

108/114/12/R6

UMKHOMAZI WATER PROJECT
MODULE 3 – POTABLE WATER MODULE

**Revised Mgeni System Operating Rules During
uMkhomazi Raw Water Tunnel Shutdowns**

Revision 1

October 2015



**Planning Services
Engineering & Scientific Services
Umgeni Water**

Prepared By:

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CONSULTING

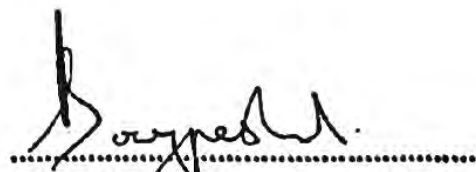
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uMkhomazi Water Project

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Raw Water Tunnel Shutdowns**

Report No. 108/114/12/R6

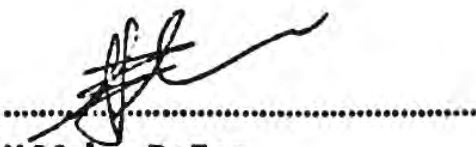
Prepared by Knight Piésold Consulting



A Doorgapershad, Pr Eng

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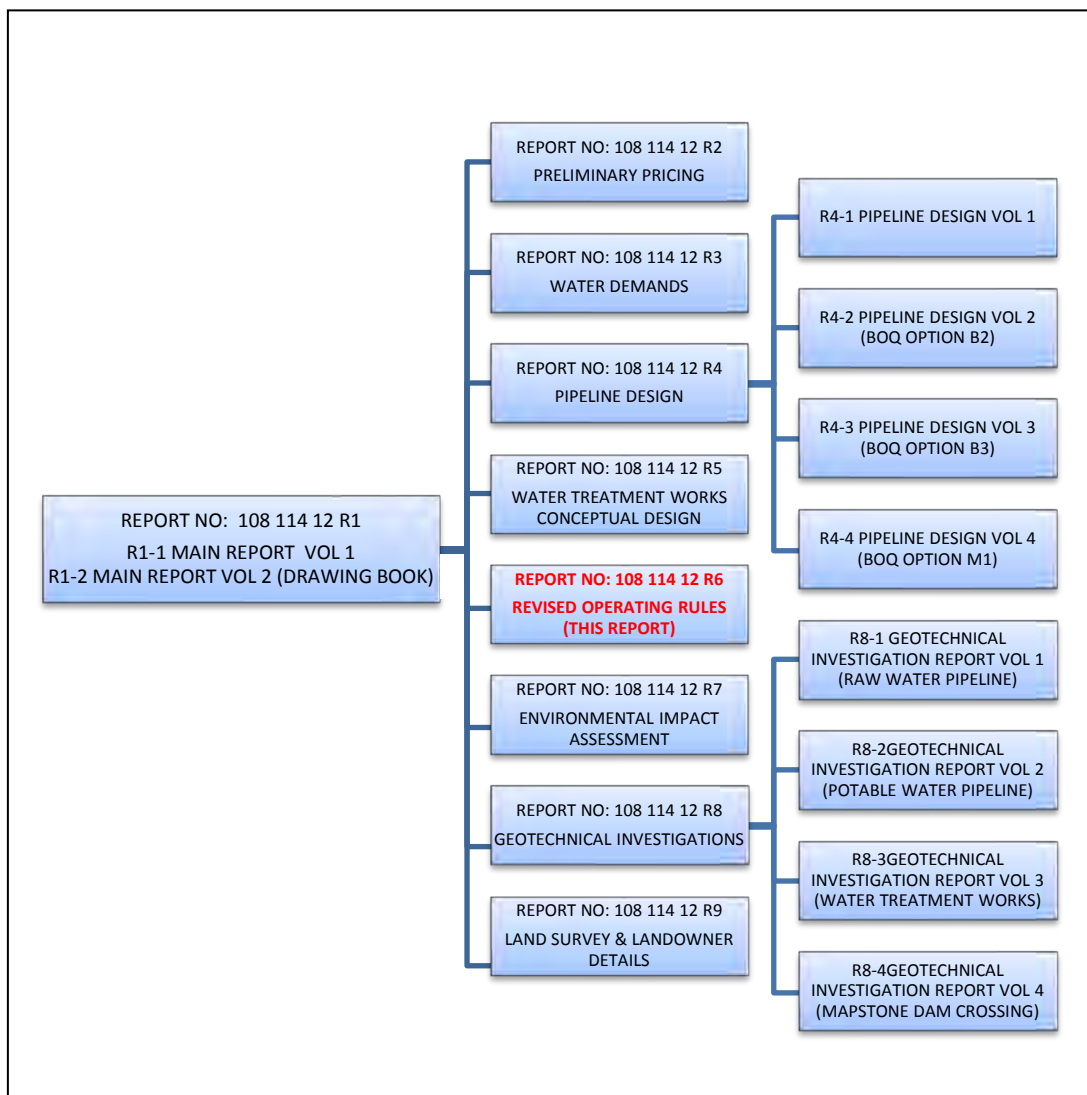
This report is to be referred in bibliographies as:

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UMKHOMAZI WATER PROJECT

MODULE 3 – POTABLE WATER MODULE

Structure of Suite of Reports



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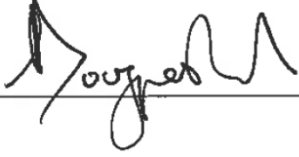
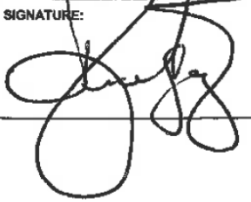

PROJECT: uMkhomazi Water Project, Potable Water Module

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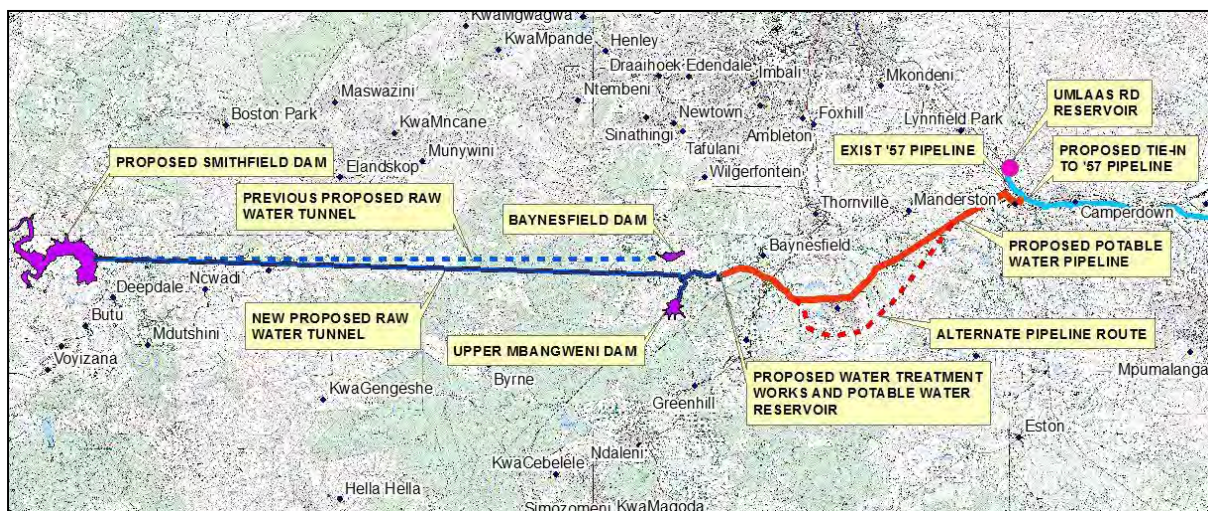
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1. Introduction

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

The first phase of the proposed uMWP comprises the Smithfield Dam, a raw water tunnel to Baynesfield, a balancing dam in the Baynesfield area, a water treatment works (WTW) at Baynesfield and a potable water pipeline from Baynesfield to Umlaas Road, where it connects to the Western Aqueduct via the '57 Pipeline. A plan layout of the proposed scheme is depicted in Figure 1.

Figure 1: Proposed uMkhomazi Water Project

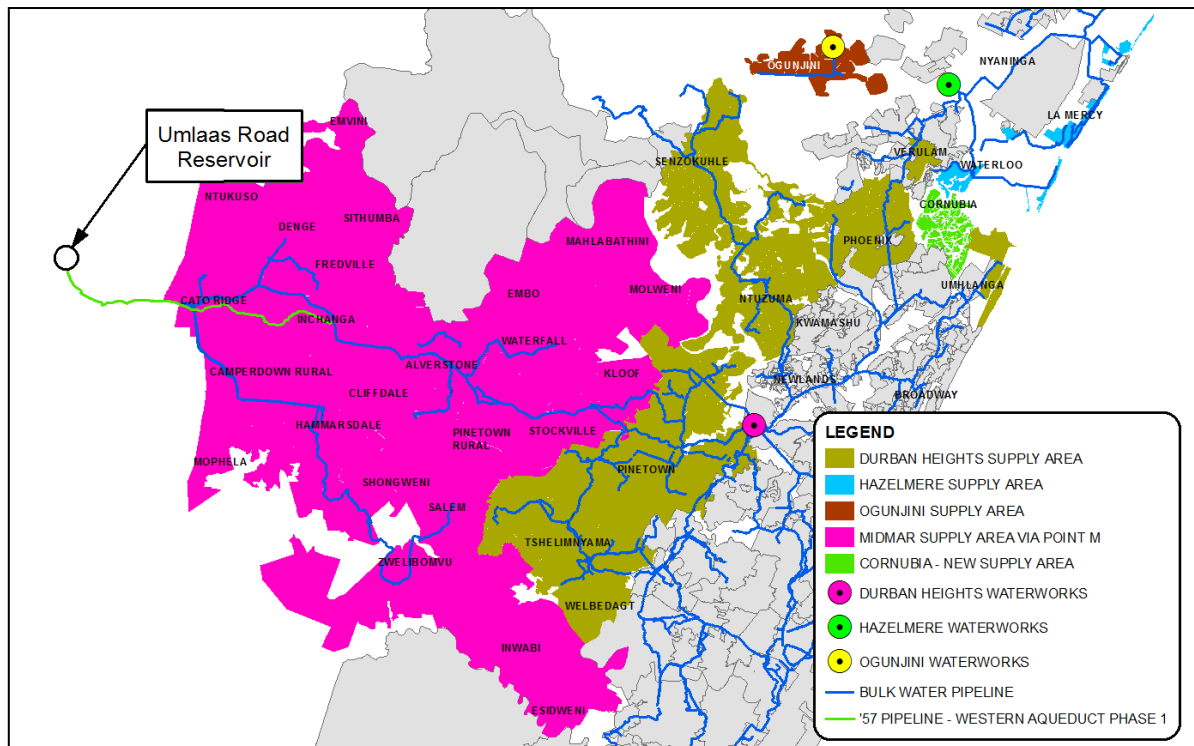


Once commissioned, the proposed uMWP will take over portions of the current WTW supply areas as indicated in Figure 2. This future augmentation to the EWS supply area from the uMWP will become the normal mode of operation for the system as shown in Figure 3. Figure 3 therefore represents the areas contributing to the water demand on the proposed uMWP. The Midmar, Durban Heights and Hazelmere supply systems will continue to serve their respective areas and the uMWP will supplement these systems with additional water required to serve growth in demand. The future uMWP supply area is also depicted in schematic drawings attached as Annexures C and D.

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

During this shut down period, water supply to the future uMWP supply zone will have to be maintained.

Figure 2: Current Water Treatment Works Supply Areas



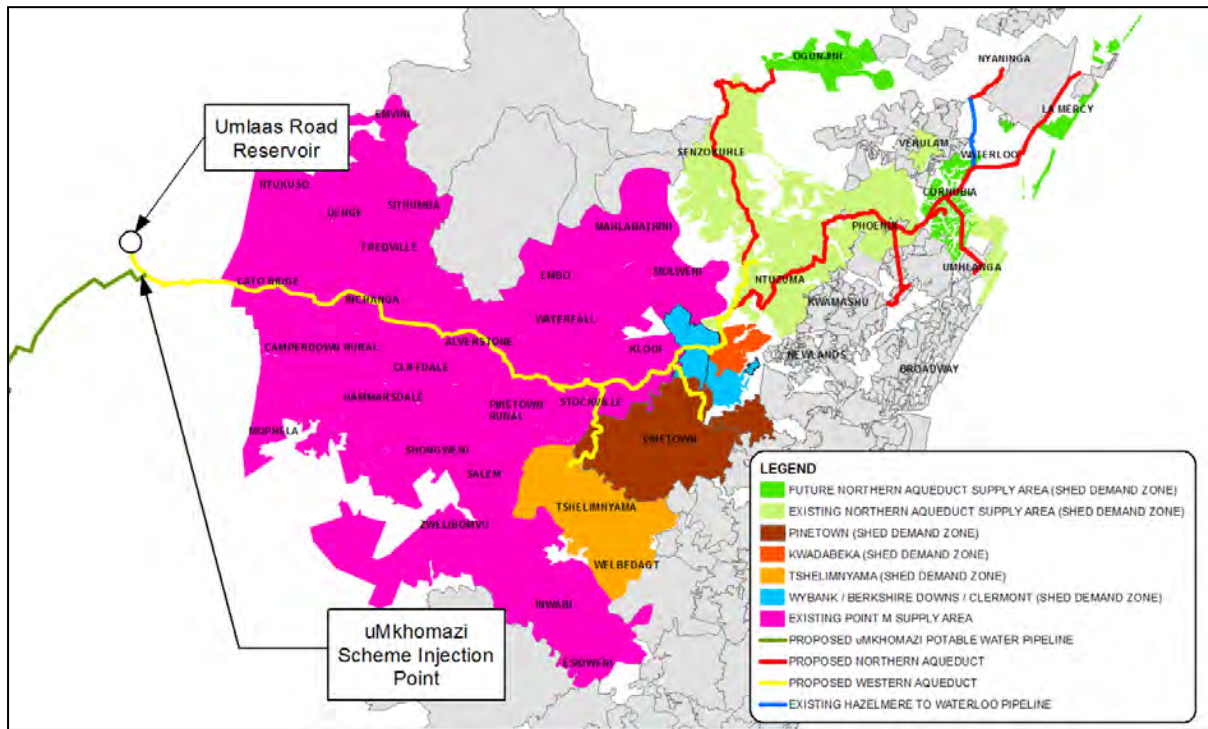
2. Background

The main purpose of the proposed Baynesfield Dam is to provide the volume of storage required to maintain a supply of raw water to the proposed uMkhomazi WTW during a three-week tunnel shutdown. AECOM, who have been appointed to conduct the Module 1 (raw water module) investigation on behalf of the Department of Water Affairs (DWA), have advised that the proposed Baynesfield Dam is expensive and inefficient as a result of the high dam wall required and large volume of unusable storage.

AECOM requested that an investigation be carried out into the capacity of the existing supply infrastructure to meet the supply requirements during tunnel shutdowns. Knight Piésold Consulting was therefore asked to investigate whether it was possible to eliminate the Baynesfield Dam by making changes to the operating rules in the Midmar, Durban Heights and Hazelmere systems; thereby maximising the utilisation of these systems.

Knight Piésold assessed the merits of the proposal and held a workshop to discuss their findings with UW and EWS operation and planning staff. Their findings are documented in this report.

Figure 3: Future uMkhomazi Water Project Supply Areas



3. Purpose of Report

The purpose of this report is:

- To document the viability of supply from the existing system during a tunnel shutdown based on investigations into proposed operating rule changes,
- to document the outcomes and decisions taken at a workshop held on 10 January 2013.

4. Methodology

Knight Piésold was requested by UW to carry out all investigations on the assumption that the proposed uMWP would be commissioned in the year 2023. AECOM advised that the proposed raw water tunnel would be shut down for inspections in the years 2024, 2034 and 2044. Water demand projections that have been carried out extend to the year 2042. The years considered in the analysis are therefore 2024, 2034 and 2042. The study area used in developing water demands as well as the projected demand curve used in this exercise are depicted in Figures 3 and 4 respectively.

In addition to the growth in water demand over the years, the declining availability of potable water from the Midmar system to Point M had to be taken into account. This declining availability (depicted in Figure 5) is due to UW’s approach to reserve water to meet the growth in demand from customers upstream of Point M.

Point M presently receives its water supply via the '61 Pipeline and the '57 Pipeline. The '57 Pipeline is an aged pipeline that is in a poor condition. There are no plans to repair or replace this pipeline. As a result of its poor condition, one set of analyses was carried out assuming that the '57 Pipeline would be available and another set assuming that it would be decommissioned.

UW indicated that the Lower Thukela Bulk Water Supply System would not have sufficient yield to contribute a supply of water to assist the EWS region during a shutdown of the uMkhomazi raw water tunnel. The Midmar, Durban Heights and Hazelmere supply systems were considered as the only possible systems that could assist during tunnel shutdowns.

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

Figure 4: Projected Water Demands

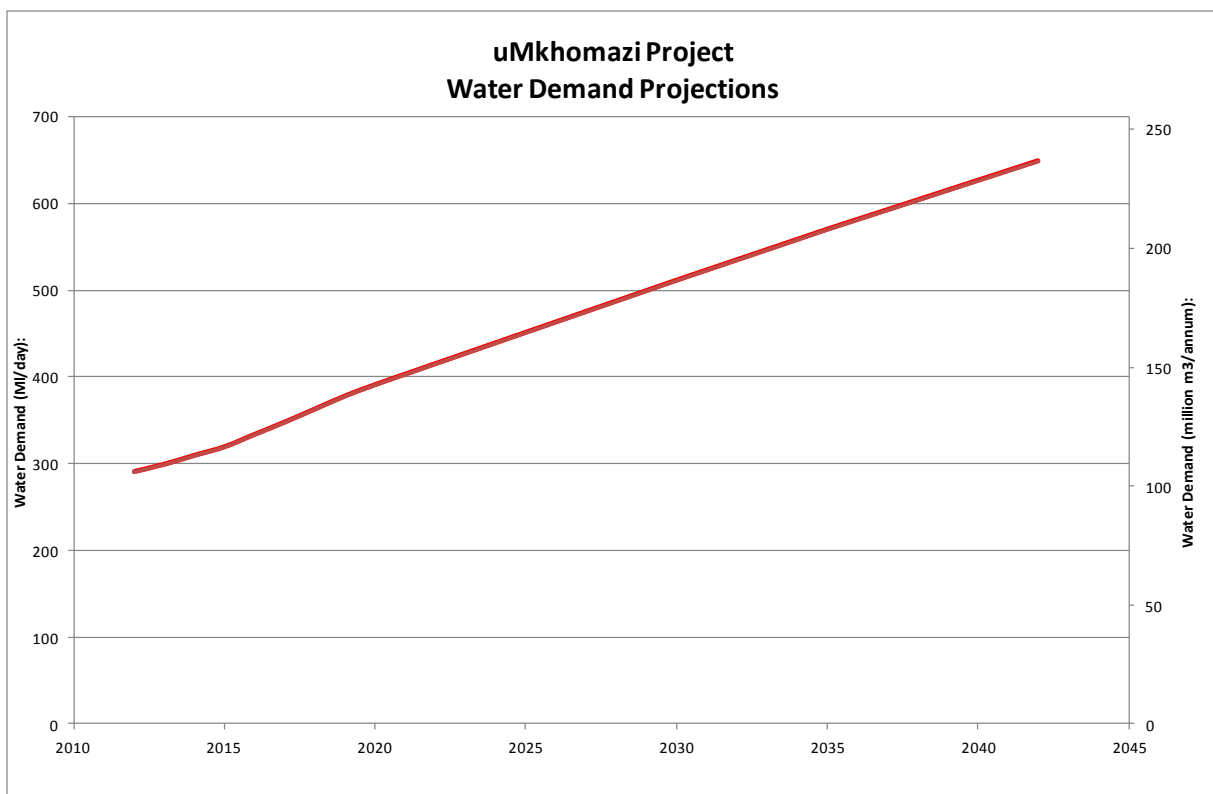
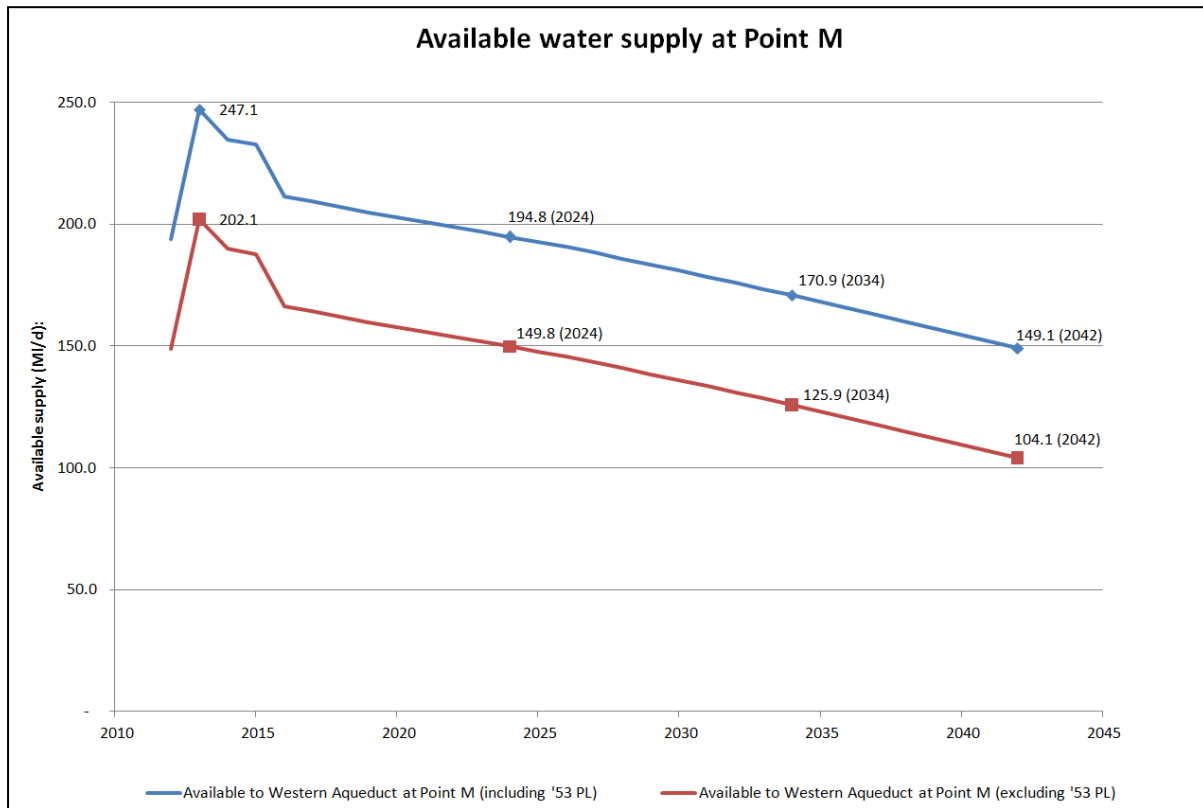


Figure 5: Declining Availability of Water at Point M



5. Summary of Assumptions

- First phase of the uMWP to be commissioned in 2023.
- Western Aqueduct Phase 2 and Northern Aqueduct Phases 1, 2 and 3 to be commissioned prior to the year 2023.
- Pump stations at Durban Heights, Ntuzuma 2 and Hazelmere WTW to be maintained in a state of readiness to resume operation when needed.
- The average capacity of the Western Aqueduct pipeline is 420 MI/day.
- No major upgrades to the existing pump stations and pipelines would be made.
- The Wiggins WTW will have sufficient spare capacity to continue to supply 100 MI/day of water to the Ridge via the high lift pumps.
- The capacity of Durban Heights WTW was taken to be 615 MI/day as advised by UW.

6. Results of Investigations

The outcomes of the revised system operating rules during a tunnel shutdown are listed in Table 1. At the request of UW, this exercise was repeated with the projected demands increased by 10%; the results of which are listed in Table 2. Tables 1 and 2 should be read in conjunction with the schematic diagrams attached as Annexures A, B, C and D.

NB. Text highlighted in blue indicates that the supply to the zone is shared by more than one WTW.

Table 1: Revised Operating Rules - Summary of Results with Original Projected Demands

	Midmar supplies water to:	Durban Heights / Wiggins supplies water to:	Hazelmere supplies water to:	Total System Surplus (+) or Deficit (-)
2024: Typical future operation - uMWP Operational	Outer / Inner West, Tshelimnyama, Wyebank, KwaDabeka, Mzinyathi, Ntuzuma, Phoenix, Umhlanga, Waterloo, iNyanninga, La Mercy / Zimbali	Pinetown, Core NA supply area, Central & Southern areas	Grange / Verulam, Ndwedwe	+235 MI/d
2024: uMWP shut down, ('53 Pipeline capacity incl.)	Outer / Inner West, Tshelimnyama, Wyebank, KwaDabeka, Mzinyathi	Pinetown, Core NA supply area, Central & Southern areas, Ntuzuma, Phoenix, Umhlanga, Waterloo, iNyanninga, La Mercy / Zimbali	Grange / Verulam, Ndwedwe	+109 MI/d
2024: uMWP shut down, ('53 Pipeline capacity excl.)	Outer / Inner West, Tshelimnyama	Wyebank, Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix, Umhlanga, Waterloo, iNyanninga, La Mercy / Zimbali	Grange / Verulam, Ndwedwe	+64 MI/d
2034: Typical future operation - uMWP Operational	Outer / Inner West, Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Mzinyathi, Ntuzuma, Phoenix, Umhlanga , Waterloo, iNyanninga, La Mercy / Zimbali	Core NA supply area, Central & Southern areas, Phoenix / Umhlanga	Grange / Verulam, Ndwedwe, iNyanninga, La Mercy / Zimbali	+ 95 MI/d
2034: uMWP shut down, ('53 Pipeline capacity incl.)	Outer / Inner West, Wyebank, Mzinyathi	Tshelimnyama, Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas Phoenix, Umhlanga, Waterloo	Grange / Verulam, Ndwedwe, Waterloo , iNyanninga, La Mercy / Zimbali	-55 MI/d
2034: uMWP shut down, ('53 Pipeline capacity excl.)	Outer / Inner West, Wyebank	Tshelimnyama, Wyebank , Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix, Umhlanga	Grange / Verulam, Ndwedwe, Waterloo, iNyanninga, La Mercy / Zimbali	-100 MI/d
2042: Typical future operation - uMWP Operational	Outer / Inner West, Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Mzinyathi, Ntuzuma, Phoenix, Umhlanga , Waterloo, iNyanninga, La Mercy / Zimbali	Core NA supply area, Central & Southern areas, Phoenix / Umhlanga , Waterloo, iNyanninga, La Mercy / Zimbali	Grange / Verulam, Ndwedwe	+ 82 MI/d
2042: uMWP shut down, ('53 Pipeline capacity incl.)	Outer / Inner West, Mzinyathi	Tshelimnyama, Wyebank , Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix, Umhlanga	Grange / Verulam, Ndwedwe, Waterloo, iNyanninga, La Mercy / Zimbali	-184 MI/d
2042: uMWP shut down, ('53 Pipeline capacity excl.)	Outer / Inner West	Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix, Umhlanga	Grange / Verulam, Ndwedwe, Waterloo, iNyanninga, La Mercy / Zimbali	-229 MI/d

Table 2: Revised Operating Rules - Summary of Results with Projected Demands Increased by 10%

	Midmar supplies water to:	Durban Heights / Wiggins supplies water to:	Hazelmere supplies water to:	Total System Surplus (+) or Deficit (-)
2024: Typical future operation - uMWP Operational	Outer / Inner West, Tshelimnyama, Wyebank, KwaDabeka, Mzinyathi, Ntuzuma, Phoenix, Umhlanga, Waterloo, iNyaninga, La Mercy / Zimbali	Pinetown, Core NA supply area, Central & Southern areas	Grange / Verulam, Ndwedwe, iNyaninga	+147 MI/d
2024: uMWP shut down, ('53 Pipeline capacity incl.)	Outer / Inner West, Tshelimnyama, Wyebank, KwaDabeka, Mzinyathi	Wyebank, Pinetown, Core NA supply area, Central & Southern areas, Ntuzuma, Phoenix, Umhlanga, Waterloo, La Mercy / Zimbali	Grange / Verulam, Ndwedwe, iNyaninga	+22 MI/d
2024: uMWP shut down, ('53 Pipeline capacity excl.)	Outer / Inner West, Wyebank, Mzinyathi	Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix / Umhlanga,	Grange / Verulam, Ndwedwe, Waterloo, iNyaninga, La Mercy / Zimbali	-23 MI/d
2034: Typical future operation - uMWP Operational	Outer / Inner West, Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Mzinyathi, Ntuzuma, Phoenix, Umhlanga	Core NA supply area, Central & Southern areas, Phoenix / Umhlanga, Waterloo, iNyaninga, La Mercy / Zimbali	Grange / Verulam, Ndwedwe	+ 93 MI/d
2034: uMWP shut down, ('53 Pipeline capacity incl.)	Outer / Inner West, Mzinyathi, Ntuzuma	Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix/Umhlanga	Grange / Verulam, Ndwedwe, Waterloo, iNyaninga, La Mercy / Zimbali	-156 MI/d
2034: uMWP shut down, ('53 Pipeline capacity excl.)	Outer / Inner West	Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix, Umhlanga	Grange / Verulam, Ndwedwe, Waterloo, iNyaninga, La Mercy / Zimbali	-201 MI/d
2042: Typical future operation - uMWP Operational	Outer / Inner West, Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Mzinyathi, Ntuzuma, Phoenix, Umhlanga	Core NA supply area, Central & Southern areas, Ntuzuma, Phoenix-Umhlanga, Waterloo, iNyaninga	Grange / Verulam, Ndwedwe, iNyaninga, La Mercy / Zimbali	-26 MI/d
2042: uMWP shut down, ('53 Pipeline capacity incl.)	Outer / Inner West, Wyebank	Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix-Umhlanga	Grange / Verulam, Ndwedwe, Waterloo, iNyaninga, La Mercy / Zimbali	-297 MI/d
2042: uMWP shut down, ('53 Pipeline capacity excl.)	Outer / Inner West	Tshelimnyama, Wyebank, Pinetown, KwaDabeka, Ntuzuma, Core NA supply area, Central & Southern areas, Phoenix, Umhlanga	Grange / Verulam, Ndwedwe, Waterloo, iNyaninga, La Mercy / Zimbali	-342 MI/d

7. Results of Exercise and Workshop Outcomes

The results in Tables 1 and 2 indicate that revised operating rules are only successful in delaying the need for a balancing dam at Baynesfield during the planned 2024 shutdown. No subsequent shutdowns can be carried out without providing some form of storage in the Baynesfield region that can supply water to the treatment works during a tunnel shutdown. Potable water storage within the EWS system is not designed to cater for the large volume of temporary storage required.

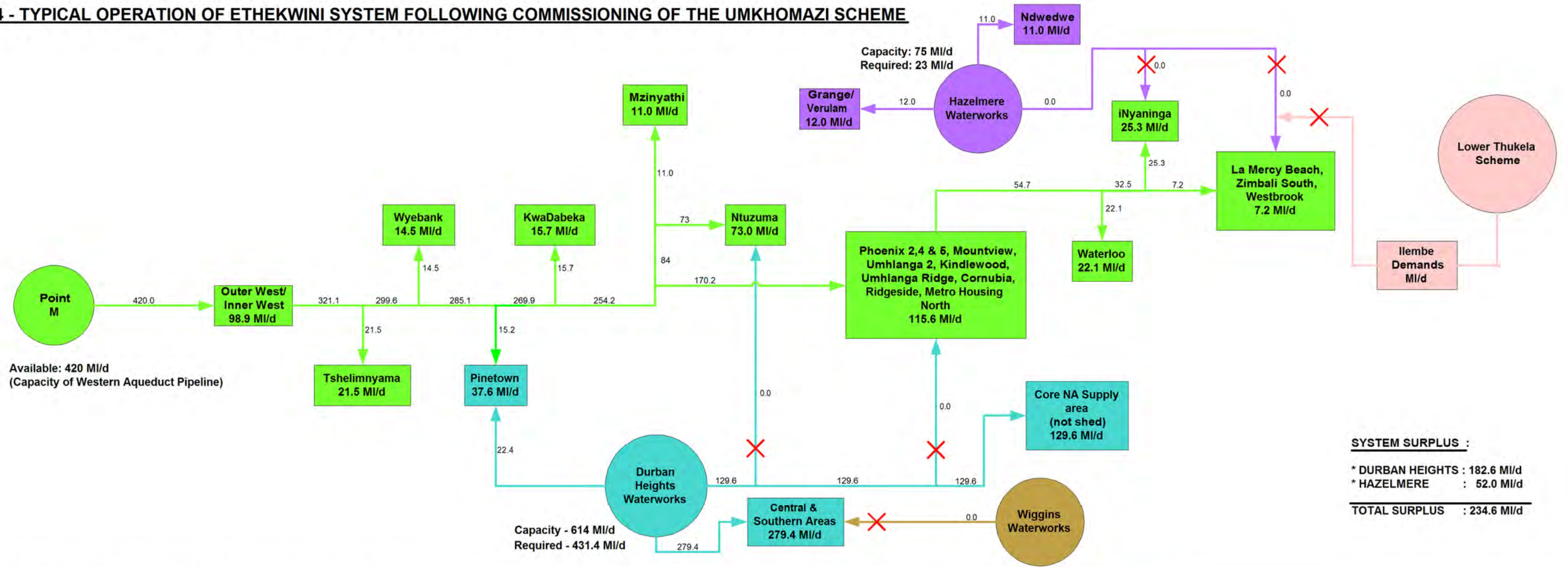
The shortfall in supply in the year 2042 is 229 MI/day if the calculations are based on the original demand projections. Using projected demands increased by 10%, the shortfall in 2042 is 342 MI/day. The original demands are considered to be more realistic. The minimum usable storage from a balancing dam that would be required to meet a shortfall of 229 MI/day over a three week period is 4830 MI or 4.8 million m³.

UW and EWS indicated that they were concerned at the risk involved in trying to deal with the demand shortfall by making operational changes to an aged supply system, even if only for three weeks. There was also concern that it did not seem practical to maintain the pump stations in a state of readiness to operate for a three week period once every ten years.

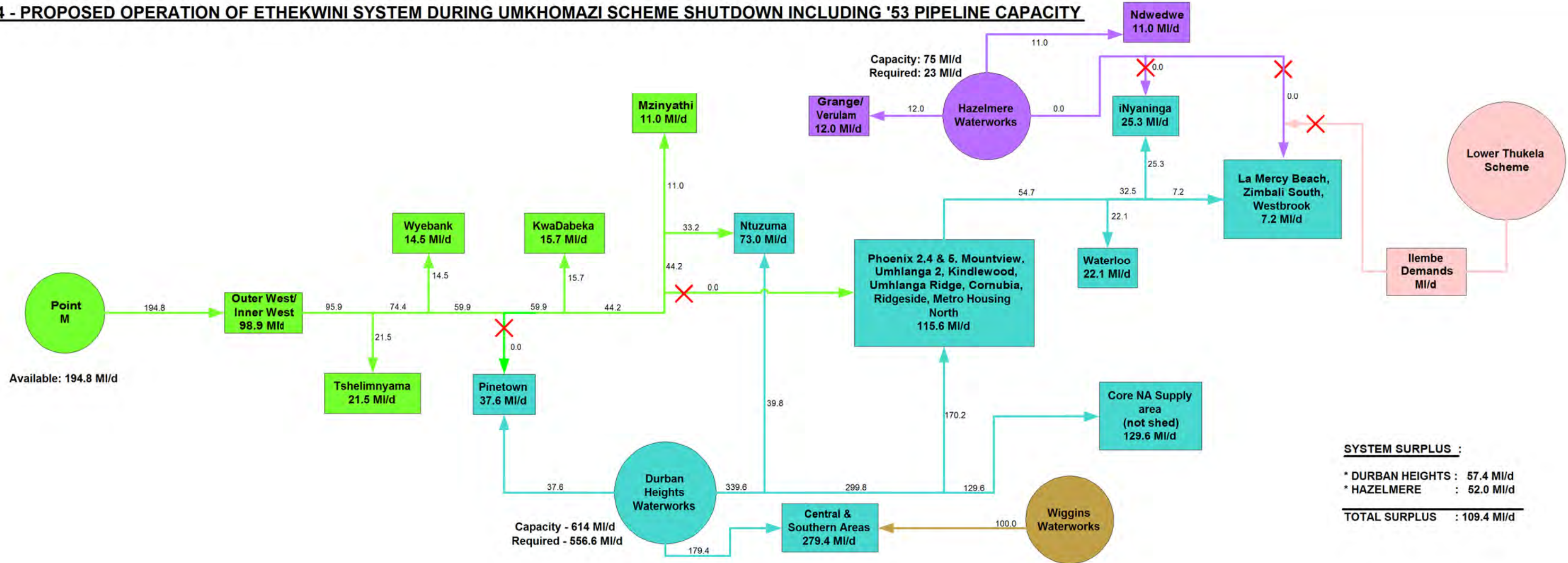
For practical reasons therefore, it is unlikely that revised system operating rules combined with a minimum storage provision at Baynesfield will be sufficient to meet the demands of the portion of the EWS system that is to be supplied from the uMWP Scheme. The size of dam constructed would need to cater for the full uMWP demand to the EWS system, without relying on the existing systems for assistance during the tunnel inspection period.

Annexure A: Schematic Diagrams for Typical and Shutdown Scenarios for 2024, 2034 and 2042. Based on Original Demand Projections

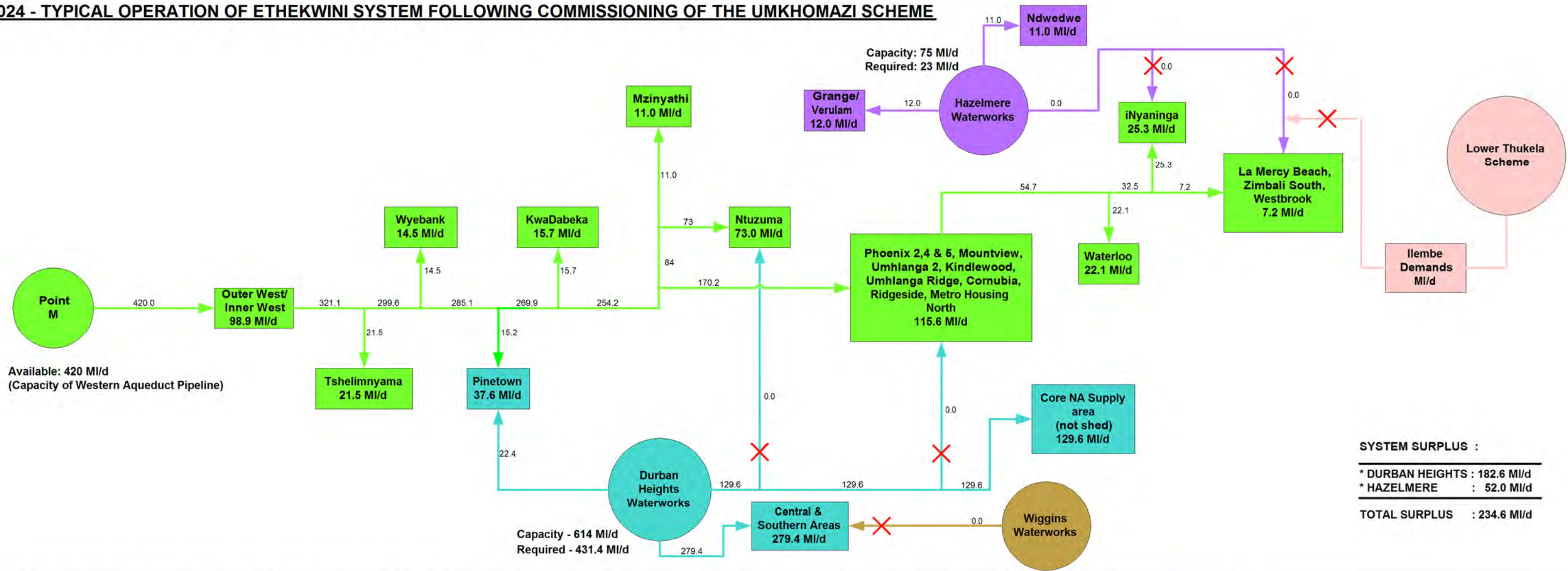
2024 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME



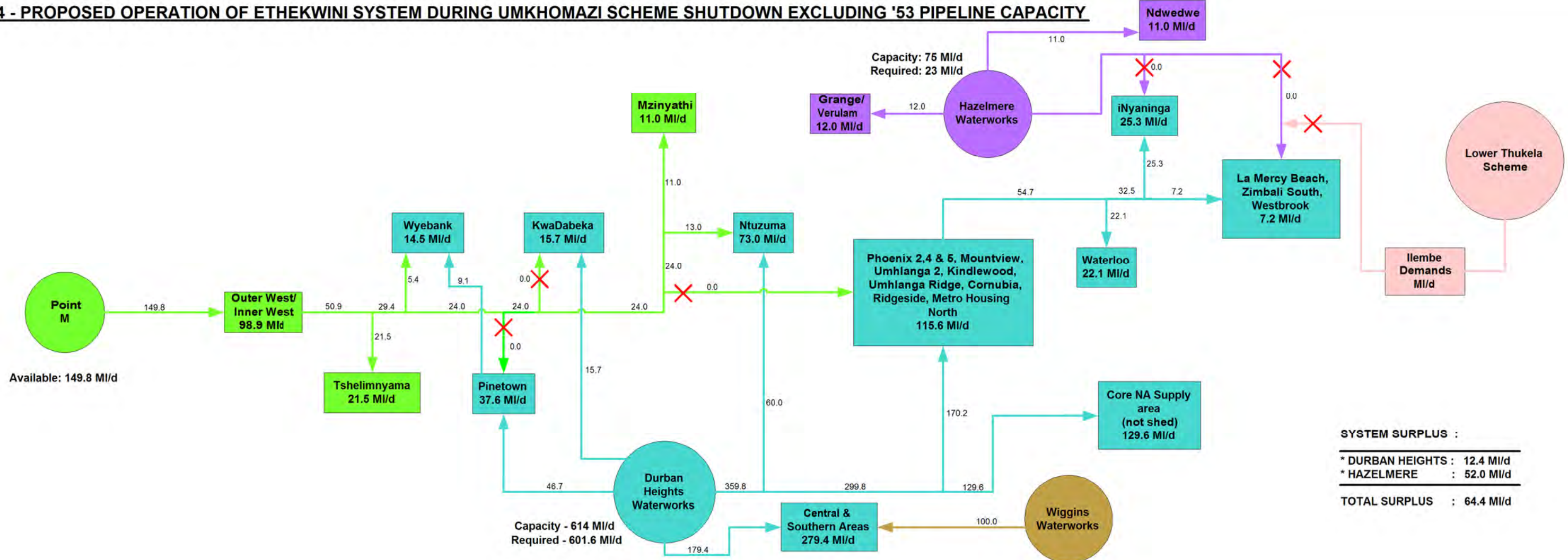
2024 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN INCLUDING '53 PIPELINE CAPACITY



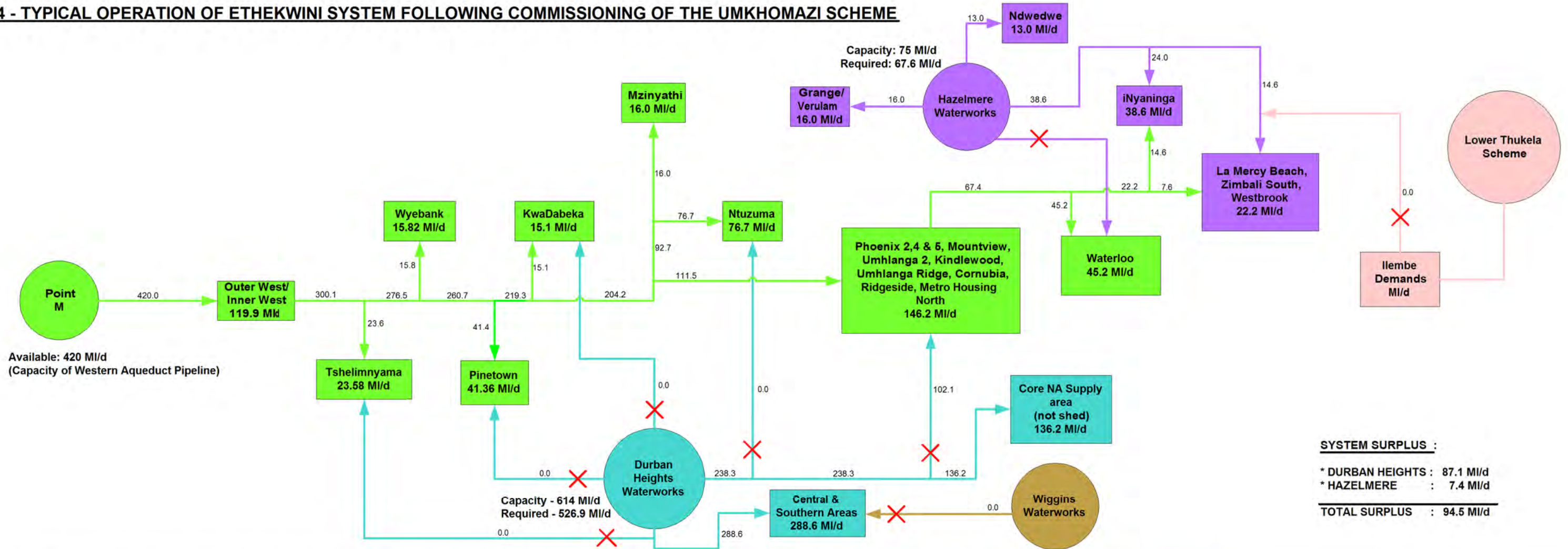
2024 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME



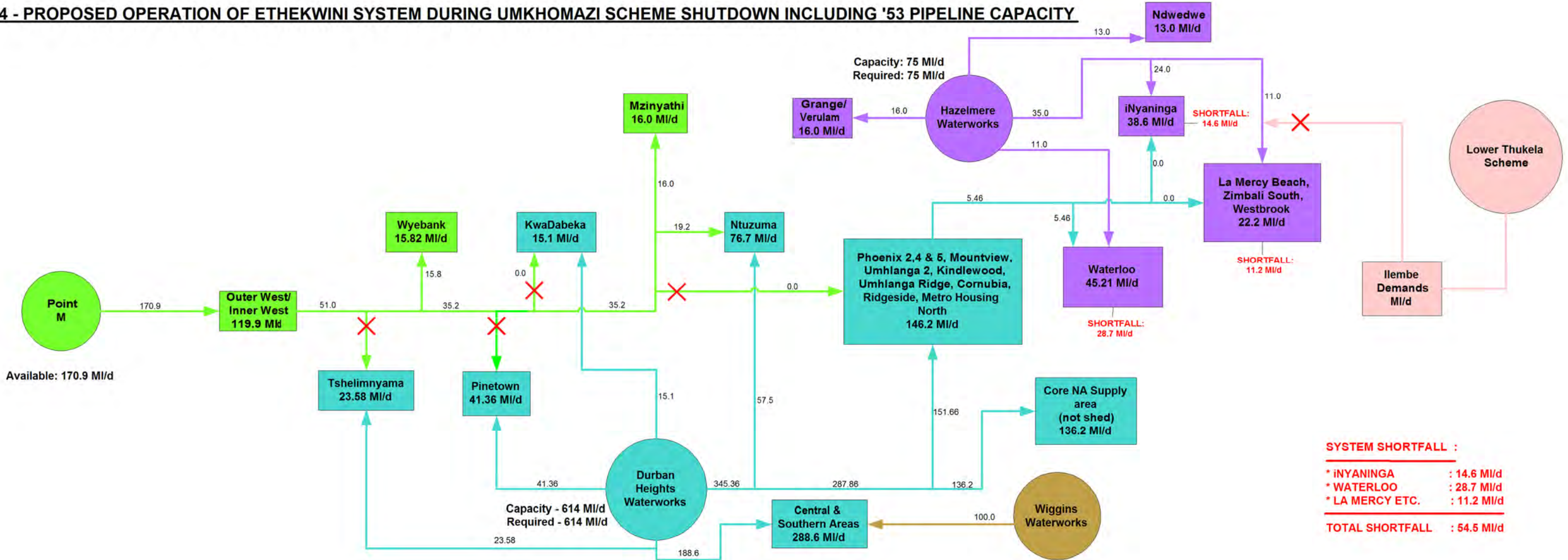
2024 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN EXCLUDING '53 PIPELINE CAPACITY



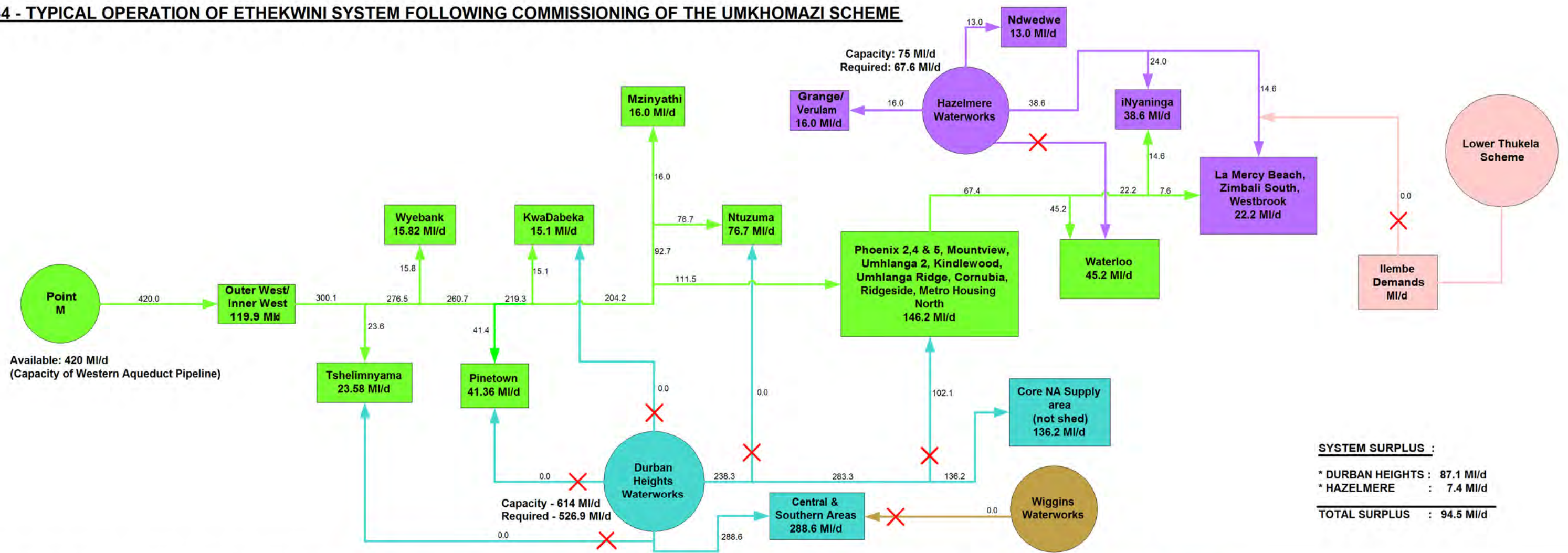
2034 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME



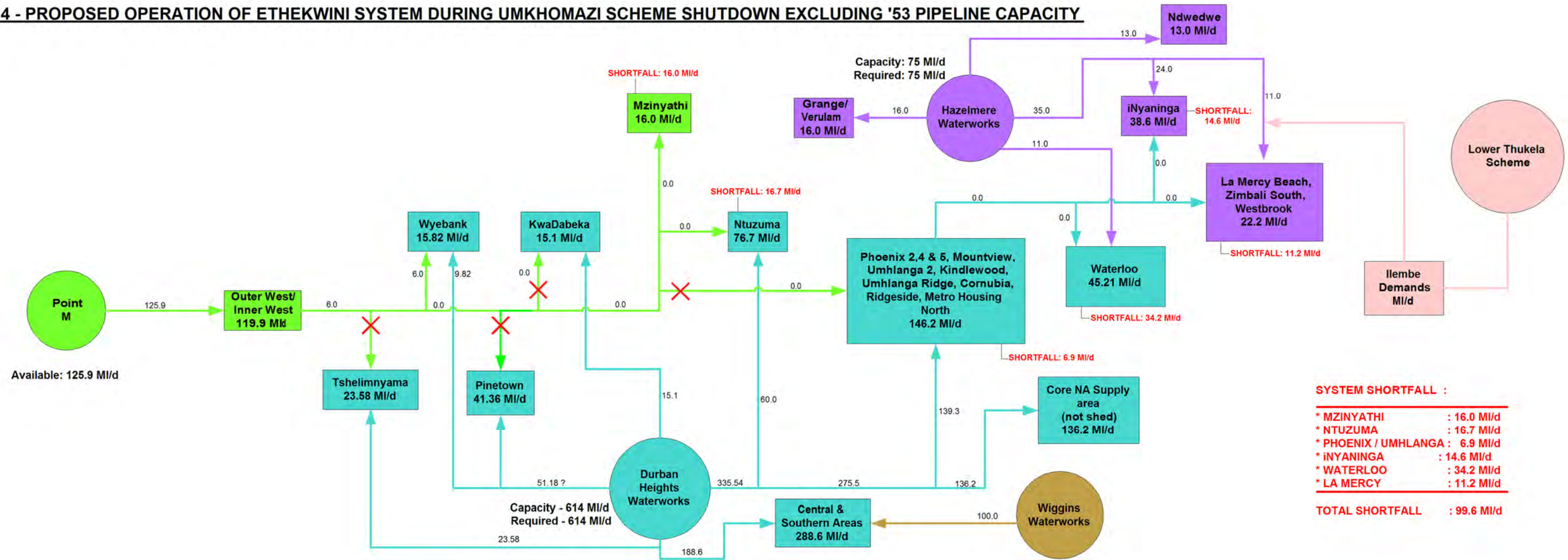
2034 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN INCLUDING '53 PIPELINE CAPACITY



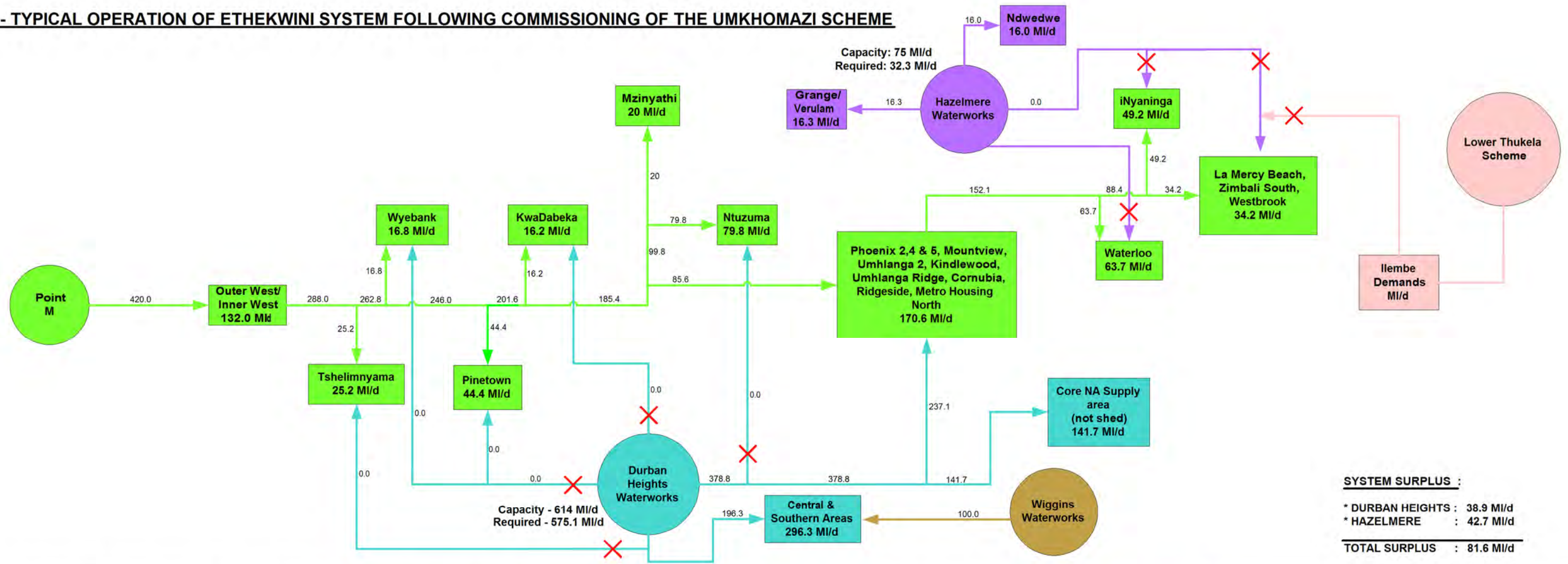
2034 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME



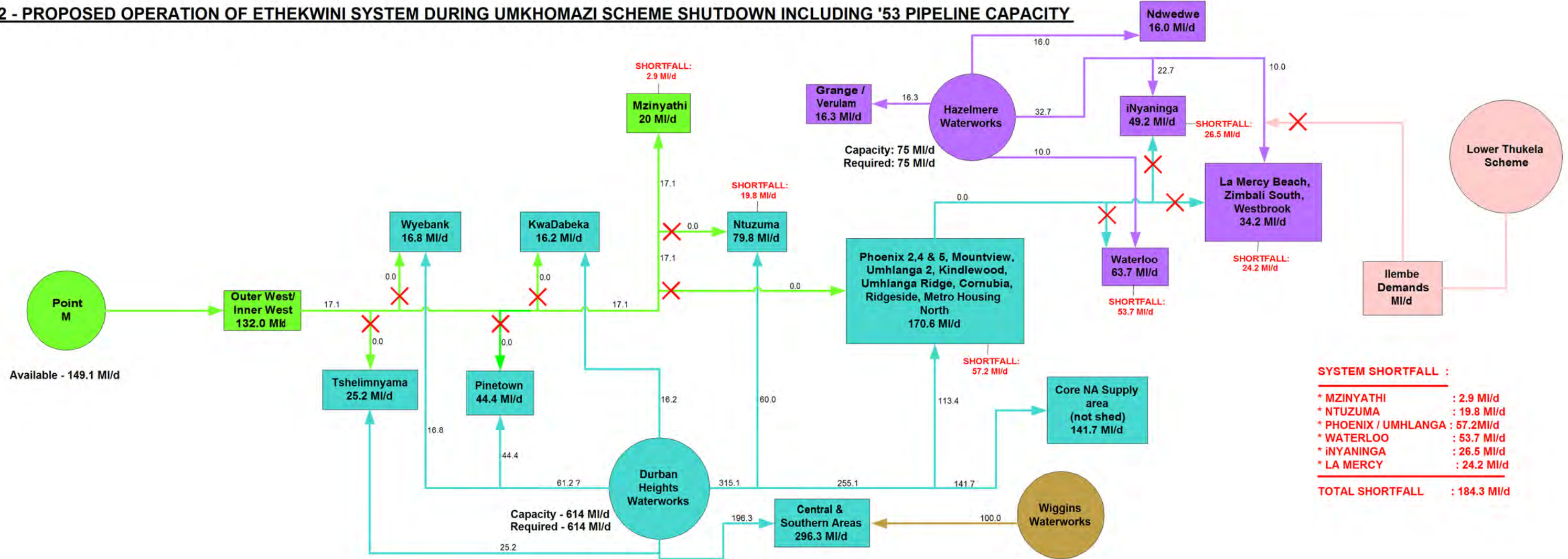
2034 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN EXCLUDING '53 PIPELINE CAPACITY



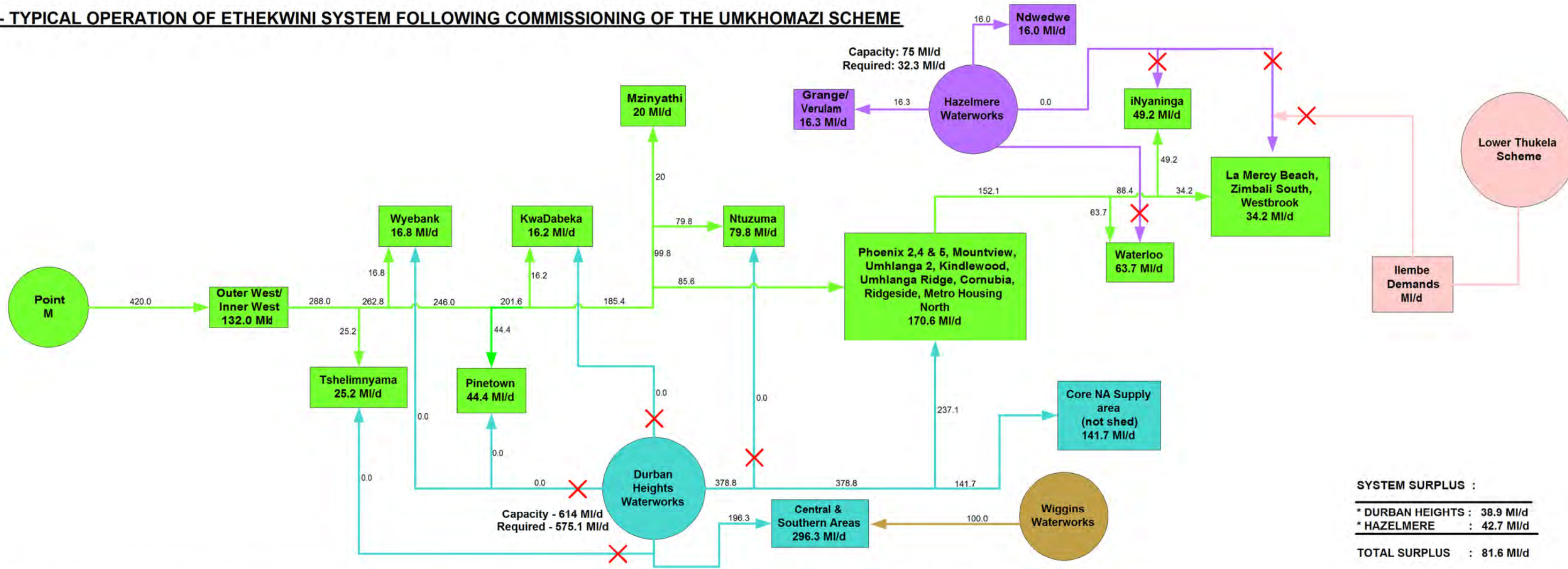
2042 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME



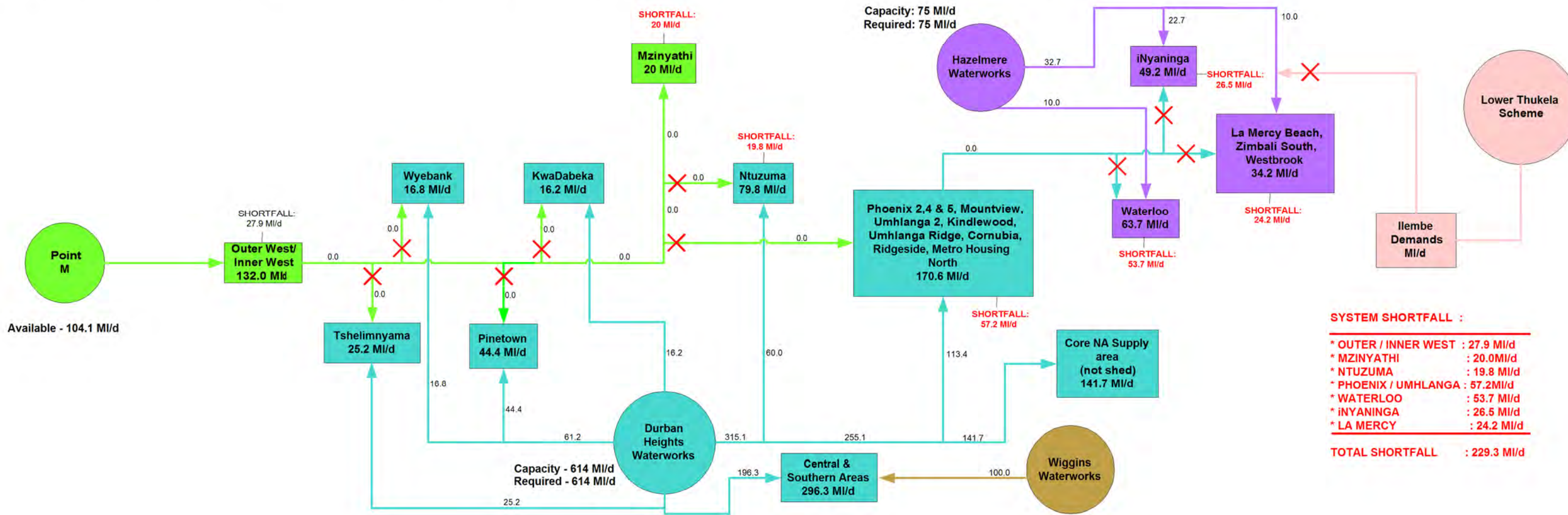
2042 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN INCLUDING '53 PIPELINE CAPACITY



2042 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME



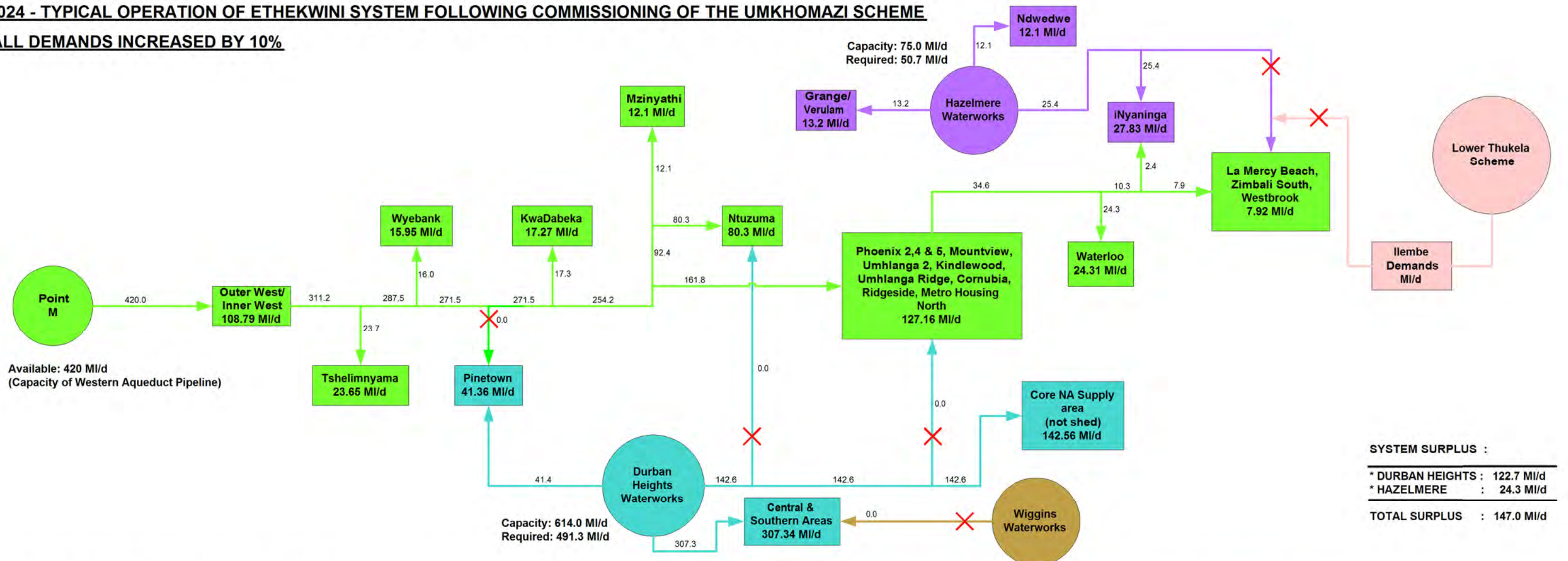
2042 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN EXCLUDING '53 PIPELINE CAPACITY



Annexure B: Schematic Diagrams for Typical and Shutdown Scenarios for 2024, 2034 and 2042

2024 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME

ALL DEMANDS INCREASED BY 10%

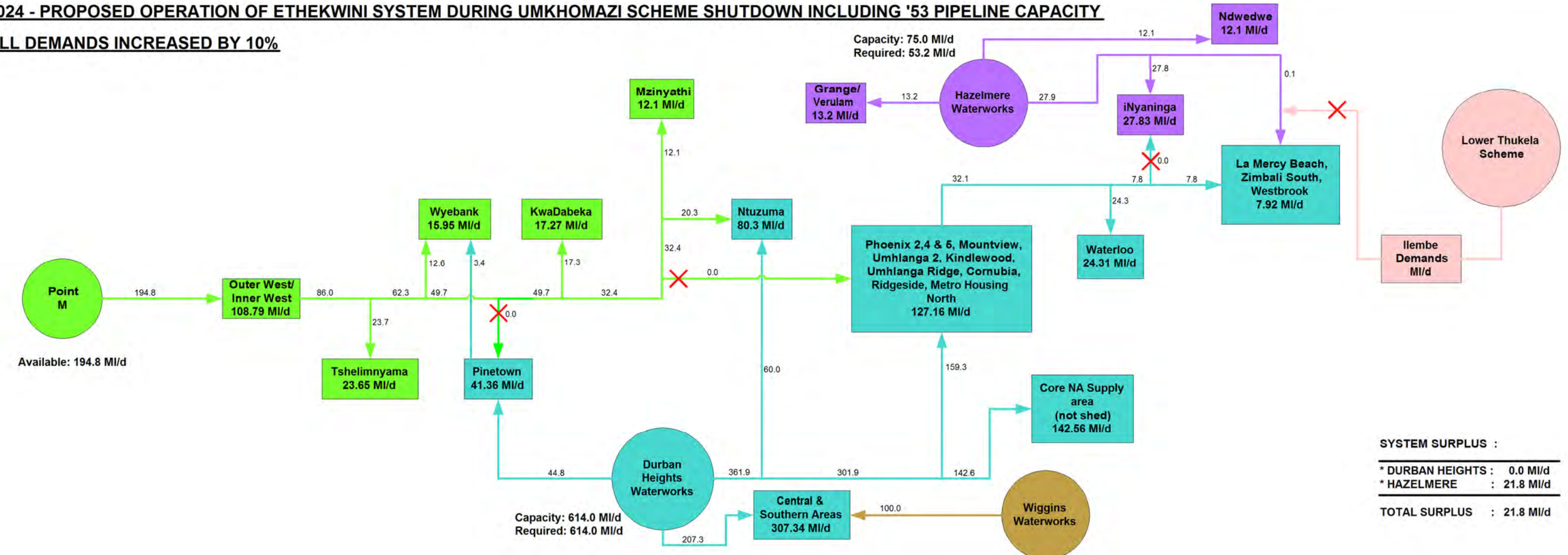


SYSTEM SURPLUS :

* DURBAN HEIGHTS	: 122.7 MI/d
* HAZELMERE	: 24.3 MI/d
TOTAL SURPLUS	: 147.0 MI/d

2024 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN INCLUDING '53 PIPELINE CAPACITY

ALL DEMANDS INCREASED BY 10%

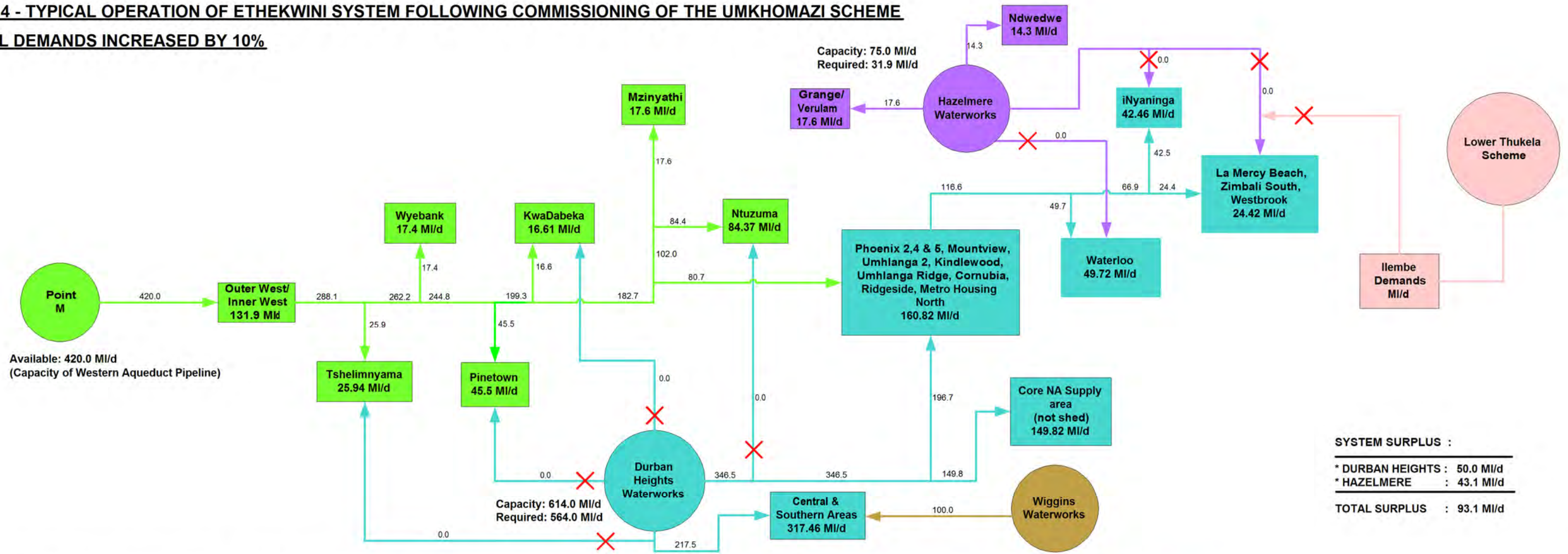


SYSTEM SURPLUS :

* DURBAN HEIGHTS	: 0.0 MI/d
* HAZELMERE	: 21.8 MI/d
TOTAL SURPLUS	: 21.8 MI/d

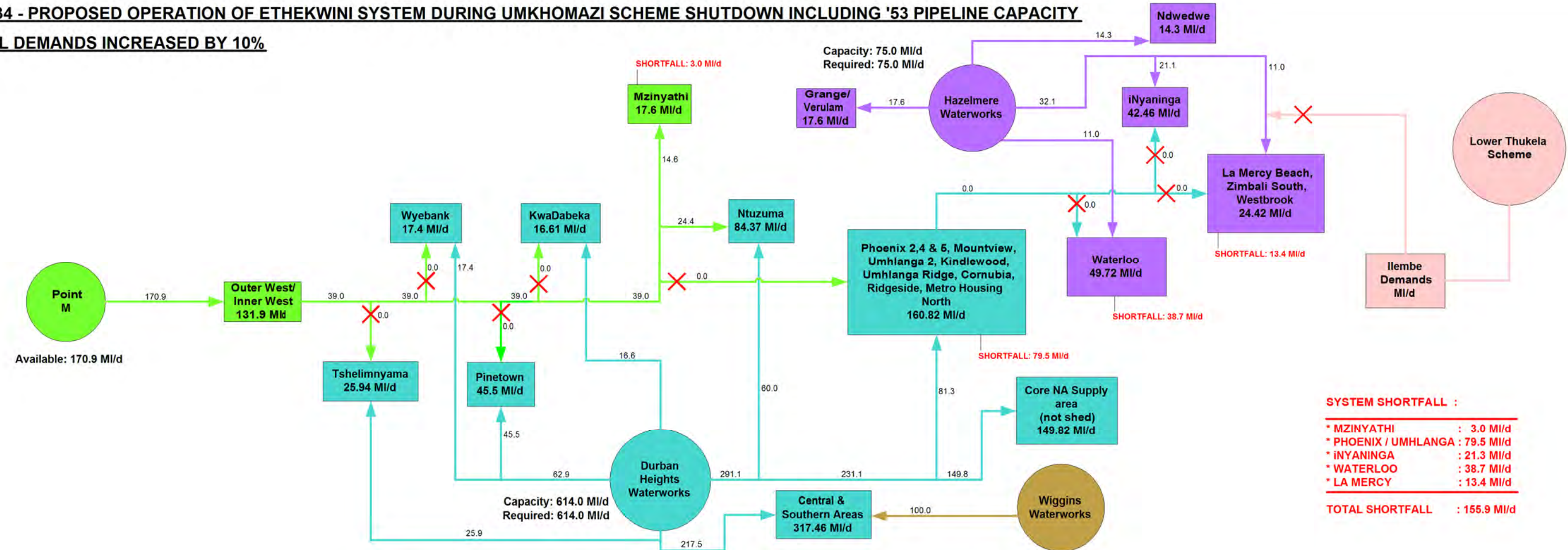
2034 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME

ALL DEMANDS INCREASED BY 10%



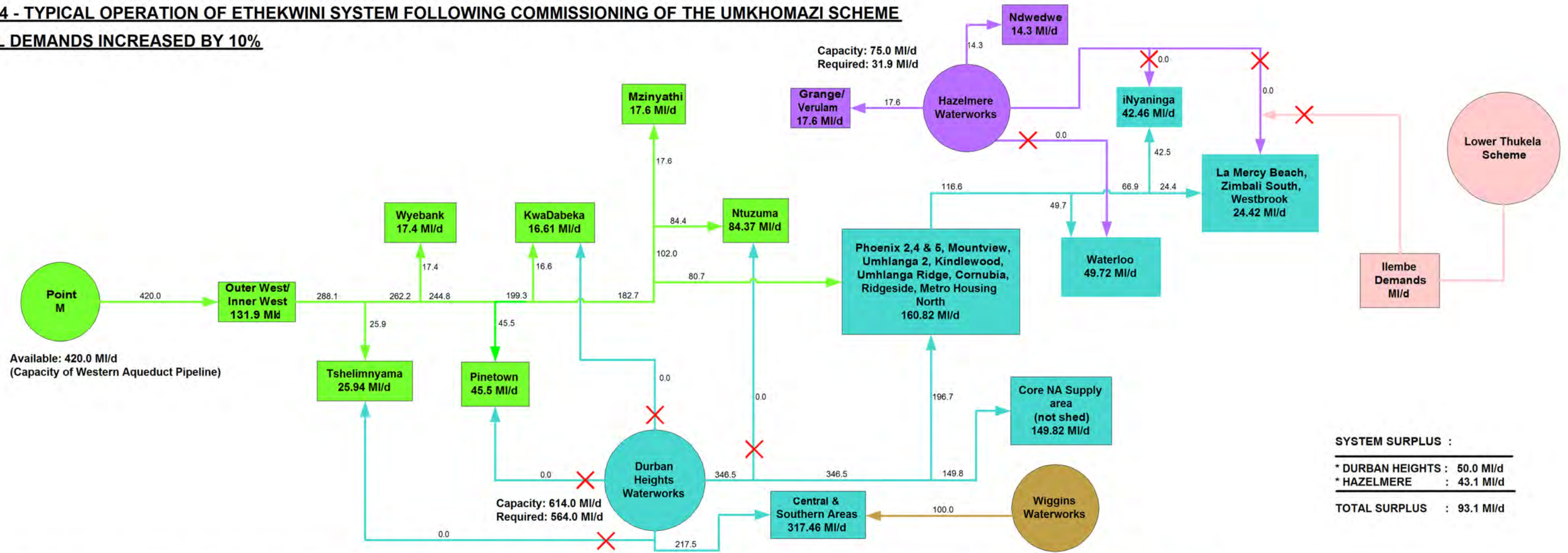
2034 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN INCLUDING '53 PIPELINE CAPACITY

ALL DEMANDS INCREASED BY 10%



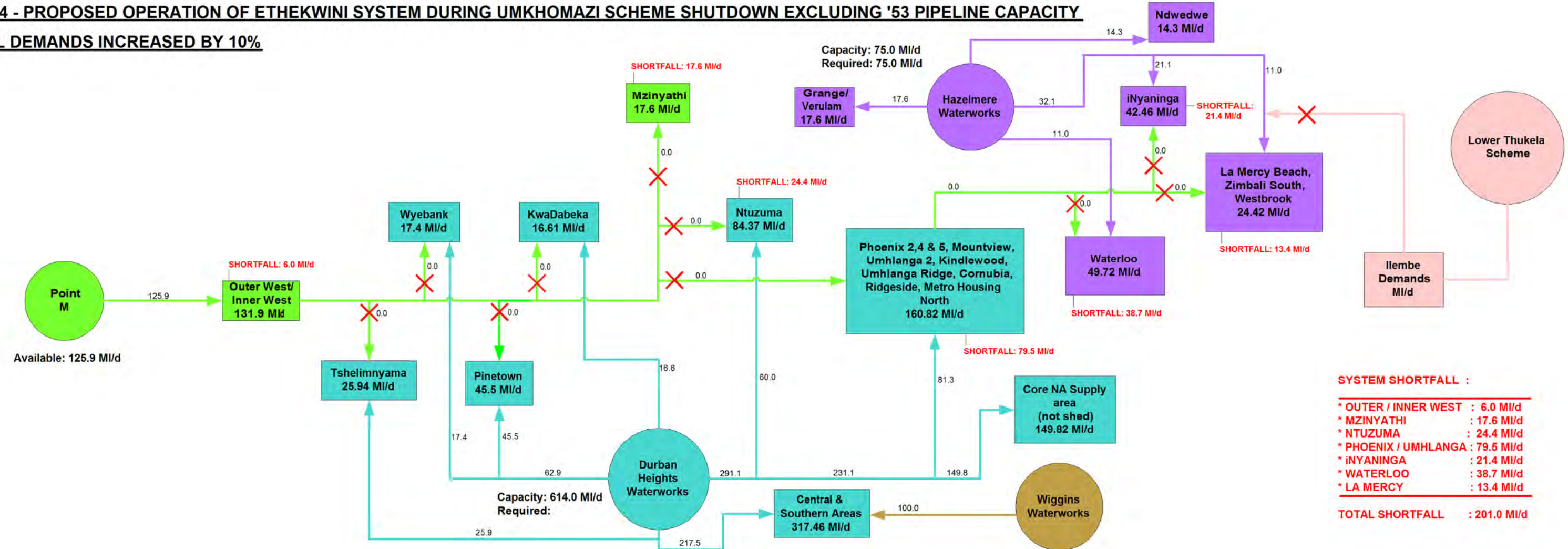
2034 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME

ALL DEMANDS INCREASED BY 10%



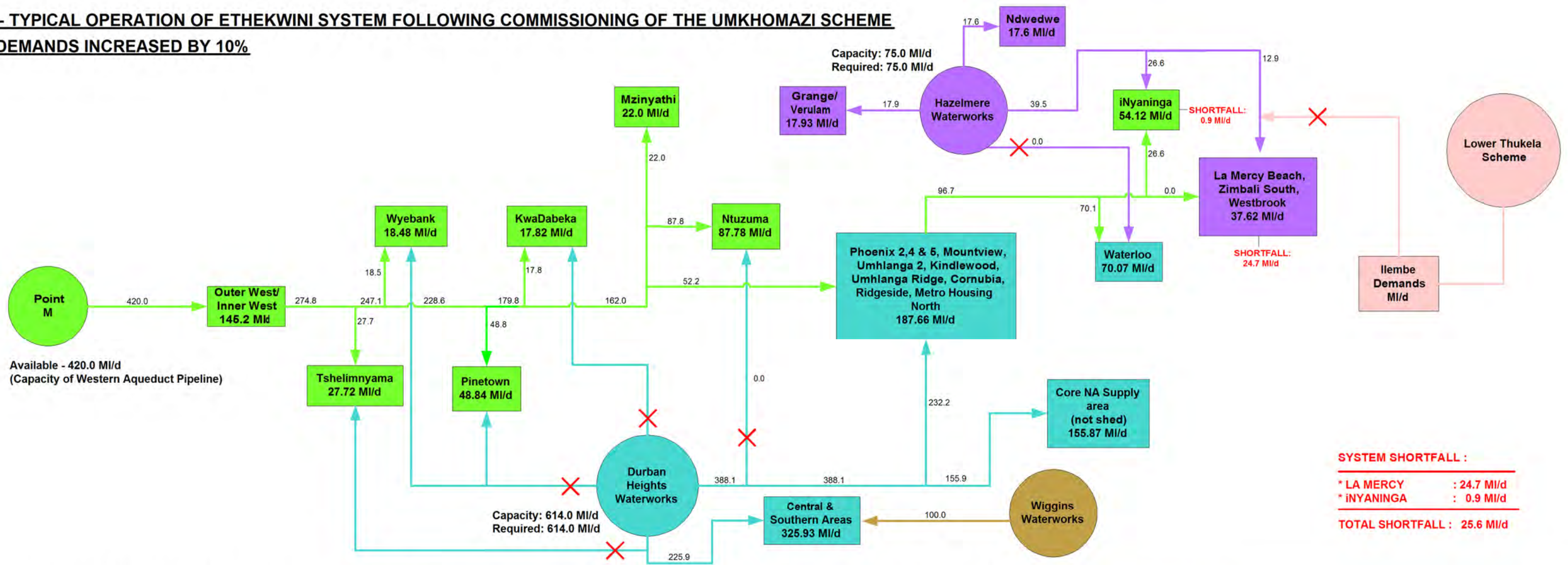
2034 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN EXCLUDING '53 PIPELINE CAPACITY

ALL DEMANDS INCREASED BY 10%



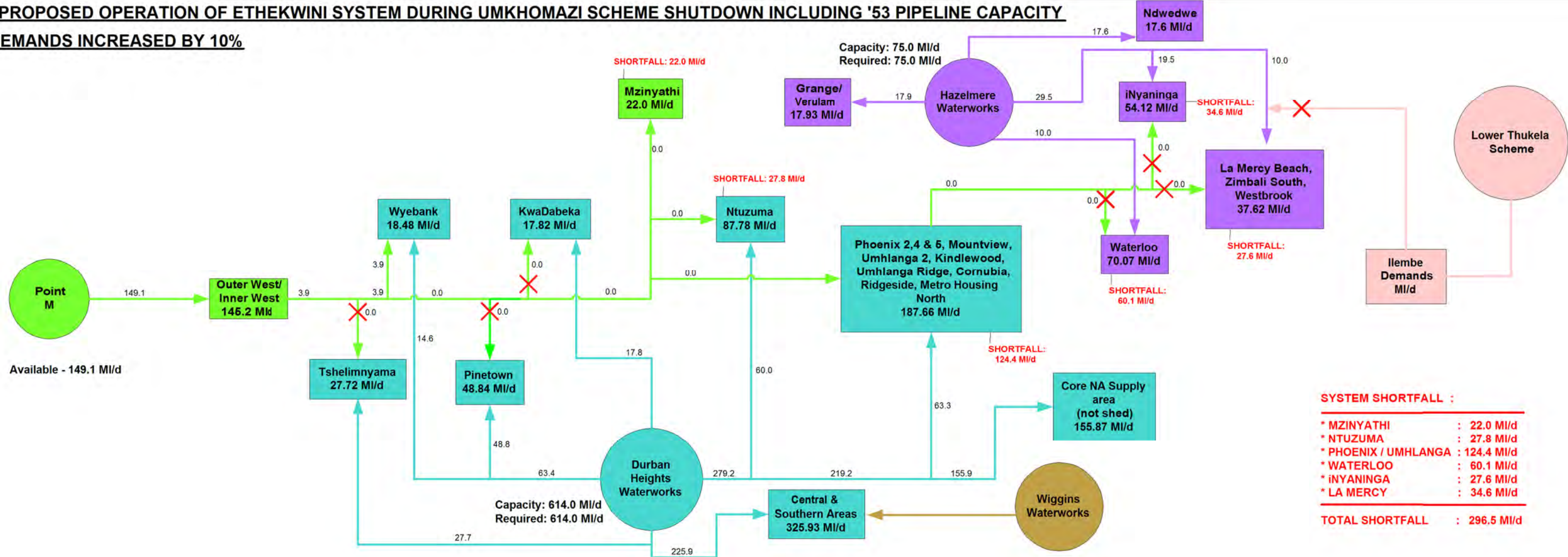
2042 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME

ALL DEMANDS INCREASED BY 10%



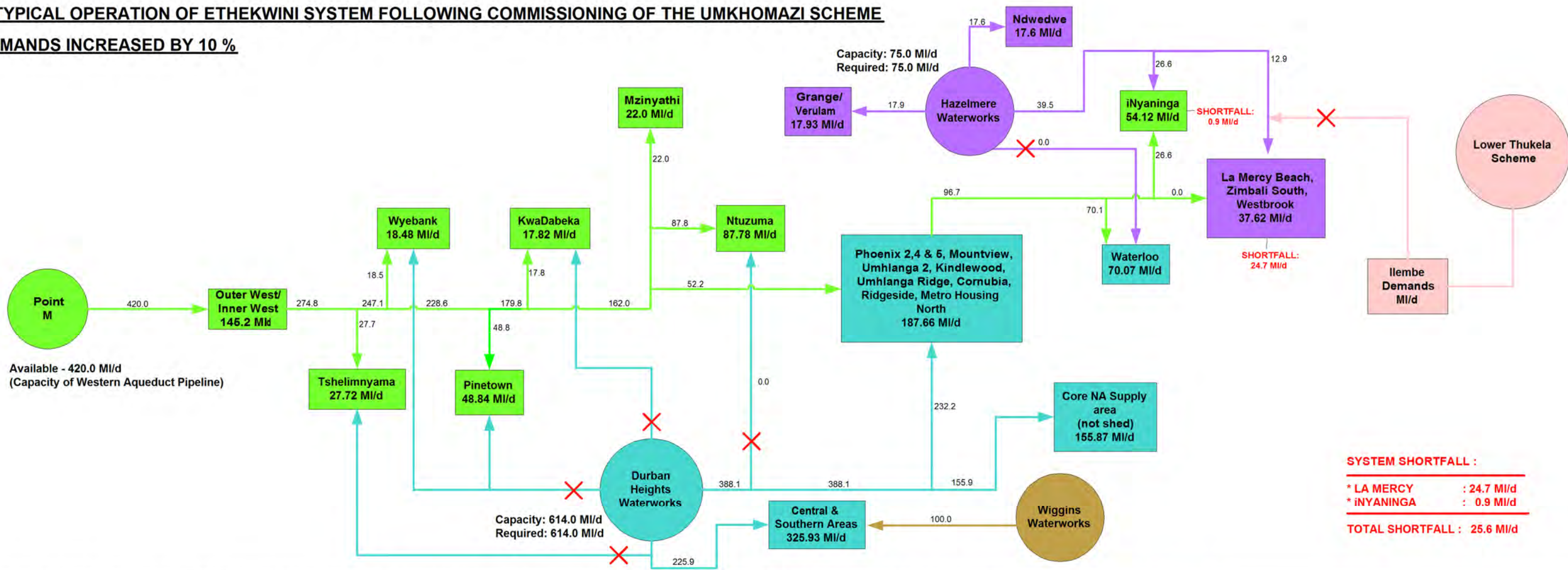
2042 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN INCLUDING '53 PIPELINE CAPACITY

ALL DEMANDS INCREASED BY 10%



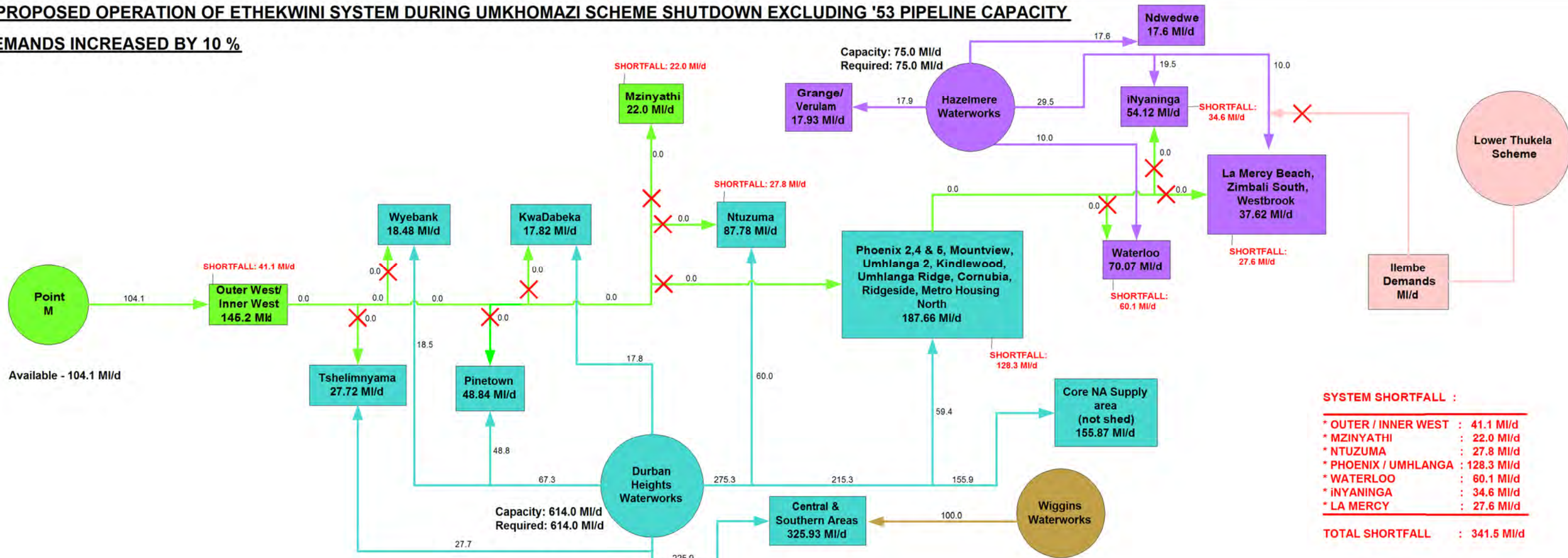
2042 - TYPICAL OPERATION OF ETHEKWINI SYSTEM FOLLOWING COMMISSIONING OF THE UMKHOMAZI SCHEME

ALL DEMANDS INCREASED BY 10 %



2042 - PROPOSED OPERATION OF ETHEKWINI SYSTEM DURING UMKHOMAZI SCHEME SHUTDOWN EXCLUDING '53 PIPELINE CAPACITY

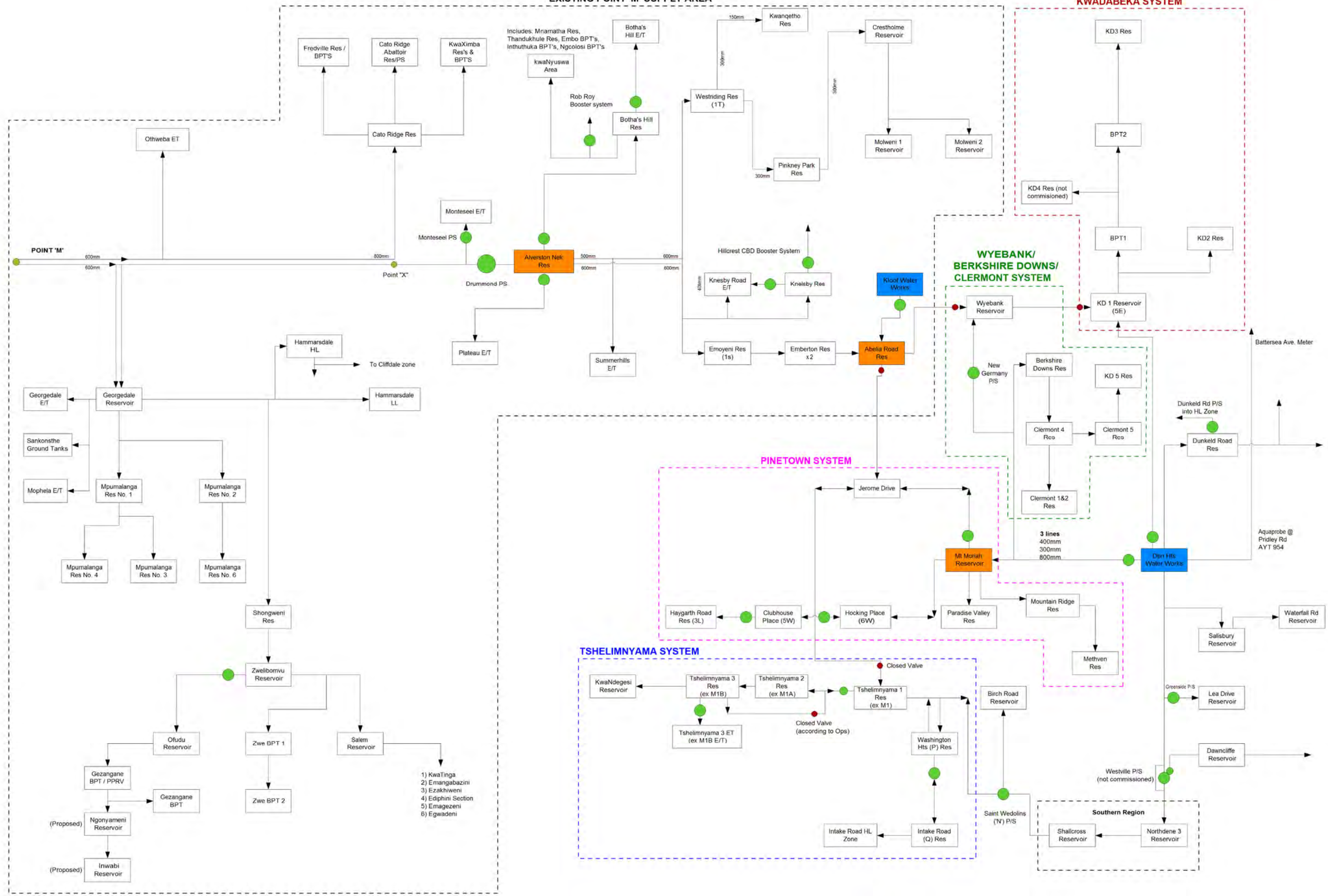
ALL DEMANDS INCREASED BY 10 %



Annexure C: Detailed Schematic Diagram of the Western Supply Area

EXISTING POINT 'M' SUPPLY AREA

KWADABEKA SYSTEM



CLIENT: **UMGENI WATER AMANZI**

TITLE: **EWS - WESTERN OPERATIONAL AREA WATER DEMAND REGIONS**

DATE ORIGINAL: 23/01/13 SCALE: NTS

REVISION: A JOB NO.: DU303-00413/01 DRAWING NO.:

REVISIONS		
NO.	DATE	DESCRIPTION

CHECKED: A.D DRAWN: I.D

PROJECT: **UMKHOMAZI PROJECT POTABLE WATER MODULE**

CONSULTANTS: **Knight Piésold CONSULTING**

Annexure D: Detailed Schematic Diagram of the Northern Supply Area

