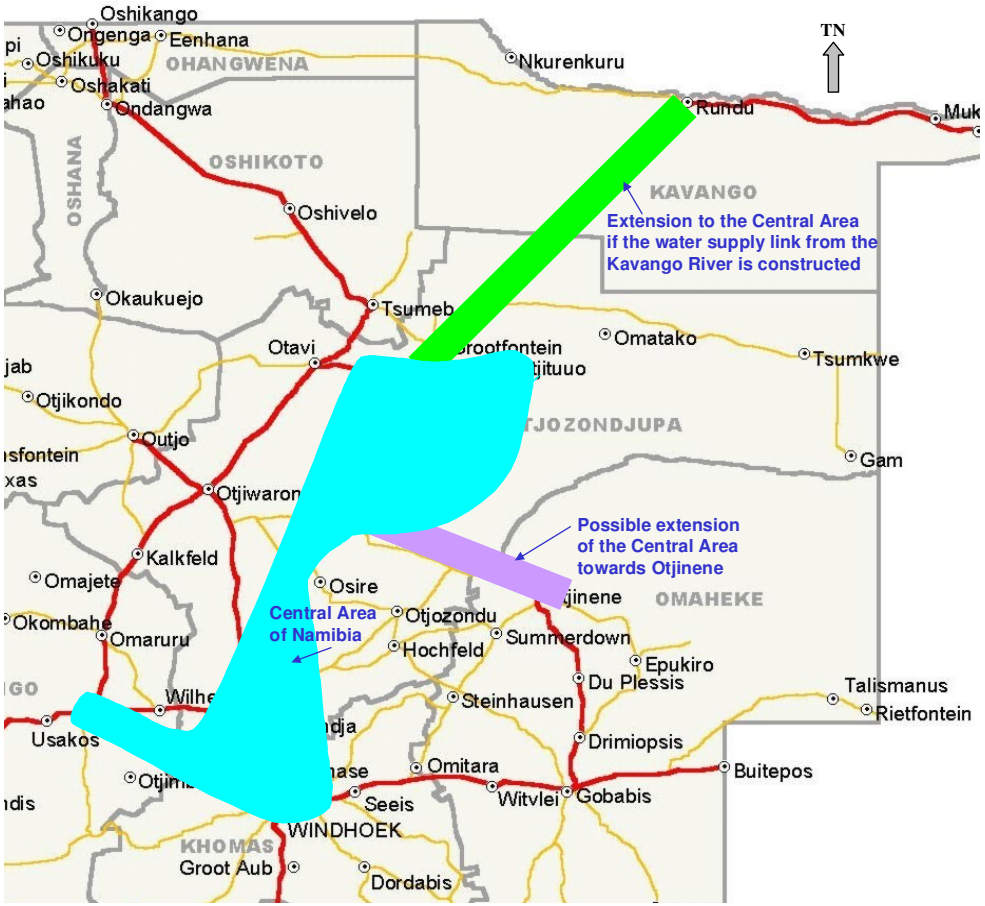
WINDHOEK
MANAGED AQUIFER RECHARGE

Immo Peters

City of Windhoek

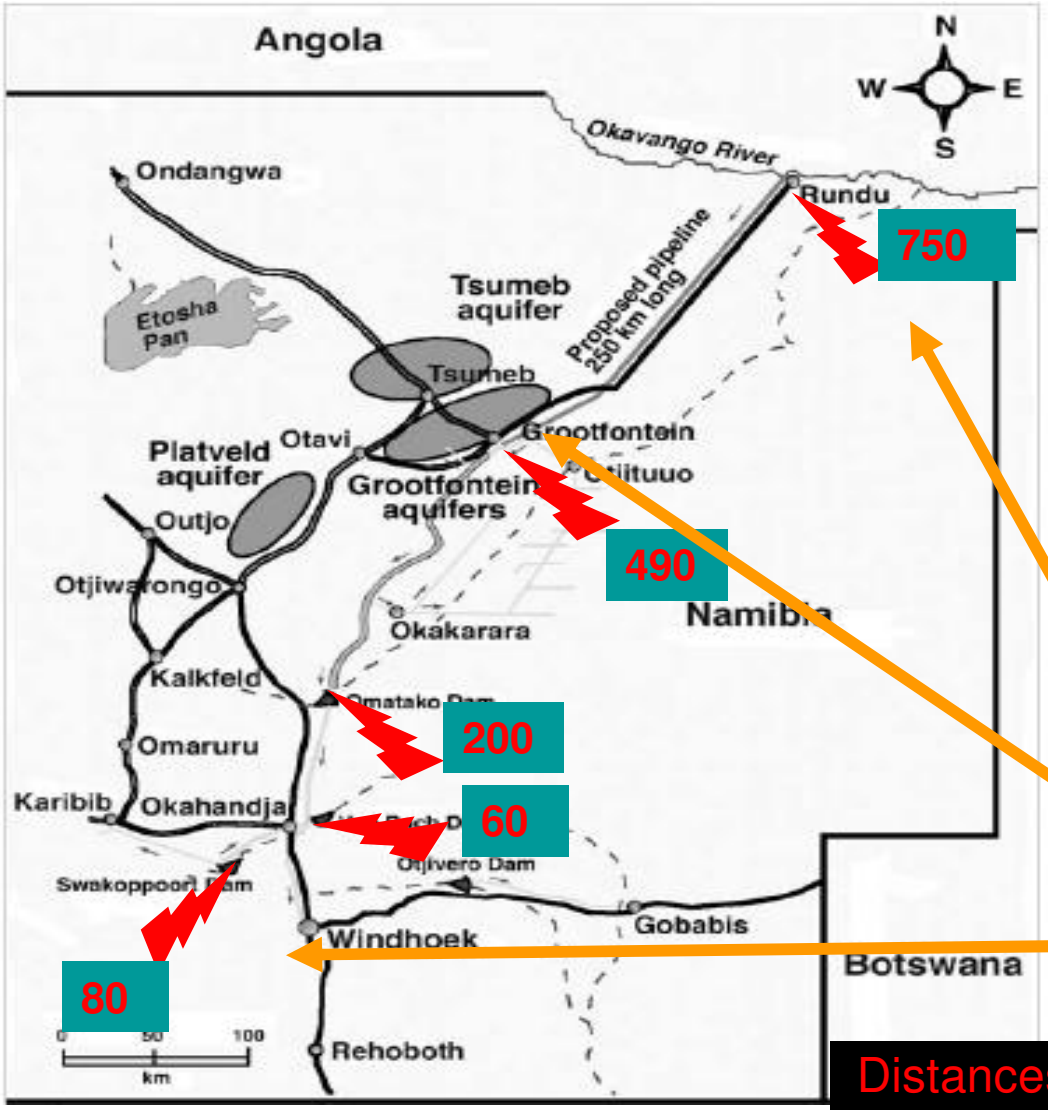
Content



Water Supply to the Central Areas of Namibia with a view towards Managed Aquifer Recharge and creating a Water Bank

- -Water Supply Set-up
- -Managed Aquifer Recharge and Benefits
- -Key Issues and Economic benefits

Water Supply and Relevant Cost to Windhoek

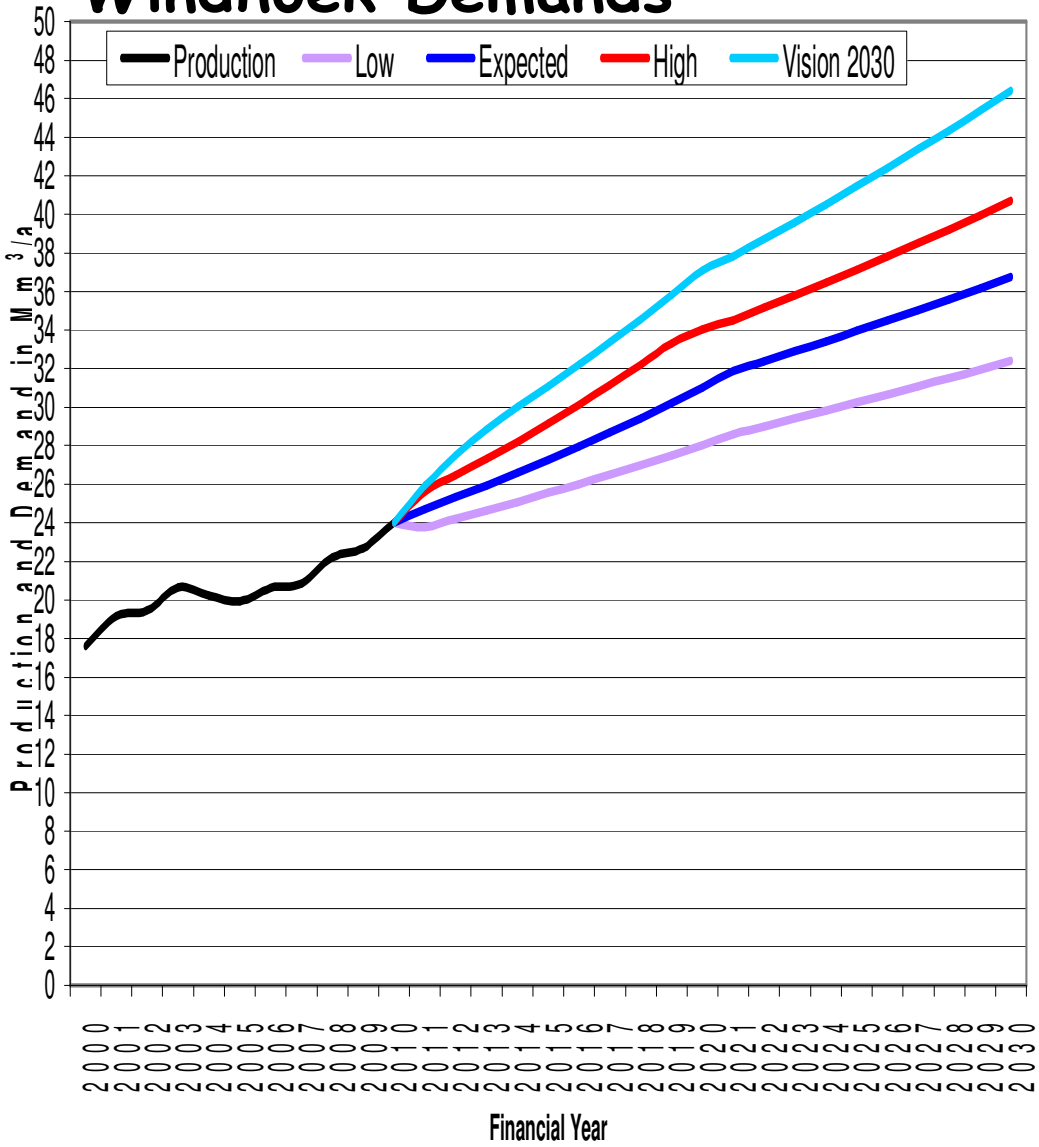


Cost of Water (2013)

Windhoek supplies

	N$/m³
Ground water	4.80
NamWater Supply	9.00
Reclaimed	9.00
Re-use irrigation	6.30
Additional supplies	
Okavango pipeline	45.00
Tsumeb aquifer	30.00
Aquifer Recharge	16.20

Windhoek Demands



Available Sources

Conventional Sources

	Mm³/a
Three dam system	17
Ground water Karst	2.8
Windhoek boreholes	1.73

UNCONVENTIONAL SOURCES

WDM:	30%+ realised
Savings since 1994	(+/-) 96

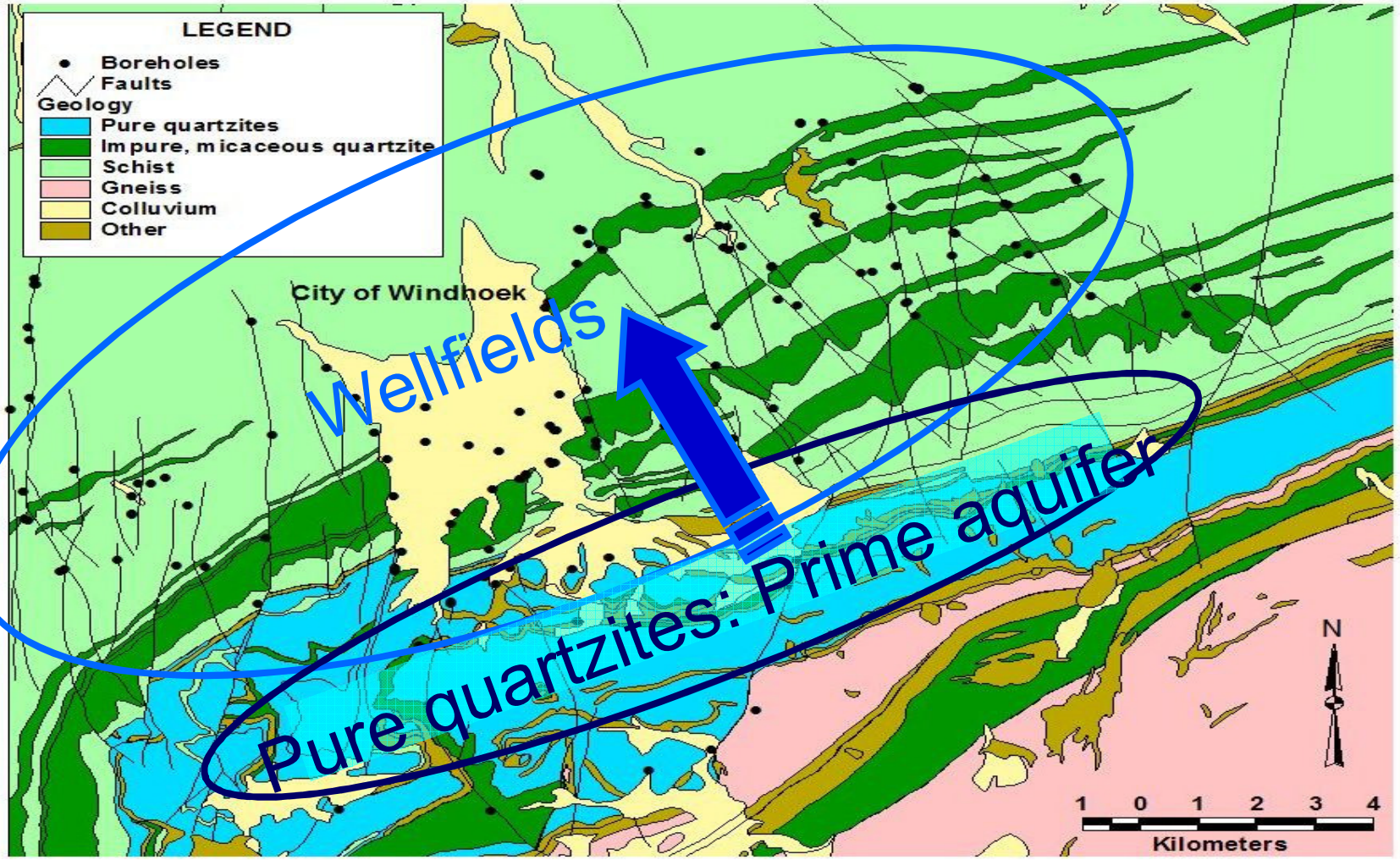
POTABLE REUSE (1968)

Plant capacity	7.6
% total supply	32%
	(7% unblended)

Shortfalls in the Past

- In 1981/84 shortfall of 40%
- In 1996/97 shortfall 50%, inflow 6 weeks before restrictions, Berg Aukas pipeline collar failure took 3 years to fix
- November 2010, Von Bach 34% Swakoppoort water not treatable as result of Blue Green Algae

Hydrogeological Set-up

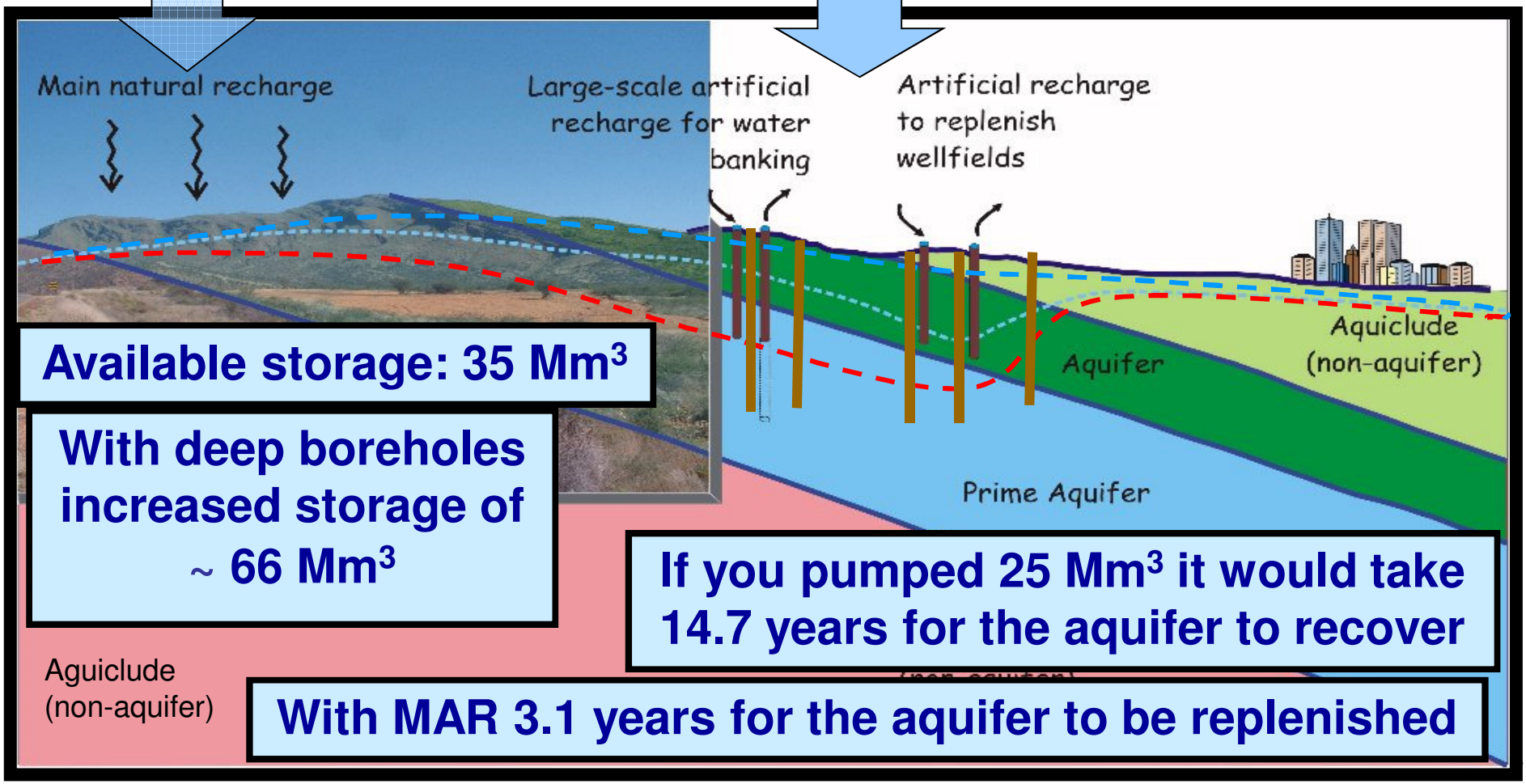


VALUE WITH MAR

Natural replenishment 1.7 Mm^3/year (~ 7% of demand)

Borehole injection 8 Mm^3/year (~ 32%)

City's water use: Currently ~ 25 Mm^3/year



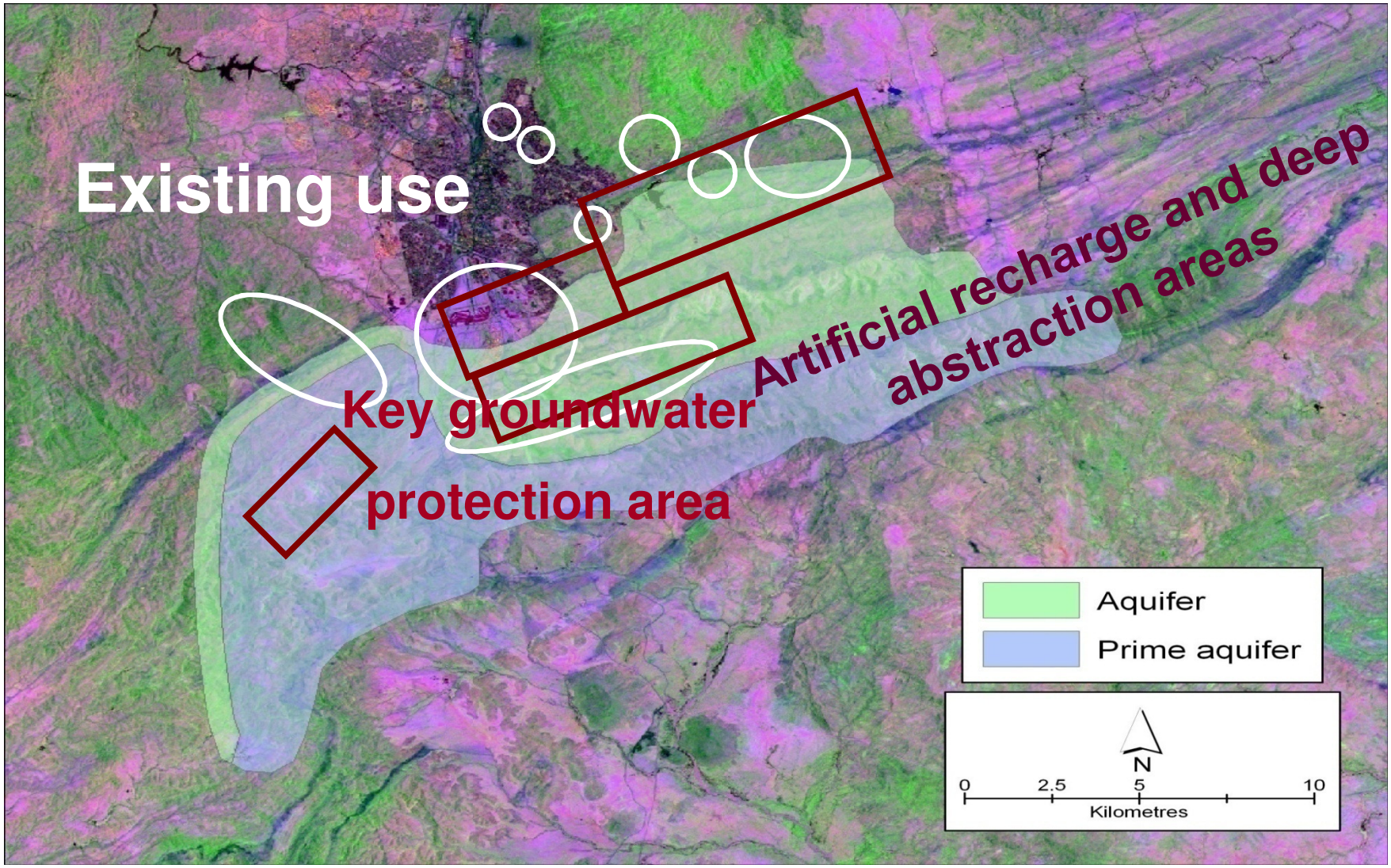
Available storage: 35 Mm^3

With deep boreholes increased storage of ~ 66 Mm^3

If you pumped 25 Mm^3 it would take 14.7 years for the aquifer to recover

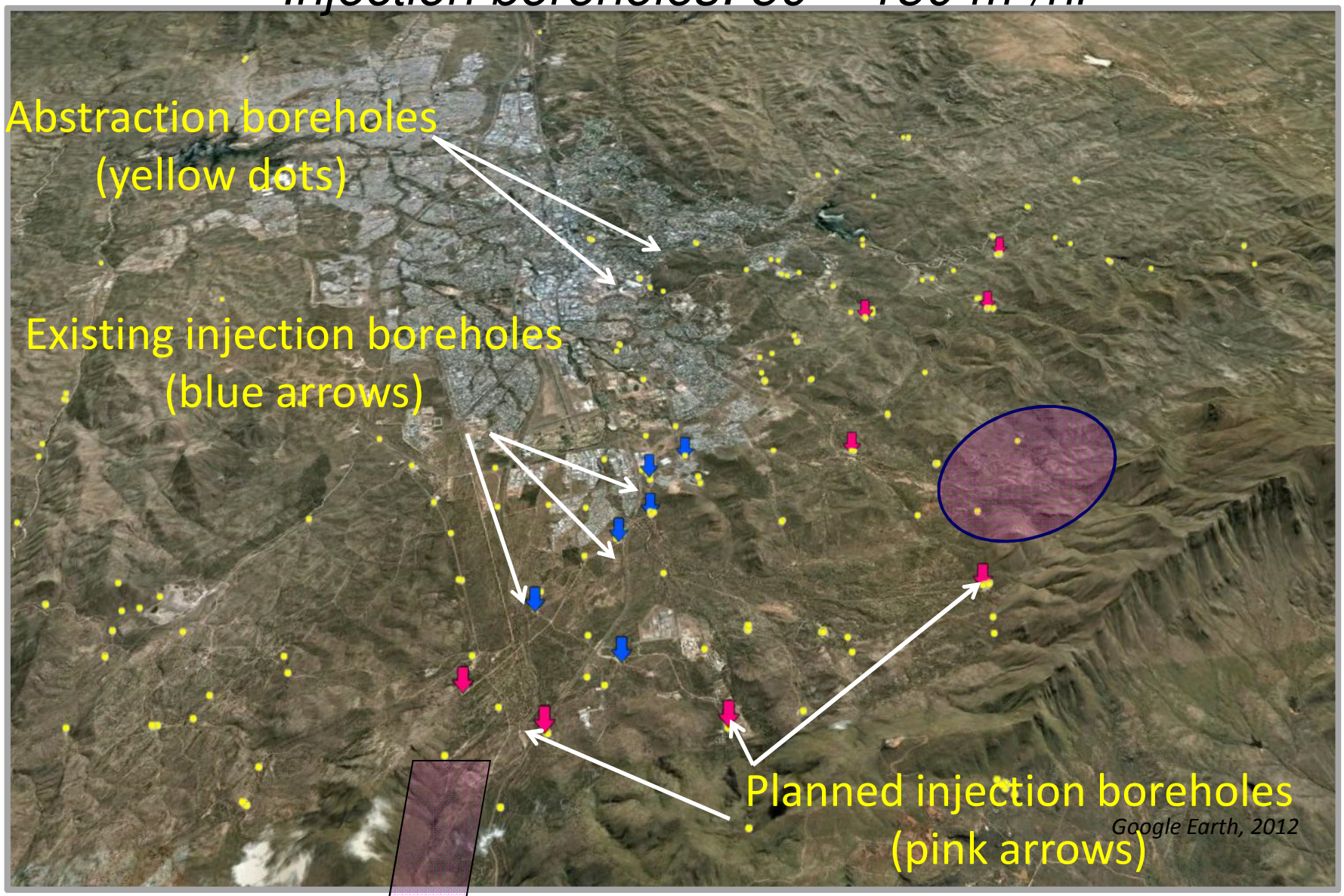
With MAR 3.1 years for the aquifer to be replenished

Main Well Field Area and MAR Areas

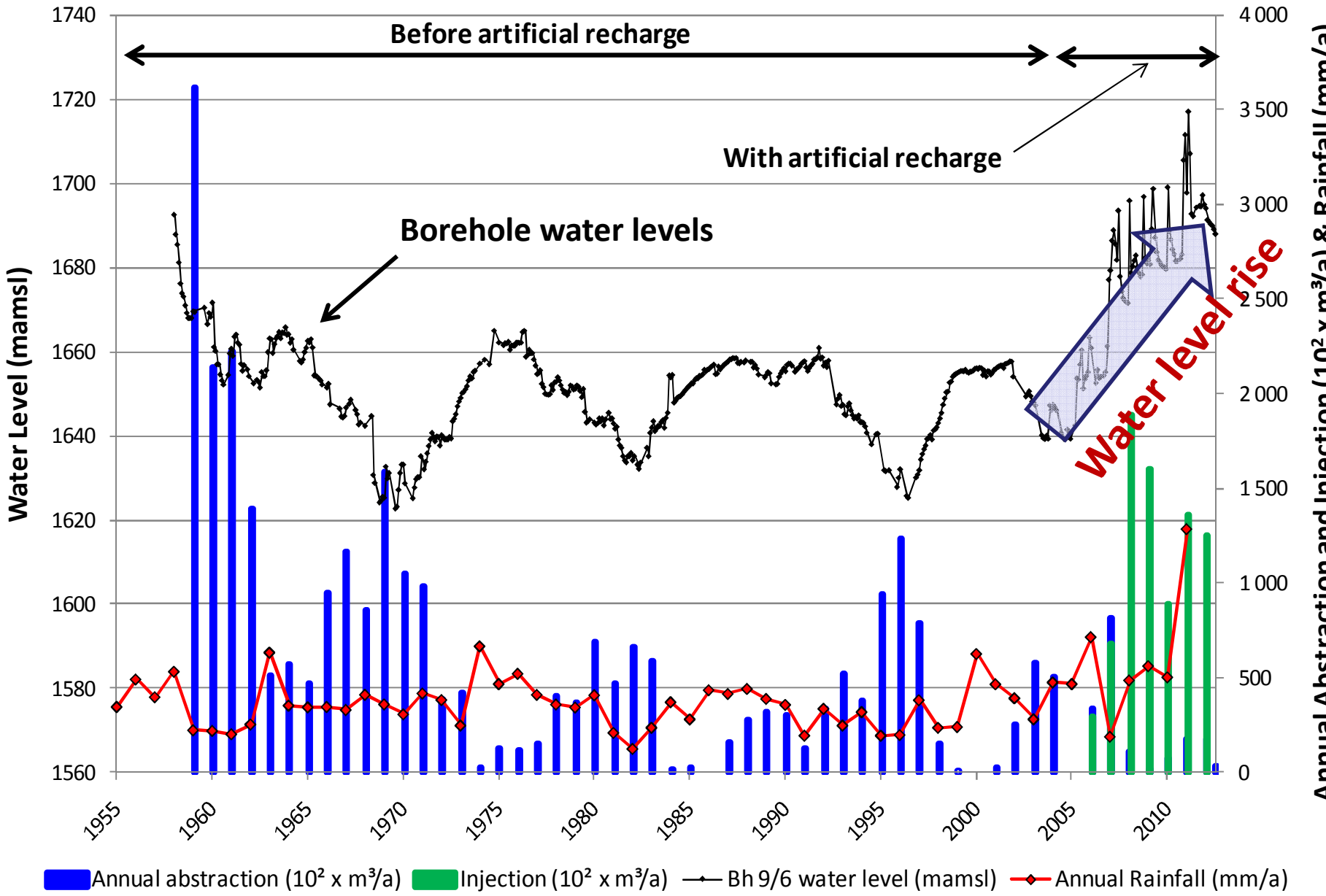


Abstraction boreholes: Planned pump depths up to 350 m; yields up to 200 m^3/hr

Injection boreholes: 50 – 150 m^3/hr



Borehole 9/6 - Water level vs Annual Abstraction and Injection



The water levels are back to their pre-1960 levels for the first time

Benefits to SADC and Windhoek

- Reduction of potential abstraction from the Okavango River or other sources
- Demonstration project for other arid SADC countries

- It is an efficiency improvement of existing sources (lower evaporation, bigger water bank)
- Previously non-viable sources become viable to keep the "water bank" full
- Water demand management actions will free up water for injection
- Lower peaks on the bulk system through aquifer storage and recovery
- The environmental impacts are minimal

MANAGED AQUIFER RECHARGE

(Unconventional, R&D 1998/99, Phase 1 2004 completed)

Year	2004 (Mm^3/a)	2008 (Mm^3/a)	2011 (Mm^3/a)	2018 (Mm^3/a)
Required abstraction rate	5.5	11.0	16.5	19.0
Estimated aquifer storage	35.0	47.0	66.0	66.0
Total artificial recharge	3.1	4.0	4.0	8.0

- Boreholes completed up to 2008 target
- Borehole infrastructure way behind
- Injection infrastructure 3.5 Mm^3/a
- CoW capital investment to date 57.8 million

RISK OF FAILURE CAN

The probability of failure based on the current status of bulk supply from May 2014 is:

- 98% probability that shortfalls up to 10 Mm^3/a;
- 80% probability that shortfalls up to 25 Mm^3/a;
- 50% probability that shortfalls up to 33 Mm^3/a;
- 20% probability that shortfalls up to 38 Mm3/a may occur in any year.

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WATER QUALITY PRINCIPLES

- No negative environmental impact of significance.
- Sustainable use of water from the Windhoek Aquifer for drinking water purposes preferably with limited treatment such as stabilisation and disinfection:

a) The recharge water should meet modern drinking water standards)

b) No additional health risk for the residents of Windhoek.

- No technical problems should arise due to injection water quality, such as clogging, corrosion and demand for extensive treatment of water before distribution.
- Accept a deterioration of certain quality parameters of the water within the aquifer provided that the water quality after abstraction complies with acceptable water quality guidelines.

OPERATIONAL WATER QUALITY

- Injected water:
- Average salinity: 68 mS/m or 456 mg/L TDS (based on a 95% percentile)
- Average Dissolved Organic Carbon (DOC): 4.9 mg/L (based on a 95% percentile and 2.9 mg/L on a 50% percentile).
- AOC not measured
- Recovered water:
- The water is blended with natural groundwater.
- Average salinity : 91 mS/m or 610 mg/L TDS (based on a 95% percentile)
- Average DOC of 1.1 mg/L (based on a 95% percentile and 0.4 on a 50% percentile).

NAMWATER PROJECTS

Project	Institution	Costs (N$ million)	Remarks
Pump station upgrade	NamWater	200	Required not only for WMARS
Von Bach recycling of supernatant	NamWater	23,5	Important for security of supply. Recycle water is enough to supply water to Okahandja and surrounding users.
Von Bach Windhoek Pipeline	NamWater	908	Required not only for MAR
DAF Swakoppoort	NamWater	47,8	Important for security of supply
Powerline upgrade Swakoppoort	NamWater	34	Not required for WMARS important for security of supply

CoW ESTIMATED CAPITAL

Component	Total (N$ Million)
Reservoir storage	10
Pipelines and Recharge Pump Stations	150
Boreholes	65
Mechanical & Electrical Works including supply	130
Civil Works	10
Total Development Cost	**365**

FINANCIAL INDICATORS

Indicator	Discount Rate WACC (13.42%/y)	Discount Rate Bonds (11.28%/y)
NPV N$ million until 2030	220.19	448.43
IRR until 2030	16.40%	16.40%
PI until 2030	1.08	1.15

CHALLENGES

SWAKOPPOORT DAM (Blue Green Algae)

- Quality of water put underground
- Pollution threat (existing & new developments)
- MAR Scheme management (Company?)
- Implementation on time

ECONOMIC POTENTIAL

1. Loss by industry Windhoek & Okahandja = estimated N$ 5.35 billion/a (17 N$ Million/day)

2. Loss by stopping new buildings/construction = estimated N$ 2.45 billion/a+ (2012)

3 Potential job losses in general industry and building/construction = approximately 6% of total employment in the country

Required Capital Investment

NamWater	N$ 200 million
City of Windhoek	N$ 375 million

LARGE DIAMETER DEEP BOREHOLE

CARBON FILTRATION 1998

"We are faced with a series of great opportunities brilliantly disguised as impossible situations"

Adapted from Charles Swindoll

"If you can't fly run. If you can't walk, crawl. But whatever you do keep moving"

Martin Luther King