The Determination Of Water Resource Classes, Reserve And Resource Quality Objectives For Secondary Catchments (A5-A9) Within The Limpopo WMA And Secondary Catchment B9 in the Olifants WMA

Project Steering Committee Meeting No. 2

WETLANDS

Presented by James MacKenzie
Date: 14 March 2024

WATER IS LIFE - SANITATION IS DIGNITY

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Department:
Water and Sanitation
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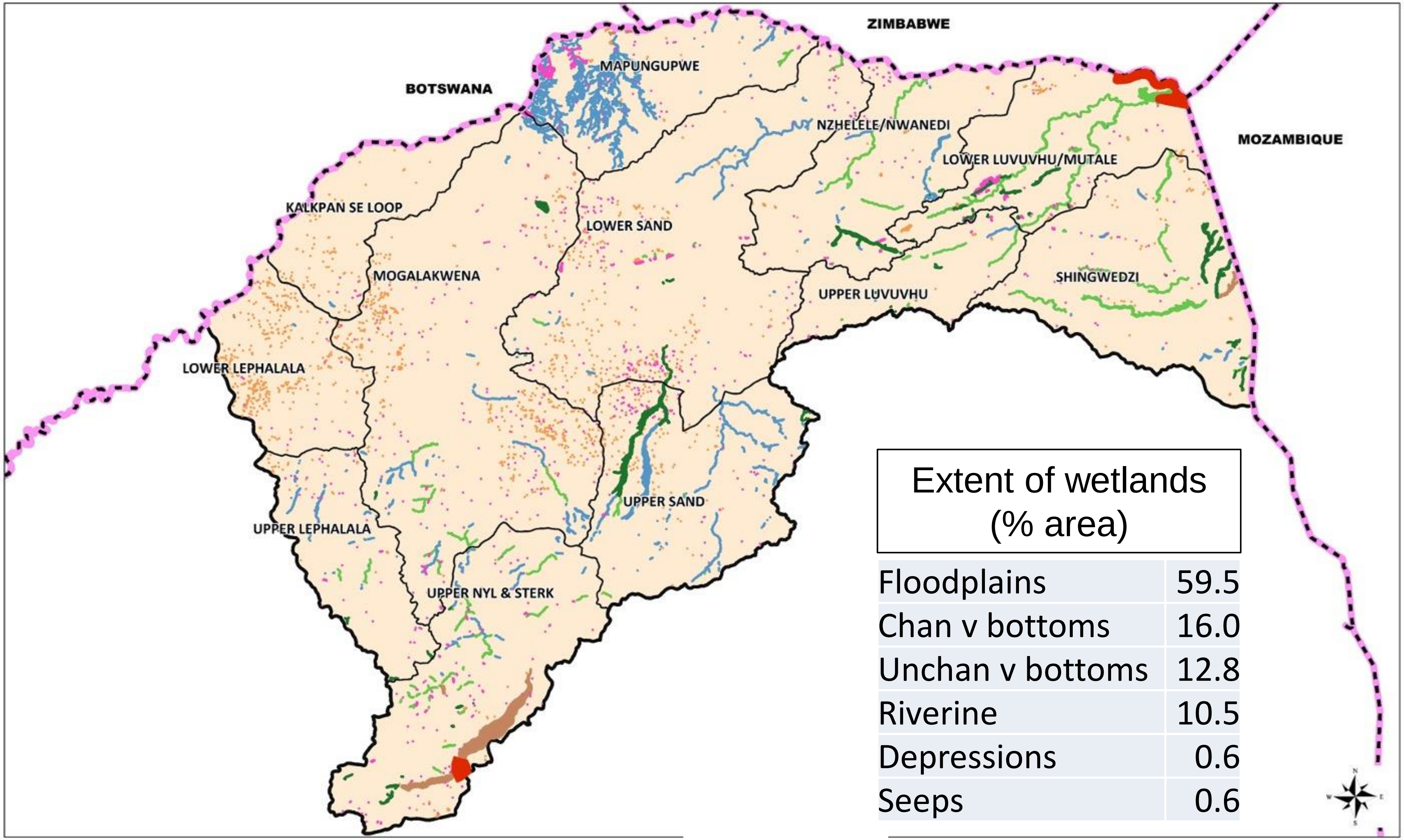
WETLANDS

This presentation summarises the wetland component of the study which comprises 2 volumes as follows:

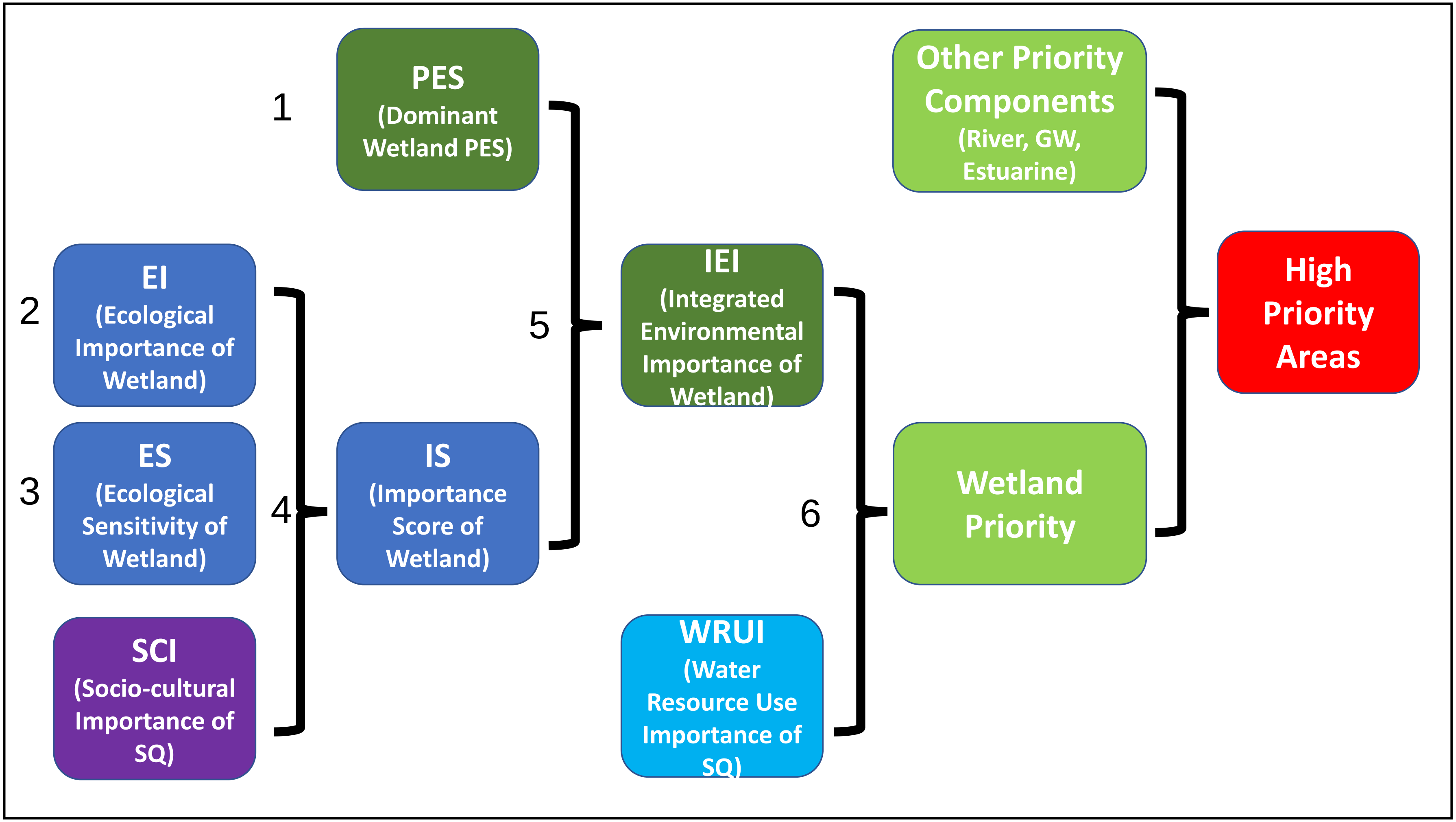
- Recap of wetland prioritisation – process and outcomes (vol 1)
- PES, EI and ES of high priority wetlands (vol 1)
- Hydrodynamic modelling (vol 2)
- Wetland EWR for Ramsar sites (vol 2)
  - Nyl floodplain (Nylsvley)
  - Luvuvhu floodplain (Makuleke)

OVERVIEW: Distribution of Different Types in the Study Area



Extent of wetlands (% area)	
Floodplains	59.5
Chan v bottoms	16.0
Unchan v bottoms	12.8
Riverine	10.5
Depressions	0.6
Seeps	0.6

WETLAND PRIORITISATION – 6-STEP PROCESS

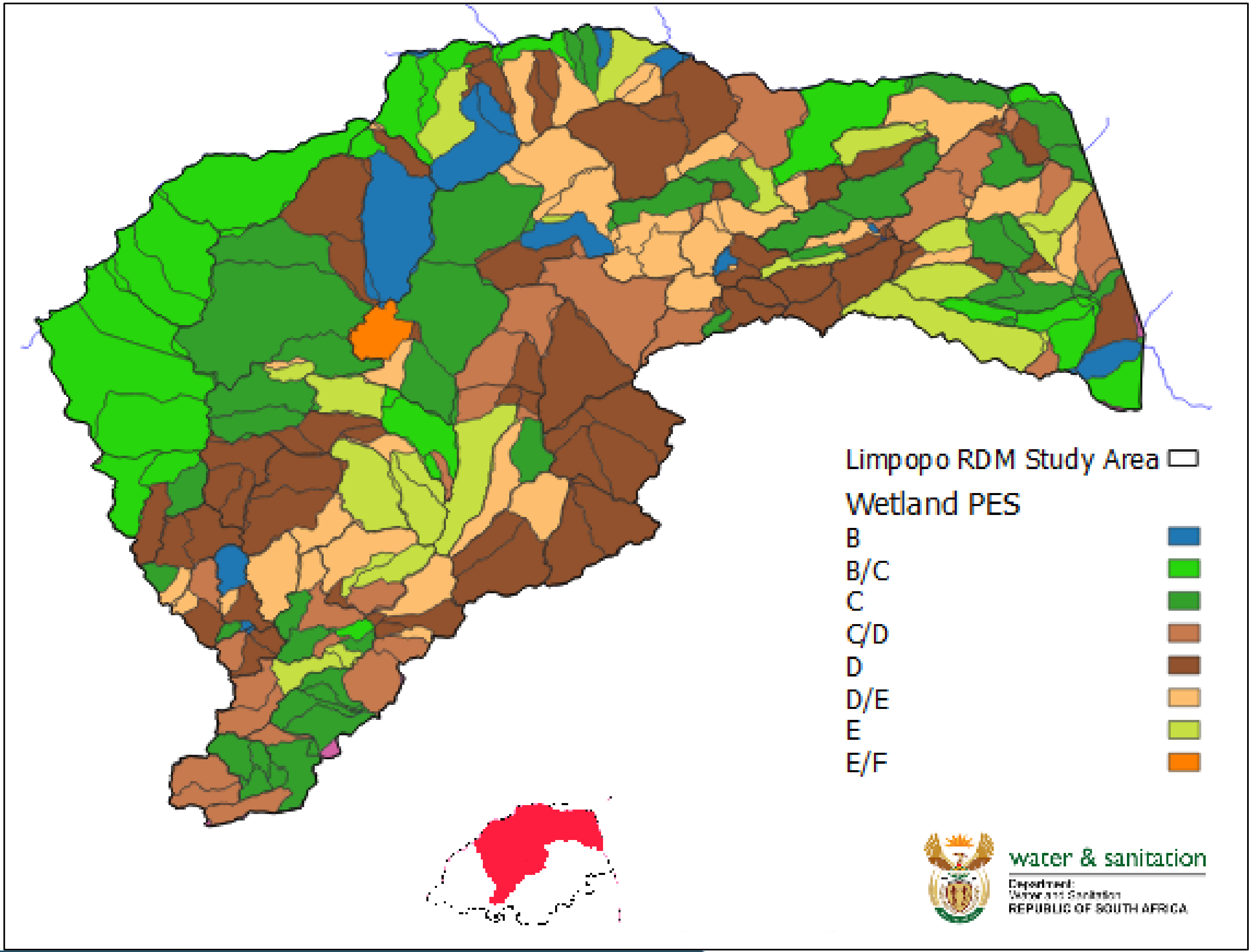


WETLAND APPROACH: PES

The assessment of wetland PES relied on best available data from mainly 3 sources (NB – these outcomes are updated for highest priority wetlands):

- The riparian and wetland metrics within the PES/EI/ES database (DWS, 2014).
- The wetland condition metric (WETCON) within the new wetland map (NWM) metadata from the 2018 national biodiversity assessment (van Deventer *et al*., 2018).
- The wetland condition metric (WETCON) within the NFEPA map metadata (Nel *et al.*, 2011).

WETLAND RESULTS: PES



WETLAND APPROACH: EI

The determination of EI considered the following criteria from the following data sources:

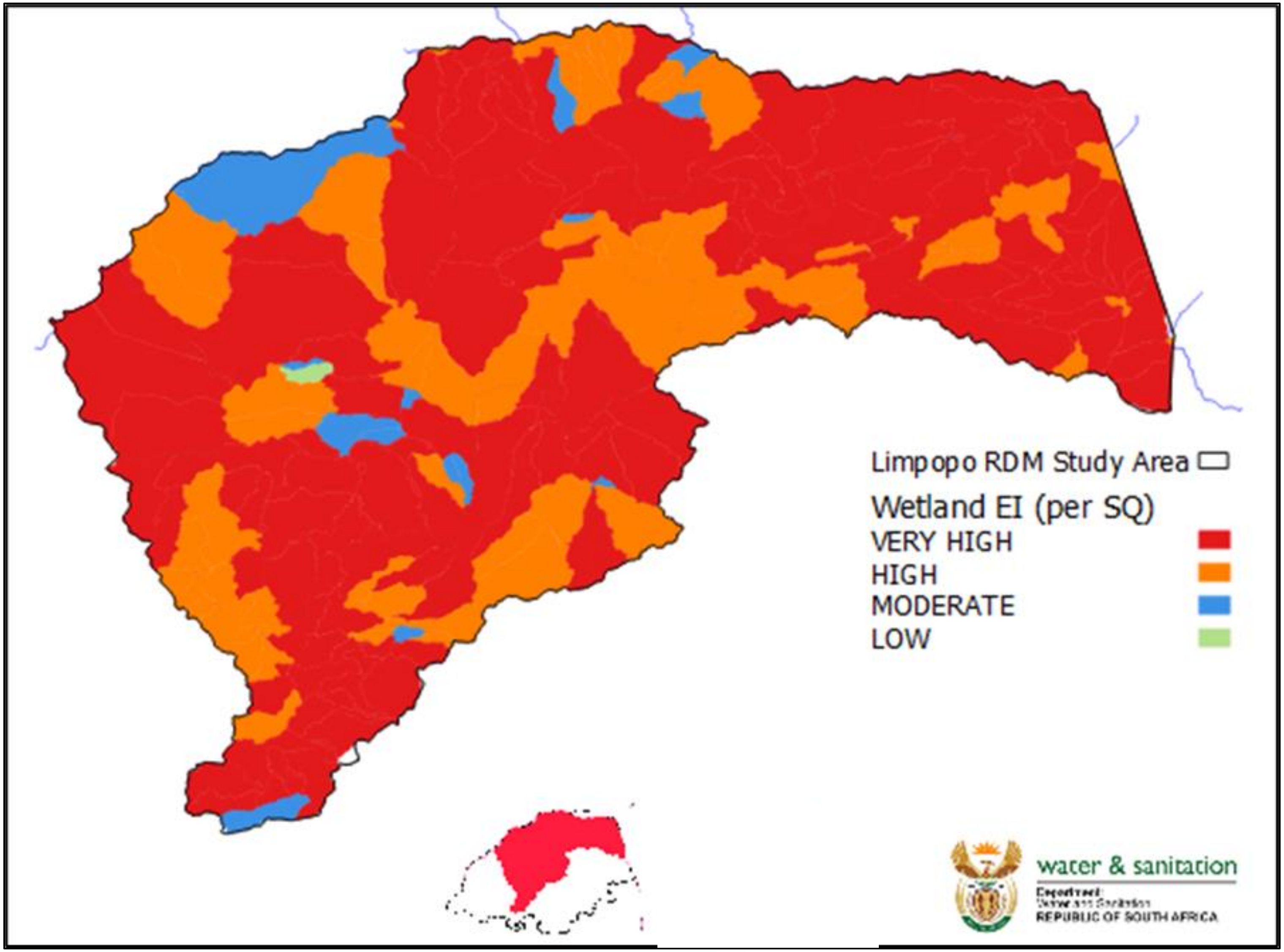
- National Biodiversity Assessment (new wetland map, 2018)
  - Diversity of wetland Hydrogeomorphic (HGMs) within quinary catchment - this is a count of different HGMs within the SQ excluding estuaries.
  - Overall extent of wetlands within quinary catchment (Ha per SQ).
- NFEPA (2011)
  - RAMSAR status – any wetland designated as a RAMSAR site would automatically be assigned a VERY HIGH EI.
  - Wetland FEPA status – any wetland denoted as a FEPA wetland was assigned a HIGH EI.
  - Wetland Cluster – does any of the wetlands within the SQ form part of a designated NFEPA wetland cluster.
  - Habitats for rare and endangered species including:
    - Cranes - wetlands (excluding dams) with the majority of its area within a sub-quaternary catchment that has sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes.
    - Amphibians - wetlands within 500 m of an IUCN threatened frog / toad point locality.
    - Water Birds - wetlands within 500 m of a threatened waterbird point locality.

WETLAND APPROACH: EI (cont)

The determination of EI considered the following criteria from the following data sources:

- PES/EI/ES (DWS, 2014) – EI score (0 - 5) normalised to 4 for integration with other metrics.
- Known important peatland sites.
- Important Birding Areas (2015) - The Important Bird and Biodiversity Areas (IBA) Programme is a BirdLife International Programme to conserve habitats that are important for birds. These areas are defined according to a strict set of guidelines and criteria based on the species that occur in the area.
- Regions / Centres of Plant Endemism (Van Wyk & Smith, 2001) – wetland that occur in regions or centres of plant endemism
- Regional Conservation Plans including (eg):
    - Limpopo Conservation Plan, version 2 (2013)

WETLAND RESULTS: Ecological Importance

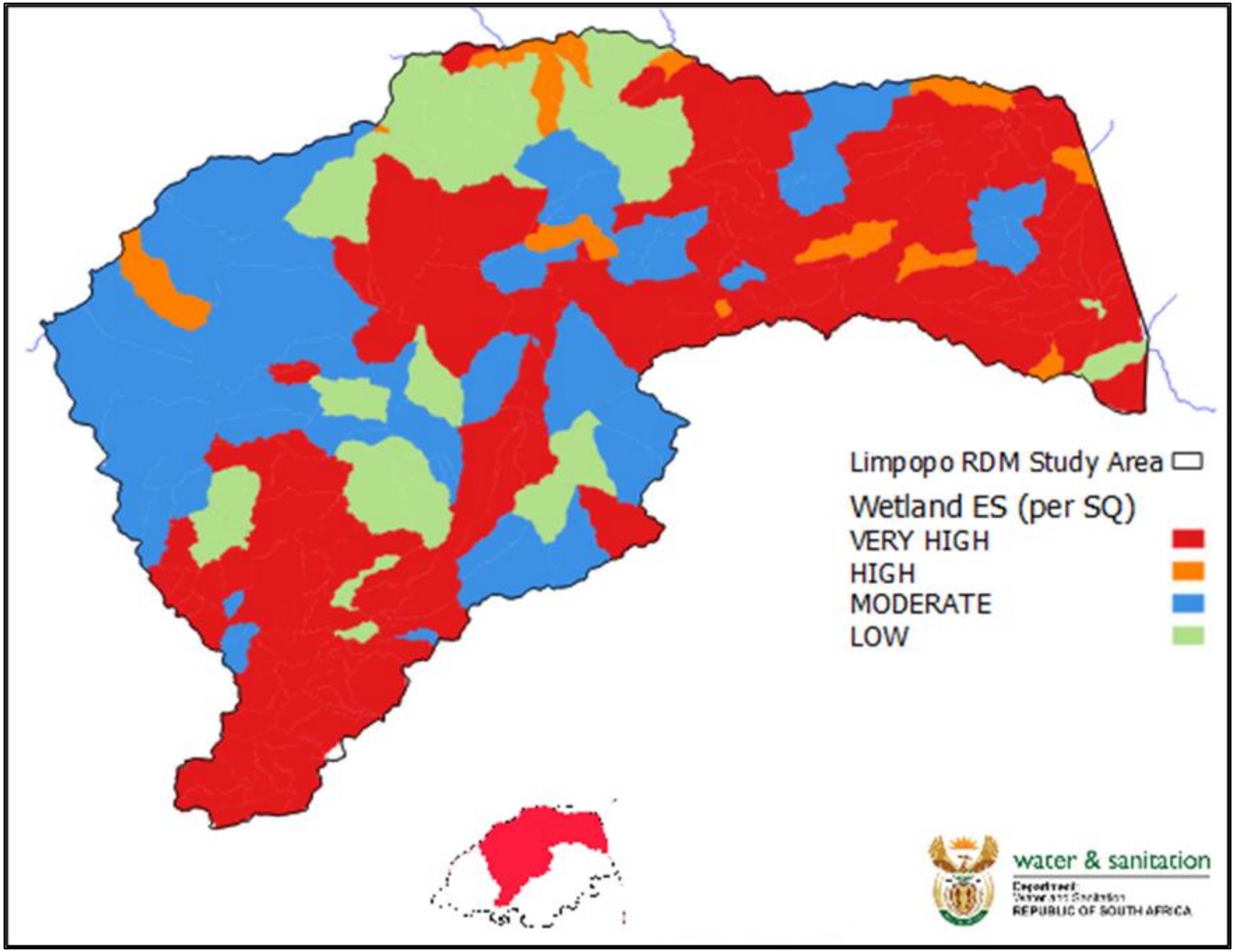


WETLAND APPROACH: Ecological Sensitivity

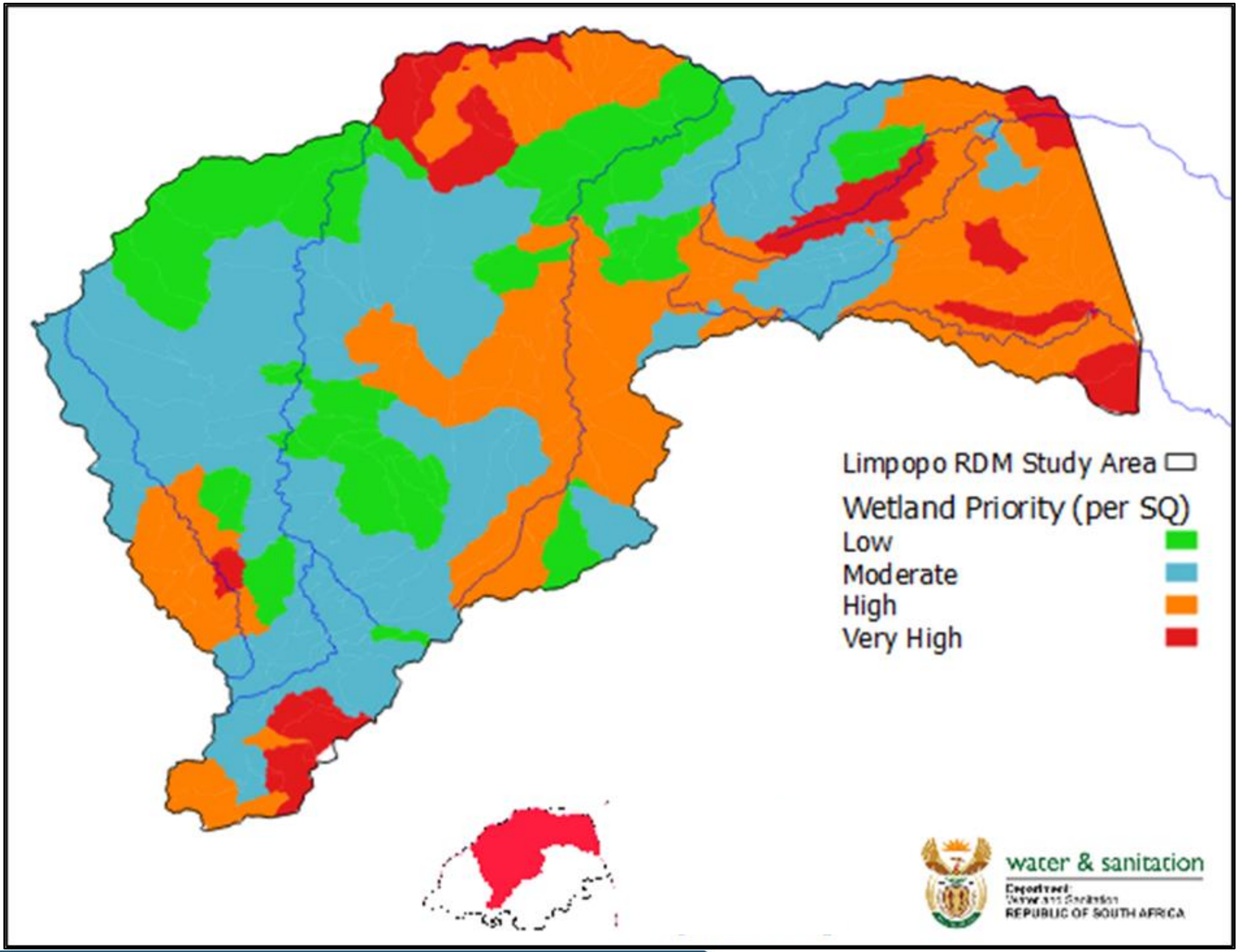
The determination of ES considered the following criteria from the following data sources:

- National Biodiversity Assessment (new wetland map, Van Deventer *et al.*, 2018) -
  - Dominant protection level of wetlands within SQR.
  - Dominant threat status of wetlands within SQR.
- Threatened Ecosystems (SANBI, 2011, remaining extent of natural vegetation; NBA 2018 Technical Report Volume 1: Terrestrial Realm).
- Threatened Plant Species within SQ (SANBI, 2009).
- PES/EI/ES (DWS, 2014) – ES score (0 - 5) normalised to 4 for integration with other metrics.

WETLAND RESULT: ES



WETLAND RESULTS: Priority



WETLAND RESULTS: Priority

Very High priority wetlands comprised 9.7% of SQs and 37.7% of SQs had a High priority wetlands with 52% of SQs with a Moderate or Low priority. The following high priority wetlands were assessed in the field for higher confidence validation / evaluation of the PES, EI and ES:

- Luvuvhu Floodplain (Makuleke)
- Nyl River Floodplain
- Wonderkrater
- Nyl Pans
- Maloutswa Floodplain (Mapungubwe)
- Kolope Wetlands
- Lake Fundudzi
- Mutale Wetlands
- Mokamole wetlands – a tributary of the Mogalakwena River
- Thermal spring / Peat domes in KNP (Malahlapanga; Mfayeni)
- Bububu wetlands – a tributary of the Shingwedzi River

WETLAND RESULTS: PES, EI, ES

The assessment of the ecostatus of high priority wetlands was achieved through the following:

- Validation of the PES
- Determination of the EIS
- Determination of the REC

Both the WetHealth Level 1 and the Wetland Habitat Integrity (Wetland IHI) were used within the framework of the DWS Decision Support Protocol (DSP; Ollis et al., 2014) to determine the wetland Present Ecological Status (PES).

Summary of the PES score and category, the EI and ES and the REC for all wetlands that were assessed.

High Priority Wetland	PES Score	PES Category	EI	ES	REC	How to achieve the REC
Luvuvhu Floodplain (Makuleke)	80.0	B/C	Very High	Very High	B/C	Maintain PES
Nyl River Floodplain	65.0	C	Very High	Very High	C	Maintain PES
Wonderkrater	80.0	B/C	Very High	High	B/C	Maintain PES
Nyl Pans	57.0	D	High	Very High	C/D	Improve water quality
Maloutswa Floodplain	66.0	C	Very High	Very High	C	Maintain PES
Kolope Wetlands	90.0	A/B	Very High	Low	A/B	Maintain PES
Lake Fundudzi	78.0	B/C	Very High	Very High	B/C	Maintain PES
Mutale Wetlands	62.0	C/D	Very High	Very High	C/D	Maintain PES
Mokamole (tributary of the Mogalakwena)	80.0	B/C	High	High	B/C	Maintain PES
Malahlapanga	78.0	B/C	Very High	Moderate	B	Reduce trampling pressure from megaherbivores
Bububu wetlands (tributary of the Shingwedzi)	97.0	A	Very High	High	A	Maintain PES

HYDRODYNAMIC MODEL: Nyl

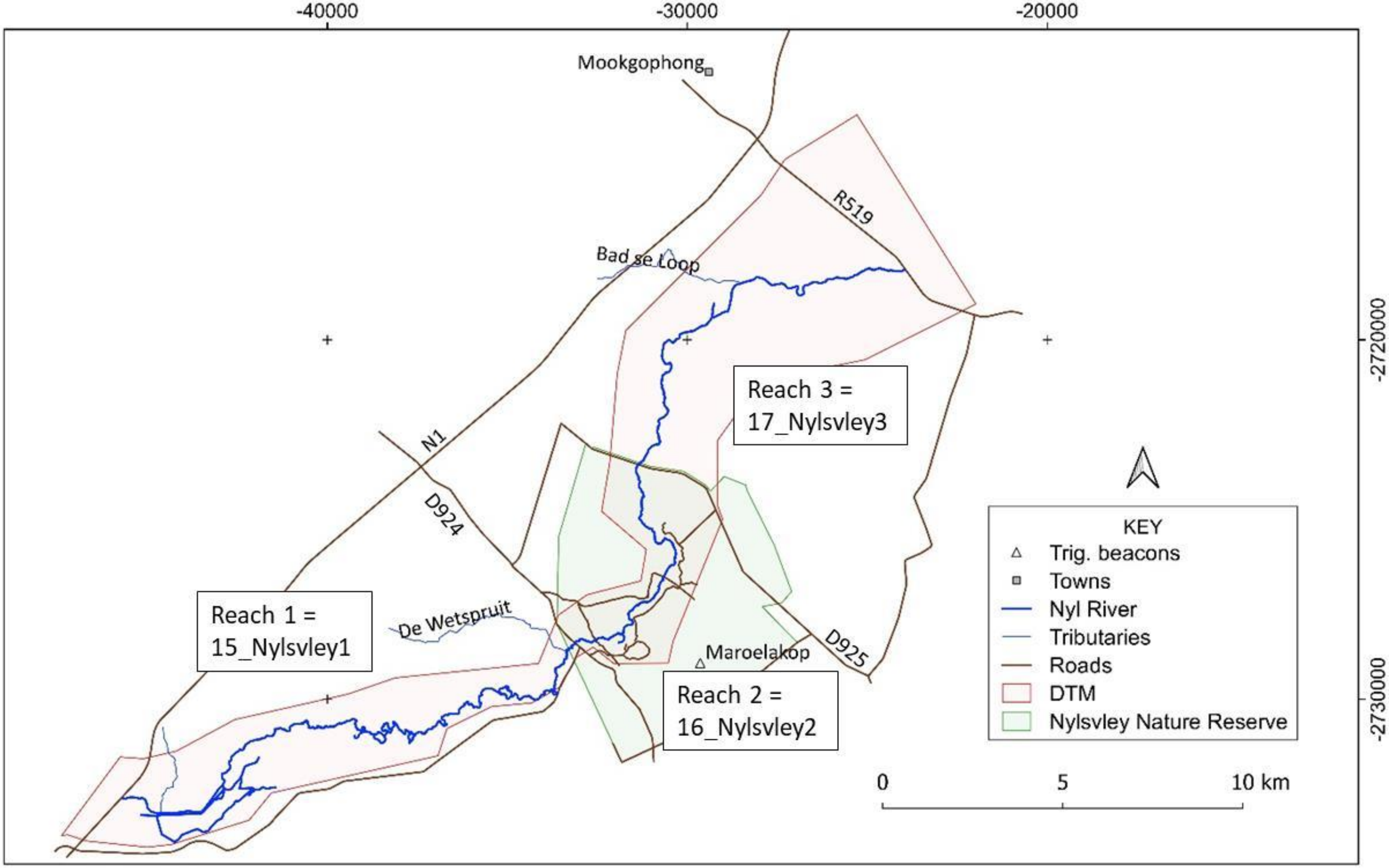
For modelling purposes, the study area was divided into three distinct, contiguous zones and for each of these an individually calibrated and verified hydraulic model was developed:

- Reach 1: Middelfontein to District Road D924 (~upstream boundary of Nylsvley);
- Reach 2: D924 to D925 (Vogelfontein - downstream boundary of Nylsvley); and
- Reach 3: D925 to Regional Road R519 (Mosdene).

Each reach is represented as an EWR zone in DRIFT-Nylsvley:

- Reach 1 = EWR zone 15_Nylsvley1
- Reach 2 = EWR zone 16_Nylsvley2
- Reach 3 = EWR zone 17_Nylsvley3.

HYDRODYNAMIC MODEL: Nyl



HYDRODYNAMIC MODEL: Nyl

Three 2001 HECRAS sub-models were designed, one per reach using a multitude of cross sections.

De-archived, reformatted and georeferenced cross-sections on the Nyl River floodplain, on a Bing satellite image; CRS is Hartebeeshoek94 Lo29

HYDRODYNAMIC MODEL: Nyl

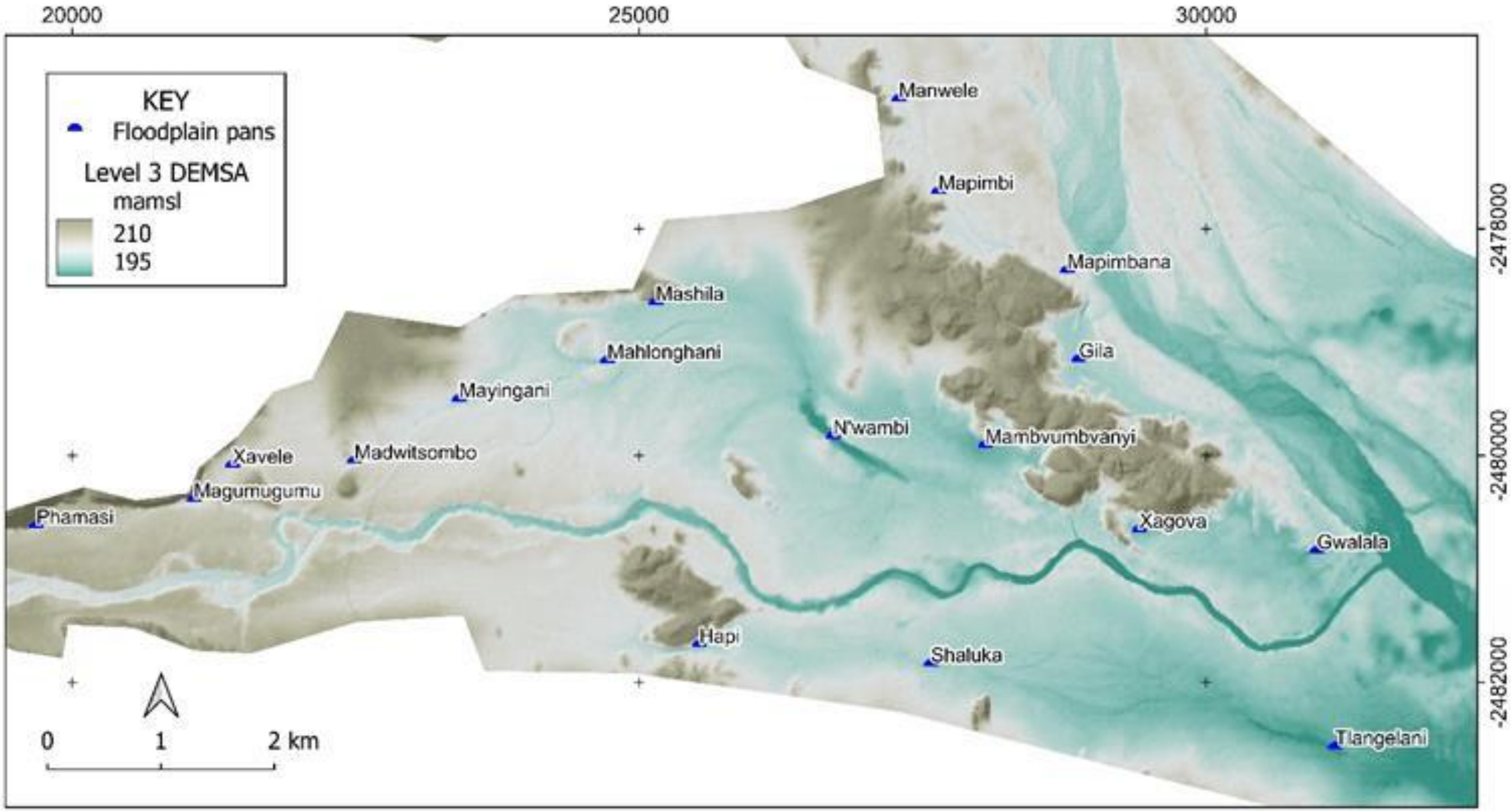
Modelled PES (2022) scenarios (1925 to 2021) for the Nyl River floodplain: a) inundated area, b) average depth

HYDRODYNAMIC MODEL: Luvuvhu

In order to develop the hydrodynamic model

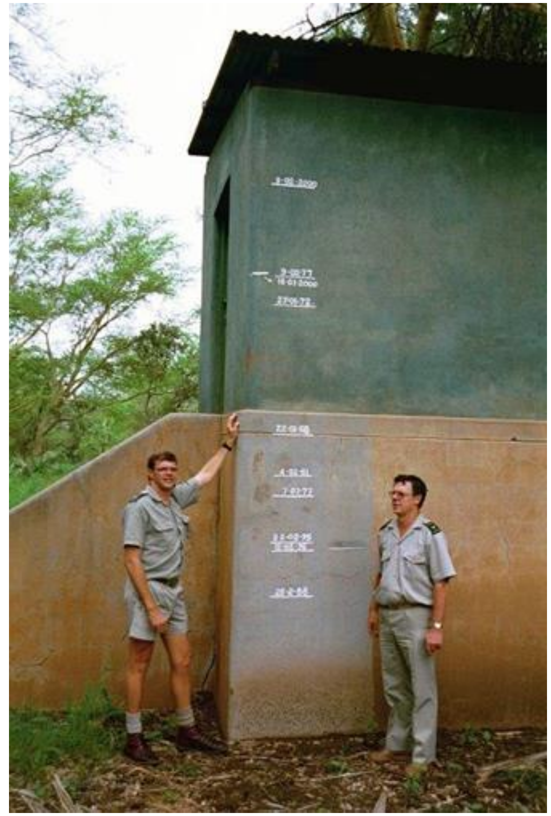
- One needs to first set up a Digital Elevation Model (DEM) which requires a Digital Terrain Model (DTM)
- Topographic information is required in the form of a Digital Terrain Model (DTM).
    - The DTM was extracted from stereo aerial imagery (dated 2008 and 2015), with > 95% of surface features taller than 1.5m removed to comprise the DEM.
- Contours at 0.2m intervals were generated from the DTM to assist with the delineation of the floodplain, together with ecological point data measured in the field.
- The point elevation data that was surveyed using a Trimble® Catalyst™ DA2 receiver on the data collection field trips provided comparative measurements to assess the vertical accuracy of the DTM.

HYDRODYNAMIC MODEL: Luvuvhu



Digital Elevation Model (DEM) of the Luvuvhu River floodplain to the Limpopo River confluence

HYDRODYNAMIC MODEL: Luvuvhu



Marked historic floods levels: left) (February 2000) - on beacons on the tar road crossing the Luvuvhu River, Middle) marked on a wall at the Theba Pump House between 1958 and 2000 - date unknown, Right) includes the 2013 flood that is the second highest recorded after 2000 (photograph October 2022)

HYDRODYNAMIC MODEL: Luvuvhu

Conceptual approach adopted to develop a HECRAS 1-d model for the Luvuvhu and Limpopo Rivers and adjacent floodplains:

Water sources (viz. sub-catchment runoff, overtopping of the Luvuvhu River's banks and backflooding from the Limpopo River) and flow paths across the Luvuvhu floodplain that result in filling of the pans; the EWR sites in DRIFT-Luvuvhu are numbered: 18_Luvuvhu2, 19_Hapi, 20_N'wanbi, 21_Mambvumbvanyi, 22_Tlangelani, 23_Luvuhu3

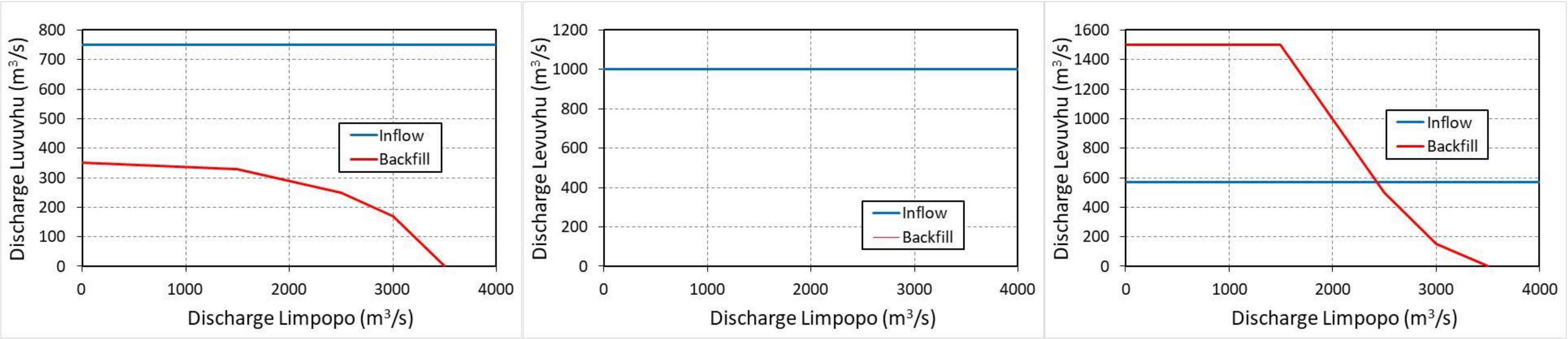
HYDRODYNAMIC MODEL: Luvuvhu

Return periods for filling pans through only overtopping of the Luvuvhu/Limpopo riverbanks (excludes rainfall and associated runoff).

Pan	Return period for flooding from Luvuvhu/Limpopo Rivers (years)											
	Natural			**PES (2022)**			Future1			Future2		
	I	B	O	I	B	O	I	B	O	I	B	O
Luvuvhu Floodplain												
N'wambi	7.0	2.8	2.8	**7.0**	**4.7**	**4.7**	9.3	5.1	5.1	18.7	7.0	7.0
Mambvumbvanyi	7.0	2.8	2.8	**7.0**	**4.7**	**4.7**	9.3	5.1	5.1	18.7	7.0	7.0
Hapi	9.3		9.3	**18.7**		**18.7**	18.7		18.7	56.0		56.0
Tlangelani	6.2	11.2	5.1	**6.2**	**14.0**	**5.6**	7.0	14.0	6.2	14.0	14.0	9.3

I: Inflow
B: Backfill
O: Overall

HYDRODYNAMIC MODEL: Luvuvhu



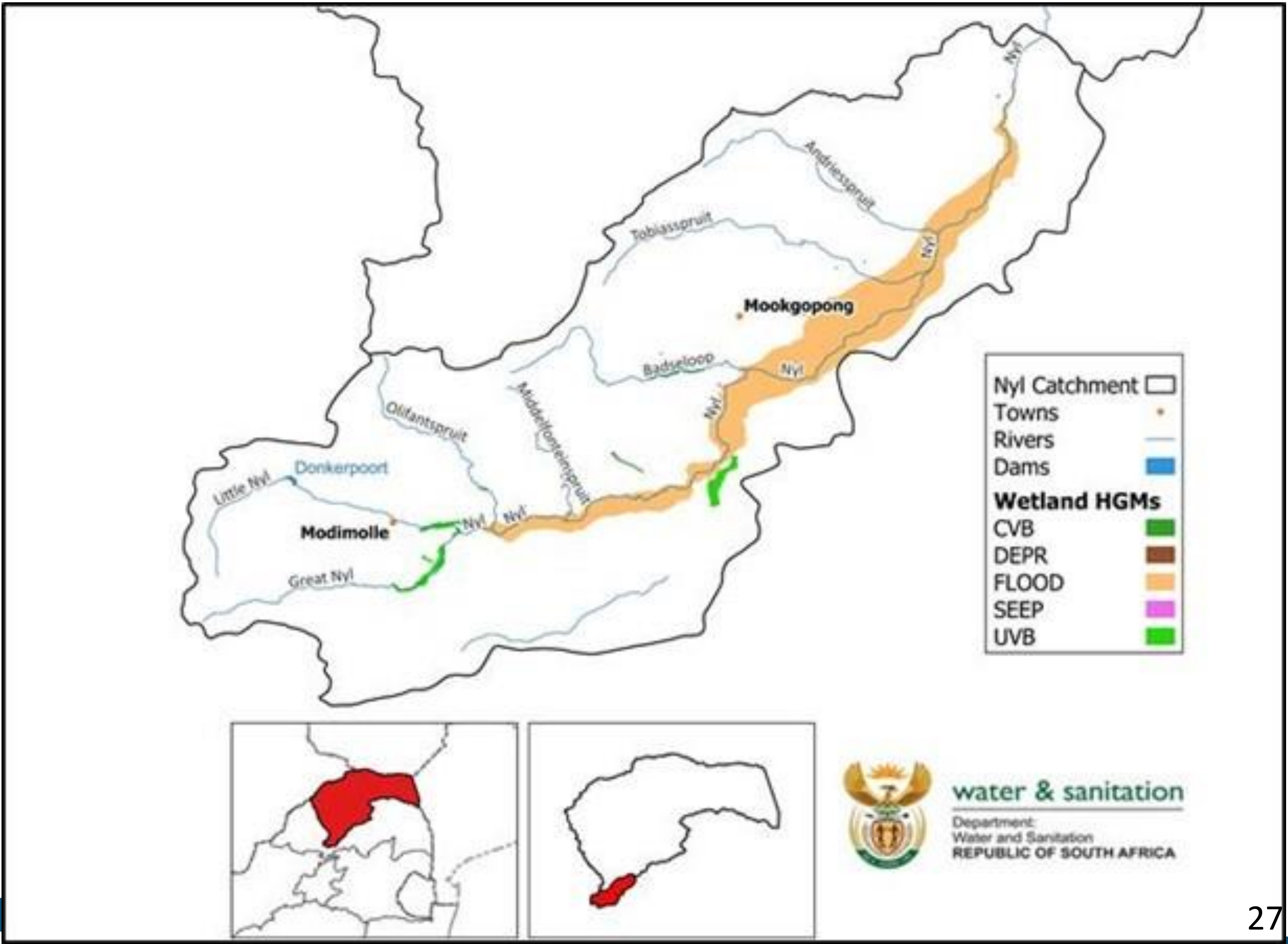
The combinations of discharge in the Luvuvhu and Limpopo Rivers that breach the levees and flood the floodplain to fill the Nwambi and Mambvumbvanyi (left), Hapi (center) and Tlangelani (right) pans.

WETLAND EWR

There are no formal RDM methods that are appropriate for use for the Nyl and Luvuvhu River floodplains, but investigations of the EWR for the two areas are meaningless without a reliable and efficient hydrodynamic model to predict the extent, duration and timing of flooding on the floodplains. For this reason, the approach adopted for the EWR assessments was to:

- focus on developing a reliable and efficient hydrodynamic model to predict the extent, depth and duration or flooding on the floodplains
- create vegetation maps and groundtruth the mapped plant communities, including the use of satellite data (Sentinel 2)
- review the literature on key biota (indicators of flow) and undertake an EcoStatus assessment using existing tools
- populate a DRIFT model for each floodplain that represents a sound understanding of the hydro-ecological functioning
- evaluate the ecological outcome of future development or climate change scenarios as appropriate.

WETLAND EWR: Nyl Floodplain



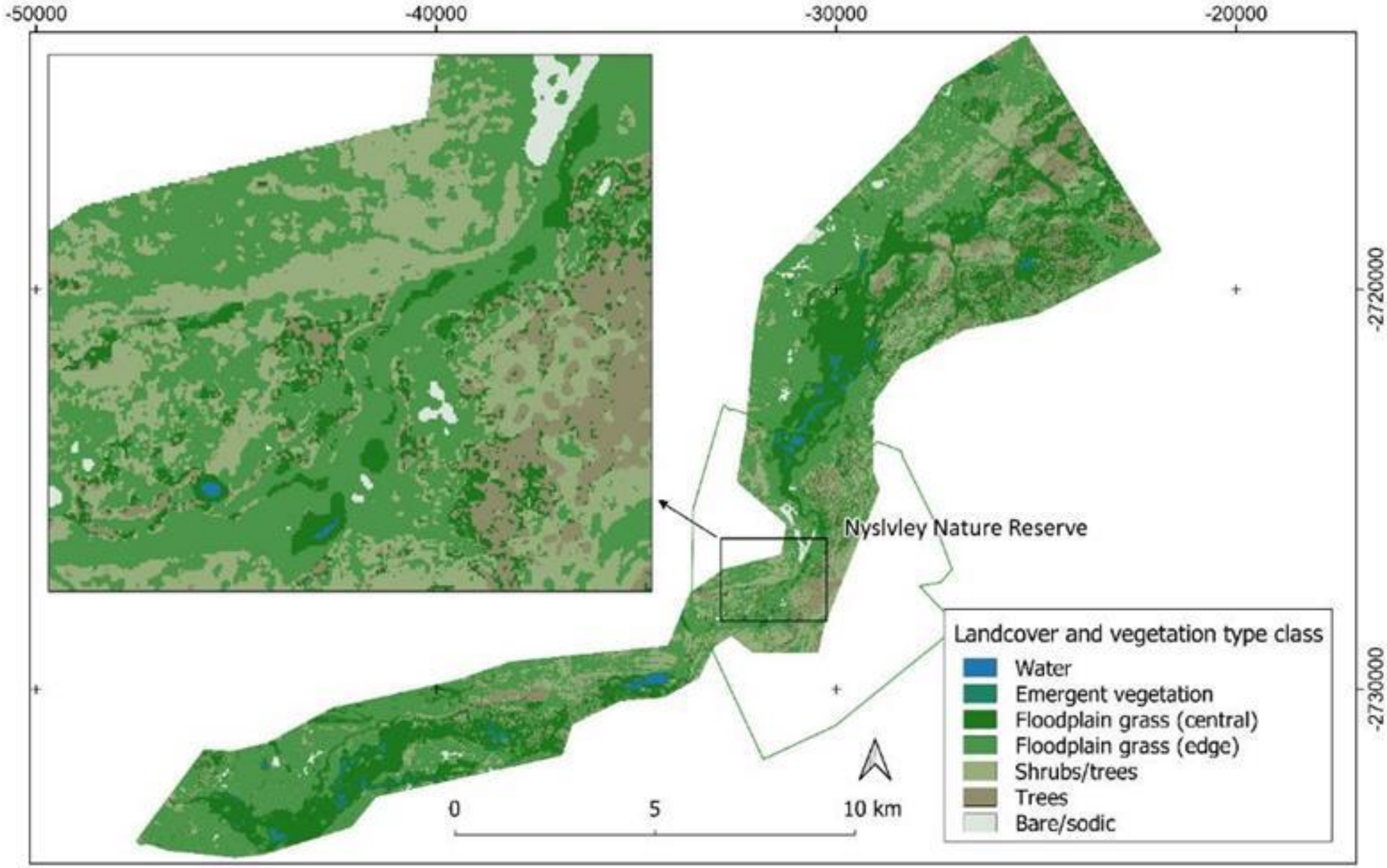
WETLAND EWR: Nyl Floodplain

As part of developing wetland-scale hydrodynamic models, it was necessary to link depth of inundation to the underlying landcover and distribution of vegetation types, which requires mapping or classification. The following vegetation types were identified and mapped using a combination of ground-truthing in combination with visual assessments of the distribution of types from high-resolution Near Colour Composites (NCC, Bing and Google Earth) and medium-resolution NCC and False Colour Composites (Sentinel 2A) imagery:

- emergent vegetation (reeds)
- floodplain grasses (central)
- floodplain grasses (edge)
- shrubs and trees (floodplain)
- Trees (terrestrial)

WETLAND EWR: Nyl Floodplain

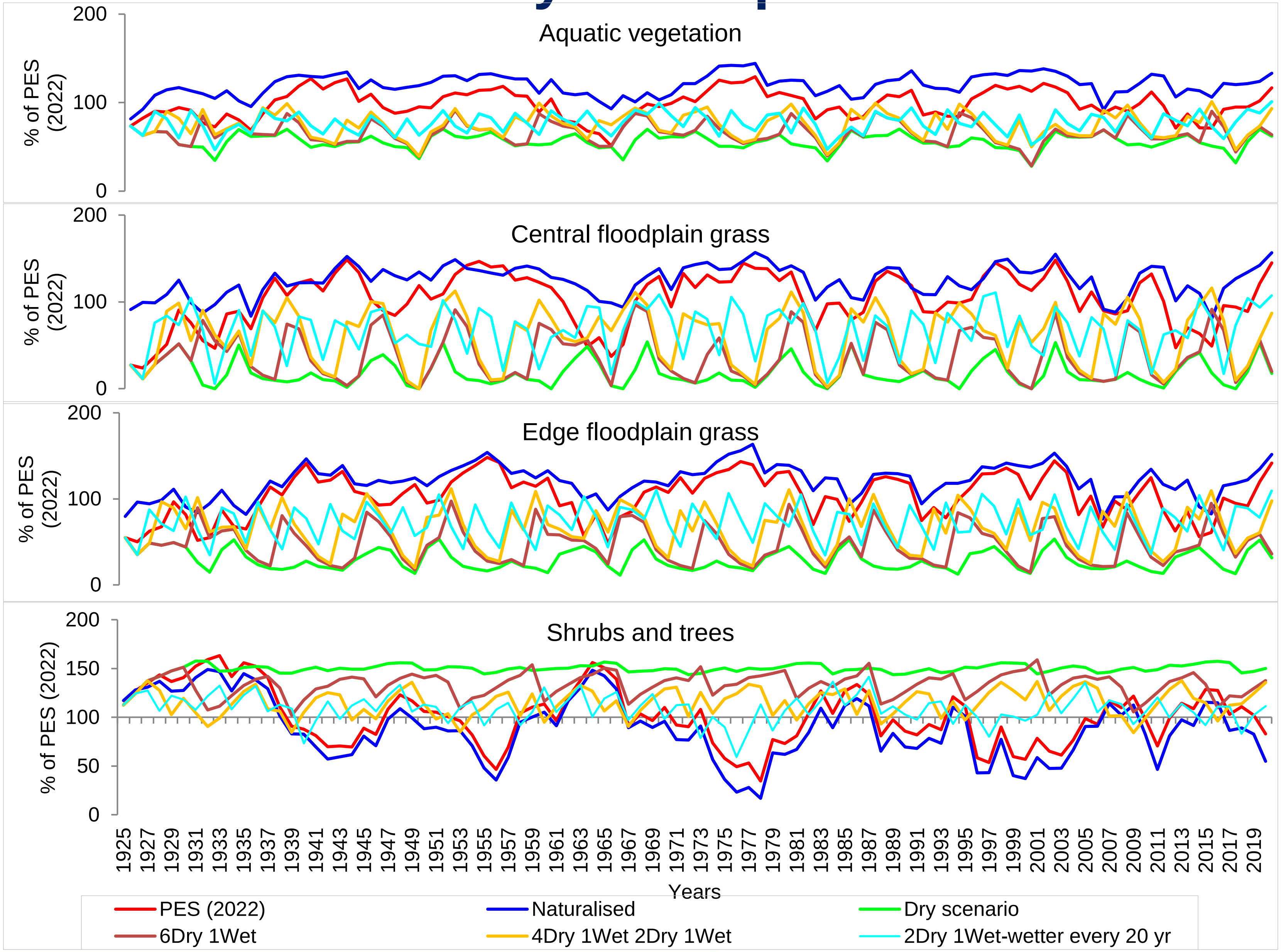
Landcover and vegetation types of the Nyl River floodplain



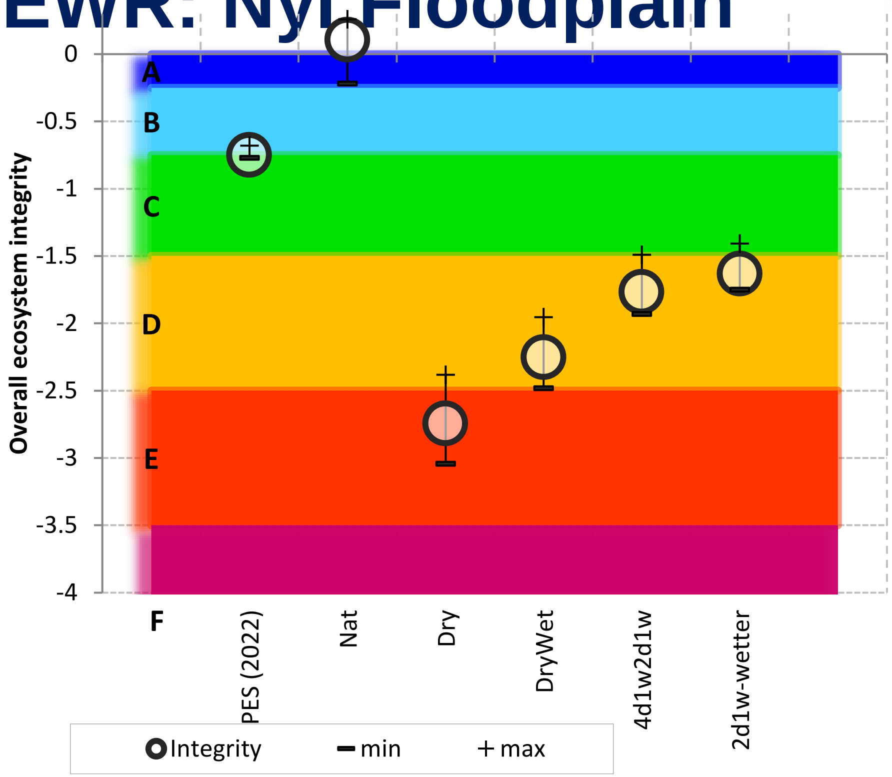
WETLAND EWR: Nyl Floodplain

Indicator	Reason for selection	EWR zone		
		15	16	17
Aquatic vegetation	Aquatic plants are important as food for many animals and provide habitat for aquatic organisms, and some improve water quality. They also have medicinal and food value for humans.	X	X	X
Reeds	Reeds are eaten by domestic and wild herbivores and provide important habitat for aquatic invertebrates.	X	X	X
Central floodplain grass (wet)	Central floodplain grasses are an important source of food for birds and mammals and as breeding grounds for birds, fish, amphibians and mammals. They are also grazing areas for domestic livestock and play a role in flood attenuation and erosion control.	X	X	X
Edge floodplain grass (dry)	Edge floodplain grasses are important grazing areas for wildlife and domestic livestock. They also provide habitat for wildlife when the central floodplain grasses are inundated. They are also play a role in flood attenuation and erosion control.	X	X	X
Shrubs and trees	Shrubs and trees grow on the edges of the floodplain or on raised mounds and are important habitat for a variety of floodplain animals.	X	X	X
Coenogrionidae	Coenogrionids inhabit marginal vegetation in slow flowing water and are an important food source for birds and fish.	X	X	X
White-breasted cormorant	White-breasted cormorants feed on fish in open water (pools, pans, backwaters and the channel). They were selected to represent all birds that feed in open water because they are very abundant at Nylsvley.	X	X	X
White-faced duck	White-faced ducks spend time on open water and in marginal vegetation, are omnivorous eating seeds, tubers and invertebrates (insects, crustaceans and worms). They were selected to represent all dabbling waterfowl (ducks and teals) because they were very abundant at Nylsvley.	X	X	X
Water buck	Waterbuck inhabit grasslands and are highly dependent on water to maintain their hydration. They also favour reeds as one of their food items. They were selected because they are one of the flagship water-dependent antelope at Nylsvley.	X	X	X
Floodplain dependent fish	Floodplain dependent fish move onto the floodplains to breed and the inundated floodplains provide nursery areas for juvenile fish.	X	X	X

WETLAND EWR: Nyl Floodplain



WETLAND EWR: Nyl Floodplain



	PES	Nat	Dry	6d1w	4d1w-1d1w	2d1w-20W
Vegetation	C/D	B	F	E/F	D/E	D/E
Inverts	B	A	C/D	C	C	C
Fish	C	A	E	D/E	D	D
Birds	B/C	A	E	D/E	D	D
Mammals	B/C	A	D	C/D	C	C
Overall	**C**	**A**	**D/E**	**D**	**D**	**C/D**

WETLAND EWR: Nyl Floodplain

Flood Requirements:
The objective of the flood requirements was

- to inundate 60-80% of central floodplain grasses with small floods
- 70 – 90% with a medium flood
- 80 - 100% with a large flood
- and that the return period of these floods would roughly match that described by Higgins *et al*. (1996): channel flows in 7 out of 10 years (small floods), floodplain inundation in 4 out of 10 years (medium floods) and large floods in 2 out of 10 years

WETLAND EWR: Nyl Floodplain

Flood requirements:

- 3 - 5 m^3/s annual flood
- 16 - 20 m^3/s flood every two years for a duration of 3 to 4 months
- 28 - 30 m^3/s flood every three years for 50* to 90 days
- 45 - 50 m^3/s flood every five years for 90 to -150** days.

*50 days is the minimum duration for successful bird breeding

**150 days being optimum for *Oryza longistaminata* to effectively complete its life cycle (Marneweck pers. comm. 2023)

Return period / flood frequency	Flood magnitude (m3/s)	15_Nyl 1		16_Nyl 2		17_Nyl 3	
		Central	Edge	Central	Edge	Central	Edge
		% area of floodplain grasses inundated					
1:1	3 - 5	30-39	10-19	50-59	40-49	30-39	30-39
1:2	16 - 20	60-69	50-59	80-89	70-79	90-99	70-79
1:3	28 - 30	70-79	60-69	80-89	80-89	90-99	80-89
1:5	45 -50	80-89	70-79	90-99	80-89	100	100

Based on PES (2022) scenario

WETLAND EWR: Nyl Floodplain

In addition the following EWRs were specified using DRIFT:

- Inflows from the Nyl River at the N1 to maintain the PES (2022) of a C for the Nyl River floodplain (shown in next slide as an example).
- Inflows from the Olifantspruit to maintain the PES (2022) of a C at the river EWR site 3_Olifantspruit and the PES (2022) of a C for the Nyl River floodplain.

WETLAND EWR: Nyl Floodplain

nMAR	61.871	MCM	
S.Dev.	2.659		
CV	0.043		
Q75	0.080		
Ecological Category	C		
	MCM	% nMAR	
Total EWR	43.963	71.055	
Maint. Lowflows	24.145	39.024	Excludes floods with return period ≥1:2 years.
Drought Lowflows	12.016	19.420	
Maint. Highflows	19.818	32.031	

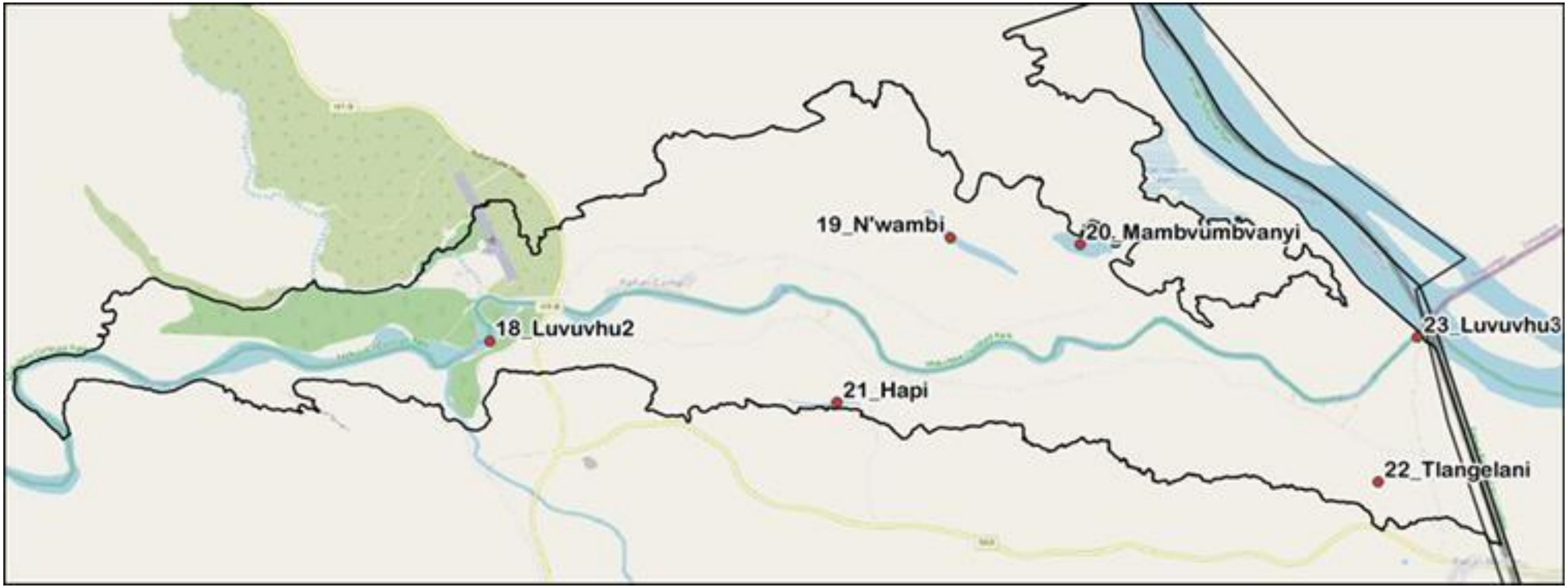
Monthly Distributions (MCM)

	Natural	Modified Flows (EWR)			
		Lowflows		Highflows	Total EWR
Month	Mean	Maint.	Drought	Maint.	Maint.
Oct	1.622	0.552	0.526	0.202	0.754
Nov	4.513	1.462	0.865	2.116	2.876
Dec	7.585	2.163	1.163	4.314	5.113
Jan	9.294	2.544	1.272	5.631	6.380
Feb	11.553	3.513	1.541	7.202	7.449
Mar	9.212	3.330	1.418	5.202	6.884
Apr	5.944	2.817	1.178	2.621	5.319
May	3.845	2.369	1.030	0.990	3.299
Jun	2.734	1.948	0.901	0.303	2.251
Jul	2.243	1.601	0.817	0.096	1.698
Aug	1.836	1.108	0.712	0.053	1.161
Sep	1.491	0.739	0.593	0.040	0.778
Total	61.87	24.14	12.02	28.77	43.96

WETLAND EWR: Nyl Floodplain

Floods. *Flood can occur in the month before or after the month indicated*								
	Within year floods <1:2 years				Inter annual floods >=1:2 years			
Flood Class	Class1	Class2	Class3	Class4	1:2	1:5	1:10	1:20
Ave peak discharge (m^3/s)	1.40	2.90	5.60	10.90	22	40	53	106
Ave duration (days)	8	8	10	10	10	18	8	15
Number	6	5	3	2				
Oct								
Nov								
Dec	1							
Jan	1	2						
Feb	1	1	1	1	1	1	1	1
Mar	1	1	1	1				
Apr	1	1	1					
May	1							
Jun								
Jul								
Aug								
Sep								
Vol ($10^6 m^3$)	2.73	3.64	4.99	5.69	6.01	10.87	9.42	22.93
% PES (2022) MAR	5.16	6.87	9.43	10.75	11.35	20.55	17.80	43.33

WETLAND EWR: Luvuvhu Floodplain



Map showing the Luvuvhu floodplain (new delineation) and the 6 EWR sites (4 pans and 2 river sites) used in DRIFT

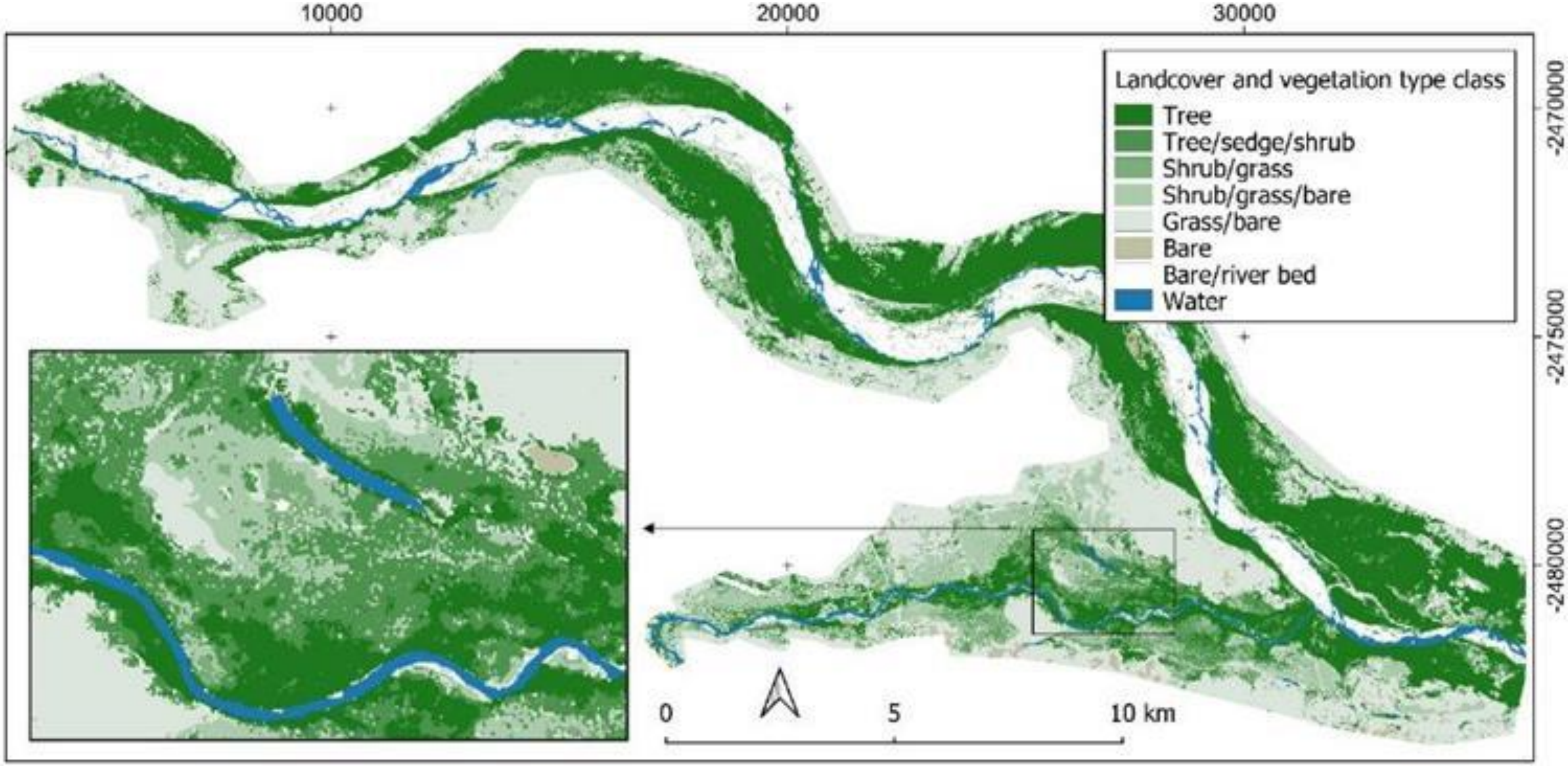
WETLAND EWR: Luvuvhu Floodplain

The same process as used for the Nyl was used to classify and map the vegetation but the models for the Nyl and Luvuvhu River floodplains differ from each other because the two ecosystems are functionally quite different.

<table>
<tr><th>Indicator</th><th colspan="3">Description</th></tr>
<tr><td>Tree</td><td rowspan="7">Vegetation</td><td rowspan="5">Floodplain</td><td>Forest / Woodland</td></tr>
<tr><td>Tree/sedge/shrub</td><td>Mix of trees/shrubs/sedge plants</td></tr>
<tr><td>Shrub/grass</td><td>Scrub thicket</td></tr>
<tr><td>Shrub/grass/bare</td><td>Mix of shrubs/grass plants and bare ground</td></tr>
<tr><td>Grass/bare</td><td>Mix of grass/sedge plants and bare ground</td></tr>
<tr><td>Tree</td><td rowspan="2">Riparian</td><td>Forest/thicket</td></tr>
<tr><td>Bare/riverbed</td><td>Reeds/potential reed habitat</td></tr>
<tr><td>Bare</td><td rowspan="2">Landcover</td><td>Bare</td><td>No plants</td></tr>
<tr><td>Water</td><td>Water</td><td>Aquatic plants, refuge areas</td></tr>
</table>

WETLAND EWR: Luvuvhu Floodplain

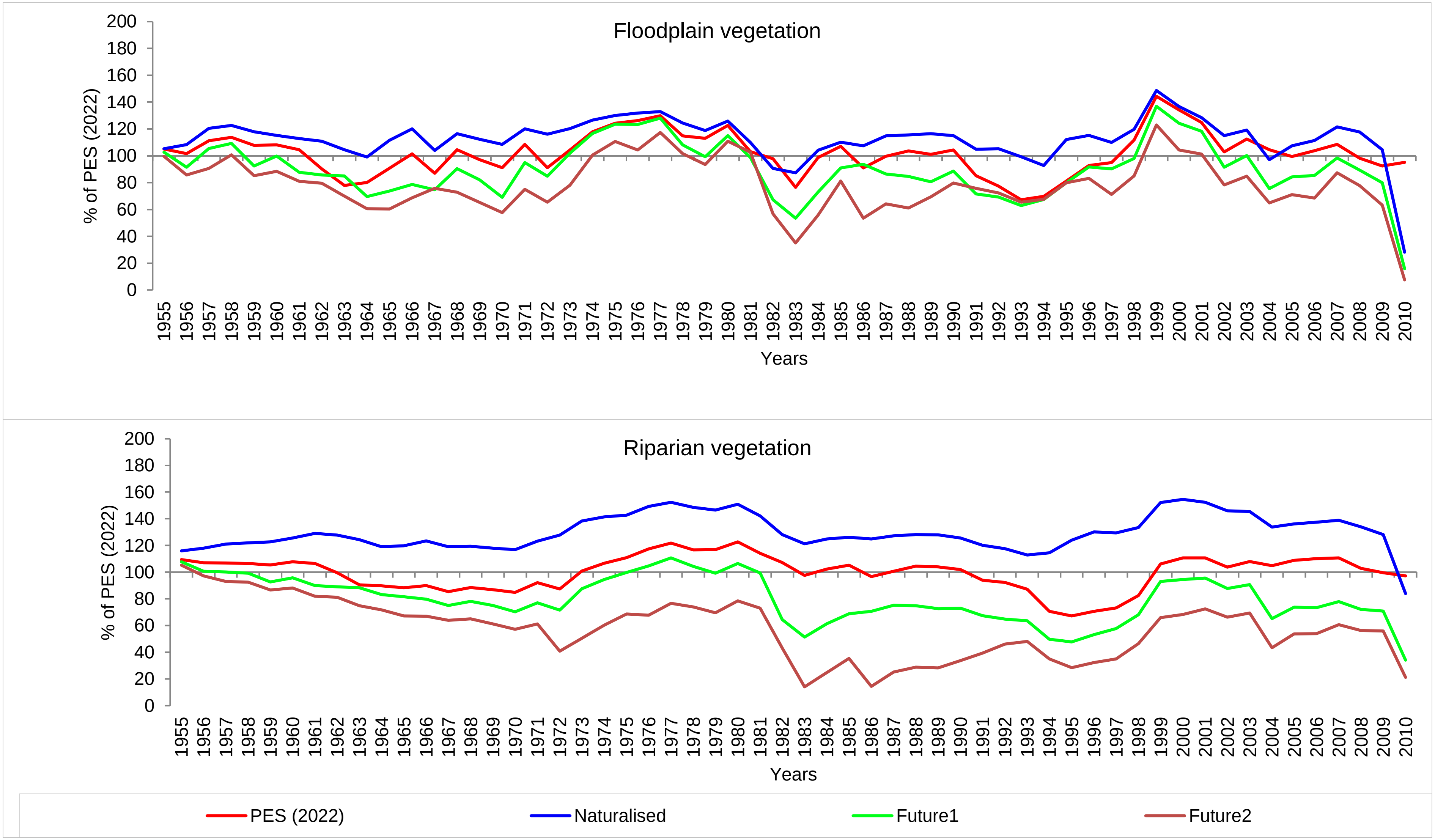
Landcover and vegetation types of the Luvuvhu and Limpopo floodplains



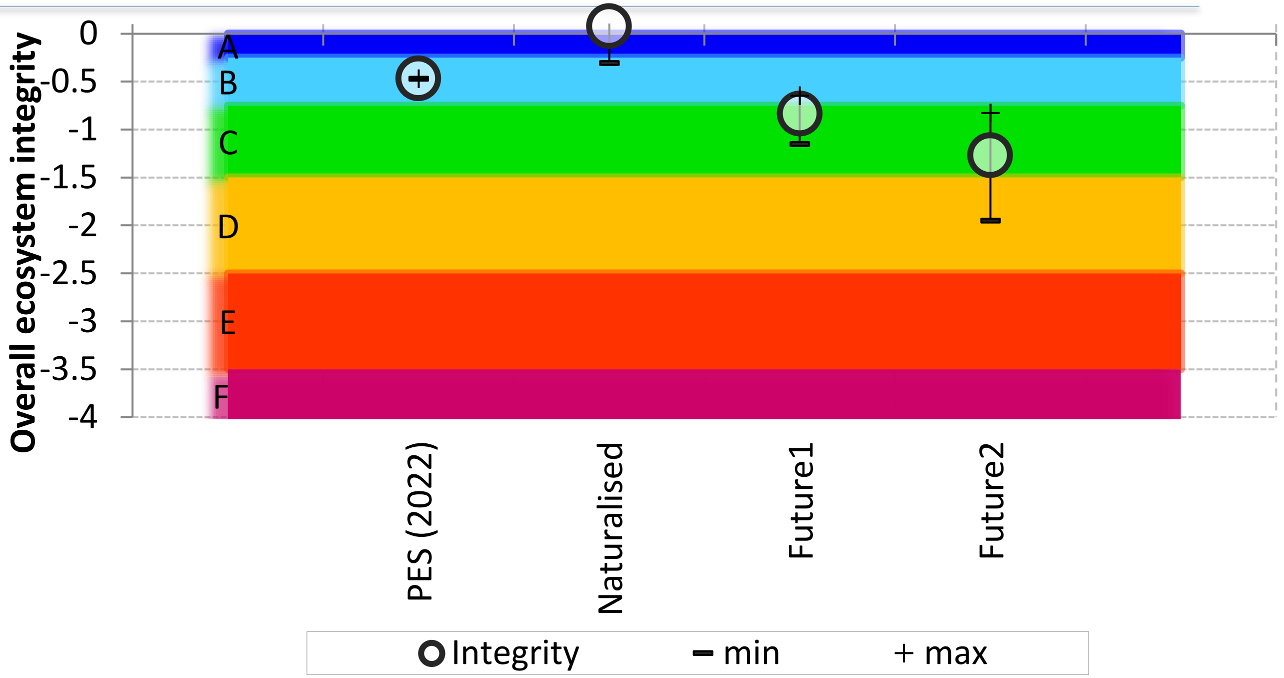
WETLAND EWR: Luvuvhu Floodplain

Indicator	Reason for selection	EWR site					
		18	19	20	21	22	23
Hippo pool	A large pool at the junction of the Luvuvhu and Limpopo rivers that supports hippopotami and crocodiles in the dry season.						X
Riparian vegetation	Riparian plants, e.g., marginal reeds and trees, grow on the riverbanks and are habitat for riparian fauna. They also stabilise banks and attenuate floods.	X					X
Floodplain vegetation	Floodplain forests, floodplain shrubs and floodplain grasslands, all variously associated with the floodplain and pans, and all of which provide habitat and food for wildlife.		X	X	X	X	
White-faced duck	Represents dabbling ducks and teals that occur on the pans feeding on seeds, tubers and invertebrates (insects, crustaceans and worms); e.g., the Yellow-billed Duck and the African Black Duck.		X	X*	X	X	
African fish eagle	Represents carnivorous birds that nest in and hunt from tall riparian trees; it eats fish, rodents and other small animals; this group includes the Pied and Malachite Kingfishers.	X	X	X*	X	X	X
Tolerant fish	Fish that are tolerant to a range of flow and water quality variables and are able to persist when trapped in the pans.	X	X	X*	X	X	X
Crocodile	Crocodiles are aquatic reptiles, an apex predator that mostly feed on fish, but take any prey. They need permanent water and sandy banks for nesting.	X	X	X*	X	X	X
Hippopotamus	Hippos are semi-aquatic mammals that need pools deep enough in which to submerge during the day and floodplain grasslands to graze at night.	X	X	X*	X	X	X

WETLAND EWR: Luvuvhu Floodplain



WETLAND EWR: Luvuvhu Floodplain



	PES	Naturalised	Future1	Future2
Vegetation	B	A	C	D
Fish	B/C	B	B/C	C
Birds	B/C	A	C	C/D
Wildlife	B	A	B/C	C
Overall	B/C	A	C	C/D

WETLAND EWR: Luvuvhu Floodplain

The EWRs are separated into floods and low flows. The floods are derived from the PES (2022) flood requirements that inundate the floodplain and fill the pans. A description of the low flows to maintain perenniality of the Luvuvhu River are derived from the PES (2022) and Future1 flow scenarios, the former for use prior to development and the latter post-development, and an EWR river requirement in the Luvuvhu main channel using DRIFT.

WETLAND EWR: Luvuvhu Floodplain

The Luvuvhu River floodplain floods in three ways:

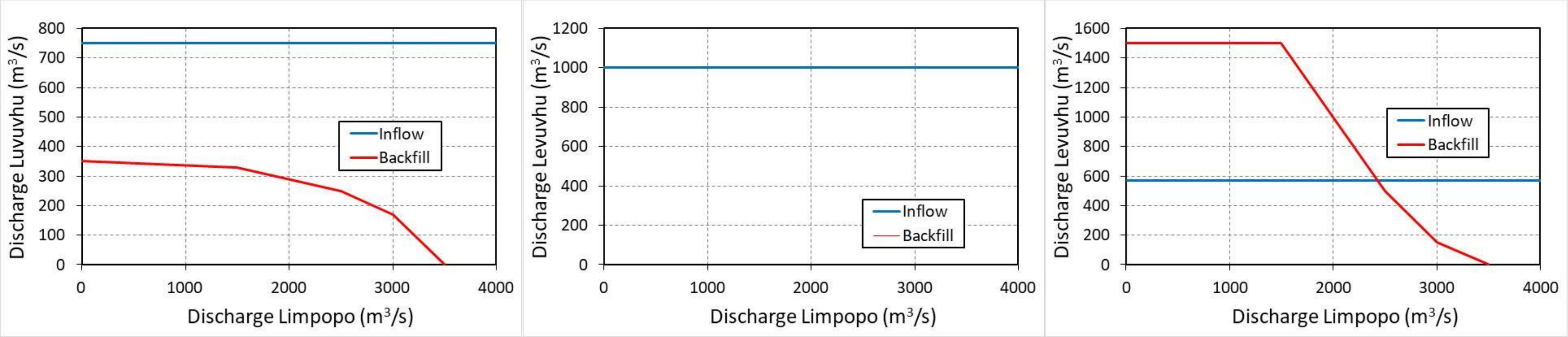
- the Luvuvhu River breaching its banks and depending on the size of the flood may flood one or several of the pans
- back flooding in an upstream direction when the Limpopo River floods and pushes up the Luvuvhu River
- direct input from rainfall and smaller catchment and tributary flows during rain events.

The three of these options may occur in any combination, which adds to the complexity of the flooding characteristics. The PES (2022) return periods for filling the four EWR pan sites are given below).

Pan	Source	Return period
Nwambi/ Mambvumbvanyi	Luvuvhu River breaches levees	7.0
	Limpopo River backs up	4.7
	Both combined	**4.7**
Hapi	Luvuvhu River breaches levees	18.7
	Limpopo River backs up	na
	Both combined	**18.7**
Tlangelani	Luvuvhu River breaches levees	6.2
	Limpopo River backs up	14.0
	Both combined	**5.6**

WETLAND EWR: Luvuvhu Floodplain

The combinations of discharge in the Luvuvhu and Limpopo Rivers that breach the levees and flood the floodplain to fill the Nwambi and Mambvumbvanyi (left), Hapi (centre) and Tlagelani (right) pans.



Flood requirements to maintain PES (2022) conditions of the Luvuvhu River floodplain and pans

Pan	Return period of pan filling	Source of flood	Minimum discharge (m^3/s)
Nwambi and Mambvumbvanyi	1 : ~5 years*	Inflow (Luvuvhu River)	752
		Backfill (Luvuvhu and Limpopo River)	Refer to Figure above for a combination of floods to maintain desired frequency
Hapi	1 : ~20 years*	Inflow (Luvuvhu River)	1 000 – 1 204
		N/A.	N/A.
Tlangelani	1 : 5 years*	Inflow (Luvuvhu River)	575
		Backfill (Luvuvhu and Limpopo River)	Refer to Figure above for a combination of floods to maintain desired frequency

WETLAND EWR: Luvuvhu Floodplain

Low flows in the Luvuvhu River

Perennial low flows in the Luvuvhu River are important to sustain groundwater levels for the floodplain and riparian forests that rely on groundwater* to persist through the dry season. The average depth to groundwater on the floodplain is shallow, ranging from 2.4 – 6.8 m (Ramsar Information Sheet 2007). Maintaining perennial low flows in the Luvuvhu River is also critical to maintain pool depth as habitat for hippopotami, crocodiles and fish, especially in the 'hippo pool' at the confluence of the two rivers.

* Many riparian and floodplain tree species are phreatophytic, meaning they extract water from aquifers or the capillary fringe above the water table.

WETLAND EWR: Luvuvhu Floodplain

Ecological Water Requirements for low flows, small floods (< 1:2 year return period) and larger floods (≥ 1:2 year return period) at 18_Luvuvhu2 upstream site. The larger floods are included in the EWRs because of their importance in maintaining the integrity and connectivity of the floodplain and pan ecosystems.

WETLAND EWR: Luvuvhu Floodplain

nMAR	684.802	MCM			
S.Dev.	59.346				
CV	0.087				
Q75	1.399				
Ecological Category	B/C				
	MCM	% nMAR			
Total EWR	325.505	47.533	Excludes floods with return period ≥1:2 years.		
Maint. Lowflows	257.382	37.585			
Drought Lowflows	164.938	24.085			
Maint. Highflows	68.123	9.948			
Monthly Distributions (MCM)					
	Natural	Modified Flows (EWR)			
		Lowflows		Highflows	Total EWR
Month	Mean	Maint.	Drought	Maint.	Maint.
Oct	16.618	4.515	6.044	0.789	5.304
Nov	26.380	7.941	7.790	3.134	11.076
Dec	51.665	15.830	11.889	15.911	26.298
Jan	106.801	35.912	20.703	47.738	51.233
Feb	173.508	58.163	27.922	91.650	72.761
Mar	138.716	63.627	31.124	51.285	78.426
Apr	64.796	36.422	20.073	8.115	44.217
May	32.384	13.348	11.265	0.865	14.214
Jun	23.561	7.965	8.568	0.109	8.074
Jul	19.651	5.897	7.401	0.099	5.996
Aug	16.205	4.176	6.378	0.017	4.193
Sep	14.517	3.585	5.781	0.129	3.714
Total	684.80	257.38	164.94	219.84	325.50

WETLAND EWR: Luvuvhu Floodplain

Floods. *Flood can occur in the month before or after the month indicated*								
	Within year floods <1:2 years				Inter annual floods >=1:2 years			
Flood Class	Class1	Class2	Class3	Class4	1:2	1:5	1:10	1:20
Ave peak discharge (m^3/s)	11.10	23.40	50.40	88.70	200	593	1029	1660
Ave duration (days)	5	7	9	9	10	15	20	34
Number	3	2	1	1	As per return period			
Oct								
Nov	1							
Dec		1						
Jan			1					
Feb				1	1	1	1	1
Mar	1	1						
Apr	1							
May								
Jun								
Jul								
Aug								
Sep								
Vol ($10^6 m^3$)	8.66	14.49	16.39	28.72	74.55	208.14	420.84	787.78
% PES (2022) MAR	1.81	3.04	3.43	6.02	15.62	43.61	88.19	165.08

THANK YOU