GROUNDWATER – UNDERSTANDING AQUIFERS

By Dr Johann van Wyk & Willem Botes (Pr. Tech Eng.)
Current Options Being Considered
(derived from various media reports)

- **Groundwater abstraction**
  Cape Flats and Table Mountain Aquifers

- **Desalination plant** (400 000 m$^3$/day)
  West Coast

- **Augmentation of Voëlvlei Dam**
  From Berg River

- **Re-use of Waste Water**
  Zandvliet WWTW
Considering the information supplied by City of Cape Town to the public re the alternatives to augment the water supply to Cape Town with specific reference to groundwater abstraction:

there are some doubts around the City’s apparent understanding of the basic concept of groundwater abstraction and the functioning of aquifers.
Aquifers

An **aquifer** is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be abstracted using a borehole or well.

There are three types of aquifers:

- **Unconfined aquifers**
- **Confined aquifers**
- **Semi-confined aquifers**
Unconfined (open) Aquifers

Where the aquifer material between the ground surface and the water table is porous it is known as an unconfined aquifer.

Recharged from surface water runoff:
- Residential
- Industrial
- Agricultural
- Natural environment

Porous ground (sand)

Aquifer

Aquitard (A layer of rock or clay)

Water table
Unconfined Aquifers

Abstraction from an unconfined aquifer (borehole or well)

- Water table
- Aquitard (A layer of rock or clay)
- Porous ground (sand)
- Effect on water table
- Abstraction (borehole or well): Borehole
Unconfined Aquifers

Water Quality

Recharged from surface water runoff:
- Residential
- Industrial
- Agricultural
- Outflows from sewage plants

Adverse quality due to pollutants:
- Microbiological (Bacteria and pathogens) and viruses
- Toxic inorganics (Ammonia and metals)
- Petroleum hydrocarbons
- Pesticides and herbicides
Confined Aquifers

Where an aquifer is overlain by a layer of rock or clay (aquitard) that may hold some groundwater but is not porous enough to allow water to flow through it, it is known as a confined aquifer.

Recharged from:
- Less developed land
- Natural environment

Fractured rock or gravel that is porous enough to hold water and allow it to flow

Aquifers (Layers of rock or clay)

Water table
Confined Aquifers

Abstraction from a confined aquifer (borehole).

Aquitards (Layers of rock or clay)

Effect on water table

Aquifer

Water table

Abstraction (borehole):

Borehole
Confined Aquifers

Water Quality

Recharged from:
• Less developed land
• Natural environment

Shielded from pollutants from developed area and agri-land:
• Microbiological (Bacteria and pathogens) and viruses
• Toxic inorganics (Ammonia and metals)
• Petroleum hydrocarbons
• Pesticides and herbicides

Aquitards (Layers of rock or clay)

Aquifer
The Cape Flats Aquifer is an unconfined (open) aquifer!

Recharged from surface water runoff:
- Residential
- Industrial
- Agricultural
- Outflows from sewage plants

Adverse quality due to pollutants:
- Microbiological (Bacteria and pathogens) and viruses
- Toxic inorganics (Ammonia and metals)
- Petroleum hydrocarbons
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Groundwater Abstraction: Implications

The volume estimated to changed over months – reduced to 35 000 m³/day:

Abstraction cannot be from one point

A labyrinth of new pipelines with pump stations will be required for collection at one/few points before transferring to an existing WTW – given the highly dense built-up area on the Cape Flats
Groundwater Abstraction: Implications

Quality of the Cape Flats aquifer:

Due to the deterioration of groundwater quality, significant upgrades at the current WTW will be required (for advanced treatment processes)

An example of the spatial variation of water quality in the Cape Flats
(Water SA vol.36 n.4 Pretoria Jul. 2010.)
Groundwater Abstraction: Implications

The SINKING Coastal Cities of the World

Climate change
- Accelerated sea level rise
- Extreme weather events

Socio-economic development
- Urbanization and population growth
- Increased water demand

Sea level rise 3 - 10 mm/year

Subsidence 6 - 100 mm/year

Causes
- Groundwater extraction
- Oil, gas mining
- Tectonics

Sinking coastal cities
G. Erkens, T. Bucx, R. Dam, G. de Lange, and J. Lambert
Published: 12 November 2015
The **SINKING** Coastal Cities of the World

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Impacts
- Increased flood risk
- Damage to buildings, infrastructure
- Disruption of water management

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New Orleans, Louisiana, US
14.5 inches of sea level rise by 2040

Groundwater pumping and dewatering are believed to be the primary reasons.
The **SINKING** Coastal Cities of the World

**Causes**
- Groundwater extraction
- Oil, gas mining
- Tectonics

**Tokyo, Japan**

Up until the 1960s, the city was sinking by almost 4 inches every year. The rate went down after regulations were imposed on groundwater use.
Groundwater Abstraction: Implications

The **SINKING** Coastal Cities of the World

**Causes**
- Groundwater extraction
- Oil, gas mining
- Tectonics

**Ho Chi Minh City, Vietnam**

Many parts of the city are sinking by 0.2-0.4 inches per year.

The main reasons cited were **over-exploitation of underground water**
Groundwater Abstraction: Implications

The **SINKING** Coastal Cities of the World

**Causes**
- Groundwater extraction
- Oil, gas mining
- Tectonics

**Dhaka, Bangladesh**
The city has been sinking due to **extensive groundwater extraction**, leading to increased flooding.
Groundwater Abstraction: Implications

The SINKING Coastal Cities of the World

Causes
- Groundwater extraction
- Oil, gas mining
- Tectonics

Shanghai, China
In the last 100 years, the country’s biggest city has sunk by over 2.5 meters due to pumping of groundwater.
Groundwater Abstraction: Implications

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**Causes**
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Manila, Philippines

The capital city is sinking by about 4 inches each year due to over-pumping of groundwater.
Groundwater Abstraction: Implications

The SINKING Coastal Cities of the World

Causes
• Groundwater extraction
• Oil, gas mining
• Tectonics

Jakarta, Indonesia
One of the fastest sinking cities in the world (9.8 inches/year)
The main reason - residents rely heavily on wells extracting water from aquifers.
Groundwater Abstraction: Implications

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**Impacts**
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**Causes**
- Groundwater extraction
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Houston, Texas, US

Extensive extraction of groundwater and oil have led to the city sinking by around 2 inches per year.
Thank You