water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

The Determination of Water Resources Classes and Resource Quality Objectives for the water resources in in the Breede-Gouritz WMA

Municipality Sector Meeting

13th June 2018
Worcester

Study Objectives

Co-ordinate implementation of the Water Resources Classification System (WRCS):

- **Determine Water Resources Classes (WRCs)**
- **Determine Resource Quality Objectives (RQOs)**
- **Support Gazetting of Recommended Water Resources Classes and RQOs**

for the water resources in the Breede-Gouritz WMA:

- Rivers - Estuaries - Groundwater
- Dams - Wetlands

Objectives of the Meeting

- Provide overview of:
  - Study progress to date
  - Classification and RQOs Approach
- Present water resource classes and proposed scenario
- Present RQO findings
- Address concerns and clarifications

Overview of Study Process

Legal Mandate

- Chapter 3 of the National Water Act, (No. 36 of 1998) deals with the protection of water resources
- The measures for protection of water resources are:
  - Classification (S13)
  - Resource Quality Objectives (S13)
  - Reserve (S16)
- S12 requires the Minister to establish the Water Resource Classification System, (WRCS)
- WRCS was published as Regulation 810 in Government Gazette No. 33541 dated 17 September 2010
- The WRCS defines:
  - water resource classes and
  - the procedure to determine Class, RQOs and Reserve
- According to the NWA, once the WRCS has been gazetted all significant water resources must be classified and Resource Quality Objectives determined.

Classification and RQOs Steps

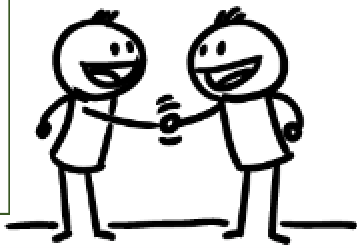
7-step process to determine WRCs

1. Delineate IUA's and describe status quo
2. Link value & condition of water resource
3. Quantify EWRs and changes in non-water quality EGSAs
4. Determine scenarios
5. Evaluate scenarios within IWRM process
6. Evaluate scenarios with stakeholders
7. Gazette & Class configuration

Aligned

7-step process to determine RQOs

1. Delineate Resource Units (RUs)
2. Establish Vision for Catchment
3. Prioritise & select prelim RU for RQO
4. Prioritise sub-components for RQO & select indicators
5. Draft RQOs & Numerical limits
6. Agree to RU, RQOs and numerical limits with stakeholders
7. Gazette WRC & RQO



Stakeholder engagement

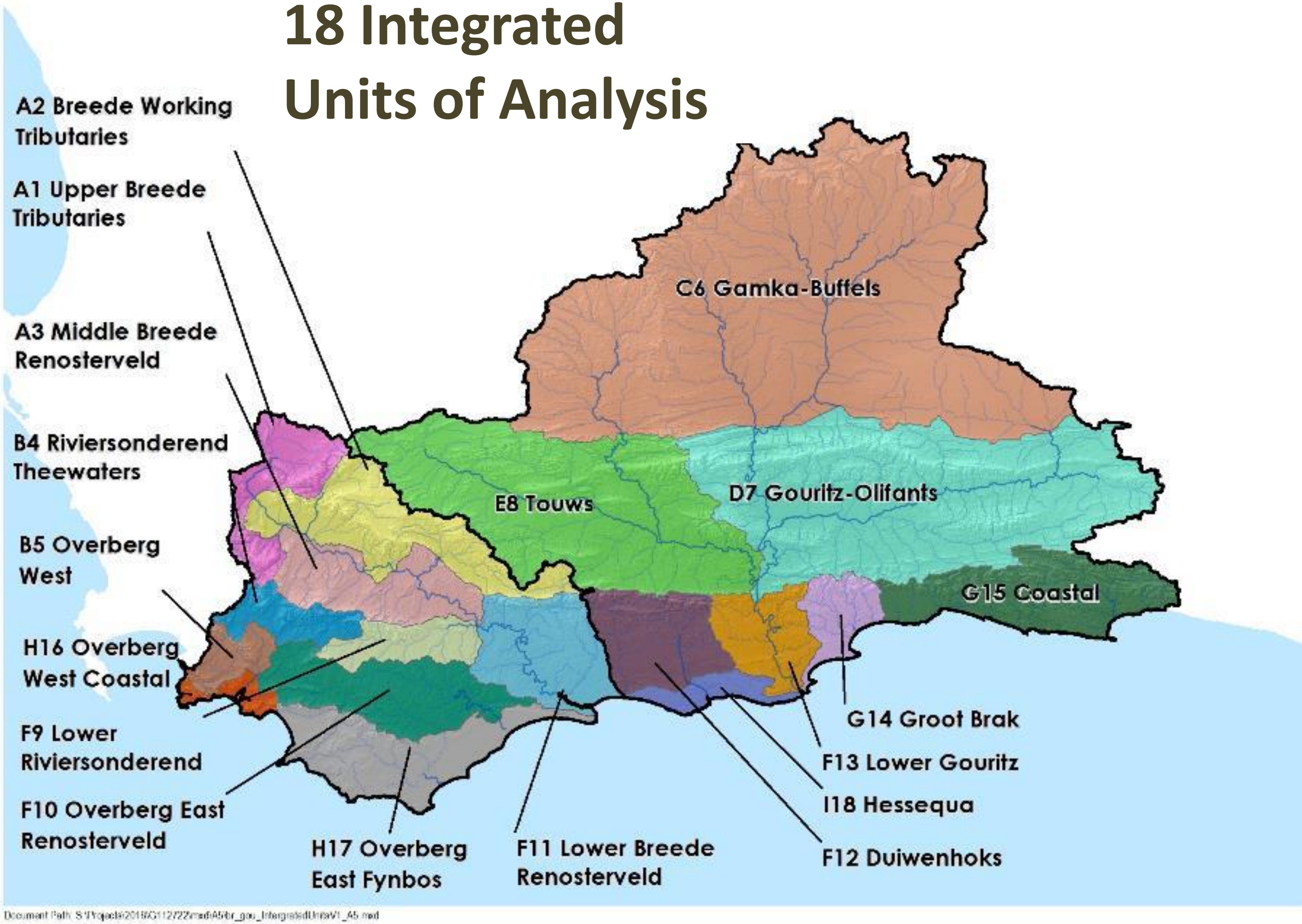
- Role of stakeholders is to engage and to provide comment – DWS makes decisions
- Stakeholders are engaged & consulted through SMC meetings, TTG meetings, Sector meetings, & public meetings
- Draft study reports distributed for comment
- Request for this workshop made at TTG meetings

Classification

Defined Integrated Units of Analysis (IUAs)

- Identified **significant resources**:
  - Based on Physical, Biological & Socio-economic factors
- Each IUA represents a similar area requiring a Water Resources Class (WRC)
- Why do we need these?
  - Broad-scale units to assess socio-economic implications of scenarios *(possible future situations)*
  - Report on ecological conditions at a sub-catchment scale
  - Set WR Classes for different parts of a catchment
- 18 IUAs delineated - 10 in the Breede-Overberg & 8 in the Gouritz-Coastal areas

18 Integrated Units of Analysis



Defined Resource Units (RUs) and Nodes

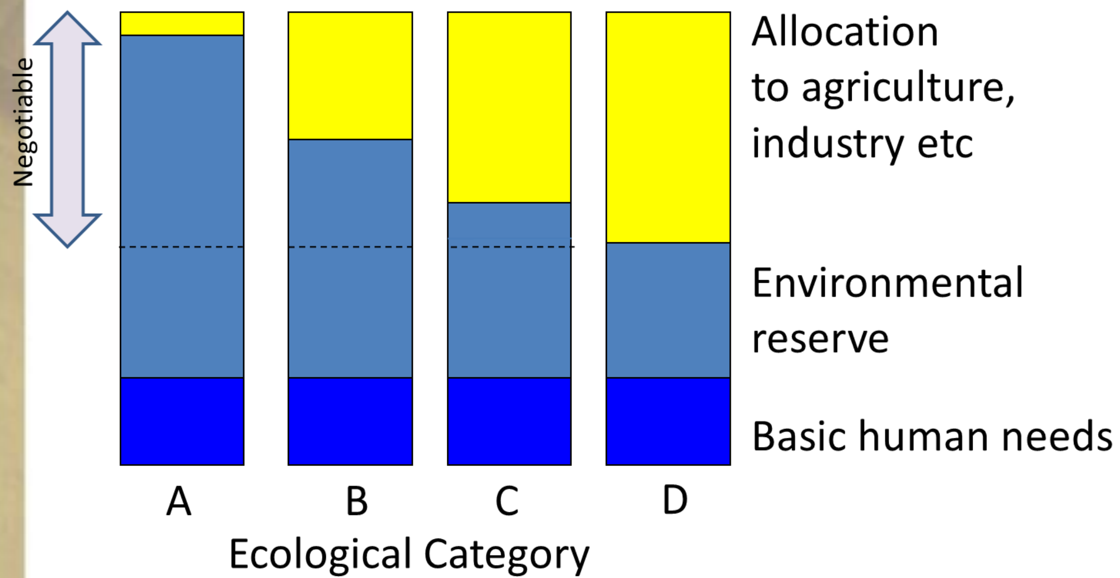
- **Resource units (RUs)** are grouped areas e.g. river basins, deemed similar in terms of various characteristics
- Are used to transfer information between catchments
- Groundwater

- **Nodes** are locations of interest (points) in a water resource (rivers, dams, wetlands, estuaries)
- Are sited using:
  - Water infrastructure
  - Aquatic ecosystem attributes
- Are used to allocate water for environment and development

Socio-economics

Rationale

- In setting the Reserve for aquatic ecosystems,
  - Need to trade off the economic value of allocating water to ecosystems versus to other uses
  - Need to take non-monetary factors into account, including meeting biodiversity conservation targets

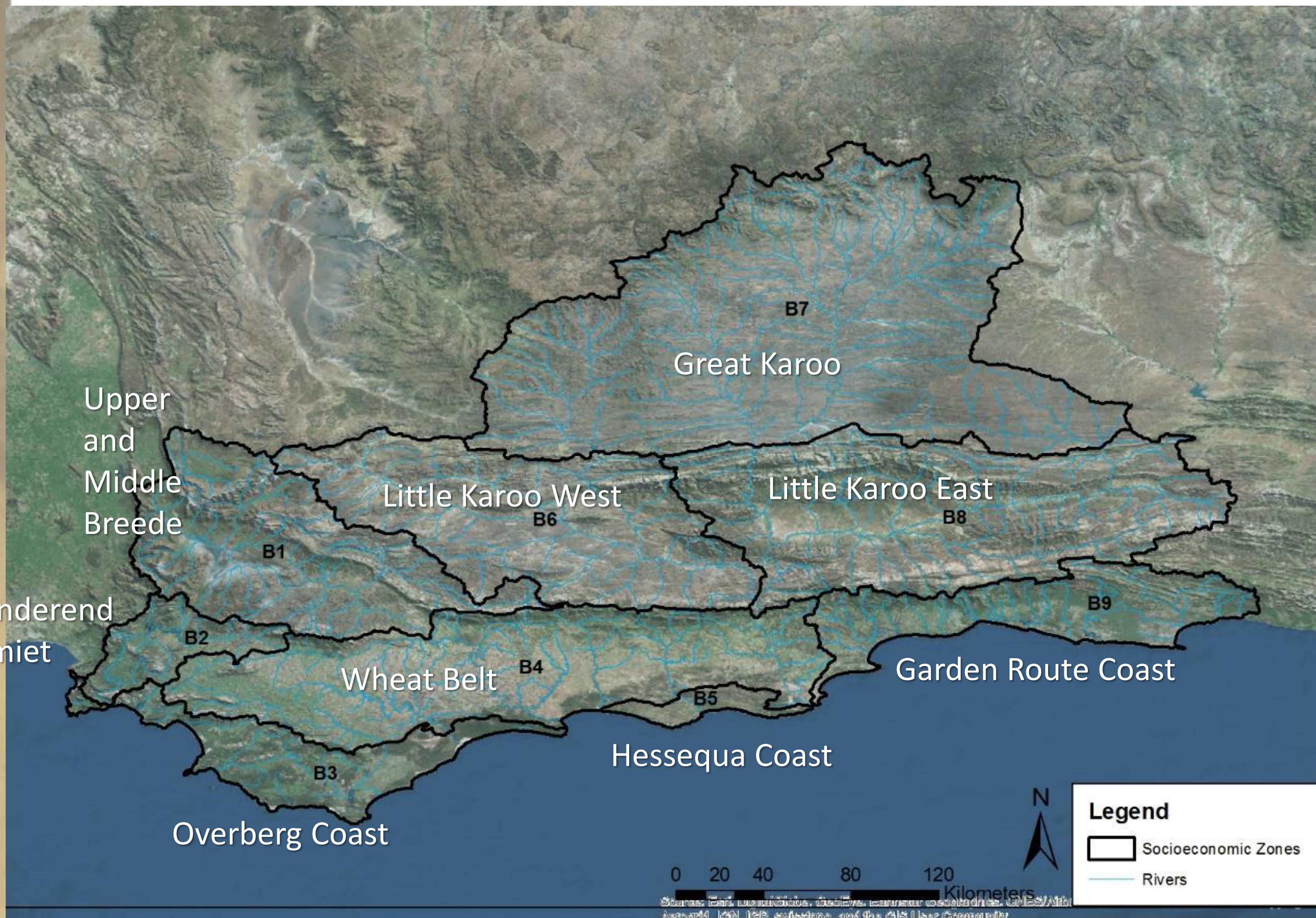


Increasing EC means have to either curtail water rights, or supply water from alternative sources (higher cost)

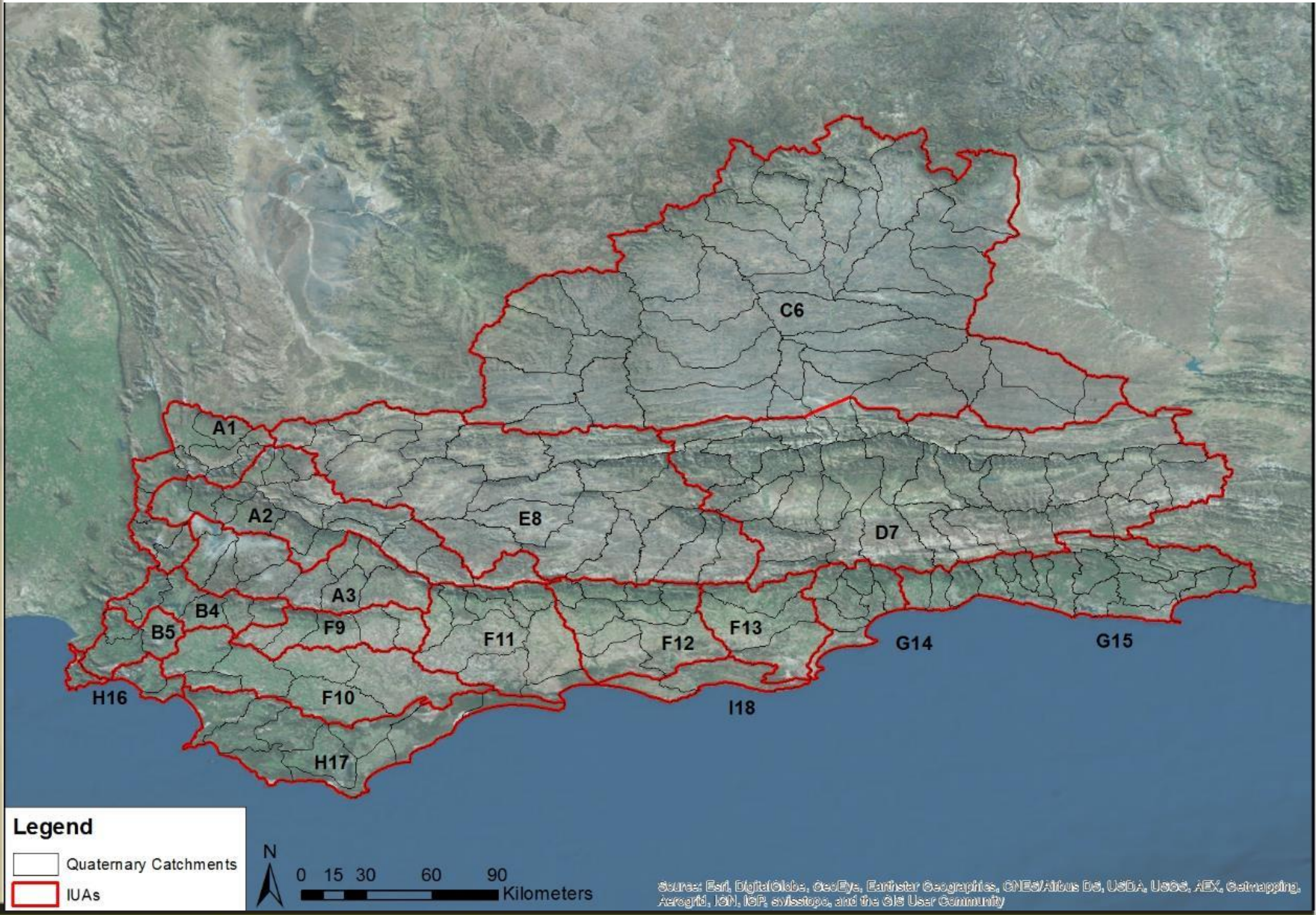
Socio-economics component

- Review economic value of activities in the study area, with emphasis on water-dependent activities
- Estimate the value of aquatic ecosystem services
- Estimate the relationship between ecosystem health and ecosystem value
- Undertake scenario analysis to estimate costs and benefits of different levels of environmental protection (classification scenarios)

Socio-economic zones

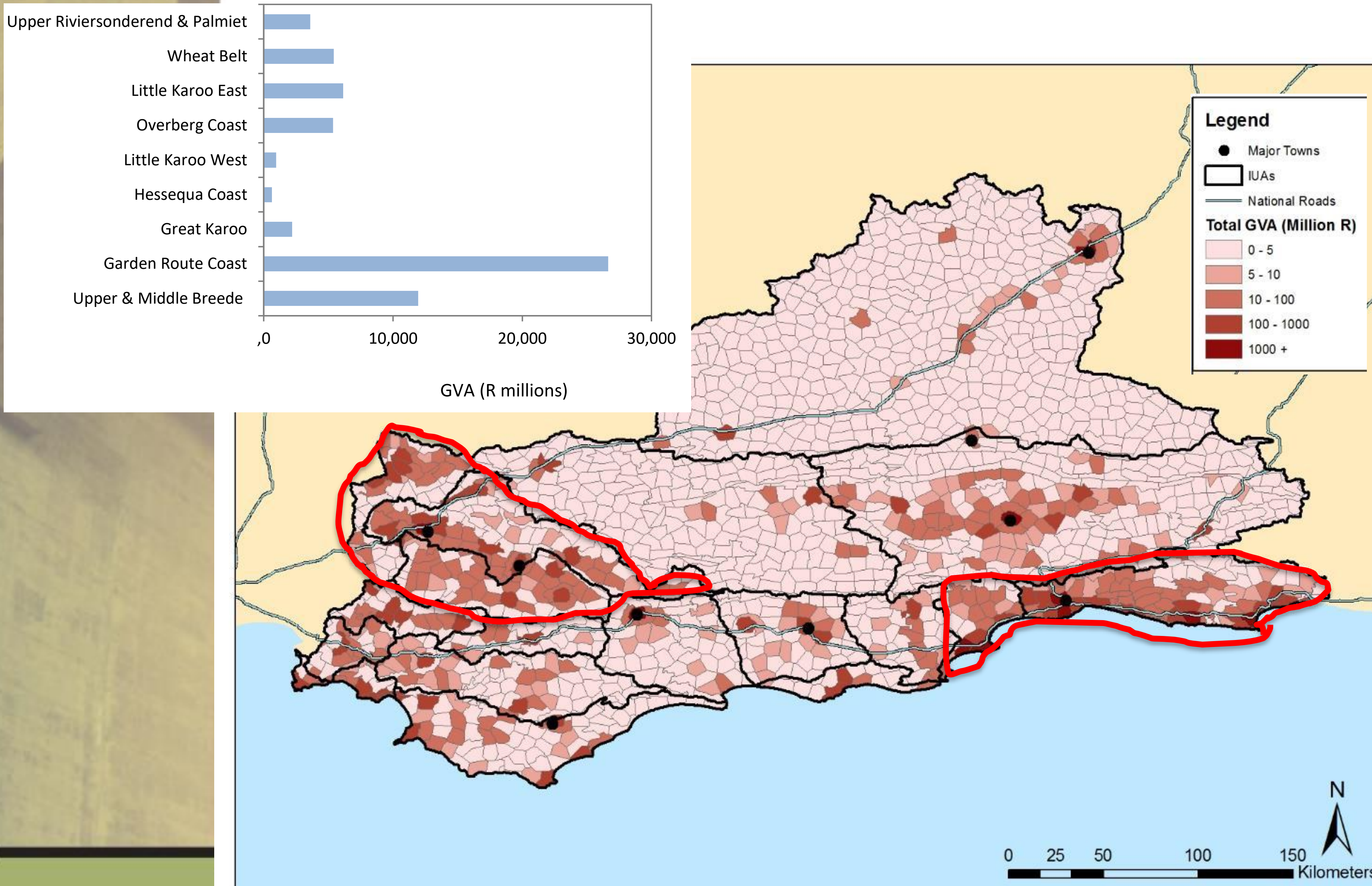


IUAs

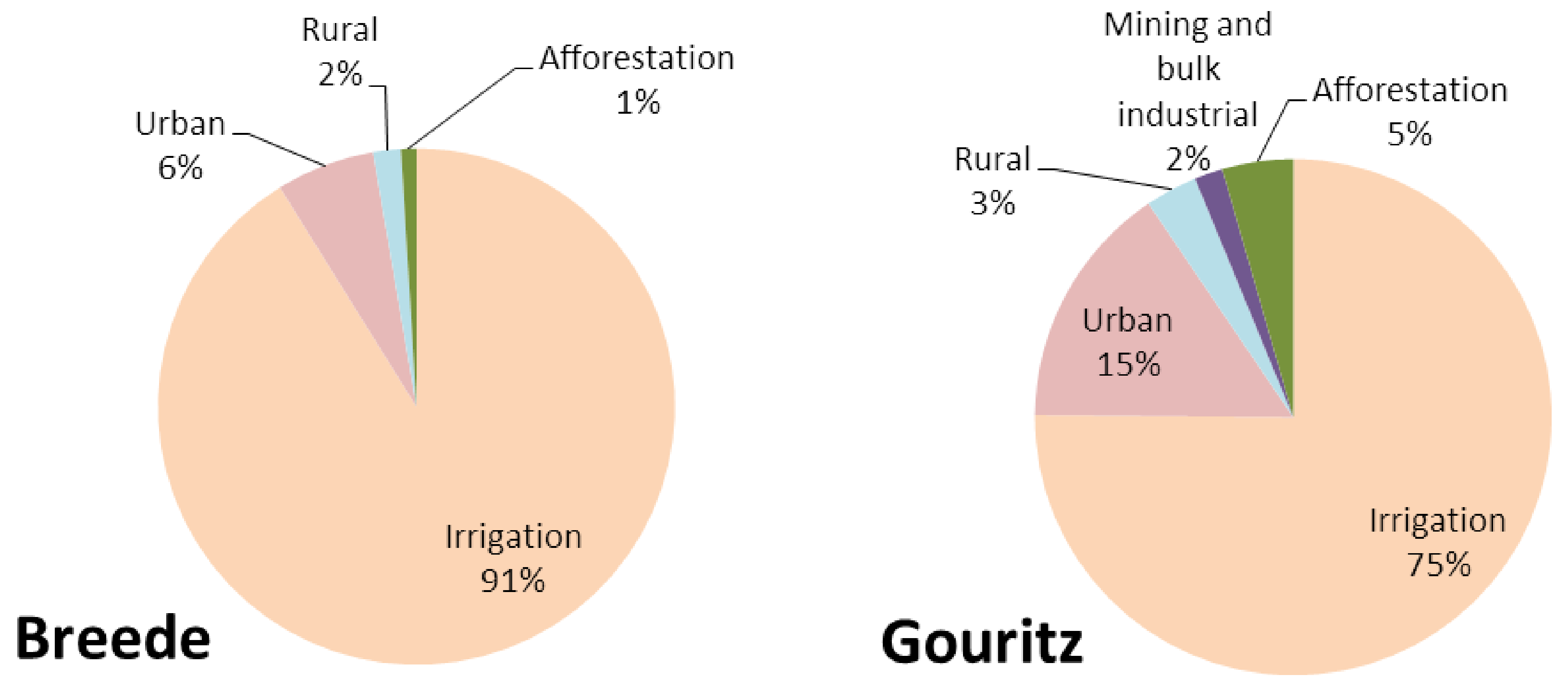


C6
A1
A2
E8
D7
A3
B4
F9
B5
F11
F12
F13
G14
G15
H16
F10
I18
H17
Legend
Quaternary Catchments
IUAs
N
0 15 30 60 90
Kilometers
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Contribution to GGP – all sectors



Current water use



Scenarios considered

- Extract as much water as possible* (ESBC)
- Maintain present condition (PES)
- Recommended ecological condition (REC)
- Spatially-targeted mix

Also (for comparative purposes only)

- what would happen without environmental constraints (No EC), and
- with climate change (No EC + CC)

Scenario assumptions

- Agricultural & forestry use is capped
  - No further increases in water allocation apart from existing plans
- High growth in urban & industrial water demand
  - i.e. worst case scenario (now less likely, but balances lack of CC)
  - Taken from Small Towns Study projections based on population and economic growth
- Planned surface water schemes are implemented
- **Demands are met**
  - If classification requires an increase in the environmental Reserve, resulting shortfalls in water supply will be remedied to ensure that projected demands will be met
  - This will happen by accelerating the implementation of planned infrastructure + additional measures as required

Scenario assumptions

- Costs of substituting surface water abstractions are based on recent estimates
  - May be overestimates (technological advances) or underestimates
  - Non-flow measures could reduce this requirement.
- Environmental impacts of the alternate options are minimized
  - (ie in the price), but we acknowledge that they would not be zero
- We have not considered who will bear the cost in the analysis (beyond our scope). Options include
  - Government subsidy.
  - User pays: this will drive technological innovation, efficiency gains and adaptive strategies.
  - Urban users pay: will reduce urban demand; demonstrated WTP for secure and “greener” water.

Scenario analysis

1. Determine flow requirements (ecologists)

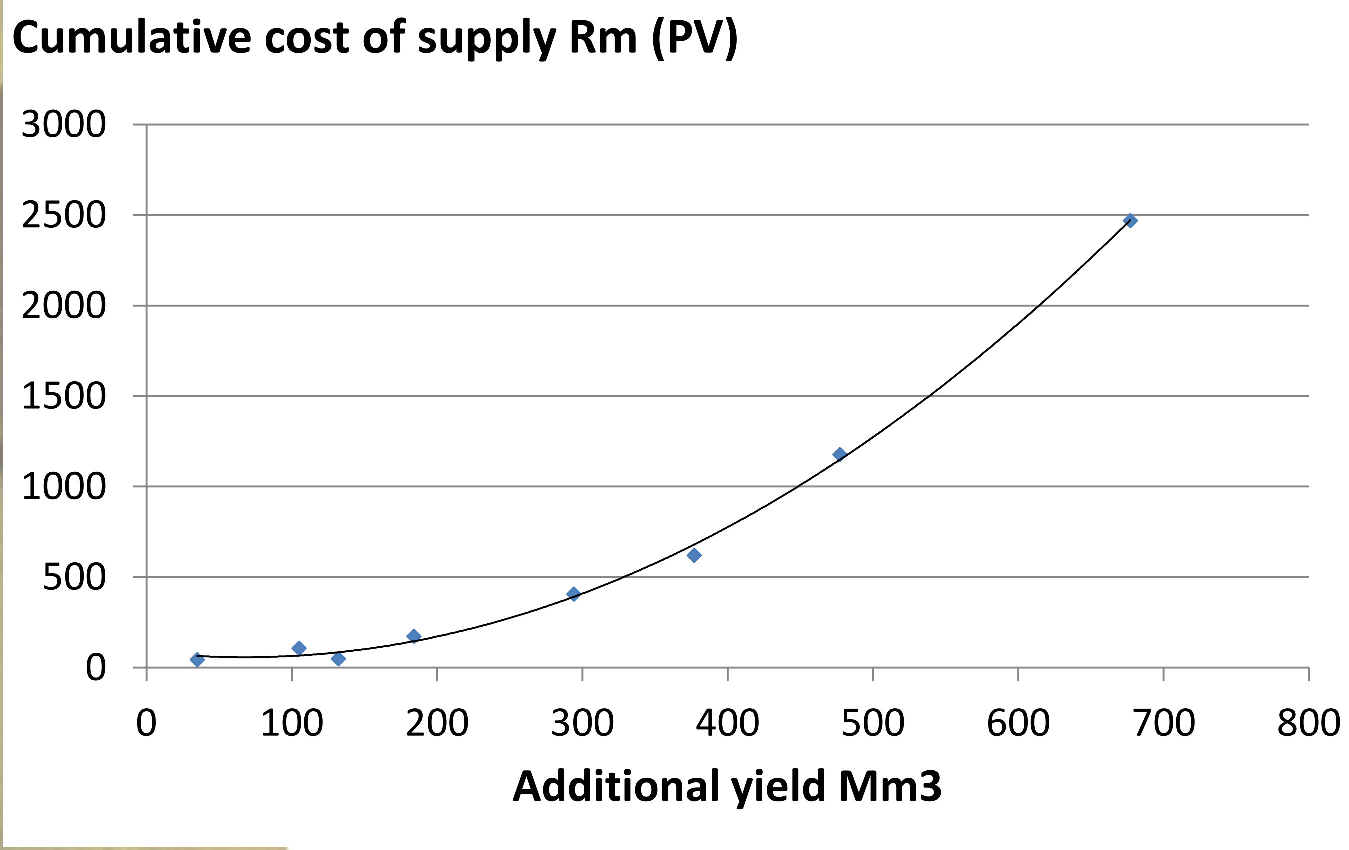
   Based on the ECs of the scenario,

2. Estimate resultant shortfall (if any), and how to rectify (hydrologists)

   Only what is actually feasible (in physical terms), taking sustainable yields of groundwater into account

3. Estimate the additional water supply costs (engineers)
4. Estimate changes in value of ecosystem services
5. Change in water supply costs and ecosystem services analysed over 25 years (2017-40)

Water supply costs (WCWSS)



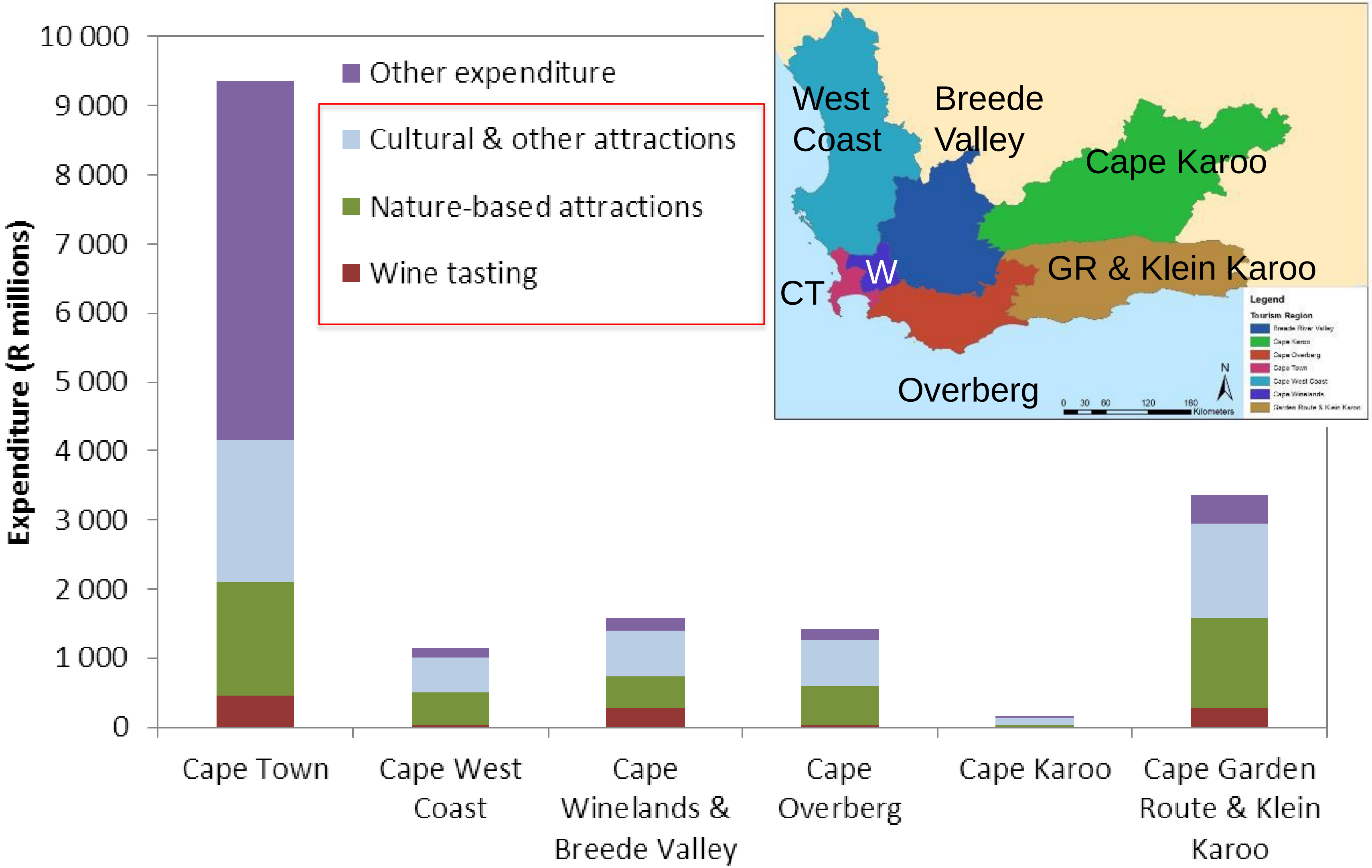
The faster that water demands grow, the sooner we move to the next (more expensive) option

- Cost estimates explained in next segment

Ecosystem services considered

- Harvested natural resources
  - for subsistence
- Amenity values
  - Tourism
  - Property
- Nursery value of estuaries
  - Contribution to inshore fisheries

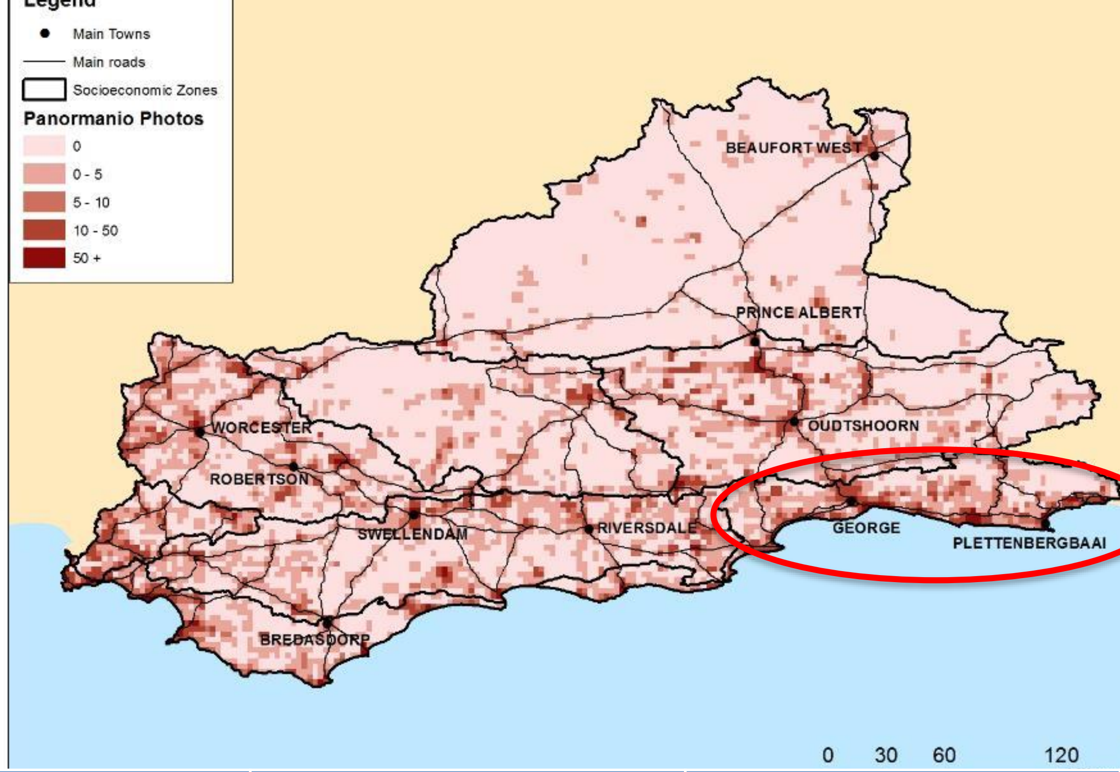
Tourism



10 000
9 000
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
Expenditure (R millions)
Other expenditure
Cultural & other attractions
Nature-based attractions
Wine tasting
Cape Town
Cape West Coast
Cape Winelands & Breede Valley
Cape Overberg
Cape Karoo
Cape Garden Route & Klein Karoo
West Coast
Breede Valley
Cape Karoo
W
CT
GR & Klein Karoo
Overberg
Legend
Tourism Region
N
0 30 60 120 180
Kilometers

Tourism value

- At least R2.4bn
- Estuary-based tourism: R800m – R3bn p.a.



Socio-economic zone	Gross Output (R million per year)	% at/near rivers and estuaries	Estimated contribution of rivers and estuaries (R million per year)
Upper and Middle Breede	679.4	55%	**370.9**
Upper Riviersonderend	336.1	47%	156.5
Great Karoo	143.5	67%	96.6
Little Karoo East	598.5	61%	**363.2**
Little Karoo West	270.9	48%	130.9
Wheat Belt	624.6	57%	**355.2**
Garden Route Coast	1 163.1	63%	**734.2**
Overberg Coast	841.7	23%	179.2
Hessequa Coast	97.5	39%	37.9
	4 755.3		**2 442.4**

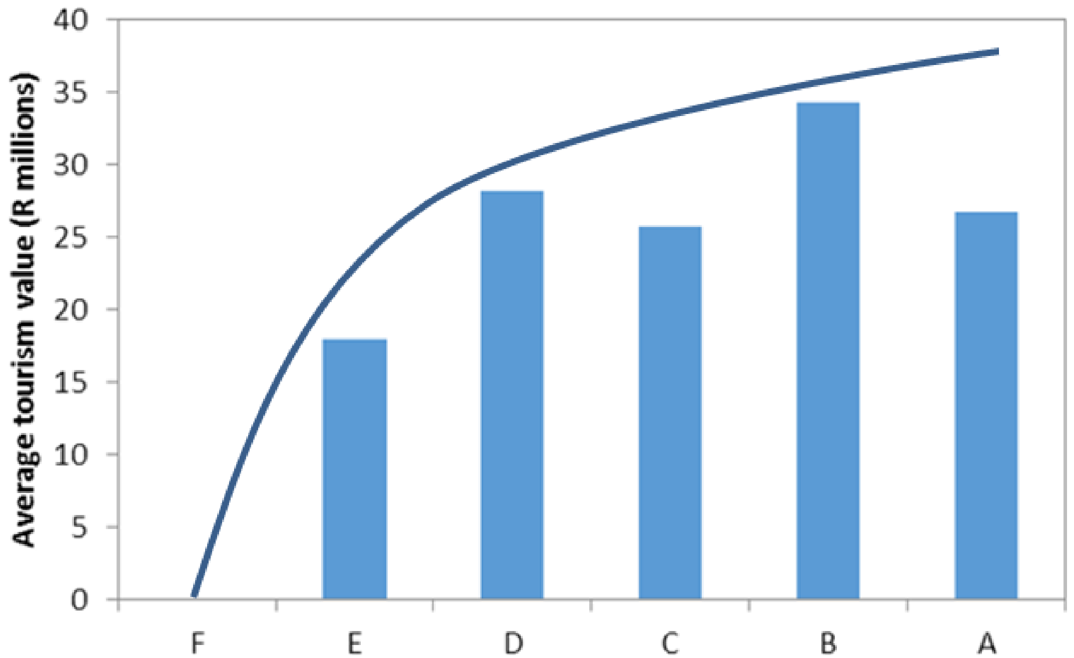
Property value

- Annualised premiums associated with views/proximity
- Total R272m/y just for estuaries

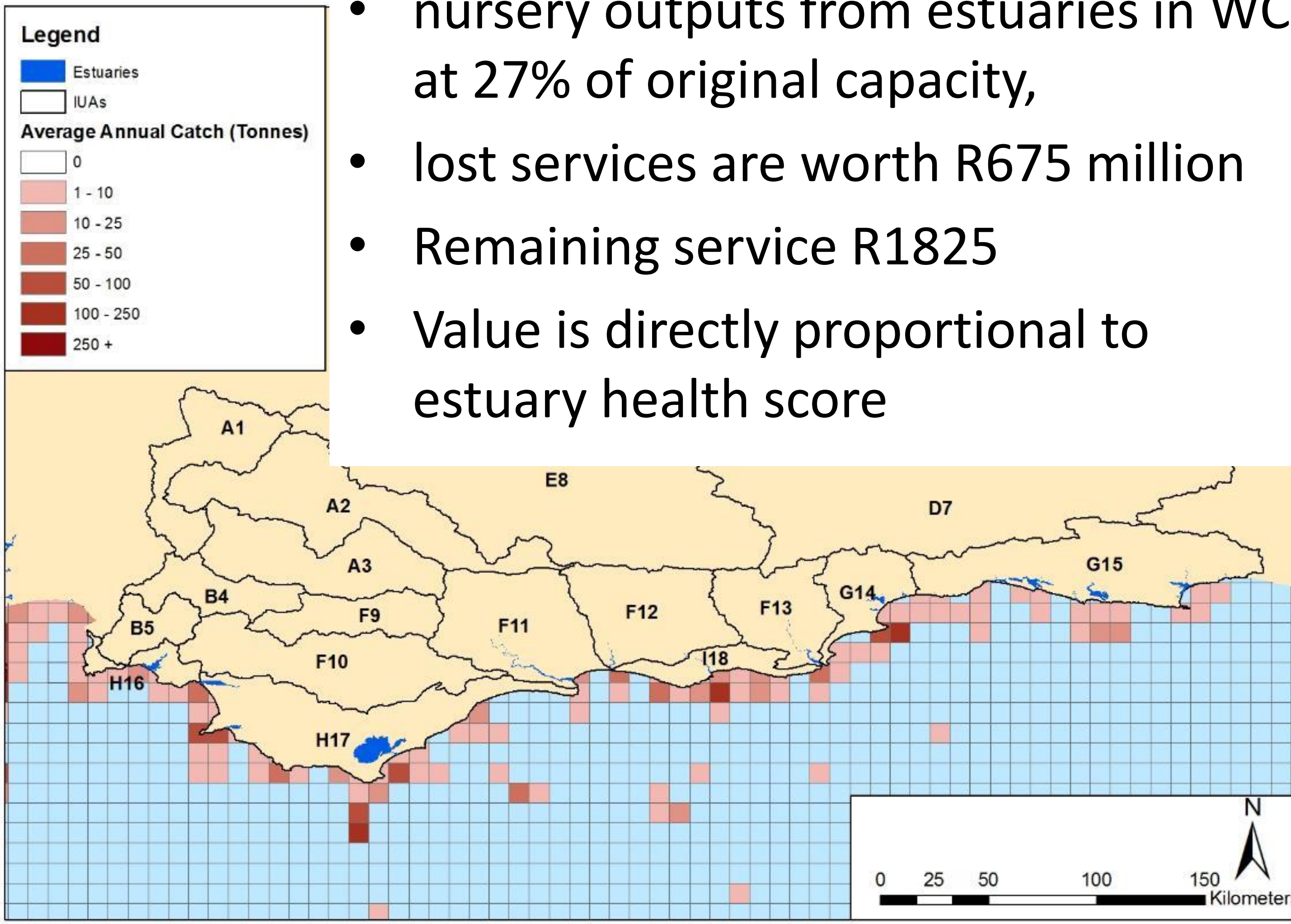
Zone	Estuary	Value R/y	Zone	Estuary	Value R/y
Overberg	Rooiels	2.2	Garden Route	Hartenbos	1.1
	Buffels (Oos)	2.7		Klein Brak	2.1
	Bot/Kleinmond	25.4		Groot Brak	20.0
	Onrus	2.6		Kaaimans	0.5
	Klein	1.5		Wilderness	10.2
	Uilskraals	2.0		Swartvlei	16.4
Wheat Belt	Breede	42.9		Knysna	67.6
Wheat Belt	Duiwenhoks	2.4		Noetsie	0.1
Hessequa	Goukou	26.7		Piesang	1.9
Wheat Belt	Gourits	18.2		Keurbooms	19.7
				Groot (Wes)	5.9

Relationship to ecosystem health

- Based on our estimates, logarithmic relationship between amenity value and estuary health
- From this, can estimate % change from PES to scenario EC



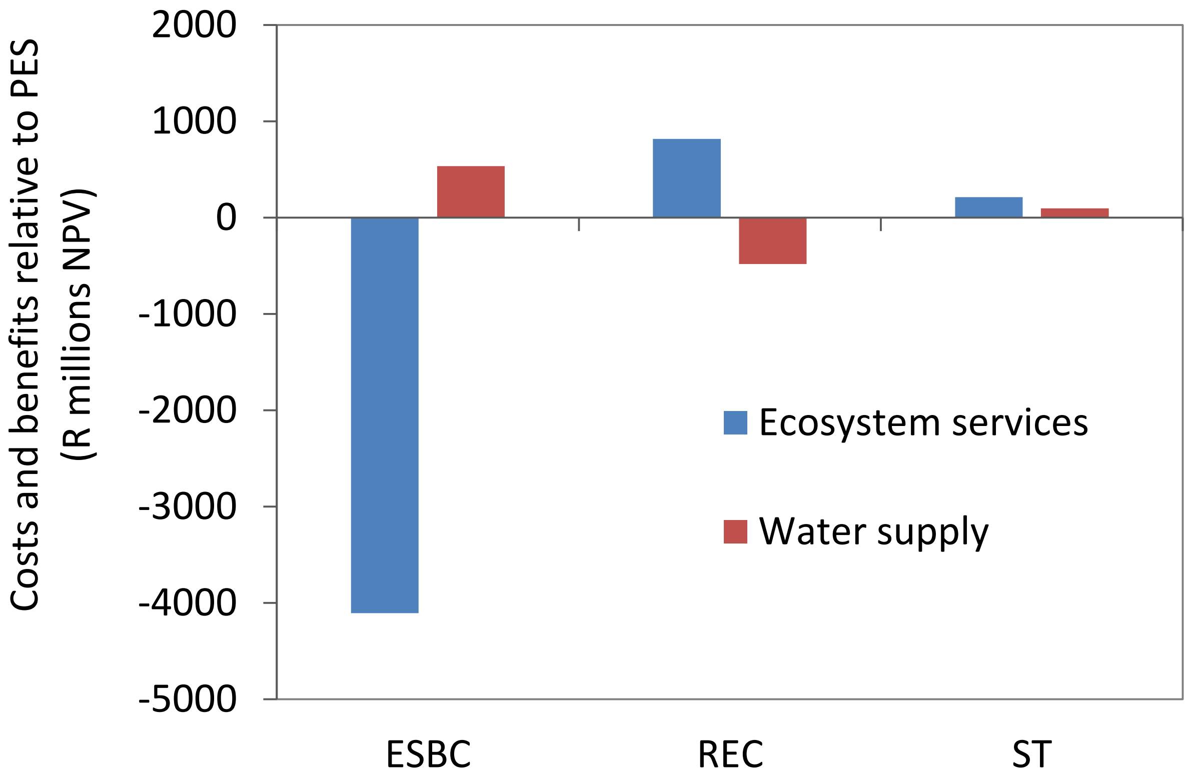
Nursery value



- nursery outputs from estuaries in WC at 27% of original capacity,
- lost services are worth R675 million
- Remaining service R1825
- Value is directly proportional to estuary health score

Scenario analysis

- Costs/benefits relative to PES scenario



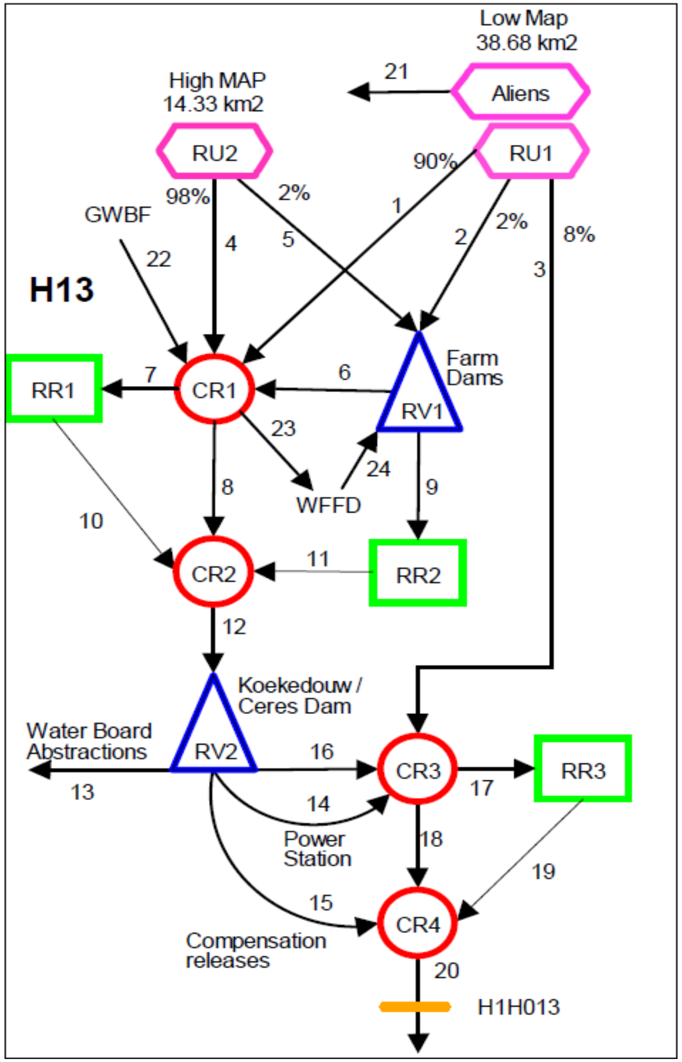
- ESBC comes at v high cost to society
- REC has highest net benefit
- Spatially-targeted scenario avoids water losses
  - Net benefit similar to REC
- Maintaining PES = third best outcome

Hydrology, water demands & infrastructure costing

Surface water hydrology

- WRSM2012 Pitman Rainfall-Runoff Catchment Modelling System - previously configured for all rivers in the Breede-Gouritz WMA (WRC, 2016).
- Configurations covered both Natural and Current-day catchment conditions.
- Configurations were refined/corrected ito bulk infrastructure, farm dams, irrigation/urban water requirements, return flows.
- These improved configurations were further sub-divided to reflect river and estuary nodes.
- Generated 90-year monthly flow sequences at all river and estuary nodes using monthly rainfall inputs for period 1920/21 – 2009/2010.
- Different sets of flow sequences used for different water requirement scenarios: Natural; Current-day; Projected for 2040 with New Bulk Infrastructure; Climate Change super-imposed on the latter.

Typical Pitman Rainfall-Runoff Catchment Model Configuration – Koekedouw River - Upper Breede



Irrigation water requirements

- Irrigation requirements in WRSM2012 and combined farm dam volumes per hydrological unit was reviewed and updated from:
  - WARMS (Aurecon 'cleaned' version)
  - Cape Farm Mapper (WC DoA)
  - Google earth
  - Breede-Overberg V&V
- Smaller irrigation schemes was often not adequately configured in the model – this was corrected
- Total irrigation <u>use</u> modelled is 822 million m^3/a

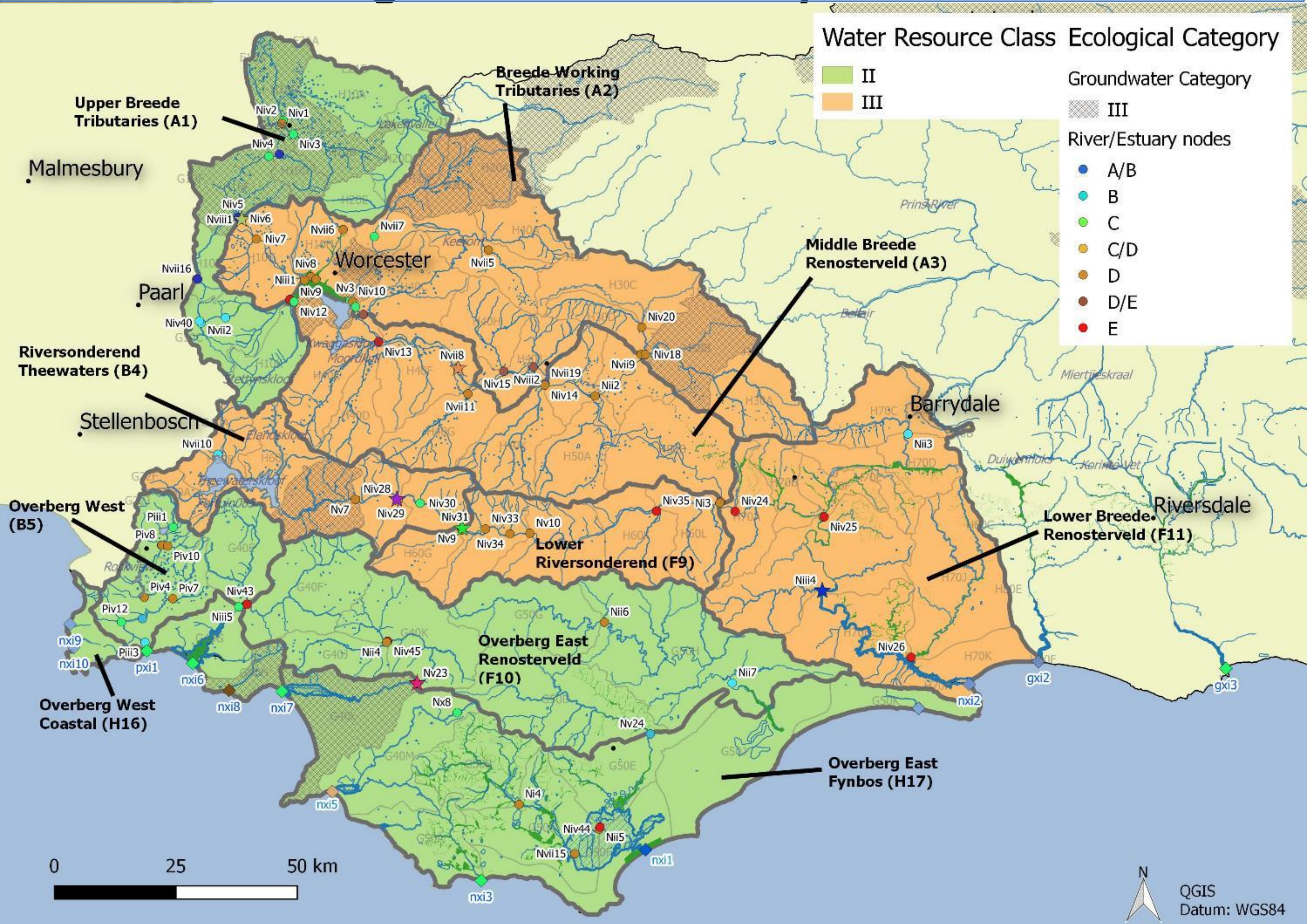
Urban water requirements

IUA	Location	Current (million m³/a)	High Growth (million m³/a)
G15	Knysna	4.0	8.8
G15	Bitou	3.8	8.1
G15	Greater George	11.3	32.5
G14	Mossel Bay	7.9	12.7
F12	Heidelberg	0.4	1.0
F11	Riversdale	1.6	3.7
D7	Oudtshoorn	6.0	11.6
D7	Uniondale	0.2	0.6
E8	Ladismith	1.1	2.1
E8	Touws River	0.9	1.4
C6	Calitzdorp	0.5	0.9
C6	Beaufort West	2.6	3.8
D7	Prince Albert	0.3	0.5
B5	Grabouw	1.3	2.6
H16	Rooi Els/Pringle Bay/ Betty's Bay	0.8	3.0
F10	Caledon	1.6	3.1
F10	Bredasdorp	1.0	2.0
H16	Kleinmond	0.8	2.8

IUA	Location	Current (million m³/a)	High Growth (million m³/a)
H16+H17	Greater Hermanus	4.3	12.9
H17	Gansbaai	1.8	12.3
A2	Barrydale	0.3	0.7
F11	Swellendam	1.4	2.4
B4	Villiersdorp	0.4	0.8
F10	Genadendal, Greyton, etc.	0.3	0.6
F9	Riviersonderend	0.4	0.8
A3	Ashton	2.4	4.8
A2	Montagu	1.0	2.0
A3	Robertson	2.2	3.9
A3	McGregor	0.2	0.4
A3	Bonnievale	1.2	2.5
A2	De Doorns	0.7	1.4
A2	Worcester	13.6	23.0
A1	Wolseley	1.3	1.7
A1	Rawsonville	0.3	0.5
A1	Ceres	4.2	8.8
A1	Prince Alfred Hamlet	0.4	1.0

Proposed Scenario

Integrated Units of Analysis and Nodes



Breede-Overberg Region

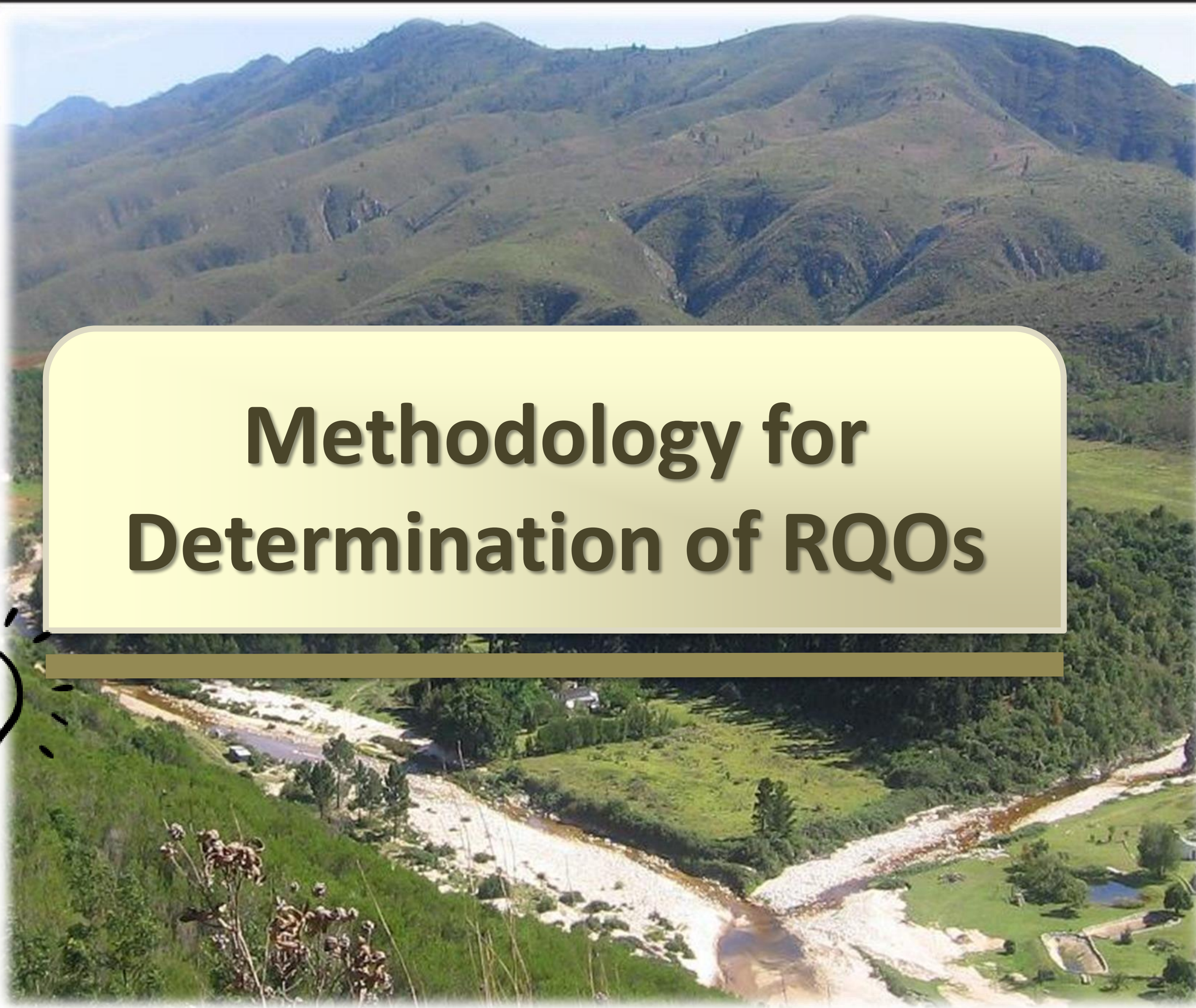
Integrated Unit of Analysis (IUA)	Recommended Classes
A1 Upper Breede Tributaries	II
A2 Middle Breede Renosterveld	III
A3 Breede Working Tributaries	III
B4 Riversonderend Theewaters	III
F9 Lower Riversonderend	III
B5 Overberg West	II
H16 Overberg West Coastal	II
F10 Overberg East Renosterveld	II
H17 Overberg East Fynbos	III
F11 Lower Breede Renosterveld	II

Integrated Units of Analysis and Nodes

Gouritz-Coastal Region

	Integrated Unit of Analysis (IUA)		Recommended Classes
	Gamka Buffels	C6	II
	Touws	E8	III
	Gouritz-Olifants	D7	III
	Lower Gouritz	F13	II
	Duiwenhoks	F12	III
	Hessequa	I18	III
	Groot Brak	G14	III
	Coastal	G15	II

Methodology for Determination of RQOs



Study Status: RQOs

STEP 1: DELINEATE CATCHMENT

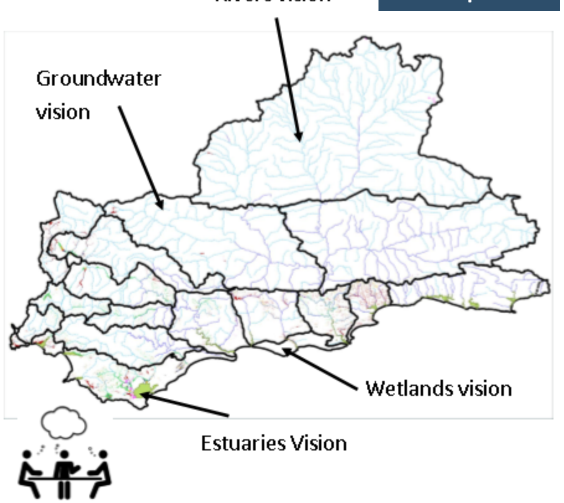
<u>Outcome</u>: Integrated Units of Analysis and Resource units as defined in the WRCS approach.

Complete

STEP 2: ESTABLISH VISION FOR CATCHMENT

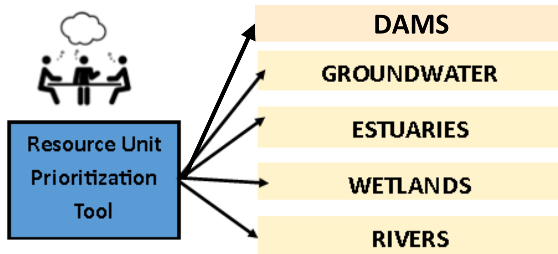
<u>Outcome</u>: Align the diverse and competing interests in the resource into a collective desired future state. This involves multiple stakeholders in the strategic planning process.

Complete



STEP 3: PRIORITISE & SELECT PRELIMINARY RESOURCE UNITS FOR RQO

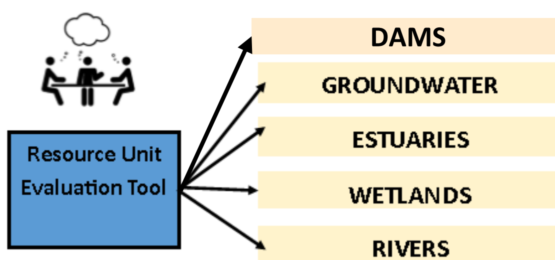
<u>Outcome</u>: Use the resource unit prioritization tool to sect priority resource units.



Final

STEP 4: PRIORITISE SUB-COMPONENTS FOR RQO & SELECT INDICATIORS FOR MONITORING

<u>Outcome</u>: Identify & prioritize sub-components that may be important to users or environment. Select sub-components and associated indicators for RQOs and Numerical Limits.



Draft

STEP 5: DEVELOP DRAFT RQOs & NUMERICAL LIMITS

<u>Outcome</u>: RQOs are essentially narrative but sometimes broadly quantitative descriptions of the resource. These are gazette, whilst Numerical Limits are not. These should be set for discussion with stakeholders.

Draft

STEP 6: AGREE RESOURCE UNITS, RQOs AND NUMERICAL LIMITS WITH STAKEHOLDERS

<u>Outcome</u>: .Stakeholders who were involved in the setting of the vision are involved in reviewing how their input has been considered and taken forward. Decide on Resource Units, RQOs and Numerical Limits.

STEP 7: GAZETTE RESOURCE QUALITY OBJECTIVES

<u>Outcome</u>: A Water Resource Class configuration and associated RQOs for the entire catchment is published by the Minister in the Government Gazette as required in the National Water Act of 1998.

Overview

Classification:

- Proposed Scenario
  (RUs with Targeted ECs (TECs) for water resources, per IUA class)

↓

RQOs:

- Resource Unit prioritisation (using RUPT Tool, where applicable)
- Resource Unit evaluation (using RUET Tool, where applicable)
- Define RQO and Numerical Limits
- Define Monitoring Program

Evaluation of RUs - method

- Customised DWS **RU Evaluation Tool** used to identify selected indicators *for prioritised RUs* for which RQOs (descriptive and numerical) have be written, by identifying:

Components — *Quantity, Quality Habitat, Biota*

↓

Sub-components

↓

Indicators

Example of indicators: River Example

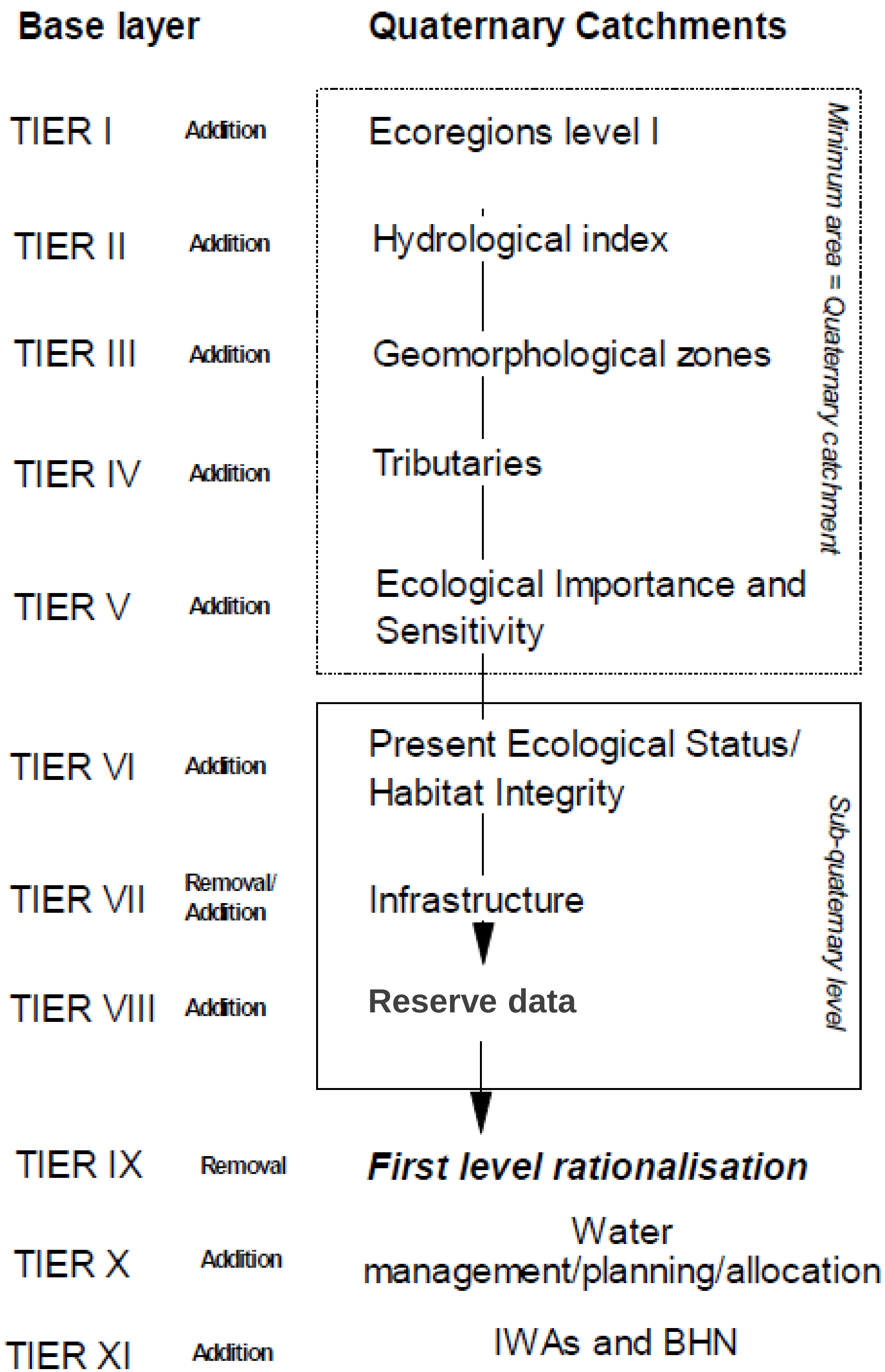
Component	Sub-Component	Indicator example
QUANTITY	Flow	Water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles
QUALITY	Nutrients	NO_3/NO_2
HABITAT	Geomorphology	Sediment particle size (D_{50})
BIOTA	Macroinvertebrates	SASS and ASPT scores

Overview

- **Prioritised Resource Unit per IUA**
  - i.e. grouped areas e.g. river basins, deemed similar in terms of various characteristics
- **Component/ Sub-component**
  - E.g. Quantity/ Flow
- **Indicator**
  - Representation of trend tracking the measurable change in a system over time. Focuses on a small manageable set of information
- **Resource Quality Objective (RQO)**
  - Descriptive broad statements describing overall objectives for the Resource Unit
- **Numerical limit**
  - Quantitative descriptors of different components of the Resource Unit

Rivers

- Selecting rivers in the Breede Gouritz WMA
- Modelling flow-condition relationships
- Outcome of flow scenarios on river condition
- RQOs for rivers (indicators to monitor)
- Monitoring programme for rivers



Selecting rivers

Methodology (DWAF, 2007):

- Eleven "tiers" of rules used to establish river nodes.

Nodes:

- 66 river nodes - Gouritz WMA
- 76 river nodes - Breede WMA

Modelling links between flow and ecological condition

1. Define the scenarios
2. Describe surface flows and ecological conditions (EC)
3. Quantify changes in flow and ecological conditions

a) The balancing tool contains:

   i. Baseline ecological conditions for rivers and estuaries.

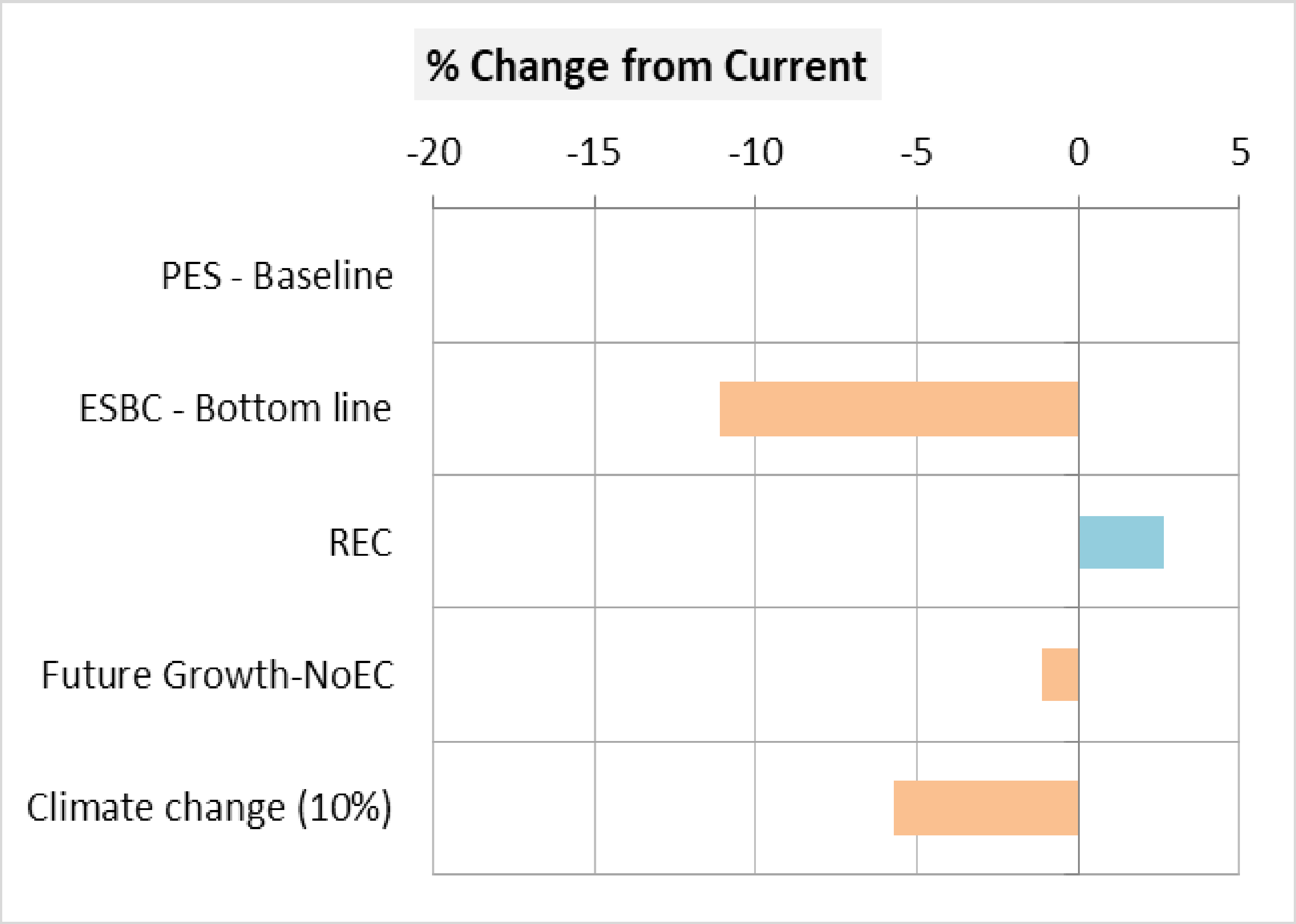
   ii. Modelled current day and natural flows.

   iii. Modelled Reserve flows for a range of ecological conditions, based on various Reserve studies.

b) Allows the user to toggle flow and see changes in condition.

c) Reports surpluses of deficits in flow relative to current day.

Outcome of scenarios on ecological condition of rivers



Gouritz-Coastal River sites for RQOs

Quat #	Node code	River	REC	PES	%nMAR
J12L	gviii1	Doring	C/D	C/D	43.79
J12L	gv5	Touws	B/C	B/C	43.01
J11H	gv4	Buffels	C	C	66.36
J11J	gv6	Groot		D	44.48
J13C	gii3	Groot		B	42.01
J25A	giv20	Gamka	C	C/D	51.49
J31C	giii2	Olifants	C	C	84.08
J34C	gv36	Kammanassie	C/D	C/D	71.93
J40B	gi4	Gouritz	C	C	54.89
H80D	giii8	Duiwenhoks	D	D	93.51
H90A	giii7	Goukou	C/D	C/D	87.04
K20A	gviii2	Groot-Brak	B/C	B/C	93.62
K30B	gvii9	Malgas	C	C	95.29
K30C	gvii11	Kaaimans	B	B	94.03
K40A	giii10	Diep	A/B	B	96.64
K40C	gvii13	Karatara	A/B	B	94.21
K40E	gviii9	Goukamma	B/C	B/C	87.31
K50A	gvii14	Knysna	B	B	95.54
K50B	gviii11	Gouna	A/B	A/B	92.12
K60C	giv6	Keurbooms	B/C	C	84.09

Breede-Overberg River sites for RQOs

Quat	Node	River	REC	PES	%nMAR
H10F	Nviii1	Breede	D	D/E	55.19
H10J	Nvii2	Molenaars	B	B	89.88
H20G	Nvii7	Hex	C	C	79.43
H40F	Nvii8	Breede	C/D	C/D	50.52
H50B	Ni2	Breede		D	49.09
H60B	Nvii10	Du Toits		B	90.12
H60D	Nv7	Riviersonderend		D	53.58
H60E	Niv28	Baviaans	B	B	84.98
H60F	Nv9	Riviersonderend	D	D	56.66
H60L	Ni3	Riviersonderend		D	52.67
H70G	Niii4	Breede	B/C	C	53.4
G40C	Piii1	Palmiet	B	C	87.4
G40D	Piii2	Palmiet	B/C	B/C	49.11
G40D	Piii3	Palmiet	B	B	57.99
G50B	Ni4	Nuwejaar	D	D	45.46
G50D	Nv24	Kars	B	B/C	89.16
G40K	Nv23	Klein	C	C/D	84.71

Indicators for monitoring RQOs

QUANTITY: flow

low flows and high flows, monthly average volume (MCM)

QUALITY:

nutrients, salinity, system variables, toxins and pathogens

HABITAT: condition/geomorphology/vegetation

IHI, PAI, GAI, VEGRAI

sediment particle size (D_{50}), channel-width/depth

% cover of indigenous and alien cover in 3 zones

BIOTA: condition/macroinvertebrates/fish

MIRAI, FRAI

SASS and ASPT scores, # of families present, key indicator families

CPUE of fish species present, FROC

Monitoring programme

Hydrology:

- Continuous discharge data from gauging weirs (Activity H1)
- Visual inspection of flow during the dry season (Activity H2)

Geomorphology:

- GAI score (Activity G1)
- Sediment size (Activity G2)
- Width and depth (Activity G3)
- Habitat diversity (Activity G4)

Riparian vegetation:

- VEGRAI score (Activity R1)
- Cover of indigenous and exotic species in three lateral zones (Activity R2)

Macroinvertebrates:

- MIRAI score (Activity M1)
- SASS5 and ASPT scores (Activity M2)
- Diversity of macroinvertebrates (Activity M3)

Fish:

- FRAI score (Activity F1)
- FROC or CPUE of fish species (Activity F2)

EXAMPLE: Doring River @ GOUR_DORI_J12L

QUANTITY: Flow – excludes inter-annual floods

```
Desktop Version 2, Generated on 10/03/2017
Summary of Desktop (Version2) estimate for Quaternary Catchment Area:
Total Runoff :            gviii
Annual Flows (Mill. cu. m or index values):
MAR                 =    2.868
S.Dev.             =    3.492
CV                  =    1.218
Q75                 =    0.013
Q75/MMF             =    0.054
BFI Index           =    0.207
CV(JJA+JFM) Index =      6.371

Ecological Category = C/D

Total IFR           =    0.345 (12.02 %MAR)
Maint. Lowflow      =    0.174 ( 6.06 %MAR)
Drought Lowflow     =    0.002 ( 0.06 %MAR)
Maint. Highflow     =    0.171 ( 5.96 %MAR)

Monthly Distributions (Mill. cu. m.)
Distribution Type : E.Karoo
```

Month	Natural Flows Mean	SD	CV	Modified Flows (IFR) Low flows Maint.	Drought	High Flows Maint.	Total Flows Maint.
Oct	0.247	0.538	2.176	0.017	0.000	0.031	0.048
Nov	0.302	0.569	1.883	0.021	0.000	0.031	0.052
Dec	0.322	0.797	2.474	0.019	0.000	0.000	0.019
Jan	0.280	1.232	4.402	0.012	0.000	0.031	0.043
Feb	0.271	1.214	4.483	0.009	0.000	0.000	0.009
Mar	0.195	0.565	2.890	0.015	0.000	0.000	0.015
Apr	0.392	1.064	2.713	0.016	0.000	0.079	0.095
May	0.259	0.465	1.793	0.017	0.000	0.000	0.017
Jun	0.082	0.121	1.466	0.013	0.000	0.000	0.013
Jul	0.106	0.333	3.146	0.010	0.000	0.000	0.010
Aug	0.226	0.617	2.725	0.012	0.002	0.000	0.012
Sep	0.184	0.591	3.209	0.012	0.000	0.000	0.012

EXAMPLE: Doring River @ GOUR_DORI_J12L

Water Quality

Sub-component	TEC	RWQO	Indicator	Numerical Limits	Present state (50/95%tile) J1H018Q01
Nutrients	C	Maintain in a mesotrophic (moderately enriched) or better condition.	Phosphate (PO_4-P) Total inorganic nitrogen (TIN)	Median ≤ 0.075 mg/l PO_4-P Median ≤ 1.75 mg/l TIN	PO4 0.010 / 0.024 TIN 0.058 / 0.183
Salts		Salt concentrations should be maintained at present day levels.	Electrical conductivity (EC)	95th %tile ≤ 1500 mS/m EC	EC 873 / 1440
System variables		pH, temperature, and dissolved oxygen are important for the maintenance of ecosystem health.	pH Dissolved oxygen	6.5 ≥ pH ≤ 8.5 5th percentile ≥ 6 mg/l DO	pH 8.2 / 8.5 No DO data
Toxins		Toxicity not pose a threat to aquatic ecosystems.	None specified as it is not a concern in this RU		No data
Pathogens		Maintained in an Acceptable category for full contact recreation.	Escherichia coli	95%tile ≤ 165 cfu/100ml E coli	No data

EXAMPLE: Doring River @ GOUR_DORI_J12L

BIOTA: Riparian vegetation

Metric	RQOs	TPC
Marginal zone		
Exotic species	No exotic plant species.	Occurrence of exotic plant species.
Terrestrial woody species	No terrestrial woody species.	Cover > 1%
Indigenous woody species	Cover < 10%.	Cover > 10%.
Non-woody indigenous species	Cover 30-50%.	Cover < 10%
Reeds	Cover < 30%.	Cover > 40%.
Lower zone		
Exotic species	Cover < 5%.	Cover > 15%.
Terrestrial woody species	Cover < 10%.	Cover > 15%.
Indigenous woody species	Cover < 20%.	Cover > 20%.
Non-woody indigenous species	Cover 30-50%.	Cover < 10%
Reeds	Cover < 30%.	Cover > 40%.
Upper zone		
Exotic species	Cover < 10%.	Cover > 20%.
Terrestrial woody species	Cover </= 15%.	Cover > 20%.
Indigenous woody species	Cover < 70%.	Cover > 75%.
Non-woody indigenous species	Cover 30-50%.	Cover < 10%

EXAMPLE: Doring River @ GOUR_DORI_J12L

BIOTA: Macroinvertebrates

Parameters	RQOs	TPCs
SASS5 and ASPT score	SASS5 score >90, ASPT ≥ 4.5.	SASS5 scores < 90, ASPT < 4.5.
Diversity of invertebrate community	>/= 15 families, at an abundance of A to C.	<15 families. Any taxon (adult) with an abundance of 1.

EXAMPLE: Doring River @ GOUR_DORI_J12L

BIOTA: Fish

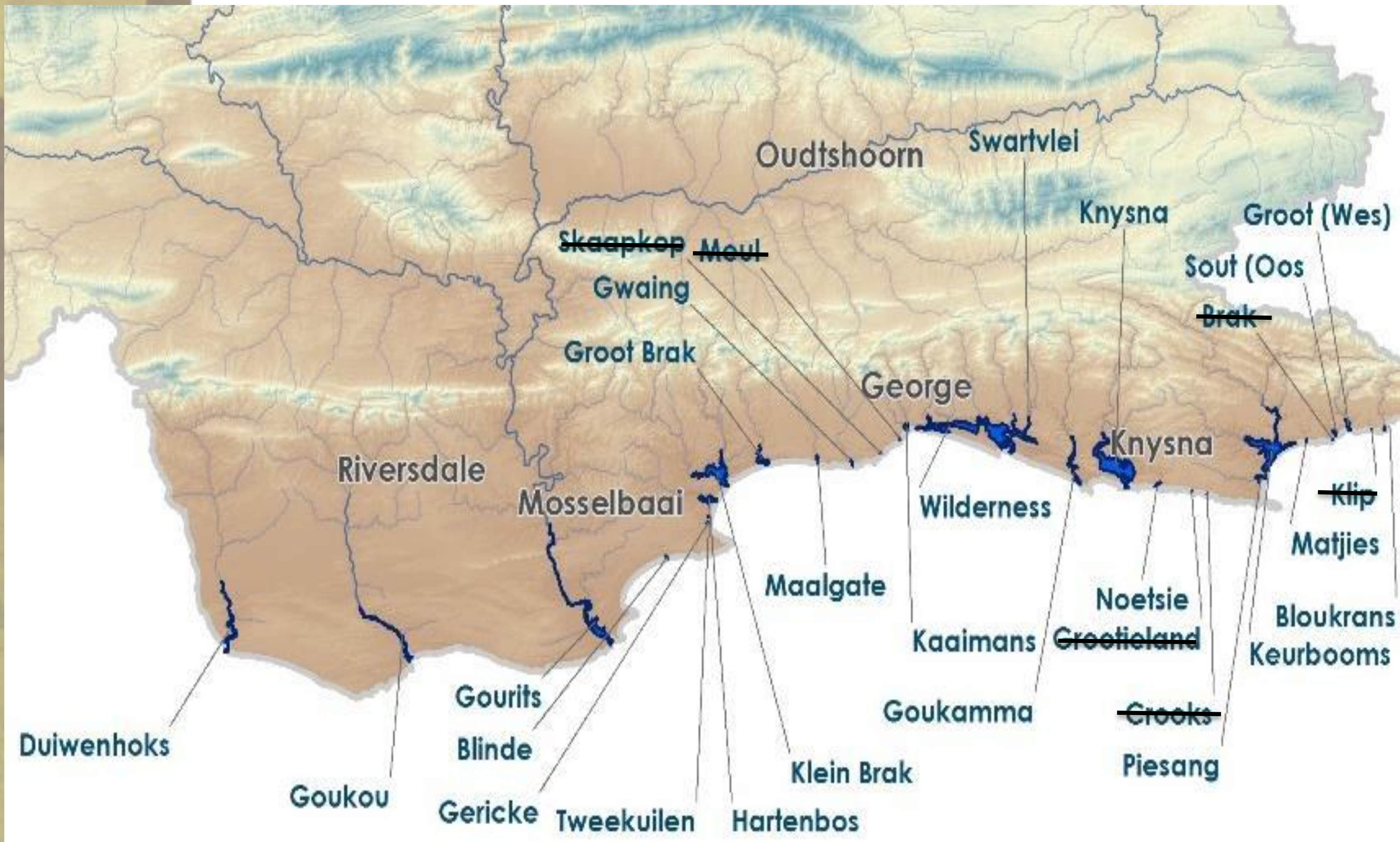
Metric	RQOs	TPC
Indigenous species richness	All four of the indigenous fish species should be present: *Labeo umbratus, Pseudobarbus asper , Sandelia capensis, Barbus anoplus*	< 2 indigenous species
Pseudobarbus asper	FROC = 0.5	*Pseudobarbus asper* absent for two consecutive surveys OR present at FROC of < 0.5. Also absence of juvenile fish in catches.
Barbus anoplus	FROC = 0.5	*Barbus anoplus* absent for two consecutive surveys OR present at FROC of < 0.5. Also absence of a range of life stages (juvenile to adult) in catches.
Labeo umbratus	FROC = 0.5	*Labeo umbratus* absent for two consecutive surveys OR present at FROC of < 0.5. Also absence of juvenile fish in catches.
Sandelia capensis	FROC = 0.5	*Sandelia capensis* absent for two consecutive surveys OR present at FROC of < 0.5. Also absence of juvenile fish in catches.
Exotic fish species	No increase in CPUE for: *Tilapia sparmanii* (0.6 ind/min)	Presence of any additional exotic/introduced species or increase in CPUE of any listed.

Estuaries

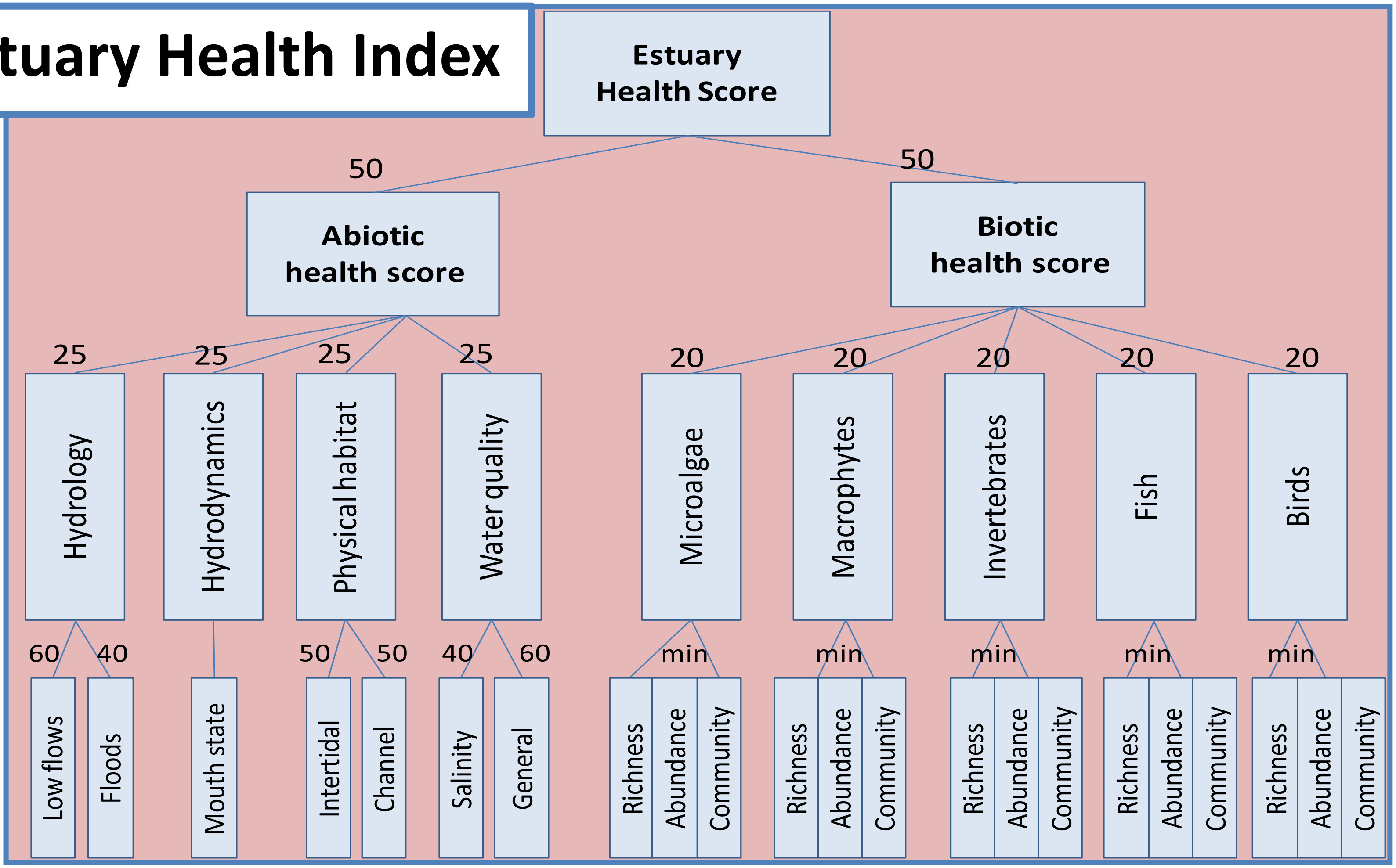
1. Estuaries in the Breede Gouritz WMA
2. Evaluating estuary health
3. Relationship between estuary health and flow
4. Recommended Ecological Categories (REC) for estuaries
5. Impacts of flow scenarios on estuary health
6. RQOs for priority estuaries (example)
7. Monitoring programmes for estuaries (example)

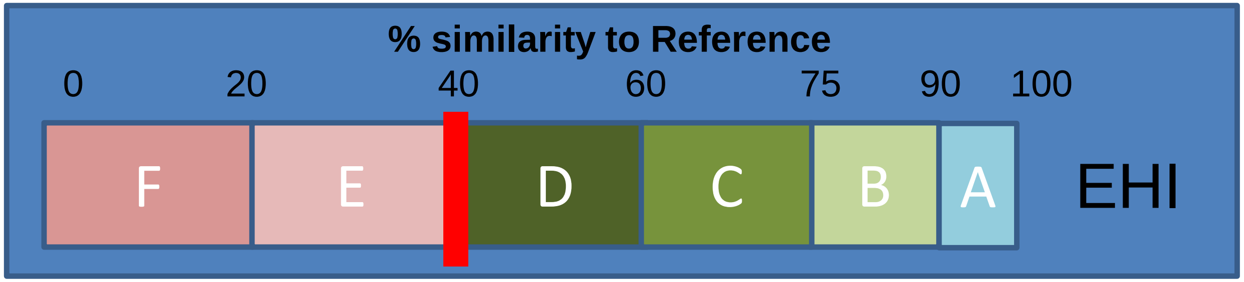
Estuaries in the Breede Overberg Region

Estuaries in the Gouritz region

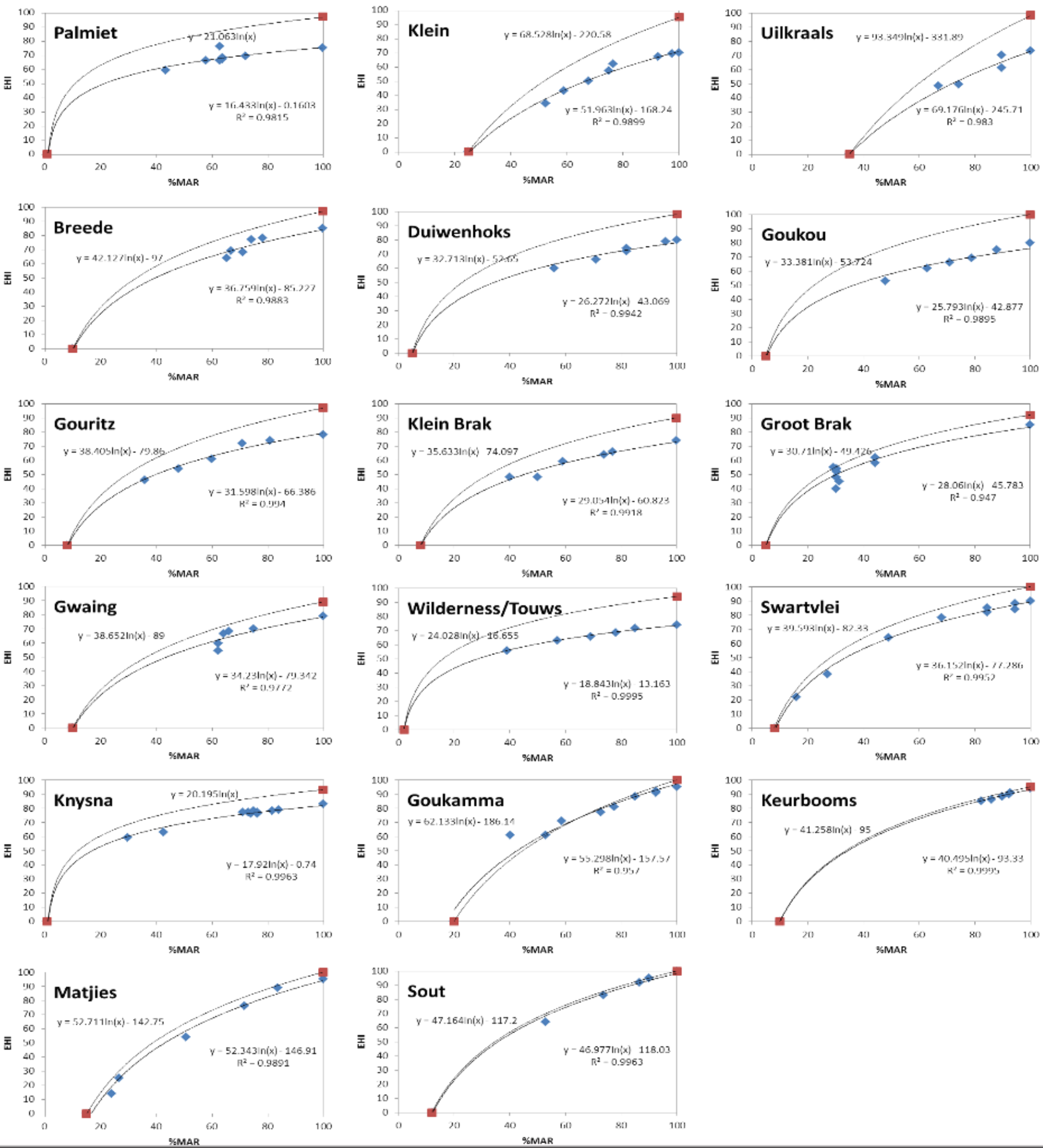


Estuary Health Index





Change in Estuarine Health with Flow



Flow scenarios considered for the Breede-Gouritz WMA

HOW TO DETERMINE REC FOR AN ESTUARY?

		PRESENT ECOLOGICAL STATUS			
		A	B	C	D, E or F
Estuary importance	Protected or desired protected status	A or BAS	A or BAS	A or BAS	A or BAS
	Highly important (80 – 100)	A	A	B	C
	Important (60 – 80)	A	A	B	C
	Of low to average importance (0 – 60)	A	B	C	D

EHI scores under different scenarios: Breede-Overberg

Estuary	Rec	PES - Baseline	% nMAR	ESBC - Bottom line	% nMAR	REC	% nMAR	Future Growth-NoEC	% nMAR	Climate change (10%)	% nMAR	Spatially Targeted Scenario	% nMAR
Rooiels	B	B	98.6	D	71.7	B	98.6	B	98.6	C	84.5	B	98.6
Buffels	B	B	81.9	B	81.9	B	81.9	B	81.9	B	69.9	B	81.9
Palmiet	B	C	70.1	C	45.2	C	70.1	C	68.4	C	59.7	C	70.1
Bot	B	C	81.8	D	57.9	C	81.8	C	81.8	D	56.2	C	81.8
Onrus	D	D	51.8	D	51.8	D	51.8	E/F	27.2	E	36.7	D	51.8
Klein	B	C	80.3	D	55.7	B	98.1	C	80.3	D	54.3	C	85.6
Uilkraal	C	E	43.9	E	43.9	C	63.7	E/F	40.4	E/F	27.3	C/D	58.8
Ratel	C	C	90.0	D	58.5	C	90.0	C	90.0	C/D	66.0	C	90.0
Klipdrifsfontein	A	A	64.8	A	64.8	A	64.8	A	64.8	C	48.0	A	64.8
Heuningnes	A	C	68.8	D	58.8	A/B	78.0	C	71.2	D	49.0	A/B	78.2
Bree	B	B	49.5	B	46.9	B	50.2	B	44.5	C	39.4	B	47.2

EHI scores under different scenarios - Gouritz region

Estuary	Nat MAR	REC	PES scenario		ESBC scenario		REC scenario		Future growth - NoEC		Climate change		Spatially targeted	
			EC	%nMAR	EC	%nMAR	EC	%nMAR	EC	%nMAR	EC	%nMAR	EC	%nMAR
Gouritz	612.4	B	C	61.9	D	39.1	C	66.0	C	59.4	D	43.8	C	59.7
Duiwenhoks	88.8	A	B	91.9	C	51.7	B	91.9	B	90.7	B/C	65.7	B	91.9
Goukou	110.5	B	C	81.4	D	48.3	C	81.4	C	79.1	C/D	56.9	C	81.4
Klein-Brak	50.7	C	C	77.0	D	44.0	C	77.0	C	77.0	D	53.4	C	77.0
Groot-Brak	29.8	C	E	56.2	E	48.6	E	56.2	F	31.1	F	40.2	E	56.2
Blinde	1.3	B	B	69.2	C/D	40.8	B	69.2	B	69.2	C	46.3	B	69.2
Tweekuilen	1.3	D	D	96.7	D	72.3	D	72.3	D	96.7	D/E	64.7	D	72.3
Gericke	0.4	D	D	96.8	D	72.3	D	72.3	D	96.8	D/E	64.7	D	72.3
Hartenbos	5.1	C	D	65.0	D	72.0	C	80.7	D	65.0	E	44.4	D	65.0
Maalgate	37.4	B	B	79.3	C	51.6	B	79.3	B	79.3	C	62.8	B	79.3
Gwaing	26.6	B	B	85.0	C/D	55.1	B	85.0	C	72.5	C	67.5	B	85.0
Kaaimans	48.7	B	B	72.5	D/E	27.5	B	72.5	C	52.2	C	58.3	B	72.5
Wilderness	32.7	A	B	88.6	C/D	34.1	B	88.6	B	88.6	B/C	69.0	B	88.6
Swartvlei	88.0	B	B	86.6	D	31.1	B	86.6	B	86.6	B	85.5	B	86.6
Goukamma	52.9	A	B	87.5	D	44.3	B	87.5	B	87.5	B/C	71.0	B	87.5
Knysna	90.5	B	B	90.6	C/D	25.6	B	90.6	B/C	80.9	B/C	73.2	B	86.8
Noetsie	5.5	A	B	92.5	D	42.5	B	92.5	B	92.5	B/C	73.5	B	92.5
Piesang	6.9	B	C	73.0	D	53.8	B/C	82.8	C	73.0	C	58.1	C	73.8
Keurbooms	169.0	A	A	91.2	D	34.8	A	91.2	A/B	83.5	A/B	73.5	A	90.0
Matjies	5.1	B	B	83.7	D	44.1	B	83.7	B	83.7	B/C	70.7	C	70.5
Sout(Oos)	7.0	A	A	85.6	D	30.0	A	85.6	A	85.6	A/B	72.3	A	85.6
Groot(Wes)	12.8	B	B	86.7	C	51.2	B	86.7	B	86.7	B/C	73.3	B	86.7
Bloukrans	40.1	A	A	98.0	D	30.0	A	98.0	A	98.0	A	85.2	A	98.0

Estuary RQO Template - Hartenbos

IUA	Node	Quat	REC		Current		Target	
			EC	%nMAR	PES	%nMAR	EC	%nMAR
G14-Groot Brak	Gxi22	K10B	C	80.7	D	65.0	C	65.0

MOTIVATION FOR ACHIEVING REC/TEC

The Hartenbos estuary is considered to be of "average importance" from a biodiversity conservation perspective (ranked 75 out of 273 estuaries in South Africa) and has not been included on the list of existing or desired protected areas (Turpie et al. 2012). The system is nonetheless important from a socio-economic perspective – it is an important node for recreation, tourism and contributes significantly to property value. It is also important to maintain the system in a state of health that is safe for contact recreation. The REC for the estuary is thus a C, one category higher than present. However, it has been determined that water abstraction from this system cannot be reduced in future without compromising requirements for other users in this region. The MAR for the Target Ecological Condition thus remains as for present (65.0%). The most important threats to the Hartenbos estuary include freshwater deprivation (due to abstractions from the Hartbeeskuil Dam, for agricultural and domestic use), sedimentation (due to reduced flow and concomitant changes in mouth dynamics) and impaired water quality (due to agricultural return flows and poor quality of stormwater from informal settlements). Given that it is not possible to restore flows required to achieve the REC, concerted effort on the part of DWS and other stakeholders (local, provincial and other national government agencies) is thus required to address other threats to the estuary in accordance with the Ecological Specifications included below, thereby facilitating its restoration to the REC.

Component	SPECIFICATIONS
Flow	• %nMAR: 65.0, dry season flow >0.05 Mm^3/month
Mouth condition	• % time mouth closed should not increase/decrease by >10% from present; no period of closure >3 months
Water quality	• DIN not to exceed 200 µg/ℓ (average); DIP not to exceed 50 µg/ℓ (average)
Microalgae	• Phytoplankton not to exceed 8 µg/ℓ (median), and/or 20 µg/ℓ (once-off) and/or cell density not to exceed 10 000 cells/ml (once-off) • Benthic microalgae not to exceed 42 mg/m^2 (median)
Macrophytes (plants)	• Maintain distribution of macrophyte habitats within 20% of present (Supratidal salt marsh: 29%, Reeds & sedges: 10%, sand/mud banks: 10%)
Invertebrates	• Populations of key invertebrate species should not deviate from average baselines (as determined in first three visits) by more 30%
Fish	• Relative contribution for key groups of fish (estuarine resident, marine migrant, freshwater, etc.) should not deviate from average baselines (as determined in first three visits) by more 30%
Birds	• Number of birds in any group, other than species that are increasing regionally such as Egyptian geese, should not deviate by more than 30% from baseline median (determined by past data and/or initial surveys)

IUA	Node	Quat	REC		Current		Target	
			EC	%nMAR	PES	%nMAR	EC	%nMAR
G14-Groot Brak	Gxi22	K10B	C	80.7	D	65.0	C	65.0

Additional (non-flow related) interventions to achieve the REC:

- Dam construction has resulted in a reduction in base flow and floods to the system, with a shift in the onset of the high flow period and an increase in the duration of the low flow period;
- Artificial breaching;
- Loss of tidal flows and habitat as result of bridge construction (e.g. old N2, railway bridge);
- Infilling of estuary channel and mouth area as a result of loss of floods and artificial breaching;
- A significant reduction in water quality as a result of the Mossel Bay WWTW discharge and urban runoff;
- Development in the EFZ;
- Alien vegetation;
- Limited bait collection and fishing effort; and
- Human disturbance (which influences bird abundance).

Source of information	DWS (2015) Desktop Assessment of Estuaries in the Gouritz WMA

Estuary monitoring programme

1. Additional baseline surveys to improve confidence of EWR study on the Klein Brak Estuary (priority components are highlighted).

Action	Temporal Scale (frequency and timing)	Spatial Scale (Number of stations)
Sediment dynamics		
Monitoring berm height using appropriate technologies.	Quarterly.	Mouth.
Bathymetric surveys: Series of cross section profiles and a longitudinal profile collected at fixed 500 m intervals, but in more detail in the mouth including the berm (every 100 m). Vertical accuracy at least 5 cm.	Once-off.	Entire estuary.
Collect sediment grab samples (at cross section profiles) for analysis of particle size distribution and organic content (and ideally origin, i.e. microscopic observations).	Once-off.	Entire estuary.
Water quality		
Collect samples for pesticides/herbicide and metal determinations in river inflow.	Once-off.	Near head of estuary in Moordkuils (K1H5) and Brandwag (K1H4) tributaries.
Collect surface and bottom water samples for inorganic nutrients (and organic nutrient) and suspended solid analysis, together the in situ salinity, temperature, pH, DO and turbidity profiles.	Quarterly, preferably for 2 years	Entire estuary (10 - 13 stations).
Measure pesticides/herbicides and metal accumulation in sediments (for metals investigate establishment of distribution models – refer to Newman and Watling, 2007).	Once-off.	Entire estuary, including depositional areas (i.e. muddy areas).
Microalgae		
Record relative abundance of dominant phytoplankton groups, i.e. flagellates, dinoflagellates, diatoms, chlorophytes and blue-green algae. Chlorophyll-a measurements taken at the surface, 0.5 m and 1 m depths, under typically high and low flow conditions using a recognised technique, e.g. spectrophotometer, HPLC or fluoroprobe. Intertidal and subtidal benthic chlorophyll-a measurements (four replicates each) using a recognised technique, e.g. sediment corer or fluoroprobe.	Quarterly, preferably over two years	Along length of estuary minimum five stations (include stations in upper reaches of Brandwag and Moordkuil arms).

Dams

- Resource Unit prioritisation
- Resource Unit evaluation
- Define RQO and Numerical Limits
- Worked example

8 Prioritised dams

Breede-Overberg area

- Theewaterskloof
- Greater Brandvlei
- Ceres-Koekedouw
- Eikenhof
- Kogelberg
- Arieskraal

Gouritz-Coastal area

- Stompdrift
- Wolwedans

Resource Unit Prioritisation

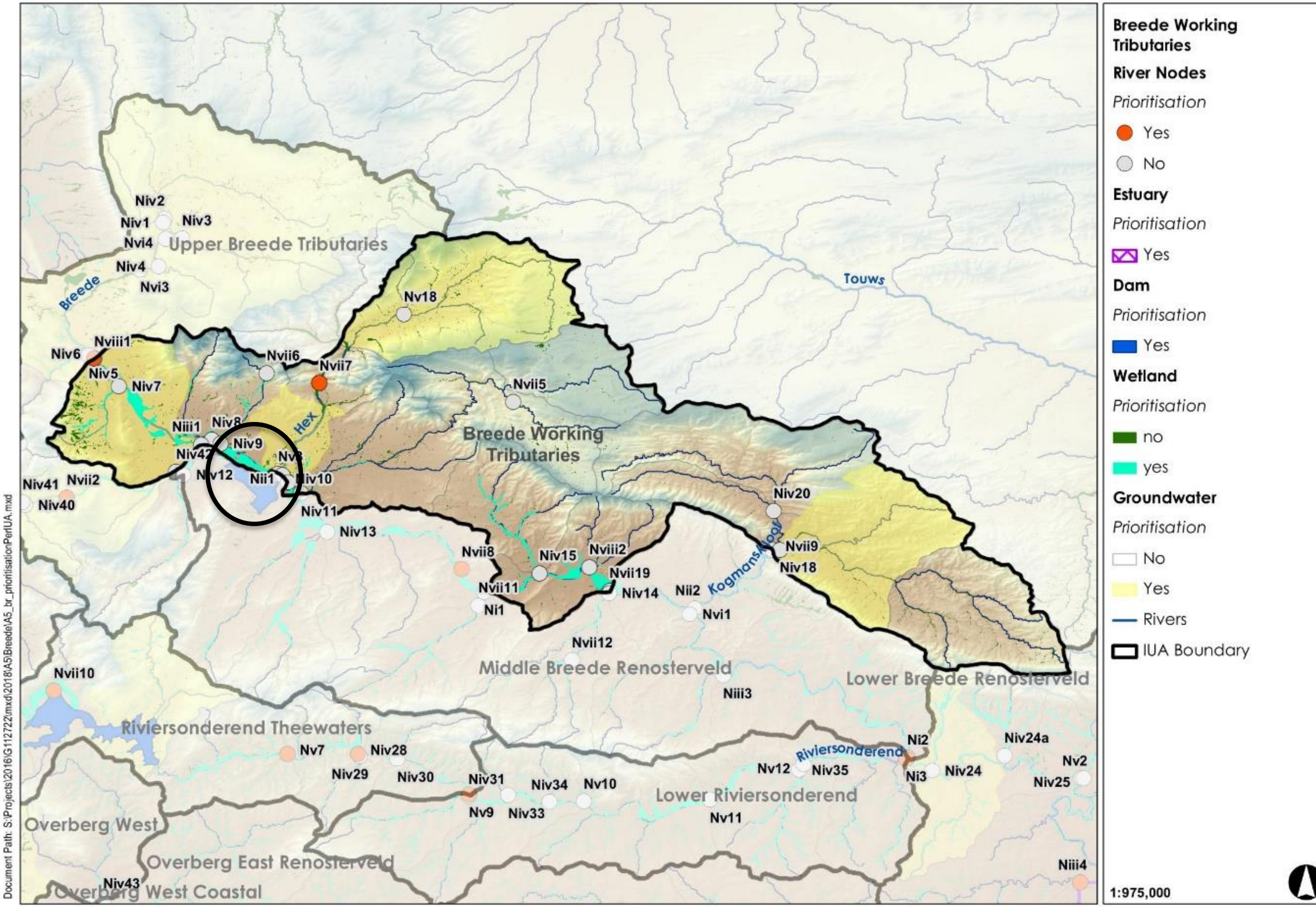
High and low priority RUs

Greater Brandvlei Dam

(IUA A2 Breede Working Tributaries)

- Largely an off-channel dam (impounds small lower Brandvlei River) with limited natural inflow, and limited farm dams located upstream. During the dry season significant irrigation releases are made.
- The important Papenkuils floodplain wetland is located just upstream of the dam, below the canal off-takes from the Smalblaar and Holsloot rivers.
- Water in the dam is mainly used for irrigation along the Breede River and for urban and rural use. Irrigation water is distributed by a system of canals receiving water directly from the dam as well as pumps and canals abstracting released water downstream.
- significant recreational activities include abseiling, sailing, kayaking and fishing, among others.

Greater Brandvlei Dam (IUA A2 Breede Working Tributaries)



Greater Brandvlei Dam

(IUA A2 Breede Working Tributaries)

Sub-comp.	Rationale for sub-component choice	Indicator selection
Low flows	Dam levels must remain sufficient to make releases for irrigation, as well as releases for ecosystem function downstream.	EWR
Nutrients	The system must be maintained in an oligotrophic state.	Ortho-phosphate, nitrogen, ammonium
Salts	Salt levels must be maintained at concentrations where they do not impact negatively on the ecosystem.	Electrical conductivity
Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. The re-infestation of alien species from the dam should be prevented. Consumption of fish must not pose a health risk.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011), fish health evaluation

Quantity & Biota RQOs for Greater Brandvlei Dam

Sub-comp.	RQO Narrative description	Indicator/ measure	Numerical limits	TPC
Low flows	During the dry season dam levels must be sufficient for releases for irrigation and human use and protection of ecosystem function downstream. Dependent on whether increased summer base flows, lack of flow variability and turbid water can be managed. Flow releases made to manage salinity only if essential	Flow releases: Breede EWR3 in H40F nMAR = 1210 million m³/a pMAR: 763 million m³/a REC = CD category	Breede EWR 3 site in Breede River – specified flows 	Not applicable
Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support the local recreational angling industry. Consumption of fish must not pose a health risk.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011)	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.	Habitat suitability and fish wellbeing (FRAI) in a state worse than a D ecological category.
		Populations of indigenous fish	Fish demographics and species assemblage of indigenous fish should be the same or better than the baseline status.	To be established from baseline

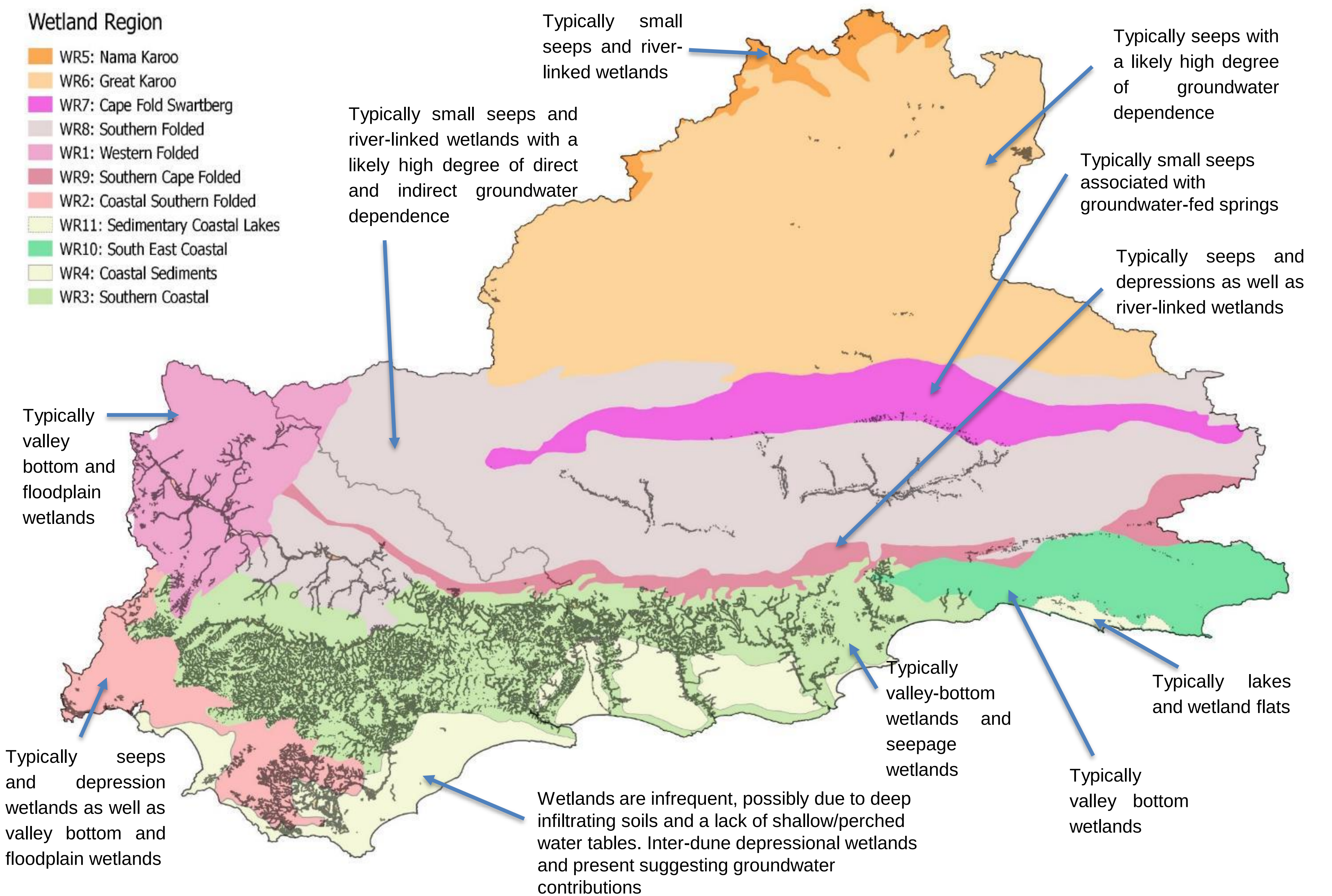
Quality RQOs for Greater Brandvlei Dam

Sub-comp.	RQO Narrative description	Indicator	Numerical Limits	Threshold of Potential Concern	Present state (50/95%tile) H1R001Q01
Nutrients	The system must be maintained in an oligotrophic state	Ortho-phosphate (PO_4-P)	Median ≤ 0.015 mg/ ℓ P	0.010 mg/ ℓ P	PO4 0.005 / 0.025
		Total inorganic nitrogen (TIN)	Median ≤ 0.70 mg/ℓ N	0.60 mg/ℓ N	TIN 0.05 / 0.208
Salts	Salt levels must be maintained at concentrations where they do not impact negatively on the ecosystem, and are acceptable for rural use, and in an Ideal category for irrigation water use	Electrical conductivity	95th percentile ≤ 40 mS/m	35 mS/m	EC 8 / 12
Phytoplankton	The system must be maintained in an oligotrophic state	Chlorophyll a	Median ≤ 10 µg/ℓ Chl a	Chl a ≤ 8 µg/ℓ	6 µg/ℓ

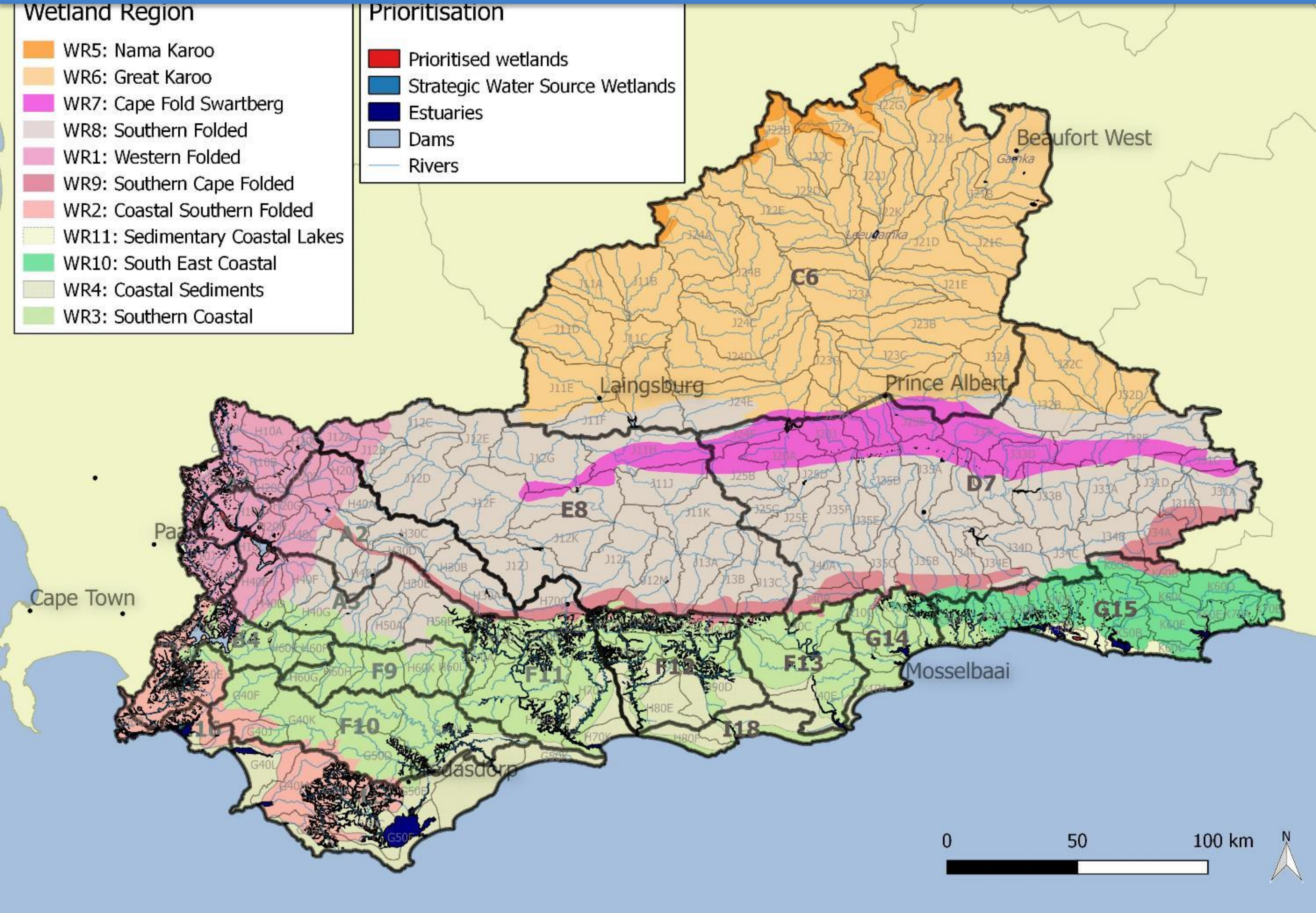
Wetlands

- Resource Unit prioritisation
- Resource Unit evaluation
- Define RQO and Numerical Limits
- Worked example

Resource Unit Prioritisation – Wetland Regions



Resource Unit Prioritisation



Resource Unit Prioritisation – Breede-Overberg

IUA	Wetland Region	Wetland Resource Unit	Name	Ecol NB	Supply
A1 Upper Breede Tributaries	WR1 Western Folded	Wetlands within Strategic Water Source Areas	N/A		x
		East Coast Shale Renosterveld Floodplain (Papenkuils)	Papenkuils	x	x
A2 Breede Working Tributaries	WR1 Western Folded	East Coast Shale Renosterveld Floodplain (Papenkuils)	Papenkuils	x	x
A3 Middle Breede Tributaries	WR1 Western Folded	East Coast Shale Renosterveld Floodplain	Breede River		x
	WR8 Southern Folded	East Coast Shale Renosterveld Floodplain	Breede River	x	x
F11 Lower Breede Renosterveld	WR3 Southern Coastal	East Coast Shale Renosterveld Floodplain	Breede River		x
B4 Riviersonderend Theewaters	WR3 Southern Coastal	Wetlands within Strategic Water Source Areas	Riviersonderend River	x	x
B5 Overberg West	WR3 Southern Coastal	Wetlands within Strategic Water Source Areas	Palmiet River		x
F10 Overberg East Renosterveld	WR8 Southern Coastal	Southwest Ferricrete Fynbos Floodplain	Kars River	x	x
H16 Overberg West Coastal	WR2 Coastal Southern Folded	Southwest Sand Fynbos Channelled Valley Bottom	Bot-Kleinmond Estuary	x	
		Wetlands within Strategic Water Source Areas	N/A		x
H17 Overberg East Fynbos	WR4 Coastal Sediments	Southwest Ferricrete Fynbos Flat, Depression and Floodplain	Agulhas Wetland System	x	x
		East Coast Shale Renosterveld Floodplain	De Hoop Vlei	x	

Note: Although HIGH priority wetlands have been identified, these may be considered a representative sample of wetlands in the Breede-Gouritz WMA. All wetlands are still to be considered under the National Water Act for triggering activities, and will need to be assessed fully. The benefit of identifying HIGH priority wetlands is to identify a representative sample of wetlands whereby further information is required, or where information is available to ensure that monitoring occurs.

Resource Unit Prioritisation – Gouritz-Coastal

IUA	Wetland Region	Wetland Resource Unit	Name	Ecol NB	Supply
C6 Great Karoo	WR6 Great Karoo	Lower Nama Karoo Depression	N/A	x	x
D7 Touws	WR7 Cape Fold Swartberg	Wetlands within Strategic Water Source Areas	N/A		x
G15 Coastal	WR10 Sedimentary Coastal Lakes	Freshwater Lake	Groenvlei	x	x
		Freshwater Lake	Wilderness Lakes	x	x
	WR11 South East Coastal	Wetlands within Strategic Water Source Areas	N/A		x
F13 Lower Gouritz	WR3 Southern Coastal	Albany Thicket Floodplain	Gouritz River	x	x
F12 Duiwenhoks	WR3 Southern Coastal	East Coast Shale Renosterveld Channelled Valley Bottom	Goukou Wetland	x	x
		East Coast Shale Renosterveld Channelled Valley Bottom	Duiwenhoks Wetland	x	x

Resource Unit Evaluation

- The steps for evaluation were:
  - Developed a conceptual model of:
    - **Wetland hydrological functioning and geomorphology**
    - Wetland water quality amelioration
    - Wetland vegetation
    - Important wetland biota

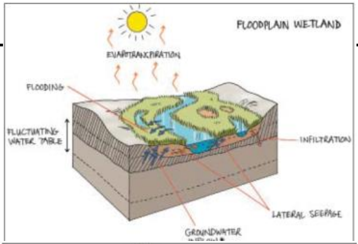
BASELINE

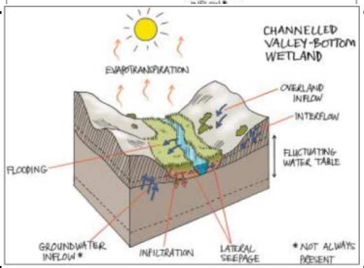
  - Validation and site selection (required as part of monitoring)
  - Monitoring should take account of the relevant RQO and if required develop a baseline of Wetland Health

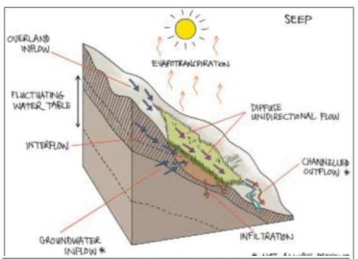
Resource Unit Evaluation

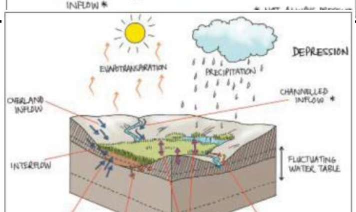
- Conceptual model of wetland functioning
  - When looking at a wetland system an indicator needs to be useful for monitoring and be informed by the prioritisation process
  - In all wetland types most NB driver is hydrology, followed by geomorphology and water quality

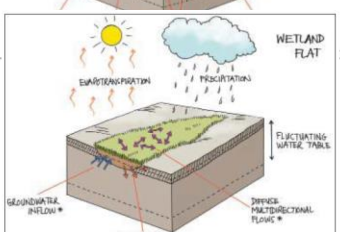
Drivers and Responders: The drivers of a wetland are primarily responsible for the presence and maintenance of the system, whilst responders may react to short term fluctuations.











Wetland HGM type	QUANTITY		HABITAT	WQ	HABITAT	WQ	BIOTA
	Flow	Water retention & distribution patterns	Geomorphology	Water Quality	Vegetation	Diatoms*	Fish
Floodplain	**xx**	**xx**	**xx**	x	x	x	x
Channelled Valley-Bottom		**xx**	**xx**	x	x	x	x
Unchannelled Valley-Bottom		**xx**	**xx**	x	x	x	
Seep		**xx**	**xx**	x	x	x	
Depression		**xx**	**xx**	x	x	x	
Flat		**xx**		x	**xx**	**xx**	

Characteristics of different Wetland Types

Quantity

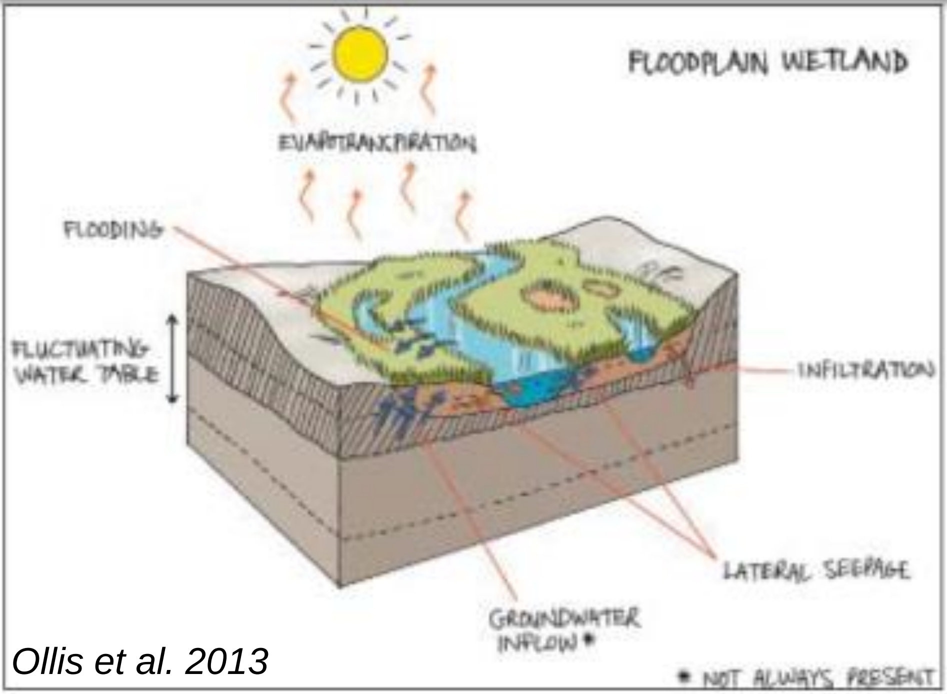
Flow | **Water retention & distribution**

Type	High flows	Baseflow	Surrounding runoff
Floodplain	x	x	x
Channelled Valley-Bottom		x	x
Unchannelled Valley-Bottom		x	x
Seep		x	x
Depression		x	x
Flat		x	x

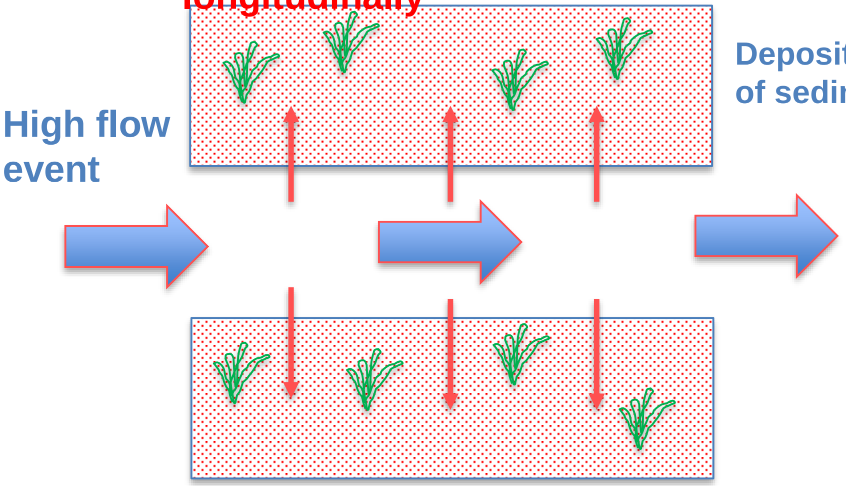
Maintain high flow events

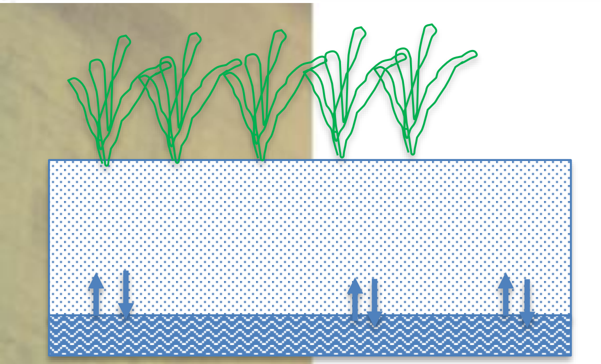
Maintain water levels

High flow events: FLOODPLAINS



Ollis et al. 2013

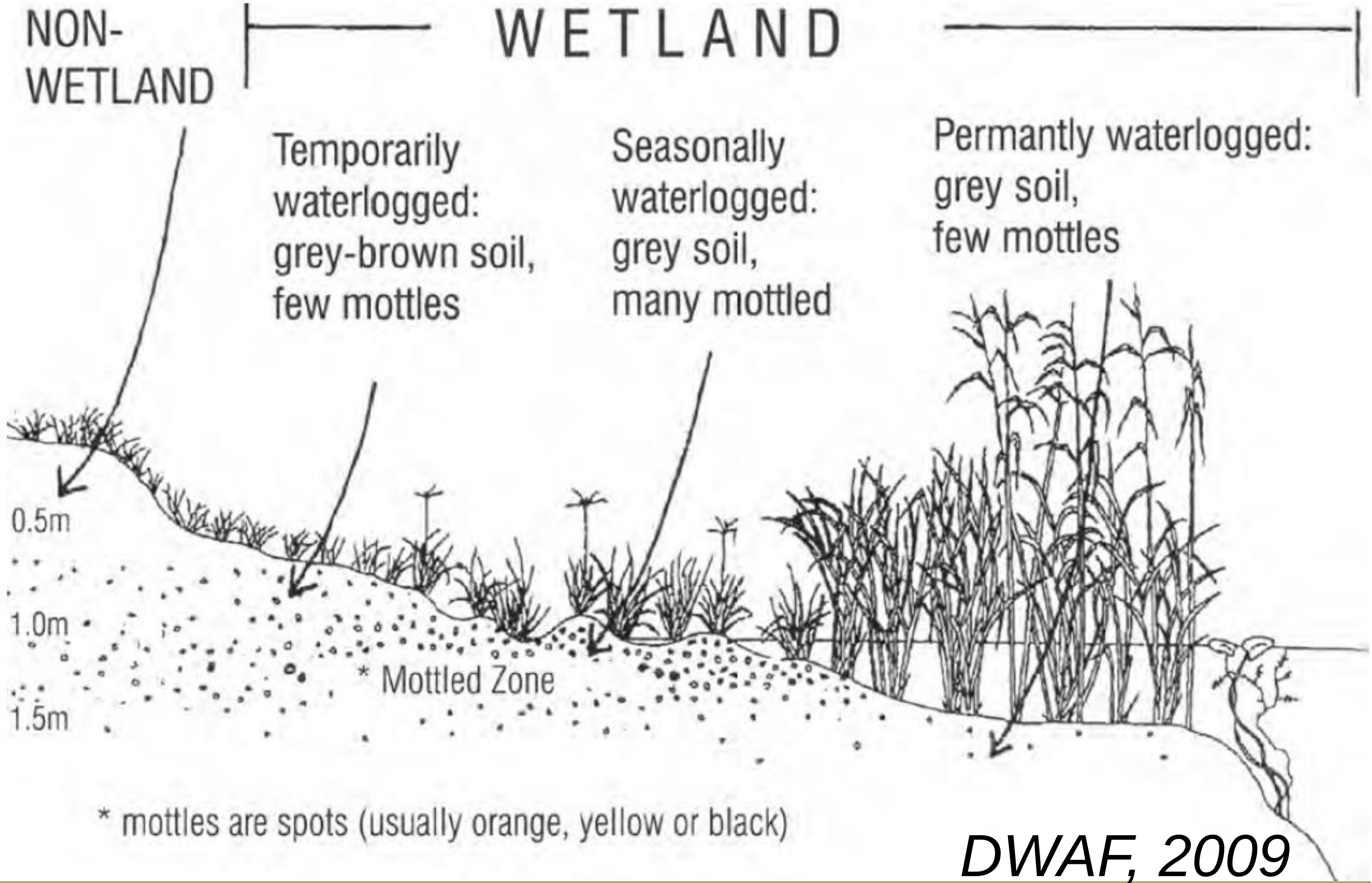




- **Generally receive most water during high flow events when waters overtop the streambank.**
- **NB flood attenuation because of the nature of vegetation and topographic setting. Flood attenuation is likely to be high early in the season until the floodplain soils are saturated, whilst in the late season flood attenuation is reduced.**
- **As flood waters overtop streambanks the waters drop sediments, and nutrient bound sediments, which are left behind to accumulate.**
- **The nature of clayey soils in floodplains means that soils retain water, thus limiting contribution to streamflow and groundwater recharge.**

Water retention & distribution: ALL

Quantity: Flow/Water retention & distribution

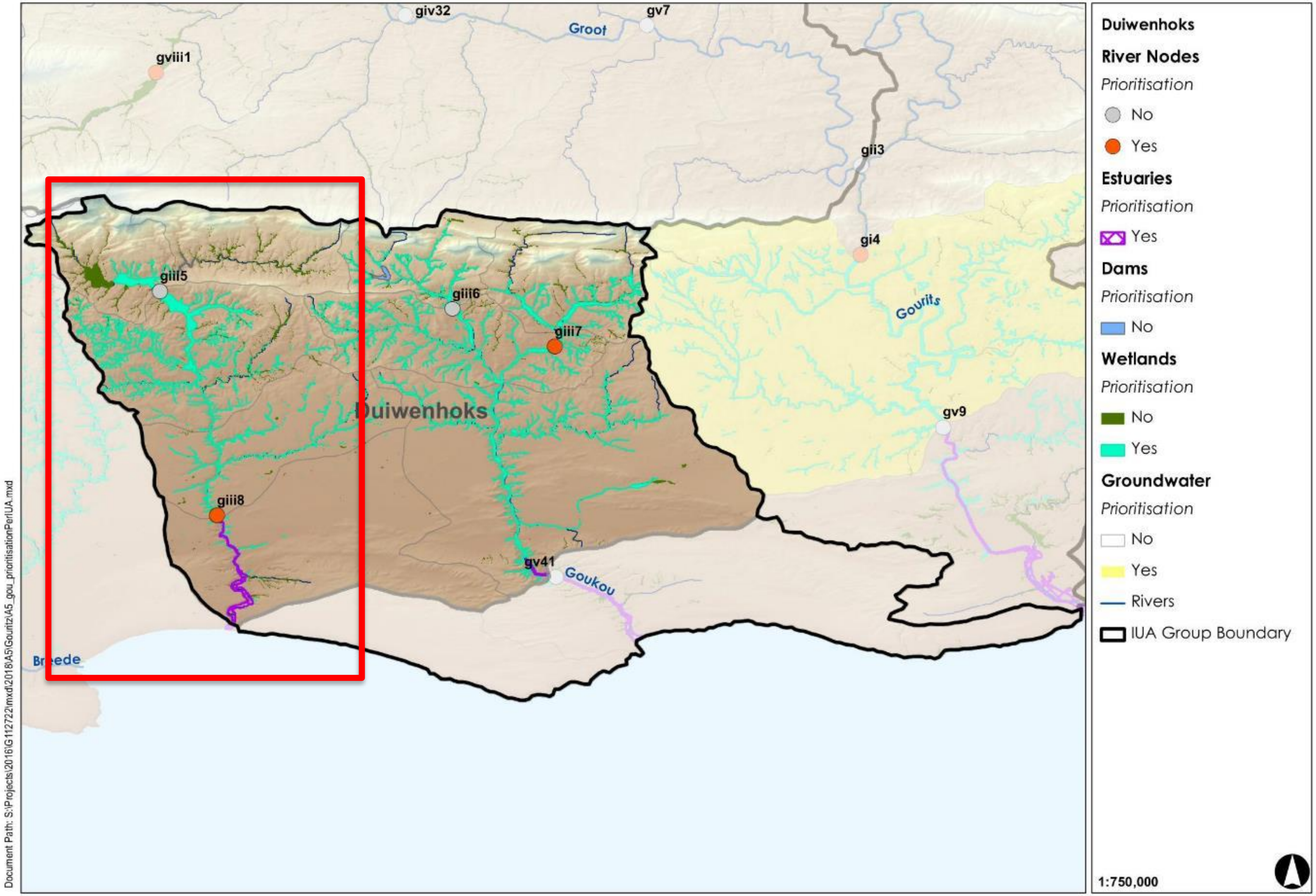


DWAF, 2009

Resource Unit Evaluation

Component		Sub-Component	Reason for selection	Indicator example
	QUANTITY	Flow	Floodplain wetlands require high flow events in order to overtop banks.	River flow RQOs are given as monthly average volumes (MCM) that include maintenance low and high flows combined.
	QUALITY	Diatoms	Diatoms are a reliable indicator of water quality. Diatom monitoring is also a cheap, reliable surrogate for water quality in much the same way that aquatic invertebrates are used to indicate water quality in rivers.	Diatoms presence
	HABITAT	Geomorphology	The relationship of water and sediment creates a stable equilibrium for a wetland. Any change to this equilibrium will push a wetland into a vulnerable state of either aggradation (sediment deposition) or degradation (sediment removal).	Sediment accumulation

Evaluation: Duiwenhoks Wetland



Evaluation: Duiwenhoks Wetland

			Indicator	Driver	Conceptual model	Monitoring
F12	Southern Coastal (WR3)	**East Coast Shale Renosterveld Unchannelled and Channelled Valley Bottom (Duiwenhoks)**	Monitor active erosion sites and density of alien invasive plants (especially Acacia mearnsii).	Unchannelled and Channelled-valley bottom wetland. Retention of water is important, particularly for unchannelled valley bottom wetlands. This is under threat by the concentrated flows through the erosion donga.	Upper Duiwenhoks is within the Southern Fold Wetland Region (WR), but where river flows into flatter coastal belt. Deposition of alluvium derived from steep mountainous streams, and associated vegetation growth on alluvium, resulted in extensive Valley-Bottom wetlands. The Duiwenhoks historically would have been characterised by unchannelled and weakly channelled Valley-Bottom wetlands dominated by Palmiet and Phragmites vegetation. Although the upper-western part of the wetland remain relatively intact, there is still evidence of invasive alien plants and most importantly an actively eroding donga. This erosion has resulted in reduced flows on the wetland and altering flows through berms/drains/roads have caused increased flow.	Working for Wetlands have been working in the area since 2006 (2008, 2009, 2015). Alien invasive plants have been removed, and follow up removal is conducted annually. Work has been done to stabilise the erosion donga.

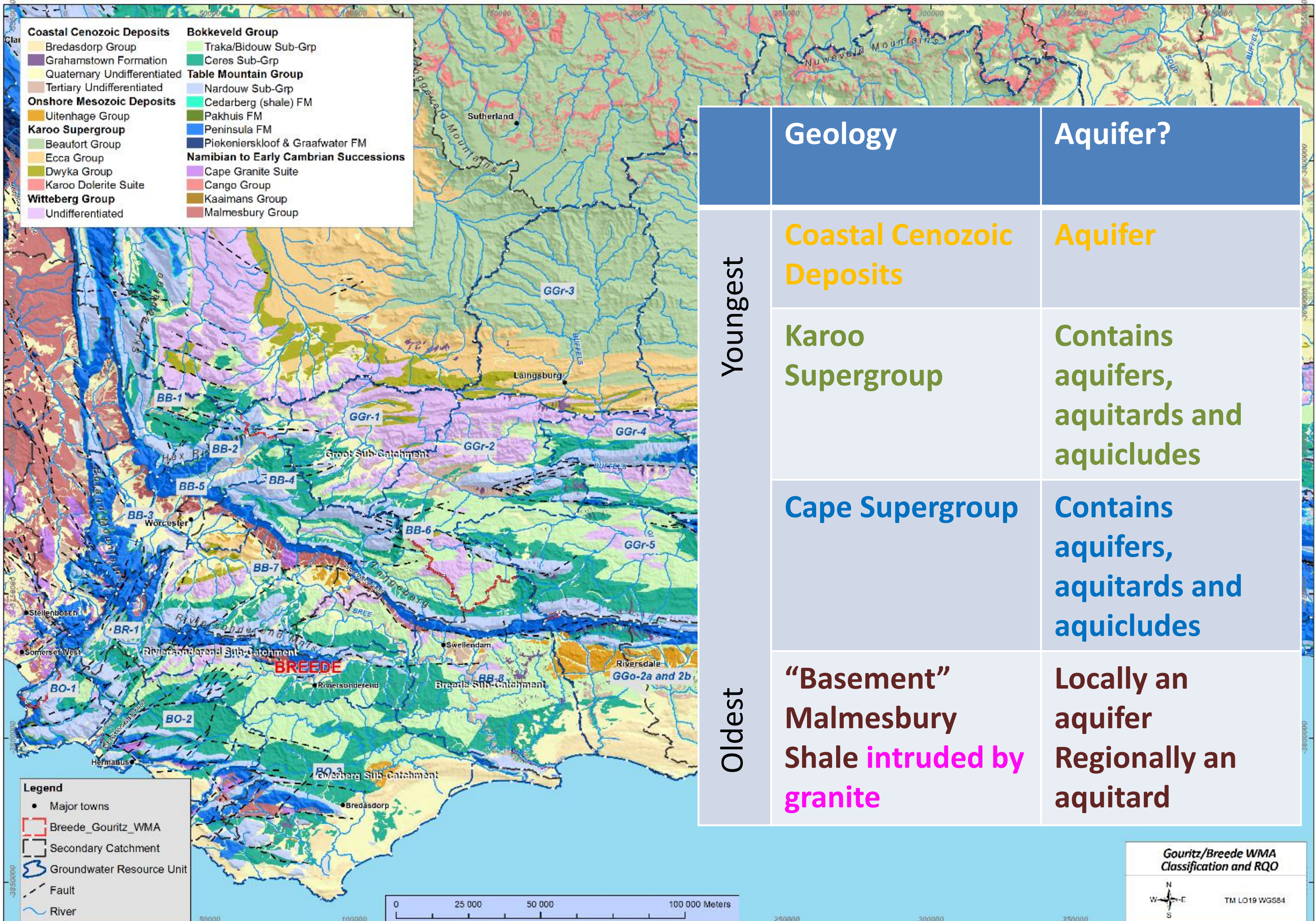
Evaluation: Duiwenhoks Wetland

	Component	Sub-component	Indicator/ measure	RQO	Numerical limits
East Coast Shale Renosterveld Channelled Valley Bottom (Duiwenhoks)	QUANTITY	Water distribution and retention patterns	Flow concentration	Active erosion concentrates flows and increases the rate of flow movement through the wetland. This concentration of flows needs to be managed to ensure that water distribution still occurs across the wetland.	Every three years: Map erosion features in the wetland and monitor whether the wetland is drying out near the erosion feature.
	HABITAT	Geomorphology	Erosion	Active erosion removes sediment and vegetation from the wetland. The erosion of banks and headcuts need to managed in order to reduce habitat removal.	Every three years: Map erosion features, particularly noting bank erosion and headcuts, and monitor impacts of erosion on natural vegetation.
	HABITAT	Wetland vegetation	Alien invasive plants	Alien invasive plants, particularly Acacia mearnsii, affect the water distribution and cause bank erosion. The density of alien invasive plants need to be managed, especially in the vicinity of active erosion areas.	Every three years: Monitor the density of Acacia mearnsii, especially near erosion features.

Groundwater

1. Key aquifers in the Breede-Gouritz WMA
2. Evaluating groundwater status
3. Relationship between groundwater status and EWRs
4. Impacts of scenarios on groundwater
5. Future groundwater status
6. RQOs for priority groundwater resource units (example)
7. Monitoring programmes for groundwater (example)

1. Key aquifers

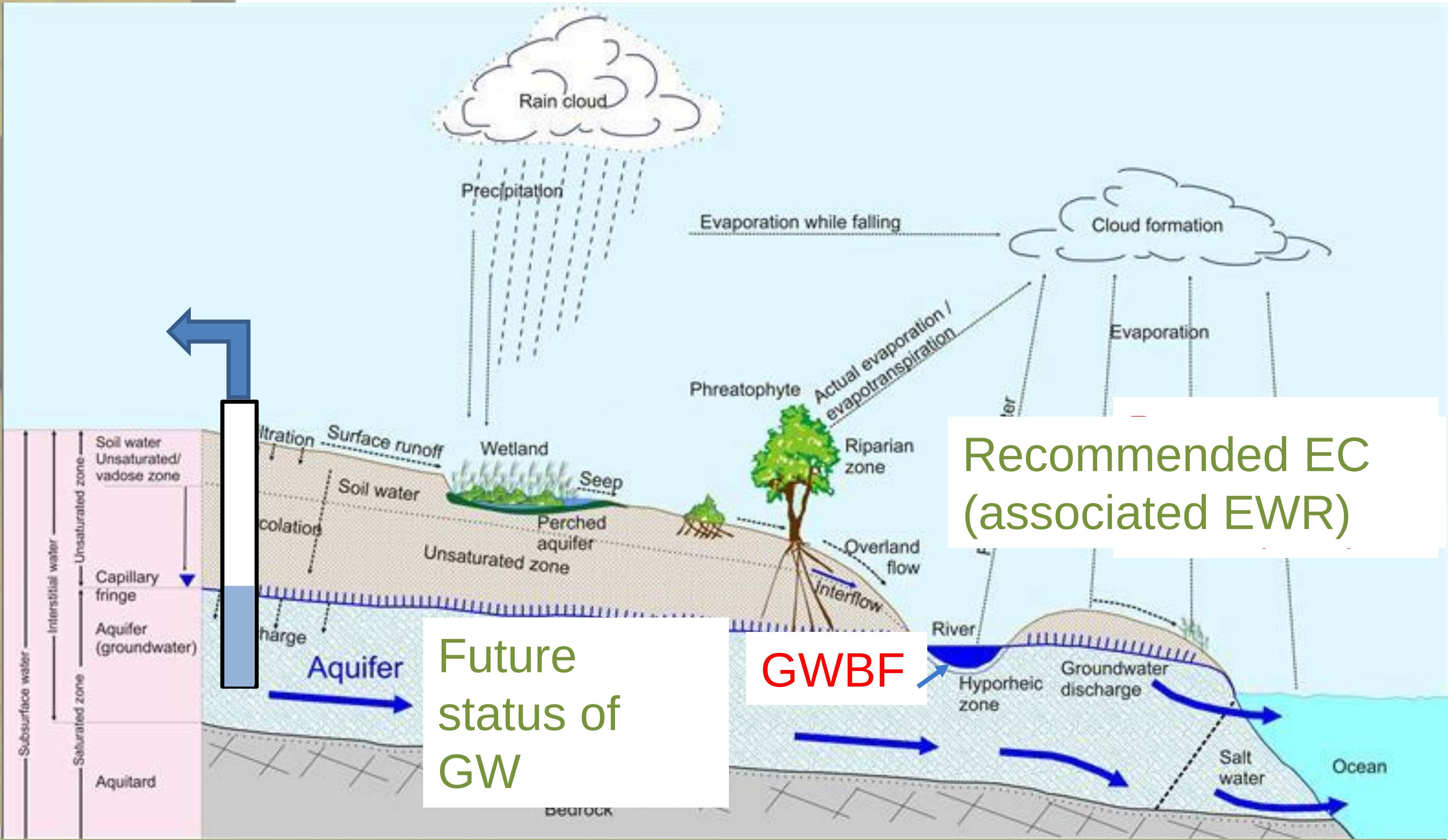


	Geology	Aquifer?
Youngest	Coastal Cenozoic Deposits	Aquifer
	Karoo Supergroup	Contains aquifers, aquitards and aquicludes
	Cape Supergroup	Contains aquifers, aquitards and aquicludes
Oldest	"Basement" Malmesbury Shale intruded by granite	Locally an aquifer Regionally an aquitard

2. Evaluating groundwater status

- Status quo and EWR report included analysis of current groundwater situation:
  - Groundwater quality, groundwater levels, analysis of trends in both of these
  - Development of groundwater balance model quantifying recharge, groundwater contribution to baseflow, current groundwater use, remaining groundwater availability
  - Identification of areas critical for groundwater use for domestic supply, agricultural supply, and for GW-SW interactions
  - Present status related to use based on stress index (use / recharge)

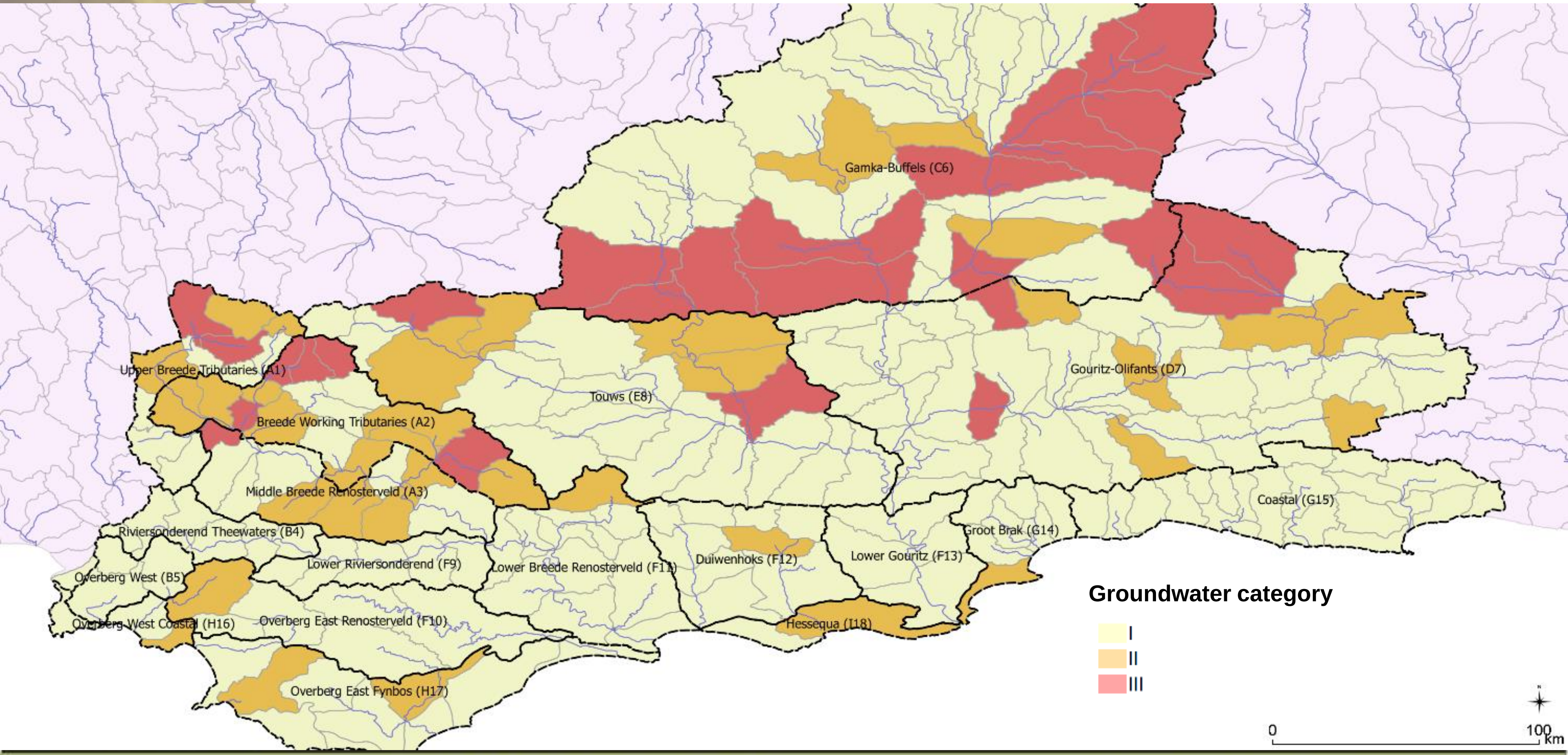
3. Relationship between groundwater status and EWRs



3. Relationship between groundwater status and EWRs

- The above relationships may well be widely accepted, and are theoretically acceptable, but implementation challenges remain
  - simplifying assumptions required to implement the theory,
  - scale complexities,
  - data availability,
  - varying hydrogeological terrains across SA,
  - integration between disciplines (data, models, scales)
  - modelling methods & challenges.

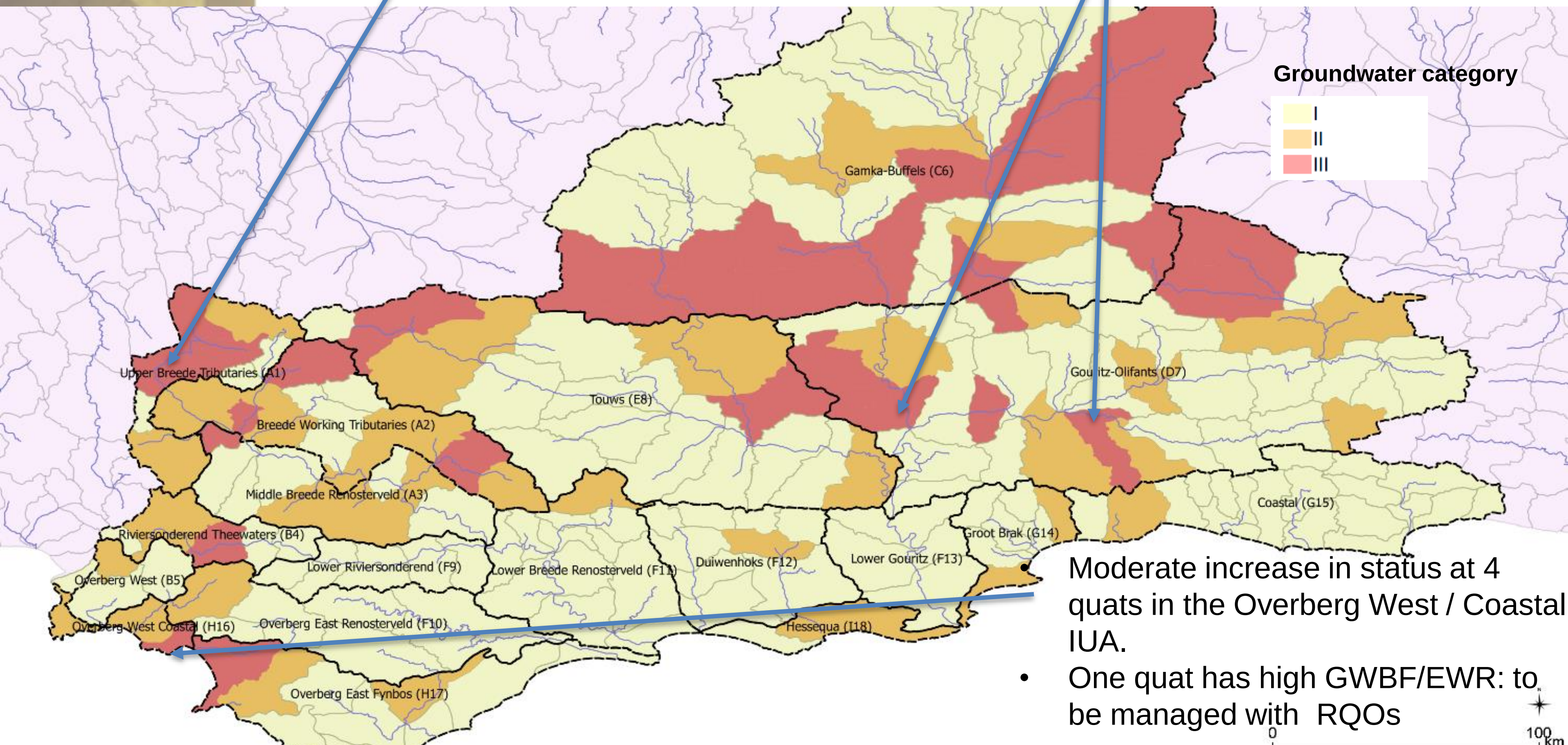
Present status



4. Impacts of scenarios on groundwater

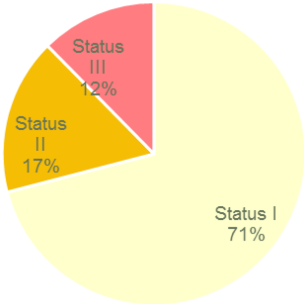
- Increase in status at 4 quats in the Upper Breede Tributaries IUA.
- 2 of these have significant increase.
- None are high GWBF/EWR.

- Moderate increase in status at 7 quats in the Gouritz-Olifants IUA.
- 4/7 change from I to III
- None are high GWBF/EWR.



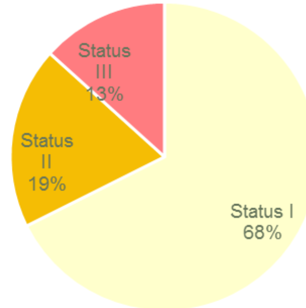
- Moderate increase in status at 4 quats in the Overberg West / Coastal IUA.
- One quat has high GWBF/EWR: to be managed with RQOs

5. Future groundwater status



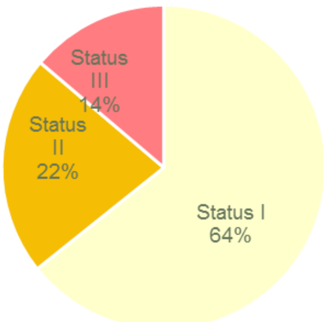
PES – Baseline:

- Total groundwater use 215 million m^3/a



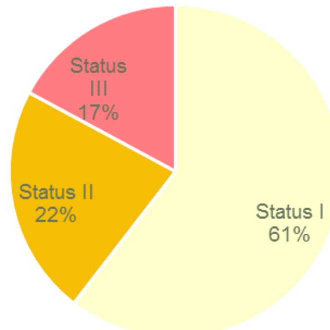
Future Growth – NoEC:

- Total groundwater use 293 million m3/a
- Increase in groundwater use 36%



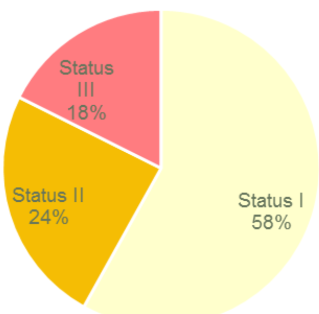
ESBC – Bottom line:

- Total groundwater use 338 million m3/a
- Increase in groundwater use 57%



Spatially targeted:

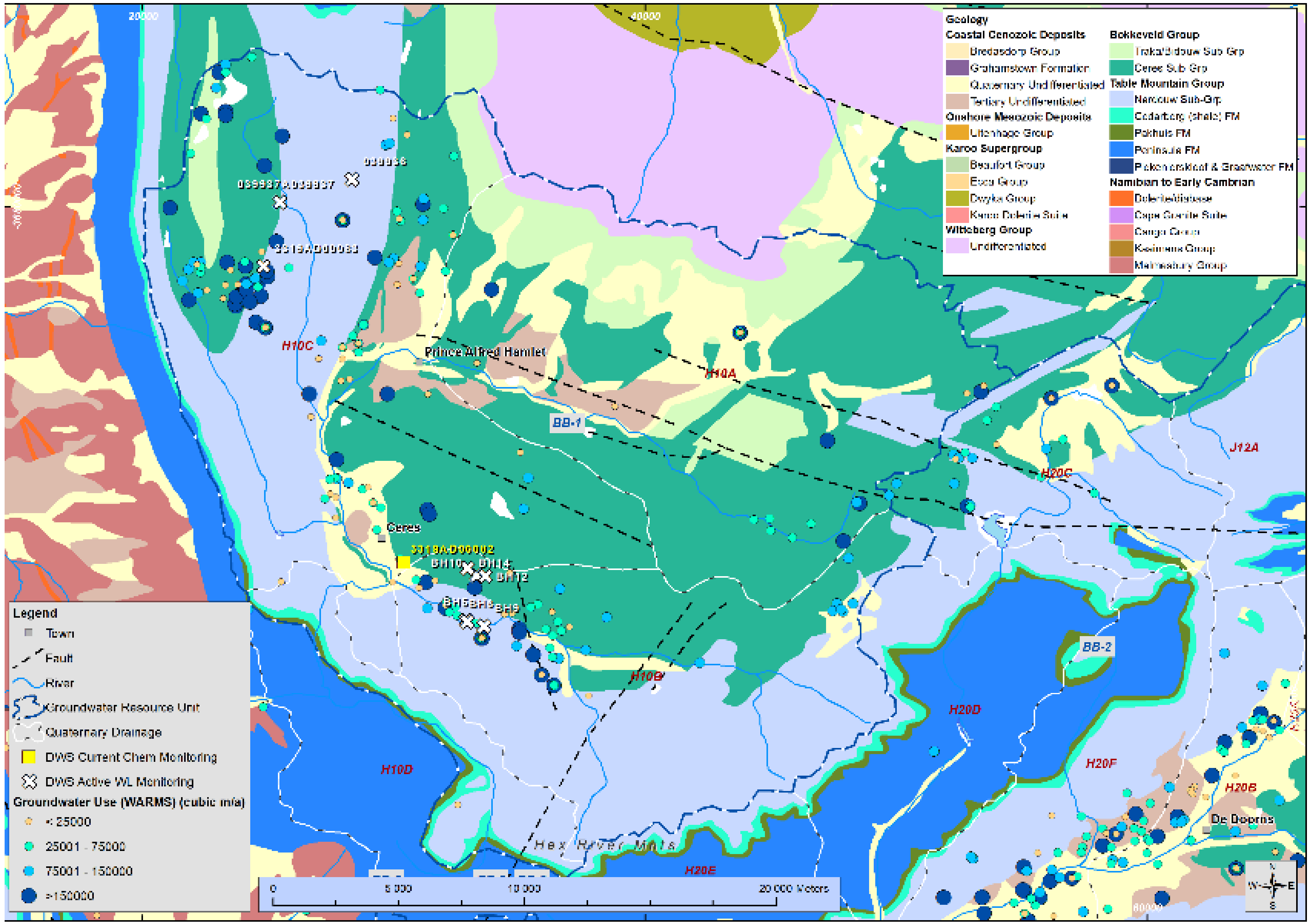
- Total groundwater use 429 million m3/a
- Increase in groundwater use 99%



REC:

- Total groundwater use 482 million m3/a
- Increase in groundwater use 124%

6. RQOs EXAMPLE: Groundwater Resource Unit BB-1



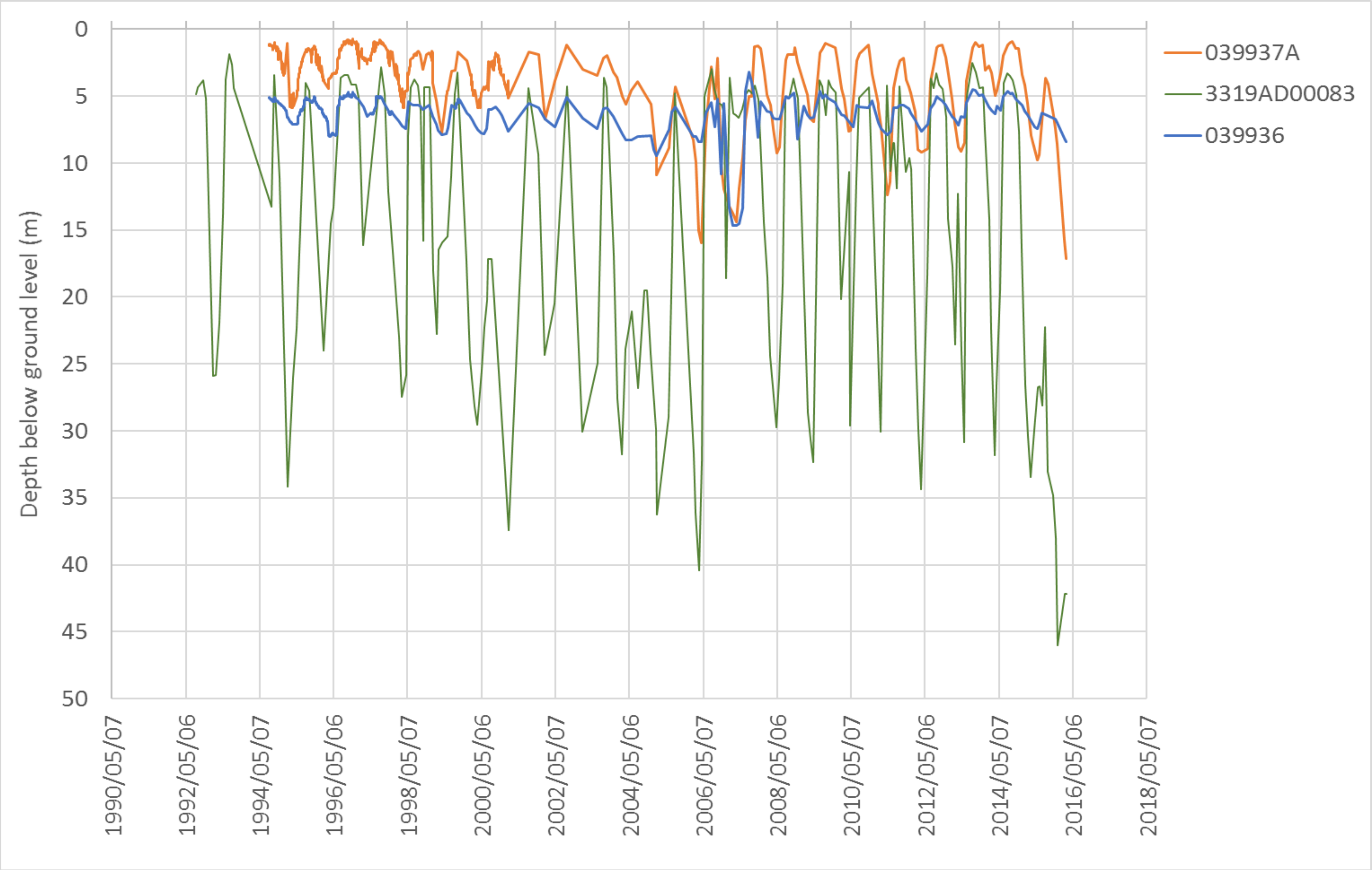
6. RQOs EXAMPLE: Groundwater Resource Unit BB-1

BB-1

Excludes the buried Peninsula (so not "all' and not "TMG“) given the deep Peninsula may not mimic surface topography, will not be in connection with rivers, and may be drilled into.

GRU	Quat(s)	Aquifer	Component	Sub-Component	RQO Description (narrative)	Indicator	Numerical Limit
BB-1	H10A, H10B, H10C	Bokkeveld Group, Nardouw Group, Cenozoic coastal deposits	Quantity	Abstraction	Groundwater use should be sustainable for all users and the environment	Seasonal abstraction: … water level decline stabilises under consideration of aquifer response time.	n/a
				Discharge	The natural gradient between groundwater and surface water should be maintained	Relative water levels between groundwater and suface water (in mamsl)	n/a
				Discharge	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs.	Buffer zones	250m
				Low flow in river	Compliance to the low flow requirements in the river, as per surface water RQO requirement	Compliance with the lowflow requirements in the river	See section 3.1

6. RQOs EXAMPLE: Groundwater Resource Unit BB-1



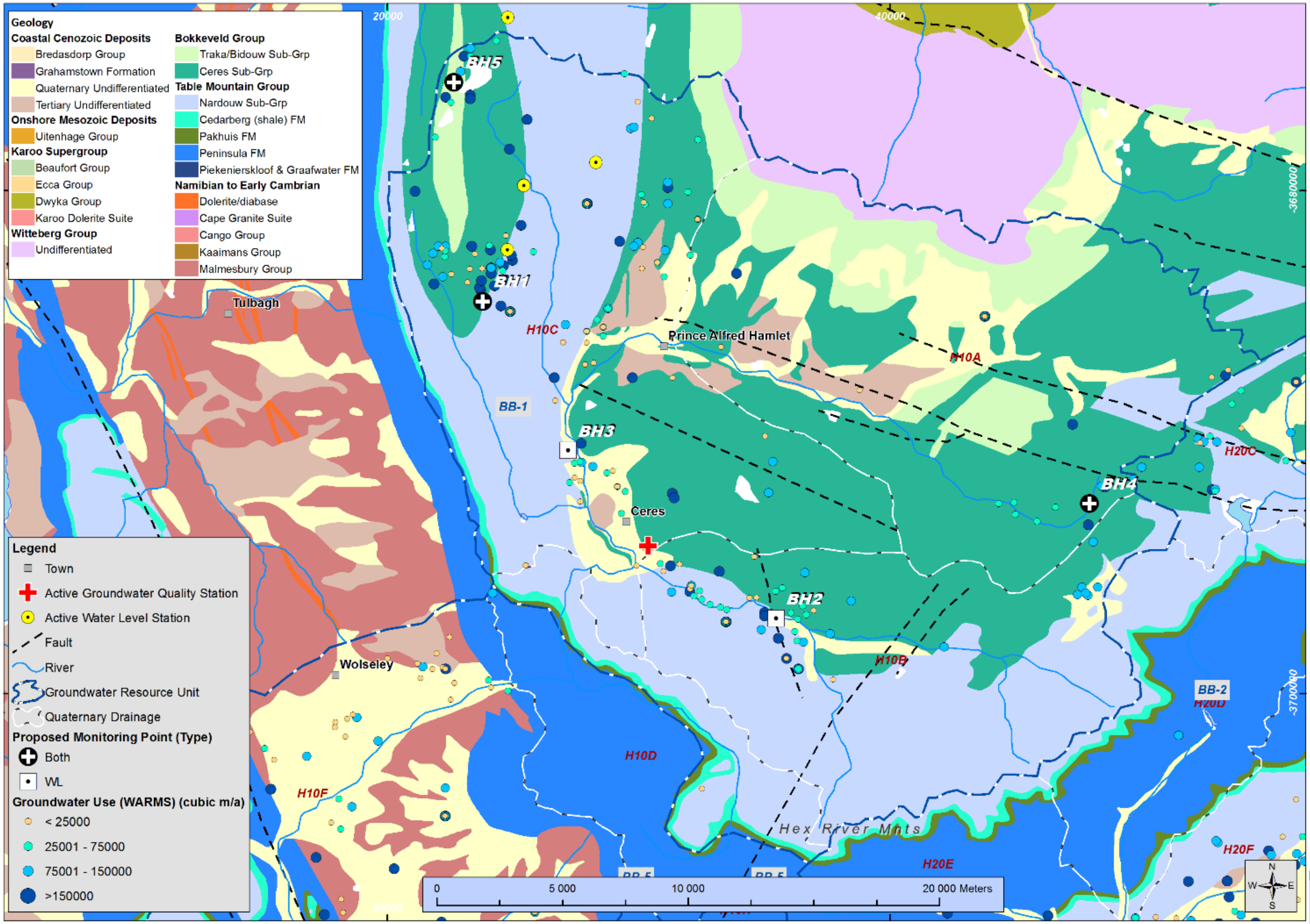
6. RQOs EXAMPLE: Groundwater Resource Unit BB-1

BB-1

95% from this geology in this region
90% from this geology in this region
95% from this geology across the region

GRU	Quat(s)	Aquifer	Component	Sub-Component	RQO Description (narrative)	Indicator	Numerical Value
BB-1	H10A, H10B, H10C	Cenozoic coastal deposits - alluvium	Quality	Nutrients	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	NO_3 (as N)	**6.8 mg/l**
				Salts		EC	**311 mS/m**
		Bokkeveld Group		Nutrients		NO_3 (as N)	**2.4 mg/l**
				Salts		EC	**236 mS/m**
		Nardouw Group		Nutrients		NO_3 (as N)	**4.4 mg/l**
				Salts		EC	**119 mS/m**
		Bokkeveld Group, Nardouw Group, Cenozoic coastal deposits		Pathogens		E-coli	0 counts / 100 ml
				Pathogens		Total Coliform	10 counts / 100ml

MONITORING EXAMPLE: Groundwater Resource Unit BB-1



Thank you, Any discussion?

Way Forward

- Comments from this workshop that influence reports to be addressed
- Draft Gazette prepared
- Period allowed for comment on the draft gazette

Additional slides