Technical Inputs to Water Allocation Plans

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Government of South Australia
Department of Environment, Water and Natural Resources

What are tools for managing water resources ?

- State Water Acts regulate groundwater allocation, use and protection
- Various State Policies, Strategies, Guidelines
- Statutory Water Allocation Plans

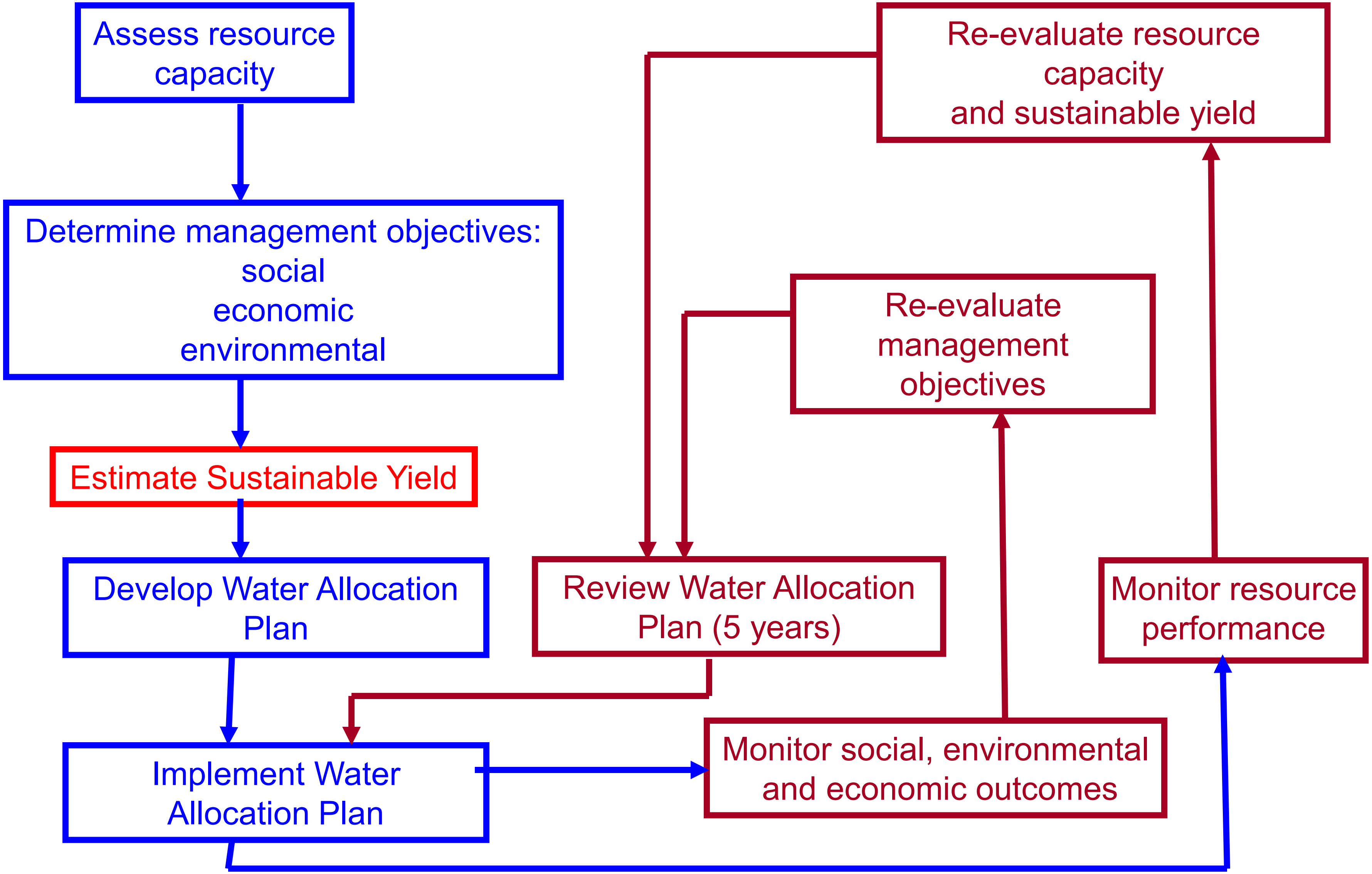
What does a WAP consider ?

- Water quantity
- Water quality (to some extent)
- Water dependent ecosystems
- Balance between social, economic and environmental needs

What does a WAP include ?

- Sustainable yield / allocation limit
- Resource condition limits (triggers)
- Rules to protect existing users
- Local trading rules
- Monitoring requirements
- Process for allocation reductions if necessary

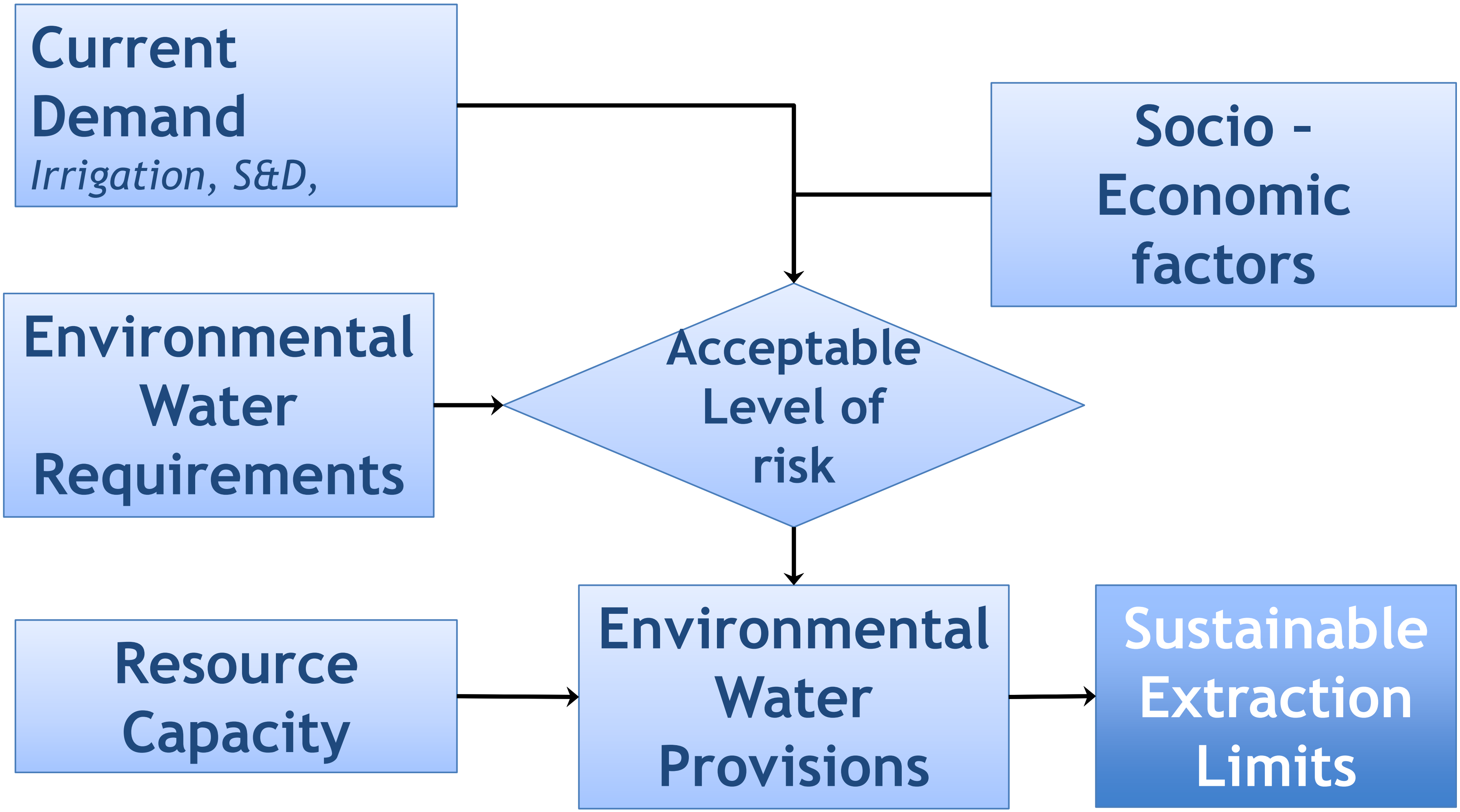
The Planning Cycle



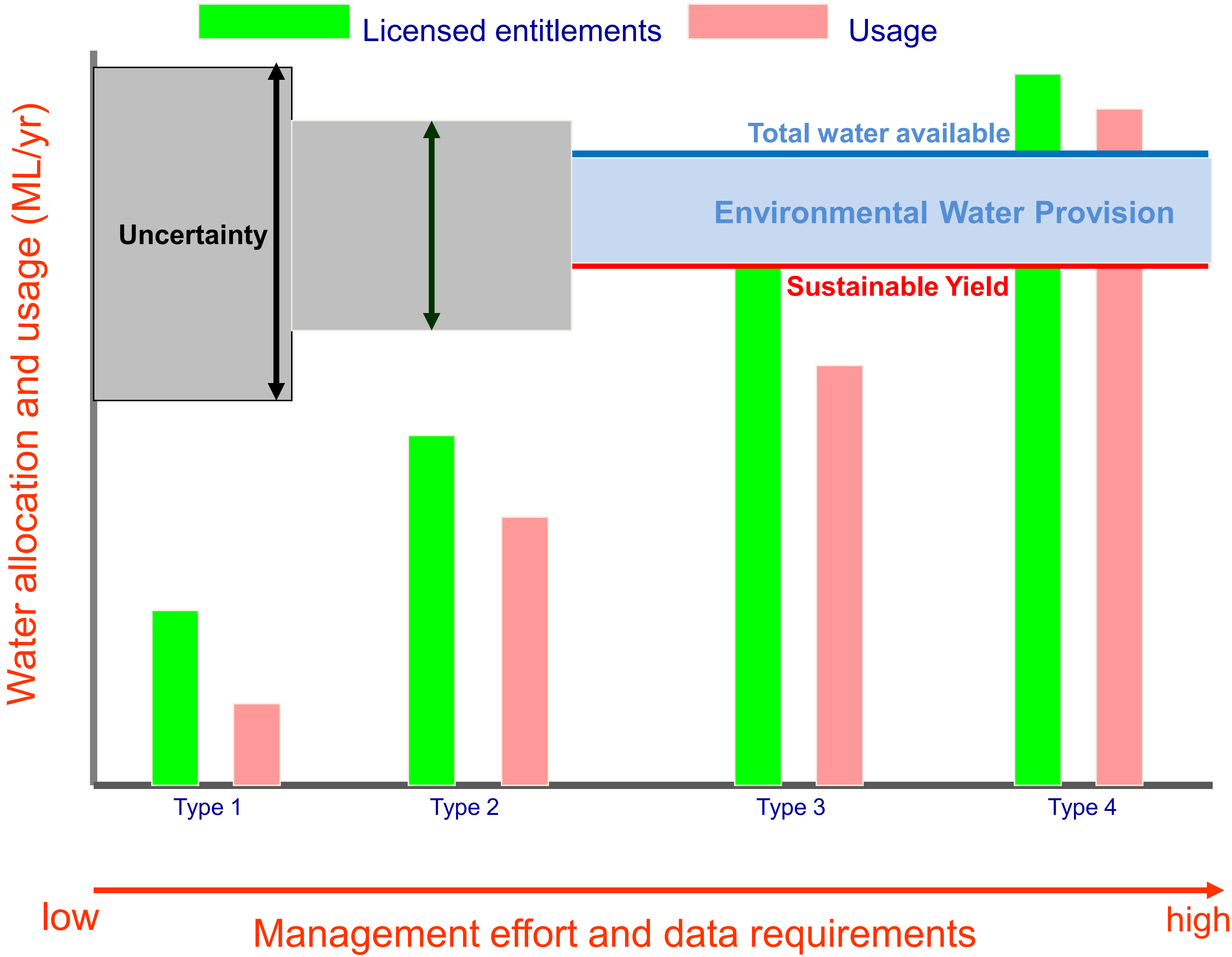
Technical inputs to Water Allocation Plans

Questions to consider;

1. How much water can be allocated ?
2. Are there any adverse impacts ?
3. Are there surface water / groundwater interactions ?
4. Provision for water dependent ecosystems



Current Demand
Irrigation, S&D,
Socio - Economic factors
Environmental Water Requirements
Acceptable Level of risk
Resource Capacity
Environmental Water Provisions
Sustainable Extraction Limits


Licensed entitlements
Usage
Uncertainty
Total water available
Environmental Water Provision
Sustainable Yield
Water allocation and usage (ML/yr)
Type 1
Type 2
Type 3
Type 4
low
high
Management effort and data requirements

Surface water

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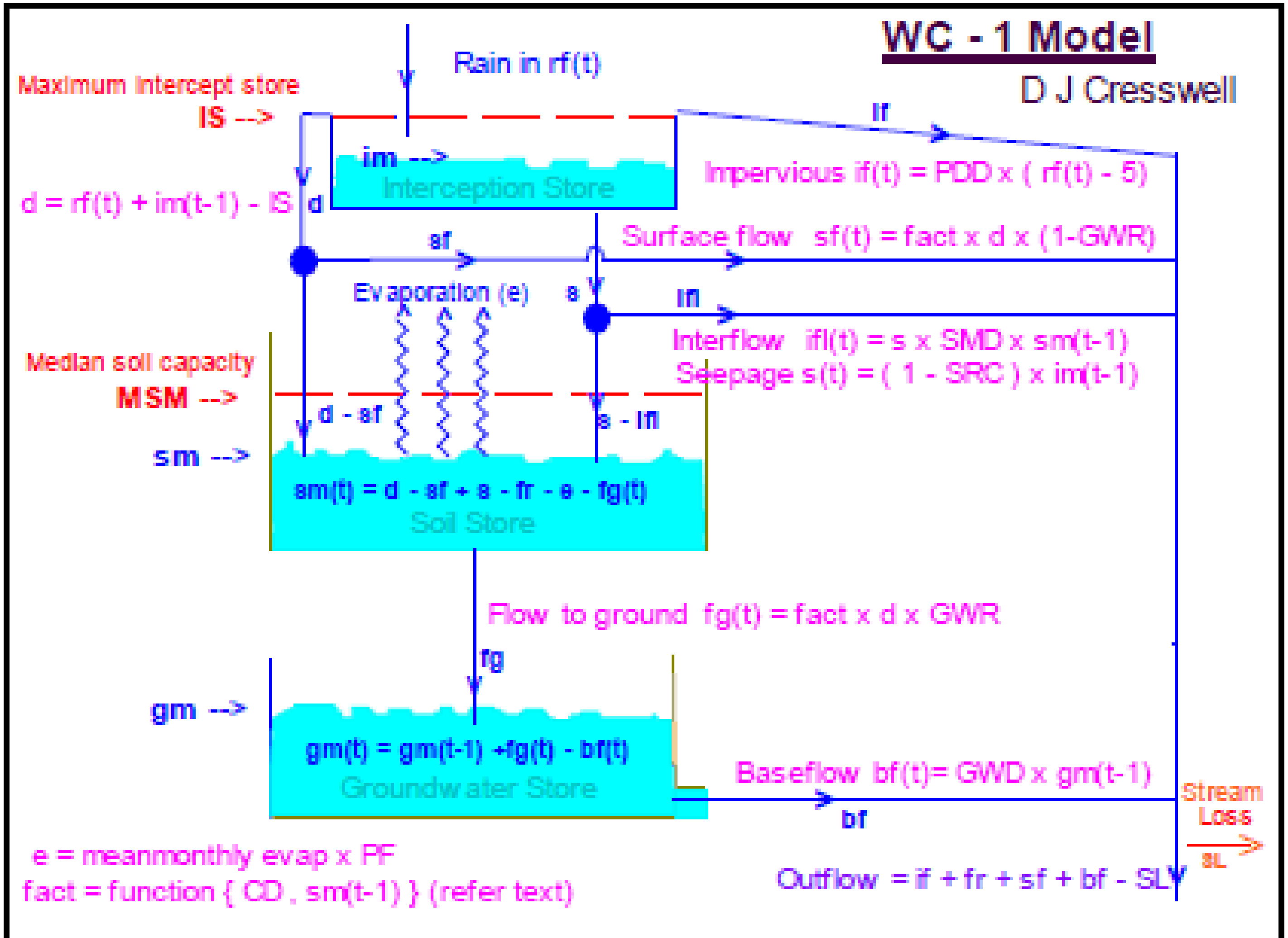
Mt Lofty Ranges PWRAs

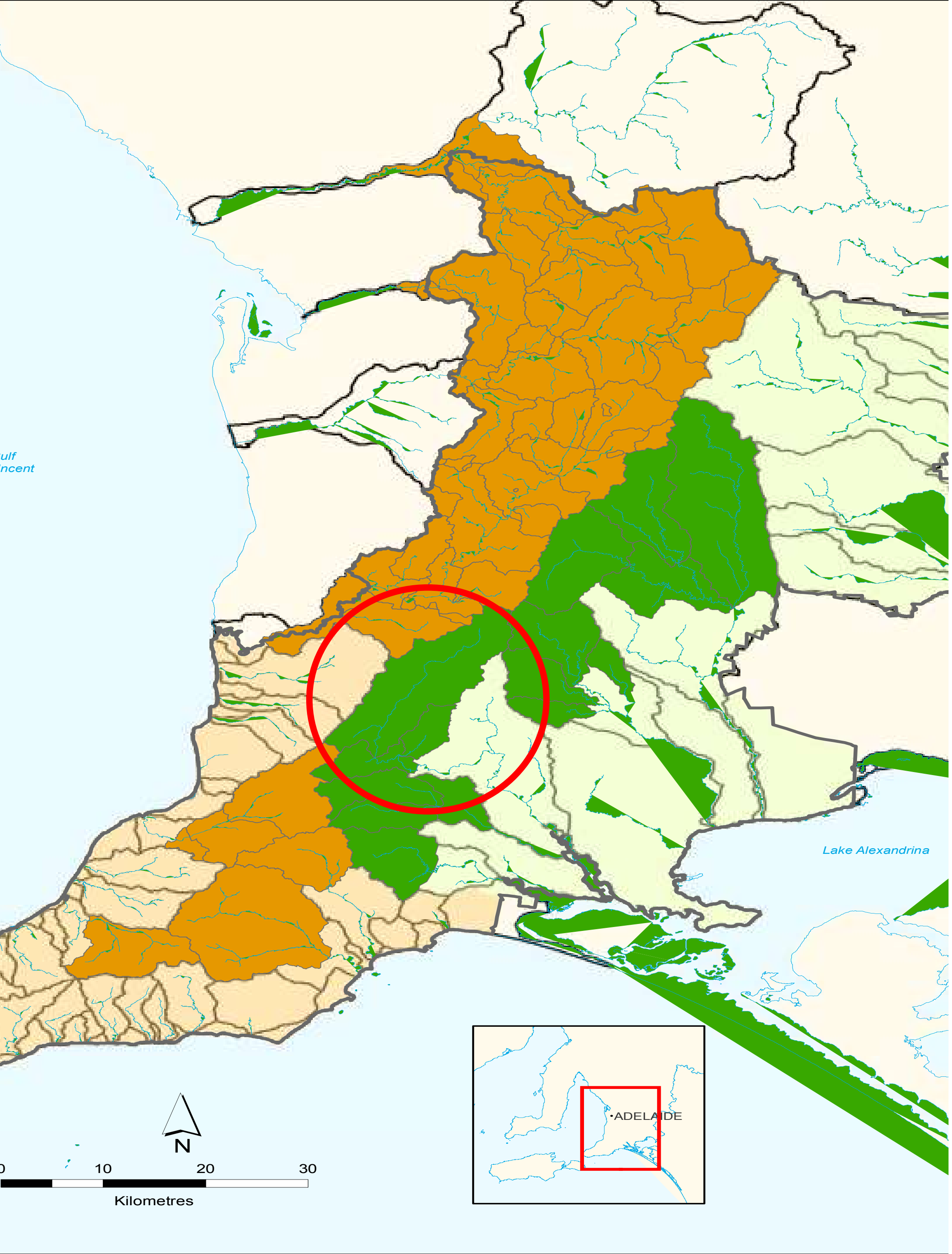
Figure 1. Mount Lofty Ranges Prescribed Region

- 72 catchments
- Ephemeral streams
- Rain 1200 - 400mm
- Water supply reservoirs
  + 20,000 farm dams
  + WC extractions
- Ecosystems
- flora & fauna
- permanent pools, SF swamps, Lakes

Catchment rainfall-runoff models

WaterCress - Node-link resource modelling platform





Example – Upper Finniss catchment


Major Sub-Catchments
Kuitpo
Meadows - West
Meadows - East
Meadows - North
Finniss Subcatchment
Blackwood Creek
Streams
Farm Dams (1999)
Stream Gauging Station
Minor subcatchments
0 1 2 4 km
Projection: Map Grid of Australia 1994 (UTM)
Datum: Geocentric Datum of Australia 1994
Date: June 2003
Data Sources:
CLIMATE STATIONS AND RAINFALL:
Bureau of Meteorology
TOWNS AND LOCALITIES:
Information and Data Analysis, Planning SA
Produced by the Surface Water Group,
Knowledge and Information Division, DWLBC

Resource capacity estimation

- Model calibrated to daily streamflow data (~ 30 years)
- Farm dams & forestry accounted for
- Resource Capacity (how much water available to be shared amongst all users) - modelled baseline flows (pre-development) with the impacts of farm dams, water course extractions & forestry removed

Water dependent e

Physical habitats

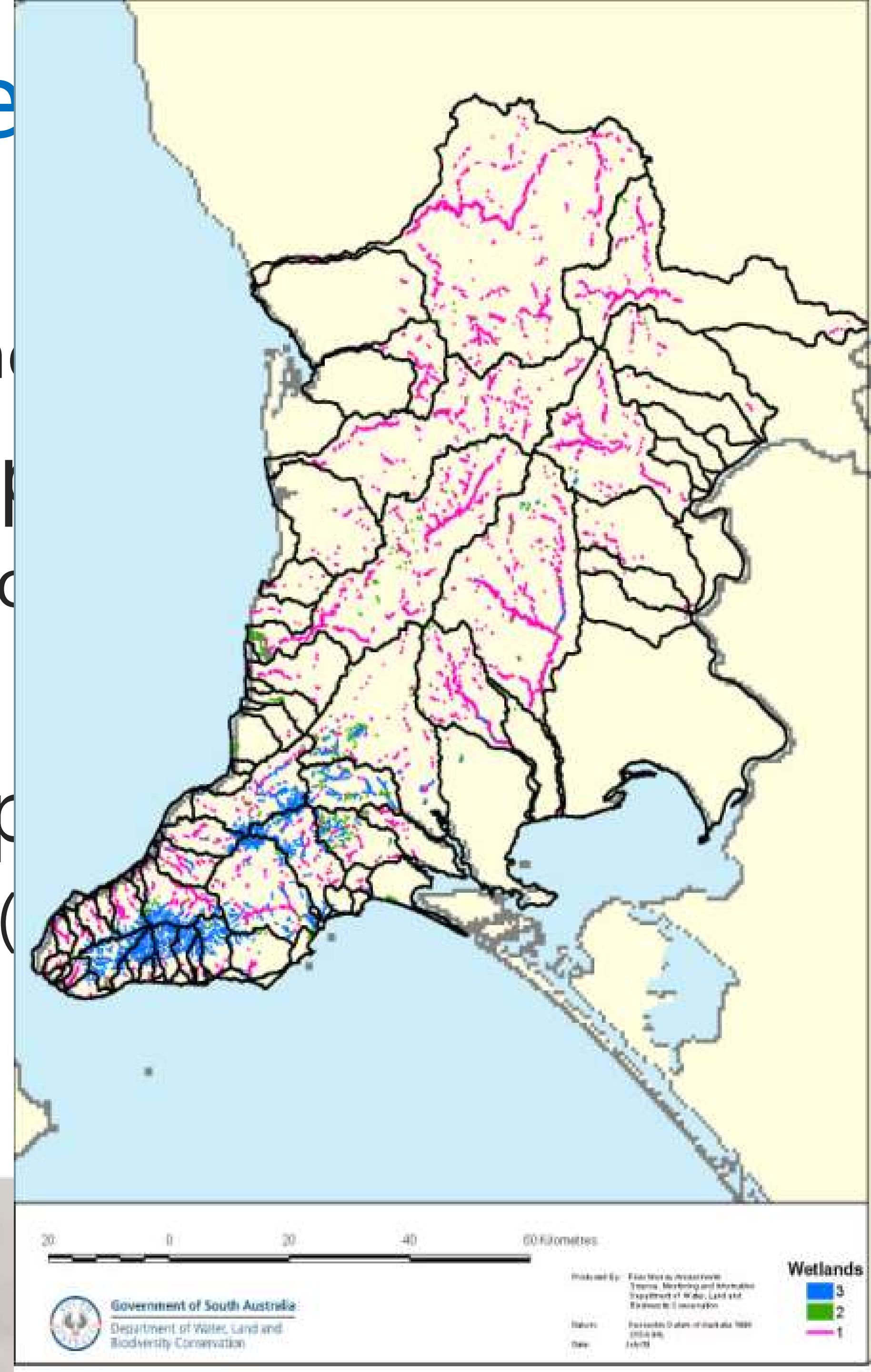
- Fleurieu Swamps, wetlan

Biotic functional grou

- Plants (10 groups), macr
  and fish (10 groups

Reach types (geomor

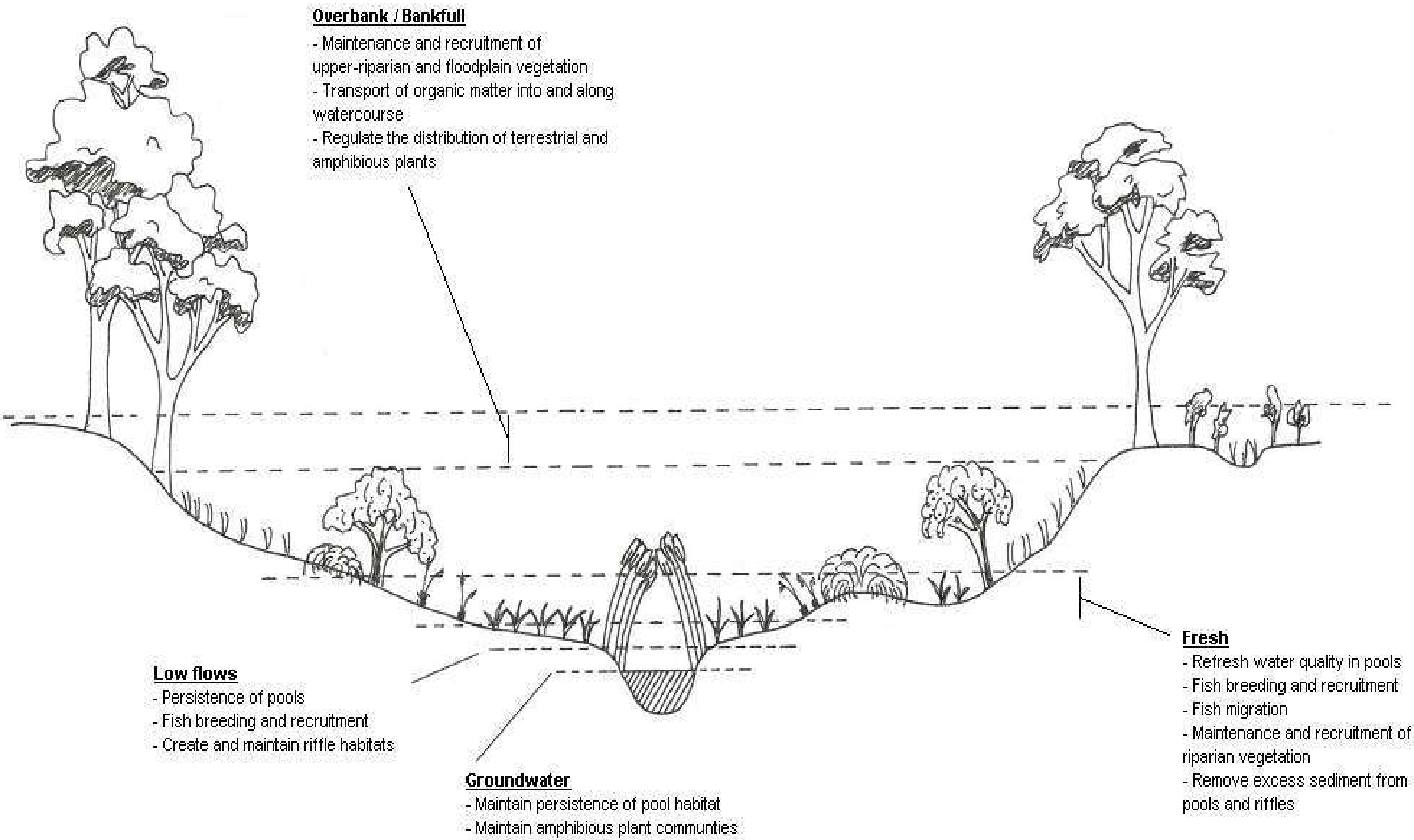
- Headwaters, pool riffles (
  wetlands,....



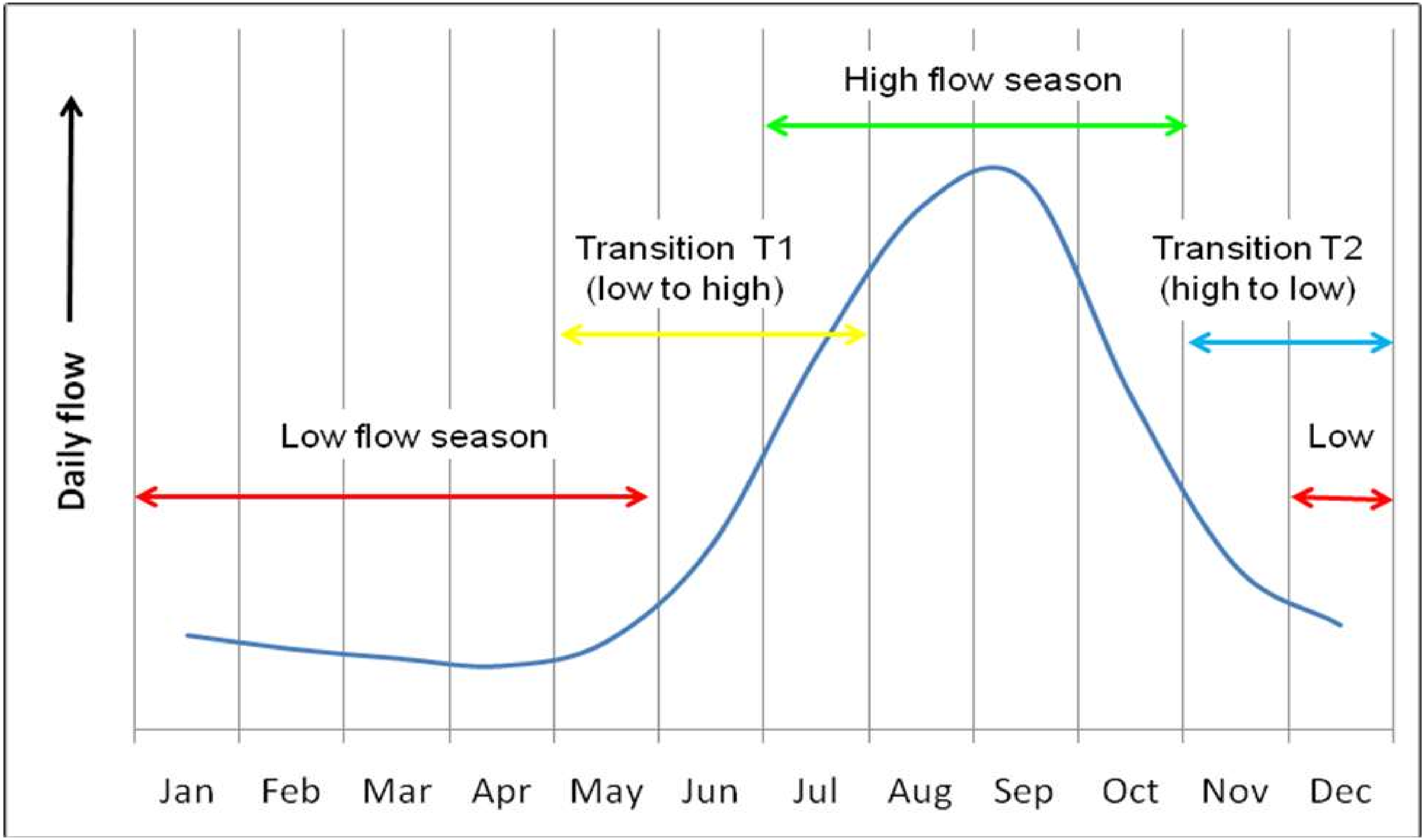
Environmental water requirements

- The water regime needed to sustain the ecological values of aquatic ecosystems, including their processes and biological diversity, at a low level of risk
- EWRs usually fully met only in pristine systems with no development
- Need to relate EWRs to streamflow (which can be measured, modelled and managed)

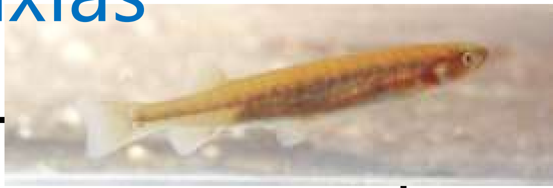
EWRs need to consider ecological processes and the flow conditions that support them



and flow seasons



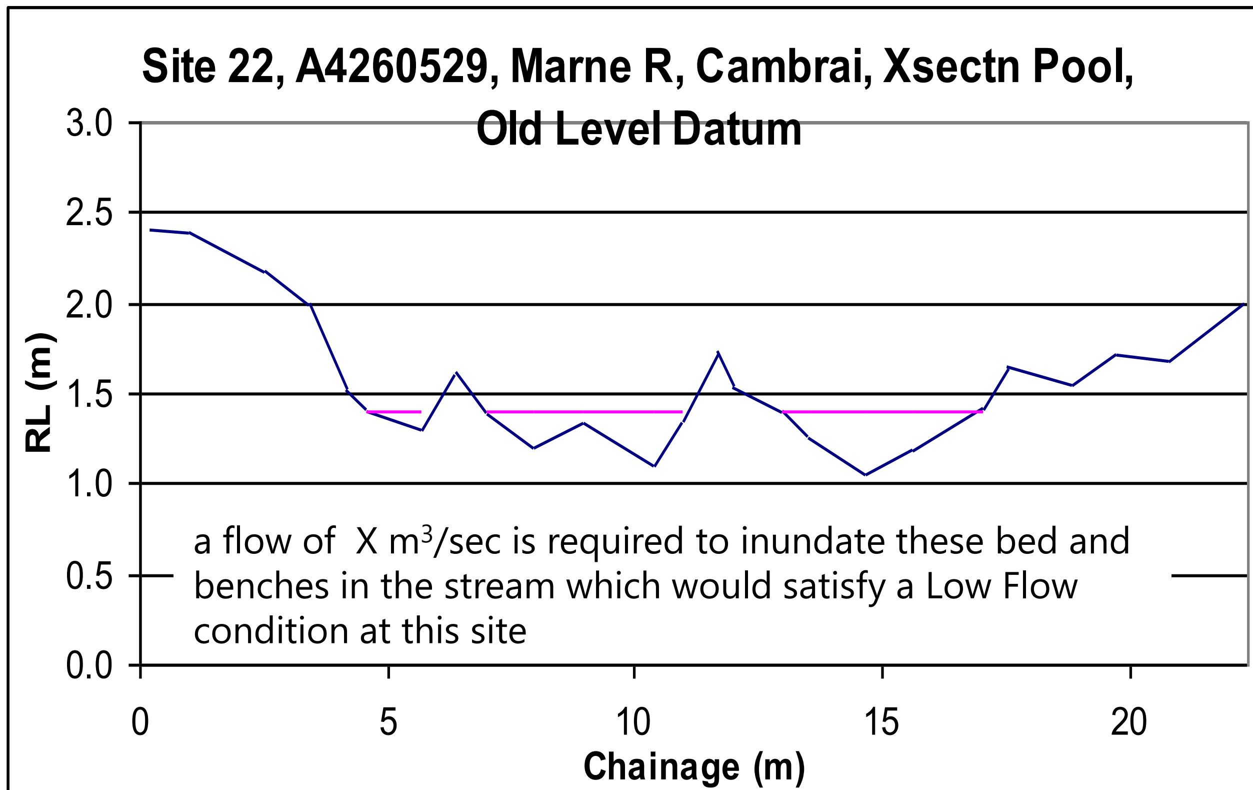
Example of EWRs for Mountain Galaxias



Process	Water requirements
Refuge pools stay wet	**Groundwater inflow & low flows** over low flow season Sufficient flow over higher flow seasons to fill
Refuge pools not too salty	**Freshes over low flow season** to reduce salinity in refuge pools
Refuge pools stay deep enough	**High flows and bankfull** flows to scour out silt and maintain deep pools any time
Movement between pools for breeding and recolonising	**Freshes and high flows** to link pools for transitional flow seasons and high flow season (autumn to spring)
Clean areas to lay eggs	**Freshes** to flush silt in **transitional** 1(low-high) season (late autumn)
Triggers to spawn	Increased flows in transitional 1(low-high) season
Discourage exotic fish	High and bankfull flows to wash them out any time

Need to relate EWRs (qualitative) to flow metrics (quantitative)

Use stream cross sections to relate streamflows to EWRs (low flow, freshes, bankfull in different flow seasons)



Developing hydrological metrics for EWRs

The rainfall- runoff model (pre-development) was used to calculate the hydrological metrics applicable to most test sites across the MLR

EWR component	Hydrological measure
Low flows	**80th percentile** exceedance flow for the flow season of interest (calculated on **non-zero** flows)
Fresh	**2 times** the **median** of all non-zero flows in the flow season of interest
Bankfull/ Overbank	**1.5** annual return interval flow (based on annual maximum flows)

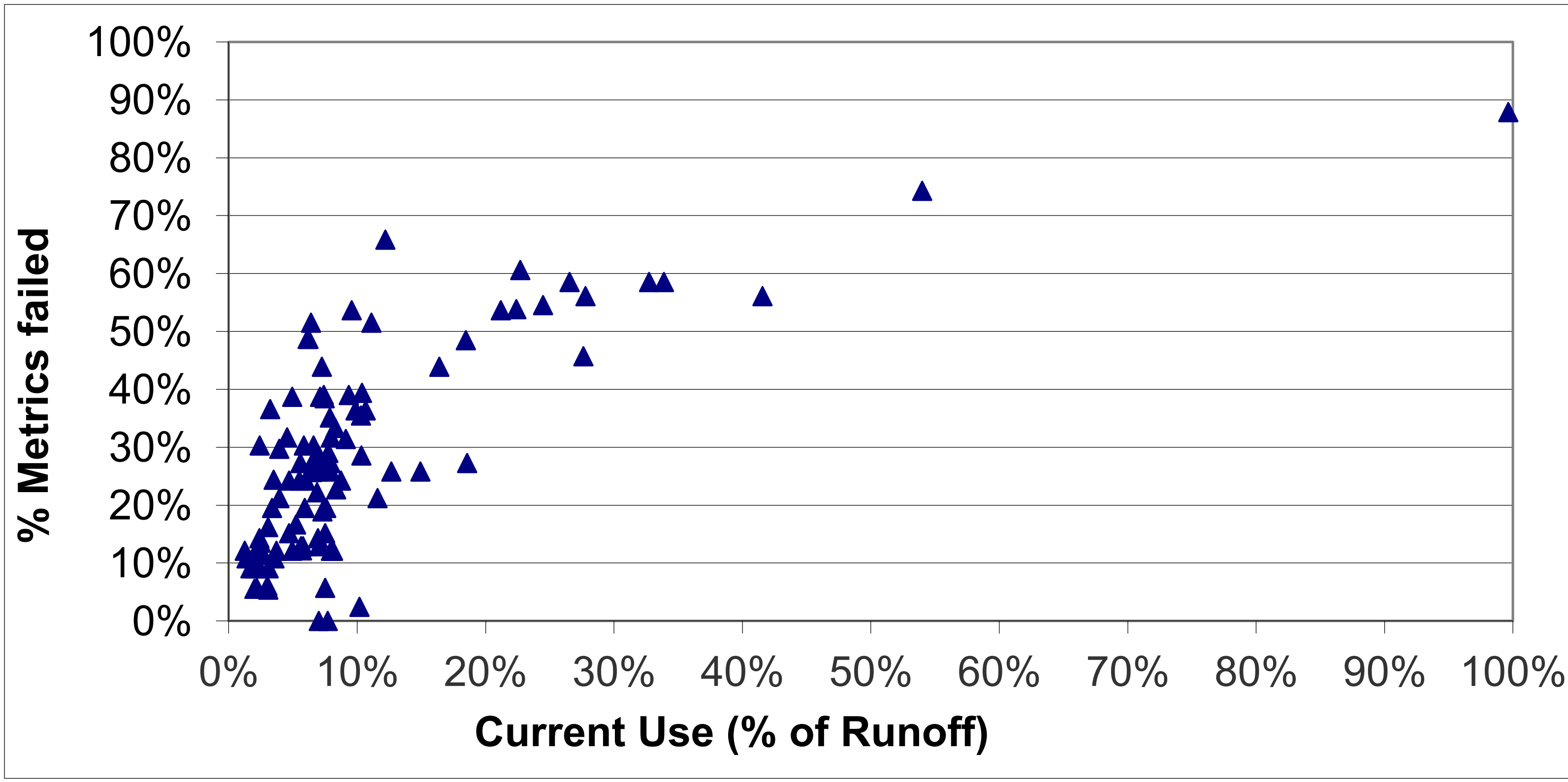
Example of EWR Metric assessment

Kersbrook		Wet Upper Pool Riffle	#	Measurement units	Threshold	Priority	Natural	Current	Change	Threshold change	Rating
Annual											
	Bankfull	Number of years with 1 or more bankfull flows	1	# years		2	21	23	1.10	1.10	met
		Average number of bankfull flows per year	2	events/year	2	na	2.4	2.8	1.17	1.17	na
		Average duration of bankfull flow spells	3	days	2	2	2.1	1.9	0.92	0.92	met
		Average total duration of bankfull flow per year	4	days/year	2	2	5.0	5.4	1.07	1.07	met
		Return time of pairs of years with sequential bankfull flows	6	every ... years		na		2.1			na
Low Flow Season											
	Low Flows	Average daily LFS flow	7	ML/day		3	0.98	0.36	0.37	0.37	not met
		80th percent exceedence non-zero flow	8	ML/day		1	0.03	0.02	0.67	0.67	not met
	Zero Flows	Number of years with LFS zero flow spells	9	# years	4	1	33	33	1.00	1.00	met
		Average number of LFS zero flow spells per year	10	events/season	4	2	5.8	3.9	0.68	0.68	not met
		Average duration of LFS zero flow spells	11	days/spell	4	1	11.7	23.5	2.01	2.01	not met
		Average total duration of LFS zero flow per year	12	days/season		na	67.5	92.8	1.37	1.37	na
	Low Flow Fres	Number of years with one or more LFS freshes	13	# years		1	33	32	0.97	0.97	met
		Average number of LFS freshes per year	14	events/season		1	4.0	3.3	0.83	0.83	met
		Average duration of LFS freshes	15	days/spell		na	7.9	4.6	0.59	0.59	na
		Average total duration of LFS freshes per year	16	days/season		2	31.7	15.5	0.49	0.49	not met
Transitional (Low-High) Season											
	Low Flows	Average daily T1 flow	17	ML/day		3	5.91	3.22	0.54	0.54	met
		80th percent exceedence non-zero flow	18	ML/day		1	0.38	0.19	0.50	0.50	not met
		Current month reaching median flow of natural T1 median (delay)	19	# years		1	14	16	0.47	0.47	not met
	Zero Flows	Number of years with T1 zero flow spells	20	# years	4	1	11	20	1.82	1.82	not met
		Average number of T1 zero flow spells per year	21	events/season	4	2	0.4	0.8	1.00	1.00	met
		Average duration of T1 zero flow spells	22	days/spell	4	1	8.3	14.8	1.78	1.78	not met
		Average total duration of T1 zero flow per year	23	days/season		na	3.3	11.2	3.43	3.43	na
	T1 Freshes	Number of years with one or more T1 freshes	24	# years		1	33	29	0.88	0.88	met
		Average number of T1 freshes per year	25	events/season		1	5.3	3.5	0.66	0.66	not met
		Average duration of T1 freshes	26	days/spell		na	3.8	2.9	0.76	0.76	na
		Average total duration of T1 freshes per year	27	days/season		2	19.8	10.0	0.50	0.50	not met
		Number of years with 2 or more T1 Freshes	28	# years		2	32	27	0.84	0.84	met
		Frequency of spells higher than LFS fresh level	29	events/season		na	2.3	3.5	1.52	1.52	na
High Flow Season											
	Low Flows	Average daily HFS flow	30	ML/day		3	17.54	18.82	1.07	1.07	met
		80th percent exceedence non-zero flow	31	ML/day		1	0.42	0.63	1.50	1.50	met
	Zero flows	Number of years with HFS zero flow spells	32	# years	4	1	8	7	0.88	0.88	met
		Average number of HFS zero flow spells per year	33	events/season	4	2	0.4	0.3	1.00	1.00	met
		Average duration of HFS zero flow spells	34	days/spell	4	1	4.4	6.7	1.52	1.52	not met
		Average total duration of HFS zero flow per year	35	days/season		na	1.6	2.2	1.40	1.40	na
		Number of years with average zero flow spell duration > 7 days in HF:	36	# years		na	2.0	2.0	1.00	1.00	na
	HFS Freshes	Number of years with one or more HFS freshes	37	# years		1	33	33	1.00	1.00	met
		Average number of HFS freshes per year	38	events/season		1	7.5	6.7	0.89	0.89	met
		Average duration of HFS freshes	39	days/spell		na	6.1	7.0	1.14	1.14	na
		Average total duration of HFS freshes per year	40	days/season		2	46.4	46.9	1.01	1.01	met
		Number of years with 1 or more spell greater than the annual 5th p.e. f	41	# years		2	27	28	1.04	1.04	met
		Number of years with 2 or more freshes early in the season (Jul, Aug)	42	# years		na	31	30	0.97	0.97	na
Transitional (High-Low) Season											
	Low Flows	Average daily T2 flow	43	ML/day		3	2.60	3.10	1.19	1.19	met
		Median non-zero daily T2 flow	44	ML/day		2	0.18	0.33	1.82	1.82	met
		80th percent exceedence non-zero flow	45	ML/day		1	0.03	0.05	1.67	1.67	met
		Current month reaching median flow of natural T2 median (early onset	46	# years		1	23	2	0.92	0.92	met
	Zero flows	Number of years with T2 zero flow spells	47	# years	4	1	18	15	0.83	0.83	met
		Average number of T2 zero flow spells per year	48	events/season	4	2	0.9	0.7	1.00	1.00	met
		Average duration of T2 zero flow spells	49	days/spell	4	1	6.3	7.0	1.11	1.11	met
		Average total duration of T2 zero flow per year	50	days/season		na	5.9	4.9	0.83	0.83	na
	T2 Freshes	Number of years with one or more T2 freshes	51	# years		1	27	28	1.04	1.04	met
		Average number of T2 freshes per year	52	events/season		1	1.0	1.1	1.09	1.09	met
		Average duration of T2 freshes	53	days/spell		na	9.0	10.5	1.16	1.16	na
		Average total duration of T2 freshes per year	54	days/season		2	9.3	11.7	1.26	1.26	met
		Frequency of spells higher than LFS fresh level	55	events/season		na	1.0	1.1	1.06	1.06	na
		Number of years with 1 or more spell greater than the annual 5th p.e. f	56	# years		2	4	5	1.25	1.25	met
		Number of consecutive years with no T2 fresh	57	# years		na	2	1	0.50	0.50	na
		Number of years with bankfull flows in T2	58	# years		na	1	2	2.00	2.00	na

Assessments were made using the rainfall- runoff model to compare pre-development and current conditions (eg dams, forestry etc)

Are EWRs currently being met?

If it assumed that all metrics must be fulfilled to meet EWRs, the modelled impact of current development conditions (eg dams, forestry etc) suggests that EWRs are generally <u>not being met</u>



Average metrics failed is 32%

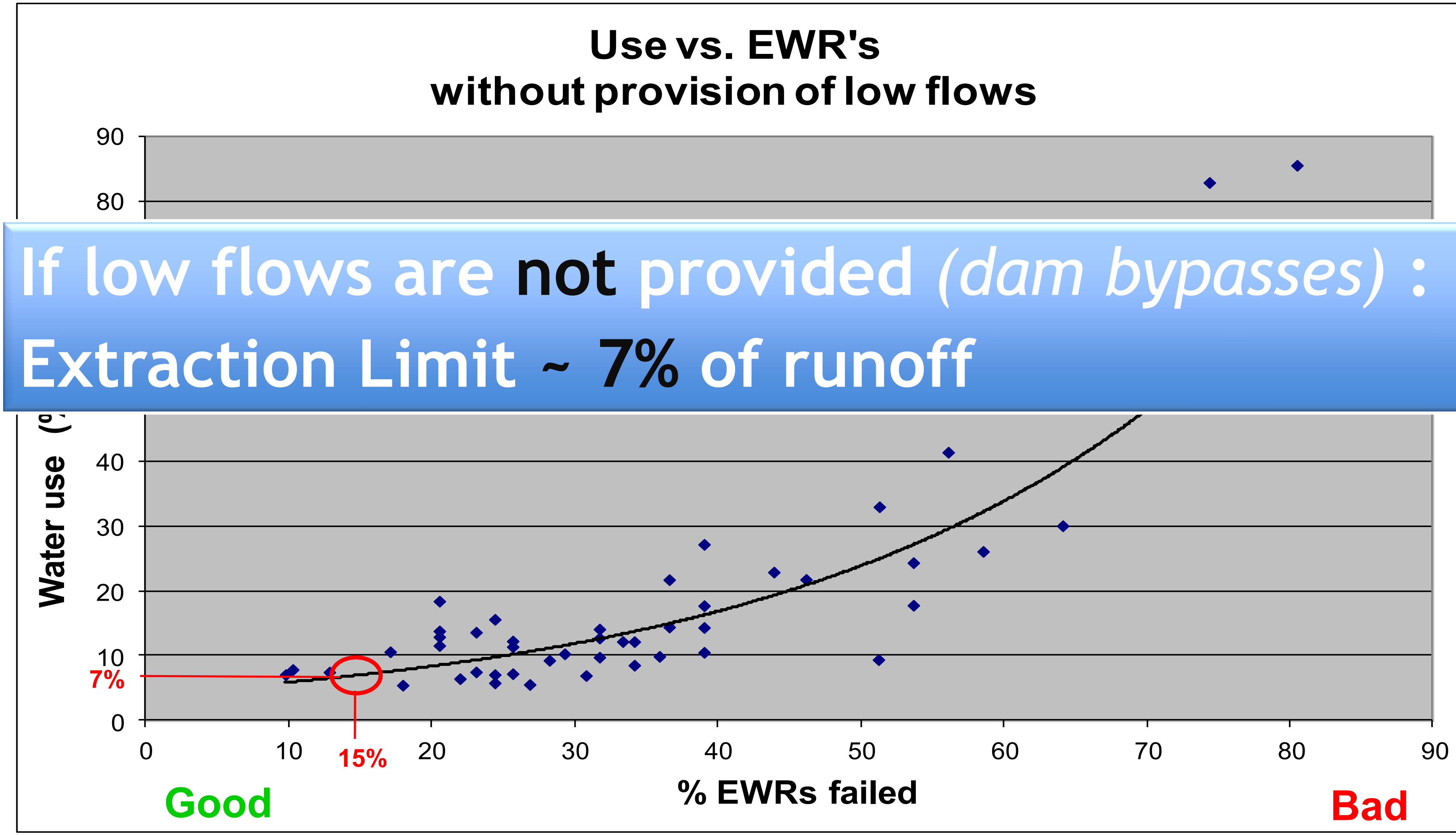
EW Requirements vs Provisions

- Environmental water requirement is to pass all of the metrics, which is not likely to be achievable in the current landscape
- Need EWPs that balance social, economic and environmental needs for water
- How many metrics need to pass to achieve acceptable ecological outcomes ? – to maintain self sustaining communities that are resilient with an acceptable risk
- No more than 15% of EWR metrics NOT met for at least 75% of sites

Role of science

- In the EWR vs EWP debate, the role of science (ie the technical input) is to assist in achieving the balance between social, economic and environmental needs
- This can be achieved by investigating the implications of implementing various policy options
- An example is the provision of low flow conditions which has been identified as a major issue
- The rainfall-runoff model can be used to evaluate options to address this issue

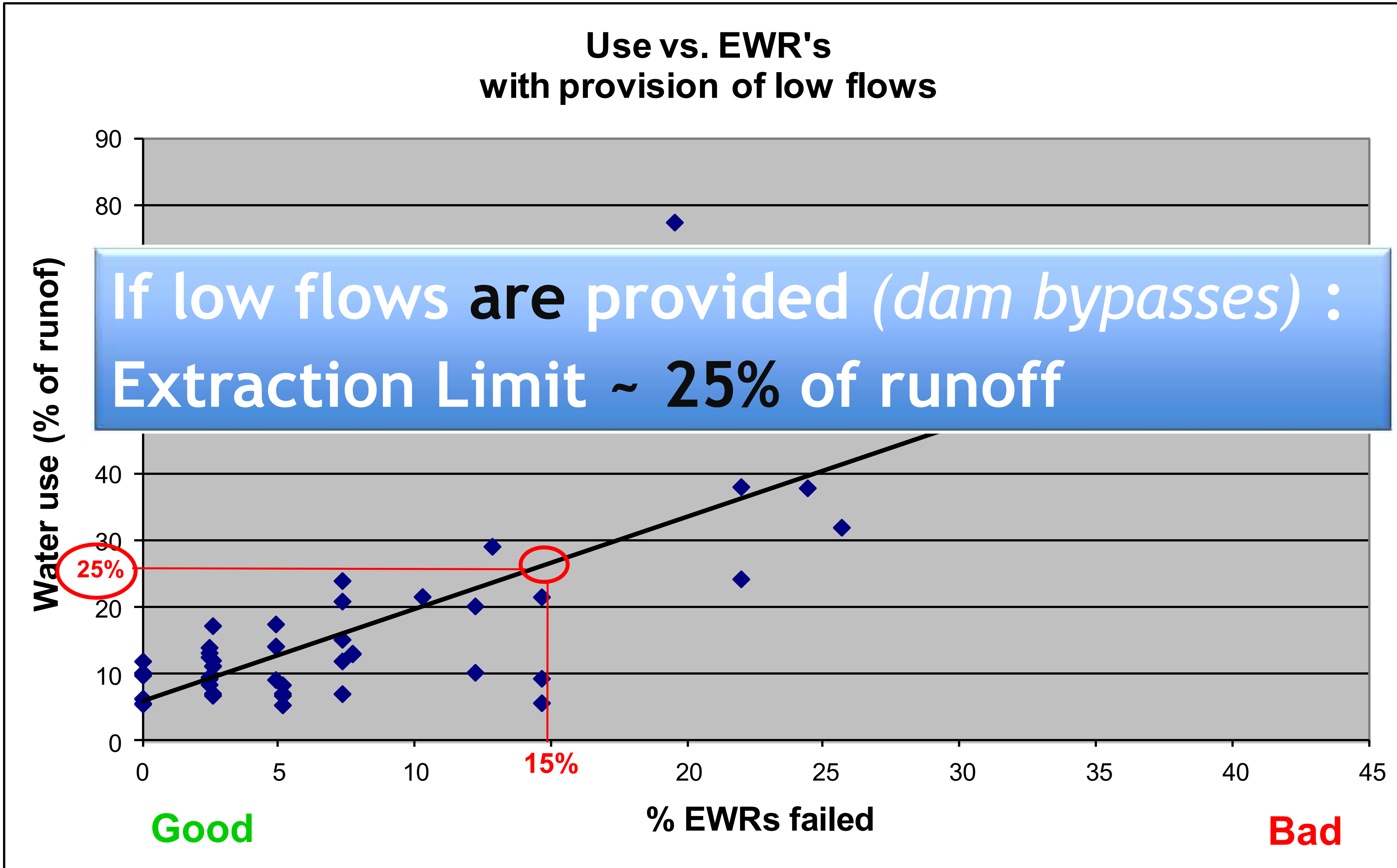
EWP without provision of low flow conditions



If low flows are **not** provided *(dam bypasses)* :

Extraction Limit ~ **7%** of runoff

EWP with provision of low flows



Groundwater

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Sustainable yield

<u>Technical definition in SA</u>

"the groundwater extraction regime, measured over a specified planning timeframe, that allows acceptable levels of stress and protects the higher value uses associated with the total resource"

Sustainable yield

- This definition is flexible
- Higher value uses could be irrigation, town water supply, industry or ecosystem support
- Determination and ranking of these uses, as well as deciding what are acceptable impacts, will require both community and expert opinion
- There is no single formula for SY, each resource requires a specific method

Quantifying sustainable yield

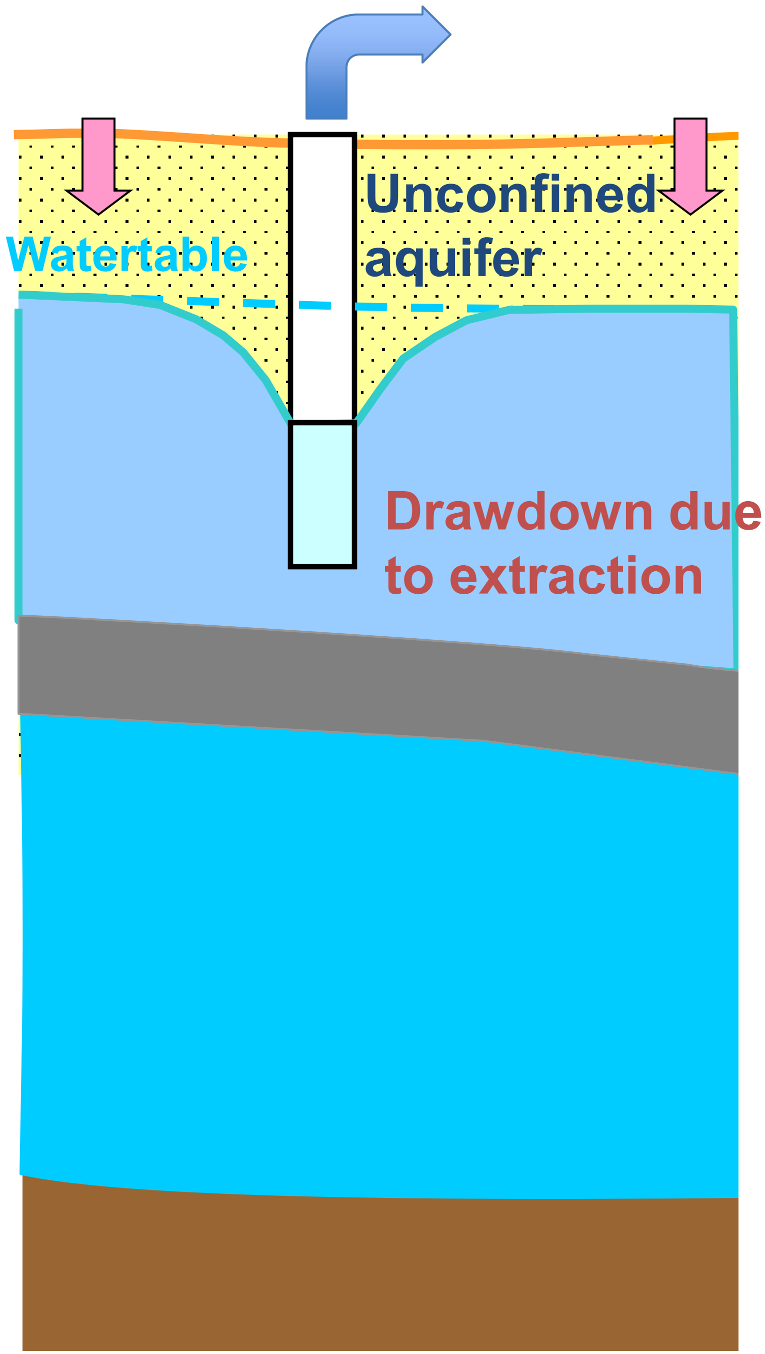
- Fundamental to GW management
- Difficult to do without the right data
- Methods range from simple water balance methods to complex numerical groundwater flow models
- Need to understand the uncertainties and risks to the resource

Data requirements

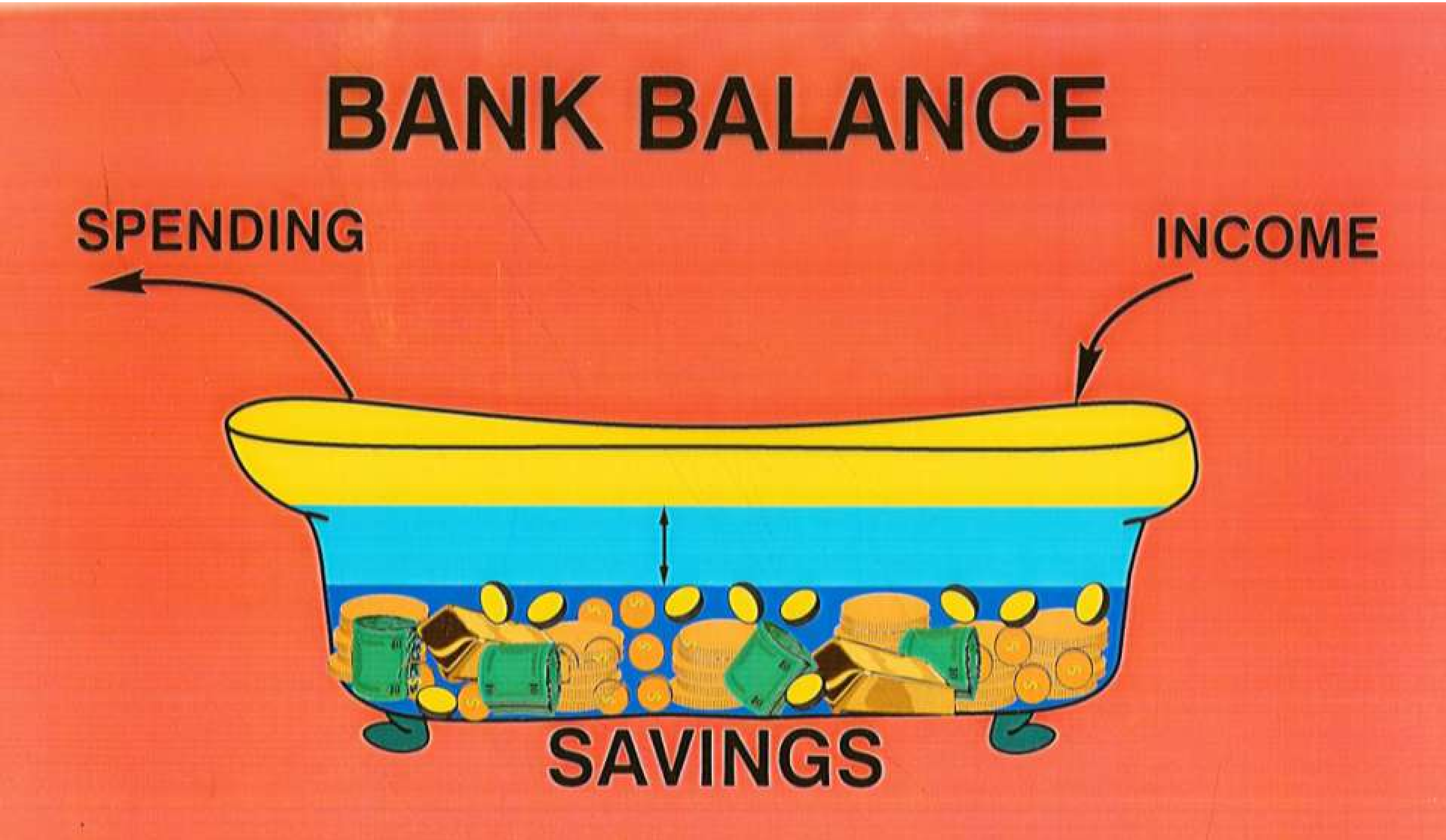
- Areal extent of aquifers and conf layers
- Saturated thickness of aquifers
- Aquifer parameters (T, k, Sy)
- Rainfall, evaporation, streamflow data
- Extraction – where and how much
- Salinity distribution
- Water level and salinity trends

Unconfined aquifers in SA

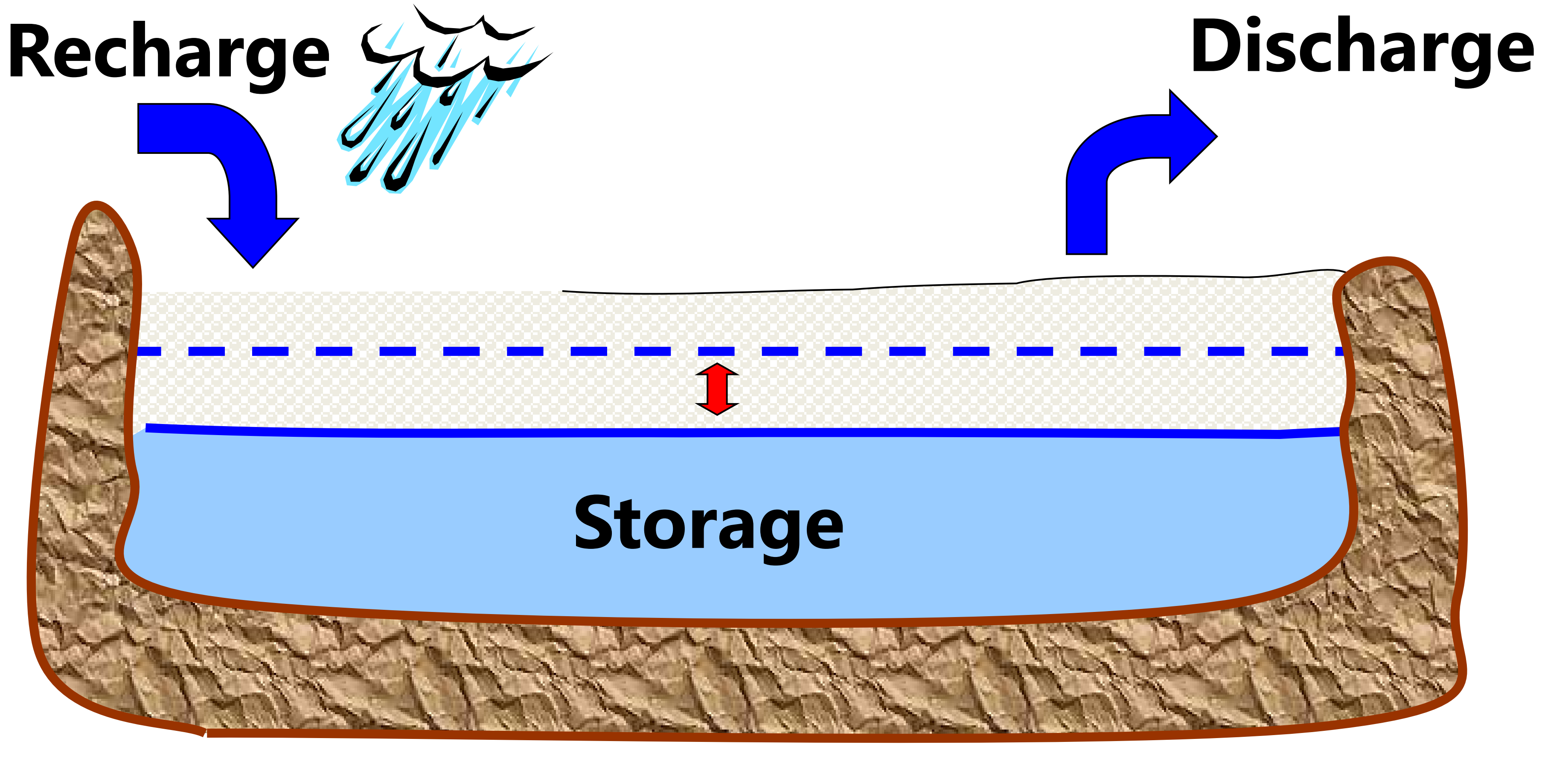
- Unconfined aquifers are found in both the fractured rock and sedimentary environments
- Because they are recharged by rainfall, groundwater level trends follow rainfall trends
- These are widely developed for use in the higher rainfall areas of SA, namely
  - Southeast
  - Mt Lofty Ranges
  - Eyre Peninsula


Unconfined
aquifer
Watertable
Drawdown due
to extraction

How do we manage unconfined aquifers ?

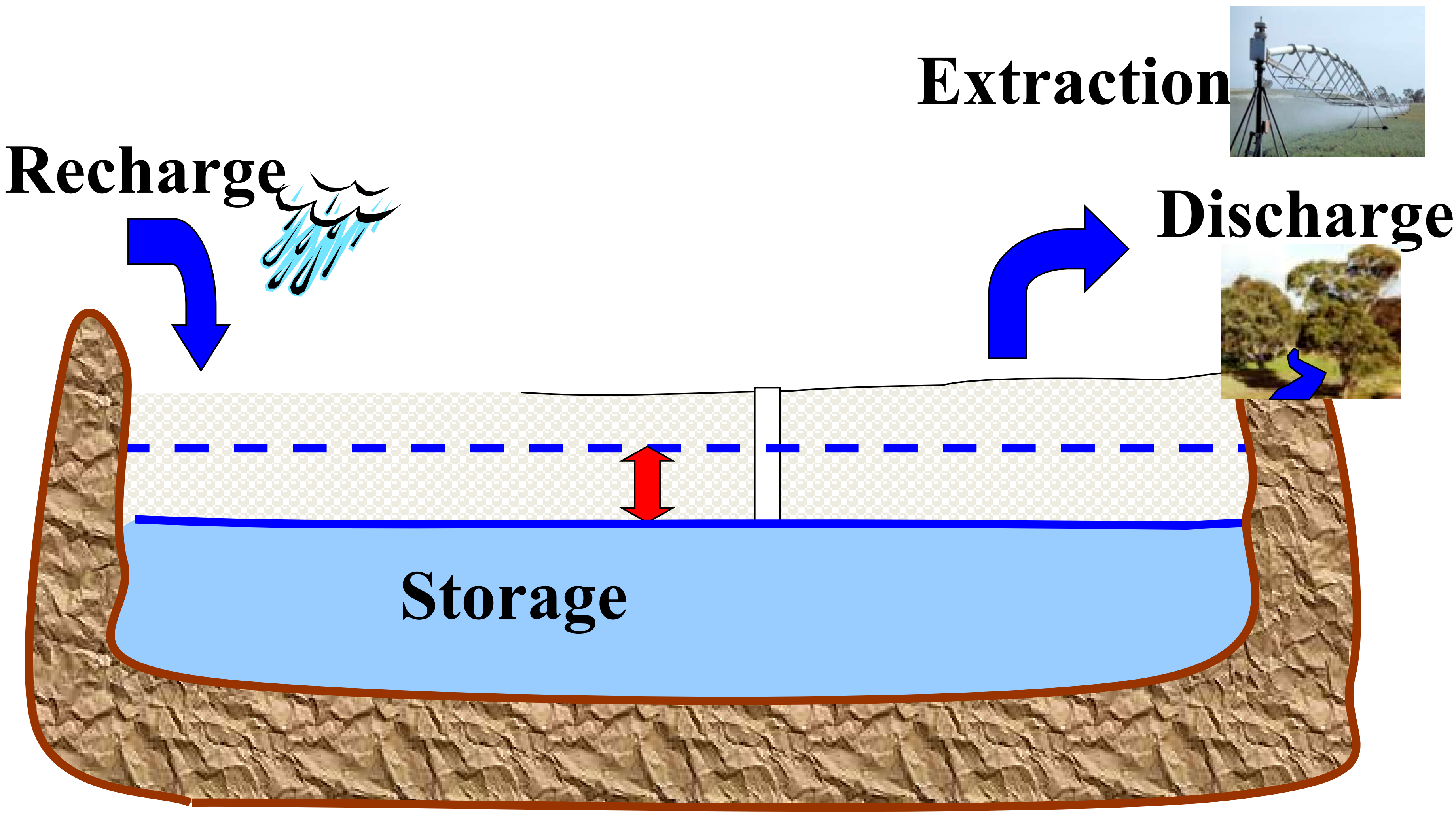


GROUNDWATER BALANCE



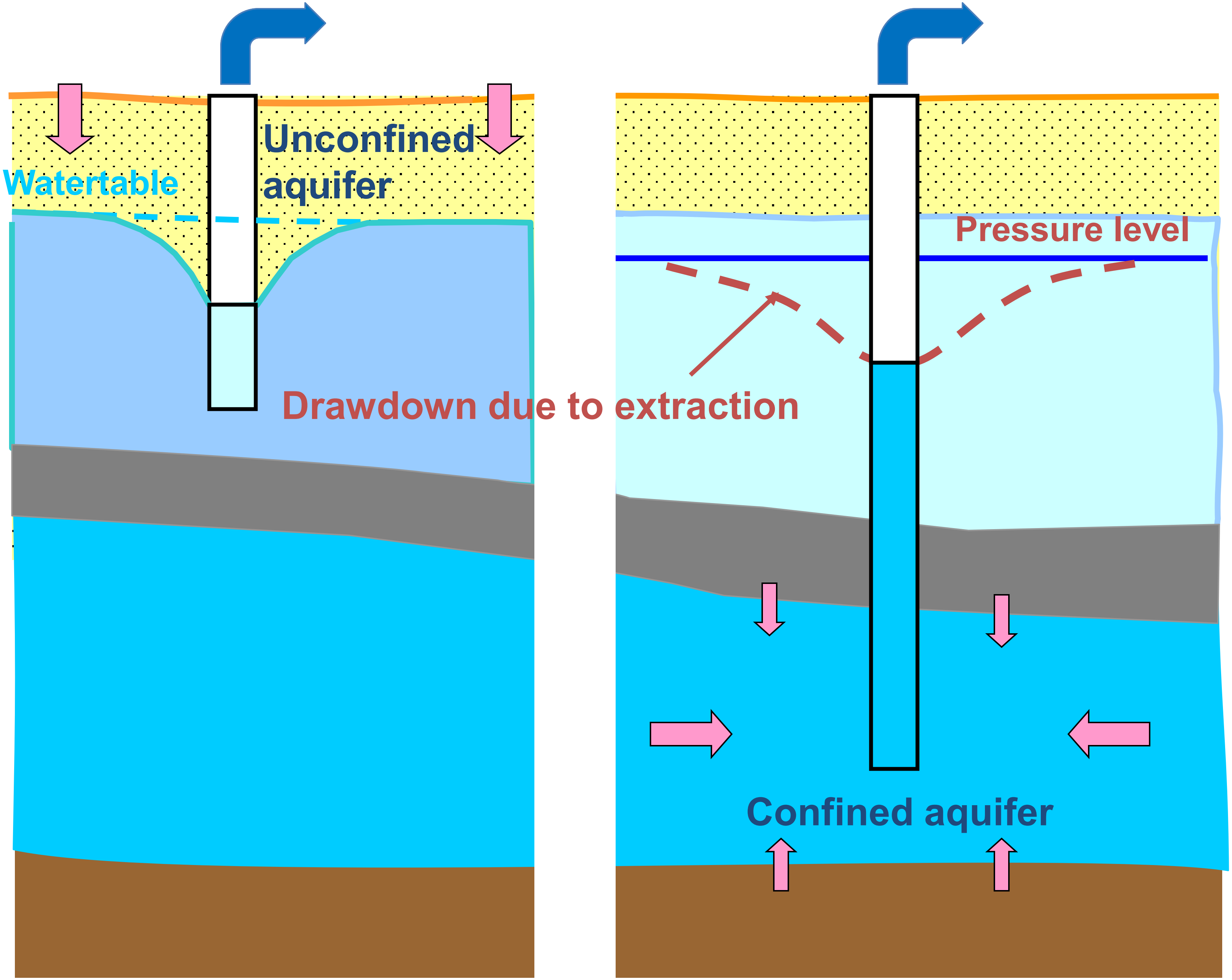
Unconfined aquifer management approach

- Recharge used to determine extraction limits in most unconfined aquifers (SE, MLR, EP)
- Recharge cannot be measured directly and varies over time and spatially, estimates +/- 30%
- Increasing use of adaptive management, supported by modelling and resource condition limits
- This approach especially appropriate for climate change
- Extensive and accurate monitoring data essential


Extraction
Recharge
Discharge
Storage

Confined aquifers in SA

- These systems have very little or no dependence on direct rainfall recharge
- The response delay to rainfall changes could vary from decades to hundreds of years
- These aquifers are found throughout SA,
  - Southeast and Mallee
  - GAB
  - St Vincent and Willunga Basins

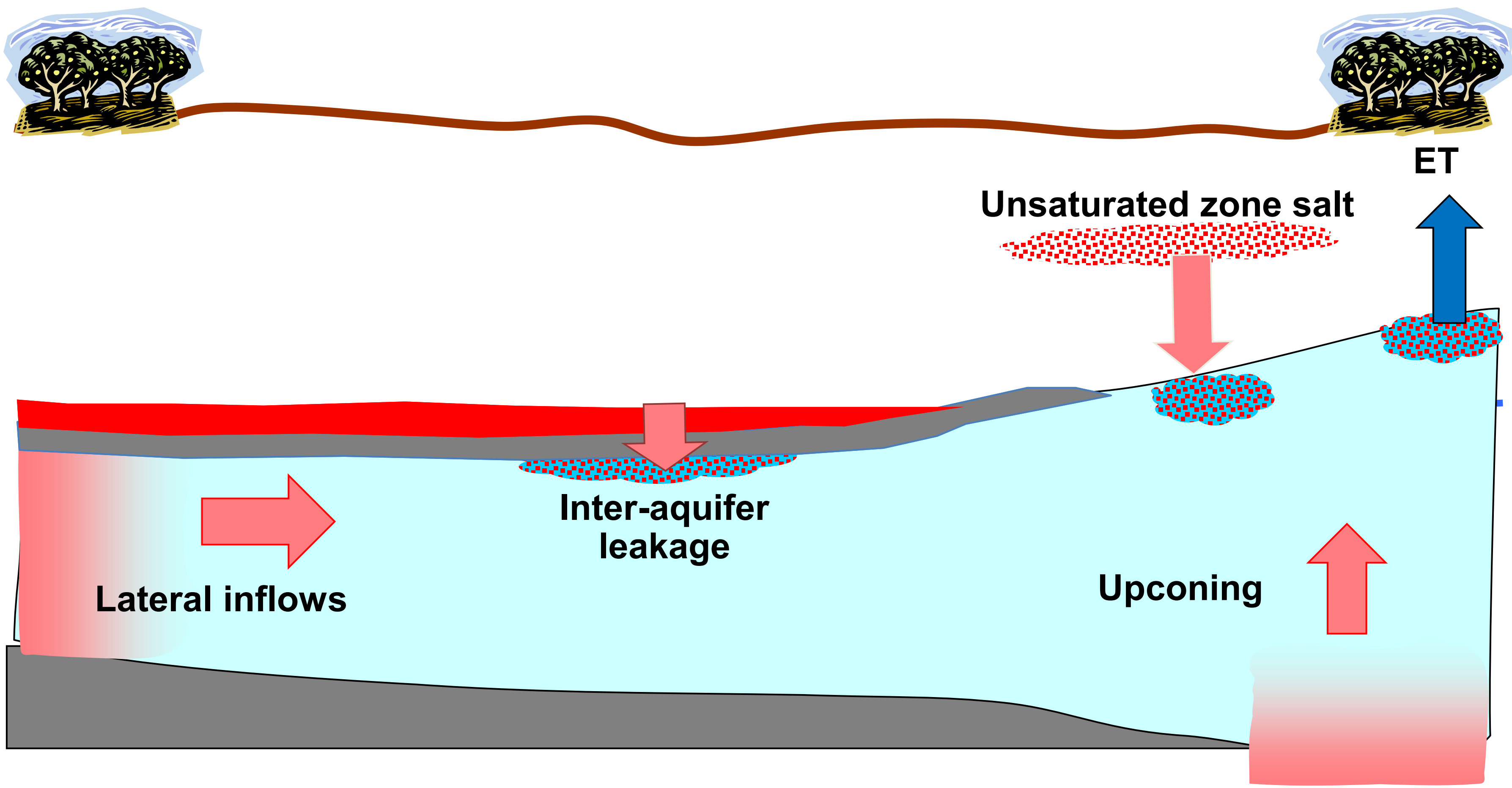

Unconfined aquifer
Watertable
Pressure level
Drawdown due to extraction
Confined aquifer

Confined aquifer management approach

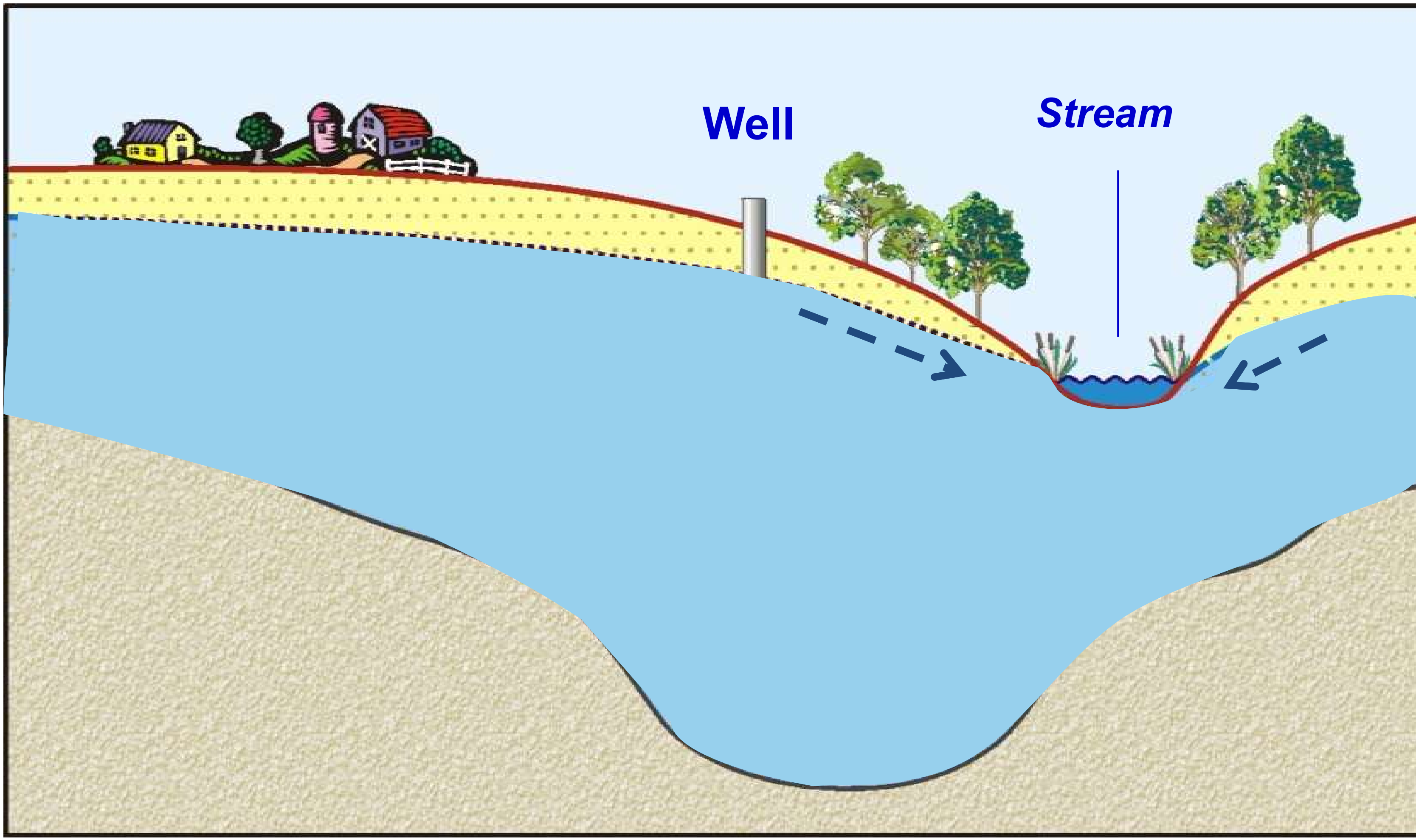
- Although not directly recharged from rainfall, extraction is balanced by lateral inflows and leakage
- Sustainable yield determined by limiting adverse impacts resulting from extraction
- Adverse impacts can be excessive drawdowns or inflows of saline groundwater (vertical leakage or laterally)
- Groundwater modelling usually required to determine limit, with on-going monitoring and adaptive management

Salinity Management

<u>Regional</u> processes that cause salinity increases

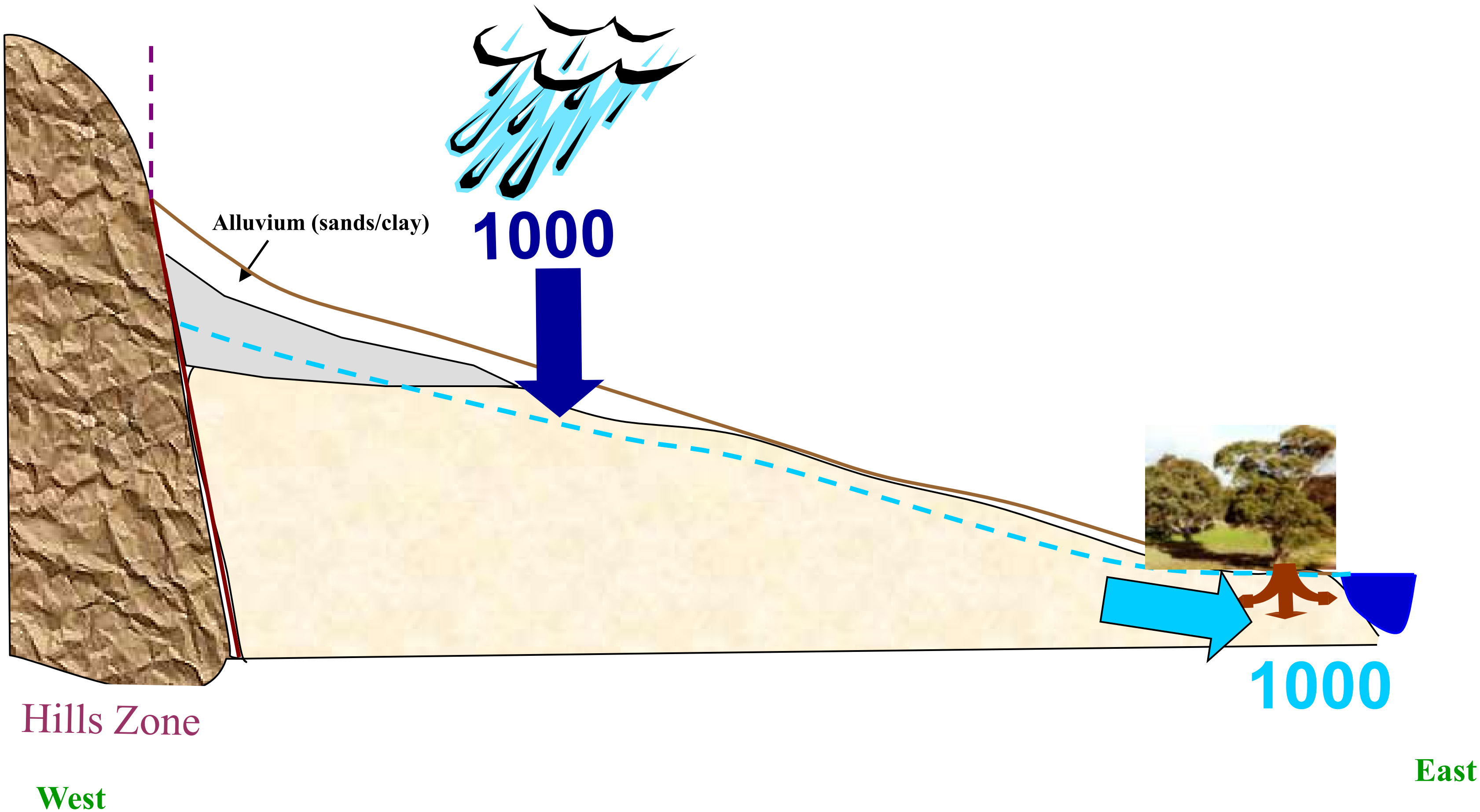


Surface water / groundwater interactions



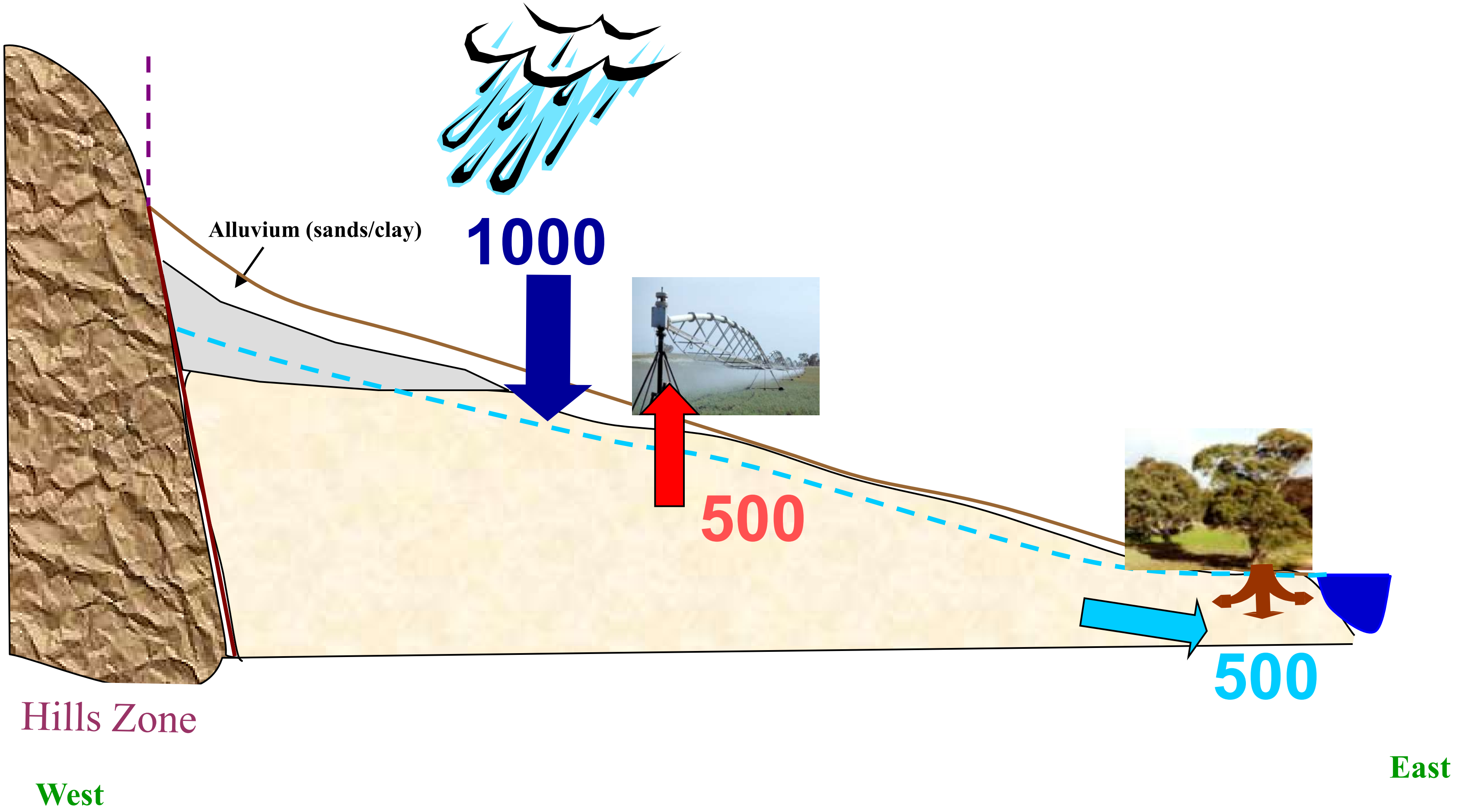
BEFORE DEVELOPMENT – Mt Lofty Ranges

Recharge = Discharge



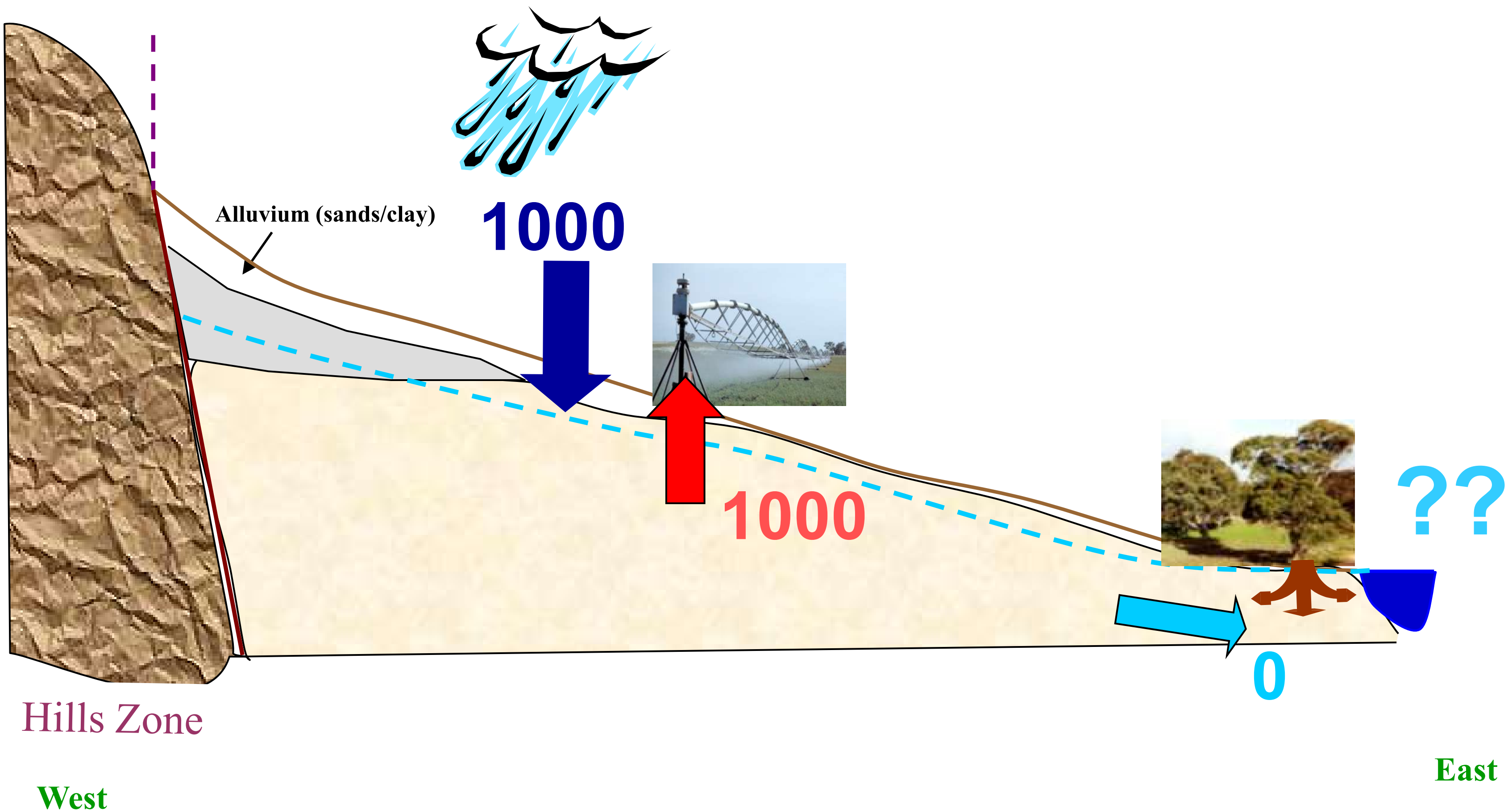
AFTER DEVELOPMENT

Recharge = Pumping + Discharge



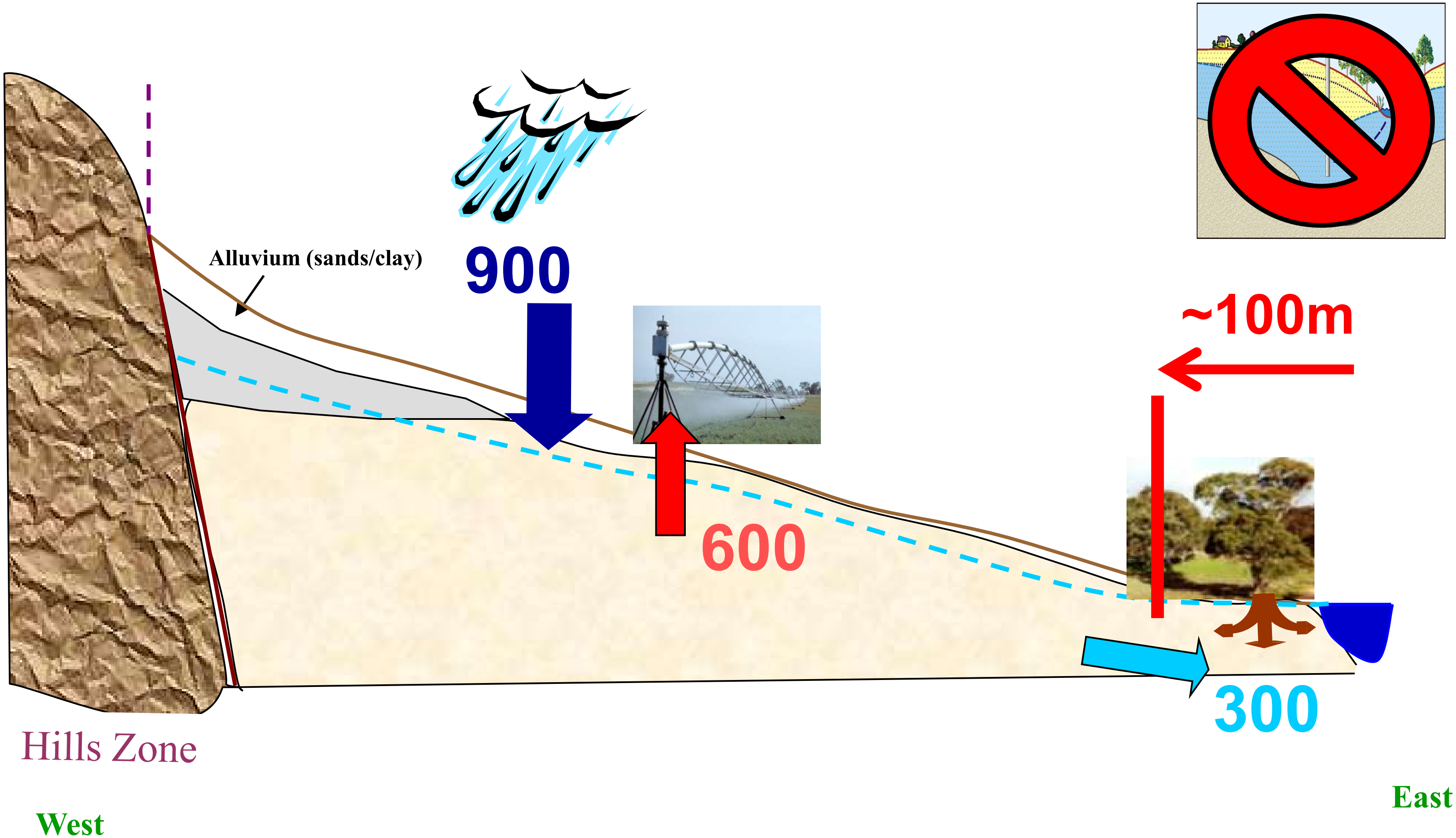
DEVELOPMENT AT SAFE YIELD

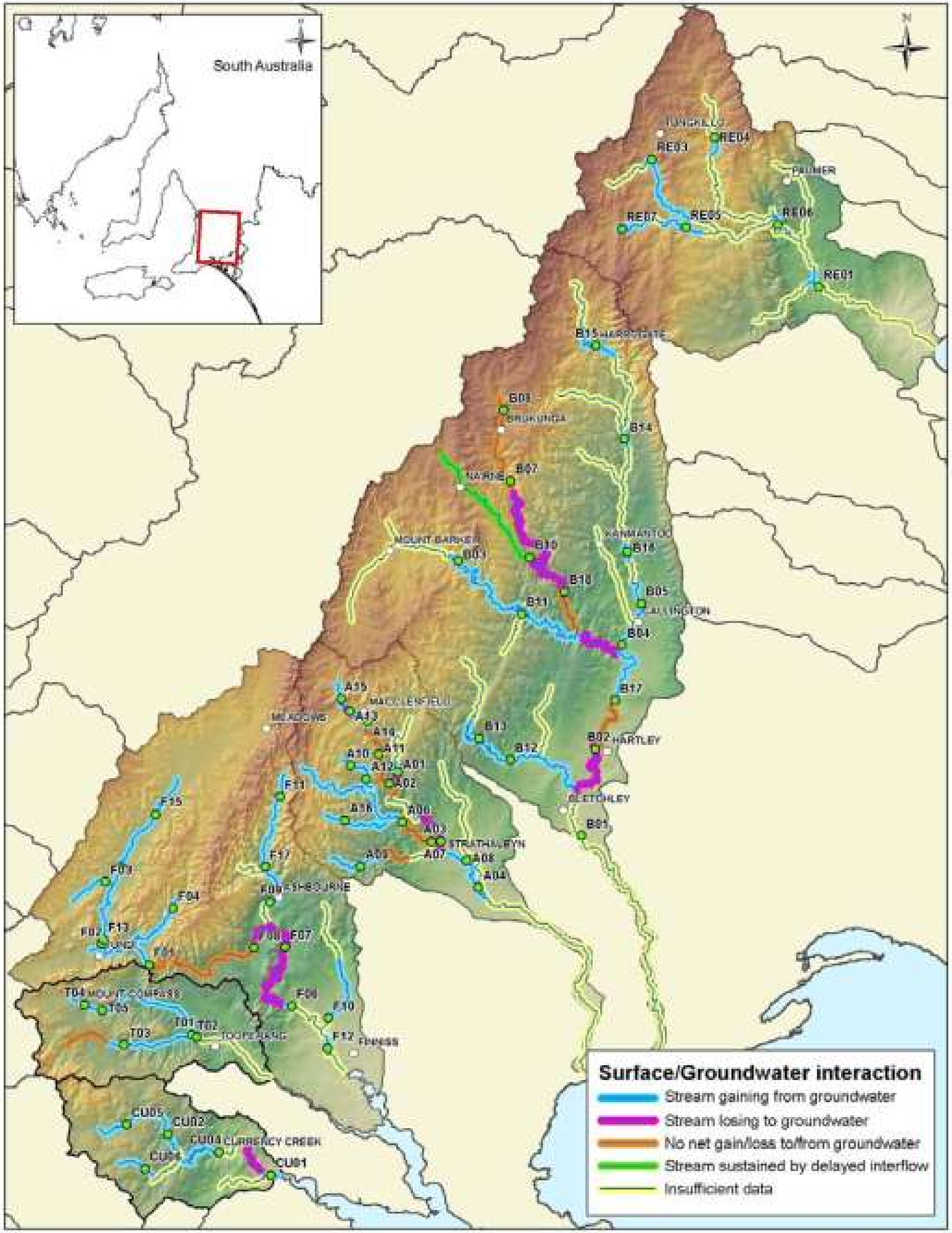
Recharge = Pumping



SUSTAINABLE DEVELOPMENT

Recharge = Extraction limit + Baseflow





Surface Water / Groundwater Interactions in Eastern Mount Lofty Ranges Catchments

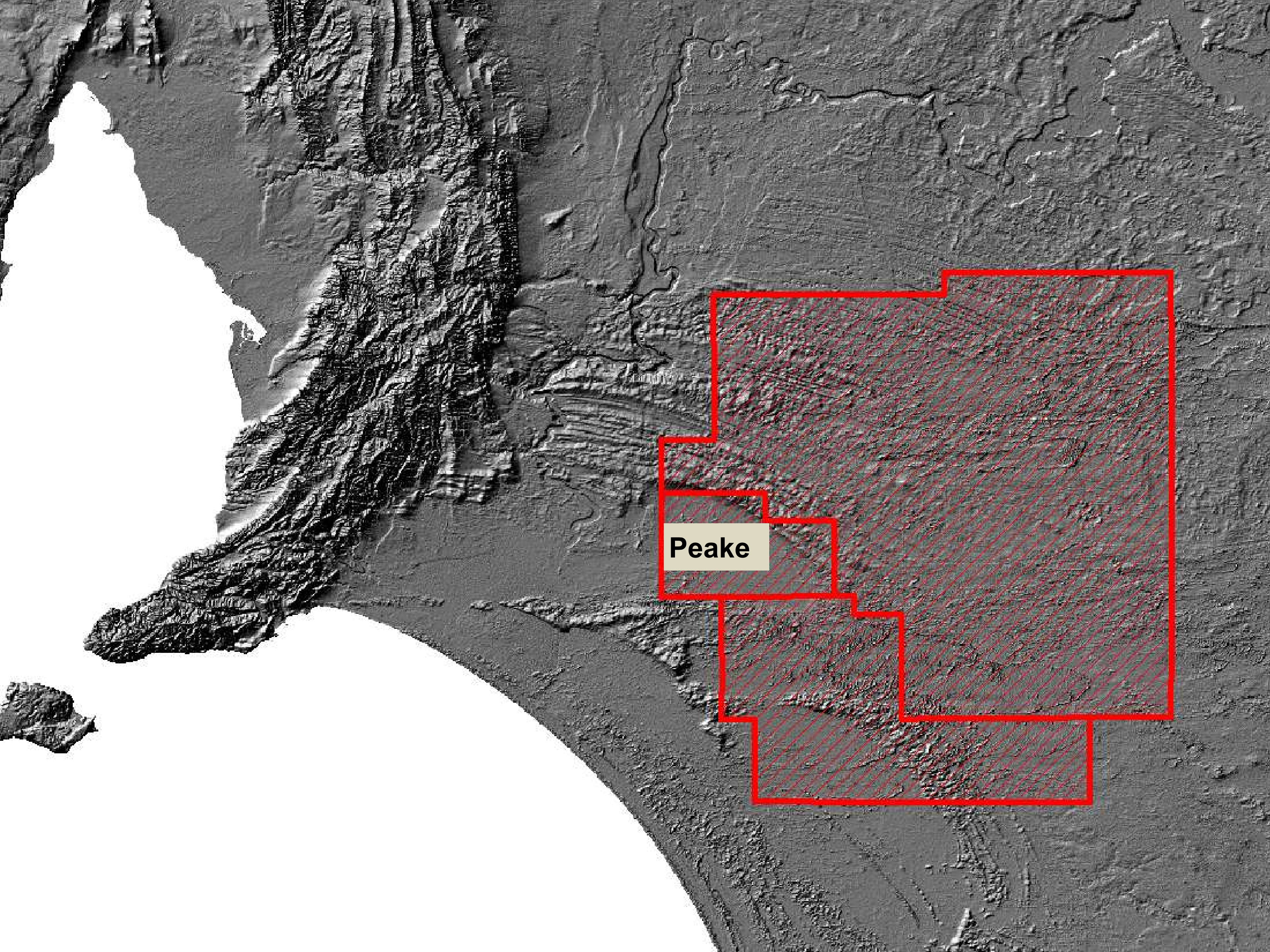
Surface Water and Groundwater Interaction

Defining gaining or losing reaches by hydrochemistry and streamflow measurements

Groundwater case studies

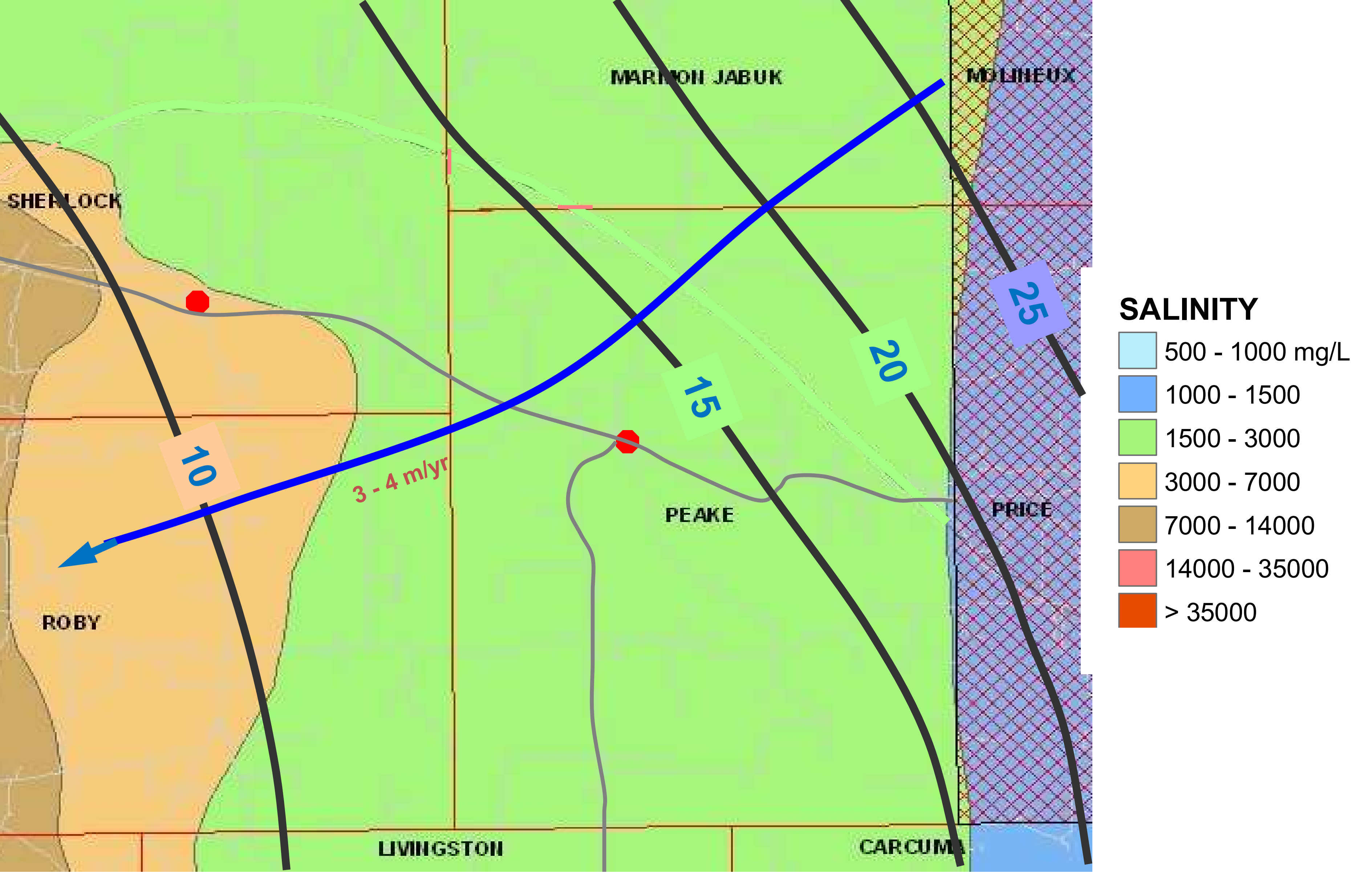
Government of South Australia

Department of Environment, Water and Natural Resources

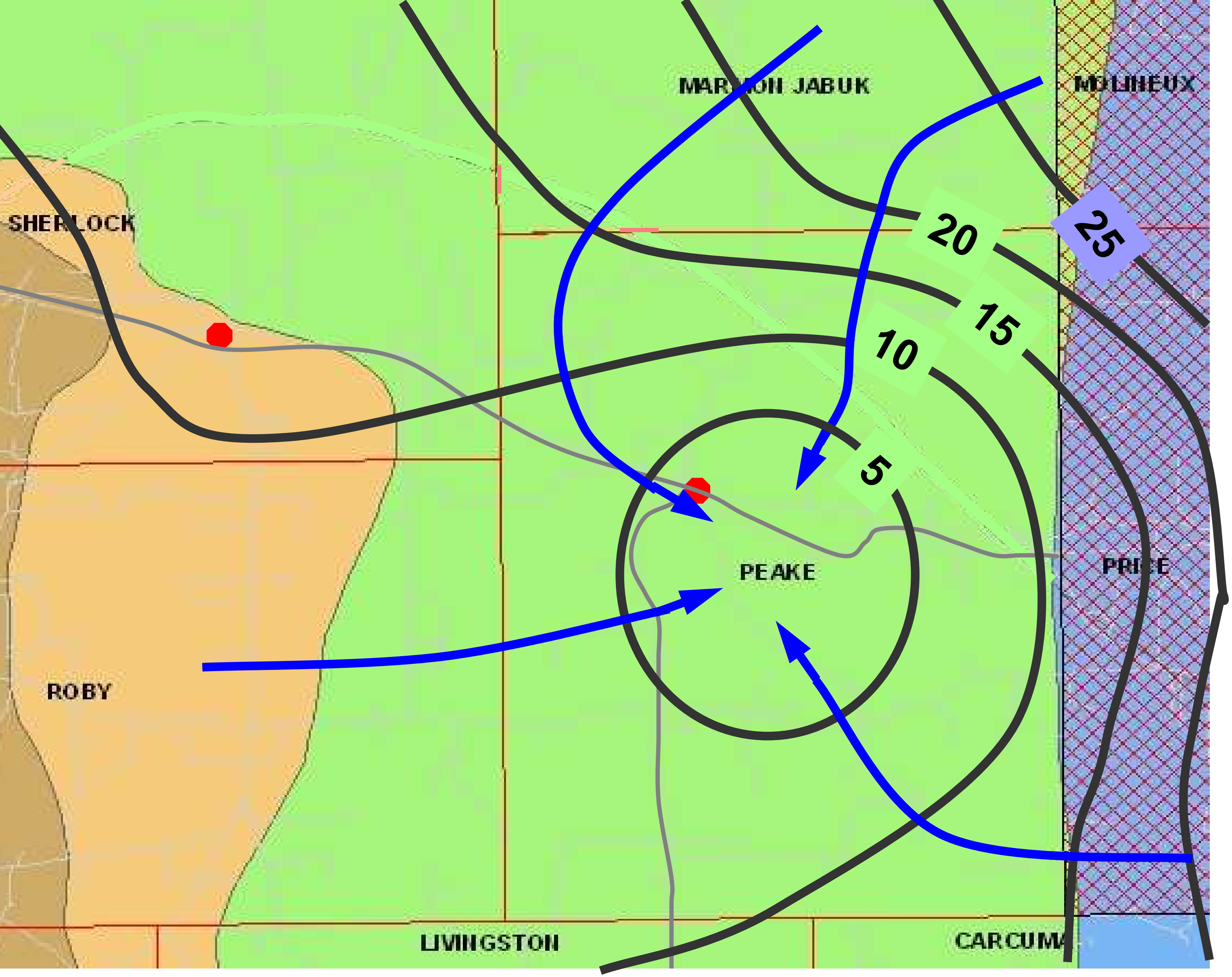

Peake

Peake, Roby and Sherlock Prescribed Wells Area

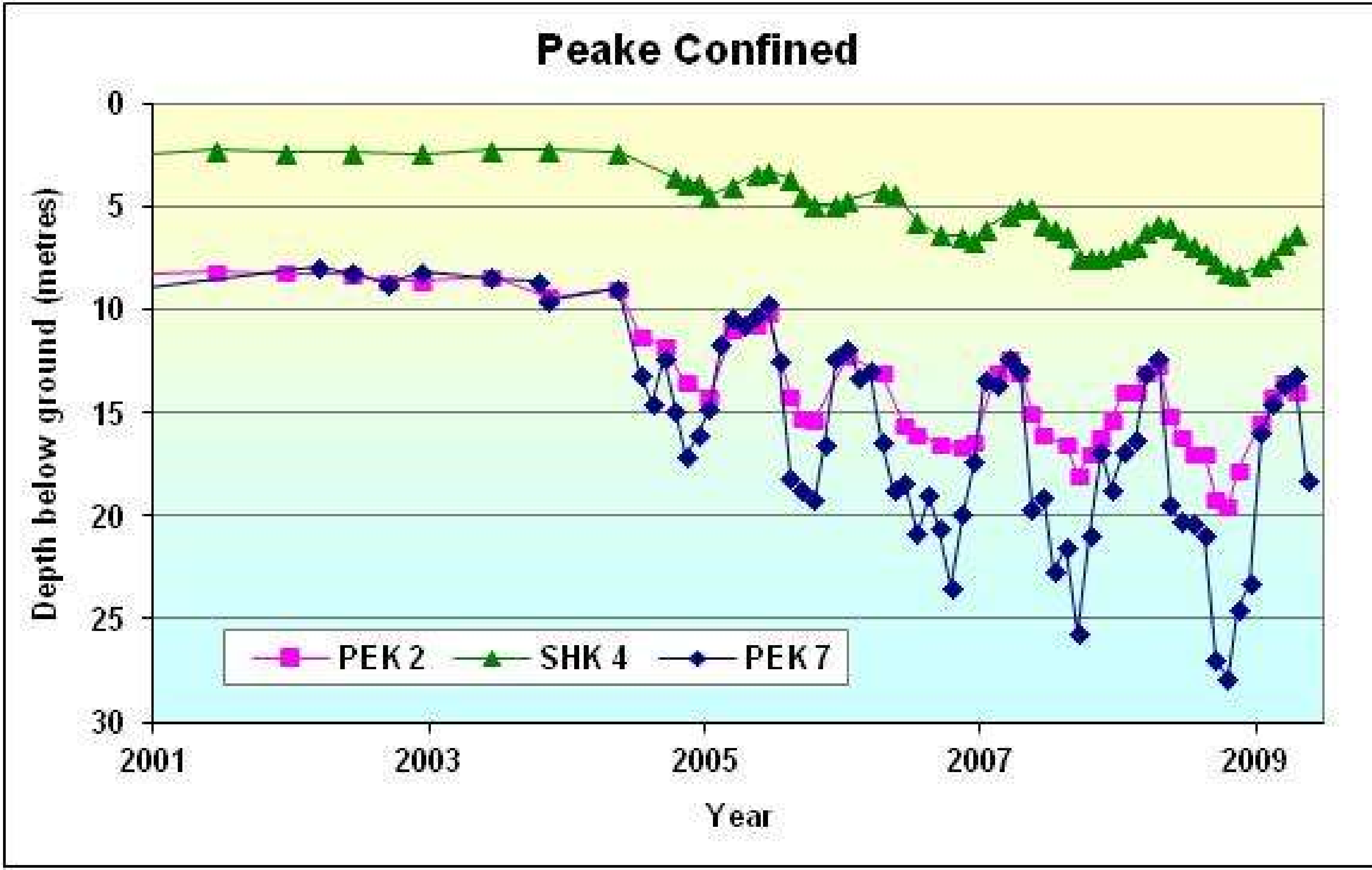
- Confined aquifer only source of water for town water supply (TWS), stock and domestic supplies
- Rapid development of confined aquifer by one main irrigator, outside any management area i.e. no controls



BEFORE PUMPING



DURING PUMPING


Peake Confined
Depth below ground (metres)
0
5
10
15
20
25
30
2001
2003
2005
2007
2009
Year
PEK 2
SHK 4
PEK 7

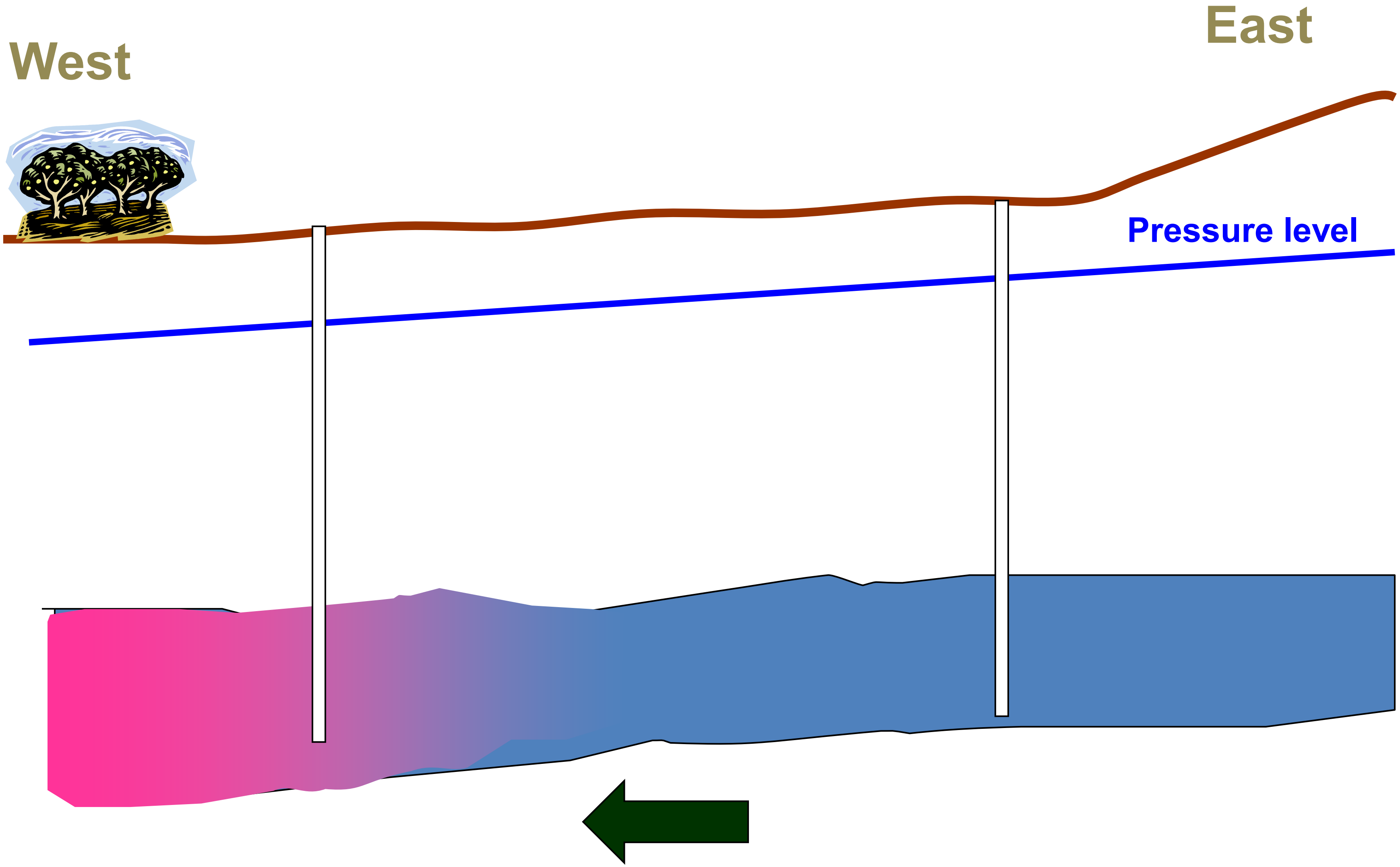
Management issues

- Extractions have caused significant drawdowns
- Adverse impacts include ;
- Flow reversal of more saline groundwater
- Forcing S&D users to deepen / upgrade pumps
- How to determine sustainable yield of the confined aquifer?

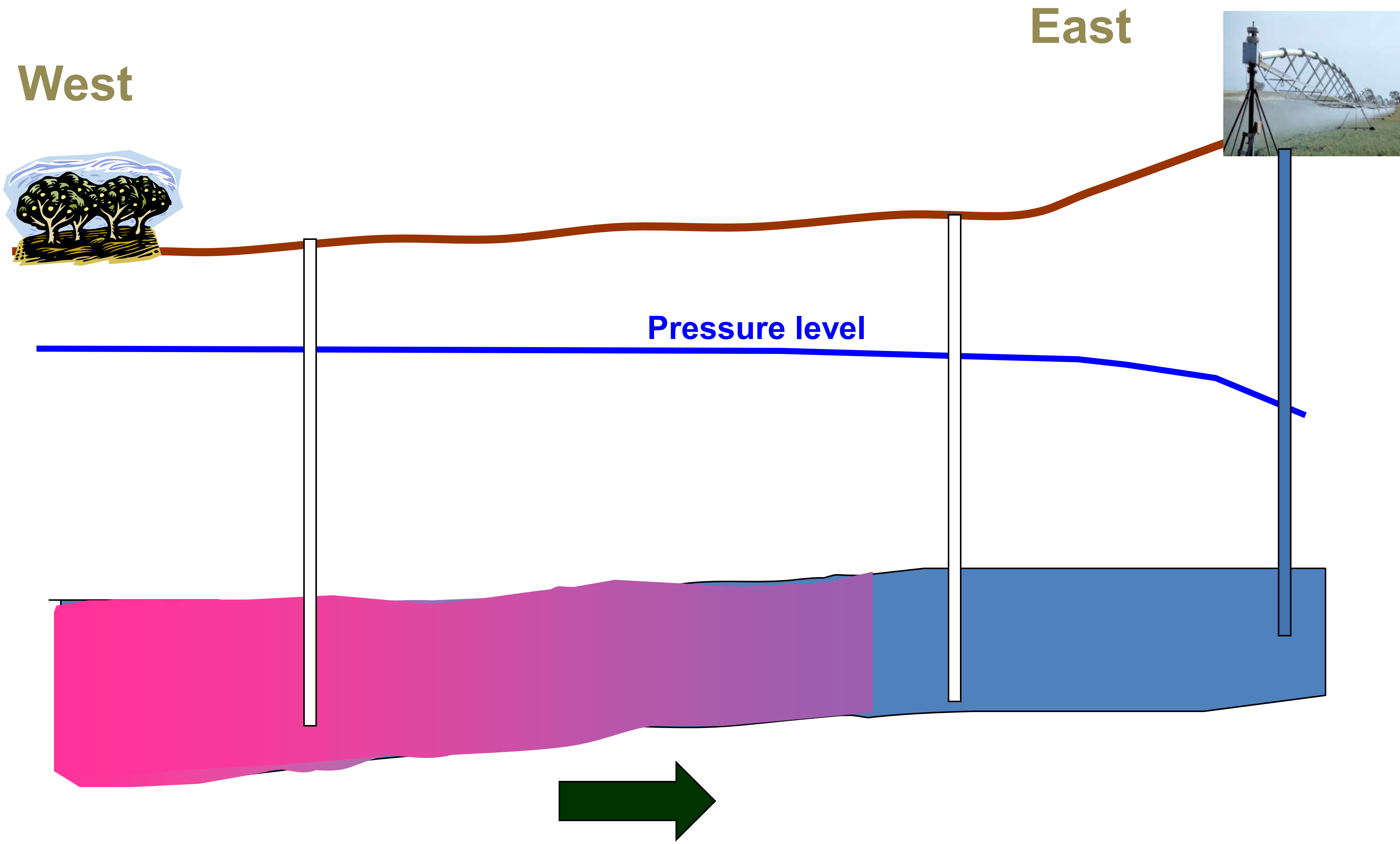
Peake, Roby and Sherlock PWA sustainable yield

What don't we want to happen to the resource?
(i.e. what are unacceptable impacts?)

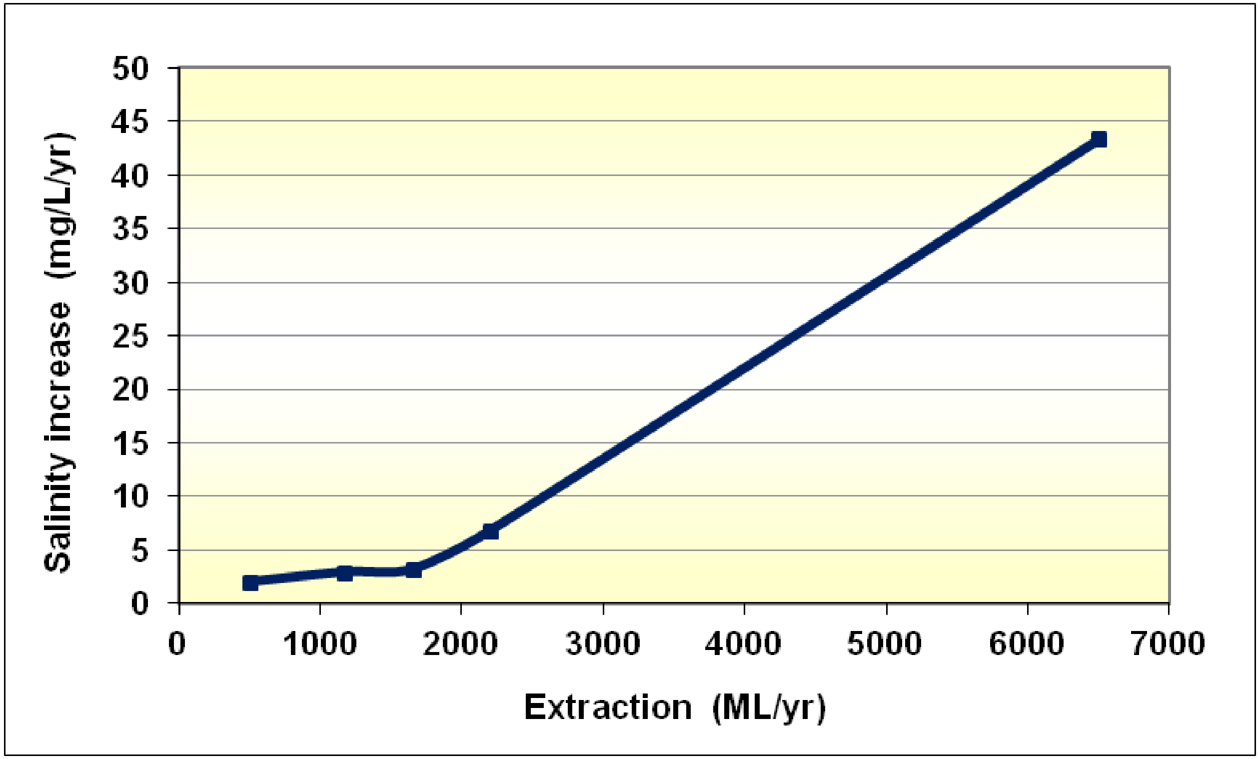
1. Water level ;
   a. Should not fall below confining layer?
   b. Should not affect stock and domestic users?
2. Salinity ;
   a. Should not affect the use of the resource?



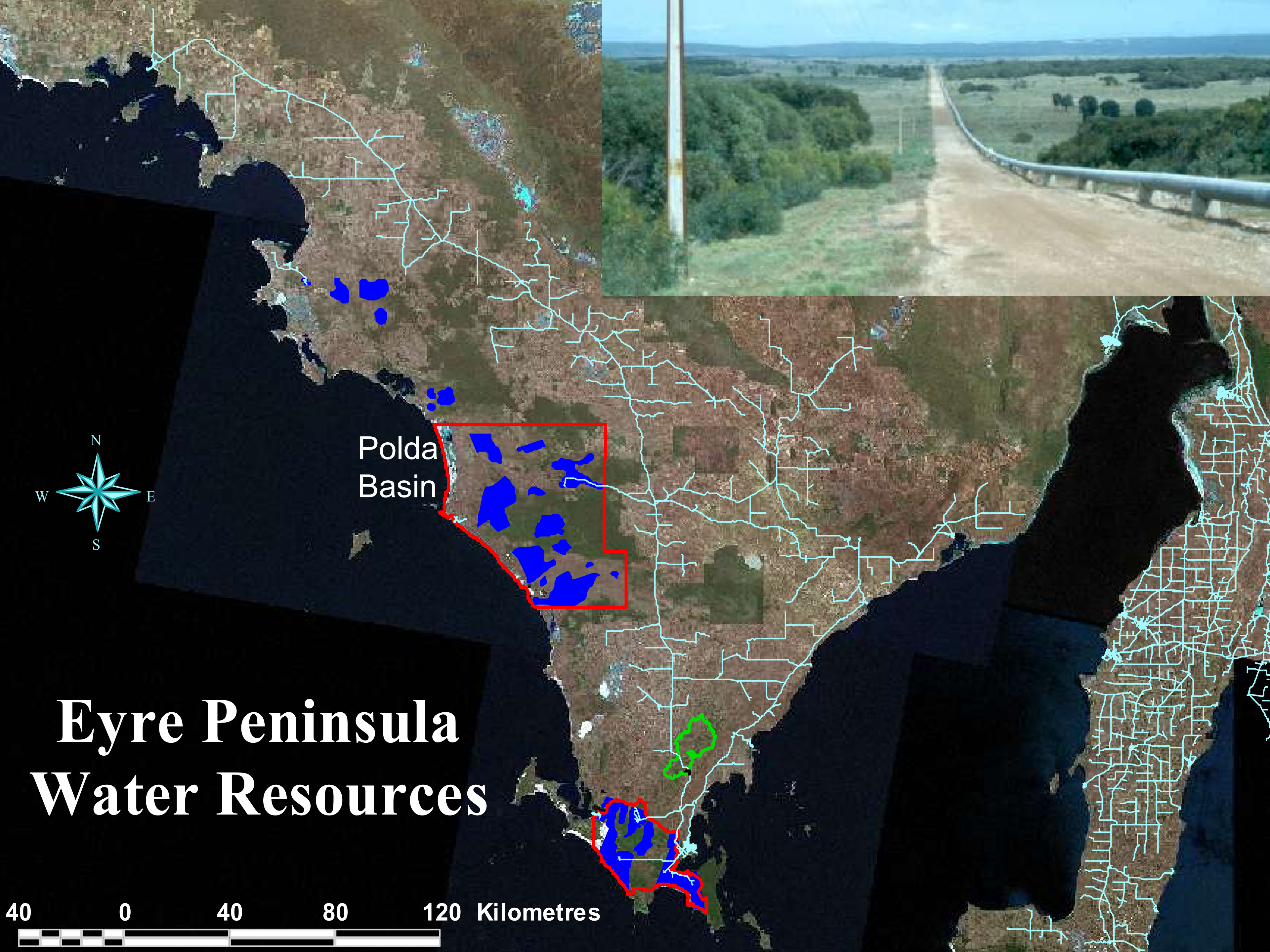
West
East
Pressure level


East
West
Pressure level

- Groundwater model can predict salinity increases at various extraction rates
- What is an acceptable value of salinity increase ?



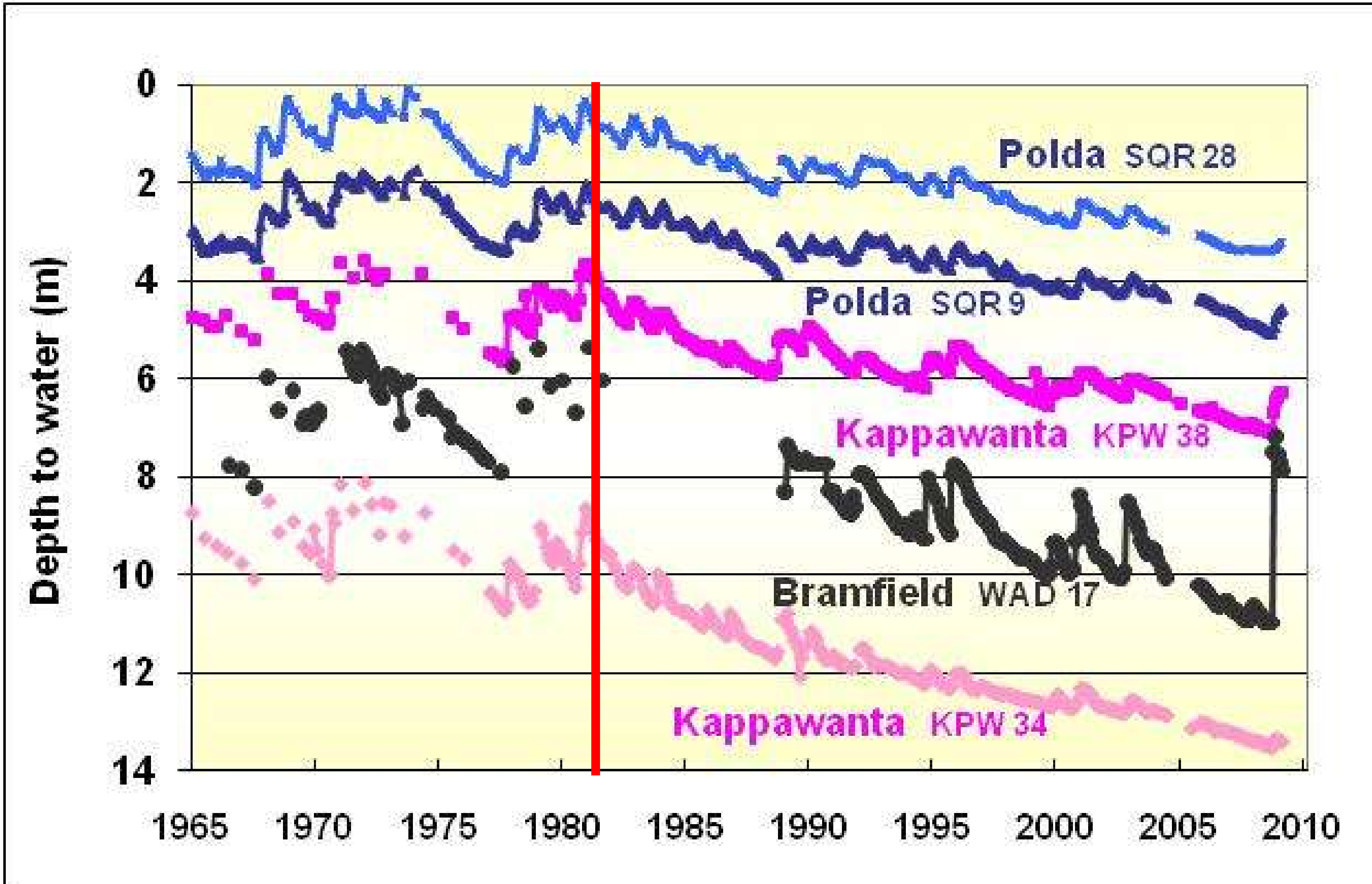
- Who decides what the acceptable rate of salinity increase is?
- Not the hydrogeologist! Community consultation the key
- In effect, the chosen value will be used to set initial allocations, but then adaptive management and salinity monitoring will be used in future


Eyre Peninsula
Water Resources
Polda
Basin
N
S
W
E
40
0
40
80
120
Kilometres

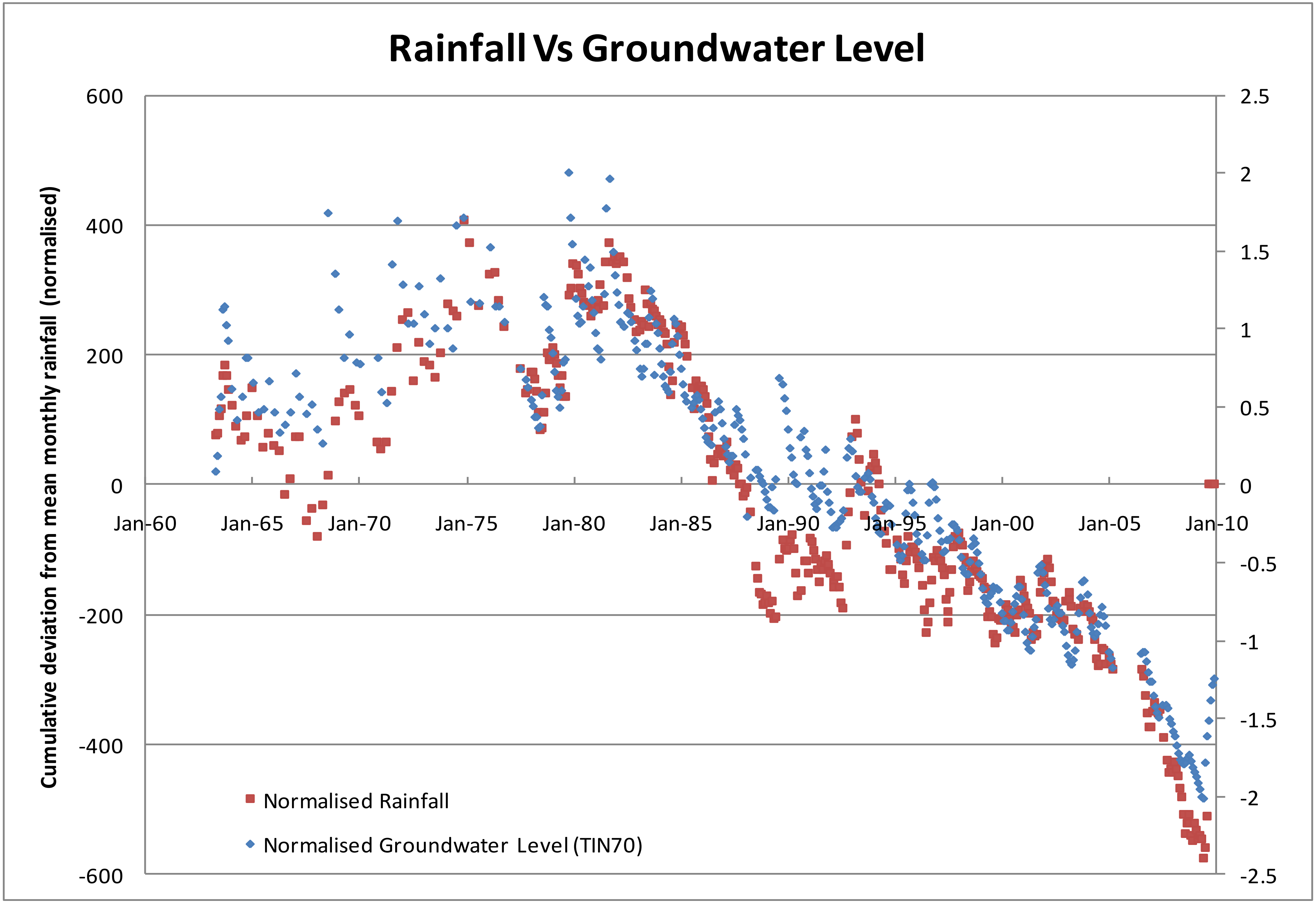
Polda Basin (Musgrave PWA) - volume and salinity

- Shallow and thin limestone aquifers
- Amount of groundwater stored in aquifer very sensitive to rainfall recharge
- Contains low salinity groundwater

Musgrave PWA Groundwater Basins

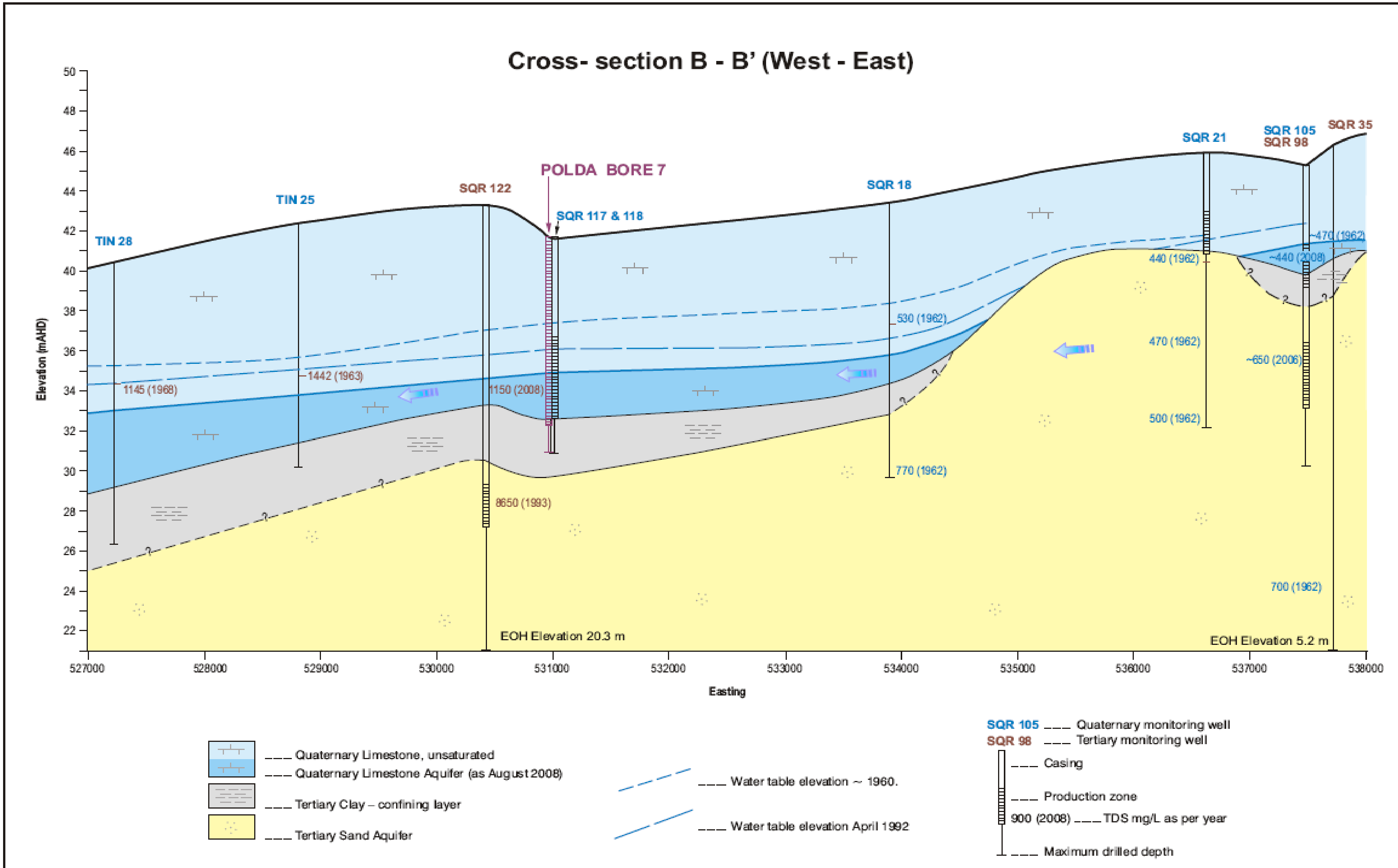


Groundwater levels falling from 1980 to 2009

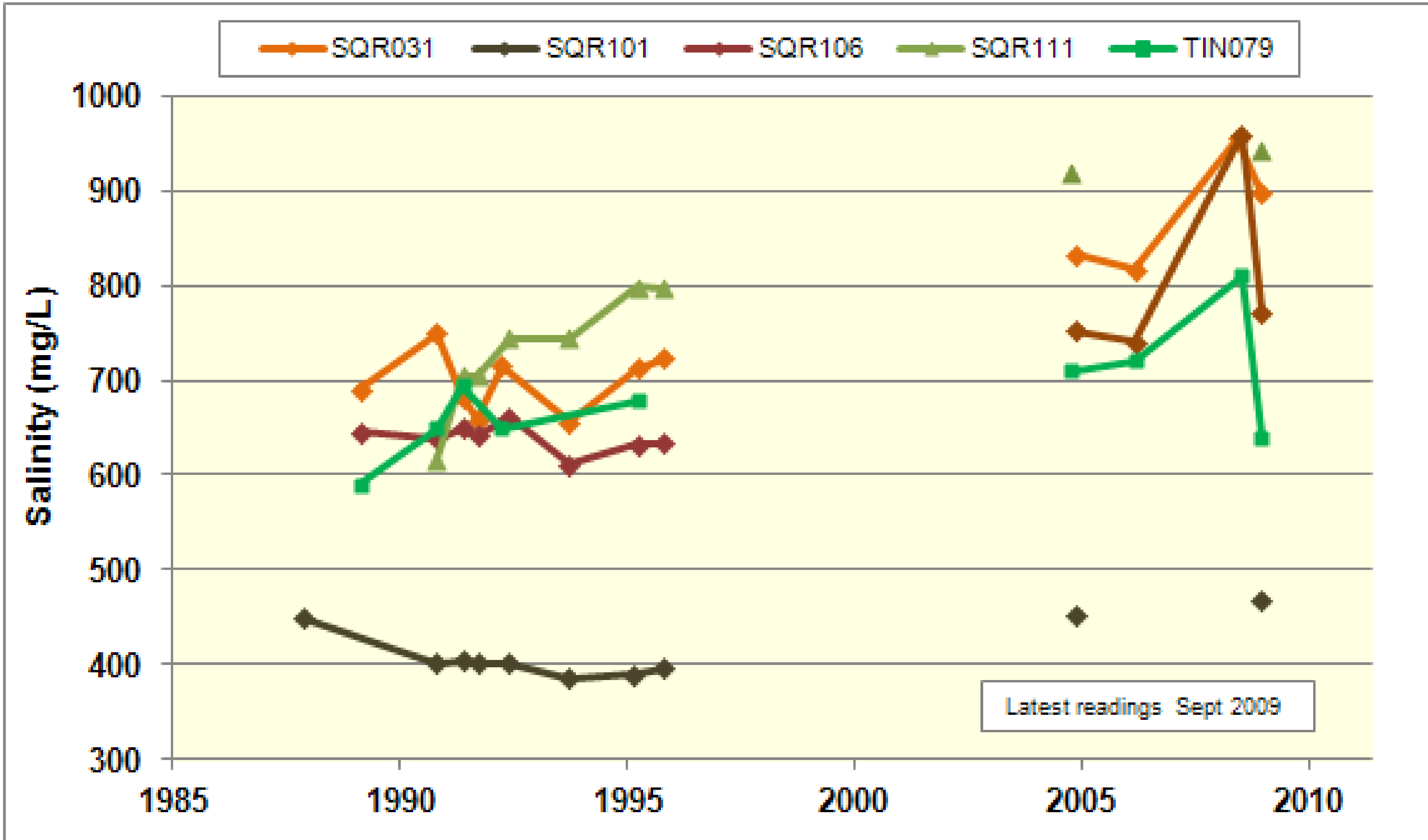


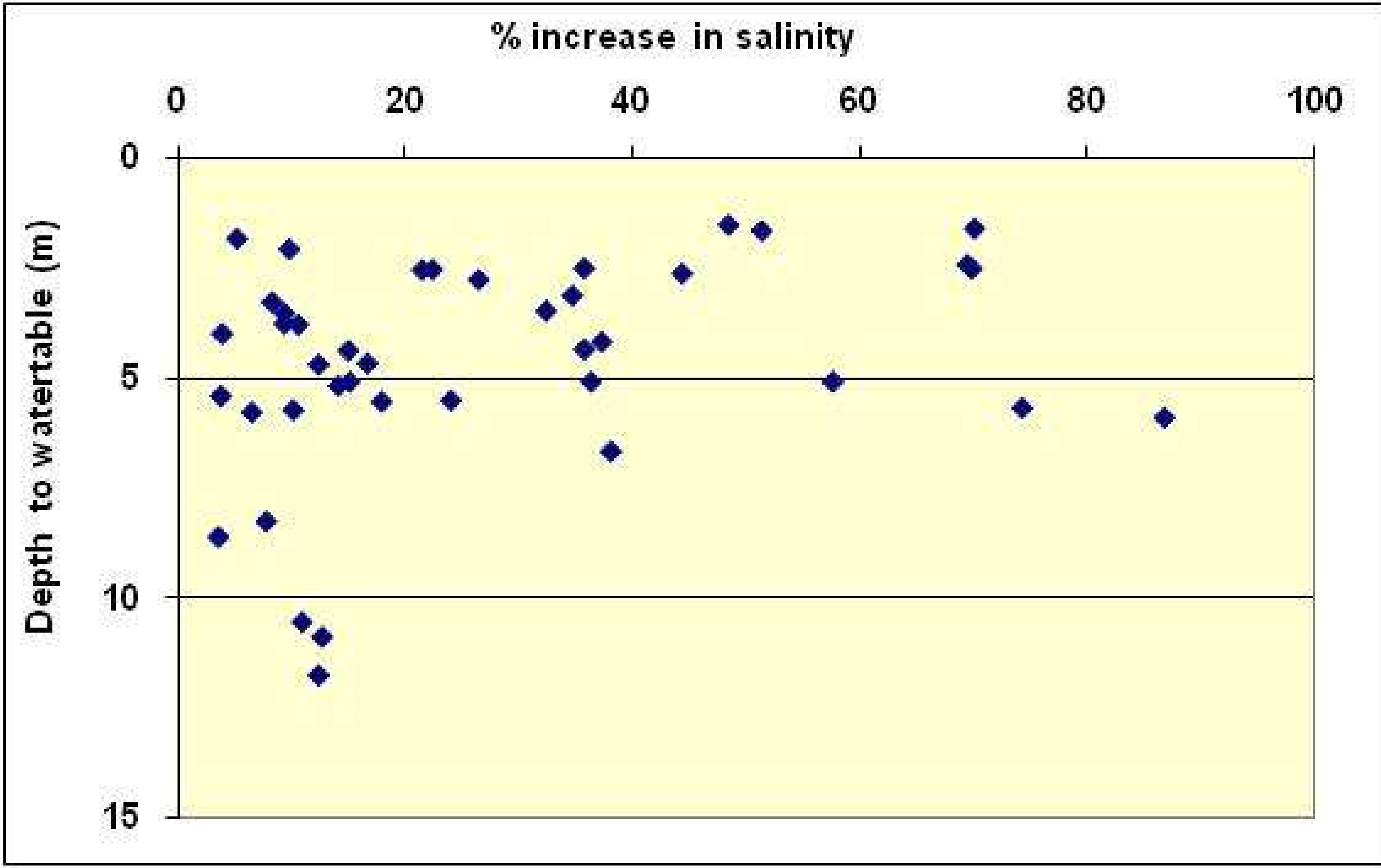
Rainfall Vs Groundwater Level
Cumulative deviation from mean monthly rainfall (normalised)
600
400
200
0
-200
-400
-600
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Normalised Rainfall
Normalised Groundwater Level (TIN70)

Polda Basin – water levels 1960, 1992 and 2008

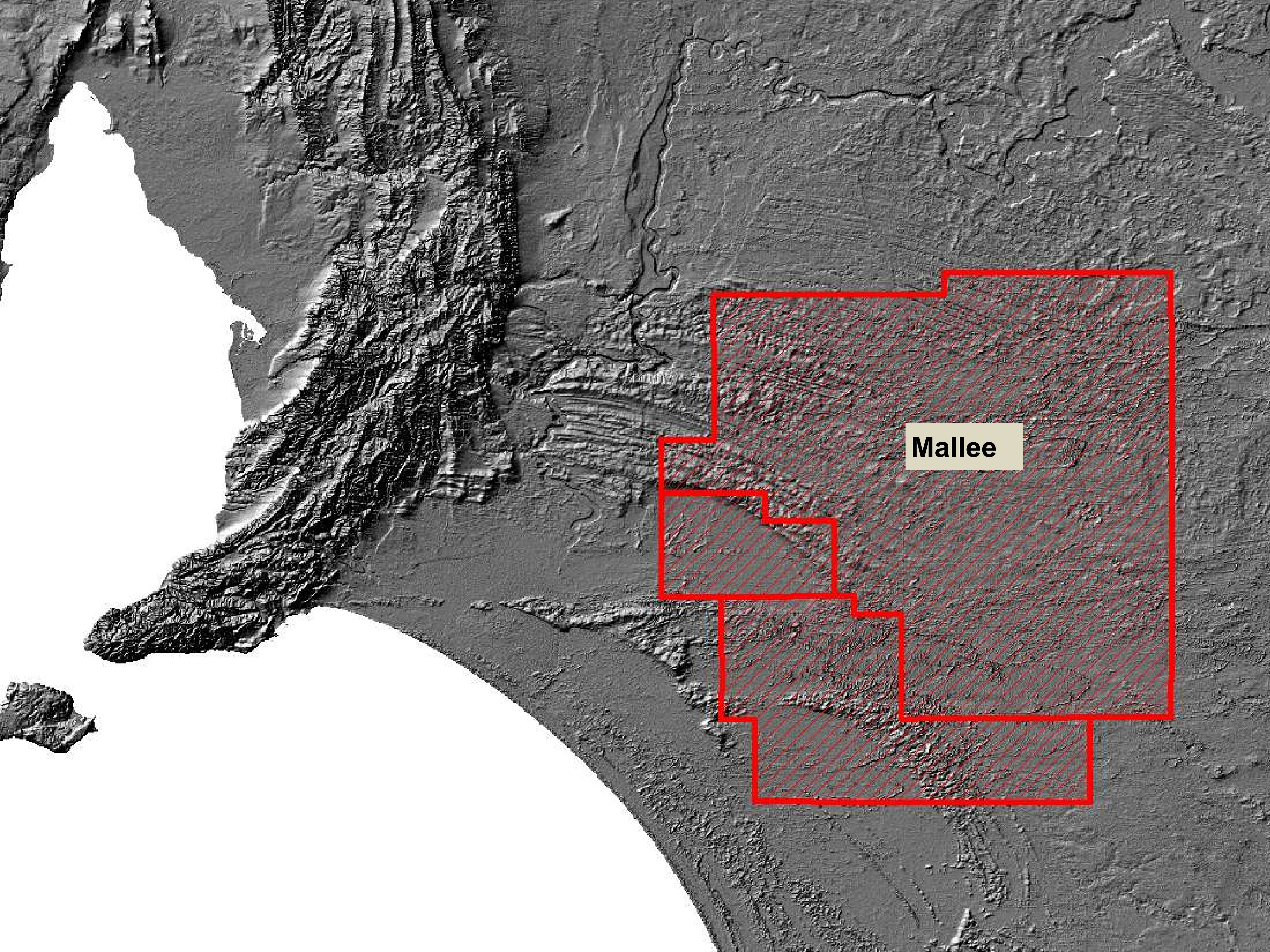


Polda Basin – salinity levels




% increase in salinity
0
20
40
60
80
100
0
5
10
15
Depth to watertable (m)

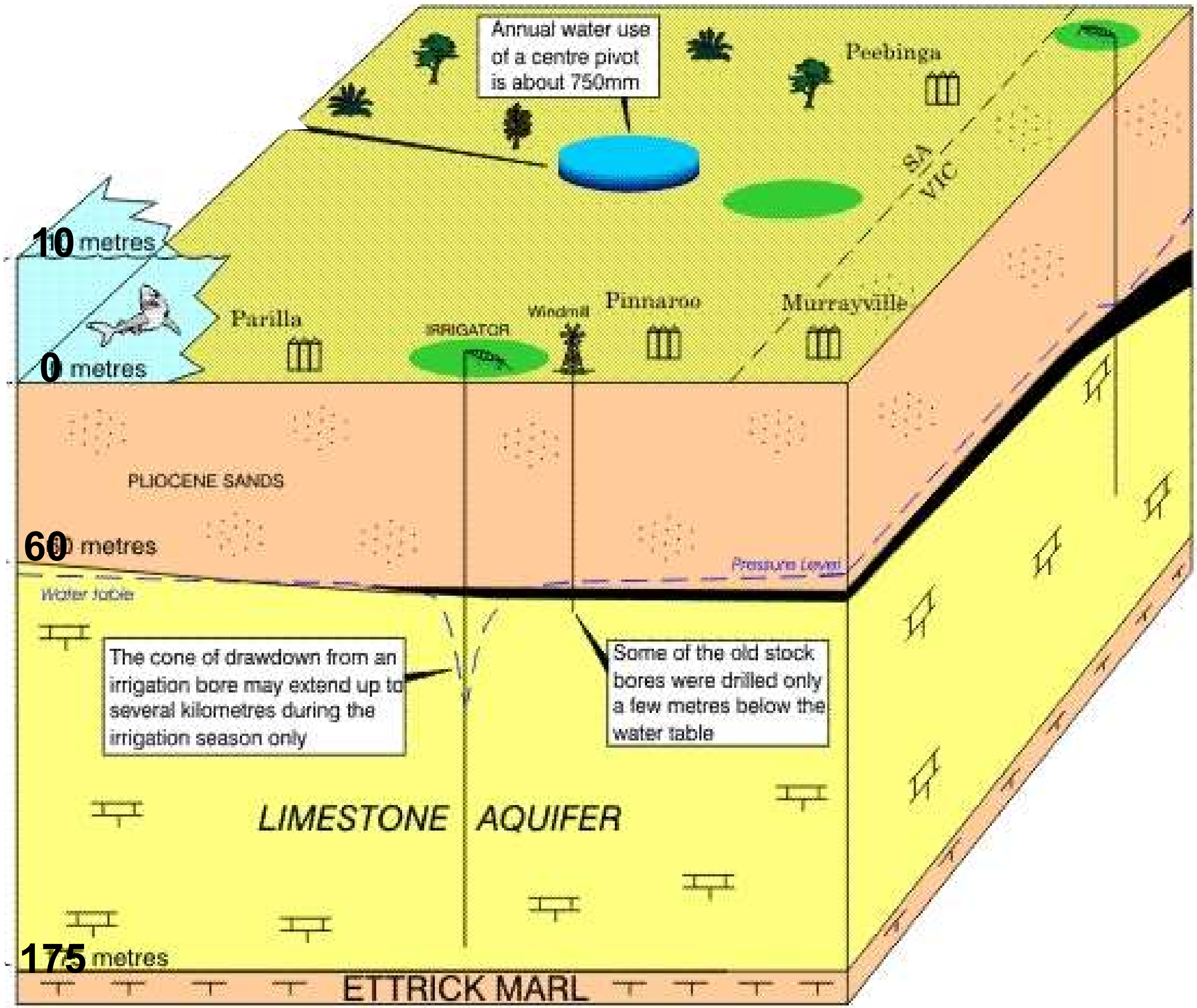
- What is the cause of the salinity increase that occurs with a fall in groundwater level?
- Some discharge processes take salt as well
- Natural discharge always in conflict with recharge – and sometimes wins!
- Can this be managed?


Mallee

Mallee PWA - Volume

- Large areas underlain by a limestone aquifer with irrigation quality groundwater
- Current recharge is very low, last significant recharge was 20,000 yrs ago
- Aquifer averages over 100m in thickness and contains about 100 million ML in storage

MALLEE REGION
GROUNDWATER SECTION

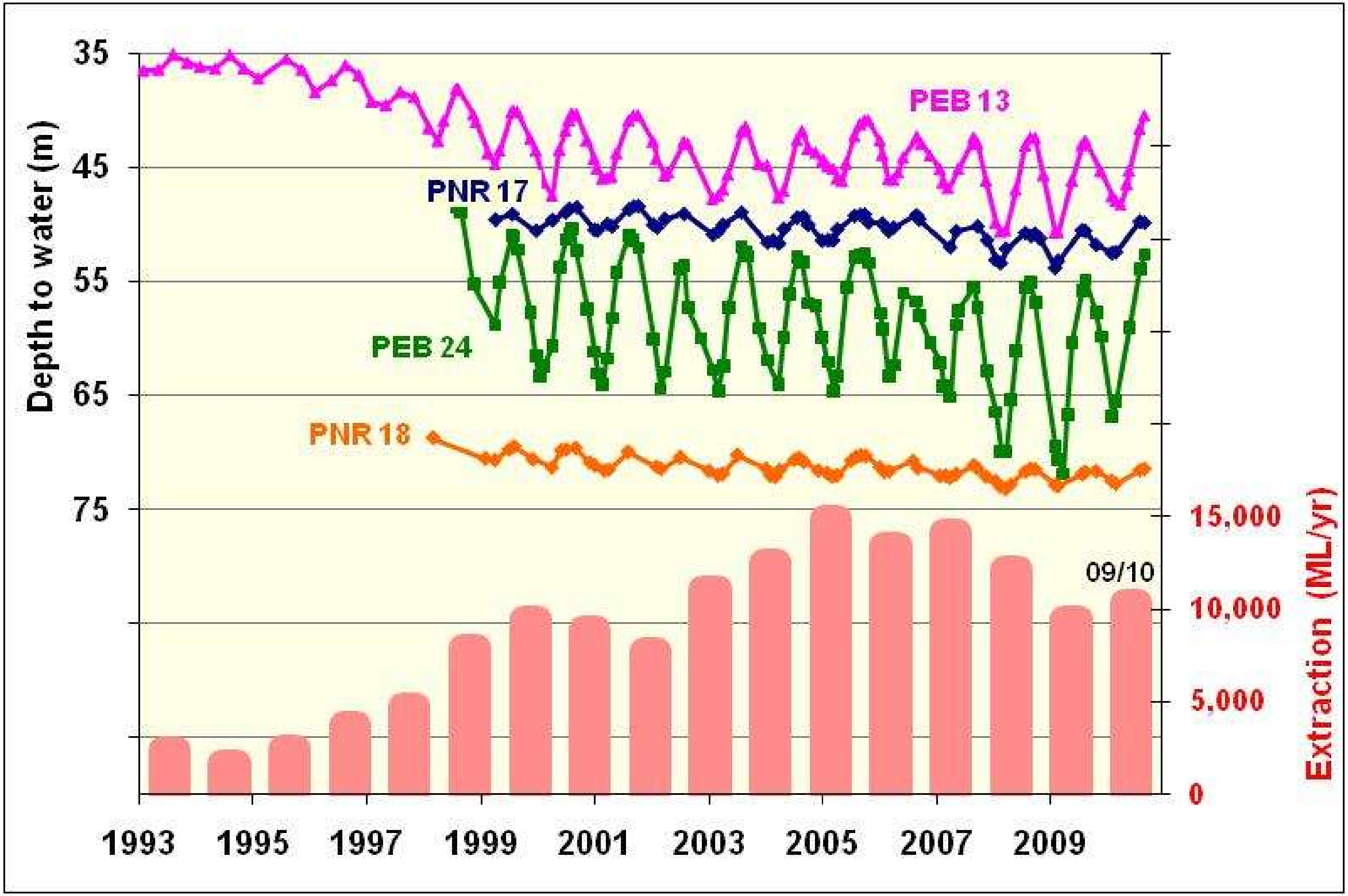


Centre pivot irrigation of potatoes generates about $75 million/yr

Sustainability issues

- Is this a non-renewable resource?
- Should the huge amount of storage be left for the use of future generations?
- If so, WHEN should they start using it?
- By starting to use it now, ‘permission’ is given for future generations to use it also

Mallee PWA new post-development equilibrium



- SY determined as ‘mining’ a small portion of the huge storage (= 5cm/yr drawdown)
- Resource will be depleted by 15% in 300 years
- Drawdown impacts mitigated by cost sharing scheme to pay for pump lowering and well deepening for S&D users
- Salinity risk low and may take decades to detect (modelling and monitoring)
- Buffers around existing irrigation wells to minimise concentration of pumping

Summary

- Complex science is routinely applied to determining sustainable extraction limits and evaluating policy options for WAPs
- There is no standard formula – each resource is different and requires a special approach
- The science must be sound, transparent and understood by stakeholders

Challenges

- Resourcing in a drying fiscal climate
- Scepticism of science from some community members (usually with other agendas)
- Maintaining appropriate monitoring (stream guaging)

Challenges

- **Modelling limitations, confidence levels & applicability**
- **Runoff / flow:** Volumes VS Flow regimes!
- **Scaling:** Catchment – sub-catchment – property - ..
- **Ungauged catchments: ………….**
- **Low & High Flows:** measurement, gaugings, ratings..
- **Surface - Ground water interction**
- Science - Policy - Legal Interface
- **Articulate the above : Community Confidence**




END



QUESTIONS?

Government
of South Australia

Department of Environment,
Water and Natural Resources