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

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Issue 213

The Clay Research Group

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Innovation Group fund the Clay Research Group and have provided claims data for the District Risk articles.

Precise level monitoring is undertaken by GeoServ Ltd., funded by Crawford & Co.

MatLab Ltd met the cost of site investigations, soil testing and the installation of the precise levelling stations together with the datum.

Aldenham School in north west London have kindly allowed access to their grounds for the duration of the project

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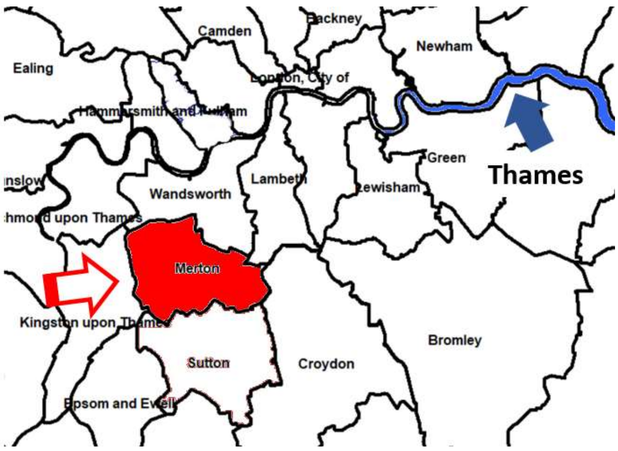
District and Sector Risk

An updated model of Merton, south London, is the topic of the District Risk series in this month's edition and increased resolution is provided with two examples at postcode sector level.



Aldenham Willow

Change over Time

The Clay Research Group was formed in 2006 with the objective of improving our understanding of tree root activity and associated ground movement.

In this edition, we look at ground movement over nearly 17 years, comparing the results with the original estimates of heave obtained using a range of soil tests.

Contributions Welcome

We welcome articles and comments from readers. If you have a contribution, please Email us at:
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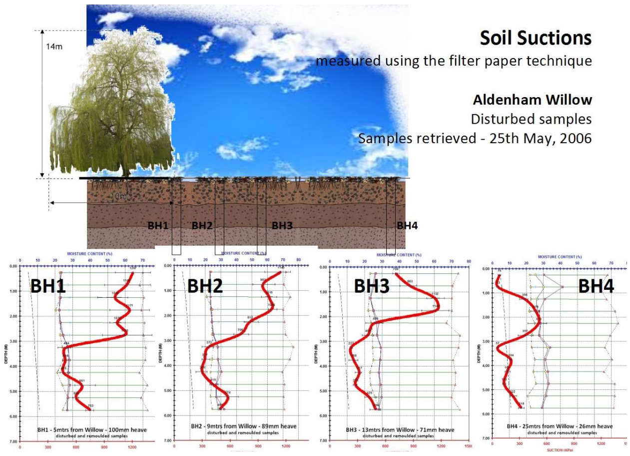
Ground Movement Profile Over Time

Aldenham Willow

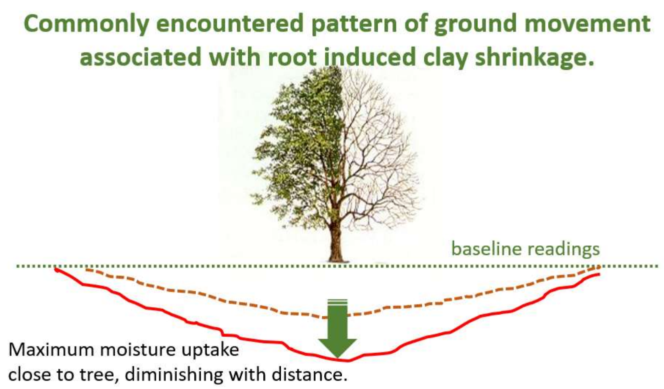
Right, graphs plotting the results of soil samples retrieved from the site of the Aldenham willow in May 2006 tested using the filter paper technique.

Soil suction profiles were highest in BH1 located nearest to the tree, diminishing with distance, as we might expect.

Estimated heave in BH1 was 100mm, and in BH4, 26mm.



These profiles (i.e. greater closer to the tree, reducing with distance) were as expected. Below, left, a sketch of the generally accepted precise level profiles associated with root induced clay shrinkage.

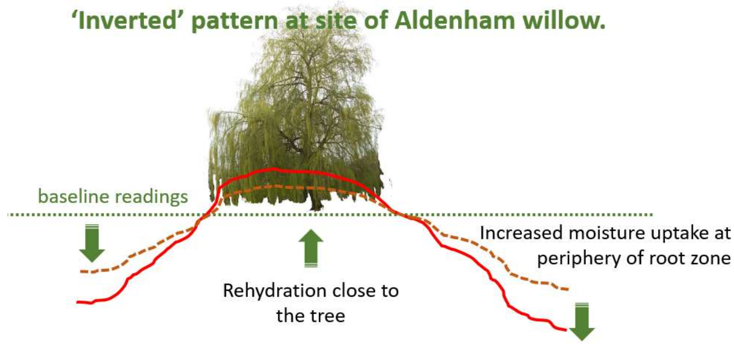


Over time, precise levels at the site of the Aldenham willow have revealed an unusual pattern of movement – see sketch below.

There has been recovery of the soil closer to the tree, and ongoing subsidence towards the root periphery. The values fluctuate seasonally of course, but the trendlines (see pages 4, 5 and 6) tell the story.

The soil tests reproduced at the top of this page show soil suctions exceeding 1,200kPa, approaching the wilting point of 1,500kPa. Towards the root periphery, soil suctions were around 500kPa.

It would appear that soil drying close to the tree resulted in an increase in root stress which resulted in extended growth and moisture uptake at the root periphery.



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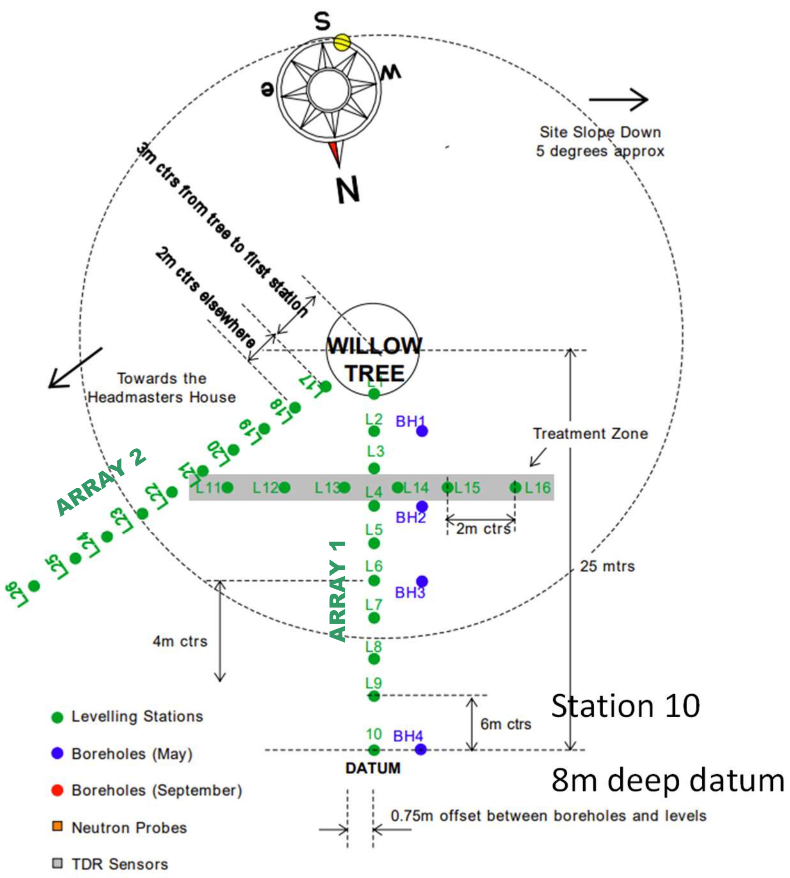
Movement Over Time – the Aldenham Willow

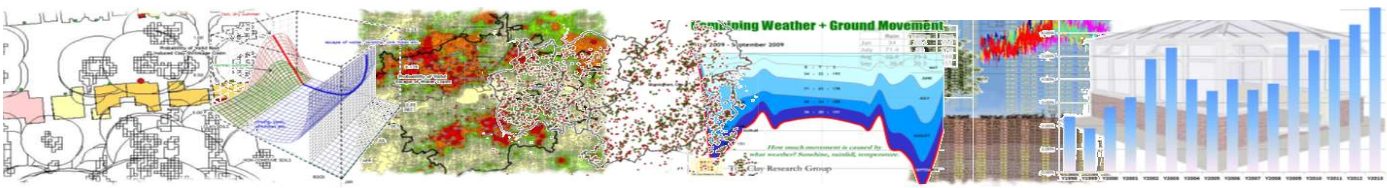
Precise level data gathered since May 2006 provide an interesting insight into water uptake and resulting ground movement over time, revealing the difference with distance from the Aldenham willow.

The soil was already desiccated when the first investigations were undertaken in May 2006. Results of site investigations reproduced on the following pages reveal the extent of desiccation and the link with ground movement.



Also of interest, we see differences in water uptake between the two precise level arrays relative to an 8m deep datum – station 10 on the site plan above, array 1.

Obviously, this data is unique to the Aldenham willow. It is however useful in understanding the dynamic system of tree root activity and, incidental to the exercise, the accuracy of estimates of heave using soils results.



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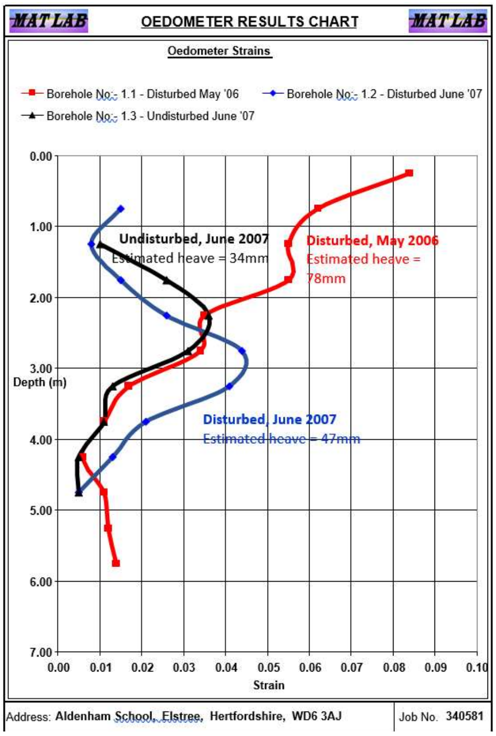
Ground Movement and Moisture Uptake

- The Aldenham Willow -

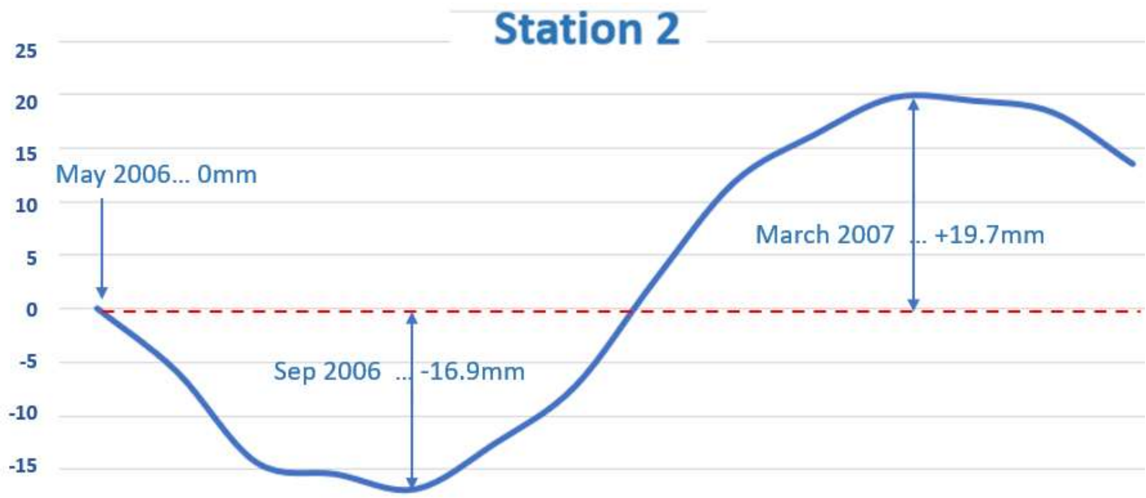


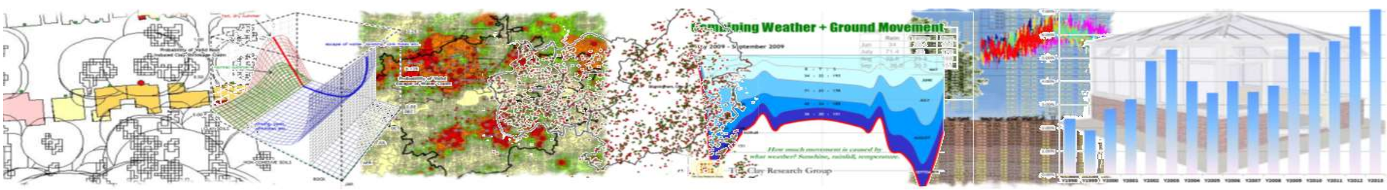
Right, the results of soil tests from boreholes sunk in May 2006 (red) and June 2007 (blue) around 5mtrs from the Aldenham willow. The location of the boreholes corresponds to precise level Station 2 in array 1, shown on the previous page.

The oedometer tests from samples retrieved in May 2006 from disturbed samples estimated a swell potential of around 78mm, demonstrating that the ground was already desiccated when level readings began.

Samples taken in June of the following year using both disturbed and undisturbed samples revealed that significant rehydration had taken place with estimated residual heave of 34mm from the undisturbed samples and 47mm from the disturbed samples.

The measured ground recovery is shown below – data from precise level station 2 shows recovery of 19.7mm in March, when compared with the starting point. This follows a dip of 16.9mm in September 2006.





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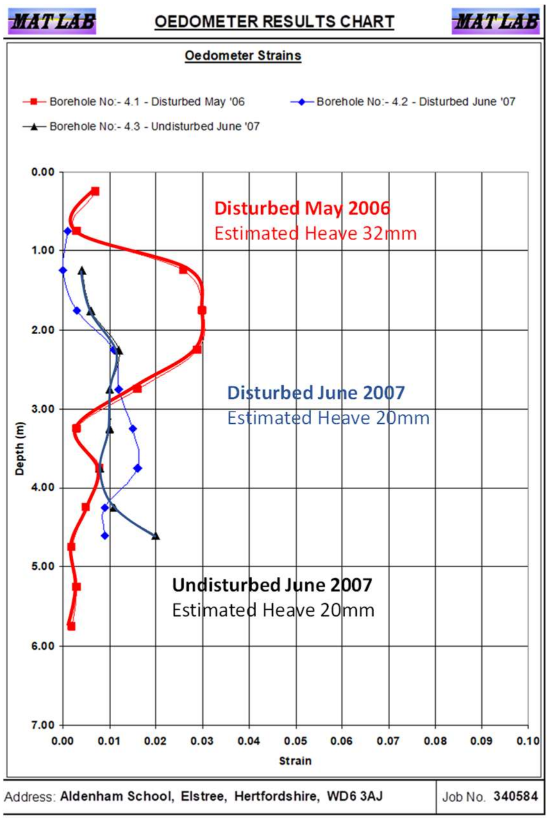
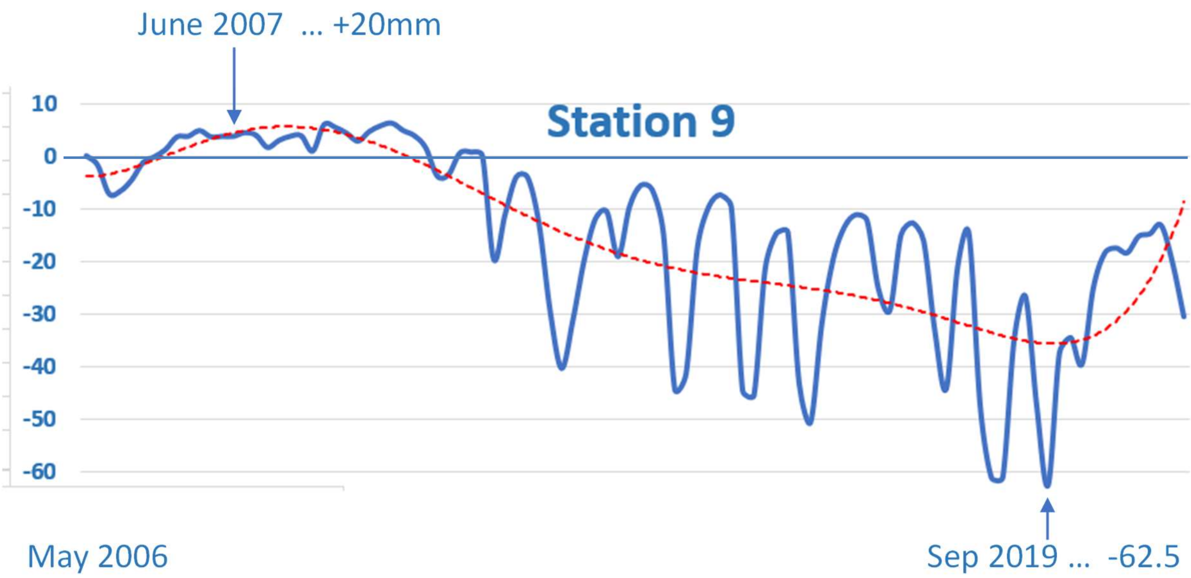
A similar exercise, looking at soil samples tested from boreholes sunk 25mtrs away from the willow and comparing estimates of swell with precise level data from station 9 situated 19mtrs from the willow tree delivered the following results.

In May 2006, the estimated heave from the disturbed soil samples tested using the oedometer was 32mm. In June 2007 both disturbed and undisturbed samples yielded estimates of heave of around 20mm.

As we see below, the actual recovery in that period derived from precise level readings matched the estimates of heave from the soil testing - 20mm.

Since that time there has been significant subsidence of the site in this location (i.e. 19mtrs from the tree) associated with soil drying, reaching 62.5mm in September 2019.





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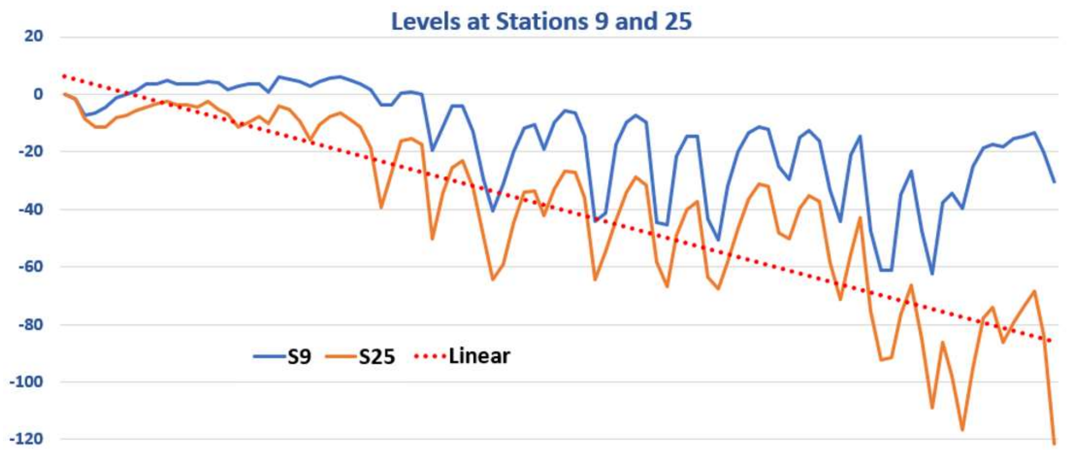
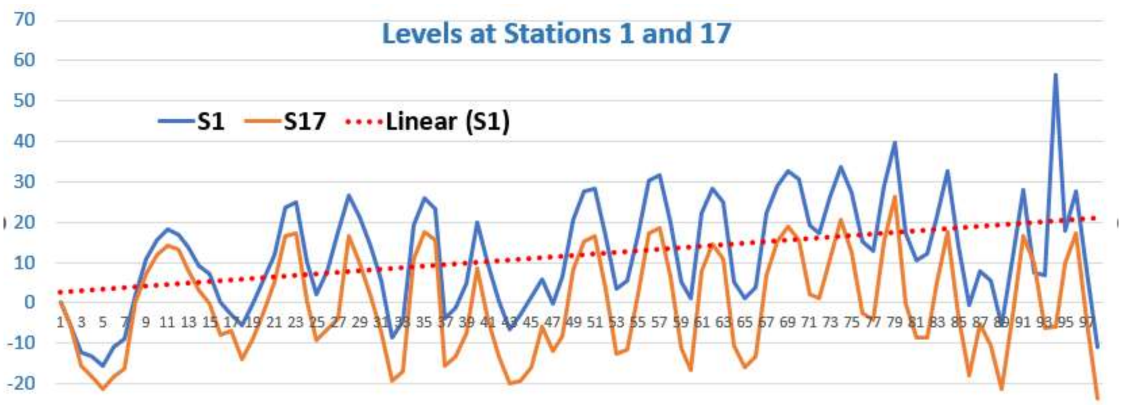
Below, a summary of comparison profiles from the two arrays comparing movement at stations 9 and 25, with those at stations 1 and 17.



Above, readings from stations 9 and 25 over the last 16 years or so. From May 2006 to August 2022 downward movement of the site has increased year on year, reaching a maximum of 62.5mm from the starting point.

In contrast, and over the same period, movement nearer to the tree at stations 1 and 17 has shown recovery associated with an increase in moisture due to reduced root activity. Recovery reached a maximum of 56.5mm in December 2021.



The heave potential calculated at BH 1 (page 4) was 78mm, which suggests there may be a potential for further recovery.

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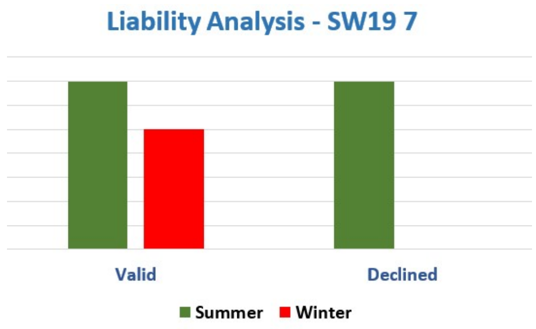
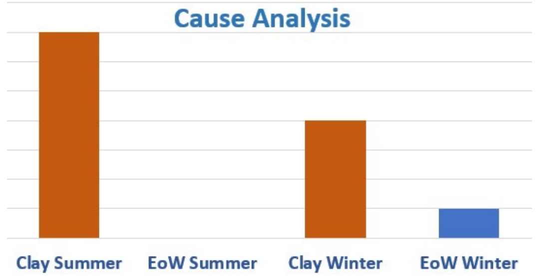
MERTON Area Sector Level Sample.
Using Past Claims Data to Infer Geology and Derive Probability of Cause and Liability





SW19 7 – Clay shrinkage is the dominant peril as might be expected given the presence of London clay across the district and what appear to be shallow deposits (see CRG map, page 11) of sand and gravel and river terrace. See also the 1:625,000 scale BGS maps on page 10.

Average claim settlement cost from the sample we hold is around £9k.

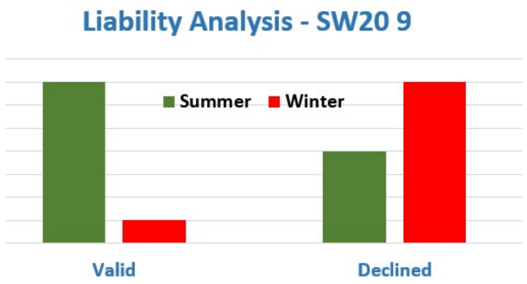
The sector has a risk rating 6x the national average - 0.279 on a normalised scale.

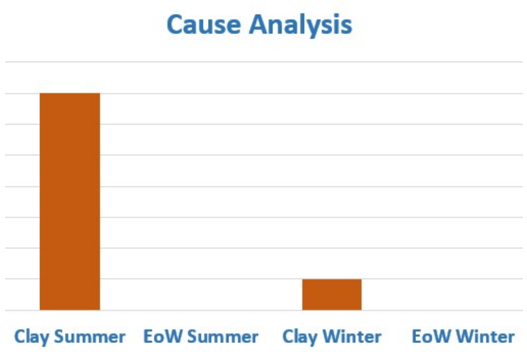
SW20 9 – comprises predominantly terraced houses in private ownership.

It is rated 2.62 times the UK average risk at postcode sector level - 0.121 on a normalised scale.

The high percentage of clay shrinkage claims shown in the lower graph, right, suggest shallow drift deposits overlying the solid geology of London clay.

All perils from claims listed on our database were clay related - the claim notified in the winter related to damage caused by heave.





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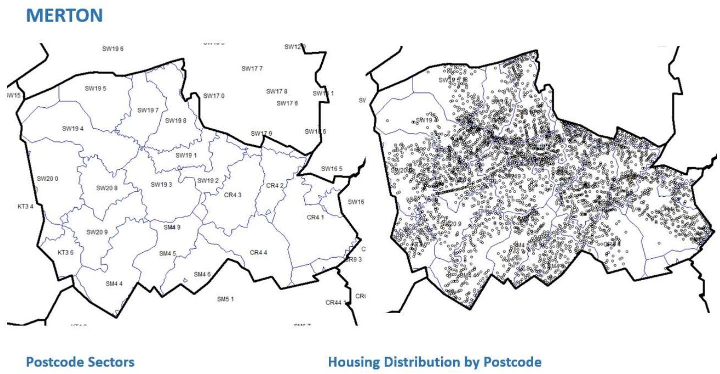
Subsidence Risk Analysis – MERTON

Merton is situated in south west London and occupies an area of 37.6km^2 with around 80,000 houses and a population of around 206,186.



Distribution of housing stock using full postcode as a proxy. Each sector covers around 2,000 houses on average across the UK and full postcodes include around 15 – 20 houses on average, although there are large variations.

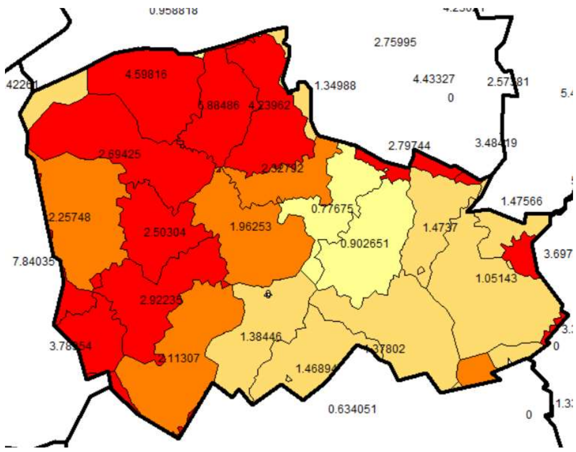
Sector and housing distribution across the district (left, using full postcode as a proxy) helps to clarify the significance of the risk maps on the following pages. Are there simply more claims in a sector because there are more houses?

Using a frequency calculation (number of claims divided by private housing population) the relative risk across the borough at postcode sector level is revealed, rather than a 'claim count' value.

From the sample we hold, sectors are rated for the risk of domestic subsidence compared with the UK average – see map, right.

Merton is rated 39th out of 413 districts in the UK from the sample analysed and is around 1.8x the risk of the UK average, or 0.47 on a normalised scale.

There is an increased risk to the north and west of the borough as can be seen from the sector map, right, which corresponds with outcropping London clay.



Merton district is rated around 1.8 times the UK average risk for domestic subsidence claims from the sample analysed. Above, risk by sector.

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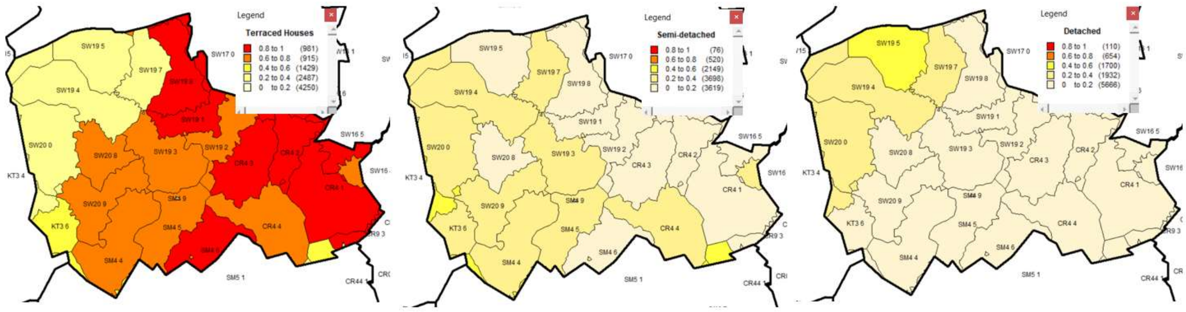
MERTON - Properties by Style and Ownership

Below, the general distribution of properties by style of construction, distinguishing between terraced, semi-detached and detached. Unfortunately, the more useful data is missing at sector level – property age. Risk increases with age of property and the model can be further refined if this information is provided by the homeowner at the time of application.

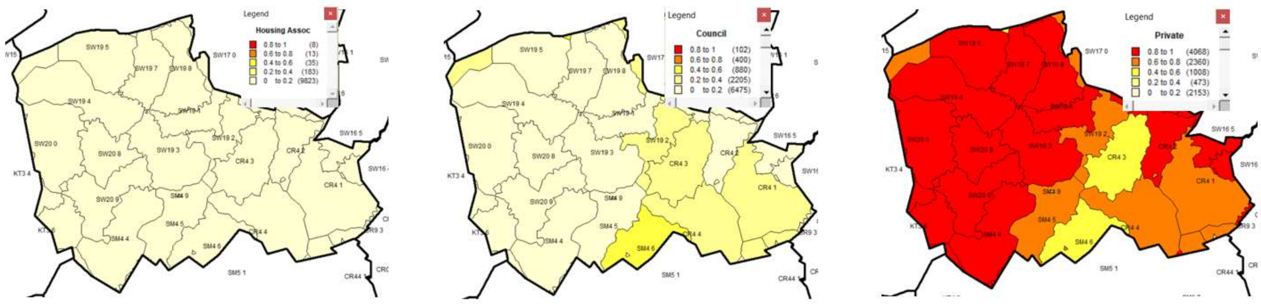
MERTON - Distribution by House Type



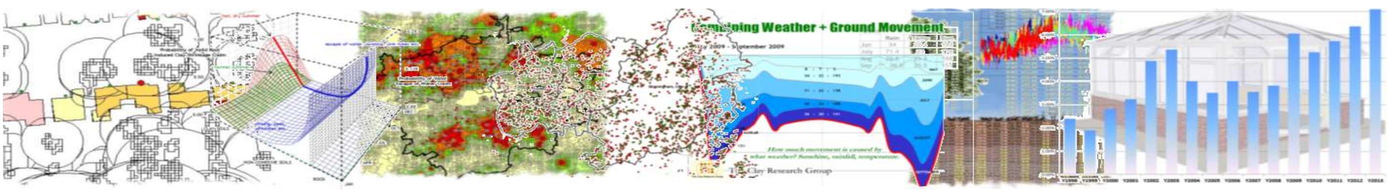
Terraced **Semi-Detached** **Detached**

Distribution by ownership is shown below. Privately owned, terraced properties are the dominant class and are spread across the borough. See page 10 for distribution of risk by ownership.

MERTON - Distribution by Ownership



Housing Association **Council Ownership** **Private Ownership**



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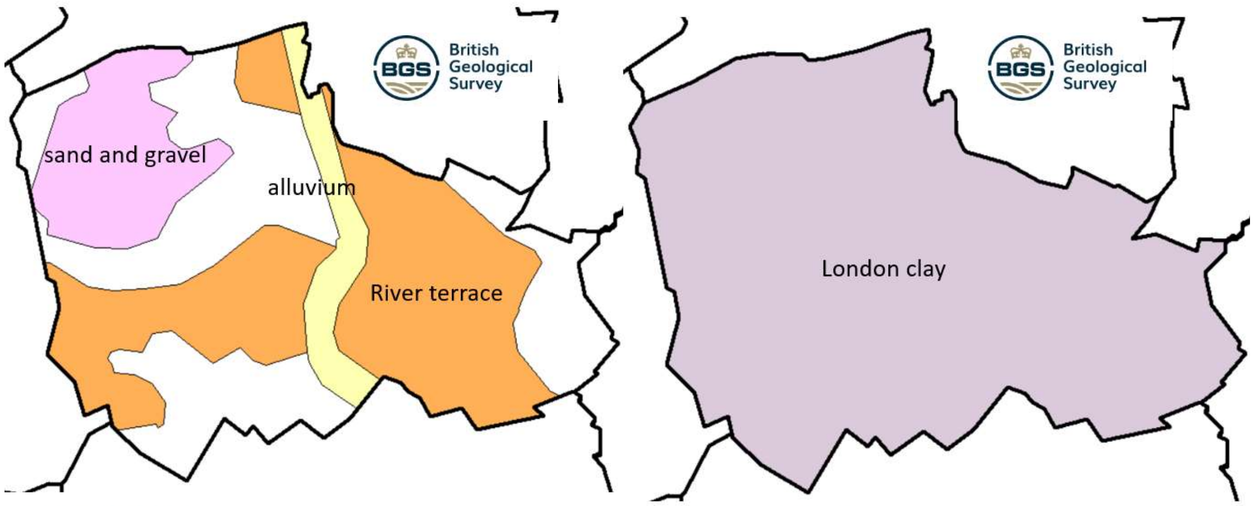
Subsidence Risk Analysis – MERTON

Below, extracts from the British Geological Survey low resolution 1:625,000 scale geological maps showing the solid and drift series. View at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html for more detail.

See page 13 for a seasonal analysis of the sample which reveals that, at district level, there is a greater than 70% probability of a claim being valid in the summer and of the valid claims, there is a high probability (greater than 80% in the sample) that the cause will be clay shrinkage.

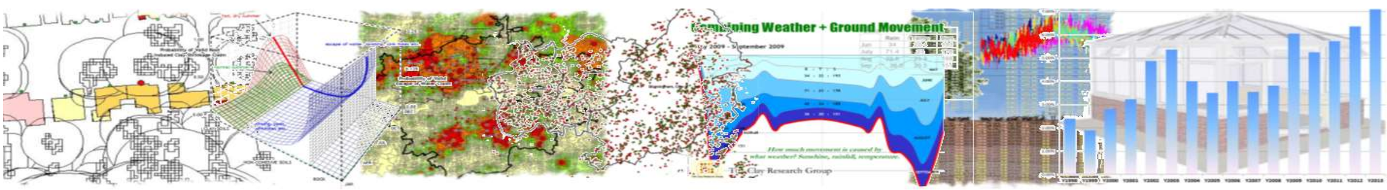
In the winter the likelihood of a claim being valid falls to around 30% - and if valid, there is a greater than 80% probability the cause will be due to an escape of water. Maps at the foot of the following page plot the seasonal distribution.

MERTON : BGS Geology – 1:625,000 scale



DRIFT DEPOSITS **SOLID GEOLOGY**

Above, extracts from the 1:625,000 series British Geological Survey maps. Working at postcode sector level and referring to the 1:50,000 series delivers far greater benefit when assessing risk. Clay shrinkage is the dominant cause of valid subsidence claims.



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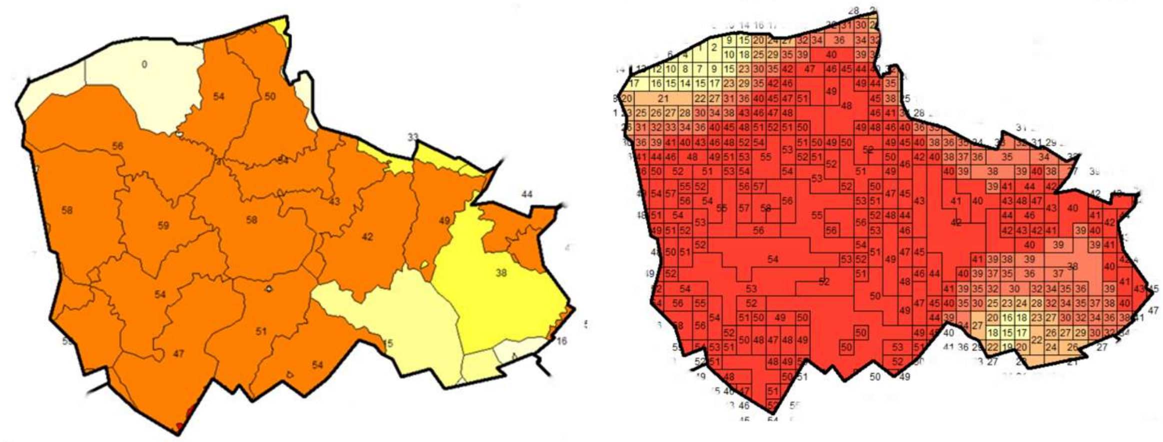
Liability by Geology and Season

Below, the average PI by postcode sector (left) derived from site investigations and interpolated to develop the CRG 250m grid (right). The higher the PI values, the darker red the CRG grid. The data gathered from investigations undertaken investigating claims suggests drift deposits in the area are quite shallow.

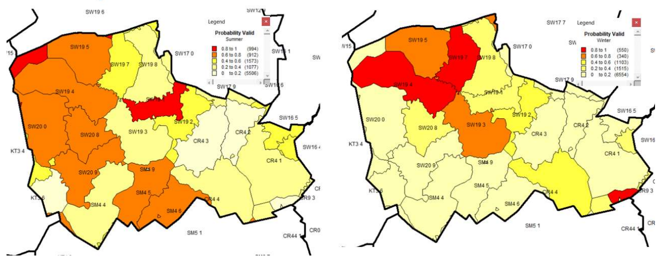
MERTON – Soil Plasticity Index



Soil PI Averaged by Sector **PI Interpolated on 250m CRG grid**

Zero values for PI in some sectors may reflect the absence of site investigation data - not necessarily the absence of shrinkable clay. A single claim in an area with low population can raise the risk as a result of using frequency estimates.

MERTON – by season

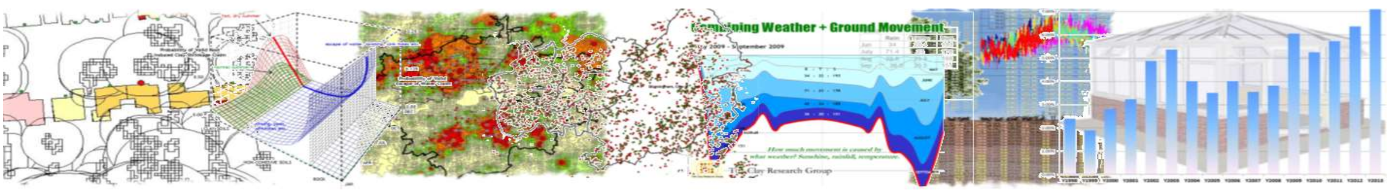


Probability Valid, Summer **Probability Valid, Winter**

The maps, left, show the seasonal difference from the sample used.

Combining the risk maps by season and reviewing the table on page 13 is perhaps the most useful way of assessing the potential liability, likely cause and geology using the values listed.

The ‘claim by cause’ distribution and the risk posed by the soil types is illustrated at the foot of the following page. A high frequency risk can be the product of just a few claims in an area with a low housing density of course and claim count should be used to identify such anomalies.



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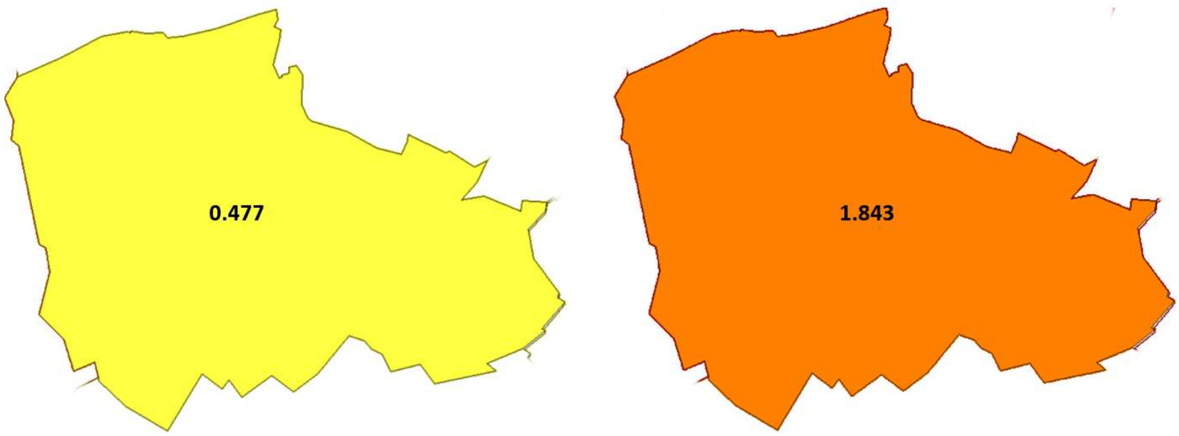
District Risk -v- UK Average. EoW and Council Tree Risk.

MERTON - Subsidence Risk Relative to UK

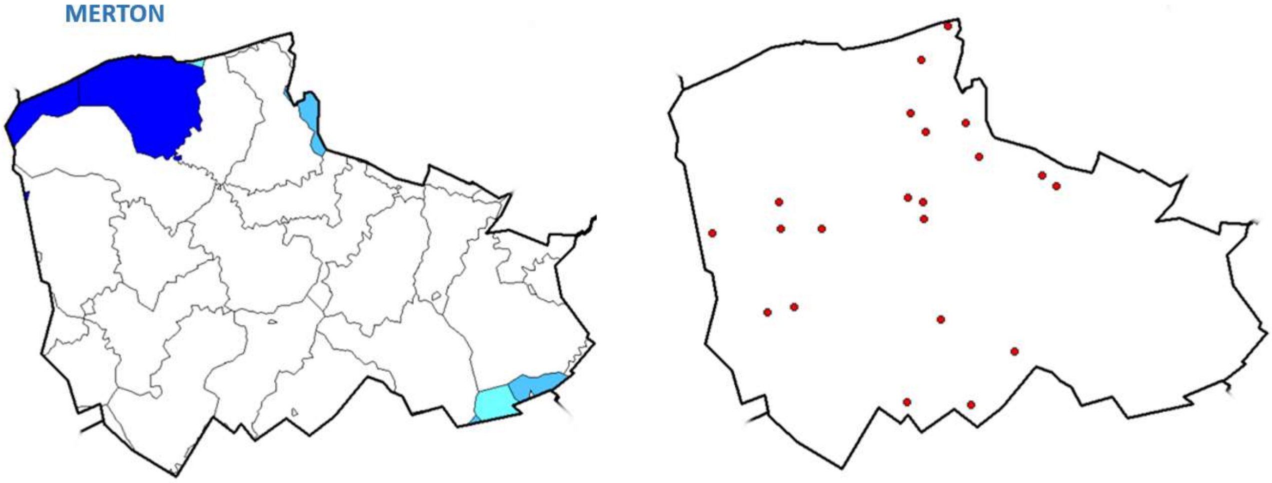


Normalised (0 – 1) Scale | Relative to UK Average

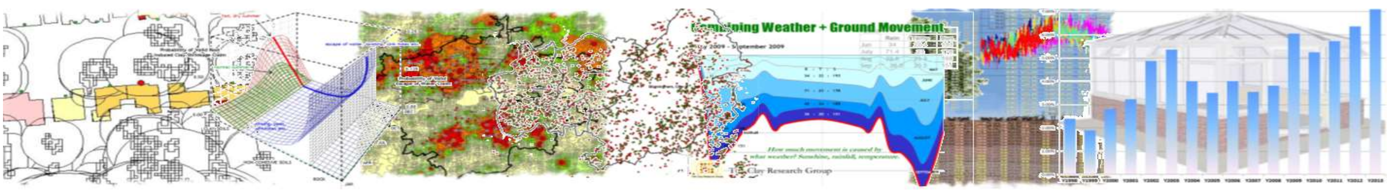
Below, left, mapping the frequency of escape of water claims reflects the presence of non-cohesive soils – River Terrace deposits of alluvium, sands and gravels etc. The absence of shading can indicate a low frequency rather than the absence of claims.

Below right, map plotting claims where damage has been attributable to vegetation in the ownership of the local authority from a sample of around 2,858 UK claims.

MERTON



Higher Risk Escape of Water | Claims Involving Council Tree (2,858 UK claim sample)



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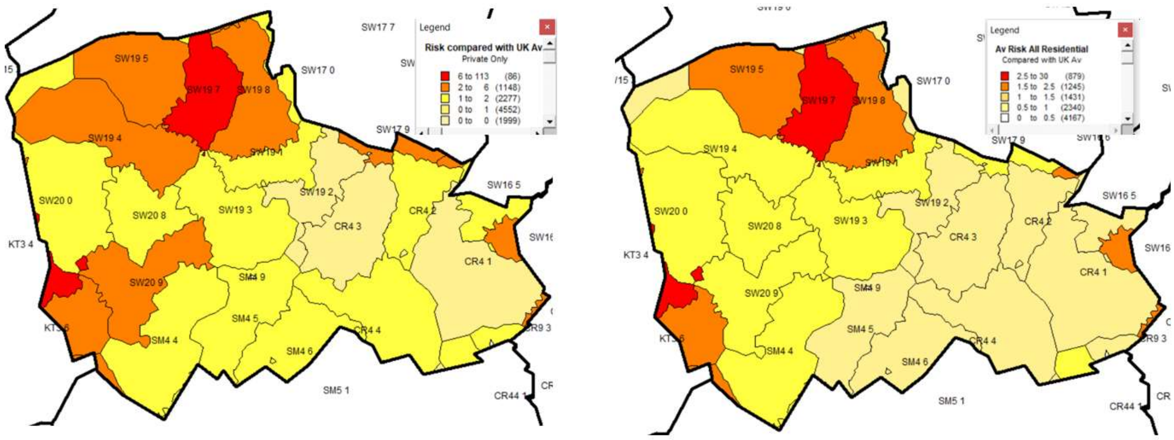
MERTON - Frequencies & Probabilities

Below, mapping the total housing stock by ownership reveals the importance of understanding claims frequency relating to the number of properties at risk. Left, claims frequency for private ownership only reveals an increased risk compared with claims frequency for the total housing stock with council and housing association properties included.

MERTON - Sector Risk Compared with UK Average



Private Only **All Properties**

On a general note, the reversal of rates for valid-v-declined by season is a characteristic of the underlying geology. For clay soils, the probability of a claim being declined in the summer is usually low, and in the winter, it is high.

Valid claims in the summer are likely to be due to clay shrinkage, and in the winter, escape of water. For non-cohesive soils, sands gravels etc., the numbers tend to be fairly steady throughout the year.

Liability by Season - MERTON

District	valid summer clay	valid summer EoW	Repudiation Rate (summer)	valid winter clay	valid winter EoW	Repudiation Rate (winter)
Merton	0.667	0.104	0.229	0.04	0.27	0.69

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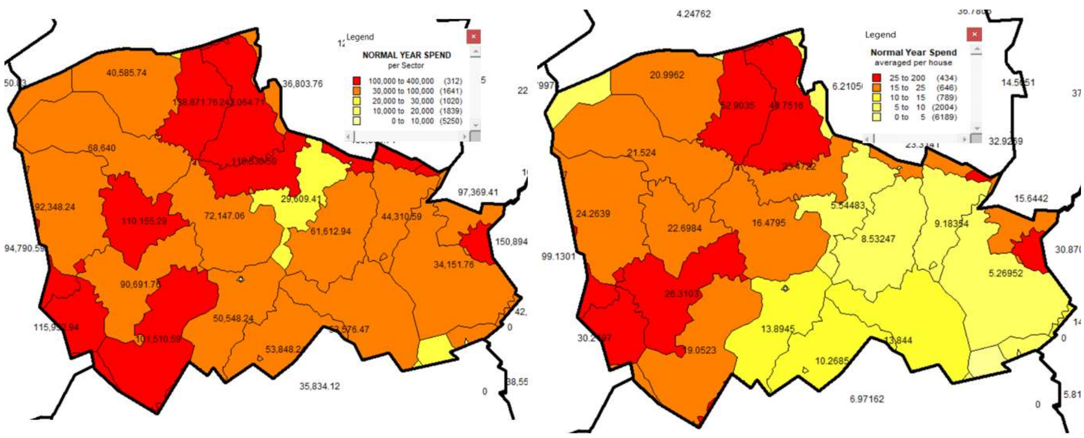
Aggregate Subsidence Claim Spend by Postcode Sector and Household in Surge & Normal Years

The maps below show the aggregated claim cost from the sample per postcode sector for both normal (top) and surge (bottom) years. The figures will vary by the insurer's exposure, claim sample and distribution.

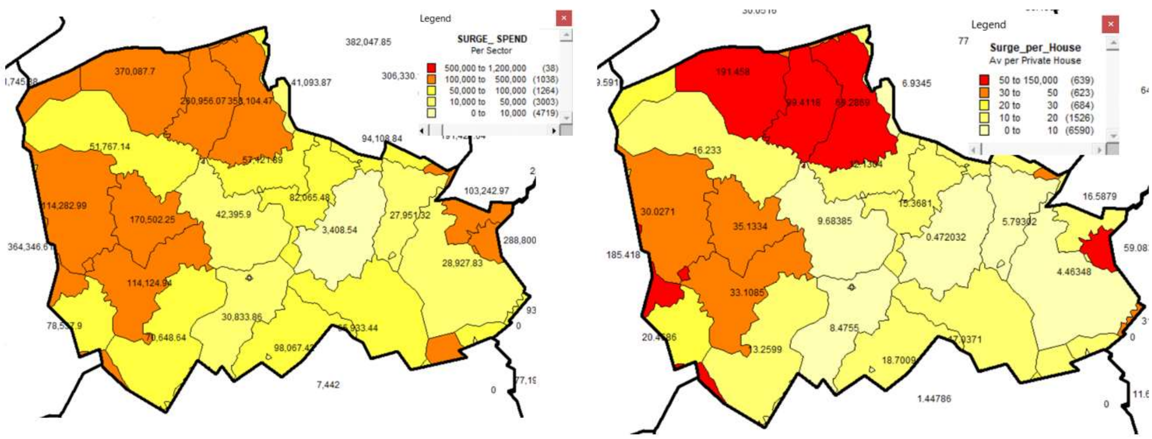
NORMAL YEAR SPEND – MERTON



Spend by Sector **Spend Averaged over Housing Population**

It will also be a function of the distribution of vegetation and age and style of construction of the housing stock. The images to the left in both examples (above and below) represent gross sector spend and those to the right, sector spend averaged across housing population to derive a notional premium per house for the subsidence peril. The figures can be distorted by a small number of high value claims.

SPEND in SURGE – MERTON



Spend by Sector **Spend Averaged over Housing Population**

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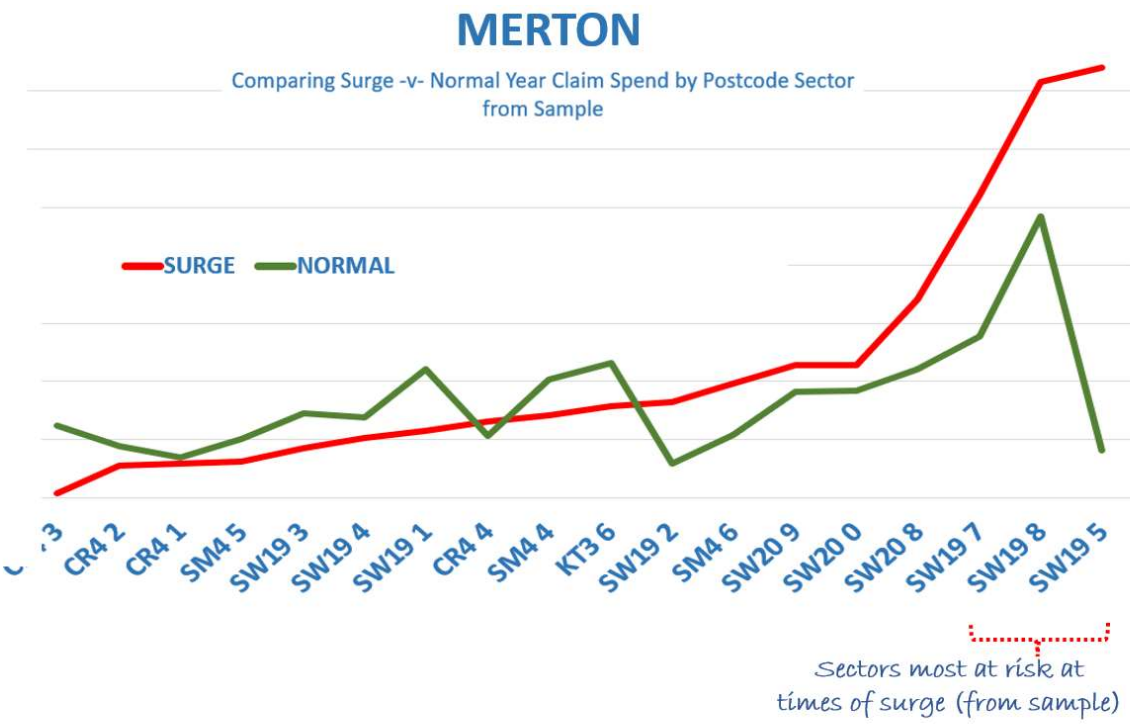

The above graph identifies the variable risk across the district at postcode sector level from the sample, distinguishing between normal and surge years. Divergence between the plots indicates those sectors most at risk at times of surge (red line).

It is of course the case that a single expensive claim (a sinkhole for example) can distort the outcome using the above approach. With sufficient data it would be possible to build a street level model.

In making an assessment of risk, housing distribution and count by postcode sector play a significant role. One sector may appear to be a higher risk than another based on frequency, whereas basing the assessment on count may deliver a different outcome. This can also skew the assessment of risk related to the geology, making what appears to be a high-risk series less or more of a threat than it actually is.

The models comparing the cost of surge and normal years are based on losses for surge of just over £400m, and for normal years, £200m.