

SUBSIDENCE MANAGEMENT SERVICES

ENGINEERING REPORT

Name of Engineer: David Crean
BSc (Hons) MCIOB MRICS Cert CII

Infront Innovation Reference: IFS-AVI-ROF-13-0044713

Name(s) of property Owners: Mrs Grandison

Address of Property: 24 Ramblers Way, Waterlooovile, PO7 8RE

Date of Report: 2nd February 2016

1. Scope of instructions:

- 1.1. In December 2013 InFront-Innovation (now Subsidence Management Services) were instructed by Woolwich to take over the running of any existing claim which had been managed from inception by previous engineers, Crawford's.
- 1.2. This report has been prepared to support the application to remove the TPO's in order to fell the 2no oak trees (T1 & T2) located beyond the rear garden of 24 Ramblers Way, Waterlooovile, PO7 8RE. The trees are identified as T1 & T2 within the Arboricultural Report dated 31st January 2014 reference SW/0901141542/WA provided by Marishal Thompson Group.

2. Documents considered

The key documents considered in the report are listed below.

Table 1 – Documents considered

ID	Produced by	Description	Date
1	Crawford	Engineer's Report	26/09/2013
2	SubsNet Geotechnical Report	Site Investigation Report	20/11/2015
3	InFront	Re-Visit Report	06/01/2014
4	Marishal Thompson Group	Consultant report on trees	31/01/2014
5	Subsnet Geotechnical Report	Site Investigation Report	10/02/2014

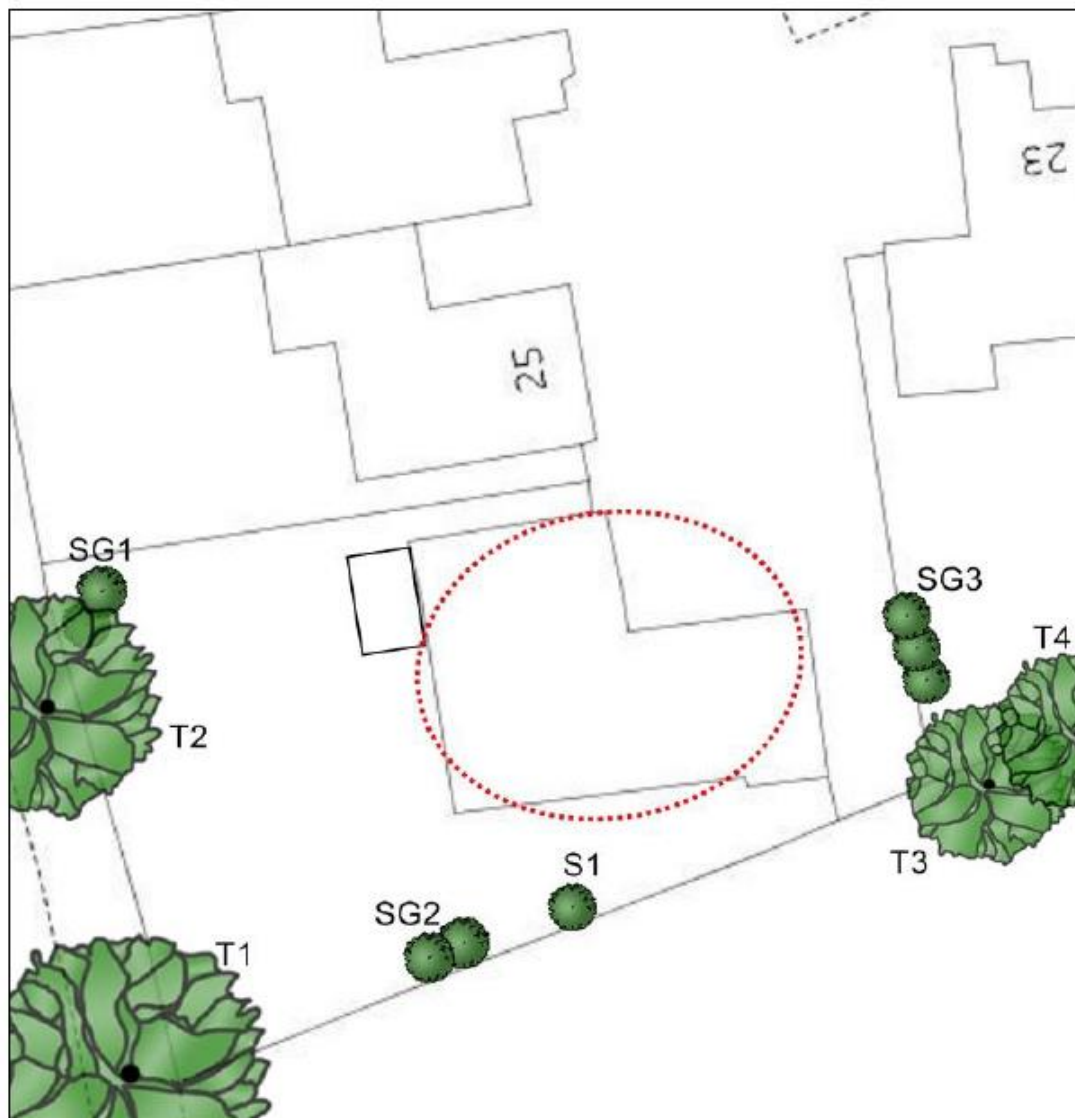


Figure 1 – Sketch taken from Marishal Thompson Group survey showing location of the principal vegetation in relation to Property

3. History and background

- 3.1. The property is a two storey detached house of traditional construction with solid brick walls and surmounted by a ridged tiled covered roof. A single storey rear extension was added in 1994 on foundations said to be in the region of 2.9m in depth.
- 3.2. The damage was discovered on 31st August 2013. However, it is understood that the property suffered from subsidence shortly after construction and the developer, Millers, bought the property back from the people who bought from

new. The main house is known to have been underpinned using an unknown underpinning scheme in circa 1989. Mr. Gradison considered the underpinning to be a piled scheme however paperwork reviewed by the Crawford's engineer on site suggests traditional mass concrete underpinning was employed by Roger Bullivant Ltd.

- 3.3. The garage was extended to first floor level in 2004. This included improvements to the foundations to support the first floor level independently from the original garage.
- 3.4. Two neighbouring properties have suffered subsidence issues with extensions to the properties having been rebuilt. There have been issues with neighbouring Oak trees, some have been removed, but others are protected by a Tree Preservation Order.
- 3.5. Site investigations were carried out in both February 2014 and November 2015 by SubsNet from which it was concluded that the property had been affected by clay shrinkage subsidence. Marishal Thompson Group subsequently recommended removal of the Oak trees at the rear (reference T1 & T2). Additionally, it was recommended in the same report, that the local authority hawthorn tree (T3) be removed to guard against future risk. The LA oak tree (T4) and three other trees in the ownership of the Insured were recommend to be maintained at their current dimensions to avoid any future risk issues
- 3.6. Tree roots obtained from the boreholes undertaken in November 2015 were subsequently examined by industry experts, EPSL Botanical Identifications and roots obtained in boreholes BH4, BH5 and BH6 were encountered at between 1.4m and 3.5m below ground level were positively identified as belonging to Quercus spp (oak trees).

4. Description of Damage

- 4.1. The damage was described in the re-visit report of January 2014.
- 4.2. Damage was said to be widespread about the property with cracking in most rooms. The sun room extension which the insured advised was built for them recently on deep foundation has also rotated away from the main property and the garage which has been extended over has also suffered from foundation related damage with the brickwork below DPC dropping and leaving a gap along the membrane.
- 4.3. Given knowledge of the local area it is considered that the damage to the property is attributable to clay shrinkage subsidence exacerbated by the effects of the nearby vegetation and in particular the Oak trees.

5. Evidence of root encroachment

- 5.1. A site investigation was carried out initially in February 2014 by Subsnet UK. This comprised two external trial pits/boreholes: TP/BH1 next to the rear extension / sun room and TP/BH2 located at the front left corner of the property (garage).

- 5.2. The site investigation confirmed that the sun room (**TP/BH1**) to the rear of the property had been constructed on a mass filled concrete strip footing, 2.5m thick at a depth of 2.9m below ground level. The soils at foundation level were described as very stiff with insitu strength readings indicating the soils increased shear strength and possible desiccation.
- 5.3. The cracking around the property demonstrated that the problem is not one of seasonal influence just from the ground but the proximity of adjacent vegetation also. Roots of live appearance were noted within the trial pit to the rear of the property, down to 2.5m. Although the 2014 investigation recovered tree roots they could not be identified, hence why the additional investigation was carried out.
- 5.4. Additional boreholes were excavated in 2015 as detailed. BH6 was located at the rear corner of the sun room whilst BH5 was located at the rear left corner of the main dwelling. Quercus roots were identified in both boreholes to a maximum depth of 3.5m. The roots within BH5 had diameters of 13mm. The identification of the roots supports the view that T1 & T2 are of influence.

6.1 Table 1 - Current Claim Requirements

These recommendations may be subject to review following additional site investigations

Tree No.	Species	Age Cat	Approx. Height (m)	Distance to Building (m)	Ownership	Action	Requirement
T1	Oak	3	20	12.9	B - Local Authority	Remove	Remove.
T2	Oak	3	10.5	8.4	B - Local Authority	Remove	Remove.
Age Cat: 1 = Younger than property; 2 = Similar age to the property; 3 = Significantly older than property							

Figure 2: Recommendations set out in Arborist Report

- 5.5. Trial pit 2 (**TP/BH2** – 2014 SI) was located adjacent to the extended front left corner of the garage and found the foundations to be a concrete strip footing, 400mm thick at a depth of 1.4m below ground level.
- 5.6. The foundations were bearing onto a stiff brown clay and roots were noted below the footings, down to a depth of 2.4m below ground level.
- 5.7. The soils became very stiff by 2m and then softened to stiff again by 3m. This increase in shear strength between 2 and 3 metres correlated with tree root activity.
- 5.8. Laboratory analysis of the soils indicated desiccation throughout both boreholes and this appeared to be tree root induced.
- 5.9. Again, whilst no positive identification of the roots was available in the original investigation, it was suspected the roots came from T3 and possibly T4.
- 5.10. BH4 (borehole 4) was located in this area in February 2015 which revealed roots of root diameters up to 9mm between 1.4m and 2.4m, identified as

Quercus spp. belonging to oak trees. This would support Marishal Thompson's view that T3 should be removed to avoid future risk.

Sub Sample	Species Identified		Root Diameter	Starch
BH4:				
1.4-2.4m	Quercus spp.	1	9 mm	Abundant
BH5:				
1.4-2.4m	Quercus spp.	2	13 mm	Abundant
BH6:				
2.5-3.5m	Quercus spp.	3	2 mm	Abundant

Figure 3: Root identification by EPSL November 2015

6. Soil Conditions

- 6.1. With reference to the 1:50,000 scale British Geological Survey Map (solid and drift edition) suggests that the underlying geology to be alluvium – Clay, silt and gravel.
- 6.2. The laboratory analysis (2014) of the soil indicated the clay was of high plasticity, meaning that it has a high shrinkage potential. In essence, the soil is very sensitive to changes in moisture content below a certain level and hence the dry summer appears to have dried the soils to a point where they have shrunk.
- 6.3. The Moisture profiles indicate vegetation induced moisture depletion below the foundations in both trial pits excavated in 2014. The fact that the results are such considering the time of year suggests that the effects will be much greater in the summer.
- 6.4. It is universally accepted that moisture contents generally decrease with depth due to the effects of overburden pressure (the weight of soil above squashes the clay below and thus reduces its moisture content). It is expected that a soil with equilibrium moisture content will have a linear reduction in moisture content with depth.
- 6.5. Borehole 2 (see figure 4 - 2014) shows that the moisture content actually increases at 3.00m to 30% having been identified at foundation level at 28% and reducing to 27% at 2.0m and 2.5m below ground level.
- 6.6. Similar readings were discovered in the 2015 moisture profiles (see figure 5) which reinforce the findings.
- 6.7. Atterberg Limits Testing allows interpretation of results in the terms of Driscoll's assessment of desiccation (soil dryness). This compares the soil's actual moisture content with its liquid and plastic limits. It is acknowledged that Driscoll's theory is unreliable in isolation however it does provide another benchmark to assess potential desiccation. It is suggested that if the moisture content exceeded 50% of its liquid limit there was no desiccation. At 50% the onset of desiccation occurred and below 40% the soil sample had attained significant desiccation. The results of the clay soil below the depths of the

foundations indicate the samples to be desiccated even given the timing of the samples taken (February 2014 & November 2015).

Lab Ref	Depth (m)	MC (%)	Corr MC (%)	LL (%)	PL (%)	PI (%)	% Passing .425mm
Samples from BH1							
001	2.90	33	33	81	32	49	100
002	3.40	33	33	78	32	46	100
Samples from BH2							
003	1.40	28	28	79	31	48	100
004	2.00	27					
005	2.50	27	27	76	30	46	100
006	3.00	30					
007	3.50	30	30	79	31	48	100

Figure 4 – Summary of soil test results from 2014 investigation.

Lab Ref	Depth (m)	MC (%)	Corr MC (%)	LL (%)	PL (%)	PI (%)	% Passing .425mm
Samples from BH6							
001	2.50	22	22	72	27	45	98
002	3.00	27					
003	3.50	27	27	70	26	44	99
004	4.00	28	28	75	29	46	99
Samples from BH4							
005	1.40	24	24	68	29	39	100
006	1.90	24					
007	2.40	26	26	73	28	45	100
008	2.90	28					
009	3.40	23	23	74	26	48	100
010	3.90	29					
011	4.40	29	29	70	29	41	100
Samples from BH5							
012	1.40	24	24	67	28	39	100
013	1.90	25					
014	2.40	27	27	68	29	39	100
015	2.90	28					
016	3.40	29	29	65	30	35	100
017	3.90	30					
018	4.40	31	31	72	27	45	100

Figure 5 – Summary of soil test results from 2015 investigation

- 6.8. Heave calculations were carried out the 2015 site investigation soil data using suction profiles. The maximum surface heave potential of 53mm has been confirmed. The predicted heave is that expected of the ground if it were allowed to fully re-hydrate and come to equilibrium. No allowance has been made for the weight of the building and its anticipated damping effect on that result. In the context of level monitoring results, this also confirms the result to be reasonably accurate although heave of less than 53mm is more likely to be expected and would be welcome in the context of foundation recovery and crack closure.

- 6.9. The heave potential calculations indicating 53mm of upward movement at the rear based on the soils analysis carried out in November 2015 is a strong indicator that the risk of long term heave as a result of tree removal is acceptable particularly bearing in mind following the winter and recent prolonged and heavy rain.

7. Drains

- 7.1. Consideration has been given to the potential effect of the drainage system. However, given its location and factoring in the ground conditions, form of construction and timing of the damage it is not considered to be an influencing factor.

8. Monitoring

- 8.1. Level monitoring involved fixing pins around the perimeter of the building from which levels were taken to determine where the external walls and hence by implication the foundations are moving and by how much.
- 8.2. Level monitoring was set up in April 2014 and readings have been taken at approximately 8 week intervals and results up to and including January 2016.

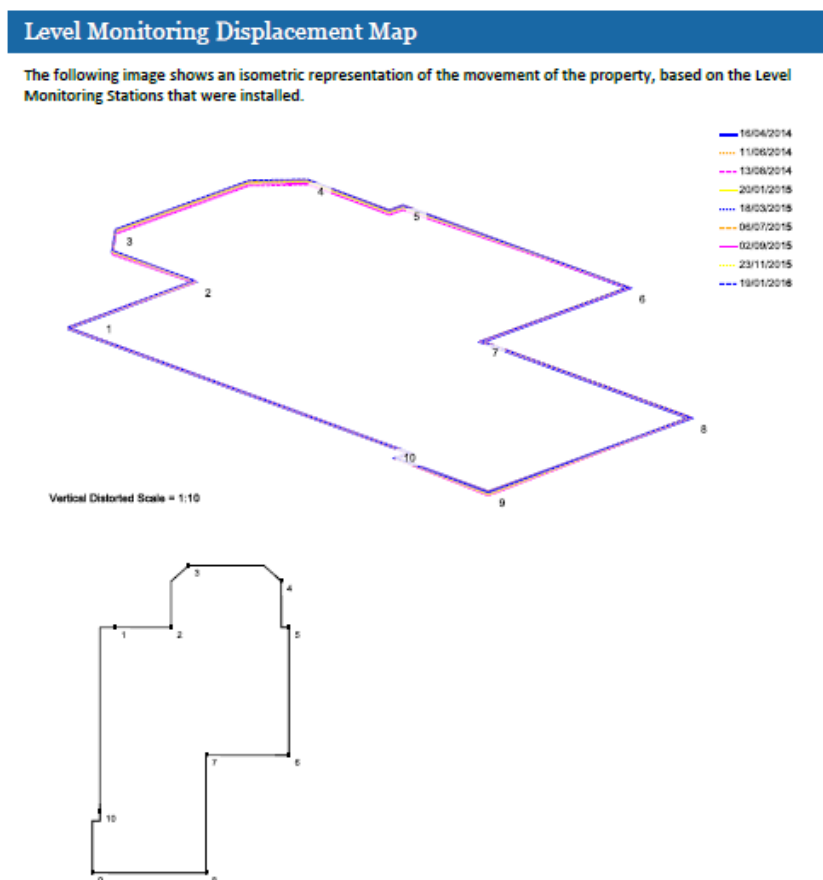


Figure 6 – Monitoring location positions

- 8.3. The monitoring results, which are presented in below, show that the property is affected by seasonal downward movement to the rear extension and also to the corner of the garage.
- 8.4. The maximum degree of seasonal downward movement occurring at point 5 of -12.5mm and -.7.8mm at point 9.
- 8.5. The remaining areas to the main dwelling have shown minimal movement in comparison and what has been observed would be within accepted tolerances.
- 8.6. The monitoring shows the affected parts of the property moving down during the summer months when the trees are in leaf, demanding larger amounts of water and rainfall is lower and the net moisture content within the clay soil below the property decreases. Recovery or upward movement is then witnessed during the winter months when the tree loses leaf, demands less moisture and the rainfall events increase, allowing the soil to rehydrate to some degree and swell, causing upward movement and consequential closing of cracks within the property.
- 8.7. While climate alone can cause some small changes in the surface soil (to a depth of 500 mm or so), the foundations of the house, being in excess of 2.5m in depth are beyond this zone and seasonal movements can be dismissed, with the damage being indicative of root-induced shrinkage associated with a large tree.

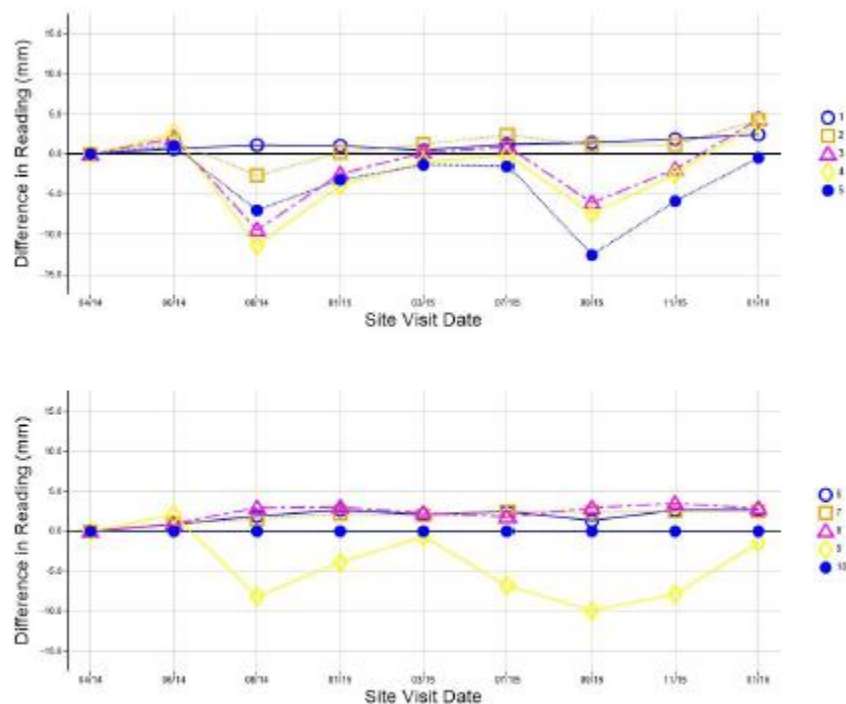


Figure 7 – Level monitoring results indicating seasonal movement in areas of concern.

9. Cause of Damage

- 9.1. In my opinion, the evidence points conclusively towards the damage, initially reported in 2013 by Crawford's and confirmed by Subsidence Management Services in 2014, having been caused by root-induced shrinkage in the subsoil. Specifically, we have:
- Damage characteristic of subsidence.
 - The damage is focussed on the rear extension and corner of the garage (when viewed from the front).
 - Damage appearing during late summer.
 - Evidence of root activity below foundation level
 - Presence of a clay subsoil with a high shrinkage potential.
 - Level monitoring showing seasonal movement (upward in winter, downward in summer).
- 9.2. Given its proximity and the presence of *Quercus spp* roots in the subsoil, the implicated trees identified with the Arborist report as T1, T2 & T3 are the only plausible explanations for the seasonal movements recorded to the affected parts of the property.
- 9.3. There is no reason to suspect that drainage defects have contributed materially to the damage under consideration and there are no other credible explanations for the evident foundation movement at the rear.
- 9.4. The monitoring results (*Figures 5 & 6*) clearly indicate an unacceptable scale of seasonal foundation movement of the property and this has now been confirmed by the subsequent monitoring results.
- 9.5. Where a tree is causing movement significant parts of a property it is common for the effects to be transmitted throughout the superstructure and for cracks to appear at weak points, such as the junctions of walls and ceilings or the ends of lintels. In my opinion, the seasonal movement associated with the implicated vegetation is now the only plausible explanation for the movement at the rear of the property.

10. Remedial options

- 10.1. Although the damage is relatively moderate in structural terms, it will be expensive to rectify because of the size of the rooms and the extensive decorations that will be required.
- 10.2. Even if there were some doubt as to the extent of the damage that can be reasonably attributed to the influence of the oak trees identified as T1, T2 & T3, the current recorded seasonal foundation movements are unacceptably large. If the influence of the implicated trees are not eliminated, an engineering solution will be needed to stabilise the property.
- 10.3. A range of underpinning solutions is available depending on the area that requires stabilisation and the depth required. Traditional, mass concrete, underpinning is generally the most economical solution where the required depth is relatively shallow. It has the added advantage that the underpinning also acts as a root barrier. However, it tends to become uneconomical, and the Health & Safety considerations become increasingly onerous, where the required depth exceeds 2.5 m. Most underpinning is extended to a metre below the last discovered root (measured at 3.5m in this instance) and this makes it an unacceptable risk from a health and safety perspective and should be discounted.
- 10.4. Pile-based underpinning solutions tend to be more economical where (i) the required depth exceeds 2.5 m and (ii) it is necessary to stabilise internal walls as well as external walls. A common variant is the piled-raft which consists of a reinforced concrete slab under the entire footprint of the property supported on driven or bored piles.
- 10.5. It is very difficult to partially underpin a property with a piled raft as the transition between stabilised and un-stabilised parts of the property is very vulnerable to cracking as a consequence of the minor seasonal fluctuations which might be expected in the traditionally founded part relative to the very stable piled section.
- 10.6. In this instance, I would have some reservations about the use of traditional underpinning because of the depth of the root activity indicated in the Geotechnical Report and the fact that the previous depth of the underpinning has proved to be inadequate. In addition, the potential benefits of the barrier provided by the traditional underpinning are likely to be outweighed by the advantages that a piled raft offers in providing a long term solution particularly if all of the property was stabilised although there is no technical justification beyond the avoidance of differential movement.
- 10.7. In the light of the depth of the roots found, to undertake a partial underpinning scheme to the remainder of the property could cost in the region of £45,000.00 exclusive of the serving of Party Wall Notices and professional fees.
- 10.8. I have considered whether the implicated trees could be controlled by regular pruning. However, recent research indicates that even heavy canopy reduction is likely to be effective for no more than one growing season. In my view it

would be impractical to place the burden of annual tree management on the owner of neighbouring property due to the large cost for such works. Annual management, in any case, would destroy most of the amenity value of the tree which would be the only impediment to its removal. It would also leave the property susceptible to damage in an exceptional summer such as 2003 when even recently-pruned trees can cause significant soil shrinkage.

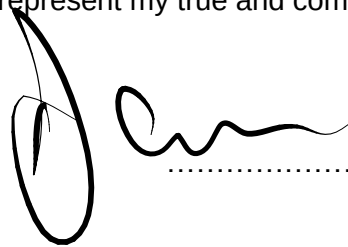
11. Summary of Conclusions

- 11.1. The nature and distribution of the cracking first reported in 2013 was indicative of subsidence with the focal point of the movement at the rear of the property.
- 11.2. Root samples recovered from below foundation level and identified as *Quercus spp* that indicate that roots from the oak trees (T1, T2 & T3) had encroached into the soil underlying 24 Ramblers Way, Waterlooovile, PO7 8RE.
- 11.3. Soil testing found conclusive evidence of desiccation in the surface soil, and the heave predictions would not preclude the removal of the trees.
- 11.4. There was no evidence to suggest that water escaping into the soil from defective drainage or other sources caused any significant movement to the foundations or otherwise contributed materially to the reported damage.
- 11.5. The level monitoring confirmed that the foundations were moving seasonally and with greater movement at the rear elevation
- 11.6. The submitted evidence therefore points conclusively towards the oak trees being the substantial and effective cause of the damage that appeared in 2013. It also indicated the scale of the movement associated with the tree to be unacceptable.
- 11.7. If the implicated trees are not removed, it will be necessary to underpin the property to prevent a recurrence of the damage. The most cost effective scheme is likely to be a piled raft scheme. On further consideration of the depth at which roots were found, the extent of the underpinning scheme envisaged previously would suffice. The cost of the scheme is likely to be in the region of £45,000 inclusive of VAT, but exclusive of professional fees and alternative accommodation.
- 11.8. The cost of superstructure repairs is in the region of £8,500.00 but exclusive of professional fees. .
- 11.9. Alternative methods of reducing the influence of the implicated tree, such as annual pruning or the installation of a root barrier are not practical in this instance.

12. Statement of truth:

I confirm that insofar as the facts stated in my report are within my own knowledge I have made clear which they are and I believe them to be true, and that the opinions I have expressed represent my true and complete professional opinion.

Signed:



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Name of Engineer:

David Crean BSc (Hons) MCIOB MRICS Cert CII

Dated:

16/02/2015