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The uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water

WATER RESOURCES YIELD ASSESSMENT REPORT

FINAL

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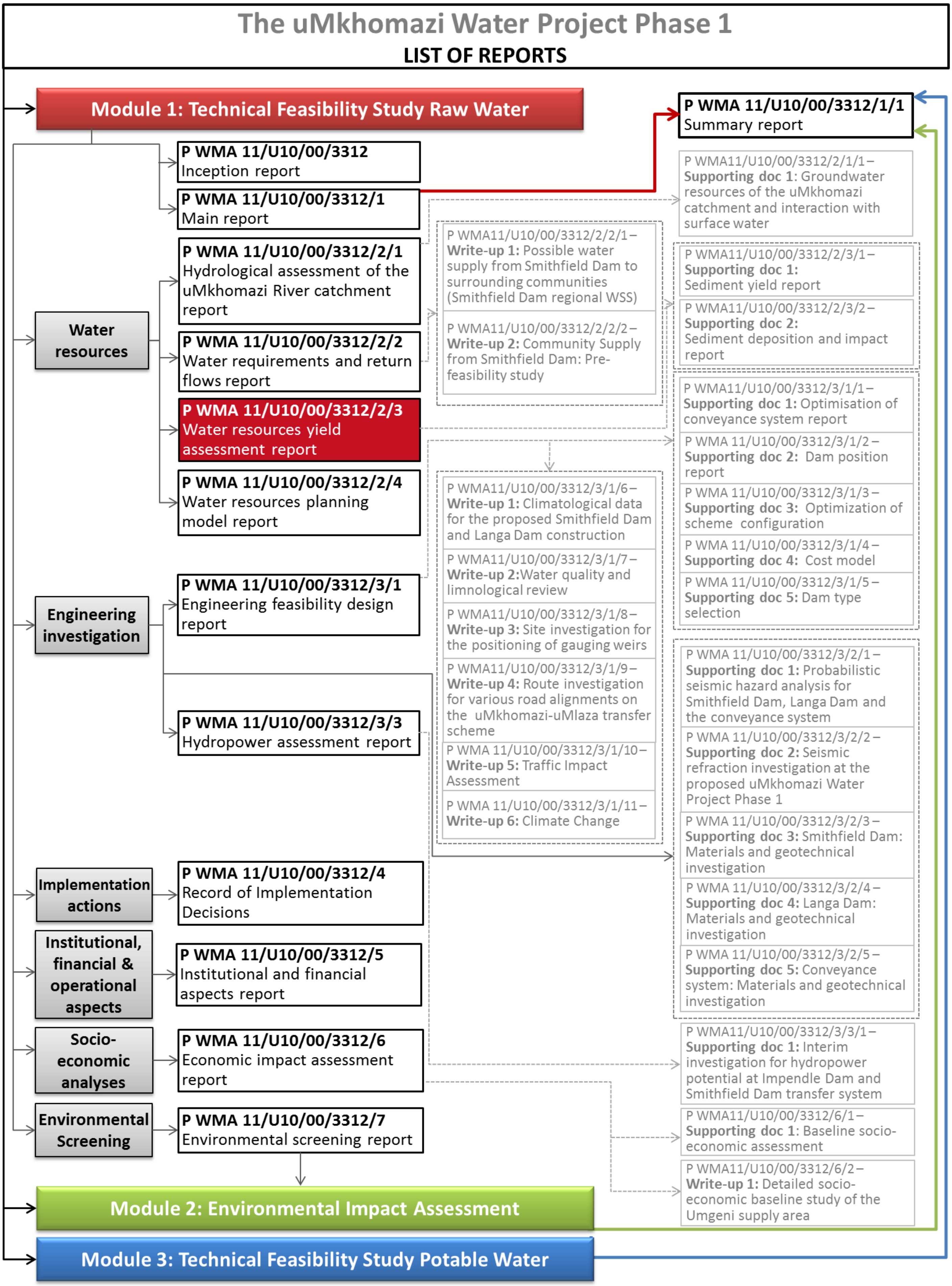
PREAMBLE

In June 2014, two years after the commencement of the uMkhomazi Water Project Phase 1 Feasibility Study, a new Department of Water and Sanitation was formed by Cabinet, including the formerly known Department of Water Affairs.

In order to maintain consistent reporting, all reports emanating from Module 1 of the study will be published under the Department of Water Affairs name.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Executive summary

The purpose of this report is to provide a detailed description of the water resource yield assessment undertaken for both phases of the uMkhomazi Water Project (uMWP), as well as for proposed developments in the lower uMkhomazi and upper uMlaza river catchments. The primary objectives of the assessment can be summarised as follows:

- *Determine the water supply potential ("yield") of the proposed uMWP-1 (Smithfield Dam) and uMWP-2 (Smithfield Dam in combination with Impendle Dam).*
- *Provide a preliminary estimate of the implementation date of Impendle Dam.*
- *Quantify the available resources in the lower uMkhomazi River catchment, particularly the development of either the proposed Ngwadini Dam, or the Lower uMkhomazi Abstraction Weir (which will be operated with support from Smithfield Dam).*
- *Assess the filling time of the proposed Langa balancing dam in the upper uMlaza River catchment and, based on the results, make recommendations on the need to fill and support the balancing dam from Smithfield Dam.*

Based on the results of the yield assessment, the main ***conclusions*** *were as follows:*

- *For the proposed Smithfield Dam (uMWP-1), storage sizes above 50% of the natural mean annual runoff (MAR) are fairly inefficient from a yield perspective, with the most favourable range being in the region of 30% to 40% of the MAR.*
- *As part of the Optimization of Scheme Configuration task undertaken in this study, a full supply level (FSL) of 930 metres above sea level was selected for the feasibility design of Smithfield Dam. This dam size corresponds to a live storage capacity of 226 million m^3 (a 31% MAR dam) and provides a 1:100-year yield of 220 million m^3/a (at the 2050-development level).*
- *Based on the selected 930 m FSL Smithfield Dam and updated water requirement projections for the proposed uMWP area of supply (developed in the parallel study uMWP-1: Module 3: Technical Feasibility Study: Potable Water) an annual projected water balance was developed for the integrated Mgeni Water Supply System. This resulted in a preliminary estimate for the implementation date of Impendle Dam of 2046.*
- *When combined with the selected 930 m FSL Smithfield Dam, the implementation of Impendle Dam (uMWP-2) will increase the total yield of the system from 220 million m^3/a to between 303 million m^3/a (for a 50% MAR Impendle Dam) and 375 million m^3/a (for a 150% MAR Impendle Dam).*

- *The selected operating rule for uMWP-2 (i.e. the conditions under which support is provided from Impendle Dam to Smithfield Dam) was found to have a negligible impact on the total system yield.*
- *If SAPPI-SAICCOR develops the proposed off-channel Ngwadini Dam the scheme will provide a 1:100-year yield of 54 million m^3/a. This volume is in line with their licensed water use of 53 million m^3/a. However, the dam will significantly increase SAPPI-SAICCOR's annual assurance of supply to 99%, compared to the current situation where they experience supply failures almost every second year.*
- *If Umgeni Water develops Ngwadini Dam the scheme would provide a 1:100-year yield of 34 million m^3/a (93 Mℓ/d). After Smithfield Dam is commissioned, the yield of Ngwadini can be maintained at that level, with support from Smithfield Dam. However, the result will be a decrease in the yield of Smithfield Dam, from 220 to 214 million m^3/a.*
- *Developing the Lower uMkhomazi Abstraction Weir in combination with the uMWP-1 will increase the total yield of the system. However, this will result in the remaining yield available from Smithfield Dam to decrease significantly. For example, a yield of 34 million m^3/a (95 Mℓ/d) can be achieved at the weir but with a corresponding decrease in the yield of Smithfield Dam from 220 to 202 million m^3/a.*
- *If the proposed Langa balancing dam is not provided with support from Smithfield Dam it will take 50 years to fill from local inflows. If the balancing dam is both filled and supported from Smithfield Dam, projected water volumes can be maintained above 15.0 million m^3 (or 96% of the gross dam storage volume), at a probability of 99%.*

*Based on the above conclusions and other considerations, the following **recommendations** can be made:*

- *It was found that storage sizes for Smithfield Dam (uMWP-1) ranging from 30% to 40% MAR are most favourable from a yield perspective and this provides further motivation for the FSL of 930 m (31% MAR dam) selected for the feasibility design of the dam.*
- *The projected water balance developed for the Mgeni Water Supply System resulted in an estimated implementation date for Impendle Dam (uMWP-2) of 2046. However, this date should be treated as preliminary and will be refined in the later Water Resources Planning Analysis task of the study.*

- *For the development of available resources in the lower uMkhomazi River catchment, Ngwadini Dam should be considered in favour of the Lower uMkhomazi Abstraction Weir. The Ngwadini Dam-option requires less (or no) support from Smithfield Dam, resulting in more yield being available at Smithfield Dam for transfer into the Mgeni WSS. The added advantage of Ngwadini Dam is that, unlike the Lower uMkhomazi Abstraction Weir, it does not require support from Smithfield Dam and can therefore be developed prior to the uMWP.*
- *Since local inflows are insufficient to fill and maintain the proposed Langa balancing dam at acceptable storage volumes, it is recommended that the dam is both filled and supported from Smithfield Dam. However, this operating rule was not optimised as part of this study and further investigations in this regard are therefore required.*
- *Results from the recently commissioned RDM Reserve Study were not available in time for consideration in this yield assessment. It is therefore recommended that, when the RDM study is completed, the impact of the Reserve on the uMWP and proposed developments in the lower uMkhomazi and upper uMlaza river catchments are re-evaluated.*

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LIST OF ABBREVIATIONS

ARC	Agricultural Research Council
ARMA	Autoregressive Moving Average
BWSS	Bulk Water Supply Scheme
CD: NGI	Chief Directorate: National Geo-spatial Information
D: HS	Directorate: Hydrological Services
DM	District Municipality
D: NWRP	Directorate: National Water Resource Planning
DSL	Dead Storage Level
DWA	Department of Water Affairs
EKZNW	Ezemvelo KwaZulu-Natal Wildlife
ETM+	Multi-temporal Landsat 7 Enhanced Thematic Mapper
FSL	Full Supply Level
GG	Government Gazette
GWSWIM	Groundwater-Surface Water Interaction Model
IAP	Invasive Alien Plant
KZN	KwaZulu-Natal
LM	Local Municipality
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MAE	Mean Annual Evaporation
masl	Metres Above Sea Level
MMA	Mogoba Maphuthi and Associates

MMTS-1	Mooi-Mgeni Transfer Scheme Phase 1
MMTS-2	Mooi-Mgeni Transfer Scheme Phase 2
NLC2000	South African National Land Cover 2000
PMC	Project Management Committee
PSC	Project Steering Committee
Rain-IMS	Rainfall Data Information Management System
RI	Recurrence Interval
RSA	Republic of South Africa
SD	Standard Deviation
SFR	Stream Flow Reduction
S-pan	Symons-pan
uMWP	uMkhomazi Water Project
uMWP-1	uMkhomazi Water Project – Phase 1
uMWP-2	uMkhomazi Water Project – Phase 2
URV	Unit Reference Value
WAA	Water Availability Assessment
WRC	Water Research Committee
WRSM2000	Water Resources Simulation Model 2000
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WRYM-IMS	Water Resources Yield Model Information Management System
WSS	Water Supply System
YRC	Yield-Reliability Characteristics

LIST OF UNITS

km^2	square kilometre
m	metre
m^3	cubic metre
million m^3/a	million cubic metre per annum
Mℓ	mega litre

1 INTRODUCTION

The Department of Water Affairs (DWA) appointed **BKS (Pty) Ltd** in association with three sub-consultants **Africa Geo-Environmental Services, MM&A and Urban-Econ** with effect from 1 December 2011 to undertake the **uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study Raw Water** study.

On 1 November 2012, BKS (Pty) Ltd was acquired by **AECOM Technology Corporation**. The new entity is a fully-fledged going concern with the same company registration number as that for BKS. As a result of the change in name and ownership of the company during the study period, all the final study reports will be published under the AECOM name.

In 2010, the Department of Arts and Culture published a list of name changes in the Government Gazette (GG No 33584, 1 October 2010). In this list, the Mkomazi River's name was changed to the **uMkhomazi River***. The published spelling will thus be used throughout this technical feasibility study.*

1.1 BACKGROUND TO THE PROJECT

The current water resources of the integrated Mgeni Water Supply System (WSS) are insufficient to meet the long-term water requirements of the system. The Mgeni WSS is the main water source that supplies about five million people and industries in the eThekwini Municipality, uMgungundlovu District Municipality (DM) and Msunduzi Local Municipality (LM), all of which comprise the economic powerhouse of the KwaZulu-Natal Province.

The Mgeni WSS comprises the Midmar, Albert Falls, Nagle and Inanda dams in KwaZulu-Natal, a water transfer scheme from the Mooi River and the newly constructed Spring Grove Dam. The current system (Midmar, Albert Falls, Nagle and Inanda dams and the MMTS-1) has a yield of 334 million m^3/a (measured at Inanda Dam) at a recurrence interval (RI) of failure of 1:100 years (or an annual assurance of supply of 99%). The short-term augmentation measure, Phase 2 of the Mooi-Mgeni Transfer Scheme (MMTS-2), currently being implemented with the construction of Spring Grove Dam, will increase water supply from the Mgeni

WSS by 60 million m³/a. However, this will not be sufficient to meet the long-term requirements of the system.

Pre-feasibility investigations indicated that Phase 1 of the uMkhomazi Water Project (uMWP-1), which entails the transfer of water from the undeveloped uMkhomazi River to the existing Mgeni WSS, is the scheme most likely to fulfil this requirement. The uMkhomazi River is the third-largest river in KwaZulu-Natal in terms of mean annual runoff (MAR).

Eight alternative schemes were initially identified as possible alternatives, and the Impendle and Smithfield scheme configurations have emerged as suitable for further investigation. The pre-feasibility investigation, concluded in 1998, recommended that the Smithfield Scheme be taken to a detailed feasibility-level investigation as its transfer conveyances would be independent of the existing Mgeni WSS, thus reducing the risk of limited or non-supply to eThekwini and some areas of Pietermaritzburg, and providing a back-up to the Mgeni WSS.

The ***Mkomazi-Mgeni Transfer Pre-feasibility Study*** concluded that the first phase of the uMWP would comprise a new dam at Smithfield on the uMkhomazi River near Richmond, a multi-level intake tower and pump station, a water transfer pipeline/tunnel to a balancing dam at Baynesfield Dam or a similar in-stream dam, a water treatment works at Baynesfield in the uMlaza River valley and a gravity pipeline to Umgeni Water's bulk distribution reservoir system, below the reservoir at Umlaas Road. From here, water will be distributed under gravity to eThekwini and possibly low-lying areas of Pietermaritzburg. Phase two of the uMWP may be implemented when needed, and could comprise the construction of a large dam at Impendle further upstream on the uMkhomazi River to release water to the downstream Smithfield Dam. Together, these developments have been identified as having a 99% assured stochastic yield of about 388 million m³/a.

The DWA aims to have this scheme implemented by 2023.

1.2 OBJECTIVE OF THE STUDY

According to the Terms of Reference (November 2010), the objective of the study project is to undertake a feasibility study to finalise the planning of the proposed uMkhomazi Water Project (uMWP) at a very detailed level for the scheme to be accurately compared with other possible alternatives and be ready for implementation (detailed design and construction) on completion of the study.

The feasibility study has been divided into the following modules, which will run concurrently:

- Module 1: Technical Feasibility Raw Water (DWA) (*defined below*).
- Module 2: Environmental Impact Assessment (DWA).
- Module 3: Technical Feasibility Potable Water (Umgeni Water) (*ranging from the Water Treatment Plant to the tie-in point with the eThekwini distribution system*).

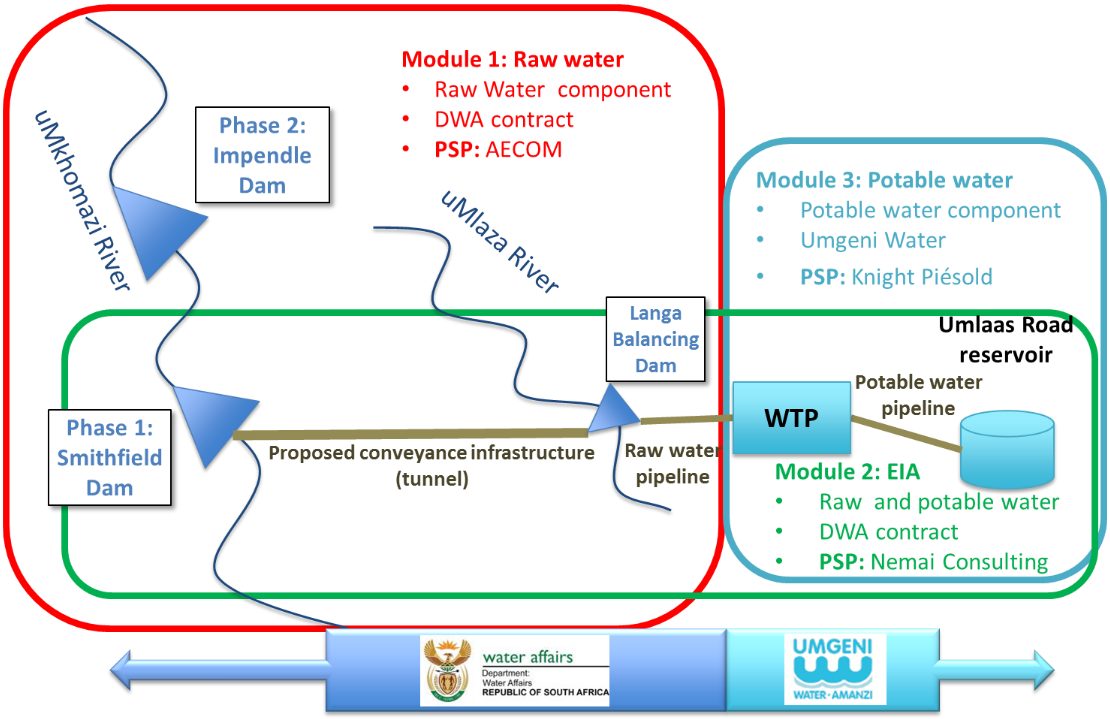

Figure 1.1: uMWP-1 feasibility study modules

This module, the raw water technical feasibility study, considers water resources aspects, engineering investigations and project planning and scheduling and implementation tasks, as well as an environmental screening and assessment of socio-economic impacts of the proposed project.

Some specific objectives for this study, recommended in the *Mkomazi-Mgeni Transfer Scheme Pre-feasibility* study are listed below:

- Smithfield Dam (Phase 1) to be investigated to a detailed feasibility level.

- Investigate the availability of water from Impendle Dam (Phase 2) as a future resource to release to Smithfield Dam, and refine the phasing of the selected schemes.
- Optimise the conveyance system between Smithfield Dam and the proposed Baynesfield Water Treatment Plant.
- Undertake a water resources assessment of the uMkhomazi River Catchment, including water availability to the lower uMkhomazi.
- Evaluate the use of Baynesfield dam as a balancing dam.
- Investigate the social and economic impact of the uMWP.

This one of three studies was undertaken in close collaboration with the DWA, Umgeni Water and the Professional Services Providers (PSPs) of the other modules.

1.3 STUDY AREA

The study focus and key objective is related to the feasibility investigation of the Smithfield Dam and related raw water conveyance infrastructure. However, this is a multi-disciplinary project with the study area defined as the uMkhomazi River catchment, stretching to the north to include the uMngeni River catchment, refer to **Figure 1.2**.

The various tasks have specific focus area, defined as:

- Water Resources: uMkhomazi and uMngeni river catchments.
- Water requirements: water users in the existing Mgeni WSS and the uMkhomazi River catchment.
- Engineering Investigations: proposed dams at Impendle (only for costing purposes) and Smithfield, and the raw water conveyance infrastructure corridor between Smithfield Dam and the Water Treatment Plant of Umgeni Water.
- Environmental screening as input for the Environmental Impact Assessment.
- Socio-economic impact assessment: regional, provincial (KwaZulu-Natal (KZN)) and national.

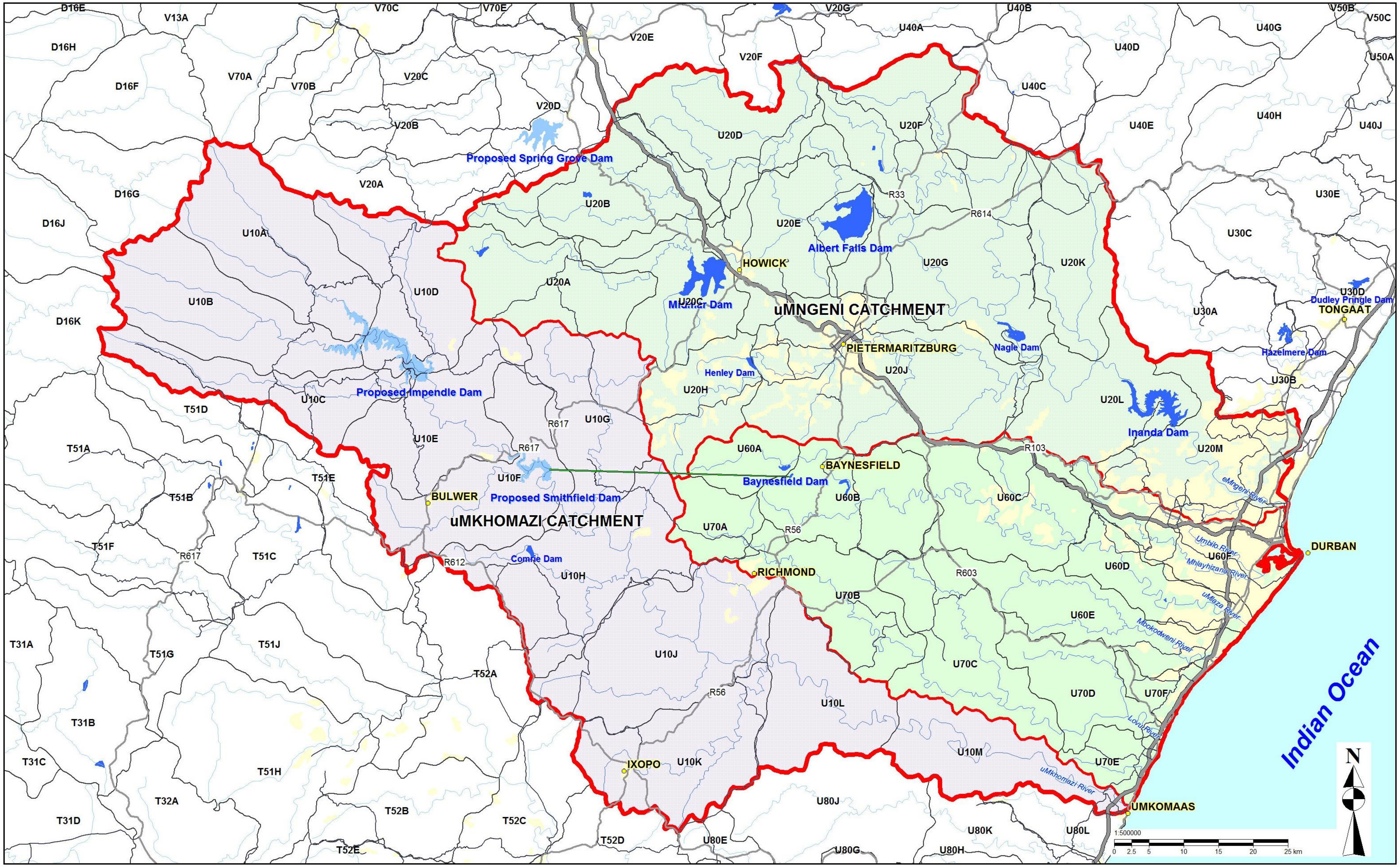

Figure 1.2: Study area of the uMWP

1.4 SCOPE OF THIS REPORT

The purpose of the report is to provide a detailed description of the water resource yield assessment undertaken for both phases of the uMWP, as well as for potential sources of water in the lower uMkhomazi River catchment. The primary objectives of the assessment were to:

- Determine the water supply potential ("yield") of both uMWP-1 (Smithfield Dam) and uMWP-2 (Smithfield Dam in combination with Impendle Dam).
- Based on results of the above, as well as projected water requirements for the uMWP supply area, provide a preliminary estimate of the implementation date of Impendle Dam.

The assessment was undertaken over a selected planning period of approximately 40 years, from the current day to 2050, and considered the possible impacts on the uMWP of:

- The selected storage size of Smithfield and Impendle dams.
- Making releases in support of ecological water requirements (EWRs) in the uMkhomazi River.
- Current and anticipated future in-catchment developments upstream of Smithfield Dam, which includes primarily irrigation and commercial forestry, as well as the commissioning of the planned Bulwer Dam.
- The future loss of utilisable storage available in Smithfield Dam due to sedimentation.

Furthermore, assessments were also made of the available resources in the lower uMkhomazi River catchment, namely:

- The proposed off-channel Ngwadini Dam on a tributary of the uMkhomazi River approximately 22 km upstream of the existing SAPPI-SAICCOR abstraction weir.
- The possible development of Ngwadini Dam as an Umgeni Water scheme to augment water supply to users on the KZN South Coast.
- The proposed Lower uMkhomazi Abstraction Weir at Goodenough on the uMkhomazi River approximately 8 km upstream of the SAPPI-SAICCOR abstraction weir. The scheme is also aimed at augmenting water supply to the KZN South Coast and will utilise available runoff from the lower uMkhomazi River catchment with support from Smithfield Dam.

Based on results from the above assessment, the following were developed:

- Storage-yield relationship curves for both uMWP-1 and uMWP-2.
- Long-term stochastic yield-reliability characteristic (YRC) curves for both uMWP-1 and uMWP-2.
- Short-term YRC curves for uMWP-1, based on a selected dam size for Smithfield Dam, for later implementation in detailed planning analysis of the integrated Mgeni WSS (AECOM, et al., 2014).
- A projected annual water balance for the integrated Mgeni WSS.

Finally, in support of the engineering investigation of the Study, analyses were also undertaken to assess the filling time of the proposed Langa Dam near Baynesfield in the upper uMlaza River catchment.

Details in this regard are provided in the following sections of the report.

2 HYDRO-METEOROLOGICAL DATA

The water resource yield assessment was undertaken based on the hydro-meteorological data set developed as part of this study and reported on in *Hydrological Assessment of the uMkhomazi River Catchment* (AECOM, et al., 2014). The data set covers the selected Study period of 84 years from the 1925 to the 2008 hydrological year (i.e. October 1925 to September 2009) and includes both the uMkhomazi River catchment (quaternary catchments U10A to U10M) and the upper uMlaza River catchment (U60A and U60B). The latter was included since the proposed Langa Dam will be located in U60B on a tributary of the uMlaza River near Baynesfield. Furthermore, the data set was developed at a quaternary catchment scale, which is in line with the spatial resolution selected for the WRYM system network model of the uMkhomazi River system. More information in this regard is provided later in **Section 4.2.1**.

Further details in this regard are provided in the remainder of this section.

2.1 RAINFALL

Representative monthly catchment rainfall time-series data sets were developed for each of the quaternary catchments in the uMkhomazi River catchment, based on a detailed analysis of gauged rainfall data and mean annual precipitation (MAP) information obtained from the *Water Resources of South Africa 1990 (WR90)* study (WRC, 1994). Catchment rainfall is used in the WRYM to account for the impact of rainfall on irrigation water requirements and for modelling rainfall directly onto the exposed surface area of small dams and wetlands scattered across the modelled catchment area in question. A summary is provided in **Table 2.1** and the corresponding time-series data sets presented in **Appendix B**.

Table 2.1: Summary of rainfall characteristics for quaternary catchments

Quaternary catchment	Area (km^2)	MAP[(1); (2)] (mm)
uMkhomazi River catchment		
U10A	418	1 287
U10B	392	1 176
U10C	267	1 091
U10D	337	999

Quaternary	Area (km^2)	MAP[(1); (2)] (mm)
U10E	327	1 034
U10F	379	963
U10G	353	981
U10H	458	924
U10J	505	878
U10K	364	793
U10L	307	758
U10M	280	858
Total/average[(3)]:	**4 387**	**981**
Upper uMlaza River catchment		
U60A	105	981
U60B	316	822
Total/average[(3)]:	**421**	**862**

Notes: (1) Mean annual precipitation (WRC, 1994).
(2) Over the period 1925 to 2008, hydrological years.
(3) Weighted average based on catchment area.

Furthermore, point rainfall data sets were developed for modelling rainfall directly onto the exposed surface area of major dams. More information in this regard is provided in *Hydrological Assessment of the uMkhomazi River Catchment* (AECOM, et al., 2014) and a summary is provided in **Table 2.2**. It is interesting to note that the site-specific MAPs shown below are significantly lower than the values in **Table 2.1** for the corresponding quaternary catchments. This is because rainfall in the areas of high altitude near the escarpment of the uMkhomazi River catchment is relatively high compared to the rainfall at the bottom of the valley where the dam sites are located.

Table 2.2: Point rainfall for proposed major dams

Dam site	Location (quaternary catchment)	MAP[(1); (2)] (mm)
Impendle Dam	U10E	920
Smithfield Dam	U10F	905
Langa Dam	U60B	810

Notes: (1) Mean annual precipitation (WRC, 1994).
(2) Over the period 1925 to 2008, hydrological years.

2.2 Evaporation

Evaporation losses from the surface area of water bodies are estimated based on 12 monthly lake evaporation values. Lake evaporation for the uMkhomazi and upper uMlaza river catchments were determined based on Symons pan (or "S-pan") evaporation data and S-pan-to-lake evaporation conversion factors obtained from the WR90 publication (WRC, 1994). The results are summarised in **Table 2.3**.

Table 2.3: Summary of lake evaporation for quaternary catchments

Quaternary catchment	Average lake evaporation, for indicated month (mm)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (MAE[1])
uMkhomazi River catchment													
U10A	100	102	122	117	108	110	83	68	57	62	78	88	1 095
U10B	100	102	122	117	108	110	83	68	57	62	78	88	1 095
U10C	100	102	122	117	108	110	83	68	57	62	78	88	1 095
U10D	100	102	122	117	108	110	83	68	57	62	78	88	1 095
U10E	100	102	122	117	108	110	83	68	57	62	78	88	1 095
U10F	100	102	122	117	108	110	83	68	57	62	78	88	1 095
U10G	96	98	117	112	104	106	80	66	55	60	75	85	1 054
U10H	91	95	105	106	99	98	80	67	57	60	70	82	1 010
U10J	91	95	105	106	99	98	80	67	57	60	70	82	1 010
U10K	91	95	105	106	99	98	80	67	57	60	70	82	1 010
U10L	91	95	105	106	99	98	80	67	57	60	70	82	1 010
U10M	91	95	105	106	99	98	80	67	57	60	70	82	1 010
Average[2]:	**96**	**99**	**114**	**112**	**104**	**104**	**81**	**67**	**57**	**61**	**74**	**85**	**1 054**
Upper uMlaza River catchment													
U60A	91	95	105	106	99	98	80	67	57	60	70	82	1 010
U60B	91	95	105	106	99	98	80	67	57	60	70	82	1 010
Average[2]:	**91**	**95**	**105**	**106**	**99**	**98**	**80**	**67**	**57**	**60**	**70**	**82**	**1 010**

Notes: (1) Mean annual lake evaporation (WRC, 1994).
(2) Weighted average based on catchment area.

2.3 Runoff

Natural runoff data are used in yield analyses as a basis for determining the historical sequence of inflows to reservoirs and other nodal points within the water resources system under consideration and thereby allow for the behaviour of the system to be simulated. Time-series of monthly incremental natural runoff data for quaternary catchments in the uMkhomazi and upper uMlaza river catchment is presented in **Appendix B** and a summary is provided in **Table 2.4**.

In this regard it should be noted that, although the WRYM network model was configured on a quaternary catchment basis, consideration was given to the physical location of water users, wetlands, small dams, proposed major dams and EWR sites within each catchment. For this purpose, the runoffs presented below were applied in the model in terms of defined sub-quaternary catchments and details in this regard are provided in **Section 4.2.2**.

Table 2.4: Summary of natural runoff characteristics for quaternary catchments

Quaternary catchment	Area (km^2)	MAR[1]			SD[2] (million m^3/a)	CV[3]
		million m^3/a	mm	% MAP		
uMkhomazi River catchment						
U10A	418	209.52	501	39%	84.20	0.40
U10B	392	164.49	420	36%	66.10	0.40
U10C	267	96.70	362	33%	38.86	0.40
U10D	337	98.22	291	29%	39.47	0.40
U10E	327	100.92	309	30%	40.56	0.40
U10F	379	67.08	177	18%	35.78	0.53
U10G	353	70.12	199	20%	37.40	0.53
U10H	458	82.66	180	20%	44.09	0.53
U10J	505	77.99	154	18%	41.60	0.53
U10K	364	40.42	111	14%	21.56	0.53
U10L	307	29.56	96	13%	15.77	0.53
U10M	280	40.06	143	17%	21.37	0.53
Totals:	**4 387**	**1 077.74**	**246**	**25%**	**464.18**	**0.43**
Upper uMlaza River catchment[4]						
U60A	105	22.65	216	22%	10.19	0.45

Notes: (1) Natural mean annual runoff, over the period 1925 to 2008, hydrological years, derived by scaling time-series data sets of gauged catchments.

(2) Standard deviation.

(3) Coefficient of variation, calculated as MAR/SD.

(4) Quaternary catchment U60B is not shown as it was not included in the hydrological investigation undertaken as part of this study (AECOM, et al., 2014).

2.4 STOCHASTIC STREAM FLOW ANALYSIS

The primary objective of using stochastically generated stream flows is to provide realistic alternative sequences that can be analysed in the same manner as the historical flow sequence. However, before the end user can place their confidence in results obtained from such sequences, it is first necessary to provide confirmation that the sequences are in fact realistic and plausible.

In the hydrological analysis undertaken as part of this study, a detailed stochastic stream flow analysis was undertaken, including verification and validation testing of generated stochastic sequences. Based on the results of this analysis it was found that the natural historical runoff time-series data sets have been well prepared and that results of the stochastic stream flow analysis could be considered to be acceptable. More information in this regard is provided in the report *Hydrological Assessment of the uMkhomazi River Catchment* (AECOM, et al., 2014).

3 PHYSICAL SYSTEM COMPONENTS

3.1 IN-CATCHMENT WATER USE

In-catchment water users often have a significant impact on the yield of downstream water supply schemes. Although the uMkhomazi River catchment is currently fairly undeveloped, extensive tracts of commercial forestry and irrigated areas are currently found in the central catchment areas around the towns of Richmond, Ixopo, Bulwer and Impendle – with the likelihood of further future expansion. Large volumes of water are also abstracted by industrial user SAPPI-SAICCOR for their mill located upstream of the uMkhomazi River estuary. Other water users include small towns and rural settlements, stock watering, dry-land sugarcane and invasive alien plants (IAPs).

A comprehensive assessment of the current and projected future in-catchment water use in the uMkhomazi and upper uMlaza river catchments was undertaken as part of this study and a detailed description of the relevant data sources, modelling methodologies and results is provided in the *Water Requirements and Return Flows Report* (AECOM, et al., 2014). A land-use summary is presented in **Table 3.1**, representative of the 2008-development level. Associated water use information is summarised in **Table 3.2**, which shows that currently the net in-catchment water use in the uMkhomazi River catchment totals 159 million m^3/a, or 15% of the total natural MAR.

It should be noted that, as discussed in the above report, in certain catchments the impact of selected water users were considered to be insignificant and were therefore not accounted for in the yield analysis. These are summarised below and shown in **Table 3.1** and **Table 3.2** in grey font for reference purposes.

- Irrigation from a specific source where the total area in the quaternary catchment irrigated from that source is less than 0.25 km^2.
- Irrigation supplied from groundwater.
- Stock watering where the total requirement in the quaternary catchment is less than 0.25 million m^3/a.

Table 3.1: Summary of land use (2008)

Quaternary catchment	Area(1) (km^2)						
	Irrigation, supplied from indicated source				Commercial forestry	Dry-land sugarcane	Invasive alien plants(4)
	Small dams	Run-of-river	Ground-water(3)	Total			
uMkhomazi River catchment							
U10A	-	-	-	-	4.73	-	1.41
U10B	-	-	-	-	22.89	-	6.49
U10C	0.75	1.95	-	2.70	20.84	-	4.08
U10D	1.81	-	-	1.81	3.16	-	4.46
U10E	-	0.25(2)	-	0.25	35.79	-	3.71
U10F	0.17(2)	1.18	-	1.35	54.51	-	3.04
U10G	4.34	5.73	-	10.07	56.69	-	2.91
U10H	8.96	10.87	-	19.83	150.38	0.46	3.66
U10J	2.47	9.30	0.02	11.80	143.01	-	4.21
U10K	4.76	6.41	0.24	11.41	92.73	12.24	4.42
U10L	-	0.69	0.23	0.92	18.26	12.88	2.67
U10M	-	0.02(2)	-	0.02(2)	1.46	0.78	2.70
Totals:	**23.26**	**36.40**	**0.49**	**60.16**	**604.45**	**26.36**	**43.76**
Upper uMlaza River catchment							
U60A	0.25	1.03	-	1.28	43.32	2.68	0.56
U60B	9.98	25.93	1.73	37.63	51.44	76.30	3.09
Totals:	**10.23**	**26.96**	**1.73**	**38.91**	**94.76**	**78.98**	**3.65**

Notes: (1) As discussed in the Water Requirements and Return Flows Report (AECOM, et al., 2014).

(2) Irrigation requirement from specific source in quaternary catchment not modelled if area less than 0.25 km^2.

(3) The impact on surface water of irrigation supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(4) Equivalent dense area, as discussed in AECOM (2014).

Table 3.2: Summary of in-catchment water use (2008)

Quaternary catchment	Water use[1] (million m^3/a)								
	Irrigation, supplied from all sources[2]	Commercial forestry	Dry-land sugarcane	Invasive alien plants	Stock watering	Domestic water use, supplied from all sources[4]	Industrial water use	Return flows	Totals
uMkhomazi River catchment									
U10A	-	0.88	-	0.38	0.36	0.06	-	-	**1.68**
U10B	-	4.26	-	1.46	0.10[3]	0.08	-	-	**5.90**
U10C	1.70	3.29	-	0.81	0.02[3]	0.08	-	0.17	**5.73**
U10D	1.12	0.42	-	0.87	0.29	0.26	-	0.11	**2.85**
U10E	-	4.82	-	0.66	0.23[3]	1.01	-	-	**6.72**
U10F	0.59	4.70	-	0.32	0.26	0.55	-	0.08	**6.34**
U10G	6.87	5.55	-	0.36	0.27	0.14	-	0.69	**12.50**
U10H	12.62	14.35	0.04	0.41	0.22[3]	0.38	-	1.26	**26.76**
U10J	8.73	13.35	-	0.42	0.30	0.31	-	1.08	**22.03**
U10K	6.05	6.74	0.79	0.35	0.41	0.69	-	0.60	**14.43**
U10L	0.23	1.24	0.75	0.15	0.19[3]	0.21	-	0.02	**2.75**
U10M	-	0.12	0.06	0.18	-	0.11	53.00[5]	2.65	**50.82**
Totals:	**37.91**	**59.72**	**1.64**	**6.37**	**2.65**	**3.88**	**53.00**	**6.66**	**158.51**
uMlaza River catchment									
U60A	0.69	4.75	0.25	0.07	0.01[3]	0.11	-	0.07	**5.81**
U60B	22.37	3.77	4.87	0.23	0.03[3]	0.94	-	2.24	**29.97**
Totals:	**23.06**	**8.52**	**5.12**	**0.30**	**0.04**	**1.05**	**-**	**2.31**	**35.78**

Notes: (1) Modelled average based on an analysis over the historical period 1925 to 2008 (hydrological years), at a constant development level as indicated.

(2) The impact on surface water of irrigation supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(3) Stock watering not modelled in quaternary catchments where the requirement is less than 0.25 million m^3/a.

(4) Urban and rural water use. The impact on surface water of users supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(5) Licenced water use by SAPPI-SAICCOR.

Furthermore **Table 3.3** provides a summary of the projected in-catchment water use in the uMkhomazi River catchment over a selected planning period of approximately 40 years up to 2050. More information on the sources of information and assumption upon which the projections are based is also provided in the *Water Requirements and Return Flows Report* (AECOM, et al., 2014).

Table 3.3: Summary of projected in-catchment water use

Water user category	Water use(1) (million m^3/a), at indicated development level				
	2008	2020	2030	2040	2050
Irrigation, supplied from all sources(2)	37.90	41.90	46.85	51.69	56.54
Commercial forestry	59.71	62.96	67.03	71.10	75.17
Dry-land sugarcane	1.64	1.64	1.64	1.64	1.64
Invasive alien plants	6.37	6.37	6.37	6.37	6.37
Stock watering(3)	2.66	2.77	2.90	3.04	3.17
Domestic water use, supplied from all sources(4)	3.89	4.09	4.27	4.44	4.61
Industrial water use(5)	53.00	53.00	53.00	53.00	53.00
Total water use:	**165.17**	**172.73**	**182.06**	**191.28**	**200.50**
Return flows	6.66	7.06	7.55	8.03	8.51
Total net water use:	**158.51**	**165.67**	**174.51**	**183.25**	**191.99**

Notes: (1) Modelled average based on an analysis over the historical period 1925 to 2008 (hydrological years), at a constant development level as indicated.

(2) The impact on surface water of irrigation supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(3) Stock watering not modelled in quaternary catchments where the requirement is less than 0.25 million m^3/a.

(4) Urban and rural water use. The impact on surface water of users supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(5) Licenced water use by SAPPI-SAICCOR.

It should be noted that the Harry Gwala (formerly known as Sisonke) District Municipality (DM) is currently in the process of planning the *Great Bulwer Donnybrook Regional Bulk Water Supply Project* aimed at providing a reliable source of water for several communities in the vicinity of Bulwer Town and Donnybrook (Jeffares & Green (Pty) Ltd, 2013). A key component of this project is the proposed Bulwer Dam as described later in **Section 3.5.4**.

Based on information obtained from the study team responsible for undertaking a detailed feasibility study on Bulwer Dam (Gray, 2013), it was concluded that the planned supply area of the dam covers the majority of communities located in the central uMkhomazi River catchment (i.e. quaternary catchments U10E to U10K) where all urban and rural users with significant water requirements are located. Consequently it was decided that, for modelling purposes, urban and rural water users would be excluded entirely from the WRYM system configuration. Instead the yield of Bulwer Dam, estimated in the Harry Gwala feasibility study to be approximately 3 million m^3/a, was imposed on the dam as a fixed abstraction. Since this abstraction far exceeds the projected urban and rural water use from surface water across the entire uMkhomazi River catchment (which totals less than 2 million m^3/a at 2050-development levels), this approach was considered to be acceptable as it would yield more conservative results.

3.2 ECOLOGICAL WATER REQUIREMENTS (EWRS)

Ecological water requirements (EWRs) adopted for sites in the uMkhomazi River and upper uMlaza River catchments are summarised in **Table 3.4**. The EWRs are based on a variety of information sources, assumptions and other considerations, notes of which are provided below the table and further information in the subsequent subsections. The associated monthly EWR rule curves for each site are provided in **Appendix C**.

Table 3.4: Summary of EWRs in the uMkhomazi and upper uMlaza river catchments

EWR site		Cate-gory	Location			Cumulative catchment		Modelled average EWR[(2)]	
No.	Name		Description	Lat. (°S)	Long. (°E)	Area (km^2)	MAR[(1)] (million m^3/a)	million m^3/a	% MAR
uMkhomazi River catchment									
1a[(4)]	Impendle	B	Impendle site	29°39'	29°46'	1 422	571	180	31%
1[(3); (5)]	Lundy's Hill	B	Outlet U10E	29°45'	29°55'	1 741	670	-	-
1b[(4)]	Smithfield	B	Smithfield site	29°46'	29°56'	2 058	726	228	31%
2[(3)]	Hella Hella	B	Outlet U10H	29°55'	30°05'	2 931	890	226	25%
3[(3)]	St Josephine's	B	u/s outlet U10J	30°01'	30°14'	3 339	953	330	35%
4[(3)]	Mfume	B	u/s outlet U10M	30°08'	30°40'	4 330	1 070	350	33%
-[(6)]	Estuary	B	Estuary	30°12'	30°48'	4 387	1 078	32	3%
-[(7)]	Bulwer	B	Bulwer site	29°50'	29°44'	46	8	3	37%
Upper uMlaza River catchment									
-[(5)]	04533, Mlazi	C	Outlet U60A	29°45'	30°19'	105.0	22.6	-	-
-[(8)]	Langa	C	Langa site	29°47'	30°18'	5.3	1.2	0.3	25%

Notes: (1) Natural mean annual runoff.

(2) Modelled average based on an analysis over the historical period 1925 to 2008 (hydrological years).

(3) Based on information from the earlier Mkomazi IFR Study (IWR Environmental, 1998). These may be revised when results from the recently commissioned RDM Reserve Study (DWA, 2013) become available.

(4) Derived from EWR 1 by scaling according to respective catchment MARs.

(5) Not part of the WRYM system model.

(6) Based on existing SAPPI-SAICCOR license conditions that allow for water to be abstracted from the river upstream of the estuary only when the flow exceeds 1 m^3/s. This may be revised when results from the recently commissioned RDM Reserve Study (DWA, 2013) become available.

(7) Based on information from the Bulwer Dam feasibility study (Gray, 2013).

(8) Derived from the U60A EWR by scaling according to respective catchment MARs.

a) uMkhomazi River

A project was recently commissioned by the DWA Directorate: Resource Directed Measures (RDM) for the *Classification of Water Resources and Determination of the Comprehensive Reserve and Resources Quality Objectives in the Mvoti to Umzimkulu Water Management Area* (DWA, 2013), which includes the uMkhomazi River catchment. Results from the RDM Reserve Study for the uMkhomazi River were, however, not available in time for consideration in the water resources yield assessment undertaken as part of this study. Consequently it was decided that, instead, the EWRs developed as part of the earlier *Mkomazi IFR Study* (IWR Environmental, 1998) would be applied in the yield analysis.

EWRs were modelled in the WRYM based on monthly EWR rule curves developed for four EWR sites on the uMkhomazi River as defined in the *Mkomazi IFR Study*. The location of the EWR sites is shown in **Figure 3.1**. However, one of these sites, EWR Site 1, is located at the outlet of quaternary catchment U10E and will be inundated by the proposed Smithfield Dam. It was therefore decided that two additional EWR sites would be defined based on the desired flow regime at EWR Site 1 but scaled according to the respective catchment MARs to represent associated flows at the following sites:

- Site 1a: Located at the proposed Impendle Dam site, upstream of Site 1.
- Site 1b: Located at the proposed Smithfield Dam site, downstream of Site 1.

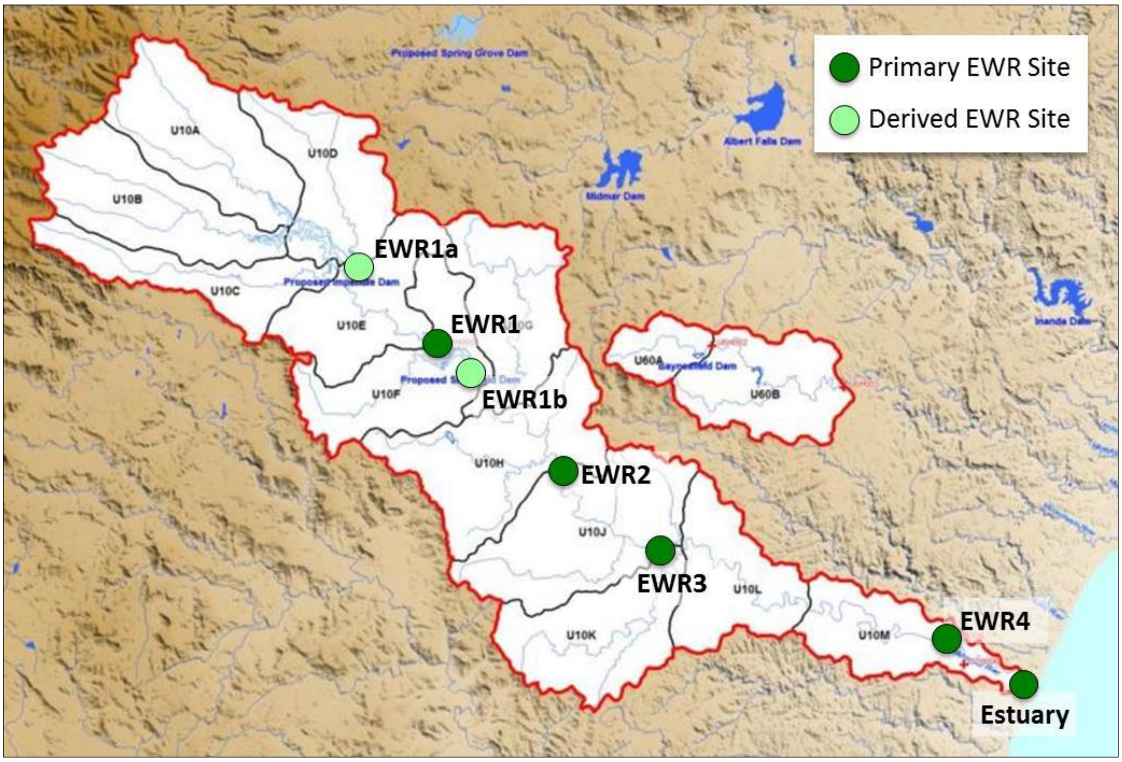

Figure 3.1: EWR sites in the uMkhomazi River catchment

Using the derived EWRs at Site 1a and 1b, the impacts of the following could be modelled in the yield analysis: (i) making releases from Impendle Dam to contribute its share towards desired flows in the river reach down to Site 1; and (ii) making releases from Smithfield Dam in support of EWR flows in the downstream river reach which would be in line with those for the nearby Site 1.

A meeting was subsequently held with the PSP team appointed to undertake the RDM Reserve Study in order to discuss the modelling of EWRs in the yield analysis. In particular, the principle was discussed of making releases from Smithfield Dam to support either the derived Site 1b (as described above) or alternatively for Site 2 located further downstream on the uMkhomazi River. In this regard the PSP team indicated that the possible benefits of supporting only Site 2, which would require smaller and less frequent releases from Smithfield Dam, should be weighed up against the possible associated negative impacts on the ecological health of the river reach directly downstream of Smithfield Dam. Such an assessment, however, did not fall within the scope of this study and it was therefore agreed that Site 1b would be adopted for yield analysis purposes as this would yield more conservative results (Louw, 18 May 2012).

b) uMkhomazi estuary

The earlier *Mkomazi IFR Study* (mentioned above) did not include the uMkhomazi River estuary. Based on discussions with the RDM study team it was therefore decided that flow requirements for the estuary would be based on the existing licence conditions of industrial water user SAPPI-SAICCOR (as discussed later in **Section 4.2.3 (f)**). In terms of these license conditions, SAPPI is only allowed to abstract water from the uMkhomazi River upstream of the estuary when the flow exceeds 1 m^3/s. This approach was adopted to ensure that implementation of estuarine flow requirements would not negatively impact upon SAPPI-SAICCOR's water supply and may be revised when results from the recently commissioned RDM Reserve Study (DWA, 2013) become available.

c) Langa Dam

Towards the end of this study results from the recently commissioned RDM Reserve Study (mentioned earlier) became available for the upper uMlaza River catchment (Louw, 6 October 2014) and could be used in the water resources yield assessment of Langa Dam. However, the site adopted for the Reserve study is at the outlet of quaternary catchment U60A while the Langa Dam site is on the Mbangweni, a tributary of the uMlaza directly downstream of U60A, as shown in **Figure 3.2**. An EWR was consequently derived for the Langa Dam site by scaling the U60A EWR according to the respective catchment MARs, results shown in **Table 3.4**.

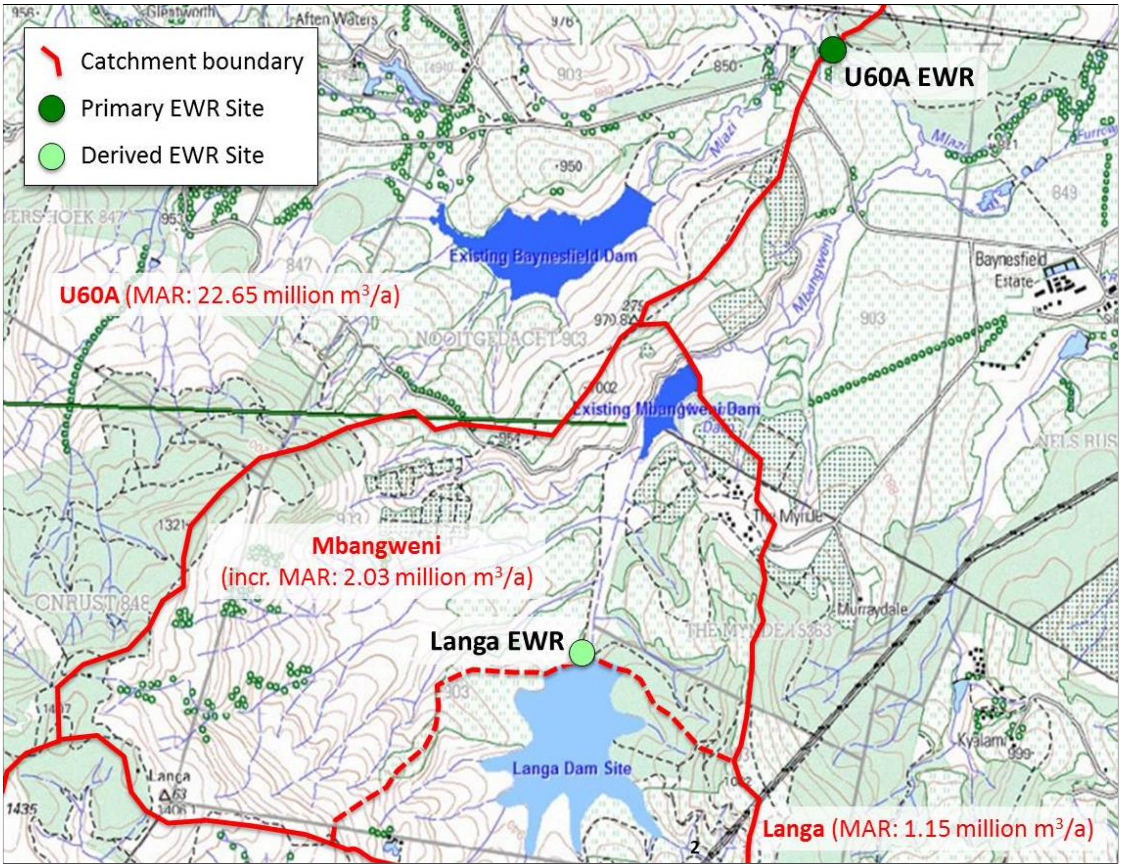

Figure 3.2: EWR sites in the upper uMlaza River catchment

d) Bulwer Dam

EWRs were developed for the proposed Bulwer Dam site on the Luhane River based on a Rapid Level II assessment undertaken as part of a recent feasibility study for the Harry Gwala DM, as discussed earlier in **Section 3.1** (Gray, 2013).

3.3 WETLANDS

The current extent, distribution and characteristics of wetlands in the uMkhomazi and upper uMlaza River was estimated based on information obtained from EnviroMap CC (1999) and Ezemvelo-KZN Wildlife (EKZNW, 2010) and other assumptions as detailed in the *Hydrological Assessment of the uMkhomazi River Catchment Report* (AECOM, et al., 2014). Wetlands were modelled in the yield analysis by combining all individual wetlands located within each quaternary catchment into a single representative modelling unit referred to as a "dummy wetland". A summary of dummy wetland characteristics adopted for the yield analysis is shown in **Table 3.5**, representative of 2008-development levels.

Table 3.5: Modelled dummy wetland characteristics (2008)

Quaternary catchment	Total nominal surface area[1] (km^2)	Total nominal water storage capacity[2] (million m^3)	Power of area-capacity relationship[2];[3]	Threshold river channel flow[2] (million m^3/month)	Proportion of flows above threshold routed to wetland[2]	Proportion of volume above nominal storage capacity routed to river channel[2]
uMkhomazi River catchment						
U10A	1.40	1.40	0.6	0.64	0.25	1.00
U10B	1.30	1.30	0.6	1.20	0.25	1.00
U10C	2.48	2.48	0.6	0.83	0.25	1.00
U10D	4.30	4.30	0.6	1.10	0.25	1.00
U10E	0.82	0.82	0.6	0.82	0.25	1.00
U10F	1.43	1.43	0.6	0.38	0.25	1.00
U10G	1.36	1.36	0.6	0.51	0.25	1.00
U10H	0.98	0.98	0.6	2.54	0.25	1.00
U10J	1.89	1.89	0.6	0.96	0.25	1.00
U10K	2.89	2.89	0.6	1.16	0.25	1.00
U10L[4]	0.12	-	-	-	-	-
U10M[4]	0.18	-	-	-	-	-
Totals:	**19.15**	**18.85**	**-**	**-**	**-**	**-**
Upper uMlaza River catchment						
U60A[4]	0.37	-	-	-	-	-
U60B	1.91	1.91	0.6	0.58	0.25	1.00
Totals:	**2.28**	**1.91**	**-**	**-**	**-**	**-**

Notes: (1) Based on coverages from EnviroMap (1999) and EKZNW (2010) for the uMkhomazi and upper uMlaza river catchments, respectively.

(2) As discussed in the Water Requirements and Return Flows Report (AECOM, et al., 2014).

*(3) As defined by the equation Area = A*Capacity^B.*

(4) Wetlands were not modelled in catchments where the total wetland area is smaller than 0.5 km^2.

Finally, it should be noted that wetlands were not modelled in catchments where the total wetland area is smaller than 0.5 km^2 and these are shown in **Table 3.5** in grey font for reference purposes.

The catchment areas of dummy wetlands were taken to be equal to the total contributing catchments of the individual wetlands that make up the dummy wetland in question. Catchments areas were delineated from the EnviroMap and

EKZNW wetland coverages discussed above, and the results are summarised later in **Table 4.2** of **Section 4.2.2**. Furthermore, the general physical location of wetlands in each catchment, relative to that of other system components, was used as a basis for the design of the WRYM system model discussed in **Section 4.2**.

Finally, historical data suggest that the number of functional wetlands in the study area declined significantly prior to 2012, largely as a result of draining or inundation for agricultural purposes. However, for planning purposes it was assumed that there would be no further deterioration of wetland areas. This assumption is based on increasing public awareness of the importance of wetlands. DWA need to enforce strict catchment management practices in future to ensure the protection and sustainability of wetlands, especially subsequent to the commissioning of the uMWP.

3.4 SMALL DAMS

The extent, distribution and characteristics of small dams in the uMkhomazi and upper uMlaza River was estimated based on spatial data obtained from the Chief Directorate: National Geo-spatial Information (CD: NGI) and other sources and assumptions as detailed in the report *Hydrological Assessment of the uMkhomazi River Catchment* (AECOM, et al., 2014). Small dams were modelled in the yield analysis by combining all individual dams located within each quaternary catchment into a single representative modelling unit referred to as a "dummy dam". A summary of dummy dam characteristics adopted for the yield analysis is shown in **Table 3.6**, representative of the 2008-development level.

Similar to wetlands discussed earlier, the catchment areas of dummy dams were taken to be equal to the total contributing catchments of the individual dams that make up the dummy dam in question. Catchments areas were delineated from the NGI coverage, discussed above, and the results are summarised later in **Table 4.2** of **Section 4.2.2**. Also, the general physical location of small dams in each catchment, relative to that of other system components, was used as a basis for the design of the WRYM system model discussed in **Section 4.2**.

Finally, it should be noted that small dams were not modelled in catchments where the total storage capacity is smaller than 0.5 million m^3 and these are shown in **Table 3.6** in grey font for reference purposes.

Table 3.6: Modelled dummy dam characteristics (2008)

Quaternary catchment	Total storage capacity(1) (million m^3)	Total surface area(2) (km^2)	Average depth (m)	Power of area-capacity relationship(3)
uMkhomazi River catchment				
U10A(4)	0.25	0.12	2.2	0.997
U10B(4)	0.30	0.14	2.2	0.996
U10C	0.70	0.32	2.2	0.996
U10D	1.91	0.85	2.2	0.983
U10E(4)	0.29	0.13	2.1	0.999
U10F	1.20	0.55	2.2	0.994
U10G	3.29	1.51	2.2	0.993
U10H	6.82	2.95	2.3	0.974
U10J	0.83	0.38	2.2	0.997
U10K	4.17	1.91	2.2	0.993
U10L(4)	0.40	0.19	2.1	0.999
U10M	-	-	-	-
Totals:	**20.16**	**9.05**	**2.2**	**-**
Upper uMlaza River catchment				
U60A	2.42(5)	0.64	3.8	0.879
U60B	12.05(6)	3.70	3.3	0.921
Totals:	**14.47**	**4.34**	**3.3**	**-**

Notes: (1) Derived from for the surface area of individual dams as discussed in the report Hydrological Assessment of the uMkhomazi River Catchment (AECOM, et al., 2014).

(2) Based on the surface area of individual dams obtained from the CD: NGI.

*(3) In the equation Area = A*Capacity^B.*

(4) Dams not modelled in catchments where total capacity is smaller than 0.5 million m^3.

(5) Includes Baynesfield Dam.

(6) Includes Thornlea and Mapstone dams.

As a large proportion of small dams in the uMkhomazi River catchment are used for irrigation purposes it was assumed that the future growth in small dam storage volume would follow that of irrigated areas supplied from small dams. Details on the latter are provided in the *Water Requirements and Return Flows Report* (AECOM, et al., 2014) and a summary of the resulting projected small dam storage volumes, over a selected planning period of approximately 40 years up to 2050, is shown in **Table 3.7**.

Table 3.7: Projected growth in dummy dam storage volumes

Quaternary catchment	Storage volume (million m^3), at indicated development level				
	2008	2020	2030	2040	2050
U10A (1)	0.25	0.27	0.29	0.30	0.32
U10B (1)	0.30	0.32	0.35	0.37	0.39
U10C	0.70	0.74	0.80	0.85	0.90
U10D	1.91	2.03	2.17	2.32	2.46
U10E (1)	0.29	0.31	0.33	0.35	0.37
U10F	1.20	1.28	1.37	1.46	1.55
U10G	3.29	3.48	3.73	3.98	4.23
U10H	6.82	7.23	7.75	8.27	8.78
U10J	0.83	0.88	0.94	1.01	1.07
U10K	4.17	4.42	4.74	5.05	5.37
U10L (1)	0.40	0.42	0.45	0.48	0.51
U10M (1)	-	-	-	0.01	0.01
Totals:	**20.16**	**21.38**	**22.92**	**24.45**	**25.96**

Note: (1) Dams not modelled in catchments where total capacity is smaller than 0.5 million m^3 at indicated development level.

3.5 MAJOR DAMS

Detailed information is provided in the following subsections on the physical characteristics of major dams in the study area, as adopted for yield analysis purposes.

3.5.1 Impendle and Smithfield Dams (uMWP)

The physical characteristics of the proposed uMWP dams in the uMkhomazi River catchment were based on detailed topographical surveys undertaken for the associated areas of inundation. More information in this regard is provided in *Supporting Document 5: Dam Type Selection Report* (AECOM, et al., 2014). A summary is provided in **Table 3.8** and **Table 3.9** as the relationship between elevation, storage capacity and surface area for Impendle and Smithfield dams, respectively. These are also shown graphically in **Figures A.2** and **A.3** of **Appendix A**. The location of the dams is shown in **Figure A.1** of **Appendix A**.

The characteristics shown for Smithfield Dam in **Table 3.9** are representative of the selected dam site “B”, a dead storage level (DSL) of 887.2 m and a full supply level (FSL) of 930.0 metres above sea level (masl) – resulting in a live storage capacity of 31% of the natural MAR. More information on the selection of the FSL is provided in **Section 5.1**. It should be noted that as part of yield assessment a range of storage sizes were analysed for a dam at the Smithfield site, up to 200% of the natural MAR (at an FSL of 998.5 masl). For this purpose the available survey data for the Smithfield Dam basin had to be extrapolated from an elevation of 940.0 m to 998.5 masl.

Table 3.8: Physical characteristics of the proposed Impendle Dam

No.	Elevation (masl[(1)])	Stage (m)	Storage capacity			Surface area (km²)	Notes
			Gross (million m³)	Live			
				(million m³)	(% MAR[(2)])		
1	1 200.0	108.0	928.02	870.88	152%	28.08	-
2	**1 199.5**	**107.5**	**914.24**	**857.10**	**150%**	**27.81**	**FSL 1[(3)]**
3	1 190.0	98.0	674.04	616.90	108%	22.72	-
4	**1 187.9**	**95.9**	**628.54**	**571.40**	**100%**	**21.70**	**FSL 2**
5	1 180.0	88.0	470.81	413.67	72%	18.01	-
6	**1 172.1**	**80.1**	**342.84**	**285.70**	**50%**	**14.63**	**FSL 3**
7	1 170.0	78.0	312.06	254.92	45%	13.72	-
8	1 160.0	68.0	194.03	136.89	24%	9.99	-
9	1 150.0	58.0	110.71	53.57	9%	6.91	-
10	**1 140.5**	**48.5**	**57.14**	**0.00**	**0%**	**4.40**	**DSL[(4)]**
11	1 135.0	43.0	36.27	-	-	3.17	-
12	1 130.0	38.0	22.67	-	-	2.31	-
13	1 125.0	33.0	12.98	-	-	1.60	-
14	1 120.0	28.0	6.74	-	-	0.94	-
15	1 115.0	23.0	3.16	-	-	0.52	-
16	1 110.0	18.0	1.27	-	-	0.26	-
17	1 100.0	8.0	0.07	-	-	0.04	-
18	**1 092.0**	**0.0**	**0.00**	**-**	**-**	**0.00**	**Bottom**

Notes: (1) Metres above sea level.

*(2) Expressed in terms of the total natural mean annual runoff for the upstream catchment, as shown later in **Table 4.1**.*

(3) Modelled full supply level for associated storage capacity as shown.

(4) Dead storage level.

Table 3.9: Physical characteristics of the proposed Smithfield Dam (Site "B")

No.	Elevation (masl[1])	Stage (m)	Storage capacity			Surface area (km^2)	Notes
			Gross (million m^3)	Live			
				(million m^3)	(% MAR[2])		
1	998.5	142.5	1 477.04	1 451.81	200%	31.90	Extrapolated
2	984.8	128.8	1 114.08	1 088.85	150%	26.36	
3	967.7	111.7	751.13	725.90	100%	20.19	
4	943.8	87.8	388.18	362.95	50%	12.94	
5	940.0	84.0	350.17	324.94	45%	11.99	-
6	935.0	79.0	300.80	275.57	38%	10.76	-
7	**930.0**	**74.0**	**251.43**	**226.20**	**31%**	**9.53**	**FSL[3]**
8	925.0	69.0	207.31	182.08	25%	8.15	-
9	920.0	64.0	169.26	144.03	20%	7.09	-
10	915.0	59.0	136.18	110.95	15%	6.15	-
11	910.0	54.0	107.51	82.28	11%	5.33	-
12	905.0	49.0	82.98	57.75	8%	4.50	-
13	900.0	44.0	62.39	37.16	5%	3.75	-
14	895.0	39.0	45.32	20.09	3%	3.09	-
15	890.0	34.0	31.38	6.15	1%	2.50	-
16	**887.2**	**31.2**	**25.23**	**0.00**	**0%**	**2.17**	**DSL[4]**
17	885.0	29.0	20.40	-	-	1.92	-
18	880.0	24.0	12.02	-	-	1.45	-
19	875.0	19.0	6.12	-	-	0.93	-
20	870.0	14.0	2.68	-	-	0.48	-
21	864.0	8.0	0.63	-	-	0.19	-
22	**856.0**	**0.0**	**0.00**	**-**	**-**	**0.00**	**Bottom**

Notes: (1) Metres above sea level.

*(2) Expressed in terms of the total natural mean annual runoff for the upstream catchment, as shown later in **Table 4.1**.*

*(3) Full supply level as selected in the engineering investigation (see **Section 5.1**).*

(4) Dead storage level.

The possible long-term impact of sediment deposition within the Smithfield Dam basin was assessed as part of this study and reported on in the *Supporting Document 1: Sediment Yield Report* (AECOM, et al., 2014). However, since an analysis of the spatial distribution of deposition within the area of inundation did not fall within the scope of this study, the following assumptions were made for yield analysis purposes:

- The full future sediment volume at the 90% confidence level would be deposited below the selected FSL of 930 m.
- A portion of the above volume, taken to be equal to the sediment volume at the 85% confidence level, would be deposited within the live storage of the dam (i.e. above the minimum outlet level).
- The remainder would be deposited in the dead storage of the dam (i.e. below the minimum outlet level).

Based on information from the sediment yield assessment, the above assumptions, as well as an assumed commissioning date for Smithfield Dam which would be shortly after 2020, sediment volumes were adopted for future yield analysis scenarios as shown in **Table 3.10**, which covers the selected planning period up to 2050.

Table 3.10: Adopted future sediment volumes for Smithfield Dam

Confidence level	Estimated future sediment volume[1] (million m^3), for indicated development level / sedimentation period (years)						Assumed zone of deposition
	2020[2]	2030	2040	2050	2060[3]	2070[3]	
	0	10	20	30	40	50	
90%	0.00	8.73	14.49	17.87	20.25	22.11	Total
85%	0.00	7.07	11.72	14.46	16.39	17.89	Live storage
Remainder	0.00	1.66	2.77	3.41	3.86	4.22	Dead storage

Notes: (1) From (AECOM, et al., 2014).
(2) Commissioning date for Smithfield Dam assumed shortly after 2020.
(3) Not within selected planning period up to 2050.

The resulting modelled Smithfield Dam storage characteristics, at the 2050-development level, are presented in **Table 3.11** and shown graphically in **Figure A.4** of **Appendix A**.

Table 3.11: Adopted physical characteristics for Smithfield Dam (2050)

Elevation (masl)	Gross storage capacity (million m^3)			Remaining live storage capacity above the minimum outlet level		Surface area (km^2)	Notes
	Original[1]	Impact of sediment deposition[2]	At 2050	(million m^3)	(% MAR)		
930.0	251.43	17.87	233.56	211.74	29%	9.53	FSL[3]
887.2	25.23	3.41	21.82	0.00	0%	2.17	DSL
856.0	0.00	0.00	0.00	-	-	0.00	Bottom

Notes: (1) At date of commissioning.

(2) Over 30-year sedimentation period, as shown earlier in ***Table 3.10****.*

(3) As selected in the engineering investigation (AECOM, et al., 2014).

3.5.2 Langa Dam

As outlined in the *Supporting Document 3: Optimization of Scheme Configuration* (AECOM, et al., 2014) it is anticipated that the proposed uMWP scheme will require balancing storage in the proximity of the water treatment plant at Baynesfield in order to accommodate scheduled or emergency maintenance on the transfer conveyance system from Smithfield Dam. The positioning and sizing of the proposed balancing dam, provisionally called “Langa” balancing dam, was undertaken as part of the engineering investigation of this study and more information in this regard is provided in the above document.

A summary of the physical characteristics of the proposed Langa Dam is provided in **Table 3.12** and shown graphically in **Figure A.5** of **Appendix A**. The location of the dam is shown in **Figure A.1** of **Appendix A** and more detail is provided in **Figure 3.3**.

Table 3.12: Physical characteristics of the proposed Langa Dam

No.	Elevation (masl[1])	Stage (m)	Storage capacity (million m^3)	Surface area (km^2)	Notes
1	935.0	55.0	28.91	1.39	
2	930.0	50.0	22.41	1.20	
3	925.0	45.0	17.59	1.03	
4	**923.0**	**43.0**	**15.67**	**0.95**	**FSL[2]**
5	920.0	40.0	12.78	0.84	
6	915.0	35.0	8.88	0.67	
7	910.0	30.0	5.82	0.51	
8	905.0	25.0	3.53	0.41	
9	900.0	20.0	1.87	0.30	
10	**898.0**	**18.0**	**1.43**	**0.26**	**DSL[3]**
11	895.0	15.0	0.87	0.13	
12	890.0	10.0	0.35	0.07	
13	885.0	5.0	0.09	0.03	
14	**880.0**	**0.0**	**0.00**	**0.01**	**Bottom**

Notes: (1) Metres above sea level.

(2) Full supply level as selected in the engineering investigation (AECOM, et al., 2014).

(3) Dead storage level.

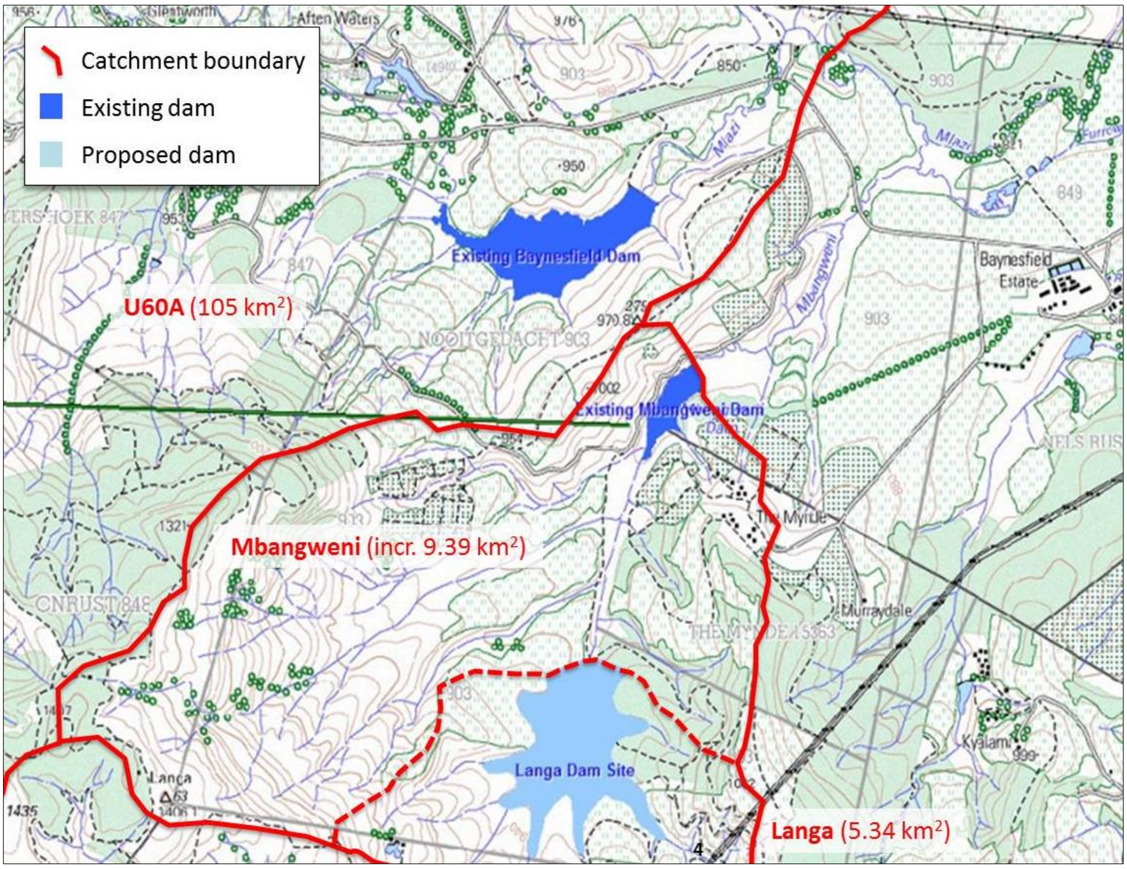

Figure 3.3: Location of the proposed Langa Dam site

3.5.3 Ngwadini Dam

Ngwadini Dam, which forms part of Umgeni Water's proposed Lower uMkhomazi Bulk Water Supply Scheme (BWSS), was originally identified by industrial water user SAPPI to increase water supply for their SAICCOR mill on the KZN South Coast. The scheme is currently being investigated by Umgeni Water as a possible additional source of water for domestic and industrial users on the South Coast to relieve reliance on the already stressed Mgeni WSS. The scheme will consist of an abstraction works on the uMkhomazi River, the off-channel Ngwadini Dam on a tributary of the lower uMkhomazi River, a 100Mℓ/d water treatment works, pump station and pipeline to deliver water to the South Coast supply area.

Information on the physical characteristics of Ngwadini Dam was obtained from SAPPI-SAICCOR's *Conceptual Design Report* (SAPPI-SAICCOR, 2005). A summary is provided in **Table 3.13** and shown graphically in **Figure A.6** of **Appendix A**. The location of the dam is shown in **Figure A.1** of **Appendix A**.

Table 3.13: Physical characteristics of the proposed Ngwadini Dam

No.	Elevation (masl[1])	Stage (m)	Storage capacity (million m^3)		Surface area (km^2)	Notes
			Gross	Live		
1	121.0	46.0	13.03	12.43	0.84	-
2	120.0	45.0	12.21	11.61	0.81	-
3	**118.0**	**43.0**	**10.66**	**10.06**	**0.74**	**FSL[2]**
4	116.0	41.0	9.25	8.65	0.68	-
5	112.0	37.0	6.78	6.18	0.56	-
6	108.0	33.0	4.78	4.18	0.45	-
7	104.0	29.0	3.17	2.57	0.36	-
8	100.0	25.0	1.92	1.32	0.27	-
9	96.0	21.0	1.06	0.46	0.17	-
10	**92.6**	**17.6**	**0.60**	**0.00**	**0.11**	**DSL[3]**
11	92.0	17.0	0.52	-	0.10	-
12	88.0	13.0	0.24	-	0.05	-
13	84.0	9.0	0.08	-	0.03	-
14	80.0	5.0	0.02	-	0.01	-
15	**75.0**	**0.0**	**0.00**	**-**	**0.00**	**Bottom**

Notes: (1) Metres above sea level.
(2) Full supply level.
(3) Dead storage level.

3.5.4 Bulwer Dam

As mentioned earlier in **Section 3.1**, the Harry Gwala DM is currently planning the development of Bulwer Dam on the Luhane River, a tributary of the uMkhomazi River upstream of the Smithfield Dam site, as part of a regional bulk water supply scheme for several communities in the vicinity of Bulwer Town and Donnybrook. The physical characteristics of the proposed Bulwer Dam were obtained from a basin survey undertaken for a detailed feasibility study by the Harry Gwala DM (Gray, 2013). A summary is provided in **Table 3.14** and shown graphically in **Figure A.7** of **Appendix A**. The location of the dam is shown in **Figure A.1** of **Appendix A**.

Table 3.14: Physical characteristics of the proposed Bulwer Dam

No.	Elevation (masl[(1)])	Stage (m)	Storage capacity			Surface area (km^2)	Notes
			Gross (million m^3)	Live			
				(million m^3)	(% MAR[(2)])		
1	1 504.0	27.5	14.21	13.30	162.3%	1.37	-
2	**1 500.5**	**24.0**	**9.92**	**9.02**	**110.0%**	**1.08**	**FSL[(3)]**
3	1 499.6	23.1	9.10	8.20	100.0%	1.02	-
4	1 494.9	18.4	5.03	4.13	50.4%	0.70	-
5	1 492.0	15.5	3.21	2.31	28.2%	0.55	-
6	1 490.0	13.5	2.21	1.31	15.9%	0.44	-
7	1 488.0	11.5	1.43	0.53	6.4%	0.34	-
8	**1 486.2**	**9.7**	**0.90**	**0.00**	**0.0%**	**0.26**	**DSL[(4)]**
9	1 486.0	9.5	0.84	-	-	0.25	-
10	1 485.0	8.5	0.61	-	-	0.21	-
11	1 484.0	7.5	0.42	-	-	0.17	-
12	1 483.0	6.5	0.27	-	-	0.13	-
13	1 482.0	5.5	0.16	-	-	0.09	-
14	1 481.0	4.5	0.09	-	-	0.06	-
15	1 480.0	3.5	0.04	-	-	0.04	-
16	1 479.5	3.0	0.02	-	-	0.03	-
17	**1 476.5**	**0.0**	**0.00**	**-**	**-**	**0.00**	**Bottom**

Notes: (1) Metres above sea level.

*(2) Expressed in terms of the total natural mean annual runoff for the upstream catchment, as shown later in **Table 4.1**.*

(3) Full supply level.

(4) Dead storage level.

4 MODEL CONFIGURATION

4.1 MODEL SELECTION AND DESCRIPTION

The yield analysis of the uMWP was undertaken using **Version 3.2.8** of the **Water Resources Yield Model Information Management System (WRYM-IMS)**. The model was developed by DWA for the purpose of modelling complex water resource systems and is used together with other simulation models, pre-processors and utilities for the purpose of planning and operating the country's water resources.

The WRYM uses a sophisticated network solver in order to analyse complex multi-reservoir water resource systems for a variety of operating policies and is designed for the purpose of assessing a system's long- and short-term yields. Analyses are undertaken based on a monthly time-step and for constant development levels, which means that the system configuration and modelled use characteristics remain unchanged over the simulation period. The major strength of the model lies in the fact that it allows for the configuration of most water resource system networks using basic building blocks. A system network and the relationships between its elements are therefore defined by means of input data, rather than by fixed algorithms embedded in the source code of the model.

4.2 DEVELOPMENT OF REPRESENTATIVE SYSTEM NETWORK MODEL

A schematic diagram of the WRYM system network model for the uMkhomazi River system is provided in **Figure A.8** of **Appendix A**. Details on the development of the model are provided in the following sub-sections.

4.2.1 Spatial resolution

The process of developing a representative system network model includes a number of aspects which includes, importantly, the identification of physical system components (as discussed earlier in **Section 3**) and the lumping and aggregation of these components to an appropriate spatial resolution. This process, however, always implies a trade-off between the need to simulate the behaviour of individual system components at a desired level of detail, on the one hand, and practical modelling limitations on the other.

For the purpose of the yield analysis of the uMWP it was decided that the WRYM would be configured on a quaternary catchment basis. While certain recent planning studies, most notably the *Water Availability Assessments* (WAAs) for the Mhlathuze, Inkomati, Berg, Crocodile West and Olifants river systems, were undertaken at a sub-quaternary scale, this was not considered to be essential for this purpose of this study. The reason for this is that the uMkhomazi River catchment is fairly undeveloped, eliminating the need for simulating the localised impacts of water users.

4.2.2 Modelled sub-catchments

WRYM modelled sub-catchments were defined based on the considerations discussed above, as well as the physical location of in-catchment water users, wetlands, small dams, proposed major dams and EWR sites, (as discussed earlier in **Section 3**). A summary of the main sub-catchments is provided in **Table 4.1** with a more detailed breakdown shown in **Table 4.2**.

Table 4.1: Summary of main WRYM modelled sub-catchments

Dam site	Incremental catchment			Cumulative catchment	
	Definition[1]	Area[2] (km^2)	MAR[3] (million m^3/a)	Area[2] (km^2)	MAR[3] (million m^3/a)
Impendle Dam	U10A to U10D & 1.4%U10E	1 422	571.40	1 422	571.40
Smithfield Dam	97.6%U10E & 83.6%U10F	635	154.50	2 057	725.90
Remainder	16.4%U10F & U10G to U10M	2 330	351.84	4 387	1 077.74
Totals:	**U10A to U10M**	**4 387**	**1 077.74**	**-**	**-**
Langa Dam	5.1%U10A[4]	5.3	1.15	5.3	1.15

Notes: (1) In terms of quaternary catchments.

(2) Based on quaternary catchment areas from WR2005 (WRC, 2008).

*(3) Natural mean annual runoff as discussed in **Section 2.3**.*

*(4) Although the proposed Langa Dam is located in U60B it was modelled based on updated hydrological information from the adjacent U60A catchment (see **Section 2**).*

Table 4.2: Detailed breakdown of WRYM modelled sub-catchments

Quaternary catchment			Catchment portion	Con-tributing area (%)	Incremental catchment		Cumulative catchment	
Name	Catch-ment area (km^2)	MAR (million m^3/a)			Area[(1)] (km^2)	MAR[(2)] (million m^3/a)	Area[(1)] (km^2)	MAR[(2)] (million m^3/a)
uMkhomazi River catchment								
U10A	418	209.52	Wetlands	4.0%	17	8.38	17	8.38
			Remainder	96.0%	401	201.14	418	209.52
U10B	392	164.49	Wetlands	9.0%	35	14.80	453	224.32
			Remainder	91.0%	357	149.69	810	374.01
U10C	267	96.70	Wetlands	11.0%	29	10.64	839	384.65
			Dams	7.0%	19	6.77	858	391.42
			Remainder	82.0%	219	79.29	1 077	470.71
U10D	337	98.22	Wetlands	14.0%	47	13.75	1 124	484.46
			Dams	13.0%	44	12.77	1 168	497.23
			Remainder	73.0%	246	71.70	1 414	568.93
U10E	327	100.92	**Impendle** / EWR1a	2.4%	8	2.47	**1 422**	**571.40**
			Wetlands	10.0%	33	10.09	1 455	581.49
			Remainder / EWR1	87.6%	286	88.36	1 741	669.85
U10F	379	67.08	Bulwer Dam	12.2%	46[(4)]	8.20	1 787	678.05
			Wetlands	37.8%	143	25.34	1 930	703.39
			Dams	14.9%	56	9.99	1 986	713.38
			Smithfield / EWR1b	18.7%	71	12.52	**2 057**	**725.90**
			Remainder	16.4%	62	11.03	2 119	736.93
U10G	353	70.12	Wetlands	9.0%	32	6.31	2 151	743.24
			Dams	19.0%	67	13.32	2 218	756.56
			Remainder	72.0%	254	50.49	2 472	807.05
U10H	458	82.66	Wetlands	39.0%	179	32.24	2 651	839.29
			Dams	5.0%	23	4.13	2 674	843.42
			Remainder / EWR2	56.0%	256	46.29	2 930	889.71
U10J	505	77.99	Wetlands	15.0%	76	11.70	3 006	901.41
			Dams	4.0%	20	3.12	3 026	904.53
			EWR3	61.8%	312	48.19	3 338	952.72
			Remainder	19.2%	97	14.98	3 435	967.70
U10K	364	40.42	Wetlands	36.0%	131	14.55	3 566	982.25
			Dams	12.0%	44	4.85	3 610	987.10
			Remainder	52.0%	189	21.02	3 799	1 008.12
U10L	307	29.56	-	100.0%	307	29.56	4 106	1 037.68

Quaternary catchment			Catchment portion	Con-tributing area (%)	Incremental catchment		Cumulative catchment	
Name	**Catch-ment area (km^2)**	**MAR (million m^3/a)**			**Area[1] (km^2)**	**MAR[2] (million m^3/a)**	**Area[1] (km^2)**	**MAR[2] (million m^3/a)**
U10M	280	40.06	Ngwadini diversion	61.6%	173	24.69	4 279	1 062.37
			Ngwadini	4.5%	13	1.80	4 292	1 064.17
			EWR4	13.5%	38	5.41	4 330	1 069.58
			Remainder	20.4%	57	8.16	4 387	1 077.74
Totals:	**4 387**	**1 077.74**	-	-	**4 387**	**1 077.74**	-	-
Upper uMlaza River catchment								
U60A	105	22.65	Langa Dam[3]	5.1%	5.3	1.15	5.3	1.15

Notes: (1) Based on quaternary catchment areas from WR2005 (WRC, 2008).

(2) Natural mean annual runoff as discussed in ***Section 2.3****.*

(3) Although the proposed Langa Dam is located in U60B it was modelled using the U60A hydrology.

(4) From Gray (2013).

4.2.3 Modelled operating rules

As discussed earlier, the proposed uMWP will form part of the integrated Mgeni WSS, which consists of a vast number of water users, dams, inter-basin transfer schemes and other system features – all of which are governed by complex operating rules. However, since the purpose of the yield analyses presented here was simply to assess the potential of the uMWP to supply water into the Mgeni WSS, there was no need to directly account for the operating rules of the Mgeni. However, for the uMkhomazi River system itself a number of basic operating rules were adopted based largely on practical considerations, the purpose of and physical layout of the system, as well as the results of detailed system analyses. These are discussed in the following subsections and a summary is provided below:

- Water will be supplied to the Mgeni WSS via the proposed transfer scheme from Smithfield Dam (uMWP-1).
- Once commissioned, Impendle Dam will support the downstream Smithfield Dam through river releases (uMWP-2).
- Water from Bulwer Dam, which is to be constructed upstream of the Smithfield Dam site, will be allocated to local users and will not make releases to support the uMWP.

- Small dams in the catchment will not make releases to support the uMWP, other proposed water supply schemes, nor downstream EWRs.
- All proposed major dams, namely Smithfield, Impendle and Bulwer, must make releases to provide their fair share to the supply of downstream EWRs.
- EWRs are supplied in preference to transfers to the Mgeni WSS and other proposed water supply schemes in the uMkhomazi River system.
- SAPPI-SAICCOR abstractions from the uMkhomazi River are limited to the total licensed volume of 53.0 million m^3/a. However, in accordance with their current license conditions, water may only be abstracted when the flow into the downstream estuary exceeds 1 m^3/s. More information in this regard is provided earlier in **Section 3.2** and it should be noted that these conditions may be revised when results from the recently commissioned RDM Reserve Study (DWA, 2013) become available.

a) The uMWP (Smithfield and Impendle Dams)

Generally, the operating rule that determines the conditions under which support from an upstream to a downstream dam occurs is of great importance since it could, for example, result in the minimisation of evaporation and/or spillage losses – thereby increasing the overall system yield. Within this context, yield analyses were undertaken as part of this investigation to evaluate alternative operating rules for Smithfield and Impendle dams and more information in this regard is provided in **Section 5.1.3**.

Finally, both Smithfield and Impendle dams will make releases in support of downstream EWRs. This is further discussed in **Subsection (f)** below.

b) Ngwadini Dam

The proposed Ngwadini Dam (as discussed in **Section 3.5.3**), which will likely be commissioned prior to the uMWP, will rely largely on water diverted from the lower uMkhomazi River. Subsequent to the commissioning of the uMWP, however, Smithfield Dam may be operated to support Ngwadini Dam by making river releases for downstream diversion. However, yield analyses undertaken as part of this assessment have shown that the benefit of this option in terms of the overall yield of the system would be small, while causing a decrease in the water remaining in Smithfield Dam for transfer into the Mgeni WSS (see **Section 5.2**). It therefore seems unlikely that Ngwadini Dam will be supported by releases from Smithfield Dam.

Furthermore, diversion from the uMkhomazi River to Ngwadini Dam will only be made after the downstream EWR has been fully supplied. This is further discussed in **Subsection (f)** below.

c) *Lower uMkhomazi Abstraction Weir*

If implemented, the proposed Lower uMkhomazi Abstraction Weir will be supported by releases from Smithfield Dam to ensure water in the lower uMkhomazi is supplied at an acceptable assurance of supply – particularly when river flows are insufficient in the dry season. Furthermore, diversion from the Lower uMkhomazi Abstraction Weir will only be made after the EWRs at Site 4 have been fully supplied. This is further discussed in **Subsection (f)** below.

d) *Bulwer Dam*

It was assumed that the water from the planned Bulwer Dam, which is to be constructed upstream of the Smithfield Dam site, will be allocated to local users and will not make releases to support the uMWP. However, the dam will be required to make releases in support of downstream EWRs. This is further discussed in **Subsection (f)** below.

e) *Small dams*

It was assumed that small dams will not make releases to support the uMWP, other proposed water supply schemes, nor downstream EWRs. However, the operation of any future in-catchment storage developments will have to be managed in order to minimise possible adverse effects on the overall system.

f) *EWRs*

EWRs in the uMkhomazi River were assigned the highest priority of all water users in the system and, as such, are supplied in preference to:

- Transfers from the uMWP to the Mgeni WSS.
- Diversion from the uMkhomazi River to Ngwadini Dam.
- Diversion from the Lower uMkhomazi Abstraction Weir.
- All controlled water users in the catchment.

Also all proposed major dams, namely Smithfield, Impendle, Bulwer and the Langa Dam must make releases to provide their fair share to supply downstream EWRs. In this regard it should be noted that all spills were assumed to contribute to EWRs and additional releases are only made to make up shortfalls. More information regarding EWRs is provided earlier in **Section 3.2**, in particular the magnitude and modelling of EWRs downstream of the proposed dams and diversion schemes in the system.

g) SAPPI-SAICCOR

Industrial user SAPPI-SAICCOR is licensed to abstract a total of 145.2 Mℓ/d (53.0 million m^3/a) directly from the lower uMkhomazi River. However, in accordance with their current license conditions, water may only be abstracted when the flow into the downstream estuary exceeds 1 m^3/s (SAPPI-SAICCOR, 2012).

h) Other water users

The supply of water to other water users from small dams in the catchment is dictated purely by the local availability of water and the modelled requirement of the user in question. Controlled curtailments are therefore not applied.

4.3 MODEL CONFIGURATION TESTING

Great care was taken to ensure that the WRYM system network model was configured correctly. This included four main testing processes as outlined below:

- Extensive checking was undertaken to verify that the sub-catchment hydrology data was applied correctly in the model. This involved comparing simulated node inflows with the net runoffs contained in the associated sub-catchment hydrology data sets.
- Simulated model results were checked against the known physical characteristics of system components, such as the full supply, dead storage and bottom levels of dams.
- The system network connectivity was checked by undertaking mass balances at each node in the system to ensure that the defined linkages in the model definition are correct.
- Simulated model results were checked to ensure that the modelled behaviour of the system reflects the intended operating rules, including situations when (i) dams are full; (ii) dams are empty; (iii) dams are drawing down; and (iv) supply priorities control the routing of water in the system.

4.4 YIELD ANALYSIS PROCEDURE

The WRYM model configuration of the uMkhomazi River catchment was used to undertake yield analyses of the uMWP and resources in the lower uMkhomazi as outlined earlier in **Section 1.4**. For this purpose, the yield of a particular resource was determined by imposing a single (variable) target abstraction (or "target draft") on the system at the point of interest and assessing the modelled behaviour of the system under target draft and scenario in question.

Furthermore, all analyses were undertaken on the following basis:

- An analysis period of 84 years from the 1925 to the 2008 hydrological year (i.e. October 1925 to September 2009). This corresponds with the selected Study period as well as with the updated and extended historical hydro-meteorological data sets developed during the hydrological analysis of the study (as described in **Section 2**).
- Long-term stochastic yield analyses based on 201 84-year stochastically generated stream flow sequences.
- Both historical and stochastic long-term yield analyses were undertaken with all dams assumed to be full at the start of the analysis period. This approach provides accurate results in cases where the dams in question are not excessively large relative to runoff.
- Short-term stochastic yield analyses based on 501 5-year stochastically generated stream flow sequences and for a range of starting storage conditions (as discussed later in **Section 5.5.2**).

5 YIELD ANALYSIS SCENARIOS AND RESULTS

The main objectives of the yield analyses undertaken as part of this study are outlined earlier in **Section 1.4**. These were achieved by analysing defined scenarios using the WRYM, aimed at assessing the performance of the uMkhomazi River system in a variety of situations. While a vast number of scenarios were analysed over the course of the study, many for the purpose of model configuration testing, only the most important scenarios were selected for inclusion in this report.

A detailed description of the selected scenarios is provided in the following subsections, as well as a summary and description of the results obtained. These are for:

- Both phases of the uMWP (described in **Section 5.1**).
- Ngwadini Dam (**Section 5.2**).
- The Lower uMkhomazi Abstraction Weir (**Section 5.3**).
- Langa Dam (**Section 5.4**).

Furthermore, the long- and short-term stochastic yield-reliability characteristics of uMWP-1 and uMWP-2 are discussed in **Section 5.5** and, finally, the projected future water balance of the Mgeni WSS in **Section 5.6**.

5.1 THE UMKHOMAZI WATER PROJECT

5.1.1 uMWP-1 and uMWP-2, at the 2050-development level

a) Scenarios with various combinations of storage sizes for Smithfield and Impendle dams

Approximately 20 scenarios were analysed to determine the yields of both the uMWP-1 and uMWP-2 schemes, based on various combinations of selected storage sizes for the dams in question, including:

- **uMWP-1**: Smithfield Dam with a live storage capacity ranging from 8% to 200% of the natural MAR of the total catchment area upstream of the dam.

- **uMWP-2**: Impendle Dam with a live storage capacity of either 50%, 150% or 200% of the natural MAR, analysed in combination with the downstream Smithfield Dam with a range of live storage capacities.

All of the scenarios were analysed based on 2050-development levels, as this roughly coincides with the anticipated implementation date of Impendle Dam (as discussed later in **Section 5.6**) and yield results obtained for Smithfield Dam are therefore representative of the projected situation at that time. For all scenarios the model configuration therefore included:

- The 2050 projected in-catchment land use, associated water requirements and small dam storage characteristics (as discussed earlier in **Sections 3.1** and **3.4**).
- The estimated 2050 sediment volume in Smithfield Dam (discussed in **Section 3.5.1**).
- The planned Bulwer Dam upstream of Smithfield Dam, with its estimated yield of 3 million m^3/a imposed on the dam as a fixed abstraction (discussed in **Section 3.1**).
- All EWRs, including those at Sites 1a, 1b, 2, 3 and 4, as well as the Bulwer Dam EWR and estuary flow allocation (as discussed in **Section 3.2**).

A summary of the defined scenarios for Smithfield and Impendle dams, numbered from **1** to **21**, is provided in **Table 5.1**, together with the associated yield analysis results, al at a recurrence interval (RI) of failure of 1:100 years (or an annual assurance of supply of 99%). Based on these results, storage-yield curves were developed for both uMWP-1 and uMWP-2 and the results are presented in **Figure 5.1**. In all cases, the yield shown on the y-axis represents the total 1:100-year yield of the scheme and the x-axis represents the total live storage capacity of the scheme, namely (i) Smithfield Dam for the uMWP-1 (shown in green); and (ii) the combined capacity of Smithfield and Impendle dams for uMWP-2 (shown in brown).

Table 5.1: Yields for the uMWP (2050)

No.	Description[(1)]	Impendle Dam		Smithfield Dam[(3)]		Combined Impendle and Smithfield dams		System yield		
		FSL[(2)] (masl)	Live storage capacity (million m^3/a)	FSL[(2)] (masl)	Live storage capacity (million m^3/a)	Total live storage capacity		Historical firm	Stochastic, at a RI[(6)] of 1:100 years[(7)]	
						(million m^3/a)	(% MAR)[(4)]	(million m^3/a)	(million m^3/a)	(as % of total live storage)
1	uMWP-1 (Smithfield only)	-	-	905.0	57.75	57.75	8%	69	101	174%
2				910.0	82.28	82.28	11%	85	130	157%
3				915.0	110.95	110.95	15%	103	163	146%
4				920.0	144.03	144.03	20%	122	181	126%
5				925.0	182.08	182.08	25%	145	200	110%
6				930.0	226.20	226.20	31%	172	220	97%
7				935.0	275.57	275.57	38%	204	247	89%
8				943.8	362.95	362.95	50%	222	269	74%
9				967.7	725.90	725.90	100%	329	339	47%
10				984.8	1 088.85	1 088.85	150%	378	379	35%
11				998.5	1 451.81	1 451.81	200%	418	407	28%
12	uMWP-2 (Smithfield & 50% MAR(5) Impendle)	1 172.1	285.70	925.0	182.08	467.78	64%	270	294	63%
13				930.0	226.20	511.90	71%	284	303	59%
14				935.0	275.57	561.27	77%	309	316	56%
15	uMWP-2 (Smithfield & 100% MAR(5) Impendle)	1 187.9	571.40	920.0	144.03	715.43	99%	338	336	47%
16				925.0	182.08	753.48	104%	344	341	45%
17				930.0	226.20	797.60	110%	353	346	43%

No.	Description[1]	Impendle Dam		Smithfield Dam[3]		Combined Impendle and Smithfield dams		System yield		
		FSL[2] (masl)	Live storage capacity (million m^3/a)	FSL[2] (masl)	Live storage capacity (million m^3/a)	Total live storage capacity		Historical firm	Stochastic, at a RI[6] of 1:100 years[7]	
						(million m^3/a)	(% MAR)[4]	(million m^3/a)	(million m^3/a)	(as % of total live storage)
18	uMWP-2 (Smithfield & 150% MAR(5) Impendle)	1 199.5	857.10	915.0	110.95	968.05	133%	385	364	38%
19				920.0	144.03	1 001.13	138%	388	366	37%
20				925.0	182.08	1 039.18	143%	393	370	36%
21				930.0	226.20	1 083.30	149%	398	375	35%

Notes: (1) All with in-catchment developments, sediment deposition in Smithfield Dam and EWRs as listed earlier in this section.

(2) Full supply level as selected for indicated scenario.

(3) For reporting purpose characteristics are shown as on date of commissioning.

(4) In terms of the natural MAR of the total Smithfield Dam catchment (725.9 million m^3/a).

(5) In terms of the natural MAR of the Impendle Dam catchment (571.4 million m^3/a).

(6) Recurrence interval of failure.

(7) Equates to an annual assurance of supply of 99%.

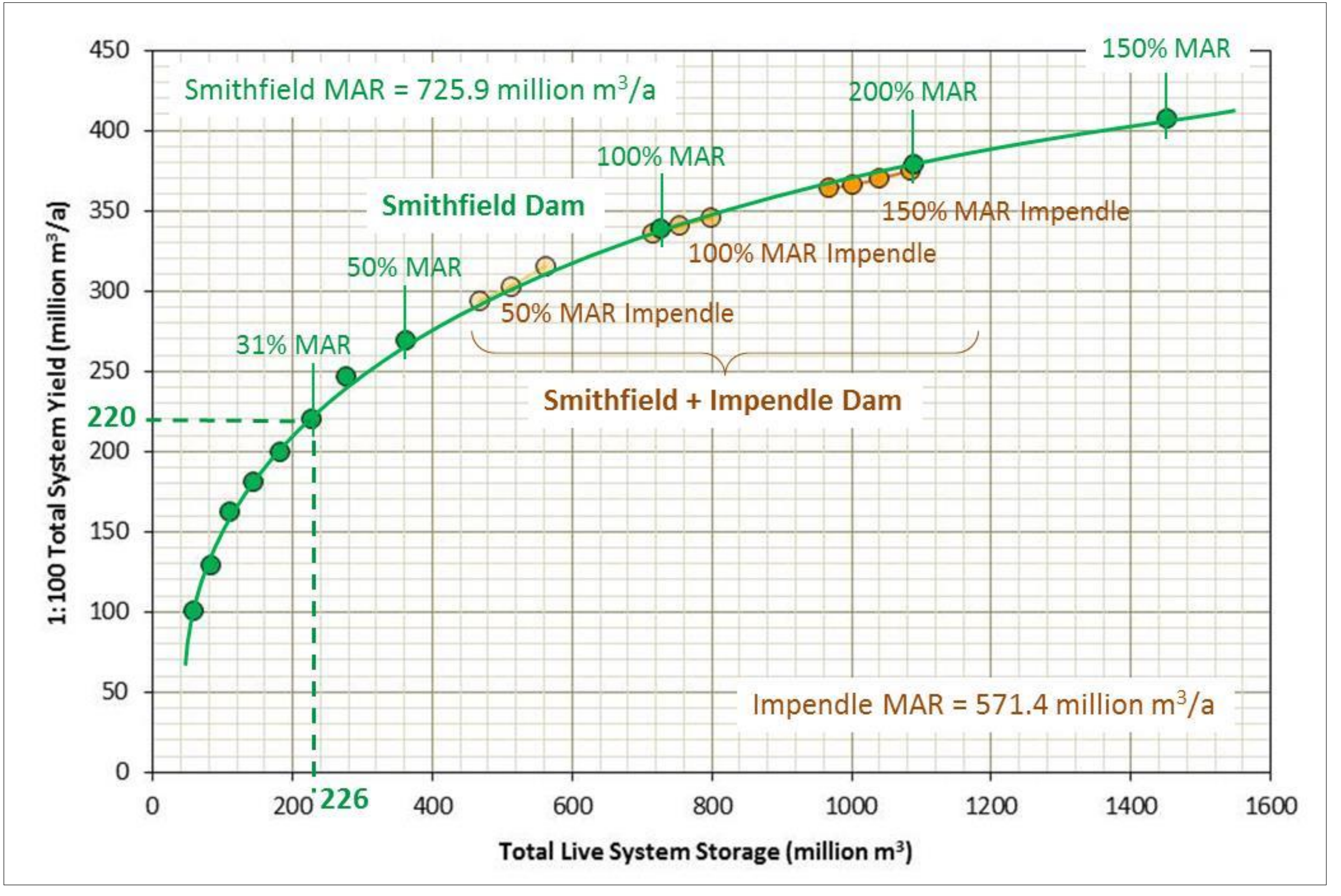

Figure 5.1: Storage-yield curves for the uMWP (2050)

Finally, two additional scenarios were analysed to compare the yield results for uMWP-1 obtained in this study with those from the earlier *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* undertaken by Ninham Shand (1999). For this purpose, Smithfield Dam was analysed with FSLs of 915 and 930 masl (i.e. similar to the configuration of **Scenarios 3** and **6**, respectively, as described earlier). However, in accordance with the approach adopted in the Pre-feasibility Study the system configuration was revised to exclude EWR 1b and Smithfield Dam made to provide support only to the downstream EWR 2.

The results are shown graphically in **Figure 5.2**, indicating a close correlation between this study (represented by the red line and data points) and the Pre-feasibility Study (represented by the grey line). The results also confirm that if support is provided from Smithfield Dam only for EWR Site 2 instead of the derived Site 1b, the 1:100-year yield of the dam increases by 23 million m^3/a, from 220 million m^3/a to 243 million m^3/a.

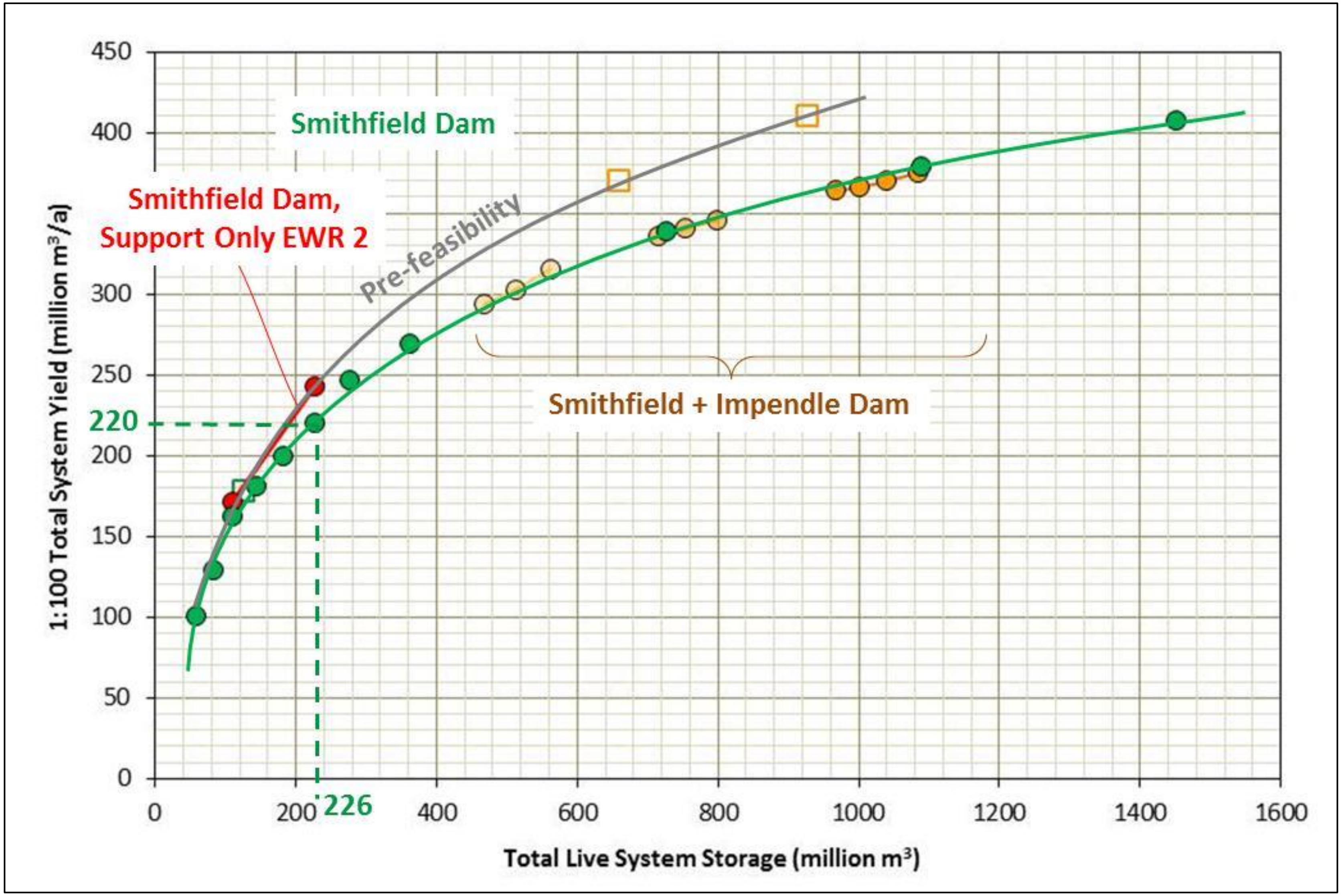

Figure 5.2: Comparison of yield results with Pre-feasibility Study (Ninham Shand, 1999)

b) Scenarios based on Smithfield Dam with an adopted FSL of 930 m

As part of the engineering investigation of this study and based on the yield results presented above, an FSL of 930 masl was selected for the feasibility design of Smithfield Dam. This dam size is highlighted earlier in **Figure 5.1** which shows the corresponding live storage capacity of 226 million m^3 (or 31% of the natural MAR) and a 1:100-year yield of 220 million m^3/a. A detailed description of the rationale behind this recommendation is provided in *Supporting Document 3: Optimization of Scheme Configuration* (AECOM, et al., 2014), which includes the following main considerations:

- For the option where the scheme is limited to only Smithfield Dam with a single conveyance system (i.e. Impendle Dam is never implemented), the 930 m FSL Smithfield Dam results in the lowest unit reference value (URV).
- For the option where the scheme is later augmented by the development of a 150% MAR Impendle Dam, the 915 m FSL Smithfield Dam results in the lowest URV. However, this option is not considered to be favourable as Smithfield Dam would provide a window of only approximately 10 years before Impendle Dam is required.
- Compared to the above situation, it was found that the 930 m FSL Smithfield Dam would provide a window of more than 20 years before Impendle Dam is required, while resulting in an comparative increase in the URV of only 2%.

With consideration of the above, **Table 5.2** provides a summary of the uMWP scenarios and system yields based on the adopted FSL of 930 m for Smithfield Dam and Impendle with a live storage capacity of either 50%, 150% or 200% of the natural MAR. Note that these correspond to **Scenarios 6**, **13**, **17** and **21** as shown earlier in **Table 5.1**, but also includes yield results for a range of recurrence intervals (RIs) of failure (in years), namely:

- 1:20 (or an annual assurance of supply of 95%).
- 1:50 (98%).
- 1:100 (99%).
- 1:200 (99.5%).

Table 5.2: Yields for the uMWP with a 930 m FSL Smithfield Dam (2050)

No.	Description[1]	Impendle Dam		Smithfield Dam[3]		Combined Impendle and Smithfield dams		System yield (million m^3/a)				
		FSL[2] (masl)	Live storage capacity (million m^3/a)	FSL[2] (masl)	Live storage capacity (million m^3/a)	Total live storage capacity		Historical firm	Stochastic, at indicated RI[6] (annual assurance of supply)			
						(million m^3/a)	(% MAR)[4]		1:20 (95%)	1:50 (98%)	1:100 (99%)	1:200 (99.5%)
6	uMWP-1 (Smithfield only)	-	-	930.0	226.20	226.20	31%	172	260	237	220	210
13	uMWP-2 (Smithfield & 50% MAR[5] Impendle)	1 172.1	285.70			511.90	71%	284	341	321	303	290
17	uMWP-2 (Smithfield & 100% MAR[5] Impendle)	1 187.9	571.40			797.60	110%	353	394	365	346	330
21	uMWP-2 (Smithfield & 150% MAR[5] Impendle)	1 199.5	857.10			1 083.30	149%	398	430	397	375	357

Notes: (1) All with in-catchment developments, sediment deposition in Smithfield Dam and EWRs as listed in ***Section 5.1.1 (a)****.*

(2) Full supply level as selected for indicated scenario.

(3) For reporting purpose characteristics are shown as on date of commissioning.

(4) In terms of the natural MAR of the total Smithfield Dam catchment (725.9 million m^3/a).

(5) In terms of the natural MAR of the Impendle Dam catchment (571.4 million m^3/a).

(6) Recurrence interval of failure (years).

Finally note that the FSL of 930 m for Smithfield Dam was also adopted for all subsequent scenarios analysed and as described in the remainder of this section of the report.

5.1.2 uMWP-1, at various development levels

Based on the selected FSL for Smithfield Dam of 930 masl (as discussed above) scenarios were analysed for a number of time-horizons over a 30-year period from 2020 to 2050, to assess the impact on the yield of the dam of the following:

- Sediment deposition (as discussed in **Section 3.5.1**).
- Making releases for downstream EWR Site 1b (as discussed in **Section 3.2**).

A summary of the eight defined scenarios, numbered from **22** to **29**, is provided in **Table 5.3**, together with the associated yield results. The results are also presented graphically in **Figure 5.3**. In all cases, the value shown on the y-axis represents the 1:100-year yield of Smithfield Dam (i.e. at an annual assurance of supply of 99%), while the x-axis represents the selected level of development.

Table 5.3: Yields for Smithfield Dam (various development levels)

No.	Development level[1]	Sedimentation period[2] (years)	EWRs included[3]	Smithfield Dam[4]			Smithfield Dam yield (million m^3/a)				
				Gross storage capacity (million m^3/a)	Live storage capacity		Historical firm	Stochastic, at indicated RI[6] (annual assurance of supply)			
					(million m^3)	(% MAR[5])		1:20 (95%)	1:50 (98%)	1:100 (99%)	1:200 (99.5%)
22	2020	-	Yes	251.43	226.20	31%	191	280	252	237	227
23	2030	10		242.70	219.13	30%	183	271	246	230	220
24	2040	20		236.94	214.48	30%	177	265	240	224	214
25	2050	30		233.56	211.74	29%	172	260	237	220	210
26	2020	-	No	251.43	226.20	31%	268	405	375	353	335
27	2030	10		242.70	219.13	30%	259	394	369	346	326
28	2040	20		236.94	214.48	30%	253	390	361	340	321
29	2050	30		233.56	211.74	29%	248	382	356	336	316

Notes: (1) All with in-catchment developments associated with indicated level of development.

(2) As shown earlier in ***Table 3.10*** *of* ***Section 3.5.1****.*

(3) As shown earlier in ***Table 3.4*** *of* ***Section 3.2****.*

(4) All for the selected FSL of 930 masl.

(5) Expressed in terms of the natural MAR of the Smithfield Dam catchment (725.9 million m^3/a).

(6) Recurrence interval of failure (years).

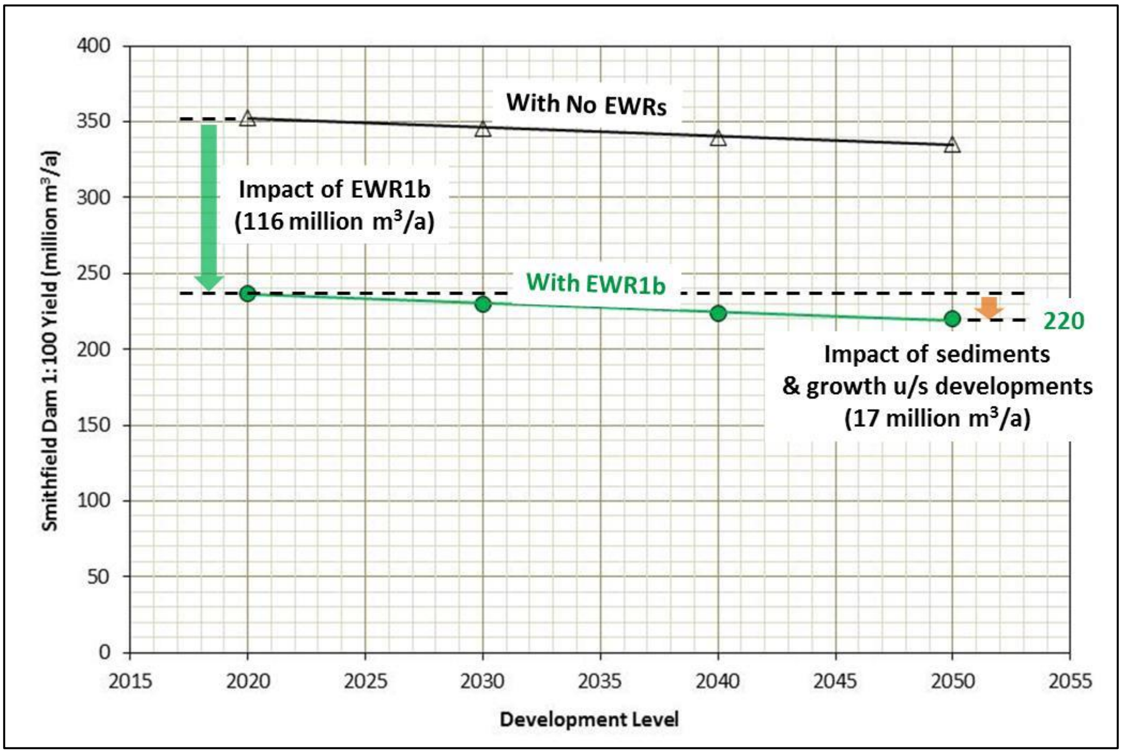

Figure 5.3: Yields for Smithfield Dam (various development levels)

As shown in **Figure 5.3** the impact on the yield of Smithfield Dam of projected sediment deposition and growth in upstream catchment developments is 17 million m^3/a – a decrease of 7%. Furthermore, the impact on the yield of making releases for downstream EWR Site 1b is 116 million m^3/a, or 33%. Finally note that **Scenario 25** above (i.e. Smithfield Dam with releases for downstream EWR Site 1b and at the 2050-development level) is, in essence identical to **Scenario 6** (as discussed earlier in **Section 5.1.1**) and in both cases the 1:100-year yield of Smithfield Dam is shown as 220 million m^3/a.

5.1.3 uMWP operating rule

Generally, the operating rule that determines the conditions under which support from an upstream to a downstream dam occurs is of great importance since it could, for example, results in the minimisation of evaporation losses and/or spillage losses from the incremental downstream catchment – thereby increasing the overall system yield. Within this context a number of scenarios were analysed to evaluate the preferred operating rule for uMWP-2. This included, specifically, two options for providing support from Impendle Dam by making releases down to Smithfield Dam under the following circumstances:

- **Option A**: When Smithfield Dam fails (is at DSL). The result of this option is, in effect, that Smithfield is used before Impendle for supply into the Mgeni WSS.
- **Option B**: When Smithfield Dam is not spilling (is below FSL). The result of this option is that Smithfield is kept full with releases from Impendle Dam and, in effect, that Impendle is used before Smithfield for supply into the Mgeni WSS.

Both options were analysed with the selected FSL for Smithfield Dam of 930 m (as discussed earlier in **Section 5.1.1 (b)**), together with three possible storage sizes for Impendle Dam, namely 50%, 100% and 150% of the natural MAR.

It was initially anticipated that Option A (Smithfield before Impendle) would result in a higher system yield because under this operating rule Smithfield Dam is generally operated at lower water levels, thereby increasing the opportunity for impounding floods from the incremental catchment downstream of Impendle Dam. Results of the analyses, however, showed that the selected operating rule had an insignificant impact on the total yield of the scheme, with the yields of comparable scenarios under Options A and B varying by less than 1%.

5.2 NGWADINI DAM

Assessments were also made of the available resources in the lower uMkhomazi River catchment for the proposed off-channel Ngwadini Dam. For this purpose, two distinct sets of analyses were undertaken as discussed in the following subsections.

5.2.1 Ngwadini Dam as a SAPPI-SAICCOR scheme

For some time industrial water user SAPPI-SAICCOR has been investigating the possibility of developing Ngwadini Dam to increase water supply to their mill near the uMkhomazi River estuary from the currently licensed 53 million m^3/a to 68.4 million m^3/a (SAPPI-SAICCOR, 2012). In order to assess the feasibility of the scheme, various scenarios were analyses to determine the impacts of the following on the yield of Ngwadini Dam:

- Various capacities of the proposed abstraction works to divert water from the uMkhomazi River to Ngwadini Dam.
- The downstream estuary EWR, which allows for abstractions to be made only from flows in the river that exceed a minimum of 1 m^3/s (as discussed in **Section 3.2**).
- The commissioning of Smithfield Dam with the selected FSL of 930 masl mentioned earlier. For these scenarios, it was assumed that releases are not made from Smithfield to support diversion for Ngwadini Dam.

A summary of the nine defined scenarios, numbered from **30** to **38**, is provided in **Table 5.4**, together with yield results for a range of recurrence intervals (RIs) of failure (in years), namely 1:20 (or an annual assurance of supply of 95%), 1:50 (98%), 1:100 (99%) and 1:200 (99.5%). The results are also presented graphically in **Figure 5.4**, with the value shown on the y-axis representing the 1:100-year yield of Ngwadini Dam (i.e. at an annual assurance of supply of 99%), and the x-axis representing the selected diversion works capacity. Note that all scenarios are representative of the 2012-development level.

Table 5.4: Yields for Ngwadini Dam as a SAPPI-SAICCOR scheme

No.	Ngwadini diversion capacity (m^3/s)	Estuary EWR included(1)	Smithfield Dam included(2)	Ngwadini Dam yield (million m^3/a)				
				Historical firm	Stochastic, at indicated RI(6) (annual assurance of supply)			
					1:20 (95%)	1:50 (98%)	1:100 (99%)	1:200 (99.5%)
30	0.425	No	No	53	66	60	57	55
31	0.750			58	72	67	62	58
32	1.000			59	75	68	62	58
33	0.425	Yes		52	64	58	54	51
34	0.750			55	72	60	55	51
35	1.000			55	72	60	55	51
36	0.425	Yes	Yes	43	52	48	45	41
37	0.750			43	52	48	45	42
38	1.000			43	52	48	45	42

Notes: (1) As shown earlier in ***Table 3.4*** *of* ***Section 3.2****.*

(2) All scenarios with Smithfield Dam included are for the selected FSL of 930 masl and with no releases to support Ngwadini diversions.

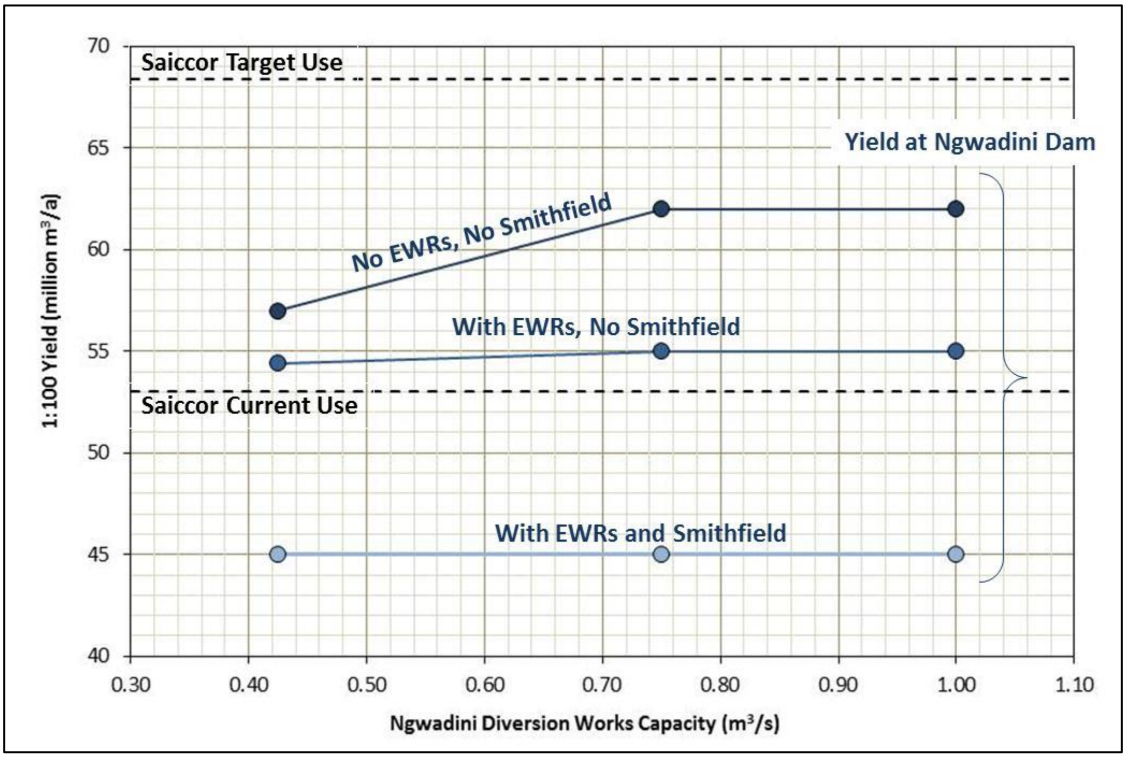

Figure 5.4: Yields for Ngwadini Dam as a SAPPI-SAICCOR scheme

Figure 5.4 shows that, prior to the implementation of Smithfield Dam, the proposed Ngwadini Dam will provide SAPPI-SAICCOR with a 1:100-year yield of 54 million m^3/a – which is line with their licensed water use of 53 million m^3/a. It should be noted, however, that the dam will significantly increase SAPPI-SAICCOR's annual assurance of supply to 99% (i.e. a 1% annual risk of non-supply), compared to the current situation where they experience supply failures almost every second year.

Based on these results, which were presented to SAPPI during the initial stages of the study, it was clear that Ngwadini Dam would not be feasible for their purposes. SAPPI therefore indicated that they were unlikely to further pursue the option of developing Ngwadini Dam (SAPPI-SAICCOR, 2013).

5.2.2 Ngwadini Dam as an Umgeni Water scheme

Within the context of the fact that SAPPI are unlikely to develop Ngwadini Dam (as discussed in the previous subsection), bulk water supplier Umgeni Water expressed interest in the scheme as a means of utilising the water resources of the lower uMkhomazi River for augmenting water supply to users on the KZN South Coast. In order to assess the potential for this option, analyses were undertaken to assess:

- The yield available at Ngwadini Dam prior to the commissioning of Smithfield Dam. This analysis was undertaken at the 2012-development level.
- The yield available at Ngwadini Dam subsequent to the commissioning of Smithfield Dam. For this situation, two options were considered, namely (i) if releases were not made from Smithfield Dam to support diversion for Ngwadini Dam; and (ii) if releases were made from Smithfield, such that a range of selected target abstractions at Ngwadini Dam would be met. These analyses were undertaken at the 2050-developmet level to enable comparison with the results of the uMWP-1 scenarios discussed earlier in **Section 5.1.1 (b)**.

Furthermore, scenarios analysed for Ngwadini Dam as an Umgeni Water scheme were based on the following assumptions:

- Diversion from the uMkhomazi River to Ngwadini Dam will only be made after both the licensed abstraction of 53 million m^3/a by SAPPI-SAICCOR and all downstream EWRs have been fully supplied. The EWRs in question are for Site 4 and the uMkhomazi estuary and more information in this regard is provided in **Section 3.2**.
- For the relevant scenarios, an FSL of 930 m for Smithfield Dam (as discussed earlier in **Section 5.1.1 (b)**).
- For the relevant scenarios, sediment deposition in Smithfield Dam (as discussed in **Section 3.5.1**).
- All releases made from Smithfield Dam to support Ngwadini diversions were assumed to be subject to river losses of 10%.

A summary of the eight defined scenarios, numbered from **39** to **46**, is provided in **Table 5.5**, together with the yield results for Smithfield Dam, Ngwadini Dam and the system as a whole. The results are also presented graphically in **Figure 5.5**, with the value shown on the y-axis representing the 1:100-year system yield (i.e. at an annual assurance of supply of 99%), and the x-axis representing the selected target abstractions at Ngwadini Dam (in Mℓ/d).

Table 5.5: Yields for Ngwadini Dam as an Umgeni Water scheme

No.	Development level[1]	Target abstraction at Ngwadini Dam			Ngwadini diversion capacity[2] (m^3/s)	Smithfield Dam[3]		Yield (million m^3/a)					
								Historical firm			Stochastic, at a RI[5] of 1:100 years[6]		
		(Mℓ/d)	(million m^3/a)	(m^3/s)		Included	Supports Ngwadini diversion[4]	Smithfield Dam	Ngwadini Dam	Total	Smithfield Dam	Ngwadini Dam	Total
39	2012	-	-	-	2.000	No	-	-	32	32	-	34	34
40	2050	-	-	-	2.000	Yes	No	172	21	193	220	24	244
41	2050	70	26	0.810	2.000	Yes	Yes	170	23	193	219	26	245
42	2050	95	35	1.100	2.000	Yes	Yes	162	31	192	214	35	248
43	2050	150	55	1.736	2.000	Yes	Yes	141	49	189	195	55	250
44	2050	70	26	0.810	3.000	Yes	Yes	168	23	191	219	26	245
45	2050	95	35	1.100	3.000	Yes	Yes	161	31	192	214	35	248
46	2050	150	55	1.736	3.000	Yes	Yes	141	49	189	196	55	250

Notes: (1) All with in-catchment developments and sediment volumes in Smithfield Dam associated with indicated level of development.

(2) Diversions only made after both downstream EWRs and licensed abstractions by SAPPI-SAICCOR have been fully supplied.

(3) All scenarios with Smithfield Dam included are for the selected FSL of 930 masl.

(4) Releases made from Smithfield Dam assumed to be subject to river losses of 10%.

(5) Recurrence interval of failure.

(6) Equates to an annual assurance of supply of 99%.

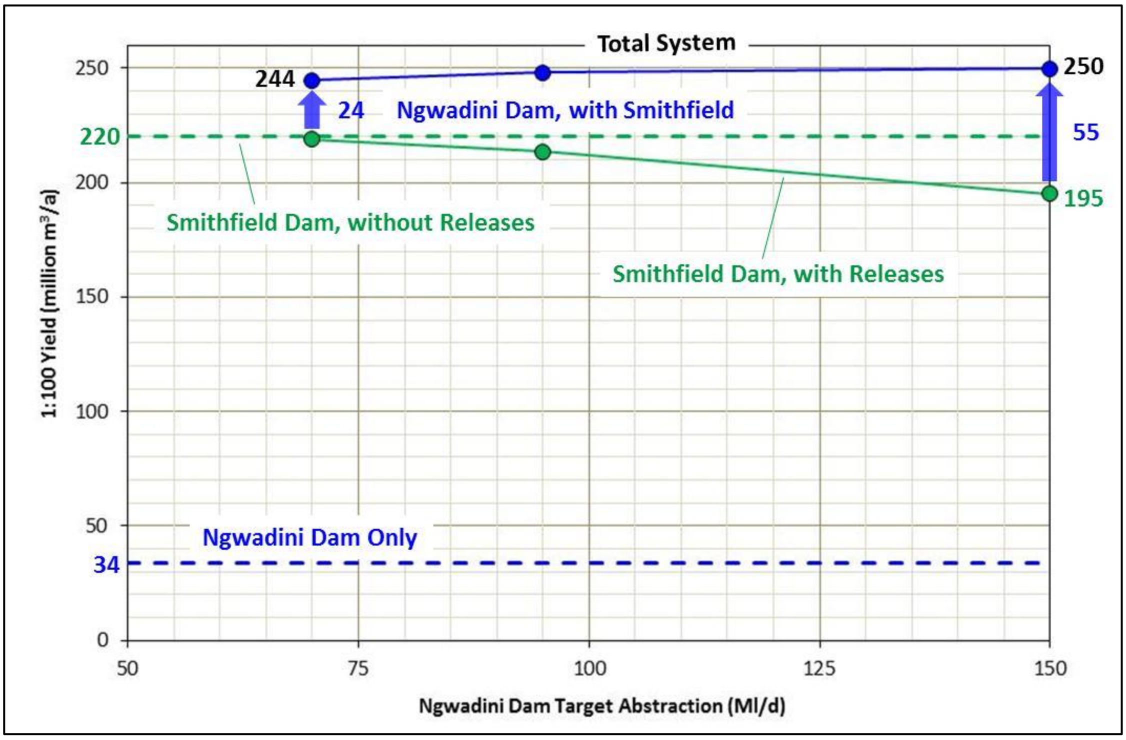

Figure 5.5: Yields for Ngwadini Dam as an Umgeni Water scheme

The results show that:

- Prior to the commissioning of Smithfield Dam (at the 2012-development level), the 1:100-year yield available at Ngwadini Dam is 34 million m^3/a (represented in **Figure 5.5** by the dashed blue line).
- When Smithfield Dam is commissioned, but no releases are made in support of Ngwadini Dam, the yield of Ngwadini decreases by 10 million m^3/a to only 24 million m^3/a (at the 2050-development level), resulting in a total system yield (i.e. from both Smithfield and Ngwadini dams) of 244 million m^3/a. Note that this option (which is represented by **Scenario 40** in **Table 5.5** above) is identical to **Scenario 6** (as discussed earlier in **Section 5.1.1**) with the 1:100-year yield of Smithfield Dam shown in both cases as 220 million m^3/a.
- By making releases from Smithfield Dam, any of the selected target abstractions from Ngwadini Dam can be achieved at an RI of 1:100-years. Note however that while this results in a slight increase in the total yield of the system (represented by the solid blue line), the remaining yield available from Smithfield Dam for transfer into the Mgeni WSS is decreased significantly (represented by the solid green line). For example, if a target abstraction of 150 Mℓ/d (55 million m^3/a) is selected for Ngwadini Dam, the system yield increases from 244 to 250 million m^3/a, but the yield of Smithfield decreases from 220 to 195 million m^3/a.

5.3 Lower uMkhomazi Abstraction Weir

Another scheme being considered for utilising the water resources of the lower uMkhomazi River for augmenting water supply to users on the KZN South Coast is the proposed Lower uMkhomazi Abstraction Weir at Goodenough. The scheme would, however, require support from Smithfield Dam to ensure water is supplied at an acceptable assurance of supply – particularly when river flows are insufficient in the dry winter season. Therefore, unlike Ngwadini Dam which could be commissioned in the short-term, the Lower uMkhomazi Abstraction Weir is dependent on the development of the uMWP.

In order to evaluate the feasibility of the scheme, analyses were undertaken to assess the impact on the yield of Smithfield Dam if releases were to be made in support of a range of selected target abstractions at the weir. These scenarios were undertaken at the 2050-developmet level to enable comparison with the results of the uMWP scenarios discussed earlier in **Section 5.1**. Furthermore, all scenarios were based on assumptions similar to those for the Ngwadini Dam analyses (discussed earlier in **Section 5.2.2**) as shown below.

- Diversion from the weir will only be made after both the licensed abstraction of 53 million m^3/a by SAPPI-SAICCOR and all downstream EWRs have been fully supplied. The EWRs in question are for Site 4 and the uMkhomazi estuary and more information in this regard is provided in **Section 3.2**.
- An FSL of 930 m for Smithfield Dam (as discussed in **Section 5.1.1 (b)**).
- Sediment deposition in Smithfield Dam (as discussed in **Section 3.5.1**).
- All releases made from Smithfield Dam to support diversions from the weir were assumed to be subject to river losses of 10%.

A summary of the four defined scenarios, numbered from **47** to **50**, is provided in **Table 5.6**, together with the corresponding 1:100-year yield results (i.e. at an annual assurance of supply of 99%). The results are also presented graphically in **Figure 5.6**, with the value shown on the y-axis representing the total system yield and the x-axis representing the selected target abstractions at the weir (in Mℓ/d).

Table 5.6: Yields for the Lower uMkhomazi Abstraction Weir

No.	Target abstraction at Lower uMkhomazi Weir[(2)]			Supported from Smithfield Dam [(3); (4)]	Yield (million m^3/a)			
					Historical firm		Stochastic, at a RI[(5)] of 1:100 years[(6)]	
	(Mℓ/d)	(million m^3/a)	(m^3/s)		Smithfield Dam	Total	Smithfield Dam	Total
47	-	-	-	-	172	172	220	220
48	70	26	0.810	Yes	158	183	209	234
49	95	35	1.100		150	185	202	237
50	150	55	1.736		130	185	185	240

Notes: (1) All with in-catchment developments and sediment volumes in Smithfield Dam associated with indicated level of development.

(2) Diversions only made after both downstream EWRs and licensed abstractions by SAPPI-SAICCOR have been fully supplied.

(3) All scenarios with Smithfield Dam included are for the selected FSL of 930 masl.

(4) Releases made from Smithfield Dam assumed to be subject to river losses of 10%.

(5) Recurrence interval of failure.

(6) Equates to an annual assurance of supply of 99%.

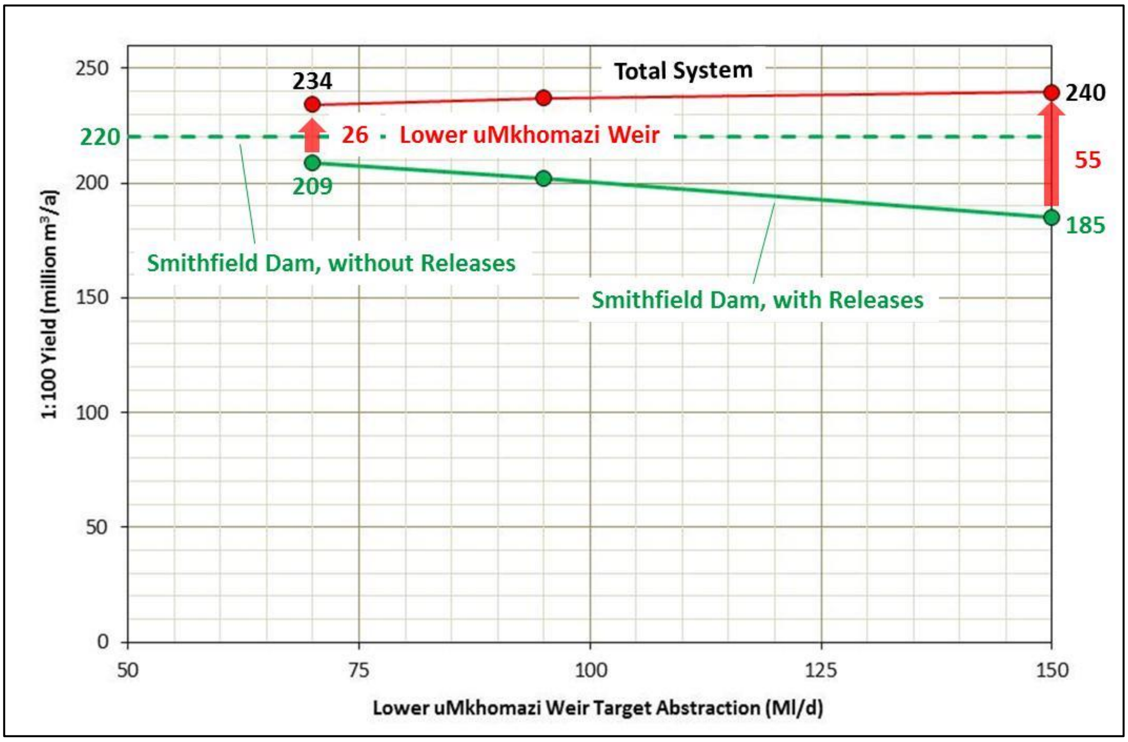

Figure 5.6: Yields for the Lower uMkhomazi Abstraction Weir

The results show:

- Developing the Lower uMkhomazi Abstraction Weir in combination with the uMWP will increase the total yield of the system (represented in **Figure 5.6** by the solid red line).
- For this option, however, the remaining yield available from Smithfield Dam for transfer into the Mgeni WSS decreases significantly (represented by the dashed and solid green lines).
- For example, if a target abstraction of 150 Mℓ/d (55 million m^3/a) is selected for the weir, the system yield increases by 20 million m^3/a to 240 million m^3/a, but the yield of Smithfield decreases from 220 to 185 million m^3/a.

Finally, a comparison is provided in **Figure 5.7** of the above results with those for Ngwadini Dam (as an Umgeni Water scheme, discussed earlier in **Section 5.2.2**). The comparison clearly shows the advantage of the Ngwadini Dam-option over the Lower uMkhomazi Abstraction Weir, as discussed below:

- The storage provided by Ngwadini Dam enables runoff from the lower uMkhomazi River to be utilised more effectively and, therefore, requires less support from Smithfield Dam in order to obtain a selected target abstraction.

- For example, a target abstraction of 150 Mℓ/d (or 55 million m^3/a) for either of the proposed schemes, results in a total system yield for the Ngwadini Dam-option of 250 million m^3/a (represented by the solid blue line), compared to 240 million m^3/a for the Lower uMkhomazi Abstraction Weir-option (represented by the solid red line).
- Furthermore, since the Ngwadini Dam-option requires less support from Smithfield Dam, the remaining yield available at Smithfield for transfer into the Mgeni WSS is also higher at 195 million m^3/a, compared to 185 million m^3/a for the Lower uMkhomazi Abstraction Weir-option (represented by the two solid green lines, as indicated).
- The added advantage of the Ngwadini Dam-option is that it can be developed prior to the uMWP, providing a 1:100-year yield of 34 million m^3/a (as discussed earlier in **Section 5.2.2**). Furthermore, subsequent to the implementation of uMWP, Ngwadini Dam could still yield 24 million m^3/a (represented by the blue arrow) – even without support from Smithfield Dam and the associated reduction in yield available for transfer into the Mgeni WSS.

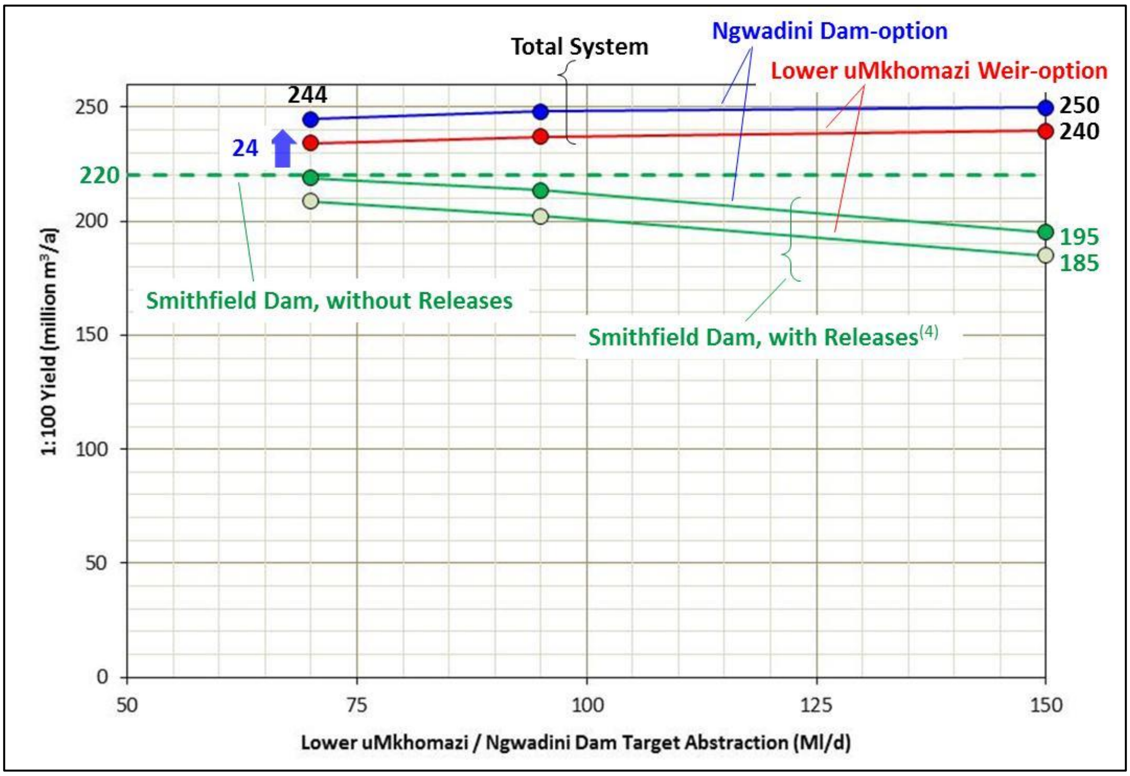

Figure 5.7: Comparison of Lower uMkhomazi Abstraction Weir and Ngwadini Dam

5.4 LANGA DAM

Finally, in support of the engineering investigation of the study, system analyses were undertaken to model the projected water volumes in the proposed Langa Dam. Specifically, the analyses were aimed at determining whether support will be required from Smithfield Dam in order to (i) fill the balancing dam, both upon commissioning and subsequently when water from Langa Dam is used for supply purposes; and (ii) to maintain the water volume in the balancing dam at acceptable levels.

The analyses included the following considerations:

- The proposed balancing dam will be located upstream of an existing dam on the Mbangweni River, a tributary of the uMlaza River. An assessment therefore had to be made of the current yield of the existing Mbangweni Dam. This was required in order to determine the need for making releases from the balancing dam to ensure that the yield of the existing dam is not adversely affected.
- The balancing dam must also make releases to support downstream EWRs (as discussed in **Section 3.2**).
- If Smithfield Dam supports the balancing dam, the support must be provided in such a way that the yield of Smithfield Dam and downstream EWRs in the uMkhomazi River are not negatively affected.
- All scenarios were undertaken at the 2020-development level as this roughly coincides with the anticipated implementation date of Smithfield Dam.

A summary of the four defined scenarios, numbered from **51** to **54**, is provided in **Table 5.7**, together with the corresponding analysis results. The projected water volumes for **Scenarios 52**, **53** and **54** are shown in **Figures D.1** to **D.4** of **Appendix D** in the form of box-and-whisker plots (or "boxplots") derived from the analysis of 1 000 stochastic sequences. These can be interpreted as follows:

- If the balancing dam is not provided with any support from Smithfield Dam it will take over 30 years to fill from local inflows, even if no releases are made for downstream EWRs (as shown in **Figure D.1**). This increases to 50 years with the implementation of the EWR (as shown in **Figure D.2**).
- If the balancing dam is filled from Smithfield Dam the following can be observed:

- The water volume in the balancing dam is maintained at fairly high levels even if no further support is provided from Smithfield Dam, with a minimum projected volume of 14.7 million m^3 at the 99% exceedance probability (as indicated by the bottom red line of the boxplots in **Figure D.3**).
- If support from Smithfield Dam is maintained between filling events, the projected water volumes in the balancing dam improve slightly, with a minimum projected volume of 15.0 million m^3 at the 99% exceedance probability (as indicated by the bottom red line of the boxplots in **Figure D.4**).

Table 5.7: Filling time analysis results for Langa Dam

No.	Existing Mbangweni Dam historical firm yield (million m^3/a)	Langa Dam included	Langa EWR included	Support from Smithfield Dam to Langa Dam	Langa Dam projected filling time (years)
51	0.63	No(1)	-	-	-
52		Yes(2)	No	No	30
53			Yes		50
54				Yes	0

Notes: (1) Scenario to determine the yield of the existing Mbangweni Dam prior to the commissioning of the Langa Dam.

(2) Langa Dam modelled with releases made to ensure that the yield of the existing Mbangweni Dam is not adversely affected.

5.5 STOCHASTIC YIELD-RELIABILITY CHARACTERISTICS

5.5.1 Long-term stochastic YRC curves for uMWP-1 and uMWP-2

Based on the yield analysis results for the uMWP presented earlier in **Sections 5.1.1 (a)** and **5.1.2**, long-term stochastic yield-reliability characteristics (YRC) curve sets were developed for the following scenarios:

- **uMWP-1**: Smithfield Dam (with the adopted FSL of 930 masl), at the 2020-development level (**Scenario 22**, as shown in **Table 5.3**).
- **uMWP-1**: Smithfield Dam (with FSL of 930 m), at the 2050-development level (**Scenario 6**, as shown in **Table 5.2**).
- **uMWP-2**: Smithfield Dam (with FSL of 930 m), in combination with Impendle Dam with a live storage capacity of 50% of the natural MAR, at the 2050-development level (**Scenario 13**, as shown in **Table 5.2**).

- **uMWP-2**: Smithfield Dam (with FSL of 930 m), in combination with Impendle Dam with a live storage capacity of 100% of the natural MAR, at the 2050-development level (**Scenario 17**, as shown in **Table 5.2**).
- **uMWP-2**: Smithfield Dam (with FSL of 930 m), in combination with Impendle Dam with a live storage capacity of 150% of the natural MAR, at the 2050-development level (**Scenario 21**, as shown in **Table 5.2**).

The YRC curve sets are presented in **Figures D.5** to **D.9** of **Appendix D** and show the system yields for each of the scenarios in question at the standard RIs of 1:20-years (or annual assurances of supply of 95%), 1:50 (98%), 1:100 (99%) and 1:200 (99.5%).

5.5.2 Short-term stochastic YRC curves for uMWP-1

Short-term YRC curve sets were developed for Smithfield Dam based on the adopted FSL of 930 masl. These curves sets were later implemented in the detailed planning analysis of the integrated Mgeni WSS using the **Water Resources Planning Model** (WRPM). For this purpose the 2050-development level was selected as this roughly coincides with the anticipated implementation date of Impendle Dam and would therefore be representative of the yield characteristics of Smithfield Dam at that time. More information in this regard is provided in the *Water Resources Planning Model Report* (AECOM, et al., 2014).

YRC curve sets were developed for a range of starting storage levels in Smithfield Dam, namely 100%, 80%, 60%, 40%, 20% and 10% of the live storage capacity. The results are shown graphically in **Figures D.10** to **D.15** of **Appendix D** and the corresponding YRC curve coefficients are provided in **Table D.1**.

5.6 PROJECTED FUTURE WATER BALANCE

Projected future water balances provide a graphical comparison of the available resources within a water resources system (including those from both existing and planned schemes and interventions) and projected water requirements. A water balance can be used as a simple planning tool for providing a preliminary estimate of, for example, the timing and sequencing of future schemes.

Water balances for the integrated Mgeni WSS have been under development for some time, most notably as part of the recent *Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas* (WRP, et al., 2009). Subsequently, as part of this Feasibility study, the water balance was updated based on (i) the yield results obtained for the uMWP-1 and uMWP-2 schemes (as discussed in the previous subsections); and (ii) the updated water requirement projections for the proposed uMWP area of supply developed in the parallel study *uMWP-1: Module 3: Technical Feasibility Study: Potable Water* (Knight Piésold, 2014). The result is shown in **Figure 5.8** and represents a selected scenario which is based on:

- The yield of the **existing Mgeni WSS**, including MMTS-1 and projected growth in Darvil return flows (shaded in purple).
- The yield of the recently completed **Spring Grove Dam**, including the pumping station and pipeline currently under development (MMTS-2) (shaded in blue). The assumed earliest date of implementation is indicated as 2023.
- The 1:100-year yield of the proposed **Smithfield Dam** (uMWP-1) with a selected FSL of 930 m, at the 2050-development level (shaded in blue).
- The contribution to the total system yield of the proposed Impendle Dam (uMWP-2) with a live storage capacity of 50%, 100% or 150% of the natural MAR, also at the 2050-development level (shaded in orange).
- The actual total historical water use in the system, from 2004 to 2011 (represented by the green line).
- The projected total system water requirements (i.e. for both the uMWP area of supply and the remainder of the Mgeni WSS), from 2012 to 2060 (represented by the purple line), based on the scenario developed in December 2013. More information in this regard is provided in the *Water Requirements and Return Flows Report* (AECOM, et al., 2014).

Based on this scenario the water balance shown in **Figure 5.8** provides a preliminary estimate for the implementation date of Impendle Dam of 2046.

Finally, it should be noted that the water balance shows an immediate decrease in the utilisation of Spring Grove Dam with the commissioning of uMWP-1. This is based on the assumption that Smithfield Dam will generally be used in preference to Spring Grove Dam as water from the latter is pumped to the uMgeni River catchment.

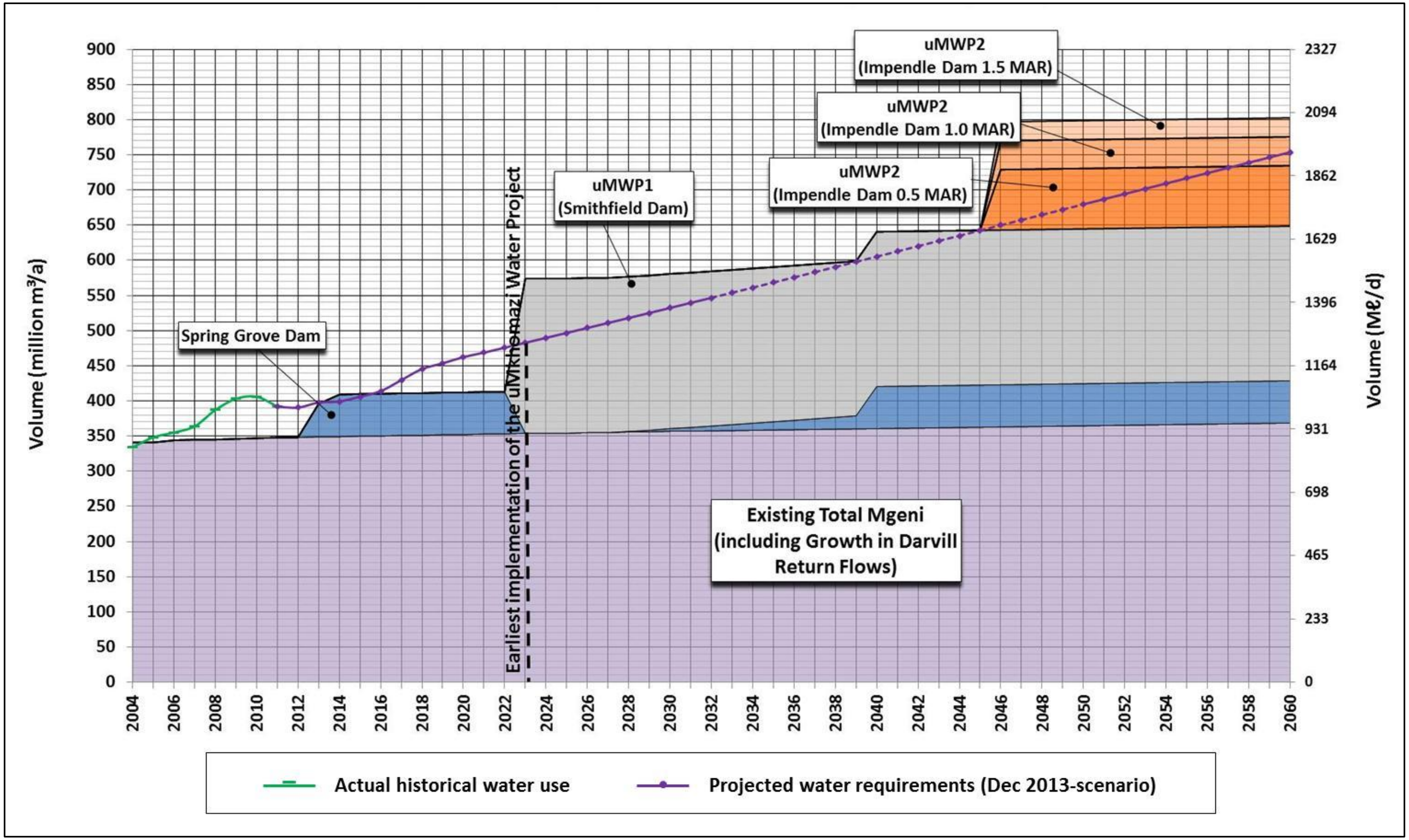

Figure 5.8: Projected future water balance of the Mgeni WSS

6 CONCLUSIONS

6.1 uMWP-1 (SMITHFIELD DAM)

Analyses of the proposed uMWP-1 scheme were undertaken over selected planning period of approximately 40 years up to 2050 and based on a range of selected live storage capacities for Smithfield Dam, from 58 million m^3 (8% of the natural MAR) to 1 452 million m^3 (200% of MAR). Based on the results obtained, the main conclusions were as follows:

- At the 2050-development level, the yield of the dam varies greatly over the range of capacities analysed, from 101 million m^3/a (for the 58 million m^3 dam) to 407 million m^3/a (for the 1 452 million m^3 dam), at a recurrence interval (RI) of failure of 1:100 years (or annual assurance of supply of 99%).
- The results exhibit the typical diminishing incremental benefit in dam yield as storage is increased, clearly illustrated by the yield-storage ratios of the above results, namely 174% (for the 58 million m^3 dam), as opposed to only 28% (for the 1 452 million m^3 dam).
- In line with the above observation, it was found that storage sizes above 50% of the MAR are fairly inefficient from a yield perspective, with the most favourable range being in the region of 30% to 40% of MAR.
- Based on this consideration, as well as other factors discussed in *Supporting Document 3: Optimization of Scheme Configuration* (AECOM, et al., 2014), an FSL of 930 masl was selected for the feasibility design of Smithfield Dam. This dam size corresponds to a live storage capacity of 226 million m^3 (a 31% MAR dam) and provides a 1:100-year yield of 220 million m^3/a, at the 2050-development level.
- The combined effect of anticipated future upstream catchment developments and the loss of utilisable storage due to sedimentation results in a total reduction in the 1:100-year yield of Smithfield Dam of 17 million m^3/a (or 7%), from 237 million m^3/a (at the 2020-development level) to 220 million m^3/a (in 2050, as stated above).

- Providing support from Smithfield Dam for ecological water requirements (EWRs) at Site 1b results in a decrease in the 1:100 yield of 116 million m^3/a (or 33%), from 353 million m^3/a to 237 million m^3/a (as stated above). Note that Site 1b was defined as part of this study and is located directly downstream of the Smithfield Dam site. The associated EWRs were derived based on those developed for the upstream Site 1 in the earlier *Mkomazi IFR Study*, since the latter will be inundated by Smithfield Dam.
- Furthermore, it was found that the yield results obtained in this study compare well to those from the earlier *Pre-feasibility Study* undertaken by Ninham Shand, if a similar modelling approach is adopted where Smithfield is required to provide support only to the downstream EWR Site 2 (as defined in the *Mkomazi IFR Study*).
- Finally, a projected annual water balance was developed for the integrated Mgeni WSS based on (i) updated water requirement projections for the uMWP area of supply developed in the parallel study *uMWP-1: Module 3: Technical Feasibility Study: Potable Water* by Knight Piésold; and (ii) the 1:100-year yield of the proposed Smithfield Dam of 220 million m^3/a (as discussed earlier). This resulted in a preliminary estimate for the implementation date of Impendle Dam of 2046.

6.2 uMWP-2 (Smithfield Dam in combination with Impendle Dam)

Analyses of the proposed uMWP-2 scheme were undertaken based on the implementation of Impendle Dam with a live storage capacity of either 50%, 150% or 200% of the MAR, analysed in combination with the downstream Smithfield Dam based on a range of live storage capacities. All analyses were undertaken at the 2050-development level as this roughly coincides with the anticipated implementation date of Impendle Dam (as mentioned above). Based on the results obtained, the main conclusions were as follows:

- When combined with the selected 930 m FSL Smithfield Dam, the implementation of Impendle Dam will increase the total 1:100-year yield of the system from 220 million m^3/a to between 303 million m^3/a (for a 50% MAR Impendle Dam) and 375 million m^3/a (for a 150% MAR Impendle Dam).
- Furthermore, the results suggest that the yield of uMWP-1 would in fact be similar to that of uMWP-2 if the total live system storage of the two schemes were equal (i.e. the storage in Smithfield Dam compared to that of a combined scheme with Smithfield and Impendle dams). This phenomenon

can be attributed to the specific physical characteristics of the system, as outlined below:

- In the case of uMWP-2, Impendle Dam, with a natural MAR of 571.4 million m^3/a, commands almost 80% of the system runoff and therefore represents the main point of regulation in the system.
- For both uMWP-1 and uMWP-2 water delivered by the scheme will be supplied via the proposed transfer conveyance system from Smithfield Dam. As a result runoff from the incremental catchment, with a natural MAR of only 154.5 million m^3/a, can be utilised effectively even though the majority of the storage in the system is provided in the upstream Impendle Dam.

- The selected operating rule for uMWP-2 (i.e. the conditions under which support is provided from Impendle Dam to Smithfield Dam) was found to have a negligible impact on the total system yield. In line with the observations discussed above this finding can be attributed to the physical characteristics of the system:

  - The selected 930 m FSL Smithfield Dam has a live storage capacity of 226 million m^3, which is fairly large compared to the MAR of 154.5 million m^3/a of the incremental catchment downstream of Impendle Dam.
  - Since all water delivered by the scheme will be supplied from Smithfield Dam, this provides the opportunity to utilise large flows from the incremental catchment, even when Smithfield is spilling.
  - With consideration of the above, it follows that even if the option is selected where water from Smithfield is utilised first for supply into the uMWP supply area, this does not significantly increase the opportunity for utilising floods from the incremental catchment downstream of Impendle Dam.
  - Finally, the surface area of Impendle Dam is much greater than that of Smithfield (a factor of 1.5 for the 50% MAR and 3.0 for the 150% MAR Impendle Dam sizes). Therefore, if water from Smithfield is utilised first, Impendle will generally be operated at higher water levels and, as a result, this will in fact result in an increase in evaporation losses from the system.

6.3 NGWADINI DAM

Based on yield assessments of the proposed off-channel Ngwadini Dam in the lower uMkhomazi River catchment (see **Section 3.5.3**) the main conclusions were as follows:

- If SAPPI-SAICCOR develops Ngwadini Dam, the scheme will provide a 1:100-year yield of 54 million m^3/a – a volume which is in line with their licensed water use of 53 million m^3/a. However, the dam will provide the benefit of significantly increasing SAPPI-SAICCOR's annual assurance of supply to 99%, compared to the current situation where they experience supply failures almost every second year.
- If Umgeni Water were to develop Ngwadini Dam, the scheme would provide a 1:100-year yield of 34 million m^3/a prior to the implementation of Smithfield Dam (at the 2012 development level).
- If Umgeni Water develops Ngwadini Dam the scheme would provide a 1:100-year yield of 34 million m^3/a (93 Mℓ/d).
- After Smithfield Dam is commissioned, the yield of Ngwadini can be maintained at that level, with support from Smithfield Dam. However, the result will be a decrease in the yield of Smithfield Dam, from 220 to 214 million m^3/a.

6.4 LOWER UMKHOMAZI ABSTRACTION WEIR

Based on yield assessments of the proposed Lower uMkhomazi Abstraction Weir, the main conclusions were as follows:

- Developing the Lower uMkhomazi Abstraction Weir in combination with the uMWP-1 will increase the total yield of the system.
- For this option, however, the remaining yield available from Smithfield Dam for transfer into the Mgeni WSS decreases significantly. For example, a yield of 34 million m^3/a (95 Mℓ/d) can be achieved at the weir but with a corresponding decrease in the yield of Smithfield Dam from 220 to 202 million m^3/a.
- The results also clearly show the advantage of the Ngwadini Dam-option over the Lower uMkhomazi Abstraction Weir. Firstly, if support is provided from Smithfield Dam, any of the selected target abstractions can be achieved in the lower uMkhomazi. However, Ngwadini Dam would require less support and, therefore, have a smaller impact on the remaining yield available at

Smithfield Dam. The added advantage of Ngwadini Dam is that, unlike the Lower uMkhomazi Abstraction Weir, it can be developed prior to the uMWP as a stand-alone scheme without the need for support from upstream storage.

6.5 LANGA DAM

Based on system analyses undertaken to model the projected water volumes in the proposed Langa Dam, the main conclusions were as follows:

- If the balancing dam is not provided with any support from Smithfield Dam it will take over 30 years to fill from local inflows, even if no releases are made for downstream EWRs. This increases to 50 years with the implementation of the EWR.
- If the balancing dam is filled from Smithfield Dam but no further support is provided, water volumes are maintained at fairly high levels. In this case the minimum projected water volume is 14.7 million m^3 at the 99% exceedance probability.
- If the balancing dam is filled from Smithfield Dam and support is maintained between filling events, the projected water volumes in the balancing dam improve slightly with a minimum of 15.0 million m^3 at the 99% exceedance probability.

7 RECOMMENDATIONS

Based on the conclusions discussed in the previous section, the following recommendation can be made:

- It was found that storage sizes for Smithfield Dam ranging from 30% to 40% of MAR are most favourable from a yield perspective and this provides further motivation for the FSL of 930 m selected for the feasibility design of the dam, which corresponds to a live storage capacity of 226 million m^3 (or 31% of MAR).
- The projected water balance developed for the Mgeni Water Supply System (WSS) resulted in an estimated implementation date for Impendle Dam (uMWP-2) of 2046. However, this date should be treated as preliminary and will be refined in the later *Water Resources Planning Analysis* task of the study.
- Since the selected operating rule for uMWP-2 (Smithfield Dam in combination with Impendle Dam) was found to have a negligible impact on the yield of the system, it is recommended that the system is operated in such a way that Smithfield is kept full with releases from Impendle Dam (which equates to water from Impendle being utilised first for supply into the uMWP supply area). The advantage of adopting this rule is that it will result in Smithfield generally being operated at higher water levels, thereby maximising the available water head and, therefore, the potential for generating hydropower through the transfer conveyance system to the Mgeni WSS.
- For the development of available resources in the lower uMkhomazi River catchment, Ngwadini Dam should be considered in favour of the Lower uMkhomazi Abstraction Weir. The Ngwadini Dam-option requires less (or no) support from Smithfield Dam, resulting in more yield being available at Smithfield Dam for transfer into the Mgeni WSS. The added advantage of Ngwadini Dam is that, unlike the Lower uMkhomazi Abstraction Weir, it does not require support from Smithfield Dam and can therefore be developed prior to the uMWP.
- Since local inflows are insufficient to fill and maintain the proposed Langa balancing dam at acceptable storage volumes, it is recommended that the dam is filled from Smithfield Dam – both upon commissioning and subsequently when water from Langa Dam is used for supply purposes.

- Between the above filling events, support from Smithfield Dam should be maintained, but in such a way that the yield of Smithfield Dam and downstream EWRs in the uMkhomazi River are not negatively affected. However, it should be noted that this operating rule was not optimised as part of this study and further investigations in this regard are therefore required.
- Results from the recently commissioned RDM Reserve Study were not available in time for consideration in this yield assessment. It is therefore recommended that, when the RDM study is completed, the impact of the Reserve on the uMWP and proposed developments in the lower uMkhomazi and upper uMlaza river catchments are re-evaluated. In particular, this includes investigations into the following:
    - Support provided from Smithfield Dam for downstream EWRs. For the purposes of this study derived EWR Site 1b was adopted. However, the possible benefits of supporting only Site 2, which would require smaller and less frequent releases from Smithfield Dam, should be weighed up against the possible associated negative impacts on the ecological health of the river reach directly downstream of Smithfield Dam.
    - Flow requirements for the uMkhomazi River estuary. For the purposes of this study estuary flows were based on the existing licence conditions of industrial water user SAPPI-SAICCOR, that allow for abstractions to be made from the river only when the flow into the estuary exceeds 1 m^3/s.

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Appendix A

Figures

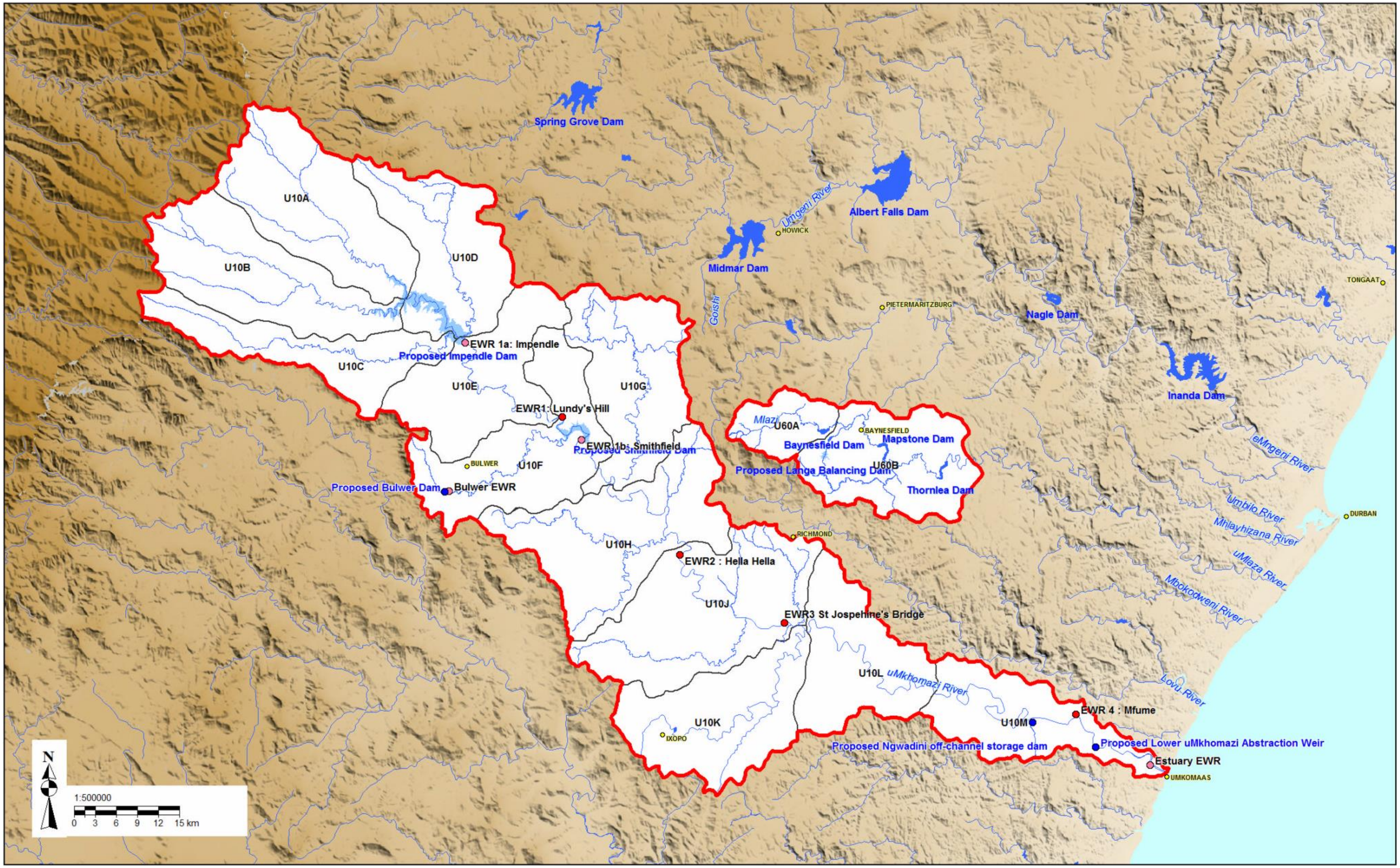

Figure A.1: Locality Map

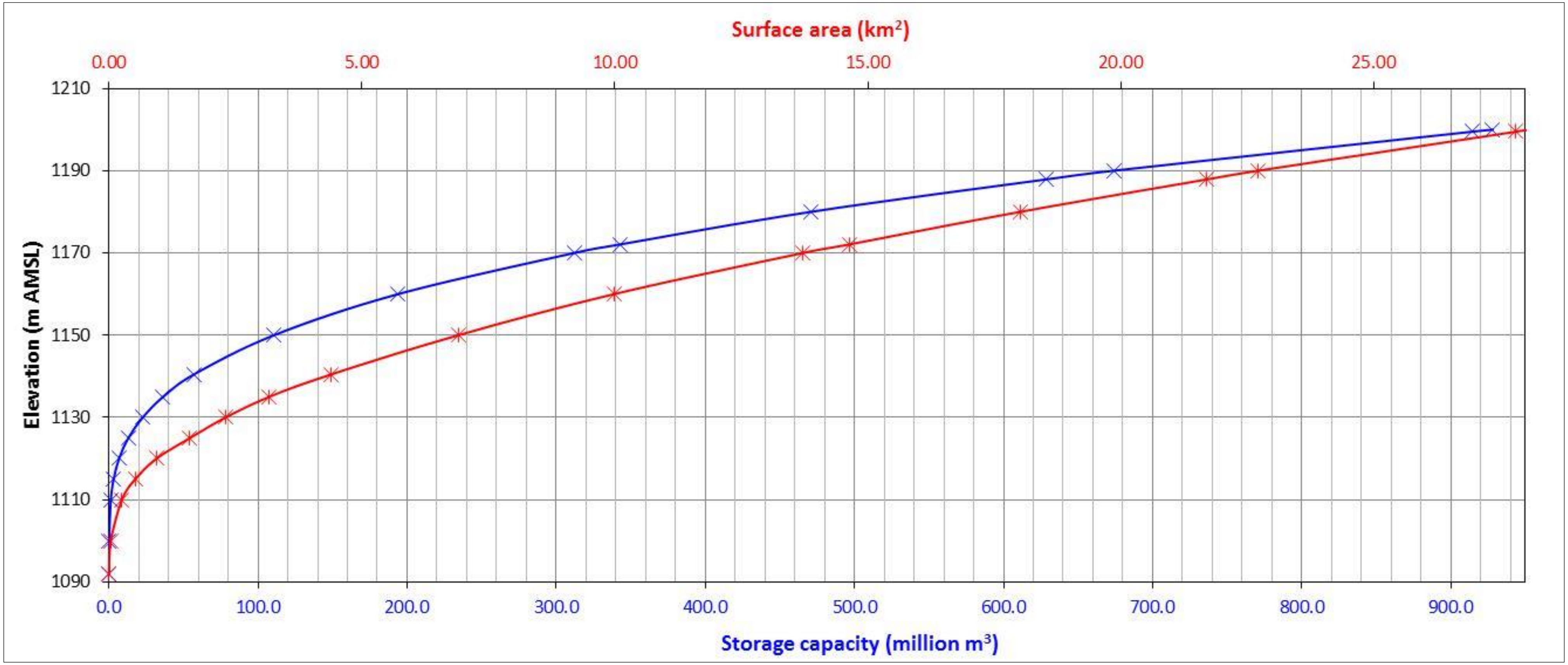

Figure A.2: Physical characteristics of the proposed Impendle Dam

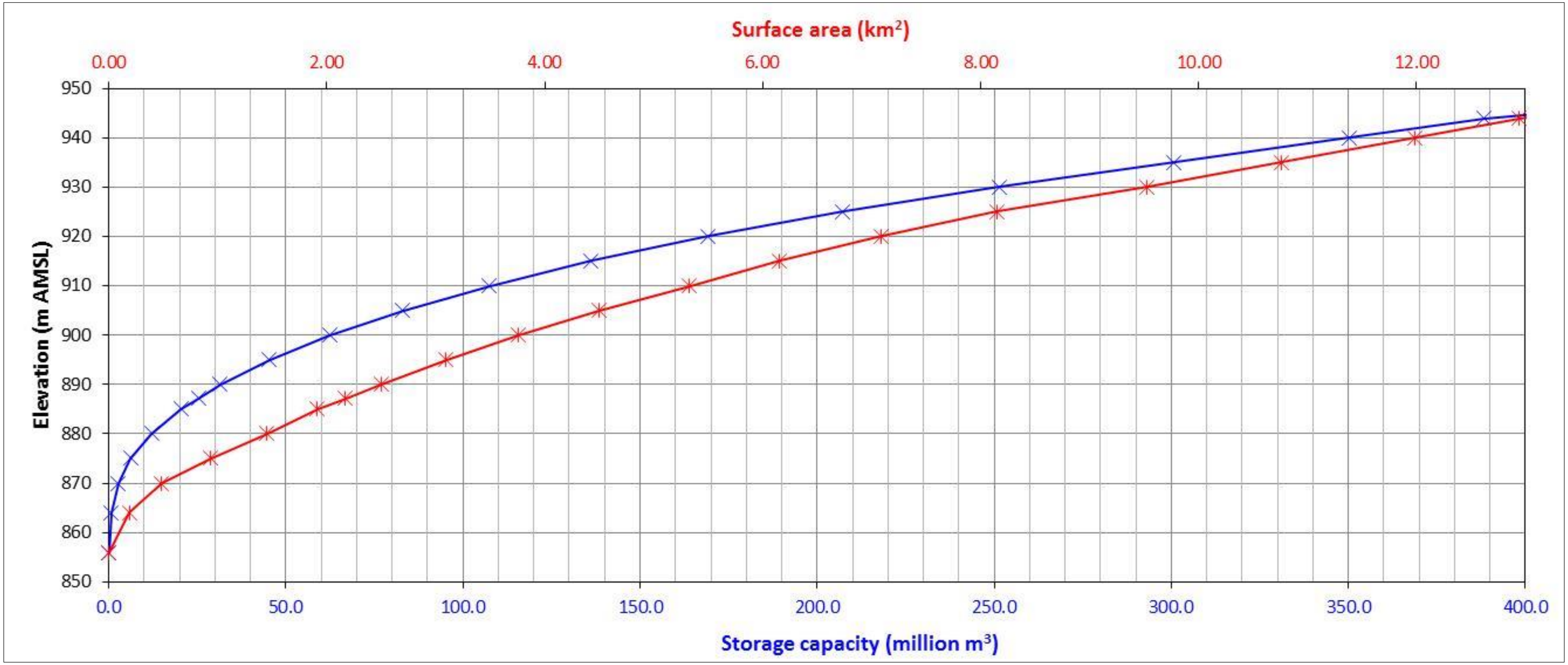

Figure A.3: Physical characteristics of the proposed Smithfield Dam (Site "B")

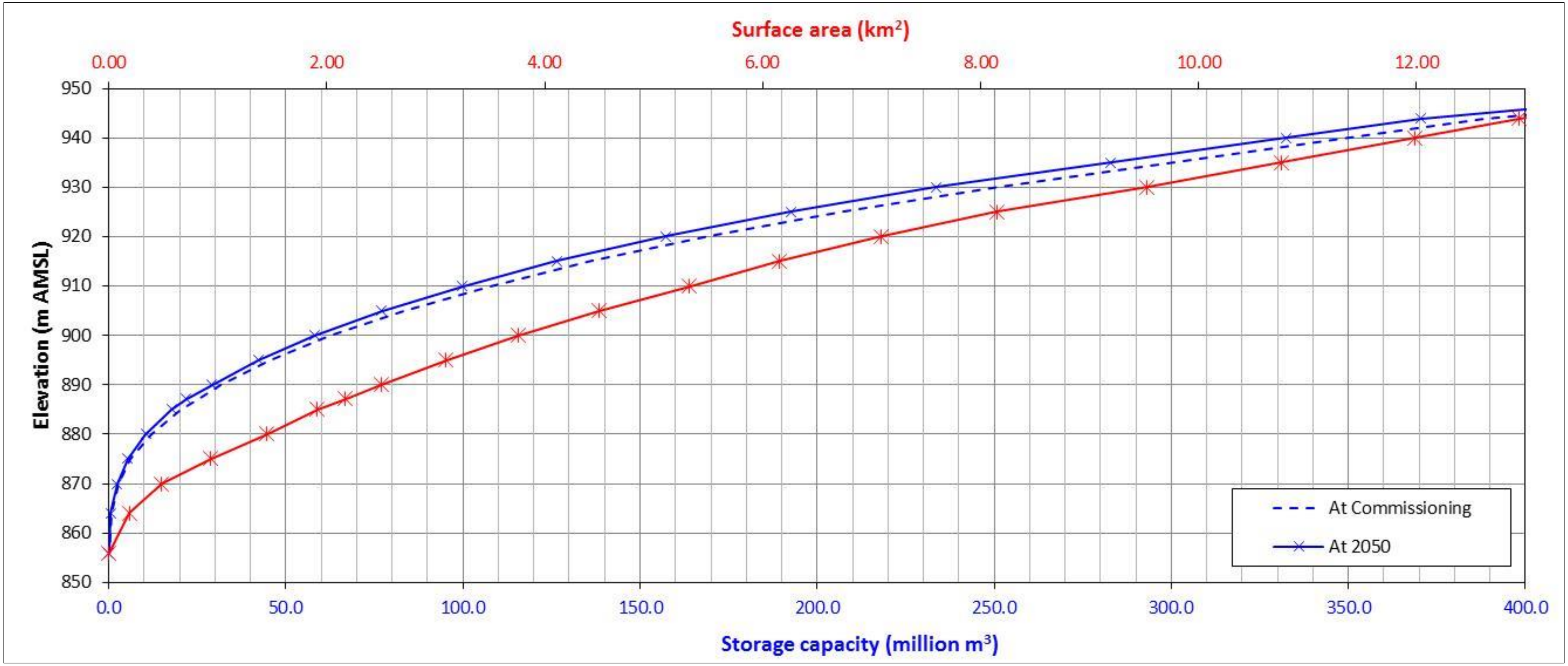

Figure A.4: Adopted physical characteristics for Smithfield Dam (2050)

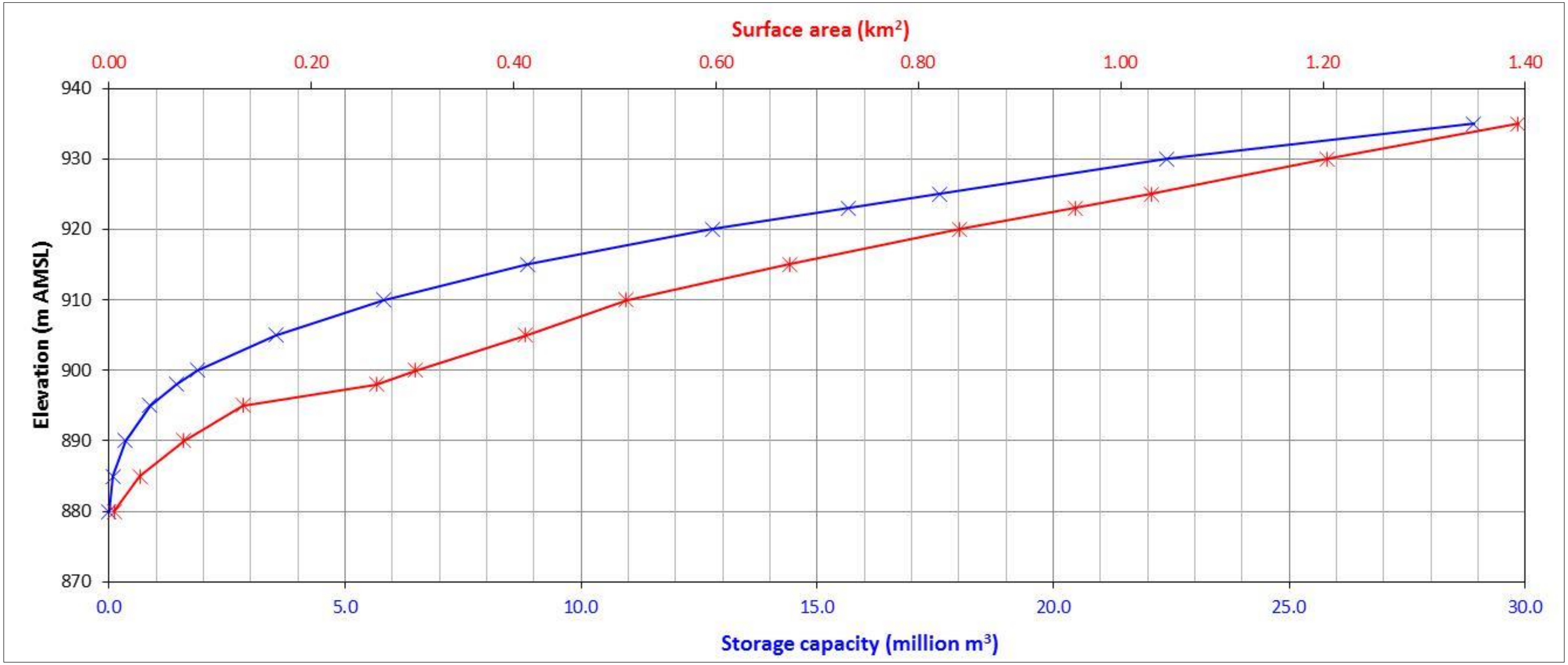

Figure A.5: Physical characteristics of the proposed Langa Dam

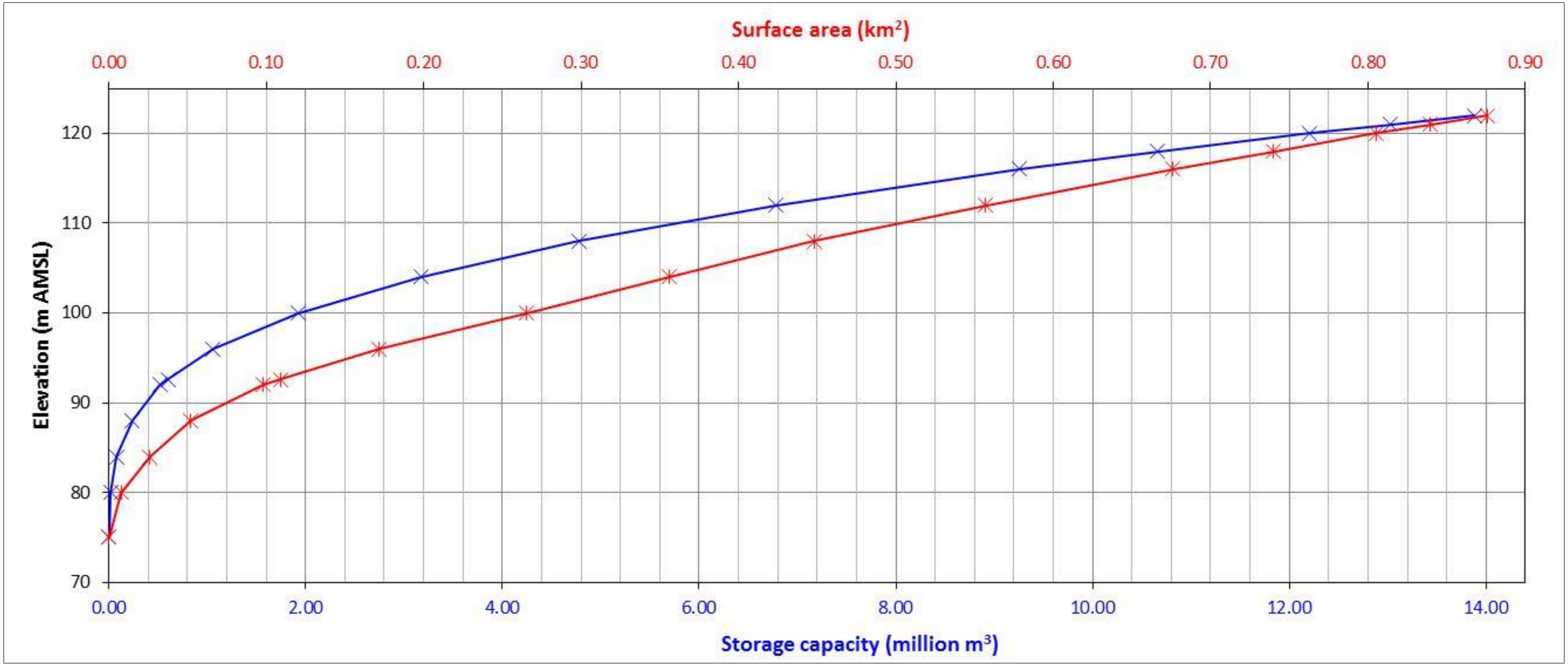

Figure A.6: Physical characteristics of the proposed Ngwadini Dam

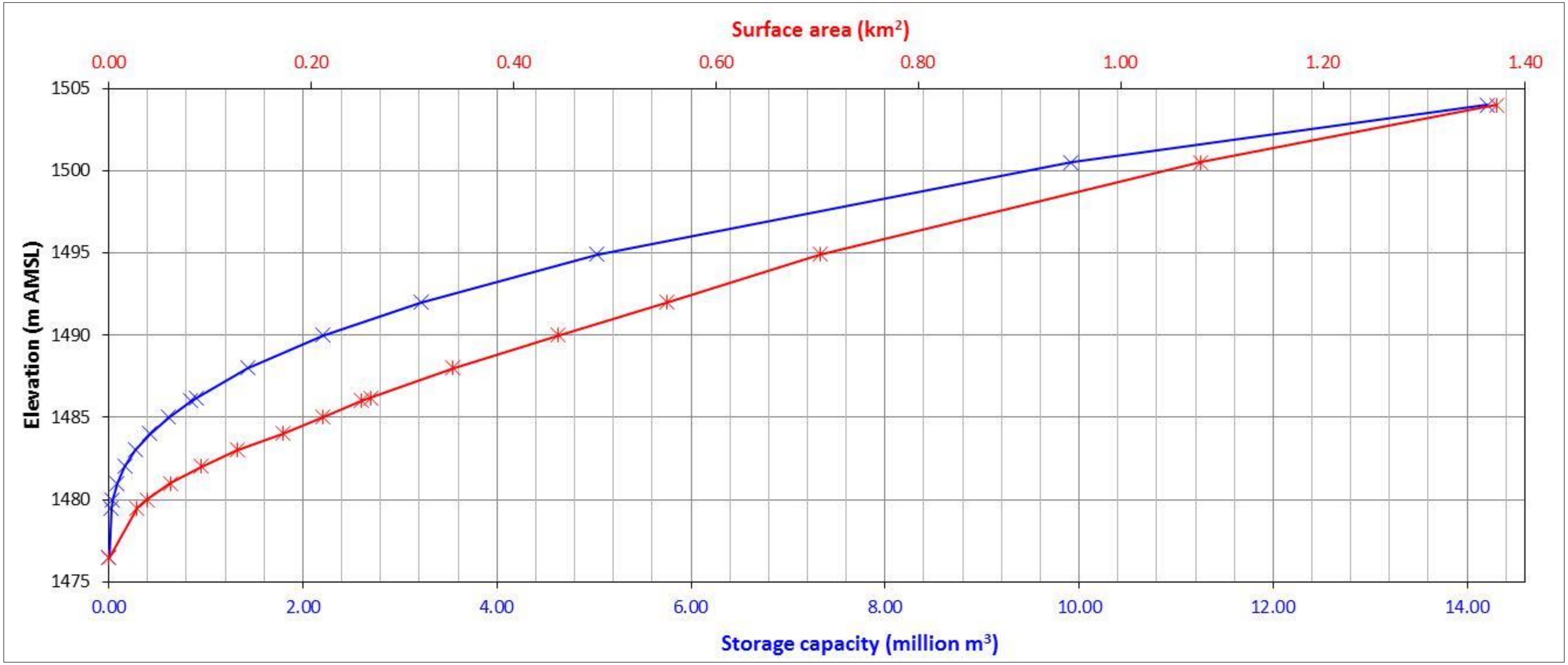

Figure A.7: Physical characteristics of the proposed Bulwer Dam

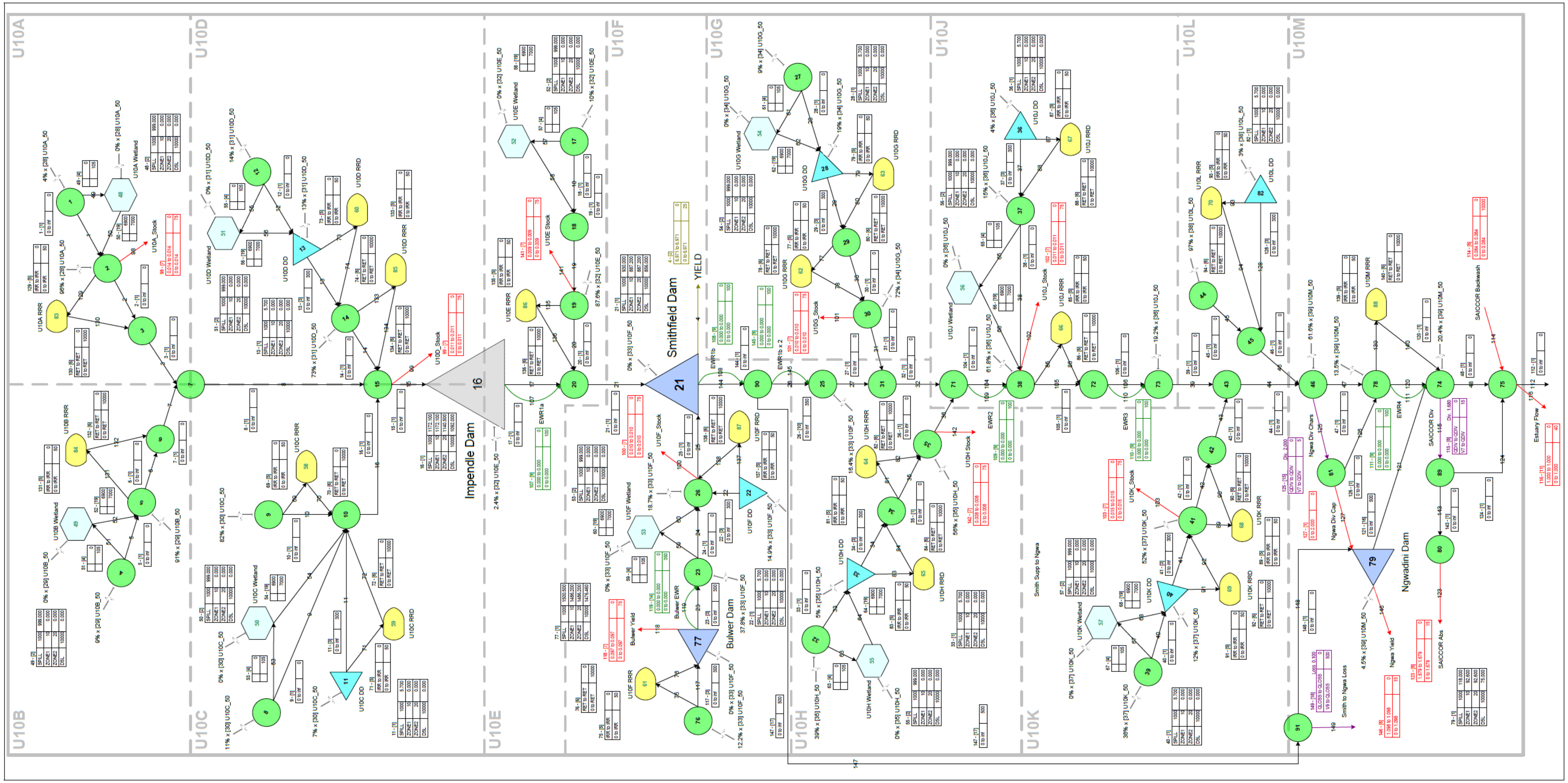

Figure A.8: WRYM system schematic diagram

Appendix B

Hydro-meteorological data

Monthly catchment rainfall (mm) for quaternary catchment U10A (U10A.RAN)

1925	122.78	88.67	123.94	173.23	155.73	183.65	22.65	29.47	40.15	0.00	0.00	164.99	1105.28
1926	83.27	109.52	235.91	206.31	144.66	152.64	47.10	6.69	0.00	15.70	68.08	19.69	1089.57
1927	150.58	70.14	239.12	311.45	165.89	267.18	24.71	31.40	0.00	1.29	47.62	11.33	1320.72
1928	144.14	99.61	264.48	217.76	91.51	247.62	78.89	90.48	68.73	87.52	1.67	141.31	1533.72
1929	119.30	178.64	152.51	249.29	179.15	194.47	12.74	23.42	0.00	6.69	35.14	14.29	1165.64
1930	76.45	101.42	308.75	147.75	178.64	146.33	72.46	1.29	0.64	71.17	0.00	6.95	1111.84
1931	65.51	73.62	101.80	206.95	294.47	70.66	7.34	34.75	4.76	4.76	1.29	92.02	957.91
1932	85.97	177.09	182.63	73.10	169.76	124.58	46.20	1.03	2.70	29.60	2.57	9.14	904.37
1933	56.89	316.22	280.82	360.10	157.01	151.99	130.63	88.03	0.77	50.58	42.47	51.22	1686.74
1934	111.20	359.59	279.79	112.36	171.69	137.32	36.29	10.81	82.75	1.16	22.01	14.80	1339.77
1935	29.73	48.65	104.76	206.43	192.02	160.49	32.30	97.30	5.02	1.54	0.00	51.35	929.60
1936	77.48	237.58	135.52	244.27	209.01	136.55	13.51	8.37	4.25	0.90	0.00	18.28	1085.71
1937	72.20	142.47	152.38	289.83	248.52	84.81	117.89	10.17	21.88	38.74	43.89	20.21	1242.98
1938	187.26	134.23	327.16	158.94	340.93	183.78	42.73	17.12	0.00	21.36	16.22	87.52	1517.24
1939	90.86	176.45	160.62	221.11	117.50	206.56	57.01	147.75	71.94	0.00	7.46	66.80	1324.07
1940	111.58	186.87	376.19	229.47	318.66	144.14	67.18	0.00	6.56	16.22	0.77	16.09	1473.74
1941	88.67	91.63	179.92	356.89	317.63	203.86	135.39	23.29	2.83	40.67	35.39	27.54	1503.73
1942	136.29	245.82	328.31	370.14	227.80	151.35	319.18	116.73	18.40	93.95	131.66	17.12	2156.75
1943	239.90	158.69	259.59	237.97	225.48	238.35	11.97	8.37	50.19	3.60	6.69	168.73	1609.52
1944	92.54	75.42	73.75	211.58	173.62	289.96	69.63	27.93	0.00	0.00	8.11	6.95	1029.47
1945	64.35	16.86	108.11	177.48	187.26	171.69	85.84	4.63	0.00	1.54	0.00	16.34	834.10
1946	54.95	203.35	142.60	197.04	276.71	198.58	42.08	63.45	48.39	11.45	0.51	30.37	1269.50
1947	93.05	185.46	248.26	282.24	188.67	224.84	74.26	50.45	0.00	0.90	0.00	21.11	1369.24
1948	71.94	103.73	159.07	209.52	208.24	221.75	70.79	9.91	0.39	4.89	12.10	54.57	1126.90
1949	43.50	145.43	244.02	104.76	257.53	340.15	126.90	74.00	4.63	37.84	104.25	22.78	1505.79
1950	23.81	124.84	261.00	318.79	143.89	107.98	79.54	1.54	2.83	0.00	95.88	51.09	1211.20
1951	103.09	22.14	261.78	294.08	259.72	123.17	80.95	31.79	11.07	34.36	40.67	25.48	1288.29
1952	74.26	167.05	146.98	199.61	227.67	74.13	54.83	1.67	17.25	0.00	31.02	75.55	1070.01
1953	113.00	150.19	244.79	168.60	331.79	181.21	35.39	94.59	8.24	4.50	0.77	86.62	1419.69
1954	136.04	146.59	226.51	377.61	276.96	103.99	68.34	39.51	26.25	7.21	0.00	46.98	1455.98
1955	46.33	79.79	335.39	129.73	327.28	230.12	30.89	16.73	0.00	0.00	34.36	23.81	1254.44
1956	98.33	195.75	397.68	312.87	172.33	227.41	78.76	26.64	20.33	16.60	68.98	195.50	1811.20
1957	169.88	105.79	252.38	314.03	172.33	141.06	109.52	11.20	0.00	0.00	0.00	79.92	1356.11
1958	74.13	129.60	308.75	188.55	154.31	98.33	65.12	291.76	0.00	28.57	19.31	24.07	1382.50
1959	89.06	176.71	156.50	149.42	193.56	205.02	123.68	22.14	0.00	4.12	16.86	46.46	1183.53
1960	49.55	181.60	290.22	65.77	157.40	185.59	114.29	0.39	12.48	3.99	4.89	61.90	1128.06
1961	41.83	131.02	205.15	208.75	159.07	107.85	69.24	15.32	0.00	0.90	45.69	6.95	991.76
1962	69.76	158.17	190.60	301.67	84.68	206.69	42.86	20.08	25.74	61.39	0.39	3.73	1165.76
1963	159.72	167.95	151.35	269.88	85.84	200.39	85.20	9.14	70.01	2.70	3.60	100.26	1306.05
1964	128.31	164.86	208.24	222.78	125.10	45.05	68.85	26.51	97.17	10.68	67.70	52.51	1217.76
1965	60.36	101.80	89.96	325.35	186.62	32.43	55.60	39.90	7.72	0.00	72.20	53.93	1025.87
1966	76.71	166.54	261.65	317.12	228.31	242.99	140.15	12.74	14.41	14.54	9.14	12.87	1497.17
1967	103.09	134.49	163.84	165.77	148.52	140.93	66.28	3.22	0.77	4.38	45.05	47.10	1023.42
1968	71.04	163.71	184.56	110.04	205.41	242.99	94.08	30.50	11.71	14.16	14.93	53.15	1196.27
1969	181.21	90.73	272.97	136.29	184.81	63.71	24.84	22.65	23.42	6.18	103.47	56.50	1166.79
1970	118.40	70.27	82.11	179.02	143.24	159.97	43.11	82.37	8.88	55.47	63.45	25.61	1031.92
1971	124.32	144.53	148.52	306.95	294.98	246.59	19.18	40.54	1.54	9.01	16.99	31.15	1384.30
1972	92.41	225.74	111.97	162.03	214.93	150.58	147.49	7.59	0.00	15.32	76.45	90.73	1295.24
1973	71.04	191.63	215.06	415.96	327.16	316.09	125.61	21.62	32.56	19.69	10.42	5.66	1752.51
1974	65.77	178.89	172.07	345.69	225.23	144.79	63.32	8.49	3.73	1.54	4.38	143.11	1357.01
1975	64.99	165.12	381.08	407.72	330.76	443.11	60.62	42.34	1.29	7.08	14.03	52.38	1970.53
1976	134.36	74.52	149.29	227.67	172.72	134.11	97.04	6.31	2.45	3.86	38.48	82.75	1123.55
1977	99.36	133.85	165.64	274.52	239.64	178.76	108.75	3.47	0.13	2.32	41.83	97.68	1345.94
1978	132.30	174.39	324.58	139.64	161.26	111.07	51.48	42.73	0.26	55.08	54.18	36.16	1283.14
1979	65.38	145.17	159.85	275.16	166.28	196.01	59.46	9.91	0.00	1.93	7.98	161.26	1248.39
1980	64.35	130.76	223.17	249.81	301.42	101.93	58.69	19.43	7.08	8.37	80.57	59.85	1305.40
1981	63.06	124.58	179.28	167.82	104.12	273.36	48.13	16.60	8.49	7.72	2.96	49.68	1045.82
1982	142.34	80.44	131.15	147.36	102.06	108.88	55.47	9.01	3.60	26.64	26.90	27.54	861.39
1983	146.98	211.07	302.70	222.14	157.66	222.14	74.77	23.81	19.56	33.46	32.18	22.78	1469.24
1984	99.10	142.47	92.79	282.50	345.04	77.48	19.18	7.85	10.04	4.63	3.86	40.28	1125.22
1985	240.67	165.12	257.79	247.23	137.71	131.02	82.11	0.13	22.52	1.42	55.34	58.69	1399.74
1986	174.65	180.18	197.30	180.57	142.86	161.00	38.87	22.01	30.12	4.38	90.73	366.80	1589.45
1987	151.99	122.39	170.66	197.68	432.43	297.81	67.95	32.05	48.52	19.82	25.23	50.58	1617.12
1988	72.84	174.39	225.23	259.20	378.51	154.57	76.32	21.36	16.47	1.29	0.39	11.33	1391.89
1989	85.97	264.48	225.35	202.70	118.28	252.38	54.95	4.25	11.45	4.76	67.57	23.29	1315.44
1990	90.35	46.85	237.84	308.11	245.56	149.03	8.11	5.79	16.60	10.94	53.41	65.12	1237.71
1991	179.28	122.27	207.34	176.32	209.52	74.39	35.91	0.64	0.00	0.00	14.67	28.96	1049.29
1992	67.95	87.52	127.80	133.98	222.78	153.02	82.24	7.21	0.00	0.00	11.58	42.34	936.42
1993	193.44	177.99	211.45	384.43	268.73	158.43	55.98	4.89	5.15	37.84	29.47	11.84	1539.64
1994	102.06	27.80	184.17	248.78	103.47	199.74	110.55	13.90	28.70	1.67	15.70	33.46	1070.01
1995	111.33	166.92	314.67	345.04	257.91	186.62	64.86	34.11	1.42	72.97	26.64	16.22	1598.71
1996	108.49	102.06	269.37	287.52	138.10	259.72	41.57	31.27	55.21	19.95	9.14	39.00	1361.39
1997	102.70	261.00	247.23	209.78	317.12	122.65	51.35	15.57	0.00	4.25	20.46	27.41	1379.54
1998	59.33	189.45	167.31	228.83	224.07	160.36	49.42	1.93	2.45	6.95	1.54	8.49	1100.13
1999	133.72	64.35	235.78	276.96	294.08	508.88	94.72	39.25	1.16	0.00	1.16	103.73	1753.79
2000	92.66	146.20	153.54	207.59	171.04	171.69	59.85	6.44	8.75	18.79	42.34	90.09	1168.98
2001	145.43	191.63	174.00	187.52	121.75	133.08	38.35	35.39	19.56	44.02	59.97	38.74	1189.45
2002	38.22	80.57	198.07	193.69	208.11	134.11	105.92	24.84	6.69	2.45	13.77	77.48	1083.91
2003	35.78	136.29	132.69	297.17	242.08	146.98	33.20	7.98	16.86	46.20	8.37	61.26	1164.86
2004	108.75	227.80	175.16	252.90	232.05	229.09	36.16	11.07	10.94	0.00	32.56	16.99	1333.46
2005	95.62	177.48	124.97	332.17	267.05	98.97	83.27	2.96	0.00	0.00	66.92	36.68	1286.10
2006	139.25	161.00	217.37	186.36	118.40	109.14	63.58	0.00	21.49	29.34	29.60	31.92	1107.46
2007	189.45	94.85	120.08	260.10	204.50	270.66	118.92	5.79	34.88	0.00	8.88	49.81	1357.91
2008	47.23	85.71	181.60	216.09	249.29	175.42	53.02	22.27	21.11	1.54	38.87	39.12	1131.27
Ave:	102.28	144.46	206.86	235.21	209.71	177.36	68.73	28.43	15.05	15.92	29.31	53.71	1287.00

Monthly catchment rainfall (mm) for quaternary catchment U10B (U10B.RAN)

1925	112.19	81.03	113.25	158.29	142.30	167.82	20.70	26.93	36.69	0.00	0.00	150.76	1009.95
1926	76.09	100.08	215.56	188.51	132.18	139.47	43.04	6.12	0.00	14.35	62.21	17.99	995.60
1927	137.59	64.09	218.50	284.59	151.59	244.14	22.58	28.69	0.00	1.18	43.51	10.35	1206.81
1928	131.71	91.02	241.67	198.98	83.61	226.26	72.09	82.67	62.80	79.97	1.53	129.12	1401.44
1929	109.02	163.23	139.36	227.79	163.70	177.69	11.64	21.40	0.00	6.12	32.10	13.05	1065.10
1930	69.85	92.67	282.12	135.00	163.23	133.71	66.21	1.18	0.59	65.03	0.00	6.35	1015.95
1931	59.86	67.27	93.02	189.10	269.07	64.56	6.70	31.75	4.35	4.35	1.18	84.08	875.30
1932	78.56	161.82	166.87	66.80	155.11	113.84	42.22	0.94	2.47	27.05	2.35	8.35	826.38
1933	51.98	288.94	256.60	329.04	143.47	138.89	119.36	80.44	0.71	46.22	38.81	46.80	1541.27
1934	101.61	328.57	255.66	102.66	156.88	125.48	33.16	9.88	75.62	1.06	20.11	13.52	1224.22
1935	27.17	44.45	95.73	188.63	175.46	146.65	29.52	88.91	4.59	1.41	0.00	46.92	849.42
1936	70.80	217.09	123.83	223.20	190.98	124.77	12.35	7.64	3.88	0.82	0.00	16.70	992.07
1937	65.97	130.18	139.24	264.84	227.09	77.50	107.72	9.29	19.99	35.40	40.10	18.46	1135.78
1938	171.11	122.66	298.94	145.24	311.52	167.93	39.04	15.64	0.00	19.52	14.82	79.97	1386.39
1939	83.03	161.23	146.76	202.04	107.37	188.75	52.10	135.00	65.74	0.00	6.82	61.03	1209.87
1940	101.96	170.76	343.74	209.68	291.18	131.71	61.39	0.00	6.00	14.82	0.71	14.70	1346.64
1941	81.03	83.73	164.40	326.10	290.24	186.28	123.72	21.29	2.59	37.16	32.34	25.17	1374.04
1942	124.54	224.62	300.00	338.22	208.15	138.30	291.65	106.66	16.82	85.85	120.30	15.64	1970.74
1943	219.21	145.00	237.20	217.44	206.04	217.80	10.94	7.64	45.86	3.29	6.12	154.17	1470.71
1944	84.55	68.91	67.38	193.33	158.64	264.95	63.62	25.52	0.00	0.00	7.41	6.35	940.68
1945	58.80	15.41	98.78	162.17	171.11	156.88	78.44	4.23	0.00	1.41	0.00	14.94	762.17
1946	50.22	185.81	130.30	180.05	252.84	181.46	38.46	57.98	44.22	10.47	0.47	27.75	1160.01
1947	85.02	169.46	226.85	257.90	172.40	205.45	67.86	46.10	0.00	0.82	0.00	19.29	1251.15
1948	65.74	94.79	145.35	191.45	190.28	202.62	64.68	9.06	0.35	4.47	11.05	49.86	1029.71
1949	39.75	132.89	222.97	95.73	235.32	310.82	115.95	67.62	4.23	34.57	95.26	20.82	1375.92
1950	21.76	114.07	238.49	291.30	131.48	98.67	72.68	1.41	2.59	0.00	87.61	46.69	1106.73
1951	94.20	20.23	239.20	268.72	237.32	112.54	73.97	29.05	10.11	31.40	37.16	23.28	1177.18
1952	67.86	152.64	134.30	182.40	208.03	67.74	50.10	1.53	15.76	0.00	28.34	69.03	977.73
1953	103.25	137.24	223.68	154.06	303.17	165.58	32.34	86.44	7.53	4.12	0.71	79.14	1297.25
1954	124.30	133.95	206.98	345.04	253.08	95.02	62.45	36.10	23.99	6.59	0.00	42.92	1330.41
1955	42.34	72.91	306.47	118.54	299.06	210.27	28.22	15.29	0.00	0.00	31.40	21.76	1146.25
1956	89.85	178.87	363.38	285.89	157.47	207.80	71.97	24.34	18.58	15.17	63.03	178.63	1654.98
1957	155.23	96.67	230.61	286.94	157.47	128.89	100.08	10.23	0.00	0.00	0.00	73.03	1239.15
1958	67.74	118.42	282.12	172.28	141.00	89.85	59.51	266.60	0.00	26.11	17.64	21.99	1263.26
1959	81.38	161.46	143.00	136.53	176.87	187.34	113.01	20.23	0.00	3.76	15.41	42.45	1081.45
1960	45.28	165.93	265.19	60.09	143.82	169.58	104.43	0.35	11.41	3.65	4.47	56.57	1030.76
1961	38.22	119.72	187.45	190.75	145.35	98.55	63.27	13.99	0.00	0.82	41.75	6.35	906.23
1962	63.74	144.53	174.17	275.65	77.38	188.87	39.16	18.35	23.52	56.10	0.35	3.41	1065.22
1963	145.94	153.47	138.30	246.61	78.44	183.10	77.85	8.35	63.97	2.47	3.29	91.61	1193.40
1964	117.25	150.65	190.28	203.57	114.31	41.16	62.92	24.23	88.79	9.76	61.86	47.98	1112.73
1965	55.15	93.02	82.20	297.29	170.52	29.64	50.80	36.46	7.06	0.00	65.97	49.27	937.39
1966	70.09	152.17	239.08	289.77	208.62	222.03	128.07	11.64	13.17	13.29	8.35	11.76	1368.04
1967	94.20	122.89	149.70	151.47	135.71	128.77	60.56	2.94	0.71	4.00	41.16	43.04	935.16
1968	64.92	149.59	168.64	100.55	187.69	222.03	85.97	27.87	10.70	12.94	13.64	48.57	1093.09
1969	165.58	82.91	249.43	124.54	168.87	58.21	22.70	20.70	21.40	5.64	94.55	51.63	1066.16
1970	108.19	64.21	75.03	163.58	130.89	146.18	39.40	75.26	8.11	50.69	57.98	23.40	942.92
1971	113.60	132.06	135.71	280.48	269.54	225.32	17.52	37.04	1.41	8.23	15.52	28.46	1264.91
1972	84.44	206.27	102.31	148.06	196.39	137.59	134.77	6.94	0.00	13.99	69.85	82.91	1183.53
1973	64.92	175.11	196.51	380.08	298.94	288.83	114.78	19.76	29.75	17.99	9.53	5.17	1601.36
1974	60.09	163.46	157.23	315.87	205.80	132.30	57.86	7.76	3.41	1.41	4.00	130.77	1239.97
1975	59.39	150.88	348.21	372.56	302.23	404.90	55.39	38.69	1.18	6.47	12.82	47.86	1800.57
1976	122.77	68.09	136.42	208.03	157.82	122.54	88.67	5.76	2.23	3.53	35.16	75.62	1026.65
1977	90.79	122.30	151.35	250.84	218.97	163.35	99.37	3.18	0.12	2.12	38.22	89.26	1229.86
1978	120.89	159.35	296.59	127.60	147.35	101.49	47.04	39.04	0.24	50.33	49.51	33.05	1172.47
1979	59.74	132.65	146.06	251.43	151.94	179.10	54.33	9.06	0.00	1.76	7.29	147.35	1140.72
1980	58.80	119.48	203.92	228.26	275.42	93.14	53.63	17.76	6.47	7.64	73.62	54.68	1192.82
1981	57.62	113.84	163.82	153.35	95.14	249.78	43.98	15.17	7.76	7.06	2.70	45.39	955.62
1982	130.07	73.50	119.83	134.65	93.26	99.49	50.69	8.23	3.29	24.34	24.58	25.17	787.10
1983	134.30	192.86	276.60	202.98	144.06	202.98	68.33	21.76	17.88	30.58	29.40	20.82	1342.52
1984	90.55	130.18	84.79	258.13	315.29	70.80	17.52	7.17	9.17	4.23	3.53	36.81	1028.18
1985	219.91	150.88	235.55	225.91	125.83	119.72	75.03	0.12	20.58	1.29	50.57	53.63	1279.02
1986	159.58	164.64	180.28	164.99	130.54	147.12	35.52	20.11	27.52	4.00	82.91	335.16	1452.36
1987	138.89	111.84	155.94	180.63	395.14	272.13	62.09	29.28	44.34	18.11	23.05	46.22	1477.64
1988	66.56	159.35	205.80	236.85	345.86	141.24	69.74	19.52	15.05	1.18	0.35	10.35	1271.84
1989	78.56	241.67	205.92	185.22	108.07	230.61	50.22	3.88	10.47	4.35	61.74	21.29	1201.99
1990	82.56	42.81	217.32	281.53	224.38	136.18	7.41	5.29	15.17	10.00	48.80	59.51	1130.96
1991	163.82	111.72	189.45	161.11	191.45	67.97	32.81	0.59	0.00	0.00	13.41	26.46	958.79
1992	62.09	79.97	116.78	122.42	203.57	139.83	75.15	6.59	0.00	0.00	10.58	38.69	855.66
1993	176.75	162.64	193.22	351.27	245.55	144.77	51.16	4.47	4.70	34.57	26.93	10.82	1406.85
1994	93.26	25.40	168.29	227.32	94.55	182.52	101.02	12.70	26.22	1.53	14.35	30.58	977.73
1995	101.72	152.53	287.53	315.29	235.67	170.52	59.27	31.16	1.29	66.68	24.34	14.82	1460.83
1996	99.14	93.26	246.14	262.72	126.18	237.32	37.98	28.58	50.45	18.23	8.35	35.63	1243.97
1997	93.84	238.49	225.91	191.69	289.77	112.07	46.92	14.23	0.00	3.88	18.70	25.05	1260.55
1998	54.21	173.11	152.88	209.09	204.74	146.53	45.16	1.76	2.23	6.35	1.41	7.76	1005.24
1999	122.19	58.80	215.44	253.08	268.72	464.99	86.55	35.87	1.06	0.00	1.06	94.79	1602.54
2000	84.67	133.59	140.30	189.69	156.29	156.88	54.68	5.88	8.00	17.17	38.69	82.32	1068.16
2001	132.89	175.11	159.00	171.34	111.25	121.60	35.04	32.34	17.88	40.22	54.80	35.40	1086.86
2002	34.93	73.62	180.99	176.99	190.16	122.54	96.78	22.70	6.12	2.23	12.58	70.80	990.43
2003	32.69	124.54	121.25	271.54	221.21	134.30	30.34	7.29	15.41	42.22	7.64	55.98	1064.40
2004	99.37	208.15	160.05	231.08	212.03	209.33	33.05	10.11	10.00	0.00	29.75	15.52	1218.45
2005	87.38	162.17	114.19	303.53	244.02	90.43	76.09	2.70	0.00	0.00	61.15	33.52	1175.18
2006	127.24	147.12	198.63	170.28	108.19	99.72	58.09	0.00	19.64	26.81	27.05	29.16	1011.95
2007	173.11	86.67	109.72	237.67	186.87	247.31	108.66	5.29	31.87	0.00	8.11	45.51	1240.80
2008	43.16	78.32	165.93	197.45	227.79	160.29	48.45	20.34	19.29	1.41	35.52	35.75	1033.70
Ave:	93.46	132.00	189.02	214.92	191.62	162.06	62.81	25.98	13.75	14.54	26.78	49.08	1176.00

Monthly catchment rainfall (mm) for quaternary catchment U10C (U10C.RAN)

1925	76.03	52.87	115.07	130.47	77.36	121.13	23.40	43.77	44.14	0.00	2.55	138.96	825.73
1926	113.86	122.34	260.81	170.12	172.30	251.84	37.59	7.15	0.00	32.86	53.84	8.61	1231.32
1927	90.58	117.98	229.53	218.86	109.13	143.56	20.98	58.20	0.00	4.61	48.62	34.56	1076.60
1928	48.50	64.14	189.88	270.39	120.04	121.37	35.77	25.22	106.82	53.96	12.97	91.91	1140.99
1929	60.87	184.18	198.49	261.54	139.20	156.66	17.82	39.16	4.97	19.64	48.86	38.56	1169.97
1930	68.14	114.95	172.18	278.76	139.20	161.39	55.78	0.00	0.00	67.17	0.00	4.00	1061.57
1931	67.78	54.69	120.04	165.39	249.05	137.99	4.97	65.60	41.83	4.97	0.00	31.89	944.20
1932	85.40	125.20	153.77	116.67	131.23	146.19	47.36	4.19	3.91	13.06	7.29	14.56	848.85
1933	43.46	213.16	224.48	297.35	165.80	84.93	68.68	61.70	1.56	28.94	24.18	23.20	1237.45
1934	101.78	188.72	259.89	123.17	113.44	110.80	57.85	22.76	66.47	0.00	15.62	17.50	1078.02
1935	43.99	53.21	110.30	197.34	177.70	128.73	45.03	84.93	2.62	2.48	0.00	40.96	887.29
1936	65.87	216.18	84.47	210.14	184.68	129.42	29.54	0.00	0.32	0.00	0.84	18.76	940.21
1937	55.46	132.17	116.39	181.46	211.83	119.61	135.05	2.95	16.42	27.72	46.00	29.18	1074.24
1938	149.27	130.19	265.30	150.10	325.66	146.39	40.54	25.23	6.16	10.77	7.02	96.38	1353.02
1939	77.58	101.63	173.39	153.34	160.10	186.15	47.39	128.56	46.90	0.00	2.21	53.70	1130.94
1940	70.35	129.92	294.18	190.84	153.19	155.49	59.23	0.00	3.24	10.43	1.90	9.72	1078.50
1941	77.85	79.31	140.35	281.58	291.23	178.53	107.41	35.59	0.00	13.96	26.58	26.90	1259.30
1942	125.91	156.65	312.60	248.57	192.64	188.75	224.05	64.04	10.53	48.10	106.30	12.84	1690.99
1943	177.85	232.40	197.35	184.14	151.35	153.21	15.87	2.85	29.12	6.20	1.68	112.79	1264.82
1944	98.82	84.86	65.37	198.81	186.23	231.29	48.24	23.15	0.00	1.05	3.39	6.57	947.77
1945	54.17	23.94	134.71	142.42	152.12	117.03	88.91	12.56	1.16	1.37	0.87	11.25	740.51
1946	50.59	167.98	120.32	179.06	252.15	165.37	44.75	40.03	50.11	10.78	1.92	26.81	1109.85
1947	59.64	145.08	194.87	279.26	169.88	253.18	75.04	43.60	0.00	0.47	0.00	17.48	1238.49
1948	64.30	76.15	110.87	126.96	235.21	159.29	61.47	5.10	0.00	7.20	20.03	41.13	907.72
1949	39.10	62.87	167.51	99.50	208.46	259.56	79.44	53.19	0.17	29.66	84.24	17.97	1101.69
1950	33.68	113.02	217.34	267.17	132.09	90.00	47.88	0.00	4.31	0.00	64.88	40.57	1010.94
1951	116.83	19.65	165.49	195.95	308.05	69.77	66.23	2.68	12.14	29.62	25.80	15.63	1027.84
1952	58.65	119.79	152.28	200.01	124.77	80.24	32.82	9.60	14.59	0.00	11.18	62.75	866.68
1953	102.57	163.17	135.95	237.02	173.86	165.85	33.03	77.11	10.63	6.75	0.72	46.71	1153.37
1954	121.18	75.20	143.06	316.56	146.59	53.05	79.10	15.53	17.43	1.46	0.12	24.15	993.43
1955	46.82	74.47	141.81	91.86	341.62	163.50	26.83	27.00	0.00	0.00	11.97	42.69	968.56
1956	66.03	174.15	377.00	283.74	143.64	162.46	41.35	13.32	12.44	6.95	51.81	87.12	1420.02
1957	126.10	77.27	159.69	226.78	161.38	76.60	106.05	10.79	0.00	0.00	0.00	22.42	967.08
1958	22.46	141.42	217.42	133.86	135.01	55.38	49.19	301.71	4.66	17.74	14.89	21.03	1114.77
1959	57.71	95.01	130.87	101.39	133.77	144.56	87.72	36.28	0.00	0.00	13.30	47.89	848.51
1960	37.50	189.58	250.94	126.47	142.47	240.68	112.36	4.66	7.50	5.24	0.00	43.30	1160.71
1961	18.41	177.25	123.85	229.41	198.77	165.98	58.35	0.00	0.30	0.00	62.92	2.33	1037.57
1962	75.44	178.05	216.06	308.76	131.42	219.64	57.99	7.92	19.32	71.70	0.00	2.68	1288.98
1963	161.72	225.50	138.90	249.46	101.17	110.83	68.24	9.95	79.80	5.82	0.00	51.77	1203.16
1964	136.99	93.46	133.81	222.74	149.05	54.62	57.65	9.06	124.75	7.97	69.73	30.51	1090.35
1965	69.12	93.59	85.88	288.96	143.91	27.80	67.16	47.45	9.12	0.00	56.62	48.80	938.42
1966	47.86	115.16	152.49	240.88	179.53	202.86	106.54	9.58	8.10	19.60	5.85	5.13	1093.59
1967	78.31	106.80	130.52	135.44	86.36	154.89	79.28	1.74	0.35	3.24	31.50	47.53	855.96
1968	46.09	129.60	119.90	78.58	135.72	175.23	52.69	27.40	6.79	7.60	6.06	32.97	818.65
1969	141.86	70.21	217.96	108.12	144.70	50.91	26.25	26.06	18.54	6.11	111.41	61.11	983.24
1970	138.42	86.14	89.51	198.12	153.62	177.72	34.42	67.90	7.24	53.14	58.31	15.50	1080.04
1971	106.74	116.58	154.08	249.10	241.82	234.96	44.84	33.49	0.82	14.93	14.07	25.97	1237.42
1972	67.17	191.78	123.58	113.48	206.72	136.32	130.57	7.25	0.00	9.70	65.44	65.53	1117.55
1973	53.18	168.80	175.35	366.18	291.42	297.94	106.11	16.40	25.81	16.25	10.57	3.93	1531.95
1974	51.14	132.73	133.21	292.32	179.22	118.96	38.82	10.19	5.82	1.64	4.74	108.32	1077.11
1975	55.17	144.01	302.67	395.32	310.16	391.90	57.66	33.78	2.11	3.21	4.63	36.17	1736.82
1976	118.53	58.93	121.57	170.04	172.58	91.70	88.14	8.22	0.00	3.74	29.03	70.92	933.38
1977	92.35	119.18	147.78	260.03	242.35	136.88	81.94	2.36	0.18	1.96	46.25	94.23	1225.48
1978	126.25	157.11	270.21	96.76	156.07	105.52	39.63	19.79	0.00	54.48	48.91	31.84	1106.58
1979	58.43	136.81	176.19	232.14	165.86	200.18	36.50	10.78	0.00	2.00	6.39	127.69	1152.97
1980	60.29	118.14	156.67	185.15	234.99	107.72	38.39	13.89	0.22	11.94	69.64	54.01	1051.05
1981	48.14	110.98	168.58	177.71	74.19	217.70	37.75	12.25	4.58	9.44	2.47	50.27	914.07
1982	112.42	92.12	120.07	126.49	115.47	98.69	43.79	5.47	1.65	18.21	21.47	17.63	773.48
1983	135.50	167.85	315.64	210.99	138.48	188.23	70.43	8.78	16.29	32.15	23.55	10.92	1318.83
1984	74.51	159.92	72.23	247.58	322.83	49.73	16.34	6.24	2.27	0.00	3.78	38.86	994.28
1985	224.06	131.61	231.58	226.43	106.07	107.25	74.40	0.18	21.23	1.17	35.69	54.66	1214.32
1986	175.70	126.66	154.69	127.80	89.57	102.50	34.67	23.01	23.74	1.64	73.31	305.90	1239.18
1987	132.80	102.80	150.78	155.37	431.10	278.45	58.36	22.72	37.49	21.23	29.91	46.95	1467.95
1988	71.52	134.17	200.10	217.35	346.25	103.34	72.58	16.83	9.02	1.17	0.47	10.05	1182.85
1989	80.29	210.71	167.15	182.35	108.89	210.98	48.91	3.18	11.74	4.38	59.62	14.26	1102.45
1990	68.86	32.73	231.27	189.12	206.18	129.47	3.41	4.40	16.28	12.14	61.40	57.77	1013.05
1991	151.06	105.45	192.29	161.42	177.34	60.27	31.64	0.85	0.00	0.00	14.32	25.57	920.23
1992	59.58	70.32	70.55	118.79	151.54	129.88	63.71	7.38	0.00	0.00	13.19	43.53	728.47
1993	157.88	182.10	191.98	316.34	287.46	148.36	47.27	4.52	1.69	31.29	29.97	13.04	1411.91
1994	80.99	21.36	168.06	194.72	107.05	144.09	81.88	12.35	22.66	2.06	19.76	34.30	889.29
1995	94.14	130.99	203.08	285.33	193.34	149.33	63.66	30.92	1.34	32.84	25.25	12.80	1223.01
1996	87.86	75.46	214.89	254.18	106.35	216.29	20.85	6.99	34.97	13.56	7.94	40.87	1080.21
1997	100.94	259.95	269.80	160.45	215.45	99.97	28.56	14.90	0.00	3.52	14.54	27.79	1195.87
1998	60.42	134.44	162.22	183.01	214.71	149.15	53.29	0.00	3.00	8.00	0.00	0.00	968.24
1999	112.47	54.08	198.27	232.90	247.21	427.82	79.65	33.02	0.94	0.00	0.96	87.26	1474.58
2000	77.94	122.91	129.03	174.55	143.77	144.30	50.26	5.45	7.32	15.85	35.55	75.71	982.65
2001	122.28	161.15	146.29	157.60	102.32	111.85	32.24	29.79	16.48	36.98	50.41	32.54	999.93
2002	32.17	67.69	166.53	162.90	175.00	112.77	89.08	20.88	5.65	2.04	11.55	65.15	911.41
2003	30.03	114.58	111.60	249.88	203.57	123.56	27.96	6.72	14.13	38.89	6.98	51.56	979.47
2004	91.40	191.47	147.23	212.57	195.11	192.61	30.38	9.34	9.19	0.00	27.33	14.26	1120.90
2005	80.41	149.23	105.04	279.28	224.51	83.24	70.01	2.44	0.00	0.00	56.28	30.79	1081.23
2006	117.06	135.34	182.72	156.69	99.59	91.71	53.50	0.00	18.04	24.71	24.85	26.83	931.04
2007	159.24	79.77	100.92	218.69	171.91	227.60	99.95	4.90	29.35	0.00	7.50	41.88	1141.70
2008	39.76	72.07	152.71	181.70	209.57	147.51	44.53	18.70	17.78	1.29	32.64	32.90	951.14
Ave:	86.19	122.51	171.42	202.62	180.99	151.42	57.80	24.09	13.77	12.75	25.05	42.40	1091.00

Monthly catchment rainfall (mm) for quaternary catchment U10D (U10D.RAN)

1925	69.98	48.66	105.92	120.09	71.21	111.50	21.54	40.29	40.63	0.00	2.34	127.90	760.05
1926	104.80	112.61	240.07	156.59	158.59	231.81	34.60	6.58	0.00	30.25	49.55	7.92	1133.38
1927	83.37	108.59	211.27	201.45	100.45	132.14	19.31	53.57	0.00	4.24	44.75	31.81	990.97
1928	44.64	59.04	174.78	248.89	110.49	111.72	32.92	23.21	98.33	49.67	11.94	84.60	1050.23
1929	56.03	169.53	182.70	240.74	128.13	144.20	16.41	36.05	4.58	18.08	44.98	35.49	1076.91
1930	62.72	105.80	158.48	256.59	128.13	148.55	51.34	0.00	0.00	61.83	0.00	3.68	977.13
1931	62.39	50.34	110.49	152.23	229.24	127.01	4.58	60.38	38.50	4.58	0.00	29.35	869.09
1932	78.56	106.12	117.43	68.75	106.68	120.94	46.56	0.00	0.74	10.50	4.25	9.04	669.57
1933	40.12	207.25	207.69	291.68	150.18	88.19	89.13	57.20	0.55	31.07	20.89	25.79	1209.72
1934	90.19	201.59	223.63	127.05	108.88	100.65	60.89	26.31	67.22	0.00	18.02	17.27	1041.68
1935	43.51	61.29	102.40	189.17	169.35	128.53	38.53	84.49	1.03	1.23	0.00	44.88	864.42
1936	66.61	206.09	78.01	182.22	164.10	114.73	26.86	0.00	1.25	0.00	2.56	18.04	860.47
1937	60.26	119.92	121.66	179.43	212.82	89.47	128.01	4.21	16.36	29.24	45.60	21.76	1028.74
1938	135.95	110.44	234.64	145.95	267.20	132.60	34.16	21.51	2.05	10.18	5.33	90.81	1190.84
1939	71.01	106.18	142.37	140.70	150.67	166.48	48.17	127.09	47.49	0.00	2.57	49.36	1052.08
1940	76.20	122.45	263.89	178.41	117.04	140.65	51.88	0.71	4.67	9.41	1.12	14.91	981.32
1941	88.77	63.58	88.37	206.86	285.36	169.77	118.42	29.45	0.65	13.98	29.39	25.36	1119.94
1942	111.41	168.69	276.82	202.63	177.18	111.02	210.91	63.41	15.20	45.29	103.80	12.44	1498.81
1943	165.37	216.03	155.78	163.28	147.40	146.06	21.55	0.00	22.13	4.88	4.15	98.29	1144.93
1944	84.84	89.07	64.19	164.08	156.53	230.62	54.67	22.71	0.00	0.61	4.56	6.60	878.48
1945	56.32	13.07	115.68	134.93	140.19	111.24	53.98	7.28	0.00	1.13	5.02	5.92	644.75
1946	44.56	162.76	117.98	151.89	222.59	141.25	29.45	35.88	56.30	9.23	0.46	35.44	1007.79
1947	71.44	151.17	177.82	227.03	181.61	185.41	49.13	33.58	0.00	1.12	0.88	16.59	1095.77
1948	87.41	80.39	117.86	125.98	140.04	107.74	58.26	21.57	0.00	10.61	16.89	39.87	806.62
1949	46.43	85.03	172.15	90.04	224.45	220.98	76.16	47.97	0.00	31.94	79.28	17.35	1091.78
1950	26.32	107.00	218.42	194.08	106.84	86.63	45.00	0.00	2.95	0.00	59.24	39.65	886.13
1951	102.24	16.40	171.19	173.25	187.36	92.98	72.98	9.90	13.37	21.59	22.85	24.87	908.98
1952	64.27	120.73	146.05	166.11	176.89	66.02	36.27	5.40	16.57	8.32	11.86	65.78	884.27
1953	100.97	137.99	173.23	191.04	195.64	143.44	24.46	72.43	13.08	2.45	0.65	52.52	1107.89
1954	115.06	77.70	119.12	292.06	161.92	62.64	74.97	17.95	14.55	2.78	0.00	30.96	969.73
1955	46.92	73.84	148.53	80.06	279.93	150.08	25.97	19.84	0.00	0.00	17.31	37.14	879.63
1956	86.15	155.29	320.40	221.85	117.64	173.26	59.99	11.97	12.13	6.91	47.49	101.80	1314.89
1957	121.13	73.02	166.60	225.00	139.84	76.73	104.25	10.26	0.00	0.00	0.28	40.69	957.79
1958	20.60	129.51	206.63	136.23	144.90	63.85	45.90	250.04	0.96	14.72	22.82	15.38	1051.55
1959	61.01	81.92	132.53	93.87	111.34	115.71	87.46	20.98	0.88	2.41	17.60	44.18	769.90
1960	47.95	168.73	238.16	109.58	122.85	191.85	76.29	8.21	13.66	1.16	1.91	33.50	1013.85
1961	22.91	154.57	117.86	172.68	157.18	131.13	60.86	5.09	0.22	0.08	55.10	3.26	880.94
1962	65.91	145.04	168.45	248.03	84.19	211.26	54.32	11.97	20.84	68.40	3.33	1.95	1083.68
1963	129.45	184.74	119.90	244.33	78.95	106.28	68.04	10.59	78.00	3.83	1.61	57.37	1083.09
1964	134.96	88.96	128.06	177.34	113.83	40.31	39.44	15.88	105.50	15.22	70.71	37.70	967.90
1965	68.74	75.27	87.52	269.39	131.86	10.47	72.94	55.53	9.97	0.65	34.53	57.44	874.32
1966	48.14	142.83	153.61	284.35	151.74	203.39	95.58	9.44	9.09	29.69	4.54	5.35	1137.75
1967	100.93	119.51	130.68	138.43	72.74	181.50	85.51	0.22	0.18	0.04	38.68	38.32	906.74
1968	41.50	92.90	121.43	94.38	148.96	152.43	63.44	38.66	2.86	6.17	13.34	29.81	805.89
1969	139.82	68.80	234.64	126.55	152.28	40.31	14.95	33.92	11.53	6.65	127.43	77.77	1034.66
1970	113.82	92.06	87.93	174.79	139.19	176.58	33.09	68.73	3.25	66.83	79.81	14.72	1050.80
1971	114.27	121.11	164.16	200.94	180.96	220.00	46.38	35.88	1.46	12.58	9.02	20.03	1126.78
1972	57.60	180.13	116.74	108.37	236.75	149.23	129.74	4.86	0.00	5.65	50.44	61.70	1101.22
1973	64.63	137.67	118.26	227.63	188.09	231.13	83.33	82.16	26.55	8.49	14.11	1.43	1183.46
1974	51.79	147.92	133.75	204.03	155.15	99.20	70.49	2.43	0.00	0.45	2.63	119.31	987.15
1975	64.32	114.96	227.43	253.25	218.09	250.00	48.04	31.93	0.00	6.77	18.69	52.03	1285.51
1976	99.33	54.45	130.06	177.35	92.91	144.25	65.39	2.01	3.80	0.09	16.37	57.61	843.63
1977	73.91	92.37	119.86	195.83	167.90	154.04	100.17	2.01	0.00	0.76	22.27	67.88	996.98
1978	94.51	111.51	267.56	113.61	115.90	65.73	50.19	42.51	0.04	24.91	45.02	30.50	962.00
1979	54.65	95.36	122.17	144.90	118.14	123.37	69.17	14.72	0.23	1.35	10.12	128.01	882.17
1980	55.50	103.64	179.07	203.93	236.30	61.78	48.06	25.87	15.54	0.00	76.06	41.44	1047.20
1981	62.21	113.00	111.01	115.11	72.96	233.77	62.17	10.87	12.57	6.07	4.98	38.59	843.32
1982	113.84	41.31	96.71	106.40	64.44	88.43	35.87	6.40	2.81	24.73	20.60	31.67	633.21
1983	102.82	159.33	179.58	136.23	90.63	155.57	50.90	19.14	14.91	22.33	19.68	17.22	968.33
1984	90.10	72.89	87.15	238.32	231.65	79.15	9.79	7.41	19.57	5.09	1.57	22.90	865.59
1985	159.17	139.69	184.06	147.75	102.28	143.03	77.50	0.00	18.88	0.80	68.27	16.43	1057.85
1986	106.36	151.03	139.83	168.92	134.56	160.89	38.54	14.11	23.20	10.43	83.75	314.82	1346.44
1987	114.77	80.86	111.91	138.58	315.57	196.90	80.15	24.95	47.96	4.73	11.84	24.95	1153.18
1988	43.06	130.84	190.94	208.75	212.74	125.81	63.93	22.50	16.52	1.39	0.00	9.75	1026.23
1989	55.47	223.93	172.26	134.47	77.16	220.61	26.00	1.97	3.94	1.48	52.46	26.36	996.10
1990	79.58	66.13	140.96	265.17	207.10	130.99	11.59	18.45	14.66	0.98	5.73	41.76	983.10
1991	142.76	93.24	158.96	94.12	138.96	61.25	28.00	0.00	0.00	0.00	6.96	9.78	734.04
1992	57.51	86.63	118.63	89.66	168.13	104.44	60.21	4.07	0.00	0.00	7.64	27.67	724.59
1993	127.48	83.96	171.58	264.37	127.92	104.94	31.77	2.74	14.16	35.20	20.94	5.93	990.97
1994	78.44	34.55	122.55	175.46	46.73	177.69	69.95	13.47	42.72	1.20	6.57	16.62	785.95
1995	91.37	141.65	317.79	285.54	221.55	157.09	33.85	27.30	6.84	137.53	11.83	7.25	1439.58
1996	81.10	123.45	186.38	234.17	103.02	193.19	63.96	45.62	64.06	17.70	14.52	22.15	1149.33
1997	81.59	148.32	80.33	201.01	269.55	86.11	50.04	12.14	0.00	3.14	25.50	22.86	980.59
1998	47.66	209.01	133.13	194.57	121.75	93.33	36.03	10.57	1.77	2.17	1.19	27.24	878.43
1999	141.34	95.68	239.80	176.98	182.87	284.17	114.12	52.60	1.44	0.00	4.65	71.06	1364.71
2000	63.92	128.41	306.27	340.84	87.26	157.81	71.65	8.24	3.41	0.43	30.48	72.25	1270.97
2001	101.77	160.08	159.27	205.30	84.34	104.13	31.41	27.40	35.21	56.22	52.30	31.44	1048.88
2002	56.21	53.10	131.01	93.24	154.32	112.35	89.40	28.82	5.53	0.73	13.12	45.93	783.76
2003	43.34	134.73	88.57	137.63	137.54	120.53	42.06	4.53	9.05	41.86	11.53	55.96	827.32
2004	80.67	141.16	169.39	254.32	192.83	140.43	37.29	11.04	2.40	0.71	18.57	25.73	1074.54
2005	79.44	90.43	114.58	203.36	136.39	87.47	110.87	30.22	3.64	2.31	62.23	23.53	944.49
2006	131.60	86.70	238.26	118.93	101.73	120.72	36.42	0.00	47.29	0.00	17.43	35.71	934.79
2007	130.61	85.84	138.78	147.06	89.41	184.02	84.84	0.00	26.28	0.86	3.64	59.96	951.31
2008	53.85	132.85	130.45	184.28	240.99	91.86	15.43	62.57	63.00	5.72	33.71	111.71	1126.40
Ave:	81.07	114.29	158.96	179.17	152.97	135.78	57.07	26.09	15.44	12.88	23.88	41.40	999.00

Monthly point rainfall (mm) for the Impendle Dam site (U10E.RAN)

1925	81.63	50.56	98.25	124.06	91.52	131.37	19.57	40.80	38.32	0.00	3.15	103.27	782.49
1926	101.00	101.66	175.38	168.16	140.87	197.23	38.90	9.28	0.00	22.41	57.07	10.44	1022.40
1927	87.04	83.21	166.14	193.18	89.30	142.53	16.55	38.37	0.00	2.53	35.77	24.02	878.63
1928	63.78	54.33	114.49	139.02	113.17	93.94	28.18	25.58	74.75	37.59	9.71	70.10	824.64
1929	65.49	137.98	134.42	166.00	97.87	138.25	29.75	18.58	13.83	18.10	44.42	35.18	899.86
1930	49.94	80.07	130.14	193.86	117.76	96.12	67.33	2.48	0.00	44.16	0.89	5.54	788.28
1931	74.32	60.17	121.85	141.50	170.34	115.25	7.99	50.37	27.43	1.27	0.32	30.52	801.33
1932	66.26	129.72	136.61	49.28	106.56	129.61	32.34	0.00	1.61	19.92	2.38	8.58	682.88
1933	44.57	205.62	179.50	268.20	122.13	133.40	81.76	56.25	1.17	40.18	20.96	33.56	1187.29
1934	73.85	197.78	183.89	120.58	105.89	130.19	74.41	27.73	77.34	0.00	19.07	18.38	1029.10
1935	35.02	45.93	100.23	162.10	177.09	115.50	23.71	79.38	1.19	1.42	0.00	44.76	786.34
1936	65.93	209.74	92.49	144.95	143.99	107.92	26.24	12.08	1.04	0.00	2.96	18.59	825.94
1937	59.56	103.76	100.12	186.32	186.56	79.51	123.87	2.52	29.93	13.56	35.36	23.91	945.00
1938	140.84	126.35	161.21	170.39	298.30	101.05	35.00	36.89	7.91	11.18	50.05	87.45	1226.62
1939	82.09	139.14	147.77	138.72	118.88	164.54	56.75	125.69	55.33	0.00	2.97	40.44	1072.33
1940	81.37	110.79	221.46	169.76	119.13	106.35	45.48	2.65	5.71	7.63	2.17	24.57	897.07
1941	74.08	78.34	75.29	181.68	255.74	148.44	70.83	39.49	1.61	16.60	30.27	44.56	1016.94
1942	118.84	201.37	229.82	108.22	102.17	131.93	212.85	63.52	16.39	103.32	127.55	14.67	1430.65
1943	159.93	158.04	132.91	145.14	139.02	125.16	26.08	3.73	22.97	7.91	7.76	86.17	1014.81
1944	90.83	69.63	56.80	143.90	137.45	202.47	55.36	20.63	0.00	2.99	5.52	14.40	799.96
1945	44.17	15.86	126.62	134.69	111.33	119.18	75.84	6.15	3.30	2.43	6.21	19.19	664.97
1946	46.29	141.90	123.78	140.79	229.70	127.08	42.65	9.95	93.84	16.95	5.18	38.34	1016.45
1947	67.27	159.37	142.56	168.42	137.28	162.97	48.72	5.13	0.62	3.25	1.09	15.06	911.73
1948	87.10	82.47	143.97	108.61	120.00	127.47	49.87	10.17	0.00	12.46	14.28	43.89	800.30
1949	50.25	86.79	154.10	78.04	150.32	223.88	71.47	37.63	0.00	38.12	59.58	22.33	972.50
1950	42.99	118.57	187.85	235.25	117.17	79.17	35.01	0.00	4.52	0.00	72.11	39.63	932.25
1951	94.60	21.50	135.47	188.13	124.27	76.63	63.38	12.44	10.68	25.54	31.00	23.18	806.81
1952	48.90	139.62	155.36	117.64	183.99	79.54	36.63	7.72	17.80	0.00	50.44	42.92	880.57
1953	68.19	96.44	150.23	149.42	177.16	84.18	31.64	64.92	12.97	5.44	1.40	52.68	894.67
1954	102.99	94.90	107.40	246.91	185.22	82.40	63.05	22.67	10.57	3.22	0.00	28.53	947.86
1955	37.44	58.80	143.54	55.95	226.69	169.33	29.71	21.14	0.00	0.00	26.10	30.88	799.57
1956	69.98	141.85	282.00	235.50	107.31	191.87	55.30	6.50	14.71	12.76	46.35	127.82	1291.96
1957	100.41	84.20	144.56	175.85	127.54	74.53	104.36	2.63	14.90	0.48	0.73	32.88	863.09
1958	32.84	121.80	191.45	129.24	144.50	109.96	41.26	203.54	0.71	19.17	24.83	19.92	1039.21
1959	59.76	87.93	124.71	92.01	103.04	80.37	84.58	13.74	0.76	4.46	15.24	44.28	710.89
1960	50.24	168.85	191.55	42.06	100.13	193.68	84.99	10.49	10.62	1.86	3.63	36.84	894.94
1961	29.68	143.36	113.76	163.74	144.32	114.08	96.86	11.23	0.00	0.70	42.33	8.66	868.71
1962	66.29	117.06	143.17	188.77	51.96	195.98	44.60	9.65	18.02	77.57	7.90	3.69	924.67
1963	129.60	127.43	109.25	228.97	65.29	118.11	58.62	7.63	61.16	8.06	4.37	61.40	979.88
1964	110.35	96.37	157.28	144.79	91.96	34.98	32.92	26.44	96.87	17.83	51.14	21.71	882.64
1965	63.41	77.24	67.82	234.00	121.05	28.67	52.54	42.12	7.99	0.29	31.36	44.22	770.71
1966	46.98	186.94	123.84	168.33	140.54	182.32	85.31	8.21	15.85	7.97	2.54	20.70	989.52
1967	77.04	106.07	132.51	112.03	72.29	96.95	70.73	0.00	2.07	0.05	36.52	31.26	737.51
1968	50.74	64.53	109.34	68.69	138.08	127.44	42.12	26.53	4.45	7.89	8.01	32.54	680.36
1969	76.83	63.77	148.42	117.63	132.29	37.26	5.78	16.24	16.86	5.53	125.43	73.85	819.88
1970	115.33	80.21	120.88	118.48	149.91	106.96	39.77	71.24	4.03	52.41	75.28	20.04	954.54
1971	88.86	93.71	147.45	176.29	180.27	179.97	27.55	35.80	6.14	15.83	11.70	14.92	978.49
1972	67.58	170.47	79.69	111.92	177.16	163.22	66.79	7.42	0.00	7.10	45.68	82.41	979.43
1973	45.09	105.28	78.15	277.15	173.57	144.10	77.02	31.23	17.60	10.85	12.64	3.97	976.65
1974	46.83	132.85	107.13	175.90	131.92	92.73	66.49	0.49	0.00	0.42	1.62	103.50	859.87
1975	40.78	118.74	187.93	226.94	236.14	216.73	60.93	21.39	0.00	3.85	17.27	72.72	1203.41
1976	111.72	76.24	130.08	178.64	76.83	110.60	66.98	4.59	6.08	0.05	20.43	56.44	838.68
1977	63.97	74.66	103.38	156.86	148.68	122.79	83.40	5.51	4.34	1.96	20.33	62.36	848.26
1978	91.56	102.21	232.04	103.22	135.37	80.62	51.29	33.75	1.47	31.76	38.32	30.78	932.39
1979	47.36	82.19	95.94	159.45	111.94	99.30	40.63	11.82	0.00	0.91	9.55	124.41	783.51
1980	44.26	101.63	152.23	209.34	201.64	68.71	50.89	13.33	20.67	3.21	67.57	38.07	971.56
1981	51.69	114.95	103.00	107.74	78.60	192.93	47.87	10.70	10.68	5.18	5.41	46.92	775.68
1982	105.07	54.62	92.98	103.16	54.44	83.89	34.48	7.32	2.86	20.25	20.95	26.05	606.07
1983	93.07	170.57	192.60	121.12	97.48	126.61	53.20	16.58	18.74	22.10	18.59	20.95	951.59
1984	87.40	78.31	86.18	230.38	207.05	60.57	13.29	7.00	14.37	5.35	1.77	22.38	814.05
1985	158.29	119.64	192.06	173.65	84.46	129.30	75.85	0.00	22.51	0.39	55.60	20.02	1031.77
1986	95.08	120.41	122.23	135.07	129.08	141.15	34.83	10.88	27.33	11.79	72.49	325.77	1226.11
1987	86.38	92.33	115.84	124.82	283.37	208.23	62.13	27.65	39.60	16.29	9.07	25.32	1091.05
1988	49.27	112.41	183.76	165.17	212.50	83.73	66.84	19.55	10.40	8.27	0.58	11.57	924.05
1989	50.14	216.91	141.75	102.20	85.94	194.57	35.59	6.57	4.31	0.88	50.27	22.85	912.00
1990	88.18	61.56	142.84	237.00	195.81	104.63	9.64	16.91	11.16	0.68	4.66	42.24	915.30
1991	131.94	101.88	132.01	87.90	127.42	63.95	21.97	0.00	0.00	0.46	10.21	18.36	696.10
1992	56.39	79.29	91.78	91.26	153.66	104.35	52.99	5.78	0.00	0.18	13.83	20.21	669.72
1993	134.91	65.36	175.34	235.88	125.53	120.28	33.40	4.55	15.13	26.75	24.63	7.40	969.15
1994	77.87	41.24	127.74	160.58	50.93	176.64	80.51	9.28	33.75	1.29	9.88	15.72	785.43
1995	87.52	129.83	290.33	271.33	229.15	158.09	39.27	22.87	7.37	109.59	13.41	9.57	1368.31
1996	83.56	104.96	155.36	221.38	81.17	188.67	63.11	41.76	72.69	16.32	10.43	20.14	1059.55
1997	71.87	136.56	68.93	180.35	232.30	121.17	52.50	14.26	0.00	2.99	26.09	22.05	929.07
1998	36.98	174.21	120.17	179.87	105.71	84.58	27.70	6.87	1.50	3.04	1.10	25.71	767.44
1999	123.50	90.35	195.43	174.29	158.29	288.02	83.37	48.44	2.07	0.00	4.13	68.88	1236.77
2000	61.75	116.08	303.14	328.18	81.01	137.96	71.51	0.67	0.46	0.06	17.61	79.63	1198.06
2001	102.45	145.24	140.64	185.91	69.12	106.58	42.15	23.08	31.74	55.40	60.45	27.08	989.83
2002	67.55	44.26	117.38	68.52	140.37	104.38	92.25	27.11	4.78	0.46	13.04	39.87	719.96
2003	39.92	127.47	93.14	142.88	156.18	107.15	51.53	4.53	6.17	39.70	8.35	56.95	833.97
2004	81.89	130.75	148.59	242.21	168.73	136.00	26.91	13.12	2.18	0.00	16.49	25.62	992.49
2005	62.08	83.92	60.39	179.36	142.01	88.26	81.77	30.50	2.83	0.00	65.47	24.56	821.14
2006	140.55	69.53	229.38	113.71	100.17	121.05	29.67	0.00	56.75	2.25	14.79	32.96	910.79
2007	113.40	80.21	154.94	118.93	63.22	159.64	87.91	0.00	25.35	0.00	0.00	55.93	859.54
2008	60.20	97.04	193.19	138.38	170.28	126.13	18.27	17.61	0.81	0.00	37.74	44.33	903.97
Ave:	76.58	107.69	142.56	159.00	138.63	126.35	53.61	22.25	15.26	13.11	24.21	40.76	920.00

Monthly point rainfall (mm) for the Smithfield Dam site (U10F.RAN)

1925	82.14	63.82	103.12	112.41	85.85	141.25	10.93	38.30	28.95	1.57	2.05	81.48	751.86
1926	98.49	93.61	137.99	144.07	110.07	221.34	32.06	13.23	0.00	22.97	61.69	15.43	950.95
1927	91.66	60.85	178.68	212.97	92.25	127.56	17.88	28.62	0.00	18.41	32.63	33.11	894.61
1928	73.46	65.73	74.51	73.75	104.05	93.45	40.55	31.50	77.10	29.13	8.38	66.88	738.48
1929	77.23	133.48	141.75	144.55	84.60	120.21	33.16	8.39	30.72	10.42	54.89	38.14	877.55
1930	41.20	87.41	112.13	180.54	89.58	103.57	46.86	2.71	18.88	59.50	0.71	6.68	749.76
1931	69.34	54.00	117.51	140.03	146.41	114.24	5.74	55.26	19.88	0.28	0.43	30.40	753.51
1932	56.97	134.46	119.66	56.76	89.35	134.29	37.93	0.00	1.45	15.54	1.68	9.95	658.04
1933	33.28	203.79	196.75	220.31	93.34	124.79	89.79	48.23	0.75	48.32	17.88	35.91	1113.14
1934	71.77	162.20	170.63	105.18	137.24	122.70	86.89	33.30	115.06	0.00	20.67	14.04	1039.67
1935	27.48	27.82	70.02	150.01	196.85	157.22	19.37	81.81	2.14	8.23	0.00	44.28	785.22
1936	65.20	216.09	79.15	126.23	192.15	89.22	26.11	11.71	7.81	1.13	3.30	12.58	830.69
1937	63.25	95.60	99.51	153.26	192.60	85.52	118.06	2.82	26.50	18.99	34.79	21.08	912.00
1938	121.84	119.57	120.23	164.74	280.98	65.55	44.75	46.80	3.59	12.98	39.61	86.92	1107.55
1939	90.06	151.85	149.22	149.11	139.86	122.58	49.68	114.57	55.17	0.00	3.24	38.40	1063.76
1940	65.35	110.99	212.61	139.99	95.13	106.34	49.26	1.84	5.88	11.08	1.27	32.53	832.27
1941	67.41	74.13	61.57	151.37	214.96	149.07	69.67	30.94	1.19	10.69	35.19	42.57	908.75
1942	117.57	168.84	223.15	110.62	102.90	122.15	197.72	61.63	14.36	79.98	108.43	10.94	1318.30
1943	160.16	217.94	161.26	111.59	135.53	121.50	32.64	1.81	19.27	5.13	7.79	90.52	1065.15
1944	72.76	67.44	50.44	139.37	123.31	208.79	52.10	29.06	0.00	1.45	4.11	9.99	758.83
1945	58.16	8.37	118.74	135.84	133.62	113.14	58.92	5.56	3.46	1.37	6.15	16.62	659.95
1946	51.83	121.98	120.68	120.26	181.56	144.48	47.49	7.73	71.62	16.53	5.71	28.72	918.57
1947	68.48	145.52	126.85	147.39	124.10	160.86	54.31	5.35	0.30	2.27	1.08	13.88	850.39
1948	109.79	90.33	134.88	106.81	116.22	139.41	46.07	8.62	0.00	11.82	17.11	44.06	825.13
1949	86.77	122.15	137.57	111.24	144.26	199.37	70.40	34.80	0.00	40.87	69.14	18.87	1035.45
1950	33.98	91.42	214.81	184.97	111.50	101.61	25.05	0.00	2.71	0.00	74.71	43.43	884.19
1951	85.63	17.41	103.96	172.53	103.94	72.19	76.03	13.66	13.56	15.64	20.61	30.71	725.88
1952	42.41	114.60	149.47	123.64	166.94	73.46	31.51	5.41	11.25	0.00	55.95	45.66	820.30
1953	80.90	102.32	143.10	143.23	149.25	89.38	44.52	66.21	11.77	6.51	3.26	52.33	892.78
1954	123.21	107.70	84.33	257.88	209.77	108.44	67.51	33.47	10.56	7.33	0.00	31.16	1041.35
1955	55.92	77.93	132.00	44.08	258.88	180.53	21.55	23.13	13.16	0.00	17.12	37.84	862.15
1956	72.01	145.91	262.36	226.04	111.03	215.18	77.65	9.23	10.08	11.45	41.28	120.76	1302.97
1957	109.32	91.25	138.14	146.44	140.64	58.28	119.20	0.88	13.53	0.33	1.33	36.07	855.41
1958	33.08	138.15	158.97	141.50	141.64	85.39	32.39	254.44	0.43	14.74	25.83	17.11	1043.66
1959	70.00	78.40	132.53	68.55	105.28	110.37	108.79	14.31	0.57	4.76	16.95	41.49	751.99
1960	65.97	150.75	185.82	118.91	94.09	247.05	121.77	12.64	9.53	4.22	5.41	38.29	1054.48
1961	36.76	139.86	116.30	146.37	166.23	138.86	75.45	5.17	0.09	0.00	56.32	7.30	888.70
1962	64.75	125.70	131.78	160.27	34.14	218.00	54.65	4.82	14.21	73.57	8.64	3.58	894.10
1963	109.03	134.18	119.22	223.72	69.66	107.98	63.53	5.86	71.68	13.08	11.64	63.43	993.01
1964	122.06	90.24	150.99	150.39	107.11	36.11	35.74	21.50	94.29	24.77	56.69	32.88	922.76
1965	113.56	126.04	65.25	207.70	107.59	18.29	49.97	38.28	7.20	2.18	29.86	50.32	816.23
1966	40.19	165.42	102.16	176.02	138.44	215.70	94.40	9.72	16.26	23.48	0.34	13.17	995.30
1967	97.67	140.50	116.82	81.52	70.73	118.62	56.80	2.64	0.57	0.00	43.37	49.68	778.92
1968	45.60	66.44	99.28	56.31	133.15	131.71	36.72	43.86	3.26	11.38	13.37	24.30	665.38
1969	111.69	88.21	172.25	115.32	112.12	23.91	14.46	34.41	17.85	4.65	109.13	87.58	891.55
1970	97.03	89.75	123.14	86.70	96.95	114.12	53.60	60.95	6.78	54.91	62.61	28.68	875.20
1971	93.52	96.92	166.60	172.63	167.44	167.83	31.93	42.93	13.74	16.87	14.93	16.18	1001.52
1972	65.22	161.54	84.10	121.19	165.33	144.16	78.60	9.58	0.00	5.89	31.83	75.58	943.00
1973	45.82	108.50	98.46	282.39	189.74	174.81	61.46	55.69	9.07	13.83	11.68	3.04	1054.49
1974	47.53	117.94	96.14	177.20	98.85	72.39	57.52	0.60	0.00	0.19	4.58	100.10	773.04
1975	62.89	101.18	148.93	227.92	193.37	233.58	59.16	26.55	0.00	8.59	13.94	60.23	1136.34
1976	120.78	61.08	129.11	149.74	74.46	129.15	50.38	3.51	3.56	0.00	18.01	54.73	794.50
1977	69.41	79.23	133.61	161.44	139.23	131.42	95.85	8.10	2.55	0.96	25.74	76.94	924.49
1978	99.70	97.59	218.13	111.16	140.42	92.13	58.77	18.49	0.85	28.63	36.95	35.88	938.69
1979	50.36	88.06	111.43	131.77	111.15	88.41	34.33	18.10	0.11	1.50	7.77	112.97	755.98
1980	51.73	103.99	128.94	189.86	209.07	77.29	46.20	19.44	16.32	4.71	69.90	44.38	961.83
1981	49.62	120.00	85.71	122.91	87.66	156.70	41.96	15.22	10.41	6.59	5.41	49.89	752.09
1982	106.02	76.48	85.47	113.33	69.02	105.69	34.87	5.59	0.90	23.66	22.00	50.89	693.92
1983	145.93	189.31	259.85	113.49	101.96	102.88	51.70	20.49	21.85	26.69	25.69	17.99	1077.85
1984	88.18	67.33	120.38	246.25	198.96	46.84	13.36	5.82	1.80	2.40	0.90	23.28	815.48
1985	167.28	101.93	190.75	169.13	83.06	122.86	80.52	0.00	23.41	0.14	44.99	30.07	1014.12
1986	78.33	102.76	93.29	120.95	125.37	105.42	27.87	5.74	29.23	14.55	67.78	348.09	1119.37
1987	86.24	106.12	107.77	100.54	229.63	200.06	53.58	31.53	33.58	18.45	4.72	42.94	1015.16
1988	41.76	121.17	152.52	120.19	188.06	62.22	64.66	12.02	3.64	10.04	0.98	13.10	790.35
1989	50.84	219.97	115.09	71.73	102.35	196.93	53.79	9.11	5.25	0.27	37.96	37.91	901.21
1990	78.17	56.66	162.84	192.28	179.62	113.87	11.78	18.51	8.43	0.00	2.78	52.59	877.55
1991	131.47	115.13	133.22	109.45	120.57	78.22	21.04	0.00	0.00	0.60	8.20	22.29	740.20
1992	60.77	78.78	47.43	98.81	114.17	101.45	50.33	8.21	0.00	0.23	20.14	24.20	604.53
1993	149.02	47.39	183.64	190.63	152.66	150.95	32.13	5.32	17.89	32.11	24.62	8.26	994.62
1994	70.88	53.97	121.43	149.36	56.52	169.60	79.08	12.80	36.75	3.54	21.66	20.78	796.36
1995	93.96	130.16	271.81	247.64	204.06	166.04	51.78	19.86	9.68	128.27	9.66	17.94	1350.85
1996	92.90	128.09	130.65	188.23	61.18	150.04	83.53	34.00	84.23	44.55	9.13	61.79	1068.33
1997	74.82	118.41	97.96	84.98	112.35	91.04	70.55	8.82	0.00	1.10	40.37	28.19	728.60
1998	41.21	111.77	133.70	157.64	116.10	68.21	10.31	0.00	2.19	2.06	0.00	14.13	657.34
1999	118.04	189.92	164.16	202.26	101.65	274.91	86.71	37.27	5.27	0.00	3.06	73.39	1256.64
2000	67.56	103.64	148.60	190.36	84.81	78.77	80.31	13.68	0.00	1.80	20.09	111.28	900.89
2001	126.11	136.67	109.08	172.38	77.59	98.43	46.82	37.30	29.86	58.90	72.29	49.56	1015.00
2002	78.88	75.04	122.70	80.21	118.42	104.80	98.26	25.21	5.89	0.00	15.96	56.77	782.12
2003	17.01	101.86	121.71	116.42	114.79	140.74	48.74	3.38	6.18	40.17	9.06	63.59	783.63
2004	105.78	87.57	116.66	291.54	127.13	123.44	16.56	14.44	5.53	0.00	23.13	29.63	941.40
2005	60.05	81.16	61.36	200.77	109.83	88.98	87.09	32.81	2.77	0.00	61.85	50.72	837.40
2006	197.41	82.48	224.67	114.04	78.20	175.50	39.46	0.00	63.19	3.05	13.65	29.00	1020.65
2007	133.30	109.34	133.03	138.14	46.77	92.06	121.79	1.71	32.06	0.00	2.91	61.47	872.58
2008	83.01	119.68	163.62	165.48	144.73	142.40	47.82	15.87	4.24	0.00	42.50	42.60	971.94
Ave:	81.36	108.68	134.47	148.03	128.95	125.88	55.72	23.37	15.76	14.31	24.28	44.19	905.00

Monthly catchment rainfall (mm) for quaternary catchment U10G (U10G.RAN)

1925	90.13	75.94	127.51	107.73	92.89	113.82	30.03	32.36	32.83	2.73	7.56	75.45	788.99
1926	116.36	118.38	152.31	141.01	101.33	196.22	46.21	13.11	0.00	17.12	59.29	27.51	988.86
1927	101.16	101.08	197.70	163.94	92.96	130.46	24.32	16.84	0.08	15.48	37.94	47.18	929.14
1928	53.49	93.40	121.14	135.20	112.08	204.06	17.36	21.96	79.50	44.98	10.29	88.14	981.61
1929	102.60	119.98	152.74	146.88	109.67	99.58	56.35	12.36	33.25	7.65	51.09	56.21	948.35
1930	86.44	124.85	140.94	129.45	100.85	111.47	62.99	6.80	0.54	51.35	8.16	18.20	842.04
1931	73.00	87.22	105.25	124.60	156.15	152.62	15.74	64.75	25.95	11.08	2.98	41.07	860.42
1932	99.87	111.19	143.81	82.37	88.80	156.15	43.56	0.00	1.10	23.62	6.13	17.58	774.18
1933	42.82	211.07	199.45	232.56	94.17	150.06	63.05	47.15	1.02	49.98	23.89	41.45	1156.69
1934	95.66	119.19	230.74	130.91	122.01	129.97	89.31	31.68	113.72	0.43	22.94	18.52	1105.09
1935	54.14	44.55	56.06	138.38	203.11	126.52	43.02	90.92	4.94	16.65	0.76	59.76	838.81
1936	104.98	236.57	80.46	143.38	147.28	116.29	20.63	5.09	11.84	6.05	5.18	32.22	909.96
1937	98.97	95.66	139.95	198.84	180.91	42.61	134.39	5.13	16.85	24.38	28.24	25.94	991.88
1938	151.57	124.98	136.83	127.87	295.89	103.13	42.16	41.38	3.67	21.03	12.24	74.11	1134.84
1939	113.72	130.34	180.48	119.65	125.90	123.02	45.72	149.97	70.72	0.30	3.40	48.45	1111.69
1940	67.55	143.23	301.47	119.33	76.44	108.74	78.58	10.81	8.03	17.41	5.49	43.74	980.83
1941	85.71	97.69	80.15	160.76	198.48	219.12	56.58	28.27	1.22	24.26	50.25	41.34	1043.82
1942	82.96	149.75	207.44	126.84	109.68	118.12	220.51	78.86	25.37	58.65	104.31	24.59	1307.08
1943	175.72	247.59	196.25	83.49	129.68	119.48	31.35	3.42	26.29	15.52	12.47	113.01	1154.26
1944	82.24	65.50	57.25	166.10	130.45	211.50	43.17	24.37	0.00	0.61	10.93	13.19	805.31
1945	80.94	42.07	125.65	154.48	132.63	134.02	43.84	9.39	11.64	3.70	3.34	24.64	766.34
1946	62.30	136.25	137.47	118.84	160.93	218.82	66.00	6.77	125.13	15.56	9.12	37.81	1094.98
1947	88.23	173.05	126.40	152.25	134.20	144.57	55.64	14.63	0.77	2.19	6.57	26.09	924.60
1948	119.06	67.26	116.73	85.42	108.29	104.36	50.95	9.90	0.20	18.69	20.78	52.57	754.21
1949	95.69	132.75	136.64	135.02	144.62	154.04	81.75	30.16	3.02	50.31	68.40	26.28	1058.68
1950	40.64	88.08	234.64	163.50	104.13	111.94	22.05	5.85	4.27	0.00	68.82	65.36	909.27
1951	101.51	40.35	124.25	166.75	108.50	107.49	76.93	17.41	20.79	14.00	19.06	31.85	828.90
1952	63.82	138.37	148.73	125.96	179.04	46.65	40.74	8.49	9.01	0.12	55.76	65.09	881.78
1953	122.95	106.47	188.50	163.66	133.53	93.65	33.36	57.75	17.34	13.25	7.27	54.32	992.06
1954	135.74	128.20	84.41	272.82	193.04	113.07	75.29	27.25	17.20	8.62	1.48	34.09	1091.19
1955	59.34	108.49	129.74	24.10	265.42	209.99	31.32	22.82	1.70	1.29	37.55	32.27	924.03
1956	78.51	142.45	224.29	157.89	119.44	148.35	62.23	12.40	5.31	12.50	45.56	142.45	1151.35
1957	137.41	126.03	112.28	167.44	167.80	44.95	116.44	5.06	4.52	0.38	4.87	30.89	918.08
1958	29.06	169.63	187.88	187.11	171.86	140.06	69.61	261.63	4.89	43.39	55.71	31.81	1352.63
1959	97.09	181.27	191.47	100.91	136.67	160.24	99.22	15.44	4.95	5.20	25.89	51.24	1069.58
1960	78.64	158.79	194.88	126.95	87.83	167.54	119.96	17.70	7.94	6.28	5.75	71.31	1043.58
1961	39.78	127.83	129.98	161.80	200.98	155.50	70.32	4.83	0.00	0.69	57.49	9.95	959.14
1962	84.88	155.64	131.60	191.94	59.63	256.92	53.40	6.62	21.84	133.88	12.01	7.61	1115.98
1963	98.28	150.32	117.39	214.93	91.23	93.71	75.62	14.00	84.77	11.35	6.57	61.81	1019.97
1964	133.13	77.52	121.60	157.43	102.70	32.03	23.18	23.24	105.05	23.08	62.06	45.22	906.25
1965	102.43	151.47	90.98	259.15	164.56	33.58	46.73	66.61	16.03	3.62	31.49	56.46	1023.11
1966	61.36	145.92	104.67	170.46	163.18	239.07	85.59	10.99	28.00	33.79	3.74	7.61	1054.38
1967	77.43	141.24	88.47	122.64	91.83	110.86	43.84	10.39	3.33	0.09	46.72	52.84	789.67
1968	48.96	74.49	103.06	71.80	168.91	205.99	39.19	59.34	2.38	27.79	13.33	38.57	853.83
1969	125.30	110.31	138.45	144.94	97.57	62.89	18.30	44.76	26.17	4.83	121.24	91.15	985.91
1970	110.39	93.41	174.01	86.24	121.02	104.31	55.59	59.37	3.55	72.70	86.20	33.70	1000.51
1971	124.26	116.84	138.80	210.76	136.23	163.60	57.42	42.22	12.59	11.80	10.66	20.09	1045.28
1972	55.26	132.31	79.51	128.86	172.18	189.60	57.64	20.99	2.19	11.02	46.97	69.88	966.41
1973	38.97	131.09	107.87	285.22	199.09	196.81	72.90	78.76	11.72	19.66	15.29	5.88	1163.27
1974	58.26	124.25	162.61	183.06	100.20	86.78	40.72	1.49	0.44	2.12	4.24	112.39	876.55
1975	52.71	126.72	197.46	236.94	167.90	327.90	81.79	38.12	1.66	3.44	24.56	75.26	1334.48
1976	120.28	55.57	132.23	167.15	93.51	124.97	47.30	6.95	10.16	3.56	21.43	46.29	829.40
1977	93.36	78.86	150.72	153.03	123.32	164.74	111.86	10.19	3.67	3.29	26.45	81.25	1000.73
1978	98.35	126.13	168.62	129.41	140.31	133.92	64.48	24.55	2.75	36.89	42.40	37.53	1005.33
1979	60.20	80.10	109.97	128.46	76.76	100.50	32.81	22.36	0.00	1.70	9.38	135.62	757.85
1980	60.80	168.83	121.82	166.73	175.55	68.36	51.74	20.33	18.42	7.03	71.17	45.98	976.75
1981	49.79	135.89	81.48	112.23	73.50	180.81	24.74	15.78	9.86	5.48	5.59	55.95	751.09
1982	109.02	92.68	121.06	83.82	76.17	107.24	51.87	12.27	1.87	29.37	24.89	70.35	780.64
1983	86.63	173.12	214.04	168.08	94.57	83.13	72.33	13.12	23.71	15.07	30.23	21.86	995.88
1984	125.32	82.01	75.92	180.20	238.05	59.83	17.50	9.31	3.58	3.63	0.50	37.51	833.36
1985	201.71	113.18	193.30	166.08	69.69	157.77	40.30	0.40	23.54	1.73	57.12	31.59	1056.41
1986	117.75	118.97	121.22	126.90	162.66	188.65	38.17	3.43	35.70	12.15	73.81	486.97	1486.38
1987	104.70	136.12	77.87	123.61	272.91	209.02	54.79	42.20	30.94	28.47	10.21	41.02	1131.86
1988	66.03	84.70	239.50	138.58	203.98	78.01	68.30	26.44	14.31	11.07	1.48	15.60	948.00
1989	61.92	306.15	173.86	105.83	87.87	164.00	41.56	14.20	6.75	1.97	72.58	23.68	1060.37
1990	103.19	80.78	173.57	150.25	194.40	131.24	26.57	53.44	10.73	0.11	5.16	76.68	1006.12
1991	119.25	85.31	123.42	108.41	125.02	107.80	53.33	0.00	2.61	2.84	8.59	22.66	759.25
1992	58.17	57.46	60.19	44.80	100.66	85.18	54.26	8.45	1.87	1.49	30.98	40.21	543.71
1993	167.50	64.63	207.26	156.18	94.26	161.30	11.88	6.87	28.02	56.76	21.89	4.41	980.95
1994	79.91	44.75	108.31	80.89	46.03	199.27	45.29	13.41	67.59	3.14	31.03	30.66	750.27
1995	88.54	139.90	347.06	169.53	201.43	157.20	29.13	19.61	12.67	227.17	2.17	35.07	1429.48
1996	97.18	146.44	235.71	198.23	102.31	119.50	111.49	31.00	91.41	21.48	32.90	76.48	1264.14
1997	80.20	190.82	83.48	205.98	185.48	112.69	24.61	5.98	0.00	1.20	31.79	24.85	947.08
1998	49.31	111.85	106.86	170.94	171.40	44.52	15.28	10.17	2.69	6.72	10.85	18.70	719.29
1999	124.90	65.45	345.77	178.26	105.06	197.37	99.76	48.33	9.71	0.07	0.00	76.89	1251.56
2000	86.51	100.91	200.33	166.71	79.83	75.41	91.86	17.95	0.00	3.99	50.61	116.23	990.34
2001	134.45	170.44	165.81	295.26	95.09	66.11	23.72	30.77	35.18	64.76	72.58	11.73	1165.91
2002	63.63	69.44	107.95	91.16	52.35	108.21	110.03	23.22	4.70	0.00	6.11	33.12	669.93
2003	16.17	96.71	121.41	111.26	146.86	130.73	46.36	2.54	12.21	54.00	10.50	69.40	818.14
2004	104.96	96.16	325.95	265.52	103.85	152.58	22.01	19.69	4.49	0.00	25.13	33.28	1153.62
2005	75.01	90.07	68.00	181.55	84.10	78.38	80.34	8.08	0.60	8.57	75.06	58.73	808.49
2006	189.54	102.21	171.75	137.12	76.49	169.63	38.62	7.35	53.41	0.30	7.08	38.35	991.85
2007	140.61	182.70	103.24	135.48	52.69	99.67	119.72	1.35	53.78	0.75	4.29	65.62	959.90
2008	106.17	111.95	135.56	108.96	371.59	92.20	38.56	6.15	10.62	0.00	51.41	36.88	1070.04
Ave:	91.93	119.73	149.19	150.18	134.90	133.36	57.06	26.49	19.08	18.80	28.18	52.09	981.00

Monthly catchment rainfall (mm) for quaternary catchment U10H (U10H.RAN)

1925	65.83	70.38	108.70	92.65	80.11	118.38	9.30	31.55	25.15	1.71	6.85	77.27	687.88
1926	119.15	112.05	133.61	131.46	93.14	201.62	45.21	17.85	0.00	25.99	76.09	21.45	977.63
1927	91.18	76.64	185.19	195.17	86.50	102.75	22.05	19.60	0.07	22.63	29.98	59.53	891.28
1928	75.12	95.89	70.97	104.54	86.64	175.68	31.15	25.16	79.86	38.24	7.72	89.07	880.05
1929	91.78	139.72	177.31	153.19	79.18	87.02	44.33	7.61	47.64	4.56	56.59	56.10	945.01
1930	47.74	120.34	135.80	170.56	75.29	120.90	32.79	2.48	19.84	56.85	4.24	13.55	800.38
1931	73.03	66.39	110.31	137.05	137.50	128.13	2.37	55.12	20.77	7.12	2.34	38.58	778.69
1932	79.09	127.72	124.17	88.76	89.58	127.57	44.36	0.00	0.57	19.01	4.43	15.45	720.70
1933	35.02	212.73	218.06	191.68	80.79	116.53	82.82	42.64	1.03	58.84	18.60	39.97	1098.69
1934	80.21	118.79	206.74	103.54	146.45	112.42	81.42	26.73	143.92	0.00	17.67	18.50	1056.36
1935	41.18	27.94	50.20	132.17	199.25	163.33	31.54	85.52	4.65	9.36	8.45	55.70	809.30
1936	78.95	229.09	71.56	146.98	168.83	68.47	20.05	6.30	12.59	7.60	4.35	20.41	835.18
1937	87.43	86.74	133.62	152.74	164.28	77.20	132.71	4.02	15.15	34.10	29.73	22.43	940.14
1938	132.80	120.23	119.38	127.65	273.70	72.06	40.53	48.77	1.61	14.77	16.17	99.24	1066.91
1939	96.69	136.62	153.46	123.76	137.69	111.13	40.80	123.29	57.09	0.00	2.81	43.07	1026.40
1940	57.85	154.79	232.56	106.91	71.66	107.53	60.45	3.25	7.06	16.17	1.69	44.97	864.88
1941	84.79	99.69	73.66	138.76	165.32	208.72	57.97	31.51	0.77	14.26	46.12	43.94	965.52
1942	92.05	160.54	201.00	109.40	101.45	114.38	233.81	65.17	16.56	63.59	85.14	16.74	1259.83
1943	188.77	273.60	193.15	80.31	136.70	121.43	32.08	4.01	20.07	7.48	9.53	96.25	1163.36
1944	67.35	69.64	55.99	132.99	118.51	191.34	48.01	31.13	0.00	0.37	6.02	8.90	730.25
1945	79.02	35.29	116.60	166.11	133.74	122.68	38.61	14.46	3.92	3.12	1.11	23.96	738.62
1946	71.76	113.81	127.35	138.10	150.30	201.88	63.19	7.67	60.20	15.85	9.73	27.46	987.30
1947	76.36	159.32	101.54	144.09	112.46	133.13	62.20	12.89	0.45	1.14	5.96	20.08	829.62
1948	122.49	87.34	115.69	106.00	114.77	125.87	44.82	12.12	0.00	9.43	19.51	52.93	810.97
1949	116.07	137.08	125.62	138.29	127.31	160.87	66.59	30.22	1.96	46.47	70.44	20.89	1041.83
1950	40.08	71.92	221.42	147.34	104.26	119.59	14.09	3.97	2.45	0.00	78.94	52.23	856.29
1951	90.95	33.60	118.83	175.76	101.77	94.18	74.06	18.93	17.59	8.16	13.80	32.62	780.26
1952	51.16	134.90	135.64	127.19	156.96	53.69	35.00	8.78	12.25	0.15	68.83	61.18	845.75
1953	119.38	106.91	136.35	131.50	131.99	91.52	54.10	65.94	7.70	13.72	7.30	54.29	920.71
1954	144.10	120.32	84.61	282.80	239.47	120.94	72.51	31.30	17.07	7.62	2.50	34.83	1158.08
1955	66.45	110.02	134.89	34.33	264.24	209.93	29.11	24.24	16.87	11.65	23.51	36.15	961.41
1956	80.89	141.09	204.37	155.79	115.40	178.87	85.94	14.44	5.87	6.18	41.67	128.39	1158.90
1957	119.99	137.27	126.35	139.95	151.54	59.61	121.17	5.68	3.78	0.09	4.23	40.91	910.58
1958	32.53	161.64	170.75	168.79	143.39	89.49	50.44	266.91	3.31	27.87	36.28	22.07	1173.45
1959	75.62	129.46	153.39	91.01	121.68	172.01	93.35	15.22	2.70	3.94	20.38	42.90	921.66
1960	67.73	150.11	192.95	146.65	85.67	219.48	133.57	15.13	5.68	4.97	10.20	61.59	1093.72
1961	32.28	118.46	122.03	140.87	192.20	146.03	63.80	3.51	0.00	0.64	53.36	8.61	881.79
1962	78.59	151.16	125.87	173.44	49.18	214.47	55.10	6.11	15.12	106.03	8.78	6.78	990.64
1963	90.86	141.33	94.40	219.80	73.83	102.15	77.88	9.20	78.03	14.45	9.81	57.10	968.84
1964	132.96	74.65	105.91	131.20	93.43	31.31	22.26	25.52	96.41	25.62	60.02	43.72	843.01
1965	99.06	141.98	87.58	242.47	145.29	23.71	42.26	55.15	10.90	2.92	32.19	52.92	936.43
1966	47.22	152.95	90.11	164.52	164.70	229.25	90.06	12.26	17.36	18.42	1.73	6.04	994.61
1967	73.14	120.09	72.06	122.11	82.74	114.32	38.78	6.35	1.39	0.04	49.53	55.59	736.14
1968	45.54	65.08	85.45	62.90	141.83	168.23	32.45	57.47	4.62	22.46	23.22	35.93	745.18
1969	145.41	112.38	150.09	119.61	94.83	62.14	24.83	44.77	19.43	4.62	110.89	88.17	977.19
1970	91.47	98.81	150.39	80.26	99.09	105.18	47.40	64.09	1.87	56.36	76.39	32.30	903.61
1971	103.20	105.12	129.81	165.12	128.90	142.04	62.61	45.97	16.29	9.56	16.85	17.45	942.91
1972	53.08	131.08	74.28	109.41	163.11	165.36	59.54	13.99	0.00	10.64	37.60	69.30	887.40
1973	33.45	129.37	117.16	279.85	184.13	165.53	58.64	63.79	9.37	24.09	12.86	4.04	1082.29
1974	46.86	123.84	127.27	178.97	107.02	65.83	41.99	1.77	1.06	2.57	5.84	105.50	808.52
1975	53.36	115.60	179.20	226.90	149.81	313.35	72.93	40.09	1.12	9.84	24.61	60.28	1247.09
1976	139.99	53.58	114.59	162.84	59.64	138.61	44.67	6.45	10.49	0.30	15.62	41.08	787.85
1977	83.43	59.47	158.34	150.74	119.35	148.54	104.42	9.75	6.48	2.16	25.02	82.30	949.99
1978	101.09	118.56	157.22	106.22	135.90	114.65	80.46	17.45	2.21	27.67	41.15	39.73	942.32
1979	63.59	75.23	105.07	113.59	57.67	84.96	40.78	19.89	1.54	2.48	10.55	125.82	701.16
1980	53.57	164.59	95.26	156.65	120.81	71.10	53.27	25.65	15.16	6.27	62.41	38.16	862.92
1981	39.40	136.46	66.69	106.34	84.76	141.94	32.18	13.16	13.50	7.13	5.23	47.57	694.35
1982	106.78	88.33	117.76	72.86	65.25	98.19	71.71	10.87	2.68	32.56	30.24	77.21	774.46
1983	66.35	158.71	174.36	146.71	79.51	74.32	63.80	11.16	21.82	13.41	30.30	18.04	858.48
1984	147.09	75.47	79.42	141.21	217.44	76.93	23.33	14.39	7.73	5.05	0.00	42.98	831.04
1985	200.14	98.80	178.46	108.95	89.60	166.21	37.15	0.93	29.81	1.53	54.33	25.50	991.39
1986	115.36	107.18	160.66	114.24	159.12	195.44	36.39	4.39	36.58	9.06	67.43	463.22	1469.06
1987	92.27	146.03	67.46	106.99	228.52	183.43	67.59	44.47	41.62	28.16	9.90	48.37	1064.80
1988	66.49	98.69	206.66	111.40	217.79	60.37	51.85	21.38	14.35	19.94	0.69	21.59	891.21
1989	61.61	332.93	97.50	111.47	87.22	175.11	42.47	13.87	9.60	2.81	85.77	23.85	1044.23
1990	117.45	66.71	164.30	142.62	205.47	118.85	32.16	42.18	8.95	1.01	3.13	65.69	968.53
1991	127.02	95.66	85.37	113.97	99.40	98.48	24.33	0.00	1.06	1.75	13.32	19.11	679.45
1992	61.59	66.38	80.22	59.29	114.90	83.28	52.36	10.67	2.50	0.26	27.54	37.91	596.91
1993	140.28	48.47	162.37	139.66	65.60	136.91	20.17	6.24	20.49	50.79	33.03	4.87	828.88
1994	85.46	46.90	97.48	107.57	40.61	160.69	43.83	12.41	59.24	3.96	17.20	47.93	723.28
1995	98.50	112.91	363.29	181.13	202.78	142.18	23.64	30.10	13.17	190.29	4.91	26.08	1388.97
1996	90.85	124.56	220.67	144.61	79.71	99.06	114.94	28.64	71.79	28.01	22.34	65.07	1090.23
1997	76.16	184.79	79.96	202.52	189.50	118.15	28.11	17.75	0.00	1.13	37.43	18.29	953.79
1998	42.96	97.90	119.12	151.92	156.56	48.27	15.35	7.20	2.47	3.49	7.68	13.24	666.16
1999	110.46	57.13	315.28	171.26	90.10	106.58	83.06	49.68	7.90	0.05	0.00	77.39	1068.90
2000	75.53	122.70	172.60	125.87	82.82	63.61	102.78	16.44	0.00	3.91	40.47	126.14	932.87
2001	114.61	174.06	172.11	266.93	80.47	61.89	55.22	32.74	34.20	82.69	83.55	32.93	1191.42
2002	66.99	72.05	103.39	78.06	90.69	101.80	68.18	40.54	5.42	0.00	17.55	39.75	684.43
2003	23.74	101.86	97.82	102.74	153.81	87.86	39.80	0.74	22.78	42.55	12.81	69.93	756.45
2004	103.72	92.78	254.75	219.87	100.09	174.43	12.03	12.60	5.15	0.28	19.78	32.20	1027.69
2005	66.56	95.50	74.31	161.79	100.67	107.12	78.56	26.55	4.08	1.41	54.55	46.91	818.00
2006	153.92	112.00	161.93	118.04	73.61	164.35	43.74	3.63	64.27	0.21	4.47	40.99	941.17
2007	122.08	208.67	104.48	164.75	63.51	96.72	94.05	1.63	33.33	0.53	3.15	49.52	942.41
2008	46.49	100.87	129.38	70.84	229.31	153.74	45.67	0.34	0.00	11.97	26.76	44.58	859.95
Ave:	86.05	116.76	136.57	140.06	125.71	125.99	55.37	25.99	17.61	17.31	26.68	49.90	924.00

Monthly catchment rainfall (mm) for quaternary catchment U10J (U10J.RAN)

1925	62.63	79.90	120.59	76.75	67.41	155.62	14.64	30.73	39.81	1.80	5.54	89.31	744.74
1926	109.02	97.12	140.65	70.55	56.57	257.67	17.32	26.16	0.00	29.79	77.40	23.64	905.89
1927	83.64	43.50	187.95	251.20	101.61	103.61	23.96	10.50	1.71	24.59	35.05	36.56	903.89
1928	98.76	92.64	52.54	73.71	81.42	176.99	51.79	36.66	103.49	40.20	7.89	80.51	896.61
1929	80.75	132.77	130.47	158.15	81.52	138.41	37.43	5.26	56.03	1.89	64.88	52.87	940.43
1930	47.50	82.85	126.13	182.61	110.01	133.99	51.44	4.92	28.28	105.93	6.00	10.91	890.57
1931	71.39	61.00	95.43	146.41	141.41	118.16	0.74	32.83	9.93	5.83	2.34	37.23	722.72
1932	56.07	146.34	107.59	63.43	66.28	130.73	50.81	0.00	1.89	8.62	5.14	15.13	652.03
1933	29.10	190.74	187.91	139.67	82.66	93.13	82.63	33.94	2.01	55.94	13.09	37.88	948.70
1934	62.00	129.58	182.45	82.76	124.14	110.16	90.75	34.69	153.94	0.76	17.47	12.45	1001.15
1935	29.42	29.07	38.51	130.51	214.89	166.85	25.62	92.84	6.60	10.47	8.97	41.49	795.22
1936	68.44	203.71	65.84	104.36	189.56	57.61	16.43	8.93	18.43	7.17	2.60	11.02	754.08
1937	59.70	79.76	112.54	115.17	170.58	70.62	119.29	6.45	11.01	41.97	31.98	13.26	832.32
1938	124.79	103.31	115.70	114.88	227.61	61.57	52.06	53.44	0.37	21.77	20.72	97.59	993.82
1939	103.85	119.01	133.51	119.68	130.18	94.83	42.05	129.92	60.09	0.00	3.48	35.20	971.80
1940	58.79	170.82	199.08	76.32	65.36	105.35	64.98	4.57	5.61	19.03	2.46	39.77	812.14
1941	76.29	87.73	75.27	134.67	151.23	172.83	65.48	31.44	2.13	23.56	45.78	37.01	903.40
1942	87.57	150.92	183.04	99.10	101.80	106.63	215.32	68.04	17.93	62.29	74.71	11.96	1179.32
1943	184.41	262.23	182.36	93.14	119.98	110.39	30.02	4.71	20.30	9.77	7.18	97.80	1122.29
1944	60.21	60.98	45.37	109.79	114.27	192.08	36.47	27.84	0.00	0.00	3.97	6.39	657.37
1945	73.52	21.57	94.21	135.62	117.67	116.14	37.23	14.27	6.27	3.32	1.49	24.93	646.23
1946	63.35	110.79	117.66	103.90	139.75	180.51	59.65	11.56	90.58	17.70	9.99	27.67	933.11
1947	71.55	150.67	107.98	134.39	99.77	118.12	58.04	15.85	0.12	1.54	5.91	19.78	783.71
1948	108.54	90.46	113.67	95.57	115.85	114.50	45.21	13.26	1.26	12.29	16.35	50.52	777.47
1949	99.45	147.55	107.15	151.13	134.79	139.21	68.92	33.63	2.71	43.86	66.54	17.32	1012.26
1950	38.20	66.81	207.98	137.13	94.65	110.00	18.91	6.61	4.37	0.00	87.59	49.49	821.73
1951	81.86	29.84	103.91	160.10	105.32	96.71	70.58	20.24	18.08	10.07	16.70	29.48	742.91
1952	43.46	95.26	133.80	112.14	138.52	49.70	30.13	10.92	13.88	0.00	73.79	58.63	760.24
1953	100.51	94.66	165.66	134.87	102.57	81.34	51.09	56.62	12.70	14.24	6.67	56.54	877.46
1954	133.45	119.15	68.20	256.12	205.74	108.10	62.11	22.82	20.72	6.50	3.92	42.58	1049.41
1955	66.03	106.87	123.16	35.19	227.09	202.08	33.35	22.92	11.95	6.64	24.55	34.59	894.41
1956	68.31	124.65	199.50	142.05	95.81	156.82	83.24	12.68	2.79	6.64	41.52	119.76	1053.77
1957	119.81	116.57	85.58	111.13	161.48	45.72	110.39	3.81	6.00	1.96	3.83	42.74	808.99
1958	31.25	157.46	156.25	170.88	131.07	76.86	50.92	251.61	2.70	19.64	32.29	29.22	1110.17
1959	81.83	136.43	131.08	67.73	105.41	147.66	102.92	12.88	2.58	5.03	21.72	42.32	857.58
1960	65.33	131.50	188.06	160.72	77.90	195.43	141.61	12.31	7.75	4.79	9.19	70.24	1064.85
1961	32.87	112.25	107.76	128.78	147.54	152.00	39.18	3.10	0.00	0.00	65.09	6.60	795.16
1962	80.79	136.29	96.34	174.65	46.69	210.85	54.37	2.58	11.60	103.51	7.53	6.88	932.07
1963	65.08	106.59	102.74	209.20	72.87	95.90	78.77	4.30	81.12	12.81	9.91	60.48	899.77
1964	129.05	67.29	108.90	112.52	85.12	42.01	34.19	28.15	105.42	25.56	64.88	37.19	840.29
1965	111.15	150.00	82.95	213.21	117.31	22.04	32.06	56.47	11.25	3.25	34.04	50.51	884.23
1966	43.04	141.51	71.45	130.37	166.17	220.11	106.18	10.15	23.42	28.12	2.97	8.35	951.85
1967	79.45	129.56	61.08	108.75	73.47	99.77	28.78	7.19	0.78	0.04	57.81	61.50	708.18
1968	46.98	66.55	62.82	44.74	120.45	161.89	33.33	55.77	4.88	21.53	23.46	47.41	689.80
1969	148.48	104.55	150.08	99.02	90.98	51.74	29.71	43.75	26.22	2.96	107.46	102.99	957.95
1970	86.53	99.92	130.62	71.33	84.46	114.66	63.76	72.23	1.65	51.91	80.69	40.68	898.43
1971	88.73	92.79	126.93	140.45	144.55	121.54	46.24	44.80	25.14	8.88	20.36	12.60	872.99
1972	50.20	121.36	80.04	110.56	158.78	119.06	55.48	9.30	0.00	11.67	41.28	67.34	825.06
1973	37.65	121.23	130.33	279.46	153.00	135.93	46.61	58.62	8.83	26.01	12.72	6.40	1016.78
1974	54.77	111.95	104.40	188.54	107.23	59.11	50.36	3.51	0.98	2.33	6.92	102.06	792.15
1975	50.99	98.42	166.92	206.48	144.64	290.73	78.73	45.21	3.71	9.58	27.53	59.18	1182.11
1976	145.68	50.92	96.02	136.13	58.22	140.36	32.19	15.74	8.25	2.91	15.46	43.45	745.36
1977	80.30	71.51	173.51	163.29	95.71	110.79	125.47	10.77	3.64	1.10	28.93	82.05	947.07
1978	107.59	176.14	145.53	97.96	134.43	102.21	66.47	18.77	1.74	33.54	39.32	41.92	965.62
1979	70.99	75.58	106.86	111.26	52.33	68.48	44.71	21.46	0.00	2.53	10.65	129.72	694.58
1980	51.72	143.86	68.45	163.75	105.16	54.00	54.16	29.45	13.87	5.66	65.38	46.33	801.80
1981	39.71	117.57	72.34	97.09	67.30	172.68	33.29	16.59	16.88	7.86	3.65	43.37	688.33
1982	108.91	68.39	89.87	67.69	46.50	102.15	66.83	13.14	1.81	34.78	35.17	50.02	685.26
1983	69.37	140.12	157.20	176.75	112.63	74.49	80.47	11.84	25.81	22.89	25.00	15.93	912.49
1984	112.68	79.12	74.11	167.21	208.29	57.07	19.95	9.87	11.45	4.60	0.35	42.95	787.65
1985	206.77	90.89	184.03	105.24	78.54	152.42	36.77	0.18	29.85	1.09	52.92	27.19	965.89
1986	116.80	101.59	157.67	104.01	124.51	153.35	32.63	8.51	28.70	15.86	78.59	462.06	1384.28
1987	84.66	146.02	65.26	88.80	195.13	185.10	55.84	45.92	39.61	29.25	11.81	46.86	994.26
1988	63.21	93.83	196.34	105.80	207.00	57.34	49.26	20.31	13.64	18.96	0.65	20.53	846.89
1989	58.55	316.43	92.67	105.90	82.90	166.48	40.38	13.18	9.13	2.67	81.54	22.68	992.51
1990	111.65	63.40	156.17	135.61	195.28	112.94	30.57	40.13	8.51	0.96	2.97	62.38	920.58
1991	120.73	90.93	81.08	108.31	94.41	93.57	23.13	0.00	1.00	1.66	12.66	18.16	645.65
1992	58.55	63.11	76.29	56.39	109.22	79.10	49.75	10.14	2.38	0.25	26.16	36.04	567.38
1993	133.28	46.05	154.26	132.71	62.30	130.06	19.18	5.93	19.46	48.26	31.41	4.63	787.55
1994	81.24	44.58	92.62	102.29	38.59	152.65	41.66	11.79	56.30	3.77	16.33	45.58	687.41
1995	93.65	107.29	345.29	172.16	192.70	135.08	22.46	28.62	12.51	180.76	4.67	24.77	1319.95
1996	86.34	118.34	209.73	137.33	75.71	94.10	109.22	27.21	68.21	26.63	21.22	61.83	1035.85
1997	72.39	175.62	76.01	192.45	180.16	112.32	26.73	16.88	0.00	1.07	35.55	17.38	906.56
1998	40.81	93.02	113.26	144.33	148.74	45.88	14.59	6.83	2.34	3.32	7.28	12.56	632.97
1999	104.98	54.27	299.62	162.76	85.66	101.23	78.89	47.22	7.50	0.05	0.00	73.57	1015.75
2000	71.76	116.66	164.00	119.52	78.71	60.43	97.72	15.61	0.00	3.72	38.45	119.90	886.47
2001	108.90	165.42	163.58	253.49	76.46	58.81	52.53	31.10	32.50	78.62	79.45	31.35	1132.22
2002	63.65	68.48	98.27	74.17	86.24	96.76	64.76	38.57	5.16	0.00	16.71	37.80	650.56
2003	22.57	96.81	92.94	97.68	146.19	83.44	37.81	0.70	21.67	40.42	12.17	66.47	718.90
2004	98.57	88.19	241.99	208.84	95.14	165.79	11.44	11.96	4.89	0.27	18.79	30.60	976.44
2005	63.23	90.78	70.62	153.78	95.69	101.83	74.65	25.25	3.89	1.34	51.85	44.58	777.49
2006	146.16	106.47	153.90	112.15	69.95	156.17	41.58	3.45	61.06	0.20	4.25	38.97	894.31
2007	116.00	198.34	99.27	156.59	60.39	91.90	89.36	1.55	31.67	0.50	2.99	47.03	895.59
2008	44.27	96.04	123.18	67.45	218.33	146.38	43.48	0.32	0.00	11.39	25.48	42.44	818.77
Ave:	81.69	110.00	126.93	130.34	117.19	119.15	54.28	25.83	18.96	18.10	27.13	48.39	878.00

Monthly catchment rainfall (mm) for quaternary catchment U10K (U10K.RAN)

1925	80.21	79.82	79.46	43.09	62.68	145.78	12.78	26.98	42.13	0.26	5.99	75.78	654.97
1926	104.24	103.76	146.10	55.64	83.90	210.58	11.46	20.93	0.00	27.74	66.56	15.31	846.22
1927	85.30	43.93	142.89	163.42	96.60	77.70	18.57	10.24	1.24	1.77	27.90	47.62	717.19
1928	68.30	63.68	50.22	69.41	65.62	156.20	33.31	25.70	81.38	40.32	9.52	82.47	746.13
1929	56.95	93.19	100.47	179.32	74.97	129.59	37.46	7.09	56.92	5.44	37.64	47.09	826.11
1930	55.04	81.38	140.98	140.17	121.61	116.74	55.75	2.94	0.94	76.71	6.97	10.01	809.24
1931	70.62	70.69	96.78	143.22	125.25	111.37	4.74	32.05	19.00	10.17	3.19	37.70	724.78
1932	63.18	103.19	137.07	53.55	59.78	76.84	32.75	0.97	2.10	18.23	4.92	15.61	568.19
1933	27.98	164.72	182.18	133.94	74.87	90.87	69.94	29.20	2.65	47.27	12.45	34.06	870.12
1934	53.94	145.23	170.37	69.77	87.51	107.57	82.62	33.37	155.71	1.45	24.84	11.37	943.75
1935	41.09	33.40	48.53	117.02	203.57	112.94	20.69	93.44	6.09	9.61	8.17	40.11	734.65
1936	60.80	207.22	61.27	108.38	140.90	44.73	13.16	5.53	16.56	9.01	4.83	13.10	685.48
1937	62.14	66.52	136.67	119.67	147.07	79.16	117.45	6.68	13.55	38.39	25.99	10.51	823.78
1938	135.14	84.70	126.83	100.32	196.41	41.02	58.94	44.17	0.66	23.04	22.81	86.91	920.93
1939	120.96	98.17	105.50	91.37	98.31	84.96	33.71	140.93	52.00	0.55	4.52	33.58	864.56
1940	57.06	194.68	154.76	65.93	73.51	115.40	48.35	0.00	3.30	19.93	2.67	37.96	773.55
1941	79.49	72.64	78.46	123.75	118.99	160.12	47.95	27.94	3.45	24.73	41.07	31.25	809.83
1942	77.03	162.83	149.41	90.62	99.74	116.12	214.79	61.43	19.36	56.54	56.68	11.24	1115.80
1943	176.02	229.53	151.96	108.93	110.06	96.72	16.09	4.27	17.12	10.13	5.12	90.46	1016.43
1944	61.00	56.18	46.01	87.26	101.69	196.90	33.81	34.03	0.21	0.42	2.39	5.00	624.89
1945	70.24	24.78	76.14	126.76	96.96	106.82	34.68	10.35	1.24	1.96	1.20	24.10	575.23
1946	59.21	105.88	102.45	98.96	125.41	140.98	64.06	14.34	69.84	12.23	8.74	23.46	825.55
1947	72.45	139.82	125.62	117.22	92.77	91.40	62.21	11.36	0.00	1.98	4.42	17.29	736.55
1948	70.23	85.09	123.57	96.86	94.28	81.99	36.32	11.23	1.88	10.69	12.04	47.39	671.57
1949	69.81	131.06	98.84	119.31	96.10	146.30	55.77	25.91	2.63	34.97	59.68	19.32	859.69
1950	35.39	61.53	175.54	144.17	85.51	90.65	20.42	10.57	3.98	0.00	72.51	44.61	744.87
1951	83.72	26.75	116.83	160.77	102.73	80.80	79.66	23.99	17.53	10.95	19.32	29.98	753.04
1952	49.58	80.83	147.58	104.82	119.53	46.91	29.07	11.34	16.74	0.00	73.72	53.68	733.81
1953	84.62	86.31	173.77	135.94	94.15	54.21	44.22	39.83	15.42	17.39	8.14	47.54	801.55
1954	121.53	103.24	70.51	234.66	171.01	82.85	51.74	5.28	22.19	1.27	4.35	45.27	913.90
1955	51.96	104.35	104.63	37.06	184.90	171.06	40.30	17.91	3.96	14.66	25.55	34.85	791.16
1956	63.17	113.26	184.42	115.12	76.67	117.44	87.02	12.70	0.91	2.53	35.77	121.33	930.34
1957	99.08	105.64	51.63	102.26	174.23	60.48	107.39	5.74	5.42	1.04	2.31	66.25	781.49
1958	23.57	142.67	126.75	173.70	116.47	85.43	50.67	194.82	3.06	21.81	34.18	30.74	1003.86
1959	75.75	135.99	112.52	68.71	93.64	117.21	79.56	9.48	4.05	6.90	18.45	43.81	766.06
1960	58.58	110.68	160.74	109.76	66.29	143.27	125.28	11.29	9.57	4.15	9.45	57.34	866.40
1961	36.69	87.87	84.64	130.48	117.91	135.46	39.54	2.24	0.00	0.00	57.73	7.59	700.14
1962	74.41	123.20	82.08	166.85	46.04	186.81	38.98	1.84	13.95	101.08	6.26	11.20	852.70
1963	59.67	83.02	93.02	168.79	60.95	86.32	69.57	3.70	69.26	11.65	6.81	55.89	768.66
1964	124.66	55.71	101.64	101.86	71.11	33.60	26.35	17.89	110.21	22.38	61.21	45.37	771.99
1965	78.30	127.03	82.46	174.88	90.42	17.17	29.45	63.12	12.52	3.56	28.93	42.74	750.57
1966	32.76	120.96	62.62	105.17	153.01	186.52	80.52	8.42	20.22	26.81	3.24	10.18	810.42
1967	67.30	123.82	59.14	109.09	60.59	72.71	22.55	6.37	1.75	0.05	56.91	53.83	634.13
1968	50.08	60.40	60.67	43.68	102.29	135.42	32.89	50.73	3.13	23.72	18.31	52.05	633.36
1969	133.18	89.95	116.67	91.16	73.67	55.53	20.10	41.24	28.12	5.25	86.10	81.77	822.75
1970	87.19	92.90	108.02	71.60	91.62	105.89	49.99	81.00	0.64	48.30	79.37	35.36	851.86
1971	84.46	85.22	116.36	121.05	131.48	89.68	49.28	39.20	16.16	5.70	10.74	13.33	762.67
1972	45.00	110.39	68.24	97.35	125.26	111.11	47.98	9.17	0.00	9.48	43.84	65.78	733.59
1973	41.31	114.41	90.28	194.39	129.55	121.60	51.90	61.90	10.13	27.52	8.29	7.23	858.51
1974	43.89	91.51	92.38	151.28	111.48	55.77	52.11	7.94	0.96	2.87	5.46	94.05	709.70
1975	35.53	82.08	160.77	171.25	140.39	245.00	77.49	38.20	4.02	6.65	30.40	57.47	1049.23
1976	115.59	53.32	85.38	144.99	81.39	113.51	22.39	11.51	11.26	0.65	24.27	43.95	708.22
1977	77.37	82.24	143.77	124.97	91.67	118.29	107.05	8.96	4.94	1.95	30.27	75.51	866.98
1978	105.39	132.30	110.61	77.88	105.71	100.49	44.72	22.20	1.16	30.19	33.36	38.99	803.00
1979	59.05	66.87	100.80	99.63	51.03	60.33	40.34	20.15	0.00	3.65	10.39	141.22	653.46
1980	48.96	130.02	58.52	142.93	85.34	47.89	50.02	32.59	13.97	6.63	66.43	47.22	730.53
1981	40.84	107.57	60.63	92.46	64.50	140.97	34.11	14.97	15.64	6.73	3.47	40.24	622.13
1982	101.64	68.64	83.49	69.68	48.75	84.97	58.47	12.07	4.85	37.98	32.44	45.96	648.93
1983	73.64	141.74	139.04	171.95	122.00	75.23	82.41	12.96	21.55	28.06	27.89	16.70	913.16
1984	100.80	82.29	68.10	151.08	219.16	48.03	25.82	11.21	15.78	4.12	0.89	36.71	764.01
1985	198.07	80.47	166.79	104.39	60.33	136.86	42.52	0.91	25.61	2.16	47.60	26.53	892.24
1986	107.01	100.08	123.54	90.84	105.09	143.02	24.84	24.72	31.91	11.66	63.26	432.65	1258.62
1987	80.51	140.18	60.75	75.00	191.17	193.11	48.46	49.51	34.41	18.75	18.76	41.98	952.58
1988	55.78	77.56	171.32	84.66	182.14	45.14	54.60	15.66	14.54	17.25	1.18	24.74	744.57
1989	58.39	291.72	76.41	83.22	73.93	162.24	38.04	11.76	7.75	1.62	76.15	23.28	904.51
1990	108.39	52.64	135.06	117.53	162.27	92.95	21.17	40.53	6.58	2.68	9.41	60.59	809.80
1991	109.92	75.55	63.31	92.55	63.87	71.83	19.97	0.52	1.91	2.70	9.75	20.52	532.40
1992	54.99	61.70	61.80	51.38	85.01	63.59	42.92	6.89	3.80	10.38	20.72	52.56	515.75
1993	118.54	52.52	142.83	105.52	41.26	135.85	15.65	6.20	11.69	46.92	32.34	4.63	713.97
1994	74.18	42.61	84.04	84.73	35.07	141.70	49.13	11.95	49.66	4.77	10.86	32.51	621.19
1995	92.56	95.05	286.83	166.75	166.19	115.02	26.76	24.49	8.58	152.77	4.66	21.19	1160.85
1996	78.02	106.88	189.58	123.84	68.30	84.91	98.68	24.59	61.59	24.09	19.14	55.85	935.45
1997	65.47	158.71	68.75	173.87	163.01	101.62	24.18	15.30	0.00	0.97	32.08	15.73	819.68
1998	36.85	84.04	102.49	130.33	134.29	41.49	13.17	6.13	2.11	2.99	6.54	11.28	571.72
1999	94.90	49.00	270.78	147.10	77.50	91.31	71.16	42.70	6.78	0.05	0.00	66.53	917.79
2000	64.79	105.57	148.12	107.73	71.13	54.56	88.42	14.07	0.00	3.37	34.71	108.44	800.91
2001	98.35	149.52	147.87	228.54	69.06	53.13	47.63	28.06	29.38	71.17	71.92	28.50	1023.11
2002	57.50	61.90	88.85	66.99	78.11	87.49	58.40	34.96	4.67	0.00	15.19	34.22	588.29
2003	20.45	87.52	83.92	88.40	132.19	75.26	34.13	0.63	19.64	36.49	11.02	60.08	649.74
2004	89.07	79.73	218.39	188.39	86.02	149.89	10.34	10.75	4.41	0.24	16.96	27.64	881.84
2005	57.09	82.11	63.82	139.05	86.52	92.15	67.47	22.90	3.53	1.22	46.86	40.28	703.01
2006	131.73	96.31	139.11	101.26	63.21	141.10	37.61	3.12	55.11	0.18	3.86	35.26	807.86
2007	104.78	179.36	89.65	141.60	54.67	83.02	80.69	1.40	28.59	0.45	2.70	42.43	809.35
2008	40.25	87.31	111.99	61.32	198.50	133.08	39.53	0.29	0.00	10.36	23.16	38.59	744.39
Ave:	75.48	100.30	114.08	115.96	104.26	104.85	49.31	23.83	17.44	16.70	24.71	46.08	793.00

Monthly catchment rainfall (mm) for quaternary catchment U10L (U10L.RAN)

1925	76.67	76.30	75.95	41.19	59.91	139.35	12.22	25.79	40.27	0.25	5.73	72.44	626.06
1926	99.64	99.18	139.65	53.19	80.19	201.28	10.96	20.00	0.00	26.51	63.63	14.63	808.87
1927	81.54	41.99	136.58	156.21	92.34	74.27	17.75	9.79	1.18	1.69	26.67	45.52	685.54
1928	65.29	60.87	48.00	66.35	62.72	149.31	31.84	24.57	77.78	38.54	9.10	78.83	713.20
1929	54.43	89.08	96.03	171.40	71.66	123.87	35.81	6.77	54.41	5.20	35.98	45.01	789.65
1930	52.61	77.78	134.76	133.98	116.24	111.59	53.29	2.81	0.90	73.33	6.66	9.57	773.53
1931	67.51	67.57	92.51	136.90	119.72	106.45	4.53	30.64	18.16	9.72	3.05	36.03	692.79
1932	60.39	98.64	131.02	51.19	57.14	73.45	31.30	0.93	2.01	17.42	4.70	14.92	543.11
1933	26.75	157.45	174.14	128.03	71.57	86.86	66.85	27.91	2.54	45.18	11.90	32.55	831.72
1934	51.56	138.82	162.85	66.69	83.65	102.82	78.97	31.90	148.84	1.38	23.75	10.87	902.10
1935	39.27	31.92	46.39	111.86	194.59	107.95	19.78	89.32	5.82	9.18	7.81	38.34	702.23
1936	58.12	198.07	58.56	103.60	134.68	42.76	12.58	5.29	15.82	8.61	4.61	12.52	655.22
1937	59.39	63.59	130.64	114.38	140.58	75.66	112.26	6.38	12.95	36.70	24.84	10.04	787.42
1938	129.17	80.96	121.23	95.89	187.74	39.21	56.34	42.22	0.63	22.02	21.80	83.07	880.29
1939	115.62	93.84	100.84	87.34	93.97	81.21	32.22	134.71	49.70	0.53	4.32	32.10	826.40
1940	54.54	186.09	147.93	63.02	70.27	110.31	46.22	0.00	3.15	19.05	2.56	36.28	739.40
1941	75.98	69.43	75.00	118.29	113.74	153.05	45.83	26.71	3.30	23.64	39.25	29.87	774.09
1942	73.63	155.64	142.82	86.62	95.33	111.00	205.31	58.72	18.51	54.05	54.18	10.74	1066.56
1943	168.25	219.40	145.25	104.13	105.20	92.46	15.38	4.09	16.36	9.69	4.90	86.47	971.57
1944	58.30	53.70	43.98	83.41	97.20	188.21	32.32	32.53	0.20	0.40	2.28	4.78	597.31
1945	67.14	23.68	72.78	121.16	92.68	102.10	33.15	9.89	1.18	1.88	1.15	23.04	549.84
1946	56.60	101.21	97.93	94.59	119.88	134.75	61.23	13.70	66.76	11.69	8.36	22.43	789.11
1947	69.25	133.65	120.08	112.05	88.68	87.37	59.46	10.86	0.00	1.90	4.23	16.53	704.04
1948	67.13	81.33	118.12	92.58	90.12	78.37	34.72	10.74	1.80	10.22	11.51	45.29	641.93
1949	66.73	125.27	94.47	114.05	91.86	139.84	53.30	24.77	2.52	33.43	57.04	18.47	821.75
1950	33.83	58.82	167.79	137.81	81.73	86.65	19.52	10.10	3.80	0.00	69.31	42.64	712.00
1951	80.03	25.57	111.68	153.67	98.20	77.24	76.14	22.93	16.76	10.47	18.47	28.66	719.80
1952	47.39	77.27	141.07	100.19	114.25	44.84	27.79	10.84	16.00	0.00	70.47	51.31	701.42
1953	80.88	82.50	166.10	129.94	89.99	51.82	42.27	38.08	14.74	16.62	7.78	45.44	766.17
1954	116.17	98.69	67.40	224.31	163.46	79.19	49.46	5.04	21.21	1.21	4.16	43.27	873.56
1955	49.67	99.75	100.01	35.42	176.74	163.51	38.52	17.12	3.78	14.01	24.42	33.31	756.24
1956	60.38	108.26	176.28	110.04	73.28	112.26	83.18	12.14	0.87	2.42	34.19	115.97	889.28
1957	94.71	100.98	49.35	97.75	166.54	57.81	102.65	5.49	5.18	0.99	2.21	63.32	747.00
1958	22.53	136.37	121.15	166.03	111.33	81.66	48.44	186.22	2.92	20.85	32.67	29.39	959.55
1959	72.41	129.99	107.55	65.68	89.50	112.04	76.04	9.06	3.87	6.60	17.64	41.88	732.25
1960	56.00	105.79	153.65	104.92	63.37	136.95	119.75	10.79	9.15	3.96	9.04	54.80	828.16
1961	35.07	83.99	80.90	124.72	112.70	129.48	37.79	2.14	0.00	0.00	55.18	7.26	669.23
1962	71.13	117.76	78.46	159.49	44.00	178.56	37.26	1.76	13.33	96.62	5.98	10.70	815.07
1963	57.04	79.36	88.92	161.34	58.26	82.51	66.50	3.54	66.20	11.14	6.51	53.43	734.73
1964	119.16	53.26	97.15	97.36	67.97	32.12	25.18	17.10	105.35	21.39	58.51	43.37	737.92
1965	74.85	121.42	78.82	167.16	86.43	16.41	28.15	60.33	11.96	3.40	27.65	40.85	717.44
1966	31.31	115.62	59.86	100.53	146.25	178.29	76.97	8.05	19.33	25.62	3.10	9.73	774.65
1967	64.33	118.36	56.53	104.28	57.92	69.50	21.56	6.09	1.67	0.04	54.40	51.45	606.14
1968	47.87	57.73	58.00	41.75	97.77	129.45	31.44	48.49	2.99	22.68	17.50	49.75	605.41
1969	127.30	85.98	111.52	87.14	70.42	53.08	19.22	39.42	26.88	5.02	82.30	78.16	786.44
1970	83.34	88.80	103.26	68.44	87.57	101.21	47.78	77.42	0.61	46.17	75.86	33.80	814.26
1971	80.73	81.46	111.23	115.71	125.68	85.73	47.10	37.47	15.44	5.44	10.27	12.74	729.00
1972	43.01	105.51	65.23	93.05	119.74	106.21	45.86	8.77	0.00	9.06	41.91	62.87	701.21
1973	39.49	109.36	86.29	185.81	123.83	116.23	49.61	59.17	9.68	26.31	7.92	6.91	820.62
1974	41.96	87.47	88.30	144.61	106.56	53.31	49.81	7.59	0.91	2.74	5.22	89.90	678.37
1975	33.96	78.46	153.67	163.69	134.19	234.19	74.07	36.51	3.84	6.35	29.05	54.93	1002.92
1976	110.49	50.97	81.61	138.59	77.80	108.50	21.40	11.00	10.76	0.62	23.20	42.01	676.96
1977	73.95	78.61	137.43	119.45	87.63	113.07	102.32	8.57	4.72	1.86	28.93	72.17	828.71
1978	100.74	126.46	105.73	74.44	101.05	96.05	42.74	21.22	1.11	28.86	31.89	37.27	767.56
1979	56.45	63.92	96.35	95.23	48.78	57.67	38.56	19.26	0.00	3.49	9.93	134.99	624.62
1980	46.80	124.28	55.94	136.62	81.57	45.78	47.81	31.15	13.36	6.34	63.50	45.14	698.29
1981	39.03	102.82	57.95	88.38	61.65	134.74	32.61	14.31	14.95	6.43	3.32	38.47	594.68
1982	97.15	65.61	79.81	66.60	46.60	81.22	55.89	11.54	4.63	36.31	31.00	43.93	620.29
1983	70.39	135.48	132.90	164.36	116.61	71.91	78.78	12.39	20.60	26.82	26.66	15.97	872.86
1984	96.36	78.66	65.10	144.42	209.48	45.91	24.68	10.71	15.09	3.94	0.85	35.09	730.29
1985	189.32	76.92	159.43	99.78	57.67	130.82	40.64	0.87	24.48	2.06	45.50	25.36	852.86
1986	102.29	95.66	118.09	86.83	100.46	136.71	23.74	23.63	30.50	11.14	60.47	413.55	1203.07
1987	76.96	133.99	58.07	71.69	182.73	184.59	46.32	47.33	32.89	17.92	17.93	40.12	910.54
1988	53.32	74.13	163.75	80.93	174.10	43.15	52.19	14.97	13.90	16.49	1.13	23.65	711.71
1989	55.82	278.85	73.03	79.55	70.66	155.08	36.36	11.24	7.41	1.54	72.79	22.25	864.59
1990	103.61	50.32	129.10	112.34	155.11	88.85	20.23	38.74	6.29	2.56	8.99	57.92	774.06
1991	105.06	72.21	60.52	88.46	61.06	68.66	19.09	0.50	1.83	2.58	9.32	19.62	508.90
1992	52.57	58.97	59.07	49.11	81.26	60.78	41.03	6.59	3.63	9.92	19.80	50.24	492.98
1993	113.31	50.20	136.53	100.86	39.44	129.86	14.96	5.93	11.18	44.84	30.92	4.42	682.45
1994	70.90	40.73	80.33	80.99	33.52	135.45	46.96	11.42	47.47	4.56	10.38	31.08	593.78
1995	88.47	90.86	274.17	159.39	158.85	109.94	25.58	23.41	8.20	146.03	4.45	20.25	1109.61
1996	74.57	102.16	181.22	118.37	65.28	81.16	94.32	23.50	58.88	23.03	18.29	53.38	894.16
1997	62.59	151.71	65.72	166.19	155.81	97.13	23.11	14.63	0.00	0.92	30.67	15.03	783.51
1998	35.22	80.33	97.97	124.57	128.37	39.66	12.59	5.86	2.02	2.85	6.25	10.78	546.48
1999	90.71	46.84	258.82	140.61	74.08	87.28	68.02	40.82	6.48	0.04	0.00	63.59	877.29
2000	61.93	100.91	141.59	102.98	67.99	52.15	84.52	13.44	0.00	3.22	33.18	103.65	765.56
2001	94.01	142.92	141.34	218.45	66.01	50.79	45.53	26.82	28.08	68.03	68.74	27.24	977.96
2002	54.96	59.17	84.93	64.03	74.66	83.63	55.82	33.42	4.47	0.00	14.52	32.71	562.32
2003	19.55	83.65	80.22	84.50	126.35	71.94	32.62	0.60	18.78	34.88	10.53	57.43	621.06
2004	85.14	76.21	208.75	180.08	82.22	143.27	9.88	10.28	4.22	0.23	16.21	26.42	842.92
2005	54.57	78.49	61.01	132.91	82.70	88.08	64.49	21.89	3.37	1.16	44.79	38.51	671.98
2006	125.92	92.06	132.97	96.79	60.42	134.87	35.95	2.98	52.67	0.17	3.69	33.70	772.20
2007	100.16	171.45	85.70	135.35	52.25	79.36	77.13	1.33	27.33	0.43	2.58	40.56	773.63
2008	38.47	83.46	107.05	58.62	189.74	127.21	37.79	0.28	0.00	9.90	22.14	36.89	711.53
Ave:	72.15	95.87	109.05	110.84	99.66	100.23	47.14	22.78	16.67	15.96	23.62	44.04	758.00

Monthly catchment rainfall (mm) for quaternary catchment U10M (U10M.RAN)

1925	115.16	85.68	39.72	27.68	57.17	130.66	1.80	29.48	31.97	0.00	2.21	61.46	583.00
1926	81.70	95.47	98.83	51.66	121.03	180.93	7.97	17.99	1.35	24.33	58.56	18.81	758.62
1927	78.05	27.40	165.37	145.54	113.84	73.94	24.35	26.48	0.35	3.40	40.97	45.89	745.58
1928	83.01	85.28	87.91	84.82	68.50	161.39	42.32	46.25	191.92	81.01	23.70	92.13	1048.23
1929	66.08	100.28	89.50	200.08	59.69	89.85	38.51	10.73	43.33	25.93	31.71	72.45	828.14
1930	64.17	86.53	147.10	159.05	72.35	136.00	37.72	3.04	5.03	97.95	12.71	32.26	853.90
1931	41.30	63.95	95.43	117.18	140.05	125.49	29.46	52.02	12.83	13.84	15.59	30.97	738.13
1932	119.51	85.50	139.29	51.22	41.64	68.53	32.34	32.00	5.07	35.05	3.76	36.27	650.17
1933	21.51	174.43	173.13	184.32	77.22	90.78	102.66	37.36	7.77	91.43	20.24	27.44	1008.28
1934	46.88	116.17	143.61	82.79	94.25	95.36	65.86	99.07	282.29	12.44	69.31	20.28	1128.31
1935	58.57	25.13	59.37	140.98	221.48	107.45	16.78	168.68	11.88	11.16	9.78	51.32	882.58
1936	64.29	246.31	36.37	103.35	146.47	38.40	34.65	4.98	37.25	24.39	26.19	21.48	784.13
1937	59.14	57.63	196.50	126.87	182.48	48.38	112.63	18.37	24.21	45.46	20.97	5.02	897.64
1938	133.09	93.72	170.77	77.39	176.30	115.39	55.53	71.45	3.88	60.17	22.25	148.93	1128.88
1939	76.51	96.60	135.32	42.17	60.02	81.96	37.96	142.29	55.12	2.91	14.95	38.09	783.92
1940	40.74	176.41	116.29	66.94	37.32	147.74	61.19	1.86	10.30	14.43	9.46	73.42	756.11
1941	51.53	90.66	61.32	168.85	62.83	154.42	74.09	50.47	2.07	10.97	59.74	29.26	816.19
1942	96.10	174.08	203.59	66.80	93.09	114.30	153.47	69.36	18.49	55.65	75.97	26.75	1147.64
1943	131.81	152.35	96.69	66.85	90.38	114.45	54.95	2.46	35.61	12.75	18.87	129.68	906.84
1944	96.66	40.12	52.56	74.03	108.44	187.33	20.27	54.22	0.60	27.02	7.82	14.27	683.34
1945	83.84	30.34	73.02	98.86	85.96	125.76	60.86	16.61	4.97	2.24	13.31	23.54	619.31
1946	78.68	103.49	118.29	87.00	121.76	144.68	137.66	33.87	87.75	12.61	30.55	34.51	990.87
1947	63.68	226.81	143.06	88.20	132.55	95.73	163.16	8.22	0.90	0.36	10.42	22.93	956.02
1948	145.86	63.86	87.43	76.78	86.00	75.17	48.67	9.35	1.03	8.55	22.01	66.06	690.77
1949	98.97	191.63	91.90	84.94	79.97	99.23	28.73	40.46	0.83	32.10	60.36	17.06	826.19
1950	35.75	59.49	160.22	141.50	59.96	105.60	13.68	14.48	3.06	3.18	64.87	65.24	727.03
1951	98.97	19.47	115.65	170.09	59.79	60.25	138.68	47.23	24.45	16.30	12.52	38.27	801.69
1952	51.58	63.44	156.49	110.76	143.10	40.35	25.64	14.23	6.51	12.61	86.13	76.18	787.03
1953	76.14	92.81	132.50	63.49	69.77	124.02	9.17	49.85	17.27	1.59	30.53	93.34	760.48
1954	338.27	56.44	22.35	240.39	74.24	271.22	28.86	6.52	28.49	30.46	0.61	86.59	1184.43
1955	81.37	88.26	56.21	22.80	152.73	276.45	101.22	7.12	70.84	2.73	71.14	54.62	985.49
1956	74.06	124.52	239.46	80.14	107.04	129.64	131.76	15.06	1.44	5.92	21.19	129.63	1059.85
1957	119.02	79.43	47.33	134.22	252.27	96.22	173.09	2.57	5.59	6.27	1.62	90.49	1008.12
1958	88.11	130.74	79.13	119.65	90.05	39.81	28.84	306.81	0.00	26.73	29.22	48.83	987.91
1959	72.60	87.72	62.91	58.96	86.50	92.14	122.11	20.42	6.94	8.77	9.96	61.16	690.18
1960	75.06	112.97	155.55	95.13	53.75	128.08	218.76	27.81	29.66	20.14	6.92	67.09	990.91
1961	50.16	88.63	60.30	117.90	101.88	132.23	33.71	11.08	1.46	0.00	56.88	13.03	667.26
1962	82.43	129.31	60.72	238.28	45.13	213.01	14.55	3.71	22.43	105.63	10.24	25.36	950.80
1963	73.70	81.43	161.85	141.95	60.24	60.38	82.19	5.48	65.29	16.78	18.00	62.30	829.59
1964	199.42	74.99	109.59	107.36	79.22	22.99	23.57	67.91	143.25	31.03	69.06	82.99	1011.37
1965	115.00	127.66	77.20	155.14	65.01	20.06	50.20	83.27	29.34	6.05	24.13	36.50	789.55
1966	19.38	91.19	65.59	105.96	140.02	150.85	98.96	0.63	14.98	22.99	2.87	23.64	737.06
1967	78.58	142.82	61.60	125.30	59.67	90.37	27.00	9.26	2.47	0.00	88.41	54.75	740.23
1968	73.80	54.60	68.62	25.11	86.20	136.63	51.59	97.41	4.17	25.57	25.23	53.78	702.71
1969	169.54	88.77	137.49	69.91	46.92	22.24	21.55	66.83	55.95	9.65	43.28	71.31	803.45
1970	152.53	94.37	111.05	69.64	140.23	112.54	53.06	123.95	0.00	64.25	104.19	32.34	1058.15
1971	43.22	62.33	164.85	61.79	165.07	37.86	17.13	54.30	25.34	30.32	16.09	12.87	691.18
1972	49.19	162.49	63.41	92.51	48.48	60.30	68.59	3.21	0.33	8.99	62.68	88.09	708.26
1973	64.74	123.40	64.35	128.80	88.77	77.04	68.29	94.30	17.87	21.35	4.71	27.12	780.73
1974	51.52	93.17	104.89	167.61	145.87	49.76	42.67	13.58	1.37	4.21	9.59	107.52	791.77
1975	33.36	86.03	140.74	159.31	195.15	330.92	89.45	72.97	3.27	19.75	44.78	51.67	1227.42
1976	141.30	70.06	81.91	145.85	151.60	112.35	11.66	15.09	15.37	4.61	36.82	57.80	844.42
1977	70.28	82.68	197.54	109.91	118.88	125.95	103.23	23.89	7.39	9.85	51.73	68.92	970.27
1978	133.64	138.08	109.18	59.81	103.81	83.59	46.53	23.83	1.85	54.75	45.28	44.54	844.88
1979	78.95	51.95	113.44	91.70	49.33	45.29	39.13	22.56	5.57	5.18	22.51	176.39	702.01
1980	36.55	134.82	79.08	160.61	65.99	43.61	43.62	53.96	19.95	11.34	102.57	58.54	810.63
1981	49.59	116.15	68.56	111.97	55.33	111.39	53.96	20.85	18.84	6.35	4.54	38.86	656.40
1982	102.62	73.68	86.86	101.90	67.02	56.61	56.87	14.90	7.77	74.17	40.90	35.71	719.00
1983	91.95	158.54	119.75	172.54	197.68	83.60	110.66	27.45	16.78	43.04	38.61	21.76	1082.36
1984	78.54	89.59	70.11	107.60	286.23	49.32	31.14	12.17	30.51	8.39	1.47	38.26	803.32
1985	241.53	122.25	168.24	121.47	47.61	183.36	65.45	1.48	25.54	2.15	86.04	31.32	1096.46
1986	109.94	107.57	132.95	95.26	71.62	122.77	26.51	60.87	35.61	17.52	63.86	528.05	1372.52
1987	82.84	165.55	70.10	93.71	205.79	265.92	39.29	71.98	39.23	14.54	44.44	36.89	1130.29
1988	60.54	78.78	167.26	62.70	187.26	33.47	82.98	11.51	18.38	18.59	1.06	40.61	763.12
1989	91.46	337.67	81.76	76.05	84.26	219.00	49.66	9.32	12.17	8.59	88.19	29.12	1087.23
1990	127.67	50.84	140.57	119.50	147.98	104.01	22.30	55.28	5.41	3.98	15.51	63.95	857.00
1991	136.01	83.03	50.60	91.50	47.33	58.40	16.48	0.57	1.43	3.84	14.89	29.35	533.43
1992	60.34	66.24	74.56	66.34	88.68	45.82	40.06	5.36	8.72	17.39	16.52	97.49	587.54
1993	120.73	56.94	155.26	101.13	23.75	147.84	14.97	7.64	8.03	55.60	35.13	5.97	732.98
1994	82.24	48.65	102.77	121.94	42.06	149.27	73.39	16.35	60.88	5.28	5.40	33.35	741.57
1995	109.88	89.79	306.80	187.32	154.20	103.76	30.05	23.88	4.78	157.52	4.08	17.61	1189.68
1996	93.06	122.25	147.64	111.34	54.01	67.01	99.45	23.46	95.72	31.46	12.39	50.87	908.68
1997	96.06	201.06	76.70	135.97	112.61	114.72	61.35	12.46	0.00	1.97	41.05	24.01	877.97
1998	33.23	99.89	135.27	112.06	110.43	41.50	23.31	0.00	9.83	0.78	0.00	0.00	566.30
1999	155.88	49.02	264.19	190.35	84.78	69.94	51.15	42.02	3.37	5.85	7.41	79.55	1003.52
2000	69.48	130.57	142.67	97.49	74.55	48.16	75.07	27.62	0.00	5.31	28.26	109.35	808.53
2001	133.42	167.14	183.39	150.44	68.04	41.03	64.41	20.65	35.26	136.85	93.72	52.16	1146.49
2002	36.26	68.82	92.77	89.80	68.32	92.87	37.16	46.10	3.63	0.00	32.28	57.64	625.65
2003	28.36	95.36	92.01	148.74	114.95	79.76	41.49	0.00	15.83	52.85	12.87	56.39	738.62
2004	72.79	84.90	120.53	164.49	91.69	95.88	13.53	9.99	5.72	0.36	17.88	40.78	718.52
2005	43.08	108.18	67.24	165.94	85.59	88.61	72.32	26.66	3.37	2.03	54.45	70.56	788.05
2006	110.55	104.52	170.59	104.03	102.47	136.64	65.65	3.54	40.34	0.00	4.61	82.08	925.03
2007	118.02	157.12	82.26	145.12	83.24	69.50	88.34	0.62	96.17	0.00	3.63	53.60	897.63
2008	75.06	132.50	104.10	151.07	177.07	84.72	21.06	4.15	0.88	5.91	27.16	72.80	856.47
Ave:	88.53	104.17	113.80	112.42	102.05	105.48	57.74	35.28	25.15	23.49	31.57	58.32	858.00

Monthly catchment rainfall (mm) for quaternary catchment U60A (U60A.RAN)

1925	76.79	61.80	75.41	28.27	78.65	116.96	0.41	22.84	36.77	0.00	6.64	88.86	593.41
1926	92.99	60.43	85.05	46.98	69.58	259.85	22.28	20.17	0.00	10.69	74.60	10.94	753.54
1927	62.29	57.35	137.05	126.28	96.80	69.74	27.70	12.07	0.97	0.00	27.46	52.73	670.44
1928	63.02	58.48	66.83	100.28	45.85	203.63	51.68	16.36	93.07	54.27	12.64	88.37	854.47
1929	88.37	61.16	103.11	151.23	65.37	72.01	35.80	8.10	35.72	9.72	44.47	52.49	727.54
1930	86.18	100.12	138.27	154.87	58.40	112.59	53.62	4.29	0.73	45.20	8.59	11.99	774.85
1931	78.73	71.52	122.15	117.29	82.62	124.01	21.30	50.06	14.58	10.61	3.16	40.99	737.02
1932	102.30	85.13	124.50	71.60	77.92	103.19	36.05	2.92	3.24	25.19	4.05	17.66	653.75
1933	36.05	193.67	187.52	159.41	82.46	114.86	89.34	61.97	0.57	73.06	34.18	36.86	1069.93
1934	47.63	93.56	169.53	150.01	95.99	89.59	55.24	59.62	211.01	0.49	18.14	18.14	1008.94
1935	42.85	46.90	53.38	130.73	185.09	142.56	13.45	111.62	25.76	12.39	42.61	30.21	837.54
1936	65.37	206.71	60.43	109.11	109.67	40.58	19.12	9.56	15.96	11.58	6.64	21.38	676.11
1937	68.61	92.75	117.29	103.52	211.49	28.59	109.67	8.83	7.13	47.39	31.43	7.53	834.22
1938	126.68	120.69	99.95	100.28	136.89	69.66	29.65	67.39	0.49	28.59	21.79	95.58	897.64
1939	72.33	114.29	108.38	74.52	107.97	109.67	51.84	171.88	58.73	1.78	4.46	47.22	923.08
1940	53.70	173.99	162.24	80.76	67.47	113.72	88.29	4.21	5.27	15.31	5.91	43.34	814.21
1941	55.73	104.17	74.28	132.92	143.21	180.31	64.31	38.39	3.81	22.92	47.79	37.42	905.26
1942	74.76	136.89	203.31	87.89	91.21	107.89	192.70	67.23	25.27	69.90	103.36	15.88	1176.28
1943	206.06	252.96	151.79	66.42	115.34	115.34	21.55	6.24	21.63	10.53	10.53	112.43	1090.83
1944	70.31	67.72	45.68	91.04	111.62	220.48	27.86	34.99	2.35	2.35	4.70	10.77	689.88
1945	85.29	25.68	80.60	124.82	107.24	100.76	40.91	14.26	9.32	4.78	1.70	19.12	614.47
1946	68.77	102.38	114.29	77.11	121.82	168.32	80.68	10.77	120.69	18.23	12.23	29.73	925.02
1947	62.13	143.05	106.76	121.01	114.62	104.57	63.02	23.17	0.32	0.16	5.51	23.81	768.12
1948	115.34	103.19	112.43	81.81	116.64	83.19	45.52	17.58	0.00	10.37	10.85	60.26	757.19
1949	85.54	153.50	115.59	147.50	106.92	120.04	38.07	37.18	1.62	37.10	59.37	15.55	917.97
1950	44.23	63.02	165.40	165.08	69.66	86.67	12.88	8.10	4.62	0.00	113.64	45.44	778.73
1951	70.31	42.69	104.17	166.29	84.65	90.64	63.91	14.58	10.04	10.21	14.18	22.76	694.41
1952	42.36	79.46	116.56	103.36	149.77	46.49	26.41	11.26	12.80	0.00	100.68	59.29	748.44
1953	92.26	74.52	163.86	88.78	71.44	75.17	36.53	56.38	10.37	18.87	7.70	58.32	754.19
1954	137.05	97.36	64.64	237.17	149.61	94.69	63.26	14.42	16.20	3.65	4.62	46.66	929.31
1955	57.43	104.33	113.40	17.74	185.65	177.31	52.00	21.06	7.61	1.22	27.30	34.10	799.15
1956	53.30	132.35	193.02	144.50	79.62	113.48	103.76	19.68	1.46	8.51	34.91	127.66	1012.26
1957	90.56	105.06	75.65	103.44	158.60	32.48	115.26	0.97	11.10	4.13	3.97	44.47	745.69
1958	22.60	122.55	116.64	141.43	136.40	73.39	45.93	345.63	3.81	21.14	37.42	42.61	1109.54
1959	77.68	113.81	116.32	66.66	94.61	153.66	68.69	7.78	6.08	3.40	20.66	43.25	772.58
1960	78.00	135.68	180.47	128.87	56.21	125.15	153.09	14.42	14.42	3.89	7.94	64.96	963.09
1961	24.38	96.96	88.86	134.30	112.43	125.39	42.28	4.46	0.00	0.00	55.73	8.42	693.20
1962	65.93	117.61	92.26	159.98	51.68	150.34	40.99	3.73	9.72	114.78	5.18	9.07	821.26
1963	61.80	75.01	75.65	155.93	69.34	81.49	73.55	6.72	45.28	9.64	7.78	66.42	728.60
1964	123.04	52.81	120.12	85.54	68.93	33.78	25.35	43.09	94.77	15.47	57.02	39.20	759.13
1965	100.28	129.60	80.19	212.22	106.92	21.79	43.82	57.43	12.72	3.16	30.86	43.42	842.40
1966	43.82	124.66	60.26	138.02	138.35	175.69	107.81	7.86	19.04	20.98	2.27	12.07	850.82
1967	97.77	98.33	85.78	138.43	63.83	84.00	18.71	16.12	10.13	0.08	54.03	40.42	707.62
1968	48.92	60.43	60.35	45.85	100.52	153.74	41.47	48.20	5.75	30.86	22.28	48.28	666.63
1969	123.85	89.91	134.95	86.83	56.05	44.71	29.00	37.42	28.11	9.96	85.70	93.23	819.72
1970	101.33	84.89	105.38	62.86	65.69	110.00	50.79	62.69	0.00	40.42	71.52	29.57	785.13
1971	92.34	75.49	129.44	115.26	135.68	70.47	41.96	40.01	21.55	7.78	13.37	12.80	756.14
1972	50.63	98.90	55.81	89.02	112.83	108.30	56.38	6.64	2.03	11.34	52.25	77.52	721.63
1973	36.29	124.34	78.41	240.08	107.16	129.52	45.77	81.08	8.26	17.90	17.98	8.26	895.05
1974	71.69	98.17	113.64	168.40	110.65	57.83	31.10	2.19	0.41	3.56	3.48	103.03	764.15
1975	42.93	79.30	133.41	186.62	100.20	233.12	101.90	37.75	1.22	4.05	33.21	52.41	1006.10
1976	119.64	60.91	66.02	146.12	64.64	122.15	25.52	25.11	2.67	3.32	23.41	32.81	692.31
1977	78.65	68.69	149.04	131.46	86.27	110.81	87.97	4.70	6.80	0.57	27.62	72.09	824.66
1978	107.33	162.65	121.91	89.34	139.24	101.17	45.28	23.98	1.54	22.44	32.56	42.61	890.03
1979	70.07	51.68	80.51	84.32	51.44	66.34	57.43	14.34	0.00	0.24	13.53	107.08	596.97
1980	62.69	118.02	87.40	180.79	107.33	76.87	39.61	33.21	21.55	2.84	69.42	33.37	833.09
1981	39.45	129.03	69.82	95.50	44.47	175.61	22.52	12.72	10.29	2.59	4.13	29.73	635.85
1982	90.40	77.92	85.05	56.38	78.65	92.99	52.89	16.69	3.40	38.72	31.02	50.87	674.97
1983	67.31	130.25	127.66	153.09	139.56	67.55	86.91	12.80	16.77	25.52	29.57	16.52	873.50
1984	122.72	62.94	53.87	108.86	220.40	49.17	25.84	12.07	15.23	5.59	0.08	38.96	715.72
1985	178.93	87.08	169.37	132.03	67.80	102.47	32.00	0.16	30.38	0.89	52.41	20.33	873.83
1986	119.72	87.08	165.89	105.95	111.62	115.10	35.64	14.90	20.33	14.01	72.98	448.34	1311.55
1987	64.48	131.14	38.39	67.96	293.06	167.59	48.20	45.04	35.88	21.47	12.31	32.40	957.91
1988	65.85	81.89	173.83	78.33	142.32	49.73	37.58	20.17	28.27	6.16	8.59	23.98	716.69
1989	69.09	298.00	69.17	73.95	70.07	141.59	57.11	14.50	7.70	16.93	71.04	22.68	911.82
1990	110.89	63.83	110.16	101.41	133.49	101.98	24.71	38.48	5.35	8.42	14.74	52.00	765.45
1991	103.92	49.09	94.53	58.08	74.52	75.74	17.33	0.00	0.65	4.46	5.75	18.55	502.61
1992	53.62	64.56	54.59	44.47	92.34	60.91	51.44	11.66	7.53	6.08	22.28	46.90	516.38
1993	109.67	33.37	157.63	107.33	31.43	154.87	16.61	5.02	15.23	68.12	38.15	1.70	739.13
1994	69.74	81.16	110.40	65.45	60.91	137.62	39.53	7.61	60.51	0.81	12.07	17.90	663.71
1995	80.60	97.61	337.37	144.59	178.69	99.87	36.77	9.56	7.86	95.74	5.43	31.83	1125.90
1996	78.73	118.42	180.47	168.48	88.13	105.79	102.55	25.60	68.77	19.52	25.43	59.94	1041.82
1997	56.62	157.46	58.89	181.20	129.68	81.97	19.68	7.45	0.00	1.46	39.53	12.80	746.74
1998	42.36	87.89	78.25	148.15	153.82	36.86	14.58	12.64	3.32	4.62	13.53	23.25	619.25
1999	90.72	56.86	269.00	144.10	61.88	118.99	93.47	38.31	7.45	0.08	0.00	58.32	939.20
2000	74.20	80.60	161.60	154.06	70.31	62.94	69.34	20.49	0.00	2.43	40.91	94.53	831.38
2001	108.38	144.59	140.62	317.76	76.06	55.81	21.87	35.24	28.92	51.84	51.35	0.00	1032.43
2002	61.32	58.32	80.76	72.82	50.06	79.46	78.25	16.85	2.59	0.00	0.16	23.33	523.91
2003	11.50	82.54	94.69	67.23	120.37	99.47	40.74	1.30	9.88	42.61	8.67	57.59	636.58
2004	90.23	73.47	268.03	243.81	78.41	138.75	9.80	19.20	5.59	0.00	19.93	28.35	975.56
2005	65.45	69.82	62.78	125.47	77.92	72.50	66.83	10.04	0.73	0.00	45.36	40.34	637.23
2006	189.78	80.60	134.14	116.40	63.50	146.77	31.35	2.43	66.42	0.41	0.89	28.03	860.71
2007	112.10	158.84	98.98	127.74	38.88	87.80	90.07	1.70	32.81	0.89	3.24	54.03	807.08
2008	45.12	104.09	134.46	144.26	169.86	65.93	16.85	16.77	7.61	0.00	42.77	21.63	769.34
Ave:	79.16	99.71	115.78	119.70	102.43	105.29	50.82	28.36	18.86	16.15	27.71	46.02	810.00

Monthly incremental natural runoff (million m^3) for quaternary U10A (U10A.INC)

1925	9.34	7.72	7.23	13.40	16.43	21.29	12.65	4.21	3.71	3.11	1.63	11.01	111.72
1926	15.50	13.37	35.61	40.56	30.24	37.51	21.74	5.18	1.68	1.31	3.39	3.54	209.63
1927	8.58	10.07	29.65	56.25	38.66	36.93	21.17	5.29	2.66	1.44	1.91	2.35	214.97
1928	6.00	7.37	25.78	44.03	26.87	26.55	18.29	8.37	9.76	12.20	8.17	9.63	203.01
1929	12.37	24.42	27.02	43.66	37.41	30.65	15.98	4.08	1.94	1.47	2.24	2.69	203.93
1930	3.66	6.47	31.70	43.75	32.89	23.91	14.15	5.71	1.95	3.25	3.60	1.77	172.81
1931	2.23	3.46	5.43	19.14	52.83	35.54	8.83	3.41	3.25	2.53	1.36	2.36	140.38
1932	5.49	15.79	22.26	13.03	12.86	16.21	10.44	4.09	1.47	1.24	1.27	0.90	105.05
1933	1.40	38.51	59.18	83.21	56.58	25.00	17.76	13.53	7.45	4.27	3.91	3.62	314.43
1934	6.70	50.82	68.29	33.74	19.04	18.01	11.04	5.23	6.02	5.66	3.07	1.68	229.29
1935	1.52	1.79	3.67	22.23	36.41	28.67	12.69	8.45	6.71	3.05	1.19	1.52	127.89
1936	3.84	32.94	26.06	30.16	40.38	25.98	9.98	3.14	1.18	0.75	0.61	0.64	175.68
1937	2.12	8.36	12.65	38.32	56.59	30.18	17.32	10.91	3.86	2.84	3.67	3.26	190.08
1938	17.83	21.28	49.69	42.22	72.78	57.03	17.49	5.10	2.26	1.53	1.69	5.10	293.99
1939	8.87	18.12	21.83	27.55	23.99	32.34	20.75	21.04	18.39	8.27	3.01	2.47	206.64
1940	6.39	18.06	64.61	62.34	53.04	35.59	14.62	5.34	1.88	1.17	1.00	0.83	264.88
1941	3.22	5.75	11.51	52.04	86.62	62.68	30.52	13.11	4.56	2.41	2.63	2.69	277.73
1942	8.85	36.55	71.84	79.61	57.51	33.62	62.65	45.44	13.44	9.59	20.31	13.90	453.30
1943	30.28	42.45	42.51	41.89	40.62	40.86	19.72	3.84	2.03	2.08	1.46	10.65	278.39
1944	14.17	10.08	5.52	18.26	29.83	55.67	33.84	8.12	2.98	1.30	0.82	0.66	181.28
1945	1.58	1.56	3.60	13.19	24.07	24.53	15.64	7.04	2.54	1.07	0.72	0.65	96.20
1946	1.45	17.63	18.69	23.67	54.96	48.89	18.99	6.29	6.32	5.65	2.92	1.68	207.16
1947	3.81	19.37	36.68	55.23	47.19	46.13	26.23	8.36	3.81	1.64	0.84	0.70	249.99
1948	2.84	5.88	11.21	20.35	32.74	36.74	19.99	6.39	2.31	1.16	1.08	1.95	142.64
1949	2.86	6.50	25.79	19.67	35.86	72.35	45.30	15.00	6.51	3.58	7.21	6.96	247.57
1950	3.52	5.95	34.13	64.78	41.47	15.40	8.54	4.41	1.71	0.87	3.60	5.60	189.98
1951	8.77	6.42	19.37	46.10	59.17	31.69	11.38	6.28	3.08	2.41	2.93	2.64	200.24
1952	3.30	12.96	18.59	26.35	38.83	22.53	6.86	3.02	1.63	1.26	1.51	3.47	140.32
1953	8.09	17.02	31.32	35.18	56.11	45.14	16.25	7.92	6.21	3.19	1.41	2.60	230.45
1954	10.80	15.40	22.66	70.73	74.13	31.04	9.89	5.87	3.59	2.22	1.27	1.27	248.87
1955	2.07	3.28	30.14	24.28	59.16	62.41	23.55	5.01	1.85	0.99	1.11	1.64	215.50
1956	4.44	21.96	81.08	92.70	49.00	40.20	24.43	7.29	3.11	2.02	3.34	20.29	349.86
1957	29.57	18.28	26.91	54.63	44.15	20.81	14.01	8.70	3.28	1.29	0.74	1.80	224.15
1958	3.40	8.20	42.00	39.02	25.80	15.67	7.64	54.69	37.83	6.85	2.78	1.93	245.79
1959	3.34	12.35	15.67	13.38	19.62	26.61	20.92	10.31	3.83	1.50	1.08	1.88	130.50
1960	2.70	13.48	52.74	21.43	26.43	29.50	46.46	7.85	4.63	3.29	2.42	2.35	213.29
1961	1.95	9.27	23.67	37.39	42.86	23.70	6.63	5.72	3.22	2.53	2.49	3.35	162.79
1962	2.55	14.83	28.91	77.62	22.35	59.16	13.80	6.30	4.41	9.96	4.03	2.52	246.45
1963	9.08	35.25	37.20	57.29	20.68	18.08	8.32	5.65	7.19	5.09	3.10	5.99	212.92
1964	8.32	28.28	23.28	35.90	40.38	7.72	5.85	3.33	7.67	7.15	4.79	7.57	180.25
1965	7.43	10.27	6.32	41.63	43.72	7.03	4.03	3.92	2.49	1.75	1.59	2.26	132.43
1966	2.45	20.72	23.52	30.07	87.56	66.40	45.24	9.09	5.30	4.58	3.22	2.35	300.49
1967	2.87	13.44	20.10	19.71	17.01	21.13	16.64	5.65	3.34	2.58	2.65	2.04	127.17
1968	1.70	7.43	17.54	5.51	8.03	44.52	26.50	7.09	4.29	3.40	2.34	3.26	131.61
1969	15.01	7.65	30.55	22.25	33.29	10.60	4.11	2.93	2.07	1.86	11.39	6.32	148.03
1970	29.64	12.12	8.11	18.45	42.68	21.04	13.84	8.70	4.48	4.33	12.30	5.03	180.71
1971	9.68	13.38	33.09	61.23	77.71	76.04	16.69	7.39	4.42	3.52	2.56	2.03	307.73
1972	3.93	13.94	8.66	7.55	39.33	23.88	28.53	16.00	4.52	3.32	4.07	4.41	158.15
1973	11.34	19.91	20.50	68.24	114.24	85.48	41.09	10.08	6.60	5.19	3.57	2.47	388.72
1974	2.47	10.84	17.94	57.08	71.46	35.06	14.38	5.56	3.50	2.71	2.09	5.56	228.65
1975	3.98	9.30	61.62	130.15	145.08	117.26	44.19	10.48	1.90	0.42	1.01	2.51	527.90
1976	10.09	12.18	10.46	28.28	38.91	37.10	18.73	5.76	3.68	2.83	2.41	3.23	173.67
1977	5.66	8.39	10.44	58.28	37.28	26.94	23.13	8.22	4.14	3.14	2.39	4.56	192.57
1978	10.37	12.43	63.86	18.99	21.20	26.15	7.49	5.92	3.24	3.38	3.82	5.07	181.92
1979	3.61	8.04	9.01	26.29	29.58	32.90	8.23	2.80	2.46	1.97	1.49	6.67	133.05
1980	8.30	5.28	23.79	44.06	70.12	30.87	6.46	4.28	2.87	2.15	2.57	8.04	208.79
1981	4.09	5.35	11.75	11.34	6.39	40.25	10.12	4.01	2.83	2.15	1.57	1.80	101.64
1982	2.13	6.66	3.30	5.65	4.55	8.71	4.55	1.76	1.12	1.04	1.17	1.19	41.82
1983	4.41	15.00	56.80	44.00	18.54	45.26	38.83	6.97	3.40	3.63	2.89	2.85	242.58
1984	4.38	5.38	5.14	37.44	80.20	24.07	5.84	3.62	2.67	2.10	1.37	1.33	173.54
1985	6.86	38.26	46.03	38.58	28.83	21.18	9.75	7.31	3.68	2.63	2.52	3.33	208.95
1986	9.09	27.99	26.47	29.36	12.39	26.58	8.43	4.18	2.98	2.56	5.11	70.89	226.02
1987	82.06	76.50	23.05	28.22	100.59	122.35	15.04	6.23	5.10	9.90	5.00	4.21	478.25
1988	4.02	13.26	34.15	49.78	79.06	27.05	7.40	4.76	1.85	3.88	2.59	1.77	229.57
1989	2.35	21.04	41.00	18.18	14.88	37.55	34.54	5.94	3.46	2.68	2.42	3.47	187.51
1990	4.49	5.01	20.00	53.53	66.95	24.74	9.08	4.95	3.34	2.41	1.71	2.14	198.35
1991	13.69	12.87	25.20	27.82	17.45	12.29	4.61	2.33	1.55	1.26	1.11	1.10	121.27
1992	1.30	3.13	2.83	9.08	24.67	29.31	14.84	3.26	1.74	1.38	1.25	1.05	93.85
1993	9.66	13.66	28.63	75.28	81.23	22.54	7.05	4.50	2.80	2.72	2.99	2.06	253.13
1994	3.28	3.88	5.68	31.98	14.30	31.34	23.24	7.84	4.41	3.19	2.20	1.70	133.05
1995	3.54	9.66	81.29	93.55	75.23	54.48	16.57	6.90	4.47	20.03	9.10	5.27	380.09
1996	6.17	10.08	27.90	74.01	23.22	59.59	17.78	7.35	6.63	8.63	5.11	2.12	248.59
1997	8.68	18.65	48.91	34.37	64.05	33.14	12.86	5.90	3.68	2.86	2.74	2.19	238.02
1998	3.11	8.95	35.57	33.89	39.76	18.70	6.94	4.08	2.62	2.02	1.48	1.16	158.30
1999	8.24	12.65	45.35	74.16	41.87	102.00	35.67	10.87	5.62	3.93	2.89	5.84	349.09
2000	5.05	17.37	36.27	37.68	23.10	18.69	20.11	7.90	4.13	3.14	2.23	13.08	188.76
2001	8.84	31.68	26.49	23.28	22.12	22.70	6.82	3.94	3.92	6.02	7.09	5.94	168.85
2002	3.30	4.54	8.63	19.35	38.62	25.42	17.02	7.33	3.94	2.68	1.88	2.83	135.51
2003	2.18	7.72	10.01	34.16	41.00	33.42	10.20	4.35	1.88	2.51	3.15	3.56	154.14
2004	5.12	12.96	32.23	62.57	25.17	25.46	15.96	5.64	3.25	2.35	2.08	1.53	194.32
2005	2.48	4.60	3.19	29.44	56.40	44.90	18.44	10.93	4.48	3.06	4.10	3.51	185.54
2006	18.34	15.66	27.87	18.87	21.78	12.16	8.85	3.73	3.13	3.12	1.97	1.44	136.90
2007	11.13	9.16	17.67	31.16	25.72	34.72	21.56	9.88	4.07	2.72	2.04	2.39	172.21
2008	1.98	3.95	11.69	24.48	65.81	49.31	14.04	6.37	3.24	2.33	2.92	1.78	187.90
Ave:	7.75	14.86	27.55	39.56	43.19	35.99	17.59	7.69	4.37	3.42	3.08	4.47	209.52

Monthly incremental natural runoff (million m^3) for quaternary U10B (U10B.INC)

1925	7.33	6.06	5.68	10.52	12.90	16.72	9.93	3.31	2.91	2.44	1.28	8.65	87.71
1926	12.17	10.50	27.95	31.84	23.74	29.45	17.07	4.06	1.32	1.03	2.66	2.78	164.58
1927	6.74	7.91	23.28	44.16	30.35	29.00	16.62	4.15	2.09	1.13	1.50	1.84	168.77
1928	4.71	5.79	20.24	34.57	21.10	20.85	14.36	6.57	7.66	9.58	6.41	7.56	159.38
1929	9.71	19.17	21.21	34.28	29.37	24.06	12.55	3.20	1.52	1.15	1.76	2.11	160.11
1930	2.87	5.08	24.89	34.35	25.82	18.77	11.11	4.48	1.53	2.55	2.83	1.39	135.67
1931	1.75	2.72	4.27	15.03	41.47	27.90	6.93	2.68	2.55	1.99	1.07	1.85	110.21
1932	4.31	12.40	17.48	10.23	10.09	12.73	8.20	3.21	1.15	0.97	0.99	0.71	82.47
1933	1.10	30.24	46.47	65.32	44.42	19.63	13.94	10.62	5.85	3.35	3.07	2.84	246.86
1934	5.26	39.90	53.61	26.49	14.94	14.14	8.67	4.11	4.73	4.44	2.41	1.32	180.02
1935	1.19	1.40	2.88	17.45	28.59	22.51	9.96	6.64	5.27	2.39	0.94	1.19	100.41
1936	3.01	25.86	20.46	23.68	31.70	20.40	7.84	2.47	0.93	0.59	0.48	0.50	137.92
1937	1.67	6.56	9.93	30.08	44.43	23.70	13.60	8.57	3.03	2.23	2.88	2.56	149.23
1938	14.00	16.70	39.01	33.15	57.14	44.77	13.73	4.00	1.78	1.20	1.32	4.01	230.81
1939	6.97	14.22	17.14	21.63	18.84	25.39	16.29	16.52	14.44	6.49	2.36	1.94	162.23
1940	5.02	14.18	50.73	48.95	41.64	27.94	11.48	4.19	1.47	0.92	0.78	0.65	207.95
1941	2.53	4.52	9.03	40.86	68.01	49.21	23.96	10.29	3.58	1.89	2.06	2.11	218.05
1942	6.95	28.69	56.40	62.50	45.15	26.39	49.19	35.67	10.55	7.53	15.95	10.91	355.88
1943	23.77	33.33	33.37	32.89	31.89	32.08	15.48	3.02	1.60	1.64	1.15	8.36	218.56
1944	11.13	7.92	4.34	14.34	23.42	43.71	26.57	6.38	2.34	1.02	0.65	0.52	142.32
1945	1.24	1.22	2.82	10.36	18.90	19.26	12.28	5.53	2.00	0.84	0.57	0.51	75.52
1946	1.14	13.84	14.67	18.59	43.15	38.39	14.91	4.94	4.96	4.44	2.29	1.32	162.64
1947	2.99	15.21	28.79	43.36	37.05	36.22	20.59	6.56	2.99	1.29	0.66	0.55	196.26
1948	2.23	4.62	8.80	15.98	25.70	28.84	15.69	5.02	1.82	0.91	0.85	1.53	111.99
1949	2.24	5.11	20.24	15.44	28.15	56.80	35.56	11.78	5.11	2.81	5.66	5.46	194.37
1950	2.76	4.67	26.80	50.86	32.56	12.09	6.70	3.46	1.35	0.69	2.83	4.40	149.15
1951	6.89	5.04	15.21	36.19	46.45	24.88	8.94	4.93	2.42	1.89	2.30	2.07	157.21
1952	2.59	10.17	14.59	20.69	30.49	17.69	5.39	2.37	1.28	0.99	1.19	2.72	110.16
1953	6.35	13.37	24.59	27.62	44.05	35.44	12.76	6.22	4.87	2.50	1.11	2.04	180.92
1954	8.48	12.09	17.79	55.53	58.20	24.37	7.76	4.61	2.82	1.74	0.99	1.00	195.39
1955	1.63	2.58	23.66	19.07	46.44	49.00	18.49	3.94	1.45	0.77	0.87	1.29	169.18
1956	3.49	17.24	63.66	72.78	38.47	31.56	19.18	5.72	2.44	1.58	2.62	15.93	274.68
1957	23.21	14.35	21.12	42.89	34.66	16.34	11.00	6.83	2.57	1.01	0.58	1.41	175.98
1958	2.67	6.44	32.97	30.63	20.26	12.30	6.00	42.93	29.70	5.38	2.18	1.52	192.97
1959	2.62	9.70	12.31	10.51	15.40	20.89	16.43	8.10	3.00	1.18	0.85	1.48	102.45
1960	2.12	10.58	41.41	16.83	20.75	23.16	36.48	6.17	3.63	2.58	1.90	1.84	167.45
1961	1.53	7.28	18.59	29.35	33.65	18.60	5.21	4.49	2.53	1.98	1.96	2.63	127.81
1962	2.00	11.64	22.70	60.94	17.55	46.45	10.83	4.95	3.46	7.82	3.17	1.98	193.49
1963	7.13	27.67	29.21	44.98	16.24	14.20	6.53	4.43	5.65	3.99	2.44	4.70	167.17
1964	6.53	22.20	18.27	28.18	31.70	6.06	4.59	2.62	6.02	5.62	3.76	5.95	141.51
1965	5.83	8.06	4.96	32.69	34.32	5.52	3.16	3.08	1.95	1.38	1.24	1.78	103.97
1966	1.92	16.27	18.47	23.61	68.74	52.13	35.52	7.13	4.16	3.59	2.53	1.84	235.91
1967	2.25	10.55	15.78	15.48	13.36	16.59	13.07	4.43	2.62	2.02	2.08	1.60	99.84
1968	1.33	5.83	13.77	4.33	6.30	34.96	20.80	5.56	3.36	2.67	1.84	2.56	103.33
1969	11.78	6.01	23.98	17.47	26.13	8.32	3.23	2.30	1.62	1.46	8.94	4.96	116.21
1970	23.27	9.52	6.36	14.49	33.50	16.52	10.87	6.83	3.52	3.40	9.66	3.95	141.88
1971	7.60	10.50	25.98	48.07	61.01	59.70	13.10	5.80	3.47	2.76	2.01	1.60	241.60
1972	3.08	10.95	6.80	5.93	30.87	18.75	22.40	12.56	3.55	2.61	3.19	3.46	124.16
1973	8.91	15.63	16.10	53.58	89.69	67.11	32.26	7.91	5.18	4.07	2.80	1.94	305.18
1974	1.94	8.51	14.09	44.81	56.10	27.53	11.29	4.37	2.75	2.12	1.64	4.37	179.51
1975	3.13	7.30	48.38	102.18	113.90	92.06	34.70	8.23	1.49	0.33	0.79	1.97	414.45
1976	7.92	9.56	8.21	22.21	30.55	29.13	14.70	4.53	2.89	2.22	1.89	2.53	136.35
1977	4.44	6.59	8.20	45.76	29.27	21.15	18.16	6.45	3.25	2.46	1.88	3.58	151.19
1978	8.14	9.76	50.14	14.91	16.65	20.53	5.88	4.65	2.54	2.65	3.00	3.98	142.82
1979	2.83	6.31	7.07	20.64	23.22	25.83	6.46	2.20	1.93	1.55	1.17	5.24	104.46
1980	6.52	4.15	18.68	34.59	55.05	24.24	5.07	3.36	2.25	1.68	2.02	6.31	163.92
1981	3.21	4.20	9.22	8.90	5.02	31.60	7.95	3.15	2.22	1.68	1.23	1.41	79.80
1982	1.67	5.23	2.59	4.43	3.57	6.84	3.57	1.38	0.88	0.81	0.92	0.93	32.83
1983	3.46	11.77	44.60	34.54	14.55	35.53	30.48	5.47	2.67	2.85	2.27	2.23	190.44
1984	3.44	4.22	4.04	29.40	62.97	18.90	4.58	2.84	2.10	1.65	1.08	1.04	136.24
1985	5.39	30.04	36.14	30.29	22.63	16.62	7.66	5.74	2.89	2.06	1.98	2.61	164.04
1986	7.13	21.98	20.78	23.05	9.73	20.87	6.62	3.28	2.34	2.01	4.01	55.66	177.45
1987	64.43	60.06	18.10	22.16	78.97	96.06	11.80	4.89	4.01	7.77	3.93	3.30	375.47
1988	3.16	10.41	26.81	39.08	62.07	21.24	5.81	3.74	1.46	3.05	2.04	1.39	180.23
1989	1.85	16.52	32.19	14.27	11.68	29.48	27.12	4.67	2.72	2.11	1.90	2.72	147.21
1990	3.52	3.93	15.70	42.03	52.56	19.42	7.13	3.88	2.62	1.89	1.34	1.68	155.72
1991	10.75	10.10	19.79	21.84	13.70	9.65	3.62	1.83	1.22	0.99	0.87	0.87	95.21
1992	1.02	2.46	2.22	7.13	19.37	23.01	11.65	2.56	1.36	1.08	0.98	0.83	73.68
1993	7.58	10.72	22.48	59.10	63.77	17.70	5.53	3.53	2.20	2.14	2.35	1.62	198.73
1994	2.58	3.05	4.46	25.11	11.23	24.61	18.24	6.15	3.46	2.51	1.73	1.33	104.45
1995	2.78	7.58	63.82	73.44	59.06	42.77	13.01	5.42	3.51	15.72	7.15	4.14	298.41
1996	4.85	7.91	21.90	58.11	18.23	46.78	13.96	5.77	5.21	6.77	4.01	1.66	195.17
1997	6.81	14.65	38.40	26.98	50.28	26.02	10.10	4.63	2.89	2.24	2.15	1.72	186.86
1998	2.44	7.02	27.93	26.61	31.22	14.68	5.45	3.20	2.06	1.59	1.16	0.91	124.28
1999	6.47	9.93	35.60	58.22	32.88	80.08	28.00	8.54	4.41	3.09	2.27	4.58	274.07
2000	3.96	13.64	28.47	29.59	18.13	14.68	15.79	6.20	3.25	2.47	1.75	10.27	148.19
2001	6.94	24.87	20.80	18.28	17.37	17.82	5.35	3.09	3.08	4.73	5.57	4.67	132.57
2002	2.59	3.56	6.77	15.19	30.32	19.96	13.36	5.75	3.09	2.10	1.47	2.22	106.39
2003	1.71	6.06	7.86	26.82	32.19	26.24	8.01	3.42	1.48	1.97	2.47	2.79	121.01
2004	4.02	10.17	25.31	49.12	19.76	19.99	12.53	4.43	2.55	1.84	1.63	1.20	152.56
2005	1.95	3.61	2.51	23.11	44.28	35.25	14.48	8.58	3.51	2.40	3.22	2.76	145.67
2006	14.39	12.30	21.88	14.81	17.10	9.54	6.95	2.92	2.46	2.45	1.55	1.13	107.48
2007	8.73	7.19	13.87	24.46	20.19	27.26	16.92	7.76	3.20	2.14	1.60	1.88	135.20
2008	1.55	3.10	9.18	19.22	51.67	38.72	11.03	5.00	2.54	1.83	2.29	1.39	147.52
Ave:	6.09	11.67	21.63	31.06	33.90	28.25	13.81	6.03	3.43	2.68	2.42	3.51	164.49

Monthly incremental natural runoff (million m³) for quaternary U10C (U10C.INC)

1925	4.31	3.56	3.34	6.19	7.58	9.83	5.84	1.94	1.71	1.44	0.75	5.08	51.56
1926	7.15	6.17	16.43	18.72	13.96	17.31	10.04	2.39	0.78	0.60	1.56	1.64	96.75
1927	3.96	4.65	13.69	25.96	17.84	17.05	9.77	2.44	1.23	0.67	0.88	1.08	99.22
1928	2.77	3.40	11.90	20.32	12.40	12.25	8.44	3.86	4.50	5.63	3.77	4.44	93.70
1929	5.71	11.27	12.47	20.15	17.27	14.15	7.38	1.88	0.89	0.68	1.04	1.24	94.12
1930	1.69	2.99	14.63	20.19	15.18	11.03	6.53	2.63	0.90	1.50	1.66	0.82	79.76
1931	1.03	1.60	2.51	8.83	24.38	16.40	4.07	1.57	1.50	1.17	0.63	1.09	64.79
1932	2.53	7.29	10.27	6.02	5.93	7.48	4.82	1.89	0.68	0.57	0.58	0.42	48.48
1933	0.65	17.78	27.32	38.40	26.12	11.54	8.20	6.24	3.44	1.97	1.80	1.67	145.12
1934	3.09	23.45	31.52	15.57	8.79	8.31	5.09	2.41	2.78	2.61	1.42	0.78	105.83
1935	0.70	0.83	1.69	10.26	16.81	13.23	5.86	3.90	3.10	1.41	0.55	0.70	59.03
1936	1.77	15.21	12.03	13.92	18.64	11.99	4.61	1.45	0.55	0.35	0.28	0.29	81.08
1937	0.98	3.86	5.84	17.68	26.12	13.93	8.00	5.04	1.78	1.31	1.69	1.50	87.73
1938	8.23	9.82	22.93	19.49	33.59	26.32	8.07	2.35	1.04	0.71	0.78	2.36	135.69
1939	4.10	8.36	10.08	12.72	11.07	14.93	9.58	9.71	8.49	3.82	1.39	1.14	95.37
1940	2.95	8.34	29.82	28.77	24.48	16.43	6.75	2.47	0.87	0.54	0.46	0.38	122.25
1941	1.49	2.65	5.31	24.02	39.98	28.93	14.09	6.05	2.10	1.11	1.21	1.24	128.18
1942	4.09	16.87	33.16	36.74	26.54	15.52	28.92	20.97	6.20	4.43	9.38	6.41	209.22
1943	13.97	19.59	19.62	19.33	18.75	18.86	9.10	1.77	0.94	0.96	0.67	4.91	128.49
1944	6.54	4.65	2.55	8.43	13.77	25.70	15.62	3.75	1.38	0.60	0.38	0.30	83.67
1945	0.73	0.72	1.66	6.09	11.11	11.32	7.22	3.25	1.17	0.49	0.33	0.30	44.40
1946	0.67	8.14	8.63	10.93	25.37	22.57	8.76	2.90	2.92	2.61	1.35	0.78	95.61
1947	1.76	8.94	16.93	25.49	21.78	21.29	12.11	3.86	1.76	0.76	0.39	0.32	115.38
1948	1.31	2.72	5.17	9.39	15.11	16.96	9.22	2.95	1.07	0.53	0.50	0.90	65.84
1949	1.32	3.00	11.90	9.08	16.55	33.39	20.91	6.92	3.00	1.65	3.33	3.21	114.26
1950	1.62	2.75	15.75	29.90	19.14	7.11	3.94	2.03	0.79	0.40	1.66	2.58	87.68
1951	4.05	2.97	8.94	21.28	27.31	14.63	5.25	2.90	1.42	1.11	1.35	1.22	92.42
1952	1.52	5.98	8.58	12.16	17.92	10.40	3.17	1.39	0.75	0.58	0.70	1.60	64.76
1953	3.73	7.86	14.46	16.24	25.90	20.84	7.50	3.66	2.87	1.47	0.65	1.20	106.36
1954	4.99	7.11	10.46	32.65	34.22	14.32	4.56	2.71	1.66	1.02	0.58	0.59	114.87
1955	0.96	1.51	13.91	11.21	27.30	28.81	10.87	2.31	0.85	0.45	0.51	0.76	99.46
1956	2.05	10.14	37.42	42.78	22.62	18.55	11.28	3.37	1.43	0.93	1.54	9.37	161.48
1957	13.65	8.44	12.42	25.21	20.37	9.61	6.46	4.01	1.51	0.59	0.34	0.83	103.45
1958	1.57	3.79	19.38	18.01	11.91	7.23	3.53	25.24	17.46	3.16	1.28	0.89	113.44
1959	1.54	5.70	7.23	6.18	9.06	12.28	9.66	4.76	1.77	0.69	0.50	0.87	60.23
1960	1.25	6.22	24.34	9.89	12.20	13.62	21.44	3.62	2.14	1.52	1.12	1.08	98.44
1961	0.90	4.28	10.93	17.26	19.78	10.94	3.06	2.64	1.49	1.17	1.15	1.55	75.13
1962	1.18	6.84	13.34	35.83	10.32	27.31	6.37	2.91	2.03	4.60	1.86	1.16	113.75
1963	4.19	16.27	17.17	26.44	9.55	8.35	3.84	2.61	3.32	2.35	1.43	2.77	98.27
1964	3.84	13.05	10.74	16.57	18.64	3.56	2.70	1.54	3.54	3.30	2.21	3.49	83.19
1965	3.43	4.74	2.91	19.22	20.18	3.25	1.86	1.81	1.15	0.81	0.73	1.05	61.12
1966	1.13	9.56	10.86	13.88	40.41	30.64	20.88	4.19	2.45	2.11	1.49	1.08	138.69
1967	1.33	6.20	9.28	9.10	7.85	9.75	7.68	2.61	1.54	1.19	1.22	0.94	58.69
1968	0.78	3.43	8.10	2.55	3.71	20.55	12.23	3.27	1.98	1.57	1.08	1.50	60.74
1969	6.93	3.53	14.10	10.27	15.36	4.89	1.90	1.35	0.95	0.86	5.26	2.91	68.32
1970	13.68	5.60	3.74	8.52	19.70	9.71	6.39	4.02	2.07	2.00	5.68	2.32	83.41
1971	4.47	6.17	15.27	28.26	35.86	35.10	7.70	3.41	2.04	1.62	1.18	0.94	142.03
1972	1.81	6.44	4.00	3.49	18.15	11.02	13.17	7.38	2.09	1.53	1.88	2.04	72.99
1973	5.24	9.19	9.46	31.50	52.72	39.45	18.96	4.65	3.05	2.39	1.65	1.14	179.41
1974	1.14	5.00	8.28	26.34	32.98	16.18	6.63	2.57	1.61	1.25	0.97	2.57	105.53
1975	1.84	4.29	28.44	60.07	66.96	54.12	20.40	4.84	0.88	0.19	0.46	1.16	243.65
1976	4.66	5.62	4.83	13.05	17.96	17.12	8.64	2.66	1.70	1.31	1.11	1.49	80.16
1977	2.61	3.87	4.82	26.90	17.21	12.43	10.67	3.79	1.91	1.45	1.10	2.10	88.88
1978	4.79	5.74	29.47	8.76	9.79	12.07	3.46	2.73	1.50	1.56	1.76	2.34	83.96
1979	1.67	3.71	4.16	12.13	13.65	15.19	3.80	1.29	1.13	0.91	0.69	3.08	61.41
1980	3.83	2.44	10.98	20.33	32.36	14.25	2.98	1.97	1.32	0.99	1.19	3.71	96.37
1981	1.89	2.47	5.42	5.23	2.95	18.58	4.67	1.85	1.31	0.99	0.72	0.83	46.91
1982	0.98	3.07	1.52	2.61	2.10	4.02	2.10	0.81	0.52	0.48	0.54	0.55	19.30
1983	2.04	6.92	26.22	20.31	8.56	20.89	17.92	3.22	1.57	1.68	1.33	1.31	111.96
1984	2.02	2.48	2.37	17.28	37.02	11.11	2.70	1.67	1.23	0.97	0.63	0.61	80.09
1985	3.17	17.66	21.24	17.80	13.31	9.77	4.50	3.37	1.70	1.21	1.16	1.54	96.44
1986	4.19	12.92	12.22	13.55	5.72	12.27	3.89	1.93	1.37	1.18	2.36	32.72	104.32
1987	37.87	35.31	10.64	13.03	46.42	56.47	6.94	2.88	2.36	4.57	2.31	1.94	220.73
1988	1.86	6.12	15.76	22.97	36.49	12.49	3.42	2.20	0.86	1.79	1.20	0.82	105.96
1989	1.09	9.71	18.92	8.39	6.87	17.33	15.94	2.74	1.60	1.24	1.12	1.60	86.54
1990	2.07	2.31	9.23	24.71	30.90	11.42	4.19	2.28	1.54	1.11	0.79	0.99	91.54
1991	6.32	5.94	11.63	12.84	8.05	5.67	2.13	1.08	0.71	0.58	0.51	0.51	55.97
1992	0.60	1.45	1.31	4.19	11.39	13.53	6.85	1.51	0.80	0.64	0.58	0.49	43.31
1993	4.46	6.30	13.22	34.75	37.49	10.40	3.25	2.08	1.29	1.26	1.38	0.95	116.83
1994	1.52	1.79	2.62	14.76	6.60	14.46	10.72	3.62	2.04	1.47	1.02	0.78	61.41
1995	1.64	4.46	37.52	43.18	34.72	25.14	7.65	3.19	2.06	9.24	4.20	2.43	175.43
1996	2.85	4.65	12.88	34.16	10.72	27.50	8.21	3.39	3.06	3.98	2.36	0.98	114.74
1997	4.00	8.61	22.57	15.86	29.56	15.29	5.94	2.72	1.70	1.32	1.26	1.01	109.85
1998	1.44	4.13	16.42	15.64	18.35	8.63	3.20	1.88	1.21	0.93	0.68	0.54	73.06
1999	3.80	5.84	20.93	34.23	19.33	47.08	16.46	5.02	2.59	1.82	1.33	2.69	161.12
2000	2.33	8.02	16.74	17.39	10.66	8.63	9.28	3.65	1.91	1.45	1.03	6.04	87.12
2001	4.08	14.62	12.23	10.75	10.21	10.47	3.15	1.82	1.81	2.78	3.27	2.74	77.93
2002	1.52	2.09	3.98	8.93	17.82	11.73	7.85	3.38	1.82	1.24	0.87	1.31	62.55
2003	1.01	3.56	4.62	15.77	18.92	15.43	4.71	2.01	0.87	1.16	1.45	1.64	71.14
2004	2.36	5.98	14.88	28.88	11.62	11.75	7.37	2.60	1.50	1.08	0.96	0.71	89.68
2005	1.15	2.12	1.47	13.59	26.03	20.72	8.51	5.05	2.07	1.41	1.89	1.62	85.63
2006	8.46	7.23	12.86	8.71	10.05	5.61	4.09	1.72	1.45	1.44	0.91	0.66	63.18
2007	5.13	4.23	8.15	14.38	11.87	16.03	9.95	4.56	1.88	1.26	0.94	1.10	79.48
2008	0.91	1.82	5.40	11.30	30.37	22.76	6.48	2.94	1.49	1.07	1.35	0.82	86.72
Ave:	3.58	6.86	12.72	18.26	19.93	16.61	8.12	3.55	2.02	1.58	1.42	2.06	96.70

Monthly incremental natural runoff (million m^3) for quaternary U10D (U10D.INC)

1925	4.38	3.62	3.39	6.28	7.70	9.98	5.93	1.97	1.74	1.46	0.76	5.16	52.38
1926	7.27	6.27	16.69	19.01	14.18	17.59	10.19	2.43	0.79	0.61	1.59	1.66	98.28
1927	4.02	4.72	13.90	26.37	18.12	17.31	9.92	2.48	1.25	0.68	0.90	1.10	100.78
1928	2.81	3.45	12.08	20.64	12.60	12.45	8.57	3.92	4.57	5.72	3.83	4.51	95.17
1929	5.80	11.45	12.67	20.47	17.54	14.37	7.49	1.91	0.91	0.69	1.05	1.26	95.61
1930	1.72	3.03	14.86	20.51	15.42	11.21	6.64	2.67	0.92	1.52	1.69	0.83	81.02
1931	1.05	1.62	2.55	8.97	24.77	16.66	4.14	1.60	1.53	1.19	0.64	1.10	65.81
1932	2.57	7.40	10.44	6.11	6.03	7.60	4.89	1.92	0.69	0.58	0.59	0.42	49.25
1933	0.66	18.06	27.75	39.01	26.53	11.72	8.33	6.34	3.49	2.00	1.83	1.70	147.41
1934	3.14	23.82	32.02	15.82	8.92	8.44	5.17	2.45	2.82	2.65	1.44	0.79	107.50
1935	0.71	0.84	1.72	10.42	17.07	13.44	5.95	3.96	3.15	1.43	0.56	0.71	59.96
1936	1.80	15.45	12.22	14.14	18.93	12.18	4.68	1.47	0.55	0.35	0.28	0.30	82.36
1937	1.00	3.92	5.93	17.96	26.53	14.15	8.12	5.11	1.81	1.33	1.72	1.53	89.11
1938	8.36	9.97	23.30	19.79	34.12	26.73	8.20	2.39	1.06	0.72	0.79	2.39	137.83
1939	4.16	8.49	10.24	12.92	11.25	15.16	9.73	9.86	8.62	3.88	1.41	1.16	96.88
1940	3.00	8.47	30.29	29.23	24.87	16.69	6.85	2.50	0.88	0.55	0.47	0.39	124.18
1941	1.51	2.70	5.39	24.40	40.61	29.38	14.31	6.15	2.14	1.13	1.23	1.26	130.21
1942	4.15	17.13	33.68	37.32	26.96	15.76	29.37	21.30	6.30	4.50	9.52	6.52	212.52
1943	14.19	19.90	19.93	19.64	19.04	19.15	9.24	1.80	0.95	0.98	0.68	4.99	130.51
1944	6.64	4.73	2.59	8.56	13.99	26.10	15.86	3.81	1.40	0.61	0.39	0.31	84.99
1945	0.74	0.73	1.69	6.18	11.29	11.50	7.33	3.30	1.19	0.50	0.34	0.31	45.10
1946	0.68	8.27	8.76	11.10	25.77	22.92	8.90	2.95	2.96	2.65	1.37	0.79	97.12
1947	1.78	9.08	17.19	25.89	22.12	21.63	12.30	3.92	1.78	0.77	0.39	0.33	117.20
1948	1.33	2.76	5.25	9.54	15.35	17.22	9.37	3.00	1.09	0.54	0.51	0.92	66.87
1949	1.34	3.05	12.09	9.22	16.81	33.92	21.24	7.03	3.05	1.68	3.38	3.26	116.07
1950	1.65	2.79	16.00	30.37	19.44	7.22	4.00	2.07	0.80	0.41	1.69	2.62	89.06
1951	4.11	3.01	9.08	21.61	27.74	14.86	5.34	2.95	1.44	1.13	1.37	1.24	93.88
1952	1.55	6.08	8.71	12.36	18.20	10.56	3.22	1.42	0.77	0.59	0.71	1.63	65.78
1953	3.79	7.98	14.69	16.49	26.31	21.16	7.62	3.71	2.91	1.50	0.66	1.22	108.04
1954	5.06	7.22	10.62	33.16	34.76	14.55	4.64	2.75	1.68	1.04	0.59	0.60	116.68
1955	0.97	1.54	14.13	11.38	27.73	29.26	11.04	2.35	0.87	0.46	0.52	0.77	101.03
1956	2.08	10.30	38.01	43.46	22.97	18.84	11.46	3.42	1.46	0.95	1.57	9.51	164.02
1957	13.86	8.57	12.61	25.61	20.70	9.76	6.57	4.08	1.54	0.60	0.35	0.84	105.08
1958	1.59	3.84	19.69	18.29	12.10	7.35	3.58	25.64	17.73	3.21	1.30	0.90	115.23
1959	1.56	5.79	7.35	6.27	9.20	12.47	9.81	4.83	1.79	0.70	0.51	0.88	61.18
1960	1.27	6.32	24.73	10.05	12.39	13.83	21.78	3.68	2.17	1.54	1.13	1.10	99.99
1961	0.92	4.34	11.10	17.53	20.10	11.11	3.11	2.68	1.51	1.18	1.17	1.57	76.32
1962	1.19	6.95	13.56	36.39	10.48	27.74	6.47	2.95	2.07	4.67	1.89	1.18	115.54
1963	4.26	16.52	17.44	26.86	9.70	8.48	3.90	2.65	3.37	2.38	1.45	2.81	99.82
1964	3.90	13.26	10.91	16.83	18.93	3.62	2.74	1.56	3.59	3.35	2.25	3.55	84.51
1965	3.48	4.81	2.96	19.52	20.50	3.30	1.89	1.84	1.17	0.82	0.74	1.06	62.09
1966	1.15	9.71	11.03	14.10	41.05	31.13	21.21	4.26	2.49	2.15	1.51	1.10	140.87
1967	1.35	6.30	9.42	9.24	7.98	9.91	7.80	2.65	1.57	1.21	1.24	0.96	59.62
1968	0.80	3.48	8.22	2.59	3.76	20.87	12.42	3.32	2.01	1.59	1.10	1.53	61.70
1969	7.04	3.59	14.32	10.43	15.61	4.97	1.93	1.37	0.97	0.87	5.34	2.96	69.40
1970	13.90	5.68	3.80	8.65	20.01	9.87	6.49	4.08	2.10	2.03	5.77	2.36	84.72
1971	4.54	6.27	15.51	28.70	36.43	35.65	7.82	3.46	2.07	1.65	1.20	0.95	144.27
1972	1.84	6.54	4.06	3.54	18.44	11.20	13.38	7.50	2.12	1.56	1.91	2.07	74.14
1973	5.32	9.33	9.61	31.99	53.56	40.08	19.26	4.73	3.09	2.43	1.67	1.16	182.24
1974	1.16	5.08	8.41	26.76	33.50	16.44	6.74	2.61	1.64	1.27	0.98	2.61	107.20
1975	1.87	4.36	28.89	61.02	68.02	54.98	20.72	4.91	0.89	0.20	0.47	1.18	247.49
1976	4.73	5.71	4.90	13.26	18.24	17.39	8.78	2.70	1.72	1.33	1.13	1.51	81.42
1977	2.65	3.94	4.90	27.32	17.48	12.63	10.84	3.85	1.94	1.47	1.12	2.14	90.28
1978	4.86	5.83	29.94	8.90	9.94	12.26	3.51	2.78	1.52	1.58	1.79	2.38	85.29
1979	1.69	3.77	4.22	12.33	13.87	15.43	3.86	1.31	1.15	0.93	0.70	3.13	62.38
1980	3.89	2.48	11.15	20.66	32.87	14.47	3.03	2.01	1.34	1.01	1.21	3.77	97.89
1981	1.92	2.51	5.51	5.32	3.00	18.87	4.75	1.88	1.33	1.01	0.73	0.84	47.65
1982	1.00	3.12	1.55	2.65	2.13	4.08	2.13	0.83	0.53	0.49	0.55	0.56	19.60
1983	2.07	7.03	26.63	20.63	8.69	21.22	18.20	3.27	1.60	1.70	1.35	1.33	113.72
1984	2.05	2.52	2.41	17.55	37.60	11.28	2.74	1.70	1.25	0.98	0.64	0.62	81.36
1985	3.22	17.94	21.58	18.08	13.52	9.93	4.57	3.43	1.73	1.23	1.18	1.56	97.96
1986	4.26	13.12	12.41	13.76	5.81	12.46	3.95	1.96	1.40	1.20	2.40	33.24	105.96
1987	38.47	35.87	10.81	13.23	47.16	57.36	7.05	2.92	2.39	4.64	2.34	1.97	224.21
1988	1.88	6.21	16.01	23.34	37.06	12.68	3.47	2.23	0.87	1.82	1.22	0.83	107.63
1989	1.10	9.86	19.22	8.52	6.97	17.61	16.19	2.79	1.62	1.26	1.13	1.62	87.91
1990	2.10	2.35	9.38	25.10	31.39	11.60	4.26	2.32	1.57	1.13	0.80	1.00	92.99
1991	6.42	6.03	11.82	13.04	8.18	5.76	2.16	1.09	0.73	0.59	0.52	0.52	56.86
1992	0.61	1.47	1.33	4.26	11.57	13.74	6.96	1.53	0.81	0.65	0.59	0.49	44.00
1993	4.53	6.40	13.42	35.29	38.08	10.57	3.31	2.11	1.31	1.28	1.40	0.97	118.67
1994	1.54	1.82	2.66	14.99	6.70	14.69	10.89	3.67	2.07	1.50	1.03	0.79	62.37
1995	1.66	4.53	38.11	43.86	35.27	25.54	7.77	3.24	2.10	9.39	4.27	2.47	178.19
1996	2.89	4.73	13.08	34.70	10.89	27.94	8.33	3.45	3.11	4.04	2.40	0.99	116.55
1997	4.07	8.75	22.93	16.11	30.03	15.54	6.03	2.76	1.73	1.34	1.28	1.02	111.59
1998	1.46	4.19	16.68	15.89	18.64	8.77	3.26	1.91	1.23	0.95	0.70	0.54	74.21
1999	3.86	5.93	21.26	34.77	19.63	47.82	16.72	5.10	2.63	1.84	1.35	2.74	163.66
2000	2.37	8.14	17.00	17.67	10.83	8.76	9.43	3.70	1.94	1.47	1.04	6.13	88.49
2001	4.15	14.85	12.42	10.92	10.37	10.64	3.20	1.85	1.84	2.82	3.33	2.79	79.16
2002	1.55	2.13	4.04	9.07	18.11	11.92	7.98	3.43	1.85	1.26	0.88	1.33	63.53
2003	1.02	3.62	4.69	16.02	19.22	15.67	4.78	2.04	0.88	1.17	1.48	1.67	72.26
2004	2.40	6.08	15.11	29.33	11.80	11.94	7.48	2.64	1.53	1.10	0.98	0.72	91.10
2005	1.16	2.16	1.50	13.80	26.44	21.05	8.64	5.13	2.10	1.43	1.92	1.65	86.98
2006	8.60	7.34	13.07	8.85	10.21	5.70	4.15	1.75	1.47	1.46	0.92	0.67	64.18
2007	5.22	4.30	8.28	14.61	12.06	16.28	10.11	4.63	1.91	1.28	0.95	1.12	80.74
2008	0.93	1.85	5.48	11.48	30.85	23.12	6.58	2.98	1.52	1.09	1.37	0.83	88.09
Ave:	3.64	6.97	12.92	18.55	20.25	16.87	8.25	3.60	2.05	1.60	1.44	2.10	98.22

Monthly incremental natural runoff (million m^3) for quaternary U10E (U10E.INC)

1925	4.50	3.72	3.48	6.46	7.91	10.26	6.09	2.03	1.79	1.50	0.78	5.30	53.82
1926	7.47	6.44	17.15	19.54	14.56	18.07	10.47	2.49	0.81	0.63	1.63	1.71	100.98
1927	4.13	4.85	14.28	27.10	18.62	17.79	10.20	2.55	1.28	0.69	0.92	1.13	103.55
1928	2.89	3.55	12.42	21.21	12.94	12.79	8.81	4.03	4.70	5.88	3.93	4.64	97.79
1929	5.96	11.76	13.02	21.03	18.02	14.77	7.70	1.96	0.93	0.71	1.08	1.29	98.23
1930	1.76	3.12	15.27	21.07	15.84	11.52	6.82	2.75	0.94	1.56	1.73	0.85	83.24
1931	1.08	1.67	2.62	9.22	25.45	17.12	4.25	1.64	1.57	1.22	0.66	1.13	67.62
1932	2.65	7.61	10.72	6.28	6.19	7.81	5.03	1.97	0.71	0.60	0.61	0.44	50.60
1933	0.68	18.55	28.51	40.08	27.26	12.04	8.55	6.52	3.59	2.06	1.88	1.74	151.46
1934	3.23	24.48	32.89	16.25	9.17	8.67	5.32	2.52	2.90	2.73	1.48	0.81	110.45
1935	0.73	0.86	1.77	10.71	17.54	13.81	6.11	4.07	3.23	1.47	0.58	0.73	61.61
1936	1.85	15.87	12.55	14.53	19.45	12.52	4.81	1.51	0.57	0.36	0.29	0.31	84.62
1937	1.02	4.03	6.09	18.46	27.26	14.54	8.35	5.26	1.86	1.37	1.77	1.57	91.56
1938	8.59	10.25	23.94	20.34	35.06	27.47	8.43	2.45	1.09	0.74	0.81	2.46	141.62
1939	4.27	8.73	10.52	13.27	11.56	15.58	9.99	10.14	8.86	3.98	1.45	1.19	99.54
1940	3.08	8.70	31.12	30.03	25.55	17.14	7.04	2.57	0.90	0.56	0.48	0.40	127.59
1941	1.55	2.77	5.54	25.07	41.73	30.19	14.70	6.31	2.20	1.16	1.27	1.29	133.78
1942	4.26	17.61	34.60	38.35	27.70	16.19	30.18	21.89	6.47	4.62	9.79	6.69	218.35
1943	14.58	20.45	20.48	20.18	19.57	19.68	9.50	1.85	0.98	1.00	0.70	5.13	134.10
1944	6.83	4.86	2.66	8.80	14.37	26.82	16.30	3.91	1.44	0.63	0.40	0.32	87.32
1945	0.76	0.75	1.73	6.35	11.60	11.82	7.53	3.39	1.22	0.52	0.35	0.31	46.34
1946	0.70	8.49	9.00	11.40	26.47	23.55	9.15	3.03	3.04	2.72	1.41	0.81	99.79
1947	1.83	9.33	17.67	26.60	22.73	22.22	12.63	4.03	1.83	0.79	0.41	0.34	120.42
1948	1.37	2.83	5.40	9.80	15.77	17.70	9.63	3.08	1.11	0.56	0.52	0.94	68.71
1949	1.38	3.13	12.42	9.48	17.27	34.85	21.82	7.23	3.14	1.72	3.47	3.35	119.25
1950	1.69	2.87	16.44	31.20	19.98	7.42	4.11	2.12	0.83	0.42	1.73	2.70	91.51
1951	4.22	3.09	9.33	22.21	28.50	15.27	5.48	3.03	1.48	1.16	1.41	1.27	96.46
1952	1.59	6.24	8.95	12.69	18.70	10.85	3.31	1.45	0.79	0.61	0.73	1.67	67.59
1953	3.90	8.20	15.09	16.95	27.03	21.75	7.83	3.81	2.99	1.54	0.68	1.25	111.01
1954	5.20	7.42	10.92	34.07	35.71	14.95	4.76	2.83	1.73	1.07	0.61	0.61	119.88
1955	1.00	1.58	14.52	11.70	28.50	30.06	11.35	2.42	0.89	0.47	0.53	0.79	103.80
1956	2.14	10.58	39.06	44.65	23.60	19.36	11.77	3.51	1.50	0.97	1.61	9.78	168.53
1957	14.24	8.80	12.96	26.31	21.26	10.03	6.75	4.19	1.58	0.62	0.36	0.87	107.97
1958	1.64	3.95	20.23	18.79	12.43	7.55	3.68	26.34	18.22	3.30	1.34	0.93	118.40
1959	1.61	5.95	7.55	6.45	9.45	12.82	10.08	4.97	1.84	0.72	0.52	0.91	62.86
1960	1.30	6.49	25.41	10.32	12.73	14.21	22.38	3.78	2.23	1.58	1.16	1.13	102.74
1961	0.94	4.46	11.40	18.01	20.65	11.41	3.20	2.76	1.55	1.22	1.20	1.61	78.42
1962	1.23	7.14	13.93	37.39	10.77	28.50	6.65	3.03	2.12	4.80	1.94	1.22	118.71
1963	4.37	16.98	17.92	27.60	9.96	8.71	4.01	2.72	3.46	2.45	1.49	2.89	102.56
1964	4.01	13.62	11.21	17.29	19.45	3.72	2.82	1.61	3.69	3.45	2.31	3.65	86.83
1965	3.58	4.94	3.04	20.05	21.06	3.39	1.94	1.89	1.20	0.84	0.76	1.09	63.79
1966	1.18	9.98	11.33	14.48	42.18	31.98	21.79	4.38	2.56	2.20	1.55	1.13	144.74
1967	1.38	6.48	9.68	9.50	8.19	10.18	8.02	2.72	1.61	1.24	1.28	0.98	61.26
1968	0.82	3.58	8.45	2.66	3.87	21.45	12.76	3.41	2.06	1.64	1.13	1.57	63.40
1969	7.23	3.69	14.72	10.72	16.03	5.11	1.98	1.41	1.00	0.90	5.49	3.04	71.30
1970	14.28	5.84	3.91	8.89	20.56	10.14	6.67	4.19	2.16	2.08	5.92	2.42	87.05
1971	4.66	6.44	15.94	29.49	37.43	36.63	8.04	3.56	2.13	1.69	1.24	0.98	148.23
1972	1.89	6.72	4.17	3.64	18.94	11.50	13.74	7.71	2.18	1.60	1.96	2.13	76.18
1973	5.46	9.59	9.88	32.87	55.03	41.18	19.79	4.86	3.18	2.50	1.72	1.19	187.24
1974	1.19	5.22	8.64	27.49	34.42	16.89	6.92	2.68	1.68	1.30	1.01	2.68	110.14
1975	1.92	4.48	29.68	62.69	69.89	56.49	21.29	5.05	0.91	0.20	0.49	1.21	254.29
1976	4.86	5.87	5.04	13.62	18.74	17.87	9.02	2.78	1.77	1.36	1.16	1.55	83.66
1977	2.73	4.04	5.03	28.07	17.96	12.98	11.14	3.96	1.99	1.51	1.15	2.20	92.76
1978	5.00	5.99	30.76	9.15	10.21	12.59	3.61	2.85	1.56	1.63	1.84	2.44	87.63
1979	1.74	3.87	4.34	12.66	14.25	15.85	3.96	1.35	1.18	0.95	0.72	3.21	64.09
1980	4.00	2.54	11.46	21.22	33.78	14.87	3.11	2.06	1.38	1.03	1.24	3.87	100.57
1981	1.97	2.58	5.66	5.46	3.08	19.39	4.88	1.93	1.36	1.03	0.75	0.87	48.96
1982	1.03	3.21	1.59	2.72	2.19	4.20	2.19	0.85	0.54	0.50	0.56	0.57	20.14
1983	2.12	7.22	27.36	21.19	8.93	21.80	18.70	3.36	1.64	1.75	1.39	1.37	116.85
1984	2.11	2.59	2.48	18.04	38.63	11.59	2.81	1.74	1.29	1.01	0.66	0.64	83.59
1985	3.31	18.43	22.17	18.58	13.89	10.20	4.70	3.52	1.77	1.27	1.21	1.60	100.65
1986	4.38	13.48	12.75	14.14	5.97	12.80	4.06	2.01	1.43	1.23	2.46	34.15	108.87
1987	39.53	36.85	11.10	13.59	48.45	58.94	7.24	3.00	2.46	4.77	2.41	2.03	230.37
1988	1.94	6.39	16.45	23.98	38.08	13.03	3.56	2.29	0.89	1.87	1.25	0.85	110.58
1989	1.13	10.14	19.75	8.76	7.17	18.09	16.64	2.86	1.67	1.29	1.17	1.67	90.32
1990	2.16	2.41	9.63	25.78	32.25	11.92	4.38	2.38	1.61	1.16	0.82	1.03	95.54
1991	6.59	6.20	12.14	13.40	8.40	5.92	2.22	1.12	0.75	0.61	0.54	0.53	58.42
1992	0.63	1.51	1.36	4.38	11.88	14.12	7.15	1.57	0.84	0.66	0.60	0.51	45.21
1993	4.65	6.58	13.79	36.26	39.13	10.86	3.40	2.17	1.35	1.31	1.44	0.99	121.93
1994	1.58	1.87	2.74	15.41	6.89	15.10	11.19	3.78	2.12	1.54	1.06	0.82	64.09
1995	1.71	4.65	39.16	45.06	36.24	26.24	7.98	3.33	2.15	9.65	4.38	2.54	183.09
1996	2.97	4.86	13.44	35.65	11.19	28.70	8.56	3.54	3.19	4.16	2.46	1.02	119.75
1997	4.18	8.99	23.56	16.56	30.85	15.96	6.20	2.84	1.77	1.38	1.32	1.05	114.65
1998	1.50	4.31	17.14	16.33	19.15	9.01	3.34	1.96	1.26	0.97	0.71	0.56	76.25
1999	3.97	6.09	21.84	35.72	20.17	49.13	17.18	5.24	2.71	1.90	1.39	2.81	168.16
2000	2.43	8.37	17.47	18.15	11.13	9.01	9.69	3.80	1.99	1.51	1.07	6.30	90.92
2001	4.26	15.26	12.76	11.22	10.66	10.93	3.28	1.90	1.89	2.90	3.42	2.86	81.34
2002	1.59	2.19	4.16	9.32	18.60	12.25	8.20	3.53	1.90	1.29	0.90	1.36	65.28
2003	1.05	3.72	4.82	16.46	19.75	16.10	4.91	2.10	0.91	1.21	1.52	1.71	74.25
2004	2.46	6.24	15.53	30.14	12.12	12.26	7.69	2.72	1.57	1.13	1.00	0.74	93.60
2005	1.20	2.21	1.54	14.18	27.17	21.63	8.88	5.27	2.16	1.47	1.98	1.69	89.37
2006	8.83	7.54	13.42	9.09	10.49	5.86	4.27	1.79	1.51	1.50	0.95	0.69	65.94
2007	5.36	4.41	8.51	15.01	12.39	16.73	10.38	4.76	1.96	1.31	0.98	1.15	82.95
2008	0.95	1.90	5.63	11.79	31.70	23.75	6.76	3.07	1.56	1.12	1.41	0.86	90.51
Ave:	3.73	7.16	13.27	19.06	20.80	17.33	8.47	3.70	2.11	1.65	1.48	2.15	100.92

Monthly incremental natural runoff (million m^3) for quaternary U10F (U10F.INC)

1925	1.92	2.15	2.38	2.32	2.12	3.85	3.41	1.80	1.30	1.09	0.72	0.98	24.03
1926	2.60	4.09	6.61	6.59	4.40	23.66	15.07	2.82	1.10	0.72	1.24	1.52	70.41
1927	1.87	2.10	7.81	22.15	13.73	5.35	3.41	1.69	0.85	0.56	0.63	0.89	61.05
1928	1.51	2.14	2.08	1.93	2.15	9.51	7.15	2.65	4.69	5.09	3.15	2.48	44.52
1929	3.12	4.97	8.46	13.80	8.65	5.05	3.89	2.11	1.38	1.24	1.30	1.63	55.60
1930	1.86	2.31	3.63	11.40	8.99	6.49	4.92	2.51	1.18	1.51	1.83	1.20	47.82
1931	1.03	1.34	1.81	3.20	9.17	10.27	5.28	2.14	1.46	1.09	0.70	0.57	38.07
1932	1.08	2.51	4.12	3.67	2.50	3.40	3.26	1.85	0.84	0.54	0.48	0.39	24.65
1933	0.39	6.35	22.54	26.49	12.16	5.43	4.73	3.68	2.27	1.75	1.71	1.39	88.88
1934	1.49	3.69	17.11	11.63	6.17	6.07	5.21	4.08	16.56	11.29	3.10	1.50	87.91
1935	0.99	0.71	0.51	1.32	19.50	21.04	8.43	4.65	3.59	1.89	1.01	0.84	64.46
1936	1.36	20.20	13.54	3.98	12.82	9.20	2.93	1.23	0.67	0.54	0.46	0.38	67.30
1937	0.70	1.36	3.21	7.54	18.44	11.31	6.26	4.60	2.14	1.39	1.36	1.09	59.40
1938	2.25	4.42	5.94	6.64	33.95	21.01	4.18	2.45	1.74	1.19	1.00	2.22	86.99
1939	3.87	7.00	10.09	7.75	7.61	6.35	3.84	7.18	7.01	4.12	1.99	1.08	67.89
1940	1.15	5.77	23.91	15.37	4.28	3.39	3.46	2.37	1.15	0.70	0.55	0.57	62.68
1941	1.14	1.92	2.00	2.99	13.48	24.58	13.21	3.80	1.92	1.09	1.09	1.27	68.50
1942	1.97	9.41	23.16	13.63	4.85	4.74	31.67	20.79	5.05	3.34	5.03	4.06	127.69
1943	12.60	40.21	33.79	11.77	5.45	5.87	4.21	1.99	0.97	0.73	0.59	1.34	119.52
1944	2.56	2.55	1.61	1.73	3.37	21.91	14.15	3.24	1.53	0.81	0.49	0.34	54.30
1945	0.61	0.76	0.99	3.00	5.83	6.60	4.64	2.40	1.15	0.63	0.41	0.34	27.37
1946	0.63	1.77	3.21	4.27	10.10	21.39	13.57	4.19	2.81	2.80	1.92	1.14	67.80
1947	1.29	6.59	7.28	7.42	6.97	8.83	7.81	3.85	1.48	0.68	0.42	0.34	52.96
1948	1.20	2.30	3.06	3.31	3.62	5.31	4.21	2.14	1.03	0.59	0.51	0.71	27.99
1949	1.70	6.26	6.54	6.46	8.50	15.10	9.57	3.61	1.91	1.32	1.88	1.97	64.82
1950	1.39	1.23	11.54	15.94	8.80	4.99	3.40	1.61	0.72	0.42	0.84	1.60	52.47
1951	2.52	2.22	1.91	7.12	6.85	4.57	4.10	3.20	1.97	1.23	0.89	0.76	37.33
1952	0.87	1.67	3.97	4.97	11.74	7.89	2.52	1.19	0.70	0.49	0.86	1.66	38.53
1953	2.89	3.86	9.54	10.66	8.97	5.72	3.19	2.41	1.92	1.32	0.86	0.91	52.26
1954	8.39	8.72	4.59	28.31	38.07	21.14	7.53	3.19	1.77	1.11	0.71	0.64	124.17
1955	1.04	1.90	2.99	2.41	17.96	34.76	17.34	3.36	1.47	0.95	0.83	0.93	85.95
1956	1.35	3.00	23.70	22.91	9.43	14.27	11.18	4.49	1.91	0.91	0.80	2.63	96.57
1957	8.78	9.13	5.57	6.17	16.23	10.26	6.23	4.52	1.90	0.85	0.49	0.56	70.71
1958	0.83	2.42	9.91	16.99	14.97	8.31	4.04	35.49	22.30	3.65	1.88	1.49	122.27
1959	1.68	4.60	8.24	5.54	3.58	8.74	8.04	4.36	2.06	0.96	0.65	0.75	49.19
1960	1.23	3.41	15.35	13.77	6.17	17.16	22.37	10.33	2.62	1.18	0.71	0.82	95.11
1961	1.07	1.82	2.79	5.41	14.47	16.93	8.60	2.92	1.21	0.56	0.71	0.84	57.31
1962	1.14	5.25	7.53	14.86	9.61	20.87	9.38	2.77	1.88	6.99	2.37	1.49	84.15
1963	1.52	7.33	7.67	18.58	9.11	5.03	3.24	2.03	3.10	1.94	1.34	1.75	62.63
1964	3.57	6.45	4.31	9.97	8.13	2.77	1.65	1.03	4.04	2.80	1.45	3.50	49.66
1965	4.31	9.47	5.02	19.57	16.80	3.56	1.87	2.00	1.47	1.29	1.07	1.39	67.80
1966	1.04	3.31	3.52	5.33	14.07	32.55	25.73	6.35	3.23	2.89	2.23	1.44	101.70
1967	1.04	7.19	2.66	0.87	0.93	8.57	7.56	1.99	1.12	0.99	1.25	1.20	35.39
1968	0.97	1.08	3.85	0.49	1.34	8.92	7.21	2.42	1.40	1.11	0.99	1.16	30.94
1969	4.63	4.10	7.51	7.53	10.14	2.95	1.13	1.04	0.72	0.97	1.97	2.08	44.76
1970	12.22	5.18	6.98	4.08	5.72	4.94	5.67	3.66	1.72	1.67	5.12	2.54	59.48
1971	3.67	5.40	10.62	15.14	14.58	17.55	7.27	3.54	2.37	1.61	1.55	1.04	84.34
1972	1.06	1.98	3.26	2.04	7.95	11.23	22.50	2.94	0.98	0.69	0.73	1.40	56.77
1973	4.06	3.40	4.05	33.10	31.58	21.18	12.61	6.19	3.26	2.57	1.71	1.16	124.88
1974	1.55	1.47	5.06	12.54	11.52	9.99	4.76	2.31	1.37	1.17	1.03	1.73	54.49
1975	1.95	2.60	9.63	26.99	27.39	54.15	14.23	5.91	4.95	4.65	3.54	1.96	157.94
1976	12.60	4.08	3.08	6.52	7.03	9.96	6.60	2.76	1.19	1.18	0.93	0.50	56.43
1977	1.77	1.50	3.07	10.42	9.04	13.44	7.36	4.24	1.97	1.37	1.26	1.55	56.99
1978	3.98	6.11	8.51	6.95	9.07	9.78	4.82	2.64	1.52	1.47	1.51	1.53	57.89
1979	1.48	0.91	1.37	1.87	1.91	4.29	1.90	1.31	0.59	0.52	0.48	1.06	17.70
1980	2.34	2.14	5.72	9.83	13.34	4.32	1.49	1.32	1.12	0.89	0.50	2.38	45.38
1981	0.89	2.42	2.05	3.52	1.85	7.77	4.85	1.62	1.21	0.93	0.81	0.81	28.72
1982	0.57	2.14	2.26	0.76	0.23	0.75	1.24	0.80	0.61	0.51	0.73	0.71	11.30
1983	0.58	1.83	9.21	12.45	2.06	6.07	3.83	2.13	1.68	0.91	0.79	0.73	42.27
1984	0.77	1.91	1.48	6.18	33.52	8.86	1.89	1.02	0.77	0.76	0.66	0.56	58.38
1985	1.84	11.44	19.45	16.36	6.27	10.27	3.21	0.98	1.03	0.90	0.62	1.33	73.69
1986	0.94	4.74	7.01	6.35	5.22	11.91	4.95	1.76	1.26	1.24	1.45	85.68	132.51
1987	54.92	15.66	8.05	3.16	22.87	37.70	17.67	4.00	2.56	2.04	1.50	1.20	171.33
1988	1.38	1.93	22.14	22.89	22.76	16.83	6.63	5.83	3.64	1.75	1.27	1.14	108.18
1989	0.90	37.05	25.67	6.31	5.18	9.13	9.63	2.90	1.62	1.43	1.38	2.10	103.31
1990	1.60	2.64	8.34	10.11	23.23	13.08	4.50	2.26	1.64	1.52	1.22	1.06	71.19
1991	2.68	4.28	3.13	2.27	2.56	3.49	1.65	0.95	0.55	0.33	0.28	0.31	22.50
1992	0.59	0.98	1.10	1.00	1.55	2.24	2.16	1.47	0.80	0.47	0.44	0.70	13.49
1993	3.48	3.84	7.47	12.53	7.97	6.27	3.09	1.29	0.85	0.97	1.32	1.05	50.15
1994	1.14	1.28	1.50	2.53	1.87	2.80	3.98	1.74	1.45	1.29	20.80	25.96	66.33
1995	13.88	3.34	49.48	46.69	32.98	21.75	6.00	2.75	1.64	13.01	4.93	2.27	198.71
1996	1.68	3.37	19.54	19.59	7.27	6.40	10.22	4.24	4.21	5.14	2.98	3.91	88.56
1997	1.95	12.48	8.99	15.42	20.48	13.52	7.06	2.86	1.99	1.42	1.38	1.33	88.88
1998	0.94	0.67	4.45	4.40	12.20	4.24	1.56	0.80	0.56	0.54	0.56	0.49	31.38
1999	0.79	0.74	33.78	33.51	12.54	12.91	14.88	6.18	2.41	1.79	1.32	1.54	122.39
2000	1.63	3.03	10.73	12.23	6.00	4.71	6.58	2.62	1.36	1.00	0.90	3.44	54.24
2001	3.72	18.30	19.48	10.88	10.98	6.93	2.85	1.75	1.88	5.01	4.65	3.41	89.86
2002	1.74	1.44	0.79	3.06	2.20	2.91	2.87	1.80	1.22	0.94	0.58	0.65	20.21
2003	0.69	1.10	1.91	2.75	3.55	7.02	2.68	1.01	0.90	0.93	1.04	1.24	24.81
2004	2.46	8.36	23.89	7.54	5.81	7.02	7.82	1.91	1.14	1.14	0.78	0.73	68.59
2005	0.61	0.90	0.69	2.87	2.73	3.98	4.18	2.63	1.36	1.18	1.06	1.45	23.63
2006	6.43	3.71	9.44	4.63	5.11	4.63	3.28	1.61	1.03	1.81	0.91	0.72	43.31
2007	2.08	16.20	11.78	8.10	5.68	3.14	3.63	3.03	1.91	1.34	0.83	0.73	58.45
2008	1.22	2.20	4.43	5.96	24.94	22.12	8.03	2.47	1.00	0.54	0.55	0.80	74.26
Ave:	3.09	5.16	8.78	9.90	10.53	11.01	6.96	3.47	2.22	1.76	1.55	2.63	67.08

Monthly incremental natural runoff (million m^3) for quaternary U10G (U10G.INC)

1925	2.00	2.25	2.49	2.43	2.21	4.03	3.56	1.88	1.35	1.14	0.75	1.03	25.12
1926	2.72	4.28	6.91	6.89	4.60	24.74	15.75	2.95	1.14	0.75	1.29	1.59	73.61
1927	1.96	2.20	8.17	23.16	14.35	5.59	3.56	1.77	0.89	0.59	0.66	0.94	63.83
1928	1.57	2.24	2.17	2.01	2.25	9.94	7.48	2.77	4.91	5.32	3.30	2.59	46.54
1929	3.26	5.20	8.84	14.42	9.04	5.28	4.07	2.21	1.44	1.29	1.36	1.70	58.13
1930	1.95	2.41	3.79	11.91	9.40	6.78	5.14	2.62	1.23	1.58	1.92	1.26	49.99
1931	1.08	1.40	1.89	3.34	9.59	10.74	5.52	2.24	1.52	1.14	0.74	0.60	39.80
1932	1.13	2.63	4.31	3.84	2.62	3.55	3.41	1.93	0.88	0.57	0.50	0.41	25.77
1933	0.40	6.63	23.56	27.70	12.72	5.67	4.94	3.85	2.38	1.83	1.79	1.45	92.92
1934	1.56	3.86	17.88	12.15	6.45	6.35	5.45	4.27	17.31	11.81	3.24	1.57	91.90
1935	1.03	0.74	0.53	1.38	20.38	21.99	8.81	4.86	3.75	1.97	1.05	0.87	67.39
1936	1.42	21.11	14.15	4.16	13.40	9.62	3.06	1.29	0.70	0.56	0.48	0.40	70.36
1937	0.74	1.43	3.35	7.88	19.28	11.82	6.55	4.81	2.24	1.45	1.42	1.14	62.10
1938	2.35	4.62	6.21	6.94	35.49	21.96	4.36	2.57	1.82	1.24	1.05	2.32	90.94
1939	4.04	7.32	10.55	8.10	7.96	6.63	4.01	7.51	7.33	4.30	2.08	1.12	70.97
1940	1.21	6.03	25.00	16.06	4.48	3.54	3.62	2.48	1.21	0.73	0.57	0.60	65.52
1941	1.19	2.01	2.09	3.13	14.10	25.70	13.81	3.98	2.01	1.14	1.14	1.33	71.61
1942	2.06	9.83	24.22	14.25	5.07	4.96	33.10	21.73	5.28	3.50	5.26	4.24	133.48
1943	13.17	42.04	35.32	12.31	5.70	6.14	4.40	2.08	1.02	0.76	0.62	1.40	124.95
1944	2.68	2.66	1.68	1.81	3.52	22.91	14.80	3.39	1.60	0.85	0.52	0.35	56.76
1945	0.64	0.79	1.03	3.13	6.10	6.90	4.85	2.51	1.21	0.66	0.43	0.36	28.61
1946	0.66	1.85	3.36	4.46	10.56	22.36	14.19	4.38	2.94	2.93	2.01	1.19	70.88
1947	1.34	6.89	7.61	7.76	7.29	9.23	8.16	4.03	1.54	0.72	0.43	0.35	55.37
1948	1.25	2.41	3.19	3.46	3.79	5.55	4.40	2.23	1.08	0.62	0.54	0.75	29.26
1949	1.78	6.54	6.84	6.75	8.89	15.78	10.00	3.77	1.99	1.38	1.97	2.06	67.76
1950	1.46	1.28	12.06	16.66	9.20	5.21	3.56	1.68	0.75	0.44	0.88	1.67	54.85
1951	2.64	2.32	2.00	7.45	7.16	4.77	4.29	3.34	2.06	1.28	0.93	0.79	39.03
1952	0.90	1.75	4.16	5.20	12.27	8.25	2.64	1.25	0.73	0.51	0.90	1.73	40.28
1953	3.02	4.03	9.97	11.15	9.38	5.98	3.34	2.52	2.01	1.38	0.90	0.96	54.64
1954	8.77	9.12	4.80	29.60	39.79	22.10	7.88	3.33	1.85	1.16	0.74	0.67	129.81
1955	1.08	1.98	3.12	2.52	18.77	36.34	18.13	3.52	1.54	1.00	0.87	0.97	89.85
1956	1.41	3.13	24.78	23.95	9.86	14.92	11.69	4.70	1.99	0.95	0.83	2.75	100.96
1957	9.18	9.54	5.82	6.45	16.97	10.73	6.51	4.73	1.99	0.89	0.52	0.59	73.92
1958	0.87	2.53	10.36	17.76	15.65	8.69	4.22	37.10	23.31	3.82	1.96	1.56	127.82
1959	1.76	4.81	8.61	5.79	3.74	9.13	8.40	4.56	2.15	1.00	0.68	0.78	51.42
1960	1.28	3.56	16.05	14.39	6.45	17.94	23.39	10.80	2.74	1.23	0.74	0.86	99.43
1961	1.12	1.90	2.92	5.65	15.12	17.69	8.99	3.05	1.26	0.58	0.74	0.88	59.91
1962	1.20	5.49	7.87	15.54	10.05	21.82	9.80	2.89	1.96	7.30	2.48	1.56	87.97
1963	1.59	7.66	8.02	19.42	9.52	5.26	3.39	2.12	3.24	2.03	1.40	1.83	65.47
1964	3.73	6.74	4.50	10.42	8.50	2.90	1.72	1.08	4.22	2.93	1.52	3.65	51.91
1965	4.50	9.90	5.25	20.46	17.56	3.72	1.95	2.09	1.53	1.34	1.12	1.45	70.88
1966	1.09	3.46	3.68	5.57	14.71	34.03	26.90	6.64	3.38	3.02	2.33	1.51	106.32
1967	1.08	7.52	2.79	0.91	0.97	8.96	7.91	2.08	1.17	1.03	1.31	1.25	37.00
1968	1.01	1.13	4.03	0.51	1.40	9.32	7.54	2.53	1.46	1.16	1.03	1.22	32.34
1969	4.84	4.28	7.85	7.88	10.60	3.09	1.18	1.09	0.75	1.01	2.05	2.17	46.79
1970	12.78	5.41	7.29	4.26	5.98	5.16	5.92	3.82	1.80	1.75	5.36	2.65	62.19
1971	3.84	5.64	11.10	15.83	15.24	18.34	7.60	3.70	2.48	1.69	1.62	1.09	88.17
1972	1.11	2.08	3.41	2.13	8.31	11.74	23.52	3.07	1.03	0.72	0.76	1.47	59.35
1973	4.25	3.55	4.23	34.60	33.02	22.15	13.19	6.47	3.41	2.69	1.79	1.21	130.55
1974	1.62	1.54	5.29	13.11	12.04	10.44	4.97	2.41	1.43	1.22	1.08	1.81	56.97
1975	2.04	2.72	10.07	28.21	28.63	56.61	14.87	6.18	5.18	4.86	3.70	2.05	165.12
1976	13.17	4.27	3.21	6.82	7.35	10.41	6.90	2.88	1.25	1.23	0.97	0.52	58.99
1977	1.85	1.56	3.21	10.90	9.45	14.05	7.69	4.44	2.06	1.43	1.31	1.62	59.58
1978	4.16	6.38	8.90	7.27	9.48	10.22	5.04	2.76	1.59	1.54	1.58	1.60	60.52
1979	1.54	0.96	1.44	1.96	1.99	4.48	1.99	1.37	0.62	0.54	0.50	1.10	18.50
1980	2.45	2.23	5.98	10.28	13.95	4.52	1.55	1.38	1.17	0.93	0.52	2.48	47.44
1981	0.94	2.53	2.14	3.68	1.93	8.12	5.08	1.69	1.27	0.97	0.84	0.85	30.03
1982	0.60	2.23	2.36	0.80	0.24	0.78	1.30	0.83	0.63	0.53	0.76	0.74	11.81
1983	0.61	1.91	9.63	13.02	2.16	6.35	4.01	2.22	1.76	0.95	0.83	0.76	44.19
1984	0.80	2.00	1.54	6.46	35.04	9.27	1.98	1.07	0.80	0.79	0.69	0.59	61.03
1985	1.92	11.96	20.33	17.10	6.56	10.73	3.35	1.02	1.08	0.95	0.65	1.39	77.04
1986	0.98	4.96	7.33	6.64	5.45	12.45	5.17	1.84	1.32	1.29	1.52	89.57	138.53
1987	57.42	16.37	8.41	3.31	23.91	39.41	18.47	4.19	2.67	2.14	1.57	1.25	179.11
1988	1.44	2.02	23.15	23.93	23.80	17.59	6.93	6.09	3.80	1.83	1.33	1.19	113.09
1989	0.94	38.73	26.84	6.60	5.41	9.54	10.07	3.03	1.70	1.49	1.45	2.20	108.00
1990	1.67	2.76	8.72	10.56	24.28	13.67	4.71	2.36	1.71	1.59	1.28	1.11	74.42
1991	2.80	4.48	3.28	2.38	2.68	3.65	1.73	0.99	0.58	0.35	0.30	0.33	23.53
1992	0.61	1.02	1.15	1.04	1.62	2.34	2.26	1.54	0.83	0.49	0.46	0.73	14.11
1993	3.63	4.02	7.81	13.10	8.33	6.56	3.23	1.35	0.89	1.02	1.38	1.10	52.43
1994	1.19	1.34	1.57	2.64	1.95	2.93	4.16	1.82	1.52	1.35	21.75	27.14	69.35
1995	14.51	3.50	51.72	48.81	34.48	22.73	6.27	2.87	1.72	13.60	5.15	2.37	207.73
1996	1.75	3.52	20.43	20.48	7.60	6.69	10.69	4.43	4.41	5.37	3.11	4.08	92.58
1997	2.04	13.05	9.39	16.12	21.41	14.13	7.38	2.99	2.08	1.48	1.45	1.39	92.92
1998	0.98	0.70	4.65	4.60	12.75	4.43	1.63	0.83	0.58	0.56	0.58	0.51	32.81
1999	0.82	0.78	35.31	35.03	13.11	13.50	15.56	6.46	2.52	1.87	1.38	1.61	127.95
2000	1.71	3.17	11.21	12.79	6.28	4.93	6.88	2.74	1.42	1.04	0.94	3.60	56.70
2001	3.89	19.13	20.37	11.38	11.48	7.24	2.98	1.83	1.97	5.24	4.86	3.57	93.94
2002	1.82	1.51	0.82	3.19	2.30	3.04	3.01	1.88	1.28	0.99	0.61	0.68	21.12
2003	0.73	1.15	1.99	2.87	3.71	7.34	2.81	1.06	0.94	0.97	1.09	1.30	25.94
2004	2.57	8.74	24.98	7.88	6.07	7.34	8.17	1.99	1.19	1.19	0.82	0.76	71.71
2005	0.63	0.94	0.72	3.00	2.85	4.16	4.37	2.75	1.42	1.23	1.11	1.52	24.70
2006	6.73	3.88	9.87	4.84	5.34	4.84	3.43	1.68	1.08	1.89	0.95	0.75	45.28
2007	2.17	16.94	12.31	8.47	5.93	3.29	3.80	3.17	1.99	1.40	0.86	0.76	61.10
2008	1.27	2.30	4.63	6.23	26.07	23.12	8.39	2.58	1.05	0.57	0.57	0.83	77.64
Ave:	3.23	5.40	9.17	10.35	11.01	11.51	7.28	3.63	2.32	1.84	1.63	2.75	70.12

Monthly incremental natural runoff (million m^3) for quaternary U10H (U10H.INC)

1925	2.36	2.65	2.94	2.86	2.61	4.75	4.20	2.21	1.60	1.34	0.88	1.21	29.62
1926	3.20	5.05	8.14	8.12	5.42	29.16	18.57	3.48	1.35	0.89	1.53	1.87	86.77
1927	2.31	2.59	9.63	27.30	16.91	6.59	4.20	2.09	1.04	0.69	0.78	1.10	75.24
1928	1.86	2.64	2.56	2.37	2.65	11.71	8.81	3.26	5.78	6.27	3.89	3.06	54.86
1929	3.84	6.13	10.42	17.00	10.66	6.22	4.80	2.60	1.70	1.53	1.60	2.01	68.52
1930	2.30	2.84	4.47	14.04	11.08	8.00	6.06	3.09	1.45	1.86	2.26	1.48	58.93
1931	1.27	1.65	2.23	3.94	11.30	12.66	6.50	2.64	1.80	1.34	0.87	0.71	46.91
1932	1.33	3.10	5.08	4.52	3.09	4.18	4.02	2.28	1.04	0.67	0.59	0.48	30.37
1933	0.48	7.82	27.78	32.65	14.99	6.69	5.82	4.53	2.80	2.16	2.11	1.71	109.53
1934	1.84	4.55	21.08	14.33	7.60	7.49	6.42	5.03	20.41	13.92	3.82	1.85	108.33
1935	1.22	0.88	0.63	1.63	24.03	25.92	10.39	5.73	4.42	2.32	1.24	1.03	79.44
1936	1.67	24.89	16.68	4.91	15.80	11.34	3.61	1.52	0.82	0.66	0.57	0.47	82.94
1937	0.87	1.68	3.95	9.29	22.72	13.94	7.72	5.66	2.64	1.71	1.67	1.34	73.21
1938	2.77	5.45	7.33	8.19	41.84	25.89	5.15	3.02	2.15	1.46	1.23	2.73	107.20
1939	4.77	8.63	12.44	9.55	9.38	7.82	4.73	8.85	8.64	5.07	2.45	1.33	83.66
1940	1.42	7.11	29.47	18.94	5.28	4.18	4.27	2.92	1.42	0.86	0.67	0.71	77.24
1941	1.40	2.37	2.47	3.68	16.62	30.29	16.28	4.69	2.37	1.34	1.34	1.57	84.42
1942	2.43	11.59	28.55	16.80	5.97	5.85	39.02	25.62	6.22	4.12	6.20	5.00	157.35
1943	15.52	49.55	41.64	14.51	6.72	7.23	5.19	2.45	1.20	0.89	0.73	1.65	147.29
1944	3.16	3.14	1.98	2.13	4.15	27.01	17.44	4.00	1.89	1.00	0.61	0.42	66.91
1945	0.75	0.93	1.22	3.69	7.19	8.13	5.71	2.96	1.42	0.78	0.51	0.42	33.72
1946	0.77	2.18	3.96	5.26	12.45	26.36	16.73	5.16	3.46	3.45	2.37	1.41	83.56
1947	1.58	8.12	8.98	9.15	8.59	10.88	9.62	4.75	1.82	0.84	0.51	0.42	65.27
1948	1.48	2.84	3.77	4.08	4.46	6.54	5.18	2.63	1.27	0.73	0.63	0.88	34.50
1949	2.09	7.72	8.06	7.96	10.48	18.61	11.79	4.45	2.35	1.62	2.32	2.43	79.88
1950	1.72	1.51	14.22	19.64	10.84	6.14	4.20	1.98	0.88	0.52	1.03	1.97	64.66
1951	3.11	2.73	2.35	8.78	8.44	5.63	5.05	3.94	2.42	1.51	1.10	0.93	46.01
1952	1.07	2.06	4.90	6.13	14.47	9.73	3.11	1.47	0.86	0.61	1.06	2.04	47.49
1953	3.56	4.76	11.76	13.14	11.06	7.05	3.93	2.97	2.37	1.62	1.06	1.13	64.41
1954	10.34	10.75	5.66	34.89	46.91	26.05	9.28	3.93	2.18	1.36	0.87	0.79	153.02
1955	1.28	2.34	3.68	2.97	22.13	42.84	21.37	4.14	1.81	1.18	1.03	1.14	105.92
1956	1.66	3.69	29.21	28.23	11.62	17.59	13.78	5.53	2.35	1.12	0.98	3.24	119.01
1957	10.82	11.25	6.87	7.60	20.00	12.65	7.68	5.57	2.34	1.05	0.61	0.69	87.14
1958	1.02	2.98	12.21	20.93	18.45	10.24	4.98	43.74	27.48	4.50	2.31	1.84	150.68
1959	2.07	5.67	10.15	6.83	4.41	10.77	9.90	5.38	2.54	1.18	0.80	0.92	60.62
1960	1.51	4.20	18.91	16.96	7.61	21.15	27.57	12.73	3.22	1.45	0.87	1.01	117.21
1961	1.32	2.25	3.44	6.66	17.83	20.86	10.60	3.60	1.49	0.69	0.87	1.04	70.63
1962	1.41	6.47	9.28	18.32	11.85	25.72	11.55	3.41	2.31	8.61	2.93	1.84	103.70
1963	1.87	9.03	9.46	22.89	11.23	6.20	4.00	2.50	3.82	2.39	1.65	2.15	77.18
1964	4.39	7.94	5.31	12.28	10.02	3.42	2.03	1.27	4.97	3.46	1.79	4.31	61.20
1965	5.31	11.67	6.19	24.12	20.70	4.39	2.30	2.46	1.81	1.58	1.32	1.71	83.56
1966	1.28	4.08	4.33	6.56	17.34	40.12	31.71	7.83	3.98	3.56	2.75	1.78	125.33
1967	1.28	8.86	3.28	1.08	1.15	10.57	9.32	2.45	1.38	1.22	1.54	1.48	43.61
1968	1.20	1.33	4.75	0.60	1.65	10.99	8.89	2.99	1.72	1.37	1.22	1.43	38.13
1969	5.70	5.05	9.25	9.28	12.50	3.64	1.39	1.28	0.89	1.19	2.42	2.56	55.16
1970	15.06	6.38	8.60	5.02	7.05	6.08	6.98	4.51	2.12	2.06	6.31	3.13	73.31
1971	4.53	6.65	13.09	18.66	17.96	21.62	8.96	4.37	2.92	1.99	1.91	1.28	103.93
1972	1.31	2.45	4.01	2.51	9.80	13.84	27.73	3.62	1.21	0.85	0.90	1.73	69.96
1973	5.01	4.19	4.99	40.79	38.92	26.11	15.55	7.63	4.01	3.17	2.11	1.43	153.89
1974	1.91	1.81	6.24	15.46	14.19	12.31	5.86	2.84	1.69	1.44	1.27	2.13	67.15
1975	2.41	3.20	11.87	33.26	33.75	66.73	17.53	7.29	6.10	5.73	4.36	2.42	194.64
1976	15.52	5.03	3.79	8.04	8.67	12.28	8.13	3.40	1.47	1.45	1.15	0.61	69.54
1977	2.18	1.84	3.79	12.84	11.14	16.56	9.07	5.23	2.43	1.69	1.55	1.91	70.23
1978	4.90	7.52	10.49	8.56	11.17	12.05	5.94	3.26	1.87	1.82	1.86	1.88	71.34
1979	1.82	1.13	1.69	2.31	2.35	5.29	2.34	1.62	0.73	0.64	0.59	1.30	21.81
1980	2.89	2.63	7.04	12.11	16.44	5.33	1.83	1.62	1.38	1.10	0.62	2.93	55.93
1981	1.10	2.98	2.52	4.34	2.28	9.58	5.98	2.00	1.49	1.14	0.99	1.00	35.40
1982	0.70	2.63	2.78	0.94	0.29	0.92	1.53	0.98	0.75	0.62	0.90	0.87	13.92
1983	0.72	2.25	11.36	15.35	2.54	7.48	4.72	2.62	2.07	1.12	0.98	0.90	52.10
1984	0.95	2.35	1.82	7.61	41.31	10.92	2.33	1.26	0.95	0.93	0.81	0.69	71.95
1985	2.26	14.09	23.97	20.16	7.73	12.65	3.95	1.20	1.27	1.11	0.77	1.64	90.81
1986	1.15	5.85	8.64	7.83	6.43	14.68	6.10	2.17	1.56	1.52	1.79	105.59	163.30
1987	67.69	19.30	9.92	3.90	28.18	46.45	21.77	4.93	3.15	2.52	1.85	1.47	211.14
1988	1.70	2.38	27.28	28.21	28.05	20.74	8.17	7.18	4.48	2.16	1.57	1.40	133.32
1989	1.10	45.66	31.64	7.78	6.38	11.25	11.87	3.57	2.00	1.76	1.70	2.59	127.31
1990	1.97	3.26	10.27	12.45	28.62	16.12	5.55	2.78	2.02	1.87	1.50	1.31	87.73
1991	3.30	5.28	3.86	2.80	3.15	4.30	2.04	1.17	0.68	0.41	0.35	0.39	27.73
1992	0.72	1.21	1.35	1.23	1.92	2.76	2.66	1.82	0.98	0.58	0.55	0.87	16.63
1993	4.28	4.74	9.21	15.45	9.82	7.73	3.81	1.59	1.05	1.20	1.63	1.30	61.81
1994	1.40	1.58	1.85	3.12	2.30	3.45	4.91	2.14	1.79	1.59	25.63	31.99	81.75
1995	17.11	4.12	60.97	57.54	40.64	26.80	7.39	3.39	2.02	16.03	6.07	2.79	244.88
1996	2.07	4.15	24.08	24.14	8.96	7.89	12.60	5.22	5.19	6.34	3.67	4.81	109.14
1997	2.40	15.38	11.07	19.01	25.24	16.66	8.70	3.53	2.46	1.75	1.70	1.64	109.54
1998	1.16	0.82	5.48	5.42	15.04	5.22	1.92	0.98	0.68	0.66	0.68	0.60	38.68
1999	0.97	0.92	41.63	41.29	15.45	15.91	18.34	7.61	2.98	2.21	1.62	1.90	150.83
2000	2.01	3.73	13.22	15.08	7.40	5.81	8.11	3.22	1.68	1.23	1.11	4.24	66.84
2001	4.58	22.56	24.01	13.41	13.53	8.54	3.52	2.16	2.32	6.18	5.73	4.21	110.74
2002	2.14	1.78	0.97	3.77	2.71	3.59	3.54	2.21	1.51	1.16	0.72	0.80	24.90
2003	0.86	1.35	2.35	3.38	4.37	8.65	3.31	1.25	1.11	1.14	1.28	1.53	30.58
2004	3.03	10.31	29.44	9.29	7.15	8.66	9.64	2.35	1.40	1.40	0.96	0.90	84.53
2005	0.75	1.10	0.85	3.54	3.36	4.90	5.15	3.24	1.67	1.45	1.31	1.79	29.12
2006	7.93	4.57	11.63	5.70	6.30	5.71	4.05	1.98	1.27	2.23	1.12	0.89	53.38
2007	2.56	19.96	14.52	9.99	6.99	3.87	4.47	3.74	2.35	1.66	1.02	0.89	72.03
2008	1.50	2.71	5.46	7.35	30.74	27.25	9.89	3.05	1.24	0.67	0.67	0.98	91.52
Ave:	3.81	6.36	10.81	12.20	12.98	13.57	8.58	4.28	2.74	2.17	1.92	3.24	82.66

Monthly incremental natural runoff (million m^3) for quaternary U10J (U10J.INC)

1925	2.23	2.50	2.77	2.70	2.46	4.48	3.96	2.09	1.51	1.26	0.83	1.14	27.94
1926	3.02	4.76	7.68	7.66	5.11	27.51	17.52	3.28	1.27	0.84	1.44	1.76	81.86
1927	2.18	2.45	9.09	25.76	15.96	6.22	3.96	1.97	0.98	0.65	0.73	1.04	70.99
1928	1.75	2.49	2.41	2.24	2.50	11.05	8.32	3.08	5.46	5.91	3.67	2.88	51.76
1929	3.63	5.78	9.84	16.04	10.06	5.87	4.53	2.46	1.61	1.44	1.51	1.89	64.65
1930	2.17	2.68	4.22	13.25	10.46	7.54	5.72	2.92	1.37	1.76	2.13	1.40	55.60
1931	1.20	1.56	2.10	3.72	10.67	11.94	6.13	2.49	1.69	1.26	0.82	0.67	44.26
1932	1.25	2.92	4.80	4.27	2.91	3.95	3.79	2.15	0.98	0.63	0.55	0.46	28.66
1933	0.45	7.38	26.21	30.80	14.14	6.31	5.50	4.28	2.64	2.03	1.99	1.61	103.34
1934	1.74	4.29	19.89	13.52	7.17	7.06	6.06	4.74	19.26	13.13	3.60	1.74	102.21
1935	1.15	0.83	0.59	1.54	22.67	24.46	9.80	5.41	4.17	2.19	1.17	0.97	74.95
1936	1.58	23.48	15.74	4.63	14.91	10.70	3.40	1.43	0.77	0.63	0.54	0.44	78.25
1937	0.82	1.59	3.73	8.77	21.44	13.15	7.28	5.34	2.49	1.61	1.58	1.27	69.07
1938	2.62	5.14	6.91	7.72	39.47	24.42	4.85	2.85	2.03	1.38	1.16	2.58	101.14
1939	4.50	8.14	11.73	9.01	8.85	7.38	4.46	8.35	8.15	4.79	2.31	1.25	78.93
1940	1.34	6.70	27.80	17.87	4.98	3.94	4.03	2.75	1.34	0.81	0.63	0.67	72.88
1941	1.33	2.23	2.33	3.48	15.68	28.58	15.36	4.42	2.23	1.27	1.27	1.48	79.64
1942	2.29	10.94	26.93	15.85	5.63	5.52	36.82	24.17	5.87	3.89	5.85	4.72	148.46
1943	14.65	46.75	39.28	13.69	6.34	6.82	4.90	2.31	1.13	0.84	0.69	1.56	138.96
1944	2.98	2.96	1.87	2.01	3.91	25.48	16.46	3.77	1.78	0.94	0.58	0.39	63.13
1945	0.71	0.88	1.15	3.49	6.78	7.67	5.39	2.80	1.34	0.73	0.48	0.40	31.82
1946	0.73	2.06	3.74	4.96	11.75	24.87	15.78	4.87	3.27	3.25	2.23	1.33	78.84
1947	1.50	7.67	8.47	8.63	8.10	10.27	9.08	4.48	1.72	0.80	0.48	0.39	61.58
1948	1.40	2.67	3.55	3.85	4.21	6.17	4.89	2.48	1.20	0.69	0.60	0.83	32.55
1949	1.98	7.28	7.61	7.51	9.89	17.55	11.12	4.20	2.22	1.53	2.19	2.29	75.36
1950	1.62	1.43	13.42	18.53	10.23	5.80	3.96	1.87	0.83	0.49	0.98	1.86	61.00
1951	2.93	2.58	2.22	8.28	7.97	5.31	4.77	3.72	2.29	1.43	1.03	0.88	43.41
1952	1.01	1.94	4.62	5.78	13.65	9.18	2.93	1.39	0.81	0.57	1.00	1.93	44.80
1953	3.36	4.49	11.09	12.40	10.43	6.65	3.71	2.80	2.24	1.53	1.00	1.06	60.76
1954	9.76	10.14	5.34	32.92	44.26	24.58	8.76	3.71	2.05	1.28	0.82	0.74	144.37
1955	1.21	2.21	3.47	2.80	20.88	40.42	20.17	3.91	1.71	1.11	0.97	1.08	99.93
1956	1.57	3.49	27.55	26.63	10.96	16.59	13.00	5.22	2.22	1.06	0.93	3.06	112.28
1957	10.21	10.61	6.48	7.17	18.87	11.93	7.24	5.26	2.21	0.99	0.58	0.65	82.21
1958	0.97	2.81	11.52	19.75	17.41	9.66	4.70	41.27	25.92	4.24	2.18	1.73	142.16
1959	1.95	5.35	9.58	6.44	4.16	10.16	9.34	5.07	2.39	1.11	0.75	0.87	57.19
1960	1.43	3.96	17.85	16.01	7.18	19.95	26.01	12.01	3.04	1.37	0.82	0.95	110.58
1961	1.24	2.12	3.25	6.28	16.82	19.68	10.00	3.39	1.40	0.65	0.82	0.98	66.64
1962	1.33	6.11	8.76	17.28	11.18	24.27	10.90	3.22	2.18	8.12	2.76	1.74	97.84
1963	1.77	8.52	8.92	21.60	10.59	5.85	3.77	2.36	3.61	2.25	1.55	2.03	72.82
1964	4.15	7.50	5.01	11.59	9.45	3.22	1.92	1.20	4.69	3.26	1.69	4.07	57.74
1965	5.01	11.01	5.84	22.76	19.53	4.14	2.17	2.33	1.71	1.50	1.24	1.61	78.83
1966	1.21	3.85	4.09	6.19	16.36	37.85	29.92	7.38	3.76	3.36	2.60	1.68	118.24
1967	1.21	8.36	3.10	1.02	1.08	9.97	8.80	2.32	1.30	1.15	1.45	1.39	41.15
1968	1.13	1.26	4.48	0.57	1.55	10.37	8.39	2.82	1.62	1.29	1.15	1.35	35.97
1969	5.38	4.76	8.73	8.76	11.79	3.43	1.31	1.21	0.84	1.12	2.28	2.41	52.04
1970	14.21	6.02	8.11	4.74	6.65	5.74	6.59	4.25	2.00	1.94	5.96	2.95	69.16
1971	4.27	6.28	12.35	17.60	16.95	20.40	8.45	4.12	2.75	1.88	1.80	1.21	98.06
1972	1.23	2.31	3.79	2.37	9.25	13.06	26.16	3.42	1.14	0.80	0.85	1.63	66.01
1973	4.72	3.95	4.71	38.49	36.72	24.63	14.67	7.20	3.79	2.99	1.99	1.35	145.19
1974	1.80	1.71	5.88	14.59	13.39	11.61	5.53	2.68	1.59	1.36	1.20	2.01	63.36
1975	2.27	3.02	11.20	31.38	31.84	62.96	16.54	6.87	5.76	5.41	4.11	2.28	183.64
1976	14.65	4.75	3.58	7.58	8.18	11.58	7.67	3.21	1.39	1.37	1.08	0.58	65.61
1977	2.06	1.74	3.57	12.12	10.51	15.63	8.55	4.93	2.29	1.59	1.46	1.80	66.26
1978	4.63	7.10	9.90	8.08	10.54	11.37	5.60	3.07	1.77	1.71	1.76	1.78	67.31
1979	1.72	1.06	1.60	2.18	2.22	4.99	2.21	1.53	0.69	0.61	0.56	1.23	20.58
1980	2.72	2.49	6.65	11.43	15.51	5.02	1.73	1.53	1.30	1.04	0.58	2.76	52.76
1981	1.04	2.81	2.38	4.09	2.15	9.03	5.64	1.88	1.41	1.08	0.94	0.94	33.40
1982	0.66	2.49	2.63	0.89	0.27	0.87	1.44	0.93	0.70	0.59	0.85	0.82	13.14
1983	0.67	2.12	10.71	14.48	2.40	7.06	4.46	2.47	1.95	1.06	0.92	0.85	49.15
1984	0.89	2.22	1.72	7.18	38.97	10.31	2.20	1.19	0.89	0.88	0.77	0.65	67.88
1985	2.13	13.30	22.61	19.02	7.29	11.94	3.73	1.13	1.20	1.05	0.73	1.54	85.68
1986	1.09	5.52	8.15	7.39	6.07	13.85	5.75	2.05	1.47	1.44	1.69	99.62	154.07
1987	63.86	18.20	9.36	3.68	26.59	43.83	20.54	4.66	2.97	2.38	1.75	1.39	199.20
1988	1.60	2.24	25.74	26.61	26.46	19.57	7.71	6.78	4.23	2.03	1.48	1.32	125.78
1989	1.04	43.08	29.85	7.34	6.02	10.61	11.20	3.37	1.89	1.66	1.61	2.44	120.11
1990	1.86	3.07	9.69	11.75	27.01	15.20	5.24	2.62	1.90	1.77	1.42	1.23	82.77
1991	3.12	4.98	3.64	2.64	2.98	4.06	1.92	1.10	0.64	0.38	0.33	0.36	26.16
1992	0.68	1.14	1.28	1.16	1.81	2.60	2.51	1.71	0.93	0.55	0.51	0.82	15.69
1993	4.04	4.47	8.69	14.57	9.27	7.29	3.59	1.50	0.99	1.13	1.54	1.22	58.31
1994	1.32	1.49	1.75	2.94	2.17	3.26	4.63	2.02	1.69	1.50	24.19	30.18	77.13
1995	16.14	3.89	57.53	54.28	38.35	25.28	6.98	3.20	1.91	15.13	5.73	2.63	231.03
1996	1.95	3.92	22.72	22.78	8.46	7.44	11.89	4.93	4.90	5.98	3.46	4.54	102.97
1997	2.27	14.51	10.45	17.93	23.81	15.72	8.21	3.33	2.32	1.65	1.61	1.55	103.34
1998	1.09	0.78	5.17	5.11	14.19	4.93	1.81	0.93	0.65	0.63	0.65	0.56	36.49
1999	0.91	0.86	39.28	38.96	14.58	15.01	17.30	7.18	2.81	2.08	1.53	1.80	142.30
2000	1.90	3.52	12.47	14.22	6.98	5.48	7.66	3.04	1.58	1.16	1.04	4.00	63.06
2001	4.32	21.28	22.65	12.65	12.77	8.05	3.32	2.04	2.19	5.83	5.41	3.97	104.48
2002	2.02	1.68	0.92	3.55	2.56	3.39	3.34	2.09	1.42	1.10	0.68	0.76	23.49
2003	0.81	1.28	2.22	3.19	4.13	8.16	3.12	1.18	1.05	1.08	1.21	1.44	28.85
2004	2.86	9.72	27.78	8.77	6.75	8.17	9.09	2.22	1.32	1.32	0.91	0.85	79.75
2005	0.71	1.04	0.80	3.34	3.17	4.63	4.86	3.06	1.58	1.37	1.24	1.69	27.47
2006	7.48	4.31	10.98	5.38	5.94	5.38	3.82	1.87	1.20	2.10	1.06	0.84	50.36
2007	2.41	18.84	13.70	9.42	6.60	3.66	4.22	3.53	2.22	1.56	0.96	0.84	67.95
2008	1.42	2.56	5.15	6.93	29.00	25.71	9.33	2.87	1.17	0.63	0.63	0.93	86.35
Ave:	3.60	6.00	10.20	11.51	12.25	12.80	8.10	4.04	2.58	2.05	1.81	3.05	77.99

Monthly incremental natural runoff (million m^3) for quaternary U10K (U10K.INC)

1925	1.16	1.30	1.44	1.40	1.28	2.32	2.05	1.08	0.78	0.65	0.43	0.59	14.48
1926	1.57	2.47	3.98	3.97	2.65	14.26	9.08	1.70	0.66	0.43	0.75	0.91	42.42
1927	1.13	1.27	4.71	13.35	8.27	3.22	2.05	1.02	0.51	0.34	0.38	0.54	36.79
1928	0.91	1.29	1.25	1.16	1.30	5.73	4.31	1.59	2.83	3.06	1.90	1.49	26.82
1929	1.88	3.00	5.10	8.31	5.21	3.04	2.35	1.27	0.83	0.75	0.78	0.98	33.50
1930	1.12	1.39	2.18	6.87	5.42	3.91	2.96	1.51	0.71	0.91	1.10	0.72	28.81
1931	0.62	0.81	1.09	1.93	5.53	6.19	3.18	1.29	0.88	0.65	0.42	0.34	22.94
1932	0.65	1.51	2.49	2.21	1.51	2.05	1.96	1.11	0.51	0.33	0.29	0.24	14.85
1933	0.23	3.82	13.58	15.96	7.33	3.27	2.85	2.22	1.37	1.05	1.03	0.84	53.55
1934	0.90	2.23	10.31	7.01	3.71	3.66	3.14	2.46	9.98	6.81	1.87	0.90	52.97
1935	0.59	0.43	0.31	0.80	11.75	12.68	5.08	2.80	2.16	1.14	0.61	0.50	38.84
1936	0.82	12.17	8.16	2.40	7.72	5.54	1.76	0.74	0.40	0.32	0.28	0.23	40.55
1937	0.42	0.82	1.93	4.54	11.11	6.82	3.77	2.77	1.29	0.84	0.82	0.66	35.79
1938	1.36	2.66	3.58	4.00	20.46	12.66	2.52	1.48	1.05	0.71	0.60	1.34	52.41
1939	2.33	4.22	6.08	4.67	4.59	3.82	2.31	4.33	4.23	2.48	1.20	0.65	40.90
1940	0.70	3.47	14.41	9.26	2.58	2.04	2.09	1.43	0.70	0.42	0.33	0.35	37.77
1941	0.69	1.16	1.21	1.80	8.12	14.81	7.96	2.29	1.16	0.66	0.66	0.77	41.27
1942	1.19	5.67	13.96	8.21	2.92	2.86	19.08	12.52	3.04	2.01	3.03	2.44	76.93
1943	7.59	24.23	20.36	7.09	3.29	3.54	2.54	1.20	0.59	0.44	0.36	0.81	72.01
1944	1.54	1.53	0.97	1.04	2.03	13.20	8.53	1.95	0.92	0.49	0.30	0.20	32.72
1945	0.37	0.46	0.60	1.81	3.51	3.98	2.79	1.45	0.70	0.38	0.25	0.21	16.49
1946	0.38	1.07	1.94	2.57	6.09	12.89	8.18	2.52	1.69	1.69	1.16	0.69	40.85
1947	0.77	3.97	4.39	4.47	4.20	5.32	4.71	2.32	0.89	0.41	0.25	0.20	31.91
1948	0.72	1.39	1.84	2.00	2.18	3.20	2.53	1.29	0.62	0.36	0.31	0.43	16.87
1949	1.02	3.77	3.94	3.89	5.12	9.10	5.76	2.17	1.15	0.79	1.14	1.19	39.05
1950	0.84	0.74	6.95	9.60	5.30	3.00	2.05	0.97	0.43	0.25	0.51	0.96	31.61
1951	1.52	1.34	1.15	4.29	4.13	2.75	2.47	1.93	1.19	0.74	0.54	0.46	22.49
1952	0.52	1.01	2.39	3.00	7.07	4.76	1.52	0.72	0.42	0.30	0.52	1.00	23.22
1953	1.74	2.33	5.75	6.42	5.41	3.45	1.92	1.45	1.16	0.79	0.52	0.55	31.49
1954	5.06	5.26	2.77	17.06	22.94	12.74	4.54	1.92	1.06	0.67	0.43	0.38	74.82
1955	0.63	1.14	1.80	1.45	10.82	20.95	10.45	2.03	0.89	0.57	0.50	0.56	51.78
1956	0.81	1.81	14.28	13.80	5.68	8.60	6.74	2.71	1.15	0.55	0.48	1.58	58.19
1957	5.29	5.50	3.36	3.72	9.78	6.18	3.75	2.72	1.14	0.51	0.30	0.34	42.61
1958	0.50	1.46	5.97	10.24	9.02	5.01	2.43	21.38	13.43	2.20	1.13	0.90	73.67
1959	1.01	2.77	4.96	3.34	2.16	5.26	4.84	2.63	1.24	0.58	0.39	0.45	29.64
1960	0.74	2.05	9.25	8.29	3.72	10.34	13.48	6.23	1.58	0.71	0.43	0.49	57.30
1961	0.64	1.10	1.68	3.26	8.72	10.20	5.18	1.76	0.73	0.34	0.43	0.51	34.53
1962	0.69	3.16	4.54	8.96	5.79	12.58	5.65	1.67	1.13	4.21	1.43	0.90	50.70
1963	0.92	4.42	4.62	11.19	5.49	3.03	1.95	1.22	1.87	1.17	0.80	1.05	37.74
1964	2.15	3.88	2.59	6.01	4.90	1.67	0.99	0.62	2.43	1.69	0.88	2.11	29.92
1965	2.60	5.71	3.02	11.79	10.12	2.14	1.13	1.20	0.88	0.77	0.64	0.84	40.85
1966	0.63	2.00	2.12	3.21	8.48	19.61	15.50	3.83	1.95	1.74	1.35	0.87	61.28
1967	0.63	4.33	1.61	0.53	0.56	5.17	4.56	1.20	0.67	0.60	0.75	0.72	21.32
1968	0.58	0.65	2.32	0.29	0.81	5.37	4.35	1.46	0.84	0.67	0.59	0.70	18.64
1969	2.79	2.47	4.52	4.54	6.11	1.78	0.68	0.63	0.43	0.58	1.18	1.25	26.97
1970	7.37	3.12	4.20	2.46	3.45	2.97	3.41	2.20	1.04	1.01	3.09	1.53	35.84
1971	2.21	3.25	6.40	9.12	8.78	10.57	4.38	2.14	1.43	0.97	0.93	0.63	50.82
1972	0.64	1.20	1.96	1.23	4.79	6.77	13.56	1.77	0.59	0.42	0.44	0.85	34.21
1973	2.45	2.05	2.44	19.94	19.03	12.76	7.60	3.73	1.96	1.55	1.03	0.70	75.24
1974	0.93	0.89	3.05	7.56	6.94	6.02	2.87	1.39	0.83	0.70	0.62	1.04	32.83
1975	1.18	1.57	5.80	16.26	16.50	32.63	8.57	3.56	2.98	2.80	2.13	1.18	95.17
1976	7.59	2.46	1.85	3.93	4.24	6.00	3.98	1.66	0.72	0.71	0.56	0.30	34.00
1977	1.07	0.90	1.85	6.28	5.45	8.10	4.43	2.56	1.19	0.82	0.76	0.93	34.34
1978	2.40	3.68	5.13	4.19	5.46	5.89	2.90	1.59	0.92	0.89	0.91	0.92	34.88
1979	0.89	0.55	0.83	1.13	1.15	2.58	1.14	0.79	0.36	0.31	0.29	0.64	10.66
1980	1.41	1.29	3.44	5.92	8.04	2.60	0.90	0.79	0.67	0.54	0.30	1.43	27.34
1981	0.54	1.46	1.23	2.12	1.11	4.68	2.93	0.98	0.73	0.56	0.49	0.49	17.31
1982	0.34	1.29	1.36	0.46	0.14	0.45	0.75	0.48	0.36	0.31	0.44	0.43	6.81
1983	0.35	1.10	5.55	7.50	1.24	3.66	2.31	1.28	1.01	0.55	0.48	0.44	25.47
1984	0.46	1.15	0.89	3.72	20.20	5.34	1.14	0.62	0.46	0.46	0.40	0.34	35.18
1985	1.11	6.89	11.72	9.86	3.78	6.19	1.93	0.59	0.62	0.54	0.38	0.80	44.40
1986	0.56	2.86	4.22	3.83	3.14	7.18	2.98	1.06	0.76	0.75	0.87	51.62	79.84
1987	33.09	9.43	4.85	1.91	13.78	22.71	10.65	2.41	1.54	1.23	0.91	0.72	103.23
1988	0.83	1.16	13.34	13.79	13.71	10.14	4.00	3.51	2.19	1.05	0.77	0.68	65.18
1989	0.54	22.32	15.47	3.80	3.12	5.50	5.80	1.75	0.98	0.86	0.83	1.27	62.25
1990	0.96	1.59	5.02	6.09	13.99	7.88	2.71	1.36	0.99	0.92	0.74	0.64	42.89
1991	1.62	2.58	1.89	1.37	1.54	2.10	1.00	0.57	0.33	0.20	0.17	0.19	13.56
1992	0.35	0.59	0.66	0.60	0.94	1.35	1.30	0.89	0.48	0.28	0.27	0.42	8.13
1993	2.09	2.32	4.50	7.55	4.80	3.78	1.86	0.78	0.51	0.59	0.80	0.63	30.22
1994	0.68	0.77	0.90	1.52	1.12	1.69	2.40	1.05	0.87	0.78	12.53	15.64	39.97
1995	8.36	2.01	29.81	28.13	19.87	13.10	3.61	1.66	0.99	7.84	2.97	1.37	119.73
1996	1.01	2.03	11.78	11.80	4.38	3.86	6.16	2.55	2.54	3.10	1.79	2.35	53.36
1997	1.17	7.52	5.41	9.29	12.34	8.14	4.26	1.72	1.20	0.86	0.83	0.80	53.56
1998	0.57	0.40	2.68	2.65	7.35	2.55	0.94	0.48	0.33	0.32	0.33	0.29	18.91
1999	0.47	0.45	20.35	20.19	7.55	7.78	8.97	3.72	1.45	1.08	0.79	0.93	73.74
2000	0.98	1.83	6.46	7.37	3.62	2.84	3.97	1.58	0.82	0.60	0.54	2.07	32.68
2001	2.24	11.03	11.74	6.56	6.62	4.17	1.72	1.06	1.14	3.02	2.80	2.06	54.14
2002	1.05	0.87	0.47	1.84	1.33	1.75	1.73	1.08	0.74	0.57	0.35	0.39	12.17
2003	0.42	0.66	1.15	1.65	2.14	4.23	1.62	0.61	0.54	0.56	0.63	0.75	14.95
2004	1.48	5.04	14.40	4.54	3.50	4.23	4.71	1.15	0.69	0.69	0.47	0.44	41.33
2005	0.37	0.54	0.42	1.73	1.64	2.40	2.52	1.58	0.82	0.71	0.64	0.87	14.24
2006	3.88	2.23	5.69	2.79	3.08	2.79	1.98	0.97	0.62	1.09	0.55	0.43	26.10
2007	1.25	9.76	7.10	4.88	3.42	1.89	2.19	1.83	1.15	0.81	0.50	0.44	35.22
2008	0.73	1.33	2.67	3.59	15.03	13.33	4.84	1.49	0.61	0.33	0.33	0.48	44.75
Ave:	1.86	3.11	5.29	5.96	6.35	6.63	4.20	2.09	1.34	1.06	0.94	1.58	40.42

Monthly incremental natural runoff (million m^3) for quaternary U10L (U10L.INC)

1925	0.84	0.95	1.05	1.02	0.93	1.70	1.50	0.79	0.57	0.48	0.32	0.43	10.59
1926	1.14	1.80	2.91	2.90	1.94	10.43	6.64	1.24	0.48	0.32	0.55	0.67	31.03
1927	0.82	0.93	3.44	9.76	6.05	2.36	1.50	0.75	0.37	0.25	0.28	0.39	26.90
1928	0.66	0.94	0.91	0.85	0.95	4.19	3.15	1.17	2.07	2.24	1.39	1.09	19.62
1929	1.37	2.19	3.73	6.08	3.81	2.22	1.72	0.93	0.61	0.55	0.57	0.72	24.50
1930	0.82	1.02	1.60	5.02	3.96	2.86	2.17	1.11	0.52	0.67	0.81	0.53	21.07
1931	0.46	0.59	0.80	1.41	4.04	4.53	2.32	0.94	0.64	0.48	0.31	0.25	16.78
1932	0.47	1.11	1.82	1.62	1.10	1.50	1.44	0.81	0.37	0.24	0.21	0.17	10.86
1933	0.17	2.80	9.93	11.68	5.36	2.39	2.08	1.62	1.00	0.77	0.75	0.61	39.17
1934	0.66	1.63	7.54	5.12	2.72	2.68	2.30	1.80	7.30	4.98	1.36	0.66	38.74
1935	0.43	0.31	0.22	0.58	8.59	9.27	3.71	2.05	1.58	0.83	0.44	0.37	28.41
1936	0.60	8.90	5.97	1.76	5.65	4.06	1.29	0.54	0.29	0.24	0.20	0.17	29.66
1937	0.31	0.60	1.41	3.32	8.13	4.98	2.76	2.03	0.94	0.61	0.60	0.48	26.18
1938	0.99	1.95	2.62	2.93	14.96	9.26	1.84	1.08	0.77	0.52	0.44	0.98	38.33
1939	1.70	3.09	4.45	3.42	3.35	2.80	1.69	3.17	3.09	1.81	0.88	0.47	29.92
1940	0.51	2.54	10.54	6.77	1.89	1.49	1.53	1.04	0.51	0.31	0.24	0.25	27.62
1941	0.50	0.85	0.88	1.32	5.94	10.83	5.82	1.68	0.85	0.48	0.48	0.56	30.19
1942	0.87	4.15	10.21	6.01	2.14	2.09	13.95	9.16	2.22	1.47	2.22	1.79	56.27
1943	5.55	17.72	14.89	5.19	2.40	2.59	1.86	0.88	0.43	0.32	0.26	0.59	52.67
1944	1.13	1.12	0.71	0.76	1.48	9.66	6.24	1.43	0.67	0.36	0.22	0.15	23.93
1945	0.27	0.33	0.44	1.32	2.57	2.91	2.04	1.06	0.51	0.28	0.18	0.15	12.06
1946	0.28	0.78	1.42	1.88	4.45	9.43	5.98	1.84	1.24	1.23	0.85	0.50	29.88
1947	0.57	2.91	3.21	3.27	3.07	3.89	3.44	1.70	0.65	0.30	0.18	0.15	23.34
1948	0.53	1.01	1.35	1.46	1.60	2.34	1.85	0.94	0.45	0.26	0.23	0.31	12.34
1949	0.75	2.76	2.88	2.85	3.75	6.65	4.22	1.59	0.84	0.58	0.83	0.87	28.56
1950	0.61	0.54	5.09	7.02	3.88	2.20	1.50	0.71	0.32	0.18	0.37	0.70	23.12
1951	1.11	0.98	0.84	3.14	3.02	2.01	1.81	1.41	0.87	0.54	0.39	0.33	16.45
1952	0.38	0.74	1.75	2.19	5.17	3.48	1.11	0.53	0.31	0.22	0.38	0.73	16.98
1953	1.27	1.70	4.20	4.70	3.95	2.52	1.41	1.06	0.85	0.58	0.38	0.40	23.03
1954	3.70	3.84	2.02	12.48	16.77	9.32	3.32	1.41	0.78	0.49	0.31	0.28	54.72
1955	0.46	0.84	1.32	1.06	7.91	15.32	7.64	1.48	0.65	0.42	0.37	0.41	37.87
1956	0.59	1.32	10.44	10.09	4.16	6.29	4.93	1.98	0.84	0.40	0.35	1.16	42.56
1957	3.87	4.02	2.46	2.72	7.15	4.52	2.75	1.99	0.84	0.38	0.22	0.25	31.16
1958	0.37	1.06	4.37	7.49	6.60	3.66	1.78	15.64	9.83	1.61	0.83	0.66	53.88
1959	0.74	2.03	3.63	2.44	1.58	3.85	3.54	1.92	0.91	0.42	0.29	0.33	21.68
1960	0.54	1.50	6.76	6.07	2.72	7.56	9.86	4.55	1.15	0.52	0.31	0.36	41.91
1961	0.47	0.80	1.23	2.38	6.38	7.46	3.79	1.29	0.53	0.25	0.31	0.37	25.26
1962	0.50	2.31	3.32	6.55	4.24	9.20	4.13	1.22	0.83	3.08	1.05	0.66	37.08
1963	0.67	3.23	3.38	8.19	4.01	2.22	1.43	0.89	1.37	0.85	0.59	0.77	27.60
1964	1.57	2.84	1.90	4.39	3.58	1.22	0.73	0.46	1.78	1.24	0.64	1.54	21.88
1965	1.90	4.17	2.21	8.63	7.40	1.57	0.82	0.88	0.65	0.57	0.47	0.61	29.88
1966	0.46	1.46	1.55	2.35	6.20	14.35	11.34	2.80	1.42	1.27	0.98	0.64	44.82
1967	0.46	3.17	1.17	0.39	0.41	3.78	3.33	0.88	0.49	0.44	0.55	0.53	15.60
1968	0.43	0.48	1.70	0.21	0.59	3.93	3.18	1.07	0.62	0.49	0.43	0.51	13.63
1969	2.04	1.81	3.31	3.32	4.47	1.30	0.50	0.46	0.32	0.43	0.87	0.91	19.72
1970	5.39	2.28	3.07	1.80	2.52	2.17	2.50	1.61	0.76	0.74	2.26	1.12	26.21
1971	1.62	2.38	4.68	6.67	6.42	7.73	3.20	1.56	1.04	0.71	0.68	0.46	37.16
1972	0.47	0.87	1.44	0.90	3.50	4.95	9.92	1.30	0.43	0.30	0.32	0.62	25.02
1973	1.79	1.50	1.78	14.59	13.92	9.34	5.56	2.73	1.44	1.13	0.75	0.51	55.03
1974	0.68	0.65	2.23	5.53	5.07	4.40	2.10	1.02	0.60	0.51	0.46	0.76	24.01
1975	0.86	1.14	4.24	11.89	12.07	23.86	6.27	2.61	2.18	2.05	1.56	0.86	69.60
1976	5.55	1.80	1.36	2.87	3.10	4.39	2.91	1.22	0.53	0.52	0.41	0.22	24.87
1977	0.78	0.66	1.35	4.59	3.98	5.92	3.24	1.87	0.87	0.60	0.55	0.68	25.11
1978	1.75	2.69	3.75	3.06	4.00	4.31	2.12	1.16	0.67	0.65	0.67	0.67	25.51
1979	0.65	0.40	0.61	0.83	0.84	1.89	0.84	0.58	0.26	0.23	0.21	0.47	7.80
1980	1.03	0.94	2.52	4.33	5.88	1.90	0.66	0.58	0.49	0.39	0.22	1.05	20.00
1981	0.39	1.07	0.90	1.55	0.81	3.42	2.14	0.71	0.53	0.41	0.36	0.36	12.66
1982	0.25	0.94	1.00	0.34	0.10	0.33	0.55	0.35	0.27	0.22	0.32	0.31	4.98
1983	0.26	0.81	4.06	5.49	0.91	2.67	1.69	0.94	0.74	0.40	0.35	0.32	18.63
1984	0.34	0.84	0.65	2.72	14.77	3.91	0.83	0.45	0.34	0.33	0.29	0.25	25.73
1985	0.81	5.04	8.57	7.21	2.76	4.52	1.41	0.43	0.45	0.40	0.28	0.59	32.47
1986	0.41	2.09	3.09	2.80	2.30	5.25	2.18	0.78	0.56	0.54	0.64	37.76	58.39
1987	24.20	6.90	3.55	1.39	10.08	16.61	7.79	1.76	1.13	0.90	0.66	0.53	75.50
1988	0.61	0.85	9.76	10.09	10.03	7.42	2.92	2.57	1.60	0.77	0.56	0.50	47.67
1989	0.39	16.33	11.31	2.78	2.28	4.02	4.25	1.28	0.72	0.63	0.61	0.93	45.52
1990	0.71	1.17	3.67	4.45	10.24	5.76	1.98	0.99	0.72	0.67	0.54	0.47	31.37
1991	1.18	1.89	1.38	1.00	1.13	1.54	0.73	0.42	0.24	0.15	0.13	0.14	9.92
1992	0.26	0.43	0.48	0.44	0.68	0.99	0.95	0.65	0.35	0.21	0.19	0.31	5.95
1993	1.53	1.69	3.29	5.52	3.51	2.76	1.36	0.57	0.38	0.43	0.58	0.46	22.10
1994	0.50	0.56	0.66	1.11	0.82	1.23	1.75	0.77	0.64	0.57	9.17	11.44	29.23
1995	6.12	1.47	21.80	20.57	14.53	9.58	2.64	1.21	0.72	5.73	2.17	1.00	87.56
1996	0.74	1.49	8.61	8.63	3.21	2.82	4.51	1.87	1.86	2.27	1.31	1.72	39.02
1997	0.86	5.50	3.96	6.80	9.03	5.96	3.11	1.26	0.88	0.63	0.61	0.59	39.17
1998	0.41	0.29	1.96	1.94	5.38	1.87	0.69	0.35	0.24	0.24	0.24	0.21	13.83
1999	0.35	0.33	14.89	14.77	5.52	5.69	6.56	2.72	1.06	0.79	0.58	0.68	53.93
2000	0.72	1.33	4.73	5.39	2.65	2.08	2.90	1.15	0.60	0.44	0.40	1.52	23.90
2001	1.64	8.07	8.58	4.80	4.84	3.05	1.26	0.77	0.83	2.21	2.05	1.50	39.60
2002	0.77	0.64	0.35	1.35	0.97	1.28	1.27	0.79	0.54	0.42	0.26	0.29	8.90
2003	0.31	0.48	0.84	1.21	1.56	3.09	1.18	0.45	0.40	0.41	0.46	0.55	10.93
2004	1.08	3.69	10.53	3.32	2.56	3.10	3.45	0.84	0.50	0.50	0.34	0.32	30.23
2005	0.27	0.39	0.30	1.26	1.20	1.75	1.84	1.16	0.60	0.52	0.47	0.64	10.41
2006	2.83	1.63	4.16	2.04	2.25	2.04	1.45	0.71	0.46	0.80	0.40	0.32	19.09
2007	0.92	7.14	5.19	3.57	2.50	1.39	1.60	1.34	0.84	0.59	0.36	0.32	25.76
2008	0.54	0.97	1.95	2.63	10.99	9.75	3.54	1.09	0.44	0.24	0.24	0.35	32.73
Ave:	1.36	2.28	3.87	4.36	4.64	4.85	3.07	1.53	0.98	0.78	0.69	1.16	29.56

Monthly incremental natural runoff (million m^3) for quaternary U10M (U10M.INC)

1925	1.15	1.28	1.42	1.39	1.26	2.30	2.03	1.07	0.77	0.65	0.43	0.59	14.35
1926	1.55	2.45	3.95	3.93	2.63	14.13	9.00	1.69	0.65	0.43	0.74	0.91	42.05
1927	1.12	1.26	4.67	13.23	8.20	3.19	2.03	1.01	0.51	0.34	0.38	0.53	36.46
1928	0.90	1.28	1.24	1.15	1.29	5.68	4.27	1.58	2.80	3.04	1.88	1.48	26.59
1929	1.86	2.97	5.05	8.24	5.17	3.02	2.32	1.26	0.82	0.74	0.78	0.97	33.21
1930	1.11	1.38	2.17	6.81	5.37	3.88	2.94	1.50	0.70	0.90	1.10	0.72	28.56
1931	0.62	0.80	1.08	1.91	5.48	6.14	3.15	1.28	0.87	0.65	0.42	0.34	22.73
1932	0.64	1.50	2.46	2.19	1.50	2.03	1.95	1.10	0.50	0.32	0.28	0.23	14.72
1933	0.23	3.79	13.46	15.82	7.26	3.24	2.82	2.20	1.36	1.04	1.02	0.83	53.08
1934	0.89	2.21	10.22	6.94	3.68	3.63	3.11	2.44	9.89	6.75	1.85	0.89	52.50
1935	0.59	0.43	0.30	0.79	11.64	12.56	5.03	2.78	2.14	1.13	0.60	0.50	38.50
1936	0.81	12.06	8.08	2.38	7.66	5.50	1.75	0.74	0.40	0.32	0.27	0.23	40.19
1937	0.42	0.82	1.92	4.50	11.01	6.75	3.74	2.74	1.28	0.83	0.81	0.65	35.48
1938	1.34	2.64	3.55	3.97	20.27	12.54	2.49	1.47	1.04	0.71	0.60	1.32	51.95
1939	2.31	4.18	6.03	4.63	4.55	3.79	2.29	4.29	4.19	2.46	1.19	0.64	40.54
1940	0.69	3.44	14.28	9.18	2.56	2.03	2.07	1.41	0.69	0.42	0.33	0.34	37.43
1941	0.68	1.15	1.20	1.79	8.05	14.68	7.89	2.27	1.15	0.65	0.65	0.76	40.91
1942	1.18	5.62	13.83	8.14	2.89	2.83	18.91	12.41	3.01	2.00	3.00	2.42	76.25
1943	7.52	24.01	20.18	7.03	3.26	3.51	2.52	1.19	0.58	0.43	0.35	0.80	71.38
1944	1.53	1.52	0.96	1.03	2.01	13.09	8.45	1.94	0.91	0.49	0.30	0.20	32.43
1945	0.36	0.45	0.59	1.79	3.48	3.94	2.77	1.44	0.69	0.38	0.25	0.21	16.34
1946	0.37	1.06	1.92	2.55	6.03	12.77	8.11	2.50	1.68	1.67	1.15	0.68	40.49
1947	0.77	3.94	4.35	4.43	4.16	5.27	4.66	2.30	0.88	0.41	0.25	0.20	31.63
1948	0.72	1.37	1.82	1.98	2.16	3.17	2.51	1.28	0.62	0.35	0.31	0.43	16.72
1949	1.01	3.74	3.91	3.86	5.08	9.02	5.71	2.15	1.14	0.79	1.13	1.18	38.71
1950	0.83	0.73	6.89	9.52	5.26	2.98	2.03	0.96	0.43	0.25	0.50	0.95	31.33
1951	1.51	1.32	1.14	4.25	4.09	2.73	2.45	1.91	1.17	0.73	0.53	0.45	22.29
1952	0.52	1.00	2.37	2.97	7.01	4.71	1.51	0.71	0.42	0.29	0.51	0.99	23.01
1953	1.73	2.31	5.70	6.37	5.36	3.42	1.91	1.44	1.15	0.79	0.51	0.55	31.21
1954	5.01	5.21	2.74	16.91	22.73	12.62	4.50	1.90	1.05	0.66	0.42	0.38	74.15
1955	0.62	1.13	1.78	1.44	10.72	20.76	10.36	2.01	0.88	0.57	0.50	0.55	51.33
1956	0.81	1.79	14.15	13.68	5.63	8.52	6.68	2.68	1.14	0.54	0.48	1.57	57.67
1957	5.25	5.45	3.33	3.68	9.69	6.13	3.72	2.70	1.13	0.51	0.30	0.34	42.23
1958	0.50	1.44	5.92	10.15	8.94	4.96	2.41	21.20	13.32	2.18	1.12	0.89	73.02
1959	1.00	2.75	4.92	3.31	2.14	5.22	4.80	2.61	1.23	0.57	0.39	0.45	29.37
1960	0.73	2.03	9.17	8.22	3.69	10.25	13.36	6.17	1.56	0.70	0.42	0.49	56.80
1961	0.64	1.09	1.67	3.23	8.64	10.11	5.14	1.74	0.72	0.33	0.42	0.50	34.23
1962	0.68	3.14	4.50	8.88	5.74	12.47	5.60	1.65	1.12	4.17	1.42	0.89	50.26
1963	0.91	4.38	4.58	11.09	5.44	3.00	1.94	1.21	1.85	1.16	0.80	1.04	37.40
1964	2.13	3.85	2.57	5.95	4.85	1.66	0.99	0.62	2.41	1.67	0.87	2.09	29.66
1965	2.57	5.66	3.00	11.69	10.03	2.13	1.12	1.19	0.88	0.77	0.64	0.83	40.49
1966	0.62	1.98	2.10	3.18	8.40	19.44	15.37	3.79	1.93	1.73	1.33	0.86	60.74
1967	0.62	4.30	1.59	0.52	0.56	5.12	4.52	1.19	0.67	0.59	0.75	0.72	21.13
1968	0.58	0.65	2.30	0.29	0.80	5.33	4.31	1.45	0.83	0.66	0.59	0.69	18.48
1969	2.76	2.45	4.48	4.50	6.06	1.76	0.67	0.62	0.43	0.58	1.17	1.24	26.73
1970	7.30	3.09	4.17	2.43	3.42	2.95	3.38	2.18	1.03	1.00	3.06	1.52	35.52
1971	2.19	3.22	6.34	9.04	8.70	10.48	4.34	2.12	1.41	0.96	0.93	0.62	50.37
1972	0.63	1.19	1.95	1.22	4.75	6.71	13.44	1.76	0.59	0.41	0.44	0.84	33.90
1973	2.43	2.03	2.42	19.77	18.86	12.65	7.53	3.70	1.95	1.54	1.02	0.69	74.58
1974	0.93	0.88	3.02	7.49	6.88	5.96	2.84	1.38	0.82	0.70	0.62	1.03	32.54
1975	1.17	1.55	5.75	16.12	16.36	32.34	8.50	3.53	2.96	2.78	2.11	1.17	94.33
1976	7.52	2.44	1.84	3.89	4.20	5.95	3.94	1.65	0.71	0.70	0.56	0.30	33.70
1977	1.06	0.89	1.83	6.22	5.40	8.03	4.39	2.53	1.18	0.82	0.75	0.93	34.03
1978	2.38	3.65	5.08	4.15	5.42	5.84	2.88	1.58	0.91	0.88	0.90	0.91	34.57
1979	0.88	0.55	0.82	1.12	1.14	2.56	1.13	0.78	0.35	0.31	0.29	0.63	10.57
1980	1.40	1.28	3.41	5.87	7.97	2.58	0.89	0.79	0.67	0.53	0.30	1.42	27.10
1981	0.53	1.44	1.22	2.10	1.10	4.64	2.90	0.97	0.72	0.55	0.48	0.48	17.15
1982	0.34	1.28	1.35	0.46	0.14	0.45	0.74	0.48	0.36	0.30	0.44	0.42	6.75
1983	0.35	1.09	5.50	7.44	1.23	3.62	2.29	1.27	1.00	0.54	0.47	0.43	25.25
1984	0.46	1.14	0.88	3.69	20.02	5.29	1.13	0.61	0.46	0.45	0.39	0.34	34.86
1985	1.10	6.83	11.61	9.77	3.75	6.13	1.91	0.58	0.62	0.54	0.37	0.79	44.01
1986	0.56	2.83	4.18	3.79	3.12	7.11	2.95	1.05	0.76	0.74	0.87	51.17	79.14
1987	32.80	9.35	4.81	1.89	13.66	22.51	10.55	2.39	1.53	1.22	0.90	0.71	102.32
1988	0.82	1.15	13.22	13.67	13.59	10.05	3.96	3.48	2.17	1.04	0.76	0.68	64.61
1989	0.54	22.13	15.33	3.77	3.09	5.45	5.75	1.73	0.97	0.85	0.83	1.26	61.70
1990	0.96	1.58	4.98	6.04	13.87	7.81	2.69	1.35	0.98	0.91	0.73	0.63	42.51
1991	1.60	2.56	1.87	1.36	1.53	2.09	0.99	0.57	0.33	0.20	0.17	0.19	13.44
1992	0.35	0.58	0.66	0.60	0.93	1.34	1.29	0.88	0.48	0.28	0.26	0.42	8.06
1993	2.08	2.30	4.46	7.49	4.76	3.74	1.85	0.77	0.51	0.58	0.79	0.63	29.95
1994	0.68	0.77	0.90	1.51	1.11	1.67	2.38	1.04	0.87	0.77	12.42	15.50	39.62
1995	8.29	2.00	29.55	27.88	19.70	12.99	3.58	1.64	0.98	7.77	2.94	1.35	118.67
1996	1.00	2.01	11.67	11.70	4.34	3.82	6.11	2.53	2.52	3.07	1.78	2.33	52.89
1997	1.16	7.45	5.37	9.21	12.23	8.07	4.22	1.71	1.19	0.85	0.83	0.79	53.08
1998	0.56	0.40	2.66	2.63	7.29	2.53	0.93	0.48	0.33	0.32	0.33	0.29	18.74
1999	0.47	0.44	20.17	20.01	7.49	7.71	8.89	3.69	1.44	1.07	0.79	0.92	73.09
2000	0.98	1.81	6.41	7.31	3.59	2.81	3.93	1.56	0.81	0.60	0.54	2.05	32.39
2001	2.22	10.93	11.63	6.50	6.56	4.14	1.70	1.05	1.13	2.99	2.78	2.04	53.67
2002	1.04	0.86	0.47	1.82	1.31	1.74	1.72	1.07	0.73	0.56	0.35	0.39	12.07
2003	0.41	0.66	1.14	1.64	2.12	4.19	1.60	0.60	0.54	0.55	0.62	0.74	14.82
2004	1.47	4.99	14.27	4.50	3.47	4.19	4.67	1.14	0.68	0.68	0.47	0.43	40.96
2005	0.36	0.54	0.41	1.71	1.63	2.38	2.50	1.57	0.81	0.70	0.63	0.87	14.11
2006	3.84	2.21	5.64	2.76	3.05	2.77	1.96	0.96	0.62	1.08	0.54	0.43	25.87
2007	1.24	9.67	7.03	4.84	3.39	1.88	2.17	1.81	1.14	0.80	0.49	0.43	34.90
2008	0.73	1.32	2.65	3.56	14.90	13.21	4.79	1.48	0.60	0.32	0.33	0.48	44.35
Ave:	1.85	3.08	5.24	5.91	6.29	6.58	4.16	2.07	1.33	1.05	0.93	1.57	40.06

Monthly incremental natural runoff (million m^3) for quaternary U60A (U60A.INC)

1925	0.74	0.89	0.89	0.67	0.64	1.15	1.04	0.65	0.64	0.56	0.41	0.64	8.92
1926	1.21	1.32	1.23	1.00	0.88	8.09	2.62	1.53	0.96	0.67	0.86	0.86	21.23
1927	0.79	0.83	1.31	2.06	2.36	2.10	1.50	0.96	0.63	0.44	0.40	0.51	13.89
1928	0.71	0.78	0.76	0.95	0.96	2.23	2.82	1.82	1.87	2.26	1.76	1.69	18.61
1929	2.13	1.91	1.76	2.50	2.47	1.93	1.49	0.99	0.79	0.71	0.71	0.85	18.24
1930	1.17	1.59	2.23	3.92	2.65	2.42	2.26	1.46	0.85	0.78	0.73	0.51	20.57
1931	0.64	0.87	1.28	1.85	1.97	2.36	1.99	1.45	1.18	0.86	0.62	0.54	15.61
1932	0.95	1.36	1.78	1.77	1.55	1.78	1.62	1.02	0.63	0.54	0.46	0.36	13.82
1933	0.35	1.33	6.09	7.44	2.96	2.87	3.00	2.76	1.89	1.69	1.72	1.37	33.47
1934	1.17	1.28	2.32	4.96	3.14	2.77	2.27	1.98	11.89	2.78	1.64	1.09	37.29
1935	0.86	0.74	0.61	0.99	2.59	7.24	2.38	2.27	2.24	1.54	1.27	1.10	23.83
1936	1.08	3.38	2.65	2.17	2.44	1.96	1.17	0.74	0.55	0.47	0.39	0.33	17.33
1937	0.46	0.80	1.28	1.68	7.81	2.46	2.17	1.86	1.10	1.00	1.03	0.76	22.41
1938	1.18	2.08	2.29	2.21	2.76	2.68	1.80	1.56	1.26	0.94	0.83	1.14	20.73
1939	1.56	1.95	2.26	1.97	2.00	2.42	2.21	6.50	3.35	2.31	1.32	1.03	28.88
1940	1.04	2.06	5.87	2.81	2.08	2.18	2.51	1.85	1.05	0.77	0.59	0.54	23.35
1941	0.67	1.01	1.18	1.60	2.65	9.98	3.02	2.26	1.47	1.04	1.04	1.01	26.93
1942	1.13	1.86	8.40	2.95	2.49	2.58	11.06	3.32	2.48	2.24	2.95	2.44	43.90
1943	8.86	19.96	7.14	2.62	2.41	2.85	2.18	1.22	0.85	0.69	0.54	0.94	50.26
1944	1.45	1.41	1.05	0.99	1.44	8.64	2.63	1.69	1.15	0.74	0.51	0.37	22.07
1945	0.55	0.58	0.56	1.03	1.64	2.04	1.80	1.22	0.81	0.59	0.42	0.33	11.57
1946	0.46	0.86	1.37	1.47	1.83	4.83	3.23	2.22	2.44	2.50	1.60	1.11	23.92
1947	1.05	1.78	2.33	2.54	2.86	2.99	2.63	1.88	1.15	0.72	0.50	0.41	20.84
1948	0.82	1.46	1.86	1.83	2.08	2.22	1.82	1.28	0.82	0.58	0.46	0.55	15.78
1949	0.92	1.92	2.64	3.40	3.29	3.32	2.63	1.81	1.22	0.97	1.15	1.02	24.29
1950	0.81	0.81	1.59	3.58	2.81	2.30	1.60	0.91	0.60	0.42	0.85	1.24	17.52
1951	1.31	1.13	1.15	2.19	2.62	2.38	2.15	1.56	1.00	0.73	0.58	0.48	17.28
1952	0.48	0.63	1.06	1.49	2.40	2.29	1.42	0.91	0.64	0.49	0.82	1.27	13.90
1953	1.62	1.73	2.46	2.71	2.14	1.82	1.45	1.31	1.10	0.83	0.65	0.67	18.49
1954	1.49	2.18	1.81	8.46	7.67	3.19	2.65	1.82	1.17	0.83	0.58	0.54	32.39
1955	0.68	1.04	1.54	1.14	1.86	8.53	2.86	1.89	1.19	0.78	0.64	0.62	22.77
1956	0.67	1.24	4.05	5.72	2.91	2.79	3.14	2.47	1.42	0.91	0.79	1.49	27.60
1957	2.27	2.50	2.17	1.96	2.86	2.44	2.27	1.89	1.09	0.76	0.53	0.50	21.24
1958	0.49	0.82	1.46	2.24	3.15	2.96	2.13	25.99	2.91	1.77	1.42	1.26	46.60
1959	1.36	1.83	2.26	1.96	1.78	2.73	2.99	1.97	1.14	0.76	0.59	0.60	19.97
1960	0.85	1.60	4.52	3.82	2.60	2.54	7.28	2.60	1.54	1.03	0.70	0.74	29.82
1961	0.74	0.87	1.14	1.69	2.33	2.91	2.53	1.51	0.86	0.56	0.62	0.59	16.35
1962	0.62	1.13	1.49	2.31	2.27	2.63	2.55	1.51	0.91	1.44	1.56	0.92	19.34
1963	0.82	0.96	1.01	1.72	2.02	1.81	1.82	1.38	1.09	0.96	0.69	0.74	15.02
1964	1.49	1.63	1.69	1.82	1.60	1.17	0.78	0.72	1.19	1.35	1.28	1.26	15.98
1965	1.54	2.33	2.31	8.18	3.37	2.23	1.35	1.28	1.11	0.77	0.65	0.69	25.81
1966	0.72	1.17	1.29	1.65	2.67	9.46	4.22	2.49	1.47	1.13	0.81	0.54	27.62
1967	0.77	1.28	1.44	1.95	2.01	1.78	1.35	0.86	0.63	0.46	0.53	0.67	13.73
1968	0.71	0.74	0.69	0.58	0.77	1.79	2.01	1.60	1.20	0.95	0.86	0.82	12.72
1969	1.46	1.97	2.40	2.41	1.81	1.28	0.91	0.78	0.76	0.65	0.92	1.60	16.95
1970	2.24	2.33	2.23	1.82	1.41	1.67	1.72	1.63	1.27	1.01	1.31	1.28	19.92
1971	1.42	1.60	1.95	2.40	3.01	2.83	2.00	1.53	1.22	0.91	0.67	0.50	20.04
1972	0.49	0.79	0.87	0.90	1.37	1.95	1.95	1.34	0.81	0.58	0.65	1.00	12.70
1973	1.06	1.41	1.63	8.72	3.42	4.77	2.73	2.41	1.92	1.28	0.97	0.68	31.00
1974	0.71	1.09	1.54	2.64	3.32	2.62	1.69	1.03	0.62	0.44	0.33	0.63	16.66
1975	0.90	0.96	1.51	4.44	3.24	15.94	3.90	2.82	1.73	1.04	0.85	0.90	38.23
1976	1.51	1.71	1.31	1.79	1.96	2.18	1.90	1.24	0.85	0.58	0.49	0.49	16.01
1977	0.70	0.91	1.55	2.44	2.51	2.59	2.76	1.99	1.13	0.74	0.60	0.81	18.73
1978	1.42	2.73	3.41	2.91	3.04	3.27	2.54	1.70	1.08	0.80	0.77	0.78	24.45
1979	0.94	0.95	0.91	1.02	0.96	0.91	0.97	0.83	0.56	0.39	0.32	0.68	9.44
1980	1.10	1.55	1.77	2.93	3.33	2.83	2.03	1.47	1.14	0.83	0.92	1.01	20.91
1981	0.76	1.19	1.49	1.72	1.63	1.92	1.98	1.20	0.82	0.64	0.52	0.54	14.41
1982	0.52	1.13	1.14	1.14	0.77	0.78	0.73	0.64	0.42	0.41	0.51	0.39	8.58
1983	0.62	1.63	2.97	2.48	6.04	2.63	2.39	1.42	1.01	0.76	0.68	0.60	23.23
1984	1.01	0.94	0.97	1.39	4.35	2.51	1.40	0.90	0.64	0.57	0.46	0.40	15.54
1985	1.42	2.22	4.32	4.23	1.95	2.20	1.65	0.58	0.47	0.56	0.64	0.53	20.77
1986	0.82	1.61	1.30	2.40	1.75	3.20	1.84	1.11	0.81	0.67	0.86	34.38	50.75
1987	4.72	4.07	2.29	1.35	14.73	10.64	3.44	1.98	1.60	1.30	1.14	1.11	48.37
1988	1.20	1.24	3.13	4.84	7.07	4.18	1.94	1.49	1.30	1.19	0.81	0.91	29.30
1989	1.06	11.02	4.38	2.28	1.35	3.78	2.88	1.67	1.27	1.22	1.25	1.13	33.29
1990	1.30	1.52	2.18	2.97	5.99	4.07	2.49	1.55	1.01	0.95	0.97	0.88	25.88
1991	1.09	1.64	1.35	1.45	1.24	1.43	1.15	1.02	0.84	0.58	0.51	0.49	12.79
1992	0.46	0.46	0.48	0.50	0.47	0.54	0.53	0.47	0.48	0.56	0.57	0.62	6.14
1993	0.67	0.66	0.67	1.08	2.64	2.32	1.27	0.99	0.78	0.54	0.68	0.63	12.93
1994	0.99	0.81	1.28	1.82	0.80	0.71	0.85	0.73	0.67	1.04	0.80	0.76	11.26
1995	0.84	0.89	10.93	7.33	10.29	4.65	2.53	1.66	0.65	2.96	1.65	1.19	45.57
1996	1.45	1.96	4.62	8.49	3.17	2.40	3.10	2.04	1.50	1.62	1.22	1.17	32.74
1997	1.40	2.15	2.98	5.48	6.01	5.33	2.73	1.71	1.15	0.93	0.84	0.81	31.52
1998	0.85	0.61	1.49	1.90	3.19	1.94	1.15	0.90	0.82	0.77	0.74	0.69	15.05
1999	0.90	0.99	7.31	6.37	3.20	1.97	3.10	1.55	1.31	1.06	0.89	0.81	29.46
2000	0.94	2.18	3.40	3.62	2.15	1.47	2.20	1.54	1.02	0.93	0.84	0.92	21.21
2001	1.20	2.92	6.30	25.35	2.01	1.80	1.51	1.11	1.08	1.47	1.95	1.53	48.23
2002	1.21	1.12	1.38	1.40	1.22	1.34	1.20	1.22	0.88	0.81	1.05	1.12	13.95
2003	0.92	0.81	0.91	1.03	1.04	1.30	1.17	0.82	0.63	0.59	0.70	0.65	10.57
2004	0.81	0.77	10.98	5.01	0.78	3.49	1.35	0.83	0.57	0.48	0.47	0.92	26.46
2005	0.85	0.70	0.93	1.42	2.43	1.95	1.55	1.35	0.86	0.70	0.68	0.86	14.28
2006	1.34	1.21	2.86	3.06	1.44	1.21	1.22	0.75	0.58	0.66	0.74	0.83	15.90
2007	0.93	2.22	3.59	3.17	2.36	2.07	1.70	1.37	0.98	0.96	0.88	0.78	21.01
2008	0.95	1.03	1.33	4.04	8.52	4.05	1.75	1.38	0.99	0.85	0.84	0.88	26.61
Ave:	1.15	1.75	2.43	3.03	2.83	3.13	2.22	1.83	1.24	0.96	0.85	1.24	22.65

Appendix C

EWR rule curve data

EWR rule curve data for Site 1 (Lundy's Hill)

Desktop Version 2, Printed on 2003/02/12
Summary of IFR rule curves for : U10E WR90 Cum. Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : D'berg ERC = B

Data are given in m^3/s mean monthly flow

	% Points									
Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.746	2.740	2.713	2.653	2.533	2.321	2.002	1.617	1.278	1.121
Nov	5.903	5.896	5.850	5.751	5.550	5.168	4.513	3.539	2.395	1.663
Dec	12.454	11.865	11.314	10.767	10.127	8.982	7.802	6.029	3.926	2.578
Jan	13.837	13.158	12.532	11.932	11.255	10.035	8.834	6.987	4.757	3.320
Feb	45.762	40.955	36.835	33.262	29.913	24.171	20.866	15.898	10.006	6.232
Mar	13.148	12.579	12.054	11.541	10.953	9.913	8.894	7.380	5.600	4.462
Apr	6.533	6.519	6.461	6.332	6.072	5.614	4.926	4.095	3.362	3.022
May	4.728	4.711	4.659	4.547	4.327	3.951	3.400	2.748	2.181	1.918
Jun	3.348	3.335	3.299	3.223	3.076	2.729	2.467	2.031	1.681	1.284
Jul	2.632	2.620	2.594	2.524	2.081	1.767	1.418	1.285	1.126	0.932
Aug	2.289	2.280	2.257	2.208	2.113	1.678	1.410	1.185	0.928	0.785
Sep	1.970	1.963	1.940	1.892	1.798	1.637	1.402	1.123	0.880	0.768

Reserve flows without High Flows

Oct	2.635	2.629	2.604	2.548	2.435	2.236	1.937	1.576	1.257	1.110
Nov	4.428	4.422	4.391	4.323	4.185	3.923	3.474	2.806	2.020	1.518
Dec	7.988	7.982	7.924	7.798	7.538	7.039	6.173	4.870	3.325	2.336
Jan	8.605	8.605	8.555	8.442	8.203	7.731	6.891	5.600	4.040	3.035
Feb	8.938	8.933	8.885	8.780	8.563	8.148	7.426	6.341	5.054	4.230
Mar	8.863	8.854	8.804	8.696	8.476	8.059	7.343	6.279	5.028	4.229
Apr	6.533	6.519	6.461	6.332	6.072	5.614	4.926	4.095	3.362	3.022
May	4.728	4.711	4.659	4.547	4.327	3.951	3.400	2.748	2.181	1.918
Jun	3.348	3.335	3.299	3.223	3.076	2.729	2.467	2.031	1.681	1.284
Jul	2.632	2.620	2.594	2.524	2.081	1.767	1.418	1.285	1.126	0.932
Aug	2.289	2.280	2.257	2.208	2.113	1.678	1.410	1.185	0.928	0.785
Sep	1.970	1.963	1.940	1.892	1.798	1.637	1.402	1.123	0.880	0.768

Natural Duration curves

Oct	25.363	16.211	13.326	11.521	7.832	5.716	4.761	4.104	2.804	1.977
Nov	53.200	33.868	26.819	22.983	19.452	16.331	13.482	10.135	7.451	2.504
Dec	72.681	59.040	44.091	34.547	29.231	27.196	21.201	17.050	9.808	6.217
Jan	77.018	67.877	59.661	53.383	49.150	38.892	32.201	27.429	18.813	15.058
Feb	95.149	76.547	64.974	54.206	46.867	39.658	33.511	31.473	26.804	15.425
Mar	66.860	56.454	48.296	39.979	34.834	30.838	27.274	21.220	18.957	11.657
Apr	34.815	24.793	22.654	18.951	16.395	14.152	12.202	10.617	8.791	3.880
May	12.662	9.622	8.096	6.823	6.058	5.770	4.772	4.268	3.417	2.066
Jun	8.972	6.556	4.225	3.547	3.086	2.729	2.488	2.031	1.798	1.284
Jul	7.040	4.237	3.072	2.524	2.081	1.767	1.418	1.285	1.126	0.932
Aug	6.838	4.318	3.771	3.099	2.342	1.678	1.410	1.185	0.928	0.785
Sep	12.808	7.078	5.481	3.780	3.126	2.580	2.223	1.621	1.096	0.783

EWR rule curve data for Site 2 (Hella Hella)

Desktop Version 2, Printed on 2003/02/12
Summary of IFR rule curves for : U10H WR90 Cum. Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : D'berg ERC = B

Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	3.583	3.574	3.541	3.465	3.313	3.045	2.642	2.155	1.725	1.526
Nov	7.768	7.758	7.698	7.568	7.304	6.805	5.947	4.672	3.173	2.215
Dec	16.436	15.663	14.938	14.218	13.373	11.861	10.296	7.943	5.153	3.366
Jan	18.233	17.339	16.517	15.728	14.839	13.236	11.659	9.234	6.307	4.420
Feb	22.613	21.190	19.927	18.767	17.557	15.438	13.723	11.145	8.088	6.129
Mar	17.300	16.552	15.860	15.184	14.409	13.038	11.694	9.696	7.346	5.845
Apr	8.596	8.578	8.503	8.335	7.997	7.401	6.506	5.424	4.471	4.029
May	6.192	6.169	6.102	5.955	5.668	5.177	4.458	3.607	2.867	2.523
Jun	4.464	4.447	4.399	4.297	4.101	3.769	3.211	2.727	2.241	1.703
Jul	3.509	3.493	3.456	3.379	2.941	2.405	1.883	1.706	1.514	1.232
Aug	3.014	3.004	2.974	2.911	2.791	2.441	2.036	1.775	1.224	1.065
Sep	2.589	2.579	2.550	2.487	2.364	2.152	1.843	1.477	1.158	1.010

Reserve flows without High Flows

Oct	3.438	3.430	3.398	3.328	3.185	2.934	2.557	2.101	1.698	1.512
Nov	5.826	5.819	5.778	5.689	5.509	5.166	4.579	3.706	2.680	2.024
Dec	10.572	10.564	10.487	10.320	9.973	9.309	8.155	6.421	4.365	3.047
Jan	11.354	11.354	11.289	11.141	10.827	10.208	9.106	7.411	5.365	4.046
Feb	11.761	11.753	11.690	11.552	11.265	10.716	9.762	8.328	6.628	5.539
Mar	11.661	11.650	11.584	11.441	11.150	10.599	9.654	8.248	6.595	5.539
Apr	8.596	8.578	8.503	8.335	7.997	7.401	6.506	5.424	4.471	4.029
May	6.192	6.169	6.102	5.955	5.668	5.177	4.458	3.607	2.867	2.523
Jun	4.464	4.447	4.399	4.297	4.101	3.769	3.211	2.727	2.241	1.703
Jul	3.509	3.493	3.456	3.379	2.941	2.405	1.883	1.706	1.514	1.232
Aug	3.014	3.004	2.974	2.911	2.791	2.441	2.036	1.775	1.224	1.065
Sep	2.589	2.579	2.550	2.487	2.364	2.152	1.843	1.477	1.158	1.010

Natural Duration curves

Oct	34.376	21.704	19.622	15.653	11.459	8.221	7.283	5.940	3.629	2.380
Nov	72.470	52.692	35.574	29.905	27.596	24.452	19.793	15.306	10.348	3.129
Dec	102.165	83.238	58.876	45.791	36.676	31.899	27.683	21.436	14.360	6.975
Jan	104.164	83.354	72.120	66.492	56.663	47.312	40.243	32.898	24.790	18.036
Feb	131.940	94.362	81.696	64.370	58.841	48.909	41.475	37.354	32.370	19.371
Mar	105.094	78.212	64.460	52.451	44.701	39.359	32.830	29.675	22.794	15.012
Apr	49.323	34.706	30.219	25.871	21.758	18.543	15.579	14.191	12.451	5.584
May	18.325	13.581	11.024	8.898	8.373	7.504	6.541	5.548	4.524	3.289
Jun	14.281	9.356	5.767	4.989	4.379	3.817	3.211	2.755	2.287	1.703
Jul	10.376	5.755	4.411	3.415	2.941	2.405	1.883	1.706	1.514	1.232
Aug	9.883	6.142	5.096	4.328	3.176	2.441	2.036	1.775	1.224	1.065
Sep	14.247	9.711	6.987	5.992	4.573	3.971	3.226	2.290	1.680	1.194

EWR rule curve data for Site 3 (St Josephine's)

Desktop Version 2, Printed on 2003/02/12
Summary of IFR rule curves for : U10J WR90 Cum. Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : D'berg ERC = B

Data are given in m^3/s mean monthly flow

	% Points									
Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	3.110	3.098	3.050	2.941	2.723	2.336	1.757	1.057	0.439	0.153
Nov	8.164	8.152	8.081	7.926	7.611	7.015	5.991	4.469	2.680	1.537
Dec	21.014	19.960	18.968	17.977	16.802	14.697	12.487	9.165	5.225	2.702
Jan	23.884	22.674	21.550	20.455	19.194	16.914	14.582	10.996	6.667	3.877
Feb	76.604	68.597	61.716	55.728	50.068	40.349	34.573	25.889	15.591	8.995
Mar	25.638	24.250	22.984	21.771	20.420	18.041	15.834	12.552	8.694	6.230
Apr	10.420	10.392	10.276	10.016	9.493	8.568	7.182	5.507	4.029	3.345
May	6.636	6.607	6.519	6.326	5.951	5.307	4.366	3.251	2.280	1.830
Jun	4.126	4.106	4.051	3.934	3.709	3.329	2.779	2.134	1.577	1.318
Jul	2.849	2.832	2.794	2.716	2.570	2.330	1.991	1.600	1.266	1.111
Aug	2.454	2.443	2.413	2.349	2.226	2.018	1.718	1.366	1.061	0.920
Sep	2.475	2.465	2.434	2.367	2.236	2.012	1.684	1.296	0.957	0.801

Reserve flows without High Flows

Oct	2.743	2.733	2.690	2.593	2.399	2.056	1.541	0.919	0.371	0.117
Nov	6.054	6.045	5.994	5.884	5.660	5.235	4.505	3.420	2.145	1.330
Dec	13.030	13.017	12.908	12.668	12.173	11.223	9.573	7.093	4.152	2.268
Jan	14.569	14.569	14.469	14.243	13.762	12.813	11.124	8.527	5.391	3.371
Feb	15.279	15.268	15.170	14.956	14.513	13.664	12.189	9.973	7.344	5.661
Mar	15.150	15.133	15.030	14.809	14.358	13.504	12.038	9.859	7.296	5.660
Apr	10.420	10.392	10.276	10.016	9.493	8.568	7.182	5.507	4.029	3.345
May	6.636	6.607	6.519	6.326	5.951	5.307	4.366	3.251	2.280	1.830
Jun	4.126	4.106	4.051	3.934	3.709	3.329	2.779	2.134	1.577	1.318
Jul	2.849	2.832	2.794	2.716	2.570	2.330	1.991	1.600	1.266	1.111
Aug	2.454	2.443	2.413	2.349	2.226	2.018	1.718	1.366	1.061	0.920
Sep	2.475	2.465	2.434	2.367	2.236	2.012	1.684	1.296	0.957	0.801

Natural Duration curves

Oct	36.198	22.996	20.924	16.907	12.289	8.902	7.935	6.516	3.978	2.551
Nov	77.089	55.125	37.826	31.398	29.049	26.074	21.190	16.495	11.244	3.454
Dec	114.547	90.966	62.397	48.713	39.644	34.862	29.485	23.377	15.709	7.607
Jan	116.746	90.219	77.708	70.644	60.915	51.312	43.277	34.421	26.286	19.207
Feb	151.994	106.111	87.179	71.356	62.109	52.639	46.182	40.151	34.922	21.037
Mar	116.780	87.949	71.798	57.308	48.963	43.374	37.132	31.968	25.005	16.007
Apr	57.147	39.064	34.457	30.607	24.457	20.341	17.336	15.978	13.512	6.402
May	20.260	15.335	12.793	10.060	9.380	8.462	7.259	6.442	5.079	3.757
Jun	16.271	10.322	6.857	5.634	5.040	4.361	3.744	3.250	2.679	1.973
Jul	11.863	6.729	4.967	4.015	3.313	2.891	2.268	2.081	1.756	1.435
Aug	11.030	6.953	5.777	4.799	3.694	2.697	2.361	2.051	1.420	1.237
Sep	15.264	10.580	7.544	6.421	5.167	4.326	3.547	2.598	1.973	1.340

EWR rule curve data for Site 4 (Mfume)

Desktop Version 2, Printed on 2003/02/12
Summary of IFR rule curves for : U10M WR90 Cum. Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : D'berg ERC = B

Data are given in m^3/s mean monthly flow

	% Points									
Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	3.273	3.264	3.227	3.144	2.977	2.682	2.239	1.703	1.231	1.013
Nov	8.669	8.656	8.581	8.417	8.084	7.452	6.369	4.758	2.864	1.654
Dec	22.241	21.134	20.090	19.044	17.802	15.575	13.226	9.696	5.510	2.828
Jan	25.126	23.864	22.689	21.543	20.221	17.829	15.374	11.599	7.040	4.103
Feb	81.273	72.779	65.479	59.125	53.119	42.805	36.669	27.446	16.508	9.501
Mar	27.066	25.612	24.285	23.009	21.586	19.078	16.740	13.262	9.173	6.561
Apr	10.993	10.963	10.841	10.567	10.017	9.044	7.585	5.822	4.267	3.547
May	7.086	7.055	6.960	6.753	6.351	5.661	4.651	3.456	2.415	1.932
Jun	4.349	4.328	4.271	4.149	3.914	3.517	2.943	2.271	1.689	1.418
Jul	3.068	3.050	3.010	2.926	2.770	2.514	2.151	1.734	1.378	1.212
Aug	2.566	2.554	2.523	2.457	2.329	2.113	1.800	1.434	1.117	0.970
Sep	2.588	2.577	2.545	2.475	2.339	2.105	1.763	1.357	1.005	0.841

Reserve flows without High Flows

Oct	2.863	2.855	2.824	2.755	2.615	2.368	1.998	1.550	1.155	0.972
Nov	6.403	6.394	6.341	6.225	5.989	5.541	4.773	3.631	2.289	1.431
Dec	13.851	13.838	13.721	13.466	12.937	11.924	10.164	7.519	4.382	2.372
Jan	15.405	15.405	15.300	15.060	14.552	13.550	11.766	9.022	5.709	3.574
Feb	16.219	16.207	16.103	15.875	15.403	14.497	12.925	10.562	7.760	5.965
Mar	16.082	16.063	15.954	15.718	15.238	14.327	12.764	10.441	7.709	5.964
Apr	10.993	10.963	10.841	10.567	10.017	9.044	7.585	5.822	4.267	3.547
May	7.086	7.055	6.960	6.753	6.351	5.661	4.651	3.456	2.415	1.932
Jun	4.349	4.328	4.271	4.149	3.914	3.517	2.943	2.271	1.689	1.418
Jul	3.068	3.050	3.010	2.926	2.770	2.514	2.151	1.734	1.378	1.212
Aug	2.566	2.554	2.523	2.457	2.329	2.113	1.800	1.434	1.117	0.970
Sep	2.588	2.577	2.545	2.475	2.339	2.105	1.763	1.357	1.005	0.841

Natural Duration curves

Oct	37.306	23.981	21.782	17.607	12.905	9.576	8.386	7.069	4.548	2.733
Nov	76.533	55.031	38.739	32.750	30.172	27.291	22.050	17.294	12.160	3.997
Dec	117.663	90.891	62.882	49.864	40.830	36.527	30.007	24.343	16.495	8.302
Jan	120.041	94.173	78.513	71.967	62.985	52.798	44.716	34.474	27.003	19.660
Feb	161.284	107.236	90.838	73.136	64.370	55.275	47.643	40.943	35.539	22.507
Mar	126.152	91.114	74.225	58.879	51.133	45.283	39.685	34.240	26.582	16.425
Apr	59.027	42.119	38.289	32.070	26.213	22.232	19.298	17.169	14.020	7.388
May	22.631	17.161	14.709	11.709	10.633	9.696	8.654	7.453	5.715	4.241
Jun	17.041	11.105	7.778	7.044	6.156	5.131	4.617	4.008	3.180	2.481
Jul	13.670	7.351	5.909	4.826	3.992	3.509	2.902	2.540	2.188	1.687
Aug	12.309	7.772	6.250	5.419	4.420	3.301	2.796	2.569	1.866	1.537
Sep	16.530	11.831	8.243	6.931	5.630	4.810	4.167	3.078	2.239	1.600

EWR rule curve data for Bulwer Dam

Desktop Version 2, Printed on 2011/05/12
Summary of IFR rule curves for : BulwerDam Generic Name
Determination based on site specific parameters from SPATSIM database.
Regional Type : D'berg ERC = B

Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.071	0.070	0.069	0.067	0.062	0.053	0.039	0.023	0.008	0.000
Nov	0.098	0.097	0.097	0.094	0.090	0.083	0.069	0.049	0.026	0.008
Dec	0.149	0.140	0.131	0.123	0.114	0.098	0.083	0.060	0.033	0.011
Jan	0.484	0.435	0.393	0.356	0.321	0.260	0.221	0.160	0.060	0.019
Feb	0.200	0.190	0.181	0.171	0.160	0.139	0.116	0.083	0.043	0.012
Mar	0.249	0.231	0.214	0.199	0.182	0.153	0.127	0.089	0.037	0.007
Apr	0.117	0.117	0.115	0.111	0.102	0.088	0.066	0.040	0.017	0.004
May	0.086	0.085	0.084	0.080	0.074	0.063	0.047	0.028	0.012	0.004
Jun	0.079	0.079	0.077	0.074	0.068	0.058	0.043	0.026	0.011	0.004
Jul	0.070	0.069	0.068	0.065	0.059	0.050	0.038	0.023	0.010	0.004
Aug	0.060	0.060	0.059	0.056	0.052	0.044	0.033	0.020	0.007	0.004
Sep	0.074	0.074	0.072	0.070	0.064	0.055	0.042	0.026	0.012	0.004

Reserve flows without High Flows

Oct	0.056	0.056	0.055	0.053	0.049	0.041	0.030	0.017	0.006	0.000
Nov	0.067	0.067	0.066	0.065	0.062	0.057	0.047	0.034	0.018	0.008
Dec	0.080	0.080	0.079	0.078	0.075	0.068	0.058	0.042	0.024	0.011
Jan	0.110	0.110	0.109	0.107	0.103	0.096	0.082	0.061	0.036	0.019
Feb	0.124	0.124	0.123	0.121	0.116	0.106	0.089	0.063	0.033	0.012
Mar	0.111	0.111	0.110	0.108	0.103	0.093	0.077	0.054	0.026	0.007
Apr	0.098	0.098	0.096	0.093	0.086	0.074	0.055	0.033	0.014	0.004
May	0.086	0.085	0.084	0.080	0.074	0.063	0.047	0.028	0.012	0.004
Jun	0.079	0.079	0.077	0.074	0.068	0.058	0.043	0.026	0.011	0.004
Jul	0.070	0.069	0.068	0.065	0.059	0.050	0.038	0.023	0.010	0.004
Aug	0.060	0.060	0.059	0.056	0.052	0.044	0.033	0.020	0.007	0.004
Sep	0.060	0.059	0.058	0.056	0.052	0.044	0.034	0.021	0.009	0.004

Natural Duration curves

Oct	0.399	0.198	0.168	0.112	0.093	0.078	0.063	0.049	0.026	0.000
Nov	0.586	0.444	0.390	0.231	0.147	0.139	0.100	0.058	0.039	0.008
Dec	0.933	0.713	0.448	0.362	0.306	0.269	0.209	0.108	0.049	0.011
Jan	1.542	1.131	0.877	0.747	0.538	0.452	0.370	0.258	0.060	0.019
Feb	1.567	1.071	0.827	0.715	0.616	0.513	0.364	0.223	0.128	0.012
Mar	1.393	0.960	0.538	0.429	0.347	0.280	0.217	0.146	0.037	0.007
Apr	0.752	0.421	0.336	0.285	0.228	0.174	0.120	0.069	0.027	0.004
May	0.515	0.299	0.239	0.213	0.179	0.127	0.086	0.052	0.019	0.004
Jun	0.363	0.316	0.212	0.177	0.147	0.123	0.073	0.039	0.012	0.004
Jul	0.332	0.175	0.149	0.134	0.108	0.090	0.049	0.034	0.011	0.004
Aug	0.261	0.194	0.142	0.112	0.093	0.082	0.056	0.030	0.007	0.004
Sep	0.258	0.181	0.127	0.104	0.089	0.081	0.054	0.031	0.023	0.004

Derived EWR rule curve data for Site 1a (Impendle)

Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.342	2.337	2.314	2.263	2.161	1.980	1.708	1.379	1.090	0.956
Nov	5.035	5.029	4.990	4.906	4.734	4.408	3.850	3.019	2.043	1.419
Dec	10.624	10.121	9.651	9.184	8.639	7.662	6.655	5.143	3.349	2.199
Jan	11.803	11.224	10.690	10.178	9.601	8.560	7.536	5.960	4.058	2.832
Feb	39.036	34.936	31.421	28.373	25.516	20.618	17.799	13.561	8.535	5.316
Mar	11.216	10.730	10.282	9.845	9.343	8.456	7.587	6.295	4.777	3.806
Apr	5.573	5.561	5.511	5.401	5.180	4.789	4.202	3.493	2.868	2.578
May	4.033	4.019	3.974	3.879	3.691	3.370	2.900	2.344	1.860	1.636
Jun	2.856	2.845	2.814	2.749	2.624	2.328	2.104	1.732	1.434	1.095
Jul	2.245	2.235	2.213	2.153	1.775	1.507	1.210	1.096	0.961	0.795
Aug	1.953	1.945	1.925	1.883	1.802	1.431	1.203	1.011	0.792	0.670
Sep	1.680	1.674	1.655	1.614	1.534	1.396	1.196	0.958	0.751	0.655

Derived EWR rule curve data for Site 1b (Smithfield)

Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	3.032	3.026	2.996	2.930	2.797	2.563	2.211	1.786	1.411	1.238
Nov	6.439	6.432	6.381	6.273	6.054	5.637	4.923	3.860	2.613	1.814
Dec	13.491	12.853	12.256	11.663	10.970	9.730	8.452	6.531	4.253	2.793
Jan	14.742	14.018	13.351	12.712	11.991	10.691	9.412	7.444	5.068	3.537
Feb	48.680	43.566	39.183	35.383	31.820	25.712	22.196	16.912	10.644	6.629
Mar	14.199	13.585	13.018	12.464	11.829	10.706	9.605	7.970	6.048	4.819
Apr	7.209	7.193	7.129	6.987	6.700	6.195	5.436	4.519	3.710	3.335
May	5.286	5.267	5.209	5.084	4.838	4.418	3.802	3.073	2.439	2.145
Jun	3.793	3.778	3.737	3.651	3.485	3.091	2.795	2.301	1.904	1.455
Jul	2.986	2.973	2.943	2.864	2.361	2.005	1.609	1.458	1.278	1.057
Aug	2.591	2.581	2.555	2.500	2.392	1.900	1.596	1.341	1.051	0.889
Sep	2.273	2.265	2.238	2.183	2.074	1.889	1.617	1.296	1.015	0.886

Appendix D

Results

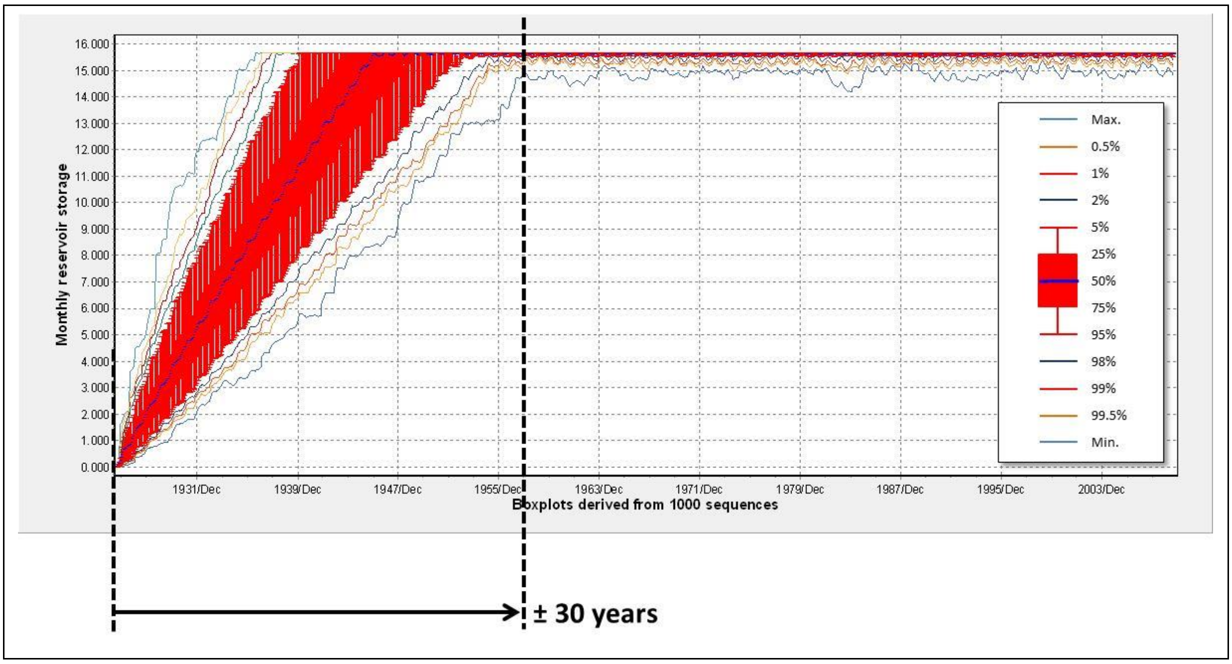

Figure D.1: Storage volume projections for the proposed Langa Dam (with no EWR and no support from Smithfield Dam)

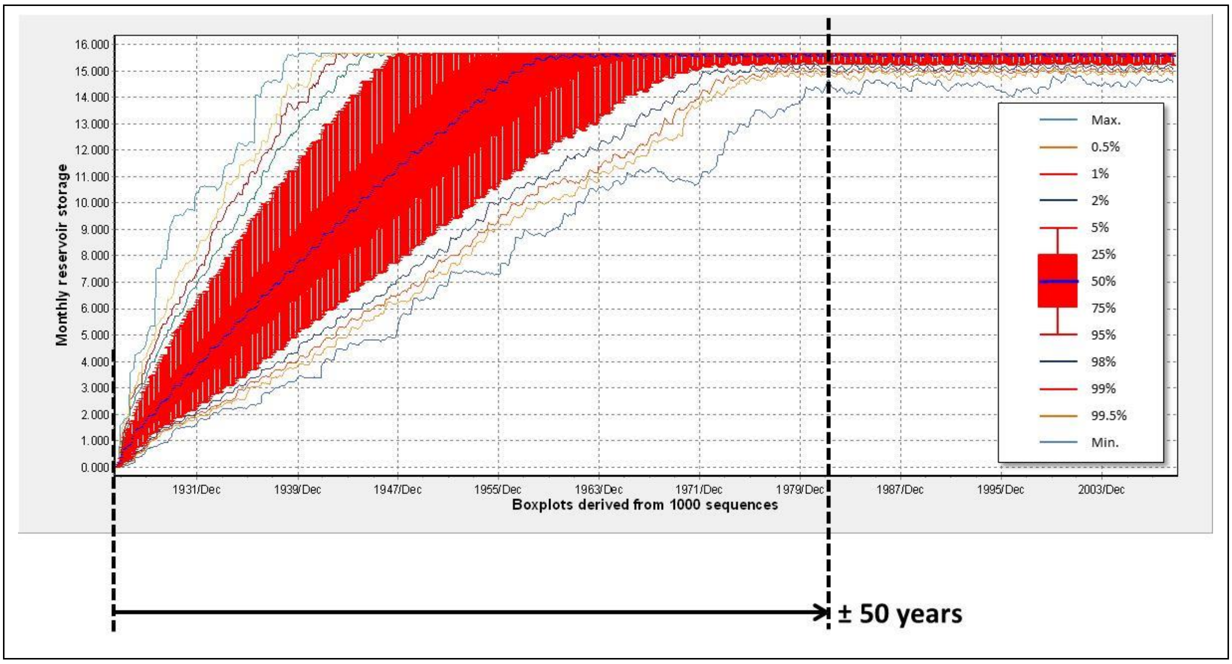

Figure D.2: Storage volume projections for the proposed Langa Dam (with EWR but no support from Smithfield Dam)

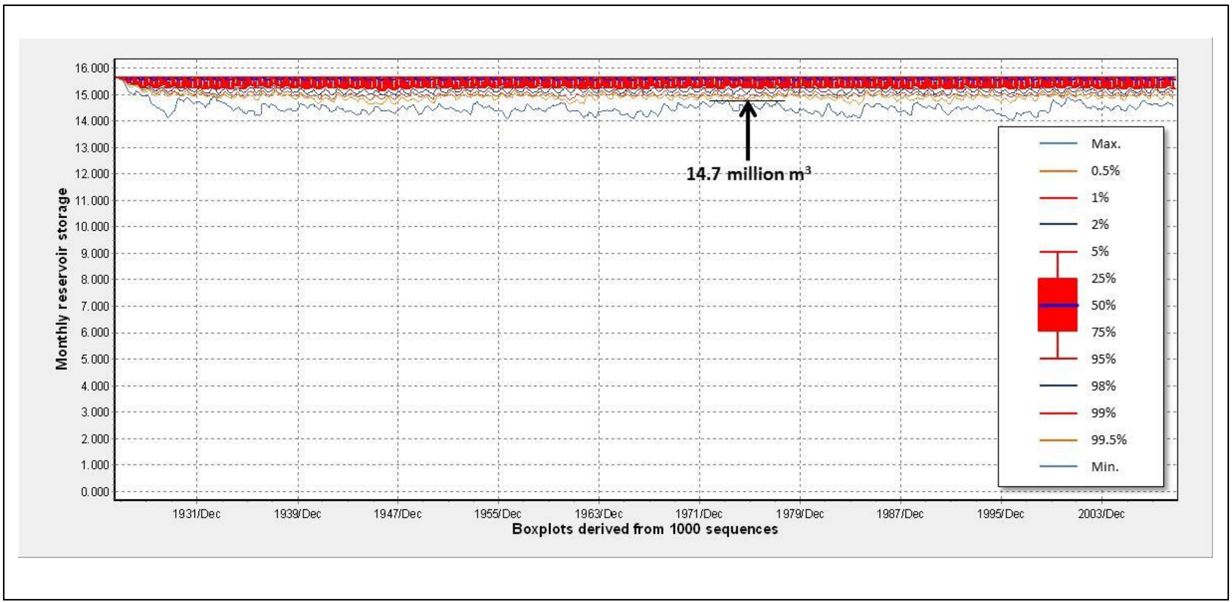

Figure D.3: Storage volume projections for the proposed Langa Dam (filled from Smithfield Dam but with no subsequent support)

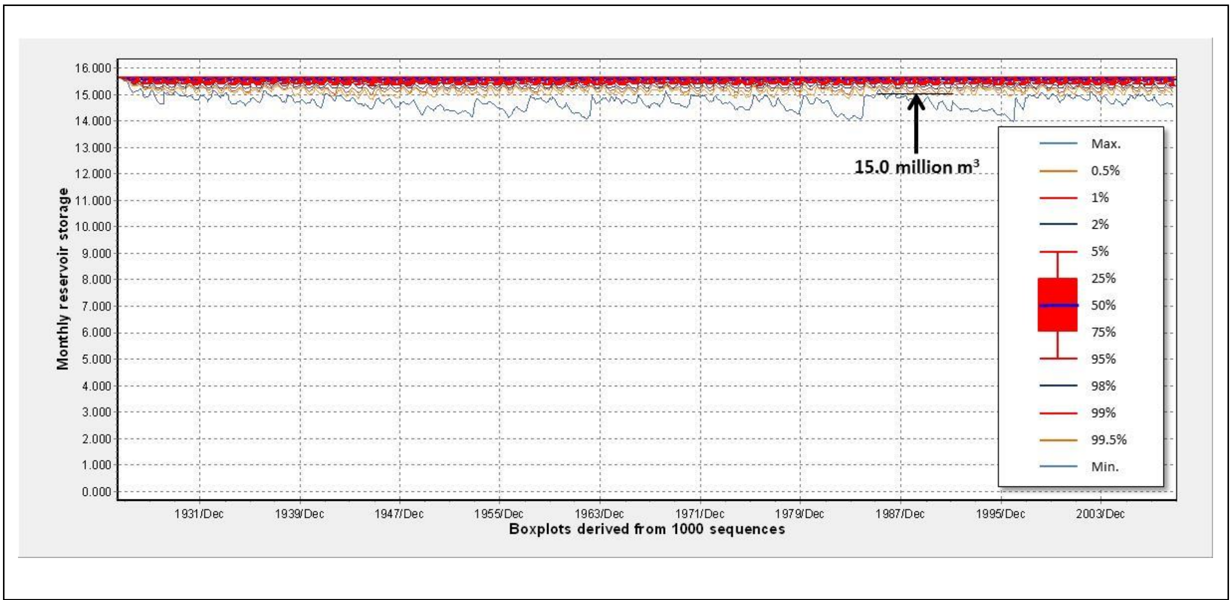

Figure D.4: Storage volume projections for the proposed Langa Dam (filled from Smithfield Dam and with subsequent support)

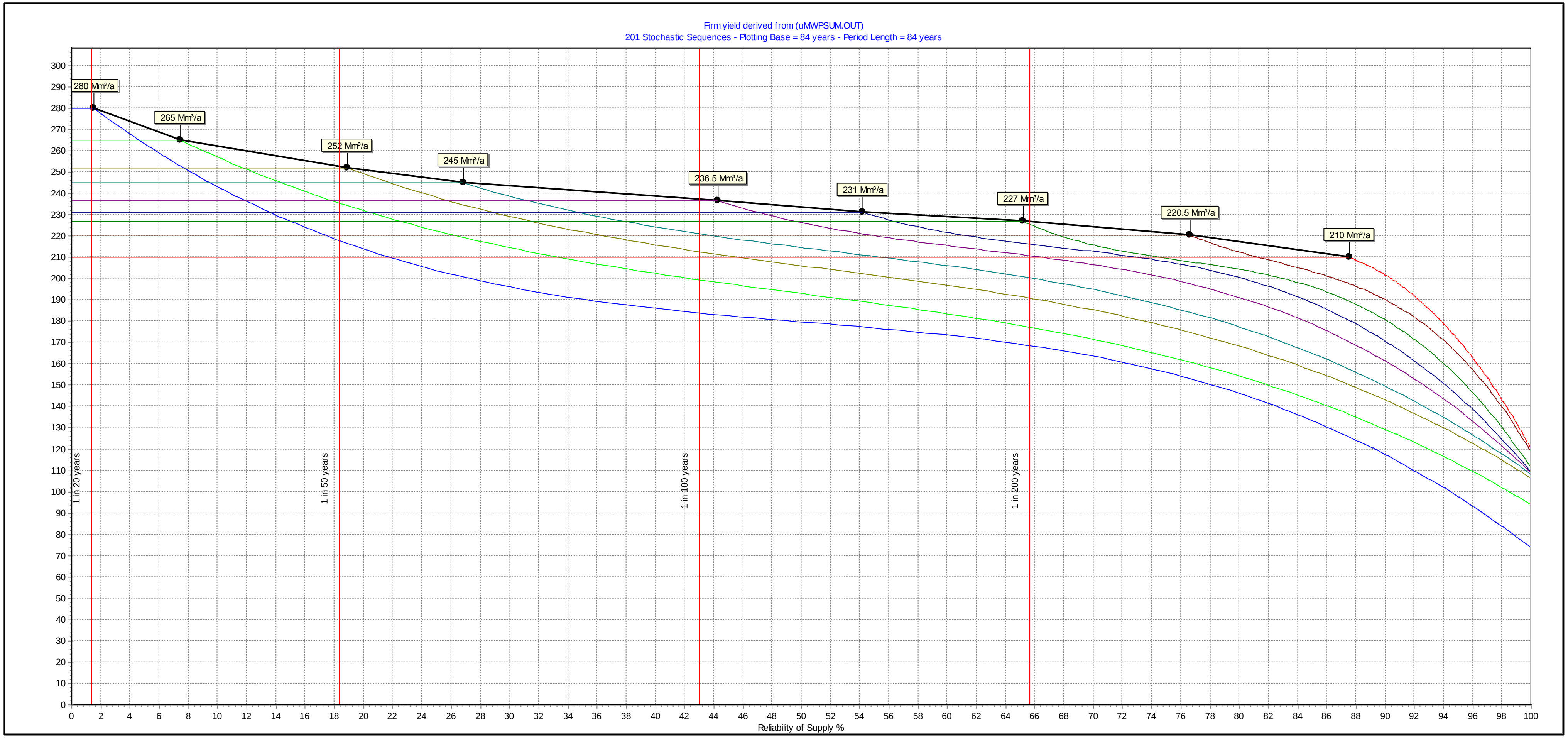

Figure D.5: Long-term stochastic YRC curves for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2020)

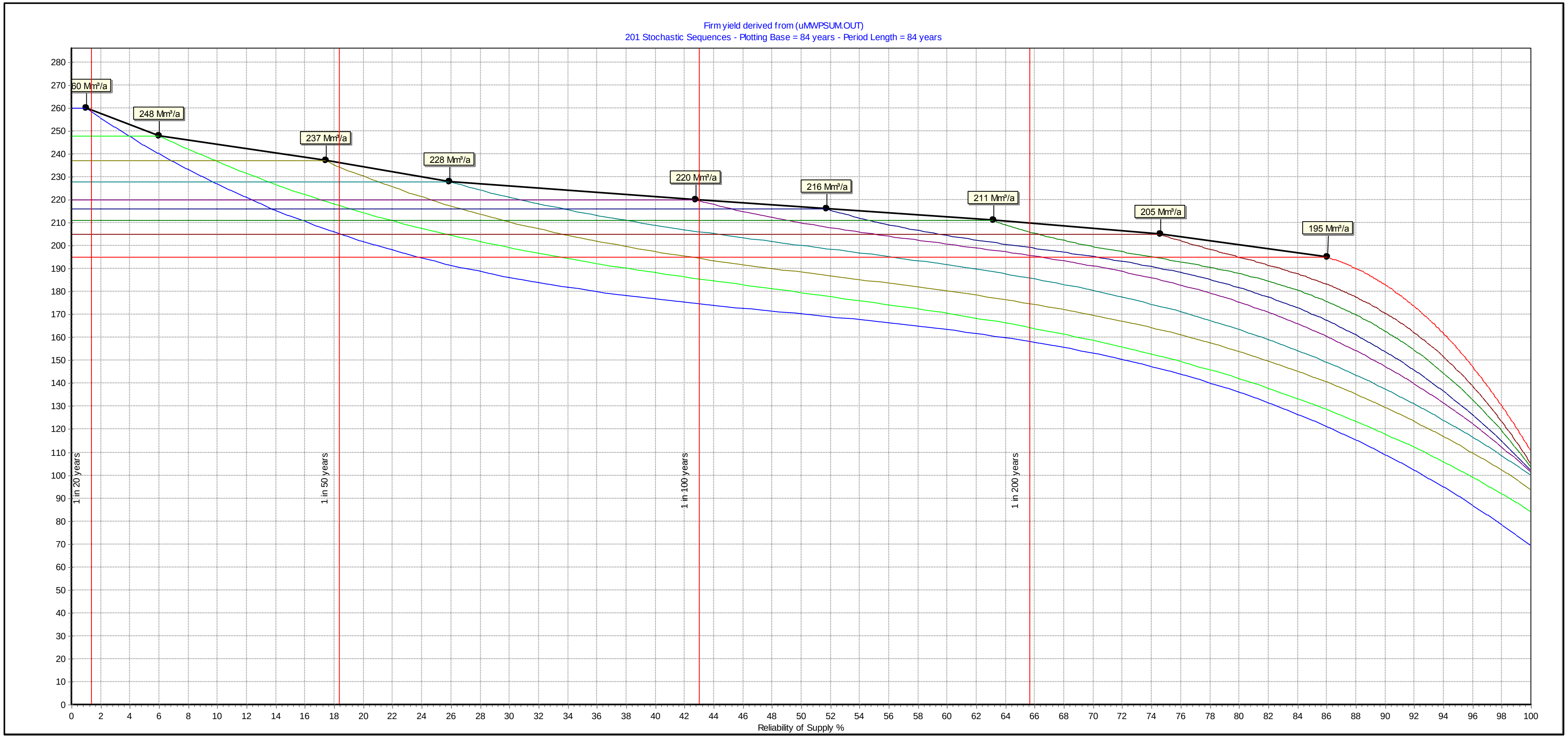

Figure D.6: Long-term stochastic YRC curves for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2050)

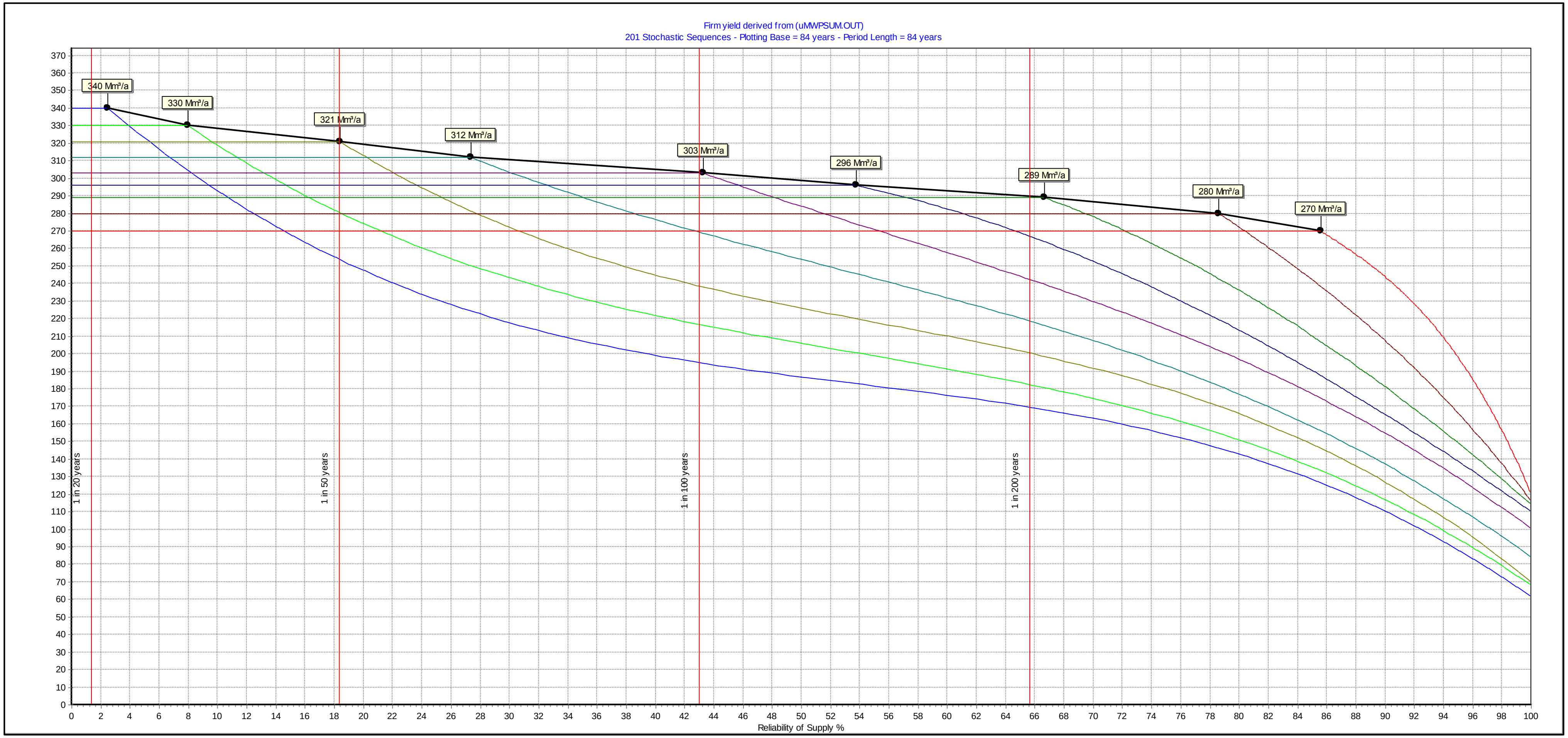

Figure D.7: Long-term stochastic YRC curves for uMWP-2: Smithfield Dam with FSL of 930 m, in combination with Impendle Dam with a live storage capacity of 50% of the natural MAR (2050)

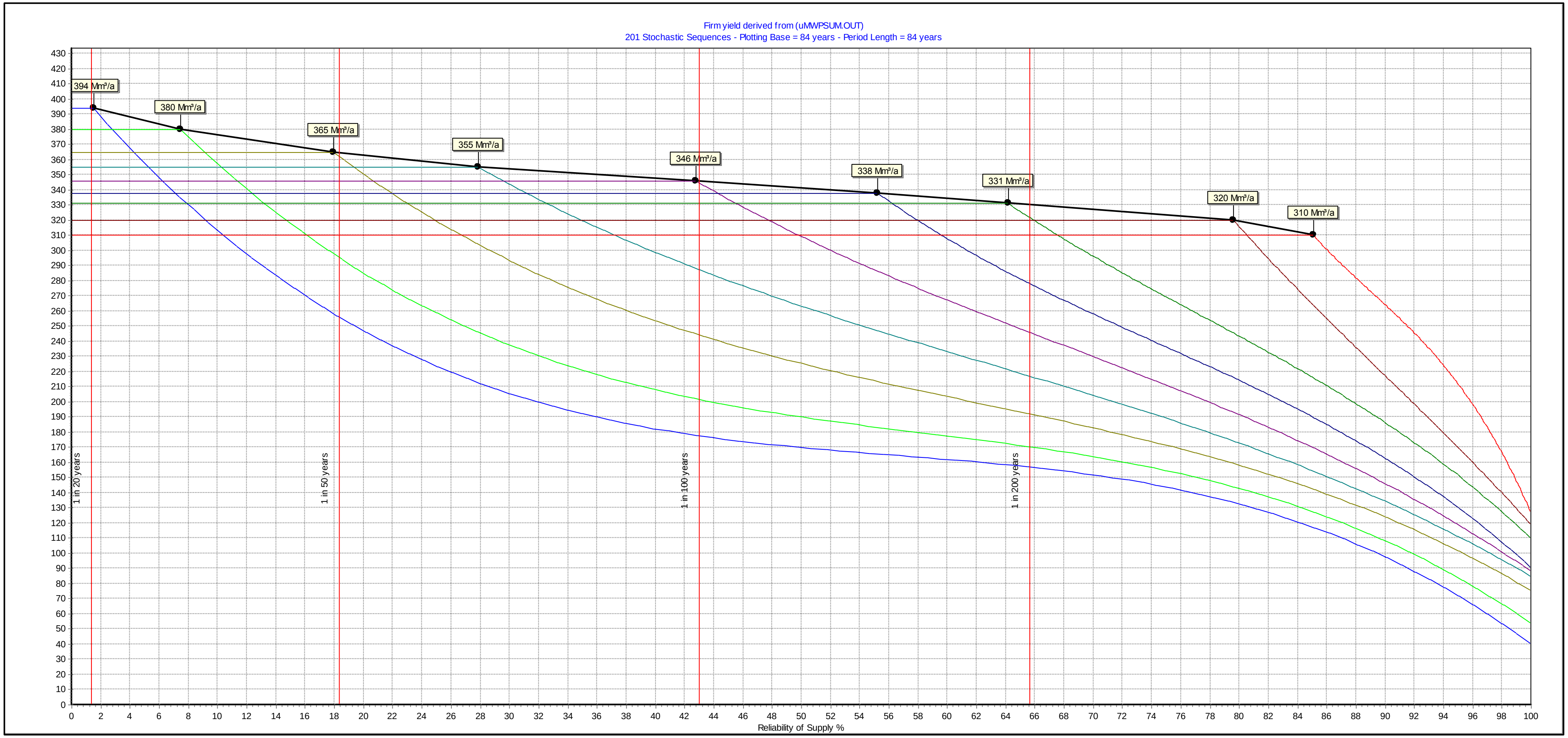

Figure D.8: Long-term stochastic YRC curves for uMWP-2: Smithfield Dam with FSL of 930 m, in combination with Impendle Dam with a live storage capacity of 100% of the natural MAR (2050)

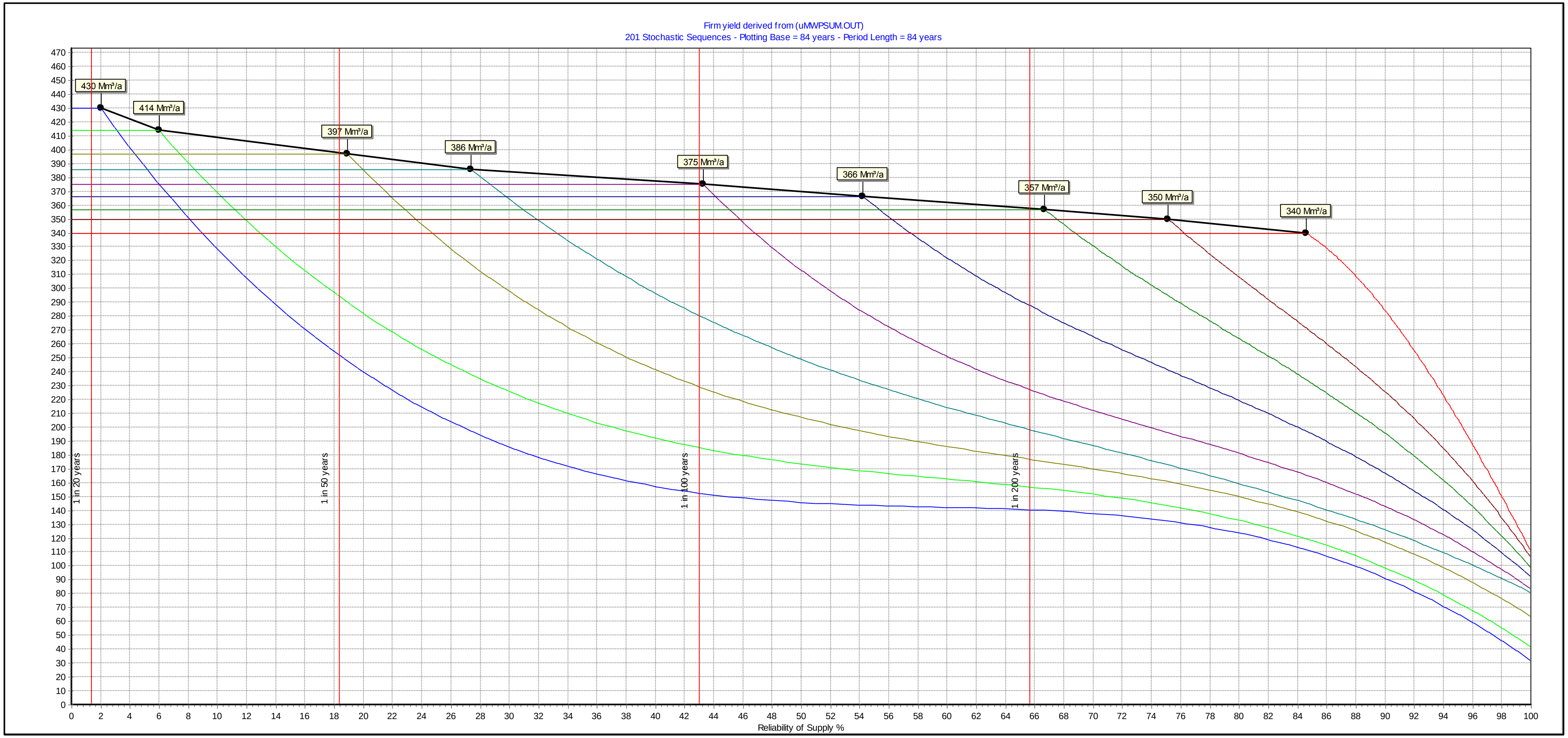

Figure D.9: Long-term stochastic YRC curves for uMWP-2: Smithfield Dam with FSL of 930 m, in combination with Impendle Dam with a live storage capacity of 150% of the natural MAR (2050)

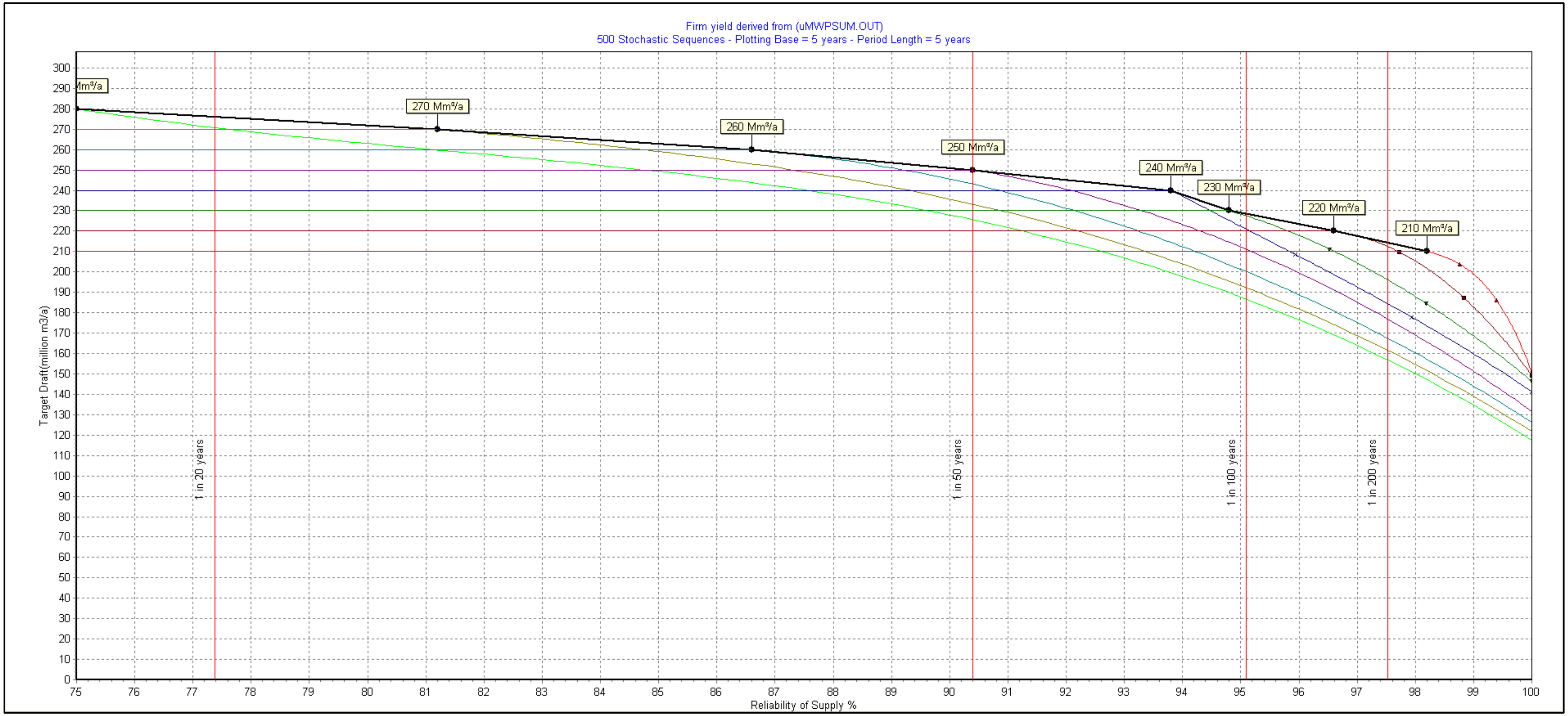

Figure D.10: Short-term stochastic YRC curves for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2050 & 100% starting storage level)

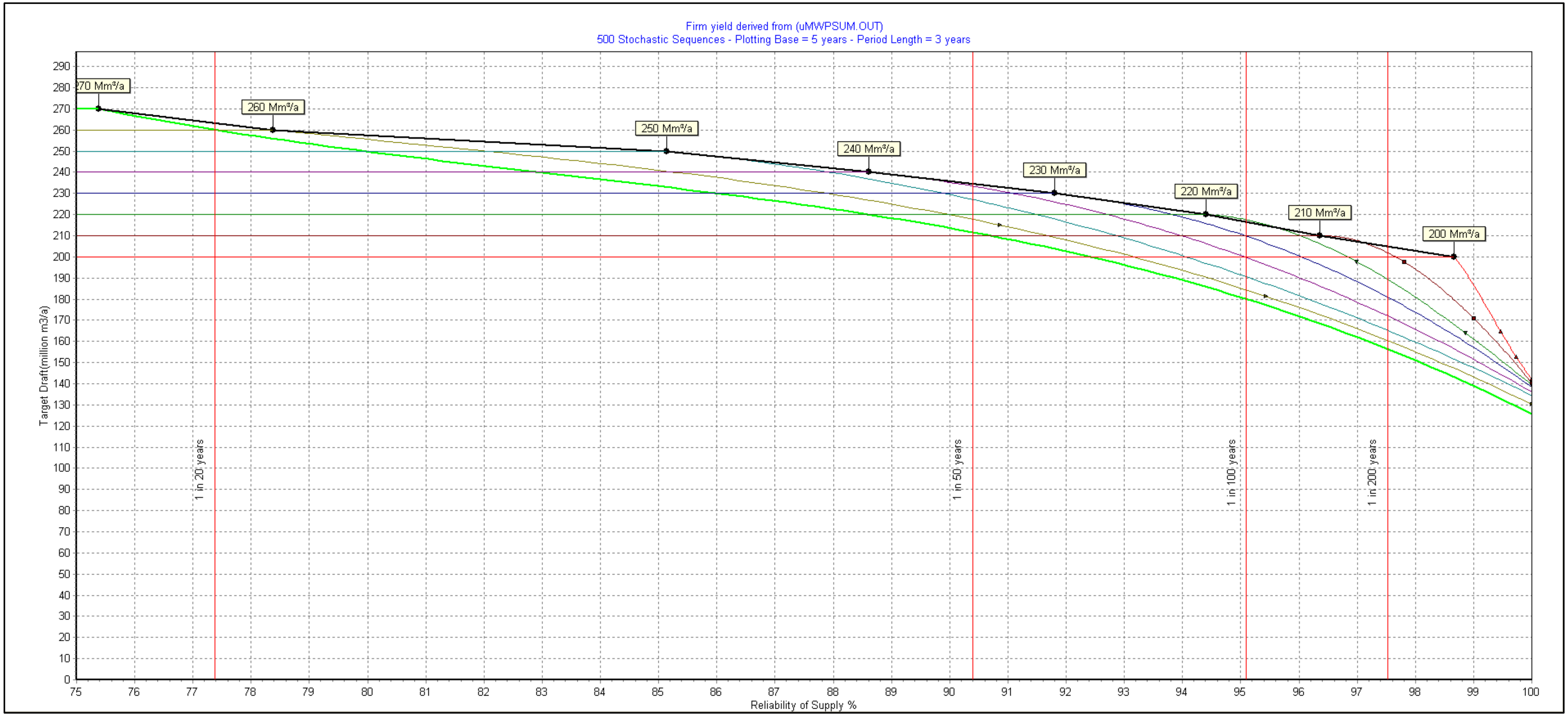

Figure D.11: Short-term stochastic YRC curves for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2050 & 80% starting storage level)

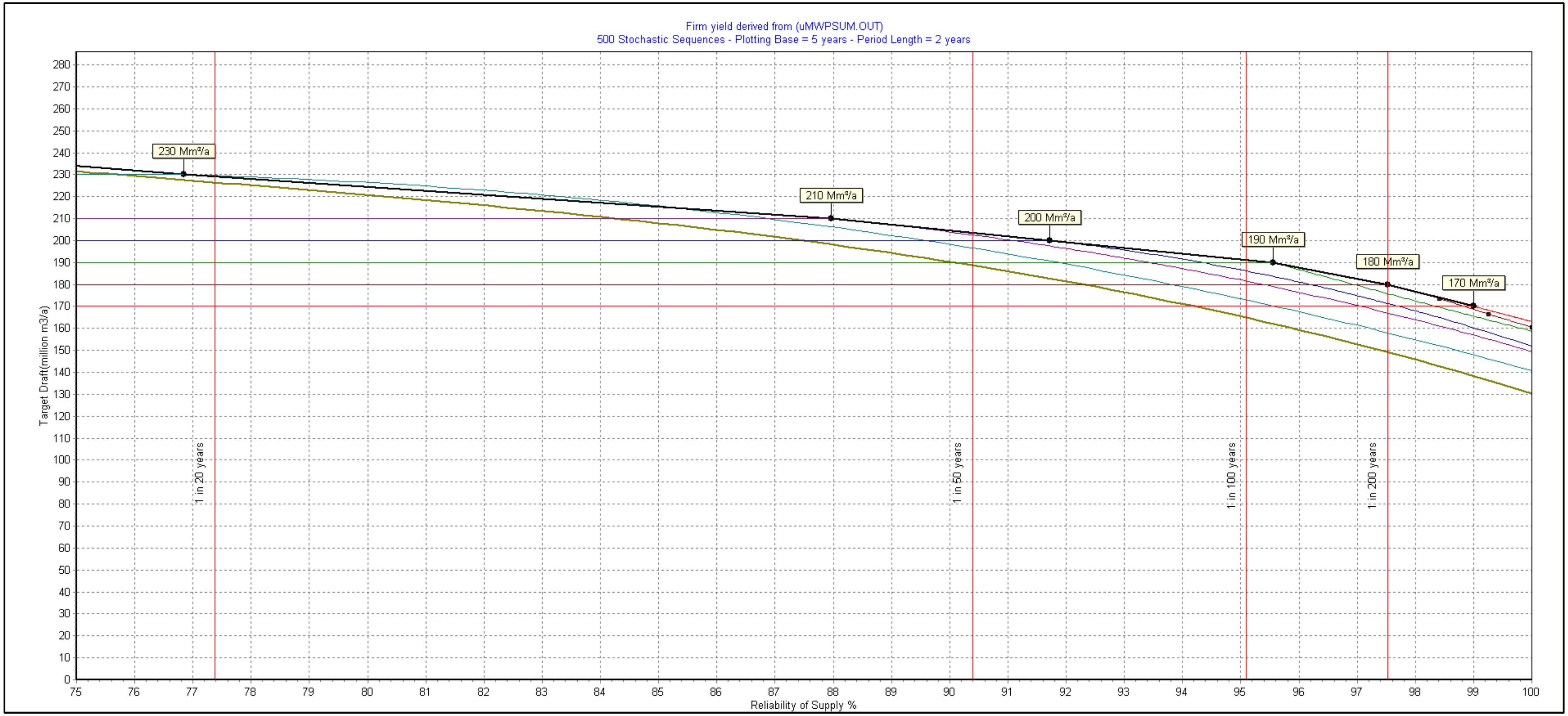

Figure D.12: Short-term stochastic YRC curves for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2050 & 60% starting storage level)

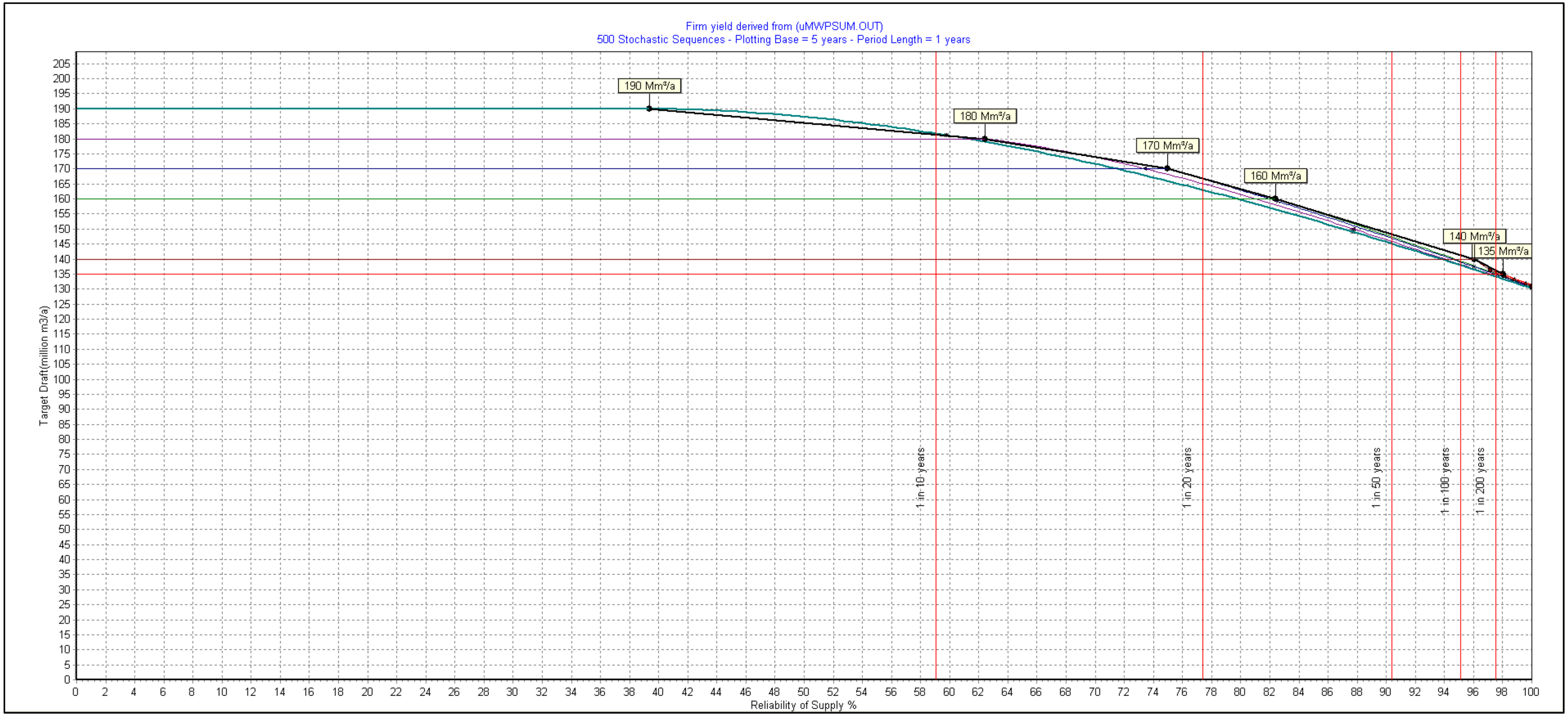

Figure D.13: Short-term stochastic YRC curves for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2050 & 40% starting storage level)

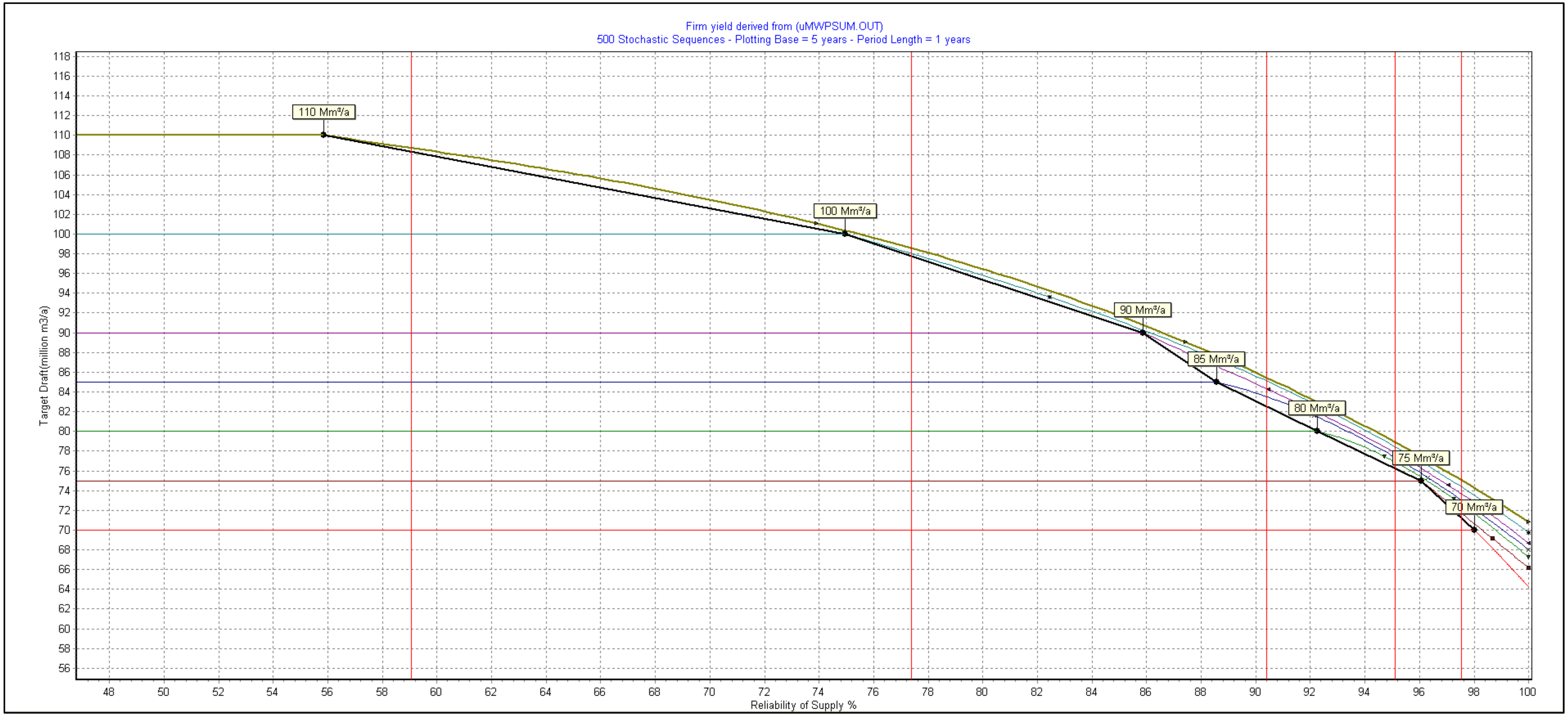

Figure D.14: Short-term stochastic YRC curves for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2050 & 20% starting storage level)

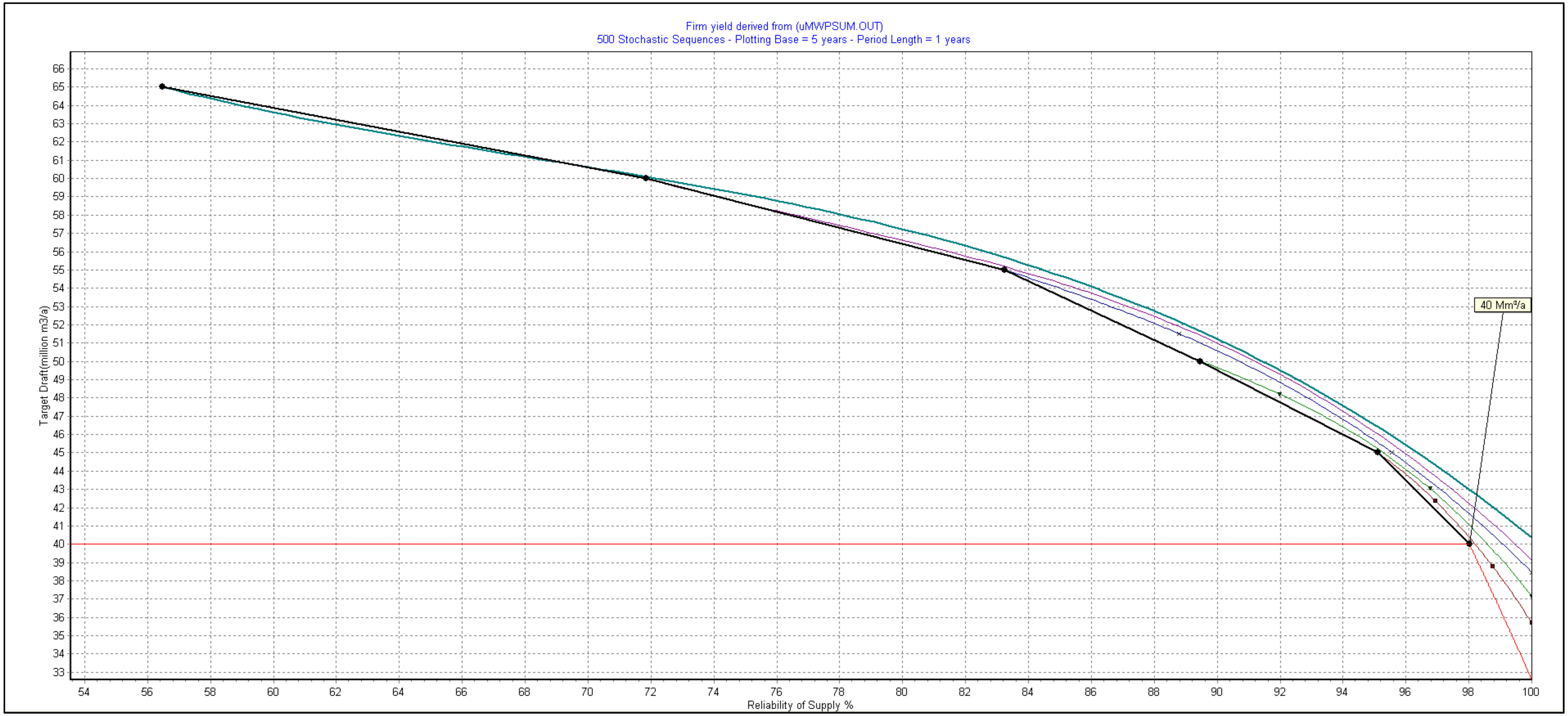

Figure D.15: Short-term stochastic YRC curves for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2050 & 10% starting storage level)

Table D.1: Short-term stochastic YRC curve coefficients for uMWP-1: Smithfield Dam with the adopted FSL of 930 masl (2050)

Target draft / yield (million m^3/a)	Curve coefficient[1]				
	1	2	3	4	5
Starting storage 100 % of live storage capacity					
280	0.57971	-1.58375	1.82954	-0.82551	0.25000
270	0.56142	-1.38236	1.33484	-0.51390	0.18800
260	0.51984	-1.00378	0.61217	-0.12824	0.13400
250	0.46281	-0.67553	0.08284	0.12987	0.09600
240	0.41132	-0.50122	0.15506	-0.06515	0.06200
230	0.36293	-0.52748	0.15147	0.01309	0.05200
220	0.32164	-0.60760	0.31089	-0.02492	0.03400
210	0.28194	-0.67096	0.56042	-0.17141	0.01800
Starting storage 80 % of live storage capacity					
270	0.54839	-1.41947	1.77592	-0.90484	0.24623
260	0.49938	-1.12395	0.98447	-0.35991	0.21623
250	0.50884	-1.28538	1.46048	-0.68393	0.14858
240	0.47383	-1.18243	1.28837	-0.57976	0.11392
230	0.46769	-1.39584	1.83836	-0.91021	0.08194
220	0.36671	-0.57450	0.08555	0.12225	0.05602
210	0.33153	-0.58070	0.15853	0.09064	0.03640
200	0.28844	-0.22502	-0.18600	0.12258	0.01330
Starting storage 60 % of live storage capacity					
250	0.47963	-1.08292	1.11858	-0.51529	0.32602
230	0.38919	-0.75494	0.42565	-0.05990	0.23157
210	0.28725	-0.43031	0.14490	-0.00183	0.12035
200	0.23263	-0.28875	-0.03236	0.08847	0.08285
190	0.20786	-0.52074	0.73923	-0.42634	0.04439
180	0.10738	-0.09817	-0.04210	0.03289	0.02481
170	0.02366	0.00140	-0.00974	-0.01533	0.00997
Starting storage 40 % of live storage capacity					
190	0.31438	-0.50960	0.08718	0.10804	0.60610
180	0.27544	-0.32923	-0.04423	0.09801	0.37597
170	0.23213	-0.25937	0.02281	0.00444	0.25035
160	0.19783	-0.33758	0.31384	-0.17409	0.17610
140	0.06451	-0.05364	0.02605	-0.03692	0.03937
135	0.02625	-0.02452	0.00024	-0.00197	0.01984

Target draft / yield (million m^3/a)	Curve coefficient[1]				
	1	2	3	4	5
Starting storage 20 % of live storage capacity					
110	0.35622	-0.71827	0.52270	-0.16065	0.44159
100	0.30243	-0.49727	0.29195	-0.09711	0.25035
90	0.23746	-0.35353	0.19908	-0.08301	0.14127
85	0.20012	-0.29122	0.07126	0.01984	0.11438
80	0.15929	-0.22358	0.03136	0.03292	0.07748
75	0.11793	-0.11810	0.00016	0.00001	0.03937
70	0.04737	0.00285	-0.01950	-0.03072	0.01984
Starting storage 10 % of live storage capacity					
65	0.37924	-0.94069	1.03374	-0.47228	0.43529
60	0.34887	-0.79065	0.75990	-0.31813	0.28158
55	0.30086	-0.52973	0.32833	-0.09946	0.16750
50	0.25732	-0.46905	0.30601	-0.09429	0.10527
45	0.20664	-0.29532	0.10071	-0.01203	0.04901
40	0.10658	0.00641	-0.04388	-0.06912	0.01984

Note: (1) Coefficients for a fitted fourth-order polynomial function that describes the shape of the base yield line for a particular analysed target draft. Derived from a WRYM analysis of 501 5-year stochastically generated stream flow sequences and with a May start month.