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YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences
Fakulteit Natuur- en Landbouwetenskappe
Lefapha la Disaense tša Tlhago le Temo

ON CEMETERIES, THEIR SITING AND HYDROLOGICAL IMPACTS

IERM – 28 September 2015

Matthys Dippenaar, Department Geology

Outline

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- Risks posed by Cemeteries
- Hydrological Processes
- Minimum Requirements
- Present Investigation Procedures
- Mitigating Risk from Cemeteries
- Vadose Zone Assessment Protocol
- The Way Forward…

Risks posed by cemeteries

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- Generally low due to:
  - Slow decay process
  - Short lifespan of bacteria outside of human body
  - Alternative reticulated water supply
  - More significant contamination sources
  - Slightly contaminated water can be used for e.g. irrigation

Risks posed by cemeteries

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- However, mandatory EIA as poorly sited cemeteries can result in:
  - Short-term impacts (flies, noise, air pollution)
  - Long-term impacts (water pollution)

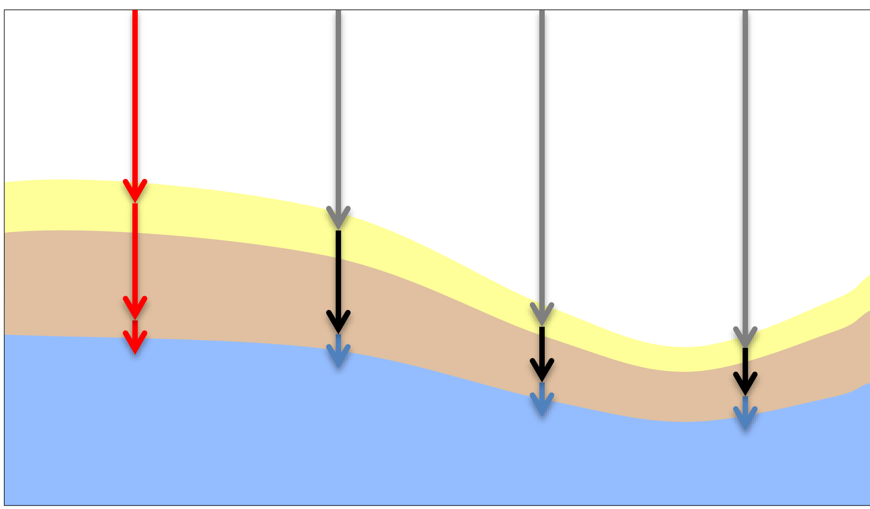
- Registered water use in terms of:
  - Section 21 of the National Water Act 36 of 1999

Risks posed by cemeteries

SPECIFIC VULNERABILITY

Risk exacerbated by specific contaminant:

- Contaminant properties/ toxicity
- Manner of contaminant disposition
- Persistence, bioaccumulation



INTRINSIC VULNERABILITY

ATMOSPHERE AND LAND SURFACE
Likelihood of infiltration:

- Precipitation (intensity/ duration)
- Topography/ slope
- Land use/ land cover

VADOSE ZONE
Likelihood of recharge:

- Distance (depth to water)
- Flow rate (K_{unsat})
- Confining layers

PHREATIC ZONE
Impact on aquifer:

- Recharge rate
- Aquifer media

Risks posed by cemeteries

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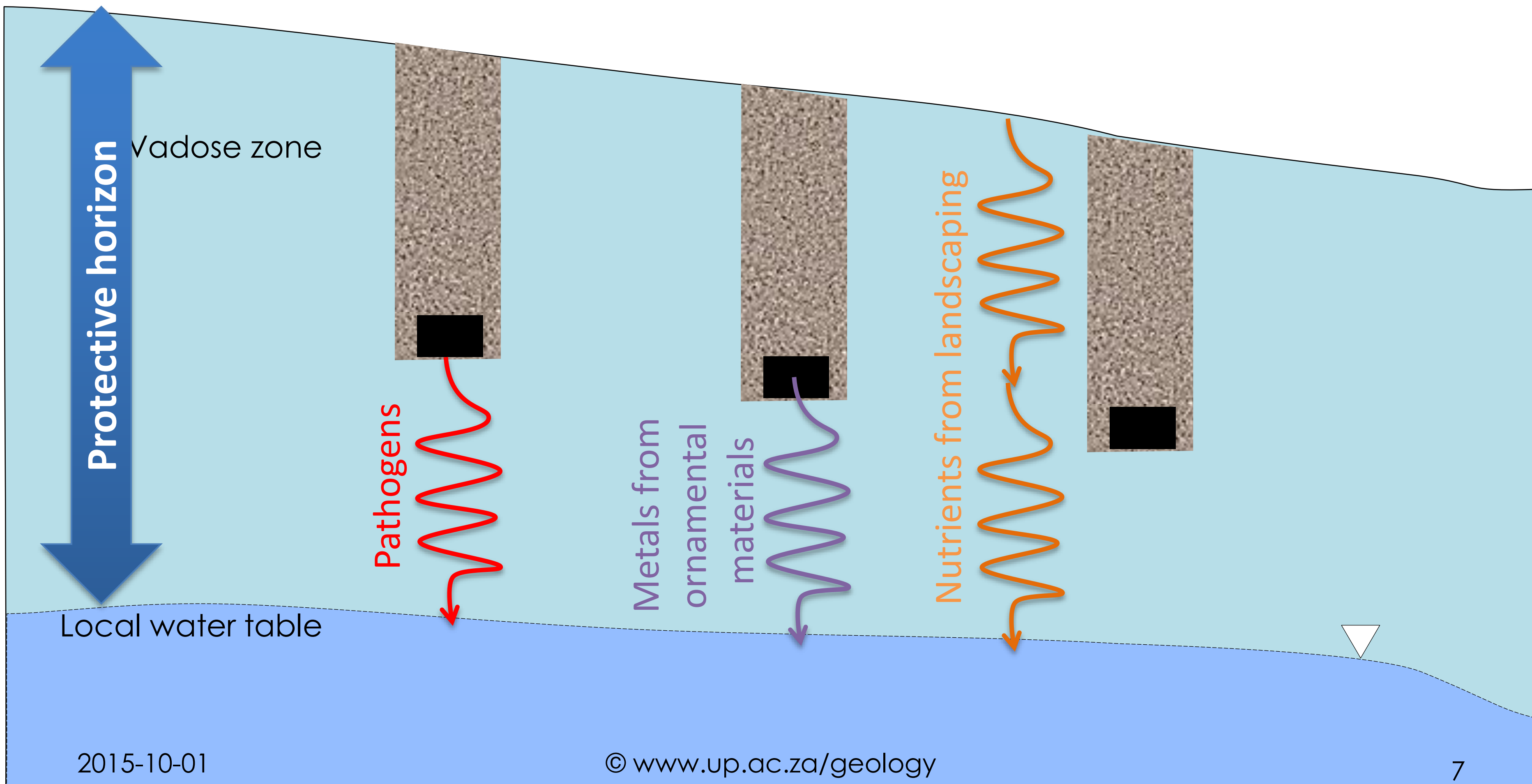
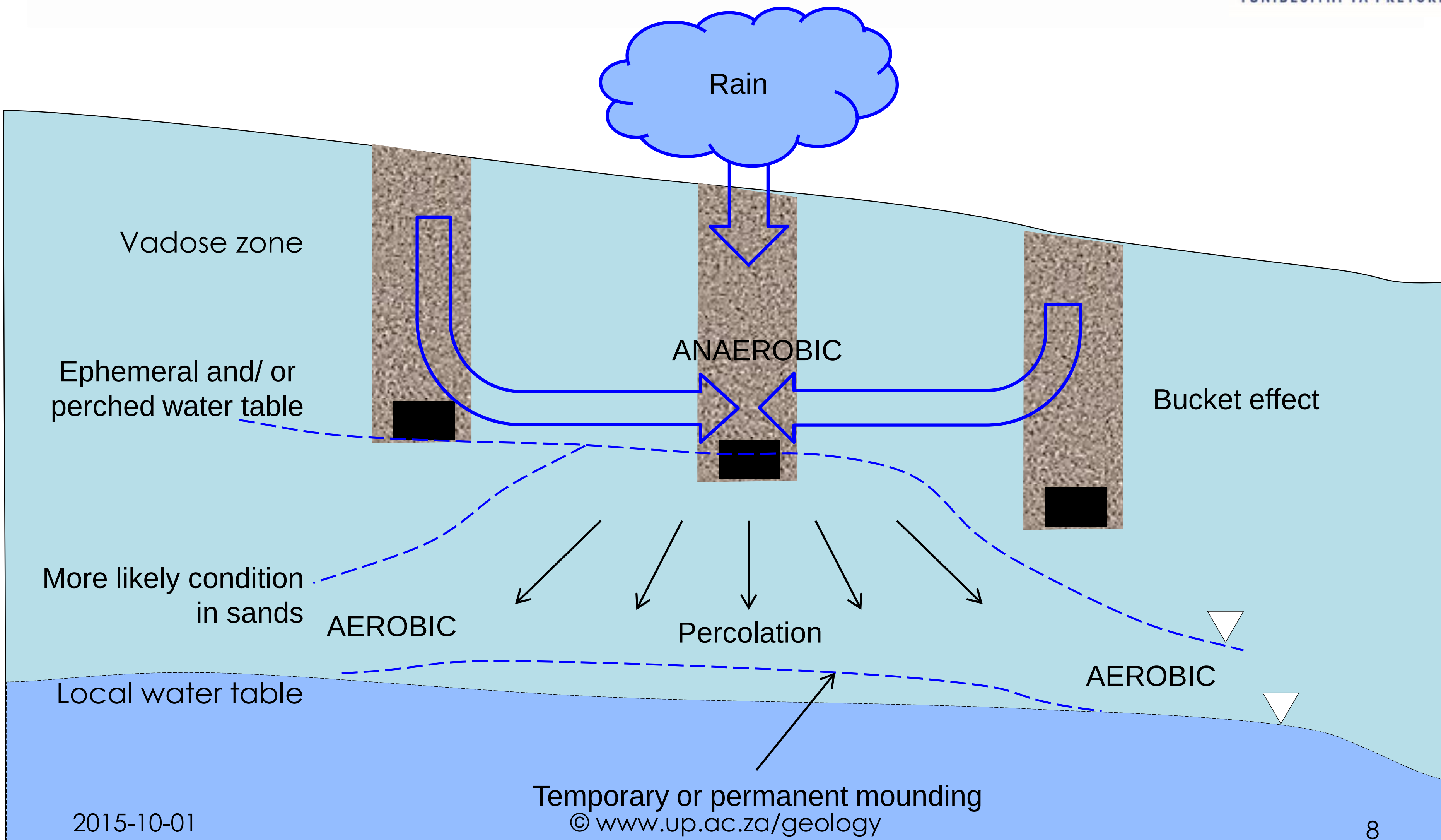
- Contaminants sourced from:
  - Decaying bodies
  - Materials associated with burial (e.g. coffins)
  - Landscaping practice

- Alternating saturated–unsaturated periods:
  - Alternating anaerobic–aerobic conditions

Risks posed by cemeteries



Hydrological processes



Hydrological processes

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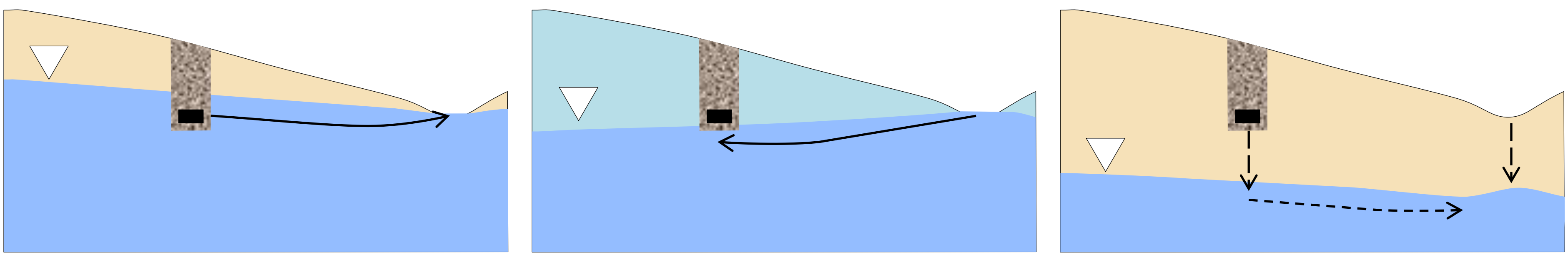
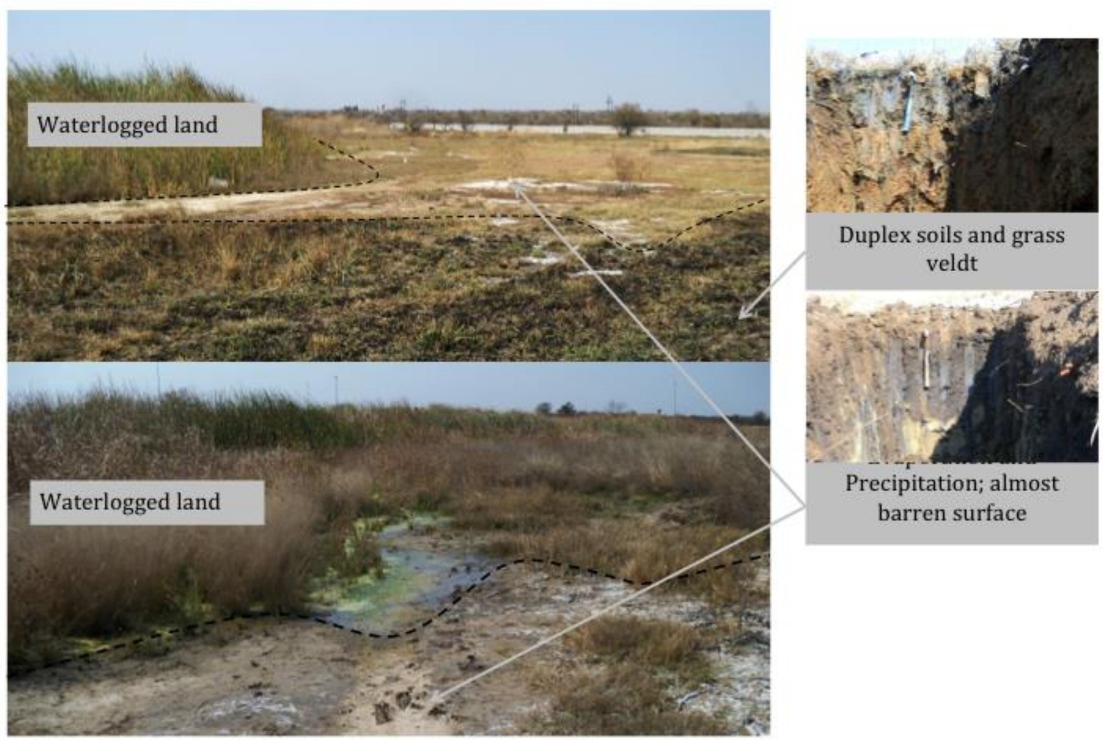
- Distinct hydrological interaction scenarios:
  a) Gaining stream
  b) Losing stream
  c) Thick vadose zone

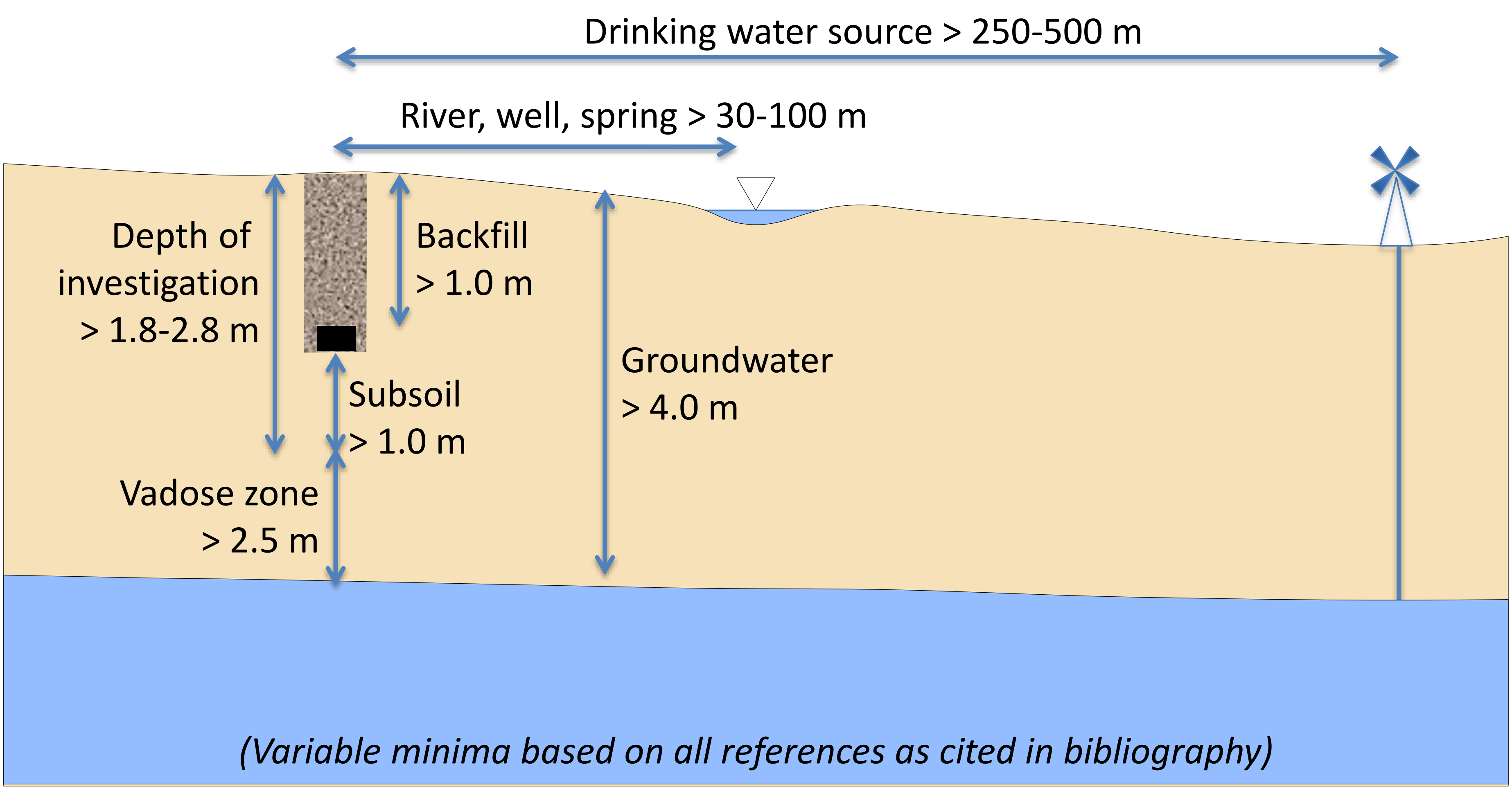


(a) (b) (c)

Hydrological processes



Minimum requirements



Present investigation procedures

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- Engineering geological/ geotechnical:
  - Excavatability – ease to > 1.80 m
  - Stability – sidewalls stable for prolonged periods
  - Workability – material to be used as compacted backfill

- Sanitary/ environmental/ hydrogeological:
  - Water table – thickness of protective vadose zone
  - Subsoil permeability – preventing ponding & rapid infiltration
  - Backfill permeability – as above

- (Hall & Hanbury 1990)

Present investigation procedures

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- Numerous dated other approaches require proving, by any means required, the following:
  - Deep water table
  - Absence of perched water tables
  - Soil conductivity 1×10^{-7} - 5×10^{-5} cm/s
  - Thick excavatable soils
  - No proximate water supply or drainage features
  - Stability of sidewalls
  - Surface gradient 2 - 6° (9° in exceptional cases)
  - Space for adequate future expansion

Mitigating risk from cemeteries

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- Risk is mitigated through
  - Proper siting (investigation prior to development)
  - Proper monitoring
  - Proper management

- Tiered multi-faceted Vadose Zone Assessment Protocol incorporates
  - Stages of investigation based on risk
  - Multi-environmental approach

Mitigating risk from cemeteries

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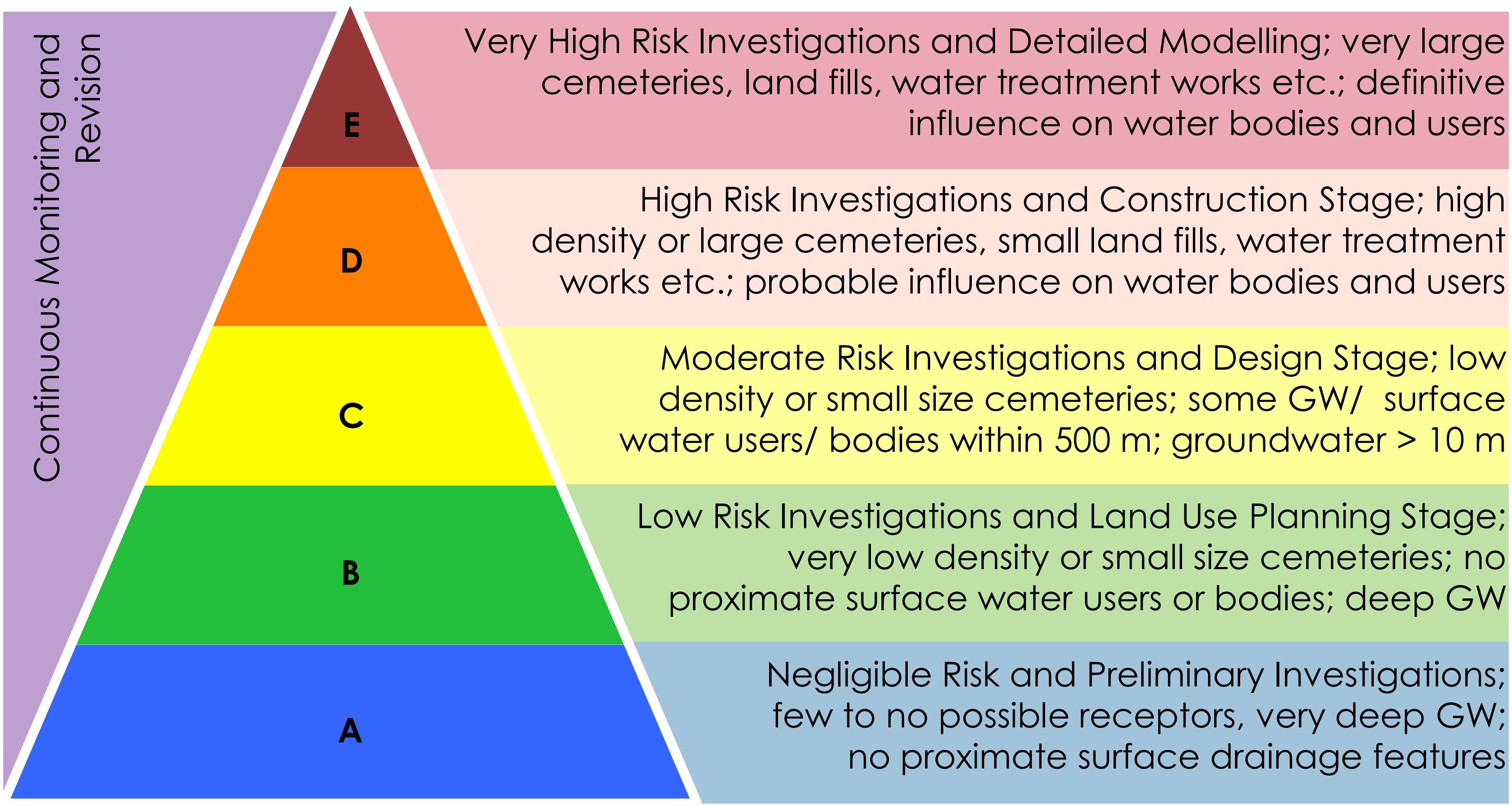

Mitigating risk from cemeteries

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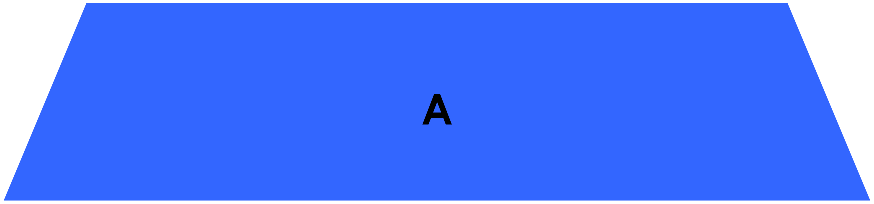
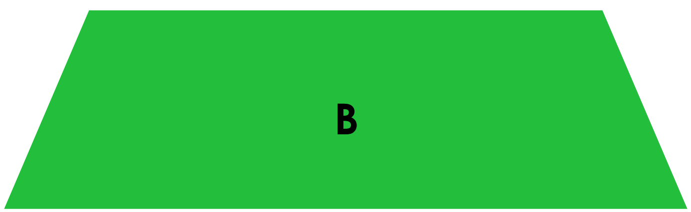
- A1. Data Collation
  - Geological and soil maps; climatic data; existing water quality data; historical reports
- A2. Assessment of Proposed Development and Associated Risks
- A3. Hydrological Pathways of Importance
  - I.e. is water required to be available to plants; is groundwater recharge and aquifer vulnerability the main concern; is water expected to influence infrastructure?



Mitigating risk from cemeteries



- B1. Detailed Surface Mapping
  - Outcropping rock, surface soils, land cover, land use, vegetation, drainage, topography)

- B2. Relative Hydrological Risk Mapping
  - Contaminant sources, water table map, water users, surface drainage)

Mitigating risk from cemeteries

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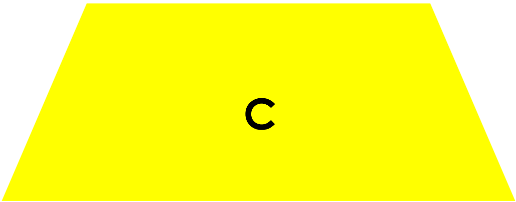
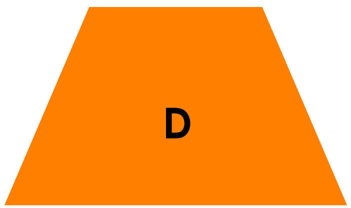


- C1. Surface Water Assessment
  - Detailed drainage; surface water quality)
- C2. Soil Zone Assessment
  - Characterisation of the shallow subsurface through existing methods such as soil profiling, infiltration testing, percolation testing, grading and hydrometer analyses, etc.)
- C3. Geotechnical Assessment
  - Excavatability; sidewall stability; geological hazards)

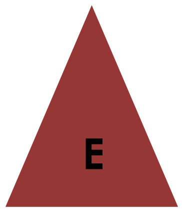
Mitigating risk from cemeteries



- D1. Phreatic Zone Assessment
  - Hydrocensus; drilling and aquifer testing if required; groundwater quality)

- D2. Intermediate Vadose Zone Assessment
  - Conceptualisation of deep soil and unsaturated bedrock conditions; drilling, augering or push probe if required)

Mitigating risk from cemeteries



- E1. Hydrological Model
  - Including all additional data requirements and if required

The way forward…

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- Commissioned by Water Research Commission:
  - State-of-the-Art Cemetery Guidelines

- Incorporating aspects of:
  - Sanitation and Hydrology
  - Human and Ecosystem Health
  - Engineering Constraints
  - Social Aspects

The way forward…

- Project Team:
  - Dr Dippenaar, UP (Engineering Geology, Hydrogeology, Vadose Zone Hydrology)
  - Prof Lorentz, UKZN/SRK (Vadose Zone Hydrology, Hydrology)
  - Prof Olivier, UP (Geography, Climatology)
  - Dr Ubomba-Jaswa, CSIR (Microbiology, Health)
- Capacity Building
  - Ms Aphane, Janse van Rensburg, Mahlangu and Mpye
  - Mr Brouwers

The way forward…

- Standard guidelines
  - Aquifer vulnerability
  - Surface hydrology
  - Vadose zone, esp. impacts of backfill and underlying strata
- Monitoring
- Case studies have since commenced
  - To offer your sites-of-concern – kindly email me
  - madip@up.ac.za

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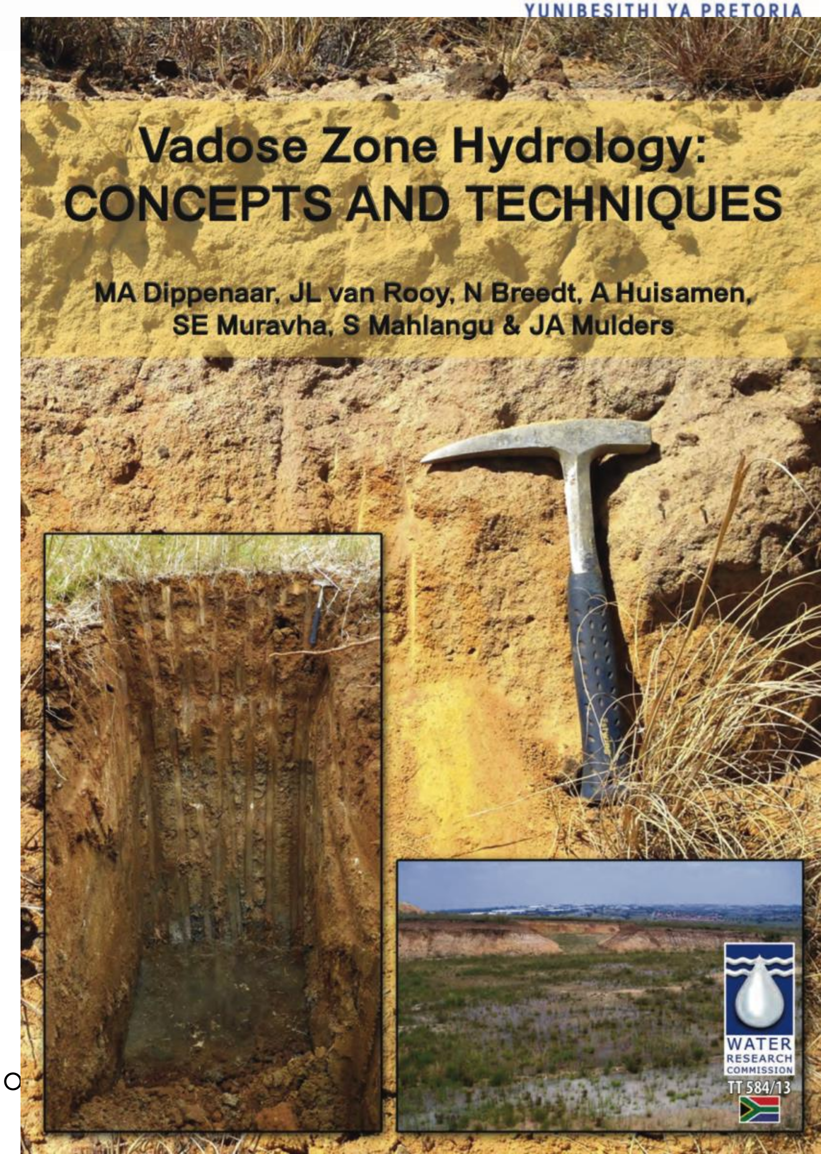

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