# 03

## Sun Light and Reflectivity Study

# 3.1 Principles of Reflectivity

These diagrams have been produced in order to illustrate the basic principles of reflectivity, that have informed this report.

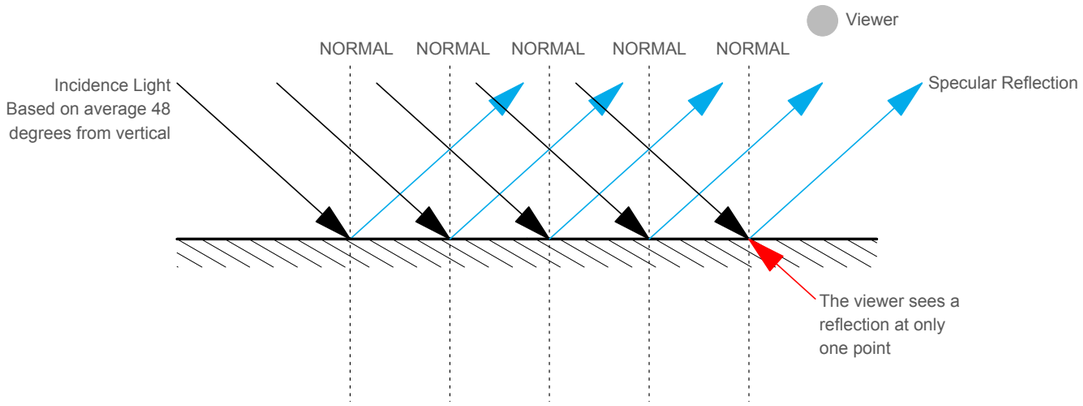



Diagram 01
Flat Mirror Like Surface in - Plan

The Angle of Incidence = The Angle of Reflection
A mirror like surface such as glass or a white gloss surface would result in a specular reflection, a directional light.

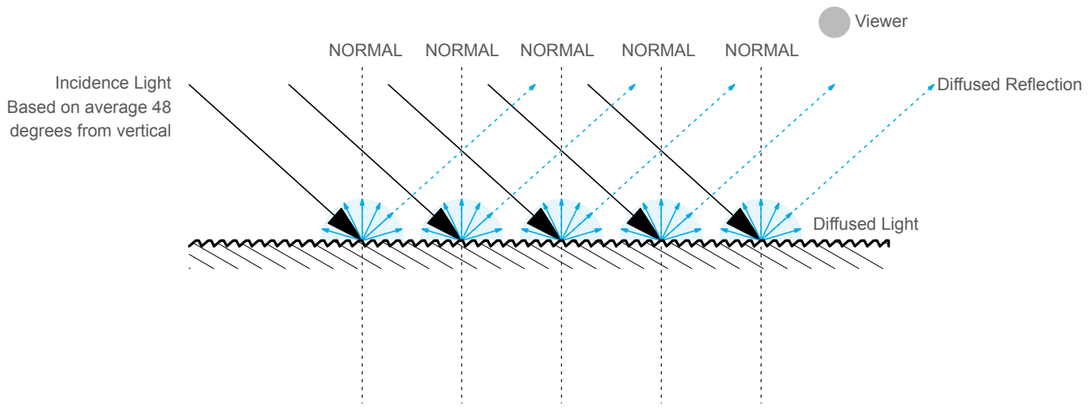



Diagram 02
Textured Bead Blasted Surface - Plan

Textured rough bead blasted surfaces result in diffused light.

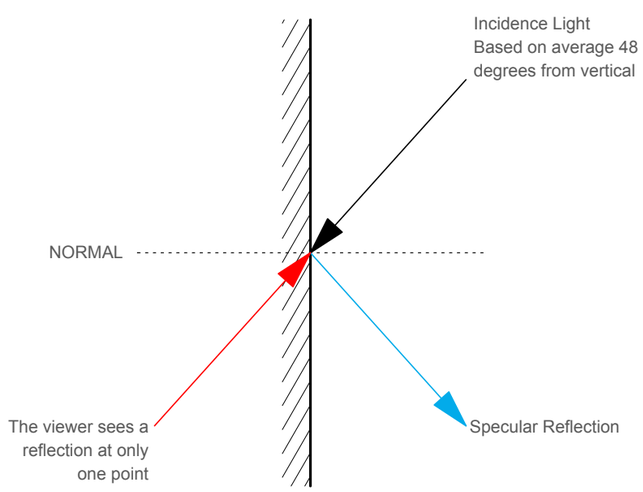



Diagram 03
Vertical Elevation

The Angle of Incidence = The Angle of Reflection

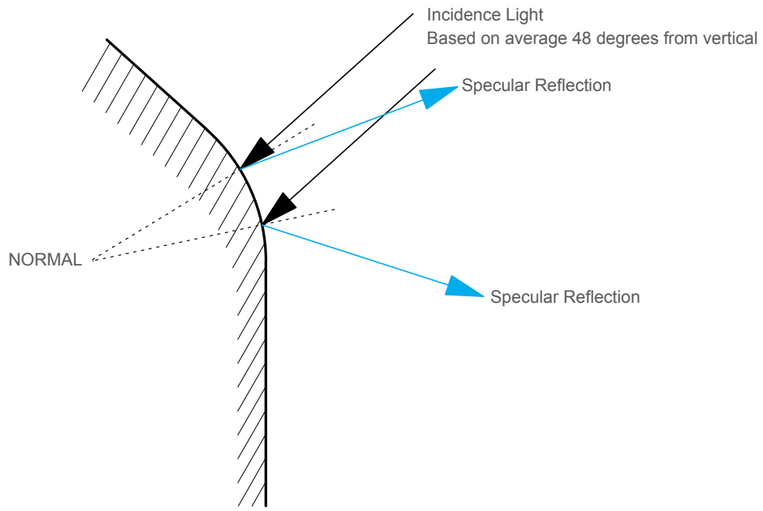



Diagram 04
Convex Curve Elevation

The Angle of Incidence = The Angle of Reflection
Diverging Reflection

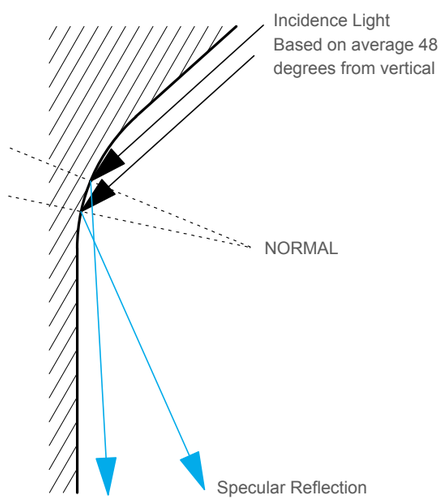



Diagram 05
Concave Curve Elevation

The Angle of Incidence = The Angle of Reflection
The light is focused into a hot spot, passing through a focal point, converging through this common point.

# Environmental Statements on Reflectivity and Heat 3.2

Due to stakeholder feedback, in relation to reflectivity, glare and heat generation concerns. Alison Brooks Architects have consulted with Max Fordham, the Mechanical and Electrical Engineers in order to technically verify the analysis presented within this report. Below are two statement that address the local stakeholder concerns.

1. Light, Reflectivity and Glare:

Reflectivity is a material property, dependent on the colour of the material. Whilst it is the colour that determines how much light is reflected, the reflection can be specular – mirror like – or diffuse, which is related to the surface roughness of the material and may affect the perception of how much light is reflected.

Glare is the human perception of light entering the centre of the visual plane. It is a visual sensation and is a result of the high relative intensity of a light source against the general view. Glare from the sun is generated by the concentration of sunlight or by strong specular reflections of the sun.

There are a small number of hours in the year when evening sunlight will hit the north facing Worcester Place elevation at an oblique angle. This is approximately 2 hours per day, over 6 months.

The Worcester Place facade is north facing, convex and made of a material that will diffuse and scatter this light. This is due to the texture applied to the material and the bead blasting finish. The scattering effect of the light across the convex roof shape will mean that any reflected sunlight will be diffused and should not generate glare.

2. Heat Generation:

The sun's heat is radiated via light waves. The roof surface has a coarse finish with a low reflectivity, resulting in a diffusion of light and little directional heat on the adjacent buildings. As a comparison, glass provides specular reflections, and does not diffuse the light source or heat source, which can lead to the concentration of the heat into 'hot spots'.

The Rimex material on the new Walton Street Quadrangle, Worcester Place facade cannot increase the overall level of heat within the adjacent street unless it concentrated the reflected sunlight into a 'hot spot.' The convex shape of the roof on this building (which in interspersed with dormers), and the roughness of the material will mean that any reflected sunlight is scattered rather than concentrated, so the facade will not create hot spots.

The heat radiation from any surface is proportional to the fourth power of the relative temperature difference between the radiation and receiving objects; and the relative colours. Due to the relative temperatures involved, the amount of radiated heat from the building will be very small and will be similar to that from any other construction material of similar colour.

# 04

## Sun Light and Reflectivity Study

# 4.1 Vertical Elevation - Worcester Place Central Learning Commons Block

As outlined within the executive summary, due to the laws of reflection meaning that the angle of incidence is equal to the angle of reflection, and the resulting diverging reflections from a convex curve, the subsequent studies focus on the vertical section of the Worcester Place elevation, the central learning commons block and the hall.

Using three dimensional environment analysis software Vasari, ABA have been able to locate a computer model of the proposed Walton Street Quadrangle and its adjacent context, in its true GPS Coordinates. This has allowed us to record the months of the year and the hours of the day in which the sun obliquely hits the north facing Worcester Place elevations.

As the summer and winter solstices are on the 21st of the month, this study has been produced by using data for the 15th of every month as the average day.

All of the information within the subsequent studies is based on weather data for a clear sunny day. It should be taken into consideration that this is not a true representation of what the hours of sun light for these months is typically. From Met Office studies, we can see that the average sun light per month for the years between 1970 and 2000 from March to September, was 295 hours per month, with March having on average 190 hours of sunshine, and June 300 hours of sunshine.

Where as this study assumes a worst case scenario of 443 hours of clear sunshine per month.

The Central Learning Commons Block:

- On average the oblique sun only hits the 101 sqm of vertical cladding for 2.3 hours per day, at 6.30 pm.

The total area of vertical cladding to the elevation directly facing Worcester Place is 101sqm.

This elevation is regularly intersected with large student room windows and desk reading windows. Therefore the largest width of vertical cladding is no greater than 2.4m.

The vertical section of metal cladding to the central learning commons block along Worcester Place, receives oblique sun light during 7 months of the year.

This sun light is from a south westerly direction, when the sun is at its highest point in the sky during the summer / spring months (solar altitude).

During these 7 months the amount of sun light hitting this section of vertical cladding varies from 20min to 4 hours, per day.

On average the sun would hit the vertical section of the elevation for only 2.3 hours per day at an average solar altitude of 48 degrees (from the horizontal), and this would take place at approximately 6.30pm.

| **Months:**<br><br>All of the dates listed are the 15th of the month 2014. | **Hour of Oblique Sun Light:**<br><br>The Hour in which the sun first shines on the vertical section of learning commons elevation, on the 15th of the month. | **Hour of Shade:**<br><br>The time at which the sun no longer shines on the vertical section of learning commons elevation. The elevation is now in the shade of the buildings adjacent, along Worcester Place. | **Total Hour of Oblique Sun Light on the Elevation:**<br><br>The total duration of oblique sun light, on the vertical section of learning commons elevation, on the 15th of the month. | **Total Hours of Oblique Sun Light on the Elevation for 7 months:**<br><br>Total duration of oblique sun light on the north elevation based on the 15th of the month x the total number of days in the month. Rounded to the hour. | **Average Hours of Sun Light in the month:**<br><br>Based on a clear day with no cloud coverage. | **Solar Angle:**<br><br>The approximate figures shown relate to the angle of degrees from the horizontal. |
|---|---|---|---|---|---|---|
| March<br>*Spring Equinox* | 6.50pm | 7.10pm | 20 min | **10 hours** | 11 hours 45 min daily<br><br>**367 hours 27 min** | 38 degrees |
| April | 6.05pm | 7.50pm | 1 hours 55 min | **57 hours** | 13 hours daily<br><br>**390 hours** | 46 degrees |
| May | 5.25pm | 8.40pm | 3 hours 15 min | **100 hours** | 15 hours daily<br><br>**465 hours** | 54 degrees |
| June<br>*Summer Solstice* | 5.15pm | 9.15pm | 4 hours | **120 hours** | 16 hours 15 min daily<br><br>**487 hours** | 62 degrees |
| July | 5.25pm | 9.05pm | 3 hours 30 min | **108 hours** | 16 hours 30 min daily<br><br>**511 hours** | 54 degrees |
| August | 5.50pm | 8.15pm | 2 hours 25 min | **74 hours** | 15 hours 30 min daily<br><br>**480 hours** | 46 degrees |
| September<br>*Autumn Equinox* | 6.20pm | 7.10pm | 50 min | **25 hours** | 13 hours 30 min daily<br><br>**405 hours** | 38 degrees |
| | | **Total Number of Hours over the relevant 7 month period:** | **15 hours** | **494 hours of sun light over 7 months of the year.**<br><br>**Average:**<br>**2.3 hours per day @ 6.30pm,48 degrees** | **3107 hours 30 min**<br><br>**Average:**<br>**14 hours 30 min per day** | |

Table 01
Directional south west sunlight hitting the vertical section of metal cladding on the learning commons block. The area of elevation is illustrated in diagram 01.

Diagram 01 - Worcester Place Elevation

Vertical Section of the Central Learning Commons Block
Area - 101 sqm

# Vertical Elevation - Worcester Place
# Central Learning Commons Block

# 4.1

Diagram 02 diagrammatically shows the path of the sun around the site for the summer solstice and the winter solstice. It then maps out the time in which the sun first hits the vertical section of the central learning commons block and the time in which the buildings adjacent finally cast shadows across this section of elevation. This can be seen in images 01, 02 and 03, on the subsequent page.

Key:

- Summer and Winter Solstice Sun Rise
- March to September Sun on the Vertical Elevation
- Summer Solstice Sun on the Vertical Elevation

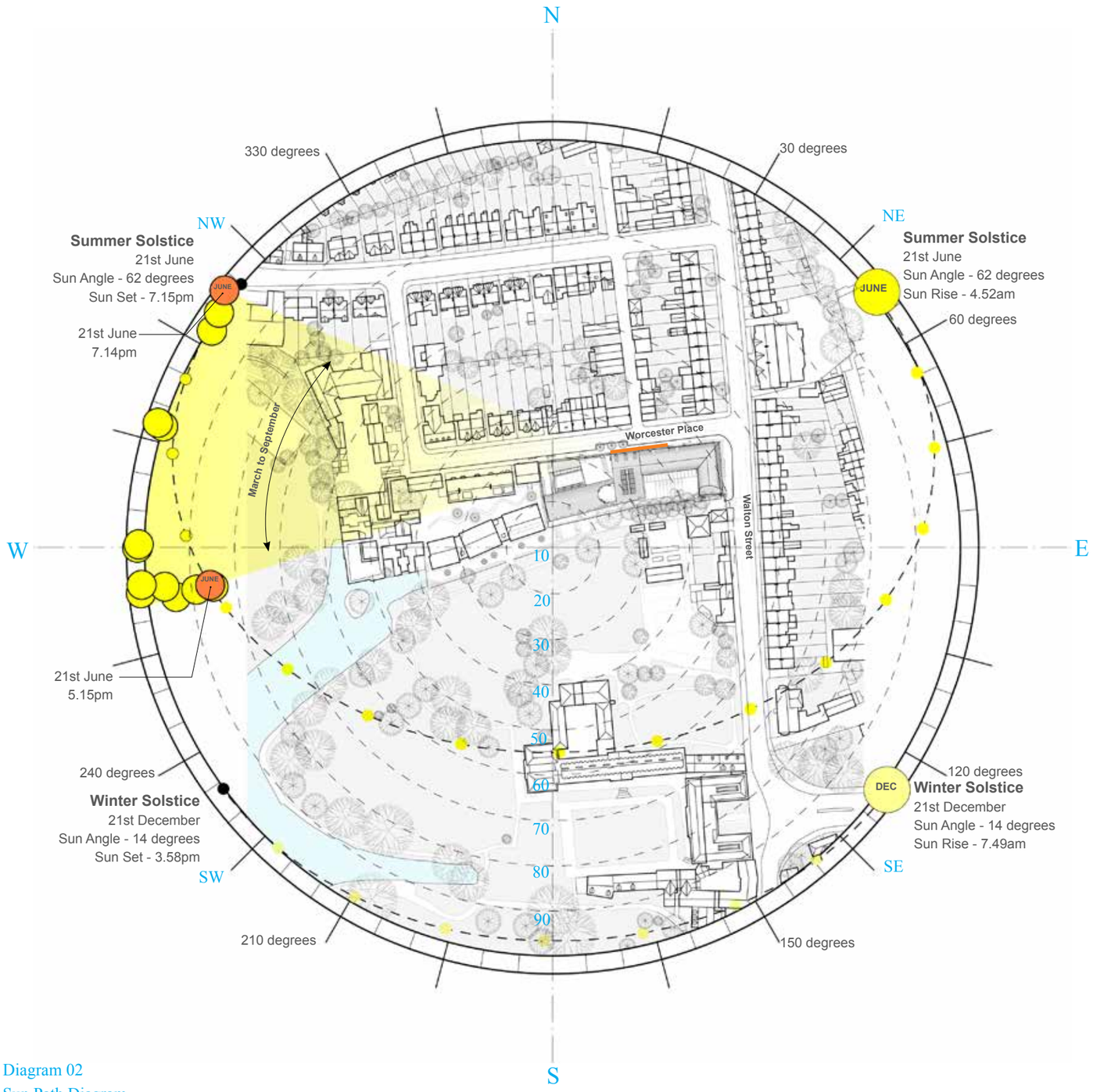



Diagram 02
Sun Path Diagram
Central Learning Commons Block Vertical Elevations

# 4.1 Vertical Elevation - Worcester Place Learning Commons Block

Diagram 03 illustrates three dimensionally the sun path around the site during the summer solstice, and the shadow and sun locations at this time.

Referring to page 20, the area highlighted in orange will receive oblique sunlight for approximately 2.3 hours per day over a 7 month period, assuming no cloud cover.

The sunlight will be reflected to the north east, with the sun being at an average solar altitude of 48 degrees from the horizontal. Therefore having no impact on any viewpoint within the local environment.

Image 01 - 21st June 5.15pm

Image 02 - 21st June 7.45pm

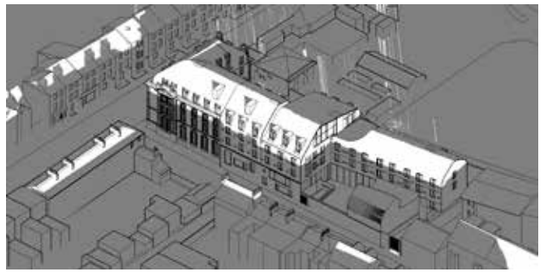


Image 03 - 21st June 9.15pm

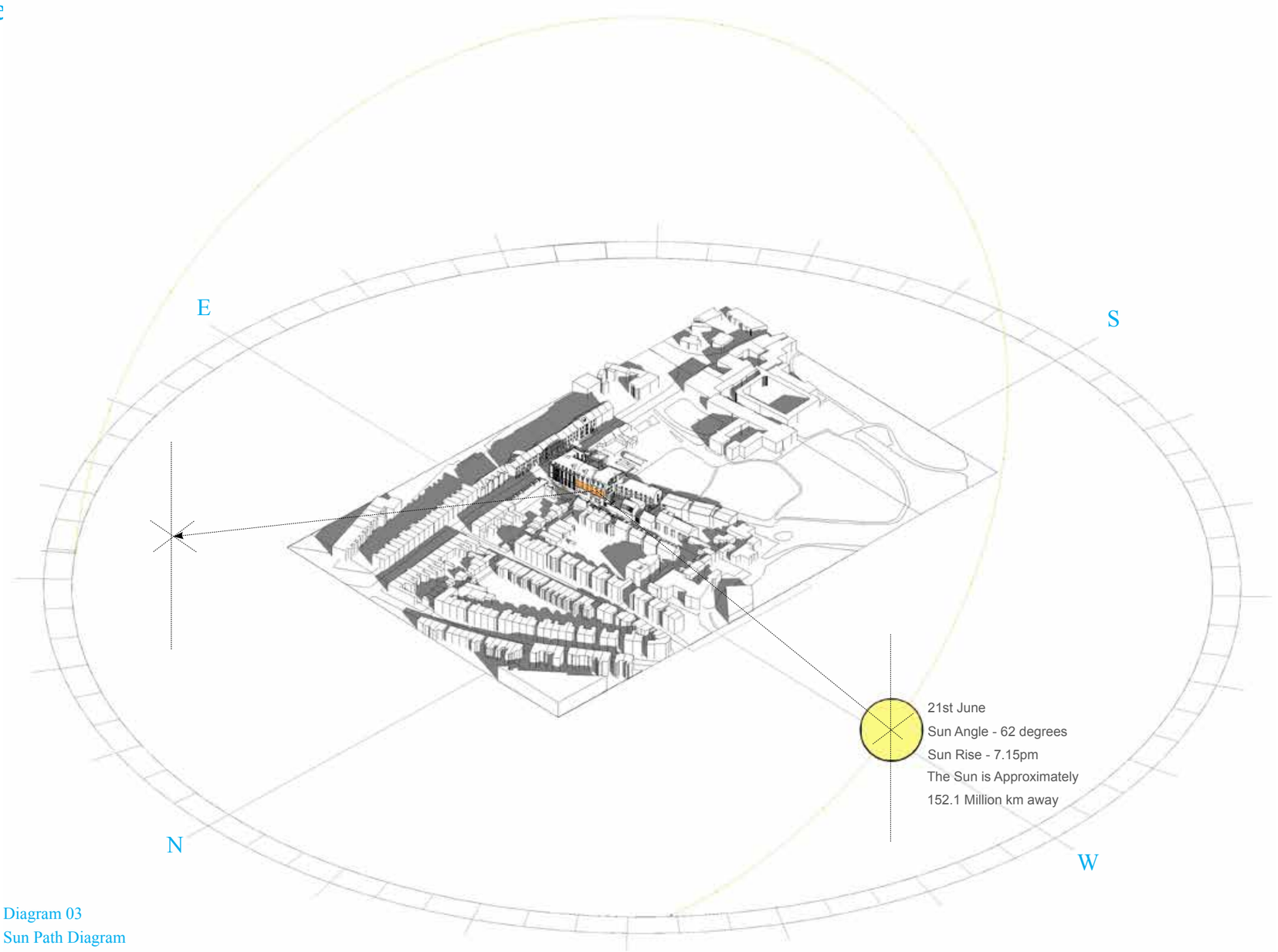



Diagram 03
Sun Path Diagram
Central Learning Commons Block Vertical Elevations

Diagram 04 - Worcester Place Elevation

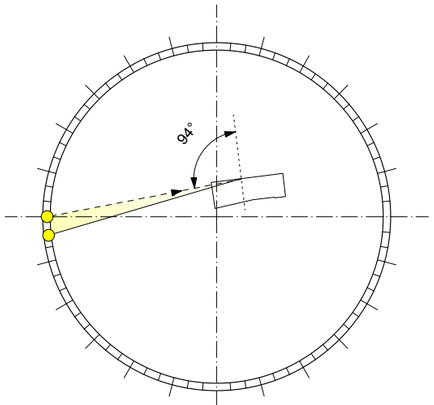
Vertical Section of the Central Learning Commons Block
Area - 101 sqm

# Vertical Elevation - Worcester Place
# Central Learning Commons Block

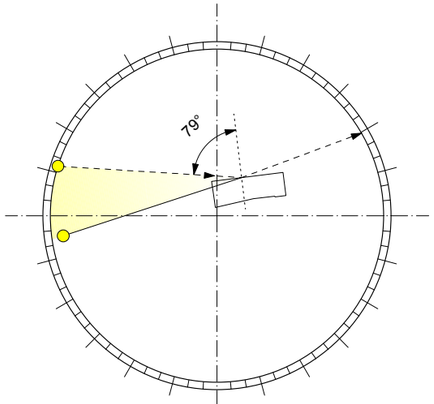
4.1

These diagrams illustrate an approximate angle of reflection, for the oblique sun light hitting the corner of the learning commons block along Worcester Place.

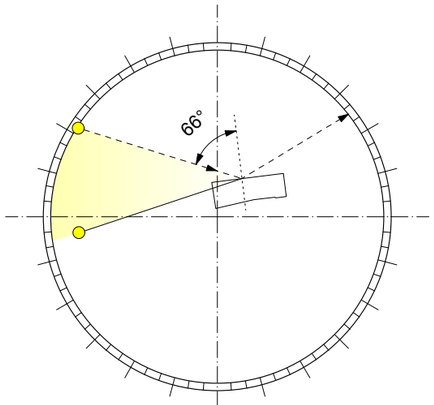
From these diagrams we can see that the angle of the sun is always greater that 60 degrees, and for this reason always results in a angle of reflection of an equal angle towards the north east, of the site.



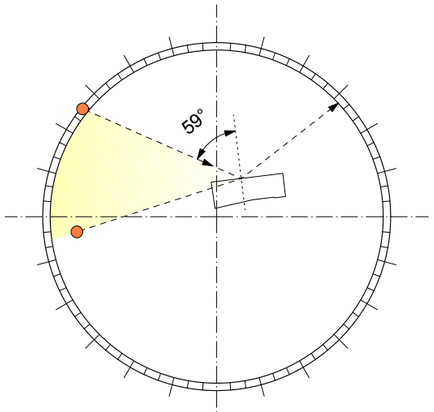

**15th March**
Sun Angle - 38 degrees
6.50pm till 7.10pm = 35min
Angle of Incidence Approximately - 94 degrees



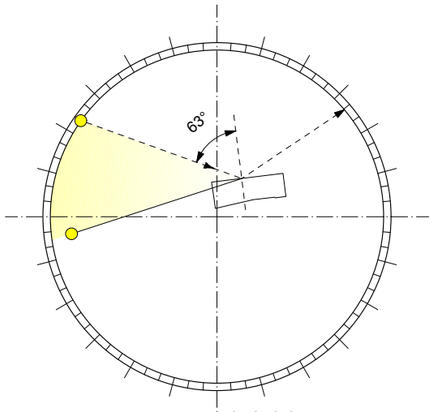

**15th April**
Sun Angle - 46 degrees
6.05pm till 7.50pm = 1hr 55min
Angle of Incidence Approximately - 79 degrees



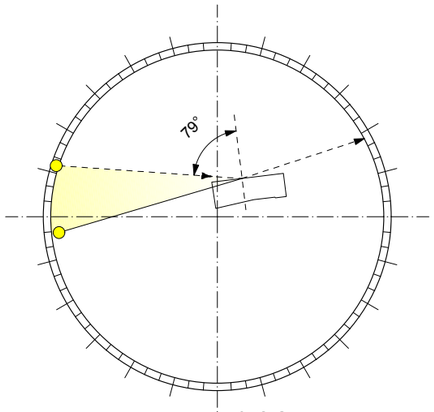

**15th May**
Sun Angle - 54 degrees
5.25pm till 8.40pm = 3hr 15min
Angle of Incidence Approximately - 66 degrees



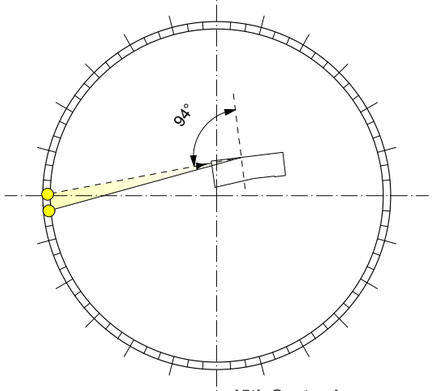

**15th June**
Sun Angle - 62 degrees
5.15pm till 9.15pm = 4hr
Angle of Incidence Approximately - 59 degrees




**15th July**
Sun Angle - 54 degrees
5.25pm till 9.05pm = 3hr 30min
Angle of Incidence Approximately - 63 degrees




**15th August**
Sun Angle - 46 degrees
5.50pm till 8.15pm = 2hr 25min
Angle of Incidence Approximately - 79




**15th September**
Sun Angle - 38 degrees
6.20pm till 7.10pm = 50min
Angle of Incidence Approximately - 94 degrees

Diagram 05
Sun Path Diagram, the Reflectivity of the Sun to the Corner of the Learning Commons Block, Vertical Elevation.

# 4.2 Vertical Elevation - Worcester Place Hall Elevation

The Hall elevation:

- On average the oblique sun only hits the 38 sqm of vertical cladding for 1.7 hours per day, at 6.00 pm.

The total area of vertical cladding to the elevation of the Hall is 38sqm.

The vertical section of metal cladding to the Hall elevation along Worcester Place, receives directional sun light during 6 months of the year.

This sun light is at a south westerly direction, when the sun is at its highest point in the sky during the summer / spring months (solar altitude).

During these 6 months, the amount of sun light hitting this section of vertical cladding varies from 10 minutes to 2 hours, 45 minutes per day.

On average the sun would only hit the vertical section of the Hall elevation for 1.7 hours per day, at an average solar altitude of 48 degrees from the horizontal, and this would take place at approximately 6.00pm.

| **Months:**<br><br>All of the dates listed are the 15th of the month 2014. | **Hour of Oblique Sun Light:**<br><br>The Hour in which the sun first shines on the vertical section Hall elevation, on the 15th of the month. | **Hour of Shade:**<br><br>The time at which the sun no longer shines on the vertical section of Hall elevation. The elevation is now in the shade of the buildings adjacent, along Worcester Place. | **Total Hour of Oblique Sun Light on the Elevation:**<br><br>The total duration of oblique sun light, on the vertical section of Hall elevation, on the 15th of the month. | **Total Hours of Oblique Sun Light on the Elevation for 6 months:**<br><br>Total duration of oblique sun light on the north elevation based on the 15th of the month x the total number of days in the month. Rounded to the hour. | **Average Hours of Sun Light in the month:**<br><br>Based on a clear day with no cloud coverage. | **Solar Angle:**<br><br>The approximate figures shown relate to the angle of degrees from the horizontal. |
|---|---|---|---|---|---|---|
| April | 6.05pm | 7.20pm | 1 hour 15 min | **37 hours** | 13 hours daily<br><br>**390 hours** | 46 degrees |
| May | 5.30pm | 7.40pm | 2 hour 10 min | **69 hours** | 15 hours daily<br><br>**465 hours** | 54 degrees |
| June<br>*Summer Solstice* | 5.15pm | 7.55pm | 2 hours 45 min | **82 hours** | 16 hours 15 min daily<br><br>**487 hours** | 62 degrees |
| July | 5.30pm | 8.00pm | 2 hours 30 min | **77 hours** | 16 hours 30 min daily<br><br>**511 hours** | 54 degrees |
| August | 5.50pm | 7.40pm | 1 hours 30 min | **46 hours** | 15 hours 30 min daily<br><br>**480 hours** | 46 degrees |
| September<br>*Autumn Equinox* | 6.20pm | 6.55pm | 35 min | **17 hours** | 13 hours 30 min daily<br><br>**405 hours** | 38 degrees |
| | | **Total Number of Hours over the relevant 6 month period:** | **10 hours 45 min** | **328 hours of sun light over 6 months of the year.**<br><br>**Average:**<br>**1.7 hours per day @ 6.00pm,48 degrees** | **2740 hours**<br><br>**Average:**<br>**14 hours 50 min per day** | |

Table 02
Directional south west sunlight hitting the vertical section of metal cladding on the Hall elevation. The area of elevation is illustrated in diagram 06.

Diagram 06 - Worcester Place Elevation

Vertical Section of the Hall elevation
Area - 38 sqm

# Vertical Elevation - Worcester Place Hall Elevation

# 4.2

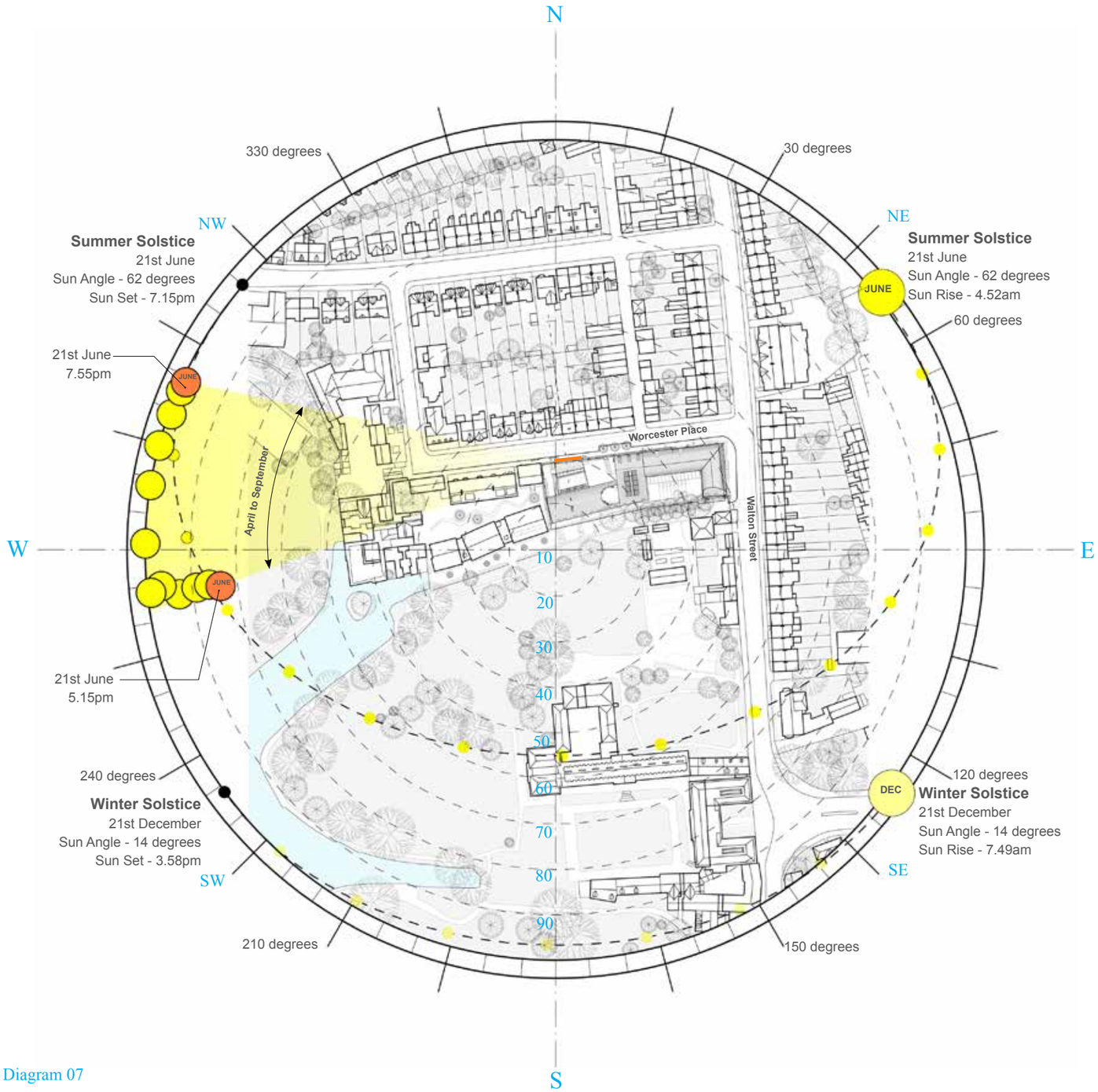



Diagram 07
Sun Path Diagram
The Hall Vertical Elevations

Diagram 07 diagrammatically shows the path of the sun around the site for the summer solstice and the winter solstice. It then maps out the time in which the sun first hits the vertical section of the hall elevation and the time in which the buildings adjacent finally cast shadows across this section of elevation. This can be seen in images 01, 02 and 03, on the subsequent page.

Key:

- Summer and Winter Solstice Sun Rise
- March to September Sun on the Vertical Elevation
- Summer Solstice Sun on the Vertical Elevation

# 4.2 Vertical Elevation - Worcester Place Hall Elevation

Diagram 08 illustrates three dimensionally the sun path around the site during the summer solstice, and the shadow and sun locations at this time.

Referring to page 24, the area highlighted in orange will receive oblique sunlight for approximately 1.4 hours per day over a 6 month period, assuming no cloud cover.

The sunlight will be reflected to the north east at an average angle of 48 degrees from the vertical, above the local roof line. Therefore having no impact on any viewpoint within the local environment.

Image 01 - 21st June 5.15pm

Image 02 - 21st June 7.30pm

Image 03 - 21st June 8.00pm

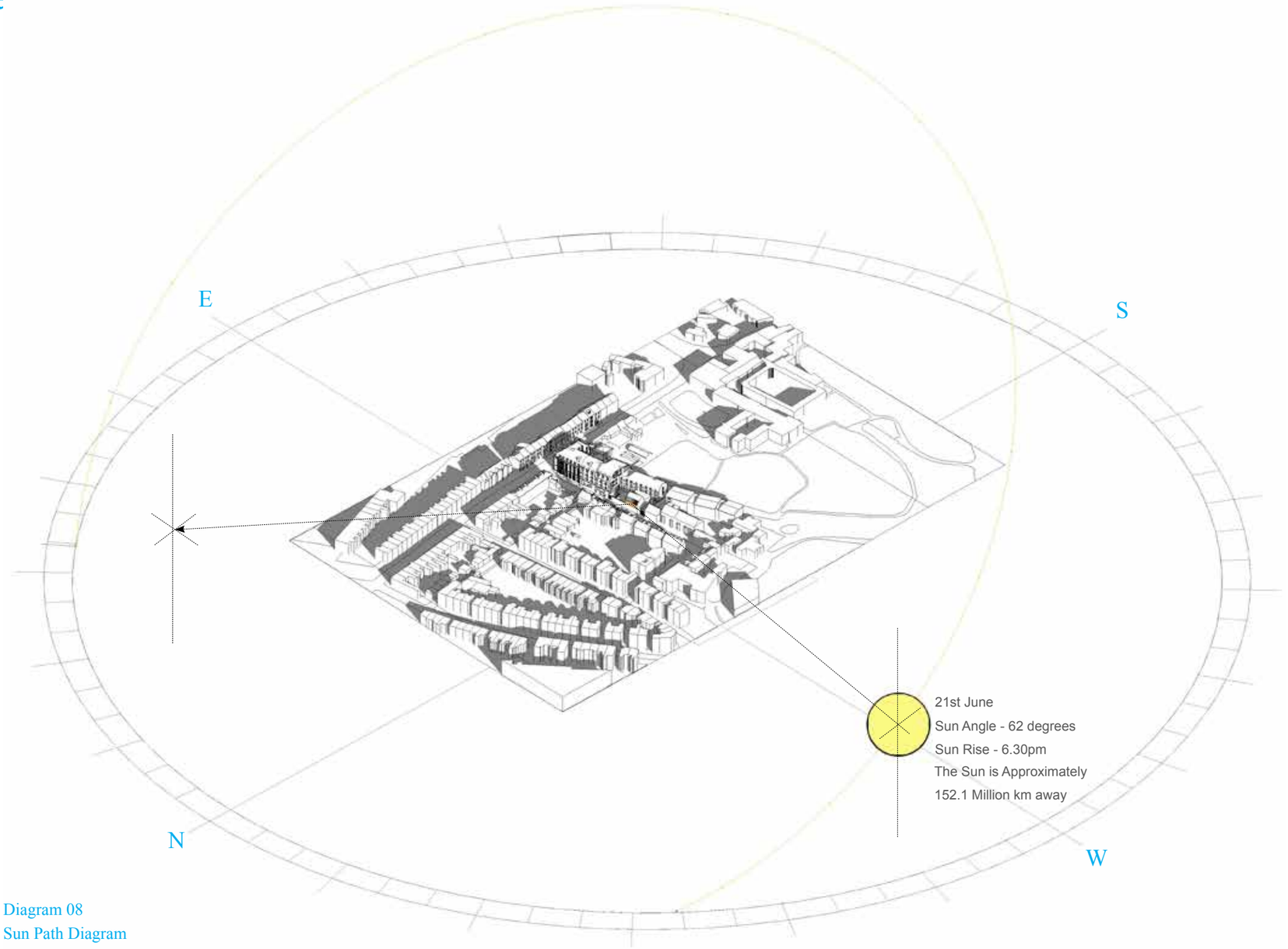



Diagram 08
Sun Path Diagram
Central Learning Commons Block Vertical Elevations

Diagram 09 - Worcester Place Elevation

Vertical Section of the Hall Elevation
Area - 38 sqm