake tower has 4 x Ø1,0 m off takes. The first is at 5 m below FSL with the second, third and fourth offtakes at further drops of 7,5 m, 7,5 m and 7,0 m relative to the top outlet. The lowest intake is approximately 10 m above the lowest riverbed level and less than 1% of the total storage. The requirement for 4th offtakes may not be required, as it could well have to be blocked off in the future. The next highest off take is approximately at 7% of total storage. This should be finalised in the detailed design stage as the 4th offtake may have application in the initial filling.

7.5.3 Valve chamber and river outlet

The valve chamber is situated in the toe of the left abutment with the floor of the operating chambers being 8 m above natural riverbed. This is estimated to be in the 1:30 return period range at ± 750 m^3/s.

The valve chambers are set out such that there is provision for a future pump area sufficiently large to accommodate possible pump sets and possible turbine installation. A Ø 400 mm blanked off flange connection will be allowed to make provision for this off take.

If required, the Adelaide bulk water supply pumping unit will be housed in one of the valve house chambers. Initially this has been proposed to be a 150 mm Ø bulk water steel delivery pipe routed up the external face of the left abutment adjacent to the access stair way. Alternatively the pipe could be routed internally through the gantry, depending maintenance access preference by the detailed designers and DWS. This pipe will then connect into the

Ø180 mm HDPE main pipe line which links into the current raw water supply line to the Adelaide treatment works.

A preliminary estimate of the hydro potential of Foxwood Dam, based on the projected annual agricultural releases, yielded an estimate 180 kW. This is not considered a viable supply that the Department would be willing to manage within this facility. This can be reviewed in the detailed design stage of this scheme.

7.5.4 Operating rules for releases

The essential operating rules post construction of these work are to meet the following discharges:

- The Environmental Water Requirements estimated to be at a maximum of 6 m^3/s.
- Provide for primary water requirements.
- Ensure that the existing downstream water license users are supplied with their allocations and at peak demands.
- Provide and meter all allocated water both from the dam and from water user's river abstractions to reconcile the discharges.
- Provide adequate quality water both to Adelaide and to the river by use of the multiple level offtakes.
- Control measurement and recording for dam discharges to be measured at the new downstream gauging weir.
- The management of discharges must be clearly understood as the system can potentially exceed the maximum flow required.
- Irrigation peak flow confirmation.

7.5.5 Gallery

A gallery is provided in the body of the concrete gravity dam to provide a means of access and space for drilling drainage holes and grouting the foundation, if required during operation of the dam. In addition the gallery could be used to provide access to the valve chamber – this should be considered in detailed design.

An approximate location of the gallery is shown on the drawings. The minimum dimensions of the gallery is 1,5 m wide by 2,4 m high with an arched roof. The gallery should be a minimum distance of 2,5 m from the upstream face of the dam (5% of the maximum anticipated depth of reservoir) and a minimum distance of 1,5 m from the foundation rock surface.

7.6 Construction materials

7.6.1 Materials availability

Details of the earthfill embankment construction materials is provided in Section 6.4. It is anticipated that the majority of earthfill materials for the earthfill embankment would be sourced from within foundation excavations. Additional material may be sourced from borrow pits investigated with priority given to borrow pit locations within the dam reservoir.

A potential Dolerite rock source for aggregate and rip-rap was also investigated to the north of the site, some 5 km north of the dam location, along the R344 gravel road, and found to be a suitable source of rip-rap and for the crushing of filter material.

7.6.2 Earthfill Requirements

The stability and seepage analysis undertaken shows that the proposed earthfill embankment is feasible. Analysis of samples from borrow pit areas indicate that suitable earthworks materials are present within the site (see Table 34 below), however borehole logs suggest an increase in granular content with depth along the embankment alignment. It is therefore recommended for selective winning of material from borrow pits and the dam foundations with the following classifications as stipulated in Table 34:

Table 34: Appropriate source locations for different materials

Material Type	Proposed use	Anticipated source
Selected Less Permeable material	within the core	May be obtained from near surface deposits, although the volume and extent of suitable material is not well defined
Less Free draining material	within the upstream shoulder	Anticipated to be readily available from near surface deposits within borrow pits and dam foundations
More Free draining material	within the downstream shoulder	Anticipated to be readily available at depth within borrow pits and dam foundations

The minimum requirements for the earthfill material are presented in Table 35.

Table 35: Minimum material specification requirements

Specification	Selected Less Permeable core material	Less Free draining material	More Free draining material
Grading (mm)			
<0,002	>10%		
<0,063		>40%	
<2,0		80 – 100%	
Undrained Strength	>90 kPa	>90 kPa	>90 kPa
Drained Angle of Friction (with c' = 0 kPa)	Anticipated >26°	>32°	>32°
Compacted Permeability	< 5 x 10^{-8} m/s	< 5 x 10^{-8} m/s	1 x 10^{-2} to 1 x 10^{-4} m/s

Filter drain
An internal blanket and chimney drain is required to filter seepage through the embankment fill materials. The anticipated specification requirements of the filter drain material are therefore based on particle size test results of the material encountered within borrow pits and within the embankment foundations. The specifications required of the filter drain are:

- D15 (particle size by which 15% are smaller by dry mass) less than 0,7 mm
- Uniformity (d60/d10) less than or equal to 10
- Permeability less than 1 x 10-4 m/s

In addition, as the filter is critical to embankment design, to ensure its long term performance the source rock of crushed filter material should have the following properties:

- Resistance to abrasion (Los Angeles test) < 40%
- Unconfined compressive Strength >60 MPa

Rip Rap
A layer of Rip Rap is required on the upstream embankment slope to provide protection against wave erosion and damage. Dimension requirements of Rip Rap has been assessed in

accordance with the method proposed by Hudson 1959 method included in Ciria C683, The Rock Manual. The fallowing assumptions have been used in the assessment:

- Density of Dolerite of 2 700 kg/m^3 (based on published data);
- Wave height of 2,3 m for 1:100 year storm event as assessed in Freeboard calculations.

The following resultant parameters have been calculated:

- Median stone diameter Dn50 of the Rip Rap is 0,56 m
- Thickness of Rip Rap layer is 1,1 m
- Median diameter Dn50 of the bedding layer is 0,25 m
- Thickness of the bedding layer is 0,8 m.

7.6.3 Concrete

Cement
The method of construction for the spillway section will be determined in the detailed design stage or by the Contractor. Whether roller compacted, structural or mass gravity, it will comply generally with SANS 1200 and SANS 1491 Parts 1&2 as applicable to GGBS and Fly Ash. The application of approved extenders will be determined based on the results of trial mixes conducted during the implementation stage.

Fine Aggregate
The geotechnical investigations stated that there are no commercial sources of natural sand or filter materials available. These will have to be manufactured from a potential dolerite quarry site which has been identified approximately 6 km from site or other established commercial sites in the region. The applications process for both the reservation of the potential site and the approval process should be considered at the earliest opportunity once the scheme has been given approval to proceed to the next stage.

Course Aggregate
The geotechnical report indicates that as a result of three boreholes the quarry is suitable as stated above for the manufacture of all grades of aggregate.

Water
Water quality from the river has no indication of deleterious content provided organic matter appropriately settled and filtered out. The pH will need to be monitored at regular intervals to determine if there are any fluctuations beyond specification limits.

7.7 Construction and dam safety

7.7.1 Programme

A high level programme has been included in Appendix E. The duration of the contract is affected by the selected gravity concrete method selected. The programme is based on a roller compacted (RCC) estimated production which will only commence when there is adequate abutment completion to allow for uninterrupted placing. The time frame is dependent on which part of the seasons the contract is commenced in. Generally it is most suitable to commence the contract prior to the end of the rainy season. The bulk volumes are relatively small such that the earth works could be completed in one year as can the gravity section.

The constraints to construction will be to supply and maintain adequate stockpiles of quarry manufactured filters; aggregate and rip rap. The other matters which will influence closure will be the bridge construction and road realignment; land matters; power and telecommunication relocations; and any environmental matters which may come up during the study and construction. It is recommended that where feasible, these contracts be commenced and completed prior to the construction of the dam or one year prior to inundation.

7.7.2 Concrete construction

Determination as to whether the spillway will be a conventional shuttered and jointed gravity concrete or the currently favored RCC with less jointing and shutter fixing, will be determined at the detailed design stage or by the selected contractor. As discussed earlier the location of the outlet works in the left bank abutment allows for the relatively uninterrupted placing of mass concrete in the spillway while the more structural reinforced concrete works in the abutments and intake tower can be completed without interfering with the bulk placing. There is an allowance in the pricing build up for precast galley shuttering. The specifications for which ever method(s) of placing, will be finalised in the design stage and will conform to DWS specifications.

7.7.3 Earth embankment construction

Specifications for the construction of earthworks materials must be carefully finalised during the final design stage considering the proposed source materials and project programme. The following sections provides discussions on likely construction requirements.

A review of borrow materials and compaction test should form part of the detailed design phase investigations. Verification testing by means of a nuclear densometer (Troxler or Humbolt), and regular classification tests must also be performed in order to ensure that the correct clay is used.

Filter drains
The method of construction of the internal chimney drain should consider the potential for contamination from cohesive embankment fills which may reduce the performance of the chimney drain. Construction of the entire embankment profile in uniform lifts is likely to be required to prevent stability issues. Typical solution to prevent contamination of granular drains is to cover with temporary geotextile separator during construction of layers of cohesive elements, then excavate a trench through the cohesive layer and backfill with granular fill. This process is repeated through the entire embankment construction.

Upstream Rip-rap slope protection
The upstream slope must first be prepared by removing all stones and smoothing the surface. After the preparation of the upstream slope a 200 to 300 mm layer of sand can be spread, thereafter a 200 to 300 mm layer of crushed gravel can be spread on the sand. The rip rap can then be dumped on to the surface by means of tippers or any other appropriate construction equipment.

7.7.4 Core Cut off Trench

Construction of the core cut off trench will need to consider construction phasing of the underlying grout curtain. It is recommended that on completion of the excavation and blasting a concrete grout cap be placed with imbedded stand pipes. A grout cap in mudstones will reduce the exposed weathering and rework as well as limit the hydraulic fracture leeks at the surface.

This phasing of construction has the following sequences:

- The excavation of the cut off trench
- Clean and trim trench
- Cast concrete grout cap
- Commence the drilling and grouting procedures

7.7.5 Backfill

Backfilling of temporary excavations will be required surrounding the foundations for the concrete gravity dam and retaining walls. Suitable excavated materials must be stockpiled and sealed while not in use. The excavation must be done in such a manner to allow for sufficient space between structures and the undisturbed natural soil. This is necessary to ensure that proper construction equipment can be accommodated in order to perform proper back filling. On the downstream side it must be ensured that drainage water is diverted away from the structure. The permeability of the backfill material must also be considered, and must be modified if deemed necessary.

7.7.6 Labour intensive construction

Labour intensive construction of the dam as opposed to labour intensive construction tasks on the dam was considered. It was considered that the approximately 300 000 m^3 of concrete could be substituted with a rubble masonry resulting in a labour intensive alternative. Estimates of production of rubble masonry were obtained from an experienced contractor who specializes in this form of dam construction. The estimated construction per day per 100 labourers was 750 m^3. This implies that if the bulk of the concrete works were to be completed in a 2 year period approximately 800 personnel would potentially be on or in close proximity to the wall. The majority being on the wall. This would be neither practical nor safe. If the construction period were extended the P&G element of the project would exceed the 10% premium. The cost of roller compacted concrete is competitive with the masonry alternative. Areas where labour intensive tasks can be carried could be in the following activities:

- Finishing and landscaping
- Slope Protection
- Structure backfilling
- Filter placement

There will be associated contracts which lend themselves to labour intensive construction or works, such as:

- The bulk water pipeline routed to connect to the existing Adelaide water supply pipeline
- The canal reinstatement with a 600 mm pipeline and canal;
- R344 Road realignment and bridge;
- Grave relocations

All of these tasks could be carried out wholly or partially as a labour intensive operation. To establish, at this stage, the comparative cost advantage or otherwise of these tasks is not of significance. Different contractors have varying approaches to tasks. It is suggested that the tender incorporated a dual rate system for any item considered suitable for labour intensive work and that if this rate is less than 10% of the machine approach then the premium on this rate will be considered without affecting the competitiveness of the tender.

7.7.7 River diversion

It is recommended that the river diversion strategy commence at the onset of a dry season in order to facilitate the installation of a diversion culvert 4,0 m wide by 3,5 m high with its invert at the river bed level of 578 masl in the middle left of the spillway section. A 60 m wide section of the spillway must be kept 4 m lower than the rest of the spillway for the duration of the spillway construction. The discharge capacity of the low section will be approximately 555 m^3/s, which will allow for the passing of floods during the dry season. The diversion culvert will keep the upstream water level at approximately the river bed level during normal dry season flows.

As the dam height increases the flood absorption capacity of the basin will increase. The 1 in 20 year flood volume will be absorbed when the embankment is at level 592 masl and the 1 in 50 year flood volume when it is at level 603 masl. The staging of the diversion is anticipated as follows:

- First stage diversion and coffer dam required for excavation and concrete placement to river bed level before installing / forming culvert for low flows
- Second stage diversion to enable excavation and concrete placement for remainder of spillway and construction of embankment
- Capacity of conduit and proposed height of coffer dam to take account of flow rates for 1:20 and 1:50 floods
- Sequence of construction of embankment in relation to spillway to ensure earthworks are not overtopped
- Closing of conduit when dam is ready for impoundment (steel stoplogs to close opening, filling with concrete and grouting).

7.7.8 Borrow areas

Should material from borrow areas be required to meet the materials balance or permeabilities, the excavations should be planned to limit trafficking distance ans impact on the landscape. Excavations within the reservoir basin will reduce the need for landscaping. The control of groundwater within borrow pit excavations should also be considered. It is noted that the development, operation and closure of borrow areas and quarry sites is subject to an environmental management plan, which needs to be submitted to and approved by the Department of Mineral Resources (DMR). However it is also noted that DWS has exemption from needing a license from DMR for a quarry or borrow areas.

7.7.9 Quarries

A potential Dolorite quarry is situated north of the dam alongside the R344 road. Excavations of this quarry could improve the road alignment, and with it, safety of road users. Excavation at this location may need to consider subsequent rehabilitation with vegetation and the safety of the public. It is recommended that the relevant environmental and mining approvals be commenced as soon as possible after project approval.

7.7.10 Quality control

There will be a requirement for a full time materials laboratory on site with the appropriately experienced technician and support staff. There should be quality inspectors at selected borrow areas, in particular where selection of material that must be tested and approved is required. Record of all testing shall be recorded and backed up at regular interval and stored off site.

7.7.11 Dam safety aspects

This is a Category III dam and as such the detailed design will be carried out in terms of the current National Water Act Chapter 12 sections 117 to 123.

Legislation Obligations
The following is required in terms of dam safety legislation and regulations:

- Design by a professional team under supervision of an Approved Profession Person (APP) for that category of dam

- An application for a permit to construct accompanied by the design drawings, report and specifications
- During construction the APP is required to provide assurance that the dam is constructed in accordance with the specification and that alterations to the design are approved and signed off.
- All permits, licenses and temporary wayleaves are in place prior to either construction and/or closure including all requested documentation and plans.
- All conditions pertaining to the construction and impoundment of the dam are adhered.
- The APP is required to submit quarterly progress reports during construction, and a completion report and record drawings at the end of construction

Instrumentation
Instrumentation will be required to monitor the performance of the dam elements. These are likely to include the following:

- Settlement monitoring points at 20 m intervals along the crest of the embankment and concrete gravity dam
- Vibrating wire piezometers within the embankment materials to monitor pore pressure during construction and be able to prevent excessive pore pressures building up within the embankment
- Downstream piezometers within the embankment to monitor seepage
- Seepage flow monitoring channels and weirs within the gallery of the concrete gravity dam
- Flow monitoring weirs within toe drainage features for the embankment

Dam break analysis
Foxwood Dam is classified as Category III or High Hazard. Due to its proximity to the town of Adelaide and the proposed new irrigation scheme located adjacent to the river line, a dam break analysis is required, by the Dam Safety Officer, to determine the potential loss of life, damage to property/infrastructure and economic losses following a hypothetical dam failure. This will then inform the inundation mapping for the emergency preparedness planning.

Due to the composite nature of the dam, at least four scenarios should be considered:

- Failure of the concrete gravity section with no incoming flood (a “sunny day” failure)
- Failure of the embankment section with no incoming flood (a “sunny day” failure)
- Failure of the concrete gravity section during a flood event (PMF and/or 200 year)
- Failure of the embankment section during a flood event (PMF and/or 200 year)

The dam break hydrographs should be routed downstream as far as practically possible i.e. as far as detailed topographic survey allows which extends to the confluence of the Fish River. This would probably be when the flood flow returns to the natural watercourse.

The flood outlines will also contribute to inundation mapping and for the emergency preparedness planning.

Emergency draw-down
Rapid draw down of the reservoir may be required to prevent a potential failure of the dam. The outlet structure is capable of drawing down 90% of capacity from full in a 3 month period. If a lesser period is required the outlets system can be designed to accommodate this at the next stage, however care must be taken on the impacts downstream.

Emergency Preparedness Plan (EPP)
An EPP will need to be developed at an early stage of the detailed design phase, to allow for any mitigation measures that may be required, and if required incorporated in the design.

The EPP for the dam will include the following:

- Notification Flow Chart
- Communications system
- Levels of Emergency – normally 4 ranging from minor to evacuation and national
- Owners details
- Disaster Management Authorities Chain and contacts with alternates
- Dam details and documentation including emergency indicators
- Dam emergency mitigation measures
- Inundation mapping
- Preparedness plan
- Suitable equipment and materials for local repair of potential minor events, such as sand bags
- Affected Parties
- Possible conditions for reoccupation and economic consequence for repair both for the dam as well as affected parties

7.8 Conclusions

- Based on the geological investigation and hydrology review, a 1 MAR size dam was selected as the preferred size of dam at the Foxwood site. For a dam of this size, a composite structure provides the lowest URV.
- The composite dam comprises a gravity concrete spillway and earth embankment.
- It is anticipated that sufficient material for the embankment section will be available from borrow pits located within, or close to, the dam basin. However some dispersion was identified in sampling and material selection must be closely monitored.
- A quarry site located approximately 5 km from the dam site indicates a good source of dolorite for use as rip-rap and for crushing to produce sand for filters and concrete manufacturing.
- Foxwood Dam is a category III dam
- The spillway has been designed to safely discharge the Safety Evaluation Flood discharge of 5 218 m3/a however this may be optimized through consideration of Kovaks + DELTA at detailed design
- The spillway has a steepness of 0,6H:1V which is achieved due to the beneficial effect of the large concrete stilling basin on the overall stability analysis. Should the stilling basin design and return to river be developed at detailed design, the dam steepness and overall stability must be reviewed.
- The embankment section has been designed with slopes of 1:3 and 1:4 for the downstream and upstream slopes respectively.
- The outlet works have been sized to discharge the Ecological Water Requirements of 6m3/s with velocities through the outlet works limited to less than 4m/s.
- Access to the right bank of the dam is provided within the design via a bridge across the spillway. It is likely that this must be reviewed during detailed design and alternative access provided by a cut in the right bank flank.

7.9 Dam statistics

The tables below provide a summary of the key dam statistics

Table 36: Dam Statistics – Locality, structure & reservoir

LOCALITY	
Province	Eastern Cape
District Municipality	Amathole District
Co-ordinates of dam	32° 40'30'' S 26° 16' 0'' E
Nearest town by road	Adelaide
CATCHMENT	
Drainage Number	Q92
River	Koonap
Catchment Area	3 334 km^2
Mean Annual Precipitation (MAP)	513 mm
Mean Annual Runoff (MAR)	79,6 million m^3/a
STRUCTURAL INFORMATION	
Type of dam	Composite concrete
Overall length of wall	485 m
Length of spillway (including piers)	267 m
Total length of left bank NOC	48 m
Length of earth fill on right bank	163 m
Length of outlet works	58,375 m
Non-overspill crest level	620,5 masl
Spillway crest level	615,0 masl
Lowest foundation level	571,6 masl
Maximum height of NOC above foundation	48,9 m
Recommended Design Discharge (1:200)	2 063 m^3/s
Excavation volume	234 388 m^3
Earth fill and backfill material volume	584 820 m^3
Total volume of reinforced concrete	51 840 m^3
Total volume mass concrete	220 183 m^3
RESERVOIR INFORMATION	
High Flood Level (HFL)-1:100	617 m
Design Flood Level (DFL) 1:200	617,50 m
Safety Evaluation Flood Level	620,50 m
Full Supply Capacity	54 995 984 m^3
Lowest Draw Down Level	585,40 m
50 year Silt Volume	6,1 million m^3
Reservoir Surface Area at HFL	4 634 414,49 m^2

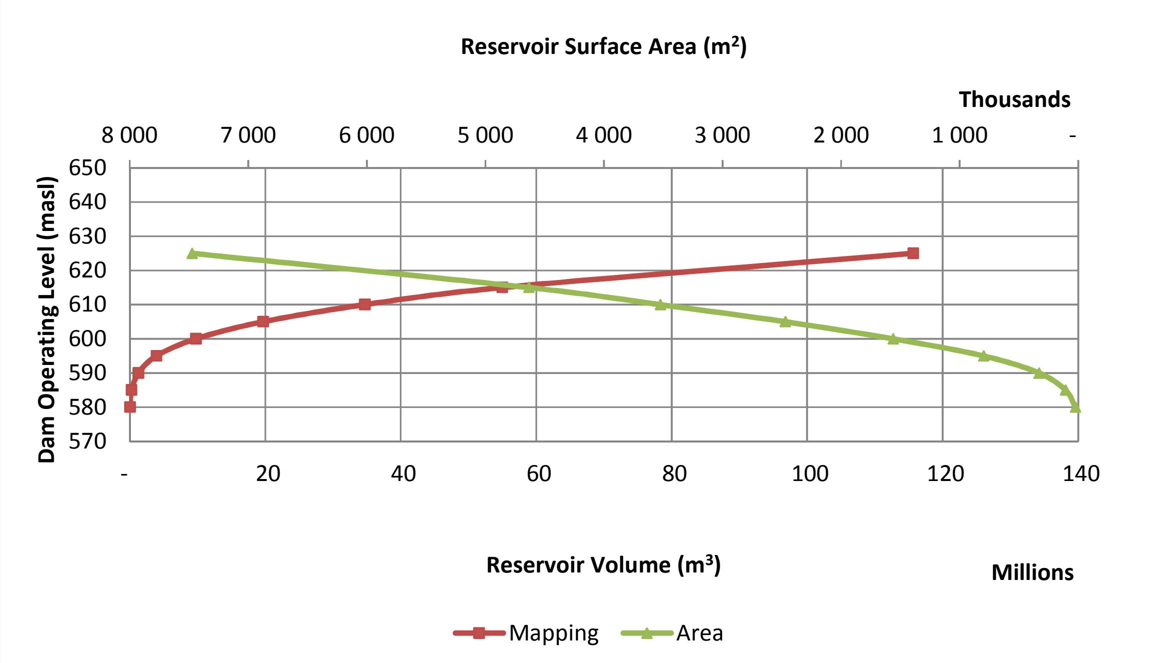

Figure 30: Dam Area-Storage capacity curve

Table 37: Dam Statistics – Design Flood Peaks & outlets

DESIGN FLOOD PEAKS	
Return Period (Years)	**Discharge**
5	176 m^3/s
10	332 m^3/s
20	555 m^3/s
50	985 m^3/s
100	1 457 m^3/s
200	2 063 m^3/s
Recommended Design Flood (PMF)	2 063 m^3/s
Regional Maximum Flood (RMF)	5 218 m^3/s
Safety Evaluation Flood (SEF) (PMF routed)	6 200 m^3/s
OUTLET WORKS	
River Outlet - 2 x Bottom Discharge Sleeve Valves	6 m^3/s
Maximum design pipe velocity	4 m/s
Multiple Intake	4 Nº

8 EXISTING INFRASTRUCTURE AND LAND MATTERS

Construction of the Foxwood Dam would impact significantly on existing lands and infrastructure and would require construction of additional ancillary infrastructure. This section reports on the following land matters and infrastructure requirements resulting from the dam construction:

- Existing bulk water supply to Adelaide and proposed bulk water supply
- Access to the dam site for operation and maintenance
- Inundation of existing roads
- Inundation of existing Eskom infrastructure
- Inundation of existing Telkom infrastructure
- Relocation of graves
- Inundation of property and other structures in the dam basin

Refer to drawing 225739-LND-0704 in Appendix A for illustration of the location of all land matters and affected infrastructure.

8.1 Bulk water supply infrastructure

8.1.1 Existing water supply canal to Adelaide

Water abstracted from the Koonap River for domestic use within Adelaide is currently abstracted at a weir to the north of the town and supplied to the town via a gravity canal which discharges to the Adelaide Dam. From the Adelaide Dam the water is supplied to the water treatment works via a ∅ 315 mm uPVC pipeline under gravity. Refer to Figure 31 and Figure 32 below.

Figure 31: Photo of Adelaide canal at discharge into Adelaide dam

Figure 32: Photo of Adelaide dam

The proposed Foxwood Dam basin will inundate a portion of the existing gravity canal. Within the PSC forum the Eastern Cape regional office of DWS requested that this gravity system be maintained as a gravity scheme. The PSP undertook to provide a provision cost for maintaining this supply. It is feasible to continue the gravity supply by providing a pipe to syphon across the proposed bridge on the relocated R344 before rejoining the existing canal and delivering to the existing Adelaide Dam. However to reconnect into the existing canal the minimum estimated relocation length is estimated at 3.4 km (refer to Figure 33 below).

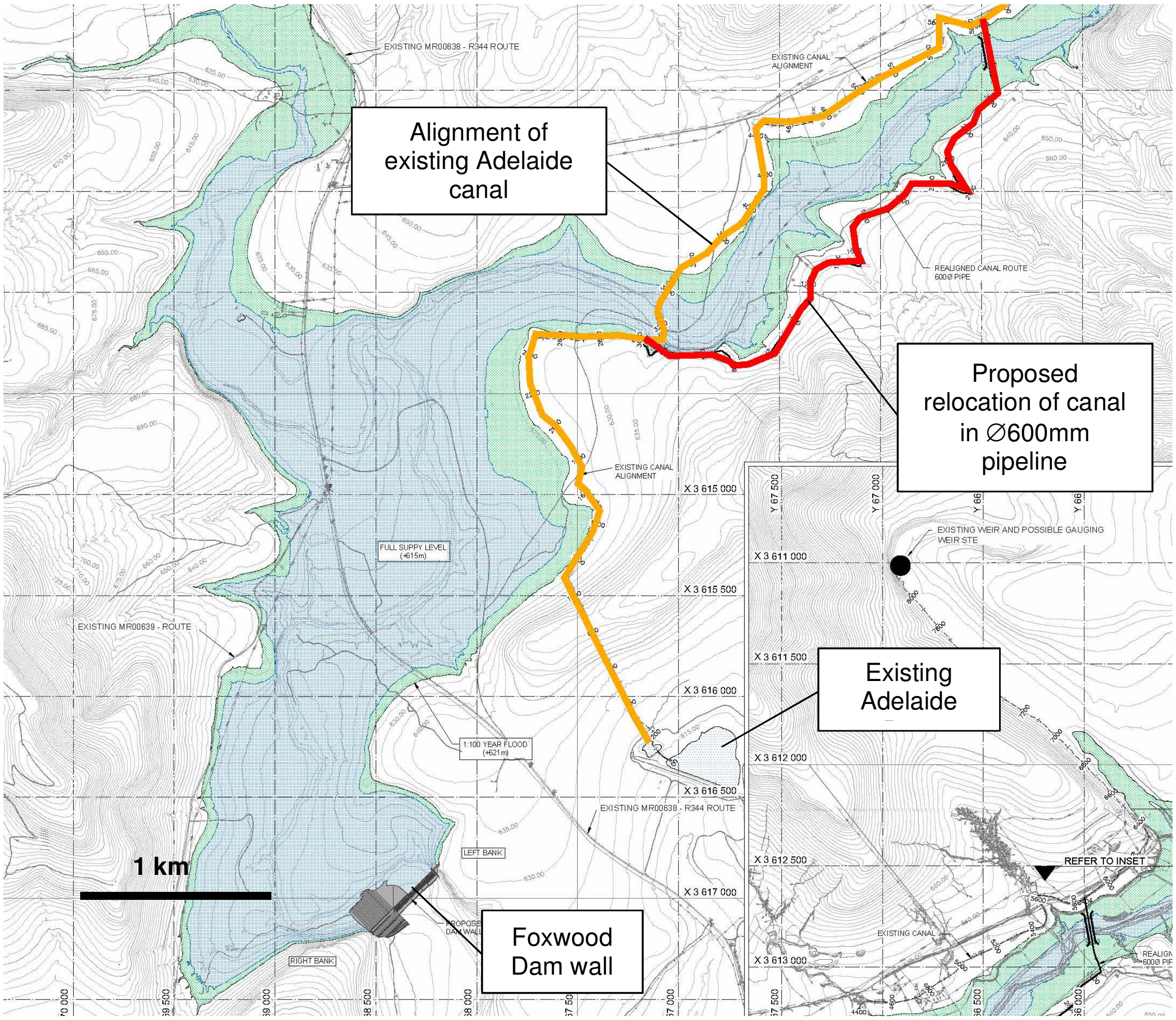

Figure 33: Proposed relocation of Adelaide canal

The canal replacement will be ∅600 mm steel. This will need to be more thoroughly calculated as the head surplus is less than 1 m at this point. The provisional cost estimate for this piped portion of the canal scheme is **R12 800 000 million** (base year 2014).

8.1.2 Bulk water pipeline from Foxwood Dam to the Adelaide treatment works

To provide additional resilience to Adelaide's domestic water supply, a pumped bulk water supply pipeline for Adelaide has been included in the feasibility design. The pipe has been designed to supply the equivalent of Adelaide's domestic water supply. The proposed pipeline connects into the existing water treatment works intake pipe from Adelaide Dam as illustrated in Figure 34 below. The pump station will be located in the valve chamber outlet works of the dam wall and the rising main will be routed along the dam access road and down a section of the R344 before tying into the existing pipeline from the storage dam to the water treatment works.

Water supply from Foxwood Dam to Adelaide will be via a pressurized pipeline routed from the dam and tying into the existing supply pipeline from Adelaide Dam to the Adelaide water treatment works.

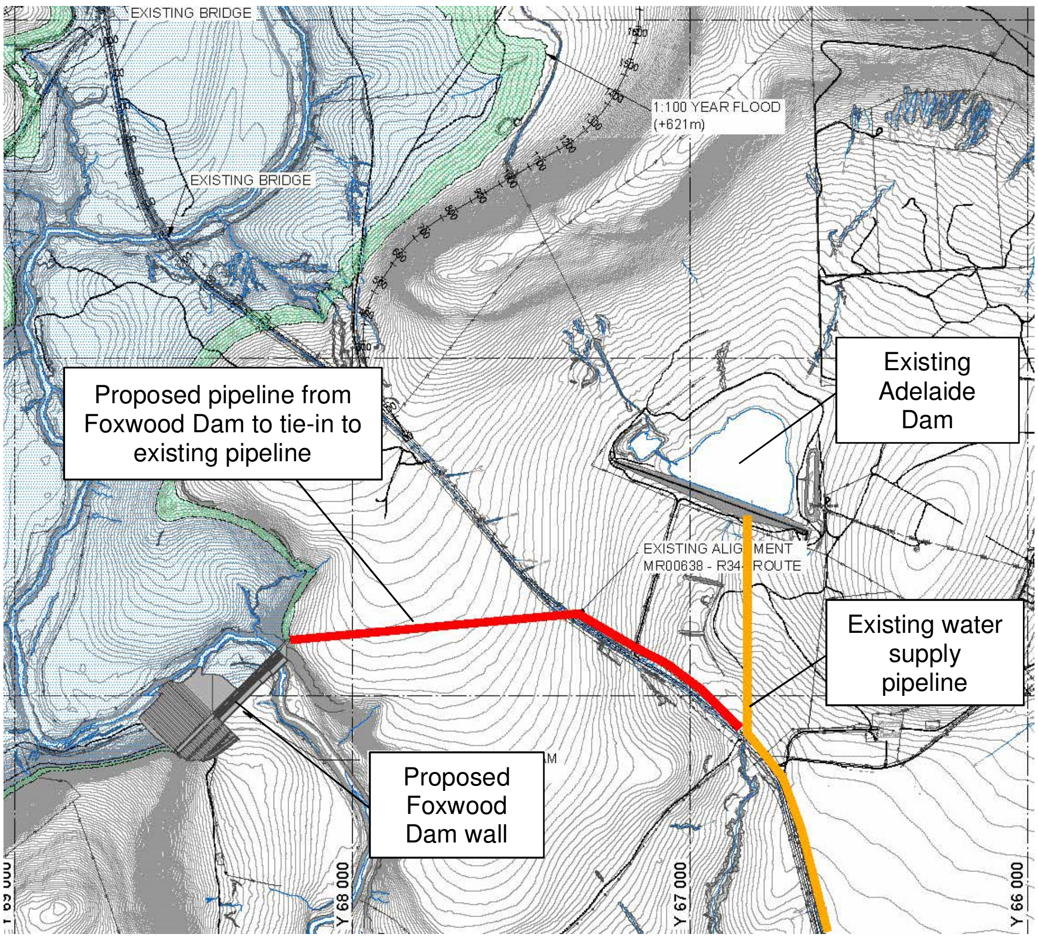

Figure 34: Proposed bulk water pipeline

The current water supply infrastructure is adequate – subject to appropriate maintenance by the WSP – to meet Adelaide's current and projected water requirements. Therefore the requirement to construct the bulk water supply line and install the mechanical workings of the pump station should be reviewed during detailed design.

Alternative abstraction sites were not considered however the final location of the gauging weir may provide an alternative site.

8.2 Access to the site

Access to the left bank is approximate 4 km outside of Adelaide on the R344 to Tarkastad. There is a municipal gate and an ill-defined track which will only partially reach the Koonap River, approximately 500 m short of the river and dam centerline. Refer to drawing 225739-DAM-0902 in Appendix A for the site access road design. Access to the right bank is proposed to be via a bridge across the spillway with a turning circle cut into the crest of the headland.

DWS have noted that it is not preferred to have a bridge over the spillway and that access to the right bank should be provided through a cutting on the right bank and accessed via the MR00639. This is illustrated in Figure 35 below. Construction of this access road would require a cut of 330 000 m^3 with an estimated 40% in hard to intermediate material to reach the crest level with a grade of 1:10. An initial cost review has indicated this option would be approximately 2x (of the order of R 40 million) the cost of the proposed bridge over the spillway. The proposed access should be reviewed in the detailed design.

DWS has also noted that a river crossing is required close to the dam wall. In the event that the bridge over the spillway is not constructed, the closest river crossing would be the existing R63 bridge immediately downstream of Adelaide, approximately 5 km south of the dam site.

Access to the base of the right bank would be via a new servitude through the Norwood Farm. Access to the base of the left bank and outlet works would be through the intake tower and the gallery to be provided to the outlet works.

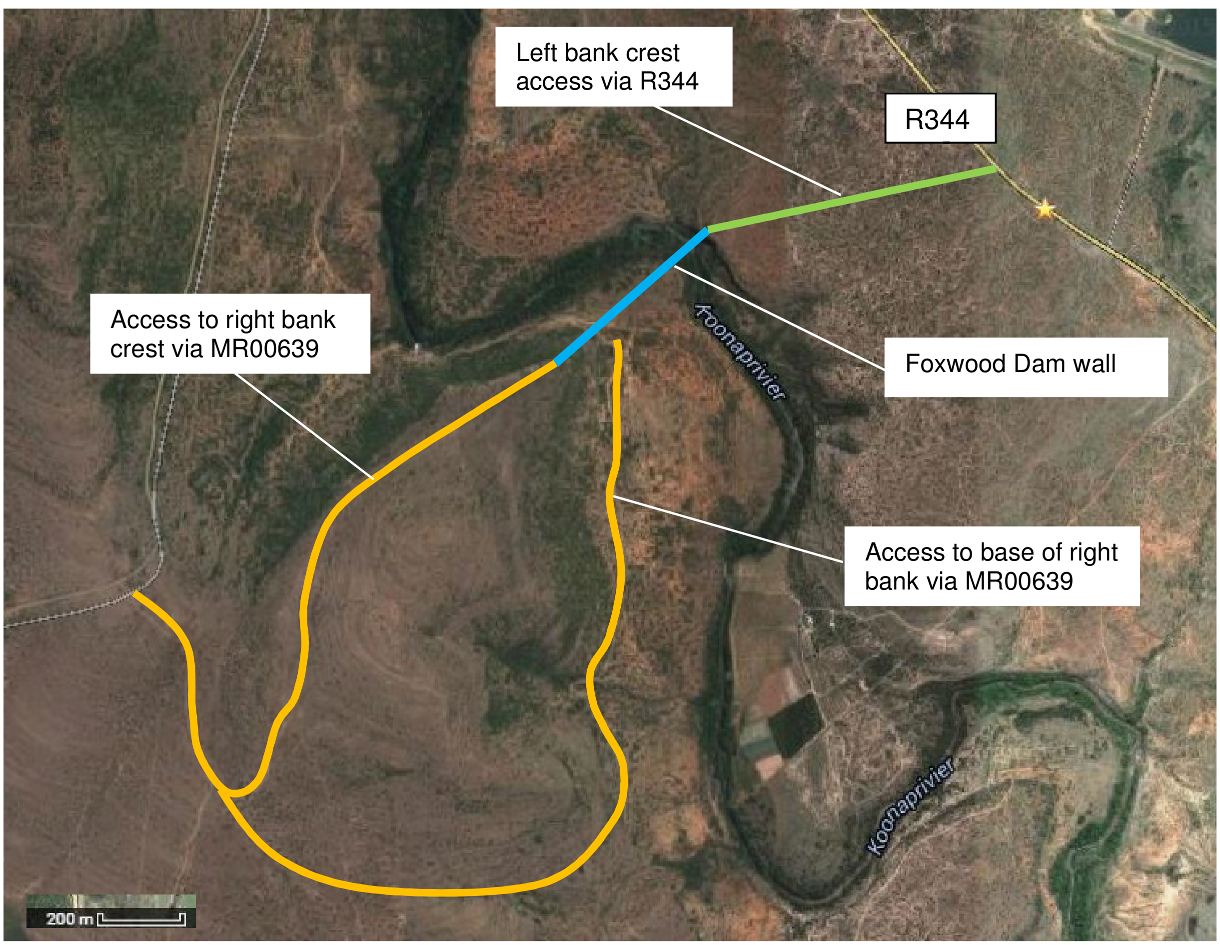

Figure 35: Sketch illustrating possible dam access routes

8.3 R344 (MR00638) & MR00639 Relocation

The Foxwood Dam basin will inundate a portion of the R344 which links Adelaide and Tarkastad and a portion of the MR00639 which provides a link between the R63 (routed between Adelaide and Bedford) and the R344 and provides a form of bypass of Adelaide for travelers routed between Bedford and Tarkastad. Refer to Figure 36 below. Photos of the two roads are given in Figure 37 below.

Consultation regarding the potential relocation of the roads has taken place with the Eastern Cape Department of Roads and Public Works (ECDRPW). This included proposed realignments and cost estimates. The structure of costing model for the road diversion followed a structure provided by the ECDRPW with detailed costing of road elements within the BOQ carried out in accordance with the Colto specification for roads and bridges.

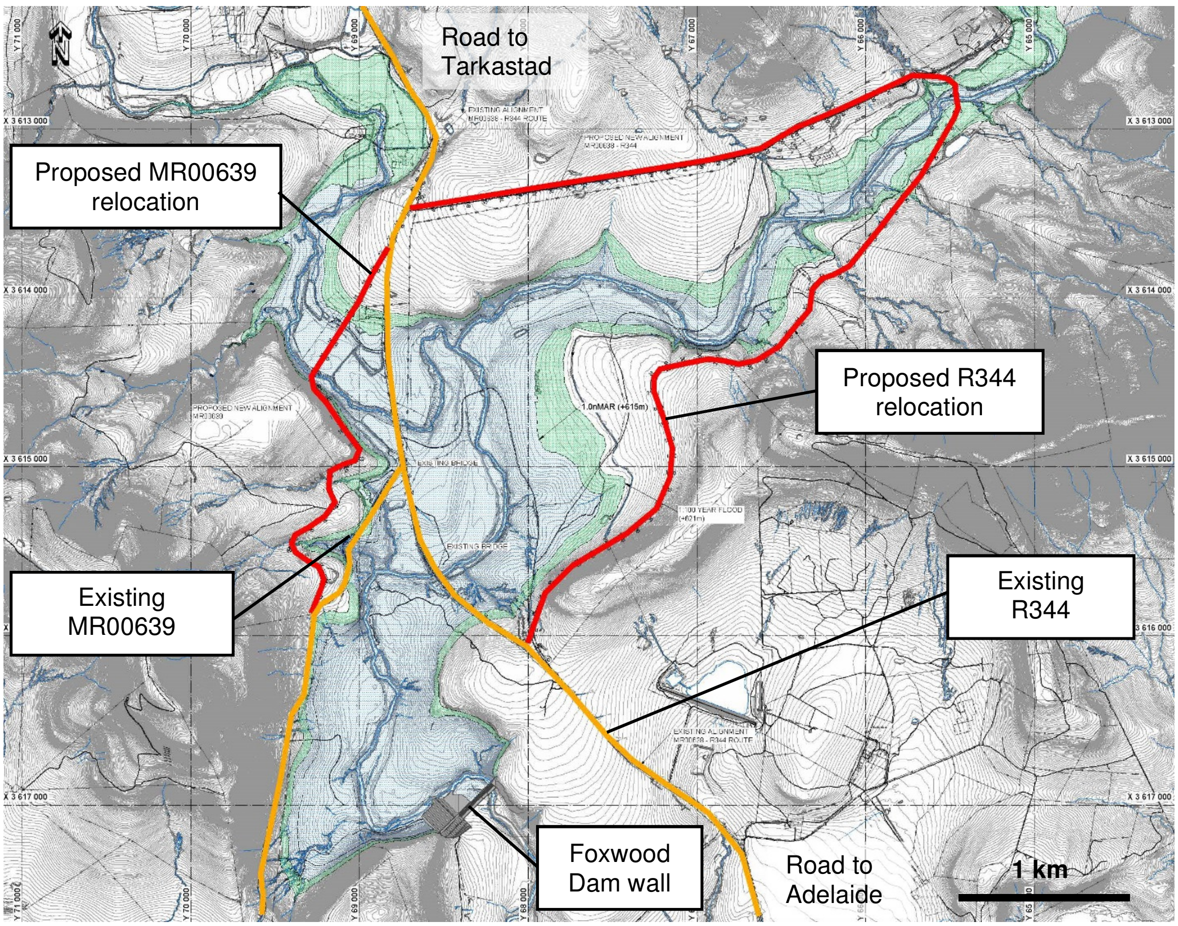

Figure 36: Proposed road relocations

Allowance has been made for the relocation of the R344 road linking Adelaide to Tarkastad to the same standard as the existing gravel road. The relocated road would include a 91 m long bridge to span the tail water of the dam.

The relocation of the MR00639 was determined but was excluded from the project cost and economic impact assessment due to anecdotal information indicating it is little used and the disproportionately high cost of relocation due to the steep and rocky terrain it would be routed through. A traffic study is to be carried out as part of the Environmental Impact Assessment (EIA) to confirm the actual usage of the road. ECDRPW indicated that the relocation of the MR00639 may not be required depending on actual usage.

R344

MR00639

Figure 37: Photo along R344 (top) and MR00639 (bottom)

Refer to the following design drawings in Appendix A:

- 225739-LND-0802 – Proposed Realignment of Road MR00638-R344 Plan Layout
- 225739-LND-0802 – Proposed Realignment of Road MR00638-R344 Plan Layout
- 225739-LND-0803 – Proposed Realignment of Road MR00638-R344 Profile

8.4 Eskom relocation

Figure 38: Photo of Eskom infrastructure located within dam basin

A 22 kV over-head power line is routed along the western side of the dam basin through the area of inundation. It will be necessary to relocate this power line around the extent of the basin. There are two possible routes and an allowance has been made for these works based on a conservative alignment length of 10 km. The proposed alignment is shown in Figure 39 below. Consultation with Eskom is forming part of the EIA process.

The Eskom relocation should be considered in conjunction with the proposed roads relocations to ensure that cost effective construction and maintenance access is achieved.

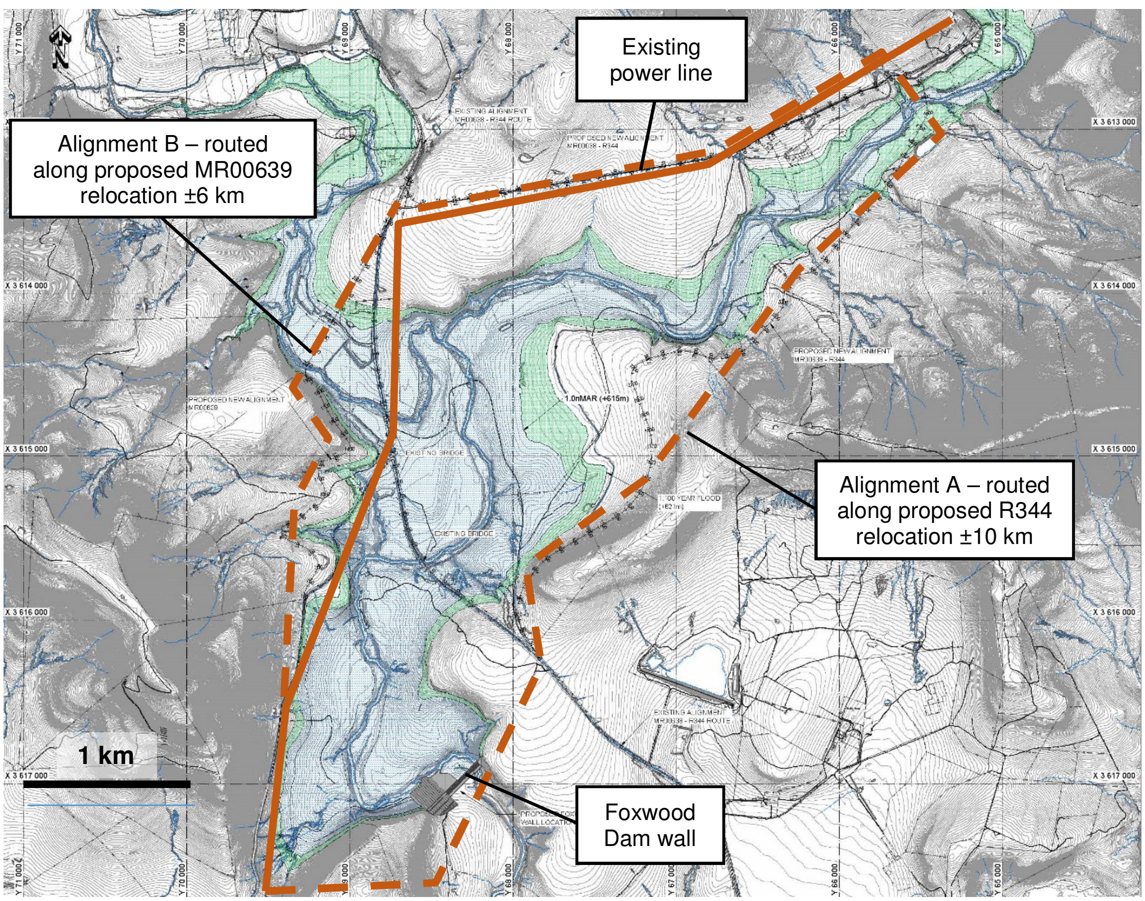

Figure 39: Proposed alternative power line routing

8.5 Telkom relocation

An existing overhead telephone line is routed along the existing R344. It is proposed that this length of line will require relocation along the proposed new routing of the R344. This will require approximately 10 km of new poles and cabling. The proposed alignment is shown in Figure 41 below.

The Telkom relocation should be considered in conjunction with the proposed roads relocations to ensure that cost effective construction and maintenance access is achieved.

Figure 40: Photo of telephone infrastructure routed through dam basin

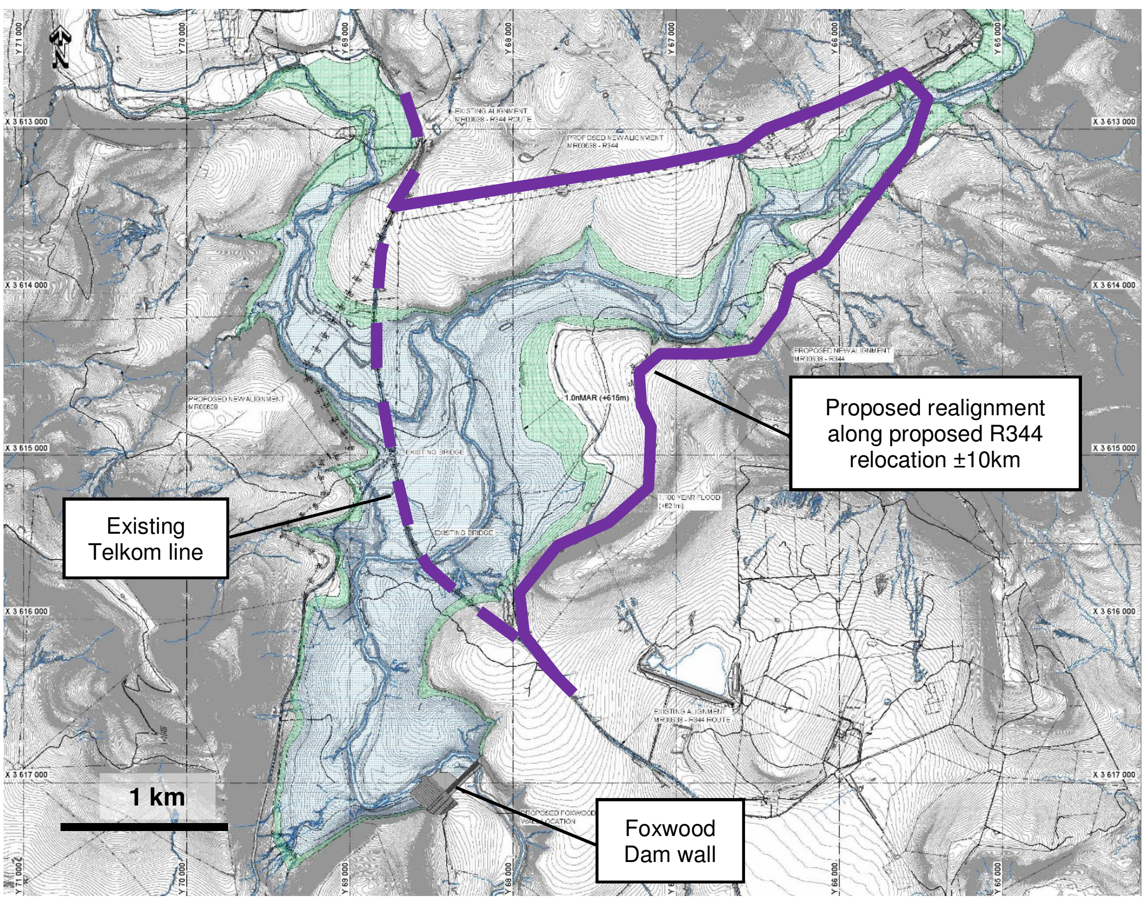

Figure 41: Proposed alternative Telkom line routing

8.6 Graves

A small burial site has been identified on the aerial imagery. Cost allowance has been made for relocating those identified graves; allowance has been made for 10 graves. A detailed study will be carried out in the EIA.

8.7 Gauging weir

DWS have indicated that upstream gauging will be incorporated within the dam instrumentation system.

The existing sharp-crested weir (Q9H002) constructed in 1928 in the Koonap River at Adelaide should be refurbished as part of the project. This cost is included in the contingent sum. Due to Q9H002 being downstream of the Cowie River confluence with the Koonap River, a new gauging weir must be constructed closer to Foxwood Dam wall.

The co-ordinates of the proposed gauging weir site in the Koonap River as identified by DWS are 32.683182 South and 26.273667 East. This location is illustrated in Figure 42 below. DWS have also indicated a possible alternative gauging weir site which is also identified below. Full details of DWS's requirements for the gauging weir, as provided to Arup, are included in Appendix C of this report.

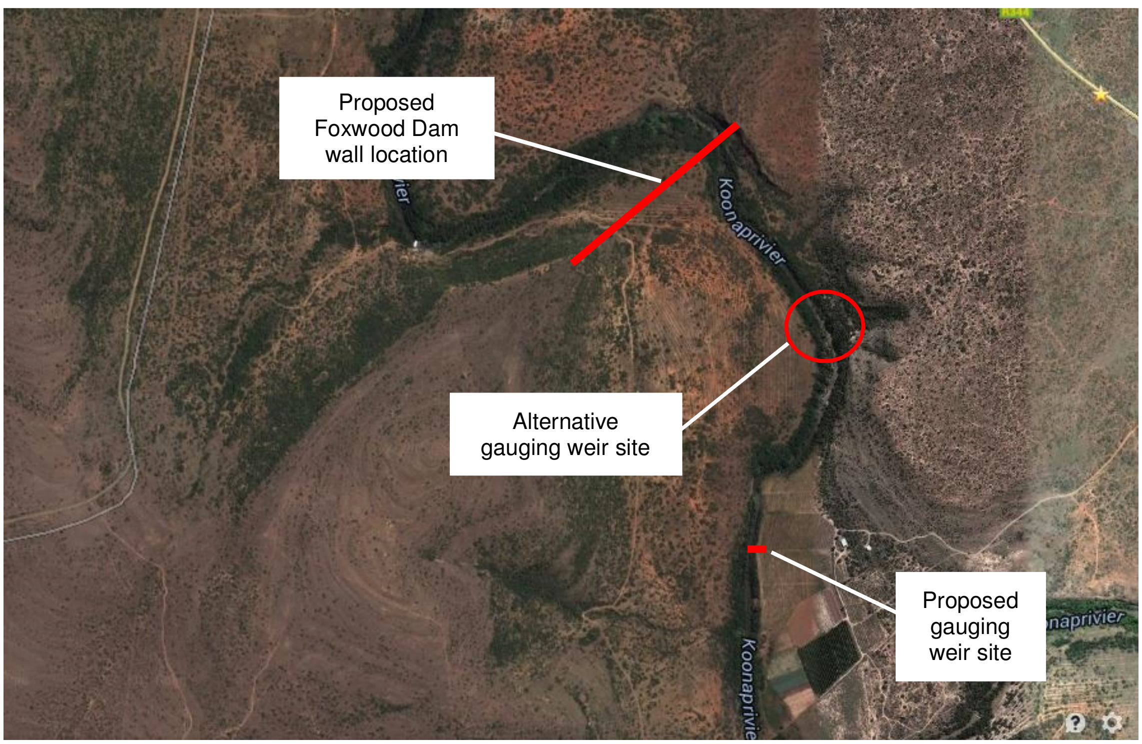

Figure 42: Proposed downstream gauging weir sites

8.8 Land inundation

A preliminary expropriation line, depicting the minimum land purchase requirements for construction of Foxwood Dam, was determined for purposes of the EIA, as background for public consultation processes and for estimating the cost of land acquisition. The backwater line for a 1:100 year flood passing through Foxwood Dam, calculated using existing mapping of the dam basin, with a 15 m horizontal or 1,5 m vertical (whichever is worse) is the basis of the preliminary expropriation line. This was determined according to the “Policy and Guidelines for the Acquisition of Land Rights at Departmental Dams”. Land rights (including servitudes) to implement and operate the required infrastructure must be acquired in accordance with Departmental policy and guidelines.

Properties affected by Foxwood Dam are mostly in private ownership and generally used for commercial farming. The process of identifying landowners for land acquisition purposes commenced in the work done for the public participation but stopped short of discussing compensation amounts. The estimated cost of land acquisition is based on a detailed inventory of the affected properties, land uses on those properties and physical improvements.

Land acquisition will bring about the need to not only provide compensation for the land and improvements but attention must be given to the management of the “unregistered rights” of farm labourers and occupants who will be affected by the project. Management of the land acquisition process is time consuming and should commence as early as possible.

8.9 Existing structures in dam basin

There are a number of structures within the dam basin that will be inundated and will be removed subject to the findings of the EIA. Provision for the removal of these structures should be made at detailed design. These structures include:

- Two bridges on the existing R344
- Disused weir immediately upstream of proposed dam wall site
- Inundated portions of MR00639 and R344 roads
- Inundated portions of Eskom and Telkom infrastructure
- Inundated portion of Adelaide canal
- Existing buildings and farming infrastructure such as storage tanks and pipelines

Other structures may be identified during the EIA stage and would need to be considered during detailed design.

The land areas affected by Foxwood Dam generally consist of natural bush grazing with some pastures, cultivated land, mountain land and citrus orchards with some fixed improvements in the form of buildings. An evaluation of land values in the Adelaide area was carried out by Uniqueco property valuers in November 2014. The ‘comparable sales’ method of valuation has been used to determine the potential market value of land. Historic sales of comparable properties within the Bedford and Fort Beaufort Registration Divisions were reviewed and average land value rates determined.

Using this approach, general land values (in ZAR / ha) for land of different standards were determined. All land inundated by the Foxwood Dam is assumed to be of a ‘Very Good’ standard. The land value determined for the inundation area is based on this general approach and does not reflect a specific assessment of each individual farm. Farm buildings and specialized improvements are valued by applying the depreciated replacement cost approach. This method starts with replacement cost determined from the AECOM Africa Property and Construction Handbook and is then adjusted to take into account physical depreciation and is then further depreciated for functional and economic depreciation.

There are no indications of land claims within the general surrounding area, however, no information could be obtained to confirm this. Figure 43 below illustrates the property boundaries within the inundation area.

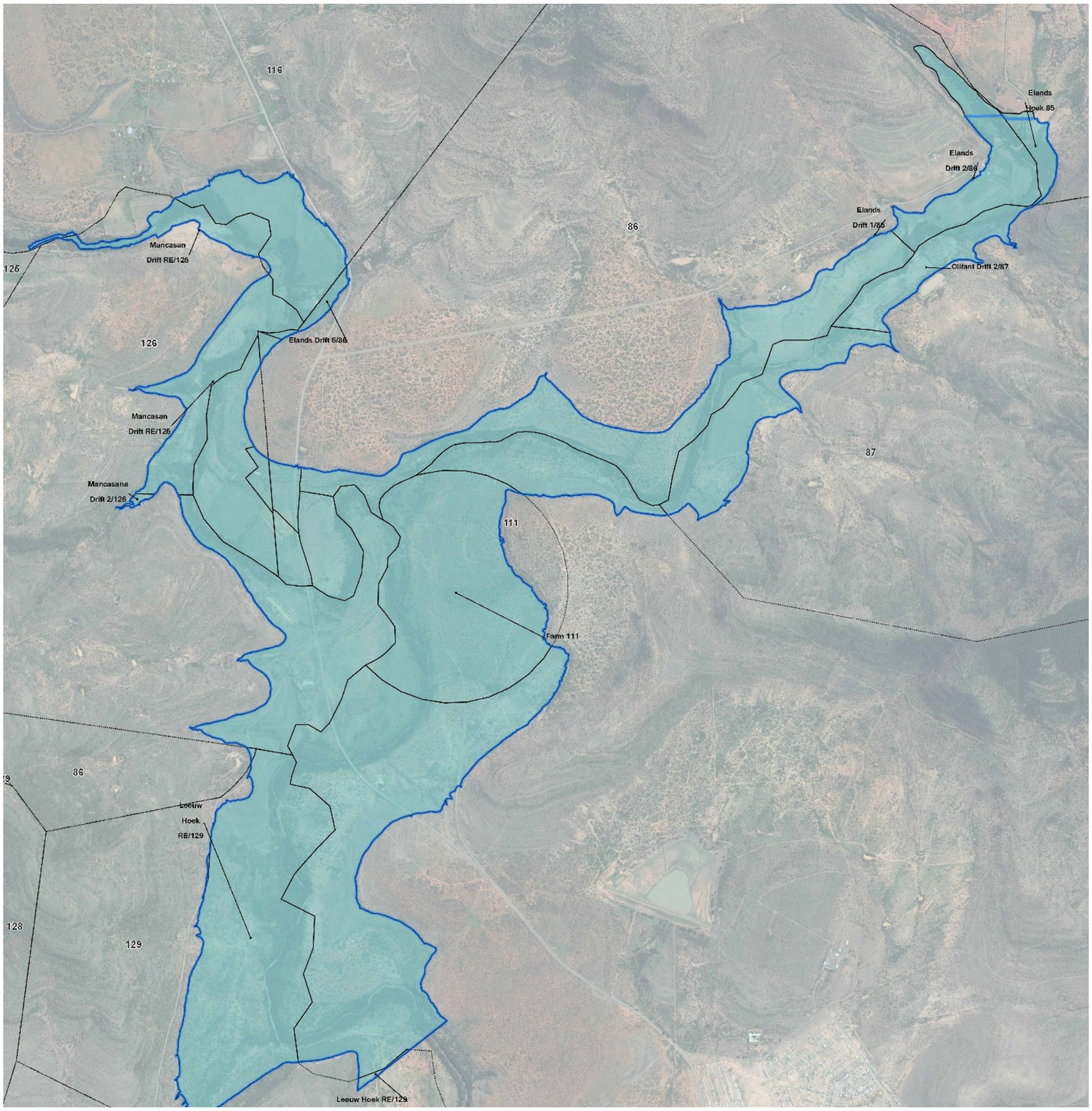

Figure 43: Inundated land areas

Table 38 below contains the average scale structure rates applied to the different land types identified on the affected properties.

Table 38: Average land rates applied

Land type	Average scale structure rates (Very Good) (ZAR/ha, base year 2014)
Natural Grazing	11 250
Cultivated Lands	28 750
Citrus Orchards	105 000

Table 39 below shows the approximate land area affected by the Foxwood Dam reservoir and calculates the associated land value dependent on land type.

Table 39: Estimated inundated land areas and associated costs

Land identification	Land type	Size (ha)	Cost (ZAR)
Eilands Hoek 85 Fort Beaufort RD PTN 0	Natural Grazing	5,70	64 125
Elands Drift 86 Fort Beaufort RD PTN 1	Natural Grazing	68,40	769 500
Elands Drift 86 Fort Beaufort RD PTN 2	Natural Grazing	20,00	225 000
	Citrus Orchards	5,00	525 000
Elands Drift 6 Bedford RD PTN 3	Natural Grazing	5,00	56 250
	Cultivated Land	1,00	28 750
Elands Drift 86 Fort Beaufort RD PTN 5	Natural Grazing	2,00	22 500
	Cultivated Land	12,00	345 000
Elands Drift 86 Fort Beaufort RD PTN 6	Natural Grazing	2,20	24 750
Elands Drift 86 Fort Beaufort RD PTN 7	Natural Grazing	4,50	50 625
Farm 111 Fort Beaufort RD	Natural Grazing	85,00	956 250
Fathers Poort 116 Bedford RD PTN 0	Natural Grazing	27,00	303 750
Leeuw hoek 129 Bedford RD PTN0	Natural Grazing	96,00	1 080 000
	Cultivated Land	1,80	51 750
Leeuw hoek 129 Bedford RD RE/2/PTN	Natural Grazing	0,10	1 125
Mancasana Drift 126 Bedford RD PTN 0	Natural Grazing	21,60	243 000
	Cultivated Land	16,00	460 000
Mancasana Drift 126 Bedford RD PTN 1	Natural Grazing	16,00	180 000
	Cultivated Land	12,00	345 000
Mancasana Drift 126 Bedford RD PTN2	Natural Grazing	52,00	585 000
	Cultivated Land	8,00	230 000
Mancasana Drift 126 Bedford RD PTN 3	Natural Grazing	12,00	135 000
Olifant Drift 87 Fort Beaufort RD PTN 0	Natural Grazing	24,00	270 000
	Cultivated Land	8,00	230 000
Olifant Drift 87 Fort Beaufort RD PTN2	Natural Grazing	10,00	112 500
	Citrus Orchards	8,00	840 000
Rooidam86 Bedford RD PTN0	Natural Grazing	0,20	2 250
Adelaide Town Planning	Natural Grazing	157,00	1 766 250
Land costs		**681**	**9 903 375**

Table 40 below summarises the estimated depreciated replacement cost for identified Fixed Improvements. The identified areas have been determined by review of aerial imagery as identified on drawing 225739-LND-0701 in Appendix A.

Table 40: Estimated depreciated replacement cost of identified Fixed Improvements

Land identification	Land type	Size (m^2)	Rate (ZAR/m^2)	Cost (ZAR)
Mancasana Drift 126 Bedford RD PTN1	Fixed Improvements - buildings	270	9 000	2 430 000
Mancasana Drift 126 Bedford RD PTN2	Fixed Improvements - buildings	40	9 000	360 000
Mancasana Drift 126 Bedford RD PTN3	Fixed Improvements - buildings	1 000	9 000	9 000 000
Fathers Poort 116 Bedford RD PTN 0	Fixed Improvements - buildings	546	9 000	4 914 000
Fathers Poort 116 Bedford RD PTN 0	Fixed Improvements - tennis courts	3	170 000	510 000
Olifant Drift 87 Fort Beaufort RD PTN 0	Fixed Improvements - buildings	200	9 000	1 800 000
Elands Drift 86 Fort Beaufort RD PTN 2	Fixed Improvements - buildings	750	9 000	6 750 000
Sub-total (fixed improvements)		**2 809**		**25 764 000**

9 PROJECT COSTING

> Full details on project costing are provided in the following report:
>
> *Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Project Feasibility Costing, P WMA 15/Q92/00/2113/13*

The objective of the Feasibility Costing is to determine the selection of the most cost effective size and type of dam at the Foxwood site and outline the cost make-up of the project to determine the project development budget which is an input into the economic impact analysis for the feasibility study. The primary purpose of the Costing report is to provide sufficient detail to determine a reliable and accurate cost estimate for the dam, and associated cost of water, to support decisions regarding the possible development of the project.

9.1 Basis of cost estimates

For high value or large quantity items related to the dam construction, construction rates have been obtained through consultation with a reputable major contractor currently completing the construction of a similar major composite dam in South Africa. Costs associated with known measurable other works (eg road construction, power line, Telkom and pipeline construction) have been determined based on recent similar construction project experience by the professional team and in the case of the district road realignments and bridges, these costs were reviewed by the Eastern Cape Department of Roads and Public Works (ECDRPW). The land matters where based on current sale values in the region. The cost of relocation of graves was based on current (2014) average rate for grave relocation at a large dam currently being completed.

Dam
The dam, quantities and measurements have been based on a detailed survey and geotechnical investigation. These have been included in a comprehensive bill of quantities.

Road Realignments
Allowance has been made for the relocation of the R344 road linking Adelaide to Tarkastad to the same standard as the existing gravel road. The relocated road would include a 91 m long bridge to span the tail water of the dam. The relocation of the MR00639, a secondary road access linking the R63 to R344 by passing Adelaide, was determined but was excluded from the project cost. This was based on anecdotal information indicating that it is little used and the disproportionately high cost (R *311 595 811)* (base year 2014) of relocation, (due to the steep and rocky terrain, as well as a long bridge of 430 m). A traffic study is to be carried out as part of the Environmental Impact Assessment to determine the extent of use.

Existing Adelaide off-channel canal bulk water supply
The existing Adelaide bulk water supply is from an off river canal which will be partially relocated over a length of approximately 3,4 km due to inundation from the dam. It is proposed that the relocation portion is constructed as a pipeline.

Land Matters
An independent evaluation of property price trends in the Adelaide, Bedford and Fort Beaufort area was carried out to determine appropriate land acquisition costs associated with the inundation of the dam basin.

Environmental Management
Allowance has been made for the implementation of the Environmental Management Plan that will be determined during the Environmental Impact Assessment.

Contingency; Professional Fees and VAT
An estimate of 30% has been include in the dam cost for Preliminary & General costs. Add-on costs have allowed for over and above the total project cost to account for the feasibility level of design that has been carried out (15% contingency allowed) and the professional services that will be required for design, supervision and implementation of the project (15% for professional services and construction supervision). 14% VAT has been included in the total cost summary for all items.

9.2 Project Cost

The estimated capital cost of the proposed works, ***2014 prices including 14% VAT***, are:

Foxwood Dam and associated infrastructure (see Table 42 below for breakdown	**R 2 084 million**
Estimated peak funding for establishment of a 1 250 ha irrigation scheme (BY OTHERS)	**R 427 million**

A summary of the dam structure construction costs and the total project costs are provided in Table 41 and Table 42 respectively, below.

Table 41: Summary of dam structure construction costs

Item No	Description	Cost (ZAR) (June 2014 Prices)	Comment
1	PRELIMINARY & GENERAL	239 411 545	*30% of item* 2-15
2	WATER CONTROL-RIVER DIVERSION	5 118 848	
3	DRILLING & GROUTING	65 895 189	
4	Earthfill	5 772 591	
5	Concrete Gravity	60 122 598	
6	GRAVITY SPILLWAY	434 835 032	
7	GRAVITY NOC	26 515 352	
8	EARTHFILL EMBANKMENT	105 196 437	
9	OUTLET WORKS	64 306 681	
10	Concrete Works	21 204 550	
11	Mechanical Equipment	39 102 131	
12	Structural Steelwork	1 750 000	
13	Electrical Equipment	2 250 000	
14	INSTRUMENTATION	7 500 000	*Provisional Sum*
15	Miscellaneous 10% & Landscaping 2.5%	88 670 942	*(12.5% of cost* (excl P&G))
	DAM CONSTRUCTION (excl VAT)	**1 167 651 897**	

Table 42: Summary of total project costs

Foxwood Dam Feasibility Cost Estimate	***ZAR (June 2014 prices)***
Foxwood Dam Structure (only)	*1 167 651 897*
Dam Access Road	*9 412 689*
Bulk water pipeline and pumpstation	*8 887 960*
Gauging Weir & other DWS hydrology structures	*5 451 000*
Relocation of R344 (MR00638)	*126 599 941*
Relocation of water supply canal	*20 400 000*
Land matters - land costs	*10 239 625*
Land matters - fixed improvements	*25 764 000*
Graves relocation (estimated 10)	*300 000*
Eskom relocation cost	*2 200 000*
Telkom relocation cost	*500 000*
Environmental management	*5 000 000*
TOTAL (excluding VAT)	***1 382 407 112***
Contingencies 15%	*207 361 067*
TOTAL DAM CONSTRUCTION (incl contingency)	***1 589 768 179***
Professional Fees 15%	*238 465 227*
TOTAL COST (incl design fees)	***1 828 233 406***
VAT	*255 952 677*
TOTAL PROJECT COST	***2 084 186 082***

June 2014 rates as priced from a large contractor rates

The capital value of the whole dam project is **R 2 084 186 082.**

9.3 Cost of water

The NWRS2 recognises that further development of surface water resources in South Africa to increase available yields will be expensive relative to historic costs of water. The URV is a common measure in South Africa to assess the economic efficiency of proposed water projects. To determine the URV of a particular scheme, the water supplied (i.e. the primary benefit derived from it) is projected over the same period and 'discounted' at the same rate to derive a 'present value' in cubic meters. The URV of the scheme is derived by dividing the present value of the costs with the present value of the water supplied, as shown in the equation below.

$$URV = \frac{Present\ Value\ of\ Costs}{Present\ Value\ of\ Quanity\ of\ Water\ Supplied}$$

The URV for the proposed Foxwood Dam has been calculated (see Appendix F) and the results given in Table 43 below for a range of discount rates:

Table 43: URV for Water from Capital, Operational & Refurbishment Costs

Discount Rate	Unit Reference Value (R/m^3)
6,0%	8,96
8,0%	11,77
10%	14,96

Assuming a discount rate of 8%, the URV for water yielded by Foxwood Dam would be R 11,77 /m^3. This value provides a reference value to reflect the expense of the water that would be yielded by the proposed Foxwood Dam and to allow comparison against other potential water resource development projects in South Africa.

However, it is assumed that the capital cost of the Foxwood Dam project would be funded by Government. Nevertheless, it may be reasonable for the Irrigation Scheme to be expected to cover the future costs resulting from the operational, maintenance and refurbishment costs for the dam over its life. Table 44 below gives the result for the URV calculation allowing for operational, maintenance and refurbishment costs of the dam only. **Assuming a discount rate of 8%, the URV for water yielded by Foxwood Dam has been taken as R 0,60 /m^3.** This figure has been assumed in the economic assessment of the dam construction as well as the Irrigation Scheme (DWS 2015c). The final water price must be determined by DWS in line with the National Water Pricing Strategy.

Table 44: URV for Water from Operational, Maintenance and Refurbishment Costs

Discount Rate	Unit Reference Value (R/m^3)
6,0%	0,619
8,0%	0,608
10%	0,602

10 REGIONAL ECONOMIC ASSESSMENT

> Full details on the Economic impact assessment are provided in the following report:
>
> *Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Economic Impact Assessment, P WMA 15/Q92/00/2113/14*

The regional economic assessment constitutes an economic impact assessment of the construction and operation of the proposed dam and the potential for irrigated agriculture which is created by the dam, as well as a socio-demographic overview of Adelaide and the local and district municipalities. The establishment of irrigated agriculture within the valley will have significant positive socio-economic impacts into the community through the entire value chain, and will stimulate supply side input industry as well as downstream opportunities for value addition and possibly export markets.

The assessment of economic activity of the Foxwood Dam project has focused on the construction and operation of the dam and the construction and operation of the proposed associated Government Irrigation Scheme only. The economic activity of the dam results from the construction of the dam, over a four year period, and then the operation of the dam and sale of water from the dam. The operation of the dam has been assessed over 6 years, which is the period until the full take up of water from the dam is assumed to be achieved, primarily from the development of the Irrigation Scheme. **It is assumed that the capital expenditure for the construction of the dam (estimated at R 2 084 million) will be funded by Treasury. The construction of the dam will be as enabling infrastructure to support the development of the proposed Irrigation Scheme and the economic activity and job creation that this will stimulate.**

Assuming a discount rate of 8%, the URV for water yielded by Foxwood Dam would be R11,77 /m^3. However, as it is assumed that the capital expenditure for dam construction will be funded by Treasury, the cost of water used within the Economic Analysis has been based on the cost of annual maintenance and operation costs (and including major refurbishment) of the dam over the life of the dam. This assumed cost of water is R 0,60c/m^3 has been applied. In the event that the project is developed, the price of water must be determined in accordance with the National Water Pricing Strategy and allow for a full review of Water Allocation within the Koonap River catchment.

> - The dam construction costs have been calculated at 2014 prices and have not been escalated.
> - The socio-economic impact of the project has been assessed against a Nxuba baseline using 2011 data with 1% growth projection and assuming construction of the Irrigation Scheme takes place in 2018 and planting commences in 2019 with first use of water from the dam.
> - Construction of the dam has been assumed to take place over four years from 2015 to 2018 with first controlled release of water achieved in 2019.
> - In the event of project implementation, the economic analysis should be revised and benchmarked to the actual implementation programme.

The Gross Domestic Product for operations and construction of the dam has been modelled, together with peak employment and sustainable employment within the Nxuba municipal area. The rates and utilities which will increase as a result of the project are also calculated, as well as the increase in fiscal revenue due to the payment of corporate taxes by contractors and the wages earned from operations. These metrics are indicated in Table 45 below.

Table 45: Summarised Construction and Operations Economic Impact for Foxwood Dam (R millions)

Economic Impact and Year:	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	TOTALS
Construction Impacts:											
Project / Construction Costs - Rm	313	521	834	417							2,084
Gross Domestic Product (GDP) Impact - Rm	335	559	894	447							2,235
Direct Employment - Jobs Per Year	474	759	1,166	559							2,958
Operations Impacts:											
Operating Revenue - Rm					6	7	9	10	12	14	59
Gross Value Added (GVA) Impact - Rm					7	9	10	12	15	17	69
Direct Employment - Jobs Per Year					3	3	4	5	5	6	26
Sustained Employment - All - Jobs Per Year					8	9	11	12	14	15	69
Sustained GVA in Municipality - Per Year					6	7	8	10	12	13	56
Construction & Operations Impacts:											
Rates & Utilities Paid to the Munic. - Rm	4.8	8.2	13.3	7.3	1.0	1.0	1.0	1.0	1.0	1.0	40
Taxes Payable to the Fiscus - Rm	23.9	39.8	63.7	31.8	0.6	0.7	0.8	1.0	1.2	1.4	165

Source: Summary of Project Cost Benefit Analysis.

Irrigation Scheme Financial Model

A large portion of the yield from the multi-purpose dam at Foxwood would be supplied to establish an irrigated agriculture industry within the Koonap River valley and an independent study, carried out by Arup and Agri-Africa has investigated the most suitable crops which could be grown in the valley based upon soil and slope conditions and a range of other agricultural conditions, including market conditions and prevailing prices. This economic impact study has worked closely with the model assumptions used to perform the agricultural analysis and used the various inputs and operating parameters to establish an economic base case and then evaluate the various scenarios postulated.

The agricultural study has recommended that there is potential within the Koonap River valley for the establishment of 1 250 ha of irrigated agriculture which would need to use 10 000 m^3 of irrigation water per hectare per annum (equivalent to 1 000 mm irrigation depth), or 12,5 million m^3/a.

The crops that have been investigated are lemons, peaches and macadamia nuts. For each crop type three scale scenarios have been investigated for farm size, with these being one hectare, twenty hectare and fifty hectare plots. Typically the employment profiles for the valley remain constant for each option, but the profitability tends to vary with the larger farms being more profitable due to the economies of scale which can be harnessed. There is no standard labour policy or union which regulates wages paid in the agricultural sector. In order to determine what an optimum wage should be for a farm worker and the ideal annual farm profit or Net Farm Income (NFI), various sources have been consulted and an average daily wage of R 104,00 has been used against the national average minimum wage of R 70,00 per day. The NFI has been deemed to be R 300 000 per annum per farm. The average daily wage has been used to estimate job creation from the projected revenue generated by the Irrigation Scheme. The NFI is used as a bench mark to consider the long term financial sustainability of the proposed Irrigation Scheme. Detailed reporting on the proposed Irrigation Scheme is provided in the Agro-Economic study report (DWS, 2015c). The summary financial output from this analysis, for a total development size of 1 250 ha (using averaged data from all crop types with individual farm sizes of 20 ha) is provided in Table 46 below. Based on a review of the projected IRR for each crop type and farm size as well as the projected employment creation for each scheme, the 20 ha farm model has been used throughout this economic impact analysis, although it is noted that various permutations of proposed Irrigation Scheme could be implemented subject to a detailed Irrigation Scheme investigation. The economic activity of the Irrigation Scheme has been assessed over the period of construction, 1 year, and then for 4 years of farm establishment and then over 6 years of revenue generation until full yields are achieved. A snapshot of financial indicators at this 10 year stage are provided to indicate the financial performance of the scheme. To assess the longer term financial sustainability of the Irrigation Scheme the IRR of the scheme has been assessed after 15 years of establishment of the scheme.

Table 46: Averaged financial performance for 1 250 ha scheme (assuming 20 ha portions)

Financial data (averaged for 1 250 ha scheme for all crops)	1 250 ha irrigation scheme	Comment
Peak funding (ZAR) (4-5 year timeframe)	437 398 862	The total funding that Government would need to provide until the scheme becomes financially profitable
Internal Rate of Return (IRR) @ year 15	8,15%	The IRR that would be achieved by year 15
Accumulated retained earnings by year 15 (ZAR)	315 284 832	These earnings indicate whether the business is worth pursuing over the medium to long term
Revenue potential in year 10 (ZAR)	389 531 163	The revenue potential of the 1 250 ha farming operation once it is in full production.
Profit earned in year 10 (ZAR)	56 651 682	Substantially more than R300k 'success' benchmark per farm (which is R 18 million for all farms)
Wages earned by year 10 (ZAR)	41 830 135	The wages earned by the farm workers.
Total direct employment (including farmer) per scenario) in year 10	1 934	Back calculated from wages, based on average daily wage per labourer of R 104.00
Total indirect & induced employment in year 10	728	Based on IDC ratio of 0,38 relative to direct jobs created
Taxation paid in year 10 (ZAR)	25 427 326	The taxes paid to the national fiscus by the farming operation
Potential beneficiation in year 10 (ZAR)	352 237 752	Assumed multiplier of potential beneficiation: 1,75 times
Gross Domestic Product in year 10 (ZAR)	503 196 788	Assumed multiplier of 'All' GDP impact 2,50 times
Export potential in year 10 (ZAR)	150 959 036	Assumed % of revenue exported: 50% Assumed % price improvement of: 150%

Socio-Economic Impact of Irrigation Scheme

A baseline assessment of the agriculture sector in Nxuba was carried out to project the growth of agriculture in Nxuba in the event that the Foxwood Dam in not constructed. This is an assessment of the ‘no-go’ scenario and demonstrates the substantial impact that Foxwood Dam would have on the economic activity in the municipality. Agriculture is responsible for 37% of employment in the municipality, however there has been a 16,5% reduction in employment in Agriculture in the 10 years from 2001 to 2011. Agriculture makes up approximately 14% of GVA contribution within the municipality however this also reduced by 2,2% in the 10 years from 2001 to 2011. In contrast to these trends, Figure 44 and Figure 45 illustrate the projected impact of the proposed Irrigation Scheme on GVA and Employment in Nxuba municipality. An average growth of agricultural sector employment over fifteen years of 5,3% is realised with 1 934 irrigated agriculture employment opportunities created, or 55% of the total of 3 488 employment opportunities project for Nxuba LM by the year 2028. An average growth of agricultural sector GVA over fifteen years of 12,5% is realised with R 352 million irrigated agriculture economic activity created, or 88,1% of the total of R 396 million agricultural sector GVA for Nxuba LM by the year 2028.

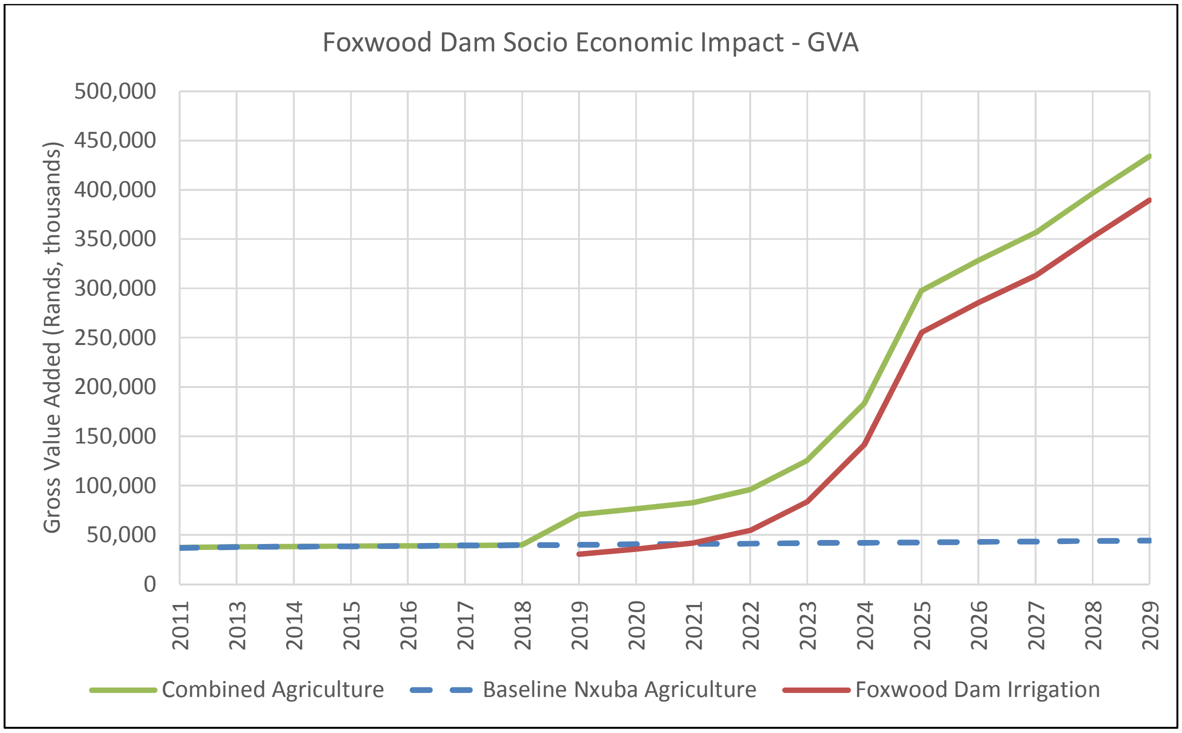

Figure 44: Projected GVA Impact in Nxuba from Foxwood

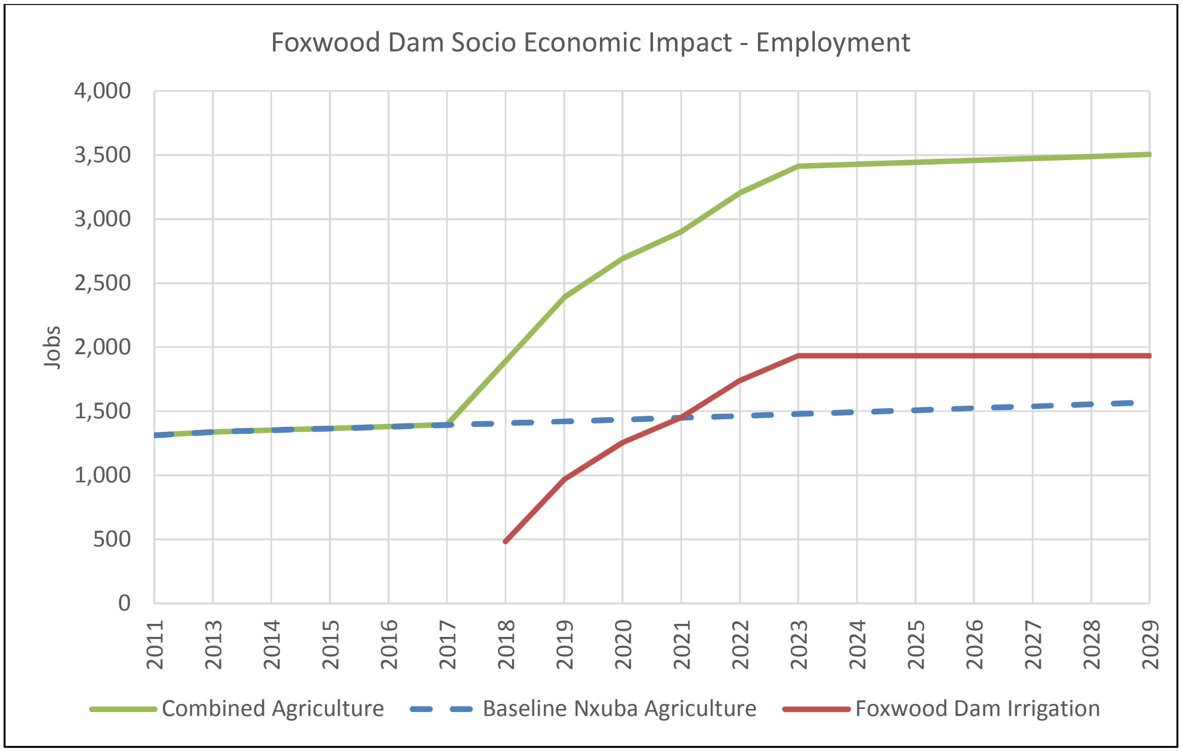

Figure 45: Projected Employment Impact in Nxuba from Irrigation Scheme

Opportunity Cost

The project opportunity cost to Government has been calculated over a fifty year life cycle for the combined Foxwood Dam and irrigated agriculture project. An opportunity cost economic simulation has been undertaken based upon the projects combined capital expenditure and operating cost scenarios over a fifty year timeframe, with the deemed cost of funds to Government being 6,5% per annum.

The positive cash flow has been calculated based upon the potential taxation revenue from the Foxwood Dam and the irrigated agriculture, together with the escalated revenue from the irrigated agriculture. The opportunity cost calculations indicate that over the 50 year life cycle of the dam, the Government would attain an Internal Rate of Return of 2,9% on the funds utilized for the combined projects. The project opportunity cost for 30 and 50 years has not been calculated as the compound interest results in an unrealistically high return. Although the opportunity cost is a valid economical indictor and is fairly low, we do not consider it to be a negative factor in the context of the proposed investment in Foxwood Dam by Government, where the primary objective of the scheme is to stimulate socio-economic upliftment and poverty alleviation.

Funding Requirement from Government

Figure 46 below illustrates the estimated required funding from Government to implement the Foxwood Dam project and associated Irrigation Scheme. It is assumed that the capital expenditure for the dam, approximately R 2 084 million (2014 prices) over four years, would be funded by Treasury and not recovered. The total funding required by Government for the Irrigation Scheme is estimated at R 437 million and would be invested over six years. The projected returns from the Irrigation Scheme would allow payback of this investment over five years, or eleven years from the start of investment in the Irrigation Scheme.

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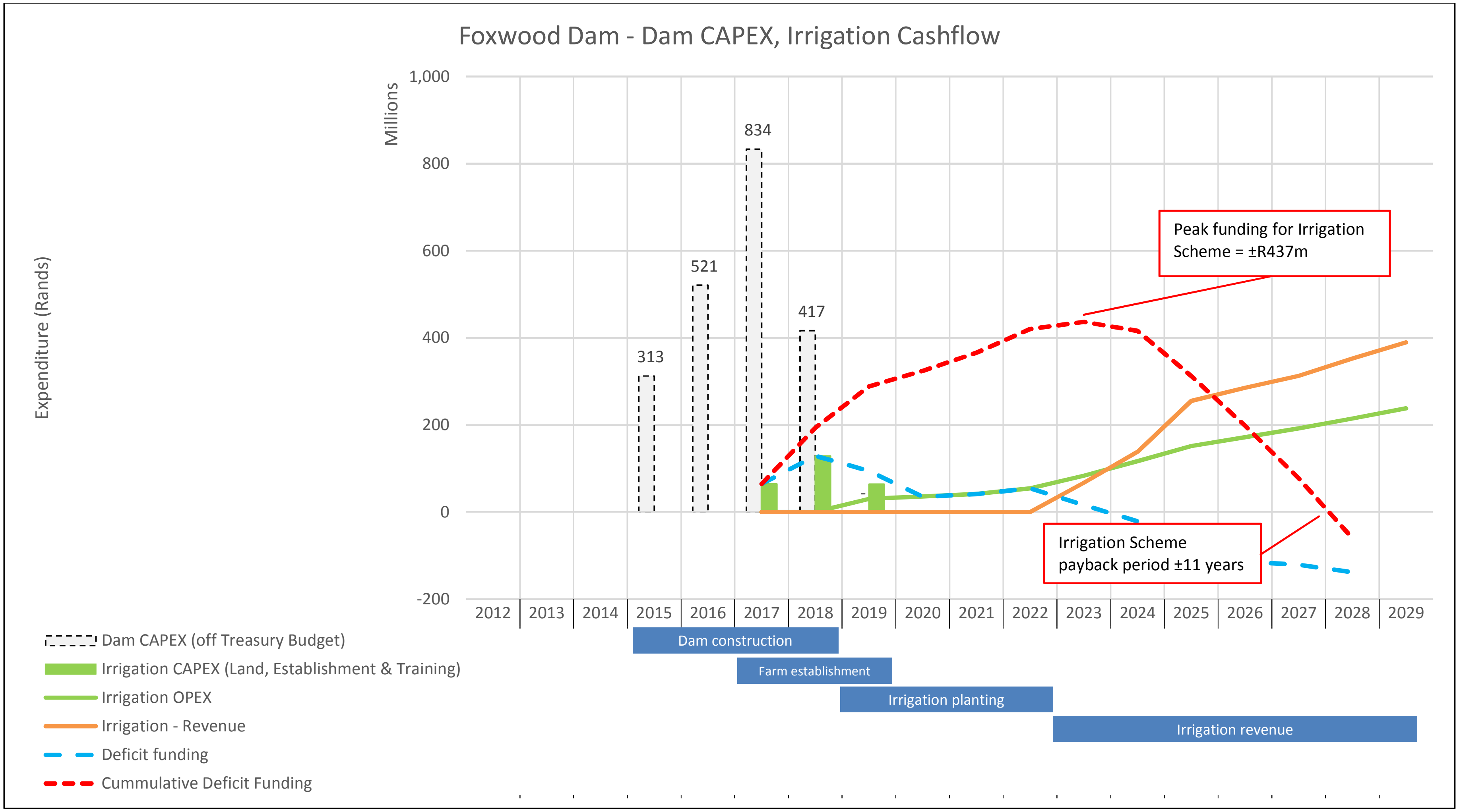

Figure 46: Projected dam CAPEX and Irrigation Scheme establishment cashflow

Conclusion

The overall economic benefit of the combined projects is positive, however there are in all likelihood additional infrastructure requirements for the establishment of the irrigated agriculture as well as the need for financing and training of the new or emerging farmers. A full agricultural options analysis report has been prepared for the various options and provides recommendations as to how the irrigated agriculture could be implemented.

Certain of the important economic benefits which are realized are as follows:

- Additional economic activity is stimulated in a region which needs it, with **R 532 million** of additional economic activity with all of its positive knock-on effects added in year 10 of the development
- Additional employment opportunities are created – **1 934 sustainable direct employment** opportunities
- Emerging and BEE farmers will be established and empowered with financial benefits and skills transfer
- There is a reasonable return on investment of approximately **8%** for the Irrigation Scheme, with payback of the peak funding estimated to be completed within approximately **11 years** of commencement of the scheme.
- The municipality will earn additional rates and charges from the project
- The national fiscus will receive additional taxation which will ultimately justify the capital expenditure of the project – **R 36,6 m** in year 10
- The potential exists for the further beneficiation of the agricultural product, and
- Potential exists for agricultural product export promotion.

The ultimate economic benefits of the combined project, the Foxwood Dam and the irrigated agriculture are in favour of the project being implemented based on the prime objectives of socio-economic upliftment. However, it needs to be noted that the implementation of the irrigated agriculture programme as envisaged within this study and the associated agricultural report, assumes that a competent implementation agency will be appointed and will implement the projects within the time and financial budgets as contained herein

11 LEGAL, FINANCIAL AND INSTITUTIONAL ARRANGEMENTS

The comprehensive version of reporting on Legal, Financial and Institutional Arrangements is provided in Appendix G.

While development of the water resources of the Koonap River has been the subject of investigations since at least about 1962, the purpose thereof has always been to alleviate water shortages for domestic use in Adelaide town and to enable irrigation of suitable land riparian to the river to take place. The proposed multi-purpose Foxwood Dam on the Koonap River in close proximity to Adelaide town has long been identified as the preferred site after various alternative sites upstream in the catchment were examined. Indications are that previous investigations and development proposals envisaged that a Government Water Scheme as contemplated in the Water Act, Act 54 of 1956, would be developed, which Act has since been replaced by the National Water Act, Act 36 of 1998 (NWA). If the development proposals emanating from these earlier investigations had found favour and led to implementation of such a scheme, Legal, Institutional and Financial Arrangements would have been put in place in compliance with the legislative framework current at that time.

This did not happen and now, about 15 years after the most recent previous investigations were undertaken in 1998, the feasibility of developing the water resources of the Koonap River is again under review. Not only has the policy, legislative and institutional framework changed, but a Constitution and new government regime is in place with a strong focus on fundamental human rights for all, which should be given effect within a framework of co-operative government.

Various policies have been published since this new regime came in place, such as the National Water Policy of 1997, the Local Government Policy of 2000, environmental policies and agricultural policies, focussing on equality and redressing the results of past social, racial and gender discrimination, while promoting environmental sustainability. Various pieces of legislation and other legislative instruments have also been promulgated to implement these policies.

From a water resource management perspective these are the NWA, the National Water Resource Strategy (Second Edition) (NWRS) and the All Towns Reconciliation Strategies. A Policy review process is also underway with intention of making the necessary amendments to the NWA and the Water Services Act, Act 108 of 1997, to give effect to policy adjustments.

For example section 6.1.3 of the NWRS2 requires equity in access to the benefits from water resource use by redressing historical inequalities and increasing participation in the governance and management of water. Allocation of water for poverty eradication is in terms of section 6.1.8 a high priority. Further, in terms of section 6.3, a primary focus of water allocation processes is to address past racial and gender imbalances in water use and to support the reduction of poverty and inequity in the country. The water allocation process should also respond to local, provincial and planning initiatives. It should be aligned with land reform and local economic development programmes.

Section 6.4.1 of the NWRS also states that water availability is crucial for implementation of the Comprehensive Rural Development Strategy. This strategy makes provision for supporting rural development through the multi-purpose use of dams, investment in appropriate water infrastructure, water allocation reform and a programme of support to small scales water users.

Of particular significance is also the fact that a National Development Plan is now in place in which a number of socio-economic developmental and other objectives are clearly defined.

The country is now governed by a Constitution and in a democratic political dispensation with the Constitution as supreme law and the rule of law applies, which is very different from that in the previous dispensation. As a consequence, proposals for development of the water resources of the Koonap River are now formulated in terms of priorities which are different from those of the past and with different criteria in mind for Legal, Institutional and Financial Arrangements.
The overriding feature of the development proposals investigated in this Feasibility Study is that the primary purpose of the initiative is to invest in water resource infrastructure development as enabling infrastructure for stimulating socio-economic development in an economically depressed rural region of the Eastern Cape Province instead of only making water available to satisfy an established and proven water need. Water should therefore be a stimulus for development and not only a resource from the development.

It is envisaged that capital investment in construction of the large infrastructure necessary to make available reliable water supplies would primarily unlock the agricultural potential of irrigable soil along the Koonap River (which are not yet under irrigation) and in so doing:

- create ***temporary work opportunities*** during the construction phase,
- create meaningful ***permanent work opportunities*** in the ongoing operation and maintenance of the infrastructure and in new irrigation farming enterprises,
- make a significant contribution to the ***eradication of poverty*** in the region through stimulating economic activities and production, and
- address ***social and economic inequities*** by (a) creating opportunities for many people to share in the benefits of effective utilization of water and soil resources, and (b) by mobilizing the human resource potential in the region.

An important component of this Feasibility Study is to identify the institutional arrangements best suited for implementing, owning and operating the proposed new water resource infrastructure and to indicate the institutional options that should be considered for implementing the envisaged new irrigation development. This should be done in a co-operative framework involving all the relevant institutions, such as all organs of state with a mandate and responsibility in this regard, and non-governmental organisations and community-based Organisations that can contribute to the development.

The funding arrangements necessary to enable these institutions to carry out their intended functions in a sustainable way must be in place before implementation can commence. It is important that organisations responsible for all phases of the project life cycle, from the planning phase through implementation (design and construction) to commissioning, operation and maintenance, are fully aware of the legal obligations that must be met.

Recommendations emanating from this study deal only with institutional and funding arrangements for implementing, owning and operating the proposed new water resource infrastructure. Funding and institutional arrangements for implementing the envisaged new irrigation development are the responsibility of government entities other than the Department of Water and Sanitation and are referred to in more general terms.

11.1 Constitutional imperatives

11.1.1 Constitutional mandate

The constitutional mandate relating to water requires among others, in terms of section 24(b) of the Constitution of the Republic of South Africa of 1996, that the environment (which includes the Koonap River, its tributaries and the other sources thereof (known as water resources)) must be protected for the benefit of the present and future generations. The protection should be afforded through reasonable legislative and other measures that ensure ecologically sustainable development for the use of these water resources, while promoting justifiable and social development.

There is in terms of section 25(4)(a) a commitment from the Nation to bring about equitable access to the water resources. The State may in terms of section 25(8) take legislative and other measures to achieve reform in the access to water in order to redress the results of past racial discrimination.

Further, everyone has in terms of section 27(1)(b) a fundamental right of access to sufficient water. The State must in terms of section 27(2) take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of this right. Giving effect to this right could also give effect to the constitutional rights, that a person has, to respect for his or her dignity as contemplated in section 10 and to the right to life as contemplated in section 11. Effect should be given to this mandate in such a manner that the other fundamental rights are respected, protected and fulfilled. These include for example the right to equal benefit of the law as contemplated in section 9(1) of the Constitution, to the free choice of a trade, occupation or profession as contemplated in section 22 and to not be deprived or expropriated from entitlements to water (except in the manner as set out in the Constitution) as contemplated in section 25.

In terms of section 25(2) of the Constitution land may be expropriated only in terms of law of general application for a public purpose, or in the public interest, and subject to compensation, the amount of which and the time and manner of payment of which have either been agreed to by those affected or approved by a court. Section 25(3) sets out the requirements for the compensation. For this purpose public interest includes, in terms of section 25(4)(a), the nation's commitment to land reform and to reforms to bring about equitable access to all South Africa's natural resources, which includes also the water resources.

11.1.2 Co-operative Government

Government is in terms of section 40 constituted as national, provincial and local spheres of government which are distinctive, interdependent and interrelated. All spheres must observe and adhere to the principles of co-operative government and intergovernmental relationship as set out in section 41 and must conduct their activities within the parameters thereof.

All spheres of government and all organs of state within each sphere must in terms of section 41(1):

- preserve the peace, national unity and the indivisibility of the Republic;
- secure the well-being of the people of the Republic;
- provide effective, transparent, accountable and coherent government for the Republic as a whole;
- be loyal to the Constitution, the Republic and its people;
- respect the constitutional status, institutions, powers and functions of government in the other spheres;
- not assume any power or function except those conferred on them in terms of the Constitution;
- exercise their powers and perform their functions in a manner that does not encroach on the geographical, functional or institutional integrity of government in another sphere; and
- co-operate with one another in mutual trust and good faith by:
    - fostering friendly relations;
    - assisting and supporting one another;
    - informing one another of, and consulting one another on, matters of common interest;

- co-ordinating their actions and legislation with one another;
- adhering to agreed procedures; and
- avoiding legal proceedings against one another.
- An Act of Parliament must in terms of section 41(2)(a) establish or provide for structures and institutions to promote and facilitate intergovernmental relations.

11.1.3 Giving effect to the Constitutional imperatives

It is not only the Department of Water and Sanitation that should be responsible for giving effect to the constitutional mandate relating to water. All three spheres of government, and the appropriated organs of state within these spheres, should be involved, but each only within its specific geographical, functional and institutional integrity. Together they should put in place the necessary strategies, plans and make funds and other resources available to give effect to the successful implementation of the Foxwood Dam and the associated development to achieve the envisaged purpose of the development. The Intergovernmental Relations Framework Act, Act 13 of 2005, was promulgated to assist in this regard.

The NWA gives effect to the legislative measures aspect of the constitutional mandate relating to water, and more specifically the water resource management component thereof. Other measures giving effect to this mandate include, for example, this feasibility study and the construction, operation and maintenance of the proposed Foxwood Dam and associated infrastructure. An important component of these measures are the institutions that would be necessary to give effect to the development proposals, and it might even be that agent(s) and care-taker(s) are appointed to assist with this. It might also be that some institutions required for this purpose must still be established.

Regarding the development of the irrigation to address the social and economic imperatives, clear policies and legislation regarding this has not really emerged, although it is receiving attention. The National Department of Agricultural, Forestry and Fisheries (DAFF) and the Eastern Cape Provincial Departments such as Rural Development and Agrarian Reform (RDAR) and Economic Development, Environment Affairs and Tourism (EDEAT) have a direct interest. They should take responsibility for the proposed irrigation scheme, taking into consideration also the principles of co-operative government and intergovernmental relationships. They may assign part of the functions associated with the proposed irrigation development to the Eastern Cape Rural Development Agency (ECRDA), an implementation arm of the RDAR.

11.2 Beneficiaries of the works

11.2.1 Adelaide town

Demographic and socio-economic assessments indicate that domestic water requirements in Adelaide are unlikely to grow significantly without a new economic stimulus being introduced. There are also no industrial water users in Adelaide and this is unlikely to change without a stimulus. If, however, the socio-economy of the region is stimulated to address the existing depressed conditions, water needs will certainly grow. There is therefore a need to improve the reliability of existing supplies to the town and to augment these supplies to meet any growth in water needs. The proposed Foxwood Dam would assist in this regard. It is, however, important in the public interest that the existing water infrastructure of the town Adelaide is maintained and operated according to acceptable sound and good practices.

The Amathole District Municipality (ADM) is the Water Services Authority (WSA) in the area as contemplated in the Water Services Act, Act 108 of 1996 and Amatola Water is the Water Service Provider (WSP) responsible for operating and maintaining existing bulk water supply systems up to the Water Treatment Works (WTW) in Adelaide. Water is then reticulated in Adelaide town by the Nxuba Local Municipality. The inhabitants of Adelaide will be the main (or only) beneficiaries of water supplies for domestic use from the proposed Foxwood Dam for the foreseeable future.

Recent assessments indicate that the present water supplies in the neighbouring towns of Bedford and Fort Beaufort are adequate for satisfying present and foreseeable domestic, municipal and industrial needs but are not sufficient to support socio-economic growth. It can be expected, however, that these towns would also benefit from a stimulus to socio-economic development in the region being introduced through development of a new secure and substantial water supply from the Koonap River.

11.2.2 The water resources of the Koonap River – The Reserve

An important beneficiary of the proposed development of the water resources of the Koonap River are the water resources themselves. While the health of the resource is fully taken into account in planning for development, it is only when a new storage dam begins to function as intended that the riverine ecology becomes a "beneficiary "of the project. The development proposals are formulated on the basis that the Reserve necessary to sustain the riverine ecology and basic human needs along the river as contemplated in section 1(1) 'reserve' of the NWA are satisfied as first priority, together with water for human consumption, before allocations can be contemplated for other economic water use sectors. The Koonap River is found to be in a reasonable to good ecological condition at present and special action must be taken to at least sustain the *status quo*. However, once other abstractions and changed land uses are contemplated, arrangements must be put in place to ensure that the integrity of the resource is sustained.

11.2.3 Existing irrigators along the Koonap River

Information documented in technical reports on various previous investigations of the potential for water resource development and that are available from the WARMS data base indicate that about 750 ha were irrigated downstream of the Foxwood Dam site and that this area has changed over time. Irrigators have enjoyed sufficient confidence in the availability of water from the river to venture into the irrigation of permanent tree crops. This is not to say that more water is being used for irrigation than before but there is little doubt that much, if not all, of this use has been lawful and will be regarded as 'an existing lawful water use' as contemplated in section 32 of the NWA. These irrigators will probably be licenced to continue this water use in future, with or without a dam at the Foxwood site. They would not be beneficiaries of the dam in respect of this use and cannot expect an increased security of supply. As none of these water entitlements are to be deprived or expropriated, effect is given to section 25 (Property) of the Constitution of 1996.

11.2.4 New irrigation development along the Koonap River

The strongest motivation for the development of a dam at the Foxwood site is to stimulate socio-economic development in the region as required in terms of sections 24(b)(iii) and 25(4)(a) and (8) of the Constitution. The availability of secure water supplies would be the long-term stimulus for this development. Development of new irrigation areas - through a new Government Irrigation Scheme - is seen as one of the most important vehicles for giving effect to the constitutional mandate regarding water by addressing important national objectives. These objectives include;

- creation of sustainable work opportunities,
- halting the spread of and alleviating poverty,
- dealing with inequalities,
- stimulating development in depressed rural areas, and
- contributing to agrarian reform.

The new farmers will be beneficiaries of the proposed new dam and, for a long time, will not be able to contribute to the cost of developing the project. However, these farmers are at present not on the land envisaged for new irrigation development and must be identified, selected and trained. There are many possible candidates in the area. While the DWS is responsible for developing the water resources of the Koonap River, the responsibility for mobilizing the other resources mentioned above, namely the soil suitable for irrigation development and the human capital in aspirant emerging farmers, resides elsewhere in government.

Other government entities that have contributed to the development proposals through participation in a Project Steering Committee, in a Stakeholder Forum and in providing expert advice and guidance could assist and take responsibility for the development proposals. These are:

National:
The Department of Environment Affairs
The Department of Agriculture, Forestry and Fisheries
The Department of Rural Development and Land Reform

Eastern Cape Provincial Government:
Office of the Premier
The Eastern Cape Provincial Department of Rural Development and Agrarian Reform
The Eastern Cape Provincial Department of Economic Development, Environment Affairs and Tourism

Local Government:
The Amathole District Municipality
The Nxuba Local Municipality

Regional Authorities:
Amatola Water

It is recognized that the proposal to develop the water resources of the Koonap River at the Foxwood Dam site is in itself not meaningful and sustainable. It is critically important that the agricultural component of the envisaged project is championed by the appropriate national, provincial, regional and local authorities, supported by local non-government and community-based organisations. For this reason an innovative and cross-cutting institutional arrangement for developing the envisaged new Government Irrigation Scheme is called for. The provincial Department of Rural Development and Agrarian Reform has a component called the Eastern Cape Rural Development Agency (ECRDA) set up for the purpose of implementing development projects. The ECRDA could be directed to fulfil the role of Implementing Agent for the envisaged Government Irrigation Scheme. This may require an adjustment to the mandate of the organization and the allocation of funding and other resources necessary for the project, probably from development budgets of National Departments such as DWS and DAFF.

This proposed new irrigation development is in line with the provisions of the NWRS through:

- providing for equity in access to the benefits from water resource use by redressing historical inequalities and increasing participation in the governance and management of water,
- making water available for poverty eradication,
- addressing past racial and gender imbalances in water use, and
- supporting the reduction of poverty and inequity in the country.

The project proposals also respond to local, provincial and planning initiatives and are aligned with land reform and local economic development programmes. It further supports rural development through the multi-purpose use of dams, investment in appropriate water infrastructure, water allocation reform and a programme of support to small-scale water users.

The DWS published a policy on “Financial assistance to resource poor irrigation farmers”. Regulations in terms of section 62 read with section 61 of the NWA was published in General Notice 1036 in *General Gazette* 30427 dated 31 October 2007 to give effect to this policy. The financial assistance in terms of these regulations could help to establish the government irrigation scheme. Certain limitations may apply in terms of the Policy and regulations.

11.3 Proposed Institutional Arrangements

An important component of the Feasibility Study is to recommend institutional arrangements for developing, owning, operating and maintaining the proposed new water resource infrastructure and the Government Irrigation Scheme described above. While responsibility for owning, constructing and operating new water resource infrastructure can follow existing models, a new model must be sought for the critically important agricultural component.

11.3.1 Water resource component

The direct beneficiaries of water supplies that can be made available from the dam will all be in the immediate vicinity – in this sense the project does not meet the test for being classified as National Water Resource Infrastructure. However, development of the project would be a strategic intervention to stimulate socio-economic development in a rural part of the Eastern Cape. This strategy would serve more than local or regional interests and could be considered to be of national importance.

In the light of the recognition given by Government in the National Development Plan (NDP) to water supply projects as mechanisms for creating employment opportunities and for stimulating and leading socio-economic development, particularly in the rural hinterland, development of the Foxwood Dam could enjoy more than local significance. In view of the relatively high levels of poverty in the Amathole District Municipality, and in the Nxuba Local Municipality in particular, there is a possibility that government would favourably consider making a grant available to finance this project. In this case the DWS would be responsible for owning and for the operation of the dam, at least for a significant time until circumstances in the region change and an alternative responsible authority is able to fulfil these functions.

The Department could be a care-taker for the dam until a suitable institution is indentified or established to assume this responsibility. It could also be that an institution should be established specifically for this purpose, such as a catchment management agency as contemplated in Chapter 7 of the NWA or a water user association as contemplated in Chapter 8 of the NWA. Such an institution could also be a Regional Water Utility as envisaged in the proposed water management policy.

If the institution is a water user association, the members of the association could be all the beneficiaries of the water from the Foxwood Dam (including the existing irrigators), the regulators involved and interested parties. Such an association could address many of the challenges with this project, such as training, transfer of experience and knowledge, and putting effective irrigation practices in place.

In this context it should be noted that about 44% the of population of the District Municipality are unemployed and presumably cannot pay for water.

Although the Foxwood Dam would serve local beneficiaries, albeit in national interest, it will be classified as a Category 3 Large Dam with a Significant Hazard Rating in terms of the Dam Safety

Regulations as contemplated in Chapter 12 of the NWA. Dams in this category present a significant dam safety risk and it will be advisable that responsibility for the design and construction of the dam be taken by the DWS, or assigned to another suitably capacitated Implementing Agent. Proper management of the design and construction of the regional water supply scheme will be assured if this component of the scheme is to be funded by a grant from Government.

11.3.2 Government Irrigation Scheme

Development of an Irrigation Scheme by Government has not been undertaken in South Africa for a very long time. The objectives and method of the Scheme that is envisaged to be supplied from the proposed Foxwood Dam in the Koonap River are not very different from those that pertained when the Loskop, the Vaal-Harts and the Rust de Winter irrigation schemes were developed, namely, to provide from a social-economic perspective an opportunity for individuals to gain access to land and to water supplies, with full government support, so as to develop eventually into successful irrigation farmers. However, a big difference lies in the socio-political circumstances that pertained then and the current circumstances now in South Africa. The categories of beneficiaries are also different.

Therefore, although some of the reasons and objectives (as set out in the various Government Policy documents) for this scheme are different from those of the previous schemes, the method of achieving these objectives are similar to the previous schemes, namely developing the water resources by constructing a dam, acquiring the necessary land for irrigation, identify and train the new irrigators and put in measures to ensure long-term sustainability. Further the role-players that should be involved now are also different from the role-players of the previous schemes.

It is envisaged that the DWS would take responsibility for developing the water resources of the Koonap River in accordance with its statutory mandate and that other government entities would, in a cooperative arrangement, implement the development of about 1 250 ha new irrigation along the Koonap River. The necessary licences, authorisations and permissions required by law should be obtained and the activities and tasks should be done within the framework of the law.
While detailed design of the irrigation infrastructure required for the envisaged scheme has not been undertaken, reliable information on the locality of soils suitable for irrigation has been documented and sufficient planning has been done to formulate a general arrangement for a realistic layout of new irrigation farms on this soil.

The entity responsible for championing and implementing the envisaged Government Irrigation Scheme would have to manage this project from a clean slate and significantly more certainty would need to be determined into the processes to establish the scheme, including at least the following:

- Acquire the land necessary for the new irrigation development from the present private owners, by expropriation or in terms of an appropriate and negotiated cooperative arrangement and probably in phases as the Scheme develops, and make the land available to new aspirant farmers. Acquiring the necessary land is in the public interest as contemplated in section 25(4)(a) of the Constitution of the Republic of South Africa, 1996. The land concerned could be obtained by agreement as well as expropriated in terms of the Expropriation Act, Act 63 of 1975;
- Select and prepare the aspirant farmers to participate in the Scheme;
- Provide the funding necessary to develop, i.e. plan, design and construct the irrigation infrastructure, comprising water abstraction works in the river and on-farm irrigation systems, as well as other facilities such as access roads, fencing, farm structures and communication systems;

- Provide training and ongoing technical and management support to the new farmers;
- Provide operating capital to the farmers for developing and running their farming enterprises, and acquiring plant, equipment and farming requirements;
- Provide project management to direct and oversee the development and operation of the Scheme, including acquisition of water in bulk from the DWS at Foxwood Dam (or at abstraction points in the river downstream of the dam) and the allocation of this water to individual farmers for irrigation of their allotments;
- Arrange for procurement and distribution among the new farmers of machinery, equipment, seeds, plant material, fertilizers, pesticides and other farming requirements;
- Develop and manage crop processing and packing facilities and marketing channels; and
- Identify suitable markets and set-offs for the products cultivated under irrigation.

No arrangements have been made to secure the commitment of any organisations to undertake the responsibilities of an Implementing Agent for the envisaged Government Irrigation Scheme and associated functions as described above. The stakeholder organisations listed in section 11.2.4 above have, however, been consulted in this regard and their guidance and opinions have informed the proposals. Of particular importance in this regard are the following government entities:

- The Eastern Cape Office of the Premier
- The Eastern Cape Provincial Department of Agriculture, Forestry and Fisheries
- The Eastern Cape Provincial Department of Rural Development and Land Reform
- The Eastern Cape Provincial Department of Rural Development and Agrarian Reform
- The Eastern Cape Provincial Department of Economic Development, Environment Affairs and Tourism.

In view of the specific functions to be fulfilled as Implementing Agent for such a long- term and multi-faceted development project, and the diversity of expertise required for the task, it is recommended that the Eastern Cape Department of Rural Development and Agrarian Reform be the lead organization and that the Eastern Cape Rural Development Agency (ECRDA), (see www.ecrda.org.za) be appointed as Project Managers and be provided with the necessary executive authority and resources to carry out this responsibility.

11.4 Funding options

11.4.1 Water resouce development

In section 11.3.2 above it is recommended that the proposed Foxwood Dam be developed by the DWS as owner and operator (which may be only as a care-taker until an appropriate institution is identified to take this responsibility over), and that the Amatola Water be considered as Implementing Agent of the DWS. This is motivated by the fact that the dam would be a multi-purpose facility serving objectives of socio-economic development that extend beyond the local context. The dam would, in that sense, be viewed as a component of National Water Resource Infrastructure.

Since beneficiaries of water supplies that can be made available from the dam will not for a very long time, if ever, be in a position to make a meaningful contribution to the redemption of the capital cost of the project, this investment would have to be funded through a grant from Government. This funding should be on the budget of the DWS who also becomes owner of the works on behalf of the State.

The total estimated cost of developing the water resources at Foxwood Dam, including all appurtenant works such as road relocations and a bulk water pipeline and pump station for supplying Adelaide but excluding VAT, at 2014 prices is R1 284 million. Implementation of the Foxwood Dam, including procurement processes, detailed design, land acquisition, construction and commissioning will probably take about five years after Environmental Authorization and all other permits and licences are in place. The construction cost, with adjustment for cost inflation from 2014, will have to be funded over that period.

11.4.2 Government Irrigation Scheme

Capital for the development of a strategic intervention to stimulate socio-economic development in National interest, as is the envisaged Government Irrigation Scheme, can only be funded by grants from the public sector through National Treasury. Beneficiaries of the scheme will for a long time not be able to make a meaningful contribution to redemption of the capital investment and will for five or six years be dependent on financial support from the government for contributions to operating capital.

The estimated cost of developing new irrigation farming enterprises, with an average irrigation allotment of 20 ha, up to a total scheme with 1 250 ha of irrigated land will be between R400 million and R450 million at 2014 prices. This peak funding includes the acquisition of land for the project, mentoring and training of aspirant farmers, physical development of the farming enterprises, and working capital for the new farmers. This estimated cost will be the peak investment required (at 2014 prices) and will accumulate at a rate depending on the development programme for the project. If the average irrigation allotment is 20 ha then 62 new farmers can be established on the Scheme. It is realistic to expect that, on average, six new farmers can be identified, trained and settled per year once the Scheme has been initiated. Full development can then be expected ten years after the project commences and the last farmer to settle on the Scheme will require funding into his or her fifth year of operation. The funding commitment may thus be required over a period of 15 years or more.

11.5 Assessment and Mitigation of Risks

The major risk is the time that it will take to obtain the various authorisations, to conclude agreements, and to obtain funding. These include:

- Prepare the application and obtain approval for RBIG funding;
- Prepare the application and obtain approval for water storage, abstraction and affecting the river course licences;
- Complete an environmental impact assessment, including public consultation and obtain environmental authorisation;
- Obtain council and board resolutions for the District Municipality and Amatola Water to enter into a WSP agreement and for the water board to partially fund the project, and to negotiate the details of such an agreement.
- Obtain the necessary land for building the dam wall, the basin and appurtenant works.

A mitigating action would be for the District Municipality, Amatola Water and DWS to take a number of binding decisions/resolutions very early on in the process.

12 ENVIRONMENTAL IMPACT AND STAKEHOLDER ENGAGEMENT

> Full details on stakeholder engagement and public participation are provided in the following report:
>
> *Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Public Participation, P WMA 15/Q92/00/2113/17*

12.1 Public Participation and Stakeholder Engagement

For the purposes of the feasibility study for Foxwood Dam, stakeholder consultation was initiated during the early phases of the study to support and facilitate meaningful Public Participation throughout the study; the details of all activities being provided in the main report (DWS, 2015m).

The main objective of the Public Participation was to identify interested and affected parties, to record their concerns and suggestions and to ensure that these are considered during the planning and implementation of the project.

The Public Participation Process supporting the feasibility study included the following key elements:

- Meeting with stakeholders through a reconnaissance field visit in the study area. This was undertaken during the period **05-06 March 2013**.
- Meeting with the Stakeholder Forum on **08 April 2013** at the Adelaide Golf Club.
- Meeting with the Agricultural Technical Working Group (ATWG) on **04 September 2013** at Midgleys Hotel, Adelaide.
- Meeting with the ATWG on **30 September 2014** at Adelaide Golf Club.
- Meeting with the Stakeholder Forum on **30 September 2014** at the Adelaide Golf Club.
- Introductory Project Newsletter 1 distributed to all stakeholders in **April 2013.**
- Project Progress and Update Newsletter 2 distributed in **April 2014**.
- Ongoing interaction with key stakeholders for the duration of the study.
- Interactions with affected landowners during the undertaking of geotechnical investigations.

There were a number of concerns and issues raised during the public participation process. These were recorded at the various meetings. To facilitate integration, all comments have been grouped and/or categorised into six main themes, presented below:

- Institutional arrangements and responsibilities.
- Water resources management.
- Infrastructure.
- Agricultural (irrigation) opportunities.
- Social and environmental impacts.
- Economic development opportunities.

Below is a summary of the various components which make up each theme:

Institutional Arrangements and Responsibilities

- Role of the Department of Water and Sanitation.
- Role of the Water Service Authority - Amathole District Municipality.
- Role of the Water Service Provider - Amatola Water.
- Role of the Nxuba Local Municipality.
- Will Government provide a subsidy for the construction of the infrastructure?

- Feasibility study access protocol to private land.

Water Resources Management
- Hydrology and yield determination for purposes of sizing the dam.
- Reserve determination requirements.
- Possible impacts on ground water.
- General need in the Eastern Cape for improved water resources management.

Infrastructure
- Dam size and repeated calls for a larger rather than a smaller dam to be built.
- Water conveyances (canals versus pipelines).
- Hydro power opportunities.
- Which farms will be affected and will downstream farmers be affected (in terms of reduced water for irrigation (abstracted directly from the river))?
- Consideration of primary water alongside water for irrigation.
- Project time frames.

Agricultural (Irrigation) Opportunities
- Commercial and emerging irrigators.
- Urban agriculture including use of the Khobonqaba Commonage.
- Optimise opportunities for resourcing poor farmers who would be major beneficiaries of a dam at Foxwood.
- Irrigable lands (probably more irrigable land than available water).
- Crops include: pastures, lucerne, avocados, maize, citrus, pecan nuts and tomatoes (tomatoes considered a specialised crop not grown by many farmers).
- Generally, cash crops are not grown because the farms are too distant from markets (transport is expensive making cash crops unviable/marginal).

Social and Environmental Impacts
- Inundation impacts, especially graves.
- Compensation to affected landowners and communities.
- Employment opportunities.
- Skills development and training are imperative.
- Wage competition during construction (contractors paying higher wages than local farmers).

Economic Development Opportunities
- Rural and economic development opportunities, including tourism.

The study team is of the opinion that the Public Participation Process undertaken for the Feasibility Study for Foxwood Dam met the objectives of the study and has also provided a solid foundation for public participation activities during the recently commissioned EIA process.

The levels of stakeholder participation throughout the feasibility study have been encouraging and stakeholders are thanked for their inputs in the process. It is, therefore, recommended that communication with I&APs, especially the key stakeholders is maintained during the EIA process to ensure similar levels of stakeholder interest in the project.

12.2 Environmental Impact

Full details on environmental screening are provided in the following report:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Environmental Screening, P WMA 15/Q92/00/2113/3

The environmental screening exercise was carried out as a best practice approach to determine the environmental legal requirements for the proposed development. This involved understanding the environmental opportunities and constraints on a particular site and the manner in which the proposed development impacts on these opportunities and constraints. The outcome of the screening exercise detailed the type and nature of the environmental impact assessment that will be required together with any potential 'red flags' or fatal flaws with the development proposal.

The outcome of the exercise confirmed that the project required a full Scoping and EIA process to be followed based on the dam having a wall higher than 5 metres and inundating an area greater than 10 hectares. The only uncertainty revolved around the complete list of triggers and was subject to further discussions with the client and stakeholders and will became clearer as the project progressed and moved into subsequent phases.

A specific recommendation was for an ecologist to confirm the status of the ecosystem and vegetation within the inundated area to confirm if any of the activities within Listing Notice 3 apply.

In the feasibility stage of the project there have been no 'red flags' identified which would preclude the project from proceeding subject to the receipt of the relevant authorisations from the competent authorities. The Environmental Impact Assessment (EIA) is currently underway and the Scoping Report has been issued. The scoping report addresses the following works of the project:

- Major storage dam (Foxwood Dam);
- Bulk water supply pipeline and pump station;
- Gauging weir;
- Access roads (construction and operational phases);
- Quarry and borrow areas;
- Eskom supply to the dam and gauging weir;
- Relocate existing infrastructure (including water supply canal, R344, MR00639, Telkom telephone line and Eskom power line);
- Construction camp; and
- Permanent offices and accommodation for dam operator.

The purpose of Scoping, which constitutes the first phase of the formal EIA process, includes the following (amongst others):

- Identify and engage with Interested and Affected Parties (I&APs) and allow for adequate participation in the process;
- Assess the receiving environment in terms of current state and potential positive or negative impacts;
- Duly consider alternatives for achieving the project's objectives;
- Identify significant issues to be investigated further during the execution of the EIA phase;

- Determine the scope of the ensuing EIA phase, in terms of specialist studies, public participation, assessment of impacts and appraisal of alternatives; and
- Allow for informed decision-making with regard to the EIA process.

The Environmental Screening study and the current EIA are not addressing the potential impact of the proposed Irrigation Scheme. The proposed irrigation scheme will be subject to separate authorisation subject to the further development of that scheme.

13 FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

- The ‘need’ for the project is driven by the potential for the undeveloped water resource of the Koonap River to be mobilized to stimulate socio-economic development in the region.
- An assessment of the hydrology and geology has been completed and it is recommended that a 1 MAR dam with total storage of 55 million m^3 is developed. This dam will yield approximately 16 million m^3/a at a 1:20 year risk of failure (considered for high value crop irrigation).
- The proposed structure of the dam is a composite earthfill embankment gravity concrete spillway dam. This structure provided the lowest relative URV and also provides some mitigation against observed dispersion in some borrow pit samples as well as avoiding the need to develop a costly side-channel spillway.
- Although sufficient materials are available in a number or borrow pits within and close to the dam basin, materials must be obtained selectively with particular attention to the presence of dispersive clays.
- There is potential for optimisation of the dam structure design during detailed design in particular to the following areas:
    - Dam access to right bank
    - Safety Evaluation Flood discharge for spillway design
    - Spillway stilling basin and return to river

- Operational and financial models have been developed for a proposed 1 250 ha Government Irrigation Scheme. Recommendations have been made regarding proposed mentoring, training, minimum employment wages and salaries in an effort to place emphasis on the reasonable long term sustainability of the scheme.
- A socio-economic impact assessment has been carried out considering the potential benefits stimulated by the construction and operation of the dam as well as the establishment of the irrigation scheme. It is recommended that the capital cost of dam construction (R 2 084 billion) is funded by the Treasury. Establishment costs for the irrigation scheme (R 437 million) should be provided as a loan with repayment through generation of revenue by the scheme.

- The overall economic benefit of the total project (dam construction and operation and irrigation scheme development and operation) is positive, however there are in all likelihood additional infrastructure requirements for the establishment of the irrigated agriculture as well as the need for financing and training of the new or emerging farmers. An agricultural options analysis report has been prepared for the various options and provides recommendations as to how the irrigated agriculture could be implemented.
- Certain of the important economic benefits which are realized are as follows:

    - Additional economic activity is stimulated in a region which needs it, with R 532 million of additional economic activity with all of its positive knock-on effects added in year 10 of the development
    - Additional employment opportunities are created – 1 934 sustainable direct employment opportunities
    - Emerging farmers will be established and empowered with financial benefits and skills transfer
    - There is a reasonable return on investment of approximately 8% for the Irrigation Scheme, with payback of the peak funding estimated to be completed within approximately 11 years of commencement of the scheme.
    - The municipality will earn additional rates and charges from the project
    - The national fiscus will receive additional taxation of R 36,6 m in year 10
    - The potential exists for the further beneficiation of the agricultural product, and
    - Potential exists for agricultural product export promotion.

- The ultimate economic benefits of the combined project, the Foxwood Dam and the irrigated agriculture are in favour of the project being implemented based on the prime objectives of socio-economic upliftment. However, it needs to be noted that the implementation of the irrigated agriculture programme as envisaged within this study and the associated agricultural report, assumes that a competent implementation agency will be appointed and will implement the project within the time and financial budgets as contained herein.
- **The most significant risk to the scheme is the need for an implementing agent to be installed to develop the associated Government Irrigation Scheme.**

- The EIA is currently underway and will address all queries and concerns raised during the public participation within this technical feasibility study.
- Following on from the EIA, further consideration must be given to the wider impact of the dam construction and operation in particular:
  - Appropriate acquisition of inundated land and fixed items
  - Relocation of infrastructure such as roads, Telkom and Eskom infrastructure
  - Removal of existing structures within the dam basin
- Table 5 below summarises the key dam statistics.

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APPENDIX A: DRAWINGS

This appendix contains a number of drawings (see list below) relevant to the salient information provided in this report. A full set of project drawings are provided in the following report::

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Book of Maps, P WMA 15/Q92/00/2113/16

Drawing Number	**Drawing Title**
	General
225739-000-0101	Locality Plan: Foxwood Dam
225739-000-0102	Water Service Area
225739-000-0103	Location Map (Koonap River Location Plan in Context of the Great Fish River
225739-000-0104	Fish River Catchment with Koonap (Q92) Sub-catchment
	Hydrology
225739-HYD-0203	Foxwood Dam Catchment Areas
225739-HYD-0205	Ecological Water Requirements, Natural and Management Resource Units
	Irrigation Development
225739-IRR-0502	Irrigation Locality Map
	Site Investigation
225739-GEO-0601	Geotech GA (Borrow Areas, Boreholes, Seismic)
	Land Matters
225739-LND-0701	Land Matters Key Plan (incl servitudes)
225739-LND-0702	Land Matters Inundated Farm Portions
225739-LND-0703	Adelaide Canal Diversion
225739-LND-0704	Combined Affected Services and Land Matters
	Road Diversion
225739-LND-0801	Foxwood Dam Impact on R344 - General Arrangement
	Dam Works
225739-DAM-0901	Dam Wall Elevation
225739-DAM-0902	Site Layout (access road, lay-down etc)
225739-DAM-0903	Bulk Pipeline - Plan & Profile
	Earthfill Dam Works

Drawing Number	Drawing Title
225739-DAM-1001	Dam Plan
225739-DAM-1002	Earthfill Dam Wall Typical Cross-sections and Details
	Foundations
225739-DAM-1101	Cut Off Trench Plan, Longitudinal Section and Details
225739-DAM-1102	Consolidation Grouting
225739-DAM-1103	Grout Curtain and Foundation Treatment - Sheet 1
225739-DAM-1104	Grout Curtain and Foundation Treatment - Sheet 2
225739-DAM-1105	Grout Curtain and Foundation Treatment - Sheet 3
225739-DAM-1106	Grout Curtain and Foundation Treatment - Sheet 4
	Gravity Concrete Dam & Spillway
225739-DAM-1201	Spillway & Concrete Gravity Dam Wall General Layout and Details
225739-DAM-1202	Spillway Excavation
225739-DAM-1203	Rockfill Bolster Return Channel
225739-DAM-1204	River Diversion Coffer Dam
	Intake / Outlets
225739-DAM-1301	Inlet / Outlet Works General Arrangement & Details

APPENDIX B: DAM OPTION SELECTION MEMORANDUM

Foxwood Dam Options Selection Memorandum - Summary

Following a meeting at DWA on 20 May 2014 it was requested that Arup clarify the criteria adopted to determine the proposed size of dam and the most appropriate dam type for that size at the Foxwood Dam site. This memorandum is a response to that request.

A more comprehensive memorandum, including details of estimated construction costs, has been provided to DWA.

1.1 Regional Water Resource Context

Arup have carried out a review of the potential of the Koonap River to contribute to regional water resource management strategies within the Great Fish River catchment. A memorandum entitled ***'Foxwood Dam – Water Resource Context'*** which was issued to DWA on 25 June 2014. conclude that:

> *From an operational point of view therefore, the opportunity for the Koonap River to add useful water to the Great Fish River is limited. It is therefore concluded that maximum benefit can be made of the water resource of the Koonap River for stimulating socio-economic development in that catchment.*

1.2 Summary of Water Resources

The Water Resources report for the study notes that:

'The EWR operating rule recommended for the Foxwood Dam system is that high flow EWRs should be met by spills from Foxwood Dam and that the low flow EWRs can be met by inflows from the incremental catchments downstream of Foxwood Dam. This operating rule impacts the storage size of Foxwood Dam as it is important that regular spills can occur.'

The abridged Scenario 3 table reproduced below indicates the yields that are available (for various degrees of assurance) where high EWR flows are supplied by natural spills from the dam and not by releases from the dam. This criterion (ie high flow EWR's supplied by spillages) is satisfied only for dam capacities ≤ 1 MAR. In these circumstances the critical period is relatively short and natural spills from the dam would satisfy the high flow EWR's. The maximum yield available when this criterion is satisfied is 19.1x10^6m³/a at 95% assurance and for a 1MAR dam.

Scenario 3 – Foxwood Dam system with low flow EWR supplied by releases, high flows from spills

Reservoir capacity as a ratio of nMAR	Live storage	Dead Storage	FSC	Long term yield (10^6m³/a) at Recurrence Interval		
	(10^6m³)	**(10^6m³)**	**(10^6m³)**	**1:20**	**1:50**	**1:100**
0.5 nMAR	23.81	6.11	29.92	12.8	11.0	9.5
0.75 nMAR	35.71	6.11	41.82	17.2	13.8	12.4
1.0 nMAR	47.61	6.11	53.72	19.1	16.4	14.6
1.5 nMAR	71.42	6.11	77.52	22.9	20.3	18.0
2.00 nMAR	95.22	6.11	101.33	26.2	22.8	20.6

For dam capacities ≥ 1.5 MAR the critical period becomes much longer, up to approximately 16 years, and the high flow EWR's would have to be supplied from the dam by releases down river, ie Scenario 2. The abridged Scenario 2 table below indicates the yield available from the dam for various dam sizes and this operating rule to satisfy the EWR's.

Scenario 2 – Foxwood Dam system with total EWR (incl. high flows) supplied by releases from storage

Reservoir capacity as a ratio of nMAR	**Live storage**	**Dead Storage**	**FSC**	**Long term yield ($10^6 m^3/a$) at Recurrence Interval**		
	($10^6 m^3$)	**($10^6 m^3$)**	**($10^6 m^3$)**	**1:20**	**1:50**	**1:100**
0.5 nMAR	23.81	6.11	29.92	9.7	7.8	6.7
0.75 nMAR	35.71	6.11	41.82	13.7	11.1	9.3
1.0 nMAR	47.61	6.11	53.72	15.9	13.3	11.3
1.5 nMAR	71.42	6.11	77.52	19.8	16.9	14.9
2.00 nMAR	95.22	6.11	101.33	22.8	19.5	17.2

These analyses indicate that the consequence of creating storage larger than approximately 1 MAR is to sacrifice net yield to the need to satisfy EWR's because water must be released from storage for this purpose. Comparison of the tables for Scenario 3 and Scenario 2 indicates that the larger dam (1.5 MAR) yields about the same as the smaller dam (1 MAR), ie just more than $19x10^6$ m^3/a.

1.3 Water Requirements

The domestic water requirements of the three towns that could potentially benefit from a water supply from the Foxwood Dam are Adelaide, Bedford and Fort Beaufort. The existing water sources available to these towns are reported to be sufficient to meet projected water needs to the year 2035 provided the water services infrastructure is well maintained and is operated effectively. The creation of additional sources can significantly improve the security of supply to Adelaide which is reliant predominantly on run-of-river diversions from the Koonap River with no significant storage.

There are no records of industrial water use in the Koonap River valley.

It is envisaged that development of the water resources of the Koonap River will stimulate the implementation of new irrigation opportunities for resource-poor farmers. Irrigable land has been shown to exist along the Koonap River and the use of this resource can make a significant contribution to the objectives of the NDP, namely to create sustainable work opportunities, eradicate poverty and reduce inequalities. An agricultural development model built a partnership between existing commercial farmers and new resource-poor farmers is envisaged. This would be real socio-economic development and would make a significant impact on rural development and agrarian reform.

Such new irrigation development would make full and effective use of the water that could be made available from a new major dam in the Koonap River, but this water would be expensive. It would be necessary for not only the cost of resource development but also the cost of establishing new irrigation farmers on viable production units to be financed by government. Significant subsidies would be necessary for both the capital investment and for operating costs would be necessary for many years.

1.4 Topographical and Geotechnical Data

Photograph 1 below shows the proposed dam site. The findings of the geotechnical investigation are reported in the Geotechnical Investigation Report which is currently under review by DWA. A summary of the findings is provided below for reference:

- The site and available construction materials are suitable either an earth embankment dam (homogenous or with clay core), a rockfill embankment dam with clay core, or for a concrete gravity dam.
- Extensive quantities of soil shell material are available but are potentially dispersive requiring gypsum stabilization.
- Shallow sandstone bedrock is expected in the left flank area which will be suitable for the location of a side spillway in the case of a rockfill or earthfill structure. However, the topography of the left flank is such that significant excavation would be required to achieve the required spillway levels for dam sizes of 1MAR and below.

1.5 Preliminary Dam Data

For context, key data for a 1 MAR dam is as follows:

- Catchment Area 1091 km^2
- Gross Mean Annual Runoff (MAR) 47.61×10^6 m^3
- Probable Maximum Flood in the order of 6000 m^3/s
- 200 year Flood Estimate 2063 m^3/s
- Full Supply Level for 1MAR storage 615 MSL
- Spillway Length – to be optimized 150 m to 250 m
- Height of Embankment 43 m
- Crest length 485 m

Photograph 1 View looking upstream, from immediately downstream of the proposed Foxwood Dam site

1.6 Dam Type and Capacity Selection

In order to select the preferred dam type and size cost estimates of four types of dam were considered, namely:

- Earthfill
- Rockfill
- Concrete Gravity, and
- Composite Gravity Spillway and Earthfill

The capacities from 0.5 MAR to 2 MAR, with a sedimentation allowance, were evaluated.

1.6.1 Cost estimates

Cost estimates were based on escalated unit rates for all major construction items from recent DWA projects. These estimates were validated against resource-based costs and benchmarked against current rates for dam construction provided by a contractor. These rates were applied in the bills of quantities for each combination of size and type of dam.

Table 1 below provides a summary of the estimated dam construction costs.

DAM OPTIONS COSTS				
	0.5 MAR	1.0 MAR	1.5 MAR	2.0 MAR
Earthfill	R 1,100,609,905	R 1,065,266,128	R 1,032,278,740	R 997,119,004
Rockfill	R 1,182,934,223	R 1,157,190,750	R 1,128,368,899	R 1,093,577,285
Gravity Concrete	R 754,079,833	R 942,822,832	R 1,090,354,742	R 1,213,159,821
Composite	R 751,689,283	R 903,883,873	R 1,030,187,388	R 1,140,320,471

Table 1 Summary of estimated dam construction costs

Figure 1 below illustrates the cost breakdown by major BoQ item for the 1MAR dam options.

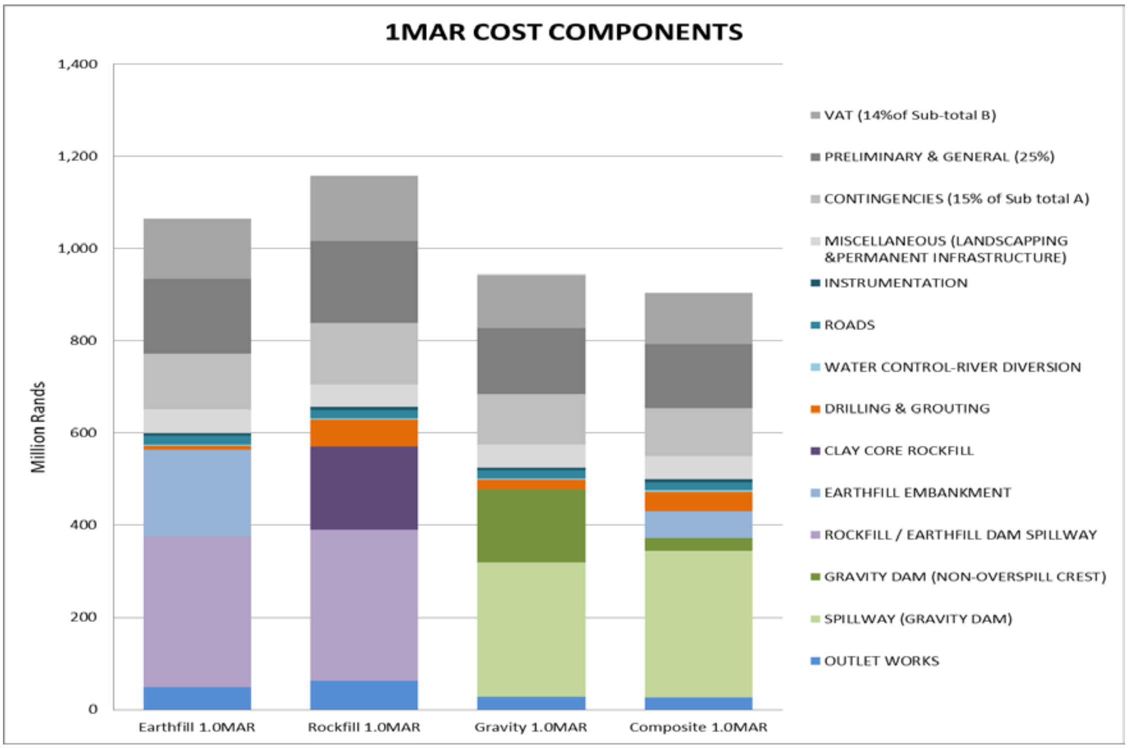


Figure 1 Cost Breakdown for 1 MAR dam options

1.6.2 Unit Reference Value

Using the DWA URV method for comparing projects over the project planning period (45 years) was followed. It is noted that varying the social discount rate does not impact on the outcome of the comparison of the different dam types for the same dam size. The calculated URVs for an 8% social discount rate are shown in the graph below.

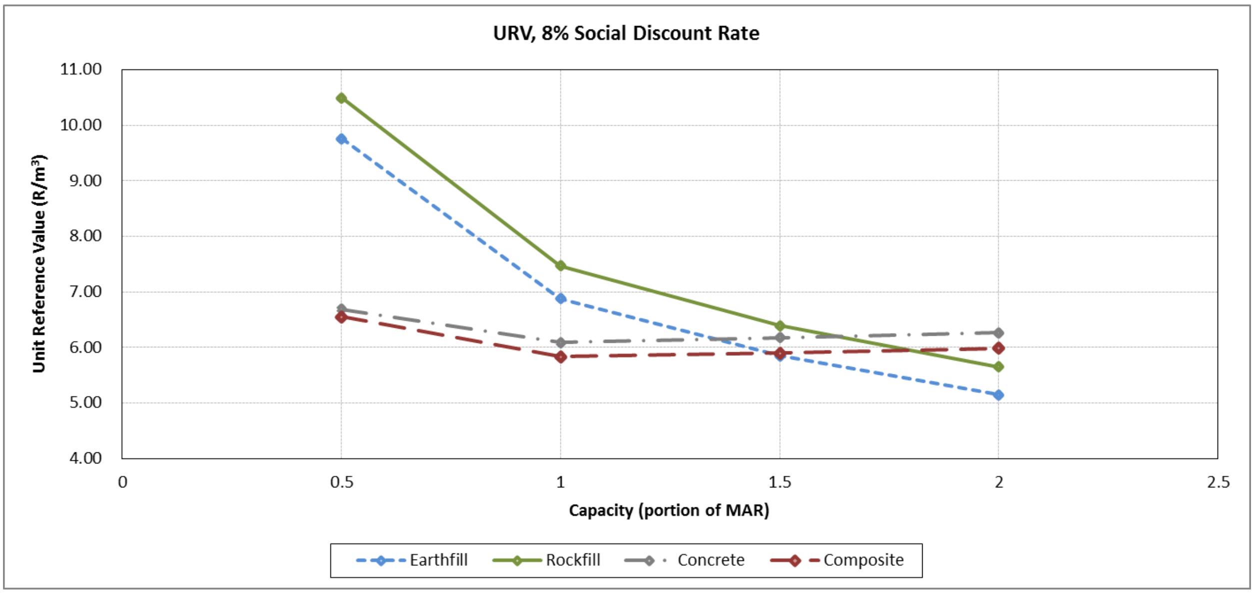


Figure 2 Unit Reference Value trends for 8% social discount rate

1.7 Conclusion and Recommendation

The URVs demonstrate that the construction costs of the earthfill and rockfill dams for sizes less than 1 MAR are very much warped by the huge cost of spillway excavations. Gravity dams are more cost effective on the basis of URVs up to 1.5MAR storage.

1.7.1 Dam size

It is recommended that a **1 MAR dam** is developed at the Foxwood Dam site:

- Impounding the Koonap River with a larger dam would impact on the natural ecological system of the river valley and would likely create complications in terms of obtaining environmental authorisation for the project.
- The analysis indicates that the available yields from a new dam are approximately equivalent for 1 MAR storage and 1.5 MAR storage due to releases from dams with larger storage capacities being needed to supply high flow EWR's (1MAR yield of 19.1 m^3/a vs 1.5MAR yield of 19.8 $x10^6 m^3/a$.).
- Providing for the Reserve from natural spillages reduces opportunity for human error.
- Storage capacities larger than 1 MAR at Foxwood would prejudice further water resource development elsewhere in the catchment.
- It is very unlikely that there will be sufficient domestic or industrial water demand in a regional context to make full use of the yield of dam larger than 1MAR.

- Providing for the development of a 1250 ha irrigation scheme on irrigable land located on various properties, now in successful production by established commercial farmers, will be a very significant development and will provide the basis for other similar schemes.
- Since rural development, irrigated agriculture and agrarian reform are competencies located in other government departments, their participation in implementation of the envisaged scheme to provide opportunities for new farmers to enter this sector is imperative. These departments have been consulted in formulating the development proposals and they have participated in deliberations of the Project Steering Committee. No institutional models, with supporting financial arrangements, have so far been put forward as a basis for implementing the irrigation scheme as a government initiative.

1.7.2 Dam type

A 1 MAR **Composite Gravity Dam with Earthfill Embankment on the right flank** is recommended for development at the Foxwood Dam site with the following motivation:

- Lowest URV among the four options for a 1 MAR dam.
- The spillway energy dissipation is more complicated for a side-channel spillway option, with significant changes of direction and the discharge of water into the river.
- No long term maintenance of a deep spillway excavation cut.
- Reduces the risks of material selection which include some elements of dispersive materials.
- The PMF and RDF design floods are best catered for with a concrete gravity dam although preliminary estimates indicate that the PMF flood will predominate for the composite option.
- Outlet works are incorporated within the gravity structure to an elevation suitable for effective discharge into the river bed. The other options require free standing towers and tunnels at founding depths similar to the cut off foundation.

APPENDIX C: DWS GAUGING WEIR REQUIREMENTS

Foxwood Dam Gauging Requirements:

1. Background

The proposed site of Foxwood Dam was visited on 3 June 2014 by Hydrological Service officials of the Eastern Cape as well as officials from Hydrological Services (Head Office). The purpose of the visit was to identify a site for the construction of a gauging weir in the Koonap River downstream of the proposed Foxwood Dam. Releases to be made from Foxwood Dam and low discharges over the spillway should be monitored with a dedicated designed gauging structure adhering to the gauging standards of Department Water Affairs. The location of the wall of Foxwood Dam with respect to the town of Adelaide in the Eastern Cape is shown in **Figure 1**.

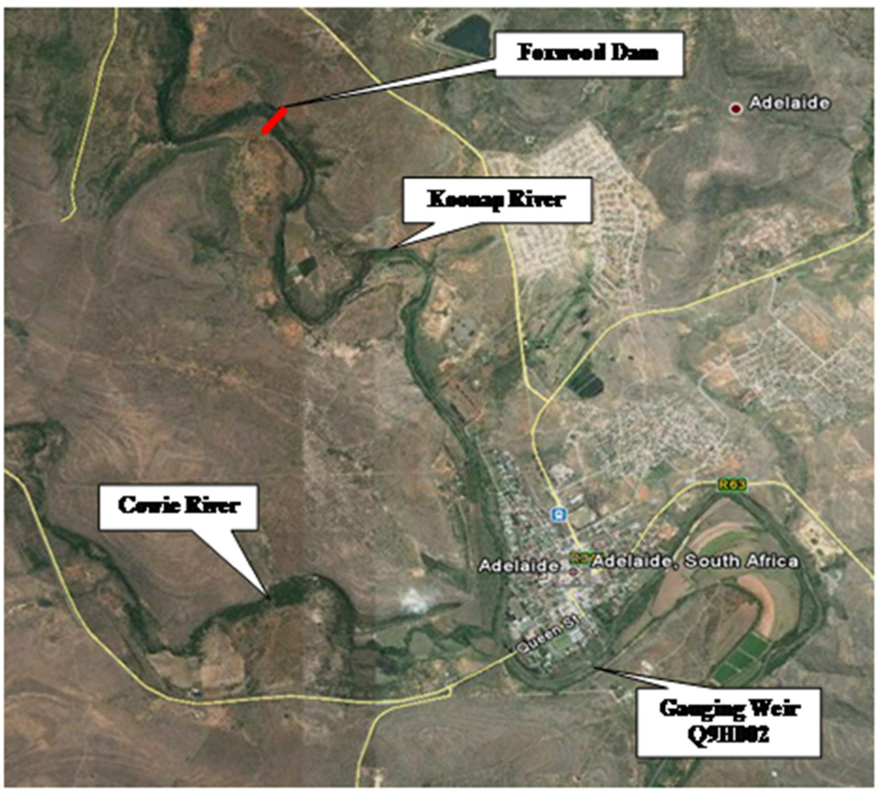


Figure 1: ***Location of the proposed Foxwood Dam***

There is an existing gauging weir structure (Q9H002) in the Koonap River at Adelaide. Flow measurements started at this station in 1928. This gauging weir is located approximately 7km downstream of the proposed Foxwood Dam. Approximately 900m upstream of the gauging weir is the Cowie River flows into the Koonap River. The catchment size of the Cowie River is approximately 140km^2. It is obvious that the size of the interim catchment between the proposed Foxwood Dam and gauging weir Q9H002 necessitates the construction of a new gauging structure closer to the Foxwood Dam site.

At present the dam wall type and spillway layout to be constructed at Foxwood Dam is unknown and this also creates an uncertainty in how near to the dam wall a gauging structure can be located. During the site visit a possible gauging weir site was identified approximately

1km downstream of the Foxwood Dam site, see **Figure 2**. The site adheres to most of the gauging weir site requirements as set by DWA. There is some rock in the river bed at the site, but no rock is visible on the river banks, see **Figure 3**. The co-ordinates of the proposed gauging weir site in Koonap River as identified during the site visit are 32.683182° South and 26.273667° East. Some extensive erosion protection works will be required to prevent outflanking of the structure and damage to the banks during floods. From Google Earth images it seems that there could be potential alternative gauging weir sites nearer to the dam, but due to the unknowns around the layout of the Foxwood Dam and time constraints during the site visit,

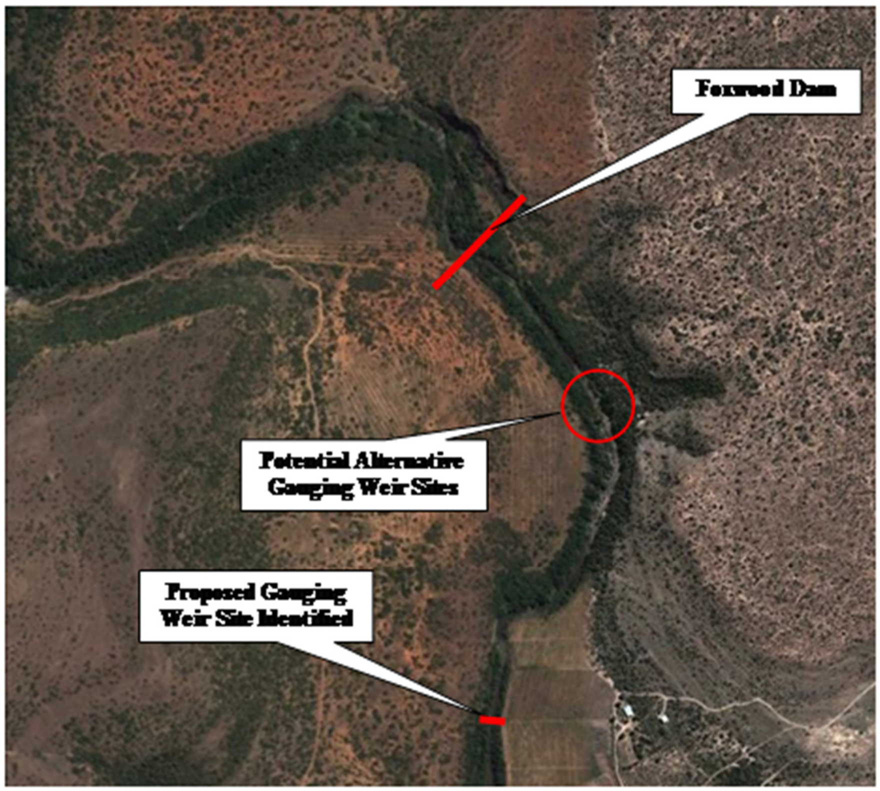


Figure 2: ***Proposed gauging weir site downstream of Foxwood Dam***

this area was not investigated.

2. Proposed gauging requirements

The following measures are proposed to ensure the proper measurement of flow at Foxwood Dam to comply with both operational and hydrological gauging requirements:

- The installation of gauge plates in the dam adhering to the standards set by Directorate Hydrological Services (HS) in the Department Water Affairs (DWA).

Figure 3: ***Gauging weir site identified downstream of Foxwood Dam***

- The installation of water level recording equipment in a vertical wet-well, not to be influenced by flow over the spillway or by releases/ abstractions from the dam. Provision should also be made for the installation of radar equipment to monitor changes in water level in the dam.
- All instrumentation to be protected against vandalism in a reinforced concrete hut. Electricity should be available in the hut. The provision of backup solar panels is a necessity.
- All abstractions made from the dam and not released into the river should be metered.
- The erection of an evaporation station complying with DWA standards at a suitable site at Foxwood Dam. The provision of running water is a necessity.
- The construction of a gauging weir structure downstream of Foxwood Dam at the site approximately 1km downstream of the dam site. This structure should comply with all standards set by DWA: HS. The structure should be capable to measure the total range of controlled releases from the dam into the river and also the first 300mm to 500mm of flow flowing over the spillway accurately. A reinforced concrete instrumentation hut equipped with a vandal proof door should be provided to safeguard the installed electronic stage logging equipment. Power to the instruments should be provided by means of a solar panel system installed on a 7.2m high concrete pipe mast (450mm in diameter) to reduce the risk of vandalism.
- All instrumentation required should be part of the Foxwood Dam project and should adhere to the standards and requirements of Hydrological Services Eastern Cape Region.

The existing sharp-crested weir (Q9H002) constructed in 1928 in the Koonap River at Adelaide should be refurbished as part of the project. The existing inlet systems to the stage measuring equipment at the station are experiencing problems with sediment blocking the systems and are also prone to damage due to debris. The crest layout of the structure needs to be investigated and altered if necessary to assist in alleviating the problems encountered with the inlet system. It will be necessary to measure flow accurately at Q9h002 after the construction of Foxwood Dam to ensure that releases made from Foxwood Dam is sufficient to supplement the flow in the Cowie River to address all water use in the Koonap River downstream of the confluence.

Pieter Wessels (Dr)
PrEng (Civil), PhD(Water Eng.)
16 June 2014

APPENDIX D: FISH RIVER CONTEXT MEMORANDUM

Subject Feasibility Study for Foxwood Dam

Date 25 June 2014 Job No/Ref 225739

Foxwood Dam – Water Resource Context

Executive Summary

This note assesses the potential wider regional benefits that could result from the construction of a multi-purpose dam at the Foxwood site on the Koonap River. Refer to the attached plan for the location of the proposed Foxwood Dam site relative to the Great Fish River.

The Koonap River is a tributary of the Great Fish River, within the Fish-Tsitsikamma Water Management Area (WMA). 575 million m^3/a of water is allocated from the Orange River Project for transfer into the Great Fish River to augment the availability of supplies for domestic and irrigation use. The introduction of Orange River water also improves the water quality in the Great Fish River. At present all of the water available for use along the Great Fish River, mainly the portion intended for new irrigation development, is not yet used in this economic sector. The potential yield of a proposed new major dam in the Koonap River is small by comparison with the as yet unused resource in the Great Fish River. As a consequence there is no apparent merit in gaining a regional benefit by using the proposed dam in the Koonap River to regulate the flow in that tributary to further increase the availability of water for use in the Lower Great Fish River.

From a water resource management and system operation point of view it is important to take cognisance of the following:

- There is a long distance from the proposed Foxwood Dam site to the confluence of the Koonap River with the Fish River, giving rise to significant losses in transmission if the river is used to convey releases from the dam, and
- The confluence of the Koonap River and the Great Fish River is downstream of all points where inter-basin transfers from the Orange River Project are abstracted for use.

From an operational point of view therefore, the opportunity for the Koonap River to add useful water to the Great Fish River is limited. It is therefore concluded that maximum benefit can be made of the water resource of the Koonap River for stimulating socio-economic development in that catchment.

Foxwood Dam Site Hydrology

An assessment of the hydrology of the catchment and resulting yields at the dam site has been carried out by Arup. Long-term yields at the dam site at a recurrence interval of 95% (failure of the dam should occur at an average frequency no greater than 1 in 20 – this interval is used as the primary use for water from Foxwood Dam is expected to be for irrigation) are provided in the table below:

Reservoir capacity as a ratio of MAR	**1:20 Long-term Yield (million m^3/a)**
0.5	9.7
1.0	15.9
1.5	19.8
2.0	22.8

Regional Domestic Water Requirements

The table below indicates the estimated domestic water requirements in Adelaide, Bedford and Fort Beaufort as recorded in the All Towns Studies carried out in 2010. These water requirements are significantly less than the potential yield from Foxwood Dam. The All Towns Studies also assessed that the currently developed water resources for each of the towns was adequate to meet most likely future water requirements of the towns.

Town	Gross annual average daily demand (million m^3/a)
Adelaide	0.850
Bedford	0.526
Fort Beaufort*	0.401

*It is noted that the Amathole District Municipality registered abstraction for Fort Beaufort is given as 1.464 million m^3/a and the actual abstraction is recorded as 3.139 million m^3/a (Viljoen, 2014).

Irrigation in the Koonap River Valley

Existing Irrigation

Approximately 338 ha of commercial irrigation downstream of the proposed Foxwood Dam site is registered in the WARMS database under abstractions from the Koonap River. Investigations into developing further commercial irrigation in the Koonap River Valley downstream of a possible dam at the Foxwood site have been carried out in the past, however it is reported that the estimated cost of water at that stage was not considered viable for commercial farming.

Potential Irrigation Development

As part of the current feasibility study an assessment of irrigable land was carried out based on detailed aerial orthophoto mapping, soil depth data obtained from the Provincial Department of Rural Development and Agrarian Reform and consultation with local farmers, landowners and stakeholders through an Agricultural Technical Working Group. The study indicates that there are in excess of 3 000 ha of land in the Koonap River Valley that would be suitable for irrigation development. However, it is noted that, in many locations, the cost of developing farming infrastructure would be high as the potentially suitable lands are spread in pockets across many cadastral boundaries and road access through the area is limited.

Proposed Irrigation Development

During stakeholder consultation, through the establishment of an Agricultural Technical Working Group (ATWG), it was clear that there was a willingness from local existing commercial farmers and resource poor farmers to collaborate through forms of partnerships. The current feasibility study is carrying out an assessment of the viability of developing 1 250 ha of new irrigation along the Koonap as a pilot scheme.
1 250 ha is the area of additional new irrigation that could be developed from the yield of a 1 MAR dam assuming 850 mm application of water per hectare and 15% distribution losses.

Water use in the Fish River catchment

Orange-Fish Transfer Scheme

In the process of investigating the development of a multi-purpose dam, it is relevant to consider all opportunities for use of the water. The Koonap River is a tributary of the Great Fish River which forms part of the Fish – Tsitsikamma Water Management Area. The Fish River receives approximately 575 million m^3/a transferred water from the Orange River. The transferred water is additional water to run-off generated within the catchment as well as to improve the water quality in the Fish River, which has a naturally high salinity. The high salinity in the upper reaches of the Great Fish results from leachate from irrigation. The high salinity in the lower reaches of the river results from irrigation return flows in addition to the leachate impact. Orange River water is used to flush the system sporadically to ensure suitable water quality for abstraction at the Hermanuskraal Weir. A schematic diagram of the Orange-Fish Sundays transfer scheme is provided at the end of this memorandum.

Lower (Great) Fish River Government Water Scheme

Currently the Lower (Great) Fish River Government Water Scheme (GWS) comprises the Hermanuskraal Weir where water is diverted via a pipeline to the Glen Melville balancing dam located on the Ecca River. Water is supplied from the Glen Melville Dam to Grahamstown as well as to the Tyhefu Irrigation Scheme via a pipeline. These systems operate under gravity. The Lower (Great) Fish River GWS was constructed with the intention to irrigate 3 000 ha, 1 500 ha on each side of the Great Fish River. Currently, it is understood, ±650ha is being utilised in the Tyhefu area on the left bank of the Fish River. No irrigation takes place on the right bank of the river as most of the farms in the Committees Drift area are operated as game farms (Geldenhuys, 2014).

Potential contribution from Koonap to the Fish River Government Water Scheme

As the confluence of the Koonap River with the Great Fish River is located downstream of the Hermanuskraal Weir, any contribution from the proposed Foxwood Dam would require transfer pipelines or canals through complicated terrain or pumping. However, releases from the proposed Foxwood Dam could benefit abstractions from the Great Fish River downstream of the Hermanuskraal Weir. It is not known whether there are any existing users who could benefit from such a scheme. It should be noted that the Koonap River confluence with the Fish River is approximately 145 km downstream of the proposed Foxwood site and the existing Tyhefu Irrigation Scheme lands are approximately 75 km downstream of the Koonap/Fish confluence. The potential for high water losses and reduction in water quality over these distances must be considered.

The Fish to Sundays Internal Strategic Perspective (DWA 2005) notes that there is potential to develop the water resource of the Koonap River at the Foxwood Dam site, but acknowledges that this would be an expensive scheme and does not note any specific priority for allocation and use of the water.

Conclusion

Despite significant investment and infrastructure development, the resource poor farmer irrigation development potential for the Government Water Scheme on the Lower Great Fish River is far from being fully realised. For the Koonap River to contribute to the existing Government Water Scheme, pumping infrastructure would be required. It does not appear that there are potential water users in the Fish River Valley downstream of the existing Government Water Scheme that could benefit from the development of a scheme making use of releases from the Koonap River from a possible dam at the Foxwood site. It is likely that water losses from any releases would be significant and opportunity for Koonap River water to improve the water quality in the Greater Fish River would be marginal.

It is concluded that the opportunity for the Koonap River to contribute significantly to water resource management within the Lower Great Fish River catchment is limited. It is recommended that the focus of the Feasibility Study for Foxwood Dam, regarding water use and irrigation development, continue addressing the potential for 1 250 ha irrigation development within the Koonap River Valley as a pilot irrigation scheme in the region, where there is a stated willingness from both existing commercial and resource poor farmers to develop further irrigation.

References

DWA, 2005 Fish to Tsitsikamma Water Management Area, Fish to Sundays Internal Strategic Perspective, Version 1, report prepared by Ninham Shand for DWA, February 2005

Gendenhuys, 2014 Email correspondence regarding the Great Fish River Government Water Scheme, Theo Geldenhuys, June 2014

Viljoen, 2014 Email correspondence regarding abstractions from the Kat River, Koos Viljoen, June 2014

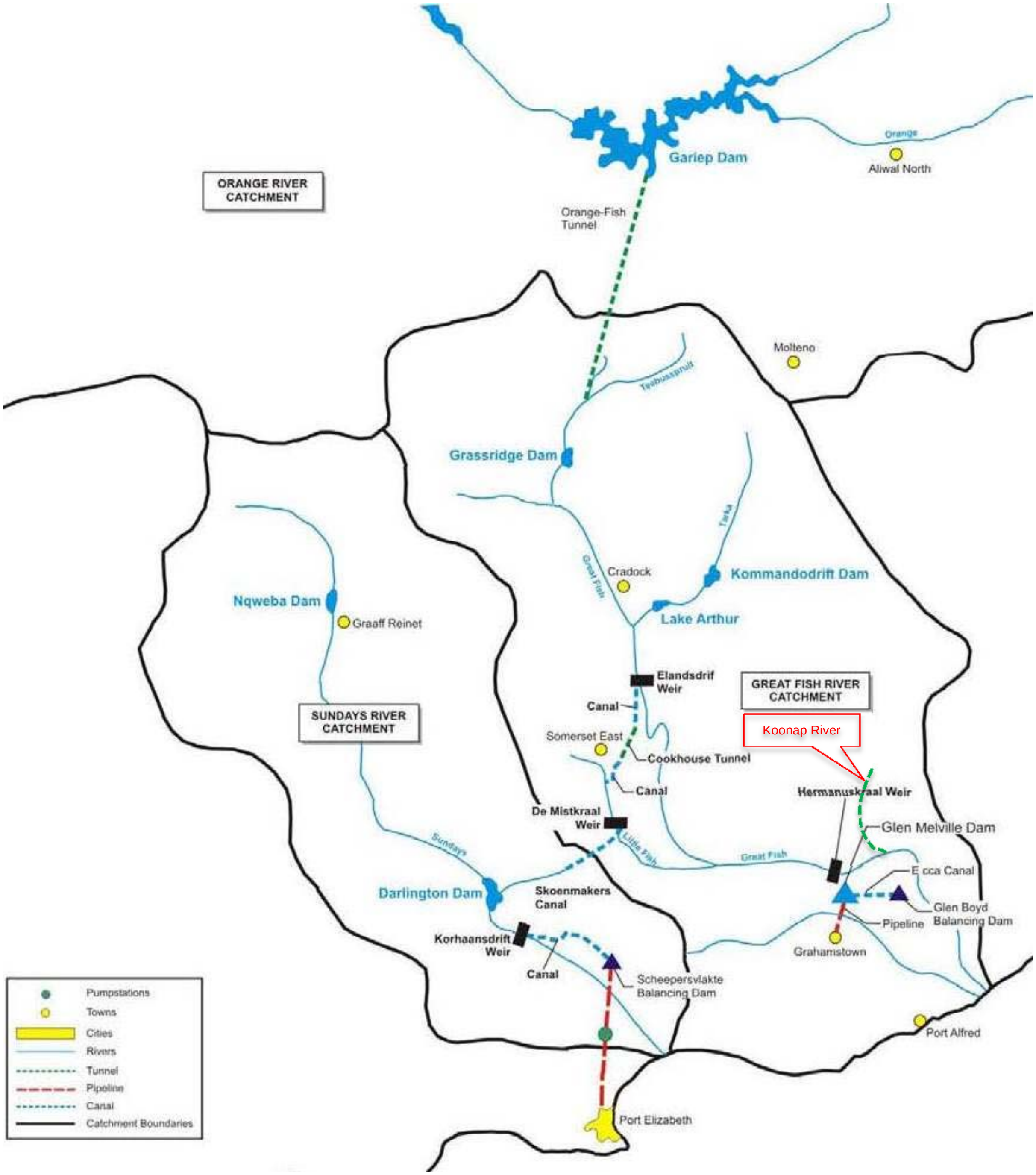
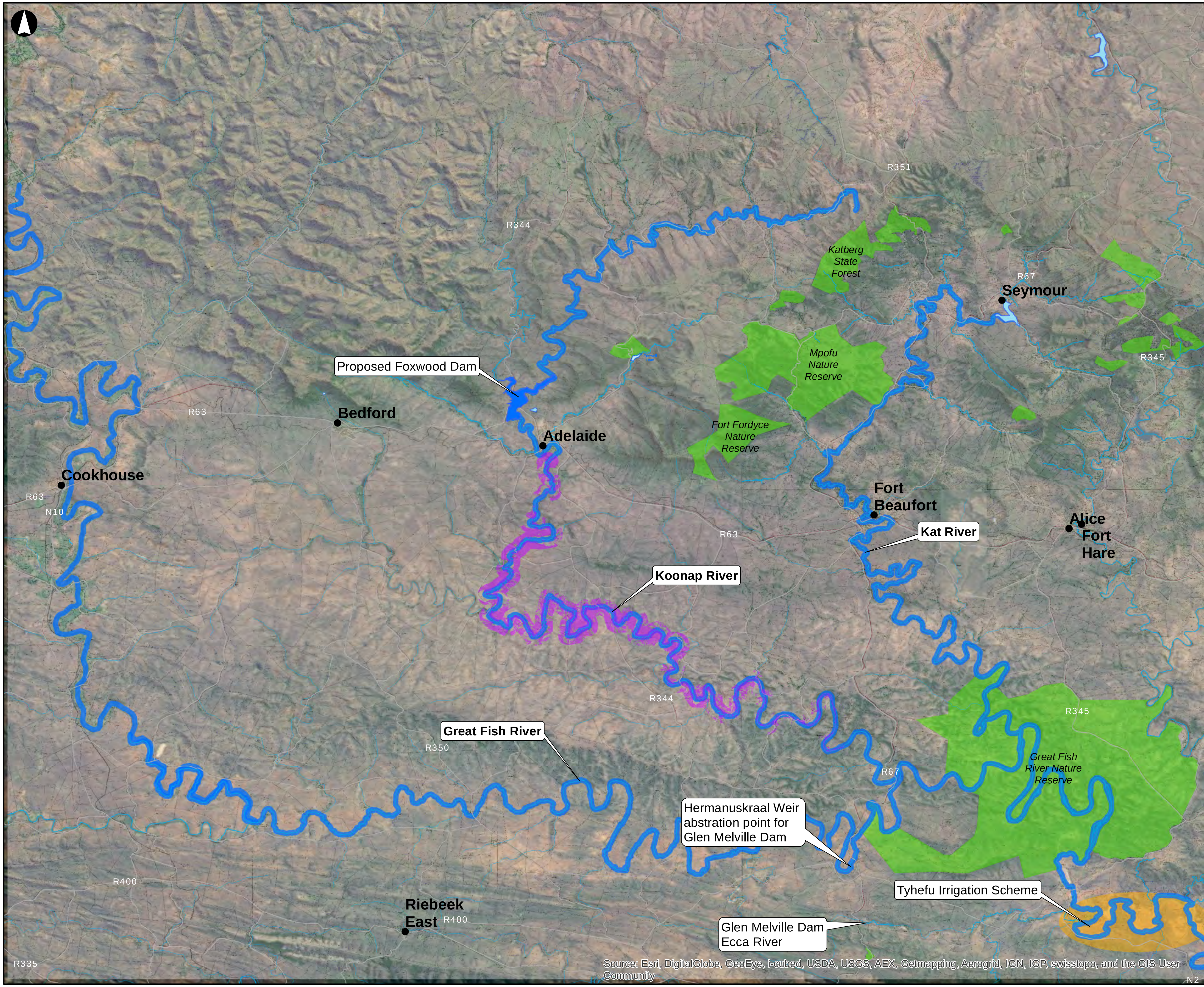


Figure 1 Schematic diagram of the Orange-Fish-Sundays Transfer Scheme showing proposed Foxwood Dam location (DWA, 2005)

A3



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Legend

- Towns
- Rivers
- Roads
- Protected Areas
- Foxwood Dam
- Tyhefu Irrigation Scheme
- Possible Irrigation Areas

Issue	Date	By	Chkd	Appd
P0	2014-06-03	YO	JB	JAH

Metres
0 5,000 10,000 20,000

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Client
Department of Water Affairs

Job Title
Foxwood Dam

Koonap River Location Plan in context of Great Fish River

Scale at A3
1:408,500

Job No
225739-00

Drawing Status
Preliminary

Drawing No
225739-028

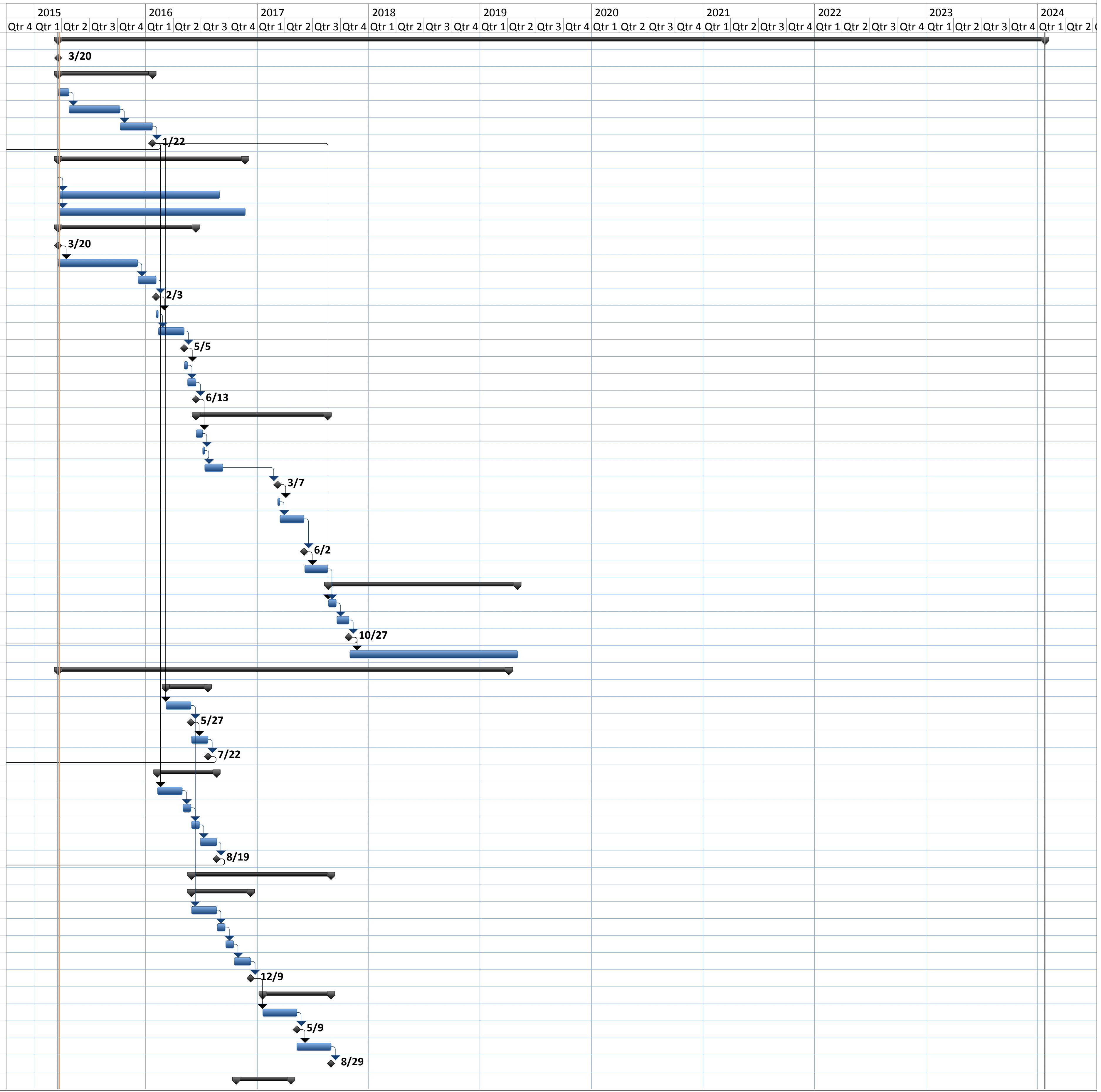
Issue
P0

MXD Location

APPENDIX E: HIGH LEVEL DEVELOPMENT PROGRAMME

FOXWOOD DAM IMPLEMENTATION

ID	Task Name	Duration	Start	Finish	Predecessors
1	**DAM DEVELOPMENT PROJECT**	**2160 days**	**Mar 20 '15**	**Jan 25 '24**	
2	Project Start	0 days	Mar 20 '15	Mar 20 '15	
3	**Record of Implementation Decision (RID)**	**205 days**	**Mar 20 '15**	**Jan 22 '16**	
4	Draft RID	25 days	Mar 20 '15	Apr 23 '15	
5	DWA Review / Comment Period on RID	6 mons	Apr 24 '15	Oct 8 '15	4
6	Finalise RID	60 days	Oct 9 '15	Jan 22 '16	5
7	Issue RID	0 days	Jan 22 '16	Jan 22 '16	6
8	**Environmental Impact Assessment**	**421 days**	**Mar 20 '15**	**Nov 21 '16**	
9	Environmental Scoping	1 day	Mar 20 '15	Mar 20 '15	
10	Further Public Participation	18 mons	Mar 23 '15	Aug 29 '16	9
11	EIA	21 mons	Mar 23 '15	Nov 21 '16	9
12	**Environmental Authorisation**	**306 days**	**Mar 20 '15**	**Jun 13 '16**	
13	Submit Application to DEA - Single Authorisation	0 days	Mar 20 '15	Mar 20 '15	
14	DEA Evaluation	186 days	Mar 20 '15	Dec 4 '15	13
15	DWA Respond to DEA Enquiry	27 days	Dec 7 '15	Feb 3 '16	14
16	Submit Application to DEA - Single Authorisation	0 days	Feb 3 '16	Feb 3 '16	15
17	DEA Acknowledgement	5 days	Feb 4 '16	Feb 10 '16	16
18	DEA Evaluation / Appeal Period	61 days	Feb 11 '16	May 5 '16	17
19	DEA Approve Authorisation	0 days	May 5 '16	May 5 '16	18
20	DWA Request Clarification on Conditions	7 days	May 6 '16	May 16 '16	19
21	DEA Evaluation	20 days	May 17 '16	Jun 13 '16	20
22	DEA Approve Ammendments to Enviro Authorisation	0 days	Jun 13 '16	Jun 13 '16	21
23	**DWA Approval Process**	**292 days**	**Jun 14 '16**	**Aug 18 '17**	
24	Obtain Stakeholder Support (WUA, SANParks, DM)	15 days	Jun 14 '16	Jul 4 '16	22
25	Prepare Ministerial Submission Sectiion 109 Notice	5 days	Jul 5 '16	Jul 11 '16	24
26	Internal Approval Process for Ministerial Submission	44 days	Jul 12 '16	Sep 9 '16	25
27	Ministerial Approval	0 days	Mar 7 '17	Mar 7 '17	26FS+110 days
28	Prepare NWA S110 Notice	5 days	Mar 8 '17	Mar 14 '17	27
29	Internal Approval Process to Publish NWA Section110 Notice	58 days	Mar 15 '17	Jun 2 '17	28
30	Publish NWA Section 110 Notice	0 days	Jun 2 '17	Jun 2 '17	29
31	Public Comment Period	55 days	Jun 5 '17	Aug 18 '17	30
32	**Ministerial Approval to Appoint PSPs**	**410 days**	**Aug 21 '17**	**May 2 '19**	
33	Preparation of Submission	20 days	Aug 21 '17	Sep 15 '17	7,31
34	Pre-Approval & Submit to Minister	30 days	Sep 18 '17	Oct 27 '17	33
35	Ministerial Approval	0 days	Oct 27 '17	Oct 27 '17	34
36	Water Licence Application	18 mons	Oct 30 '17	May 2 '19	35
37	**Environmental Authorisation Conditions**	**988 days**	**Mar 20 '15**	**Apr 4 '19**	
38	**Pre-Construction EMP**	**100 days**	**Mar 7 '16**	**Jul 22 '16**	
39	Preparation of EMP	60 days	Mar 7 '16	May 27 '16	7FS+30 days
40	Submit to DEA	0 days	May 27 '16	May 27 '16	39
41	DEA Evaluation	40 days	May 30 '16	Jul 22 '16	40
42	Approval by DEA	0 days	Jul 22 '16	Jul 22 '16	41
43	**Appoint ECO**	**140 days**	**Feb 8 '16**	**Aug 19 '16**	
44	Prepare Tender for ECO	60 days	Feb 8 '16	Apr 29 '16	7FS+10 days
45	Advertised Tender	20 days	May 2 '16	May 27 '16	44
46	Approve Evaluation Panel	20 days	May 30 '16	Jun 24 '16	45
47	Evaluate Tender & DBAC Approval	40 days	Jun 27 '16	Aug 19 '16	46
48	Appoint ECO	0 days	Aug 19 '16	Aug 19 '16	47
49	**Construction EMP (Phase 2 & 3)**	**310 days**	**May 30 '16**	**Aug 29 '17**	
50	**Appoint PSP**	**140 days**	**May 30 '16**	**Dec 9 '16**	
51	Prepare Tender for PSP	60 days	May 30 '16	Aug 19 '16	39
52	Advertised Tender	20 days	Aug 22 '16	Sep 16 '16	51
53	Approve Evaluation Panel	20 days	Sep 19 '16	Oct 14 '16	52
54	Evaluate Tender & DBAC Approval	40 days	Oct 17 '16	Dec 9 '16	53
55	Appoint PSP	0 days	Dec 9 '16	Dec 9 '16	54
56	**Preparation of EMP**	**160 days**	**Jan 18 '17**	**Aug 29 '17**	
57	Prepare EMP Documentation	80 days	Jan 18 '17	May 9 '17	55FS+10 days
58	Submit to DEA	0 days	May 9 '17	May 9 '17	57
59	DEA Evaluation	80 days	May 10 '17	Aug 29 '17	58
60	Approval by DEA	0 days	Aug 29 '17	Aug 29 '17	59
61	**Plant Rescue**	**112 days**	**Oct 24 '16**	**Apr 20 '17**	



Project: Foxwood Dam
Date: Mar 25 '15

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress

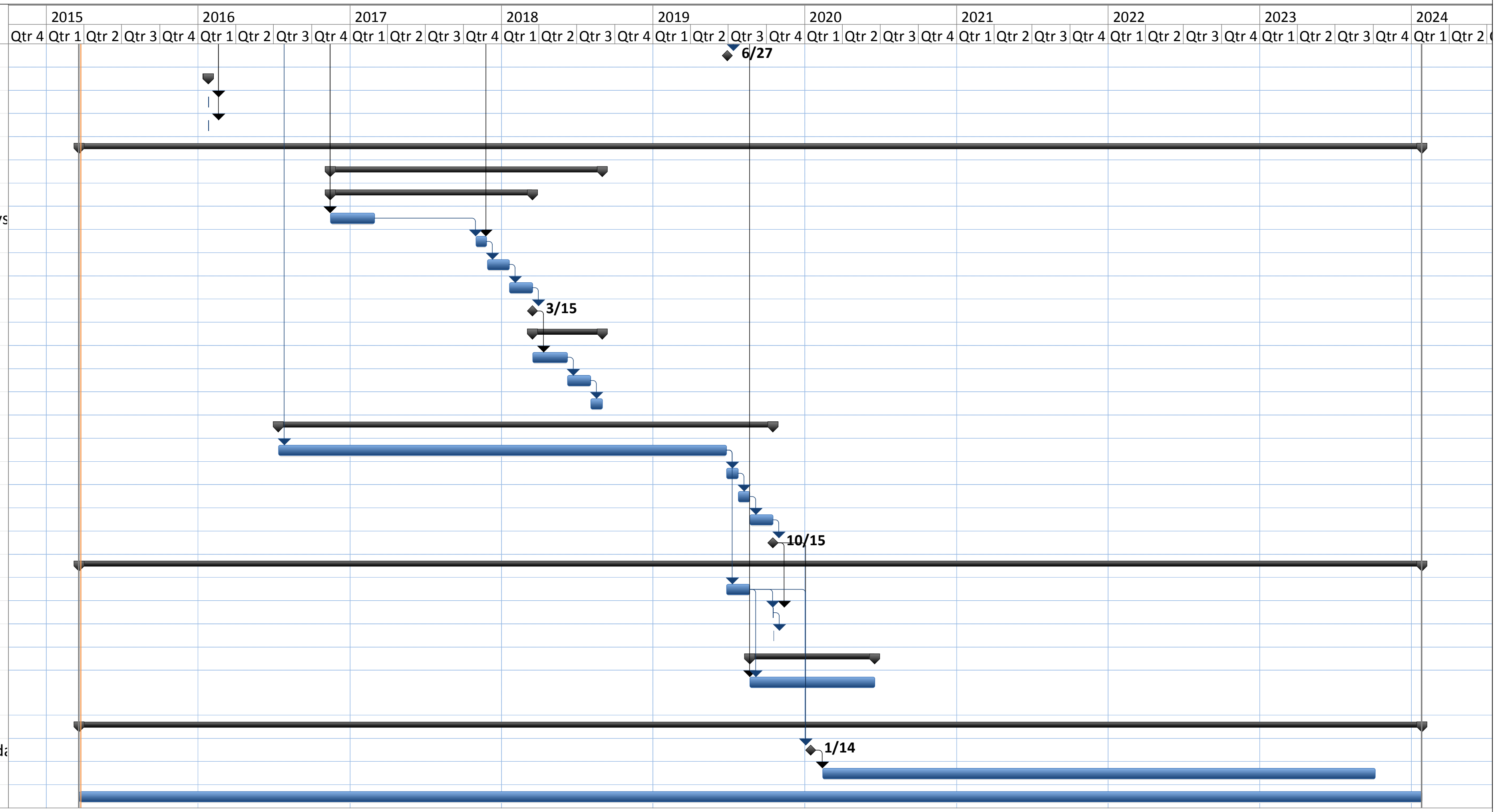
FOXWOOD DAM IMPLEMENTATION

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
62		Search RDL Floral Species	80 days	Oct 24 '16	Mar 7 '17	48FS+45 days
63		Obtain Permit to Remove Species	0 days	Mar 7 '17	Mar 7 '17	62
64		Plant Rescue in Priority Area	30 days	Mar 8 '17	Apr 18 '17	63
65		Plant Rescue in Dam Basin	1 day	Apr 19 '17	Apr 19 '17	64
66		Prepare Habitat Rehabilitation Plan	1 day	Apr 20 '17	Apr 20 '17	65
67		**Archeological Work**	**240 days**	**Apr 13 '18**	**Apr 4 '19**	
68		**Appoint PSP**	**140 days**	**Apr 13 '18**	**Oct 25 '18**	
69		Prepare Tender for Archeological Work	60 days	Apr 13 '18	Jul 5 '18	35FS+100 days,7
70		Advertised Tender	20 days	Jul 6 '18	Aug 2 '18	69
71		Approve Evaluation Panel	20 days	Aug 3 '18	Aug 30 '18	70
72		Evaluate Tender & DBAC Approval	40 days	Aug 31 '18	Oct 25 '18	71
73		Appoint PSP	0 days	Oct 25 '18	Oct 25 '18	72
74		**Implementation**	**100 days**	**Oct 26 '18**	**Apr 4 '19**	
75		Archeological Work Priority Area	20 days	Oct 26 '18	Nov 22 '18	73
76		Archeological Work - Dam Basin	80 days	Nov 23 '18	Apr 4 '19	75
77		**Grave Relocation**	**988 days**	**Mar 20 '15**	**Apr 4 '19**	
78		**Appoint PSP**	**140 days**	**Apr 13 '18**	**Oct 25 '18**	
79		Prepare Tender for Archeological Work	60 days	Apr 13 '18	Jul 5 '18	7,35FS+100 days
80		Advertised Tender	20 days	Jul 6 '18	Aug 2 '18	79
81		Approve Evaluation Panel	20 days	Aug 3 '18	Aug 30 '18	80
82		Evaluate Tender & DBAC Approval	40 days	Aug 31 '18	Oct 25 '18	81
83		Appoint PSP	0 days	Oct 25 '18	Oct 25 '18	82,106
84		**Implementation**	**100 days**	**Oct 26 '18**	**Apr 4 '19**	
85		Obtain Permit from SAHRA	20 days	Oct 26 '18	Nov 22 '18	83,7,106
86		Grave Relocation in Priority Area	20 days	Nov 23 '18	Jan 10 '19	85,106
87		Grave Relocation in Dam Basin / Conservation	60 days	Jan 11 '19	Apr 4 '19	86,108
88		**Operational of EMP**	**1 day**	**Mar 20 '15**	**Mar 20 '15**	
89		Appoint PSP & Prepare EMP	1 day	Mar 20 '15	Mar 20 '15	
90		Submit to DEA	1 day	Mar 20 '15	Mar 20 '15	
91		DEA Evaluation	1 day	Mar 20 '15	Mar 20 '15	
92		Approval by DEA	1 day	Mar 20 '15	Mar 20 '15	
93		**Land Matters**	**637 days**	**Mar 20 '15**	**Oct 12 '17**	
94		**Dam Footprint and Borrow Pits**	**637 days**	**Mar 20 '15**	**Oct 12 '17**	
95		Purchase Line Demarcation	20 days	Mar 20 '15	Apr 16 '15	
96		Prepare Land Schedules	20 days	Apr 17 '15	May 14 '15	95
97		**Appoint Evaluator**	**210 days**	**Apr 18 '16**	**Feb 28 '17**	
98		Prepare Tender Documentation	130 days	Apr 18 '16	Oct 14 '16	7FS+60 days
99		Advertised Tender	20 days	Oct 17 '16	Nov 11 '16	98
100		Approve Evaluation Panel	20 days	Nov 14 '16	Dec 9 '16	99
101		Evaluate Tender & DBAC Approval	40 days	Jan 4 '17	Feb 28 '17	100
102		Appoint PSP	0 days	Feb 28 '17	Feb 28 '17	101
103		**Valuation Investigation**	**140 days**	**Mar 29 '17**	**Oct 10 '17**	
104		Prepare Valuation Report	60 days	Mar 29 '17	Jun 20 '17	102FS+20 days
105		Evaluation of Report	60 days	Jun 21 '17	Sep 12 '17	104
106		Expropriate Dam Footprint & Borrow Pits	0 days	Oct 10 '17	Oct 10 '17	105FS+20 days
107		**Dam Basin Properties**	**2 days**	**Oct 11 '17**	**Oct 12 '17**	
108		Acquire Dam Basin Properties	1 day	Oct 11 '17	Oct 11 '17	106
109		Caretaker Agreements	1 day	Oct 12 '17	Oct 12 '17	108
110		**Infrastructure**	**843 days**	**Jan 25 '16**	**Jun 27 '19**	
111		**Appoint PSP**	**583 days**	**Jan 25 '16**	**Jun 7 '18**	
112		Prepare Tender Documentation	60 days	Jan 25 '16	Apr 15 '16	7
113		Advertised Tender	20 days	Feb 16 '18	Mar 15 '18	35FS+60 days,11
114		Approve Evaluation Panel	20 days	Mar 16 '18	Apr 12 '18	113
115		Evaluate Tender & DBAC Approval	40 days	Apr 13 '18	Jun 7 '18	114
116		Appoint PSP	0 days	Jun 7 '18	Jun 7 '18	115
117		**Tender Design & Appointment of Contractor**	**240 days**	**Jul 6 '18**	**Jun 27 '19**	
118		**Prepare Tender Documentation**	**160 days**	**Jul 6 '18**	**Mar 7 '19**	**116FS+20 days**
119		Realignment of Road R344	160 days	Jul 6 '18	Mar 7 '19	
120		Reinstate Bulk Water Supply to Adelaide Dam	160 days	Jul 6 '18	Mar 7 '19	
121		Advertised Tender	20 days	Mar 8 '19	Apr 4 '19	118
122		Approve Evaluation Panel	20 days	Apr 5 '19	May 2 '19	121
123		Evaluate Tender & DBAC Approval	40 days	May 3 '19	Jun 27 '19	122

Project: Foxwood Dam
Date: Mar 25 '15

Task	Summary	External Milestone	Inactive Summary	Manual Summary Rollup	Finish-only
Split	Project Summary	Inactive Task	Manual Task	Manual Summary	Deadline
Milestone	External Tasks	Inactive Milestone	Duration-only	Start-only	Progress

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
124		Appoint PSP	0 days	Jun 27 '19	Jun 27 '19	123
125		**Public Utilities**	**1 day**	**Jan 25 '16**	**Jan 25 '16**	
126		Eskom Services	1 day	Jan 25 '16	Jan 25 '16	7
127		Telkom Services	1 day	Jan 25 '16	Jan 25 '16	7
128		**Dam Design & Construction**	**2160 days**	**Mar 20 '15**	**Jan 25 '24**	
129		**Foundation & Borrow Pits Investigation**	**433 days**	**Nov 14 '16**	**Aug 30 '18**	
130		**Appoint PSP**	**313 days**	**Nov 14 '16**	**Mar 15 '18**	
131		Prepare Tender Documentation	60 days	Nov 14 '16	Feb 28 '17	42,48FS+60 days
132		Advertised Tender	20 days	Oct 30 '17	Nov 24 '17	35,131
133		Approve Evaluation Panel	20 days	Nov 27 '17	Jan 18 '18	132
134		Evaluate Tender & DBAC Approval	40 days	Jan 19 '18	Mar 15 '18	133
135		Appoint PSP	0 days	Mar 15 '18	Mar 15 '18	134
136		**Investigation**	**120 days**	**Mar 16 '18**	**Aug 30 '18**	
137		Foundation & Borrow Pits Investigation	60 days	Mar 16 '18	Jun 7 '18	135
138		Prepare Report	40 days	Jun 8 '18	Aug 2 '18	137
139		Evaluation of Report	20 days	Aug 3 '18	Aug 30 '18	138
140		**Tender Design & Appointment of Contractor**	**800 days**	**Jul 12 '16**	**Oct 15 '19**	
141		Prepare Tender Documentation	720 days	Jul 12 '16	Jun 25 '19	25
142		Advertised Tender	20 days	Jun 26 '19	Jul 23 '19	141
143		Approve Evaluation Panel	20 days	Jul 24 '19	Aug 20 '19	142
144		Evaluate Tender & DBAC Approval	40 days	Aug 21 '19	Oct 15 '19	143
145		Appoint PSP	0 days	Oct 15 '19	Oct 15 '19	144
146		**Dam Safety Issues**	**2160 days**	**Mar 20 '15**	**Jan 25 '24**	
147		Consider & Issue Licence to Construct	40 days	Jun 26 '19	Aug 20 '19	141
148		Consider & Issue Licence to Impound	1 day	Oct 16 '19	Oct 16 '19	147,145
149		Completion Report & Certificate	1 day	Oct 17 '19	Oct 17 '19	148
150		**Final Dam Design & Supervision**	**200 days**	**Aug 21 '19**	**Jun 16 '20**	
151		Final Design	200 days	Aug 21 '19	Jun 16 '20	7,147
152		**Dam Construction**	**2160 days**	**Mar 20 '15**	**Jan 25 '24**	
153		Site Establishment	0 days	Jan 14 '20	Jan 14 '20	147,145FS+50 da
154		Construction	45 mons	Feb 12 '20	Oct 4 '23	153FS+20 days
155		Irrigation Scheme Development	108 mons	Mar 20 '15	Jan 25 '24	



Project: Foxwood Dam
Date: Mar 25 '15

Task	Summary	External Milestone	Inactive Summary	Manual Summary Rollup	Finish-only
Split	Project Summary	Inactive Task	Manual Task	Manual Summary	Deadline
Milestone	External Tasks	Inactive Milestone	Duration-only	Start-only	Progress

APPENDIX F: UNIT REFERENCE VALUE CALCULATION

Foxwood Dam URV - Capital, Maintenance & Refurbishment

Date	Feb-15
Project Name	Foxwood Dam
Dam Type Option	Composite
Dam Capacity Option (MAR / Storage Ratio)	1
Capacity	53,7 million m3
Yield Return Period	1:20 / 95%
Yield (m³per annum)	19 100 000 m3
Initial Take Up of Yield	10 000 000 m3
Base Year	2014
Component life	45

INPUT

Capital Costs

Total	Civil	Mech & Elec	
	92,5%	7,5%	
2 084 186 082			Total Project
1 760 410 383	1 628 379 604	132 030 779	Dam only

Construction Timing

Start	End	Duration (Yrs)
2015	2018	4

Construction Cash Flow

	Year 1	Year 2	Year 3	Year 4
	312 627 912	521 046 521	833 674 433	416 837 216

Annual Maintenance and Operation Costs

Civil	Mech & Elec
0,25%	4%

RESULT

Discount Rate	Present Worth of Costs in 2013 (ZAR)	Present Value of Water Delivered	Unit Reference value
6,0%	1 921 507 109	214 371 815	8,96
8,0%	1 797 248 114	152 672 405	11,77
10%	1 694 049 848	113 212 565	14,96

Composite
1,0 MAR

Construction Costs

	Component Life	Year	Civil	M&E	VAT	Total	Present Cost 2014 @	Present Cost 2014 @	Present Cost 2014 @
Notes							6%	8%	10%
					14%				
		2014					-	-	-
		2015	252 296 210	21 938 801	38 392 901	312 627 912	294 931 992	289 470 289	284 207 193
		2016	420 493 684	36 564 668	63 988 169	521 046 521	463 729 549	446 713 410	430 616 960
		2017	672 789 893	58 503 469	102 381 071	833 674 433	699 969 130	661 797 643	626 351 941
		2018	336 394 946	29 251 734	51 190 535	416 837 216	330 174 117	306 387 798	284 705 427
	1	2019			-	-	-	-	-
	2	2020			-	-	-	-	-
	3	2021			-	-	-	-	-
	4	2022			-	-	-	-	-
	5	2023			-	-	-	-	-
	6	2024			-	-	-	-	-
	7	2025			-	-	-	-	-
	8	2026			-	-	-	-	-
	9	2027			-	-	-	-	-
	10	2028			-	-	-	-	-
	11	2029			-	-	-	-	-
	12	2030			-	-	-	-	-
	13	2031			-	-	-	-	-
	14	2032			-	-	-	-	-
	15	2033			-	-	-	-	-
	16	2034			-	-	-	-	-
	17	2035			-	-	-	-	-
	18	2036			-	-	-	-	-
	19	2037			-	-	-	-	-
	20	2038			-	-	-	-	-
	21	2039			-	-	-	-	-
	22	2040			-	-	-	-	-
	23	2041			-	-	-	-	-
	24	2042			-	-	-	-	-
	25	2043			-	-	-	-	-
	26	2044			-	-	-	-	-
	27	2045			-	-	-	-	-
	28	2046			-	-	-	-	-
	29	2047					-	-	-
	30	2048				132 030 779	18 208 567	9 644 229	5 168 016
	31	2049			-	-	-	-	-
	32	2050							-
	33	2051							-
	34	2052							-
	35	2053							-
	36	2054							-
	37	2055			-	-	-	-	-
	38	2056			-	-	-	-	-
	39	2057			-	-	-	-	-
	40	2058			-	-	-	-	-
	41	2059			-	-	-	-	-
	42	2060			-	-	-	-	-
	43	2061			-	-	-	-	-
	44	2062			-	-	-	-	-
	45	2063					-	-	-
Totals			1 681 974 733	146 258 672	255 952 677	2 216 216 861	1 807 013 355	1 714 013 368	1 631 049 537

8% of capital cost of dam structure allowed for major maintenance of Mechanical and Electric Works - eg outlet works and pump station

Composite
1,0 MAR

Maintenance & Operating Costs

Year	Civil	M&E	Total	Present Cost 2014 @	Present Cost 2014 @	Present Cost 2014 @
				6%	8%	10%
2014						
2015						
2016						
2017						
2018						
2019	4 070 949	5 281 231	9 352 180	6 988 493	6 364 937	5 806 968
2020	4 070 949	5 281 231	9 352 180	6 592 918	5 893 460	5 279 062
2021	4 070 949	5 281 231	9 352 180	6 219 734	5 456 907	4 799 147
2022	4 070 949	5 281 231	9 352 180	5 867 674	5 052 692	4 362 861
2023	4 070 949	5 281 231	9 352 180	5 535 541	4 678 418	3 966 237
2024	4 070 949	5 281 231	9 352 180	5 222 209	4 331 869	3 605 670
2025	4 070 949	5 281 231	9 352 180	4 926 612	4 010 990	3 277 882
2026	4 070 949	5 281 231	9 352 180	4 647 747	3 713 879	2 979 893
2027	4 070 949	5 281 231	9 352 180	4 384 667	3 438 777	2 708 993
2028	4 070 949	5 281 231	9 352 180	4 136 478	3 184 053	2 462 721
2029	4 070 949	5 281 231	9 352 180	3 902 338	2 948 197	2 238 838
2030	4 070 949	5 281 231	9 352 180	3 681 451	2 729 812	2 035 307
2031	4 070 949	5 281 231	9 352 180	3 473 067	2 527 604	1 850 279
2032	4 070 949	5 281 231	9 352 180	3 276 478	2 340 374	1 682 072
2033	4 070 949	5 281 231	9 352 180	3 091 017	2 167 013	1 529 156
2034	4 070 949	5 281 231	9 352 180	2 916 054	2 006 493	1 390 142
2035	4 070 949	5 281 231	9 352 180	2 750 994	1 857 864	1 263 765
2036	4 070 949	5 281 231	9 352 180	2 595 278	1 720 245	1 148 878
2037	4 070 949	5 281 231	9 352 180	2 448 375	1 592 819	1 044 434
2038	4 070 949	5 281 231	9 352 180	2 309 788	1 474 833	949 486
2039	4 070 949	5 281 231	9 352 180	2 179 045	1 365 586	863 169
2040	4 070 949	5 281 231	9 352 180	2 055 703	1 264 431	784 699
2041	4 070 949	5 281 231	9 352 180	1 939 342	1 170 770	713 363
2042	4 070 949	5 281 231	9 352 180	1 829 568	1 084 046	648 511
2043	4 070 949	5 281 231	9 352 180	1 726 008	1 003 746	589 556
2044	4 070 949	5 281 231	9 352 180	1 628 309	929 395	535 960
2045	4 070 949	5 281 231	9 352 180	1 536 141	860 551	487 236
2046	4 070 949	5 281 231	9 352 180	1 449 189	796 806	442 942
2047	4 070 949	5 281 231	9 352 180	1 367 160	737 783	402 675
2048	4 070 949	5 281 231	9 352 180	1 289 773	683 133	366 068
2049	4 070 949	5 281 231	9 352 180	1 216 767	632 530	332 789
2050	4 070 949	5 281 231	9 352 180	1 147 894	585 676	302 535
2051	4 070 949	5 281 231	9 352 180	1 082 919	542 293	275 032
2052	4 070 949	5 281 231	9 352 180	1 021 621	502 123	250 029
2053	4 070 949	5 281 231	9 352 180	963 794	464 929	227 299
2054	4 070 949	5 281 231	9 352 180	909 239	430 490	206 636
2055	4 070 949	5 281 231	9 352 180	857 773	398 601	187 851
2056	4 070 949	5 281 231	9 352 180	809 220	369 075	170 773
2057	4 070 949	5 281 231	9 352 180	763 415	341 737	155 248
2058	4 070 949	5 281 231	9 352 180	720 203	316 423	141 135
2059	4 070 949	5 281 231	9 352 180	679 437	292 984	128 305
2060	4 070 949	5 281 231	9 352 180	640 978	271 281	116 640
2061	4 070 949	5 281 231	9 352 180	604 696	251 187	106 037
2062	4 070 949	5 281 231	9 352 180	570 468	232 580	96 397
2063	4 070 949	5 281 231	9 352 180	538 177	215 352	87 634
Totals	183 192 705	237 655 402	420 848 107	114 493 754	83 234 745	63 000 312

Composite
1,0 MAR

Water Delivered (m³)

Year	Water Delivered (m³)	Present Cost 2014 @	Present Cost 2014 @	Present Cost 2014 @
	15,0%	6%	8%	10%
	up to Yield			
2014				
2015				
2016				
2017				
2018				
2019	10 000 000	7 472 582	6 805 832	6 209 213
2020	11 500 000	8 107 046	7 246 951	6 491 450
2021	13 225 000	8 795 380	7 716 660	6 786 516
2022	15 208 750	9 542 158	8 216 814	7 094 994
2023	17 490 063	10 352 341	8 749 386	7 417 494
2024	19 100 000	10 665 340	8 846 996	7 363 877
2025	19 100 000	10 061 642	8 191 663	6 694 433
2026	19 100 000	9 492 115	7 584 873	6 085 849
2027	19 100 000	8 954 825	7 023 030	5 532 590
2028	19 100 000	8 447 948	6 502 806	5 029 627
2029	19 100 000	7 969 763	6 021 117	4 572 388
2030	19 100 000	7 518 644	5 575 108	4 156 716
2031	19 100 000	7 093 060	5 162 137	3 778 833
2032	19 100 000	6 691 566	4 779 756	3 435 303
2033	19 100 000	6 312 799	4 425 700	3 123 003
2034	19 100 000	5 955 470	4 097 871	2 839 093
2035	19 100 000	5 618 368	3 794 325	2 580 994
2036	19 100 000	5 300 347	3 513 264	2 346 358
2037	19 100 000	5 000 328	3 253 022	2 133 053
2038	19 100 000	4 717 290	3 012 057	1 939 139
2039	19 100 000	4 450 274	2 788 942	1 762 854
2040	19 100 000	4 198 372	2 582 354	1 602 594
2041	19 100 000	3 960 728	2 391 068	1 456 904
2042	19 100 000	3 736 536	2 213 952	1 324 458
2043	19 100 000	3 525 034	2 049 956	1 204 053
2044	19 100 000	3 325 504	1 898 107	1 094 593
2045	19 100 000	3 137 267	1 757 507	995 085
2046	19 100 000	2 959 686	1 627 321	904 623
2047	19 100 000	2 792 157	1 506 779	822 384
2048	19 100 000	2 634 110	1 395 165	747 622
2049	19 100 000	2 485 010	1 291 820	679 656
2050	19 100 000	2 344 349	1 196 129	617 869
2051	19 100 000	2 211 650	1 107 527	561 699
2052	19 100 000	2 086 462	1 025 488	510 636
2053	19 100 000	1 968 360	949 526	464 214
2054	19 100 000	1 856 944	879 191	422 013
2055	19 100 000	1 751 834	814 066	383 648
2056	19 100 000	1 652 673	753 764	348 771
2057	19 100 000	1 559 126	697 930	317 065
2058	19 100 000	1 470 873	646 232	288 241
2059	19 100 000	1 387 616	598 363	262 037
2060	19 100 000	1 309 072	554 039	238 215
2061	19 100 000	1 234 974	512 999	216 559
2062	19 100 000	1 165 070	474 999	196 872
2063	19 100 000	1 099 122	439 814	178 975
Totals	831 423 813	214 371 815	152 672 405	113 212 565

Foxwood Dam URV - Maintenance, Operation & Refurbishment Only

Date	Feb-15
Project Name	Foxwood Dam
Dam Type Option	Composite
Dam Capacity Option (MAR / Storage Ratio)	1
Capacity	53,7 million m3
Yield Return Period	1:20 / 95%
Yield (m³per annum)	19 100 000 m3
Initial Take Up of Yield	10 000 000 m3
Base Year	2014
Component life	45

INPUT

Capital Costs

Total	Civil	Mech & Elec
	92,5%	7,5%
1 760 410 383	1 628 379 604	132 030 779

Timing

Start	End	Duration (Yrs)
2015	2018	4

Construction Cash Flow

Year 1	Year 2	Year 3	Year 4
312 627 912	521 046 521	833 674 433	416 837 216

Annual Maintenance and Operation Costs

Civil	Mech & Elec
0,25%	4%

RESULT Maintenance with refurbishment

Discount Rate	Present Worth of Costs in 2013 (R)	Present Value of Water Delivered	Unit Reference Value (R/m3)
6,0%	132 702 321	214 371 815	0,619
8,0%	92 878 974	152 672 405	0,608
10%	68 168 328	113 212 565	0,602

Composite
1,0 MAR

Construction Costs

	Component Life	Year	Civil	M&E	Eng	Total	Present Value 2014 @	Present Value 2014 @	Present Value 2014 @
Notes							6%	8%	10%
2nd year expenditure		2014				-	-	-	-
		2015				-	-	-	-
		2016				-	-	-	-
		2017				-	-	-	-
		2018				-	-	-	-
	1	2019				-	-	-	-
	2	2020				-	-	-	-
	3	2021				-	-	-	-
	4	2022				-	-	-	-
	5	2023				-	-	-	-
	6	2024				-	-	-	-
	7	2025				-	-	-	-
	8	2026				-	-	-	-
	9	2027				-	-	-	-
	10	2028				-	-	-	-
	11	2029				-	-	-	-
	12	2030				-	-	-	-
	13	2031				-	-	-	-
	14	2032				-	-	-	-
	15	2033				-	-	-	-
	16	2034				-	-	-	-
	17	2035				-	-	-	-
	18	2036				-	-	-	-
	19	2037				-	-	-	-
	20	2038				-	-	-	-
	21	2039				-	-	-	-
	22	2040				-	-	-	-
	23	2041				-	-	-	-
	24	2042				-	-	-	-
	25	2043				-	-	-	-
	26	2044				-	-	-	-
	27	2045				-	-	-	-
	28	2046				-	-	-	-
	29	2047				-	-	-	-
	30	2048		**132 030 779**		132 030 779	18 208 567	9 644 229	5 168 016
	31	2049				-	-	-	-
	32	2050							-
	33	2051							-
	34	2052							-
	35	2053							-
	36	2054							-
	37	2055				-	-	-	-
	38	2056				-	-	-	-
	39	2057				-	-	-	-
	40	2058				-	-	-	-
	41	2059				-	-	-	-
	42	2060				-	-	-	-
	43	2061				-	-	-	-
	44	2062				-	-	-	-
	45	2063				-	-	-	-
Totals			-	132 030 779	-	132 030 779	18 208 567	9 644 229	5 168 016

8% of capital cost of dam structure allowed for major maintenance of Mechanical and Electric Works - eg outlet works and pump station

Composite
1,0 MAR

Maintenance & Operating Costs

Year	Civil	M&E	Total	Present Value 2014 @	Present Value 2014 @	Present Value 2014 @
				6%	8%	10%
2014						
2015						
2016						
2017						
2018						
2019	4 070 949	5 281 231	9 352 180	6 988 493	6 364 937	5 806 968
2020	4 070 949	5 281 231	9 352 180	6 592 918	5 893 460	5 279 062
2021	4 070 949	5 281 231	9 352 180	6 219 734	5 456 907	4 799 147
2022	4 070 949	5 281 231	9 352 180	5 867 674	5 052 692	4 362 861
2023	4 070 949	5 281 231	9 352 180	5 535 541	4 678 418	3 966 237
2024	4 070 949	5 281 231	9 352 180	5 222 209	4 331 869	3 605 670
2025	4 070 949	5 281 231	9 352 180	4 926 612	4 010 990	3 277 882
2026	4 070 949	5 281 231	9 352 180	4 647 747	3 713 879	2 979 893
2027	4 070 949	5 281 231	9 352 180	4 384 667	3 438 777	2 708 993
2028	4 070 949	5 281 231	9 352 180	4 136 478	3 184 053	2 462 721
2029	4 070 949	5 281 231	9 352 180	3 902 338	2 948 197	2 238 838
2030	4 070 949	5 281 231	9 352 180	3 681 451	2 729 812	2 035 307
2031	4 070 949	5 281 231	9 352 180	3 473 067	2 527 604	1 850 279
2032	4 070 949	5 281 231	9 352 180	3 276 478	2 340 374	1 682 072
2033	4 070 949	5 281 231	9 352 180	3 091 017	2 167 013	1 529 156
2034	4 070 949	5 281 231	9 352 180	2 916 054	2 006 493	1 390 142
2035	4 070 949	5 281 231	9 352 180	2 750 994	1 857 864	1 263 765
2036	4 070 949	5 281 231	9 352 180	2 595 278	1 720 245	1 148 878
2037	4 070 949	5 281 231	9 352 180	2 448 375	1 592 819	1 044 434
2038	4 070 949	5 281 231	9 352 180	2 309 788	1 474 833	949 486
2039	4 070 949	5 281 231	9 352 180	2 179 045	1 365 586	863 169
2040	4 070 949	5 281 231	9 352 180	2 055 703	1 264 431	784 699
2041	4 070 949	5 281 231	9 352 180	1 939 342	1 170 770	713 363
2042	4 070 949	5 281 231	9 352 180	1 829 568	1 084 046	648 511
2043	4 070 949	5 281 231	9 352 180	1 726 008	1 003 746	589 556
2044	4 070 949	5 281 231	9 352 180	1 628 309	929 395	535 960
2045	4 070 949	5 281 231	9 352 180	1 536 141	860 551	487 236
2046	4 070 949	5 281 231	9 352 180	1 449 189	796 806	442 942
2047	4 070 949	5 281 231	9 352 180	1 367 160	737 783	402 675
2048	4 070 949	5 281 231	9 352 180	1 289 773	683 133	366 068
2049	4 070 949	5 281 231	9 352 180	1 216 767	632 530	332 789
2050	4 070 949	5 281 231	9 352 180	1 147 894	585 676	302 535
2051	4 070 949	5 281 231	9 352 180	1 082 919	542 293	275 032
2052	4 070 949	5 281 231	9 352 180	1 021 621	502 123	250 029
2053	4 070 949	5 281 231	9 352 180	963 794	464 929	227 299
2054	4 070 949	5 281 231	9 352 180	909 239	430 490	206 636
2055	4 070 949	5 281 231	9 352 180	857 773	398 601	187 851
2056	4 070 949	5 281 231	9 352 180	809 220	369 075	170 773
2057	4 070 949	5 281 231	9 352 180	763 415	341 737	155 248
2058	4 070 949	5 281 231	9 352 180	720 203	316 423	141 135
2059	4 070 949	5 281 231	9 352 180	679 437	292 984	128 305
2060	4 070 949	5 281 231	9 352 180	640 978	271 281	116 640
2061	4 070 949	5 281 231	9 352 180	604 696	251 187	106 037
2062	4 070 949	5 281 231	9 352 180	570 468	232 580	96 397
2063	4 070 949	5 281 231	9 352 180	538 177	215 352	87 634
Totals	183 192 705	237 655 402	420 848 107	114 493 754	83 234 745	63 000 312

Composite
1,0 MAR

Water Delivered (m³)

Year	Water Delivered (m³)	Present Value 2014 @	Present Value 2014 @	Present Value 2014 @
	15,0%	6%	8%	10%
	up to Yield			
2014				
2015				
2016				
2017				
2018				
2019	10 000 000	7 472 582	6 805 832	6 209 213
2020	11 500 000	8 107 046	7 246 951	6 491 450
2021	13 225 000	8 795 380	7 716 660	6 786 516
2022	15 208 750	9 542 158	8 216 814	7 094 994
2023	17 490 063	10 352 341	8 749 386	7 417 494
2024	19 100 000	10 665 340	8 846 996	7 363 877
2025	19 100 000	10 061 642	8 191 663	6 694 433
2026	19 100 000	9 492 115	7 584 873	6 085 849
2027	19 100 000	8 954 825	7 023 030	5 532 590
2028	19 100 000	8 447 948	6 502 806	5 029 627
2029	19 100 000	7 969 763	6 021 117	4 572 388
2030	19 100 000	7 518 644	5 575 108	4 156 716
2031	19 100 000	7 093 060	5 162 137	3 778 833
2032	19 100 000	6 691 566	4 779 756	3 435 303
2033	19 100 000	6 312 799	4 425 700	3 123 003
2034	19 100 000	5 955 470	4 097 871	2 839 093
2035	19 100 000	5 618 368	3 794 325	2 580 994
2036	19 100 000	5 300 347	3 513 264	2 346 358
2037	19 100 000	5 000 328	3 253 022	2 133 053
2038	19 100 000	4 717 290	3 012 057	1 939 139
2039	19 100 000	4 450 274	2 788 942	1 762 854
2040	19 100 000	4 198 372	2 582 354	1 602 594
2041	19 100 000	3 960 728	2 391 068	1 456 904
2042	19 100 000	3 736 536	2 213 952	1 324 458
2043	19 100 000	3 525 034	2 049 956	1 204 053
2044	19 100 000	3 325 504	1 898 107	1 094 593
2045	19 100 000	3 137 267	1 757 507	995 085
2046	19 100 000	2 959 686	1 627 321	904 623
2047	19 100 000	2 792 157	1 506 779	822 384
2048	19 100 000	2 634 110	1 395 165	747 622
2049	19 100 000	2 485 010	1 291 820	679 656
2050	19 100 000	2 344 349	1 196 129	617 869
2051	19 100 000	2 211 650	1 107 527	561 699
2052	19 100 000	2 086 462	1 025 488	510 636
2053	19 100 000	1 968 360	949 526	464 214
2054	19 100 000	1 856 944	879 191	422 013
2055	19 100 000	1 751 834	814 066	383 648
2056	19 100 000	1 652 673	753 764	348 771
2057	19 100 000	1 559 126	697 930	317 065
2058	19 100 000	1 470 873	646 232	288 241
2059	19 100 000	1 387 616	598 363	262 037
2060	19 100 000	1 309 072	554 039	238 215
2061	19 100 000	1 234 974	512 999	216 559
2062	19 100 000	1 165 070	474 999	196 872
2063	19 100 000	1 099 122	439 814	178 975
Totals	831 423 813	214 371 815	152 672 405	113 212 565

APPENDIX G: LEGAL, FINANCIAL AND INSTITUTIONAL ARRANGEMENTS

While development of the water resources of the Koonap River has been the subject of investigations since at least about 1962, the purpose thereof has always been to alleviate water shortages for domestic use in Adelaide town and to enable irrigation of suitable land riparian to the river to take place. The proposed multi-purpose Foxwood Dam on the Koonap River in close proximity to Adelaide town has long been identified as the preferred site after various alternative sites upstream in the catchment were examined. Indications are that previous investigations and development proposals envisaged that a Government Water Scheme as contemplated in the Water Act, Act 54 of 1956, would be developed, which Act has since been replaced by the National Water Act, Act 36 of 1998 (NWA). If the development proposals emanating from these earlier investigations had found favour and led to implementation of such a scheme, Legal, Institutional and Financial Arrangements would have been put in place in compliance with the legislative framework current at that time.

This did not happen and now, about 15 years after the most recent previous investigations were undertaken in 1998, the feasibility of developing the water resources of the Koonap River is again under review. Not only has the policy, legislative and institutional framework changed, but a Constitution and new government regime is in place with a strong focus on fundamental human rights for all, which should be given effect within a framework of co-operative government.

Various policies have been published since this new regime came in place, such as the National Water Policy of 1997, the Local Government Policy of 2000, environmental policies and agricultural policies, focussing on equality and redressing the results of past social, racial and gender discrimination, while promoting environmental sustainability. Various pieces of legislation and other legislative instruments have also been promulgated to implement these policies.

From a water resource management perspective these are the NWA, the National Water Resource Strategy (Second Edition) (NWRS) and the All Towns Reconciliation Strategies. A Policy review process is also underway with intention of making the necessary amendments to the NWA and the Water Services Act, Act 108 of 1997, to give effect to policy adjustments.

For example section 6.1.3 of the NWRS2 requires equity in access to the benefits from water resource use by redressing historical inequalities and increasing participation in the governance and management of water. Allocation of water for poverty eradication is in terms of section 6.1.8 a high priority. Further, in terms of section 6.3, a primary focus of water allocation processes is to address past racial and gender imbalances in water use and to support the reduction of poverty and inequity in the country. The water allocation process should also respond to local, provincial and planning initiatives. It should be aligned with land reform and local economic development programmes.

Section 6.4.1 of the NWRS also states that water availability is crucial for implementation of the Comprehensive Rural Development Strategy. This strategy makes provision for supporting rural development through the multi-purpose use of dams, investment in appropriate water infrastructure, water allocation reform and a programme of support to small scales water users.

Of particular significance is also the fact that a National Development Plan is now in place in which a number of socio-economic developmental and other objectives are clearly defined.

The country is now governed by a Constitution and in a democratic political dispensation with the Constitution as supreme law and the rule of law applies, which is very different from that in the previous dispensation. As a consequence, proposals for development of the water resources of the Koonap River are now formulated in terms of priorities which are different from those of the past and with different criteria in mind for Legal, Institutional and Financial Arrangements.
The overriding feature of the development proposals investigated in this Feasibility Study is that the primary purpose of the initiative is to invest in water resource infrastructure development as enabling infrastructure for stimulating socio-economic development in an economically depressed

rural region of the Eastern Cape Province instead of only making water available to satisfy an established and proven water need. Water should therefore be a stimulus for development and not only a resource from the development.

It is envisaged that capital investment in construction of the large infrastructure necessary to make available reliable water supplies would primarily unlock the agricultural potential of irrigable soil along the Koonap River (which are not yet under irrigation) and in so doing:

- create ***temporary work opportunities*** during the construction phase,
- create meaningful ***permanent work opportunities*** in the ongoing operation and maintenance of the infrastructure and in new irrigation farming enterprises,
- make a significant contribution to the ***eradication of poverty*** in the region through stimulating economic activities and production, and
- address ***social and economic inequities*** by (a) creating opportunities for many people to share in the benefits of effective utilization of water and soil resources, and (b) by mobilizing the human resource potential in the region.

The purpose of the proposed Foxwood Dam in the Koonap River near Adelaide is to achieve the following objectives:

- provide security to the water supplies for domestic, municipal and other needs in the town Adelaide for a planning horizon of 2035;
- ensure the availability of water in the Koonap River downstream as far as the confluence of the Fish River to maintain the Reserve for Ecological Water Requirements;
- maintain the supply of water for existing irrigation users downstream of the dam at a level of assurance that is appropriate for that use, i.e. equivalent to the present situation;
- make additional water available for irrigation use downstream of the dam for new emerging farmers who have thus far not had access to such resources due to the previous dispensation and are willing and able to enter this sector; and
- facilitate new socio-economic development in the region which has thus far been constrained by the lack of adequate water supplies, or which can be stimulated by making such supplies available, in order to generate real and sustainable work opportunities, counteract the spread of poverty and provide a means for redressing inequalities.

This Feasibility Study was undertaken to:

- identify and quantify the degree to which a new proposed Foxwood Dam, as a major storage dam in the Koonap River, and appurtenant works could achieve the objectives set out above;
- undertake an engineering investigation of the proposed Foxwood Dam and appurtenant works, and provide an estimate of the construction cost at a feasibility level of confidence;
- provide conceptual designs and cost estimates of bulk water supply infrastructure to augment supplies to Adelaide;
- identify land that could be developed for new irrigation and provide organizational models for allocating water and other essential support to new emerging farmers; and
- provide funding and water use charge proposals.

The environmental feasibility of constructing and operating this proposed infrastructure will be investigated by others in an Environmental Impact Assessment, leading to an application for Environmental Authorization.

An important component of this Feasibility Study is to identify the institutional arrangements best suited for implementing, owning and operating the proposed new water resource infrastructure and to indicate the institutional options that should be considered for implementing the envisaged new irrigation development. This should be done in a co-operative framework involving all the relevant institutions, such as all organs of state with a mandate and responsibility in this regard, and non-governmental organisations and community-based Organisations that can contribute to the development.

The funding arrangements necessary to enable these institutions to carry out their intended functions in a sustainable way must be in place before implementation can commence. It is important that organisations responsible for all phases of the project life cycle, from the planning phase through implementation (design and construction) to commissioning, operation and maintenance, are fully aware of the legal obligations that must be met.

Recommendations emanating from this study deal only with institutional and funding arrangements for implementing, owning and operating the proposed new water resource infrastructure. Funding and institutional arrangements for implementing the envisaged new irrigation development are the responsibility of government entities other than the Department of Water and Sanitation and are referred to in more general terms.

It is expected that the primary components of new water resource infrastructure would be:

- The Foxwood Dam on the Koonap River with a live storage capacity of 46 million m3, with associated infrastructure such as road relocations, bridges and power lines;
- Replacing part of the canal system from the Koonap River to the Adelaide Dam with a pipe across the stored water surface of the Foxwood Dam (attached to the proposed bridge on the relocated R344).
- A pumping station and rising main from the proposed Foxwood Dam to Adelaide;
- One or more flow measuring weirs in the Koonap River in the vicinity of the Foxwood Dam for managing releases from the dam to satisfy the Reserve requirements.

While the availability of irrigable soil in close proximity to the Koonap River downstream of the Foxwood Dam site has been confirmed, no detailed planning of the irrigation scheme has been undertaken. It has been confirmed that sufficient irrigable soil is available to accommodate the envisaged development of 1 250 ha under new irrigation, with ample provision for associated roads, buildings and other land uses.

A locality plan of the project area showing the general arrangement of the proposed new water resource infrastructure and the locality of irrigable soil is provided in plan 225739-IRR-0502 (see Appendix A).

The cost of constructing the proposed Foxwood Dam and appurtenant works is estimated to be R2 084 million (including VAT), including the cost of acquiring the necessary land. This includes the estimated cost of a pump station and rising main from the dam to the municipal water treatment works which is estimated to be R8,9 million, all in 2014 Rands. This estimate does not make provision for cost inflation to the end of construction and interest charges on capital during this period.

G1 Constitutional imperatives

G1.1 Constitutional mandate

The constitutional mandate relating to water requires among others, in terms of section 24(b) of the Constitution of the Republic of South Africa of 1996, that the environment (which includes the Koonap River, its tributaries and the other sources thereof (known as water resources)) must be protected for the benefit of the present and future generations. The protection should be afforded through reasonable legislative and other measures that ensure ecologically sustainable development for the use of these water resources, while promoting justifiable and social development.

There is in terms of section 25(4)(a) a commitment from the Nation to bring about equitable access to the water resources. The State may in terms of section 25(8) take legislative and other measures to achieve reform in the access to water in order to redress the results of past racial discrimination.

Further, everyone has in terms of section 27(1)(b) a fundamental right of access to sufficient water. The State must in terms of section 27(2) take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of this right. Giving effect to this right could also give effect to the constitutional rights, that a person has, to respect for his or her dignity as contemplated in section 10 and to the right to life as contemplated in section 11. Effect should be given to this mandate in such a manner that the other fundamental rights are respected, protected and fulfilled. These include for example the right to equal benefit of the law as contemplated in section 9(1) of the Constitution, to the free choice of a trade, occupation or profession as contemplated in section 22 and to not be deprived or expropriated from entitlements to water (except in the manner as set out in the Constitution) as contemplated in section 25.

In terms of section 25(2) of the Constitution land may be expropriated only in terms of law of general application for a public purpose, or in the public interest, and subject to compensation, the amount of which and the time and manner of payment of which have either been agreed to by those affected or approved by a court. Section 25(3) sets out the requirements for the compensation. For this purpose public interest includes, in terms of section 25(4)(a), the nation's commitment to land reform and to reforms to bring about equitable access to all South Africa's natural resources, which includes also the water resources.

G1.2 Co-operative Government

Government is in terms of section 40 constituted as national, provincial and local spheres of government which are distinctive, interdependent and interrelated. All spheres must observe and adhere to the principles of co-operative government and intergovernmental relationship as set out in section 41 and must conduct their activities within the parameters thereof.

All spheres of government and all organs of state within each sphere must in terms of section 41(1):

- preserve the peace, national unity and the indivisibility of the Republic;
- secure the well-being of the people of the Republic;
- provide effective, transparent, accountable and coherent government for the Republic as a whole;
- be loyal to the Constitution, the Republic and its people;
- respect the constitutional status, institutions, powers and functions of government in the other spheres;
- not assume any power or function except those conferred on them in terms of the Constitution;
- exercise their powers and perform their functions in a manner that does not encroach on the geographical, functional or institutional integrity of government in another sphere; and
- co-operate with one another in mutual trust and good faith by:
    - fostering friendly relations;
    - assisting and supporting one another;
    - informing one another of, and consulting one another on, matters of common interest;
    - co-ordinating their actions and legislation with one another;
    - adhering to agreed procedures; and

- avoiding legal proceedings against one another.
- An Act of Parliament must in terms of section 41(2)(a) establish or provide for structures and institutions to promote and facilitate intergovernmental relations.

G1.3 Giving effect to the Constitutional imperatives

It is not only the Department of Water and Sanitation that should be responsible for giving effect to the constitutional mandate relating to water. All three spheres of government, and the appropriated organs of state within these spheres, should be involved, but each only within its specific geographical, functional and institutional integrity. Together they should put in place the necessary strategies, plans and make funds and other resources available to give effect to the successful implementation of the Foxwood Dam and the associated development to achieve the envisaged purpose of the development. The Intergovernmental Relations Framework Act, Act 13 of 2005, was promulgated to assist in this regard.

The NWA gives effect to the legislative measures aspect of the constitutional mandate relating to water, and more specifically the water resource management component thereof. Other measures giving effect to this mandate include, for example, this feasibility study and the construction, operation and maintenance of the proposed Foxwood Dam and associated infrastructure. An important component of these measures are the institutions that would be necessary to give effect to the development proposals, and it might even be that agent(s) and care-taker(s) are appointed to assist with this. It might also be that some institutions required for this purpose must still be established.

Enough water is available at present to give effect to the fundamental right of access to sufficient water for the inhabitants in the town Adelaide. It is for the water services authority concerned (the Amathole District Municipality) and the appropriate water services providers (such as Amatola Water and the Nxuba Local Municipality) to take the necessary measures to ensure the appropriate infrastructure and systems are constructed, operated and maintained to distribute and supply the water to the inhabitants. The proposed Foxwood Dam would provide security to the water supplies for domestic, municipal and other needs in the town Adelaide for a 35 year planning horizon up to 2048.

Regarding the development of the irrigation to address the social and economic imperatives, clear policies and legislation regarding this has not really emerged, although it is receiving attention. The National Department of Agricultural, Forestry and Fisheries (DAFF) and the Eastern Cape Provincial Departments such as Rural Development and Agrarian Reform (RDAR) and Economic Development, Environment Affairs and Tourism (EDEAT) have a direct interest. They should take responsibility for the proposed irrigation scheme, taking into consideration also the principles of co-operative government and intergovernmental relationships. They may assign part of the functions associated with the proposed irrigation development to the Eastern Cape Rural Development Agency (ECRDA), an implementation arm of the RDAR.

G2 Beneficiaries of the works

G2.2 Adelaide town

Water supplies for Adelaide town are at present derived from three sources, namely:

- run-of-river diversions from a weir in the Koonap River which has been in operation for decades;
- supplies pumped from the Great Fish River in emergency circumstances; and
- groundwater from boreholes in the town.

These sources are assessed to be sufficient to meet current and foreseeable water requirements (including the water needed for giving effect to the fundamental constitutional right of “access to sufficient water”) in normal circumstances and when the existing infrastructure is in good working order. However, the reliability of these supplies is not satisfactory for human consumption. The proposed Foxwood Dam would address this reliability challenge.

Demographic and socio-economic assessments indicate that domestic water requirements in Adelaide are unlikely to grow significantly without a new economic stimulus being introduced. There are also no industrial water users in Adelaide and this is unlikely to change without a stimulus. If, however, the socio-economy of the region is stimulated to address the existing depressed conditions, water needs will certainly grow. There is therefore a need to improve the reliability of existing supplies to the town and to augment these supplies to meet any growth in water needs. The proposed Foxwood Dam would assist in this regard. It is, however, important in the public interest that the existing water infrastructure of the town Adelaide is maintained and operated according to acceptable sound and good practices.

The Amathole District Municipality (ADM) is the Water Services Authority (WSA) in the area as contemplated in the Water Services Act, Act 108 of 1996 and Amatola Water is the Water Service Provider (WSP) responsible for operating and maintaining existing bulk water supply systems up to the Water Treatment Works (WTW) in Adelaide. Water is then reticulated in Adelaide town by the Nxuba Local Municipality. The inhabitants of Adelaide will be the main (or only) beneficiaries of water supplies for domestic use from the proposed Foxwood Dam for the foreseeable future.

Recent assessments indicate that the present water supplies in the neighbouring towns of Bedford and Fort Beaufort are adequate for satisfying present and foreseeable domestic, municipal and industrial needs but are not sufficient to support socio-economic growth. It can be expected, however, that these towns would also benefit from a stimulus to socio-economic development in the region being introduced through development of a new secure and substantial water supply from the Koonap River.

G2.3 The water resources of the Koonap River – The Reserve

An important beneficiary of the proposed development of the water resources of the Koonap River are the water resources themselves. While the health of the resource is fully taken into account in planning for development, it is only when a new storage dam begins to function as intended that the riverine ecology becomes a "beneficiary "of the project. The development proposals are formulated on the basis that the Reserve necessary to sustain the riverine ecology and basic human needs along the river as contemplated in section 1(1) 'reserve' of the NWA are satisfied as first priority, together with water for human consumption, before allocations can be contemplated for other economic water use sectors. The Koonap River is found to be in a reasonable to good ecological condition at present and special action must be taken to at least sustain the *status quo*. However, once other abstractions and changed land uses are contemplated, arrangements must be put in place to ensure that the integrity of the resource is sustained.

G2.4 Existing irrigators along the Koonap River

Irrigation has been practiced along the Koonap River from at least the 1960's with most irrigated land being under pastures as the dominant crop in conjunction with dairy farming and stock production. Some irrigators have recently developed permanent fruit tree crops. Existing irrigators abstract water directly from the river with private pumps and without the benefit of significant storage. Only a basic catchment management charge is payable to the DWS and no infrastructure charges are payable. Irrigators pay for their own pumps and balancing dams, including electricity or other fuel costs for pumping and for the operation and maintenance of their own irrigation systems.

Information documented in technical reports on various previous investigations of the potential for water resource development and that are available from the WARMS data base indicate that about 750 ha were irrigated downstream of the Foxwood Dam site and that this area has changed over time. Irrigators have enjoyed sufficient confidence in the availability of water from the river to venture into the irrigation of permanent tree crops. This is not to say that more water is being used for irrigation than before but there is little doubt that much, if not all, of this use has been lawful and will be regarded as 'an existing lawful water use' as contemplated in section 32 of the NWA. These irrigators will probably be licenced to continue this water use in future, with or without a dam at the Foxwood site. They would not be beneficiaries of the dam in respect of this use and cannot expect an increased security of supply. As none of these water entitlements are to be deprived or expropriated, effect is given to section 25 (Property) of the Constitution of 1996.

G2.5 New irrigation development along the Koonap River

The strongest motivation for the development of a dam at the Foxwood site is to stimulate socio-economic development in the region as required in terms of sections 24(b)(iii) and 25(4)(a) and (8) of the Constitution. The availability of secure water supplies would be the long-term stimulus for this development. Development of new irrigation areas - through a new Government Irrigation Scheme - is seen as one of the most important vehicles for giving effect to the constitutional mandate regarding water by addressing important national objectives. These objectives include;

- creation of sustainable work opportunities,
- halting the spread of and alleviating poverty,
- dealing with inequalities,
- stimulating development in depressed rural areas, and
- contributing to agrarian reform.

It has been confirmed that sufficient soil, suitable for successful irrigation of a wide range of crop types, provided that sound farming practices are implemented, is available along the Koonap River downstream of the Foxwood Dam site. The yield of the proposed Foxwood Dam can be used effectively to realize the potential of these soil resources.

Soil and water are necessary but not sufficient to ensure that the production of irrigated crops is successful and sustainable. Willing and competent farmers are essential for sustainable success. And these new farmers will have to be trained and supported with management and other skills, and with finance which is the responsibility of organs of State other than the DWS. This should take place within the framework and principles of co-operative government and intergovernmental relationships.

The new farmers will be beneficiaries of the proposed new dam and, for a long time, will not be able to contribute to the cost of developing the project. However, these farmers are at present not on the land envisaged for new irrigation development and must be identified, selected and trained. There are many possible candidates in the area. While the DWS is responsible for developing the water resources of the Koonap River, the responsibility for mobilizing the other resources mentioned above, namely the soil suitable for irrigation development and the human capital in aspirant emerging farmers, resides elsewhere in government.

Other government entities that have contributed to the development proposals through participation in a Project Steering Committee, in a Stakeholder Forum and in providing expert advice and guidance could assist and take responsibility for the development proposals. These are:

National:
The Department of Environment Affairs
The Department of Agriculture, Forestry and Fisheries
The Department of Rural Development and Land Reform

Eastern Cape Provincial Government:
Office of the Premier
The Eastern Cape Provincial Department of Rural Development and Agrarian Reform

The Eastern Cape Provincial Department of Economic Development, Environment Affairs and Tourism

Local Government:
The Amathole District Municipality
The Nxuba Local Municipality

Regional Authorities:
Amatola Water

It is recognized that the proposal to develop the water resources of the Koonap River at the Foxwood Dam site is in itself not meaningful and sustainable. It is critically important that the agricultural component of the envisaged project is championed by the appropriate national, provincial, regional and local authorities, supported by local non-government and community-based organisations. For this reason an innovative and cross-cutting institutional arrangement for developing the envisaged new Government Irrigation Scheme is called for. The provincial Department of Rural Development and Agrarian Reform has a component called the Eastern Cape Rural Development Agency (ECRDA) set up for the purpose of implementing development projects. The ECRDA could be directed to fulfil the role of Implementing Agent for the envisaged Government Irrigation Scheme. This may require an adjustment to the mandate of the organization and the allocation of funding and other resources necessary for the project, probably from development budgets of National Departments such as DWS and DAFF.

This proposed new irrigation development is in line with the provisions of the NWRS through:

- providing for equity in access to the benefits from water resource use by redressing historical inequalities and increasing participation in the governance and management of water,
- making water available for poverty eradication,
- addressing past racial and gender imbalances in water use, and
- supporting the reduction of poverty and inequity in the country.

The project proposals also respond to local, provincial and planning initiatives and are aligned with land reform and local economic development programmes. It further supports rural development through the multi-purpose use of dams, investment in appropriate water infrastructure, water allocation reform and a programme of support to small-scale water users.

The DWS published a policy on “Financial assistance to resource poor irrigation farmers”. Regulations in terms of section 62 read with section 61 of the NWA was published in General Notice 1036 in *General Gazette* 30427 dated 31 October 2007 to give effect to this policy. The financial assistance in terms of these regulations could help to establish the government irrigation scheme. Certain limitations may apply in terms of the Policy and regulations.

G2.6 Overview

The development of a dam in the Koonap River is proposed as an investment in socio-economic development in rural Eastern Cape where the economy is severely depressed, as required in terms of the Constitution of the Republic of South Africa of 1996. While inhabitants of the nearby Adelaide would benefit from a more secure water supply for domestic purposes, other, less costly options would be their first choice for this purpose. This community could not afford to contribute to the cost of this development. Existing irrigators along the Koonap River get by without a major dam and could not afford to contribute to financing the large investment required for such a dam without a matching benefit. New irrigators, who would be established for socio-economic reasons, would also not be in a position to make a financial contribution to the development cost for a very long time.

The main beneficiary of the development proposals would be the socio-economic development of this portion of the Eastern Cape Province, and therefore all of the people of South Africa. This would be a social development project, the cost of which would be a direct and indirect investment in significantly improving the lives of many people in South Africa. Innovative institutional arrangements will be necessary to bring this multifaceted socio-economic development proposal to fruition and to ensure its sustainability.

G3 Proposed Institutional Arrangements

An important component of the Feasibility Study is to recommend institutional arrangements for developing, owning, operating and maintaining the proposed new water resource infrastructure and the Government Irrigation Scheme described above. While responsibility for owning, constructing and operating new water resource infrastructure can follow existing models, a new model must be sought for the critically important agricultural component.

G3.1 Water resource component

The proposed Foxwood Dam is envisaged to be a multi-purpose project, providing security to water supplies for domestic use, maintaining the Reserve in the Koonap River, supporting existing irrigation practices and, most importantly, providing water supplies for new irrigation undertakings as a stimulus for socio-economic development in an economically depressed rural region of the Eastern Cape.

The direct beneficiaries of water supplies that can be made available from the dam will all be in the immediate vicinity – in this sense the project does not meet the test for being classified as National Water Resource Infrastructure. However, development of the project would be a strategic intervention to stimulate socio-economic development in a rural part of the Eastern Cape. This strategy would serve more than local or regional interests and could be considered to be of national importance.

In the light of the recognition given by Government in the National Development Plan (NDP) to water supply projects as mechanisms for creating employment opportunities and for stimulating and leading socio-economic development, particularly in the rural hinterland, development of the Foxwood Dam could enjoy more than local significance. In view of the relatively high levels of poverty in the Amathole District Municipality, and in the Nxuba Local Municipality in particular, there is a possibility that government would favourably consider making a grant available to finance this project. In this case the DWS would be responsible for owning and for the operation of the dam, at least for a significant time until circumstances in the region change and an alternative responsible authority is able to fulfil these functions.

The Department could be a care-taker for the dam until a suitable institution is indentified or established to assume this responsibility. It could also be that an institution should be established specifically for this purpose, such as a catchment management agency as contemplated in Chapter 7 of the NWA or a water user association as contemplated in Chapter 8 of the NWA. Such an institution could also be a Regional Water Utility as envisaged in the proposed water management policy.

If the institution is a water user association, the members of the association could be all the beneficiaries of the water from the Foxwood Dam (including the existing irrigators), the regulators involved and interested parties. Such an association could address many of the challenges with this project, such as training, transfer of experience and knowledge, and putting effective irrigation practices in place.

In this context it should be noted that about 44% the of population of the District Municipality are unemployed and presumably cannot pay for water.

Although the Foxwood Dam would serve local beneficiaries, albeit in national interest, it will be classified as a Category 3 Large Dam with a Significant Hazard Rating in terms of the Dam Safety Regulations as contemplated in Chapter 12 of the NWA. Dams in this category present a significant dam safety risk and it will be advisable that responsibility for the design and construction of the dam be taken by the DWS, or assigned to another suitably capacitated Implementing Agent. Proper management of the design and construction of the regional water supply scheme will be assured if this component of the scheme is to be funded by a grant from Government.

Should the DWS decide not to manage the design and construction of the dam itself, then Amatola Water (a water board as contemplated in Chapter VI of the Water Services Act, Act 108 of 1997) could be appointed as an Implementing Agent. According to the Water Services Act this is a non-core function of the Water Board. The DWS recognises that existing Water Boards, such as Amatola Water, have an important role to play in providing local infrastructure, be this bulk or distribution infrastructure. Through its Institutional Realignment (IR) Project the DWS is re-assessing the role of current Water Boards to be Regional Water Utilities (RWU) with responsibilities that include, *inter alia*, providing regional water resource infrastructure and regional bulk water supply infrastructure.

Amatola Water would as Implementing Agent construct the works for a fee and would recover the full cost of the works as a stand-alone or ring-fenced project. In other words there would be a requirement for grant funding from national government or a firm repayment agreement according to which Amatola Water could recover the full cost of the works. Such agreements would be independent of the ability of Amatola Water to recover the cost of the works from consumer tariffs as that would not be a requirement in this case.

The financial risk would not be passed onto the Water Board and there would accordingly be no funding or financial advantage in this option. The only advantage of this option would be that a skilled and experienced implementing agent manages the procurement and construction of the works.

G3.2 Government Irrigation Scheme

Development of an Irrigation Scheme by Government has not been undertaken in South Africa for a very long time. The objectives and method of the Scheme that is envisaged to be supplied from the proposed Foxwood Dam in the Koonap River are not very different from those that pertained when the Loskop, the Vaal-Harts and the Rust de Winter irrigation schemes were developed, namely, to provide from a social-economic perspective an opportunity for individuals to gain access to land and to water supplies, with full government support, so as to develop eventually into successful irrigation farmers. However, a big difference lies in the socio-political circumstances that pertained then and the current circumstances now in South Africa. The categories of beneficiaries are also different.

Therefore, although some of the reasons and objectives (as set out in the various Government Policy documents) for this scheme are different from those of the previous schemes, the method of achieving these objectives are similar to the previous schemes, namely developing the water resources by constructing a dam, acquiring the necessary land for irrigation, identify and train the new irrigators and put in measures to ensure long-term sustainability. Further the role-players that should be involved now are also different from the role-players of the previous schemes.

It is envisaged that the DWS would take responsibility for developing the water resources of the Koonap River in accordance with its statutory mandate and that other government entities would, in a cooperative arrangement, implement the development of about 1 250 ha new irrigation along the Koonap River. The necessary licences, authorisations and permissions required by law should be obtained and the activities and tasks should be done within the framework of the law.
While detailed design of the irrigation infrastructure required for the envisaged scheme has not been undertaken, reliable information on the locality of soils suitable for irrigation has been

documented and sufficient planning has been done to formulate a general arrangement for a realistic layout of new irrigation farms on this soil.

This arrangement is based on allotments each having 20 ha of irrigable soil in reasonable proximity to the Koonap River. It is recognized that allotments with new irrigation development ranging from perhaps 2 ha to 50 ha may be desirable. The economic viability of new irrigation development over this range, and for various crop combinations, has been evaluated. An important aspect is that the new farmers to whom these farming units are allotted will, in due course and under very specific conditions, become eligible to take ownership of the properties in which they invested entrepreneurial capital.

The entity responsible for championing and implementing the envisaged Government Irrigation Scheme would have to manage this project from a clean slate and significantly more certainty would need to be determined into the processes to establish the scheme, including at least the following:

- Acquire the land necessary for the new irrigation development from the present private owners, by expropriation or in terms of an appropriate and negotiated cooperative arrangement and probably in phases as the Scheme develops, and make the land available to new aspirant farmers. Acquiring the necessary land is in the public interest as contemplated in section 25(4)(a) of the Constitution of the Republic of South Africa, 1996. The land concerned could be obtained by agreement as well as expropriated in terms of the Expropriation Act, Act 63 of 1975;
- Select and prepare the aspirant farmers to participate in the Scheme;
- Provide the funding necessary to develop, i.e. plan, design and construct the irrigation infrastructure, comprising water abstraction works in the river and on-farm irrigation systems, as well as other facilities such as access roads, fencing, farm structures and communication systems;
- Provide training and ongoing technical and management support to the new farmers;
- Provide operating capital to the farmers for developing and running their farming enterprises, and acquiring plant, equipment and farming requirements;
- Provide project management to direct and oversee the development and operation of the Scheme, including acquisition of water in bulk from the DWS at Foxwood Dam (or at abstraction points in the river downstream of the dam) and the allocation of this water to individual farmers for irrigation of their allotments;
- Arrange for procurement and distribution among the new farmers of machinery, equipment, seeds, plant material, fertilizers, pesticides and other farming requirements;
- Develop and manage crop processing and packing facilities and marketing channels; and
- Identify suitable markets and set-offs for the products cultivated under irrigation.

No arrangements have been made to secure the commitment of any organisations to undertake the responsibilities of an Implementing Agent for the envisaged Government Irrigation Scheme and associated functions as described above. The stakeholder organisations listed in section 11.2.4 above have, however, been consulted in this regard and their guidance and opinions have informed the proposals. Of particular importance in this regard are the following government entities:

- The Eastern Cape Office of the Premier
- The Eastern Cape Provincial Department of Agriculture, Forestry and Fisheries
- The Eastern Cape Provincial Department of Rural Development and Land Reform
- The Eastern Cape Provincial Department of Rural Development and Agrarian Reform

- The Eastern Cape Provincial Department of Economic Development, Environment Affairs and Tourism.

In view of the specific functions to be fulfilled as Implementing Agent for such a long- term and multi-faceted development project, and the diversity of expertise required for the task, it is recommended that the Eastern Cape Department of Rural Development and Agrarian Reform be the lead organization and that the Eastern Cape Rural Development Agency (ECRDA), (see www.ecrda.org.za) be appointed as Project Managers and be provided with the necessary executive authority and resources to carry out this responsibility.

G4 Funding options

G4.1 Water resouce development

In section 11.3.2 above it is recommended that the proposed Foxwood Dam be developed by the DWS as owner and operator (which may be only as a care-taker until an appropriate institution is identified to take this responsibility over), and that the Amatola Water be considered as Implementing Agent of the DWS. This is motivated by the fact that the dam would be a multi-purpose facility serving objectives of socio-economic development that extend beyond the local context. The dam would, in that sense, be viewed as a component of National Water Resource Infrastructure.

Since beneficiaries of water supplies that can be made available from the dam will not for a very long time, if ever, be in a position to make a meaningful contribution to the redemption of the capital cost of the project, this investment would have to be funded through a grant from Government. This funding should be on the budget of the DWS who also becomes owner of the works on behalf of the State.

The total estimated cost of developing the water resources at Foxwood Dam, including all appurtenant works such as road relocations and a bulk water pipeline and pump station for supplying Adelaide but excluding VAT, at 2014 prices is R1 284 million. Implementation of the Foxwood Dam, including procurement processes, detailed design, land acquisition, construction and commissioning will probably take about five years after Environmental Authorization and all other permits and licences are in place. The construction cost, with adjustment for cost inflation from 2014, will have to be funded over that period.

G4.2 Government Irrigation Scheme

Capital for the development of a strategic intervention to stimulate socio-economic development in National interest, as is the envisaged Government Irrigation Scheme, can only be funded by grants from the public sector through National Treasury. Beneficiaries of the scheme will for a long time not be able to make a meaningful contribution to redemption of the capital investment and will for five or six years be dependent on financial support from the government for contributions to operating capital.

The estimated cost of developing new irrigation farming enterprises, with an average irrigation allotment of 20 ha, up to a total scheme with 1 250 ha of irrigated land will be between R400 million and R450 million at 2014 prices. This peak funding includes the acquisition of land for the project, mentoring and training of aspirant farmers, physical development of the farming enterprises, and working capital for the new farmers. This estimated cost will be the peak investment required (at 2014 prices) and will accumulate at a rate depending on the development programme for the project. If the average irrigation allotment is 20 ha then 62 new farmers can be established on the Scheme. It is realistic to expect that, on average, six new farmers can be identified, trained and settled per year once the Scheme has been initiated. Full development can then be expected ten years after the project commences and the last farmer to settle on the Scheme will require funding into his or her fifth year of operation. The funding commitment may thus be required over a period of 15 years or more.

G4.3 Responsibilities in terms of the National Water Act

The National Water Act, Act 36 of 1998, requires, inter alia, that:

- The Minister of Water and Sanitation may in terms of section 109 of the NWA construct, operate and control government water works in order to protect, use and develop the nation's water resources in the public interest. This works may be funded in terms of section 111 of the NWA from funds appropriated by Parliament or obtained from other sources;
- The Minister may in terms of section 112(1) make water available from the works for allocation in accordance with Chapter 4 of the Act (the provisions dealing with 'water use and the authorisation thereof');
- The Minister may in terms of section 112(2) fix a charge for water allocated from a government water work in accordance with Chapter 5 (the provisions dealing with 'water use charges');
- The owner of the proposed Foxwood Dam must obtain water use licences in terms of Section 22(1)(b) of the NWA for the water uses, inter alia, (a) taking of water from a water resource, (b) storing water, (c) impeding or diverting the flow of water in a water course and (i) altering the bed, banks, course and characteristics of a watercourse;
- The Minister must determine a Reserve for the Koonap River in terms of section 16 of the NWA before the water use licences can be issued;
- The owner of the proposed dam must appoint an Approved Professional Person in terms of Chapter 12 of the NWA to take responsibility for the design of the dam and report to the Minister on the safety of the dam; and
- The owner of the proposed dam must register the dam as a dam with a safety risk.

For purposes of addressing the NWA requirements, the owner of the dam must be confirmed early in the implementation process.

The RBIG application also requires the early confirmation of which institution is the owner of the dam.

G4.4 Responsibilities in terms of the National Environmental Managements Act

Chapter 5 of the National Environmental Management Act, Act 107 of 1998, provides for Integrated Environmental Management.

Section 24 of the Act provides that the potential consequences for or impacts on the environment of listed activities or specified activities must be considered, investigated, assessed and reported on by a registered environmental assessment practitioner to the competent authority or the Minister of Environment Affairs.

Section 24 also provides for the Minister to lay down the procedure to be followed for the preparation, evaluation and adoption of prescribed environmental management instruments, including inter alia environmental impact assessments; environmental risk assessments; environmental feasibility assessments; etc.

In essence the Act requires that the owner of a listed activity, which includes an institution which wishes to construct a dam, must undertake an impact assessment of that potential dam in accordance with procedures gazetted by the Minister or MEC and obtain the authorisation of the Minister or MEC as the case may be before proceeding with the construction of that dam.

G5 Assessment and Mitigation of Risks

The major risk is the time that it will take to obtain the various authorisations, to conclude agreements, and to obtain funding. These include:

- Prepare the application and obtain approval for RBIG funding;
- Prepare the application and obtain approval for water storage, abstraction and affecting the river course licences;
- Complete an environmental impact assessment, including public consultation and obtain environmental authorisation;
- Obtain council and board resolutions for the District Municipality and Amatola Water to enter into a WSP agreement and for the water board to partially fund the project, and to negotiate the details of such an agreement.
- Obtain the necessary land for building the dam wall, the basin and appurtenant works.

A mitigating action would be for the District Municipality, Amatola Water and DWS to take a number of binding decisions/resolutions very early on in the process