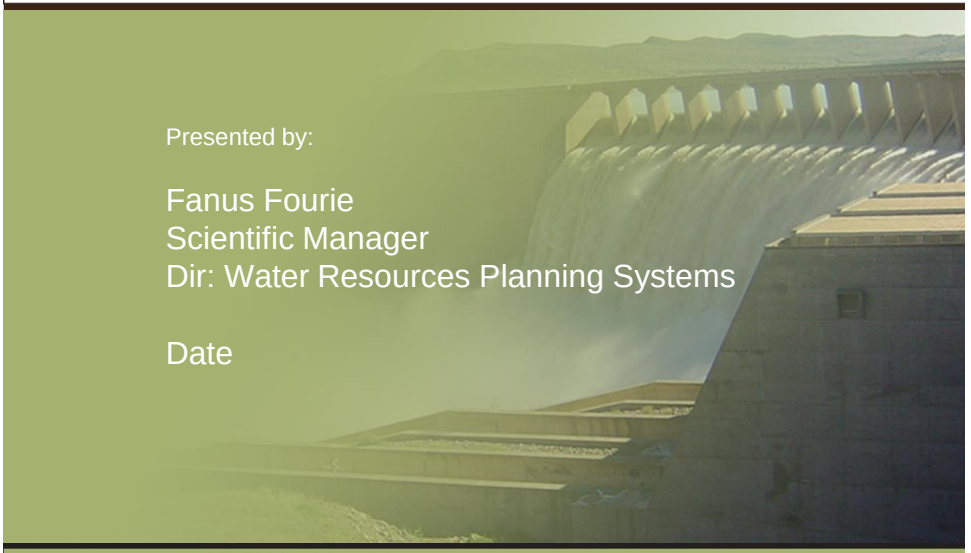
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP



Presented by:

Fanus Fourie
Scientific Manager
Dir: Water Resources Planning Systems

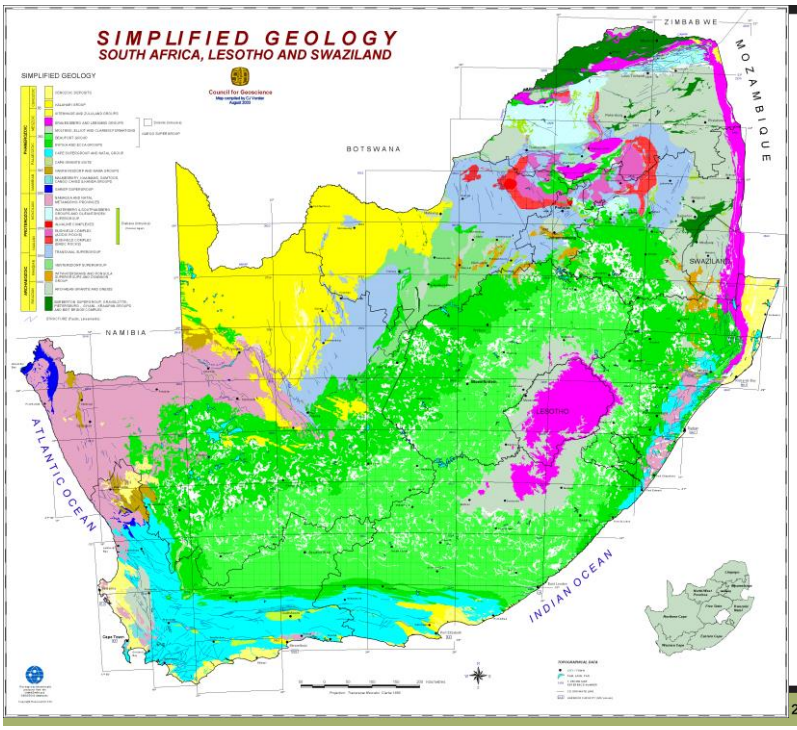
Date

WATER IS LIFE, SANITATION IS DIGNITY

Content

- Overview of Groundwater
- Groundwater Availability
- Groundwater Quality
- Definitions
- Concepts
- Planning Assistance (Guidelines, Tools, Maps)
- Assessment process
- Artificial Recharge

Overview of Groundwater



Aquifers Types

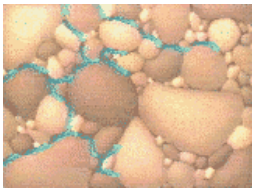
- Primary / Alluvial Aquifer (Intergranular)
- Secondary / Fracture Aquifer:
- Weather and Fractured Aquifer
- Dolomitic / Karst Aquifer

Primary / Alluvium Aquifer

- **Groundwater occurs in pore spaces that developed during deposition (alluvial)**

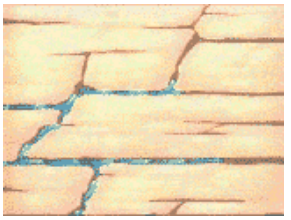
- Along rivers channels
- Coastline (dunes)
- Old Paleo Channels
- Inland sands

Eg.
- North of Richards Bay
- Kalahari
- Crocodile River
- Coastal areas



Secondary / Fracture Aquifer

- **Results from**
  solid rock that cracked upon deposition
- Most aquifers in RSA (80%+) are fracture aquifers,
- Karoo
- Crystalline

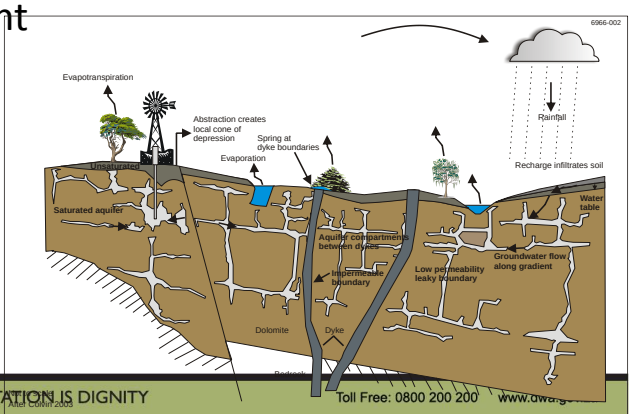


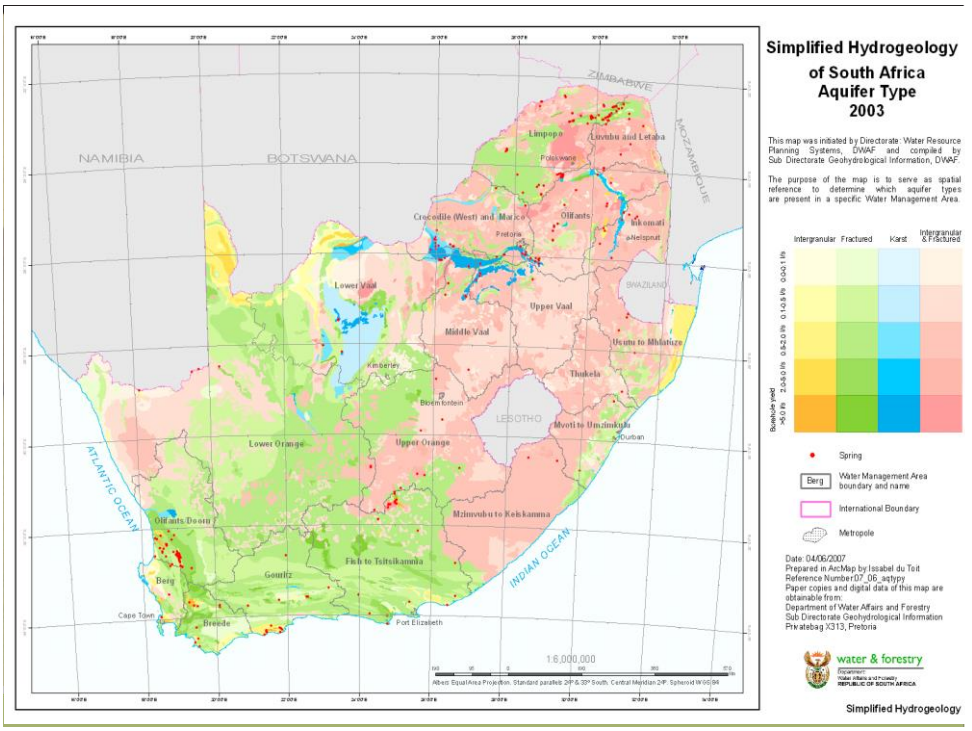
Dolomitic / Karst Aquifer

- Dissolution of carbonate rocks
- Lots of water
- Fast movement
- Sinkholes

Eg:

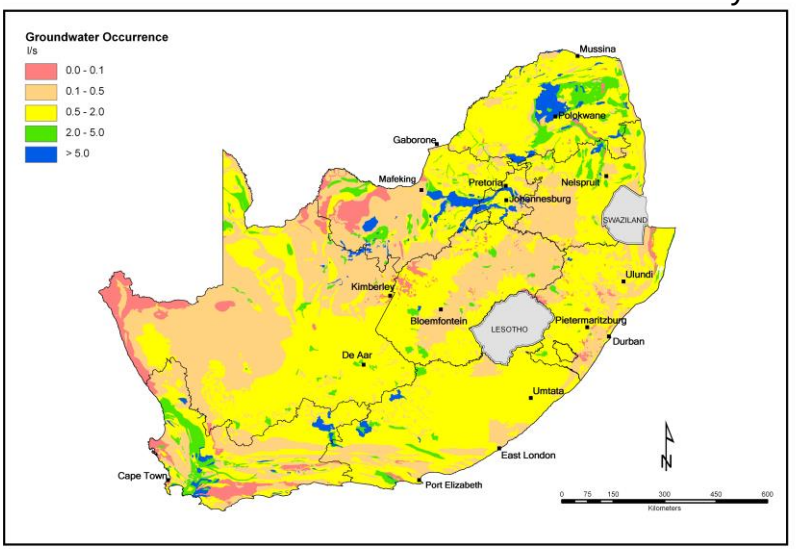
- Ghaap
- NW





Maps in the GRA I

Groundwater Occurrence – Borehole yield



Maps in the GRA II

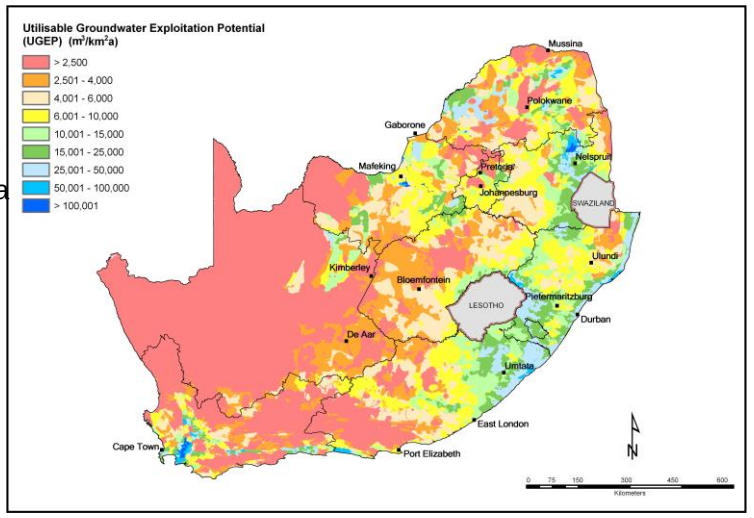
Utilisable Groundwater Exploitation Potential Aquifer Yield

2 500 $m^3/km^2/a$

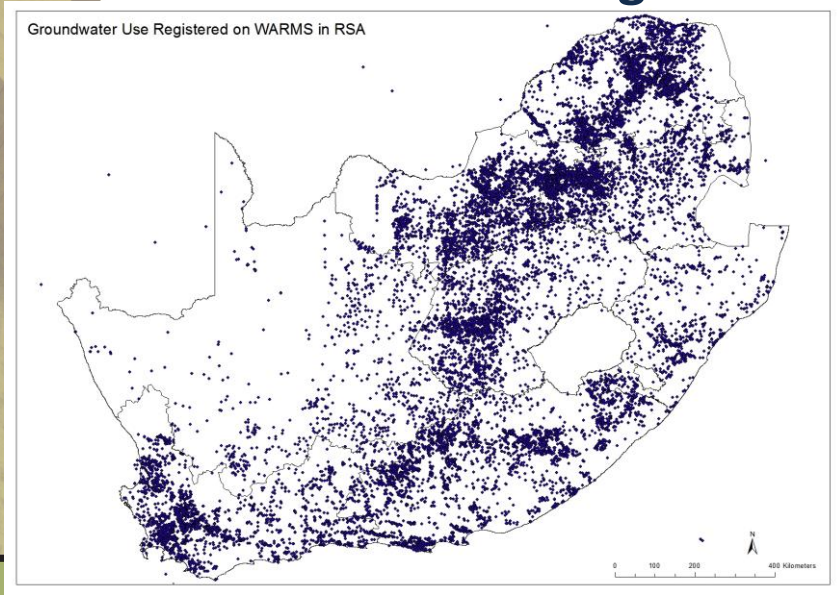
= 6.8 ℓ/ha/d

10 000 $m^3/km^2/a$

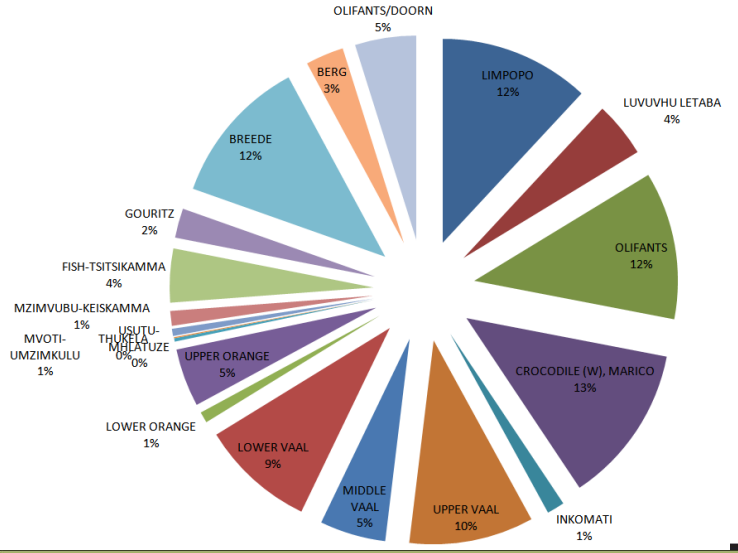
= 0.31 ℓ/s/km^2



Groundwater Use - Registered

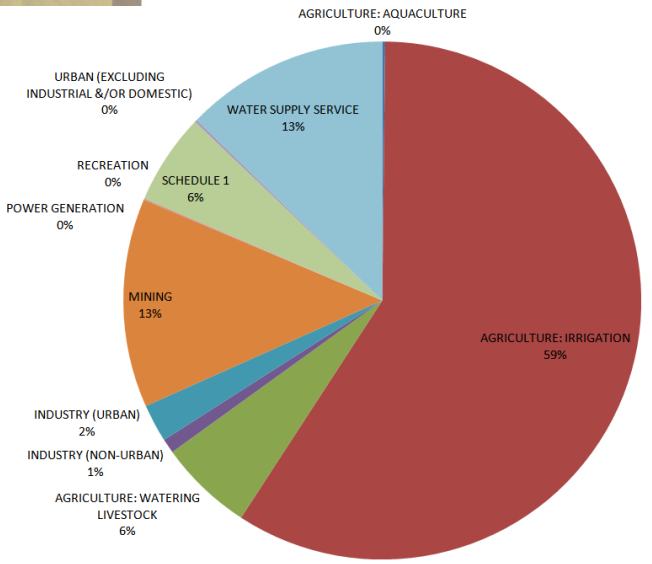


Status of Groundwater Use - WMA



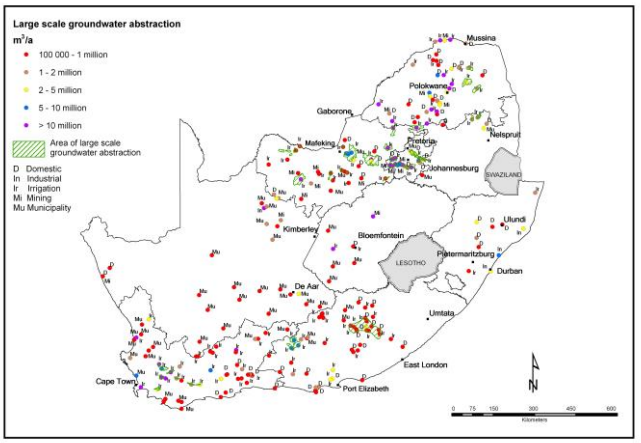
Registered volumes Groundwater Use per WMA in RSA

Status of Groundwater Use - Sector



Water Use per Sector in RSA

Groundwater Use - Large users



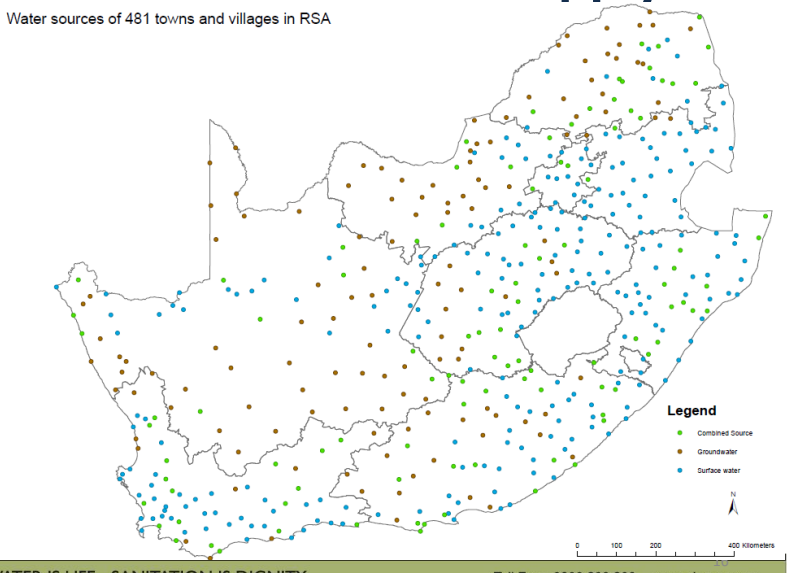
Pretoria

- Fountains 1905
- 60 ML/day or 14,9 Million m^3/a

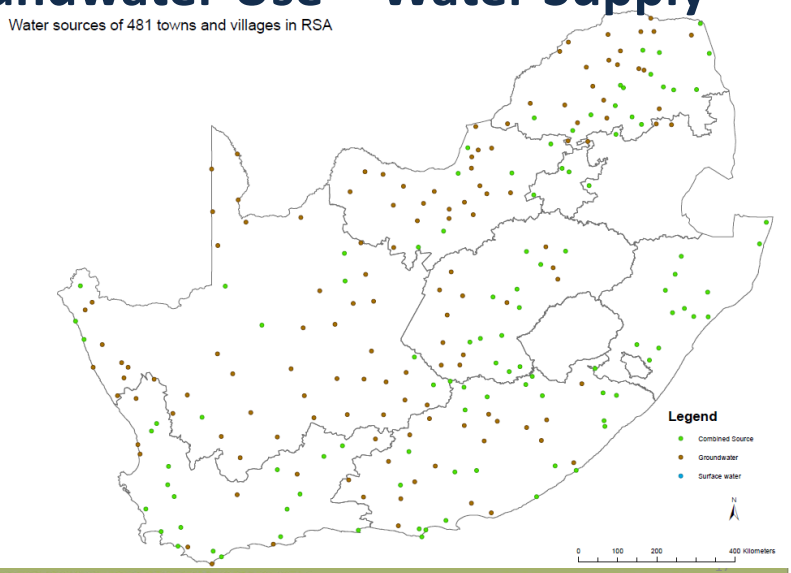
Johannesburg

- 11 ML/day

Groundwater Use – Water Supply



Groundwater Use – Water Supply



Groundwater Use

Number of Towns and Villages (Sources water) – 23 297

	Urban	Rural	Total
Groundwater	22%	59%	53%
Combined	34%	34%	34%
Surface water	44%	7%	13%

Groundwater Use

2000 – NWRS1 – 1 088 million m^3
2004 – WR2005 – 1 771 million m^3
2013 – WARMS – 2 123 million m^3
2015 – WARMS – 2 723 million m^3

Can be 3 500 million m^3

Groundwater Use

Groundwater 2013 – WARMS – 2 123 million m^3
Total water 2013 – WARMS – 16 965 million m^3
= 12.5%

Total use ~ 14 700 million m^3
= 16.1%

If Groundwater use is 3 000 million m^3
= 20%

Available Groundwater

Available Groundwater - million m^3

- Average Groundwater Resource Potential – 47 727
- Average Groundwater Exploitation Potential – 19 073
- Potable Groundwater Exploitation Potential – 14 802
- Utilisable Groundwater Exploitation Potential –

Normal – 10 345 Dry – 7 530

Groundwater Quality

Groundwater Quality

Question?

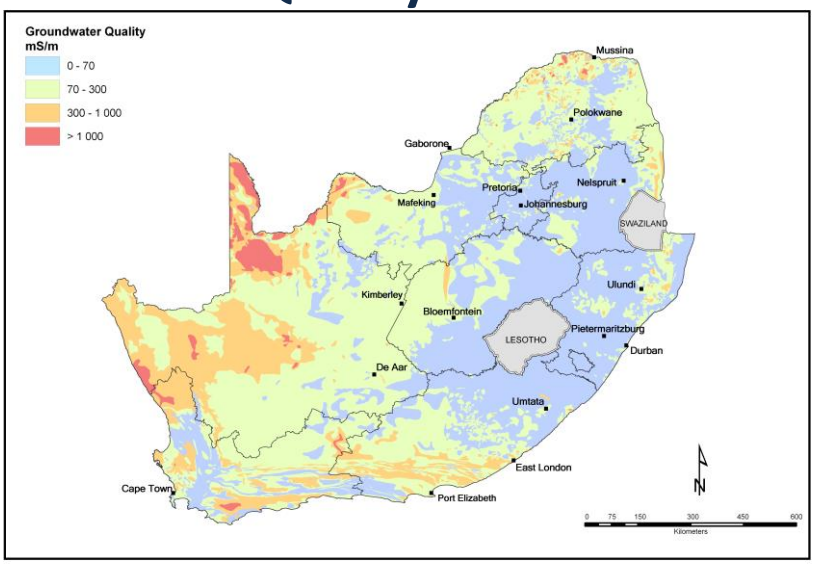
Why is groundwater handled different than surface water?

Are we drink surface water without purifying to drinking water standards ?

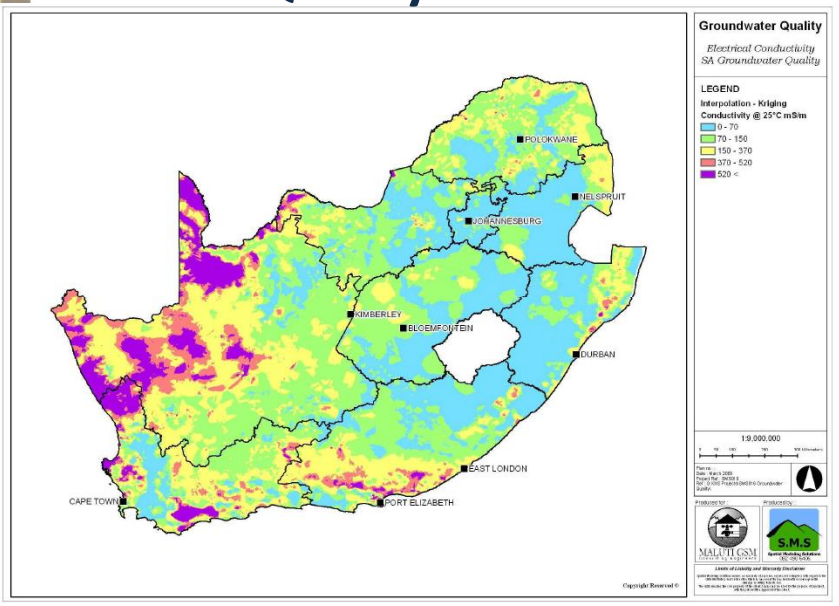
But the quality of groundwater must be at drinking water standard otherwise it is unusable?

Groundwater Quality 1943

Groundwater Quality - GRA I



Groundwater Quality – WRC 2011



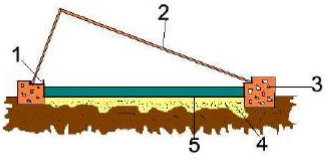
Groundwater Quality - Desalination

High cost?

High technology driven ?

Solar Stills
= 3.5 liter/m^2/day
= Low maintenance

Solar electricity-operated reverse osmosis plant
= 15m^3/day

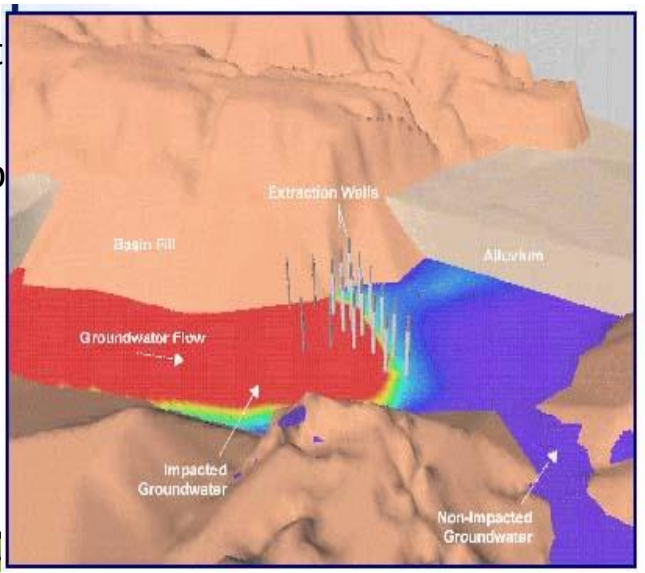


Legend:

1 – lip channel
2 – glass / perspex cover
3 – containment
4 – foundation
5 – feed water reservoir

Remediation Methods

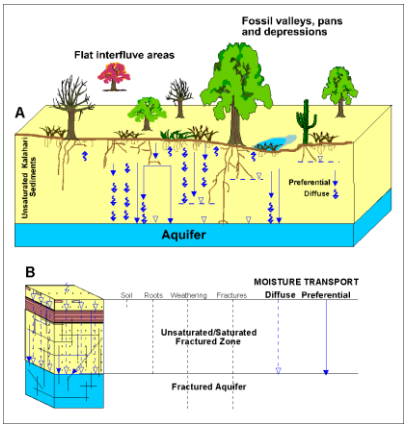
- Containment
- Withdrawal
- In-situ Rehab



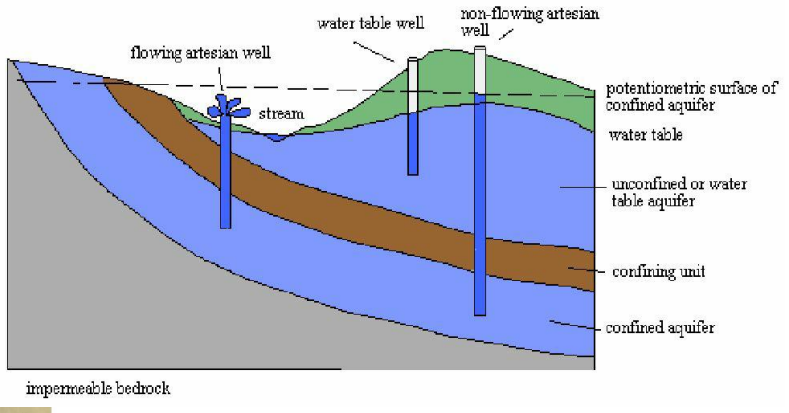
Definitions / Concepts

GEOHYDROLOGICAL TERMS

- Water that infiltrate and replenish gw is *recharge*
- Saturated portion in the subsurface is groundwater whose upper limit is defined by the *water table*.
- Groundwater moves very slowly

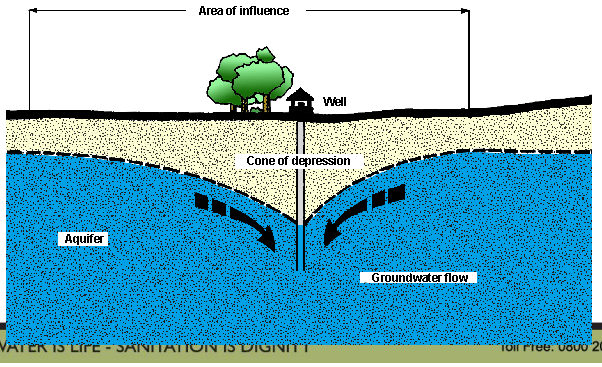


GEOHYDROLOGICAL TERMS (2)



GEOHYDROLOGICAL TERMS (3)

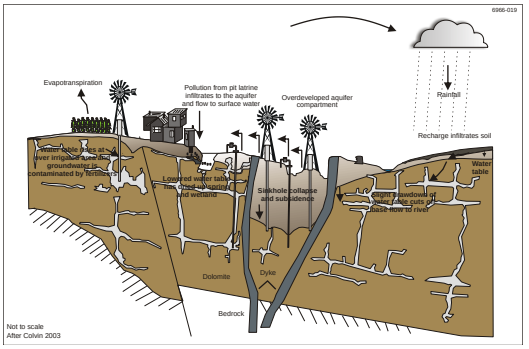
- Cone of depression: is an area around a pumping borehole where water level is significantly lowered due to pumping



GEOHYDROLOGICAL TERMS (4)

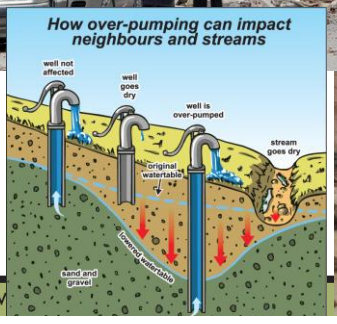
- Sustainable yield: **safe amount of water that can be abstracted without causing damage to the system**
- Transmissivity: **ability of the aquifer to transmit water**
- Storativity: **aquifer's ability to release water**
- Aquifer: **a saturated and permeable underground geological unit that can transmit or produce water of significant quantities**

Effect of over-exploitation



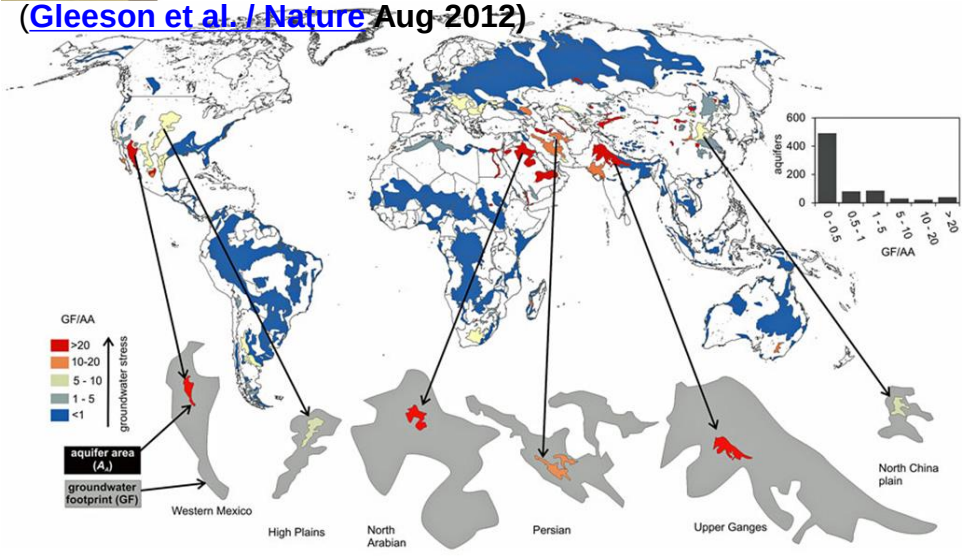
Over Abstraction

Lorca earthquake 'caused by groundwater extraction'



Over abstraction - Groundwater Footprint

(Gleeson et al. / Nature Aug 2012)



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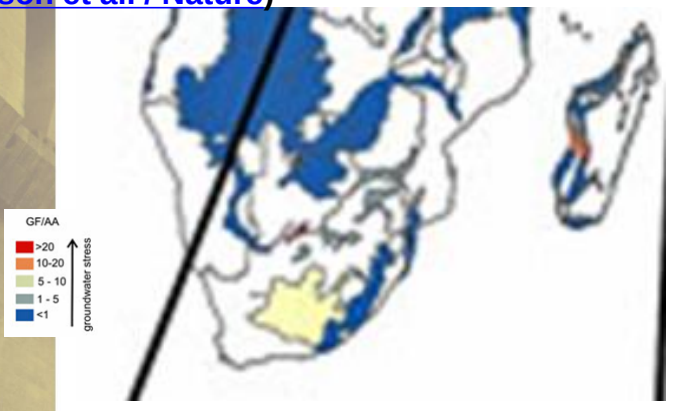
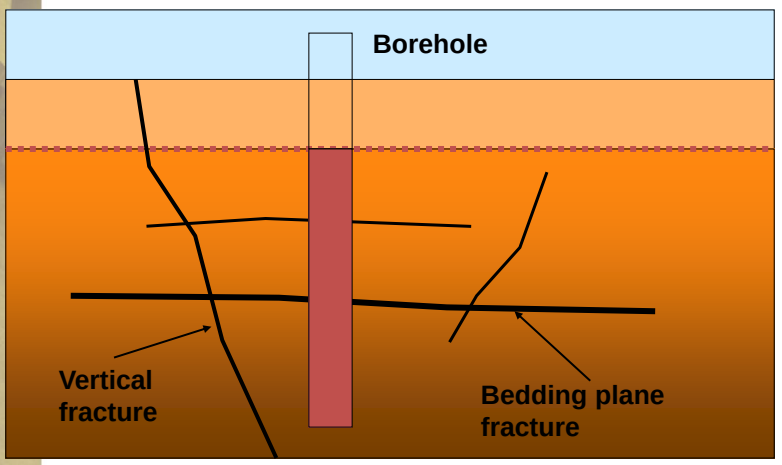
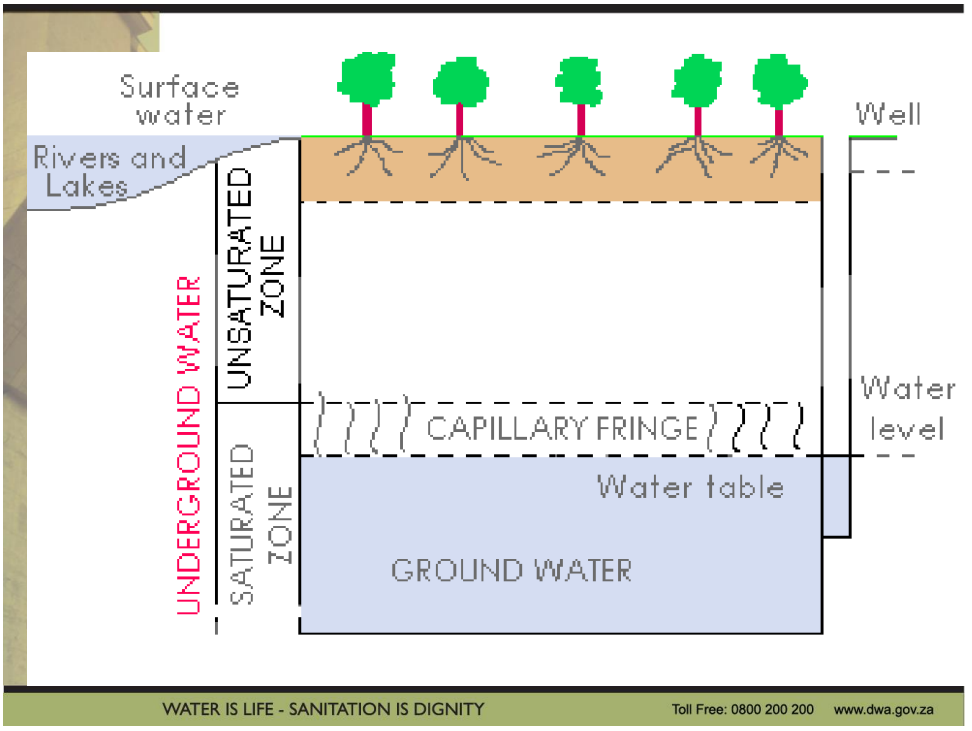


GROUNDWATER OCCURENCE

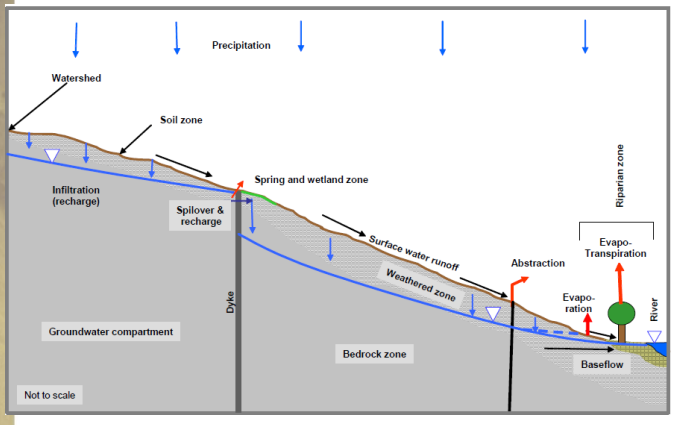


GROUNDWATER OCCURRENCE

- Is subsurface water groundwater?
  - Soil water (soil moisture) supports vegetation: occurs near surface
  - Interflow occurs within the unsaturated zone (vadose zone): source of low flows
  - Groundwater is below water table
  - Baseflow is that part of groundwater that support low flows in rivers (or streams)
  - Water in capillary fringe occurs above water table
  - Hence not all water below surface is groundwater

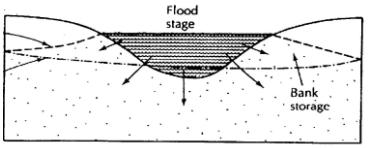


Groundwater Flow

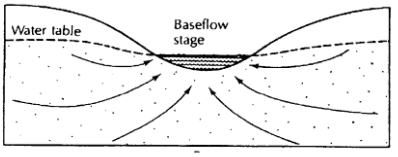


SURFACE WATER G/WATER INTERACTION

- During high flow conditions, surface water leaks into groundwater (influent stream)



- During low flow, groundwater seeps into streams (effluent stream)



Information Sources and Examples

WATER IS LIFE - SANITATION IS DIGNITY Toll Free: 0800 200 200 www.dwa.gov.za

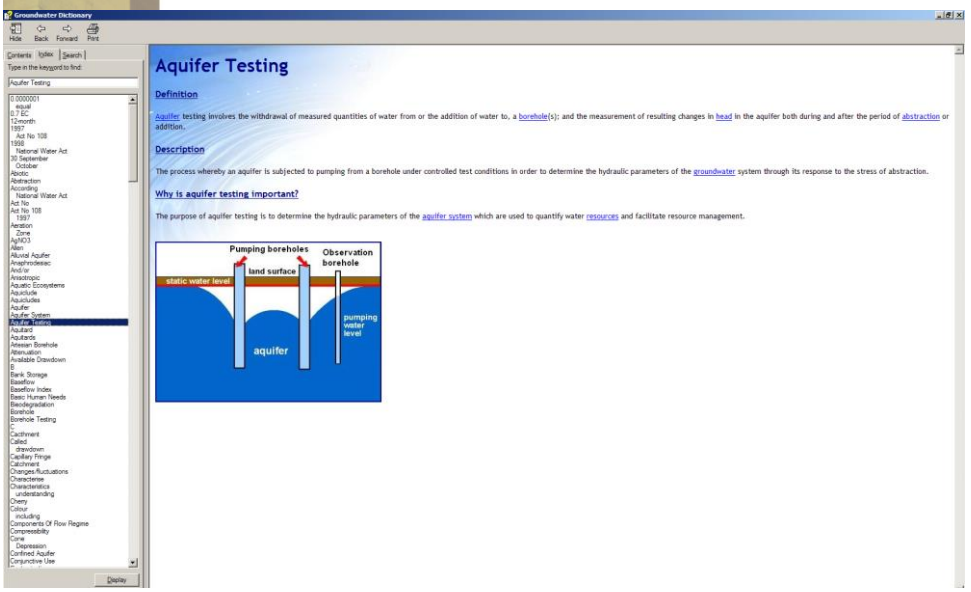
Information sources

- Your groundwater section Region Office
- National Office
- Groundwater data: National Groundwater Database (NGDB) + Groundwater Resources Information Project (GRIP)
- Groundwater quality: WMS
- GH Reports + WRC
- Maps
- georequests@dwaf.gov.za

Available Data / Info / Maps

•1: 500 000 Hydrogeological Maps (GRA1 maps)
•UGEP map (Utilisable Groundwater Exploitation Potential Aquifer Yield map)
•Groundwater Occurrence map
•Recharge map
•Rainfall (SA Weather Service or WR2005)
•Geology maps(Council of Geoscience)
•Structure Geology maps (Council of Geoscience)
•Reconciliation Strategies (DWS Website)
•Aerial photo (Land Survey: Director General)
•Airborne Geophysics (Council of Geoscience)
•Water use volumes (WARMS – DWS)
•Borehole data (National Groundwater Archieve – NGA – DWS website)
•Groundwater Quality (DWS)

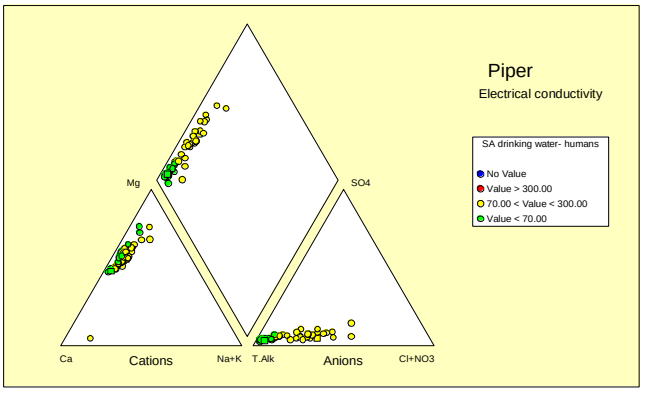
Internet-Groundwater-Dictionary



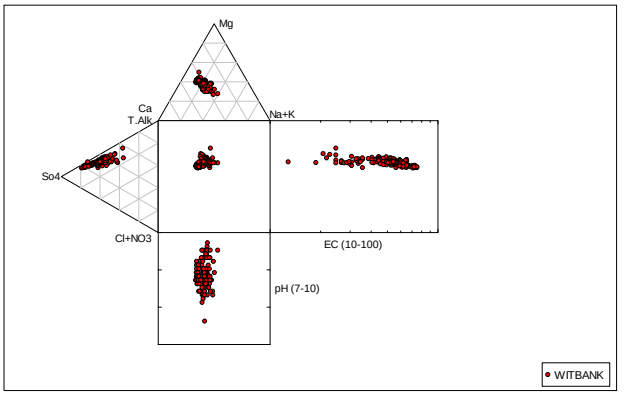
Drilling Rig

Borehole rock chips

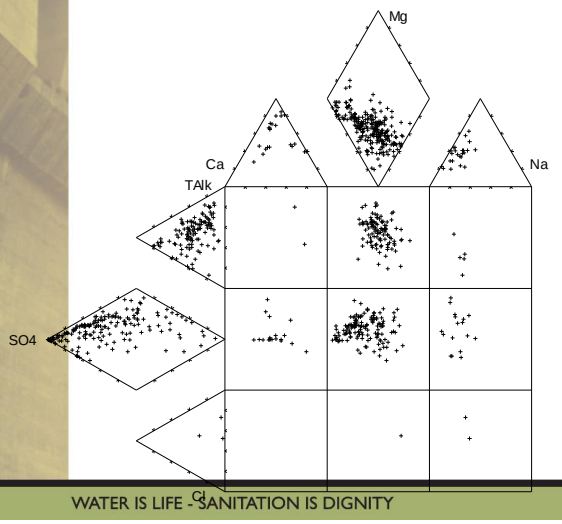
Piper plot



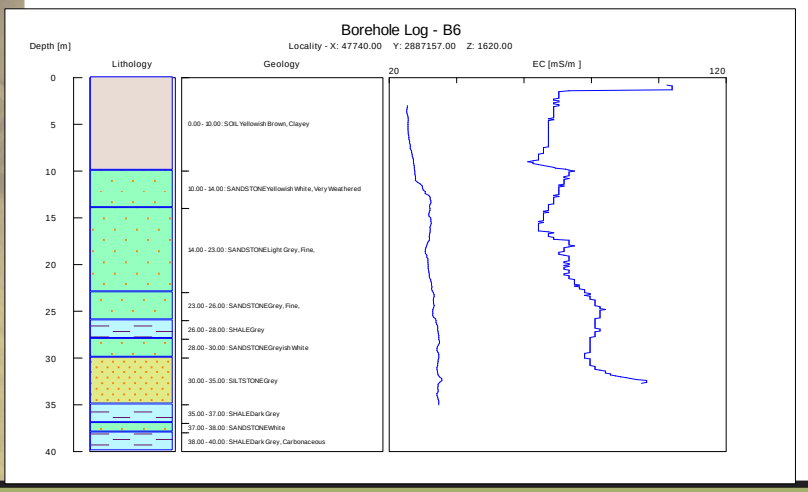
Durov plot



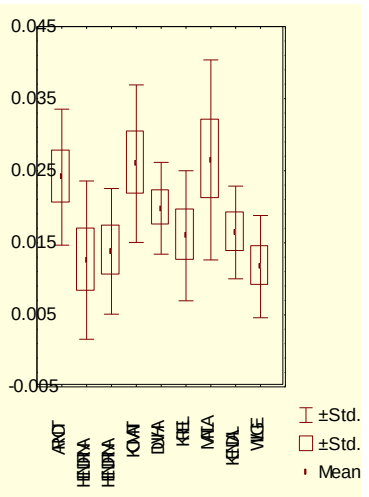
Expanded Durov plot



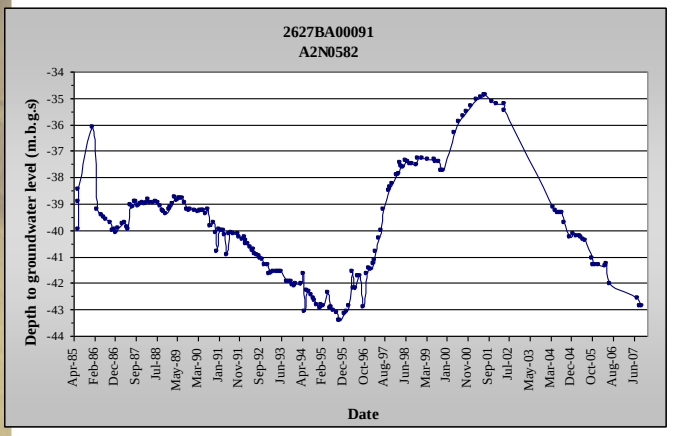
Borehole log



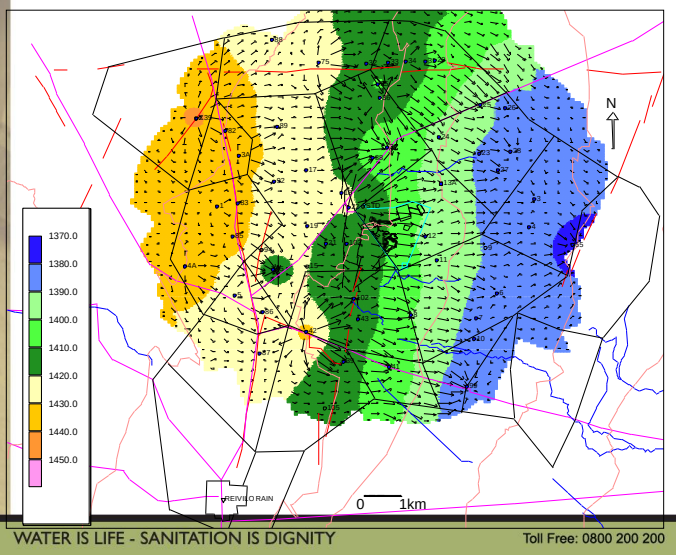
Box and whisker plot



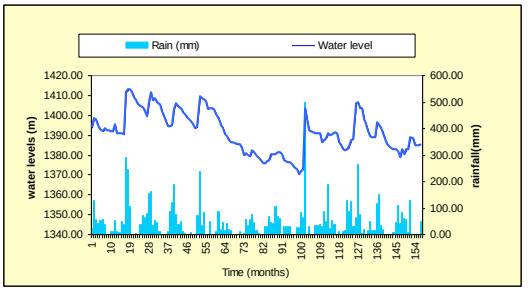
Water Level



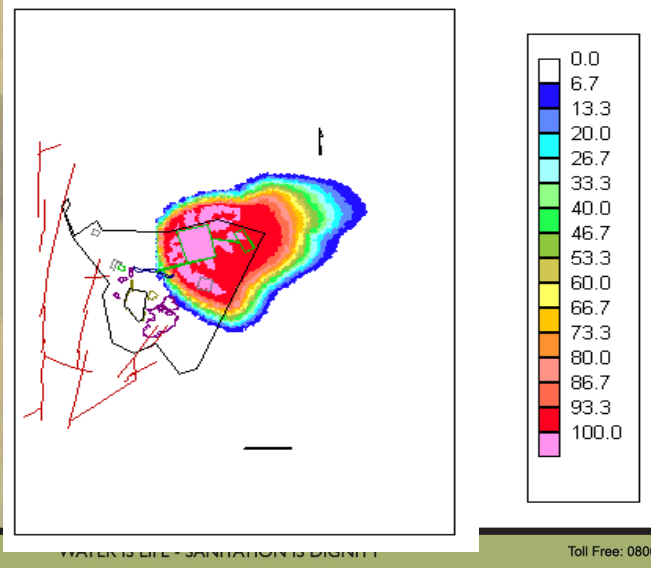
Groundwater flow vectors



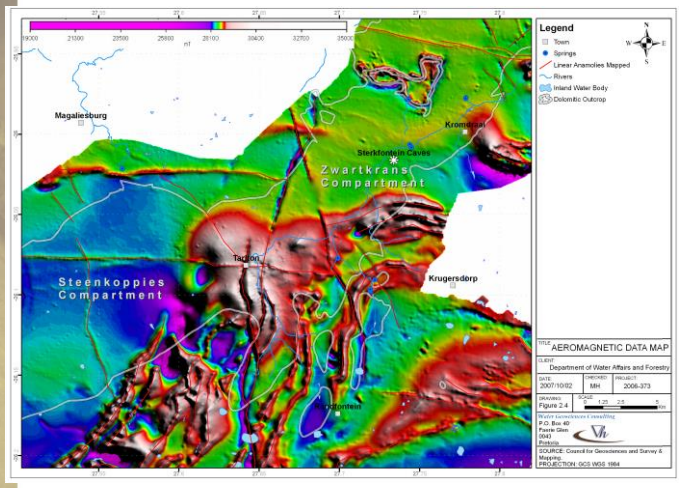
Rain vs Water level



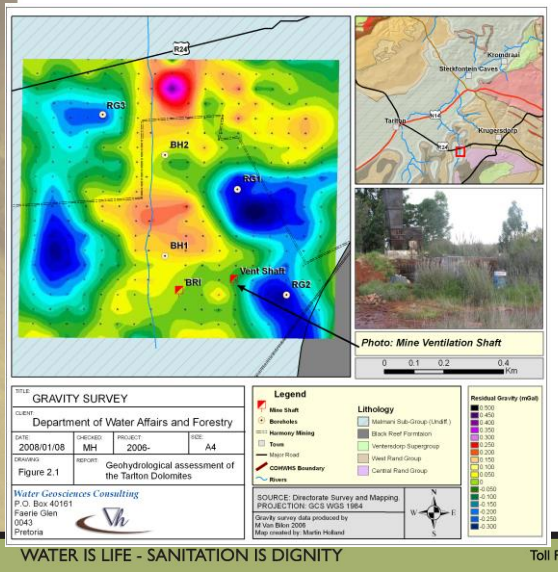
Pollution plume



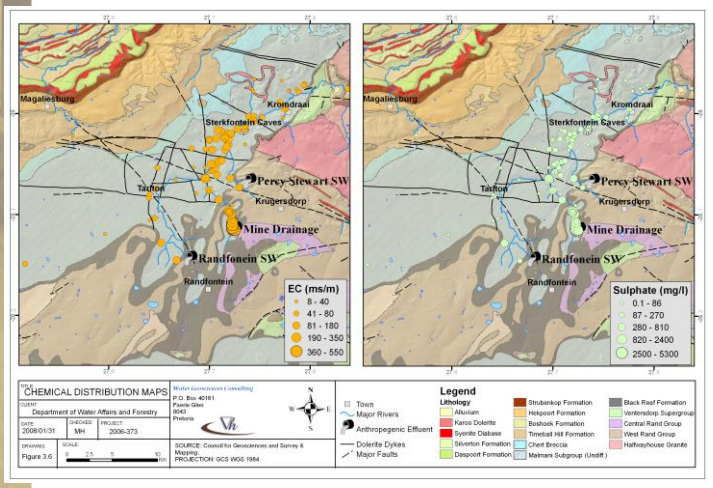
Aeromagnetic Map

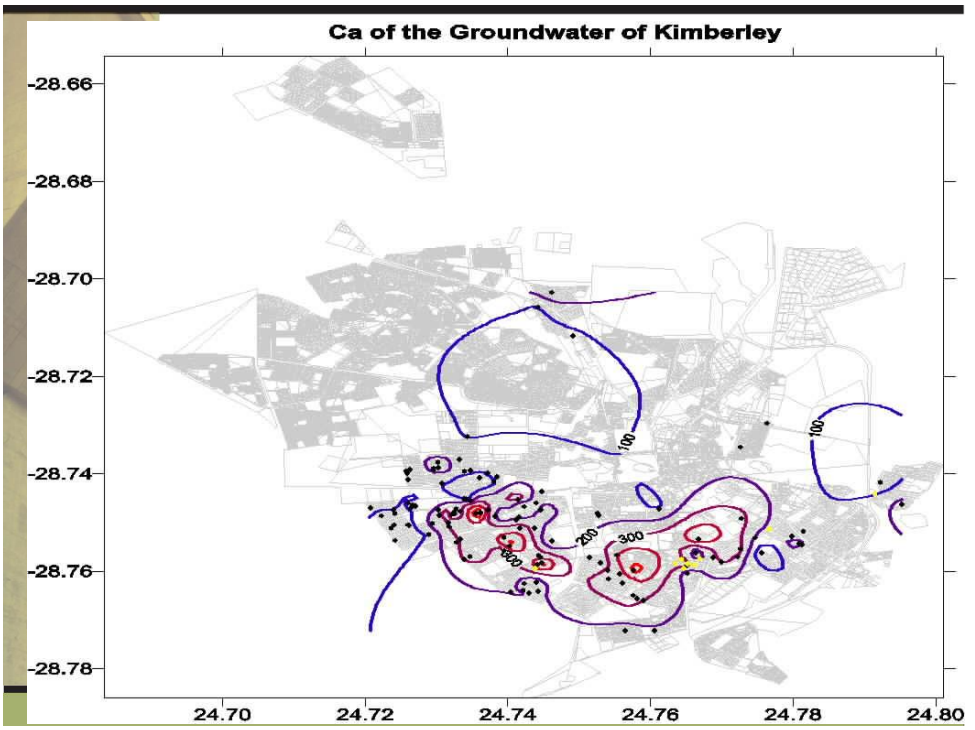


Gravity Map

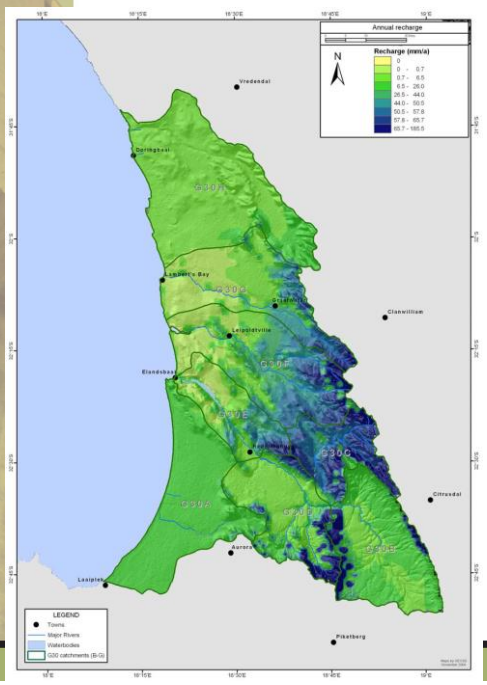


Water Quality Map

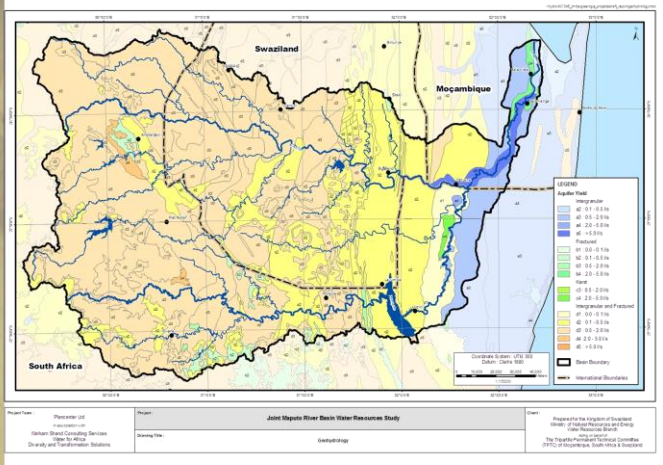




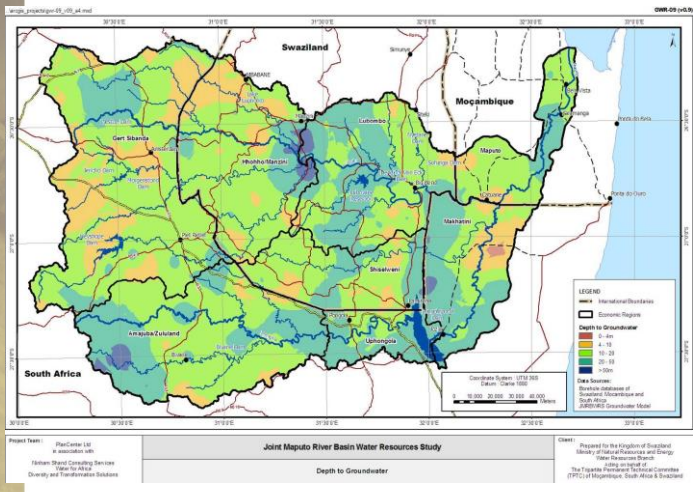
Recharge Map

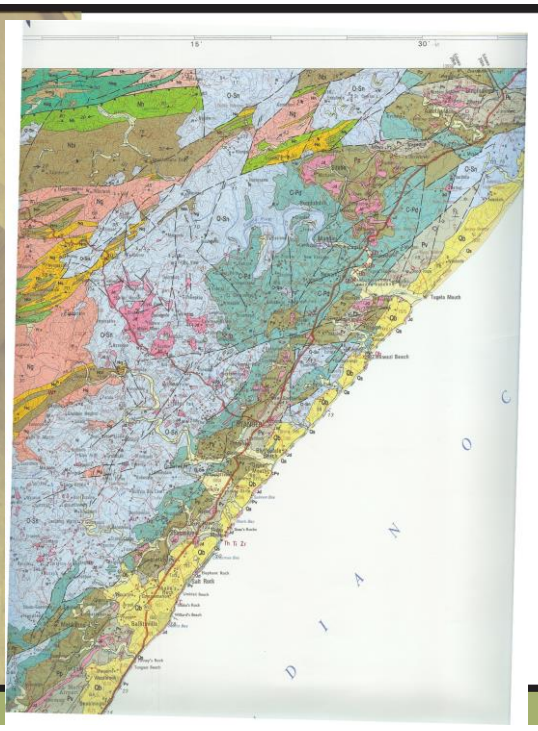


Hydrogeological Map



Depth to Groundwater

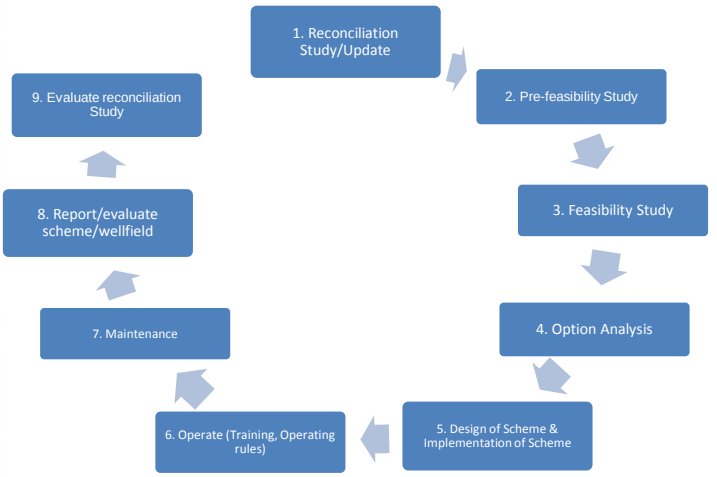




Geology Map

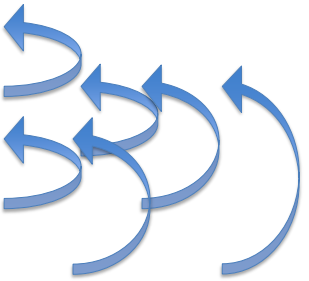
Planning process

Planning life cycle



Development Process

- Conceptualisation
- Reconnaissance
- Pre-feasibility
- Feasibility
- Design
- Construction
- Operation



Level of Study	Product / Decision	Data collection	Confidence	Scale
Conceptualisation	Inception / Planning Report	Expert evaluation of existing data	50 %	1:500 000 to 1:250 000
Reconnaissance	ID Target Areas Recommendation for and prioritisation of monitoring	Primarily desktop work with limited fieldwork and data collection, as required, (e.g. Hydrocensus) 1st order water balance model	60 %	~ 1:250 000
Pre-feasibility	Environmental monitoring and assessment ID Target Sites	Geological and ecological mapping Installation of monitoring infrastructure and ongoing monitoring of relevant processes Re-calibrate water balance model	70 %	1:100 000 to 1: 50 000
Feasibility	Exploration Yield estimation License & EIA application Feasibility Report	Site survey, borehole siting Drilling and testing of exploration boreholes Regional groundwater modeling Invest in collecting all relevant input for design purposes	80 %	1: 50 000 to 1: 10 000
Options Analysis	Options Analysis Report	Comparison of different options for water supply, based on feasibility studies	80 %	
Design *	Wellfield design and implementation Operating rules	Design all components of the scheme Wellfield model	90 %	1: 1 000 to 1:10 000
Operation & Maintenance *	Operation & Maintenance	Ongoing monitoring	95 %	

Development Process

- Incremental Development
  - Plan and design whole scheme
  - Construct initial part of scheme
  - Add elements, when required

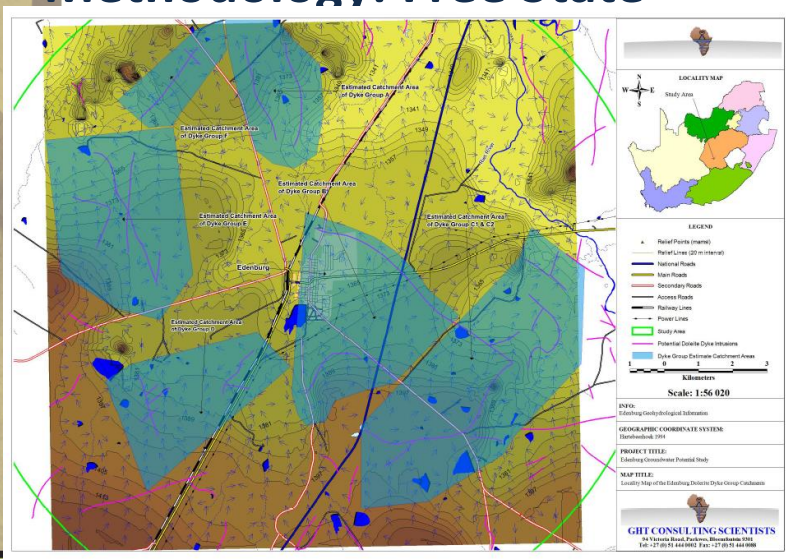
Project life cycle

Methodology: Free State

GROUNDWATER POTENTIAL DESKTOP STUDY

- Existing geohydrological data;
- Hydrocensus
- Aerial photo interpretations
- Aerial magnetic interpretations
- Geophysical field survey
- GIS map compilation
- Determination of high groundwater abstraction areas
- Recharge volume estimation
- Compilation of a Geohydrological Potential Report

Methodology: Free State



Methodology: Vaal Gamagara

GROUNDWATER POTENTIAL & DEVELOPMENT SCHEME

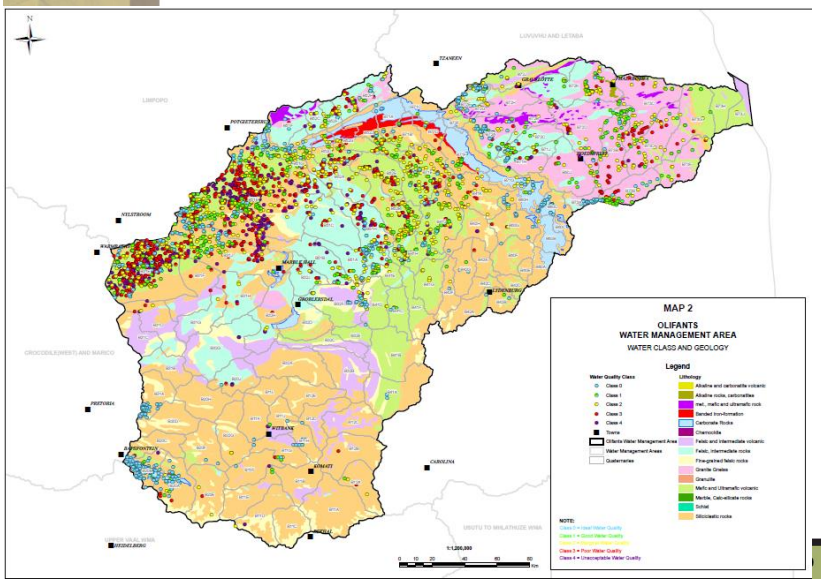
- Detail desktop study: Collation & updating Existing geohydrological data;
- Land Owner Engagement process
- Hydrocensus: Id & verification of use & sampling
- High resolution airborne geophysical surveys: magnetic & TDEM
- Detail remote sensing & assessment of airborne geophysical data
- Ground geophysical field survey: magnetic & gravity
- Test pumping existing boreholes
- Drilling of exploration/test boreholes
- Groundwater sampling on newly drilled boreholes

Methodology: Vaal Gamagara

GROUNDWATER POTENTIAL & DEVELOPMENT SCHEME

- Aquifer test pumping exploration boreholes:
  - Short term test: SDT & 24h CDT – bh yield capacity + aquifer sustainability
  - Long term test: 72h – aquifer sustainability + aquifer hydraulic parameters for modelling
- Conceptualizing of hydrogeological model
- Numerical 3D modelling: simulate aquifers + predict long term sustainability + test feasibility of implementing development
- Management recommendations: production design + buffer effect
- Compilation investigation report

What is wrong with this picture?



NB Data

- No Data!!!!!!
- Concentrated area
- Poor distribution
- Witbank & Middelburg – Coal - AMD?
- Steelpoort – Platinum mines?

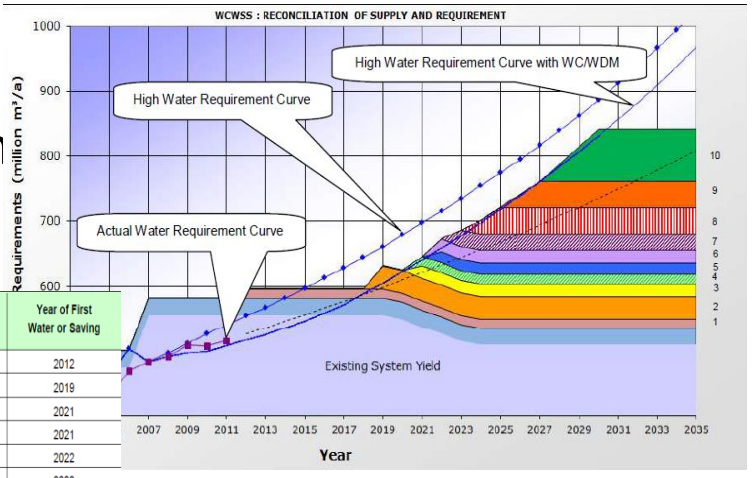
Planning Assistance

- Reconciliation Studies
- Conjunctive use
- Maps
- Guidelines
- Tools
- Methodologies
- Interventions

Reconciliation Studies

Western Cape Water Supply System

Th

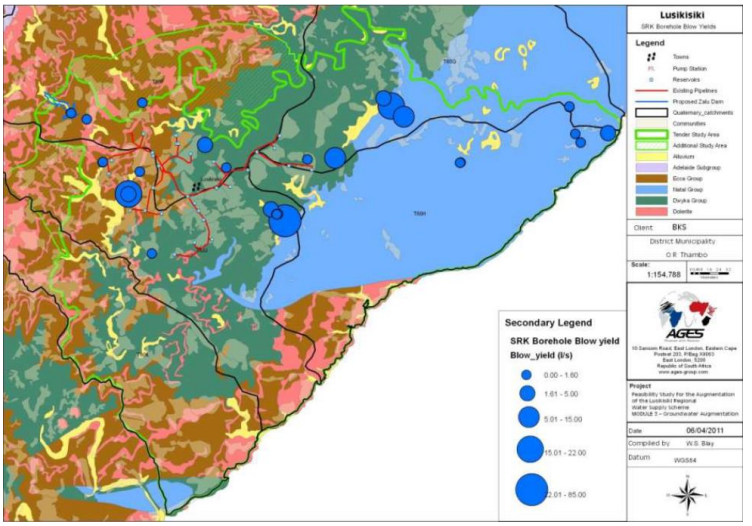


No	Intervention	Year of First Water or Saving
1	Optimise System Operation	2012
2	Voëlvlei Phase 1	2019
3	Lourens	2021
4	DWA:ASR: West Coast	2021
5	Cape Flats Aquifer	2022
6	TMG Scheme 1	2022
7	Raise Lower Steenbras	2023
8	Re-use Generic 1	2024
9	Re-use Generic 2	2026
10	Desalination	2028

Conjunctive Use

Lusikisiki Water scheme

Bulk water infrastructure Surface and groundwater

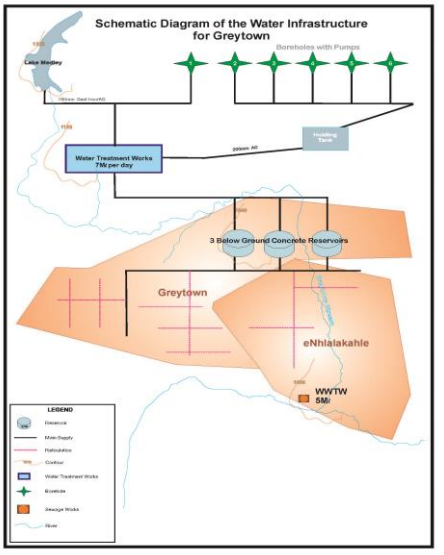


Conjunctive Use

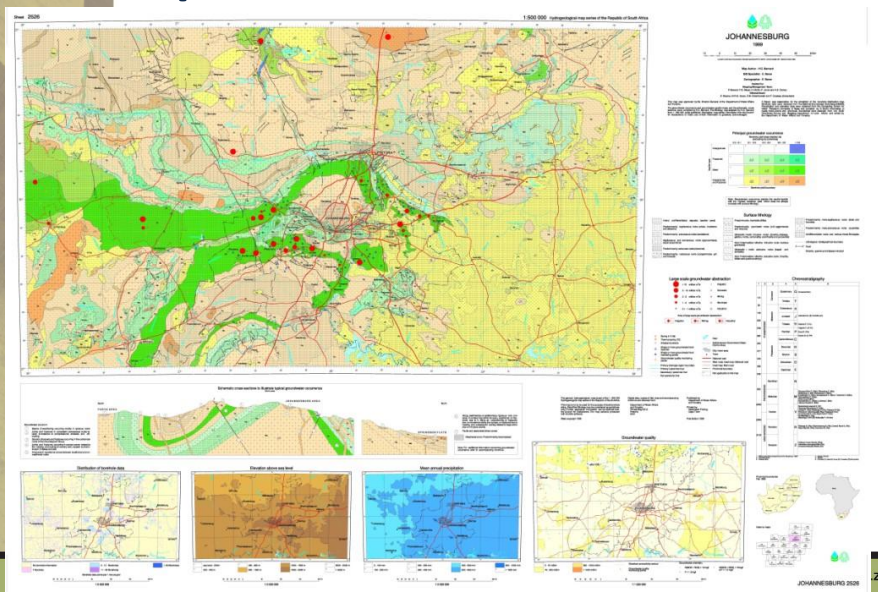
Example:

Greytown - KZN Water scheme

Dam + boreholes



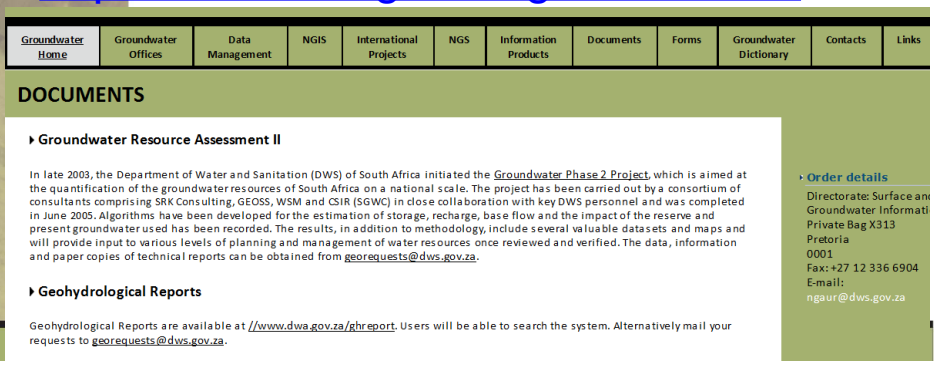
Maps of GRA I



DWS Website

http://www.dwa.gov.za/projects.aspx

http://www.dwa.gov.za/groundwater/



DWA Guideline

"**A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa**"

•DWA website at www.dwa.gov.za/groundwater/documents.aspx.

•A lack of effective assessment, planning and ma
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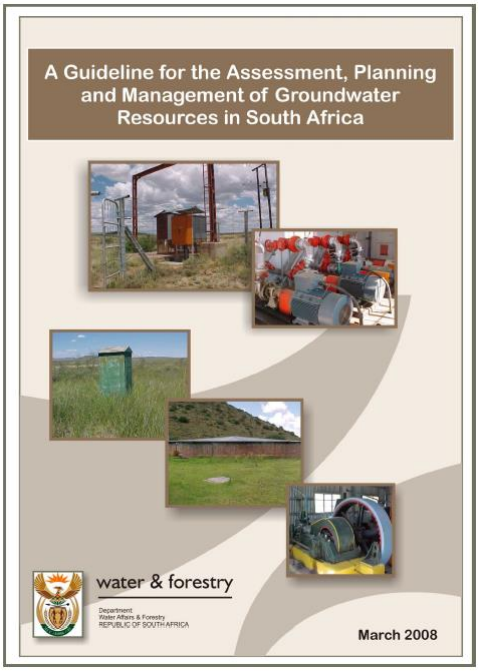
DWA Guideline



NORAD Toolkit

Consists of a collection of documents, software and maps

Aimed at improving the management of groundwater at municipal level in South Africa

http://www.dwa.gov.za/Groundwater/NORADtoolkit.aspx

• A Framework for Groundwater Management of Community Water Supply,
•Decision Making Framework for Municipalities,
•Groundwater Monitoring for Pump Operators,
•Guidelines for Protecting Boreholes and Wells,
•Guidelines for Protecting Springs,
•Guidelines for Protecting Groundwater from Contamination,
•Implementing a Rural Groundwater. Management System

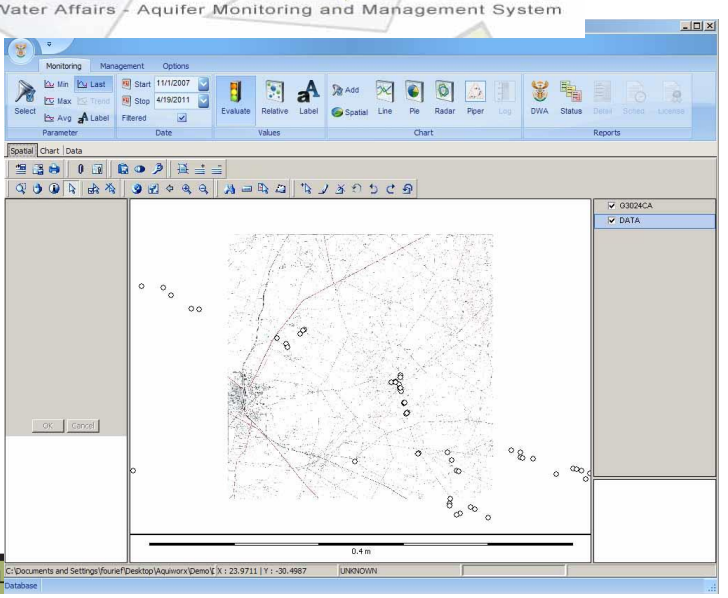
AQUIWORX

Department of Water Affairs - Aquifer Monitoring and Management System

Groundwater Management Tools

or

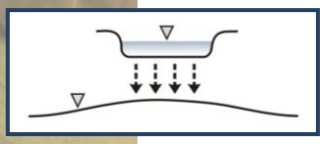
WISH

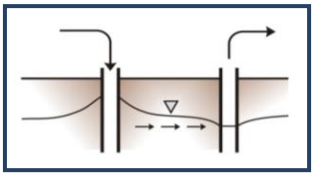


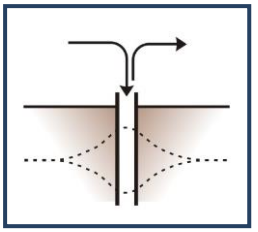
Artificial Recharge

•Artificial recharge is the process whereby surface water is transferred underground to be stored in an aquifer

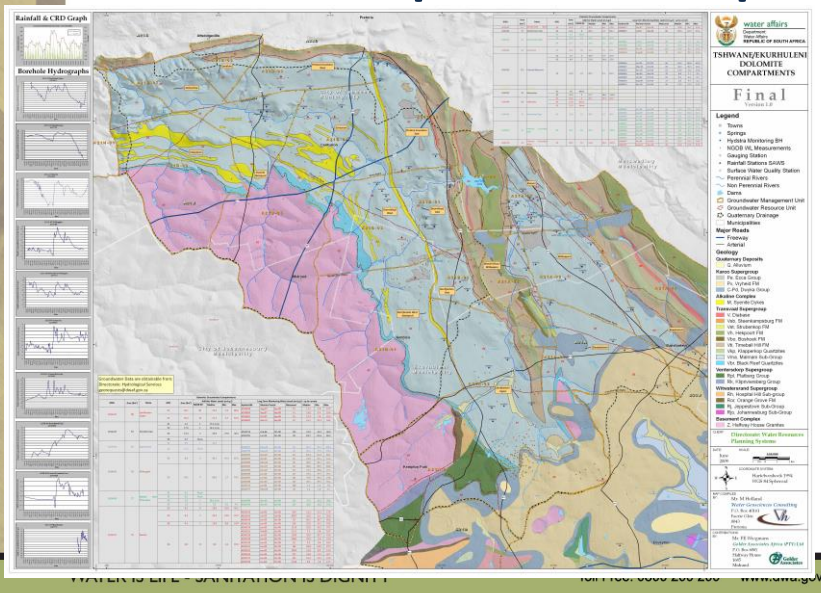
www.artificialrecharge.co.za

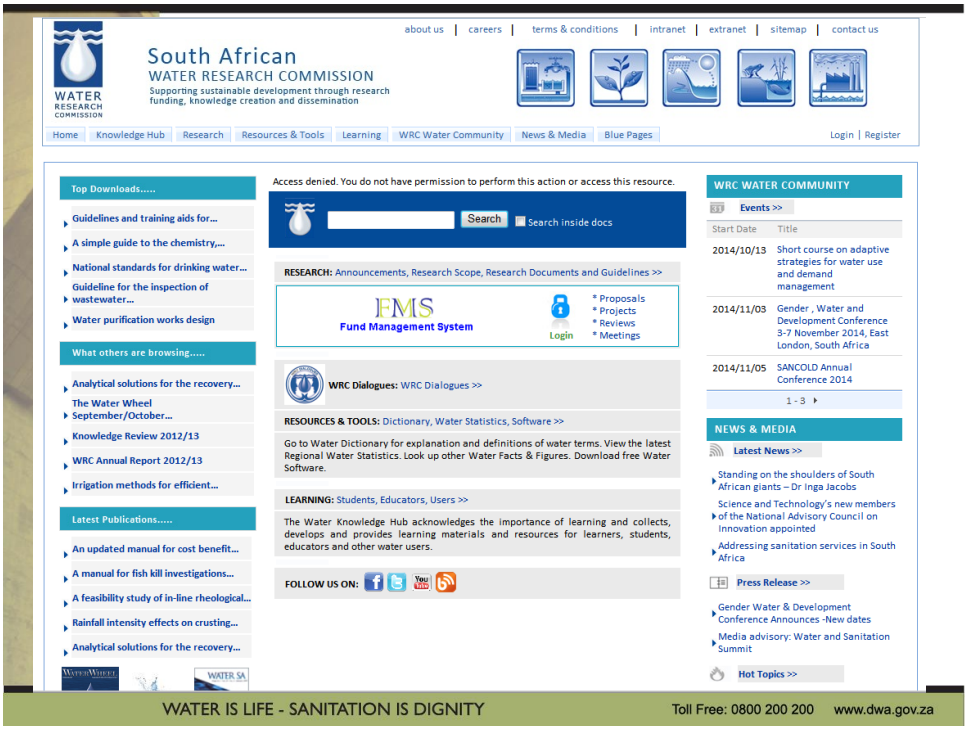






Dolomitic Compartment Maps





Institutions

Institutional Capacity

- Water management institutions must be structured and mandated in such a way that groundwater development and management can be optimally achieved. The challenge is adequate institutional functioning and support.

- Public – private partnerships must be establish to manage aquifer system and well field

Institutions: Water Supply Models

Victoria West:

- Farmer is WSP. Supply water to reservoir from private well field.

De Aar:

- Buy farm/property with groundwater (buy of registered water right)

Kenhardt:

- Incentives for groundwater from farm (servitude, land management)

Bloem Water:

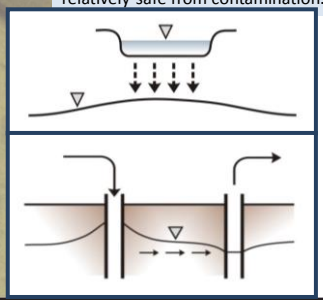
- Operate municipal well field and develop own groundwater (Private Service Provider)

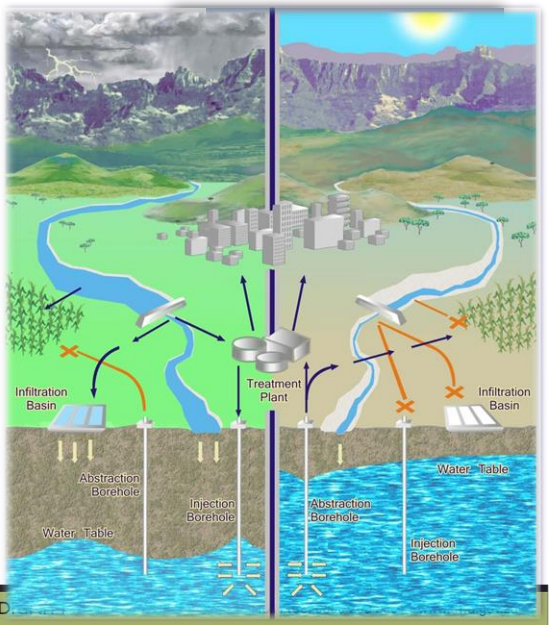
What is artificial recharge?

Artificial recharge is the **process** whereby surface **water** is **transfer**red **underground** to be stored in an **aquifer**.

The most common methods used involve **injecting** water into boreholes and transferring water into spreading **basins** where it infiltrates the subsurface.

Underground water storage is an efficient way to store water because it is **not** vulnerable to **evaporation losses** and it is relatively safe from contamination.

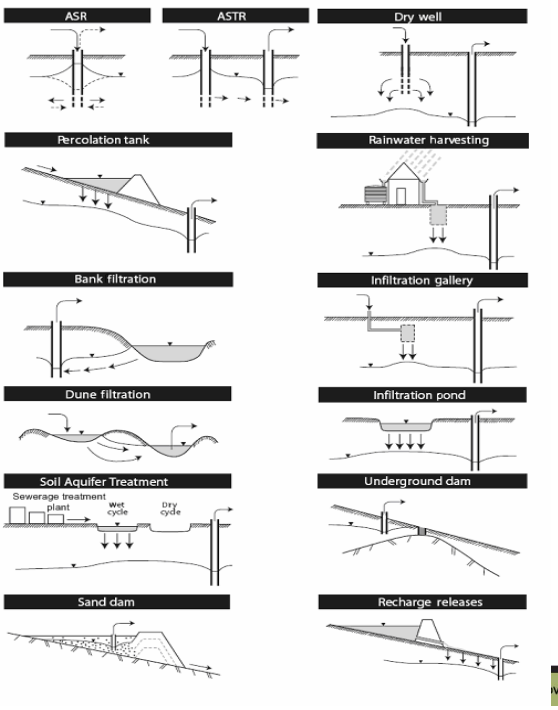




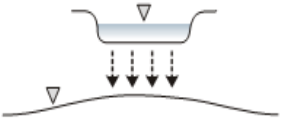
Benefits

- The on-going enhancing of aquifer yields using **treated waste water** and **storm water** (Atlantis) and treated waste water only (Polokwane);
- Enhancing aquifer yields by **transferring** groundwater from one aquifer to another (Williston);
- Enhancing aquifer yields through **opportunistic** artificial recharge whenever surface water is available (Kharkams in Namaqualand and Omdel in Namibia);
- Enhancing the **security of supply** by large-scale sub-surface **water banking** from treated dam water for long-term and seasonal storage, and for emergency requirements (Windhoek), and
- Improving water **quality** (Atlantis and Kharkams).

Types of Artificial Recharge



Atlantis



Infiltration Basins

Basins constructed in sand or gravel aquifers. Surface water is diverted to the basins and allowed to infiltrate through an unsaturated zone to the underlying unconfined aquifer.

Thank you