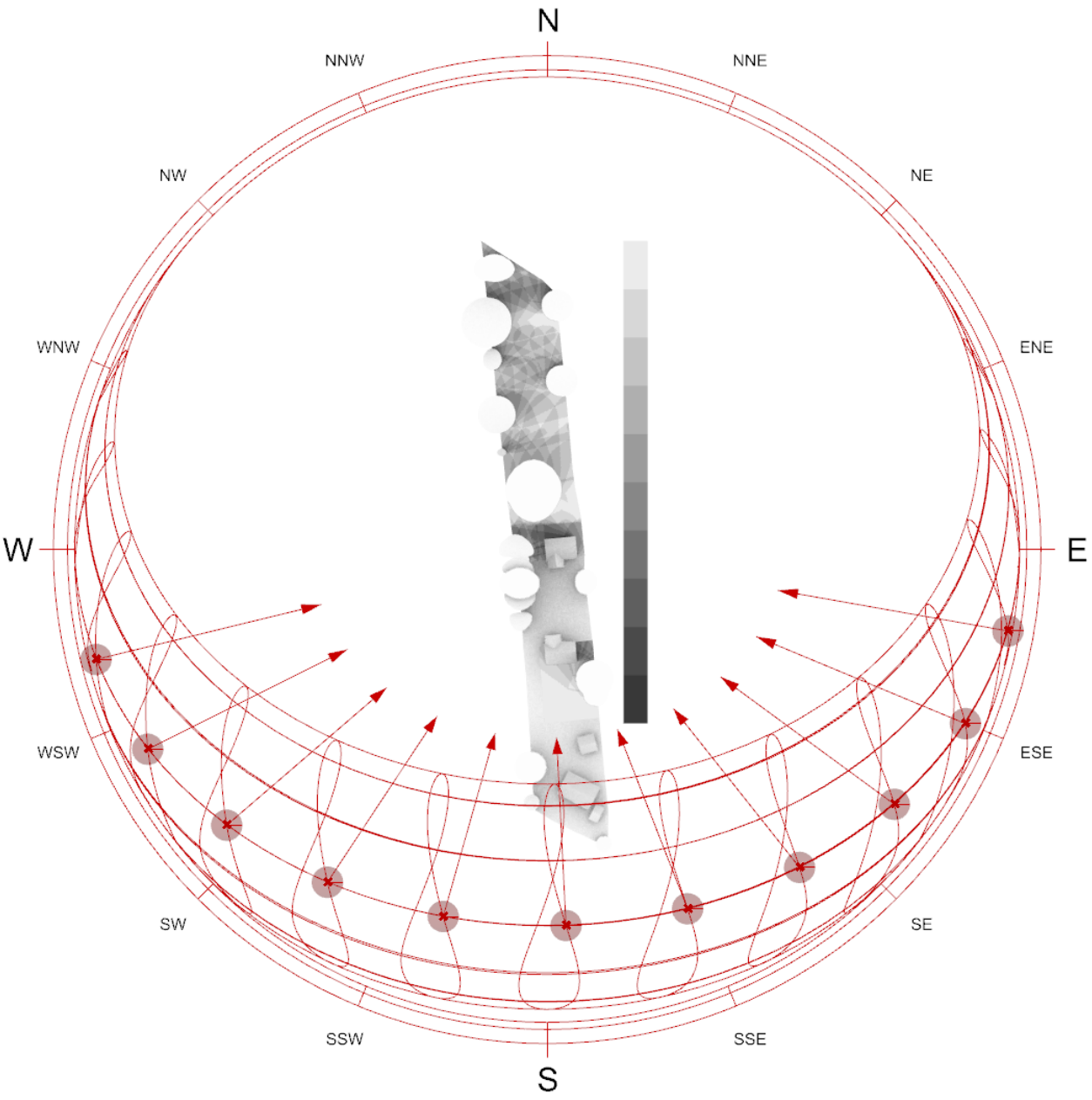
Technical Report –
Sunlight Hours Analysis in Residential Gardens



Site:
12 Thorpe Lane, South Hykeham
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Checked and issued by:
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Revision / Date:
A01 / 09 October 2023

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Introduction

1.1. Origin Design Studio Ltd. have been appointed by Mrs Robinson, the applicant, to undertake a Sunlight Study of the proposed residential development currently being considered by NKDC planning department.

1.2. This report has been prepared due to previous concerns on a previously refused planning permission, including comments from the planning inspectorate in a dismissed appeal. These previous comments were based on the suggestion that the proposed gardens would receive and adequate amount of direct sunlight and confusion over the results.

1.3. By undertaking computer simulation modelling this report looks to address the concerns of the LPA on a plot-by-plot basis.

1.4. In the previous application, no concerns were raised about the internal spaces. As such this report's objective is to only assess the external spaces.

Planning Policy

2.1. National Planning Policy Framework (NPPF)

2.1.1. Paragraph 125 (c):

local planning authorities should refuse applications which they consider fail to make efficient use of land, taking into account the policies in this Framework. In this context, when considering applications for housing, ***authorities should take a flexible approach in applying policies or guidance relating to daylight and sunlight****, where they would otherwise inhibit making efficient use of a site (as long as the resulting scheme would provide acceptable living standards).*

2.1.2. Paragraph 128:

To provide maximum clarity about design expectations at an early stage, all local planning authorities should prepare design guides or codes *consistent with the principles set out in the National Design Guide and National Model Design Code, and which reflect local character and design preferences. Design guides and codes provide a local framework for creating beautiful and distinctive places with a consistent and high quality standard of design. Their geographic coverage, level of detail and degree of prescription should be tailored to the circumstances and scale of change in each place, and should allow a suitable degree of variety.*

2.1.3. Paragraph 129:

Design guides and codes can be prepared at an area-wide, neighbourhood or site specific scale*, and to carry weight in decision-making* ***should be produced either as part of a plan or as supplementary planning documents.*** *Landowners and developers may contribute to these exercises but may also choose to prepare design codes in support of a planning application for sites they wish to develop. Whoever prepares them, all guides and codes should be based on effective community engagement and reflect local aspirations for the development of their area, taking into account the guidance contained in the National*

Design Guide and the National Model Design Code. These national documents should be used to guide decisions on applications in the absence of locally produced design guides or design codes.

2.2. Central Lincolnshire Local Plan (CLLP)

2.2.1. Policy 53: Design and Amenity:

5. Nature

a) Incorporate and retain as far as possible existing natural features including hedgerows, trees, and waterbodies particularly where these features offer a valuable habitat to support biodiversity, aligned with policies in the Natural Environment chapter of the Local Plan;

b) Incorporate appropriate landscape and boundary treatments to ensure that the development can be satisfactorily assimilated into the surrounding area, maximising opportunities to deliver diverse ecosystems and biodiverse habitats, strengthening wildlife corridors and green infrastructure networks, and helping to achieve wider goals for biodiversity net gain, climate change mitigation and adaptation and water management;

8. Homes and Buildings

a) Provide homes with good quality internal environments with adequate space for users and good access to private, shared or public spaces;

b) Be adaptable and resilient to climate change and be compatible with achieving a net zero carbon Central Lincolnshire as required by Policies S6, S7 and S8;

c) Be capable of adapting to changing needs of future occupants and be cost effective to run by achieving the standards set out in Policy S20;

*d) **Not result in harm to people's amenity** either within the proposed development or neighbouring it through overlooking, overshadowing, loss of light or increase in artificial light or glare;*

e) Provide adequate storage, waste, servicing and utilities for the use proposed;

2.3. The Central Lincolnshire Local Plan does not include a Design Code or Guide relating to sunlight and daylight.

2.4. NKDC do not have a supplemental planning document relating to sunlight and daylight.

2.5. In the absence of Area, Neighbourhood or Site Wide Design Guides and Codes alternative design guidance has been sought to provide the criteria for simulation and assessment. BR 209 - Site layout planning for daylight and sunlight, Third Edition 2022 provides guidance on daylighting and good practice for demonstrating suitability of developments. In the absence of design guides this document should be considered the authority on the matter.

The Site

3.1. The site is located North of Thorpe Lane and is a long and narrow Site. Along the North-South axis it measures approximately 183m. Along the East-West axis the site measures approximately 21.5m.

3.2. The site was topographically surveyed by Shire Surveys Ltd. This survey has been used to position the existing trees and create the terrain as a 3D model.

3.3. The site contains numerous trees and vegetation. These were surveyed by Andrew Belson Arbocultural Consultant and are included within the Arboricultural Implications Assessment. The information provided in the report has been used to accurate model the trees

3.4. The neighbouring property (East) has removed a number of boundary trees which has made a significant change to the number of trees affecting the site.

Modelling

4.1. The site has been modelled according to the Topographical Survey, the Arboricultural Implications Assessment and the Proposed Site Plan.

4.1.1. The modelling uses Computer Aided Desing (CAD) program Rhino to create the required geometry.

4.1.2. The landscape used the points and their associated level above sea level to generate a point grid at their real-world elevation. The contour lines weaving across the site were set at their respective elevation. Employing Delaunay Mesh Triangulations[1] the points and curves are used to create a triangular mesh.

4.1.3. The proposed dwellings are modelled as solid masses, the eaves, ridges and significant features as shown on the indicative site plan have been modelled. The dwellings are presumed to be 1.5 storey with an eaves height of 3.6m and a roof pitch of 35 degrees.

4.1.4. The trees were modelled as solid shapes, including trunks. The information provided in the tree report was used in the formation of the shapes. The tree report provided several metrics used to create a profile of each tree. The parameters used are: 1 – Trunk Diameter, 2 – Height, 3 - Lower Crown Height, 4 – Crown Spread (North, South, East, West)

Andrew Belson
Arboricultural Consultant

ref.	Species	Age Class	Ø m/s (mm)	Height (m)	Lower crown height (m)	Ultimate height (m)	Grade	Crown Spread N (m)	Crown Spread S (m)	Crown Spread E (m)	Crown Spread W (m)	RPA radius (m)	RPA (m^2)	Remaining Contribution (yrs)	Condition	Comments	Recommendations made at time of survey, irrespective of any layout
NT1	Mountain Ash	M	160	6	2	6	C1	2.5	2.5	2.5	2.5	1.92	11.58	20+	Reasonable	Tree on neighbouring property therefore not closely inspected. Previously pruned	No work required.
NT2	Silver Birch	M	346	12	2.5	12	B1	5	5	5	5	4.15	54.11	20+	Reasonable	Tree on neighbouring property therefore not closely inspected.	No work required.

Figure 1 - Extract of Arboricultural Implications Assessment

[1] https://people.eecs.berkeley.edu/~jrs/meshpapers/delnotes.pdf

4.1.5. The following images show the modelling of a tree from these metrics.

Figure 3 - Perspective View

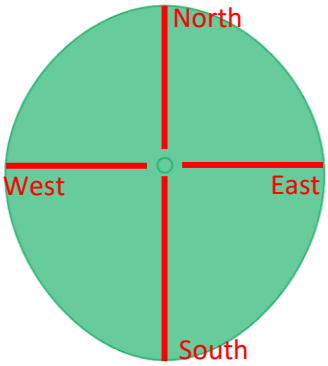

Figure 2 - Plan View

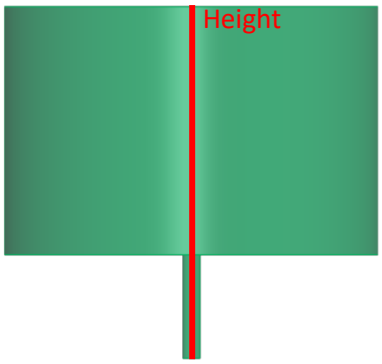

Figure 5 - Front View

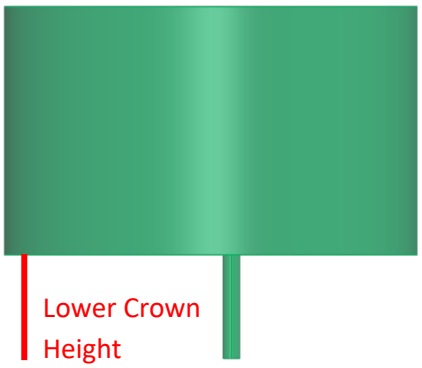

Figure 4 - Side View

4.1.6. The tree survey has certain limitations which make the results of this simulation worse than real life circumstances.

Firstly, the trees are modelled as solid masses. The reality is that trees provide dappled light which provides shade but light also filters through. This provides the worst-case shading situation.

Secondly the shape of the modelled trees does not include tapering or rounding of the edges, which would lead to improved results.

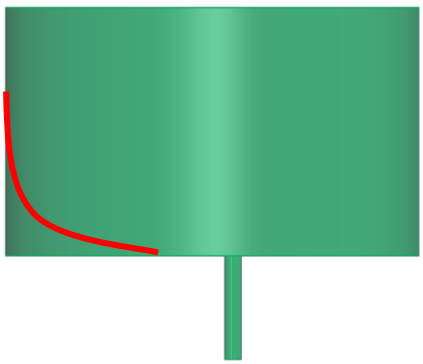

Figure 6 - Tapering of Trees

Figure 7 - Tree Reality Vs Modelled Mass

The tree report identifies 2 trees as having future growth potential. One of these trees was on a neighbouring property and has been removed, the remaining trees potential growth has been modelled to ensure the results reflect the future of the site.

4.2. The BRE209 provides the following guidance related to trees and their opacity:

Table G1 – Transparencies of tree crowns to solar radiation

		Transparency (% radiation passing)	
Botanical name	**Common name**	**Full leaf**	**Bare branch**
Acer pseudoplatanus	Sycamore	20	60
Acer saccharinum	Silver maple	15	55
Aesculus hippocastanum	Horse chestnut	20	55
Betula pendula	European birch	20	55
Fagus sylvatica	European beech	20	45*
Fraxinus excelsior	European ash	25	65
Gleditsia	Locust	30	80
Quercus robur	English oak	20	55*
Tilia cordata	Lime	10	55
Ulmus	Elm	15	65

* The beech, and some oaks, tend to retain dead leaves for much of the winter, reaching bare branch condition only briefly before new leaf growth in the spring. The transparency value for beech is an average winter value.

Figure 8 - Table G1, BRE209

The software used assumes the modelled trees to be solid. This could be adapted to provide a surface (flat/2D) which is perforated to the percentage in this table to represent the penetrations. However, this would be a 'man-made' perforation, would lack the depth trees have. As such the 3D mass is used to provide accurate shadows and ground cover, in the knowledge that these are solid and represent the absolute worst shade a tree can produce. If the site passes during this simulation the real-life results are only going to be better.

4.3. The BRE209 provides the following guidance related to trees and their reflectance:

Table G2 – Reflectances of trees

	Reflectance (%)	
	Summer	Winter
Trees with dense light-coloured foliage in summer	40	10
Trees with open foliage	20	10
Evergreen conifers	10	10

Figure 9 - Table G2, BRE209

The solar reflectance of the surfaces has not been simulated, the light potential to bounce from a surface has not been factored into the simulation. The reflectance would not be direct light and therefore not needed in the assessment. However, the ability to reflect a portion of light impacts the sense of space as an experience and not a factor of this report which is focussed on direct light, not indirect illumination.

4.3.1. Solar Reflectance is the fraction of the incident solar energy which is reflected by the surface in question. The best standard technique for its determination uses spectrophotometric measurements, with an integrating sphere to determine the reflectance at each different wavelength. The average reflectance is then determined by an averaging process, using a standard solar spectrum. This method is documented by ASTM (Amer. Soc. for Testing and Materials) as Standards E903 and E892[2].

Methodology

5.1. This daylight report is prepared after following the latest guidance of the BR 209 - Site layout planning for daylight and sunlight, Third Edition 2022. Chapter 3 specifically relates to Sunlight, with section 3.3 providing guidance on Gardens and Open Spaces.

5.1.1. The following paragraphs provide the guidance on a methodology.

> ***3.3.4*** *Each of these spaces will have different sun lighting requirements and it is difficult to suggest a hard and fast rule. However, it is clear that the worst situation is to have significant areas on which the sun only shines for a limited period over a large part of the year (Figure 28). The equinox (**21 March**) can be chosen as a date for assessment here.*
>
> ***3.3.7*** *As a check, it is recommended that at least half of the amenity areas should receive **at least two hours of sunlight** on 21 March. It is instructive to draw the 'two hours sun contour' that marks this area on plan, because the use of specific parts of a site can be planned with sunlight in mind. This could include reserving the sunniest parts of the site for gardens and sitting out, while using the shadier areas for car parking (in summer, shade is often valued in car parks). (Figure 30). If a detailed calculation cannot be carried out, and the area is a simple shape, it is suggested that the centre of the area should receive at least two hours of sunlight on 21 March.*
>
> *3.3.8* ***Locations that can and cannot receive two or more hours of sunlight on 21 March may be found using specialist software.*** *The space is divided into a grid of points with a recommended **spacing of 0.3 m** or less, and the proportion of these points that can receive two hours of sunlight on March 21 is computed. It is possible to carry out a check for the centre of an area by using the sun path indicator, which has a line for 21 March (see Appendix A). Sunlight at an altitude of 10° or less does not count, because it is likely to be blocked by low-level planting anyway. In working out the total area to be considered, driveways and hard standing for cars should be left out. Around housing, front gardens that are relatively small and visible from public footpaths should be omitted; **only the main back garden should be analysed**. Each individual garden for each dwelling in a block should be considered separately.*
>
> *3.3.9 The question of whether trees or fences should be included in the calculation depends upon the type of shade they produce. **Normally trees and shrubs need not be included**, partly because their shapes are almost impossible to predict, and partly because the **dappled shade of a tree is more pleasant than the deep shadow of a building** (this applies especially to deciduous trees). Nevertheless, choose locations for tree planting with care. The aim should normally be to have some areas of partial shade under trees while leaving other parts of the*

[2] https://heatisland.lbl.gov/resources/definitions-and-terms#:~:text=Solar%20Reflectance,reflectance%20at%20each%20different%20wavelength.

garden or amenity area in full sun. Where a dense belt or group of evergreens is specifically planned as a windbreak or for privacy purposes, it is better to include their shadow in the calculation of shaded area (Figure 31). The growth of trees and their likely final size should be allowed for. Appendix G gives more details about shade from trees and hedges.

5.1.2. The guidance on using specialist software sets the following guidance:

1 – The date of simulation should be 21 March (equinox).

2 – The test criteria should look to establish areas of ground with 2 or more hours of direct sunlight.

3 – The analysis grid spacing should be 0.3m or less.

5.1.3. Special attention should be given to the statement that 'normally trees and hedges should not be included' as they provide a pleasing shade compared to opaque objects.

5.2. A package of specialist software was used to run the analysis. The model as previously described was prepared in Rhino. The analysis setup used Grasshopper, Ladybug[3], Daysim[4] and Therm[5]

5.2.1. Grasshopper is a visual programming software that hosts the 'plug-in' software and allows them to interact with the modelled elements.

5.2.2. Ladybug is a program from a range of programs dedicated to environmental, thermal, renewable and city heating analysis.

5.2.3. DAYSIM is a validated daylighting analysis software that calculates the annual daylight availability in arbitrary buildings based on the RADIANCE backward raytracer. It uses the Light switch occupant behaviour model to mimic occupant use of personal controls such as light switches and venetian blinds and to predict energy savings from automated lighting controls such as occupancy sensors and photocell controlled diming systems.

5.2.4. THERM is a state-of-the-art computer program developed at Lawrence Berkeley National Laboratory (LBNL) for use by building component manufacturers, engineers, educators, students, architects, and others interested in heat transfer.

5.3. Weather data has been sourced from the nearest weather station to this site. In this case the location is RAF Waddington, Lincoln. Weather data is available from the EPW Map[6].

5.4. The gardens of the existing and proposed dwellings have been separated for the purpose of individual calculations, as per the guidance of the BRE209.

5.5. The analysis will take place on 21 March between the hours of 7am and 5pm.

5.6. The computer model location was adjusted to create a site-specific location its Latitude and Longitude; 53.181665N and -0.62023669E with an elevation of 12m, taken from the Topographical Survey.

[3] https://www.ladybug.tools/ladybug.html
[4] https://daysim.software.informer.com/4.0/
[5] https://windows.lbl.gov/therm-software-downloads
[6] https://www.ladybug.tools/epwmap/

Test Results

6.1. The plots were set up for simulation using all current trees modelled following the data from the tree survey, and the indicative building types.

6.2. Plot 1:

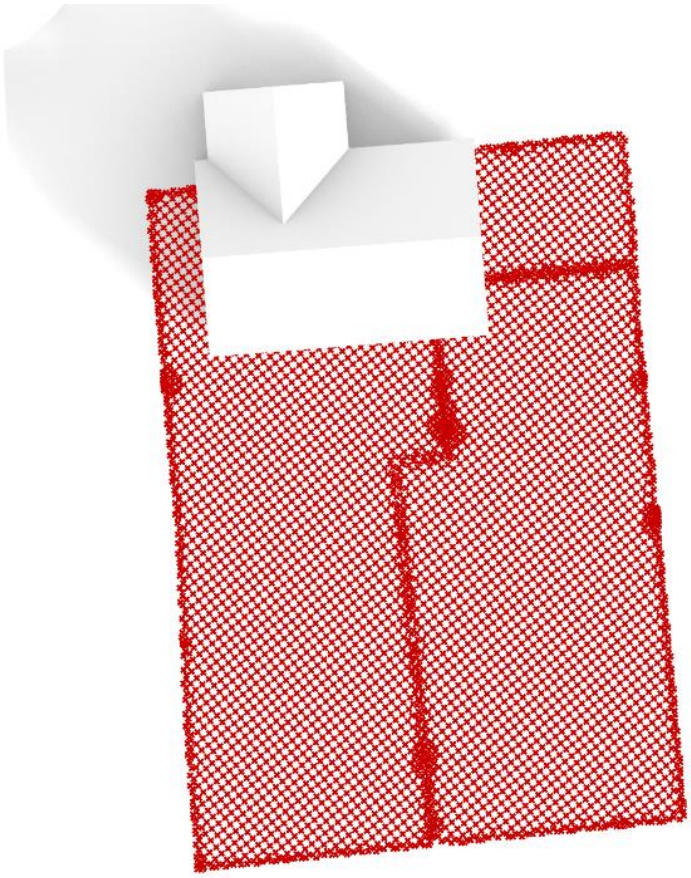

Figure 10 - Plot 1 Analysis Points

6.2.1. Plot 1 has a southern rear garden with two trees on the eastern boundary. The property being North of the site does not cause shade to the rear garden.

6.2.2. The grid size of 300mm (0.3m) produced a matrix of sample points. 6102 points were generated and assessed in the 10 hour time period.

6.2.3. 5124 points (84.03%) received 2 or more hours of direct sunlight during the day.

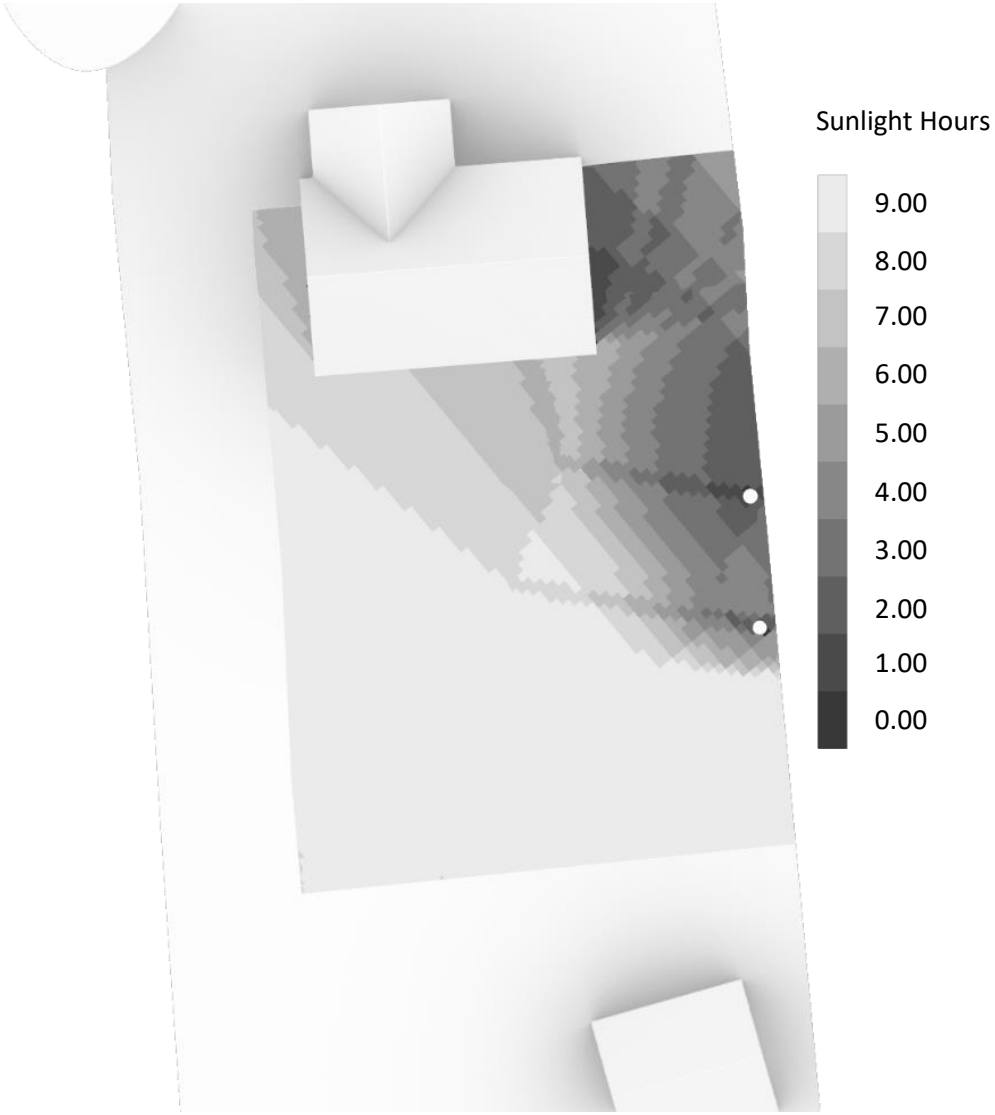

Figure 11 - Plot 1 Results Mesh

6.3. Plot 2:

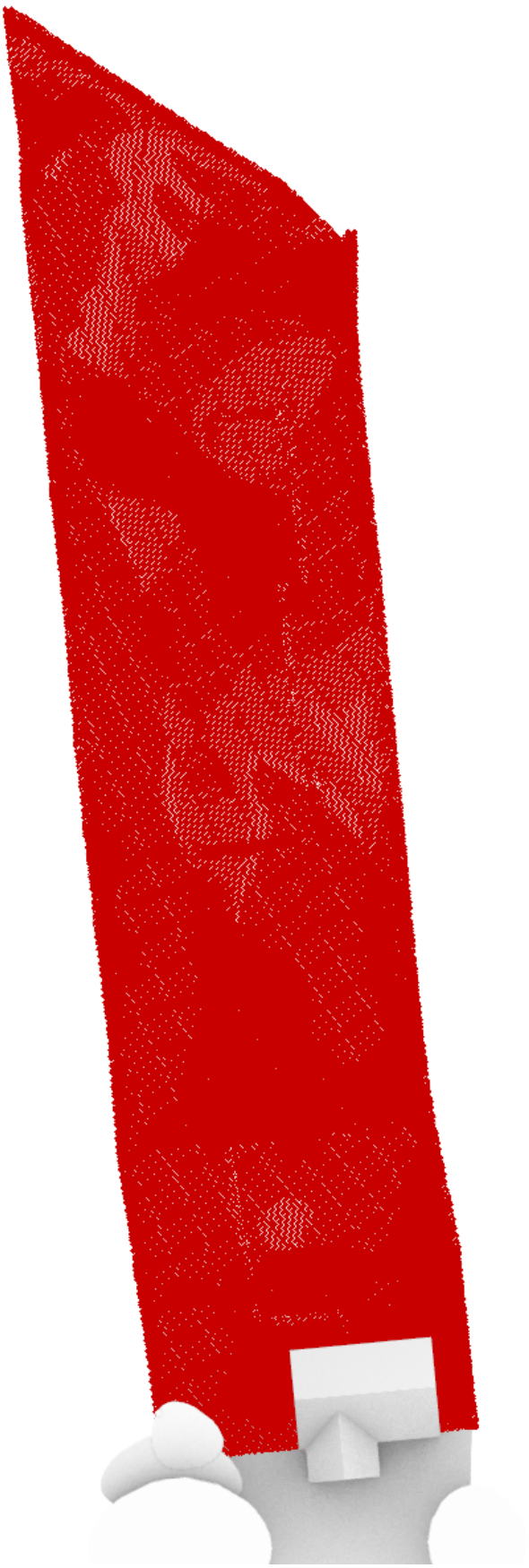

Figure 12 - Plot 2 Analysis Points

6.3.1. Plot 2 has a long Northern garden with a number of trees surrounding the boundaries. This number has been significantly reduced since the previous report.

6.3.2. The grid size of 300mm (0.3m) produced a matrix of sample points. 26939 points were generated and assessed in the 10 hour time period.

6.3.3. 24974 points (92.71%) received 2 or more hours of direct sunlight during the day.

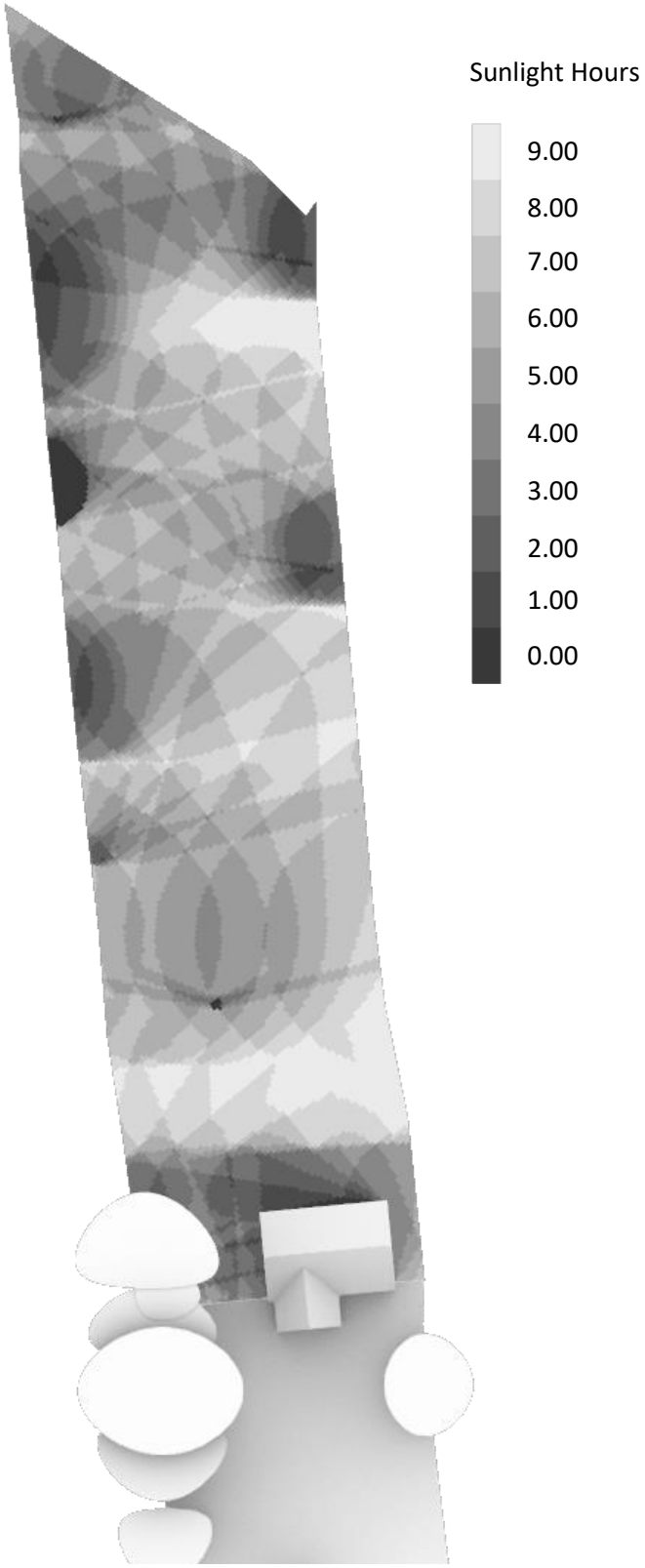

Figure 13 - Plot 2 Results Mesh

6.4. Plot 2 (Shorter Garden):

6.4.1. This analysis shows the direct sunlight received in a garden shorter than the 'remaining amount of land' and demonstrates this configuration also exceeds the BRE209 guidance.

6.4.2. The grid size of 300mm (0.3m) produced a matrix of sample points. 13233 points were generated and assessed in the 10 hour time period.

6.4.3. 12086 (91.3%) points received at least 2 hours of direct sunlight.

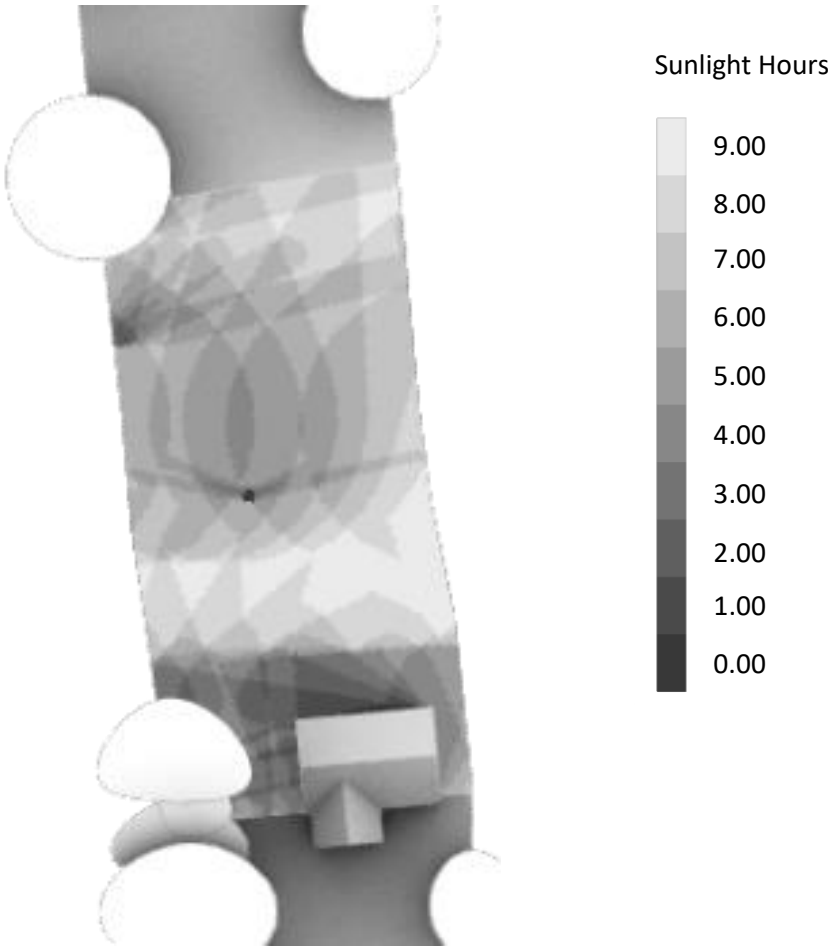

Figure 14 - Plot 2 Shorter Garden Results Mesh

6.5. The results mesh's visually show every test point total of direct sunlight over a 10-hour period on 21 March. These mesh appear complicated as they layer consecutive results over the time period, this can be seen where the shadow shapes revolve around the site.

6.5.1. The results are generated on a yes/no query. The simulation takes every point and for each hour (10) assesses them; does it have direct sunlight? If the answer is yes the point for that hour scores '1' and if not scores '0' after completing all 10 hours, the sum of the 1's and 0's are used to give the final number of direct sun hours.

6.6. The criteria of BRE209 has been achieved an exceeded.

6.7. There is no chance of perpetual shade or prolonged periods of shade.

6.8. The majority of trees are on neighbouring land and not at threat of potential residents of the proposed development.

6.9. BRE209 states that trees normally do not need modelling and the test normally focuses on permanent, opaque elements, such as buildings. The building location, form and orientation does not cause more than 50% of the garden area to not receive at least 2 hours of direct sunlight.

Further Simulation

7.1. The results show a layered series of results creating a technical and complex mesh.

7.2. We have also prepared shading results for specific instances in time, 9am, 12pm and 3pm on the Equinox (21 March and September) and Summer Solstice (21 June). These images show that the shade to the plots are not perpetual but provide pockets of light and shade, both desirable in domestic gardens.

7.2.1.

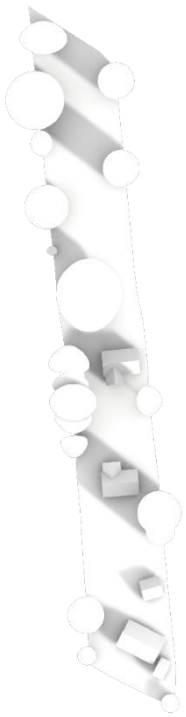

Figure 15 - 9am 21 March

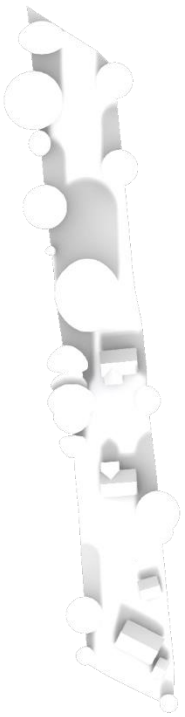

Figure 16 - 12pm 21 March

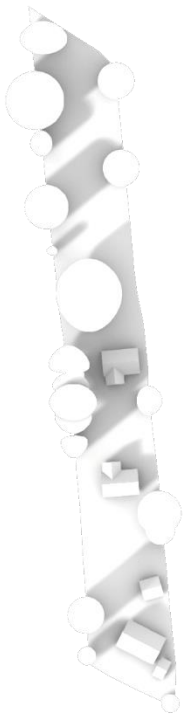

Figure 15 - 3pm 21 March

7.2.2.

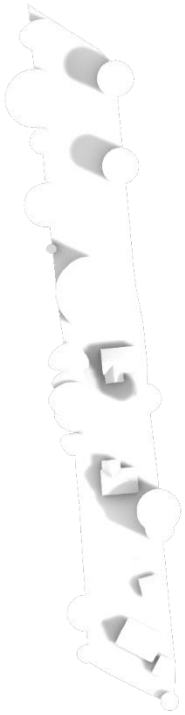

Figure 17 - 9am 21 June

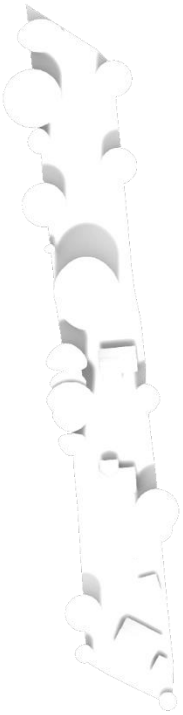

Figure 18 - 12pm 21 June

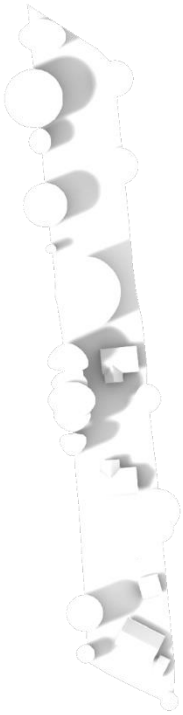

Figure 19 - 3pm 21 June

7.2.3.

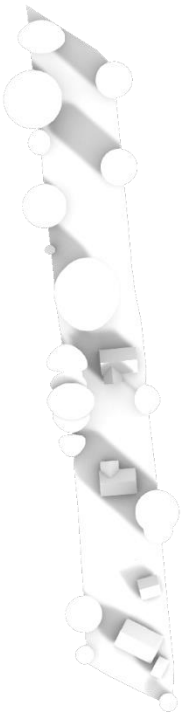

Figure 19 - 9am 21 September

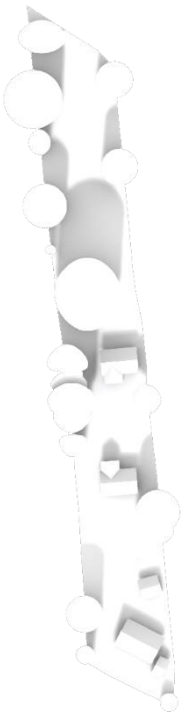

Figure 20 – 12pm 21 September

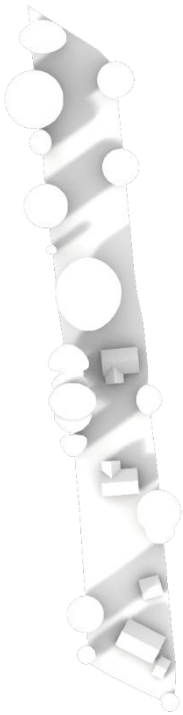

Figure 21 - 3pm 21 September

Conclusion

8.1. This report has analysed the proposed scheme against the BRE 209 guidance for sunlight hours in residential gardens in response to LPA concerns over the sunlight each plot could receive.

8.2. Each plot garden is required to achieve more than 50% of the area experiencing 2 or more hours of sunlight on 21 March.

8.3. Using specialist simulation software, the proposed gardens were converted into analysis grids with 0.3m spacing resulting in thousands of test points. Each point was tested for direct sunlight received over a 10-hour daylight period on 21 March, in accordance with the BRE209 guidance.

8.4. Both plots demonstrated that over 50% of the garden area received 2 or more hours of direct sunlight.

8.4.1. Both plots far exceeded the guidance demonstrating the suitability of the proposal.