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DEPARTMENT OF WATER AFFAIRS AND FORESTRY
DIRECTORATE OF OPTIONS ANALYSIS

LUKANJI REGIONAL WATER SUPPLY FEASIBILITY STUDY

APPENDIX 3: KEI RIVER WATER QUALITY RESERVE DETERMINATION

FINAL

NINHAM SHAND
CONSULTING SERVICES

January 2006

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APPENDIX 3

KEI RIVER WATER QUALITY RESERVE DETERMINATION

SUBMITTED BY

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FINAL

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Title	**:**	**Appendix 3 : Kei River Water Quality Reserve Determination**
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LUKANJI REGIONAL WATER SUPPLY FEASIBILITY STUDY

KEI RIVER WATER QUALITY RESERVE DETERMINATION

EXECUTIVE SUMMARY

1. INTRODUCTION

The Lukanji Regional Water Supply Study aims to review the findings of earlier regional water supply studies and make a firm recommendation on the next augmentation scheme to be developed for the supply of water to the urban complexes of Queenstown and Sada/Whittlesea. The study area lies within the Upper Kei Basin, which consists of the catchments of the Black Kei and White Kei Rivers upstream of their confluence.

Instream flow requirements were previously determined but more detailed protocols have subsequently been developed. One of the objectives of the Lukanji study is to determine the water quantity and quality Reserves for the Kei River at an intermediate level using the updated protocols. **This report** describes the water quality Reserves that were determined for the key water resources in the Kei River study area.

2. METHODOLOGY

The revised water quality reserve method for rivers was used to determine the present status and the ecological specifications. The revised documents were available in draft format at the time of preparing this document (DWAF, 2002). The five-step water quality Reserve protocol consisted of:

- Step 1 – Study initiation and scoping during which the geographic domain is specified, together with the study level and the water quality constituents.
- Step 2 – Delineation of resource units and the initial selection of water quality site to describe reference conditions and the present state.
- Step 3 – Information collection, site finalisation, specifying water quality boundary values and classifying the present state.
- Step 4 – Quantifying ecological Reserve scenarios, and
- Step 5 – Determining the water quality consequences of operational scenarios.

3. GEOGRAPHIC BOUNDARIES AND RESOURCE UNITS

The overall geographic extent of the Reserve study was defined as the catchments of the Black Kei River (S3 secondary catchment) and the White Kei River (S1 secondary catchment). Within this area, six water quality resource units were identified.

NO	WATER QUALITY RESOURCE UNIT	IFR SITE	JUSTIFICATION
1	Upper Black Kei upstream of the Klaas Smits River confluence	-	The upper Black Kei River is a catchment where the dominant land-use is subsistence agriculture and rural settlements.
2	Black Kei from the Klaas Smits confluence to the White Kei confluence	IFR 2 IFR 3	The Klaas Smits is affected by Queenstown discharges that can modify the Black Kei River quality quite substantially. It is also close to the ecoregion boundary between the Great Escarpment Mountains ecoregion and the Eastern Uplands ecoregion.
3	Klipplaat River downstream of Waterdown Dam to the confluence with the Black Kei River.	IFR 1	Insufficient water quality data to further subdivide this reach.
4	Oxkraal River from the Oxkraal Dam to the confluence with the Klipplaat River.	-	To match the IFR reach
5	Lower Klaas Smits River	-	Largely affected by Queenstown effluent (nutrients) and catchment processes (total suspended solids and total dissolved solids)
6	White Kei River from Xonxa Dam to the confluence with the Kei River.	IFR 4	No water quality data to justify further subdivision of this river reach.

4. SITE SELECTION AND WATER QUALITY INFORMATION SOURCES

For each resource unit, a monitoring point was identified where water quality data was available to characterise the present water quality state and reference conditions.

NO	WATER QUALITY RESOURCE UNIT	IFR SITE	REFERENCE SITE	PRESENT STATE SITE
1	Upper Black Kei upstream of the Klaas Smits River confluence	-	S3R001Q01	S3H004Q01 : Black Kei River at Cathcart's Gift/Endwell
2	Black Kei from the Klaas Smits confluence to the White Kei confluence	IFR 2 IFR 3	--	No water quality monitoring points in this resource unit. Water quality assessment was based on on-site observations and extrapolation of data from upstream points and major tributaries.
3	Klipplaat River down-stream of Waterdown Dam to the confluence with the Black Kei River.	IFR 1	S3R001Q01	S3R001Q01 : Waterdown Dam on Klipplaat River : near dam wall
4	Oxkraal River from the Oxkraal Dam to the confluence with the Klipplaat River.	-	S3R001Q01	S3H005Q01 : Oxkraal River at Whittlesea
5	Lower Klaas Smits River	-	S3R001Q01	S3H006Q01 : Klaas Smits River at Weltevrede/Queenstown
6	White Kei River from Xonxa Dam to the confluence with the Kei River.	IFR 4	S3R001Q01	S1R001Q01 – Xonxa Dam on the White Kei River: Near the dam wall

5. SUMMARY OF THE PRESENT STATE ASSESSMENT

The present water quality status was assessed and the classified. The water quality categories for the different resource units are summarised below.

NO	WATER QUALITY RESOURCE UNIT	IFR SITE	PRESENT WATER QUALITY STATUS				
			OVERALL	INORGANIC SALTS	NUTRIENTS	PHYSICAL VARIABLES	RESPONSE VARIABLES
1	Upper Black Kei	-	Poor (D/E)	Poor (E/F)	Fair (A/C)	Good (A/B)	Not done
2	Lower Black Kei	IFR 2 IFR 3	Fair (C/D)	Fair (C/D)	Fair (C/D)	Fair (C/D)	Poor (C/D)
3	Klipplaat River*	IFR 1	Natural (A/B)	Natural (A/B)	Good (B/C)	Good (B/C)	Good/Fair
4	Oxkraal River	-	Poor (D/E)	Poor (E/F)	Fair (C/D)	Good (A/B)	Not done
5	Lower Klaas Smits River	-	Fair (D)	Poor (E/F)	Fair (A/C)	Good (A/B)	Not done
6	Lower White Kei River	IFR 4	Good (B)	Good (B)	Good (B)	Good (A/B)	Fair (C/D)

* Status of the river reach upstream of the Oxkraal River confluence

6. CONCLUDING NOTES

Water quality in the Black Kei River deteriorates in a downstream direction up to the confluence with the Klipplaat River, largely the result of increasing salinity. The Klipplaat River and some of the smaller tributaries downstream of the Klaas Smits confluence, appeared to improve the quality of the lower Black Kei upstream of the White Kei confluence. This conclusion was based on field observations by fish and invertebrate specialists. There were no routine water quality monitoring points in the lower Black Kei to confirm the conclusion and it is strongly recommended that a routine water quality monitoring point be established in the lower Black Kei because future water supply developments for Lukanji would probably affect quality in this river reach. Development options that affect the quality in the Klaas Smits, Klipplaat and smaller tributaries would need to consider carefully the quality impacts in the main stream Black Kei River.

7. SUMMARY TABLES IN THE RDM TEMPLATE FORMAT

In the following section, the results of the water quality reserve determination was summarised in the format that is required by the RDM Directorate for compiling the documentation that will be submitted for approval to the Director-General. The RDM Directorate specifically requested that the layout if this section mirrors the layout of the Reserve documents.

Resource Unit 1 – Upper Black Kei (No IFR site)

River(s) : Black Kei River
Description : Upper Black Kei River upstream of the Klaas Smits River confluence
Drainage region : S32A, S32B, S32C and S32H (Black Kei River only)
Water management area : Mzimvubu to Keiskamma WMA

Water quality site information summary for the Reserve

REFERENCE STATE SITE	
Monitoring station	S3R001Q01: Waterdown Dam on Klipplaat River
PRESENT STATE DATA	
Monitoring station	S3H004Q01: Black Kei River at Cathcart's Gift/Endwell
Data record	Full data record: 23-03-72 to 20-02-03 (433 samples) Data record used: 8-01-98 to 20-02-03 (108 samples)
Trend significance	Slight decreasing trend observed in salinity and a slight increasing trend in nutrients has been observed since 1998.
Known point sources upstream	No known point sources upstream of the site
Confidence	Low confidence in salts and nutrients data sets due to the high variability in the observed data record, high confidence in representivity for the resource unit because the monitoring point is located close to the downstream end of the resource unit.

Ecological water quality specifications
General Chemistry – Major inorganic salts

PARAMETER	PRESENT STATE CONCENTRATION[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
$MgSO_4$ (mg/ℓ)	46	Poor (E/F)	Fair (D)	37
Na_2SO_4 (mg/ℓ)	0		Fair (D)	51
$MgCl_2$ (mg/ℓ)	122	Poor (E/F)	Fair (D)	51
$CaCl_2$ (mg/ℓ)	25	Good (B)	Fair (D)	105
NaCl (mg/ℓ)	0		Fair (D)	389
$CaSO_4$ (mg/ℓ)	0		Fair (D)	1195
Overall category		Poor (E/F)	Fair (D)	

1. 95th percentile values

Major ion concentrations corresponding to the recommended ERC for the inorganic salts (Fair/D category)

PARAMETER	PES CONCENTRATION[1]	ECOLOGICAL RESERVE[1]
Sodium (mg/ℓ)	131	131
Magnesium (mg/ℓ)	42	42
Calcium (mg/ℓ)	58	58
Chloride (mg/ℓ)	99	99
Sulphate (mg/ℓ)	36	29

1. 95th percentile values

Nutrients

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Phosphate (PO_4) (mg/ℓ)	0.068	Fair (C/D)	Fair (D)	0.125
Total Inorganic nitrogen (mg/ℓ)	0.074	Natural	Fair (D)	4.00

1. 50th percentile value

Physical water quality

PARAMETER	PES	PES CATEGORY	WATER QUALITY ERC	WATER QUALITY RESERVE
5th percentile 95th percentile	8.05 8.76	Natural (A) Good (B)	Good (B) Good (B)	5.8 9.0
Dissolved Oxygen (mg/ℓ) 5th percentile	No data	-	Good (B)	>6.5

Biotic indices

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Biotic index (ASPT score)	No data	-	Fair (D)	>5.0
Periphyton Chlorophyll a (µg/ℓ)	No data	-	Fair (D)	<84

Toxic substances and complex mixtures

PARAMETER	ECOLOGICAL RESERVE[2]
Ammonia (mg N/L as NH_3)[1]	PES = 0.013 (Good) (B) Ecospec = 0.054 (Good) (B)
Toxics (Good)	Acute toxicity: 95% of observation < 0.5 TUa Chronic toxicity: 25% of observations < 1 TUc or 60% of observations < CEV 98% of observations < AEV

where: TUa is acute Toxicity Units (TUa = 100/LC_{50} or EC_{50})
TUc is chronic Toxicity Units (TUc = 100/NOEC)
CEV is the chronic effect value
AEV is the acute effect value

1. 95th percentile
2. Ref: *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*, 1996. Department of Water Affairs and Forestry. Pretoria, South Africa

Resource Unit 2 – Lower Black Kei (IFR site 2 and IFR Site 3)

River(s) : Black Kei River
Description : Lower Black Kei River from the Klaas Smits confluence to the White Kei confluence
Drainage region : S32K, S32M
Water management area : Mzimvubu to Keiskamma WMA

Water quality site information summary for the Reserve

REFERENCE STATE SITE	
Monitoring station	S3R001Q01 – Waterdown Dam on Klipplaat River
PRESENT STATE DATA	
Monitoring station	No water quality monitoring points in this resource unit. Water quality assessment was based on on-site observations and extrapolation of data from upstream points and major tributaries.
Data record	No data
Trend significance	Probably stable for salts but increasing for nutrients due to increased effluent volumes from Queenstown and Whittlesea WWTWs.
Known point sources upstream	Queenstown and Whittlesea wastewater treatment works
Confidence	Low confidence due the absence of observed water quality monitoring in this resource unit. Present state conditions were inferred from monitoring upstream of the resource unit and on the main tributaries, and observations made during the site visits.

Ecological water quality specifications

General Chemistry – Major inorganic salts

PARAMETER	PRESENT STATE CONCENTRATION[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
$MgSO_4$ (mg/ℓ)	No data		Fair (D)	37
Na_2SO_4 (mg/ℓ)	No data		Fair (D)	51
$MgCl_2$ (mg/ℓ)	No data		Fair (D)	51
$CaCl_2$ (mg/ℓ)	No data		Fair (D)	105
NaCl (mg/ℓ)	No data		Fair (D)	389
$CaS0_4$ (mg/ℓ)	No data		Fair (D)	1195
Overall category		Fair (C/D)	Fair (D)	

1. 95th percentile values

Major ion concentrations corresponding to the recommended ERC for the inorganic salts (Fair/D category)

PARAMETER	PES CONCENTRATION	ECOLOGICAL RESERVE[1]
Sodium (mg/ℓ)	No observed data	131
Magnesium (mg/ℓ)	No observed data	42
Calcium (mg/ℓ)	No observed data	58
Chloride (mg/ℓ)	No observed data	99
Sulphate (mg/ℓ)	No observed data	29

1. 95th percentile values

Nutrients

PARAMETER	PES	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Phosphate (PO_4) (mg/ℓ)	No observed data	Fair	Fair (D)	0.125
Total Inorganic nitrogen (mg/ℓ)	No observed data	Fair	Fair (D)	4.00

1. 50th percentile value

Physical water quality

PARAMETER	PES	PES CATEGORY	WATER QUALITY ERC	WATER QUALITY RESERVE
5th percentile 95th percentile	No observed data	Good	Good Good	5.8 9.0
Dissolved Oxygen (mg/ℓ) 5th percentile	No observed data	Good	Good	>6.5

Biotic indices

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Biotic index (ASPT score)	4.1 and 3.3	Poor	Fair (D)	>5.0
Periphyton Chlorophyll a (µg/ℓ)	-	Fair	Fair (D)	<84

Toxic substances and complex mixtures

PARAMETER	ECOLOGICAL RESERVE[2]
Ammonia (mg N/L as NH_3)[1]	PES – no data Ecospec = 0.054 (Good)
Toxics (good)	Acute toxicity: 95% of observation < 0.5 TUa Chronic toxicity: 25% of observations < 1 TUc or 60% of observations < CEV 98% of observations < AEV

where: TUa is acute Toxicity Units (TUa = 100/LC_{50} or EC_{50})
TUc is chronic Toxicity Units (TUc = 100/NOEC)
CEV is the chronic effect value
AEV is the acute effect value

1. 95th percentile
2. Ref: *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*, 1996. Department of Water Affairs and Forestry. Pretoria, South Africa

Qualitative Ecological Reserve Specifications

Water from the Klipplaat River dilutes the high salt concentrations that originate from the catchment upstream of the Klipplaat River confluence. Intercepting and reducing the natural flows from the Klipplaat River and some of the tributaries of the middle Black Kei River increases the impacts of urban runoff and effluent return flows from Sada/Whittlesea and Queenstown on the lower Black Kei River.

Resource Unit 3 – Klipplaat River (IFR site 1)

River(s) : Klipplaat River
Description : Klipplaat River downstream of Waterdown Dam to the confluence with the Black Kei River
Drainage region : S32D, S32E, S32G, and S32H (Klipplaat River only)
Water management area : Mzimvubu to Keiskamma WMA

Water quality site information summary for the Reserve

REFERENCE AND PRESENT STATE DATA	
Monitoring station	S3R001Q01 : Waterdown Dam on Klipplaat River : near dam wall
Data record	Full data record: 17-05-68 to 06-01-03 (221 samples) Data record used: 7-01-98 to 6-01-03 (68 samples)
Trend significance	Slight increasing trend in salinity and nutrient concentrations.
Known point sources upstream	No known point sources upstream of the dam. The Whittlesea wastewater treatment works discharge treated effluent into the Klipplaat River downstream of the IFR site at Whittlesea.
Confidence	High confidence in salts data set but low confidence in nutrient data set. Moderate confidence in the representivity of the river between Waterdown Dam and the confluence with the Oxkraal River, low confidence in the representivity for the reach downstream of the Oxkraal confluence and Whittlesea.

Ecological water quality specifications

General Chemistry – Major inorganic salts

PARAMETER	PRESENT STATE CONCENTRATION[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
$MgSO_4$ (mg/ℓ)	16	Natural (A)	Good (B)	25
Na_2SO_4 (mg/ℓ)	4	Natural (A)	Good (B)	33
$MgCl_2$ (mg/ℓ)	8	Natural (A)	Good (B)	30
$CaCl_2$ (mg/ℓ)	16	Natural (A)	Good (B)	57
NaCl (mg/ℓ)	0		Good (B)	191
$CaS0_4$ (mg/ℓ)	0		Good (B)	709
Overall category		Natural (A)	Good (B)	

1. 95th percentile values

Major ion concentrations corresponding to the recommended ERC for the inorganic salts (Good/Fair - C category)

PARAMETER	PES CONCENTRATION[1]	ECOLOGICAL RESERVE[1]
Sodium (mg/ℓ)	8	9
Magnesium (mg/ℓ)	4	6
Calcium (mg/ℓ)	9	7
Chloride (mg/ℓ)	13	13
Sulphate (mg/ℓ)	16	36

1. 95th percentile values

Nutrients

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Phosphate (PO_4) (mg/ℓ)	0.029	Fair (C)	Good/Fair (C)	0.025
Total Inorganic nitrogen (mg/ℓ)	0.079	Good (B/C)[2]	Good/Fair (C)	1.00

1. 50th percentile value
2. The in-lake water was classified as natural but the downstream river (IFR 1) was assigned a Good category after observations of high algal growth on the rocks downstream of the dam.

Physical water quality

PARAMETER	PES	PES CATEGORY	WATER QUALITY ERC	WATER QUALITY RESERVE
5th percentile 95th percentile	7.38 7.99	Natural Natural	Good (B)	5.9 8.8
Dissolved Oxygen (mg/ℓ) 5th percentile	No data	-	Good (B)	6.5

Biotic indices

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Biotic index (ASPT score)	5.9	Good/Fair	Good (B)	6
Periphyton Chlorophyll a (µg/ℓ)	No data	Fair[2]	Good (B)	<21

1. 1:50th percentile value
2. Large amounts of periphyton observed on rocks at IFR site

Toxic substances and complex mixtures

PARAMETER	ECOLOGICAL RESERVE[2]
Ammonia (mg N/L as NH_3)[1]	PES = 0.004 (Natural) Ecospec = 0.007 (Natural)
Toxics (Good)	Acute toxicity: 95% of observation < 0.5 TUa Chronic toxicity: 25% of observations < 1 TUc or 60% of observations < CEV 98% of observations < AEV

where: TUa is acute Toxicity Units (TUa = 100/LC_{50} or EC_{50})
TUc is chronic Toxicity Units (TUc = 100/NOEC)
CEV is the chronic effect value
AEV is the acute effect value

1. 95th percentile
2. Ref: *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*, 1996. Department of Water Affairs and Forestry. Pretoria, South Africa

Qualitative Ecological Reserve Specifications

Maintain current operations by releasing water from closer to the surface in Waterdown Dam. This should probably solve some of the water quality problems experienced at the IFR site (elevated nutrients and turbidity).

Resource Unit 4 – Oxkraal River (No IFR site)

River(s) : Oxkraal River
Description : Oxkraal River to the confluence with the Klipplaat Rover.
Drainage region : S32F, S32G (Oxkraal River only)
Water management area : Mzimvubu to Keiskamma WMA

Water quality site information summary for the Reserve

REFERENCE STATE SITE	
Monitoring station	S3R001 – Waterdown Dam on Klipplaat River: near dam wall
PRESENT STATE DATA	
Monitoring station	S3H005Q01 : Oxkraal River at Whittlesea
Data record	Full data record: 10-11-71 – 23/01/03 (468 samples) Data record used: 08/01/98 - 23-01-03 (116 samples)
Trend significance	No significant trend in salinity or nutrients.
Known point sources upstream	No known point sources upstream of the monitoring point. Some non-point sources include urban runoff from the town of Sada and rural villages.
Confidence	Moderate confidence in salts data set, low confidence in nutrient and physical data sets. High confidence in representivity for the resource unit because the monitoring point is situated close to the bottom of the resource unit.

Ecological water quality specifications

General Chemistry – Major inorganic salts

PARAMETER	PRESENT STATE CONCENTRATION[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
$MgSO_4$ (mg/ℓ)	44	Poor (E/F)	Fair (D)	37
Na_2SO_4 (mg/ℓ)	0		Fair (D)	51
$MgCl_2$ (mg/ℓ)	146	Poor (E/F)	Fair (D)	51
$CaCl_2$ (mg/ℓ)	32	Good (B)	Fair (D)	105
NaCl (mg/ℓ)	0		Fair (D)	389
$CaS0_4$ (mg/ℓ)	0		Fair (D)	1195
Overall category		Poor (E/F)	Fair (D)	

1. 95th percentile values

Major ion concentrations corresponding to the recommended ERC for the inorganic salts (for a D ERC)

PARAMETER	PES CONCENTRATION[1]	ECOLOGICAL RESERVE[1]
Sodium (mg/ℓ)	97	97
Magnesium (mg/ℓ)	45	45
Calcium (mg/ℓ)	61	61
Chloride (mg/ℓ)	118	119
Sulphate (mg/ℓ)	35	29

1. 95th percentile values

Nutrients

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Phosphate (PO_4) (mg/ℓ)	0.020	Good (B)	Fair (D)	0.125
Total Inorganic nitrogen (mg/ℓ)	3.86	Fair (D)	Fair (D)	4.00

1. 50th percentile value

Physical water quality

PARAMETER	PES	PES CATEGORY	WATER QUALITY ERC	WATER QUALITY RESERVE
5th percentile 95th percentile	8.11 8.71	Natural Good	Good	5.8 9.0
Dissolved Oxygen (mg/ℓ) 5th percentile	No data	-	Good	>6.5

Biotic indices

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Biotic index (ASPT score)	No data	-	Fair	>5
Periphyton Chlorophyll a (µg/ℓ)	No data	-	Fair	<84

1. 50th percentile value

Toxic substances and complex mixtures

PARAMETER	ECOLOGICAL RESERVE[2]
Ammonia (mg N/L as NH_3)[1]	PES = 0.014 (Good) Ecospec = 0.054 (Good)
Toxics (Good)	Acute toxicity: 95% of observation < 0.5 TUa Chronic toxicity: 25% of observations < 1 TUc or 60% of observations < CEV 98% of observations < AEV

where: TUa is acute Toxicity Units (TUa = 100/LC_{50} or EC_{50})
TUc is chronic Toxicity Units (TUc = 100/NOEC)
CEV is the chronic effect value
AEV is the acute effect value

1. 95th percentile
2. Ref: *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*, 1996. Department of Water Affairs and Forestry. Pretoria, South Africa

Resource Unit 5 – Lower Klaas Smits River (No IFR site)

River(s) : Klaas Smits River
Description : Lower Klaas Smits River
Drainage region : S31E, S31G
Water management area : Mzimvubu to Keiskamma WMA

Water quality site information summary for the Reserve

REFERENCE STATE SITE	
Monitoring station	No reference site available
PRESENT STATE DATA	
Monitoring station	S3H006Q01 : Klaas Smits River at Cathcart's Gift/Endwell
Data record	Full data record: 17-01-77 to 12-12-02 (335 samples) Data record used: 2-04-98 to 12-12-02 (65 samples)
Trend significance	Moderate decreasing trend in salinity up to about 1995, increasing trend after 1995.
Known point sources upstream	No known point sources upstream of the monitoring point. The Queenstown sewage effluent is discharged into the Komani River that enters the Klaas Smits River downstream of the monitoring point.
Confidence	Low confidence in the chemical data set for salts and nutrients and low moderate confidence in representivity of the resource unit.

Ecological water quality specifications

General Chemistry – Major inorganic salts

PARAMETER	PRESENT STATE CONCENTRATION[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
$MgSO_4$ (mg/ℓ)	56	Poor (E/F)	Fair (D)	37
Na_2SO_4 (mg/ℓ)	0		Fair (D)	51
$MgCl_2$ (mg/ℓ)	107	Poor (E/F)	Fair (D)	51
$CaCl_2$ (mg/ℓ)	5	Natural (A)	Fair (D)	105
NaCl (mg/ℓ)	0		Fair (D)	389
$CaS0_4$ (mg/ℓ)	0		Fair (D)	1195
Overall category		Poor (E/F)	Fair (D)	

1. 95th percentile values

Major ion concentrations corresponding to the recommended ERC for the inorganic salts (Fair category, D category)

PARAMETER	PES CONCENTRATION[1]	ECOLOGICAL RESERVE[1]
Sodium (mg/ℓ)	83	83
Magnesium (mg/ℓ)	53	53
Calcium (mg/ℓ)	52	52
Chloride (mg/ℓ)	84	84
Sulphate (mg/ℓ)	48	29

1. 95th percentile values

Nutrients

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Phosphate (PO_4) (mg/ℓ)	0.046	Fair (C/D)	Fair (D)	0.125
Total Inorganic nitrogen (mg/ℓ)	0.088	Natural (A)	Fair (D)	4.00

1. 50th percentile value

Physical water quality

PARAMETER	PES	PES CATEGORY	WATER QUALITY ERC	WATER QUALITY RESERVE
5th percentile 95th percentile	7.65 8.71	Natural Good	Good Good	5.8 9.0
Dissolved Oxygen (mg/ℓ) 5th percentile	No data	-	Good	6.5

Biotic indices

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Biotic index (ASPT score)	No data	-	Fair (D)	>5
Periphyton Chlorophyll a (µg/ℓ)	No data	-	Fair (D)	<84

1. 50th percentile value

Toxic substances and complex mixtures

PARAMETER	ECOLOGICAL RESERVE[2]
Ammonia (mg N/L as NH_3)[1]	PES = 0.011 (Good) Ecospec = <0.054 (Good)
Toxics (Good)	Acute toxicity: 95% of observation < 0.5 TUa Chronic toxicity: 25% of observations < 1 TUc or 60% of observations < CEV 98% of observations < AEV

where: TUa is acute Toxicity Units (TUa = 100/LC_{50} or EC_{50})
TUc is chronic Toxicity Units (TUc = 100/NOEC)
CEV is the chronic effect value
AEV is the acute effect value

1. 95th percentile
2. Ref: *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*, 1996. Department of Water Affairs and Forestry. Pretoria, South Africa

Qualitative Ecological Reserve Specifications

Not applicable as there was no IFR site in this unit.

Resource Unit 6 – White Kei River (IFR site 4)

River(s) : White Kei River
Description : White Kei River from Xonxa Dam to the confluence with the Black Kei River.
Drainage region : S10H, S10J
Water management area : Mzimvubu to Keiskamma WMA

Water quality site information summary for the Reserve

REFERENCE STATE SITE	
Monitoring station	No reference site available
PRESENT STATE DATA	
Monitoring station	S1R001Q01 – Xonxa Dam on the White Kei River: Near the dam wall
Data record	Full data record: 04/06/80 – 6/12/2002 (244 samples) Data record used: 28/01/98 – 6/12/2002 (28 samples)
Trend significance	No trend in salinity and nutrients in the dam.
Known point sources upstream	No known point sources upstream of the dam.
Confidence	High confidence in salinity data set, low confidence in nutrient and physical data sets, low confidence in representivity of data site to represent the whole resource unit.

Ecological water quality specifications
General Chemistry – Major inorganic salts

PARAMETER	PRESENT STATE CONCENTRATION[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
$MgSO_4$ (mg/ℓ)	21	Good (B)	Fair (C/D)	37
Na_2SO_4 (mg/ℓ)	0		Fair (C/D)	51
$MgCl_2$ (mg/ℓ)	22	Good (B)	Fair (C/D)	51
$CaCl_2$ (mg/ℓ)	0		Fair (C/D)	105
NaCl (mg/ℓ)	0		Fair (C/D)	389
$CaSO_4$ (mg/ℓ)	0		Fair (C/D)	1195
Overall category		Good (B)	Fair (C/D)	

1. 95th percentile values

Major ion concentrations corresponding to the recommended ERC for the inorganic salts (ERC = C/D)

PARAMETER	PES CONCENTRATION[1]	ECOLOGICAL RESERVE[1]
Sodium (mg/ℓ)	22	22
Magnesium (mg/ℓ)	14	14
Calcium (mg/ℓ)	26	26
Chloride (mg/ℓ)	16	39
Sulphate (mg/ℓ)	17	22

1. 95th percentile values

Nutrients

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Phosphate (PO_4) (mg/ℓ)	0.018	Good (B)	Fair (C/D)	0.125
Total Inorganic nitrogen (mg/ℓ)	0.1722	Natural (A)	Fair (C/D)	4.00

1. 50th percentile value

Physical water quality

PARAMETER	PES	PES CATEGORY	WATER QUALITY ERC	WATER QUALITY RESERVE
5th percentile 95th percentile	8.06 8.59	Natural Good	Good Good	5.8 9.0
Dissolved Oxygen (mg/ℓ) 5th percentile	No data	Good	Good	>6.5

Biotic indices

PARAMETER	PES[1]	PES CATEGORY	WATER QUALITY ERC	ECOLOGICAL RESERVE[1]
Biotic index (ASPT score)	5.2	Fair	Fair (C/D)	>5
Periphyton Chlorophyll a (µg/ℓ)	No data	-	Fair (C/D)	<84

1. 50th percentile value

Toxic substances and complex mixtures

PARAMETER	ECOLOGICAL RESERVE[2]
Ammonia (mg N/L as NH_3)[1]	PES = 0.006 (Natural) Ecospec = 0.007 (Natural)
Toxics (Good)	Acute toxicity: 95% of observation < 0.5 TUa Chronic toxicity: 25% of observations < 1 TUc or 60% of observations < CEV 98% of observations < AEV

where: TUa is acute Toxicity Units (TUa = 100/LC_{50} or EC_{50})
TUc is chronic Toxicity Units (TUc = 100/NOEC)
CEV is the chronic effect value
AEV is the acute effect value

1. 95th percentile
2. Ref: *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*, 1996. Department of Water Affairs and Forestry. Pretoria, South Africa

Qualitative Ecological Reserve Specifications

Some concerns have been raised about elevated arsenic concentrations that were recorded in the White Kei River in the 1980s. The observations were ascribed to the dipping of cattle and the disposal of used dip in soak pits close to the river. Arsenic concentrations should be monitored to determine whether it is still a concern.

LUKANJI REGIONAL WATER SUPPLY FEASIBILITY STUDY

KEI RIVER WATER QUALITY RESERVE DETERMINATION

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ABBREVIATIONS

ASPT	Average score per taxon
DWAF	Department of Water Affairs and Forestry
EIS	Ecological importance and sensitivity
ERC	Ecological Reserve Category
IFR	Instream flow requirement
MAR	Mean annual runoff
Ref	Reference
RHP	River Health Programme
PES	Present Ecological State
SASS	South African Scoring System (*an index of aquatic invertebrate health*)
TDS	Total dissolved solids
TSS	Total suspended solids
WWTW	Waste Water Treatment Works

LUKANJI REGIONAL WATER SUPPLY FEASIBILITY STUDY

KEI RIVER WATER QUALITY RESERVE DETERMINATION

1. INTRODUCTION

The Lukanji Regional Water Supply Study that was commissioned by the Department of Water Affairs and Forestry (DWAF) commenced in March 2003. The study area lies within the Upper Kei Basin, which consists of the catchments of the Black Kei and White Kei Rivers upstream of their confluence. In essence, the study aims to review the findings of earlier regional water supply studies and, taking cognisance of new developments and priorities that have been identified in the study area, will make a firm recommendation on the next augmentation scheme to be developed for the supply of water to the urban complexes of Queenstown and Sada/Whittlesea. In addition, proposed operating rules that will be required for the existing water supply scheme and the augmentation scheme in order to provide for the equitable distribution of water between the ecological component of the Reserve, rural domestic and urban water supplies, and irrigators, will be identified.

In a previous study, instream flow requirements were determined for the Kei River at a basic level using the methods available at the time. More detailed protocols have subsequently been developed which have the backing of the new legislation (National Water Act, 1998). Water quantity and quality Reserves are therefore being undertaken for the Kei River at an intermediate level using the new protocols. The following Reserve needs were identified by DWAF:

- Releases are already made from the Waterdown Dam for downstream irrigation. The Reserve for the river below the dam should be determined. It needs to be assessed to what extent the present release patterns are in conflict with the Reserve requirements and whether any changes to the present release patterns can be accommodated to improve the ecological health of the river.
- The Reserve requirements below the Oxkraal and Xonxa Dams need to be determined.
- Reserves at one or more points in the Black Kei River need to be determined and the implications for a possible abstraction weir on the river determined.

This report describes the water quality Reserves that were determined for the key water resources in the Kei River study area.

2. METHODOLOGY

The revised water quality reserve method for rivers was used to determine the PES. The revised documents were available in draft format at the time of preparing this document (DWAF, 2002). The five step water quality Reserve protocol and the equivalent steps for the water quantity Reserve procedure are illustrated in Figure 1 and are summarised below:

- **Step 1 – Study initiation and scoping** – during this step the geographic domain of the study and the level of determination is specified by the Department. Any water quality issues are identified and lists of water quality constituents are finalised.
- **Step 2 – Delineation of resource units and preliminary water quality site selection** – during this step the resource units for the water quality Reserve determination are identified and the initial sites to characterise reference conditions and the present state are identified.
- **Step 3 – Information collection, site finalisation and specifying water quality boundary values** – during this step all the relevant data are collected and analysed, the default category boundaries for different constituents (inorganic salts, nutrients, response variables and toxic substances) are confirmed or modified for reference conditions, the present state is classified and inputs are provided into the water quantity Reserve process.
- **Step 4 – Quantify ecological Reserve scenarios** – during this step the water quality ecospecs are defined for the different categories and the ERC recommended at the specialist workshop.
- **Step 5 – Ecological consequences of operational scenarios** – during the last step inputs are provided into the water quality consequences of different operational flow scenarios.

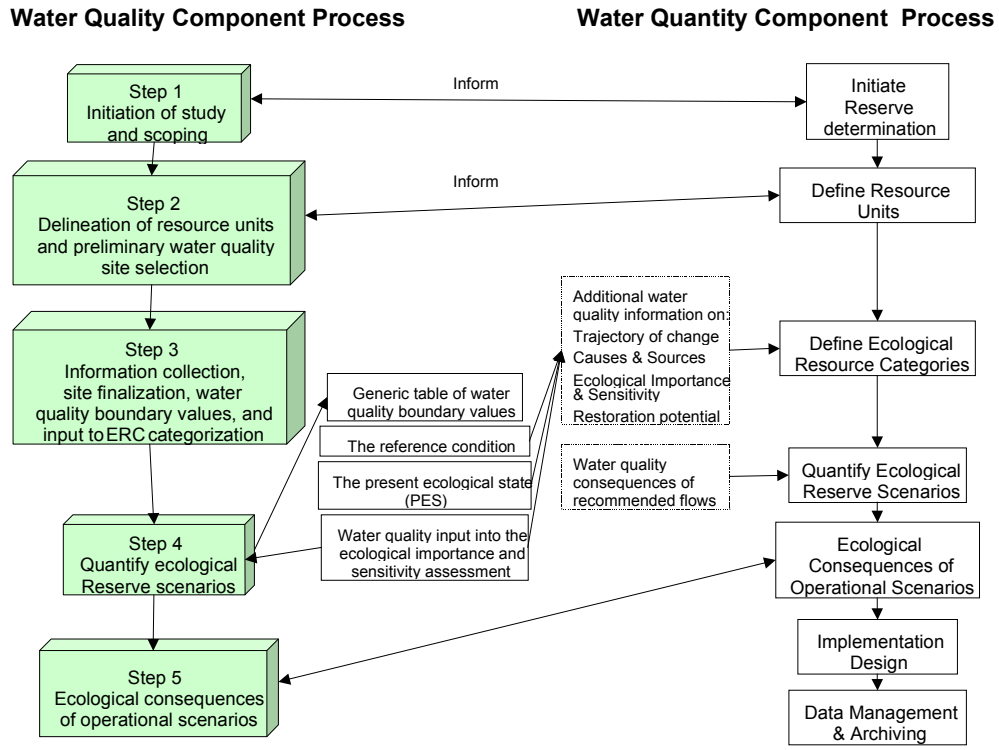

Figure 1 : Diagram showing the key steps of the water quality Reserve procedure and the interfaces with the quantity Reserve process

2.1 Layout of the Report

The first three sections of this report describe the activities undertaken to prepare for the water quality Reserve determination, namely delineating the resource units (Section 3) and selecting the sites in each resource unit that will be used to characterise reference conditions and the present water quality state, and collating the required water data and information (Section 4).

The sections that follow after Section 4 provide the following for each resource unit:

- An introduction to the resource unit,
- A description of the data and information used,
- A description of the reference conditions,
- A description of the present state conditions,
- The water quality ecological specifications for the resource unit, and
- Any additional notes relevant to the water quality Reserve for that resource unit.

3. DELINEATION OF WATER QUALITY RESOURCE UNITS

The overall geographic extent of the Reserve study was defined as the catchments of the Black Kei River (S3 secondary catchment) and the White Kei River (S1 secondary catchment). It was specified that the ecological Reserve be determined at an intermediate level at five points, namely, below Waterdown Dam, below Oxkraal Dam, the Black Kei River just downstream of its confluence with the Klaas Smits River (the proposed Stitchel Weir site), the Black Kei River just upstream of its confluence with the White Kei River and below Xonxa Dam on the White Kei River.

A resource unit is a length of river for which a single description of water quality can be given. This applies to both the natural state and the present, possibly impacted, state. The objective of this step was to subdivide the study area into resource units. A water quality reserve determination was then prepared for each resource unit.

The following aspects were considered when defining the resource units for the water quality Reserve determination of the Kei River Reserve study.

- Level 1 ecoregions – the upper Black Kei up to its confluence with the Klaas Smits, as well as the Oxkraal River and the Klipplaat River from Waterdown Dam, all fall within the Great Escarpment Mountain ecoregion. The remainder of the Kei River downstream of the Klaas Smits confluence, including the White Kei River downstream of Xonxa Dam, all fall within the Eastern Uplands ecoregion.
- Positions of dams – the positions of Waterdown Dam, Oxkraal and Xonxa Dams were taken into account and the dams were considered as the upstream boundaries of the water quality reaches for the Klipplaat, Oxkraal and White Kei Rivers, respectively.
- Positions of tributaries – The positions of tributaries were also considered, but in many cases there was insufficient data to justify a further subdivision of a water quality resource unit. It was therefore decided to treat the Klipplaat River downstream of Waterdown Dam as a single reach, and the White Kei downstream of Xonxa Dam as a single reach, even though the Cacadu and Indwe Rivers join the White Kei in this reach.

A list of six water quality resource units was identified (Table 1, Figure 2) using these considerations.

TABLE 1 : LIST OF WATER QUALITY RESOURCE UNITS FOR THE KEI RIVER WATER QUALITY RESERVE DETERMINATION

NO	WATER QUALITY RESOURCE UNIT	IFR SITE	JUSTIFICATION
1	Upper Black Kei upstream of the Klaas Smits River confluence	-	The upper Black Kei River is a catchment where the dominant land-use is subsistence agriculture and rural settlements.
2	Black Kei from the Klaas Smits confluence to the White Kei confluence	IFR 2 IFR 3	The Klaas Smits is affected by Queenstown discharges that can modify the Black Kei River quality quite substantially. It is also close to the ecoregion boundary between the Great Escarpment Mountains ecoregion and the Eastern Uplands ecoregion.
3	Klipplaat River downstream of Waterdown Dam to the confluence with the Black Kei River.	IFR 1	Insufficient water quality data to further sub-divide this reach.
4	Oxkraal River from the Oxkraal Dam to the confluence with the Klipplaat River.	-	To match the IFR reach
5	Lower Klaas Smits River	-	Largely affected by Queenstown effluent (nutrients) and catchment processes (total suspended solids and total dissolved solids)
6	White Kei River from Xonxa Dam to the confluence with the Kei River.	IFR 4	No water quality data to justify further subdivision of this river reach.

3.1 Water Quality Hotspots

Point sources

There are only two wastewater treatment works of note in the study area, one at Queenstown and one at Whittlesea. The Queenstown WWTW discharges into the Komani River from where water is abstracted for irrigation. Not all the treated effluent is abstracted for irrigation. Some treated effluent therefore flows into the Kei River via the Klaas Smits River when there is a low demand for irrigation water (Wilcock, *pers. comm*., 2005). The works complied with the general effluent standard but the nutrient budget of the Komani and lower Klaas Smits Rivers were dominated by the effluent discharge. At Whittlesea domestic effluent is treated and discharged into the Klipplaat River downstream of the Oxkraal confluence. On average, the effluent complies with the general effluent standards. Other centres rely on oxidation ponds, septic tanks and pit latrines for waste disposal.

Non-point sources

It was found that non-point sources and catchment processes controlled the TDS and TSS concentrations in the rivers but that point sources dominated the phosphorus budget in the Kei River downstream of Queenstown. Stormwater runoff from rural settlements may also affect water quality in the rivers, especially in those catchments with a high concentration of dense settlements.

4. SITE SELECTION AND WATER QUALITY INFORMATION SOURCES

The objective of this step was to identify the monitoring sites in each resource unit that could be used to characterise the reference conditions and the present state. Only data available from the DWAF National Water Quality Monitoring Network was used in the water quality reserve determination (Table 2). Interpretation of the results was supplemented with limited monitoring information collected by the DWAF Eastern Cape Regional Office (Table 3) and with discussions with water quality management staff from the Regional Office.

A major concern was the absence of any water quality monitoring points in the Black Kei River between the Klaas Smits confluence and the White Kei confluence. Some samples were collected in this resource unit during 1992/3 as part of the DWAF Regional Office monitoring and these samples were only analysed for a few constituents (Table 3).

TABLE 2 : NATIONAL WATER QUALITY MONITORING POINTS IN THE STUDY AREA, THE NUMBER OF SAMPLES COLLECTED AT EACH POINT AND THE START AND END DATE OF THE DATA RECORD

SAMPLING POINT	SAMPLE #	BEGIN	END
S1H002Q01 White Kei River At St Marks Mission/Bridge	10	23/01/1980	02/05/1996
S1H003Q01 White Kei River At Nonesi 1/Xonxa Dam	2	13/08/1997	22/09/1997
S1R001Q01 Xonxa Dam On White Kei River: Near Dam Wall	36	04/06/1980	06/12/2002
S3H002Q01 Klaas Smits River At Doornhoek/Wilgebosch	445	19/09/1958	10/07/1997
S3H003Q01 Black Kei River At Doorn Hoek/Bower Hope	321	11/09/1953	09/01/2003
S3H004Q01 Black Kei River At Cathcarts Gift/Endwell	835	23/03/1972	20/02/2003
S3H005Q01 Oxkraal River At Whittlesea	669	10/11/1971	23/01/2003
S3H006Q01 Klaas Smits River At Weltevreden/Queenstown	700	17/01/1977	12/12/2002
S3H007Q01 Komani River At Santa Georgia	7	23/01/1980	26/01/1982
S3H008Q01 Canal (Left) From Black Kei River At Doorn Hoek	39	04/07/1983	09/01/2003
S3H010Q01 Waterdown Dam On Klipplaat River: Down Stream Weir	129	14/09/1972	17/02/2003
S3H012Q01 Oxkraal Dam On Oxkraal River: Down Stream Weir	186	31/08/1992	20/02/2003
S3R001Q01 Waterdown Dam On Klipplaat River: Near Dam Wall	223	17/05/1968	06/01/2003
S3R002Q01 Bonkolo Dam On Bokolo River: Near Dam Wall	7	23/01/1980	26/01/1982
S3R003Q01 Oxkraal Dam On Oxkraal River: Near Dam Wall	81	30/11/1995	09/01/2003

TABLE 3 : EASTERN CAPE REGIONAL OFFICE WATER QUALITY MONITORING POINTS IN THE STUDY AREA

SAMPLING POINT	SAMPLE #	BEGIN	END
WQM 1 Kei Bridge	10	02/04/92	12/05/95
WQM 2 Bolo crossing	10	02/04/92	12/05/95
WQM 3 Thomas River	9	02/04/92	12/05/95
WQM 4 Bacella	10	02/04/92	12/05/95
WQM 5 Black Kei	4	02/04/92	08/08/94
WQM6 White Kei	2	02/04/92	05/12/92
WQM 8 10 km above Whittlesea	5	08/05/92	12/07/94
WQM 9 Confluence with Oxkraal	5	08/05/92	12/07/94
WQM10 5km below Whittlesea	5	08/05/92	12/07/94
1 Above Waterdown Dam	4	25/02/99	02/12/02
2 Waterdown Dam	2	08/07/01	15/10/01
3 At bridge above Whittlesea STW	16	02/02/99	22/04/03
4 Whittelsea STW	18	02/02/99	22/04/03
5 Below Whittlesea STW	16	02/02/99	22/04/03
6 Oxkraal River at bridge into Whittlesea (before confluence)	4	08/07/01	02/12/02

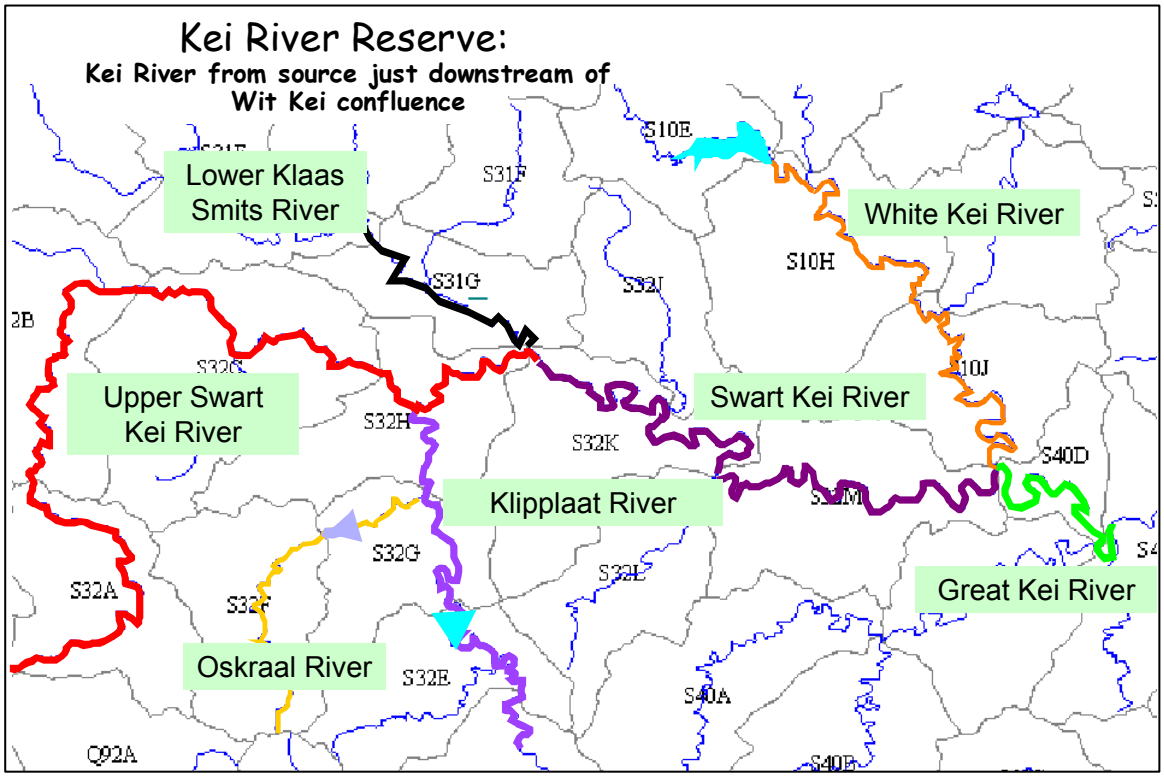

Figure 2 : Kei River resource units used for the water quality Reserve determination

5. WATER QUALITY RESERVE FOR THE UPPER BLACK KEI RIVER

Resource Unit	Upper Black Kei River	**No IFR site**
River(s)	Black Kei River	
Description	Upper Black Kei River upstream of the Klaas Smits River confluence	
Quaternary catchments	S32A, S32B, S32C and S32H (Black Kei River only)	

5.1 Introduction to the Upper Black Kei River

The Upper Black Kei River upstream of the confluence with the Klaas Smits River drains an area containing rural villages and subsistence agricultural developments. In the upper reaches the quality is suitable for domestic and agricultural water use. In the middle reaches upstream of the confluence with the Klipplaat River, the quality is poorer than required for domestic water supply and irrigation and exceeded the guidelines for conductivity, TDS and chloride (DWAF, 1993). Erosion has occurred in large areas of the Black Kei River catchment. The Black Kei River upstream of the Klipplaat confluence was proclaimed a Special Standards river and all effluents had to comply with the Special Effluent Standard. There are no known point sources in the upper Black Kei catchment that discharge into the river.

5.2 Data and Information used for the Upper Black Kei River

TABLE 4 : MONITORING POINTS USED TO CHARACTERISE THE PRESENT STATE OF THE UPPER BLACK KEI RIVER

PRESENT STATE SITE	
Monitoring station	S3H004Q01 : Black Kei River at Cathcart's Gift/Endwell
Data record	Full data record: 23-03-72 to 20-02-03 (433 samples) Data record used: 8-01-98 to 20-02-03 (108 samples)
Trend significance	Slight decreasing trend observed in salinity and a slight increasing trend in nutrients has been observed since 1998.
Known point sources upstream	No known point sources upstream of the site
Confidence	Low confidence in salts and nutrients data sets due to the high variability in the observed data record, high confidence in representivity for the resource unit because the monitoring point is located close to the downstream end of the resource unit.

5.3 Reference Conditions

Waterdown Dam (S3R001Q01) was used as a reference site to characterise possible background conditions for this resource unit.

5.4 Present State Conditions for the Upper Black Kei River

5.4.1 Overall assessment of the present state

	PRESENT STATE
Overall water quality class (Category)	Poor (D/E)
VARIABLE GROUPS	
Inorganic salts	Poor (E/F)
Nutrients	Fair (A/C)
Physical variables	Good (A/B)
Response variables	Not determined

5.4.2 Reasons for present state

Catchment processes control the present state in the upper Black Kei River. The elevated salt concentrations were probably from natural sources but affected by degradation of the catchment due to erosion and poor land-use practices. The slight increasing trend in nutrients was probably the result of fertilizer wash-off in the catchment.

5.4.3 Time series plot of TDS concentrations

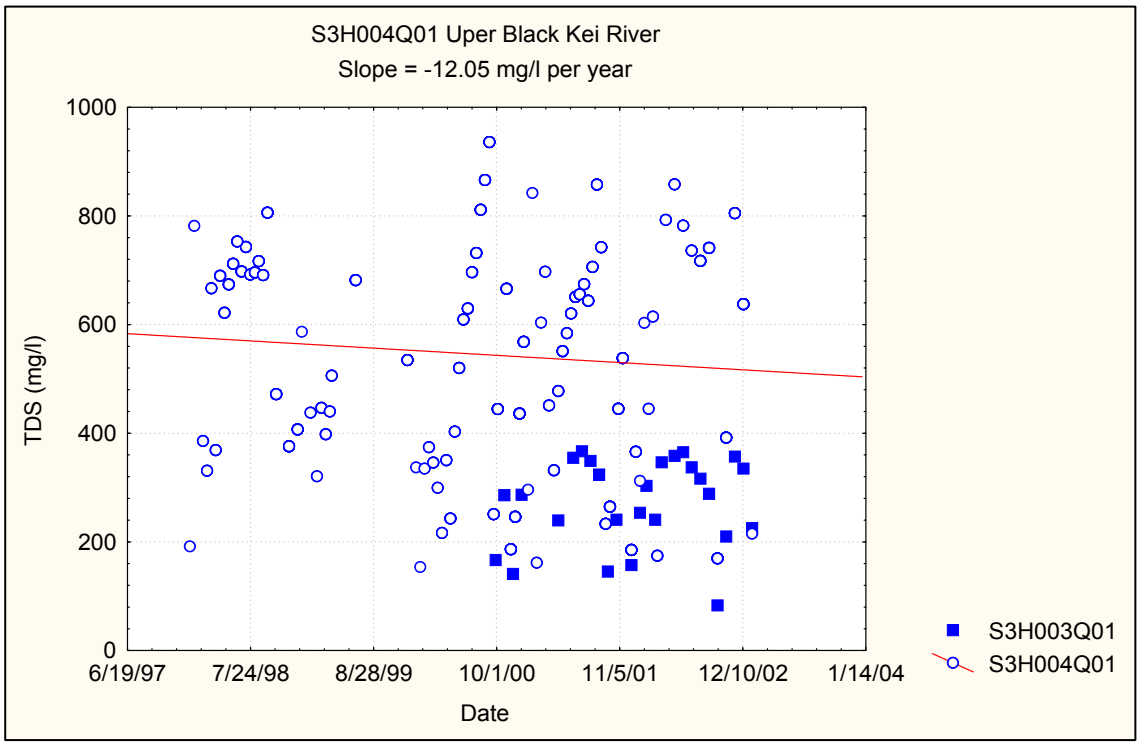

Figure 3 : Time series plot of TDS concentrations in the upper Black Kei since 1998 at S3H004 and at S3H003 further upstream showing the increase in salinity in a downstream direction

Trajectory of change – Over the most recent five years of data (1998 to present), there appeared to be a slight decreasing trend in salinity (Figure 3) of about -12 mg/ℓ per year and since monitoring began in about 1977, the long-term trend has been a decrease of about - 15mg/ℓ. If this trend continues, there would probably not be change in category over 5 years but a change in category is possible over a 20-year period. The decrease could possibly be traced back to a reduction in baseflows that generally contribute higher salt concentrations than the summer storm flows. In Figure 3 the TDS concentrations at the upstream station, S3H003Q01, are plotted and it shows the increase in salinity in a downstream direction from a median of about 288 mg/ℓ (2000-2002) at S3H003Q01 to a median of 538 mg/ℓ (2000-2002) at S3H004Q01.

There was a slight increasing trend in dissolved nutrients over the most recent 5 years of data (+0.010 mg/ℓ for NO_2NO_3-N and +0.004 mg/ℓ for PO_4-P) that could possibly be attributed to increasing use and wash-off of fertilizer in the catchment. The increasing trend would probably not result in a change in category in the short term but may result in a change in category in the long term. The possible source of elevated nutrients is agricultural non-point sources and related to flow in terms of wash-off processes. The nutrients also increased in a downstream direction when compared to the upstream S3H003Q01 sampling points. For the period 2000-2002, NO_2NO_3-N increased from a median of 0.020 mg/ℓ to 0.049 mg/ℓ and PO4 increased from a median of 0.044 mg/ℓ to a median of 0.073 mg/ℓ.

5.4.4 Classification of the present water quality status

TABLE 5 : PRESENT WATER QUALITY STATUS OF THE UPPER BLACK KEI RIVER

VARIABLE GROUP	VARIABLE	VALUE	CATEGORY	COMMENT
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	46	Poor (E/F)	
	Na_2SO_4 (mg/ℓ)	0		
	$MgCl_2$ (mg/ℓ)	122	Poor (E/F)	
	$CaCl_2$ (mg/ℓ)	25	Good (B)	
	NaCl (mg/ℓ)	0		
	$CaSO_4$ (mg/ℓ)	0		
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.0675	Fair (C	
	TIN (mg/ℓ)	0.074	Natural (A)	
Physical variables	Temperature (°C)			See Section 5.4.5 below.
	Dissolved oxygen (mg/ℓ)			No dissolved oxygen data available or concerns raised
	Turbidity			No observations but elevated turbidity reported at IFR Site 2.
	pH (range)	8.05-8.76	Natural/Good (A/B)	
Response variables	Biotic index (ASPT score)	-	-	No biotic survey done for this site
	Algal abundance	-	-	No data or survey undertaken
	Toxicity			No specific concerns raised about toxicity

5.4.5 Temperature

Temperature data were available from S3H004Q01 (412 observations). For each month the 90th percentile and the 10th percentile values were calculated and these were specified as the boundaries of the natural range of monthly temperatures.

Calendar month	1	2	3	4	5	6	7	8	9	10	11	12
Upper natural boundary (90 %tile)	30.2	29.4	28.5	24.7	21.6	19	16	19	22	25.2	30	29.7
Lower natural boundary (10 %tile)	19	16	18.2	17.8	12.1	10.8	9.5	10	13	12.7	17	19

5.5 Water Quality Ecological Specifications for the Upper Black Kei River

The ecological specifications, for water quality for all the classes in the Upper Black Kei Resource Unit, are presented in Table 6. No ERC was recommended at the IFR Workshop. The water quality team recommends an ERC of Fair (D) for this river reach.

TABLE 6 : WATER QUALITY ECOLOGICAL SPECIFICATIONS FOR THE UPPER BLACK KEI RESOURCE UNIT

THE SHADED CELLS REPRESENT THE PRESENT STATUS

VARIABLE GROUP	VARIABLE	NATURAL	GOOD	FAIR	POOR	COMMENT
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	16	27	37	>37	Default table values
	Na_2SO_4 (mg/ℓ)	20	36	51	>51	Default table values
	$MgCl_2$ (mg/ℓ)	15	33	51	>51	Default table values
	$CaCl_2$ (mg/ℓ)	21	63	105	>105	Default table values
	NaCl (mg/ℓ)	45	217	389	>389	Default table values
	$CaSO_4$ (mg/ℓ)	351	773	1195	>1195	Default table values
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.005	0.025	0.125	>0.125	Adjusted for reference state
	TIN (mg/ℓ)	0.25	1.00	4.00	>4.00	Default table values
Physical variables	Temperature (°C)					See motivation below
	Dissolved oxygen (mg/ℓ)	8.0	6.5	5.5	<5.5	Default table values
	Turbidity					Not specified
	pH (range)	6.5– 8.0	5.8-9.0	5.0-10.0	<5.0 or >10.0	Default table values
Response variables	Biotic index (ASPT score)	7	6	5		Default table values
	Algal abundance (Periphyton Chl a µg/ℓ)	1.7	21	84	>84	Default table values
	Toxicity	Natural – 100% species protection extrapolated from 95% CEV Good – 95% species protection based on 95% CEV Fair – 100% species protection extrapolated from 95% AEV				Default table values

Temperature specifications

Calendar month	1	2	3	4	5	6	7	8	9	10	11	12
Upper fair boundary	34.2	33.4	32.5	28.7	25.6	22.8	19.2	22.8	26	29.2	34	33.7
Upper good boundary	32.2	31.4	30.5	26.7	23.6	20.9	17.6	20.9	24	27.2	32	31.7
Upper natural boundary (90 %tile)	30.2	29.4	28.5	24.7	21.6	19	16	19	22	25.2	30	29.7
Lower natural boundary (10 %tile)	19	16	18.2	17.8	12.1	10.8	9.5	10	13	12.7	17	19
Lower good boundary	17.1	14.4	16.4	16	10.9	9.72	8.55	9	11.7	11.4	15.3	17.1
Lower fair boundary	15.2	12.8	14.6	14.2	9.68	8.64	7.6	8	10.4	10.2	13.6	15.2

The upper and lower "Good" boundary values are based on upper and lower "natural" boundaries plus or minus the smallest of a 10% variation or 2 °C. The upper and lower "Fair" boundary values are based on upper and lower "natural" boundaries plus or minus the smallest of a 20% variation or 4 °C.

6. WATER QUALITY RESERVE FOR THE LOWER BLACK KEI

6.1 Introduction to the Lower Black Kei

Resource Unit	Lower Black Kei River	**IFR 2 site** **IFR 3 site**
River(s)	Black Kei River	
Description	Lower Black Kei from the Klaas Smits confluence to the White Kei confluence	
Quaternary catchments	S32K, S32M	

There is uncertainty about the water quality in the middle Black Kei River, downstream of the Klipplaat and Klaas Smits confluences, because there are no routine monitoring points in this reach. It can be assumed that salinity will be affected by the natural geology of the region and would show an increase in a downstream direction. The high turbidity is caused by runoff from the degraded catchment surface and the high nutrients by the effluents from Queenstown and Sada wastewater treatment works that enter this reach via the Klaas Smits River and Klipplaat River (DWAF, 1993).

Irrigation activities appear to be constrained to the river terraces. There is therefore little opportunity for uptake of fertilizer washed off the irrigated lands by riparian vegetation next to the river.

6.2 Data and Information used for the Lower Black Kei

There are no routine water quality monitoring points in this river reach to characterise the present water quality status.

6.3 Reference Conditions

No appropriate reference data set could be identified to characterise background water quality concentrations of this resource unit.

6.4 Present Water Quality Status for the Lower Black Kei

6.4.1 Assessment of the present state

	PRESENT STATE
Overall water quality class (Category)	Fair (C/D)
Variable groups	
Inorganic salts	Fair (C/D)
Nutrients	Fair (C/D)
Physical variables	Fair (C/D)
Response variables	Poor (E/F)

6.4.2 Reasons for present state

A qualitative assessment was made of the present water quality state. Using a rough mass balance calculation, it was estimated that the high salinity in the Upper Black Kei upstream of the Klipplaat would be reduced by about 30% as a result of dilution with better quality water from the Klipplaat River, and by a further 5% at the Klaas Smits confluence. It is estimated that salinity would then remain largely unchanged up to the confluence with the White Kei River. Both the Klipplaat River and the Klaas Smits River would have elevated nutrients as a result of effluents from the Queenstown and Whittlesea wastewater treatment works. It is estimated that there would be a reduction in nutrient concentrations in a downstream direction as aquatic plants take up nutrients and bind it to the suspended sediments which then settle out.

At the IFR 2 site the invertebrate specialist observed algae and fines in the matrix and covering most rocks in the river current. This observation appeared to confirm the fact that nutrient enrichment from the Klaas Smits River was carried over into the lower Black Kei River. The ASPT score at IFR 2 site was 4.1 which was classified as poor and at the IFR 3 site the ASPT score was 3.3 and was classified as poor.

6.5 Water Quality Ecological Specifications for the Lower Black Kei

At the IFR specialist workshop (29 Sept 2003 to 2 Oct 2003) the recommended ecological reserve category (ERC) was a D for IFR 2 and C/D for IFR 3. These translate to a Fair category for water quality.

The ecological specifications, for water quality for all the classes in the Lower Black Kei Resource Unit, are presented in Table 7.

TABLE 7 : WATER QUALITY ECOLOGICAL SPECIFICATIONS FOR THE LOWER BLACK KEI RESOURCE UNIT

THE SHADED CELLS REPRESENT THE PRESENT STATE

VARIABLE GROUP	VARIABLE	NATURAL	GOOD	FAIR	POOR	COMMENT
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	16	27	37	>37	Default table values
	Na_2SO_4 (mg/ℓ)	20	36	51	>51	Default table values
	$MgCl_2$ (mg/ℓ)	15	33	51	>51	Default table values
	$CaCl_2$ (mg/ℓ)	21	63	105	>105	Default table values
	NaCl (mg/ℓ)	45	217	389	>389	Default table values
	$CaSO_4$ (mg/ℓ)	351	773	1195	>1195	Default table values
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.005	0.025	0.125	>0.125	Adjusted for reference state
	TIN (mg/ℓ)	0.25	1.00	4.00	>4.00	Default table values
Physical variables	Temperature (°C)					See motivation below
	Dissolved oxygen (mg/ℓ)	8.0	6.5	5.5	<5.5	Default table values
	Turbidity					Not specified
	pH (range)	6.5– 8.0	5.8-9.0	5.0-10.0	<5.0 or >10.0	Default table values
Response variables	Biotic index (ASPT score)	7	6	5	<5	Default table values
	Algal abundance (Periphyton Chl a µg/ℓ)	1.7	21	84	>84	Default table values
	Toxicity	Natural – 100% species protection extrapolated from 95% CEV Good – 95% species protection based on 95% CEV Fair – 100% species protection extrapolated from 95% AEV				Default table values

Qualitative objectives set at the IFR workshop (What needs to be done to improve the water quality by one category).

To maintain water quality in a Fair (D) category, non-point source controls should be implemented to reduce the generation of salts in the Upper Black Kei catchment as well as the control of irrigation return flows from riparian irrigation in the lower Klipplaat, Klaas Smits and middle Black Kei Rivers. Flow related controls refer to restoring or maintaining some of the dilution from the Klipplaat River (now a controlled system with Waterdown Dam and Oxkraal Dam in the catchment). Most of the yield from Waterdown Dam is already allocated to the farmers along the lower Klipplaat and middle Kei River. Meeting the Reserve flow requirements through releases from Waterdown Dam will in effect increase the flows which will have a beneficial effect on water quality. Point source control measures are required to reduce the nutrient loads from Whittlesea and Queenstown wastewater treatment works.

7. WATER QUALITY RESERVE FOR THE KLIPPLAAT RIVER

7.1 Introduction to the Klipplaat River

Resource Unit	Klipplaat River	**IFR 1 site**
River(s)	Klipplaat River	
Description	Klipplaat River downstream of Waterdown Dam to the confluence with the Black Kei River.	
Quaternary catchments	S32D, S32E, S32G, and S32H (Klipplaat River only)	

The Klipplaat and Oxkraal Rivers drain an area containing agricultural land as well as the town of Sada-Whittlesea. Previous studies found the water in Waterdown Dam to be suitable for domestic, irrigation and livestock watering (DWAF, 1993, 1995). It has low nutrient concentrations and low algal growth. Wastewater from Sada-Whittlesea is treated and discharged into the Klipplaat River downstream of the Oxkraal confluence. In general, the wastewater treatment plant complies with the general effluent standards (Kooverji, 2003). The Klipplaat River upstream of Waterdown Dam was proclaimed a Special Standard river and any effluents in that part of the catchment have to comply with the Special Effluent Standard (DWAF, 1993, 1995).

7.2 Data and Information used for the Klipplaat River

TABLE 8 : MONITORING POINTS USED TO CHARACTERIZE THE REFERENCE AND PRESENT STATE OF THE KLIPPLAAT RIVER

PRESENT STATE SITE	
Monitoring station	S3R001Q01 : Waterdown Dam on Klipplaat River : near dam wall
Data record	Full data record: 17-05-68 to 06-01-03 (221 samples) Data record used: 7-01-98 to 6-01-03 (68 samples)
Trend significance	Slight increasing trend in salinity and nutrient concentrations.
Known point sources upstream	No known point sources upstream of the dam, the Whittlesea wastewater treatment works discharge treated effluent into the Klipplaat River downstream of Whittlesea.
Confidence	High confidence in salts data set but low confidence in nutrient data set. Moderate confidence in the representivity of the river between Waterdown Dam and the confluence with the Oxkraal River, low confidence in the representivity for the reach downstream of the Oxkraal confluence and Whittlesea.

7.3 Reference and Present Water Quality Status of the Klipplaat River

7.3.1 Assessment of the present state

	PRESENT STATE
Overall water quality class (Category)	Largely Natural (excluding nutrients and temperature) (A/B)
VARIABLE GROUPS	
Inorganic salts	Natural (A)
Nutrients	Good (B/C)
Physical variables	Natural (excluding temperature) (A)
Response variables	Good/Fair (C/D)

7.3.2 Reasons for present state

There was an insignificant increasing trend in mean TDS (+0.73 mg/ℓ per year) in Waterdown Dam and a slight increasing trend was observed in the nutrient concentrations. The increase in nutrient concentrations was probably related to the agricultural sources in the catchment (fertilizer wash-off). If the current trends continued, no change was expected in salinity in the short and long term but nutrients could deteriorate by half a category in the long term.

7.3.3 Time series plot of TDS concentrations

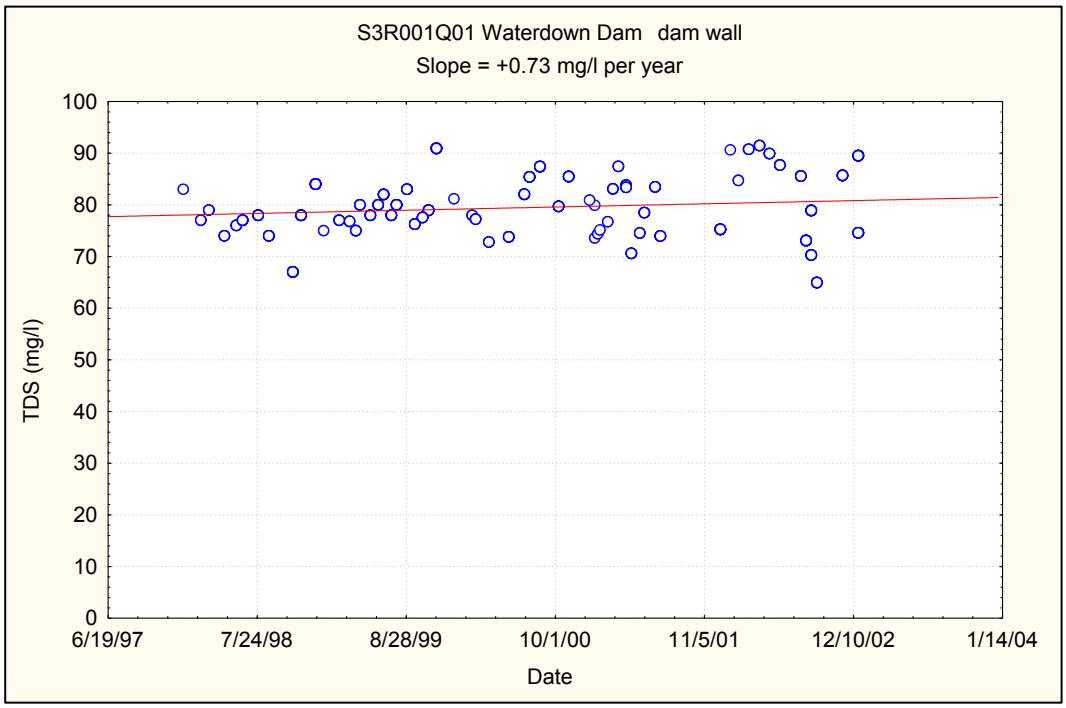

Figure 4 : Time series plots of TDS concentrations recorded in Waterdown Dam since 1998

7.3.4 Classification of the present water quality status

TABLE 9 : REFERENCE AND PRESENT WATER QUALITY STATUS OF THE KLIPPLAAT RIVER

VARIABLE GROUP	VARIABLE	VALUE	CATEGORY	COMMENT
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	16	Natural (A)	
	Na_2SO_4 (mg/ℓ)	4	Natural (A)	
	$MgCl_2$ (mg/ℓ)	8	Natural (A)	
	$CaCl_2$ (mg/ℓ)	16	Natural (A)	
	NaCl (mg/ℓ)	0		
	$CaSO_4$ (mg/ℓ)	0		
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.029	Fair (C)	High PO_4-P ascribed to irrigation on river terraces and rural settlements in catchment u/s of dam.
	TIN (mg/ℓ)	0.079	Good (B/C)	The in-lake water was classified as natural but in the downstream river (IFR 1) it was assigned a Good category after observations of high algal growth on the rocks downstream of the dam.
Physical variables	Temperature (°C)			No observed temperatures, concerns expressed about bottom releases from the dam and potential impacts on temperature.
	Dissolved oxygen (mg/ℓ)			No observed DO data for this resource unit
	Turbidity			Fairly turbid during site survey in August 2003, mostly fine suspended sediment (Uys, 2003)
	pH (range)	7.38-7.99	Natural/Natural (A/A)	
Response variables	Biotic index (ASPT score)	5.9	Fair/Good	Invertebrate survey (Uys, 2003)
	Algal abundance			Large amounts of periphyton algae observed on rocks during site visit in August 2003 (Thirion, *pers. comm.*)
	Toxicity			No specific concerns raised about toxicity

7.3.5 Temperature

Concerns have been raised about the potential temperature impacts of water released from Waterdown Dam. There are no temperature data for the river reach directly downstream of the dam to quantify the impacts. Qualitative observations during controlled releases for the IFR study were that the released water was colder than expected. It was speculated that the water was released from the bottom layers. The dam also has the effect of shifting the winter minimums and summer maximum temperatures by a month or more due to the delay in warming and cooling of the dam.

The dam is equipped with a multilevel outlet structure that can withdraw water from four levels. At the time of the IFR Specialist Workshop, no information could be obtained on the level from

which water is released under normal conditions. During controlled releases for this IFR study specialists were of the opinion that the cold temperature of the released water indicated mostly bottom releases. Subsequently it has been confirmed that under normal operating conditions water is withdrawn from the highest possible level (J Viljoen, Pers. comm.., 2004).

7.4 Water Quality Ecological Specifications for the Klipplaat River

At the IFR specialist workshop (29 Sept – 3 Oct 2003), the recommended Ecological Reserve Category (ERC) was a C (Good/Fair) category. The ecological specifications, for water quality for all the classes in the Klipplaat River Resource Unit, are presented in Table 10.

TABLE 10 : WATER QUALITY ECOLOGICAL SPECIFICATIONS FOR THE KLIPPLAAT RIVER RESOURCE UNIT
THE PRESENT STATE IS SHADED IN

VARIABLE GROUP	VARIABLE	NATURAL	GOOD	FAIR	POOR	COMMENT
Inorganic salts (95thpercentile)	$MgSO_4$ (mg/ℓ)	16	27	37	>37	Default table values
	Na_2SO_4 (mg/ℓ)	20	36	51	>51	Default table values
	$MgCl_2$ (mg/ℓ)	15	33	51	>51	Default table values
	$CaCl_2$ (mg/ℓ)	21	63	105	>105	Default table values
	NaCl (mg/ℓ)	45	217	389	>389	Default table values
	$CaSO_4$ (mg/ℓ)	351	773	1195	>1195	Default table values
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.005	0.025	0.125	>0.125	Adjusted for reference state
	TIN (mg/ℓ)	0.25	1.00	4.00	>4.00	Default table values
Physical variables	Temperature (°C)					Refer to motivation below
	Dissolved oxygen (mg/ℓ)	8.0	6.5	5.5	<5.5	Default table values
	Turbidity					Not specified
	pH (range)	6.5– 8.0	5.8-9.0	5.0-10.0	<5.0 or >10.0	Default table values
Response variables	Biotic index (ASPT score)	7	6	5	<5	Default table values
	Algal abundance (Periphyton Chl a µg/ℓ)	1.7	21	84	>84	Default table values
	Toxicity	Natural – 100% species protection extrapolated from 95% CEV Good – 95% species protection based on 95% CEV Fair – 100% species protection extrapolated from 95% AEV				Default table values

Temperature specifications

Calendar month	1	2	3	4	5	6	7	8	9	10	11	12
Upper fair boundary	34.2	33.4	32.5	28.7	25.6	22.8	19.2	22.8	26	29.2	34	33.7
Upper good boundary	32.2	31.4	30.5	26.7	23.6	20.9	17.6	20.9	24	27.2	32	31.7
Upper natural boundary (90 %tile)	30.2	29.4	28.5	24.7	21.6	19	16	19	22	25.2	30	29.7
Lower natural boundary (10 %tile)	19	16	18.2	17.8	12.1	10.8	9.5	10	13	12.7	17	19
Lower good boundary	17.1	14.4	16.4	16	10.9	9.72	8.55	9	11.7	11.4	15.3	17.1
Lower fair boundary	15.2	12.8	14.6	14.2	9.68	8.64	7.6	8	10.4	10.2	13.6	15.2

Based on the temperature data observed at S3H004Q01 (see Section 5.4.5 and 5.5).

Water quality objectives set at the IFR workshop

The water quality downstream of Waterdown Dam can be improved to a Good category by releasing water from closer to the surface rather than the bottom layers. This would have a positive effect on temperature, dissolved oxygen, turbidity and nutrient concentrations. This is the present method of operating the dam and should be maintained.

8. WATER QUALITY RESERVE FOR THE OXKRAAL RIVER

8.1 Introduction to the Oxkraal River

Resource Unit	Oxkraal River	**No IFR site**
River(s)	Oxkraal River	
Description	Oxkraal River to the confluence with the Klipplaat River	
Quaternary catchments	S32F, S32G (Oxkraal River only)	

The Klipplaat and Oxkraal Rivers drain an area containing agricultural land as well as the town of Sada-Whittlesea. Previous studies found the water in Waterdown Dam to be suitable for domestic, irrigation and livestock watering (DWAF, 1993, 1995). It has low nutrient concentrations and low algal growth. Wastewater from Sada-Whittlesea is treated and discharged into the Klipplaat River downstream of the Oxkraal confluence. In general, the wastewater treatment plant complies with the general effluent standards. The Klipplaat River upstream of Waterdown Dam was proclaimed a Special Standard river and any effluents in that part of the catchment have to comply with the Special Effluent Standard.

8.2 Data and Information used for the Oxkraal River

TABLE 11 : MONITORING POINTS USED TO CHARACTERISE THE REFERENCE AND PRESENT STATE OF THE OXKRAAL RIVER

PRESENT STATE SITE	
Monitoring station	S3H005Q01 : Oxkraal River at Whittlesea
Data record	Full data record: 10-11-71 – 23/01/03 (468 samples) Data record used: 08/01/98 - 23-01-03 (116 samples)
Trend significance	No significant trend in salinity or nutrients.
Known point sources upstream	No known point sources upstream of the monitoring point. Some nonpoint sources include urban runoff from the town of Sada and rural villages.
Confidence	Moderate confidence in salts data set, low confidence in nutrient and physical data sets. High confidence in representivity for the resource unit because the monitoring point is situated close to the bottom of the resource unit.

8.3 Present Water Quality Status of the Oxkraal River

8.3.1 Assessment of the present state

	PRESENT STATE
Overall water quality class (Category)	Poor (D/E)
VARIABLE GROUPS	
Inorganic salts	Poor (E/F)
Nutrients	Fair (C/D)
Physical variables	Good (A/B)
Response variables	Not determined

8.3.2 Reasons for present state

The present poor state is the result of high salt concentrations. There is an insignificant decreasing trend in TDS (-1.1 mg/ℓ per year) since 1998 and there is a slight increasing trend over the long term of about +2.2 mg/ℓ per year. None of these trends would result in a change in category over the short or long term if they continue as observed. The nitrate concentrations show a slight increasing trend (+0.365 mg/ℓ per year for NO_3NO_2-N) probably as a result of the use of fertilizer in the catchment and runoff from Sada. This may in the long-term result in a change to a poorer category but not in the short term.

8.3.3 Time series plot of TDS concentrations

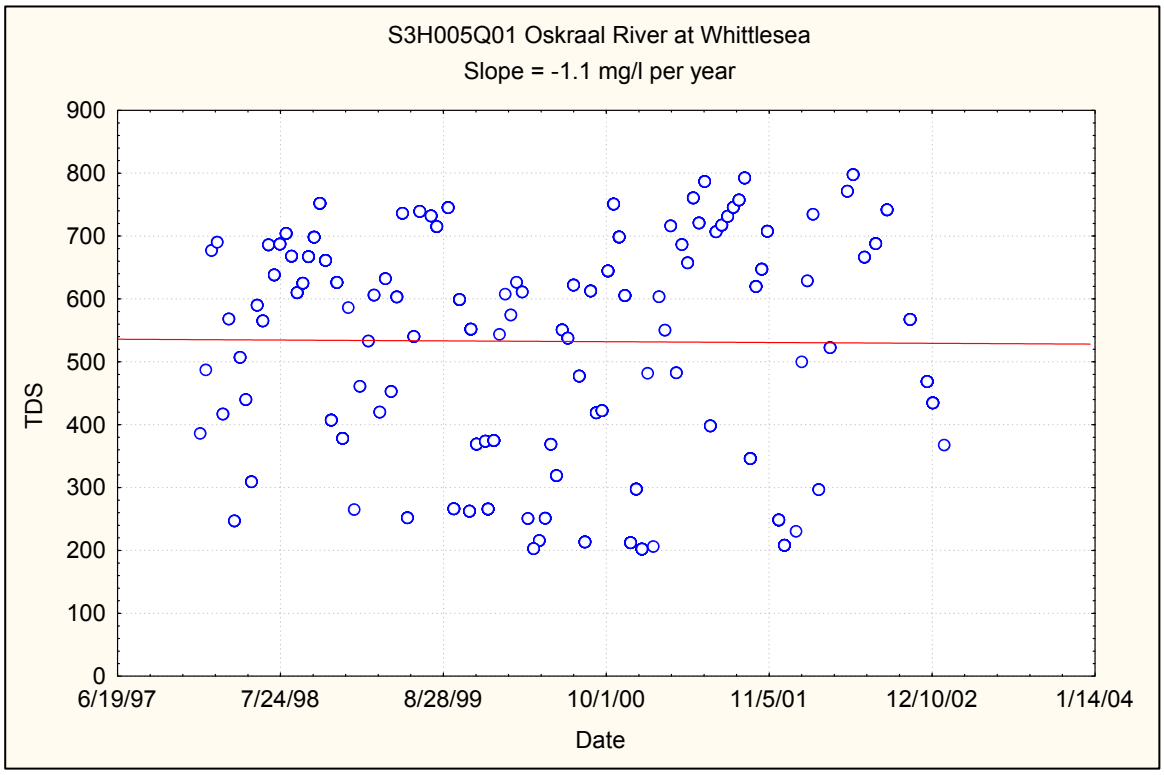

Figure 5 : Time series plot of TDS concentrations recorded in the Oxkraal River since 1998

There is however a marked deterioration in water quality between Oxkraal Dam (S3R003Q01) and the Oxkraal River at Whittlesea (S3H005Q01). Over the period 1998 to 2002, the median TDS concentration increases from 218 mg/ℓ in Oxkraal Dam to a median of 574 mg/ℓ at Whittlesea. The median NO_3NO_2-N concentration increased from 0.166 mg/ℓ at Oxkraal Dam to a median of 3.822 mg/ℓ at Whittlesea. However, the median PO_4-P concentration decreased slightly from 0.029 mg/ℓ at Oxkraal Dam to a median of 0.020 mg/ℓ at Whittlesea.

8.3.4 Classification of the present water quality status

TABLE 12 : PRESENT WATER QUALITY STATUS OF THE OXKRAAL RIVER

Variable Group	Variable	Value	Category	Comment
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	44	Poor (E/F)	
	Na_2SO_4 (mg/ℓ)	0		
	$MgCl_2$ (mg/ℓ)	146	Poor (E/F)	
	$CaCl_2$ (mg/ℓ)	32	Good (B)	
	NaCl (mg/ℓ)	0		
	$CaSO_4$ (mg/ℓ)	0		
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.020	Good (B)	
	TIN (mg/ℓ)	3.86	Fair (D)	
Physical variables	Temperature (°C)			See section below
	Dissolved oxygen (mg/ℓ)			No data
	Turbidity			
	PH (range)	8.11 – 8.71	Natural/Good (A/B)	
Response variables	Biotic community composition			No data collected during site visits.
	Algal abundance			No observations available.
	Toxicity			No concerns raised about toxicity.

8.3.5 Temperature

Temperature data were available from S3H005Q01 (279 observations). For each month the 90th percentile and the 10th percentile were calculated and these were specified as the boundaries of the natural range of monthly temperatures.

Calendar Month	1	2	3	4	5	6	7	8	9	10	11	12
Upper natural boundary (90 %tile)	29.5	28.6	29.4	23	20.5	18.5	20	20	21.5	21	26.9	25
Lower natural boundary (10 %tile)	18.4	19	17	16	14.1	11.3	9.7	10.9	11.6	11	17	16

8.4 Water Quality Ecological Specifications for the Oxkraal River

At the IFR Workshop (29 September - 3 October 2003), the recommended Ecological Reserve category (ERC) was set as a D (Fair) category. The ecological specifications, for water quality for all the classes in the Oxkraal River Resource Unit, are presented in Table 13.

TABLE 13 : WATER QUALITY ECOLOGICAL SPECIFICATIONS FOR THE OXKRAAL RIVER RESOURCE UNIT THE PRESENT STATE IS SHADED IN

Variable Group	Variable	Natural	Good	Fair	Poor	Comment
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	16	27	37	>37	Default table values
	Na_2SO_4 (mg/ℓ)	20	36	51	>51	Default table values
	$MgCl_2$ (mg/ℓ)	15	33	51	>51	Default table values
	$CaCl_2$ (mg/ℓ)	21	63	105	>105	Default table values
	NaCl (mg/ℓ)	45	217	389	>389	Default table values
	$CaSO_4$ (mg/ℓ)	351	773	1195	>1195	Default table values
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.005	0.025	0.125	>0.125	Adjusted for reference state
	TIN (mg/ℓ)	0.25	1.00	4.00	>4.00	Default table values
Physical variables	Temperature (°C)					See motivation below
	Dissolved oxygen (mg/ℓ)	8.0	6.5	5.5	<5.5	Default table values
	Turbidity					Not specified
	pH (range)	6.5– 8.0	5.8-9.0	5.0-10.0	<5.0 or >10.0	Default table values
Response variables	Biotic index (ASPT score)	7	6	5	<5	Default table values
	Algal abundance (Periphyton Chl a µg/ℓ)	1.7	21	84	>84	Default table values
	Toxicity	Natural – 100% species protection extrapolated from 95% CEV Good – 95% species protection based on 95% CEV Fair – 100% species protection extrapolated from 95% AEV				Default table values

8.4.1 Temperature Specifications

Calendar month	1	2	3	4	5	6	7	8	9	10	11	12
Upper fair boundary	33.5	32.6	33.4	27	24.5	22.2	24	24	25.5	25	30.9	29
Upper good boundary	31.5	30.6	31.4	25	22.5	20.4	22	22	23.5	23	28.9	27
Upper natural boundary (90 %tile)	29.5	28.6	29.4	23	20.5	18.5	20	20	21.5	21	26.9	25
Lower natural boundary (10 %tile)	18.4	19	17	16	14.1	11.3	9.7	10.9	11.6	11	17	16
Lower good boundary	16.5	17.1	15.3	14.4	12.6	10.2	8.73	9.81	10.4	9.9	15.3	14.4
Lower fair boundary	14.7	15.2	13.6	12.8	11.2	9.04	7.76	8.72	9.28	8.8	13.6	12.8

Based on observed temperature data at S3H005Q01 (See Section 8.3.5).

Qualitative specifications

If the sources of high salinity and high nitrogen concentrations can be identified and controlled, the water quality status can be improved to the recommended Reserve category.

9. WATER QUALITY RESERVE FOR THE LOWER KLAAS SMITS RIVER

9.1 Introduction to the Lower Klaas Smits River

Resource Unit	Lower Klaas Smits River	**No IFR site**
River(s)	Klaas Smits River	
Description	Lower Klaas Smits River	
Quaternary catchments	S31E, S31G	

The upper Klaas Smits River drains a mostly agricultural catchment. The lower Klaas Smits River is affected by the Komani River that receives variable volumes of the treated effluent from the Queenstown wastewater treatment works as well as urban runoff from Queenstown and eZibeleni. The WWTW discharges into the Komani River but is almost immediately abstracted for irrigation purposes. The volumes abstracted vary according to the crop demands with the result that some treated effluent flows down the Komani River from time to time. The return flows from the irrigated lands are regarded as diffuse source inputs. Downstream of Queenstown, the Komani River flows through an agricultural area before it joins the Klaas Smits River. The river has high suspended solids concentrations. Studies in the late 1980s and early 1990s found elevated arsenic concentrations in the Komani River but the source could not be determined (it was postulated that it could be related to the dipping of cattle and industrial sources (Du Preez, 1985)). Its impact on river biota was also not described, and there is uncertainty whether elevated arsenic is still a concern in the Komani River.

Upstream of the Komani River confluence, there was a gradual deterioration in quality from the source to the lower reaches. It was assumed that the deterioration was caused by return flows from the agricultural lands adjacent to the river and the natural geology of the catchment. The monitoring point used to characterise the present water quality status is situated upstream of the Komani River confluence and therefore does not reflect the variable impact of the Queenstown treated sewage effluent.

9.2 Data and Information used for the Lower Klaas Smits River

TABLE 14 : MONITORING POINTS USED TO CHARACTERISE THE REFERENCE AND PRESENT STATE OF THE LOWER KLAAS SMITS RIVER

PRESENT STATE SITE	
Monitoring station	S3H006Q01 : Klaas Smits River at Cathcarts Gift/Endwell
Data record	Full data record: 17-01-77 to 12-12-02 (335 samples) Data record used: 2-04-98 to 12-12-02 (65 samples)
Trend significance	Moderate decreasing trend in salinity up to about 1995, moderate increasing trend after 1995.
Known point sources upstream	No known point sources upstream of the monitoring point. The Queenstown sewage effluent is discharged into the Komani River, some is abstracted for irrigation, and what remains in the river enters the Klaas Smits River downstream of the monitoring point. Return flows from the irrigated lands are viewed as diffuse sources.
Confidence	Low confidence in the chemical data set for salts and nutrients and moderate confidence in representivity of the resource unit.

9.3 Present Water Quality Status of the Lower Klaas Smits River

9.3.1 Assessment of the present state

	PRESENT STATE
Overall water quality class (Category)	Fair (D)
VARIABLE GROUPS	
Inorganic salts	Poor (E/F)
Nutrients	Fair (A/C)
Physical variables	Good (A/B)
Response variables	-

9.3.2 Reasons for present state

The long-term trend in salinity concentrations show a decreasing trend of about -11.3 mg/ℓ since sampling started in about the mid-1970s. However, after 1995, salinity concentrations started increasing again. It should be noted that concentrations vary highly with flow, with elevated concentrations being observed in the low flow winter months and lower concentrations being observed during the high flow summer months. Nutrient concentrations had a slight decreasing trend since 1998. The changes in water chemistry at the monitoring point were related to catchment processes rather than point sources. The Klaas Smits River downstream of the Komani River is affected by the effluent discharges from the Queenstown wastewater works.

9.3.3 Time series plot of TDS concentrations

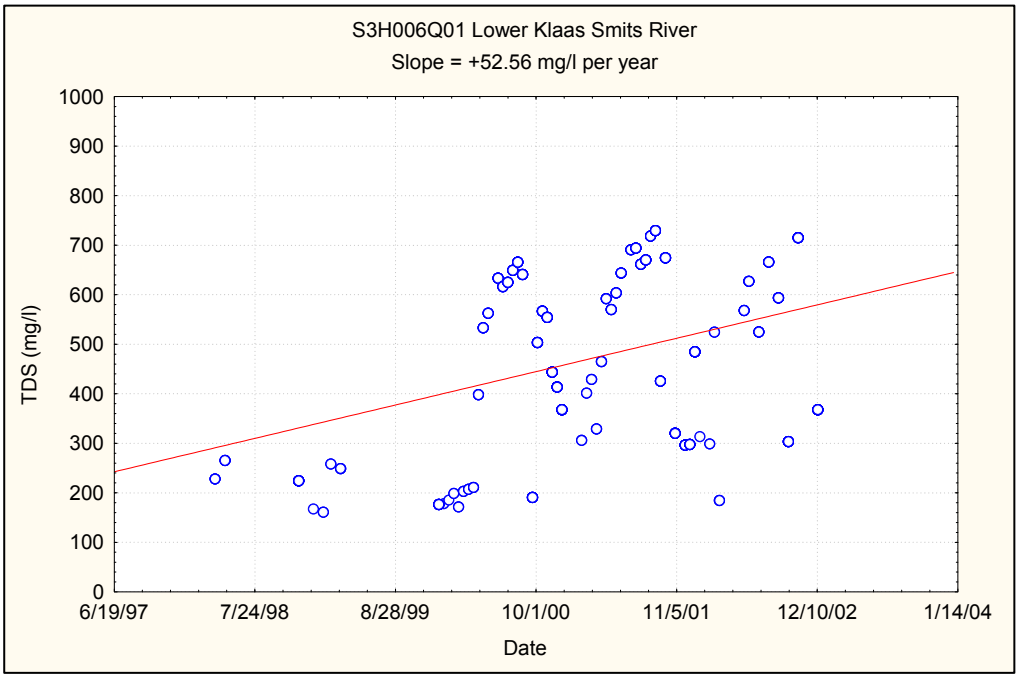

Figure 6 : Time series plot of TDS concentrations recorded in the lower Klaas Smits River since 1998

9.3.4 Classification of the present water quality status

TABLE 15 : PRESENT WATER QUALITY STATUS OF THE LOWER KLAAS SMITS RIVER

VARIABLE GROUP	VARIABLE	VALUE	CATEGORY	COMMENT
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	56	Poor (E/F)	
	Na_2SO_4 (mg/ℓ)	0		
	$MgCl_2$ (mg/ℓ)	107	Poor (E/F)	
	$CaCl_2$ (mg/ℓ)	5	Natural (A)	
	NaCl (mg/ℓ)	0		
	$CaSO_4$ (mg/ℓ)	0		
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.046	Fair (C)	
	TIN (mg/ℓ)	0.088	Natural (A)	
Physical variables	Temperature (°C)			No concerns about thermal impacts
	Dissolved oxygen (mg/ℓ)			No data
	Turbidity			Not determined
	pH (range)	7.65-8.72	Natural/Good (A/B)	
Response variables	Biotic community composition			No observed data available
	Algal abundance			No observed data available
	Toxicity			Concerns raised elevated about arsenic concentrations in the Komani River.

9.3.5 Temperature

Temperature data were available from S3H006Q01 (374 observations). For each month the 90th percentile and the 10th percentile were calculated and these were specified as the boundaries of the natural range of monthly temperatures.

Calendar month	1	2	3	4	5	6	7	8	9	10	11	12
Upper natural boundary (90 %tile)	28	27	26	25	20	18	18	18	20	24	25.6	27
Lower natural boundary (10 %tile)	18.3	16	18	15	8	8	6.8	9	10	10	16	16

9.4 Water Quality Ecological Specifications for the Lower Klaas Smits River

No ERC was recommended for the lower Klaas Smits River at the IFR specialist workshop. The water quality team recommends maintaining the resource unit in a Fair (D) category. The ecological specifications, for water quality for all the classes in the Lower Klaas Smits Resource Unit, are presented in Table 16.

TABLE 16 : WATER QUALITY ECOLOGICAL SPECIFICATIONS FOR THE LOWER KLAAS SMITS RESOURCE UNIT
THE SHADED CELLS REPRESENT THE PRESENT STATE

VARIABLE GROUP	VARIABLE	NATURAL	GOOD	FAIR	POOR	COMMENT
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	16	27	37	>37	Default table values
	Na_2SO_4 (mg/ℓ)	20	36	51	>51	Default table values
	$MgCl_2$ (mg/ℓ)	15	33	51	>51	Default table values
	$CaCl_2$ (mg/ℓ)	21	63	105	>105	Default table values
	NaCl (mg/ℓ)	45	217	389	>389	Default table values
	$CaSO_4$ (mg/ℓ)	351	773	1195	>1195	Default table values
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.005	0.025	0.125	>0.125	Adjusted for reference state
	TIN (mg/ℓ)	0.25	1.00	4.00	>4.00	Default table values
Physical variables	Temperature (°C)					See motivation below
	Dissolved oxygen (mg/ℓ)	8.0	6.5	5.5	<5.5	Default table values
	Turbidity					Not specified
	pH (range)	6.5– 8.0	5.8-9.0	5.0-10.0	<5.0 or >10.0	Default table values
Response variables	Biotic index (ASPT score)	7	6	5	<5	Default table values
	Algal abundance (Periphyton Chl a µg/ℓ)	1.7	21	84	>84	Default table values
	Toxicity	Natural – 100% species protection extrapolated from 95% CEV Good – 95% species protection based on 95% CEV Fair – 100% species protection extrapolated from 95% AEV				Default table values

9.4.1 Temperature specifications

CALENDAR MONTH	1	2	3	4	5	6	7	8	9	10	11	12
Upper fair boundary	32	31	30	29	24	21.6	21.6	21.6	24	28	29.6	31
Upper good boundary	30	29	28	27	22	19.8	19.8	19.8	22	26	27.6	29
Upper natural boundary (90 %tile)	28	27	26	25	20	18	18	18	20	24	25.6	27
Lower natural boundary (90 %tile)	18.3	16	18	15	8	8	6.8	9	10	10	16	16
Lower good boundary	16.5	14.4	16.2	13.5	7.2	7.2	6.12	8.1	9	9	14.4	14.4
Lower fair boundary	14.6	12.8	14.4	12	6.4	6.4	5.44	7.2	8	8	12.8	12.8

Based on observed temperature data at S3H006Q01 (See Section 9.3.5).

Qualitative objectives

Water quality in the lower Klaas Smits River already affects the lower Black Kei River. A deterioration or improvement in quality of the Klaas Smits River would have a direct impact on the Black Kei River and care should be taken to maintain the quality at its present status.

10. WATER QUALITY RESERVE FOR THE LOWER WHITE KEI RIVER

10.1 Introduction to the Lower White Kei River

Resource Unit	Lower White Kei River	**IFR 4**
River(s)	White Kei River	
Description	White Kei River from Xonxa Dam to the confluence with the Black Kei River.	
Quaternary catchments	S10H, S10J	

The White Kei River downstream of Xonxa Dam has two tributaries that affect its quality, the Cacadu River and the Indwe River. The land-use in the catchment of the White Kei and its major tributaries is mostly subsistence agriculture and rural settlements. Water quality in Xonxa Dam is suitable for domestic, irrigation and livestock water use. Xonxa Dam has high suspended sediment concentrations, attributed largely to extensive erosion in the upper catchment. In the lower reaches the conductivity and chloride guidelines were exceeded (DWAF, 1993). High concentrations of arsenic were observed in the lower reaches and were attributed to the contamination of groundwater from cattle dips situated on the banks of the river (Du Preez, 1985). High iron and manganese concentrations were also observed in the lower reaches and were attributed to hypolimnetic releases from Xonxa Dam (Du Preez, 1985). However, according to information supplied by the DWAF Eastern Cape Regional Office, no downstream releases have been made from the dam in recent times.

10.2 Data and Information used for the Lower White Kei River

There are two monitoring points on the White Kei River, the in-lake monitoring point at Xonxa Dam (S1R001Q01) where data have been collected on about a monthly frequency and further downstream at the R61 road bridge on the Queenstown/Tsomo road (S1H002Q01) where 8 of the 10 samples collected at this point were collected in the early 1980s. In the absence of any recent data in the lower reaches of the White Kei River, data from Xonxa Dam was used to classify the present state. The confidence in the ability of the Xonxa Dam data to characterise the lower reaches is low because the Indwe and Cacadu Rivers influence the water quality in the lower reaches to a large degree.

TABLE 17 : MONITORING POINTS USED TO CHARACTERISE THE REFERENCE AND PRESENT STATE OF THE LOWER WHITE KEI RIVER

PRESENT STATE SITE	
Monitoring station	S1R001Q01 – Xonxa Dam on the White Kei River: Near the dam wall
Data record	Full data record: 04/06/80 – 6/12/2002 (244 samples) Data record used: 28/01/98 – 6/12/2002 (28 samples)
Trend significance	No trend in salinity and nutrients in the dam.
Known point sources upstream	No known point sources upstream of the dam.
Confidence	High confidence in salinity data set, low confidence in nutrient and physical data sets, low confidence in representivity of the monitoring point to represent the whole resource unit.

10.3 Present Water Quality Status of the Lower White Kei River

10.3.1 Assessment of the present state

	PRESENT STATE
Overall water quality class (Category)	Good (B)
VARIABLE GROUPS	
Inorganic salts	Good (B)
Nutrients	Good (B)
Physical variables	Good (A/B)
Response variables	

10.3.2 Reasons for present state

The present state appears to be good but the data set is inadequate to draw any meaningful conclusions about trends in water quality. Catchment processes and runoff from subsistence agricultural lands and rural villages largely control water chemistry in the dam and the lower White Kei River.

10.3.3 Time series plot of TDS concentrations

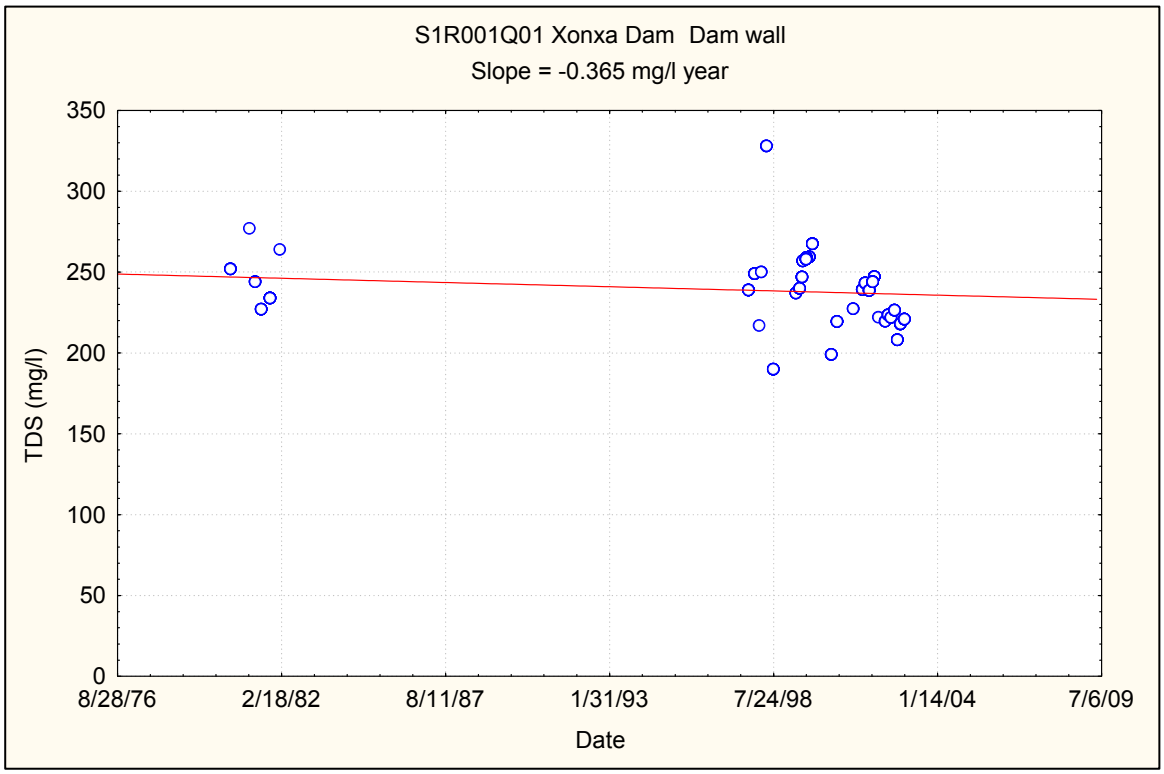

Figure 7 : Time series plot of TDS concentrations recorded in Xonxa Dam since the 1980s

10.3.4 Classification of the present water quality status

TABLE 18 : PRESENT WATER QUALITY STATUS OF THE LOWER WHITE KEI RIVER

VARIABLE GROUP	VARIABLE	VALUE	CATEGORY	COMMENT
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	21	Good (B)	
	Na_2SO_4 (mg/ℓ)	0		
	$MgCl_2$ (mg/ℓ)	22	Good (B)	
	$CaCl_2$ (mg/ℓ)	0		
	NaCl (mg/ℓ)	0		
	$CaSO_4$ (mg/ℓ)	0		
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.018	Good (B)	
	TIN (mg/ℓ)	0.1722	Natural (A)	
Physical variables	Temperature (°C)			No observed data, concerns raised about hypolimnetic releases from Xonxa Dam. Should not affect IFR site.
	Dissolved oxygen (mg/ℓ)		Good	No data, no concerns expressed about low DO concentrations.
	Turbidity		Fair	Although low turbidity was observed during the site visit in July 2003, the substrate was covered with very fine silt that was easily disturbed resulting in very turbid water.
	pH (range)	8.06 – 8.59	Natural/Good (A/B)	
Response variables	Biotic community composition	5.2	Fair	Biotic survey for the IFR study
	Algal abundance		Good	Some periphyton observed on rocks during site visit in July 2003.
	Toxicity			Historically, concerns have been raised about elevated arsenic concentrations in the lower reaches and these were attributed to the contamination of groundwater from cattle dips situated on the banks of the river. High iron and manganese concentrations were also observed in the lower reaches and were attributed to hypolimnetic releases from Xonxa Dam.

10.4 Water Quality Ecological Specifications for the Lower White Kei River

At the IFR specialist workshop (29 Sept 2003 to 2 Oct 2003) the recommended ecological reserve category (ERC) was a C/D for IFR 4. This translates to a Fair category for water quality.

The ecological specifications, for water quality for all the classes in the Lower White Kei Resource Unit, are presented in Table 19.

TABLE 19 : WATER QUALITY ECOLOGICAL SPECIFICATIONS FOR THE LOWER WHITE KEI RESOURCE UNIT
THE SHADED IN CELLS REPRESENT THE PRESENT STATE

VARIABLE GROUP	VARIABLE	NATURAL	GOOD	FAIR	POOR	COMMENT
Inorganic salts (95th percentile)	$MgSO_4$ (mg/ℓ)	16	27	37	>37	Default table values
	Na_2SO_4 (mg/ℓ)	20	36	51	>51	Default table values
	$MgCl_2$ (mg/ℓ)	15	33	51	>51	Default table values
	$CaCl_2$ (mg/ℓ)	21	63	105	>105	Default table values
	NaCl (mg/ℓ)	45	217	389	>389	Default table values
	$CaSO_4$ (mg/ℓ)	351	773	1195	>1195	Default table values
Nutrients 50th percentile	PO_4-P (mg/ℓ)	0.005	0.025	0.125	>0.125	Adjusted for reference state
	TIN (mg/ℓ)	0.25	1.00	4.00	>4.00	Default table values
Physical variables	Temperature (°C)					See motivation below
	Dissolved oxygen (mg/ℓ)	8.0	6.5	5.5	<5.5	Default table values
	Turbidity					Not specified
	pH (range)	6.5– 8.0	5.8-9.0	5.0-10.0	<5.0 or >10.0	Default table values
Response variables	Biotic index (ASPT score)	7	6	5	<5	Default table values
	Algal abundance (Periphyton Chl a µg/ℓ)	3	25	260	>260	Default table values
	Toxicity	Natural – 100% species protection extrapolated from 95% CEV Good – 95% species protection based on 95% CEV Fair – 100% species protection extrapolated from 95% AEV				Default table values

10.4.1 Temperature specifications

CALENDAR MONTH	1	2	3	4	5	6	7	8	9	10	11	12
Upper fair boundary	32	31	30	29	24	21.6	21.6	21.6	24	28	29.6	31
Upper good boundary	30	29	28	27	22	19.8	19.8	19.8	22	26	27.6	29
Upper natural boundary (90 %tile)	28	27	26	25	20	18	18	18	20	24	25.6	27
Lower natural boundary (90 %tile)	18.3	16	18	15	8	8	6.8	9	10	10	16	16
Lower good boundary	16.5	14.4	16.2	13.5	7.2	7.2	6.12	8.1	9	9	14.4	14.4
Lower fair boundary	14.6	12.8	14.4	12	6.4	6.4	5.44	7.2	8	8	12.8	12.8

Based on observed temperature data at S3H006Q01 (See Section 9.3.5 and 9.4.1).

11. CONCLUDING REMARKS

Water quality in the Black Kei River deteriorates in a downstream direction, largely as a result of increasing salinity. The Klipplaat River and some of the smaller tributaries downstream of the Klaas Smits confluence, appeared to provide temporary dilution of the salts which appeared to improve the quality of the lower Black Kei upstream of the White Kei confluence. This observation was based on comments by the invertebrate and fish specialists at the IFR workshop. The impact of the Klaas Smits River is probably slightly negative because it carries irrigation return flows and some treated sewage effluent. There were no routine water quality monitoring points in the lower Black Kei to confirm any of the theories described above and it is strongly recommended that a routine water quality monitoring point be established in the lower Black Kei. Future water supply developments for Lukanji would probably affect quality in this river reach and it is essential that the impacts be monitored. Development options that affect the quality in the Klaas Smits, Klipplaat and smaller tributaries would also need to consider carefully the quality impacts in the main stream Black Kei River.

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APPENDIX A

Copies of the Ecological Water Quality Reserve (EWQR) spreadsheet calculation results

Station:	S3H004 : Black Kei River at Cathcart's Gift/Endwell					
Full data period : 8-01-1998		Period used 20-02-2003				
	Present State Characterisation					
	5th %ile	median	95th %ile		Cat	No. used
Ca	19	42	58			95
Mg	8	28	42			95
K	2	3	5			95
Na	14	65	131			95
Cl	14	55	99			95
SO4	10	21	36			95
MgSO4	13	26	46		Poor	
Na2SO4	0	0	0		Natural	
MgCl2	15	71	122		Poor	
CaCl2	0	0	25		Good	
NaCl	0	0	0		Natural	
CaSO4	0	0	0		Natural	
PH	8.0474	8.524	8.7604		Natural/Good	108
NH4	0.02	0.02	0.14055			108
NO2_NO3	0.02	0.02	0.4239			108
PO4	0.0197	0.0675	0.1821		Fair	108
TIN	0.04	0.074	0.55345		Natural	108
NH3	0.001101	0.00311	0.012507		Good	108
TDS	186.1618	551.056	820.8365			95
TP	ND	ND	ND			0
KN	ND	ND	ND			0
KN:TP	ND	ND	ND			0
TAL	93.1385	269.541	394.3866			95

Reserve Criteria			
	N	G	F
MgSO4	16	27	37
Na2SO4	20	36	51
MgCl2	15	33	51
CaCl2	21	63	105
NaCl	45	217	389
CaSO4	351	773	1195
pH lower	6.5	5.8	5.0
pH upper	8.0	9.0	10.0
PO4	0.005	0.025	0.125
TIN	0.25	1.00	4.00
NH3	0.007	0.054	0.100
DO	8.0	6.5	5.5

Major Ion Reserve values corresponding to the selected salt benchmarks

Ca	58
Mg	42
Na	131
Cl	99
SO4	36

EWQRCalc Version 2.4.2

Corrected nutrient benchmarks and calculations

Station: S3R001 - Waterdown Dam on Klipplaat River : near dam wall						
Full data period 7-01-1998		Period used 6-01-2003				
	Present State Characterisation					
	5th %ile	median	95th %ile		Cat	No. used
Ca	6	7	9			68
Mg	3	3	4			68
K	1	1	2			68
Na	6	7	8			68
Cl	5	7	13			68
SO4	5	9	16			66
MgSO4	6	11	16		Good	
Na2SO4	0	0	4		Natural	
MgCl2	0	4	8		Natural	
CaCl2	0	7	16		Natural	
NaCl	0	0	0		Natural	
CaSO4	0	0	0		Natural	
PH	7.3847	7.766	7.99685		Natural/Natural	68
NH4	0.02	0.02	0.1687			68
NO2_NO3	0.02	0.0505	0.2323			68
PO4	0.015	0.029	0.15495		Fair	68
TIN	0.04	0.079	0.4153		Natural	68
NH3	0.000249	0.000709	0.004474		Natural	68
TDS	71.13725	78.707	90.43925			66
TP	ND	ND	ND			0
KN	ND	ND	ND			0
KN:TP	ND	ND	ND			0
TAL	28.55595	34.6	41.0378			68

Reserve Criteria			
	N	G	F
MgSO4	16	27	37
Na2SO4	20	36	51
MgCl2	15	33	51
CaCl2	21	63	105
NaCl	45	217	389
CaSO4	351	773	1195
pH lower	6.5	5.8	5.0
pH upper	8.0	9.0	10.0
PO4	0.005	0.025	0.125
TIN	0.25	1.00	4.00
NH3	0.007	0.054	0.100
DO	8.0	6.5	5.5

Major Ion Reserve values corresponding to the selected salt benchmarks

Ca	9
Mg	4
Na	8
Cl	13
SO4	16

EWQRCalc Version 2.4.2
Modified for correct nutrient boundary values

Station:	S3H005 : Oxkraal River at Whittlesea					
Full data period 8-01-1998			Period used 23-01-2003			
	Present State Characterisation					
	5th %ile	median	95th %ile		Cat	No. used
Ca	24	46	61			116
Mg	8	31	45			116
K	3	4	5			116
Na	17	69	97			116
Cl	18	76	119			116
SO4	10	23	35			116
MgSO4	12	29	44		Poor	
Na2SO4	0	0	0		Natural	
MgCl2	20	97	146		Poor	
CaCl2	0	7	32		Good	
NaCl	0	0	0		Natural	
CaSO4	0	0	0		Natural	
PH	8.10975	8.41	8.70755		Natural/Good	128
NH4	0.02	0.02	0.1519			128
NO2_NO3	0.3085	3.822	7.683			128
PO4	0.005675	0.02	0.1356		Good	128
TIN	0.3611	3.8665	7.8021		Fair	128
NH3	0.001282	0.002821	0.014653		Good	128
TDS	214.9978	574.378	753.5375			115
TP	ND	ND	ND			0
KN	ND	ND	ND			0
KN:TP	ND	ND	ND			0
TAL	101.6	248.3125	319.575			116

Reserve Criteria			
	N	G	F
MgSO4	16	27	37
Na2SO4	20	36	51
MgCl2	15	33	51
CaCl2	21	63	105
NaCl	45	217	389
CaSO4	351	773	1195
pH lower	6.5	5.8	5.0
pH upper	8.0	9.0	10.0
PO4	0.005	0.025	0.125
TIN	0.25	1.00	4.00
NH3	0.007	0.054	0.100
DO	8.0	6.5	5.5

Major Ion Reserve values corresponding to the selected salt benchmarks

Ca	61
Mg	45
Na	97
Cl	119
SO4	35

EWQRCalc Version 2.4.2
Corrected nutrient benchmarks and calculations

Full data period 2-04-1998			Period used 12-12-2002			
	Present State Characterisation					
	5th %ile	median	95th %ile		Cat	No. used
Ca	16	36	52			65
Mg	8	27	53			65
K	2	3	5			65
Na	14	42	83			65
Cl	5	33	84			65
SO4	10	26	48			65
MgSO4	12	33	59		Poor	
Na2SO4	0	0	0		Natural	
MgCl2	7	43	107		Poor	
CaCl2	0	0	5		Natural	
NaCl	0	0	0		Natural	
CaSO4	0	0	0		Natural	
PH	7.654	8.513	8.715		Natural/Good	71
NH4	0.02	0.02	0.0925			71
NO2_NO3	0.02	0.047	0.533			71
PO4	0.0155	0.046	0.218		Fair	71
TIN	0.04	0.088	1.397		Natural	71
NH3	0.000628	0.002848	0.011328		Good	71
TDS	176.7404	443.394	710.678			65
TP	ND	ND	ND			0
KN	ND	ND	ND			0
KN:TP	ND	ND	ND			0
TAL	87.1564	230.825	333.4292			65

Reserve Criteria			
	N	G	F
MgSO4	16	27	37
Na2SO4	20	36	51
MgCl2	15	33	51
CaCl2	21	63	105
NaCl	45	217	389
CaSO4	351	773	1195
pH lower	6.5	5.8	5.0
pH upper	8.0	9.0	10.0
PO4	0.005	0.025	0.125
TIN	0.25	1.00	4.00
NH3	0.007	0.054	0.100
DO	8.0	6.5	5.5

Major Ion Reserve values corresponding to the selected salt benchmarks

Ca	52
Mg	53
Na	83
Cl	84
SO4	48

EWQRCalc Version 2.4.2
Modified for correct nutrient boundary values

Station: S1H002 : White Kei River at St Marks mission/bridge						
Full data period 23-01-1990			Period used 2-05-1996			
	Present State Characterisation					
	5th %ile	median	95th %ile		Cat	No. used
Ca	27	32	47			10
Mg	14	20	44			10
K	2	2	3			10
Na	25	48	96			10
Cl	23	65	183			10
SO4	5	12	29			10
MgSO4	6	16	36		Fair	
Na2SO4	0	0	0		Natural	
MgCl2	31	61	126		Poor	
CaCl2	0	18	109		Fair	
NaCl	0	0	32		Natural	
CaSO4	0	0	0		Natural	
PH	7.126	8.18	8.3465		Natural/Good	10
NH4	0.02	0.06	0.2122			10
NO2_NO3	0.0965	0.4285	1.69			10
PO4	0.00735	0.0215	0.12245		Good	10
TIN	0.2415	0.4585	1.743		Good	10
NH3	0.000246	0.001638	0.018617		Good	10
TDS	259.55	347.5	636.3			10
TP	0.1069	0.664	1.2211			2
KN	0.4707	1.224	1.9773			2
KN:TP	ND	ND	ND			2
TAL	117.215	143.7	240.975			10

Reserve Criteria			
	N	G	F
MgSO4	16	27	37
Na2SO4	20	36	51
MgCl2	15	33	51
CaCl2	21	63	105
NaCl	45	217	389
CaSO4	351	773	1195
pH lower	6.5	5.8	5.0
pH upper	8.0	9.0	10.0
PO4	0.005	0.025	0.125
TIN	0.25	1.00	4.00
NH3	0.007	0.054	0.100
DO	8.0	6.5	5.5

Major Ion Reserve values corresponding to the selected salt benchmarks

Ca	47
Mg	44
Na	96
Cl	183
SO4	29

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Modified for correct nutrient boundary values

Station: S1R001 : Xonxa Dam on the White Kei River : Near Dam Wall						
Full data period 28-01-1998 Period used 6-12-2002						
	Present State Characterisation					
	5th %ile	median	95th %ile		Cat	No. used
Ca	18	23	26			28
Mg	9	13	14			28
K	1	2	2			28
Na	14	17	22			28
Cl	8	12	16			28
SO4	6	9	17			28
MgSO4	7	11	21		Good	
Na2SO4	0	0	0		Natural	
MgCl2	11	16	22		Good	
CaCl2	0	0	0		Natural	
NaCl	0	0	0		Natural	
CaSO4	0	0	0		Natural	
PH	8.06455	8.35	8.59485		Natural/Good	28
NH4	0.02	0.02	0.05995			28
NO2_NO3	0.0948	0.1475	0.21715			28
PO4	0.0055	0.0185	0.03985		Good	28
TIN	0.1207	0.172	0.2493		Natural	28
NH3	0.001057	0.002163	0.006145		Natural	28
TDS	202.2584	237.8475	264.7061			28
TP	ND	ND	ND			0
KN	ND	ND	ND			0
KN:TP	ND	ND	ND			0
TAL	113.4971	128.447	142.727			28

Reserve Criteria			
	N	G	F
MgSO4	16	27	37
Na2SO4	20	36	51
MgCl2	15	33	51
CaCl2	21	63	105
NaCl	45	217	389
CaSO4	351	773	1195
pH lower	6.5	5.8	5.0
pH upper	8.0	9.0	10.0
PO4	0.005	0.025	0.125
TIN	0.25	1.00	4.00
NH3	0.007	0.054	0.100
DO	8.0	6.5	5.5

Major Ion Reserve values corresponding to the selected salt benchmarks

Ca	26
Mg	14
Na	22
Cl	16
SO4	17

EWQRCalc Version 2.4.2
Modified for correct nutrient boundary values