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Engineering

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Groundwater, Mining and Sustainability in the Tropics :
Some Research Case Studies

PECC Bora Bora Water Resources Seminar
13 November 2007

Sustainability in 21st Century …

- **TWO KEY CHALLENGES :**

  - ENERGY ***- WATER***

- **Energy is closely linked to climate change**
- **Water is multi-faceted : quantity, quality, consumption …**
- ***Demonstrating long-term sustainability is the key challenge***

Presentation Overview

- **Sustainability – quick definition**
- **Groundwater in the Tropics**
  - **strong seasonality, water balance, recharge**
  - **Case Study : Ranger uranium mine, NT**
- **Mining in the Tropics**
  - **environmental considerations**
  - **Case Study : Rum Jungle uranium project, NT**
- **Groundwater and Climate Relationships**
  - **analysis techniques, climate change issues**
- **Summary**

‘Sustainability’

- **Brundtland Commission (WCED) :**

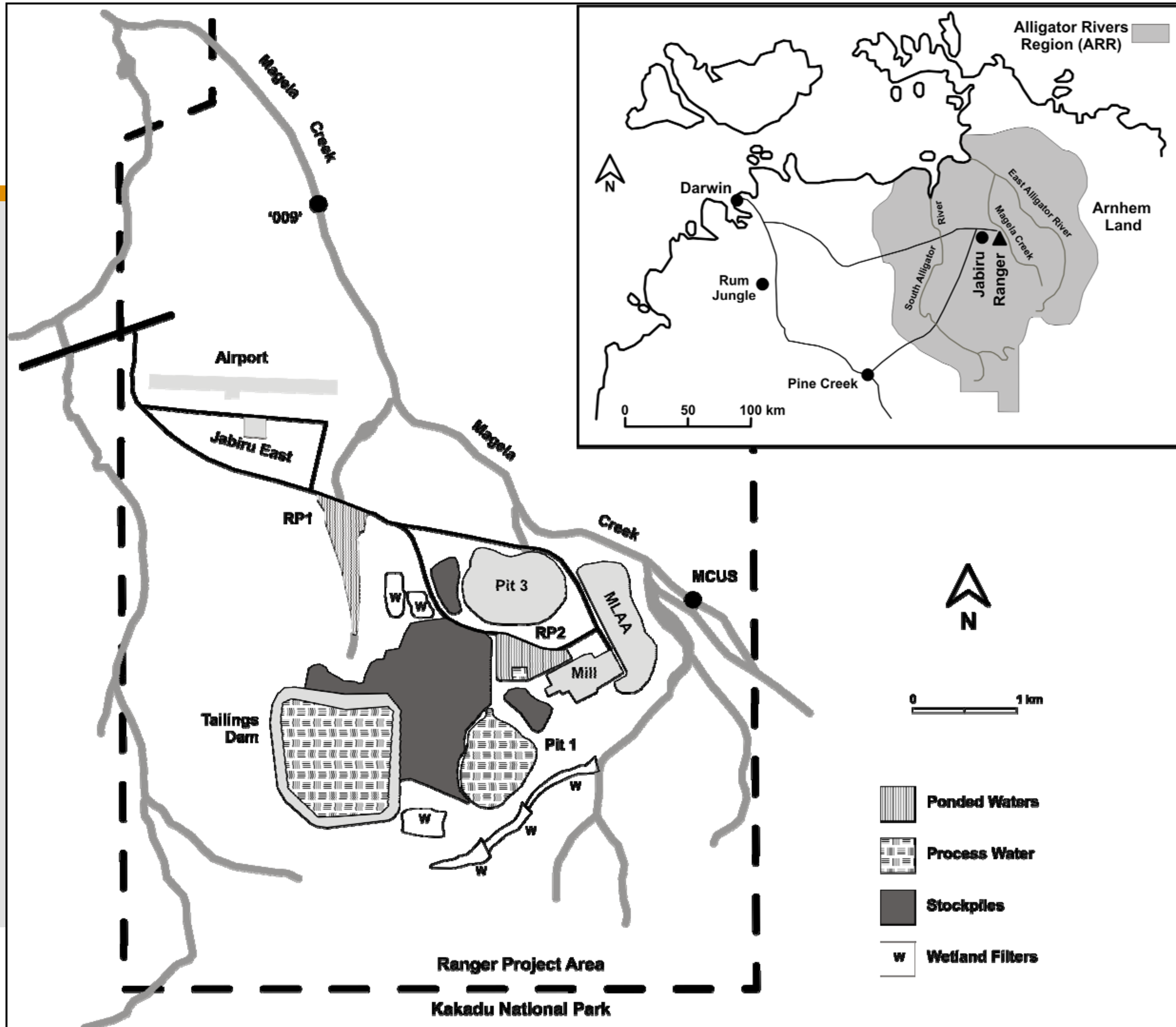
  “to meet the needs of the present without compromising the ability of future generations to meet their needs”

- **In general, taken to mean ongoing resource availabiltiy, healthy environment and vibrant, strong communities**
- **In practice, this is hard to demonstrate, especially quantify**
- **Tropical Islands : *imperative***

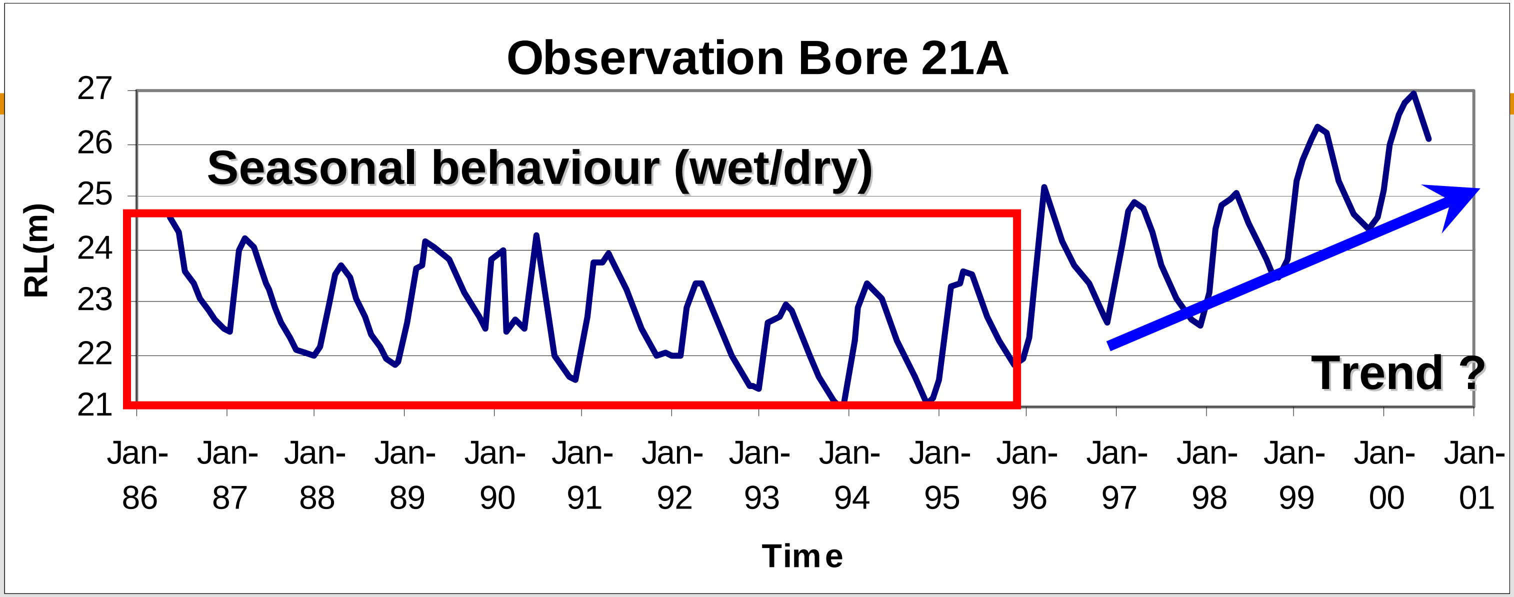
Groundwater in the Tropics

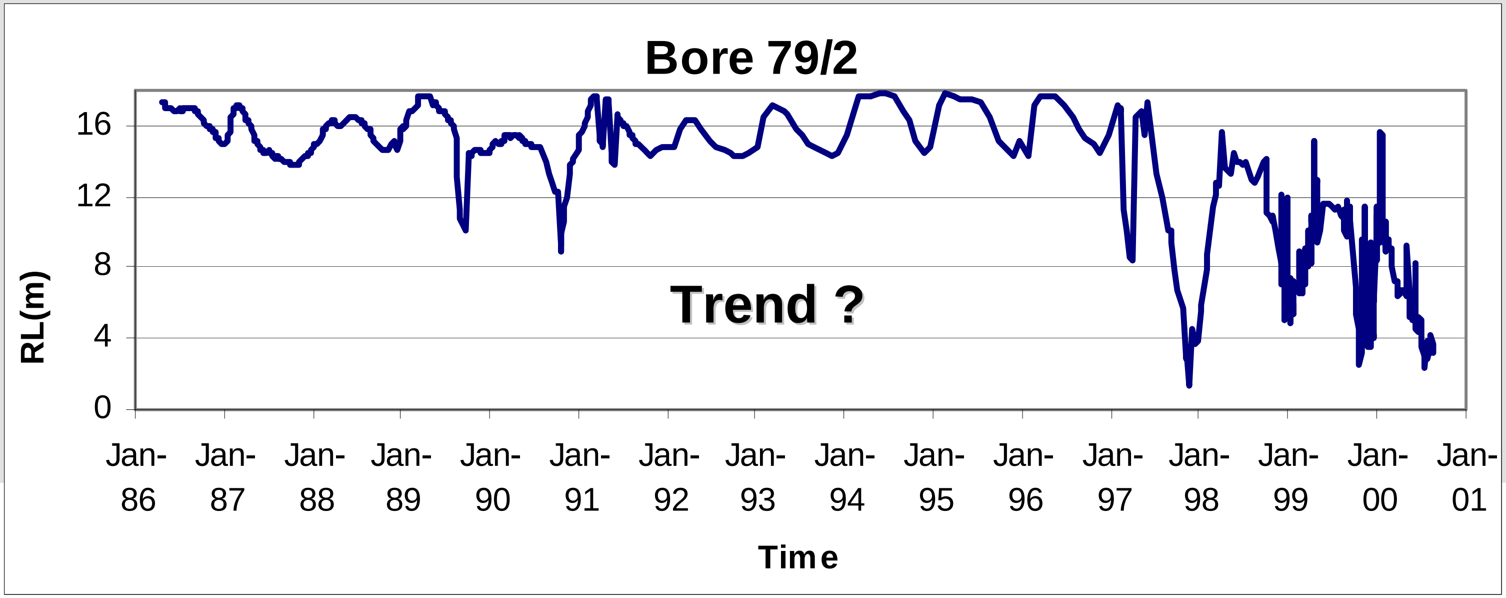
- Groundwater resources in tropics are very different to temperate and arid regions
- Strong seasonal climate drives seasonal recharge-discharge processes
- Groundwater resources are dynamic – responsive to climate or other drivers
- In northern Australia, groundwater behaviour can be interpreted as ‘one-dimensional’ : that is, mostly vertical through recharge during the ‘wet’, evapotranspiration in the ‘dry’

Ranger Uranium Project, NT



Ranger Uranium Mine, NT





Mining in the Tropics

- Mining is a major industry across the tropics
- Often adjacent to sensitive environments and/or concerned communities
  - *need for sound "sustainability" management*
- In northern Australia, major issues include location, mineral commodity, land use, and indigenous land rights
- Major mining projects include :
  - *uranium, lead-zinc-silver, bauxite, iron ore, gold , …*

Tropical Minesite Water Management

- In general, mines in tropical Australia are not allowed to discharge minesite waters to adjacent rivers : preference is for a 'zero-release' water management system
- Water quantity is important but often the most critical issue is water quality
- There remains a significant legacy of abandoned or poorly rehabilitated mines
- Significant debate is emerging over competition between mining / agriculture


URANIUM
MINING
NOT IN KAKADU
NOT ANYWHERE
URANIUM
LEAVE IT IN
THE GROUND
HIROSHIMAS

Ranger Water Quality Regulation

	pH	EC	Mg	SO_4	Mn	U	^{226}Ra
ANZECC Level	-	µS/cm	mg/L	mg/L	µg/L	µg/L	mBq/L
Focus	5.9-6.5 [a]	21 [b]	use EC [c]	use EC [c]	7 [d]	0.3 [e]	*not set*
Action	5.6-6.7 [a]	30 [b]	use EC [c]	use EC [c]	11 [d]	0.9 [e]	*not set*
Guideline / Limit	5.0-6.9 [a]	43 [b]	use EC [c]	use EC [c]	26 [d]	6 [e]	10 difference [f]
Retention Pond 1 (1980 to 1999) [g]	6.3-7.7	25-500	2.3-28	1-100	<2-37	0.2-10	*no data*
Retention Pond 2 (Sept. 2001 to Aug. 2004)	6.0-9.3	1,030-1,785	130-250	500-1,100	10-1,600	2,750-14,800	*no data*
Process Water (Nov. 1989 to Aug. 2000)	3.9-6.7	8,900-40,000	2,400-10000	6,700-61,000	710,000-4,200,000	420-3,900	*no data*
OSS Pre-ANZECC Concentrations	5.5-6.5 mean *(statistical)*	*not set*	20 limit *(ecological)*	200 limit *(drinking)*	50 limit *(human)*	10 limit *(toxicology)*	*not set*
NTDME Pre-ANZECC Maximum Allowable Additions	*not set*	*not set*	1.0	19	24	3.8	*not set*
Pre-ANZECC Loads	*not set*	*not set*	*not set*	*not set*	6 t/yr	~3.5 t/yr [h]	13 GBq/year

[a] A range is specified for pH to reflect natural variation in water quality processes.
[b] This is a combination of statistical analyses of MCUS and 009 data and is intended to provide a compromise between existing water quality impacts, the practicality of dilution v
the desire to work towards the express wishes of the Mirarr traditional owners for no change in water quality.
[c] Due to the Mg-SO_4 signature at 009, and the results emerging from research into the ecotoxicological effects of the Ca:Mg ratio, EC is used as a surrogate for Mg and SO_4.
[d] Based on flow in the middle of the wet season due to the seasonal behaviour of Mn in the Magela Creek catchment.
[e] As discussed in the text, the initial limit trigger of 5.5 µg/L was rounded to one significant figure ('6' µg/L) for regulatory simplicity.
[f] Radium standards are primarily considered with respect to human health and radiological exposure assessments, especially through uptake of ^{226}Ra by species favoured as 'bush tuc
[g] Years 1999-2004 are excluded due to elevated concentrations caused by runoff from the northern tailings dam wall stockpiles. Note that in the long-term EC, Mg and SO_4 are gene
[h] Based on human health criteria from a total ^{234}U and ^{238}U activity of 88 GBq/year (pp 24) (OSS-AR, 1985) (ie. as specified in the Ranger Authorisation).

Rum Jungle : Water Quality

- **Heavy and lasting impacts on surface waters due to mainly acid mine drainage BUT**
- **Radionuclide loads (U, 226Ra) remain poorly quantified (despite U being highly soluble in acidic, oxidised geochemical environments)**
- **Groundwater polluted but not remediated during rehabilitation works – ongoing source of metals**

Table 7. Finniss River water quality, downstream of Rum Jungle, 1992/93 wet season (µg/L) [13]

(† mg/L)	Al †	Ca †	Fe †	As	Ba	Co	Cr	Cu	Ni	Pb	Th	U
Average	3.6	9.9	1.71	4.1	37	176	5	485	169	76	3.3	33
Minimum	0.21	4.2	0.096	0.6	21	53	0.7	180	53	2	0.02	6
Maximum	9	29	14	41	120	480	33	1,100	430	880	26	63

The Rum Jungle Legacy …

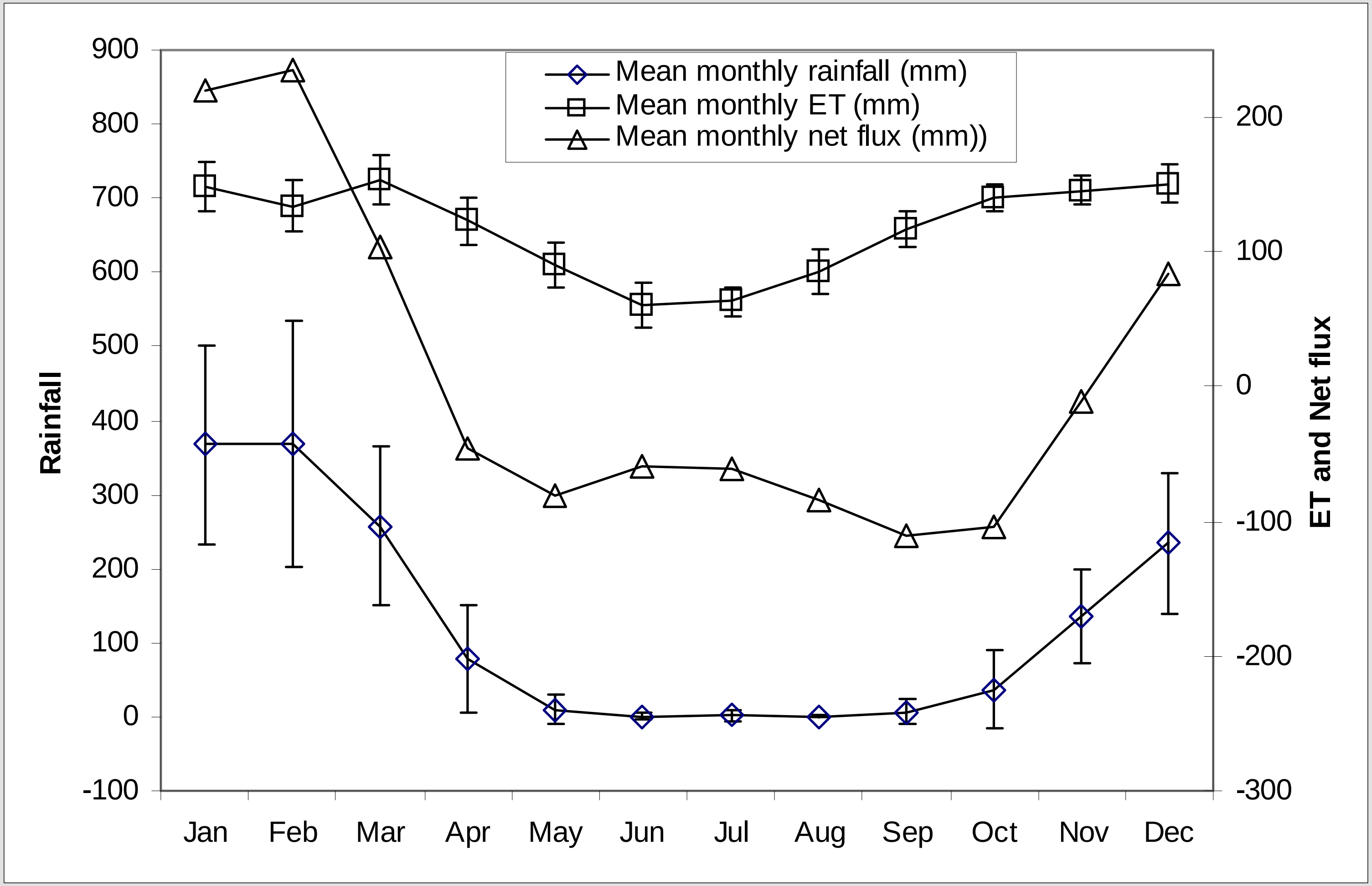
1970's

27 July 2007

Groundwater-Climate Relationships

- The strong seasonality of groundwater is clearly linked to climate : wet-dry seasons
- Climate change impacts are of real concern, especially for wetlands & mine rehabilitation
- Simple visual observation does not provide sufficient rigour in identifying the effects of above/below average wet seasons
- Time series statistical techniques are being adapted for the Ranger uranium project, combined with physical modelling ('SeepW')

Groundwater-Climate #1



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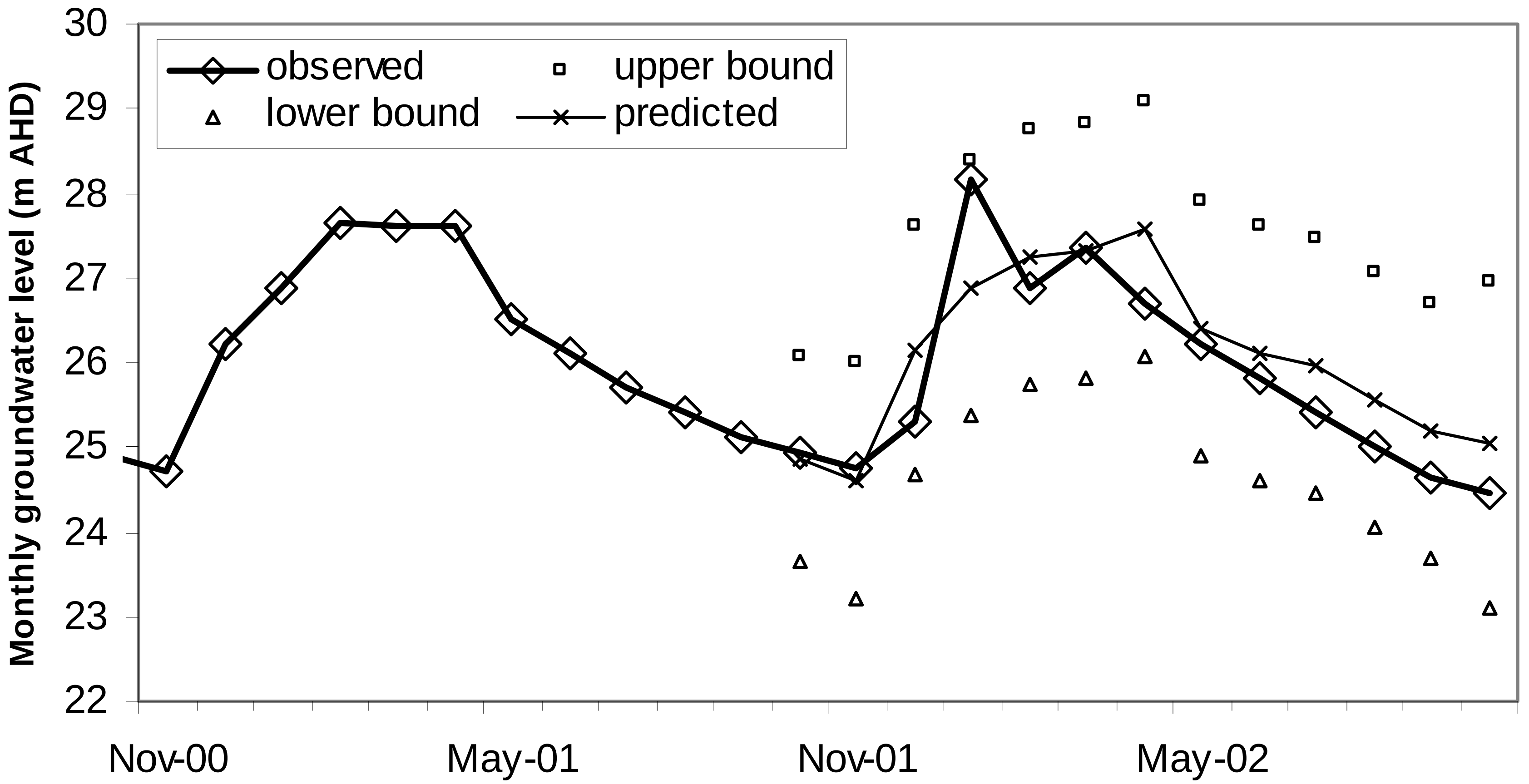
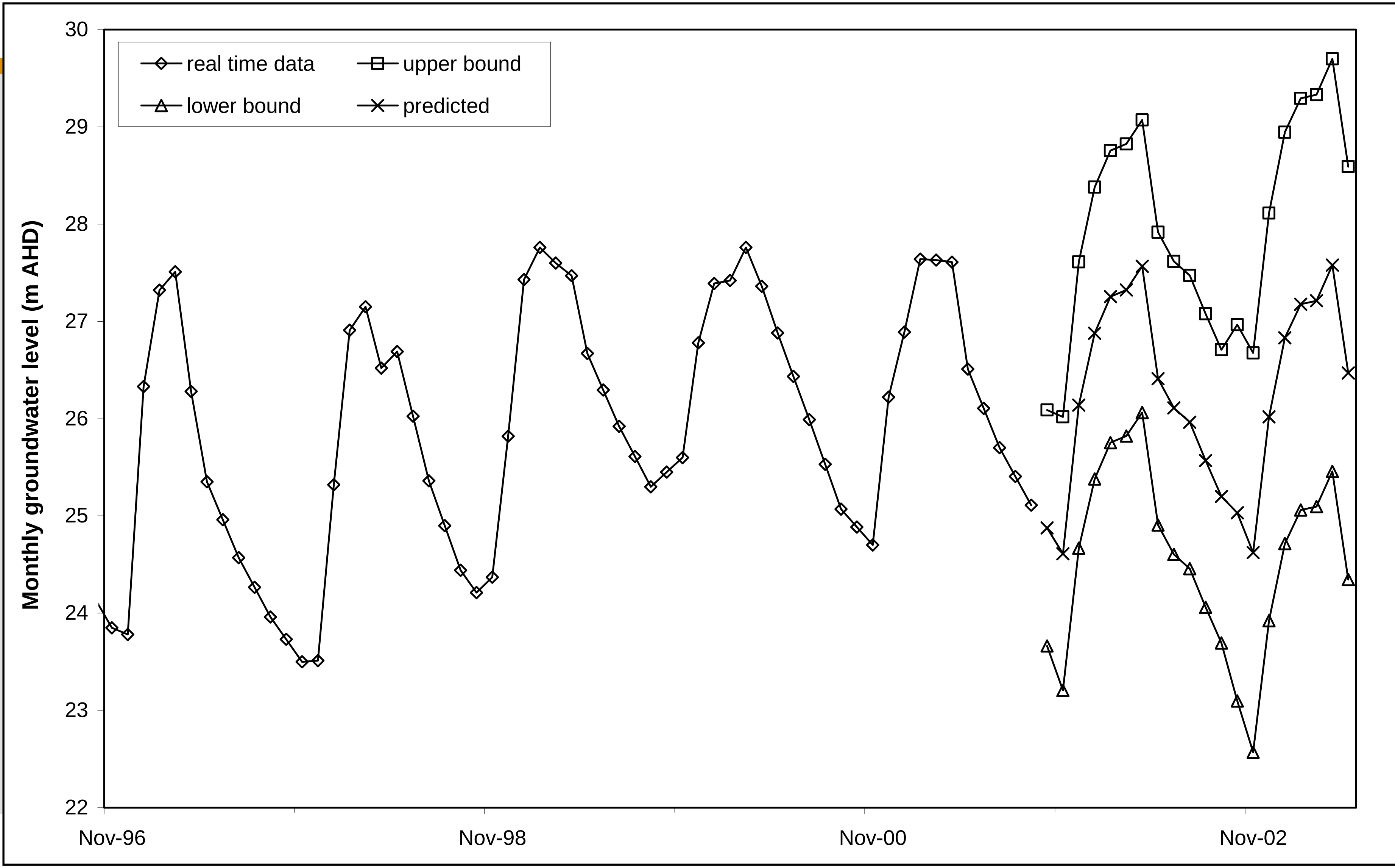
Groundwater-Climate #2



Groundwater-Climate #3



Some Lessons So Far …

- Regular and frequent monitoring is vital
- Looking for different techniques of analysis is critical – many options are available, need to discern the most viable
- Climate change is going to be a major concern into the future – especially since groundwater resources are strongly linked to climate-forcing conditions
- Major implications for mining and the environment