CLASSIFICATION OF SIGNIFICANT WATER RESOURCES AND DETERMINATION OF RESOURCE QUALITY OBJECTIVES FOR WATER RESOURCES IN THE LOWER ORANGE CATCHMENT

WORKSHOP ON DRAFT RESOURCE QUALITY OBJECTIVES (RQOs)

ESTUARIES

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7 Steps Procedure for RQO Determination (DWS, 2011)

Step 1: Delineate the integrated units of analysis and define the resource units;

Step 2: Establish a vision for the catchment and integrated units of analysis;

Step 3: Prioritise and select preliminary resource units for RQO determination;

Step 4: Prioritise sub-components for RQO determination and select indicators for monitoring;

Step 5: Develop draft resource quality objectives and numerical limits;

Step 6: Agree on resource units, RQOs and numerical limits with stakeholders;

Step 7: Finalise and gazette RQOs.

7 Steps Procedure for RQO Determination (DWS, 2011)

Step 1: Delineate the integrated units of analysis and define the resource units

IUA	Delineation	Quaternary Catchment
1	Lower Orange from Vaal confluence to Augrabies Waterfall	C92C, D71A, D71B, B71C, D71D, D72A, D72B, C72C, D73B, D73C, D73D, D73E, D73F, ~80% of D81A
2	Downstream Augrabies Waterfall to Pella	Portion of D81A – D81G
3	Pella to Vioolsdrift weir	D82A – D82G
4	Downstream Vioolsdrift weir to Orange River Estuary	D82H, D85J, D82K, D82L
5	**Orange River Estuary**	**Estuarine Functional Zone boundary in D82L**
6	Ongers/Brak	D61A, D61B, D61C, D61D, D61E, D61F, D61G, D61H, D61J, D61K, D61L, D61M, D62A, D62B, D62C, D62D, D62E, D62F, D62G, D62H, D62J
7	Hartbees/Sak	D52 - D58
8	**Coastal Area**	**F10A to F60A**
9	Upper Molopo and Upper Kuruman	D41B, D41C, D41D, D41E, D41F, D41H, D41K, D41G, D41M
10	Lower Kuruman and Lower Molopo	D42A, D42B, D42C, D42D, D42E, D81C

Integrated Units of Analysis (IUAs) in the Lower Orange River catchment

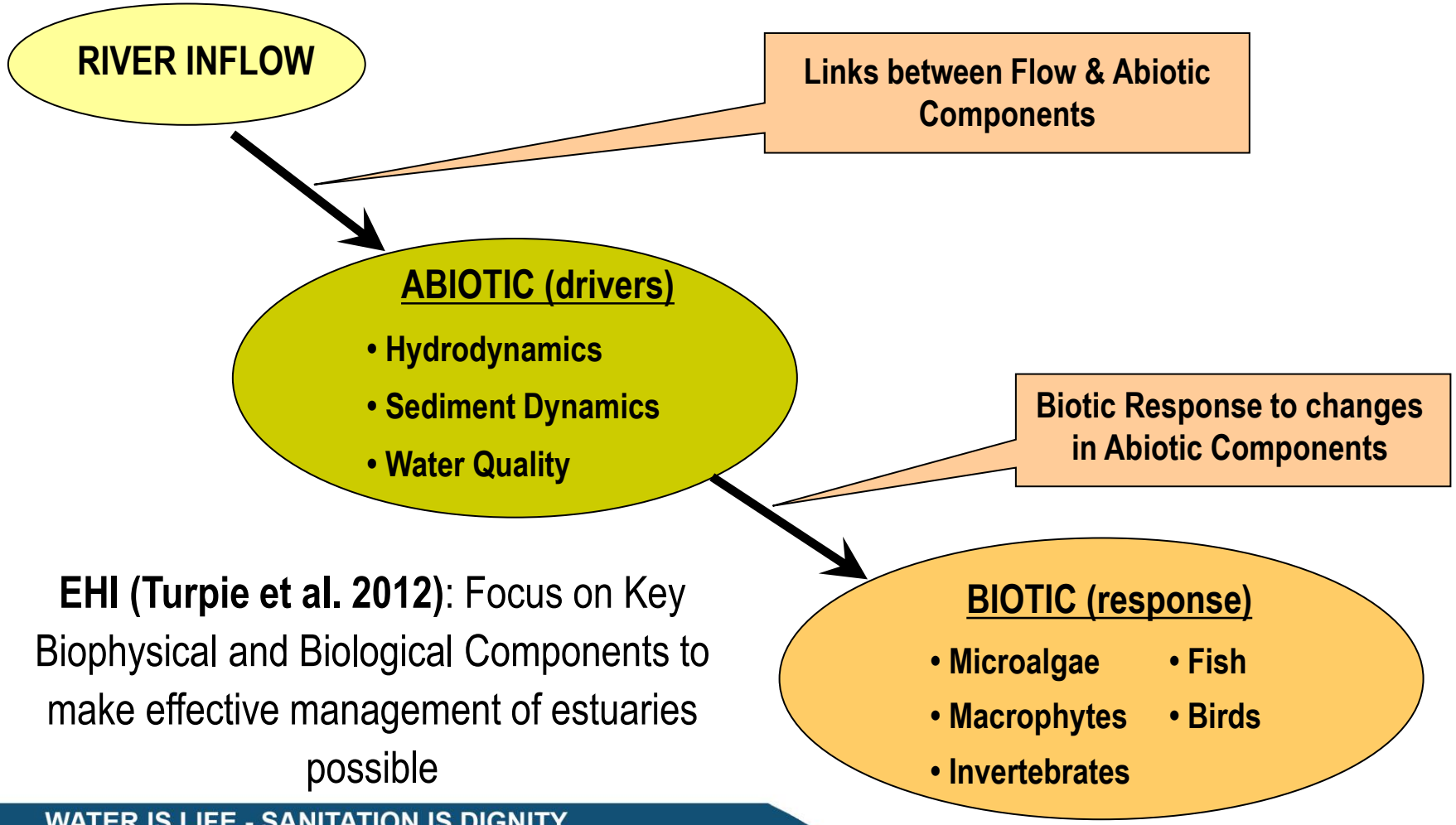
7 Steps Procedure for RQO Determination (DWS, 2011)

Step 3: Prioritise and select preliminary resource units for RQO determination

RU Number	Resource Unit	Catchment/s; Reach
IUA 5: Orange River Estuary		
5.1	From EFZ (2km upstream (Ernest Oppenheimer Bridge) to ocean	D82L10-03298 Estuarine functional Zone delineation
IUA 8: Coastal Areas		
8.1	Holgat and Kamma catchments	F10-F20
8.2	Buffels catchment area	F30
8.3	Swartlintjies sub-catchment	F40A-40D
8.4	Spoeg, Bitter sub-catchment	F40E – F40G
8.5	Groen and Hartbees sub-catchments	F50A-G
8.6	Brak sub-catchment	F60A

7 Steps Procedure for RQO Determination (DWS, 2011)

Step 4: Prioritise sub-components for RQO determination and select indicators for monitoring;



EHI (Turpie et al. 2012): Focus on Key Biophysical and Biological Components to make effective management of estuaries possible

7 Steps Procedure for RQO Determination (DWS, 2011)

Step 5: Develop draft Resource Quality Objectives and numerical limits;

Estuary Health Index (EHI) (Turpie et al. 2012):

1. Determine the ecological health score of each of the four abiotic and five biotic components (Reference condition = 100)
2. Determine the Present Ecological State of the estuary (Change from natural)
3. Determine Estuarine Importance Score (EIS)
4. Determine the Recommended Ecological Category (REC)

Estuarine Health Index Process

1. Establish **baseline (Reference condition)** and present state.
2. **Compare present features** with pristine state.
3. Use **weighted scoring** for composite health scores.
4. Indicators are **scored based on deviation** from natural / reference conditions.
5. **Weighting reflects the importance** of each indicator to estuary health.
6. Composite scores determine overall classification.

Define Reference Condition

Objective: Establish baseline for comparison with the present condition.

Describe the pristine state of the estuary before human-induced changes:

- Natural river inflow patterns
- Unaltered physical and biological characteristics in catchment or in estuary
- Absence of anthropogenic impacts (e.g., artificial breaching)

Assess Present Condition

Objective: estimating the degree to which features of the Present State resemble the Reference Condition.

Key aspects in determining the Present Condition:

- Evaluate current abiotic and biotic features
- Determine deviations from the Reference Condition - Use field data, historical records, and expert opinions
- Usually requires expert specialist judgement in conjunction with local knowledge and historical data discussed and debated in a workshop setup
- Account for dynamic estuarine variability
- Determine if the system is on a trajectory of change

Determine Ecological Health Score

1. Determine the ecological health score of each of the four abiotic and five biotic components (Reference condition = 100)

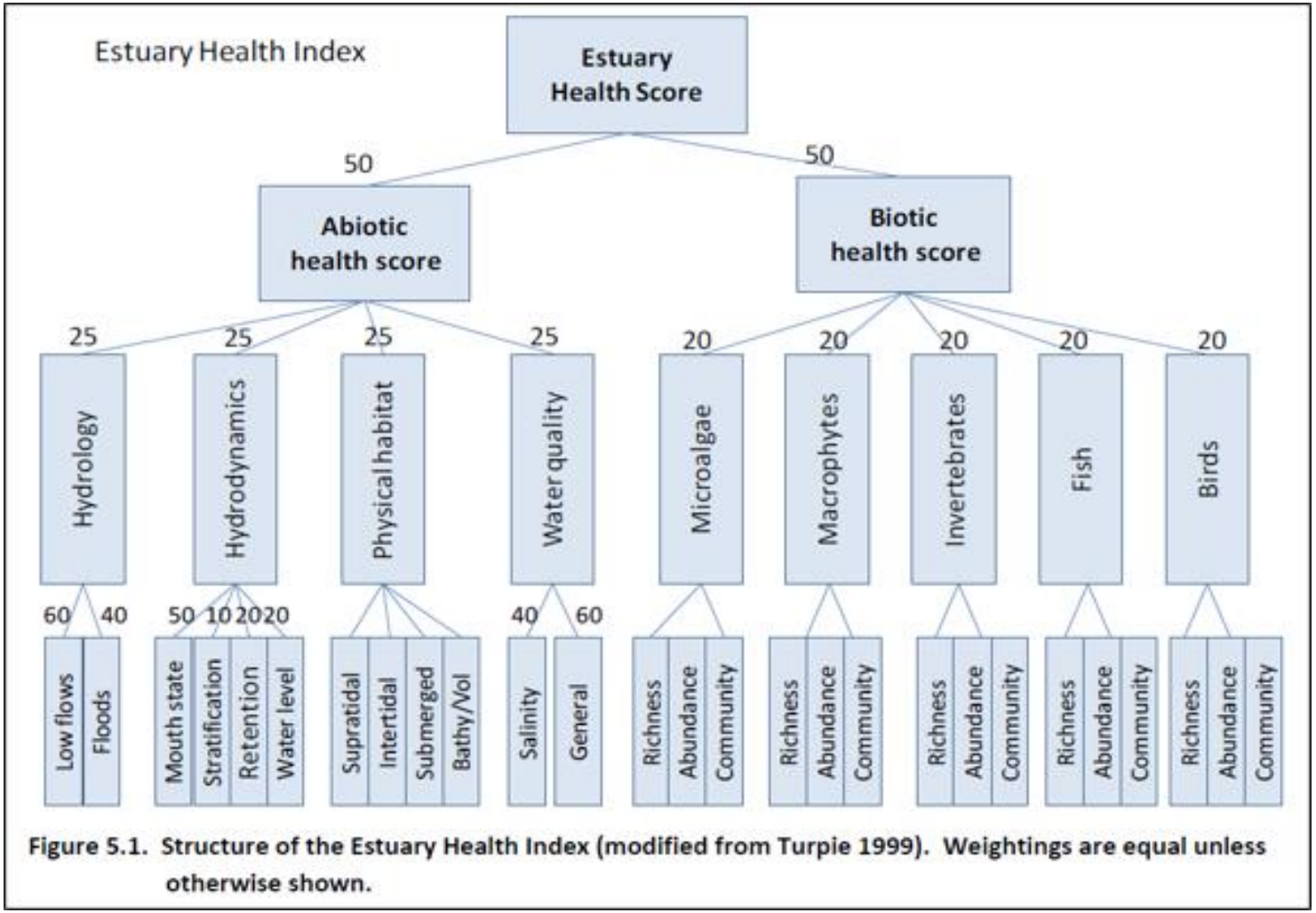


Figure 5.1. Structure of the Estuary Health Index (modified from Turpie 1999). Weightings are equal unless otherwise shown.

Table 5.2. Summary description of the measures used in scoring the 1st tier variables that make up the 2nd and 3rd tier scores.

2nd Tier	1st Tier	Measures used in scoring
Hydrology	Low flows	Similarity in the amount of flow during a defined low flow period or simply % natural MAR (data poor).
	Floods	Similarity in the magnitude and frequency of floods. Usually summarized as the average volume of the highest 2% of average monthly flows, based on the simulated monthly flows described above.
Hydrodynamics	Abiotic/mouth states	Similarity in terms of proportion of time the estuary is in different states, e.g. closed, open freshwater dominated.
	Stratification	Similarity in the degree of mixing or stratification in the water column
	Retention	Similarity in the duration of water retention in different parts of the estuary
	Water level	Similarity in average water levels
Physical habitat	Supratidal area	Similarity in supratidal physical habitat
	Intertidal area	Similarity in intertidal extent and sediment characteristics
	Subtidal/ submerged area	Similarity in subtidal extent and sediment characteristics
	Bathymetry/volume	Similarity in channel morphology and estuary volume
Water quality	Salinity	Similarity in axial salinity gradient and vertical salinity stratification, based on the amount of time in which different zones of the estuary are within different salinity ranges, or at worst (data poor) considering just average salinity.
	General	Similarity among different variables (N & P, suspended solids, dissolved oxygen, toxins), based on a scoring guideline (Unmodified = 100; largely natural = 80; moderately modified = 60; largely modified = 40; seriously modified = 20; completely modified = 0).
Microalgae, macrophytes, invertebrates, fish and birds	Richness, abundance and community composition	Similarity in estimated average instantaneous species richness, total abundance (biomass or numbers), and community composition, with the latter being based on the estimated abundance of defined subgroups of the biotic component (e.g. waterfowl, waders, etc.).

Determine Ecological Health Score

Table 5.19. The Estuary Health Index used to estimate the overall Estuary Health Score, giving an example in italics.

Variable	Weight	Score
Abiotic (habitat) variables		
Hydrology	25	41
Hydrodynamics and mouth condition	25	80
Water quality	25	59
Physical habitat	25	80
1. Habitat health score = weighted mean	50	65
Biotic variables		
Microalgae	20	60
Macrophytes	20	60
Invertebrates	20	70
Fish	20	60
Birds	20	90
2. Biological health score = weighted mean	50	70
ESTUARY HEALTH SCORE = weighted mean of 1 and 2		68.5

Determining PES

Overall Estuary Habitat Integrity score is calculated, which informs the PES

Table 4.7. Transformation of Habitat Integrity score into Present Ecological Status.

Class	Description	Score
A	Unmodified, pristine	100
B	Largely natural with a small number of localised impacts	81-99
C	Limited stretches of estuarine habitat are lost, but the ecosystem is largely still functional	61-80
D	No more than half of the estuary is impacted and the loss of ecosystem function is evident	41-60
E	More than half of the estuary has been impacted and ecosystem loss is serious	21-40
F	Impacts effect the entire estuary with an almost complete loss of ecosystem function	0-20

Condition (% of pristine)	≥91%	90-75	75 - 61	60 - 41	40-21	≤20
Ecological Category	A Natural	B Largely natural / few changes	C Moderately modified	D Largely modified	E Highly degraded	F Extremely degraded
State	Excellent	Good	Fair		Poor	
Functionality	Retain Process & Pattern		Loss of Process or Pattern		No / Little Process & Pattern	

Continuum	A	A/B	B	B/C	C	C/D	D	D/E	E	E/F	F

Category	Description
A	**Unmodified, or approximates natural condition.** The natural abiotic processes should not be modified. The characteristics of the resource should be determined by unmodifed natural disturbance regimes. There should be no human induced risks to the abiotic and biotic processes and function.
B	**Largely natural with few modifications**. A small change in natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged.
C	**Moderately modified**. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	**Largely modified**. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	**Seriously modified**. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	**Critically modified**. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural abiotic processes and associated biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Confidence Levels

- Defined as the level of available historical data, in combination with the level of effort expended during an assessment, determines the level of confidence of the study.
- Subjective assessment, based on the amount of available information as well as the experience of the specialist

Limit	Degree of confidence
Very Low	If no data were available for the estuary or similar estuaries (i.e. < 40% certain)
Low	Limited data were available, and estimates could be out by >60% (40 - 60% certain of estimate)
Medium	If reasonable data were available for the estuary and estimates could be out by 20-60% (i.e. 60% – 80% certain of estimate)
High	If good data were available for the estuary and estimates are probably not more than 20% out (i.e. > 80% certain of estimate)

Limitations and Challenges

- Where limited or no historic data and information available, reference conditions are estimated based on the**The Estuary Health Index** approach described in Turpie *et al*. (2012):
  - Hydrological characteristics, or river flow entering an estuary primarily control the other abiotic states in the estuary
  - Biotic components, in turn, respond to changes in the abiotic states
- So where limited or no data is available, a team of estuarine specialists predict, based on expertise and experience, changes from reference condition of the abiotic and biotic components.
- Influence of non-flow related impacts also considered, i.e. anthropogenic impacts, catchment impacts, and pressures on the estuary.

PES: ORANGE RIVER MOUTH ESTUARY

COMPONENT	PES 2003 (DWAF 2003)	PES 2013 (Louw, et al 2013)	PES 2018 (NBA 2018)
Hydrology	D	D	D
Hydrodynamics and mouth condition	D	C	C
Water quality	C	D	D
Physical habitat alteration	B	B	B
Habitat Health Score	**C**	**C**	**C**
Microalgae	D	E	E
Macrophytes	D	D	D
Invertebrates	E	D	D
Sigh	D	D	D
Birds	E	E	E
Biotic Health Score	**D**	**D**	**D**
PRESENT ECOLOGICAL STATE	**D**	**D**	**D**

Present Ecological State

Based on the estuary health index (EHI) assessment PES was rated as a D category; reflecting a largely modified system.

Variable	Weight	EHI score	Confidence
Hydrology	35	45	Low/Medium
Hydrodynamics and mouth condition	91	70	Low
Water quality	62	54	Medium
Physical habitat alteration	59	59	Medium
Habitat (abiotic) health score		62	
Microalgae	53	40	Low
Macrophytes	50	50	Medium
Invertebrates	45	45	High
Fish	50	50	Medium
Birds	22	22	Medium
Biotic health score		44	
OVERALL ESTUARY HEALTH SCORE		53	
ECOLOGICAL CATEGORY (PES)		D	Medium

- Significant freshwater flow modification – both loss of floods and increased base-flows;
- Lack of estuary mouth closure and resulting back-flooding of salt marshes with fresher water;
- Road infrastructure such as the old causeway crossing the saltmarshes and old bridge supports;
- Nutrient and salinity input from catchment;
- Gill netting of indigenous fish species and considerable fishing effort at the mouth on both sides of the estuary;
- Riparian infrastructure - levees preventing back-flooding;
- Mining activities; and
- Wastewater disposal (sewage and mining return flow).

Determining EIS

Determine Estuarine Importance Score (EIS) is based on:

- Size
- Zonal Type Rarity - the rarity of the estuary type within its biographical zone
- Habitat Diversity, and
- Biodiversity Importance of the estuary.

See Appendix D of NBA 2018

Determining Recommended Ecological Category (REC)

4. Determine the Recommended Ecological Category (REC) based on PES and EIS

- Protected Area = A or Best Attainable State (BAS)
- Desired Protected Area = A or BAS
- Highly Important = PES+1, Min B, or BAS
- Important = PES+1, Min C, or BAS
- Of Average Importance = PES (min D)

DETERMINING REC

Estuaries in these highly or extremely degraded states should, as a minimum, be improved to reflect an Ecological Category D.

PES	Description	Minimum Ecological Category
A	Unmodified, natural	A
B	Largely natural with few modifications	B
C	Moderately modified	C
D	Largely modified	D
E	Highly degraded	D
F	Extremely degraded	D

DRAFT RESOURCE QUALITY OBJECTIVES

DRAFT RESOURCE QUALITY OBJECTIVES: ORANGE RIVER ESTUARY

IUA 5 – Orange River Estuary
Resource Unit 5.1: Orange River Estuary

• The Orange Estuary is delineated as a RU. The estuary is a management unit with requirements and ecological specifications that are different to river systems.
• The Orange River Estuary is rated as 'highly important':
  ○ The area is a RAMSAR site requiring additional protection and management.
  ○ Protected Area on the Namibian side
  ○ Desired protected area in the South African Biodiversity Plan
• Flow related pressures include flow modification.
• Non-flow impacts include structures in estuary (human development), wastewater discharges, algal blooms, mining activities, toxic substances, fishing effort in the estuary, grazing and hunting.

DRAFT RESOURCE QUALITY OBJECTIVES: ORANGE RIVER ESTUARY

- REC should be aimed at a Category A or at least its best attainable state.
- In the case of the Orange River Estuary, the best attainable state, based on reasonable reversibility of pressures was estimated as Category C.
- While the C Category is the ecological objective over the long term, a C/D category is recommended as the Target Ecological Category (TEC) (interim over the next 10 years -2035/2040) until such time that some of the interventions both flow (e.g. mouth closure) and non-flow can be implemented to alleviate the stresses (this includes the building of the Vioolsdrift Dam to re-regulate the flow requirements).

DRAFT RESOURCE QUALITY OBJECTIVES:

Orange River Estuary

DRAFT RESOURCE QUALITY OBJECTIVES: COASTAL ESTUARY

IUA 8: Coastal Areas

- IUA is primarily a groundwater driven system and, with the tributaries being ephemeral with very little to almost no surface flow.
- Coastal estuaries largely **groundwater driven estuarine systems**.
- Based on the groundwater categorisation, where aquifer stress, vulnerability and quality relevant for the groundwater classification, the proposed IUA class is Class III.
- The impact of marine aerosols and water-rock formation interaction along the West Coast GRU 8.3 is significant and puts a permanent (natural) **saline signature on the groundwater quality** (elevated salinity, *e.g*. NaCl and fluoride).

PES: Buffels, Swartlintjies, Spoeg, Groen & Sout

Component Category	Buffels	Swartlintjies	Spoeg	Groen	Sout
Hydrology	D/E	B	B/C	C	D/E
Hydrodynamics	D	B	B	C	E/F
Water quality	D	B	A/B	B	D
Physical habitat alteration	D	B	A/B	A	E
Habitat health	D	B	B	B	D/E
Microalgae	D	B	A/B	B	E
Macrophytes	E	C	A	B	E/F
Invertebrates	D	C/D	A	C	E
Fish	E	B	A	B	E/F
Birds	D	A/B	A	B	E
Biotic health	D/E	B/C	A	B	E
PES	↓ D	B	A/B	B	E
Confidence	Low	Low	Low	Low	Low

DRAFT RESOURCE QUALITY OBJECTIVES:

Coastal Estuaries