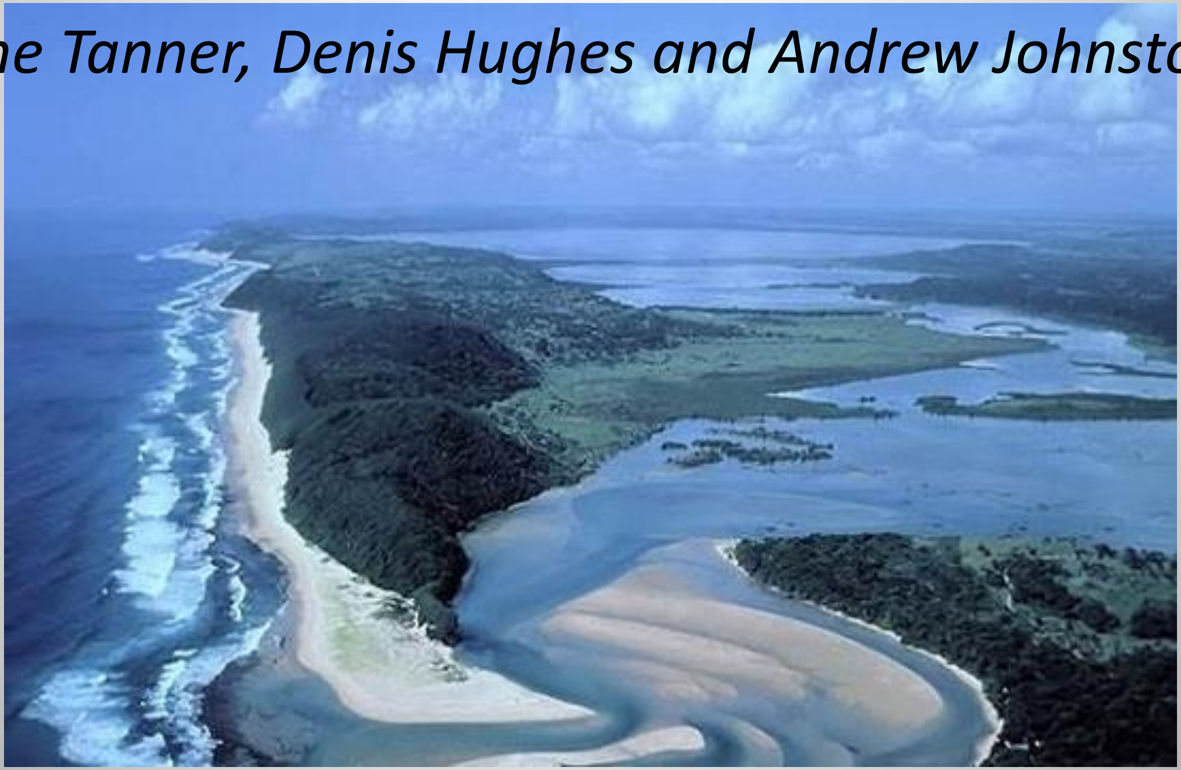
The effects of land use change on the surface water/groundwater resources supporting the coastal lakes and wetlands within the iSimangaliso Wetland Park, South Africa.

Jane Tanner, Denis Hughes and Andrew Johnstone



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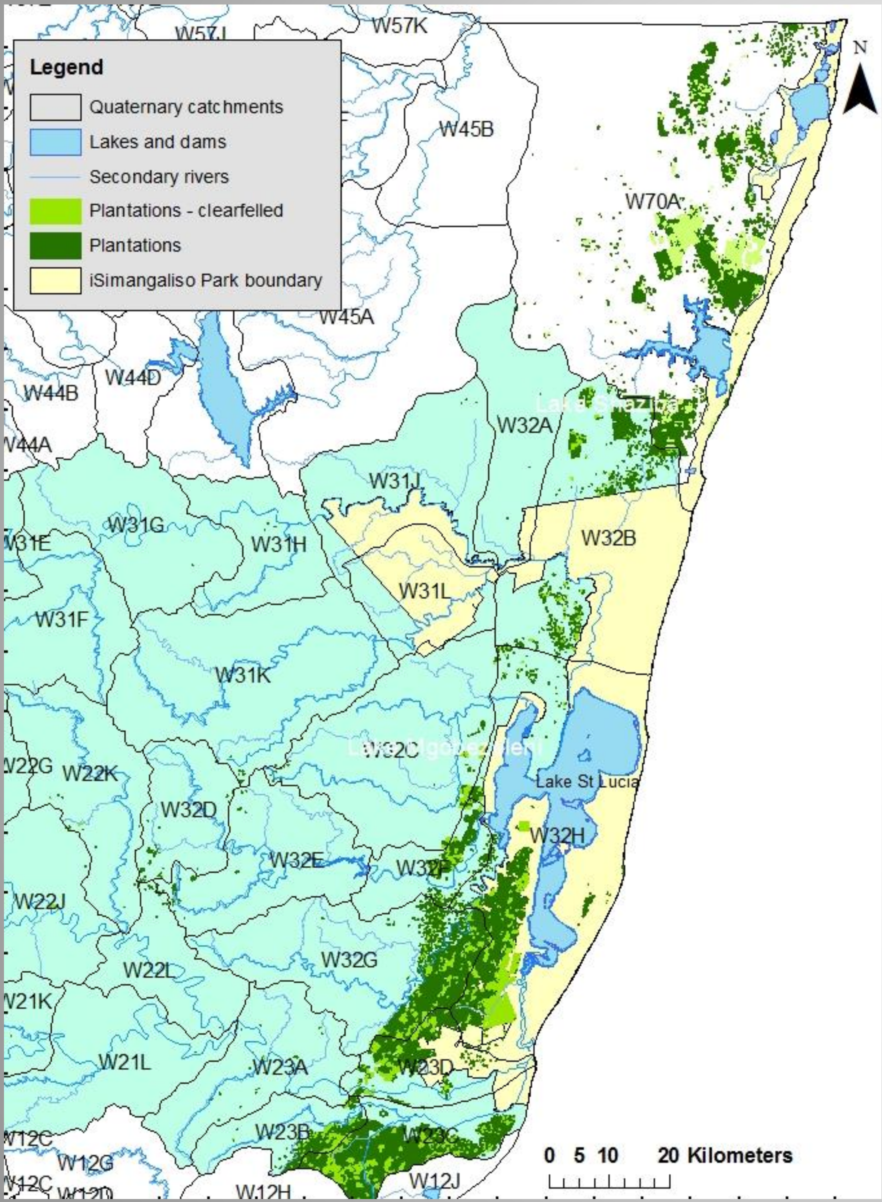
iSimangaliso Wetland Park



- South Africa's first World Heritage Site (1999),
- 3320 km^2 in size,
- Lakes, wetlands, swamp forests and Africa's largest estuarine system.

iSimangaliso Wetland Park

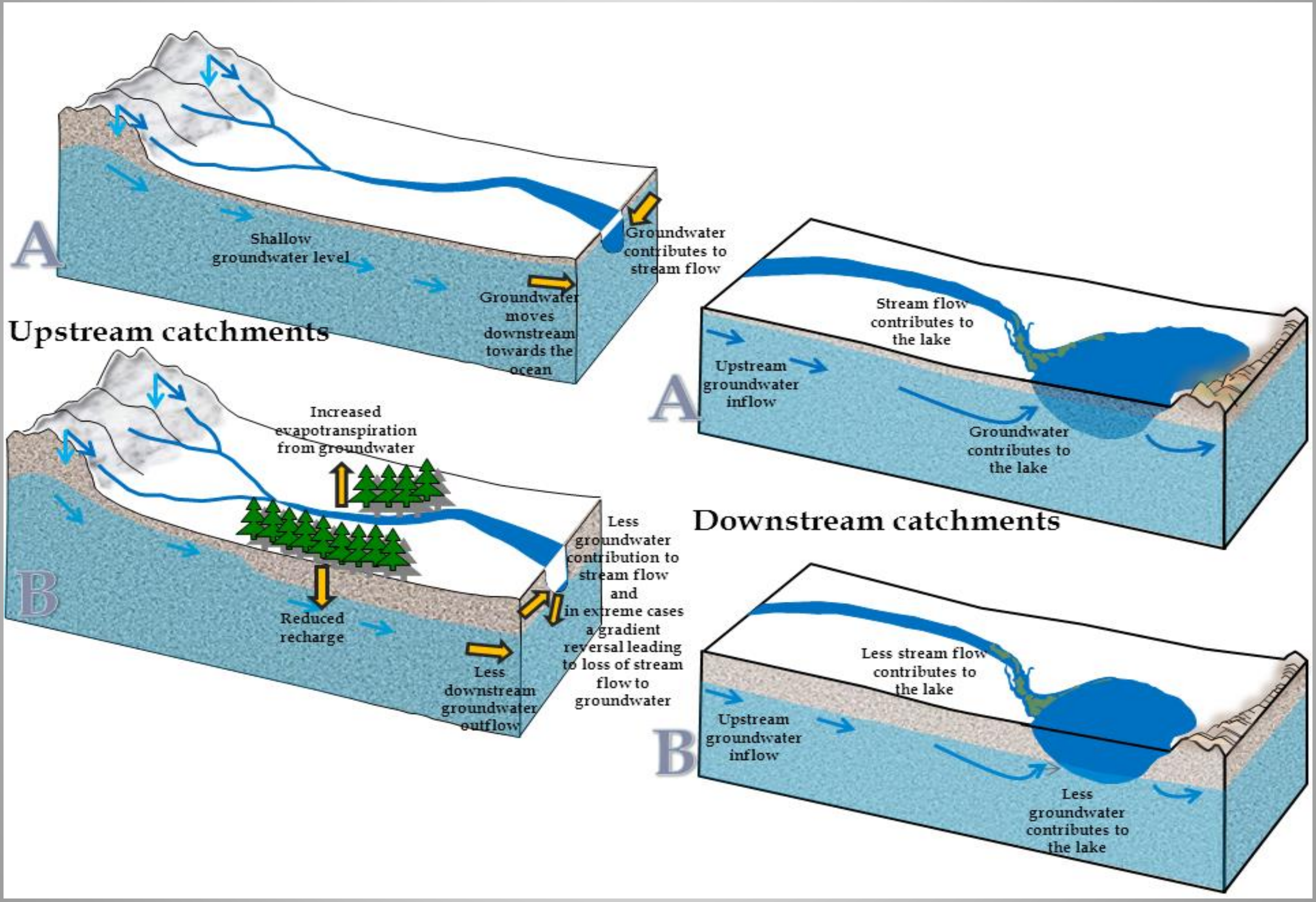
The research was funded through the iSimangaliso Wetland Park Authority's Global Environment Facility (GEF) project.

The effects of stream flow reduction activities on the water resources in the Park?

Introduction to investigation

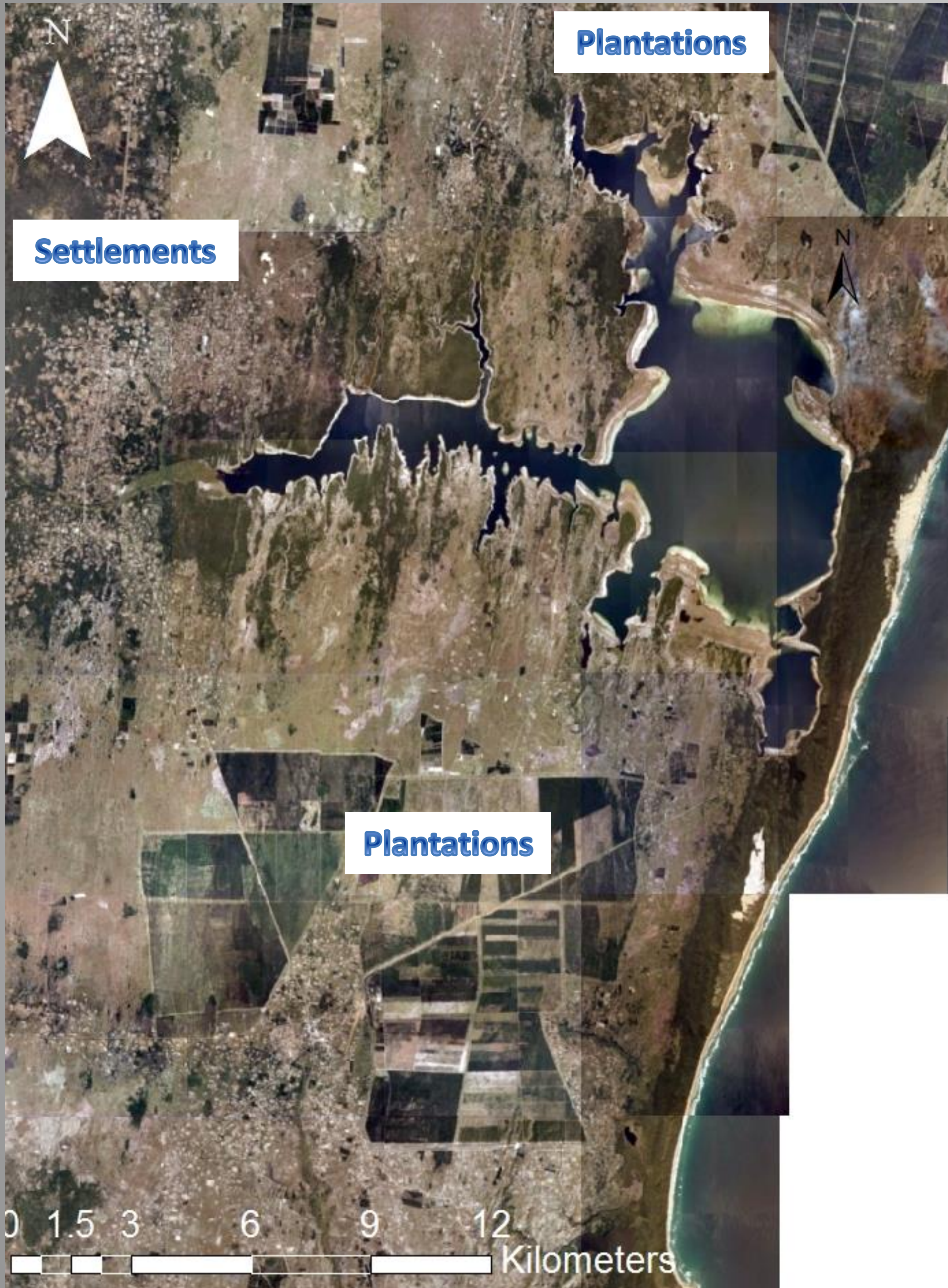
- Aimed to quantify surface water and groundwater resources sustaining lakes and wetlands in the Park,
- The lakes and wetlands can be viewed as surface expressions of the GW table,
- Significant water use outside of the Park, but within the catchment area of the lakes and wetlands,
- This includes substantial commercial plantation forestry,
- A primary aquifer with shallow GW levels mean plantation trees transpire both soil moisture and groundwater,
- Very little data, most information based on modelling exercises (scarce calibration/validation data).

SW and GW interactions in the coastal plain



Lake Sibaya

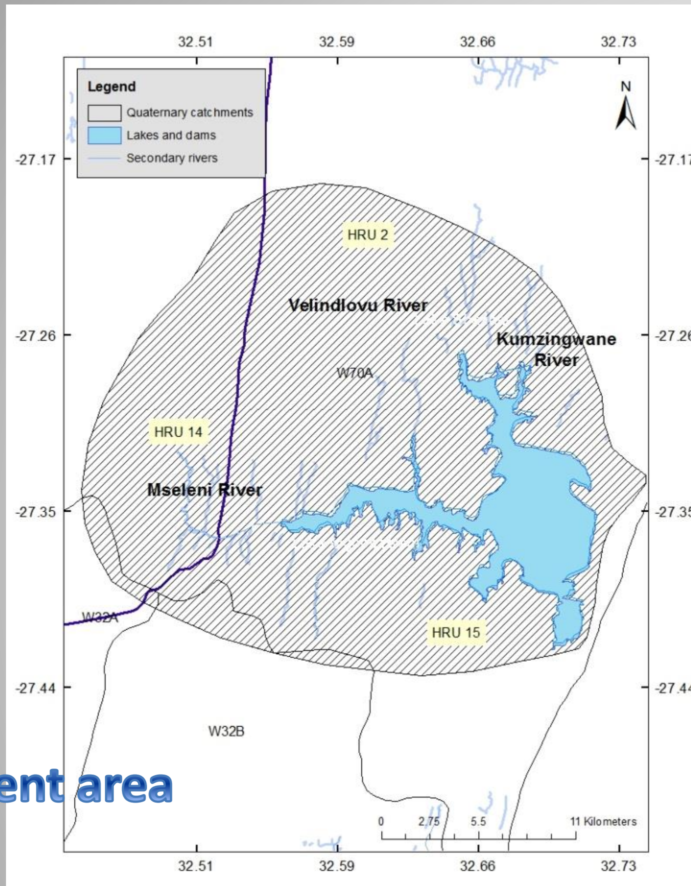
- Largest inland freshwater lake in RSA,
- Average surface area of 65 km^2,
- Predominantly GW Driven



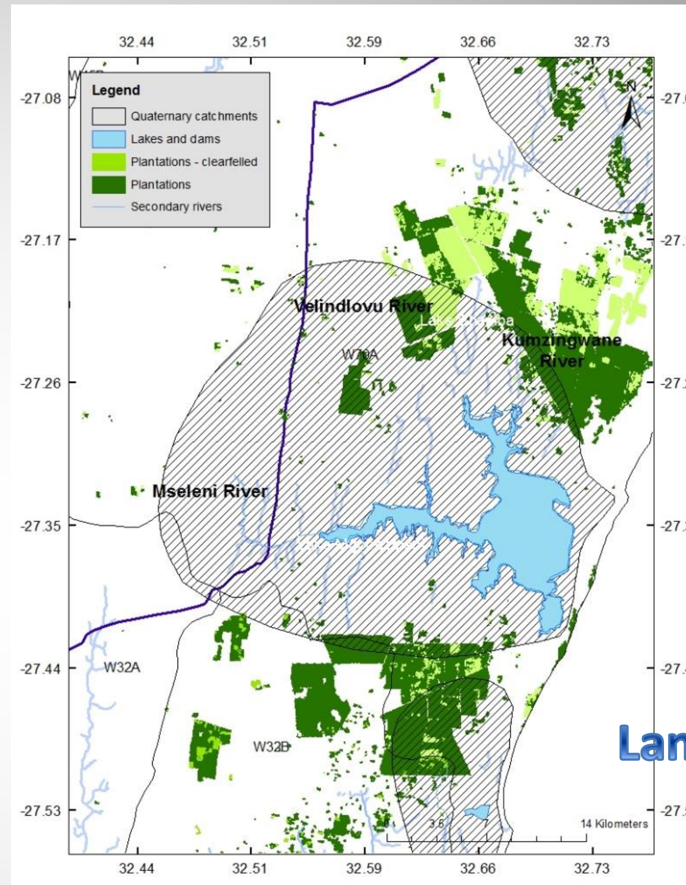
Lake Sibaya

- Underlain by the largest primary aquifer in RSA,
- Catchment area +- 500 km^2,
- MAP:
  - 700 mm/yr inland
  - 1000 mm/yr coast
- Bathymetry shows that small drops in volume cause significant changes to area of the lake,

Lake Sibaya



Catchment area



Land use

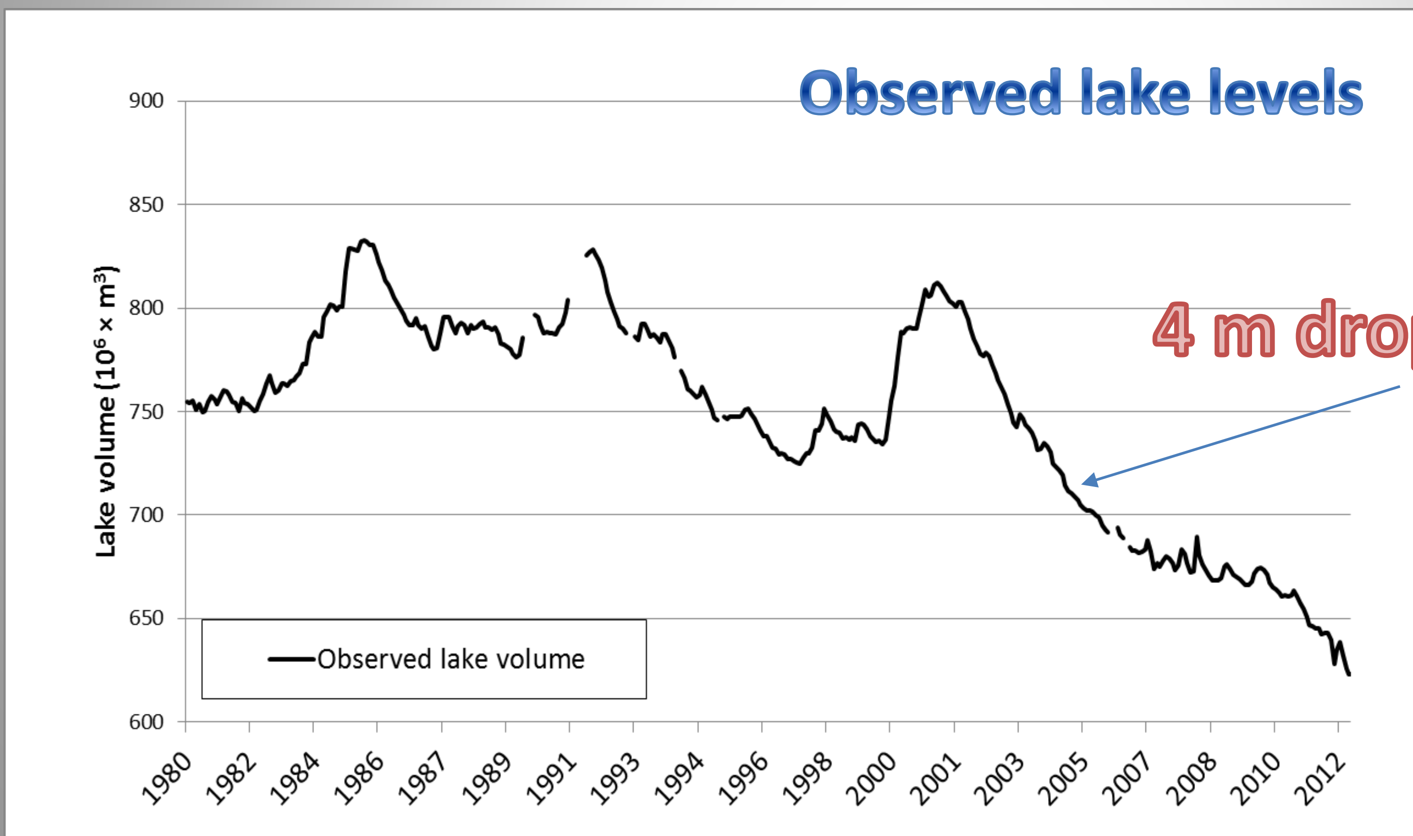
Hydrogeology (Meyer and Godfrey, 1995; Jeffares and Green, 2012)

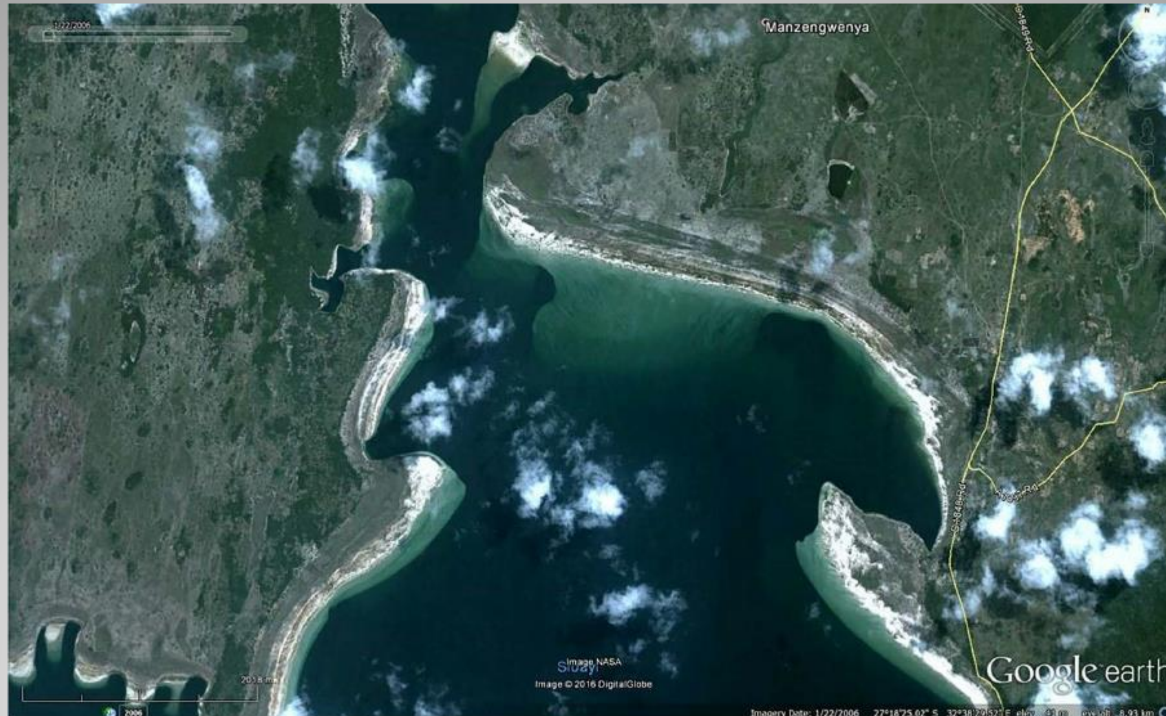
Aquifer name	Thickness (m)	K (m d^{-1})	T (m^2 d^{-1})	Borehole yields (L s^{-1})
Sibaya/KwaMbonambi	20-30*	0.87-15.6 (mean:~5)	-	0.5-5
Kosi Bay /Port Durnford Formation	15-20*	4-5 (mean:4.3)	-	2-10
Uloa/Umkwelane Formation	5-20	0.5-25 (mean:4.5)	116	5-25
St Lucia Formation	900	-	-	<1

Conceptual model of Lake Sibaya

Inflows:
- SW Runoff (incl. GW baseflow)
- Precipitation onto lake
- GW seepage

Outflows:
- ET
- Lake outflow
- Lake abstraction

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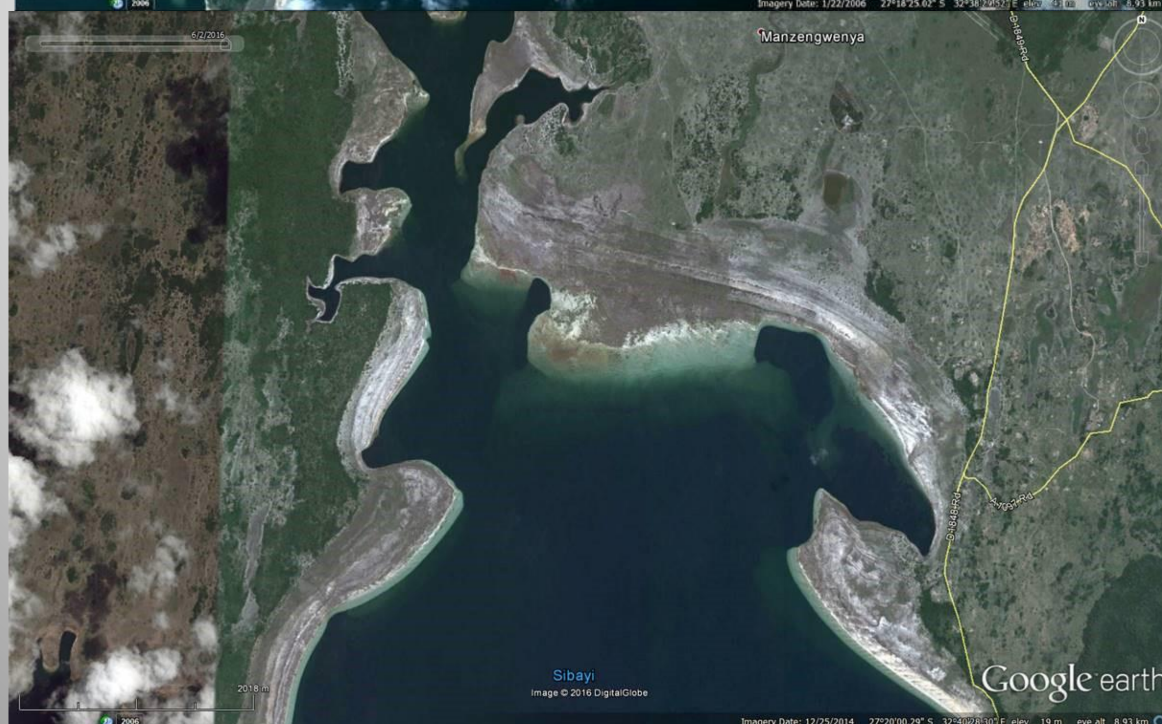
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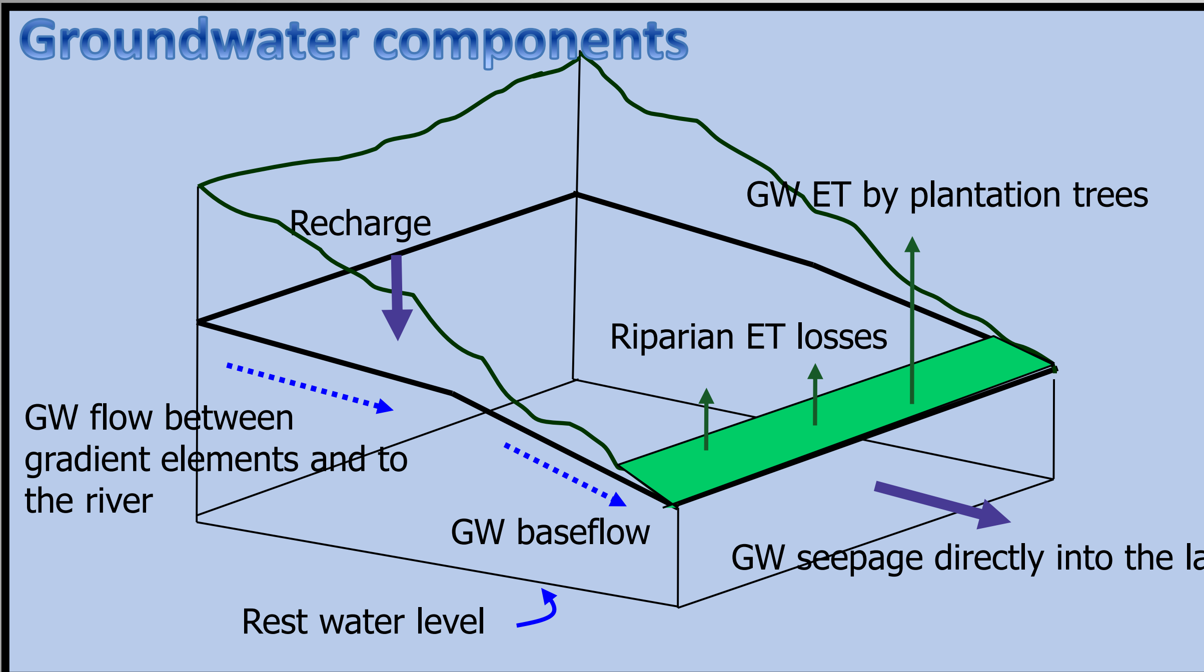
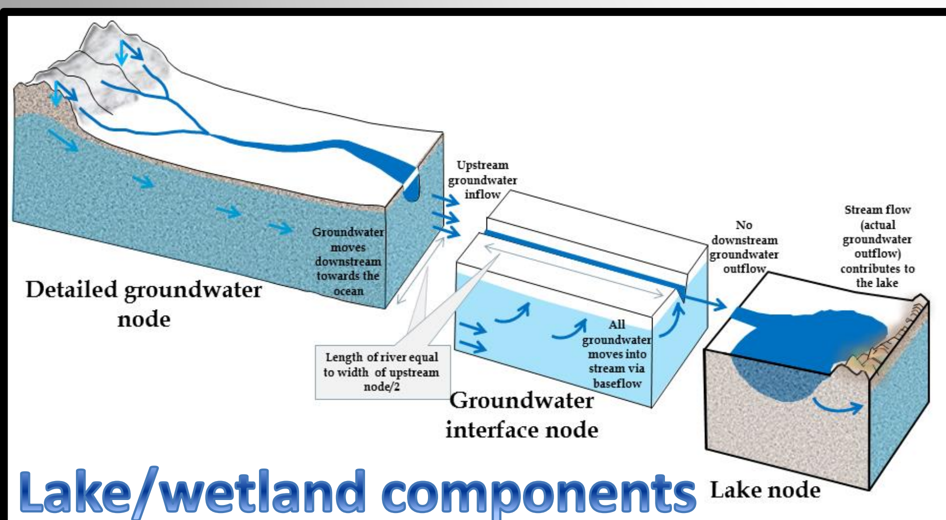
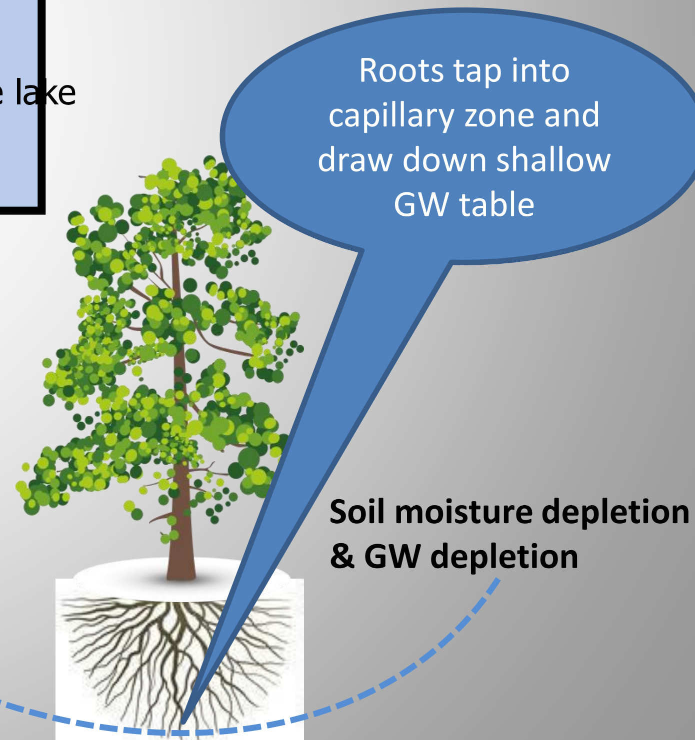
Setting up the Integrated Pitman Model



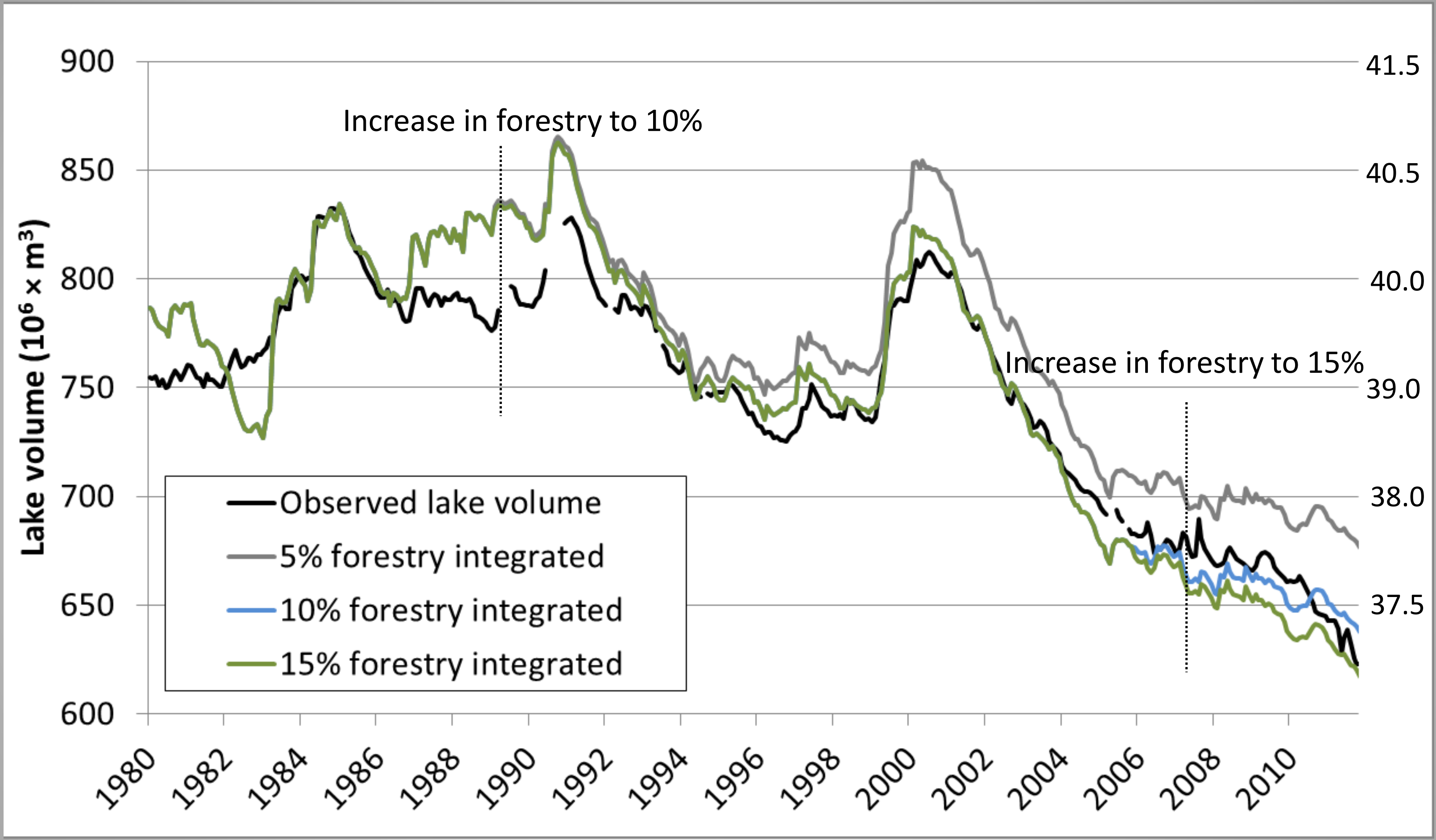
Lake outflow – Estimated area of palaeochannel & Darcy's Law

Brites (2013) Plantation GW use near Lake St Lucia





Results

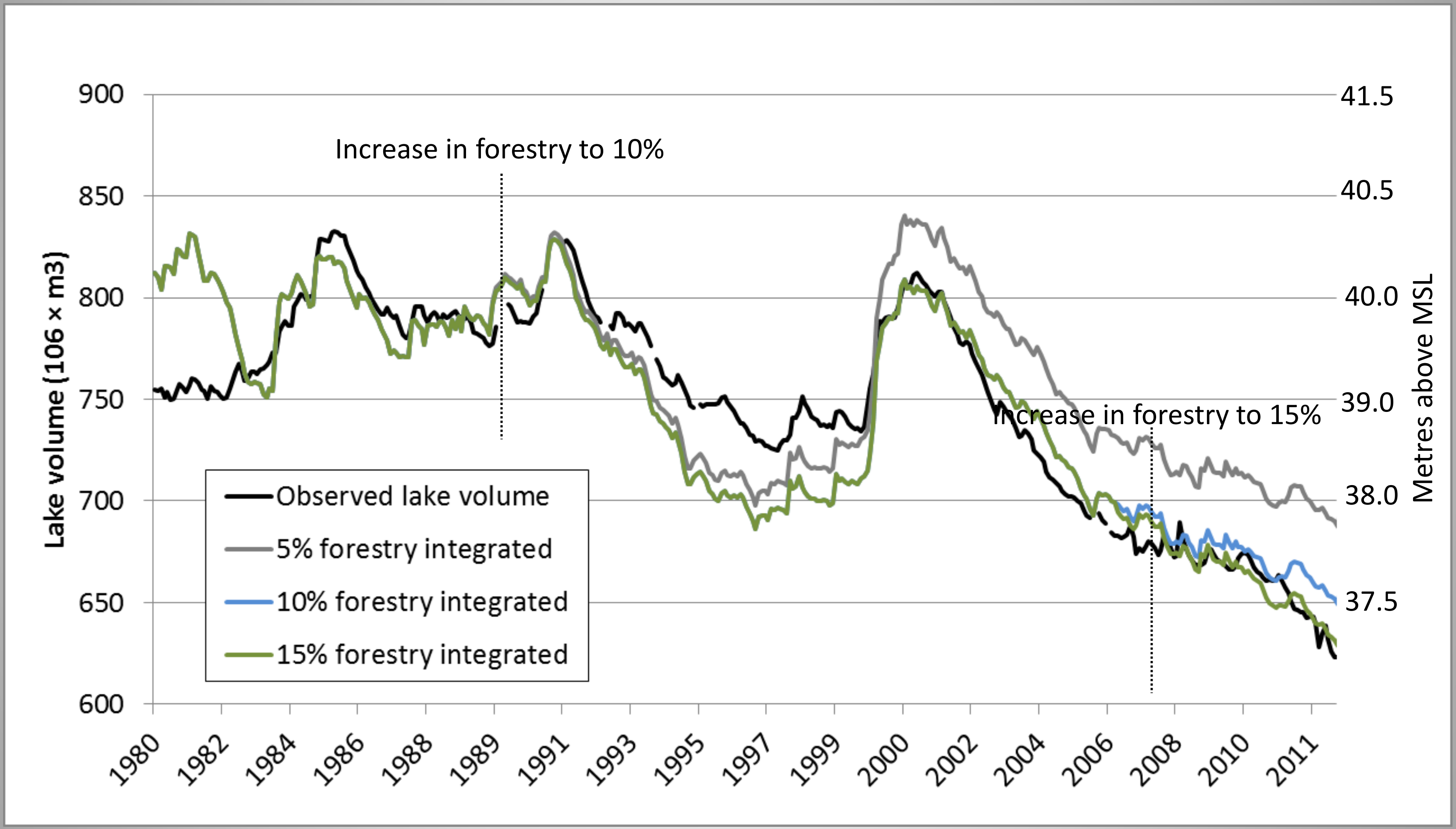


- **WR2005 climate data (with CRU from 2005)**
- **Integrated forestry**

Integration based on:

Simulation time period	Lake abstraction (10^6 m^3)	Groundwater abstraction (10^6 m^3)	Forestry - % of catchment area
1980	1.984	0	5.0
2000	2.284	0.0146	10.1
2011	2.884	0.0146	15.4

Results



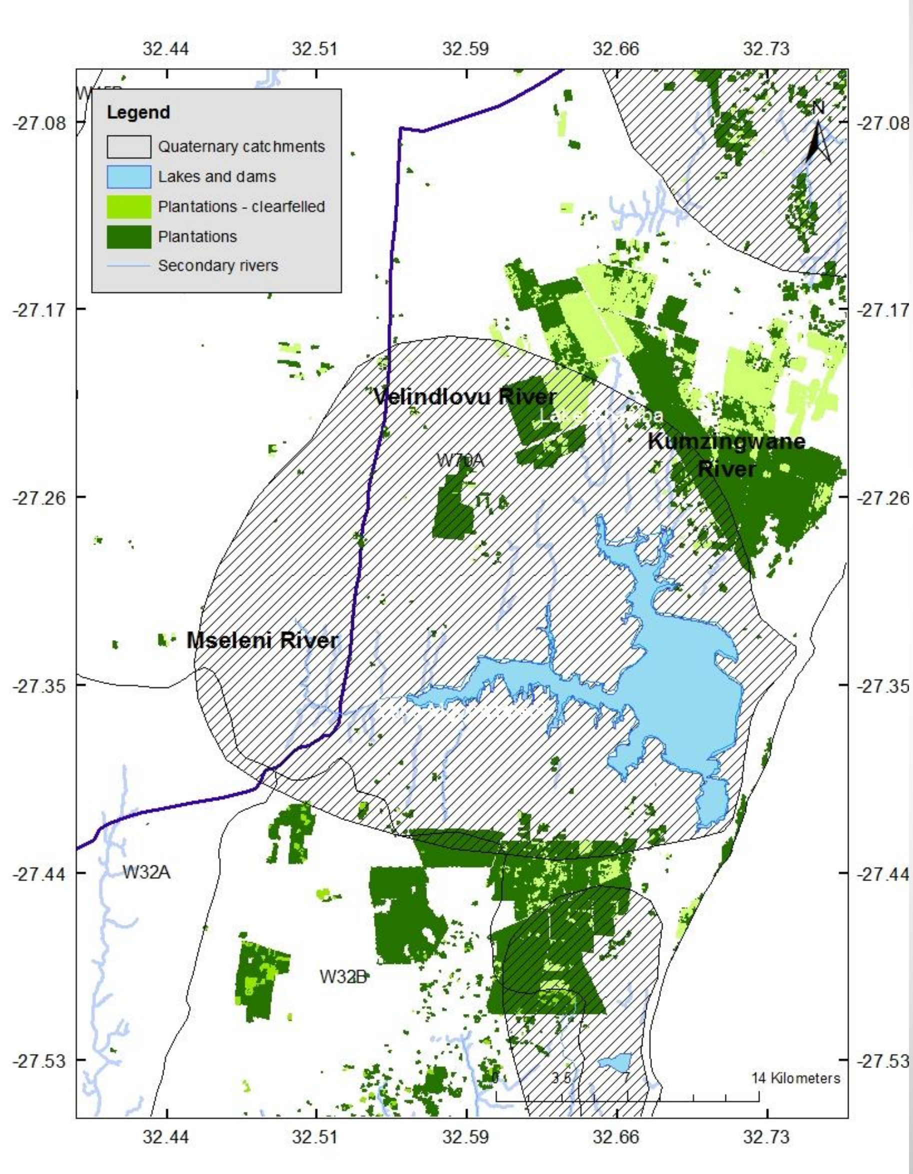
- **with CRU rainfall**
- **Integrated forestry**

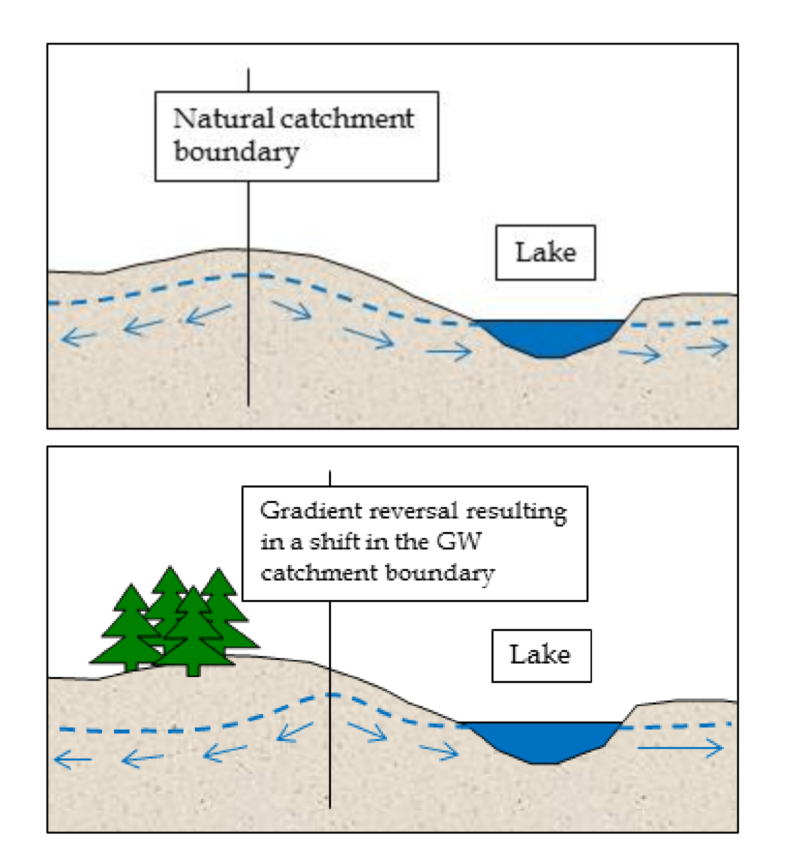
Simulated water balance

Water balance component (10^6 x m^3 $year^{-1}$)	1980 Water Use + 5% forestry	2000 Water Use + 10% forestry	2011 Water Use + 15% forestry
Precipitation onto the lake	61.3	60.2	59.9
Surface runoff into the lake	10.5 (2.5% MAP)	9.7 (2.3%)	8.7 (2.1% MAP)
Groundwater seepage into the lake	45.0 (10.6%)	39.7 (9.4%)	34.6 (8.2% MAP)
Lake evaporation	100.1	98.4	97.8
Lake outflow to the sea	16.6	14.9	14.4
Change in storage	+0.1	-3.7	-9

Difference between scenario A (1980) and scenario c (2011)	
Precipitation onto the lake	-1.4 (2% difference)
Surface runoff into the lake	-1.8 (17% difference)
Groundwater seepage into the lake	-10.4 (23% difference)
Lake evaporation	-2.2 (2% difference)
Lake outflow to the sea	-2.2 (13% difference)

Reversal of GW gradient?





Localised drawdown = reduced catchment boundary

Conclusions

- Significant impacts on lakes from anthropogenic sources for both SW and GW resources,
  - Majority of impact from forestry (24%),
- 4 m drop in lake level largely due to cumulative rainfall deficit from MAP,
- SW and GW so closely linked in this environment that system must be modelled in an integrated fashion (using a coupled model),
- GW use affects both GW seepage and GW baseflow,
- More research on forestry water use in regions with shallow groundwater.

Acknowledgment

This presentation is based on research commissioned by the iSimangaliso Wetland Park Authority on the effect of stream flow reduction activities on the water resources in the Park. The research was funded through the iSimangaliso Wetland Park Authority's Global Environment Facility (GEF) project.

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