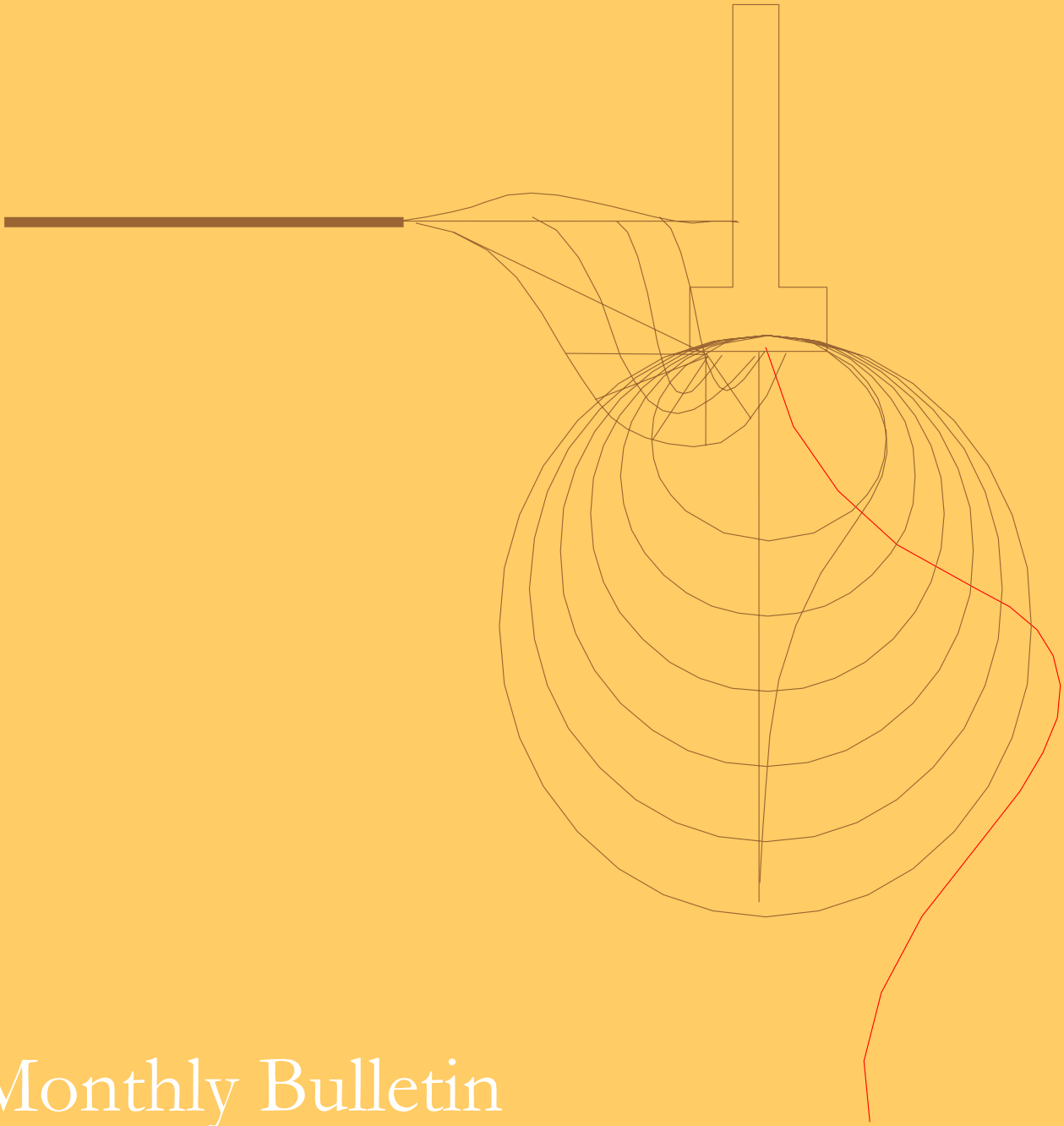
The Clay Research Group



Monthly Bulletin

The Clay Research Group

www.theclayresearchgroup.org

November 2006.

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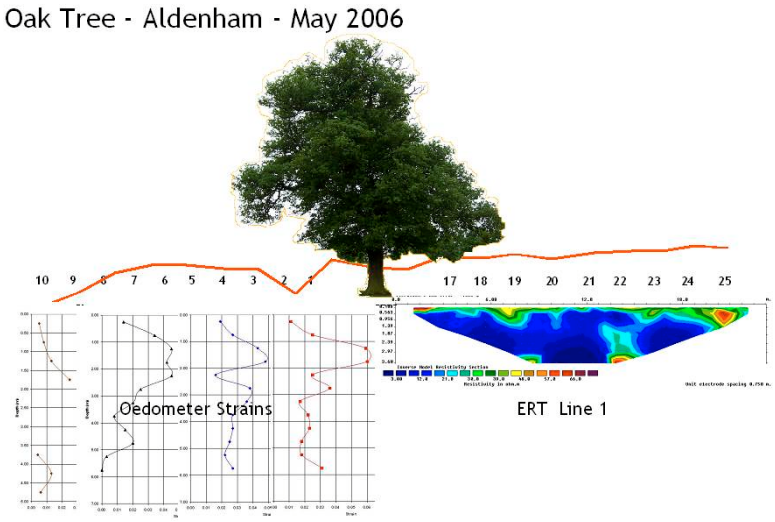
Breaking News

Hilary Skinner is leaving The Building Research Establishment to take up employment with consulting engineers Whitby Bird, which is good news for them, and appalling news for us.

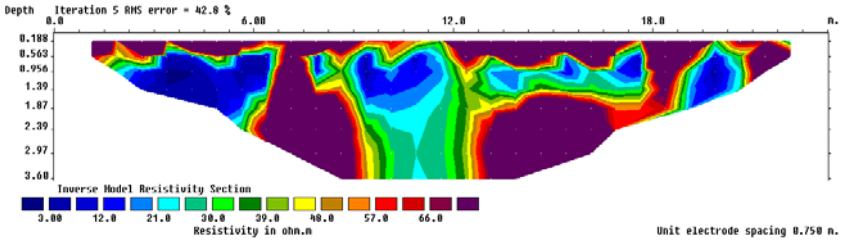
No doubt she will be back soon, begging to re-join the CRG and we will have to pretend to give this serious consideration before accepting her application, but in the meantime, our very best wishes.

Combining the Data

Below is an image combining the ERT data, precise levels and soils results (strains) from bores sunk in May.



We now have a moving image of moisture change by month, from April, throughout the summer and the associated ground movement. Below is the September ERT image from array 2 of the Oak and we see the resistivity changing from a saturated mid to dark blue (May) to a deeper purple, as we would expect as the ground dries.



Telemetry

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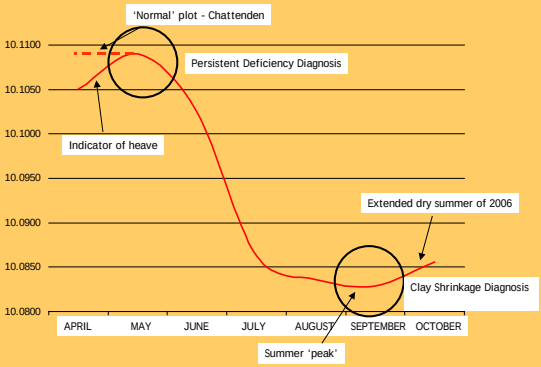
So What?

As interesting as the ground monitoring and imaging is – and we can certainly see the benefits of precise levelling over other means of assessing desiccation – our objective at Aldenham is to research ways of shortening the whole process. We are looking at ways of reducing cost by gathering more data, of a better quality, quicker.

We have characterised the signatures of various failure patterns and causation can be determined in a very short period of time. 2 months if the electrolevels can be installed quickly enough.



The web based interpretation application identifies root induced clay shrinkage by identifying small amounts of movement over short periods of time and uses the data 'in the alternative' – where we don't see this pattern, then clearly it will be something other than seasonal movement.

We have already seen the benefits of tracking movement by the hour or by the day.

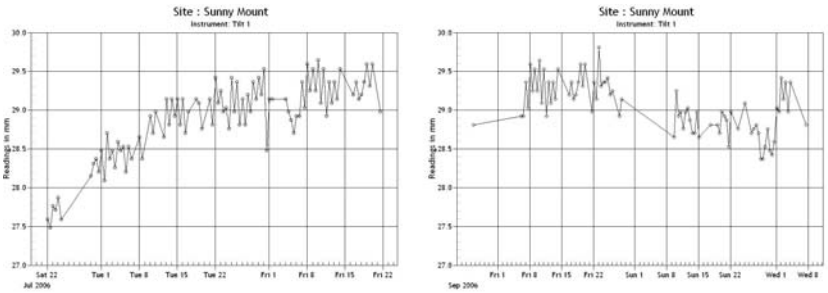
Waiting two or three months between readings, missing the point of contraflexure and the inability to produce meaningful trend lines in a short period of time reduce the value of traditional methods of monitoring.

The new style sensors are much smaller units, housing the battery, electrolevel and wireless technology in a small, self-contained unit.

Test switches make sure the system is working and transmitting data before leaving site.

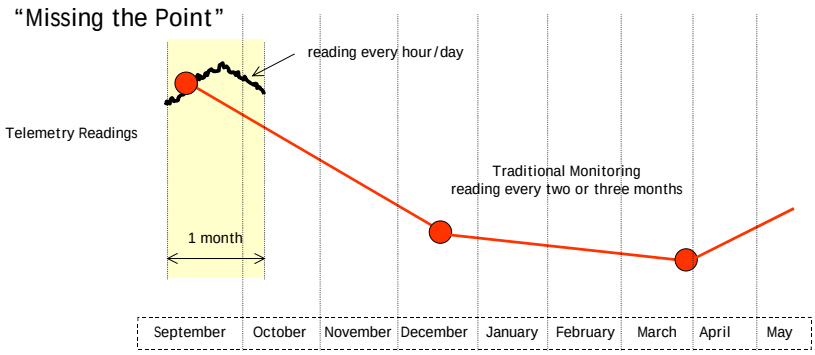
Telemetry Reduces Monitoring Cycle by 3 - 9 Months

Remote monitoring data is coming through regularly, and we see below how movement peaked in September, and is now entering the recovery phase.



The technology has proven to be robust, transmitting information with very few lapses, recording the crucial point of contraflexure and allowing diagnosis to be made much quicker than might otherwise be the case.

The traditional technique of taking readings every 2 or 3 months leads to the situation we see below (red line), where we might take readings before or after the event, missing the onset of the recovery phase (black line). In this sort of situation we can see how telemetry would cut 3 to 9 months off the diagnosis period.



From the commercial point of view, the technology is cheap and reliable, saving both time and unnecessary disruption.

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Clay Research Group Resume

The Clay Research Group is a 'virtual' research body in the sense it is a grouping of like minded individuals who share an interest in the study of climate change, moisture movement in fine grained soils and the interaction between trees and ground movement.

Academic members include Prof. Powrie, Dr Derek Clark, Dr Joel Smethurst, Dr Nigel Cassidy and Glenda Jones. In addition, Hilary Skinner is/was acting as a reviewer – see Page 1. Most adjusters and insurers subscribe or receive our newsletter.

We have a research site in North London at Aldenham School where we have instrumented a mature Oak and Willow tree.

The CRG have produced a series of risk models for clients as well as introduced electrolevels to the domestic claims industry at a sensible price along with enabling technology.

The research topics we cover include …

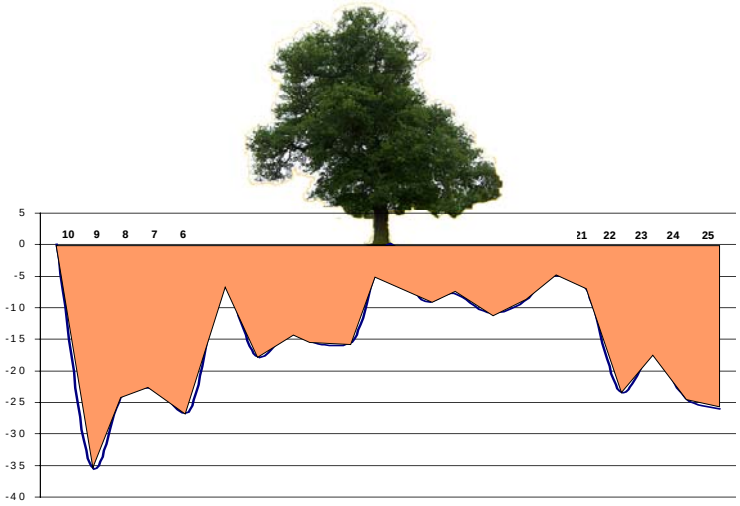
- Electrical Resistivity - imaging moisture movement below ground.
- Telemetry - delivery of data output via the web from a range of remote sensors.
- TDR sensors - measuring ground moisture and temperature change every day over time using telemetry.
- Precise levels - we have over 40 stations where we measure ground movement in the root zone of the Oak and Willow trees.
- Root imaging using radar.
- Samples - disturbed and undisturbed - are retrieved and tested in a variety of ways. Filter paper, oedometer, moisture …
- This year we hope to explore electrokinesis. Moving moisture and particles from one place to another.
- Neutron Probes are installed to measure volumetric moisture change.
- There is a weather station on site.
- We are also building applications to model moisture change/soil strains/ground movement in relation to a variety of trees, climate and ground conditions.
- We are working in the area of BioSciences to better understand how trees work, and if there is any intervention procedures that might alter their behaviour.

The objective is to improve our understanding of how moisture flows through the ground in relation to tree root activity and climate to improve the quality of the data we receive and the frequency, allowing us to measure change over a period of time cheaply and from our desk.

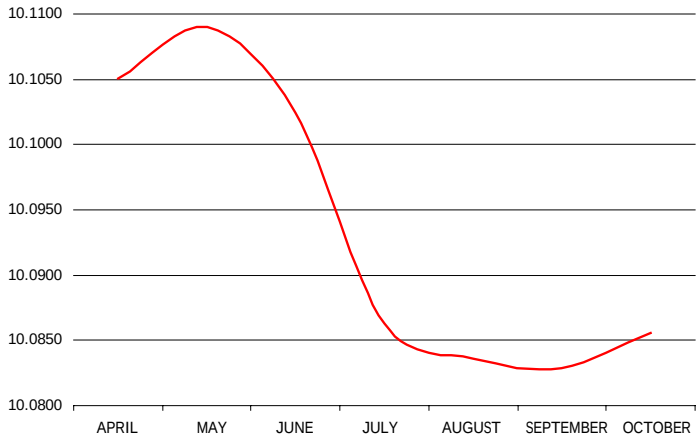
Ground Movement

Below we have plotted the maximum ground movement between the extremes – 25/05/06 and 28/09/06 on this particular site. Station 9 has subsided by about 35mm at the root periphery.

The datum (Station 10) is 8mtrs deep and has been sunk in a primarily sandy gravel strata.



Plotted 'by station' over the period April to October, the movement is shown below. Most stations follow a similar pattern; it is the magnitude that varies. The pattern follows that already graphed by the B.R.E. at Chattenden, following on the excellent work of Mike Crilly , Richard Driscoll, Tim Freeman and others.



We can detect the 'peak' around September and the prolonged dry summer of 2006 is revealed by the duration of the flattened curve from August through to October.

Telemetry & ERT

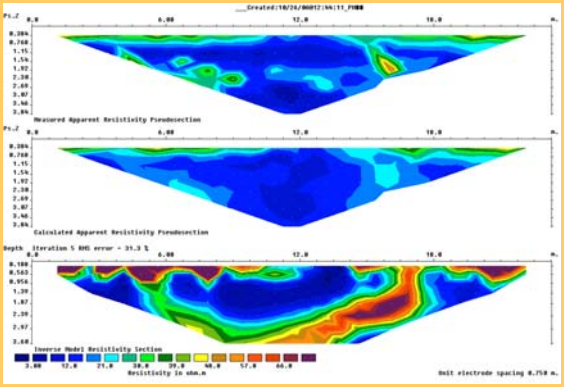
Glenda Explains ... ERT Images

The ERT results display 3 images. The first (top) is a pseudosection that plots the measured apparent resistivity data acquired in the field.

The measured apparent resitivity is not the true resistivity as it is a value which is derived assuming the subsurface is homogenous which is highly unlikely in reality. Hence the term apparent.

A plot of these apparent resistivity values is therefore referred to as a pseudosection and primarily shows the spatial variation in resistivity. Pseudosections also contain geometrical distortions which vary significantly depending upon the type of electrode array used - in ERT surveying, different resistivity electrode arrays have different benefits dependent on what it is you are trying to survey.

In order to produce an image showing the true depth and subsurface resistivity, and remove geometrical distortions an inversion must be carried out.



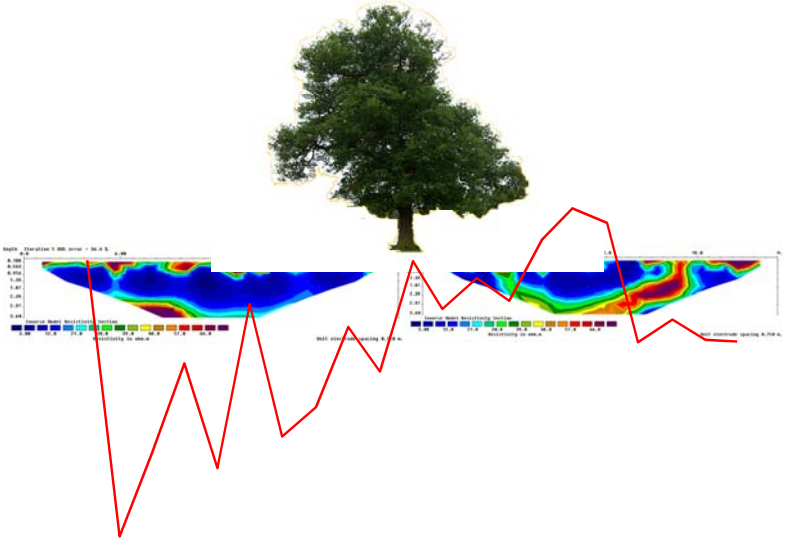
Top Image = Measured PseudoSection
Middle Image = Calculated PseudoSection
Lower Image = Inversion

Inversions are a form of data processing which essentially tries to find a model for the subsurface by matching output data from the model to the measured field data giving an inversion model which can then be used for interpreting the subsurface (the bottom image of the 3 displayed in the ERT results is the inversion model).

The second (middle) image is the pseudosection computed from the model to be used for the inversion process (once again not an image of true formation resistivity).

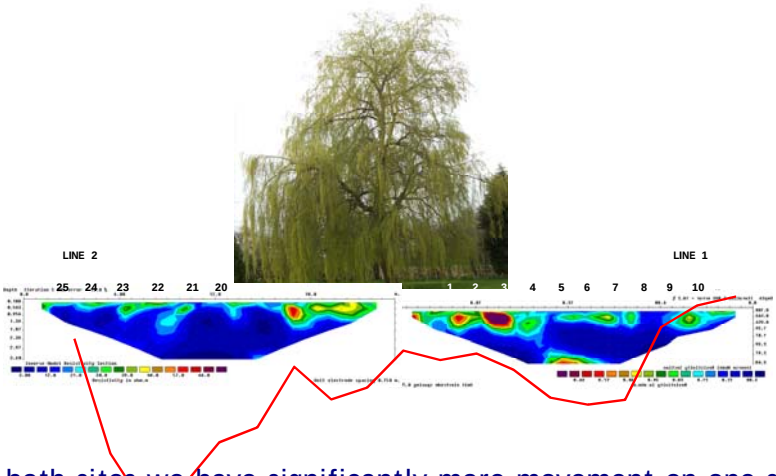
October 2006 ERT + Levels

We are recording recovery in the level readings taken towards the end of October, with Station 21 of the Oak array actually rising above its starting position, confirming the presence of a persistent deficiency.



Station 21 has always been a 'high spot', moving less than its neighbours and we see in the ERT values the dark blue associated with rehydration in this location, and immediately to the right of this, at Station 22 and 23, the oranges and reds associated with dry soil where the levels confirm greater subsidence and slower recovery. Maximum movement recorded was 34.8mm at Station 9.

Below we see the profile at the Willow site, with maximum movement of 42.7mm at Station 23.

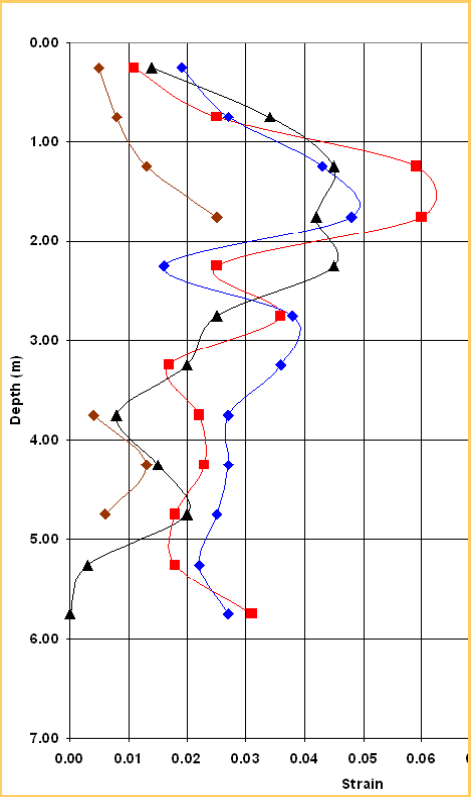


On both sites we have significantly more movement on one side of the root zone when compared with the other.

Modelling

Soils Prediction

Below we reproduce the results from the investigations undertaken in May 2006. They confirmed a persistent moisture deficit and provided an estimate of swell on expiration.



The estimate of heave was 76mm using the filter paper method and about 80mm using the oedometer. Estimates of heave are often conservative, and the modelled value of 50 - 70mm is probably more realistic.

The interpretations below are outside of UKAS accreditation.

Heave Potential Analysis :-

Total of Column dh (potential heave increment per layer)

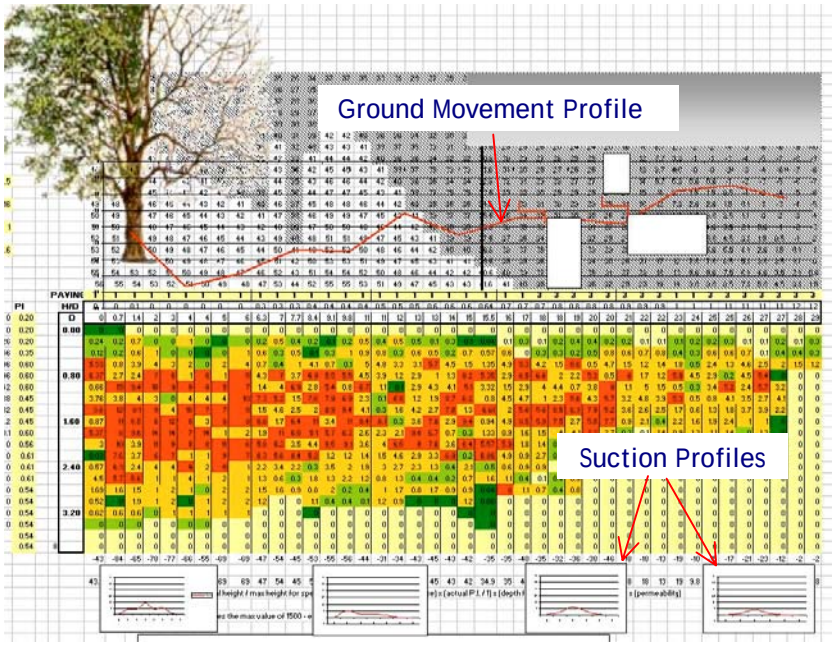
Is Approx. : 76 mm.

The soils data for both the Oak and Willow were similar.

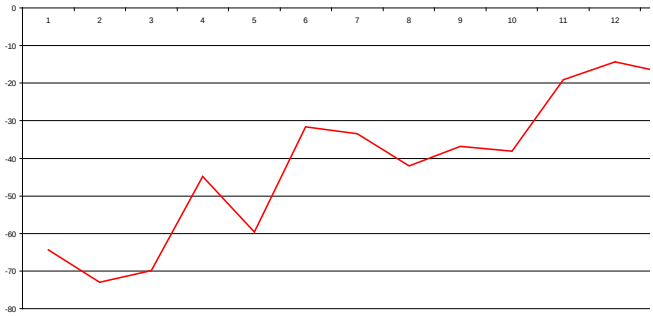
Modelling takes about 20 minutes and can be done from our desk. It costs far less than visiting site, digging holes and testing soils. The output is, for most routine cases, as good if not better than soil testing and we recommend it for straightforward, uncontested cases.

The Model -v- Real Life

Running the model using the species Oak, a dry summer and entering the tree height (16mtrs) and the soil P.I. (50%), we have produced a modelled output (below) and a ground movement profile along with suction profiles.



The model estimates ground movement of between 70mm close to the tree, reducing to less than 20mm or so at its 'root influence zone' periphery and below we have extracted the ground movement profile from the image above to clarify this.



This model would apply equally to the Oak and Willow as high risk species.

In the knowledge we have a persistent moisture deficit on both the Willow and Oak sites, we can see how useful the model has been. It suggests that on expiration of this deficiency, we should measure about 70mm of swell. This coincides with the estimates from boreholes and soil testing undertaken in May 2006 – see test results, left.

In short, the application has modelled the real world remarkably well.

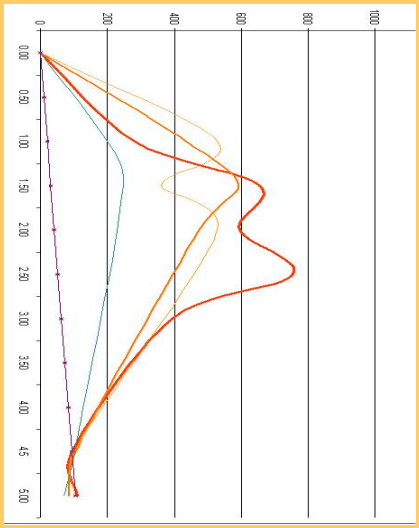
Neutron Probe & TDR Data

November 2006.

Modelling Suctions

What do modelled soil suctions look like? If they are to be effective, the output should resemble the results of 'real' tests. We should see irregular lines (as previous page), peaking at variable depths depending on the degree of root activity, climatic influence, tree species and soil type etc.

See graph below. Here we have modelled the negative porewater pressures for an 18mtr high Oak tree, in the summer, for a soil with a Plasticity Index of 60%.



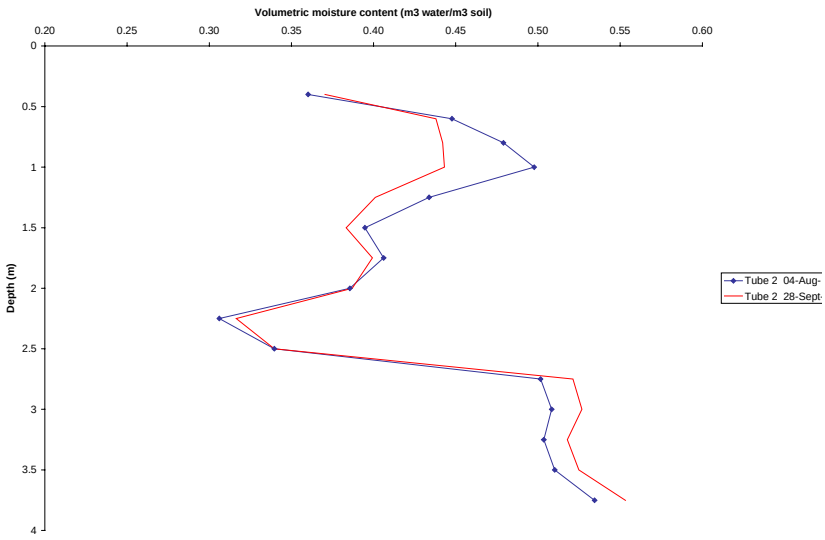
The graphs show a series of possible profiles at 6, 9.5, 15 and 25mtrs from the tree.

The depth of peak activity below ground level varies and we see something of the variable mineralogy on the red line. The Ko line is shown to the left of the image.

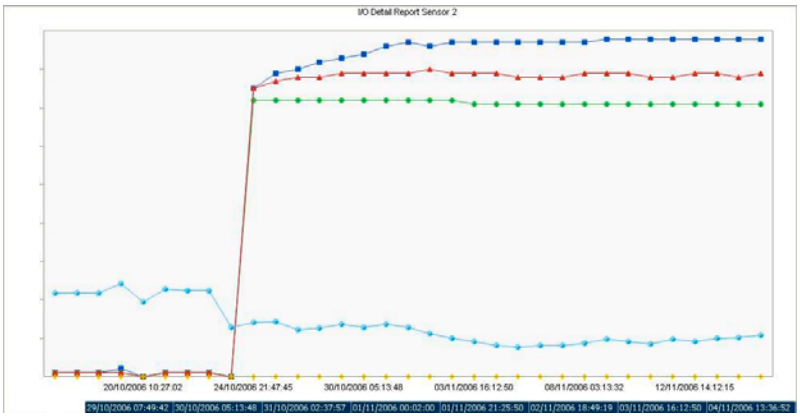
Disorder reflects the natural world. Climate, trees, soils are all in a state of disorder, and the model needs to reflect this uncertainty.

August –v- September

We reproduce below the extremes measured by Southampton University using the neutron probe at Station NP2 (top) and illustrate the graph from the newly installed TDR sensors (bottom).



Below is the readout from the TDR and temperature sensors, received via the web. We can see the unit was live on the 24th September 2006, and the first reading was taken at 21.47 hours.



The temperature dropped from a starting point of 13.75 degrees in the office environment, to less than 8 degrees or so on site and the moisture content of the ground is rising steadily from 41% to 43.5% expressed volumetrically.

Further calibration is needed, which is why the sensors have been situated near to the Neutron Probes.