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
Artificial Intelligence

January 2018
Edition 152

The Clay Research Group

CONTENTS

Issue 152, January, 2018

Extending the Risk Model

Last month's edition considered how we might model the risk of trees taking into account species, metrics, climate, environment and maintenance history.

This month, we explore how this approach can be integrated into the London risk model to build a risk assessment tool that can respond dynamically to these elements.

The approach is statistical and risk based, rather than arboricultural, and could resolve complex calculations for tens of thousands of trees at a time, at the press of a button.

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

Working Together to Find a Solution.

Last year (May 2017, edition 144), Andrea Plucknett, Treasury Management & Insurance Officer at Welwyn Hatfield Borough, asked why, if insurers modelled risk, they didn't share their findings with those responsible for the maintenance of the tree population to help avoid claims.

It is a good question and one that we hope to address over the coming year. Which houses are at risk from root induced clay shrinkage, and can interest groups work together to help resolve the problem?

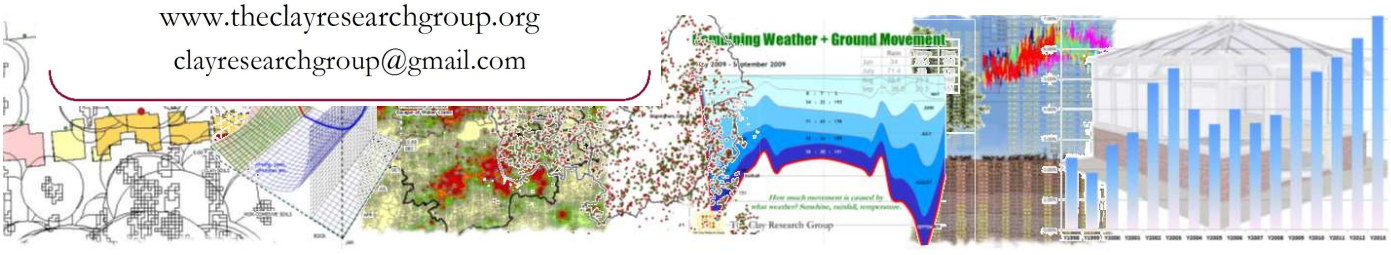
Sinkhole Vibrator Alert

Tony Boobier notified us of a new device to provide an alert of potential sinkhole activity in vulnerable areas. Whether this would reassure or alert people thinking of buying a property in a sinkhole susceptible area is another matter but it fits in with the remote sensing objective.

https://www.economist.com/news/science-and-technology/21732491-they-are-caused-collapse-pillars-salt-way-predict-sinkholes

Ground Movement over Time

How much movement has taken place at the site of the Aldenham willow since levels were first taken in 2006? Has the ground exhibited a periodic signature, rising in the winter and falling in the summer, as we might expect? Yes. Has there been a year where no movement has been recorded? No. On pages 12 & 13 we review the change in ground profiles over the monitoring term. Imagine if there was a house nearby, within influencing distance.



The Clay Research Group

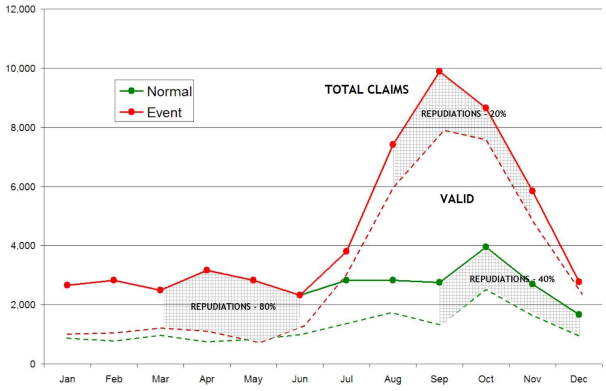
Subsidence Risk - Spatial and Temporal Variations

Traditionally the industry quotes annual figures of valid-v-declined claims with little to distinguish temporally or spatially. We miss the value of understanding that the data vary considerably across the UK based on month of notification (or appearance of damage more correctly) and by geological series.

This study is the first in a series, exploring a different postcode sector each month to help improve our understanding of (a) the probability of whether a claim is likely to be valid or declined, (b) the dominant peril and (c) any seasonal/geological influence.

19 claims are reviewed from postcode sector N20 8 and categorised as either valid or declined, along with the date of notification (or when damage was first noticed), settled cost or incurred if still ongoing, and causation.

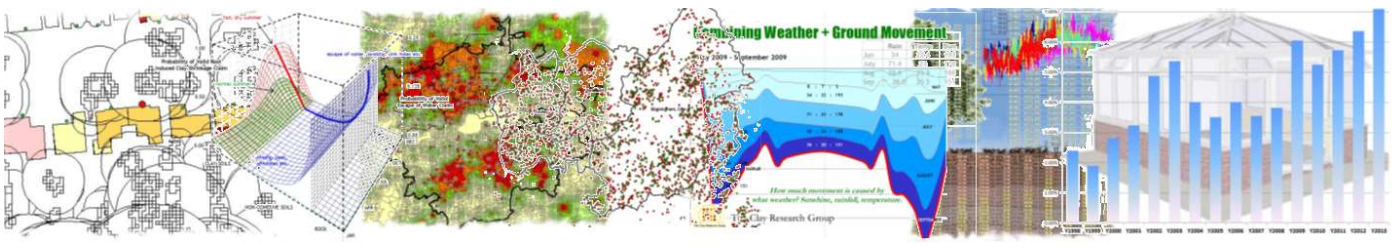
The date damage appeared is categorised as 'summer' between mid-July and mid-November. The dates defined by the claims graphs – see right.



The claims were plotted onto the 1:50,000 solid and drift geological map published by the British Geological Survey using a geographic information system (GIS)

To understand the influence of the underlying geology on claims experience, postcode sector N20 8 was selected as being almost entirely outcropping London clay. As the study progresses, it is hoped that differences in risk between series (cohesive and non-cohesive) will become clearer.

The objective is to improve our understanding of the role of both weather and geology on the variable nature of risk across the UK temporally and spatially.

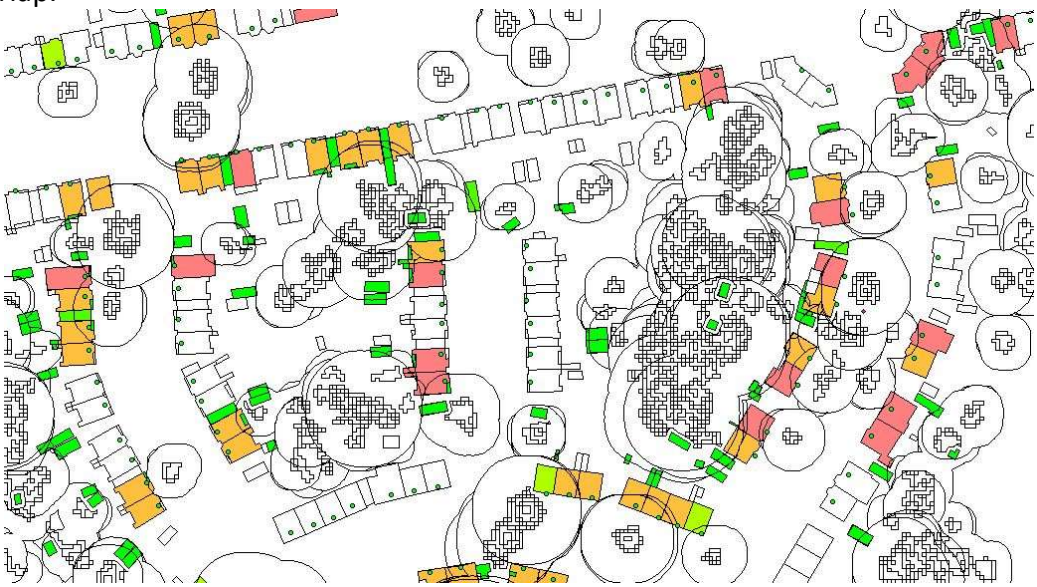


The Clay Research Group

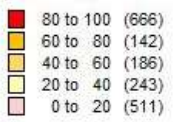
Developing the Model

To illustrate the approach, below is an extract from a sample thematically plotting the risk grading in 20% root overlap bands – see legend below. Houses judged to be outside the zone of tree root influence are unshaded.

Just how effective is the model in terms of detecting risk? In many areas, over half of the houses are judged to be within influencing distance of root activity. In the absence of species identification, the model currently relies on tree height and estimated root overlap.

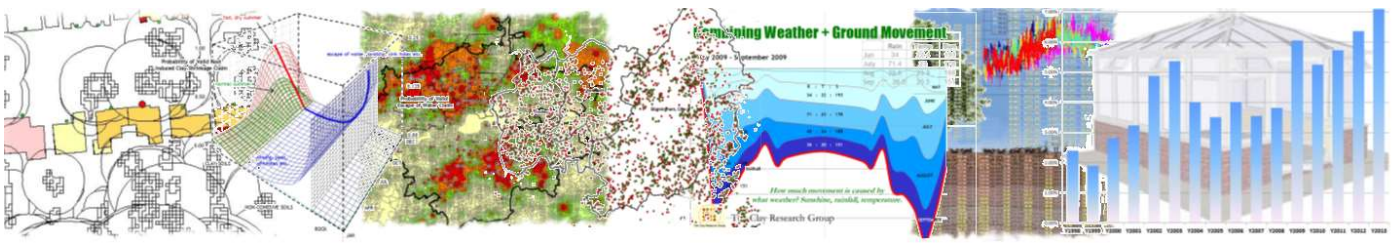


The legend is shown, right. In this random (i.e., not N20 8) example of 1,748 houses, there are 666 with a modelled root overlap of between 80 – 100%, 142 houses with a modelled root overlap of between 60 =- 80% etc…



Are there any characteristics that might be regarded as significant vulnerability indicators? Would it be possible, working alongside the London Boroughs with tree species identified, to jointly develop an improved risk indictor that would (a) allow the Boroughs to target certain trees with the aim of reducing maintenance spend and (b) reduce claim costs for both insurers and councils, and (c) reduce disruption and distress for the homeowner?

On the following pages we look at how this might be achieved. The technique makes use of the model described in last month's newsletter.



The Clay Research Group

Study Area - N20 8 – in brief

We may typically hear it said (for example) that 50% of claims were valid in a particular year, or, 70% are due to root induced clay shrinkage, without recognising that the figures are averages, with considerable variation by location, season and geology.

19 claim records in N20 8 were made available for this study, of which 11 were valid and 8 declined.

Analysis reveals that the probability of a valid claim in the summer months was 82%, and in the winter, 25%. Of the valid claims, 82% were the result of root induced clay shrinkage and 18% were linked to an escape of water.

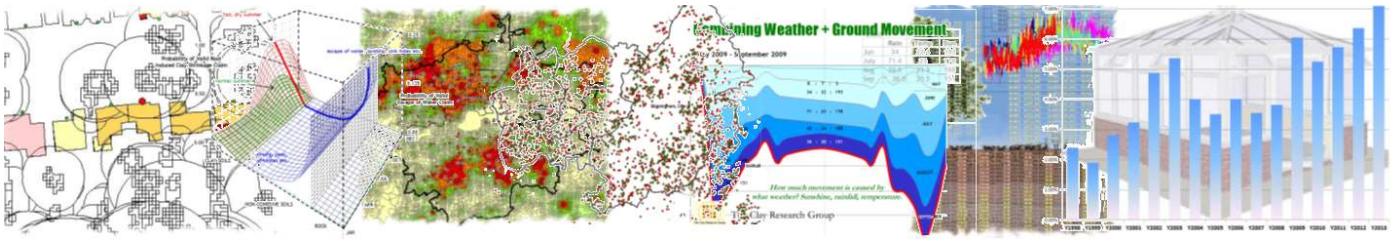
It can be seen that the use of annual averages can be misleading – the date of notification, or recording when damage occurred, is central to any triage system.

The average cost of the valid, root induced clay shrinkage claims was slightly over £27k. The average cost of an escape of water claim was £4.6k from this very small sample. The average modelled root overlap for valid claims, expressed as a percentage of the building footprint, was 70% and the soil plasticity index across the sector was between 35-40%.

How 'accurate' or useful is the existing risk model? The background to the study is the LiDAR survey mentioned earlier.

In this study, it correctly identified all of the houses with valid subsidence claims resulting from root induced clay shrinkage. The next stage is to see if any estimate of 'percentage overlap' of the root system beneath the building footprint poses a particular risk. For example, are houses with 20% root overlap more at risk than those with 100%, or is the reverse true? Can the model be refined to improve identifying the risk of claims?

Species identification would add significantly to the calibration and reference is being made to software like Treezilla - see right - (https://www.treezilla.org/treezilla/map/) and iTree (https://www.itreetools.org/) in anticipation of future developments.

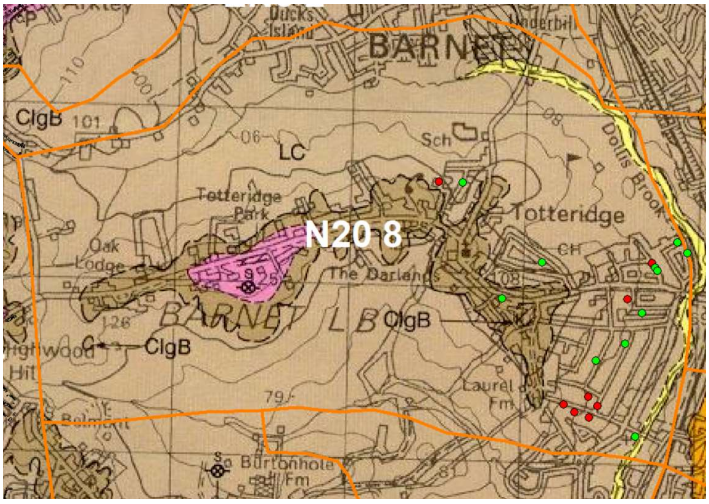


The Clay Research Group

Initial Study Area – N20 8

Postcode sector N20 8 covers Totteridge, Barnet. The method involves superimposing actual claims (both valid – shaded green - and declined - red) onto the LiDAR based root-overlap model to understand the relationship. Zoom in to see claim locations. The sector has over 1,572 households and has a population of about 4,342. Claims from our sample all fall to the west of the sector - the area of higher housing density. See map below.

The first step is to determine the underlying geology. Trees exert an influence on highly shrinkable clay soils and peat. Below, claims superimposed onto the BGS 1:50,000 scale solid and drift series map revealing that the study area is predominantly (but not exclusively) outcropping London clay.

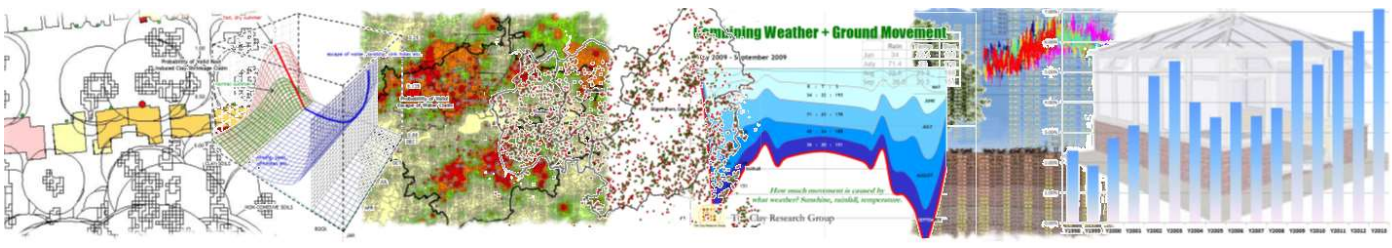


Valid claims are shown as green dots, and declinatures as red. Zoom in to see the location of the dots. All but one of the claims are situated on London clay. The average soil PI from site investigations is around 35 – 40%.

The darker, central shading illustrates the extent of the Claygate beds – a mixture of clay, silt and sand. Pink shaded areas indicate sands and gravels of the Stanmore formation overlying the Claygate beds and yellow is Dollis Brook.

Of the 19 claims in the study, 11 were valid and 8 were declined. The distribution suggests a selection from 'normal' claim years. Of the declinatures, two were notified in a summer (i.e. September) month. The remainder were notified between December and March. The first point of interest is the date of notification. Taken as an average throughout the year, and not accounting for the month of notification, there was a 46% chance of a claim being valid.

Of the valid claims, 9 were notified between August and October and 8 of those were due to root induced clay shrinkage. All 8 were situated on outcropping London clay. The exception (an escape of water claim) was situated on the Claygate series comprising clay, sands and silt. Two valid claims were notified outside the 'summer' period (one in December and another in June) and both resulted from an escape of water. The study reveals the importance of the date of notification and the link with the geology.

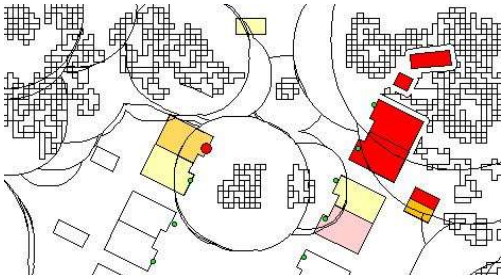


The Clay Research Group

N20 8 Study Area – Valid Claims

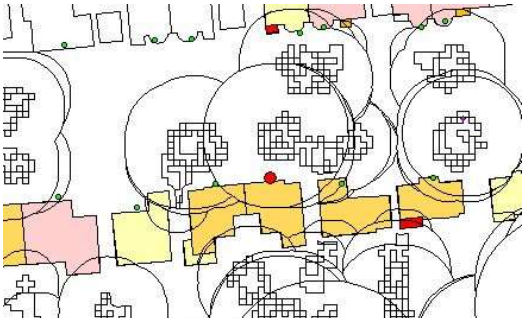
First, a review of the valid claims. Left, a large property with a settled cost of around £23k with damage due to a neighbour's willow tree, 23m tall and 4mtrs distant. Modelled root overlap is around 80%.

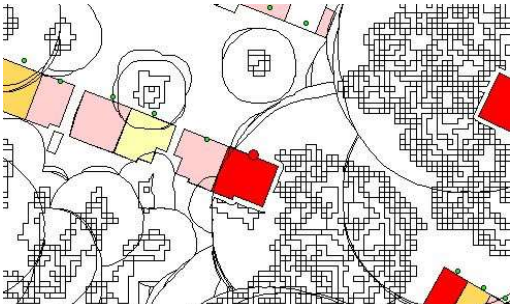
Right, another valid claim with damage caused by a 10m tall birch tree, 3mtrs away from the building and in the ownership of the policyholder. Modelled root overlap of around 80%.



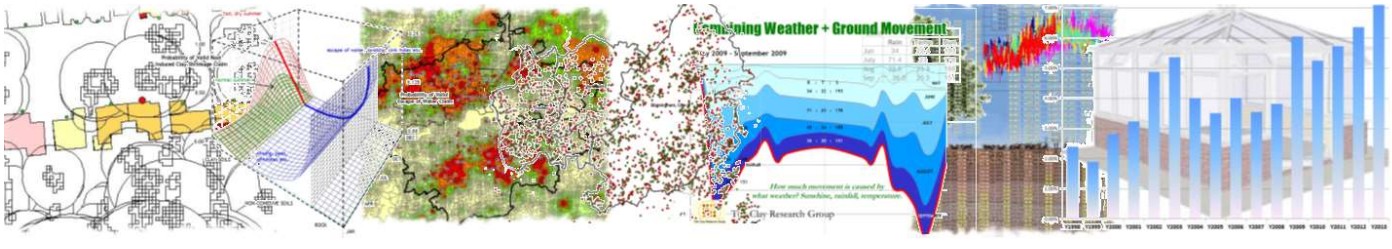
Left, a property identified by the model as being at risk. Subsidence damage associated with 11m tall willow, 6mtrs distant and in the ownership of the neighbour. Repair costs £12k. Modelled root overlap, 45%.

Right, another valid claim, this time associated with an unidentified broadleaf tree, in Council ownership, 11mtrs tall and 7mtrs from the front wall of the house. Cost of repairs were nearly £20k. 60% modelled root overlap.



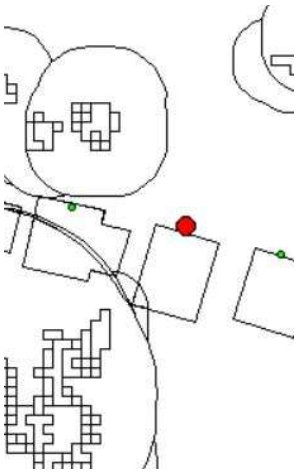


Finally, damage caused by a 17m tall willow tree with modelled root overlap of around 60% delivering a £33k claim. Tree in neighbour's ownership.



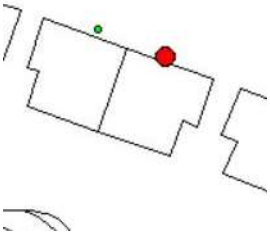
The Clay Research Group

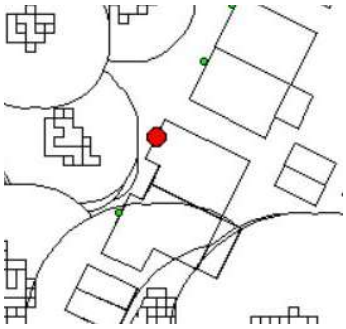
N20 8 Study Area – Declinatures

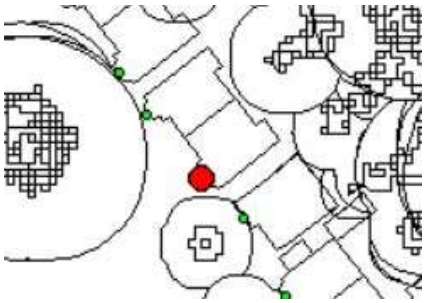


On this page, five declinatures under the subsidence peril in the N20 8 postcode sector. Of the five, the model correctly identifies four as being 'safe' in terms of root encroachment.

The model confirms little, if any, root growth beneath these four properties.



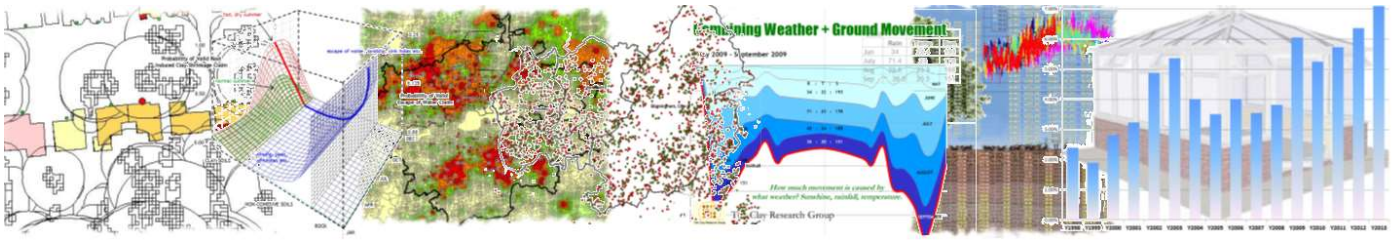




Right, a declinature with around 40% modelled root overlap beneath the building footprint.

Fortunately, the property was not suffering from subsidence damage although it is potentially at risk from root induced clay shrinkage and an arborists advice should be sought regarding the tree species and likely root zone, and whether action is required.

For example, should the tree owner be put on notice and is canopy reduction required?



The Clay Research Group

Study Area – N20 8

This initial study reveals that claims for subsidence damage to properties on shrinkable clay soils notified in the summer months are likely to be valid. Whilst the annual figure may tell us that 46% of claims were valid, this preliminary study suggests that the figure increases significantly in the summer, on clay soil, and reduces in the winter.

This is important when building a triage application, as is understanding the likely cost of such claims when compared with their counterparts – escape of water claims.

Of course, not all claims within the root zone of vegetation will suffer subsidence damage in one year, if at all. However, this is a significant risk indicator, and claims relating to fresh incidents will continue to be notified year on year.

Conversely, not all claims relate to root induced clay shrinkage, but those on outcropping, shrinkable clay soils take up a disproportionate percentage of the total.

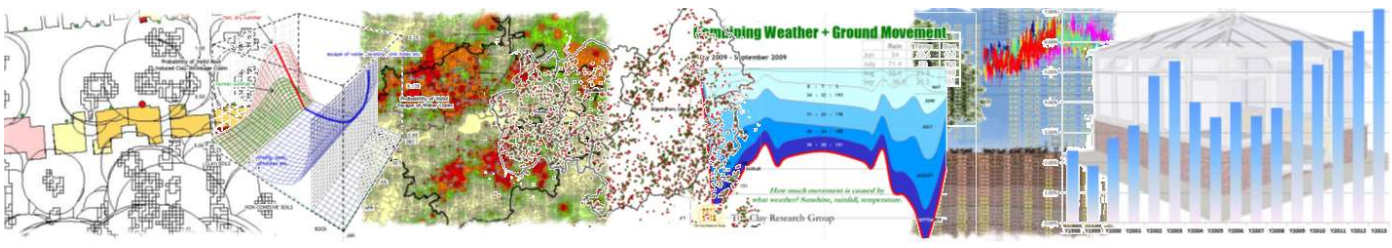
What does this mean in terms of modelling the risk? All of the valid claims were correctly identified. That compares with the current situation of not having any idea where the risk lies, and is judged a favourable result.

The question is, can the model assist insurers in underwriting risk, and Local Authority arborist in terms of (a) targeting maintenance programs and (b) reducing their exposure to claims?

The aim of the study, which will be extended through the coming year, is to see if the root overlap model is reliable and if there are any metrics (species, height and distance etc.) that might be regarded as risk indicators. Any local authority willing to work in partnership would be welcome, specifically by adding the tree species to any sectors that will form part of the study going forward. To be clear, we do not require details of the total council's tree stock – just those for agreed study sectors on outcropping clay soil.

Finally, the majority of claims relate to trees in private ownership. Trees under the control of the Local Authority are estimated to account for just over 12% of claims, in line with their percentage as a part of the tree population. That is, they are no more, or less risky that trees in private ownership.

Further sectors of variable geology will be analysed over coming months. Next month the study will cover another area of outcropping London clay, sector NW11 6.

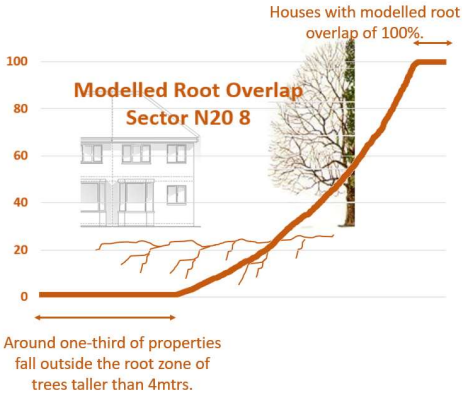


The Clay Research Group

Study Area – N20 8

Right, the modelled root overlap distribution, by property, for all houses in N20 8. Around one-third of the houses are free from root activity of trees 4m tall and above. Those houses may still be within influencing distance of smaller trees and shrubs, or situated on non-shrinkable soils.

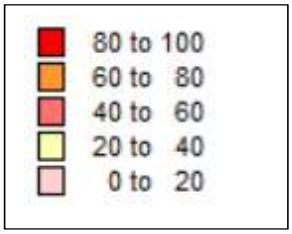
The variations across the postcode sector can be seen from the extracts below. The two samples do not show the extremes. Left, the lower-risk street scene, and right, a road with a higher risk, based on modelled root zones.

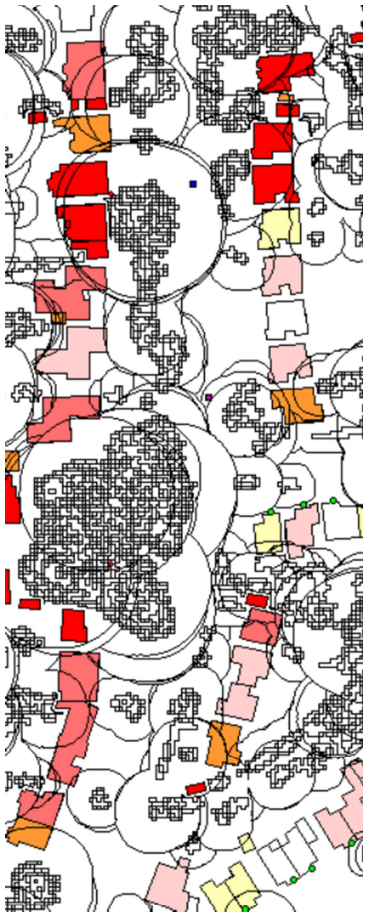


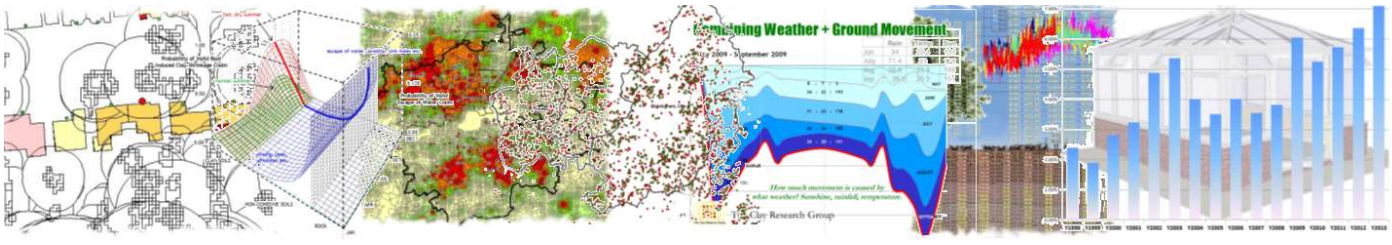
The graph above follows a fairly typical profile with slightly higher number of houses with no modelled root zone extending beneath the building footprint.

Root radius estimates are 1.2 x the measured tree height at the time of the survey, to account for future growth.

This preliminary study suggests the figure to be adequate whilst recognising the margin for error both in the absence of identifying the species and variation due to health, soil mineralogy and environment etc.







The Clay Research Group

Summary Findings – Study Area N20 8

The model correctly identified all of the valid claims where damage was due to root activity resulting in subsidence, and those 'free from risk' - declinatures. In the one instance where the property had modelled root activity beneath the building footprint but no damage, the property was correctly identified as being 'at risk'.

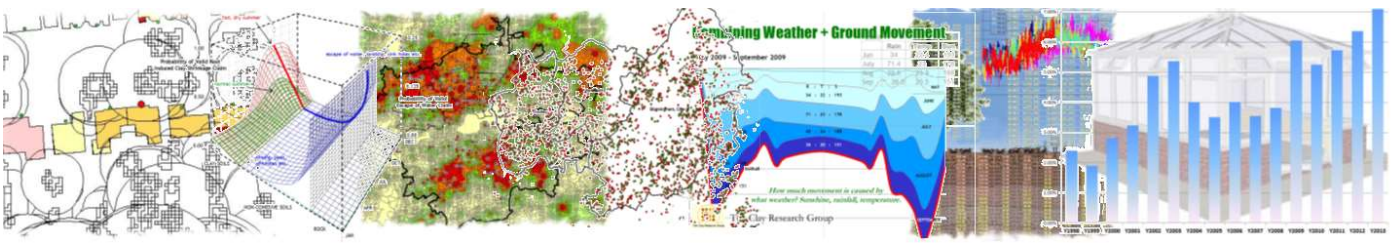
The approach raises several issues. Do insurer's, armed with such information, decline cover for houses potentially at risk? Would it trigger disputes with homeowners whose home is potentially at risk writing to neighbours, putting them on notice when their property falls within influencing distance of a neighbour's tree? Would it result in a reduction in the tree population and run contrary to the Urban Greening plan?

Both solutions and problems arise from the study. The objective is to improve our understanding of the issues, and put the risk into perspective. Hopefully the discussion will bring different interest groups together with the aim of jointly agreeing a way forward, armed with good evidence.

The TDAG initiative – piling all new homes whether there are trees within influencing distance of properties or not at the time of construction – falls into this category.

Whilst the underwriting model may seem over-conservative (i.e. damning too many trees), and the number of cases each year quite small in the scheme of things, we estimate that over 100,000 trees have been involved in causing subsidence damage to domestic properties in the term 1990-2000.

The 'Chainsaw Massacre' publication, dated 2007, reported that over a five-year period the London Boroughs lost 2,000 trees as a result of subsidence damage. Extrapolating this suggests a loss of 4,000 over 10 years. If council trees account for around 12% of root induced clay shrinkage claims, this would equate to over 10,000 claims from the estimated claim/tree population, so adding in claims where the trees were not felled, but crown reduced/thinned etc., suggests the above estimate may not be far off. The greatest number of tree-related claims falls within the London Boroughs as a result of the geology and population density.



The Clay Research Group

Escape of Water Claims on Outcropping London Clay?

As a general rule, claims on outcropping clay soils involve vegetation. When carrying out a risk analysis at postcode sector level it is odd to see exceptions – claims due to an escape of water from a leaking drains or water service for example. The answer is provided in the picture below.

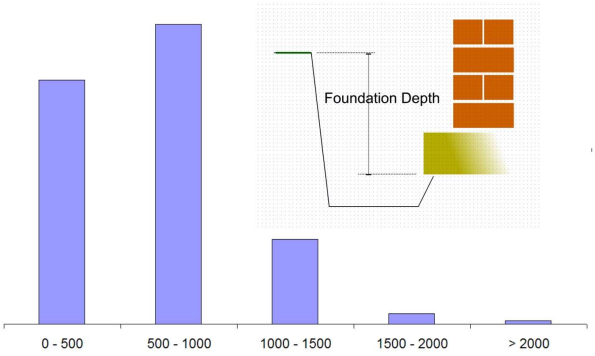
Whilst the BGS map may well show outcropping clay, many older houses have shallow foundations bearing onto a mixture of topsoil, fill and/or loose drift deposits, some with organic content.

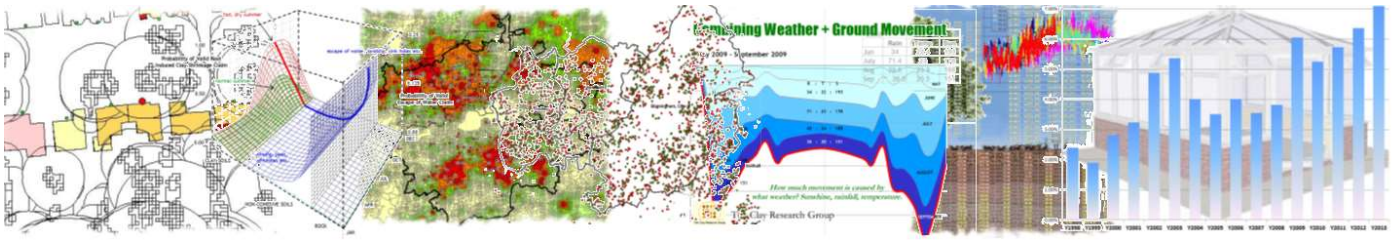
From a sample of valid claims, 56% foundations were less than 600mm deep, typically occurring in houses built in the periods pre-1910, 1930-1940 and early 1960s, prior to Building Regulations specifying minimum depths.

33% were between 600mm and 1m deep. The remainder (11%) were between 1 – 3mtrs deep. 3mtrs was the deepest recorded - the sample does not include piling schemes.

The deeper foundations included claims where underpinning had already been carried out, and further damage had been reported.

Shallow foundations of the sort recorded above also account for why older houses are riskier than modern ones, and peaks in subsidence claims relating to escape of water reflect periods of increased housebuilding between the wars and the subsequent housing booms. An added risk for these houses is the use of rigid jointed drainage connections that are vulnerable to damage from minor ground movement.

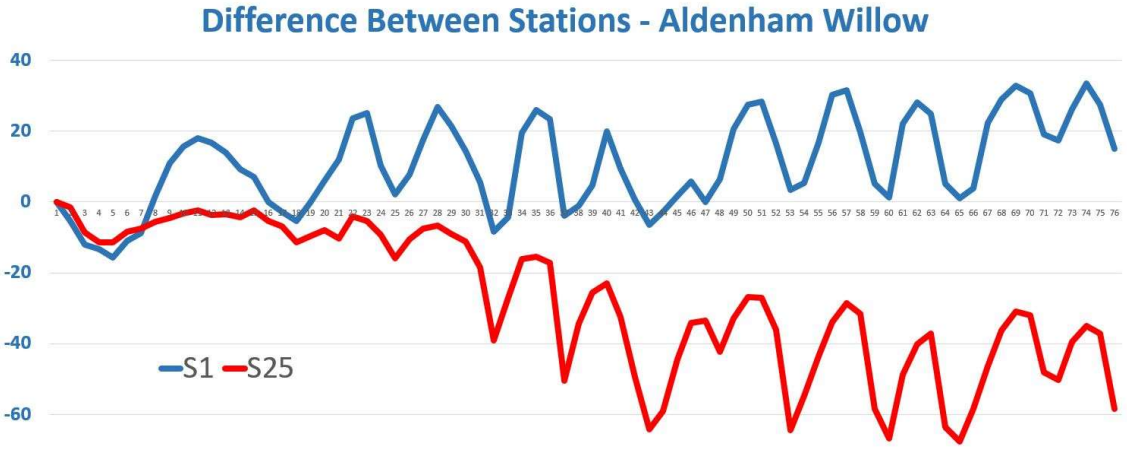


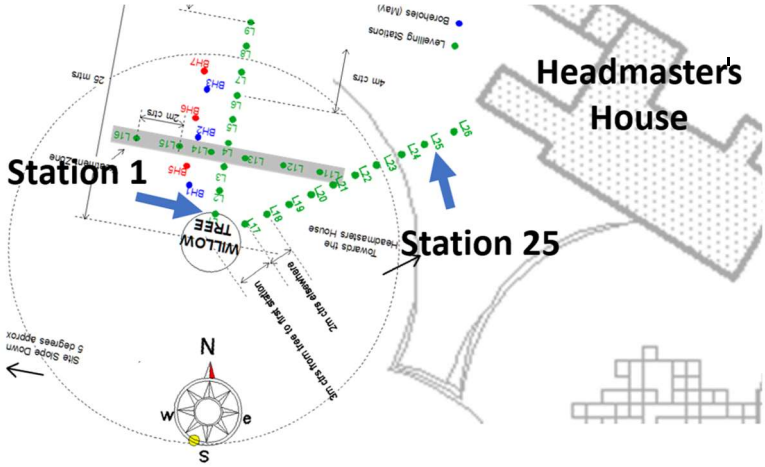


The Clay Research Group

Ground Movement - Difference Over Time Between Stations 1 and 25 of the Aldenham Willow

Stations 1 and 25 show the maximum variation between ground levelling points with a recorded difference of 4.2mm in Sep 2006, increasing to 73.4mm in September 2017. **Station 1** closest to the tree is recovering from its original position as the ground rehydrates. **Station 25** shows a persistent deficit that is increasing year on year. All readings relative to the initial values on 25th May, 2006.

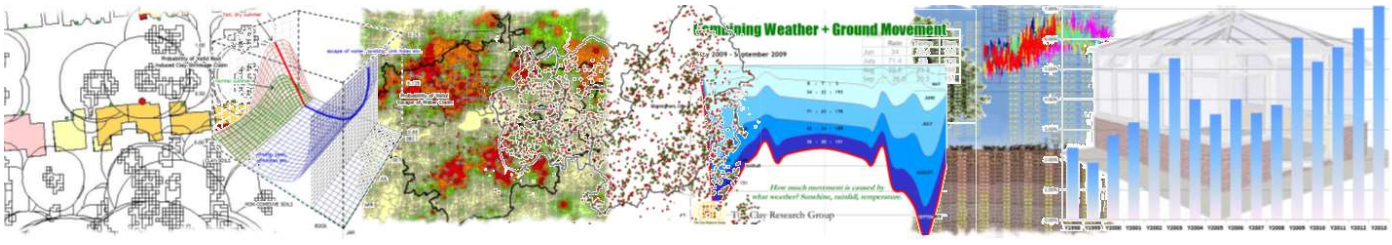




Left, site plan showing the location of the stations in relation to the willow.

Station 1 is nearest to the tree on the north/south array. Station 25 is second from the end of the north-east array.

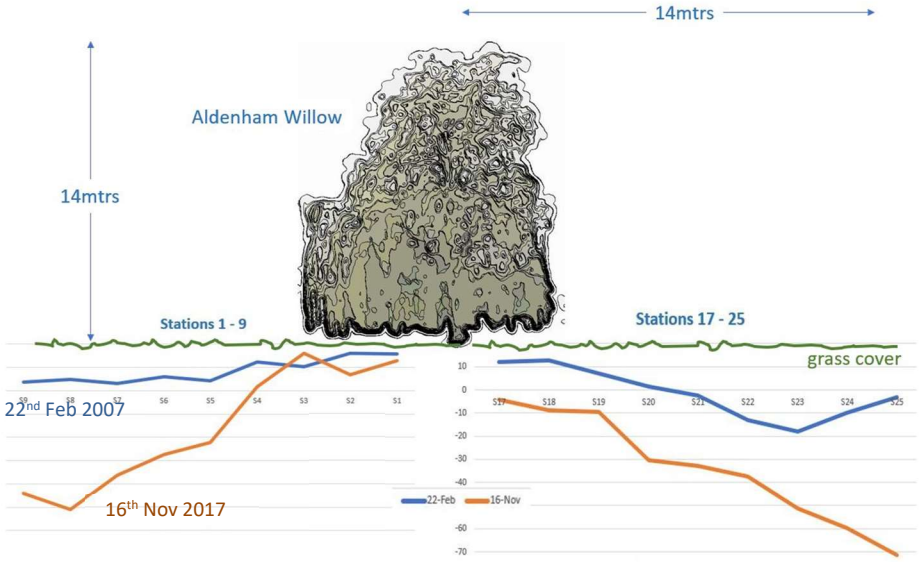
The station nearest the tree appears to be recovering from a persistent moisture deficit. A developing persistent deficit is evident at Station 25. Both exhibit a typical season profile



The Clay Research Group

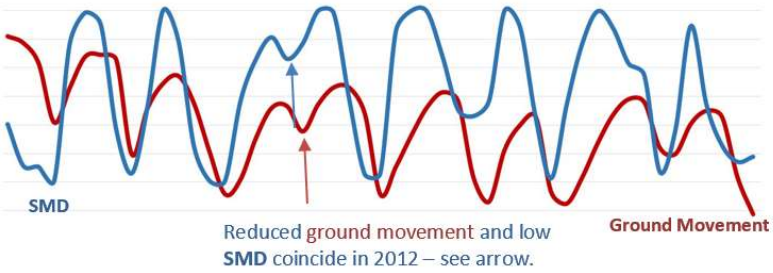
Ground Movement Profiles – Comparing 2007 with 2017

Precise levelling data obtained by GeoServ Limited and funded by Crawford & Co., provide an interesting insight into ground movement over time, and rarely do we have the opportunity to visualise change over a 10-year term. Below, the blue line traces the ground profile in February 2007 and the orange line, the situation in November 2017.



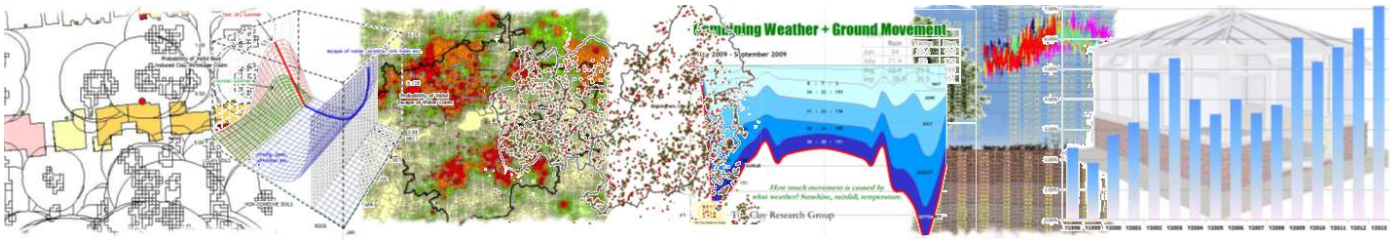
Ground Movement at Station 25 and Relationship with SMD

Below, graphs showing the relationship between ground movement (red – station 25) from the Aldenham willow and SMD (MORECS tile 161), extending from the 28th May, 2009 to 16th November, 2017. The SMD values have been divided by a factor of 2.5 to align the profiles on the 'y' axis. The ground movement profile for station 25 is trending downwards from left to right, reflecting the persistent deficit.



The graph illustrates the variation year on year and reveals the link between them when the two traces followed similar, shallow, outlines associated with the heavy rainfall in 2012, indicated by the arrow.

The delayed response of ground movement to the SMD can be seen every year.



The Clay Research Group

2017 on Reflection

The ABI publication "Key Facts" reviewing 2016 confirmed that insurers spend on the subsidence peril remains unchanged from 2015, amounting to 4% of insurers total spend across all perils.

As Richard Rollit has pointed out, the gap of over 10 years between events is not in itself unusual, although a link to increased atmospheric moisture and associated rainfall could be a factor that changes the industry going forward. Time will tell, but our current view favours the latter.

Looking through last year's newsletters, data and artificial intelligence have been a constant feature. In January 2017 (edition 140), pattern matching techniques were explored to interpret soils results.

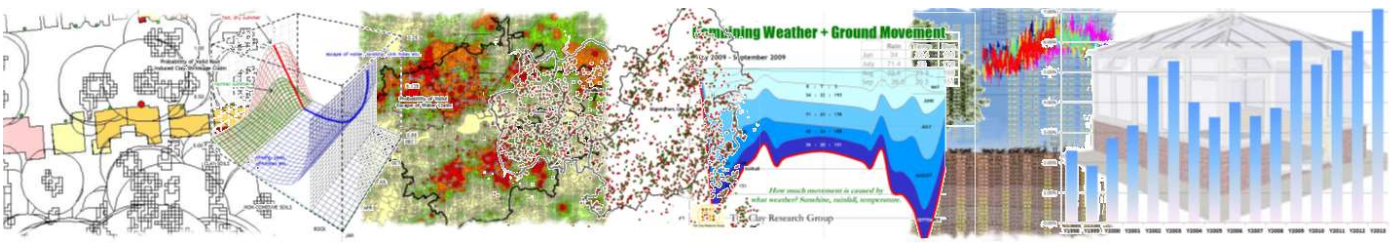
Celebrities trees were mentioned in several editions. Bill Oddie, Daniel Craig and Rachel Weisz, Diana Quick and Bill Nighy, and later in the year, Dame Joan Bakewell received a mention. Bill Oddie was perhaps the most interesting, revealing his conflict at being a conservationist but facing the very real problem when a tree caused subsidence damage to his home.

The link between ground movement and weather was also a recurring theme, continued in this edition.

Edition 142 (March) contained an interesting re-print of an article from Clive Richardson entitled "Keep Calm and Carry on Wallpapering", providing a realistic view of how relatively minor foundation movement producing cracks that would have been filled at one time, and the rooms decorated, now falls under the heading of 'subsidence' and changes the way such damage is viewed by homeowners, Building Societies, building professionals and insurers. The description used to be reserved for foundation movement that threatened the stability of the home.

The long-awaited patent was granted for the Intervention Technique in April. The application was lodged in 2013. The aim of the technique is to resolve root induced clay shrinkage claims where there is minor seasonal movement, quickly, almost on a 'see and fix' basis. Over 150 cases have been treated so far; the 'offending' trees have been retained and insurers have benefitted from substantial savings. All cases have had the full support of the homeowner and none have re-opened.

The May issue (144) introduced the work of TDAG and continued the theme of using data to develop intelligent systems, including risk maps of London showing the distribution by peril (distinguishing between clay shrinkage and escape of water claims) and spend. Water uptake of the Aldenham willow was estimated with the usual caveats.

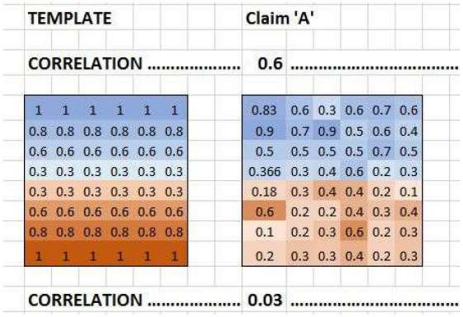


The Clay Research Group

2017 on Reflection *… continued*

In June, thoughts from industry experts relating to the TDAG discussion document were published, together with an estimate of costs to pile every new house to take account of future tree planting and avoid the risk of root induced clay shrinkage. The July edition continued with further discussions around the TDAG proposals. Risk maps showing the claim distribution and frequency risk at postcode sector level appeared in June, followed by further risk maps covering soil PI, "% passing" and private housing stock. July contained a study of tree canopy cover in the Barnet/Finchley areas of London, as part of the 'urban greening' project.

August (issue 147) continued the study of mapping canopy cover. It also discussed artificial intelligence, describing the Association Matrix and the application of pattern matching. The series on risk mapping came to a conclusion with a map combining all elements – claim frequency and cost etc. Soil sample disturbance and the influence on results considered two commonly used tests – suctions and oedometer. Estimates of heave gave widely varying results.

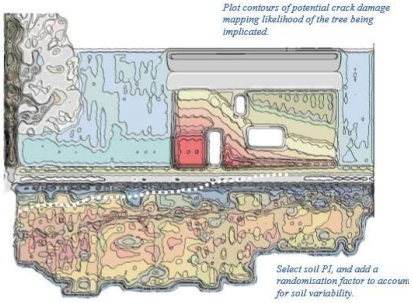


TEMPLATE						Claim 'A'					
CORRELATION						0.6	.....				
1	1	1	1	1	1	0.83	0.6	0.3	0.6	0.7	0.6
0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.7	0.9	0.5	0.6	0.4
0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.7	0.5
0.3	0.3	0.3	0.3	0.3	0.3	0.366	0.3	0.4	0.6	0.2	0.3
0.3	0.3	0.3	0.3	0.3	0.3	0.18	0.3	0.4	0.4	0.2	0.1
0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.2	0.2	0.4	0.3	0.4
0.8	0.8	0.8	0.8	0.8	0.8	0.1	0.2	0.3	0.6	0.2	0.3
1	1	1	1	1	1	0.2	0.3	0.3	0.4	0.2	0.3
CORRELATION						0.03	.....				

September (issue 148) looked at modelling-v-site investigations and considered if there was a predictive link between weather (temperature, rainfall and hours of sunshine) and event years. Areas of damage using actual claims were compared with modelled root zones using the LiDAR dataset. ASUC provided costings for improved foundations to new housing, joining in the TDAG discussion.

October (issue 149): Data entry using a web interface, describing various screens to enable and encourage homeowner interaction. Re-visiting the so-called Disorder Model – see below. Is it possible to model ground movement associated with tree root activity influence on clay soils? The issue also included a seven-page study of Havering to determine the subsidence risk across the borough.

November (issue 150): data entry using a web interface, more on ground movement at the site of the Aldenham willow, weather and a study of the risk of subsidence in Harrow.



December (issue 151): Looking at the SMD and risk modelling in general, and trees in particular. How do we build a model that predicts the pattern of crack damage associated with trees of a certain species, height and distance on soils with a known PI, taking into account weather and possibly maintenance and surrounding paving etc? When damage is reported, can a model help identify which tree is involved?