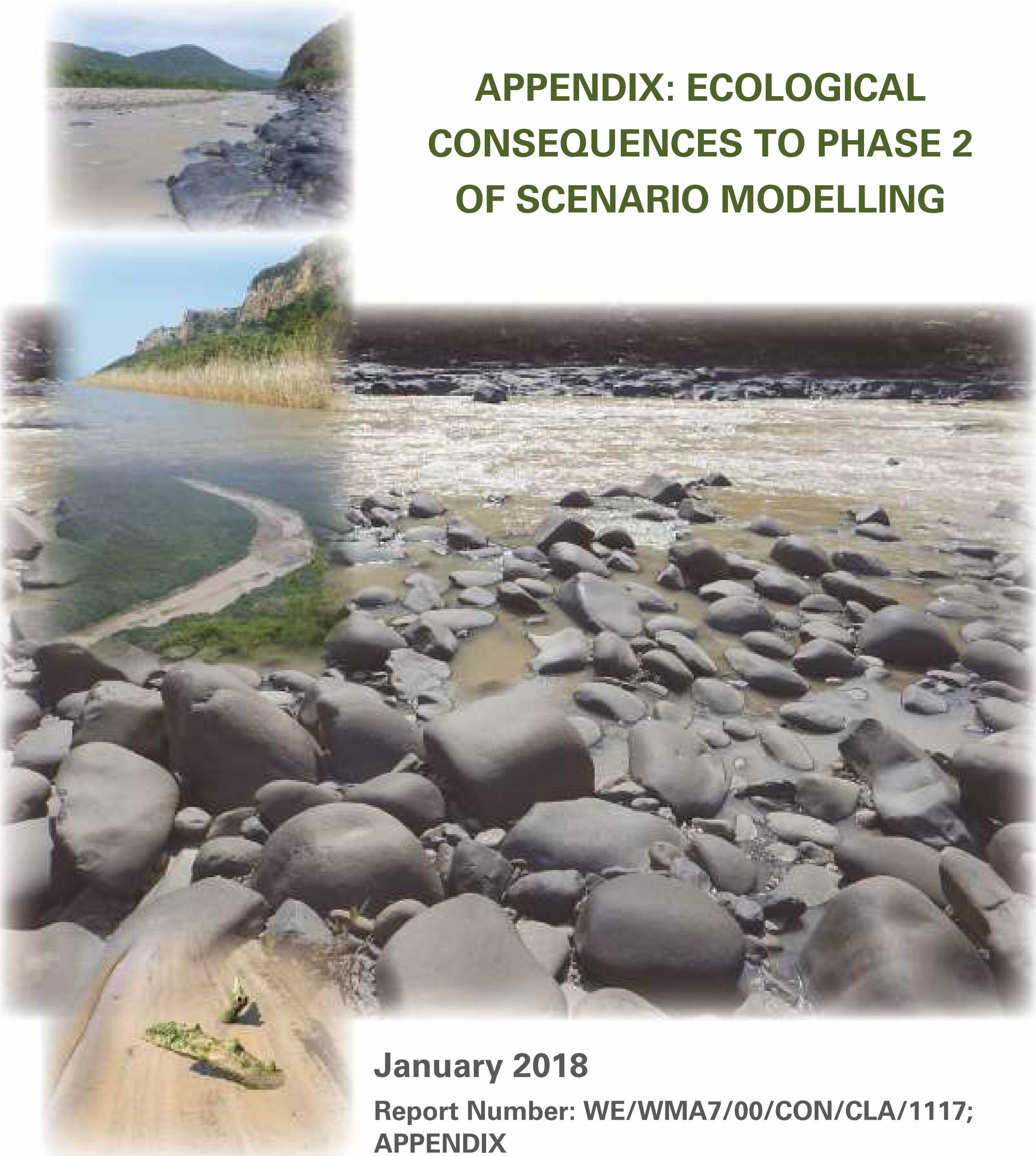
water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WP 11004

DETERMINATION OF WATER RESOURCE CLASSES AND RESOURCE QUALITY OBJECTIVES FOR THE WATER RESOURCES IN THE MZIMVUBU CATCHMENT



APPENDIX: ECOLOGICAL CONSEQUENCES TO PHASE 2 OF SCENARIO MODELLING

January 2018

Report Number: WE/WMA7/00/CON/CLA/1117; APPENDIX

Published by

Department of Water and Sanitation
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This report should be cited as:

Department of Water and Sanitation (DWS), South Africa. 2018. Determination of Water Resource Classes and Resource Quality Objectives for Water Resources in the Mzimvubu Catchment. Appendix to Ecological Consequences Report: Ecological Consequences to Phase 2 of Scenario Modelling. Prepared by Koekemoer Aquatic Services, Rivers for Africa eFlows Consulting (Pty) Ltd. and CSIR for Scherman Colloty and Associates cc.. Report no. WE/WMA7/00/CON/CLA/1117: Appendix.

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DOCUMENT INDEX

Report name	Report number
Inception Report	WE/WMA7/00/CON/CLA/0116
Survey Report	WE/WMA7/00/CON/CLA/0216
Status Quo and (RUs and IUA) Delineation Report	WE/WMA7/00/CON/CLA/0316
River Workshop Report	WE/WMA7/00/CON/CLA/WKSP/0117
River Desktop EWR and Modelling Report: Volume 1 – Systems Modelling Volume 2 – Desktop EWR Assessment	 WE/WMA7/00/CON/CLA/0217, Volume 1 WE/WMA7/00/CON/CLA/0217, Volume 2
BHNR Report (Surface and Groundwater)	WE/WMA7/00/CON/CLA/0317
Estuary Workshop Report	WE/WMA7/00/CON/CLA/WKSP/0417
Scenario Description Report	WE/WMA7/00/CON/CLA/0517
River EWR Report	WE/WMA7/00/CON/CLA/0617
Estuary EWR Report	WE/WMA7/00/CON/CLA/0717
Groundwater Report	WE/WMA7/00/CON/CLA/0817
Wetland EcoClassification Report	WE/WMA7/00/CON/CLA/0917
Scenario Non-ecological Consequences Report	WE/WMA7/00/CON/CLA/1017
Ecological Consequences Report. **Appendix: Ecological Consequences to Phase 2 of Scenario Modelling.**	**WE/WMA7/00/CON/CLA/1117; Appendix**
WRC and Catchment Configuration Report	WE/WMA7/00/CON/CLA/0118
River and Estuary RQO Report	WE/WMA7/00/CON/CLA/0218
Wetlands and Groundwater RQO Report	WE/WMA7/00/CON/CLA/0317
Monitoring and Implementation Report	WE/WMA7/00/CON/CLA/0418
Water Resource Classes and RQOs Gazette Template Input	WE/WMA7/00/CON/CLA/0518
Main Report	WE/WMA7/00/CON/CLA/0618a
Close Out Report	WE/WMA7/00/CON/CLA/0618b
Issues and Response Report	WE/WMA7/00/CON/CLA/0718

Bold indicates this report

APPROVAL

TITLE:	Appendix: Ecological Consequences to Phase 2 of Scenario Modelling
DATE:	January 2018
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REPORT NO:	WE/WMA7/00/CON/CLA/1117; Appendix
FORMAT:	MSWord and PDF
WEB ADDRESS:	http://www.dws.gov.za

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REPORT SCHEDULE

Version	Date
First draft	January 2018
Final	

EXECUTIVE SUMMARY

The Mzimvubu catchment has been prioritised for implementation of the Water Resource Classification System (WRCS) in order to determine appropriate Water Resource Classes and Resource Quality Objectives (RQOs) in order to facilitate the sustainable use of water resources without impacting negatively on their ecological integrity.

The main aims of the project, as defined by the Terms of Reference (ToR), are to undertake the following:

- Coordinate the implementation of the WRCS as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine RQOs using the DWS's procedures to determine and implement RQOs for the defined classes, and
- review work previously done on Ecological Water Requirements (EWRs) and the Basic Human Needs Reserve (BHNR) and assess whether suitable for the purposes of Classification.

The purpose of this report is to document the ecological consequences of the additional scenarios modelled as Phase 2, and their expected ecological impacts on the affected rivers and estuary of the study area.

OPERATIONAL SCENARIOS

The operational scenarios (Sc) considered in this Appendix are summarised below:

Scenario 2b fully utilises the available yield of the new proposed dams, following the design of the MWP Feasibility study of 2014. This scenario was assessed during Phase 1 and is included for comparison purposes.

Scenario 2c was based on Scenario 2b but with the latest MWP infrastructure design information and optimised hydropower operating rules from the design phase of the project incorporated, i.e. the MWP Design Phase of 2017.

Scenario 53 forms part of Phase 1 scenario modelling and was based on Scenario 51 but with the hydropower generation <u>further</u> reduced in the dry winter months. There is no EWR release from Lalini Dam under this scenario.

Scenario 54 was an optimisation of Scenario 53, but with a Category D low flow EWR release from Lalini Dam to ensure no zero flows from the dam to the outlet. The flow to be provided in the reach downstream of Lalini Dam can be further adjusted, but further optimisation of Scenarios 53 and 54 will depend on the outcome of the economic analysis.

Scenario 61 includes the 2017 MWP design phase information and EWR releases.The hydropower operating rules are significantly different to the rules applied in Scenario 2b, which influences the flows at the EWR sites.

Scenario 62 was based on Scenario 61 but with the hydropower generation reduced in the dry winter months. The purpose of the scenario was to decrease the flows at MzimEWR4 and especially the estuary, as it could be seen Sc 61 would provide unnaturally high and constant baseflow.

Scenario 63 was based on Scenario 62 but with the hydropower generation design capacity increased in the wet summer months to utilise the additional storage gained (due to the reduced hydropower generation in the dry winter months) for additional hydropower generation in the wet summer months.

Scenario 65 was based on Scenario 62 where hydropower generation was further reduced during the dry winter months. Initial analyses of Scenario 62 showed that the increased baseflows due to hydropower releases were still a problem and needed to be reduced further.

Scenario 69 was based on Scenario 63, where hydropower generation was further reduced during the dry winter months. The aim would be to come as close as possible to Scenario 54 which was the optimised scenario evaluated during the first round of assessments. Initial analyses of Scenarios 63 showed that the increased hydropower generation design capacity with the associated increased hydropower releases in the wet summer months was acceptable from an ecological perspective, but that the baseflows due to hydropower releases in the dry months were still a problem and needed to be reduced further, as with Scenario 62.

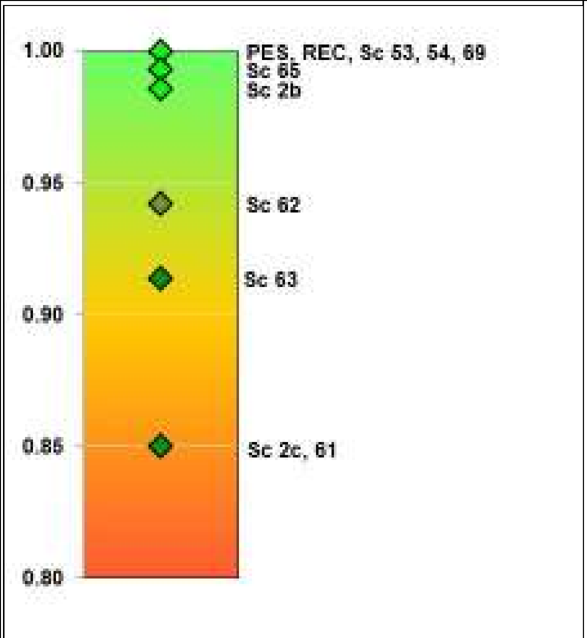
Scenario 70 was not modelled (and therefore does not appear in the scenario matrix table) as flows are the same or similar to Scenario 69. The difference between Scenario 70 and Scenario 69 is that, as for Scenario 53, Scenario 70 does NOT include an EWR flow release from Lalini Dam. The 4.8 km river reach between the Lalini Dam and Tsitsa Falls will be dry except when the dam spills, which will be of aesthetic, socio-cultural, tourism and recreational concern. The rest of the reach (13.5 km) to the outfall will also be dry except for spills and inflows of some tributaries (but not that there are no significant tributaries between the dam wall and the falls). The evaluation was therefore for a NO EWR flow over the falls, and the impact thereof. The ecological impact of this situation is the same as for Scenario 53 and will therefore not be evaluated. Ecosystem services, recreation and tourism impacts were evaluated for this scenario.

ECOLOGICAL CONSEQUENCES: RIVERS

The ecological consequences on the three EWR sites are provided in the tables below. The ranking of the scenarios are provided in the traffic diagram below the table. Note that the colouring of the traffic diagram denotes an improvement from red through orange to green. Shading is therefore according to the colours of a traffic light; implying that the items at the top (in the green section) are better than the ones below.

MzimEWR4 (Mzimvubu River)

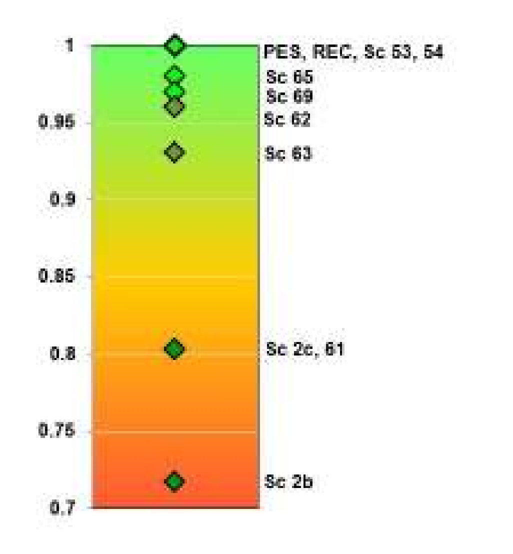
Component	PES and REC	Sc 2b	Sc 53	Sc 61	Sc 62	Sc 63	Sc 65
Physico-chemical	A/B	A	A/B	A	A/B	A/B	A/B
Geomorphology	C	C	C	C	C	C	C
Riparian vegetation	C/D	D	C/D	E	D	D	C/D
Fish	C	B/C	B	C	C	C	C
Invertebrates	C	C	B	C/D	C	C	C
EcoStatus	C (67.2%)	C (66.3%)	C (71.3%)	D (49.7%)	C/D (59.4%)	D (57.1%)	C (67.7%)



Ranking rationale: The ranking of the scenarios indicates that Sc 69 achieves the REC (and PES) requirements. Scenario 65 maintains the REC, with fish slightly deteriorating within the PES category. The rest of the scenarios result in a deterioration from the PES and REC, mainly due to increased baseflows above natural in the dry season impacting the middle and lower riparian zones, and ultimately the habitat availability for biota. As Sc 53 and 54 were not part of the 2017 design phase (Pro-Plan data), Sc 69 is recommended as the most suitable scenario.

MzimEWR1 (Tsitsa River)

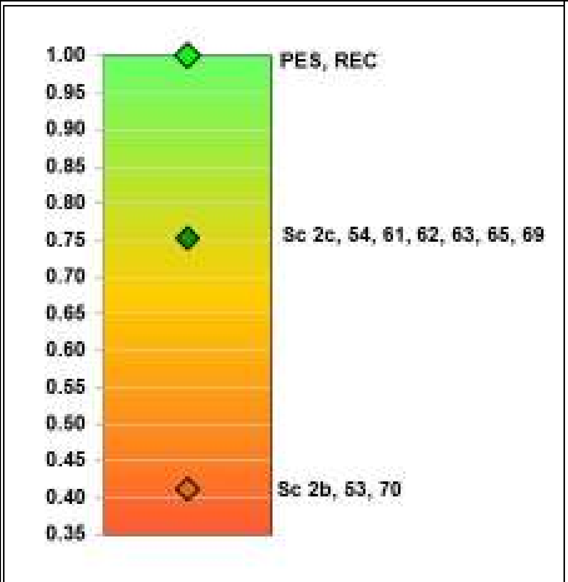
Component	PES and REC	Sc 2b	Sc 53	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
Physico-chemical	B	C/D	B	A/B	B	B	B	B
Geo-morphology	C	C	C	D	D	D	D	D
Riparian vegetation	C/D	D/E	C/D	D/E	D	D	C/D	D
Fish	C	D	C	C	C	C	C	C
Invertebrates	C	D/E	C	C	C	C	C	C
EcoStatus	C (65.1%)	D (42.7%)	C (66.9%)	D (49.2%)	C/D (61.7%)	C/D (59.4%)	C (65.1%)	C (63.7%)



Ranking rationale: Scenarios 65 and 69 maintain the REC (and PES), with Sc 69 resulting in the riparian vegetation deteriorating. The rest of the scenarios result in deterioration from the PES and REC, mainly due to increased baseflows above natural in the dry season impacting the middle and lower riparian zones and ultimately the habitat availability for biota. As Sc 53 and 54 are not part of the Pro-Plan design, and Sc 69 is a better option at MzimEWR4, which is the most important ecological EWR river site, Sc 69 is recommended as the most suitable scenario.

EWR1 Lalini (Tsitsa River)

Component	PES and REC	Sc 2b	Sc 54
Physico-chemical	B	E	C
Geomorphology	C	C	D
Riparian vegetation	C/D	F	D
Fish	C	D/E	D
Macroinvertebrates	C	F	D
EcoStatus	C (65.05%)	E/F (19%)	D (47.55%)

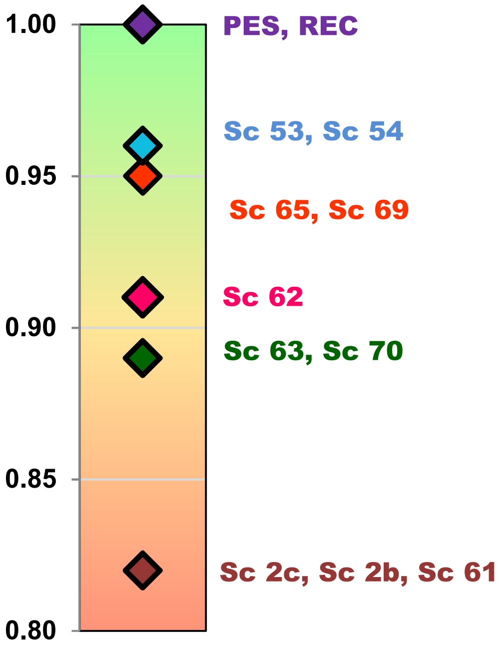


Ranking rationale: The DWS has indicated that management options associated with Sc 2b, 53 and 70, i.e. no flow over Tsitsa Falls, would be unacceptable. As some flow is therefore required in the reach immediately downstream of Lalini Dam, any of the other scenarios will be acceptable.

INTEGRATED RIVER ECOLOGICAL RANKING

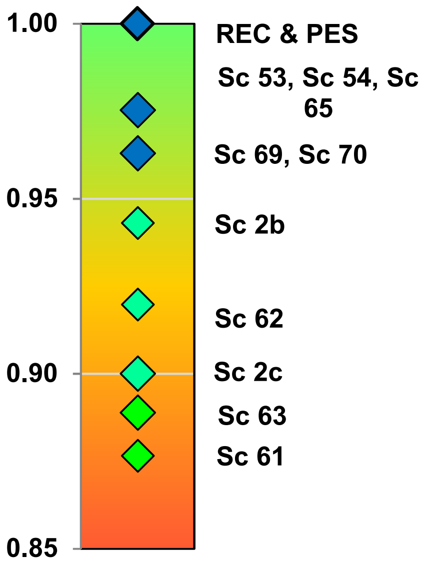
The first step in the process to determine an integrated ranking is to determine the relative importance of the different EWR sites occurring in the study area. The site weighting process indicated that MzimEWR4 carries the highest weight due to the site being the most downstream site in the study area and represents the accumulated impact of all upstream activities. Once the weighting was applied to the ranking value for each scenario at each EWR site, an integrated score and ranking for the operational scenarios, was derived as shown below.

INTEGRATED RIVER RANKING



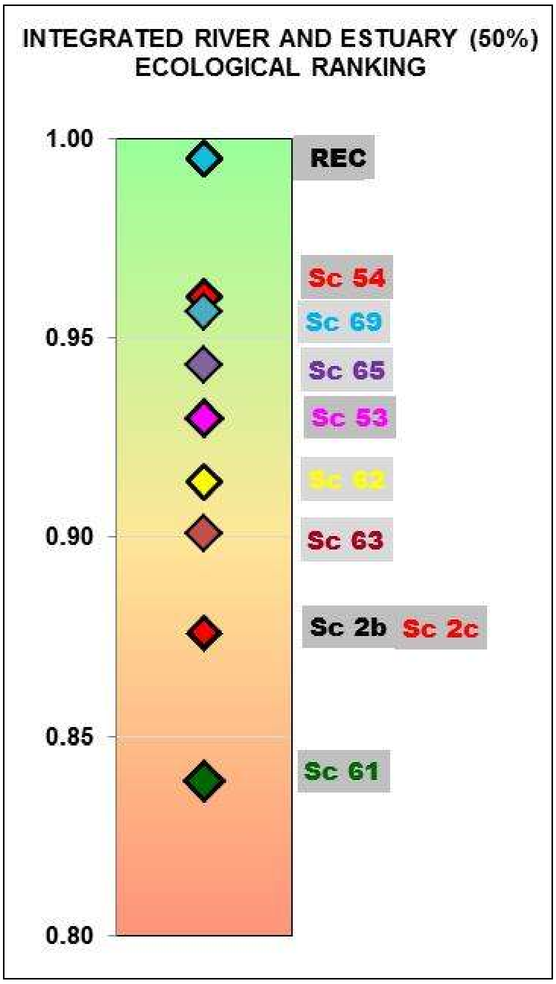
ECOLOGICAL CONSEQUENCES: ESTUARY

Scenario 53, 54 (optimised scenario; see Section 8.4 of the Phase 1 consequences report, Report no. WE/WMA7/00/CON/CLA/1117), 65 and 69 (and therefore also Sc 70) will maintain PES (and therefore the REC) of the Mzimvubu Estuary and is a significant improvement on the other scenarios. This is due to the decreased baseflows being closer to natural compared to the other scenarios. As Sc 69 has been recommended as the optimal scenario for the river sites, it is considered acceptable as the scenario of choice for the estuaries. The estuary ecological ranking of the Phase 2 scenarios is shown below.



RIVER AND ESTUARY INTEGRATED ECOLOGICAL CONSEQUENCES

To provide the ecological metric as input to the Water Resource Class Determination Tool, the rivers and estuaries must be reduced to a final ecological ranking, expressed relative to how the scenarios achieve the REC. This means that as the river EWR sites were weighted (**Section B2.5**), the estuary must now also be weighted and all EWR site weights adjusted pro rata. Factors considered in the rating are ecological and conservation importance, the PES, the functionality of the estuary, the sensitivity of the estuary to scenario changes and the length or size (area) of the river and estuary respectively. Due to the ecological and socio-economic importance of the Mzimvubu Estuary, a weight of 50% was applied to the estuary (although 30% and 40% were also tested – ranking order was the same under all weightings). The integrated ecological consequences for the rivers and estuary is shown below.



CONCLUSIONS AND RECOMMENDATIONS

For both the estuary and river sites, Scenarios 54 and 69 are the recommended options. As Sc 54 is based on 2014 operational options, the recommendations (from an ecological viewpoint) will focus on Scenario 69. In conclusion, the optimisation of the dam design and meeting of EWRs must be conducted by the dam designers. From an ecological point of view, increased flows from releasing the full EWR below Lalini Dam, for example, would be acceptable as long as the balance of flows below the outlet are the same as for Scenario 69, so as to meet ecological recommendations. For the assessment purposes, a D EWR low flow was used from Lalini Dam. However, the exact flow required to make the additional hydropower facility cost-effective must be determined by the developers. As long as the flows downstream of the outfall are as for Scenario 69, the EWR flows released could be the D EWR low flows or any higher flows.

TABLE OF CONTENTS

DOCUMENT INDEX .... **B-i**
APPROVAL .... **B-ii**
ACKNOWLEDGEMENTS .... **B-iii**
AUTHORS .... **B-iv**
REPORT SCHEDULE .... **B-iv**
EXECUTIVE SUMMARY .... **B-v**
TABLE OF CONTENTS .... **B-xii**
LIST OF TABLES .... **B-xiv**
LIST OF FIGURES .... **B-xv**
B1: INTRODUCTION **B1-1**
B1.1 BACKGROUND B1-1
B1.2 PHASE 2 OF SCENARIO MODELLING B1-2
b1.3 SUMMARISED DESCRIPTION OF SCENARIOS B1-5
B1.3.1 Scenario 2b B1-5
B1.3.2 Scenario 2c B1-5
B1.3.3 Scenario 53 .... B1-5
B1.3.4 Scenario 54 .... B1-5
B1.3.5 Scenario 61 .... B1-5
B1.3.6 Scenario 62 .... B1-5
B1.3.7 Scenario 63 .... B1-6
B1.3.8 Scenario 65 .... B1-6
B1.3.9 Scenario 69 .... B1-6
B1.3.10 Scenario 70 .... B1-6
B2: PHASE 2 SCENARIO ASSESSMENT – RIVER CONSEQUENCES **B2-1**
B2.1 ECOLOGICAL CONSEQUENCES: MZIMEWR4 (MZIMVUBU RIVER) B2-1
B2.1.1 Evaluated Scenarios B2-1
B2.1.2 Consequences B2-1
B2.1.3 Conclusions B2-5
B2.2 ECOLOGICAL CONSEQUENCES: MZIMEWR1 (TSITSA RIVER) B2-5
B2.2.1 Evaluated Scenarios B2-5
B2.2.2 Consequences B2-5
B2.2.3 Conclusions B2-9
B2.3 ECOLOGICAL CONSEQUENCES: EWR1 LALINI (TSITSA RIVER) B2-9
B2.3.1 Evaluated Scenarios B2-9
B2.3.2 Consequences B2-9
B2.3.3 Conclusions B2-10
B2.4 CONCLUSIONS: RIVER ECOLOGICAL CONSEQUENCES B2-10
B2.5 INTEGRATION OF CONSEQUENCES FOR RIVER SITES B2-11
B3: PHASE 2 SCENARIO ASSESSMENT – MZIMVUBU ESTUARY CONSEQUENCES ... **B3-13**
B3.1 ABIOTIC STATES UNDER PHASE 2 SCENARIOS B3-13
B3.2 HYDROLOGY B3-18
B3.3 PHYSICAL HABITAT B3-19
B3.4 HYDRODYNAMICS AND MOUTH CONDITION B3-20
B3.5 WATER QUALITY B3-21
B3.6 MICROALGAE B3-22

B3.7 MACROPHYTES B3-23
B3.8 INVERTEBRATES B3-24
B3.9 FISH B3-25
B3.10 BIRDS B3-26
B3.11 ECOLOGICAL CATEGORIES ASSOCIATED WITH PHASE 2 SCENARIOS B3-27
B3.12 CONCLUSIONS: ESTUARY ECOLOGICAL CONSEQUENCES B3-27
B4: INTEGRATED RIVER AND ESTUARY RESULTS AND FINAL RECOMMENDATIONS B4-1
B4.1 RIVER AND ESTUARY RANKING B4-1
B4.2 RIVER AND ESTUARY INTEGRATED ECOLOGICAL CONSEQUENCES B4-1
B4.3 CONCLUSION AND RECOMMENDATIONS B4-2
B5: REFERENCES B5-1
APPENDIX C: PHASE 2 SCENARIOS – ESTUARINE RUNOFF SIMULATIONS C-1
SCENARIO 61 (m^3/s) C-1
SCENARIO 62 (m^3/s) C-2
SCENARIO 63 (m^3/s) C-3
SCENARIO 65 (m^3/s) C-4
SCENARIO 69 (m^3/s) C-5
APPENDIX D: COMMENTS REGISTER D-1

LIST OF TABLES

Table B1.1	Scenario matrix (mostly Phase 2 of modelling)	B1-3
Table B2.1	MzimEWR4: Consequences of the scenarios on the driver and response component Ecological Categories	B2-1
Table B2.2	MzimEWR4: Ecological consequences	B2-4
Table B2.3	MzimEWR1: Consequences of the scenarios on the driver and response component Ecological Categories	B2-5
Table B2.4	MzimEWR1: Ecological consequences	B2-8
Table B2.5	EWR1 Lalini: Ecological consequences	B2-10
Table B2.6	Weights allocated to EWR sites relative to each other	B2-11
Table B2.7	Ranking value for each scenario resulting in an integrated river score and site ranking	B2-12
Table B3.1	Description of Mzimvubu additional future scenarios	B3-13
Table B3.2	Summary of the monthly flow (in m^3/s) under Sc 61	B3-13
Table B3.3	Summary of the monthly flow (in m^3/s) under Sc 62	B3-14
Table B3.4	Summary of the monthly flow (in m^3/s) under Sc 63	B3-14
Table B3.5	Summary of the monthly flow (in m^3/s) under Sc 65	B3-14
Table B3.6	Summary of the monthly flow (in m^3/s) under Sc 69	B3-15
Table B3.7	Summary of change in low flow conditions under reference, present and Phase 2 scenarios	B3-18
Table B3.8	Summary of twenty highest simulated monthly volumes under reference, present and Phase 2 scenarios	B3-18
Table B3.9	Summary of hydrological changes under present and Phase 2 scenarios	B3-19
Table B3.10	Hydrology health scores for present and Phase 2 scenarios	B3-19
Table B3.11	Summary of physical habitat changes under additional future scenarios	B3-19
Table B3.12	Physical habitat health scores for present and future scenarios	B3-20
Table B3.13	Summary of occurrence of abiotic states under the reference (ref), present (pres) and Phase 2 scenarios	B3-20
Table B3.14	Summary of hydrodynamic changes under Phase 2 scenarios	B3-20
Table B3.15	Hydrodynamic health scores for present and Phase 2 scenarios	B3-21
Table B3.16	Summary of changes in average water quality concentrations under Phase 2 scenarios	B3-21
Table B3.17	Water quality health scores for present and Phase 2 scenarios	B3-22
Table B3.18	Summary of changes in microalgae under Phase 2 scenarios	B3-22
Table B3.19	Microalgae health scores for present and Phase 2 scenarios	B3-23
Table B3.20	Summary of changes in macrophytes under Phase 2 scenarios	B3-24
Table B3.21	Macrophytes health scores for present and Phase 2 scenarios	B3-24
Table B3.22	Summary of changes in invertebrates under Phase 2 scenarios	B3-24
Table B3.23	Invertebrate health scores for present and Phase 2 scenarios	B3-24
Table B3.24	Summary of changes in fish under Phase 2 scenarios	B3-25
Table B3.25	Fish health scores for present and Phase 2 scenarios	B3-26
Table B3.26	Summary of changes in birds under Phase 2 scenarios	B3-26
Table B3.27	Bird health scores for present and Phase 2 scenarios	B3-26
Table B3.28	EHI score and corresponding ecological categories under present, recommended flow from Phase 1 (Scenario 53) and Phase 2 scenarios	B3-27

LIST OF FIGURES

Figure B1.1 Project plan for the Mzimvubu Classification study B1-1
Figure B1.2 Scenario flow diagram showing the linkages between scenarios B1-3
Figure B1.3 Simplified schematic of the Mzimvubu Water Project (DWS Design Phase, 2017) B1-4
Figure B2.1 MzimEWR4: Ecological ranking of Phase 2 operational scenarios B2-4
Figure B2.2 MzimEWR1: Ecological ranking of Phase 2 operational scenarios B2-9
Figure B2.3 EWR1 Lalini: Ecological ranking of Phase 2 operational scenarios B2-10
Figure B2.4 Integrated ecological ranking of the scenarios on the Tsitsa and Mzimvubu rivers B2-12
Figure B3.1 Occurrence of the various abiotic states under Sc 61 .....B3-15
Figure B3.2 Occurrence of the various abiotic states under Sc 62 .....B3-16
Figure B3.3 Occurrence of the various abiotic states under Sc 63 .....B3-16
Figure B3.4 Occurrence of the various abiotic states under Sc 65 .....B3-17
Figure B3.5 Occurrence of the various abiotic states under Sc 69 .....B3-17
Figure B3.6 Mzimvubu Estuary: Ecological ranking of additional operational scenarios B3-28
Figure B4.1 Integrated ecological ranking with the Mzimvubu Estuary weighted at 50% B4-1

B1: INTRODUCTION

B1.1 BACKGROUND

The Department of Water and Sanitation (DWS) initiated this study to determine Water Resource Classes and associated RQOs for the Mzimvubu catchment in Water Management Area (WMA) 7. The main aims of the project, as defined by the Terms of Reference (ToR), is to undertake the following:

- Coordinate the implementation of the Water Resource Classification System (WRCS) as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine Resource Quality Objectives (RQOs) using the DWS's procedures to determine and implement RQOs for the defined classes, and
- review work previously done on Ecological Water Requirements (EWRs) and the Basic Human Needs Reserve (BHNR) and assess whether suitable for the purposes of Classification.

This document serves to define operational scenarios and to identify scenarios for further analysis, as well as the context of the scenarios and how they fit into the integrated steps of the WRCS process, i.e. Step 4 (**Figure B1.1**).

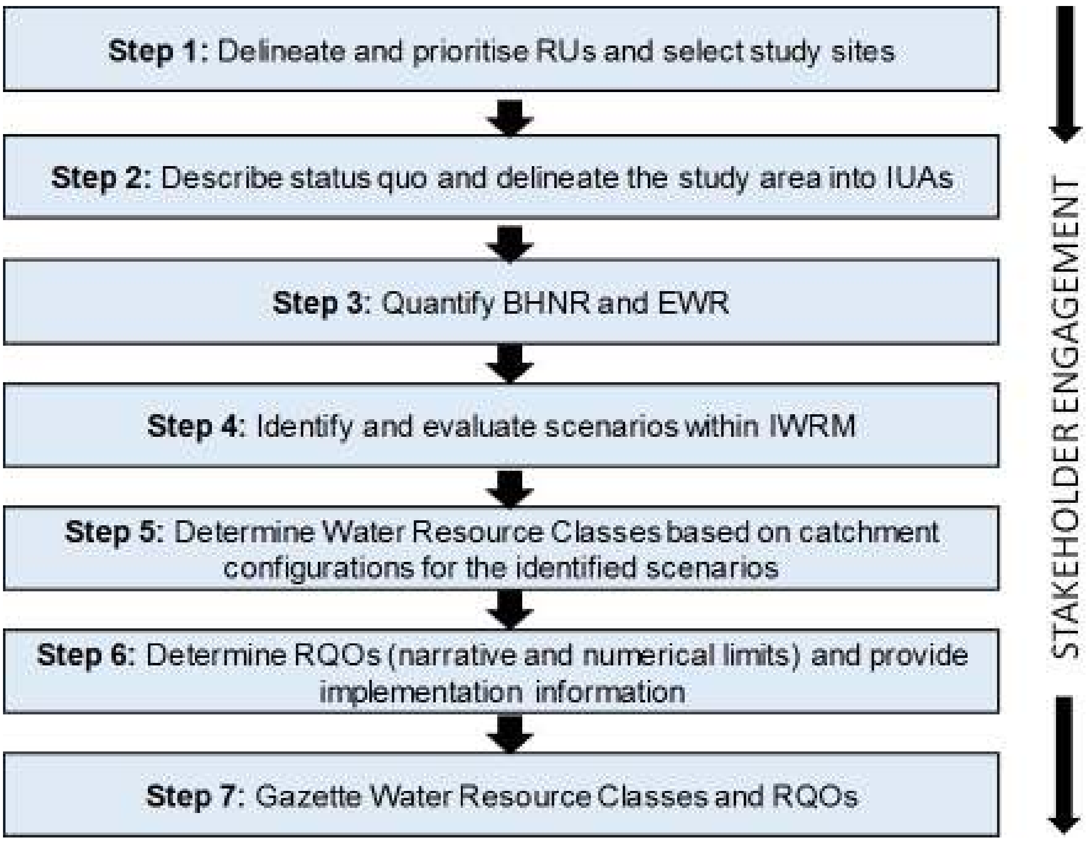


Figure B1.1 Project plan for the Mzimvubu Classification study

B1.2 PHASE 2 OF SCENARIO MODELLING

The main body of this report serves to define operational scenarios and to identify scenarios for analysis, as well as the context of the scenarios and how they fit into the integrated steps of the WRCS process, i.e. Phase 1 of scenario modelling. The associated ecological consequences are also presented. This appendix (**Appendix B**) then reports on the ecological (rivers and estuary) consequences to a second set of scenarios modelled during October 2017. Refined infrastructure design information and optimised hydropower operating rules became available from the design phase of the Mzimvubu Water Project (MWP) shortly after the first phase of the scenario analysis had been completed. Scenarios 61–69 (**Table B1.1**) were therefore run as the second phase of modelling and used the latest available dam design and operations information. Information regarding the design and proposed operation of the Ntabelanga and Lalini dams and HEPPs were taken from van Wyk and de Jager (2016); also referred to as Pro-Plan design information or Design Phase (2017) of the MWP. The study was conducted on behalf of DWS.

The hydropower operating rules were significantly different to previous scenarios (Phase 1 of modelling, based on MWP information from the DWS Feasibility study of 2014), and influenced flows at the EWR sites located downstream of the planned hydropower plant. Operations were different as follows:

- MWP (Feasibility Study, 2014): Lalini Dam is drawn down continuously and supported by Ntabelanga when the water levels reached the Dead Storage Level i.e. water is kept in Ntabelanga Dam.
- MWP (Design Phase, 2017): Lalini Dam is operated to stay at ±75% nett storage i.e. when the dam level ≤±75% nett storage, support is provided from Ntabelanga Dam up to a minimum level to avoid failure. Lalini Dam is therefore 'kept full' for maximum head.

More detailed information about the modelling can be found in the Scenario Description Report, Report No. WE/WMA7/00/CON/CLA/0517 (DWS, 2017). Note that only the scenarios relevant to Phase 2 of modelling are shown in **Table B1.1**. A flow diagram to illustrate the development of the scenarios are provided as **Figure B1.2**. Scenarios 2b, 53 and 54 are included from Phase 1 of the modelling for comparative purposes. These were used as a benchmark for the optimisation process followed to define scenarios with the new operating rules.

All scenarios included updated water demands projected to 2040 at an *ultimate projection*, i.e. including all identified demands associated with increased growth from the current development levels (present day), and are the demands imposed to fully utilise the available yield of the new proposed dams.

A simplified schematic of the MWP is illustrated in **Figure B1.3**. From the figure it can be seen that hydro-electric power plants (HEPPs) are proposed as follows:

1. Ntabelanga Dam HEPP: Located at the Ntabelanga Dam and ultilises the EWR releases and Lalini Dam support releases to generate electrical power.
2. Lalini Dam HEPP: Located at the Lalini dam utilises the EWR releases from the Lalini Dam to generate power.
3. Main HEPP: Located below the Tsitsa Falls and utilises releases from the Lalini Dam through a water conveyance system and the water is then discharged back into the river downstream of the falls.

Table B1.1 Scenario matrix (mostly Phase 2 of modelling)

Scenario (Sc)	EWR			Development options	
	Mzim EWR4	Mzim EWR1	EWR1 Lalini (scaled)	MWP (Feasibility Study, 2014)	MWP (Design Phase, 2017)
2b	No	No	No	Yes	No
2c	No	No	No	No	Yes
53	Low	Low	No	Yes – Further reduced hydro in dry months	No
54	Low	Low	D Low	Yes – Further reduced hydro in dry months	No
61	Low	Low	D Low	No	Yes
62	Low	Low	D Low	No	Yes – Reduced hydro in dry months[1]
63	Low	Low	D Low	No	Yes – Reduced hydro in dry months (Increased hydro capacity in wet months)
65	Low	Low	D Low	No	Yes – Further reduced hydro in dry months
69	Low	Low	D Low	No	Yes – Further reduced hydro in dry months (Increased hydro capacity in wet months)

Hydro: hydrology

[1] Reduced hydropower implies a reduction in the hydropower output initially envisaged. This reduction is undertaken to minimise the impact of increased baseflows in the downstream river in an attempt to reach ecological targets. The economic implications of the reduction will be reported on in the Non-ecological Consequences Report.

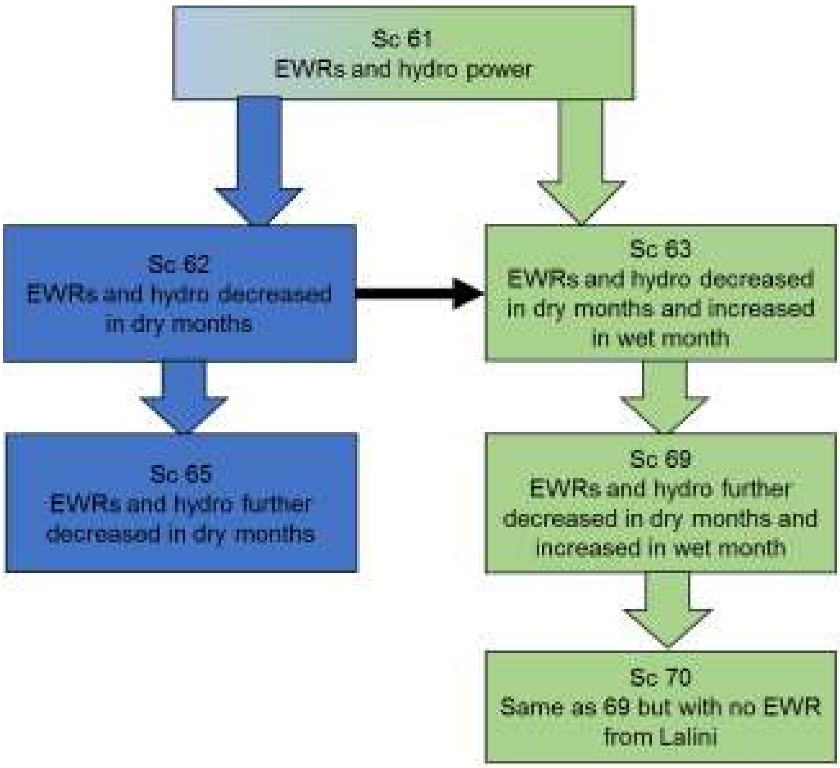


Figure B1.2 Scenario flow diagram showing the linkages between scenarios

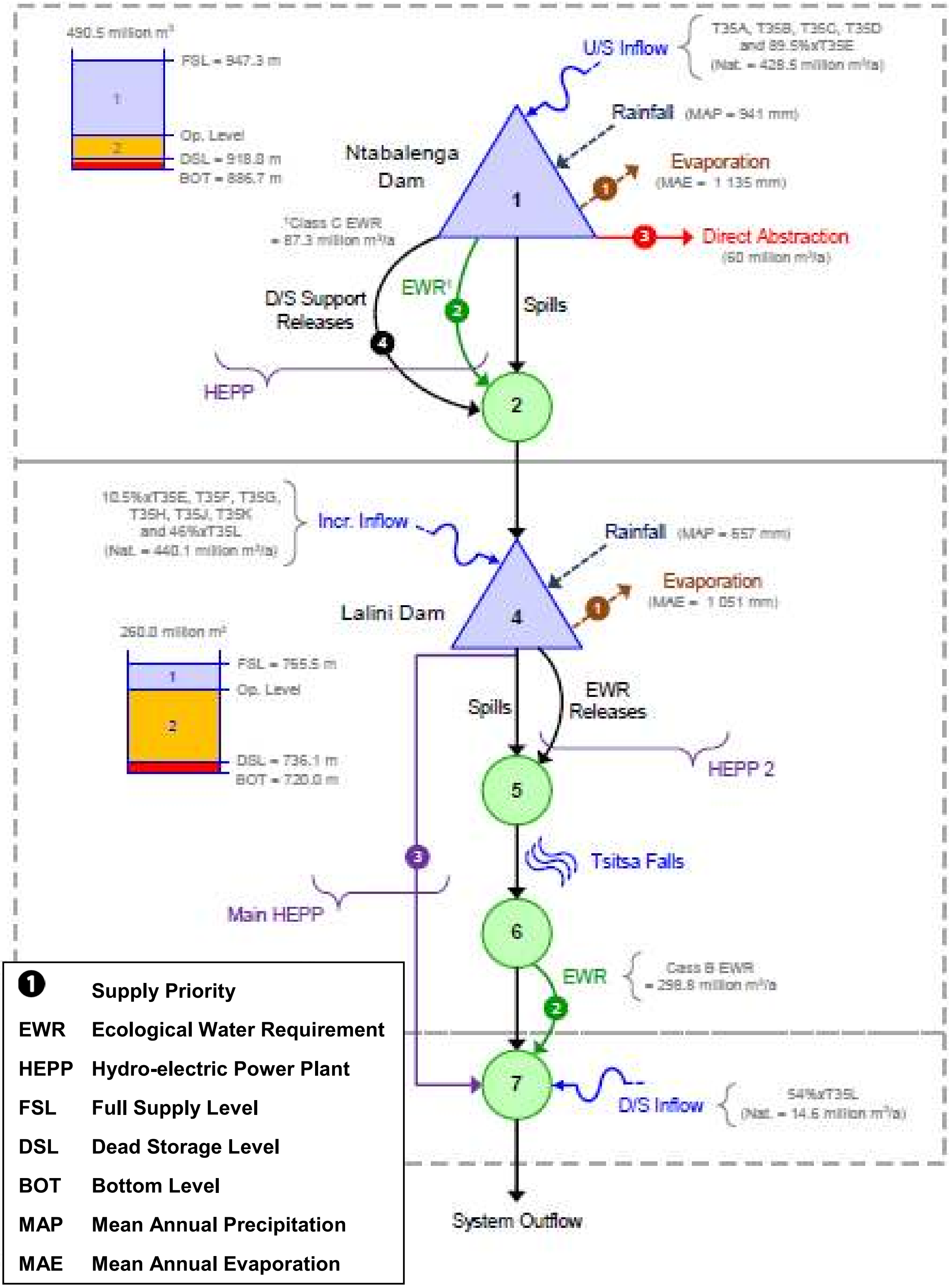


Figure B1.3 Simplified schematic of the Mzimvubu Water Project (DWS Design Phase, 2017)

B1.3 SUMMARISED DESCRIPTION OF SCENARIOS

B1.3.1 Scenario 2b

Scenario 2b fully utilises the available yield of the new proposed dams, following the design of the MWP Feasibility study of 2014. This scenario was assessed during Phase 1 and is included for comparison purposes.

B1.3.2 Scenario 2c

Scenario 2c was based on Scenario 2b but with the latest MWP infrastructure design information and optimised hydropower operating rules from the design phase of the project incorporated, i.e. the MWP Design Phase of 2017. The operating rules are significantly different to the rules applied in Scenario 2b, which influences the flows at the EWR sites. Apart for the MWP hydropower generation, there are no other users influenced by the different water requirements projections. Less water is available for hydropower and the environment with the ultimate development projection, which is more conservative. The DWS Feasibility Study and the Design Phase both used the ultimate development projection for the domestic supply from the MWP.

B1.3.3 Scenario 53

Scenario 53 was based on Scenario 51 but with the hydropower generation further reduced in the dry winter months. Initial analysis of Scenarios 51 and 52 showed that the increase in baseflows due to hydropower releases were still problematic and needed to be reduced further. There is no EWR release from Lalini Dam under this scenario. See Scenario 70 for further explanation regarding the Lalini Dam situation.

B1.3.4 Scenario 54

Initial investigations showed that Scenario 53 was likely to achieve the ecological objectives. However, it included no flows for the reach immediately downstream of the proposed Lalini Dam and as the Tsitsa Falls may be dry frequently, it was felt that this would be an environmental flaw. To test the economic implications, a D category low flow EWR was released from Lalini Dam to ensure no zero flows from the dam to the outlet. The total volume whether released via the canal/pipeline or into the river, will therefore be the same as for Sc 53. This would ensure flow over the falls at all times but would drop the Ecological Category in the reach and may have additional (to Scenario 53) economic impacts. The flow to be provided in the reach.

B1.3.5 Scenario 61

Scenario 61 includes the 2017 MWP design phase information and EWR releases. The hydropower operating rules are significantly different to the rules applied in Scenario 2b, which influences the flows at the EWR sites.

B1.3.6 Scenario 62

Scenario 62 was based on Scenario 61 but with the hydropower generation reduced in the dry winter months. The hydropower generation in the wetter summer moths was as per the latest hydropower infrastructure capacities and operating rules received from the design team.

The purpose of the scenario was to decrease the flows at MzimEWR4 and especially the estuary, as it could be seen that the previous modelled scenarios would provide unnaturally high and constant baseflow.

B1.3.7 Scenario 63

Scenario 63 was based on Scenario 62 but with the hydropower generation design capacity increased in the wet summer months to utilise the additional storage gained (due to the reduced hydropower generation in the dry winter months) for additional hydropower generation in the wet summer months.

B1.3.8 Scenario 65

Scenario 65 was based on Scenario 62 where hydropower generation was further reduced during the dry winter months. Initial analyses of Scenario 62 showed that the increased baseflows due to hydropower releases were still a problem and needed to be reduced further.

B1.3.9 Scenario 69

Scenario 69 was based on Scenario 63, where hydropower generation was further reduced during the dry winter months. The aim would be to come as close as possible to Scenario 54 which was the optimised scenario evaluated during the first round of assessments. Initial analyses of Scenarios 63 showed that the increased hydropower generation design capacity with the associated increased hydropower releases in the wet summer months was acceptable from an ecological perspective, but that the baseflows due to hydropower releases in the dry months were still a problem and needed to be reduced further, as with Scenario 62.

B1.3.10 Scenario 70

Scenario 70 was not modelled (and therefore does not appear in the scenario matrix table) as flows are the same or similar to Scenario 69. The difference between Scenario 70 and Scenario 69 is that, as for Scenario 53, Scenario 70 does NOT include an EWR flow release from Lalini Dam. The 4.8 km river reach between the Lalini Dam and Tsitsa Falls will be dry except for when the dam spills, which will be of aesthetic, socio-cultural, tourism and recreational concern. The rest of the reach (13.5 km) to the outfall will also be dry except for spills and inflows of some tributaries (note that there are no significant tributaries between the dam wall and the falls). The evaluation was therefore for a NO EWR flow over the falls, and the impact thereof. The ecological impact of this situation is the same as for Scenario 53 and will therefore not be evaluated. Ecosystem services, recreation and tourism impacts were evaluated for this scenario.

In conclusion, the optimisation of the dam design and meeting of EWRs must be conducted by the dam designers. From an ecological point of view, increased flows from releasing the full EWR (i.e. a C category EWR flow to be harnessed for hydropower at Lalini Dam HEPP (van Wyk and de Jager, 2016)), would be acceptable as long as the balance of flows below the outlet are the same as for Scenarios 53, 54 and 69, so as to meet ecological recommendations.

B2: PHASE 2 SCENARIO ASSESSMENT – RIVER CONSEQUENCES

B2.1 ECOLOGICAL CONSEQUENCES: MZIMEWR4 (MZIMVUBU RIVER)

B2.1.1 Evaluated Scenarios

Scenarios 2b, 53 and 54 were evaluated during Phase 1 of scenario modelling and the ecological consequences are repeated here for comparison purposes. Scenarios 61, 62, 63, and 65 were evaluated as part of Phase 2 modelling. The analysis of the operational scenarios indicated that the following scenarios were similar and no distinguishable ecological responses could be differentiated:

- **Sc 53** = Sc 54 = Sc 69 = Sc 70
- **Sc 61** = Sc 2c

B2.1.2 Consequences

A summary explanation of the consequences of the scenarios compared to the PES and the REC are provided in **Table B2.1**.

Table B2.1 MzimEWR4: Consequences of the scenarios on the driver and response component Ecological Categories

Physico-chemical variables						
PES and REC	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**
A/B: 88.3%	A: 93.5%	A/B: 91.85%	A: 93.5%	A/B: 90%	A/B: 90%	A/B: 90%
Water quality state at MzimEWR4 is good, with a slight impact from nutrient load and increased turbidities. ▪ Sc 2b: Results in an improvement to an A Category as there is substantially more water than the PES EWR requirements, resulting in a dilution of the small nutrient load. The impact of the upstream dams will result in the trapping of sediments, resulting in clearer water, which would be more similar to the natural state. ▪ Sc 53: Conditions may stay in an A/B Category due to slightly lower flows in dry months as compared to other scenarios. ▪ Sc 61, Sc 62, Sc 63 and Sc 65: Scenario 61 will move the category into an A as there is substantially more water than the PES EWR in the dry season. As the current water quality state is already an A/B Category, the resolution does not exist to easily differentiate between the other scenarios. They may therefore stay in an A/B Category but improve slightly. NOTE that the confidence in this assessment would be higher if more operational detail was available to inform the water quality assessment. A multi-level release is assumed.						
Geomorphology						
PES and REC	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**
C: 76.5%	C: 76.5%	C: 76.5%	C: 77.4%	C: 77.4%	C: 77.4%	C: 77.4%
▪ Sc 2b: No spill data was available for analysis. However, given that no EWR is being released, the frequency of spills will increase as more water is retained in the dam. No change in the PES is expected. ▪ Sc 53: No spill data for Lalini was available and therefore the scenario could not be evaluated. However it is not likely to be very different to the PES. ▪ Sc 61, Sc 62, Sc 63 and Sc 65: Flows under all these scenarios are very close to annual in the wet season and increased by about 50% in the dry season. As under present day conditions the site will continue to be impacted by upstream catchment erosion but flows will be sufficient to move most excess sediment. There may be some local armouring of gravel beds due to increased dry season flows and scour of sand deposits. NOTE that the confidence in this assessment would be higher if more detail and information (e.g. from sediment modelling) were available to inform the geomorphological assessment.						

Riparian vegetation						
PES and REC	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**
C/D: 59.4%	D: 55.7%	C/D: 59.4%	E: 36.5%	D 46.7%	D 46.7%	C/D: 61.4%

The expected proportion of marginal zone vegetation inundation in the dry season is 4.4% or 11.1% under natural flow conditions. These values are 20%, and 8.9% for Sc 2b, and 53 respectively. Inundation in the dry season is therefore more than natural, except for Sc 53, which will result in marginal zone shrinkage as vegetation succumbs to inundation stress at periods of low growth.

- Sc 61: This scenario has markedly higher flows in the dry season compared to all other scenarios and natural, and at mid to high percentiles i.e. the ecological experience is severe inundation stress for marginal and lower zone vegetation during the dry season. The marginal zone will not and the lower zone is also likely to shrink.
- Sc 69 is similar to Sc 53 with slightly more flow in the dry season but only at lower percentiles. Ecologically there is no significant difference that results in any change to the VEGRAI scoring.
- Sc 62 and Sc 63: Ecologically similar and both are generally either similar to, or higher than Sc 53. Frequently flows are more than Sc 53, particularly at higher percentiles and in some wet season months and for most of the dry season. Flows are also mostly higher than natural. The result will be shrinkage of the marginal and lower zones and the marginal zone may even become undefined. Scenario 62 and 63 result in more flow (worse) than Sc 2a and 2b in most wet season months.
- Sc 65 is similar to Sc 69. Most months are indiscernible but with flows slightly higher in October and lower in November and April at high percentiles. Flows are similar in the dry season and at low to mid percentiles but lower at higher percentiles in the wet season (closer to natural). Sc 65 is better than Sc 53 in the wet season i.e. the lower wet season is closer to natural. Vegetation will respond similarly to that described for Sc 53, but to a slightly higher degree i.e. more of an improvement.

Fish						
PES and REC	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**
C: 76.1%	B/C: 81.8%	B: 82.8%	C: 64.3%	C: 69.8%	C: 69.6%	C: 74%

- Sc 2b: All scenarios assessed are expected to improve the ecological state from a PES of C towards a Category B/C. The improvement is associated with improved water quality, as well as general improvement in fast habitat for fish (fast shallow to fast deep), availability and quality (higher dry season flows may flush sediment from rocky substrates). This improvement will especially benefit the four eel species (improvement in food source and general habitat conditions). The higher than natural (and present) dry season flows may have a slightly negative impact on vegetative cover (marginal zone and aquatic vegetation), as well as the availability of slow habitats for fish (slow shallow and slow deep). These changes are however expected to be minimal and would not negate the positive impact of the wet season flows as well as improved fast habitats in the dry season. Seasonality will remain unchanged and migratory cues and depth (for longitudinal migration) will be adequate under all scenarios.
- Sc 53: The improvement will be more significant under this scenario which is expected to improve the fish towards a Category B. This improvement is primarily attributed to improved marginal vegetation conditions (not exceeding natural dry season flows), and hence being more favourable for species such as *Barbus anoplus* and *Oreochromis mossambicus*. Scenario 69 is similar to Sc 53 with a slight improvement in conditions towards a Category B expected. Habitat suitability and availability is generally better than under present day (especially fast habitat during dry season), while better water quality is also expected.
- Sc 61: The fish assemblage is expected to decrease towards a much lower Category C (risk of moving over to a C/D). Although water quality is expected to improve (based on water quality assessment), a significant deterioration in the marginal vegetation habitat cover for fish is expected (riparian zone assessment). This can be expected to impact significantly on various species with a preference for this feature. The habitat availability (and condition) of both fast and slow habitats will also be lower in especially the dry season, and some increased sedimentation of bottom substrates may also occur.
- Sc 62 and 63: The impact on the habitat availability and condition will be similar in these two scenarios, being especially notable on fast habitats during the dry season, and slow habitat during drought condition in the dry season. Vegetative cover for fish will also be lower than under present day, while some seasonality changes is evident under Sc 63. Overall the fish assemblage will deteriorate but remain within the Category C (as the PES and REC).
- Sc 65: A slight decrease in the fish assemblage is expected but it will remain within a Category C (PES and REC). The expected decrease is attributed to slight deterioration in fast and slow habitats during dry season droughts, slightly less suitable vegetative habitats and slight seasonality changes.

Macroinvertebrates						
PES and REC	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**
C: 74.1%	C: 73.1%	B: 85.2%	C/D: 61.6%	C: 74.1%	C: 65.9%	C: 74.1%

- Sc 2b: Elevated wet season flows will result in an increase in diversity and abundance of the macroinvertebrate taxa, which should result in the community more closely resembling the reference community. However during the dry season, elevated flows and the associated increase in habitat availability result in increased abundances of both Flow Dependent Invertebrates (FDIs) and taxa with a preference for Marginal Vegetation (MVIs). Seasonal cues are altered and this is likely to affect reproductive patterns. Under these scenarios, there is an increased opportunity for an imbalance to arise in the macroinvertebrate community, e.g. through dominance of a taxon that is particularly successful in the dry season as a result of elevated flows. The overall community deviation from natural (reference) increases (as shown in MIRAI), resulting in a lowering of the PES to a C Category. The macroinvertebrate response to these scenarios is likely to have the same effect on the PES.
- Sc 53: As flows emulate a very similar pattern and timing to those of natural hydrology, and water and habitat quality are somewhat improved, additional high-scoring taxa (such as the 'expected' taxa) may occur, and abundances will increase during the wet season months. The baseflow reductions that occur naturally in the dry season are mirrored in this scenario. As a result, the community will more closely resemble the natural or reference community. Therefore, deviation from natural (reference) decreases and the MIRAI PES score increases to 85% (B Category). During November and December, flows under Sc 69 exceed natural by a factor of up to 2 for approximately a third of the time. This implies that for short periods during these summer months one could anticipate up to double the natural flow in the system. The flows which exceed natural are however still within the 0-10 stress range for wet season, and this suggests that the biotic response should, if anything, be a positive one. The higher flows slightly elevate the velocities through the various biotopes, but lower velocity areas should still be present and the overall hydraulic habitat shift should be tolerated for short periods. While no assumptions can be made about the quality or temperature of the released water (due to lack of technical information), there is likely to be an improvement in habitat quality and quantity, and increased opportunity for the more sensitive flow dependent invertebrates to occupy it and therefore maintain the PES and REC.
- Sc 61: Emulates natural and present day during the summer months, however extremely elevated flows relative to natural and present day from May to October. During the summer months (November to April), flows are generally reduced relative to natural and present day, but still substantially higher than those of the PES EWR. The impact of the unseasonal high flows is not predictable and will be influenced by water temperature and quality. There is inadequate engineering information (e.g. level of dam release) on which to base assumptions. It is however likely that these high flows during an on-average lower flow period will over the longer term, have a substantial effect on the macroinvertebrate biota. The physical effects may include the flushing out of sediments and mobilising some of the cobble substrates, as well as the presence of high-velocity flow through the normally quiet marginal vegetation areas. This equates to a shift in habitat quality, diversity and availability. The biotic response could include reduced abundances of stone-dwelling taxa (which may be flushed out by high flows), a reduction in abundance and presence of those biota which would use marginal vegetation as a refuge area, and an increase in flow-dependent taxa in the marginal vegetation areas (this may lead to dominance of these taxa in the community). Over the longer term, macroinvertebrate breeding and development cycles - which are adapted to summer high flows and winter low-flows (on average) would be disrupted by this altered hydrological regime, and the community composition would likely adjust, favouring a more resilient fauna. Over the short term the REC would likely be met, however over the mid to long-term it is likely that the PES would deteriorate to a C/D Category and therefore the REC would not be met. This is a low-confidence assessment.
- Sc 62: October to early May the flows hover relatively close to those of natural and present day, and flows are well in excess of those for PES and REC. From mid-May to September, flows are somewhat raised relative to natural and present day, but still substantially lower than those of Sc 2c. The margin by which flows are elevated has the effect of increasing width and depth and average/maximum velocities, but not substantially (based on available hydraulic information). While this change in regime will affect both hydraulic habitat and biotic responses, it is difficult to predict in which direction, as it is likely that these increased flows (if one assumes good water quality and ambient water temperature) will have the effect of elevating the abundances of many of the flow-dependent macroinvertebrates, without the negative effect of flushing them out as in the case of Sc 2c. Overall, at a low confidence, the assessment is that REC is maintained under this scenario, despite the unseasonal raised flows.
- Sc 63: The major impact is during October when (total and low) flows are substantially higher than natural and present day. During July, August and September flows exceed natural and present day by a far smaller margin, but for the majority of the time. During the summer months, Sc 63 flow exceeds the PES and REC EWR. The relatively high flows during the early summer months are likely to disrupt or

Macroinvertebrates
shift natural cues to the biota (e.g. breeding, emergence) and to affect the habitat template (unnaturally high velocity flows through vegetation and boulder/cobble areas). Over the longer term, with this as a consistent flow pattern rather than an event, this is likely to have an effect on community structure and composition. Depending on water quality and temperature, there will be numerous shifts – for example, marginal vegetation (now serving as a high-velocity habitat) is likely to be colonised by flow-dependent taxa such as Simuliidae, which could then shift the community structure from balanced to dominated. A low-confidence revision of the MIRAI, based on predicted long-term outcomes, result in a downward shift in PES to 65.9%. ▪ Sc 65: This scenario emulates seasonal flows on average between natural, present day, and the PES and REC EWR. Higher flow exceedance values than natural are relatively few (October), and flows are below the REC EWR only for a small percent of the time in a few months. Scenario 65 is assessed as meeting the REC and was not evaluated further.

The resulting ECs for each component and the EcoStatus are provided in **Table B2.2**. The ranking of the scenarios is provided as a traffic diagram (**Figure B2.1**).

Table B2.2 MzimEWR4: Ecological consequences

Component	PES and REC	Sc 2b	Sc 53	Sc 61	Sc 62	Sc 63	Sc 65
Physico-chemical	A/B	A	A/B	A	A/B	A/B	A/B
Geomorphology	C	C	C	C	C	C	C
Riparian vegetation	C/D	D	C/D	E	D	D	C/D
Fish	C	B/C	B	C	C	C	C
Macroinvertebrates	C	C	B	C/D	C	C	C
EcoStatus	C (67.2%)	C (66.3%)	C (71.3%)	D (49.7%)	C/D (59.4%)	D (57.1%)	C (67.7%)

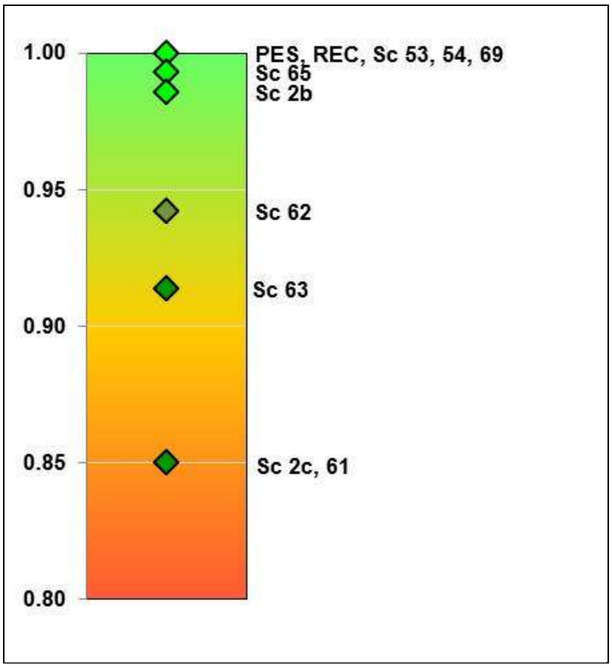


Figure B2.1 MzimEWR4: Ecological ranking of Phase 2 operational scenarios

B2.1.3 Conclusions

The ranking of the scenarios indicates that Sc 69 achieves the REC (and PES) requirements. Scenario 65 maintains the REC, with fish slightly deteriorating within the PES category. The rest of the scenarios result in a deterioration from the PES and REC, mainly due to increased baseflows above natural in the dry season impacting the middle and lower riparian zones, and ultimately the habitat availability for biota. As Sc 53 and 54 were not part of the 2017 design phase (Pro-Plan data), Sc 69 is recommended as the most suitable scenario.

B2.2 ECOLOGICAL CONSEQUENCES: MZIMEWR1 (TSITSA RIVER)

B2.2.1 Evaluated Scenarios

Scenarios 2b, 53 and 54 were part of the original scenario analysis and the ecological consequences are repeated here for comparison purposes with the Phase 2 scenarios. Scenarios 2c, 62, 63, 65 and 69 were evaluated additionally. The analysis of the operational scenarios indicated that the following scenarios were similar and no distinguishable ecological responses could be differentiated:

- **Sc 61** = Sc 2c
- **Sc 69** = Sc 70

B2.2.2 Consequences

A summary explanation of the consequences of the scenarios compared to the PES and the REC are provided in **Table B2.3**.

Table B2.3 MzimEWR1: Consequences of the scenarios on the driver and response component Ecological Categories

Physico-chemical variables							
PES and REC	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**	**Sc 69**
B: 86.4%	C/D: 61.8%	B: 87.3%	A/B: 90%	B: 87.3%	B: 87.3%	B: 86.4%	B: 87.3%
Water quality is good at Site MzimEWR1, with potential issues being related to slightly elevated nutrients and elevated turbidity levels. ▪ Sc 2b: Conditions worsen under dry season flows and become very poor, with impacts on salts, nutrients, temperatures, oxygen levels, turbidity and toxics. ▪ Sc 53: Dry season flows are similar to the PES EWR requirements, with an overall improvement in water quality under this set of scenarios due to improved nutrient and turbidity levels during the high flow season. However, water quality remains in a B Category. ▪ Sc 61, Sc 62, Sc 63, Sc 65, and Sc 69: In the dry season all scenarios show higher flows than the PES EWR most of the time, with Sc 61 flows much higher during some of the months. Flows under the other scenarios are also elevated as compared to the PES EWR during the wet season. These higher flows will result in an improvement in water quality due to the flushing out of any accumulated nutrients and sediments. NOTE that the confidence in this assessment would be higher if more operational detail was available to inform the water quality assessment. A multi-level release is assumed.							
Geomorphology							
PES and REC	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**	**Sc 69**
C: 68.7%	C: 68.7%	C: 68.7%	D: 45%	D: 55%	D: 55%	D: 55%	D: 55%
▪ Sc 2b: No spills data was available to evaluate this scenario. Given that no EWR is being released the frequency of spills will increase as more water is retained in the dam. ▪ Sc 53: The dam is full most of the time during the wet season so spills should be of sufficient volume to meet EWR Class 1–4 flood requirements. Larger floods are less likely to be achieved. Attenuation of flows means that increased volume is required to achieve the same peak as under natural conditions.							

Although the EWR is likely to be achieved, the frequency of floods is likely to be reduced from natural. Sediment trapped in dam but local input continues. Reduced sediment in flood flows often result in channel widening as flood benches cannot recover after large floods. Dry season baseflow is below present day but matches the EWR requirement. There may be some increase of fines on the bed. Overall, positive and negative impacts balance out and result in a C Category.

- Sc 61, Sc 62, Sc 63, Sc 65, and Sc 69: Flows in summer months for Sc 61 are significantly reduced below natural but above the EWR flows. High flows are maintained through the winter months. Sediment inputs will be greatly reduced by the Ntabelanga Dam, at least until the confluence with the Inxu River. This is likely to cause armouring of the bed and erosion of banks. Sand bars will be reduced in size. There will be significant loss of the marginal zone sediments. For Sc 62-69 the reduction in wet season flows below natural is less than for Sc 61 and there is no increase in wet season flows. The effects will be similar to those for Sc 61 but armouring may be less severe, bank erosion and loss of marginal habitat more severe.

NOTE that the confidence in this assessment would be higher if more detail and information (e.g. from sediment modelling) were available to inform the geomorphological assessment.

Riparian vegetation

PES and REC	Sc 2b	Sc 53	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
C/D: 59%	D/E: 40.2%	C/D: 61.4%	D/E: 40.8%	D 52.2%	D 52.2%	C/D: 59%	D: 56.2%

- Sc 2b: This scenario has more flows than the EWR requirement and mostly close to present day and natural, but in the dry season zero flows occur frequently. Stream permanency is reduced from 100% to 66% and is bordering a seasonal stream. Seasonality is maintained but becomes extreme in the dry season. The prevalence of the wet season base and higher flows will maintain the upper zone and bank woody vegetation and prevent encroachment to within the channel, but the lack of flows in the dry season will have severe impacts on marginal and lower zone grasses and sedges. Mortality from water stress is likely to be high and the marginal and lower zones are likely to support less vegetation to the point of being mostly bare. This, together with existing grazing pressure, will likely increase the probability of erosion.
- Sc 53: This scenario is similar to the EWR requirement in the dry season and more than the EWR requirement in the wet season, but less than natural. Seasonality and stream permanency remain intact. Spill analyses show that floods are met and some additional flooding occurs, mostly Class 2 to 4 floods. This will benefit the *Arundinella napalensis* population in the upper zone on the flood benches and also prevent encroachment of alien woody species such as wattle into the channel floor or towards the marginal zone.
- Sc 61, Sc 62, Sc 63, and Sc 69: At low percentiles (10-20%) all scenarios occur between REC and natural flows for most of the time except for Sc 61 which has markedly higher flows than both REC and natural during the dry season. This is even more marked at mid percentiles (40-60%) where Sc 62 and 63 also become more than natural. At high percentiles (80%) Sc 62, 63 and 69 edge higher than natural in the early wet season (Oct to Dec) but return to being around natural in the dry season. Scenario 62 is slightly better than Sc 63 in some months but overall the ecological response will be similar. Scenario 61 however has significantly more flow in the dry season than natural as well as the wet season such that natural seasonality is completely compromised. Higher flows (more than natural) in early summer will reduce marginal and lower zone vegetation to some degree as sub-zones shrink and shift, but higher flows (more than natural) in the dry season will likely result in more sever loss of such vegetation.
- Sc 65: Meets the REC and is not more than natural often enough to result in a discernible vegetation response.

Fish

PES and REC	Sc 2b	Sc 53	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
C: 68.3%	D: 51.6%	C: 71.6%	D: 51.6%	C: 68.3%	C: 68.3%	C: 68.3%	C: 68.3%

- Sc 2b: A significant deterioration can be expected in the fish assemblage, decreasing from a Category C to a D. The most significant impact on the fish is expected to be the cessation of flow during the dry season, resulting in notable loss of habitat (fast and slow habitats) for both expected fish species. The wet season flows may be slightly better than the PES but the slight improvement in habitat will be totally negated due to the lack of flow in the dry season. A notable deterioration in water quality is expected that may influence especially *B. anoplus*. The loss of marginal and possibly instream vegetation will furthermore impact significantly on this species. Seasonality will also be impacted due to the extreme low flows or cessation of flows in the dry season, transforming the river towards a seasonal system. The impact of the Lalini and Ntabelanga dams on migration were not considered, and can be expected to further aggravate the impact if not addressed.

- Sc 53: A slight improvement in the fish assemblage can be expected but the fish will remain in the same Ecological Category (C). The improvement is primarily attributed to slight improvement in water quality and generally improved habitat for fish in the wet season. No notable changes are expected in the dry season, while vegetative cover and substrate quality is expected to remain unchanged in terms of its suitability for fish. The impact of the Lalini and Ntabelanga dams on migration were not considered, and it can be expected that they may result in a decreased ecological status of this reach if adequate mitigation measures are not considered.
- Sc 61: A notable deterioration in fish is expected. Although water quality is expected to improve (based on water quality assessment), there will be a noted deterioration in the availability of marginal vegetation as cover for fish (*B. anoplus*). The significantly higher than natural (and PD) flows during the dry season will result in change in slow and fast habitat composition that will negatively impact on fish assemblage. The fish will furthermore be impacted by slight changes in seasonality (especially within seasons, such as higher flows during December and lower during February), that could disturb natural breeding and migratory cycles of indigenous fish species.
- Sc 62, Sc 63, Sc 65 and Sc 69: Although slight changes in conditions for fish may be expected (slightly improved water quality, and slight decrease in vegetative cover), the fish assemblage (two species) is not expected to change notably (remain within PES and REC). The seasonal changes (high flows in December and low in February) should be avoided should these scenarios be considered for implementation.

Macroinvertebrates							
PES and REC	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**	**Sc 69**
C: 72.9%	D/E: 41.2%	C: 72.9%	C/D: 61.4%	C: 72.9%	C: 65.4%	C: 72.9%	C: 72.9%

- Sc 2b: During the wet season total and baseflows match or exceed the flows set for the EWR, and approximate natural or PD at times. For the period of May to October (late summer, winter dry season and early summer), flows are either extremely low and there are long periods of no flow. The hydrology is thus transformed from perennial seasonal to temporary seasonal. The dry season macroinvertebrate taxa are adapted to a perennial seasonal flow regime and this transformation will initially result in the eradication of the more sensitive elements of the fauna, and ultimately the majority of the macroinvertebrate fauna (assuming sustained periods of zero flow and therefore dry-down). Only the most resilient taxa will survive in pools at the EWR site. It is uncertain to what extent the eggs laid in summer will become non-viable, but it is expected that a high percentage will be lost, so that recovery of the community during summer will be reliant on recolonisation. The MIRAI PES is based on the changes during the May to October period, as these will most likely govern the future character of the macroinvertebrate fauna.
- Sc 53: During the wet season, these flows approximate natural and PD flows. During the June to September period the proposed flows are similar to natural for a small percentage of the time, and for the balance of the time approximate the EWR flows. There may be a slight improvement in PES during the wet season; however, this is likely to be balanced by the effect of the reduced flows (relative to present day) during the dry season. It is expected that overall the macroinvertebrate PES will remain within a C Category, with slight variances in percentage between wet and dry season.
- Sc 61: Extremely high flows relative to natural and present day from May to October (May to August are winter and on average dry season months). As with EWR4, these elevated flows will certainly create a disruption to seasonal cues and will result in substantial outcomes for the biota. The physical effects on habitat may include the flushing out of sediments and mobilising some of the cobble substrates, and the presence of high-velocity flow through the normally quiet marginal vegetation areas. Low-velocity areas are reduced substantially. This equates to a shift in habitat quality, diversity and availability; and in hydraulic habitat terms, an increase in depth and velocity. The biotic response could include reduced abundances of stone-dwelling taxa (which may be flushed out by high flows), a reduction in abundance and presence of those biota which would use marginal vegetation as a refuge area (particularly juveniles), a flushing out of food sources such as algae, and an increase in flow-dependent taxa in the marginal vegetation areas (this may lead to dominance of these taxa in the community). Over the longer term, macroinvertebrate breeding and development cycles which are adapted to summer high flows and winter low-flows (on average) would be disrupted by this altered hydrological regime, and the community composition would likely adjust, favouring a more resilient fauna. Over the short term the REC would likely be met, however over the mid to long-term it is likely that the PES would decline to a C/D of 61.4 (MIRAI revised based on seasonal changes). This is a low-confidence assessment.
- Sc 62: Discharge exceeds natural and present day for part of the time in October, November and December. For the rest of the months, Sc 62 flows are elevated relative to PES/REC EWR but are lower than natural and present day. As the maximum flows predicted in October still equate to a wet season stress in the vicinity of 2, no adverse biotic response is predicted. While one cannot make assumptions about water quality and temperature in the absence of technical dam-release information,

- it is likely that the water quality will be good and, in this case, flow-dependent macroinvertebrates may increase in abundance. The REC will be maintained.
- Sc 63: For most of the month of October, discharges are well in excess of natural and present day discharges (by a factor of up to 3). High flows associated with Sc 63 during October (>16 m^3/s for 50% of the time) are higher than the discharges assigned a zero stress rating for the macroinvertebrates during the wet season (13.5 m^3/s). The implication is that these high flows are likely to have a negative effect on the biota over time, particularly as this is an early summer month during which breeding, egg-laying, hatching and emergence all occur for different life-stages. The various changes e.g. high velocity flows, scouring of habitat, flushing out of juvenile stages and other taxa, flushing out of food sources such as algae, are likely to have a cumulative negative effect over the longer term. A low-confidence revision of the MIRAI based on possible long-term outcomes result in a downward shift in PES to 65.4%.
- Sc 65: This scenario is assessed as meeting the REC and has not been evaluated further.
- Sc 69: During November and December, flows exceed natural for a large portion of the time, and during April for a short period. For most of this time, the flow values are within the 0-10 stress range for invertebrates for wet season. This suggests that the biotic response should, if anything, be a positive one. The higher flows slightly elevate the velocities through the various biotopes, but lower velocity areas should still be present and the overall hydraulic habitat shift should be tolerated for short periods. While no assumptions can be made about the quality or temperature of the released water (due to lack of technical information), there is likely to be an improvement in habitat quality and quantity, and increased opportunity for the more sensitive flow dependent invertebrates to occupy it.

The resulting ECs for each component and the EcoStatus are provided in **Table B2.4**. The ranking of the scenarios is provided as a traffic diagram (**Figure B2.2**).

Table B2.4 MzimEWR1: Ecological consequences

Component	PES and REC	Sc 2b	Sc 53	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
Physico-chemical	B	C/D	B	A/B	B	B	B	B
Geo-morphology	C	C	C	D	D	D	D	D
Riparian vegetation	C/D	D/E	C/D	D/E	D	D	C/D	D
Fish	C	D	C	C	C	C	C	C
Macro-invertebrates	C	D/E	C	C	C	C	C	C
EcoStatus	C (65.1%)	D (42.7%)	C (66.9%)	D (49.2%)	C/D (61.7%)	C/D (59.4%)	C (65.1%)	C (63.7%)

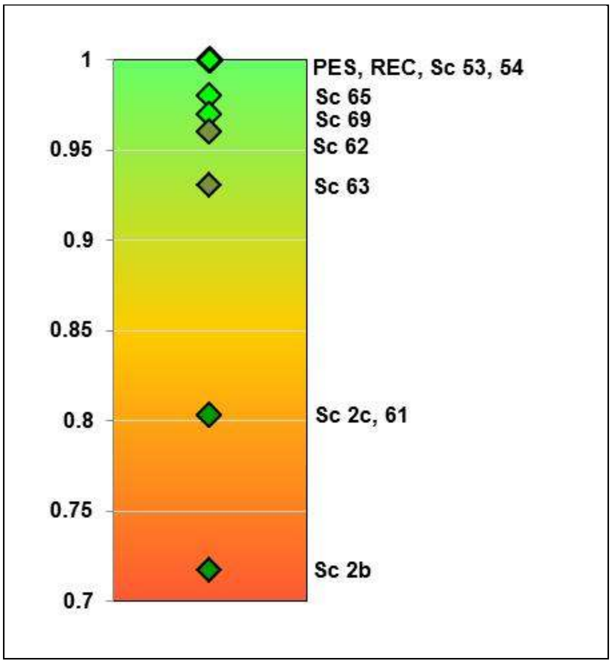


Figure B2.2 MzimEWR1: Ecological ranking of Phase 2 operational scenarios

B2.2.3 Conclusions

Scenarios 65 and 69 maintain the REC (and PES), with Sc 69 resulting in the riparian vegetation deteriorating due to increased baseflows. The rest of the scenarios result in deterioration from the PES and REC, mainly due to increased baseflows above natural in the dry season impacting the middle and lower riparian zones and ultimately the habitat availability for biota. As Sc 54 is not part of the Pro-Plan design, and Sc 69 is a better option at MzimEWR4, which is the driving river site, Sc 69 is recommended as the most suitable scenario.

B2.3 ECOLOGICAL CONSEQUENCES: EWR1 LALINI (TSITSA RIVER)

B2.3.1 Evaluated Scenarios

Scenarios 2b, 53 and 54 were part of the original scenario analysis and the ecological consequences are repeated here for comparison purposes with the Phase 2 scenarios. The analysis of the operational scenarios indicated that the following scenarios were similar and no distinguishable ecological responses could be differentiated:

- **Sc 2b** = Sc 53 = Sc 70
- **Sc 54** = Sc 2c = Sc 61 = Sc62 = Sc 63 = Sc 65 = Sc 69

B2.3.2 Consequences

A summary explanation of the consequences of the scenarios compared to the PES and the REC are provided in **Table B2.5.** All scenarios that include D category EWR flows (see scenario matrix) have similar ecological consequences as Scenario 54. It is assumed that under these scenarios the PES will degrade from a C to a D Ecological Category (EC), as the flows were designed to achieve this D category. This is only relevant for the section immediately downstream of the Lalini Dam to where the flows generated for hydropower are released back into the river. The purpose of this EWR release is, however, not to maintain a specific EC, but rather to ensure some nominal flow over the lower Tsitsa Falls.

However, scenarios 2b, 53 and 70 do not include EWR flow releases from Lalini Dam. For the same reach as relevant above, this river section will be dry except for infrequent spills and inflows from drainage lines, therefore showing a significant and associated drop in ecological status, as the falls will be dry for large periods of time.

The resulting ECs for each component and the EcoStatus are provided in **Table B2.5**. The ranking of the scenarios is provided as a traffic diagram (**Figure B2.3**).

Table B2.5 EWR1 Lalini: Ecological consequences

Component	PES and REC	Sc 2b	Sc 54
Physico-chemical	B	E	C
Geomorphology	C	C	D
Riparian vegetation	C/D	F	D
Fish	C	D/E	D
Macroinvertebrates	C	F	D
EcoStatus	C (65.05%)	E/F (19%)	D (47.55%)

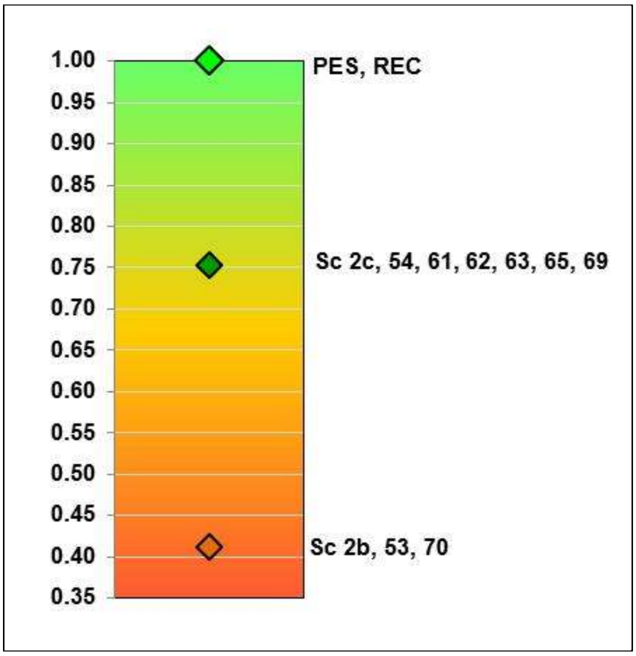


Figure B2.3 EWR1 Lalini: Ecological ranking of Phase 2 operational scenarios

B2.3.3 Conclusions

The DWS has indicated that management options associated with Sc 2b, 53 and 70, i.e. no flow over Tsitsa Falls, would be unacceptable. As some flow is therefore required in the reach immediately downstream of Lalini Dam, any of the other scenarios will be acceptable.

B2.4 CONCLUSIONS: RIVER ECOLOGICAL CONSEQUENCES

A summary of the ecological consequences of the additional scenarios are provided below:

- **MzimEWR4 (Mzimvubu River):** Scenario 69 (incorporating the 2017 design information) maintains the REC (and PES) requirements and is recommended as the most suitable scenario.
- **MzimEWR1 (Tsitsa River):** Scenario 65 and 69 maintain the REC, with Sc 69 resulting in riparian vegetation deteriorating due to increased baseflows. As Sc 69 is the preferred option at MzimEWR4, the driving river site, Sc 69 is recommended as the most suitable scenario.
- **EWR1 Lalini (Tsitsa River):** The DWS has indicated that management options associated with Sc 2b, 53 and 70, i.e. no flow over Tsitsa Falls, would be unacceptable. As some flow is therefore required in the reach immediately downstream of Lalini Dam, any of the other scenarios will be acceptable.

B2.5 INTEGRATION OF CONSEQUENCES FOR RIVER SITES

The process followed to determine an integrated ranking of the different scenarios across river sites is described in detail in **Section 3.3** of the main report of this volume**.**

The first step in determining an integrated RIVER ranking (i.e. integrating MzimEWR1, EWR1 Lalini and MzimEWR4) was to determine the relative importance of these EWR sites occurring in the study area. The site weight (**Table B2.6**) indicates that the MzimEWR4 site carries the highest weight due to the site being the most downstream river site in the study area. The accumulated impact of the scenarios is therefore expected to be the highest within this river reach (distance from the outfall of Lalini Dam to the Mzimvubu Estuary is 137 km). The importance of the MzimEWR1 site is lower due to lower accumulated impacts of scenarios within the 76 km reach demarcated from Ntabelanga Dam to Lalini Dam. EWR1 Lalini has the lowest weight as the EIS is Moderate and the site is situated in a relatively isolated reach in the Tsitsa River (it is 18 km from Lalini Dam to the outfall).

Site weights are based on the conversion of the PES and EIS to numerical values to determine the normalised weight.

Table B2.6 Weights allocated to EWR sites relative to each other

EWR site	PES	EIS	Locality in protected areas	Distance	Position	Normalised weight
MzimEWR1	C	Moderate	1	0.33	0.10	0.25
EWR1 Lalini	C	Moderate	2	0.07	0.10	0.17
MzimEWR4	C	Moderate	1	0.6	1.00	0.57

The weight was applied to the ranking value for each scenario at each EWR site and this provided an integrated score and ranking for the operational scenarios. The ranking of '1' refers to the REC (which is the same as the PES in this circumstance), with the rest of the ranking illustrating the degree to which the scenarios meet the REC. The results are provided in **Table B2.7**, i.e. once the weights have been taken into account.

Table B2.7 Ranking value for each scenario resulting in an integrated river score and site ranking

Site	PES and REC	Sc 2b	Sc 53	Sc 54	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69	Sc 2c	Sc 70
MzimEWR1	0.25	0.18	0.25	0.25	0.20	0.24	0.24	0.25	0.25	0.20	0.25
EWR1 Lalini	0.17	0.07	0.07	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.07
MzimEWR4	0.58	0.57	0.58	0.58	0.49	0.54	0.53	0.57	0.58	0.49	0.58
	1.00	**0.82**	**0.90**	**0.96**	**0.82**	**0.91**	**0.89**	**0.95**	**0.95**	**0.82**	**0.89**

The above results are plotted on a traffic diagram (**Figure B2.4**) to illustrate the integrated river ecological ranking of scenarios.

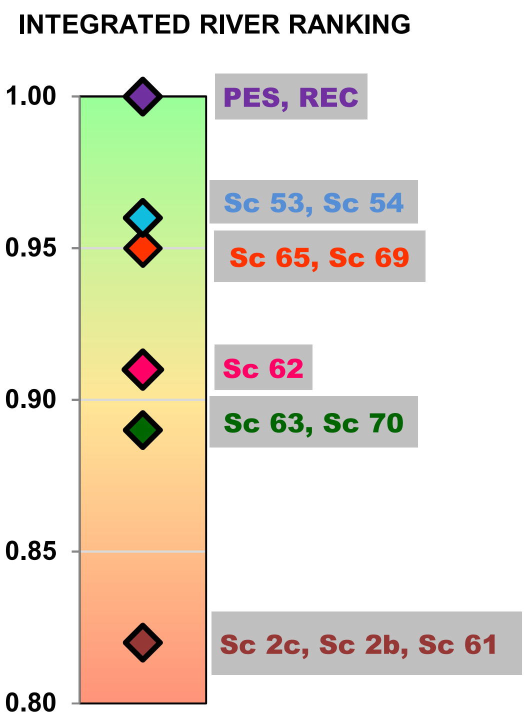


Figure B2.4 Integrated ecological ranking of the scenarios on the Tsitsa and Mzimvubu rivers

B3: PHASE 2 SCENARIO ASSESSMENT – MZIMVUBU ESTUARY CONSEQUENCES

B3.1 ABIOTIC STATES UNDER PHASE 2 SCENARIOS

The estuaries team was presented with five additional scenarios to evaluate in October 2017 (see **Section B1.2** for details), subsequent to the twelve operational scenarios that were assessed during Phase 1 of the modelling. These are listed in **Table B3.1**.

Table B3.1 Description of Mzimvubu additional future scenarios

Scenario	MAR (MCM)	% of nMAR	% Change from natural
Natural	2 737.0	100.0	0.0
Present day	2 613.5	95.5	4.5
61	2 539.1	92.8	7.2
62	2 536.3	92.7	7.3
63	2 537.5	92.7	7.3
65	2 535.5	92.6	7.4
69	2 536.3	92.7	7.3

The occurrences of the flow distributions (mean monthly flows in m^3/s) under the operational scenarios derived from the 1920 to 2004 simulation period are provided in **Tables B3.2** to **B3.6** and in **Figures B3.1** to **B3.5**. The full sets of 85-year series of simulated monthly runoff data for the future scenarios are provided in **Appendix C.**

Table B3.2 Summary of the monthly flow (in m^3/s) under Sc 61

Percentiles	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
100	297	382	402	575	668	970	470	362	284	294	143	713
99	239	347	355	541	602	691	371	230	281	218	141	245
90	91	142	221	290	470	370	166	71	55	47	45	64
80	64	85	158	158	270	237	112	56	41	39	36	35
70	46	65	119	133	189	194	98	46	33	32	30	32
60	38	54	70	99	148	150	80	36	31	29	27	28
50	32	43	50	79	115	130	65	35	27	25	25	26
40	28	36	39	64	84	106	51	31	25	23	23	24
30	27	32	34	54	69	78	45	28	24	23	22	22
20	24	29	28	46	55	58	42	26	23	21	21	21
10	22	25	23	30	43	49	32	24	21	21	20	20
1	17	21	17	13	25	25	17	11	7	10	11	12
0	14	18	11	10	13	13	14	9	6	5	7	12

Table B3.3 Summary of the monthly flow (in m^3/s) under Sc 62

Percentiles	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
100	323	415	404	579	671	970	504	391	292	309	151	757
99	265	379	372	577	614	691	377	235	289	230	142	261
90	94	170	245	307	504	377	174	66	47	38	41	60
80	64	85	162	174	275	239	112	50	33	31	28	30
70	46	65	126	146	191	204	102	39	26	24	22	27
60	38	54	72	99	155	161	80	29	23	21	19	23
50	32	43	52	79	121	137	65	28	20	17	17	21
40	28	36	39	66	86	111	52	24	17	16	15	19
30	27	32	34	54	69	79	45	20	16	15	14	18
20	25	29	29	46	57	62	42	19	15	14	13	16
10	22	26	25	33	43	49	32	17	14	13	12	15
1	20	23	20	22	27	27	22	14	12	11	11	14
0	19	21	19	21	21	24	22	14	12	11	11	14

Table B3.4 Summary of the monthly flow (in m^3/s) under Sc 63

Percentiles	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
100	323	383	403	575	669	970	459	362	291	308	141	720
99	265	369	360	541	595	691	369	230	289	226	140	253
90	97	161	225	299	467	372	166	66	47	38	37	59
80	69	90	163	161	269	241	116	49	33	30	28	30
70	52	70	124	138	195	194	102	39	26	24	22	27
60	43	59	74	104	151	151	82	29	23	21	19	23
50	37	49	55	82	119	130	69	28	19	17	17	21
40	33	42	44	69	87	109	55	24	17	16	15	19
30	32	38	40	57	74	81	50	20	16	15	14	17
20	29	34	34	51	59	64	47	19	15	13	13	16
10	27	31	30	36	49	54	38	17	13	13	12	15
1	23	28	23	16	30	27	16	11	8	10	10	12
0	18	27	16	10	16	13	12	9	8	5	7	12

Table B3.5 Summary of the monthly flow (in m^3/s) under Sc 65

Percentiles	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
100	324	440	416	611	672	970	519	391	293	313	154	766
99	275	395	387	599	622	691	379	235	291	234	143	271
90	94	181	251	312	508	377	174	66	45	37	39	58
80	64	90	166	178	280	246	112	49	31	28	26	25
70	46	65	129	146	194	204	102	37	23	22	19	20
60	38	54	72	104	155	162	80	28	21	18	16	17
50	32	43	51	79	121	137	65	26	17	14	14	15
40	28	36	39	67	86	111	52	22	15	14	13	13
30	27	32	34	54	69	83	45	19	13	12	12	11
20	25	29	29	46	57	62	42	17	13	11	10	10
10	22	26	25	33	43	49	32	16	11	10	10	9
1	20	23	20	22	27	27	22	13	10	9	8	8
0	19	21	19	21	21	24	22	12	10	9	8	8

Table B3.6 Summary of the monthly flow (in m^3/s) under Sc 69

Percentiles	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99.9	324	415	404	578	671	970	471	379	292	312	154	740
99	275	394	371	574	608	691	371	233	289	229	143	263
90	94	181	251	309	490	373	170	65	45	36	36	55
80	60	95	167	168	269	243	117	47	31	28	26	25
70	42	71	133	144	196	202	102	37	23	22	19	20
60	34	60	74	105	155	166	82	28	21	18	16	17
50	28	50	56	84	123	132	70	26	17	15	14	15
40	24	43	45	70	89	113	57	22	15	13	13	13
30	23	39	41	58	75	81	51	19	13	12	12	11
20	21	35	35	52	61	65	48	17	13	11	10	10
10	18	32	31	39	50	55	39	15	11	10	10	9
1	15	29	26	29	33	33	27	12	9	9	8	8
0.1	15	27	26	27	28	31	19	11	8	6	7	8

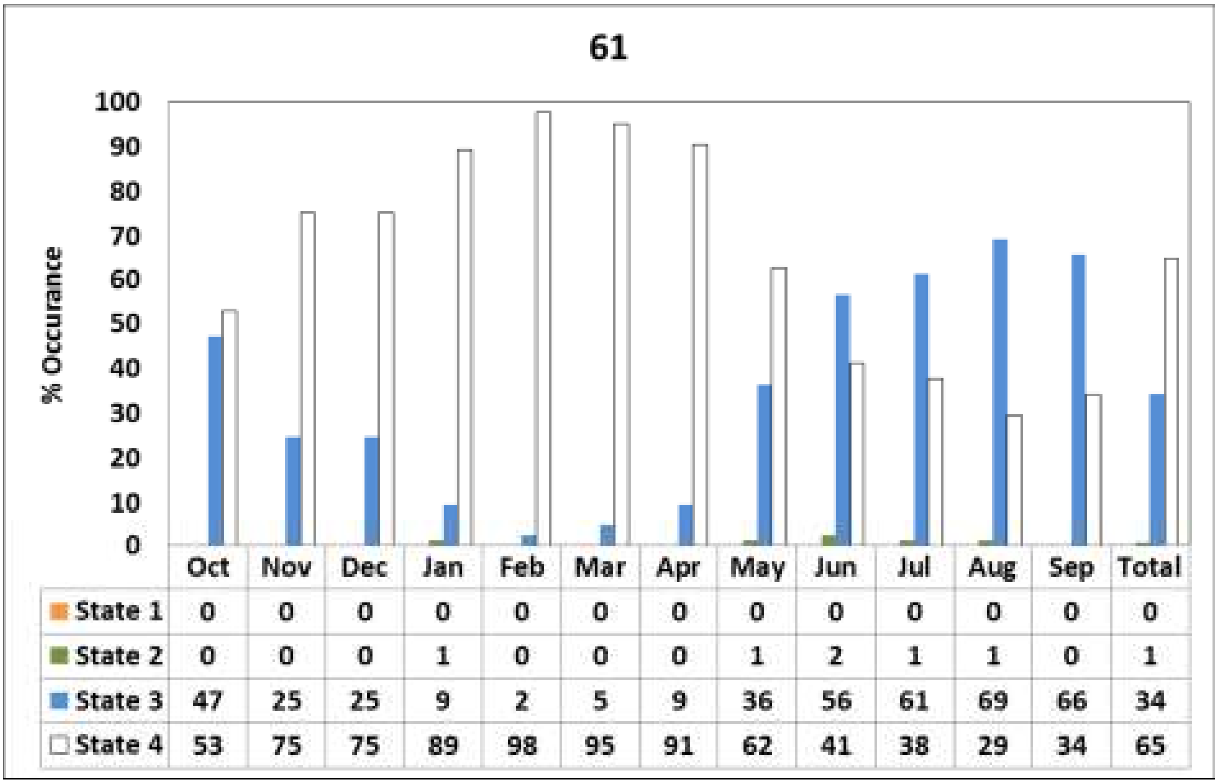
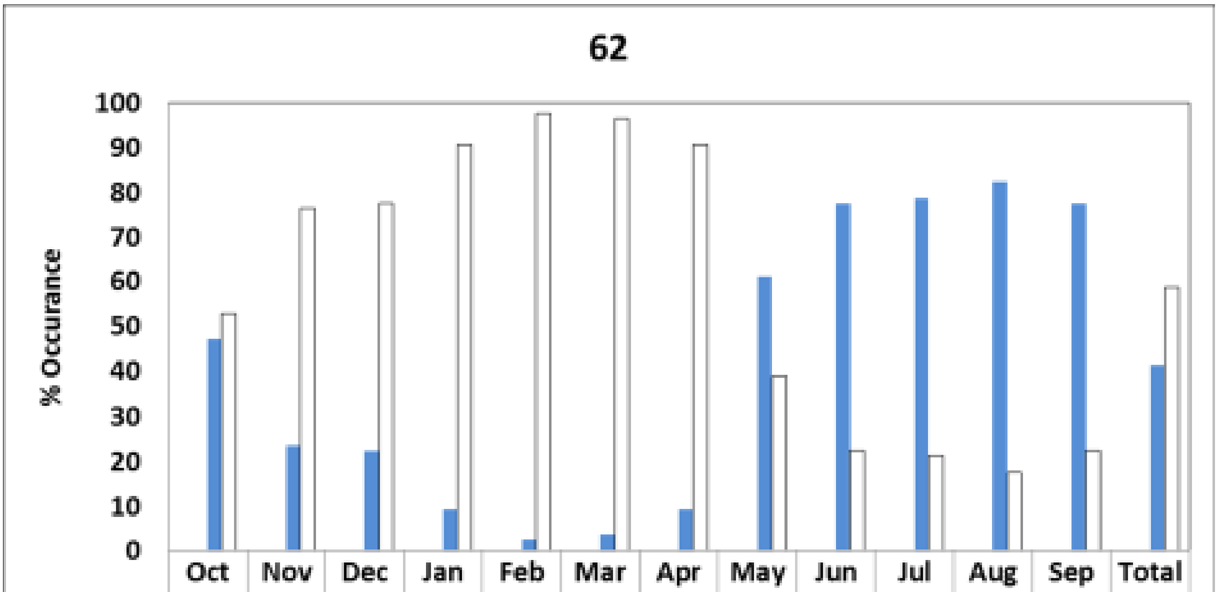
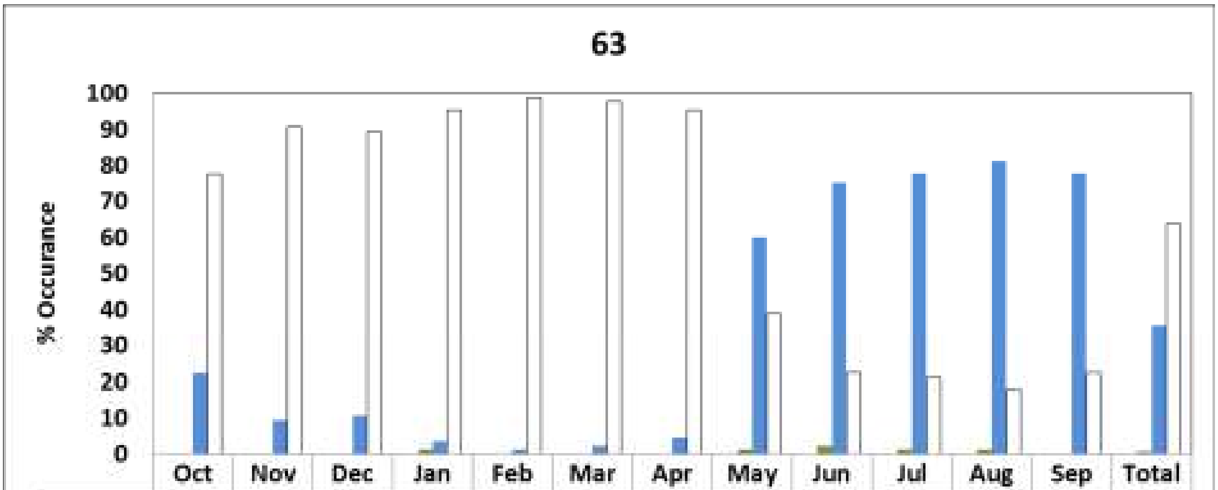


Figure B3.1 Occurrence of the various abiotic states under Sc 61



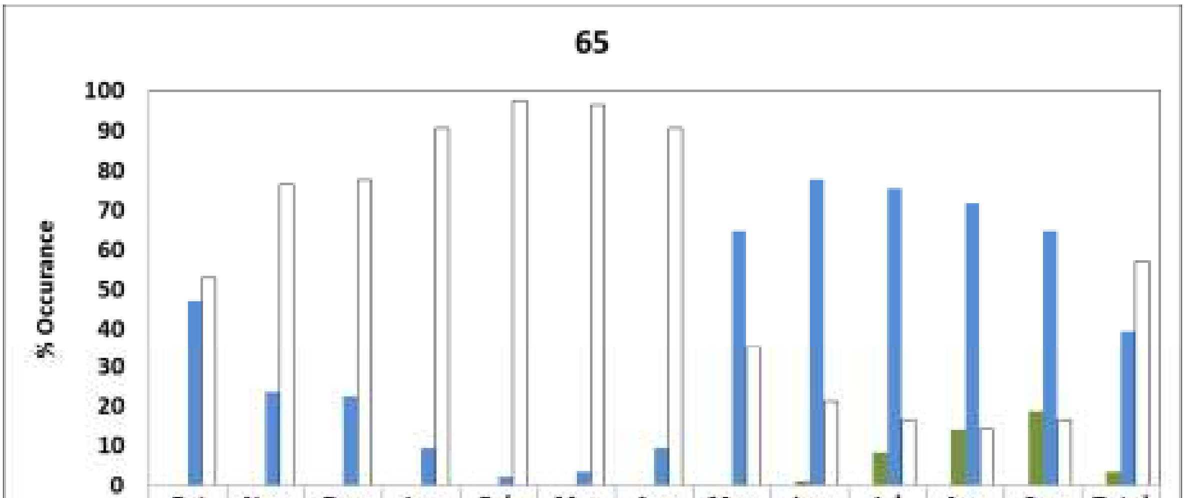
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
State 1	0	0	0	0	0	0	0	0	0	0	0	0	0
State 2	0	0	0	0	0	0	0	0	0	0	0	0	0
State 3	47	24	22	9	2	4	9	61	78	79	82	78	41
State 4	53	76	78	91	98	96	91	39	22	21	18	22	59

Figure B3.2 Occurrence of the various abiotic states under Sc 62



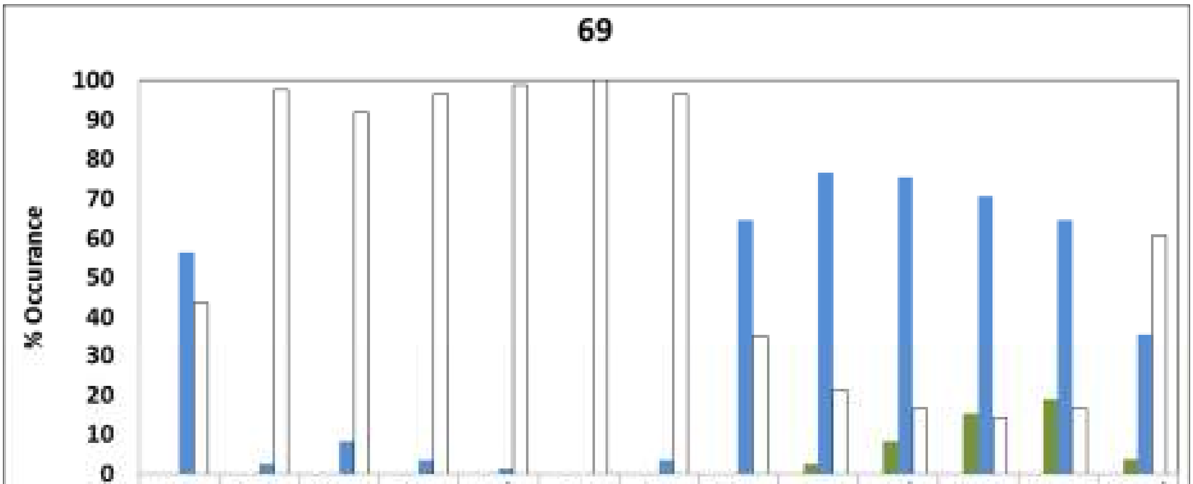
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
State 1	0	0	0	0	0	0	0	0	0	0	0	0	0
State 2	0	0	0	1	0	0	0	1	2	1	1	0	1
State 3	22	9	11	4	1	2	5	60	75	78	81	78	35
State 4	78	91	89	95	99	98	95	39	22	21	18	22	64

Figure B3.3 Occurrence of the various abiotic states under Sc 63



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
State 1	0	0	0	0	0	0	0	0	0	0	0	0	0
State 2	0	0	0	0	0	0	0	0	1	8	14	19	4
State 3	47	24	22	9	2	4	9	65	78	75	72	65	39
State 4	53	76	78	91	98	96	91	35	21	16	14	16	57

Figure B3.4 Occurrence of the various abiotic states under Sc 65



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
State 1	0	0	0	0	0	0	0	0	0	0	0	0	0
State 2	0	0	0	0	0	0	0	0	2	8	15	19	4
State 3	56	2	8	4	1	0	4	65	76	75	71	65	36
State 4	44	98	92	96	99	100	96	35	21	16	14	16	61

Figure B3.5 Occurrence of the various abiotic states under Sc 69

B3.2 HYDROLOGY

Tables B3.7 and **B3.8** provide a summary of the changes in low flows and flood regime under the various scenarios (Sc). Low flows (also called baseflows) were taken as the flow range that is exceeded for 70% or more of the time. The average change in the 10, 20 and 30 percentile (%ile) was taken as change in the low flows to the estuary.

Table B3.7 Summary of change in low flow conditions under reference, present and Phase 2 scenarios

%ile	Monthly flow (m^3/s)						
	Ref	Pres	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
30	20.6	18.2	27.8	24.2	26.3	22.6	22.2
20	14.9	12.5	24.5	19.7	19.2	16.5	16.3
10	11.4	8.9	21.5	15.4	15.1	12.1	12.1
% similarity in low flows		**83**	**63**	**78**	**77**	**92**	**93**

Table B3.8 Summary of twenty highest simulated monthly volumes under reference, present and Phase 2 scenarios

Date	Monthly volume (MCM/month)						
	Ref	Pres	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
Mar-76	2 675	2 658	2 680	2 680	2 680	2 680	2 680
Sep-87	2 260	2 221	1 983	2 105	2 001	2 071	2 055
Mar-27	1 782	1 751	1 486	1 557	1 486	1 557	1 493
Mar-00	1 694	1 677	1 693	1 693	1 693	1 693	1 693
Jan-96	1 669	1 636	1 418	1 541	1 417	1 588	1 466
Feb-39	1 660	1 640	1 649	1 654	1 654	1 654	1 654
Jan-76	1 618	1 591	1 429	1 545	1 429	1 597	1 535
Mar-25	1 601	1 580	1 575	1 575	1 562	1 579	1 560
Jan-34	1 571	1 544	1 550	1 550	1 550	1 550	1 550
Jan-00	1 556	1 528	1 328	1 408	1 353	1 405	1 410
Feb-98	1 523	1 491	1 436	1 470	1 415	1 485	1 453
Apr-78	1 488	1 466	1 248	1 344	1 215	1 331	1 251
Feb-85	1 468	1 434	1 178	1 236	1 141	1 183	1 212
Mar-94	1 429	1 408	1 417	1 417	1 417	1 417	1 417
Mar-63	1 398	1 380	1 384	1 384	1 384	1 384	1 384
Jan-55	1 397	1 365	1 174	1 200	1 187	1 177	1 190
Dec-76	1 369	1 327	1 091	1 091	1 091	1 036	1 091
Feb-88	1 359	1 333	1 342	1 342	1 342	1 342	1 340
Feb-96	1 345	1 325	1 262	1 326	1 270	1 326	1 326
Mar-67	1 325	1 303	1 170	1 234	1 151	1 227	1 187
% similarity in floods		**98**	**91.4**	**93.8**	**91.2**	**93.6**	**92.6**

Summaries of the hydrological changes under each of the scenarios and the hydrology health scores for various scenarios are provided in **Tables B3.9** and **B3.10**, respectively.

Table B3.9 Summary of hydrological changes under present and Phase 2 scenarios

Sc	Summary of change
61	There is a 37% increase in baseflows from Reference. Floods are similar to reference with a 9 % decline in magnitude.
62	There is a 22% increase in baseflows from Reference. Floods are similar to reference with a 6% decline in magnitude.
63	There is a 23% increase in baseflows from Reference. Floods decline by 9% in magnitude from Reference conditions.
65	There is a 8% increase in baseflows from Reference. Floods are similar to reference with a 6% decline in magnitude.
69	There is a 7% **increase** in baseflows from Reference. Floods are similar to reference with a 7% decline in magnitude.

Table B3.10 Hydrology health scores for present and Phase 2 scenarios

Variable	Weight	Scenarios					
		Pres	61	62	63	65	69
a. % Similarity in low flows	60	83	63	78	77	92	93
b. % Similarity in flood volumes	40	98	91	94	91	94	93
Score: weighted mean (a, b)		**89**	**74**	**84**	**83**	**93**	**93**

B3.3 PHYSICAL HABITAT

Summaries of the physical habitat changes under each of the scenarios and the physical habitat scores for various scenarios are provided in **Tables B3.11** and **B3.12**, respectively. No numerical modelling was done to assess the changes in the sediment processes under the various scenarios.

Table B3.11 Summary of physical habitat changes under additional future scenarios

Sc	Summary of change
61 and 63	Represents the worst case scenario from a sediment perspective as a result of the decline in floods. Infilling of the supratidal, intertidal and subtidal areas are expected (scores varying between 75 and 70). It is also assumed that the subtidal will be subjected to the most change and is expected to be more muddy.
62 and 65	Some infilling of the supratidal, intertidal and subtidal areas are expected (scores varying between 85 and 80). It is also assumed that the subtidal will be subjected to the most change and is expected to be more muddy.
69	Some infilling of the supratidal, intertidal and subtidal areas are expected (scores varying between 83 and 78). It is also assumed that the subtidal will be subjected to the most change and is expected to be more muddy.

Note: Scores referred to in **Table B3.11** are shown on **Table B3.12**.

Table B3.12 Physical habitat health scores for present and future scenarios

Variable		Scenarios					
		Pres	61	62	63	65	69
a	Supratidal area and sediments	95	75	85	75	85	83
b	Intertidal areas and sediments	95	75	85	75	85	83
c	Subtidal area and sediments	90	70	80	70	80	78
d	Estuary bathymetry/ water volume	95	75	85	75	85	83
Score: mean (a to d)		**94**	**74**	**84**	**74**	**84**	**82**

B3.4 HYDRODYNAMICS AND MOUTH CONDITION

The percentage occurrence of various abiotic states under reference, present and future scenarios is summarised in **Table B3.13**.

Table B3.13 Summary of occurrence of abiotic states under the reference (ref), present (pres) and Phase 2 scenarios

Abiotic state	Scenarios						
	Ref	Pres	61	62	63	65	69
State 1: Significant saline penetration	0.0	0.0	0.0	0.0	0.0	0.0	0.0
State 2: Intermediate saline penetration	6.7	13.1	0.6	0.0	0.6	3.5	3.7
State 3: Limited saline penetration	35.4	31.5	34.3	41.3	35.5	39.3	35.6
State 4: Freshwater dominates	57.9	55.4	65.1	58.7	63.9	57.2	60.7

A summary of the hydrodynamic changes under each of the scenarios and the hydrodynamic scores for various scenarios are provided in **Tables B3.14** and **B3.15**, respectively.

Table B3.14 Summary of hydrodynamic changes under Phase 2 scenarios

Sc	Summary of change
61	Mouth conditions will similar to present, i.e. 100% open. Retention decreases slightly as a result of elevated baseflows from reference conditions, i.e. 6% loss of State 2: Intermediate saline penetration.
62	Mouth conditions will similar to present, i.e. 100% open. Retention decreases slightly as a result of elevated baseflows from reference conditions, i.e. 6% loss of State 2: Intermediate saline penetration.
63	Mouth conditions will similar to present, i.e. 100% open. Retention decreases slightly as a result of elevated baseflows from reference conditions, i.e. 7% loss of State 2: Intermediate saline penetration.
65	Mouth conditions will similar to present, i.e. 100% open. Retention decreases slightly as a result of elevated baseflows from reference conditions, i.e. 3% loss of State 2: Intermediate saline penetration.
69	Mouth conditions will similar to present, i.e. 100% open. Retention decreases slightly as a result of elevated baseflows from reference conditions, i.e. 3% loss of State 2: Intermediate saline penetration.

Table B3.15 Hydrodynamic health scores for present and Phase 2 scenarios

Variables		Scenarios					
		Pres	61	62	63	65	69
a	% similarity in mouth condition	100	100	100	100	100	100
b	% similarity in water retention time	95	94	94	93	97	97
Score: mean (a, b)		98	97	97	97	99	99

B3.5 WATER QUALITY

Expected change in water quality characteristics under each of the scenarios and the water quality health scores are provided in **Tables B3.16** and **B3.17**, respectively.

Table B3.16 Summary of changes in average water quality concentrations under Phase 2 scenarios

Parameter	Scenarios	Summary of change	Zone[1]		
			Lower	Middle	Upper
Salinity	Reference		12	1	0
	Present	Slight increase in salinity penetration.	12	2	0
	61	Decrease in salinity penetration.	10	0	0
	62		11	0	0
	63		10	0	0
	65		12	1	0
	69		11	1	0
DIN (µg/ℓ)	Reference		93	92	92
	Present	Increased nutrient input from diffuse sources in the catchment, mainly settlements and cattle herds.	156	175	180
	61		162	180	180
	62		159	180	180
	63		162	180	180
	65		158	179	180
	69		160	179	180
DIP (µg/ℓ)	Reference		13	13	13
	Present	Increased nutrient input from diffuse sources in the catchment, mainly settlements and cattle herds.	23	29	30
	61		25	30	30
	62		24	30	30
	63		25	30	30
	65		24	30	30
	69		24	30	30
Dissolved oxygen (mg/ℓ)	Reference		8	8	8
	Present	No marked change from reference.	8	8	8
	61		8	8	8
	62		8	8	8
	63		8	8	8
	65		8	8	8
	69		8	8	8
Turbidity (NTU)	Reference		164	189	170
	Present	Limited erosion as a result of catchment practices. However, this catchment naturally introduced turbid waters to the estuary. Slight increase in future scenarios relates to increase in high flow states (States 3 and 4).	172	195	198
	61		194	218	218
	62		184	213	213
	63		192	217	217
	65		180	208	208
	69		185	211	211
Toxic substances	61-63, 65,69	Some accumulation (e.g. trace metals) associated with urban development along banks of estuary (90).			

[1] *Refer to Estuary EWR Report (Report No. WE/WMA7/00/CON/CLA/0717) for zones.*

Table B3.17 Water quality health scores for present and Phase 2 scenarios

Variables		Weight	Scenarios					
			Pres	61	62	63	65	69
1	Salinity	40	88	70	66	71	88	90
2	General water quality							
a	DIN/DIP concentrations	60	67	66	66	66	67	67
b	Turbidity		98	92	94	93	95	94
c	Dissolved oxygen		100	100	100	100	100	100
d	Toxic substances		90	90	90	90	90	90
Score: weighted mean (1,2 [min a-d]))			75	68	66	68	75	76

B3.6 MICROALGAE

A summary of the changes in microalgae under each of the scenarios and the microalgae health scores for various scenarios are provided in **Tables B3.18** and **B3.19**, respectively.

Table B3.18 Summary of changes in microalgae under Phase 2 scenarios

Sc	Summary of change
61	An increase in residence time results in an increase in phytoplankton biomass, particularly in the River-Estuary Interface zone (REI) and favours a shift in community structure away from that dominated by diatoms to one that has higher dominance of flagellates and greater presence of dinoflagellates; development of an REI requires >2 weeks of residence time. Phytoplankton biomass is likely to remain low (<5 µg/L) throughout the estuary (the average biomass flowing in river water is elevated as a result of elevated nutrients but the estuary acts as a conduit). The dam is likely to trap coarser sediments and there should be a shift in sediment composition to fines (muddier). The benthic microalgal scores were determined based on changes to ‘muddiness’ of inter- and subtidal zones alone; assuming half of the present state change was related to nutrients (8% for richness and composition, and 10% for abundance), then the average change in physical characteristics of the inter- and subtidal zones for Sc 61 (20%) was used to determine benthic microalgal scores.
62	An increase in residence time results in an increase in phytoplankton biomass, particularly in the REI and favours a shift in community structure away from that dominated by diatoms to one that has higher dominance of flagellates and greater presence of dinoflagellates; development of an REI requires >2 weeks of residence time. Phytoplankton biomass is likely to remain low (<5 µg/L) throughout the estuary (the average biomass flowing in river water is elevated as a result of elevated nutrients but the estuary acts as a conduit). The dam is likely to trap coarser sediments and there should be a shift in sediment composition to fines (muddier). The benthic microalgal scores were determined based on changes to ‘muddiness’ of inter- and subtidal zones alone; assuming half of the present state change was related to nutrients (8% for richness and composition, and 10% for abundance), then the average change in physical characteristics of the inter- and subtidal zones for Sc 61 (10%) was used to determine benthic microalgal scores.
63	An increase in residence time results in an increase in phytoplankton biomass, particularly in the REI and favours a shift in community structure away from that dominated by diatoms to one that has higher dominance of flagellates and greater presence of dinoflagellates; development of an REI requires >2 weeks of residence time. Phytoplankton biomass is likely to remain low (<5 µg/L) throughout the estuary (the average biomass flowing in river water is elevated as a result of elevated nutrients but the estuary acts as a conduit). The dam is likely to trap coarser sediments and there should be a shift in sediment composition to fines (muddier). The benthic microalgal scores were determined based on changes to ‘muddiness’ of inter- and subtidal zones alone; assuming half of the present state change was related to nutrients (8% for richness and composition, and 10% for abundance), then the average change in physical characteristics of the inter- and subtidal zones for Sc 61 (20%) was used to determine benthic microalgal scores.
65	An increase in residence time results in an increase in phytoplankton biomass, particularly in

Sc	Summary of change
	the REI and favours a shift in community structure away from that dominated by diatoms to one that has higher dominance of flagellates and greater presence of dinoflagellates; development of an REI requires >2 weeks of residence time. Phytoplankton biomass is likely to remain low (<5 µg/L) throughout the estuary (the average biomass flowing in river water is elevated as a result of elevated nutrients but the estuary acts as a conduit). The dam is likely to trap coarser sediments and there should be a shift in sediment composition to fines (muddier). The benthic microalgal scores were determined based on changes to 'muddiness' of inter- and subtidal zones alone; assuming half of the present state change was related to nutrients (8% for richness and composition, and 10% for abundance), then the average change in physical characteristics of the inter- and subtidal zones for Sc 61 (10%) was used to determine benthic microalgal scores.
69	An increase in residence time results in an increase in phytoplankton biomass, particularly in the REI and favours a shift in community structure away from that dominated by diatoms to one that has higher dominance of flagellates and greater presence of dinoflagellates; development of an REI requires >2 weeks of residence time. Phytoplankton biomass is likely to remain low (<5 µg/L) throughout the estuary (the average biomass flowing in river water is elevated as a result of elevated nutrients but the estuary acts as a conduit). The dam is likely to trap coarser sediments and there should be a shift in sediment composition to fines (muddier). The benthic microalgal scores were determined based on changes to 'muddiness' of inter- and subtidal zones alone; assuming half of the present state change was related to nutrients (8% for richness and composition, and 10% for abundance), then the average change in physical characteristics of the inter- and subtidal zones for Sc 61 (12%) was used to determine benthic microalgal scores.

Table B3.19 Microalgae health scores for present and Phase 2 scenarios

Variable		Scenario					
		Pres	61	62	63	65	69
Phytoplankton							
a	Species richness	70	83	79	82	71	72
b	Abundance	72	85	81	84	73	74
c	Community composition	65	78	74	77	68	67
Benthic microalgae							
a	Species richness	85	65	75	65	85	73
b	Abundance	83	63	73	63	83	71
c	Community composition	85	65	75	65	85	73
Score: min (a-c)		**65**	**63**	**73**	**63**	**68**	**67**

B3.7 MACROPHYTES

A summary of the changes in macrophytes under each of the scenarios and the macrophyte health scores for various scenarios are provided in **Tables B3.20** and **B3.21**, respectively.

Table B3.20 Summary of changes in macrophytes under Phase 2 scenarios

Sc	Summary of change
61	The large increase in baseflow together with higher nutrients and lower salinity is likely to increase reed and filamentous macroalgal growth. The reduction in floods will result in a more stagnant system leading to expansion of reeds into the main water channel.
62	Compared to present there is a decline in floods leading to some habitat infilling in the intertidal and supratidal zones. The increase in sediment stability will encourage macrophyte growth and spread into the main channel. There is a decrease in saline intrusion but increase in nutrients that will encourage macroalgal and reed growth.
63	Conditions are very similar to Sc 61.
65	Conditions are very similar to Sc 62.
69	The macrophytes respond to a decrease in floods. System stability will encourage macrophyte growth particularly reeds into the main channel and macroalgae where flow is low.

Table B3.21 Macrophytes health scores for present and Phase 2 scenarios

Variable		Scenarios					
		Pres	61	62	63	65	69
a	Species richness	85	78	81	78	81	80
b	Abundance	63	56	59	56	59	58
c	Community composition	66	59	61	59	61	61
Score: min (a to c)		**63**	**56**	**59**	**56**	**59**	**58**

B3.8 INVERTEBRATES

A summary of the changes in invertebrates under each of the scenarios and the invertebrate health scores for various scenarios are provided for **Tables B3.22** and **B3.23**.

Table B3.22 Summary of changes in invertebrates under Phase 2 scenarios

Sc	Summary of change
61 62 63	The increases in flow for these scenarios and the resultant loss of State 2 is considered to have no effect on species richness as the small number of freshwater-tolerant and opportunistic species which are found within the estuary would still occur in the lower zone. However, the increase in baseflows over the critical low flow periods resulting in a loss of the productive middle zone as an estuary habitat means that overall abundance will be reduced and species composition is slightly altered by the fresher conditions.
65 69	The will be some increase in the prevalence of State 3 compared to reference conditions (at the expense of State 2, which is reduced, and lost completely in the late Spring and early Summer months). This will result in a loss typical estuarine condition in the productive middle zone of the estuary, and the overall abundance of estuarine invertebrates will be reduced and species composition is slightly altered by the fresher conditions.

Table B3.23 Invertebrate health scores for present and Phase 2 scenarios

Variable		Scenario					
		Pres	61	62	63	65	69
Zooplankton							
a	Species richness	95	95	95	95	95	95
b	Abundance	95	85	85	85	92	90
c	Community composition	95	87	87	87	93	92
Benthic macro-invertebrates							
a	Species richness	95	95	95	95	95	95

Variable		Scenario					
		Pres	61	62	63	65	69
b	Abundance	95	75	73	75	90	85
c	Community composition	95	85	83	85	92	90
Score: min (a-c)		95	75	73	75	90	85

B3.9 FISH

A summary of the changes in fish under each of the scenarios and the invertebrate health scores for various scenarios are provided in **Tables B3.24** and **B3.25**, respectively.

Table B3.24 Summary of changes in fish under Phase 2 scenarios

Sc	Summary of change
61 62 63	The most important aspect of all of these scenarios is that they all involve baseflows higher than reference (and present) conditions. Under scenarios, hydrodynamic and associated water quality State 2 will occur with considerably reduced frequency compared to reference (and present) conditions, especially in the low flow period. In the case of scenario 61, State 2 is lost from the system completely. Significant impacts can be expected with changes in salinity regime. Fish in this estuary are sensitive to changes salinity distribution (in time and space) in the range of freshwater to oligohaline, and much less so in the mesohaline and polyhaline ranges. The loss of salinity penetration into the middle zones of the system therefore affects the estuary's nursery function and fisheries value, especially for estuarine dependent fishes (fish category IIa, Whitfield, 1998). Some estuarine migrant fishes (particularly some mullet species, most notably *Myxus capensis* and *Mugil cephalus*) and estuarine resident species (such as *Gilchristella aestuaria*) will remain in the middle zone of the estuary under fresh conditions but the abundance of many others will decline markedly. This is important when considering that only two of the three estuarine zones (under the estuarine delineation considered, i.e. the lower and middle zones) experience salinity intrusion under the hydrodynamic states considered (reference, present and scenarios). Therefore at least 50% of the present estuarine influence by salinity, and the entire middle reach, will be affected in the low flow months because of elevated baseflows under these scenarios. The estuarine nature of the system will be lost during these low flow periods. This is the critical nursery period that coincides with estuarine dependant marine fishes breeding and recruitment cycles. Complete loss of estuarine dependant marine species under these freshwater conditions is unlikely. Even species that generally show a preference for saline water will include a small percentage of individuals which will comfortably inhabit the middle zone under freshwater conditions. The full species compliment will remain in the estuary as a whole, as the saline states generally persist in the lower reaches of the system over most of the low flow period. Indeed, while the system as a whole will see reduced abundance of fishes because of reduced habitat for estuarine dependent marine species, the concentrations of these fishes in the lower reaches may increase under conditions of the middle reaches not being favourable (assuming that the lower reaches are not presently used to full capacity, which is unlikely given fishing pressure). This may make these populations susceptible to increased exploitation by fishing in the lower reaches. Under conditions of increased freshwater state in the middle reaches of the estuary it is unlikely that loss of abundance of estuarine dependent marine fishes will be offset by an increase in freshwater fish abundance. The latter are largely restricted by daytime habitat availability (reed beds along the estuary banks). Impacts from turbidity (and other water quality changes) are probably negligible in the light of the changes in salinity. There is some decrease in floods which may affect the offshore estuary and result in changes in recruitment cueing signals. This might affect recruitment of Anguillid eels, Zambezi sharks, and (to a lesser degree) estuarine fish. These impacts a probably not significant over the short term, but in the long-term population changes in the estuary, and the river upstream may result. In this regard it is also important that the "offshore estuary" be considered. This is the area offshore of the Mzimvubu that is seasonally affected by the summer outflows. This is a critical area that is used by the estuarine fish assemblage under high flow conditions. During these periods these fishes are dependent on the turbid, low salinity conditions that are created offshore. Floods are therefore important for the fish assemblage of the Mzimvubu Estuary.

Sc	Summary of change
	Sediment budgets might be an issue at the the Mzimvubu depocentre, which is likely to be a feeding ground for some estuarine species. Scenarios that involve relative reductions in high flow floods (S61 and S63) are therefore likely to result in some degree of loss of fish health score in the estuary, over the long term.
65	Flows under these scenarios are broadly similar to those under reference (and present) conditions, but also involve increases in baseflows which reduce the frequency of occurrence of State 2 in the estuary. In both scenarios this state is completely lost from late spring and early summer months. Impacts on the fish community are similar to those described above, with losses in abundance of estuarine dependent marine species. These fishes are more susceptible to the complete loss of salinity than they are to slight gains in the mesohaline and polyhaline ranges which typify present day conditions. Impacts to the fish health score can be anticipated, and although not as significant as those associated with flow scenarios above, these changes are expected to result in a loss in fish health score to below those experienced under present day conditions.
69	

Table B3.25 Fish health scores for present and Phase 2 scenarios

Variable		Scenarios					
		Pres	61	62	63	65	69
a	Species richness	100	100	100	100	100	100
b	Abundance	77	62	62	62	77	75
c	Community composition	78	65	65	65	76	74
Score: min (a to c)		**77**	**62**	**62**	**62**	**76**	**74**

B3.10 BIRDS

A summary of the changes in birds under each of the scenarios and the invertebrate health scores for various scenarios are provided in **Tables B3.26** and **B3.27**, respectively.

Table B3.26 Summary of changes in birds under Phase 2 scenarios

Sc	Summary of change
61, 62, 63	The scenarios all involve a small (2-3%) decrease in freshwater inflows relative to present, but with higher low season flows resulting in an overall fresher system. There is a small decrease in floods under all scenarios. Minor variations between the scenarios are mainly attributed to differences in salinity, intertidal habitat impacts, and fish abundance. Bird numbers in the system are low and unlikely to be limited by invertebrate abundance. Effects of changes in turbidity are expected to be negligible. In general, waterfowl numbers increase from present as a result of the system being fresher; waders decrease as a result of decreased habitat and benthic invertebrate abundance; piscivores decrease as a result of decreased fish abundance.
65, 69	These scenarios have similar total flows but have a much smaller increase in baseflows relative to natural. However, the system remains fresh water-dominated and this does not have a significant impact on birds relative to the above scenarios.

Table B3.27 Bird health scores for present and Phase 2 scenarios

Variable		Scenarios					
		Pres	61	62	63	65	69
a	Species richness	90	90	90	90	90	90
b	Abundance	61	62	62	62	62	62
c	Community composition	76	74	75	73	75	75
Score: min (a to c)		**61**	**62**	**62**	**62**	**62**	**62**

B3.11 ECOLOGICAL CATEGORIES ASSOCIATED WITH PHASE 2 SCENARIOS

The individual health scores for the various abiotic and biotic components are used to determine the ecological status or ecological category for the Mzimvubu Estuary under various operational scenarios (**Table B3.28**), again using the the Estuary Health Index (EHI) score.

Table B3.28 EHI score and corresponding ecological categories under present, recommended flow from Phase 1 (Scenario 53) and Phase 2 scenarios

Variable	Weight	Scenario								
		Pres	53 (REC)	61	62	63	65	69	2c* (61<2c>62)	54* (53)
Hydrology	25	89	97	74	84	83	93	93		
Physical habitat	25	94	99	97	97	97	99	99		
Hydrodynamics/mouth condition	25	98	89	68	66	68	75	76		
Water quality	25	75	77	75	84	74	84	82		
Habitat health score	**50**	**89**	**90**	**78**	**83**	**80**	**88**	**87**	**80**	**90**
Microalgae	20	65	68	63	73	63	68	67		
Macrophytes	20	63	62	59	59	56	59	58		
Invertebrates	20	95	75	75	73	75	90	85		
Fish	20	77	72	62	62	62	76	74		
Birds	20	61	62	62	62	62	62	62		
Biotic health score	**50**	**72**	**68**	**64**	**66**	**64**	**71**	**69**	**65**	**68**
ESTUARY HEALTH SCORE		**81**	**79**	**71**	**74**	**72**	**79**	**70**	**73**	**79**
ECOLOGICAL CATEGORY		**B**	**B**	**B/C**	**B/C**	**C**	**B**	**B**	**B/C**	**B**

** Further refinements of scenarios not officially scored by entire specialist team, but assumed to be sufficiently similar to previously scored scenarios as indicated.*

B3.12 CONCLUSIONS: ESTUARY ECOLOGICAL CONSEQUENCES

Scenario 53, 54 (optimised scenario; see Section 8.4 of the Phase 1 consequences report, Report no. WE/WMA7/00/CON/CLA/1117), 65 and 69 (and therefore also Sc 70) will maintain PES (and therefore the REC) of the Mzimvubu Estuary and is a significant improvement on the other scenarios. This is due to the decreased baseflows being closer to natural compared to the other scenarios. As Sc 69 has been recommended as the optimal scenario for the river sites, it is considered acceptable as the scenario of choice for the estuaries. The estuary ecological ranking of the Phase 2 scenarios is shown below.

The estuary ecological ranking of the Phase 2 scenarios is illustrated in **Figure B3.6**.

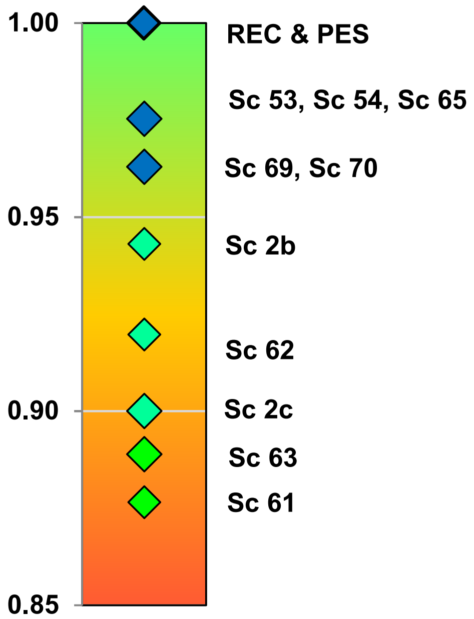


Figure B3.6 Mzimvubu Estuary: Ecological ranking of additional operational scenarios

B4: INTEGRATED RIVER AND ESTUARY RESULTS AND FINAL RECOMMENDATIONS

B4.1 RIVER AND ESTUARY RANKING

The ecological state (or health) rating is expressed relative to how the scenario achieves the REC. This is quantified as a numerical ratio ranging usually between 1 and 0, where a score of 1 indicates the scenario achieves the REC and zero when the scenario is typically in an F EC.

To provide the ecological metric as input to the Water Resource Class Determination Tool, the rivers and estuaries must be reduced to a final ecological ranking, expressed relative to how the scenarios achieve the REC. This means that as the river EWR sites were weighted (**Section B2.5**), the estuary must now also be weighted and all EWR site weights adjusted pro rata. Factors considered in the rating are ecological and conservation importance, the PES, the functionality of the estuary, the sensitivity of the estuary to scenario changes and the length or size (area) of the river and estuary respectively. Due to the ecological and socio-economic importance of the Mzimvubu Estuary, a weight of 50% was applied to the estuary (although 30% and 40% were also tested - ranking order was the same under all weightings).

B4.2 RIVER AND ESTUARY INTEGRATED ECOLOGICAL CONSEQUENCES

The integrated ecological consequences for the rivers and estuary is provided in **Figure B4.1**.

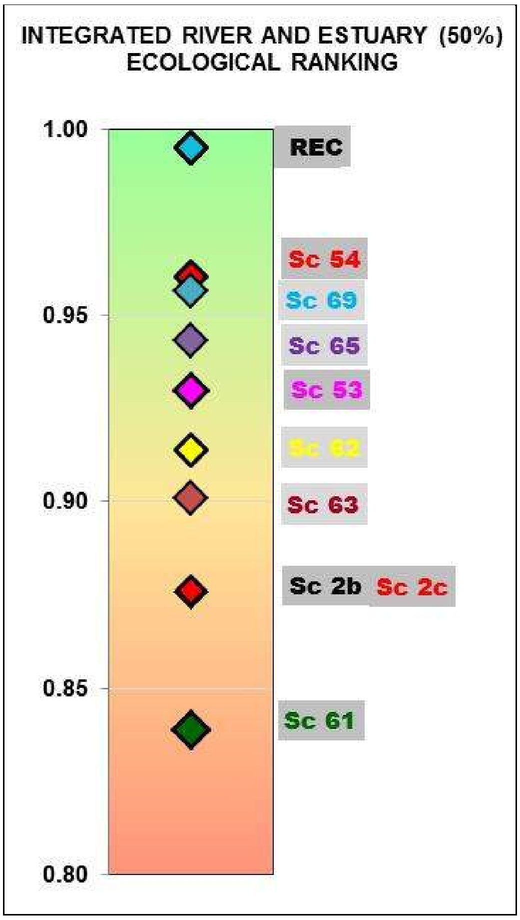


Figure B4.1 Integrated ecological ranking with the Mzimvubu Estuary weighted at 50%

B4.3 CONCLUSION AND RECOMMENDATIONS

For both estuary and rivers, Sc 54 and 69 are the recommended options. As Sc 54 is based on 2014 operational options, the recommendations (from an ecological viewpoint) will focus on Scenario 69.

In conclusion, the optimisation of the dam design and meeting of EWRs must be conducted by the dam designers. From an ecological point of view, increased flows from releasing the full EWR below Lalini Dam, for example, would be acceptable as long as the balance of flows below the outlet are the same as for Scenario 69, so as to meet ecological recommendations. Note that the exact flows required to make the additional hydropower facility cost-effective must be determined by the developers. As long as the flows downstream of the outfall are as for Scenario 69, the EWR flows released could be the D EWR low flows or any higher flows.

B5: REFERENCES

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APPENDIX C: PHASE 2 SCENARIOS – ESTUARINE RUNOFF SIMULATIONS

SCENARIO 61 (m^3/s)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1920	128.9	26.5	28.5	28.3	85.6	198.4	118.9	50.0	28.9	22.6	20.0	23.7
1921	29.1	229.9	206.9	67.6	33.5	27.7	22.2	81.8	80.1	46.1	41.8	34.1
1922	55.0	121.0	73.5	193.6	513.7	278.0	66.2	24.0	23.3	201.7	96.2	25.9
1923	21.8	21.3	26.7	88.7	121.5	93.4	44.7	24.7	24.5	21.9	21.8	26.4
1924	26.3	32.5	264.1	136.8	58.6	588.0	309.3	59.4	27.9	22.6	20.3	23.4
1925	23.8	33.5	30.1	63.0	43.3	247.0	108.5	31.1	37.5	32.1	22.8	33.0
1926	44.6	41.0	56.9	42.2	48.2	555.0	220.8	27.4	21.6	22.5	24.0	22.2
1927	32.7	29.4	71.0	238.6	177.4	90.7	43.7	24.5	23.1	21.3	26.7	24.8
1928	27.7	31.6	45.0	37.7	37.3	191.1	97.3	29.9	53.6	58.8	38.6	82.2
1929	75.9	69.5	140.8	150.5	57.7	112.0	79.9	35.9	31.3	29.2	47.1	42.5
1930	31.4	25.5	31.6	275.7	314.9	287.3	117.5	34.6	23.0	302.4	140.3	25.2
1931	28.4	32.6	59.4	37.7	264.1	129.8	33.0	27.7	29.1	34.1	27.8	40.9
1932	41.8	151.5	164.5	51.1	27.9	39.0	36.9	24.1	20.7	21.2	20.2	19.5
1933	18.8	247.0	297.2	578.7	238.8	151.0	72.2	28.7	24.1	32.6	28.9	21.4
1934	40.9	64.9	131.9	70.2	39.0	53.2	130.7	100.7	87.9	47.2	40.7	32.1
1935	24.3	24.1	20.3	24.3	221.2	136.5	46.0	68.8	48.0	31.6	24.7	21.4
1936	31.8	385.5	158.4	61.0	512.0	219.5	42.9	23.0	21.2	20.7	19.8	20.3
1937	22.7	24.3	36.1	86.5	191.7	78.0	92.7	54.2	34.6	36.3	33.4	26.5
1938	27.8	37.0	182.8	197.3	675.5	218.5	34.4	31.5	29.0	32.9	31.1	106.3
1939	71.2	53.1	40.8	33.7	355.6	194.9	64.5	124.0	70.0	28.9	22.1	35.0
1940	32.1	34.4	78.2	103.8	125.8	67.0	51.1	34.4	23.4	23.5	22.8	21.0
1941	26.2	26.1	21.3	64.3	295.9	205.3	90.9	53.4	31.1	22.6	25.6	28.4
1942	38.9	203.9	331.6	173.6	53.8	132.2	185.9	82.5	46.2	38.9	142.8	77.2
1943	72.8	271.0	300.1	157.1	115.0	147.5	58.6	24.8	32.9	31.6	23.5	145.9
1944	84.4	30.0	19.3	49.4	180.6	213.5	79.6	26.0	22.9	21.0	19.6	19.0
1945	36.5	27.5	23.0	79.5	73.9	114.9	67.1	38.8	29.6	23.8	20.8	19.9
1946	22.5	37.8	44.4	82.4	121.1	160.5	86.7	35.2	55.9	43.1	25.7	25.8
1947	28.9	259.9	158.0	139.4	304.0	277.8	102.1	34.9	23.7	21.3	19.7	18.9
1948	25.6	26.0	24.1	49.7	69.0	61.5	46.4	31.2	23.3	22.2	21.0	20.7
1949	21.6	26.4	27.1	32.5	194.5	347.3	135.6	50.4	36.3	30.4	60.8	43.4
1950	33.3	29.3	158.2	94.7	119.2	68.2	36.3	25.3	22.4	20.8	25.6	34.9
1951	49.6	30.0	21.2	50.1	160.4	83.9	43.9	33.0	27.3	26.0	22.6	27.7
1952	27.7	33.2	78.0	59.3	59.9	48.2	47.8	35.8	23.0	20.5	21.5	34.7
1953	51.1	55.2	56.6	49.8	62.5	79.0	51.9	64.2	55.7	36.7	24.2	24.4
1954	54.4	42.4	27.4	438.1	418.7	118.5	48.1	36.0	33.6	27.5	21.0	22.3
1955	27.6	41.1	34.2	28.0	142.8	234.9	98.2	32.3	30.8	25.4	21.3	23.8
1956	29.1	83.4	345.5	305.5	145.9	216.7	121.5	39.2	27.1	25.1	30.8	85.4
1957	78.1	43.4	40.1	159.9	105.3	46.7	64.2	48.1	27.6	23.1	21.0	20.5
1958	20.7	91.0	187.0	77.2	73.6	54.0	55.1	376.8	155.7	42.5	41.2	31.7
1959	27.7	35.7	36.0	51.3	51.1	46.7	45.6	36.3	25.4	21.9	24.4	30.0
1960	29.0	44.8	119.9	69.3	55.0	109.5	132.4	63.0	31.2	23.2	22.6	21.3
1961	19.7	42.3	51.4	48.6	168.0	149.1	65.8	32.4	24.0	20.9	21.8	20.7
1962	23.1	69.1	60.5	316.3	229.8	516.6	210.9	39.6	25.0	49.4	36.1	21.3
1963	81.9	125.8	69.0	132.3	73.2	124.6	101.1	46.0	280.3	117.3	29.6	27.6
1964	86.9	47.4	28.0	46.0	68.8	37.9	27.3	26.7	167.0	115.2	65.7	41.5
1965	69.2	76.7	35.1	222.3	152.1	29.9	23.5	60.2	43.9	25.0	26.8	28.6
1966	24.9	23.8	38.3	154.9	141.0	437.0	254.6	64.2	41.0	43.0	31.6	21.5
1967	22.9	28.8	29.0	27.6	32.5	56.8	43.4	26.5	21.0	20.7	23.1	27.4
1968	25.2	26.8	18.0	13.9	49.0	164.0	85.7	46.9	32.3	24.6	22.4	20.9
1969	37.9	31.6	33.3	24.0	54.7	28.6	13.2	9.0	15.5	11.5	50.4	52.1
1970	101.6	59.7	31.5	89.3	80.8	51.3	41.9	60.3	42.6	39.7	51.7	36.0
1971	135.0	74.1	37.2	121.9	372.4	254.7	77.6	28.7	25.1	22.6	20.5	20.3
1972	22.3	76.2	43.1	28.4	221.2	138.0	77.9	35.7	22.9	22.9	24.8	27.1
1973	27.0	58.2	43.9	337.5	451.1	528.9	189.4	74.9	50.3	31.5	24.5	20.6
1974	20.9	57.6	58.6	44.9	57.4	50.1	41.1	26.8	21.3	20.4	20.2	59.5
1975	38.1	31.2	407.4	533.5	501.5	1000.5	349.7	72.4	42.0	27.9	22.7	33.0
1976	226.7	111.2	27.2	69.1	105.7	83.1	46.9	29.3	23.7	24.3	23.1	29.7
1977	57.0	48.9	63.7	66.8	63.4	159.1	481.3	202.4	33.8	23.3	25.3	40.7
1978	62.5	65.1	144.7	63.6	82.4	53.3	41.7	29.8	24.5	36.8	38.6	30.6
1979	27.5	24.8	27.2	95.5	123.4	59.2	32.0	24.1	21.5	20.8	19.6	94.7
1980	55.3	54.6	36.1	92.6	169.5	80.8	29.8	35.8	33.1	24.9	32.4	31.3
1981	24.8	28.8	33.3	53.8	67.6	226.4	110.9	35.6	32.3	34.1	26.9	25.1
1982	47.0	38.3	21.3	13.4	12.0	11.6	17.2	11.9	7.7	20.2	11.7	11.7
1983	17.8	62.1	158.0	104.5	82.0	113.4	95.9	46.4	32.1	39.1	30.1	22.1
1984	34.0	43.3	28.5	112.4	482.4	167.0	26.0	21.5	20.2	19.8	18.8	18.8
1985	188.6	112.9	90.9	185.5	111.7	55.8	37.0	24.7	22.7	22.2	29.3	33.4
1986	93.0	102.9	50.0	35.3	45.6	67.5	44.4	24.6	24.5	22.8	37.5	765.0
1987	303.1	61.6	40.2	59.1	549.7	385.7	108.4	51.4	37.6	31.8	28.4	26.6
1988	27.0	49.0	119.6	110.6	501.4	182.9	134.7	62.6	30.0	28.8	23.1	19.3
1989	42.2	339.3	185.7	79.1	39.5	276.8	132.0	35.8	26.4	24.5	27.8	23.9
1990	27.3	23.9	47.4	133.5	162.7	66.1	27.0	20.8	20.6	19.9	18.8	22.5
1991	181.9	98.6	116.9	61.9	86.7	57.5	38.2	26.3	21.0	19.6	21.1	20.6
1992	14.1	17.7	10.2	9.3	48.9	101.8	52.5	17.8	6.1	4.3	6.2	12.0
1993	99.6	64.3	129.6	152.7	196.5	258.2	93.8	24.0	21.9	28.1	28.5	21.5
1994	20.8	32.9	29.6	58.8	40.8	134.4	100.6	44.9	39.6	32.2	22.2	22.7
1995	30.8	32.6	266.8	529.3	517.0	165.9	50.8	28.3	24.8	40.6	31.4	22.7
1996	26.1	128.3	178.6	299.2	179.3	115.7	104.9	55.2	284.5	135.6	38.9	26.0
1997	28.0	39.0	28.3	69.4	588.5	401.4	105.9	37.5	27.1	24.3	26.2	23.1
1998	22.1	49.4	115.6	128.2	254.0	147.2	48.5	26.8	22.5	21.7	19.7	19.0
1999	32.8	33.8	261.6	495.8	408.1	632.1	293.0	77.0	41.5	26.3	21.5	28.8
2000	38.9	43.8	79.9	145.6	114.4	91.9	61.2	36.0	25.3	25.1	25.0	27.2
2001	42.7	273.4	230.2	133.2	96.4	147.1	64.0	37.9	34.6	46.8	79.3	66.3
2002	36.0	24.3	34.3	53.5	43.7	58.6	42.7	30.5	26.3	22.0	21.3	27.7
2003	23.9	22.8	20.5	34.9	70.5	121.3	66.0	26.9	23.2	38.5	36.4	70.5
2004	47.6	66.4	128.4	120.5	90.5	70.2	41.7	25.5	21.8	20.2	20.6	19.0
Average	49.9	71.5	92.8	123.4	175.7	173.9	89.0	46.0	39.9	36.6	31.4	41.5
Min	14.1	17.7	10.2	9.3	12.0	11.6	13.2	9.0	6.1	4.3	6.2	11.7
Max	303.1	385.5	407.4	578.7	675.5	1000.5	481.3	376.8	284.5	302.4	142.8	765.0

SCENARIO 62 (m^3/s)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1920	128.9	26.5	28.5	28.3	85.6	198.4	118.9	42.6	21.0	14.5	12.2	18.8
1921	29.1	229.9	220.3	69.0	33.5	27.7	22.2	74.4	72.2	38.0	51.2	29.3
1922	55.0	161.1	73.5	193.6	513.7	278.0	66.2	16.7	15.4	213.8	99.1	21.1
1923	21.8	21.3	26.7	88.7	121.5	93.4	44.7	17.4	16.6	13.8	13.9	21.5
1924	26.3	32.5	289.7	151.4	58.6	588.0	309.3	59.4	20.0	14.5	12.5	18.6
1925	23.8	33.5	30.1	63.0	43.3	247.0	108.5	23.8	29.6	24.0	15.0	28.2
1926	44.6	41.0	56.9	42.2	48.2	581.4	255.2	20.1	13.7	14.4	16.2	17.2
1927	32.8	29.4	71.0	277.4	177.4	90.7	43.7	17.2	15.2	13.2	18.9	20.0
1928	27.7	31.6	45.0	37.7	37.3	224.2	99.6	22.6	45.7	52.4	30.8	79.6
1929	95.1	82.3	140.8	150.5	57.7	112.0	79.9	28.6	23.4	21.1	39.3	37.7
1930	31.4	25.5	31.6	293.4	334.6	287.3	117.5	27.2	15.1	317.4	140.3	20.4
1931	28.4	32.6	59.4	37.7	269.2	129.8	33.0	20.3	21.2	26.0	20.0	36.0
1932	41.8	176.4	176.0	51.1	27.9	39.0	36.9	16.8	12.8	13.1	12.4	14.4
1933	18.8	247.0	332.9	578.7	238.8	151.0	72.2	21.4	16.2	24.5	21.1	16.5
1934	40.9	64.9	141.7	81.7	39.0	67.3	130.7	100.7	85.3	39.2	32.9	27.3
1935	24.3	24.1	20.3	24.3	221.2	136.5	46.0	61.4	40.1	23.5	16.9	16.6
1936	31.8	419.5	178.1	66.8	512.0	219.5	42.9	15.7	13.3	12.6	12.0	15.5
1937	22.7	24.3	36.1	86.5	191.7	78.0	107.5	49.0	26.7	28.2	25.6	21.6
1938	27.8	37.0	198.9	233.5	677.5	218.5	34.4	24.5	21.1	24.7	23.3	101.4
1939	71.2	53.1	40.8	33.7	365.6	221.4	64.5	124.0	62.1	20.8	14.3	30.2
1940	32.1	34.4	78.2	103.8	125.8	67.0	51.1	27.0	15.6	15.4	15.0	16.0
1941	26.2	26.2	21.3	64.3	295.9	205.4	90.9	46.1	23.2	14.5	17.8	23.5
1942	38.9	215.2	334.2	176.1	53.8	153.2	204.8	81.7	38.8	30.8	152.5	84.4
1943	77.3	310.1	300.1	157.1	115.0	147.5	58.6	17.5	25.0	23.5	15.7	156.4
1944	92.6	30.0	19.3	49.4	180.6	226.0	79.6	18.7	14.9	12.9	11.8	14.0
1945	36.7	27.5	23.0	79.5	73.9	117.5	67.1	31.5	21.7	15.7	13.0	14.9
1946	22.5	37.8	44.4	82.4	121.2	166.2	96.1	27.9	48.0	35.1	17.9	20.9
1947	28.9	259.9	211.1	174.7	304.0	277.8	102.1	27.6	15.8	13.2	11.9	13.8
1948	25.6	26.0	24.1	49.8	69.1	61.5	46.4	23.9	15.4	14.1	13.2	15.8
1949	21.6	26.5	33.4	39.5	194.5	364.9	135.6	45.7	28.4	22.3	53.1	38.6
1950	33.3	29.3	158.2	94.7	125.0	77.4	36.3	18.0	14.5	12.7	17.8	30.1
1951	49.6	30.0	21.2	50.1	160.4	83.9	43.9	25.6	19.4	17.9	14.8	22.9
1952	27.7	33.2	78.0	59.3	59.9	48.2	47.8	28.5	15.1	12.4	13.7	29.9
1953	51.1	55.2	56.6	49.8	62.5	79.0	51.9	56.9	47.8	28.6	16.4	19.5
1954	54.4	48.0	35.3	448.0	530.8	151.4	59.2	28.7	25.7	19.4	13.2	17.5
1955	27.6	41.1	34.2	28.0	142.8	234.9	102.1	25.0	23.0	17.3	13.5	19.0
1956	29.1	83.4	365.8	340.6	160.5	236.6	121.5	31.9	19.2	17.0	23.0	80.6
1957	78.1	43.4	40.1	159.9	129.7	46.7	64.2	40.7	19.7	14.9	13.2	15.5
1958	20.7	91.0	187.1	77.2	74.5	61.8	63.1	408.6	155.7	37.6	33.4	26.9
1959	27.7	35.7	36.0	51.3	51.1	46.7	45.6	29.1	17.4	13.8	16.6	25.2
1960	29.0	44.8	119.9	69.3	55.0	113.3	150.6	58.3	23.3	15.1	14.8	16.3
1961	19.7	42.3	51.5	48.7	180.4	193.7	73.4	25.1	16.1	12.8	14.0	15.7
1962	23.2	69.1	60.5	349.3	232.5	516.6	210.9	32.3	17.1	41.3	28.2	16.5
1963	81.9	131.0	74.2	133.2	73.1	139.4	109.6	38.7	289.0	117.3	21.8	22.8
1964	86.9	47.4	28.0	46.0	69.3	42.4	27.3	19.4	182.1	115.2	57.9	36.6
1965	69.2	83.7	35.1	227.9	152.1	29.9	23.5	52.9	36.0	16.9	19.0	23.8
1966	24.9	23.8	38.3	154.9	141.0	460.8	266.7	63.2	33.1	34.9	23.8	16.7
1967	22.9	28.8	29.0	27.6	32.5	56.8	43.4	19.2	13.1	12.5	15.4	22.6
1968	25.2	26.8	25.9	22.7	56.8	164.0	91.6	39.6	24.4	16.5	14.6	15.9
1969	38.0	31.7	34.9	31.9	54.7	34.8	22.1	15.4	21.0	16.8	42.6	47.3
1970	101.6	59.7	31.5	89.3	80.8	51.3	41.9	53.0	34.7	31.6	43.9	31.2
1971	135.0	74.1	37.2	121.9	408.2	296.0	77.6	21.3	17.2	14.5	12.7	15.5
1972	22.3	76.2	43.1	28.4	221.2	173.4	78.1	28.4	15.0	14.8	17.0	22.3
1973	27.0	58.2	43.9	358.5	467.1	528.9	189.4	67.6	42.4	23.4	16.7	15.7
1974	20.9	57.6	58.6	44.9	57.4	50.1	41.1	19.5	13.4	12.3	12.4	54.7
1975	38.1	31.2	407.4	577.0	531.7	1000.5	349.7	72.4	35.8	19.8	14.9	28.2
1976	253.3	111.2	27.2	69.1	105.7	83.1	46.9	22.0	15.8	16.2	15.3	24.9
1977	57.0	48.9	63.7	66.8	63.4	159.1	518.5	202.4	25.9	15.2	17.5	35.9
1978	62.5	65.1	144.7	63.6	85.7	57.5	41.7	22.5	16.6	28.7	30.8	25.7
1979	27.5	24.8	27.2	95.5	123.4	59.2	32.0	16.8	13.6	12.7	11.8	89.9
1980	55.3	54.6	36.1	92.6	186.4	80.8	29.8	28.6	25.1	16.8	24.6	26.5
1981	24.8	28.8	33.3	53.8	67.6	226.4	110.9	28.3	24.4	26.0	19.1	20.3
1982	47.0	38.3	21.3	20.8	20.6	24.1	28.1	17.8	13.7	25.8	18.1	20.7
1983	29.6	62.1	158.0	104.5	82.0	113.4	95.9	39.1	24.2	31.0	22.3	17.3
1984	34.0	43.3	28.5	112.4	506.4	167.0	26.0	14.2	12.3	11.7	11.0	14.0
1985	188.6	112.9	123.7	221.5	126.5	62.2	37.0	17.4	14.8	14.1	21.5	28.6
1986	93.0	108.3	53.0	35.3	45.6	67.5	44.4	17.3	16.6	14.7	29.7	812.1
1987	328.9	61.6	40.2	59.1	549.7	385.7	108.4	44.1	29.7	23.7	20.6	21.6
1988	27.1	49.0	145.5	120.4	501.4	182.9	134.7	59.8	22.1	20.7	15.3	14.5
1989	42.2	371.4	185.7	79.1	39.5	276.8	132.0	28.5	18.5	16.4	20.0	19.0
1990	27.3	23.9	47.4	133.5	162.7	66.1	27.0	13.5	12.8	11.8	11.0	17.7
1991	181.9	98.6	116.9	61.9	86.7	57.5	38.2	19.0	13.1	11.6	13.3	16.8
1992	22.0	30.6	24.1	22.5	57.4	109.6	58.4	18.7	12.5	11.0	12.8	18.5
1993	99.6	64.3	129.6	152.7	196.5	260.1	93.8	16.7	14.0	20.0	20.7	16.7
1994	20.8	32.9	29.6	58.8	40.8	134.4	100.6	37.6	31.7	24.1	14.4	17.9
1995	30.8	32.6	271.0	575.2	543.1	165.9	50.8	21.0	16.9	32.5	23.6	17.9
1996	26.1	128.3	197.1	316.1	179.3	115.7	104.9	47.9	292.1	135.6	31.0	21.2
1997	28.0	39.0	28.3	69.4	602.1	401.4	105.9	30.2	19.2	16.2	18.4	18.3
1998	22.1	49.4	127.2	145.5	261.2	147.2	48.5	19.5	14.6	13.5	11.9	13.9
1999	32.9	33.9	261.6	525.5	414.7	632.1	293.0	77.0	33.6	18.2	13.7	24.0
2000	38.9	43.8	79.9	145.6	114.4	91.9	61.1	28.8	17.4	17.0	17.2	22.3
2001	42.7	285.8	262.5	152.4	96.4	147.1	64.0	30.6	26.7	38.7	71.5	63.2
2002	36.0	24.3	34.3	53.5	43.7	58.6	42.7	23.2	18.3	13.9	13.5	22.9
2003	23.9	22.8	20.5	34.9	70.5	121.3	66.0	19.6	15.3	30.4	28.6	65.7
2004	47.6	66.4	128.4	174.4	118.3	79.6	41.7	18.1	13.9	12.1	12.8	13.9
Average	51.1	74.4	97.2	130.3	181.1	179.2	91.5	40.4	33.3	29.8	24.6	37.9
Min	18.8	21.3	19.3	20.8	20.6	24.1	22.1	13.5	12.3	11.0	11.0	13.8
Max	328.9	419.5	407.4	578.7	677.5	1000.5	518.5	408.6	292.1	317.4	152.5	812.1

SCENARIO 63 (m^3/s)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1920	128.9	31.6	33.6	33.5	87.0	181.9	118.9	42.7	21.0	14.5	12.2	18.8
1921	34.3	235.0	212.1	72.7	38.6	32.8	27.4	74.4	72.2	38.0	34.0	29.3
1922	60.1	152.5	73.5	193.6	513.7	278.0	71.4	16.7	15.4	208.8	99.1	21.1
1923	26.9	26.4	31.8	93.8	126.6	98.6	49.8	17.4	16.6	13.8	13.9	21.5
1924	31.4	37.6	269.3	126.8	63.7	583.3	309.3	59.4	20.0	14.5	12.5	18.6
1925	29.0	38.6	35.2	68.1	48.4	252.1	113.6	23.8	29.6	24.0	15.0	28.2
1926	49.8	46.2	62.1	47.3	53.3	555.0	220.8	20.1	13.7	14.4	16.2	17.2
1927	37.9	34.6	76.1	261.8	177.4	95.8	48.8	17.2	15.2	13.2	18.9	20.0
1928	32.8	36.7	50.1	42.9	42.4	196.2	94.5	22.6	45.7	50.7	30.8	79.1
1929	95.1	82.3	140.8	150.5	57.7	112.0	79.9	28.6	23.4	21.1	39.3	37.7
1930	36.6	30.6	36.7	280.9	331.5	287.3	117.5	27.2	15.1	317.4	140.3	20.4
1931	33.5	37.7	64.5	42.8	246.8	129.8	38.2	20.3	21.2	26.0	20.0	36.0
1932	47.0	165.9	176.0	56.2	33.1	44.2	42.1	16.8	12.8	13.1	12.4	14.4
1933	23.9	242.4	312.4	578.7	238.8	151.0	72.2	21.4	16.2	24.5	21.1	16.5
1934	46.0	70.1	137.0	76.3	44.1	62.6	130.7	100.7	85.3	39.2	32.9	27.3
1935	29.5	29.3	25.4	29.5	226.4	141.7	51.1	61.4	40.1	23.5	16.9	16.6
1936	36.9	384.6	171.5	66.8	512.0	219.5	48.0	15.7	13.3	12.6	12.0	15.5
1937	27.8	29.5	41.3	91.6	196.8	83.1	97.8	46.9	26.7	28.2	25.6	21.6
1938	32.9	42.1	187.7	211.0	677.5	218.5	39.6	24.5	21.1	24.7	23.3	101.4
1939	76.3	58.2	45.9	38.8	360.7	200.4	66.7	121.9	62.1	20.8	14.3	30.2
1940	37.2	39.5	83.3	108.9	130.9	72.1	56.2	27.0	15.6	15.4	15.0	16.0
1941	31.4	31.4	26.4	69.4	301.1	210.5	96.1	46.1	23.2	14.5	17.8	23.5
1942	44.0	215.2	334.2	173.6	58.9	130.9	183.2	75.2	38.3	30.8	141.2	76.7
1943	77.9	300.9	300.1	157.1	115.0	147.5	61.2	17.5	25.0	23.5	15.7	153.8
1944	92.6	35.1	24.5	54.5	185.8	216.6	84.7	18.7	14.9	12.9	11.8	14.0
1945	41.9	32.7	28.2	84.6	79.0	120.1	72.2	31.5	21.7	15.7	13.0	14.9
1946	27.7	43.0	49.5	87.5	126.3	165.7	91.8	27.9	48.0	35.1	17.9	20.9
1947	34.1	265.1	163.2	144.8	304.0	277.8	102.1	27.6	15.8	13.2	11.9	13.8
1948	30.7	31.2	29.3	54.9	74.2	66.6	51.5	23.9	15.4	14.1	13.2	15.8
1949	26.7	31.6	38.5	44.7	199.6	352.4	140.7	43.1	28.4	22.3	53.1	38.6
1950	38.5	34.4	162.5	91.9	120.8	73.3	41.4	18.0	14.5	12.7	17.8	30.1
1951	54.7	35.2	26.4	55.3	165.5	89.0	49.0	25.6	19.4	17.9	14.8	22.9
1952	32.8	38.3	83.2	64.5	65.0	53.3	52.9	28.5	15.1	12.4	13.7	29.9
1953	56.2	60.3	61.8	54.9	67.6	84.1	57.1	56.9	47.8	28.6	16.4	19.5
1954	59.5	53.1	40.4	443.3	423.8	123.6	53.3	28.7	25.7	19.4	13.2	17.5
1955	32.7	46.3	39.3	33.2	147.9	240.1	103.3	25.0	23.0	17.3	13.5	19.0
1956	34.3	88.6	350.6	310.6	151.0	212.5	121.5	31.9	19.2	17.0	23.0	80.6
1957	83.2	48.5	45.2	165.0	110.5	51.8	69.3	40.7	19.7	14.9	13.2	15.5
1958	25.9	96.2	192.2	82.4	78.8	59.2	60.3	377.0	155.7	37.6	33.4	26.9
1959	32.8	40.8	41.1	56.5	56.3	51.9	50.8	29.0	17.4	13.8	16.6	25.2
1960	34.2	49.9	125.0	74.5	60.1	114.7	137.5	55.6	23.3	15.1	14.8	16.3
1961	24.9	47.5	56.6	53.8	173.1	150.8	70.5	25.1	16.1	12.8	14.0	15.7
1962	28.3	74.3	65.7	321.5	231.6	516.6	210.9	32.3	17.1	41.3	28.2	16.5
1963	87.0	130.9	74.1	137.4	78.3	129.8	106.2	38.7	288.1	117.3	21.8	22.8
1964	92.1	52.5	33.2	51.2	73.9	43.0	32.5	19.4	151.1	115.2	57.9	36.6
1965	74.4	81.8	40.3	219.5	152.1	35.0	28.7	52.9	36.0	16.9	19.0	23.8
1966	30.0	29.0	43.4	160.0	146.1	429.8	262.2	63.2	33.1	34.9	23.8	16.7
1967	28.1	33.9	34.2	32.8	37.7	61.9	48.5	19.2	13.1	12.5	15.4	22.6
1968	30.4	31.9	31.0	17.5	51.5	169.2	90.9	39.6	24.4	16.5	14.6	15.9
1969	43.1	36.8	40.1	30.1	57.4	29.5	12.0	9.0	15.5	11.5	42.6	47.3
1970	106.8	64.9	36.6	94.4	85.9	56.4	47.1	53.0	34.7	31.6	43.9	31.2
1971	140.1	79.3	42.3	127.0	372.4	247.1	77.6	21.3	17.2	14.5	12.7	15.5
1972	27.4	81.3	48.2	33.5	226.4	148.1	78.1	28.4	15.0	14.8	17.0	22.3
1973	32.2	63.3	49.0	343.1	467.1	528.9	189.4	67.6	42.4	23.4	16.7	15.7
1974	26.1	62.7	63.7	50.0	62.5	55.3	46.3	19.5	13.4	12.3	12.4	54.7
1975	43.2	36.3	407.4	533.5	529.7	1000.5	349.7	72.4	35.8	19.8	14.9	28.2
1976	253.3	111.2	32.3	74.3	110.9	80.6	52.1	22.0	15.8	16.2	15.3	24.9
1977	62.2	54.0	68.9	71.9	68.6	164.3	468.6	202.4	25.9	15.2	17.5	35.9
1978	67.6	70.2	149.8	68.7	87.5	58.4	46.8	22.5	16.6	28.7	30.8	25.7
1979	32.7	29.9	32.3	100.7	128.6	64.3	37.1	16.8	13.6	12.7	11.8	89.9
1980	60.5	59.7	41.2	97.7	178.0	80.8	34.9	28.6	25.1	16.8	24.6	26.5
1981	29.9	33.9	38.5	59.0	72.7	231.6	116.0	28.3	24.4	26.0	19.1	20.3
1982	52.1	43.4	26.5	26.0	14.5	11.6	17.2	11.9	7.6	20.0	11.7	11.7
1983	17.8	66.3	163.1	109.6	87.1	118.6	101.1	39.1	24.2	31.0	22.3	17.3
1984	39.1	48.4	33.6	117.6	467.3	167.0	31.1	14.2	12.3	11.7	11.0	14.0
1985	193.7	118.0	96.0	190.6	112.7	59.0	42.1	17.4	14.8	14.1	21.5	28.6
1986	98.1	108.0	55.1	40.4	50.7	72.6	49.6	17.3	16.6	14.7	29.7	771.9
1987	328.9	61.6	43.7	55.7	549.7	385.7	108.4	44.1	29.7	23.7	20.6	21.6
1988	32.2	54.2	135.3	120.4	501.4	182.9	134.7	59.8	22.1	20.7	15.3	14.5
1989	47.4	366.1	185.7	79.1	44.6	272.2	132.0	28.5	18.5	16.4	20.0	19.0
1990	32.4	29.1	52.5	138.6	167.8	71.2	32.1	13.5	12.8	11.8	11.0	17.7
1991	187.0	103.7	122.0	67.0	91.9	62.7	43.3	19.0	13.1	11.6	13.3	16.8
1992	27.1	31.3	15.3	9.3	48.9	104.4	53.1	14.5	8.6	4.6	6.2	12.0
1993	104.8	69.4	134.7	157.9	201.7	245.7	98.9	16.7	14.0	20.0	20.7	16.7
1994	26.0	38.1	34.7	63.9	45.9	139.6	105.7	37.6	31.7	24.1	14.4	17.9
1995	35.9	37.7	271.9	529.1	520.3	165.9	55.9	21.0	16.9	32.5	23.6	17.9
1996	31.2	133.4	182.1	316.1	179.3	115.7	105.2	47.9	291.7	135.6	31.0	21.2
1997	33.1	44.2	33.5	74.5	579.7	401.4	105.9	30.2	19.2	16.2	18.4	18.3
1998	27.3	54.6	120.8	141.7	261.2	147.2	53.6	19.5	14.6	13.5	11.9	13.9
1999	38.0	39.0	266.7	505.2	414.7	632.1	293.0	77.0	33.6	18.2	13.7	24.0
2000	44.0	49.0	85.0	150.8	119.5	97.1	66.2	28.8	17.4	17.0	17.2	22.3
2001	47.8	273.4	234.4	152.4	96.4	147.1	69.2	30.6	26.7	38.7	71.5	61.5
2002	41.2	29.5	39.4	58.7	48.8	63.7	47.8	23.2	18.3	13.9	13.5	22.9
2003	29.0	28.0	25.7	40.0	75.6	126.4	71.1	19.6	15.3	30.4	28.6	65.7
2004	52.8	71.6	133.5	125.5	85.0	75.3	46.8	18.1	13.9	12.1	12.8	13.9
Average	55.7	77.6	98.2	128.5	179.5	176.3	92.3	39.6	32.7	29.5	24.1	37.1
Min	17.8	26.4	15.3	9.3	14.5	11.6	12.0	9.0	7.6	4.6	6.2	11.7
Max	328.9	384.6	407.4	578.7	677.5	1000.5	468.6	377.0	291.7	317.4	141.2	771.9

SCENARIO 65 (m^3/s)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1920	128.9	26.5	28.5	28.3	85.6	198.4	118.9	41.2	18.6	12.0	9.5	12.4
1921	29.1	229.9	235.6	69.0	33.5	27.7	22.2	72.9	69.7	39.7	53.5	26.5
1922	55.0	163.9	73.5	193.6	513.7	278.0	66.2	15.1	13.0	217.7	99.1	14.7
1923	21.8	21.3	26.7	88.7	121.5	93.6	44.7	15.9	14.5	11.3	11.2	15.1
1924	26.2	32.4	310.8	151.4	58.6	587.9	309.3	59.4	17.5	12.0	9.8	12.2
1925	23.8	33.5	30.1	63.0	43.3	247.0	108.5	22.2	27.2	21.5	12.3	21.9
1926	44.6	41.0	56.9	42.2	48.2	610.3	255.2	18.6	11.3	11.9	13.4	11.0
1927	32.7	29.4	71.0	292.7	177.4	90.7	43.7	15.7	12.7	10.7	16.1	13.6
1928	27.7	31.6	45.0	37.7	37.3	239.4	99.6	21.0	45.1	54.5	28.1	82.4
1929	95.1	82.3	140.8	150.5	57.7	112.0	79.9	27.1	21.0	18.6	36.6	33.7
1930	31.4	25.5	31.6	306.5	334.6	287.3	117.5	25.7	12.7	321.3	140.3	14.0
1931	28.4	32.6	59.4	37.7	276.0	129.8	33.0	18.8	18.8	23.5	17.2	29.7
1932	41.8	192.1	176.0	51.1	27.9	39.0	36.9	15.2	10.4	10.6	9.7	8.3
1933	18.8	256.6	338.8	578.7	238.8	151.0	72.2	19.9	13.8	22.0	18.3	10.2
1934	40.9	64.9	157.0	81.7	39.0	67.3	130.7	100.7	85.3	36.7	30.2	20.9
1935	24.3	24.1	20.3	24.3	221.2	136.6	46.0	60.1	39.5	21.0	14.2	10.2
1936	31.8	444.8	178.1	66.8	512.0	219.5	42.9	14.2	10.9	10.1	9.2	9.1
1937	22.7	24.3	36.1	86.5	191.7	92.9	107.7	49.0	24.3	25.7	22.9	15.3
1938	27.8	37.0	212.6	233.5	677.5	218.5	34.4	22.9	18.6	22.2	20.5	95.0
1939	76.8	54.1	40.8	33.7	375.1	221.4	64.5	124.0	61.7	18.3	11.5	23.8
1940	32.1	34.4	78.2	103.8	125.8	67.0	51.1	25.5	13.1	12.9	12.2	9.9
1941	26.2	26.1	21.3	64.3	295.9	205.3	90.9	44.6	20.8	12.1	15.1	17.2
1942	38.9	215.2	362.4	189.9	53.8	153.2	204.8	81.7	38.8	28.3	154.9	84.4
1943	77.3	310.1	300.1	157.1	115.0	147.5	58.6	15.9	22.6	21.0	12.9	165.8
1944	92.6	30.0	19.3	49.4	180.6	226.0	79.6	17.2	12.5	10.5	9.1	7.9
1945	36.5	27.5	23.0	79.5	77.2	129.7	67.1	29.9	19.3	13.3	10.3	8.8
1946	22.5	37.8	44.4	82.4	121.1	181.4	96.1	26.4	45.5	32.6	15.1	14.6
1947	28.9	270.9	215.8	174.7	304.0	277.8	102.1	26.1	13.4	10.7	9.2	7.7
1948	25.6	26.0	24.1	49.7	69.0	61.5	46.4	22.4	12.9	11.6	10.4	9.5
1949	21.6	26.4	33.4	39.5	194.5	364.9	135.6	45.7	26.4	19.8	50.3	32.2
1950	33.3	29.3	163.6	117.7	141.5	77.4	36.3	16.4	12.1	10.2	15.1	23.7
1951	49.6	30.0	21.2	50.1	160.4	83.9	43.9	24.1	16.9	15.5	12.1	16.5
1952	27.7	33.2	78.0	59.3	59.9	48.2	47.8	27.0	12.6	9.9	11.0	23.6
1953	51.1	55.2	56.6	49.8	62.5	97.8	53.0	65.9	56.2	26.2	13.6	13.2
1954	54.4	48.0	35.3	467.4	530.8	151.4	59.2	28.7	23.2	16.9	10.5	11.1
1955	27.6	41.1	34.2	28.0	142.8	246.3	104.5	23.5	20.5	14.8	10.7	12.7
1956	29.1	83.4	381.1	340.6	160.5	236.6	121.5	30.3	16.7	14.5	20.3	74.3
1957	78.1	43.4	40.1	174.7	130.1	46.7	64.2	39.2	17.3	12.5	10.4	9.4
1958	20.7	91.0	198.0	77.2	79.2	61.8	63.0	408.6	155.7	37.6	31.6	20.5
1959	27.7	35.7	36.0	51.3	53.1	48.5	45.6	27.6	15.0	11.4	13.9	18.8
1960	29.0	44.8	119.9	69.3	55.0	132.9	150.6	58.3	20.9	12.6	12.0	10.1
1961	19.7	42.3	51.4	48.6	195.4	193.7	73.4	23.5	13.7	10.3	11.3	9.6
1962	23.1	69.1	60.5	364.5	232.5	516.6	210.9	30.7	14.7	38.8	25.5	10.1
1963	81.9	146.8	74.2	133.2	73.1	139.4	109.6	37.2	290.5	117.3	19.0	16.4
1964	86.9	47.4	28.0	46.0	79.0	42.4	27.3	17.9	183.7	115.2	57.9	30.3
1965	69.2	90.1	35.1	227.9	152.1	29.9	23.5	51.4	33.6	14.4	16.2	17.4
1966	24.9	23.8	38.3	154.9	141.0	476.0	266.7	63.2	30.6	32.4	21.1	10.3
1967	22.9	28.8	29.0	27.6	32.5	56.8	43.4	17.7	10.7	10.1	12.6	16.2
1968	25.2	26.8	25.9	22.7	56.8	179.6	95.5	38.1	21.9	14.0	11.8	9.8
1969	37.9	31.6	34.9	31.9	54.7	34.8	22.1	13.9	18.5	14.4	39.8	40.9
1970	101.6	59.7	31.5	89.3	80.8	51.3	41.9	51.5	32.3	29.1	41.2	24.8
1971	135.0	74.1	37.2	121.9	467.5	296.0	77.6	19.8	14.8	12.0	10.0	9.1
1972	22.3	76.2	43.1	28.4	221.2	188.8	78.1	26.9	12.6	12.3	14.3	15.9
1973	27.0	58.2	43.9	373.8	467.1	528.9	189.4	66.1	40.0	20.9	14.0	9.4
1974	20.9	57.6	58.6	44.9	57.4	50.1	41.1	18.0	11.0	9.8	9.6	48.3
1975	38.1	31.2	418.7	596.1	531.7	1000.5	349.7	72.4	35.8	17.3	12.2	21.8
1976	264.7	111.2	27.2	69.1	105.7	83.1	46.9	20.4	13.4	13.7	12.5	18.5
1977	57.0	48.9	63.7	66.8	63.4	159.1	534.5	202.4	23.5	12.7	14.7	29.5
1978	62.5	65.1	149.7	66.3	92.2	57.5	41.7	20.9	14.2	26.2	28.1	19.4
1979	27.5	24.8	27.2	95.5	123.4	59.2	32.0	15.3	11.2	10.1	9.0	83.5
1980	55.3	54.6	36.1	92.6	186.4	85.6	29.8	27.0	22.7	14.4	21.9	20.1
1981	24.8	28.8	33.3	53.8	67.6	226.4	110.9	26.7	21.9	23.5	16.3	13.9
1982	47.0	38.3	21.3	20.8	20.6	24.1	28.1	16.3	11.3	23.3	15.3	14.3
1983	29.6	62.1	158.0	104.5	82.0	113.4	95.9	37.5	21.8	28.5	19.5	10.9
1984	34.0	43.3	28.5	112.4	567.8	186.8	26.0	12.7	9.9	9.2	8.3	7.9
1985	188.4	131.0	129.3	221.5	126.5	62.2	37.0	15.9	12.4	11.6	18.7	22.2
1986	93.0	124.1	53.0	35.3	45.6	67.5	44.4	15.7	14.5	12.2	26.9	821.3
1987	328.9	61.6	40.2	59.1	549.7	385.7	108.4	42.6	27.2	21.2	17.9	15.4
1988	27.0	49.0	160.6	120.4	501.4	182.9	134.7	59.8	19.6	18.2	12.5	8.1
1989	42.2	385.6	185.7	79.1	39.5	276.8	132.0	26.9	16.1	13.9	17.2	12.7
1990	27.3	23.9	47.4	133.5	162.7	66.1	27.0	12.0	10.3	9.3	8.3	11.3
1991	181.9	98.6	116.9	61.9	86.7	57.5	38.2	17.5	10.6	9.1	10.6	10.5
1992	22.0	30.6	24.1	22.5	57.4	109.6	58.4	17.1	10.1	8.5	10.0	13.9
1993	99.6	64.3	129.6	152.7	203.4	266.5	101.1	15.2	11.5	17.5	18.0	10.3
1994	20.8	32.9	29.6	58.8	40.8	134.4	100.6	36.1	29.3	21.7	11.7	11.5
1995	30.8	32.6	300.5	612.7	543.1	165.9	50.8	19.4	14.5	30.0	20.8	11.5
1996	26.1	129.9	210.8	316.1	179.3	115.7	104.9	46.4	293.7	135.6	28.9	14.8
1997	28.0	39.0	28.3	69.4	611.2	401.4	105.9	28.6	16.8	13.7	15.6	12.0
1998	22.1	49.4	142.4	145.5	261.2	147.2	48.5	18.0	12.1	11.1	9.2	7.8
1999	32.8	33.8	261.6	540.7	414.7	632.1	293.0	77.0	31.2	15.7	11.0	17.6
2000	38.9	43.8	79.9	145.6	114.8	102.0	61.2	27.2	14.9	14.5	14.4	16.0
2001	42.7	304.8	262.5	152.4	96.4	147.1	64.0	29.1	24.2	36.2	72.5	68.7
2002	36.0	24.3	34.3	53.5	43.7	58.6	42.7	21.7	15.9	11.4	10.7	16.5
2003	23.9	22.8	20.5	34.9	70.5	121.3	66.3	18.0	12.8	28.0	25.9	65.2
2004	47.6	67.0	129.2	197.4	118.3	79.6	41.7	16.6	11.5	9.6	10.0	7.8
Average	51.3	76.2	100.0	132.9	183.6	181.8	91.9	39.2	31.3	27.7	22.1	32.4
Min	18.8	21.3	19.3	20.8	20.6	24.1	22.1	12.0	9.9	8.5	8.3	7.7
Max	328.9	444.8	418.7	612.7	677.5	1000.5	534.5	408.6	293.7	321.3	154.9	821.3

SCENARIO 69 (m^3/s)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1920	128.9	32.8	34.8	34.6	88.2	177.4	118.9	41.2	18.6	12.0	9.5	12.4
1921	25.0	236.2	233.6	73.9	39.8	34.0	28.5	72.9	69.7	35.6	34.6	26.5
1922	50.9	168.2	73.5	193.6	513.7	278.0	72.5	15.1	13.0	211.6	99.1	14.7
1923	17.6	27.3	33.0	95.0	127.8	99.8	51.0	15.9	14.2	11.3	11.2	15.2
1924	22.1	38.8	276.7	151.4	64.9	582.3	309.3	59.4	17.5	12.0	9.8	12.2
1925	19.7	39.8	36.4	69.3	49.6	253.3	114.8	22.2	27.2	21.5	12.3	21.9
1926	40.5	47.3	63.2	48.5	54.5	557.3	255.2	18.6	11.3	11.9	13.4	11.0
1927	28.6	35.7	77.3	284.4	177.4	97.0	50.0	15.7	12.7	10.7	16.1	13.6
1928	23.5	37.9	51.3	44.0	43.6	206.8	99.6	21.0	45.1	54.5	28.1	82.4
1929	95.1	82.3	140.8	150.5	57.7	112.0	79.9	27.1	21.0	18.6	36.6	33.7
1930	27.3	31.8	37.9	298.2	334.6	287.3	117.5	25.7	12.7	321.3	140.3	14.0
1931	24.2	38.9	65.7	44.0	260.0	129.8	39.3	18.8	18.8	23.5	17.2	29.7
1932	37.7	190.1	176.0	57.4	34.2	45.4	43.2	15.2	10.4	10.6	9.7	8.3
1933	14.6	247.0	328.0	578.7	238.8	151.0	72.2	19.9	13.8	22.0	18.3	10.2
1934	36.7	71.2	155.1	81.7	45.3	61.6	130.7	100.7	85.3	36.7	30.2	20.9
1935	20.2	30.4	26.6	30.6	227.5	142.8	52.3	59.9	37.6	21.0	14.2	10.2
1936	27.6	417.5	178.1	66.8	512.0	219.5	49.2	14.2	10.9	10.1	9.2	9.1
1937	18.5	30.6	42.4	92.8	198.0	84.3	99.0	45.4	24.3	25.7	22.9	15.3
1938	23.6	43.3	205.1	233.5	677.5	218.5	40.7	22.9	18.6	22.2	20.5	95.0
1939	70.8	59.4	47.1	40.0	361.9	215.6	67.8	120.8	61.7	18.3	11.5	23.8
1940	27.9	40.7	84.5	110.1	132.1	73.3	57.3	25.5	13.1	12.9	12.2	9.9
1941	22.0	32.4	27.6	70.6	302.2	211.6	97.2	44.6	20.8	12.1	15.1	17.2
1942	34.7	215.2	334.2	173.6	60.1	132.1	204.2	81.7	38.8	28.3	154.9	84.4
1943	77.3	310.1	300.1	157.1	115.0	147.5	62.4	15.9	22.6	21.0	12.9	162.1
1944	92.6	36.3	25.6	55.7	186.9	217.8	85.9	17.2	12.5	10.5	9.1	7.9
1945	32.4	33.8	29.3	85.8	80.2	121.2	73.4	29.9	19.3	13.3	10.3	8.8
1946	18.4	44.1	50.7	88.7	127.4	166.8	93.0	26.4	45.5	32.6	15.1	14.6
1947	24.8	266.2	185.4	174.7	304.0	277.8	102.1	26.1	13.4	10.7	9.2	7.7
1948	21.4	32.3	30.4	56.0	75.3	67.8	52.7	22.4	12.9	11.6	10.4	9.5
1949	17.4	32.7	39.7	45.8	200.8	353.6	141.9	41.6	25.9	19.8	50.3	32.2
1950	29.2	35.6	163.7	93.1	121.9	75.1	42.6	16.4	12.1	10.2	15.1	23.7
1951	45.4	36.3	27.5	56.5	166.7	90.2	50.2	24.1	16.9	15.5	12.1	16.5
1952	23.5	39.5	84.3	65.6	66.2	54.5	54.1	27.0	12.6	9.9	11.0	23.6
1953	46.9	61.5	62.9	56.1	68.8	85.3	58.2	55.4	45.4	26.2	13.6	13.2
1954	50.2	54.3	41.6	444.4	479.2	151.4	59.2	28.7	23.2	16.9	10.5	11.1
1955	23.4	47.4	40.5	34.3	149.1	241.2	104.5	23.5	20.5	14.8	10.7	12.7
1956	25.0	89.7	364.0	340.6	160.5	236.6	121.5	30.3	16.7	14.5	20.3	74.3
1957	74.8	49.7	46.4	166.2	129.6	53.0	70.5	39.2	17.3	12.5	10.4	9.4
1958	16.5	97.3	193.3	83.5	79.9	60.3	61.4	395.2	155.7	37.6	31.6	20.5
1959	23.5	42.0	42.3	57.6	57.4	53.0	51.9	27.6	15.0	11.4	13.9	18.8
1960	24.8	51.1	126.2	75.6	61.3	115.8	138.7	54.1	20.9	12.6	12.0	10.1
1961	15.5	48.6	57.7	54.9	174.3	182.4	73.4	23.5	13.7	10.3	11.3	9.6
1962	19.0	75.4	66.8	356.3	232.5	516.6	210.9	30.7	14.7	38.8	25.5	10.1
1963	77.7	151.1	75.4	138.5	79.4	130.9	107.4	37.2	289.0	117.3	19.0	16.4
1964	83.9	53.7	34.3	52.3	75.0	44.1	33.6	17.9	163.1	115.2	57.9	30.3
1965	65.1	94.4	41.4	221.6	152.1	36.2	29.8	51.4	33.6	14.4	16.2	17.4
1966	20.7	30.1	44.6	161.2	147.3	443.3	266.7	63.2	30.6	32.4	21.1	10.3
1967	18.8	35.1	35.3	33.9	38.8	63.0	49.7	17.7	10.7	10.1	12.6	16.2
1968	21.1	33.1	32.2	29.1	63.1	170.3	92.0	38.1	21.9	14.0	11.8	9.8
1969	33.8	37.9	41.2	38.2	61.0	41.1	18.6	10.5	15.9	11.8	39.8	40.9
1970	97.5	66.0	37.8	95.6	87.1	57.6	48.2	51.5	32.3	29.1	41.2	24.8
1971	130.8	80.4	43.5	128.2	372.4	282.8	77.6	19.8	14.8	12.0	10.0	9.1
1972	18.1	82.5	49.4	34.7	227.5	168.4	78.1	26.9	12.6	12.3	14.3	15.9
1973	22.9	64.5	50.2	365.5	467.1	528.9	189.4	66.1	40.0	20.9	14.0	9.4
1974	16.8	63.9	64.9	51.1	63.7	56.5	47.4	18.0	11.0	9.8	9.6	48.3
1975	33.9	37.5	407.4	573.0	531.7	1000.5	349.7	72.4	35.8	17.3	12.2	21.8
1976	264.7	111.2	33.5	75.5	112.0	81.8	53.2	20.4	13.4	13.7	12.5	18.5
1977	52.9	55.2	70.0	73.1	69.7	165.4	482.5	202.4	23.5	12.7	14.7	29.5
1978	58.3	71.4	151.0	69.9	88.7	59.6	48.0	20.9	14.2	26.2	28.1	19.4
1979	23.3	31.1	33.5	101.8	129.7	65.5	38.3	15.3	11.2	10.1	9.0	83.5
1980	51.2	60.9	42.4	98.9	179.5	80.8	36.1	27.0	22.7	14.4	21.9	20.1
1981	20.6	35.1	39.6	60.1	73.9	232.7	117.2	26.7	21.9	23.5	16.3	13.9
1982	42.8	44.6	27.7	27.1	26.9	30.4	34.4	16.3	11.3	23.3	15.3	14.3
1983	25.4	68.4	164.3	110.8	88.3	119.7	102.2	37.5	21.8	28.5	19.5	10.9
1984	29.8	49.6	34.8	118.7	496.5	167.0	32.3	12.7	9.9	9.2	8.3	7.9
1985	184.2	119.2	97.2	191.8	123.2	62.2	43.3	15.9	12.4	11.6	18.7	22.2
1986	88.8	122.2	56.3	41.6	51.9	73.8	50.7	15.7	14.2	12.2	26.9	793.0
1987	328.9	61.6	44.8	55.1	549.0	385.7	108.5	42.6	27.2	21.2	17.9	15.4
1988	22.9	55.3	158.7	120.4	501.4	182.9	134.7	59.8	19.6	18.2	12.5	8.1
1989	38.1	389.9	185.7	79.1	45.8	271.1	132.0	26.9	16.1	13.9	17.2	12.7
1990	23.1	30.2	53.7	139.8	169.0	72.4	33.3	12.0	10.3	9.3	8.3	11.3
1991	177.7	104.9	123.2	68.2	93.0	63.8	44.5	17.5	10.6	9.1	10.6	10.5
1992	17.8	36.9	30.4	28.8	57.6	112.9	54.1	13.7	7.4	5.9	7.3	11.6
1993	95.5	70.6	135.9	159.0	202.8	250.9	100.1	15.2	11.5	17.5	18.0	10.3
1994	16.7	39.2	35.9	65.1	47.1	140.7	106.9	36.1	29.3	21.7	11.7	11.5
1995	26.6	38.9	273.1	547.4	543.1	165.9	57.1	19.4	14.5	30.0	20.8	11.5
1996	21.9	134.6	204.4	316.1	179.3	115.7	106.4	46.4	292.2	135.6	28.9	14.8
1997	23.8	45.3	34.6	75.7	595.2	401.4	105.9	28.6	16.8	13.7	15.6	12.0
1998	18.0	55.7	140.5	145.5	261.2	147.2	54.8	18.0	12.1	11.1	9.2	7.8
1999	28.7	40.1	267.9	526.3	414.7	632.1	293.0	77.0	31.2	15.7	11.0	17.6
2000	34.7	50.1	86.2	151.9	120.6	98.2	67.4	27.2	14.9	14.5	14.4	16.0
2001	38.5	286.4	262.5	152.4	97.3	146.3	70.3	29.1	24.2	36.2	68.7	66.3
2002	31.9	30.6	40.6	59.8	50.0	64.9	49.0	21.7	15.9	11.4	10.7	16.5
2003	19.7	29.1	26.8	41.2	76.8	127.6	72.3	18.0	12.8	27.9	25.9	59.4
2004	43.5	72.7	134.7	131.8	118.3	79.6	48.0	16.6	11.5	9.6	10.0	7.8
Average	47.4	80.6	101.8	133.3	183.1	179.5	94.4	38.7	30.8	27.5	21.8	31.9
Min	14.6	27.3	25.6	27.1	26.9	30.4	18.6	10.5	7.4	5.9	7.3	7.7
Max	328.9	417.5	407.4	578.7	677.5	1000.5	482.5	395.2	292.2	321.3	154.9	793.0

APPENDIX D: COMMENTS REGISTER

Page / Section	Report statement	Comments	Changes made?	Author comment