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

March 2021
Issue 190

The Clay Research Group

CONTENTS

Issue 190, March 2021

A New Form of Subsidence – Maybe?

Subsidence or artwork?
Slipping façade in Margate, Kent by the artist Alex Chinneck.

Weather and Surge.

The Met Office's MOREC's data estimates soil moisture deficit (SMD) across the country, but which elements correlate closest to annual subsidence claim numbers? Are high subsidence claim numbers associated with low rainfall or is it warmer summers – or perhaps increased hours of sunshine? Claims resulting from clay shrinkage account for the wide fluctuation in numbers annually, but what are the main drivers?

Is a dry Spring or a dry preceding year a precursor to high claim numbers, or is there a more immediate link between weather and subsidence claims?

Using Met Office data from the Heathrow weather station this edition looks at the data to find the most likely driver using correlation techniques.

Risk Mapping - Camden

This month's edition re-visits the Borough of Camden, mapping the risk of domestic subsidence at postcode sector level. The original review appeared in edition 69, February 2011. This update takes into account seasonal changes affecting areas on shrinkable clay soil, spend by normal and surge years and provides maps consistent with the current series.

Contributions Welcome

We welcome articles and comments from readers. If you have a contribution please Email us at:
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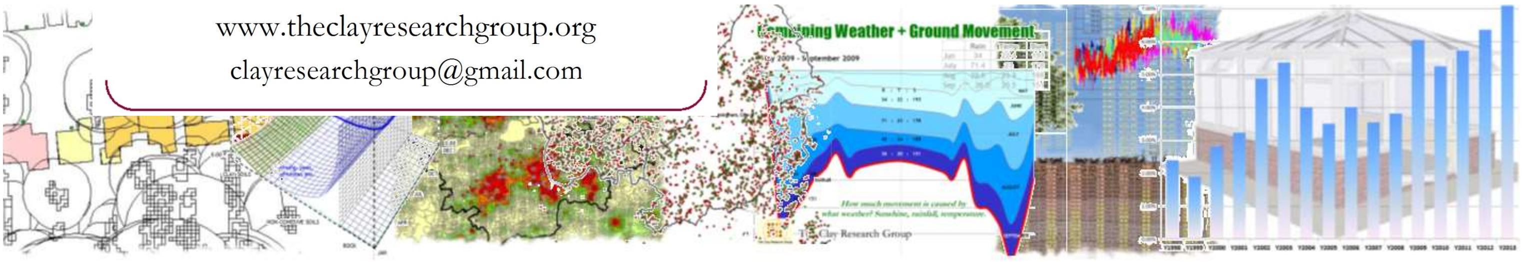
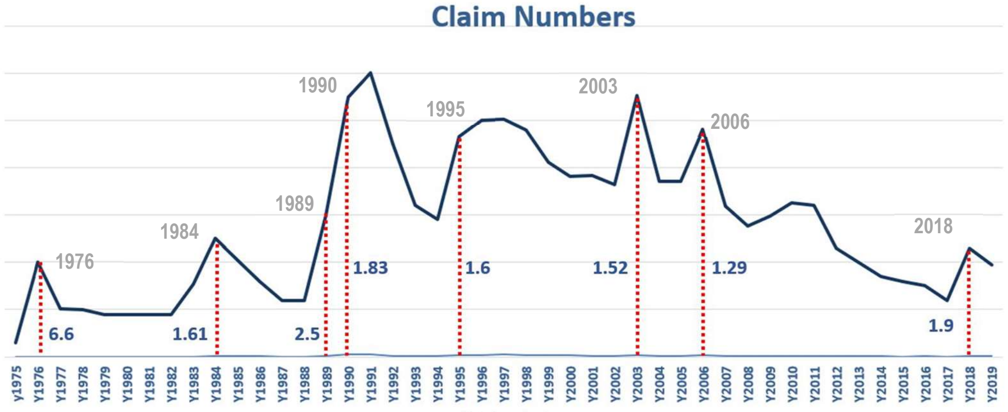


Surge Defined

Before we link claim numbers with weather elements, it's useful to define surge. We use the term to describe an increase in claim numbers when compared with the previous year, rather than count alone. Below, the graph plots ABI claim numbers and the vertical red lines indicate the increase from the previous year. Note – the figures relate to claim notifications and not necessarily those found to be valid following investigation.



As an example, there were 12,000 claims registered in 1988 and 30,000 in 1989. The surge value for 1989 in the above graph = 30/12 = 2.5. Note: the ABI figures for earlier years are rounded to the nearest thousand.

YEAR	SURGE VALUE
1976	6.6
1989	2.5
2018	1.9
1990	1.83
1984	1.61
1995	1.6
2003	1.52
2006	1.29

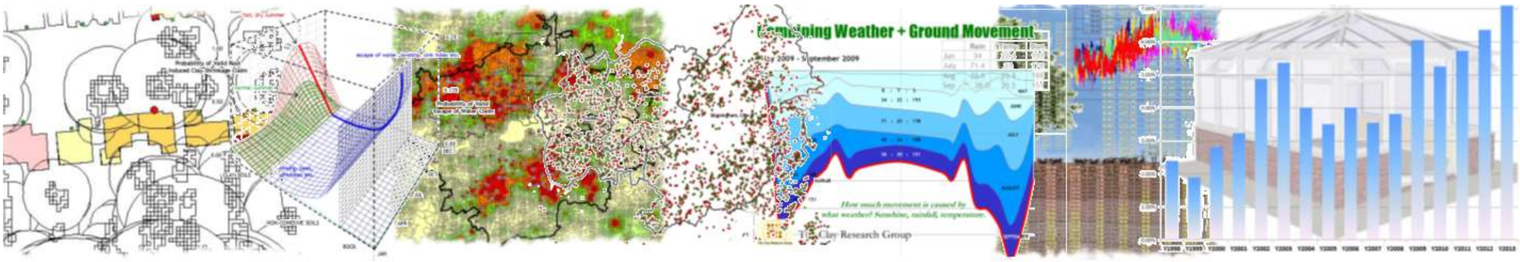
Surge defined by the increase in claim numbers from the previous year.

YEAR	CLAIM NUMBERS
2003	55,400
1990	55,000
2006	48,100
1995	46,500
1989	30,000
1984	25,000
2018	23,000
1976	20,000

Claim numbers in rank order by year.

Above, tables outlining the rank order of surge values exceeding 1 (left) and associated claim numbers (right). The greatest surge occurred in 1976 whilst the highest claim numbers from the list were notified in 2003, followed closely by 1990.

1976 follows the introduction of subsidence to the household policy in the early 70's and a hot summer, but the numbers were relatively low compared with subsequent years.



Weather Elements Generating Surge

Right, graphs plotting Tmax, Hours of Sunshine and Rainfall by month published by the Met Office from the Heathrow weather station for the period 2003 to 2018.

Surge years are identified as follows:

- — **Yr 2003**
- — **Yr 2006**
- — **Yr 2018**

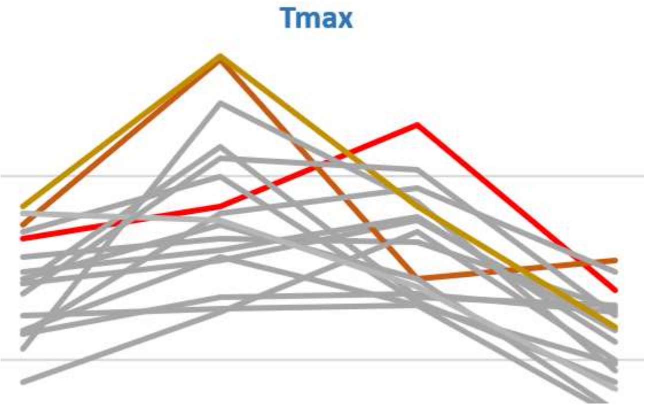
They are identified by high values for Tmax and Hours of Sunshine and low values for Rainfall by Month. The graphs provide a clear indication of the profiles that generate surge.

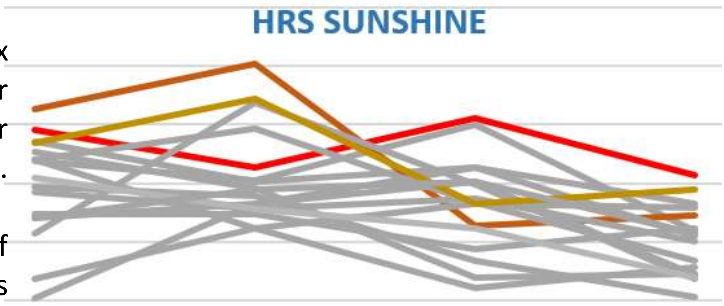
2003, the year delivering the highest count of subsidence claims, is shown in red and values for all elements peak in August.

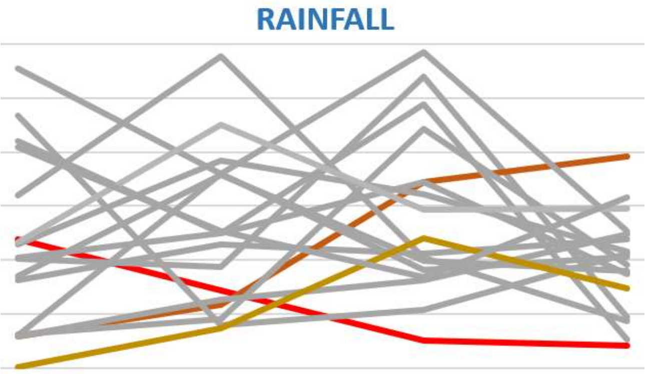
Both 2006 and 2018 follow similar profiles, peaking in July. The difference between the high points for both temperature and hours of sunshine and the low point for rainfall have been combined to deliver the equations Tmax-Rainfall and (Tmax+HrsSunshine)-Rainfall.

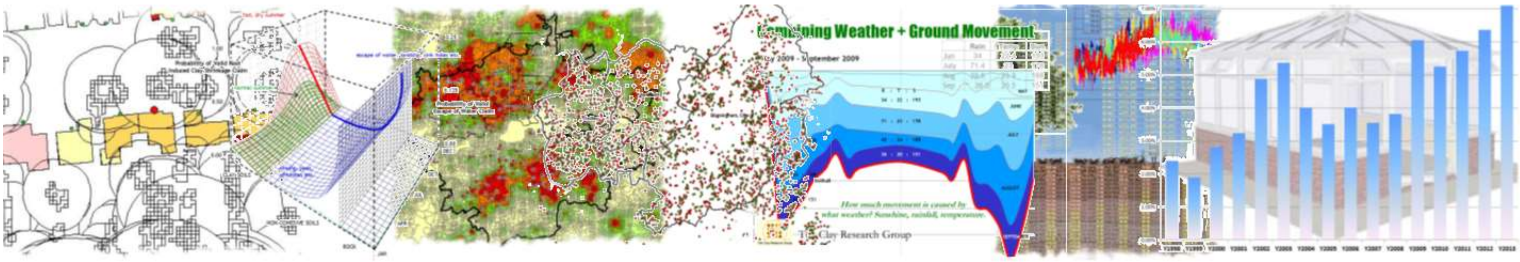
Values for all three elements have been normalised on a 0 – 1 scale to deliver comparative values.

See following pages.





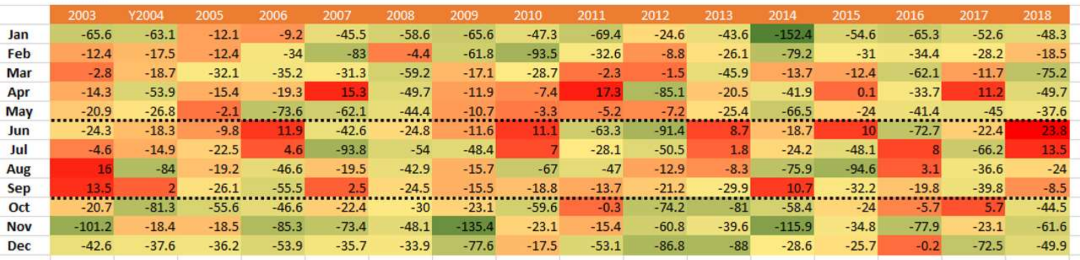




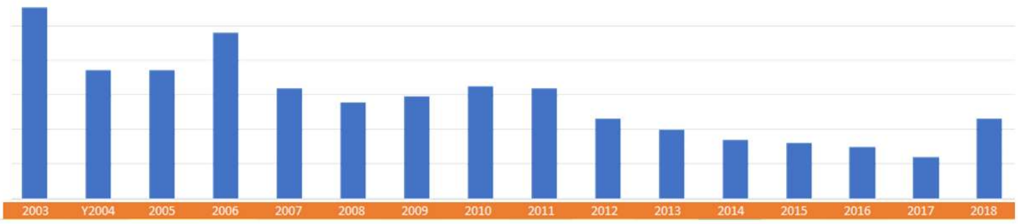
Improved Correlation by Combining Elements

Subtracting rainfall from maximum temperature delivers a correlation of 0.35. Low, but not surprising given the nature of the elements we are dealing with.

Tmax - Rainfall

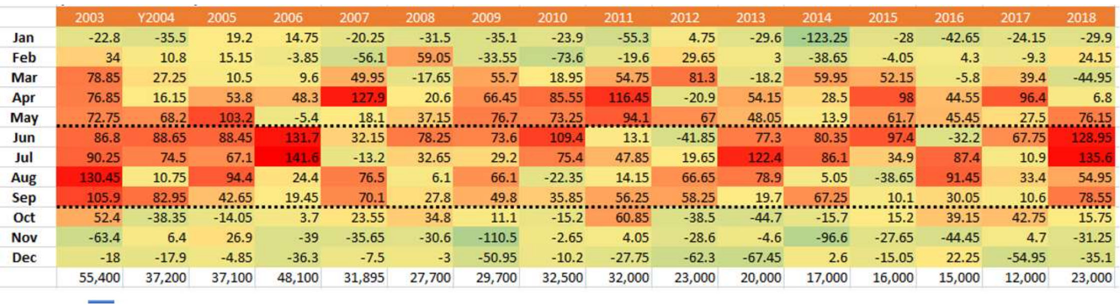


	2003	Y2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Jan	-65.6	-63.1	-12.1	-9.2	-45.5	-58.6	-65.6	-47.3	-69.4	-24.6	-43.6	-152.4	-54.6	-65.3	-52.6	-48.3
Feb	-12.4	-17.5	-12.4	-34	-83	-4.4	-61.8	-93.5	-32.6	-8.8	-26.1	-79.2	-31	-34.4	-28.2	-18.5
Mar	-2.8	-18.7	-32.1	-35.2	-31.3	-59.2	-17.1	-28.7	-2.3	-1.5	-45.9	-13.7	-12.4	-62.1	-11.7	-75.2
Apr	-14.3	-53.9	-15.4	-19.3	15.3	-49.7	-11.9	-7.4	17.3	-85.1	-20.5	-41.9	0.1	-33.7	11.2	-49.7
May	-20.9	-26.8	-2.1	-73.6	-62.1	-44.4	-10.7	-3.3	-5.2	-7.2	-25.4	-66.5	-24	-41.4	-45	-37.6
Jun	-24.3	-18.3	-9.8	11.9	-42.6	-24.8	-11.6	11.1	-63.3	-91.4	8.7	-18.7	10	-72.7	-22.4	23.8
Jul	-4.6	-14.9	-22.5	4.6	-93.8	-54	-48.4	7	-28.1	-50.5	1.8	-24.2	-48.1	8	-66.2	13.5
Aug	16	-84	-19.2	-46.6	-19.5	-42.9	-15.7	-67	-47	-12.9	-8.3	-75.9	-94.6	3.1	-36.6	-24
Sep	13.5	2	-26.1	-55.5	2.5	-24.5	-15.5	-18.8	-13.7	-21.2	-29.9	10.7	-32.2	-19.8	-39.8	-8.5
Oct	-20.7	-81.3	-55.6	-46.6	-22.4	-30	-23.1	-59.6	-0.3	-74.2	-81	-58.4	-24	-5.7	5.7	-44.5
Nov	-101.2	-18.4	-18.5	-85.3	-73.4	-48.1	-135.4	-23.1	-15.4	-60.8	-39.6	-115.9	-34.8	-77.9	-23.1	-61.6
Dec	-42.6	-37.6	-36.2	-53.9	-35.7	-33.9	-77.6	-17.5	-53.1	-86.8	-88	-28.6	-25.7	-0.2	-72.5	-49.9



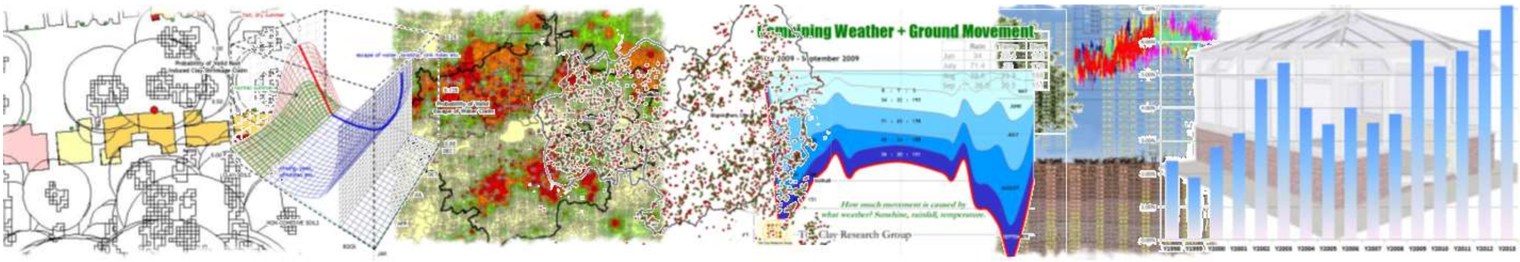
Subsidence Claims

(Tmax + Hrs Sunshine) - Rainfall



	2003	Y2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Jan	-22.8	-35.5	19.2	14.75	-20.25	-31.5	-35.1	-23.9	-55.3	4.75	-29.6	-123.25	-28	-42.65	-24.15	-29.9
Feb	34	10.8	15.15	-3.85	-56.1	59.05	-33.55	-73.6	-19.6	29.65	3	-38.65	-4.05	4.3	-9.3	24.15
Mar	78.85	27.25	10.5	9.6	49.95	-17.65	55.7	18.95	54.75	81.3	-18.2	59.95	52.15	-5.8	39.4	-44.95
Apr	76.85	16.15	53.8	48.3	127.9	20.6	66.45	85.55	116.45	-20.9	54.15	28.5	98	44.55	96.4	6.8
May	72.75	68.2	103.2	-5.4	18.1	37.15	76.7	73.25	94.1	67	48.05	13.9	61.7	45.45	27.5	76.15
Jun	86.8	88.65	88.45	131.7	32.15	78.25	73.6	109.4	13.1	-41.85	77.3	80.35	97.4	-32.2	67.75	128.95
Jul	90.25	74.5	67.1	141.6	-13.2	32.65	29.2	75.4	47.85	19.65	122.4	86.1	34.9	87.4	10.9	135.6
Aug	130.45	10.75	94.4	24.4	76.5	6.1	66.1	-22.35	14.15	66.65	78.9	5.05	-38.65	91.45	33.4	54.95
Sep	105.9	82.95	42.65	19.45	70.1	27.8	49.8	35.85	56.25	58.25	19.7	67.25	10.1	30.05	10.6	78.55
Oct	52.4	-38.35	-14.05	3.7	23.55	34.8	11.1	-15.2	60.85	-38.5	-44.7	-15.7	15.2	39.15	42.75	15.75
Nov	-63.4	6.4	26.9	-39	-35.65	-30.6	-110.5	-2.65	4.05	-28.6	-4.6	-96.6	-27.65	-44.45	4.7	-31.25
Dec	-18	-17.9	-4.85	-36.3	-7.5	-3	-50.95	-10.2	-27.75	-62.3	-67.45	2.6	-15.05	22.25	-54.95	-35.1
	55,400	37,200	37,100	48,100	31,895	27,700	29,700	32,500	32,000	23,000	20,000	17,000	16,000	15,000	12,000	23,000

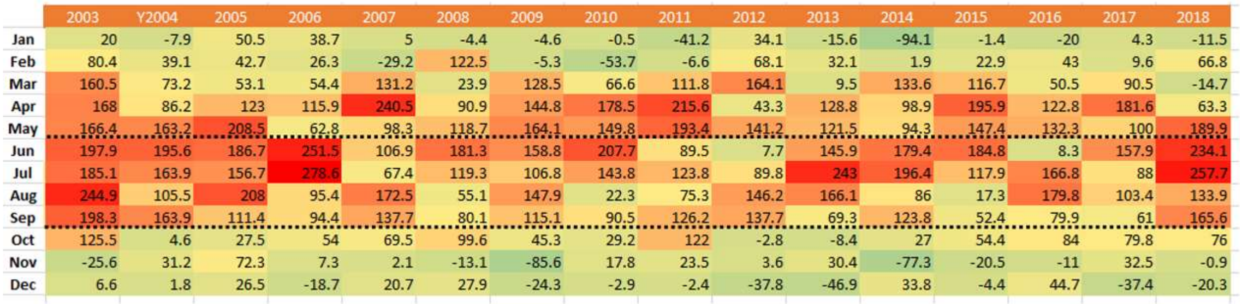
Subtracting rainfall from hours of sunshine plus maximum temperature improves the correlation, delivering a value of 0.67.



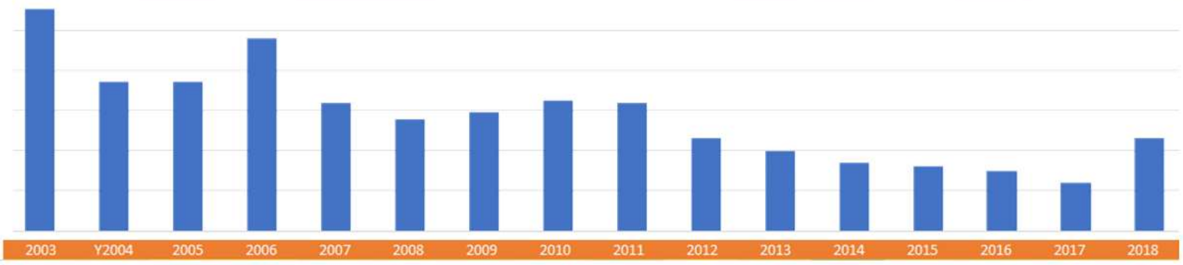
Hours of Sunshine - Rainfall

The highest score – the closest correlation between a weather element and claim numbers – is provided by subtracting rainfall from hours of sunshine which delivers a value of 0.754. Exceptionally high given the nature of the elements we are dealing with. See below.

Hrs Sunshine - Rainfall



	2003	Y2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Jan	20	-7.9	50.5	38.7	5	-4.4	-4.6	-0.5	-41.2	34.1	-15.6	-94.1	-1.4	-20	4.3	-11.5
Feb	80.4	39.1	42.7	26.3	-29.2	122.5	-5.3	-53.7	-6.6	68.1	32.1	1.9	22.9	43	9.6	66.8
Mar	160.5	73.2	53.1	54.4	131.2	23.9	128.5	66.6	111.8	164.1	9.5	133.6	116.7	50.5	90.5	-14.7
Apr	168	86.2	123	115.9	240.5	90.9	144.8	178.5	215.6	43.3	128.8	98.9	195.9	122.8	181.6	63.3
May	166.4	163.2	208.5	62.8	98.3	118.7	164.1	149.8	193.4	141.2	121.5	94.3	147.4	132.3	100	189.9
Jun	197.9	195.6	186.7	251.5	106.9	181.3	158.8	207.7	89.5	7.7	145.9	179.4	184.8	8.3	157.9	234.1
Jul	185.1	163.9	156.7	278.6	67.4	119.3	106.8	143.8	123.8	89.8	243	196.4	117.9	166.8	88	257.7
Aug	244.9	105.5	208	95.4	172.5	55.1	147.9	22.3	75.3	146.2	166.1	86	17.3	179.8	103.4	133.9
Sep	198.3	163.9	111.4	94.4	137.7	80.1	115.1	90.5	126.2	137.7	69.3	123.8	52.4	79.9	61	165.6
Oct	125.5	4.6	27.5	54	69.5	99.6	45.3	29.2	122	-2.8	-8.4	27	54.4	84	79.8	76
Nov	-25.6	31.2	72.3	7.3	2.1	-13.1	-85.6	17.8	23.5	3.6	30.4	-77.3	-20.5	-11	32.5	-0.9
Dec	6.6	1.8	26.5	-18.7	20.7	27.9	-24.3	-2.9	-2.4	-37.8	-46.9	33.8	-4.4	44.7	-37.4	-20.3



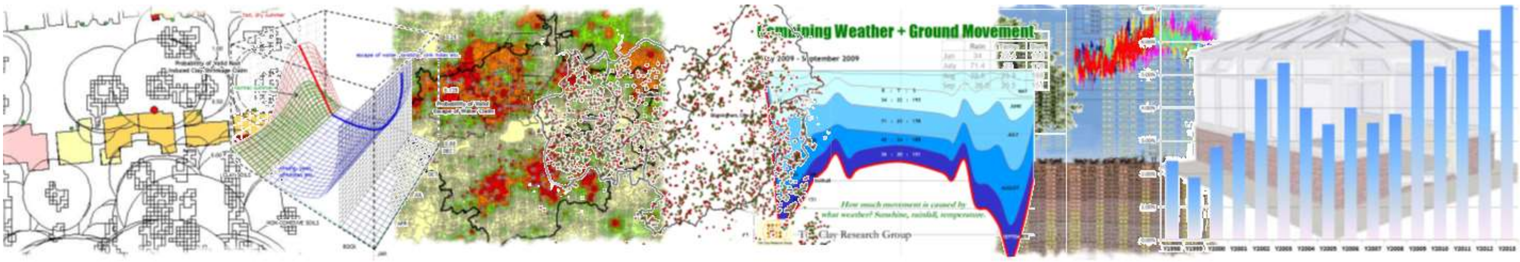
Subsidence Claims

The red shaded grids indicate the top 25 percent of values using the *Hrs Sunshine – Rainfall* equation, yellow 50 percent and green the lower 25 percent. For example, 2003 delivered the highest number of claims from the sample and the red shaded tiles reflect this, with values reaching 244.9 in August and the risk period extending over seven months. Values in 2006 reached 278.6 in July but the duration of risk was less, extending over two months, which may account for the lower count of claims.

2018 is an anomaly. The values exceeding 25 percent extend over 5 months with a peak value of 257.7, but the claim count for the year is lower. This follows a gradual reduction in claim numbers since 2006 although the sudden increase over the third quarter puts 2018 into the surge category according to the approach outlined on page 2.

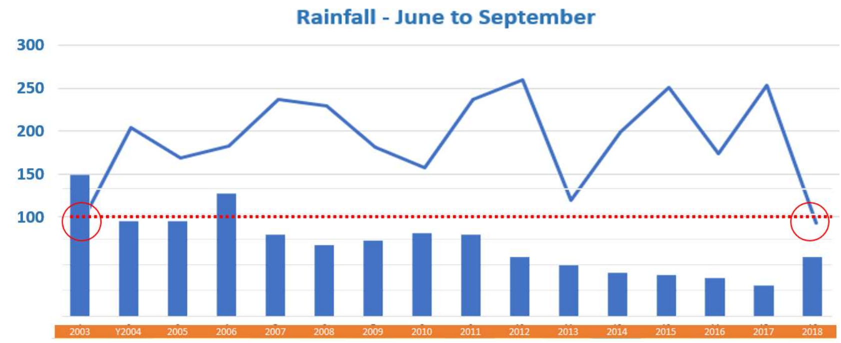
	CORRELATION
Hrs Sunshine - Rainfall	0.754
Hrs Sunshine	0.7
(Tmax + HrsSunshine) - Rainfall	0.679
TMax - Rainfall	0.354
Tmax	0.013
Rainfall	-0.35

Correlation table comparing items listed with claim numbers for the period 2003 to 2018, inclusive.



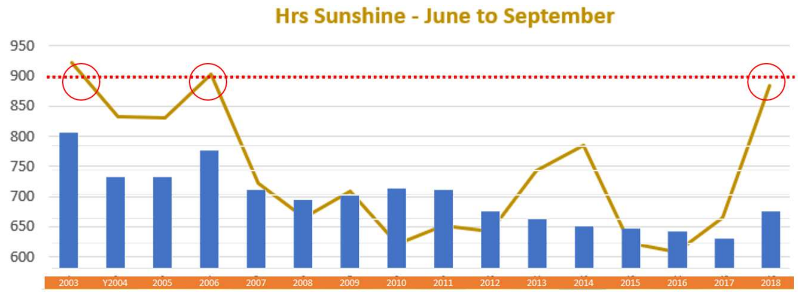
Seasonal Analysis - June to September

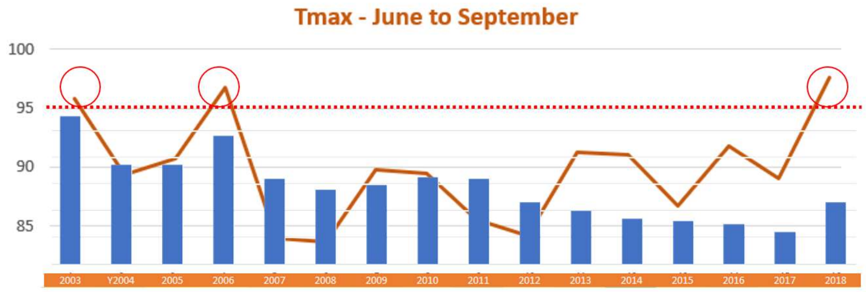
Analysing annual weather data has value, but looking at the figures for the summer delivers more information, as we see below. Taking the period June through to September, inclusive, identifies the elements that deliver surge years. Peaks for both temperature and hours of sunshine coincide with years delivering high numbers. Annual claim numbers are shown by the blue bar graph.



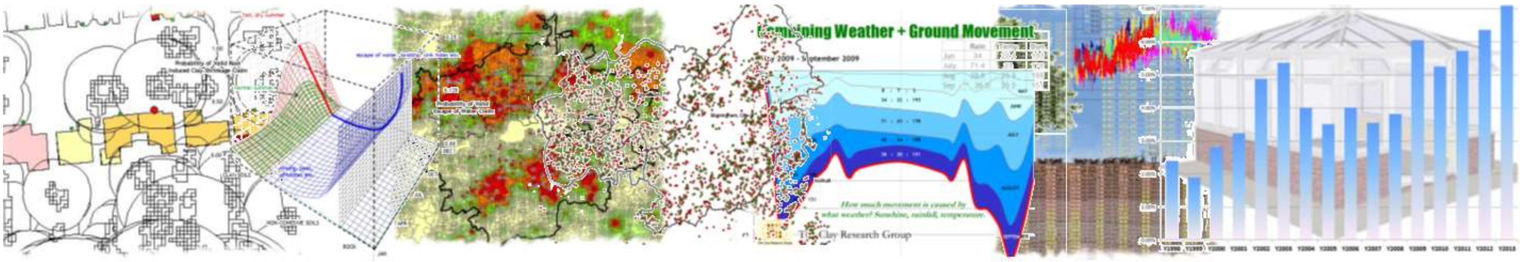
Low rainfall is recorded in 2003 and 2018. The total for the four-month period for both years is around 100mm. 2006 is an exception with rainfall nearer the average.

Total hours of sunshine for the four-month period reached around 900hrs in all three surge years – 2003, 2006 and 2018.





Maximum temperatures share the above profile with a value of 95degC for the combined months of June through to September, inclusive.



Does Weather have Predictive Qualities?

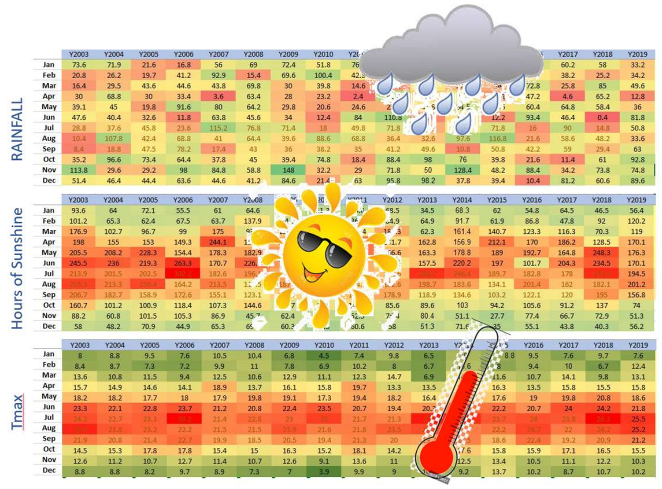
The Met Office have difficulties predicting weather with any claim to accuracy more than seven days ahead, so the chance of predicting surge months in advance are zero. There are of course the usual issues relating to the underlying data. The values are monthly – daily data would be far better, allowing a more detailed analysis to see if there are distinguishing signatures associated with these months.

No doubt there is a correlation between ice cream sales and surge – such is the nature of data analysis. The saving grace here is that ice cream sales don't have a correlation with the presence of clay sub-soils or vegetation, or at least as far as we know.

The data also lacks important values including wind, evaporation, humidity and vapour pressure deficit. All are important factors in determining water uptake. However, knowledge is central to building advanced Ai applications and in the matter of surge, weather is central.

The properties of the various elements means that a predictive model is unlikely.

Surge years appear to be a product of prevailing weather conditions and whilst there will be situations where dry weather from previous years or a dry early spring may influence individual claims, the main driver is the prevailing weather.



RAINFALL

	Y2003	Y2004	Y2005	Y2006	Y2007	Y2008	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Y2019
Jan	73.6	71.9	21.6	16.8	56	69	72.4	51.8	76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60.2	58	33.2
Feb	20.8	26.2	19.7	41.2	92.9	15.4	69.6	100.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	38.2	25.2	34.2
Mar	16.4	29.5	43.6	44.6	43.8	69.8	30	39.8	14.6	[illegible]	[illegible]	[illegible]	[illegible]	72.8	25.8	85	49.6
Apr	30	68.8	30	33.4	3.6	63.4	28	23.2	2.4	[illegible]	[illegible]	[illegible]	[illegible]	47.2	4.6	65.2	12.8
May	39.1	45	19.8	91.6	80	64.2	29.8	20.6	24.6	[illegible]	[illegible]	[illegible]	[illegible]	60.4	64.8	58.4	36
Jun	47.6	40.4	32.6	11.8	63.8	45.6	34	12.4	84	110.8	[illegible]	[illegible]	12.2	93.4	46.4	0.4	81.8
Jul	28.8	37.6	45.8	23.6	115.2	76.8	71.4	18	49.8	71.8	[illegible]	[illegible]	71.8	16	90	14.8	50.8
Aug	10.4	107.8	42.4	68.8	41	64.4	39.6	88.6	68.8	36.4	32.6	97.6	116.8	21.6	58.6	48.2	33.6
Sep	8.4	18.8	47.5	78.2	17.4	43	36	38.2	35	41.2	49.6	10.8	50.8	42.2	59	29.4	63
Oct	35.2	96.6	73.4	64.4	37.8	45	39.4	74.8	18.4	88.4	98	76	39.8	21.6	11.4	61	92.8
Nov	113.8	29.6	29.2	98	84.8	58.8	148	32.2	29	71.8	50	128.4	48.2	88.4	34.2	73.8	74.8
Dec	51.4	46.4	44.4	63.6	44.6	41.2	84.6	21.4	63	95.8	98.2	37.8	39.4	10.4	81.2	60.6	89.6

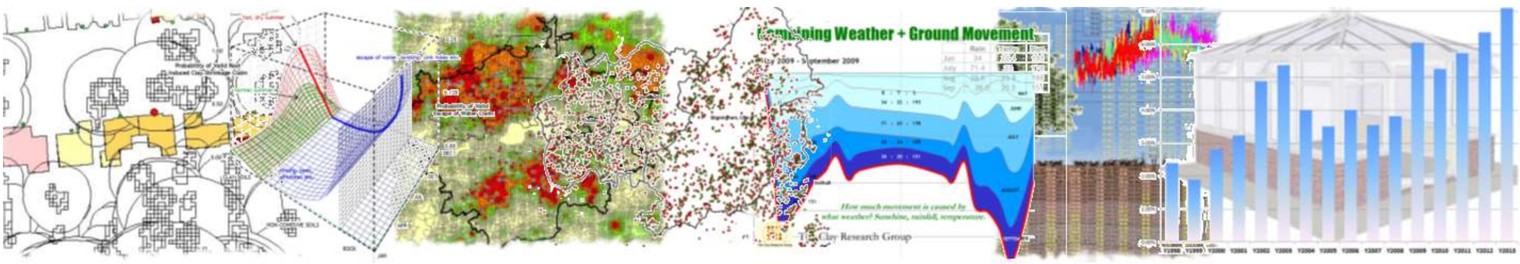
Hours of Sunshine

	Y2003	Y2004	Y2005	Y2006	Y2007	Y2008	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Y2019
Jan	93.6	64	72.1	55.5	61	64.6	[illegible]	[illegible]	[illegible]	[illegible]	34.5	68.3	62	54.8	64.5	46.5	56.4
Feb	101.2	65.3	62.4	67.5	63.7	137.9	[illegible]	[illegible]	[illegible]	[illegible]	64.9	91.7	61.9	86.8	47.8	92	120.2
Mar	176.9	102.7	96.7	99	175	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	62.3	161.4	140.7	123.3	116.3	70.3	119
Apr	198	155	153	149.3	244.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	162.8	156.9	212.1	170	186.2	128.5	170.1
May	205.5	208.2	228.3	154.4	178.3	182.9	[illegible]	[illegible]	[illegible]	[illegible]	163.3	178.8	189	192.7	164.8	248.3	176.3
Jun	245.5	236	219.3	263.3	170.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	157.5	220.2	197	101.7	204.3	234.5	170.1
Jul	213.9	201.5	202.5	302.2	182.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	246.4	189.7	182.8	178	[illegible]	194.5
Aug	255.3	213.3	250.4	164.2	213.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	198.7	183.6	134.1	201.4	162	182.1	201.2
Sep	206.7	182.7	158.9	172.6	155.1	123.1	[illegible]	[illegible]	[illegible]	178.9	118.9	134.6	103.2	122.1	120	195	156.8
Oct	160.7	101.2	100.9	118.4	107.3	144.6	[illegible]	[illegible]	[illegible]	85.6	89.6	103	94.2	105.6	91.2	137	74
Nov	88.2	60.8	101.5	105.3	86.9	[illegible]	62.4	[illegible]	[illegible]	[illegible]	80.4	51.1	27.7	77.4	66.7	72.9	51.3
Dec	58	48.2	70.9	44.9	65.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51.3	71.6	35	55.1	43.8	40.3	56.2

Tmax

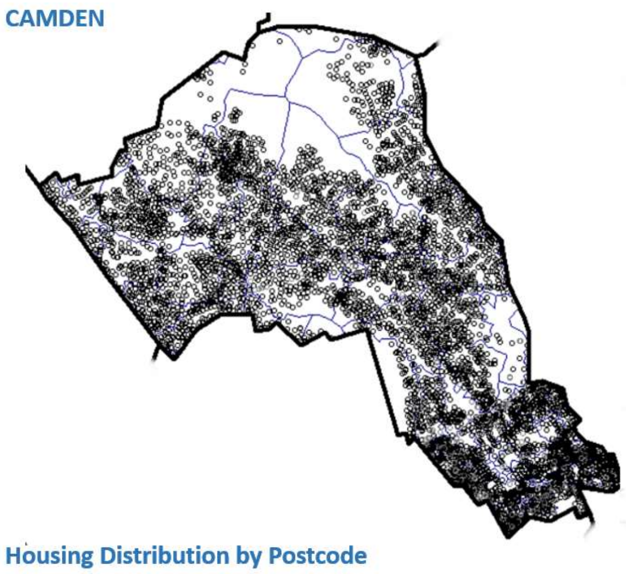
	Y2003	Y2004	Y2005	Y2006	Y2007	Y2008	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Y2019
Jan	8	8.8	9.5	7.6	10.5	10.4	6.8	4.5	7.4	9.8	6.5	[illegible]	8.8	9.5	7.6	9.7	7.6
Feb	8.4	8.7	7.3	7.2	9.9	11	7.8	6.9	10.2	8	6.7	[illegible]	8	9.4	10	6.7	12.4
Mar	13.6	10.8	11.5	9.4	12.5	10.6	12.9	11.1	12.3	14.7	6.9	[illegible]	11.6	10.7	14.1	9.8	13.1
Apr	15.7	14.9	14.6	14.1	18.9	13.7	16.1	15.8	19.7	13.3	13.5	[illegible]	16.3	13.5	15.8	15.5	15.8
May	18.2	18.2	17.7	18	17.9	19.8	19.1	17.3	19.4	18.2	16.4	[illegible]	17.6	19	19.8	20.8	18.6
Jun	23.3	22.1	22.8	23.7	21.2	20.8	22.4	23.5	20.7	19.4	[illegible]	[illegible]	22.2	20.7	24	24.2	21.8
Jul	24.2	22.7	23.3	28.2	21.4	22.8	23	25	21.7	21.3	[illegible]	[illegible]	23.7	24	23.8	[illegible]	25.5
Aug	[illegible]	23.8	23.2	22.2	21.5	21.5	23.9	21.6	21.8	23.5	[illegible]	[illegible]	22.2	24.7	22	24.2	25.2
Sep	21.9	20.8	21.4	22.7	19.9	18.5	20.5	19.4	21.3	20	[illegible]	[illegible]	18.6	22.4	19.2	20.9	21.2
Oct	14.5	15.3	17.8	17.8	15.4	15	16.3	15.2	18.1	14.2	[illegible]	[illegible]	15.8	15.9	17.1	16.5	15.5
Nov	12.6	11.2	10.7	12.7	11.4	10.7	12.6	9.1	13.6	11	[illegible]	12.5	13.4	10.5	11.1	12.2	10.3
Dec	8.8	8.8	8.2	9.7	8.9	7.3	7	3.9	9.9	9	[illegible]	9.2	13.7	10.2	8.7	10.7	10.2

This brief analysis will be extended in the next edition to cover the period from 1975. Any input from arboriculturalists or plant physiologists in terms of maximum moisture uptake by deciduous trees would be welcome.



Subsidence Risk Analysis – CAMDEN

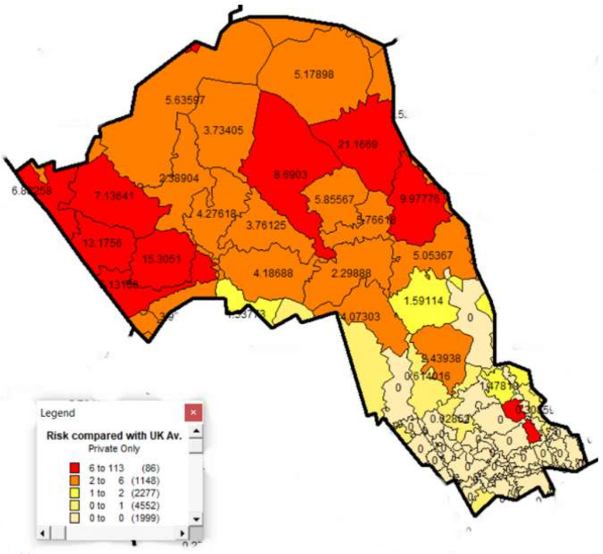
Camden occupies an area of 21.8km^2 with a population of around 260,000. The district was originally covered in edition 69, February 2011 of the CRG newsletter. It is re-visited here to bring it in line with the current series and allow comparisons in terms of risk.



Distribution of housing stock using full postcode as a proxy. Each postcode in the UK covers on average 15 – 20 houses, although there are large variations.

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 because there are more houses?

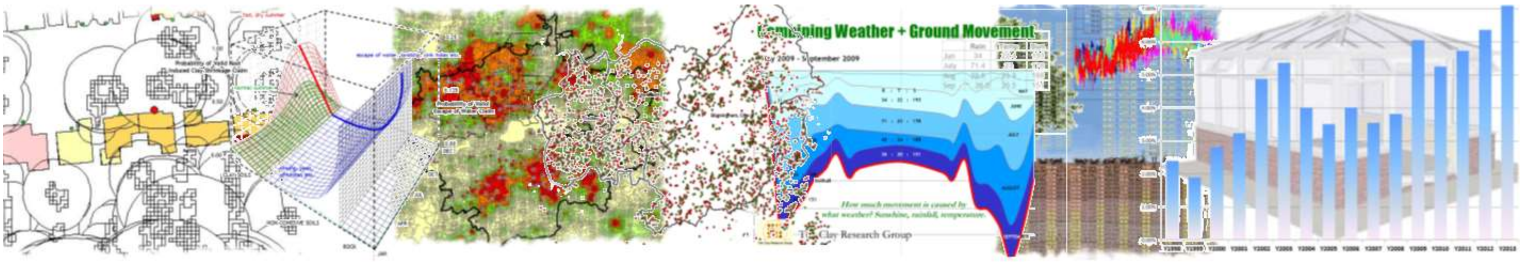
Using a frequency calculation (number of claims divided by private housing population) the relative risk across the borough at postcode sector level is revealed, rather than a 'claim count' value.



Risk compared with UK Average.
Camden is rated as high risk for domestic subsidence claims from the sample analysed. Above, values at postcode sector level compared with UK average.

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

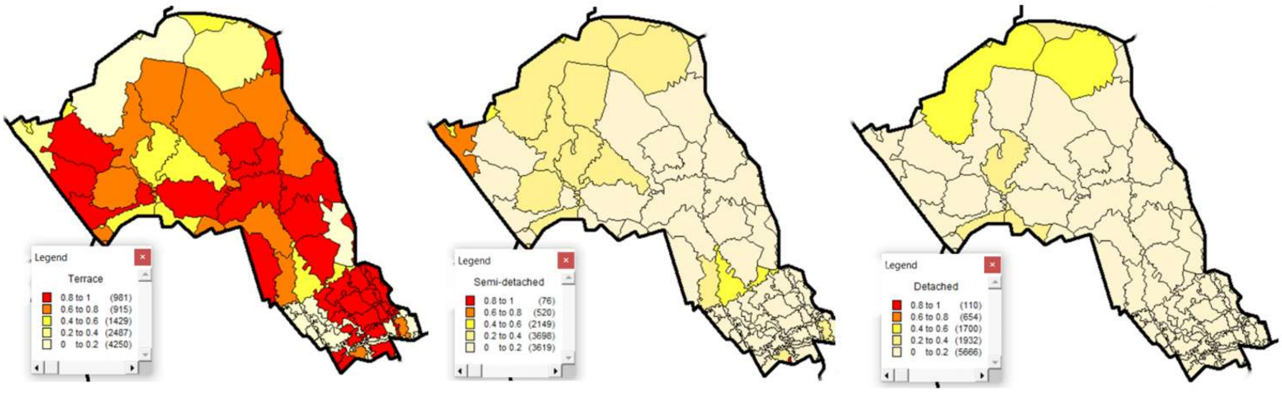
Camden is rated as high risk and in the top ten districts in the UK.



CAMDEN - 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 policies allow insurers to assign a rating to individual properties.

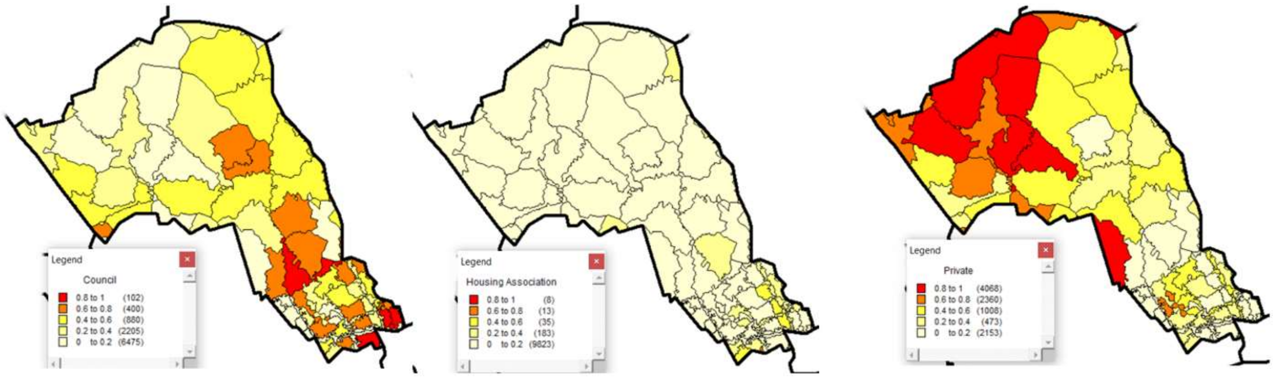
CAMDEN - Distribution by House Type



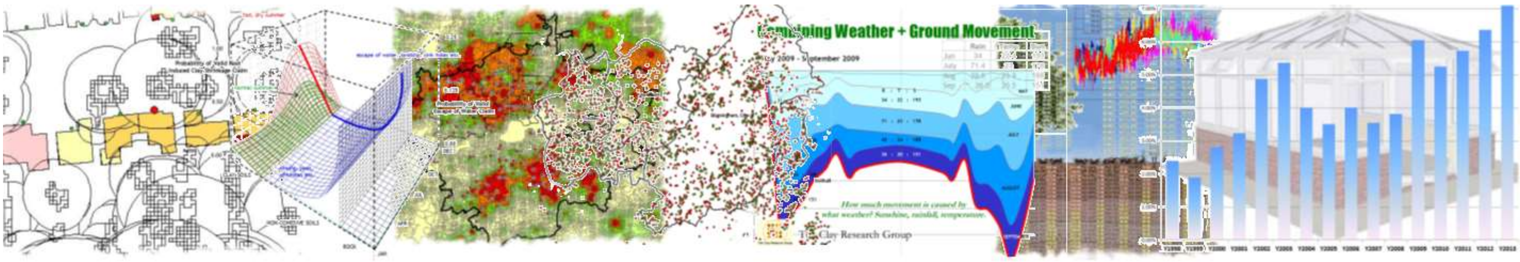
Terraced **Semi-Detached** **Detached**

Distribution by ownership is shown below. The maps reveal predominantly privately-owned properties across the borough with a high number of terraced properties to the east.

CAMDEN - Distribution by Ownership



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



Subsidence Risk Analysis – CAMDEN

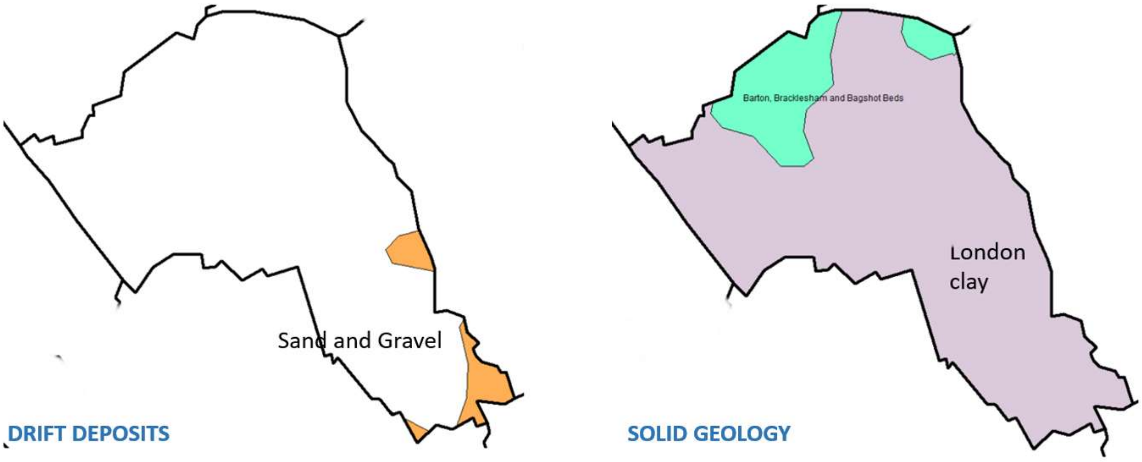
Below, extracts from the British Geological Survey low resolution 1:625,000 scale geological maps showing the solid and drift series. View at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html for more detail.

See page 13 for a seasonal analysis which reveals that in the summer there is around an 80% probability of a claim being valid, and of the valid claims, there is a high probability (90% in the sample) that the cause will be due to clay shrinkage.

In the winter the situation reverses. The likelihood of a claim being declined exceeds 80%.

The analysis reflects the influence of the underlying clay series and the apparent shallow thickness of the superficial deposits.

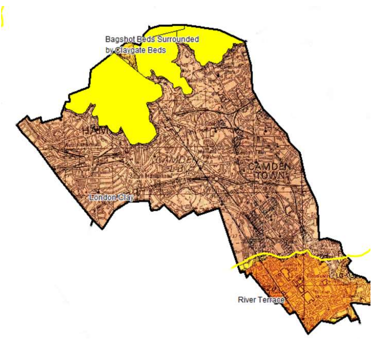
CAMDEN : BGS Geology – 1:625,000 scale

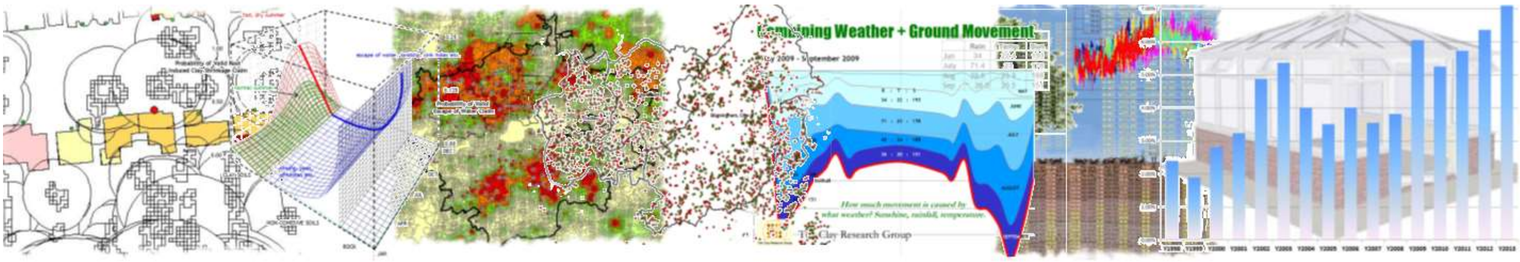


DRIFT DEPOSITS

SOLID GEOLOGY

Right, 1:50,000 scale extract from the British Geological Survey map showing Bagshot and Claygate beds to the north of the district and River Terrace deposits to the south. The distribution clarifies the subsidence risk maps on other pages, particularly to the south of the area. The 1:625,000 scale maps above are less useful for plotting the risk of subsidence.

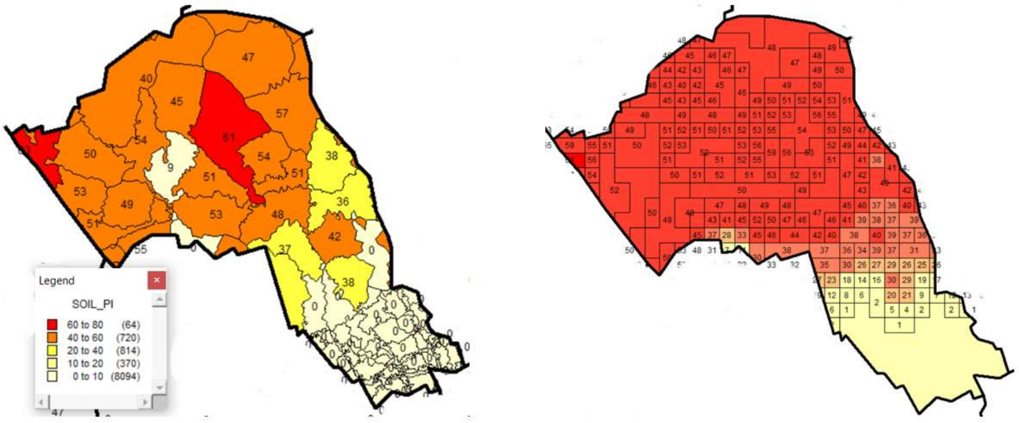




Liability by Geology and Season

Below, the average PI by postcode sector (left) derived from site investigations and interpolated to develop the CRG 250m grid (right). The presence of a shrinkable clay in the CRG model matches the BGS maps on the previous page with clay having an average PI of around 50% where it exists. The higher the PI values, the darker red the CRG grid.

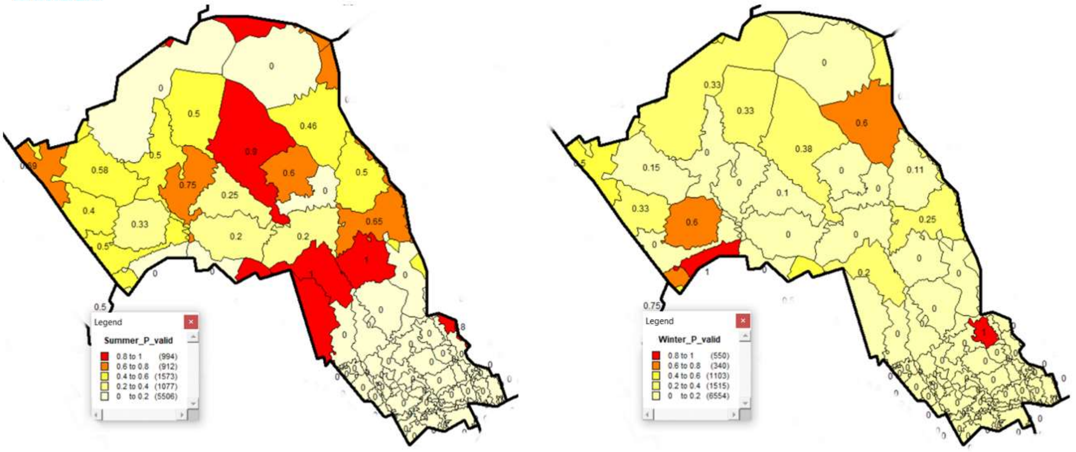
CAMDEN – Soil Plasticity Index



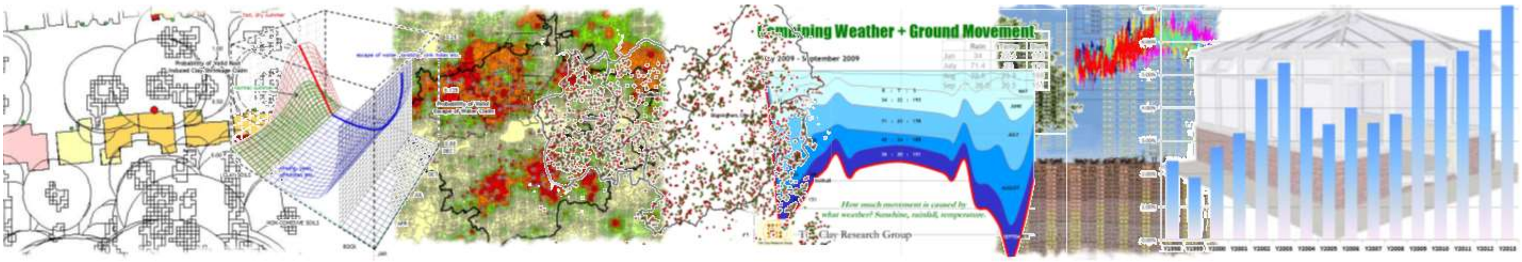
Soil PI Averaged by Sector **PI Interpolated on 250m CRG grid**

Zero values for PI in some sectors may reflect the absence of site investigation data - not necessarily the absence of shrinkable clay. The widespread influence of the shrinkable clay plays an important role in determining whether a claim is likely to be valid or declined by season. A single claim in an area with low population can raise the risk as a result of using frequency estimates.

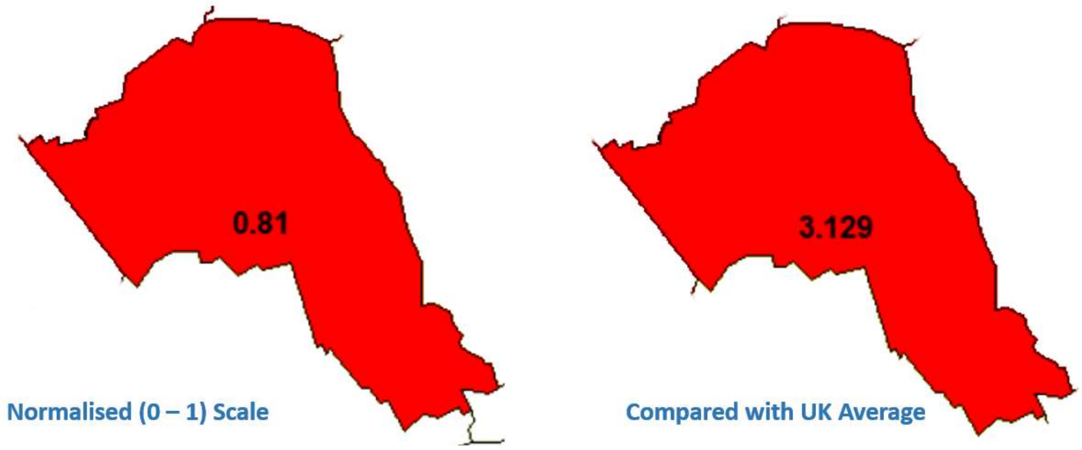
CAMDEN



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



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

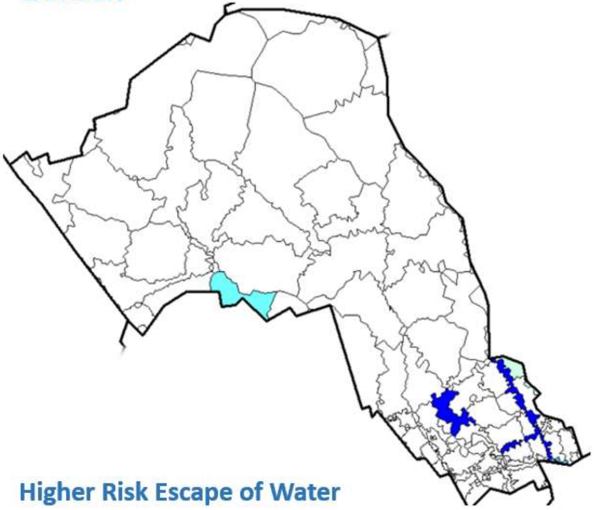

CAMDEN - Subsidence Risk

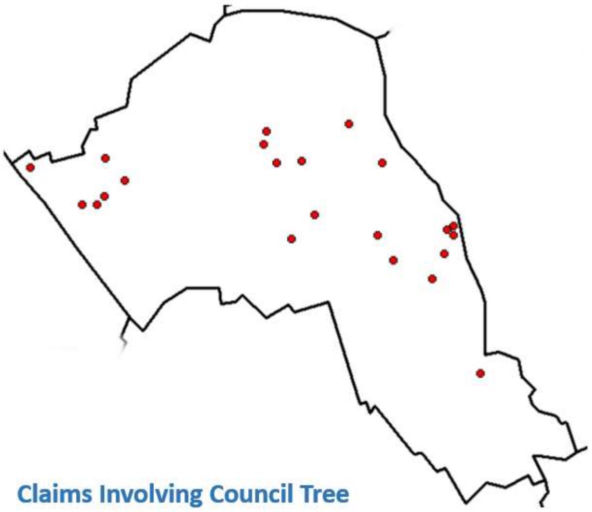
Normalised (0 – 1) Scale

Compared with UK Average

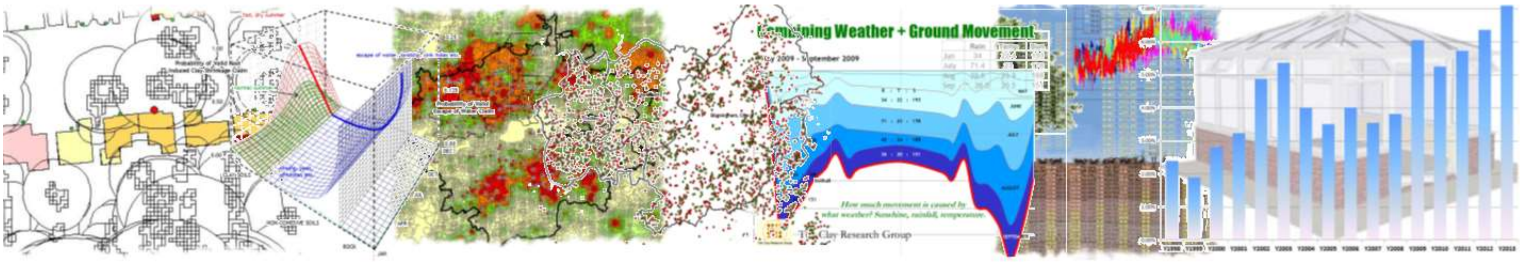
Below, left, mapping the frequency of escape of water claims from the sample reflects the absence of drift deposits (sands and gravels etc). The absence of shading does not indicate an absence of claims, but a low frequency. Such claims are often due to shallow foundations of older houses bearings onto disturbed ground or topsoil. Below, right, 'Council Tree Claims' map plotting claims from a small sample of around 2,700 UK claims where damage has been attributable to vegetation in the ownership of the local authority.

CAMDEN


Higher Risk Escape of Water


Claims Involving Council Tree

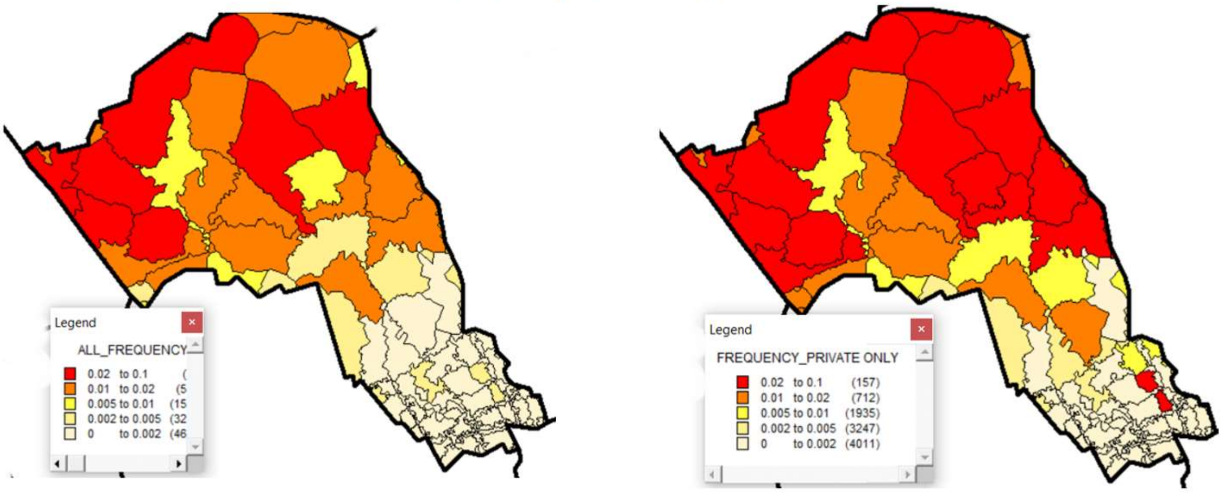
(2,700 UK claim sample)



CAMDEN - Frequencies & Probabilities

Mapping claims frequency against the total housing stock, left (council, housing association and private) and private housing only, right, reveals the importance of understanding risk by portfolio.

CAMDEN - Postcode Sector Subsidence Risk (frequency) by Ownership

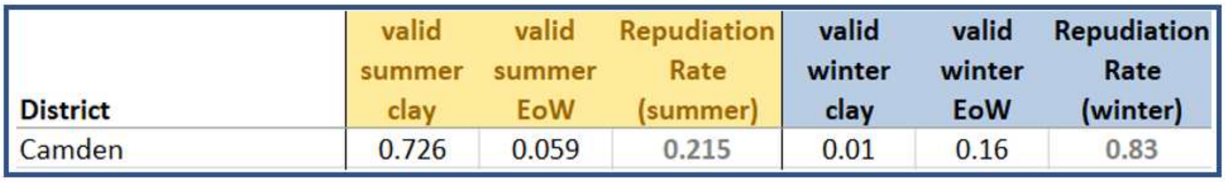


Combined Public and Private Frequency **Private Only**

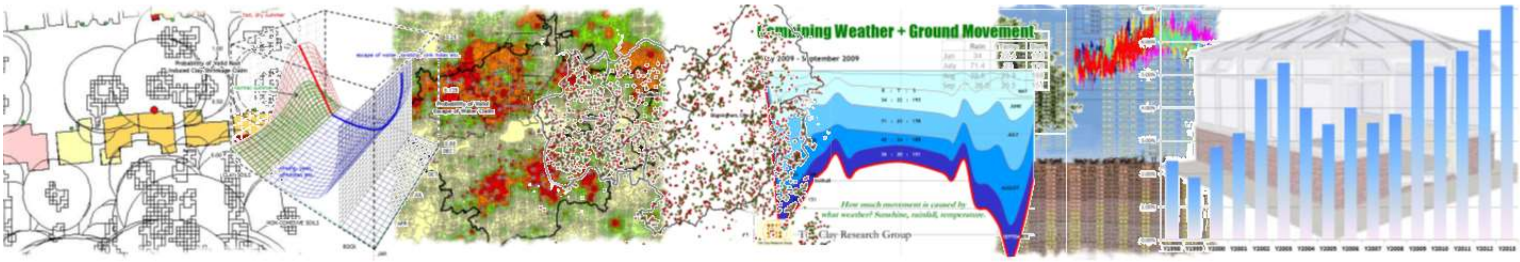
The reversal of rates for valid -v- declined by season is a characteristic of the underlying geology. The probability of a claim being valid in the summer is just under 80%, and in the winter, it falls to less than 20%. Valid claims in the summer are likely to be due to clay shrinkage, and in the winter, escape of water.

The probabilities of causation reverse between the seasons and the values are typical signatures of an outcropping, highly shrinkable, clay soil.

Liability by Season - CAMDEN



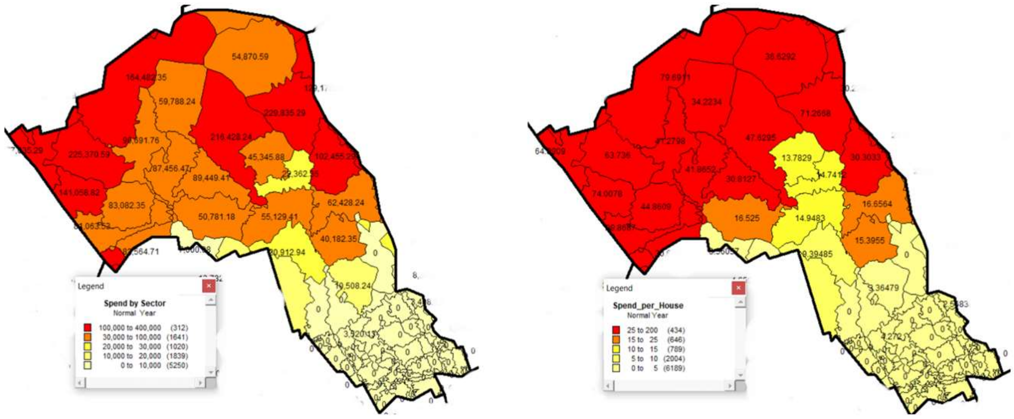
District	valid summer clay	valid summer EoW	Repudiation Rate (summer)	valid winter clay	valid winter EoW	Repudiation Rate (winter)
Camden	0.726	0.059	0.215	0.01	0.16	0.83



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

The maps below show the aggregated claim cost from the claim 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.

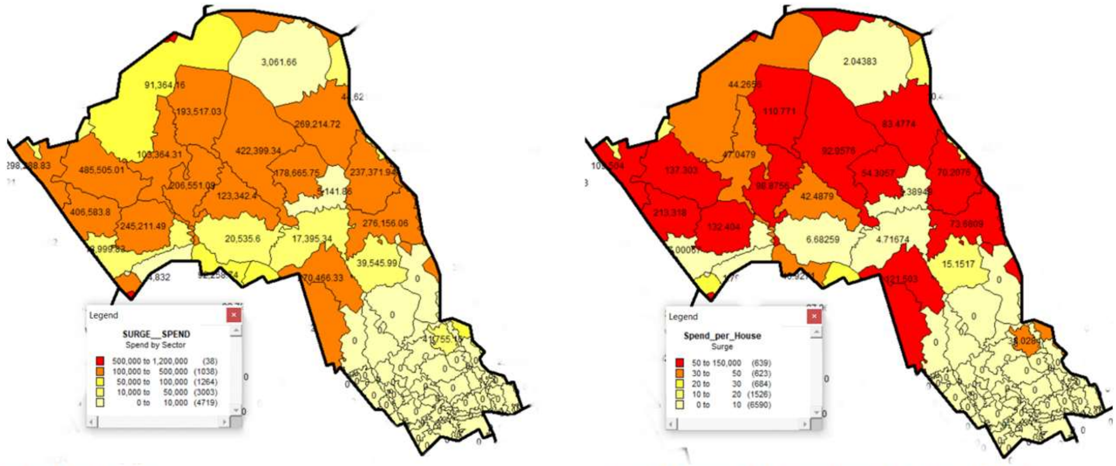
NORMAL YEAR SPEND – CAMDEN



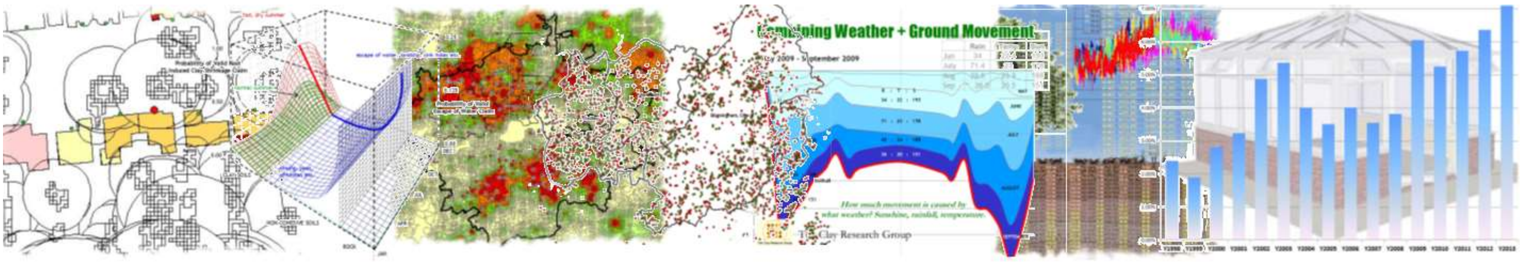
Spend by Sector **Spend Averaged over Housing Population**

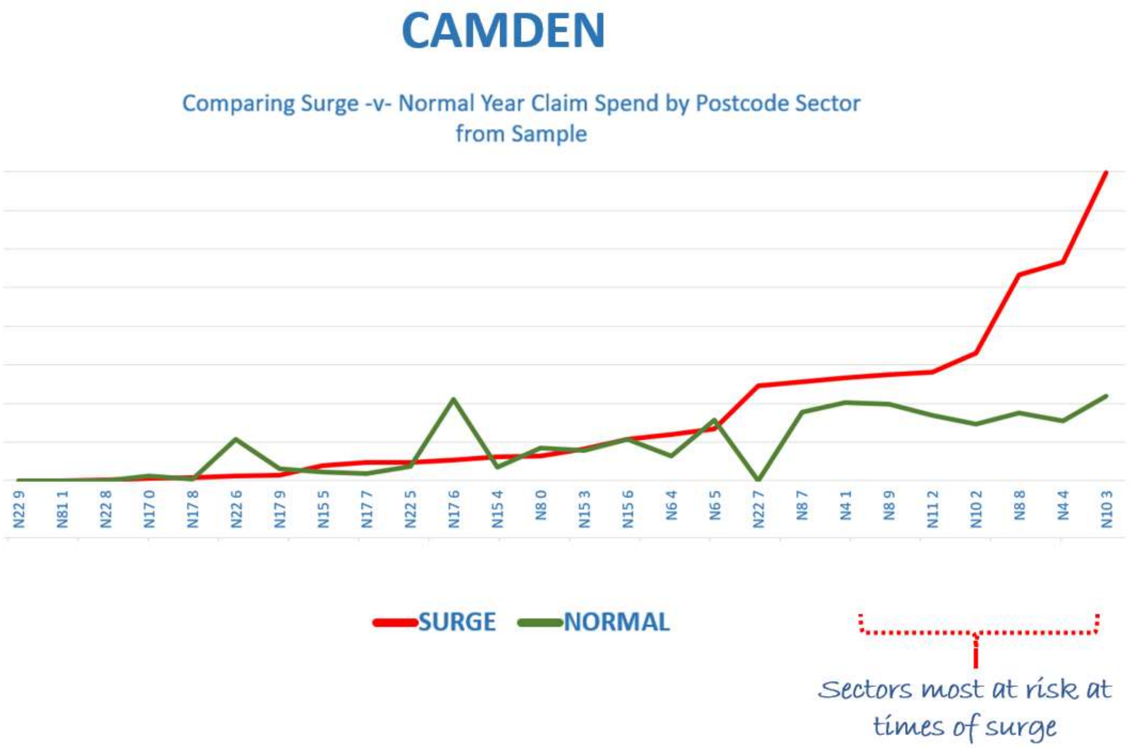
It will also be a function of the distribution of vegetation and age and style of construction of the housing stock. The images to the left in both examples (above and below) represent gross sector spend and those to the right, sector spend averaged across housing population to derive a notional premium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

SPEND in SURGE – CAMDEN



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



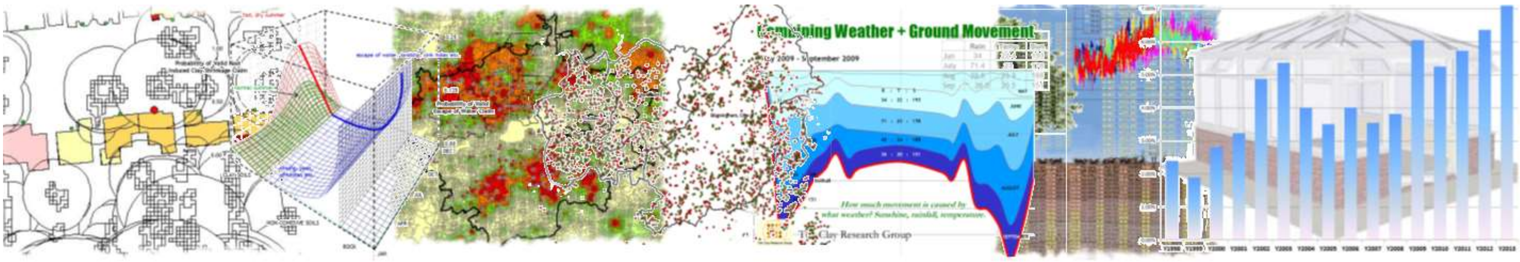


The above graph identifies the variable risk across the district at postcode sector level, distinguishing between normal and surge years. Divergence between the plots indicates those sectors most at risk at times of surge (red line).

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.

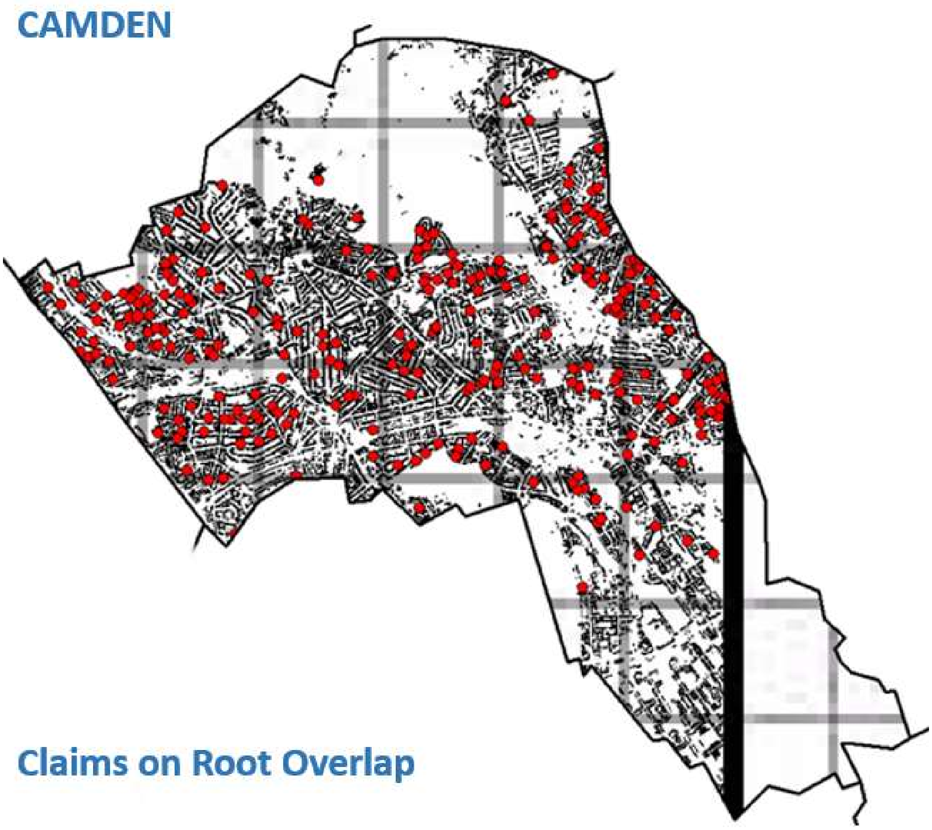
In making an assessment of risk, housing distribution and count by postcode sector play a significant role. One sector may appear to be a higher risk than another based on frequency, whereas basing the assessment on count can deliver a different outcome. This can also skew the assessment of risk related 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 is based on losses for surge of just over £400m, and for normal years, £200m.



Modelled Root Overlap – Public and Private Trees

Below, a map showing the modelled root encroachment (grey shading - public and private trees) beneath domestic properties in Camden using a root radius value of 1.2 x the tree height.



Red dots indicate valid, root induced clay shrinkage claims from a sample of 54k claims covering the UK.

Right, an enlarged portion of the above map. Only that area of the house with the modelled root zone beneath its footprint is shown.