S333 Architecture + Urbanism

The Old Dairy, Wakefield Street

Document 6
Sunlight and daylight availability

Rev. 0

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Sunlight and daylight availability

Specialist report

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Contents

1 Executive summary

A sunlight and daylight availability study has been carried out for The Old Dairy, Wakefield Street, mixed use development in London.

The effect of the development on the surrounding buildings and the effect of the development on itself has been assessed using recommendations set in BRE 209 [Ref. 1] and BS 8206-2 [Ref. 2]

The conclusion of the study is that:

Effect of the development on the surrounding buildings

- All calculation points considered meet the proposed target value for vertical sky component.
- All calculation points considered meet the proposed target value for annual probable sunlight hours.
- All calculation points considered, but two, meet the proposed target value for winter probable sunlight hours.
- The two points that do not meet the winter probable sunlight target have already a very low performance in the baseline model and the absolute difference will be negligible. Furthermore the overall annual sunlight availability will not be compromised.
- Sunlight availability in open spaces is well above the target.
- The proposed development has negligible effects on daylight and sunlight availability for the surrounding buildings.
- No mitigation measures are necessary in regard to the effect of the development on the existing buildings.

Effect of the development on itself

- Most of the rooms analysed are well above the target value during winter and during summer time (the effect of the trees located on the southern edge of the site is modelled for both scenarios).
- Only three rooms show an average daylight factor below the required target value.
- Two of these rooms, located at basement level, have a particularly low level of daylight and it is suggested that these are considered not habitable spaces.
- The third room, located at first floor, is a combined kitchen/ living room space which, although below the target value for kitchens, meets the target value for living rooms. Nevertheless, it is considered that the proposed configuration would achieve a reasonable level of daylight/ sunlight.

2 Introduction

Arup Lighting has been commissioned by S333 Architects to carry out a sunlight and daylight availability study for The Old Dairy, Wakefield Street, mixed use development, in London.

The aim of this study is to assess the effect of this proposed development on the surrounding properties and on itself.

The report illustrates standard and guidelines used and the methodology of the assessment.

Results are presented in section 5 and discussed with a commentary in Section 6.

Section 7 summarises findings and Section 8 concludes the report with recommendations.

3 Standards and Targets

3.1 General

The design criteria used to assess the effect of the proposed development on the existing properties are based on the recommendations set out in BRE document 209 [Ref. 1]. This document is the de facto standard for planning and daylight and sunlight availability. BRE 209 provides guidelines, set targets and describes the methodology to assess the daylight and sunlight availability for buildings.

The document states "*The guide is intended for building designers and their clients, consultants and planning officials. The advice given here is not mandatory and this document should not be seen as an instrument of planning policy. Its aim is to help rather than constrain the designer. Although it gives numerical guidelines, these should be interpreted flexibly because natural lighting is only one of the many factors in site layout design*"

The document also indicates where the guidelines and target set are applicable: "*The reference point [calculation point] is in the external plane of the window wall. Windows to bathrooms, toilets, store rooms, circulation areas and garages need not be analysed.*"

The effect of the development on itself has been estimated by using the criteria contained in the BS 8206-2 [Ref. 2]. BS 8206-2 provides target values for average daylight factor. Daylight factor is the "*measure of general illumination from skylight. It is considered good practice to ensure that rooms in dwellings and in most other buildings have a predominantly daylit appearance*". Furthermore BS 8206-2 explains that daylight is one of the key elements that need to be accounted to create a good design, however it is not the only one. Therefore the designer is invited to express "*careful judgement [...] when using the criteria given in the standard*".

3.2 Effect of the proposed development on the existing buildings

3.2.1 Vertical Sky Component

Vertical sky component [VSC] is the measure of the amount of daylight that is incident on a window, and is expressed as a percentage of the horizontal illuminance at the same point under an unobstructed sky.

BRE 209 [Ref. 1] states that for existing properties a 27% vertical skylight component or a figure that is 80% of the base line condition is acceptable.

BRE 209 [Ref. 1] explains that 80% of the base line condition is not a noticeable reduction and therefore it is an acceptable level of reduction.

3.2.2 Total annual probable Sunlight Hours

The total annual probable sunlight hours are calculated for any window that has an orientation within 90° of due south. Thus other orientations are not analysed. In the case of this report only one window has been excluded due to orientation. All other have been analysed.

Due to the solar altitude in summer the balconies have less of an effect on sunlight than they do on daylight [VSC]. However, due to the sun's movement in the sky, the orientation of the test window will have a greater or lesser effect on results. For example a west facing façade will not receive the benefit of morning sunlight and similarly for east facing facades they will not receive the benefit of afternoon sunlight.

3.2.3 Sunlight availability in open spaces

BRE 209 proposes that:

"no more than two-fifths and preferably no more than a quarter of any garden or amenity area should be prevented by buildings from receiving any sun at all on 21 March. If, as a result of new development, an existing garden or amenity area does not meet these guidelines, and the area which can receive some sun on 21 March is less than 0.8 times its former value, then the loss of sunlight is likely to be noticeable."

The amenity areas referred to in the above include:

- gardens, usually the main back garden of a house, and allotments;
- parks and playing fields;
- children's playgrounds;
- outdoor swimming pools and paddling pools;
- sitting-out areas, such as those between non domestic buildings and in public squares; and
- focal points for views, such as a group of monuments or fountains

3.3 Effect of the proposed development on itself

3.3.1 Average daylight factor

Average Daylight Factor is the ratio of illuminance at a point on a given plane due to light received from a sky of known or assumed luminance distribution, to illuminance on a horizontal plane due to an unobstructed hemisphere of this sky.

For example, a daylight factor of 2%, under an overcast sky, with an unobstructed exterior illuminance of 10,000 lux, corresponds to an interior illuminance of 200 lux.

BS 8206-2 states that *"The average daylight factor is used as the measure of general illumination from skylight. It is considered good practice to ensure that rooms in dwellings and in most other buildings have a predominantly daylit appearance. In order to achieve this, the average daylight factor should be at least 2%".*

The minimum value for average daylight factor is tabulated and applies to three designations of use: kitchens, living rooms and bedrooms. If designations of use are combined the most stringent requirement should prevail.

3.4 Summary of proposed target values

The tables below summarise the numerical target values used in the assessment.

Effect of the development on the surrounding buildings	
Parameter	**Design target values**
Vertical skylight component [VSC]	>27% (or 80% of existing)
Sunlight availability	>25% (or 80% of existing)
Winter Sunlight Availability	>5% (or 80% of existing)
Percentage of permanent shadow	< 25% (or 80% of existing)

Table T1 summarises daylight availability requirements for dwellings (effect of the development on the existing buildings), as in BRE 209 [Ref. 1].

Effect of the development on itself	
Designation of use	**Minimum average daylight factor [%]**
To provide daylit appearance	>2%
Kitchen	>2%
Living room	>1.5%
Bedroom	>1%

Table T2 summarises daylight factor requirements for dwellings (effect of the development on itself), as in BS 8206-2:2008 [Ref. 2].

4 Assumptions and Methodology

4.1 Assumptions

A 3D model corresponding to the proposed development set with the context of surrounding streets and properties was provided by the architect.

The longitude and latitude of the site were set to:

- latitude 51.5°N
- longitude 1.2°W

The following assumptions were made on the material palette and used in the simulation:

Material	Reflectance	Transmission
Glass	-	70%
Internal surfaces	50%	-
Ground surface and exterior surfaces	30%	-

Table T3 Assumptions used for the materials in the 3d model used for daylight factor calculations.

The frame of the windows has been included in the 3D model and it has been assumed a maintenance factor for all glazed area of M = 0.92.

To approximate effect of the trees on daylight, a continuous surface has been located along the southern boundary of the site. This surface has been characterised with a light transmission of 70% for winter (bare branches) and 20% for summer (full canopy) time.

4.2 Methodology

4.2.1 General

Specialised software developed and tested by Arup Lighting was used to calculate the lighting performances of the proposed design configuration. The software is a development of Radiance, a ray-tracing analysis program which is well-used and well-regarded in the lighting industry.

A series of points were analysed; these points were positioned based on the location of windows on the surrounding existing buildings in accordance with the guidelines within BRE document 209 [Ref. 1]. Calculations were made for the proposed development set within surrounding buildings and for the existing condition. Only points within 90° of due South were analysed for probable sunlight hours. All points were tested for vertical skylight component.

The methodology used consists in tracing a number of rays from the locations set (the windows of the existing buildings) and checking that these rays are not blocked by the proposed development. The number of rays that can effectively reach the sky is the percentage of sunlight or skylight available to the existing location. Note that the rays used for winter sunlight, annual sunlight and skylight are not the same. A different set of rays are used for each different calculation type.

Sunlight availability in open spaces was assessed using the same ray tracing technique, but using the sunlight rays for the 21st of March, to ascertain the area in permanent shadow

(the calculations were carried out at 5 minute intervals and only for sun altitude angles of 10 degrees of higher).

Average daylight factor was assessed using directly the Radiance ray tracing system software with the same 3d model used for the vertical skylight component. The calculations account for the effect of trees during the winter and summer seasons. It may be argued that it is the winter season when skylight is more important.

Assumptions were made on the material properties, transmittance and reflectance of surfaces (see table T3). Calculation grids were placed in every room (excluding toilets and circulation areas). Single values of daylight factor were estimated over each grid, at a 0.25mx 0.25m interval. Average daylight factor was calculated as the average of each grid.

5 Results – Effect of the development on the surrounding buildings

The following sections illustrate the effects of the development on the surrounding buildings for vertical skylight component, total annual and winter probable sunlight hours, sunlight availability in open spaces.

For vertical skylight component and probable sunlight hours, each location considered is represented on the model of the existing buildings by small circles of squares in various colours. The colours used allow reading the calculated value at each point. The images are intended to provide a quick overview of the site and to allow to spot values but are not the complete results of the analyses.

To read all the calculated values and check sunlight and daylight availability against the BRE 209 [Ref. 1] recommendations please refer to Section 5.5 where all the values for vertical sky component, annual and winter probable sunlight hours are shown in table T4 and T5.

Table T6 summarises findings for sunlight availability in open areas.

5.1 Calculation points location

The following images show the location of analysis points and the numbering used to locate them onto the existing buildings (locations are shown as yellow circles).

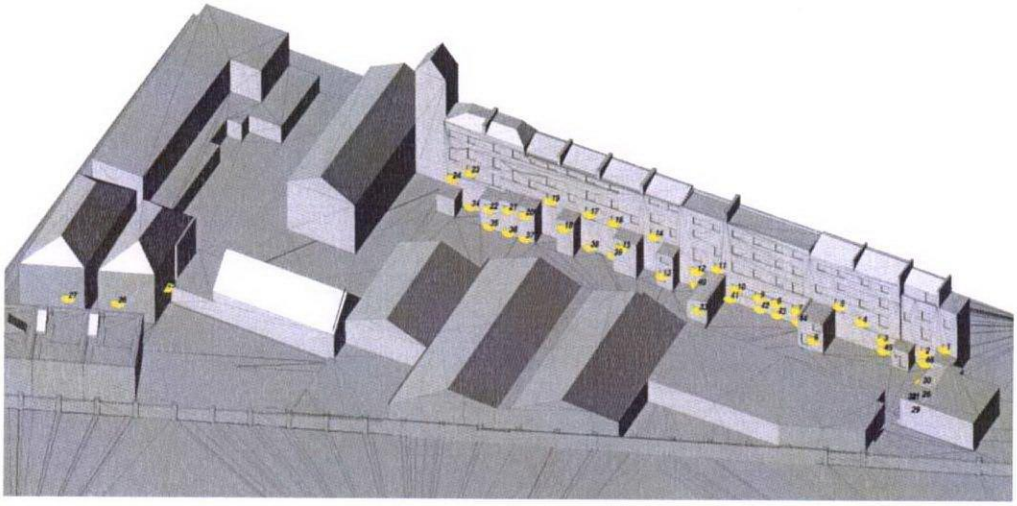

Figure 1 – Points location – Overview view

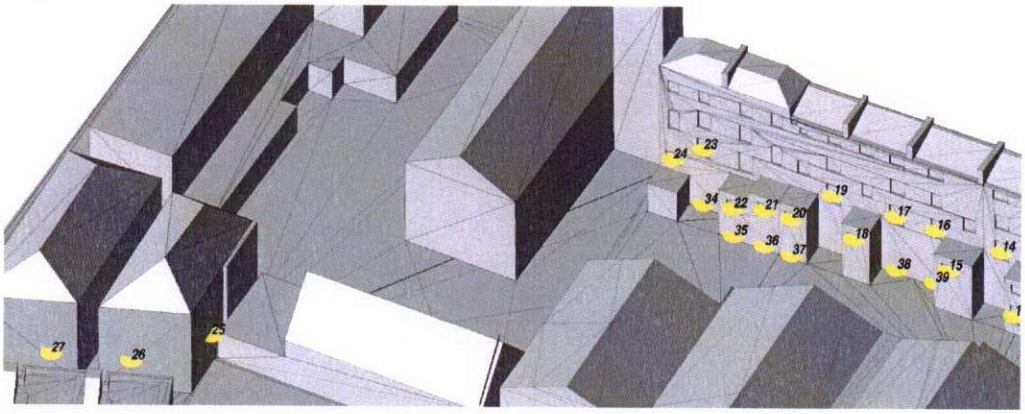

Figure 2 – Points location - Close-up view 1

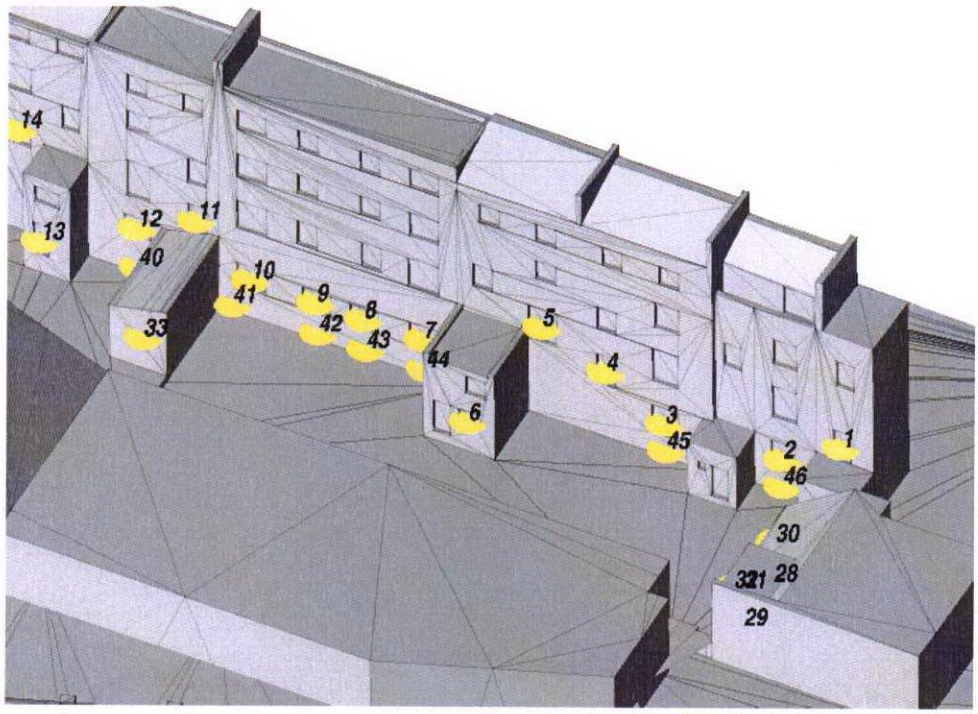

Figure 3 – Points location - Close-up view 2

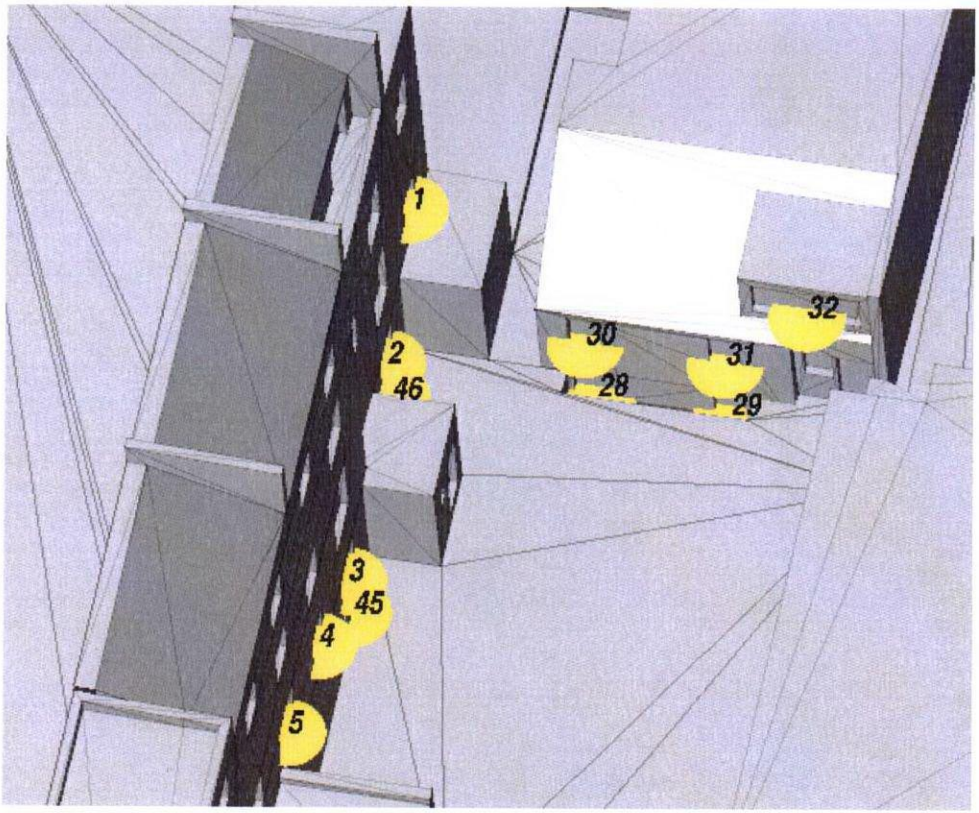

Figure 4 – Points location - Close-up view 3

5.2 Vertical Sky Component – base condition and proposed development

The following images show the distribution of Vertical Sky Component across the development. Numbers shown correspond to the value of vertical skylight component.

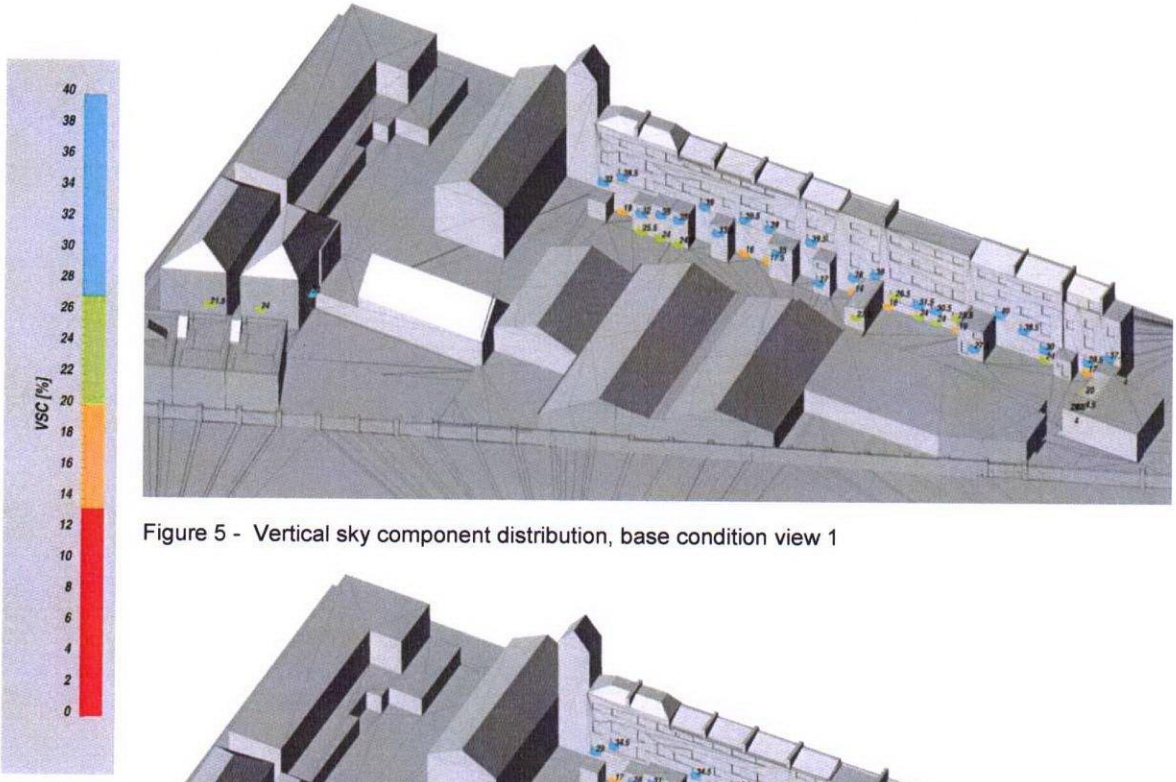

Figure 5 - Vertical sky component distribution, base condition view 1

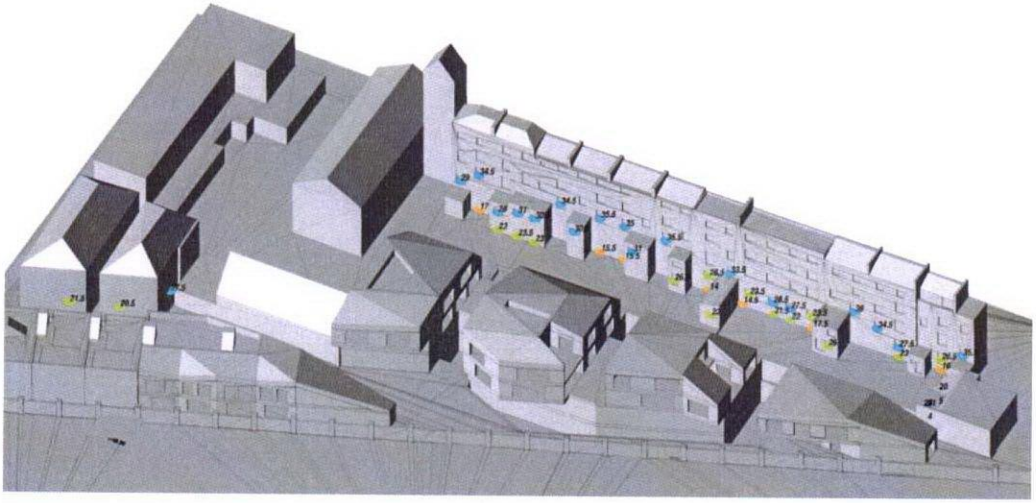

Figure 6 - Vertical sky component distribution, proposed development view 1

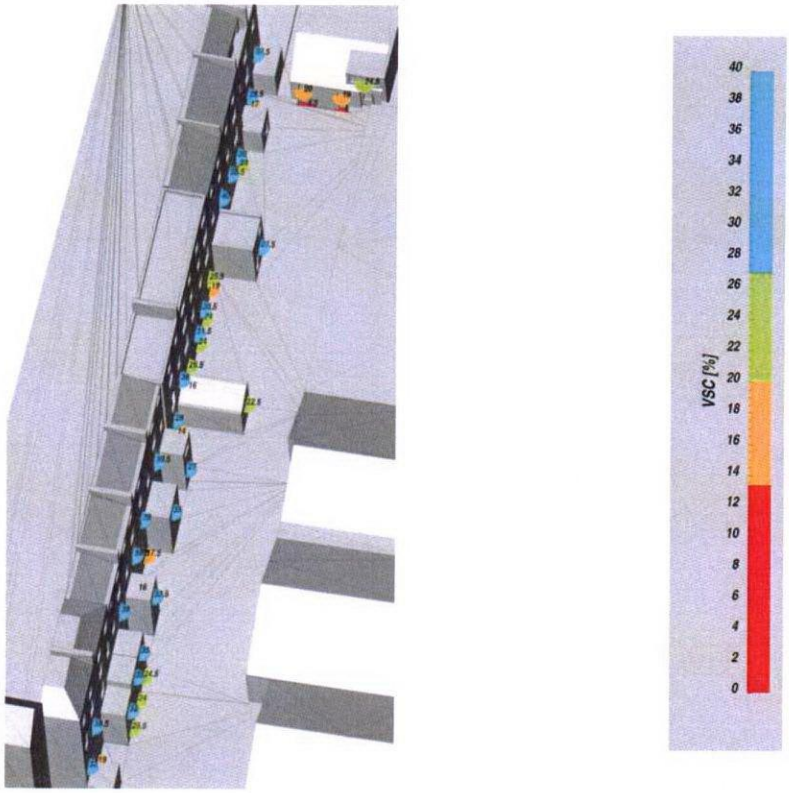

Figure 7 - Vertical sky component distribution, base condition view 2

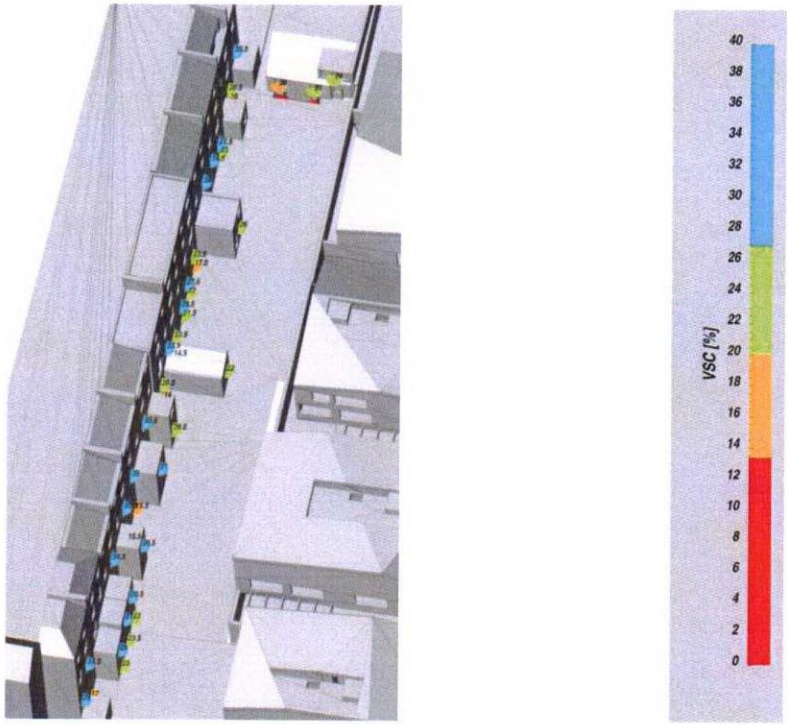

Figure 8 - Vertical sky component distribution, proposed development view 2

5.3 Probable annual sunlight hours – base condition and proposed development

The following images show the distribution of probable annual sunlight hours across the development. Numbers shown correspond to the value of probable annual sunlight hours.

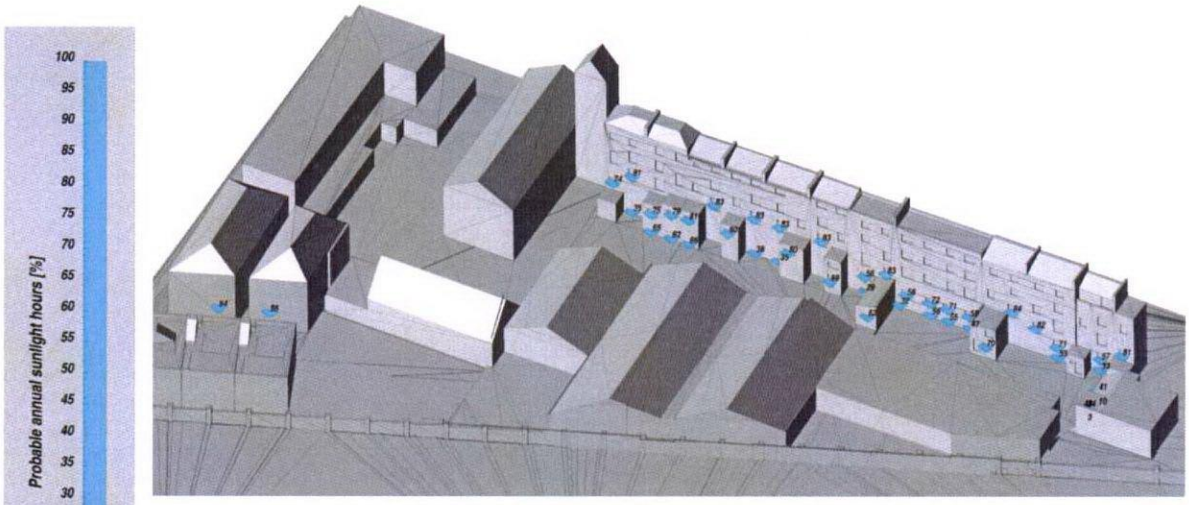

Figure 9 - Probable annual sunlight hours distribution, base condition view 1

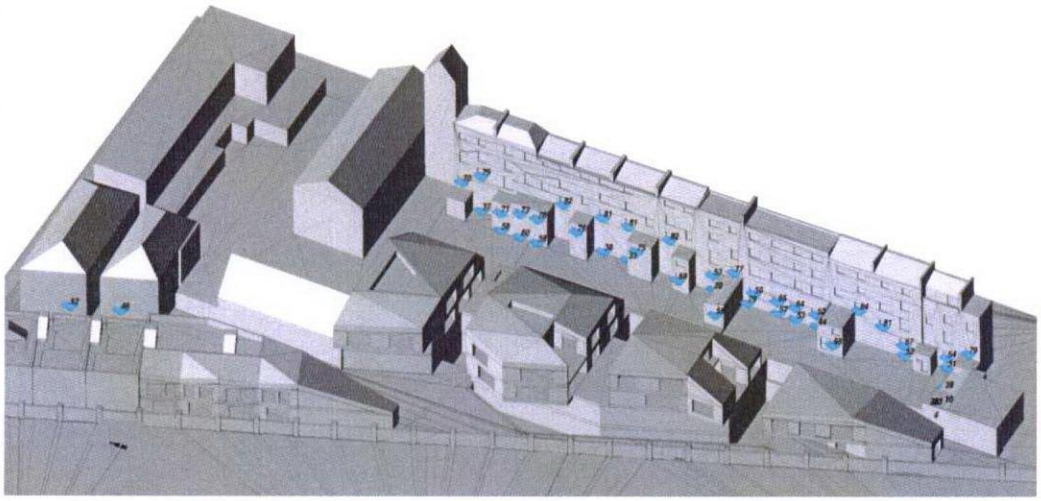

Figure 10 - Probable annual sunlight hours distribution, proposed development view 1

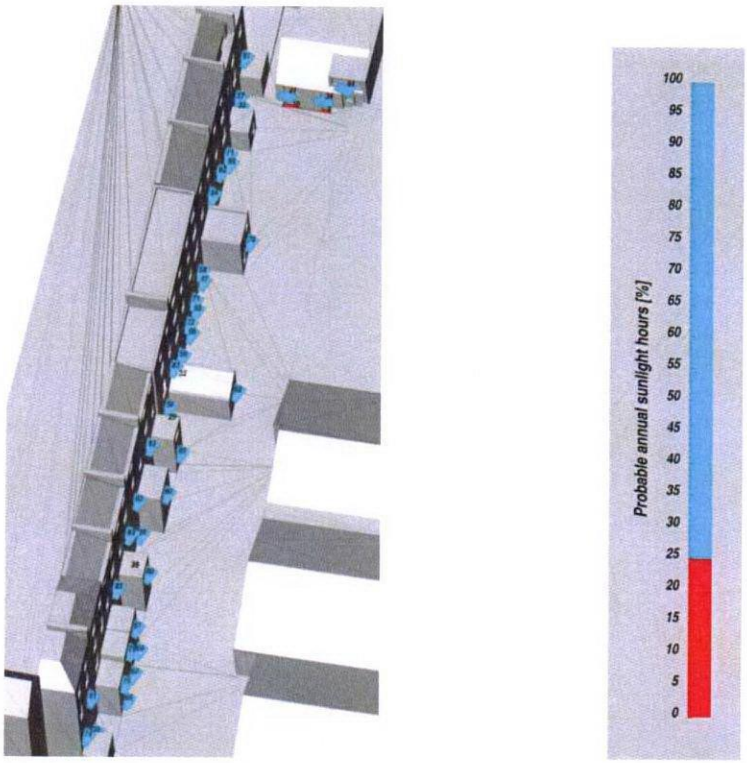

Figure 11 - Probable annual sunlight hours distribution, base condition view 2

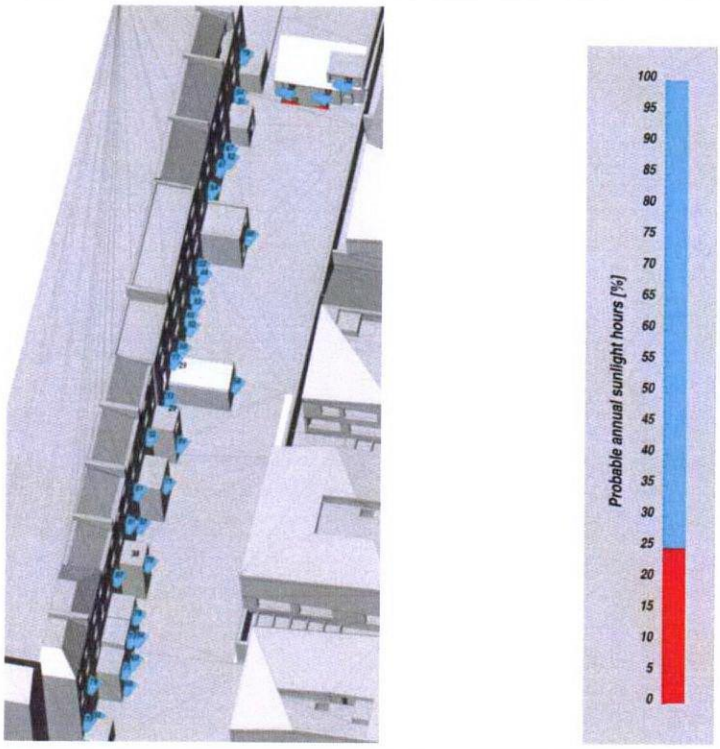

Figure 12 - Probable annual sunlight hours distribution, proposed development view 2

5.4 Probable winter sunlight hours – base condition and proposed development

The following images show the distribution of probable winter sunlight hours across the development. Numbers shown correspond to the value of probable winter sunlight hours.

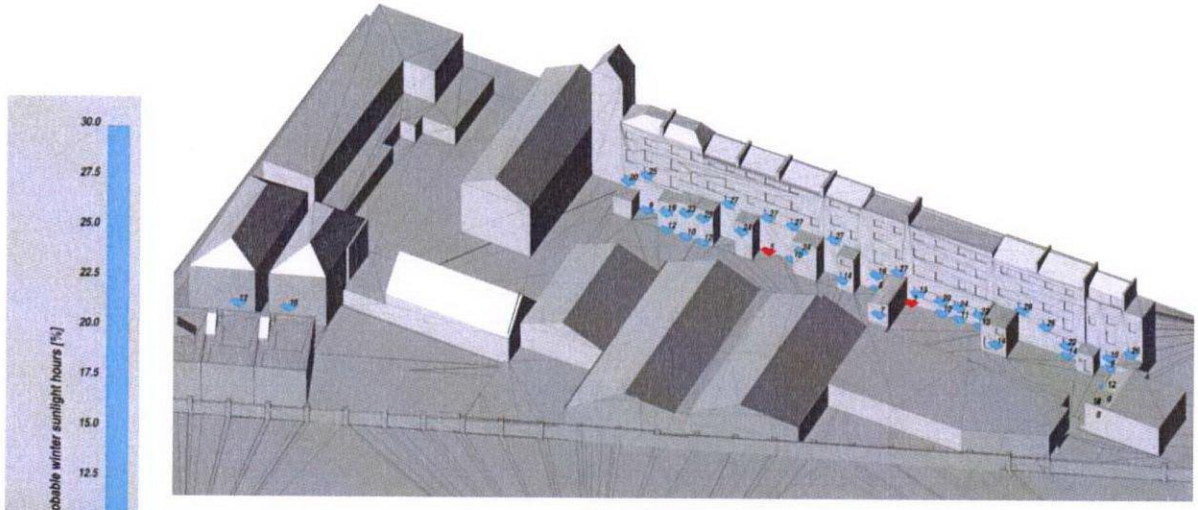

Figure 13 - Probable winter sunlight hours distribution, base condition view 1

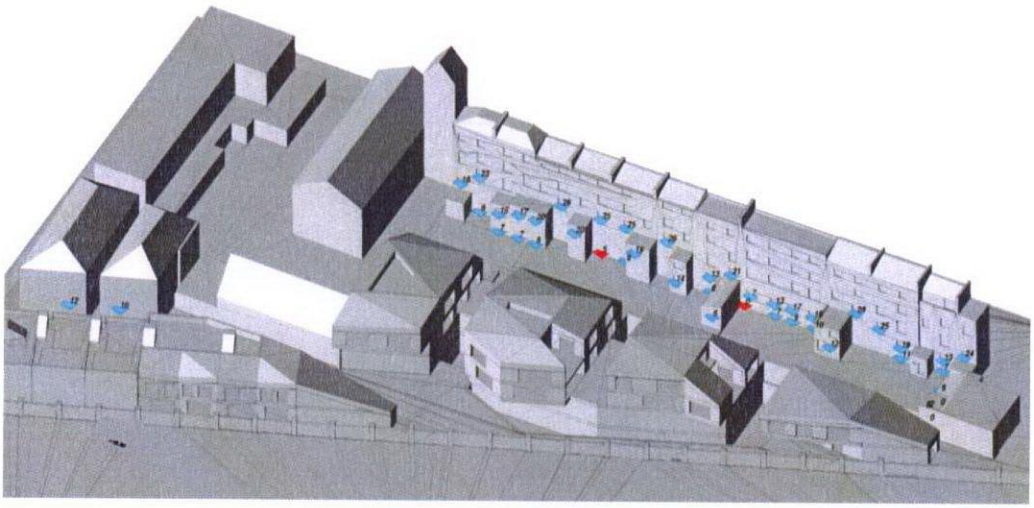

Figure 14 - Probable winter sunlight hours distribution, proposed development view 1

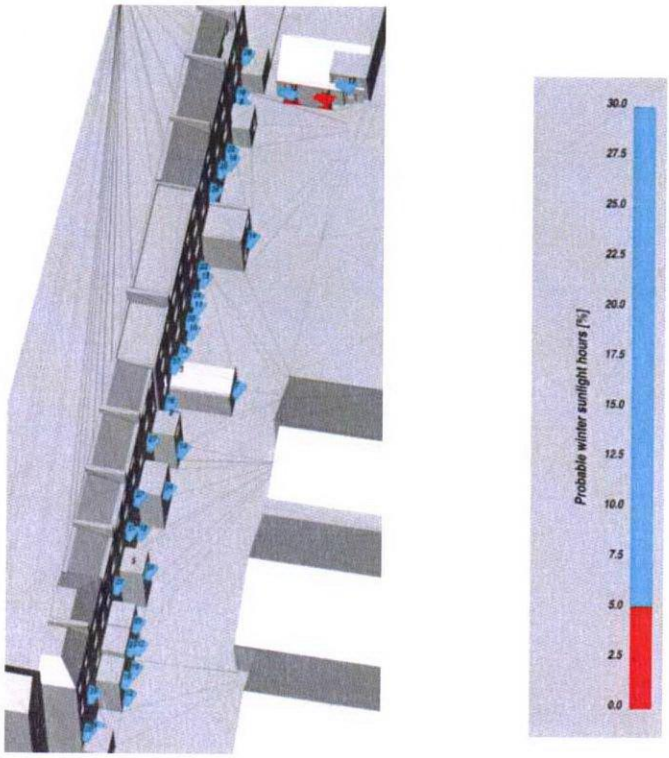

Figure 15 - Probable winter sunlight hours distribution, base condition view 2

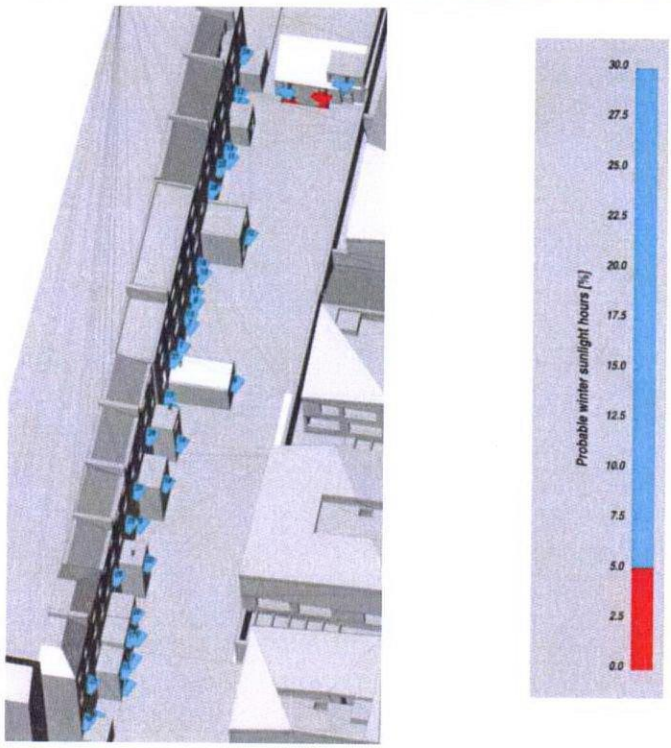

Figure 16 - Probable winter sunlight hours distribution, proposed development view 2

5.1 Summary tables

The following tables summarise the numerical values for vertical skylight component, sunlight probable annual and winter hours and compare the proposed with the baseline condition.

Point	*Vertical sky component*			*Annual probable sunlight hours*		*Winter probable sunlight hours*	
	Base line condition	*Proposed development >27*	*Ratio [proposed/ base%] >80%*	*Base line condition*	*Proposed development >25%*	*Base line condition*	*Proposed development >5%*
1	37.5	35.5		81	79	26	24
2	28.5	26.5	93%	57	54	16	13
3	30	27.5		71	67	22	18
4	38.5	34.5		82	81	26	25
5	40	38		84	84	28	28
6	27.5	26	95%	70	68	14	12
7	25.5	23.5	92%	58	52	22	16
8	30.5	27.5		71	64	24	17
9	31.5	28.5		72	65	20	13
10	26.5	23.5	89%	56	50	13	7
11	38	33.5		83	77	27	21
12	28	26.5	95%	56	53	16	13
13	27	26.5	98%	69	69	14	14
14	39.5	35.5		83	82	27	26
15	35	31		80	75	24	19
16	39	35		83	81	27	25

Table T4 – Effect of the proposed development on surrounding buildings.

Point	*Vertical sky component*			*Annual probable sunlight Hours*		*Winter probable sunlight hours*	
	Base line condition	*Proposed development >27%*	*Ratio [proposed/ base%] >80%*	*Base line condition*	*Proposed development >25%*	*Base line condition*	*Proposed development >5%*
17	39.5	35.5		83	81	27	25
18	33.5	30.5		80	76	24	20
19	39	34.5		83	82	27	26
20	35	30.5		81	76	25	20
21	35	31		79	73	23	17
22	32	28		75	71	19	15
23	38.5	34.5		81	79	25	23
24	32	29		74	70	20	16
25	32	27.5		-	-	-	-
26	24	20.5	85%	56	46	10	10
27	21.5	21.5	100%	54	52	12	12
28	4.5	5	111%	10	10	0	0
29	4	4	100%	3	4	0	0
30	20	20	100%	41	38	12	9
31	19	21	111%	34	33	4	2
32	24.5	24	98%	44	38	12	6

Table T5 – Effect of the proposed development on surrounding buildings.

Point	*Vertical sky component*			*Annual probable sunlight Hours*		*Winter probable sunlight hours*	
	Base line condition	*Proposed development >27%*	*Ratio [proposed/ base%] >80%*	*Base line condition*	*Proposed development >25%*	*Base line condition*	*Proposed development >5%*
33	22.5	22	98%	62	58	7	6
34	19	17	89%	35	32	9	6
35	25.5	23	90%	65	58	12	7
36	24	23.5	98%	62	60	10	7
37	24.5	23	94%	66	58	12	6
38	16	15.5	97%	38	38	5	5
39	17.5	15.5	89%	35	33	10	8
40	14	14	100%	29	29	8	8
41	16	14.5	91%	32	29	3	**0**
42	24	21.5	90%	56	52	10	7
43	24	22	92%	55	53	11	9
44	19	17.5	92%	47	44	13	10
45	24	23	96%	55	52	14	11
46	17	16	94%	33	31	9	7

Table T6 – Effect of the proposed development on surrounding buildings.

5.2 Sunlight availability in open spaces

The following images show the distribution of permanent shadow in the gardens of the surrounding properties with and without the proposed development in place.

The resulting data is summarized below, in table T6. The following diagrams show the sunlight availability distribution: the magenta colour is used to highlight the area of permanent shadow.

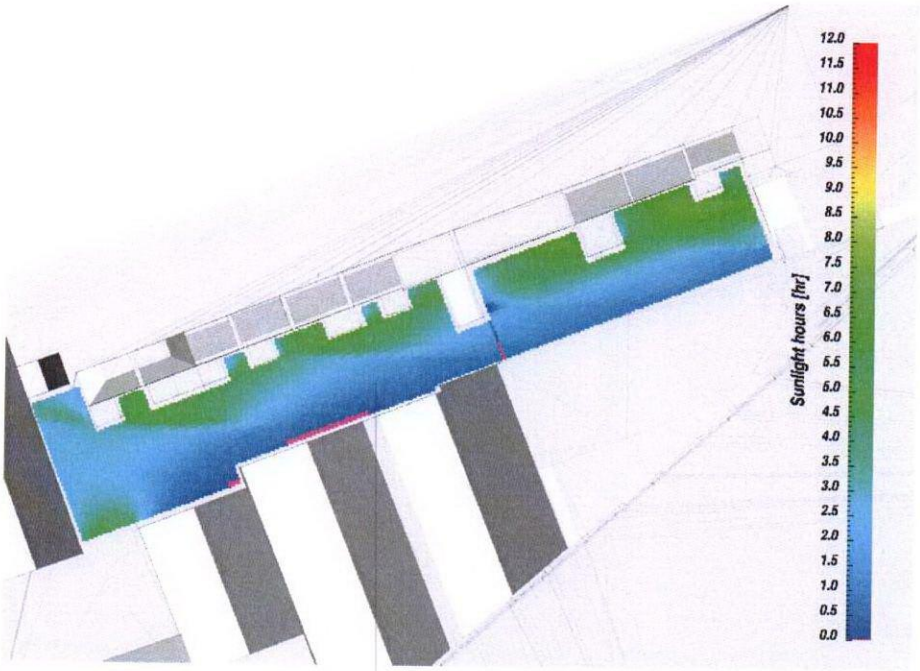

Figure 17 - Sunlight availability in open spaces, base condition

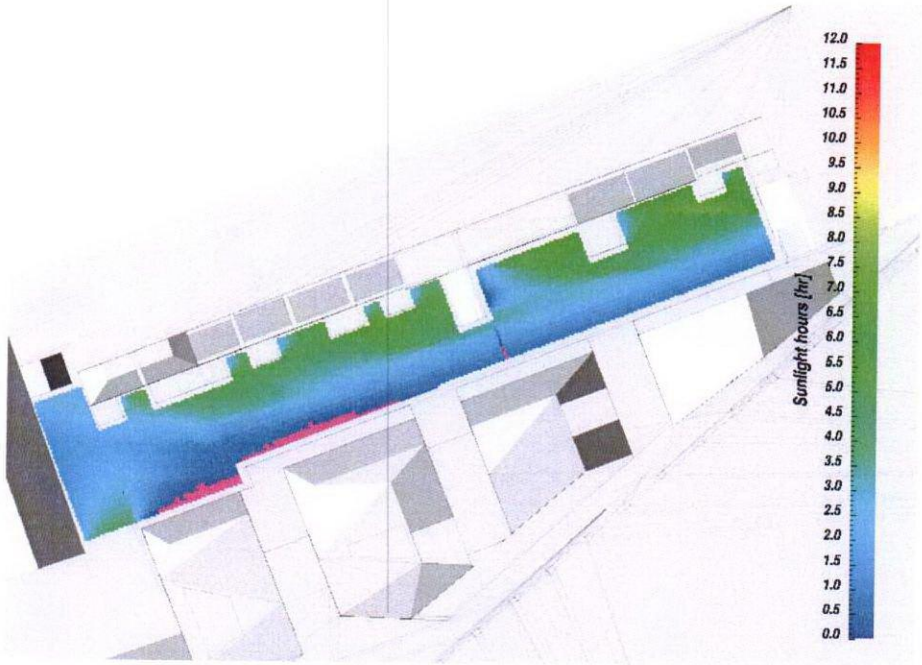

Figure 18 - Sunlight availability in open spaces, proposed development

Grid designation	*Base line*	*Proposed development* <25%
001	0.8%	3.1%

Table T7 – Sunlight availability in open spaces, percentage of area in permanent shadow.

6 Results: Effect of the development on itself

6.1 Daylight factor distribution and calculation grid designation

The following images show the location of calculation grids used in the assessment. A numerical code is used to identify each calculation grid. Average values of daylight factor on a given grid are listed in tables T8, T9 and T10.

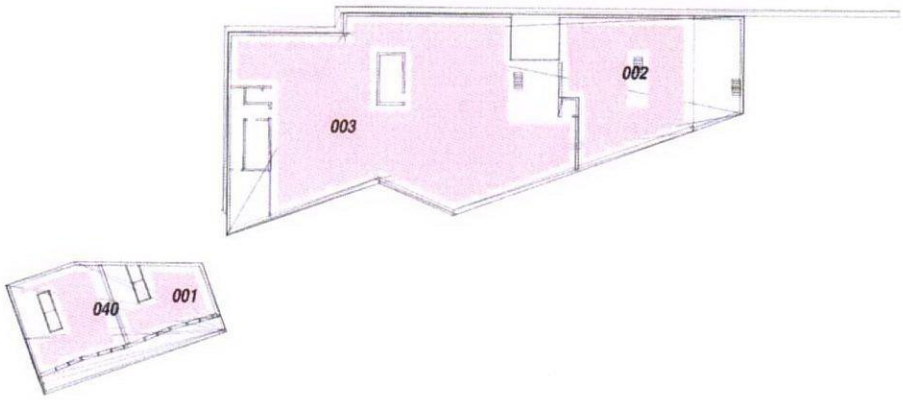

Figure 19 – Basement

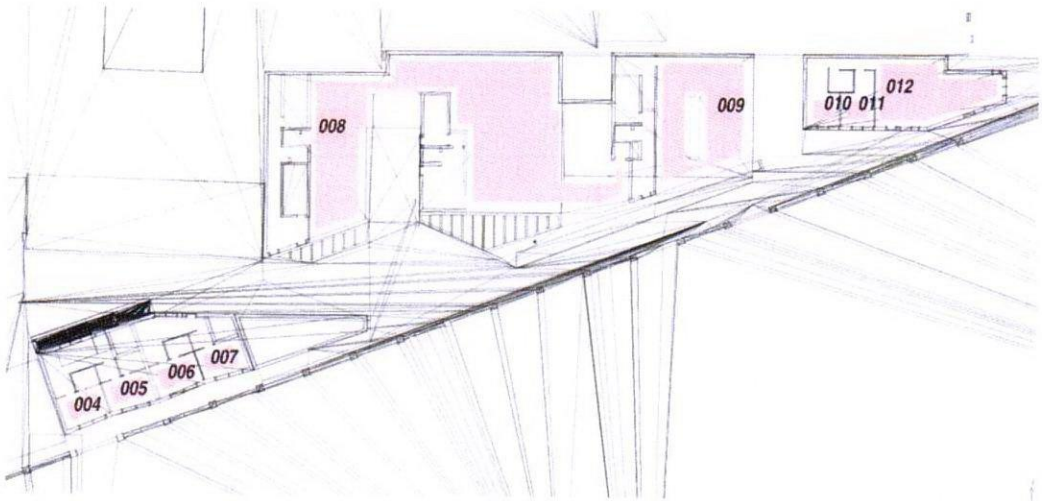

Figure 20 - Ground Floor

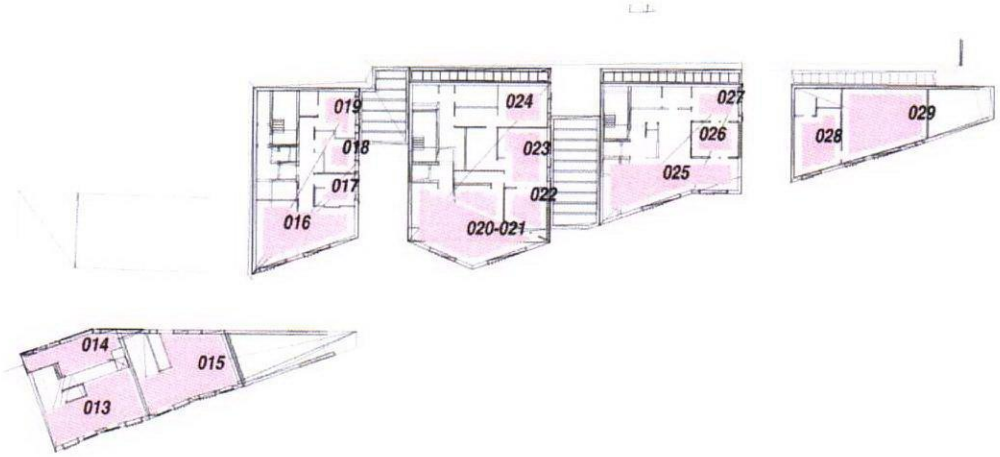

Figure 21 - First Floor

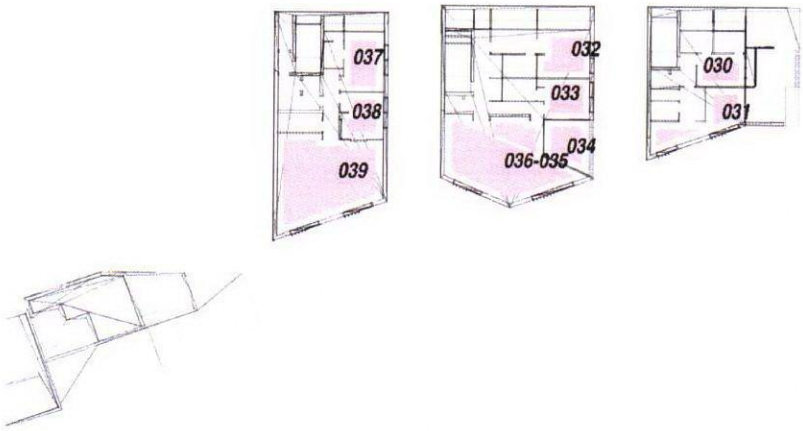

Figure 22 - Second Floor

Floor	*Block*	*Grid number*	*Room designation*	*Target Value*	*Average Daylight Factor Winter (Trees with bare branches)*	*Average Daylight Factor Summer (Trees with full canopy)*
Lower Ground	1	040	Studio space	1.5%	**0.2%**	**0.2%**
		001	Studio space	1.5%	**0.2%**	**0.2%**
	2-3-4	002	Commercial	2%[1]	1.4%	1.4%
		003	Commercial	2%[1]	1.7%	1.6%
Ground	1	004	Bedroom	1%	2.3%	1.7%
		005	Bedroom	1%	2.2%	1.6%
		006	Bedroom	1%	2.2%	1.6%
		007	Bedroom	1%	2.3%	1.7%
	2-3	008	Commercial	2%[1]	5.8%	5.6%
	4	009	Commercial	2%[1]	7.5%	7.1%
	5	010	Bedroom	1%	1.1%	1.0%
		011	Bedroom	1%	1.3%	1.1%
		012	Living Room / Kitchen	2%	2.4%	2.3%

Note 1: For rooms which do not have a specific requirement (commercial areas),if a daylit appearance is required, the reference value of 2% is proposed as a target.

Table T8 – Average daylight factor results.

Floor	*Block*	*Grid number*	*Room designation*	*Target Value*	*Average Daylight Factor Winter (Trees with bare branches)*	*Average Daylight Factor Summer (Trees with full canopy)*
First Floor	1	013	Living Room / Kitchen	2%	2.9%	2.6%
		014	Living Room	1.5%	4.2%	4.2%
		015	Living Room / Kitchen	2%	2.3%	2.1%
	2	016	Living Room / Kitchen	2%	**1.5%**	**1.5%**
		017	Bedroom	1%	1.6%	1.5%
		018	Bedroom	1%	1.2%	1.2%
		019	Bedroom	1%	1.9%	1.8%
	3	020-021	Living Room / Kitchen	2%	2.8%	2.6%
		022	Terrace[2]	2%[1]	31.2%	31.1%
		023	Bedroom	1%	1.7%	1.7%
		024	Bedroom	1%	1.6%	1.6%
	4	025	Living Room / Kitchen	2%	2.9%	2.7%
		026	Terrace[2]	2%[1]	34.5%	34.5%
		027	Bedroom	1%	4.5%	4.5%
	5	028	Bedroom	1%	1.2%	1.1%
		029	Living Room / Kitchen	2%	2.2%	2.0%

Note 1: For rooms which do not have a specific requirement (commercial areas),if a daylit appearance is required, the reference value of 2% is proposed.

Note 2: These areas are terraces and therefore the values are typical outdoor values of average daylight factor.

Table T9 – Average daylight factor results.

Floor	*Block*	*Grid number*	*Room designation*	*Target Value*	*Average Daylight Factor Winter (Trees with bare branches)*	*Average Daylight Factor Summer (Trees with full canopy)*
Second Floor	4	030	Bedroom	1%	3.0%	3.0%
		031	Bedroom	1%	3.4%	3.3%
	3	032	Bedroom	1%	2.0%	2.0%
		033	Bedroom	1%	2.9%	2.9%
		034	Terrace[2]	2%[1]	59.6%	59.6%
		035-036	Living Room / Kitchen	2%	2.4%	2.4%
	2	037	Bedroom	1%	2.0%	2.0%
		038	Bedroom	1%	2.1%	2.1%
		039	Living Room / Kitchen	2%	2.7%	2.7%

Note 1: For rooms which do not have a specific requirement (commercial areas),if a daylit appearance is required, the reference value of 2% is proposed.

Note 2: These areas are terraces and therefore the values are typical outdoor values of average daylight factor.

Table T10 – Average daylight factor results.

7 Comments on results

This commentary is intended to summarise the key aspects of the numerical results of the assessment. The commentary is organised in two main sections: effect on the surrounding buildings and effect of the proposed development on itself.

7.1 Effect of the development on the surrounding buildings

7.1.1 Vertical Sky Component

All of the calculation points considered exceed the required target value of 27% or 80% of the existing condition. This means that for all the locations considered, the effect on the amount of daylight of the proposed development is not significant.

7.1.2 Probable annual sunlight hours

All locations considered exceed the required target value of 25% probable annual sunlight hours or 80% of the existing condition.

7.1.3 Probable winter sunlight hours

All calculation points considered, but two (point 31 and point 41), exceed the required target value of 5% winter probable sunlight hours or 80% of the existing condition.

Point 31 and 41 can access a reduced amount of winter sunlight probable hours. Both points receive sunlight for a reduced amount of time during winter but overall, during the year, the sunlight availability is still above the target value. It is important to note that the base line condition for both points is below 5% of probable winter sunlight hours.

All other locations receive a provision of sunlight above the recommended minimum.

7.1.4 Sunlight penetration in open spaces

The sunlight availability in open spaces is above the target and the permanent shadow area is well below 25%.

7.2 Effect of the development on itself

7.2.1 Average daylight factor

Most of the rooms assessed meet and well exceed the daylight factor target values of BS 8206-2 [Ref. 2].

Of the commercial spaces, if a daylit appearance is required and 2% average daylight factor is taken as the target values, only two rooms are slightly below the proposed value. These two rooms, grids 002 and 003, are located at basement level. It may be argued that a predominately daylit appearance at basement level is very difficult to achieve. The proposed scheme has the merit of being very close to this target as both grids have average daylight factors around the 1.5% value. It is proposed that the current performance is considered satisfactory.

Of the remaining residential areas, only three rooms do not meet the minimum target values, of these:

- Two rooms are located in building block 1 (040 and 001), at basement level, and receive daylight from a narrow slot on the southern elevation and a skylight on the northern edge. The current configuration does not provide the minimum daylight requirement of 1.5% average daylight factor. Both rooms are proposed as studio spaces and will be not be used for habitable accommodation.
- One room is located in building block 2 (015), at the first floor. The average daylight factor is below the recommended minimum value for living room / kitchen (if living

room and kitchen are combined the target value for kitchen prevails) but it meets the minimum target for a living room. Nevertheless, it is considered that the proposed configuration would achieve a reasonable level of daylight.

8 Conclusions and recommendations

The proposed development has negligible effect on daylight and sunlight availability for the existing properties. In our view no mitigation measures are required.

The effect of the development on itself is generally within the proposed targets, in fact in most of the area analysed the daylight distribution is well above the minimum requirements.

Only three rooms are below the daylight factor target values, of these:

- Room 001 and 040, located at basement level, should not be considered habitable spaces as daylight levels are very low and electric lighting will be required all the time.
- Room 16, located at first floor of block 2, is a combined kitchen with living room. This room scores below the target value for kitchens but above the target value for living rooms. To meet the daylight target values for kitchens, the area of the glazed facade would need to be increased by 33%. This mitigation measure may not be practical (if for example requirements such as privacy are considered). It is proposed that the room 16 is kept as it is, accepting a slightly reduced performance.

The remaining rooms are all above the target values for daylight factor and do not require mitigation measures.

9 References

[Ref.1] BR 209 1998, "Site layout planning for daylight and sunlight: a guide to good practice".

[Ref.2] BS 8206 2008, Lighting for buildings – Part 2: Code of practice for daylighting