# The
# Clay Research Group

RESEARCH AREAS

Climate Change : Data Analysis : Electrical Resistivity Tomography
Time Domain Reflectometry : BioSciences : Ground Movement
Soil Testing Techniques : Telemetry : Numerical Modelling
Ground Remediation Techniques : Risk Analysis
Mapping : Software Analysis Tools
Electrokinesis Osmosis
Intelligent Systems


Edition 143

April 2017

# The Clay Research Group

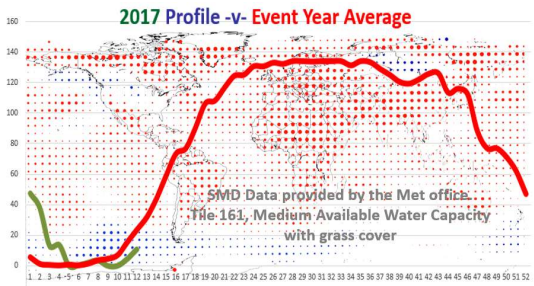
## CONTENTS

Edition 143, April, 2017



## Soil Moisture Deficit

See page 12 and 13 for weather-related research and predictions. Met Office report says "It has been a dry winter, with the UK receiving 76% of its average seasonal rainfall."




THE CLAY RESEARCH GROUP
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## Aston Conference

Suggestions welcomed for speakers and topics for the Annual Subsidence Conference at Aston University. This CPD course provides an excellent venue to exchange ideas and meet colleagues.

Will anyone wishing to deliver a talk please send a brief resume to the Email address shown bottom left.

## Modelled Root Zone

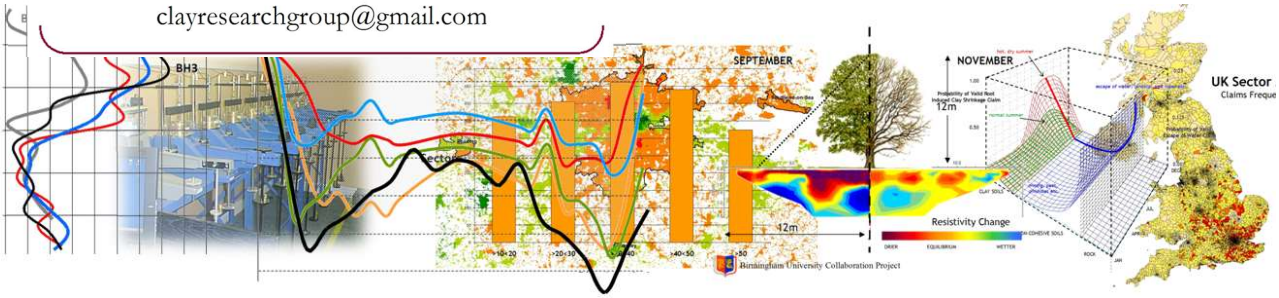
This month we compare modelled root overlap zones with subsidence risk. Three postcode areas are examined to see if there is a correlation, and if there is, is it meaningful?

## Intervention Technique Patent

Innovation have been granted a patent for the Intervention Technique. The application took just over four years to consider and one of the conditions is that details were not widely publicised in the process.

Independent verification is now being sought and we are asking experts from our industry to set up trials. As we have level monitoring over a 10 year term at the site of the Aldenham willow, this may be an ideal location – subject of course to what the experts determine.

The technique has already been used on over 100 claims by Innovation to resolve root induced clay shrinkage claims. The tree has been retained in all instances and none have required foundation strengthening. Go to page 8 for background article.



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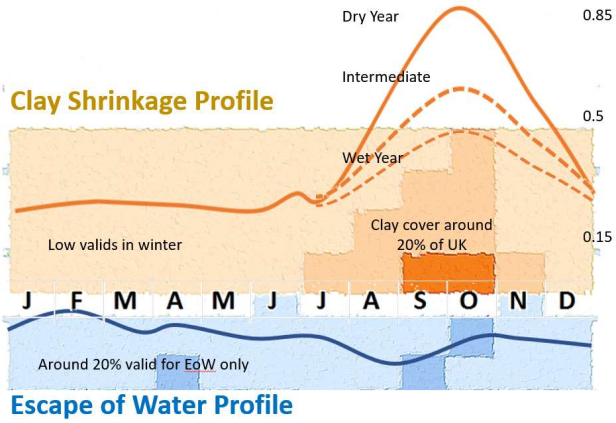
## Historic Signatures by Postcode Sector

When a claim is notified, an $A_i$ system will refer to the historic claim profile for the postcode sector in terms of (a) numbers by month of notification and (b) the percentage of valids.

In the past, have there been a steady number of claims of nominal cost throughout the year (blue line in diagram below) with a low number of valids? Or did claim numbers peak in the summer with a high percentage (compared with the UK average) of valids, and were they more expensive to settle (orange line)?

In an average year across the UK, valid claims are likely to account for around 50% of the total received. In a dry year, this increases to around 80% or so, predominantly driven by numbers in the south east on outcropping clay. In the winter, the percentage of valid claims falls to around 20%.

If notifications are consistent and low in number throughout the year (blue), the most likely cause is EoW. If claims peak in the late summer (orange), then clay shrinkage is the likely peril.




*Diagrammatic showing profiles for claim profiles indicating likely cause and probability of being valid for two perils indicated.*

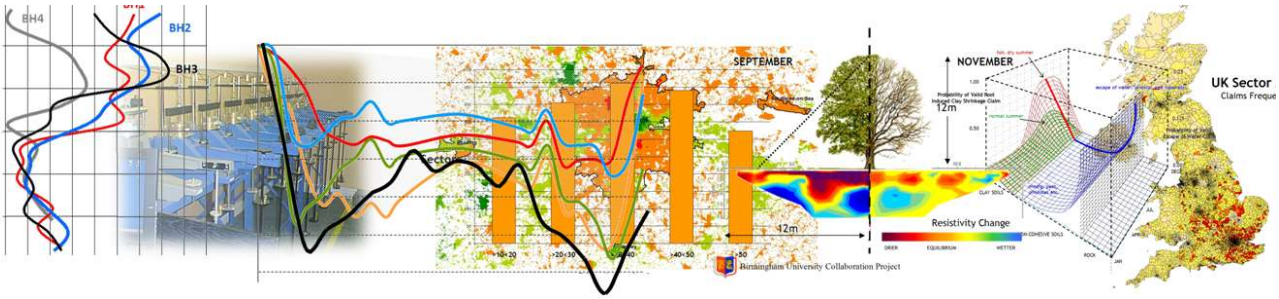
This is a low cost, easy to develop application that delivers valuable information immediately on postcode entry. The output reflects the geology and weather and inferences about risk, demographics, property age and style. It also serves to direct further enquiries and investigations.

## Artificial Intelligence Takeover

A report by Price Waterhouse Cooper (PwC) entitled "Will Robots Steal our Jobs?" has concluded that 38% of jobs in the United States will be replaced by robots and artificial intelligence by the early 2030s.

They suggest that 61% of jobs in financial services are at risk of a robot takeover in the USA compared to 30% of jobs in the UK (or 32.2% to be accurate), 35% in Germany and 21% in Japan.

One of the most secure employments is in the erection of flat-pack furniture.



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## Vulnerability of Property by Age of Construction

Revisiting "Subsidence Damage to Domestic Buildings" by Driscoll and Crilly, we came across the following graph showing susceptibility ranking by age of property. Comparing the number of claims by age of property and comparing the output with the number of properties built in each period, it can be seen that the risk is diminishing over time, predominantly no doubt as a result of deeper foundations being adopted.

Right, Figure 9 from "Subsidence damage to domestic buildings", by Driscoll and Crilly, published by the BRE in September, 2000.

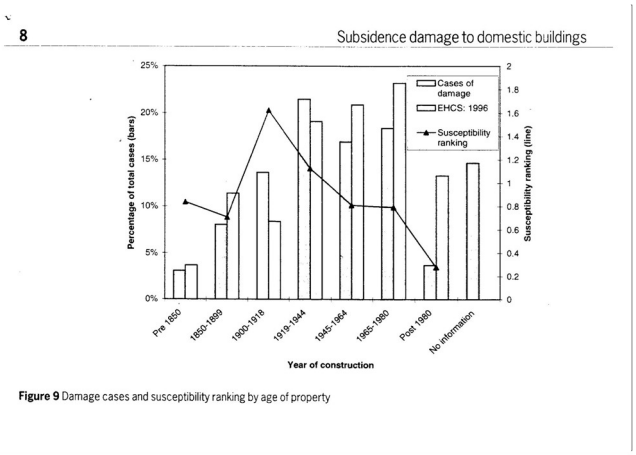
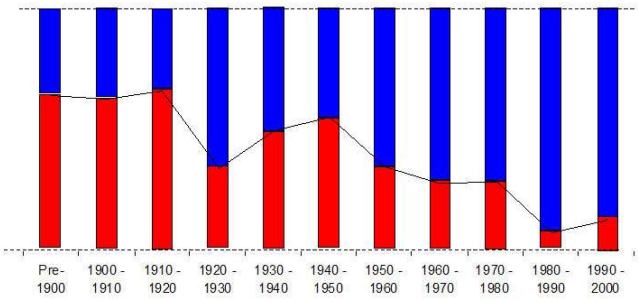



**Figure 9** Damage cases and susceptibility ranking by age of property

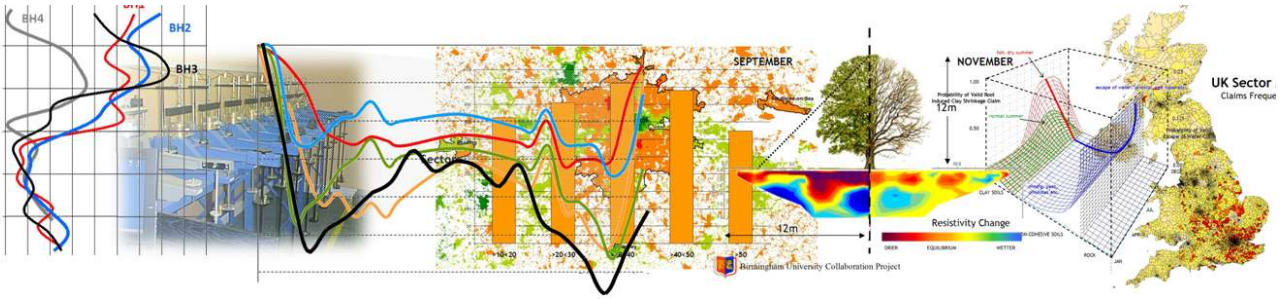
Below, the 'risk by age' graph that appeared in the CRG Newsletter 32, November 2007. Our study, undertaken using a larger sample, revealed a similar pattern.




Spot the difference.

There isn't one. Or at least, no difference worthy of note. Both show that risk increases with age of property. The CRG graph aggregates pre-1990 properties whereas the BRE version breaks down the ages into pre-1850 and 1850-1899, but otherwise the findings are very similar.

To clarify, the CRG graph above plots the risk on a normalised scale – otherwise, the 'houses at risk' value wouldn't be visible. Whilst there are different housing populations for every year, the total is shown on a standardised scale of 0 – 1. In contrast, the risk value is stretched to illustrate the difference clearly.



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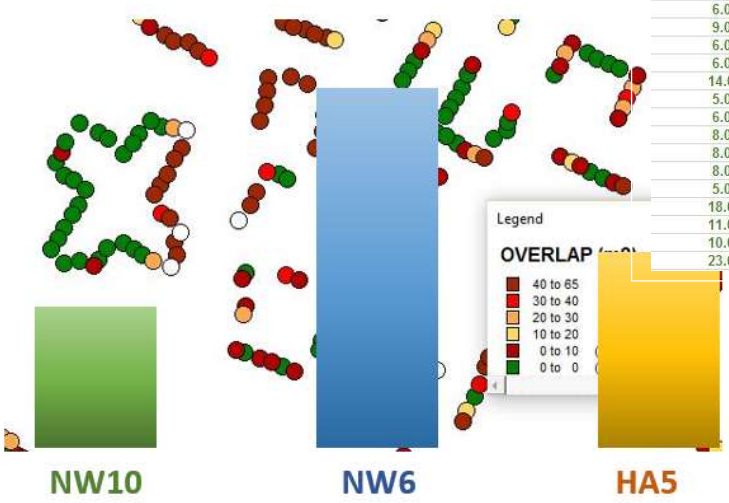
## Subsidence Risk and Modelled Root Overlap

On the following pages, three postcode areas are compared in terms of their risk rating based on historic claims (expressed as frequency) and percentage root overlap (based on modelled data).

Is there a correlation between the two? Are areas with higher percentage of 'no root-overlap houses' safer than those with an overlap, and if not, is there any obvious link with a particular percentage overlap? If the latter is true, and we have no data on species and health etc., is the link something to do with engineering properties and how buildings respond?




| MAX_HGT | OVERLAP | PER_OVER | SOIL_PI |
|---|---|---|---|
| 15.00 | 50.62 | 19.29 | 0.50 |
| 6.00 | 13.95 | 19.32 | 0.51 |
| 9.00 | 16.77 | 19.32 | 0.50 |
| 6.00 | 11.76 | 19.33 | 0.52 |
| 6.00 | 11.76 | 19.33 | 0.52 |
| 14.00 | 24.35 | 19.33 | 0.55 |
| 5.00 | 7.99 | 19.34 | 0.47 |
| 6.00 | 17.70 | 19.36 | 0.49 |
| 8.00 | 17.65 | 19.36 | 0.50 |
| 8.00 | 17.65 | 19.36 | 0.50 |
| 8.00 | 17.65 | 19.36 | 0.50 |
| 5.00 | 14.19 | 19.36 | 0.51 |
| 18.00 | 21.56 | 19.37 | 0.50 |
| 11.00 | 22.21 | 19.37 | 0.53 |
| 10.00 | 21.98 | 19.38 | 0.52 |
| 23.00 | 19.29 | 19.38 | 0.47 |

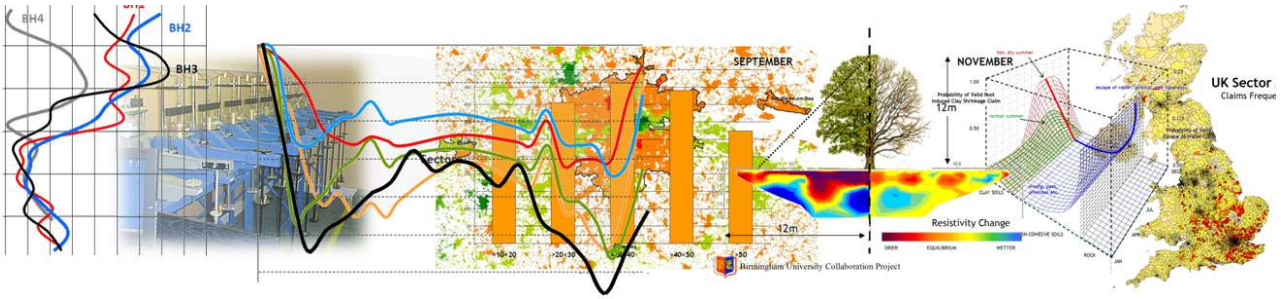
*Above, an extract from the table underlying the model listing the height of a tree within influencing distance of a house built on clay, root overlap (expressed in sq mtrs or a % f the floor plan) and the soil PI on a normalised scale.*

*Left, postcode frequency ranking in terms of the number of claims divided by the housing population.*

This is a topic that will annoy many experts from several fields, and understandably so. The idea we can 'bottle' the experience of qualified exerts with many years experience might be seen as offensive, but that isn't the objective.

The exercise is based on developing our understanding of the interaction between damaged houses and their environment with a view to improving service delivery and cater for surge events. It also acknowledges the future will bring change, and hopefully analytics will deliver an improved understanding of the topic.

On the following pages we seek to see if there is a pattern linking risk with root overlap profiles.



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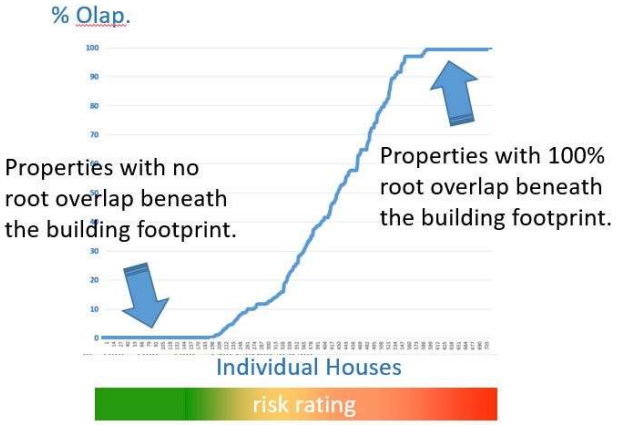
## Modelled Root Overlap and Risk of Subsidence




A note about how the graphs have been prepared.

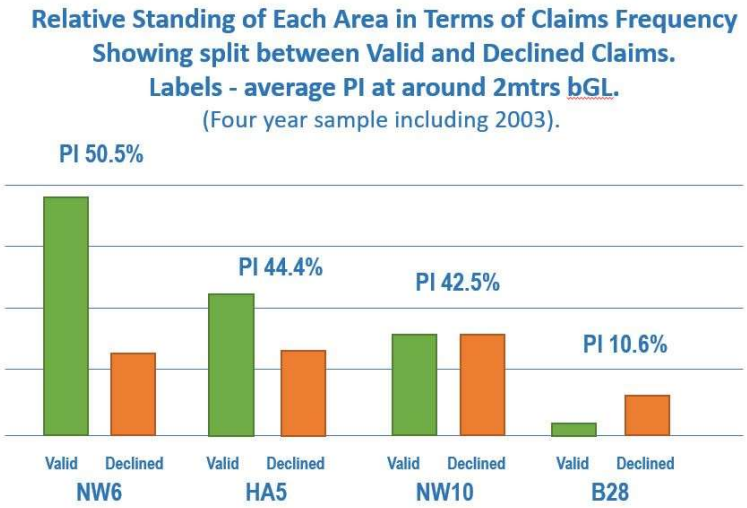
Left, the distribution of modelled root overlap beneath buildings within influencing distance, and on clay soil, for each of the postcodes noted.

Below, bar chart summarising the risk for each postcode showing the ratio of valid to declined claims and the average PI.

In addition, a postcode from the Birmingham area has been included to show the relative standing compared with the three London codes.

NW6 presents by far the highest risk – nearly double that of HA5 and 2.5 times the risk of NW10 – in respect of valid claims.

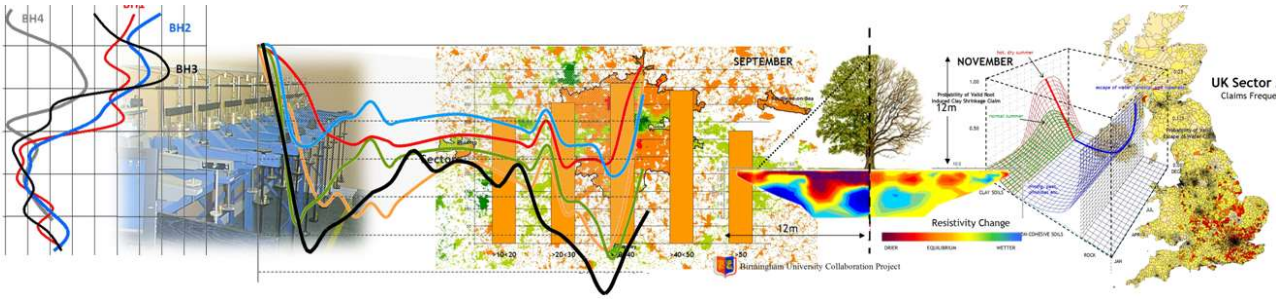
It also stands out as a postcode where, when a claim is received, it is far more likely to be valid than the others.




*Number of claims for each postcode (distinguishing between valid and declined), and the soil PI. NW6 is the riskiest of the group with more valid claims.*

Of course, the fact that there is a correlation between modelled tree root overlap and risk doesn't mean that overlap is by itself the causative factor.

Species, metrics, maintenance regime, soil shrinkability and building age and style of construction are all important contributory factors.



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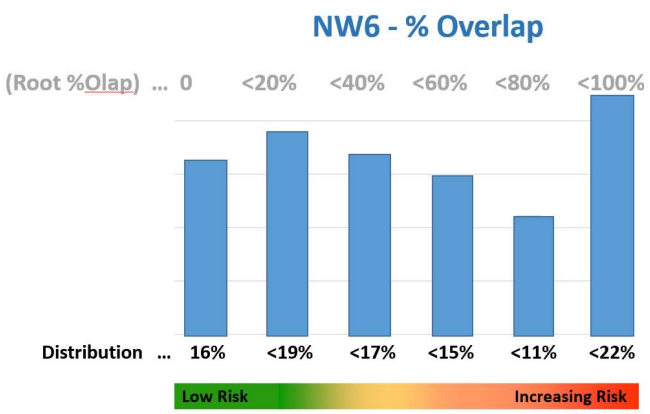



## NW6

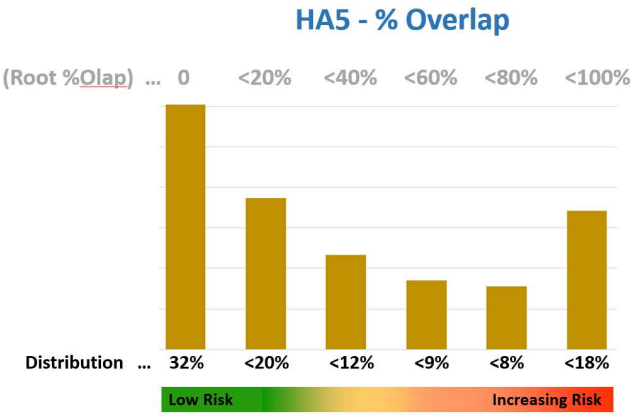
### Risk Rating = 0.039252

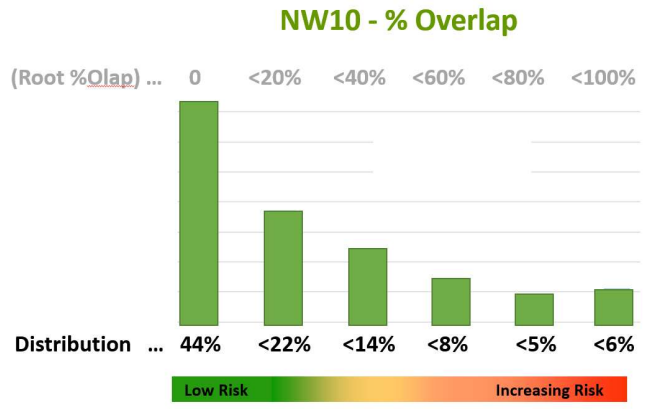
The riskiest of the three areas considered. NW6 is judged (on the basis of a claim sample exceeding 100k) to be 1.8 times riskier than HA5 and 2.5 times riskier than NW10. Is there anything about the modelled root overlap distribution that might account for this?

## HA5

### Risk Rating = 0.02153

HA5 distribution has a greater number of houses with no root overlap, and fewer houses with 100% overlap compared with NW6.



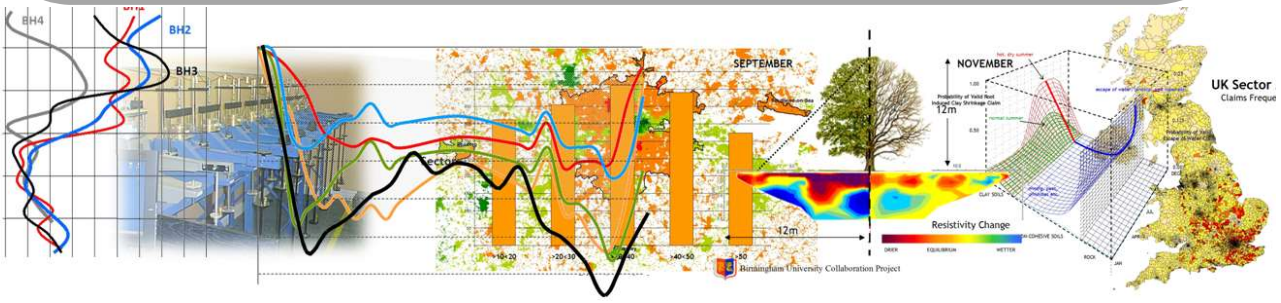




## NW10

### Risk Rating = 0.015582

NW10 has the highest count of houses with no root overlap. NW6 has 16% with no overlap, HA5 32% and NW10 44%.

It also has fewer “100% Olap” at 6%, compared with 18% (HA5) and 22% (NW6).



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## TDAG Update – Future Proofed Foundations and Crown Reduction Update

Sue James has circulated the notes of a TDAG meeting held on 23rd March at the Royal Horticultural Society which contained the following:

Neil Hipps confirmed that the Subsidence Forum had his report on crown reduction and water uptake.

Anne Jaluzot represented TDAG at a Subsidence Forum meeting last October and made a presentation in which two questions were put:

1. Should exploring potential alternative solutions to help reduce tree related subsidence in new build be the focus of a new Subsidence Forum Subgroup?

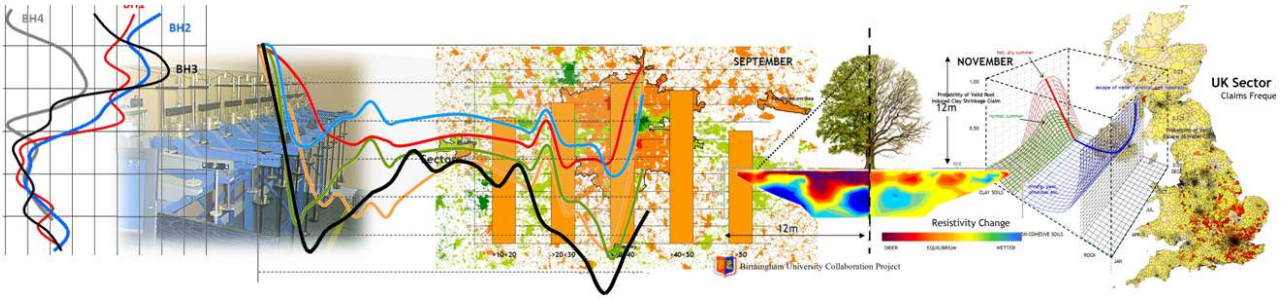
2. Should insurance premiums be lower for low-rise buildings with more 'future proofed' foundations?

Membership of TDAG by the Subsidence Forum as an organisation is on the AGM agenda for 18th May and Jim Smith will attend the meeting for TDAG.

Loosely connected to these topics, Keiron Hart forwarded a press cutting from a 2016 press article reporting that, in response to a request from a local media outlet, Reading Borough Council in Berkshire revealed that in the 2014/15 financial year it paid out damages for two subsidence compensation claims of £39,000 and £26,000. The top two claims for 2013/14, again both relating to subsidence, were for £6,700 and £4,820.

London boroughs on clay soil will have paid out considerably more – in some years the figure far exceeds £1m. Responsible planting, long term maintenance and how owners and their insurers react when notified of possible tree root damage are important issues both in terms of environmental impact, budgets, handling subsidence claims and the distress to individuals whose home is the subject of root induced clay shrinkage.

In next month's edition we explore the data and try to determine the scale of the problem, the real risk posed by trees, irrespective of ownership and explore the alternatives being considered by TDAG.



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## Intervention Technique – Grant of Patent

The objectives of the Intervention Technique are to (a) stabilise properties that suffer minor but recurrent damage as a result of root induced clay shrinkage and (b) retain the tree.

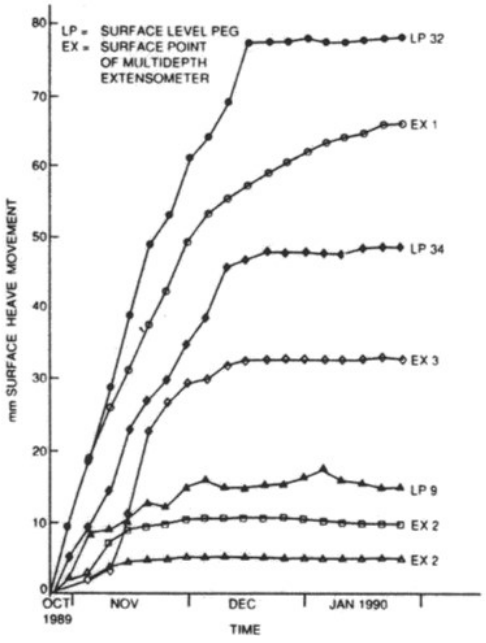
The approach is environmentally friendly, and may be regarded as an alternative to root barriers and underpinning for a certain class of claim.

In due course, we hope it may lead to a 'see and fix' method of resolving what can otherwise be complex claims with a long run-off.

Root induced clay shrinkage accounts for around 60 – 70% of valid claims received by insurers under the subsidence peril. They are technically challenging, often more expensive than their counterparts (subsidence caused by leaking drains for example) and require extensive investigations that increase settlement times and costs.

Where Third Party trees are involved, litigation may be involved.

The background to the research began around 1992 with a review of various techniques prepared by Professor Richard Chandler at Imperial College, exploring the merits of rehydration by flooding or sinking small diameter bores and filling them with water.

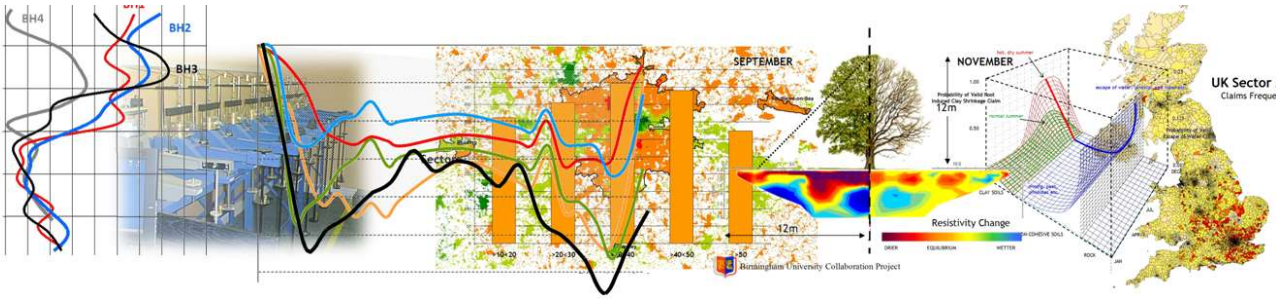



*One of several examples recorded in a review of rehydration projects. Time surface heave relationship observed during flooding. Recovery was largely completed two months from the date of flooding. Blight et al* (1992) "Pre-heaving of expansive soils by flooding – failures and successes". *International Conference on Expansive Soils*.

This approach was tested on several claims over a few years with success.

Often the building would respond within weeks when water was added to the soil at an appropriate depth coincident with root activity, although the end game at that time was still to remove the tree.

Rehydration was used to reduce the time it took to carry out repairs to the property.



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## Intervention Technique – Grant of Patent

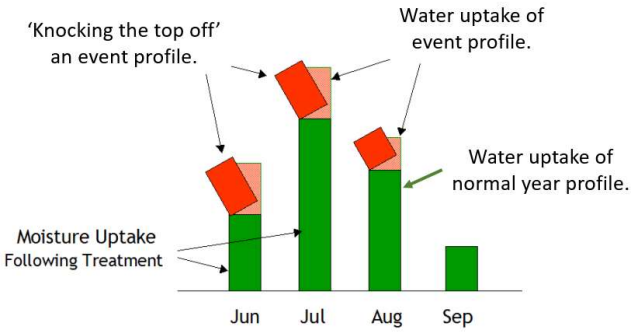
Research by plant physiologists (in particular Professor William Davies and his team at Lancaster University) identified a method of (a) triggering the expression of the hormone Abscisic Acid (ABA) and (b) using a technique known as Partial Root Drying (PRD) to conserve water by reducing transpiration.

Vegetation responds to drought by closure of the stomata to conserve water. As the majority of water that passes through a tree delivers little physiological benefit, the health of the tree doesn't suffer by this reduction in flow. In fact, turgor and fruit production can increase.

ABA produced in the root drought zone is transported to the crown by water supplied in the hydrated zone as a product of overnight equilibration. Without water, the ABA would not reach its target (the stoma guard cells) in the leaf. The effectiveness of ABA is increased by raising the pH in the xylem using the water supplied.

In practical terms, the outcome is a recognition that we cannot hope to satisfy the water demand of a mature tree. Instead, the objective is to reduce its water uptake by triggering naturally occurring hormones by rehydrating the soil in the vicinity of damage.

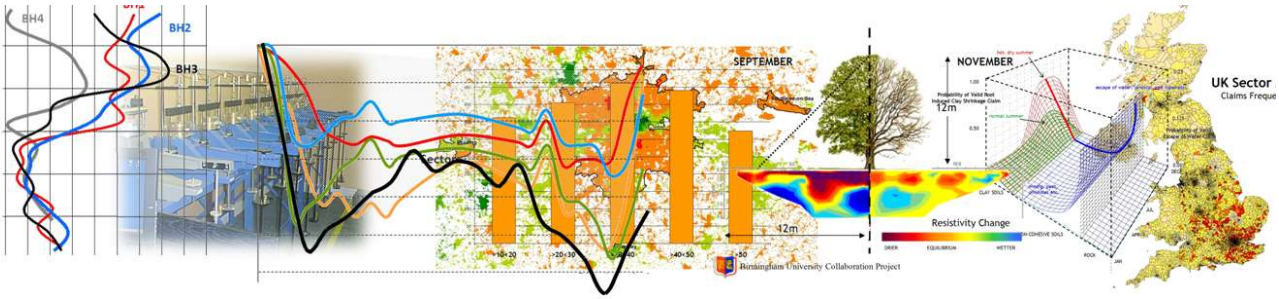
The technique seeks to 'knock the top off' a moisture deficit in an event year so that it resembles a normal year. See sketch above, right.




*The objective isn't to remove the deficit entirely, but to reduce it in event years to emulate a normal year. In addition, partial root drying (i.e. partial wetting) stimulates the production of what is termed 'effective ABA'. ABA is produced as a matter of course, but under the influence of PRD becomes more effective according to plant physiologists.*

Fortunately, neither of the approaches has to be 100% effective. Instead we are tackling the problem by trying to replicate a normal year in times of surge. We are trying to reduce the soil moisture deficit rather than restore equilibrium in the soil moisture regime – see sketch above.

In addition, rather than rely on natural percolation through soils with low hydraulic conductivity, we are using root induced suctions to achieve hydraulic redistribution much more quickly than would otherwise be the case following rainfall.



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## Intervention Technique – Grant of Patent

A trench is excavated about 1m deep at a convenient point somewhere between the house and the tree. Small diameter bores are sunk into the base of the excavation to a depth of around 2mtrs below ground to target peak suctions of mature trees. The bores and the base of the trench are then filled with a naturally occurring combination of minerals. Rainwater is conserved by re-routing downpipes to feed underground harvesting chambers concealed in the trench.

A full supporting system of drainage is installed to ensure the chambers do not flood, and that there is adequate ventilation. Overflow pipes divert excess water back to the main drain.

Each system is individually designed to take account of available annual rainfall, moisture uptake by tree, by species and the hydraulic conductivity of the soil. Annual rainfall is increased by available roof area to estimate water input to the system.

Account is taken of soil permeability to assess how much water would be lost due to gravity in soils that are heterogenous, and a design fill is required to release water only under negative pressure (suctions) from the roots.

In highly shrinkable soils with a low permeability, we can sometimes use a sharp sand to ensure the sides of the bore are not sealed due to saturation.

### Summary

The Intervention Technique has been developed to resolve a selection of complex claims quickly and cheaply. The principal benefits are…

1. Retaining mature trees

2. Avoiding litigation

3. Delivering an environmentally sustainable solution

4. Supporting the London Boroughs in their ‘greening’ project

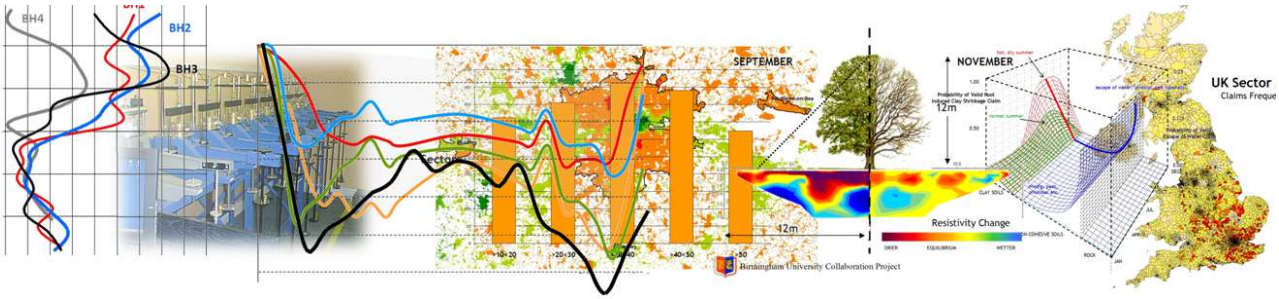
5. Taking account of the risk posed by Climate Change

6. Enhancing the reputation of insurers that adopt this method.

7. Anticipating the risk posed by the extension of the tree canopy in London by 20%

8. Resolving complex claims faster and at a reduced cost

9. Remove the need for lengthy and costly site investigations, soil testing, monitoring, arborist’s reports etc.



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## Intervention Technique – Grant of Patent

10. Resolve surge – at least in part. Tree related claims are the key element of surge.

11. Simplifying the claim resolution – removing the delay caused by monitoring, site investigation and litigation – will be a major change to the way these claims are handled.

12. it doesn't prejudice any further work should the need arise at some future date. Unlike underpinning and piling, all options remain open to the engineer.

Removing conflict from this class of claim has delivered significant benefits, not least of which are the financial savings. Insurers who have used this technique have seen over £10m savings directly attributable to the Intervention Technique.

### CAVEATS

The Intervention Technique should not be used in free draining soils, or where the clay strata overlie chalk or other soluble materials at shallow depth.

The technique is not suitable for all root induced clay shrinkage claims. The engineer will take account of the tree metrics, species and location in relation to the area of damage. They will also undertake an analysis of the degree of movement and the nature of the above-ground repair.

### Where are we now?

The first site was treated in 2008. The technique has been used on over 100 complex, high value and technically demanding claims to assess its robustness and longevity.

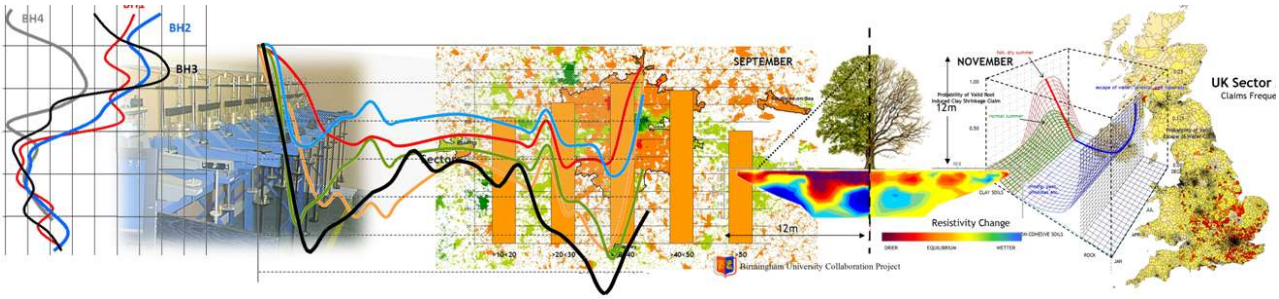
No expressions of dissatisfaction have been received so far and none of the treated houses have required foundation strengthening as a result of ongoing movement.

A selection of completed cases are being monitored for research purposes.

### Objectives

The approach should allow a claims handler to (a) receive a claim, (b) make a desk-top assessment using a Triage system to establish the soil properties and location of damage in relation to the tree root zone using LiDAR imagery, and (c) once the engineer has visited and agreed a valid claim exists, arrange for the Intervention Technique to be installed prior to repairing the home a few months later.

This would reduce the duration of root induced clay shrinkage claims to around 6 months. In summary, it would completely change the way that claims are handled by reducing their duration, stress and cost.



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## Predicting Jet Stream Position and Weather Patterns

"Drivers and potential predictability of summer time North Atlantic polar front jet variability", Climate Dynamics, August 2016.

Research undertaken by PhD student Richard Hall and Professor Edward Hanna from the University of Sheffield's Department of Geography working in conjunction with Professor Adam Scaife, Head of long range forecasting at the Met Office, has identified a number of possible factors that may influence the Atlantic jet stream and help predict summer climate.

When the Jet Stream moves north it leads to warm, dry summers. A shift to the south delivers wetter, cooler weather.

The question the researchers have been exploring is, what are the drivers behind jet stream movement?

Their study suggests the latitude of the Atlantic jet stream in summer is influenced by several factors including solar variability, sea-surface temperatures, and the extent of Arctic sea-ice, indicating a potential long-term memory and predictability in the climate system. They conclude that 35% of this variability may be predictable.

## Met Office Summary Forecast for 2017

**PRECIPITATION**:

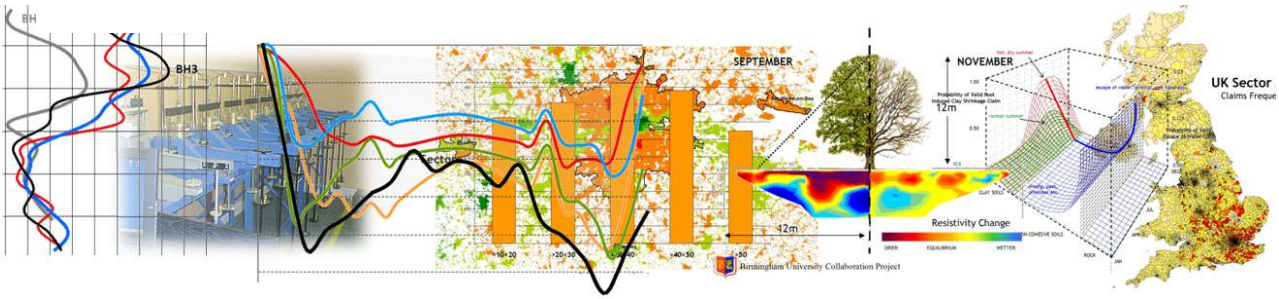
"For April, and April-May-June as a whole, below-average precipitation is considered slightly more probable than above-average. Overall, the probability that the UK-average precipitation for April-May-June will fall into the driest of our five categories is between 15 and 20% and the probability that it will fall into the wettest of our five categories is around 20% (the 1981-2010 probability for each of these categories is 20%)."

**TEMPERATURE**:

"For April and April-May-June, above-average temperatures are more probable than below-average. Overall, the probability that the UK-average temperature for April-May-June will fall into the coldest of our five categories is 5% and the probability that it will fall into the warmest of our five categories is around 45% (the 1981-2010 probability for each of these categories is 20%)."

This looks promising – the probability of being wetter or drier is somewhere around average for precipitation. Regarding temperature, it looks a good bet that it will be warmer than the 1981 – 2010 average.

So, average rainfall, but warmer. Possibly. Our own amateur pseudo-Bayesian analysis points away from 2017 being an event year and suggests 'more of the same', although the prediction has been designed to self-destruct in extremely dry, hot weather.

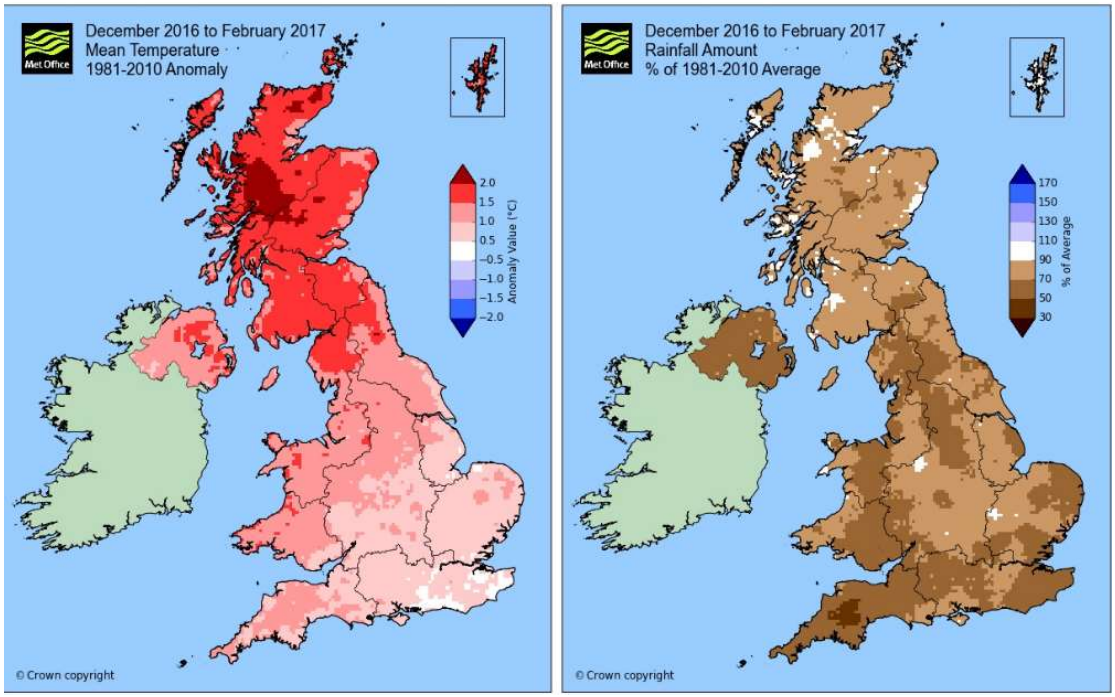


# The Clay Research Group

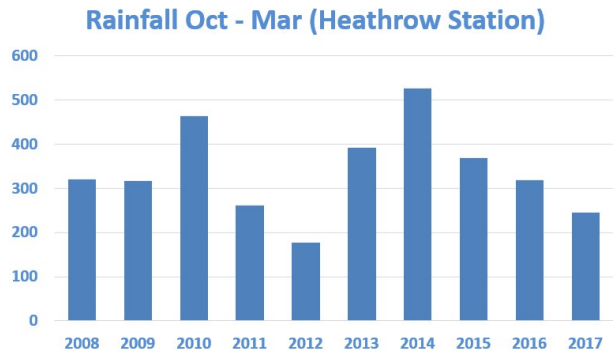
## Dry, warm winters.
## Busy year ahead?

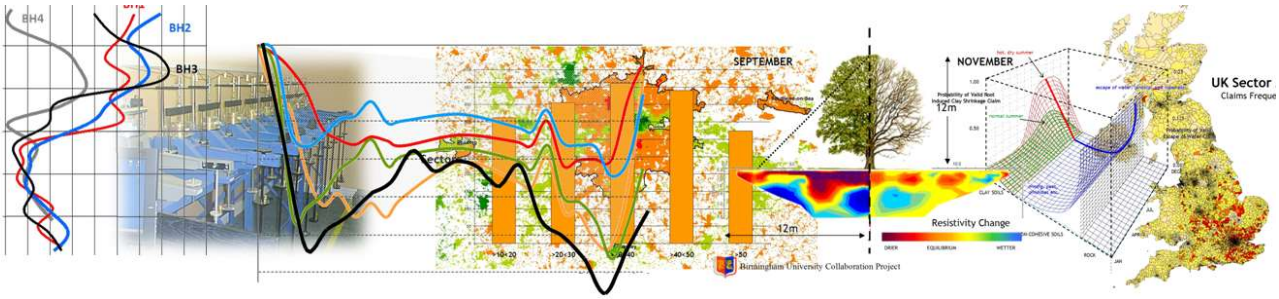
The Met Office report that parts of the southeast received less rainfall than average and, for the UK as a whole, it has been the driest October – March since 1995-96.

Emma Sharpies of the Met Office explained it was always difficult to forecast far in advance but within the next 30 days the UK should be experiencing increasingly settled weather and predicts that late April should be relatively dry.




Right, bar graph showing rainfall for the period October – March over the last 10 years using Met Office data from the Heathrow weather station. Dry winters do not inevitably lead to busy subsidence claim years – in fact, quite the opposite. It is too early to estimate what the summer might hold.

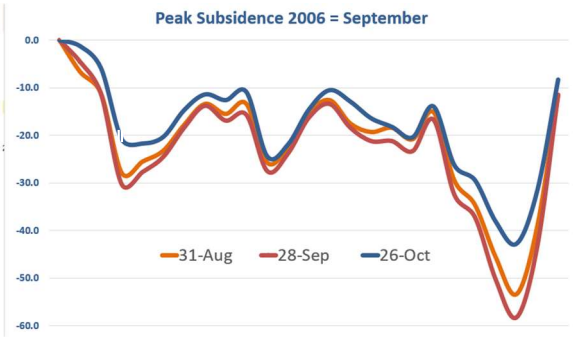


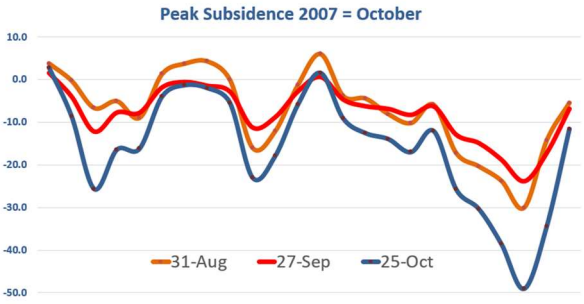
# The Clay Research Group

## Month of Peak Ground Subsidence 2006 and 2007

### Aldenham Willow




Maximum ground movement recorded at station 23 showing the month, location and amplitude of peak subsidence. 2006 above and 2007 below.

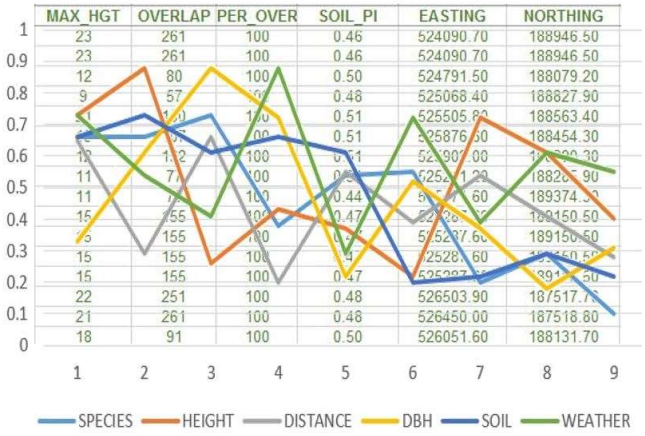



In 2006 (top), movement peaked in September with recorded subsidence (relative to the May 2006 value) of 58.2mm. In 2007, subsidence peaked in October and reached 49mm.

See page 13 for differences in water uptake between 2006 and 2007.

## Valid Claim?

The two graphs below illustrate the starting point for determining the risk of the individual elements for the claims listed in edition 136 of the newsletter.




Above, graphs of the risk posed by the individual components – tree, soil, weather etc. - per claim listed. In many cases, the zig-zagging lines might look chaotic. In fact, they reflect the decision-making process that the engineer and arborist face when they arrive at site.

Below, mapping risk as dots.