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The uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water

SUMMARY REPORT

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1 INTRODUCTION

The Department of Water and Sanitation (DWS) undertook the uMkhomazi Water Project (uMWP) Feasibility Study, as part of exploring options to meet the long-term water requirements of the about five million domestic and industrial water users in the eThekwini and Pietermaritzburg regions of KwaZulu-Natal. This area is the economic hub of KwaZulu-Natal, and needs long-term reliable, efficient and sustainable water supplies.

The objective of the study was to undertake a feasibility study to finalise the planning of the proposed uMWP Phase 1 (uMWP-1) at a detailed level. This feasibility study follows on from other investigations into the water resources of the Mgeni Water Supply System (WSS), including the *KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy*, and these are regarded as part of the motivation for the uMWP.

The feasibility study was divided into the following modules, which ran concurrently:

- Module 1: Technical Feasibility Raw Water (DWS) (this water resource study);
- Module 2: Environmental Impact Assessment (DWS); and
- Module 3: Technical Feasibility Potable Water (UW) (ranging from the water treatment works to the tie-in point with the eThekwini pipe distribution system).

2 BACKGROUND TO THE PROJECT

The current water resources of the Mgeni WSS are insufficient to meet the long-term water demands of the system. The Mgeni WSS is the main water source that supplies the municipalities of eThekwini, uMgungundlovu and Msunduzi, all of which comprise the economic powerhouse of the KwaZulu-Natal Province.

There are four major dams in the Mgeni WSS, comprising Nagle, Midmar, Albert Falls and Inanda dams on the uMngeni River. Further it is augmented by the Mooi-Mgeni Transfer Scheme (MMTS), comprising of the Mearns Weir and Spring Grove Dam, both on the Mooi River. The current resources of the system will not be sufficient to meet the long-term requirements of the system.

Previous investigations indicated that the development of the undeveloped uMkhomazi River, the third-largest river in KwaZulu-Natal in terms of mean annual runoff (MAR), to transfer water to the existing Mgeni WSS, most likely will fulfil this requirement.

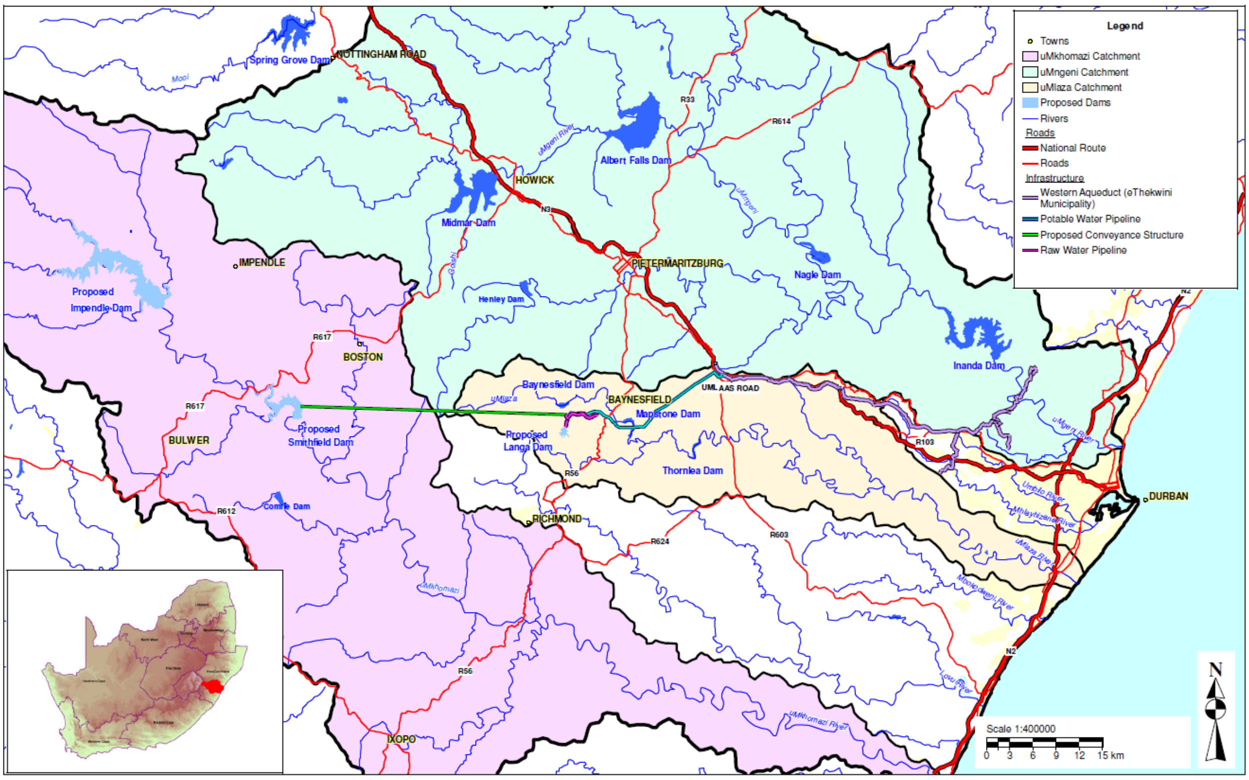

Figure 1: Locality map: study area of the uMWP

The project area is defined as the uMWP-1 infrastructure, shown on **Figure 1**, stretching from the uMkhomazi River to the uMngeni River catchment.

3 NEED FOR AUGMENTATION FOR THE MGENI WATER SUPPLY SYSTEM

The cities of eThekwini and Msunduzi are the two largest in the province of KwaZulu-Natal, the former begin a major port and the latter the current administrative capital, about 90 km inland. Urban and industrial development in this area is extensive and has a major impact on water demand. Surrounding areas (north and south coast) are also developing at a significant rate and require water for sustainable growth. A shortage of water in the region will be a limitation on economic growth.

The principal source of water supply for the region is the uMngeni River, rising in the lower foothills of the Drakensberg at an altitude of 1 500 m. There are currently four storage reservoirs on the uMngeni River namely Midmar, Albert Falls, Nagle and Inanda dams, with a stochastic yield of 334 million m³/annum (measured at Inanda Dam) at a 99% assurance of supply. The Mgeni WSS is augmented by 60 million m³/year (at a 99% assurance of supply) through the MMTS (a combination of Spring Grove Dam and Mearns Weir).

Figure 3.1 shows the uMngeni River Catchment, surrounding catchments and the locality of all the dams.

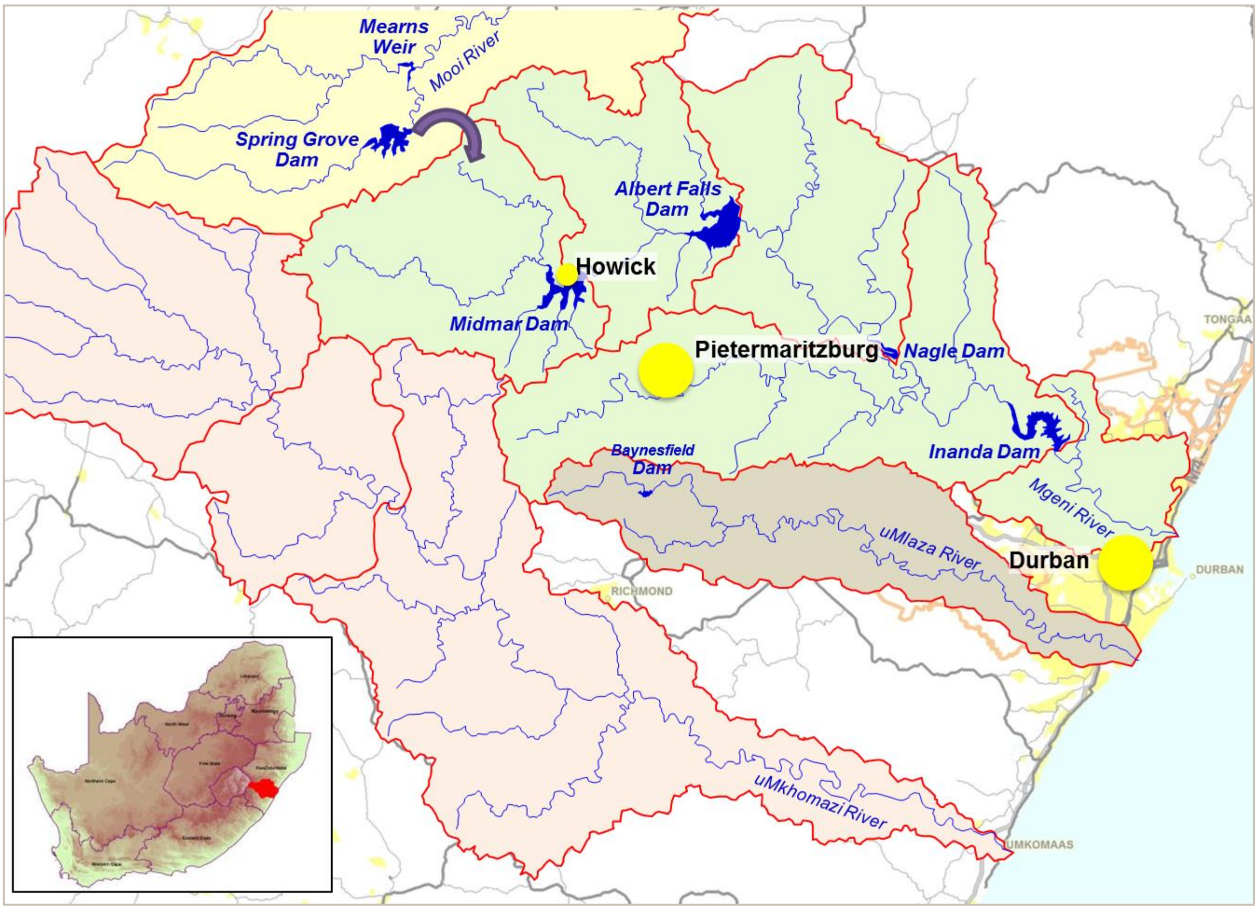

Figure 3.1: Locality of uMngeni and uMkhomazi River Catchments

3.1 FUTURE WATER REQUIREMENTS AND WATER BALANCE OF THE MGENI WSS

Figure 3.2 shows the updated water requirement projections (represented by the purple line) for the Mgeni WSS, including the expanded supply area along the North and South Coast, growing from the current (2013) 398 million m^3/a to about 480 million m^3/a in 2023 and 612 million m^3/a in 2040. The actual total historical water use in the system, from 2004 to 2012 is shown by the green line.

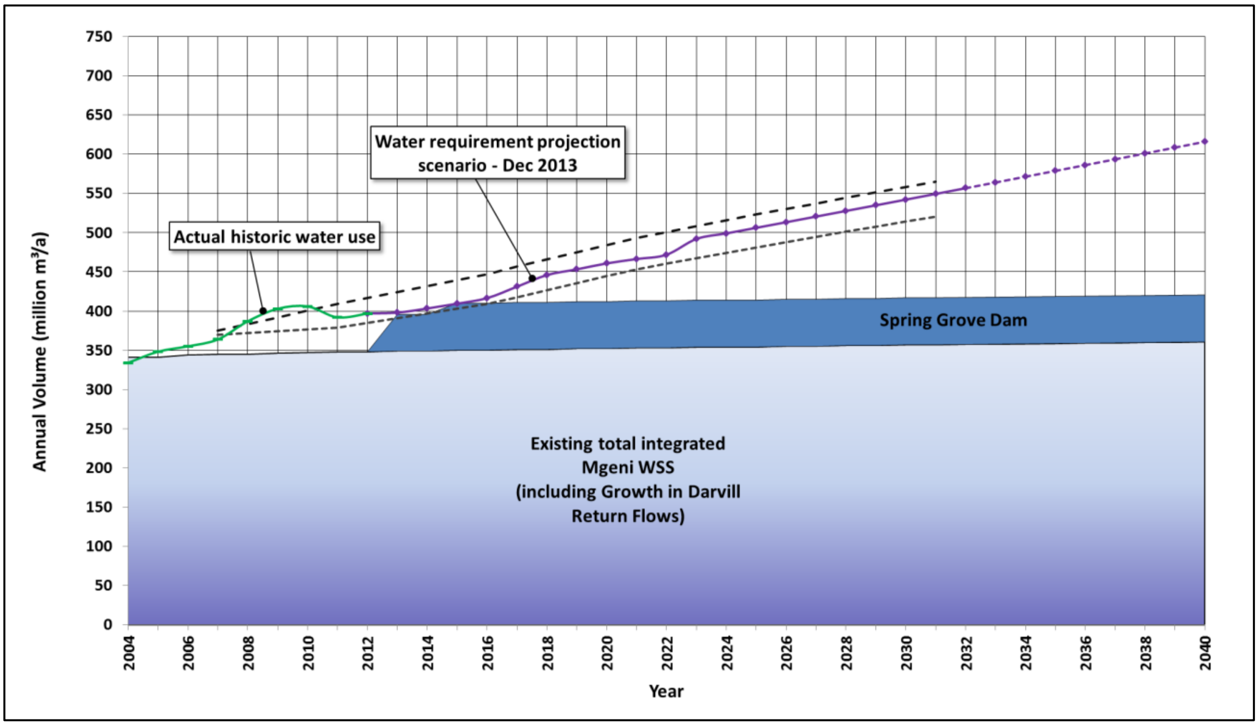

Figure 3.2: Long-term balance between available yield and water requirements for the integrated Mgeni WSS, also showing the completed Spring Grove Dam

Water balances for the resources and water requirements for the integrated Mgeni WSS have been developed as part of the ongoing DWS planning process contained in the *Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas*. **Figure 3.2** shows the yield of the **existing integrated Mgeni WSS**, including MMTS-1 and projected growth in Darvill return flows (shaded in a gradient of purple), and the incremental yield of the **Spring Grove Dam** (shaded in dark blue).

The water balance indicates that the current Mooi-Mgeni WSS is able to assure water supply at acceptable levels of risk to ***2016***. Thus, the water resources to supply this region are under stress and urgent augmentation is required.

3.2 Options to Augment the Mgeni WSS

Pre-feasibility investigations, undertaken by the DWS in 1998 and confirmed with the KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy, indicated that the uMWP, which entails the transfer of water from the uMkhomazi River (a combination of dams at Smithfield and Impendle) to the Mgeni WSS, is the scheme most likely to fulfil this requirement.

Other augmentation options, such as Water Conservation Demand Management (WCDM), re-use and desalination, were also investigated. However, it was confirmed during the *KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy* that these options would not be viable long-term alternatives for the uMWP, either due to cost, insufficient quantity or technical difficulties.

Due to the location and the design of a gravity system, the uMWP is the only augmentation option that will supply water in gravitation, using almost no energy. Implementation of two hydropower plants should be considered for development as part of the system.

4 DESCRIPTION OF UMKHOMAZI RIVER CATCHMENT

As described in previous sections, the proposed uMWP is the most attractive next long-term option to meet the growing water requirements of the Mgeni WSS. As such the water resources of the uMkhomazi River catchment were further assessed and details are provided in this section.

The uMkhomazi River catchment is situated in the Mvoti to uMzimkulu Water Management Area (WMA) and has a catchment area of 4 387 km². The hydrological characteristics of the catchment are summarised in **Figure 4.1**. The total natural mean annual natural runoff (MAR) of the catchment is 1 078 million m³/a, with 571 million m³/a (or 53%) generated upstream of the proposed Impendle Dam site and a further 151 million m³/a (14%) upstream of the Smithfield Dam site.

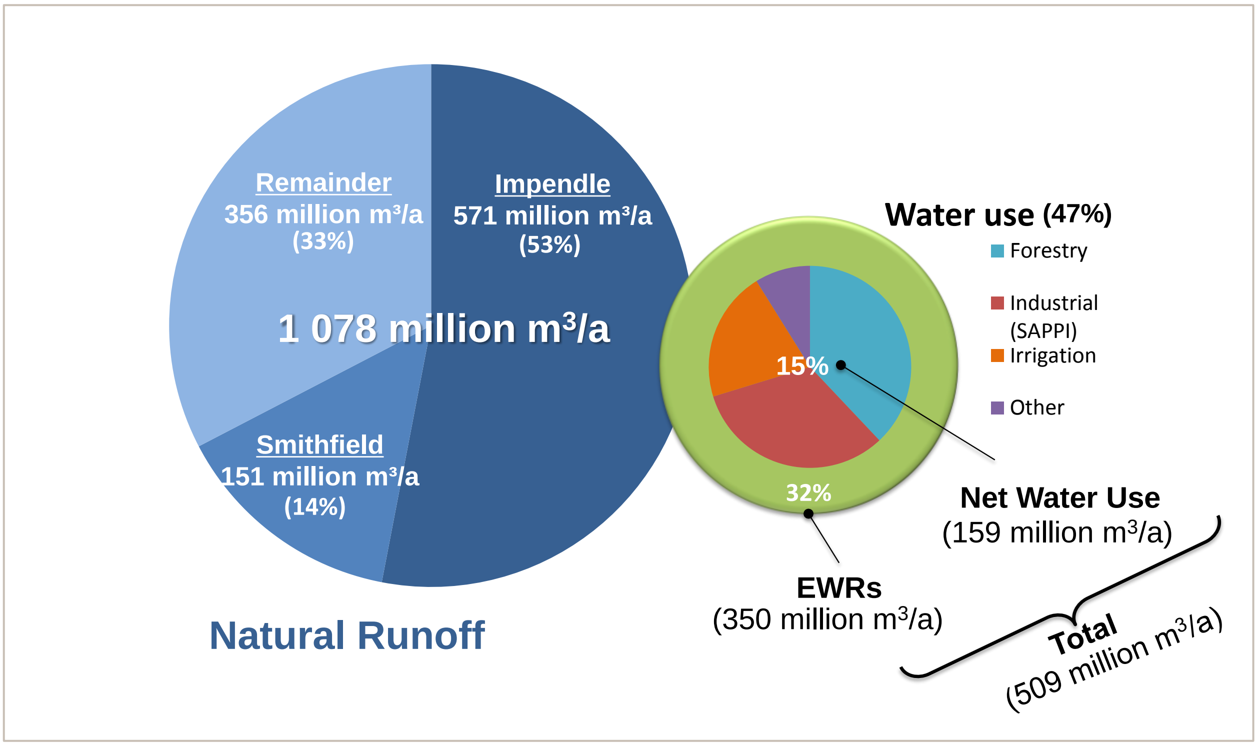

Figure 4.1: Summary of the hydrology and water use in the uMkhomazi River catchment (2012-development levels)

Figure 4.1 also shows net water use in the catchment, totalling 159 million m³/a at the 2012-development level. This is projected to increase to over 190 million m³/a by 2050. The uMkhomazi River catchment is fairly undeveloped, with the notable exception of large tracts of commercial forestry and irrigated areas in the central catchment areas around the towns of Richmond, Ixopo, Bulwer and Impendle.

The largest single water user in the catchment is the SAPPI-SAICCOR mill located near the coastal town of Umkomaas. SAPPI-SAICCOR is licensed to abstract a total volume of 53.0 million m³/a directly from the uMkhomazi River. However, due to a lack of storage SAPPI-SAICCOR's current assurance of supply is very low. They experience shortfalls almost on an annual basis – mostly during the winter (low-flow periods).

An additional 350 million m³/a (32% of the natural MAR) is allocated for supplying Ecological Water Requirements[1] (EWRs) and sustaining the system's riverine health at a desirable level after the implementation of uMWP. It should be noted that updated EWR results from the later *Classification Study*[2] by DWS were only published after the water resources modelling for this study had been completed and are therefore not reflected in the results presented in this report.

Figure 4.2 shows the 1:100 year stochastic yield for a range of dam sizes at Smithfield (in **green**). From the optimisation studies of the uMWP undertaken in this feasibility study, a full supply level (FSL) of 930 masl was selected for the feasibility design of Smithfield Dam. This dam size corresponds to a live storage capacity of 226 million m³ (a 31% MAR dam) and provides a 1:100 year yield (i.e. at an annual assurance of supply of 99%) of 220 million m³/a, at the 2050 development level.

The yield for the uMWP was modelled for various catchment development, EWR and sedimentation scenarios. The results show that the impact on the 1:100-year yield of Smithfield Dam of projected sediment deposition and growth in upstream catchment developments from 2020 to 2050 is 17 million m³/a (a decrease of 7%). Furthermore,

[1] *From the Mkomazi IFR Study (DWA & Umgeni Water, 1998).*

[2] *Classification of Water Resources and Determination of the Comprehensive Reserve and Resources Quality Objectives in the Mvoti to Umzimkulu Water Management Area ("Classification Study") commissioned by the (then) DWA Directorate: Resource Directed Measures. Importantly, while updated EWR results from the Classification Study could not be used in this study, they were found to differ significantly from those published in the earlier Mkomazi IFR Study. The most significant differences include the following:*

- *Since EWR Site 1 is situated upstream of the proposed Smithfield Dam it was not included in any of the operational scenarios undertaken for the Classification Study.*
- *In the case of EWR Site 2, which is located downstream of the Smithfield Dam site, the final average EWR from the Classification Study is given as 315 million m³/a, or 35% of the natural MAR. This is 89 million m³/a higher (almost 40%) compared to the EWR 2 of 226 million m³/a used in this study.*

support from the dam for downstream EWRs[3] results in a decrease in yield from 336 million m³/a to 220 million m³/a (a decrease of 34%).

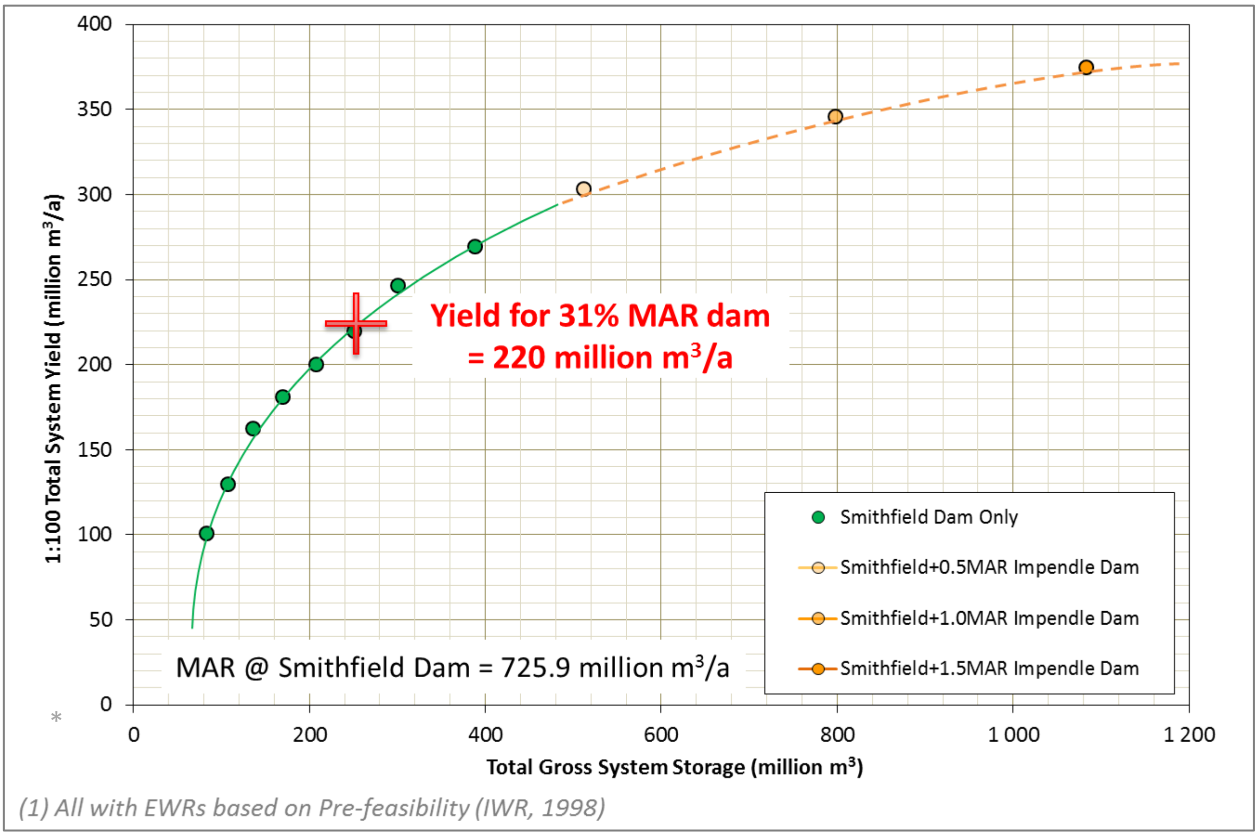

Figure 4.2: 1:100 year stochastic yield for Smithfield and Impendle Dams for the projected 2038 water use in the uMkhomazi River catchment

An assessment of the total yield for both phases of the uMWP, including a future Impendle Dam of either 0.5, 1.0 or 1.5 times the MAR, is also shown in **Figure 4.2** (in **orange**). The combined yield curve evens out with a larger storage at Impendle. This suggests that a combination of Smithfield Dam with a 1.0 MAR Impendle Dam will probably provide close to the optimum system size, and will increase the total yield of the scheme from 220 million m³/a to almost 350 million m³/a (an increase of 60%). However, the optimum size of the Impendle Dam needs to be confirmed in future studies.

[3] As discussed earlier, updated EWR results from the parallel Classification Study were not used in this study's water resources analyses. Although subsequent analysis to assess the possible impact of these differences on the yield of Smithfield Dam were later undertaken. In summary the results show that if the Classification Study EWR2 is implemented instead of EWR1b from the Feasibility Study, the 1:100-year yield of the dam will decrease by approximately 5 million m³/a (a decrease of 2%).

5 DETAILS OF THE PROPOSED DEVELOPMENT

As defined and detailed in the Technical Feasibility Study, the proposed layout for uMWP-1, as shown in **Figure 5.1**, comprise the following components:

- A new dam at Smithfield on the uMkhomazi River;
- Conveyance infrastructure (tunnel and pipeline) to the water treatment works (WTW) in the uMlaza River valley, including a balancing dam; and
- A WTW in the uMlaza River valley, followed by a gravity pipeline to the UW bulk distribution system, connecting in the area of the Umlaas Road reservoir. From Umlaas Road, water will be distributed under gravity through existing infrastructure to eThekwini. (The potable water infrastructure forms part of Module 3 of the Feasibility Study and is not addressed further in this document.)

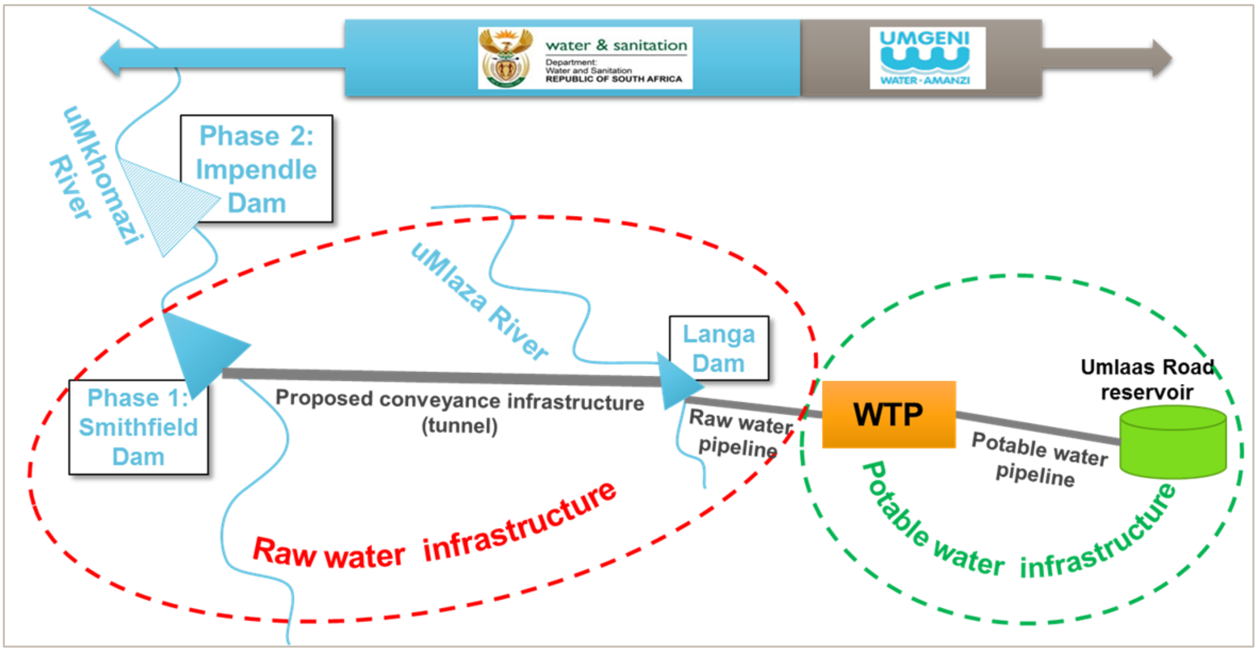

Figure 5.1: Schematic layout of the raw and potable water infrastructure of the uMWP

Phase two of the uMWP is scheduled for commissioning in 2043. It will comprise the construction of a second large dam at Impendle further upstream on the uMkhomazi River to release water to the downstream Smithfield Dam, and will also provide for an additional transfer tunnel from Smithfield Dam to the uMlaza River.

5.1 SMITHFIELD DAM

The proposed dam to be constructed on the uMkhomazi River at the farm Smithfield is situated about 35 km north-west of Richmond and about 6 km south-east of where the

R617 Road crosses the uMkhomazi River. ***A name for the dam has not yet been decided upon, although it is referred to as Smithfield Dam***.

Various positions for the proposed Smithfield Dam were considered and the lowest cost option at site B (the pre-feasibility study site) was selected, which also conforms to the requirement of the transfer of water through a pressure tunnel and pipeline. The dam type and position was not only guided by the best dam site, but also by the operating levels required for a gravity scheme, all the way to Umlaas Road.

A detailed dam type selection analysis, considering cost, spoil of construction materials, time to construct and other aspects indicated that the preferred layout for Smithfield Dam is an 81 m high zoned earth core rockfill dam, with a 26 m high earthfill saddle embankment. The geotechnical investigation identified three earthfill borrow areas.

The following components of the proposed Smithfield Dam and appurtenant structures will be implemented:

- An 81 m high earth core rockfill dam (main dam) constructed with a residual dolerite earthfill core, dolerite rockfill outer zones and an inner shale rockfill zone;
- A primary side channel spillway with a gravity weir structure, chute and ski jump structure;
- A bottom outlet with a permanent double pipe multi-draw off in an intake structure connected to a pipe in one of the two 8 m diameter tunnels (used initially for river diversion). An access bridge from the main dam crest to the Intake Tower will be provided. The Intake Tower will be designed for both uMWP phases.
- A zoned earthfill embankment saddle dam of 26 m high.
- A secondary fuse plug spillway.
- Material to be obtained from the excavations, as well as specific quarries.
- Access roads for construction and operations.
- Deviation of the R617 road necessitated by flooding of the dam basin, and new access roads to communities that will be cut-off by the impounded reservoir.
- Provision to support the Eskom high voltage power line across the new reservoir.
- River diversion using two 8 m diameter tunnels and an array of six cofferdams to accommodate construction during varying flooding conditions of the mighty uMkhomazi River.

Table 5.1: Smithfield Dam characteristics

Parameter	Description
General	
Name	Smithfield Dam

Parameter	Description	
General		
Purpose	Bulk water supply for domestic and industrial use	
River	uMkhomazi River	
Nearest town	Richmond	
District	KwaZulu-Natal	
Location	29°46'33.36" S; 29°56'26.62" E	
Classification: Category	III	
Hazard potential	High	
Non-overspill crest level	RL 936 masl	
Full supply level (FSL)	RL 930 m	
Gross storage capacity at FSL	251 million m^3	
Water surface area at FSL	9.53 km^2	
	Main wall	**Saddle wall**
Wall height above river level (Maximum height)	81 m (855 masl to 936 masl)	26 m (910 masl to 936 masl)
Type of dam wall	Earth core rockfill	Zoned earth fill
Crest length	1 200 m	1 090 m
Spillway type	Side channel with ogee weir, chute and ski jump	Fuse plug with gravel and sand, controlled by a concrete sill which acts as a broad crested weir when breached
Spillway length	150 m	100 m
Freeboard	6 m	2 m
Hydrology and floods		
Catchment area	2 058 km^2	
Safety evaluation flood (RMF+Δ)	5 650 m^3/s	
Regional maximum flood	4 540 m^3/s	
$Q_{1:200}$	2 620 m^3/s	
$Q_{1:100}$	2 389 m^3/s	
Outlet works		
Dam Outlet	Dual pipe system of ND 1.8 m, six intakes, Butterfly and gate valves	
Tunnel Inlet	Tri pipe system of ND 2 m, six intakes, Butterfly and gate valves	
Foundations		
Description of dam wall foundations	The site comprises shales with sub-ordinate sandstones and intrusions of dolerite. Three near-horizontal dolerite sills have intruded mainly concordantly into the sedimentary strata and are responsible for the narrow river valley at the dam site and the presence of good quality dolerite rock for concrete aggregate and rockfill at depth.	

An artistic impression of the proposed Smithfield Dam is shown in **Figure 5.2**.

Figure 5.2: Artist's impression of the completed Smithfield Dam

5.2 CONVEYANCE INFRASTRUCTURE

In transferring water from the proposed Smithfield Dam on the uMkhomazi River to the uMngeni River catchment, the scheme crosses the uMlaza River valley. The proposed conveyance infrastructure consists of a pressure tunnel, a raw water pipeline to a WTW and a gravity potable water pipeline (the WTW and potable water pipeline is not further discussed in this study).

5.2.1 uMkhomazi-uMlaza Tunnel

The transfer tunnel extends from the left side of Smithfield Dam Reservoir to the upper reaches of the Langa Dam in the Mbangweni River. The shortest route through the mountain range between the two valleys was identified based on an economic comparison analysis between pumping schemes and the selected gravity conveyance system, shown in **Figure 5.3**.

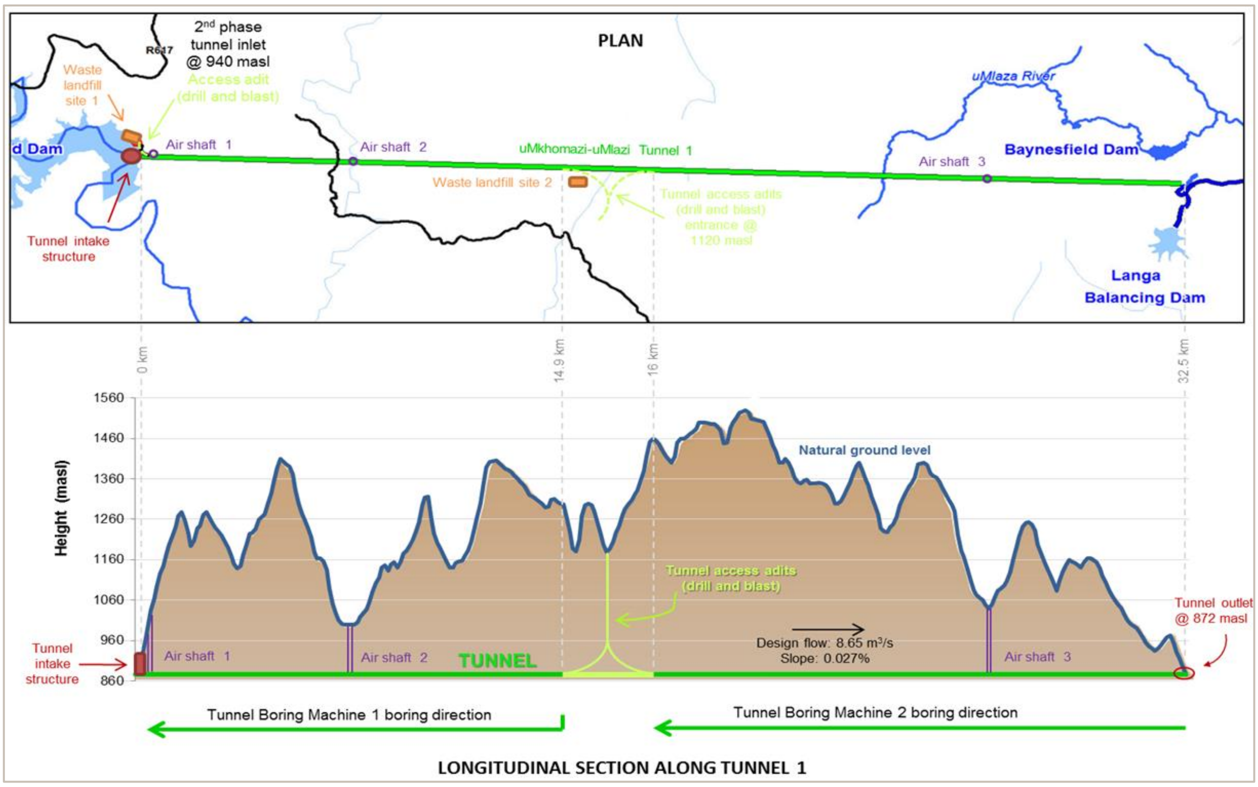

Figure 5.3: uMkhomazi-uMlaza tunnel plan and longitudinal alignment

The tunnel is 32.5 km long and the selected optimum inside diameter for a discharge at peak demand of 8.65 m^3/s is 3.5 m diameter. This pressure tunnel has to be driven through hard quality shales and dolerites (the latter about 40% of the distance) and is connected with a pressure pipeline from the tunnel end to the site of the Baynesfield WTW. This system is sized to accommodate design flows with Smithfield Dam at the minimum operating level (MOL).

Based on lower cost and limiting the critical construction path of the project, the tunnel was designed for two Tunnel Boring Machines (TBMs). The tunnel was laid out with a slope towards the east and the TBMs have to bore in the upstream direction (west), accommodating encountered ground water in gravity flow requirements. The tunnel was designed for drainage during construction as seepage from groundwater is expected. Some parts of the tunnel, e.g. a central access adit with a 5 m diameter, are to be excavated using drill and blast techniques (DBT).

Based on cost considerations and to ensure stable rock portals the inlet and outlet portals of the tunnel are to be formed through excavation of weathered rock materials. These excavated materials will be available for construction purposes.

Air entrainment of the tunnels to accommodate flowing water will be facilitated through two shafts, a central access adit and a shaft and pipe through the intake structure. The central 5 m diameter adit is also necessary for construction and later maintenance purposes.

The second phase of the project, to be implemented at a later date, involves the construction of a similar tunnel which is to be built alongside this tunnel discussed above. The first 100 m of the second tunnel will be excavated during the construction of the first tunnel. Thus, an additional excavation will take place at the inlet and this excavation will be done using DBT. The inlet of the second tunnel will be at an elevation of 940 masl.

5.2.2 Raw water pipeline

The pressure pipeline from the tunnel outlet to the WTW, as shown in **Figure 5.4**, has an internal diameter of 2.6 m and also connects to the Langa Dam with a 1.6 m diameter pipeline.

Figure 5.4: Raw water pipeline route

The maximum flow velocity in the pipeline, from the tunnel to the WTW, is 1.63 m/s with a thickness of roughly 22.5 mm to accommodate water hammer as well as the potential hydropower. A total of 20 high points for air valves and 27 low points for scours were identified along the proposed route. The total length of the raw water pipeline to the WTW is about 5.2 km.

The 1.6 m diameter pipeline that will supply raw water to the balancing dam and the take-off is about 1.3 km downstream of Langa Dam. During maintenance periods of the tunnel, the stored water in Langa Dam will be supplied via this pipeline under gravity to the WTW, at a flow rate of 8.65 m^3/s, for the duration of the maintenance period or until the dam is empty.

Bedding materials for laying the pipeline would probably be imported from commercial sources, although it is advised to consider using some of the tunnel spoils, where appropriate.

A stilling basin (or possible hydropower plant), with a tailrace water level of 872 masl, is provided at the end of the pipeline for dissipating the energy of the water from the Smithfield Dam before it is routed through the water treatment works. This is required to provide water under gravitation to the Umlaas Road Pipeline.

5.3 LANGA DAM

The Langa Dam site is located in the uMlaza Catchment on the Mbangweni River at the downstream end of the tunnel outlet portal on the farm Nooitgedacht 903. This dam is required for storing water to supply Umgeni Water (UW) during emergency and maintenance periods of the tunnel. It is connected through the raw water pipeline to the tunnel and WTW. ***A name for the dam has not yet been decided upon, although it is referred to as Langa Dam***[4].

The Langa Dam site was selected based on the tunnel alignment, together with the storage requirements, shown in **Figure 5.5**. A dam at the FSL of 923 masl has a gross capacity of 15.7 million m^3 that can supply the uMWP-1 for 23 days at the maximum supply rate of the conveyance system. Langa Dam together with the existing Mgeni WSS can provide two months' storage of the maximum demand to maintain the tunnel.

A dam type selection study indicated a Concrete Face Rockfill Dam (CFRD) to be the optimum cost dam type. The rockfill will consist of shales from the reservoir (dam basin) of the dam. Finer bored rockfill from the tunnel will be used on its downstream toe section and the rest of the excavations from the outlet portal will be accommodated in a berm on the downstream side of the dam. A dolerite rockfill layer will be used as protection of the shale rockfill on the downstream face.

[4] Standing policy dictates that a new dam be identified by the farm name on the right flank of the dam wall, in this case Nooitgedacht. However, since the name Nooitgedacht is already allocated to an existing dam, the balancing dam is uniquely referred to as Langa Dam, the name of a nearby hill, as was concluded during the 5th PMC.

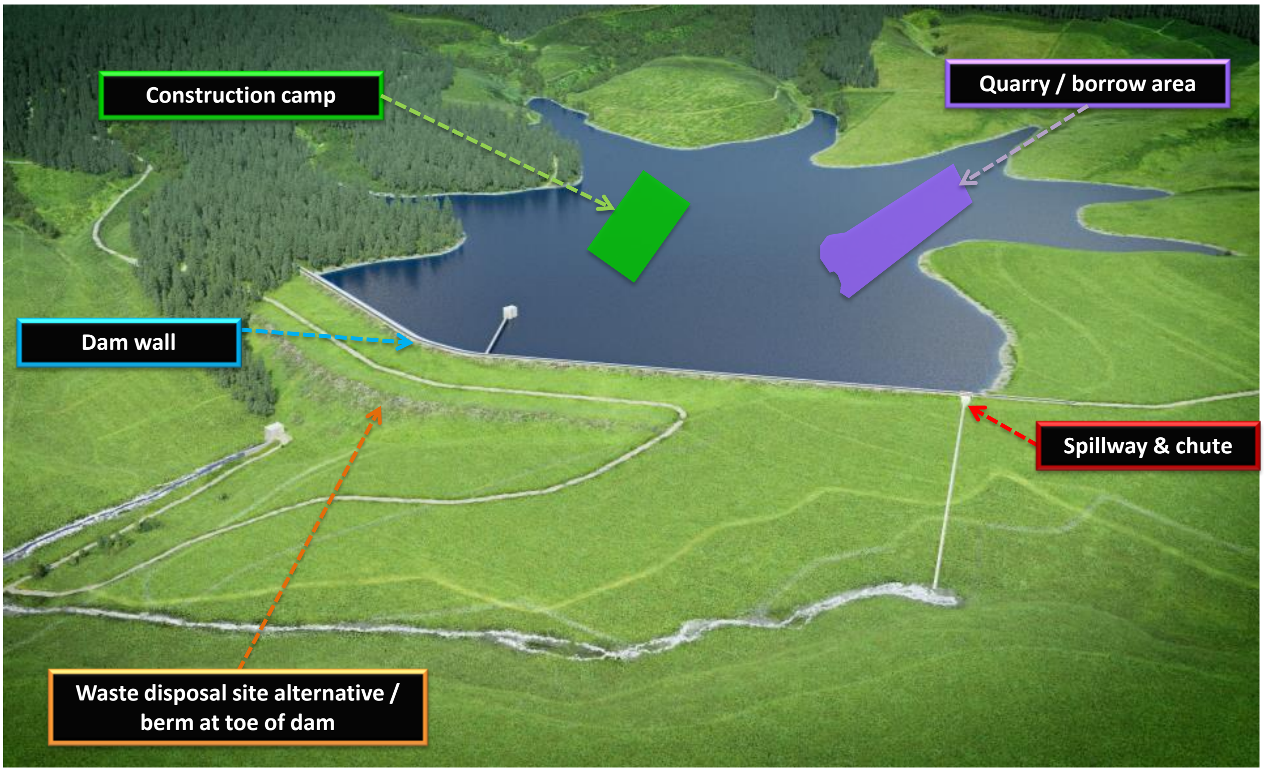

Figure 5.5: Schematic layout of the proposed Langa Dam in the Mbangweni River

Furthermore, a side spillway on the left flank would ensure that the dam cannot be overtopped during flood events. A single level draw-off but double pipe intake system in an intake tower and bottom outlet would facilitate water to fill the dam from Smithfield Dam under gravitation, to release the required reserve water to accommodate wetlands and to release water for supply when required.

Table 5.2: Langa Dam characteristics

Parameter	Description
Name	Langa Dam
Purpose	Balancing dam to provide water during tunnel maintenance of emergencies
Type of dam	Concrete Faced Rockfill Dam (CFRD)
River	Mbangweni River, a tributary of the uMlaza River
Nearest town	Richmond
District	KwaZulu-Natal
Location	29° 47' 17.75"S, 30° 18' 01.80"E
Catchment area	5.34 km^2
Recommended design flood (RDF)	1:200 year
Peak inflow of the 1:200 year flood	204 m^3/s
Regional maximum flood (RMF)	283 m^3/s

Parameter	Description
Safety evaluation flood (SEF)	313 m^3/s
Full supply level (FSL)	923.0 masl
Maximum wall height of the embankment	46.60 m
Maximum wall width of the embankment	202.72 m
Minimum operating level (MOL)	898.2 masl
Non overspill crest level (NOC)	926.6 masl
Area at full supply level	95.48 ha
Total length of the dam wall	573 m
Embankment crest width	7 m
Proposed upstream and downstream slopes of the rockfill embankment	1V:2H and 1V:2.2H.
Gross storage volume at FSL, including additional storage created by the quarry	15.67 million m^3
Live storage volume at FSL, including additional storage created by the quarry	14.82 million m^3
Estimated sediment volume after 50 years	0.21 million m^3
Mean annual runoff (MAR)	2.03 million m^3/a
Time of supply at 7.10 m^3/s	24 days

From an environmental point of view, the proposed dolerite downstream protection layer for the embankment, shown in **Figure 5.5**, may not be acceptable, and vegetation on the downstream slope of the embankment may be considered during detail design.

In accordance with the water yield analysis, the following operating rule was developed for the operation of Langa Dam:

- Langa Dam shall be filled and topped up from Smithfield Dam, preferably when Smithfield Dam is spilling;
- Langa Dam shall release water for EWR between the dam and the new Mbangweni Dam; and
- Langa Dam shall provide water to the Baynesfield WTW through the raw water pipeline during maintenance and repair periods of the tunnel.

5.4 Associated Infrastructure

For a mega project such as the uMWP, several other related infrastructure components will need to be developed, either as an integral part of the infrastructure required or due to the impact of the project on existing infrastructure. This includes but is not limited to gauging weirs, roads and the possibility of hydropower generation.

5.4.1 Gauging weirs

Three gauging weirs are required to measure river flows at the following positions, as shown on **Figure 5.6**:

- Weir 1: Downstream of Impendle Dam (location: 29°39'8.92"S; 29°46'29.65"E) to measure inflow to Smithfield dam,
- Weir 2: Downstream of Smithfield Dam (location: 29°46'53.09"S; 29°55'52.70"E) to determine the discharges from Smithfield dam required for the dam balance, and
- Weir 3: Further downstream of Smithfield dam (location: 29°55'12.31"S; 30° 5'14.26"E) to determine the run-off from the incremental catchment downstream of Smithfield Dam to assist with the operation of the ecological water requirement.

Figure 5.6: Positions of the proposed uMWP gauging weirs

The three gauging weirs were designed as Crump weirs to accommodate monitoring of 80% of the flows.

5.4.2 Roads infrastructure

The R617, a public road between Pietermaritzburg/Howick and Underberg, will be inundated by the new proposed Smithfield reservoir and should be deviated. This is a major project that will impact the traffic flow towards Underberg.

Furthermore, the following access roads to the project components are needed during and after construction, and also to provide access for communities that will be cut-off due to the inundation of the dam:

- Access road to Nonguqa;
- Access road to tunnel inlet portal;
- Access road to dam wall;
- Access road to ventilation/air shafts and centre tunnel adit entry;
- Access road to tunnel outlet portal and Langa Dam;
- Access road to Water Treatment Works (WTW); and
- Access roads to gauging weirs.

Figure 5.7 shows the deviation of R617, and the access roads around Smithfield Dam.

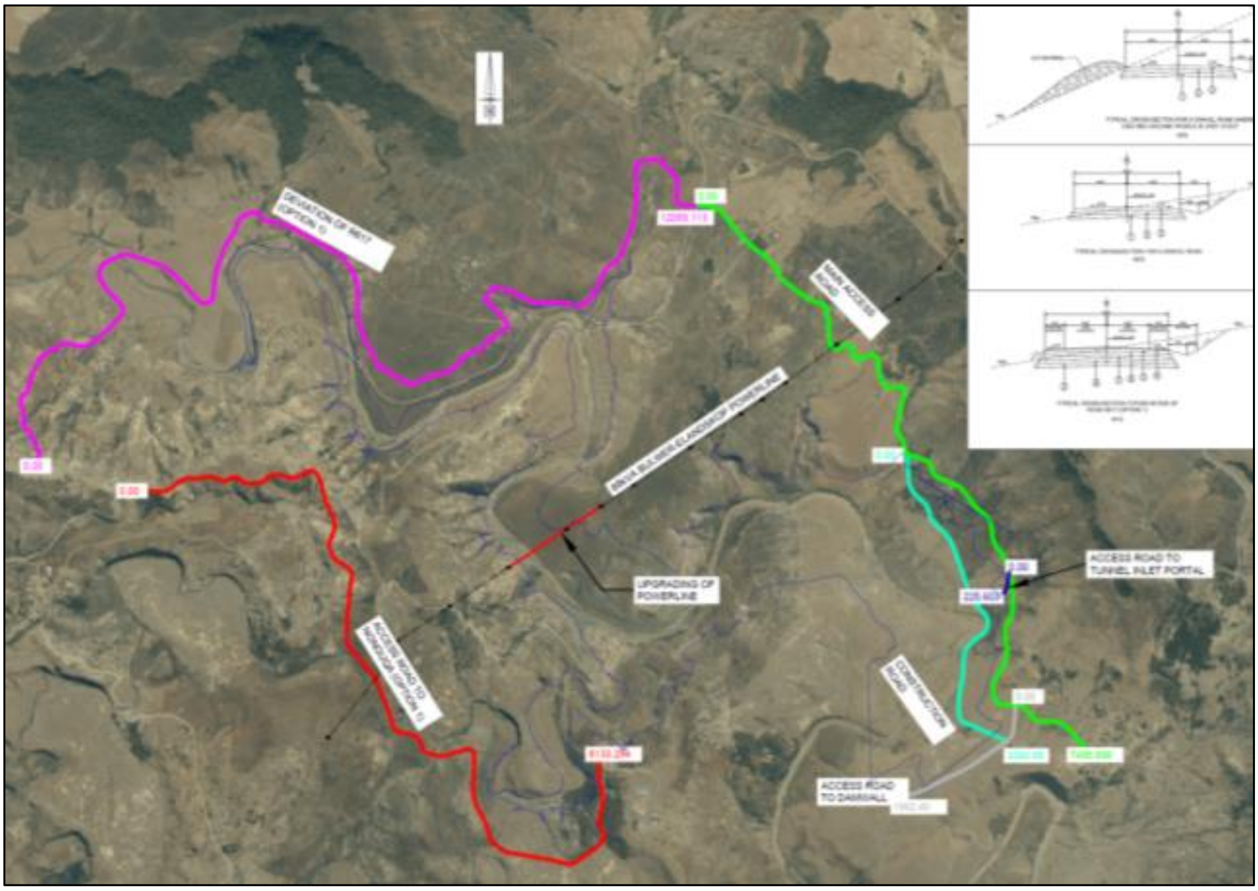

Figure 5.7: Deviation of roads surrounding Smithfield Dam

5.4.3 Waste disposal sites

The tunnel muck and excavated material, mostly from the tunnel construction, will be disposed at two waste disposal sites, one near the tunnel inlet portal and one midway along the tunnel length near the central tunnel access adits, and material from the downstream outlet portal will be used for the construction of Langa Dam. The waste disposal sites will only be operational for the construction period of uMWP-1 and will be rehabilitated afterwards.

5.4.4 Hydropower assessment

A pre-feasibility viability assessment of hydropower generation as a secondary, but potential major benefit to the uMWP-1 was undertaken at the entrance to the Baynesfield WTW, and on the outlet works of Smithfield Dam. The proposed Baynesfield HPP was conceptually designed for a flow rate of 8.65 m^3/s flow and 41.7 m net head, which has the potential of 3 MW power. The Smithfield Dam HPP was conceptually designed for a potential of 2.6 MW for a flow rate of 5.0 m^3/s flow and 64.0 m net head.

Although the hydropower options are feasible, the development of HPPs is not within the mandate of the DWS, as the National Water Act (NWA) of 1998 and subsequent amendments are silent on the topic. Therefore, the DWS should confirm their involvement in the development of hydropower, or identify other entities, such as UW, a municipality or private company, that would be interested in developing the hydropower scheme in a renewable energy program for small hydropower schemes.

5.5 Possible water supply from Smithfield Dam to surrounding communities

The Smithfield Dam site is located within the Water Services Authority (WSA) Harry Gwala District Municipality's (DM) area of jurisdiction, that is supplied by the Bulwer Donnybrook Water Supply Scheme (WSS), including the towns of Bulwer, Donnybrook, Creighton and Ixopo and surrounding communities. Currently there are no communities that will be inundated by the proposed dam, only a few scattered households. However, while such a large water resource development is taken place in the area, cognisance must be taken of sustainable and cost effective supply to the local communities. A pre-feasibility-level study was carried out to ascertain the following:

- the current water sources being used by the communities surrounding the dam,
- the possibility of feasibly supplying these communities with water, either from existing Harry Gwala DMs resources or from Smithfield Dam in the future.

The current (2015) estimated combined water requirement of communities within the Bulwer Donnybrook WSS was in the order of **3.45 million m³/a,** which will grow to an ultimate future water requirement of **4.13 million m³/a** in 2045.

The current and planned resources (including the under construction Bulwer Dam Scheme) of the Bulwer Donnybrook WSS will not be able to supply the water requirements in the long-term, and Smithfield Dam was recognised as a future intervention. Also, the Harry Gwala DM has an agreement in place with Sappi-Saicor to use water for a period of 10 years from the Comrie Dam.

From the several options investigated to supply water to the Bulwer Donnybrook WSS from either/or Smithfield and Comrie dams, the raising of Comrie Dam to augment the Bulwer Donnybrook WSS seems to be the most feasible options, with the provider that Harry Gwala DM need to secure the water from Comrie Dam from Sappi-Saicor for the long-term and raise the dam. It is recommended that this option is pursued.

However, if the Harry Gwala DM does not get permanent access to the water of Comrie Dam, the Bulwer Donnybrook WSS will be augmented from Smithfield Dam, through a pumping scheme via Comrie Dam at a capital cost of about out **R155.5 million,** including engineering fees as well as environmental and social costs. The operational and maintenance costs, including water treatment and pumping cost is estimated at **R 3.8 million/annum**, mainly due to the large elevation difference of 638 m. It is then recommended that an estimated water requirement of approximately **1 million m³/a** is provided from Smithfield Dam to supply Bulwer Donnybrook WSS.

Before large capital schemes are considered, local resources (i.e. springs, groundwater and surface water supplies from a weir on the Luhane River) should be considered to supply communities in the Bulwer Donnybrook WSS' area. Further, 2024 is the milestone for first delivery of water from the proposed Smithfield Dam, thus management interventions such as Water Conservation/Water Demand Management (WC/WDM) should be implemented.

5.6 COST ESTIMATE FOR SMITHFIELD DAM

A detail cost estimate was done for all the uMWP-1 components (including the Umgeni Water potable water infrastructure), as summarised in **Table 5.3**, with a base date of March 2014, excluding VAT.

Table 5.3: Summary of cost estimate for uMWP-1, both raw and potable water components (2014 Rands)

Component	Capital cost (R million)
1. Raw water system activities (incl. miscellaneous)	
Smithfield Dam	2 018
uMkhomazi-uMlaza tunnel	3 901
Langa Dam	439
Raw Water Pipeline	365
Transmission lines	5
Smithfield Dam and Baynesfield hydropower plants	Nil[(1)]
Waste disposal sites	15
Flow gauging stations	30
Roads and bridges	232
Sub-total of activities	**7 005**
Ps&Gs (25% of activity cost)	1 752
Professional fees (12% of activity cost)[(2)]	841
Environmental, landscaping and social costs	450
Land acquisition (lump sum)	37
Sub-total of activities and value-related costs	**10 084**
Contingencies (25% of above sub-total)	2 521
Implementing agent - TCTA[(3)]	200
Total: Raw water system	**12 805**
2. Potable water system activities (incl. miscellaneous)[(4)]	
Baynesfield WTW-Umlaas Road Pipeline	1 143
Baynesfield WTW and potable water reservoirs	795
Sub-total of activities	**1 938**
Ps&Gs (25% of activity cost)	485
Professional fees (12% of activity cost)[(2)]	233
Environmental, landscaping and social costs (5% of activity cost)	97
Land acquisition (lump sum)	10
Sub-total of activities and value-related costs	**2 762**
Contingencies (25% of above sub-total)	691
Implementing agent - Umgeni Water (5% of sub-total)[(3)]	138
Total: Potable water system[(4)]	**3 591**
3. Grand total	
uMkhomazi Water Project Phase 1 (excl VAT)	**16 396**
uMkhomazi Water Project Phase 1 (incl VAT)	**18 691**

(1) Hydropower is not included, as it does not form part of the raw water system. However, the cost of the Smithfield-Baynesfield hydropower is estimated as R 83.3 million.

(2) Project management, design and construction monitoring costs are included as professional fees.

(3) Administration costs include raising funds, procurement, project management and administration of the project as implementing agent.

(4) Refer to Module 3 reports for cost of potable water components.

5.7 Programme

The imminent deficit in the Mgeni System requires the fast-tracking of this large project, providing water by no later than 2023. An optimistic construction programme for this comprehensive multidisciplinary project shows the following milestones in **Figure 5.8**.

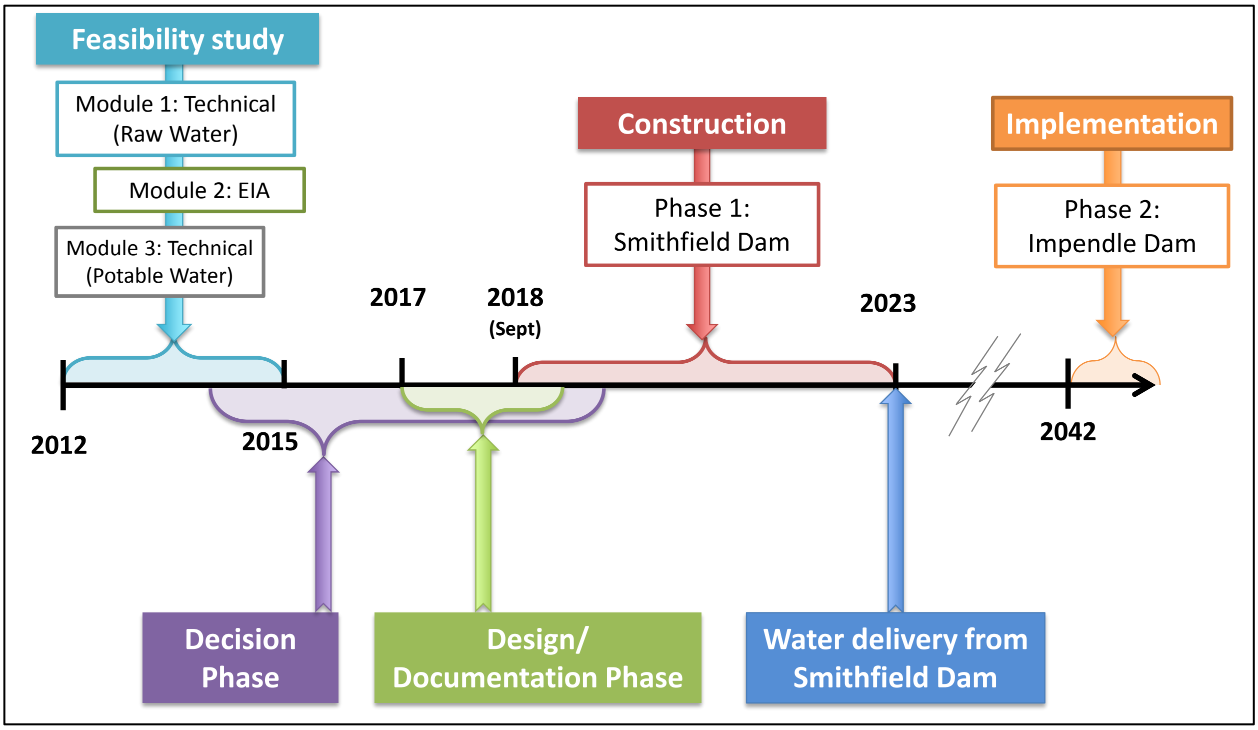

Figure 5.8: Summarised proposed implementation programme

6 Funding and Institutional Arrangements

6.1 Institutional and Financial Arrangements

The uMWP's raw water components will form part of the national water resource infrastructure and therefore ownership and control will be vested in the Government of the Republic of South Africa, and thus administered by the Department of Water and Sanitation. Umgeni Water (UW) is responsible for bulk water supply and will be the owner and developer of the uMWP potable bulk water components of the scheme, with the upstream battery limit being at the inlet to the Baynesfield WTW.

The uMWP will supplement the Mgeni WSS and as such will form an integral component of this strategically important system. This system provides water to the greater economically important eThekwini Metropolitan area, where the DWS owns the major dams in the uMngeni Catchment as well as some dams in neighbouring catchments, such as Spring Grove Dam. The Mgeni WSS is currently operated by UW.

The institutional arrangement as shown in **Figure 6.1** below is recommended.

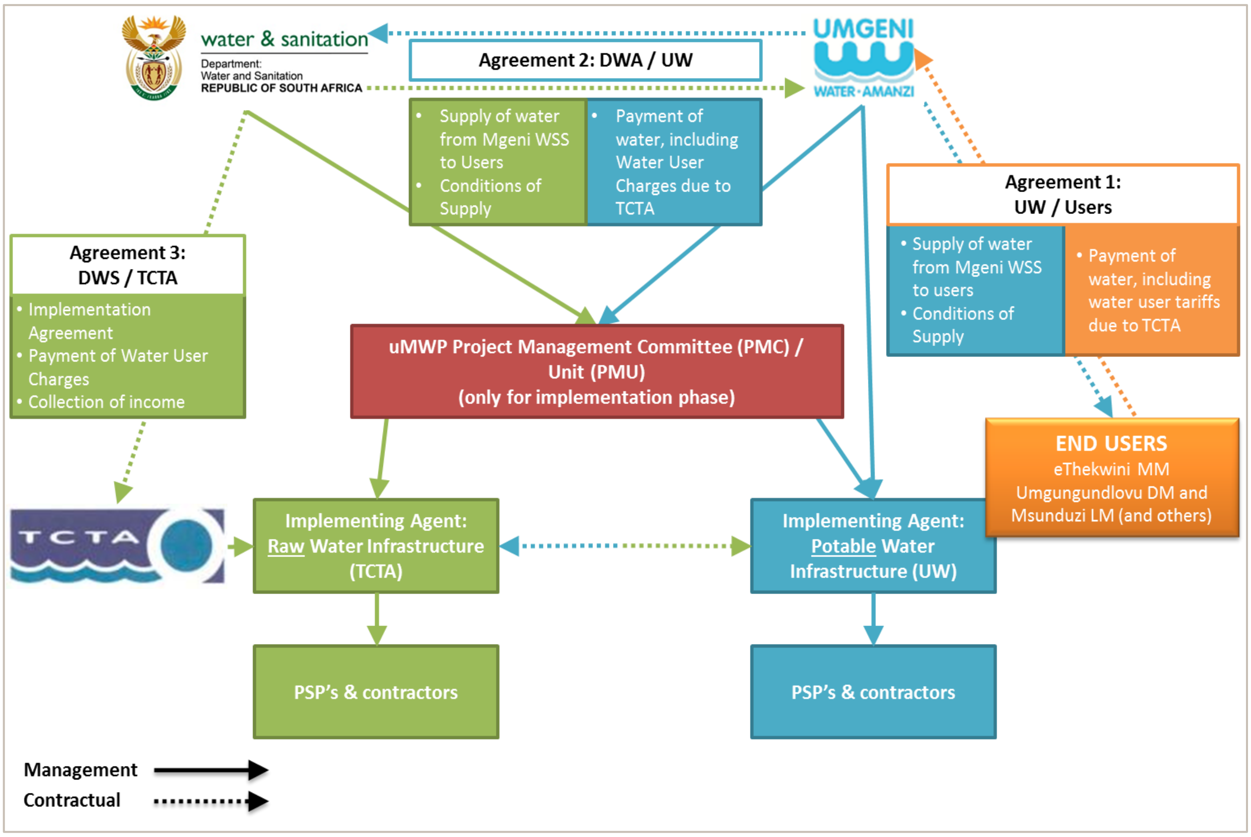

Figure 6.1: Proposed institutional arrangements during the implementation phase

It is recommended that the TCTA proceed with implementation of the project as soon as off-take agreements have been signed with the relevant Water Service Authorities (WSAs) for at least 85% of the current water volume as this has proven to be acceptable to DWS and bankers on previous projects.

It is further recommended that UW fund and implement the potable bulk water component of the project and that UW operate the complete project (raw and potable water supply) once it has been commissioned.

The institutional arrangements relating to the possible development of the hydropower project(s) has not been included, as the full feasibility of the hydropower potential needs to be further investigated and is therefore not regarded as part of the uMWP infrastructure. Should the hydropower be implemented, it will most probably be developed by UW or an Independent Power Producer (IPP).

6.2 Financial Aspects

The water tariffs were determined based on the capital and operating costs for the development of uMWP-1, in light of sources of funding including off-budget loan financing and possible partial subsidisation through grant funding.

The two major policy considerations in deciding on the appropriate funding model for the uMWP are the *2007 Pricing Strategy for Raw Water Use Charges* that explicitly supports ***the concept of allocating State Funding to the social component of the water supply*** and the ***historic precedent*** created through the implementation of schemes such as MMTS-2 and the Berg Water Project that recognised the economic and financial capacity of users to cover the costs of large bulk water supply schemes. However, the Pricing Strategy also recognises that the debts on projects where loan repayments overlap should not cause "***.....financial strain to end users or unhealthy financial balance in the water sector***", as will be the case for the Mgeni WSS users due to the recently completed Spring Grove Dam scheme.

From these policy considerations, the water tariff was calculated for the scenario where the uMWP-1 is fully funded off-budget by private sector loan (debt) funding, and a scenario where National Treasury provide a 25% grant, funding the remaining 75% off-budget.

With these assumptions, the UW's bulk potable tariff would need to be increased by a constant real surcharge of ***R 2.70/kℓ in terms of 2014 prices*** (or R 4.57/kℓ in 2023 prices), of which R 1.88/kℓ in 2014 would be for the raw water component.

This uMWP future tariff of R 2.70/kℓ constitutes a ***59% increase*** which will financially strain end users (UW bulk water tariff increase from ***R 4.55/kℓ*** to ***R 7.25/kℓ***).

The impact will be lessen to ***R 2.12/kℓ in terms of 2014 prices*** (or R 3.58/kℓ in 2023 prices) with a grant of 25%.

The substantial increase of the tariff raises affordability concerns, which, together with the number of poorer households affected (which use about 25% of the water), makes it ***recommended that National Treasury considers grant funding*** of the capital cost of the project to facilitate continued access to water for all.

It is recommended that TCTA, as preferred implementing agent for the raw water components, fund the remaining approximately 75% of the raw water component of the project with private sector funding. The TCTA loans should be recovered through the UW tariff. This is the same approach as that adopted for the funding of the MMTS2 project.

Further, the phasing in of a tariff increase prior to the raising of any funding or implementation of the scheme may soften the impact of a substantial tariff increase. However, a suitable strategy should be composed to ensure that the surplus funds gained are earmarked for the loan repayment, otherwise there is a risk that the surplus funds will be used for other purposes, thereby necessitating further tariff increases later.

7 LEGISLATIVE REQUIREMENTS

7.1 ENVIRONMENTAL IMPACT ASSESSMENT

An environmental screening process investigated the different options proposed by identifying environmental "red flags" and "fatal flaws" that would render an option unsuitable and not worthy of further investigation during the feasibility study. Subsequently, a comprehensive Environmental Impact Assessment (EIA) was conducted to obtain approval for the uMWP-1. Detail of the EIA process is contained in a separate study, uMWP-1 Module 2 EIA.

The feasibility study complemented the EIA's public participation programme through the workings of the Project Steering Committee (PSC) and ongoing consultations with key stakeholders, specifically also the Water Services Authorities (WSAs) that will be signatories to the off-take agreements.

7.2 ECONOMIC IMPACT ASSESSMENT

The Economics Impact Assessment aimed at providing input into the Environmental Authorisation and an economic motivation for the project.

This uMWP-1 will have an impact on the regional and local economies during the construction (short-term) and operational and refurbishment (long-term) phases, through direct, indirect and induced economic impacts. The impact during construction is considerable, especially on the uMkhomazi Catchment, yet it is not sustainable in the long-term as the construction will only last for approximately 60 months. The operational phase (modelled for a 50-year period) has a more sustainable contribution to the domestic economy.

Total additional production (new business sales) anticipated to be generated by the project equates to R86 661 million (direct, indirect and induced over 55 years). Gross domestic product (GDP) is anticipated to increase by R30 305 million (direct, indirect and induced over 55 years). The analysis shows that the uMWP-1 development has the potential to generate high levels of employment creation (directly up to 9 670 annualised job opportunities over 55 years). This will stimulate business and human capital development and assist in raising living standards.

The Economic Cost-Benefit Analysis (ECBA), a quantitative comparison of options, calculated a R58 370 million net effect at a NPV of 8%. The positive net effect, when the cost of implementation is less than the benefits, indicates the project is profitable; i.e. by implementing the project there will be greater benefits than costs.

8 WAY FORWARD

The following **high level[5] recommendations** are made for the development of the uMWP:

- Develop the uMWP-1 for water delivery in 2024, with the following components:
  - a dam at Smithfield on the uMkhomazi River with storage volume equal to 31% of the MAR, FSL 930 masl;
  - a Balancing Dam with a gross storage volume of 15. 7 million m³ on the Mbangweni River; and
  - A single 3.5 m internal diameter uMkhomazi to uMlaza Tunnel and associated 2.6 m diameter pipeline to the Baynesfield WTW with a design (seasonal) transfer capacity of 8.65 m³/s. A single 1.6 m diameter pipeline will carry water from this pipeline to the balancing dam.
- Finalise the financial and institutional arrangements for the project and secure funding, taking the following steps:
  - Appointment of TCTA as the Implementing Agent by the Minister for DWS for the uMWP-1 Raw water component,
  - Determination of the availability of funds for National Treasury for subsidisation of the costs of the project through grant funding,
  - Development of the financial models for the raw water and potable water components by TCTA and UW respectively,
  - Finalise off-take agreements with water service authorities that constitute 85% of the volume of the current water users, by September 2017,
  - Formulation of a procurement strategy and programme for the implementation of the uMWP-1 by TCTA and UW to ensure an integrated approach towards timeous completion of the project in 2023, and

[5] *Detail recommendations for each component of the study are included in the relevant reports.*

  - Appointment of UW as operator for the whole uMWP-1 (raw and potable water components).

- Conduct additional geotechnical investigations during the design stage of the tunnel, Smithfield Dam and Langa Dam and roads, as per geotechnical report.
- Conduct a hydraulic model study of Smithfield Dam's spillway and tunnel intake arrangement.
- Confirm the preferred feasible scheme to augment the Donnybrook-Bulwer WSS (either Comrie or Smithfield dams), for development. Also, consider the optimal use of groundwater for communities in the uMkhomazi River catchment.
- Finalise the RID once the environmental authorisation approval is received in 2016.
- DWS to confirm their involvement in the development of hydropower, or identify other entities, such as UW, a municipality or private company, that would be interested in developing the hydropower scheme in a renewable energy program for small hydropower schemes.
- Consider short term interventions, such as water demand management, desalination, re-use, etc., to supply the Mgeni WSS until the first delivery from the uMWP-1.
- Since final results from the Reserve Study were not available, and although conservative assumptions were used in this analysis, re-evaluate the impact of the Reserve on the Smithfield and balancing dams and also consider the final EWRs in the uMkhomazi and uMlaza rivers to determine detailed operating rules.
- Optimise the operating rules for the uMWP-1 together with the proposed development in the lower uMkhomazi.

9 REFERENCES

The suit of feasibility reports, listed below, should be used to provide a more comprehensive view of the project and support this summary report and the RID.

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