CLASSIFICATION OF SIGNIFICANT WATER RESOURCES INTHE MOKOLO AND MATLABAS CATCHMENTS: LIMPOPO WATER MANAGEMENT AREA (WMA) AND CROCODILE (WEST) AND MARICO WMA
WP 10506

water affairs
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GROUNDWATER RESOURCES:

DOLOMITE AQUIFER SYSTEMS.

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1-. Hydrogeological Background

- Dolomite aquifer systems is a specific aquifer type characterized by its unique nature, hydraulic properties and flow regimes:
  - Nature: It's a carbonate (altered limestone) rock type which gets eroded under acidic conditions, like rainwater with a natural high carbonic acid concentrations.
  - Hydraulic Properties: Subsequently large, well connected subsurface flow systems (cavernous like) developed over time which also enhances the permeability (flow) and storativity (storage) of the aquifer.
  - Flow Regimes: Dolomite aquifer systems have a high recharge ration (between 5 and 10% of Mean Annual Precipitation), but is highly vulnerable to direct pollution due to local land use activities.

1-. Hydrogeological Background

- Dolomite terrain characteristics
  - Soil cover: Very little due to the carbonate nature of the rock chemistry. May weather under wet climate conditions to form thick residue mix of clay-like material called wad and un-dissolved siliceous rock (viz. chert). The latter being present as primary chert lenses in the dolomite formations and enhances the secondary solution process significantly.
  - Water Table Conditions: Under natural conditions, the water table are shallow (<20m). Water quality is excellent, but may be classified as hard due to its hydrochemical nature (CaMg-HCO_3).
  - Ground Stability Concerns: Due to the cavernous subsurface characteristics, large water filled caves are present which may collapse and form large sinkholes when the water table drops due to over-abstraction.

1-. Hydrogeological Background

- Dolomite aquifer systems occurs as dolomitic compartments due to the intrusion of secondary dyke systems:
  - Flow/Boundary Systems: Compartments may overflow from one to another along the topographic gradient and may discharge as dolomite springs (or eye's) at the downstream boundary. Dolomite springs like the Pretoria Fountains, Maloney's Eye, Molopo Eye are examples of high-flow dolomite springs;
  - Groundwater Resource Units (GRU's): A groundwater body, which represents a hydrogeological homogenous zone, that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit. A single dolomite compartment is typical a GRU; and
  - Groundwater Management Units (GMU's) : Several dolomite compartments (or GRU's) may be grouped together as Groundwater Management Units, based on surface water drainages and hydrogeological considerations.

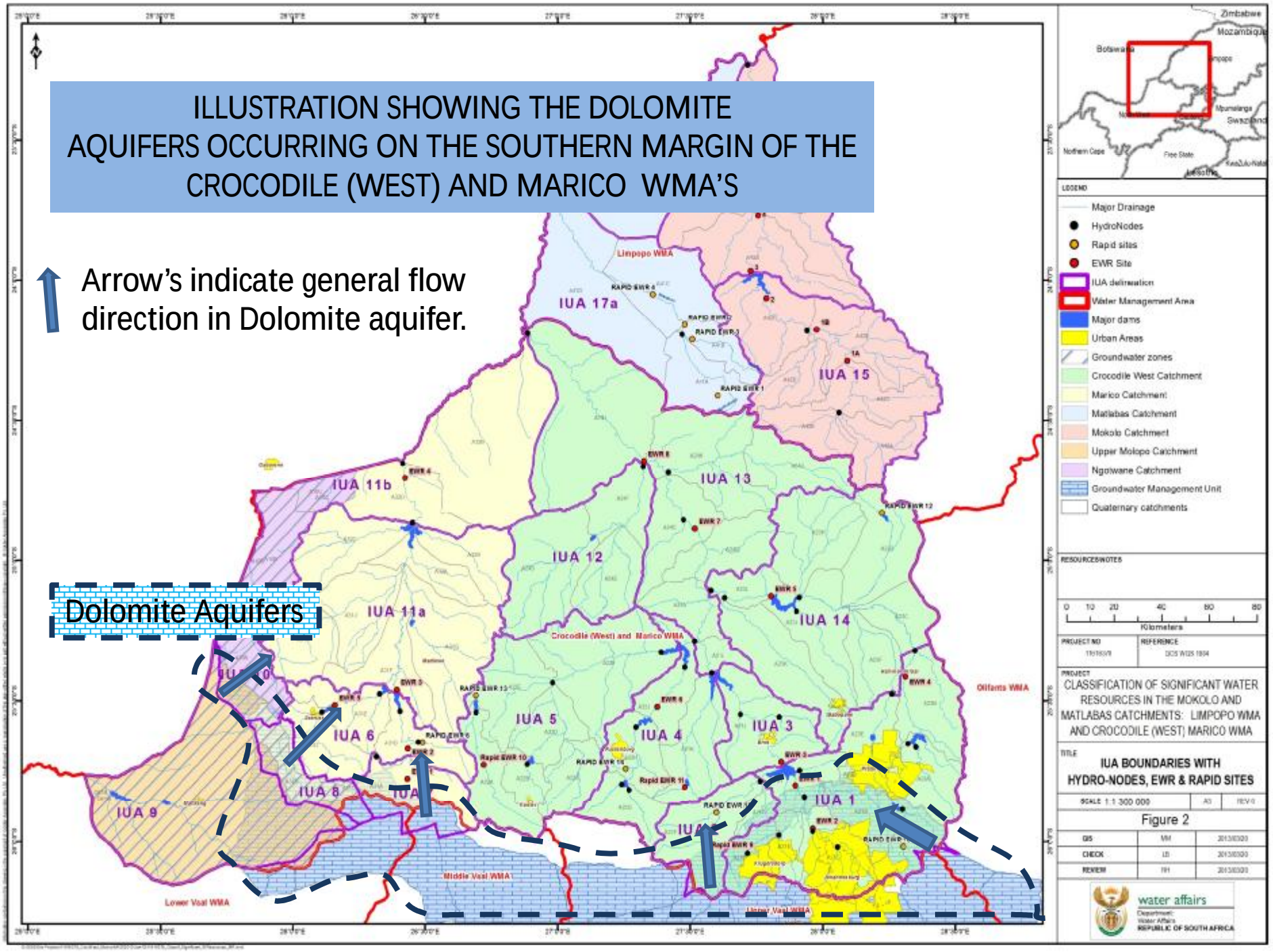
ILLUSTRATION SHOWING THE DOLOMITE AQUIFERS OCCURRING ON THE SOUTHERN MARGIN OF THE CROCODILE (WEST) AND MARICO WMA'S
Arrow's indicate general flow direction in Dolomite aquifer.
Dolomite Aquifers
IUA 17a
IUA 15
IUA 13
IUA 11b
IUA 12
IUA 11a
IUA 14
IUA 5
IUA 4
IUA 3
IUA 6
IUA 8
IUA 9
IUA 1
Limpopo WMA
Crocodile (West) and Marico WMA
Olifants WMA
Middle Vaal WMA
Lower Vaal WMA
Upper Vaal WMA
Major Drainage
HydroNodes
Rapid sites
EWR Site
IUA delineation
Water Management Area
Major dams
Urban Areas
Groundwater zones
Crocodile West Catchment
Marico Catchment
Matlabas Catchment
Mokolo Catchment
Upper Molopo Catchment
Ngotwane Catchment
Groundwater Management Unit
Quaternary catchments
CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE MOKOLO AND MATLABAS CATCHMENTS: LIMPOPO WMA AND CROCODILE (WEST) MARICO WMA
IUA BOUNDARIES WITH HYDRO-NODES, EWR & RAPID SITES
Figure 2
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2. Integrated Units of Analysis (IUAs)

IUAs are the spatial units that are defined as significant water resources. The objective of defining IUAs is to establish broad scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on the ecological conditions at a sub-catchment scale (DWA, 2007a).

Delineation of IUAs was based on:

- Socio-economic zones (SEZs);
- Catchment area boundaries (drainage regions and water resource systems);
- Similar land use characteristics/land based activities;
- Eco-regions and geomorphology;
- Ecological information;
- Present Ecological State (PES); and
- Stakeholder input.

19 IUAs were delineated within the study area!!!!!!

2-. Integrated Units of Analysis (IUAs)

- Delineation of GMA's and IUA's.
  - Groundwater Management Area's (GMA's): GMA's boundaries generally coincide with surface catchments (e.g. quaternary catchments) or dolomite compartment boundaries formed by impermeable dykes. A GMA generally includes more than one GMU grouped together;
  - Integrated Units of Analysis (IUA's): IUAs are the spatial units that are defined as significant water resources. The objective of defining IUAs is to establish broad scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on the ecological conditions at a sub-catchment scale (DWA, 2007a).
  - Where?: Occurs on the southern boundary of the WMA, from Bapsfontein (East) to Dinokana (West);

2-. Integrated Units of Analysis (IUAs)

- Adjusted IUA's in relation to the Quaternary Catchments.
  - Adjusted Quaternary Catchment (QC's) Boundaries: After detailed assessment of the Groundwater Aquifer Units (viz. individual dolomite compartments), it was necessary to address the boundaries of the IUA's accordingly;
  - Which Ones?:
    - **A21A**: (Rietvlei Catchment – east of Pretoria) – Only limited changes;
    - **A21F**: (Head waters of the Maloney's Eye, Tarlton Area) - To include part of the Holfontein GRU with the Steenkoppies GRU;
    - **A31A**: (Expand the Marico/Holpan Dolomite Area) – Some GRU from the Middle and Lower Vaal has been included in the Marico WMA;
    - **A31C**: (Expand the Zeerust Dolomitic Area) – Include a portion of the Lower Vaal WMA based on characteristics of dolomite GRU's;
    - **D41A**: (Head waters of the dolomite GRU in the head waters region) – minor changes to the Upper Molopo and Lower Vaal WMA's); and

2-. Integrated Units of Analysis (IUAs)

- Adjusted IUA's in relation to the Quaternary Catchments.
  - Which Ones cont.:
    - **A10A**: (Dinokana Spring head waters GRU) – Due to the GRU's hydrogeological setting, it's contribution to the QC has been confirmed by mapping.

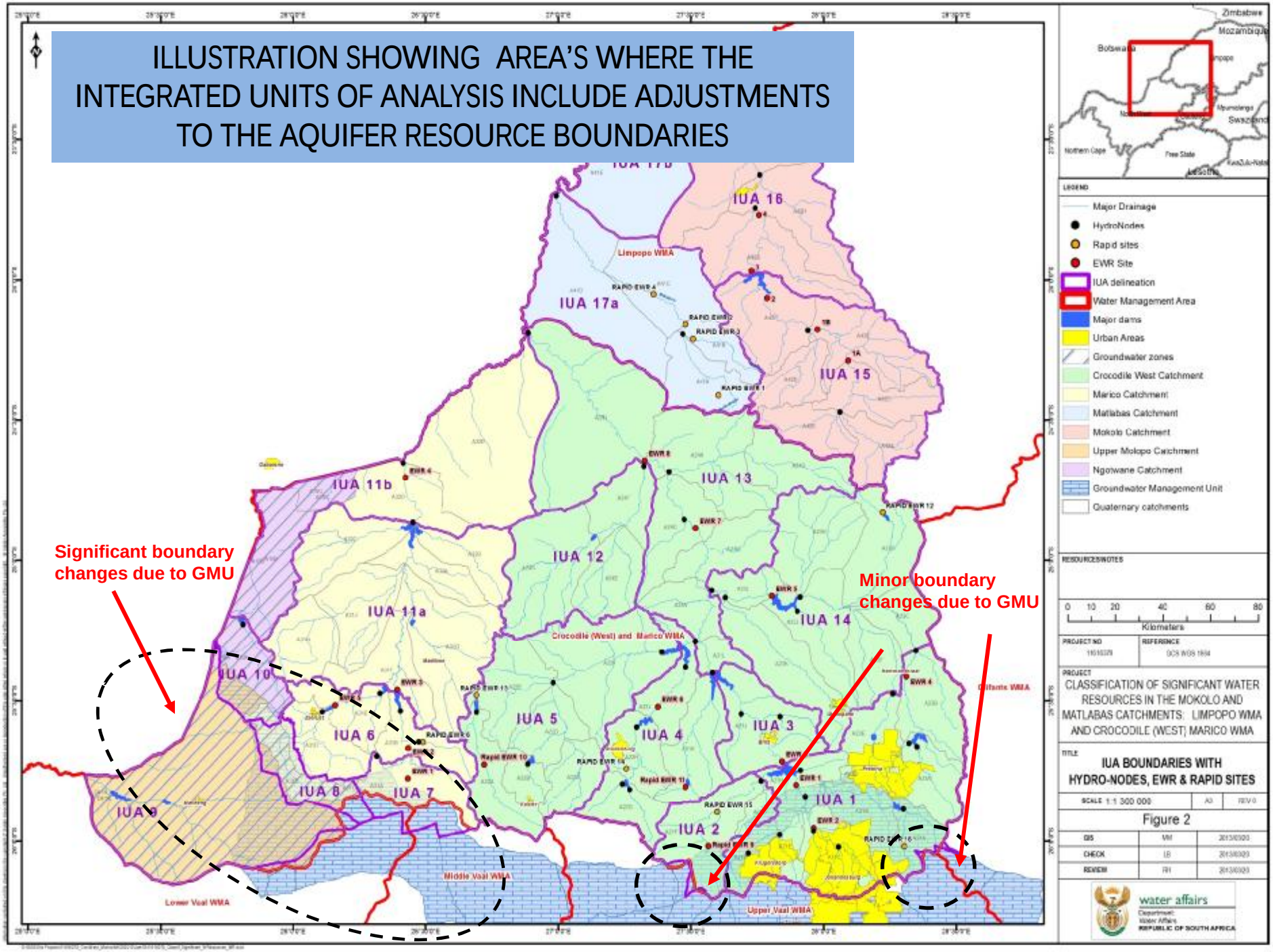
ILLUSTRATION SHOWING AREA'S WHERE THE INTEGRATED UNITS OF ANALYSIS INCLUDE ADJUSTMENTS TO THE AQUIFER RESOURCE BOUNDARIES
Significant boundary changes due to GMU
Minor boundary changes due to GMU
IUA 16
IUA 17a
IUA 15
IUA 13
IUA 11b
IUA 12
IUA 11a
IUA 14
IUA 10
IUA 5
IUA 4
IUA 3
IUA 6
IUA 8
IUA 7
IUA 9
IUA 1
IUA 2
Limpopo WMA
Crocodile (West) and Marico WMA
Olifants WMA
Middle Vaal WMA
Lower Vaal WMA
Upper Vaal WMA
Major Drainage
HydroNodes
Rapid sites
EWR Site
IUA delineation
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Mokolo Catchment
Upper Molopo Catchment
Ngotwane Catchment
Groundwater Management Unit
Quaternary catchments
Kilometers
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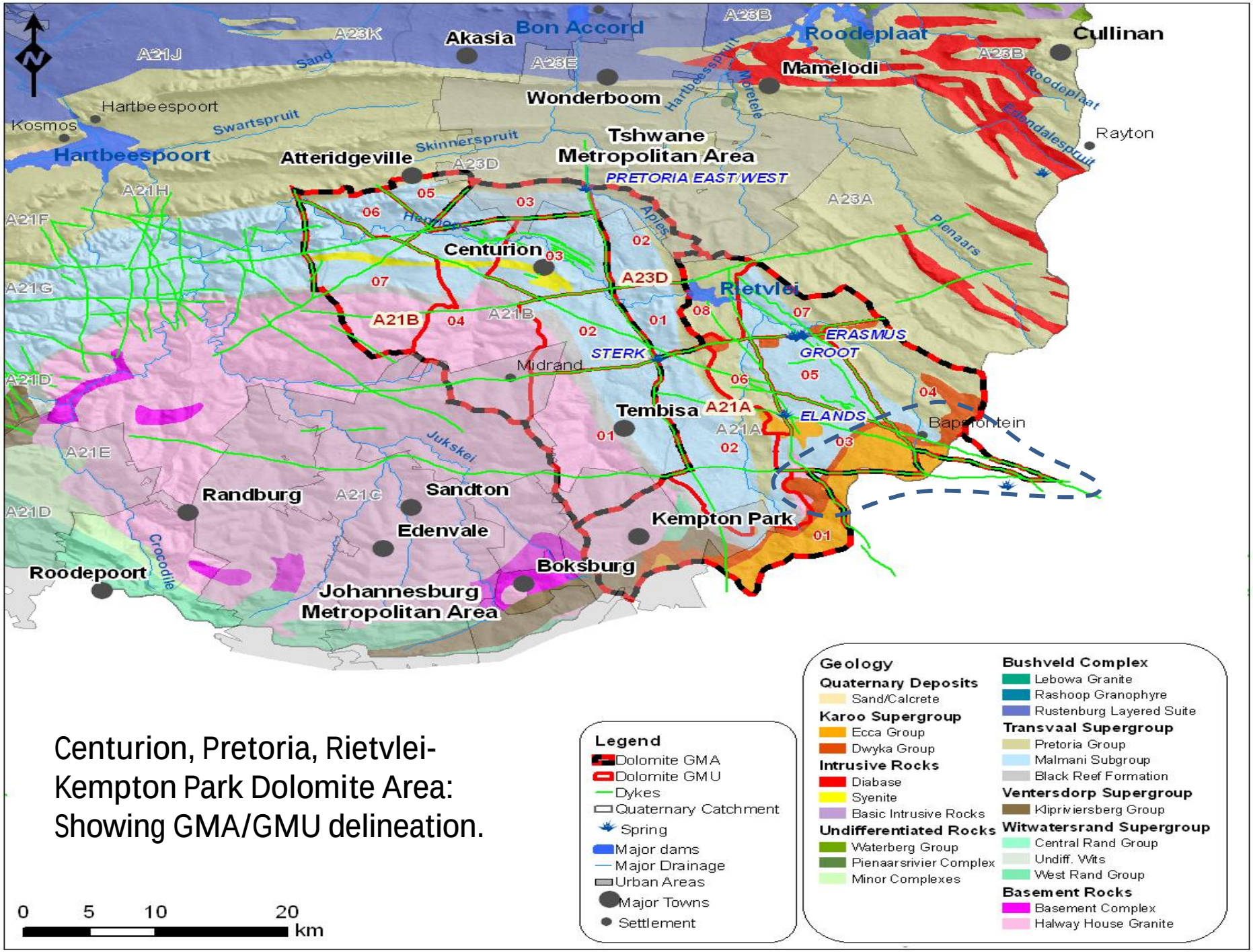
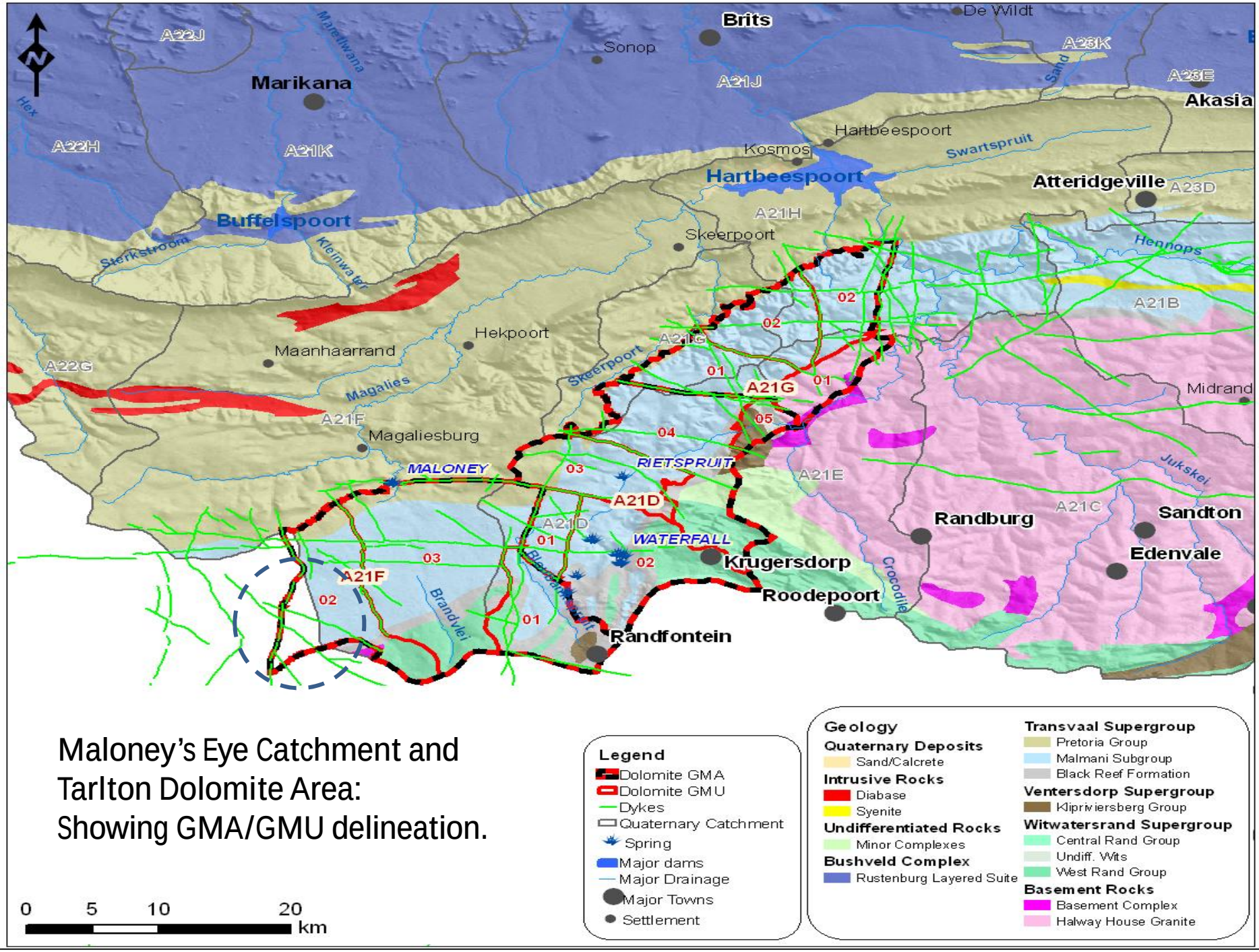
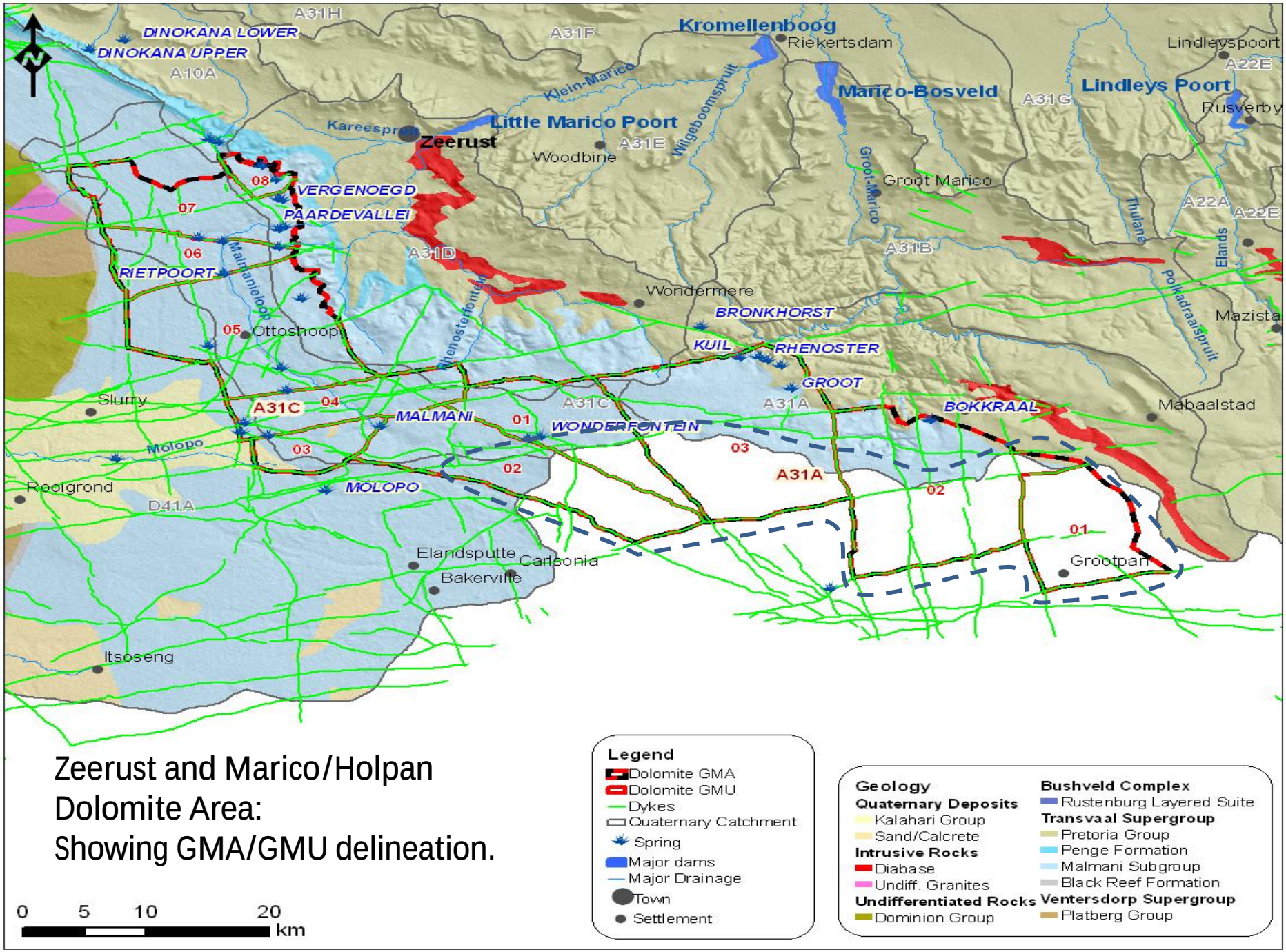


Centurion, Pretoria, Rietvlei-Kempton Park Dolomite Area: Showing GMA/GMU delineation.



Maloney's Eye Catchment and Tarlton Dolomite Area: Showing GMA/GMU delineation.



Zeerust and Marico/Holpan Dolomite Area:
Showing GMA/GMU delineation.

METHODOLOGY APPLIED FOR CLASSIFICATION OF GROUNDWATER RESOURCES.

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3. Significant Groundwater Resources

- **Aquifer Types** Classification (Hydrogeology: Mapping Gwater Resources)

ü Karst/dolomite aquifers
ü Fractured Karoo and Waterberg Group aquifers
ü Intergranular Alluvial aquifers
ü Intergranular and fractured aquifers (near confluence of Limpopo River)

- **Borehole Yield Class** and **Aquifer Rating** (Hydrogeology: Assessment)

Borehole Yield Class (l/s)	Aquifer Rating
0.0 to 0.5 l/s	Insignificant
>0.5 to 2.0 l/s	Minor
>2.0 to 5.0 l/s	Moderate
>5.0 l/s	Significant

- Delineation of **Major Dolomite Resources** (Hydrogeology: Assessment)

ü Centurion, Pretoria, Rietvlei-Kempton Park
ü Maloney's Eye catchment and Tarlton
ü Zeerust and Marico/Holpan

3-. Registered Groundwater Use

The main water user sectors of groundwater in the catchments are:

- Commercial irrigation farming in all three catchments;
- Urban water use in the main towns of Mafikeng, Zeerust, Groot Marico, Itsoseng, Pretoria and Centurion; and
- Rural domestic water use.
- Both the Mokolo and Matlabas catchments are part of the Limpopo WMA, which is a semi-arid region, with economic activity centred on livestock farming, irrigation and future mining developments.

- WARMS data was reviewed and compared 2008 and 2013 users to determine the stress index.
- There are issues with under and over registration in WARMS data and DWA is still correcting this

4.0 Groundwater Resource Classification Criteria

The classification used is based on quantity and quality of groundwater as follows:

- Quantity - Stress Index

Present category	Description	Compliance (spatial/Temporal)
I	Minimally used	≤20%
II	Moderately used	20% - 65%
III	Heavily used	>65%

- Quality - Hydrochemistry (SAWQG Vol.1 – Domestic Use)

Present category	Description	Compliance (spatial/temporal)
I	DWA Class 0 or 1 natural background	95%
II	DWA Class 2 (95% compliance) or natural background (75% compliance)	75%
III	DWA class 3 or 4 or natural background (<75% compliance)	<75%

5. Groundwater Resource Classification Determination

To determine the groundwater management classes the following data was used:

- Groundwater recharge per catchment and sub-catchment (data from GRAII, recharge maps, specialist studies);
- Groundwater quality from DWA monitoring database, GRAII and specialist reports; and
- Groundwater Use – WARMS data (as in January 2013).

6. Classification and Management Class
Mokolo Catchment

IUA Catchment	QC	Area (Km^2)	Recharge Mm^3	Groundwater Use Mm^3/a	Stress Index (SI)	Present Category (SI)	Present Category (Impact)	Present Category (Quality)
IUA15 Upper Mokolo	A42A	1095	33.96	9.02	27%	II	I	II
	A42B-F	3224	99.33	19.20	19%	I	I	II
IUA16 Lower Mokolo	A42G	1207	26.40	0.13	1%	I	I	[1]III
	A42H-J	2869	30.95	2.21	7%	I	II	[1]III

[1]III Poor groundwater quality status due to natural (mostly geological) conditions. Resource is minimally used (<20%) due to the poor groundwater quality.

6-. Classification and Management Class
Matlabas Catchment

IUA (Catchment)	QC's	Area (Km^2)	Recharge Mm^3	[1]Groundwater Use Mm^3/a	Stress Index (SI)	Present Category (SI)	Present Category (Impact)	Present Category (Quality)
IUA 17a Upper Matlabas	A41A A41B	1050	25.53	0.315	5%	I	I	-
IUA 17a Lower Matlabas	A41C A41D	3024	29.95	1.64	10%	I	I	[1]III
IUA 17a		4074	55.48	1.95	4%	I	I	II
IUA17b Steenbokpan	A41E	1940	12.41	1.79	14%	I	I	II
[1]WARMS 2013								

[1]III Poor groundwater quality status due to natural (mostly geological) conditions. Resource is minimally used (<20%) due to the poor groundwater quality.

6-. Classification and Management Class
Crocodile West Catchment

IUA	Area (Km^2)	Recharge Mm^3	[1]Groundwater Use Mm^3/a	Stress Index (SI)	Present Category (SI)	Present Category (Impact)	Present Category (Quality)
IUA 1	5823	218.93	73.300	34%	II	II	I
IUA 2	1472	79.267	39.197	49%	II	II	I
IUA 3	1150	29.893	13.700	46%	II	II	I
IUA 4	2534	65.398	22.772	35%	II	II	I
IUA 5	4546	117.239	15.174	13%	I	II	I
IUA 12	2606	43.222	6.007	14%	I	I	[1]II
IUA 13	6805	146.281	59.866	41%	II	II	II
IUA 14	4964	76.000	18.112	24%	II	II	II

[1]III Marginal groundwater quality status due to natural (mostly geological) conditions. Resource is minimally used (<20%) due to moderate groundwater quality.

6-. Classification and Management Class
Marico Catchment

- Springs were considered as groundwater sources

IUA	QC's	Area (Km^2)	Recharge Mm^3	Groundwater Use Mm^3/a	Stress Index (SI)	Present Category (SI)	Present Category (Impact)	Present Category (Quality)
IUA 6		1901	54.17	6.857	12.7%	I	I	I
IUA 7		1162	55.165	2.986	5.4%	I	I	I
IUA 8		485	15.045	3.089	21%	I	II	I
IUA 10		558	19.945	0.672	3.4%	I	II	-
IUA 11a		5670	117.795	5.774	5%	I	I	[1]II
IUA 11b		4626	52.768	0.533	1%	I	I	II

[1]II Marginal groundwater quality status due to natural (mostly geological) conditions. Resource is minimally used (<20%) due to moderate groundwater quality.

6-. Classification and Management Class
Eastern Kalahari Catchment

IUA	QC's	Area (Km^2)	Recharge Mm^3	Groundwater Use Mm^3/a	Stress Index (SI)	Present Category (SI)	Present Category (Impact)	Present Category (Quality)
IUA 9- D41A (Dolomite Aqf.)	D41A	973	50.79	53.47	105%	III	III	I
IUA 9- D41A (Other Aqf.)	D41A	2987	23.75	0.29	1.2%	I	I	II
IUA 9		3960	74.54	53.76	72%	III	III	II

5. Conclusion: Groundwater Classification

- Delineation of groundwater resources were part of the initial Integrated Units of Analysis (IUA's), special cases however exists which required additional refinement;
- Dolomite aquifer systems required special assessment due to their compartmentalized nature and flow patterns; thus IUA boundaries were adopted to include compartments forming one unique flow system;
- Groundwater contribution to surface water systems is required to sustain Ecological Water Requirements in several cases:
  - Dolomite springs supporting downstream reserve requirements;
  - Flow links between different upstream dolomite compartments to sustain bulk flow at discharge area (normally a spring); and
  - Aquifer systems supporting the baseflow component of river systems.
- Several IUA's contains groundwater resources with moderate to poor water quality which relates to certain geological conditions (viz. saline shales or tillites); the water use in these cases are low indicating moderately to minimally used groundwater resources.