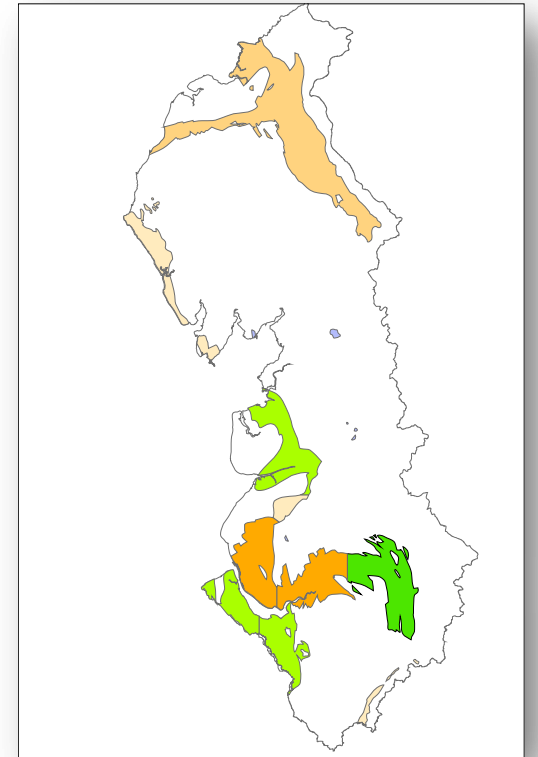




Reflections of a retired hydrogeologist on...

**...the use, management and understanding
of the Permo-Triassic sandstones
of north west England.**

Keith Seymour (vice president for regional groups)



Reflections of a retired hydrogeologist on
**the use, management and understanding of the
Permo-Triassic sandstones of north west England.**



- Introduction – *my credentials*
- Setting the scene – geology and hydrogeology of NW
- History of abstraction
- History of regulation
- Key insights
 - Compartmentalisation
 - Saline intrusion
 - Recharge
- Chalk and cheese: drought and flood responses

Introduction

1976



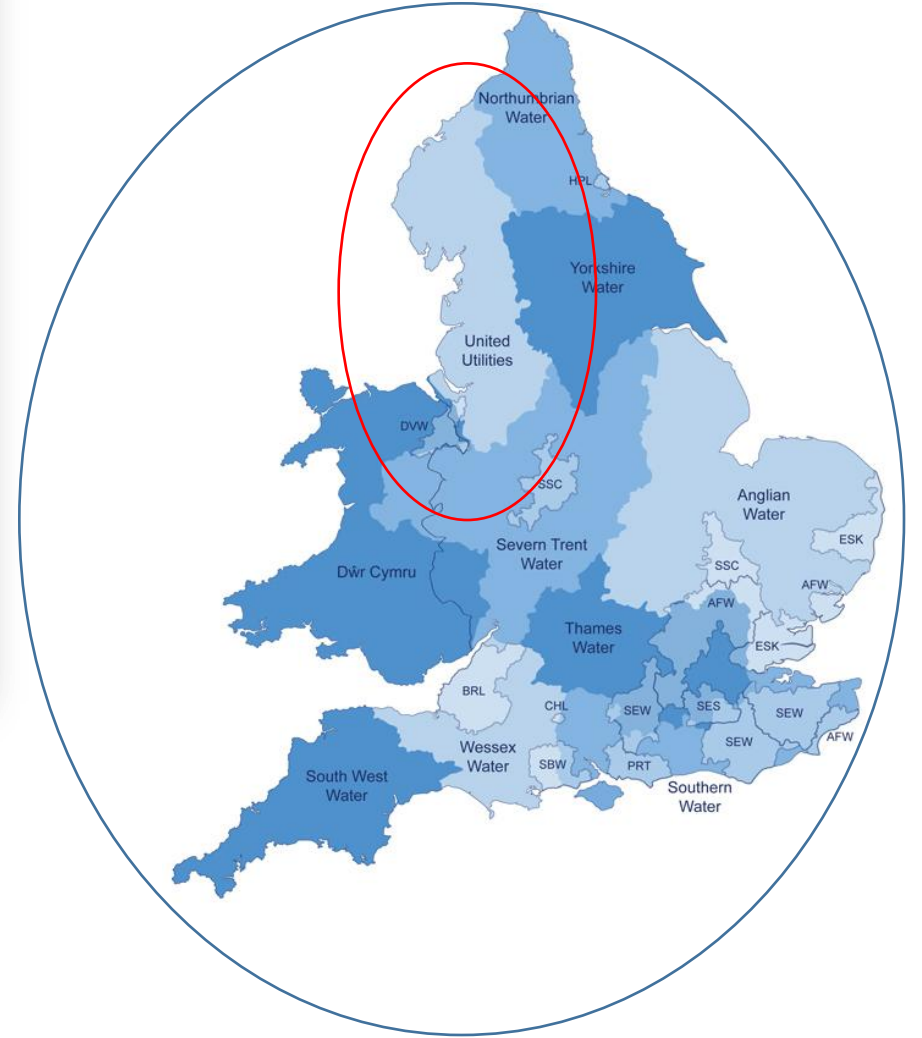
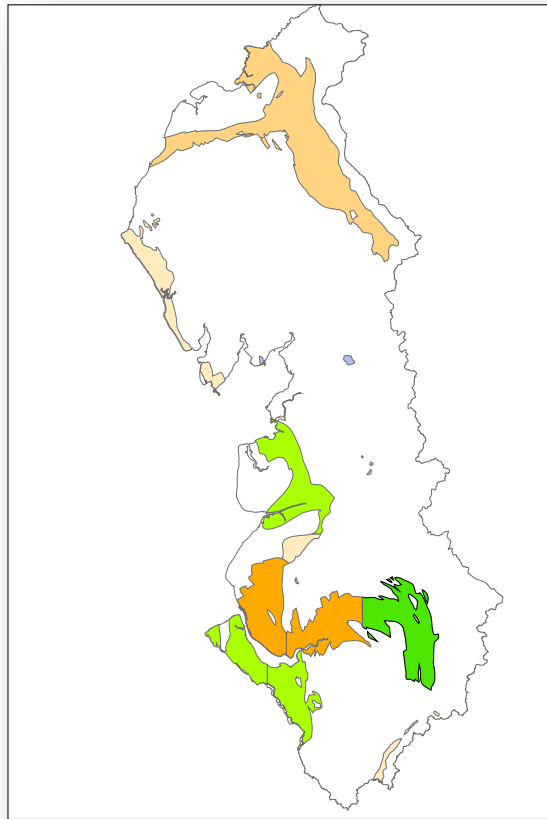
1989



1996

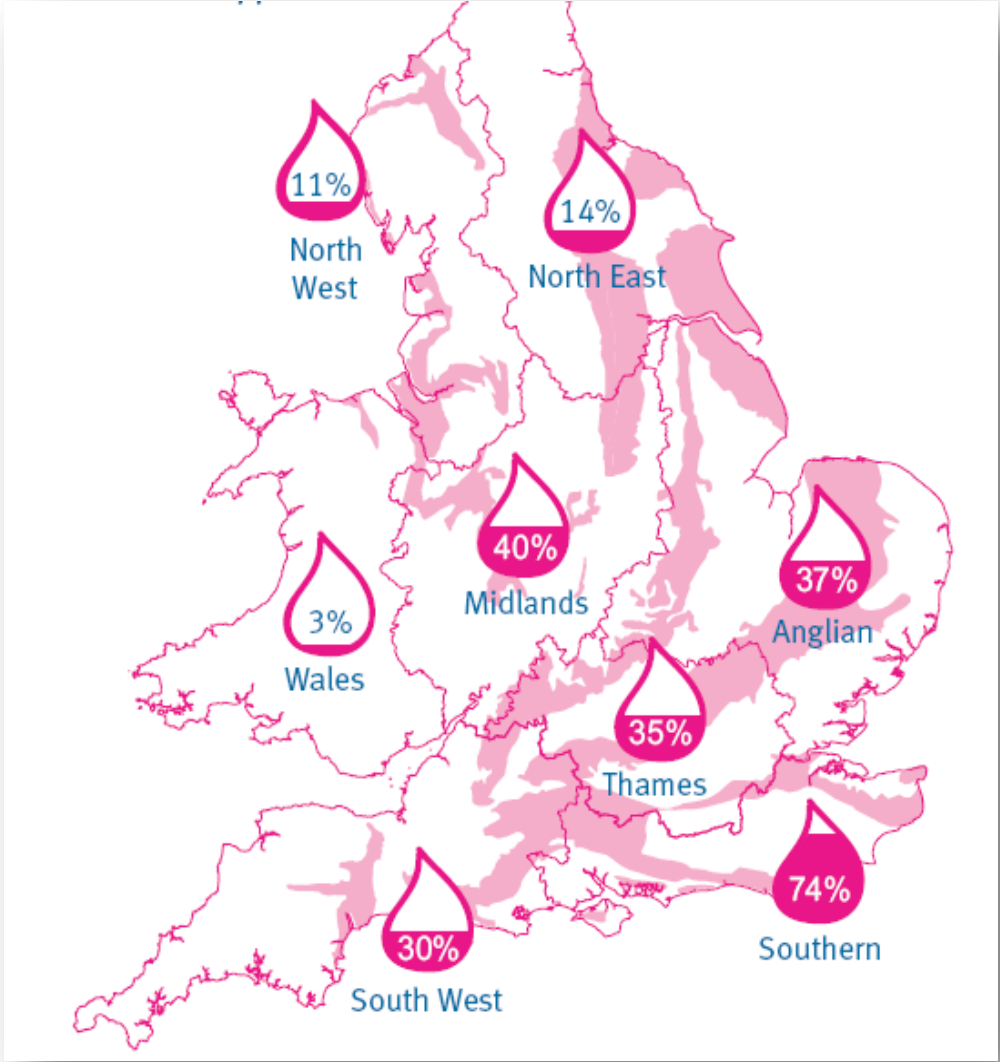
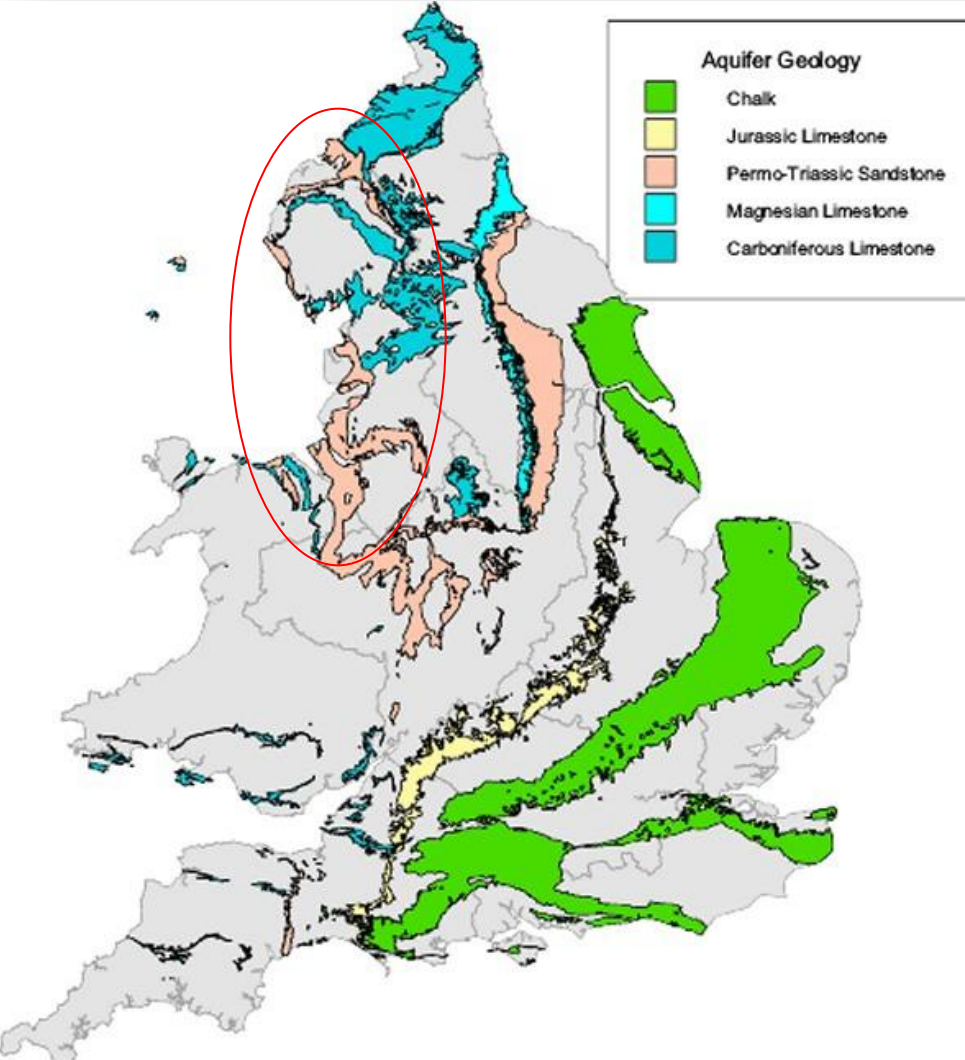


2008/14



'Credentials'

Our principal aquifers



~importance for public water supply

Why is groundwater only 11% of PWS in the NW?



Weather or not,



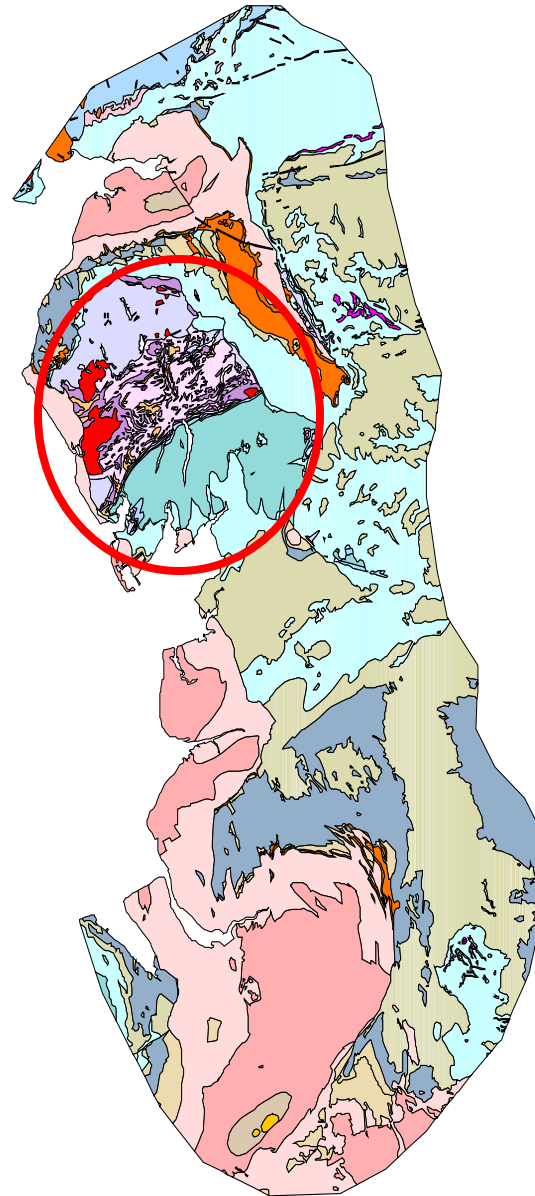
is it a 'geology thing'?

Setting the scene:

- Geology and hydrogeology of NW

Geology of NW

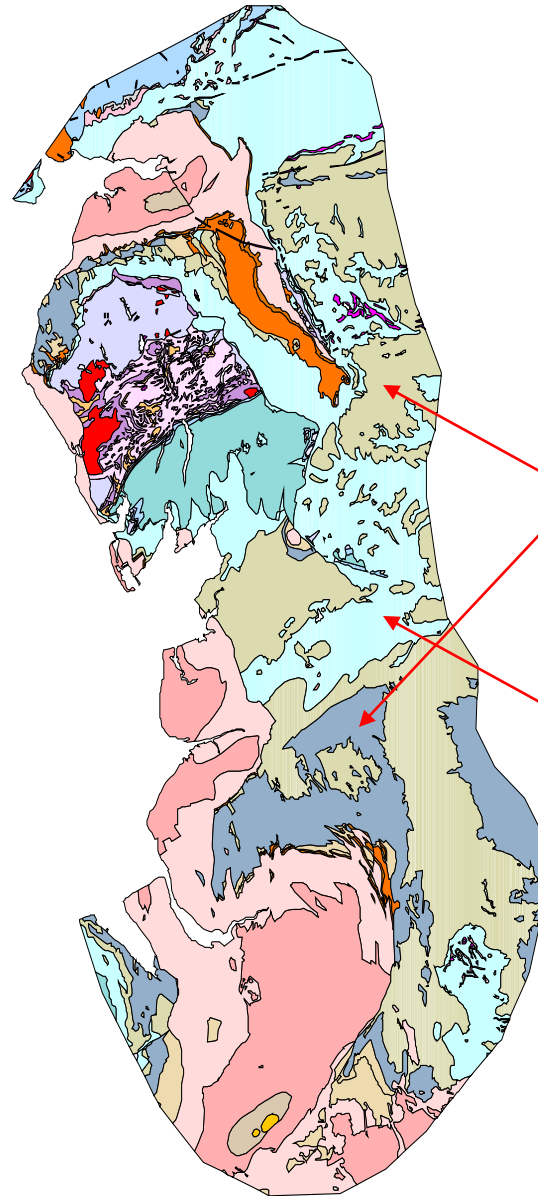
ERA		Date*	PERIOD	
CENOZOIC		2.6	QUATERNARY	
		23	NEOGENE	
		65	PALAEOGENE	
MESOZOIC		145	CRETACEOUS	
		199	JURASSIC	
		251	TRIASSIC	
		299	PERMIAN	
PALAEOZOIC	LATE		CARBONIFEROUS	
			359	DEVONIAN
	EARLY		416	SILURIAN
			443	ORDOVICIAN
			488	CAMBRIAN
	542			



Lower Palaeozoic

Geology of NW

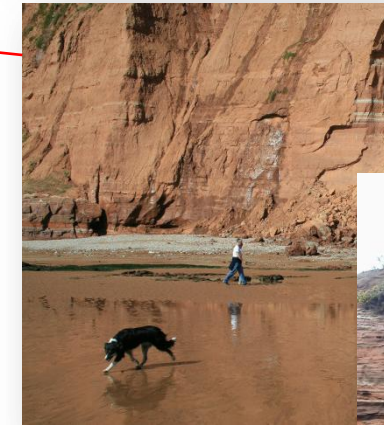
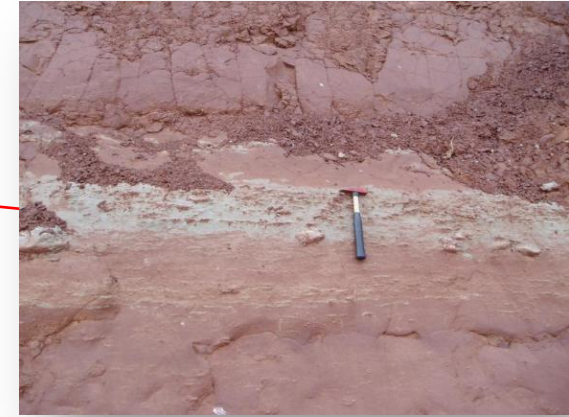
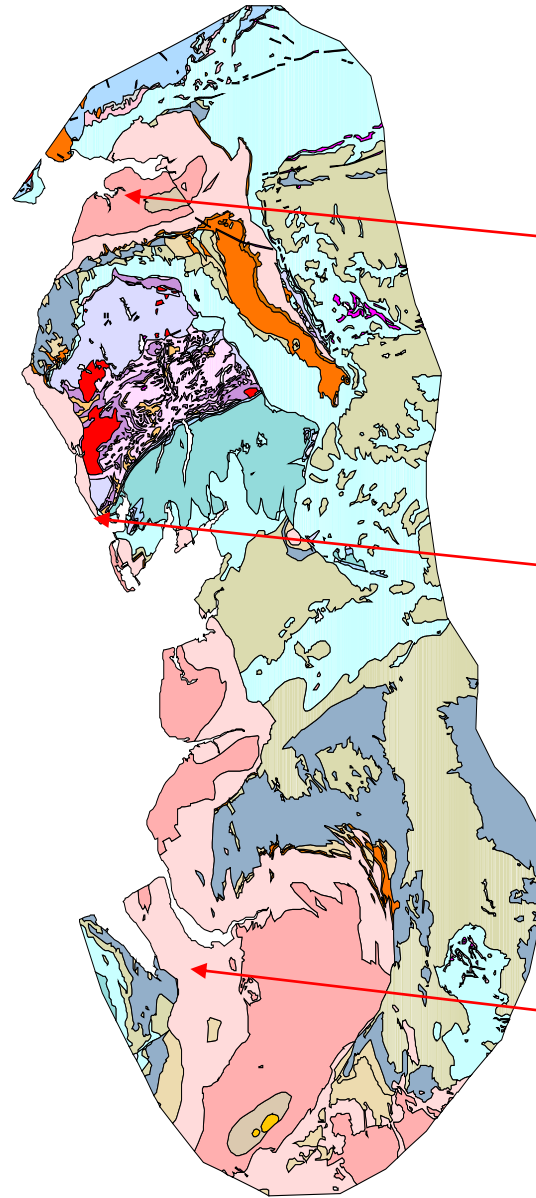
ERA		Date*	PERIOD	
CENOZOIC		2.6	QUATERNARY	
		23	NEOGENE	
			PALAEOGENE	
MESOZOIC		65	CRETACEOUS	
		145	JURASSIC	
		199	TRIASSIC	
	PALAEOZOIC		251	PERMIAN
		LATE	299	CARBONIFEROUS
	359	DEVONIAN		
PALAEOZOIC	EARLY	416	SILURIAN	
		443	ORDOVICIAN	
		488	CAMBRIAN	
		542		



Carboniferous

Geology of NW

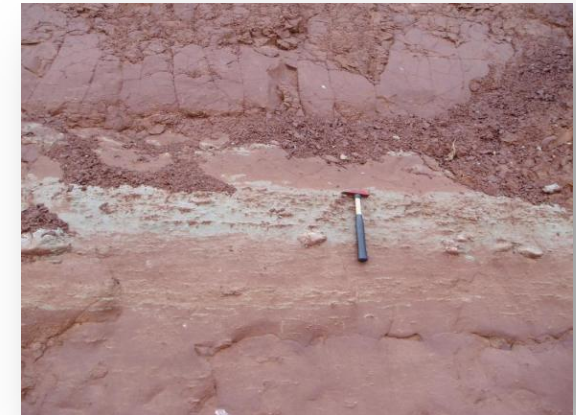
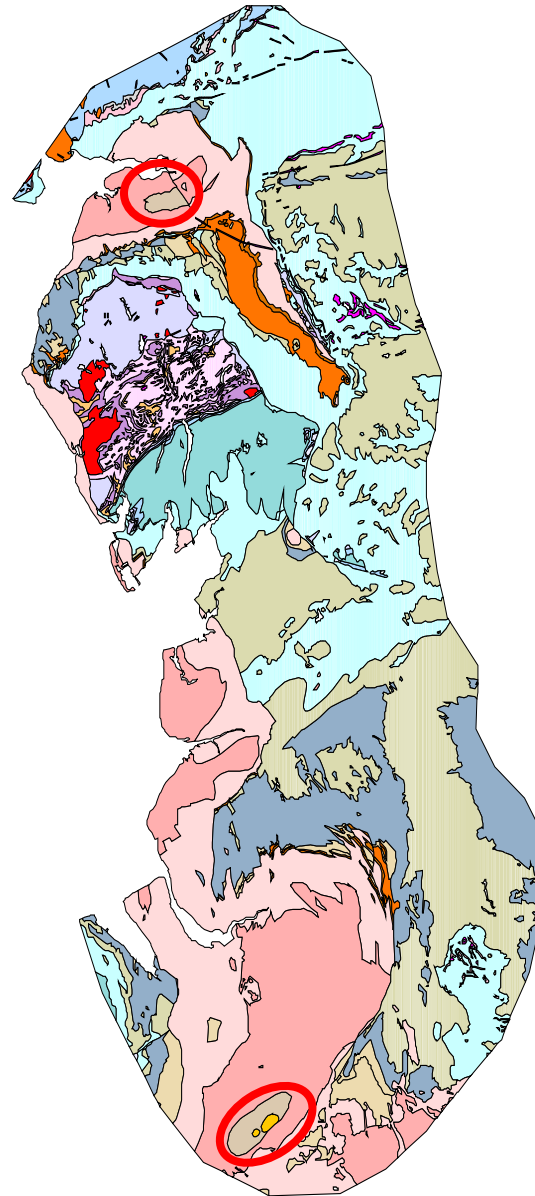
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		65	PALAEOGENE	
MESOZOIC		145	CRETACEOUS	
		199	JURASSIC	
		251	TRIASSIC	
		299	PERMIAN	
PALAEOZOIC	LATE		CARBONIFEROUS	
			359	DEVONIAN
			416	SILURIAN
	EARLY		443	ORDOVICIAN
			488	CAMBRIAN
			542	



Permo- Triassic

Geology of NW

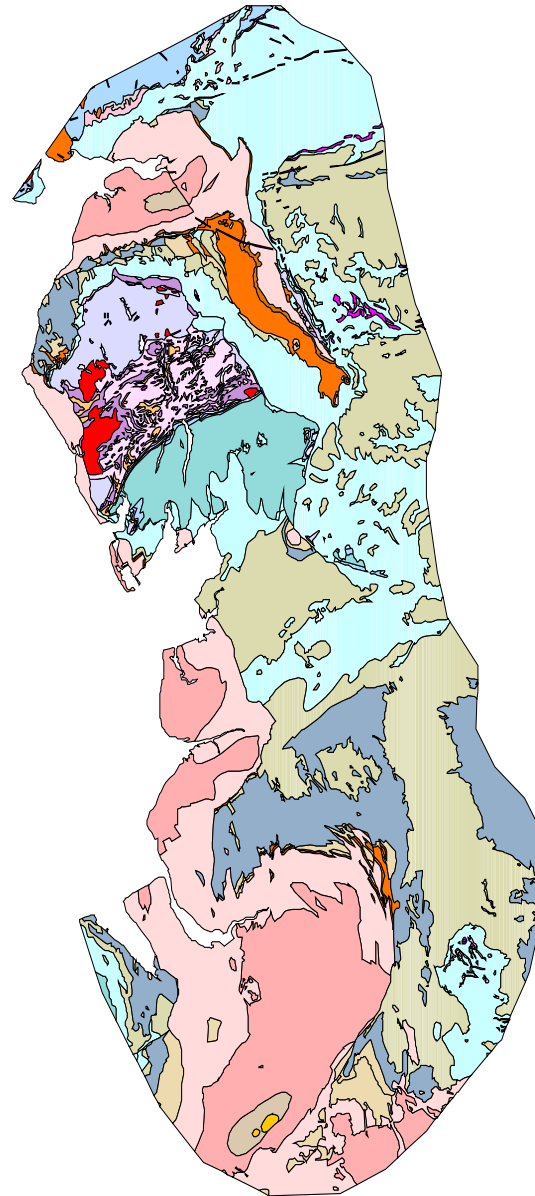
ERA		Date*	PERIOD
CENOZOIC		2.6	QUATERNARY
		23	NEOGENE
		65	PALAEOGENE
MESOZOIC		145	CRETACEOUS
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		299	PERMIAN
		359	CARBONIFEROUS
PALAEOZOIC	LATE	416	DEVONIAN
		443	SILURIAN
	EARLY	488	ORDOVICIAN
		542	CAMBRIAN



Jurassic (Lias)

Geology of NW

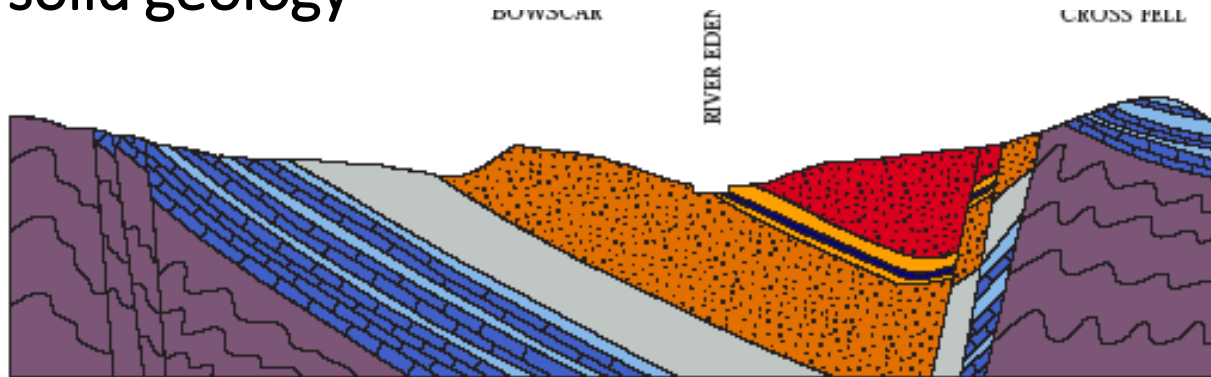
ERA	Date*	PERIOD	
CENOZOIC	2.6	QUATERNARY	
	23	NEOGENE	
		PALAEOGENE	
MESOZOIC	65	CRETACEOUS	
	145	JURASSIC	
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	251	PERMIAN	
	299	CARBONIFEROUS	
PALAEZOIC	LATE	359	DEVONIAN
		416	SILURIAN
		443	ORDOVICIAN
	EARLY	488	CAMBRIAN
		542	



Quaternary
(Superficial/Drift)

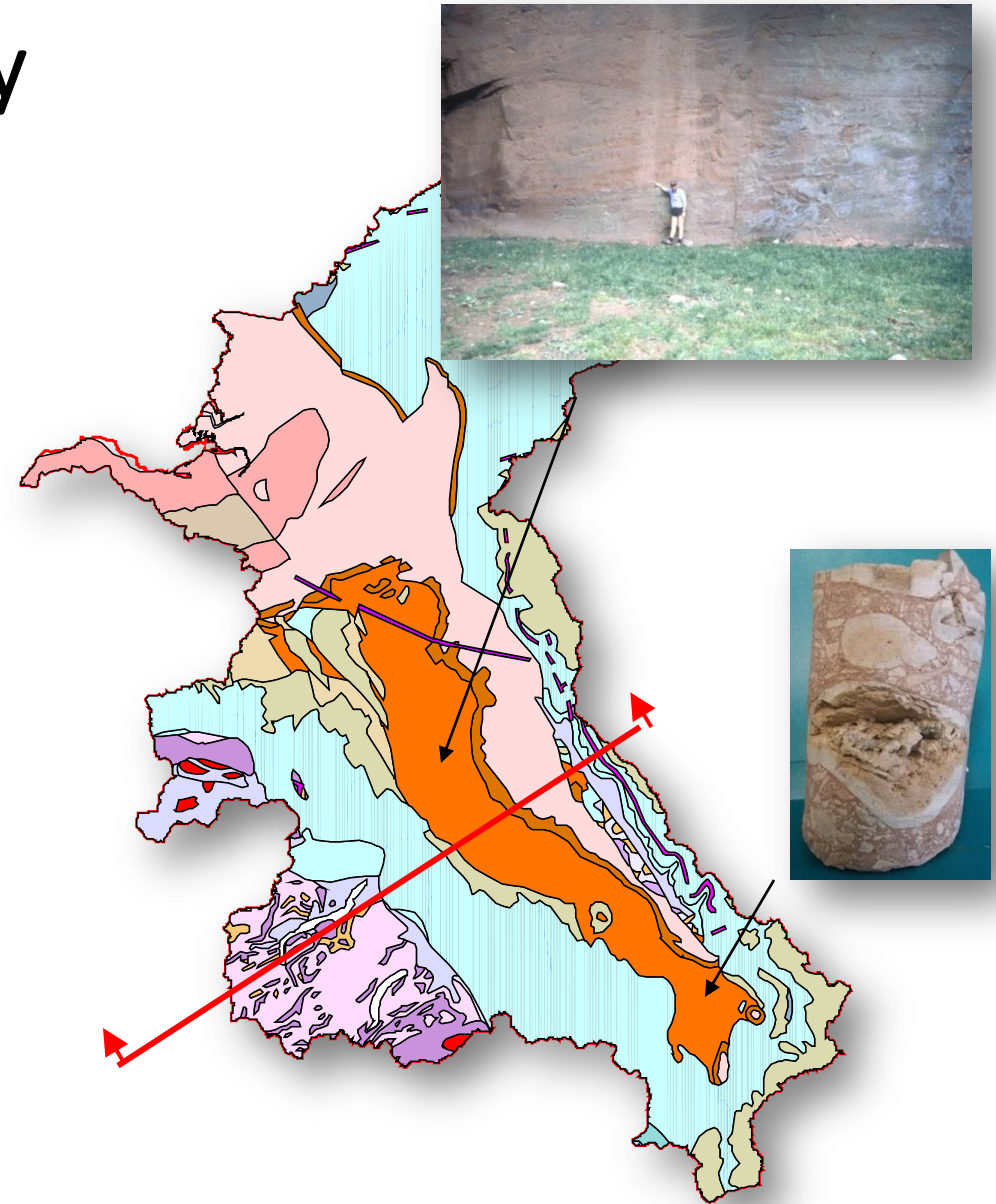
Basin deposition : The Eden Valley

solid geology



Legend

- | | | |
|---|----------------------------|-------------------|
|  | St Bees Sandstone | - Triassic |
|  | Eden Shales |) |
|  | Penrith Sandstone |) - Permian |
|  | Millstone Grit Series |) |
|  | Limestone Series |) - Carboniferous |
|  | Borrowdale Volcanic Series | - Ordovician |

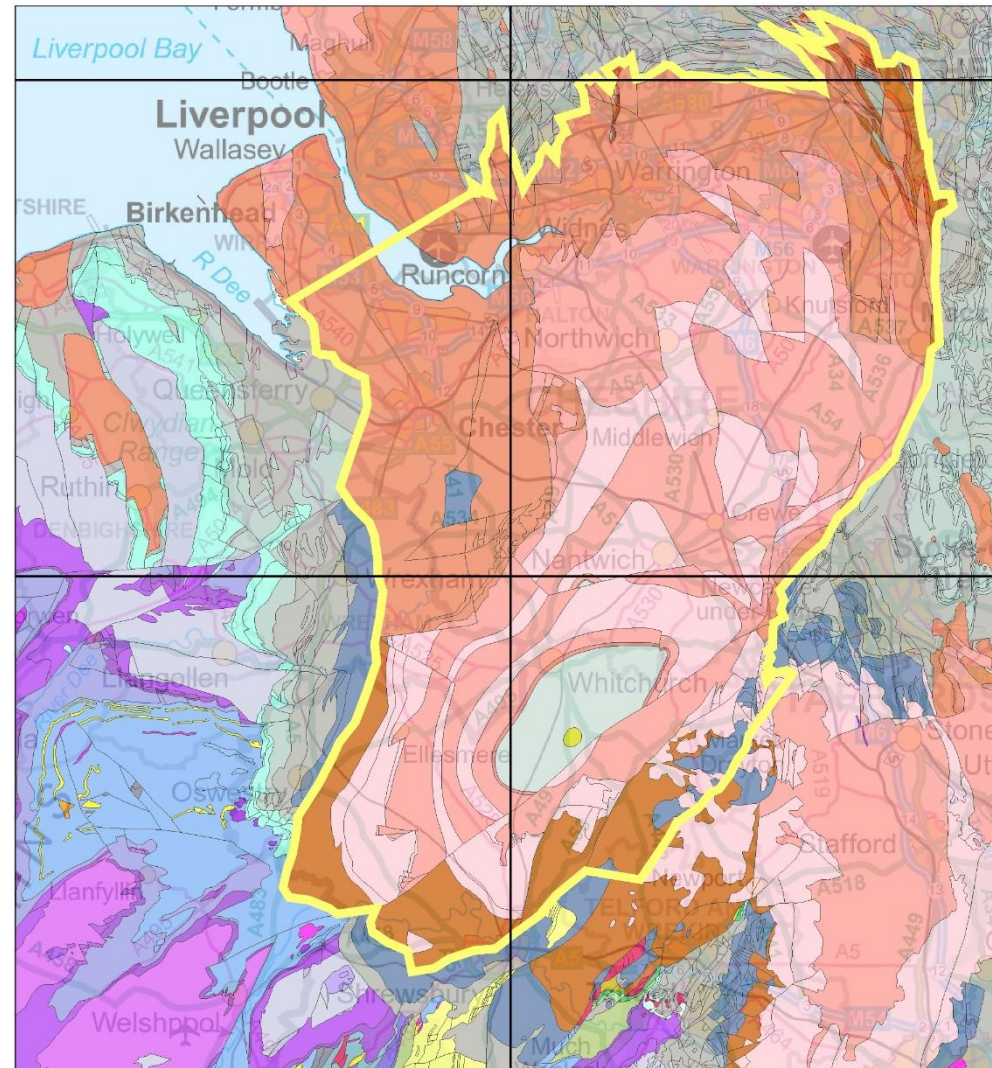


The Cheshire Basin



- Up to 5km of Permo-Triassic rocks
- Defined by a series of prominent geological faults that displace the rocks in places by over 3km
- Rocks are deepest in the east -asymmetrical (half graben)

Geology extract from DiGMapGB 50



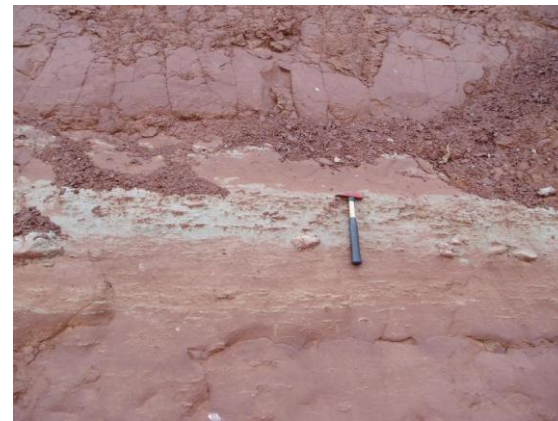
Sherwood Sandstone Group

- Fine to coarse grained sandstone with well rounded “pebbles”. Red or reddish brown in colour
- Pebble content decreases northwards in the Cheshire Basin
- Mixture of wind deposited and river deposited sediments over 1000m thick
- Deposited at the same time as active faults at the eastern margin of the basin



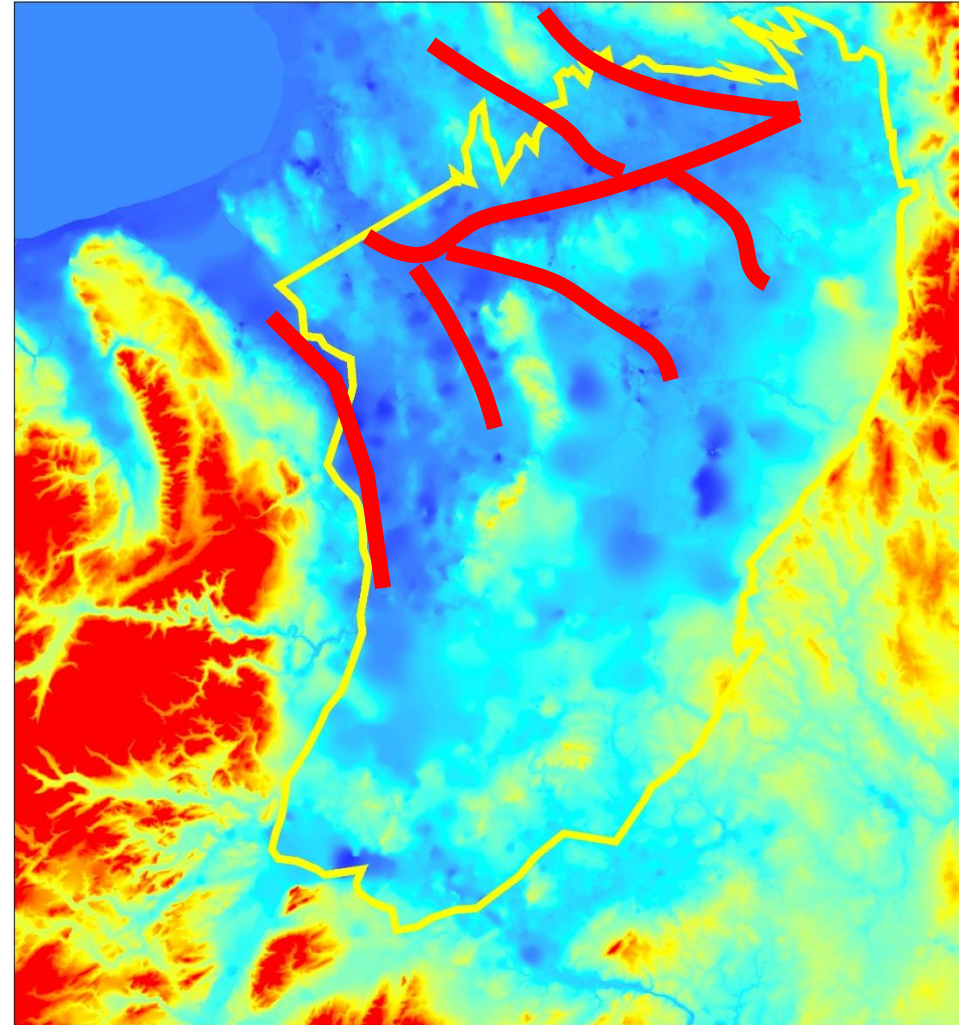
Mercia Mudstone Group

- Mainly mudstone and siltstone about 1200m thick
- Layers of evaporitic minerals – SALT and GYPSUM deposited in an enclosed basin



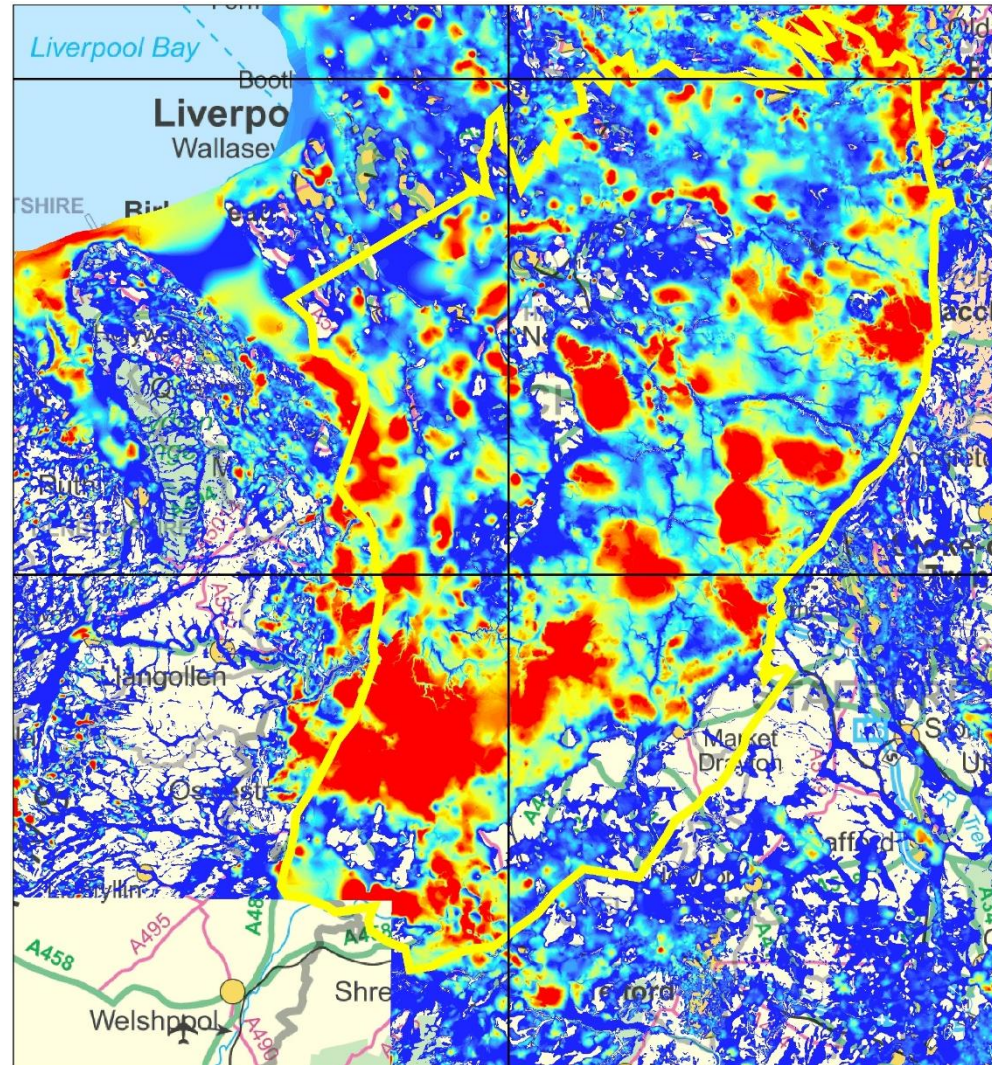
Elevation of the bedrock surface

- Very variable and cut down to deeper than -80m below SL (BLUE = DEEP) (RED = HIGH)
- Characterised by buried channels or “tunnel valleys” cut into the bedrock surface



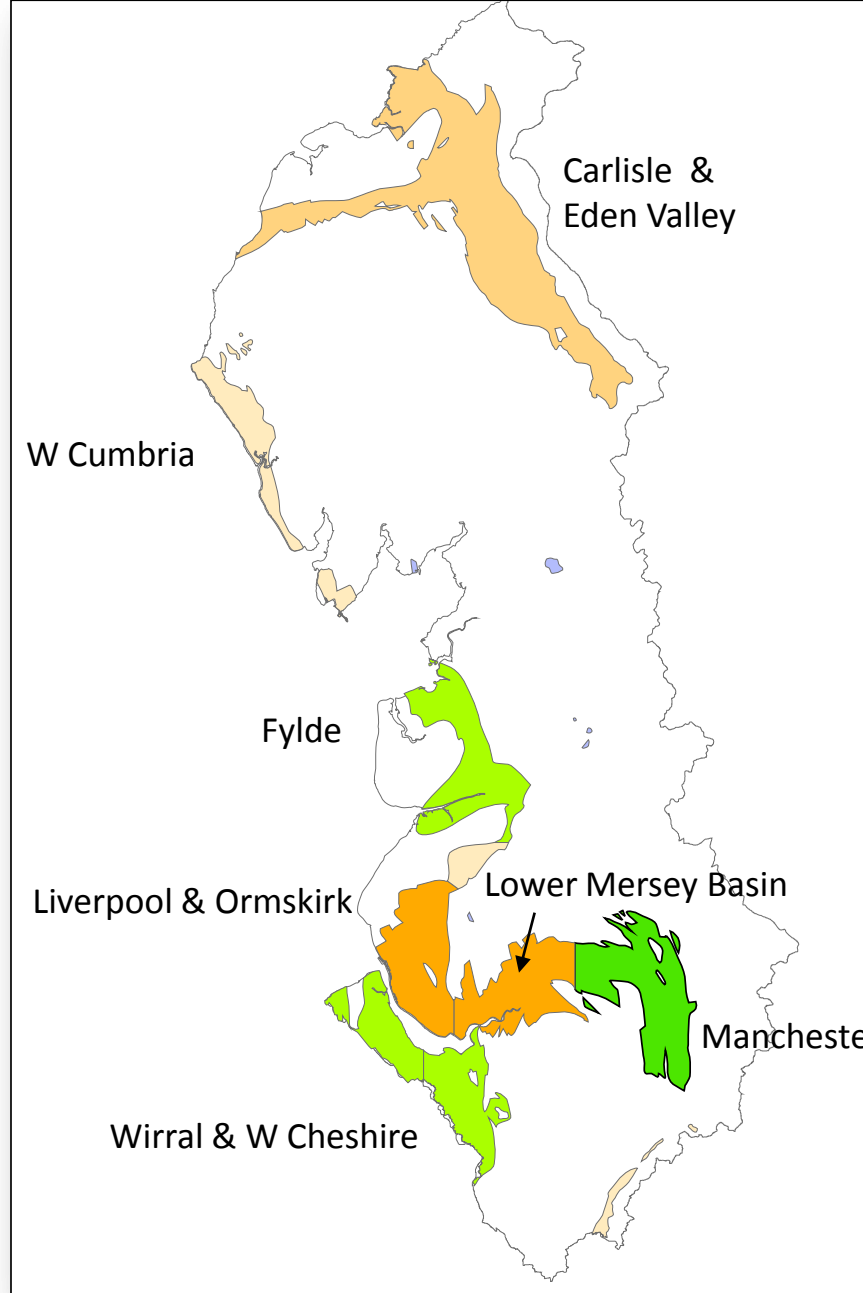
Ice Age

- Deposits range from Till (sandy gravelly clay) to sand and gravel
- Thickness of superficial deposits very variable from less than 2m (BLUE) to over 100m thick (RED)



Now back to groundwater stuff

.....and the why only 11%



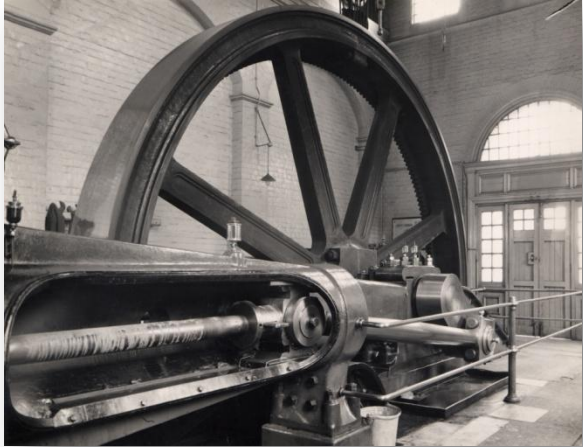
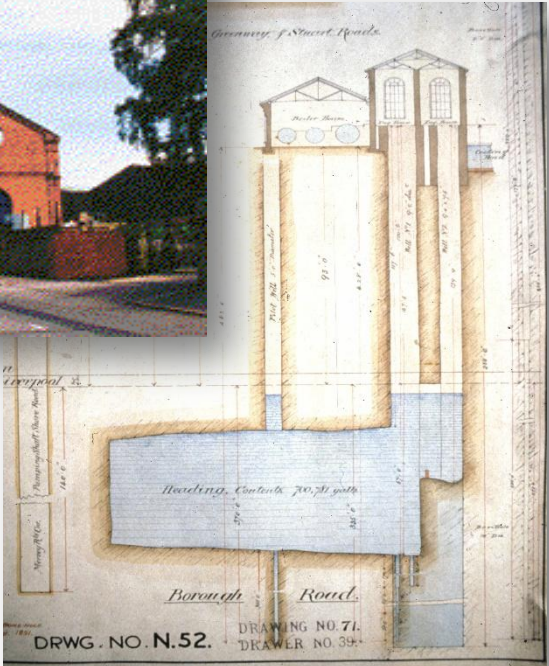
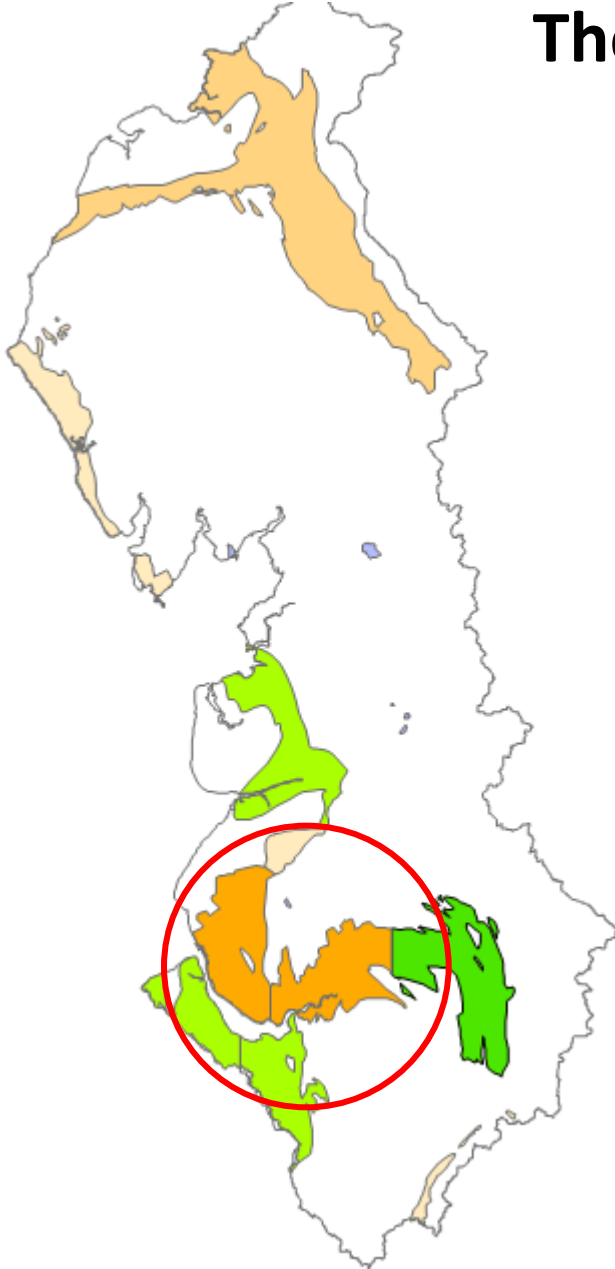
Permo-Triassic (Principal) Aquifer Management Units



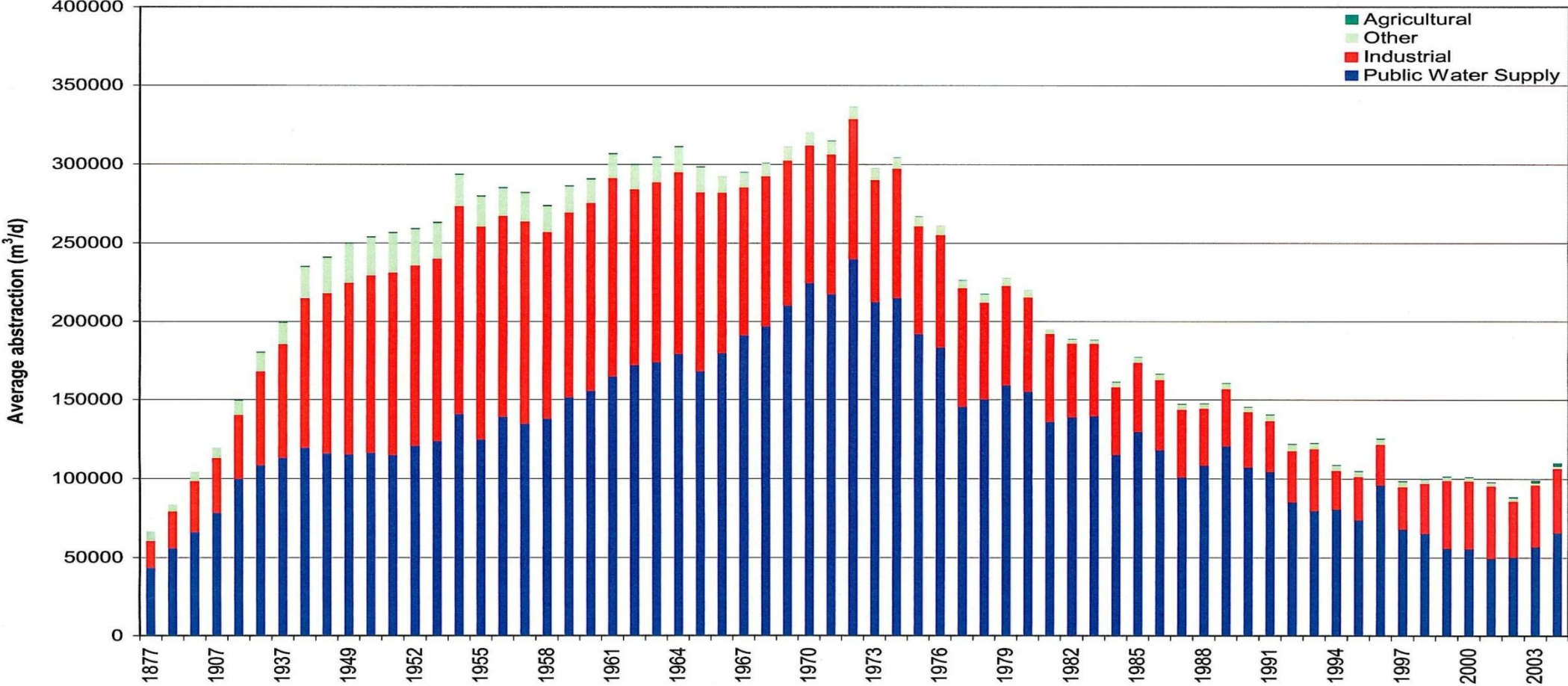
Abstraction history and water supply in the NW

The Mersey Basin

~ long history of groundwater abstraction

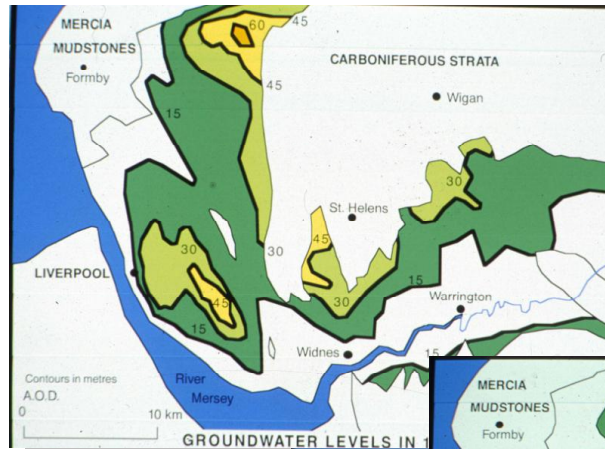


Mersey Basin groundwater abstractions

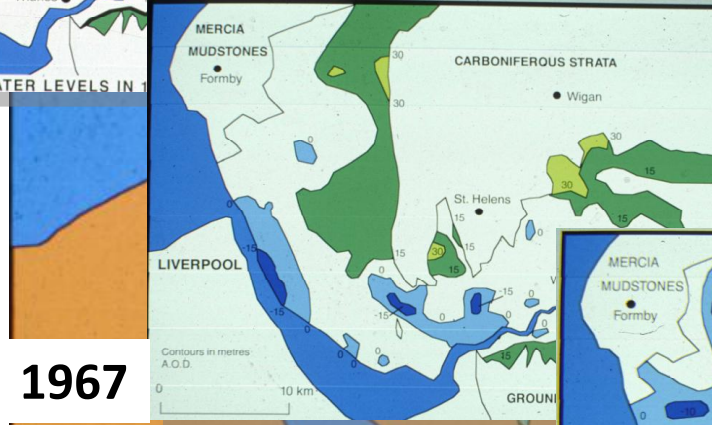


Mersey Basin - Groundwater Levels

1869



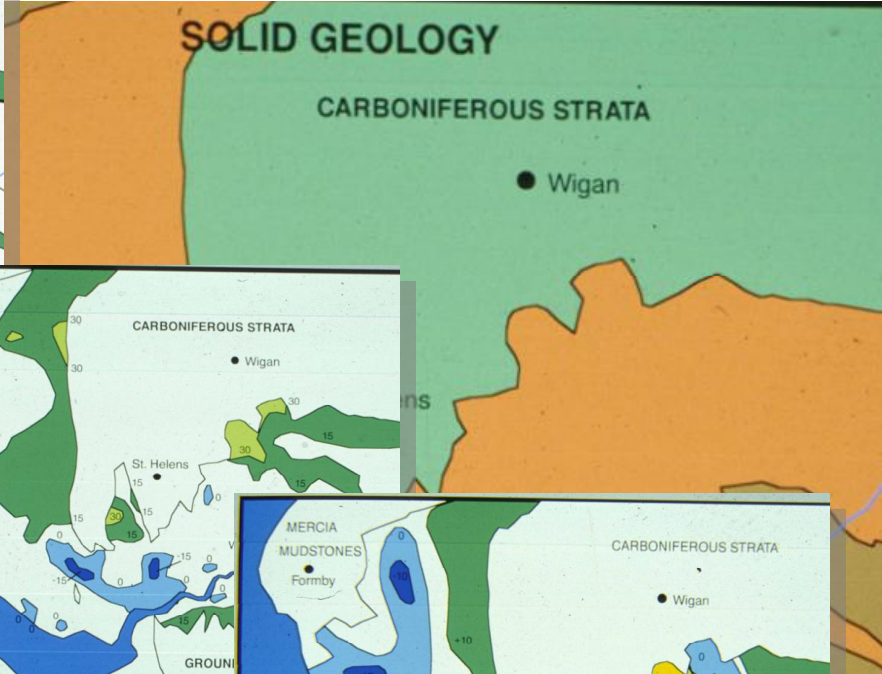
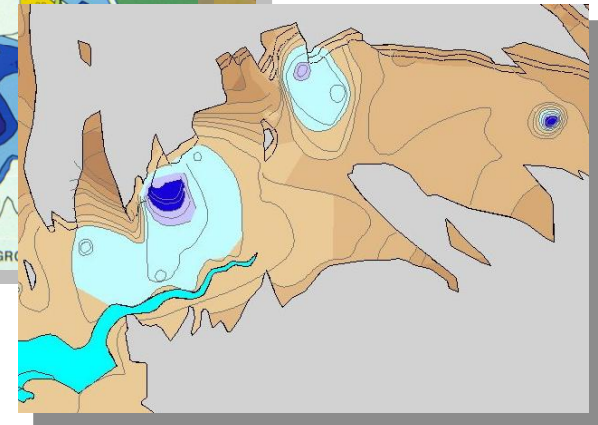
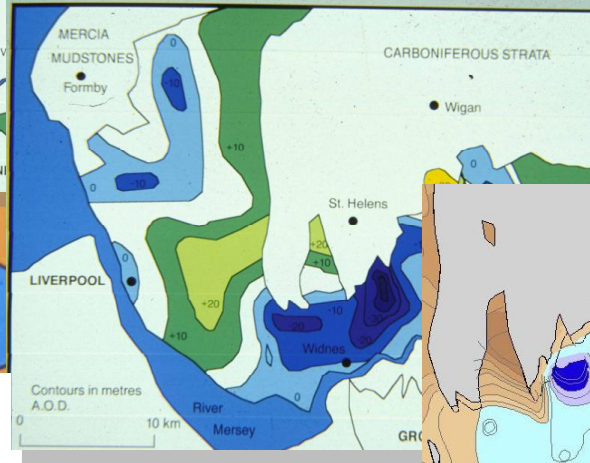
1967



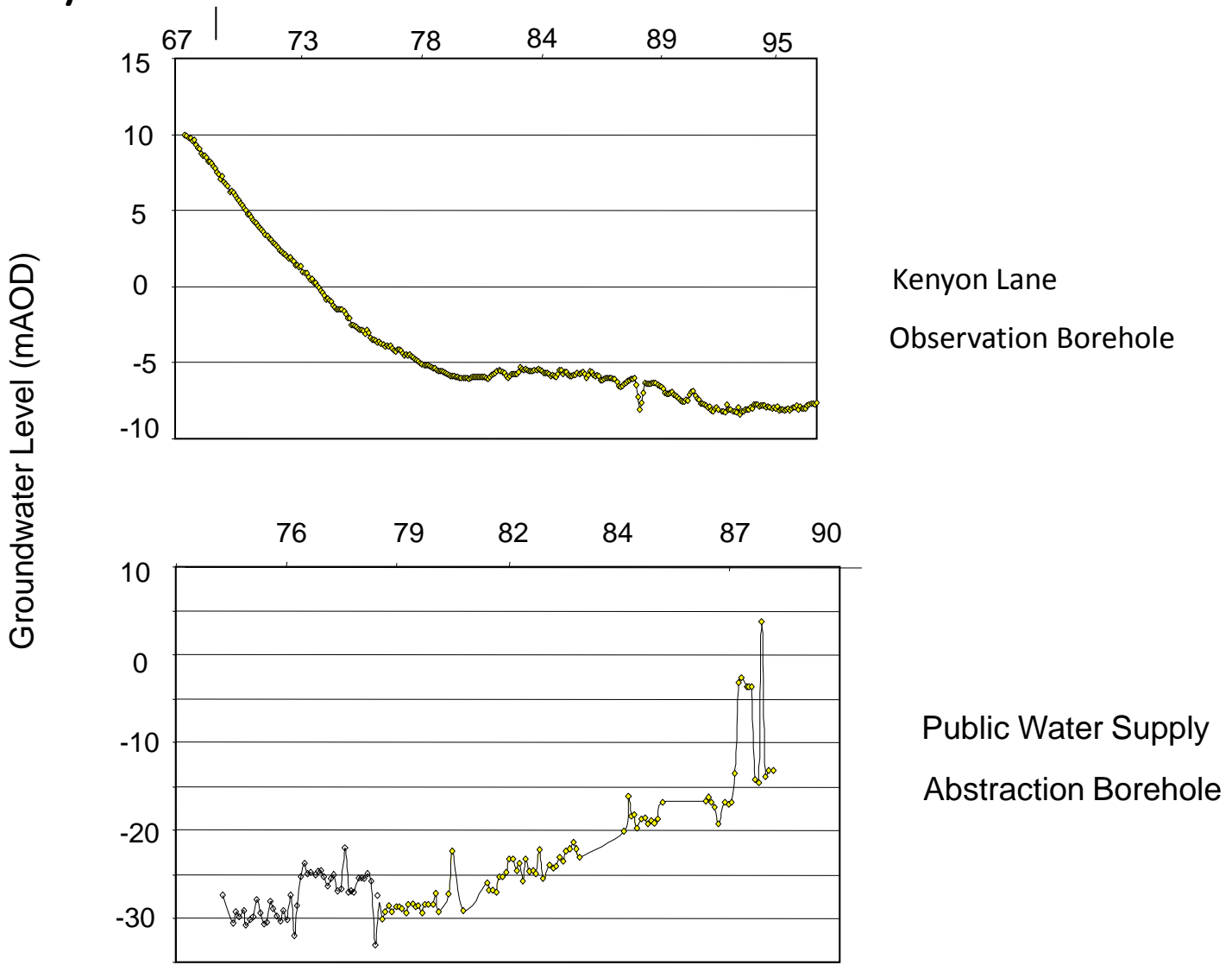
1980



2000



Groundwater Hydrographs Mersey Basin



Groundwater Lake - Winwick



Regulation history

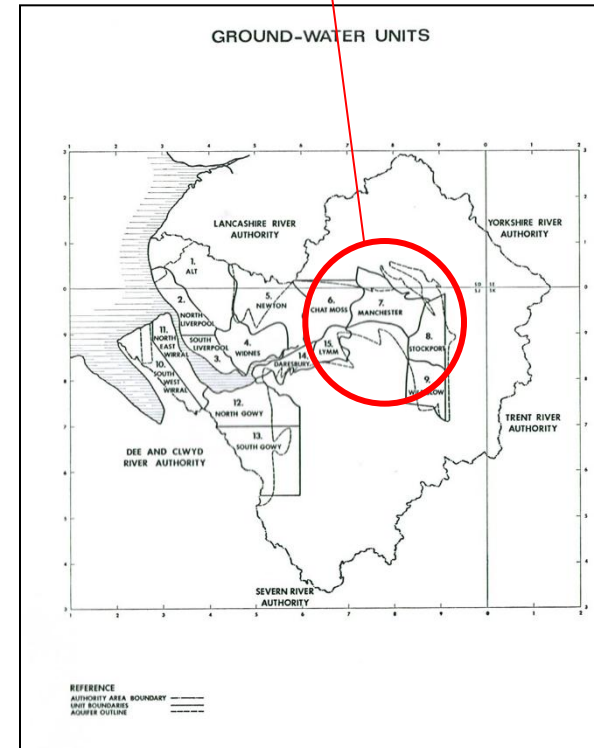
... and **manage**
groundwater

Mersey and Weaver River Authority

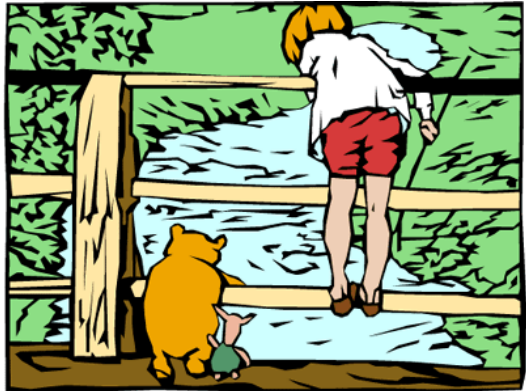
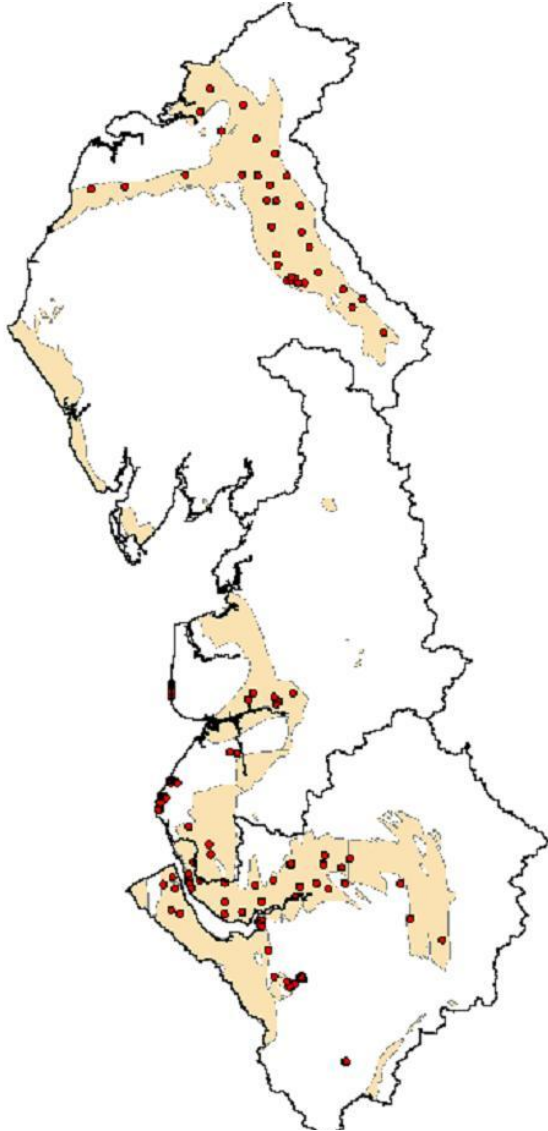
Statement of Policy for Ground-Water Management 1973



9.9 Within the Manchester Ground-Water Unit, there are some signs of slight improvement in ground-water level and the main aim must be not to exceed the present rates of abstractions. Some temporary increases could be considered so long as these were spaced well away from the area within Trafford Park where abstractions are at present concentrated.



Resources Assessment - *the start of monitoring*



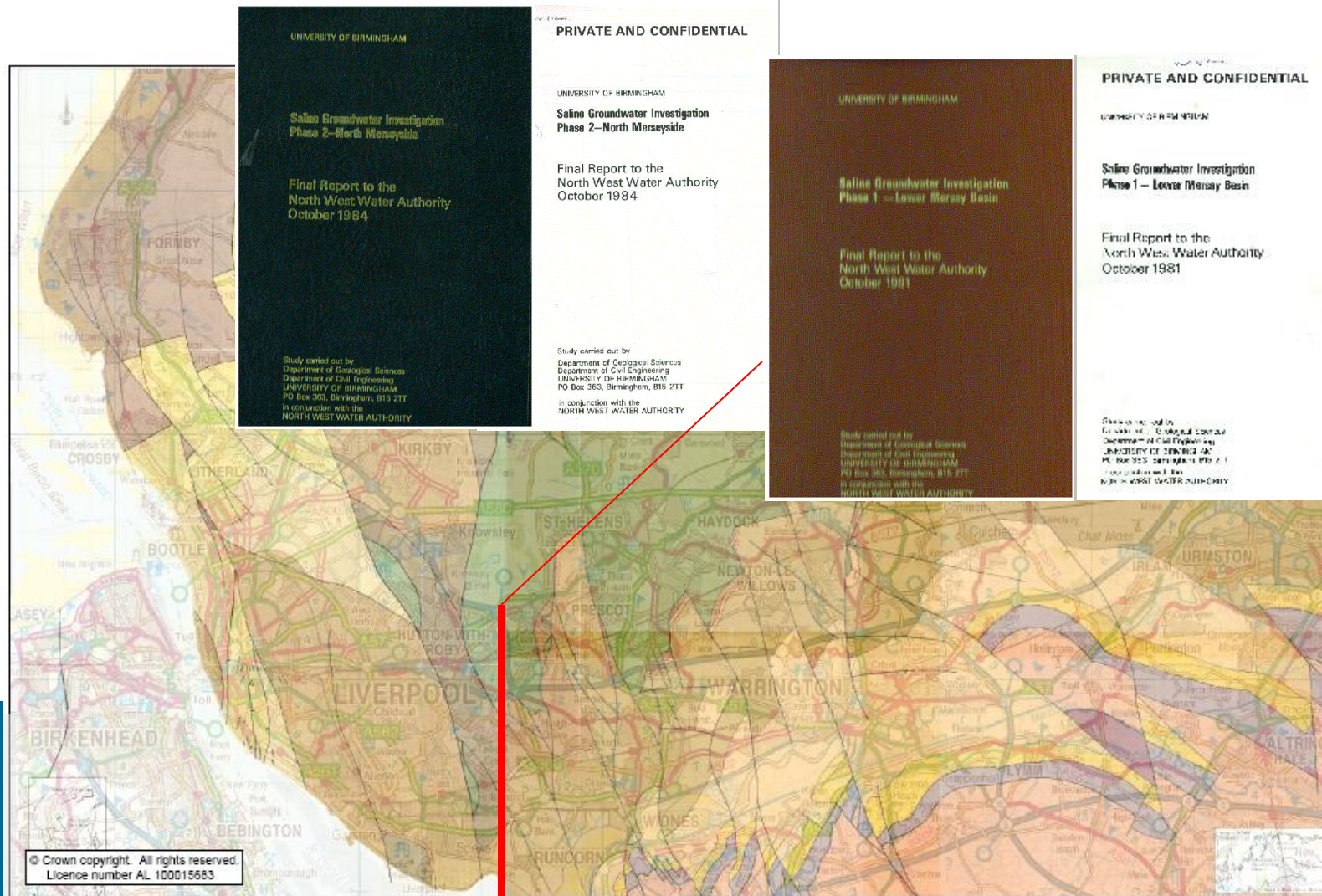
Development

NW Observation borehole network

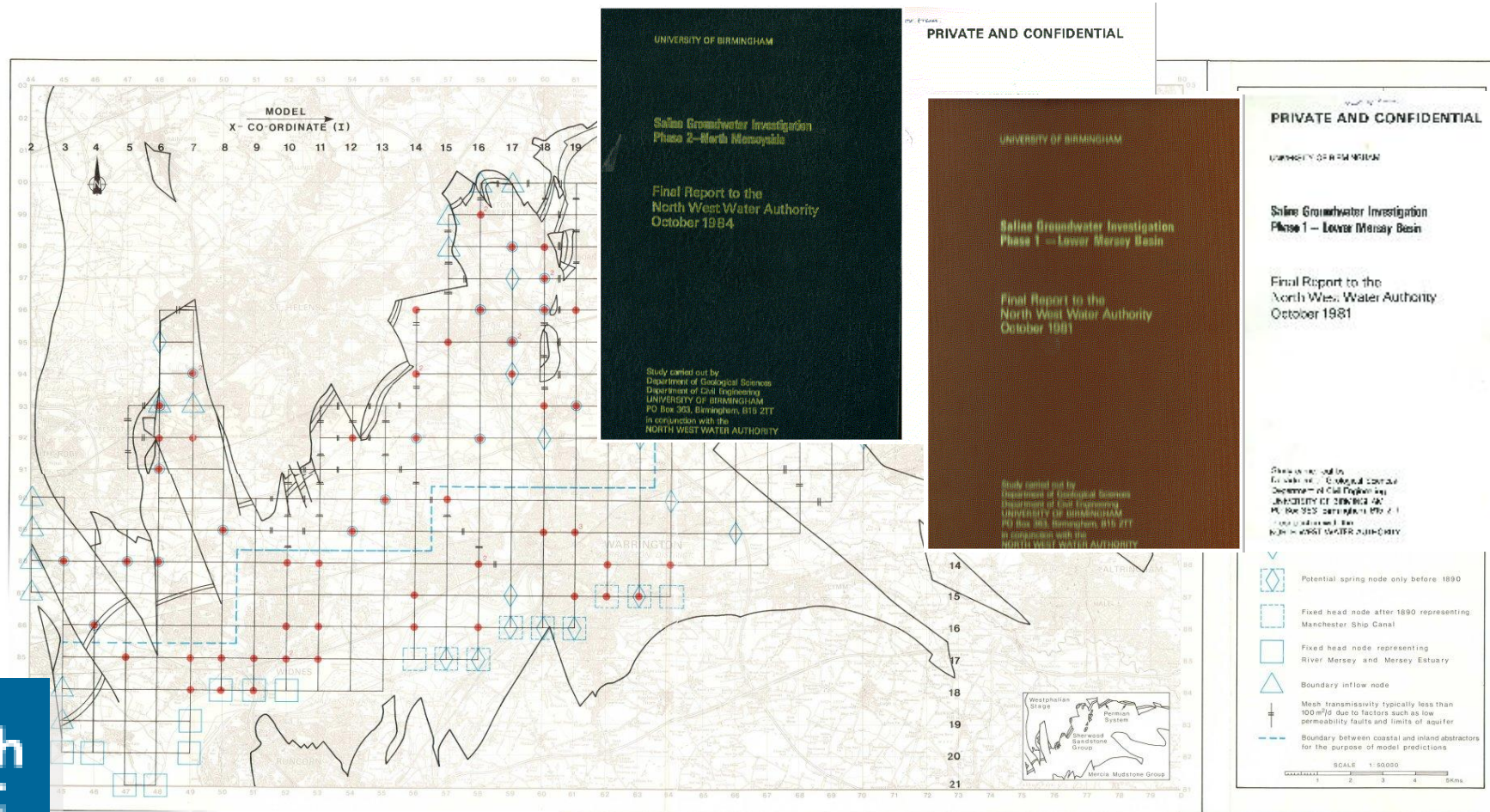
Monitoring

Resources Assessment - *the early days*

~ 1980's Mersey Basin Saline Groundwater Study



Groundwater development history & previous studies



What's changed?

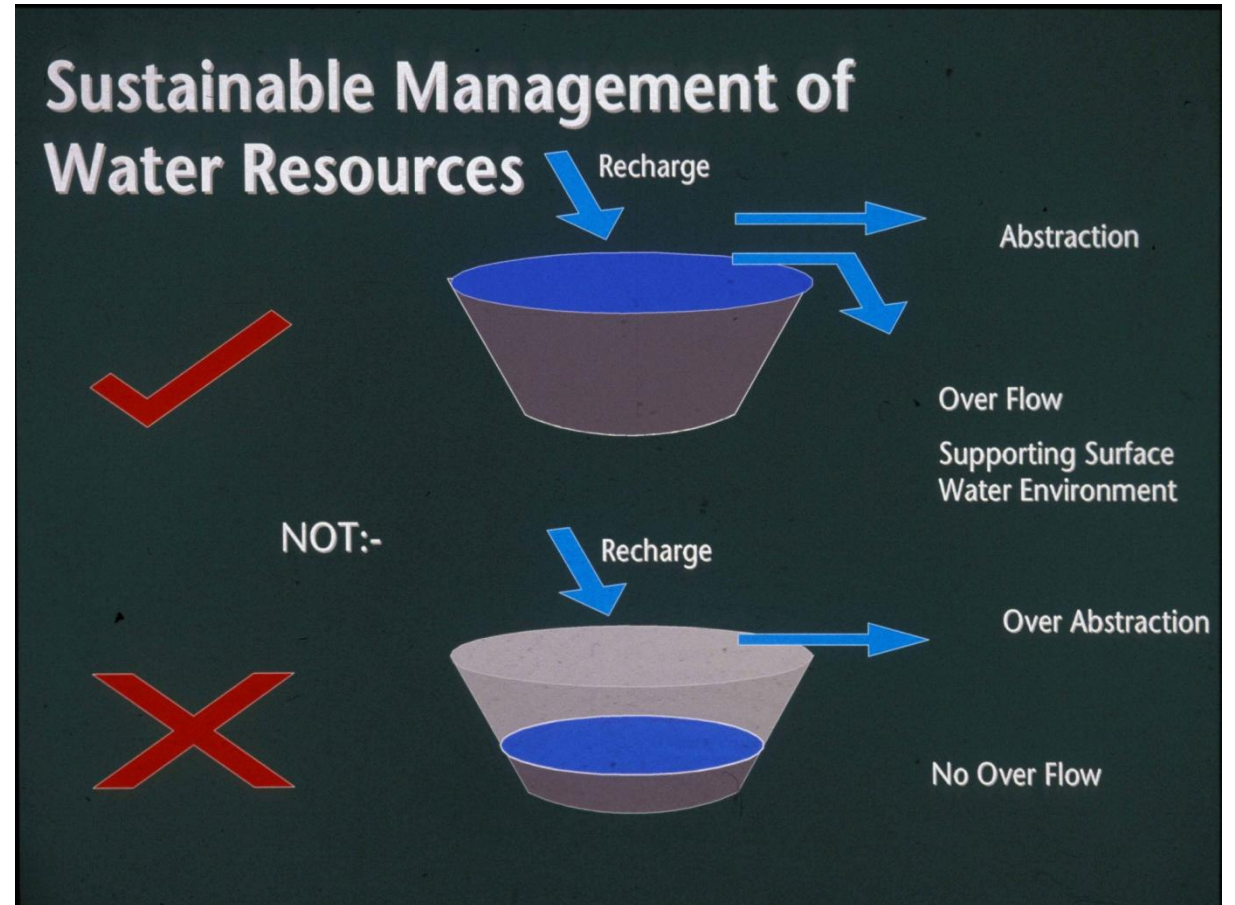
How do 'we' manage (ground) water resources now on a regional scale?

CAMS & WfD

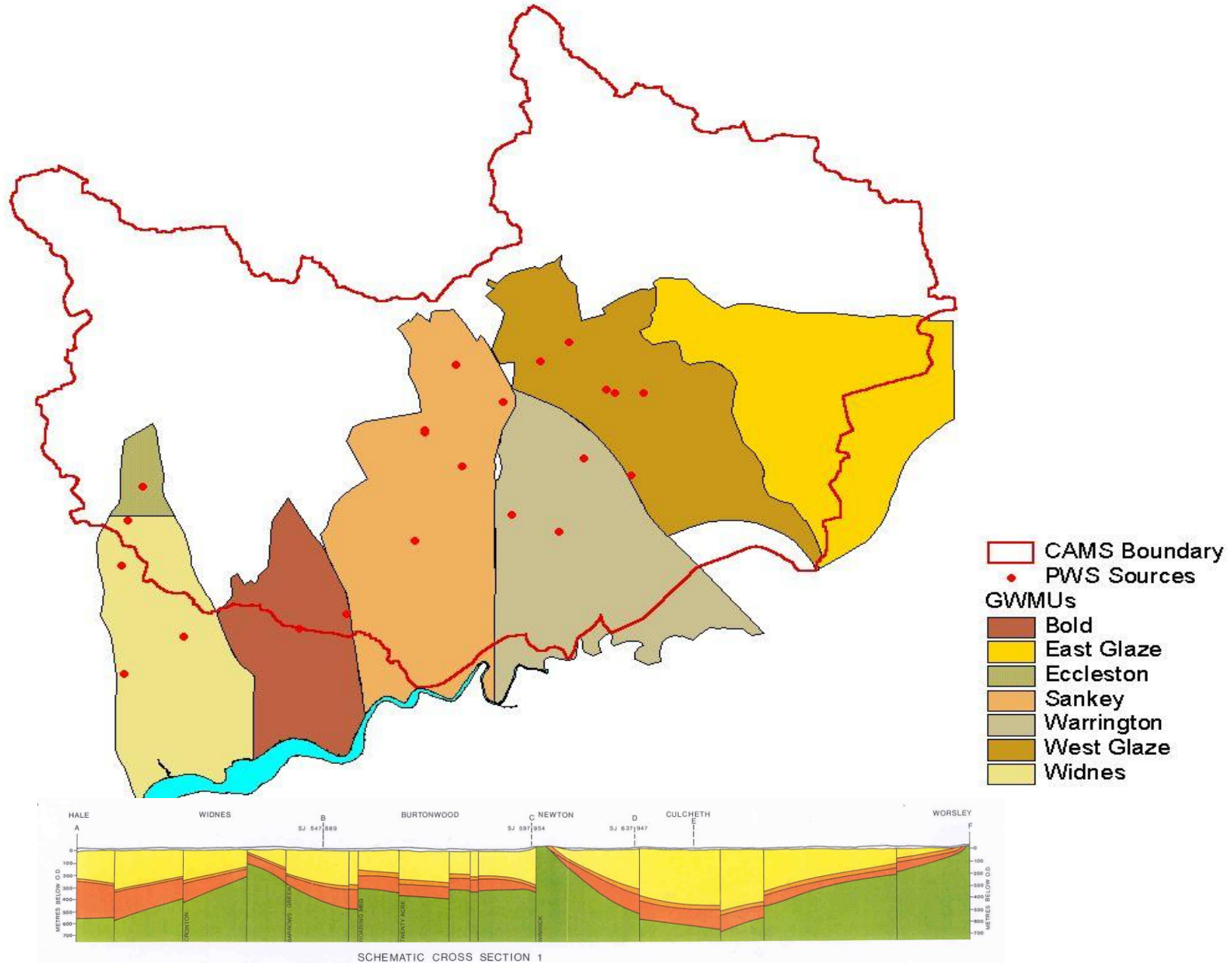
Catchment Abstraction

Management Strategies-

- Integrated SW/GW
- ecology
- environmental needs
- defines water resource availability



CAMS still use groundwater management units



Key insights:



- Compartmentalisation/structural controls
- Salinity
- Limited recharge

from

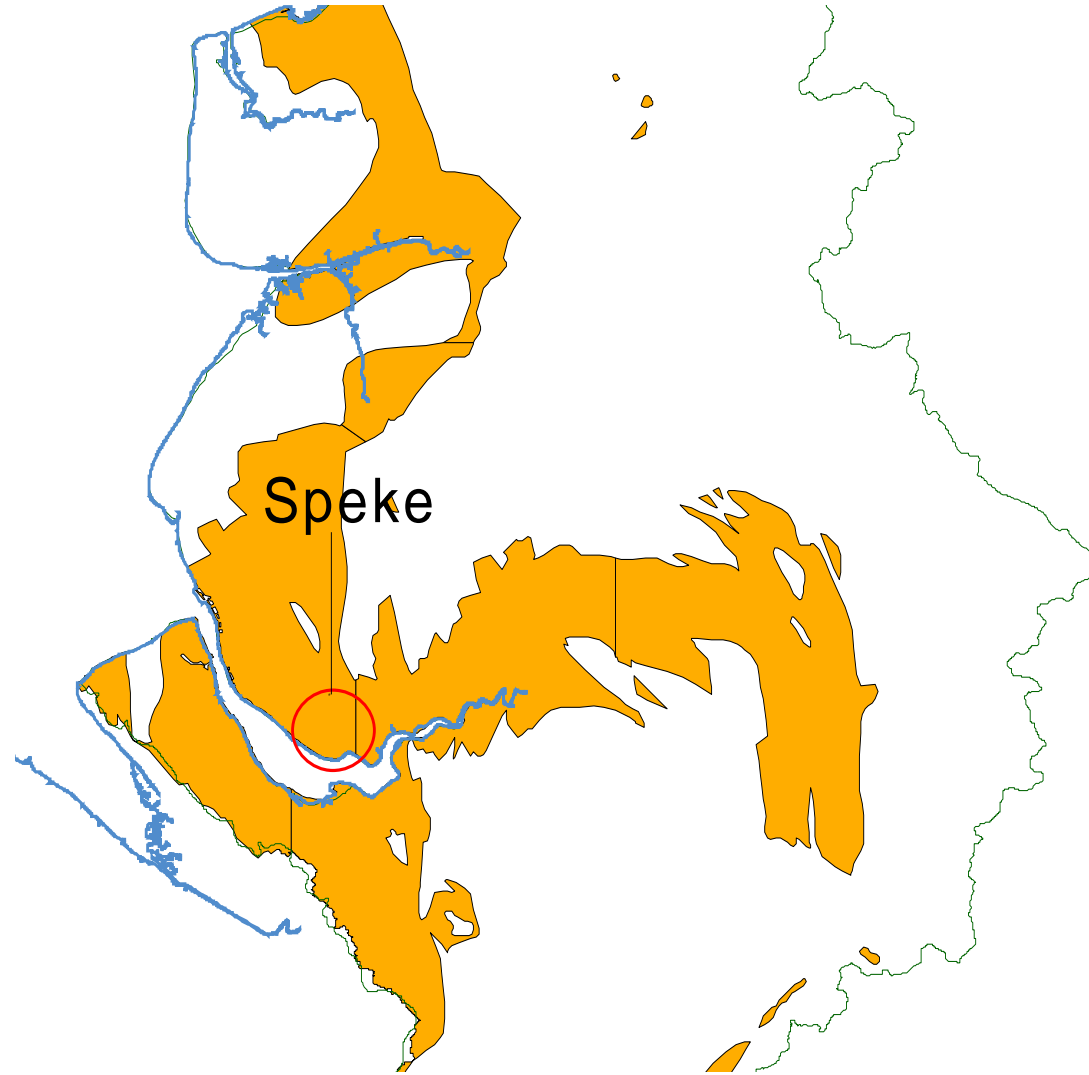
- Operational testing (groundwater investigation consents)
- Groundwater level monitoring data
- Groundwater resources (modelling) studies

Key insights:

- Compartmentalisation/structural controls

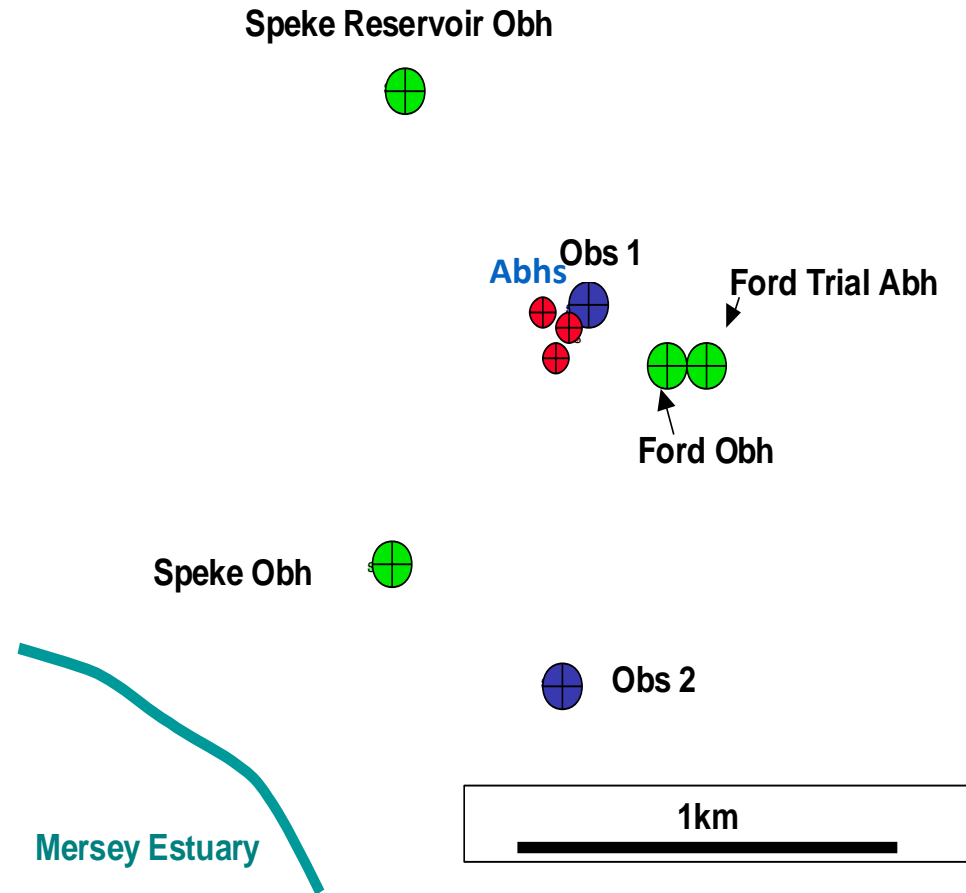
Operational
Test pumping

Speke

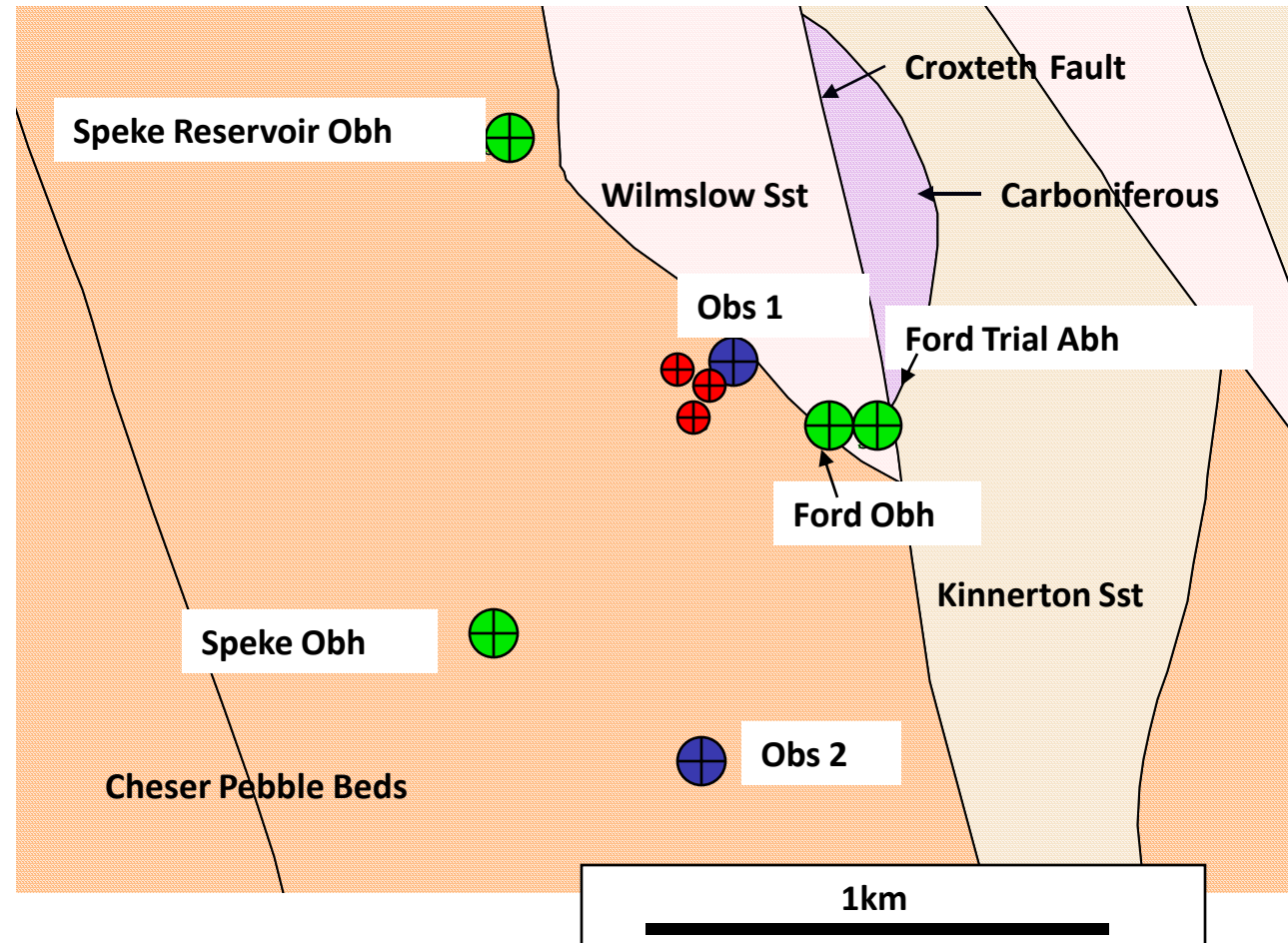


Speke

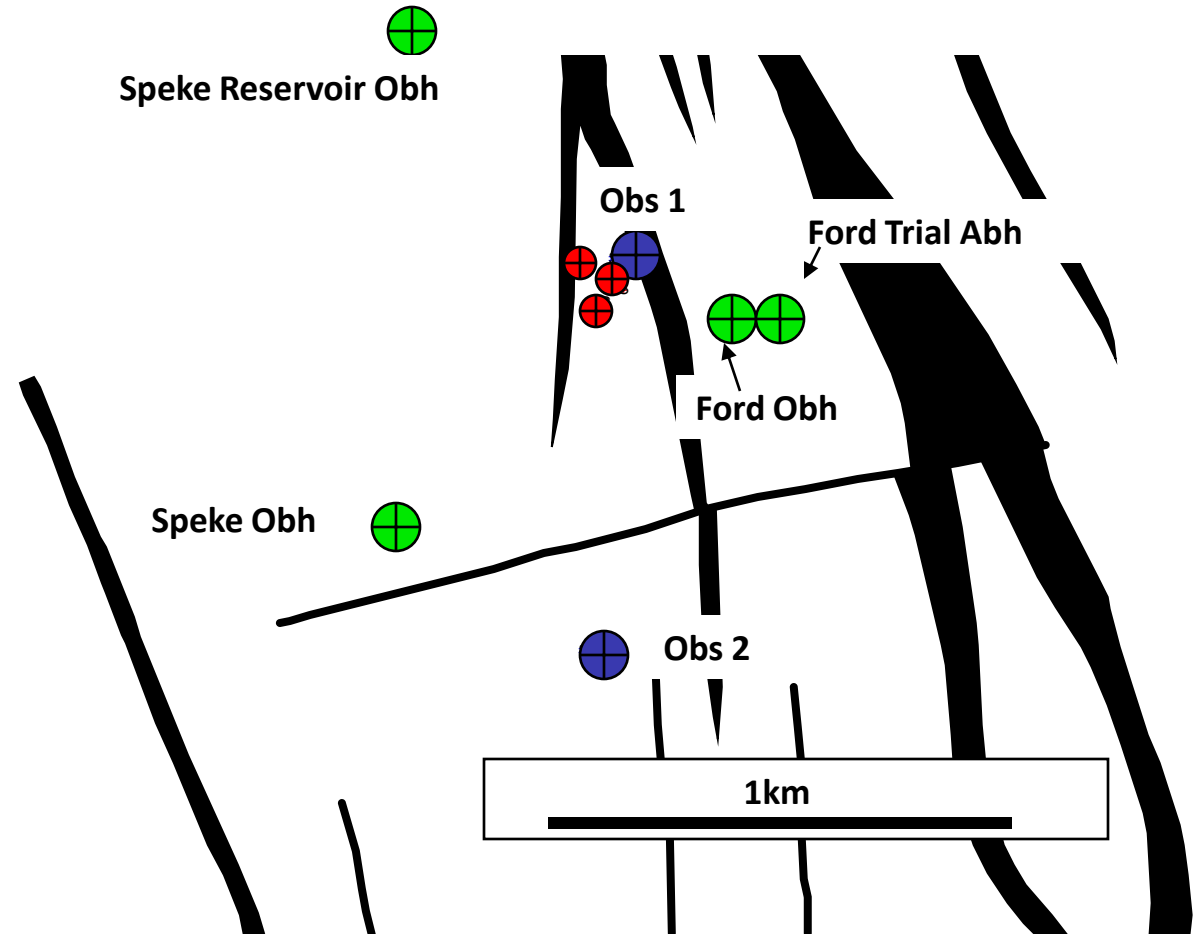
- Industrial Abstn
 - licence increase
- Saline intrusion?
- Sustainability?

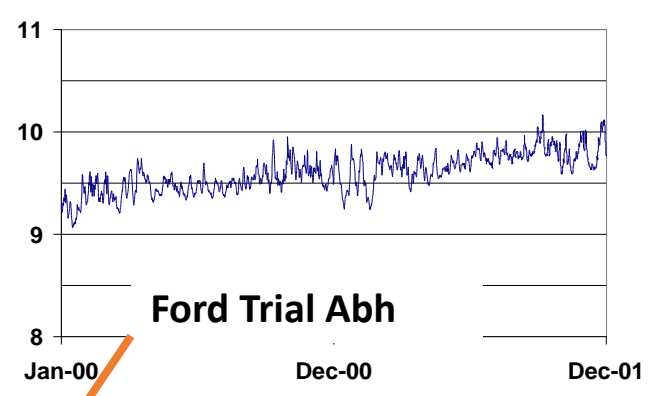
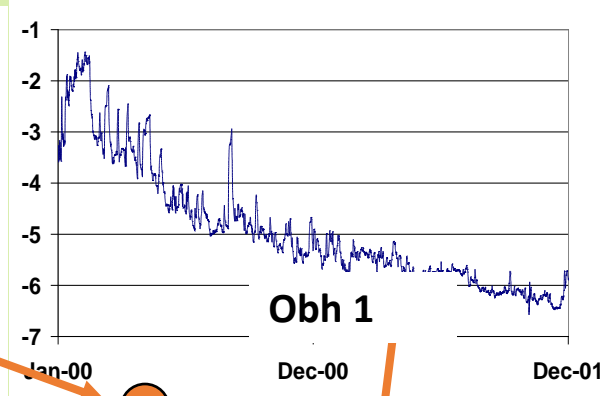
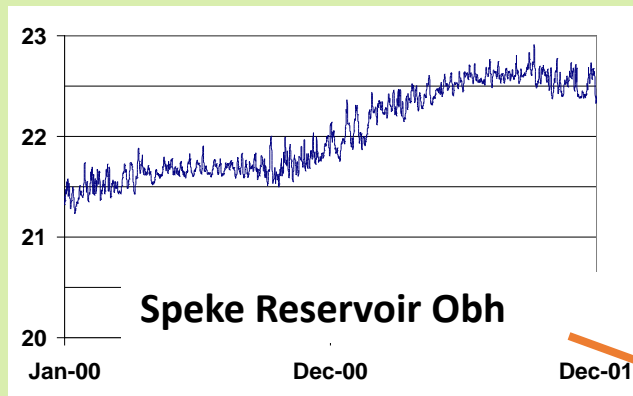


Speke - Solid Geology

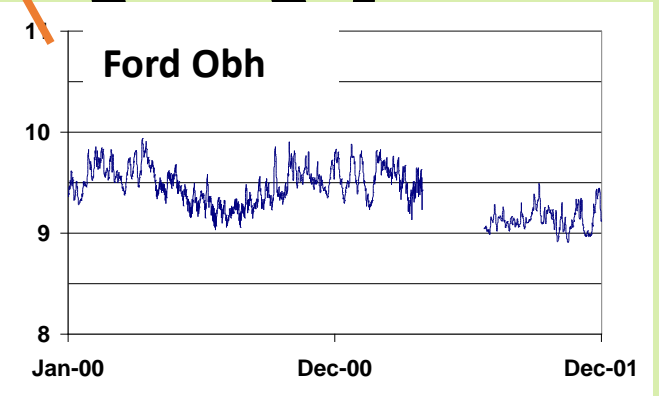
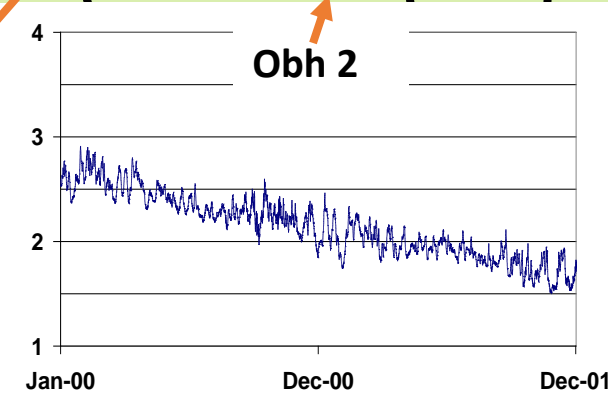
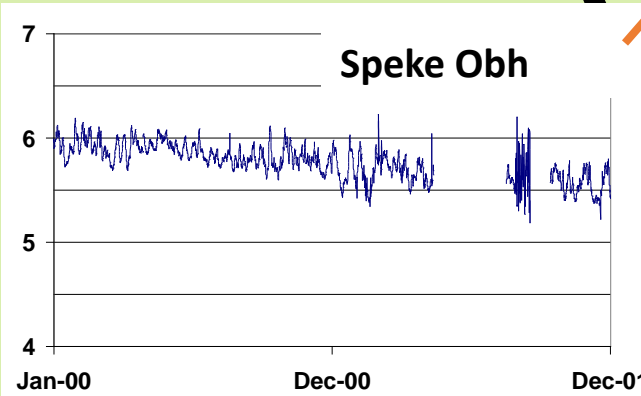
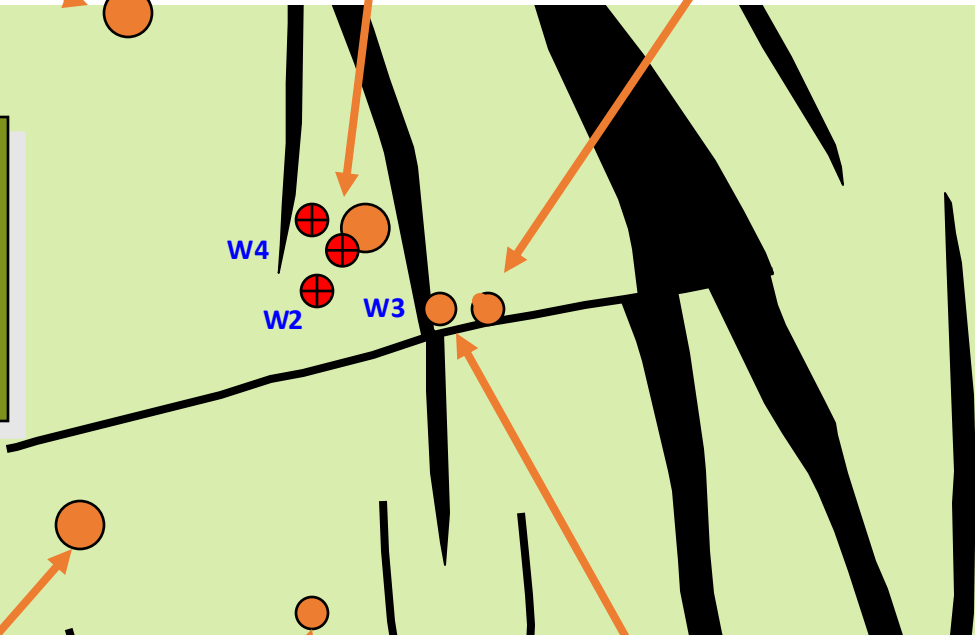


Speke - faults *(from seismic)*

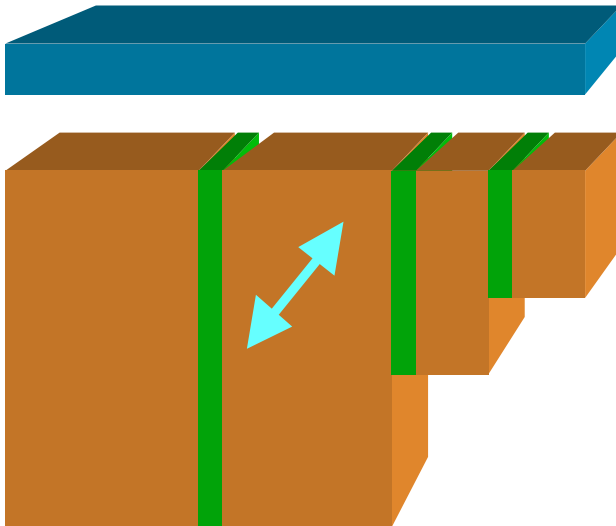


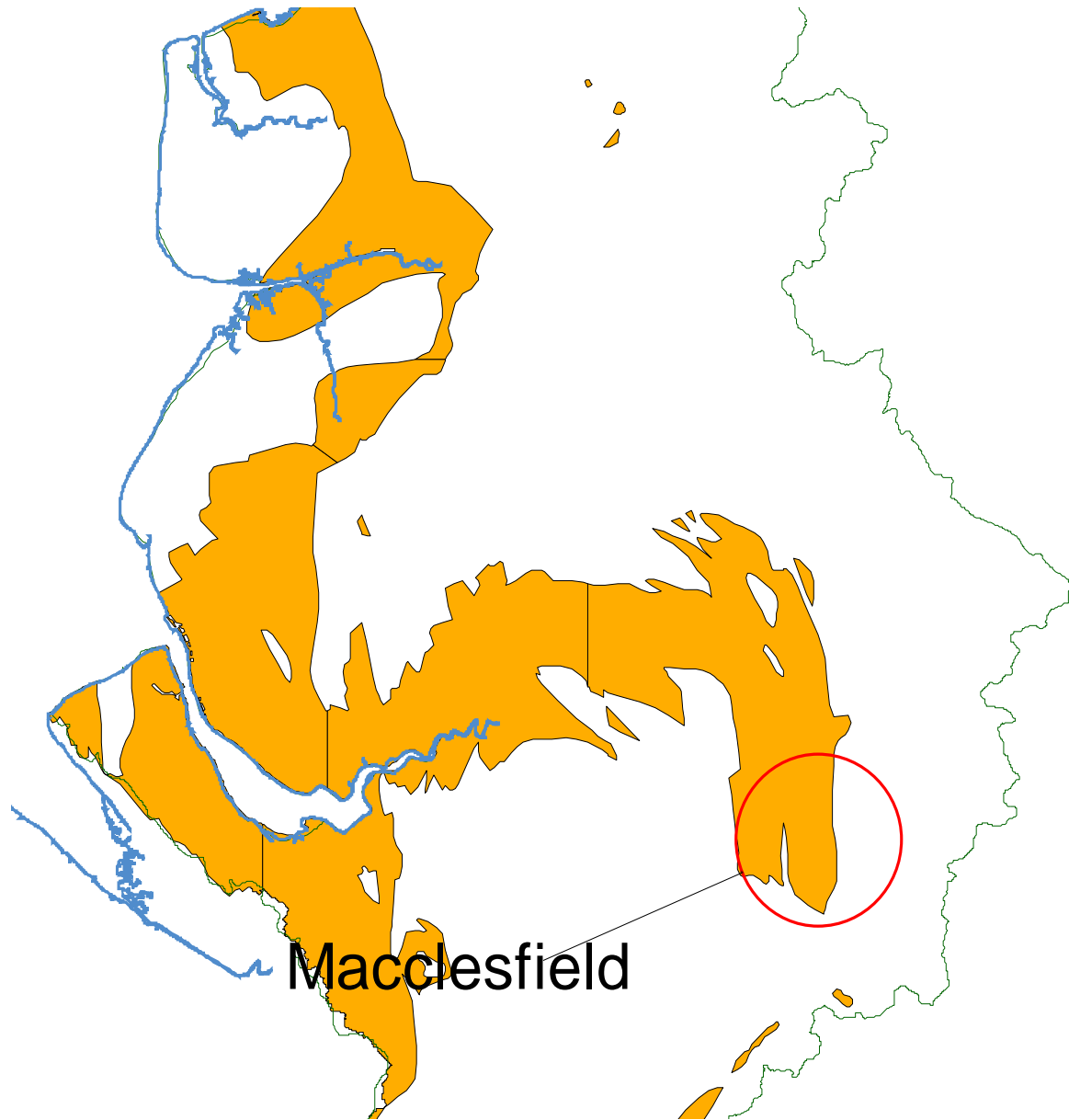


2 year Operational Pumping Test (under TLL)



Speke - Summary

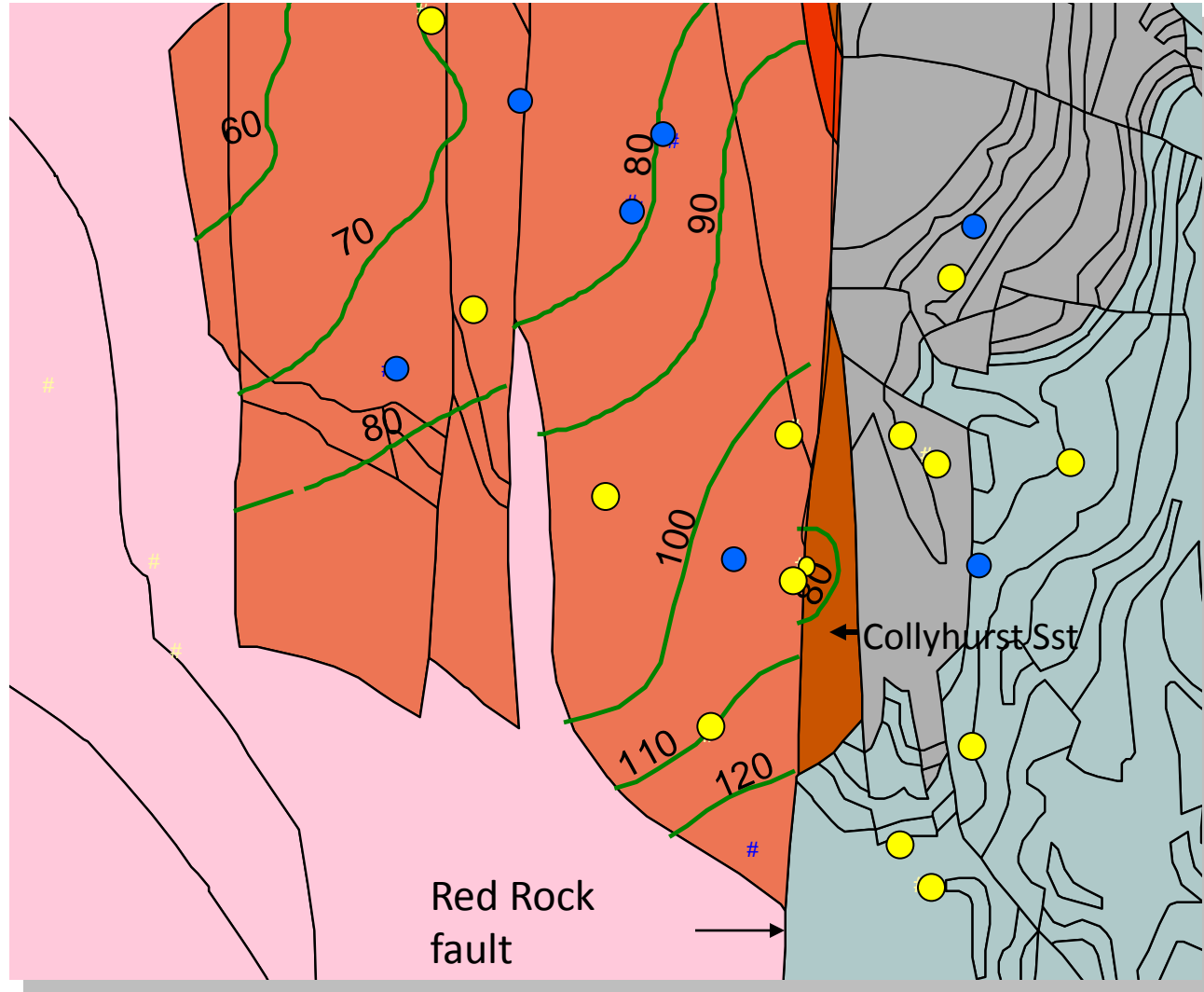




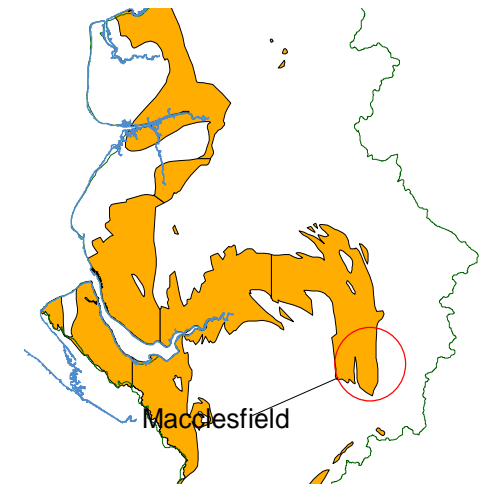
Macclesfield

Macclesfield

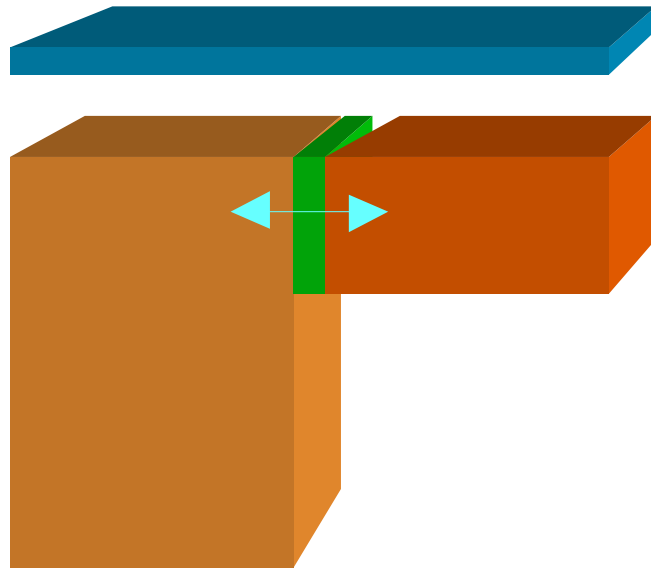
Macclesfield Geology & GW levels (2000)



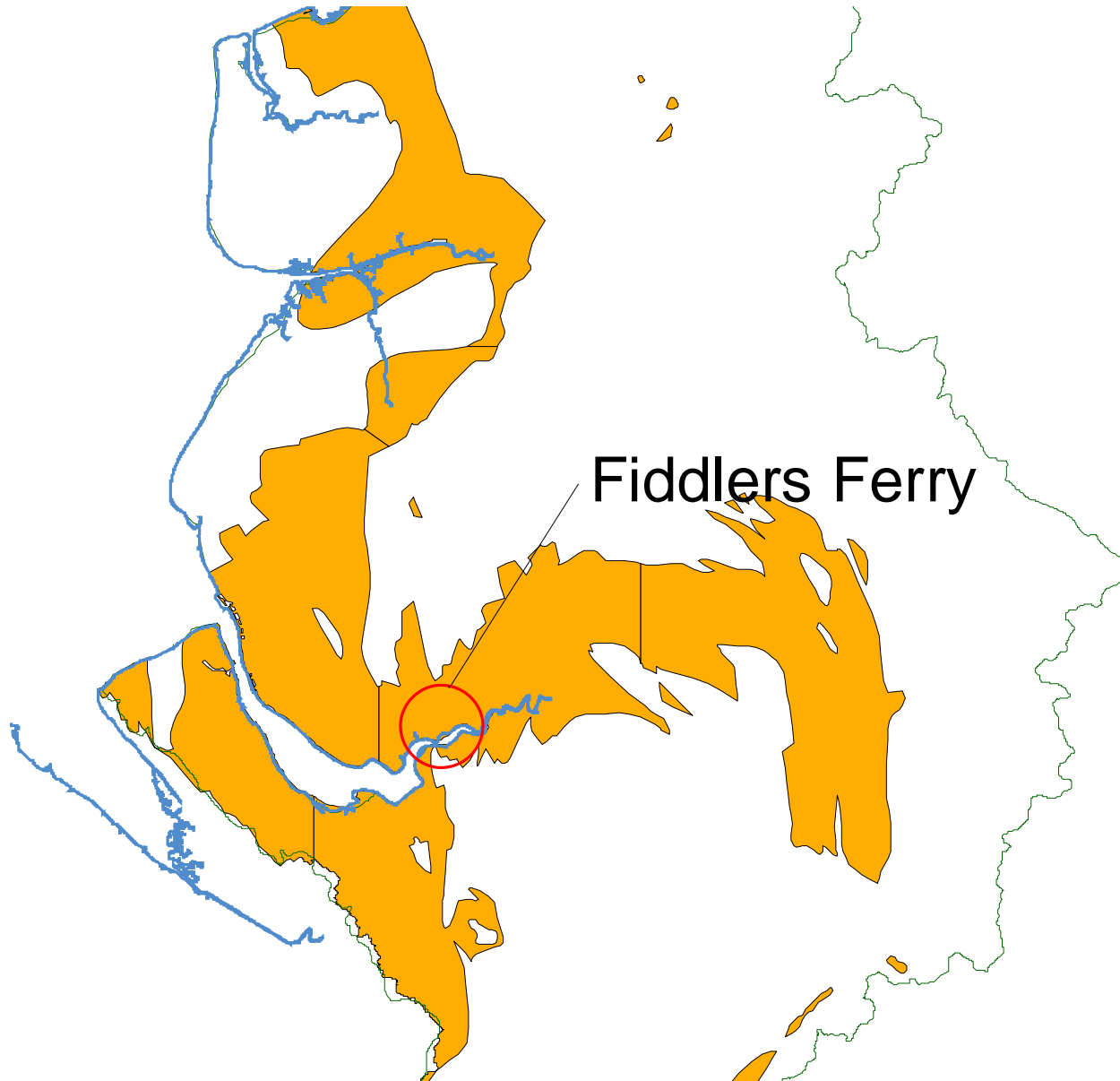
- PWS Abhs
- Industrial Abhs



Macclesfield - Summary



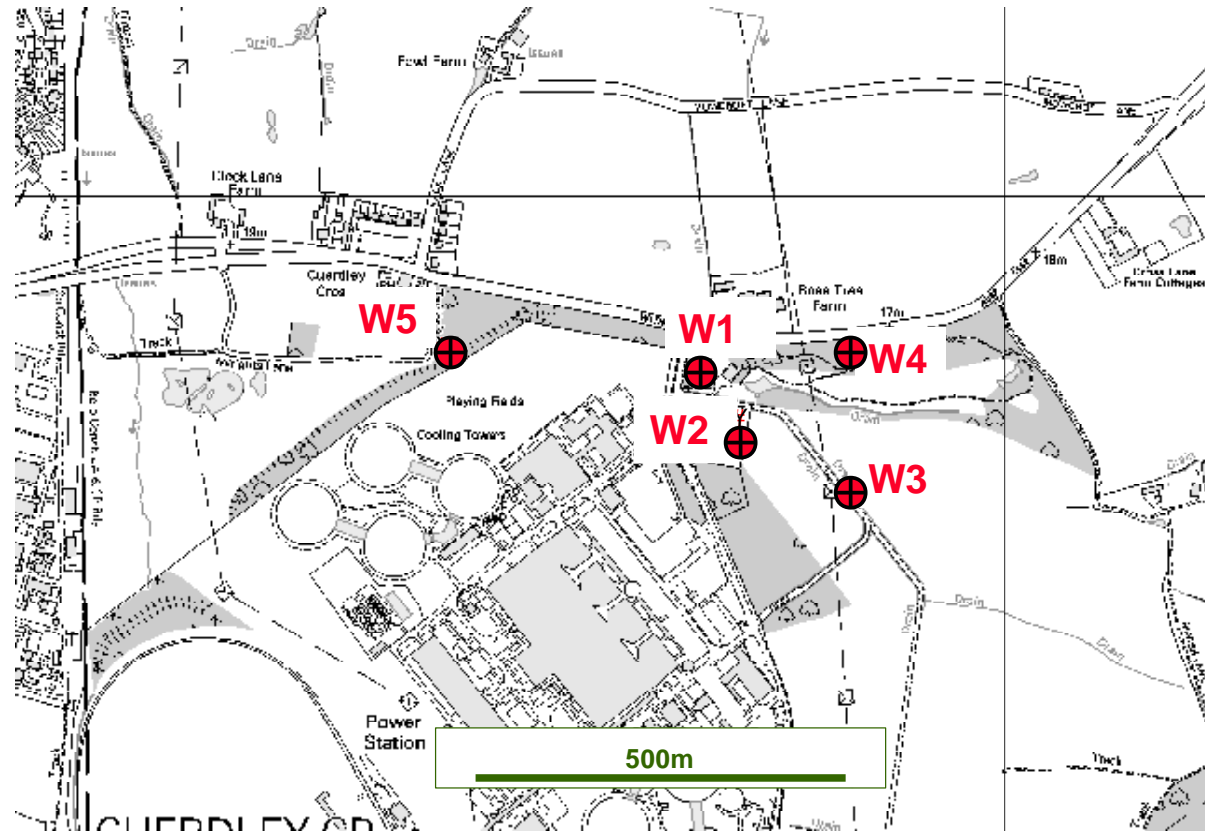
Fiddlers Ferry Power Station



Fiddlers Ferry

Fiddlers Ferry

- Power station
- Independent water supply
- Investigations 1984
- 5 trial bhs





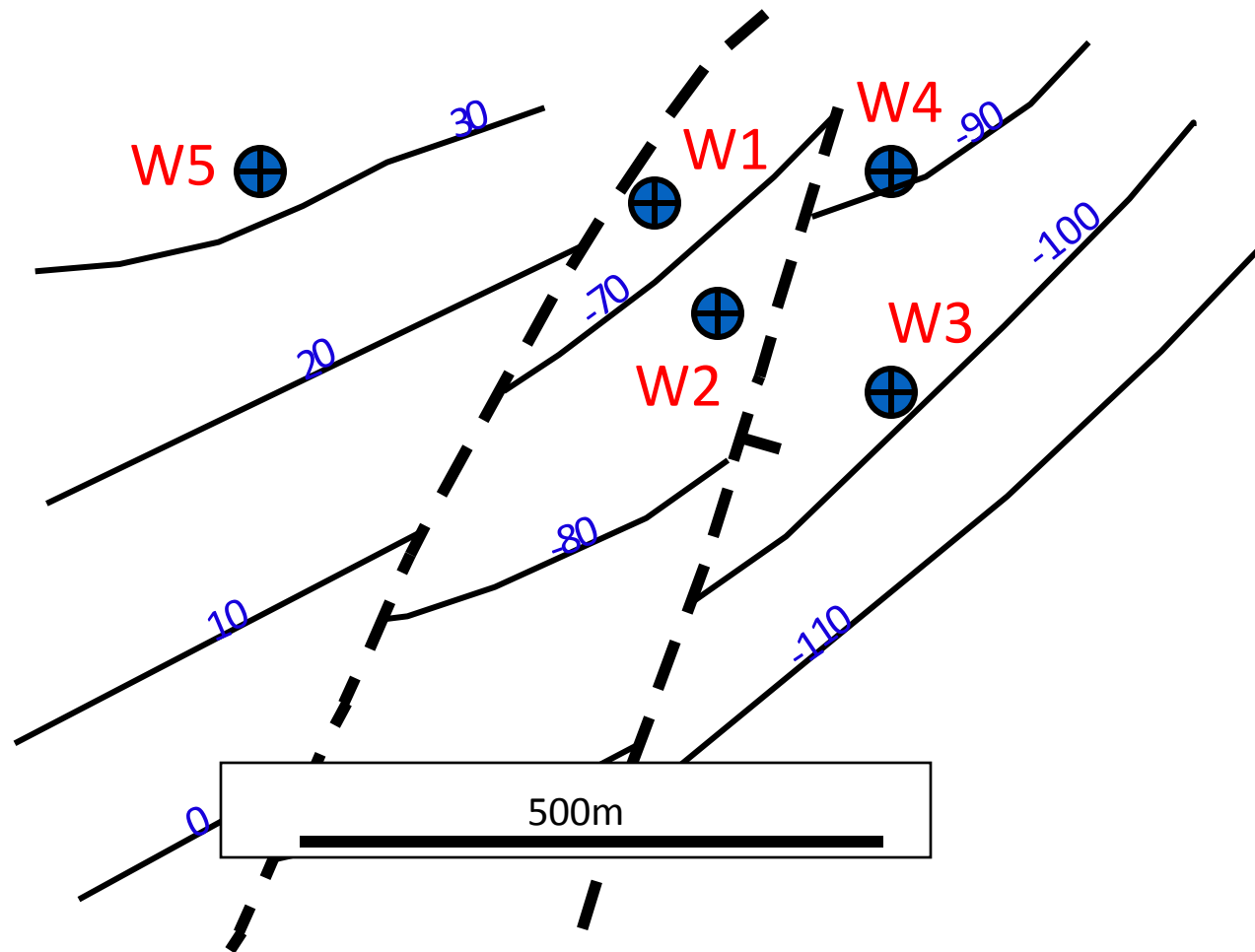
500m

Fiddlers Ferry - Water Levels mAOD (1984)



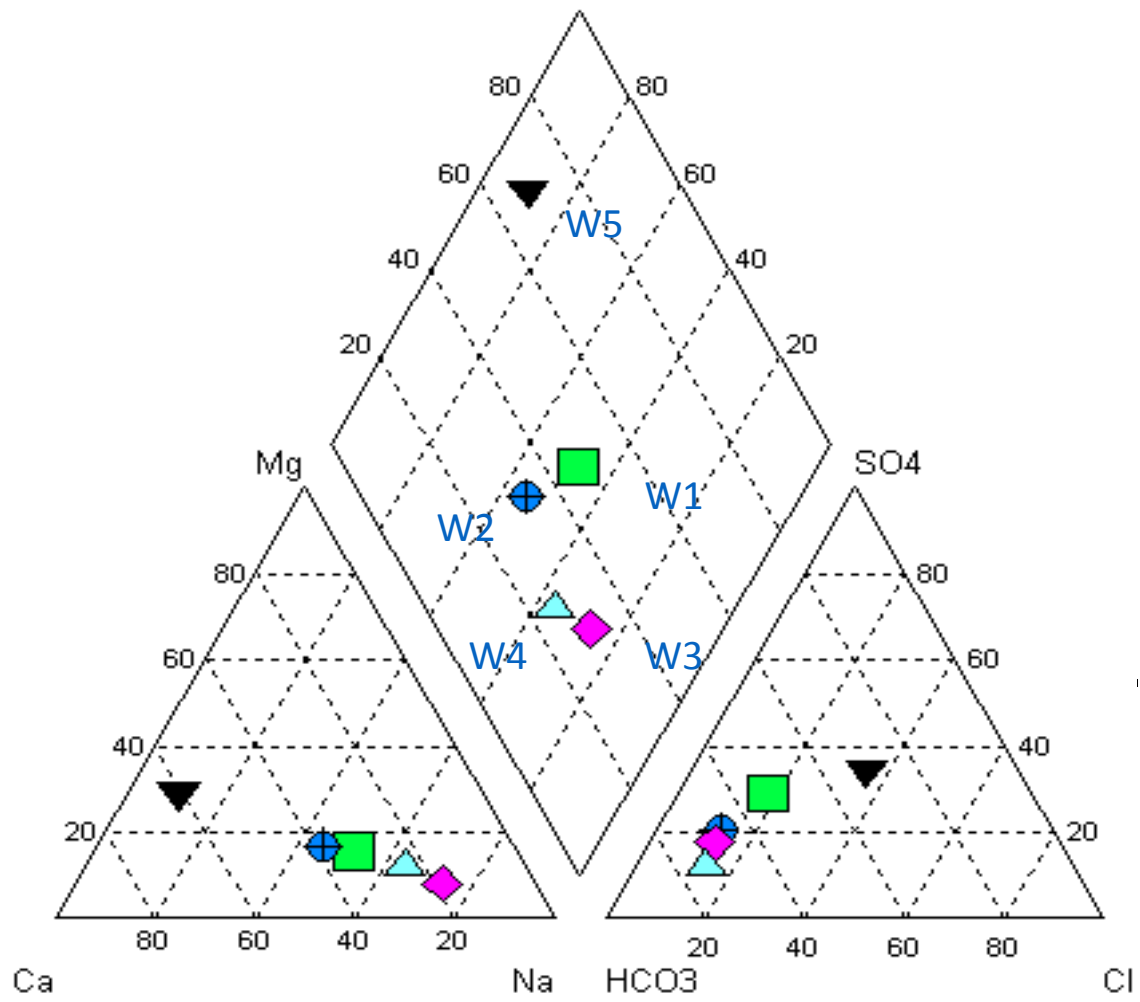
500m

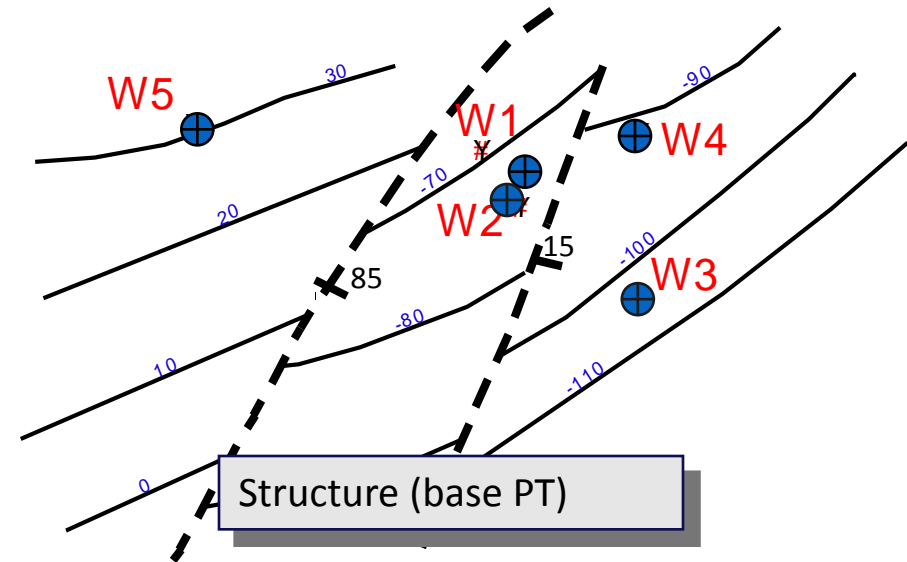
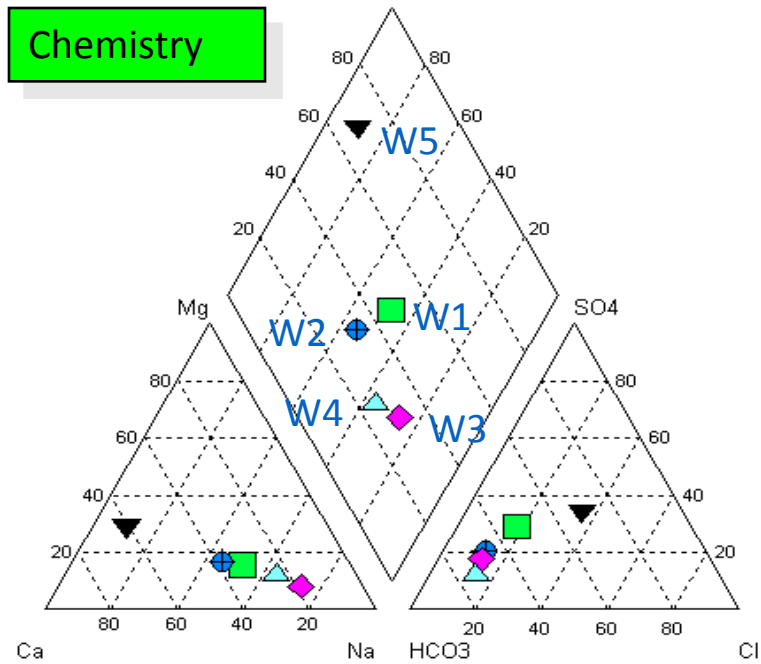
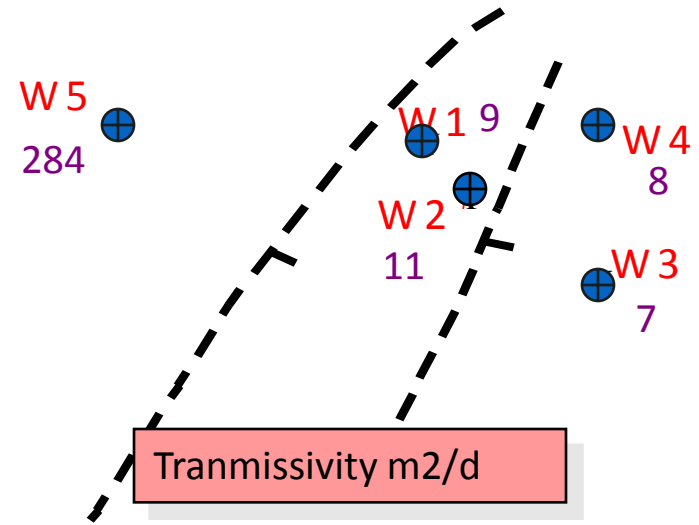
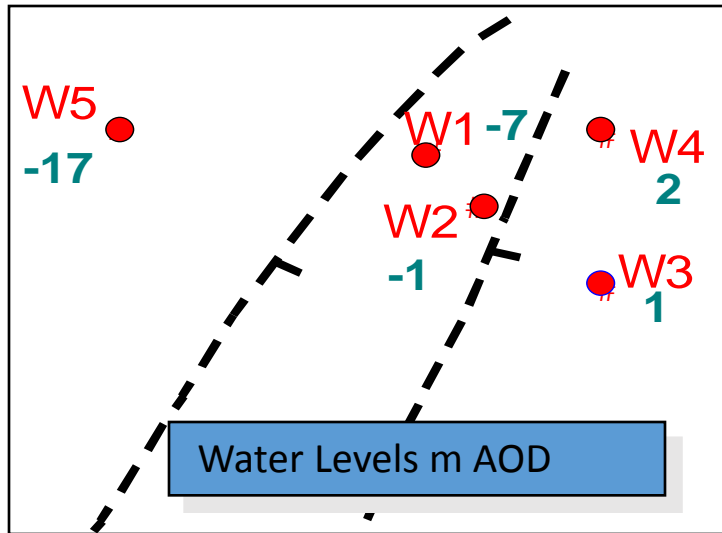
Fiddlers Ferry - Transmissivity (m²/d)



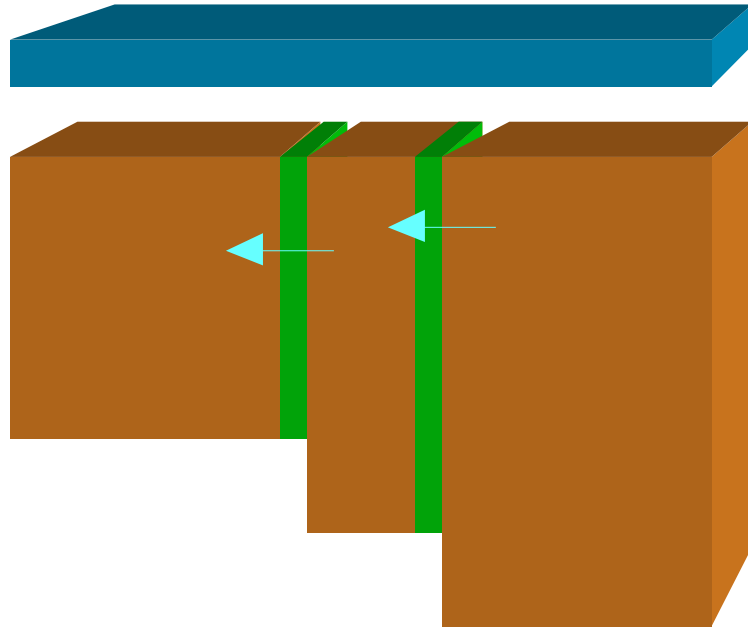
Fiddlers Ferry - Structure (base Wilmslow Sst)

Fiddlers Ferry - Major Ion Chemistry





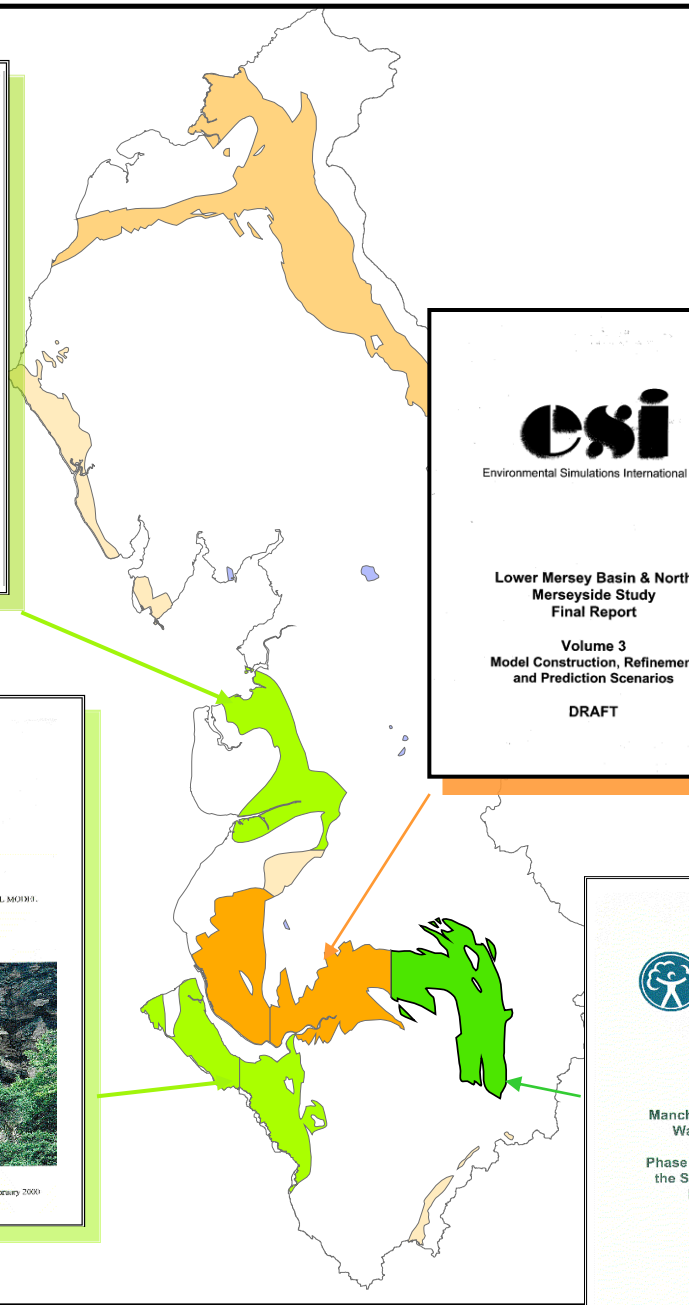
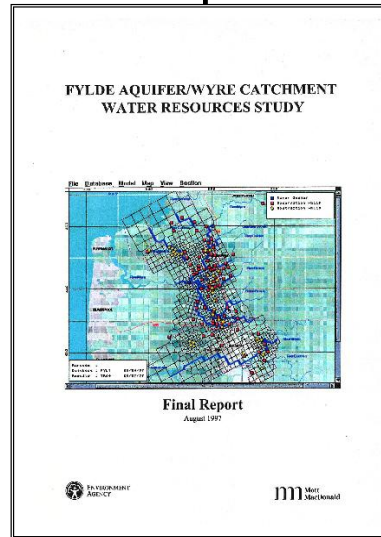
Fiddlers Ferry - summary



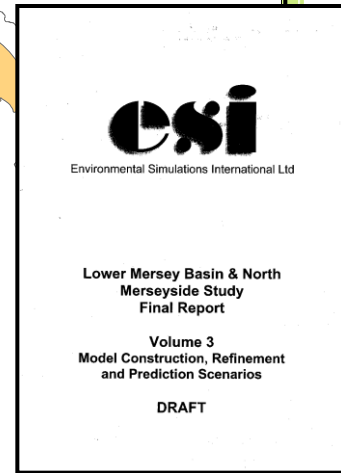
Recent groundwater resources
investigations (modelling studies)

NW Region Groundwater Resource Investigations

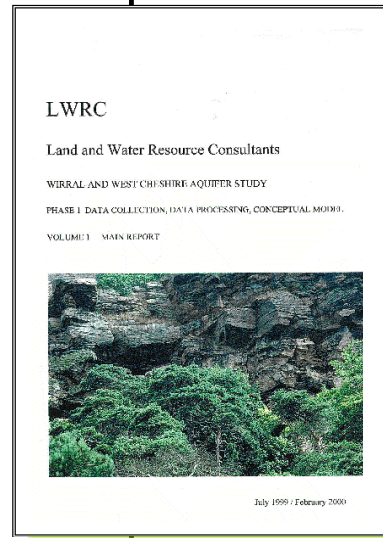
1997



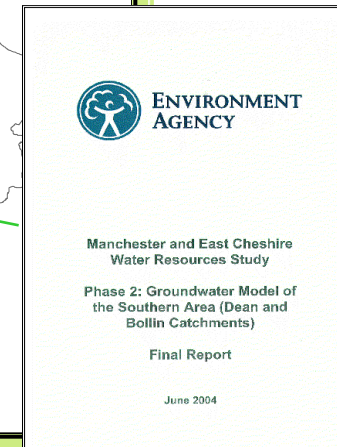
2007



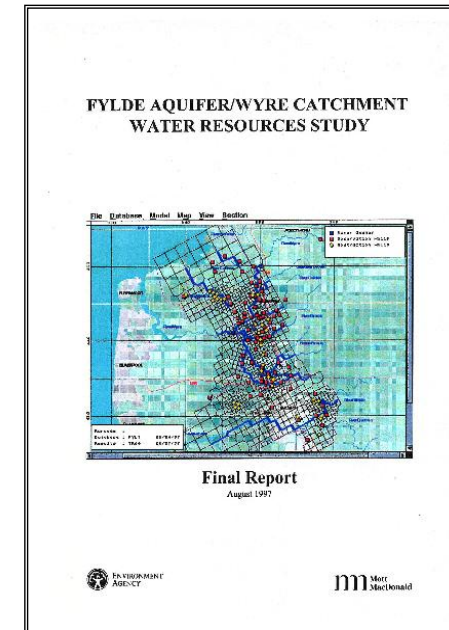
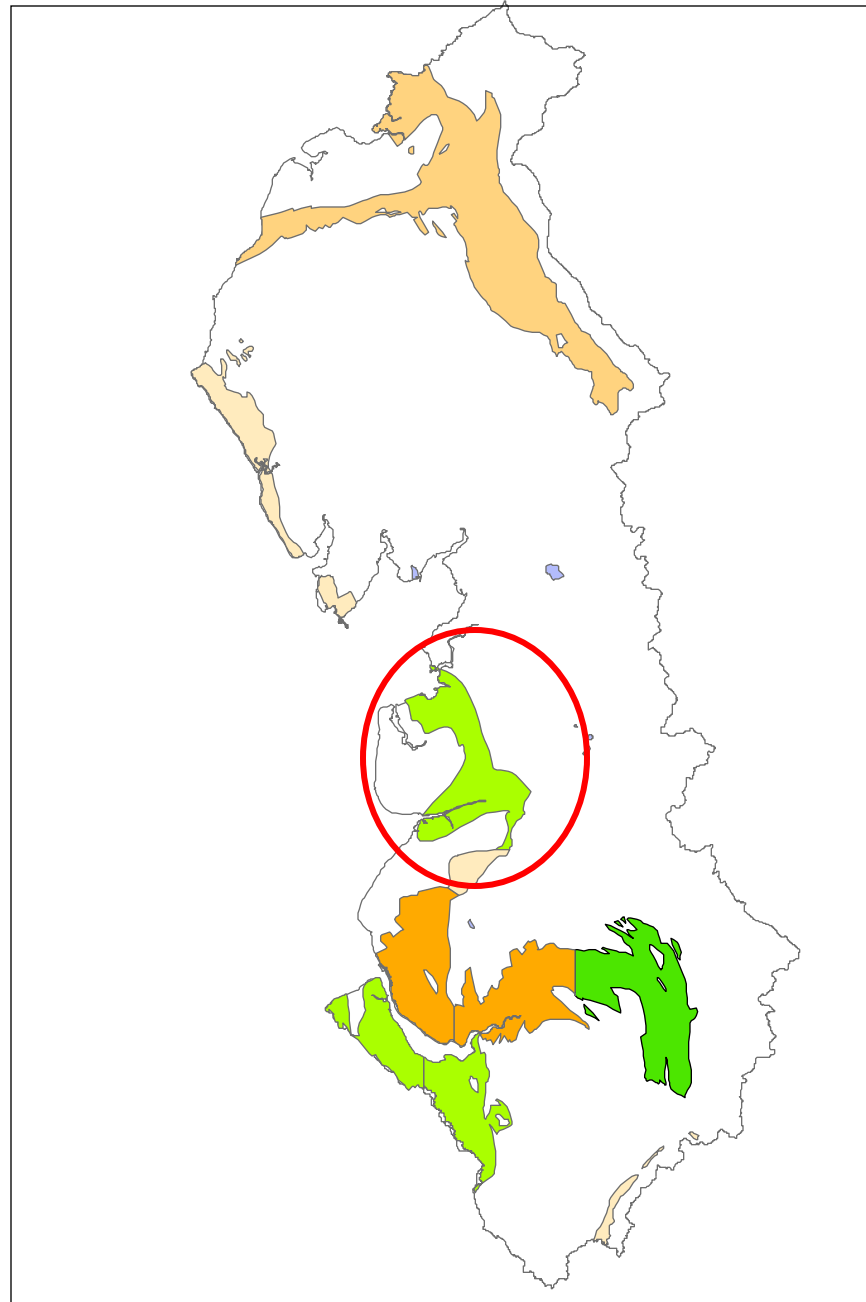
2000



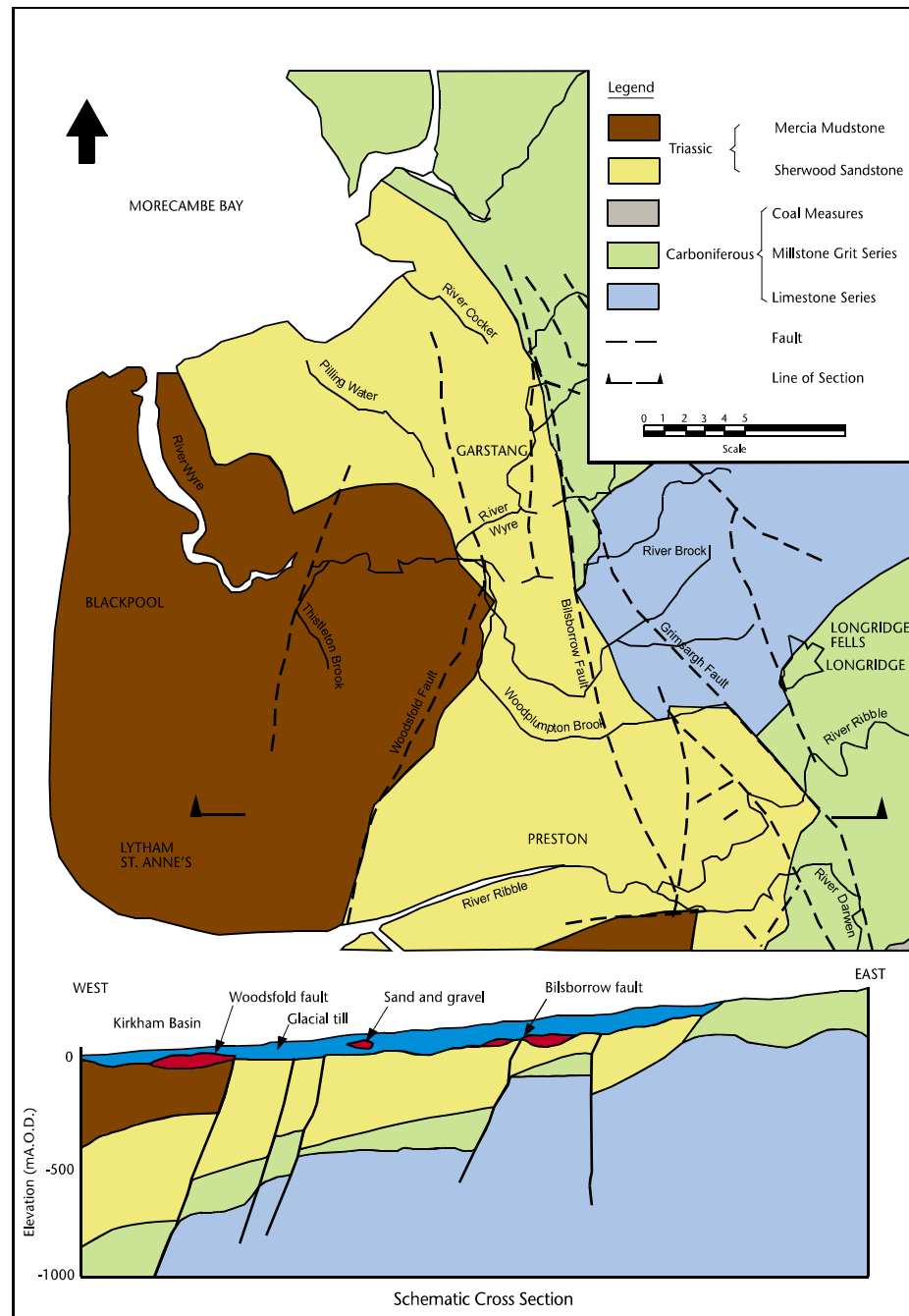
2004



Fylde Aquifer

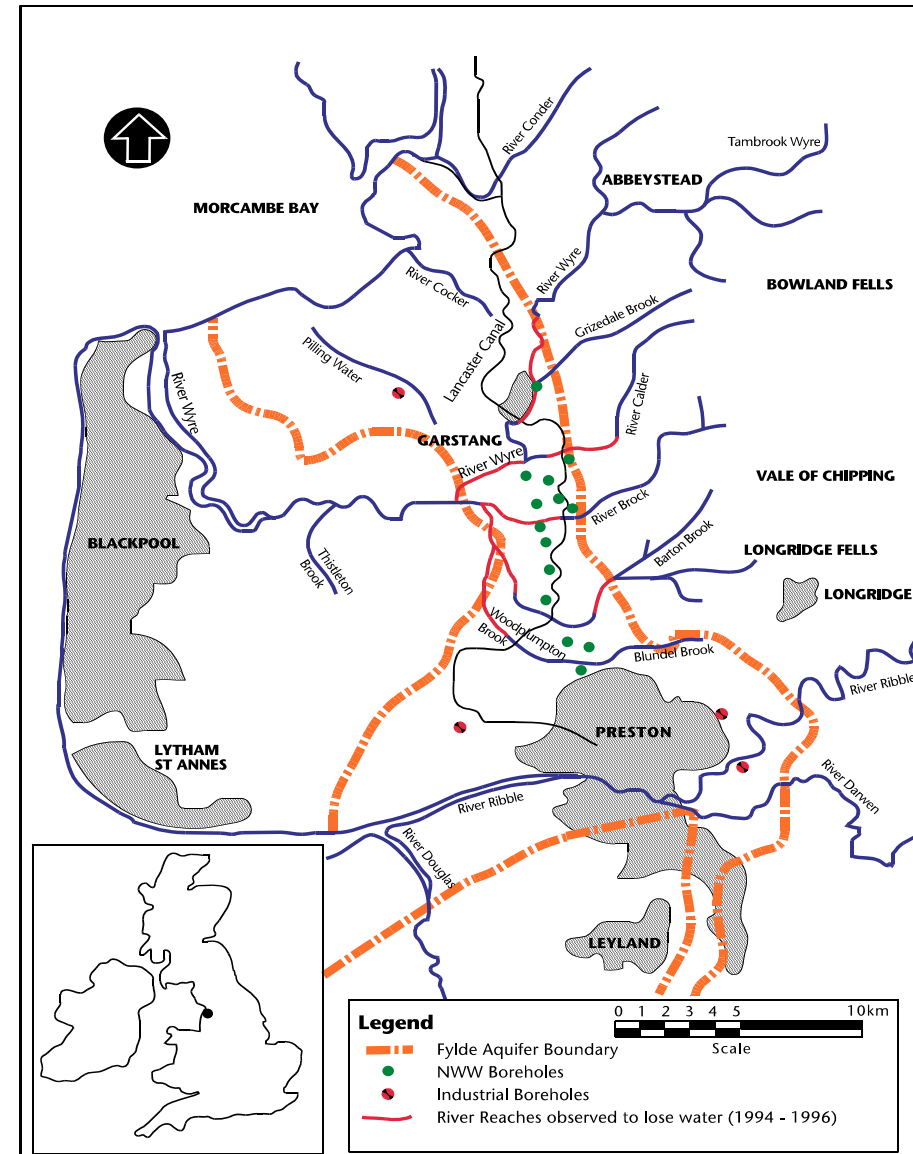


Fylde Aquifer Geology

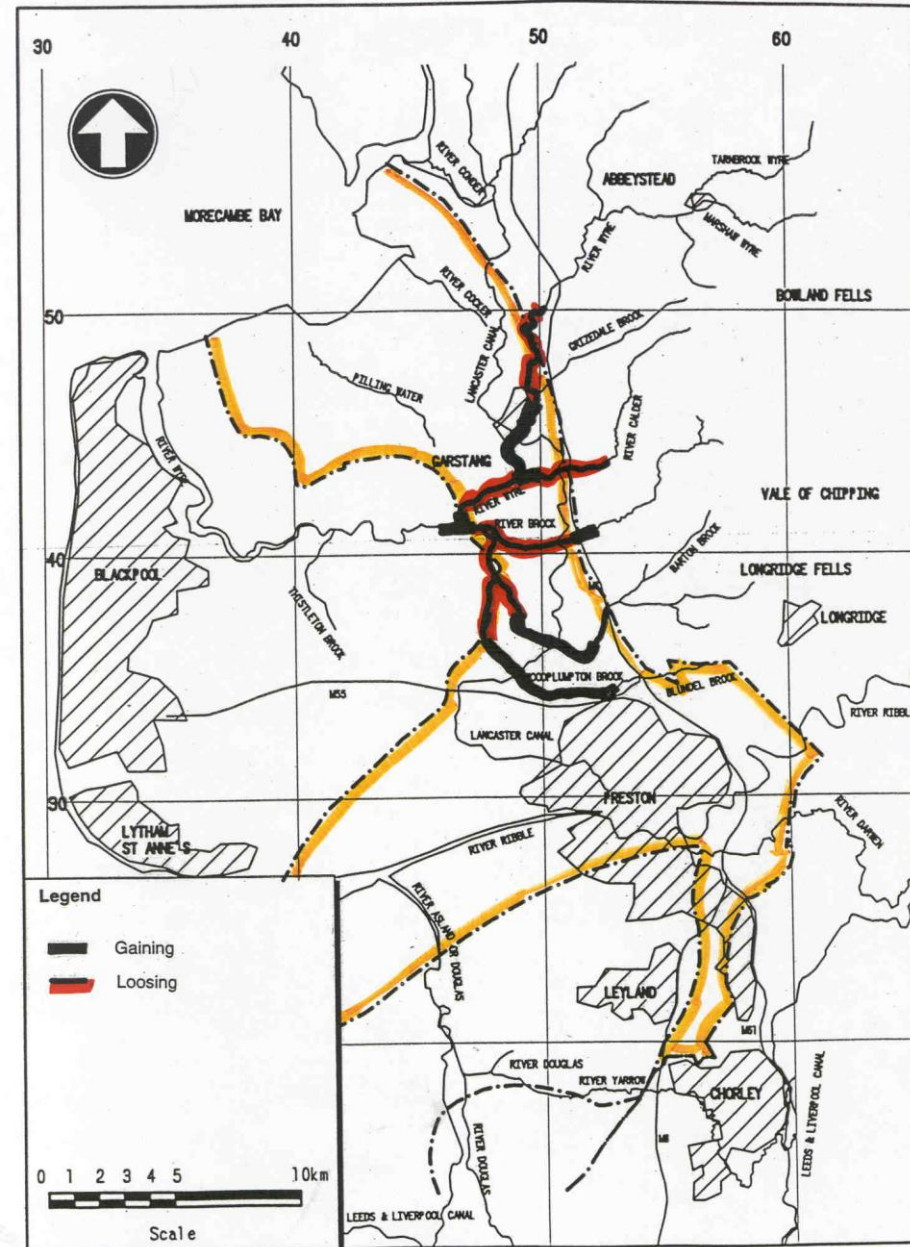


Fylde Aquifer

- Abstractions
 - Industrial
 - PWS
- LCUS
 - seasonal abstraction
 - detailed investigations
 - 30 years operation



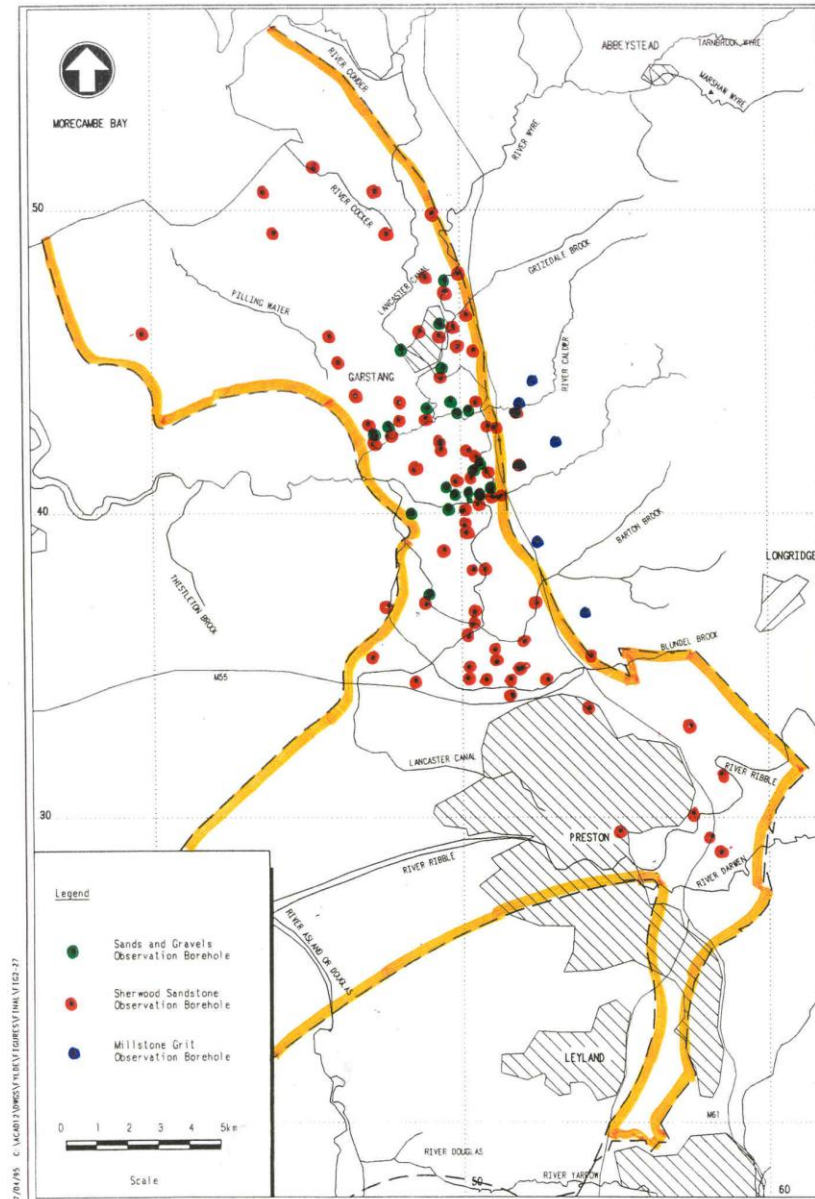
Gaining/Losing River Reaches - July 1994



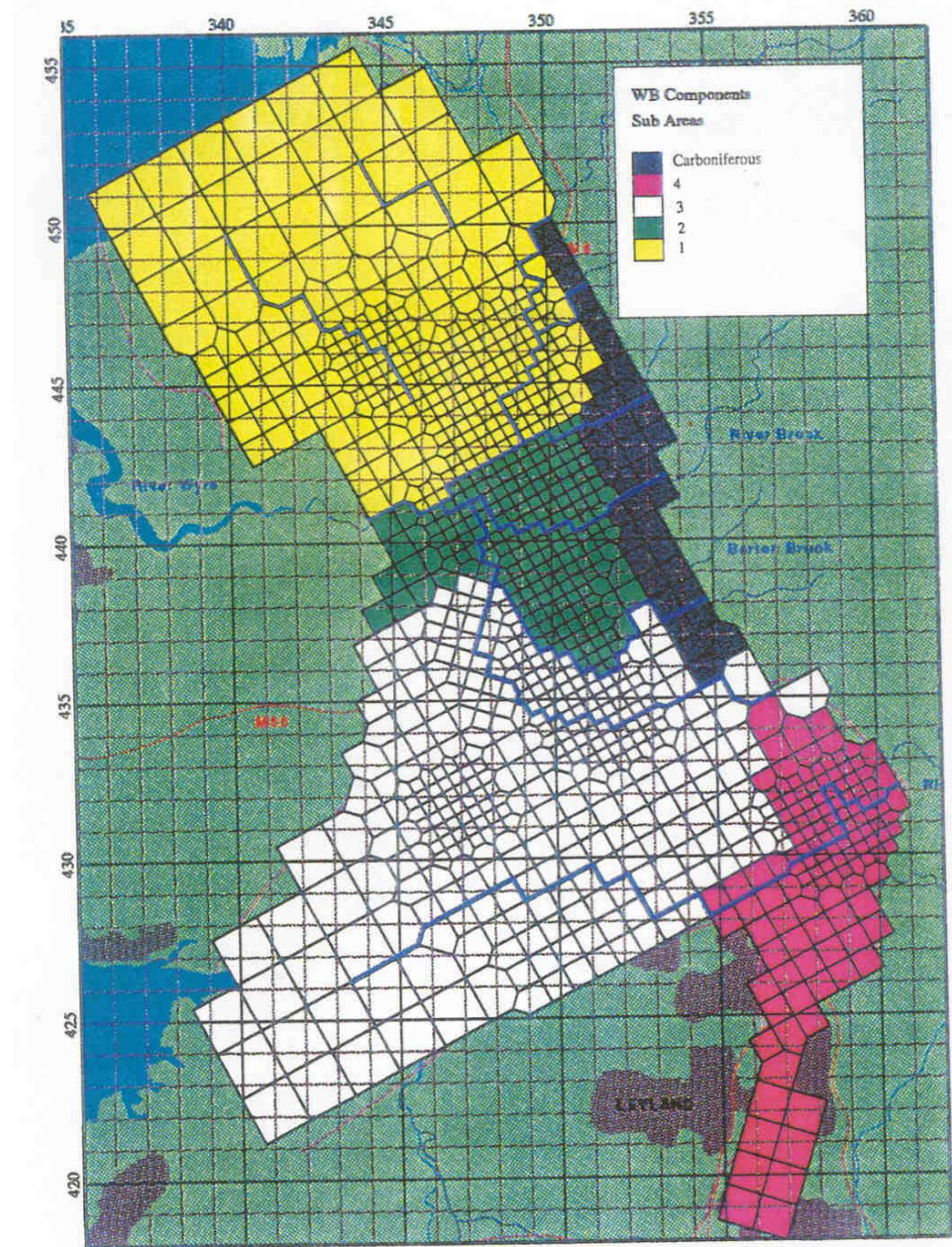
Fylde Aquifer/Wyre Catchment Water Resources Study

- Why?
 - sustainability of licence
 - impact on rivers
- How:
 - data review, conceptual & numerical model
- Who?
 - EA, United Utilities, Mott MacDonald, Ken Rushton

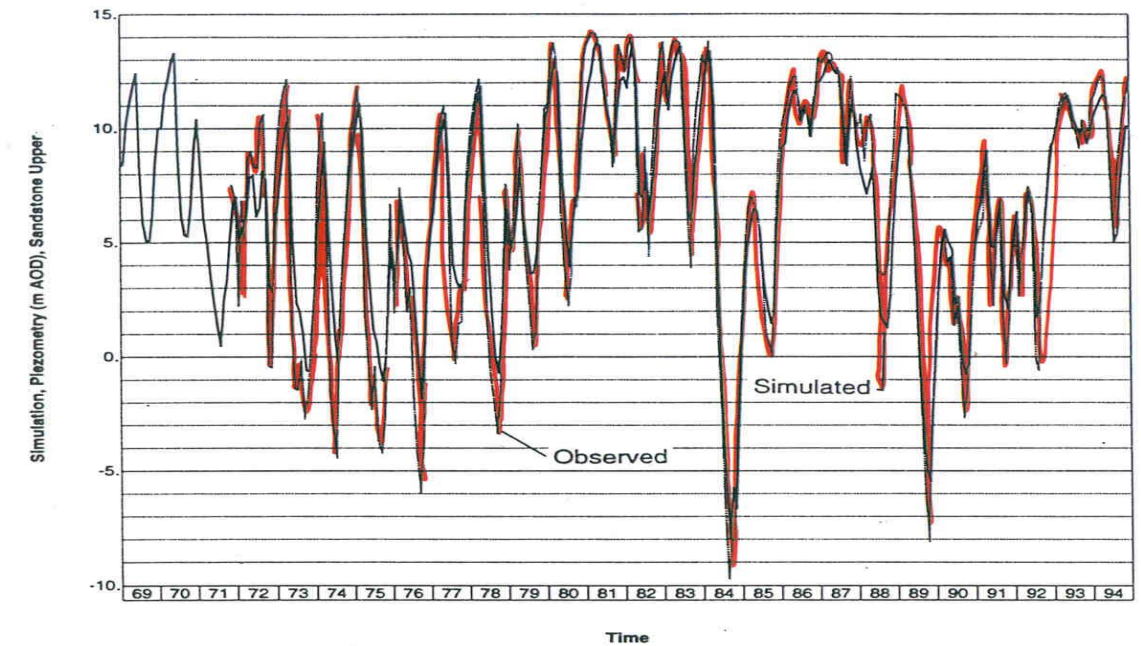
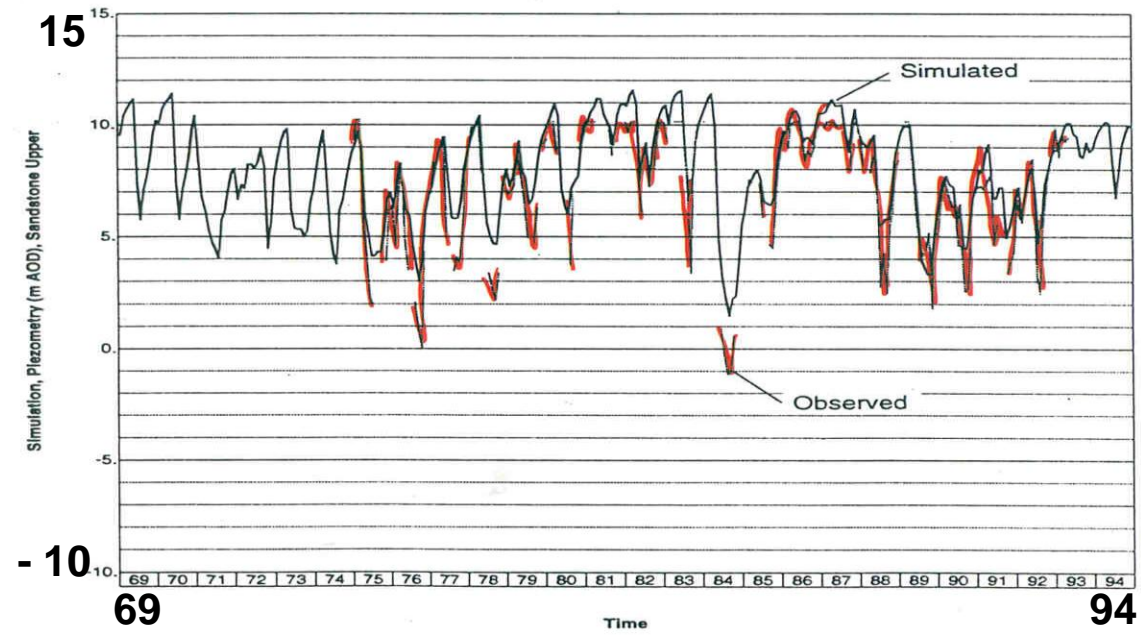
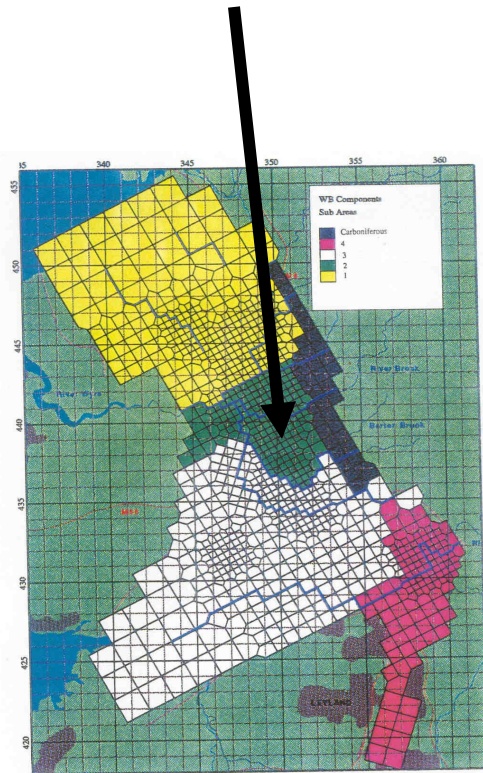
Location of Observation Boreholes



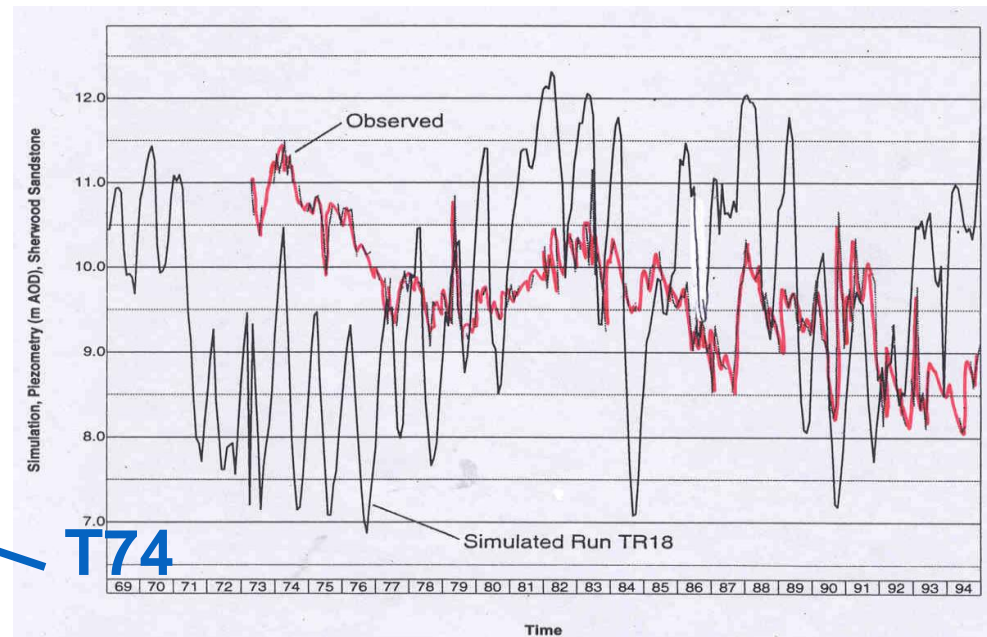
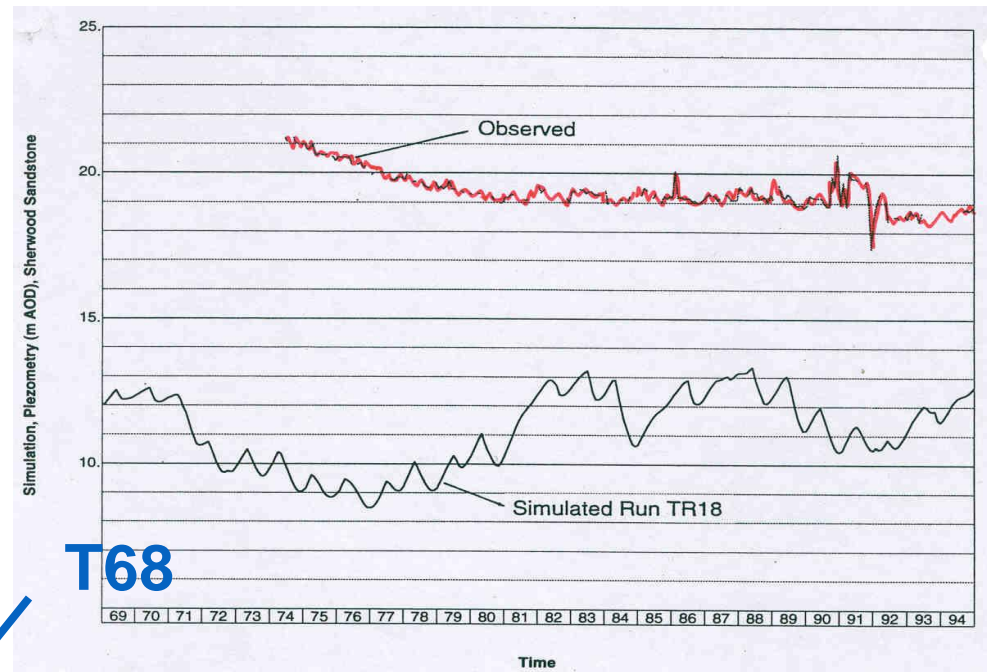
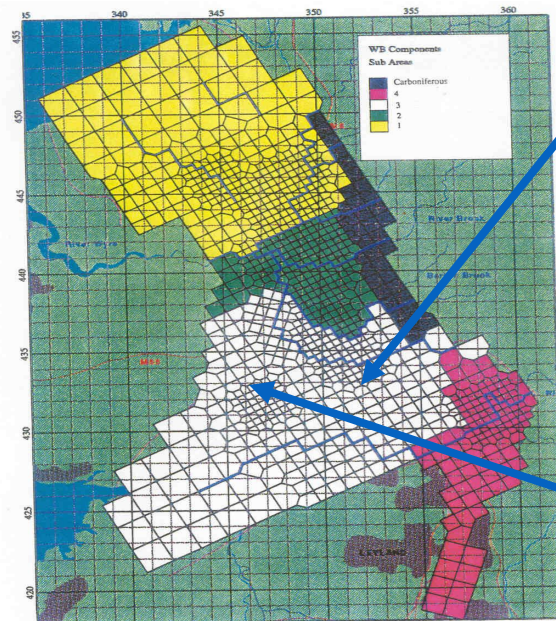
Sub Areas of the Model



Calibration: Simulated Groundwater Levels in the Central Area

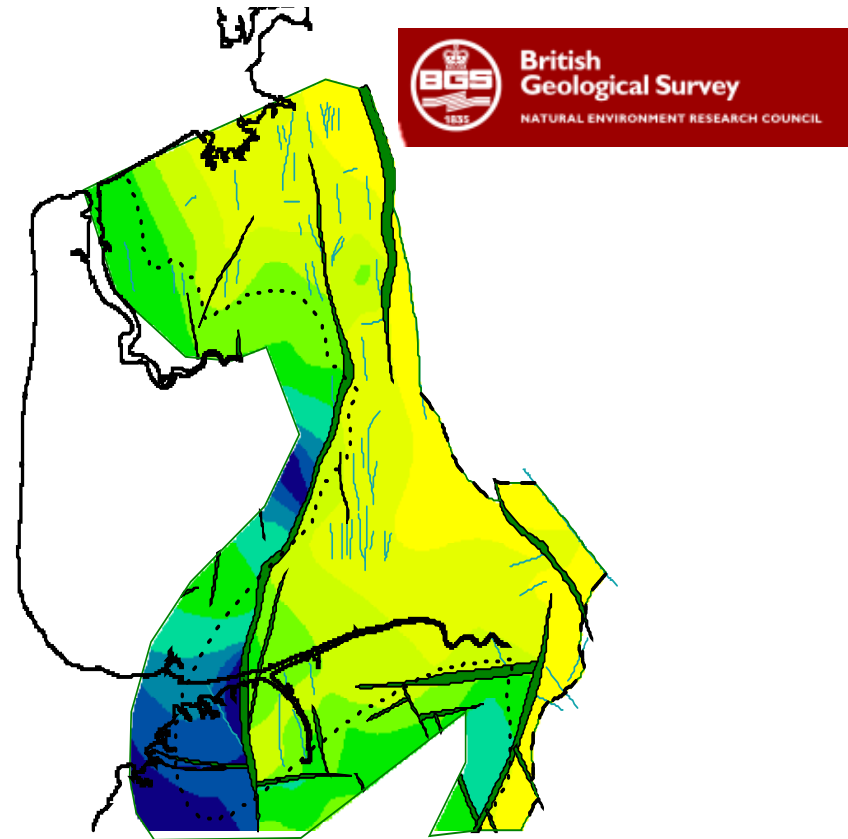


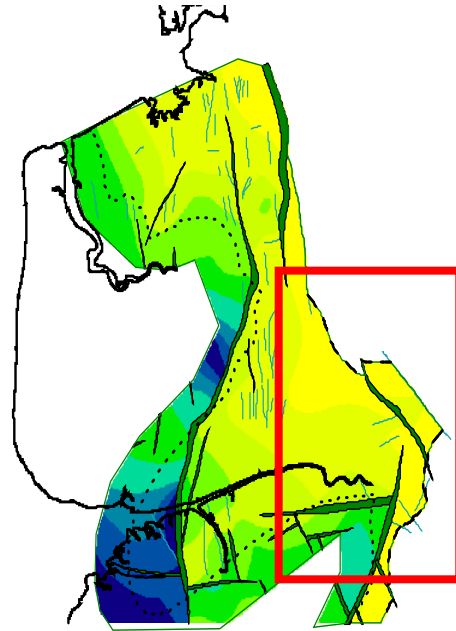
Early Simulations - Southern area



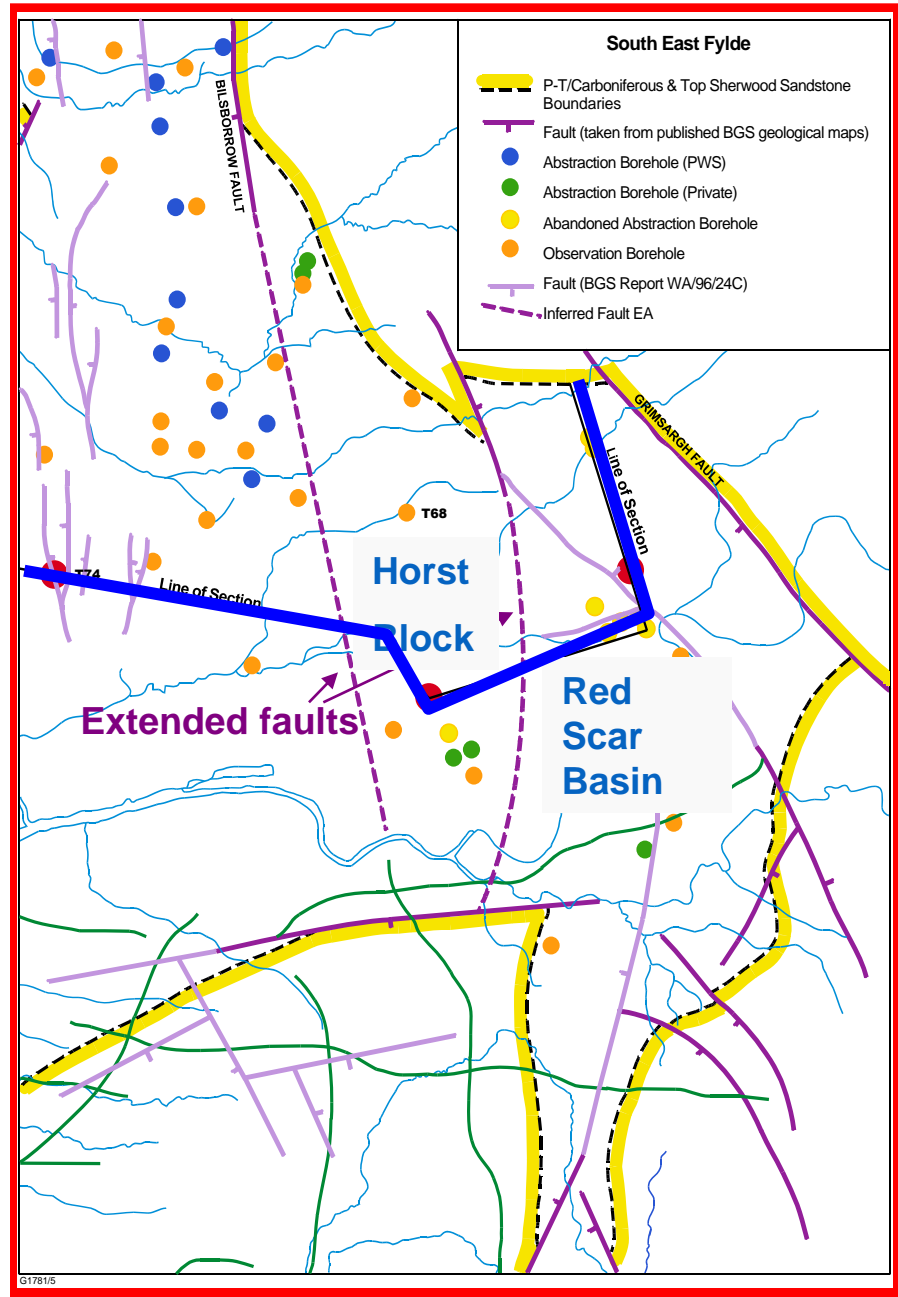
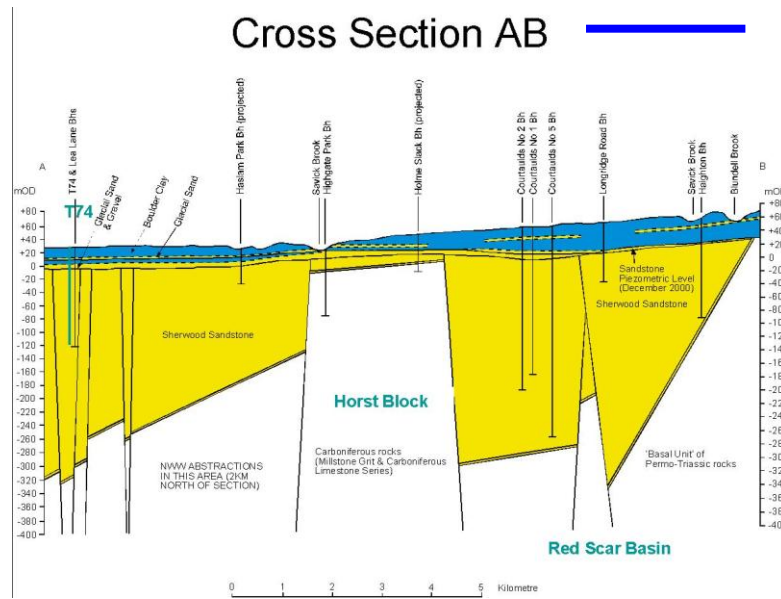
Fylde Aquifer/Wyre Catchment Water Resources Study

- Reconceptualisation
 - time for a rethink!:
- Structural controls?

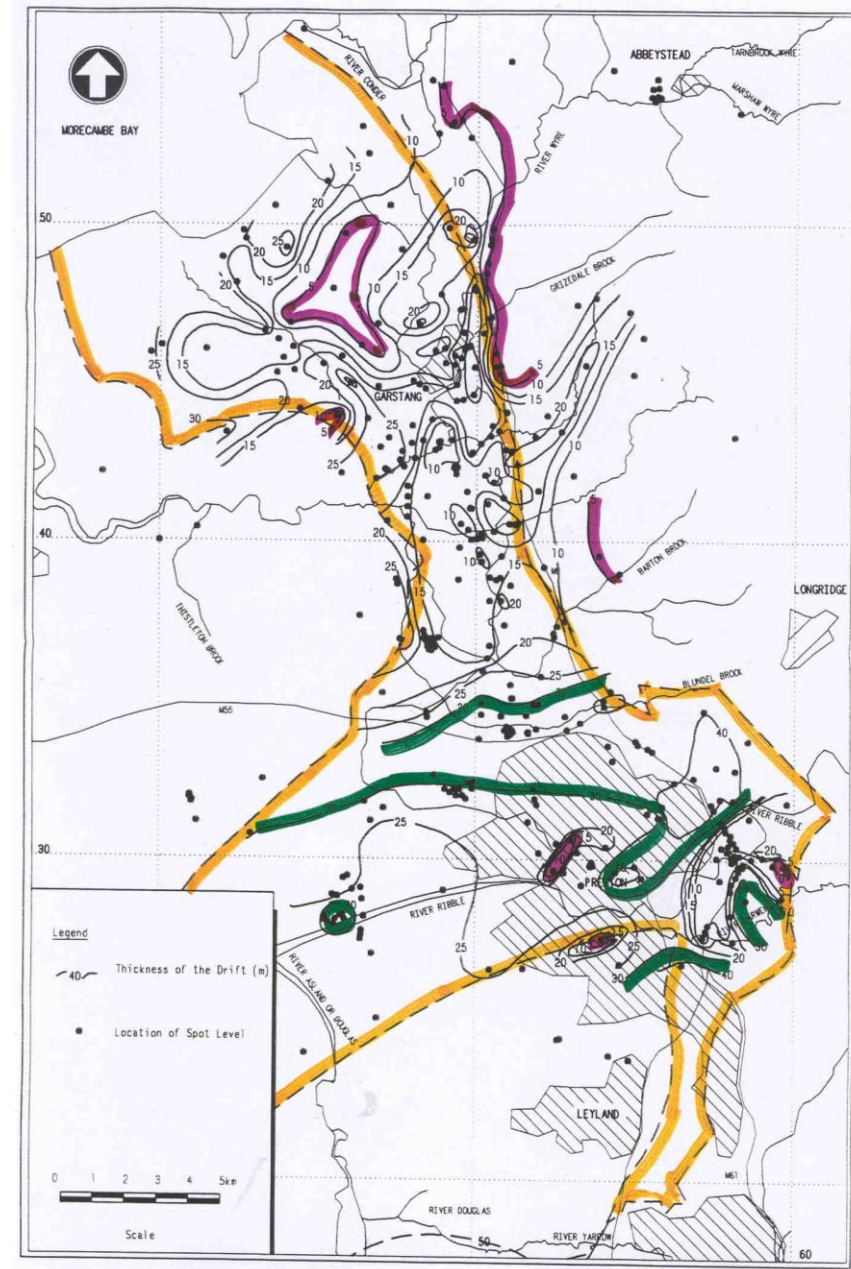




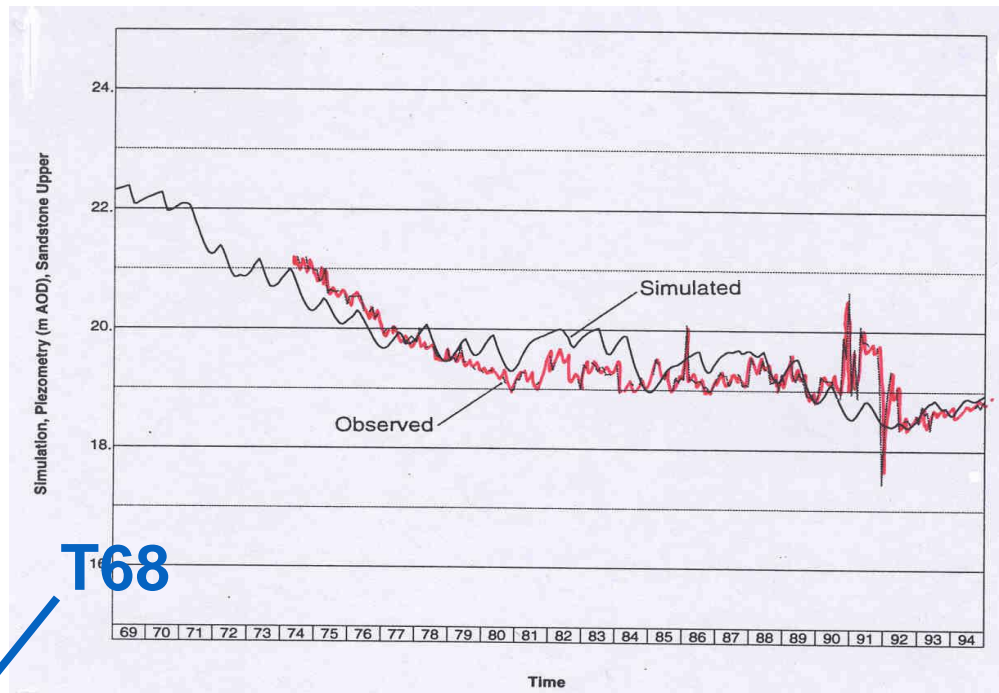
Cross Section AB



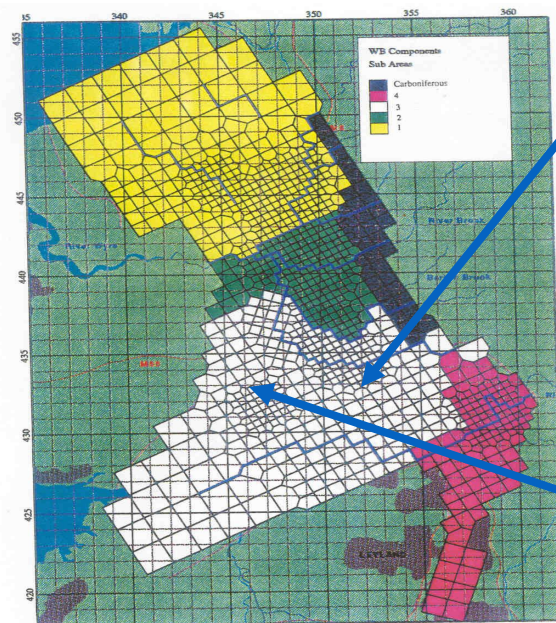
Thickness of Drift



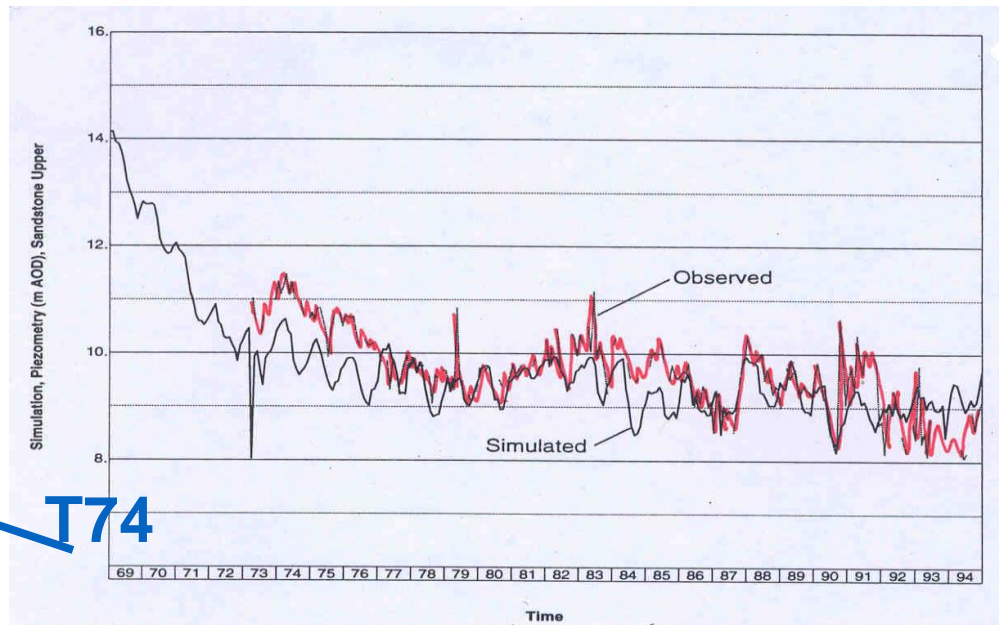
Final Calibration: - Southern area



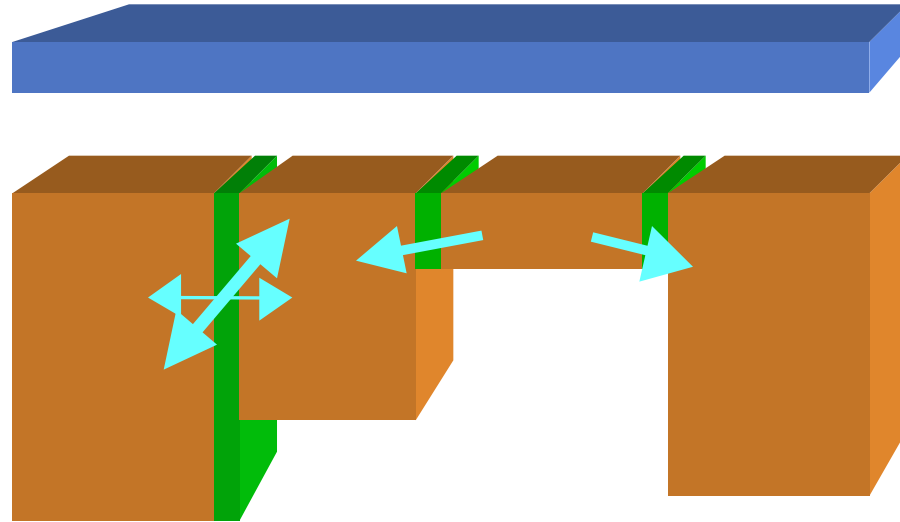
T68



T74

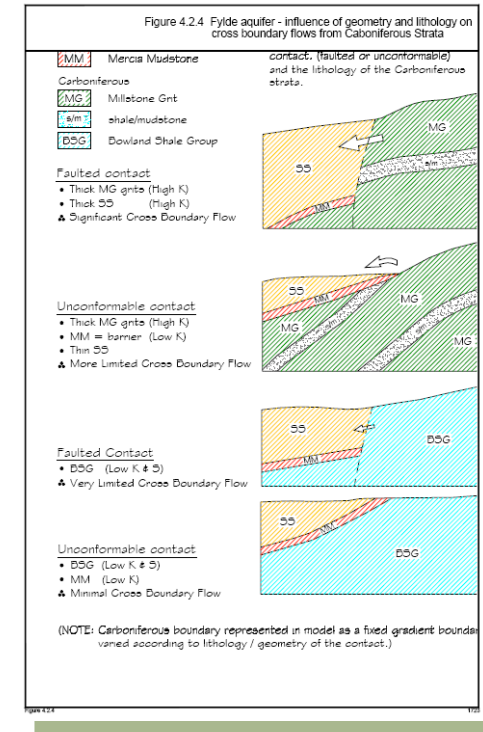
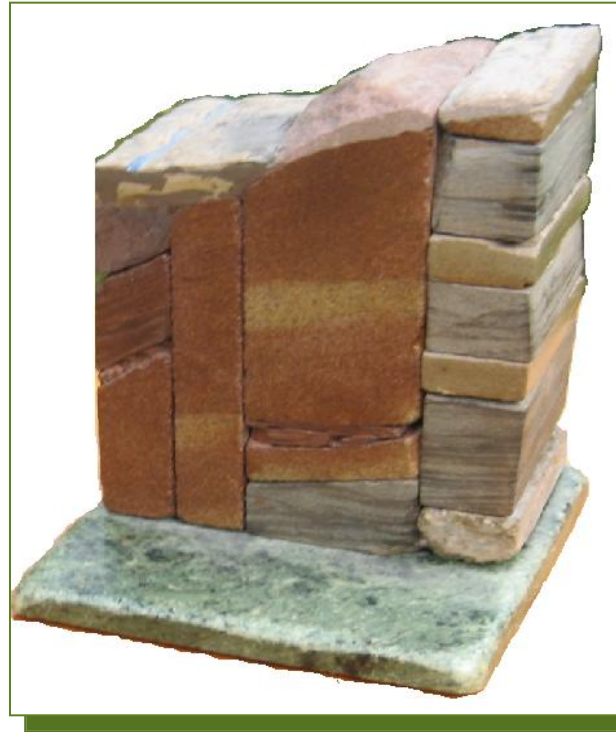
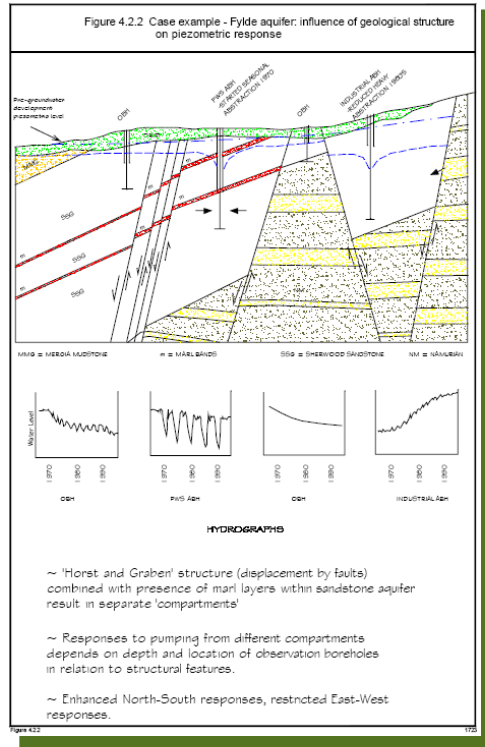


Fylde - Summary:

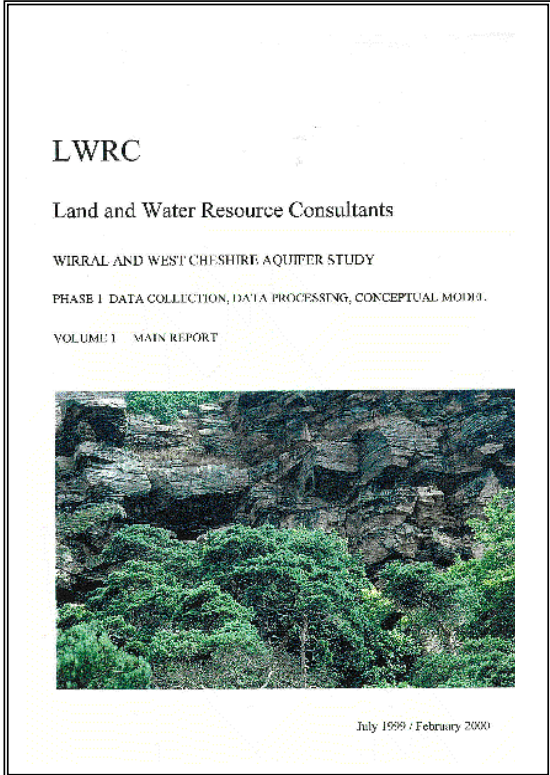
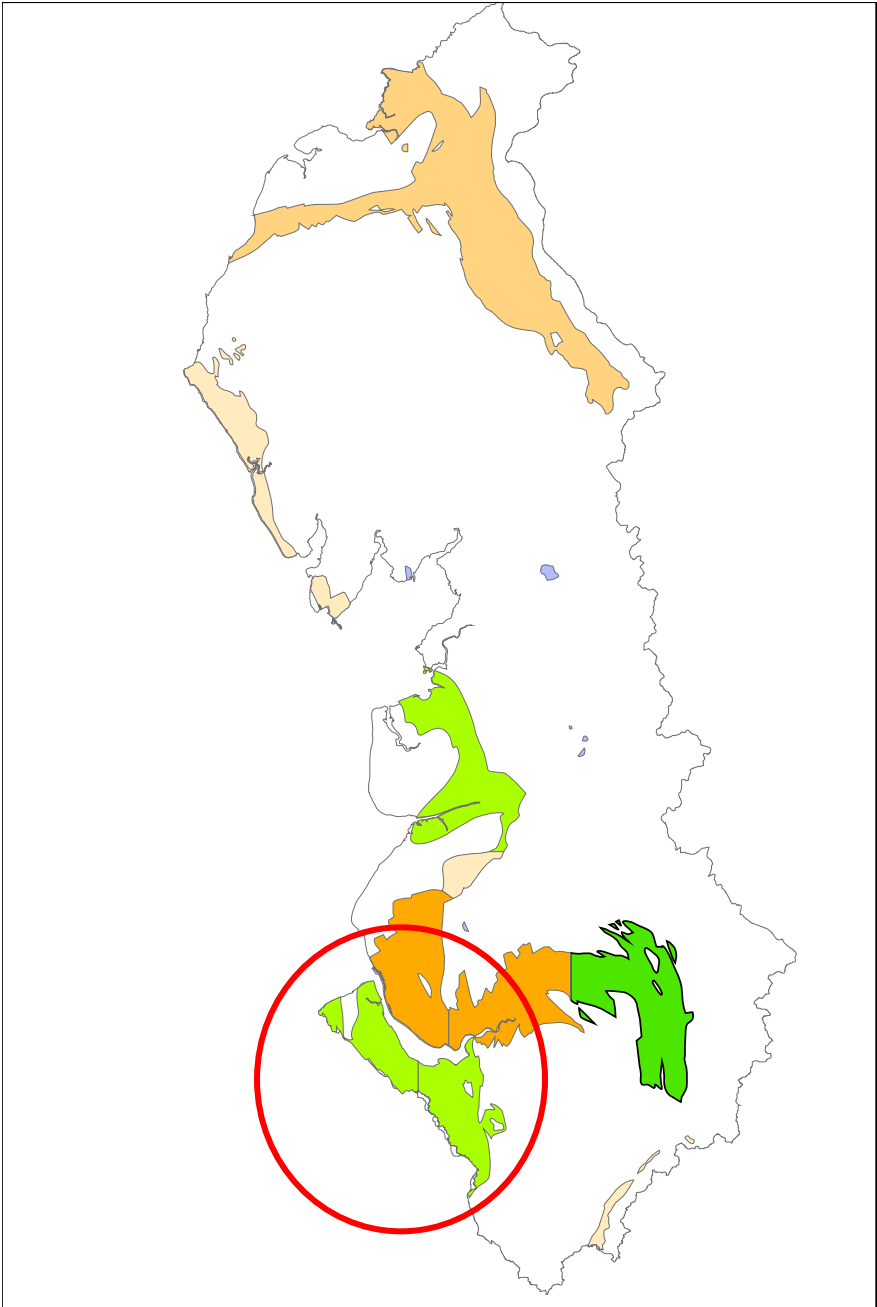


the importance of the conceptual model

the Fylde

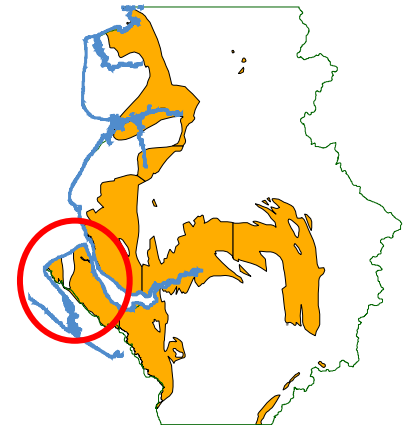
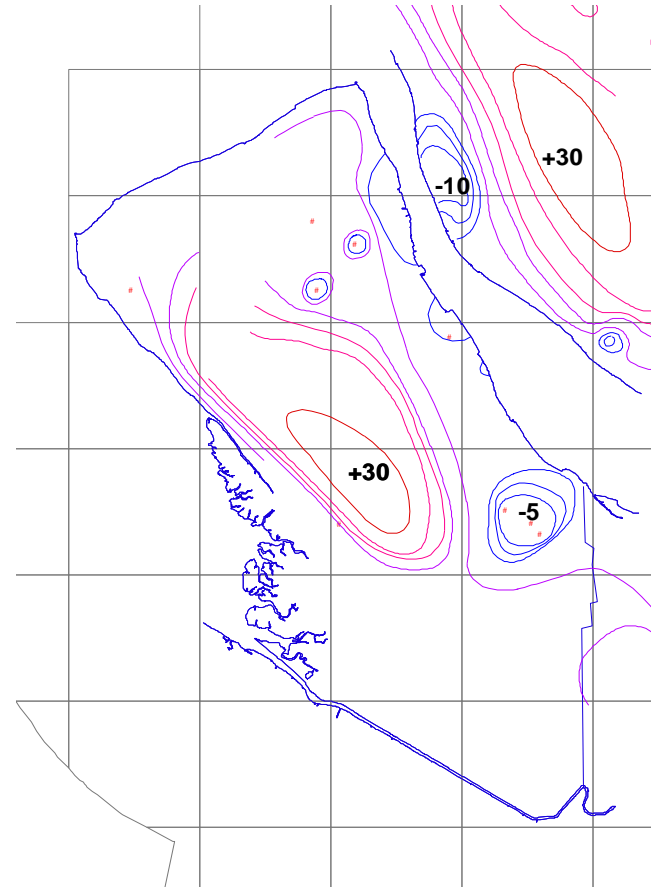


Wirral

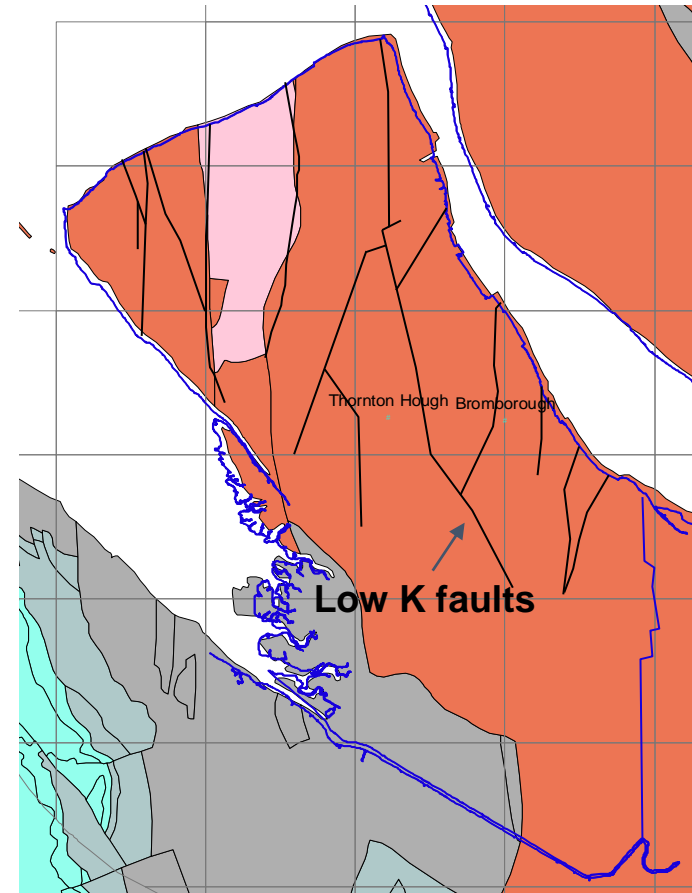
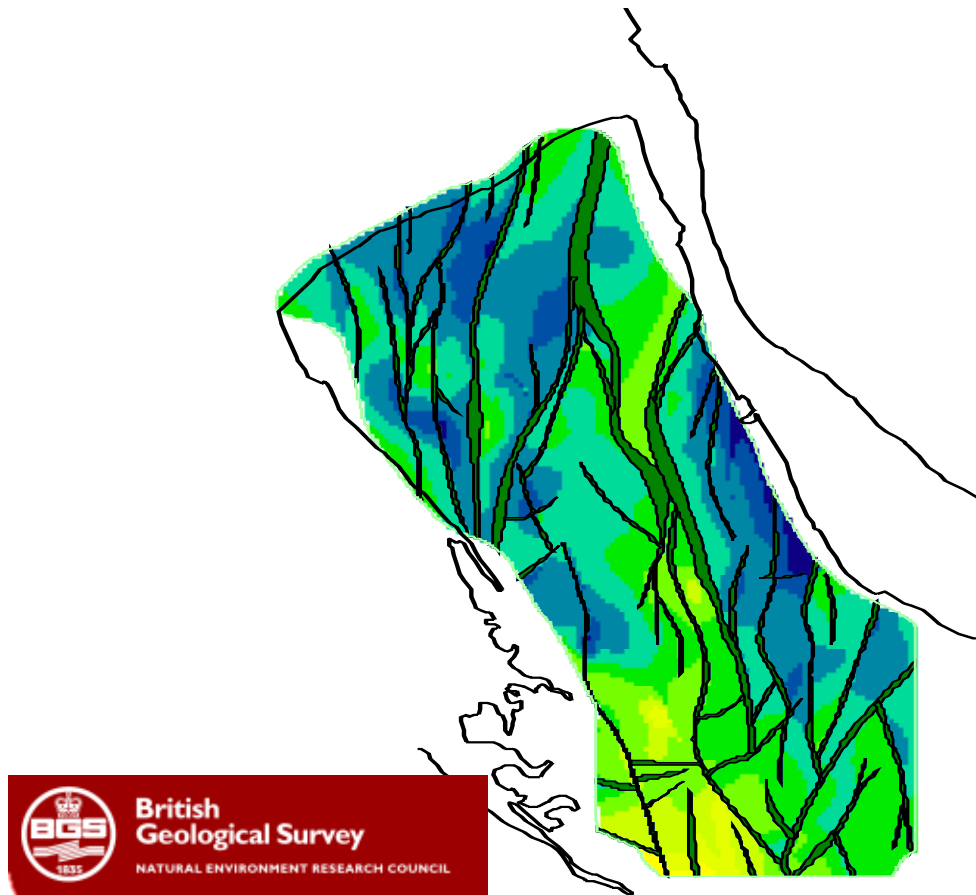


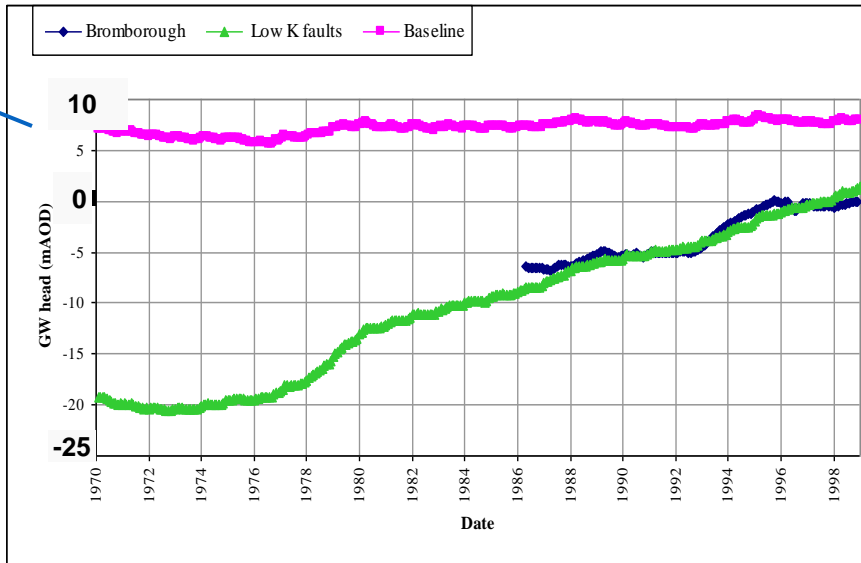
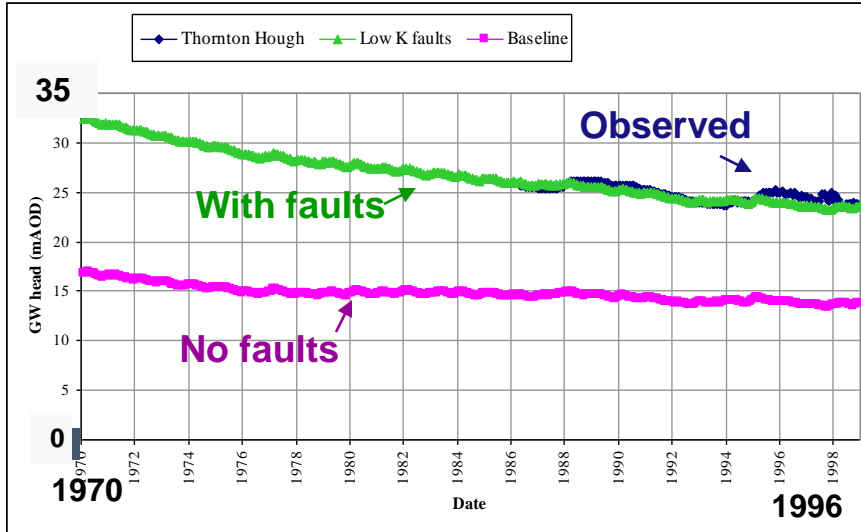
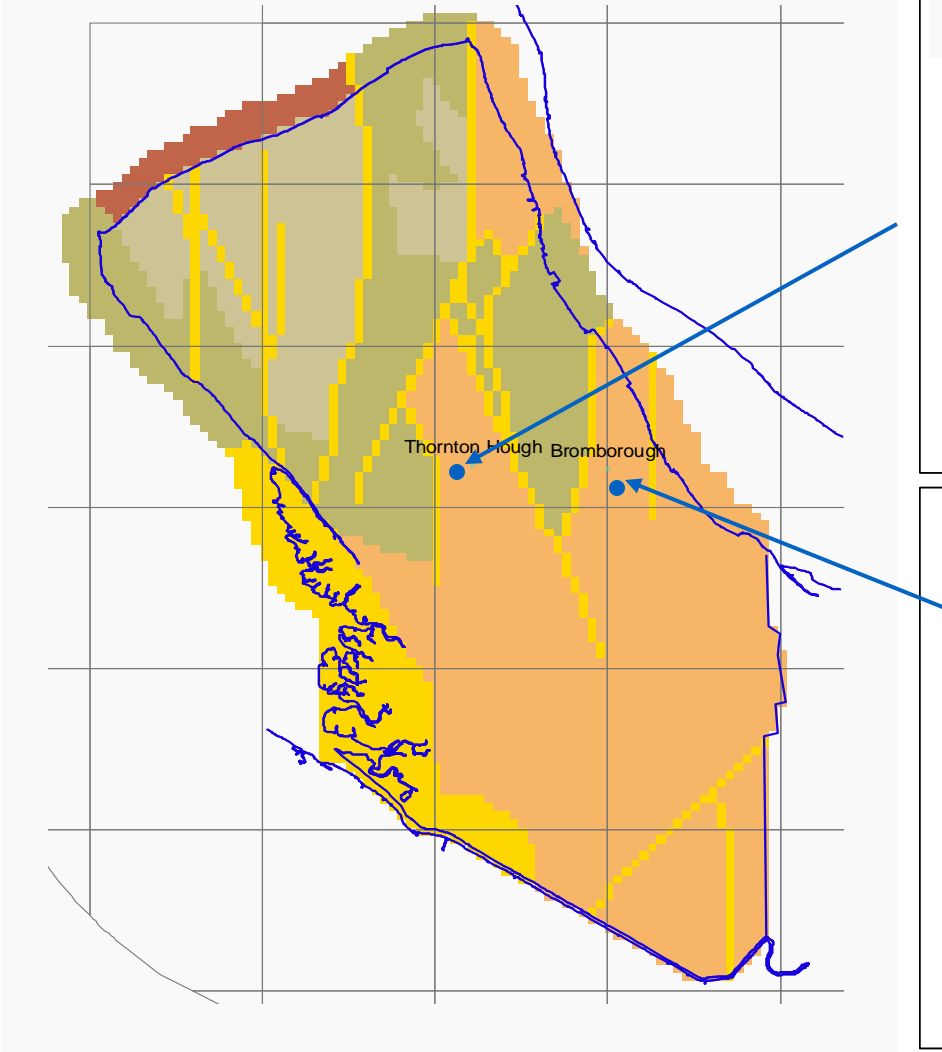
Wirral

- GW levels 2000
- Historic Abstrn
 - 75 years
- Saline intrusion
- Steep GW gradients
- Sustainable Abstraction?



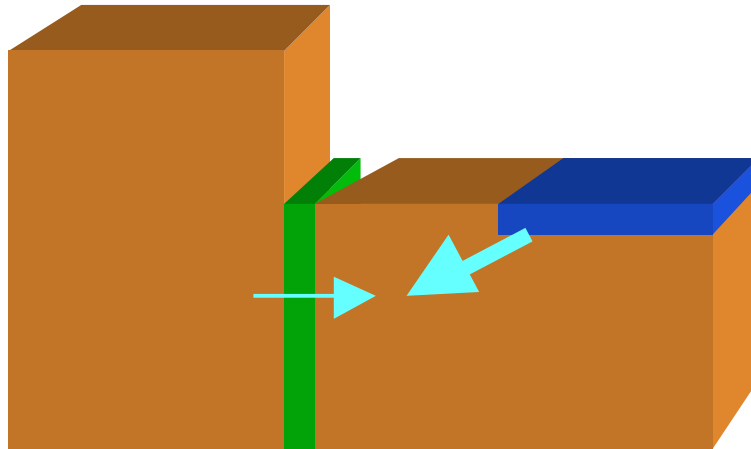
Wirral Model – Fault Representation



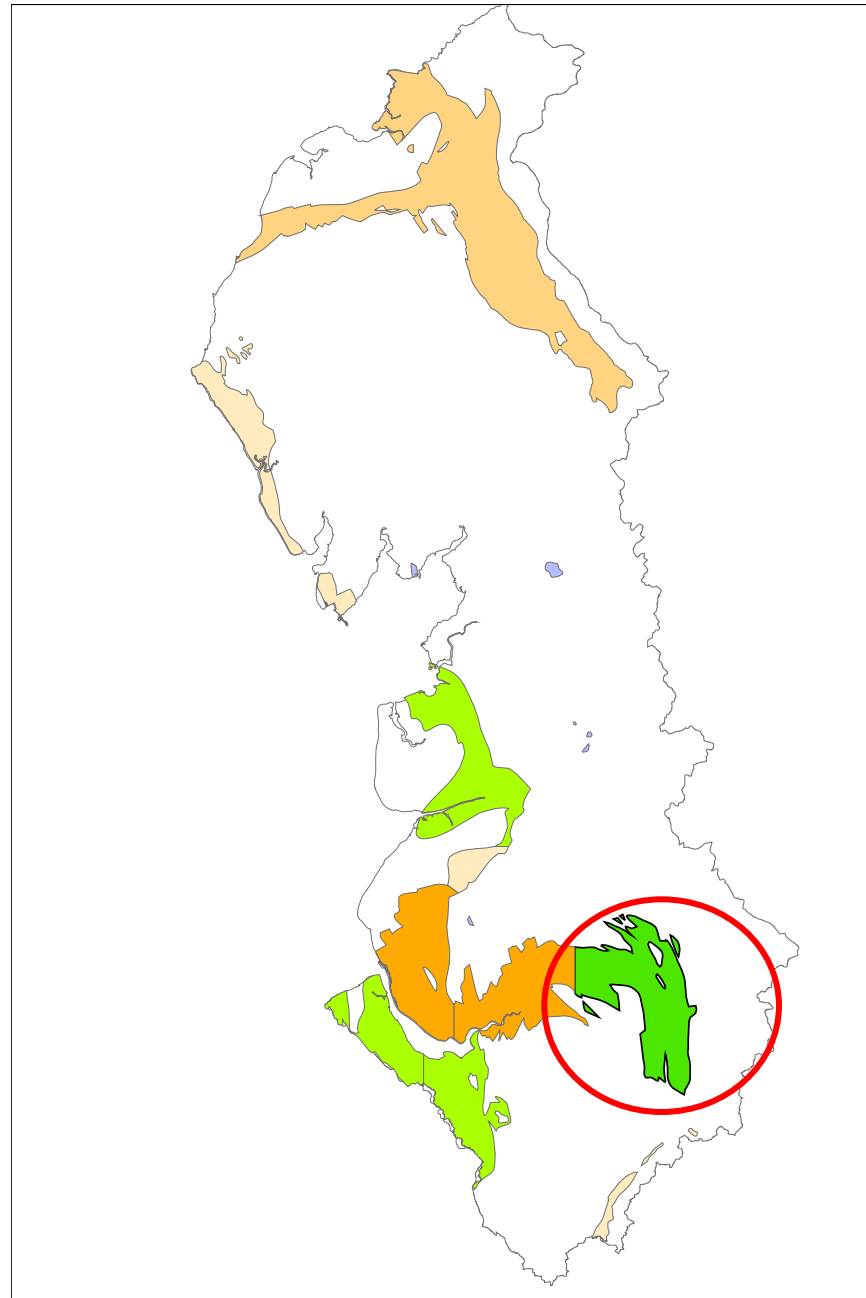


Wirral Model Results

Wirral – Summary:



Manchester & East Cheshire Groundwater Resources Study



**ENVIRONMENT
AGENCY**

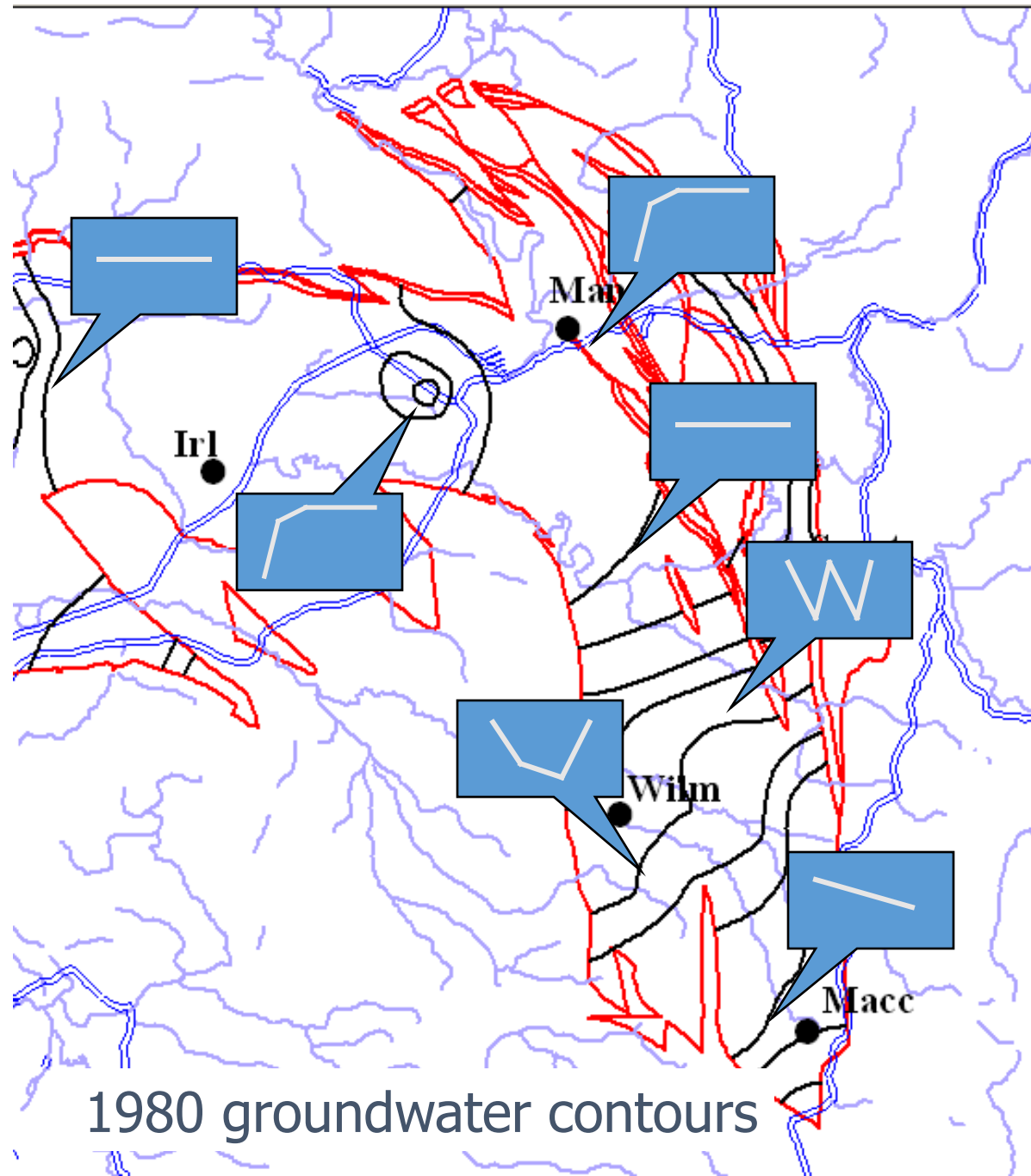
**Manchester and East Cheshire
Water Resources Study**

**Phase 2: Groundwater Model of
the Southern Area (Dean and
Bollin Catchments)**

Final Report

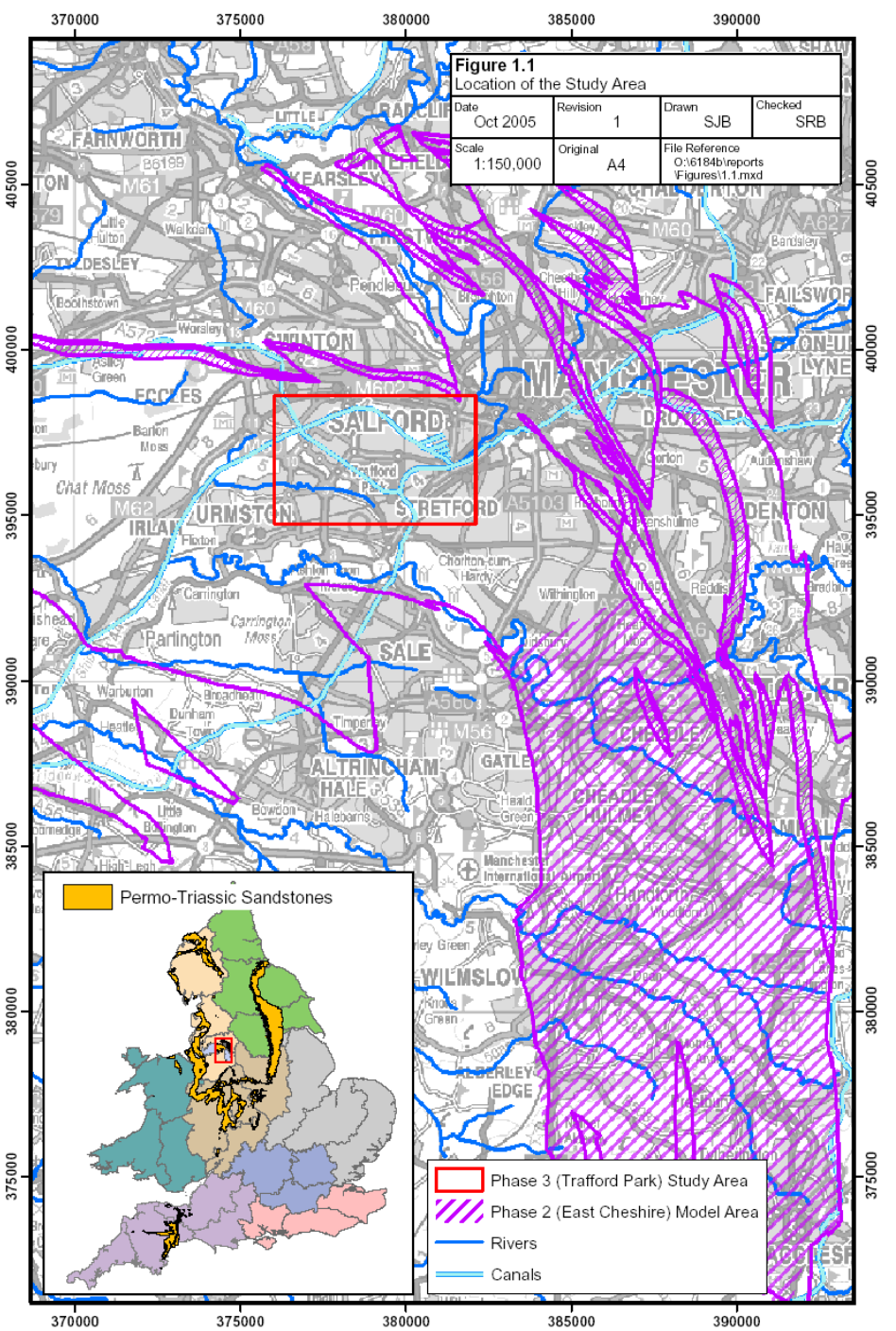
June 2004

Groundwater Flows and Levels



Manchester & East Cheshire Study Area

Trafford Park:
- the hardest
- the last!

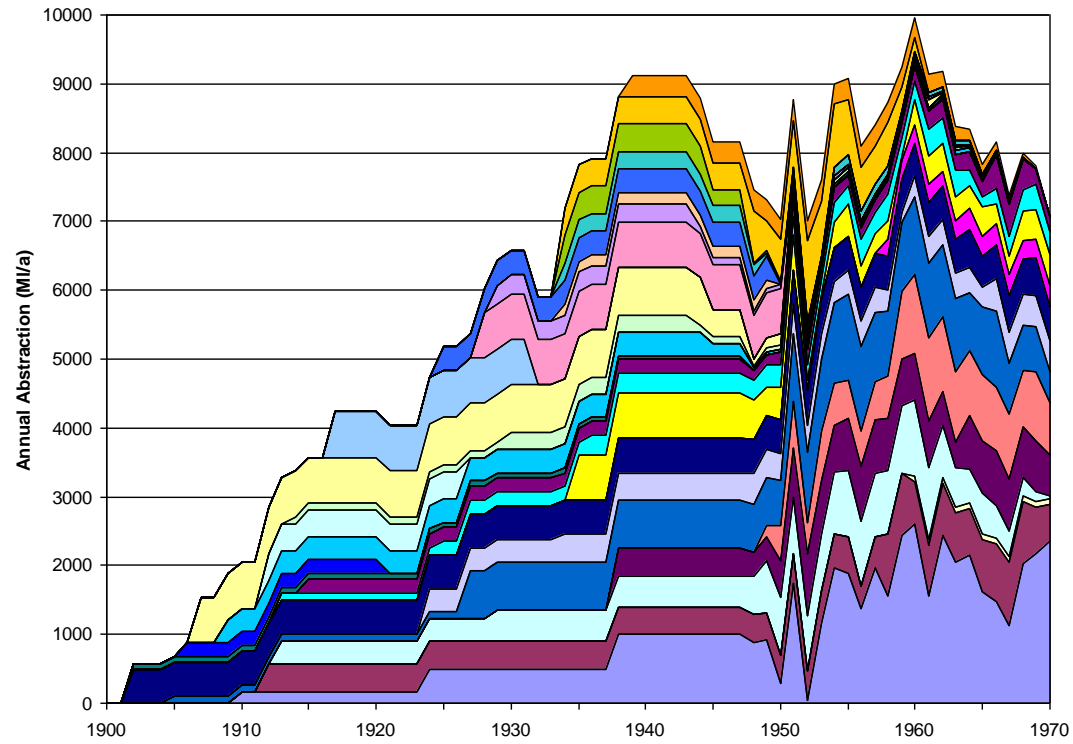


Lower Mersey Basin - Groundwater Levels (2000)



Trafford Park

Historic over abstraction -> falling water levels

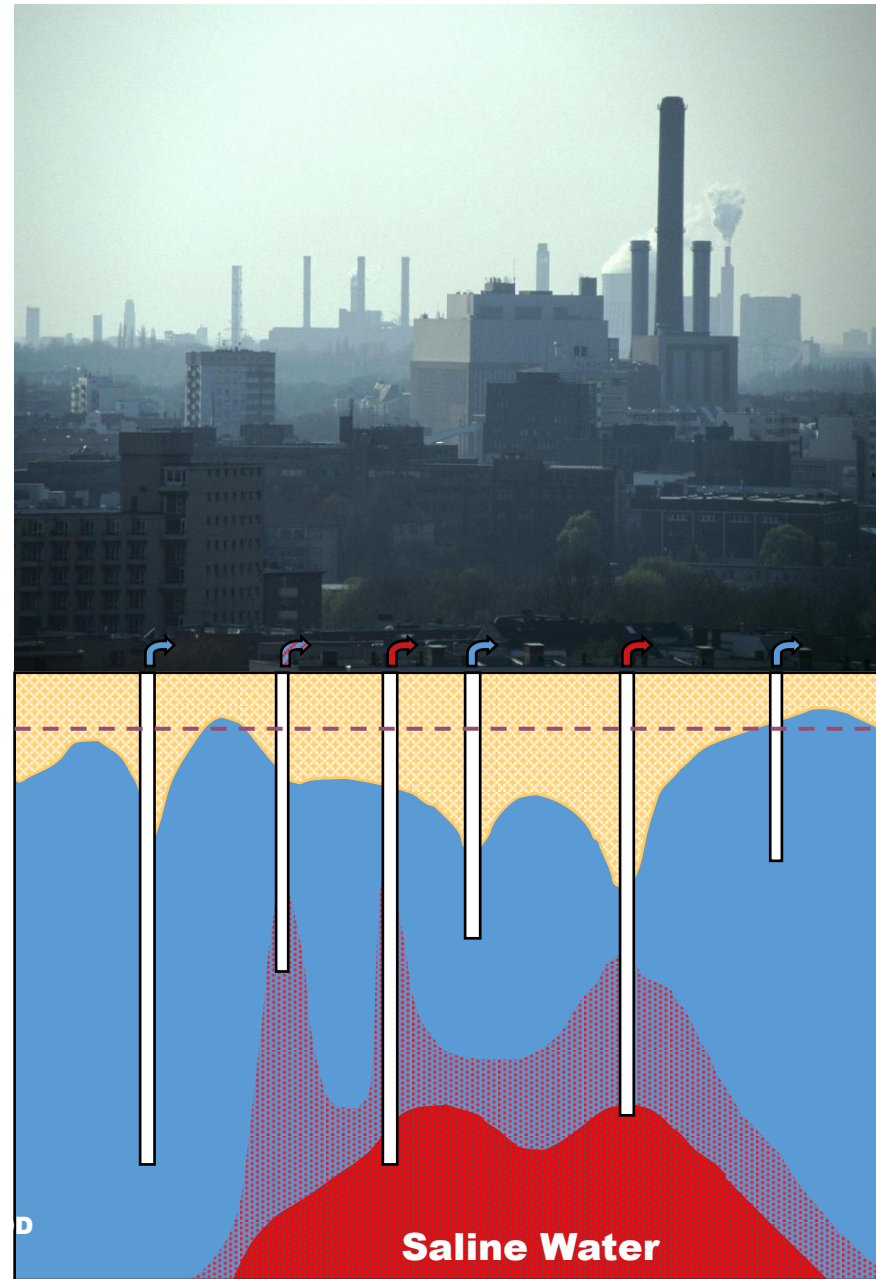


Trafford Park ~ the problem

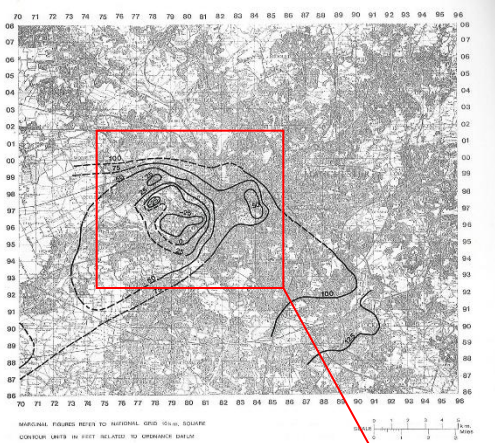
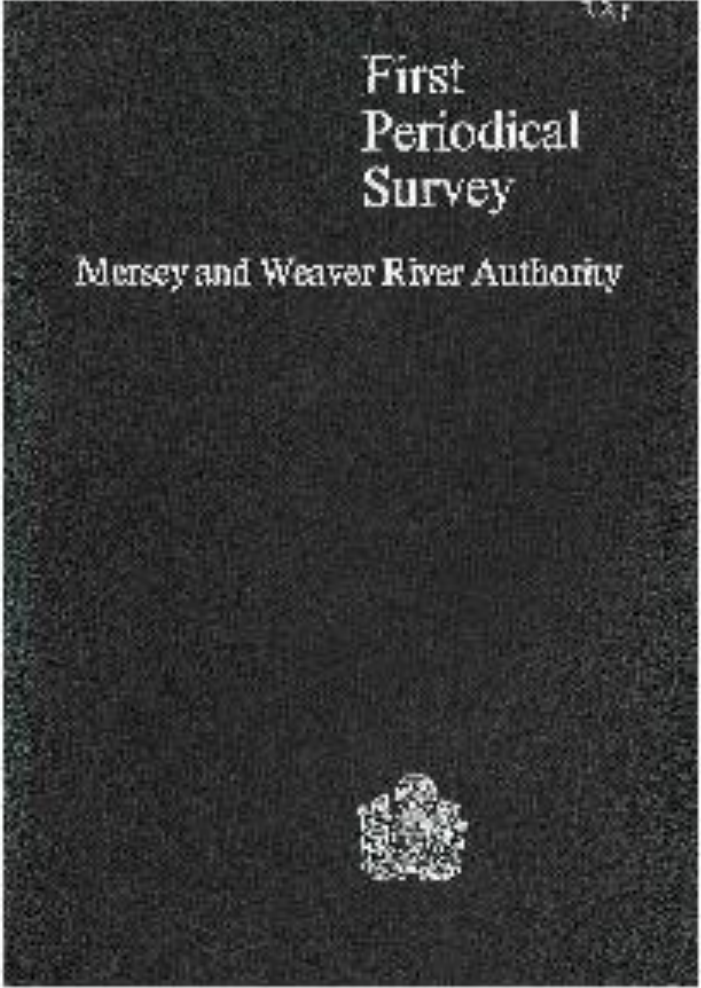
Falling water levels

->

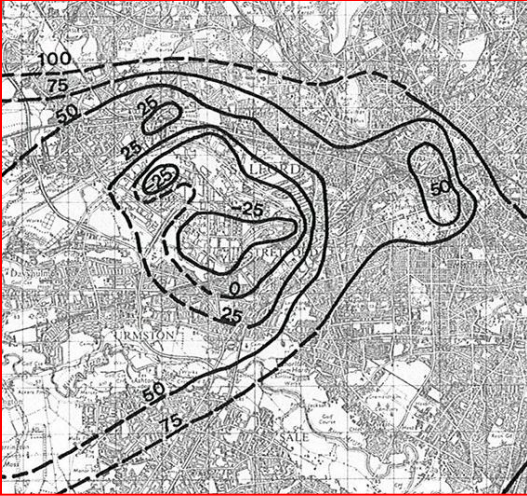
Saline upconing



Historic problem recognised



MANCHESTER GROUND WATER DISTRICT
GROUND WATER CONTOURS
1965

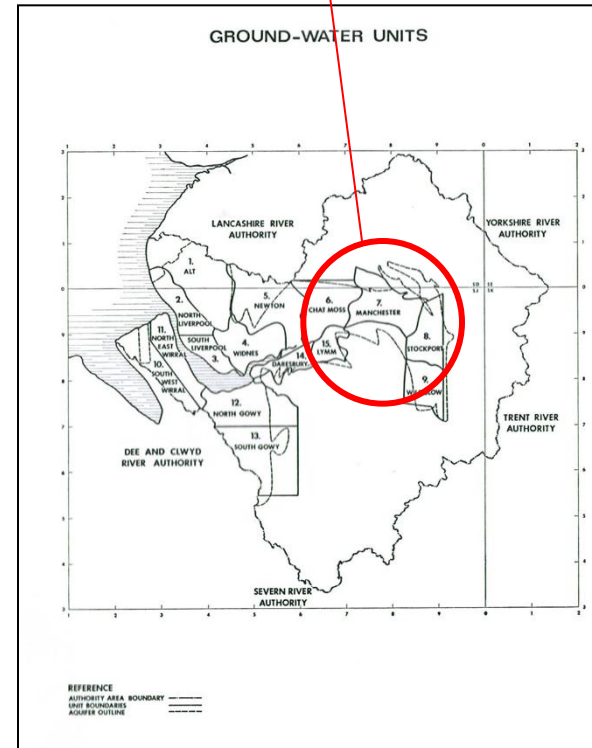


Mersey and Weaver River Authority

Statement of Policy for Ground-Water Management 1973



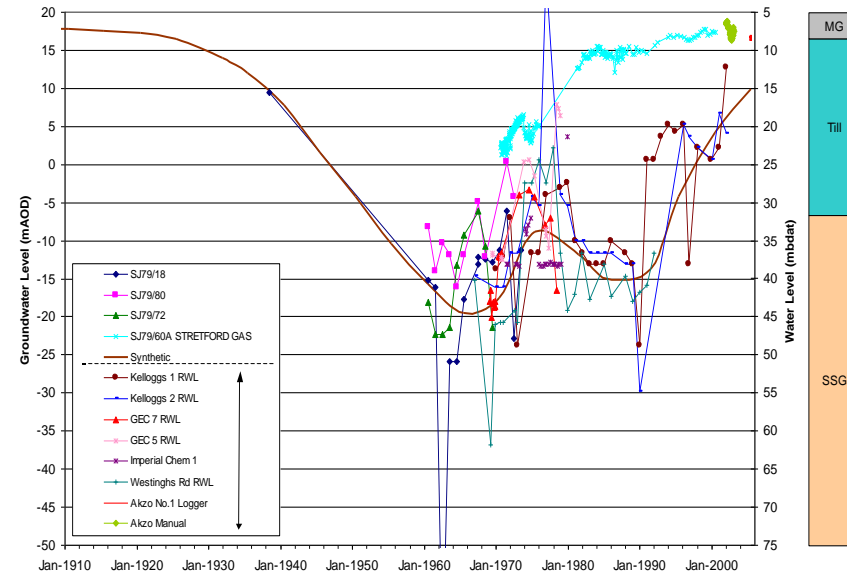
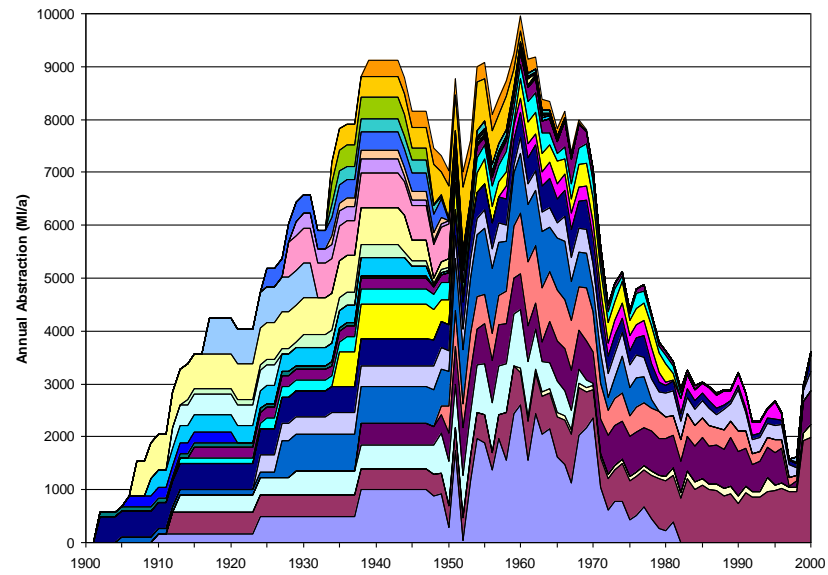
9.9 Within the **Manchester Ground-Water Unit**, there are some signs of slight improvement in ground-water level and the main aim must be not to exceed the present rates of abstractions. Some temporary increases could be considered so long as these were spaced well away from the area within Trafford Park where abstractions are at present concentrated.



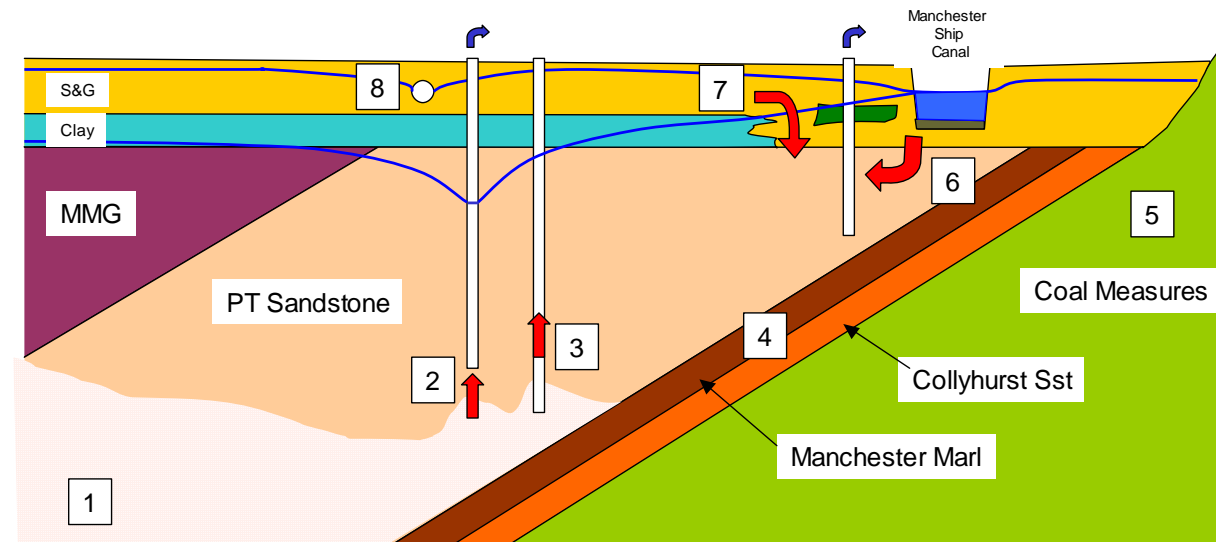
Since 1970

- New concerns
 - Contaminated land
 - Rising groundwater levels
 - Iron rich groundwaters
 - Abandoned coal mines
 - Ground source heat pumps

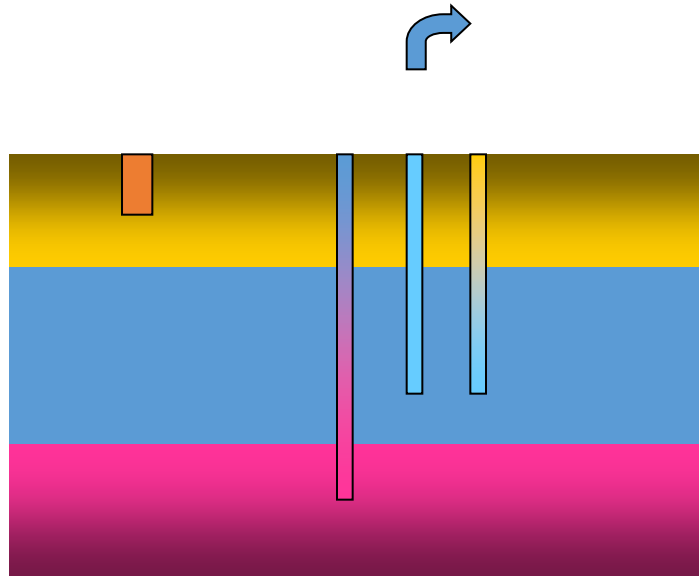
Since 1970



So...Trafford Park: Conceptual model & issues



So...Trafford Park: Conceptual Model & the issues



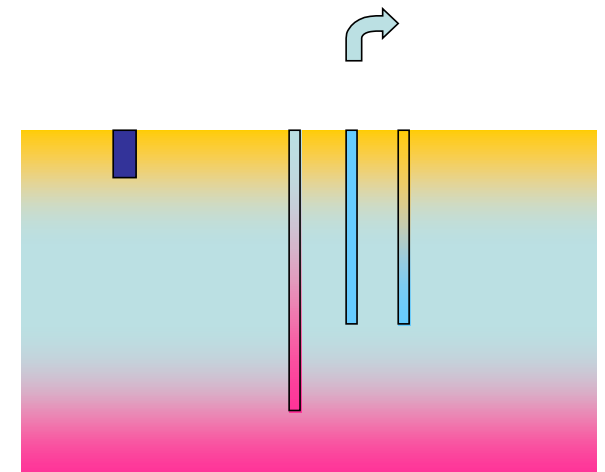
So...what are the issues?

CAMS: (catchment scale) -



How to deal with new licence applications?

- What is the sustainable resource? (sustainable level of abstraction)?
- Where is water (recharge) coming from
 - Below (saline)?
 - Above (contamination, shallow iron)?
 - Surface waters?
 - Laterally (outside of Trafford Park)?



So...what are the issues?

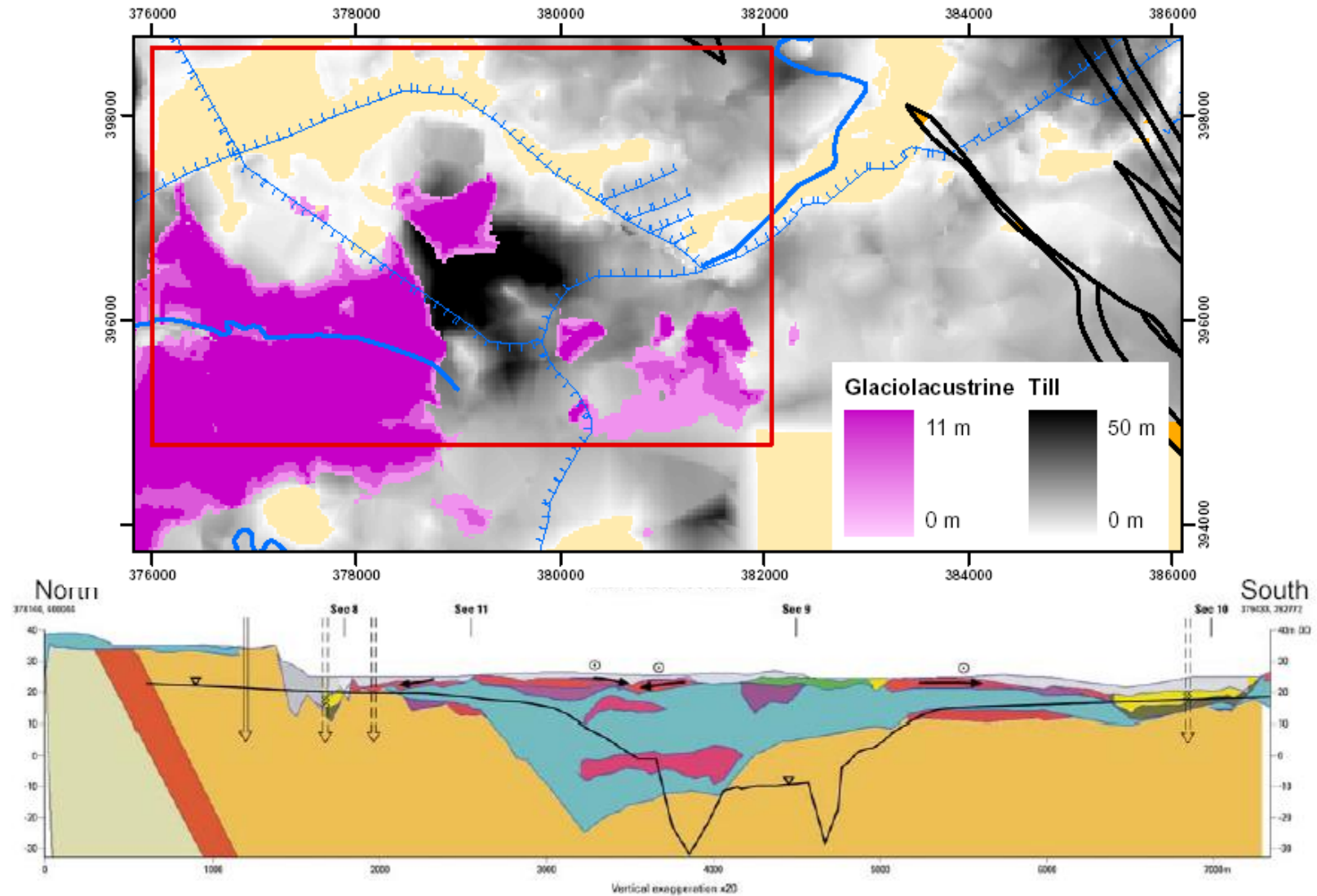


Licensing Decisions: (site specific)

- Can we licence additional abstraction?
- What will the impact be on the quality/groundwater levels
- will groundwater quality deteriorate (timescales?)
- how certain are we? (Risk - consequences)
- What are appropriate conditions

Superficial Deposits

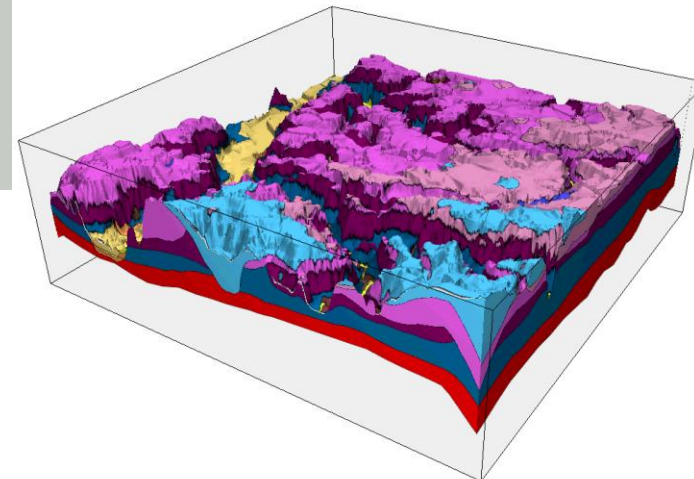
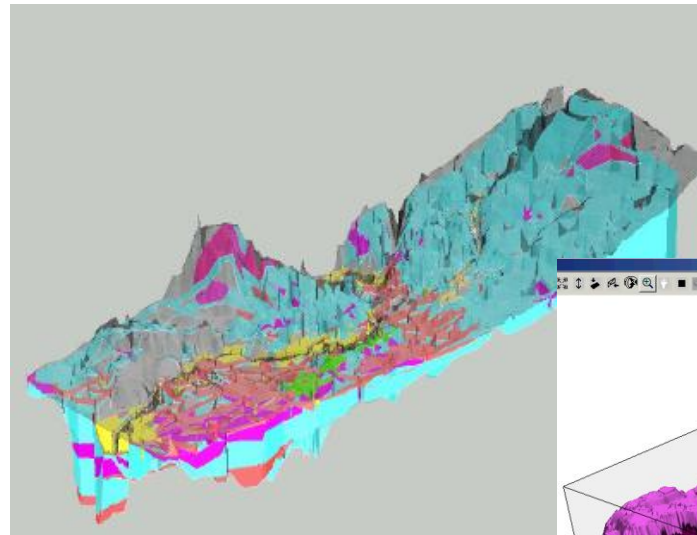
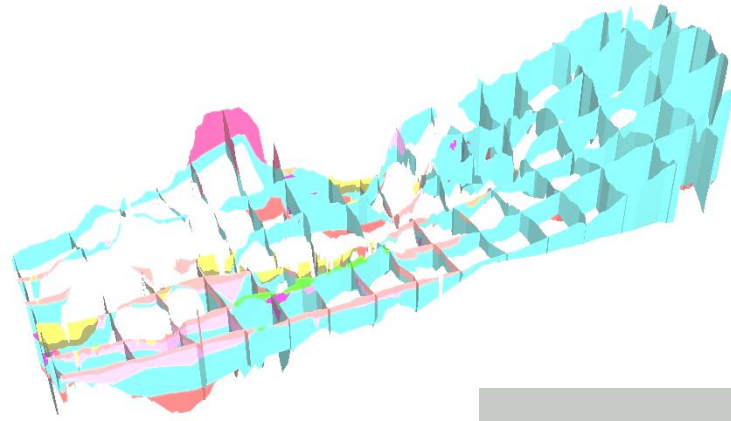
- Importance of BGS mapping





British
Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL



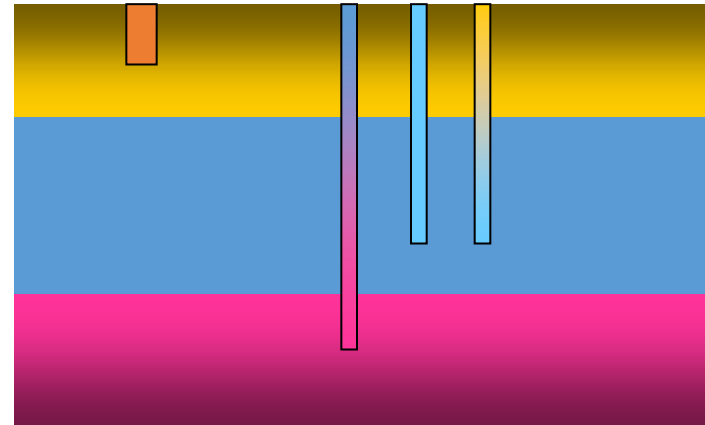
Manchester Urban Model

Iron Rich Groundwater

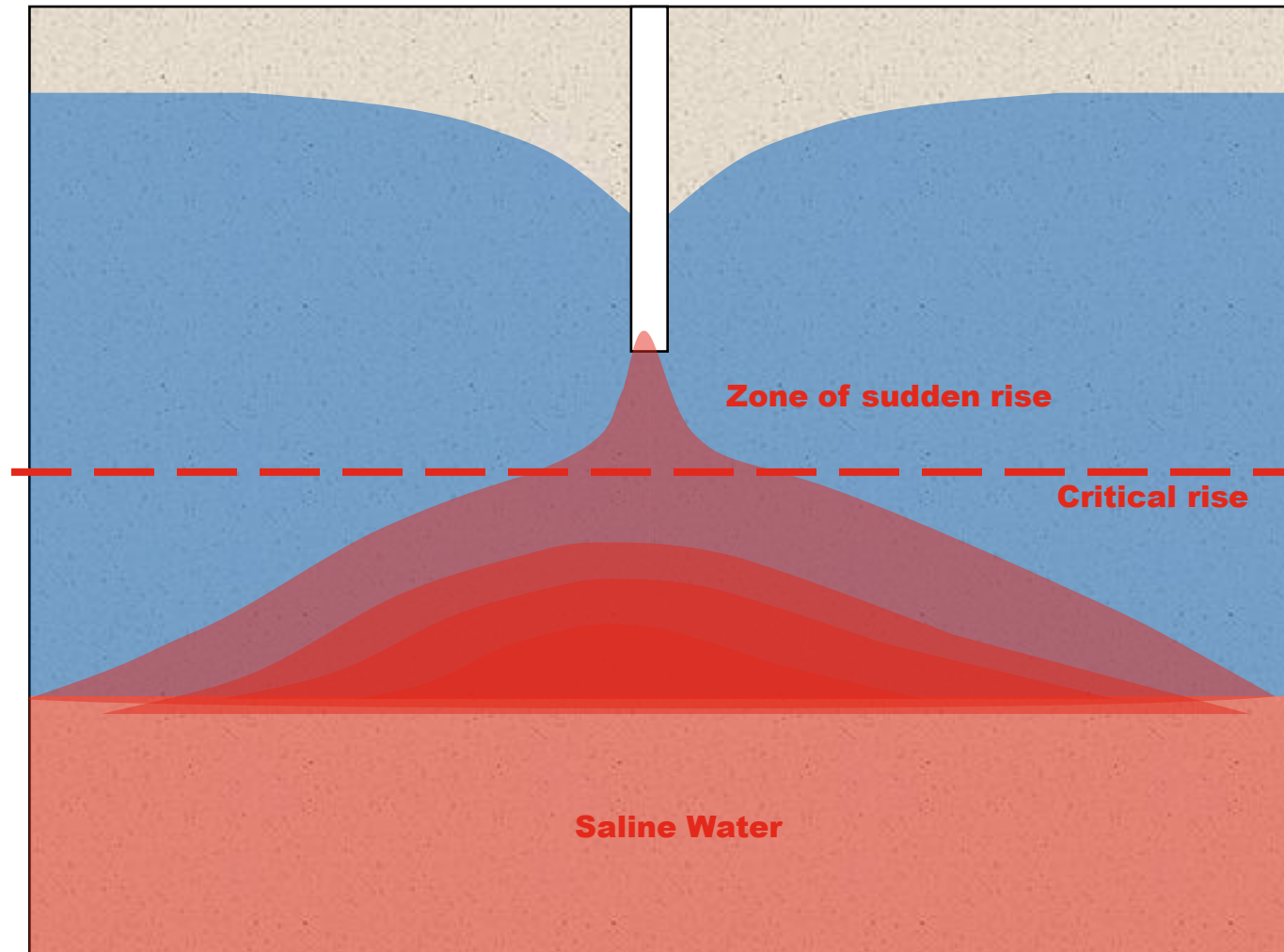
Potential sources:

- Coal Measures
- Bridgewater Canal sediments
- Sherwood Sandstone Group
- Superficial Deposits

Onus on new applicants to investigate



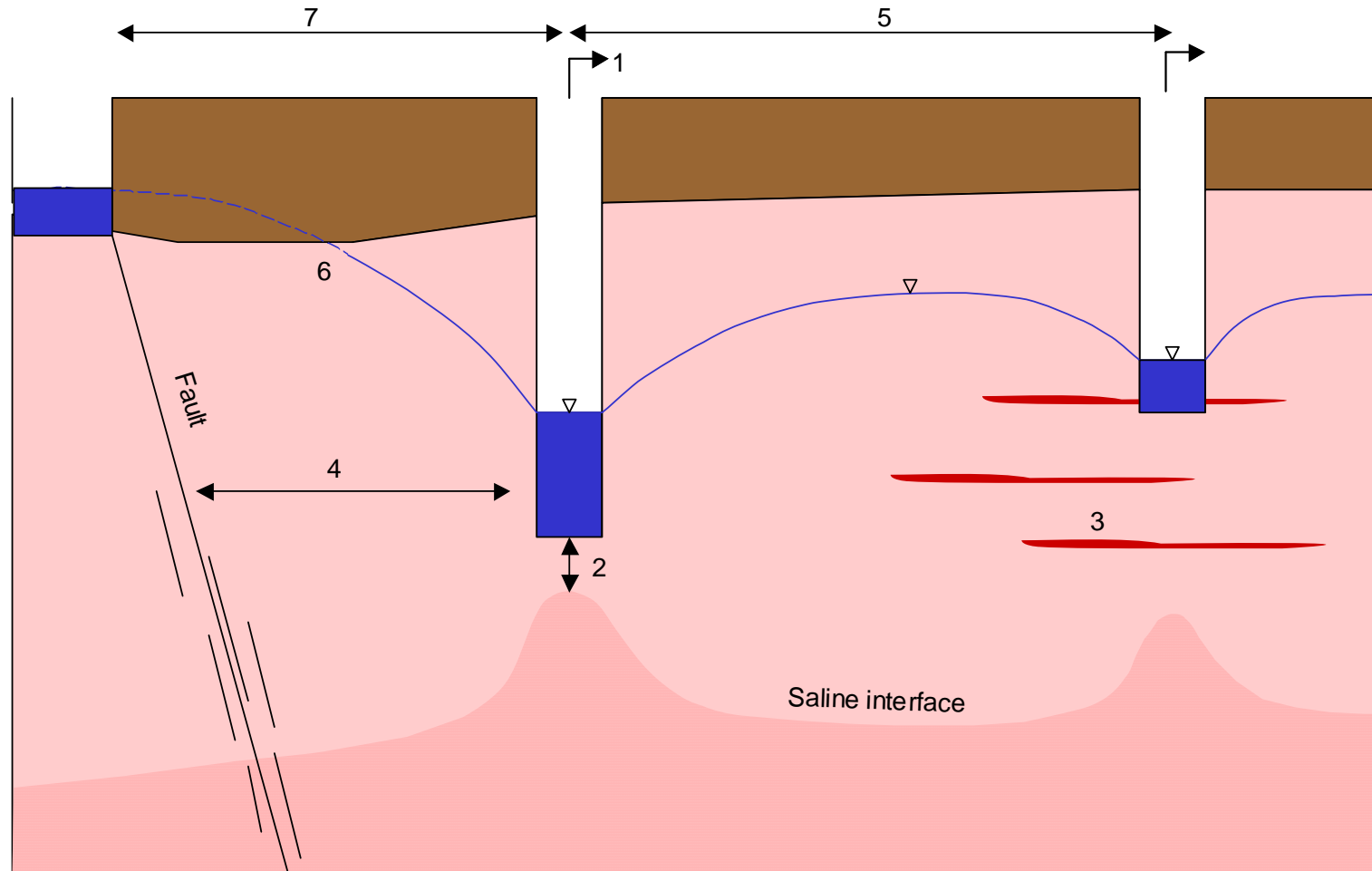
Saline upconing



Factors affecting saline upconing

- Pumping rate
- Depth of borehole (above saline interface)
- Vertical 'permeability' (inc. faults and abandoned boreholes)

Risk factors for saline upconing



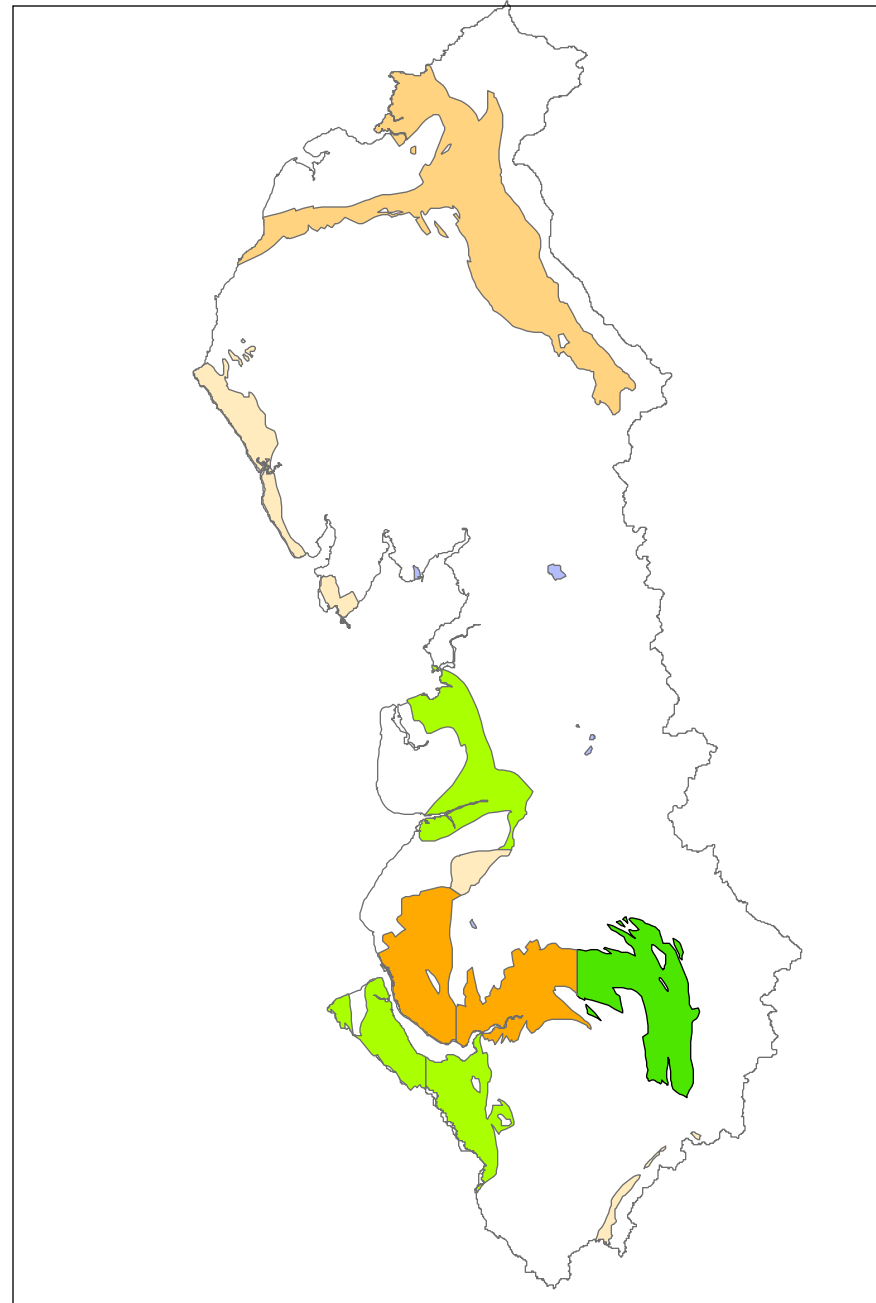
- 1 Rate of abstraction
- 2 Elevation of base of borehole above saline interface
- 3 Presence of marl bands
- 4 Proximity to faults (or abandoned boreholes)

- 5 Proximity to other abstractions
- 6 Confined/unconfined
- 7 Distance to connected surface water body

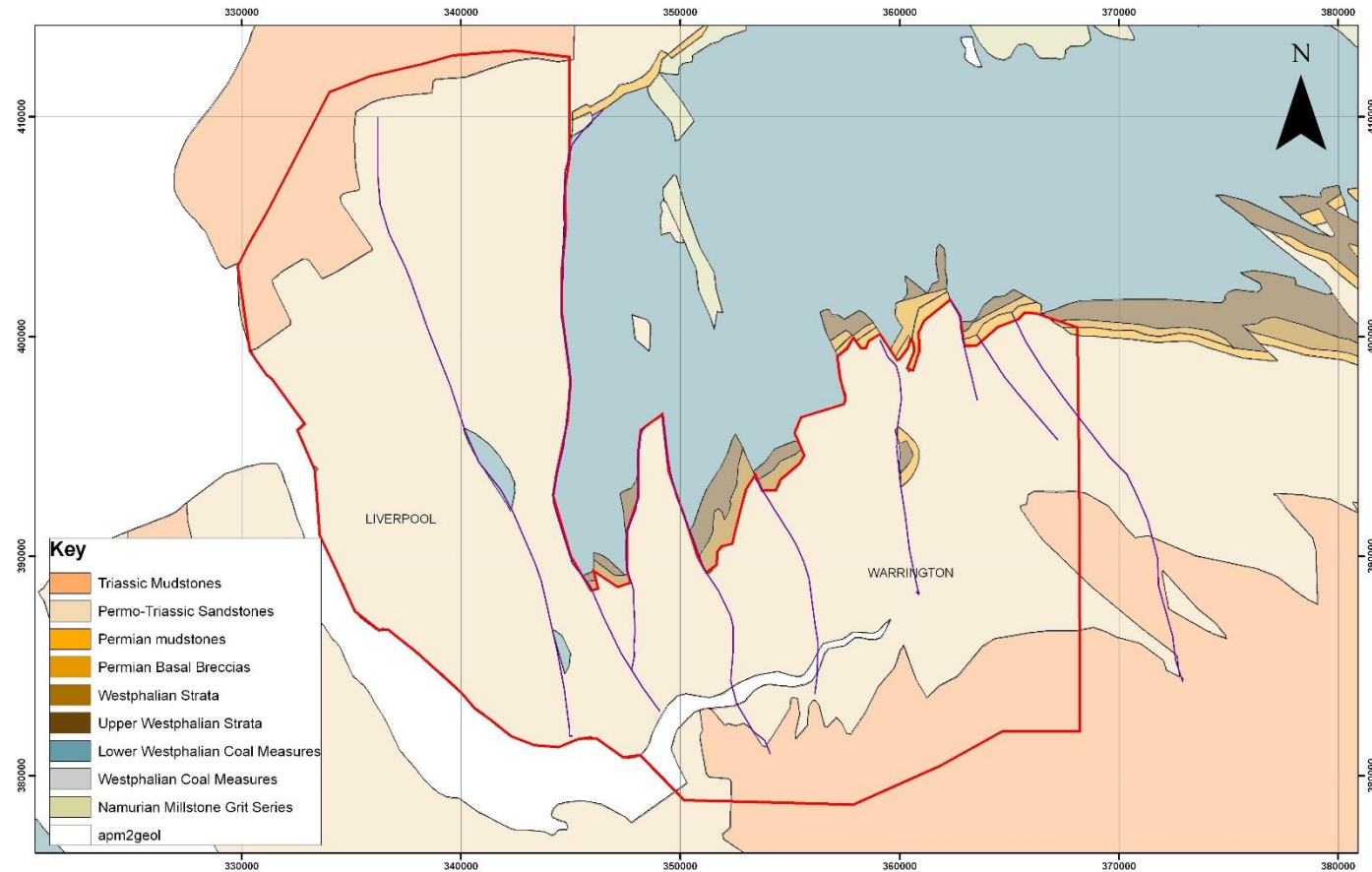
Where next

– back to where we started

- **Lower Mersey Basin & North Merseyside**

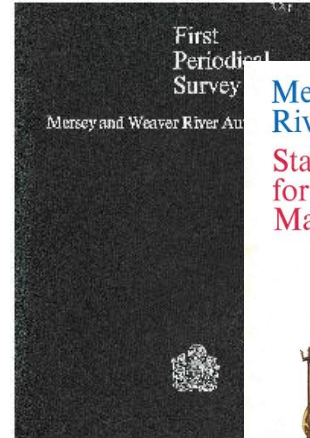
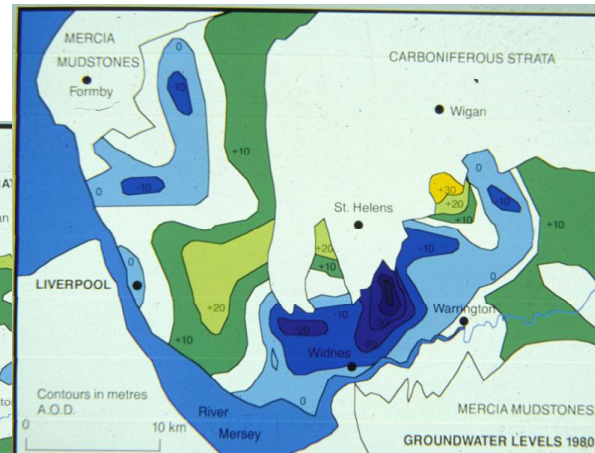
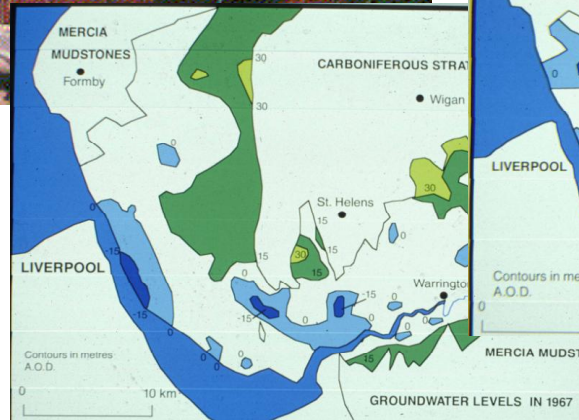
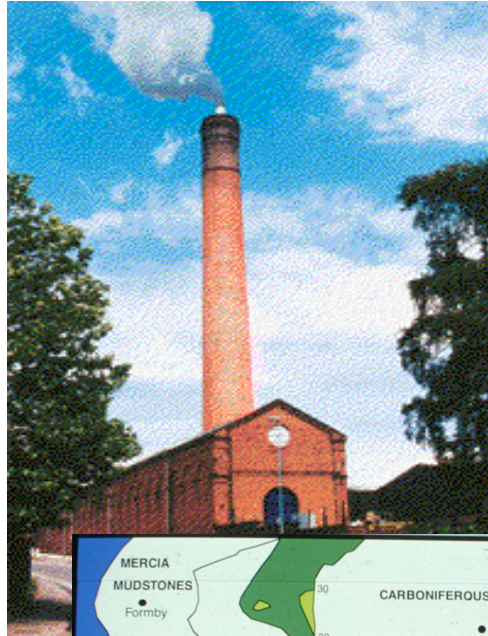


Where Next?



Recap of Part 1

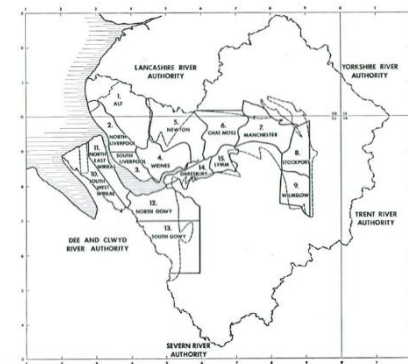
Groundwater development history & previous studies



Mersey and Weaver River Authority
**Statement of Policy
for Ground-Water
Management 1973**

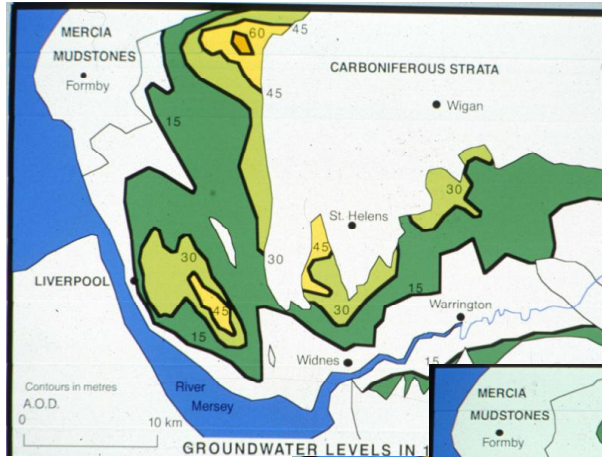


GROUND-WATER UNITS

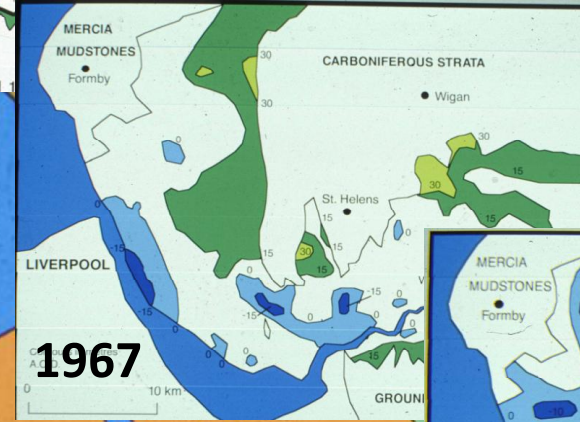


REFERENCE
AUTHORITY AREA BOUNDARY
RIVER COURSE
RIVER TOWER

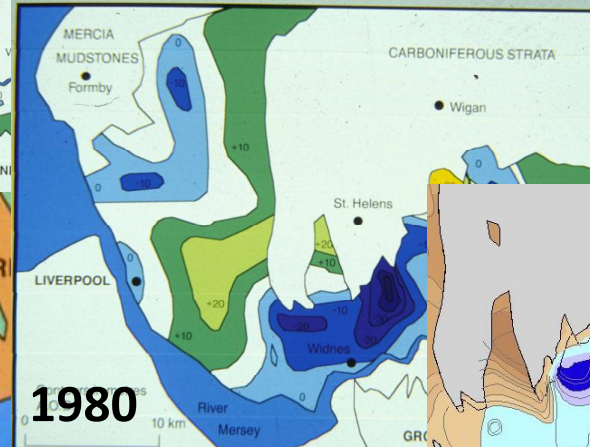
Mersey Basin - Groundwater Levels



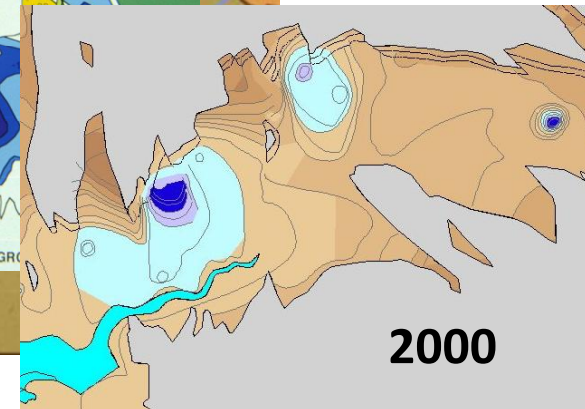
1869



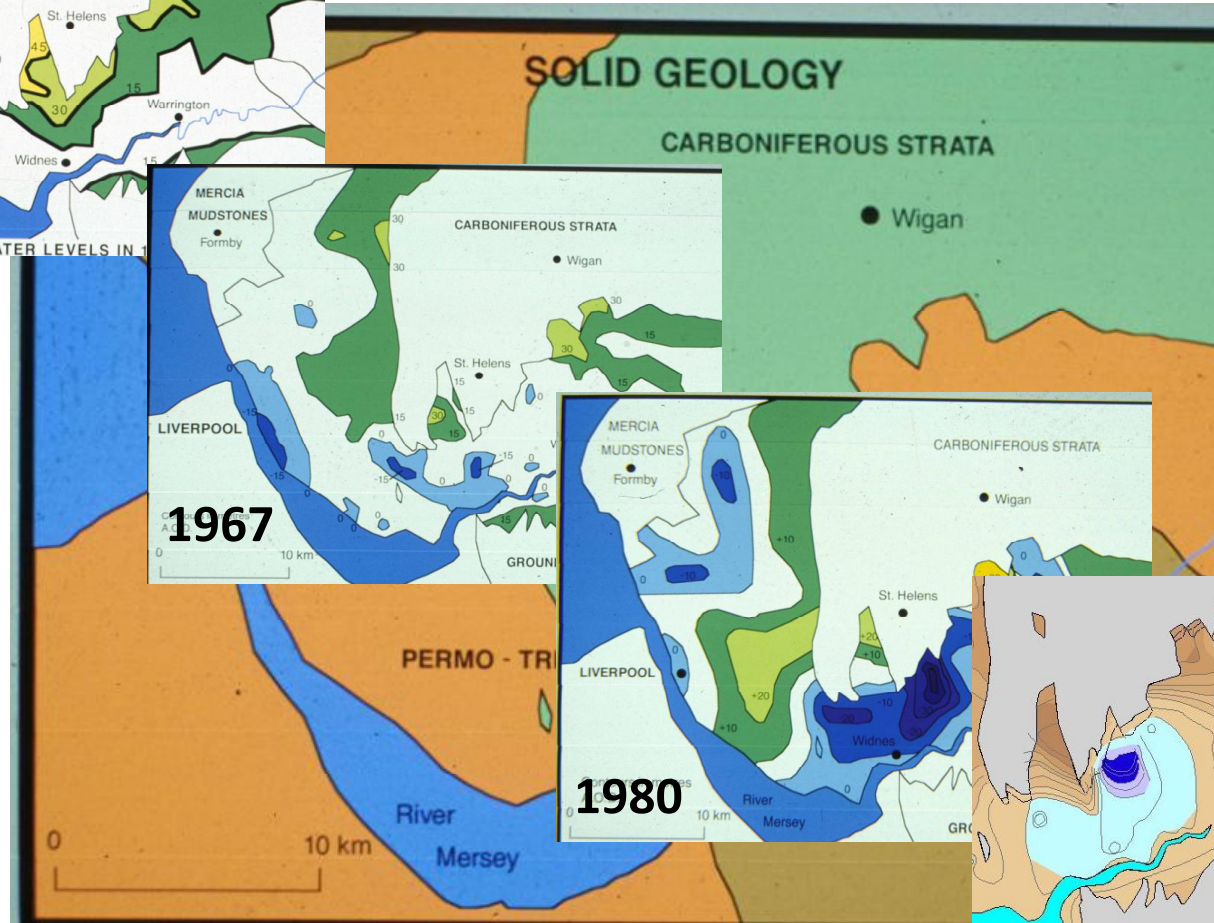
1967



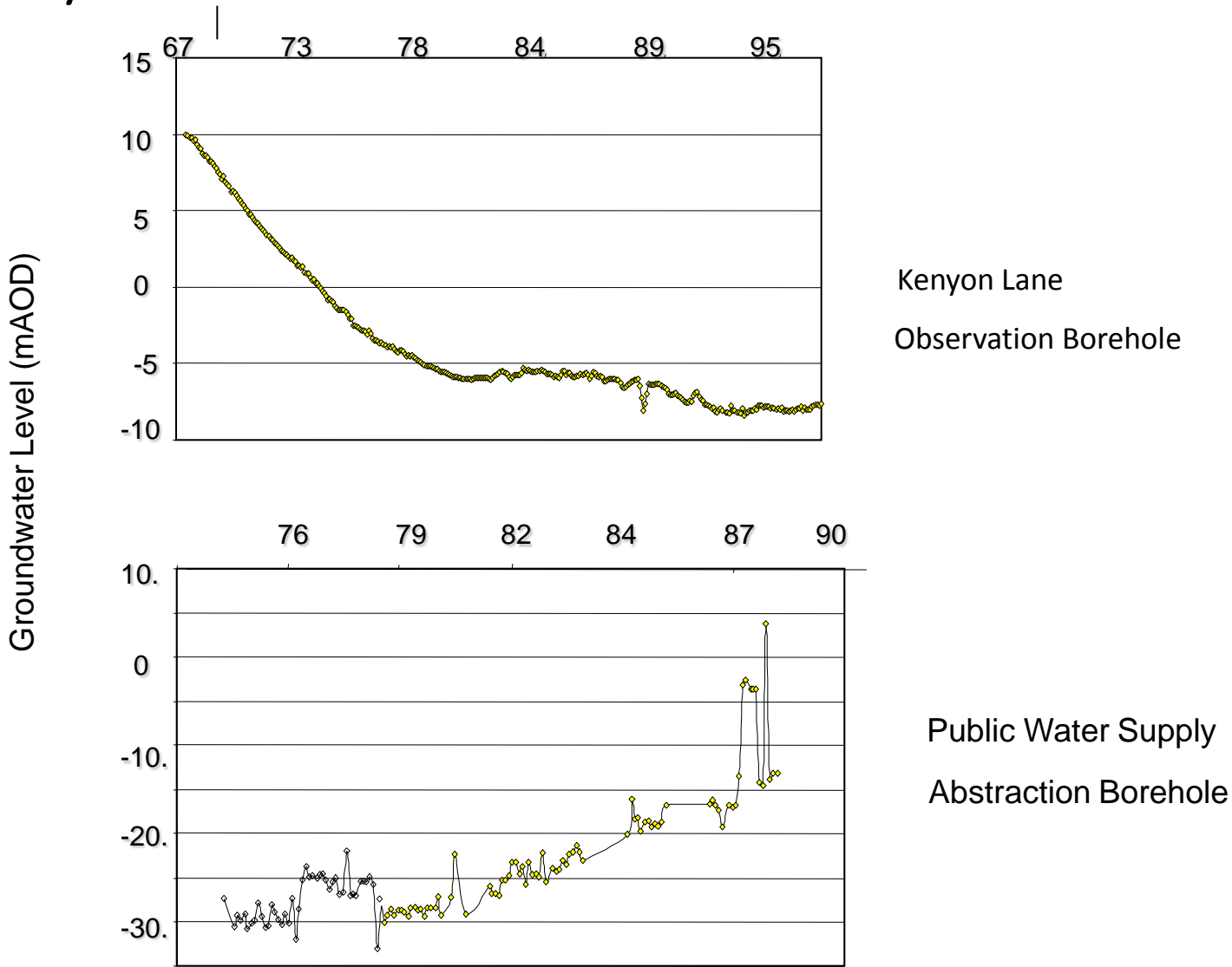
1980



2000



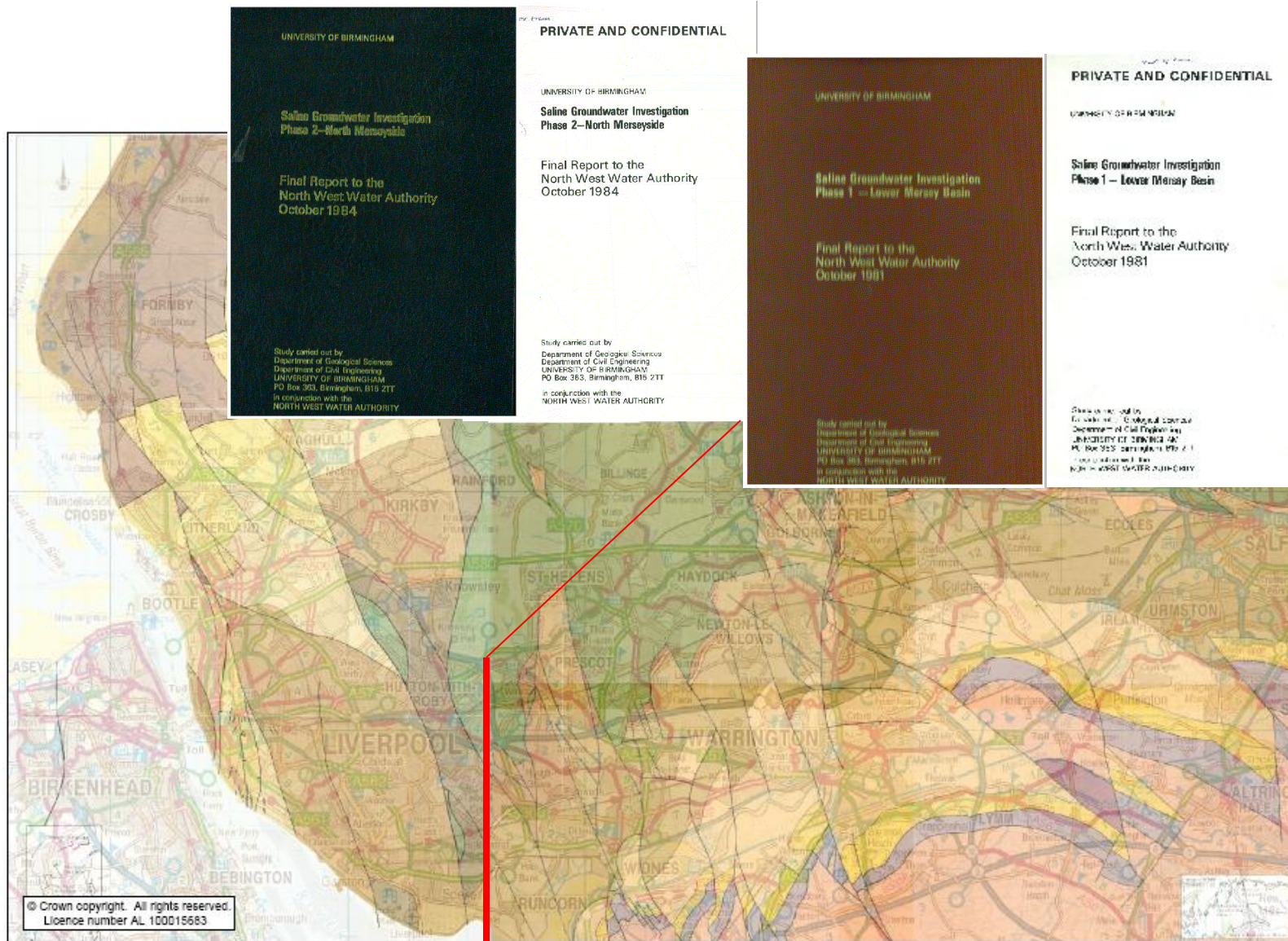
Groundwater Hydrographs Mersey Basin



Groundwater Lake - Winwick

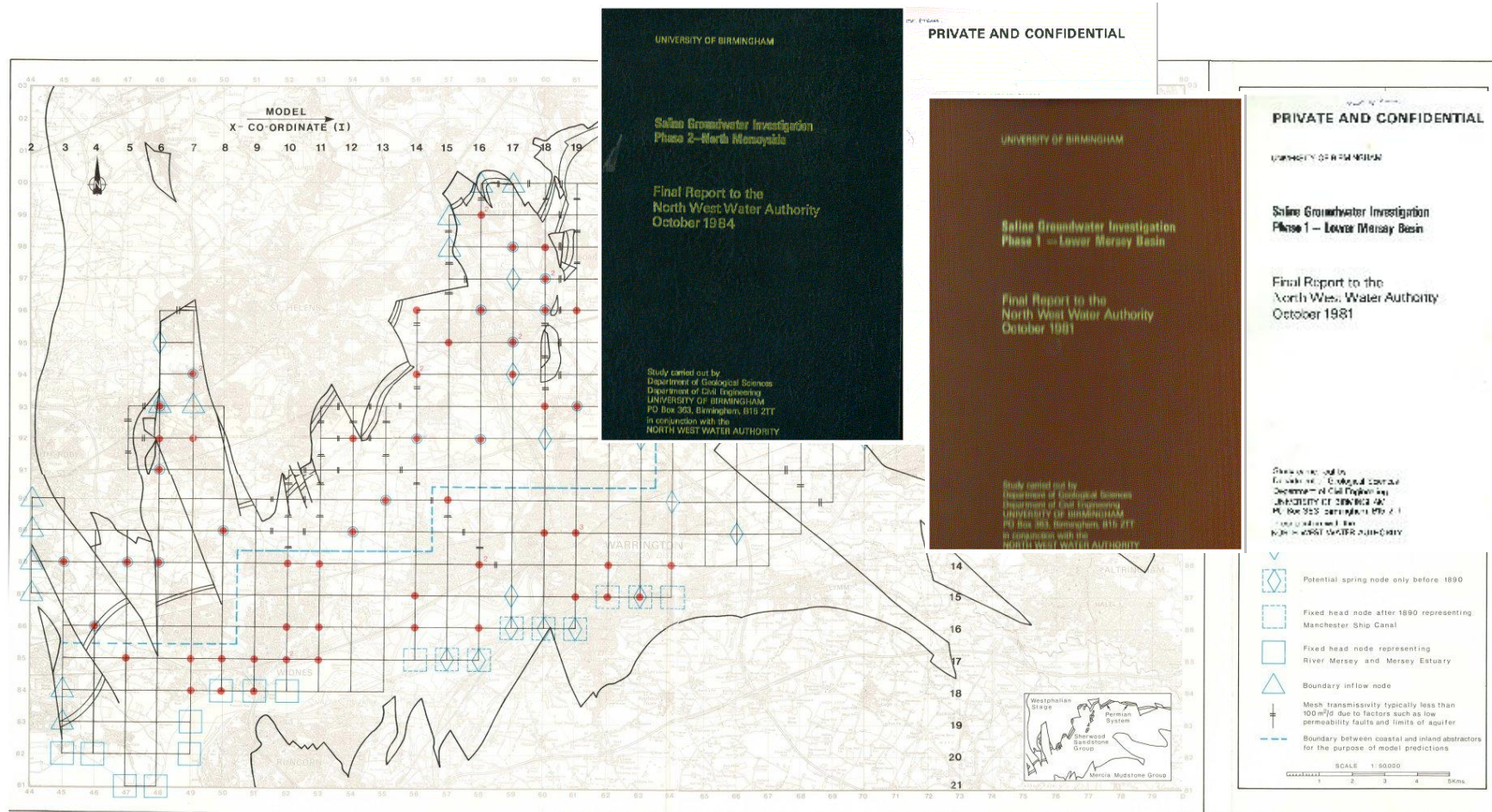


Previous Investigations ~ 1980's Saline GW Study

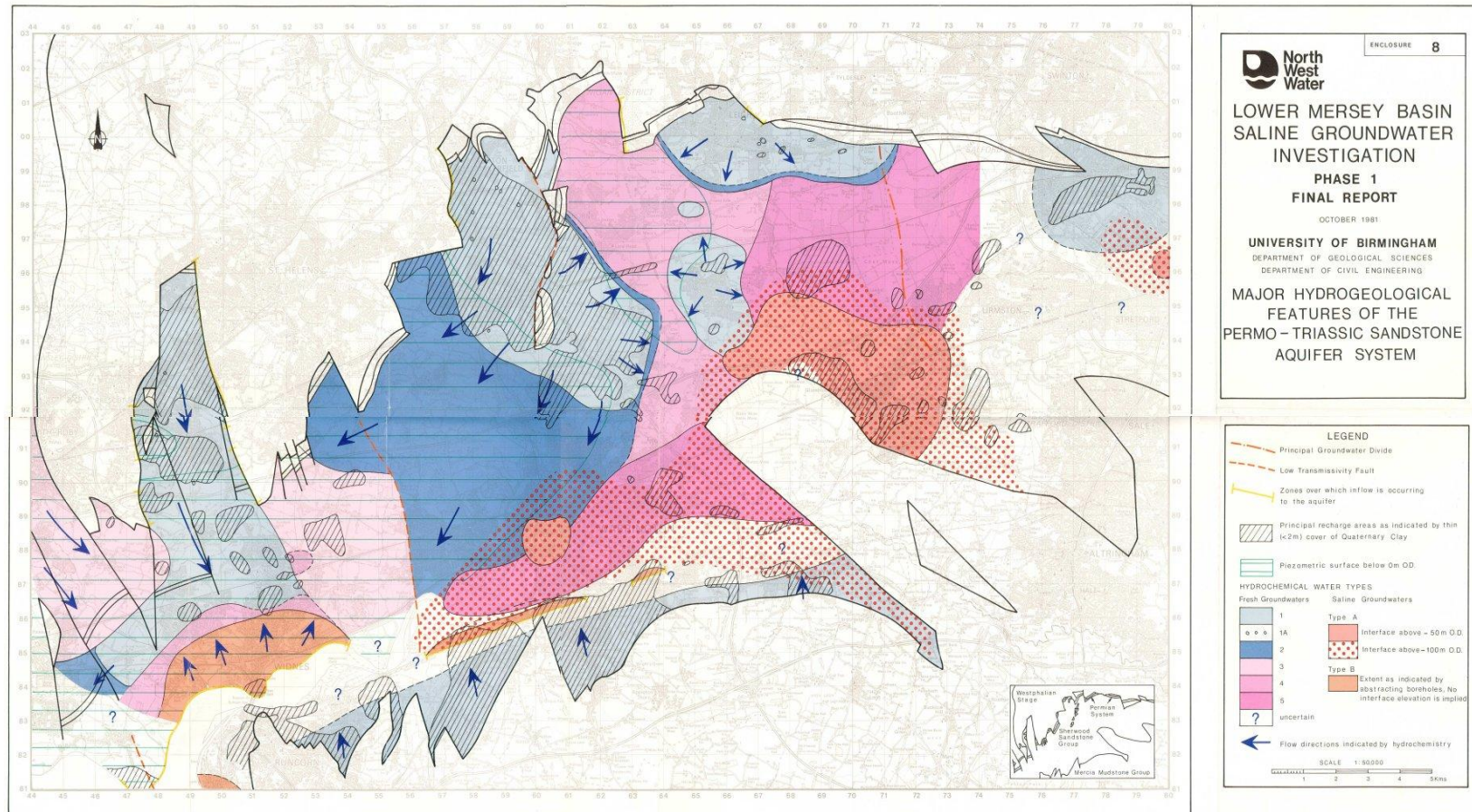


Recap of Part 1

Groundwater development history & previous studies



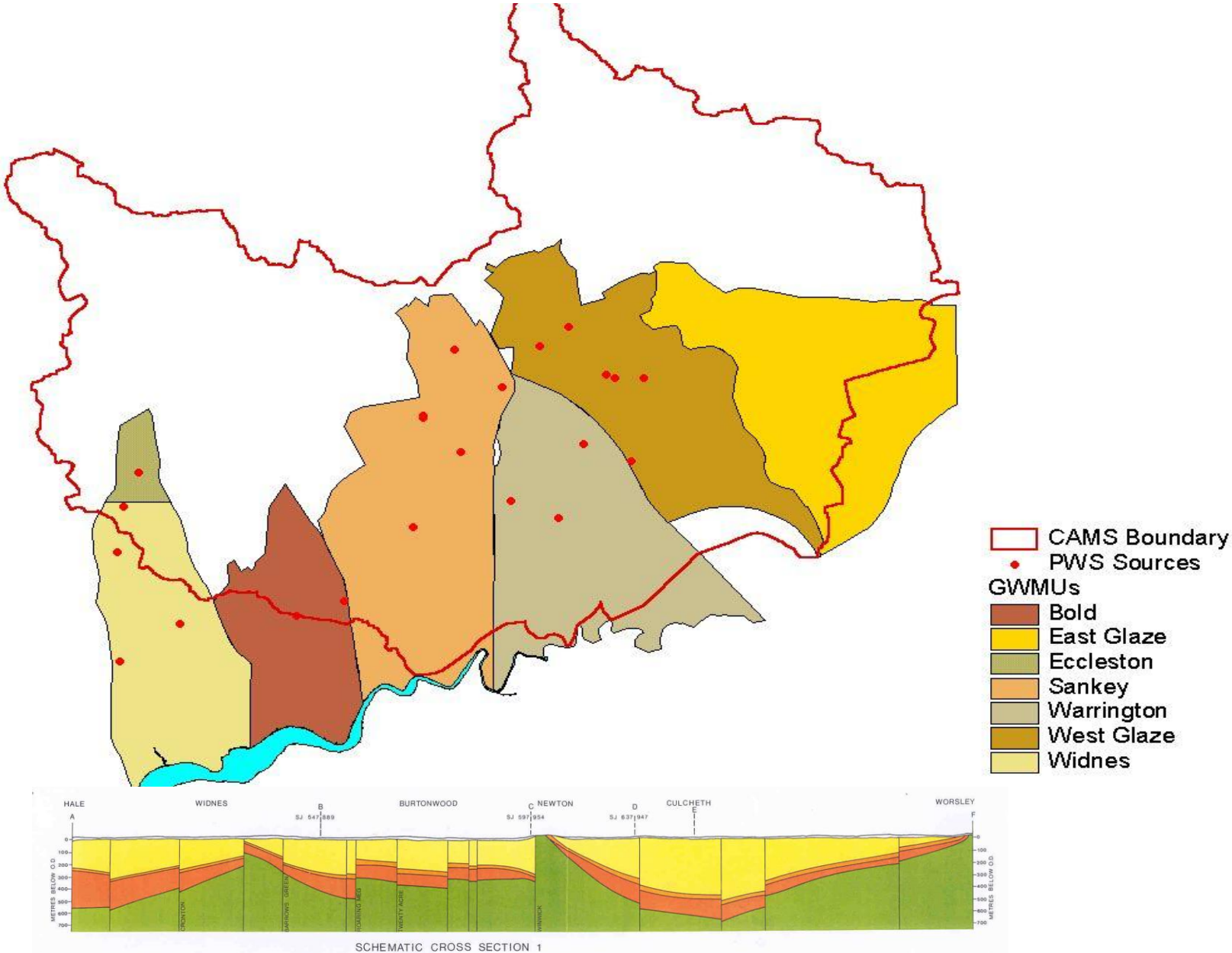
Lower Mersey Basin ~ water types



Mersey Basin revisited:

Why ~ what are the issues?

Why?: Refining CAMS input



Why? - On the rebound?

Groundwater Rebound



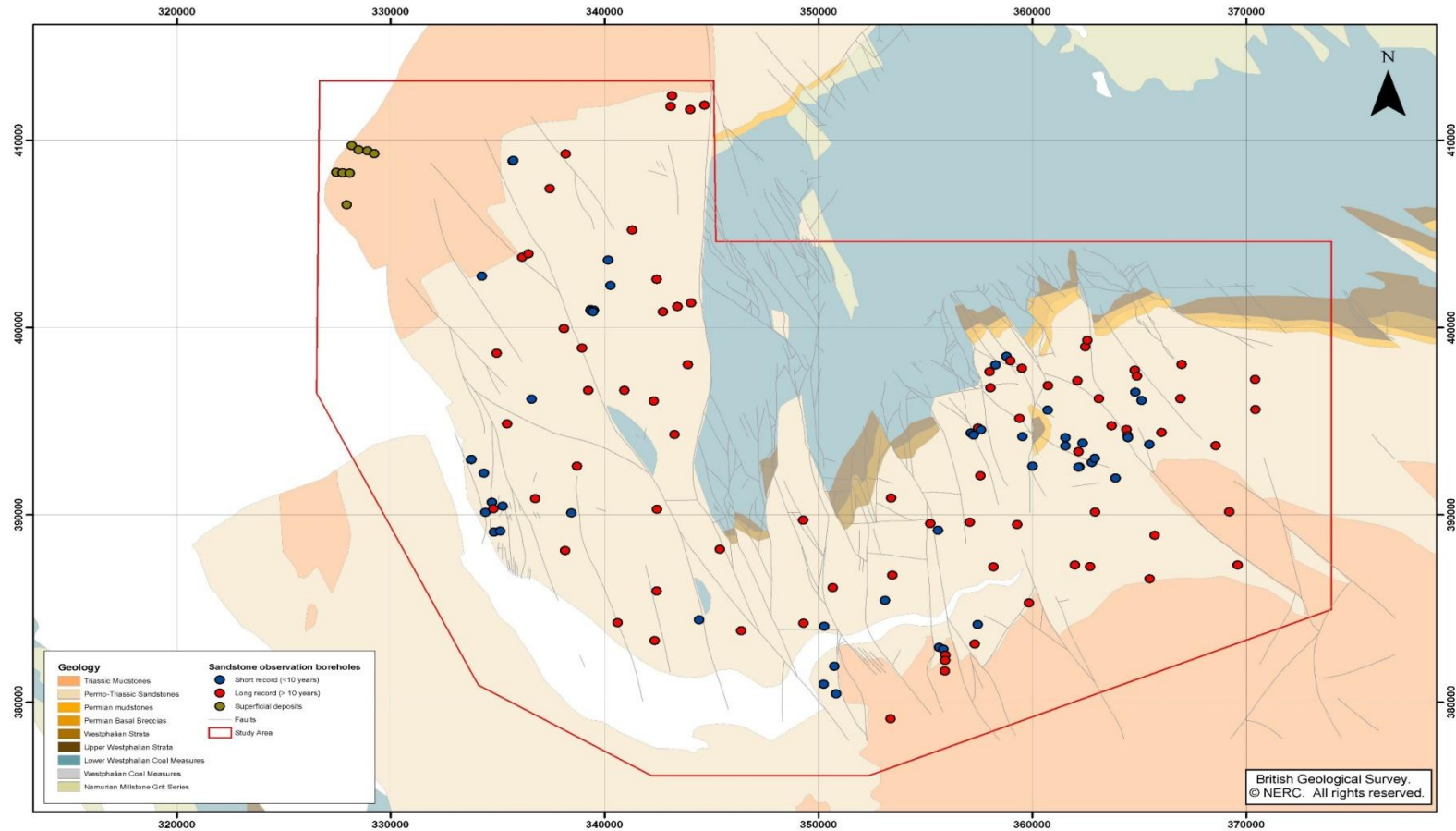
Impact on Infrastructure
e.g. Liverpool Loop Line

Potential impact on Contaminated Land

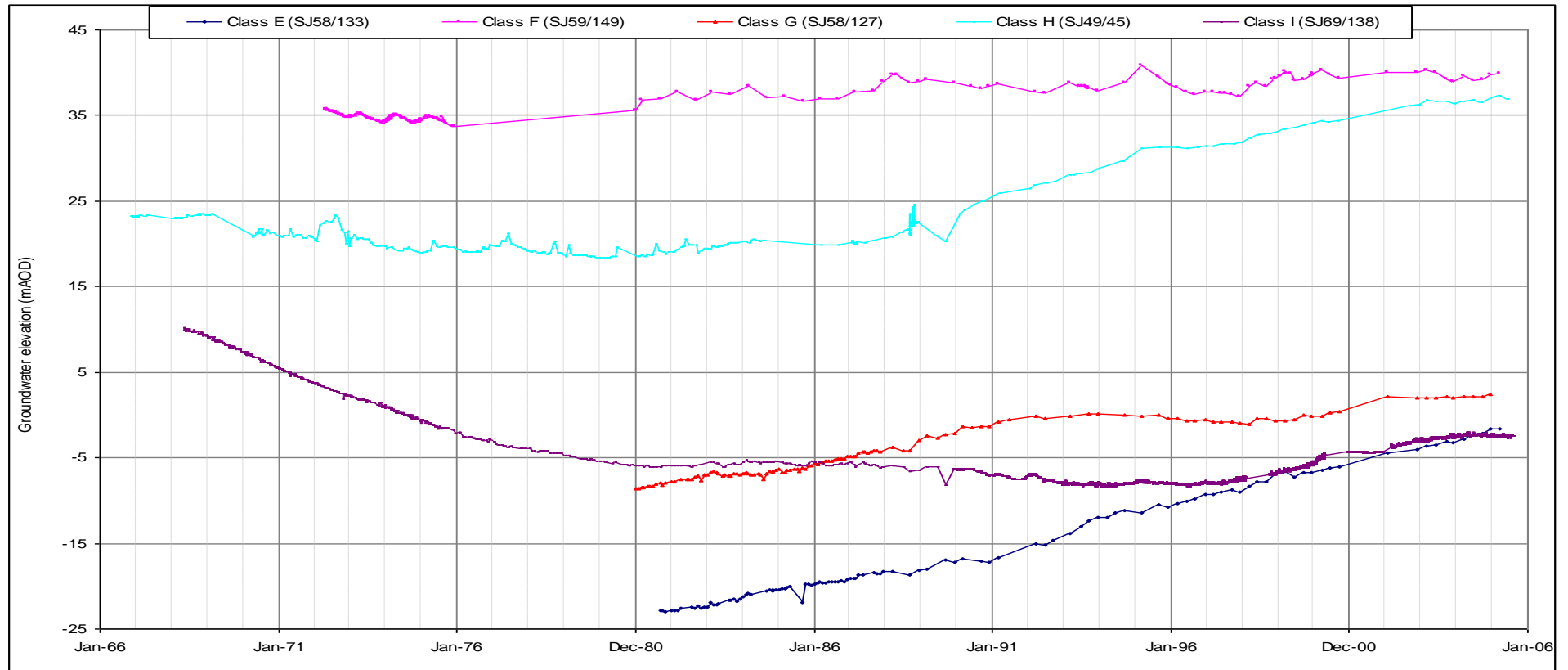


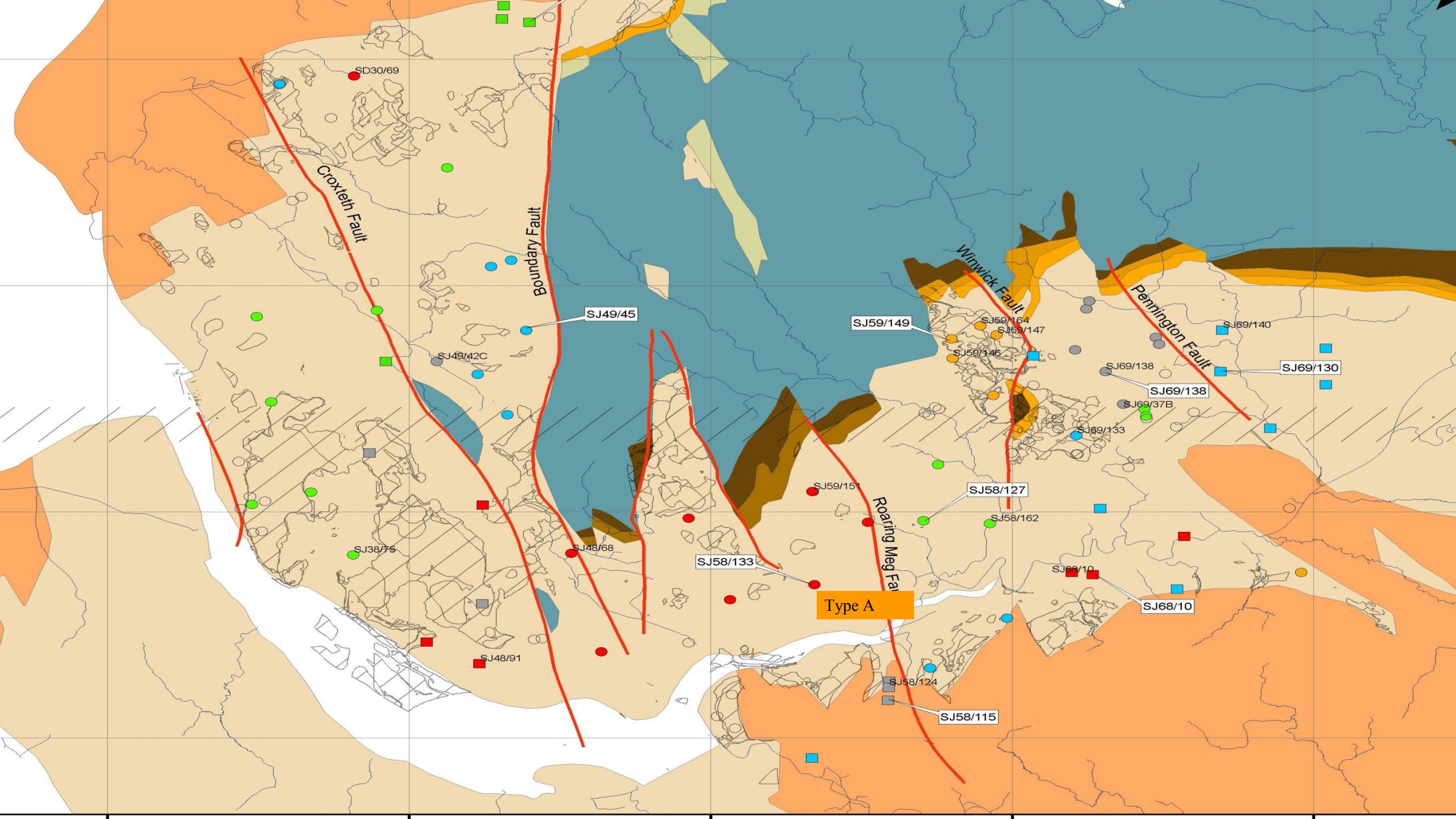
Groundwater levels

– Agency observation network

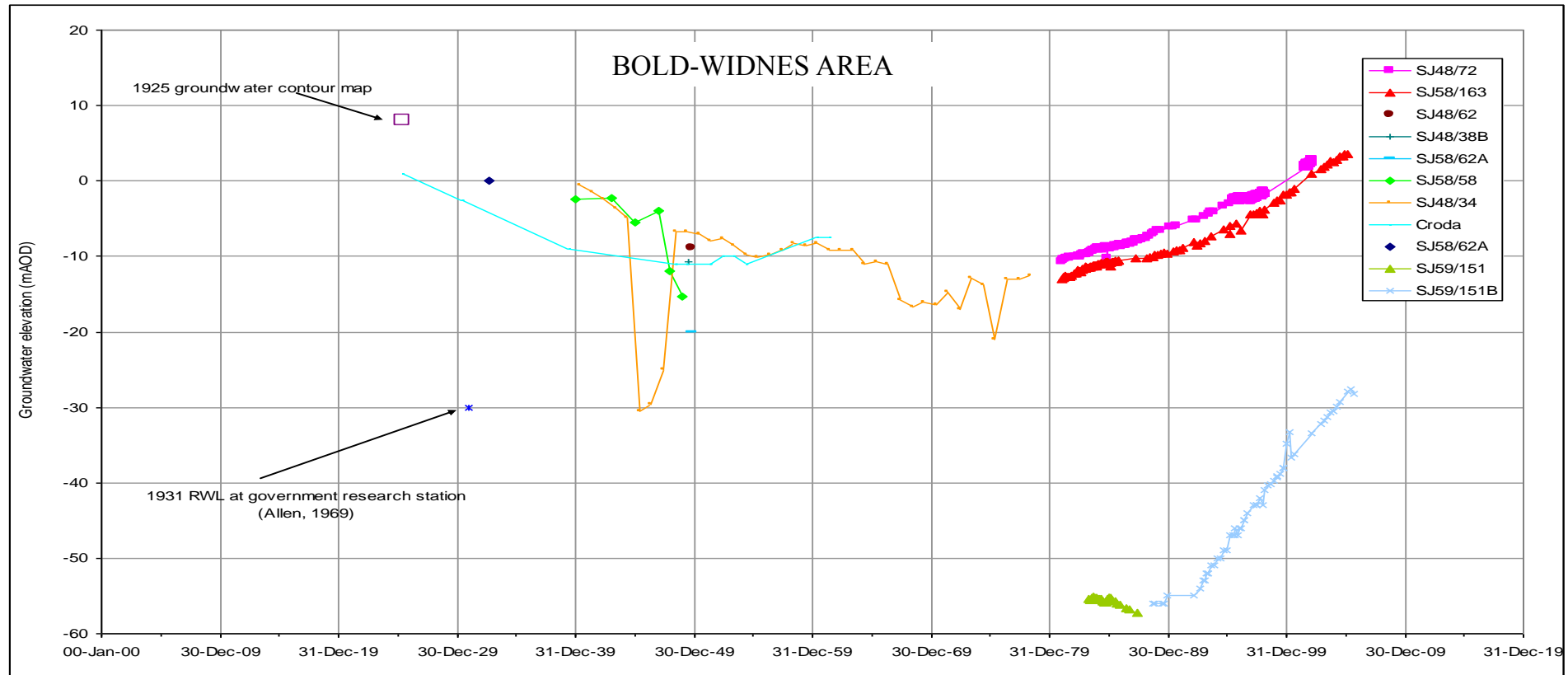


Groundwater levels – Type hydrographs



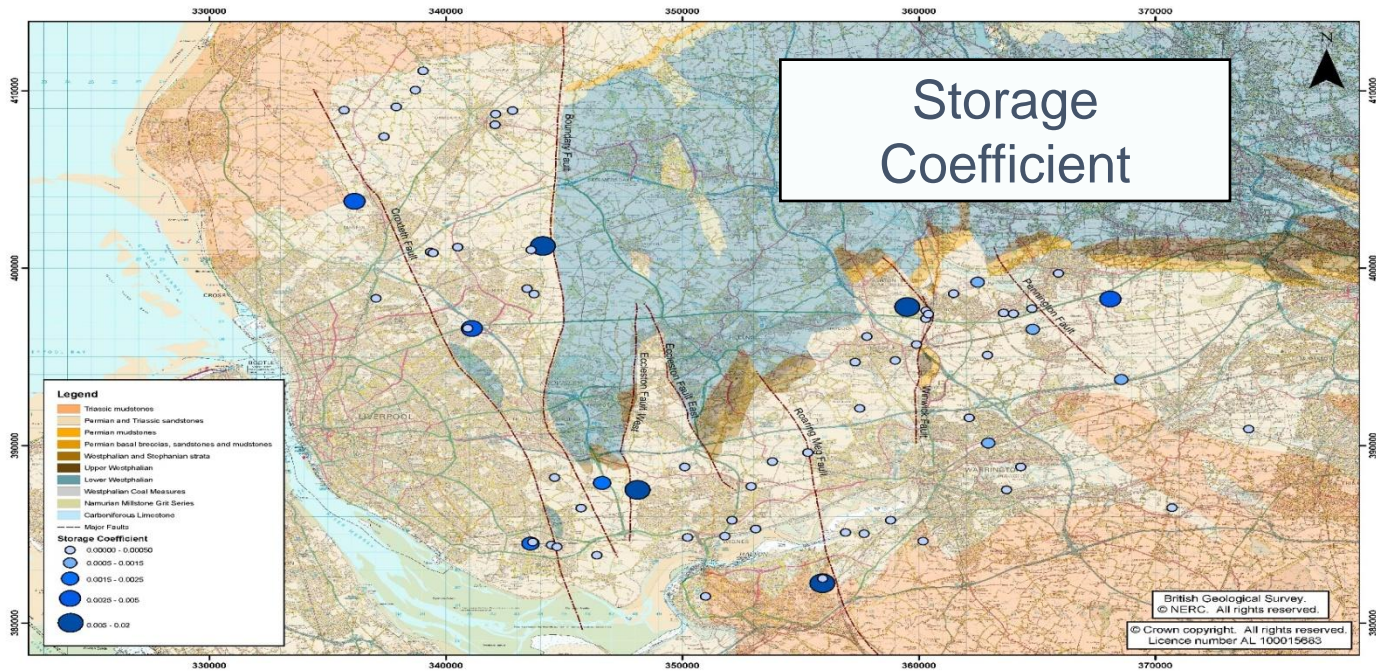
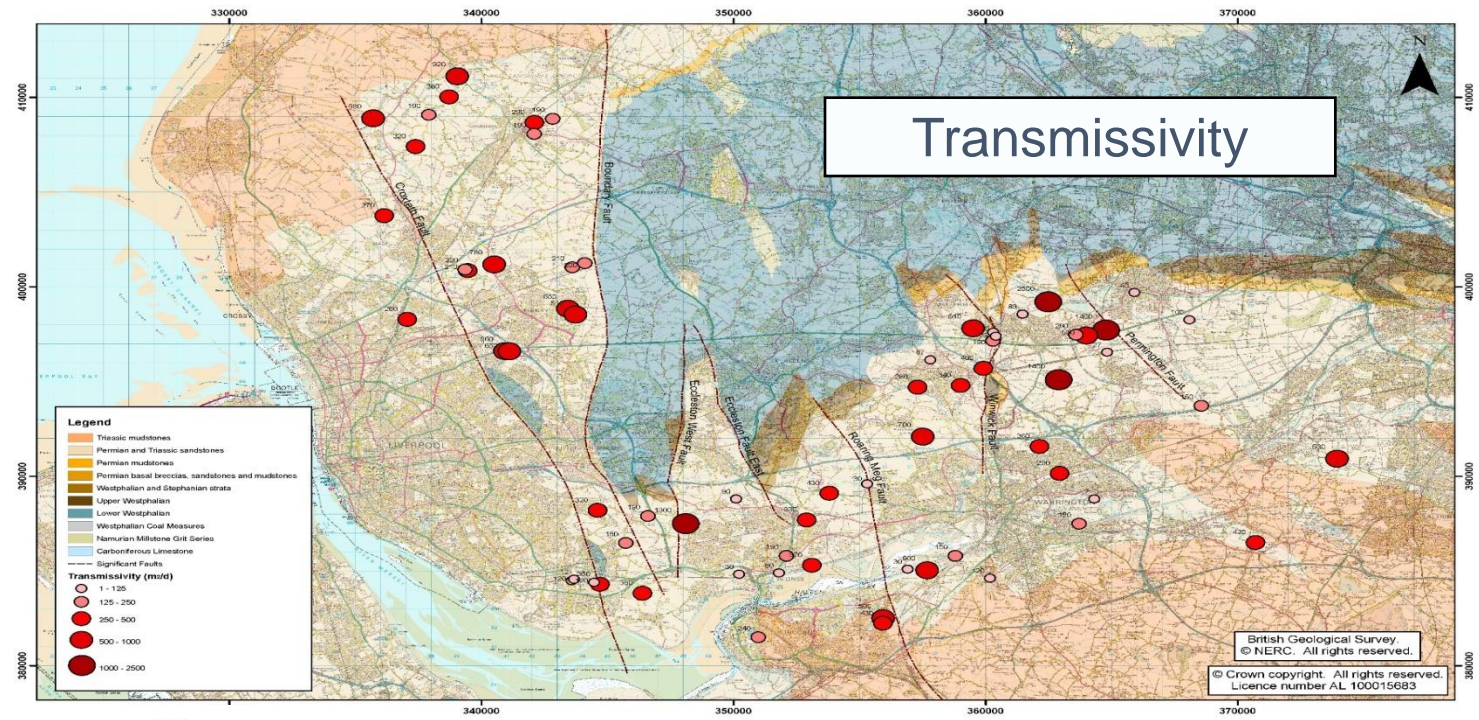


Groundwater levels – long-term variation



How does the aquifer behave?

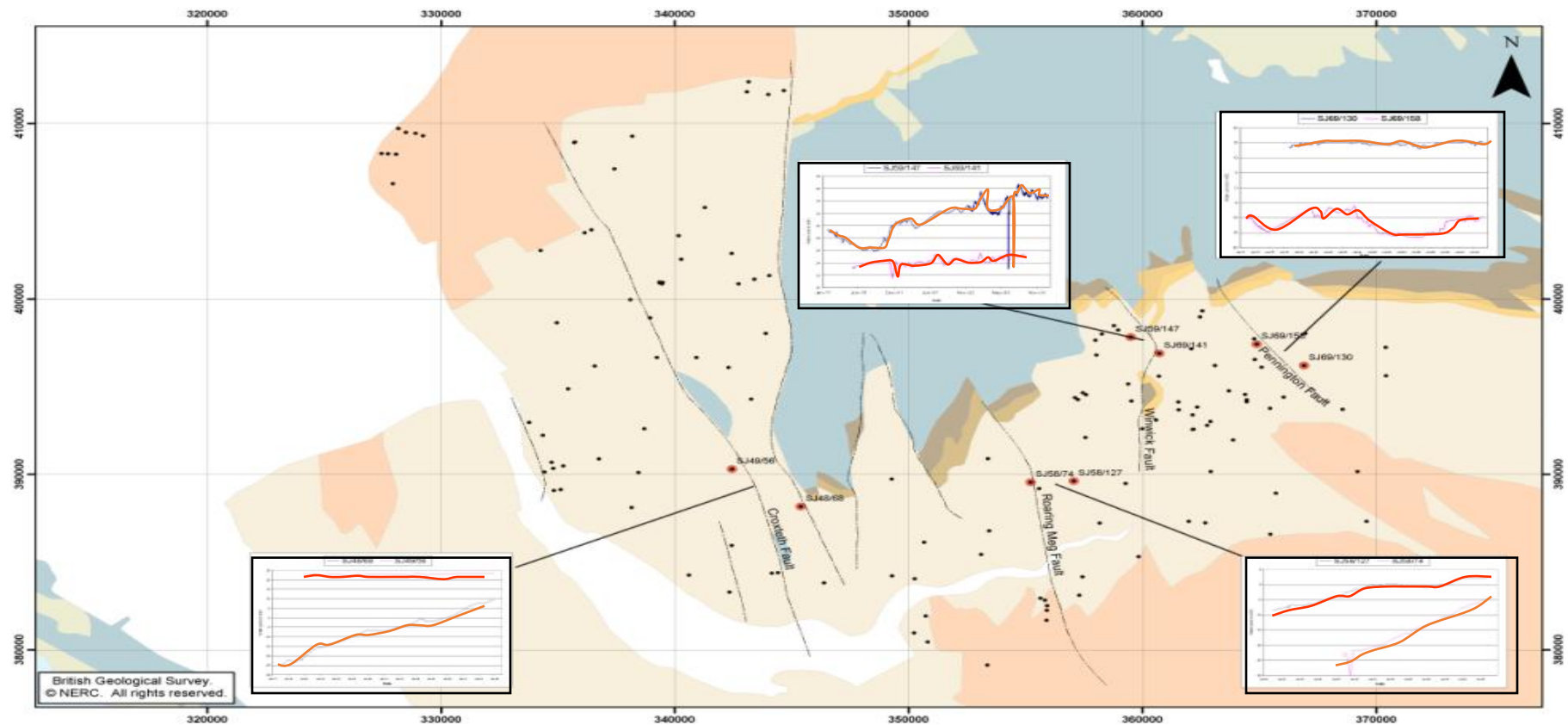
- rock properties



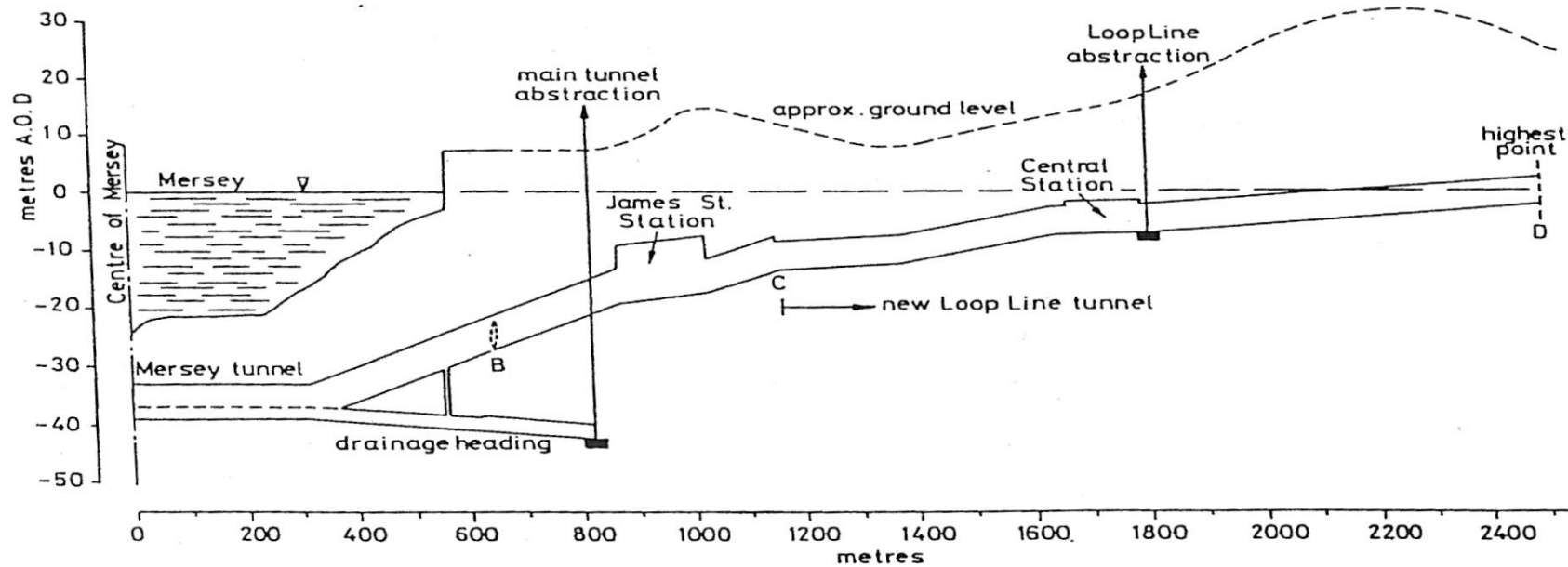
(from 'Aquifer Properties Manual')

But is it faulty?

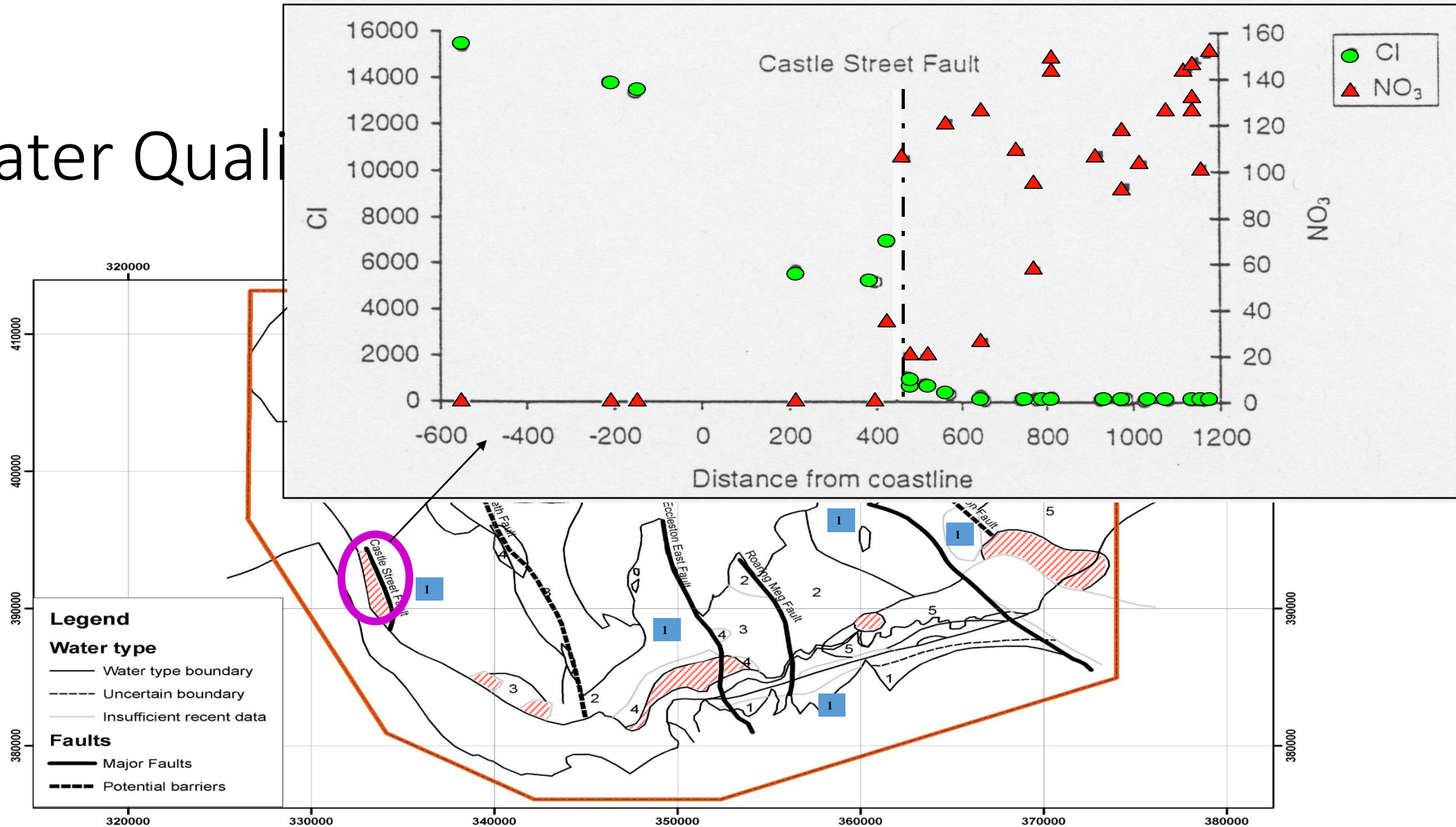
Groundwater responses across faults



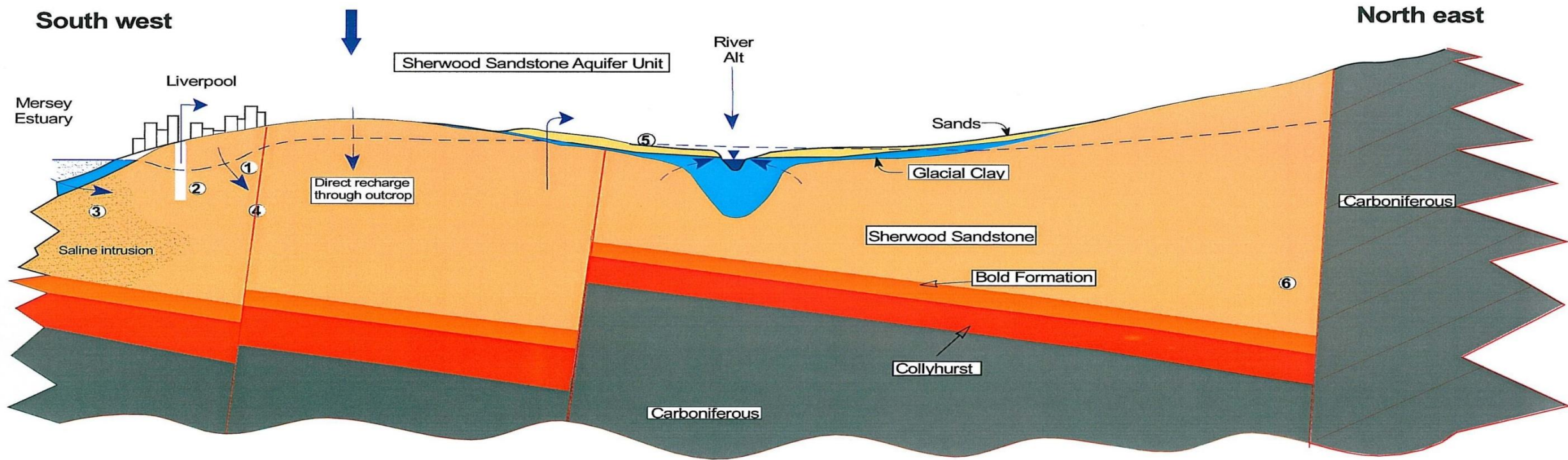
Liverpool Loop Line



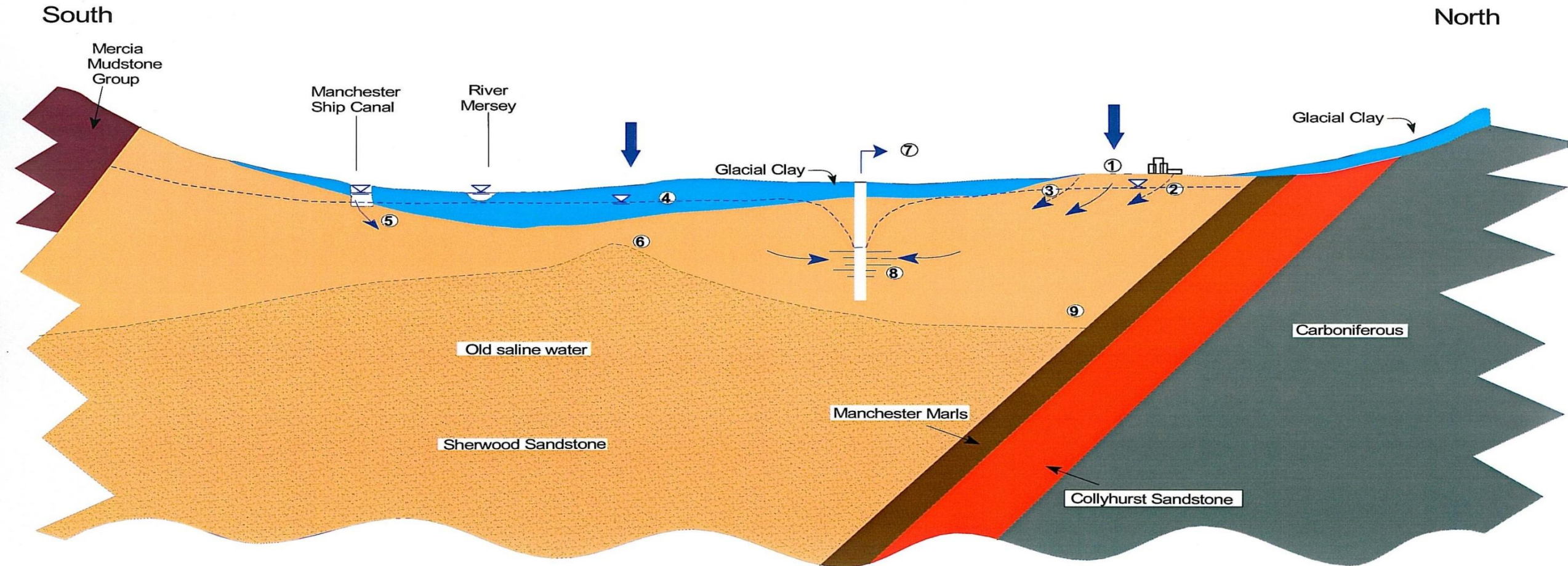
Water Quality



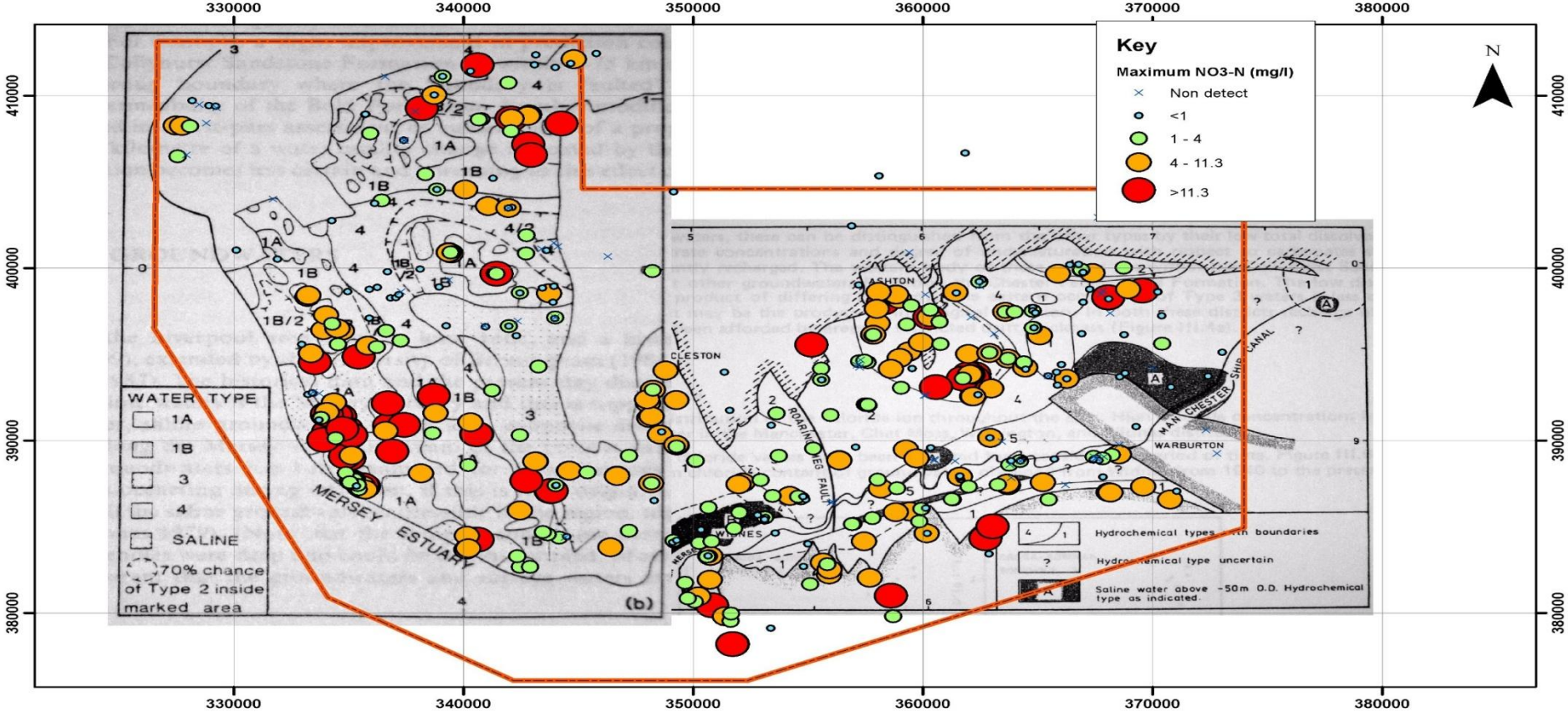
Conceptual model:
Liverpool- Ormskirk ~ SW- NE section



Conceptual model: Lower Mersey Basin ~ N-S section



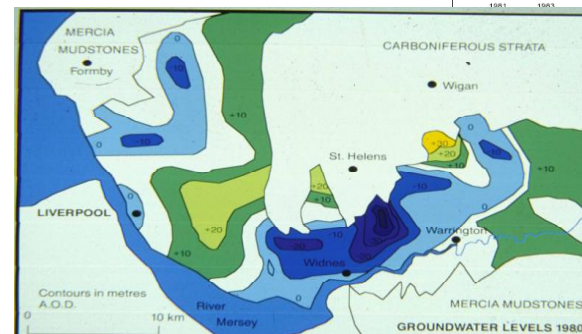
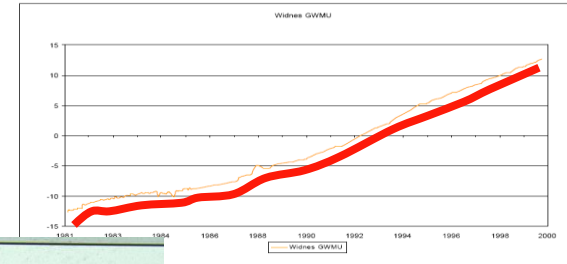
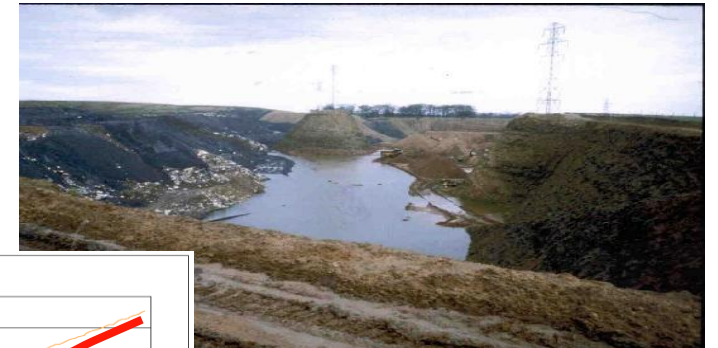
Nitrate distribution



Groundwater Rebound ~ *flood risk mapping?*

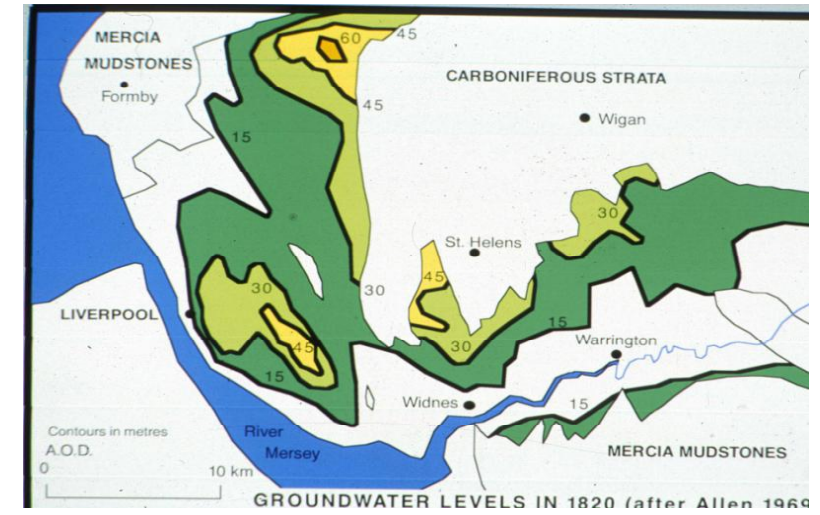
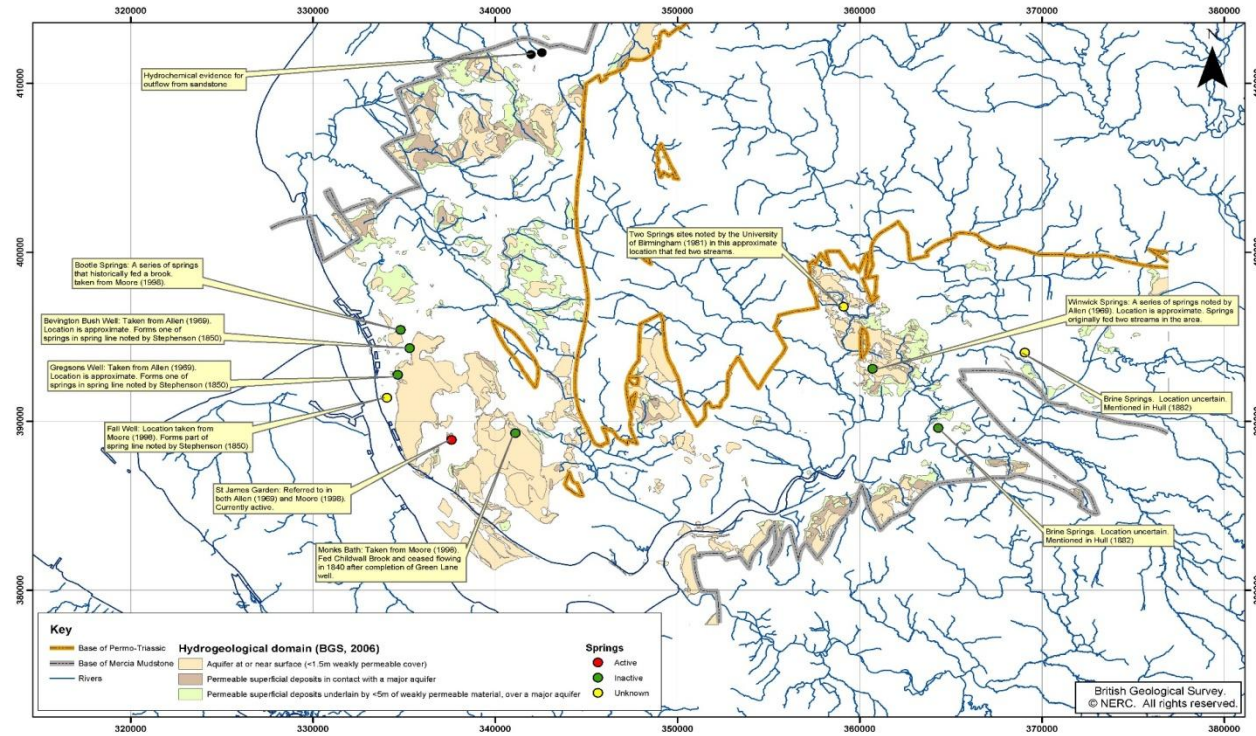
- Complicated!!

- water levels
- abstraction
- elevation
- geology



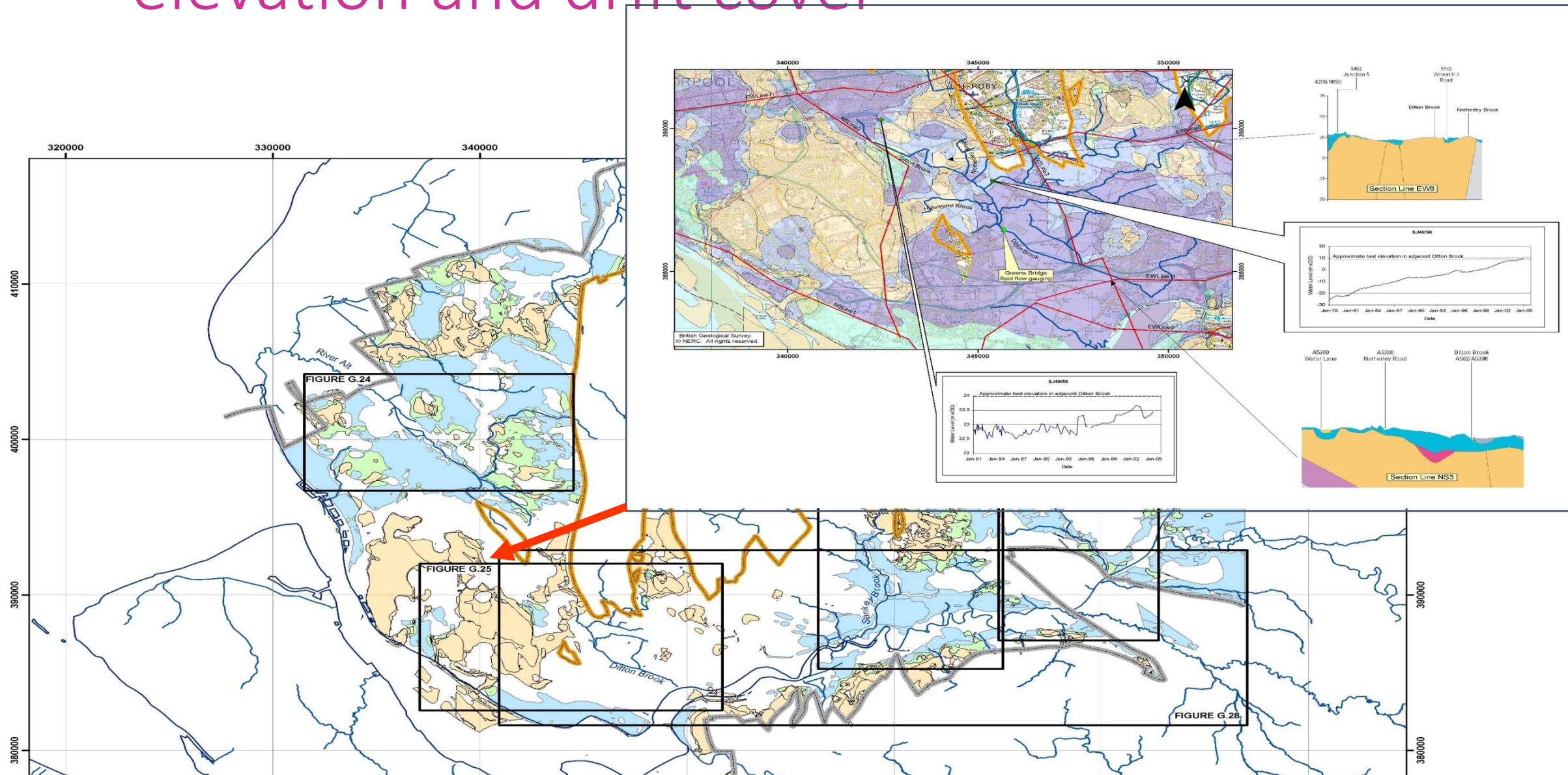
Where could it come out?

~ *Back to the future? Historic springs*

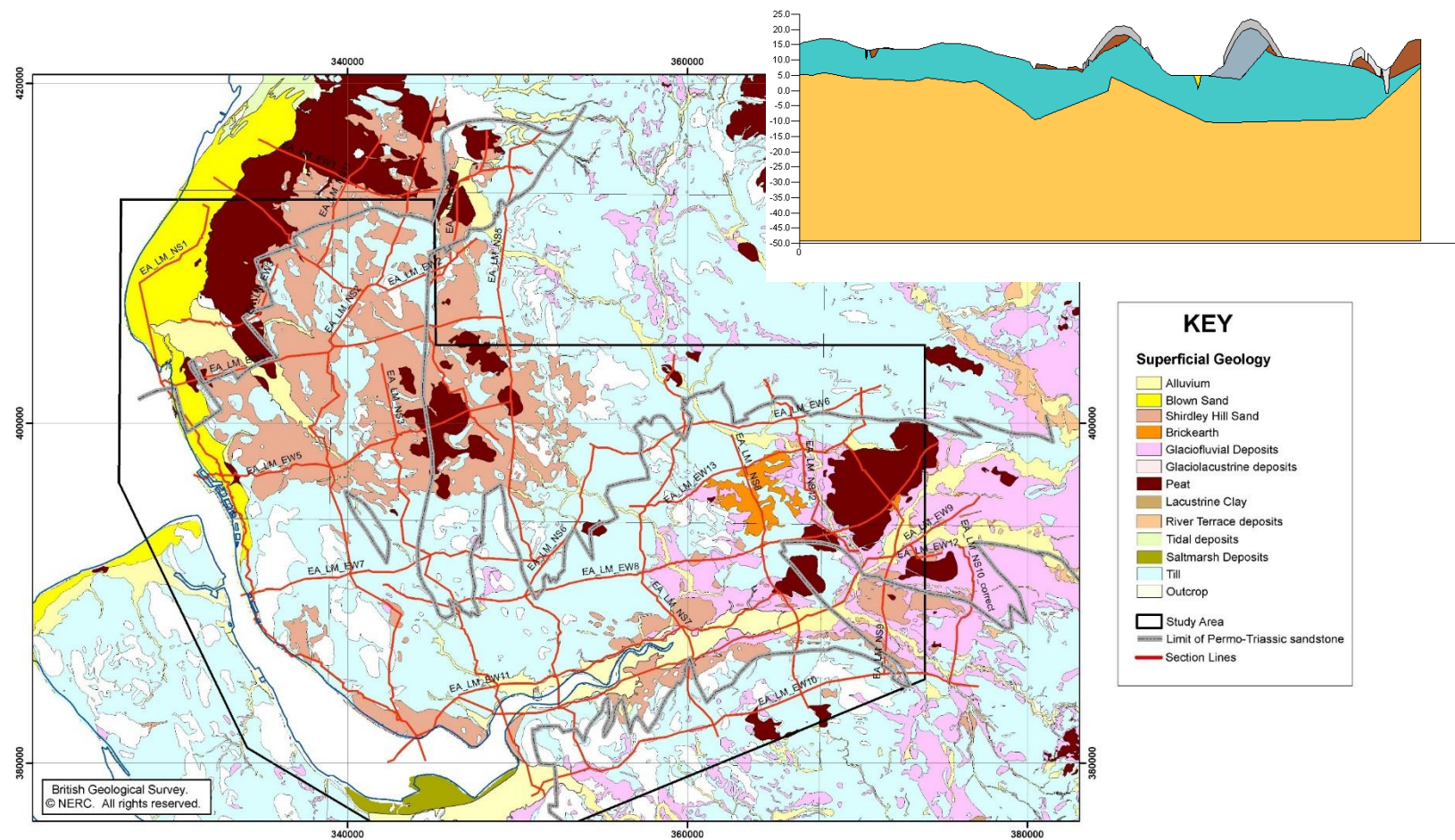


Where can it get out?

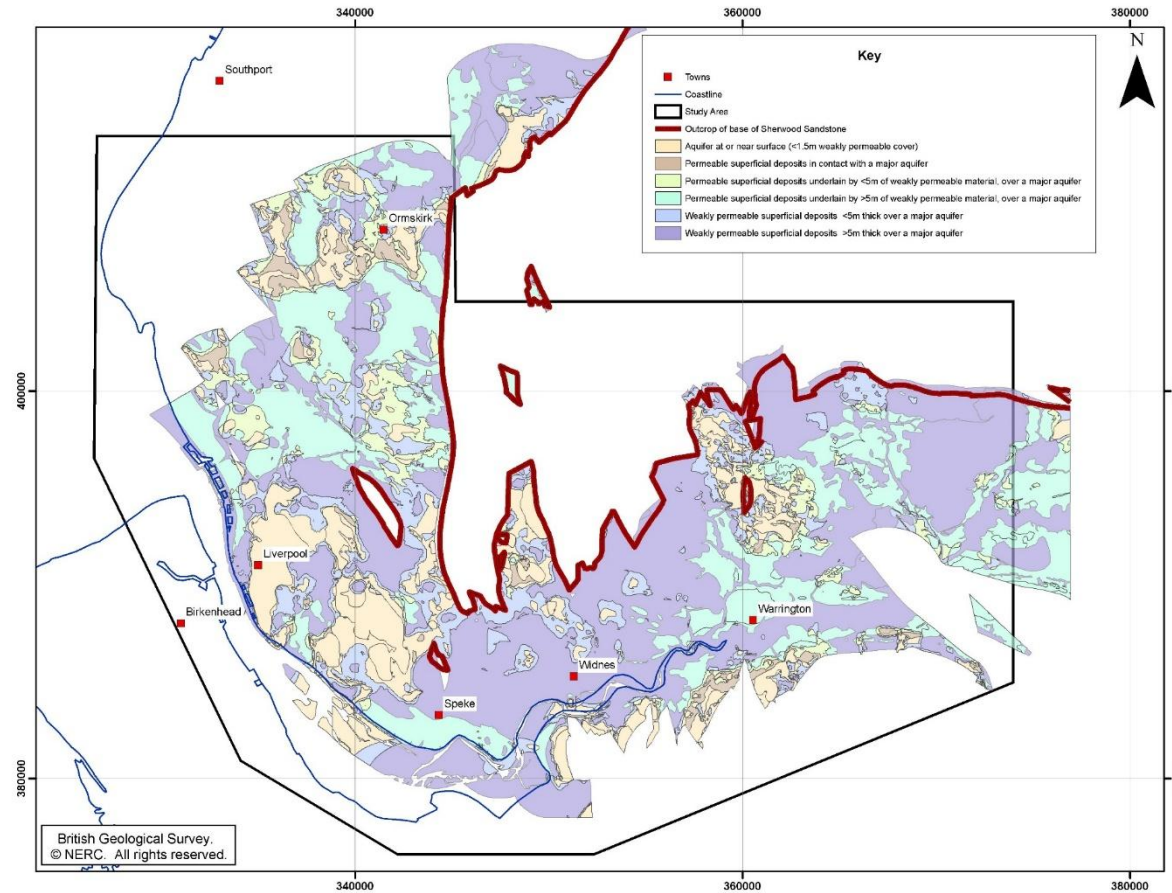
~ elevation and drift cover



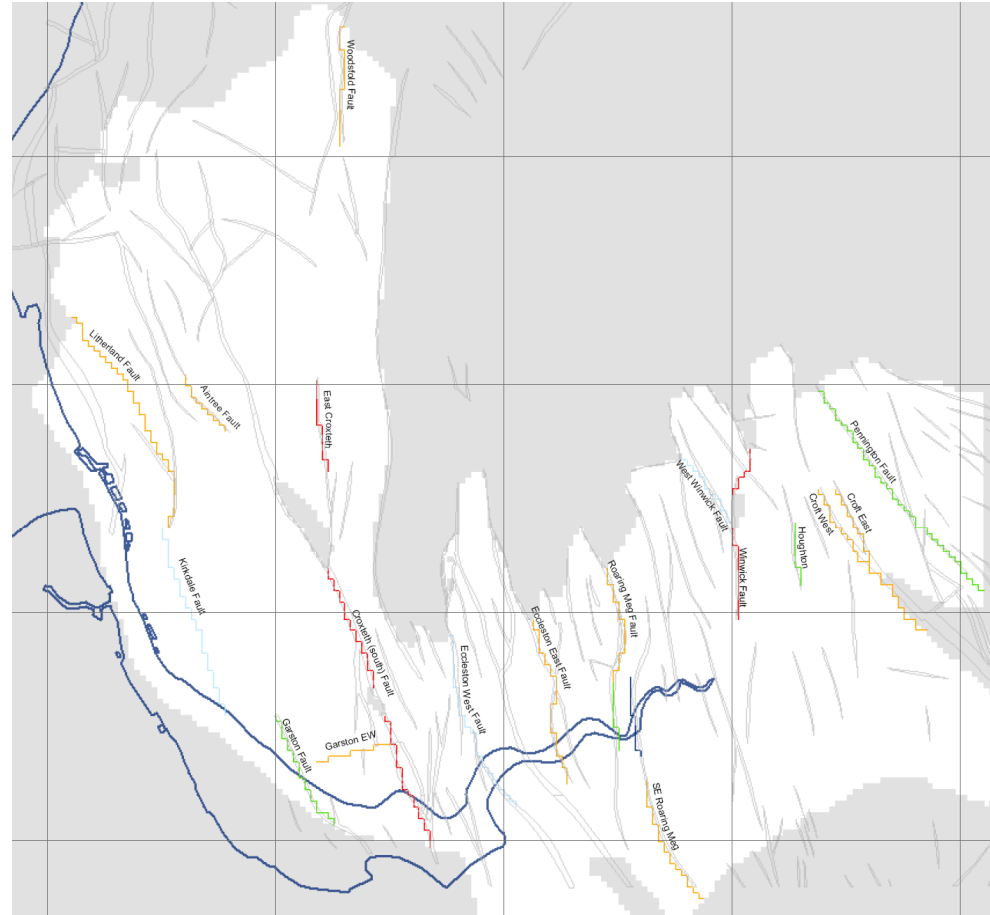
Superficial geology sections



Superficial deposits - Hydrodomains

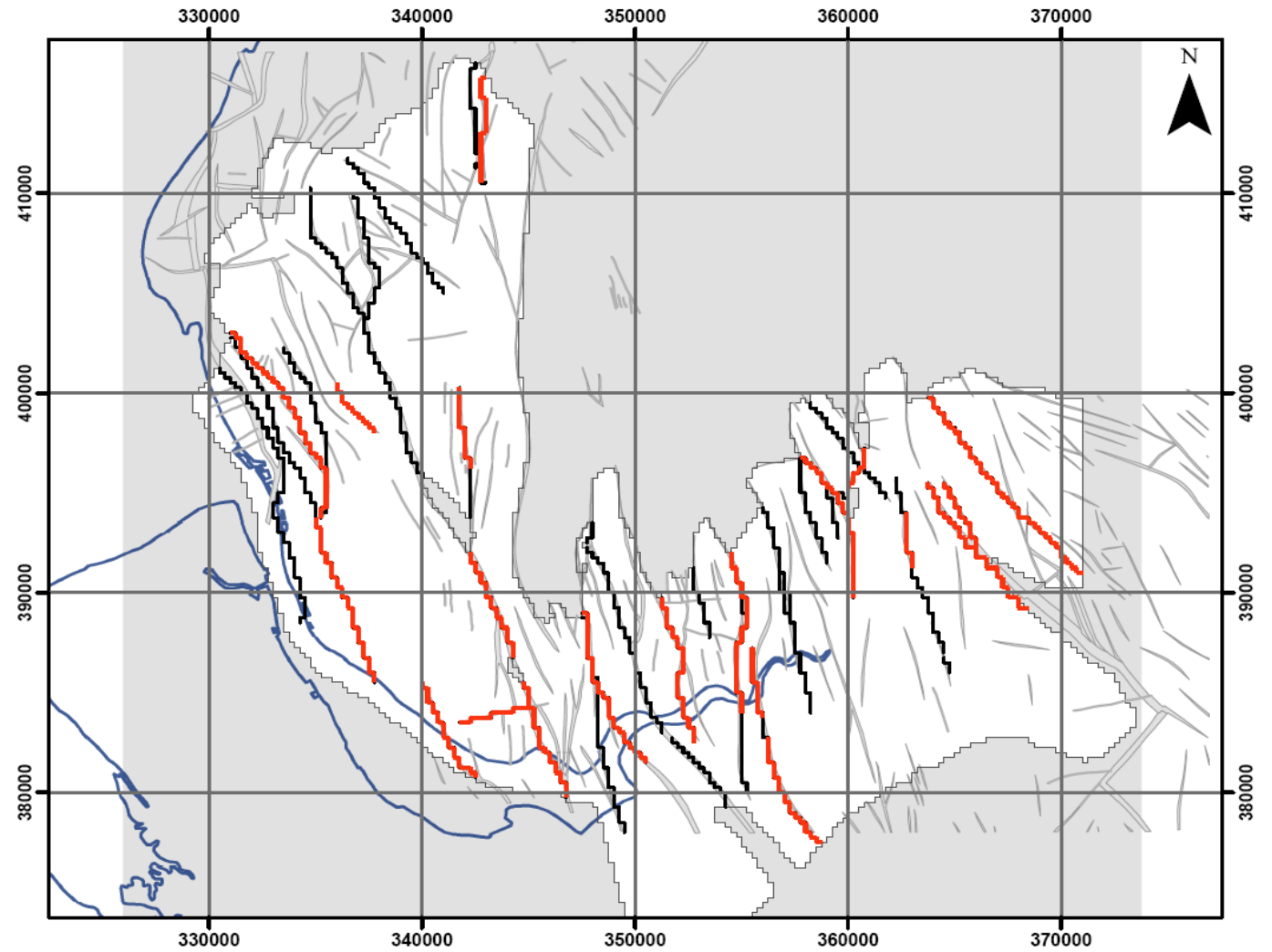


Faults






What have we learnt
~ value of BGS data

Faults

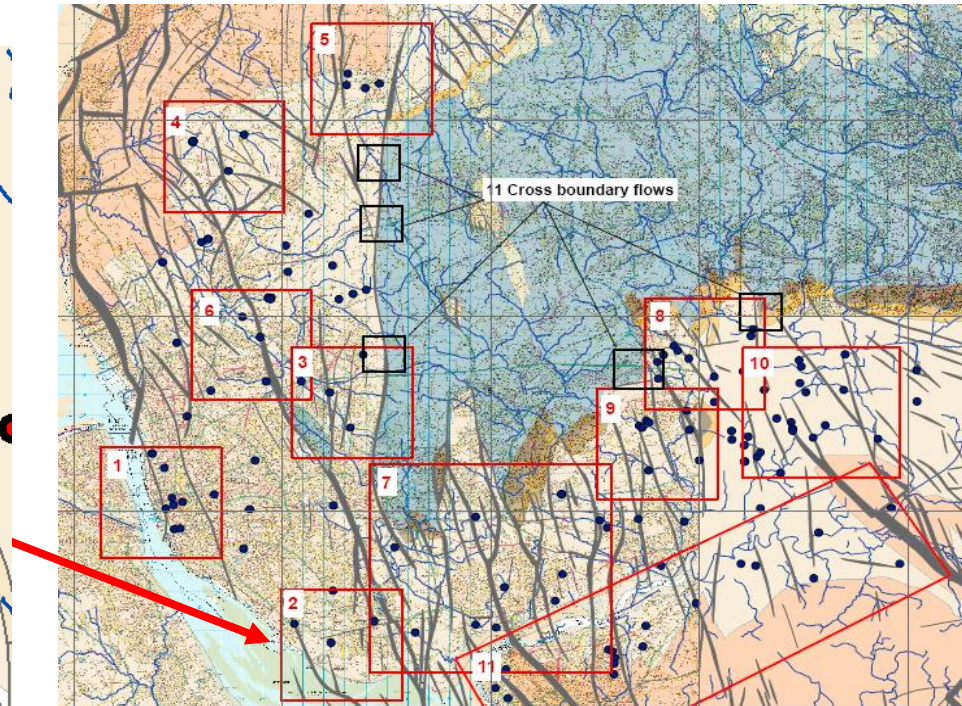
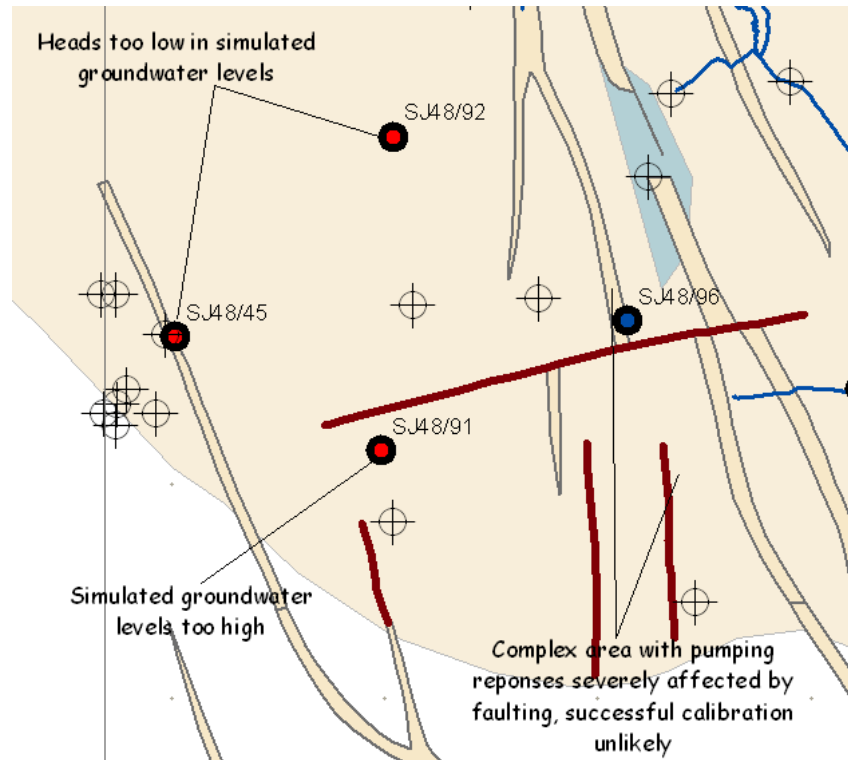


Key

-  Faults included in final model
-  Faults tested during model refinement
-  BGS-mapped faults (vertical)

Models with Faults.... and Faults with Models

- Local issues – grid scale e.g. Speke



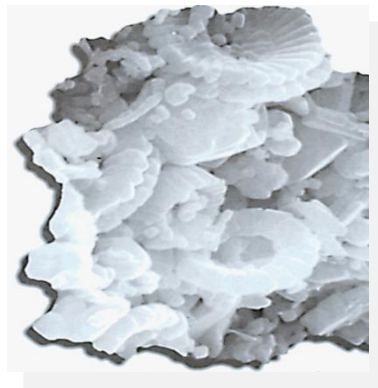
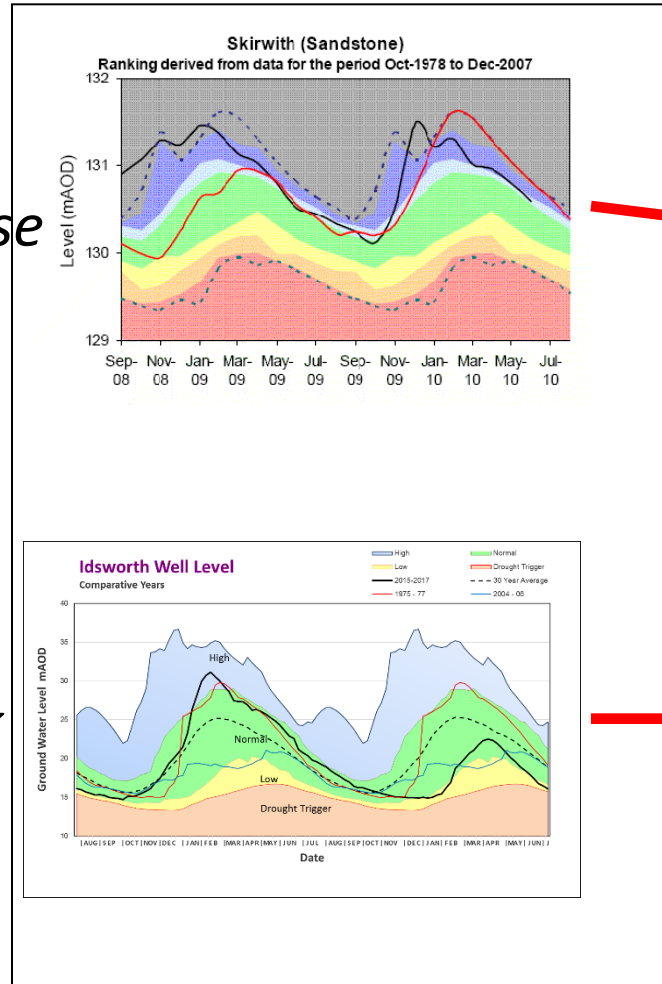
Chalk and cheese:

A bit about drought and flood
responses

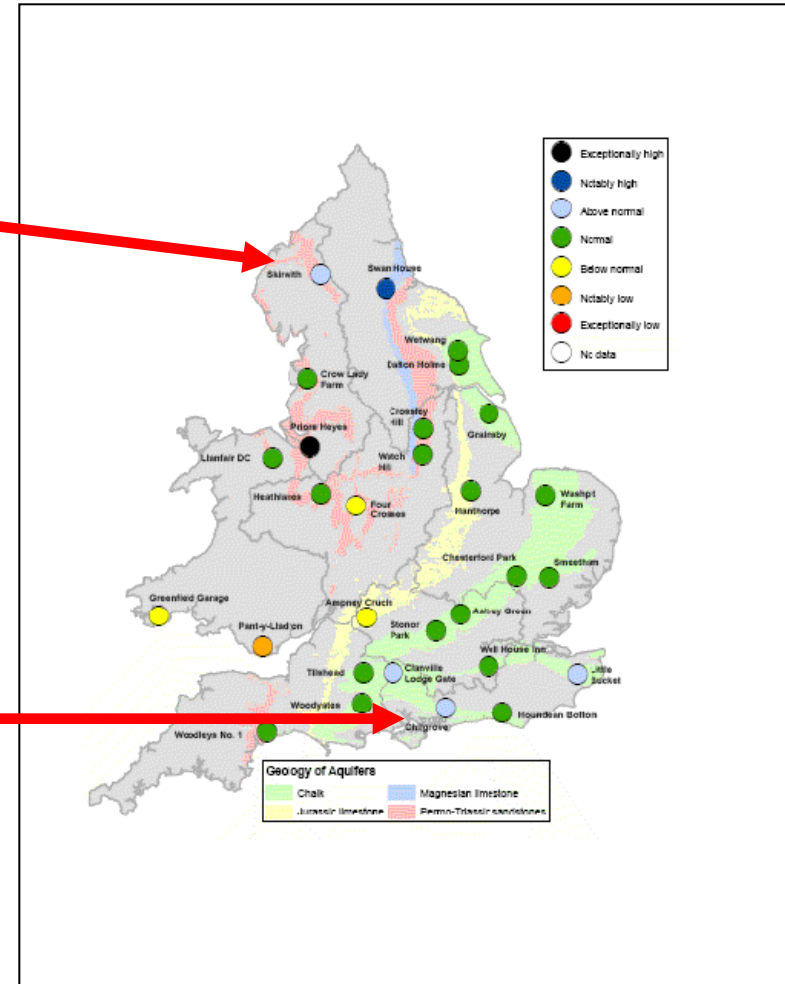
Hydrograph response - Chalk and cheese?



cheese

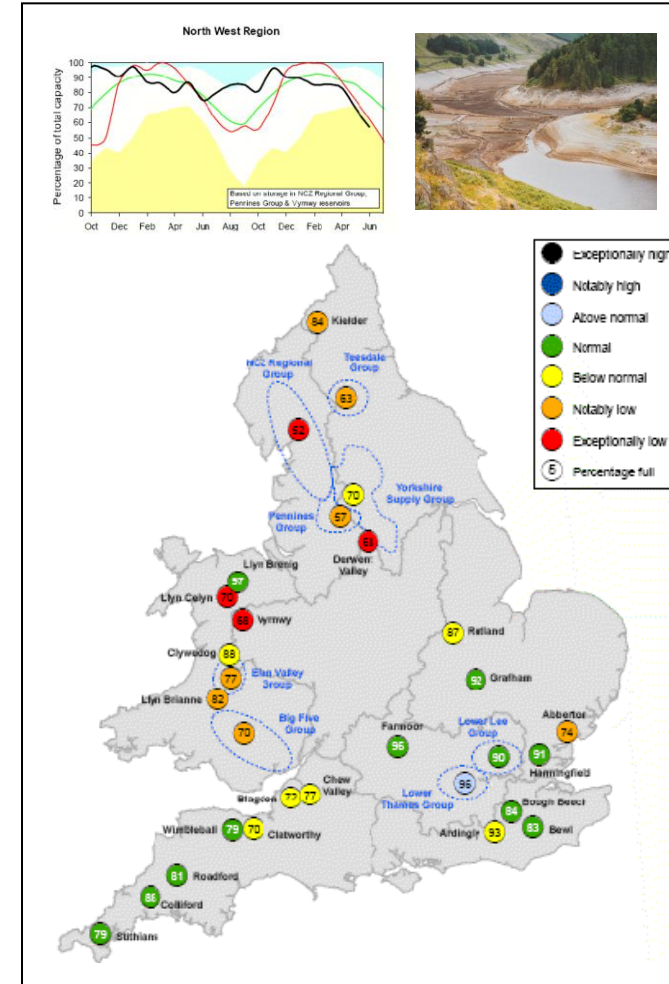
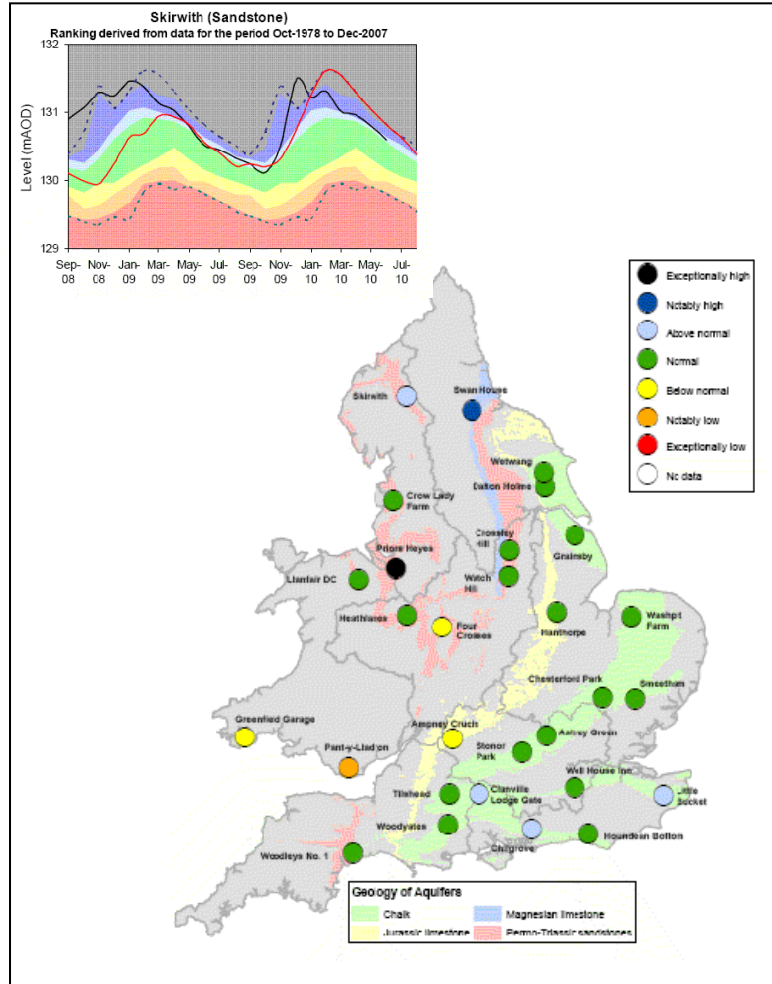


chalk



June 2010

Groundwater - of strategic value in Droughts:



June 2010

So, what are my reflections?



On the aquifer: -

- Permo –Triassic Sandstone in NW is faultyonly shows when ‘under stress’
- Recharge is limited – get my drift?
- High storage – strategic resourcebut
- ‘Baseload pumping’ depletes storage
 - Can cause saline upflow/intrusion
 - Or reduce baseflow to rivers
- Droughts and floods – bovered?...but
- On the rebound in places

~ A supertanker ...with a lid!

So, what are my reflections?



On the 'process':

- Importance of conceptual model – understanding
- Numerical models can be useful...but also faulty!
- Value of collaborative working e.g. BGS

So, what are my reflections?

On my career as a hydrogeologist/regulator in NW:



- **There are worse jobs!!**

- The people
- The patch
- The subject!

Finally - thanks: Team effort



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