GOLDER

# TECHNICAL MEMORANDUM

**DATE** 5 February 2021

**Project No.** 20350974_TM002

**TO** Frik F. Vermaak, Two Rivers Platinum

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**RESULTS OF WATER BALANCE MODELLING**

## 1.0 INTRODUCTION

Two Rivers Platinum (Pty) Ltd. (TRP), a joint venture between African Rainbow Minerals (ARM) (51%) and Impala Platinum Holdings Limited (Implats) (49%), is managed by ARM. ARM's economic interest in Two Rivers is 55%. TRP has a New Order Mining Right to explore and mine the Platinum Group Metals (PGM's), other precious metals (gold and silver), and associated base metals and ores on portions of the farm Dwarsrivier 373 KT. TRP will be expanding their mining reserves to mine the Merensky Reef in addition to the UG2 Reef. Mining of the Merensky Reef will commence in July 2023 and both Merensky and UG2 Reserves are available to allow for mining to continue until the year 2046. As part of the Merensky expansion, a new 200ktpm plant for the processing of the Merensky ore will be constructed. TRP is also planning to construct a new Tailings Storage Facility (TSF) as well as two new Return Water Dams. The current TSF will be utilised until December 2021 after which the new TSF will be utilised.

TRP has requested that Golder Associates Africa (Pty) Ltd. (Golder) assists with the water balance update of the TRP operation with the specific aim of determining the additional water volumes required for the Merensky mining and processing operation. One of the key project objectives is to conduct a water availability assessment study to determine the updated water supply potential from the Dwars River catchment. This memorandum summarises the results of the yield assessment conducted.

## 2.0 CURRENT WATER BALANCE

The water balance for the current mining operation was assessed for the period from September 2018 until August 2019. The reason for selecting this period is that this is the latest most representative mining operation period. Some operations were not fully operational during some of the Covid-19 lockdown period. The water balance is shown in Table 1. The tonnages, supply from river and borehole volumes are actual recorded numbers. The recorded return flows were not available and were simulated based on the mine operational rules. The plant water make is therefore calculated based on the total supply to the plant from the river, boreholes and return flows and represents both the plant water demand as well as the underground mining demand.

**Table 1 : Current water balance**

| | UG2 current average | UG2 current maximum |
|---|---|---|
| Tonnes mines [tonnes/mon] | 319 295 | 432 299 |
| Feed to Plant [tonnes/mon] | 282 641 | 302 236 |
| Plant and mine water make supplied [m$^3$/mon] | **215 525** | **367 994** |
| Return flows available [m$^3$/mon] | 74 018 | 150 837 |
| BH supply available [m$^3$/mon] | 2 239 | 3 204 |
| Supply from River [m$^3$/mon] | **139 268** | **213 953** |

The recorded flows of the supply received by TRP from the river over the years is shown in Figure 1 and the statistics of the metered volumes are listed in Table 2.

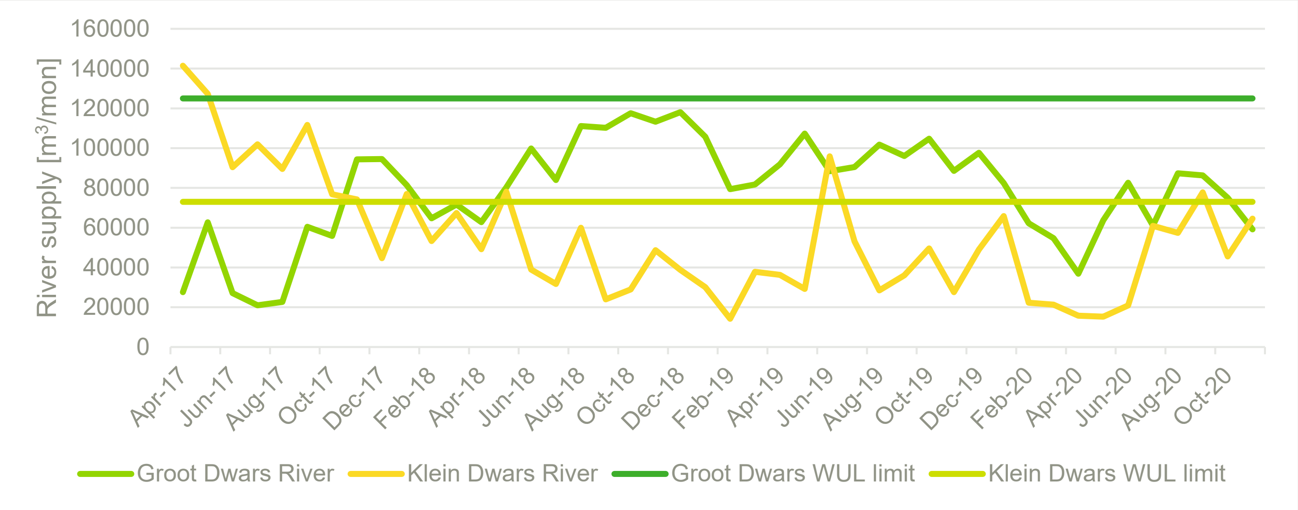


**Figure 1 : Historic recorded abstractions from the Dwars catchment**

**Table 2 : Statistics for the recorded supply of river water to TRP**

| | Klein Dwars [m$^3$/mon] | Groot Dwars [m$^3$/mon] | Total [m$^3$/mon] |
|---|---|---|---|
| **Min** | 502 | 1 278 | 4 217 |
| **Average** | 40 891 | 69 788 | 110 285 |
| **95$^{th}$ perc** | 90 928 | 110 316 | 171 202 |

| | Klein Dwars [m³/mon] | Groot Dwars [m³/mon] | Total [m³/mon] |
|---|---|---|---|
| **Max** | 141 444 | 125 022 | 230 521 |

# 3.0 FUTURE WATER BALANCE

## 3.1 Feed to plant tonnages

The tonnages as supplied by TRP to be processed at the UG2 and Merensky plants are plotted in Figure 2. The planned tonnage profile shows the ramp up at the Merensky plant starting in July 2023 and levelling off in 2026 at about 210 000 tonne/month. The tonnes processed at UG2 remains at about 305 000 tonne/month until 2034 when the tonnage start to drop. The maximum tonnes processed are over the period 2026 to 2034 at about 530 000 tonne/month.

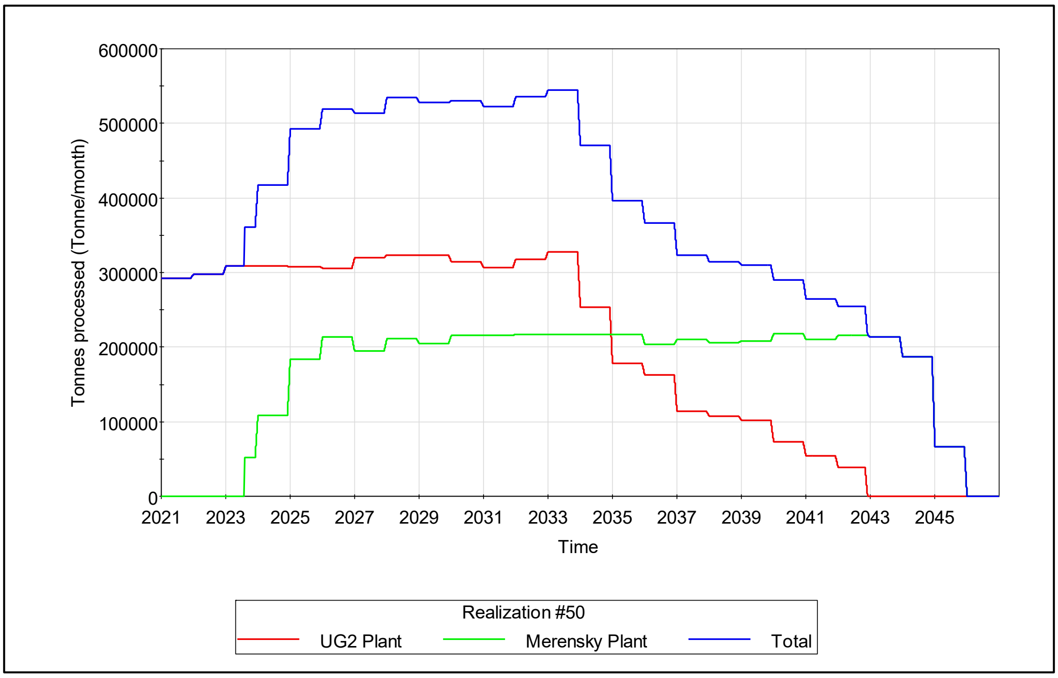


**Figure 2 : Plot of planned tonnages to be processed at UG2 and Merensky Plants**

## 3.2 Water Requirements

The main water requirements on site are the plant water make up requirements and the make-up water required for mining at the mine shafts. The plant water requirements were calculated using the tonnes and moisture contents of the stream entering and leaving the plants. The inputs to the plant are the water in the plant feed ore and the outputs are the moisture in the concentrate and chromite and the water volume in the tailings slurry pumped to the TSF. The difference of the input and output water volumes gives an indication of the make-up water volume required at the plants. The water in the tailings slurry is by far the largest output from the plants. The dry tailings tonnes and the percentage solids in the tailings slurry of 53% was used to estimate the water volume in the slurry pumped to the TSF.

The plant water make up calculated for the two plants and the total plant water requirements over time are shown in Figure 3. The total plant water requirements increase from the current 250 000 m$^3$/month to about 450 000 m$^3$/month during the peak processing period.

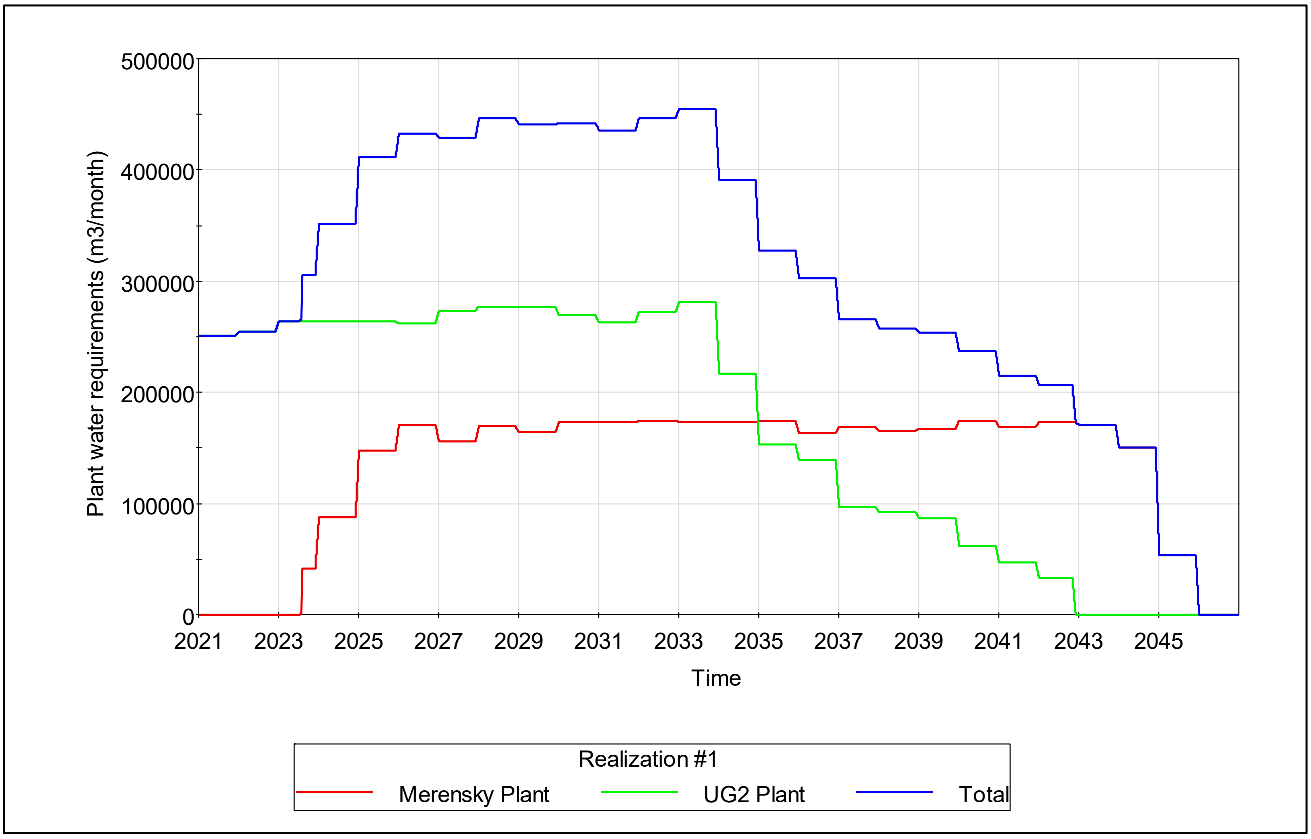


**Figure 3 : Calculated Plant Water Requirements**

The water used for mining at the shafts is largely recirculated with a portion of the water sent underground for mining recovered and brought to surface for re-use. TRP provided a typical mining water requirement unit use of 0.36 $m^3$/tonne mined that is required to be sent underground for mining. The available flow meter data at the shafts did not allow an assessment to be made of the mine make up water requirements at the shafts. Currently make up water is sourced from the storm water and treated sewage effluent stored in the pollution control dams at the shafts as well as water sent from the UG2 plant to the shafts when there are shortfalls. After discussions with TRP, it was decided not to use the model to estimate the make-up requirements due to the numerous assumptions that have to be made in developing the shaft water balances. The approach agreed was to assume the fraction of the water sent underground that is recovered and use the conservative assumption that the make-up water required is sent from the UG2 Plant. A 50% recovery of the water sent underground was assumed. The make-up water requirement was calculated based on the mining tonnes and a 0.18 $m^3$/tonne (50% of 0.36 $m^3$/tonne) make up water requirement. The calculated mining water requirement is plotted in Figure 4.

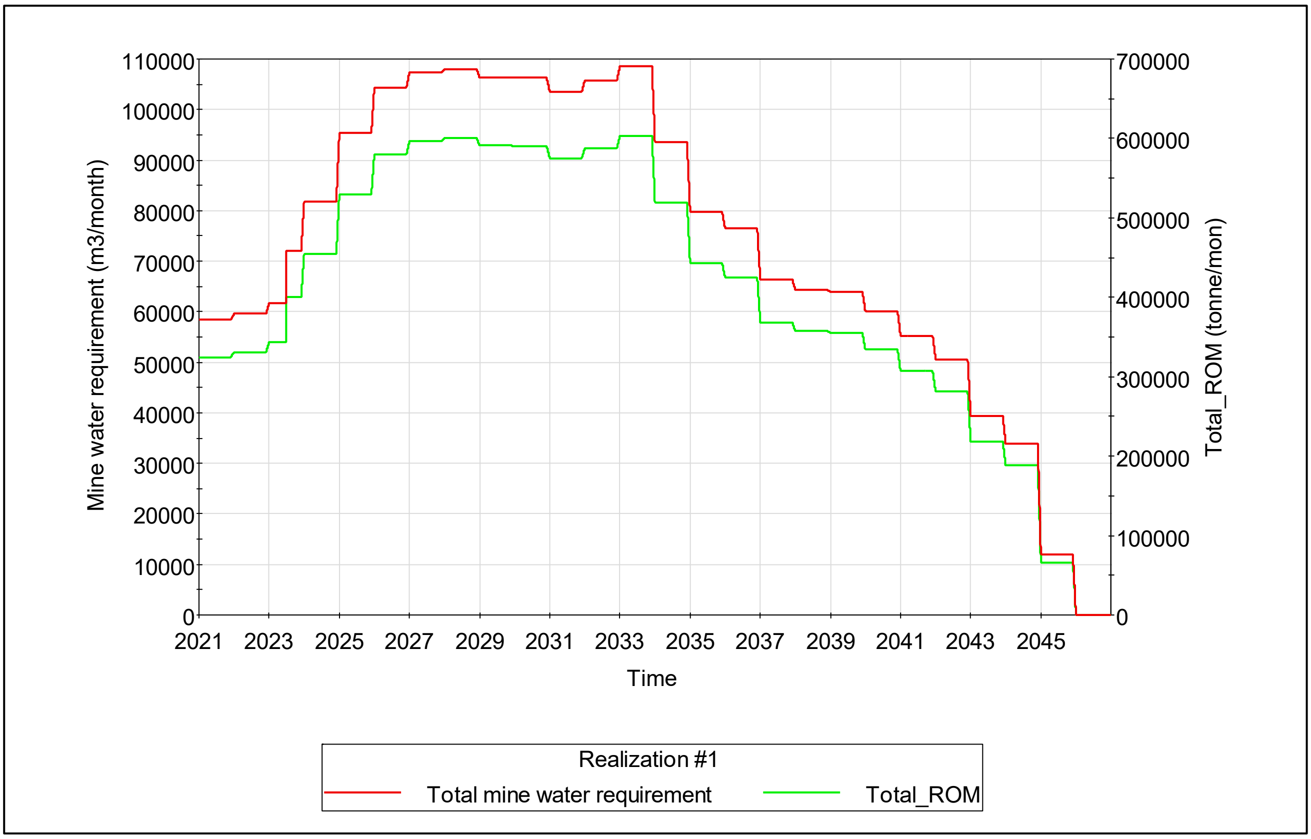


**Figure 4 : Plot of total Run of Mine (ROM) and mining water requirement based on 0.18 m$^3$/tonne make up requirement.**

Borehole water supply was not considered to be a reliable supply and was removed from the future Merensky water supply. Water supply to underground workings was determined from the simulation by applying operating rules to the dams in the model.

## 3.3 Potable Water Requirements

The potable water requirements on site are met from boreholes located at the shafts and at the plant. The yield of the boreholes is considered sufficient to meet the potable water requirements on site going forward and were not considered further in the water balance assessment.

# 4.0 WATER AVAILABILITY

The main sources of water on site are:

- Return flows from the TSF. A water balance model was built for the Old and New TSFs. The average return volume from the TSF was simulated to be an average of 56% of the slurry water sent to the TSFs. The 56% average return compares well with the return percentage of 54% reported in the TSF design report.

- Abstractions from the Klein and Groot Dwars River. TRP are licenced to abstract 73 000 m$^3$/month from the Klein Dwars and 125 000 m$^3$/month from the Groot Dwars. The abstractions from the Klein and Groot Dwars are supported by releases from the Inyoni and Der Brochen Dams respectively. The 1 in 100-year yield of the two dams was estimated using the DWS Water Resource Yield Model.

- The plant borehole which is used to meet the plant water requirements. The volume that can be supplied from the borehole on average is 2900 $m^3$/month. This is a small volume compared to the plant and mine water requirements. The borehole volume is not considered in the reconciliation of the water requirements and water availability.
- Storm water collected on site in the PCDs. These volumes are seasonal and small in relation to the mine water requirements. The volumes were ignored in the water supply assessment.
- Lebalelo water supply scheme.

The volumes from each of the sources of water were calculated and compared to the total mine water requirements. Any shortfalls after using the return flows and the current licenced Dwars River abstractions were assumed to be supplied from the Lebalelo Scheme.

## 4.1 Yield Assessment of De Brochen and Inyoni Dams

The yield of the Inyoni and Der Brochen Dams was evaluated using the Water Resource Yield Model (WRYM). All system data was based on the Olifants Water Management Area planning model. The following should be noted:

Inyoni Dam catchment area - Klein Dwars – 80 $km^2$

De Brochen Dam catchment area – Groot Dwars – 150 $km^2$

Inyoni Dam capacity – 0.5 $Mm^3$

De Brochen Dam capacity – 9.02 $Mm^3$

Inyoni Dam footprint – 0.1 $km^2$

De Brochen Dam footprint – 1.35 $km^2$

Refer to Figure 5 for the Groot and Klein Dwars River catchments at the De Brochen and Inyoni Dams respectively.

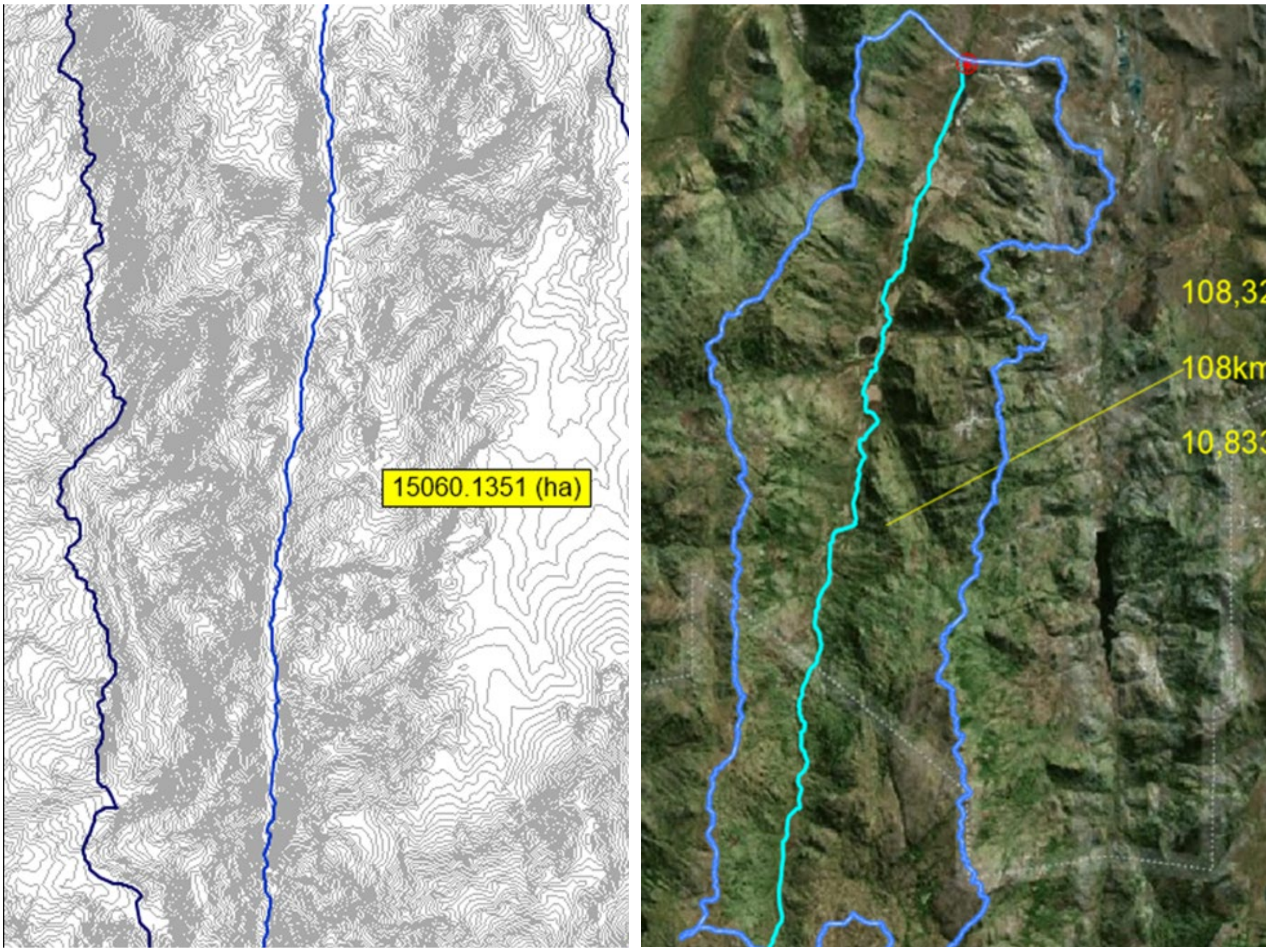


**Figure 5 : Groot and Klein River catchments**

### 4.1.1 Klein Dwars sub-catchment

The runoff from the Klein Dwars sub-catchment reports to the Inyoni Dam. The Water Resource Yield Model (WRYM) was applied to calculate the historic firm yield using the historic flow record and the stochastically generated flow sequences were used to calculate the 100-year yield from the Inyoni Dam. The historic firm yield was calculated to be 1.07 $Mm^3/a$ (89 167 $m^3$/month) and the 1:100-year yield is 0.964 $Mm^3/a$ (80 333 $m^3$/month). Refer to Figure 6 for the simulated Inyoni Dam volume and Figure 7 for the catchment runoff into Inyoni Dam. The 100-year yield is similar to the licenced abstraction from the Klein Dwars of 73 000 $m^3$/month.

### 4.1.2 Groot Dwars sub-catchment

The runoff from the Groot Dwars sub-catchment reports to the De Brochen Dam. The historic firm yield was calculated to be 6.6 $Mm^3/a$ (550 000 $m^3$/month). The 1:100-year yield was calculated to be 6.466 $Mm^3/a$ (538 833 $m^3$/month). Refer to Figure 8 for the simulated De Brochen Dam volume and Figure 9 for the catchment runoff into the De Brochen Dam. Discussions with DWS and data from the WARMS database shows that the current allocations made from the dam total 6.9 million $m^3/a$ of which TRP has an allocation of 1.5 million $m^3/a$ (125 000 $m^3$/month). The total allocated volumes are similar to the 100-year yield of the dam.

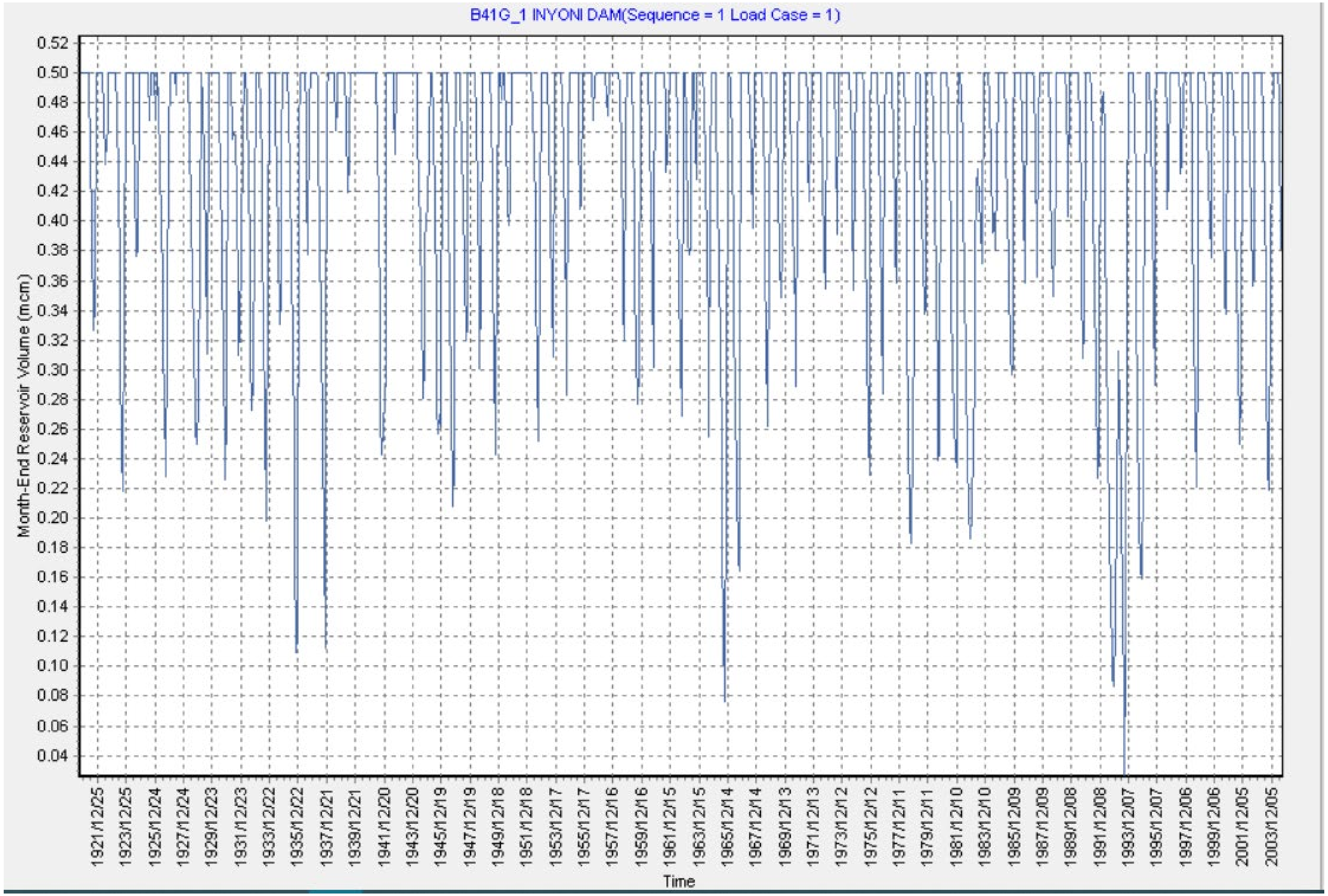


**Figure 6 : Inyoni Dam Volume**

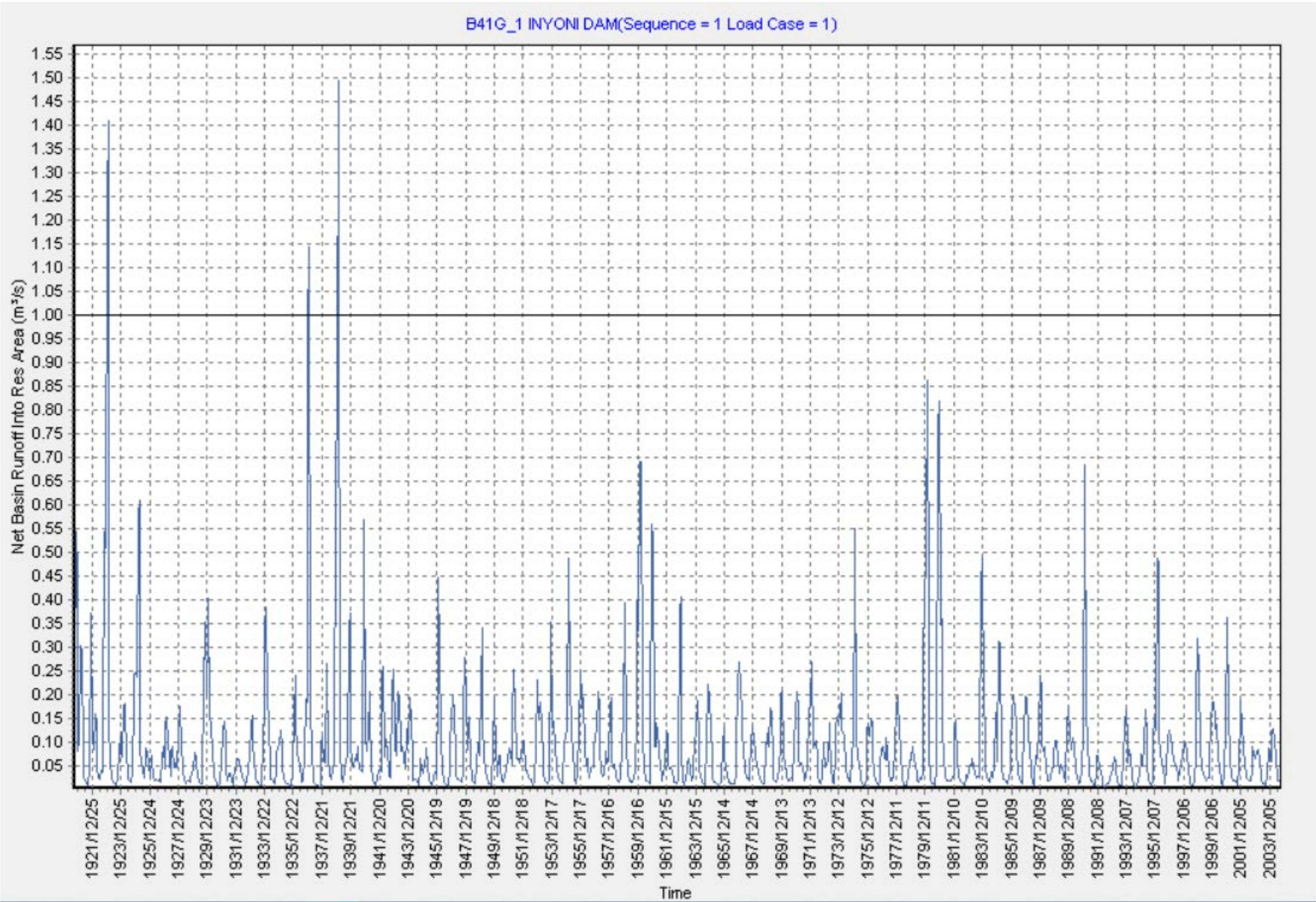


**Figure 7 : Runoff into Inyoni Dam**

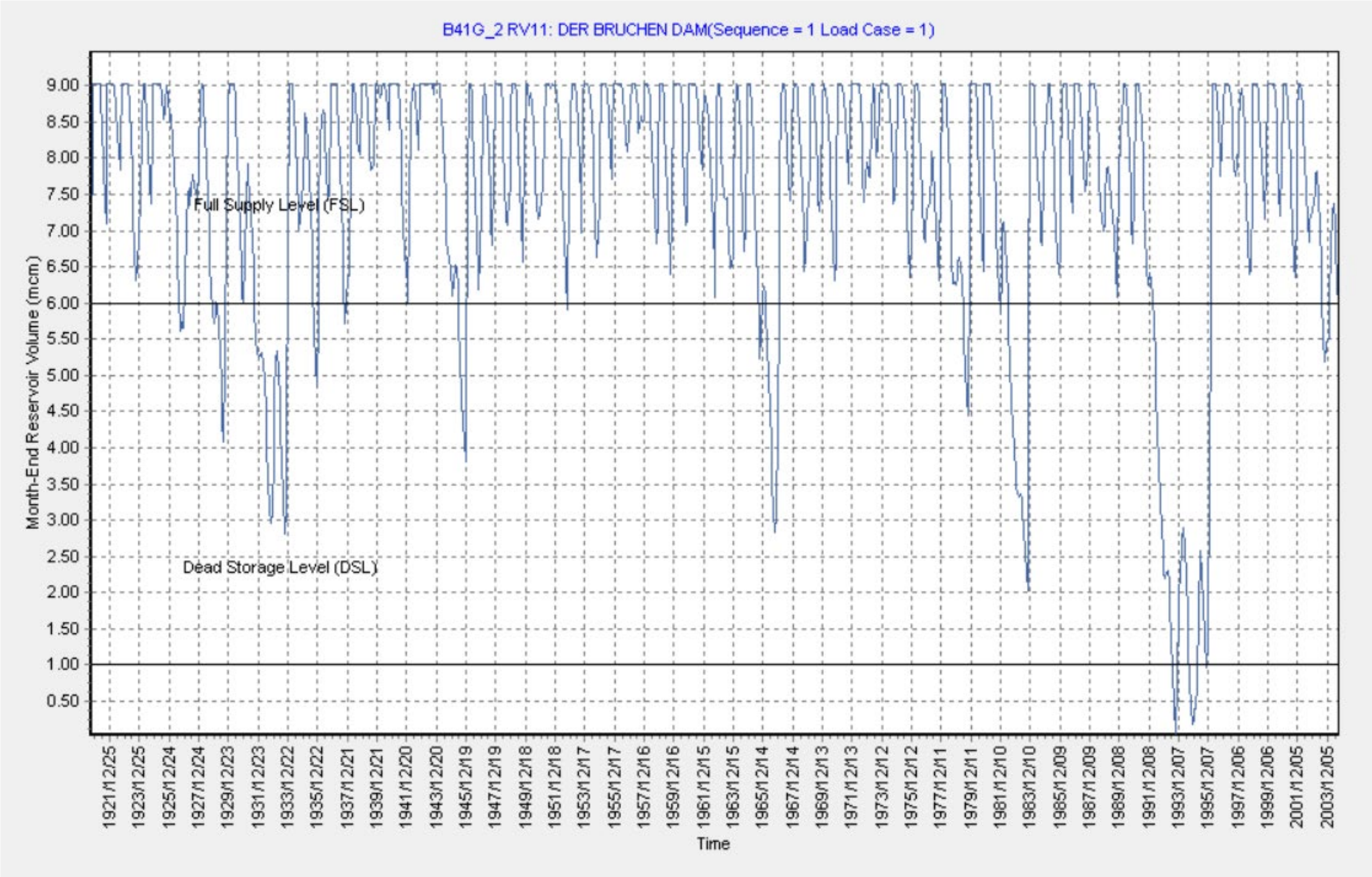


**Figure 8 : De Brochen Dam Volume**

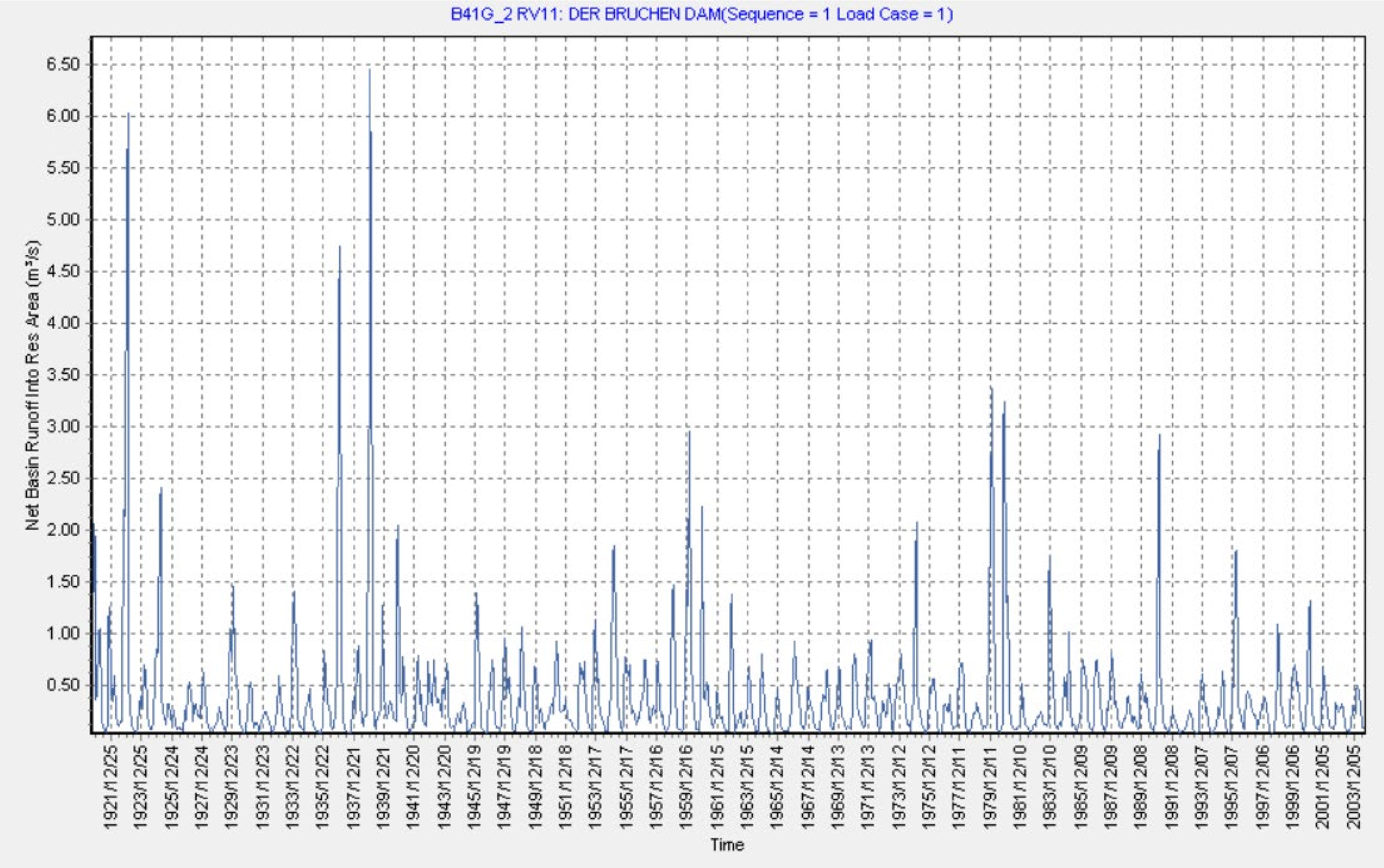


Figure 9 : Runoff into De Brochen Dam

## 4.2 TSF Return flows

The return flows from the TSFs were simulated over the period 1 Jan 2021 to 31 December 2046. The model was run for 50 realisations and the probability distribution of the return flows over the life of mine was calculated. The plot of the Figure 10. The plot highlights the following:

- The seasonality of the return flows.
- The storm water volumes harvested at the TSF are small because the slurry volumes are significantly larger than the stormwater runoff volumes.

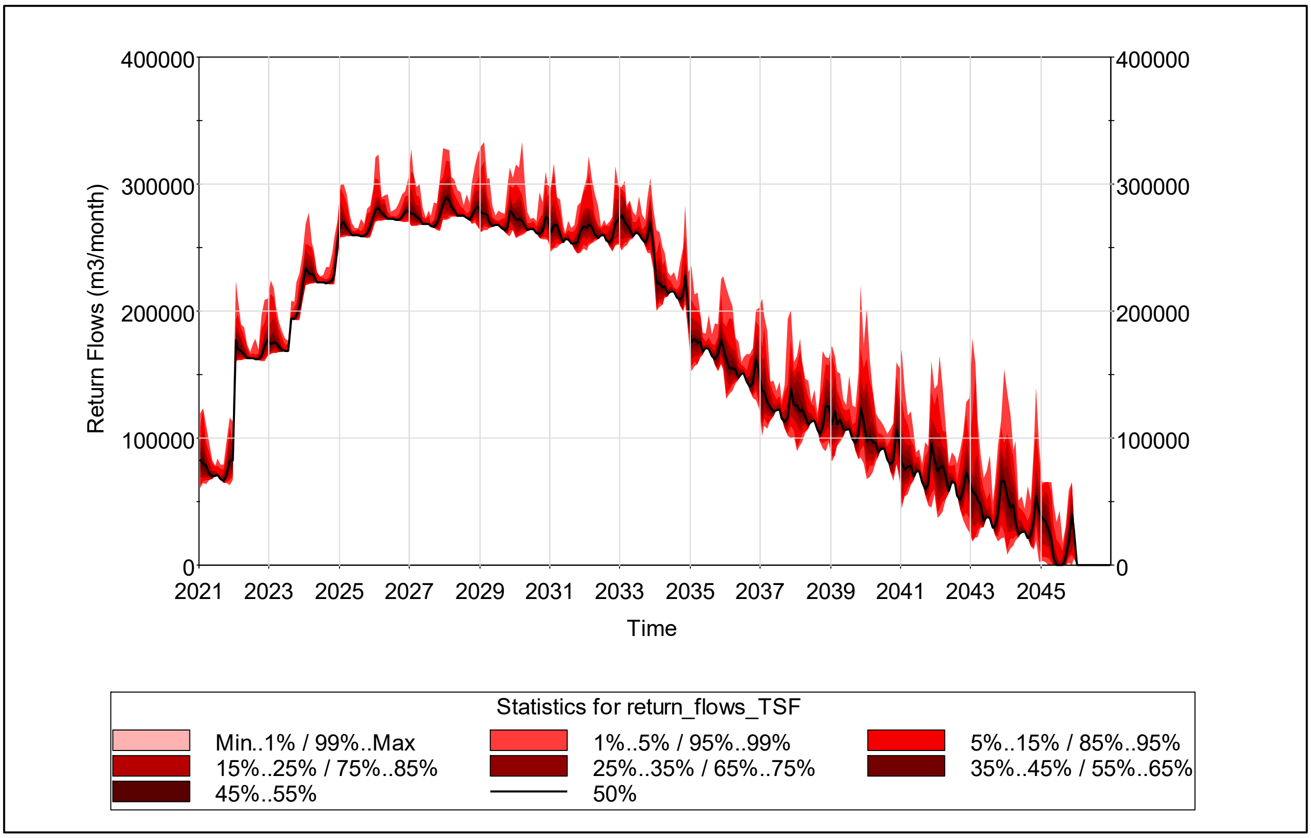


**Figure 10 : Simulated return flow volumes from TSFs**

# 5.0 RECONCILIATION OF REQUIREMENTS AND AVAILABILITY

TRP reported that losses between the volumes released from the dams and the abstraction points on the Groot and Klein Dwars rivers has been observed due to the growth of extensive reed beds in the rivers. Two scenarios were therefore run using the model. The first was assuming no river losses and the second a 25% loss in the water released from the dams i.e. a 25% reduction in yield.

The total mine water requirement (plants and mining at shafts) is compared to the available water in **Figure 11** for Scenario 1. The available water is the total of the licenced volume from De Brochen and the Inyoni Dams as well as the return flow volumes from the TSF. The return flow volumes are the median of the 50 realisations over the life of the mine.

The plot highlights the following:

- During the ramp up period from 2022 until 2027 and during the ramp down from 2039, there is sufficient water available to meet the requirements. The system is more or less in balance.
- During the period from 2027 to 2035, there is a shortfall in supply that will have to be made up from Lebalelo water supply system. The probability distribution of the makeup water required from Lebalelo is shown plotted in Figure 12. The makeup water required peaks in 2035 at 3 500 $m^3$/d.

The daily Lebalelo demand volumes per year is shown in Table 3 for scenario 1.

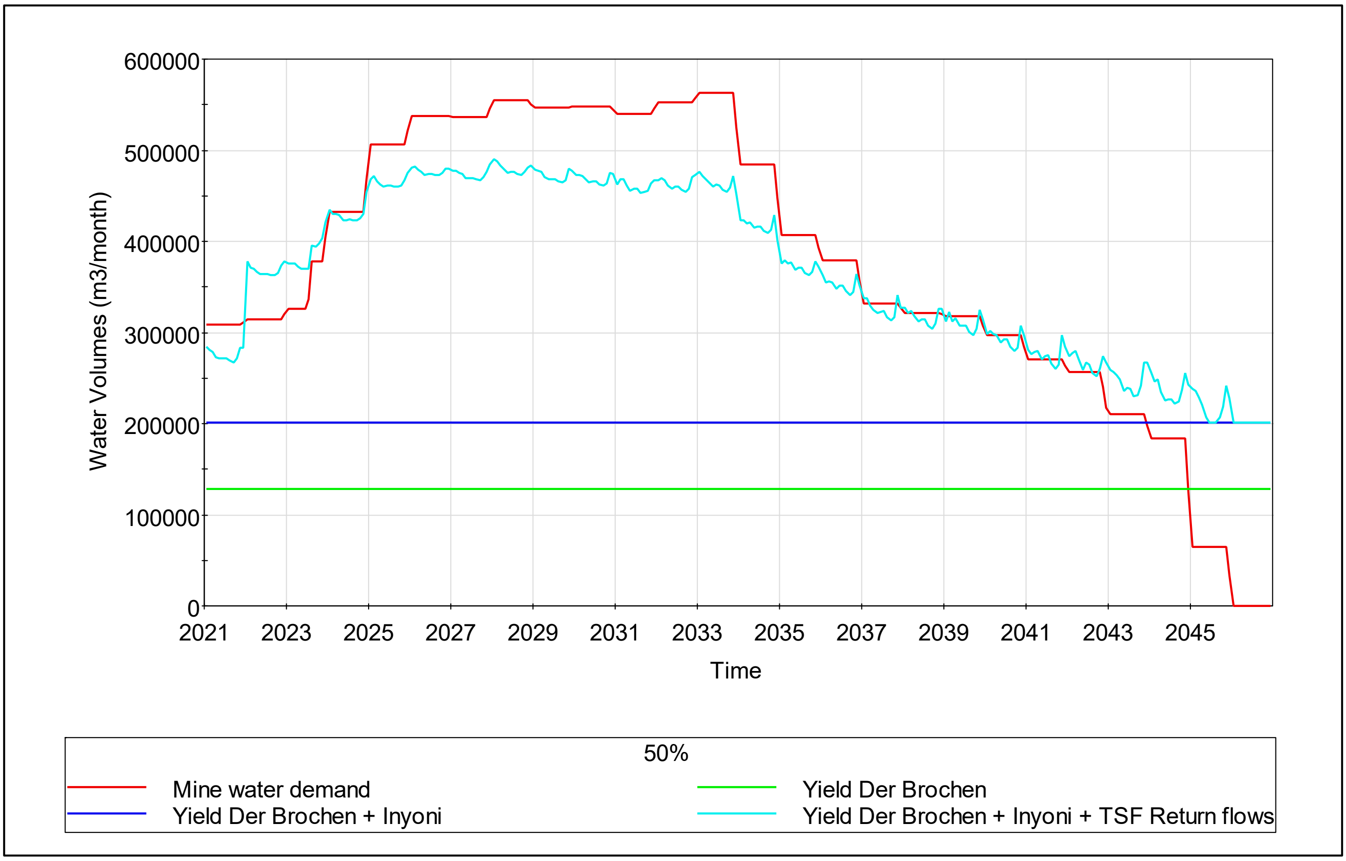


**Figure 11 : Total mine water requirements compared to available water – scenario 1 no river losses**

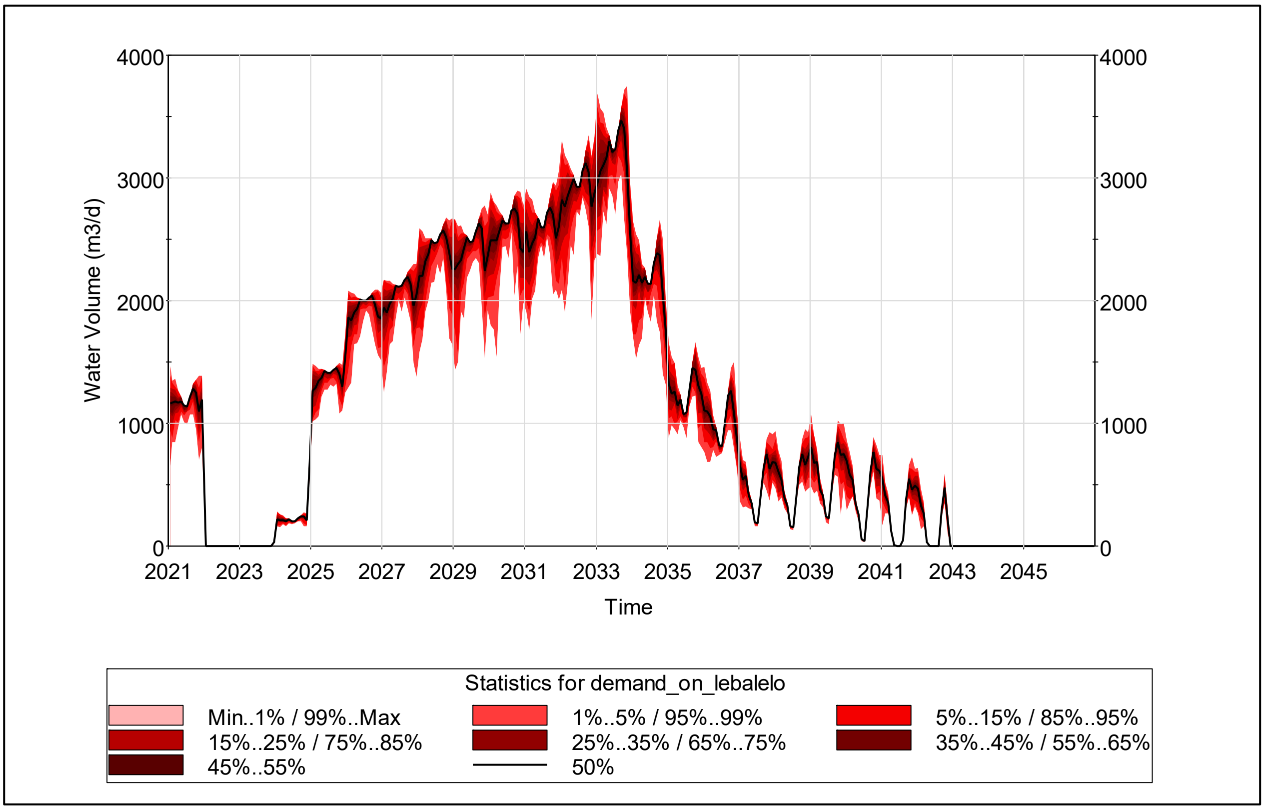


**Figure 12 : Plot of simulated water make up volumes required from Lebalelo - Scenario 1 no river losses)**

**Table 3: Annual daily average of additional water required to be sourced from Lebalelo for the no-loss case**

| Years | Min daily [m3/d] | 5th percentile daily [m3/d] | Average daily [m3/d] | 95th percentile daily [m3/d] | Max daily [m3/d] |
|---|---|---|---|---|---|
| **2021** | 915 | 1021 | 1182 | 1279 | 1301 |
| **2022** | 0 | 0 | 0 | 0 | 0 |
| **2023** | 1 | 2 | 2 | 3 | 3 |
| **2024** | 207 | 220 | 256 | 286 | 288 |
| **2025** | 1185 | 1240 | 1389 | 1464 | 1475 |
| **2026** | 1646 | 1771 | 1942 | 2035 | 2047 |
| **2027** | 1700 | 1834 | 2058 | 2177 | 2188 |
| **2028** | 1981 | 2127 | 2403 | 2545 | 2567 |
| **2029** | 1957 | 2132 | 2431 | 2580 | 2616 |
| **2030** | 2085 | 2309 | 2583 | 2752 | 2773 |
| **2031** | 2163 | 2272 | 2592 | 2774 | 2807 |
| **2032** | 2394 | 2549 | 2924 | 3118 | 3144 |
| **2033** | 2625 | 2810 | 3158 | 3405 | 3451 |

| Years | Min daily [m3/d] | 5th percentile daily [m3/d] | Average daily [m3/d] | 95th percentile daily [m3/d] | Max daily [m3/d] |
|---|---|---|---|---|---|
| **2034** | 1718 | 1885 | 2167 | 2346 | 2376 |
| **2035** | 986 | 1068 | 1252 | 1378 | 1403 |
| **2036** | 774 | 848 | 1021 | 1136 | 1172 |
| **2037** | 346 | 394 | 503 | 575 | 607 |
| **2038** | 363 | 396 | 504 | 586 | 612 |
| **2039** | 391 | 460 | 590 | 681 | 710 |
| **2040** | 310 | 342 | 454 | 520 | 538 |
| **2041** | 176 | 202 | 279 | 336 | 358 |
| **2042** | 106 | 122 | 174 | 216 | 228 |
| **2043** | 0 | 0 | 0 | 0 | 0 |
| **2044** | 0 | 0 | 0 | 0 | 0 |
| **2045** | 0 | 0 | 0 | 0 | 0 |
| **2046** | 0 | 0 | 0 | 0 | 0 |

The plot of the available water and the total mine requirement for Scenario 2 is shown in **Figure 13**. The plot highlights the same points as for Scenario 1 but more make up water will be required from Lebalelo during the 2027 to 2039 period. The simulated maximum make-up water requirement is 5 000 m$^3$/d which will have to be supplied from Lebalelo. The daily Lebalelo demand volumes per year is shown in Table 4 for scenario 1.

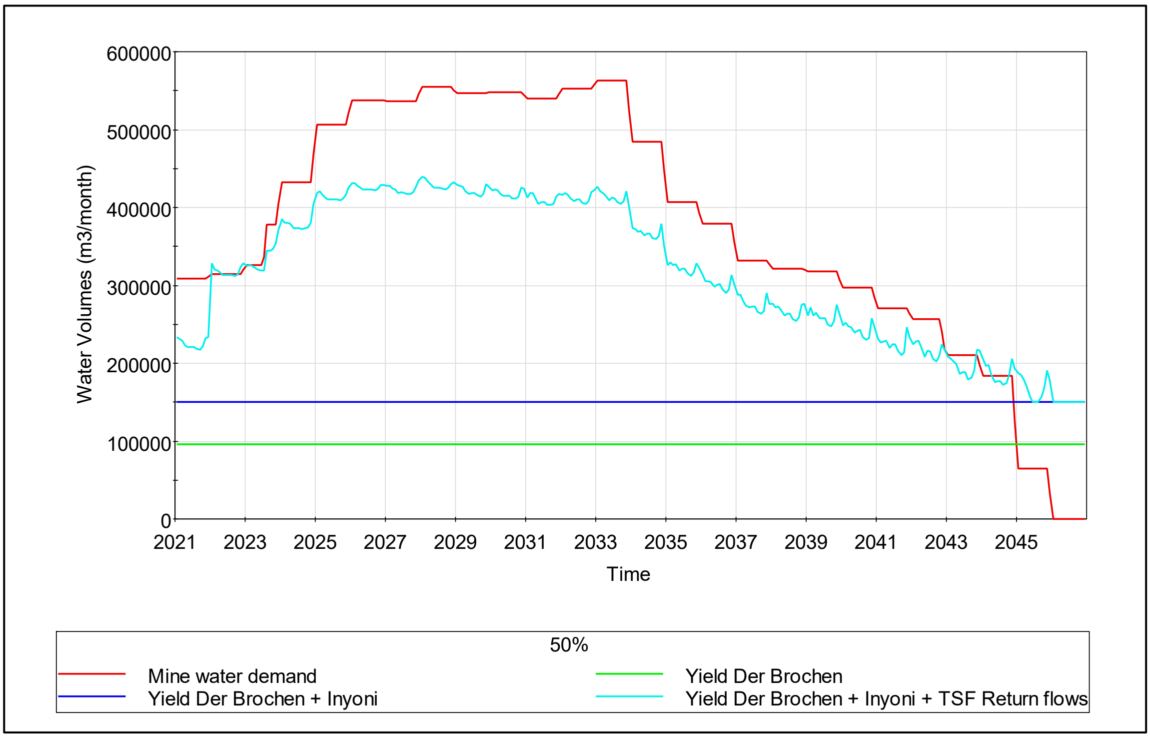


**Figure 13 : Total mine water requirements compared to available water – Scenario 2 - 25% river losses**

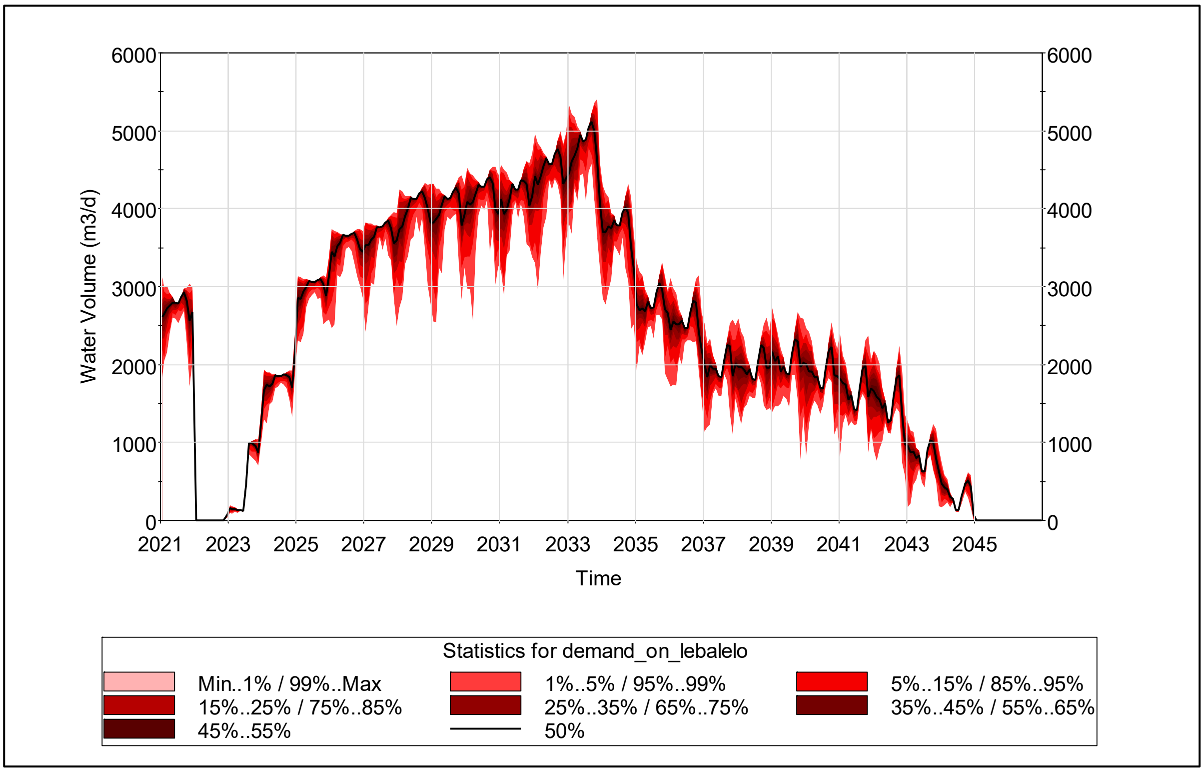


**Figure 14 : Plot of simulated water make up volumes required from Lebalelo - Scenario 2 - 25% river losses)**

**Table 4: Annual daily average of additional water required to be sourced from Lebalelo for the 25%-loss case**

| Years | Min daily [m3/d] | 5th percentile daily [m3/d] | Average daily [m3/d] | 95th percentile daily [m3/d] | Max daily [m3/d] |
|---|---|---|---|---|---|
| **2021** | 2290 | 2435 | 2745 | 2910 | 2945 |
| **2022** | 3 | 4 | 6 | 8 | 8 |
| **2023** | 426 | 465 | 529 | 570 | 576 |
| **2024** | 1575 | 1665 | 1827 | 1925 | 1935 |
| **2025** | 2645 | 2747 | 3006 | 3114 | 3124 |
| **2026** | 3099 | 3313 | 3566 | 3684 | 3697 |
| **2027** | 3119 | 3306 | 3681 | 3823 | 3837 |
| **2028** | 3355 | 3619 | 4017 | 4195 | 4217 |
| **2029** | 3349 | 3603 | 4041 | 4228 | 4261 |
| **2030** | 3457 | 3799 | 4195 | 4399 | 4423 |
| **2031** | 3600 | 3742 | 4186 | 4424 | 4457 |
| **2032** | 3788 | 4003 | 4527 | 4765 | 4793 |

| Years | Min daily [m3/d] | 5th percentile daily [m3/d] | Average daily [m3/d] | 95th percentile daily [m3/d] | Max daily [m3/d] |
|---|---|---|---|---|---|
| **2033** | 4066 | 4312 | 4755 | 5049 | 5098 |
| **2034** | 3081 | 3327 | 3748 | 3984 | 4025 |
| **2035** | 2286 | 2448 | 2785 | 3004 | 3034 |
| **2036** | 2018 | 2178 | 2535 | 2759 | 2815 |
| **2037** | 1482 | 1653 | 1986 | 2178 | 2245 |
| **2038** | 1520 | 1626 | 1978 | 2191 | 2250 |
| **2039** | 1484 | 1688 | 2060 | 2286 | 2348 |
| **2040** | 1418 | 1554 | 1915 | 2107 | 2157 |
| **2041** | 1256 | 1367 | 1685 | 1887 | 1942 |
| **2042** | 1046 | 1180 | 1491 | 1710 | 1767 |
| **2043** | 490 | 608 | 831 | 974 | 1000 |
| **2044** | 184 | 227 | 327 | 389 | 406 |
| **2045** | 0 | 0 | 0 | 0 | 0 |
| **2046** | 0 | 0 | 0 | 0 | 0 |

## 6.0 RISKS, ASSUMPTIONS AND CONCERNS

The water balance and catchment yield evaluation were conducted based on the following key assumptions:

- The allocations from the Groot Dwars system total 6 942 300 $m^3$/a (19 020 $m^3$/d) which exceeds the 100-year yield of De Brochen Dam by 7%. TRPs allocation from the Groot Dwars system is 1.5 million $m^3$/a (4 200 $m^3$/d) which is 22% of the allocation.
- Assumptions of a 25% river loss was assumed for Scenario 2. This could be confirmed by measuring the discharge volume from the dam and the flow at the abstraction point.
- The yield assessment assumed direct abstraction from the Dams.
- The mining water requirement is based on a 50% recovery of mine water from the underground workings. TRP is installing meters and the shaft make up requirements should be re-evaluated when metered flow information becomes available. The 50% recovery is a considered to be a conservative assumption.

**Golder Associates Africa (Pty) Ltd.**

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Trevor Coleman
*Principal*

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https://golderassociates.sharepoint.com/sites/132262/project files/7 correspondence/memo/20350974_tm002_waterbalanceresults_final_05-02-2021.docx