

CHAPTER 1

Surface Water Component

**SANDVELD
PRELIMINARY (RAPID)
RESERVE
DETERMINATIONS**

**Langvlei, Jakkals and
Verlorenvlei Rivers.
Olifants-Doorn WMA G30**

SURFACE WATER COMPONENT

**FINAL REPORT: RESERVE
SPECIFICATIONS**



**MAY
2003
FINAL REPORT**



**SOUTHERN WATERS
ECOLOGICAL RESEARCH AND
CONSULTING, in association with
COASTEC ENVIRONMENTAL
CONSULTANTS**

Contents

INTRODUCTION 1-1

- 1. SCOPE 1-1**
- 2. STUDY AREA 1-1**
 - 2.1 Individual Study Sections 1-1
 - 2.2 Aquatic Ecosystem Typology 1-2
 - 2.3 Study Constraints 1-4
 - 2.4 Limitations of the RDM Protocols 1-4
- 3. STUDY APPROACH 1-5**

SECTION A: VERLORENVLEI IFR 1 (KRUIS RIVER) AT DUIKERFONTEIN 1-7

- 1. ASSESSED REACH 1-7**
- 2. REFERENCE CONDITIONS 1-7**
 - 2.1 Hydrology 1-7
 - 2.2 Morphological Characteristics 1-8
 - 2.3 Water Quality 1-8
 - 2.4 Vegetation 1-8
 - 2.5 Aquatic Biota 1-9
- 3. PRESENT ECOLOGICAL STATUS CATEGORY (PESC) 1-11**
 - 3.1 Water Quality 1-11
 - 3.2 Aquatic Invertebrates 1-11
 - 3.3 Habitat Integrity Assessment 1-11
- 4. ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY
(EISC) 1-13**
- 5. RECOMMENDED RESERVE 1-16**
 - 5.1 Quantification of the Preliminary Reserve (Rapid Level) 1-16
 - 5.2 COMPUTATION OF THE RESERVE 1-16
 - 5.3 Confidence Level 1-16
 - 5.4 Verlorenvlei IFR 1 (Kruismans River): Category C (Recommended) 1-17
 - 5.5 Verlorenvlei IFR 1 (Kruismans River): Category C/D 1-18
 - 5.6 Verlorenvlei IFR 1 (Kruismans River): Category D 1-19

SECTION B: VERLORENVLEI IFR 2 AT REDELINGHUYS 1-20

- 1. ASSESSED REACH 1-20**
- 2. REFERENCE CONDITIONS 1-22**
 - 2.1 Hydrology 1-22
 - 2.2 Morphological Characteristics 1-22
 - 2.3 Water Quality 1-22
 - 2.4 Vegetation 1-22
 - 2.5 Aquatic Biota 1-22
- 3. PRESENT ECOLOGICAL STATUS CATEGORY (PESC) 1-23**
 - 3.1 WATER QUALITY 1-23
 - 3.2 AQUATIC INVERTEBRATES 1-23
 - 3.3 Habitat Integrity Assessment 1-23

4.	ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	1-25
5.	RECOMMENDED RESERVE	1-27
5.1	Quantification of the Preliminary Reserve (Rapid Level).....	1-27
5.2	Computation of the Reserve	1-28
5.3	Confidence Level.....	1-28
5.4	VERLORENVLEI IFR 2 (VERLORENVLEI RIVER): (Category B) (Recommended).....	1-29
5.5	VERLORENVLEI IFR 2 (VERLOREN RIVER): (Category C).....	1-30

SECTION C: LANGVLEI RIVER IFR AT WADRIF1-31

1.	ASSESSED REACH	1-31
2.	REFERENCE CONDITIONS	1-33
2.1	Hydrology	1-33
2.2	Morphological Characteristics.....	1-33
2.3	Water Quality	1-33
2.4	Vegetation.....	1-34
2.5	Aquatic Biota.....	1-34
3.	PRESENT ECOLOGICAL STATUS CATEGORY (PESC)	1-34
3.1	WATER QUALITY	1-35
3.2	Aquatic Invertebrates.....	1-35
3.3	Habitat Integrity Assessment.....	1-35
4.	ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	1-37
5.	RECOMMENDED RESERVE	1-39
5.1	Quantification of the Preliminary Reserve (Rapid Level).....	1-40
5.2	Computation of the Reserve	1-40
5.3	Confidence Level.....	1-40
5.4	Langvlei River IFR (at WADRIF) (Category C).....	1-41
5.5	Langvlei River IFR (at WADRIF) (Category D)	1-42

SECTION D: JAKKALS RIVER IFR AT KOOKFONTEIN1-43

1.	ASSESSED REACH	1-43
2.	REFERENCE CONDITIONS	1-45
2.1	Hydrology	1-45
2.2	Morphological Characteristics.....	1-45
2.3	Water Quality	1-45
2.4	Vegetation.....	1-46
2.5	Aquatic Biota.....	1-46
3.	PRESENT ECOLOGICAL STATUS CATEGORY (PESC)	1-46
3.1	Water Quality	1-46
3.2	Aquatic Invertebrates.....	1-47
3.3	Habitat Integrity Assessment.....	1-47
4.	ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	1-49
5.	RECOMMENDED RESERVE	1-51
5.1	Quantification of the Preliminary Reserve (Rapid Level).....	1-51
5.2	Computation of the Reserve	1-51

5.3	Confidence Level.....	1-51
5.4	Jakkals River IFR (at KOOKFONTEIN) (Category C)	1-52
5.5	Jakkals River IFR (at Kookfontein) (Category D).....	1-53

SECTION E: WATER REQUIREMENTS (Preliminary Rapid Reserve) – WADRIF WETLAND1-54

1.	INTRODUCTION	1-54
2.	METHODOLOGY	1-55
3.	REFERENCE CONDITIONS	1-59
4.	PRESENT ECOLOGICAL STATUS (PESC).....	1-60
5.	ECOLOGICAL STATUS CLASS (EISC)	1-61
6.	DEFAULT ECOLOGICAL STATUS CATEGORY (DESC)	1-61
7.	ECOLOGICAL MANAGEMENT CATEGORY (TARGET, EMC)	1-61
8.	PRELIMINARY RESERVE (PWR) SPECIFICATION, WADRIF WETLAND	1-62

SECTION F: WATER REQUIREMENTS (Preliminary Rapid Reserve) – WADRIF PAN.....1-63

1.	INTRODUCTION	1-63
1.1	Methodology.....	1-63
2.	REFERENCE CONDITIONS	1-66
3.	PRESENT ECOLOGICAL STATUS (PESC).....	1-67
4.	ECOLOGICAL STATUS CLASS (EISC)	1-69
5.	DEFAULT ECOLOGICAL STATUS CATEGORY (DESC)	1-69
6.	ECOLOGICAL MANAGEMENT CATEGORY (TARGET, EMC)	1-69
7.	PRELIMINARY RESERVE (PWR) SPECIFICATION, WADRIF PAN	1-70

SECTION G: WATER REQUIREMENTS (Preliminary Rapid Reserve) - JAKKALSVLEI.....1-71

1.	INTRODUCTION	1-71
2.	METHODOLOGY	1-71
3.	REFERENCE CONDITIONS	1-75
4.	PRESENT ECOLOGICAL STATUS (PESC).....	1-76
5.	ECOLOGICAL STATUS CLASS (EISC)	1-77
6.	DEFAULT ECOLOGICAL STATUS CATEGORY (DESC)	1-77
7.	ECOLOGICAL MANAGEMENT CATEGORY (TARGET, EMC)	1-77
8.	PRELIMINARY RESERVE (PWR) SPECIFICATION, JAKKALSVLEI PAN	1-78

SECTION H: WATER REQUIREMENTS (Water Level)
(Preliminary Rapid Reserve) - VERLORENVLEI COASTAL LAKE....1-79

1.	INTRODUCTION	1-79
2.	METHODOLOGY	1-79
3.	LAKE AND ESTUARY: REFERENCE CONDITIONS	1-83
4.	LAKE PRESENT ECOLOGICAL STATUS (PESC)	1-84
4.1	Water Quality	1-84
5.	LAKE ECOLOGICAL STATUS CLASS (EISC)	1-85
6.	DEFAULT ECOLOGICAL STATUS CATEGORY (DESC)	1-85
7.	ECOLOGICAL MANAGEMENT CATEGORY (TARGET, EMC)	1-86
8.	ESTUARINE CHANNEL - PRESENT ECOLOGICAL STATUS (PESC)	1-86
9.	ESTUARY ECOLOGICAL STATUS CLASS (EISC)	1-87
10.	PRELIMINARY RAPID RESERVE SPECIFICATION, VERLORENVLEI	1-88
10.1	Basis for Establishing the Water Level Reserve Conditions for Verlorenvlei	1-88
10.2	Confidence Level.....	1-89
10.3	Existence of Alleged Physical Barriers to Meeting the Reserve.....	1-89

List of Figures

<i>Figure 1: Project Study Area. Locations of the individual EFR sites are indicated by yellow flags.</i>	<i>1-3</i>
<i>Figure A1: Position of Verlorenvlei IFR (1) in relation to Study Area</i>	<i>1-10</i>
<i>Figure B1: Position of Verlorenvlei IFR (2) in relation to Study Area</i>	<i>1-21</i>
<i>Figure C3: Position of Langvlei IFR in relation to Study Area</i>	<i>1-32</i>
<i>Figure D1: Position of Jakkals River IFR in relation to Study Area</i>	<i>1-44</i>
<i>Figure E1: Position of Wadrif Wetland in relation to Study Area</i>	<i>1-56</i>
<i>Figure E2: Aerial view of the Wadrif wetland, looking south, and highlighting the major impacts.</i>	<i>1-57</i>
<i>Figure E3: Topography of the Wadrif wetland (extent of wetland demarcated with green shaded area; arrow shows water flowpath)</i>	<i>1-58</i>
<i>Figure F1: Position of Wadrif Pan WLR in relation to Study Area</i>	<i>1-64</i>
<i>Figure F2: Views of the Wadrif Pan, looking east from the railway line, showing (left) pan full, and (right) dry. Arrow indicates position of waters edge at the specified wet season maximum level.</i>	<i>1-65</i>
<i>Figure G1: Position of Jakkalsvlei WLR in relation to Study Area</i>	<i>1-73</i>
<i>Figure G2: View of the (full) Jakkalsvlei looking east from the berm. Inserts show (bottom left) aerial view of full vlei and (right) dry vlei (head of vlei at bottom right to the left of the road and railway line).</i>	<i>1-74</i>
<i>Figure H1: Position of Verlorenvlei WLR in relation to Study Area</i>	<i>1-81</i>
<i>Figure 2: Morphology and bathymetry of Verlorenvlei</i>	<i>1-82</i>
<i>Figure H3: Water levels for Verlorenvlei for the period 1994-2002. The period covered by this study is circled.</i>	<i>1-88</i>

List of Tables

TABLE A1: VERLORENVLEI IFR 1 – SUMMARY OF WATER QUALITY DATA	1-11
TABLE A2: CRITERIA AND WEIGHTINGS EMPLOYED FOR THE HABITAT INTEGRITY ASSESSMENT.....	1-12
TABLE A3: INTERPRETATION OF THE HABITAT INTEGRITY SCORE, AND DERIVATION OF THE PRESENT ECOLOGICAL STATUS CLASS (PESC)..	1-12
TABLE A4. KRUISMANS RIVER AT DUIKERFONTEIN (VERLORENVLEI G30B).....	1-13
TABLE A6: INTERPRETATION OF THE ECOLOGICAL IMPORTANCE MEDIAN SCORE, AND ALLOCATION OF AN EISC.....	1-14
TABLE A7: SCORING OF ECOLOGICAL IMPORTANCE DETERMINANTS FOR IFR 1 (KRUISMANS RIVER AT DUIKERFONTEIN).....	1-15
VERLORENVLEI (KRUISMANS RIVER) PRELIMINARY RESERVE (RAPID LEVEL) DETERMINATION: IFR SITE 1 (DUIKERFONTEIN):	1-18
INFORMATION SUMMARY AND ECOLOGICAL RESERVE SPECIFICATION	1-18
VERLORENVLEI IFR 1: KRUISMANS RIVER AT DUIKERFONTEIN (CATEGORY C/D).....	1-18
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (SUMMER) AND 50 % (WINTER) MAR (VIRGIN): 18.869 (10 ⁶ M ³) MAR (PRESENT): ~ 12 (10 ⁶ M ³)	1-18
VERLORENVLEI IFR 1: KRUIS RIVER AT DUIKERFONTEIN (CATEGORY D) ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (SUMMER) AND 50 % (WINTER) MAR (VIRGIN): 18.869 (10 ⁶ M ³) MAR (PRESENT): ~ 12 (10 ⁶ M ³).....	1-19
TABLE B1: VERLORENVLEI IFR 2 – SUMMARY OF WATER QUALITY DATA	1-23
TABLE A2: CRITERIA AND WEIGHTINGS EMPLOYED FOR THE HABITAT INTEGRITY ASSESSMENT.....	1-23
TABLE B3: INTERPRETATION OF THE HABITAT INTEGRITY SCORE, AND DERIVATION OF THE PRESENT ECOLOGICAL STATUS CLASS (PESC)..	1-24
TABLE B4. VERLORENVLEI RIVER AT REDELINGHUYS.....	1-24
(VERLORENVLEI G30D)	1-24
TABLE B5: RATING SCALE FOR ECOLOGICAL IMPORTANCE DETERMINANTS....	1-25
TABLE B6: INTERPRETATION OF THE ECOLOGICAL IMPORTANCE MEDIAN SCORE, AND ALLOCATION OF AN EISC	1-25
TABLE B7: SCORING OF ECOLOGICAL IMPORTANCE DETERMINANTS FOR IFR 2 (VERLORENVLEI RIVER AT REDELINGHUYS).....	1-26
VERLORENVLEI IFR 2: VERLORENVLEI RIVER AT REDELINGHUYS (CATEGORY B).....	1-29

ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (SUMMER) AND 50 % (WINTER).....	1-29
MAR (VIRGIN): 40.897 (10 ⁶ M ³) MAR (PRESENT): ~ (10 ⁶ M ³).....	1-29
VERLORENVLEI RIVER PRELIMINARY RESERVE DETERMINATION:	1-29
IFR SITE 2 (REDELINGHUYS):.....	1-29
INFORMATION SUMMARY AND ECOLOGICAL RESERVE SPECIFICATION	1-29
VERLORENVLEI IFR 2: VERLORENVLEI RIVER AT REDELINGHUYS (CATEGORY C).....	1-30
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (SUMMER) AND 50 % (WINTER).....	1-30
MAR (VIRGIN): 40.897 (10 ⁶ M ³) MAR (PRESENT): ~ (10 ⁶ M ³).....	1-30
TABLE C1: LANGVLEI RIVER IFR 1 – SUMMARY OF WATER QUALITY DATA.....	1-35
TABLE C2: CRITERIA AND WEIGHTINGS EMPLOYED FOR THE HABITAT INTEGRITY ASSESSMENT.....	1-36
TABLE C3: INTERPRETATION OF THE HABITAT INTEGRITY SCORE, AND DERIVATION OF THE PRESENT ECOLOGICAL STATUS CLASS (PESC)..	1-36
TABLE C4. LANGVLEI RIVER AT WADRIF (LANGVLEI G30F).....	1-36
INTERMEDIATE HABITAT INTEGRITY – IFR	1-36
TABLE C5: RATING SCALE FOR ECOLOGICAL IMPORTANCE DETERMINANTS....	1-37
TABLE C6: INTERPRETATION OF THE ECOLOGICAL IMPORTANCE MEDIAN SCORE, AND ALLOCATION OF AN EISC.....	1-38
TABLE C7: SCORING OF ECOLOGICAL IMPORTANCE DETERMINANTS FOR THE LANGVLEI RIVER IFR AT WADRIF.....	1-39
LANGVLEI IFR 1: LANGVLEI RIVER AT WADRIF (CATEGORY C)	1-41
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (SUMMER) AND 50 % (WINTER).....	1-41
MAR (VIRGIN): 1.740 (10 ⁶ M ³) MAR (PRESENT): (10 ⁶ M ³).....	1-41
LANGVLEI RIVER PRELIMINARY RESERVE DETERMINATION:.....	1-42
IFR SITE 1 (WADRIF):	1-42
INFORMATION SUMMARY AND ECOLOGICAL RESERVE SPECIFICATION	1-42
LANGVLEI IFR 1: LANGVLEI RIVER AT WADRIF (CATEGORY C)	1-42
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (SUMMER) AND 50 % (WINTER).....	1-42
MAR (VIRGIN): 1.740 (10 ⁶ M ³) MAR (PRESENT): (10 ⁶ M ³).....	1-42
TABLE D1: JAKKALS RIVER IFR 1 – SUMMARY OF WATER QUALITY DATA.....	1-47
TABLE D2: CRITERIA AND WEIGHTINGS EMPLOYED FOR THE HABITAT INTEGRITY ASSESSMENT.....	1-47
TABLE D3: INTERPRETATION OF THE HABITAT INTEGRITY SCORE, AND DERIVATION OF THE PRESENT ECOLOGICAL STATUS CLASS (PESC)..	1-48
TABLE D4. JAKKALS RIVER AT KOOKFONTEIN.....	1-48

(JAKKALS G30G).....	1-48
TABLE D5: RATING SCALE FOR ECOLOGICAL IMPORTANCE DETERMINANTS ...	1-49
TABLE D6: INTERPRETATION OF THE ECOLOGICAL IMPORTANCE MEDIAN SCORE, AND ALLOCATION OF AN EISC	1-49
TABLE D7: SCORING OF ECOLOGICAL IMPORTANCE DETERMINANTS FOR THE JAKKALS RIVER IFR AT KOOKFONTEIN	1-50
JAKKALS IFR 1: JAKKALS RIVER AT KOOKFONTEIN (CATEGORY C)	1-52
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (SUMMER) AND 50 % (WINTER).....	1-52
MAR (VIRGIN): 1.740 (10 ⁶ M ³) MAR (PRESENT): ~ (10 ⁶ M ³).....	1-52
JAKKALS RIVER PRELIMINARY RESERVE DETERMINATION:.....	1-53
IFR SITE 1 (KOOKFONTEIN):	1-53
INFORMATION SUMMARY AND ECOLOGICAL RESERVE SPECIFICATION	1-53
JAKKALS IFR 1: JAKKALS RIVER AT KOOKFONTEIN (CATEGORY D)	1-53
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (SUMMER) AND 50 % (WINTER).....	1-53
MAR (VIRGIN): 1.740 (10 ⁶ M ³) MAR (PRESENT): ~ (10 ⁶ M ³).....	1-53
TABLE E1: WADRIF WETLAND – PRESENT ECOLOGICAL STATUS ASSESSMENT ..	1-60
TABLE E2: WADRIF WETLAND: ECOLOGICAL IMPORTANCE CLASS ASSESSMENT	1-61
TABLE E3: WADRIF WETLAND: PRELIMINARY RESERVE WATER SPECIFICATION	1-62
TABLE F1: WADRIF PAN – PRESENT ECOLOGICAL STATUS EVALUATION	1-67
TABLE F2: WADRIF PAN: ECOLOGICAL IMPORTANCE CLASS EVALUATION	1-69
TABLE F3: WADRIF PAN: PRELIMINARY RESERVE WATER SPECIFICATION	1-70
TABLE G1: JAKKALS VLEI – PRESENT ECOLOGICAL STATUS EVALUATION.....	1-76
TABLE G2: WADRIF PAN: ECOLOGICAL IMPORTANCE CLASS EVALUATION.....	1-77
TABLE G3: JAKKALS VLEI: PRELIMINARY RESERVE WATER SPECIFICATION.....	1-78
TABLE H1: VERLORENVLEI – PRESENT ECOLOGICAL STATUS EVALUATION.....	1-84
TABLE H1A: VERLORENVLEI LAKE – SUMMARY OF WATER QUALITY DATA.....	1-84
AS COLLECTED AT GAUGING STATION G3R001	1-84
TABLE H2: VERLORENVLEI: ECOLOGICAL IMPORTANCE CLASS EVALUATION...	1-85
TABLE H3: VERLORENVLEI ‘ESTUARINE’ CHANNEL – PESC ASSESSMENT	1-86
TABLE H4: VERLORENVLEI ‘ESTUARINE’ CHANNEL – EISC ASSESSMENT.....	1-87
TABLE H5: VERLORENVLEI: PRELIMINARY RAPID RESERVE WATER LEVEL SPECIFICATION	1-88

Executive Summary

This report summarizes the final Ecological Reserve (Rapid Level) specifications for surface waters for components of three river systems in the G30 (Sandveld, Olifants Doorn Water Management Area) drainage region. This document needs to be read in conjunction with the supporting specialist reports.

The assessed components (and relevant quaternary catchments) are:

Langvlei River (G30F):

- (i) Instream Flow Requirement (IFR) for the lowest reach;
- (ii) Environmental Flow Requirement (EFR) for the Wadrif Wetland;
- (iii) Environmental Flow Requirement (EFR) for the Wadrif Pan.

Jakkals River (G30G):

- (i) Instream Flow Requirement (IFR) for the lowest reach;
- (ii) Environmental Flow Requirement (EFR) for the Jakkalsvlei Pan.

Verlorenvlei River (G30B-E)

- (i) Instream Flow Requirement (IFR) for the Kruismans River (upper mainstem, and the Verlorenvlei River – lowest reach of the mainstem);
- (ii) Environmental Flow Requirement (Water Level Specification) for the Verlorenvlei Lake, inclusive of provisional requirements for maintaining acceptable hydrodynamics for maintaining the seasonal connection to the sea.

The Sandveld, and in particular the Langvlei and Jakkals Rivers, are the focus of an in-depth groundwater study being performed by the Department of Water Affairs and Forestry (DWAF). The demand for irrigation water in the Sandveld region is primarily met from groundwater sources – a resource that is rapidly becoming stressed through over-abstraction.

It should be noted that while the first phase of the surface water study has been completed, the groundwater investigation remains ongoing. Further development and refinement of the Rapid Level surface water Reserves set here will only be possible following completion of the groundwater investigation and the compilation of a geo-hydrological model for the individual and inter-linked catchments; and completion of further investigations identified from this surface water study.

This investigation has accumulated an enormous amount of data and information – much of which simply cannot be reported on within the budgetary constraints of this investigation – but should serve as the basis of the inception report for subsequent studies.

The setting of Reserves for the surface water components of the three study catchments required a 'pilot study' approach necessary to accommodate the following **constraints**:

- Lack of a methodology for identifying groundwater dependent surface ecosystems;
- Setting of surface water Reserves in systems driven primarily by, and highly dependent on, groundwater;
- Determination of Environmental Flow Requirements (EFRs) in longitudinal wetlands as opposed to 'true' rivers;
- Determination of EFRs in a poorly studied, arid and highly seasonal environment;
- Determination of EFRs in disconnected catchments having multiple inflows of varying quality and which support, during the dry season, isolated nodes of ecological importance;
- Undertaking Reserve assessments for wetlands and lakes, for which no methodologies currently exist within the RDM framework at the Rapid level;
- Formulating Reserve requirements in ecologically-demanding environments such as seasonal pans – for which no methodologies currently exist within the RDM framework at all;
- Non-inclusive nature of the Terms of Reference which limited the investigations to, essentially, only the lowest reaches of each system.

The Sandveld encompasses the Verlorenvlei RAMSAR area, as well as the adjacent Wadrif salt pan, an area of avifaunal importance deemed to be of greater significance than that provided by Verlorenvlei. In addition, these two sites are in close proximity to the Jakkalsvlei Pan (assessed in this study) to the north, and Rocher Pan to the south. These areas are all deemed complementary to the avifaunal habitat provided by Verlorenvlei. **Accordingly the need to sustain or enhance the environmental integrity of the aggregate area is of international significance.**

Notwithstanding the array of constraints, the surface water project team was able to devise a methodology which informed the identification of groundwater dependent ecosystems (GWDEs) and which, when later overlain with the initial findings of the groundwater study, revealed a 100% match.

The condensed preliminary findings of the surface water investigation showed that **all three river systems are severely impacted, primarily through the over-abstraction of groundwater**, and secondly by indirect agricultural pressures such as grazing, trampelling and nutrient loading. **Of the three rivers the Langvlei and Jakkals are the most severely impacted, while the Verlorenvlei remains in an acceptable yet highly threatened condition. All of the unique biotic elements of the three catchments were confined to shrinking ecological islands. Specific aquatic components of these systems have suffered near-total loss** (e.g. the devastation of the Wadrif Wetland and many of the wetlands previously occurring in the upper Langvlei catchment), or massive loss of the ecological services formerly provided to avifauna by the Wadrif and Jakkalsvlei Pans as a consequence of the sustained and negative changes in their hydrology.

In summary the specialist team undertaking this study **concluded** that:

- No further pressure should be placed on the surface and groundwater resources of the Langvlei and Jakkals River catchments. In order to sustainably restore the environmental damage that has occurred it will be necessary to curtail extant levels of water use such that water is returned to the environment;
- The mainstem of the Verlorenvlei catchment is poised at a tenuous balance between sustainability and over-abstraction. This remains to be determined on a component by component basis during future phases of this study;
- The extremely high ecological importance, of international import, of the assessed catchments dictates that a comprehensive and sustained environmental management package be formulated for the Sandveld.

The recommended Reserve specifications may be summarized as follows (detailed specifications for each individual system is provided in Sections A-G).

<i>SANDVELD RAPID RESERVE - SUMMARY</i>				
<i>EFR Location</i>	<i>PESC</i>	<i>EISC</i>	<i>DESC</i>	<i>Recommended EMC</i>
Langvlei River IFR	E/F	C	C	C
Wadrif Wetland EFR	F	B	-	C
Wadrif Pan EFR	E	C	-	C
Jakkals River IFR	D	C	C	C
Jakkalsvlei Pan EFR	E	C	-	C
Verlorenvlei IFR (1)	C	B	C	C
Verlorenvlei IFR (2)	C	B	C	B
Verlorenvlei Lake	C	B	-	B

With respect to the development of methodologies, the investigation showed or provided the following:

- Strong correlation between observed GWDE characteristics, and the findings of the groundwater investigation;
- Existence of key GWDE vegetation indicator assemblages, these common to all three catchments;
- Presence of rare and endangered, unique and hitherto undiscovered/undescribed biota;
- A basis for developing a methodology appropriate to the assessment of longitudinal wetlands driven by flows that occur primarily in the hyporheic zone. This should be further development during future phases of the Sandveld study;
- A basis for a methodology for determining the integrative ecological importance of multi-nodal GWDE ecosystems. This should be further development during future phases of the Sandveld study;

- Conceptual approaches for underpinning the determination of environmental flows for wetlands and pans;
- ‘Rapid’ level Reserves are not relevant for complex systems (e.g. wetlands or multinodal systems). In order to formulate an adequate level of understanding that will inform the Reserve, these systems require specialist input at a minimum level and time frame more commonly allocated for the Intermediate Reserve.

Please note:

Comments Period

This report in Draft format was submitted to the client for comment at the end of January 2003. As of end-May no comments of any nature were forthcoming. In order to comply with the scheduled final submission date of 30 May 2003 the report has been finalized with minor additions of new information that became available after submission of the Draft document.

Introduction

1. SCOPE

This document summarizes the Environmental Flow Requirements (EFRs) deemed necessary to meet the requirements of the Preliminary Ecological Reserve (Rapid Level) for the specified components (hereunder) the Langvlei, Jakkals and Kruis/Verlorenvlei Rivers. Also presented are details of the complexities and associated constraints with applying the Resource Directed Measures (RDM) protocols in the Study Area, and how these were addressed and accommodated. Guidelines for further investigative needs are also provided.

2. STUDY AREA

The three systems studied (see Figure 1) form the greater part of the aquatic ecosystems within the northern Sandveld (see Section 2.2). General climatic and biophysical details pertaining to this area are provided in the report prepared for the Sandveld Technical Workshop held on 30 January 2003, and are not repeated here.

2.1 *Individual Study Sections*

The Terms of Reference (TOR) for this appointment (see Appendix A - Contract) confined the determination of the Preliminary Ecological Reserves (Rapid Level) to the following sections of the rivers studied (maps accompany each of the EFR sub-sections):

- Langvlei River: Section of the river between the farm Wadrif and the Sishen/Saldanha railway line. This study section encompasses the lowest reach of the river as it enters the wetland at the head of the pan, the wetland itself and the pan upstream of the railway. The greater extent of the system was, accordingly, excluded. Separate EFRs were determined for the lowest reach of the river, the wetland and the pan.
- Jakkals River: Lowest reach of the river immediately upstream of the Jakkalsvlei pan, and the Jakkalsvlei Pan itself. The greater extent of the system was, accordingly, excluded. Separate EFRs were determined for the river and pan.
- Verlorenvlei River. The Kruis/Verlorenvlei River mainstem and the Verlorenvlei coastal lake and outlet channel. Excluded from the study were the Bergvallei, Krom Antonies and Witte Rivers, and the Redelinghuys wetland upstream of the head of the lake. In terms of this some 40% of the greater catchment area was excluded. Separate EFRs were determined for each of the two IFRs, and for the lake. Within the scope of a Rapid Reserve Determination, the lake EFR was provisionally set on the basis of water levels.

2.2 Aquatic Ecosystem Typology

The Study Area (see Figure 1) comprises three parallel river systems of varying length, catchment area (see Table 1) and complexity. All three systems are extensive longitudinal wetlands with localised and weak riverine components. While short sections of morphologically distinct river channels do exist (e.g. Upper Kruis, Bergvallei, Krom Antonies Rivers and the headwaters of the Langvlei tributaries – the Alexandershoek and Lambertshoek) the dominant characteristic of these systems, as well as others in the adjacent catchments, is that of bank-to-bank corridors of reeds. In the case of the upper Jakkals River, the aquatic ecosystem is comprised of a series of temporary vleis and meadows, with a poorly defined central channel. Important secondary characteristics are the presence of multiple freshwater springs or ‘eyes’, occurring along the length of all three systems. Lateral intrusions of brackish to saline water also occur. Distinct variations in water quality and plant species occur throughout each of the three systems.

In essence these systems exist as a series of wetlands, connected by surface channels in places, but mostly by flow through the hyporheos. All of the systems assessed here were found to be largely groundwater driven or groundwater dependent ecosystems (GWDEs) (see Appendix for outline of methodology).

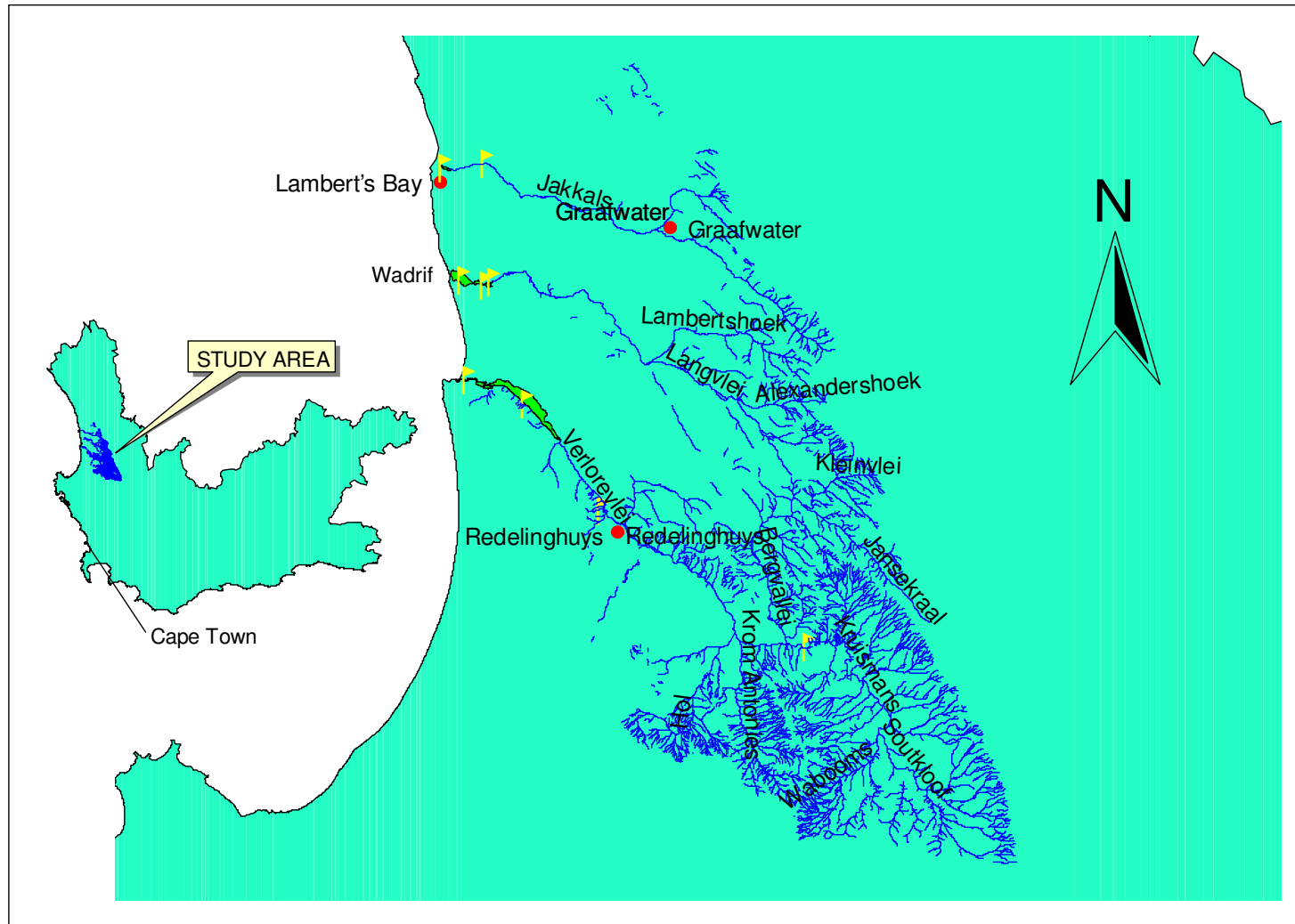


Figure 1: Project Study Area. Locations of the individual EFR sites are indicated by yellow flags.

2.3 Study Constraints

The assessment of EFRs in this study area was constrained by the following:

1. A dearth of observed hydrological records. In the case of Verlorenvlei, all of the major tributaries confluence with the mainstem downstream of the gauging position. Furthermore, flow data exist for only a single gauging weir within the entire G30 drainage area.
2. Confinement of the Study Sections to the lower end of each system (with the partial exception of Verlorenvlei) added to the difficulty of understanding both the hydrology and the inter-linked biotic nature. It proved difficult to unravel the disconnected, multiple groundwater sources, and to integrate their individual roles in sustaining the systems during the dry season
3. High levels of groundwater abstraction in all three catchments, but most marked in the Langvlei River, the upper Jakkals River (as a consequence of impoundment) and in the major tributaries of the Verlorenvlei system (impoundments and groundwater abstraction);
4. Extensive clearing and modification of the local environment for crop farming and grazing;
5. The predominantly non-riverine nature of the systems assessed, which meant that many of the RDM methodologies were not directly applicable (see 2.4);
6. The location of the Study Area: The Western Cape dry to arid environment, winter rainfall region is not presently well-supported by hydrological models;
7. The highly seasonal nature of the pans at the end of the Langvlei and Jakkals Rivers;
8. Marked intra-year water quality variations (natural, evaporation-driven salinity progressions) for the Wadrif Pan and Jakkalsvlei Pan;
9. High degree of inter- and intra-annual variation in rainfall, and hence in surface runoff;
10. The disconnected, multi-nodal nature of the rivers during the dry season;
11. Few water quality data for the study area other than recorded at the gauging weir;
12. A paucity of biophysical data other than outdated information for the lake component of Verlorenvlei itself;
13. Time constraints applicable to the generation and integration of data from the parallel groundwater study. The groundwater study is following a longer initial schedule. Given the very high level of groundwater dependency apparent in these catchments, integration of the groundwater findings into the final Reserves is of crucial importance.

2.4 Limitations of the RDM Protocols

1. The Rapid (Desktop) Model generally supports rivers having perennial or reliably seasonal flows, and has not been calibrated for wetlands, or for groundwater driven ecosystems;
2. There are no protocols at the Rapid level for lakes or wetlands;
3. There are no protocols at any level for seasonal or temporary pans;
4. Prototypical nature of the available RDM protocols for wetlands. Although prototype methodologies for wetlands (palustrine and lacustrine) have been proposed, these have not

- been comprehensively tested. No protocols exist for the wider spectrum of wetland types, nor an adaptive generic methodology for same;
5. Applicability of the existing wetland protocols to lacustrine and morphologically well-defined palustrine environments within the summer rainfall region only;
 6. The riparian vegetation in the longitudinal wetland sections did not display the distinct zonation evident in many other river systems. Thus the commonly-used approach that identifies vegetation zones could not be applied.

3. STUDY APPROACH

The Rapid RDM assessment process is intended as a short duration, low cost assessment that will inform the applicable higher level of study and, if required, to support the compulsory licensing process. As they are currently formulated, the RDM protocols provide direction for only rivers and estuaries at the Rapid level.

The Rapid Assessment is normally accompanied by limited biotic (usually botanical) and faunal (aquatic macroinvertebrate) verification of the conditions during a single annual (seasonal) window. Application of preliminary level assessments to more complex systems, or in the absence of relevant directive protocols, can be compensated for by the inclusion of a broader spectrum of relevant specialist input – within the allowed budget constraints. The latter approach was adopted for this study through the involvement of water quality, avifaunal and fish (freshwater and estuarine) specialists, over and above the core team of wetland, riverine and botanical specializations. This study was also extended to encompass the spring and summer periods (2002/3). In addition, a prototype method for identifying groundwater dependency was tested, and two integrative workshops were held.

Initial site work indicated the importance of assessing the full length of each catchment in order to be able to understand the hydrologic cause and effect pathways impinging on conditions in the individual Study Sections. Consequently, the Study Team extended its Scope of Work to include a pilot investigation of the upstream sections of the rivers. This will provide a baseline set of biophysical and chemical data that can inform an Intermediate or Comprehensive Reserve Determinations.

**APPENDIX:
BASIS FOR SCREENING METHODOLOGY FOR IDENTIFYING
GROUNDWATER DEPENDENT ECOSYSTEMS (VERSION 1.0)**

DRAFT PROTOCOL FOR IDENTIFYING AND CLASSIFYING GROUNDWATER DEPENDENT (GWD) ECOSYSTEMS (GWDEs)				
		Response		
		Yes	No	Unknown
Terrestrial Vegetation				
	<i>Query Level 1</i>			
	Are there vegetation communities known to be associated with groundwater?			
	Are there vegetation communities capable of withstanding extreme climatic conditions?			
	Are there vegetation communities that should be investigated for groundwater associations?			
	Are fauna with known groundwater associations present?			
	Do aerial photographs suggest the presence of damp areas or wetland echoes?			
	Does the geology suggest the presence of groundwater?			
	<i>Query Level 2</i>			
	Is the water table within the root zone of the ecosystem at anytime in a natural cycle?			
	Are any primary aquifers known to be present?			
	Does the water chemistry suggest the presence of groundwater?			
	Is the vegetation known to sustain growth during droughts?			
	Does the vegetation remain lush within an otherwise arid environment?			
	Do obligate GWD plant species occur?			
	Do facultative GWD plants (can occur in wetlands and non-wetlands) occur?			
	Are there any indicator species that suggest or demonstrate groundwater dependency?			
	<i>Query Level 3</i>			
	Do paleo pollen studies indicate the presence of GW associated vegetation?			
	How many species of obligate GWD plants occur?			
	How many species of facultative GWD plants occur?			
Rivers (baseflow)				
	<i>Query Level 1</i>			
	Are there any aquatic ecosystems with a known GWDE component?			
	Are there any aquatic ecosystems with perennial water availability?			
	Are gaining streams present?			
	Do any rivers or streams exhibit longitudinal variations in water quality?			
	Are there any permanent water bodies?			
	Are there any aquatic ecosystems that should be assessed for GWD associations?			
	Are production boreholes present in the area?			
	<i>Query Level 2</i>			
	Do any rivers or streams have visible discharge areas?			
	Are there permanent pools along the length of streams and rivers?			
	Are springs associated with the streams or rivers?			
	Are any ecosystems associated with appearing/disappearing streams or rivers?			
	Is a component of the baseflow known to be comprised of groundwater?			
	Are there any GWDE indicators present?			
	<i>Query Level 3</i>			
	Does the geology suggest the presence of groundwater?			
Wetlands				
	<i>Query Level 1</i>			
	Are known GWD wetlands present?			
	Do wetlands exist that support birds during times of drought?			
	Do wetlands exist in the upland (terrestrial) environment (e.g. on slopes)?			
	Are there any wetlands associated with paleochannels?			
	Do morphological features (drift lines, sedimentation, watermarks) suggest presence of wetlands?			
	Are any lacustrine ecosystems GWD?			
	Are there any freshwater-associated nodes of vegetation in estuaries?			
	Are any wetlands associated with coastal systems?			
	Are any wetlands associated with brack or saline environments?			
	Are there any wetlands that should be assessed for GWD?			
	<i>Query Level 2</i>			
	Does groundwater form a component of the hydrological regime of any wetlands?			
	Does the lithology (hydric soils) suggest the presence of wetlands?			
	Does peat accumulations occur in the area?			
	Is there visible discharge of water into the wetland?			
	Does the wetland contain water during droughts or long into the dry season?			
	Is the water table shallow in the vicinity of the wetland?			
	Do any freshwater species or indicators occur in otherwise saline environments?			
	Do historic records indicate the previous presence of wetlands?			
	<i>Query Level 3</i>			
	Do paleo pollen studies indicate the presence of GW associated vegetation?			
	Do sites exist with 2/3 wetland characteristics (hydrology, hydric soils, vegetation)?			
	Do sites exist with 3/3 wetland characteristics (hydrology, hydric soils, vegetation)?			
	Does soil saturation pertain for > 20% of the duration of the growing season?			
	Are any identified wetlands likely to be anthropogenically induced?			
Other (probable) ecosystems				
	<i>Query Level 1</i>			
	Do known relicts of GWDEs occur?			
	Are there any sites with socio-economic or historical/cultural significance?			
	Are there any systems that should be assessed for GWD?			
	<i>Query Level 2</i>			
	Do populations of migratory birds occur in the area?			

SECTION A

VERLORENVLEI IFR 1 (KRUIS RIVER) AT DUIKERFONTEIN

1. ASSESSED REACH

The IFR site representing the assessed reach (see Figure A1) is situated immediately upstream of the Department of Water Affairs and Forestry (DWAF) gauging weir at Het Kruis (outlet of quaternary catchment G30B). The assessed reach is that portion of the river from Het Kruis (downstream) to the Eendekuil Road (upstream). The Study Site is located downstream of the settlement of Eendekuil on the Kruismans River. The position of the IFR site (18.7997E, 32.6052S) was located where the river passes through a narrow defile with steep, rocky gradients on either side. The site is located a short distance upstream of a causeway which may have influenced the geomorphological characteristics over time, and under the influence of reduced flows.

This section of the river rises on the eastern slopes of the Piketberg (Cape Fold Mountains, Southern Coastal Belt) as a complex of streams north of, and including, the Spoornetkloof. These streams flow east and north to confluence with the Kruismans River. The river is termed the Kruismans upstream of the gauging weir, and becomes the Verlorenvlei downstream thereof. The major tributaries of the Verlorenvlei, namely the Krom Antonies, Bergvallei and the Witte, confluence with the mainstem downstream of Het Kruis.

Landuse in the reach comprises a mixture of dryland and borehole irrigated agriculture. No impoundments occur in the reach, but a number of weirs and sumps, with abstraction points, occur at intervals between the source and the gauging weir. Standing water is generally found in the deeper sections of the river upstream of the ElandsBay/Piketberg Road.

2. REFERENCE CONDITIONS

2.1 *Hydrology*

The catchment (G30B) for the Kruismans River to Het Kruis experiences the highest rainfall and MAR within the greater Verlorenvlei catchment (G30B-E) (see main body of this report for details). Comparative MARs are provided in the main body of this report. With some exceptions streams draining the steep slopes of the Piketberg would have been seasonal. The hydrology of these streams has not been mapped. Dry season flows in wet years would have been sustained by groundwater in the upper mainstem of the Kruismans for much of the year (i.e. flows would have been predominantly through the hyporheic zone). During dry years flows would typically cease during February, and resume during April/May. During the dry period the reach would comprise a

mixture of damp to soggy reed bed zones, receding pools, permanent pools and dry river bed. Springs and seeps would have maintained wet nodes along the reach throughout the year. The MAR for G30B, an area of 66 000 ha, is 28.7 mm.

Floods, evident from gauged flows in excess of 3.5 cumecs (the upper measuring limit of the gauging weir G3H001 at Het Kruis) would have occurred between July and September, and would have been inter-annually variable in timing and duration. A notable characteristic thereof would have been periods of elevated flows of up to 20 days, but typically of 7-9 days (see Hydrological Assessment in the main body of this report).

2.2 Morphological Characteristics

Shortly after leaving the foothill zone the river existed as a sandy channel of variable width and depth, interspersed with deep pools. East of the present ElandsBay/Piketberg Road the channel became wider and descended towards Eendekuil, joined at regular intervals by streams draining the northern Piketberg. West of Eendekuil the gradient levels and the channel profile became less typical of a river, and more characteristic of a longitudinal wetland lined with *Phragmites*. North and west of Eendekuil the river flows along the southern edge of the Duinefontein escarpment to Het Kruis. A floodplain of variable width occurred to the south of this section. Approximately 1.5 km upstream of Het Kruis the river passes through a narrow defile – the point selected for determination of the IFR (see Figure A2).

2.3 Water Quality

No historic water quality data are available for the reach under investigation. Accordingly, the water quality has been inferred from a recent IFR Determination performed on the Spoornetkloof Stream (headwaters of the Kruismans River, SouthernWaters 2001). This indicates that the water draining the exposed Bokkeveld shales of the Piketberg would have been of excellent quality, acidic, low in dissolved salts and alkalinity, and with nil detectable nutrient.

2.4 Vegetation

The dominant vegetation graded from the West Coast Renosterveld of the slopes into dense riparian shrubs (e.g. *Cliffortia*, *Athanasia* and *Metalasia* spp.). Downstream thereof the channel would have been dominated by lilies (*Nymphaea mucronata*) in the pools and shallow standing zones, pondweed (*Potamogeton*), arum lilies (*Zantedeschia aethiopica*) and sedges and grasses (*Cyperus*, *Juncus*, *Bolboschoenus*, *Typha*, *Phragmites*, *Pennisetum*). Clear zonation of graminoid growth was characterized by *Typha* in the fresher permanently wet zones, and with *Phragmites* dominating the channel as soil salinities and perennial water availability decreased. Dominant riparian shrubs at this site would have been *Galenia*, *Melianthus* and *Conyza*, with *Juncus* and *Cyperus* on the wetland margin. *Phragmites* would have occurred in the river bed, but dying back during the summer as water levels receded. Freshwater nodes would have been characterized by unique floral species and assemblages, with elements thereof demonstrating relatively rapid response to reduced water availability.

2.5 *Aquatic Biota*

The aquatic invertebrate fauna comprised 9 taxa with an Average Score per Taxon (ASPT) of 6.2 (see main body of report). However, the results (low diversity and presence of tolerant species) clearly illustrates the inapplicability of using SASS in the type of aquatic ecosystems being assessed here.

Indigenous species of fish and molluscs would have occurred in the upper Kruis River, and with populations of these sustained during dry periods by the presence of pools and soggy areas within the reedbeds. The reed-lined course of the river would have provided an important east-west faunal corridor, and especially for migrant bird species seeking the pans and wetlands nearer the coast.

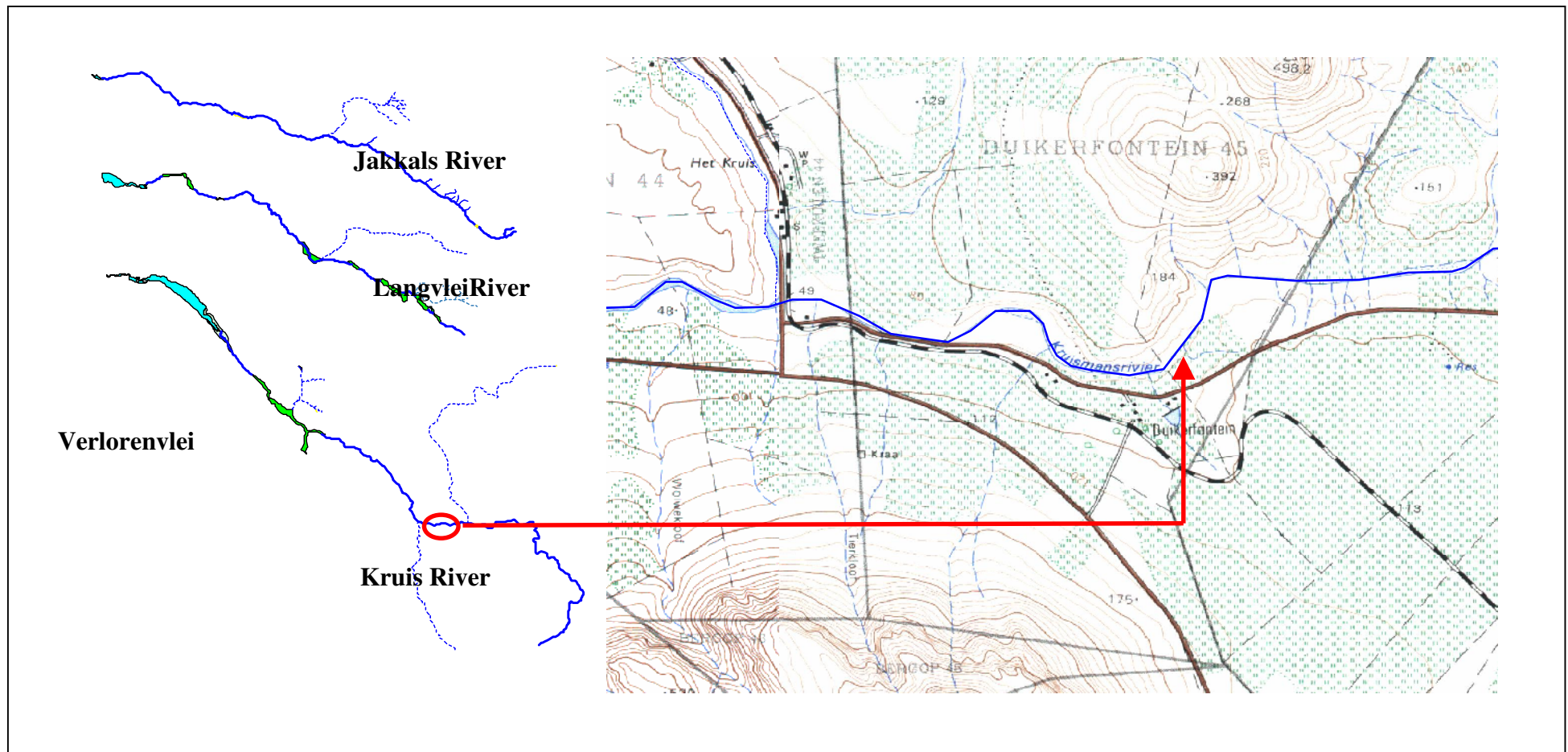


Figure A1: Position of Verlorenvlei IFR (1) in relation to Study Area

3. PRESENT ECOLOGICAL STATUS CATEGORY (PESC)

3.1 *Water Quality*

The water quality was limited to the analysis of single grab samples collected during September 2002 (baseflow) and January 2003 (trickle flow). No flow was recorded during February 2003. Summarized water quality data are provided in Table A1. The flow during January was curiously much fresher just prior to flow ceasing than was the case on the previous two occasions. It is not known whether the flow was caused by transfer of stored or groundwater into the river channel at the time of sampling.

TABLE A1: VERLORENVLEI IFR 1 – SUMMARY OF WATER QUALITY DATA

<i>Date</i>	<i>pH</i>	<i>EC</i>	<i>Na</i>	<i>Mg</i>	<i>K</i>	<i>Ca</i>	<i>Cl</i>	<i>SO₄</i>	<i>TAlk</i>	<i>NO_x as N</i>	<i>TP</i>	<i>PO₄ as P</i>
Units>		mS/m	mg/l									
Sep 02	8.2	449	515	93	7	35	1041	89	135	< 0.04		0.047
Oct 02		545					1536					
Jan 03	7.8	281	392	69	5	45	-	59	146	0.10		<0.03

3.2 *Aquatic Invertebrates*

Conditions at the site at the time of sampling were more typical of a wetland environment (high levels of vegetative detritus, organic and sulphurous anoxic muds, and negligible ‘in-stream’ habitat – further complicated by extremely shallow flows. Accordingly the use of the SASS methodology was deemed unsuitable.

3.3 *Habitat Integrity Assessment*

The Habitat Integrity Assessment was conducted in the usual manner using the methodology according to Kleynhans (1996), as set out in the RDM documentation (DWAF, 1999), and with criterion weightings as set out in Table A2, and their translation into categories (Table A3).

TABLE A2: CRITERIA AND WEIGHTINGS EMPLOYED FOR THE HABITAT INTEGRITY ASSESSMENT

<i>INSTREAM CRITERIA</i>	<i>WEIGHT</i>	<i>RIPARIAN ZONE CRITERIA</i>	<i>WEIGHT</i>
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	100	TOTAL	100

TABLE A3: INTERPRETATION OF THE HABITAT INTEGRITY SCORE, AND DERIVATION OF THE PRESENT ECOLOGICAL STATUS CLASS (PESC)

<i>CATEGORY</i>	<i>DESCRIPTION</i>	<i>SCORE (% OF TOTAL)</i>
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

**TABLE A4. KRUISMANS RIVER AT DUIKERFONTEIN
(VERLORENVLEI G30B)**

INTERMEDIATE HABITAT INTEGRITY – IFR 1*	
	IFR Reach
Overall category	D (52.0)
Instream weighted score	52 (D)
Riparian weighted score	58.6 (D)
Rating of criteria	
Instream Criteria	
Abstraction	25
Water quality	5
Flow modifications: Floods	5
Flow modifications: Low flows	25
Bed modifications	20
Channel modification	10
Inundation	0
Exotic macrophytes	5
Exotic fauna*	20
Solid waste disposal	0
Riparian Zone Criteria	
Indigenous vegetation removal	5
Exotic vegetation encroachment	9
Bank erosion	5
Channel modification	10
Water abstraction	25
Inundation	0
Flow modification	25
Water quality	10

**Note: Application of this methodology for the determination of PESC does not examine certain aspects that pertain to longitudinal wetlands e.g. grazing pressure and nutrient accumulation (instream) or grazing pressure (riparian). Allowance for this has been included in the score for Exotic Fauna.*

4. ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)

This assessment estimates and places within a category (EISC) the ecological importance and sensitivity of the system reach being assessed. The approach considers various biotic and habitat determinants deemed relevant to the EISC of the reach being investigated. These determinants are rated according to a 4-point scale (see Table A5), and interpreted according to a median score (Table A6).

Allocation of values for this procedure was performed at the Specialist Integration Workshop held for this study. Where insufficient information was available minimum precautionary scores of 1 were allocated.

TABLE A5: RATING SCALE FOR ECOLOGICAL IMPORTANCE DETERMINANTS

<i>Four point scale</i>	<i>Definition</i>
1	One species/taxon judged as rare or endangered at a local scale.
2	More than one species/taxon judged to be rare or endangered on a local scale.
3	One or more species/taxon judged to be rare or endangered on a Provincial/regional scale.
4	One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books)

TABLE A6: INTERPRETATION OF THE ECOLOGICAL IMPORTANCE MEDIAN SCORE, AND ALLOCATION OF AN EISC

<i>Ecological Importance and Sensitivity Categories</i>	<i>General description</i>	<i>Range of median</i>
Very high (A)	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High (B)	Quaternaries/delineations that are considered to be unique on a national scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	>2-≤3
Moderate (C)	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/marginal (D)	Quaternaries/delineations that are not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

**TABLE A7: SCORING OF ECOLOGICAL IMPORTANCE DETERMINANTS FOR IFR 1
(KRUISMANS RIVER AT DUIKERFONTEIN)**

<i>DETERMINANT</i>	<i>SCORE</i>		<i>MOTIVATION</i>
	<i>Natural</i>	<i>Present</i>	
<i>Biotic Determinants</i>			
Rare and endangered biota	4	4	Under natural conditions the system would have contained indigenous fish (<i>Galaxias</i> , <i>Pseudobarbus</i> and <i>Sandelia</i>). Two of these genera (<i>Galaxias</i> and <i>Sandelia</i>) are still present. Unknown importance for macroinvertebrates.
Unique biota	4	4	The system would have, and still does, contain isolated populations of the large endemic bivalve <i>Unio caffer</i> . This has important ecological implications in terms of mollusc:fish interactions, and water quality. Presence of <i>Psoralea</i> nov. at the freshwater nodes.
Intolerant biota (water flow and quality)	3	3	The faunal components are adapted to arid and/or seasonal environments. <i>Psoralea</i> nov. highly intolerant to reduced availability of freshwater.
Species/taxon richness	3	3	3 species of fish, one species of bivalve, diverse avifauna and mammals (otters).
<i>Aquatic Habitat Determinants</i>			
Diversity of aquatic habitat types or features	3	2	Relatively diverse at this level of study. Probable that a more intensive investigation will reveal a greater level of diversity.
Refuge value of habitat type	4	4	System requires the availability of damp to wet habitat during the dry season.
Sensitivity of habitat to flow changes/water availability	3	3	System sensitive to extensive droughting or reduction in groundwater-generated baseflow. <i>Psoralea</i> nov. highly intolerant to reduced availability of freshwater.
Sensitivity of flow related water quality changes	3	3	Fish and bivalves intolerant of reduced water quality.
Migration route/corridor for instream and riparian biota	3	3	River corridor provides an important east-west (RAMSAR) migration route for birds. Additional likely importance for mammals.
National parks, wilderness areas, Nature Reserves, Natural Heritage sites, Natural areas, PNEs	3	3	Much of the lower Verlorenvlei system is a proclaimed RAMSAR environment. This has important implications for the upstream environments that sustain it.
Median score	3	3	It is the consensus opinion of the Project Specialist Team that these ratings will be strengthened and confirmed by a higher level Reserve investigation.
Ecological Importance and Sensitivity (EISC) Category	HIGH (B)	HIGH (B)	

5. RECOMMENDED RESERVE

In the light of the importance of the findings of this assessment, and given the integral role of the upper Verlorenvlei system with the proclaimed international importance of the environment provided in its lower reaches, it is recommended that a minimum level of a **C-Category** be set for the Target Ecological Resource Category. It is further recommended that this allocation be pending the findings of a higher level determination of the Reserve. C/D and D Reserves were also computed and provided (Section 6.2).

5.1 Quantification of the Preliminary Reserve (Rapid Level)

The Reserve determinations presented below were done using the ‘Hughes and Münster Model’ as described in Appendix 13 of the RDM manual (DWAF 1999).

The Rapid Reserve method that has been used here provides a low-confidence estimate of the quantity component of the Ecological Reserve for rivers and was developed in response to the need for a number of very quick estimates where the application of the more detailed Intermediate or Comprehensive Reserve determinations are not considered appropriate. Such situations could arise when the degree of water resource development in a catchment is relatively small and no serious clashes between the requirements for the Reserve and water users are expected, or when a rapid method of pinpointing likely problem areas in a catchment is required in advance of selecting sites to carry out more intensive, higher confidence estimates. The method is based on a generic regionalisation of past instream flow requirement (IFR) assessments that were carried out using the building block methodology (BBM). As such, it is recognised that there may be site specific ecological, or channel morphology considerations that might mean that the model used will generate under- or over-estimates of the Reserve. Furthermore, as has been alluded to elsewhere in this study, the approach does not appear to be generically applicable to the types of aquatic environment dealt with in this Sandveld investigation.

5.2 COMPUTATION OF THE RESERVE

The Reserve was computed for one site (see Figure A1). Section 6.3 summarises the flows and their occurrence rules required for the Ecological Reserve.

5.3 Confidence Level

The Rapid Reserve for IFR 1 (Kruismans River at Duikerfontein) is made with a Low to Medium level of confidence. A higher level of confidence may be obtained by:

- A more detailed hydrological evaluation accompanied by input from a fluvial geomorphologist. This approach will provide a greater level of insight as to the nature of historical changes in flow patterns in the upper reaches of the system;
- A comprehensive biotic survey of the upper reaches between Spoornetkloof and Het Kruis, particularly to map zones where bivalves (*Unio caffer*) still occur, as well as the presence, if any, of fish. The presence of *U. caffer* has important food web and water quality implications for this reach of the river. The larvae of this bivalve are parasitic on the gills of fish, and the decline in numbers of this species has been variously attributed to

reductions in fish stocks due to over abstraction and loss of habitat, particularly dry season refugia;

- Completion of a detailed instream and riparian vegetation and habitat mapping and condition assessment;
- Mapping of all springs and seeps influencing habitat in or proximal to the mainstem of the river;
- Mapping and analysis of the vegetation assemblages associated with the identified freshwater seeps;
- Mapping of the water quality parameters of the springs and seeps;
- Development and testing of an appropriate methodology for EFR assessments in longitudinal wetlands;
- Selection of one or more additional IFR sites and interlinking of the results between the assessed sites;
- An analysis of agricultural pressure (grazing and abstraction) on the wetland and riverine environments,
- An analysis of nutrient loading, and its impact on reedbed and/or atypical expansion of vegetation.

5.4 Verlorenvlei IFR 1 (Kruismans River): Category C (Recommended)

VERLORENVLEI IFR 1: KRUISMANS RIVER AT DUIKERFONTEIN (Category C)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 18.869 (10⁶ m³) MAR (PRESENT): ~ 12 (10⁶ m³)

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH	FLOW	VOLUME	DEPTH	FLOW	DURATION	VOLUME	DEPTH	FLOW	VOLUME
	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)	(m)	m ³ s ⁻¹ Daily average	(days)	(10 ⁶ m ³)	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)
OCT		0.172	0.460		0.527	3	0.082		0.073	0.195
NOV		0.093	0.241						0.040	0.102
DEC		0.019	0.050						0.008	0.021
JAN		0.002	0.005						0.001	0.002
FEB		0.001	0.002						0.000	0.001
MAR		0.001	0.002						0.000	0.001
APR		0.006	0.014						0.002	0.006
MAY		0.023	0.061		0.865	3	0.135		0.010	0.026
JUN		0.078	0.202		1.956	4	0.355		0.033	0.086
JUL		0.092	0.247		1.080	4	0.196		0.039	0.105
AUG		0.168	0.451		3.511	5	0.719		0.071	0.191
SEP		0.175	0.453		1.080	4	0.196		0.074	0.192
TOTAL			2.189				1.683			0.930
% OF MAR (VIRGIN)			11.60				8.92			4.93

**VERLORENVLEI (KRUISMANS RIVER) PRELIMINARY RESERVE (RAPID LEVEL)
DETERMINATION: IFR SITE 1 (DUIKERFONTEIN):
INFORMATION SUMMARY AND ECOLOGICAL RESERVE SPECIFICATION**

Water Management Area (WMA)	Olifants Doorn
Quarternary	G30B
Latitude/Longitude (at IFR site)	32°36'41"S;18°46'28"E
Ecoregion (Level 1)	Southern Coastal Belt
Acocks Vegetation Veld Type	70
Present Ecological Status Category (PESC)	C
Ecological Importance and Sensitivity Category (EISC)	B
Default Ecological Status Category (DSC)	C
Target Ecological Resource Category	C
MAR (Virgin)	=18.869 MCM a ⁻¹
Total IFR (% MAR)	=3.872 MCM.a ⁻¹ (20.52%)
Maintenance Lowflow (% MAR)	=2.189 MCM.a ⁻¹ (11.60%)
Drought Lowflow (% MAR)	=0.930 MCM.a ⁻¹ (4.93%)
Maintenance Highflow (% MAR)	=1.683 MCM.a ⁻¹ (8.92%)

5.5 Verlorenvlei IFR 1 (Kruismans River): Category C/D

**VERLORENVLEI IFR 1: KRUISMANS RIVER AT DUIKERFONTEIN (Category C/D)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 18.869 (10⁶ m³) MAR (PRESENT): ~ 12 (10⁶ m³)**

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH	FLOW	VOLUME	DEPTH	FLOW	DURATION	VOLUME	DEPTH	FLOW	VOLUME
	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)	(m)	m ³ s ⁻¹ Daily average	(days)	(10 ⁶ m ³)	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)
OCT		0.157	0.420		0.500	3	0.078		0.073	0.195
NOV		0.085	0.220						0.040	0.102
DEC		0.017	0.046						0.008	0.021
JAN		0.002	0.004						0.001	0.002
FEB		0.001	0.002						0.000	0.001
MAR		0.001	0.002						0.000	0.001
APR		0.005	0.013						0.002	0.006
MAY		0.021	0.056		0.800	3	0.124		0.010	0.026
JUN		0.071	0.185		1.500	4	0.272		0.033	0.086
JUL		0.084	0.226		0.800	4	0.145		0.039	0.105
AUG		0.154	0.412		3.500	5	0.717		0.071	0.191
SEP		0.160	0.414		0.800	4	0.145		0.074	0.192
TOTAL			2.000				1.481			0.930
% OF MAR (VIRGIN)			10.60				7.85			4.93

5.6 Verlorenvlei IFR 1 (Kruismans River): Category D

VERLORENVLEI IFR 1: KRUIS RIVER AT DUIKERFONTEIN (Category D)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 18.869 (10⁶ m³) MAR (PRESENT): ~ 12 (10⁶ m³)

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH	FLOW	VOLUME	DEPTH	FLOW	DURATION	VOLUME	DEPTH	FLOW	VOLUME
	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)	(m)	m ³ s ⁻¹ Daily average	(days)	(10 ⁶ m ³)	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)
OCT		0.073	0.195		0.489	3	0.076		0.073	0.195
NOV		0.040	0.102						0.040	0.102
DEC		0.008	0.021						0.008	0.021
JAN		0.001	0.002						0.001	0.002
FEB									0.000	0.001
MAR									0.000	0.001
APR		0.002	0.006						0.002	0.006
MAY		0.010	0.026		0.802	3	0.125		0.010	0.026
JUN		0.033	0.086		1.813	4	0.329		0.033	0.086
JUL		0.039	0.105		1.001	4	0.182		0.039	0.105
AUG		0.071	0.191		3.253	5	0.666		0.071	0.191
SEP		0.074	0.192		1.001	4	0.182		0.074	0.192
TOTAL			0.930				1.559			0.930
% OF MAR (VIRGIN)			4.93				8.26			4.93

SECTION B

VERLORENVLEI IFR 2 AT REDELINGHUYS

1. ASSESSED REACH

The IFR site representing the assessed reach (see Figure B1) is situated immediately upstream of the town of Redelinghuys. The assessed reach represents the short stretch of river between the Verlorenvlei (downstream) and the Redelinghuys causeway. At this point the river forms for a short distance between the Redelinghuys wetland and the upper reaches of the Verlorenvlei itself. The IFR site (18.5188E, 32.4569S) was positioned in line with an elevated ridge of land entering the river corridor from the north.

The IFR site is located at the lowest end of the river upstream of Verlorenvlei, at the point of discharge from quaternary catchment G30D. At this point the river carries the aggregate flow of the Kruismans, Krom Antonies, Bergvallei and Witte Rivers. The floodplain upstream of the IFR site is located at the foot of a shallow descent from the valley lying between Het Kruis and Redelinghuys. Although an IFR site upstream of the Redelinghuys wetland would have been preferable, the level of degradation, or the presence of braided channels confounding the hydraulic assessment, necessitated the selection of this site.

Landuse in the reach consists of borehole irrigated agriculture. No impoundments occur in the reach, but a large number of sumps and boreholes are present. The wetland provides grazing for animals during the dry season, and it is understood that this practice includes the movement of stock animals to this area during the summer.

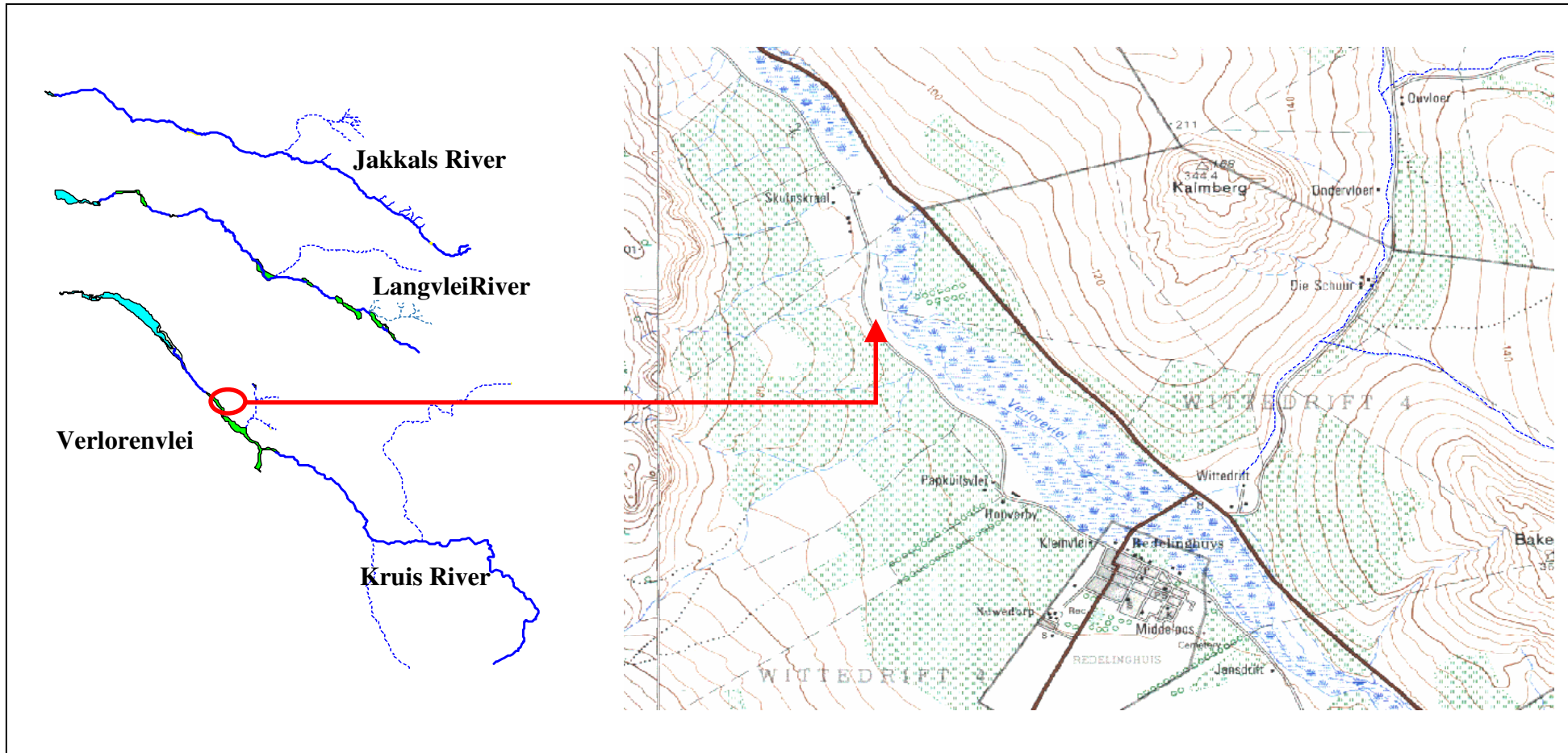


Figure B1: Position of Verlorenvlei IFR (2) in relation to Study Area

2. REFERENCE CONDITIONS

2.1 Hydrology

The IFR site is located at the outlet of catchment G30D. The hydrology of the aggregate flows at this point in the G30 B,C & D drainage areas has not been mapped. No discharge data were available for a disused DWAF gauging structure (G3H002) at Redelinghuys. High flows at this point would present as broad shallow sheet flows over the surface of the wetland. The MAR for G30D is 22.3 mm.

2.2 Morphological Characteristics

The site is characterized by a short section of river draining an extensive wetland. The channel would have adopted a meandering pattern between the promontory to the north and the higher lying ground to the south. The channel would have been incised into sandy soils and muds, and may at times evidenced a braided, multi-channel character.

2.3 Water Quality

No historic water quality data are available for the reach under investigation. Accordingly, the water quality has been inferred from data collected during this study. All of the tributary rivers, as does the upper Kruismans, deliver good quality water into the system, and with acidic, high quality delivered by the Krom Antonies and the Witte (the latter being less a river than a strong 'eye' draining via a longitudinal wetland into the Verlorenvlei). It is inferred that water quality would have been excellent between Het Kruis and Redelinghuys, generally acidic to neutral, low in dissolved salts and poor in nutrients. Nutrient levels, derived from organic detritus, would have leached from the wetland into the Verlorenvlei Lake, providing a valuable and almost sole source of nutrients for the latter.

2.4 Vegetation

This site would have had no riparian shrub zone. Dominant vegetation on the floodplain would have been *Bolboschoenus* (dying back in summer) and *Sarcocornia*. Marginal vegetation would have been comprised of *Cotula* and *Eleocharis* (the latter also dying back in summer). The in-channel vegetation would have comprised lush mixtures of pondweeds (*Potamogeton pectinatus*, *Ceratophyllum* and *Crassula*), lilies (Nymphaeids) and macroalgae (*Nitella*).

2.5 Aquatic Biota

Species of indigenous fish would have occurred in this reach. The high level of organic detritus and anoxia is likely to have precluded species of Unionidae from being present. The wetland would have been extremely important habitat for aquatic invertebrates and birds.

3. PRESENT ECOLOGICAL STATUS CATEGORY (PESC)

3.1 WATER QUALITY

The water quality was limited to the analysis of single grab samples collected during September 2002 (baseflow). No flow was recorded during January 2003. See Table B1 for summarized data.

TABLE B1: VERLORENVLEI IFR 2 – SUMMARY OF WATER QUALITY DATA

<i>Date</i>	<i>pH</i>	<i>EC</i>	<i>Na</i>	<i>Mg</i>	<i>K</i>	<i>Ca</i>	<i>Cl</i>	<i>SO₄</i>	<i>TAlk</i>	<i>NO_x</i> <i>as N</i>	<i>TP</i>	<i>PO₄</i> <i>as P</i>
Units>		mS/m	mg/l									
Sep 02	8.1	257	283	63	5	38	635	67	93	< 0.04		0.020
Jan 03	Dry											

3.2 AQUATIC INVERTEBRATES

The aquatic invertebrate fauna comprised 9 taxa with an Average Score per Taxon (ASPT) of 5.3 (see main body of report). However, the results (low diversity and presence of tolerant species) clearly illustrates the inapplicability of using SASS in the type of aquatic ecosystems being assessed here.

3.3 Habitat Integrity Assessment

The Habitat Integrity Assessment was conducted in the usual manner using the methodology according to Kleynhans (1996), as set out in the RDM documentation (DWAF, 1999), and with criterion weightings as set out in Table B2, and their translation into categories (Table B3).

TABLE A2: CRITERIA AND WEIGHTINGS EMPLOYED FOR THE HABITAT INTEGRITY ASSESSMENT

INSTREAM CRITERIA	WEIGHT	RIPARIAN ZONE CRITERIA	WEIGHT
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	100	TOTAL	100

TABLE B3: INTERPRETATION OF THE HABITAT INTEGRITY SCORE, AND DERIVATION OF THE PRESENT ECOLOGICAL STATUS CLASS (PESC)

<i>CATEGORY</i>	<i>DESCRIPTION</i>	<i>SCORE (% OF TOTAL)</i>
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

**TABLE B4: VERLORENVLEI RIVER AT REDELINGHUYS
(VERLORENVLEI G30D)**

INTERMEDIATE HABITAT INTEGRITY – IFR 2*	
	IFR Reach
Overall category	C (61.6)
Instream weighted score	60.9 (C)
Riparian weighted score	63.3 (C)
Rating of criteria	
Instream Criteria	
Abstraction	18
Water quality	10
Flow modifications: Floods	5
Flow modifications: Low flows	18
Bed modifications	5
Channel modification	16
Inundation	0
Exotic macrophytes	2
Exotic fauna*	19
Solid waste disposal	0
Riparian Zone Criteria	
Indigenous vegetation removal	5
Exotic vegetation encroachment	9
Bank erosion	5
Channel modification	16

Water abstraction	18
Inundation	0
Flow modification	15
Water quality	10

**Note: Application of this methodology for the determination of PESC does not examine certain aspects that pertain to longitudinal wetlands e.g. grazing pressure and nutrient accumulation (instream) or grazing pressure (riparian). Allowance for this has been included in the score for Exotic Fauna.*

4. ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)

This assessment estimates and places within a category (EISC) the ecological importance and sensitivity of the system reach being assessed. The approach considers various biotic and habitat determinants deemed relevant to the EISC of the reach being investigated. These determinants are rated according to a 4-point scale (see Table B5), and interpreted according to a median score (Table B6).

Allocation of values for this procedure was performed at the Specialist Integration Workshop held for this study. Where insufficient information was available minimum precautionary scores of 1 were allocated.

TABLE B5: RATING SCALE FOR ECOLOGICAL IMPORTANCE DETERMINANTS

<i>Four point scale</i>	<i>Definition</i>
1	One species/taxon judged as rare or endangered at a local scale.
2	More than one species/taxon judged to be rare or endangered on a local scale.
3	One or more species/taxon judged to be rare or endangered on a Provincial/regional scale.
4	One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books)

TABLE B6: INTERPRETATION OF THE ECOLOGICAL IMPORTANCE MEDIAN SCORE, AND ALLOCATION OF AN EISC

<i>Ecological Importance and Sensitivity Categories</i>	<i>General description</i>	<i>Range of median</i>
Very high (A)	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High	Quaternaries/delineations that are considered to be unique on a national	>2-≤3

<i>Ecological Importance and Sensitivity Categories</i>	<i>General description</i>	<i>Range of median</i>
(B)	scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	
Moderate (C)	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/marginal (D)	Quaternaries/delineations that are not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

TABLE B7: SCORING OF ECOLOGICAL IMPORTANCE DETERMINANTS FOR IFR 2 (VERLORENVLEI RIVER AT REDELINGHUYS)

<i>DETERMINANT</i>	<i>SCORE</i>		<i>MOTIVATION</i>
	<i>Natural</i>	<i>Present</i>	
<i>Biotic Determinants</i>			
Rare and endangered biota	4	4	Under natural conditions the system would have contained seven species indigenous fish (<i>Galaxias</i> , <i>Pseudobarbus</i> , <i>Mugil cephalus</i> , <i>Liza richardsoni</i> , <i>Gilchristella</i> and <i>Sandelia</i>). Two of these genera (<i>Galaxias</i> and <i>Sandelia</i>) are still present, and a more comprehensive study could reveal more. Unknown importance for macroinvertebrates. Adjacent RAMSAR site.
Unique biota	4	4	<i>Galaxias</i> , <i>Pseudobarbus</i> and <i>Sandelia</i> . The system may have supported populations of the large endemic bivalve <i>Unio caffer</i> . This has important ecological implications in terms of mollusc:fish interactions, and water quality. Adjacent RAMSAR site. Unique vegetation signatures.
Intolerant biota (flow and water quality)	3	3	The floral and faunal components are adapted to arid and/or seasonal environments.
Species/taxon richness	3	3	7 species of fish, one species of bivalve, diverse avifauna and mammals (otters). Natural complement of fish but with alien species present.
<i>Aquatic Habitat Determinants</i>			
Diversity of aquatic habitat types or features	3	2	Site between a wetland and a coastal lake.
Refuge value of habitat type	4	4	System requires the availability of damp to wet habitat during the dry season.
Sensitivity of habitat to flow changes/water availability	3	3	System sensitive to extensive inter-annual droughting or reduction in groundwater-generated baseflow.
Sensitivity of flow related water quality changes	3	3	Fish and bivalves intolerant of reduced water quality.

<i>DETERMINANT</i>	<i>SCORE</i>		<i>MOTIVATION</i>
	<i>Natural</i>	<i>Present</i>	
<i>Biotic Determinants</i>			
Migration route/corridor for instream and riparian biota	4	4	River corridor provides an important east-west (RAMSAR) migration route for birds. Additional likely importance for mammals.
National parks, wilderness areas, Nature Reserves, Natural Heritage sites, Natural areas, PNEs	4	4	The lower Verlorenvlei system is a proclaimed RAMSAR environment. This has important implications for the proximal upstream environments that sustain it.
Median score	3.5	3.5	
Ecological Importance and Sensitivity (EISC) Category	VERY HIGH (B)	VERY HIGH (B)	It is the consensus opinion of the Project Specialist Team that these ratings will be confirmed by a higher level Reserve investigation.

5. RECOMMENDED RESERVE

In the light of the importance of the findings of this assessment, and given the integral role of the upper Verlorenvlei system with the proclaimed international importance of the environment provided in its lower reaches, it is recommended that a minimum level of a B-Category be set for the Target Ecological Resource Category. It is further recommended that this allocation be pending the findings of a higher level determination of the Reserve. A C-Category Reserve was also computed and provided (Section 6.4).

5.1 *Quantification of the Preliminary Reserve (Rapid Level)*

The Reserve determinations presented below were done using the ‘Hughes and Münster Model’ as described in Appendix 13 of the RDM manual (DWAF 1999).

The Rapid Reserve method that has been used here provides a low-confidence estimate of the quantity component of the Ecological Reserve for rivers and was developed in response to the need for a number of very quick estimates where the application of the more detailed Intermediate or Comprehensive Reserve determinations are not considered appropriate. Such situations could arise when the degree of water resource development in a catchment is relatively small and no serious clashes between the requirements for the Reserve and water users are expected, or when a rapid method of pinpointing likely problem areas in a catchment is required in advance of selecting sites to carry out more intensive, higher confidence estimates. The method is based on a generic regionalisation of past instream flow requirement (IFR) assessments that were carried out using the building block methodology (BBM). As such, it is recognised that there may be site specific ecological, or channel morphology considerations that might mean that the model used will generate under- or over-estimates of the Reserve. Furthermore, as has been alluded to elsewhere in this study, the approach does not appear to be generically applicable to the types of aquatic environment dealt with in this Sandveld investigation.

5.2 Computation of the Reserve

The Reserve was computed for one site (see Figure B1). Section 6.2 summarises the flows and their occurrence rules required for the Ecological Reserve.

5.3 Confidence Level

The level of confidence with which this Reserve has been computed is Low. The level of confidence may be increased by augmenting the extant data with the following information:

- Hydrological analysis for each of the main tributaries, and for the aggregate main stem at Redelinghuys;
- Derivation of a conceptual model for groundwater flow in the Verlorenvlei catchment, and determination of the proportional role (spatial and temporal) that this plays in the overall hydrology of the system;
- Extension of the IFR assessments to include the tributaries, and inter-linking of the IFR results into a composite whole;
- Undertaking of an instream and riparian habitat assessment over the full length of the system;
- Development and testing of an appropriate methodology for EFR assessments in longitudinal wetlands;
- Development and testing of an appropriate methodology for linking hydrology, hydraulics and ecological functioning in the Redelinghuys wetland;
- Mapping of all springs and seeps influencing habitat in or proximal to the mainstem of the river;
- Mapping and analysis of the vegetation assemblages associated with the identified freshwater seeps;
- Mapping of the water quality parameters of the springs and seeps;
- Integration of the riverine/wetland EFR results with the hydrology of Verlorenvlei (lake component);
- Integration of avifaunal specialist input pertaining to the value of the wetland components within the RAMSAR context;
- Extension of the fish study to encompass the full length of the mainstem and the tributaries, and in particular to discern what, if any, role the impoundments may play in providing havens for indigenous fish or, alternatively, may be serving as nursery areas for alien species.

5.4 VERLORENVLEI IFR 2 (VERLORENVLEI RIVER): (Category B) (Recommended)

**VERLORENVLEI IFR 2: VERLORENVLEI RIVER AT REDELINGHUYS (Category B)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 40.897 (10⁶ m³) MAR (PRESENT): ~ (10⁶ m³)**

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH	FLOW	VOLUME	DEPTH	FLOW	DURATION	VOLUME	DEPTH	FLOW	VOLUME
	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)	(m)	m ³ s ⁻¹ Daily average	(days)	(10 ⁶ m ³)	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)
OCT		0.281	0.754		1.831	4	0.332		0.039	0.104
NOV		0.147	0.381						0.020	0.052
DEC		0.026	0.070						0.004	0.010
JAN		0.001	0.003						0.000	0.000
FEB		0.000	0.000						0.000	0.000
MAR		0.001	0.002						0.000	0.000
APR		0.012	0.032						0.002	0.004
MAY		0.057	0.152		4.000	5	0.819		0.008	0.021
JUN		0.190	0.493		9.000	6	2.061		0.026	0.068
JUL		0.228	0.610		4.872	5	0.998		0.031	0.084
AUG		0.424	1.136		14.000	7	3.532		0.058	0.156
SEP		0.348	0.903		4.872	5	0.998		0.048	0.124
TOTAL			4.537				8.739			0.623
% OF MAR (VIRGIN)			11.09				21.37			1.52

**VERLORENVLEI RIVER PRELIMINARY RESERVE DETERMINATION:
IFR SITE 2 (REDELINGHUYS):
INFORMATION SUMMARY AND ECOLOGICAL RESERVE SPECIFICATION**

Water Management Area (WMA)	Olifants Doorn
Quaternary	G30D (cumulative)
Latitude/Longitude (at IFR site)	32°27.56;S;18°31'00"E
Ecoregion (Level 1)	Southern Coastal Belt
Acocks Vegetation Veld Type	34
Present Ecological Status Category (PESC)	C
Ecological Importance and Sensitivity Category (EISC)	B
Default Ecological Status Category (DSC)	C
Target Ecological Resource Category	B
MAR (Virgin)	=40.897 MCM a ⁻¹
Total IFR (% MAR)	=13.276 MCM.a ⁻¹ (32.46%)
Maintenance Lowflow (% MAR)	=4.537 MCM.a ⁻¹ (11.09%)
Drought Lowflow (% MAR)	=0.623 MCM.a ⁻¹ (1.52%)
Maintenance Highflow (% MAR)	=8.739 MCM.a ⁻¹ (21.37%)

5.5 VERLORENVLEI IFR 2 (VERLOREN RIVER): (Category C)

**VERLORENVLEI IFR 2: VERLORENVLEI RIVER AT REDELINGHUYS (Category C)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 40.897 ($10^6 m^3$) MAR (PRESENT): ~ ($10^6 m^3$)**

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH	FLOW	VOLUME	DEPTH	FLOW	DURATION	VOLUME	DEPTH	FLOW	VOLUME
	(m)	($m^3 s^{-1}$)	($10^6 m^3$)	(m)	$m^3 s^{-1}$ Daily average	(days)	($10^6 m^3$)	(m)	($m^3 s^{-1}$)	($10^6 m^3$)
OCT		0.150	0.403		1.429	4	0.259		0.039	0.104
NOV		0.079	0.204						0.020	0.052
DEC		0.014	0.037						0.004	0.010
JAN		0.001	0.002						0.000	0.000
FEB		0.000	0.000						0.000	0.000
MAR		0.000	0.000						0.000	0.000
APR		0.007	0.017						0.002	0.004
MAY		0.030	0.081		3.585	5	0.734		0.008	0.021
JUN		0.102	0.263		7.909	5	1.619		0.026	0.068
JUL		0.122	0.326		3.802	5	0.779		0.031	0.084
AUG		0.227	0.607		13.526	7	3.413		0.058	0.156
SEP		0.186	0.482		3.802	5	0.779		0.048	0.124
TOTAL			2.424				7.583			0.623
% OF MAR (VIRGIN)			5.93				18.54			1.52

SECTION C

LANGVLEI RIVER IFR AT WADRIF

1. ASSESSED REACH

The IFR site representative of the assessed reach is situated immediately downstream of the farm Wadrif, and immediately upstream of the Wadrif Pan and wetland (see Figure C1). At this point the Langvlei River discharges from the Langvlei plateau down a steep cascade to the coastal floodplain. A short reach of river, represented by the IFR site, exists within a narrow gorge at the foot of the cascade, just before the flows disperse into the wetland. The IFR site (18.3812E, 32.2094S) is positioned at the eastern boundary of the Study Area for this river.

The area encompassing the interface between the Wadrif Pan, wetland and the lowest end of the Langvlei River has been extensively modified. A series of in-channel dams occur immediately upstream of the cascade, and various weirs and diversions exist at the foot thereof. The immediate area is extensively mined for groundwater. Various access roads, berms and embankments, pipelines and shallow ponds have been constructed, and fences have been erected. The area has been excavated along several transects for the provision of electricity to borehole stands.

Landuse in the immediate vicinity of the IFR site is limited to grazing.

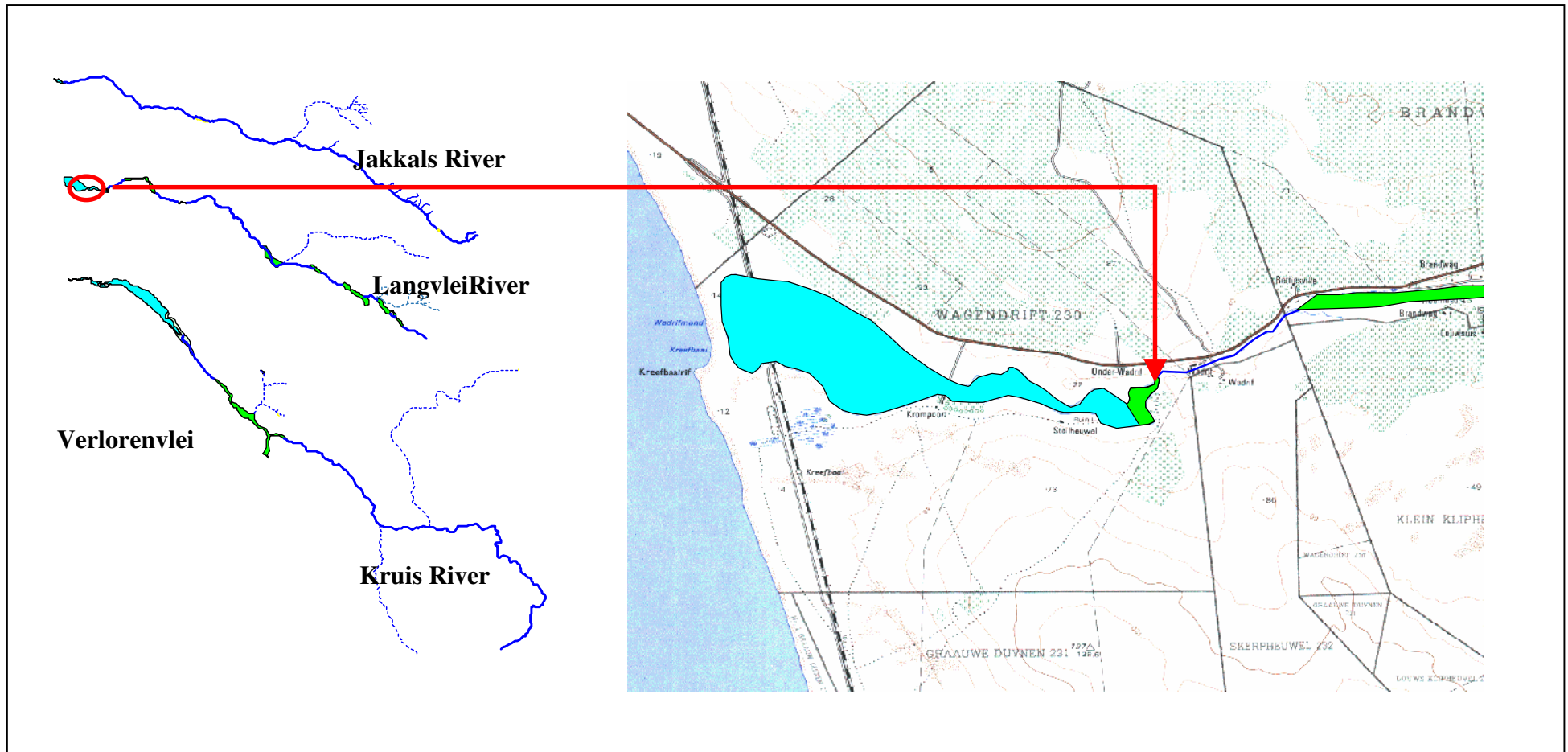


Figure C3: Position of Langvlei IFR in relation to Study Area

2. REFERENCE CONDITIONS

2.1 Hydrology

The Langvlei River, and its two tributaries (Alexandershoek and Lambertshoek Rivers) drain the G30F quaternary catchment – an area of 78 000 ha. The hydrology of the catchment has not been mapped. The MAR for G30F is low, viz. 8.7 mm.

With the exception of the steeply draining headwaters section of the mainstem and the tributaries, the course of the Langvlei River would have comprised a series of longitudinal wetlands (17 or more) connected by short reaches of shallow river channel, or via the hyporheos. The hydrology of the river was driven to a large extent by groundwater, with flows primarily within the hyporheic zone.

The hydrology at the IFR site is complex, comprising a combination of surface and groundwater flows from the Langvlei, and groundwater flows from a spring draining the Wadrif Primary Aquifer (situate to the south-east of the IFR site). Flows at the surface would have originated from groundwater for much of the hydrological year.

It is apparent from discussions held with long-term residents of the area that ‘floods’ or short durations of elevated flows, occurred at reasonably regular intervals, at least on a biennial basis. These are reported as mostly being nocturnal pulses of flow downstream of the farm Boplaas.

2.2 Morphological Characteristics

Shortly after leaving the foothill zone the river existed as a broad floodplain overlain with a series of wetlands. The substrate was primarily sandy, with occasional outcrops of rock. The lower reaches of the system exhibit rocky channels leading to the cascade down to the coastal floodplain. Numerous springs and seeps intersected with the river along its course (see above). Most of these springs introduced excellent quality water into the system, but certain areas, such as downstream of Boplaas (Langvlei proper) were distinctly saline. The river descends to the coastal floodplain via a rock cascade, a short section of rock pools and riffles, and a short section of sandy channel with some rock as it enters the wetland zone.

2.3 Water Quality

No historic water quality data are available for the Langvlei. Intermittent flows of fresh, good quality water would have occurred during the wet season. Thereafter, surface flows would have receded, leaving pools and soggy areas. Salinity levels would have increased in the lower reaches downstream of the farm Boplaas.

2.4 *Vegetation*

Sand Strandveld with elements of *Cyperus*, *Isolepis* and *Cotula* in proximity to the stream line. Reeds (*Phragmites*) would have occurred within the wet littoral and in-stream.

2.5 *Aquatic Biota*

Unique assemblages of high diversity flora would have occurred in the wetlands near the foothill zone of the river and its tributaries. Unique vegetation signatures would have demarcated and delineated the freshwater nodes. Indigenous fish (*Galaxias zebratus* and *Sandelia capensis*) would have occurred – with the possibility of bivalves as have been found in the Verlorenvlei (see Section A). The river would have provided an important biotic corridor between the Wadrif Pan and lagoon, and the Paleisheuvel area (i.e. the headwater zones of the Bergvallei (Verlorenvlei), Jakkals and Langvlei Rivers).

3. PRESENT ECOLOGICAL STATUS CATEGORY (PESC)

The lower reaches of the Langvlei River, and the associated wetland, have been subjected to massive levels of devastation. Insofar as can be elucidated from this investigation, this has chronologically occurred as follows:

- Prior to 1975/1980. The river and wetland interface at the head of the coastal plain existed as an acidic permanently wet, palmiet- (*Prionium serratum*) dominated area, sustained to an unknown yet evidently large degree by groundwater daylighting within and proximal to the wetland. The wetland would have served as a major source of nutrients to the ecologically and crucially-important downstream Wadrif Pan;
- *Circa* 1979. Mining of the groundwater resource in the Wadrif wetland, to provide a source of potable water for Lamberts Bay, commenced;
- During the 1980s the pivot method of irrigation was introduced, along with the availability of ESCOM lines providing electricity for large output borehole pumps;
- Water levels in the Wadrif wetland receded, soil moistures declined, and the stands of palmiet and other obligate wetland species were placed under stress;
- *Circa* 1990: A fire in the now dry stands of vegetation burnt for many months, resulting in total loss of both the surface vegetation and the accumulated layer of peat, a meter or more deep in places, over the eastern and southern portion of the wetland. Notwithstanding the absence of soil moisture for seed regeneration, the combination of heat and sheer duration of the fire also resulted in the sterilization of the seed bank, precluding reestablishment;
- During the same period groundwater abstraction increased throughout the Langvlei catchment, to the extent that it now has an effective negative water balance (see Geohydrological Section of the main body of this report);
- Post-1990. Increased abstraction pressure on the wetland, and the near total absence of surface flows, has all but brought about the near total devastation of the local aquatic environment during a short period of approximately 20 years.

3.1 WATER QUALITY

The water quality was limited to the analysis of grab samples collected during August and September 2002 and February 2003. No flow was recorded during January 2003, and the flow during February was investigated and found to be the result of an overflow from one of the upstream dams.

TABLE C1: LANGVLEI RIVER IFR 1 – SUMMARY OF WATER QUALITY DATA

<i>Date</i>	<i>PH</i>	<i>EC</i>	<i>Na</i>	<i>Mg</i>	<i>K</i>	<i>Ca</i>	<i>Cl</i>	<i>SO₄</i>	<i>TAlk</i>	<i>NO_x as N</i>	<i>TP</i>	<i>PO₄ as P</i>
Units>		mS/m	mg/l									
Jul 02	8.4	138	182	32	13	21	333	70	46	1.00	0.760	
Sep 02												
Oct 02	7.7	419	562	114	19	72		135	94	1.4		< 0.2
Jan 03	Dry											

The water quality was found to be typical of that emanating from the Wadrif Primary Aquifer. Investigation revealed that flows from the outlet of this aquifer were historically diverted towards the Wadrif farm, and thence to the course of the Langvlei River. Flows, although allegedly now a fraction of what they were in earlier years, remain perennial. Accordingly, the quality observations should not be deemed characteristic of the Langvlei River.

3.2 Aquatic Invertebrates

The aquatic invertebrate fauna comprised 5 taxa with an Average Score per Taxon (ASPT) of 3 (see main body of report). However, the results (low diversity and presence of tolerant species) clearly illustrates the inapplicability of using SASS in the type of aquatic ecosystems being assessed here.

3.3 Habitat Integrity Assessment

The Habitat Integrity Assessment was conducted in the usual manner using the methodology according to Kleynhans (1996), as set out in the RDM documentation (DWAF, 1999), and with criterion weightings as set out in Table C2, and their translation into categories (Table C3).

TABLE C2: CRITERIA AND WEIGHTINGS EMPLOYED FOR THE HABITAT INTEGRITY ASSESSMENT

<i>INSTREAM CRITERIA</i>	<i>WEIGHT</i>	<i>RIPARIAN ZONE CRITERIA</i>	<i>WEIGHT</i>
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	100	TOTAL	100

TABLE C3: INTERPRETATION OF THE HABITAT INTEGRITY SCORE, AND DERIVATION OF THE PRESENT ECOLOGICAL STATUS CLASS (PESC)

<i>CATEGORY</i>	<i>DESCRIPTION</i>	<i>SCORE (% OF TOTAL)</i>
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

**TABLE C4. LANGVLEI RIVER AT WADRIF (LANGVLEI G30F)
INTERMEDIATE HABITAT INTEGRITY – IFR**

	<i>IFR Reach</i>
Overall category	E (38.1)
Instream weighted score	37.4 (E)
Riparian weighted score	38.8 (E)
Rating of criteria	
Instream Criteria	
Abstraction	25

	<i>IFR Reach</i>
Water quality	25
Flow modifications: Floods	5
Flow modifications: Low flows	25
Bed modifications	25
Channel modification	16
Inundation	0
Exotic macrophytes	13
Exotic fauna*	0
Solid waste disposal	0
Riparian Zone Criteria	
Indigenous vegetation removal	25
Exotic vegetation encroachment	9
Bank erosion	5
Channel modification	16
Water abstraction	25
Inundation	0
Flow modification	25
Water quality	20

4. ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)

This assessment estimates and places within a category (EISC) the ecological importance and sensitivity of the system reach being assessed. The approach considers various biotic and habitat determinants deemed relevant to the EISC of the reach being investigated. These determinants are rated according to a 4-point scale (see Table C5), and interpreted according to a median score (Table C6).

Allocation of values for this procedure was performed at the Specialist Integration Workshop held for this study. Where insufficient information was available minimum precautionary scores of 1 were allocated.

TABLE C5: RATING SCALE FOR ECOLOGICAL IMPORTANCE DETERMINANTS

<i>Four point scale</i>	<i>Definition</i>
1	One species/taxon judged as rare or endangered at a local scale.
2	More than one species/taxon judged to be rare or endangered on a local scale.
3	One or more species/taxon judged to be rare or endangered on a Provincial/regional scale.
4	One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books)

**TABLE C6: INTERPRETATION OF THE ECOLOGICAL IMPORTANCE MEDIAN SCORE,
AND ALLOCATION OF AN EISC**

<i>Ecological Importance and Sensitivity Categories</i>	<i>General description</i>	<i>Range of median</i>
Very high (A)	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High (B)	Quaternaries/delineations that are considered to be unique on a national scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	>2-≤3
Moderate (C)	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/marginal (D)	Quaternaries/delineations that are not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

**TABLE C7: SCORING OF ECOLOGICAL IMPORTANCE DETERMINANTS FOR THE
LANGVLEI RIVER IFR AT WADRIF**

<i>DETERMINANT</i>	<i>SCORE</i>		<i>MOTIVATION</i>
	<i>Natural</i>	<i>Present</i>	
Biotic Determinants			
Rare and endangered biota	4	4	Two species of indigenous fish: <i>Galaxias</i> and <i>Sandelia</i> . Avifaunal populations – the lower Wadrif Pan system is deemed to be of greater significance for birds than is Verlorenvlei.
Unique biota	3	3	Genetically distinct fish populations and vegetation assemblages. Unique GWDE associations.
Intolerant biota (flow and water quality)	3	3	Fish and vegetation.
Species/taxon richness	3	3	Extremely varied at all biotic levels, and within a very small and limited geographical footprint.
Aquatic Habitat Determinants			
Diversity of aquatic habitat types or features	3	2	Only perennial water flow in lower Langvlei.
Refuge value of habitat type	3	3	Only perennial water flow in lower Langvlei.
Sensitivity of habitat to flow changes/water availability	3	3	High sensitivity.
Sensitivity of flow related water quality changes	3	3	High sensitivity
Migration route/corridor for instream and riparian biota	4	4	Equivalent to RAMSAR importance.
National parks, wilderness areas, Nature Reserves, Natural Heritage sites, Natural areas, PNEs	3	3	Equivalent to RAMSAR importance
Median score	3	3	It is the consensus opinion of the Project Specialist Team that these ratings will be confirmed by a higher level Reserve investigation.
Ecological Importance and Sensitivity (EISC) Category	HIGH	HIGH	

5. RECOMMENDED RESERVE

In the light of the importance of the findings of this assessment, the level of devastation of the environment in the study area, and given the complementary role of the lower Langvlei system in the context of the adjacent Verlorenvlei RAMSAR environment, it is recommended that a provisional minimum level (see following) of a C-Category be set for the Target Ecological Resource Category. It is further recommended that this allocation be pending the findings of a higher level determination of the Reserve. A D-Category Reserve was also computed and provided (Section 6.4).

Integration of the EFRs for the Wadrif Pan, the Wadrif Wetland and the lower Langvlei River indicate that, even in the unlikely event that the IFR is met, surface flows will not support the downstream EFR requirements. Accordingly, while the C-category Reserve will go some way to offsetting the present level of devastation, it is not adequate for sustaining the desired overall targets.

5.1 *Quantification of the Preliminary Reserve (Rapid Level)*

The Reserve determinations presented below were done using the ‘Hughes and Münster Model’ as described in Appendix 13 of the RDM manual (DWAF 1999).

The Rapid Reserve method that has been used here provides a low-confidence estimate of the quantity component of the Ecological Reserve for rivers and was developed in response to the need for a number of very quick estimates where the application of the more detailed Intermediate or Comprehensive Reserve determinations are not considered appropriate. Such situations could arise when the degree of water resource development in a catchment is relatively small and no serious clashes between the requirements for the Reserve and water users are expected, or when a rapid method of pinpointing likely problem areas in a catchment is required in advance of selecting sites to carry out more intensive, higher confidence estimates. The method is based on a generic regionalisation of past instream flow requirement (IFR) assessments that were carried out using the building block methodology (BBM). As such, it is recognised that there may be site specific ecological, or channel morphology considerations that might mean that the model used will generate under- or over-estimates of the Reserve. Furthermore, as has been alluded to elsewhere in this study, the approach does not appear to be generically applicable to the types of aquatic environment dealt with in this Sandveld investigation.

5.2 *Computation of the Reserve*

The Reserve was computed for one site (see Figure C1). Section 6.2 summarises the flows and their occurrence rules required for the Ecological Reserve.

5.3 *Confidence Level*

The level of confidence with which this Reserve has been computed is Low to Medium. The level of confidence may be increased by augmenting the extant data with the following information:

- Extension of the study to include the full length of the Langvlei and its tributaries;
- Derivation of a conceptual model for groundwater flow in the Langvlei catchment, and determination of the proportional role (spatial and temporal) that this plays in the overall hydrology and water balance of the system;
- Extension of the IFR assessments to include the tributaries, and inter-linking of the IFR results into a composite whole;

- Undertaking of an instream and riparian habitat assessment over the full length of the system;
- Development and testing of an appropriate methodology for EFR assessments in longitudinal wetlands;
- Mapping of all springs and seeps influencing habitat in or proximal to the mainstem of the river;
- Mapping and analysis of the vegetation assemblages associated with the identified freshwater seeps;
- Mapping of the water quality parameters of the springs and seeps;
- Integration of the riverine/wetland EFR results with the hydrology of the Wadrif Pan;
- Integration of avifaunal specialist input pertaining to the value of the Pan within the RAMSAR context;
- Determination of the primary and secondary production levels in the Wadrif Pan, insofar as these relate to the sustainable support of the migrant waterbird populations.

5.4 Langvlei River IFR (at WADRIF) (Category C)

(Provisional pending integration with groundwater study – Category C does not meet downstream EFRs).

LANGVLEI IFR 1: LANGVLEI RIVER AT WADRIF (Category C)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 1.740 (10⁶ m³) MAR (PRESENT): (10⁶ m³)

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH	FLOW	VOLUME	DEPTH	FLOW	DURATION	VOLUME	DEPTH	FLOW	VOLUME
	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)	(m)	m ³ s ⁻¹ Daily average	(days)	(10 ⁶ m ³)	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)
OCT		0.001	0.002		0.034	2	0.004		0.000	0.000
NOV		0.001	0.002						0.000	0.000
DEC		0.000	0.001						0.000	0.000
JAN		0.000	0.000						0.000	0.000
FEB		0.000	0.000						0.000	0.000
MAR		0.000	0.000						0.000	0.000
APR		0.000	0.001						0.000	0.000
MAY		0.002	0.005		1.000	3	0.156		0.000	0.000
JUN		0.012	0.030		4.000	4	0.726		0.000	0.000
JUL		0.007	0.020		2.500	3	0.389		0.000	0.000
AUG		0.007	0.018		0.450	2	0.054		0.000	0.000
SEP		0.004	0.009		0.900	2	0.109		0.000	0.000
TOTAL			0.089				1.437			0.000
% OF MAR (VIRGIN)			5.09				21.09			0.00

**LANGVLEI RIVER PRELIMINARY RESERVE DETERMINATION:
IFR SITE 1 (WADRIF):
INFORMATION SUMMARY AND ECOLOGICAL RESERVE SPECIFICATION**

Water Management Area (WMA)	Olifants Doorn
Quaternary	G30F
Latitude/Longitude (at IFR site)	32°12'37.8"S;18°22'41.7"E
Ecoregion (Level 1)	Southern CoastaBelt
Acocks Vegetation Veld Type	47
Present Ecological Status Category (PESC)	F
Ecological Importance and Sensitivity Category (EISC)	C
Default Ecological Status Category (DSC)	C
Target Ecological Resource Category	C
MAR (Virgin)	=6.817 MCM a ⁻¹
Total IFR (% MAR)*	=1.957 MCM.a ⁻¹ (28.71%)
Maintenance Lowflow (% MAR)	=0.520 MCM.a ⁻¹ (7.63%)
Drought Lowflow (% MAR)	=0.000 MCM.a ⁻¹ (0.00%)
Maintenance Highflow (% MAR)	=1.437 MCM.a ⁻¹ (21.09%)

*: Note. While this IFR will sustain the lowest section of the river, and will likely meet the surface requirements of the wetland, it will not deliver sufficient water to the pan (5 MCM). It is not known what component of outflow from the wetland to the pan was previously contributed by groundwater.

5.5 Langvlei River IFR (at WADRIF) (Category D)

**LANGVLEI IFR 1: LANGVLEI RIVER AT WADRIF (Category C)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 1.740 (10⁶ m³) MAR (PRESENT): (10⁶ m³)**

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH	FLOW	VOLUME	DEPTH	FLOW	DURATION	VOLUME	DEPTH	FLOW	VOLUME
	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)	(m)	m ³ s ⁻¹ Daily average	(days)	(10 ⁶ m ³)	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)
OCT		0.002	0.004		0.034	2	0.004		0.000	0.000
NOV		0.001	0.003						0.000	0.000
DEC		0.000	0.001						0.000	0.000
JAN		0.000	0.000						0.000	0.000
FEB		0.000	0.000						0.000	0.000
MAR		0.000	0.000						0.000	0.000
APR		0.001	0.002						0.000	0.000
MAY		0.004	0.009		0.900	3	0.140		0.000	0.000
JUN		0.019	0.050		2.800	4	0.508		0.000	0.000
JUL		0.012	0.033		2.000	4	0.363		0.000	0.000
AUG		0.016	0.043		0.352	2	0.043		0.000	0.000
SEP		0.008	0.021		0.703	3	0.109		0.000	0.000
TOTAL			0.168				1.167			0.000
% OF MAR (VIRGIN)			2.46				17.12			0.00

SECTION D

JAKKALS RIVER IFR AT KOOKFONTEIN

1. ASSESSED REACH

The IFR site for the assessed reach is situated on the farm Kookfontein, immediately upstream of where the Doringbaai Road crosses the Jakkals River (see Figure D1). The assessed reach is thus that portion of the river between the Jakkalsvlei Pan (downstream), and for a distance of 5 km upstream. Immediately downstream of the IFR site (18.3053E, 32.0847S) a small, shallow pond has been created by the culverting of the road embankment. Upstream inundation caused by this obstruction does not reach or affect the conditions at the IFR site.

The assessed reach flows through a shallow and narrow valley from the vicinity of the IFR site to immediately upstream of the Jakkalsvlei Pan. Local land use in the vicinity of the IFR site is comprised of limited grazing. Downstream of the site various municipal activities (sand mining, borrow pits, a solid waste and compost processing site) take place. Although the homesteads of some farms occur in the reach, their agricultural activities are confined in the main to the higher ground north and south of the course of the river.

The location of the IFR site represents the upstream (east) boundary of the Study Section as defined by the TOR for this project.

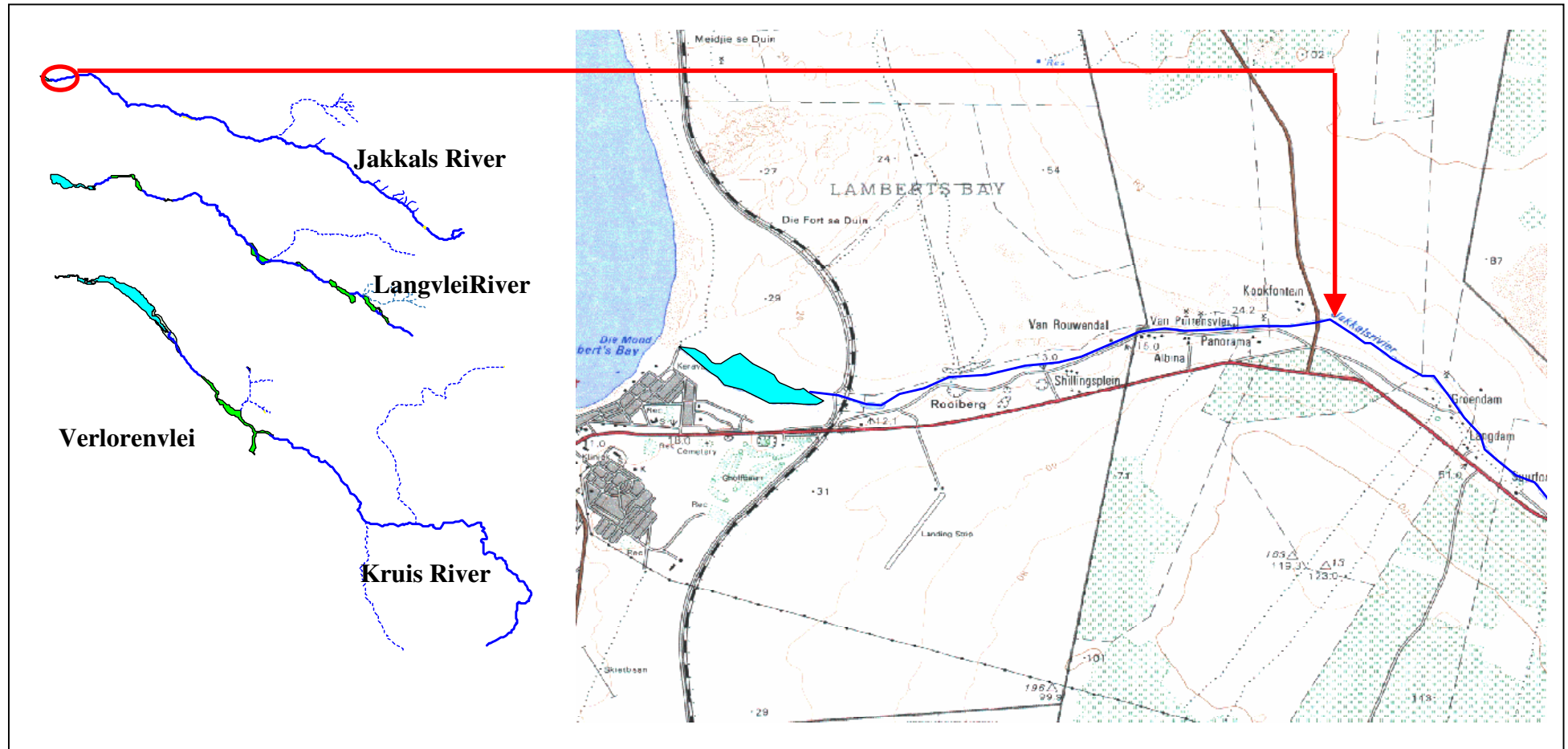


Figure D1: Position of Jakkals River IFR in relation to Study Area

2. REFERENCE CONDITIONS

2.1 Hydrology

The Jakkals River, and its tributary the Peddies River (confluent at Graafwater) drains an area of 65 000 ha comprising the G30G quaternary catchment. The hydrology of the catchment has not been mapped. The MAR is extremely small, viz. 5.4 mm.

It is evident from the assessment that flows would have been highly seasonal, but with perennial baseflows in the mid- to lower reaches in most years. These constant flows would have been of crucial importance in maintaining water levels against evaporation losses in the Jakkalsvlei Pan.

Various springs, evidencing water qualities from fresh to saline, occur along the course of the river. The contribution from the Peddies River, draining the western slopes of the mountains north-west of the town of Graafwater is unknown, but would appear to be small.

2.2 Morphological Characteristics

Investigation of the Jakkals River catchment revealed that the river flows through two distinct zones. The river rises some 50 km northeast of the IFR site on the slopes north-east of the farm Jakkalsvlei. Thereafter it flows south-west across a wide sandy plain to the town of Graafwater. Downstream of Graafwater the river flows in a shallow valley, alternating with floodplain zones, until it reaches the Pan (see Section x).

Between the source and the town of Graafwater the river existed as a series of pools, wetland meadows and shallow temporary vleis, with a poorly-defined central channel sparsely lined with reeds. Hyporheic flows persisted for much of the dry season. Downstream of Graafwater the river exists as a defined shallow channel, often flowing between outcrops of rock, or through wide floodplains.

Large flood events would appear to be relatively rare. Recorded events indicate massive flooding during the 1920s, as well as during the mid-1990s – at which point the berm constructed at the outlet of the Pan (see Section x) was washed away.

2.3 Water Quality

No historical water quality data are available for the Jakkalsvlei. Investigations conducted during this survey indicate that the water quality in the upper reaches is very good (low pH, low in salts and nutrients), and becoming progressively more brack with progression downstream and the stage of the seasonal cycle.

2.4 Vegetation

Sand Strandveld with *Sporobolus*, *Bolboschoenus*, *Sarcocornia*, with *Phragmites* and *Juncus* in the wetter zones.

2.5 Aquatic Biota

There are no records and few indications of what the assemblage of aquatic biota would have comprised. Key zones (pools in floodplain areas and the dams in the upper catchment), features outside of the TOR for this investigation, are likely to provide clues as the nature of the reference biotic component. The Jakkalsvlei Pan is extremely important for migrant and local avifauna, with concomitant extension of this importance to the condition of the upstream environments.

3. PRESENT ECOLOGICAL STATUS CATEGORY (PESC)

The lower reaches of the Jakkals River, and the Pan, have been severely and negatively impacted by impoundment of flows in the headwater reaches. This had had the effect of effectively negating the annual passage of freshets and freshwater 'bulk' flows to the downstream riverine and pan environments. This has not only negated the biological cues that would have been provided by these pulses, but has also resulted in the expansion of the naturally-saline, seasonal flora of the river corridor between Graaftwater and the coast.

Although outside of the assessed IFR reach, the impact of impoundments is deemed to be so great that it has been incorporated into the PESC assessment.

3.1 Water Quality

The water quality was limited to the analysis of grab samples collected during September 2002. No flow was recorded during January and February 2003 – although the stream bed above and below the IFR site varied from damp to muddy.

The water quality at this survey was found to have elevated salinity and nitrates. A survey of water quality between Graaftwater, where saline water with an EC of 4 000 mS m⁻¹ was found to be daylighting in the river bed just north of the town, and the study site revealed a wide range of variations in total dissolved solids, and a range of EC between 100 and 4000 mS m⁻¹. It was thus apparent that the course of the river is intersected by groundwater flows at intervals.

The available water quality data are summarized in Table D1.

TABLE D1: JAKKALS RIVER IFR 1 – SUMMARY OF WATER QUALITY DATA

<i>Date</i>	<i>pH</i>	<i>EC</i>	<i>Na</i>	<i>Mg</i>	<i>K</i>	<i>Ca</i>	<i>Cl</i>	<i>SO₄</i>	<i>Talk</i>	<i>NO_x as N</i>	<i>TP</i>	<i>PO₄ as P</i>
Units>		mS/m	mg/ℓ									
Jul 02	7.6	2540	4417	736	108	333	8438	1336	111	0.16	0.40	
Sep 02	7.7	4850	3741	704	70	353	7984	643	93	0.52		0.015
Jan 03	Dry											

3.2 *Aquatic Invertebrates*

The aquatic invertebrate fauna comprised 7 taxa with an Average Score per Taxon (ASPT) of 6.3 (see main body of report). However, the results (low diversity and presence of tolerant species) clearly illustrates the inapplicability of using SASS in the type of aquatic ecosystems being assessed here.

3.3 *Habitat Integrity Assessment*

The Habitat Integrity Assessment was conducted in the usual manner using the methodology according to Kleynhans (1996), as set out in the RDM documentation (DWAF, 1999), and with criterion weightings as set out in Table D2, and their translation into categories (Table D3).

TABLE D2: CRITERIA AND WEIGHTINGS EMPLOYED FOR THE HABITAT INTEGRITY ASSESSMENT

<i>INSTREAM CRITERIA</i>	<i>WEIGHT</i>	<i>RIPARIAN ZONE CRITERIA</i>	<i>WEIGHT</i>
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	100	TOTAL	100

TABLE D3: INTERPRETATION OF THE HABITAT INTEGRITY SCORE, AND DERIVATION OF THE PRESENT ECOLOGICAL STATUS CLASS (PESC)

<i>CATEGORY</i>	<i>DESCRIPTION</i>	<i>SCORE (% OF TOTAL)</i>
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

**TABLE D4. JAKKALS RIVER AT KOOKFONTEIN
(JAKKALS G30G)**

INTERMEDIATE HABITAT INTEGRITY – IFR	
	IFR Reach
Overall category	48.1 (D)
Instream weighted score	43.6 (D)
Riparian weighted score	52.6 (D)
Rating of criteria	
Instream Criteria	
Abstraction	25
Water quality	25
Flow modifications: Floods	15
Flow modifications: Low flows	25
Bed modifications	15
Channel modification	15
Inundation	
Exotic macrophytes	3
Exotic fauna*	
Solid waste disposal	8
Riparian Zone Criteria	
Indigenous vegetation removal	5
Exotic vegetation encroachment	3
Bank erosion	
Channel modification	15
Water abstraction	25
Inundation	
Flow modification	25
Water quality	25

4. ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)

This assessment estimates and places within a category (EISC) the ecological importance and sensitivity of the system reach being assessed. The approach considers various biotic and habitat determinants deemed relevant to the EISC of the reach being investigated. These determinants are rated according to a 4-point scale (see Table D5), and interpreted according to a median score (Table D6).

Allocation of values for this procedure was performed at the Specialist Integration Workshop held for this study. Where insufficient information was available minimum precautionary scores of 1 were allocated.

TABLE D5: RATING SCALE FOR ECOLOGICAL IMPORTANCE DETERMINANTS

<i>Four point scale</i>	<i>Definition</i>
1	One species/taxon judged as rare or endangered at a local scale.
2	More than one species/taxon judged to be rare or endangered on a local scale.
3	One or more species/taxon judged to be rare or endangered on a Provincial/regional scale.
4	One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books)

TABLE D6: INTERPRETATION OF THE ECOLOGICAL IMPORTANCE MEDIAN SCORE, AND ALLOCATION OF AN EISC

<i>Ecological Importance and Sensitivity Categories</i>	<i>General description</i>	<i>Range of median</i>
Very high (A)	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High (B)	Quaternaries/delineations that are considered to be unique on a national scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	>2-≤3
Moderate (C)	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species).	>1-≤2

<i>Ecological Importance and Sensitivity Categories</i>	<i>General description</i>	<i>Range of median</i>
	These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	
Low/marginal (D)	Quaternaries/delineations that are not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

TABLE D7: SCORING OF ECOLOGICAL IMPORTANCE DETERMINANTS FOR THE JAKKALS RIVER IFR AT KOOKFONTEIN

<i>DETERMINANT</i>	<i>SCORE</i>		<i>MOTIVATION</i>
	<i>Natural</i>	<i>Present</i>	
Biotic Determinants			
Rare and endangered biota	2	2	The biotic importance of the site is inferred and extrapolated from the importance of the downstream pan. Presence of relict and unique vegetation signatures is evident from the botanical assessment.
Unique biota	2	2	
Intolerant biota (flow and water quality)	3	3	
Species/taxon richness	3	3	
Aquatic Habitat Determinants			
Diversity of aquatic habitat types or features	2	2	Low to moderate, but requires a greater level of integration with the hydrological characteristics and a longitudinal habitat assessment to detect mosaic habitat patterns.
Refuge value of habitat type	1	1	See above.
Sensitivity of habitat to flow changes/water availability	3	3	High. The lower reaches of the Jakkals River, and the downstream pan, require annual freshwater flow-generated biotic cues, as well as bulk freshwater pulses. Loss of instream and riparian vegetation will have resulted in reduced nutrient pulses to the pan, with concomitantly lower levels of primary and secondary productivity – this impacting negatively on the food resource for birds.
Sensitivity of flow related water quality changes	3	3	
Migration route/corridor for instream and riparian biota	2	2	Important avifaunal habitat.
National parks, wilderness areas, Nature Reserves, Natural Heritage sites, Natural areas, PNEs	2	2	Complementary value in terms of the adjacent RAMSAR site at Verlorenvlei.
Median score	2	2	It is the consensus opinion of the Project Specialist Team that these ratings will be confirmed and strengthened by a higher level Reserve investigation.
Ecological Importance and Sensitivity (EISC) Category	MOD (C)	MOD (C)	

5. RECOMMENDED RESERVE

In the light of the importance of the findings of this assessment, the level of devastation of the environment in the study area, and given the complementary role of the lower Langvlei system in the context of the adjacent Verlorenvlei RAMSAR environment, it is recommended that a provisional minimum level (see following) of a **C-Category** be set for the Target Ecological Resource Category. It is further recommended that this allocation be pending the findings of a higher level determination of the Reserve. A D-Category Reserve was also computed and provided (Section 6.4).

5.1 *Quantification of the Preliminary Reserve (Rapid Level)*

The Reserve determinations presented below were done using the ‘Hughes and Münster Model’ as described in Appendix 13 of the RDM manual (DWAF 1999).

The Rapid Reserve method that has been used here provides a low-confidence estimate of the quantity component of the Ecological Reserve for rivers and was developed in response to the need for a number of very quick estimates where the application of the more detailed Intermediate or Comprehensive Reserve determinations are not considered appropriate. Such situations could arise when the degree of water resource development in a catchment is relatively small and no serious clashes between the requirements for the Reserve and water users are expected, or when a rapid method of pinpointing likely problem areas in a catchment is required in advance of selecting sites to carry out more intensive, higher confidence estimates. The method is based on a generic regionalisation of past instream flow requirement (IFR) assessments that were carried out using the building block methodology (BBM). As such, it is recognised that there may be site specific ecological, or channel morphology considerations that might mean that the model used will generate under- or over-estimates of the Reserve. Furthermore, as has been alluded to elsewhere in this study, the approach does not appear to be generically applicable to the types of aquatic environment dealt with in this Sandveld investigation.

5.2 *Computation of the Reserve*

The Reserve was computed for one site (see Figure D1). Section 6.2 summarises the flows and their occurrence rules required for the Ecological Reserve.

5.3 *Confidence Level*

The level of confidence with which this Reserve has been computed is **Low to Medium**. The level of confidence may be increased by augmenting the extant data with the following information:

- Extension of the study to include the full length of the Jakkals River;
- Derivation of a conceptual model for groundwater flow in the Jakkals catchment, and determination of the proportional role (spatial and temporal) that this plays in the overall hydrology and water balance of the system;

- Extension of the IFR assessments to include the river above and below Graaftwater, and inter-linking of the IFR results into a composite whole;
- Undertaking of an instream and riparian habitat assessment over the full length of the system;
- Mapping of all springs and seeps influencing habitat in or proximal to the mainstem of the river;
- Mapping and analysis of the vegetation assemblages associated with the identified freshwater seeps;
- Mapping of the water quality parameters of the springs and seeps;
- Integration of the riverine/wetland EFR results with the hydrology of the Jakkalsvlei Pan;
- Integration of avifaunal specialist input pertaining to the value of the Jakkalsvlei Pan within the RAMSAR context;
- Determination of the primary and secondary production levels in the Jakkalsvlei Pan, insofar as these relate to the sustainable support of the migrant waterbird populations.

5.4 Jakkals River IFR (at KOOKFONTEIN) (Category C)

Recommendation requires integration with pan – survey and bathymetry outstanding.

JAKKALS IFR 1: JAKKALS RIVER AT KOOKFONTEIN (Category C)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 1.740 (10⁶ m³) MAR (PRESENT): ~ (10⁶ m³)

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH (m)	FLOW (m ³ s ⁻¹)	VOLUME (10 ⁶ m ³)	DEPTH (m)	FLOW m ³ s ⁻¹ Daily average	DURATION (days)	VOLUME (10 ⁶ m ³)	DEPTH (m)	FLOW (m ³ s ⁻¹)	VOLUME (10 ⁶ m ³)
OCT		0.001	0.002		0.007	2	0.001		0.000	0.000
NOV		0.001	0.002						0.000	0.000
DEC		0.000	0.001						0.000	0.000
JAN		0.000	0.000						0.000	0.000
FEB		0.000	0.000						0.000	0.000
MAR		0.000	0.000						0.000	0.000
APR		0.000	0.001						0.000	0.000
MAY		0.002	0.005		0.193	3	0.030		0.000	0.000
JUN		0.012	0.030		0.734	4	0.133		0.002	0.005
JUL		0.007	0.020		0.491	3	0.076		0.001	0.003
AUG		0.007	0.018		0.053	2	0.006		0.001	0.003
SEP		0.004	0.009		0.107	3	0.017		0.001	0.001
TOTAL			0.089				0.263			0.014
% OF MAR (VIRGIN)			5.09				15.13			0.79

**JAKKALS RIVER PRELIMINARY RESERVE DETERMINATION:
IFR SITE 1 (KOOKFONTEIN):
INFORMATION SUMMARY AND ECOLOGICAL RESERVE SPECIFICATION**

Water Management Area (WMA)	Olifants Doorn
Quaternary	G30G
Latitude/Longitude (at IFR site)	32°05'21.9"S;18°21'08.7"E
Ecoregion (Level 1)	Southern Coastal Belt
Acocks Vegetation Veld Type	34
Present Ecological Status Category (PESC)	D
Ecological Importance and Sensitivity Category (EISC)	C
Default Ecological Status Category (DSC)	C
Target Ecological Resource Category	C
MAR (Virgin)	=1.740 MCM a ⁻¹
Total IFR (% MAR)	=0.352 MCM.a ⁻¹ (20.22%)
Maintenance Lowflow (% MAR)	=0.089 MCM.a ⁻¹ (5.09%)
Drought Lowflow (% MAR)	=0.014 MCM.a ⁻¹ (0.79%)
Maintenance Highflow (% MAR)	=0.263 MCM.a ⁻¹ (15.13%)

5.5 Jakkals River IFR (at Kookfontein) (Category D)

**JAKKALS IFR 1: JAKKALS RIVER AT KOOKFONTEIN (Category D)
ASSURANCE OF MAINTENANCE LOW FLOWS: 50 % (summer) and 50 % (winter)
MAR (VIRGIN): 1.740 (10⁶ m³) MAR (PRESENT): ~ (10⁶ m³)**

MONTH S	MAINTENANCE LOW FLOWS			HIGH FLOWS				DROUGHT LOW FLOWS		
	DEPTH	FLOW	VOLUME	DEPTH	FLOW	DURATION	VOLUME	DEPTH	FLOW	VOLUME
	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)	(m)	m ³ s ⁻¹ Daily average	(days)	(10 ⁶ m ³)	(m)	(m ³ s ⁻¹)	(10 ⁶ m ³)
OCT		0.001	0.003		0.006	2	0.001		0.000	0.000
NOV		0.001	0.000						0.000	0.000
DEC		0.000	0.000						0.000	0.000
JAN		0.000	0.000						0.000	0.000
FEB		0.000	0.000						0.000	0.000
MAR		0.000	0.000						0.000	0.000
APR		0.000	0.000						0.000	0.000
MAY		0.001	0.003		0.200	3	0.031		0.000	0.000
JUN		0.003	0.008		0.900	4	0.163		0.002	0.005
JUL		0.001	0.003		0.500	3	0.078		0.001	0.003
AUG		0.002	0.005		0.045	2	0.005		0.001	0.003
SEP		0.001	0.001		0.089	2	0.011		0.001	0.001
TOTAL			0.023				0.289			0.014
% OF MAR (VIRGIN)			1.34				16.61			0.79

SECTION E

WATER REQUIREMENTS (Preliminary Rapid Reserve) – WADRIF WETLAND

1. INTRODUCTION

This section details the results of the specialist deliberations pertaining to the setting of a preliminary Reserve for the Wadrif Wetland. The Wadrif Wetland is a small wetland at the point of discharge of the Langvlei River onto the coastal plain, immediately upstream of and grading into the Wadrif Pan. As such the wetland constitutes a floodplain system but with a high degree of riverine character in its upper reaches, and pan shoreline at the downstream. The wetland is situated over an area of groundwater discharge that forms the focus of an intensively mined wellfield, supplying water for irrigation and raw potable water for Lamberts Bay. The wetland has a very high degree of groundwater dependence.

The lower reaches of the Langvlei River, and the associated wetland, have been subjected to massive levels of devastation. Insofar as can be elucidated from this investigation, this has chronologically occurred as follows:

- Prior to 1975/1980. The river and wetland interface at the head of the coastal plain existed as an acidic permanently wet, palmiet- (*Prionium serratum*) dominated area, sustained to an unknown yet evidently large degree by groundwater daylighting within and proximal to the wetland. The wetland would have served as a major source of nutrients to the ecologically and crucially-important downstream Wadrif Pan. During the normal process of wetland development it became underlain by a layer of peat approximately 2 m in depth;
- Circa 1979. Mining of the groundwater resource in the Wadrif wetland, to provide a source of potable water for Lamberts Bay, commenced;
- During the 1980s the pivot method of irrigation was introduced, along with the availability of ESCOM lines providing electricity for large output borehole pumps;
- Water levels in the Wadrif wetland receded, soil moistures declined, the peat layer became dessicated and the stands of palmiet and other obligate wetland species were placed under stress;
- Circa 1990: A fire in the now dry stands of vegetation burnt for many months, resulting in total loss of both the surface vegetation and the accumulated layer of peat, a meter or more deep in places, over the eastern and southern portion of the wetland. Notwithstanding the absence of soil moisture for seed regeneration, the combination of heat and sheer duration of the fire also resulted in the sterilization of the seed bank, precluding reestablishment;
- During the same period groundwater abstraction increased throughout the Langvlei catchment, to the extent that it now has an effective negative water balance (see Geohydrological Section of the main body of this report);

- Post-1990. Increased abstraction pressure on the wetland, and the near total absence of surface flows, has all but brought about the near total devastation of the local aquatic environment during a short period of approximately 20 years.

2. METHODOLOGY

The RDM methodology for wetlands is incomplete. Furthermore, no process is available for the integration of riverine, groundwater and surface water requirements in interlinked and interdependent systems such as the Wadrif wetland (although a protocol for this should be derived from this study). Accordingly, the following pilot approach was employed for this preliminary determination of the water requirements for the Wadrif wetland.

- 1) Identification and description of the reference conditions;
- 2) Identification of the key drivers, cause and effect functions and stressors that underpin the ecological, functional and socio-economic functioning of the wetland;
- 3) Undertaking of preliminary level hydrology, hydraulics, water quality and biotic (floral and faunal – inclusive of sediments) verification of the condition of the wetland and its (transect-based) association with its upland (terrestrial) environment, and longitudinal connections up- and downstream;
- 4) Determination of the Present Ecological Status Class (PESC) using the Wetland Rehabilitation and Assessment Protocol (WRAP) (Southern Waters, in development);
- 5) Determination of the Trajectory of Change of the identified key components of system functionality;
- 6) Determination of the Ecological Importance and Significance (EISC) of the system – using a specialist workshop process and other pertinent information;
- 7) Identification of key indicators that support the identification of water levels and durations of inundation;
- 8) Determination of the desired Ecological Management Category (EMC)
- 9) Determine the (preliminary) water requirements (PWR) to meet the EMC;
- 10) Compare and contrast the PWR with the availability of water from the IFR assessment in order to link the PWR to the system hydrology;
- 11) Specify the degree of confidence in the recommendations, and identify such further work as may be required to develop the required level of understanding.

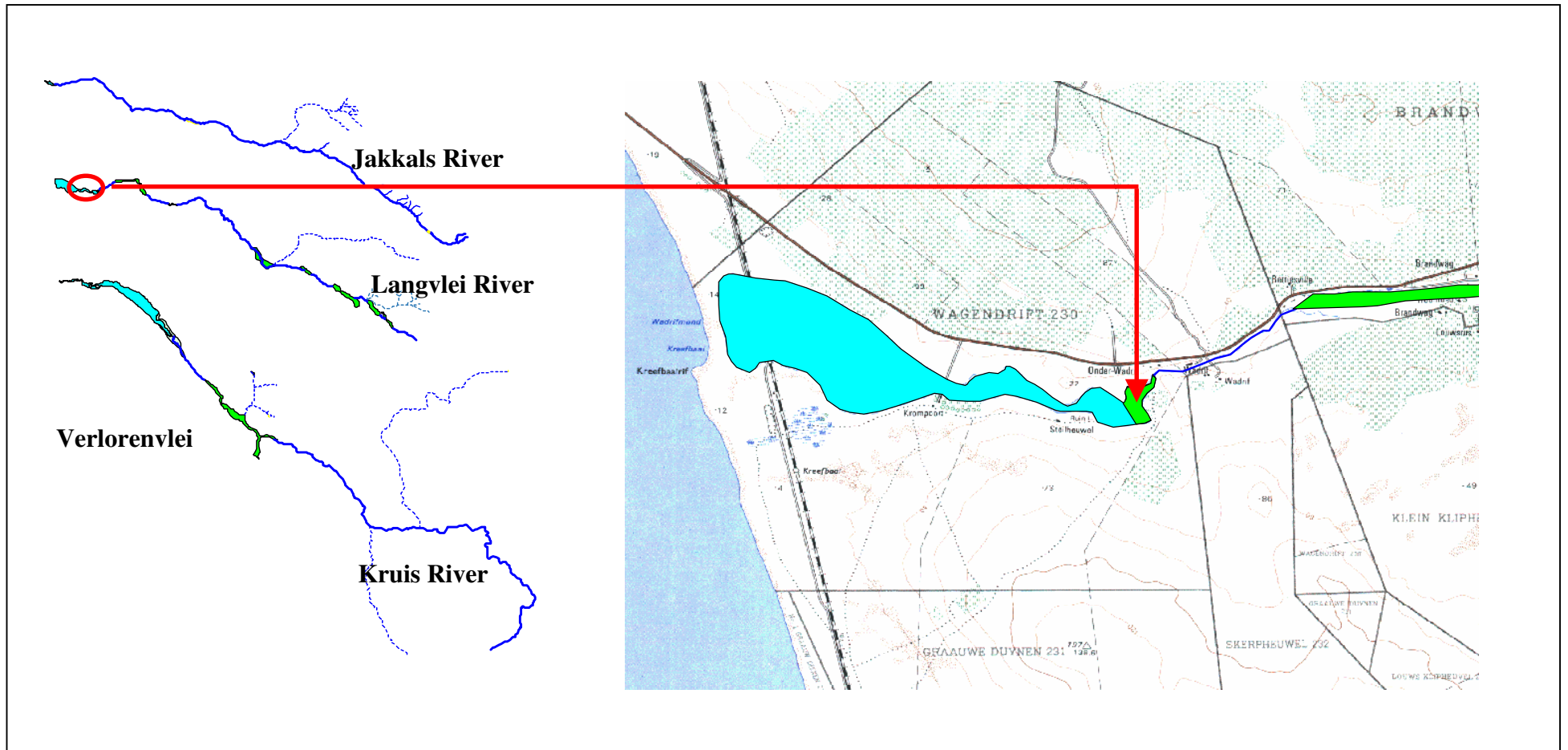


Figure E1: Position of Wadrif Wetland in relation to Study Area

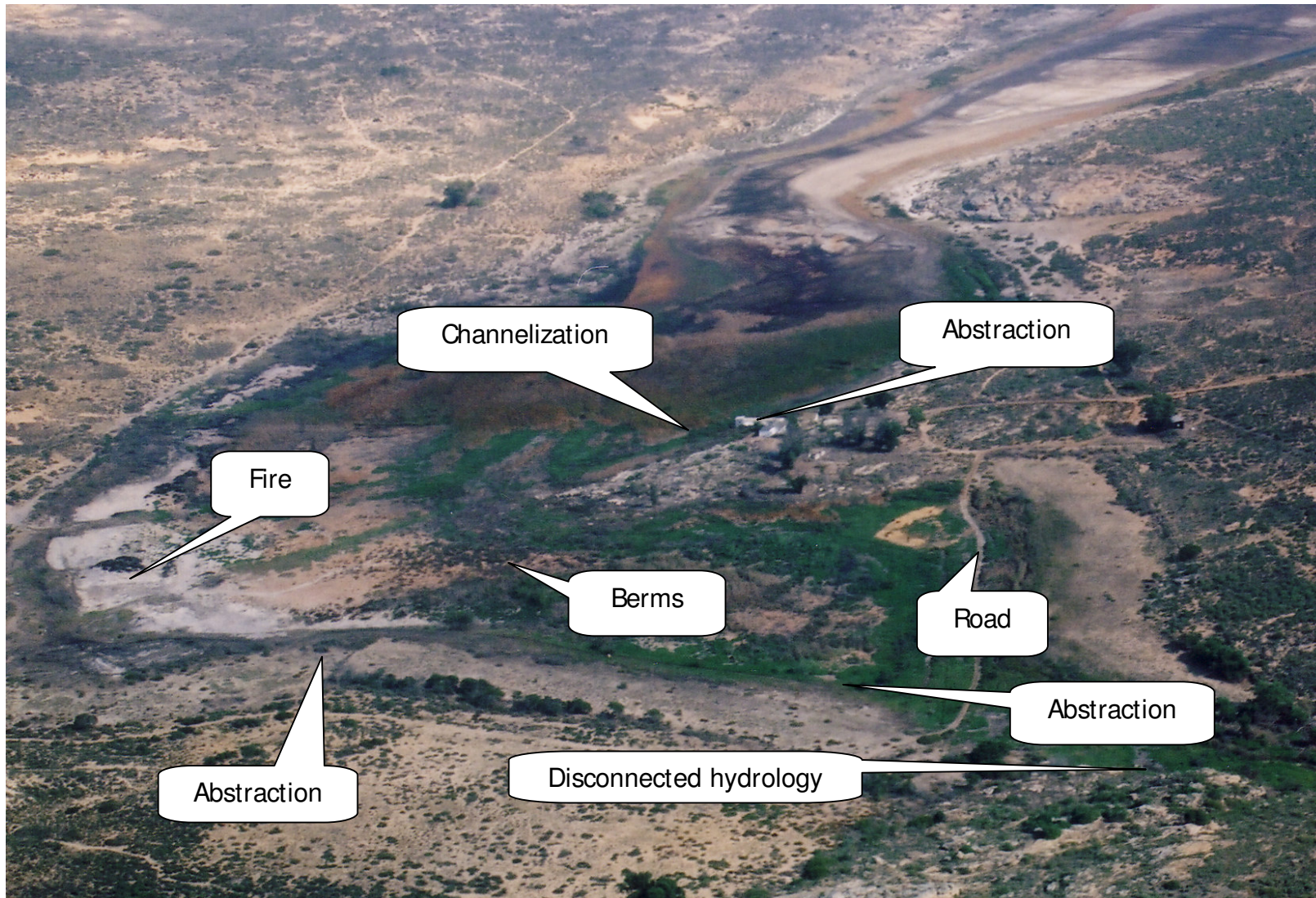


Figure E2: Aerial view of the Wadrif wetland, looking south, and highlighting the major impacts



Figure E3: Topography of the Wadrif wetland (extent of wetland demarcated with green shaded area; arrow shows water flowpath)

3. REFERENCE CONDITIONS

The Langvlei River leaves the Langvlei (Boplaas) plateau and wetland and descends through a short kloof onto the coastal plain. The river discharges into a small valley confined to the north by rock and to the east and south by rising ground (see Figure 3). The river passed through this area in a bedrock channel following essentially the northern edge of the valley, before widening out over an alluvial fan at the head of the Wadrif Pan.

A combination of overbank flooding, backing up of water levels in the pan, and the discharge of groundwater (especially along the eastern and southern shores of the wetland – see Figure 3) created a permanently wet (soggy) area. The discharge of fresh groundwater, and/or the close proximity of groundwater to the surface, resulted in the formation of a dense ‘riverine’ fringe of palmiet (*Prionium serratum*) along the eastern and southern fringes of the wetland – typical of other western Cape palmiet-lined river channels. These areas graded westwards down a shallow gradient into (dynamic) terraces of salt marsh vegetation (*Sarcocornia*) at or above the high water mark of the pan. The course of the Langvlei River, the water quality of which changes from fresh to brack during each hydrological cycle, was delineated by a dense and tall fringe of fluitjiesriet (*Phragmites*). Slightly elevated areas of the wetland associated with freshwater discharge were dominated by stands of the woody *Psoralea* sp., this tree being a key indicator of sustained fresh groundwater nodes. Other species would have included *Juncus*, *Cyperus*, *Mariscus*, *Ficinia*, *Schoenoplectus*, *Bolboschoenus*, *Typha*, *Cliffortia*, *Kniphofia*, *Conyza*, *Berzelia*, *Pennisetum*, *Carpha*, *Rumex*, *Persicaria* and *Cotula*.

Much of the course of the mainstem of the Langvlei River from near the source to Wadrif comprised wetlands – remnants of some 17 such areas are evident from recent aerial photography. Many of these were associated with nodes of fresh groundwater discharge, arising from the Wadrif primary aquifer system, which sustained the local vegetation during the dry season. The Wadrif was an extension of, and similar in floral character to, the wetlands upstream of it.

During the dry season the course of the Langvlei transposed into a series of pools, with those in the lower reaches becoming increasingly saline. Nodes within the larger wetlands would have remained permanently wet through the year.

The wetland is situated at the confluence of surface and subsurface flows from the Langvlei system, as well as surface and sub-surface flows from the springs south-east of the wetland. These springs are characterized by tall and dense forests of *Psoralea* as overstory to a varied assemblage of facultative and obligate wetland flora. Surface discharge of very fresh water within these areas flowed overland to join with the course of the Langvlei just upstream of the descent onto the coastal plain. These surface flows were perennial.

In terms of functionality the wetland provided hydraulic energy dissipation, limited sediment retention, habitat, refugia, detrital energy loss to the Wadrif Pan and water supply to the pan during the dry season. As the pans evaporated and dried shrinkage of the water surface and movement of biota would have been eastwards towards the wetland.

4. PRESENT ECOLOGICAL STATUS (PESC)

TABLE E1: WADRIF WETLAND – PRESENT ECOLOGICAL STATUS ASSESSMENT

<i>Component</i>	<i>Motivation</i>
Hydrology	Severely impacted as a consequence of abstraction. The water balance of the G30F Quaternary catchment shows a net annual loss of 30 MCM.
Hydraulics and hydraulic (surface) connectivity	Severely impacted as a consequence of groundwater mining, sumps, diversions, roads, paths, berms and causeways, forced infiltration and vegetation removal.
Groundwater dependence	Severely impacted as a consequence of groundwater mining.
Littoral and riparian vegetation	Large areas removed. Other areas affected by grazing, fires and dessication.
Loss of wetland area	Severe. Some 60% of the previously fresh character wetland has been permanently lost as a consequence of sustained and extreme dessication, compounded by fires that have destroyed the seedbank and precluded reseeded. An additional 30% has been affected by farming, grazing and activities related to water mining.
Water quality	Insufficient information but early onset of brack to saline conditions has been exacerbated. Mild to moderate eutrophication and grazing-related nutrient loading anticipated.
Phytoplankton	Not relevant.
Macroalgae	Insufficient information.
Zooplankton	No information.
Zoobenthos	No information.
Fish	Large proportion of refugia for <i>Galaxias</i> and <i>Sandelia</i> lost.
Birds	Reduced to loss of vegetation cover and tall woody species, as well as access to fresh water.
Herpetofauna	Insufficient information but not likely to be relevant at the aquatic ecosystem level.
Mammals	Corridor value severely impaired as a consequence of physical barriers, sumps, causeways, dams, fences and reduced water availability.
OVERALL PESC	F (Critically impaired)
TRAJECTORY OF CHANGE	Negative (-)

5. ECOLOGICAL STATUS CLASS (EISC)

TABLE E2: WADRIF WETLAND: ECOLOGICAL IMPORTANCE CLASS ASSESSMENT

<i>Determinants</i>	<i>Natural Score</i>	<i>Present Score</i>	<i>Comments</i>
Biota			
Rare /endangered	3	3	Two species of indigenous fish.
Unique (endemic/isolated)	3	3	Unique vegetation signatures. Two species of indigenous fish having the possibility of being genetically distinct from other isolated populations
Intolerant (flows, quality)	4	4	The wetland is highly susceptible to reductions in ground- and surface hydrology.
Species richness	3	3	High.
Habitat			
Refugia	3	3	Only vegetated freshwater node on the coastal plain of the Langvlei.
Sensitivity to hydrology	4	4	Very sensitive
Sensitivity to water quality	3	3	Moderate to highly sensitive depending on groundwater availability in the root zone.
Migration route	3	3	Highly important.
Nursery area(s)	3	3	Two species of indigenous fish.
Conservation importance	3	3	Complementary RAMSAR value.
Functional importance	3	3	Very high. Energy generation (detritus) for the Wadrif Pan.
Wetland production services	1	1	Not relevant.
Median Score	3	3	
IMPORTANCE RATING	HIGH (B)	HIGH (B)	

The assessment is made with a Medium to High level of confidence.

6. DEFAULT ECOLOGICAL STATUS CATEGORY (DESC)

Not provided for by RDM.

7. ECOLOGICAL MANAGEMENT CATEGORY (TARGET, EMC)

It is recommended that a minimum of a Category C (subject to revision following higher-level [Intermediate] assessment) level of Reserve be set for the Wadrif Wetland.

8. PRELIMINARY RESERVE (PWR) SPECIFICATION, WADRIF WETLAND

TABLE E3: WADRIF WETLAND: PRELIMINARY RESERVE WATER SPECIFICATION

<i>Component</i>	<i>Requirement</i>
Period of inundation	Perennial wetness to surface. Standing pools of water within the stands of palmiet.
Depth	Not relevant. Wetland is essentially on a descending bend in the river, and should evidence groundwater discharge.
Downward seepage losses	Moderate to high
Groundwater discharge	High, quantity undetermined.
Evaporation loss	Exacerbated by evapotranspiration
Contribution from groundwater	Significant
PWR Volume requirement	Surface component will be met by IFR. However, a significant proportion of the EFR will be required from groundwater. This is to be addressed following integration with groundwater component. Volume of the groundwater component has crucial and important implications for the Wadrif Pan.
Interannual frequency for meeting PWR	Annually.

SECTION F

WATER REQUIREMENTS (Preliminary Rapid Reserve) – WADRIF PAN

1. INTRODUCTION

This section details the results of the specialist deliberations for the Wadrif Pan system. The Wadrif Pan is an elongated (2 km length) seasonal pan terminating in a blind estuary (see Figure E1). The pan, a component of the Langvlei River, has its upstream end a short distance downstream of where the river discharges onto the coastal plain. The longitudinal continuity of the pan is interrupted by a causeway and a railway (ISCOR Sishen Saldanha) railway embankment.

1.1 Methodology

No RDM methodology is available at any level (Preliminary – Comprehensive) for the determination of EFRs for seasonal pans in arid environments. Furthermore, no process is available for the integration of riverine, groundwater and surface water requirements in interlinked and interdependent systems such as the Langvlei/Wadrif. Accordingly, the following pilot approach was employed for this preliminary determination of the water requirements, in terms of **quantity and timing**, for the Wadrif Pan.

- 1) Identify and describe the reference conditions;
- 2) Determination of the Present Ecological Status Class (PESC) using the Wetland Rehabilitation and Assessment Protocol (WRAP) (Southern Waters, in development);
- 3) Determine the present hydrological character of the system;
- 4) Determination of the Ecological Importance (ESC) of the system – using a specialist workshop process and other pertinent information;
- 5) Identification of key indicators that support the identification of water levels and durations of inundation;
- 6) Determine the Desired Ecological Status Class (DESC);
- 7) Determine the (preliminary) water requirements (PWR) to meet the DESC;
- 8) Compare and contrast the PWR with the availability of water from the IFR assessment in order to link the PWR to the system hydrology;

Specify the degree of confidence in the recommendations, and identify such further work as may be required to develop the required level of understanding.



Figure F2: Views of the Wadrif Pan, looking east from the railway line, showing (left) pan full, and (right) dry. Arrow indicates position of waters edge at the specified wet season maximum level.

2. REFERENCE CONDITIONS

The Wadrif Pan covers approximately 250 ha and comprises three components: The upper pan to the east of the central (road) causeway, the lower pan between the causeway and the railway embankment, and the backshore pan or lagoon between the ridge of coastal dunes and the railway line.

The floor of the pan is essentially flat and level, with the exception of the gradient upward into the wetland. The pan lies at the terminus of the Langvlei River system, a system originally typified by extensive longitudinal tracts of wetland, fed by both surface and ground water.

The Wadrif Pan is endorheic (internally draining or emptying as a consequence of prolonged evaporation). Filling of the pan would have typically commenced from as early as April, but mainly during June-July, with the pan filling to an average depth of between 0.8 and 1.0 m. The outlet of the pan to the sea has been closed during the recent geological lifespan of the system, and outward breaching were extremely infrequent. The only recorded (manual) breaching took place during the 1920s (*circa* 1921 according to local records).

Vegetation surrounding the pan would have been sparse, primarily comprised of *Sarcocornia* demarcating the high water mark, and *Juncus* upland thereof. *Phragmites* and/or *Typha*, together with *Schoenoplectus* and *Bolboschoenus* around the freshwater springs in or above the littoral zone.

During a typical year water would have remained in the pan until November/December, with late rains extending this into January. On average, standing water would have been present in the pan for between 6 and 8 months of each year. Following the cessation of inflows the pan would progressively dry out as a consequence of evaporation, and with increasing concentration of the, primarily, geologically-derived salinity to conditions of hypersalinity. The pattern of filling and drying would have been characterized by marked inter- and intra-annual variability. Sustained baseflows well into the dry season would have been provided by discharge from the extensive areas of wetlands in the catchment. While the pan would not have filled completely on an annual cycle, the surface of the pan would have been inundated, provided necessary although undefined stimuli to the micofauna.

The relationship between volumes and the characteristics of inundation of the pan (area and depth) are provided in the accompanying Appendix (Section F1- Appendix).

The nett (after evaporation) water requirements for the filling of the pan to the vegetation-derived high water mark (see Figure F2) would have been of the order of 5 MCM+, i.e. a significant proportion of the 6.2 MCM virgin MAR. At this stage it is not known what proportion of the inflow to the pan would have been derived from groundwater and, in particular, how this source of water would have sustained water levels after the end of the wet season. It is likely that this contribution would have been volumetrically and temporally significant. Isolated springs occurred throughout the catchment inclusive of around the shorelines of the pan. These would have supported local nodes of vegetation, as well as maintaining water levels in areas of the pan. This contribution is likely to have been highly important to the annual hydrological cycle of the pan.

Nutrient cycling in the pan would have been based on a finely balanced cycle. The onset of rains and inflows into the pan would concomitantly have introduced nutrient-bearing sediments and plant detritus (from the upstream wetlands). Freshening of conditions in the pan would have triggered the annual cycles with the salt marshes, as well as initiating germination of rooted submerged macrophytes (pondweeds). Nutrient losses during the dry season would have been exacerbated by wind action (aeolian erosion). The development of a standing stock of macrophytes would have been followed by the development of zooplankton and zoobenthos populations, and heralded conditions suitable for the arrival of coastal migrant birds (see avifaunal specialist report elsewhere in this document).

The Wadrif Pan, together with the other Sandveld pan systems and the Verlorenvlei/Redelinghuys wetland, are extremely important for the life cycles of pan coastal and intra-African migrant birds prior to their moving inland to complete their breeding cycles in the summer rainfall regions of South Africa. The Wadrif Pan is considered to be more valuable in RAMSAR terms than the Verlorenvlei system (Dr A. Williams, Avian Demography Unit, University of Cape Town, by letter), and one of the most important localities for birds within the winter rainfall region of South Africa.

The feeding actions of particularly flamingoes, played a key role in the finely-balanced nutrient cycling and primary and secondary production cycles of the pan. The stirring action caused by the feet of these birds, plus the nutrient contribution from their urine and faeces, constitute key elements of the nutrient cycle. A temporally varied and successional assemblage of flora and fauna would have occurred during the period of changing water chemistry (increasing salinity) and declining water levels.

Tidal intrusion as dune overwash occurred during high tides and storm periods, with limited numbers of fish entering the pan by this means. These fish would have either been caught by artisanal fishermen, or died during the drying out of the pan during the summer.

3. PRESENT ECOLOGICAL STATUS (PESC)

TABLE F1: WADRIF PAN – PRESENT ECOLOGICAL STATUS EVALUATION

<i>Component</i>	<i>Motivation</i>
Hydrology	Severely impaired, in terms of both quantity and timing (later onset), as a consequence of large-scale upstream abstraction for irrigation and raw potable water, as well as the loss of wetlands in the catchment. This impact has become extreme during the past 20 years following the increase in abstraction related to the introduction of centre pivot irrigation systems. The annual availability of standing water has reduced from 6-8 months to as little as 1 month between 1980 and 2000.
Hydraulics and hydraulic (surface) connectivity	Moderately impaired as a consequence of the road causeway, and severely as a result of the railway embankment. The barrier caused by the road and the single culvert has resulted in shrinking and narrowing (hourglass impact) of the pan, with upstream sediment deposition and a change in bed levels.

<i>Component</i>	<i>Motivation</i>
	The railway embankment has effectively isolated the upper and lower pans from the backshore lagoon area, and precluded any aquatic (upstream) connection between the two.
Littoral and riparian vegetation	Moderately to severely impacted as a consequence of grazing, and to a lesser extent from roads, pathways and clearing. Shoreline vegetation largely driven by direct inundation and groundwater influences and thus largely disconnected from the hydrological condition of the pan. The system is now considerably less 'fresh' during the early inundation cycle than it was 20 years ago.
Water quality	Insufficient information, but likely to have severely reduced inputs of low salinity water during the early to mid wet season. Imbalanced nutrient cycling as a consequence of changes in hydrology; eutrophication from grazing animals, particularly upstream of the causeway.
Phytoplankton	Insufficient information available, but probable high level of impact due to shortened period of inundation and delivery of sediments and nutrients. Successional changes probably largely towards the short-lived halotolerant genera.
Macroalgae	Nil information available.
Zooplankton	Available information suggests impoverished levels of secondary (heterotrophic) production.
Zoobenthos	Available information suggests typical taxa present, but in severely reduced numbers.
Fish	Not a key indicator of this temporary system. Any fish that are washed into the backshore lagoon area will not be able to reach the pans areas to the east of the railway embankment.
Birds	Severely reduced numbers of migrant birds as a consequence of the impacted hydrology. Extant bird species are highly vulnerable to the loss of habitat, and the pan has a very high level of importance for pan coastal migrant species. Barriers caused by causeway and railway embankment are exacerbated by overhead powerlines. The feeding of small numbers of birds is sustained in the upper pan until approximately November as a result of leakage from a riparian spring into the upper pan.
Herpetofauna	Not a key indicator at the level of the pan within its local environment.
Mammals	Insufficient information but evidence that otters (presence of couches and scat) move up and down the system.
OVERALL PESC	E (Severely impaired)
TRAJECTORY OF CHANGE	Negative (-)

4. ECOLOGICAL STATUS CLASS (EISC)

TABLE F2: WADRIF PAN: ECOLOGICAL IMPORTANCE CLASS EVALUATION

<i>Determinants</i>	<i>Natural Score</i>	<i>Present Score</i>	<i>Comments</i>
Biota			
Rare /endangered	4	4	White pelican
Unique (endemic/isolated)	4	4	Pan coastal and intra-African migrant bird assemblages
Intolerant (flows, quality)	4	4	Maintenance of hydrology crucial
Species richness	4	4	Avifaunal
Habitat			
Refugia	3	3	Presence of water for bird protection
Sensitivity to hydrology	4	4	Habitat dependent on timing and volume
Sensitivity to water quality	2	3	Increased sensitivity - impaired hydrology
Migration route	4	4	Pan coastal migrant birds
Nursery area(s)	3	3	Key avifaunal conservation area
Conservation importance	4	4	Key avifaunal conservation area = complementary RAMSAR site.
Median Score	4	4	
IMPORTANCE RATING	HIGH	HIGH	

The assessment is made with a Medium to High level of confidence.

Note: The general area has high social importance from its historical and cultural perspectives.

5. DEFAULT ECOLOGICAL STATUS CATEGORY (DESC)

Not provided for by RDM.

6. ECOLOGICAL MANAGEMENT CATEGORY (TARGET, EMC)

It is recommended that a provisional minimum Category C (subject to revision following higher-level [Intermediate] assessment) Reserve level be set for the Wadrif Pan.

7. PRELIMINARY RESERVE (PWR) SPECIFICATION, WADRIF PAN

TABLE F3: WADRIF PAN: PRELIMINARY RESERVE WATER SPECIFICATION

<i>Component</i>	<i>Requirement</i>
Period of inundation	July to December, with water entering the system from April (standing water present for between six and eight months of the annual cycle).
Depth	Wet season maximum 1.5 m AMSL (1.0 m above lowest point of pan). This depth to be achieved during July to August. Wet season minimum. 0.8 m AMSL (provisional). Dry season maximum. 0.55 m AMSL (0.15 m above lowest point of pan during 1 st week of December).
Downward seepage losses	Negligible (estimated <0.001 m d ⁻¹)
Evaporation loss	1.2- 1.6 m a ⁻¹
Contribution from groundwater	Undetermined
PWR Volume requirement	5 MCM (wet year), 1.5-2.5 MCM dry year.
Interannual frequency for meeting PWR	2/3 years (provisional)

SECTION G

WATER REQUIREMENTS (Preliminary Rapid Reserve) JAKKALSVLEI

1. INTRODUCTION

This section details the results of the specialist deliberations pertaining to the setting of a preliminary Reserve for Jakkalsvlei. Jakkalsvlei is a small (approx. 0.5 x 1.4 km), narrow seasonal vlei that, until recently, discharged via a small estuarine linkage to the sea just north of the town of Lamberts Bay. This linkage to the sea is now closed, ostensibly as a consequence of increased sheltering of the coastline and widening of the beach following connection of the harbour breakwater to Bird Island. In addition the dynamics of the vlei mouth were significantly altered by the construction of a berm across the outlet (early 1990s) in an attempt to retain water in the vlei for longer periods – this as a consequence of reduced water availability in the Wadrif Pan (Dr A. Williams, personal communication).

2. METHODOLOGY

No RDM methodology is available at any level (Preliminary – Comprehensive) for the determination of EFRs for seasonal pans in arid environments. Furthermore, no process is available for the integration of riverine, groundwater and surface water requirements in interlinked and interdependent systems such as the Jakkalsvlei. Accordingly, the following pilot approach was employed for this preliminary determination of the water requirements, in terms of **quantity and timing**, for Jakkalsvlei.

- 1) Identification and description of the reference conditions;
- 2) Identification of the drivers, cause and effect functions and stressors underpinning the ecological functioning of the system;
- 3) Undertaking of preliminary level hydrology, hydraulics, water quality and biotic (floral and faunal – inclusive of sediments) verification of the condition of the wetland and its association with its upland (terrestrial) environment, and longitudinal connections up- and downstream;
- 4) Estimation of the present level of eutrophication and the impact thereof, if any, on the extant functioning of the system;
- 5) Determination of the Present Ecological Status Class (PESC) using the Wetland Rehabilitation and Assessment Protocol (WRAP) (Southern Waters, in development);

- 6) Determination of the Trajectory of Change of the identified key components of system functionality;
- 7) Determination of the Ecological Importance (ESC) of the system – using a specialist workshop process and other pertinent information;
- 8) Identification of key indicators that support the identification of water levels and durations of inundation;
- 9) Determination of the Desired Ecological Management Class (EMC);
- 10) Determination of the (preliminary) water requirements (PWR) necessary to meet the EMC;
- 11) Comparison of the PWR with the availability of water from the IFR assessment and other assessments in order to link the PWR to the system hydrology;
- 12) Specification of the degree of confidence in the recommendations, and identification of such further work as may be required to develop the required level of understanding.

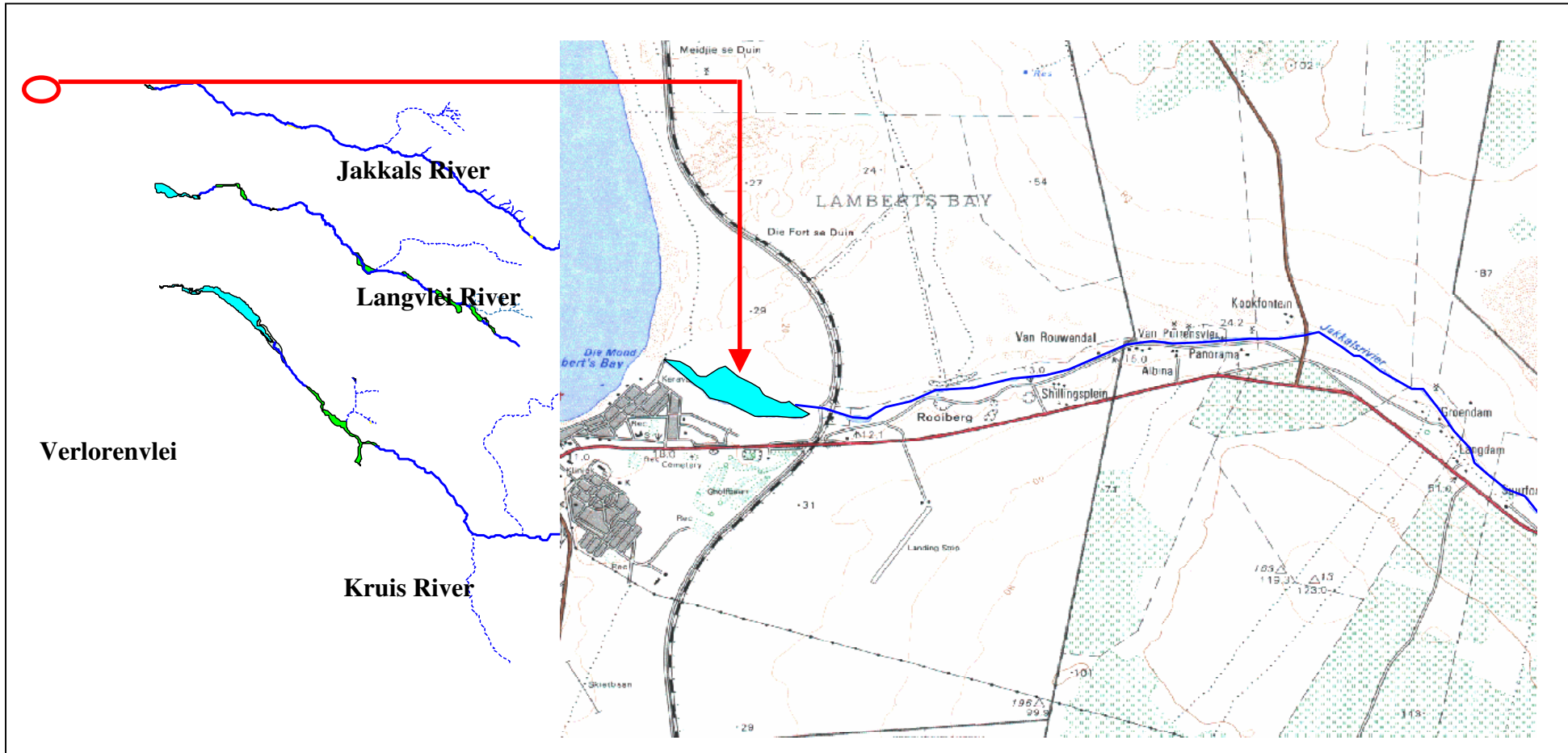




Figure G2: View of the (full) Jakkalsvlei looking east from the berm. Inserts show (bottom left) aerial view of full vlei and (right) dry vlei (head of vlei at bottom right to the left of the road and railway line).

3. REFERENCE CONDITIONS

The Jakkalsvlei is a small (52 ha) narrow V-profile coastal vlei fed by the Jakkals River. The vlei functioned as a brackish to saline coastal lagoon for much of the year, receiving water bearing geologically-derived salts from the catchment, or marine salts via tidal ingress. The Jakkals River downstream of Graafwater is a naturally brack environment.

The vlei was surrounded by robust upland vegetation, with a band of salt marsh vegetation inbetween. A number of small springs entered the vlei at various locations around the shoreline.

The volume of the vlei (at the present Full Supply Level dictated by the weir, 4.3 m MSL) is 683 000 m³ (as surveyed during March 2003, DWAF Geomatics Directorate). Prior to impoundment the area and volume of the vlei would have been considerably smaller and governed by the variable height of the beach (sanddune) berm.

During a typical year water would have remained in the vlei until November/December, with late rains extending this into January. Evaporation would be offset by sustained low flows. Following the cessation of inflows the pan would rapidly dry out as a consequence of evaporation, and with increasing concentration of the, primarily, geologically-derived salinity to conditions of hypersalinity. The pattern of filling and drying would have been characterized by marked inter- and intra-annual variability, as well as wide-ranging fluctuations in water levels. Scouring of the lagoon would have occurred during (infrequent) floods. During the dry season the river would have flowed as a narrow central stream through the vlei.

The relatively short temporal nature of inundation of this vlei would have precluded the establishment of rooted macrophytes other than occasional developments of stands of pondweed. Macroalgae, including *Enteromorpha* spp., would have predominated, and the primary invertebrate food source during summer is likely to have been brine shrimp (*Artemia* sp. or large cladocerans such as *Daphnia*.)

The feeding actions of particularly flamingoes, played a key role in the finely-balanced nutrient cycling and primary and secondary production cycles of the vlei. The stirring action caused by the feet of these birds, plus the nutrient contribution from their urine and faeces, constitute key elements of the nutrient cycle.

Tidal intrusion would have been relatively frequent resulting in fish entering the vlei. These fish would have either been caught by artisanal fishermen, or died during the drying out of the pan during the summer.

4. PRESENT ECOLOGICAL STATUS (PESC)

TABLE G1: JAKKALSVLEI – PRESENT ECOLOGICAL STATUS EVALUATION

<i>Component</i>	<i>Motivation</i>
Hydrology	Severely impaired as consequence of (a) impoundment in the upper reaches of the catchment; (b) mining of groundwater and (c) infestation by aliens.
Hydraulics and hydraulic (surface) connectivity	Moderately impaired as a consequence of the road causeway and railway embankment at the head of the lagoon, and severely by the stabilization of the beach and construction of the berm.
Littoral and riparian vegetation	Slightly impacted as a consequence of grazing to the north. Western shoreline adjacent to dunes has been narrowed and impaired by the construction of the berm, without provision of access routes.
Water quality	Insufficient information, but likely to have severely reduced inputs of low salinity water as a consequence of dams in the upper catchment. System hypersaline (EC = 7800 mS/m; Na = 18250 mg/l) just prior to the pan drying up completely.
Phytoplankton	Insufficient information available. Prevailing water chemistry likely to support marine and halotolerant diatom species.
Macroalgae	<i>Enteromorpha</i> dominant in lower reaches. Some <i>Rhizoclonium</i> in mid-reach.
Zooplankton	Insufficient information. Strong development of cladocerans (<i>Daphnia</i>) at the time of this assessment.
Zoobenthos	Available information suggests typical taxa present, but in severely reduced numbers.
Fish	Not a key indicator for this temporary system.
Birds	Severely reduced numbers of nationally-important populations as a consequence of the impacted hydrology. Extant bird species are highly vulnerable to the loss of habitat, and the pan has a very high level of importance for pan coastal migrant species.
Herpetofauna	Not a key indicator at the level of the pan within its local environment.
Mammals	Insufficient information.
OVERALL PESC	E (Severely impaired)
TRAJECTORY OF CHANGE	Negative (-)

5. ECOLOGICAL STATUS CLASS (EISC)

TABLE G2: WADRIF PAN: ECOLOGICAL IMPORTANCE CLASS EVALUATION

<i>Determinants</i>	<i>Natural Score</i>	<i>Present Score</i>	<i>Comments</i>
Biota			
Rare /endangered	1	1	White pelican
Unique (endemic/isolated)	1	1	Nationally important populations. Undescribed species of <i>Polypedilum</i> .
Intolerant (flows, quality)	3	3	Maintenance of hydrology crucial to sustaining the ecosystem on an annual cycle.
Species richness	2	2	Avifauna
Habitat			
Refugia	2	2	Presence of water for bird protection. Complementary to Verlorenvlei and compensatory for Wadrif.
Sensitivity to hydrology	3	3	Habitat dependent on timing and volume
Sensitivity to water quality	2	2	Increased sensitivity - impaired hydrology
Migration route	1	1	Pan coastal migrant birds
Nursery area(s)	2	2	Avifaunal conservation area
Conservation importance	2	2	Avifaunal conservation area
Median score	2	2	
IMPORTANCE RATING	MOD	MOD	

The assessment is made with a Medium level of confidence.

6. DEFAULT ECOLOGICAL STATUS CATEGORY (DESC)

Not provided for by RDM.

7. ECOLOGICAL MANAGEMENT CATEGORY (TARGET, EMC)

It is recommended that a Category C (subject to revision following higher-level [Intermediate] assessment) Reserve be allocated to the Jakkalsvlei Pan.

8. PRELIMINARY RESERVE (PWR) SPECIFICATION, JAKKALSVLEI PAN

TABLE G3: JAKKALSVLEI: PRELIMINARY RESERVE WATER SPECIFICATION

<i>Component</i>	<i>Requirement</i>
Period of inundation	July to November/December
Depth	1 m average depth
Volume at average depth	0.155 MCM
Surface area at average depth	25 ha
Downward seepage losses	Negligible (estimated $<0.001 \text{ m d}^{-1}$)
Evaporation loss	1.2 m a^{-1}
Contribution from groundwater	Undetermined
PWR Volume requirement	0.5 MCM
Interannual frequency for meeting PWR	1 in 2 years (provisional)

SECTION H

WATER REQUIREMENTS (Water Level) (Preliminary Rapid Reserve) VERLORENVLEI COASTAL LAKE

1. INTRODUCTION

This section details the results of the specialist deliberations for the Verlorenvlei coastal lake, inclusive of considerations of the requirements for the estuary. The Verlorenvlei is a narrow, elongated (13.4 x 1.5 km) coastal lake terminating in a sinuous seasonally-open estuarine channel (see Figure 1).

2. METHODOLOGY

The extant RDM methodologies provide for the determination of water level-based Reserve for lacustrine systems. The methodology as published is preliminary, and does not allow for integration with other components of the Reserve process, particularly insofar as hydrological linkages are concerned. Accordingly, the following modified approach was employed for this preliminary determination of the water requirements, in terms of **water levels and timing** for Verlorenvlei.

Coastal Lake

- 1) Identification and description of the reference conditions;
- 2) Undertaking of preliminary level hydrology, hydraulics, water quality and biotic (floral and faunal – inclusive of sediments) verification of the condition of the lake;
- 3) Estimation of the present level of eutrophication and the impact thereof, if any, on the extant functioning of the system;
- 4) Determination of the Present Ecological Status Class (PESC) using the Wetland Rehabilitation and Assessment Protocol (WRAP) (Southern Waters, in development);
- 5) Determination of the Trajectory of Change of the identified key components of system functionality;
- 6) Determination of the Ecological Importance (ESC) of the system – using a specialist workshop process and other pertinent information;
- 7) Identification of key indicators that support the identification of water levels and durations of inundation;

- 8) Determination of the Desired Ecological Management Class (EMC);
- 9) Determination of the (preliminary) water requirements (PWR) necessary to meet the EMC;
- 10) Comparison of the PWR with the availability of water from the IFR assessment and other assessments in order to link the PWR to the system hydrology;
- 11) Specification of the degree of confidence in the recommendations, and identification of such further work as may be required to develop the required level of understanding.

Connection to the sea

- 1) Identification of the reference conditions;
- 2) Undertaking of preliminary level hydrology, water quality and biotic (floral and faunal – inclusive of sediments) verification of the condition of the lake's outlet channel (and with particular reference to the functionality of the channel as a corridor for ingress and egress of marine migrants to and from the lake);
- 3) Determination of the Present Ecological Status Class (PESC) in terms of the Desktop methodology contained in the RDM manual for estuaries;
- 4) Determination of the Ecological Importance (ESC) of the system – using a specialist workshop process and other pertinent information;
- 5) Identification of key indicators that support the identification of water levels and durations of inundation;
- 6) Determination of the Desired Ecological Management Class (EMC);
- 7) Determination of the (preliminary) water requirements (PWR) necessary to meet the EMC;
- 8) Comparison of the PWR with the availability of water from the IFR assessment and other assessments in order to link the PWR to the system hydrology;
- 9) Specification of the degree of confidence in the recommendations, and identification of such further work as may be required to develop the required level of understanding.

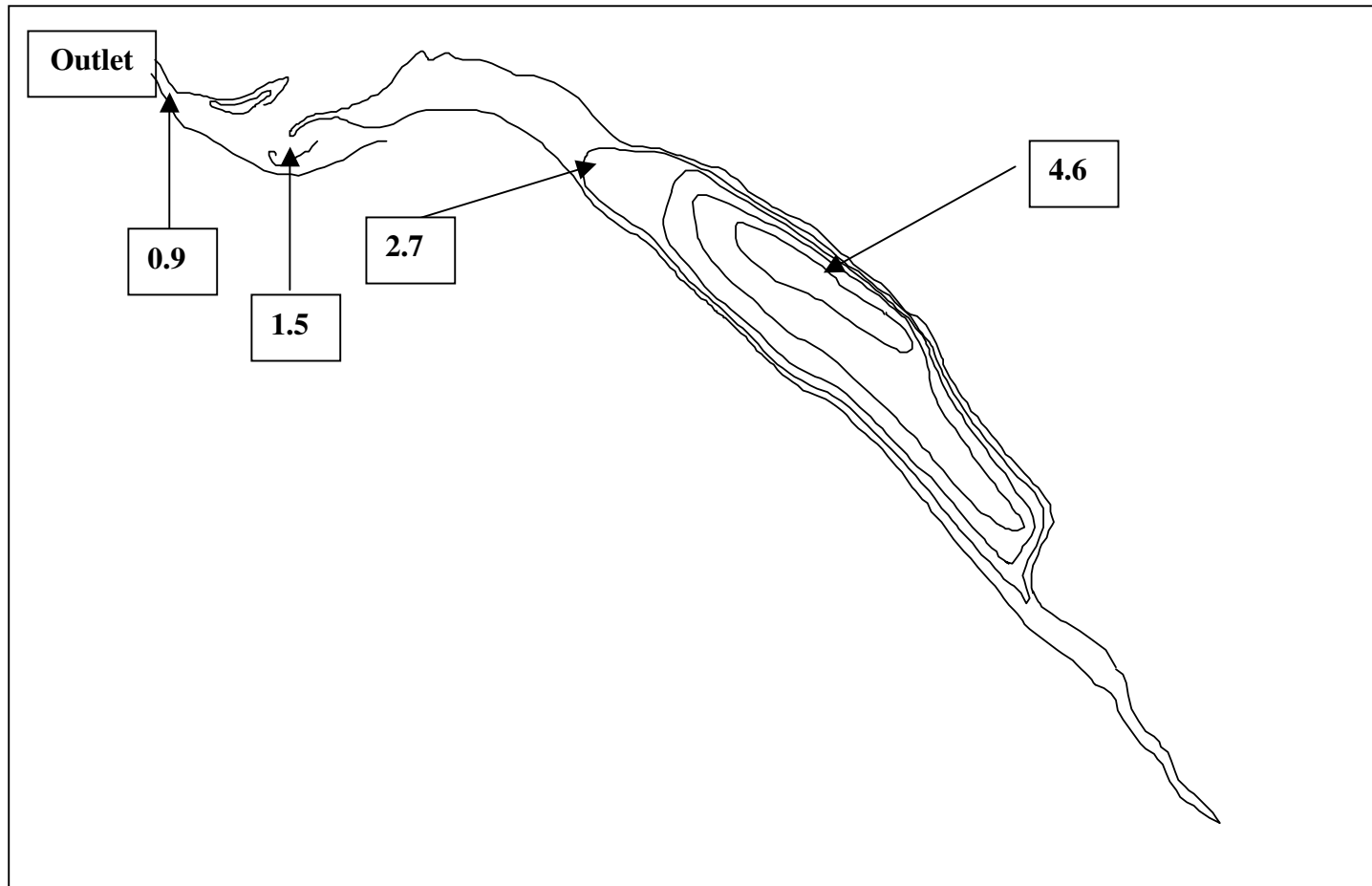


Figure 2: Morphology and bathymetry of Verlorenvlei

3. LAKE AND ESTUARY: REFERENCE CONDITIONS

(from CSIR-ECRU 1986, Grindley and Grindley, 1987; and Meadows et al., 1996)

“Verlorenvlei is the colloquial name given to the closed coastal estuarine lake, river and reed swamp system located at Elands Bay. The Verlorenvlei River and its tributaries are allogenic and intermittent, feeding the swamp only during the rainfall months of winter and early summer. The open water lake, which extends for 13 km and has a maximum width of 1.5 km, is linked to the sea by a narrow, hydraulically inactive estuary channel. Occasionally, winter flooding or high spring tides have been known to breach the sandbar which overlies the rock-barrier obstruction at the mouth, resulting in interchange between the sea and the lake”.

A number of springs enter the lake and wetland systems at various points along the northern shore.

The lake grades upstream from *Schoenoplectus* (? *Scirpus marginatus*) and *Phragmites* reed stands to *Typha* as the prevailing salinity decreases. The channel from Grootdrif to Redelinghuys is almost totally occluded by reeds. The wide variety of extensive habitat types, especially for birds, underpins the conservation value of the area.

“The origins of the catchment lie in the Piketberg and Olifants River mountains”. “The lake lies within the semi-arid to sub—arid region of the western Cape.” “Inter-annual rainfall frequency is high, but with 80% of the rainfall falling between April and September. Large evaporative losses occur during the summer.” Evaporation losses are compensated for, to an unknown by likely significant degree, by base- and interflows.

“Verlorenvlei has long been recognized by botanists for its high species diversity – this typical of an ecotonal area”. A wide range of terrestrial, semi-aquatic and aquatic plant species have been reported for the area (see Botanical specialist report).

Despite the irregular inter-annual frequency of mouth opening, the lake provides valuable habitat for large populations of marine migrants (see Specialist Fish Report undertaken for this study). The lake was also important for several indigenous species, notably *G. zebratus* and *B. burgi*.

4. LAKE PRESENT ECOLOGICAL STATUS (PESC)

TABLE H1: VERLORENVLEI – PRESENT ECOLOGICAL STATUS EVALUATION

<i>Component</i>	<i>Motivation</i>
Hydrology	Moderately impacted as a consequence of abstraction in the upper reaches of the main stem and all tributaries, as well as alien vegetation in middle reaches.
Hydraulics and hydraulic (surface) connectivity	Weirs in the upper reaches of Kruismans, Bergvallei, Krom Antonies, and large dam in the Witte. Disruptions to the bed of the Bergvallei.
Littoral and riparian vegetation	Longitudinal riparian habitat integrity study not included at this level. Riparian vegetation appears disturbed or altered over the greater length of the system.
Water quality	Minimally impacted at the gauged point – nil information available for the lake itself other than that generated from this investigation (See Table H1a).
Phytoplankton	Insufficient information but primary data from this assessment are comparable with those from previous <i>ad hoc</i> records.
Macroalgae	Insufficient information
Zooplankton	As expected – insufficient information.
Zoobenthos	As expected but possibly depauperate.
Fish	High importance for marine migrants. Indigenous freshwater species no longer present in lake.
Birds	Largely stable.
Herpetofauna	Not relevant at the aquatic level.
Mammals	Moderate to high importance but longitudinal connectivity interrupted.
OVERALL PESC	C
TRAJECTORY OF CHANGE	(-) but with strong potential for mitigation.

4.1 Water Quality

Table H1a summarizes the water quality in Verlorenvlei as during early and late summer - September 2002 and January /February 2003. The results are entirely typical of a coastal lake environment, i.e. slightly elevated salinities and low nutrient availability.

**TABLE H1a: VERLORENVLEI LAKE – SUMMARY OF WATER QUALITY DATA
as collected at Gauging Station G3R001**

<i>Date</i>	<i>PH</i>	<i>EC</i>	<i>Na</i>	<i>Mg</i>	<i>K</i>	<i>Ca</i>	<i>Cl</i>	<i>SO₄</i>	<i>TAlk</i>	<i>NO_x as N</i>	<i>TP</i>	<i>PO₄ as P</i>
Units>		mS/m	mg/ℓ									
Sep 02	8.4	204	283	63	8	38	616	58	106	0.062	-	0.020
Jan 03	9.3	315	498	77	12	54	-	58	150	0.080	-	<0.03
Feb 03	9.1	318	454	78	11	54	-	54	155	0.080	-	<0.03

The data reflect some concentration of salts as would be expected during the course of the dry season. Notwithstanding the fact that the lake was phosphorus limited during the period assessed, the phytoplankton assemblage was representative of a eutrophic lake. The assemblage mainly comprised cyanobacterial (= blue-green algal) genera (*Anabaena*, *Lyngbya*, *Anabaenopsis*, *Merismopedia*, *Microcystis*) and with minor contributions from chloro- (*Scenedesmus*) and bacillariophytes (*Cyclotella*, *Nitzschia*).

The algal assemblage was indicative of an elevation in trophic status that has been in place for some time, and probably reflects eutrophication-associated damage to the lower levels of the foodweb (e.g. depauperate zooplankton and coarse fish dominance).

5. LAKE ECOLOGICAL STATUS CLASS (EISC)

TABLE H2: VERLORENVLEI: ECOLOGICAL IMPORTANCE CLASS EVALUATION

<i>Determinants</i>	<i>Natural Score</i>	<i>Present Score</i>	<i>Comments</i>
Biota			
Rare /endangered	4	4	RAMSAR populations of birds; indigenous fish spp.
Unique (endemic/isolated)	4	4	Indigenous fish, bird populations and hitherto unknown spp. of invertebrate (<i>Polypedilum</i>).
Intolerant (flows, quality)	3	3	Water levels crucial for mouth opening.
Species richness	4	4	Very high throughout an extensive system.
Habitat			
Refugia	4	4	Very high level of provision of habitat and refugia.
Sensitivity to hydrology	3	3	Implications for mouth hydrodynamics.
Sensitivity to water quality	3	3	Sensitive to eutrophication.
Migration route	4	4	RAMSAR site.
Nursery area(s)	4	4	Extremely important for marine migrant fish, and birds.
Conservation importance	4	4	RAMSAR proclaimed (1991)
IMPORTANCE RATING	HIGH	HIGH	

The assessment is made with a **Medium** level of confidence.

Note: The general area has high social importance from its historical and cultural perspectives. The oldest homestead (circa 1710) was visited by Van der Stel and Lady Anne Barnard.

6. DEFAULT ECOLOGICAL STATUS CATEGORY (DESC)

Not provided for by RDM.

7. ECOLOGICAL MANAGEMENT CATEGORY (TARGET, EMC)

It is recommended that a Category B (definition of RAMSAR overriding status is not provided for in the relevant section of the RDM methodologies).

8. ESTUARINE CHANNEL - PRESENT ECOLOGICAL STATUS (PESC)

Verlorenvlei is not an estuary *per se*, rather a coastal lake with a channel connection to the sea. This statement is supported by the water chemistry, macrobenthos and fish assessments.

Because of the significance of the lake for marine migrant fish, the RDM Rapid Reserve Methodology for Estuaries was applied to the channel.

TABLE H3: VERLORENVLEI 'ESTUARINE' CHANNEL – PESC ASSESSMENT

Criterion	Description of change	Score	Confidence (H, M, L)
<i>Habitat-related or abiotic components</i>			
% of total recharge abstracted	90% abstracted	1	
Changes in seasonal inflow patterns	Reduction in low flows/flushing	3	
Changes in mouth condition		4	
Changes in water quality	Eutrophication evident	3	
Change in natural habitat (bed and bank and flow modifications)	Causeways	2	
Changes in riparian habitat (bank and floodplain)	Farming	3	
<i>Biotic components</i>			
Botanical importance		3	
Benthic invertebrates		3	
Fish		2	
Birds		3	
No of criteria assessed		10	
Mean PES score		2.6	L-M
PESC		C	

The methodology rates the PESC for Verlorenvlei as a Category C estuarine environment.

9. ESTUARY ECOLOGICAL STATUS CLASS (EISC)

TABLE H4: VERLORENVLEI ‘ESTUARINE’ CHANNEL – EISC ASSESSMENT

ECOLOGICAL IMPORTANCE AND SENSITIVITY OF ESTUARIES: VERSION 1(PRELIMINARY = DESKTOP)		
Rare, endangered or limited populations		
Habitat diversity (number of habitat types):		3
1. Open water surface		
2. Sand flats		
3. Mudflats		
4. Submerged macrophyte beds		
5. Intertidal salt marsh		
6. Supratidal salt marsh		
7. Reeds and sedges		
8. Mangroves		
9. Swamp forest		
10. Rocks		
11. Deep channels		
Rarity or unique features		5
Input to the sea		1
Modifying determinants	RAMSAR designation	5
No of criteria assessed		4
Mean score		3.5

Note: In terms of the methodology RAMSAR status invokes the highest EISC, namely “A” (Page D/6 RDM for Estuaries, Version 1, 1999).

10. PRELIMINARY RAPID RESERVE SPECIFICATION, VERLORENVLEI

10.1 Basis for Establishing the Water Level Reserve Conditions for Verlorenvlei

The water level has been provisionally set on observed conditions relating to the timing and duration of the mouth of Verlorenvlei being open to the sea in terms of providing passage for migrant fish into and out of the lake. The requirements for the latter are based on the findings of the Specialist Fish Report (see main body of this report). The opening (end-July 2002) and closing (end-September 2002) have been inferred from the water level records for the vlei (DWAF) (see Figure H3 and Table H5). The values set remain to be confirmed by a higher level of Reserve Determination. From the graph it is evident that the mouth opened during 1994, 1996/7, 1999, 2001 and 2002. The mouth was opened for the longest duration of these events during 1996 & 7.

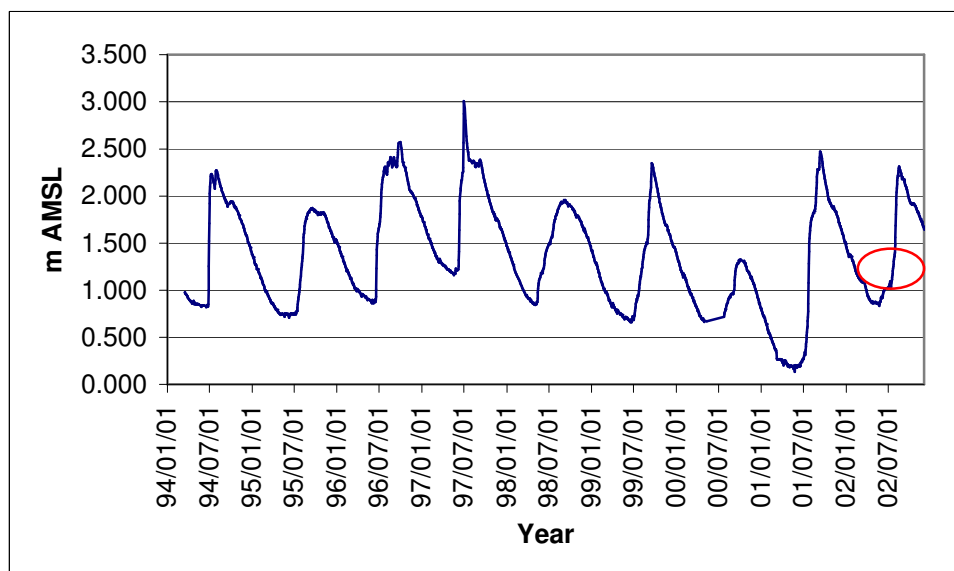


Figure H3: Water levels for Verlorenvlei for the period 1994-2002. The period covered by this study is circled.

TABLE H5: VERLORENVLEI: PRELIMINARY RAPID RESERVE WATER LEVEL SPECIFICATION

Component	Requirement/Motivation
Frequency and duration of opening	Twice in any single year (autumn, early winter and spring), or alternatively; A single extended period from winter through into spring.
Mouth open conditions	“Semi-closed”, i.e. continuous outflow with minimal seawater intrusion.
Water level (Mouth open)	2.20 m MSL
Water level (1.95 m MSL
Water level (Breaching)	Unknown but less than 2.5 m MSL

10.2 Confidence Level

This assessment is made with a **low to medium** level of confidence. The Reserve thus set, while being the minimum deemed necessary to sustain the PESC, remains to be confirmed by:

- Detailed hydrological analysis and water balance data;
- Greater resolution of the water level conditions pertaining to mouth opening, closing and drying out of the outlet channel during the summer;
- Comprehensive assessment of the lake littoral for zones having unique water level requirements;
- Detailed water quality assessment of the lake in terms of nutrient accumulation, nutrient balance and the need for flushing;
- Expansion and updating of the level of biotic understanding presently available for the lake.

10.3 Existence of Alleged Physical Barriers to Meeting the Reserve

Various reports have indicated that the 'causeway' in the outlet channel of the lake poses a barrier to the migration of fish, and that the road embankment beneath the railway line constitutes a similar impedence.

In this connection site visits made during January and February 2003 revealed that:

- The man-made causeway previously laid on the natural rock sill in the outlet channel has been removed;
- There are some remnants of the roadway still in place beneath the railway bridge on the downstream side, but these are unlikely to present any barrier to fish at the water levels prevailing when the mouth is open.

Accordingly the alleged barriers are not deemed to be detrimental to the hydraulics of the outlet channel.

APPENDIX (SECTION F)

INUNDATION SCENARIOS – WADRIF PAN

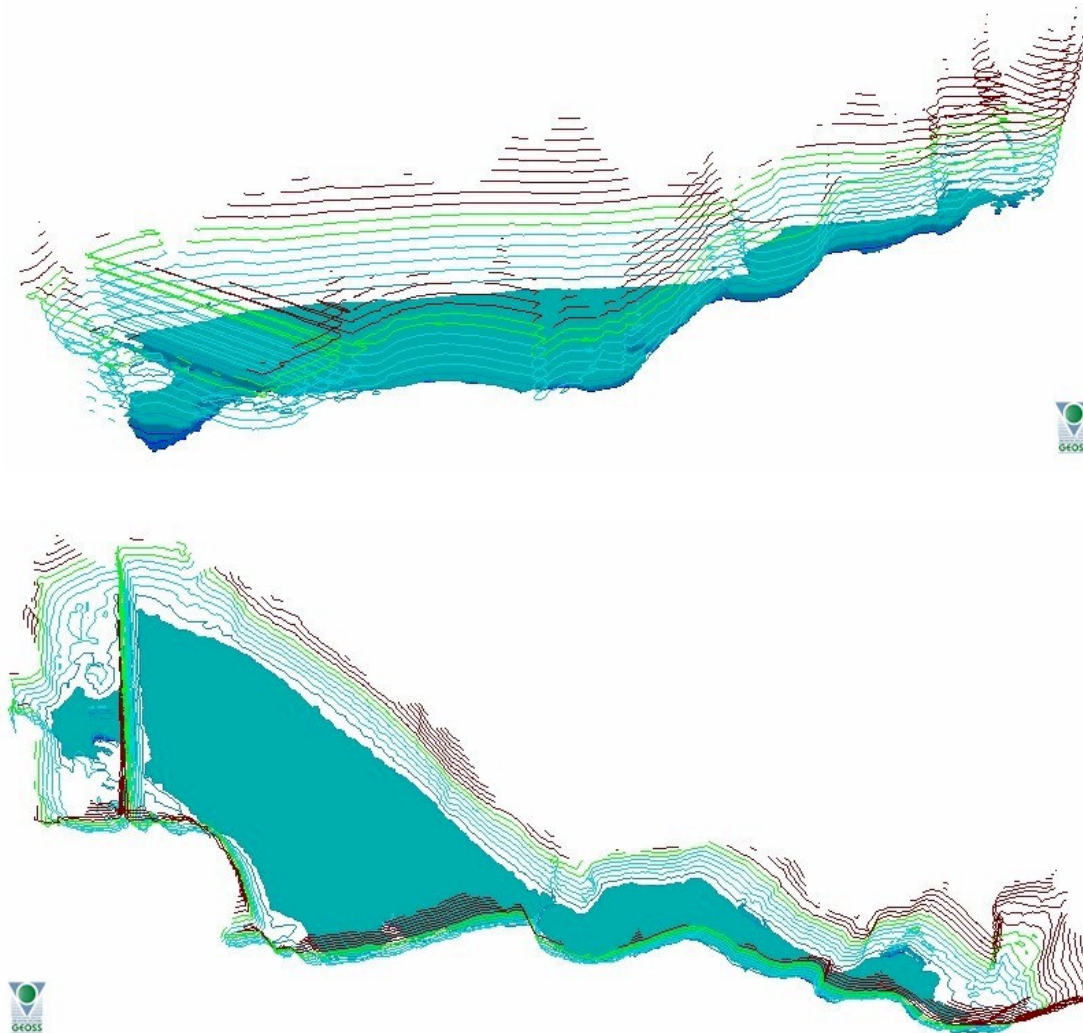


Figure 1: Pan filled to 1 m AMSL (one meter above mean sea level).

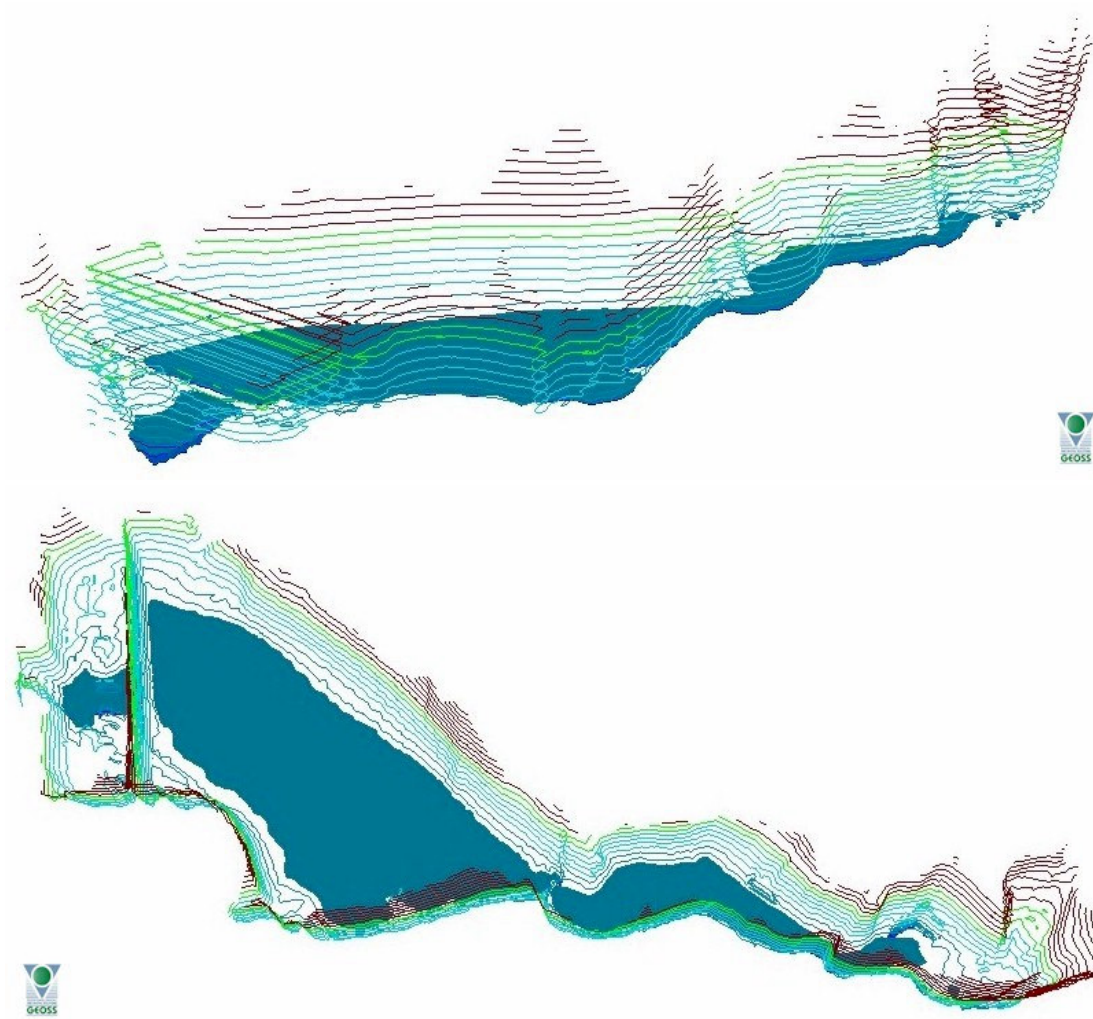


Figure 2: Pan filled to 0.7 m AMSL (one meter above mean sea level).

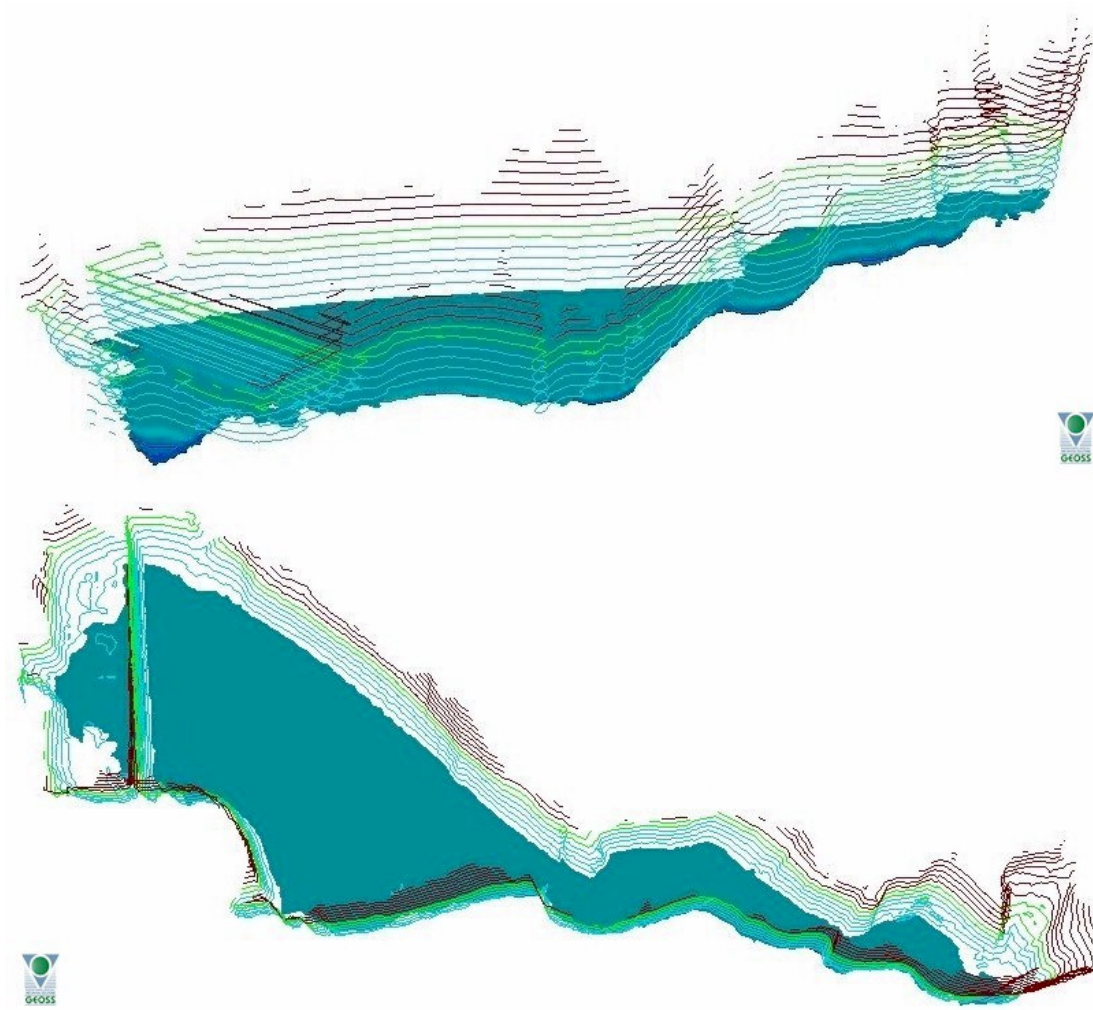


Figure 3: Pan filled with 2.5 million m³ of water

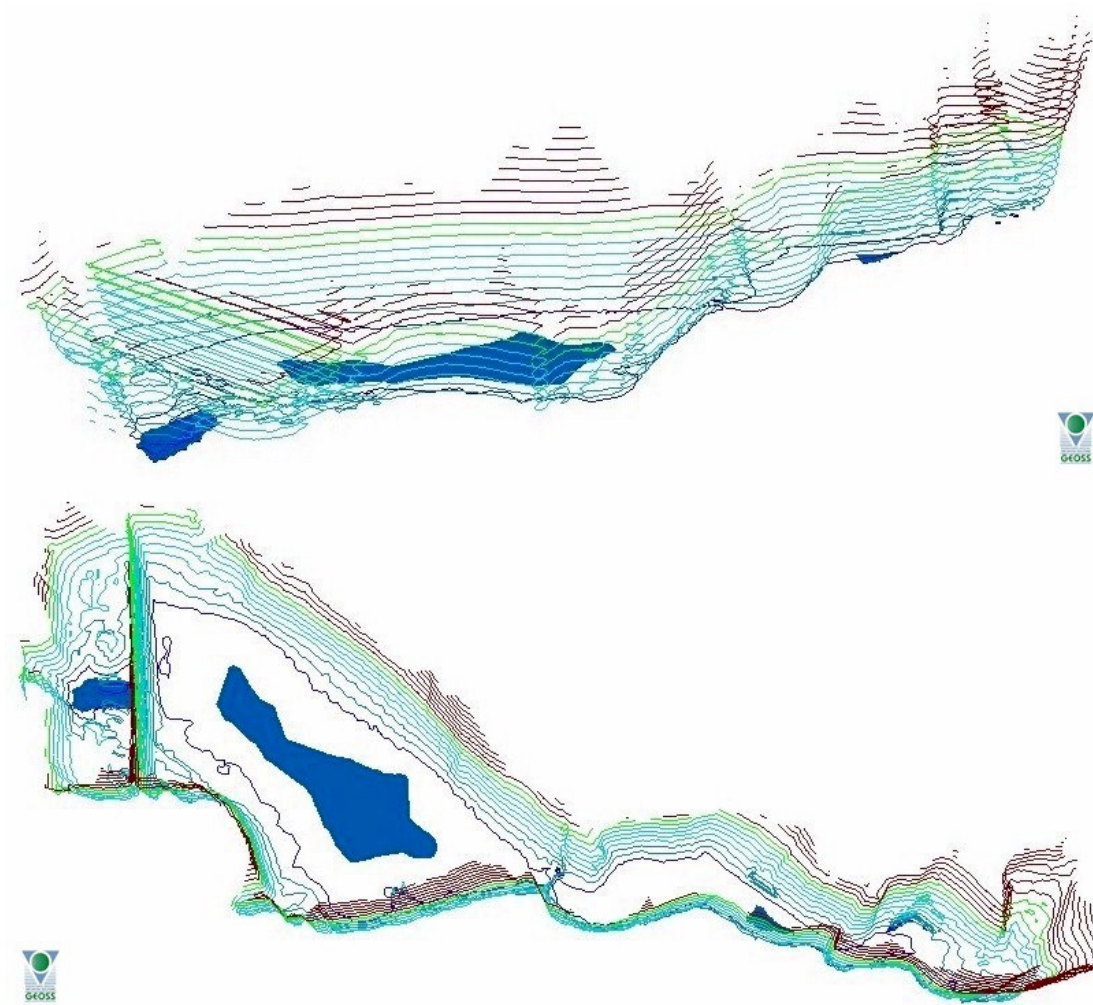


Figure 4: Pan filled with 50 000 m³ (contribution from typical annual direct rainfall) – assuming annual rainfall to occur in a single event.

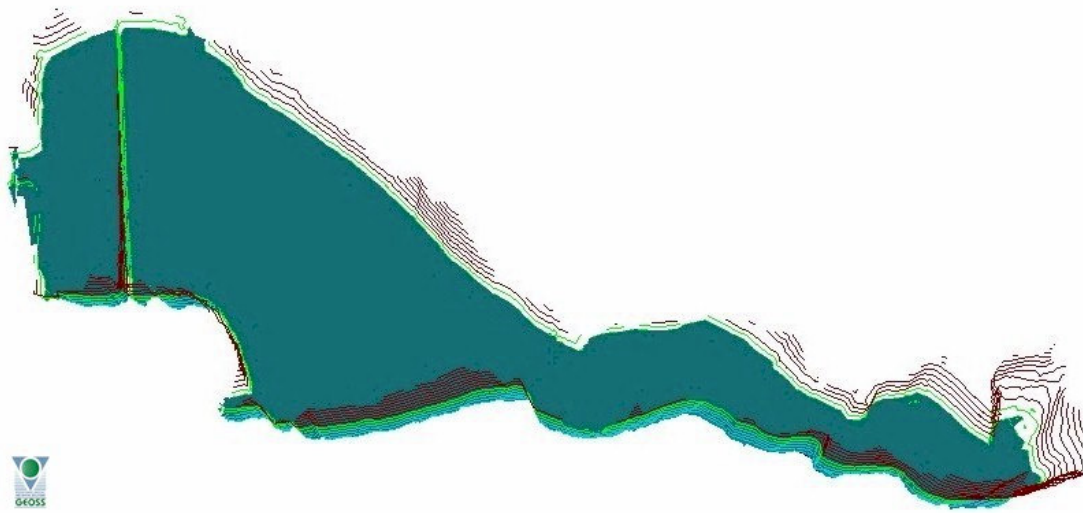


Figure 5: Pan filled to 1921 flood level (this was the only known instance when the mouth of the pan was breached .