108/114/12/R1-1

UMKHOMAZI WATER PROJECT

MODULE 3 – POTABLE WATER MODULE

Detailed Feasibility Study

Main Report - Volume 1

Revision 1

October 2015

Planning Services
Engineering & Scientific Services
Umgeni Water

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UMGENI WATER **OCTOBER 2015**

uMkhomazi Water Project

Detailed Feasibility Study – Main Report – Volume 1

Report No. 108/114/12/R1-1

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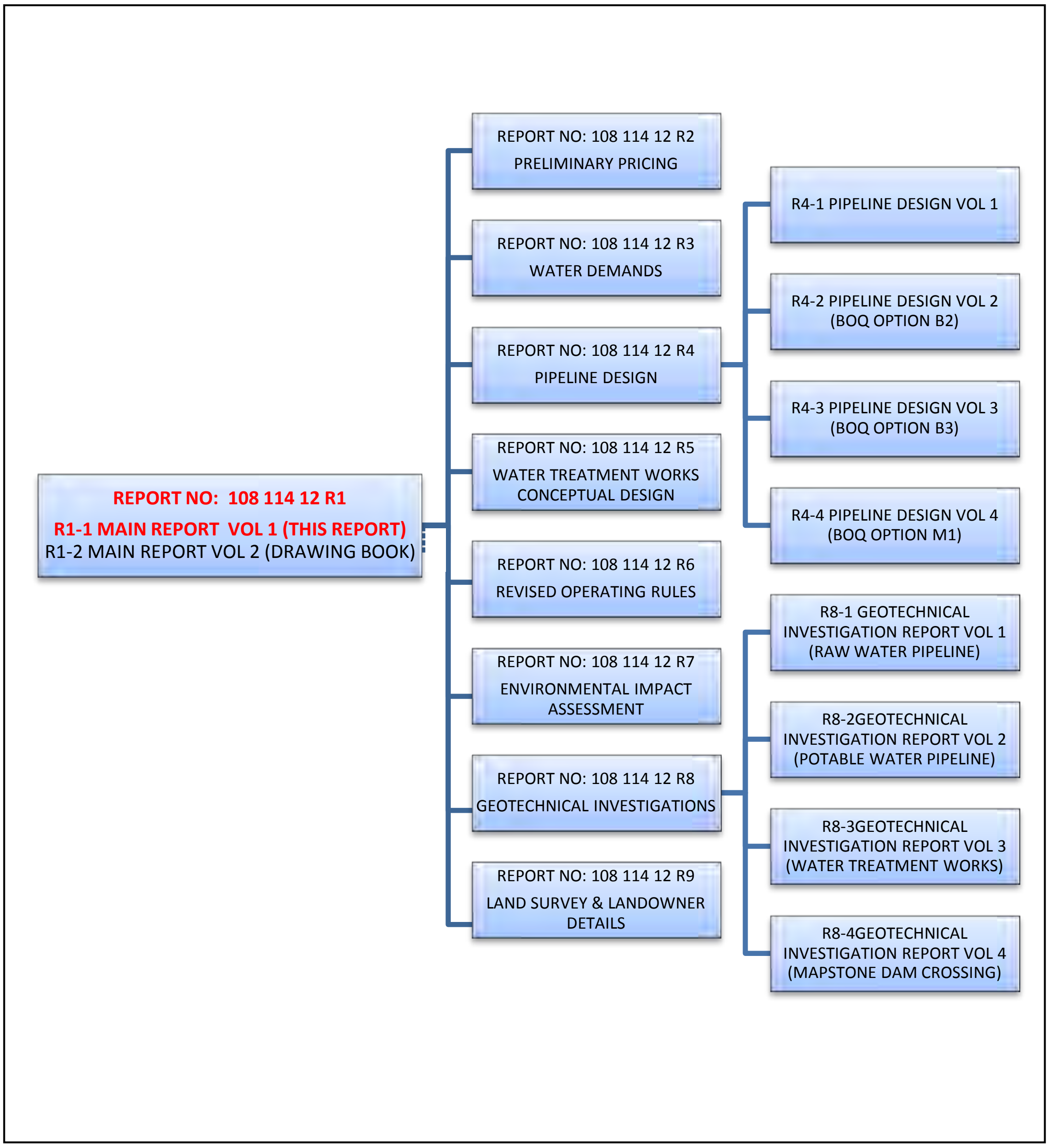
UMKHOMAZI WATER PROJECT

MODULE 3 – POTABLE WATER MODULE

Structure of Suite of Reports



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EXECUTIVE SUMMARY:

Introduction: The high economic significance of the greater eThekwini-Msunduzi region requires that the water supply to this region is supplied at a 99% level of assurance from the Mgeni Water Supply System (Umgeni Water, 2014: 50). The required assurance of supply has been compromised for several years; however good rains in the Mgeni catchment have allowed the region to avoid the potentially devastating effects of a drought (Schroder & de Jager, 2014: 2-1).

The projected growth in water demands in the greater eThekwini-Msunduzi region will further compromise the assurance of supply of the Mgeni Water Supply System (WSS).

The Mgeni WSS is fully developed and there are no further infrastructure options available to improve the system yield. The completion of the Mooi-Mgeni Transfer Scheme Phase 2 (MMTS-2) will maximise the benefits that can be obtained from the Mooi River to support the Mgeni system (Umgeni Water, 2014: 54). After the MMTS-2 is commissioned however, the Mgeni WSS will not be in a positive situation for long as a result of continued growth in water demands (Schroder & de Jager, 2014: 2-1).

A new source of water is therefore required to support the Mgeni WSS to meet the projected water demand growth in the greater eThekwini-Msunduzi region. Options to augment the water resources in the Mgeni WSS that have been investigated to date include Sewage Effluent Reuse, Desalination, Reduction of Mgeni WSS Support to the South Coast System and the uMkhomazi Water Project (Department of Water & Sanitation, 2014).

It is clear that the only option capable of meeting the long-term growth in water demand in the eThekwini region is the uMkhomazi Water Project (uMWP). A pre-feasibility study undertaken in 1999 for the proposed uMWP investigated several scheme configurations and recommended that the Smithfield Scheme proceed to the next phase of investigation in a Detailed Feasibility Study (Department of Water Affairs and Forestry & Umgeni Water, 1999: 11). The Smithfield Scheme is now referred to as the uMWP Phase 1 (uMWP-1) and comprises the infrastructure described below.

The uMWP-1 includes the Smithfield Dam on the uMkhomazi River, a raw water tunnel from Smithfield Dam to the Baynesfield region, the Langa Balancing Dam at Baynesfield, a raw water pipeline from the tunnel outlet to a water treatment works (WTW) at Baynesfield, potable water reservoir at Baynesfield and a potable water pipeline from Baynesfield to Umlaas Road where it would tie into UW's existing '57 Pipeline.

Phase 2 of the uMWP (uMWP-2) will include the Impendle Dam located upstream of the Smithfield Dam on the uMkhomazi River, a second raw water tunnel and raw water pipeline, an increase in WTW capacity and potable water storage and a second potable water pipeline.

The detailed feasibility studies for the uMWP-1 are presently being undertaken in the following modules:

- **Module 1 – Raw Water Module**: Proponent: DWS; Consultant: AECOM
- **Module 2 – Environmental Impact Assessment**: Proponents: DWS (Raw Water Module) and UW (Potable Water Module); Consultant; NEMAI
- **Module 3 – Potable Water Module**: Proponent: UW; Consultant: Knight Piésold

Scope of study: Knight Piésold was appointed in July 2012 to undertake a detailed feasibility study for the potable water component of the uMWP-1, including a water treatment works (WTW), potable water storage reservoir and potable water pipeline from the WTW to the Umlaas Road tie-in to the existing '57 Pipeline. The scope of the uMWP-1 Module 3 study included:

- Water demand forecasts for the areas to be served by the proposed uMWP-1.
- Conceptual WTW design and an investigation into potential sites for the location of the proposed WTW.
- An investigation into the sizing and location of a potable water storage reservoir.
- Detailed feasibility level pipeline design and routing for the potable water pipeline.
- Geotechnical investigations for the pipeline routes and the WTW site.
- Engineering survey for the pipeline routes and the WTW site.
- Potable water infrastructure cost estimates.
- Development of a programme and cash flows for project implementation.

It was a requirement that Module 3 be designed as a gravity system.

Water demands: A demand projection exercise was undertaken to determine the water demand that the uMWP-1 would need to cater for. Low and High Road water demand projections were developed up to the year 2053, i.e. the end of the design period for this study. The Low Road scenario was adopted for use in both the Module 1 and Module 3 studies as it was considered more realistic than the High Road Scenario. According to the Low Road scenario, the water demand that will have to be supplied from the uMWP in the year 2053 is 685 Ml/day. Since a significant portion of the projected demand is made up of load shedding from Durban Heights WTW, the uptake in demand on the uMWP-1 can be phased by delaying the shedding of a portion of the Durban Heights WTW demands to the uMWP-1.

WTW sites: Five WTW sites were initially investigated, viz. Baynesfield 1 (B1), Baynesfield 2 (B2), Baynesfield 3 (B3), Mapstone 1 (M1) and Crookes 1 (C1). The B1 and C1 sites were excluded from further investigation as a result of landowner objections. In addition, the C1 site had a large imbalance in earthworks cut and fill quantities that would require large volumes of material to be spoiled off site. The remaining three sites were investigated in detail. The recommended site for the WTW was the B2 site as it had the most equally balanced earthworks cut and fill.

Pipeline routing: Pipeline routes were developed to suit each of the WTW sites above. Route options B2, B3 and M1 were investigated in detail. A detailed cost analysis of each option found that route option B2 was the least expensive as a result of having the shortest length of all the pipeline routes. The overall cost of Option B2 including the pipeline and WTW was also the lowest. The recommended pipeline route and WTW location was therefore Option B2.

The pipeline routes investigated above generally follow the shortest path between Baynesfield and Umlaas Road that allows gravity flow. As a result, all these routes cross Mapstone Dam.

Although feasible options were developed for the crossing of Mapstone Dam as discussed below, it was considered prudent to investigate alternative routes that did not require the pipeline to cross the dam. In this regard, pipeline routes to the north and south of Mapstone Dam were investigated. The northern route was not considered to be feasible. The southern route is technically feasible and although not recommended because of the significant length it adds to the pipeline route, it does provide an alternative to crossing Mapstone Dam, should it be needed.

Crossing of Mapstone Dam: The following four options were investigated for the crossing of Mapstone Dam:

- Pipe buried and concrete encased in the dam basin
- Suspension bridge spanning the entire dam
- Steel pipe bridge on concrete support piers
- Pipe spanning between concrete piers

In accordance with discussions with the Upper Umlaas Water Users Association, the recommended option is burying the pipeline through the dam, which will require the dam to be drained. This option will require Module 1 of the project to be commissioned prior to construction of the dam crossing in order to maintain a supply to irrigators during the period that Mapstone Dam is drained.

Water treatment works design: In order to meet the proposed phased increases in demand as well as a requirement to provide support to the Mgeni WSS, the capacity of the uMWP-1 WTW was proposed to be 500 Ml/day upon commissioning in 2023. A further 125 Ml/day phase would be required in 2044.

The proposed WTW layout was constrained by the requirement for gravity supply in the overall system between Smithfield Dam and the Umlaas Road tie-in, as well as a requirement to keep the WTW footprint to a minimum. The proposed plant layout combines features of accessible and compact unit process configuration, minimum lengths of interconnecting pipework, minimum volume of excavation and ease of future extension.

Based on the water quality and physical-chemical assessment of the raw water, it was recommended that conventional water treatment technology, as typically applied in river water treatment plants, would be the most appropriate for the uMkhomazi WTW. Treated water would comply with the SANS 241: 2011 Drinking Water Guidelines.

The recommended WTW processes are pre-chlorination, coagulation/flocculation, high-rate clarifiers, rapid gravity filtration, granular activated carbon (GAC) filtration, final chlorination and sludge treatment.

Although high-rate processes were recommended, actual flow rates were limited at UW's request. It is recommended that UW give consideration to experimenting with and increasing these flow rates as such an increase will result in a considerable future saving on the cost of additional clarifiers when the WTW reaches the limit of its design capacity at the limited process flow rates.

Dealing with sludge: Large volumes of sludge will be generated from the WTW process. It is proposed that clarifier underflow, sand filter backwash and GAC filter backwash water be collected and treated in a dedicated sludge handling facility on site. The water recovered by this facility would be returned to the inlet works of the plant while the thickened and dried final sludge would be disposed of off-site.

It is recommended that belt presses are used for sludge dewatering as the technology is more economical than centrifuges and results in a much lower water content in the final sludge; which could halve the total volume of sludge that has to be disposed of. Final sludge could be used for brick manufacturing, which would be the most environmentally friendly way to dispose of sludge and will reduce the overall carbon footprint of the plant. Sludge could also be disposed of by land application at farms in the WTW vicinity or at landfill sites.

Potable water reservoir: The potable water reservoir was sized to accommodate a minimum of six hours of the daily WTW capacity. Based on the WTW phasing discussed above the first 500 Ml/day WTW phase would require 125 Ml of storage, with a further 31.25 Ml required when the next 125 Ml/d WTW phase is constructed in 2044, i.e. a total of 156.25 Ml of storage for the uMWP-1.

The reservoir required for the uMWP-1 would require a footprint of 2.2 hectares. In light of a requirement to keep the WTW footprint to a minimum, it was proposed that potable water storage be constructed beneath various WTW structures.

Potable water pipeline: The potable water pipeline was designed to accommodate an average annual daily demand of 602 Ml/day; equivalent to the 1:100 year yield of the Smithfield. The peak design capacity was 753 Ml/day.

To convey the peak demand of 753 Ml/day, three possible pipeline configurations were investigated in this study, namely:

1. Single Pipeline Configuration: A single pipeline sized to convey a peak flow of 753 Ml/day.
2. Double Equal Pipeline Configuration: Two pipelines of equal capacity, each sized to convey a peak flow of 377 Ml/day or a total combined flow of 753 Ml/day. For this option, both pipelines would be commissioned at the same time.
3. Double Unequal Pipeline Configuration: Two pipelines of unequal capacity intended to be built in two phases. The first phase, to be commissioned in 2023, would be sized to match the peak capacity of the Western Aqueduct pipeline, i.e. approximately 490 Ml/day. The second phase, to be commissioned around 2044, would be sized to provide a further 263 Ml/day to give a total capacity of 753 Ml/day.

All pipeline configurations were technically feasible. An economic analysis showed that the Double Unequal Pipeline option had the lowest Net Present Value (NPV), which was R129 million less than the next cheapest option, the Single Pipeline option. The Single Pipeline option was however recommended as it was considered more practical to construct than the Double Unequal option.

Geotechnical Investigations: Geotechnical investigations indicated that good conditions could be expected for pipe laying operations with some occurrence of rock that may require blasting.

Only limited geotechnical investigations could be undertaken at the preferred WTW due to lack of access. Although the limited investigations did not highlight any problems, further investigations are recommended.

Geotechnical investigations undertaken for the proposed Mapstone Dam crossing indicated good founding conditions for all crossing options.

Recommended Module 3 Infrastructure: The recommended Module 3 infrastructure based on Option B2 is:

1. Raw water conveyance: Single 3030mm OD x 5.0 km long steel pipeline
2. WTW: 500 Ml/day conventional water treatment plant located at the Baynesfield 2 site
3. 170 Ml potable water storage reservoir
4. Potable water conveyance:
    a) Section 1: Single 2820mm OD x 15.1 km long steel pipeline
    b) Section 2: Single 2540mm OD x 4.6 km long steel pipeline

Capital and Total Implementation Costs: The estimated capital cost for the recommended Option B2 is R3.07 billion. The estimated all-inclusive project implementation costs including professional services, capital costs, land acquisition, an allowance for safety, health, environmental, quality & community liaison, project office costs and contingencies is R 4.50 billion.

Programme and Cash Flow: The planned commissioning date for the uMWP-1 is 2023. In order to achieve this date, landowner and servitude negotiations must commence in April 2016 and professional services appointments need to be completed early in the third quarter of 2016. Construction contracts should be awarded during the course of 2018 with allowance made for advanced works contracts and ordering of pipe. The potable water reservoir would be on the critical path and the design and tenders for this portion of the work should be fast-tracked. Construction and commissioning has been estimated to take 4.5 years, starting in 2019 and ending in mid-2023. Forecast cash flows are included in the table below.

TOTAL VALUE 2016 - 2023	PROJECTED CASH FLOW (R million)							
	2016	2017	2018	2019	2020	2021	2022	2023
R 4 500.7	R 49.8	R 94.6	R 355.8	R 352.9	R 798.5	R 1 240.5	R 1 191.9	R 416.8

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1. Introduction

The projected increase in water demand in the greater Durban region is predicted to exceed supply from all current sources within the next ten years. Several new water supply schemes are presently being investigated by Umgeni Water (UW) and eThekwini Water and Sanitation (EWS) as possible solutions to the predicted supply shortage. One of the schemes under investigation is the proposed uMkhomazi Water Project (uMWP).

Phase 1 of the proposed uMkhomazi Water Project (uMWP-1), will comprise the Smithfield Dam, a raw water tunnel to Baynesfield, the Langa balancing dam at Baynesfield, a raw water pipeline, a water treatment works (WTW) in the Baynesfield area and a potable water pipeline from the WTW to Umlaas Road, where it will connect to the Western Aqueduct via UW's '57 Pipeline. The proposed scheme is depicted in **Figure 1** as well as **Drawing No. 30300413/A11** included in **Volume 2** of this report.

The feasibility investigations for this project have been split into three Modules.

Module 1 covers the raw water component of the study, i.e. Smithfield Dam, the raw water tunnels from Smithfield Dam to Baynesfield, a balancing dam in the Baynesfield area and a raw water pipeline from the tunnel outlet to the proposed WTW.

Module 2 covers the Environmental Impact Assessment for Modules 1 and 3.

Module 3 covers the potable water component of the study, i.e. a potable water treatment works, potable water storage reservoir and potable water pipelines from the WTW to the Umlaas Road tie-in to the existing '57 Pipeline owned by Umgeni Water.

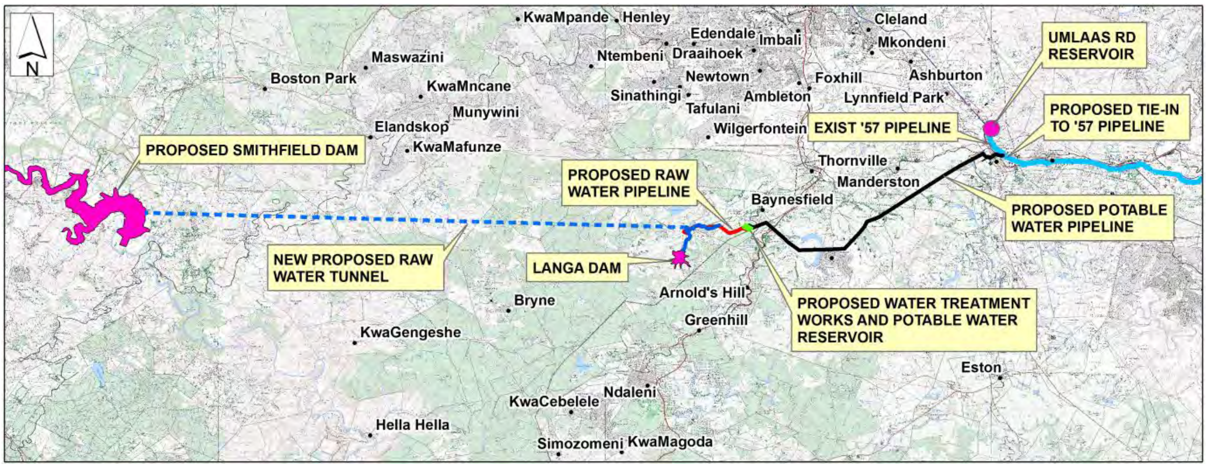

Figure 1: Proposed uMkhomazi Water Project

Umgeni Water appointed Knight Piésold in July 2012 to carry out a Detailed Feasibility Study for Module 3 of the proposed uMkhomazi Water project, i.e. the Potable Water Module. This report summarises the findings of the Module 3 study.

2. Background and Need for Project

The eThekwini region is presently experiencing a period of sustained growth. This growth is expected to continue over several decades as the city rolls out infrastructure developments based on its Spatial Development Framework (SDF). Planning investigations for the residential and commercial developments and the related increase in water demand to serve the expected growth have indicated that the water demand from eThekwini's proposed new developments cannot be met without compromising the assurance of supply from the Mgeni system. According to UW's Infrastructure Master Plan (IMP) 2014 Vol 1, water from the Mgeni system is required to be supplied at a 99% level of assurance (i.e. a 1:100 year risk of failure) due to the economic and strategic significance of the greater eThekwini-Msunduzi region (Umgeni Water, 2014: 50).

The Infrastructure Masterplan further states:

> "A holistic view of the projected water demands from the entire Mgeni system is shown in Figure 2.36 together with the existing yield (at a 99% level of assurance) available from the system. This yield includes the maximum additional support that it can obtain from the Mooi River. Since the demand exceeds the available yield, the system is currently in deficit with a worsening situation predicted into the future. This deficit means that water is being supplied at a lower level of assurance than is required and therefore the risk of a shortfall being experienced has increased. This risk increases as the size of the deficit increases." (UW, 2014: 50).

The following is an extract from the 2013/14 eThekwini Municipality SDF:

> "The water supply to the KwaZulu-Natal Coastal Metropolitan Area is experiencing serious difficulties. Poor long term infrastructure planning and decline in investment in bulk infrastructure over the last 20 years and above average rainfall over the last few years has led to a false sense of security regarding the water supply situation.
>
> A below average rainfall period will result in the need for water restrictions with their associated impacts on the local economy. The continued economic growth and development of the KwaZulu-Natal Coastal Metropolitan area requires an assured water supply in line with DWA's policy of water for growth and development.
>
> The level of assurance of water supply from the uMgeni system has dropped from 99% to 95% and will drop further. The situation is sufficiently severe that water restrictions are inevitable once rainfall returns to normal and the Head: Water and Sanitation has reported this to the eThekwini Council with a recommendation that a senior political delegation request a meeting with the Minister of Environment and Water Affairs to unblock the obstacles around bulk water supply and the finalisation of river reserve determinations.
>
> The augmentation of supply from the Springrove Dam will only become a reality in 2013/14 and even with this additional capacity eThekwini will still suffer from a water supply shortage. Water recycling may, if all the approvals are received, come on stream in 2016 but more efficient utilisation of the existing resource is a priority. From the point of view of current

water supply, there is insufficient supply to deal with any further development as envisaged in the SDF and SDPs." (eThekwini Municipality, 2013: 98).

As indicated in the above extract from eThekwini Municipality's 2013/14 SDF, the 1:100 year yield of the Mgeni system that supplies raw water to Durban Heights WTW is presently compromised, resulting in an increased risk of failure in this supply system, i.e. increased chances of water shortages and rationing of supply. This situation will be exacerbated if additional demands are placed on this already stressed system.

The views in UW's IMP and EWS's SDF are confirmed in the 2014 Department of Water & Sanitation (DWS) report titled "*Continuation of the Reconciliation Strategy of the KwaZulu-Natal Coastal Metropolitan Area Phase 2*" (the *Reconciliation Strategy*). The *Reconciliation Strategy* confirms that good rains in the Mgeni Water Supply System (WSS) have allowed the region to avoid the potentially devastating effects of a drought (Schroder & de Jager, 2014: 2-1). Even after the Mooi-Mgeni Transfer Scheme Phase 2 (MMTS-2) is commissioned, the Mgeni WSS will not be in a positive situation for long as a result of continued growth in water demands (Schroder & de Jager, 2014: 2-1).

Durban Heights Waterworks along with its vast network of bulk water mains and pump-stations is the main supply of potable water to the Greater Durban region. Both the WTW and its Northern Aqueduct (NA) pipe supply network are presently at the limit of their respective capacities. After commissioning of the Western Aqueduct (WA) pipeline in 2018, spare capacity will be made available at Durban Heights WTW when a portion of its demand is shed to the WA.

The WA is a current eThekwini Water & Sanitation (EWS) project to convey potable water from the Midmar system to eThekwini's western and northern supply areas via a large diameter pipeline. The WA is integral with UW's '57 Pipeline system and runs from Point M through the Outer and Inner West regions terminating at Ntuzuma just north of Durban.

The spare capacity that would be created at Durban Heights after the WA is commissioned cannot be utilised until the restrictions in the NA are addressed. EWS has undertaken a project to augment the NA, which when completed, will be allow the pipeline system to convey the full capacity available at Durban Heights WTW to consumers north of Durban. The water demand projections for the Durban region however indicate that even after shedding a portion of its demand to the WA, Durban Heights WTW will be unable to meet the demand growth in its supply area.

There is little point in increasing the capacity of Durban Heights WTW as the Mgeni WSS, the source of raw water to Durban Heights WTW, is presently compromised. Umgeni Water's Infrastructure Masterplan confirms that the MMTS-2 project, when commissioned, will maximize the benefits that can be obtained from the Mooi River to support the entire Mgeni system (Umgeni Water, 2014: 54).

A new source of water is therefore required to meet the projected water demand growth in the Greater Durban region.

Several options to augment the water resources in the Mgeni WSS have been reported on in the *Reconciliation Strategy*. These include Sewage Effluent Reuse, Desalination, Reduction of Mgeni WSS Support to the South Coast System and the uMkhomazi Water Project (Department of Water & Sanitation, 2014).

From the graphs of water resource yields vs projected water demands in the Reconciliation Strategy for the Mgeni WSS, it is clear that the only scheme capable of meeting the long-term water demand projections in the Durban region is the uMWP.

Figure 2 that has been extracted from the *Reconciliation Strategy* (2014: 4-6), shows the effects of the various schemes in relation to the Mgeni WSS projected demands. It is clear that the Reuse, Toti Flow Reduction and Desalination projects if implemented, will only delay the need for the uMWP, which will eventually be required regardless of any earlier interventions.

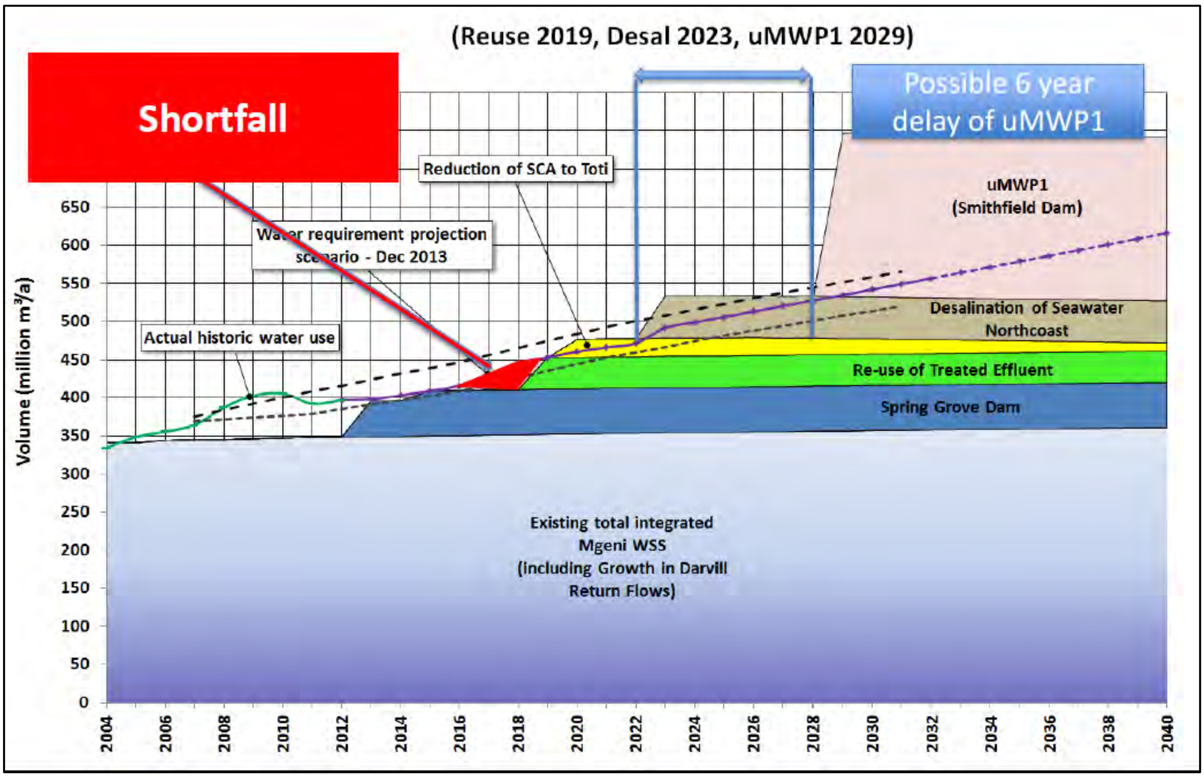

Figure 2: Water Balance for Mgeni WSS

The uMkhomazi Water Project will provide a supply of water to the region from a completely new source via an inter-catchment transfer. It also indirectly improves the water supply to the Greater Pietermaritzburg region by removing a significant portion of the EWS demand from the Upper Mgeni system at Umlaas Road, thereby making this water available to the Greater Pietermaritzburg region.

According to a joint Department of Water & Sanitation-Umgeni Water pre-feasibility study into different configurations of the proposed uMWP, the Smithfield Scheme was recommended as the preferred scheme from all those investigated to proceed to the next phase of investigation in a

Detailed Feasibility Study (Department of Water Affairs and Forestry & Umgeni Water, 1999: 11). The Smithfield Scheme is now referred to as the uMWP Phase 1 (uMWP-1) and comprises the infrastructure described in **Section 1** of this report.

The proposed uMkhomazi Water Project is therefore viewed by all key stakeholders as a critically important project to reliably meet Durban's growth in water demand in the long term.

3. Scope of Study

The scope of Module 3 is a Detailed Feasibility Study into the potable water component of the proposed uMkhomazi Water Project. The study included the following:

- A water demand forecast for the region that would receive water from the proposed uMWP-1, i.e. the Greater Durban region.
- An investigation into potential sites for the location of the proposed WTW.
- An investigation into the sizing and location of a potable water storage reservoir.
- An investigation into routing and sizing for the potable water pipeline to convey the required water demand to the delivery point at Umlaas Road. Although forming part of the Module 1 study, the raw water pipeline routing and sizing was included.
- Geotechnical investigations along the proposed raw and potable water pipeline routes and the WTW site.
- Engineering survey along the proposed raw and potable water pipeline routes and the WTW site including determining ownership of properties affected by the pipelines and WTW.
- Development of detailed costs estimates for all potable water infrastructure. For the sake of completeness, the raw water pipeline was also priced.
- Development of a programme and cash flows for the project implementation.

4. Scope of report

The uMWP-1 Module 3 study comprises several reports as described in **Section 6**. This report provides a detailed summary of the overall study investigations, findings and recommendations.

5. Study Management & Organisational Structure

The uMWP-1 is a joint study between Umgeni Water and the Department of Water & Sanitation (DWS). As discussed in **Section 1**, the project is split into the following three modules:

- **Module 1 – Raw Water Module**: Department of Water & Sanitation
- **Module 2 – Environmental Impact Assessment**: Department of Water & Sanitation (Raw Water Module) and Umgeni Water (Potable Water Module).
- **Module 3 – Potable Water Module**: Umgeni Water

The Module 3 study was commissioned by Umgeni Water's Planning Services Department and was carried out in close cooperation with the Department of Water & Sanitation.

A Project Management Committee (PMC) was constituted, the structure and composition of which is depicted in **Figure 3**.

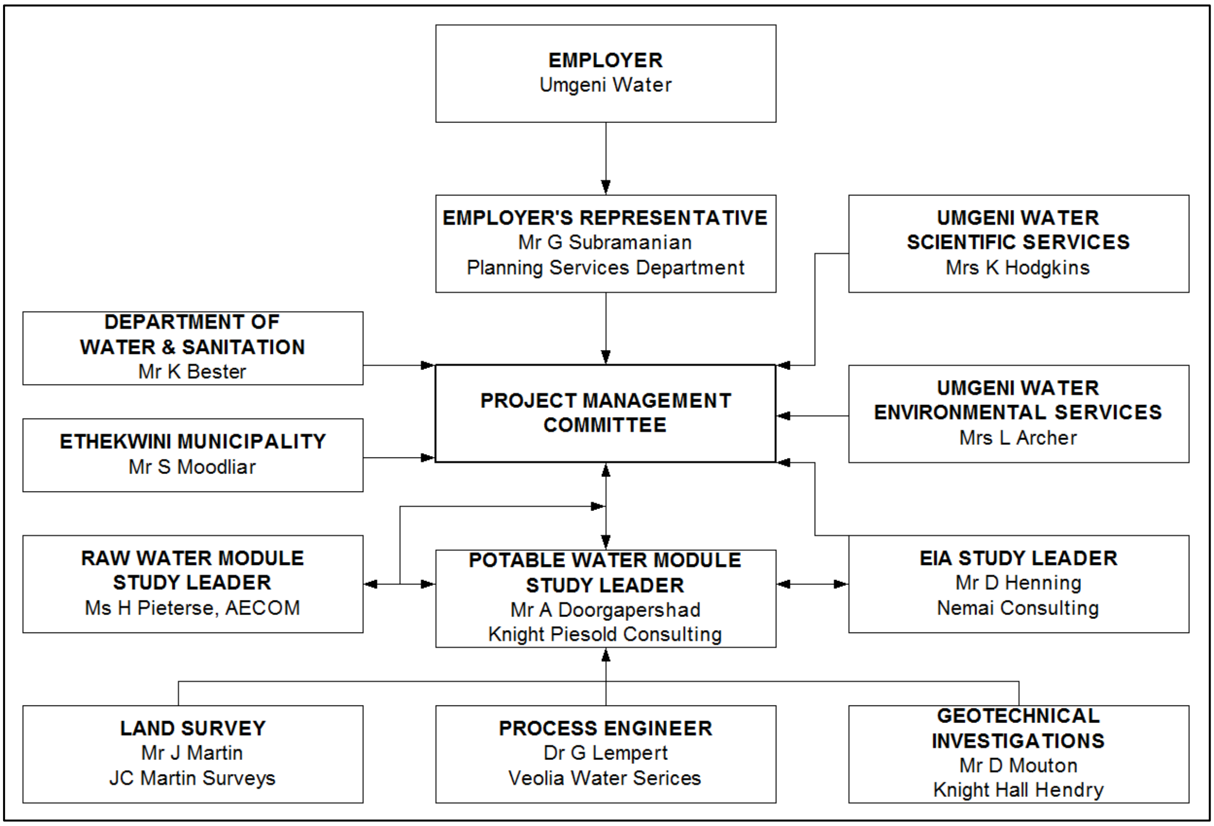

Figure 3: Study Management & Organisational Structure

6. Reports Comprising the uMWP Detailed Feasibility Study

Module 3 of the uMWP-1 comprises several reports as depicted in the structure of the suite of reports in the opening pages of this report as well as **Table 1**.

Table 1: Structure of Suite of Reports

Report No:	Report details:
R1-1	**Title**: Main Report - Volume 1 **Description**: The Main Report Volume 1 provides a detailed summary of the findings of the Module 3 study.
R1-2	**Title**: Main Report - Volume 2 (Drawing Book) **Description**: The Main Report Volume 2 comprises a set of drawings and maps that are referenced in the Main Report Volume 1.
R2	**Title**: Preliminary Pricing of Potable Water Module Options **Description**: The purpose of this report was to provide preliminary capital costs for Module 3 to AECOM for their financial calculations for the overall scheme. The costing in this report was based on rule of thumb estimates as the Module 3 study had not progressed to the detailed costing stage at the time that the estimates were required by AECOM. The cost estimates in the **R2** report have been superseded by those included in reports **R4-1** and **R5**.
R3	**Title**: Water Demand Projections and Phasing of Infrastructure **Description**: This report documents the water demand projection exercise undertaken for the uMkhomazi Project. These water demands were used for both the Module 1 and Module 3 studies.
R4-1	**Title**: Pipeline Design Report - Volume 1 **Description**: This report provides details of the potable water investigations including WTW locations, pipeline routes & hydraulics, potable water reservoir sizing. The raw water pipeline, although forming part of Module 1, has been included in this report.
R4-2	**Title**: Pipeline Design Report - Volume 2 (BOQ Option B2) **Description**: This report provides a priced Bill of Quantities for all configurations of Route Option B2.
R4-3	**Title**: Pipeline Design Report - Volume 3 (BOQ Option B3) **Description**: This report provides a priced Bill of Quantities for all configurations of Route Option B3.
R4-4	**Title**: Pipeline Design Report - Volume 4 (BOQ Option M1) **Description**: This report provides a priced Bill of Quantities for all configurations of Route Option M1.
R5	**Title**: Water Treatment Works Conceptual Design Report **Description**: This report provides details of the WTW design and treatment technology proposed as well as detailed cost estimates for the WTW.
R6	**Title**: Revised Mgeni System Operating Rules During uMkhomazi Raw Water Tunnel Shutdowns **Description**: The purpose of this report was to investigate whether the existing Mgeni Water Supply System infrastructure could accommodate a three week shutdown of the uMkhomazi system for planned maintenance purposes.
R7	**Title**: Environmental Impact Assessment **Description**: This report documents the Environmental Impact Assessment (EIA) process for Module 3. At the time of submission of the final study reports to UW, this report had not been completed.
R8-1	**Title**: Geotechnical Investigation Report - Volume 1 (Raw Water Pipeline) **Description**: This report documents the outcome of geotechnical investigations for the Raw Water Pipeline route.
R8-2	**Title**: Geotechnical Investigation Report - Volume 2 (Potable Water Pipeline) **Description**: This report documents the outcome of geotechnical investigations for the Potable Water Pipeline route.
R8-3	**Title**: Geotechnical Investigation Report - Volume 3 (Water Treatment Works) **Description**: This report documents the outcome of geotechnical investigations for the Water Treatment Works.
R8-4	**Title**: Geotechnical Investigation Report - Volume 4 (Mapstone Dam Crossing) **Description**: This report documents the outcome of geotechnical investigations for the Mapstone Dam Crossing.
R9	**Title**: Land Survey and Landowner Details **Description**: This report provides details of the engineering survey carried out for the proposed pipeline routes and WTW site. It also provides landowner contact details and information on all affected properties.

7. Preliminary Pricing of the uMWP Potable Water Module

Shortly after the Module 3 study commenced, AECOM, the consultants for the raw water component of the project, requested preliminary cost estimates for the potable water component of the project. The purpose of this request was to enable AECOM to complete their financial calculations for the overall scheme.

The requested costs were provided to AECOM in **Report Number 108/114/12/R2** titled **Preliminary Pricing of Potable Water Module Options.**

Since the Module 3 study had not progressed to the detailed costing stage at the time that the estimates were requested, the above report was based on ‘rule of thumb’ costs as well as experience with similar recently completed projects.

The costs in in the **Preliminary Pricing** report have been superseded by detailed costing contained in the following reports:

- Report Number 108/114/12/R4-1 titled **Pipeline Design Report - Volume 1**.
- Report Number 108/114/12/R4-2 titled **Pipeline Design Report - Volume 2**.
- Report Number 108/114/12/R4-3 titled **Pipeline Design Report - Volume 3**.
- Report Number 108/114/12/R4-4 titled **Pipeline Design Report - Volume 4**.
- Report Number 108/114/12/R5 titled **Water Treatment Works Conceptual Design Report**.

8. Revised Mgeni System Operating Rules

Once commissioned, the proposed uMWP will take over portions of the supply areas presently served from Durban Heights and Hazelmere WTWs. When this takes place, the Durban Heights and Hazelmere WTWs will continue to serve a reduced portion of their respective supply areas and the uMWP scheme will take over supply to the remaining portion of these areas.

Supply from the uMWP to its new ‘zone’ with reduced supply from the Durban Heights and Hazelmere WTWs would become the normal mode of operation for the uMWP and Mgeni systems after commissioning of the uMWP.

The raw water tunnel is a critical component of the raw water transfer infrastructure for the uMWP and its integrity needs to be carefully monitored at pre-planned intervals. For this reason, it is planned that the tunnel will be shut down periodically for routine inspection and maintenance activities. Each planned shutdown would be for a three-week period, every 10 years commencing in 2024 (Pieterse, 2012).

During this shutdown period, water supply to the future uMWP supply zone would have to be maintained. One option to maintain water supply during a tunnel shutdown is to construct a balancing dam in the Baynesfield area that would provide a supply of water to the proposed uMWP WTW during the time that the tunnel is not in operation. The Baynesfield Dam is however an expensive option and the DWS queried whether the construction of the dam could be delayed.

Delaying the construction of the Baynesfield Dam can only be achieved if the Mgeni System has spare capacity to take over the demand from the uMWP supply zone during the time that the tunnel is shut down.

The DWS and UW therefore requested that Knight Piésold investigate whether the Mgeni system would have spare capacity to cater for the shortfall in supply if the uMWP did not operate for a period of three weeks in the tunnel shutdown years 2024, 2034 and 2044.

A simplified schematic diagram of the combined Midmar, Durban Heights and Hazelmere systems was drawn up and demands were allocated to reservoir supply zones in accordance with the demand forecast for the relevant tunnel shutdown year. Taking cognisance of the capacities and limitations of the existing WTW and bulk pipeline infrastructure, the water available at the Midmar, Durban Heights and Hazelmere systems was distributed to the various reservoir zones for each shutdown year. If the total system demand for a shutdown year could be met from the Mgeni and Hazelmere systems, the intervention was considered a success. Where a shortfall in demand occurred, the intervention was considered a failure.

The analysis results indicated that revised operating rules would only be successful in delaying the need for a balancing dam at Baynesfield during the planned 2024 shutdown. No subsequent shutdowns could be carried out without providing some form of storage in the Baynesfield region that could supply water to the uMWP WTW during a tunnel shutdown. Potable water storage within the UW and EWS water supply systems is not designed to cater for a three week shutdown.

The schematic diagrams and analysis results are presented in **Report Number 108/114/12/R6** titled **Revised Mgeni System Operating Rules During uMkhomazi Raw Water Tunnel Shutdowns**.

9. Projected Water Demands

A detailed demand projection exercise was undertaken to determine the water demand that the project would need to cater for. Full details of this exercise are contained in **Report Number 108/114/12/R3** titled **Water Demand Projections and Phasing of Infrastructure**. The projected demand curve as determined in the Water Demand report is depicted in **Figure 4**.

The design period for the potable water module of this project is 30 years, i.e. 2023 to 2053. The Low Road scenario depicted in **Figure 4** was considered by the uMWP PMC to be the most realistic and was adopted for use in the Module 1 and Module 3 studies. The projected demand in the year 2053 is 685 Ml/day.

Figure 4 also depicts the 1:100 year yield of Smithfield Dam, excluding Impendle Dam. The total projected water demand will exceed the Smithfield Dam yield in the year 2044 when demand is expected to reach 602 Ml/day. It is however possible to phase the uptake of demand so as not to exceed the yield of the system as indicated in **Figure 4**.

The phased uptake in demand can be achieved by allowing portions of the Mgeni System demand to remain with Durban Heights WTW.

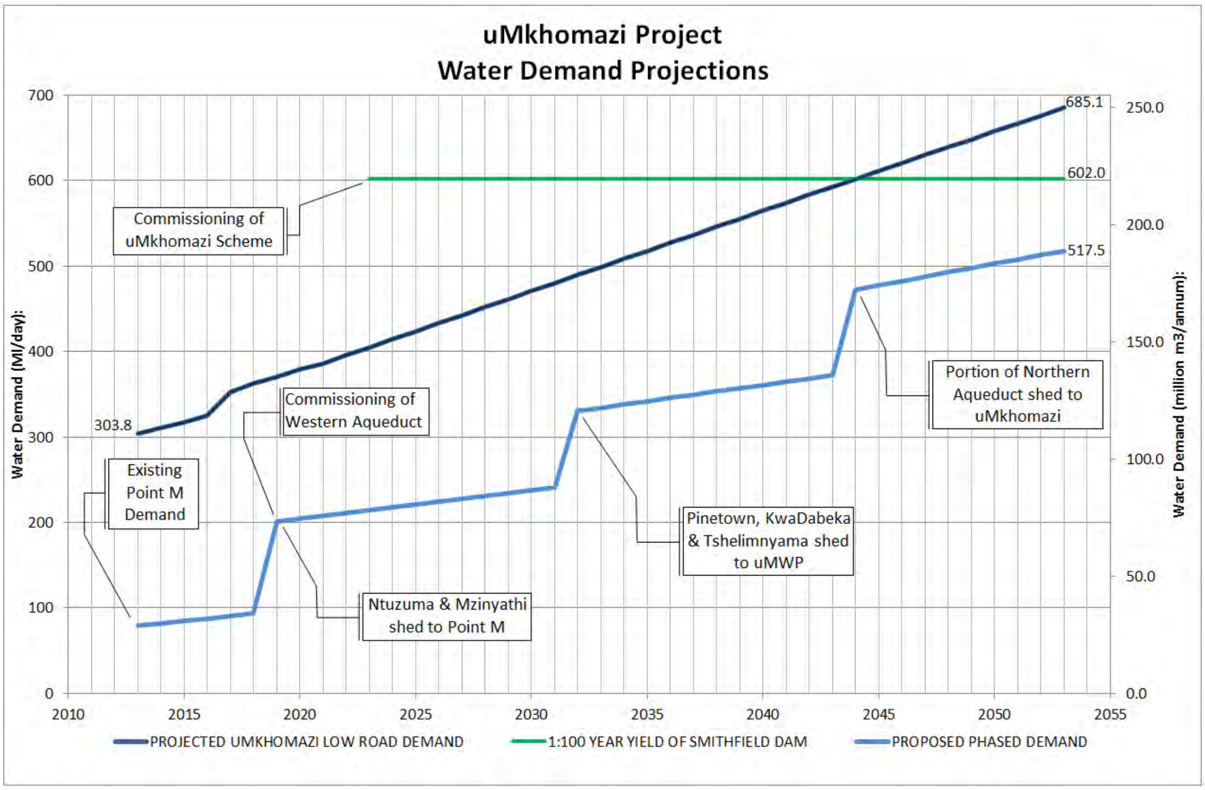

Figure 4: Projected Water Demands

10. Water Treatment Works

10.1 WTW Capacity

An initial phasing of the WTW was proposed based on a phased water demand curve. This initial phasing proposed that the first WTW phase have a capacity of 375 Ml/day upon commissioning in 2023, with an augmentation in 2038 of 250 Ml/day, taking the capacity to a total of 625 Ml/day. As the WTW is designed in 125 Ml/day modules, this would require four modules to be built in 2023 with a further two in 2038. This proposed phasing is represented in **Figure 5** by the curve titled **PROPOSED WTW CAPACITY (INITIAL RECOMMENDATION)**.

As the outcome of a report titled "*The uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study, Raw Water - Water Resources Planning Model Report*", relating to the risk of failure in the Mgeni system in relation to the utilisation of the Smithfield Dam, DWS advised the uMWP PMC, that if the initial proposed WTW phase of 375 Ml/d was adopted, the available storage in Smithfield Dam would be underutilised while the Mgeni system would be exposed to supply violations from 2028 (AECOM: 2015, p. 4-2). In order to limit the risk of a supply violation, a further 125 Ml/d WTW module would be required in 2028 to bring the WTW capacity to a total of 500 Ml/d. Given the relatively short time frame between the commissioning of the initial 375 Ml/d phase in 2023 and the subsequent increase to 500 Ml/d in 2028, the uMWP PMC agreed to adopt a capacity of 500 Ml/day for the first phase of the WTW. A further 125 Ml/day increase to 625 Ml/day would be required in 2044. Five WTW modules would therefore be required in 2023, with a sixth in 2044. This proposed phasing is represented in **Figure 5** by the curve titled **PROPOSED WTW CAPACITY (BASED ON DWS WRPM REPORT)**.

For demonstrative purposes, a curve has been included in **Figure 5** that depicts the latest possible dates for the commissioning of various phases of the WTW. These latest commissioning dates match the latest dates on which demand can be shed from the Durban Heights System to the uMkhomazi System. This latest possible phasing is not considered to be practically implementable and is included for demonstrative purposes only. This proposed phasing is represented in **Figure 5** by the curve titled **PROPOSED WTW CAPACITY (LATEST COMMISSIONING DATES)**.

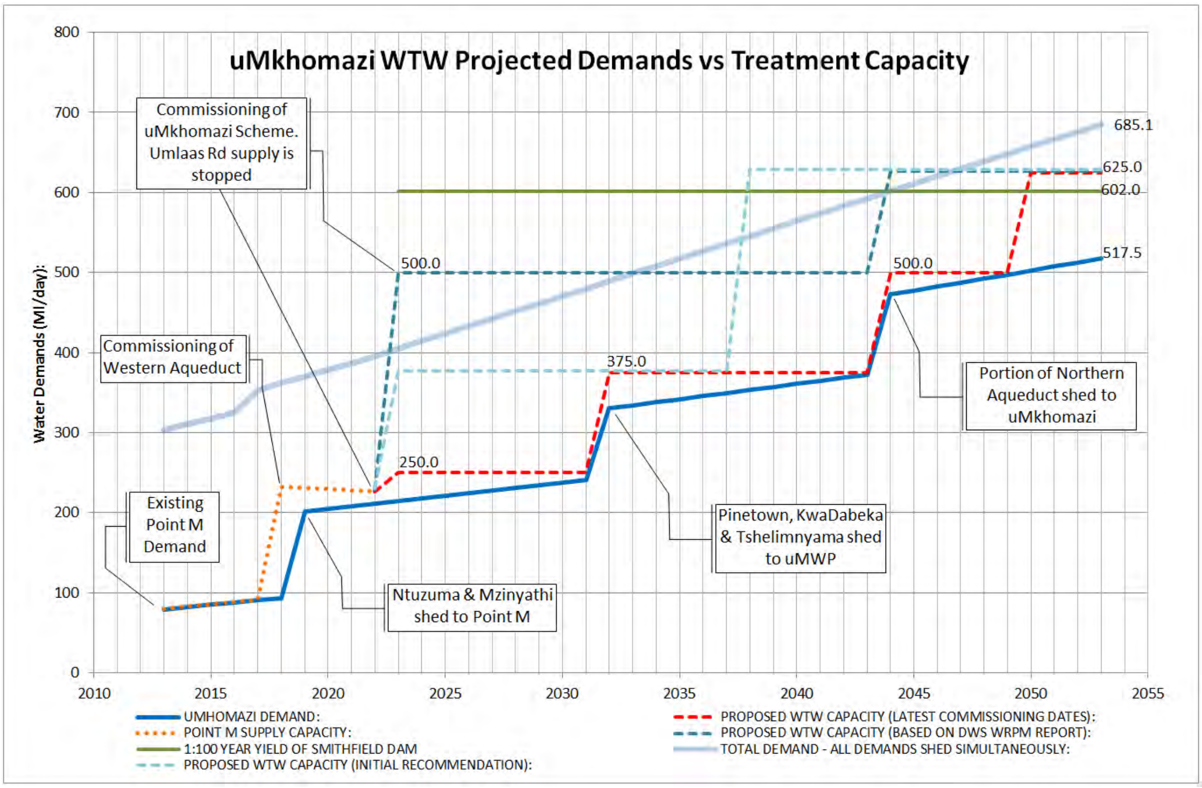

Figure 5: Proposed WTW Phasing

10.2 Water Treatment Works Location:

The following five WTW sites were initially investigated. These sites are depicted in **Figure 6.**

- Baynesfield 1 (B1)
- Baynesfield 2 (B2)
- Baynesfield 3 (B3)
- Mapstone 1 (M1)
- Crookes 1 (C1)

The B1 and C1 sites were excluded from further investigation as a result of landowner objections. In addition, the C1 site had a large imbalance in earthworks cut and fill quantities that would require large volumes of material to be spoiled off site. The remaining three sites were investigated in detail.

A full description of the WTW site investigations undertaken is included in **Report No. 108/114/12/R4-1 Pipeline Design Report – Volume 1**.

The above report recommended that the WTW be located at the B2 site. The recommended WTW site is depicted in **Drawing No. 30300413/B02-02** in **Volume 2** of this report.

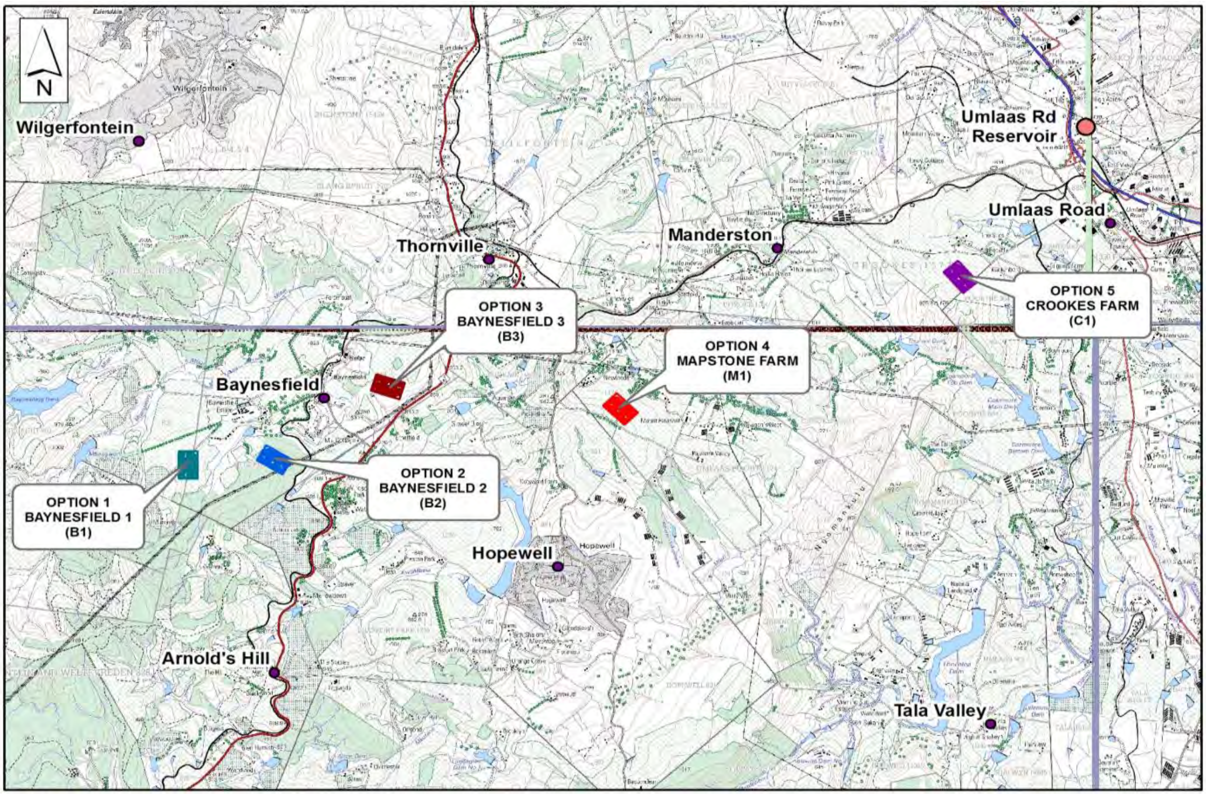

Figure 6: Water Treatment Works Locations

10.3 Water Treatment Works Technology:

The proposed WTW layout was constrained by the requirement for gravity supply in the overall system between Smithfield Dam and the Umlaas Road tie-in, as well as by the necessity to keep the total WTW footprint to a minimum. The proposed plant layout combines features of accessible and compact unit process configuration, minimum lengths of interconnecting pipework, minimum volume of excavation and ease of future extension.

Based on the water quality and physical-chemical assessment of the raw water, it was recommended that conventional water treatment technology, as typically applied in river water treatment plants, would be the most appropriate for the uMkhomazi WTW. The treated water would comply with the SANS 241: 2011 Drinking Water guidelines.

Figure 7 depicts the process flow diagram showing the unit processes proposed for the WTW. The layout of the proposed WTW is depicted in **Figure 8**. Detailed technical information on the WTW design is contained in **Report Number 108/114/12/R5** titled **Water Treatment Works Conceptual Design**. Drawing numbers **1301.X01.UW-110** and **1301.X01.UW-100** included in **Volume 2** of this report depict the WTW processes and layout.

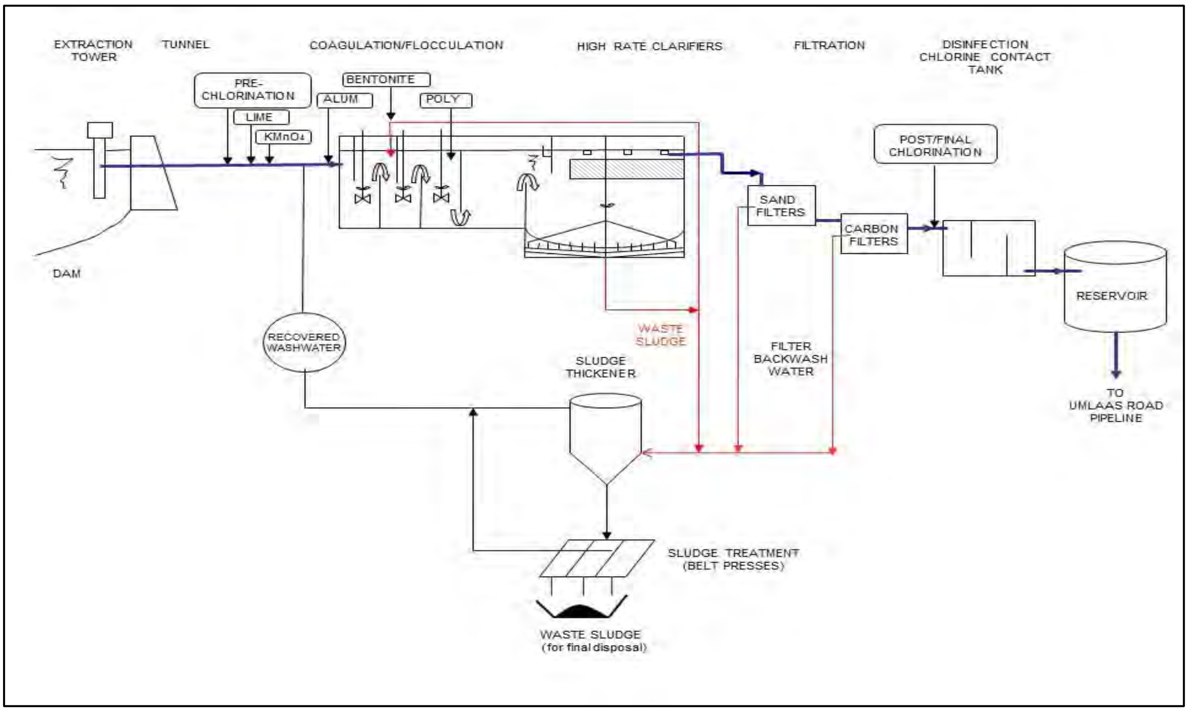

Figure 7: WTW Process Flow Diagram

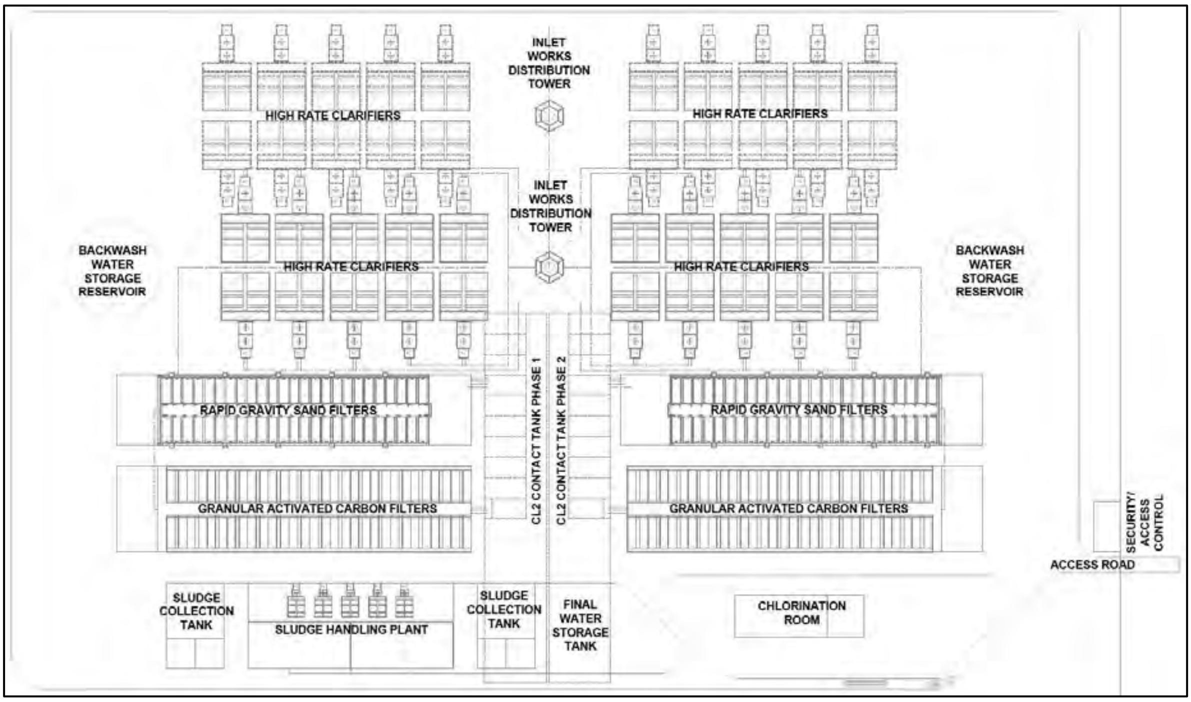

Figure 8: Proposed WTW Layout

The following water treatment processes and auxiliary facilities have been proposed:

1. Pre-chlorination, water stabilisation with lime and iron and manganese oxidation with potassium permanganate at or upstream of the inlet works of the plant.

2. Coagulation with alum using mechanical mixing to achieve the desired mixing intensity. Hydraulic or static mixers were not recommended as they would increase the total head required between the start and end of the WTW process.

3. Flocculation with an organic polyelectrolyte using mechanical mixing to achieve the desired mixing intensity. To reduce hydraulic losses, hydraulic mixing methods for flocculation were not recommended.

4. Clarification/sedimentation using high-rate clarifiers that may employ bentonite as ballasting agent and will include micro-flocculation or sludge recirculation for the rapid formation of heavy flocs. These high rate clarifiers significantly reduce the overall plant footprint. For Phase 1, these high-rate clarifiers would operate at relatively low linear upflow rates of 4.5 m/h. It is recommended that UW gradually increase the throughput in order to meet the actual design upflow rates of 9.0 m/h by the time Phase 2 is being implemented.

5. Rapid gravity sand filters with a dual-media bed of anthracite and silica sand to ensure maximum floc penetration and filter run times. Double bed filters will be used with a normal filtration rate of 8.75 to 10 m/h. Backwashing will be done using both air and water.

6. Granular activated carbon (GAC) filtration was recommended as a polishing step because the raw water presently shows high dissolved organic carbon (DOC) values. GAC filtration has been allowed for in the plant design, but may not be implemented initially. The source water should be closely monitored with regards to total organic carbon (TOC)/DOC and should it become more enriched with nutrients, the GAC polishing step will become necessary for the removal of organic material. GAC filters will have a double-bed configuration so that an upflow-downflow operation sequence can be achieved.

7. Chlorination using chlorine gas has been allowed for to also give residual disinfection capability to prevent contamination of the final water in the water distribution system. The chlorination installation will allow for the application of chlorine to the raw water (pre-chlorination) as well as the final water (post-chlorination).

8. Final water will be stored on site in an 80 000 m^3 intermediate tank to serve the plant's final water demand, with a retention time of 3 hours. This will provide sufficient storage capacity to provide for emergency backwash water for sand and carbon filter backwashing for 2 days.

9. An additional potable water reservoir serving the distribution system downstream, has been provided for balancing storage as described in **Report No. 108/114/12/R4-1 Pipeline Design Report - Volume 1**.

10. Various auxiliary facilities have also been included in the WTW design. These will be vital for the successful operation of the plant:

    i. Facilities at the plant will include a control room, laboratory, operator change rooms and ablutions, chemical make-up and storage area and general storage areas. Site services will include security fencing with access control, flood lighting, access road to the plant, sanitation, safety equipment and adequate drainage.

ii. Chemical storage and dosing of all chemicals coagulants and flocculants, including alum, potassium permanganate, lime, polyelectrolyte, bentonite and chlorine. Dry feeding of alum, lime, potassium permanganate and bentonite is suggested, while provision will be made for the preparation and dosing of dry as well as liquid polyelectrolyte.

iii. The chlorination equipment will be housed in a separate building from all other chemicals for safety reasons. All necessary safety equipment as well as a chlorine neutralisation scrubber system would have to be provided.

iv. Clarifier underflow, sand filter backwash and GAC filter backwash water will be collected and treated in a dedicated sludge handling facility on site. The water recovered by this facility will be returned to the inlet works of the plant while the thickened and dried final sludge will be disposed of off-site.

v. The final, waste sludge produced will be 45 t/day at 50% (m/m) dry solids (DS) content and can only economically be produced when using belt press sludge dewatering technology. If centrifuges are used, only 25% (m/m) DS will be achieved, resulting in double the volume of sludge that has to be disposed of.

vi. Final sludge could be used for brick manufacturing. This will be the most environmentally friendly way to dispose of sludge and will reduce the overall carbon footprint of the plant.

11. Potable Water Reservoir

Umgeni Water requested that the potable water reservoir be sized to accommodate a minimum of six hours of storage based on the WTW capacity. Based on the WTW phasing proposed in **Section 10.1**, the first 500 Ml/day WTW phase would require 125 Ml of storage, with a further 31.25 Ml of storage required when the next 125 Ml/d phase is constructed in 2044, i.e. a total of 156.25 Ml of storage for Phase 1 of the uMkhomazi scheme. If the WTW was developed to its ultimate size of 1250 Ml/day when Phase 2 is fully developed, 312.5 Ml of storage will be required.

The storage volume required for the full 625 Ml/d capacity of the uMWP-1, results in a reservoir with a very large footprint of 2.2 hectares. Since land would have to be reserved for the ultimate size of WTW and reservoir, the ultimate size reservoir would have a footprint of 4.4 hectares. UW's Environmental Services noted their concern about the combined 23 hectare footprint that would be required for the WTW and reservoir and requested that the footprint be reduced as far as practically possible.

In light of this requirement to minimise the overall WTW-reservoir footprint, it was proposed that potable water storage be constructed beneath various WTW structures.

There are three proposed reservoir complexes. Complex no. 1 will have a size of about 132 Ml and will be located beneath the left bank of Granular Activated Carbon Filters and Sludge Handling Plant. Complex no. 2 will have a size of 38 Ml and will be located beneath the Sludge Collection Tank and Wash-water Recovery Tank. Complex no. 3, required for Phase 2 of the uMWP, will have a size of 132 Ml and will be located beneath the right bank of Granular Activated Carbon Filters and the Chlorine Room.

As a result of being located beneath roads and various structures required for the initial 500 Ml/day WTW, complexes 1 and 2 will have to be completed with the first WTW phase. This will give a total storage volume of 170 Ml, which is sufficient to meet the storage requirements of Phase 1 of the uMWP when fully developed.

The proposed potable water reservoir complexes are depicted in **Figure 9** with a larger scale drawing included as **Drawing Number 30300413/G13** in **Volume 2** of this report. Further information on the potable water reservoir investigations is provided in **Report No. 108/114/12/R4-1, Pipeline Design**.

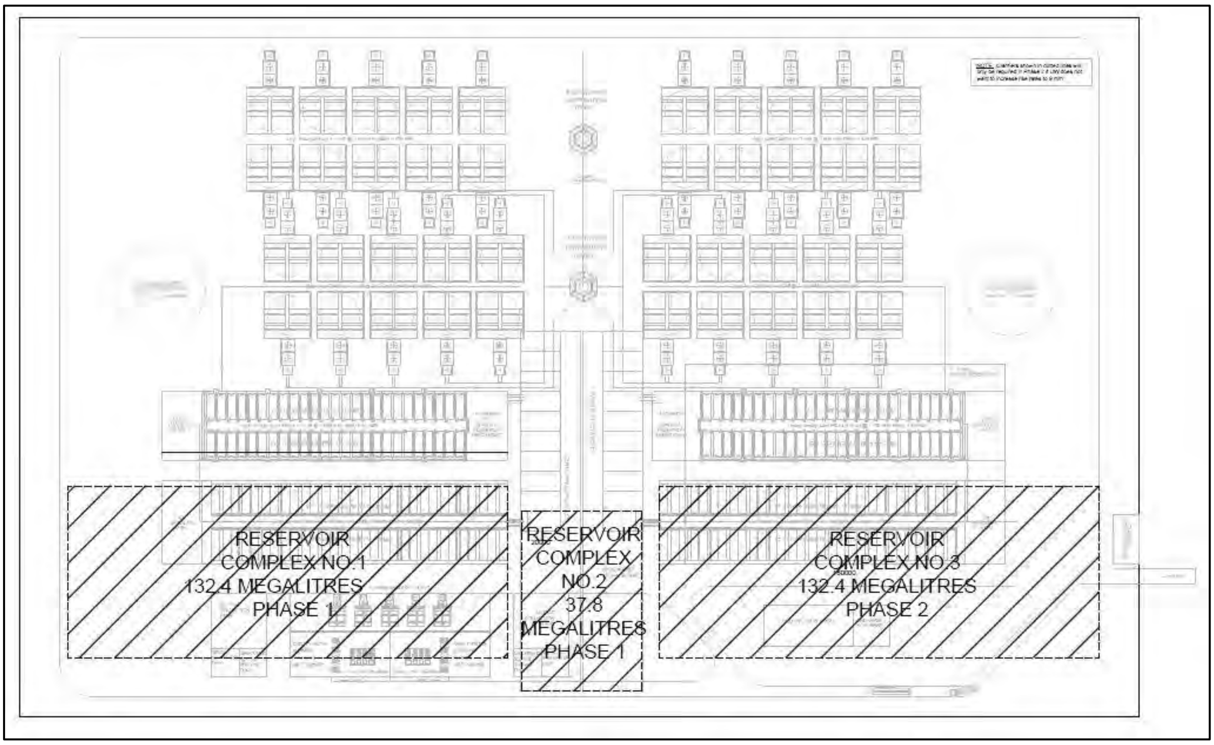

Figure 9: Proposed Potable Water Storage

12. Potable Water Pipeline

12.1.1 Pipeline Route Options

Pipelines route options B1, B2, B3, M1 & C1 depicted in **Figure 10** were initially investigated. Full details of these investigations are contained in **Report No. 108/114/12/R4-1, Pipeline Design**. Each route is differentiated by the position of the WTW associated with the route. Options B1 and C1 were ruled out when the WTW sites associated with them were excluded from the study as described in **Section 10.2**.

The remaining three route options B2, B3 and M1 were investigated in detail. A detailed cost analysis of each option found that route option B2 was the least expensive as a result of having the shortest length of all the pipeline routes.

Option B2 was therefore recommended as the preferred pipeline route. Maps of the proposed B2 route showing pipeline alignment as well as permanent and temporary servitudes are included in **Volume 2** of this report.

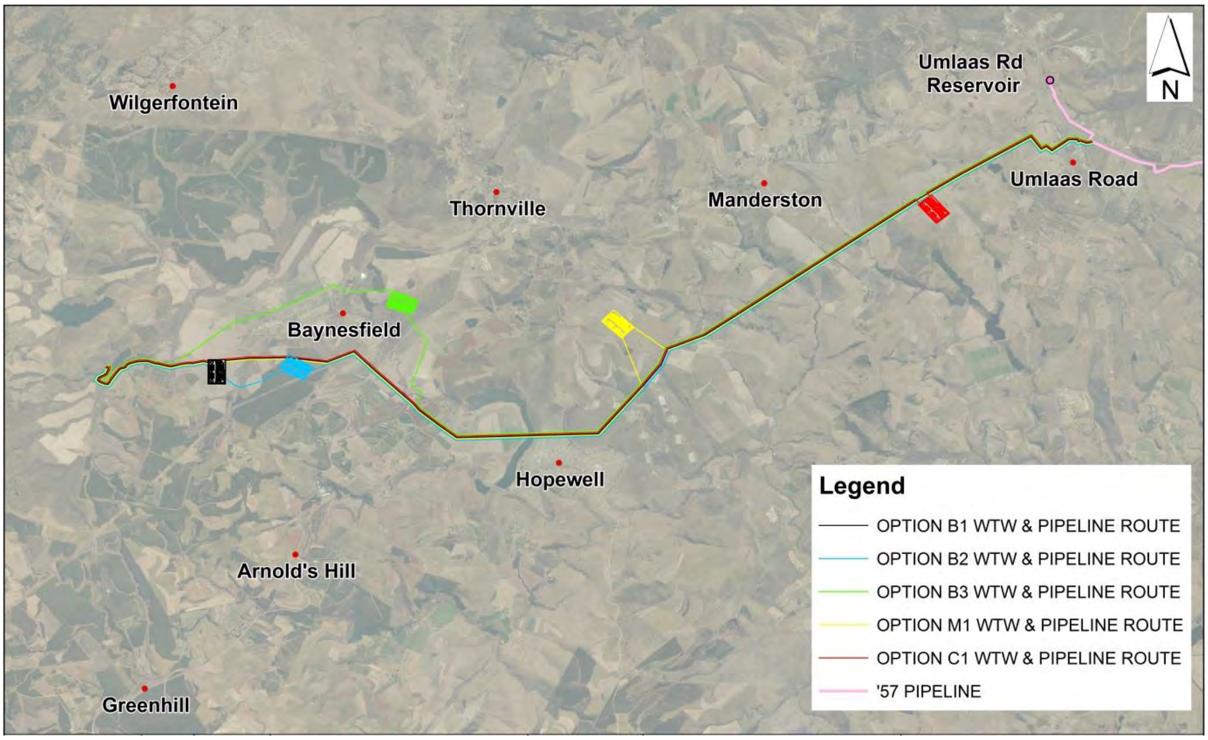

Figure 10: Proposed Pipeline Routes

12.1.2 Route Alternatives

The routes investigated in **Section 12.1.1** generally follow the shortest path between Baynesfield and Umlaas Road that allows gravity flow. As a result, all these routes cross Mapstone Dam.

Although feasible options were developed for the crossing of Mapstone Dam, it was considered prudent to investigate alternative routes that do not require the pipeline to cross the dam. In this regard, pipeline routes to the north and south of Mapstone Dam were investigated as described in **Sections 12.1.2.1** and **12.1.2.2**.

In addition to the routes investigated in **Section 12.1.1**, two alternatives around Mapstone Dam were investigated. These routes were considered

12.1.2.1 Alternate Northern Route

The alternate northern route depicted in **Figure 11** is challenging as a result of the requirement to bench the pipe into a steep slope over approximately 1.8 kilometres of its length. The pipeline or pipelines would need to be benched into the side of the slope within a very specific elevation range. A level too high would result in the pipeline being located higher than the hydraulic grade line, which would prevent gravity flow.

Detailed investigations indicated that benched platforms of up to 39 metres in width and 29 metres in height would be required to facilitate construction along this alternate route. This route was ruled out by the uMWP-1 PMC due to the difficult terrain through which the pipeline would be required to be constructed.

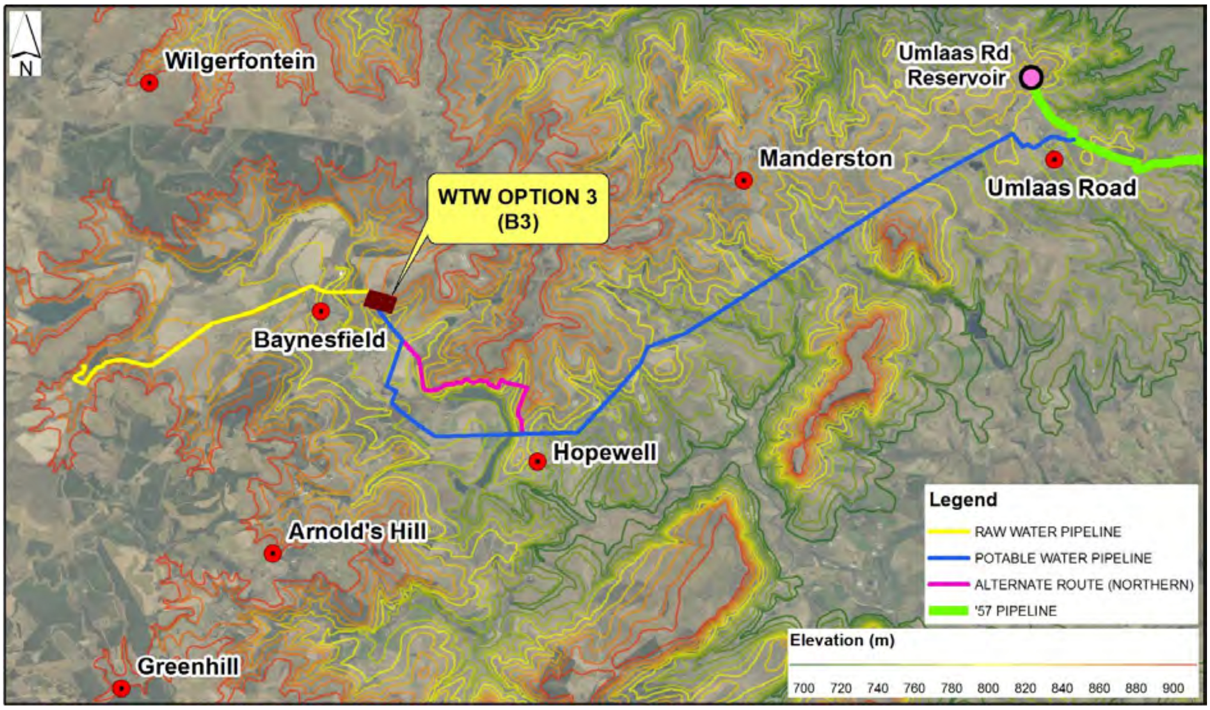

Figure 11: Alternate Pipeline Routing North of Mapstone Dam

12.1.2.2 Alternate Southern Route

A technically feasible route around the south side of Mapstone Dam was found that allows gravity flow. This route is depicted in **Figure 12**.

The southern alternative route adds approximately 3.4 kilometres to the pipeline length, which results in an additional cost of about R 157 million. This cost is considerably higher than the most expensive Mapstone Dam crossing option at R 47 million.

Although more expensive, the proposed southern route does provide an alternative should it be required.

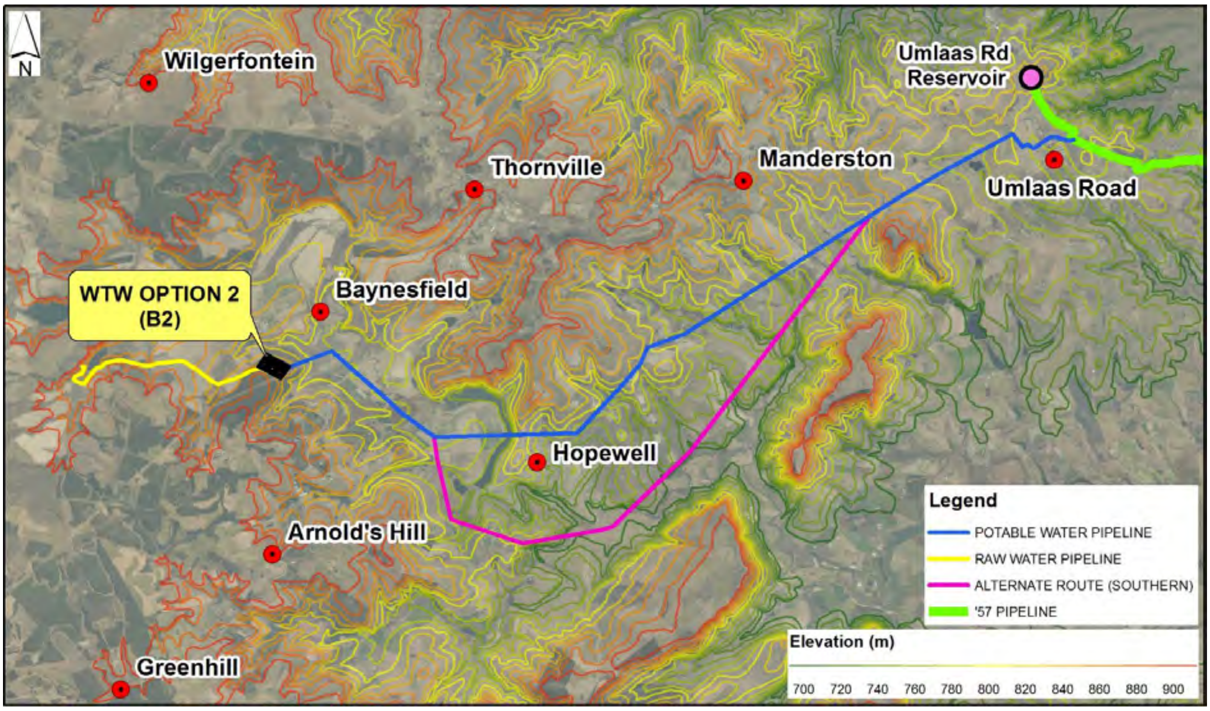

Figure 12: Alternate Pipeline Routing South of Mapstone Dam

12.1.3 Pipeline Crossing of Mapstone Dam

As discussed in **Section 12.1.2**, all proposed pipeline routes with the exception of the alternative northern and southern routes are required to cross Mapstone Dam as depicted in **Figure 13**. The pipeline has been routed to cross the dam at its narrowest section measuring 120 metres.

Figure 13: Location of Mapstone Dam crossing

The crossing options considered along with their estimated capital costs are listed below. Each of these options is reported on in more detail in **Report Number 108/114/12/R4-1** titled **Pipeline Design**.

- Pipe buried in the dam basin, R 6.2 million (**Figure 14**).
- Suspension bridge spanning the entire dam, R 47.0 million (**Figure 15**).
- Steel pipe bridge on concrete support piers, R 9.5 million (**Figure 16**).
- Pipe spanning between concrete piers, R 7.1 million (**Figure 17**).

Larger scale drawings of the dam crossing options have been included in **Volume 2** of this report.

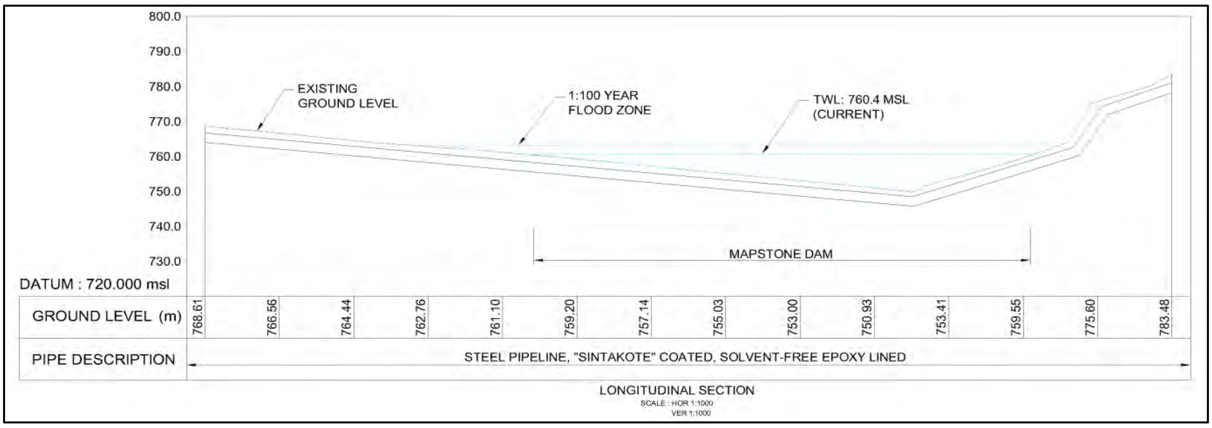

Figure 14: Pipe Buried Through Dam

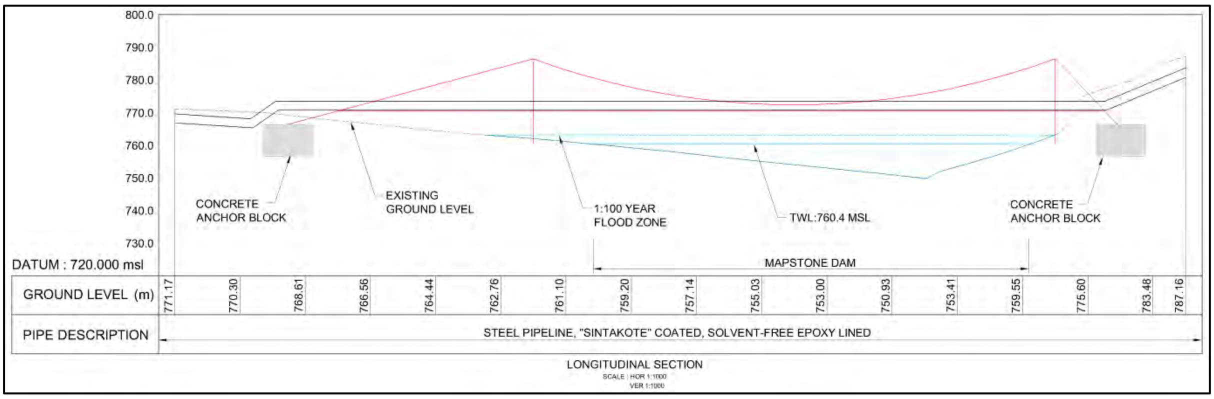

Figure 15: Proposed Suspension Bridge

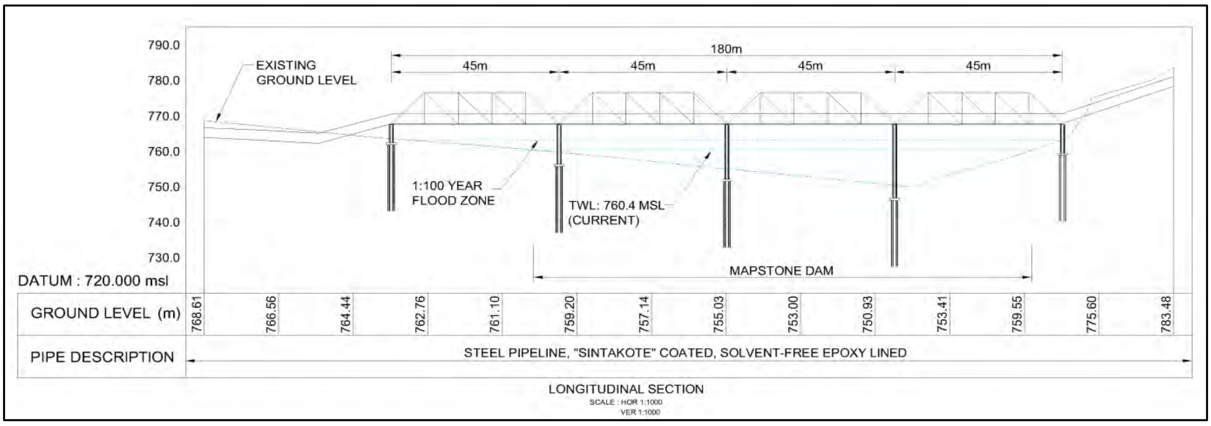

Figure 16: Steel Pipe Bridge

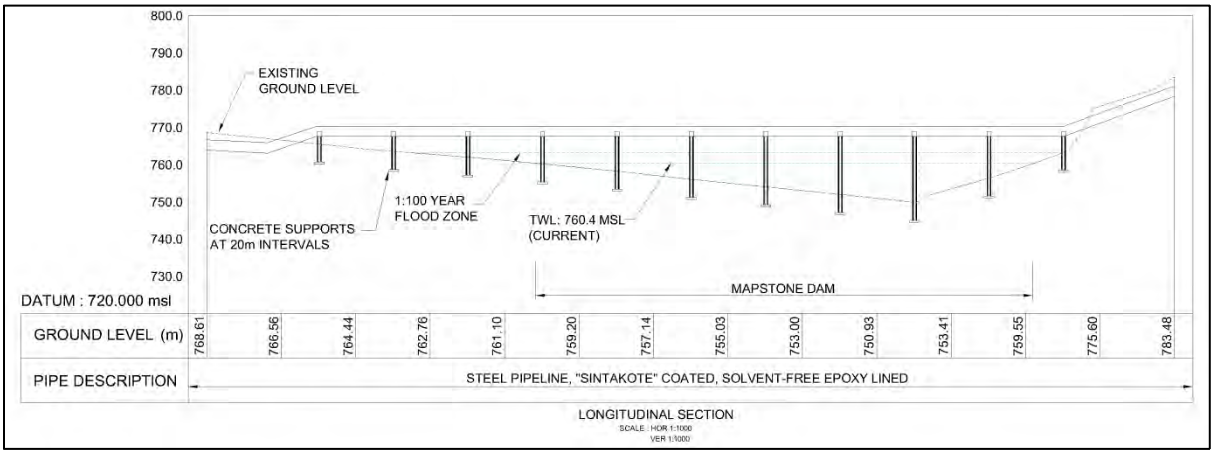

Figure 17: Pipe on Concrete Piers

12.1.3.1 Recommendation for Crossing Mapstone Dam

At a meeting with Mr. E. Mapstone, the Chairman of the Upper Umlaas Irrigation Board that manages Mapstone Dam, Mr. Mapstone advised that all options to cross the dam with a bridge or pipeline above the dam water level were not supported as they created a security risk for the farmers by breaching the barrier created by Mapstone Dam.

Mr. Mapstone advised that the preferred method of crossing the dam was by burying the pipe though the dam. This would require the dam to be drained.

Mr. Mapstone proposed a methodology for draining the dam while mitigating the consequences to downstream irrigators. This would require the raw water module of the project to be commissioned prior to Mapstone Dam being drained. The uMWP raw water system would then maintain a supply to irrigators during the period that Mapstone Dam would be drained and in addition, would be used to refill the dam when the crossing is completed. Further details of the meeting with Mr. Mapstone and the proposed emptying of the dam are contained in **Report Number 108/114/12/R4-1** titled **Pipeline Design Report – Volume 1**.

A buried pipe through the dam was adopted by the uMWP-1 PMC as the preferred means of crossing Mapstone Dam. Although the pipe buried is preferred, the suspension bridge option has been used for costing purposes to cater for the worst case scenario.

12.1.4 Pipeline Design Capacity

The design capacity selected for the pipeline is 602 Ml/day. This figure is an average annual daily demand (AADD) and has been selected to match the 1:100 year yield of Smithfield Dam. The factors considered in determining the pipeline design capacity are described in **Report Number 108/114/12/R4-1** titled **Pipeline Design Report – Volume 1**.

The peak design flow rate for the pipelines is 753 Ml/day, which is equivalent to the AADD with a peak factor of 1.25.

12.1.5 Pipeline Configuration Options

To convey the peak demand of 753 Ml/day, three possible pipeline configurations were investigated in this study, namely:

4. Single Pipeline Configuration: A single pipeline sized to convey a peak flow of 753 Ml/day.
5. Double Equal Pipeline Configuration: Two pipelines of equal capacity, each sized to convey a peak flow of 377 Ml/day or a total combined flow of 753 Ml/day. For this option, both pipelines will be commissioned in the year 2023, i.e. the planned commissioned date for the uMkhomazi Water Project.
6. Double Unequal Pipeline Configuration: Two pipelines of unequal capacity intended to be built in two phases. The first phase, to be commissioned in 2023, will be sized to match the peak capacity of the Western Aqueduct pipeline, i.e. approximately 490 Ml/day. The second phase, to be commissioned around 2044, will be sized to provide a further 263 Ml/day to give a total capacity of 753 Ml/day.

The three configurations above were investigated for each of the pipeline route options, i.e. B2, B3 and M1 as described in **Section 12.1.1**.

12.1.6 Hydraulic Analysis Results

Each of the Single, Double Equal and Double Unequal pipeline configurations described in **Section 12.1.5**, was modelled for each of the proposed B2, B3 and M1 pipeline routes. The outcome of the hydraulic analyses was a recommended pipeline diameter for each route and configuration option. The results are presented in **Table 2**. The results in **Table 2** should be interpreted as follows:

For the B2 route option (for example), the Single Pipeline configuration would require a 3030mm OD raw water pipeline, 2820mm OD pipeline for Section 1 of the potable water pipeline route and a 2540mm OD pipeline for Section 2 of the potable water pipeline route.

Section 1 of the potable water pipeline route refers to the pipeline between the WTW at Baynesfield and a high point along the route that occurs at Crookes Farm. Section 2 refers to the pipeline from Crookes Farm to the tie-in at Umlaas Road. Sections 1 & 2 are depicted in the pipeline longitudinal section drawings included in **Volume 2** of this report.

Table 2: Hydraulic Modelling Results

ROUTE OPTION:	CONFIGURATION OPTION:	RAW WATER PIPELINE OD:	POTABLE WATER PIPELINE OD (SECTION 1 UP TO HIGH POINT):	POTABLE WATER PIPELINE OD (SECTION 2 UP TO UMLAAS RD):
B2:	Single	3030 mm	2820 mm	2540 mm
	Double Equal	2337 mm	2234 mm	1829 mm
	Double Unequal Phase 1	2540 mm	2450 mm	2032 mm
	Double Unequal Phase 2	2032 mm	1930 mm	1524 mm
B3:	Single	3030 mm	2820 mm	2540 mm
	Double Equal	2337 mm	2234 mm	1829 mm
	Double Unequal Phase 1	2540 mm	2450 mm	2032 mm
	Double Unequal Phase 2	2032 mm	1930 mm	1524 mm
M1:	Single	3030 mm	3330 mm	2540 mm
	Double Equal	2286 mm	2540 mm	1829 mm
	Double Unequal Phase 1	2540 mm	2820 mm	2032 mm
	Double Unequal Phase 2	2032 mm	2450 mm	1524 mm

13. Summary of Geotechnical Investigations

13.1 Raw Water Pipeline Route

The detailed findings of the geotechnical investigations for the raw water pipeline route can be found in the report **108/114/12/R8-1 Geotechnical Investigation Report – Volume 1 (Raw Water Pipeline).**

According to the published geological map, 2930 DURBAN (1:250 000 scale), the site is generally underlain by the Pietermaritzburg Group. This group belongs to the Karoo Supergroup, with strata made up of mostly shale, siltstone and sandstone. Dolerite intrusions in the form of sills and dykes are found scattered in the area.

Two main soils were encountered along the pipeline route, namely colluvial sandy clays and residual shale. The residual shale weathers to a silty and clayey material with minor occurrences of sand and gravel.

Two broad geological zones were identified on the raw water pipeline route, i.e. Zones A and B. Both Zone A and Zone B are equally distributed over the area. Zone A is characterized as generally shallow rock, where bedrock and/or residual soils were encountered within the reach of the TLB (3m). Transported soils exceeding 3m in thickness overlying relatively thick residual shale were encountered in Zone B.

Slight water seepage was encountered only once along the proposed route at a depth of 3,2m at test pit RW05.

In terms of the defined excavatability categories, no hard rock was encountered within the reach of the TLB that would require blasting during construction.

The material along the pipeline routed was deemed unsuitable for bedding material due to its high plasticity characteristics.

The soils encountered at the potable water pipeline and alternative pipeline route are generally corrosive to mildly corrosive towards steel. The pipeline will therefore require cathodic protection.

13.2 Potable Water Pipeline Route

The detailed findings of the geotechnical investigations for the potable water pipeline route can be found in the report **108/114/12/R8-2 Geotechnical Investigation Report – Volume 2 (Potable Water Pipeline).**

It should be noted that no geotechnical investigations were carried out for a 7.8 kilometre section of the pipeline route as the landowners refused access to the geotechnical team. The geotechnical conditions for this section of pipeline are therefore unknown.

According to the published 1:250 000 scale geological map, 2930 DURBAN, the potable water pipeline is generally underlain by the Dwyka and Pietermaritzburg Groups. These groups belong to the Karoo Supergroup, with strata made up of mostly shale, siltstone and sandstone. The oldest and lowermost formation of the Karoo Supergroup is the Dwyka Group, consisting mainly of tillite. Dolerite intrusions in the form of sills and dykes are found scattered in the area.

A contact between the tillite (east) and shale (west) is visible from the geological map and occurs just towards the west of the Mapstone Dam in close proximity of Hopewell. The contact occurs between test pits PL14 (shale) and PL15 (tillite).

Three main soil types were encountered along the pipeline route, namely colluvial sandy clays, residual shale and residual tillite. Both the residual shale and residual tillite comprise silty and clayey materials with minor occurrences of sand.

Due to the similarity of the silty sandy clays encountered in both residual shale and residual tillite, they were not regarded as two separate geologic zones for the purpose of the proposed pipeline. Instead two broad geologic zones were identified according to depth of weathering, viz. Zone A and Zone B. Most of the route comprises Zone B, with scattered areas of Zone A. Zone A is characterised by the presence of bedrock within the 3m reach of the TLB machine, while Zone B is characterised by relatively thick soil horizons (>3m).

Slight water seepage was encountered only once in Zone A at 0,3m depth and seven times in Zone B between a depth of 0,3m and 2,4m.

Zone B can easily be excavated to an average depth of 3m across the entire pipeline route, whereas Zone A has a TLB refusal depth of between 0,5m and 2,3m. Hard and intermediate excavation will occasionally be required in Zone A.

Blasting may be required from depths below 2.5 metres for a total length of about 800 metres along this route. In addition, blasting may also be required from depths below 3.5 metres for a total length of about 5 kilometres along this route.

The material along the pipeline route was deemed to be unsuitable for bedding material due to its high plasticity characteristics. It is not considered feasible to obtain bedding materials from borrow pits along the route, due to the widespread nature of fine-grained soils in the area. Spoil from the pipe trench excavation is however suitable for general backfilling, while the residual tillite soils comply with the relaxed bedding specification by the Department of Water & Sanitation.

The soils encountered at the potable water pipeline and alternative pipeline route are corrosive to mildly corrosive towards steel. The pipeline will therefore require cathodic protection.

13.3 Water Treatment Works Site

The detailed findings of the geotechnical investigations for the proposed WTW sites can be found in the report **108/114/12/R8-3 Geotechnical Investigation Report – Volume 3 (Water Treatment Works).**

It should be noted that for the Baynesfield 2 site, access was extremely limited as a result of the tree plantation. In order to conclusively determine the ground conditions at this site, some trees will have to be cut and drilling is recommended to the depth of the WTW structures and potable water reservoir foundations. At the time of conducting the geotechnical investigations, the cutting of trees was not possible and access to the site was limited by NCT Forestry.

Geotechnical investigations were conducted for the proposed WTWs for Options Baynesfield 2 and Baynesfield 3. The geotechnical investigation was conducted by means of excavation of test pits with a TLB machine across the site, where representative samples were collected for laboratory testing. DPL tests were also conducted at both sites in order to supplement the test pit information.

According to the published geological map, 2930 DURBAN (1:250 000 scale), the Baynesfield 2 and Baynesfield 3 sites are generally underlain by the Pietermaritzburg Group. This group belongs to the Karoo Supergroup, with strata made up of mostly shale, siltstone and sandstone. Dolerite intrusions in the form of sills and dykes occur in scattered areas of the Baynesfield 2 and Baynesfield 3 sites.

Two broad geological zones were identified at each of the sites. Zone A and Zone B (with sub-zones B1 and B2) occur at the Baynesfield 2 site while Zone C and Zone D occur at the Baynesfield 3 site.

Zone A at the Baynesfield 2 site contains thick soil profiles to mostly 3m depth containing colluvium overlying residual dolerite. Numerous dolerite cobbles and boulders were encountered in this area. Zone B1 contains thin soil profiles of maximum 1,4m thickness comprising colluvium overlying shale bedrock or residual shale. Zone B2, at the southern portion of the site, contains soil profiles of up to 2,7m depth, consisting of colluvial soil overlying residual shale, which transitions with depth to very soft rock shale.

Zone C at the Baynesfield 3 site contains thin soil profiles of between 0,5m and 1,4m consisting of colluvial soil overlying residual shale or very soft rock shale. Zone D contains colluvium, which is underlain by residual dolerite to at least 3m depth. The contact between the shale and dolerite traverses the site in an east to west direction.

All the materials at the site are low in potential expansiveness, while most of the materials contain a pinhole voided soil structure, which might be prone to collapse settlement upon wetting.

No water seepage was encountered in any of the test pits at both the Baynesfield 2 and Baynesfield 3 sites during the investigation. The presence of ferricrete is an indication of a fluctuating ground water table and therefore measures should be in place to deal with possible groundwater.

Foundation recommendations for the Baynesfield 2 and Baynesfield 3 sites are provided in **Report No. 108/114/12/R8-3 Geotechnical Investigation Report – Volume 3 (Water Treatment Works)**. Due to shallow soil profiles and more cost effective conditions it is recommended that most of the heavy structures at the Baynesfield 2 and Baynesfield 3 sites be constructed in Zone B1 and Zone C respectively.

The soils at the Baynesfield 2 site are mildly corrosive to non-corrosive towards steel at the WTW site, while the soils are corrosive to non-corrosive at the Baynesfield 3 site.

13.4 Mapstone Dam Crossing

The detailed findings of the geotechnical investigations for the Mapstone Dam crossing can be found in the report **108/114/12/R8-4 Geotechnical Investigation Report – Volume 4 (Mapstone Dam Crossing).**

A total of five boreholes were drilled along the proposed alignment of the pipeline across Mapstone Dam. The drilling results indicated that unweathered tillite rock occurs at a relatively shallow depth of between three and seven metres along the pipeline alignment. The eastern bank is steep and is characterised by scattered tillite outcrop.

13.4.1 Recommendations for Laying Pipe in the Dam Basin

Pipe trench excavations along the dam floor will be required for the option of laying the pipe in the dam basin. The pipe will be concrete encased and the encasement should be founded on the highly weathered tillite rock that has a bearing capacity of around 800 kPa. The trench excavation will take place in fully saturated clayey soils and the trench sides will have to be sloped accordingly. The area must be dewatered during construction.

13.4.2 Recommendations for Bridge and Pier Foundations

It is recommended that foundations for the bridge piers or suspension bridge abutments be taken down to sound tillite. Rock anchoring for suspended structures can be done in the sound rock, which has good foundation properties.

13.5 Dealing with Spoil Material

A project of the magnitude of the uMWP-1 involving significant lengths of large diameter steel pipelines will generate a significant volume of spoil material. Based on Option B2, the volumes of spoil expected to be generated from the raw and potable water pipelines are 77000 m³ and 260000 m³ respectively. It is recommended that spoil material be dealt with as follows.

1. In the first instance, it should be a requirement of the construction contract to use as much excavated material as possible for backfilling of the pipeline. In this regard, the contractor should be required to set up a material processing operation near the construction site to sort usable material as well as blend borderline unsuitable material with better quality material.
2. The pipeline bedding and selected fill specifications should be relaxed as far as practically possible to allow the maximum excavated material to be reused without compromising the integrity of the pipeline. This is particularly important as Umgeni Water's bedding specification is very stringent and if strictly adhered to, would result in the contractor having to import all the material required for the pipe bedding and selected fill blanket.
3. After maximising the options above, excess spoil material could be used to rehabilitate existing borrow pits. Two sites were identified as described in **Report No. 108/114/12/R4-1**. This option would require environmental authorisation.
4. Spoil material could also be offered to farmers for use on their farms. This option would require environmental authorisation and would need to be carefully managed to mitigate possible negative knock-on effects to the receiving environment.

14. Topographical Survey and Landowner Details

A topographical survey of the proposed Option B2 pipeline route was conducted between 2013 and 2015. The detailed surveyor's reports have been included in **Report No. 108/114/12/R9**.

14.1 Survey

14.1.1 Primary Control

Primary control was completed in November 2013 in static mode recording. The survey procedure was to capture data on trig beacons in the area along the route in such a way as to be able to post process baselines between them.

14.1.2 Secondary Control

Secondary Control commenced in April 2014. This stage entailed the placement of 20 Secondary Control beacons. These were concreted into the ground and surveyed by checked GPS static observations and post processing at approximately 500 metre intervals along the accessible portions of the pipeline route.

14.1.3 Topographical Survey

The topographical survey of the route commenced in April 2014 and continued at intervals until December 2014. The method employed for the survey was RTK-GPS measurements of all relevant features within a specified 50 metre wide strip, i.e. 25 metres on either side of the proposed raw water and potable water pipe centre lines. Delays due to mature cane were unavoidable, as were 'no-go' portions of the route. A 7.5 kilometre long section of the potable water pipeline route could not be surveyed as the landowners refused access to the surveyor.

Additional topographical survey was completed in March 2015 for the upgrading of the R56/P315 intersection and the portion of P315 leading to the turn-off to the proposed water treatment works site. The route from the P315 across the Baynesfield farm to the railway line was also surveyed but the section through the wattle plantation could not be surveyed as access was denied.

14.1.4 Data Capture

The final stage was data capture of the surveyed pipeline routes for the generation of the proposed DTM and topographical features that would appear on the line mapping.

14.1.5 Aerial Survey

After the surveyor was refused permission to a 7.5 kilometre long section of the potable water pipeline route, UW appointed LRI to conduct a LIDAR survey. The appointment entailed an aerial survey of the proposed WTW site Option B2 and a 50m wide corridor along the proposed raw water and potable water pipeline routes for Option B2.

A high accuracy Digital Terrain Model (DTM) along with ortho-imagery and 0.5m interval contours derived from the LIDAR data was generated for the WTW site and pipeline route.

14.2 Landowner Data

14.2.1 Land Owners

The properties affected by the proposed raw and potable water pipeline routes were identified using GIS cadastral shape files obtained from Mkhambatini Municipality. A list of affected properties is provided in **Report No. 108/114/12/R9**.

14.2.2 Surveyor General Diagrams

Survey diagrams and data were requested from the Survey General's Office and land owner details were requested from the Deeds Office. Allowance was made for the calculation of boundary co-ordinates for the properties affected to enable servitude positions to be staked at the points that they cross boundaries. This was necessary as some of the farm diagrams were outdated.

The Surveyor General diagrams for the affected properties are provided in **Report No. 108/114/12/R9**.

15. Capital Cost Estimates

The results of the costing exercise are presented in **Table 3.** Detailed costing for the pipelines and potable water reservoir is presented in a separate Bill of Quantities for each pipeline route option in **Report Nos. 108/114/12/R4-2, R4-3** and **R4-4**. Detailed costs for the WTW are included in **Report No. 108/114/12/R5**.

The costs in **Table 3** include all the potable water module components, i.e. pipeline material supply and construction, land acquisition and crop compensation, the Mapstone Dam crossing, potable water reservoir, the WTW including internal and external access roads and Eskom power supply.

Table 3: Summary of Capital Costs

WTW LOCATION/ PIPELINE ROUTE:	COST R (MILLION):			
	SINGLE PIPELINE:	DOUBLE EQUAL PIPELINES:	DOUBLE UNEQUAL PIPELINES PH1:	DOUBLE UNEQUAL PIPELINES PH2:
B2:	R 3 074.33	R 3 446.88	R 2 807.87	R 678.90
B3:	R 3 290.36	R 3 715.72	R 2 942.79	R 712.97
M1:	R 3 369.44	R 3 801.15	R 3 013.63	R 875.16

16. Conclusions & Recommendations

In order to arrive at a recommended pipeline route option and configuration, a two-tier screening process was used as described below.

a) **First tier screening**: Given that there were no environmental fatal flaws with the B2, B3 and M1 route options and that there were no distinct technical advantages that would cause one option to be preferred over the others, the selection of a preferred pipeline route was based purely on cost.

The capital cost summary in **Table 3** shows that each pipeline configuration for Route Option B2 is less expensive than the respective configuration for Options B3 and M1. The main reasons for this are:

- The B2 route is shorter than the B3 and M1 route options.
- The WTW associated with the B2 route has the most equally balanced cut and fill volumes.

Given that it is the least expensive, the recommended pipeline route and WTW site is Option B2.

b) **Second tier screening**: Having settled on a pipeline route in (a) above, the Single, Double Equal and Double Unequal pipeline configurations were assessed for the B2 pipeline route.

Since the Double Unequal configuration requires a phased approach, a Net Present Value (NPV) analysis was carried out for each pipeline configuration for route Option B2, the results of which are listed in **Table 4**. Given that the WTW, potable water reservoir and access roads are common for all three pipeline configurations for the B2 option, their associated costs were excluded from the NPV analysis. The NPV analysis was carried out for discount rates of 6%, 8% and 10% over a 30 year analysis period.

Table 4: NPV Analysis Results

OPTION:	NPV (R MILLION);		
Discount rate:	6.0%	8.0%	10.0%
Single pipeline:	R1 266	R1 166	R1 076
Double equal pipelines:	R1 600	R1 472	R1 358
Double unequal pipelines:	R1 189	R1 037	R923

At a discount rate of 8%, the Double Unequal pipeline configuration has the lowest NPV and is R 129 million less than the next cheapest option, i.e. the Single Pipeline configuration. This ranking does not change for discount rates of 6% and 10%. The reason for the lower NPV for the Double Unequal pipeline option is the initial requirement of a smaller diameter pipeline and the postponement of R 679 million in capital expenditure to the years 2040 to 2044 when the second pipeline is proposed to be constructed.

The Double Equal pipeline option has the highest NPV. The reasons for this are:

- The overall cost of a single large diameter pipeline is less than the cost of two equal diameter pipelines due to the duplication of pipe laying activities. The cost of earthworks for the deeper trench required for a single larger diameter pipeline, is less than the cost of earthworks required for a shallower but wider trench for two smaller diameter double pipelines. In addition, the pipe supply costs for a single pipeline are lower than those of twin pipelines of equivalent capacity.

- Whereas the Double Unequal pipeline would be implemented in phases, the Double Equal option would be built in one phase. This option therefore does not benefit from deferring a portion of capital expenditure to a later date.

The Single Pipeline option will result in a scheme with a pipeline capacity of 602 Ml/day, equivalent to the 1:100 year yield of Smithfield Dam and will comprise a single 3030mm OD raw water pipeline and a single 2820mm OD potable water pipeline reducing to 2540mm OD.

The first phase of the Double Unequal pipeline option will result in a scheme with a pipeline capacity of 490 Ml/day, equivalent to the capacity of the Western Aqueduct and will comprise a single 2540mm OD raw water pipeline and a single 2450mm OD potable water pipeline reducing to 2032mm OD.

In present day terms, the Single Pipeline option costs R 129 million or 12.4% more than the first phase of the Double Unequal option, but provides 53% more pipeline supply capacity.

Drawing No. 30300413/G15 included in **Volume 2** of this report depicts the total width of the corridor that would be required to successfully construct the large diameter pipelines that are required for the uMWP-1. A reduction of this corridor can be allowed in short sections, but will negatively impact both the progress rate and cost of pipeline construction.

Although the Double Unequal Pipeline option has the lowest NPV, in terms of the logistics of construction, the laying of a second large diameter pipeline parallel to the first in years to come would cause great disruption to farming, business and residential activities. The Umlaas Road region is rapidly developing and if this development results in a lack of working space, it may prove difficult to duplicate the pipeline in the future, even if the permanent servitude is purchased up front.

The practical problems that may be experienced with laying the Phase 2 pipeline for the Double Unequal option need to be weighed up against the present day saving of R 129 million when it is compared to the Single Pipeline option.

Figure 18 depicts recent developments along the proposed pipeline route in the Umlaas Road area. A new shaded vehicle parking area has been constructed alongside the proposed route and a space restriction has been created between the new car park and the Rainbow Chickens building where the pipeline route is proposed to run. It is expected that if this route is not changed, the shaded parking area would need to be partially demolished and reconstructed at Umgeni Water's expense when the pipeline is built. While this is not an insurmountable problem, it is typical of the problems that may arise in the coming years and that will worsen with time.

It is therefore considered to be very risky to plan to construct the pipeline in phases as there is no guarantee that land will be available along the proposed pipeline route at a future date to provide the necessary working space for pipeline construction.

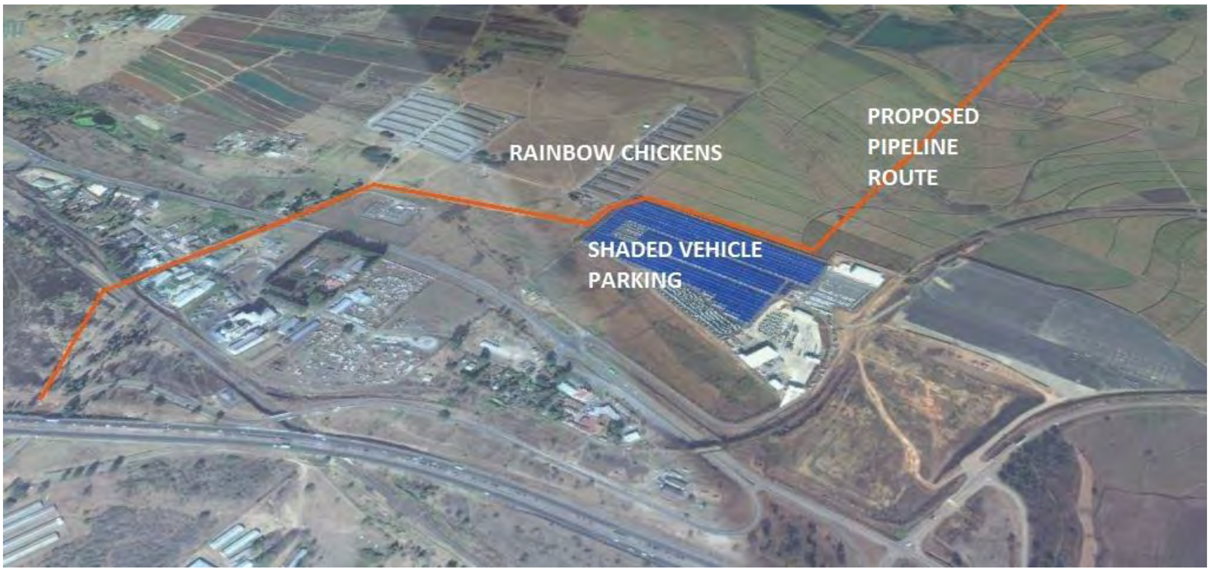

Figure 18: Recent Commercial Developments along the Proposed uMkhomazi Pipeline Route

It is therefore recommended that Umgeni Water proceed with the Single Pipeline Option with the B2 WTW site and pipeline route to preliminary and detailed design.

The recommended scheme as depicted in **Figure 19** and **Figure 20** and based on Option B2 will be:

1. Raw water conveyance: Single 3030mm OD x 5.0 km long steel pipeline
2. WTW: 500 Ml/day conventional water treatment plant located at the Baynesfield 2 site
3. 170 Ml potable water storage reservoir
4. Potable water conveyance:
    a. Section 1: Single 2820mm OD x 15.1 km long steel pipeline
    b. Section 2: Single 2540mm OD x 4.6 km long steel pipeline

It is further recommended that the pipeline servitudes and WTW sites be purchased as soon as possible in order to secure the property rights and prevent further development on the land required for the potable water infrastructure. In addition, given the need for adequate working space for construction of the large diameter pipelines, it is recommended that Umgeni Water gives consideration to how it may deal with developments in the proposed temporary servitude in the years leading up to the pipeline construction.

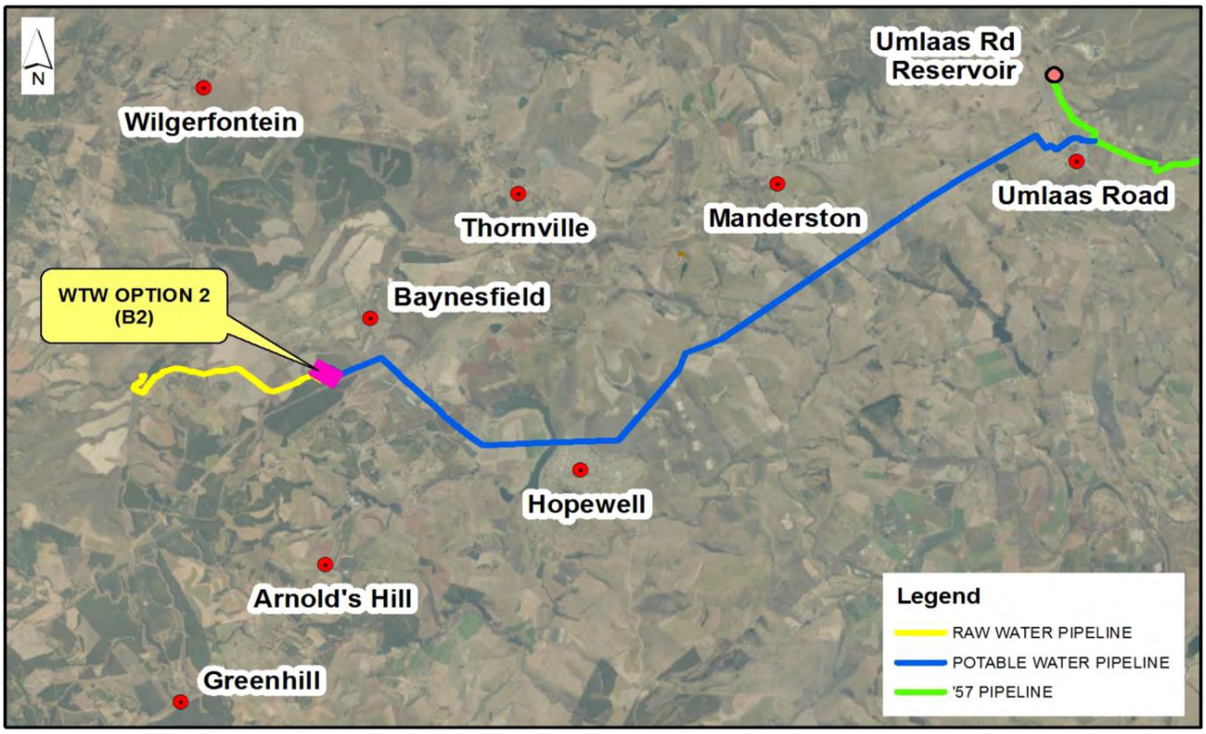

Figure 19: Pipeline Routing & WTW Location

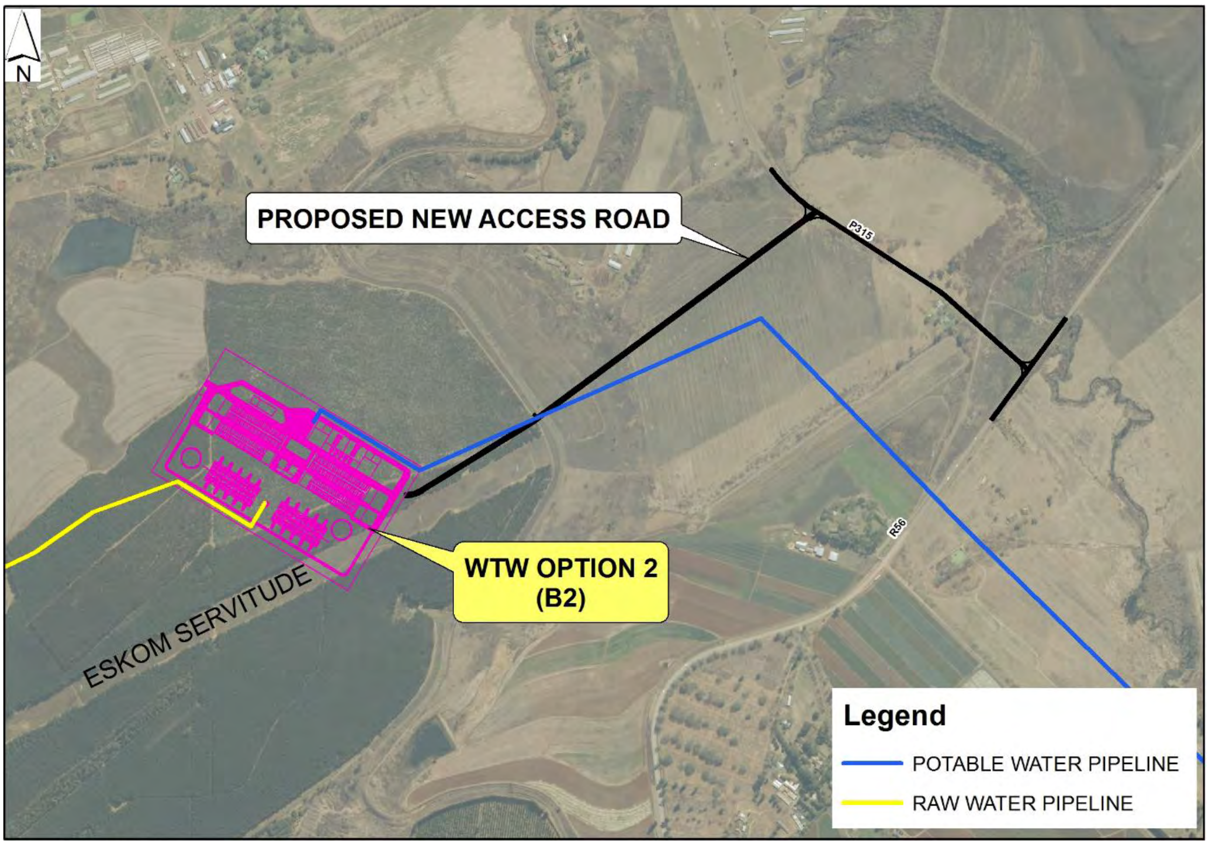

Figure 20: WTW Orientation & Access

17. Total Project Costs

A cost summary of the recommended infrastructure is included in **Table 5**.

Table 5: Option B2 Cost Breakdown

PROJECT COMPONENT	CAPITAL COST
Raw Water Pipeline	R 277,358,359.80
Potable Water Pipeline	R 953,743,967.97
Land Acquisition and Crop Compensation	R 40,501,107.39
Pipe Bridge	R 44,228,054.00
Access Road	R 12,999,470.88
Water Treatment Works	R 1,551,215,453.02
Potable Water Reservoir	R 194,287,465.26
TOTAL	**R 3,074,333,878.33**

The estimated project costs including Engineering Consulting fees, Subconsultants, Environmental and Community Liaison, Health & Safety, Project Office and Contingency costs are listed in **Table 6**.

Table 6: All-inclusive Project Cost Estimate

Consultants	**R 542,582,851.56**
Design and Tender Documentation	R 427,002,851.56
Geotechnical Investigations	R 500,000.00
Land Survey	R 1,000,000.00
Cathodic Protection	R 20,000,000.00
Construction Monitoring	R 94,080,000.00
Construction	**R 3,033,832,770.94**
Pipe Supply	R 465,924,018.00
P&G	incl
Pipeline Construction	R 731,978,842.64
Pipe Bridge/Jack	R 77,427,521.13
Pumpstation	R 0.00
Water Works	R 1,564,214,923.90
Reservoir	R 194,287,465.26
Dam	R 0.00
Abstraction	R 0.00
Land Acquisition	R 40,501,107.39
Environmental, Community Liaison	R 2,000,000.00
Health & Safety, Quality Assurance	R 3,000,000.00
Project Office (4%)	R 121,353,310.84
Contingencies (25%)	R 758,458,192.73
TOTAL	**R 4,501,728,233.46**

18. Design and Construction Phase Programme

A Gantt chart was drawn up for the design, tender and construction phases of the project. The project was scheduled with a fixed end date of 30 June 2023. Once durations were entered for the various linked activities, this resulted in a latest start date for the project of 18 April 2016. The Gantt chart has been included in **Annexure A** of this report.

The critical path activities are as follows:

- Landowner and servitude negotiations must commence in April 2016 at the latest.
- The pipeline route will be finalised once land acquisition and servitude acquisition have progressed sufficiently. A six month lag has been allowed between the start of land acquisition and pipeline route finalisation.
- Most of the WTW infrastructure sits above the potable water reservoir. The WTW preliminary design is therefore required to provide the loading for the reservoir design. The WTW preliminary design needs to commence at the same time as the pipeline route finalisation. Six months have been allowed for this activity.

- Detailed design of the potable water reservoir will thereafter proceed for a period of 15 months.
- Once the detailed design of the reservoir is complete, the reservoir contract will be put out to tender and an award made. The complete tender process is estimated to take about 10 months.
- Reservoir construction will commence in February 2019 and will take approximately two years to complete.
- Once the reservoir construction is nearing completion, the WTW construction will commence. Construction will take approximately three years.
- The final critical path activity will be commissioning of the scheme which will commence upon WTW construction completion and will take approximately three months.

All other non-critical activities are as depicted in the Gantt chart included in **Annexure A** of this report.

19. Projected Cash Flow

Projected cash flows for the project were drawn up based on the project Gantt chart. The forecast expenditure is summarised in **Table 7**. All values listed are 2014 costs excluding VAT.

Table 7: Projected Cash Flow

ITEM:	TOTAL VALUE	PROJECTED CASH FLOW (R million)							
	2016 - 2023	2016	2017	2018	2019	2020	2021	2022	2023
Professional Services:	**(R million)**								
Pipeline design	R 58.6	R 2.9	R 17.6	R 29.3	R 8.8	R 0.0	R 0.0	R 0.0	R 0
Pipe bridge design	R 10.8	R 0.0	R 1.1	R 8.7	R 1.1	R 0.0	R 0.0	R 0.0	R 0
WTW design	R 217.2	R 10.9	R 10.9	R 152.0	R 43.4	R 0.0	R 0.0	R 0.0	R 0
Reservoir design	R 21.4	R 0.0	R 16.0	R 5.3	R 0.0	R 0.0	R 0.0	R 0.0	R 0
Electrical & mechanical design	R 118.0	R 0.0	R 11.8	R 82.6	R 23.6	R 0.0	R 0.0	R 0.0	R 0
Geotech Survey	R 0.5	R 0.1	R 0.4	R 0.1	R 0.0	R 0.0	R 0.0	R 0.0	R 0
Land Survey	R 1.0	R 0.5	R 0.5	R 0.0	R 0.0	R 0.0	R 0.0	R 0.0	R 0
Cathodic Protection	R 20.0	R 0.0	R 1.0	R 15.0	R 4.0	R 0.0	R 0.0	R 0.0	R 0
Construction Monitoring	R 94.1	R 0.0	R 0.0	R 0.0	R 18.8	R 18.8	R 18.8	R 18.8	R 19
Materals & Construction:									
Pipe Supply	R 465.9	R 0.0	R 0.0	R 0.0	R 93.2	R 186.4	R 186.4	R 0.0	R 0
Pipeline Construction	R 732.0	R 0.0	R 0.0	R 0.0	R 0.0	R 219.6	R 219.6	R 219.6	R 73
Pipe Bridge/Jack	R 77.4	R 0.0	R 0.0	R 0.0	R 0.0	R 7.7	R 61.9	R 7.7	R 0
Water Works	R 1 564.2	R 0.0	R 0.0	R 0.0	R 0.0	R 234.6	R 547.5	R 625.7	R 156
Reservoir	R 194.3	R 0.0	R 0.0	R 9.7	R 106.9	R 77.7	R 0.0	R 0.0	R 0
Miscellaneous:									
Land Acquisition	R 40.5	R 20.3	R 20.3	R 0.0	R 0.0	R 0.0	R 0.0	R 0.0	R 0
Environmental, Community Liaison	R 2.0	R 0.0	R 0.0	R 0.0	R 0.0	R 0.5	R 0.5	R 0.5	R 1
Health & Safety, Quality Assurance	R 3.0	R 0.0	R 0.0	R 0.0	R 0.0	R 0.0	R 1.0	R 1.0	R 1
Project Office (4%)	R 121.4	R 15.2	R 15.2	R 15.2	R 15.2	R 15.2	R 15.2	R 15.2	R 15
Contingencies (10%)	R 758.5	R 0.0	R 0.0	R 37.9	R 37.9	R 37.9	R 189.6	R 303.4	R 152
TOTAL	**R 4 500.7**	R 49.8	R 94.6	R 355.8	R 352.9	R 798.5	R 1 240.5	R 1 191.9	R 416.8

20. Project Risks

The following risks have been identified for the Potable Water Module.

20.1 Geotechnical Investigations

As described in **Report No. 108/114/12/R8-2: Geotechnical Investigation Report, Potable Water Pipeline**, access to six properties was refused by the landowners. Geotechnical investigations could therefore not be carried out on these properties. The total length of the potable water pipeline route for which geotechnical investigations could not be carried out is 7.5 kilometres.

This presents a risk as the geotechnical conditions for the affected section, i.e. 50% of the potable water pipeline route, are not known.

In addition it should be noted that for the proposed B2 WTW site, access was extremely limited as a result of the tree plantation. In order to conclusively determine the ground conditions at this site, some trees will have to be cut and drilling is recommended to the depth of the WTW structures and potable water reservoir foundations. At the time of conducting the geotechnical investigations, the cutting of trees was not possible and test pits were permitted only alongside access roads.

Although no problems were reported from the limited investigations at the B2 site, further investigations are recommended.

20.2 Effect of the uMWP on the Western Aqueduct Pipeline

It has been proposed that the uMkhomazi Potable Water Pipeline connects to the ’57 Pipeline and Western Aqueduct Pipeline at Umlaas Road. The present supply to the Western Aqueduct is from Umlaas Road Reservoir with a top water level of 844 msl. The top water level (TWL) of the proposed uMkhomazi Potable Water Reservoir is 862 msl, i.e. the ’57 Pipeline and Western Aqueduct Pipelines will be subjected to an additional 18 metres of static head.

Both the ’57 Pipeline and Western Aqueduct pipeline have been designed to accept test pressures that result in a maximum of 56.25% of the minimum yield strength (MYS) of the steel. Test pressures vary between 889 and 900 msl, which are higher than the TWL of the proposed potable water reservoir. There is therefore a sufficient factor of safety in the design of the WA and ’57 Pipelines to handle the additional pressure.

A detailed analysis of the Western Aqueduct pipeline system is however recommended to ensure that the valves and fittings specified do not move into a higher pressure class when subjected to the higher TWL of the uMkhomazi potable water reservoir.

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22. ANNEXURE A

Annexure A(i):	**Gantt Chart 30300413/01**	**-**	**uMkhomazi Water Project: Project Programme**

ID	Name
1	**UMWP PROPOSED CONSTRUCTION PROGRAMME**
2	**DESIGN PHASE**
3	Landowner & servitude negotiations
4	Finalise pipeline route
5	Preliminary WTW design
6	Detailed design - Reservoir
7	Detailed design - WTW
8	Detailed design - Pipeline
9	**TENDER PHASE**
10	Tender phase - Advanced works contracts
11	Tender phase - Pipe supply contract
12	Tender phase - Pipe laying contract
13	Tender phase - Reservoir contract
14	Tender phase - WTW contract
15	**CONSTRUCTION PHASE**
16	Advanced works contracts
17	Pipe delivery
18	Construction - Pipeline
19	Construction - Reservoir
20	Construction - WTW
21	Commissioning
22	Completion