Johannesburg Water (SOC) Ltd

Johannesburg Water

CONTRACT JW 11053 & JW 13037

FOR

LENASIA HIGH LEVEL RESERVOIR, HOSPITAL HILL PUMP STATION AND CONNECTING LENASIA PIPELINE

PRELIMANARY DESIGN REPORT

Prepared for:		*Prepared by:*	
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00	29-04-2014	Rev 0 (Included rising main & floor reinforcing options)	V Scholtz	FJ de Lange
01	30-05-2014	Rising main size, pump station, reservoir pipework	V Scholtz	FJ de Lange
02	23-10-2014	JW Comments Addressed, Pump Station included, Split into 3 contracts	V Scholtz	FJ de Lange
03	05-12-2014	Pump Station Scope Amended, JW Comments addressed	V Scholtz	FJ de Lange
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PRELIMANARY DESIGN REPORT APPROVAL

CONTRACT NAME: LENASIA HIGH LEVEL RESERVOIR
CONTRACT NUMBER: JW11053
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EXECUTIVE SUMMARY

The report describes a preliminary investigation for the design and construction of a proposed new reservoir in Lenasia South in the Gauteng Province. The proposed new reservoir will supplement the existing 6Ml Lenasia High Level reservoir.

The report investigates available information collected by means of a desktop study and site investigations. The existing pump station at the nearby Hospital Hill reservoir and rising main to Lenasia HL was investigated along with the construction of the proposed new reservoir and necessary pipework and valves. A cost estimate and high level programme forms part of this report.

This report recommends that a 15Ml reservoir be constructed along with a 1.2Km ND600 steel pipeline that will supply the reservoir. In addition a recommendation for upgrading the Hospital Hill pump station is also made. The reservoir, pipeline and pump station will improve water supply to Lenasia South ext.1 and 4, Migson Manor (Lenasia South ext. 7), Zakariyya Park as well as the additional areas of Vlakfontein Proper, Finetown, Hospital Hill and Lehae.

The total construction cost for the reservoir, pipeline and pump station (including 10% contingencies and CPA) is estimated at approximately R 60 million (excl. VAT).

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LIST OF ABBREVIATIONS AND TERMINOLOGY

JW - Johannesburg Water

CoJ - City of Johannesburg

RW - Rand Water

AADD - Average Annual Daily Demand

AMDD – Average Monthly Daily Demand

ℓ - Litres

kl – Kilolitre

ML - Mega litre

ℓ/s – Litre per second

m - Metre

s - Second

h – Hour

d - Day

mm – millimetre

Ø - Diameter

PRV - Pressure Reducing Valve

HL – High Level

NRW – Non-revenue-water

TWL – Top water level

BWL – Bottom water level

AC – Asbestos Cement

1 INTRODUCTION

In a letter dated 7 October 2013, Johannesburg Water (SOC) Ltd appointed Nyeleti Consulting (Pty) Ltd for the provision of Professional civil and structural services for the Lenasia High Level Reservoir (Contract JW 11053). This report outlines the investigations undertaken for the assignment, cost estimates, conclusions and recommendations.

1.1 Background

In February 2012 a Works Request was submitted to the Strategic Planning Manager by the Ennerdale Depot. The request stated that the demand of the areas supplied by the reservoir is higher than the supply to the reservoir, resulting in insufficient head at the reservoir. As a short term solution water was pumped directly from the Hospital Hill reservoir into the reticulation system. Water had to be pumped 24 hours a day. During a site inspection on 10 January 2014 it was confirmed that water is still being pumped from the Hospital Hill reservoir for 24 hour a day.

Infrastructure Development decided to address the above mentioned problem by means of an additional reservoir to supplement the existing 6ML reservoir. Nyeleti Consulting (Pty) Ltd was awarded a tender for designing a new 12.5ML reservoir. During the inception meeting JW stated that the infrastructure planning division actually requires a 15ML reservoir as was suggested in the report titled **Network Analysis: Lenasia Water Sub-Districts (Updated Report) (PS610)** by GLS Consulting (Pty) Ltd in 2009. In a letter dated 8 April 2014 the scope was confirmed as 15ML reservoir. The design of the rising main between Hospital Hill reservoir pump station and Lenasia HL reservoir was also added to the scope in the same letter.

Subsequent discussions with JW Operations (Electromechanical) have revealed that the problem is not only shortage of reservoir storage, but also insufficient pump capacity to supply the reservoir. Nyeleti Consulting did a cursory investigation of the pump station and submitted a proposal for the upgrade of Hospital Hill pump station on 22 September 2014.

Nyeleti Consulting was awarded Contract JW13037 for Provision of Professional Services on 15 September 2014. Consequently in a letter dated 20 October 2014 Nyeleti Consulting was given a works order for the Lenasia Pump Station Upgrade (Project no: S1304B). During a meeting on 21 October 2014 Mr. Nqobizitha Ndimande stated that Nyeleti Consulting will be remunerated for their services on the pipeline and pump station under the Provision of Professional Services contract and it is consequently assumed that the upgrade of both the pump station and pipeline is implied by the description “Lenasia Pump Station Upgrade”.

1.2 Purpose

The overall objective of the project is to improve the supply to and create additional capacity for the Lenasia High Level Reservoir to supply adequate water to Lenasia South ext.1 and 4, Migson Manor (Lenasia South ext. 7), Zakariyya Park as well as the additional areas of Vlakfontein Proper, Finetown, Hospital Hill and Lehae.

The purpose of this report is to investigate the current situation and formulate a solution that will result in adequate supply and storage at Lenasia High Level reservoir.

1.3 Scope

The following activities were envisaged in the investigation:

- Collection of information.
- Possibilities and options for construction of the new reservoir and associated pipework.
- Possibilities and options for constructing a new rising main from Hospital Hill reservoir pump station to Lenasia HL reservoir.
- Possibilities to increase the water supply to the existing and new reservoir by improving the efficiency of the pump station at Hospital Hill reservoir.

1.4 Objectives

The objectives of the investigation are to:

- Produce a basis for design and construction of the Lenasia High Level reservoir.
- Produce a basis for design and construction of the rising main.
- Provide solutions to improve water supply to the current and new proposed Lenasia High Level reservoirs and provide a basis of design to upgrade the existing pump station.

2 INVESTIGATIONS

2.1 Data Gathering

2.1.1 Locality

The existing Lenasia High Level reservoir, proposed additional Lenasia High Level reservoir and Hospital Hill reservoir are located in the township of Lenasia South in Gauteng Province, South Africa. It is part of the City of Johannesburg Metropolitan Municipality. Lenasia is approximately 35 kilometres south west of the Johannesburg central business district. See Figure 1 below indicating the location of the existing and proposed Lenasia HL reservoirs. The reservoir site is at the following GPS Co-ordinates:

	Longitude (E)	Latitude (S)
Lenasia HL Reservoir	27^0 51' 52.93''	26^0 22' 32.90''
Hospital Hill Reservoir	26° 22' 29.52"	27° 51' 16.35"

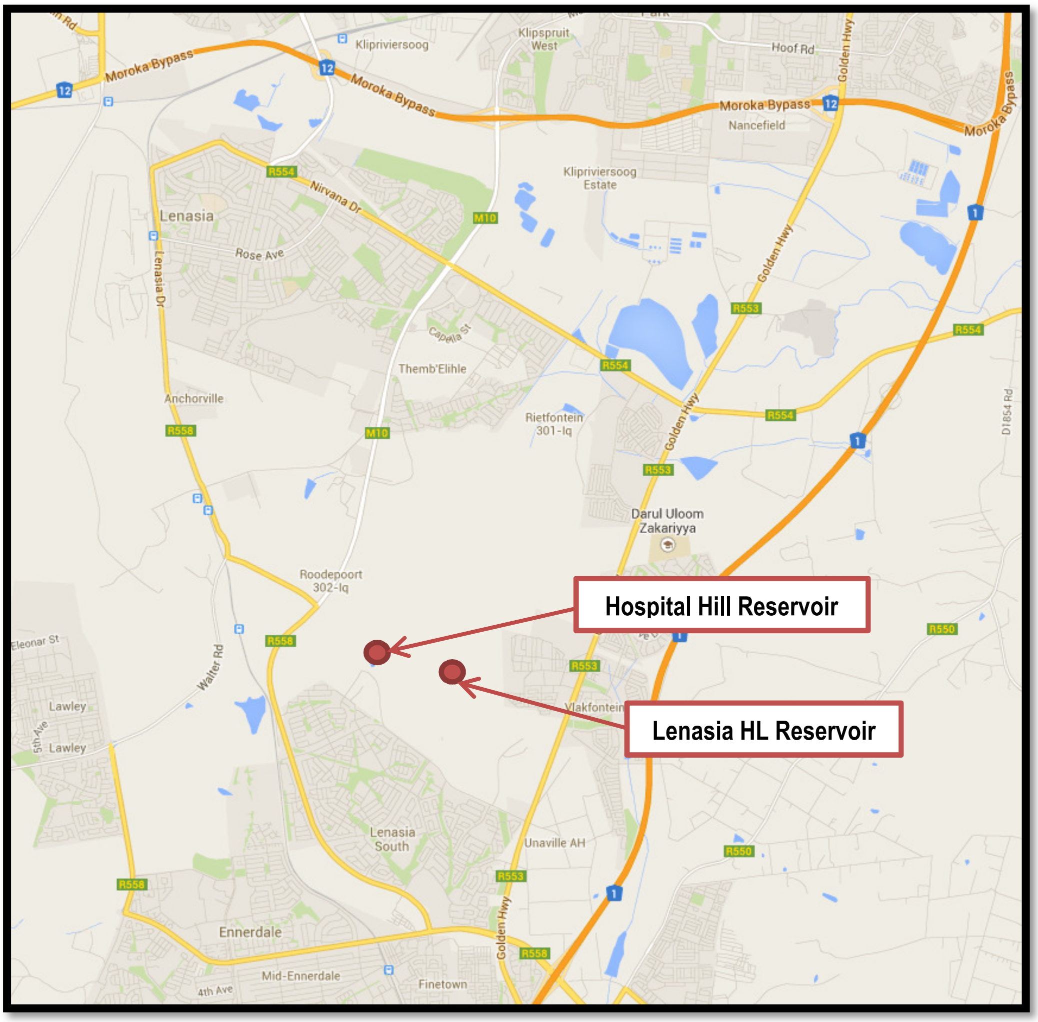

Figure 1: Locality plan

2.1.2 Previous Reports

The ***Network Analysis: Lenasia Water Sub-districts (Updated Report) (PS61)*** compiled by GLS Consulting (Pty) Ltd, dated October 2009, provided valuable information that is presented in this report.

2.1.3 Drawings

Schematic layouts of the existing pipework around Lenasia High Level and Hospital Hill reservoirs as well as Hospital Hill pump station was obtained from JW.

2.1.4 Geotechnical Information

A desktop study revealed that the reservoir site is probably not located on dolomitic soil. A full geotechnical investigation was done by Knight Piésold and in their report titled ***Lenasia High Level Reservoir – Geotechnical Investigation*** it was confirmed.

2.1.5 Site investigation

On 10 January 2014 the consultant visited the existing Lenasia High Level reservoir for the first time, accompanied by John Lourens and Gordon Wynne from the JW Electromechanical division. Numerous other visits have subsequently occurred.

2.1.6 Monthly Water Volumes for the Lenasia District

A record of the monthly volume of water drawn through the Rand Water connection RW1984 was available for the period of almost four years between Aug 2010 and June 2014. These records indicate the water used by the entire Lenasia district for each month.

2.1.7 Telemetric Data of the Level in Hospital Hill Reservoir

Telemetric data indicating the water level of Lenasia Hospital Hill reservoir was available for a three week period between 1 and 21 August 2014.

2.2 Existing water supply configuration

The existing Lenasia water sub-districts receive water supplied by Rand Water.

<u>The system was designed to function as follows:</u>

Water is pumped from Randwater's Zuurbekom pump station that lies to the north of Lenasia. The 675 mm Ø bulk supply pipeline supplies the Cosmos reservoir (43.6 ML). From

Cosmos reservoir water is pumped via an Asbestos Cement bulk supply pipeline to Hospital Hill reservoir (36ML). According to ***Network Analysis: Lenasia Water Sub-districts (Updated Report) (PS61)*** the size of the pipeline is 800mm Ø, but JW Electromechanical operations contradicted this information stating that it was smaller, most likely 500mm Ø . From the Hospital Hill reservoir it is pumped to the existing Lenasia HL reservoir (6ML) via a 400mm Ø bulk supply pipeline. The system described above is shown in Figure 2.

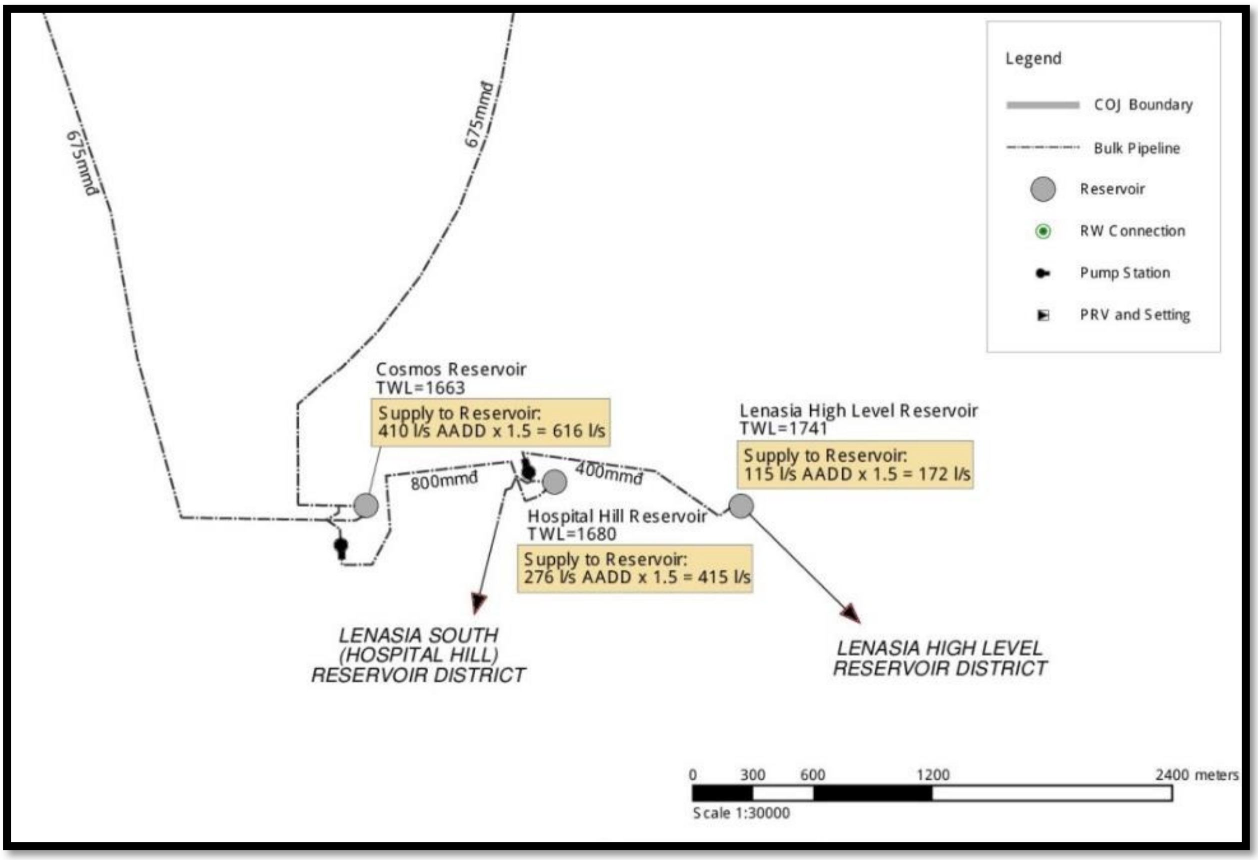

Figure 2: Existing Configuration (GLS Consulting (Pty) Ltd, 2009).

<u>Currently the system is being operated as follows:</u>

In 2009 a bypass was constructed around the Cosmos pump station, thus allowing JW to feed water directly to Hospital Hill reservoir utilising the pressure available from the Randwater connection. This option has increased the amount of water that can be supplied to Hospital Hill reservoir and also decreased energy costs at the same time.

2.2.1 Existing pump station at Hospital Hill reservoir

The existing pump station at Hospital Hill can accommodate four pumps on plinths. When the pump station was visited for the first time only two pump sets were installed.

The two pumps needed to run 24 hours a day in order to just satisfy the demand. Pump systems are not designed to operate without spare capacity. There was no standby pump in case one of the pumps broke down. If that happened the supply to the townships served by Lenasia HL reservoir would have been instantly reduced to approximately 60% of normal demand.

Furthermore, regional power outages lasting anything between 4 hours and 1 or 2 days, occur on a monthly basis. JW has a 540 kVA mobile generator which is utilised in these instances. Load shedding, whereby regular scheduled power outages occur frequently (almost on a weekly basis) has since also become a reality that South Africa will face for most likely the next couple of years.

2.2.2 Existing rising main between Hospital Hill reservoir and Lenasia HL reservoir

Water is supplied from the pump station at Hospital Hill Reservoir through a 400 mm Ø rising main to Lenasia High Level reservoir over a distance of approximately 1200 m. The Network Analysis: Lenasia Water Sub-Districts report (PS610) stated that the 400 mm Ø rising main can supply the reservoir at the required rate of 1.5 x AADD =172 ℓ/s at a velocity of 1.4 m/s, but the existing pumps are inadequate to deliver this flow.

The existing rising main is extremely old and according to As-built drawings and Electromechanical operations the line was constructed with asbestos cement pipes. The pipes were joined utilising Triplex couplings with rubber seals, which have now aged and most likely deteriorated. Increasing the pressure in the line is consequently a risk as some of the seals might not be able to withstand the additional pressure. And when this happens there is no backup supply to Lenasia HL reservoir. Increasing pump pressure is therefor considered a major risk. Any of the couplings can also start leaking at any time.

2.2.3 Existing Lenasia HL reservoir

The current Lenasia HL Reservoir is a round concrete reservoir with a flat roof and a capacity of 6 Ml. The following information was given (GLS Consulting (Pty) Ltd, 2009):

TWL: 1741m

BWL: 1733.5m

In addition the following information was collected by measurement or calculation:

Measured height between floor and overflow: 7.6m

Measured freeboard: 0.5m

Measured height between floor and top of roof: 8.3m

Calculated diameter: ± 32m

3 DESIGN GUIDELINES & CRITERIA

3.1 General

The following criteria will be used when designing any pipework. These guidelines and criteria are based on recommendations made in the following publications:

1) "Guidelines and standards for the design and maintenance of water and sanitation services", published by the Investment Delivery Division of Johannesburg Water (Pty) Ltd
2) "Guidelines for human settlement, planning and design", published by the Building and Construction Technology Division of the CSIR; and
3) The Standardized Specification for Civil Engineering Construction (SANS 1200), published by the South African Bureau of Standards.

3.2 Bulk Water Services

The design guidelines adopted are as listed in Table 1 below.

Table 1: Bulkwater Design Guidelines

Parameter	Element	Guidelines
Flow Velocity	Supply mains to reservoirs (max)	2.0 m/s
	Supply mains to reservoirs (rec.)	1.5 m/s
	Special Fittings	6.0 m/s
Pipe materials	Distribution Mains over 315mm but less than 600mm	HDPE Class 16, PE100 SDR11 jointed by electro fusion or butt welding, SAPPMA approved welder to be used.
	600mm diameter and above	Welded steel – internal lining approved by JW (welded), bitumen wrapped, or coated with a fusion bonded medium density polyethylene material, approved by JW in accordance with SANS 4427.

Parameter	Element	Guidelines
Valves	Type	Only Wedge type gate valves are allowed on reservoir sites, no Resilient Seal Valves will be installed. PN16 or PN25
	Closing	Counter Clockwise, non-rising spindle
VJ Couplings & Flange Adaptors		Not allowed
Bypass valves		Required for isolating valves greater than 400mm or where pressures exceed 900kPa
Reservoir Level Control	Where there is dedicated supply to the reservoir	Altitude Level Control

4 WATER PLANNING ISSUES

4.1 Description of the Development and Water Demand

4.1.1 Predicted Water Demand

The Network Analysis: Lenasia Water Sub-Districts report (PS610) was predominantly concerned with determining water demand and analysing the network. The report did supply valuable information regarding water demands to be met by Lenasia HL reservoir. The study area comprises predominately residential areas in the medium/low income to informal category with a few areas zoned for business/commercial and light industrial. Table 2 provides information on estimated future water demands and phasing of potential future land developments that will be supplied by Lenasia HL reservoir. Water demands used includes non-revenue water. See Figure 3 for the locations of these developments.

Table 2: Potential Future Land Developments (GLS Consulting (Pty) Ltd, 2009)

Ref. No.	Anticipated Land Use	Development			Water Demand			
		Gross Area (ha)	Density (units/ha)	Number of Units*	Unit Demand (kl/ha)	Unit Demand (kl/unit/d)	5-Year Water Demand (kl/d)	Ultimate Water Demand (kl/d)
S_LS1	Residential	4.7	35	165	50	1.4	103	
S_LS12_1	Residential	14	35	489	50	1.4		308
S_LS13_1	Residential	3.8	35	131	50	1.4		83
S_LS2	Residential	30.1	35	1052	50	1.4		662
S_LS9	Residential	3.3	35	115	50	1.4		72
S_VF1	Residential	2.9	35	101	50	1.4	63	
S_VF2	Residential	50.3	35	1762	50	1.4	1107	
S_VF3	Residential	15.3	35	534	50	1.4	336	
S_VF4	School	5	0	2	0	0	36	
S_VF5	Residential	9.2	35	322	50	1.4	202	
S_VF6	Residential	2.9	35	103	50	1.4	65	
S_VF7	Residential	7.6	35	266	50	1.4		167
S_VF8	Residential	4.9	35	170	50	1.4	107	
S_ZA01	Residential	2.6	21	56	30	1.4	48	
S_ZA02	Residential	2.8	21	59	30	1.4	50	
S_ZA03	Residential	11.5	21	242	30	1.4		207
Total		170.9		5569			2117	1499

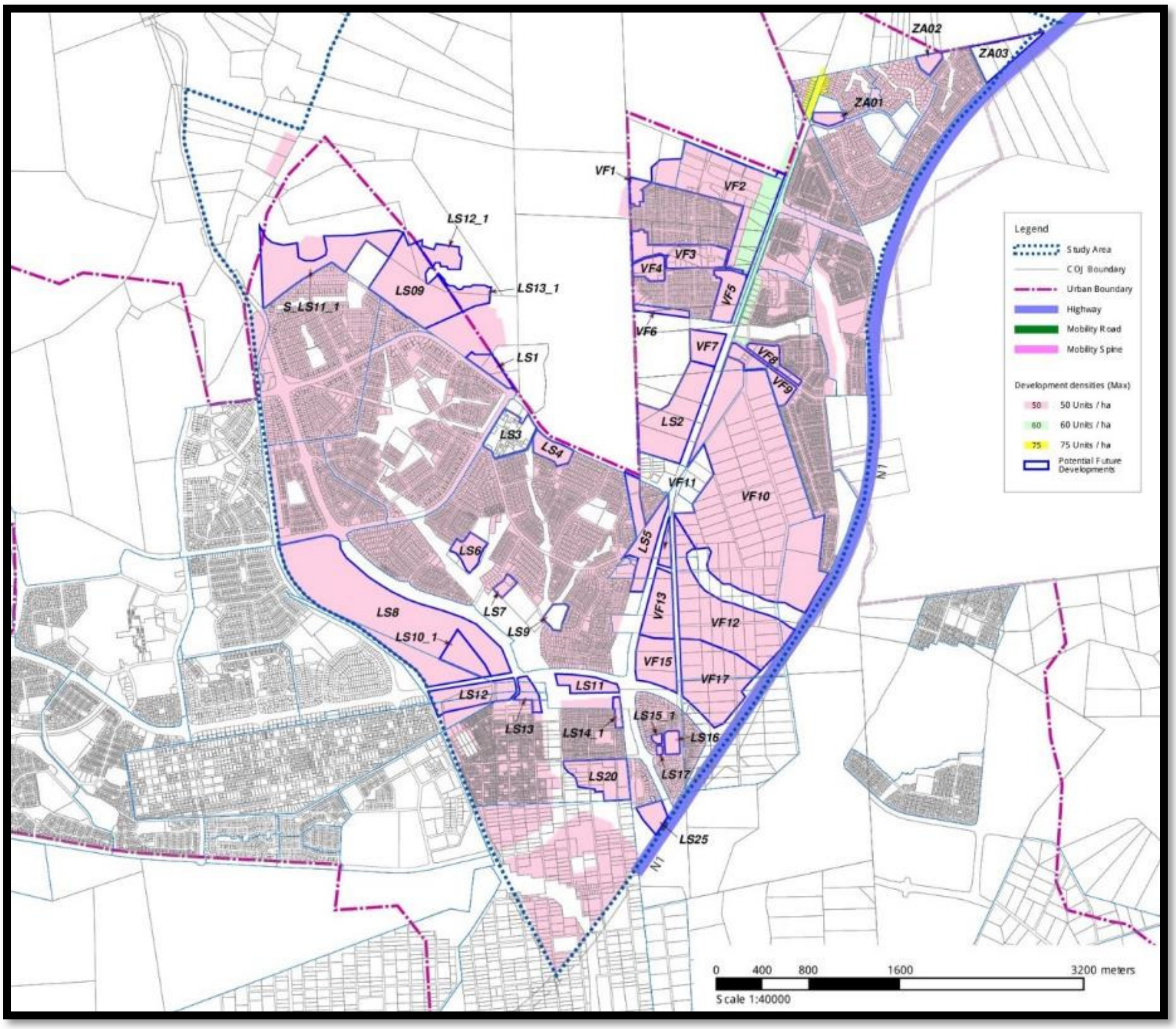

Figure 3: Proposed Development Densities and Potential Future Developments (GLS Consulting (Pty) Ltd, 2009)

No further densification of existing developed areas was considered (GLS Consulting (Pty) Ltd, 2009). An AADD was determined for July 2009, along with an AADD for 5-year and ultimate development scenarios. The 5-year development scenario will be considered as the estimated current scenario.

The available storage capacity of Lenasia HL reservoir, expressed as hours x AADD, as calculated based on the AADDs obtained from the Network Analysis: Lenasia Water Sub-Districts report (PS610) (GLS Consulting (Pty) Ltd, 2009) for different development stages are:

Estimated current scenario: 10 h x AADD

Estimated ultimate scenario: 8.5h x AADD

The minimum required reservoir storage is 24 x AADD in accordance with the JW's Modelling Guidelines (Ref. 2) (GLS Consulting (Pty) Ltd, 2009). Currently the Lenasia High Level reservoir has inadequate storage capacity and no spare capacity. This is due to the development of areas of Vlakfontein, Finetown, Hospital Hill and Lehae that now also receives water from the Lenasia HL reservoir. A breakdown of the past, present and future AADD's are shown in Table 3. The AADD's include non-revenue water.

Table 3: Past, Present and Future AADDs (GLS Consulting (Pty) Ltd, 2009)

Water Sub-districts	AADD July 2009 (kl/day)	Estimated current AADD (kl/day)	Estimated ultimate AADD (kl/day)
Lenasia HL Reservoir	5 600	9 600	11 135
Lenasia HL Reservoir - PRV1	600	665	910
Lenasia HL Reservoir - PRV5	2 800	3 900	3900
Total for Lenasia HL Reservoir	**9 000**	**14 165**	**15 945**
Total for Entire Lenasia District	**44 800**	**53 270**	**65 000**

4.1.2 Actual Water Demand

Comparing the monthly volume of water drawn through the Rand Water connection RW1984 during the past four years (between Aug 2010 and June 2014) with the values estimated by the Network Analysis: Lenasia Water Sub-Districts Report (PS610) compiled by GLS Consulting (Pty) Ltd revealed the following about water demand for the Lenasia District:

- Water usage in Lenasia has grown at an annual rate of 7% during the last 4 years. The report calculated an average growth rate of 3.5% annually for the period between 2009 and 2014.
- The report also estimated that by 2014 the AADD would be 53 270 kl/day. The actual current AADD was calculated as 62 129 kl/day which is 16.6% more.
- The ultimate AADD estimated by the report is 65 000 kl/day. The Average Monthly Daily Demand (AMDD) as calculated from the records has already exceeded this value for two months (in September 2013 and June 2014).
- The report suggests that the ultimate AADD that has to be supplied by Lenasia High Level reservoir is 15 945 kl/day. In practice the pump station is just supplying the current demand without excess capacity to fill the reservoir. It is estimated that the pump station supplies 16 930 kl/day. This leads us to believe that the ultimate AADD for the Lenasia High Level supply area has already exceeded 15 945 kl/day.

- All of these comparisons make it clear that the growth in the Lenasia area has been much more than estimated by Network Analysis: Lenasia Water Sub-Districts Report (PS610). When studying the areas which are developed, it does not seem that additional land than what was used to calculate the future AADD's was developed. The growth must therefore be attributed either to higher population densities or massive leakage / illegal connections within the networks.
- The belief that a significant portion of the dramatically increased water demand can be attributed to leaks in the system is strengthened by information received from the Operations Division. According to them the only way to increase the water level inside the reservoir is to partially close the valve to the supply network at night times only allowing a small amount of pressure in the network. This points to the likelihood of leaks in the network as there is no other way to explain large usage volumes during night times.
- JW are currently busy with discretisation projects in many areas (such as Soweto) to install meters and subdivide areas into discrete zones which are also bulk metered in order to mitigate leakage and illegal connections. Based on all the information available about Lenasia it is our recommendation that JW should make implementing one of these discretisation projects in Lenasia a top priority.

4.1.3 AADD Peak Factor

- The monthly water usage volumes were also analysed for seasonality. The annual growth was subtracted from all values in order to view seasonal trends. Average values were also determined for each month.
- As indicated by the graph (Figure 4) no distinct seasonal peaks can be established.
- Only Monthly peaks could be observed. Peaks occurred in February, July and November.
- The peaks are however not that drastic and the largest peak, occurring in July, is only 1.1 times the average AMDD. For this reason the summer peak factor of 1.5 as suggested and used by the Network Analysis: Lenasia Water Sub-Districts Report (PS610) appears to be unnecessarily large.

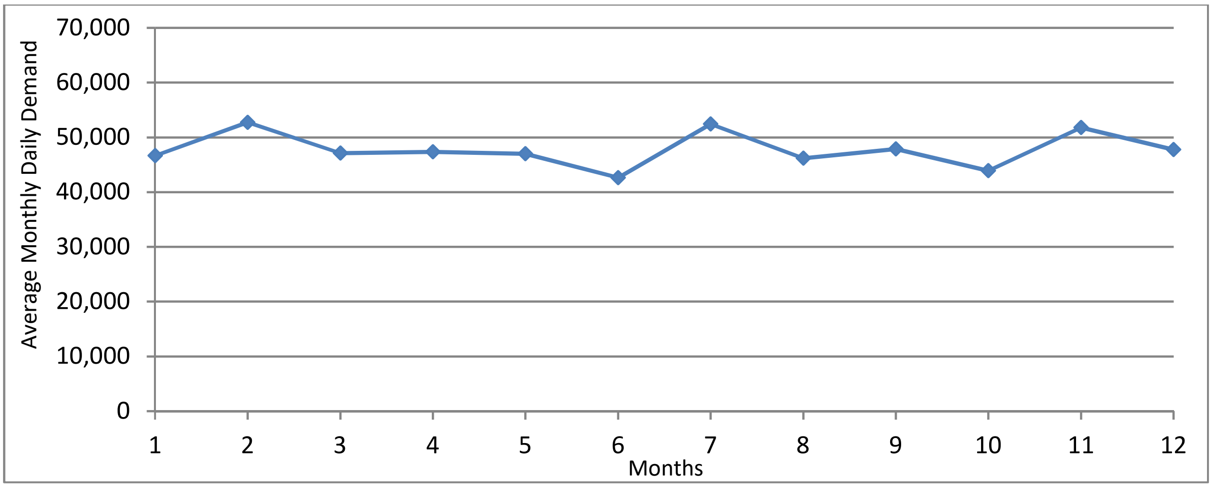

Figure 4: Average Daily Demand Indicated for Each Month (With Annual Growth Subtracted)

4.1.4 Logged Flow Rates

Due to the many uncertainties highlighted above a decision was taken to log flows at the following locations for a seven day period:

- Flow into Hospital Hill Reservoir
- Flow into the network fed by Hospital Hill reservoir
- Flow into the network fed by Lenasia High Level reservoir

A graph indicating the draw-off patterns for the seven day period is attached as Annexure B. Table 4 provides a summary of the data obtained. The data was used to calculate an AADD which could be compared to the values obtained from the Network Analysis: Lenasia Water Sub-Districts Report (PS610). The comparison is shown in Table 5.

Table 4: Summary of Logged Flow Values

	Into Hospital Hill Reservoir	To Hospital Hill Network	To Lenasia HL Network
Average Flow (ℓ/s)	422	272	212
Maximum Flow (ℓ/s)	570	354	309
Minimum Flow (ℓ/s)	381	216	150

Table 5: Comparison of AADD values

Water Sub-districts	Estimated current AADD (kl/day)	Estimated ultimate AADD (kl/day)	Logged AADD March 2015 (kl/day)
Lenasia HL Reservoir	14 165	15 945	18 312
Lenasia Hospital Hill Reservoir	15 470	20 000	23 500

The logged flow rates indicate that water consumption in the Lenasia High Level Sub-district is already approximately 30% more than what it was estimated to be and 15% more than the maximum demand which that was estimated. The situation for the Lenasia Hospital Hill Reservoir Sub-district is even more alarming with values of 52% and 18%.

The minimum flow rate rates for both reservoirs' networks are alarmingly high (150 ℓ/s at the Lenasia High Level network and 216 ℓ/s at the Hospital Hill network) and are the same each day, which can be attributed to leaks in the networks.

4.2 Required Supply

If the new 15ML reservoir is constructed the two Lenasia HL reservoirs will provide a total storage capacity of 21ML. Once the estimated ultimate AADD is reached the reservoirs will provide approximately 32 hours of storage capacity.

The flow rates (in ℓ/s) required for sufficient supply was calculated for three different scenarios:

- To supply the ultimate AADD
- To supply the ultimate AADD with summer peak factor (Peak factor = 1.5)
- To fill the existing 6ML and proposed 15ML reservoirs

Flows were calculated for pumping 24 hours a day and for pumping 18 hours a day. The required flow rates for normal all three scenarios are shown in Table 6.

Table 6: Flow Required for Sufficient Supply

	Ultimate AADD	Ultimate AADD + Summer PF	Existing + New Reservoir
Peak Factor	1.0	1.5	1.32
Required Volume (kl)	15 945	23 918	21 000
Required Flow rate when pumping 24h/day (ℓ/s)	184.5	276.8	243.1
Required Flow rate when pumping 18h/day (ℓ/s)	246.1	369.1	324.1

It is important to note that building an additional 15ML reservoir, as was recommended by the Network Analysis: Lenasia Water Sub-districts report (PS610) (GLS Consulting (Pty) Ltd, 2009), will only increase the total capacity to 21ML. Approximately 24 ML is required to store the AADD x 1.5 Summer peak factor, which will require the construction of an additional 18ML reservoir instead.

4.3 Upgrades proposed by the Network Analysis: Lenasia Water Sub-Districts Report (PS610)

The Network Analysis: Lenasia Water Sub-Districts Report (PS610) makes the following recommendations in their report (GLS Consulting (Pty) Ltd, 2009):

- Upgrade the existing pump station at Hospital Hill reservoir to deliver 275 ℓ/s @ 60m head.
- Upgrade the existing Lenasia HL reservoir capacity by constructing an additional 15 ML reservoir.

5 CONSTRUCTION OF THE REQUIRED INFRASTRUCTURE

The water requirements at Lenasia High Level reservoir can only be adequately met by addressing the inadequacies in the entire Lenasia complex (comprising the Cosmos, Hospital Hill and High Level reservoirs). Nyeleti Consulting will however only address supply to and storage at Lenasia High Level reservoir.

The rest of the system will be evaluated and improved by others. It is important to note that JW are aiming to implement a new, larger diameter pipeline to Hospital Hill reservoir, which will improve supply and reduce risks of pipeline failure. Steel pipes have previously been procured for this purpose and are available on site.

The portion of the work for which Nyeleti Consulting has been appointed will be split into three separate contracts as follow:

- Construction of the 15ML reservoir and pipework within the reservoir site boundaries
- Construction of the ND600 steel rising main between Hospital Hill pump station and Lenasia High Level reservoir and overflow pipeline
- Upgrade of Hospital Hill pump station

Advantages of splitting the required upgrades into three separate contracts in this manner are:

- Skill required for the three contracts (concrete work, pipe laying, electromechanical) are vastly different from each other and contractors more suitable to construct each element can be appointed.
- Upgrade of the pump station is the most urgent step. Upgrading the pump station while the other elements are not yet complete will have immediate benefits. Having this as a separate contract will allow faster implementation and an interim solution can be created. Once the pump station is upgraded water supply to Lenasia High Level reservoir can be improved by 30%, even if the rising main is not yet upgraded.
- The pipelines (rising main and overflow pipeline) will require an EIA, which will delay construction of the other two elements.
- Construction of the reservoir cannot start until the land has been acquired. As the land acquisition process in complex it can also potentially delay the other projects.

6 CONSTRUCTION OF THE RESERVOIR AND PIPEWORK

Nyeleti Consulting proposes that the new reservoir be constructed on the North-western side of the existing reservoir. The proposed area belongs to the Gauteng Provincial Department and will have to be bought or leased by JW. Final positioning of the reservoir is there for dependant on the success in obtaining the land. A drawing indicating the proposed location is attached as Annexure C.

6.1 Concrete reservoir

6.1.1 Reservoir Dimensions - Alternatives

There are two main considerations for deciding on the height and diameter of the proposed new reservoir: cost and simplicity of operation.

As a rule of thumb for a reservoir of this capacity a wall height of 10m is considered to be most economical. With 9.5m water depth the diameter will be approximately 45m.

On the other hand if the reservoir is to be designed for simplicity of operation it is proposed that the new reservoir should have the same TWL and BWL as the existing reservoir. If the water level is 7.5m high (to match that of the existing reservoir) the reservoir would have an internal diameter of about 50m. The wall height of the reservoir would then be 8m.

If the 10m high reservoir option is chosen and the reservoirs are not the same height, the TWL of the two reservoirs should at least correspond. The reason being that if the reservoirs have different TWLs the reservoir with a lower TWL will overflow when attempting to fill the reservoir with higher TWL. Therefore, for the reservoirs to have the same TWL an additional 2m deep excavation would be required for a 70m by 70m area. A further complication is that the existing outlet pipework will almost certainly be higher than the outlet of the new reservoir. Existing outlet pipework would have to be re-laid.

A basic cost breakdown for the two reservoir alternatives is shown in Table 7. It shows that the additional earthworks and pipework costs almost offsets the benefits of the more economical 10m high reservoir.

Table 7: Reservoir Dimension Alternatives

Item	7.5m Water level (8m Wall height)	9.5m Water level (10m Wall height)
Construction of reservoir	R 9 300 000	R 8 400 000
Earthworks	R 3 800 000	R 3 000 000
2m additional excavation		R 1 200 000
Re-lay outlet pipework		R 400 000
	R 13 100 000	**R 13 000 000**

Based on the fact that the two alternatives cost roughly the same it is recommended that the reservoirs be constructed with the same TWL and BWL.

6.1.2 Structural layout

Although the existing reservoir is built below ground, the JW Guidelines recommends that reservoirs be built above ground. Thus the proposed new reservoir will be built above ground with the associated slopes and terraces.

The structure will have post tensioned concrete cylindrical walls and a reinforced concrete floor. The roof, supported on circular columns, will be flat and a 100mm layer of stone will be placed on the roof to limit thermal effects. On the walls the roof will be supported on Teflon sliding bearings.

It is recommended that the floor be designed as a jointless slab, thus limiting maintenance as well as the probability of leakage. However JW indicated during the prelim design meeting that they would prefer a jointed slab. JW later requested that the floor be constructed with a channel running down the center to facilitate ease of cleaning the reservoir. JW requested that Nyeleti Consulting investigates different alternatives and do a cost comparison for construction of the reservoir floor slab. The alternatives are discussed in section 6.2. Below the floor a subfloor drainage system consisting of a 200mm layer of no-fines concrete and slotted HDPE pipes will be installed. This will have a dual function. Firstly during construction, it will facilitate in the water tightness test. Secondly it will in future indicate leakage serving as an indicator of maintenance requirements. The subfloor drainage system will be zoned to facilitate the determination of the position of possible defects.

A small scour sump will be provided in the floor to allow for cleaning. The sump will drain to a precast concrete chamber outside the structure.

An overflow pipe will be provided for emergency overflow, which will drain water to a concrete chamber, which in turn drains to the retention dam on site, similar to the existing reservoir. In terms of pipe work, the structure will have a top inlet and bottom outlet. Operation and pipe details will be discussed under the pipe work section of this report.

After construction of the structure, it will be tested for water tightness. The Client should allow for the water supply to fill the structure at that stage. The structure will be cleaned and disinfected prior to filling and the water used for testing can thus be taken into the pipe network.

Level monitoring will be electronically via the telemetry system.

6.1.3 Concrete

The following codes of practise will be used:

- SANS 0160 - Loading
- SABS 0100 – Reinforced concrete design
- BS 8007 – Design for concrete structures retaining aqueous liquids revised in 1987
- Structural Steel Design - SABS 0162 as revised 1993
- Density = 25kN/m3
- 28 Day Compressive strength (Fcu) = 35 MPa (class 35/19)
- Modulus of elasticity (Ec) = 8 GPa
- Poisson ratio = 0.2
- Minimum crack width = 0.2mm
- Shrinkage strain = 200 E-6
- Concrete mix design c:w ratio = 2

6.1.4 Reinforcement

Tensile strength (fy)

- High tensile steel = 450 MPa
- Mild steel = 250 MPa
- Modulus of elasticity = 200 GPa
- Minimum cover to footings = 40mm

6.1.5 Post tensioning

- Type of cable = Low relaxation; bonded
- Residual compression = 1 MPa

6.2 Alternatives for Construction of the Reservoir Floor Slab

6.2.1 Background Information

Nyeleti Consulting evaluated three different options for the floor slab of the new Lenasia HL reservoir. The three options will be discussed in further detail in this section. Drawings are also included in Annexure D to provide visual aid to the descriptions discussed below. A cost comparison was done with these three options.

6.2.2 General Notes

The first option is to construct a conventional floor with joints in it at 6.0m center to center grid. The second alternative is to construct the reinforced slab without joints. By limiting joints in the slab, probability of leakage as well as maintenance is reduced significantly. The third alternative is to construct a post tensioned floor slab also without joints.

The minimum slope that the floor will have is 0.5%. This slope shall drain from the wall to the center line of the reservoir from where it will drain into a drainage channel. As the slope varies, with a constant level at the wall and channel, it will result in a max slope of 6.1% at the two ends of the channel.

The trench/channel shall be cast in-situ and have its invert sloped at 1%. This slope shall be formed as indicated in the drawings. The channel will start off with a depth of 500mm. The channel at the lowest point drains into a scour valve pipe which will drain the water out of the reservoir.

For all 3 alternatives a zoned subfloor drainage system will be installed as discussed in paragraph 6.1.2 of this document.

6.2.2.1 Option 1: Conventional Floor Slab with Joints

This option is for the conventional 250mm thick reinforced concrete floor slab with joints at 6.0m center to center forming a grid. The floor slopes at minimum 0.5% to a central drainage channel as described above for maintenance purposes. Floor joints consist of water stop, joint filler, sealant as well as a bandage. The in situ concrete channel also has joints matching slab joints at 6.0m center to center.

6.2.2.2 Option 2: Jointless RC Floor Slab

Constructing jointless floors are in line with international trends. Joints for this option will be limited to the trench perimeter only. This will limit the leakage and the maintenance needed on the floor slab. The floor will have a thickness of 250mm and will be heavily reinforced and designed to BS 8007 for 0.2mm crack width.

No joints are specified for the channel.

Nyeleti Consulting has successfully completed a number of smaller reservoirs using this method. We have also successfully completed a large number of substations and buildings with deep, watertight basements at Medupi and Kusile power stations. We are also currently constructing a 250Ml/day filter block for Rand Water using jointless construction.

6.2.2.3 Option 3: Post Tensioned Floor Slab

The advantage of a post tensioned (PT) floor slab is that the slab thickness can be reduced along with reduced reinforcement. Because of the post tensioning, the concrete in the floor will be completely in compression, thus no cracking and even minor cracks that formed during construction will be closed due to the compression.

The floor slab will have a thickness of 200mm and will have a band of reinforced concrete 2.0m wide along its perimeter and 4.0m wide along the center, as indicated in the drawing. The remainder concrete inside this band shall be unreinforced. The floor will be post tensioned to 1.0MPa residual compression to BS 8007 using a bonded post tensioning system.

The channel will be positioned under the floor slab as indicated in the drawing. Slots will be positioned directly above the channel (in the floor slab) and covered with grating (500x600mm) allowing access for maintenance. These covered slots will be spaced at 1m center to center. As in both the above mentioned cases, the channel will drain to the scour pipe.

No joints are specified for the channel.

Although Johannesburg Water does not have a post tensioned reservoir floor it is widely used internationally. Rand Water has also constructed 2 resevoirs with post tensioned floors: Daleside 40Ml Reservoir and Weltevreden 100Ml Reservoir. The designer of the Daleside Reservoir will be the designer for this Lenasia Reservoir.

6.2.3 Cost Comparison

A Cost comparison between the three options was done and the results are shown below in Table 8.

Table 8: Cost Comparison for Reservoir Floor Slab Options

Slab Option	Cost
1: Conventional slab with joints	R2 383 942
2: Jointless Slab	R2 421 222
3. Post Tensioned Slab	R1 902 000

As a conventionally constructed jointless slab is not significantly more expensive than a slab with joints it is recommended that a jointless slab be constructed.

6.3 Pipework and Valves

6.3.1 General

A Schematic layout indicating the proposed pipework required at Lenasia HL reservoir is attached as Annexure E. Existing chambers are indicated by the prefix EC and new chambers are indicated by the prefix NC.

Pipework for the two reservoirs will be designed in such a manner that the two reservoirs will function as a unit. Pipework will allow each of the reservoirs to be isolated and only the other used at any stage, for maintenance purposes etc. All new pipework inside the reservoir terrain shall be ND500 pipes to simplify ordering of pipes.

No RSV- or butterfly valves will be installed, as instructed by the JW Electromechanical division.

There will be no strainers installed in any of the chambers as instructed by JW Electromechanical.

Only electro-magnetic water meters will be installed as per instruction received from JW during a meeting on 14 August 2014.

6.3.2 Measuring Inflow and Outflow

The JW Electromechanical division requested that the existing water meter measuring outflow at Lenasia HL reservoir should be replaced. The existing water meter chamber (EC7 & EC8) also do not comply with the current JW standard details for Bulk Water meter Chambers. It is proposed that a new water meter chamber (NC3) shall be constructed just downstream of the existing outlet chamber (EC5). The new meter chamber will be designed to the latest JW specifications.

The water meter chamber (EC1) measuring inflow into the existing Lenasia HL reservoir was recently refurbished and will be retained. The water meter will however be replaced with an electromagnetic flow meter.

A new water meter chamber (NC1) complying with the latest JW specifications will be constructed to measure both inflow and outflow into the new Lenasia HL reservoir. This water meter chamber will also house a water sampling point as was requested by JW. This chamber will also function as an inlet and outlet isolation chamber.

The new reservoir terrain will consequently have a total of four water meters allowing for inflow and outflow into both reservoirs to be measured separately.

6.3.3 Inlet Pipework

The rising main delivering water to the reservoir is a 400mm ø asbestos cement (AC) pipe and will be replaced with a 600mm ø steel pipe (construction thereof will be done under a separate contract). Where the rising main enters the reservoir terrain a new 600x600 Y-piece will be installed. The Y-piece will split the flow between the existing ND400 pipeline (to the existing reservoir) and the new ND500 pipeline (to the new reservoir).

As the existing reservoir has a top inlet, the new reservoir will also have a top inlet. Because the reservoir will have post-tensioned walls, the walls of the reservoir will move radially as temperature increase and decrease. If the inlet pipe enters the reservoir through the wall there is a risk that the radial movement will cause fatigue in the pipe over the long term. For this reason the pipe will enter the reservoir through the floor. At the top the DN500 pipe will split into two DN300 pipes spanning 20m each which will diffuse and circulate the water in the reservoir.

The pipes inside the reservoir will be stainless steel as per JW specifications.

6.3.4 Outlet Pipework

The outlet pipework of the new reservoir will replicate that of the existing reservoir. Outlet control and metering with isolating valves and a water sampling point will be housed inside chamber NC1.

6.3.5 Bypasses

A new ND500 bypass pipeline will be constructed for the existing reservoir. The bypass will be opened and closed in chambers NC2 and NC3. Chamber NC3 will house a Pressure Reducing Valve (PRV) to protect the network pipes.

A ND300 bypass will be constructed to bypass the new reservoir. The valves to open and close the new bypass as well as a PRV will be housed in chamber NC1.

This installation will allow the option to bypass each reservoir independently from the other.

6.4 Overflow and Scour Water

The reservoir drains, overflow and scour pipes from the new reservoir will all drain into a concrete chamber (NC4). From the chamber it will be drained via a ND525 concrete pipe to the existing scour pond. From the existing pond it will be drained to the stormwater system via the old AC rising main (which will now function as a drainage pipe) and new ND315 uPVC sewer pipe, which will form part of the next contract.

6.5 Replacing Existing Valves and Pipes

JW Electromechanical Operations have requested that the existing valves that will function in the new system be replaced, as these valves are old and do not meet the currents standards and specifications. The following valves will be replaced:

Inlet Valve Chamber (EC 4) – New ND400 Gate Valve will be installed

Air Valve on Inlet side – New ND100 Air Valve and Gate Valve will be installed and a new brick chamber will be constructed to accommodate the vlaves.

Outlet Valve Chamber (EC 5) – ND450 Gate Valve will be installed

Overflow and Scour Chamber (EC6) – ND200 Gate Valve will be installed

Meter Chamber (EC1) – ND400 Electromagnetic Water Meter will be installed

6.6 Reservoir Terrain and Security

As part of the project the entire reservoir terrain will be upgraded to adhere to JW specifications.

A clear view fence and (such as Clearvu) will be erected around the perimeter of both reservoirs. All existing concrete palisade fencing will be dismantled so that the reservoirs will be enclosed in a single encampment.

Access for large vehicles through the existing entrance gate is very difficult and JW has requested that the entrance gate be moved. Consequently a new entrance gate will be constructed on the Southern side of the new reservoir, allowing the existing access road to be used without modification.

A guard hut, which will double as a telemetry hut, will be constructed on the new reservoir terrain. The guard hut will be provided with electricity, water and toilet facilities. Sewerage will be discharged to a septic tank and soak away system.

High level lighting in the form of energy saving floodlights will also be installed. It is proposed that a lamp post will be erected approximately every 20m along the perimeter of the fence.

Prior to finalising the detail design, a meeting will be set-up with Mr. Keith Boshoff from JW security to confirm the specifications and requirements for all these elements.

The matter of supplying electricity to Lenasia High Level reservoir remains a contentious issue as the prevalence of cable theft makes it impossible to connect the Lenasia High Level reservoir to the electrical supply at the Hospital Hill pump station via a conventional electrical cable. The possibility of using a hydro-turbine was comprehensively investigated, but the technology to generate and store the required amount of electricity (approximately 4kW) is not available yet.

For this reason the only viable option is solar power. 16 Solar panels requiring an area of approximately 30m^2 will be required. It is suggested that the solar panels be installed on the new reservoir roof as the will be less visible and difficult to access.

7 CONSTRUCTION OF THE RISING MAIN AND OVERFLOW PIPELINE

7.1 Rising Main

7.1.1 Pipeline Size and Material

The existing line has a diameter of ND400 and does not have sufficient hydraulic capacity to supply the 1.5 x Ultimate AADD. The smallest pipe size that would be able to supply the 1.5 x AADD of 23 918Kl in 24 hours is a ND560 HDPE pipe. However, when comparing the capacity of a ND560 HDPE pipe with a ND600 steel pipes (the smallest size steel pipe allowed by JW) the ND560 HDPE pipe has almost half the capacity of the ND600 steel pipe, due to its wall thickness. Capacities of both pipes are shown in Table 9.

Table 9: Comparison between ND560 HDPE pipe and ND600 Steel pipe

	Flow (V = 1.5m/s)	24h Supply (V = 1.5m/s)	Flow (V = 2m/s)	24h Supply (V = 2m/s)
	ℓ/s	Kl	ℓ/s	Kl
600 Ø Steel	421	36 400	562	48 533
560 Ø HDPE	239	20 612	318	27 483

The cost of installing a ND560 HDPE pipe and a ND600 Steel pipe are very similar, but the ND600 steel pipe is preferred as it will offer much lower lifecycle cost due to its significantly higher capacity. Details of the pipe are shown in Table 10 below.

Table 10: Pipe Characteristics

Size	ND600
Material	Welded Steel
Class	PN16
External Coating	Finalise when considering Cathodic Protection requirements
Internal Lining	Most likely epoxy – but will be finalised along with Cathodic Protection

7.1.2 Pipeline Route

The proposed new ND600 steel pipe will follow the same route as the existing Asbestos Cement pipe. The new steel pipe will be laid far enough from the existing pipe to allow for adequate soil to remain around the existing pipe to protect it and prevent it from kicking. The length of the new pipe will be approximately 1.2km.

There is no development alongside the servitude and following this route would limit disturbance to the community. Furthermore few or no services at all are expected to intersect the proposed pipeline route are expected. The proposed route is shown in Figure 5.

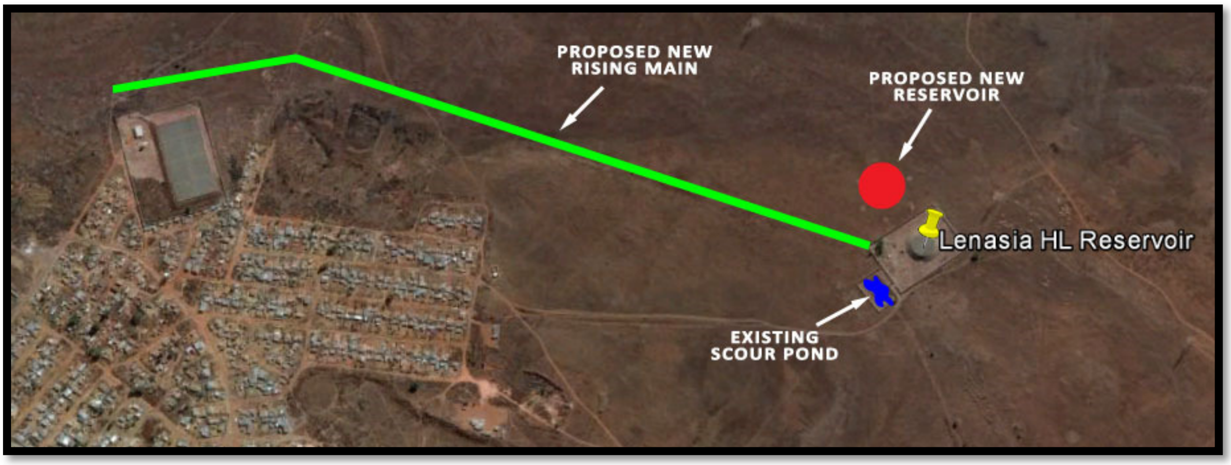

Figure 5: Schematic representation of the pipeline route

7.1.3 Connections to Existing Pipework

The entire portion of Asbestos Cement pipe will be replaced; the new steel pipe will therefore be connected to existing steel pipework close to the reservoirs. Figure 6 schematically indicates how the new steel pipe will be connected to the existing steel pipe at the Hospital Hill pump station. As the pipes will be laid some distance apart a gooseneck will be used on each side. Details of the connection at Lenasia HL reservoir are shown in Figure 7. A Y-piece will be installed to split flow to the new and existing reservoirs.

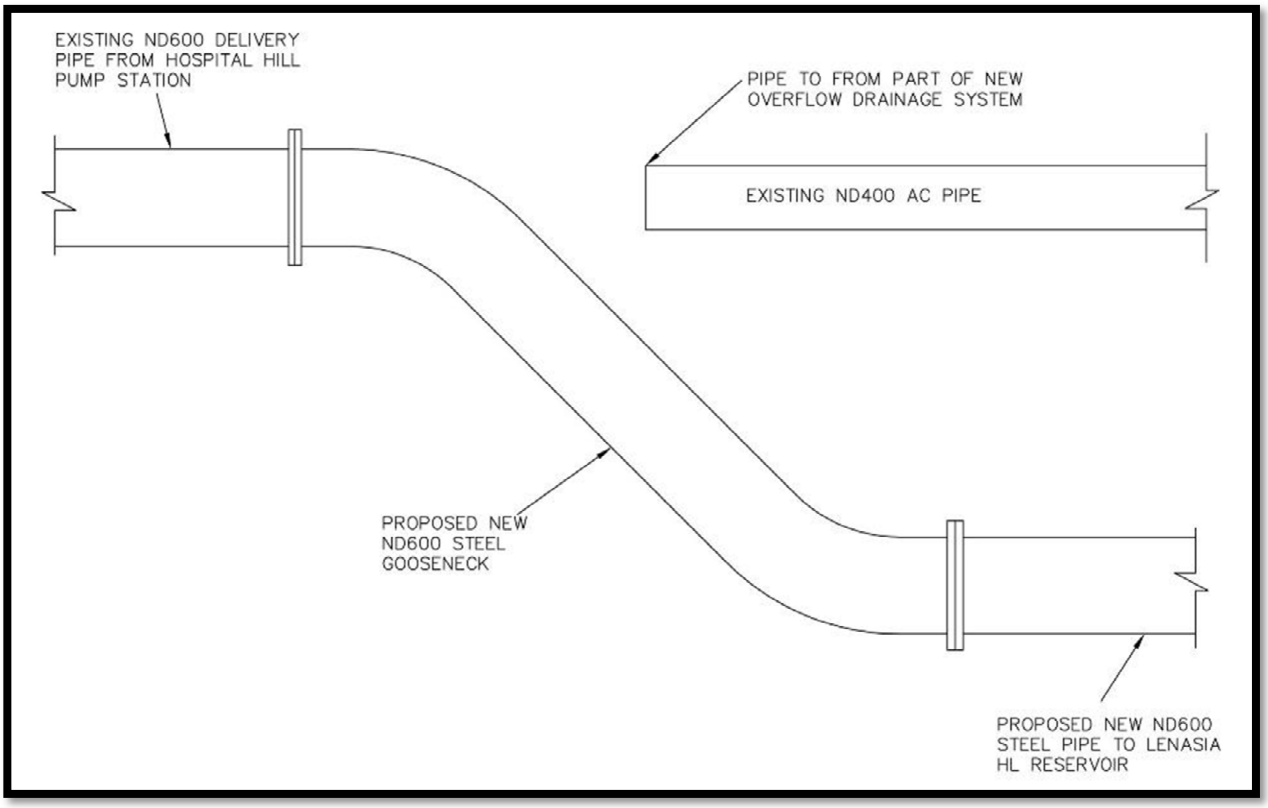

Figure 6: Connection of new steel pipeline to existing pipe at Hospital Hill pump station

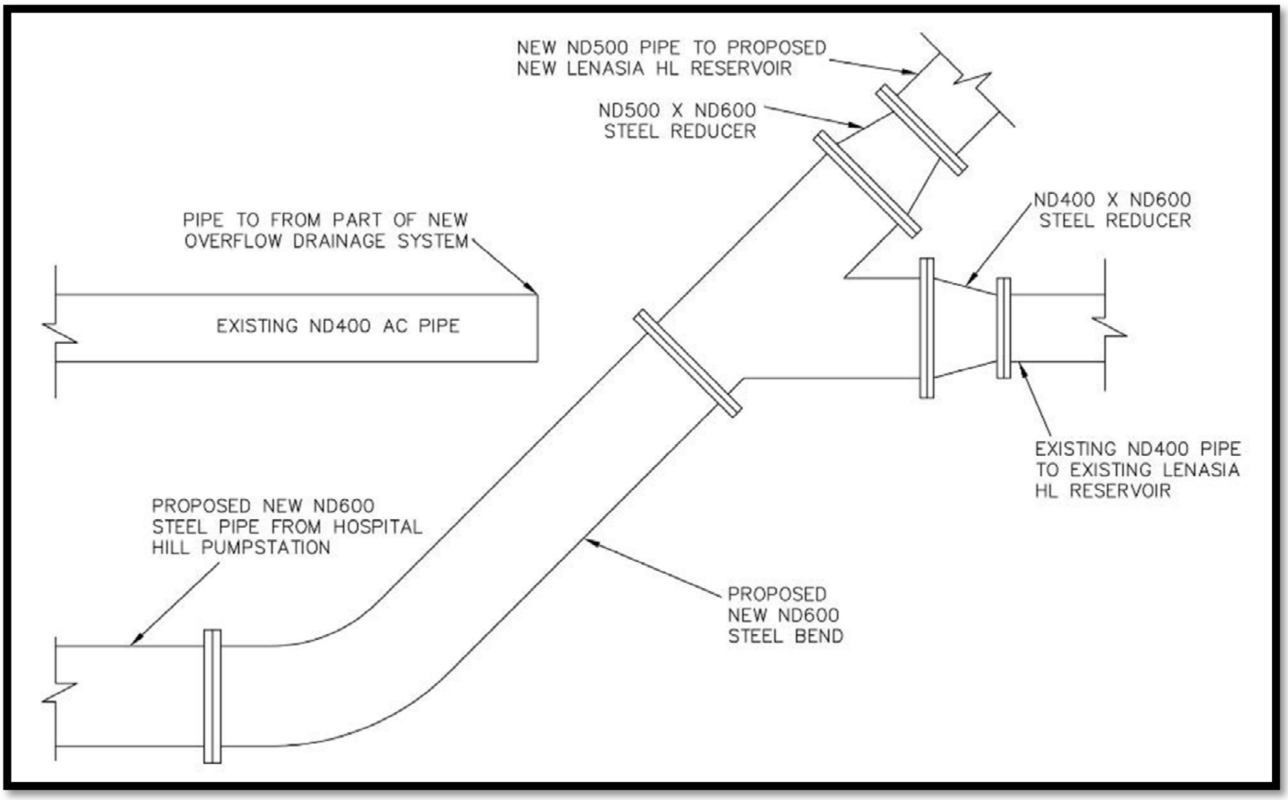

Figure 7: Connection of new steel pipeline to existing pipe at Lenasia HL reservoir

7.1.4 Cathodic Protection

The pipeline will need cathodic protection and details thereof will be discussed with JW Operations: Electrical Support Department (Mr. Edward Livesey) prior to finalising the detail design. A specialist subconsultant will be appointed for the Cathodic protection design.

A soil corrosivity analysis will be required to finalise Cathodic protection requirements. Specifications of linings and coatings will also be determined with the input from Mr. Livesey and the Electrical Support Department.

The pipeline contract will also make provision for the appointment of a specialist subcontractor to install the Cathodic Protection system on the pipeline.

7.1.5 Future possibilities for Redundant Asbestos Cement pipe

Once water flow has been switched over to the new Steel pipe, the existing Asbestos Cement pipe will be blanked off to protect it and keep it clean. The AC pipe will now become available to form part of the overflow pipeline (to be discussed under the next section). As the overflow water will not flow under pressure, the possibility of triplex couplings failing under pressure will not be risk if the pipe is used for this purpose.

7.2 Overflow Pipeline

The existing reservoir drains overflow and scour water to a scour pond located on the South-western side of the reservoir. It was initially planned that the new reservoir will also drain scour and overflow water to the existing pond without any further complication. However in an email dated 24 June 2014, Mr. John Lourens (JW Operations: Electro) stated that “the current pond is not adequate and has spilled into the informal settlement in the past”.

During a meeting on site on 20 August 2014 Mr. Gordon Wynne (JW Operations) also stated that the scour outlet of Hospital Hill reservoir discharges into an area that was once open veld but informal dwellings have now been constructed over the area. Consequently JW Operations cannot scour the Hospital Hill reservoir at all without flooding some of the dwellings in the informal settlement. For this reason the reservoir has never been washed by JW, since they took over the reservoir.

Nyeleti Consulting suggested that another scour pond be built to accommodate overflow from the new reservoir. However at a meeting on 14 August 2014 Mr. Nqobizitha Ndimande expressed JW's preference to not have a scour pond if it can be avoided at all.

In order to not construct a scour pond the overflow water will have to be drained to the stormwater system. The closest stormwater pipes run along Cosmos Street or Wimbledon Road, which is 1.2km away as the crow flies.

As previously mentioned, the reservoir drains, overflow and scour pipes from the new reservoir will all drain into a concrete chamber (NC4). From the chamber it will be drained via a ND 525 concrete pipe to the existing scour pond. The initial suggestion was that from the existing pond it will be drained to the stormwater system via a ND315 uPVC sewer pipe.

If the reservoir does overflow, a ND315 pipe will allow approximately four hours before the scour pond will overflow, during which time supply to the reservoir needs to be stopped.

Mr. John Lourens from JW Electromechanical Operations however suggested that the AC pipe which will become redundant can be used as the overflow discharge pipe.

There are two possible sets of reasoning for choosing an optimum route for the uPVC pipe from the scour pond to the stormwater system. Option 1 is aimed at utilising the now redundant ND400 AC pipe for a portion of the route to reduce costs. Option 2 is based on laying the pipe along the shortest possible route between the scour pond and the storm water system. The options are shown in Figure 8 and the details discussed below. Nemai Consulting (Environmental Consultants) are currently evaluating the environmental implications of both options.

The two options will cost roughly the same (within 5% of one another). Option 1 has the additional benefit to allow the Hospital Hill to be scoured through the same pipeline and thereby allowing JW Operations to clean the Hospital Hill reservoir which is not possible at this stage. Solving the problems experienced with scouring both reservoirs by a dual solution is less expensive (approximately R500 000) than addressing the problems with scouring each reservoir individually.

Figure 8: Options to drain scour pond

7.2.1 Option 1 – Utilising the rising main trench

If Option 1 is decided on the ND400 AC pipe will be utilised between the scour pond and Hospital Hill reservoir. However for the portion skirting the reservoir terrain and then running alongside the road to Cosmos street where it will discharge into the stormwater system a trench will have to be dug specifically for the scour pipe.

The estimated cost to construct Option 1 is approximately R 540 000.

The advantages of Route Option 1 are:

- The scour outlet at Hospital Hill reservoir can be connected to the stormwater system, which will enable scouring of the reservoir without flooding the dwellings surrounding it.
- Because the old AC rising main will be used for a portion and the other portion runs in the roadway there will be no additional environmental impact.
- Because the existing AC pipe will be used or the uPVC runs in the roadway there is almost no risk of encountering hard rock that will require blasting.

- As this route follows the same route as the existing pipeline or falls inside the road reserve no servitude will need to be registered.

7.2.2 Option 2 – Laying the pipe along the shortest route

If Option 2 is decided on the scour pipe will be laid in a northerly direction to where it will discharge into an existing stormwater channel (shown below in Figure 9) which runs along an existing boundary fence. Route Option 2 offers no possibility to drain scour and overflow water from Hospital Hill reservoir. In addition this route will require the registration of a servitude for the pipe, which can lead to further administrative costs (not currently quantified) and delays.

Figure 9: Existing Stormwater Channel

The estimated cost to construct Option 2 is approximately R 540 000.

Advantages of Route Option 2 are:

- The route is shorter.

8 UPGRADE OF HOSPITAL HILL PUMP STATION

When Nyeleti Consulting inspected the pump station for the first time only two KSB WKLn 150 2-stage pumps were operational. A third similar pump was available but was unsuitable for use as it was a 3-stage pump. The third pump was sent to KSB in November 2014 only to find that it was incorrectly labelled and in fact a 2-stage pump. The third pump was subsequently installed in November 2014. Schematic layouts of the current pump station are based on the two pump scenario.

8.1 Current Situation at Hospital Hill Pump station

The pump station now houses three identical centrifugal pumps with characteristics shown in Table 11. The pump station has been designed to accommodate two additional end-suction pumps. The layout of the pump station is shown in Figure 10 and Figure 11.

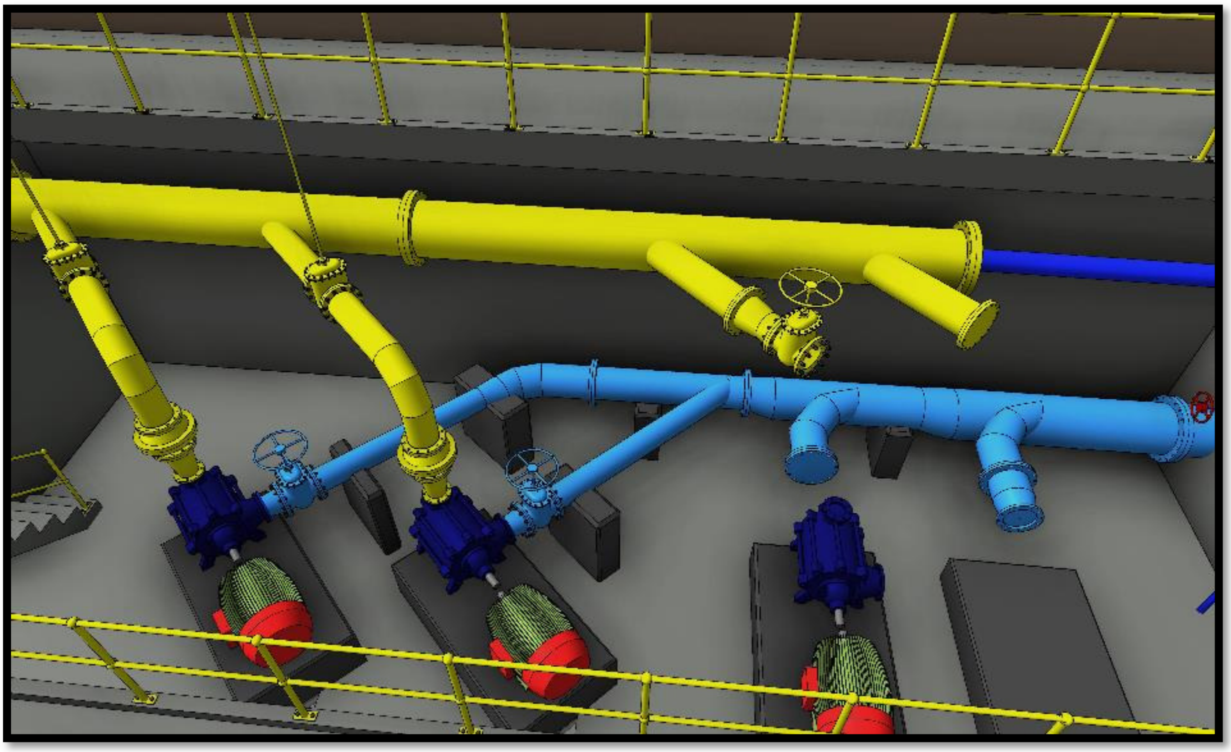

Figure 10: Three-Dimensional Image of Hospital Hill Pump Station

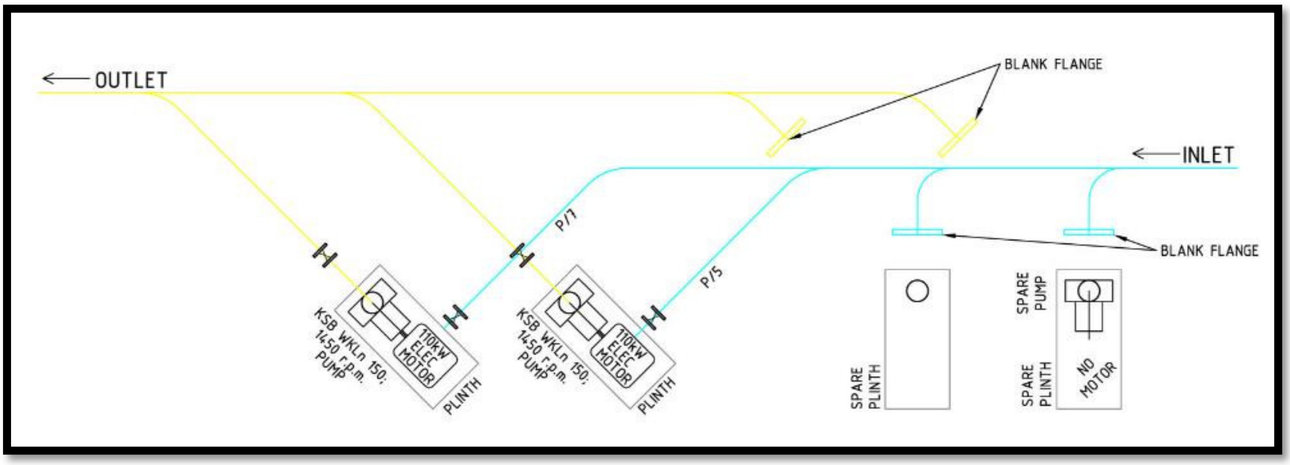

Figure 11: Schematic Layout of Pump station

Table 11: Existing Pump Characteristics

Type of pump	KSB WKLn 150
Motor	Dutchi NL 110kW; 50 Hertz
Impeller diameter	360mm
Number of stages	2 (with a dummy stage)
Rotational speed	1450 r.p.m.

Preliminary calculations based on our observations at the pump station were done. A number of assumptions regarding the existing pump line and pump system were made where firm information was lacking.

Upon studying the pump curves and analysing the system the following became evident:

- It is assumed that due to its age the surface roughness of the existing ND400 Asbestos Cement rising main is relatively high (k_s = 0.6mm). The existing two pumps can deliver 188 ℓ/s @ 80m head. The flow velocity will be 1,6m/s. In theory the two pumps can therefor supply the ultimate AADD of 15 945kl over a period of 23.5 hours.
- In November 2014 a third similar pump was installed, the system can now deliver an estimated 237 ℓ/s @ 86m head, which is enough to supply the calculated ultimate AADD over a period of 18.7 hours. The flow velocity is approximately 2,0m/s through the existing ND400 Asbestos Cement rising main. The flow velocity equals JW's prescribed maximum flow velocity of 2m/s.

8.2 Pump station Bypass Possibilities

During the site visit on 10 January Mr. Gordon Wynne pointed out pipework close to the Hospital Hill pump station that seems to be a bypass around the pump station that has been decommissioned. The possibility of reinstating the bypass and providing water to Lenasia High Level reservoir without utilising the Hospital Hill pump station was investigated.

The following information was gathered from the Network Analysis: Lenasia Water Sub-Districts Report (PS610):

- The Static pressure required between the Bottom Water Level (BWL) at Cosmos reservoir and the Top water Level at Lenasia High Level reservoir is 86m (plus additional dynamic pressures which are difficult to quantify with the limited information available).
- The pressure available before Cosmos reservoir is between 40m and 60m, which is clearly not enough to overcome the static pressure between Cosmos and High Level reservoir and therefor reinstating of the connection between Cosmos and Lenasia High Level reservoirs will have no benefit.
- The pump station at Cosmos reservoir is currently already bypassed to feed Hospital Hill reservoir.

Mr. John Lourens from JW Operations: Electromechanical also expressed the Operation Division's need to be able to bypass the Hospital Hill reservoir in order to clean it, while still maintaining flow into the network and pump station. The As-built drawing of Hospital Hill was studied and a manner to bypass the reservoir utilising the existing pipework was determined. The bypass methodology was tested on site on 2 December 2014 to confirm that both the pump station and the network receive adequate water when the reservoir is bypassed.

The method was found to be successful, but in order for this method to be implemented over longer periods, level control must be installed at the break pressure tower.

As indicated on Figure 12, when all the valves encircled in red are closed and the valves encircled in green are open, water can flow via the path indicated in dark blue into the pump station while the reservoir can be cleaned. At the same time flow into the network will be maintained via the path indicated in light blue.

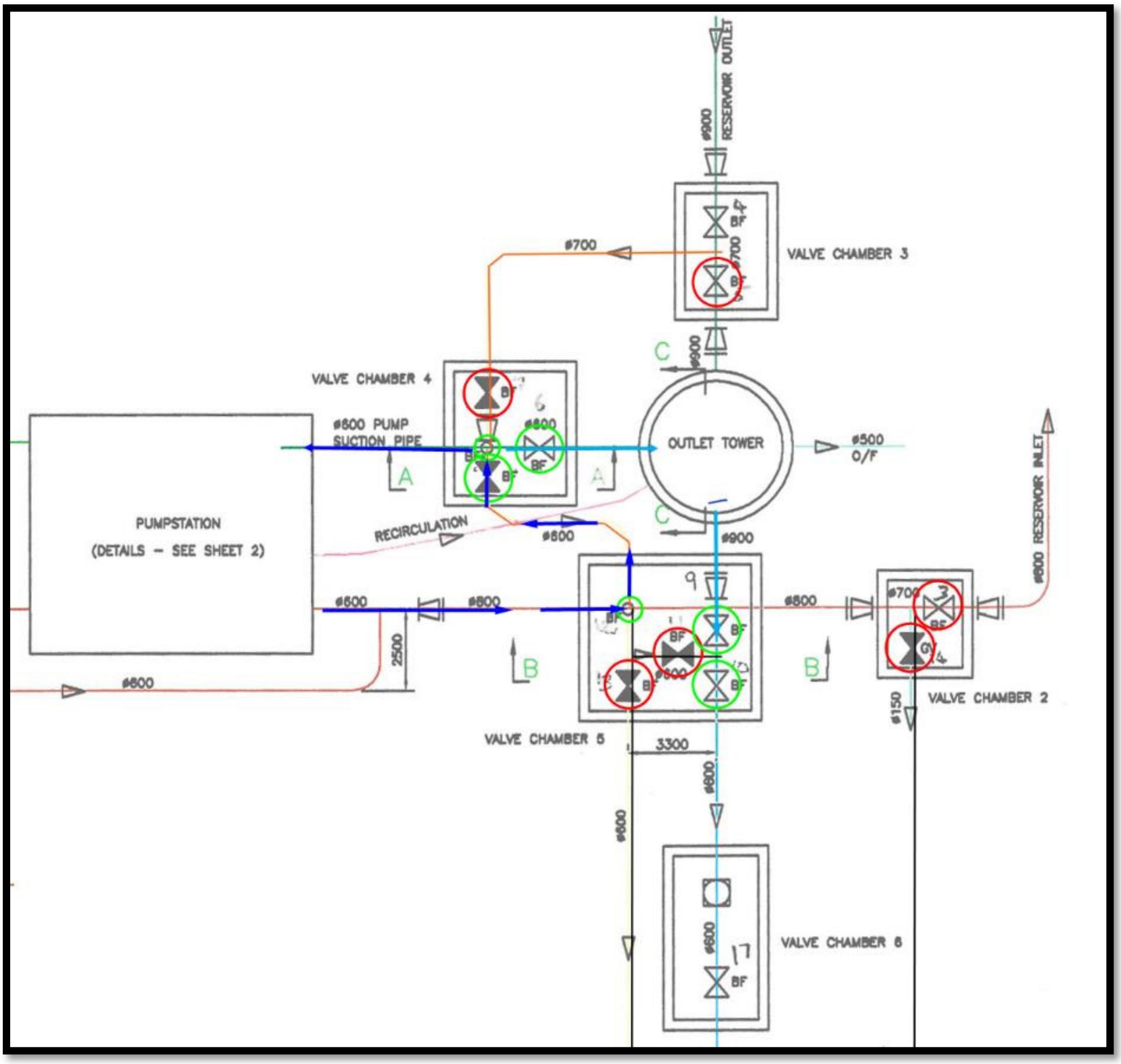

Figure 12: Possible Solution to Bypass Hospital Hill Reservoir

8.3 Proposed Pump Station Upgrade

Proposed upgrades to Hospital Hill pump station should be sufficient to ensure that the pump station will operate for the next 30 years. The implication is that all pumps, motors, electrical components, switchgear and valves will be replaced.

The following upgrades will be implemented:

- Three new KSB ETA B 200-50 single stage, end suction pumps will be installed. Under normal operating conditions only two pumps will pump at a time. In order to prevent a situation where all the pumps will need to be replaced at once, cycling between the three pumps will occur with one of the pumps only working 1 in 5 cycles. The pump characteristics are summarised in Table 12. The full pump and motor specifications are included as Annexure F.

Table 12: New Pump Characteristics

Type of pump	KSB ETA B 200-50
Motor	WEG Premium Efficiency Plus 185KW
Impeller diameter	480mm
Number of stages	1
Rotational speed	1490 r.p.m.

- Two of the existing plinths and inlet pipework were designed for end suction pumps and will be utilised for two of the new pumps, although modifications will be required. The other two plinths which currently support the centrifugal pumps will be demolished to accommodate a third new plinth.
- Upgrading of the pump station will be done in phases with P1 and P2 being installed first and once the pumps are running the old pumps can be removed to construct the new plinth P3. In the end the two branches on the supply side manifold (EP1 and EP2) will be blanked off.
- A New Motor Control Cubicle (MCC), electrical cabling and Variable Speed Drives (VSDs) will be installed for the new pumps and motors. The VSDs will control the switching on and off of the pumps, ensuring that it is gradual and energy efficient.
- A schematic layout of the proposed pump station upgrade is shown in Figure 13.

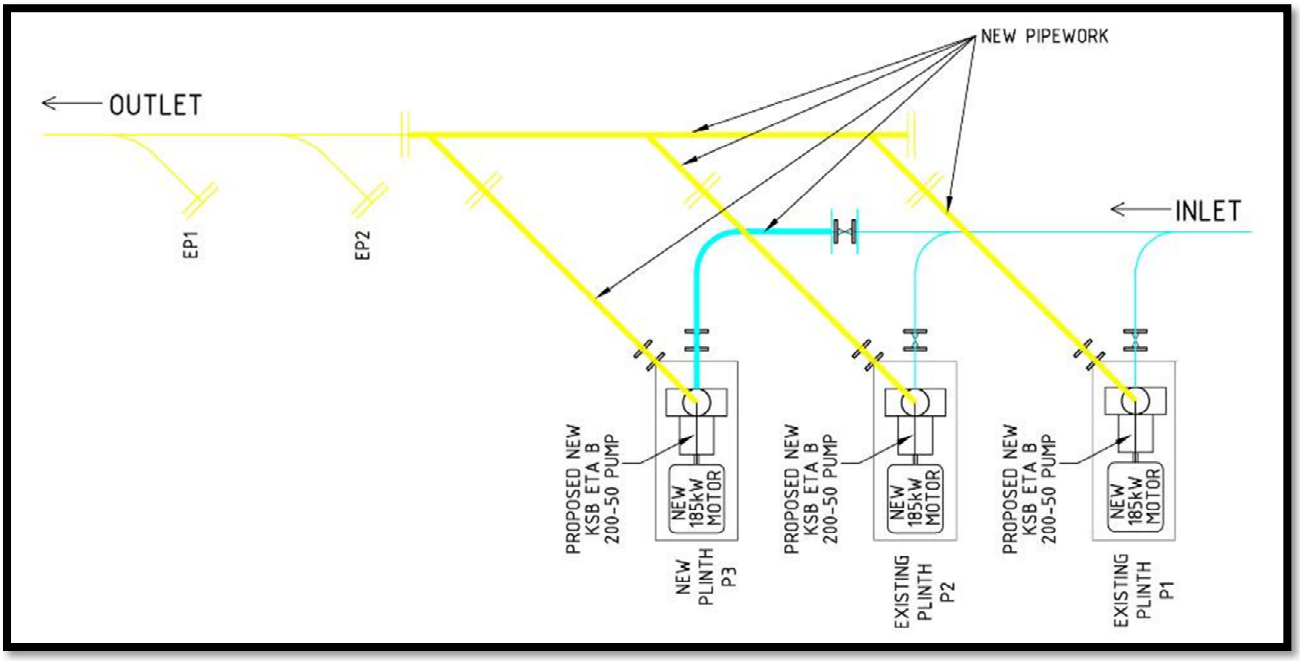

Figure 13: Proposed new configuration of Hospital Hill Pump Station

8.4 Capacity of the Upgraded Pump station in Combination with the Proposed New ND600 Rising Main

- The current draw-off from Lenasia High Level reservoir, which is estimated to be 16 930kl/day, can be supplied by 2 of the proposed new pumps in less than 13 hours. It is important to consider the balance of the entire Lenasia reservoir complex as there is a limited amount of water available through the RW1984 Rand Water connection. If more water is delivered to Lenasia High Level reservoir it can put the Hospital Hill reservoir at risk to be emptied.
- As previously stated JW are in the process of investigating and improving the entire Lenasia reservoir complex. Should supply to Hospital Hill reservoir improve, JW will have the possibility to pump with two pumps for 24 hours a day. In this case 31 870kl/day can be supplied which is twice the Ultimate AADD of 15 945kl.
- Based on the above two observations it becomes clear that at times one pump will almost be sufficient to supply the AADD. However, water demand is not constant throughout the day and there will be morning and evening peaks, with very little water usage around the midnight hours.
- In order to use the pump system in the most efficient manner possible it is necessary to log outflows from the Hospital Hill and Lenasia High Level reservoirs to accurately determine the draw-off patterns from the reservoirs. This process is currently underway and the data obtained will be used to optimise the final design.

8.5 Power Supply to the Pump Station

- The mini substation outside the pump station was recently replaced with a new 630kVa substation. This is sufficient to power the proposed two 185kW motors. The main low voltage circuit breaker is also sufficient to support the motors. The previous mini substation was smaller and was only sufficient to support the two 110kW motors currently installed.
- The low voltage supply cables between the miniature substation and the pump station must be upgraded to match the newly installed 630kVA substation.
- A 900kVA Diesel Standby Generator shall be installed as a backup system for power failures. The generator will have a tank providing 48 hours of back fuel supply. The generator is sufficient to drive 2 pumps (even 3); therefore the pump station will continue to operate as normal when powered by the generator.
- The generator will be contained in a brick room with concrete floor and roof. The building will have sound attenuated inlet and outlet louvers. The bulk fuel tank will

also require the construction of a foundation slab and a bund wall. The bund wall is required to be 1.5m away from the sides of the fuel tank and will be able to accommodate 110% of the tank's volume.

- In order to keep diesel on site an application will need to be made to the Fire Department for a licence, which must be renewed each year.

8.6 Emergency Solution

The additional WKLn 150 (3-stage) pump which was available and motor has been installed as an emergency solution. The three existing WKLn 150 pumps can deliver 238 ℓ/s @ 86m head, which is enough to supply approximately 20 500Kl over 24 hours. The flow velocity is calculated to be 2,0m/s.

8.7 Interim Situation

In the scenario where the pump station upgrade has been completed but the rising main has not yet been completed the following can be achieved:

Utilising two proposed new KSB ETA B 200-50 pumps through the existing ND400 AC rising main the system will deliver 223 ℓ/s. Over a period of 24 hours this will equate to 19 291kl/day, which is approximately equal to 1.2 times the ultimate AADD of 15 945kl.

The pressure in the pipeline will be almost the same (86m) as when three existing WKLn150 pumps are used and this is not considered to be a risk.

It is important to take note that delivery (223 ℓ/s) of the two proposed new KSB ETA B 200-50 pumps through the existing ND400 pipeline (the interim phase where the pump station has been upgraded but not the pipeline) will produce slightly less flow than what is currently achieved with the three existing KSB WKLn 150 pumps (238 ℓ/s).

8.8 Level control for Hospital Hill Reservoir

As previously stated the level control valve at Hospital Hill reservoir is currently not being operated. The operations division prevents the reservoir from overflowing by manually throttling a gate valve situated at Cosmos reservoir. Manual operation in turn requires staff to work overtime. The reason for controlling flow at Cosmos reservoir site is because the pipeline between the Cosmos and Hospital Hill reservoirs is an old Asbestos Cement pipeline with rubber jointed pipes. If flow is stopped at Hospital Hill reservoir pressure in the pipeline increases and it is feared that the increase in pressure can cause some of the rubber joints to fail.

Under normal circumstances an acceptable solution would have been to utilise the level control valve at the Hospital Hill reservoir that would shutoff or modulate flow from Cosmos reservoir. Due to the possibility of the Asbestos Cement pipeline failing under increased pressure, flow control will need to be conducted in the vicinity of Cosmos reservoir.

Flow control will be done with a combination Solenoid Control and Rate of Flow Control Valve, which will receive a signal from Hospital Hill reservoir. In order to make the system more robust and maintainable the valves installed should not be larger than ND300, which means that 2 valves will be required. These valves will be installed in parallel and each valve should be isolatable. A schematic layout of the chamber is shown in Figure 14.

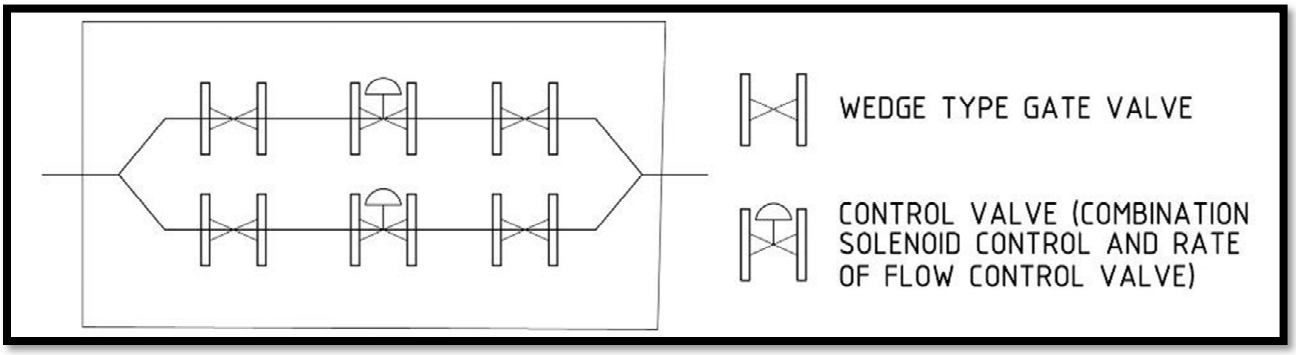

Figure 14: Schematic Layout of Level Control Chamber at Cosmos Reservoir

8.9 Replacement of Valves at the Hospital Hill Reservoir Site

As part of the philosophy that the pump station upgrade should be sufficient to not necessitate another upgrade in the next 30 years, the Operations division has requested that the valves on site be replaced. In addition to this they have requested that the butterfly valves on the site be replaced with gate valves.

Nyeleti Consulting did a thorough investigation of the practical possibilities to implement this request. Most of the butterfly valves will be challenging to replace due to space constraints as gate valves are much larger than butterfly valves. Furthermore the size of the valves (up to ND 700) will make it an extremely expensive operation. And lastly due to the difficulty in opening gate valves under differential pressures JW requires gate valves larger than ND 400 to be equipped with a bypass line with a smaller valve to equalise pressure before opening the main valve. Due to the break pressure effect of the reservoir on the upstream side of the valves the installation of a bypass will be ineffective under these circumstances.

Based on the considerations above Nyeleti Consulting and the Operations division identified the two inlet valves as critical to be replaced. These two valves will be replaced with butterfly valves that meet the JW Electromechanical Operations division's standards.

The low frequency at which some of the valves are operated validated the decision to not go through the intricate and expensive operation of replacing all the valves right now.

8.10 Ancillary works

A brick guard hut will be constructed on the reservoir terrain. The guard hut will be provided with electricity, water and toilet facilities. As there is no sewer close by a septic tank and French drain will be constructed for the guard hut. Positioning of the guard hut on the terrain will be done in concurrence with Mr. Keith Boshoff (JW Security).

The Operations Division requested that upgrading of the existing concrete palisade fencing to clear view fencing (Clearvu) be done as part of the contract. Cost to replace the existing fence and gate will amount to approximately R 950 000 and is provisionally included in the planning.

9 EPWP GUIDELINES

9.1 Suitability for LIC

Constructing reinforced concrete structures by nature contain many items that can only be done labour-intensively or are best suited to labour intensive construction.
The following items are very suitable to be done labour intensively:

- Local excavation for valve boxes
- Construction of valve boxes
- Reinforcement fixing
- Disinfection of structure
- Construction of apron slab
- Erection of fence
- Placing of stone on roof
- Compaction of pipeline trenches (using a whacker)
- Brickwork for guard huts

9.2 Suitability of Contractor

The contractor to be appointed must understand the principles of LIC and should have site staff who received LIC training.

10 PROGRAMME AND COST ESTIMATE

10.1 Programme

A preliminary proposed project programme is included as Annexure F.

The program clearly distinguishes between each of the three proposed contracts. Table 13 provides target dates for some of the major milestones on each contract.

Table 13: Milestones and Target Dates

Milestone	Target Date
Approval of PDR	13/04/2015
Reservoir Contract	
Concept Drawings Ready for Review	05/12/2014
Tender Drawings Ready for Approval	30/03/2015
Approval of Drawings	07/04/2015
Submission of Draft Tender Document	10/04/2015
Acceptance of Bid	07/08/2015
Completion of Construction	05/09/2016
Pump Station Contract	
Tender Drawings Ready for Approval	15/04/2015
Submission of Draft Tender Document	21/04//2015
Acceptance of Bid	18/08/2015
Completion of Construction	09/02/2016
Pipelines Contract	
Concept Drawings Ready for Review	04/05/2015
Tender Drawings Ready for Approval	08/05/2015
Approval of Drawings	21/05/2015
Submission of Draft Tender Document	26/05/2015
Acceptance of Bid	25/09/2015
Completion of Construction	17/05/2016

It is also important to take note of the following:

- For all three contracts 8 weeks have been allowed for the acceptance of a tender. If this process can be fast-tracked, construction completion dates can be improved.

- For both the pump station and pipelines contract a three month period has been allowed for the procurement of pumps, motors, pipes, valves and fittings (as these items have long lead times).

10.2 Cost Estimate

A preliminary cost estimate has been made for each of the three proposed contracts and the professional fees associated with it.

10.2.1 Cost Estimate for Construction of the Reservoir

A construction cost estimate is shown in Table 14 and a professional fees estimate is shown in Table 15, with a summary of the estimated project cost in Table 16. Due to the fact that a 15ML reservoir will now be constructed provision has been made for an additional 2 months of construction supervision.

Table 14: Construction Cost Estimate for Construction of Reservoir

No	Item	Unit	Amount
1.1	Construct 15ML Reservoir	Sum	R 10 000 000
1.2	Construct Valve Chambers (Concrete)	Sum	R 850 000
1.3	Earthworks for Reservoir	Sum	R 4 500 000
1.4	Pipework and Valves	Sum	R 6 200 000
1.5	Telemetry, Cathodic and Lighting Protection	Sum	R 600 000
1.6	Clear View Fencing & Gate	Sum	R 1 100 000
1.7	Power Supply (Solar Panels)	Sum	R 300 000
1.8	Guard hut and Lights	Sum	R 500 000
	Sub-Total		**R 24 050 000**
2	P & G's	15%	R 3 607 500
	Sub-Total		**R 27 657 500**
3	Contingencies	10%	R 2 765 750
	Sub-Total		**R 30 423 250**
4	CPA (Escalation)	8%	R 2 433 860
	Total Construction Cost		**R 32 857 110**

Table 15: Professional Fees Estimate for Construction of Reservoir

No	Item	Unit	Amount
5.1	Tendered Professional Fees	Sum	R 2 444 915
5.2	Tendered Construction Monitoring Fees	Sum	R 433 345
5.3	Tendered Recoverable Items	Sum	R 287 826
5.4	Additional Professional Fees	Sum	R 284 474
5.5	2 Months Additional Construction Monitoring Fees	Sum	R 86 669
5.6	Additional Recoverable Expenses	Sum	R 37 114
	Total Professional Fees		**R 3 574 344**

Table 16: Summary of Estimated Project Cost for Construction of Reservoir

Total Construction Cost	R 32 857 110
Total Professional Fees	R 3 574 344
Total Project Cost	**R 36 431 454**

10.2.2 Cost Estimate for Construction of Rising Main and Overflow Pipeline

A construction cost estimate is shown in Table 17 and a professional fees estimate is shown in Table 18, with a summary of the estimated project cost in Table 19.

Table 17: Construction Cost Estimate for Construction of Pipelines

No	Item	Unit	Amount
1.1	Install 600ø Steel Pipeline	Sum	R 6 800 000
1.2	Connection to Existing Pipe	Sum	R 250 000
1.3	Overflow Discharge Pipe	Sum	R 550 000
1.4	Cathodic Protection	Sum	R 400 000
1.5	Valves and Chambers	Sum	R 450 000
	Sub-Total		**R 8 450 000**
2	P & G's	15%	R 1 267 500
	Sub-Total		**R 9 717 500**
3	Contingencies	10%	R 971 750
	Sub-Total		**R 10 122 530**
4	CPA (Escalation)	8%	R 855 140
	Total Construction Cost		**R 11 544 390**

Professional fees have been estimated as per contract JW 13037.It was estimated that this project should require 6 months of construction supervision for monitoring the construction of the pipelines.

Table 18: Professional Fees for Construction of Pipelines

No	Item	Unit	Amount
5.1	Professional Fees	Sum	**R 923 551**
5.2	6 Months Construction Monitoring Fees	Sum	**R 276 048**
5.3	Recoverable Expenses	Sum	**R 119 960**
	Total Professional Fees		**R 1 319 559**

Table 19: Summary of Estimated Project Cost for Construction of Pipelines

Total Construction Cost	**R 11 544 390**
Total Professional Fees	**R 1 319 559**
Total Project Cost	R 12 863 949

10.2.3 Cost Estimate for the Upgrade of Hospital Hill Pump Station

Estimated construction cost for the upgrade of the pump station is shown in Table 20, professional fees in Table 21 and estimated total project cost to upgrade the pump station in Table 22. Professional fees have been estimated as per contract JW13037. The construction duration is estimated as 4 months.

Table 20: Estimated Construction Cost for Pump Station Upgrade

No	Item	Unit	Amount
1.1	Install 3 new pumps, motors, pipework and MCC	Sum	R 4 110 000
1.2	Standby 900KVa Generator and fuel tank	Sum	R 3 500 000
1.3	Pump Station Gantry	Sum	R 300 000
1.4	Guard Hut & Septic Tank	Sum	R 150 000
1.5	Clearvu Fence and Gate	Sum	R 950 000
1.6	Level Control Chamber	Sum	R 900 000
1.7	Replace Valves	Sum	R 1 200 000
1.8	Telemetry and Controls	Sum	R 300 000
	Sub-Total		**R 11 410 000**
2	P & G's	15%	R 1 711 500
	Sub-Total		**R 13 121 500**
3	Contingencies	10%	R 1 312 150
	Sub-Total		**R 14 433 650**
4	CPA (Escalation)	7%	R 1 010 356
	Total Construction Cost		**R 15 444 006**

Table 21: Estimated Professional Fees for Pump Station Upgrade

No	Item	Unit	Amount
5.1	Professional Fees	Sum	R 1 235 520
5.2	Construction Monitoring Fees	Sum	R 184 032
5.3	Recoverable Expenses	Sum	R 141 955
	Total Professional Fees		**R 1 561 508**

Table 22: Summary of Estimated Project Cost for Pump Station Upgrade

Total Construction Cost	R 15 444 006
Total Professional Fees	R 1 561 508
Total Project Cost	**R 17 005 513**

11 SUMMARY AND CONCLUSION

The report investigated available information collected by means of a desktop study and site investigation for the design and construction of a proposed new reservoir and bulk water pipeline in Lenasia South in the Gauteng Province. The proposed new reservoir will supplement the existing 6ML Lenasia High Level reservoir.

The existing pump station at the nearby Hospital Hill reservoir and rising main that supply water to Lenasia HL reservoir was investigated along with the construction of the proposed new reservoir and necessary pipework and valves.

Following the investigation, the following remarks can be made:

- The construction of the proposed new 15ML reservoir to supplement the existing Lenasia HL reservoir is imperative. (To supply 1.5 X Ultimate AADD 18ML is actually required).
- It would however be futile to construct a new reservoir without improving water supply to the reservoirs, as currently the Hospital Hill pump station is unable to even fill the existing 6ML reservoir.

Based on the above remarks, the following scope of works is recommended:

- Construct a 15ML reservoir with post tensioned concrete cylindrical walls and a flat roof supported by columns. Three alternative methods are presented to construct the floor of which the jointless floor slab is recommended. The reservoir will be 8m high and approximately 53m in diameter. The top- and bottom water levels should match that of the existing reservoir. A new combined inlet water meter and outlet chamber and scour chamber (accommodating scour, overflow and subsurface drainage pipes) must be constructed. The existing water meter chamber measuring outflow from the reservoir must be replaced with a chamber meeting JW design specifications. A bypass for the new reservoir, as well as a new bypass for the existing reservoir will be constructed.

- A new ND600 steel pipeline must be constructed to replace the existing Asbestos Cement rising main. The pipeline will be approximately 1.2km long and will follow the same route as the existing rising main. The now redundant DN400 Asbestos cement pipe will be used as an overflow pipe. A ND315 pipe will be constructed to extend the route.
- Upgrade the Hospital Hill pump station by installing three new KSB ETA 200-50 pumps and 185Kw motors (along with upgrading the electrical cabling and Motor Control Cubicle). Furthermore, install a 900kVA Containerised Diesel Standby Generator for backup during power failures.

- The total construction cost for all three contracts (including 10% contingencies and CPA) is estimated at R 60 million (excl. VAT).
- The total project cost for all three contracts (including 10% contingencies) is estimated at R 66.3 million (excl. VAT).

The reservoir, pipeline and pump station upgrades will improve water supply to Lenasia South ext.1 and 4, Migson Manor (Lenasia South ext. 7), Zakariyya Park as well as the additional areas of Vlakfontein Proper, Finetown, Hospital Hill and Lehae.

12 REFERENCES

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ANNEXURE A

ANNOTATED PHOTOS

Figure 15: Existing pump station at Hospital Hill Reservoir

Figure 16: Inlet (blue) and outlet (yellow) pipes inside the Hospital Hill pump station

Figure 17: Existing pumps and motors at the Hospital Hill pump station, viewed from the side

Figure 18: Existing pumps and motors at the Hospital Hill pump station, viewed from the top

Figure 19: Existing 6Ml Lenasia HL Reservoir

Figure 20: Proposed location for the new 15Ml Lenasia HL Reservoir

ANNEXURE B

DRAW-OFF PATTERNS

ANNEXURE C

LAND TO BE AQUIRED BY JOHANNESBURG WATER

ANNEXURE D

DRAWINGS OF RESERVOIR FLOOR SLAB OPTIONS

ANNEXURE E

SCHEMATIC LAYOUT OF PROPOSED PIPEWORK AT LENASIA HL RESERVOIR

ANNEXURE F

PUMP AND MOTOR SPECIFICATIONS

ANNEXURE G

PROGRAMME OF WORKS

ANNEXURE H

DRAFT TENDER DRAWINGS