108/114/12/R1

uMkhomazi Water Project – Potable Water Module

Preliminary Pricing of Potable Water Module Options

October 2012

Planning Services
Engineering & Scientific Services
Umgeni Water

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Project Name:	**uMkhomazi Water Project: Potable Water Module**
Report title:	**Preliminary Pricing of Potable Water Module Options**
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Knight Piésold reference no:	**DU 30300413/01**

19 OCT 2012	1 (Final)	Project Use	A. Doorgapershad	G. Subramanian	Approved
10 OCT 2012	B (Draft)	Client Review	A. Doorgapershad	G. Subramanian	Approved
08 OCT 2012	A (Draft)	Internal Review	A. Doorgapershad	I. Watson	Approved
DATE	**REV**	**ISSUED FOR**	**ISSUED BY**	**APPROVER**	**STATUS**

Preliminary Pricing of Potable Water Module Options

Contents

Preliminary Pricing of Potable Water Module Solutions to Match Additional Raw Water Module Proposals by BKS

1. Introduction

At a meeting held with BKS on 16 August 2012, Knight Piésold (KP) was informed that BKS had developed additional raw water options for the uMkhomazi Project. There are four options (Options 2, 3, 4 and 5) that need to be investigated as requested by BKS. Each option is described below. Smithfield Dam with a Full Service Level (FSL) of Reduced Level (RL) 915 and twin 3.5 metre diameter pressure tunnels are common to all options. A graphical representation of each option as provided by BKS is included in Annexure A.

2. Basis of cost estimates

As agreed with both Umgeni Water and BKS, the infrastructure cost estimates provided in this report are 'rule of thumb' estimates derived from experience with similar recently completed projects. More accurate cost estimates for each option will be provided once Knight Piésold has undertaken further detailed investigations.

3. Assumptions

The sizes of the modules for the waterworks as well as the total ultimate size of the works will be dependent on the updated water demand projections for eThekwini's Western and Northern regions. These demand projections are not available at this stage and will be developed in a subsequent part of this study. For the purposes of this report therefore, assumptions had to be made regarding the sizing of the modules and ultimate size of the scheme.

According to Umgeni Water's terms of reference (TOR) for the PWM study, two pipelines of approximately 1.8 metres in diameter will be required to meet the ultimate demand and waterworks sizing is expected to be approximately 350 Ml/day per module.

The ultimate combined 30-year demand in eThekwini's Western and Northern regions has been previously calculated to be approximately 694 Ml/day including the areas presently supplied from Umlaas Road Reservoir, Durban Heights Waterworks and the Northern Aqueduct. This figure includes existing demand, shed demand, growth in demand within existing areas and demands from new developments.

It was therefore decided that for the purposes of the costs estimates in this report, it would be assumed that two waterworks modules of 350 Ml/day would be required.

Initial hydraulic modelling has indicated that one DN2000 pipeline is required to convey the water produced by each 350 Ml/day waterworks module under gravity. Two DN2000 pipelines were therefore allowed for in the pricing of each option.

An allowance for 150 Ml of potable water storage for each waterworks module has been made in accordance with the PWM study TOR. In addition, Umgeni Water's process engineers have advised that a minimum of 12 hours or 175 Ml of raw water storage will be required for each waterworks module. This storage volume is an absolute minimum requirement and may need to be increased as the study progresses. A slightly more conservative volume of 200 Ml per module was therefore used for pricing purposes.

4. Proposed configuration and estimated costs

4.1. Option 1:

The tunnels discharge raw water into a balancing dam at Baynesfield at RL 879.2. A water treatment works will be located near Baynesfield Dam with the head of works at RL 872. A clear water reservoir will be located downstream of the waterworks site with a floor level of RL 860. Gravity potable water pipelines will then run from the clear water reservoir to Umlaas Rd where they will either feed into the existing reservoir or tie into the existing '57 Pipeline. This option is basically according to Knight Piésold's original scope of work. BKS has stated that this Raw Water Module (RWM) option is too expensive and is not being considered further. **BKS have advised that no Potable Water Module (PWM) solution is required for this option.**

4.2. Option 2a:

In this option, Baynesfield Dam is eliminated and the waterworks receives its supply under the residual pressure of the tunnel. It is assumed for this option that emergency storage that would otherwise have been provided by the Baynesfield Dam will be provided from the Mgeni system. It should be noted that the feasibility of transferring this emergency storage to the Mgeni system is yet to be investigated.

As a result of not constructing a dam at Baynesfield, additional balancing storage may be required for the waterworks. The size of the storage will depend on the risk that Umgeni Water is prepared to accept in the event of a minor raw water supply interruption. For the purposes of this report, it has been assumed that a total of 24 hours of storage will be required for this option, shared between potable and raw water storage. The ratio of raw to potable water storage may be varied without affecting the cost estimate.

The water treatment works will be located at Baynesfield. A short length of raw water pipeline will link the water treatment works to the tunnel outlet. A potable water pipeline will then connect the water treatment works to either Umlaas Road Reservoir or the '57 Pipeline.

The original PWM scope of work (Option 1) covers all activities required for Option 2a where the waterworks is located at the Baynesfield site – Option 2a therefore replaces Option 1.

The estimated costs for this option are noted in **Table 1**. There is no pumping required for this option.

Table 1: Estimated costs for Option 2a

Item:	Size / Capacity:	No. Off.	Estimated cost (millions):
DN2000 x 2 raw water pipelines (km)	5.7 km	2	R 345.41
DN2000 x 2 potable water pipelines (km)	23.9 km	2	R 1,440.39
Water treatment plant - 2 x 350 ML/d modules (Ml/d)	350 ML/d	2	R 2,695.00
Raw water reservoirs - 2 x 200 ML/d modules (Ml)	200 ML	2	R 360.00
Potable water reservoirs - 2 x 150 ML/d modules (Ml)	150 ML	2	R 270.00
TOTAL:			**R 5,110.80**

4.3. Option 2b:

This option is as per Option 2a; however, Option 2b will involve identifying an alternative waterworks site at a location between Baynesfield and Umlaas Rd. This will increase the length of the raw water pipeline while decreasing the length of the potable water pipeline. The terminal connections at Umlaas Road will be as per Option 2a.

The estimated costs for this option are noted in **Table 2**. No pumping is required for this option.

Table 2: Estimated costs for Option 2b

Item:	Size / Capacity:	No. Off.	Estimated cost (millions):
DN2000 x 2 raw water pipelines (km)	25.1 km	2	R 1,516.44
DN2000 x 2 potable water pipelines (km)	4.6 km	2	R 275.09
Water treatment plant - 2 x 350 ML/d modules (Ml/d)	350 ML/d	2	R 2,695.00
Raw water reservoirs - 2 x 200 ML/d modules (Ml)	200 ML	2	R 360.00
Potable water reservoirs - 2 x 150 ML/d modules (Ml)	150 ML	2	R 270.00
TOTAL:			**R 5,116.53**

4.4. Option 3:

In this option, a raw water pipeline is proposed from the tunnel outlet to the Umlaas Rd precinct that will operate under the residual pressure available at the tunnel exit. A balancing dam is proposed to be built at Umlaas Rd with a waterworks and clear water reservoir constructed downstream of the dam. Alternatively, the balancing dam may be omitted and the raw water delivered directly to the proposed waterworks. A potable water pipeline will then link the reservoir to the existing '57 Pipeline.

As per instruction from Umgeni Water, KP has not investigated the costs of a dam in the Umlaas Road area as this will fall within the BKS scope of work. BKS would need to investigate the availability of a suitable site.

The estimated costs for this option are noted in **Table 3**. The dam costs will need to added by BKS. In addition, BKS would need to include any pumping costs from the dam to the water treatment works in the capital and operational costs for this option. No pumping is required for the PWM in this option, however this may change if the site proposed for the waterworks location is not available.

Table 3: Estimated costs for Option 3

Item:	**Size / Capacity:**	**No. Off.**	**Estimated cost (millions):**
DN2000 x 2 raw water pipelines (km)	25.9 km	2	R 1,560.77
DN2000 x 2 potable water pipelines (km)	3.5 km	2	R 208.50
Water treatment plant - 2 x 350 ML/d modules (Ml/d)	350 ML/d	2	R 2,695.00
Raw water reservoirs - 2 x 200 ML/d modules (Ml)	200 ML	2	R 360.00
Potable water reservoirs - 2 x 150 ML/d modules (Ml)	150 ML	2	R 270.00
TOTAL:			**R 5,094.28**

4.5. Option 4:

This is as per Option 1 with the exception that a smaller balancing dam is proposed at Baynesfield. A pump station will transfer water to the waterworks when the balancing dam water level drops below a given value. The proposed locations and elevations for the waterworks do not vary from Option 1. From a PWM perspective, this option is identical to Option 1.

The PWM costs related to this option are as per Option 2a. This assumes that the raw water pump station falls within the Module 1 scope of work. In evaluating this option, consideration needs to be given to the fact that the raw water pumps may be unutilised for extended periods of time.

4.6. Option 5:

This option is as per Option 1, except that Baynesfield Dam is replaced with the proposed Mbangweni off-channel balancing dam which has a higher FSL. The dam will supply raw water to the waterworks. In addition, a separate raw water pipeline will supply water directly from the tunnel outlet to the waterworks to cater for the scenario when the Mbangweni Dam is operating well below its FSL. From a PWM perspective, this option is identical to Option 1. The PWM costs related to this option are as per Option 2a.

4.7. Pros and Cons of Each Option

The pros and cons of each of the proposed PWM options are listed in **Table 4**.

Table 4: Pros and Cons of Each Option

Option:	Pros:	Cons:
2a	• Full gravity supply throughout. • The expensive and inefficient Baynesfield Dam is eliminated.	• Tunnel outlet location is problematic when trying to maintain gravity flow from the tunnel to the waterworks. • Dependent on the Mgeni system during a tunnel shutdown. • Potable water storage is remote from where it is required.
2b	• Full gravity supply throughout. • Waterworks and potable water reservoir are located close to (within 5 kms of) the injection point on the '57 Pipeline.	• Tunnel outlet location is problematic when trying to maintain gravity flow from the tunnel to the waterworks.
3	• Dam, waterworks and potable water reservoir are located closer to the injection point on the '57 Pipeline than any other option, hence lowest risk of supply interruption to the waterworks.	• Tunnel outlet location is problematic when trying to maintain gravity flow from the tunnel to the waterworks. • Umlaas Rd precinct is not suitable for a dam. • It is likely that pumping would be required from the dam to the waterworks.
4	• Dam is cheaper than original Baynesfield Dam.	• Pumping will be required if the dam level drops sufficiently. • Pumps may remain unused for long periods of time, resulting in increased maintenance requirements. • Potable water storage is remote from where it is required.
5	• Full gravity supply throughout. • The higher TWL of Mbangweni Dam could result in smaller diameters for the potable water pipelines. BKS to advise on a reliable minimum water level in the dam on which to base the pipe diameter calculation.	• Potable water storage is remote from where it is required.

5. Important Findings to Date

5.1. Position of Raw Water Tunnel Outlet

Knight Piésold has observed the following issue which needs to be brought to the attention of both Umgeni Water and BKS as a matter of urgency, as it may affect the direction of the Raw Water Module part of the study.

The raw water tunnels from Smithfield Dam exit at a position and level that is ideal to provide a gravity supply into the proposed Baynesfield Dam (Option 1). This exit location is however not ideal for Options 2a, 2b and 3 from the Potable Water Module perspective, as the raw water pipeline connects directly to the tunnel outlet.

The problem encountered is that it is extremely difficult to find a pipeline route that can convey water without the need for pumping, from the current position of the tunnel outlet. The reason for this is that the tunnel outlet lies in a depression from which the ground level rises sharply in all directions.

There are two options to overcome this.

a. Excavate a trapezoidal channel or create a benched platform into the slopes adjacent to the existing Baynesfield Dam. This earthworks exercise will create an open trench or benched platform with a floor level of around 880 metres above sea level (msl). The excavation for the pipeline trench would then commence from the floor level of the trench or benched platform. The geology of the area is unknown and geotechnical investigations would be needed to assess the viability of this option. This option will be investigated further as part of the Potable Water Module investigations. The approximate depths of the proposed platforms are listed in **Table 5**.

Table 5: Platform lengths and depths

Section:	Length (metres):	Depth (metres):
a	220	21
b	460	15
c	155	8
d	291	6

b. Another option to deal with this problem is to extend the raw water tunnel by approximately 1.8 kilometres such that the tunnel outlet is located beyond the depression. The raw water pipeline will then connect to the tunnel outlet at an elevation of approximately 879 msl. This will require realignment of the tunnel to avoid the existing Baynesfield Dam.

5.2. Routing of Pipeline Through Farm Dam

A large farm dam alongside the Hopewell township was encountered along the proposed pipeline route. The extent of the dam tailwaters as well as the contour levels in the vicinity make it difficult to find an alternate route around the dam. The shortest pipeline route when compared to a route directly through the dam, adds a further 6.5 kilometres to the pipeline length. This results in an additional cost of R 394 million. The additional cost is noted in **Table 6**.

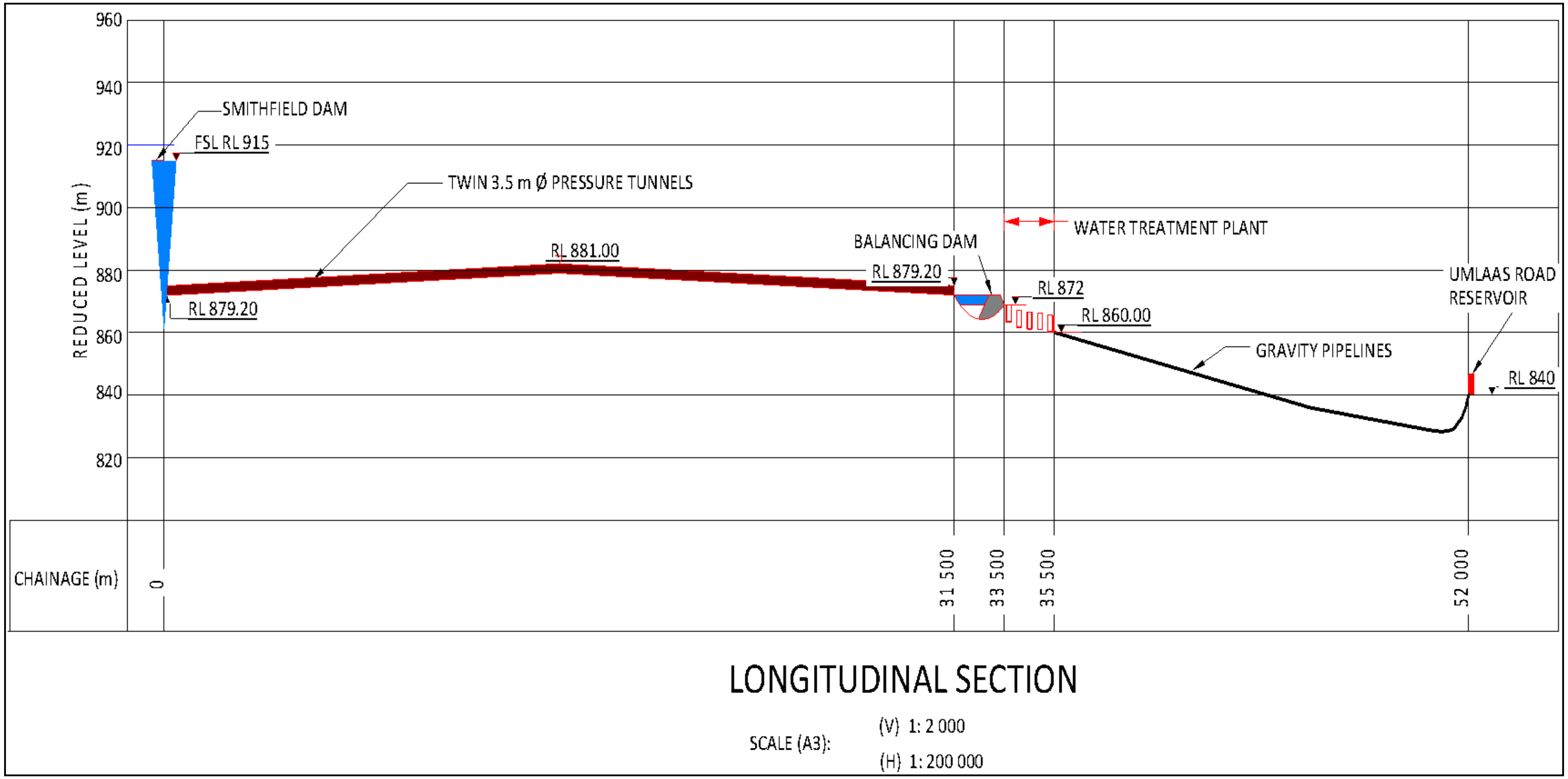
It is felt that such a detour is too costly and that an alternate means of constructing the pipelines through or over the dam can be achieved at a fraction of the cost of the detour.

Table 6: Estimated costs for detour around Hopewell Dam

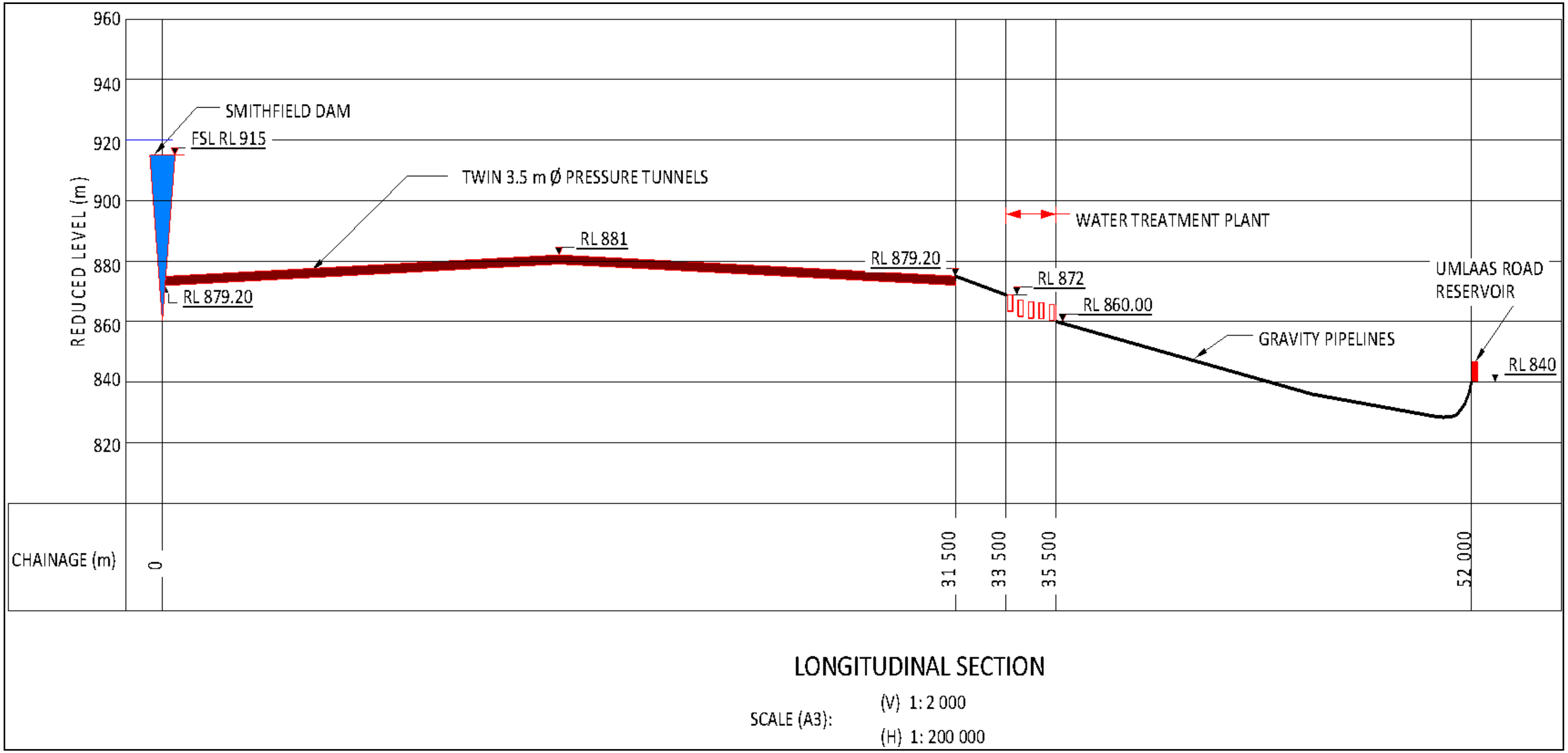
Item:	Size / Capacity:	No. Off.	Estimated cost (millions):
DN2000 x 2 pipelines (km)	6.5 km	2	**R 394.26**

Annexure A: Raw Water Balancing Options provided by BKS

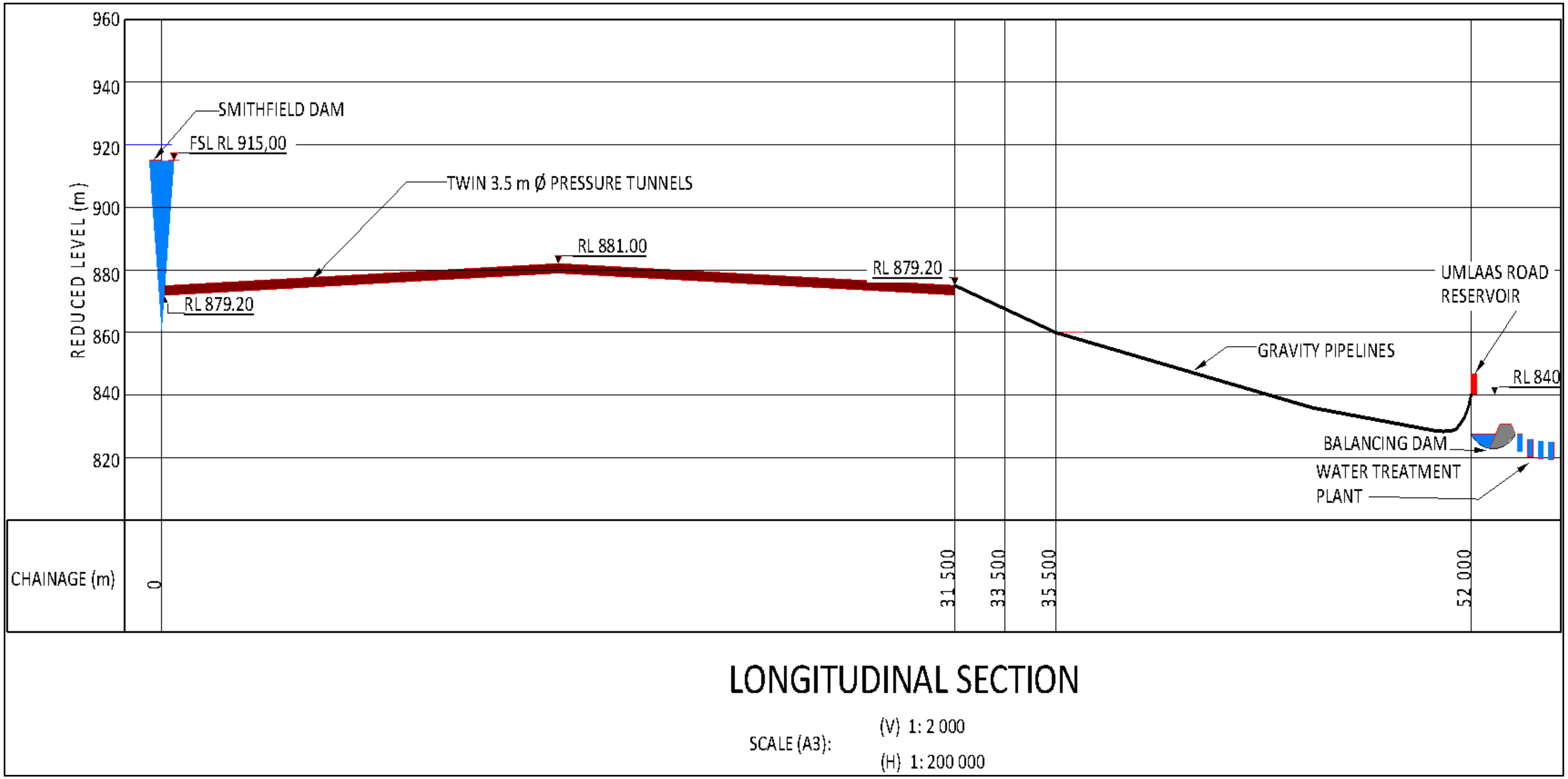
TECHNICAL FEASIBILITY STUDY: RAW WATER BALANCING OPTIONS



OPTION 1


960
940
920
900
880
860
840
820
REDUCED LEVEL (m)
SMITHFIELD DAM
FSL RL 915
TWIN 3.5 m Ø PRESSURE TUNNELS
RL 881
RL 879.20
RL 879.20
WATER TREATMENT PLANT
RL 872
RL 860.00
GRAVITY PIPELINES
UMLAAS ROAD
RESERVOIR
RL 840
CHAINAGE (m)
0
31 500
33 500
35 500
52 000
LONGITUDINAL SECTION
SCALE (A3):
(V) 1: 2 000
(H) 1: 200 000

OPTION 2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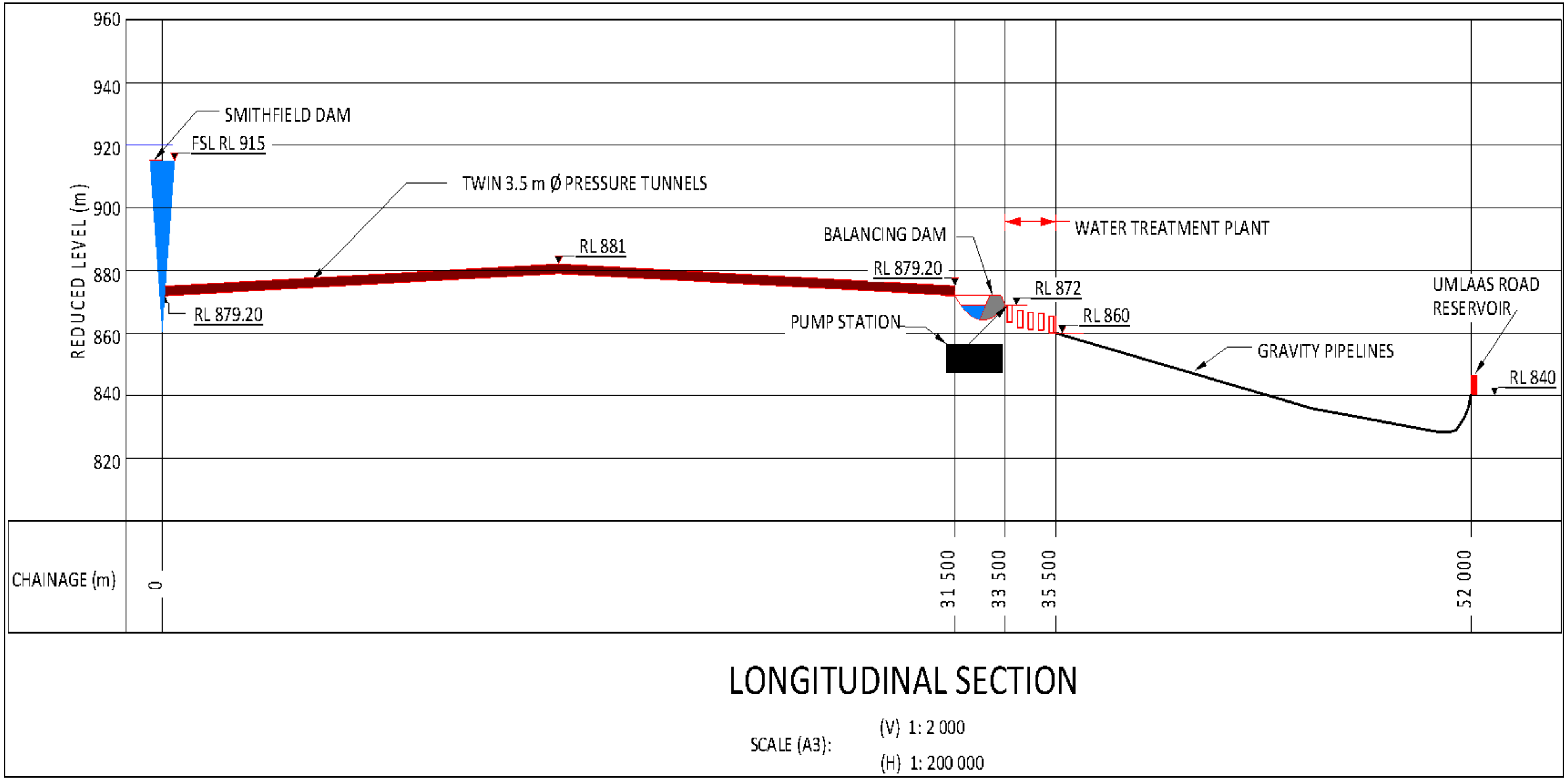
840
820
REDUCED LEVEL (m)
SMITHFIELD DAM
FSL RL 915,00
TWIN 3.5 m Ø PRESSURE TUNNELS
RL 881.00
RL 879.20
RL 879.20
UMLAAS ROAD
RESERVOIR
GRAVITY PIPELINES
RL 840
BALANCING DAM
WATER TREATMENT
PLANT
CHAINAGE (m)
0
31 500
33 500
35 500
52 000
LONGITUDINAL SECTION
SCALE (A3):
(V) 1: 2 000
(H) 1: 200 000

OPTION 3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920
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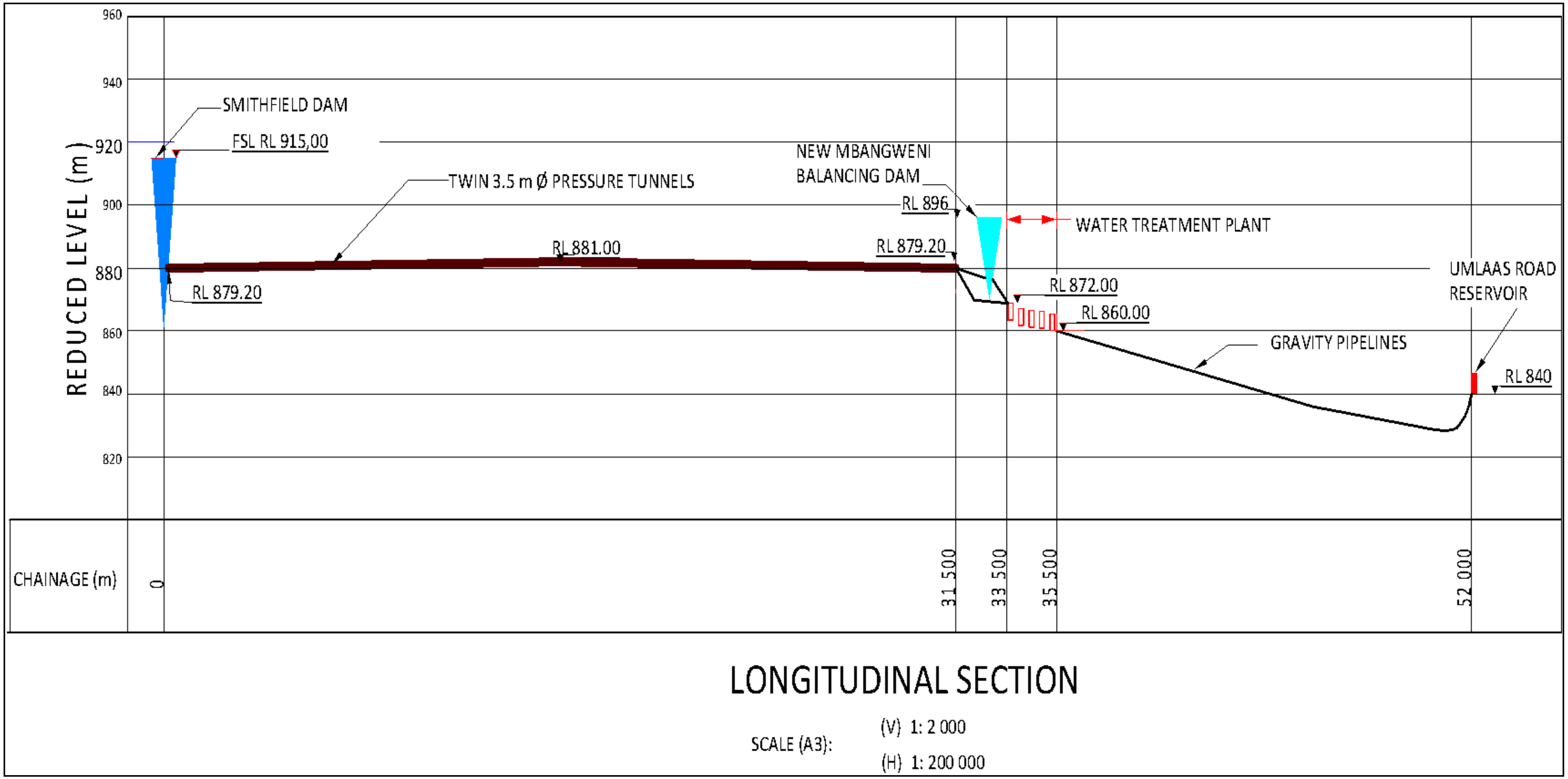
880
860
840
820
REDUCED LEVEL (m)
SMITHFIELD DAM
FSL RL 915
TWIN 3.5 m Ø PRESSURE TUNNELS
RL 881
BALANCING DAM
RL 879.20
WATER TREATMENT PLANT
RL 872
RL 860
RL 879.20
PUMP STATION
UMLAAS ROAD
RESERVOIR
GRAVITY PIPELINES
RL 840
CHAINAGE (m)
0
31 500
33 500
35 500
52 000
LONGITUDINAL SECTION
SCALE (A3):
(V) 1: 2 000
(H) 1: 200 000

OPTION 4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940
920
900
880
860
840
820
REDUCED LEVEL (m)
SMITHFIELD DAM
FSL RL 915,00
TWIN 3.5 m Ø PRESSURE TUNNELS
RL 881.00
RL 879.20
NEW MBANGWENI
BALANCING DAM
RL 896
RL 879.20
WATER TREATMENT PLANT
RL 872.00
RL 860.00
GRAVITY PIPELINES
UMLAAS ROAD
RESERVOIR
RL 840
CHAINAGE (m)
0
31 500
33 500
35 500
52 000
LONGITUDINAL SECTION
SCALE (A3):
(V) 1: 2 000
(H) 1: 200 000

OPTION 5