Report No: P WMA
19/G10/00/2413/6

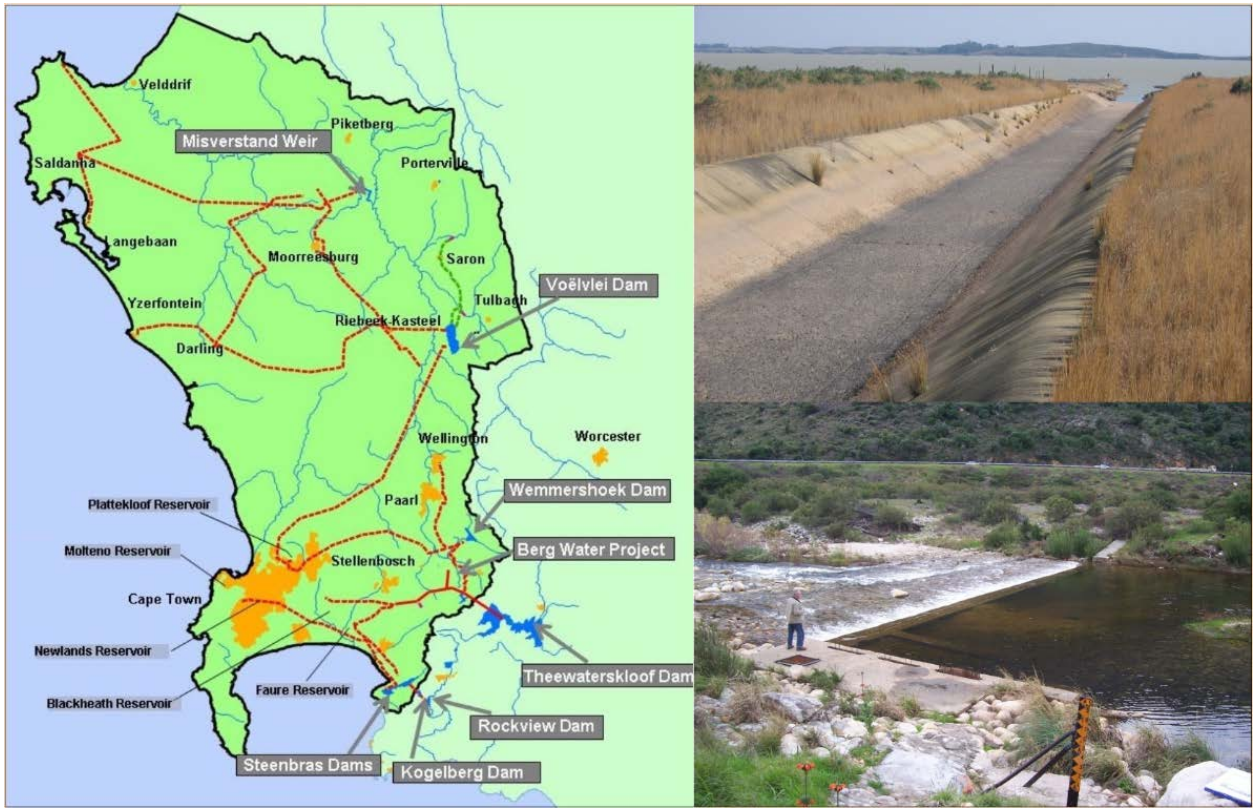
**Department of Water Affairs**
**Directorate: Options Analysis**

# PRE-FEASIBILITY AND FEASIBILITY STUDIES FOR AUGMENTATION OF THE WESTERN CAPE WATER SUPPLY SYSTEM BY MEANS OF FURTHER SURFACE WATER DEVELOPMENTS

## REPORT No.3 – VOLUME 2
## Breede-Berg (Michell's Pass) Water Transfer Scheme

## APPENDIX No.7

## Ecological Water Requirements Assessment Summary for the Berg River-Voëlvlei Augmentation Scheme, and the Breede Berg (Michell's Pass) Water Transfer Scheme




**December 2012**

## STUDY REPORT LIST

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| | | | | Appendix 2: EWR data for the Palmiet River |
| | | | | Appendix 3: EWR data for the Berg River |
| | | | | Appendix 4: Task 3.1: Rapid Reserve assessments (quantity) for the Steenbras, Pombers and Kromme Rivers |
| | | | | Appendix 5: Habitat Integrity Report – Breede River |
| | | Vol 2 | PWMA19 G10/00/2413/2 | **Rapid Determination of the Environmental Water Requirements of the Palmiet River Estuary** |
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| | | | | Appendix B: Summary of baseline data requirements and the long-term monitoring programme |
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| 2 | PRELIMINARY ASSESSMENT OF OPTIONS | | PWMA19 G10/00/2413/4 | Appendix 1: Scheme Yield Assessments and Diversion Functions |
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|---|---|---|---|---|
| 3 | **FEASIBILITY STUDIES** | Vol 1 | PWMA19 G10/00/2413/5 | **Berg River-Voëlvlei Augmentation Scheme** |
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| | | | | Appendix 3: Monitoring Water Quality During Flood Events in the Middle Berg River (Winter 2011), for the Berg River-Voëlvlei Augmentation Scheme |
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| | | | | Appendix 7 - 12: See list under Volume 2 below |
| | | Vol 2 | PWMA19 G10/00/2413/6 | **Breede-Berg (Michell's Pass) Water Transfer Scheme** |
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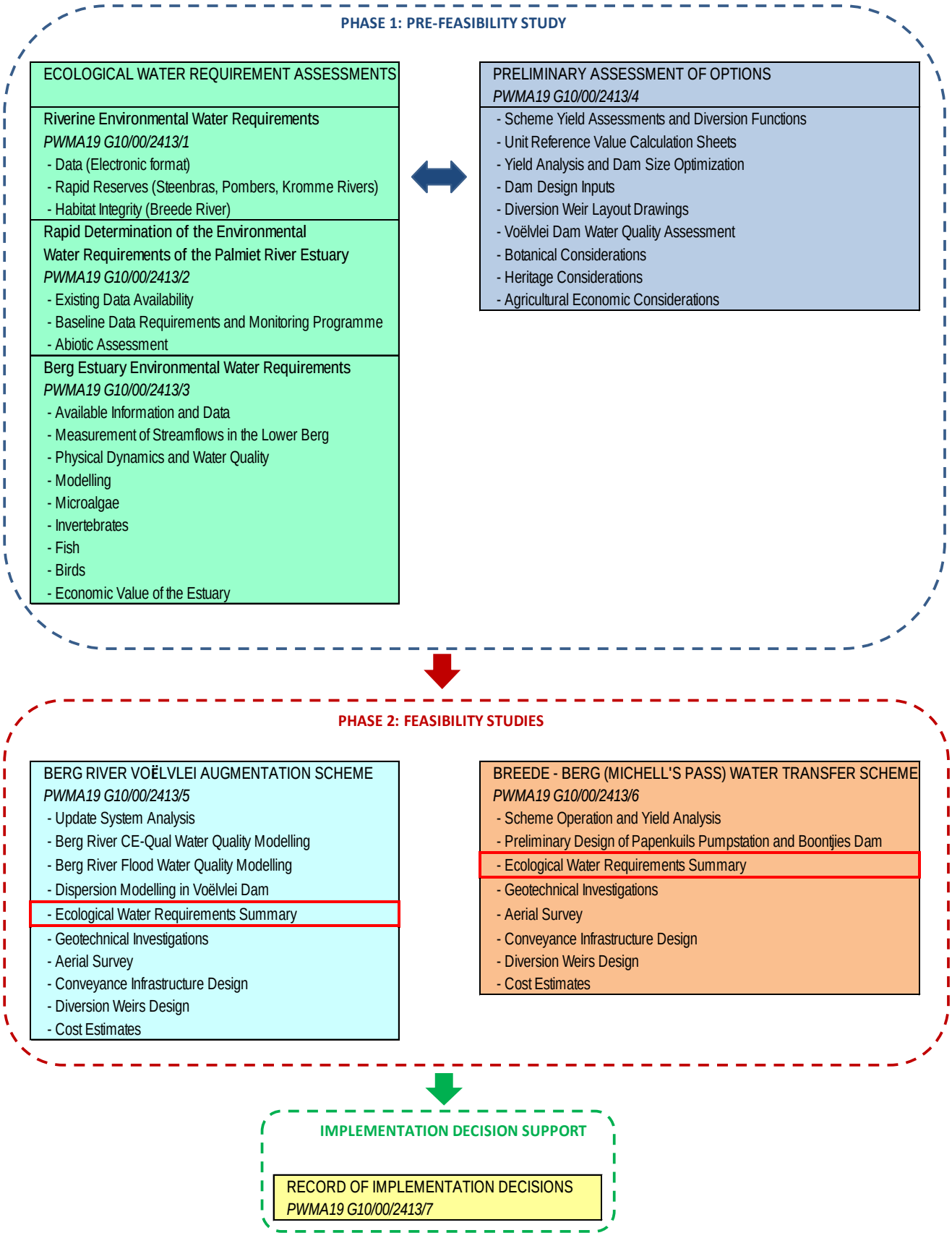
| 4 | **RECORD OF IMPLEMENTATION DECISIONS** | | PWMA19 G10/00/2413/7 | |

# STUDY REPORT MATRIX DIAGRAM



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**LIST OF ACRONYMS**

| | |
|---|---|
| AEC | Alternative Ecological Category |
| BAS | Best Attainable State |
| DWA | Department of Water Affairs |
| DWAF | Department of Water Affairs and Forestry (pre-2009) |
| EC | Ecological Category |
| ECOREGION: | A recurring pattern of ecosystems associated with characteristic combinations of soil and landform that characterise that region |
| EIS | Ecological Importance and Sensitivity: ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) |
| EPHEMERAL: | Characterised as episodic, and lasting only a short time |
| ECOLOGICAL RESERVE: | The requirement for water that is allocated to sustain ecosystem functions and is directly aligned with options for human use arising from rivers to deliver a suite of ecosystem goods and services to society. |
| ERC | Ecological Reserve Category |
| EWR | Environmental Water Requirement: prescribes water regimes needed to sustain the ecological values of water dependent ecosystems at a low level of risk |
| GAI | Geomorphology Driver Assessment Index |
| GEOMORPHIC ZONE: | A section of river distinguished by its position in the longitudinal profile and which is dominated by macro-reaches having characteristic valley form and valley-floor shape |
| HI | Habitat Integrity: A measure of the ability of an ecosystem to support and maintain a balanced, integrated, adaptive community of organisms that has a species composition, diversity and functional organisation comparable to that of natural habitat of the region |
| IFR | Instream Flow Requirement |
| MAR | Mean Annual Run-off |
| MCM | Million cubic meters |
| MIRAI | Macroinvertebrate Response Assessment Index |
| NODE: | A modelling point which "represent(s) the downstream end of a reach or area for which a suite of relationships apply |
| PERENNIAL: | Characterised as throughout the year, constantly |
| PES | Present Ecological Status: |
| QUATERNARY: | Refers to drainage regions of the fourth order |
| RDM | Resource Directed Measures |
| REC | Recommended Ecological Category |
| SASS5 | South African Scoring System version 5 |
| VEGRAI | Riparian Vegetation Response Assessment Index |
| WCWSS | Western Cape Water Supply System |
| WRCS | Water Resources Classification System |
| WMA | Water Management Area |

# 1 VOLUME 1: MAIN REPORT AND APPENDICES 1-5

Volume 1 addresses the generation of Ecological Water Requirement (EWR) data for the rivers in the Breede, Palmiet and Berg Catchments.

It used the procedures recommended for undertaking the ecological aspects of the Water Resources Classification System (WRCS) *(*Dollar *et al.* 2006*)*. These include the identification of nodes; the extrapolation of information from representative sites to other nodes, and the generation of Ecological Water Requirements for maintenance of the rivers in B, C and D categories at each node.

## 1.1 STUDY AREA

EWR data were generated for:

- Sixty-three river nodes in the Breede River catchment (Figure 1.1; Table 1.1);
- Ten river nodes in the Palmiet River catchment (Figure 1.2; Table 1.2); and
- Twenty-three river nodes in the Berg River catchment (Figure 1.3; Table 1.3).

EWR data for the Palmiet and Berg estuaries are available in other volumes, *viz*.:

- Report 1, Vol 2: Palmiet Estuary EWR Report
- Report 1, Vol 3: Berg Estuary EWR Report.

EWR data for the Breede Estuary are available in DWAF (2003).

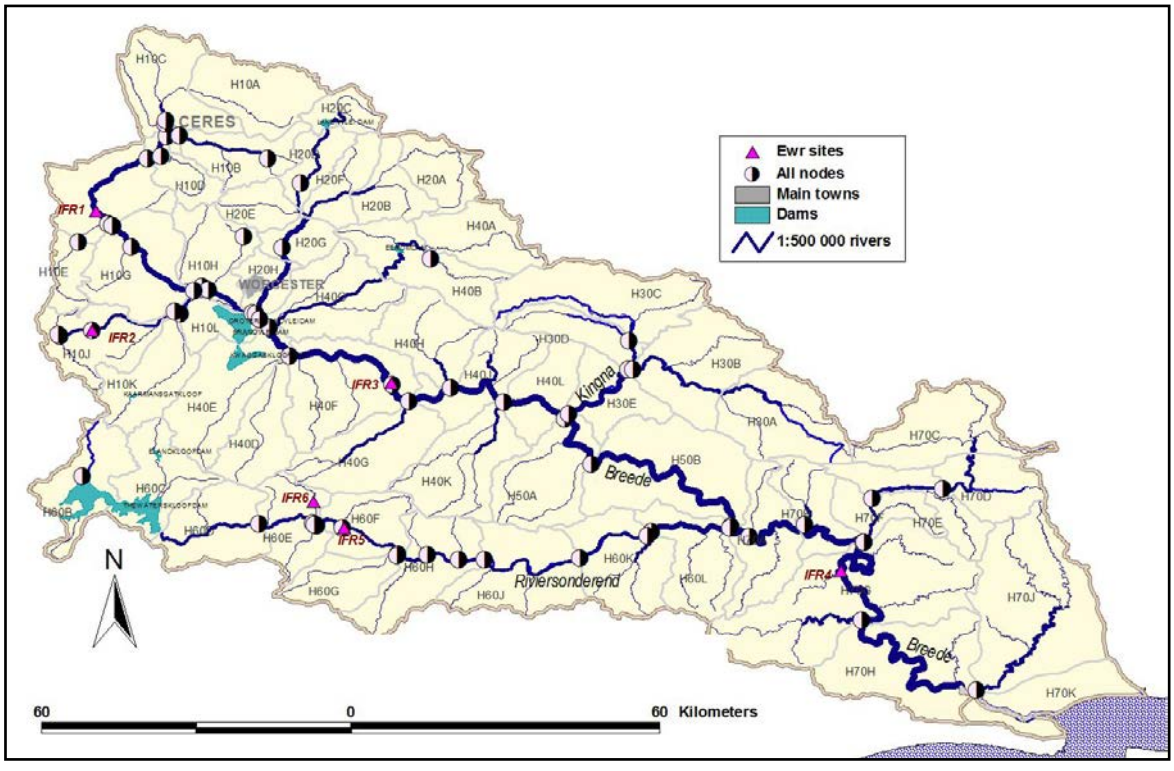


**Figure 1.1** The Breede River catchment, showing the sixty-three nodes established.

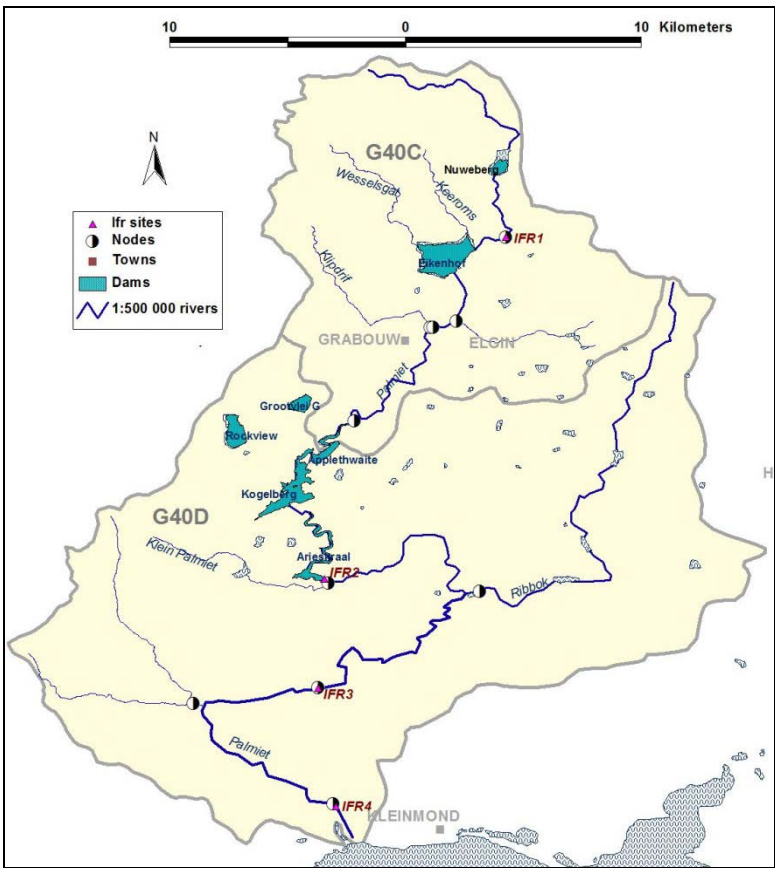


**Figure 1.2** The Palmiet River catchment, showing the 10 nodes established.

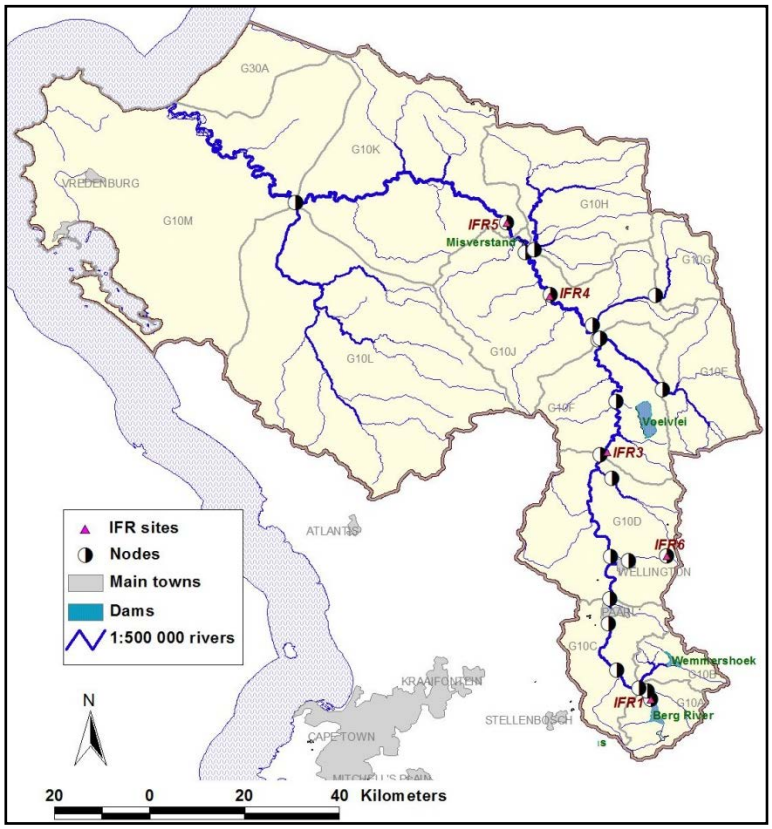


**Figure 1.3** The Berg River catchment, showing the 23 nodes established.

## 1.2 GENERATION OF EWR ESTIMATES

The Desktop Model (Hughes and Münster 2000) was used to generate EWR estimates for all nodes in the three river systems. The results were calibrated using the results from past EWR assessments (Breede Catchment: Ewart-Smith and Brown 2002; Louw and Brown 2001; Palmiet Catchment: Brown *et al.* 2000; Berg Catchment: DWAF 1996; Harding and Brown 2002) and some data generated in this study (Appendices 4 and 5). The assurance rules together with the time series of natural flows per node were used to construct representative time series' of EWR requirements (Report 1, Volume 1, Appendices 1, 2 and 3).

For each node a summary of the desktop estimate (*.tab), an assurance table (*.rul) and the time series of monthly flows (*.mrv) is provided for each ecological category. In most cases these were B, C and D, althought in some cases other categories were determined, for example a BC or CD as appropriate. In all cases, and for each node, a time series of monthly flow data for LOW FLOWS only was also generated.

## 1.3 APPENDICES 1, 2 AND 3: .TAB, .RUL AND .MRV DATA

The EWR data are presented as .tab, .rul and .mrv files for:
Appendix 1: Breede River;
Appendix 2: Berg River;
Appendix 3: Palmiet River.

## 1.4 APPENDIX 4: RAPID RESERVE ASSESSMENTS (QUANTITY) FOR THE STEENBRAS, POMBERS AND KROMME RIVERS

Rapid II level Ecological Water Requirement (EWR) determinations were done for the Steenbras, Pombers and Kromme rivers to provide details information for the proposed Wit River Diversion sceheme and to provide input to the catchment-wide assessment of EWRs that was done as part of the Western Cape Feasibility and Pre-feasibility Studies.

The location of the EWR sites are:

- Steenbras (S34.19379$^{o}$, E18.82467$^{o}$)
- Pombers (S33.62554$^{o}$, E19.08985$^{o}$)
- Kromme (S33.62577$^{o}$, E19.08166$^{o}$)

Ecoclassification assessments were done using:

Present Ecological Status (PES), Ecological Importance and Sensitivity (EIS), Recommended Ecological Category (REC) were determined for each site (Table 1.4).using:

| | |
|---|---|
| Geomorphology: | GAI (Level IV) (Rountree and Du Preez, in prep). |
| Vegetation: | VEGRAI (Kleynhans *et al.* 2008). |
| Macroinvertebrates: | MIRAI (Thirion 2008). |

The Desktop Model (Hughes and Hannart 2003) was used to determine EWRs for the Steenbras, Pombers and Kromme Rivers (Table 1.5).

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**Table 1.1 Node table for the Breede River basin (quat = quaternary, ER = ecoregion, HI = hydrological Index, GZ = geomorphological zone, Alt = altitude, EISC = ecological importance and sensitivity, PES = present ecologiucal status)**

| Node | Comment | River | LON (E) | LAT (S) | Quat | ER | HI | GZ | EISC | Alt | PES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Niv1 | U/s of confluence with Dwars | Koekedou | 19.29834 | 33.35961 | H10C | WFM | 1 | UF | M | 460 | C |
| Niv2 | U/s of confluence with Koekedou | Dwars | 19.30059 | 33.35445 | H10C | WFM | 1 | LF | M | 460 | D |
| Niv3 | U/s of confluence with Breede | Titus | 19.32356 | 33.37987 | H10B | WFM | 1 | LF | M | 460 | D |
| Nvii3 | U/s of confluence with Titus, at gauge H1H016 | Rooikloof | 19.47768 | 33.42146 | H10B | WFM | 1 | T | M | 960 | D |
| Nvi4 | 2 km d/s of confluence with Dwars/ Titus | Breede | 19.30243 | 33.38080 | H10C | WFM | 1 | UF | M | 440 | C |
| Niv4 | U/s of confluence with Breede | Witels | 19.29239 | 33.41749 | H10D | WFM | 1 | T | M | 320 | B |
| Nvi3 | U/s of junction of roads R46/ R43 | Breede | 19.26843 | 33.42148 | H10D | WFM | 1 | UF | M | 300 | C |
| Nvi2 | At Tweede Tol on Bainskloof Pass (R303) | Wit | 19.14786 | 33.56785 | H10E | WFM | 1 | UF | VH | 280 | B |
| Nviii1 | D/s confluence with Wabooms, nearest quaternary boundary to EWR 1 | Breede | 19.20737 | 33.53969 | H10F | WFM | 1 | LF | M | 240 | D/E |
| Niv6 | U/s of confluence with Breede | Wabooms | 19.20618 | 33.53827 | H10F | WFM | 1 | UF | M | 240 | D |
| Niv5 | U/s of confluence with Breede | Wit | 19.19943 | 33.53577 | H10F | WFM | 1 | LF | M | 240 | D |
| Niv7 | U/s of confluence with Slanghoek | Slanghoek | 19.24024 | 33.57666 | H10G | WFM | 1 | UF | M | 220 | D |
| Niv40 | U/s of confluence with Molenaars | Elands | 19.11566 | 33.73389 | H10J | WFM | 1 | T | VH | 520 | B |
| Niv41 | U/s of confluence with Molenaars | Krom | 19.11231 | 33.73017 | H10J | WFM | 1 | T | VH | 520 | B |
| Nvii2 | At gauging weir H1H018, EWR 2 | Molenaars | 19.17085 | 33.72392 | H10J | WFM | 1 | UF | VH | 380 | B |
| Niv42 | Just South of Rawsonville | Molenaars (Smalblaar) | 19.31593 | 33.68995 | H10J | WFM | 1 | UF | VH | 220 | D |
| Niv12 | Just South of Rawsonville | Holsloot | 19.32507 | 33.69400 | H10K | WFM | 1 | LF | VH | 220 | D |
| Nvii4 | At gauging weir H2H005, 7 km West of Hex River Valley | Sanddrif (Spek) | 19.53609 | 33.46457 | H20D | WFM | 1 | UF | M | 460 | D |
| Nvii7 | At gauging weir H2H006, North of Worcester on N1 | Hex | 19.50331 | 33.57849 | H20G | WFM | 1 | UF | M | 320 | D |
| Niv10 | U/s of confluence with Breede | Hex | 19.45648 | 33.69419 | H20H | WFM | 1 | LF | M | 200 | D |
| Niii1 | U/s of confluence with Molenaars (Smalblaar) | Breede | 19.34871 | 33.65347 | H10G | WFM | 1 | LR | H | 200 | C |
| Niv8 | U/s of confluence with Breede | Bothaspruit/ Witrivier | 19.36343 | 33.64720 | H10H | WFM | 1 | LF | H | 200 | D |
| Nvii6 | At gauging weir H1H020, 7.5 km North of Worcester | Hartbees | 19.43593 | 33.55895 | H10H | WFM | 1 | MH | H | 560 | C |
| Niv9 | U/s of confluence with Breede | Hartbees/ de Wetskloof | 19.37469 | 33.65185 | H10H | WFM | 1 | T | H | 200 | E |
| Nvii5 | At gauging weir H4H008, 2.3 km North of Worcester | Koo | 19.76294 | 33.59730 | H40B | SFM | 2 | U | M | 720 | C |
| Nv3 | U/s of confluence with Hex (at Brandvlei reservoir) | Breede | 19.45005 | 33.69210 | H10H | WFM | 1 | LR | H | 200 | C |
| Nii1 | D/s of Hex/Breede confluence | Breede | 19.46299 | 33.70234 | H10L/H10H | WFM | 2 | LR | H | 200 | C |
| Niv11 | U/s of confluence with Breede | Nuy | 19.48130 | 33.71801 | H40C | WFM | 2 | LF | H | 200 | C |
| Niv13 | U/s of confluence with Breede, d/s of Hoeks/Doring (Bobbejaans/Kiesie) | Doring | 19.52113 | 33.76716 | H40D | WFM | 1 | U | H | 200 | E |
| Nvii8 | At gauging weir H4H017, EWR 3 | Breede | 19.69470 | 33.81871 | H40F | SFM | 1 | LR | M | 180 | C/D |
| Ni1 | U/s of confluence with Poesjenels | Breede | 19.72813 | 33.84932 | H40F | SFM | 2 | LR | M | 180 | D |
| Niv14 | U/s of confluence with Breede | Keisers | 19.88989 | 33.85032 | H40K | SFM | 2 | U | M | 160 | E |
| Niv15 | U/s of confluence with Breede | Vink | 19.79753 | 33.82419 | H40H | SFM | 2 | U | M | 180 | E |
| Niv20 | U/s of confluence with Keisie | Pietersfontein | 20.10834 | 33.73904 | H30C | SFM | 2 | UF | M | 280 | E |
| Niv18 | U/s of confluence with Kogmanskloof | Kingna | 20.11600 | 33.79284 | H30B | SFM | 2 | LF | M | 220 | E |

| Node | Comment | River | LON (E) | LAT (S) | Quat | ER | HI | GZ | EISC | Alt | PES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nvii9 | U/s of confluence with Kogmanskloof | Keisie | 20.10709 | 33.79276 | H30D | SFM | 2 | LR | M | 220 | E |
| Nii2 | At gauging weir H3H011, u/s of confluence with Breede | Kogmanskloof | 20.00323 | 33.87040 | H30E | SFM | 1 | LF | M | 140 | D |
| Nvi1 | U/s of confluence with Kogmanskloof | Breede | 19.99688 | 33.87915 | H40L | SFM | 1 | LF | M | 140 | D |
| Niii3 | U/s of confluence with Boesmans | Breede | 20.04238 | 33.95968 | H50A | SFM | 1 | LF | M | 120 | C |
| Ni2 | U/s of confluence with Riviersonderend | Breede | 20.28653 | 34.06804 | H50B | SCB | 1 | LF | M | 80 | C |
| Niv24 | U/s of confluence with Riviersonderend | Leeu | 20.31862 | 34.08595 | H70A | SCB | 1 | UF | M | 80 | E |
| Niv24a | U/s of confluence with Riviersonderend | Klip | 20.41509 | 34.06616 | H70B | SCB | 1 | UF | H | 80 | E |
| Nv13 | At Suurbraak | Buffeljags | 20.65671 | 34.00276 | H70D | SCB | 1 | LF | H | 120 | C |
| Nv14 | U/s of Buffeljags Dam | Buffeljags | 20.53304 | 34.01939 | H70E | SCB | 1 | LF | H | 80 | E |
| Niv25 | U/s of confluence with Riviersonderend | Buffeljags | 20.52031 | 34.09445 | H70F | SCB | 1 | LF | M | 60 | D |
| Nv2 | U/s of confluence with Buffelsjag | Breede | 20.51719 | 34.09571 | H70B | SCB | 1 | LR | M | 60 | C |
| Niii4 | D/s of EWR 4, at Napkei confluence | Breede | 20.51240 | 34.23484 | H70G | SCB | 1 | E/LF | H | 20 | C |
| Niv26 | U/s of confluence with Breede | Slang | 20.71492 | 34.35731 | H70J | SCB | 1 | U | M | 20 | C |
| Nvii10 | U/s of Theewaterskloof Dam | Du Toits | 19.15394 | 33.97951 | H60B | SFM | 1 | UF | H | 320 | B |
| Nv7 | 2.5 km u/s of confluence with Meul | Riviersonderend | 19.46327 | 34.06361 | H60D | SCB | 1 | LF | H | 240 | C |
| Niv28 | U/s of confluence with Riviersonderend, d/s of EWR 6 on Baviaans | Baviaans | 19.55670 | 34.06331 | H60E | SCB | 1 | UF | VH | 220 | B |
| Niv29 | U/s of confluence with Riviersonderend | Sersants | 19.55914 | 34.06608 | H60E | SCB | 1 | UF | H | 220 | D |
| Niv30 | U/s of confluence with Riviersonderend | Gobos | 19.60911 | 34.07054 | H60F | SCB | 1 | UF | H | 200 | E |
| Nv8 | South of Genadendal, d/s of R404 bridge | Riviersonderend | 19.56392 | 34.06627 | H60E | SCB | 1 | LF | H | 220 | D |
| Niv31 | U/s of confluence with Riviersonderend | Kwartel | 19.70304 | 34.12027 | H60G | SCB | 1 | LF | H | 180 | D |
| Nv9 | At confluence with Kwartel, EWR 5 | Riviersonderend | 19.70425 | 34.11639 | H60F | SCB | 1 | LF | H | 180 | E |
| Niv33 | U/s of confluence with Riviersonderend | Soetmelksvlei | 19.75634 | 34.11850 | H60H | SCB | 1 | UF | H | 180 | D |
| Niv34 | U/s of confluence with Riviersonderend | Slang | 19.81128 | 34.12776 | H60H | SCB | 1 | UF | H | 160 | C |
| Nv10 | D/s of confluence with Slang and Lindeshof town | Riviersonderend | 19.85624 | 34.12656 | H60H | SCB | 1 | LF | H | 160 | D |
| Nv11 | 9 km u/s of Stormsvlei, alongside N2 | Riviersonderend | 20.02322 | 34.12470 | H60J | SCB | 1 | LF | H | 120 | D |
| Niv35 | U/s of confluence with Riviersonderend | Kwassadie | 20.14142 | 34.08539 | H60K | SCB | 1 | LR | H | 100 | E |
| Nv12 | D/s of confluence with Kwassadie | Riviersonderend | 20.14743 | 34.07773 | H60K | SCB | 1 | LF | H | 100 | D |
| Ni3 | U/s of confluence with Breede | Riviersonderend | 20.28513 | 34.07071 | H60L | SCB | 1 | LF | H | 80 | D |

| | |
|---|---|
| Western Folded Mountains | WFM |
| Southern Folded Mountains | SFM |
| Southern Coastal Belt | SCB |
| South Western Coastal Belt | SWCB |

| | | | |
|---|---|---|---|
| Lowland River | LR | Transitional | T |
| Lower Foothills | LF | Unclassified | Uc |
| Upper foothills | UF | Mountain headwater | MH |
| | | Estuary | E |

| |
|---|
| A/B: Natural/Largely Natural |
| B: Largely natural |
| C: Moderately modified |

| |
|---|
| VH=Very High |
| H=High |
| M=Moderate |

**Table 1.2 Node table for the Palmiet catchment (quat=quaternary, ER = ecoregion, HI = hydrological index, GZ = geomorphological zone, Alt = altitude, EISC = ecological importance and sensitivity, PES = present ecological status)**

| Node | Comment | River | LON (E) | LAT (S) | Quat | ER | HI | GZ | EISC | PES | Alt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pvi1 | U/s of Applethwaite reservoir | Palmiet | 18.99791 | -34.18428 | G40C | SFM | 1 | LF | M | D | 260 |
| Piv9 | U/s of confluence with Klipdrif, 0.5 km u/s of R321 | Palmiet | 19.02777 | -34.14880 | G40C | SFM | 1 | LF | M | D | 280 |
| Piv8 | U/s of confluence with Palmiet, 0.5 km u/s of R321 | Klipdrif | 19.02679 | -34.14871 | G40C | SFM | 1 | Uncl | M | D | 280 |
| Piv10 | U/s of confluence with Palmiet, 0.5 km West of R321 | Witklippieskloof | 19.03684 | -34.14637 | G40C | SFM | 1 | Uncl | M | D | 280 |
| Piii1 | U/s Eikenhof Dam at EWR 1 | Palmiet | 19.05545 | -34.11436 | G40C | SFM | 1 | MS→UF | M | C | 340 |
| Piii3 | Top of estuary, at EWR 4 | Palmiet | 18.99073 | -34.33053 | G40D | SFM | 1 | UF→LF | VH | B | 5 |
| Piv12 | D/s of confluence of Dwars and Louws[1] | Dwars/ Louws | 18.93654 | -34.29163 | G40D | SFM | 1 | LF | VH | C | 60 |
| Piii2 | At EWR 3 | Palmiet | 18.98457 | -34.28571 | G40D | SFM | 1 | UF→LF | VH | C | 60 |
| Piv7 | U/s of confluence with Palmiet | Krom/ Ribbok | 19.04561 | -34.24897 | G40D | SFM | 1 | LF | VH | C | 120 |
| Piv4 | U/s of confluence with Palmiet | Klein-Palmiet | 18.98786 | -34.24584 | G40D | SFM | 1 | Uncl | VH | C | 160 |

| | |
|---|---|
| Western Folded Mountains | WFM |
| Southern Folded Mountains | SFM |
| Southern Coastal Belt | SCB |
| South Western Coastal Belt | SWCB |

| | |
|---|---|
| Mountain Stream | MS |
| Upper Foothill | UF |
| Lower Foothill | LF |
| Lowland River | LR |
| Transitional | T |
| Estuary | E |
| Unclassified | Uncl |

| |
|---|
| A/B: Natural/Largely Natural |
| B: Largely natural |
| C: Moderately modified |

| |
|---|
| VH=Very High |
| H=High |
| M=Moderate |

1 This section of river d/s of the confluence of the Dwars and the Louws,u/s of the Palmiet River, is unnamed on the 1:50 000 maps.

**Table 1.3 Node table for the Berg River catchment (quat = quaternary, ER = ecoregion, HI = hydrological index, GZ = geomorphological zone, Alt = altitude, EISC = ecological importance and sensitivity, PES = present ecological status)**

| Node | Comment | River | LON (E) | LAT (S) | Quat | ER | HI | GZ | Alt (m) | EISC | PES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bviii1 | D/s of Berg River dam at EWR 1 | Berg | 19.05265 | -33.89657 | G10A | SWCB | 1 | UF | 180 | H | C |
| Biv5 | U/s of confluence with Berg | Franschoek | 19.0455 | -33.88126 | G10A | SWCB | 1 | UF→LF | 180 | H | D |
| Biii2 | U/s of confluence with Berg | Wemmershoek | 19.03034 | -33.87662 | G10B | SWCB | 1 | LR→LF | 160 | H | D |
| Bvii2 | Skuifraam pump station area, 1.0 km d/s of confluence with Dwars | Berg | 18.98828 | -33.84149 | G10C | SWCB | 1 | LF | 140 | L | D |
| Bvii9 | U/s of Paarl | Berg | 18.97234 | -33.75494 | G10C | SWCB | 1 | LF | 120 | L | D |
| Biii3 | At gauging weir G1H020 | Berg | 18.97438 | -33.70766 | G10C | SWCB | 1 | UF→LF | 100 | L | D |
| Bvii3 | North of Wellington, at gauging weir G1H037 | Krom/ Kromme | 19.00971 | -33.63549 | G10D | SWCB | 1 | UF | 120 | M | D |
| Bvii10 | D/s of confluence with Krom/ Kromme, at gauging weir G1H015 | Berg | 18.97668 | -33.62711 | G10D | SWCB | 1 | LF | 100 | M | D |
| Bviii2 | At EWR 6, Rapid II Reserve, d/s of confluence with Pombers | Krom/ Kromme | 19.08166 | -33.62577 | G10D | SWCB | 1 | UF | 260 | M | D |
| Bvii4 | At gauging weir G1H041 | Kompanjies | 18.97811 | -33.4792 | G10D | SWCB | 1 | LF | 80 | M | D |
| Bvii5 | At gauging weir G1H036 and u/s of EWR 3 | Berg | 18.95691 | -33.43499 | G10D | SWCB | 1 | LR | 60 | M | D |
| Biii4 | At gauging weir G1H008 | Klein Berg | 19.07438 | -33.31159 | G10E | SWCB | 1 | LF | 120 | M | D |
| Bvii11 | U/s of Voelvlei canal | Berg | 18.98714 | -33.33408 | G10F | SWCB | 1 | LR | 60 | M | D |
| Biv3 | U/s of confluence with Berg | Klein-Berg | 18.95629 | -33.21508 | G10F | SWCB | 1 | LF→LR | 60 | M | D |
| Biv1 | U/s of confluence Klein-Berg | Berg | 18.95037 | -33.21477 | G10F | SWCB | 1 | LR | 60 | M | D |
| Bi1 | At gauging weir G1H028 | Vier-en-Twintig | 19.0608 | -33.1339 | G10G | WFM | 1 | T→UF | 140 | H | B |
| Biii5 | At gauging weir G1H035 | Matjies | 18.83264 | -33.04735 | G10H | SWCB | 1 | LF | 40 | M | D |
| Biv4 | U/s of confluence with Berg | Vier-en-twintig | 18.94183 | -33.19003 | G10J | SWCB | 1 | LF→LR | 60 | M | D |
| Bvii6 | D/s of EWR 4, at gauging weir G1H013 | Berg | 18.86193 | -33.13282 | G10J | SWCB | 1 | LR | 40 | M | D |
| Bvii8 | U/s Misverstand reservoir, d/s confluence with Matjies | Berg | 18.81488 | -33.05225 | G10J | SWCB | 1 | LR | 40 | M | D |
| Bvii12 | 3.5 km d/s of Misverstand reservoir, at EWR 5 | Berg | 18.77929 | -32.99602 | G10K | SWCB | 1 | LR | 20 | H | D |
| Biv2 | U/s of confluence with Sout, head of estuary | Berg | 18.3808 | -32.95804 | G10K | SWCB | 1 | LF | 5 | L | D |
| Bii1 | U/s of confluence with Berg | Sout | 18.38059 | -32.95847 | G10L | SWCB | 2 | LR | 5 | L | D |

| | |
|---|---|
| Western Folded Mountains | WFM |
| Southern Folded Mountains | SFM |
| Southern Coastal Belt | SCB |
| South Western Coastal Belt | SWCB |

| | |
|---|---|
| Lowland River | LR |
| Lower Foothills | LF |
| Upper foothills | UF |
| Transitional | T |
| Unclassified | Uc |
| Mountain headwater | MH |
| Estuary | E |

| |
|---|
| A/B: Natural/Largely Natural |
| B: Largely natural |
| C: Moderately modified |

| |
|---|
| VH=Very High |
| H=High |
| M=Moderate |

**Table 1.4 Ecological Categories (ECs) of the different components of the river at each EWR site.**

| River | Hydrology | Geomorphology /Floodplain (GAI) | Riparian vegetation (VEGRAI) | Macroinvertebrates (MIRAI) | Overall | | Recommended EC for Ecological Reserve | Alternative EC |
|---|---|---|---|---|---|---|---|---|
| Steenbras River | E/F | B/C | B/C | A | B/C | | B/C | None |
| Pombers River (Sub-reach 1) | *E/F | *C | *D | *B | *C | D | C | None |
| Pombers River (Sub-reach 2) | E/F | D | E | *B | D | | | |
| Kromme River | E/F | D/E | F | B/C | D/E | | D | None |

*Visited by specialists but no detailed data collected, ECs were estimated based on specialists' observation.

**Table 1.5 EWR summary results for the Steenbras, Pombers and Kromme Rivers**

| River | REC | nMAR/a (MCM) | Total EWR (MCM) |
|---|---|---|---|
| Steenbras | B/C | 54.876 | 7.404 (13.49 %nMAR) |
| Pombers | C | 1.518 | 0.331 (21.82 %nMAR) |
| Kromme | D | 3.557 | 0.505 (14.19 %nMAR) |

## 1.5 APPENDIX 5: HABITAT INTEGRITY

Ecological Reserves for rivers and estuaries rely on information on the present day ecological condition of aquatic systems. Since no recent assessments were available for the Breede River and its tributaries, up-to-date (September 2009) condition assessments were done for 50 nodes (see Section 1.1) in the basin (Table 1.6), using the Habitat Integrity (HI) method (Kleynhans 1996).

To provide an idea of changes over time, the 2009 data were compared with the desktop estimates of ecological condition (PES[1]) for the same river system (Kleynhans 2000) that was originally developed to serve the National Water Balance.

[1] Present Ecological Status

**Table 1.6 WRCS nodes in the Breede basin**

| Node | Comment | River | LON (E) | LAT (S) | Quat | Assessed? | Group |
|---|---|---|---|---|---|---|---|
| Nvii3 | U/s of confluence with Titus, at gauge H1H016 | Rooikloof | 19.4777 | -33.42146 | H10B | N | 1 |
| Niv3 | U/s of confluence with Breede | Titus | 19.3236 | -33.37987 | H10B | Y | 1 |
| Nvi4 | 2 km d/s of confluence with Dwars/ Titus | Breede | 19.3022 | -33.38129 | H10C | Y | 1 |
| Niv2 | U/s of confluence with Koekedou | Dwars | 19.3006 | -33.35445 | H10C | Y | 1 |
| Niv1 | U/s of confluence with Dwars | Koekedou | 19.2983 | -33.35961 | H10C | Y | 1 |
| Nvi3 | U/s of junction of roads R46/ R43 | Breede | 19.2684 | -33.42148 | H10D | Y | 2 |
| Niv4 | U/s of confluence with Breede | Witels | 19.2924 | -33.41749 | H10D | Y | 2 |
| Nvi2 | At Tweede Tol on Bainskloof Pass (R303) | Wit | 19.1479 | -33.56785 | H10E | Y | 2 |
| Nviii1 | D/s confluence with Wabooms, nearest quaternary boundary to EWR 1 | Breede | 19.2073 | -33.53985 | H10F | Y | 2 |
| Niv6 | U/s of confluence with Breede | Wabooms | 19.2062 | -33.53827 | H10F | Y | 2 |
| Niv5 | U/s of confluence with Breede | Wit | 19.1994 | -33.53577 | H10F | Y | 2 |
| Niii1 | U/s of confluence with Molenaars (Smalblaar) | Breede | 19.3491 | -33.65363 | H10G | N | 3 |
| Niv7 | U/s of confluence with Slanghoek | Slanghoek | 19.2402 | -33.57666 | H10G | Y | 2 |
| Niv8 | U/s of confluence with Breede | Bothaspruit/ Witrivier | 19.3634 | -33.6472 | H10H | Y | 3 |
| Nv3 | U/s of confluence with Hex (at Brandvlei reservoir) | Breede | 19.451 | -33.69282 | H10H | Y | 3 |
| Nvii6 | At gauging weir H1H020, 7.5 km North of Worcester | Hartbees | 19.4359 | -33.55895 | H10H | N | 3 |
| Niv9 | U/s of confluence with Breede | Hartbees/ de Wetskloof | 19.3747 | -33.65185 | H10H | Y | 3 |
| Niv40 | U/s of confluence with Molenaars | Elands | 19.1157 | -33.73389 | H10J | Y | 2 |
| Niv41 | U/s of confluence with Molenaars | Krom | 19.1123 | -33.73017 | H10J | Y | 2 |
| Nvii2 | At gauging weir H1H018, EWR 2 | Molenaars | 19.1709 | -33.72392 | H10J | Y | 2 |
| Niv42 | Just South of Rawsonville | Molenaars/ Smalblaar | 19.3159 | -33.68995 | H10J | Y | 3 |
| Niv12 | Just South of Rawsonville | Holsloot | 19.3251 | -33.69406 | H10K | Y | 3 |
| Nii1 | D/s of Hex/Breede confluence | Breede | 19.4638 | -33.70374 | H10L/ H10H | N | 3 |
| Nvii4 | At gauging weir H2H005, 7 km West of Hex River Valley | Sanddrif/ Spek | 19.5361 | -33.46457 | H20D | N | 3 |
| Nvii7 | At gauging weir H2H006, North of Worcester on N1 | Hex | 19.5033 | -33.57849 | H20G | Y | 3 |
| Niv10 | U/s of confluence with Breede | Hex | 19.4565 | -33.69419 | H20H | Y | 3 |
| Niv18 | U/s of confluence with Kogmanskloof | Kingna | 20.116 | -33.79284 | H30B | Y | 4 |
| Niv20 | U/s of confluence with Keisie | Pietersfontein | 20.1083 | -33.74194 | H30C | Y | 4 |
| Nvii9 | U/s of confluence with Kogmanskloof | Keisie | 20.1068 | -33.79282 | H30D | Y | 4 |
| Nii2 | At gauging weir H3H011, u/s of confluence with Breede | Kogmanskloof | 20.0032 | -33.87049 | H30E | Y | 4 |
| Nvii5 | At gauging weir H4H008, 2.3 km North of Worcester | Koo | 19.7629 | -33.5973 | H40B | N | 3 |
| Niv11 | U/s of confluence with Breede | Nuy | 19.4813 | -33.71801 | H40C | Y | 3 |
| Niv13 | U/s of confluence with Breede, d/s of Hoeks/Doring (Bobbejaans/Kiesie) | Doring | 19.5158 | -33.76905 | H40D | Y | 3 |
| Ni1 | U/s of confluence with Poesjenels | Breede | 19.7252 | -33.84912 | H40F | Y | 4 |
| Nvii8 | At gauging weir H4H017, EWR 3 | Breede | 19.6947 | -33.81871 | H40F | Y | 4 |
| Niv15 | U/s of confluence with Breede | Vink | 19.7975 | -33.82419 | H40H | Y | 4 |
| Niv14 | U/s of confluence with Breede | Keisers | 19.8899 | -33.85032 | H40K | Y | 4 |
| Nvi1 | U/s of confluence with Kogmanskloof | Breede | 19.9965 | -33.87871 | H40L | N | 4 |
| Niii3 | U/s of confluence with Boesmans | Breede | 20.0426 | -33.95977 | H50A | N | 4 |
| Ni2 | U/s of confluence with Riviersonderend | Breede | 20.2866 | -34.06867 | H50B | N | 4 |
| Nvii10 | U/s of Theewaterskloof Dam | Du Toits | 19.1539 | -33.97951 | H60B | Y | 6 |
| Nv7 | 2.5 km u/s of confluence with Meul | Riviersonderend | 19.4633 | -34.06361 | H60D | Y | 6 |
| Niv28 | U/s of confluence with Riviersonderend, d/s of EWR 6 on Baviaans | Baviaans | 19.5567 | -34.06331 | H60E | Y | 6 |
| Nv8 | South of Genadendal, d/s of R404 bridge | Riviersonderend | 19.5639 | -34.06627 | H60E | Y | 6 |
| Niv29 | U/s of confluence with Riviersonderend | Sersants | 19.5591 | -34.06608 | H60E | Y | 6 |
| Niv30 | U/s of confluence with Riviersonderend | Gobos | 19.6091 | -34.07054 | H60F | Y | 6 |
| Nv9 | At confluence with Kwartel | Riviersonderend | 19.7049 | -34.11756 | H60F | N | 6 |
| Niv31 | U/s of confluence with Riviersonderend | Kwartel | 19.703 | -34.12027 | H60G | Y | 6 |
| Nv10 | D/s of confluence with Slang and Lindeshof town | Riviersonderend | 19.8562 | -34.12656 | H60H | Y | 6 |
| Niv34 | U/s of confluence with Riviersonderend | Slang | 19.8113 | -34.12776 | H60H | Y | 6 |
| Niv33 | U/s of confluence with Riviersonderend | Soetmelksvlei | 19.7563 | -34.1185 | H60H | Y | 6 |

| Node | Comment | River | LON (E) | LAT (S) | Quat | Assessed? | Group |
|---|---|---|---|---|---|---|---|
| Nv11 | 9 km u/s of Stormsvlei, alongside N2 | Riviersonderend | 20.0232 | -34.1247 | H60J | Y | 6 |
| Niv35 | U/s of confluence with Riviersonderend | Kwassadie | 20.1414 | -34.08539 | H60K | Y | 6 |
| Nv12 | D/s of confluence with Kwassadie | Riviersonderend | 20.1474 | -34.07773 | H60K | N | 6 |
| Ni3 | U/s of confluence with Breede | Riviersonderend | 20.2851 | -34.07071 | H60L | N | 6 |
| Niv24 | U/s of confluence with Riviersonderend | Leeu | 20.3186 | -34.08595 | H70A | Y | 4 |
| Nv2 | U/s of confluence with Buffelsjag | Breede | 20.5172 | -34.09622 | H70B | N | 4 |
| Niv24a | U/s of confluence with Riviersonderend | Klip | 20.4151 | -34.06616 | H70B | Y | 4 |
| Nv13 | At Suurbraak | Buffeljags | 20.6567 | -34.00276 | H70D | N | 4 |
| Nv14 | U/s of Buffeljags Dam | Buffeljags | 20.5726 | -34.00277 | H70E | Y | 4 |
| Niv25 | U/s of confluence with Riviersonderend | Buffeljags | 20.5188 | -34.09603 | H70F | N | 4 |
| Niii4 | D/s of EWR 4, at Napkei confluence | Breede | 20.5146 | -34.23372 | H70G | N | 5 |
| Niv26 | U/s of confluence with Breede | Slang | 20.7149 | -34.35731 | H70J | N | 5 |

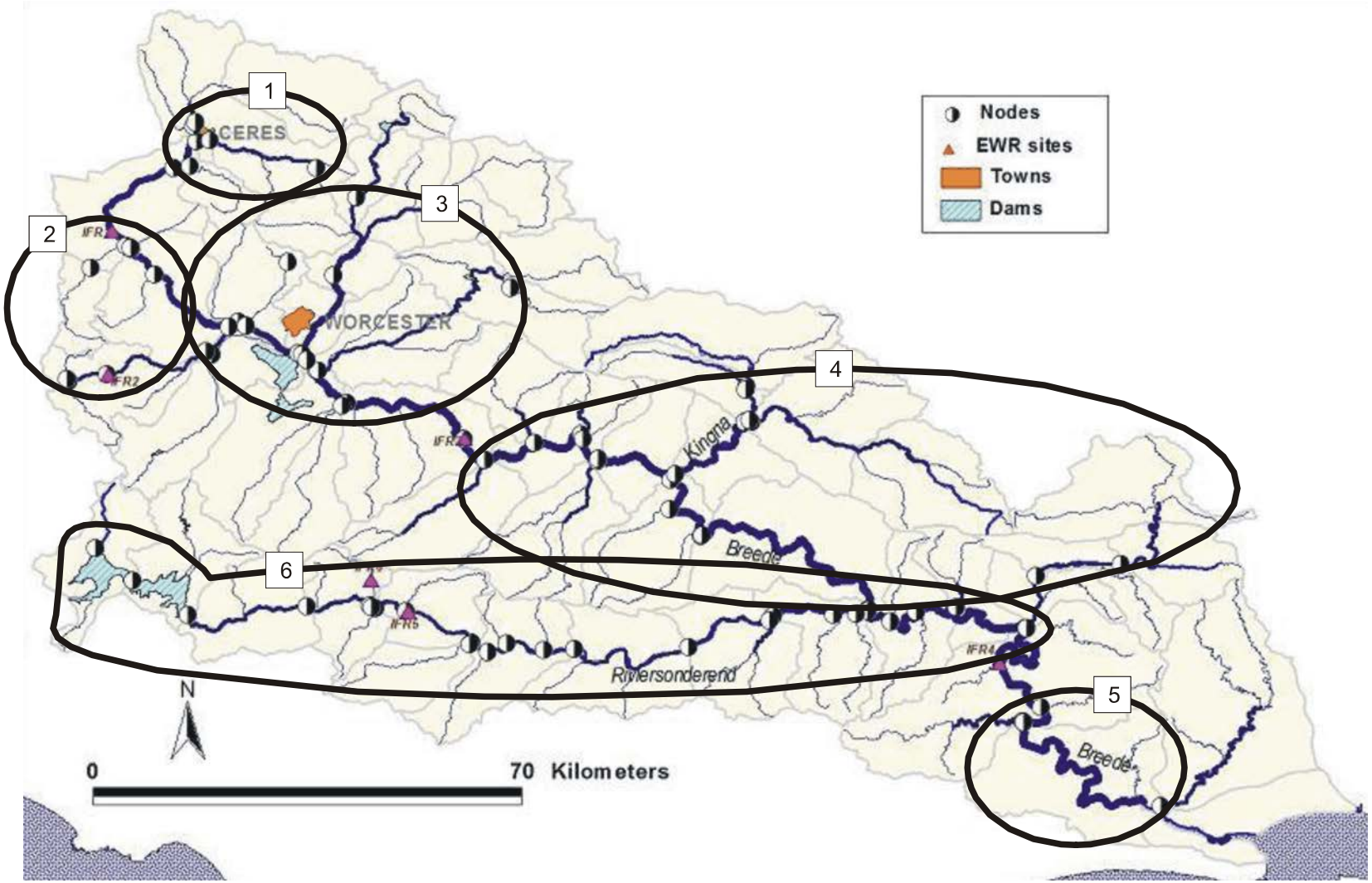


**Figure 1.4 Breede River catchment showing the 63 WRCS nodes, grouped into six groups (1-6)**

### 1.5.1 Group 1: Headwaters of the Breede River surrounding the town of Ceres

In general, the rivers scored better in the 2009 assessments than they did in 2000 (Table 1.7). This is probably a result of clearing of alien vegetation and improved management, e.g., of Koekoedou Dam.

**Table 1.7 Comparison of PES (Kleynhans 2000) and HI (2009) for nodes in Group 1**

| Node | PES (2000) | HI 2009 | |
|---|---|---|---|
| | | Instream | Riparian |
| Niv1: Koekedou River | D | C | C |
| Niv2: Dwars River | D | D | D |
| Niv3: Titus River | D | D | D |
| Nvii3: Rooikloof river | D | - | - |
| Nvi4: Breede River, Ceres | D | D | C |

### 1.5.2 Group 2: Headwaters of the Breede River

Seven of the ten nodes assessed in Group 2 were in a better condition than reported by Kleynhans (2000) (Table 1.8). There could be various reasons for this, but at least some of the improvement appears to be a result of extensive clearing of alien vegetation in the Breede (in Mitchell's Pass), Witte and Molenaars Rivers in the past decade, with a concomitant improvement in condition. Slanghoek and Wabooms Rivers both declined in condition between 2000 and 2009, and are now both aggressively dredged and channelised. The riparian vegetation alongside them has been all but completely destroyed and the impacts of over-abstraction are noticeable to the naked eye.

**Table 1.8 Comparison of PES (Kleynhans 2000) and HI (2009) for nodes in Group 2**

| **Node** | **PES (2000)** | **HI (2009)** | |
|---|---|---|---|
| | | Instream | Riparian |
| Niv4: Witels River | C | B | B |
| Nvi3: Breede River, Mitchells Pass/R43 | C | C | B |
| Nvi2: Witte River | C | B | B |
| Nviii1: Breede River (IFR1: Witbrug) | A | C | D |
| Niv6: Wabooms River | D | D | D |
| Niv5: Breede River, Slanghoek bridge | D | - | - |
| Niv7: Slanghoek River | D | E | D |
| Niv40: Krom River | D | B | B |
| Niv41: Elands River | C | B | B |
| Nvii2: Molenaars River (IFR 2) | C | B | C |

### 1.5.3 Group 3: Breede River and triburaties around Worcester

Nine of the fourteen nodes in this group were assessed (Table 1.9). Of these, none was in a better condition, and most were considerably worse, in 2009 than in 2000. In general, the condition of these rivers was poorer than that of Group 1 or 2. For the most part, the tributaries of the Breede River in this area have been extensively 'engineered', with a consequent loss of ecological function and value. Indeed, much of the protection from poor quality runoff from their catchments that would have been afforded these rivers by their riparian vegetation has been destroyed. It is likely that this will have affected not only river condition, but also the reliability of supply for those who depend on these rivers for drinking water.

**Table 1.9 Comparison of PES (Kleynhans 2000) and HI (2009) for nodes in Group 3**

| Node | PES (2000) | HI (PES) 2009 | |
|---|---|---|---|
| | | Instream | Riparian |
| Niv42: Molenaars (Smalblaar) River | C | D | E |
| Niv12: Holsloot River | C | D | E |
| Nvii4: Sanddrif River | D | - | - |
| Nvii7: upper Hex River | D | D | D |
| Niv10: lower Hex River | D | D | D |
| Niii1: Breede River, u/s of Papenkuils | D | - | - |
| Niv8: Bothaspruit River | C | D | D |
| Nvii6: Hartbees River | C | - | - |
| Niv9: Hartbees River | C | E | D |
| Nvii5: Koo River | C | - | - |
| Nv3: Breede River, Papenkuils | C | C | C |
| Nii1: Breede River, d/s of Papenkuils | C | - | - |
| Niv11: Nuy River | C | D | C |
| Niv13: Doring River | C | E | E |

### 1.5.4 Group 4: Middle Breede and tributaries

Apart from two nodes on the Breede mainstem, which remained the same, the condition of all other nodes was lower than that in 2000 (Table 1.10). The current condition of these systems is cause for serious concern. Almost without exception, these tributaries have been dredged, bulldozed, channelized and in some instances levees have been constructed alongside them to prevent overbank flooding. In most cases only hardy and pioneering annuals or exotic species remained in the riparian areas, and there was little or no variety of instream habitat. Some, for example, the Vink, the Kingna and the Kogmanskloof had excessive algal growth and/or exotic instream vegegtation, an indication of a nutrient surplus and a breakdown in the self cleansing functions of the ecosystem. The Leeu, the Klip and the middle Buffeljags Rivers were in the worst condition as the impacts listed above were exacerbated by a complete cessation of flows in September, when the other rivers – themselves subjected to high levels of abstraction – were flowing.

**Table 1.10 Comparison of PES (Kleynhans 2000) and HI (2009) for nodes in Group 4**

| Node | PES (2000) | HI (2009) | |
|---|---|---|---|
| | | Instream | Riparian |
| Nvii8: Breede River, Le Chasseur (IFR3) | D | C | C |
| Ni1: Breede River, Poesjenels | D | C | C |
| Niv14: Keisers River | D | E | E |
| Niv15: Vink River | D | E | D |
| Niv20: Pietersfontein River | C | E | D |
| Niv18: Kingna River | C | E | D |
| Nvii9: Kiesie River | C | E | D |
| Nii2: Kogmanskloof River | C | D | D |
| Nvi1: Breede River, Ashton | D | - | - |
| Niii3: Breede River, Bonnievale | C | - | - |
| Ni2: Breede River, confluence with Riviersonderend River | C | - | - |
| Niv24: Klip River | C | E | E |
| Niv24: Leeu River | C | E | E |
| Nv13: upper Buffeljags/ Tradouw River | C | | |
| Nv14 middle Buffeljags River | D | E | E |
| Niv25, lower Buffeljags River | C | D | E |
| Nv2: Breede River, Swellendam | C | - | - |

### 1.5.5 Group 5: Rivers on the Agulhas Plain

Not assessed.

### 1.5.6 Group 6: Riviersonderend

Thirteen of the 15 nodes in this group were assessed. Of these, only the du Toits River was in a better condition that in 2000 (Table 1.11). Eight of the rivers were in poorer condition in 2009 than in 2000. The sorts of impacts recorded were similar to those for Group 3 and 4, although alien infestation was higher in Groups 6 than in Group 3 and 4.

**Table 1.11 Comparison of PES (Kleynhans 2000) and HI (2009) for nodes in Group 6**

| Node | PES (2000) | HI (PES) 2009 | |
|---|---|---|---|
| | | Instream | Riparian |
| Nvii10: du Toits River | C | B | B |
| Nv7: Riviersonderend, Helderstroom | C | C | C |
| Niv28: Baviaans River | C | D | D |
| Niv29: Sersants River | C | D | D |
| Niv30: Gobos River | C | D | E |
| Nv8: Riviersonderend, Genadendal | C | D | D |
| Niv31: Kwartel River | C | D | D |
| Nv9: Riviersonderend, Greyton | C | - | - |
| Niv33: Soetmelksvlei River | C | D | D |
| Niv34: Slang River | C | C | C |
| Nv10: Riviersonderend, u/s of Riviersonderend | C | D | D |
| Nv11: Riviersonderend, d/s of Riviersonderend | D | D | D |
| Niv35: Kwassadie River | D | E | E |
| Nv12: Riviersonderend, d/s Stormsvlei | D | - | - |
| Ni3: Riviersonderend, confluence with Breede River | D | - | - |

### 1.5.7 Summary

The six groups of nodes are shown in Table 1.12. In general, the condition of the rivers declined from the upper reaches of the Breede eastwards to the estuary. The sites assessed in Groups 1 and 2, near Ceres and in the Du Toitskloof Mountains were in a better condition than those of the other groups. Seventy-five percent of reaches in Group 1 and 80% of those in Group 2 were in a C category or higher. Group 3 nodes near Worcester were generally in a C or D category. Group 4, from Robertson to Swellendam, were in the worst condition with 83% in a D or an E category. Half of the Group 6 nodes were in a D category, the remainder in a B, C or E.

**Table 1.12 Proportion of HI Categories for all nodes in the six groups. Data are percentages. The proportion change is a comparison against the PES assessment of Kleynhans (2000) and denotes an improvement or decline in category. Ins. = Instream, Rip. = Riparian.**

| Group | Category | | | | |
|---|---|---|---|---|---|
| | A Ins.-Rip. | B Ins.-Rip. | C Ins.-Rip. | D Ins.-Rip. | E Ins.-Rip. |
| 1 | 0 - 0 | 25 - 25 | 50 - 50 | 25 - 25 | 0 - 0 |
| 2 | 20 - 0 | 40 - 50 | 20 - 30 | 10 - 20 | 10 - 0 |
| 3 | 0 - 0 | 0 - 0 | 55 - 45 | 45 - 55 | 0 - 0 |
| 4 | 0 - 0 | 0 - 0 | 17 - 17 | 42 - 42 | 41 - 41 |
| 5 | | | | | |
| 6 | 0 - 0 | 8 - 8 | 17 - 25 | 67 - 50 | 8 - 17 |

# 2 VOLUME 2: PALMIET ESTUARY EWR REPORT AND APPENDICES A-C

Volume 2 addresses the generation of Ecological Water Requirement (EWR) data for the Palmiet Estuary, a small system located 75 km south east of Cape Town.

The **Present Ecological Status** of the estuary is a **C**. Major drivers of change in the system were a significant reduction in river inflow (floods and baseflows), increased mouth closure; reduced sediment scouring and an increased nutrient load from the catchment. Of special concern were the occurrence of macrophyte blooms in the estuary as a result of increase nutrients, reduce baseflow and closed (or semi-closed) mouth conditions. Die-off of these macrophyte blooms causes hypoxic or anoxic conditions in the estuary, which in turn puts the rest of the ecosystem under stress. An additional concern was the long periods of artificial droughts the estuary were currently experiencing and the impact this would have on fish recruitment.

The overall **Estuarine Importance Score** for the Palmiet Estuary, based on its present state, is **58**, signifying that the estuary is of **average importance**. The Palmiet Estuary abuts the Kogelberg Biosphere, and is included in a core set of estuaries that needs to be protected to meet biodiversity targets in South Africa. The pressures currently contributing to the degraded health of the Palmiet Estuary are poor water quality and reduction in river inflow in summer, which can be easily mitigated. Thus, the **REC for the Palmiet Estuary is a Category B.**

## 2.1 QUANTIFICATION OF THE RESERVE

Hydrological data were provided by Aurecon Consulting Engineers for the Reference Conditions, Present State and Scenarios 1 to 4. Scenario 5 and 6 were generated at the EWR workshop and represent minor changes to the Present State.

**Table 2.1 EWR scenarios**

| Scenario name | MAR (million $m^3$) | % Remaining | Description |
|---|---|---|---|
| Reference Condition | 256.3 | 100 | Natural (~ 100 to 150 years ago) |
| Present State | 163.7 | 63.9 | Current level of catchment development |
| Scenario 1 | 185.2 | 72.2 | Minimum Degradation - Campanula Dam |
| Scenario 2 | 161.3 | 62.9 | Different pump rates |
| Scenario 3 | 148.7 | 58.0 | No EWR releases and Lower Steenbras raised |
| Scenario 4 | 111.18 | 43.4 | Lower Steenbras raised, Campanula Dam and no EWR releases |
| Scenario 5 | 163.7 | 63.9 | Similar to Present State, with a 66 % reduction in nutrient input from the catchment |
| *Scenario 6 | 161.3 | 62.9 | Similar to Scenario 2, but elevate base flows, with flows <1.0 $m^3s^{-1}$ occurring for 22 % of the time, i.e. flows not less than 1.0 $m^3s^{-1}$ for longer than 3 months in a year. |

The recommended Ecological Water Requirement is defined as the runoff scenario (or a slight modification thereof) that represents the highest reduction in river inflow that will still protect the aquatic ecosystem of the estuary and keep it in the recommended EC. In evaluating Scenarios 1 to 4, it was assumed that only river inflow from the Palmiet Catchment would be modified and that other related anthropogenic activities (e.g. fishing, bait collection and human disturbance) will remain at present levels.

**Table 2.2 EcoStatus scores for each scenario**

| Variable | Present | Future Runoff Scenario | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| Score | 67 | 69 | 66 | 66 | 59 | 68 | 76 |
| Category | C | C | C | C | D | C | B |

Scenario 6 was selected as the recommended Ecological Water Requirement for the Palmiet Estuary.

**Table 2.3 Flow distributions for the recommended flow scenario (Scenario 6)**

| | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 99%ile | 20.44 | 8.79 | 3.58 | 2.81 | 2.35 | 2.44 | 6.71 | 12.85 | 25.23 | 43.50 | 36.36 | 27.49 |
| 90%ile | 10.43 | 3.90 | 1.43 | 0.82 | 0.83 | 1.05 | 3.53 | 7.91 | 19.45 | 22.70 | 26.15 | 17.93 |
| 80%ile | 6.61 | 2.52 | 1.00 | 0.57 | 0.68 | 0.81 | 2.06 | 5.38 | 12.39 | 17.16 | 19.62 | 13.37 |
| 70%ile | 5.89 | 1.98 | 1.00 | 0.52 | 0.54 | 0.56 | 1.50 | 4.34 | 9.39 | 13.35 | 16.73 | 11.27 |
| 60%ile | 4.52 | 1.66 | 1.00 | 0.52 | 0.52 | 0.51 | 1.19 | 3.78 | 8.25 | 11.40 | 15.80 | 9.75 |
| 50%ile | 3.66 | 1.47 | 1.00 | 0.52 | 0.49 | 0.44 | 1.00 | 3.12 | 7.03 | 9.91 | 13.54 | 7.91 |
| 40%ile | 3.17 | 1.36 | 1.00 | 0.45 | 0.34 | 0.33 | 1.00 | 2.56 | 5.46 | 8.88 | 11.20 | 6.58 |
| 30%ile | 2.81 | 1.20 | 1.00 | 0.35 | 0.32 | 0.30 | 1.00 | 2.13 | 4.14 | 6.64 | 9.94 | 6.05 |
| 20%ile | 2.40 | 1.00 | 1.00 | 0.32 | 0.29 | 0.27 | 1.00 | 1.60 | 3.57 | 5.43 | 8.43 | 5.67 |
| 10%ile | 1.76 | 1.00 | 1.00 | 0.28 | 0.26 | 0.25 | 1.00 | 1.30 | 2.56 | 4.63 | 7.01 | 5.05 |
| 1%ile | 1.22 | 1.00 | 1.00 | 0.10 | 0.08 | 0.12 | 1.00 | 1.00 | 1.27 | 3.00 | 5.02 | 3.95 |

## 2.2 RECOMMENDATIONS

Note that an increase in river inflow in itself (i.e. Scenario 6) would not be sufficient to ensure the recommended level of estuarine functioning. The following restoration measures are required to improve the present health of the Palmiet Estuary:

- Manage anthropogenic nutrient and organic matter inputs to the estuary through improved agricultural and urban landscape management;
- Improve the compliance monitoring of fishing and bait collection activities on the estuary. This will assist in controlling illegal harvesting of the estuarine living resources. At present recreational angling (and the occasional gillnetting) accounts for approximately 0.2 tonne annually. This includes the requirement for improved control of the harvesting of eels from the catchment.
- Restrict bait collection when the mouth is closed, since recruitment cannot occur during extended periods of mouth closure as it leads to the depletion of important food resources in the estuary.
- Install a fish ladder at the gauging weir and an eelway at the dams to facilitate migration of fishes into the lower river reaches.

Any assessment of future water-resource developments should also include an evaluation of the success of the implementation of these non-flow related mitigation measures in restoring the habitat and protecting biota. The setting and achievement of national management objectives for the Palmiet Estuary will require a high level of co-operative governance between the various management authorities. Lastly, it is recommended that a Palmiet Estuarine Management Plan be developed.

# 3 VOLUME 3: BERG ESTUARY EWR REPORT AND APPENDICES A-J

Volume 3 addresses the generation of Ecological Water Requirement (EWR) data for the Berg Estuary, a large system located on the West Coast, north of Cape Town.

The **Present Ecological Status** of the estuary is a **C**. Major drivers of change in the system were a significant reduction in river inflow (floods and baseflows), but it is likely that the estuary is on a negative trajectory of change, because of the extremely low lowflows under the present state (< 1 $m^3s^{-1}$), particularly during the summer months. Maintaining the *status quo* would therefore likely result in a decline in condition. The estuary is considered highly important.

Total economic value of the Berg estuary is estimated to be R75.6 million, with by far the largest component of this value being derived from turnover in the property sector (R48.6 million), followed closely by visitor expenditure (R18.3 million) and nursery value (R8.1 million). Subsistence and existence value make relatively small contributions to total economic value. This places the Berg estuary firmly on the upper end of the value spectrum for temperate estuaries in South Africa.

The recommended Ecological Reserve Category (ERC) represents the level of protection assigned to an estuary. In addition to being categorised as a 'highly important estuary', the Berg River Estuary has also been targeted as a Desired Protected Area (DWAF 2004a). Therefore, according to the guidelines for assigning a recommended ERC, the condition of the estuary should be elevated to a Category A or the Best Attainable State (BAS).

## 3.1 QUANTIFICATION OF THE RESERVE

Hydrological data were provided by Aurecon Consulting Engineers for the Reference Conditions, Present State and future scenarios (Table 3.1).

**Table 3.1 EWR scenarios**

| Scenario Name | Scenario Description | Summer lowflow ($m^3s^{-1}$) | Historic Firm Yield ($Mm^3$) | Historic Firm Yield: wrt. BRD (%) | Revised Estuary MAR (1920-2004) |
|---|---|---|---|---|---|
| Present state | Present day with Berg River Dam in Place | 0.3 | 547 | 0 | 500 |
| Scenario 1 | Present day without Berg River Dam | 0.3 | 462 | -85 | 594 |
| Scenario 2 | Augmentation of Voelvlei dam - Phase1 - No raising. $3m^3s^{-1}$ diversion | 0.3 | 574 | 27 | 471 |
| Scenario 3 | Augmentation of Voelvlei dam - Phase2a - No raising. $20m^3s^{-1}$ diversion | 0.3 | 591 | 44 | 450 |
| Scenario 4 | Augmentation of Voelvlei dam - Phase2b - $20m^3s^{-1}$ diversion, raise Voelvlei dam by 9 m | 0.3 | 613 | 66 | 394 |
| Scenario 5 | Raised Misverstand, Imposed resdss ifrC. Ifr = 23% of natural flow | 0.3 | 571 | 24 | 405 |
| Scenario 6 | Raised Misverstand, Imposed resdss ifrD. Ifr = 15% of natural flow | 0.3 | 585 | 38 | 396 |
| Scenario 7 | Present day with Berg River Dam in Place | 0.9 | 539 | -8 | 506 |

| Scenario Name | Scenario Description | Summer lowflow ($m^3s^{-1}$) | Historic Firm Yield ($Mm^3$) | Historic Firm Yield: wrt. BRD (%) | Revised Estuary MAR (1920-2004) |
|---|---|---|---|---|---|
| Scenario 8 | Raised Misverstand, Imposed resdss ifrD. Ifr = 15% of natural flow | 0.15 | 587 | 40 | 395 |
| Scenario 9 | Present state with increased lowflows | Dec 2, Jan 1.5, Feb - Mar 1, Apr 3 | 529 | -18 | 513 |
| Scenario 10 | Present state with increased lowflows and improved anthropogenic | Dec 2, Jan 1.5, Feb - Mar 1, Apr 3 | 529 | -18 | 513 |

Given the extent of the existing water resources infrastructure in the catchment (e.g. Berg River Dam) and the extent of transformation, it would be impractical to improve the condition of the Berg River Estuary to a Category of A, or indeed a Category B. Using flow alone, the condition could only be improved by 3% (from 64 to 67%). Even if non-flow related mitigation measures, such as removing unutilised infrastructure in the lower estuary, reducing agricultural impacts on the floodplain, reducing the application of fertilizers in the catchment and eradicating illegal gill net fishing in the estuary, were also implemented the condition would not reach a Category B. Thus, the BAS for the estuary is a **Category C.**

**Table 3.2 EcoStatus scores for each scenario**

| VARIABLE | Present | Future Runoff Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Score | 64 | 66 | 62 | 61 | 59 | 59 | 58 | 65 | 58 | 67 | 72 |
| Category | C | C | C | C | D | D | D | C | D | C | C |

Most of the scenarios evaluated in this study resulted in the Berg River Estuary dropping into lower category than PES mainly because the summer lowflows were lower than Present Day. Reduced summer lowflows increase the upstream extent of saline water penetration. The impact of reduced high flows was less pronounced.

**Scenario 7**, the Present inflow scenario with marginally reduced minimum summer low requirements of 0.6 x $m^3s^{-1}$ was selected as the recommended EWR for the Berg River Estuary.

Impacts of the various flow scenarios examined in this study on economic value of the Berg estuary was estimated for turnover in the real estate sector, visitor expenditure, and the nursery value of the estuary. Total estimated value for the Berg estuary for these three components examined for the future flow scenarios is R75.0 million per annum at present. This value increases marginally under most of the future scenarios (aside from Scenario 9), due to increases in all components of value under these scenarios up a maximum of R78.6 million per annum under Scenario 10. Under Scenario 9, modest increases in real estate turnover are offset by the lack of any change in recreational utility and a reduction in nursery value.

**Table 3.3 Flow distribution for the recommended flow scenario (Scenario 7)**

| | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 99%ile | 46.97 | 30.38 | 14.58 | 5.30 | 7.03 | 8.36 | 23.43 | 64.98 | 120.14 | 220.34 | 185.50 | 139.78 |
| 90%ile | 22.06 | 12.70 | 2.71 | 1.46 | 1.24 | 1.81 | 7.51 | 29.83 | 63.86 | 114.04 | 117.06 | 54.26 |
| 80%ile | 15.53 | 8.51 | 0.93 | 0.90 | 0.90 | 0.90 | 5.61 | 13.83 | 37.23 | 60.90 | 85.14 | 38.81 |
| 70%ile | 11.56 | 6.26 | 0.60 | 0.90 | 0.90 | 0.90 | 3.91 | 10.26 | 31.42 | 46.06 | 55.93 | 32.27 |
| 60%ile | 9.69 | 4.88 | 0.60 | 0.90 | 0.90 | 0.90 | 2.08 | 8.59 | 19.69 | 36.07 | 44.29 | 23.95 |
| 50%ile | 8.28 | 4.02 | 0.60 | 0.90 | 0.90 | 0.90 | 1.42 | 6.90 | 16.13 | 27.74 | 28.66 | 20.15 |
| 40%ile | 7.56 | 3.74 | 0.60 | 0.90 | 0.90 | 0.90 | 1.00 | 5.43 | 11.46 | 21.97 | 22.95 | 15.90 |
| 30%ile | 6.69 | 3.31 | 0.60 | 0.90 | 0.90 | 0.90 | 0.90 | 4.33 | 9.78 | 17.19 | 19.04 | 14.13 |
| 20%ile | 6.22 | 2.73 | 0.60 | 0.90 | 0.90 | 0.90 | 0.90 | 3.43 | 7.75 | 13.22 | 15.91 | 11.00 |
| 10%ile | 5.22 | 2.32 | 0.60 | 0.90 | 0.90 | 0.90 | 0.90 | 2.73 | 6.19 | 8.81 | 11.34 | 8.44 |
| 1%ile | 3.79 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.90 | 1.49 | 3.61 | 4.67 | 7.28 | 4.83 |

Allowing the condition of the Berg River Estuary to further decline from PES may have the following implications:

- Nuisance macroalgal growth during the summer months, with negative impacts on bird fauna, recreational usage and aesthetics (i.e. 'loss of value').
- Increase in abundance and occurrence of nuisance macrophytes, notably water hyacinth in the upper estuary and *Enteromorpha* in the lower estuary, with negative impacts on marginal salt marsh vegetation, intertidal invertebrate populations inhabiting sand and mudflats in the lower estuary, bird fauna of the estuary, and recreational usage and aesthetics.
- Reduced numbers of estuarine dependent fish and invertebrate species, particularly those that use the upper reaches of the estuary as a spawning and nursery ground.
- Reduced cueing effect to estuarine dependent invertebrate and fish species, and a possible reduction in diversity and abundance of fish in the estuary.

These are also likely to have a ripple effect on economic goods and services provided by the adjacent marine environment, e.g. the marine fisheries.

## 3.2 RECOMENDATIONS

Thus, it is strongly recommended that decisions regarding the future state of the Berg River Estuary carefully consider potential impacts on all users. Given the importance of the Berg River Estuary, every effort should also be made to implement the measures required to mitigate the non-flow related impacts on the system, such as:

- eradicate invasive alien vegetation (especially dense tree stands) from floodplains;
- remove derelict, redundant and old quays, jetties, wharfs and revetments; and rehabilitate banks to natural sediments;
- prohibit dredge spoil dumping (from lower main channel as well as marina) in inappropriate areas;
- install additional culverts into road and rail bridge embankments;
- manage agricultural practises in the estuary to avoid trampling of estuarine vegetation by livestock;
- manage agricultural practises in the catchment to minimise nutrient and sediment loads entering the estuary;
- control fish factory effluent discharged to the estuary to reduce nutrient loading to the system;
- upgrade the sewage treatment works in the catchment to reduce nutrient inputs to the estuary.

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