

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 249

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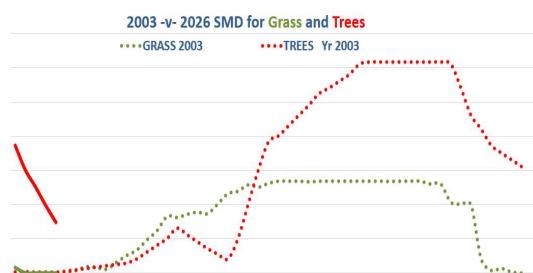
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TENDRING

SMD Graph



Plotting the correlation between the Soil Moisture Deficit for a surge year (2003) and the current year.

Contributions Welcome

We welcome articles and comments from readers. If you have a contribution, please Email us at: clayresearchgroup@gmail.com

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District and Sector Risk

Tendring is situated on the Essex coastline with an area of around 366km² and a population around 157,000.

It is the subject of the 'Risk by District' series in this month's edition. Its geology comprises small areas of drift deposits overlying bedrock – see Page 10.



The risk maps are built from a data sample covering four claim years, including one surge and three 'normal' years.

Aldenham Willow



This month we review data collected from the Aldenham willow, comparing ground movement nearest and furthest away from the tree, and the relationship with the moisture content of the soil.



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ChatGPT

Question to ChatGPT



Is there a correlation between the Soil Moisture Deficit (SMD) and tree root induced ground movement?

Response

Yes — there is a clear and well-established correlation between Soil Moisture Deficit (SMD) and tree-root-induced ground movement, particularly in shrink-swell (expansive) clay soils. The relationship is indirect but strong.

1. How SMD and tree roots are linked

Soil Moisture Deficit (SMD)

- SMD represents how much water the soil lacks compared to **field capacity**.
- Higher SMD = drier soil = greater potential for **soil shrinkage**.

Tree root activity

- Trees extract water from the soil through transpiration.
- Root water uptake increases:
 - During the growing season
 - With larger or more water-demanding species
 - In dry weather or drought conditions

2. Mechanism of ground movement

In **clay soils**, the sequence is:

1. **Tree roots extract water**
2. **Local SMD increases**, especially near the tree
3. **Clay soil shrinks as moisture content decreases**
4. **Differential ground movement** occurs (settlement)
5. Buildings experience **subsidence or seasonal movement**

When moisture returns (rainfall, reduced transpiration), the clay **swells**, potentially causing **heave** if trees are removed.

3. Strength of the correlation

- **Higher SMD → greater shrinkage potential**
- **Greater shrinkage → larger tree-related ground movement**

Empirical and monitoring studies show:

- Seasonal ground movement closely follows **seasonal SMD curves**
- Maximum settlement typically occurs at or near **peak annual SMD**
- Tree influence zones often show **higher SMD than surrounding ground**

However, the relationship is **not linear** and depends on several modifiers.



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4. Key controlling factors

The correlation between SMD and tree-induced movement is strongest when:

Soil factors

- High plasticity clays (high PI, high shrink–swell index)
- Thick clay strata
- Poor drainage

Tree factors

- High water demand species (e.g. oak, willow, poplar)
- Large mature trees
- Close proximity to foundations
- Root depth matching active clay layer

Climate factors

- Prolonged dry periods
- High evapotranspiration rates
- Repeated seasonal drying–rewetting cycles

5. Practical implications (engineering & arboriculture)

- SMD is often used as a **proxy indicator** for potential tree-related subsidence risk.
- In the UK and similar climates:
 - **Peak SMD years** often coincide with **subsidence claim spikes**
 - Long-term SMD trends are used in **risk modelling and climate change projections**
- SMD alone **cannot predict movement**, but it is a critical input alongside:
 - Soil plasticity
 - Tree species and distance
 - Foundation depth

6. Important limitations

- High SMD **without trees** does not necessarily cause damaging movement.
- Trees on **non-expansive soils** may raise SMD but cause little or no movement.
- Root barriers, deep foundations, or desiccated historical soils can weaken the correlation.

7. Summary

Yes — SMD and tree-root-induced ground movement are strongly correlated, especially in clay soils:

- Trees increase local SMD through water uptake
- Increased SMD leads to clay shrinkage
- Shrinkage causes ground movement and potential structural damage

SMD is best viewed as a **climate-soil driver**, while trees act as a **local intensifier** of moisture loss.

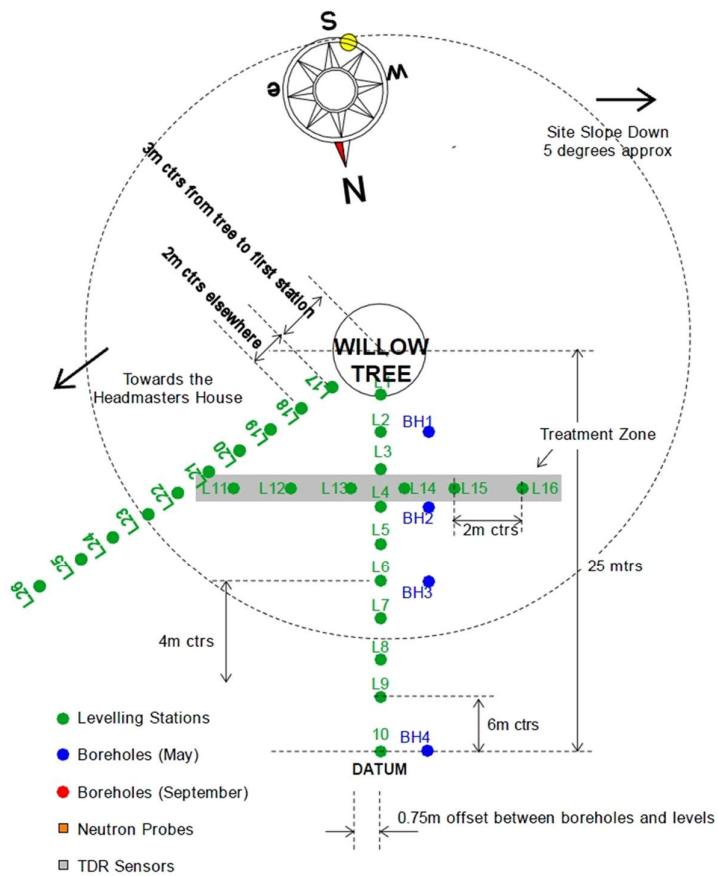


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The Aldenham Willow Revisited

Site investigations and precise levels were established at the Aldenham research site in May 2006. Monitoring of ground movement continued until August 2022. Below, the site plan illustrating the position of the level monitoring stations and location of bores that were sunk to obtain soil samples. What is the relationship between ground movement and soil moisture content?

Aldenham Research Site - Willow Tree



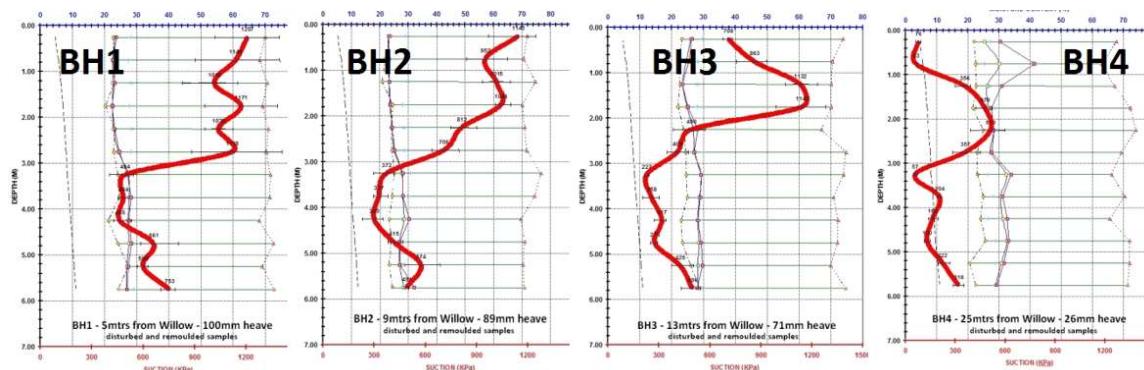
Level stations 1 and 17 were located 3mtrs from the willow. Stations 9 and 25 were furthest away at 19mtrs. The datum was 8mtrs deep.

Borehole 1 was 5mtrs away, BH2, 9mtrs, BH3, 13mtrs and BH4, 25mtrs.



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Below, the results of laboratory tests from the soil samples retrieved in May 2006 using the filter paper technique. Various tests were undertaken (suctions, oedometers, penetrometer, moistures etc.) and comparisons made between disturbed and undisturbed samples. Estimates of heave varied but all confirmed the general pattern of root activity and soil drying.

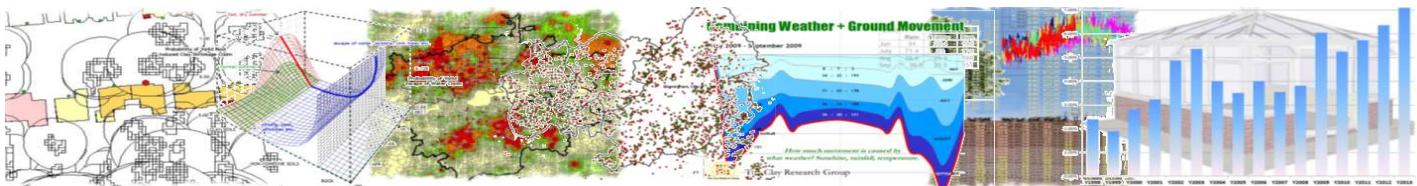


The interesting point is the degree of desiccation in all boreholes in the month of May clearly indicate a persistent moisture deficit. The estimate in the sample above suggested a heave potential in BH1 of around 100mm should the tree be removed.

Precise levels at the stations nearest the tree (stations 1 and 17) and those furthest away (stations 9 and 25) provide an interesting view of root activity of the mature willow.

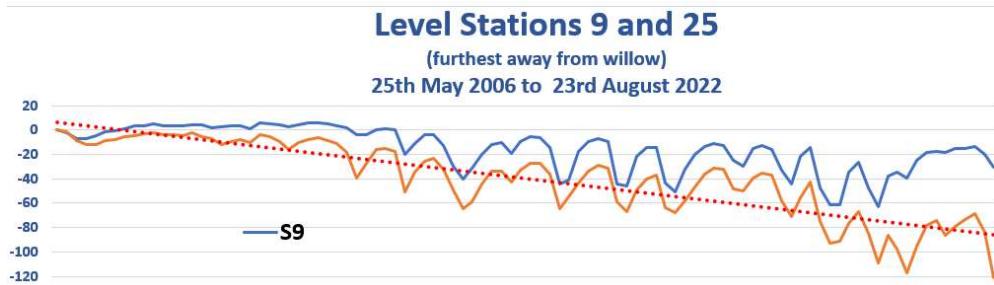
Levels nearest the tree (see below) rose significantly over the 16-year monitoring term. This, combined with the persistent deficit that existed in May 2006 revealed that the root system nearest the tree was no longer as active as it had been in the past.

The soil was rehydrating steadily with some seasonal movement, rarely exceeding 30mm.



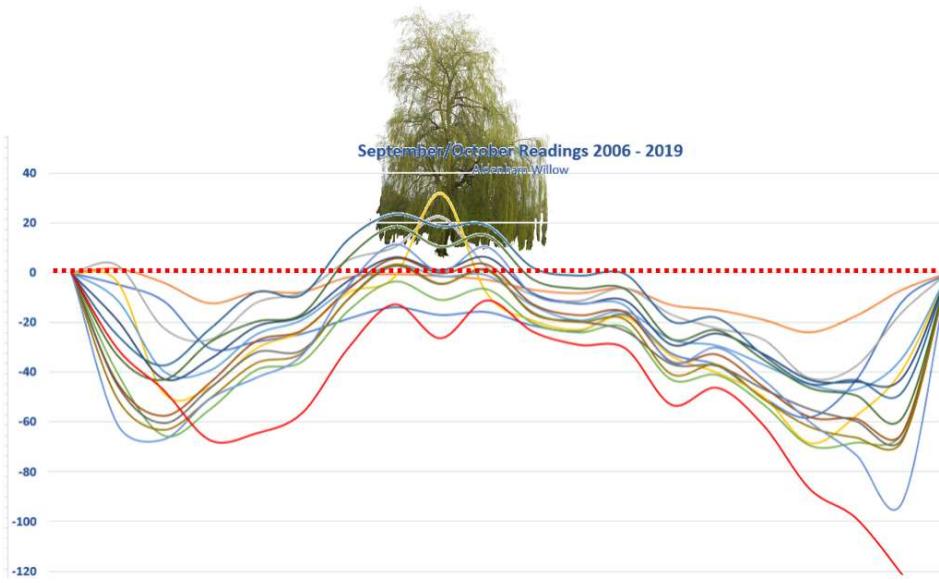
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In contrast, the levels furthest away from the willow revealed a different profile, with the soil shrinking and the ground subsiding with little evidence of recovery in the winter – particularly at station 25 which subsided 120mm in the monitoring term. This produced a persistent deficit at the root periphery.



The difference between the stations (i.e. far and near) reached a value of 110mm in August 2022.

Below, a graph plotting changing profiles in the summer months from 2006 to 2019, revealing the rehydration profile.



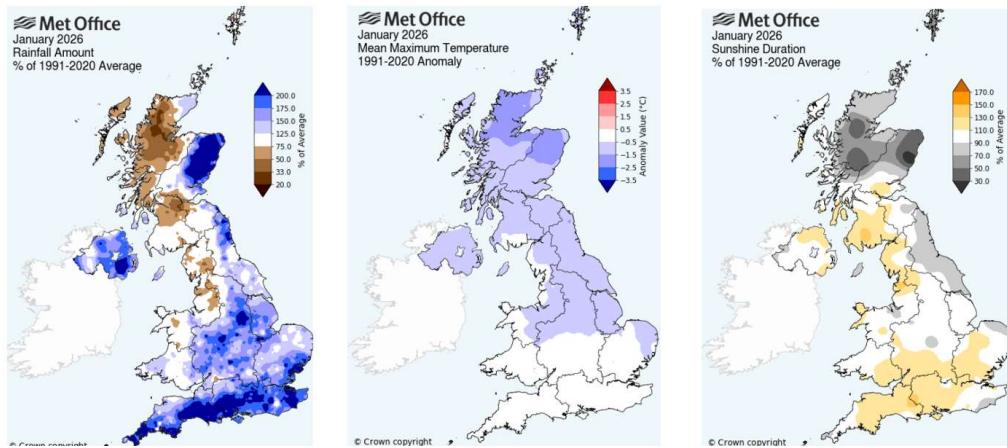
The soils nearest the tree had not reached equilibrium (taking account the estimate of heave from the samples retrieved in May 2006) despite the measured recovery, with a potential for around a further 50mm of swelling. The roots at the periphery are clearly active and likely to produce further ground movement.



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Met Office Anomaly Maps for January 2026

Anomaly maps from the Met Office web site for the month of January 2026 comparing data with the 1991 – 2020 average, reproduced below.



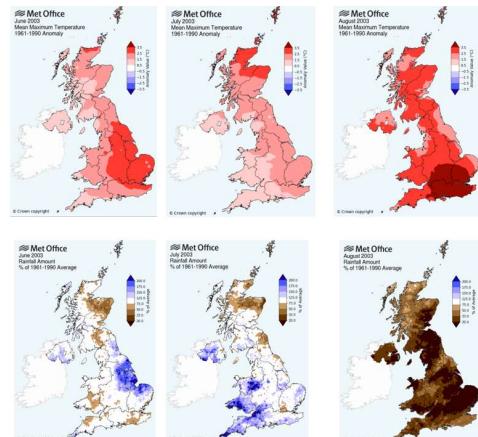
The predominant change is fairly heavy rainfall across the south and east of the UK compared with 1991 – 2020 averages.

<https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-actual-and-anomaly-maps>

Anomaly Data for 2003 – a Surge Year

What caused the surge in subsidence claims in 2003? Clearly the weather but what sort of change was needed, and when?

The Met Office provide valuable information as we can see from the maps below, plotting rainfall and temperature for June, July and August compared with the 1961 – 1990 average



The top row plots mean maximum temperature and the row below, the amount of rainfall.

The images provide a good clue about the cause of the problem but unfortunately, have little, if any, predictive value.

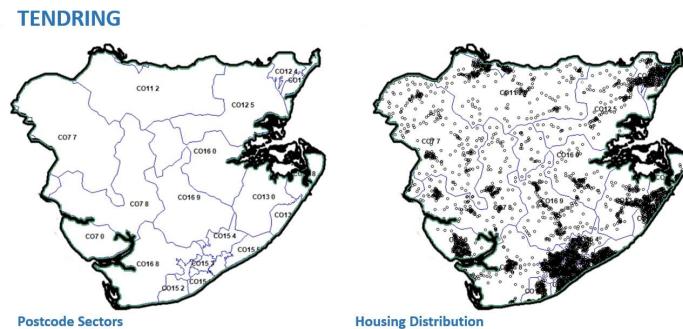
Certainly, the higher temperatures in the south east combined with the absence of rainfall over the highly populated areas and clay rich soils explain the factors driving the 2003 surge.



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Subsidence Risk Analysis – Tendring

Tendring is situated on the coast of north east Essex and occupies an area of 366km² and a population around 157,000.



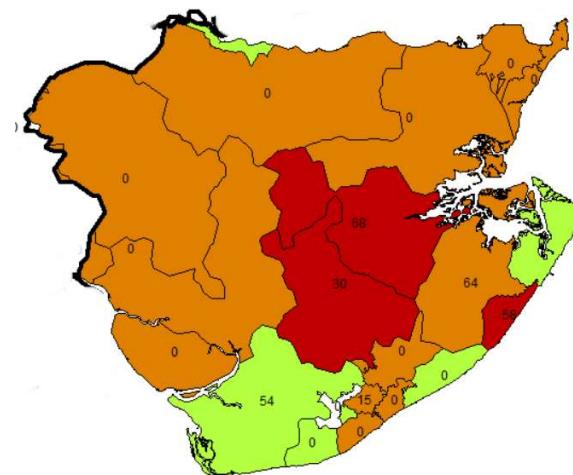
Distribution of postcode sectors and housing stock using full postcode as a proxy. Each sector covers around 3,000 houses on average across the UK and full postcodes include around 15 – 20 houses on average, although there are large variations.

Tendring is rated 65th out of 413 districts in the UK from the sample analysed and is around 1.612x the risk of the UK average, or 0.417 on a normalised 0 - 1 scale.

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

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.



Subsidence Risk Compared to UK Average

Sector risk compared to UK average from the sample analysed.



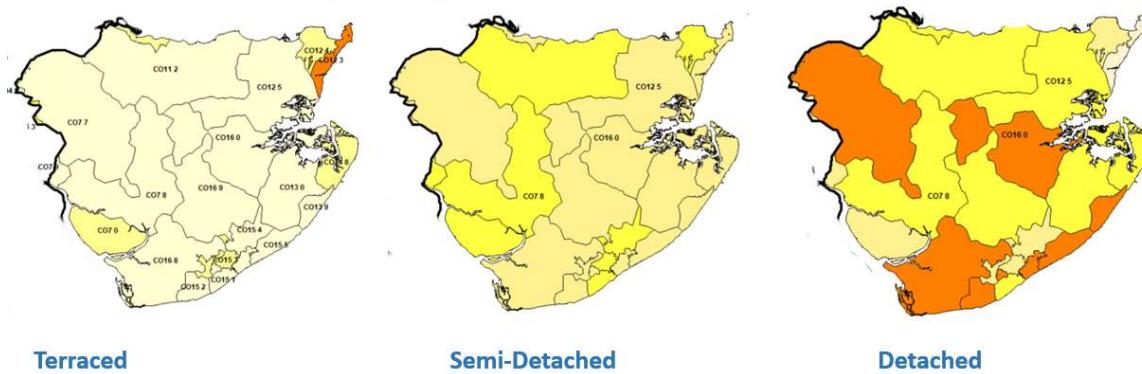
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Tendring - Properties by Style and Ownership

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 taking out the policy.

TENDRING - Distribution by House Type



Distribution by ownership is shown below. Detached, private properties are the dominant class across the district.

TENDRING - Distribution by Ownership



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Subsidence Risk Analysis – Tendring

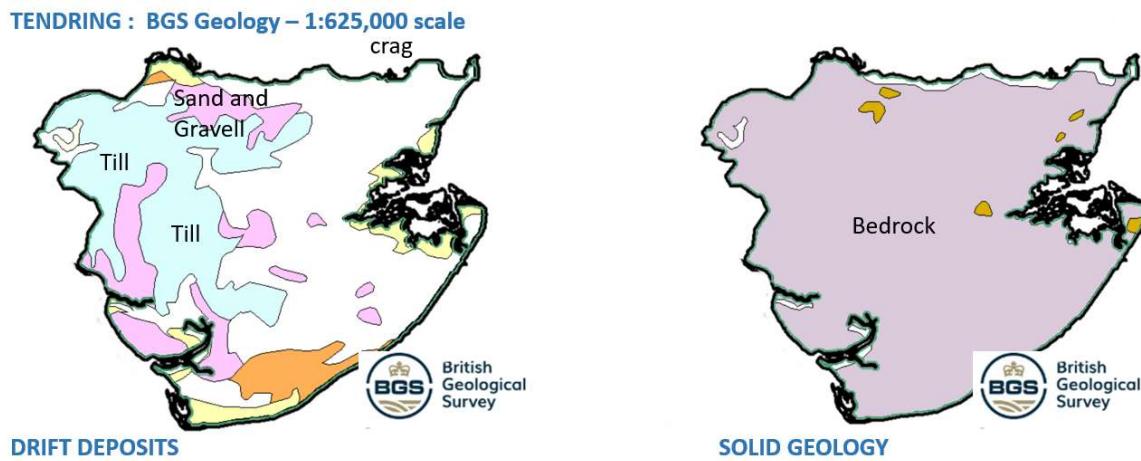
Below, extracts from the British Geological Survey low resolution 1:625,000 scale geological maps showing the solid and drift series. View at:

<http://mapapps.bgs.ac.uk/geologyofbritain/home.html>

See page 13 for a seasonal analysis of the sample which reveals that, at district level, there is around a 70% probability of a claim being valid in the summer and, of the valid claims, there is a 80% probability that the damage will have been caused by clay shrinkage. Site investigations undertaken relating to claims confirms the presence of clay soils (see following page) with a PI ranging from 30 – 60%.

In the winter, the likelihood of a claim being valid is around 30% and of the valid claims, 80% are attributable to escape of water.

A postcode sector map on the following page records the PI of soils retrieved following site investigations from actual claims.



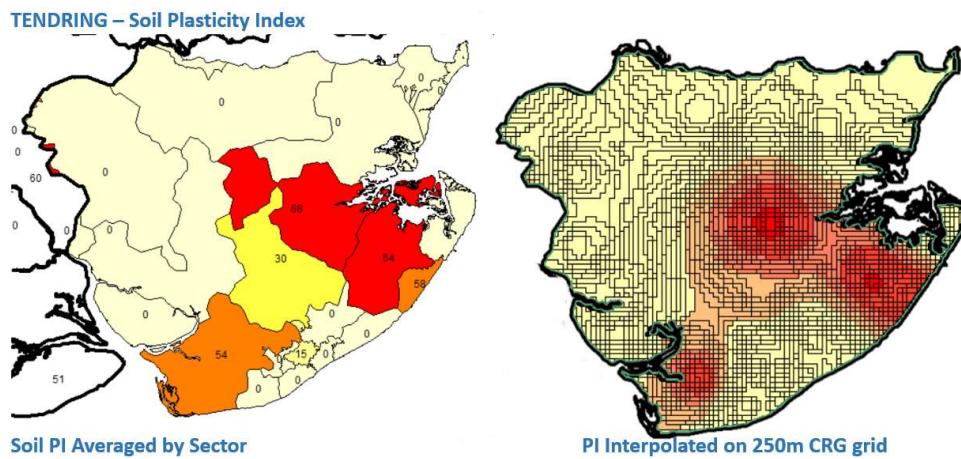
Above, extracts from the 1:625,000 series British Geological Survey maps. Working at postcode sector level and referring to the 1:50,000 series delivers far greater benefit when assessing risk.



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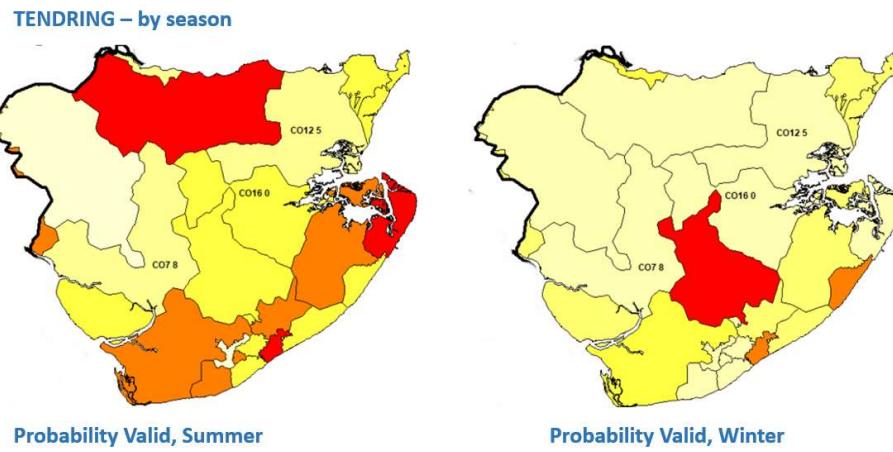
Liability by Geology and Season

Below, the average PI by postcode sector (left) derived from site investigations and interpolated to develop the CRG 250m grid (right), both confirming the varied geology across the district.



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.

The maps below 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.



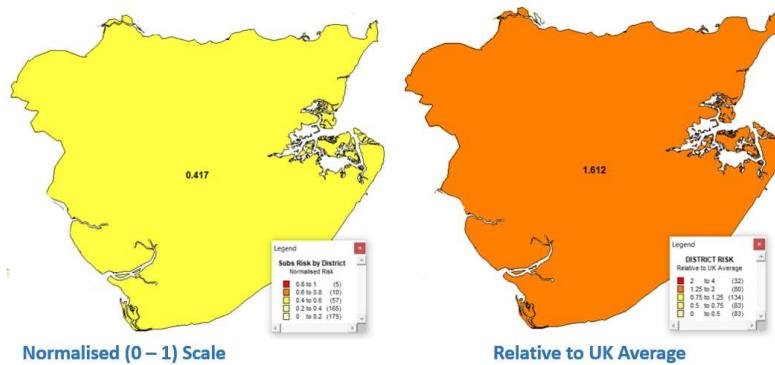
A high frequency risk can be the product of just a few claims in an area with a low housing density of course and claim count should be used to identify such anomalies.



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District Risk. EoW and Council Tree Risk.

TENDRING - Subsidence Risk Relative to UK

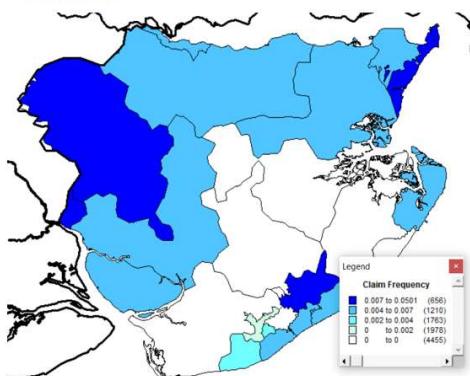


Below, left, mapping the frequency of escape of water claims reflecting the presence of drift deposits of non-cohesive soils including sand and gravel and clay with flints underlain by chalk.

As we would expect, the 1:50,000 scale BGS map provides a more detailed picture. The CRG 1:250 grid reflects claims experience.

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 confirming the presence of shrinkable clay soils.

TENDRING



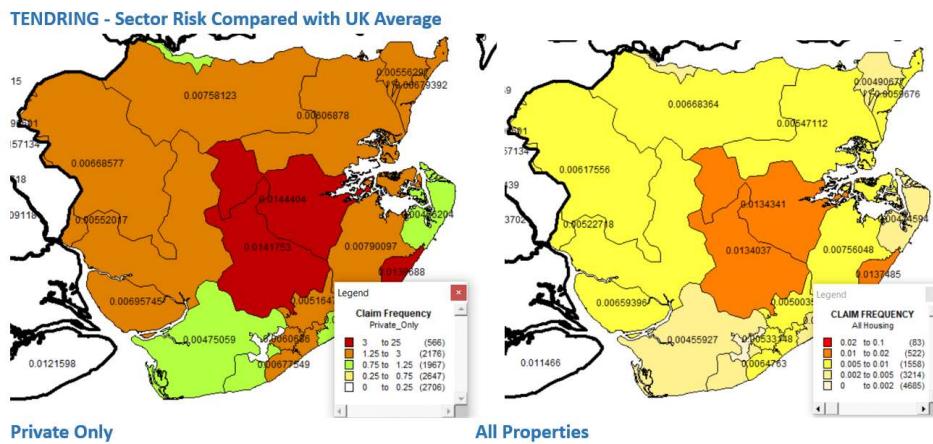
Escape of Water

Claims Involving Council Tree
(2,858 UK claim sample)

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Tendring - Frequencies & Probabilities

Below, mapping the risk of subsidence by ownership. Claims frequency that includes council and housing association properties delivers a misleading value of risk as they self-insure. The following show the normalised risk, taking account of the private housing population – that is, the rating compared with the average value for each category.



To reiterate, a 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.

In this case, the numbers reflect the presence and influence of the underlying clay series.

Liability by Season - TENDRING

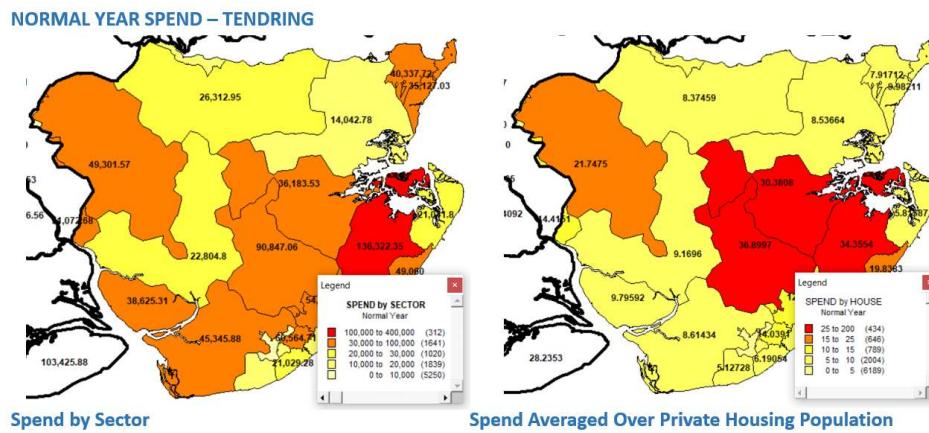
District	valid	valid	Repudiation	valid	valid	Repudiation
	summer	summer	Rate	winter	winter	Rate
	clay	EoW	(summer)	clay	EoW	(winter)
Tendring	0.645	0.121	0.234	0.05	0.26	0.69



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Aggregate Subsidence Claim Spend by Postcode Sector and Household in Normal & Surge 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 of course.



The images to the left in both examples (above and below) represent gross sector spend and those to the right, sector spend averaged across private housing population to derive a notional premium per house for the subsidence peril.

In this case, the absence of any distinct difference between surge and normal years reflects the geology.

