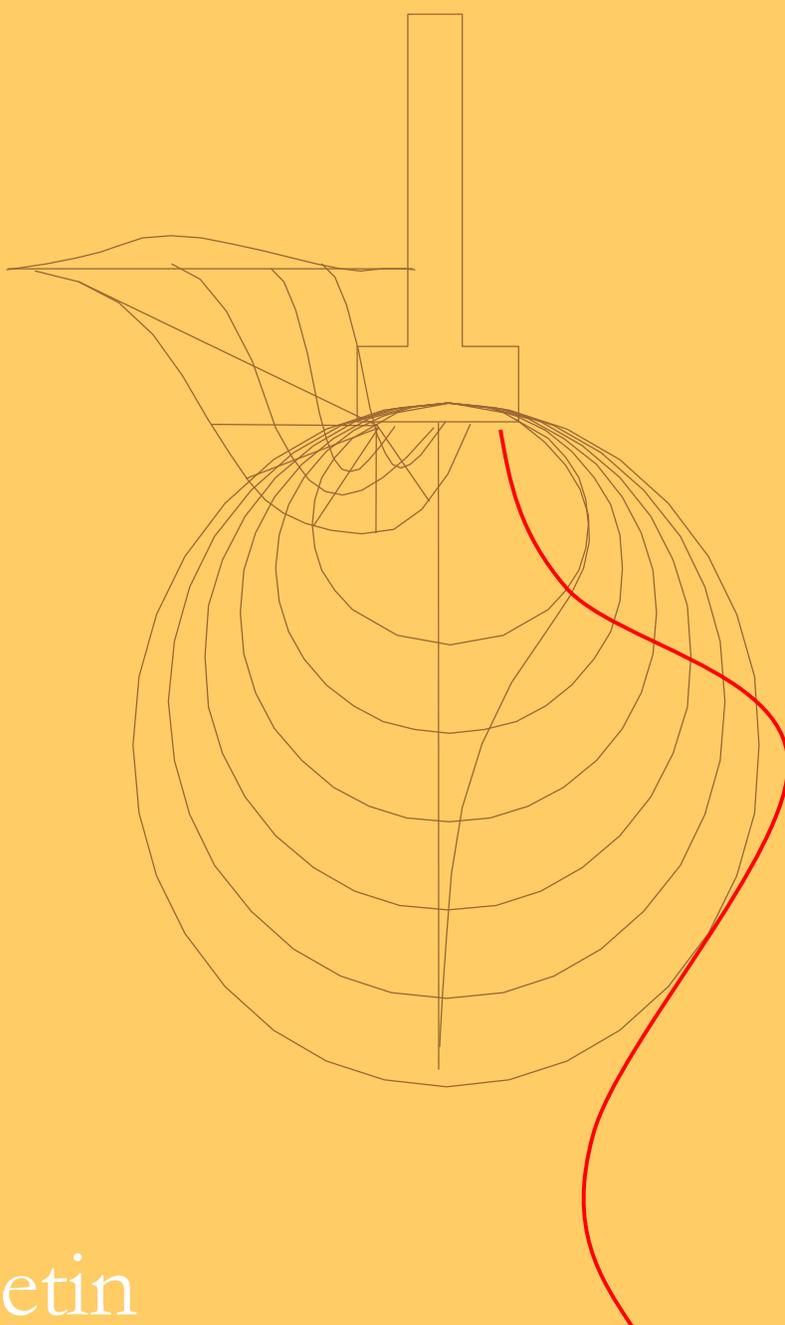


# The Clay Research Group



Monthly Bulletin

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## DIARY NOTES

We are talking to the engineers at Mott McDonald on the 31<sup>st</sup> July, with the hope of exchanging data and understanding their approach to modelling.

We have contacted Andy Tipping who is the chair of the London Tree Officers, asking if a meeting would be possible given the concerns raised by some of the tree officers at the Aston conference with regard to the risk models we have mentioned.

He has promised to get back to us shortly.



The Clay Research Group

[www.theclayresearchgroup.org](http://www.theclayresearchgroup.org)

## Technical Review

We have 12 months precise levelling data, a variety of soil results using different test techniques and data from the neutron probe.

Encouragingly, all of the methods detected desiccation and there is broad agreement about the depth below ground level and magnitude of the moisture deficit.

Soil heterogeneity is one of the main reasons for any differences, but also the methodology of testing.

The oedometer test using disturbed samples is reviewed and we find the correlation with the filter paper test to be robust. Both have UKAS accreditation. Sample preparation is the essential ingredient to assessing swell from the oedometer. Comparisons over several hundred tests confirm it to be as accurate as any other.

The permutations between soil, climate and trees are endless and we can only ever expect to register qualitative measures. This leads us to consider the modelling approach. Most academic journals carry articles using numerical modelling of root growth, soil response to climate change. It is now almost routine for scientists to simulate these and we have to catch up.

We noted the following titles from a brief review of a single edition of a soil research journal...

*“Artificial Neural Network Estimation of Saturated Hydraulic Conductivity”, “A Parallel Model for Simulating Three-Dimensional Water Flow and Solute Transport in Variably Saturated Soils” and “Applied Flow and Solute Transport Modelling in Aquifers: Fundamental Principles and Analytical and Numerical Methods”, “Stochastic Methods in Subsurface Contaminant Hydrology” and “A Framework for Modelling the Interplay between Roots and Soil”*

Ground movement is all about moisture change and we are fortunate to have a wealth of statistical data to call on to establish meaningful correlations.

We have to embrace new techniques and leave behind the ‘perceived wisdom’ that has dogged the technical investigation of claims and the innate conservatism of practitioners. Insurers spend millions of pounds on investigations, and get very little by way of value in return.

Much of the work can be done from our desk with no little risk. We can then divert our attention to investigating the exceptions.

We have an opportunity to change the way we work for the better and hopefully the research we undertake will provide some confidence that there are different ways that are worth considering.

# The Clay Research Group

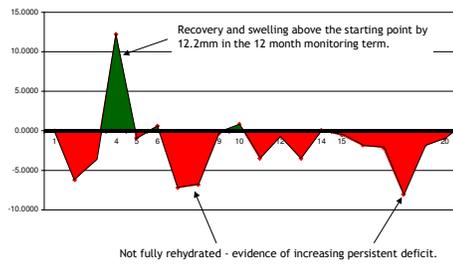


## Persistent Moisture Deficiency - Oak Tree

Aldenham has provided the first glimpse of data over time from a site with a persistent moisture deficit beneath a mature Oak tree.

Comparing May 2006 with May 2007 confirms that the deficit is, in the main, increasing - see the red shaded areas below. Not all of the level stations have recovered to their original position.

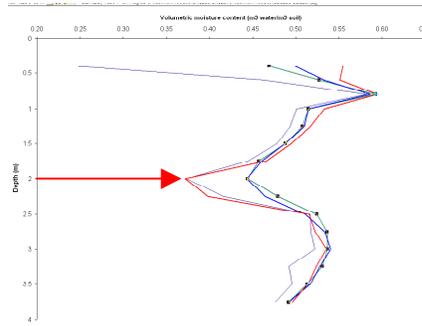
Recovery - May 2006 to May 2007.



Only one has exceeded the start position - indicated as green shading in above illustration. Several remain below the starting point of May 2006.

Bearing in mind the recent rainfall - record wet spells in May and June - we can see just how difficult it is to rehydrate soils in these conditions where the hydraulic conductivity is very low.

## Root Danger Zones



2mtrs below ground level is a danger zone with regard to desiccation in clay soils, in the presence of mature trees.

Above we plot the data from the neutron probe provided by Southampton University and we can see a very clear deficit at 2mtrs bGL.

These findings are generally in agreement with the suctions profiles as we see later.

The stress zones across the root plate are shown on Page 7.

It is an interesting fact that most botanists tell us that roots grow at a much shallower depth than we see deficits occurring.

Our thanks to Marishal Thompson once more for agreeing to sponsor an upgrade to the weather station.

To complete our calculations we need an 'hours of sunshine' sensor. Cyril Nazareth has placed the order with Tempcon Limited and we hope to have it on site in the next few weeks.

Marishal's sponsored the original weather station.

## SITE INVESTIGATIONS

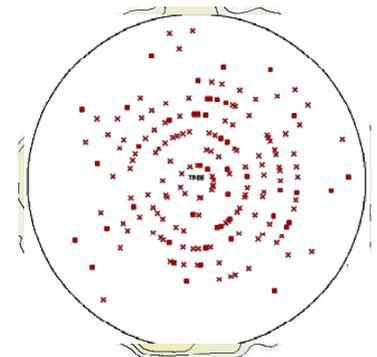
A further series of boreholes were sunk adjacent to the Oak and Willow trees towards the end of June, and both disturbed and undisturbed soil samples were retrieved for testing using the oedometer and filter paper techniques.



## Root Zones

Many arborists and engineers ask the question "why do some houses suffer damage when others, equidistant from the same tree, do not?", and it is a good question best answered by our work in ERT.

If we look at the image to the right we see significant variations in stress across the root zone related to the soil mineralogy, moisture availability and possibly climate (i.e. North or South facing). These changes have also been reflected in the levels.



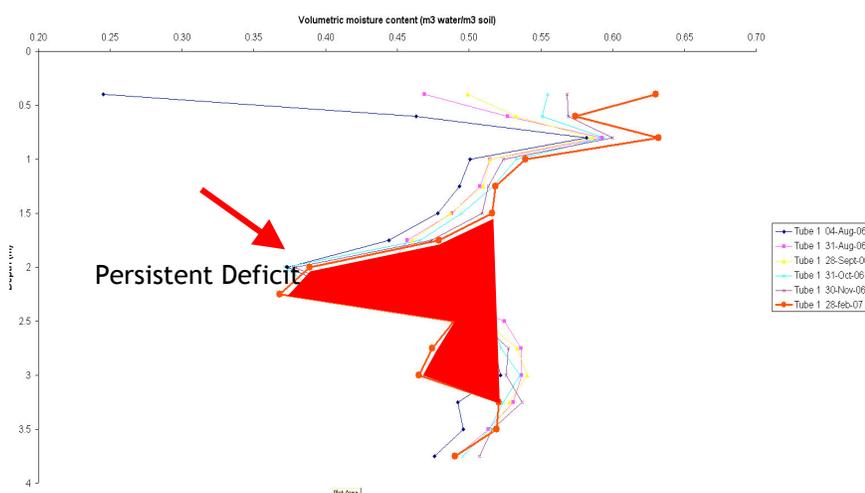
A plan on the root zone of a mature tree, modelled from cross sections through the ERT survey and using precise levels.

### Persistent Deficiency Evidence

#### Neutron Probe Data - February 2007

Below are the neutron probe data from the tube closest to the tree. The February readings are shown as a bold red line.

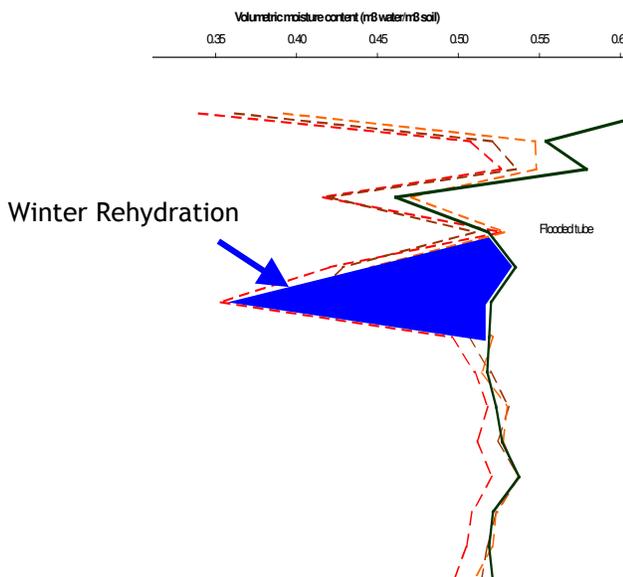
We can see the saturated profile at superficial level associated with winter rainfall, but the 'bulge' at 2.25mtrs bGL confirms the soil is as dry in February as it was in the summer months. There has been no recovery at all, which coincides with the absence of movement beneath the tree canopy when we view the precise level data.



In contrast, below is the plot of the neutron probe data furthest away from the tree where we see full recovery in February 2007 at around 1.75mtrs bGL, but a residual moisture deficit at 1mtr which is a little perverse as most recovery is driven by rainfall.

The gravel strata may account for variations of this sort. The readings show saturation at ground level.

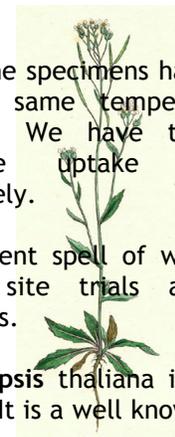
The recharge is reflected in the precise level data around the periphery of the root zone.



Richard Rollit has made a significant contribution to the understanding of root treatment following a study over several months and following our visit to Lancaster University.

We will test his proposals using (a) untreated plants as a control, (b) an equal number treated with 'a solution' to trigger the production of ABA, (c) another set, treated as before but adding a buffer and finally (d) a group treated with the buffering agent alone.

In theory, the buffered solution should enhance and extend the effect of the treatment. We need trials to ensure the combination of two compounds has no deleterious effect.



All of the specimens have to grow at the same temperature and climate. We have to measure moisture uptake reasonably accurately.

The recent spell of wet weather means site trials are largely valueless.

*Arabidopsis thaliana* is the likely choice. It is a well known research species.

The life cycle is short - about 6 weeks from germination to seed maturation and seed production is prolific plus the plant is easily cultivated in restricted space.

As usual, any one with ideas of where we might cultivate the plants bearing in mind the need for rigorous controls and analysis, please contact us.

We will require photographic records of all groups taken every four hours and tight controls on watering so a remote site won't be attractive. Hopefully Richard will solve this but anyone with ideas, let him know.

richard.rollit@crawco.co.uk

# The Clay Research Group

We now have a suite of web applications for subscribers to use and for an initial period of one month and we welcome people to test.

First, the Triage application. On entering an address it returns the claim frequency, proportion of valid claims amongst them, the soil shrink/swell characteristics, the likely operating peril and a possible secondary cause.

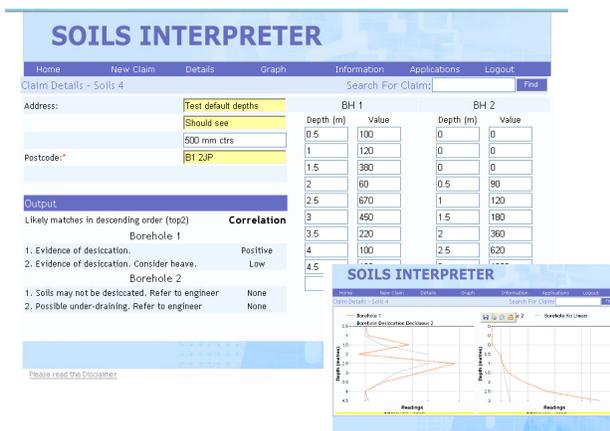
It also includes a limited script to help users. This provides an attribute of risk for the age of the house, alerts users to the NHBC/Zurich warranty on new houses along with several other prompts.



DataREADER interprets data from the new range of sensors using telemetry. This application retrieves data from the suppliers web site, graphs it and interprets it plus produces a report with just a few keystrokes by the user.

DataREADER both simplifies and speeds up the monitoring process, improving technical standards as well as helping the business.

The we have the Soils Interpreter. Enter soils data - suctions or strains - the application will help you recognise the difference between a desiccated soil, one with variable mineralogy, under-draining, anomalous filter paper results and undesiccated soils by using a pattern matching engine.



Graphical output is provided to check the match against the data.

Initially the results have to be entered by hand, but exchanging the data with your laboratory would be easy to arrange.



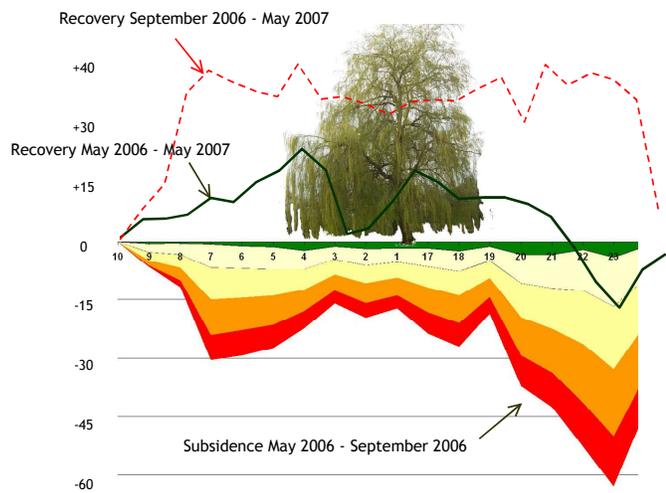
Finally, OSCAR. The One, Soils, Climate and Arboricultural Reporting tool. Bring your operation up to date by modelling from your desk. Go to site with the reports ready. Edit when you return. Back-office operation with training.

For access details, E-mail [ael@blueyonder.co.uk](mailto:ael@blueyonder.co.uk). These are available free for a short trial period but longer term use will be based on an initial subscription and then a 'pay per use' transactional charge.

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## Aldenham Willow

Below we see the ground profiles at the site of the Willow, showing the difference over time.

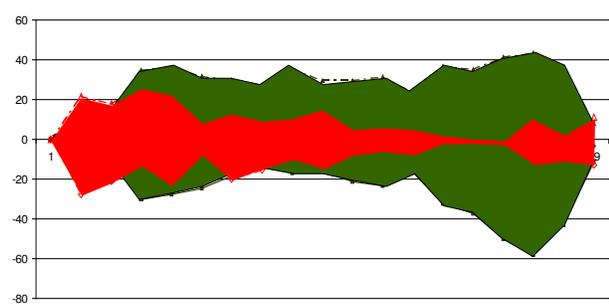


At Station 23 the ground is 15mm lower in May 2007 than it was in May 2006, which tells us the persistent deficit is increasing in this location.

The recovery to the left of the Willow (Stations 1 - 10, September 2006 to May 2007) of 40mm exceeds the subsidence that took place between May 2006 and September 2006, providing further evidence of a persistent deficit in May 2006.

Between May and June the deficit at Station 23 increased by 5mm to nearly 20mm even though it was one of the wettest months.

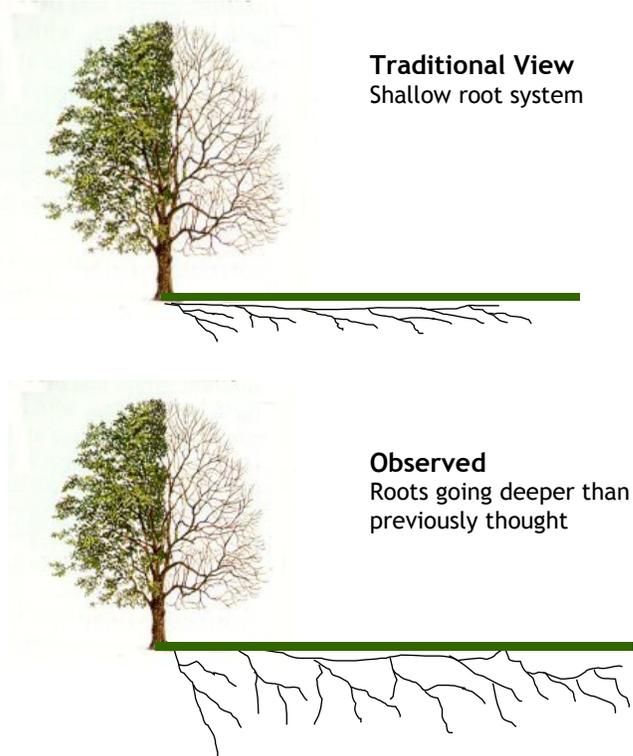
The coloured cumulative plot between May 2006 and September 2006 (the month when most downward movement was recorded) records subsidence exceeding 60mm at Station 23.



Above we record the envelope of difference between the ground movement surrounding the Willow (green shading - max 100mm diff.) and the Oak (red - around 40mm) between seasons. The Willow has caused significantly more ground movement, which we suspect reflects the fact that the persistent deficit beneath the Oak is greater.

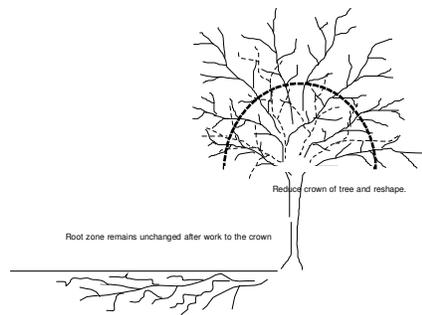
## ROOTING DEPTHS

The traditional view of plant physiologists is that trees have a fairly shallow root system that dry the soil 'top down' and the evidence of desiccation peaking at 2 and 3mtrs bGL came as a surprise.



We often discover roots at these depths in boreholes and the evidence provided by the Neutron Probe (Page 3) is clear. Some tradition concepts have to be challenged including root proliferation in soils with high strains which was previously thought to be an unsustainable environment.

It is now widely recognised that root systems can remain in place even if the crown is thinned or pollarded. This needs to be taken into account when using models like OSCAR and VISCAT.



Regeneration following tree surgery can often lead to vigorous root activity. Always use the mature, pre-reduction height when using these applications.

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## Technical Review of the Aldenham Data - Soil Testing

Disturbed soil samples were retrieved by MatLab Limited in May 2006 and tested using both the filter paper technique and the oedometer. In addition, moisture content deficits were recorded by Southampton University using the Neutron Probe throughout the latter part of the year. The purpose of the tests was to establish (a) if there was a reasonable qualitative agreement between the various methods, (b) if the oedometer test gave 'reliable' results when compared with the filter paper test and (c) if the modelled solution was reliable.

### Is there a Qualitative Agreement between the Various Methods of Testing?

There is generally a good agreement between the tests in detecting stress/moisture deficits. All methods registered highest stress/moisture deficits near to the tree, diminishing with distance from the trunk. The differences between them lies in the methodology.

### Does the Oedometer Test Deliver Reliable Results when Compared with the Filter Paper Test?

The results have already been published and we can see no qualitative or significant quantitative difference between the two methodologies. Both seem to deliver very similar results. The estimates of swell from the samples taken in May are reproduced below.

Both tests detected desiccation at similar depths. Both use similar methods in terms of sample disturbance and selection of the clay fraction from that sample. Both will probably over-estimate swell in variable soils containing bands/lenses of sands, silts or gravels.

### Is the Modelled Solution Reliable?

An assessment of reliability would require comparisons with several hundred trees on many sites in differing climatic conditions and it is impossible to arrive at a decision based on our work at Aldenham alone. The model suggested less movement than any of the tests as we would expect given the natural tendency of swell estimates to be conservative.

	<b>BH 1</b>	<b>BH 2</b>	<b>BH 3</b>	<b>BH 4</b>
<b>Oedometer (Strains)</b>	84	84	64	20
<b>Filter Paper Suctions</b>	71	76	62	21
<b>Modelled Solution</b>	69	55	34	18

When compared with the precise levels, the modelled values were similar. One drawback of the precise levels was the fact they could not take account of the ground shrinkage that had already taken place because of the persistent moisture deficit, whereas the model attempted to do this and was better in that respect.

Our view on the model at this stage is (a) the estimate of ground movement is probably more accurate than the laboratory test, (b) it is able to cater for a persistent deficiency if the worst case scenario is selected - that is to say, a very dry summer, (c) it can estimate root zone influence reasonably well if the mature height of the tree is used in cases where it has been pollarded.

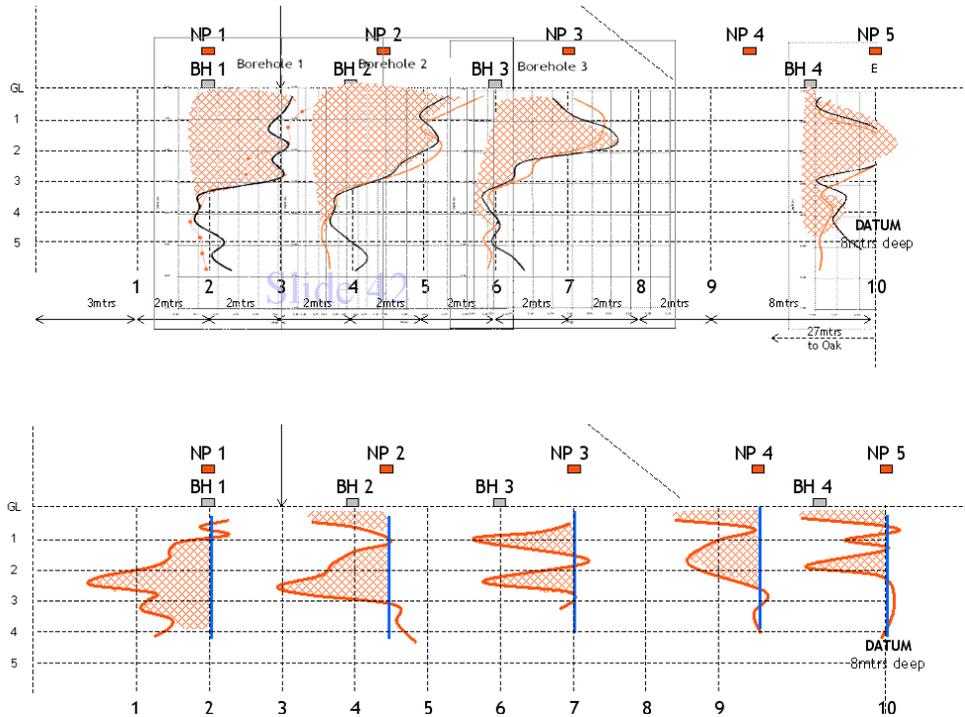
Crawford confirm their VISCAT application has been used for around 3 years and provides sensible values when compared with the results gathered from investigation and precise levelling.

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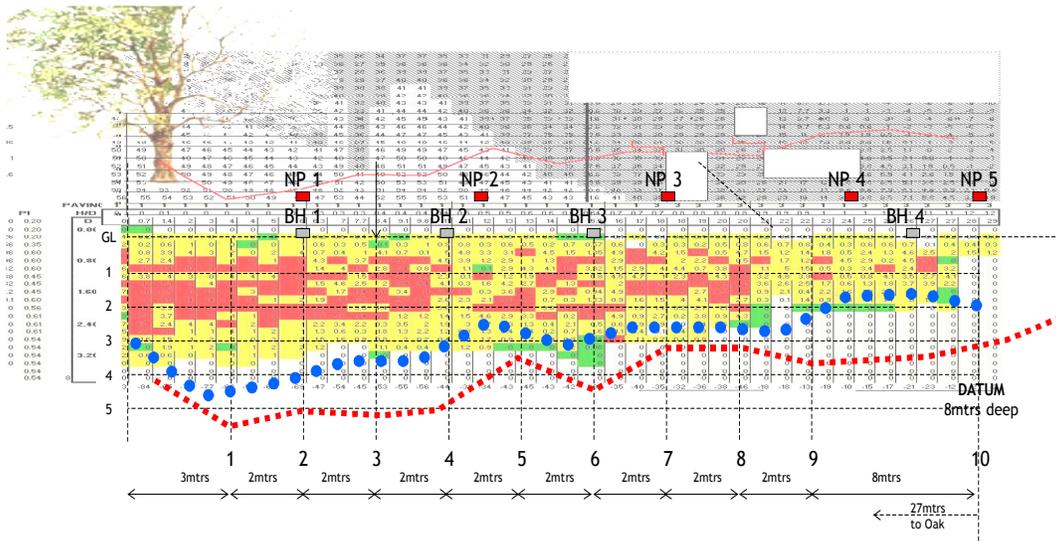
## Soil Stress Using the Neutron Probe, Filter Paper and Oedometer Test

The laboratory results from disturbed samples taken in May 2006 are shown along the top. The black line represents the filter paper test, and the red line, the oedometer results. We can see there is good agreement between them.

The lower row plots the Neutron Probe data from August 2007. NP 1 corresponds with BH 1, and although they have been sampled at different times, we can see a qualitative relationship. All methods detect soil stress/strains or moisture deficiency.



Below we see the precise level plot (red broken line), adjusted to take account of the deficiency (we have added the estimate of swell to the precise level values), against the estimate of ground movement using the disorder model (blue dotted line). There is good agreement given the fact that we are dealing with trees, climate and soils, and any difference wouldn't change the outcome although full investigations (and/or monitoring) are always recommended when (a) the geology is unknown from previous investigations, (b) in cases where the tree is mature and we suspect a persistent moisture deficit and (d) the pattern of distress is unusual.



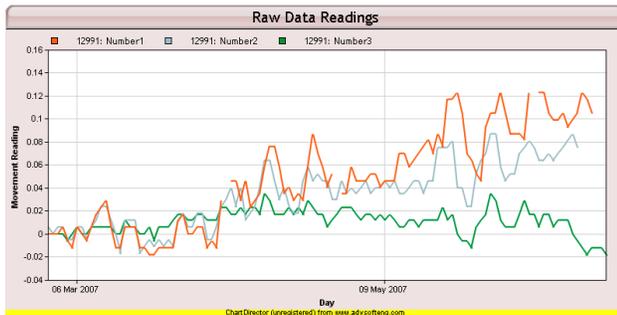
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## Electrolevel Case Studies

Below we have plotted 119 days worth of data from a claim where we have electrolevels installed.

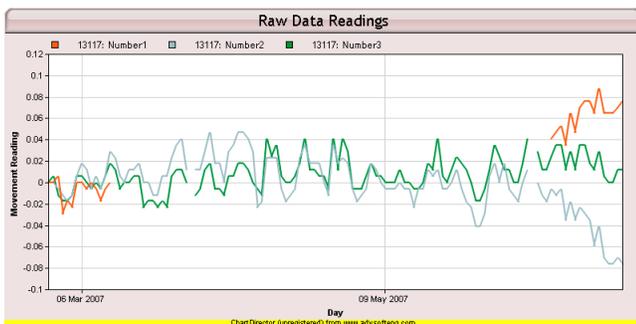
DataREADER tells us that Sensor 3 (green line) matches closest the root induced clay shrinkage peril with a probability match of 73%. The other sensors return a value of 44% and 45%.

We are also able to see the sensors are recording anti-clockwise rotation.



The recent rainfall has confounded the pattern matching algorithm a little, flattening the curve over the last month but this is just the sort of information we need to fine tune the interpretation engine.

There are also teething problems with the technology with signals dropping from time to time. This confuses the interpreter although it uses statistical techniques to overcome most of the problems by sampling from specific threads.



Above is another example. Sensor 1 (red) has a 99% chance of being a root induced clay shrinkage, Sensor 2 (blue line) 87% and the Datum (green line), only 15%.

This diagnosis has been made in spite of the fact we have a dropped signal on Sensor 1 (red) for a prolonged period of time.

In terms of 'structurally significant' movement, Sensor 1 has recorded 0.117, Sensor 2, 0.141 and the Datum 0.064, which fits in with our suggestion that 0.1 might be regarded as the rotation that signals onset of damage.

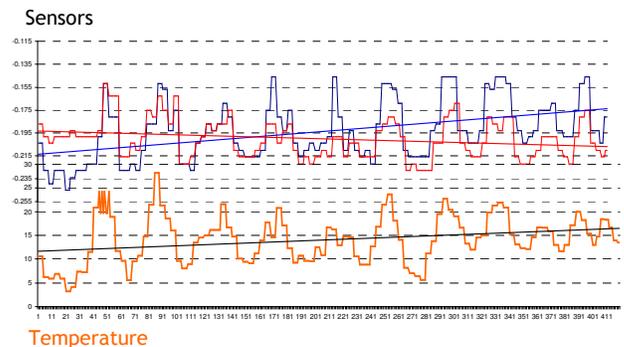
## Retaining Wall - Case Study

In Edition 24 we featured an actual claim relating to monitoring of a retaining wall on a sloping site. Below we reproduce the latest readings, with the sensor data plotted above the temperature readings.

There is a good correlation between the slope of the linear trendline for the 'blue' sensor and temperature, indicating any movement that is taking place is temperature driven, even to the diurnal fluctuations.

The 'red' sensor is moving in a different direction, even though it has the same orientation. We believe this reflects the 'snake-like' distortion associated with the absence of a movement joint in a wall over 15mtrs long and variable restraint conditions.

In summary, the two sensors are rotating by the same amount and the movement is related to temperature - so far at least.



We believe the temperature record is essential when reviewing data from the electrolevels as we see here. Reviewing the data without them might lead someone to conclude there was structural movement that warranted remedial work.

We will report on progress throughout the year.

### MONITORING

Giles Biddle pointed out that crack monitoring is probably the least effective technique for determining subsidence at the conference at the IET in London last month.

Crack monitoring doesn't distinguish between thermal and foundation movement. It provides only the broadest view that movement is taking place.