British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Applied geoscience for our changing Earth

Measuring *insitu* permeability of Quaternary Deposits: Examples from Forres, Morayshire

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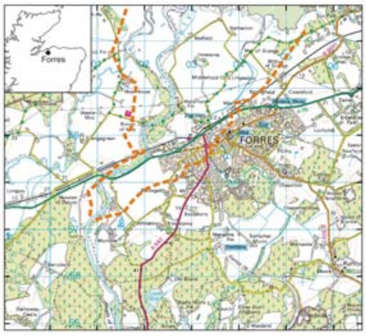
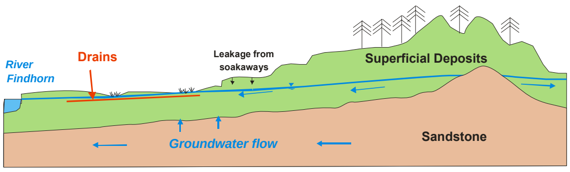
Background Flooding in Forres

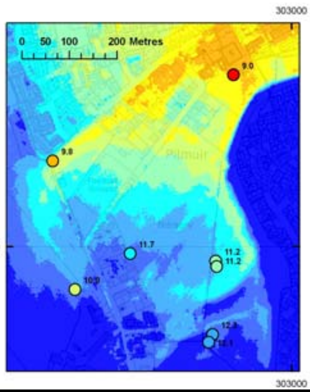


- Large part of the town flooded 1997, 2001
- Muckle Spate of 1829
- New flood alleviation schemes

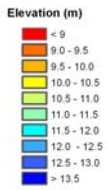
Background Flooding in Forres



Background Flooding in Forres



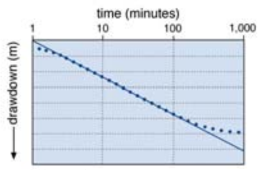
- Groundwater close to the surface
- Expectation that FAS stop all flooding
- Pressure for new houses
- Permeability of the Quaternary crucial to designing scheme



Estimating permeability

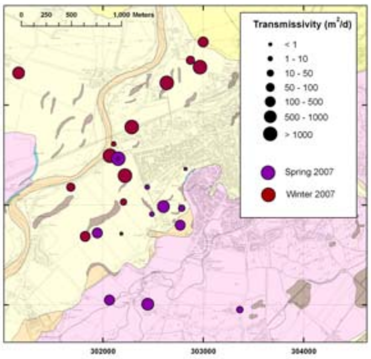
1. Pumping tests
2. Particle size distribution
3. Slug tests
4. Geology and modelling: putting it all together

Pumping tests: gold standard



- Persuaded Client to undertake pumping tests.
- Site investigation boreholes modified to be suitable for short tests
- Short 1 hour single hole tests carried
- Several 4 hour tests with observation boreholes.

Pumping tests: transmissivity



high T > 1000 m²/d

Great variability

No obvious pattern

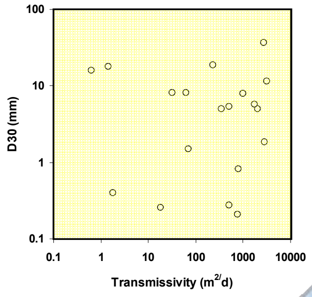
T and particle size distribution

PSD undertaken on bagged samples from drilling

Use PSD of screened section

No correlation of drillers logs with transmissivity

Difficult to extrapolate across flood plain

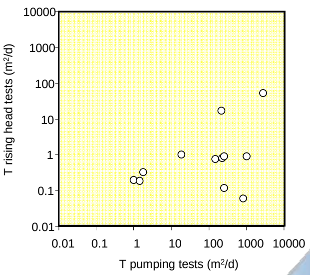


T and rising head tests

Carried out by contractors to British Standards

Rising head tests consistently under recorded T by 1 – 3 orders magnitude

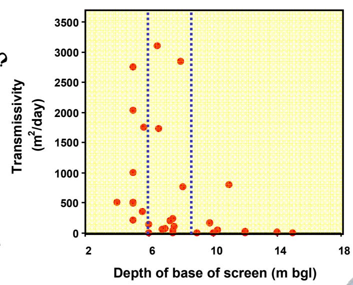
Is it a universal problem with slug tests ?



Transmissivity variations with depth

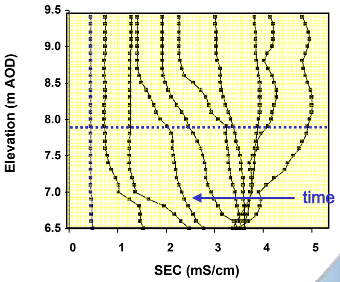
How do we get transmissivity distribution for groundwater model?

Best relationship with depth

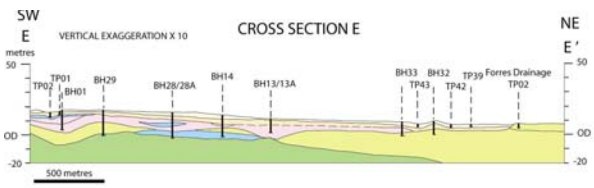


Transmissivity variations with depth

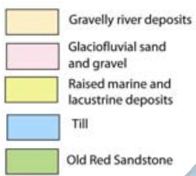
Backed up by salt dilution tests



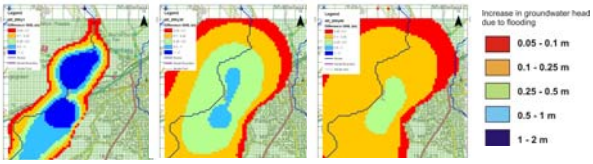
→ Build a geological model



Deposit	Number samples	Median T (m²/day)
Ardesier Silts	2	1.1
Till	1	1.8
Glaciofluvial /till	3	18
Glaciofluvial	10	281
ice contact	2	615
River deposits	10	629



Groundwater model



FAS has been modified to account for groundwater flooding

Should now be little additional risk due to FAS

Going back for more…

Why did the PSD and drillers logs not work out?

Testing the geological units with confidence – particularly low K

Measuring permeability at outcrop

Geologist – tell us exactly what unit we are in.
Engineering geologists – do standard tests and descriptions
Hydrogeologists – test permeability *insitu*

Guelph permeameter

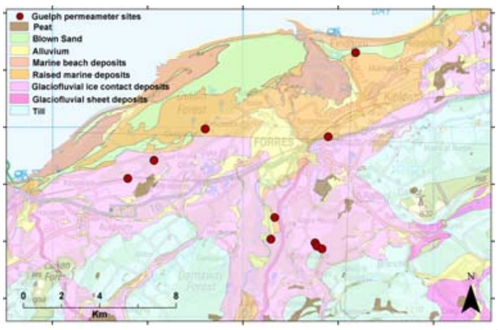
Make auger hole 10 cm deep

Difficult due to location of outcrops

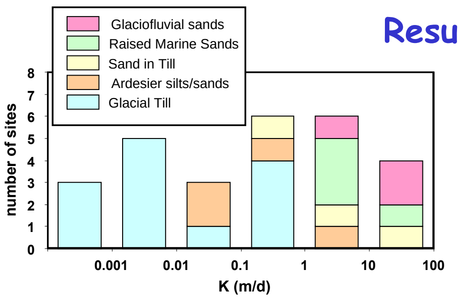
Carry out test (<1 hour)

Range 0.001 – 20 m/d

Location of Guelph permeameter sampling sites



Results



Wide range over all deposits

Distinct populations

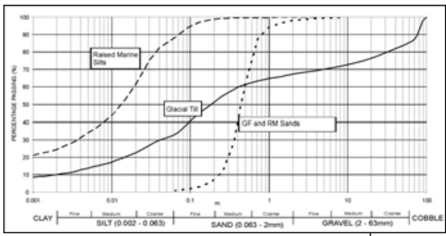
Detail interesting and sometimes surprising

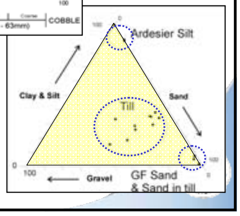
Comparing Guelph to Ptests

Deposit	Guelph		Ptest
	min	max	Median K (m/day)
Ardesier Silts	0.1	3	0.5
Till	<0.001	1	0.6
Glaciofluvial /till	1	10	6
Glaciofluvial	> 20	>20	90

Gave much more confidence to Ptest results

Particle Size distribution





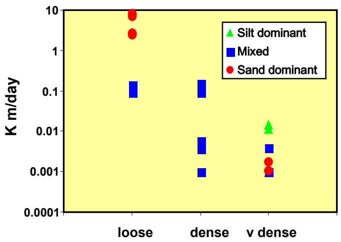
Well-graded slightly fine sandy SILT (Ardesier silt)

Gap-graded silty fine SAND and coarse GRAVEL with some cobbles (Till)

Uniform medium SAND (Glaciofluvial sands and sands in Till)

Relating descriptions to permeability

Compaction and stiffness of deposit a strong control on permeability

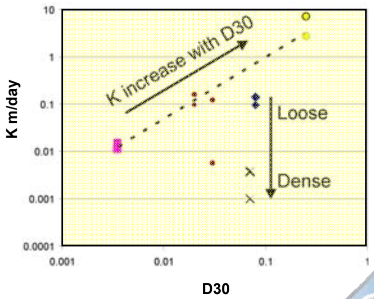


Relating to permeability

Use D30 as a proxy for matrix

Particle size and density show equally strong controls

What about fractures??



Conclusions – estimating spatial K

1. Gold Standard of pumping tests
2. Build a geological understanding
3. Unresolved issues over slug tests
4. If in doubt go to outcrops and measure K with permeameter
5. Be wary of extrapolation using grainsize (more to come)
6. interdisciplinary approaches beneficial