# 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 139

December 2016

# The Clay Research Group

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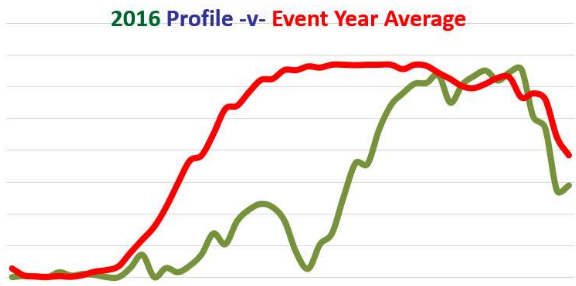
Edition 139, December, 2016



## SMD Updater – Indian Summer?

SMD Data provided by the Met office for Tile 161, Medium Available Water Capacity with grass cover.




*The current-year profile is falling away after peaking briefly from September onwards. Too little, too late to deliver more than a small and brief increase in claims.*

THE CLAY RESEARCH GROUP
www.theclayresearchgroup.org
clayresearchgroup@gmail.com

## This month's edition …

In this edition, Richard Rollit explores a new index (the Aridity Index) for assessing surge year frequency retrospectively – even prior to the addition of subsidence cover to the household policy in 1971. Is there a relationship that will improve our understanding of the link between surge years and weather?

## Ripon Sinkhole

Update from our industry colleagues recording progress on the backfilling operation of the Ripon sinkhole. Not quite a 'completed in a week' as was the Fukuoka incident in Japan, but undertaken expediently and after detailed investigations.

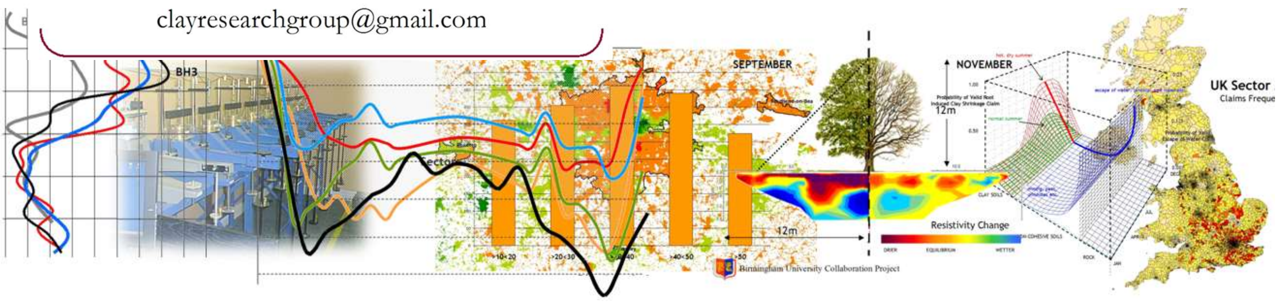
## Augmented Reality

Police forces around the world (Holland, America, New Zealand etc.) are developing augmented reality techniques to survey crime scenes according to recent press reports.

Wearing purpose built glasses, the survey can be supervised by specialists sitting in the office. Sounds a familiar theme? Yes, the future for surveying domestic subsidence claims and other perils isn't far away.

## TDAG Award

Congratulations to our colleagues at TDAG on winning the Landscape Institute Award 2016 for Policy and Research for *Trees in the Townscape* and *Trees in Hard Landscapes.*



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# Intervention Technique and Soakaways

The Intervention technique relies on providing water to the soil, at a depth appropriate to maximum root activity, to keep the tree healthy and reduce ground movement that would otherwise occur.

The approach isn't to be confused with a soakaway - a device to allow the removal of excess storm water in the absence of a drainage system. Under the Building Regulations, soakaways are not permitted closer than 5mtrs to the building. In contrast, the Intervention Technique is only used on low hydraulic conductivity clay soils (i.e. clays) that are entirely inappropriate for the free draining purpose of a soakaway.

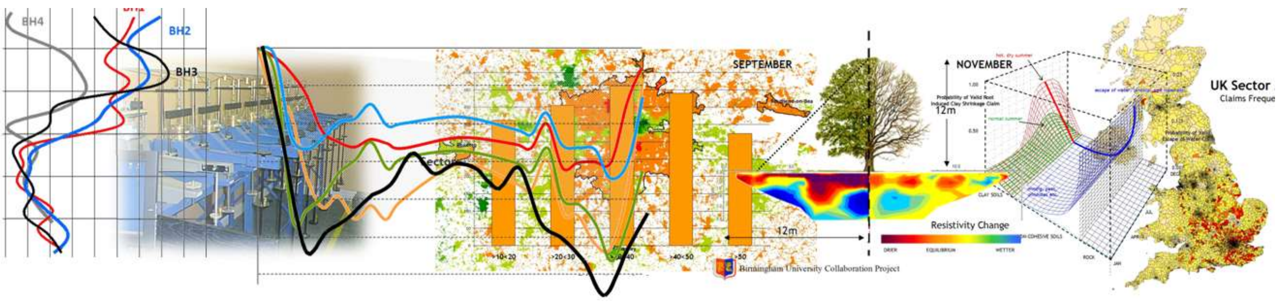
The Construction Industry Research and Information Association (CIRIA) provide a note explaining the difference. They explain that the use of an infiltration device closer than 5mtrs is acceptable (contrary to the guidelines contained in the Building Regulations) "following a soil assessment and consultation with a foundation engineer". The device should take account of groundwater conditions and fluctuating water tables etc.

The Intervention Technique caters for this situation using a self-regulating feeder, collecting rainwater from nearby roofs etc., with diversion pipework in place to cater for potential overflow in times of heavy rainfall.

The engineer will want to ensure the soil is a plastic clay (the presence of which is the reason why the Intervention Technique is being used) and there is no chalk/gypsum/water soluble strata in proximity that could be eroded, leading to the development of swallow holes etc.

To summarise, the Intervention Technique can be used within 5mtrs of a building provided (a) it is installed in a low hydraulic conductivity clay soil, (b) a suitable non-return vale and overflow facility is incorporated to prevent flooding and (c) water does not escape into an underlying water soluble or non-cohesive strata.

InterTeQ utilises Partial Root Drying (PRD) to maintain tree health under drought stress by triggering the release of a hormone, Abscisic Acid (ABA). Recent research by a team in southern Italy compared the health of orange trees grown in southern Italy and found …" compared with the full irrigation treatment, PRD at 50% of crop water demand increased the fruit yield by 20% in 2013 and 10% in 2014." See Consoli, et al, "Partial root zone drying irrigation in orange orchards; effects on water use and crop production characteristics". European Journal of Agronomy. Vol. 82, Jan 2017. The study also involved the use of ERT.



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# Droughts and Surge Frequency

Richard Rollit, BSc (Hons) MBA CEng MICE ACILA
Managing Director, Subsidence Management Services.

Since subsidence cover was introduced in 1971 we have seen several surge years, notably 1976, 1989/91, 1995/97 and 2003, together with smaller events in 1983/4 and 2006.

During a surge we can see a fourfold increase in claim numbers but that isn't the whole story. The number of valid claims can nearly treble. This puts huge pressure on the industry both in terms of scaling resources to meet demand, but also controlling costs and still delivering a great service.

Any advanced warning helps with the planning phase and this is why we track the Soil Moisture Deficit (SMD) so religiously.

Looking at our experience with subsidence, we might expect to see a surge about every 8 years, but with only 45 years of data, it is a relatively small sample to consider. This made us wonder if there is other meteorological data that might help to inform this debate and we have started to look at 'drought years'.

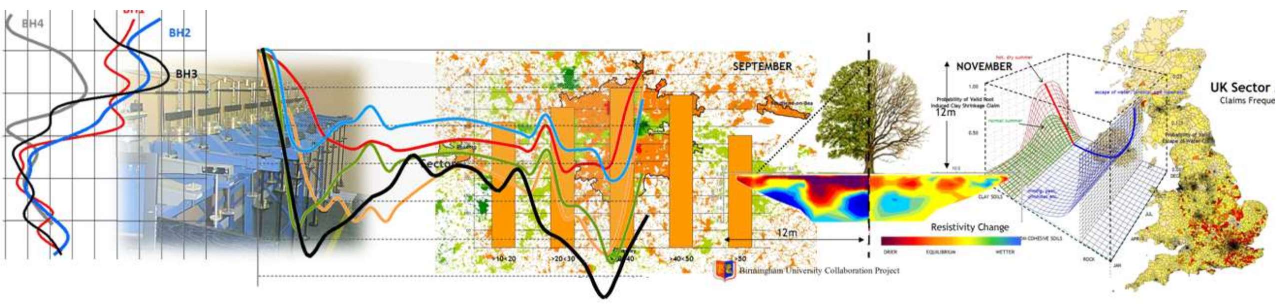
There has been considerable research into drought years because of the impact it has on our water supplies. But what is a drought?

Intuitively we might regard it as a spell of hot, dry weather but some more meaningful categories exist; meteorological droughts (rainfall deficiency), hydrological droughts (shortfalls in run-off or aquifer recharge – often driven by dry winters/springs e.g. May 2006 which was described as the 'wettest drought on record') and agricultural droughts (e.g. the availability of soil water through the growing season).

Although an agricultural drought feels like the right measure, we have found that subsidence surges follow long periods of dry, hot weather and even relatively small amounts of rainfall in July and August tend to 'take the edge' off things.

Looking at the records, we found our experience with subsidence surges is more closely linked to the Aridity Index (shown on following page for England and Wales 1776 – 2005).

When we look at data over a longer timescale, it is interesting to note that we have had a number of recent events 1995, 2003 and an arguable 2006.



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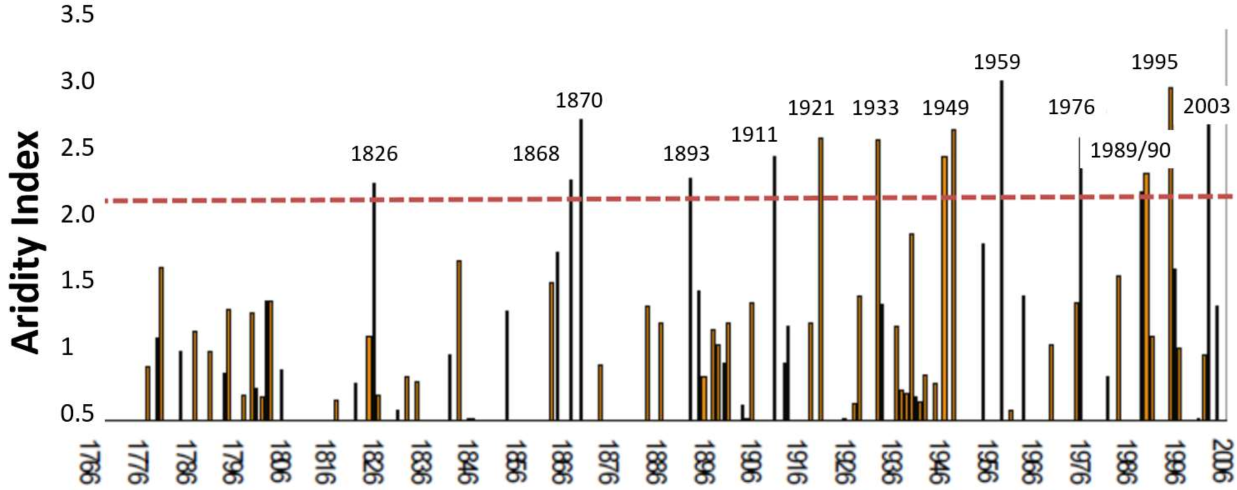
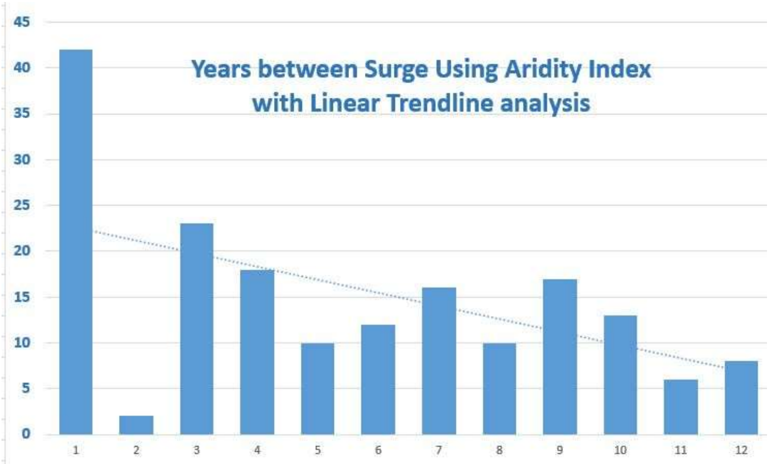


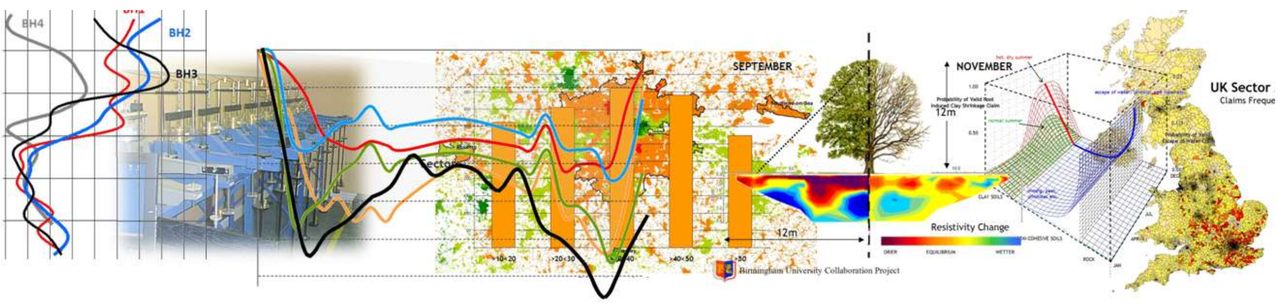

If we took 1989/90 as our surge threshold (red dotted line) this would suggest 13 potential subsidence surges and a frequency of 19 years. The graph seems to show, however, that deficits have become more prevalent since the 1860s and a frequency of about 14 years might be more appropriate.

So, a little like waiting for a bus, if three come together, do we have to wait longer for the fourth? Reverend Bayes might have been able to answer that question but, clearly, the probability of surge next year is unchanged (by previous events).




Perhaps, however, we should modify our expectation of a surge from an eight-year period to a 14-year period?

*Left, the interval between surges using data from the Aridity Index, extended before the grant of subsidence cover, reveals event years to be closer together more recently.*

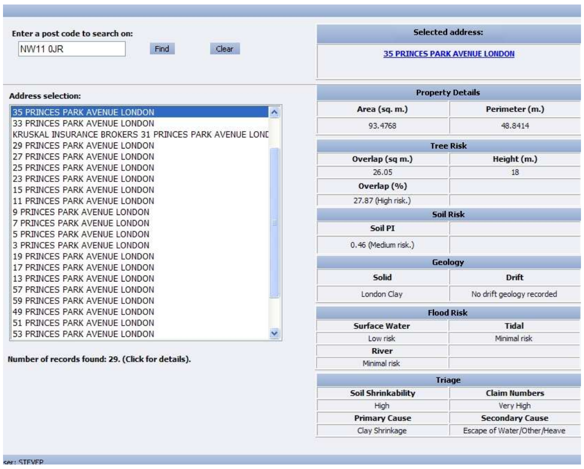


# Doing more from the Desk

Right, an application that illustrates what can be done from the desk at the time of the initial conversation with the homeowner. Enter the postcode in the top left hand corner of the screen, and select the property from the drop-down list.

The boxes on the right of the screen auto-populate. Top, the floor area and building perimeter from the Ordnance Survey Master Map series.

Let the system check the Sum Insured while you talk to the homeowner.




*Enter the postcode, select the address and see the floor area, building perimeter, root overlap, nearby tree height, soil PI, geology and other peril data listed.*

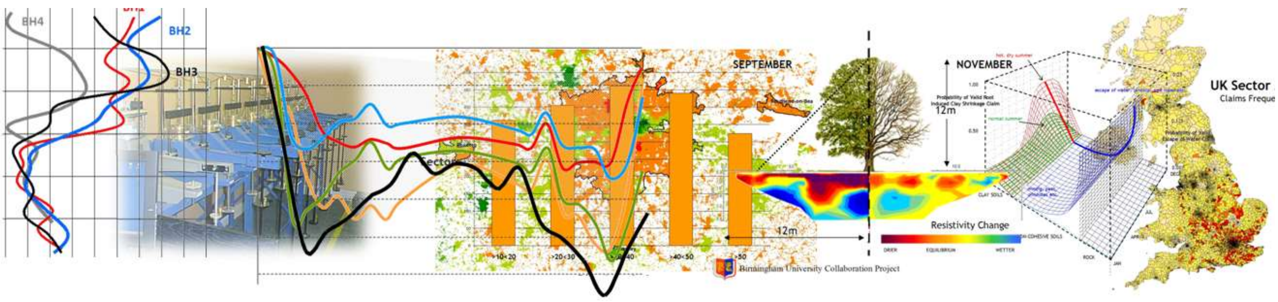
Next, are there any trees nearby, within modelled influencing distance of the property? If so, how tall are they and what is the modelled overlap of roots beneath the building footprint, expressed both as a percentage and in square metres.

The normalised soil shrink swell potential followed by a description of the series are recorded. In the above example, the soil is London clay with a normalised PI value of 0.46 (0.46 x 0.8 = 36%), classified as medium shrink/swell.

The application moves on to list the risk of other perils – in this case flood. The system could be extended to cover most perils.

Finally, the Triage summary boxes. The soil is shrinkable, the property is situated in a high claims area and primary cause is likely to be root induced clay shrinkage. Prompts would appear asking if the homeowner can identify the species of the tree, date the damage was first noted and gather background information relevant to the likely peril etc.

This model is some 10 years old and as can be seen from recent editions of the newsletter, an updated version would automatically take account of date of notification etc.



## Doing more from the Desk *... continued*

Click on the address to carry out a virtual inspection of the site. The link opens Google Earth and takes you to Street View. Using the co-ordinates in the system, you arrive outside the subject property. If the damage is to the front of the property, are there trees in likely influencing distance? If so, can the arborist identify the species from his desk?

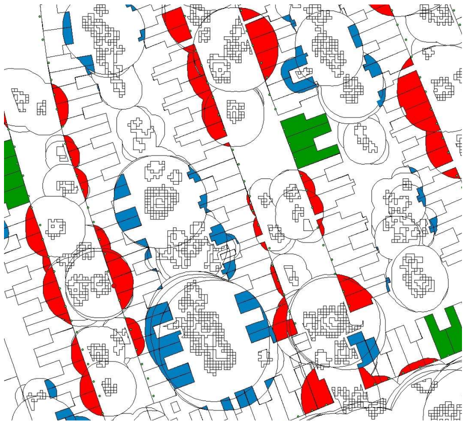
What would we do if there was damage to the front bay window but no vegetation evident, in influencing distance?

Can we see any drains nearby? Have windows been replaced recently?

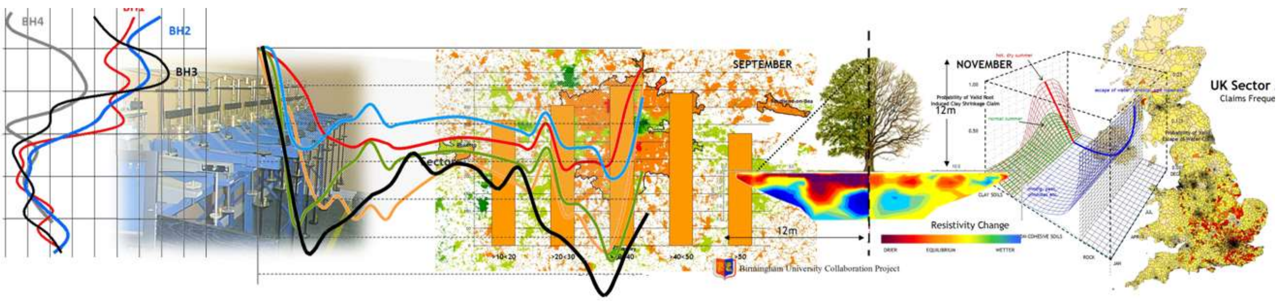
The conversation can be better directed when you have an image of the property and in this example (left) we might ask when the driveway was paved and if it was recent, what was the covering before?

Click a button to see the modelled data. Does the area of damage coincide with modelled root encroachment? Our experience suggests that in many cases not only does the zone contain the area of damage, the root periphery is the point at which to look for damage.

The objectives are (a) to engage with the homeowner by making use of some fairly basic tools, (b) speed up diagnosis, (c) better direct investigations and (d) deliver an audit trail.



In summary, the system illustrates the benefit of engaging with the homeowner at a more meaningful level at the time of the initial telephone conversation, delivering reassurance that the person handling their claim has both an interest and expertise to resolve their concerns.



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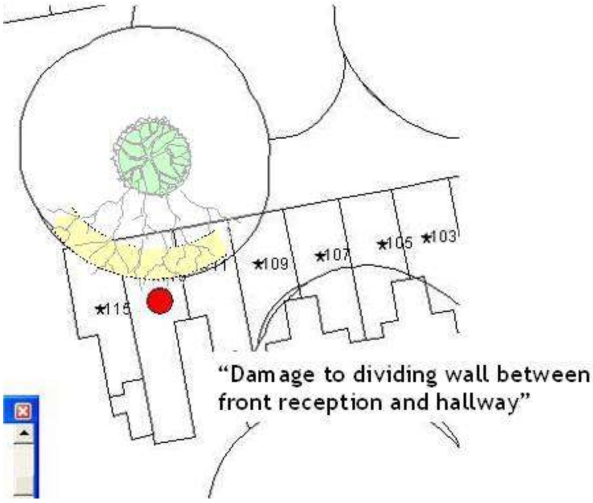
## Doing more from the Desk *... continued*

Arrange investigations from the office, produce a scale plan of where trial holes are to be excavated, boreholes sunk, along with the position of level stations, adding the paving and in some instances, existing ground conditions. For example, "reinstate paving to front driveway" from the picture on the previous page.

Does this mean the end for engineers?

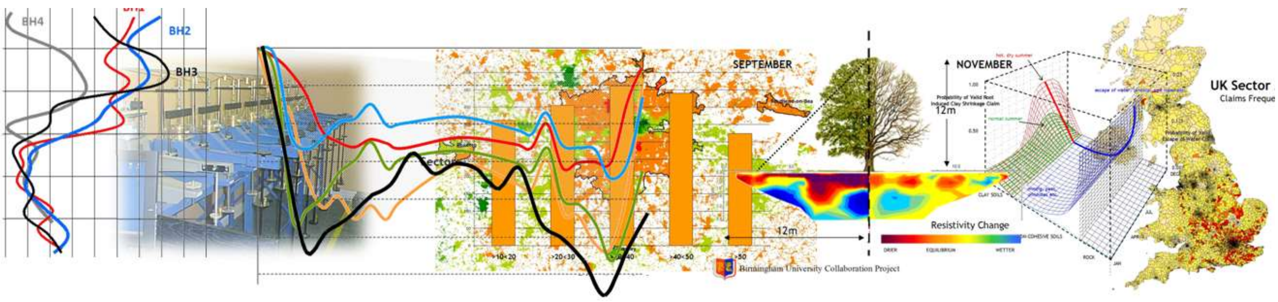
Absolutely not. The objective is to use skills where they deliver maximum benefit, and allocate resources to deliver a high-quality service. Rather than having engineers travelling hundreds of miles at times of peak requirement, we double the output and tackle surge.




*The engineer describes the location of the damage which coincides with the periphery of the overlapping root zones. The soils database records clay soils with a PI of 38%.*

## Ripon Sinkhole

Left, a view into the sinkhole from the safety of a cherry picker. The hole opened up close to the rear wall of the properties and led to the evacuation of 12 houses. Following a detailed survey, backfilling is taken place - right. Thanks to Allan Tew for the update.



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## Root Overlap Zones

A few years ago, following the Sidcup Road review, the riskiest root overlap was thought to be around 20%.

This made some sense. By just 'catching' the property, root induced clay shrinkage would introduce a natural fulcrum with the clay soil nearest the tree shrinking, whilst the remainder of the building – that part outside the zone – remaining stable. What better way to induce cracking?

Or is it the case that the 20% zone was simply one more often encountered in the sample?

In this and following editions we consider whether this initial assumption was correct, or simply a coincidence of a combination of a particular tree species and environment.

The method behind modelling the root zone was as follows.

Tree data was obtained from the LiDAR survey undertaken ten years ago, in 2006. The height and canopy spread were measured directly, and estimated root zones plotted.

The timing of the survey was fortuitous because it coincided closely with the claim sample used to determine frequency risk at postcode sector level.

Had the tree data been more recent, some will have been felled, cut back or grown and comparisons between the two – the tree database and the claim sample – would have been flawed.

The root radius was estimated at 1.2 times the tree height. Clearly this is no more than an estimate and will vary by tree species, health and environment etc.

The building footprint was derived from the Ordnance Survey Master Map series. By superimposing the modelled root zone onto the building footprint, the root overlap (the area, expressed in both square metres and as a percentage of the building floor plan) was estimated.

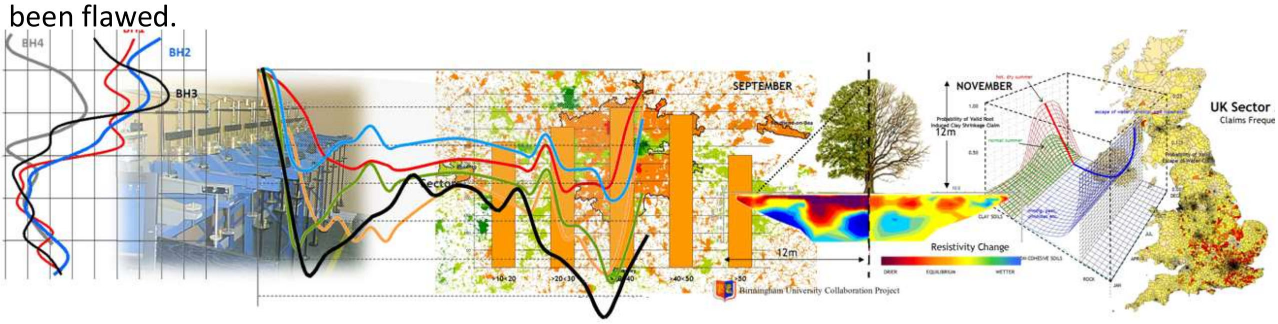
The model is then superimposed onto our unique geology of the UK, which has been built from investigations and soil testing from actual claims, with the soil PI taken from around 2mtrs below ground level.

The soil data is interpolated between sites where investigations have been undertaken.

All of the usual caveats are recognised and acknowledged. The tree species, environment, management records etc., were not known.

Nobody knows the exact extent of tree roots, although that can be said even if a skilled arboriculturalist makes a site inspection. There is a wide variability both between and within species in terms of the influence of roots on clay soils, even ignoring climate.

The model seeks to derive a pattern from the variables to determine risk from species, height and distance and this 'first pass' analysis may help.



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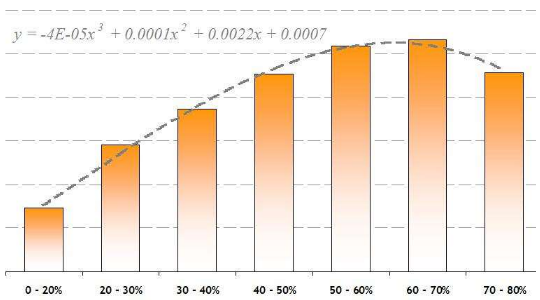
## Root Overlap Zones

(continued)

That said, every engineer, arboriculturalist and geotechnician uses modelling to arrive at a decision. Rarely on domestic subsidence claims is everything known.

Quite simply, the cost of repairing the damage doesn't warrant the costs associated with excessive investigations.

Our starting point is the risk presented by the clay soil. Below, the chart from earlier studies.

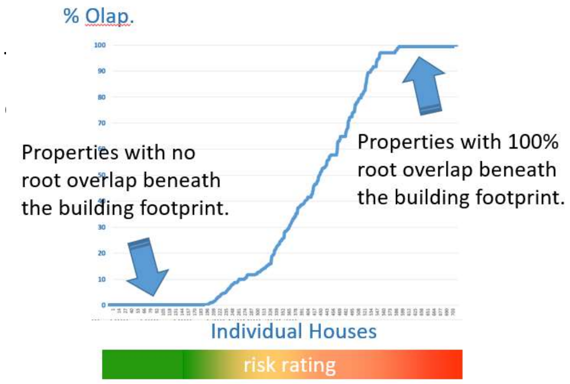



*The basis of the risk model relating to trees is the volume change potential of the clay soil. Broadly, the higher the PI, the greater the risk. The influence of tree roots varies accordingly.*

Risk is linked to the shrink/swell characteristics of the clay soil and broadly, the higher the PI, the greater the risk.

Next, the percentage overlap of roots beneath the building, expressed as a percentage. See above, right.

The graph plots modelled root overlap with each profile representing a specific PI. To the left of the graph, houses with no modelled root overlap and to the right, houses with 100% root overlap - according to the model.

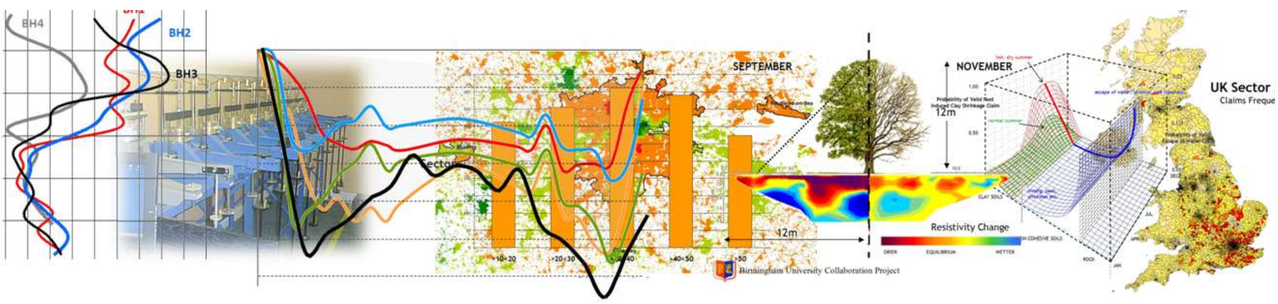



*The generic profile of root intrusion beneath properties in a particular (defined) postcode/area. A risk value can be derived by factoring the soil PI with the root zone.*

A root overlap value of '0' means the risk is low with no roots extending beneath the building according to the model.

A value of 100% would suggest roots extend beneath the entire building footprint, with the caveats described above taken into account.

The next stage – and one requiring a manual survey – would be to add species, health and environment to the model, to deliver a more precise comparison between the soil categories, noting if the tree had been managed and its canopy size and density for example.

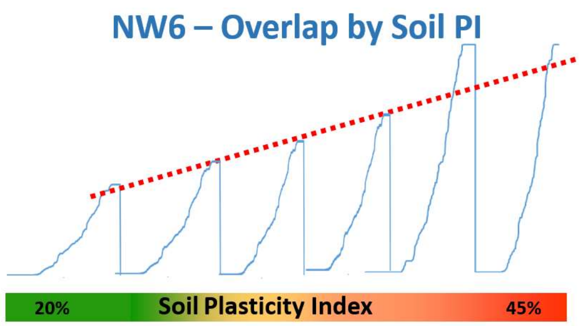


## Root Overlap Zones

(continued)

Two houses, each with 100% root overlap, but sitting on soils with different PI, present differing risks. Soils with a PI of say 20% present around half the risk of a soil with a PI of 80% - approximately.

Below, a diagrammatic representation of the root overlap profiles (blue line) for each band of soil PI. Starting at the left, the root overlap risk as a function of soils with a low PI. The risk increases as we move to the right along the 'x' axis as the PI increases.

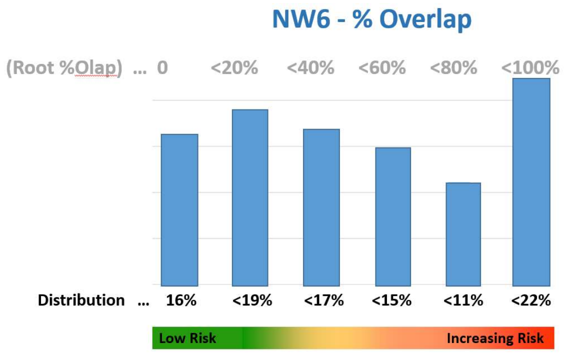



*Modelled root overlap profiles for soils in 10% bands illustrating the variation in risk as a function of clay shrink/swell characteristics. The blue line plots root overlap in the range 0 – 100% as described on the previous page.*

Where the model records 100% overlap, the risk to the properties on soils with a lower PI are less than properties with a higher PI. The red broken line is taken from the soil graph on the previous page.

Next, testing the model. How does it fare when compared with actual risk/claims data?

Is there a correlation, and if so, can we factor this into the model to refine our assessment when a claim is received?

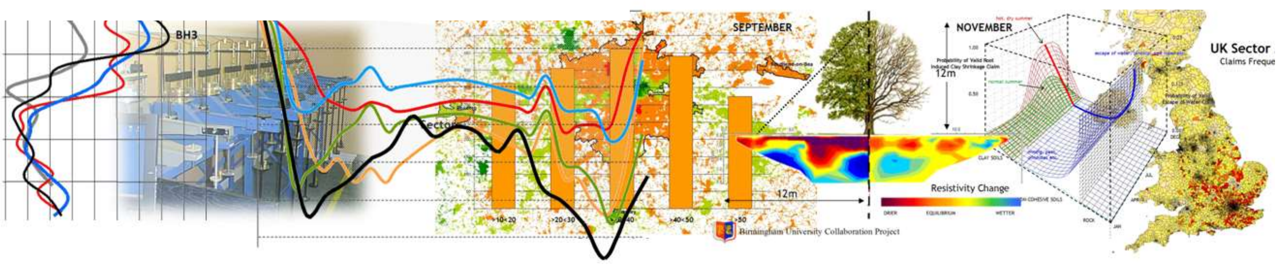



Above, rating the risk by combining the two factors – soil PI and root overlap. The bar graph represents the distribution of properties by root overlap for the entire area, irrespective of soil PI. To the left, 16% of the houses in NW6 are outside the influence of tree roots (the model does not take account of small shrubs).

They score "Root %Olap = 0" (grey typeface). In contrast, 22% of the houses in this postcode area have 100% root overlap – according to the model.

The blue line graph (left column) plots the root overlap profile by soil PI (itself plotted by the green/red horizontal risk bar at the bottom of the image). The red dotted line indicates how each band has to be factored to take account of the influence of the shrink/swell properties of the soil.

In following edition's we consider (a) whether correlation alone is an indicator of risk and (b) how does the model fare against actual claims?



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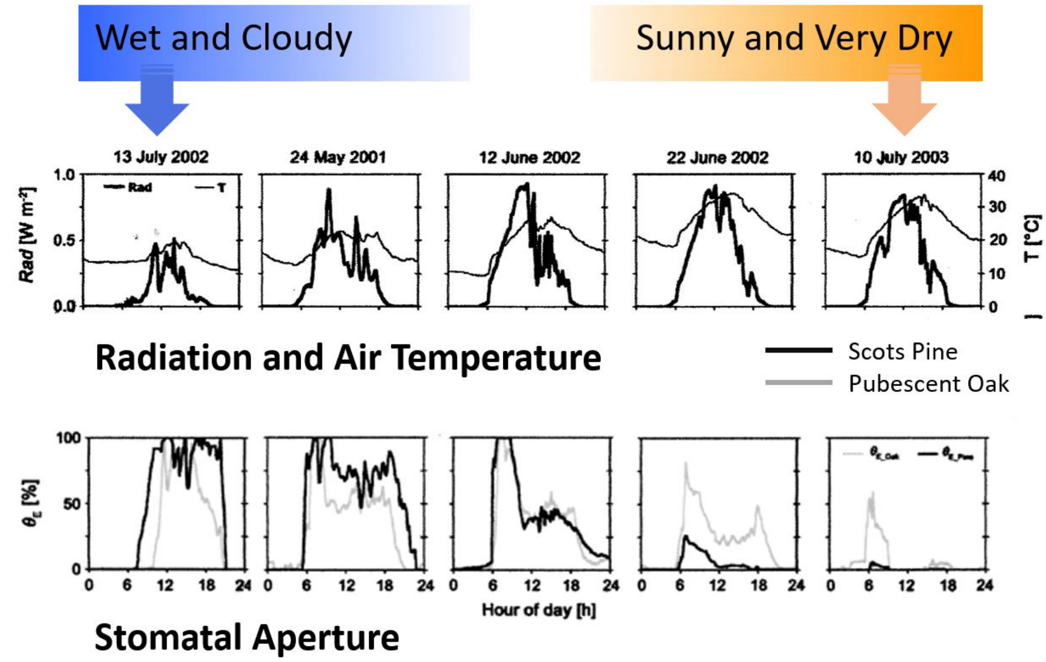
## Stomatal Aperture and Weather

Taken from Zweifel *et al.* **Stomatal Regulation by Microclimate and Tree Water Relations: interpreting ecophysiological field data with a hydraulic plant model.** Journal of Experimental Botany. 2007.

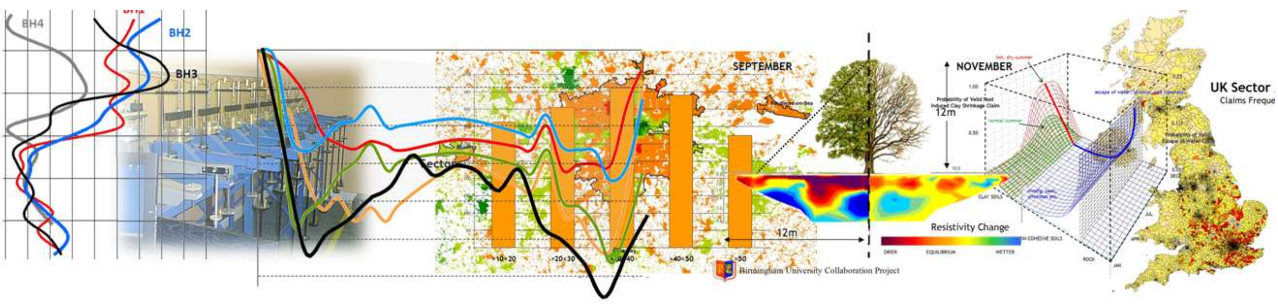
This study has been mentioned before in the newsletter and below we have reproduced the graphs of stomatal opening throughout the day, linked to changes in weather. Specifically, variation between days that were wet and cloudy and those that were sunny and dry.




*The above graphs have been taken from Figure 2 of the reference paper where it is titled "Measurements on five days with different drought stress".*

The stomatal apertures open on the 13th July which was wet and cloudy, and transpiration is much higher than sunny, dry days, when the stoma close to conserve water. The response to the environment (the weather on the day) is immediate, rather than gradual and seasonal.

This study, published in 2007, illustrates clearly the relationship between the weather and the physiological response of the subject trees – the Scots pine and Pubescent oak. It also reinforces the difficulty in modelling surge events.



## South Coast Cliff Erosion.

Cliffs along south coast of the UK are eroding at a faster rate than ever before according to a paper delivered by M. D. Hurst *et al,* in the Proceeding of the National Academy of Sciences.

The researchers estimate that erosion rates a few hundred years ago were between 20 – 60mm a year. This figure has increased to 220 – 320mm a year.

## Good Data - Dodgy Interpretation

Articles in several journals this month draw attention to the problems surrounding gathering and interpreting data. Do we really understand the output and are there instances when the interpretation aims to deliver a particular result from the outset, based on the analyst's viewpoint?

It's a common theme.

Analysts note particular events and then draw conclusions. 'X' happened after 'y', and therefore the two are linked … *for this reason*.

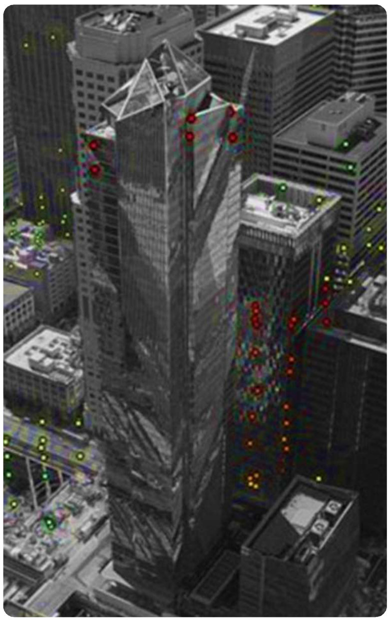
As Jim Adler of the Toyota Research Institute has remarked, "In the vacuum of no decision, any decision is attractive".

Adding numbers to nebulous events can give the impression of value. 'Let 'x' = leaves on the tree', and 'y' = ground movement on Friday may be attractive when struggling to prove you have a point, but the question is, do you?

## The Leaning Tower of … San Francisco.

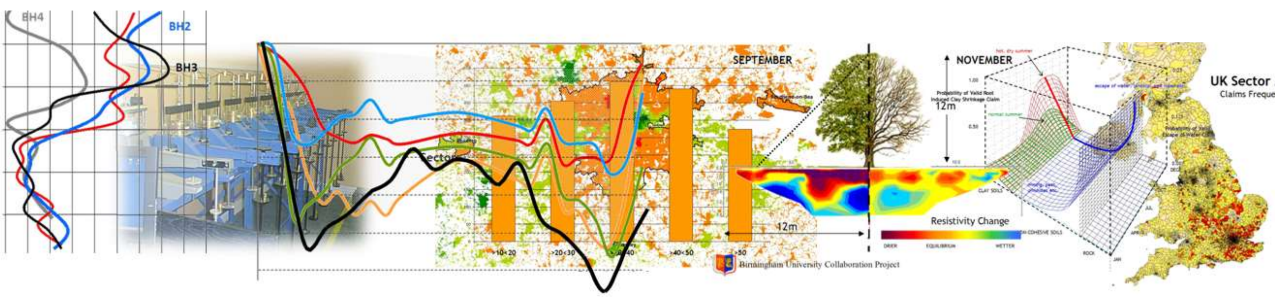
The European Space Agency satellite, Sentinel 1, has detected that the 58 storey Millennium Tower in San Francisco is sinking by around 50mm a year. They estimate subsidence of just over 400mm has taken place since its construction seven years ago.

Subsidence has been accompanied by lateral tilt amounts of around 150mm. Colour coded dots on the picture below reveal the extent of lateral movement. Red = lots of movement, yellow = less.



Investigations are underway to determine the cause of movement. The suggestion is that the end bearing piles were not taken deep enough. More at :

http://www.esa.int



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## Augmented Reality – subsidence surveying in the future

Police forces in several countries are looking at the benefits of undertaking augmented reality surveys of crime scenes.

Instead of highly qualified and experienced detectives spending hours in the car, travelling between crime scenes and manually recording data – possibly missing some – the survey is undertaken by a surveyor trained to operate the equipment that gathers it.

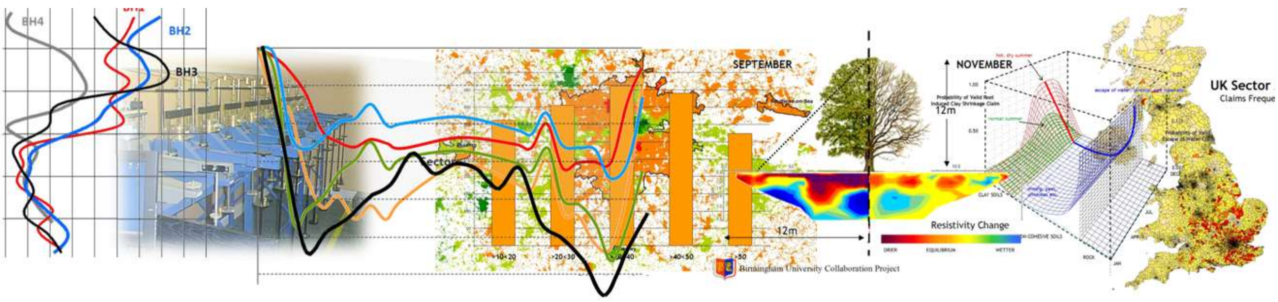
Above, this example from the police force in Holland shows the application in action. The office based detective is indicating which elements are to be retrieved, where finger prints might usefully be taken and the survey is recorded for evidence.


Not too far removed (if removed at all) from the article in edition 105 of the CRG Newsletter, February, 2014

Our skilled and experienced office based engineer guides the surveyor while he carries out his inspection using augmented reality goggles.

What do we mean by 'augmented reality'? The goggles have a camera, linked to the office and running an application that can detect cracks, plot them in the context of a room (location relating to the front door, a nearby tree or drain etc.), whilst carrying out analytics of the sort described in recent newsletters.

At times of surge, claim numbers can increase by a factor of three or even four. Recruiting experienced engineers for three or four months is out of the question. Enabling existing staff to handle more claims is the way to resolve this whilst delivering improved customer satisfaction.



# Innovative Underpinning Solution

Researchers in the UK are working on a method of overcoming subsidence of weak soil by populating the ground with bacteria. The idea is, the E. coli bacteria naturally swell in response to an increase in pressure.

Newcastle Press Office released the following statement on their web page. "A team of scientists from Newcastle and Northumbria Universities, led by architecture academic Dr Martyn Dade-Robertson, are investigating how they can create a new kind of material – biocement – where engineered cells react to changes in the environment and strengthen the soil around them."

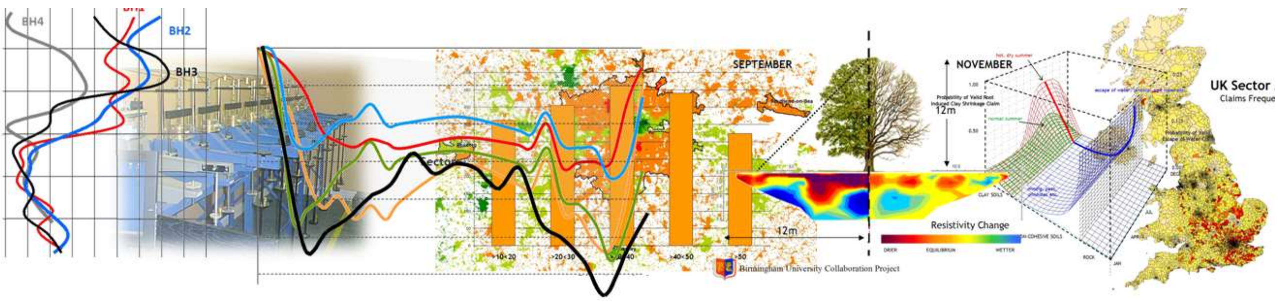
The researchers – a team of undergraduates - grew a common gut bacterium in surrogate soil — a "hydrogel" shaped into a cylinder. They subjected the bacteria-laden hydrogel to pressures up to 10 times that experienced at sea level.

The team identified 122 bacterial genes that increased their activity by at least threefold by the pressure change. The team then modified the bacterial genome so that the regulatory DNA responsible for activating one of these genes was attached to a gene for a protein that glows when produced.

*Dr Martyn Dade-Robertson explained "We are trying to create a responsive material which could have broad architectural applications, for example creating foundations for buildings without needing to dig trenches and fill them with concrete."*

The team from Northumbria and Newcastle Universities presented their findings on 29 October at the Association for Computer Aided Design in Architecture conference in Ann Arbor, Michigan.

Just how homeowners will respond to the suggestion we add these helpful bacteria to the soil beneath their home is another matter, and wording of sales particulars could be difficult but it's evidence of an open-minded approach to seeking new and novel solutions to problems.



# The Clay Research Group

## The 80m Tall Giant Sequoia

The December edition of National Geographic describes how a team of experts have finally managed to take a picture of one of the tallest trees in existence. At just under 80mtrs,

Thought to be over 3,000 years old, the tree is still growing. It took the team 32 days and 126 photographs to assemble the image, which can be seen at:

http://www.wimp.com/this-3200-year-old-tree-is-so-big-its-never-been-captured-in-a-single-photograph-until-now/

Assuming a root spread equal to the tree height, the picture, right, tells the story if they were ever to be introduced to the street scene in North London. Or anywhere else on a clay soil. A formidable tree that puts the native species into context.

## Next Month and beyond …

Next month (January 2017), the usual reflection on the previous year. 2016 has been quiet and illustrates the routine of normal domestic claims without the surge associated with dry spells and root induced clay shrinkage claims. Fewer cases involving litigation over Third Party trees.

Modelled root zones are examined in more detail.

Is the fact that there is a correlation between modelled root overlap and claims a sensible approach? Is the fact that there are more houses in a particular category and this correlates with risk a good indicator? Or does it miss the fact that claim numbers are relatively low when compared with tree numbers, and the risk would increase if the percentage of a certain class of overlap was better understood?

Do we risk falling into the trap we describe on Page 12?

Three postcode areas are compared to see if there is a correlation between root zones, PI and risk, and then in February 2017, examining actual claims to improve our understanding.