# Mhlathuze system simplified water balances

**Compiled by Norman Ward retired engineer from the Goedertrouw Dam**

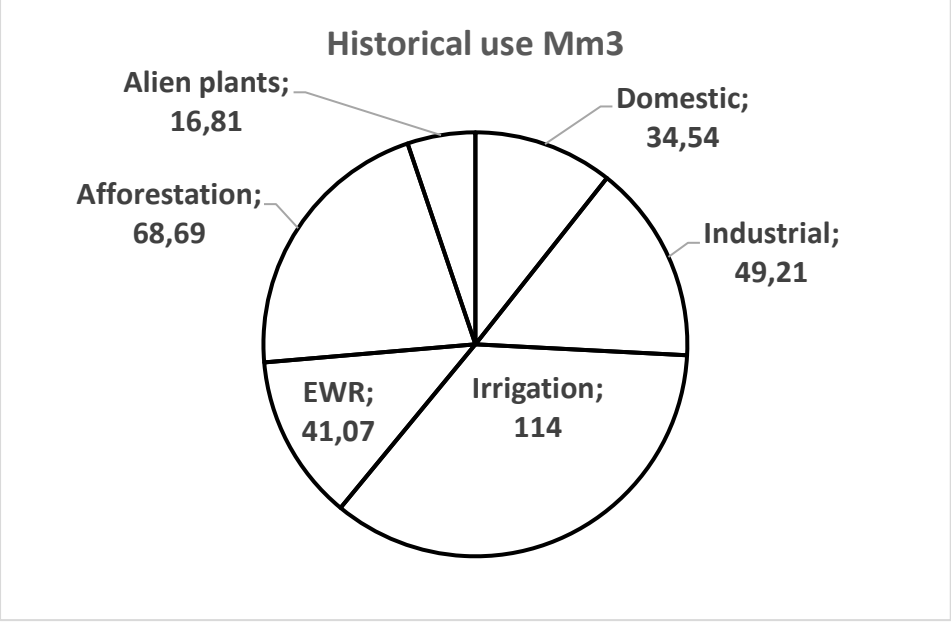
## Whole system

The holistic approach to water balancing requires sophisticated modelling, using different assurances of supply to different users. This is done regularly by DWS through Reconciliation strategies for all the Metros of South Africa. The 2015 strategy for the Mhlathuze is currently being updated by a consortium of consultants with the water balance component being handled by WRP consultants.

To further explain the complexities let me emphasise that the study area consists of 9 quaternary sub-catchments W12 A-J plus inter-basin transfers from the Tugela and Umfolozi rivers. The flow at the Mhlathuze weir, one of the main abstraction points of the system is fed from 5 of these quaternaries, namely W12 A-E, of which A and B feed the Goedertrouw Dam and C, D and E feed the weir directly. The remaining four feed the lakes and the groundwater around them.

The runoff from these quaternaries has to supply conventional uses as well as environmental flows. Certain water uses are fed directly from rain, but because they consume more water than Indigenous vegetation, they are listed as stream flow reduction activities. These are mainly Afforestation and Alien Plants. The model takes account of them by modifying the runoff.

Here is a chart showing the historical use by all types:



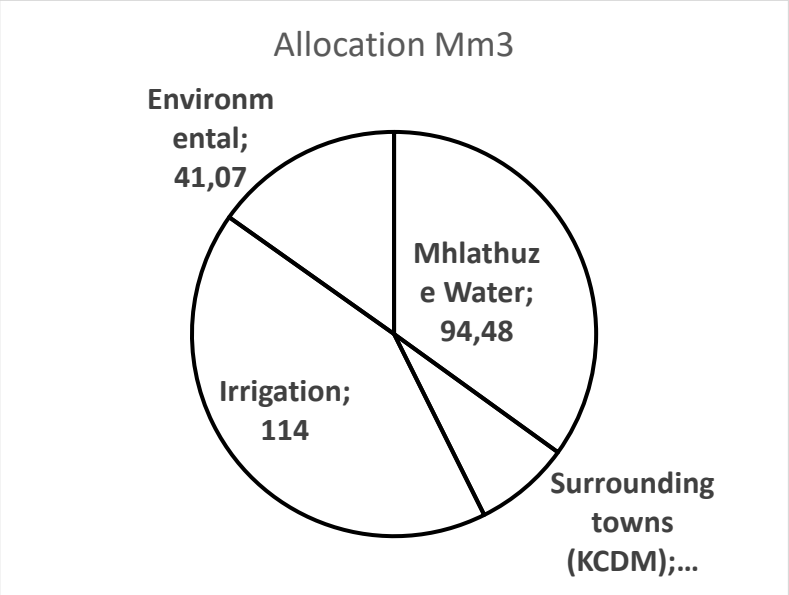

As can be seen, the largest use is from Irrigation, but this is at a low assurance of supply, and thus it is normally drastically curtailed during droughts. Also of importance is the Industrial use, which is substantially larger than the Domestic use. This is an unusual feature of Richards

Bay. Most urban centres are dominated by Domestic use. Industry requires a high assurance of supply in order to meet market commitments and avoid job losses.

**From Goedertrouw to Mhlathuze weir**

Let us break the water uses and their sources down for a greater understanding of the catchment. The river reach from Goedertrouw Dam to the Mhlathuse weir contributes a large volume of water to the weir, it is essential that flows from the dam be reduced during these times to maximise use of this water, without which there would be a deficit in the catchment. This is the incremental flow from subcatchments W12C,D and E. Below is a table of uses on this stretch of river as well as a graph, showing the magnitude of each use. These are the volumes allocated under Compulsory Licensing.

| User | Allocation Mm3 |
|---|---|
| Mhlathuze Water | 94.48 |
| Surrounding towns (KCDM) | 20.8 |
| Irrigation | 114 |
| Environmental | 41.07 |
| **Supplied from dam** | **270.35** |
| **Goedertrouw + Tugela** | **245.8** |
| **Allocation Deficit** | **24.5** |




| Upper Water Sources | | | |
|---|---|---|---|
| **Water sources** | **Live storage Mm3** | | **Historical Firm yield Mm3** |
| Goedertrouw dam | 320 | | 214.3 |

| | | | |
|---|---|---|---|
| Existing Tugela Transfer | | | 31.5 |
| | | | **245.8** |

**The lakes of the Mhlathuze**

Now let us zoom in on the lakes. Consultants have battled to put a number to the yield of the lakes, as their actual storage volume should include the groundwater surrounding each lake, which is substantial but unknown. I have assumed the long term yield of the lakes to be the same as their storage volume for those with small storage, and Lake Nhlabane was calculated at 30% of average inflow. Before compulsory licensing RBM had a registered abstraction of 18 Mm3, however they asked us to halve this and transfer the shortfall on to their other sources. They said it was in the light of recent experience with large areas of community blue-gum plantations surrounding the lake and depleting the groundwater. The modellers thought that was too drasic, so the figure above is probably realistic. The same problem is presenting itself near Mzingazi and Cubu lakes as well, but to a lesser extent, owing to urbanisation.The lakes also respond very differently to the dam as they are replenished quickly in the wet years but drop rapidly once the groundwater is depleted during a drought. Thus they are subject to a shorter cycle than the dam. Some also have little storage relative to their inflows as can be seen from the table below.

**Assumed characteristics of the lakes**

| | **Live storage Mm3** | **Lakes average inflow (not yield) Mm3** | **Assumed yield** | **store % of inflow** |
|---|---|---|---|---|
| Mzingazi Lake | 20.2 | 52.5 | 20.2 | 38% |
| Nsezi Lake | 3.3 | 88.7 | 3.3 | 4% |
| Cubu Lake | 3.6 | 18 | 3.6 | 20% |
| Nhlabane Lake | 22.3 | 33.2 | 9.96 | 67% |
| | | **Lakes total** | **37.1** | |

The demands from the lakes are each supplied from that specific lake. For instance City of Mhlathuze takes the bulk of their water from Lake Mzingazi. The lake dropped to its minimum level within the first year of the drought, causing the water plant to shut. The full demand of Richards Bay then had to be met by purchases of water from Mhlathuze Water, putting additional strain on Goedertrouw. Likewise Lake Cubu dropped low, although it never failed, but water from the Mhlathuze Weir had to be blended with lake water. Thus although the demand of the City of Mhlathuze, (36,22 Mm3) should have been partially met by yield of about 23,8 Mm3, it was fully met for the first year and then almost all the demand came from the Goedertrouw dam, thus dramatically increasing the deficit on the Goedertrouw dam.

In similar fashion, RBM draw most of their water from Lake Nhlabane, supplemented by the Umfolozi River until these sources are depleted, and then draw from Lake Nsezi. The lake has to be supplemented from the Mhlathuze weir, and Mhlathuze Water were hard-pressed to meet this demand as well as supply their water plant, owing to constraints with their pipeline.

While the lakes should be fully exploited during the wet years to conserve Goedertrouw dam, there needs to be greater flexibility in their operation such that withdrawals are reduced early in a drought so that they do not reach minimum level until late in the cycle. Having some water in each lake would allow for greater flexibility in the operation of the Mhlathuze weir, which has practically no storage. This would make releases from the dam easier to manage, as a shortage at the weir for a day or two would not be critical.

The lakes are an integral part of the system and must be fully utilized. The lakes have fully recovered and are spilling. The current under-utilisation of lakes by City of Mhlathuze is seriously affecting the system and could have serious consequences if the Goedertrouw dam does not fully recover and another drought hits the system.

**Yield from Quats W12C,D,E**

This source cannot be accurately determined. There are substanitial flows lasting from 2 days up to 25 days. It can only be determined by modelling, but as modelling is normally done on monthly balances, it is not accurate. It also depends largely on the correct operation of the dam, as there is minimal storage in the Mhlathuze weir. If Mhlathuze Water had a greater pipeline capacity from the weir, I calculated that a saving 23 Mm3 could be achieved by pumping excess water to lake Nsezi when the weir is spilling.

**Summary of the source of water.**

In summary, there are currently four natural sources of water:

| Source | Description |
|---|---|
| Goedertrouw Dam | Large and reliable long term yield. |
| Coastal lakes and groundwater around them. | Yield Smaller and indeterminate. Can be substantial during wet years but unreliable during drought. They must be utilized flexibly in order to conserve Goedertrouw dam |
| Tugela Transfer | Smallish but reliable yield. Very expensive operating cost as well as capital cost. Only operates during drought sequence. |
| Yield from Quats W12C,D,E | Substantial intermittent flows even in drought. They must be utilized in order to conserve Goedertrouw dam. Dam operation must be constantly controlled. |

**Compulsory Licensing and the growth in demand**

Each Province in SA were asked to undertake compulsory licensing in one priority catchment as a test case. The Mhlathuze was chosen because it was a catchment with a large over-allocation. This was due to three things: A reduction in yield when the hydrology was updated after the drought of the 1980's, an increase in allocations to the urban sector and the introduction of the environmental flow requirements.

This resulted in a large deficit whenever models were run using allocated volumes, however it was common knowledge that some of the larger industries were using far less than their allocations. In the irrigation sector DWS had accurate readings of use, as users were paying

based on metered flows. The irrigation use **AVERAGED 40%** of allocations, despite some users using up to 100% of their allocations.

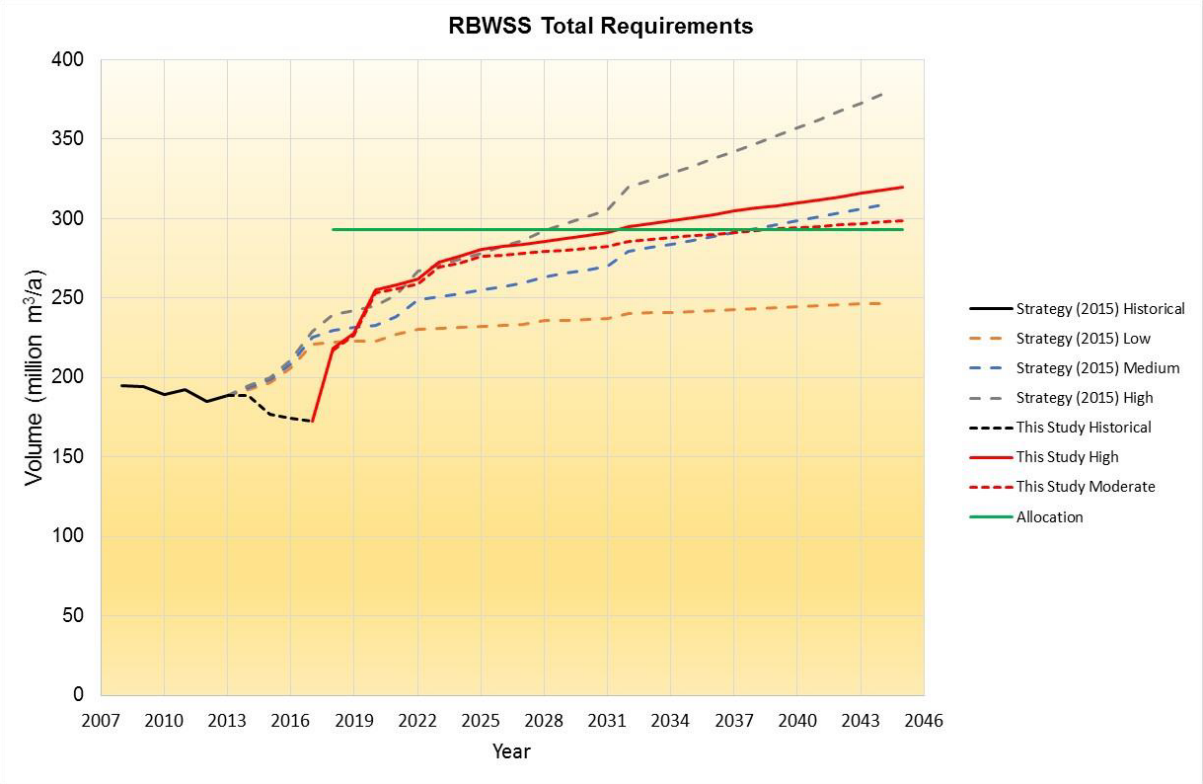
The Goedertrouw dam alone could only meet 60% of the historical allocations across the catchment, thus DWS decided to reduce the Irrigation sector allocations to 60% of the original allocation, as it cannot be justified to pump water at such expense for irrigation. Then the models were re-run with the Tugela transfer operating, and the remaining water was only sufficient to allocate 90% of the historical allocations to Urban and Industrial use. The result was that there was no surplus available to allow for growth in any sector.

Furthermore during the process there were such strong objections from some sectors of Agriculture that DWS Head Office sanctioned an increase to 66% of historical allocations, thus creating an immediate but small deficit in allocations. However with actual use in both Irrigation and Industry below the new allocations, this was deemed an acceptable risk.

**The current actual use pattern**

The deficits indicated above are not surprising, given the process just explained above, as they are based on allocations in most cases. The big unknown factor is the rate of growth of development in the Industrial sector. The 2015 reconciliation strategy showed rapid growth from the Industrial Development Zone (IDZ) and other role-players, thus giving little lead time for new development, but the updated strategy has had better information from the users and has put more realistic targets in place. Thus the current reconciliation strategy shows that with actual use there is still water for a number of years of growth before the next intervention is needed.

Below is a graph indicating a surplus, courtesy of the current Reconciliation strategy: It is assumed that the drop due to the drought restrictions will be rapidly reversed when restrictions are lifted.




This then begs the question as to why the Tugela Transfer scheme was being duplicated in such haste. It appears from actual experience during this drought that in fact augmentation is already necessary. I believe the modelling does not accurately reflect the reliability of the lakes, nor does it reflect the abstraction efficiency of the Mhlathuze weir and the release patterns from the dam, as it is a monthly model and not able to capture inter-month variability.

The current Reconciliation Strategy has gone into great detail with each of the users to try and pin down the future use in compiling this strategy. It is therefore likely that the projections are more realistic than before.

**The drought cycle in the Mhlathuze system**

- During the early part of a drought the groundwater around the lakes becomes depleted, but is not immediately apparent.
- Then the lakes begin dropping fast, but the dam remains relatively full. (This is why DWS should monitor the lake levels, but at present this information sits with various institutions: Mzingazi and Nsezi with Mhlathuze Water, Cubu with the City of Mhlathuze and Nhlabane with RBM.)
- Then the lakes reach a critical level and the full demand of the system comes on to Goedertrouw Dam. The dam begins to drop rapidly. If the dam has been poorly operated during the early onset of the drought, then the system is already at increased risk. At this point the annual operating forum is likely to impose restrictions and commence pumping from the Tugela River.

- Restrictions are gradually tightened and user awareness is increased, with saving measures being applied in order to meet restrictions. Some consumers respond immediately, while others do not.
- When the rains return the lakes and the groundwater around the lakes recovers first, allowing the dam level to recover and restrictions to be reduced, but not lifted. Pumping continues from the Tugela until the dam reaches a safe level as determined by the annual operating forum.
- Finally the dam recovers to a safe level and possibly spills soon thereafter.