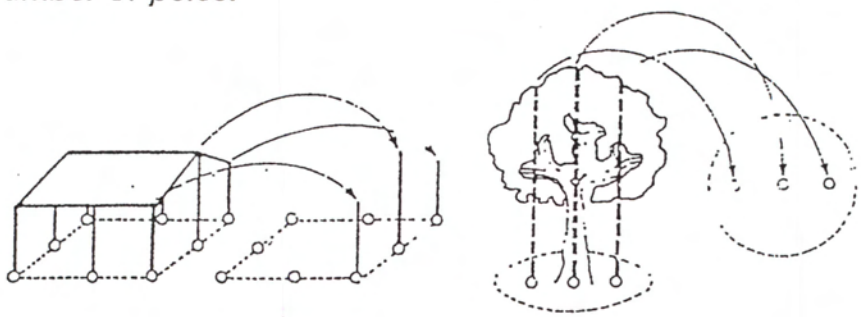
Appendix

DETERMINING SHADOW PATTERN
APPENDIX "A"

The shadow pattern for a building (or tree) can be determined by treating the building as a number of poles:



The shadow lengths for each pole are laid out for the critical times of day. The composite of all shadows for all poles yields the pattern for the building.

For York County (40 degree North Latitude) the shadow lengths are laid out for 9:00 a.m., noon and 3:00 p.m. On short winter days this is when the most solar energy is available. For instance, on December 21st, the shortest day of the year, 90% of the day's sunlight would fall during these six (6) hours.

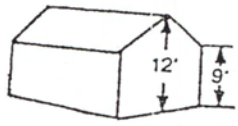
Use the following steps to determine the shadow length for December 21st. An example is given as an illustration

DETERMINING SHADOW PATTERN

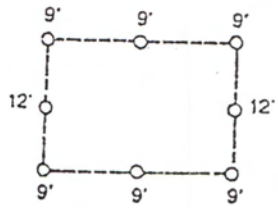
EXAMPLE

Step 1. *Determine building height the corners and the ridge.*

Proposed building is 9′ high at at eaves and 12′ at peak.



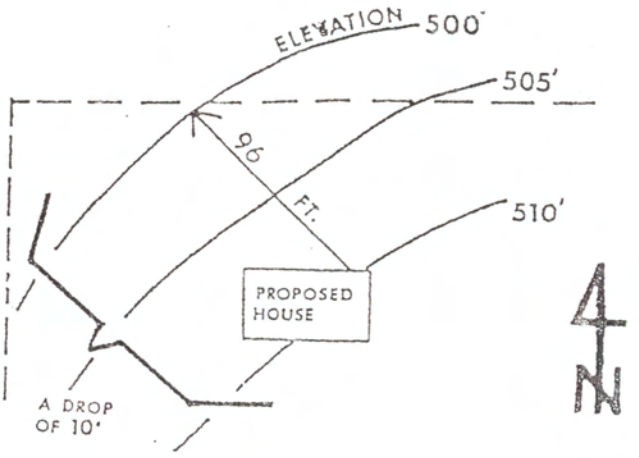
Step 2. *Drawn an overhead plan of the building using a series of poles.*



EXAMPLE

Step 3. *Figure the downhill slope of the yard on the north side of the proposed building.*

Slope is the vertical distance divided by the horizontal distance ("rise over run").



Yard slopes downhill to the northwest. The topographical map shows that 96 feet away from the proposed house the land has dropped 10 feet.

$$\text{Slope} = \frac{\text{Vertical Distance}}{\text{Horizontal Distance}}$$

$$\text{Slope} = \frac{10'}{96'} = .104$$

Slope = about 10%

Step 4. *From the Shadow Length Table (pg. A-3) find the shadow shadow values for a.m., noon, and p.m. Multiply these ratios time the height of the poles*

For 10% slope to northwest:

SHADOW LENGTH

	a.m. (9.1)	noon (2.3)	p.m. (4.8)
9' Pole	81.9'	20.7'	43.2'
12' Pole	109.2'	27.6	57.6

Shadow Length Table

LATITUDE 40° North

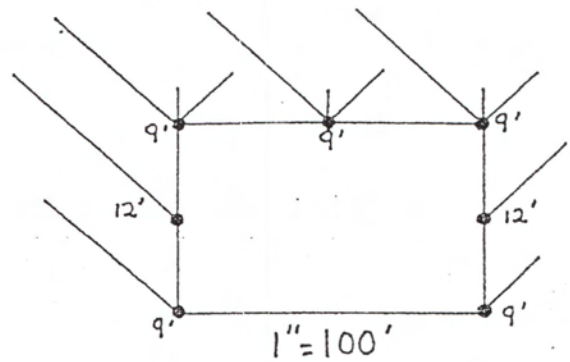
	N			NE			E			SE			S			SW			W			NW		
SLOPE	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM
0%	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8
5%	5.7	2.2	5.7	4.8	2.2	6.2	4.1	2.0	5.7	3.8	1.9	4.8	4.1	1.8	4.1	4.8	1.9	3.8	5.7	2.0	4.1	6.2	2.2	4.8
10%	7.2	2.5	7.2	4.8	2.3	9.1	3.6	2.0	7.2	3.2	1.8	4.8	3.6	1.7	3.6	4.8	1.8	3.2	7.2	2.0	3.6	9.1	2.3	4.8
15%	9.6	2.9	9.6	4.8	2.6	16.6	3.2	2.0	9.1	2.8	1.7	4.8	3.2	1.6	3.2	4.8	1.7	2.8	9.6	2.0	3.2	16.6	2.6	4.8
20%	14.5	3.4	14.5	4.8	2.8	97.5	2.8	2.0	14.5	2.4	1.6	4.8	2.8	1.5	2.8	4.8	1.6	2.4	14.5	2.0	2.8	97.5	2.8	4.8

EXAMPLE

Step 5. *Draw the shadow lengths to scale on the overhead view of the building.*

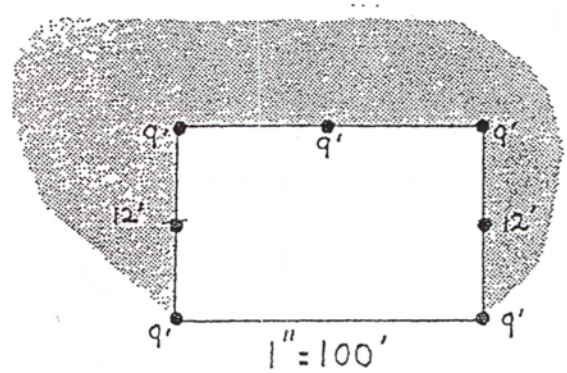
- *Draw a.m. shadows 45 degrees west of north*
- *P.M. shadows should be laid out 45 degrees east of north*
- *Draw noon shadows due north*

Shadow Lines



Step 6. *Connect the end points of the shadow lines. This shows the approximate area of ground shaded by the building between 9 a.m. and 3 p.m. on December 21st.*

Building Shadow Pattern



If the diagram was accurately drawn to scale, it will not be easy to tell whether the proposed building will shade the south-facing wall of any nearby building.

SOLAR SKYSPACE EASEMENT
APPENDIX "B"

INTRODUCTION

In order to operate effectively, a solar energy system should receive direct sunlight for most of the day. The more the collector area is shaded, the less energy the system will supply.

This Zoning Ordinance includes provisions that protect solar collectors and south-facing walls from shading (see Section 300.5). However, a solar skyspace easement can provide additional protection from shading and offers the individual a greater degree of control over factors that affect his or her property. The purpose of this Appendix is to explain in more detail: (1) what a solar skyspace is, and (2) what should be included in a solar skyspace easement.

SOLAR SKYSPACE; WHAT IS IT?

A solar skyspace is the portion of the sky that a collector (solar panel, south-facing glass area, etc.) must "see" to perform effectively. It is this skyspace, which is based on the sun's position in the sky, that must be protected from shading by trees, buildings or other obstructions.

Because of the earth's movement in relationship to the sun, the sun's position in the sky varies throughout the year. On December 21st, the shortest day of the year, the sun rises several degrees south of true east, and reaches a height of 27 degrees above the horizon. By the longest day of the year, June 21st, the sun's path has shifted considerably; it rises several degrees north of tree east, and reaches the highest altitude above the horizon, 73 degrees. These figures are for 40 degrees north latitude, which is York County's approximate location. (See Figure 1).

An object casts its longest shadow when the sun is lowest in the sky. Thus, if a collector is protected from shading on December 21, when the sun is lowest in the sky, it should be protected the year round. (One exception could be a deciduous tree that casts very little shadow when it is bare in winter but shades extensively during the summer.)

The critical hours for protection on December 21 are from about 9:00 a.m. to about 3:00 p.m. Standard Time. During these hours, most (90%) of the sun's radiation for that day falls on the earth. It is not necessary to protect solar collectors from sunrise to sunset; when the sun is low in the sky, its rays are very indirect, and most of the solar radiation is absorbed or blocked by the atmosphere, clouds or smog.

FIGURE 1 - Paths of the Sun at Winter & Summer Solstrices at 40 Degrees North Latitude

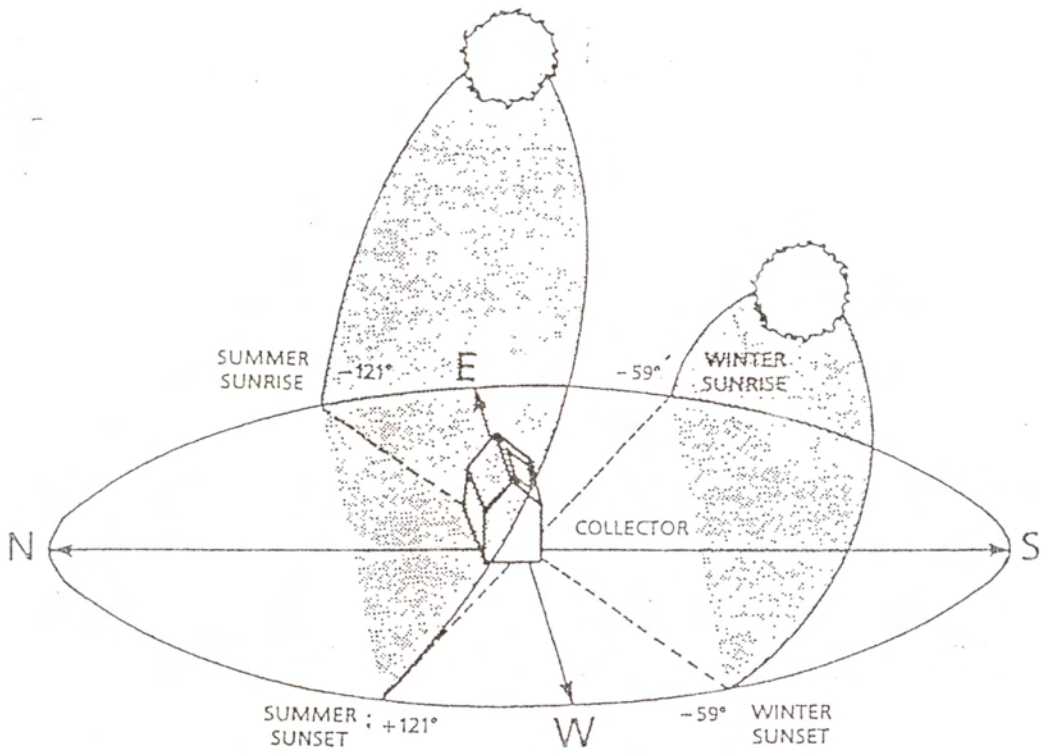


FIGURE 2 - Solar Skyspace (Plan View)

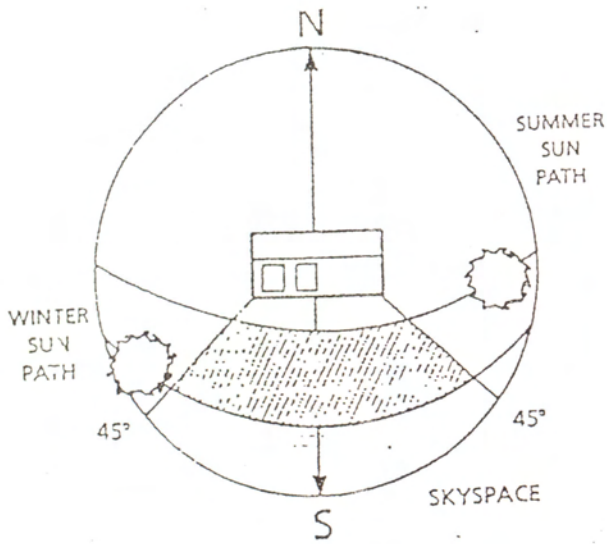
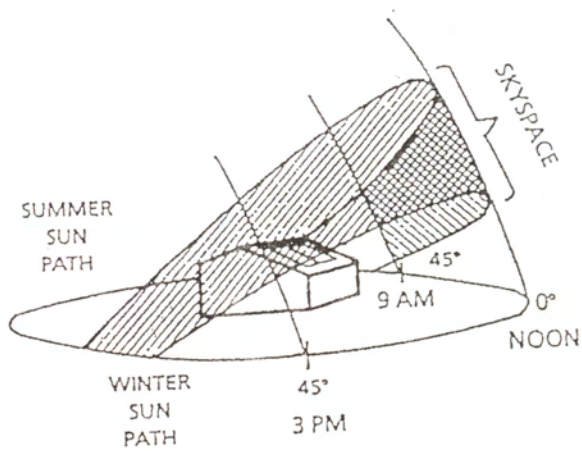


FIGURE 3 - Solar Skyspace (Isometric View)



Another way to express the 9:00 a.m. to 3:00 p.m. time period is to refer to the sun's position at those times. On December 21st at about 9:00 a.m., the sun is 45 degrees east of south; and at about 3:00 p.m. it is 45 degrees west of south. (At true solar noon, which is time halfway between sunrise and sunset, the sun is directly to the south). Figures 2 and 3 are two ways of drawing a solar skyspace using the 45 degree position (azimuth). Figure 4 shows more simplified drawings that could be used to describe skyspace in a solar easement.

Exactly how much protection a solar system owner wishes to have will vary. First, the collector height above ground level must be considered. Solar panels on the roof, south-facing windows on the first floor, and a solar greenhouse with glazing that extends down to ground level will each need a different skyspace.

Secondly, the owner may recognize that providing full protection from shading may unfairly limit the development of the neighboring property. This problem could occur in an area where lots are small and houses are built close together. Also, it may be difficult to avoid shading when the property to the south is uphill from the solar collectors (see Figure 5). In these instances, the owner seeking solar access protection may settle for fewer hours of sunlight, such as 10:00 a.m. to 2:00 p.m.

SOLAR SKYSPACE EASEMENT

A solar skyspace easement is a private agreement between two (2) adjoining property owners. It should be drawn up, conveyed and recorded in the same manner as other types of easements. A skyspace easement should run with the land being protected and with the land being burdened with the easement. To properly and accurately draw up an easement, it may be helpful to consult a lawyer, surveyor and/or a solar consultant.

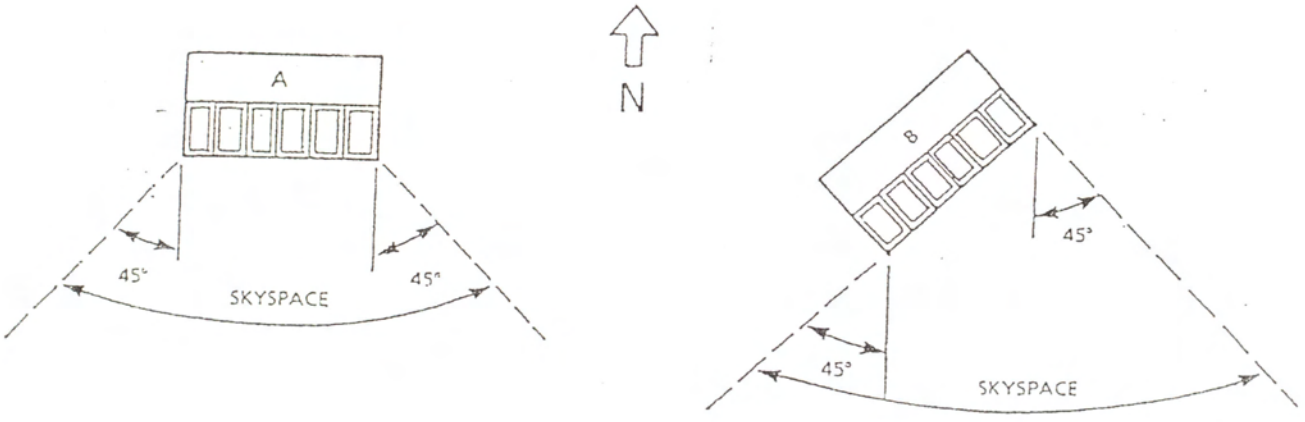
The easement could include the following:

(1) The location of the solar collector(s) on the owner's property.

(2) The boundaries of the solar skyspace that is being protected; that is, the area of sky over the neighboring property that the neighboring property owner agrees <u>not</u> to use. There are several ways of defining this area such as:

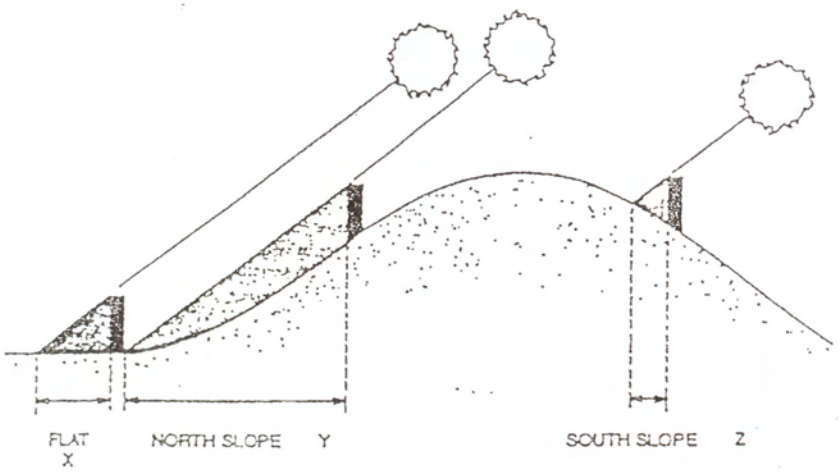
(a) Using a height restriction. "All space over the neighboring property (or over a certain portion of the neighboring property) at a height greater than ____ feet." In other words, the neighbor granting the easement will not build a structure or allow vegetation to grow higher than the height stated in the easement.

FIGURE 4 - Solar Skyspace (Plan View)



The 45 Degree Angles Represent The Angles Off Due South

FIGURE 5 - Shadow Lengths Are Shorter and Higher Densities Easier on South Slopes



Distance "X" on A Flat Slope is Less Than Distance "Y" On A North Slope. For Identical Poles, Distance "Z" On A South Slope is the Least.

(b) *Using a variable height restriction. The closer an object is to your property, the farther its shadow will fall across your property. Therefore, an easement could define a "stair step" skyspace, by increasing the maximum height for areas of the neighboring property that are farther from the solar collector.*

(c) *Using times of day. This method of describing a skyspace may be used alone or in combination with (a) or (b) above. For example, "No shadow shall be cast from three (3) hours before noon to three (3) hours after noon from September 22nd through March 21st" - which would protect the collectors during the heating season. If year-round protection is needed for a domestic hot water system, add to that " ... from three (3) hours before noon to three (3) hours after noon on December 21st," since protection from shadows on the shortest day of the year will probably insure protection for the whole year.*

Another type of solar skyspace easement is called a "solar plane easement." It is similar to the stair step technique in that it allows a building or tree on the neighboring property to be higher if it is farther away from the area that needs protection.

Figures A and B are drawings of one homeowner's solar plane easement. The owner planned to build a Trombe Wall (a type of passive solar system) on the wall that faced 20 degrees east of true south. He obtained an easement in which the neighboring owner agreed that no structures or vegetation would be allowed above a 21 degree plane that began at the base of the Trombe wall area (4-1/2 feet above the ground). From side to side, this plane extended from the edges of the Trombe Wall (which covered the whole side of the house) 43 degrees east and west of true south.

This easement did not give the solar system the maximum protection from shading that would have been obtained from a 12 or 15 degree plane extending 45 degrees east and west of south (protection from 9:00 a.m. to 3:00 p.m. on December 21st). However, it was the best that could be obtained from the adjoining owner and the permitted amount of shading would not substantially impair the effectiveness of the system. The owner in this case used the following model easement. It is included as an example of how to prepare an easement.

Note that the base point used in this easement should be a point at the bottom corner of the solar collector area. In other words, it is the highest point above the ground that shadows could fall without shading the collector.

DRAWINGS OF A SOLAR PLANE EASEMENT

FIGURE A
Top View

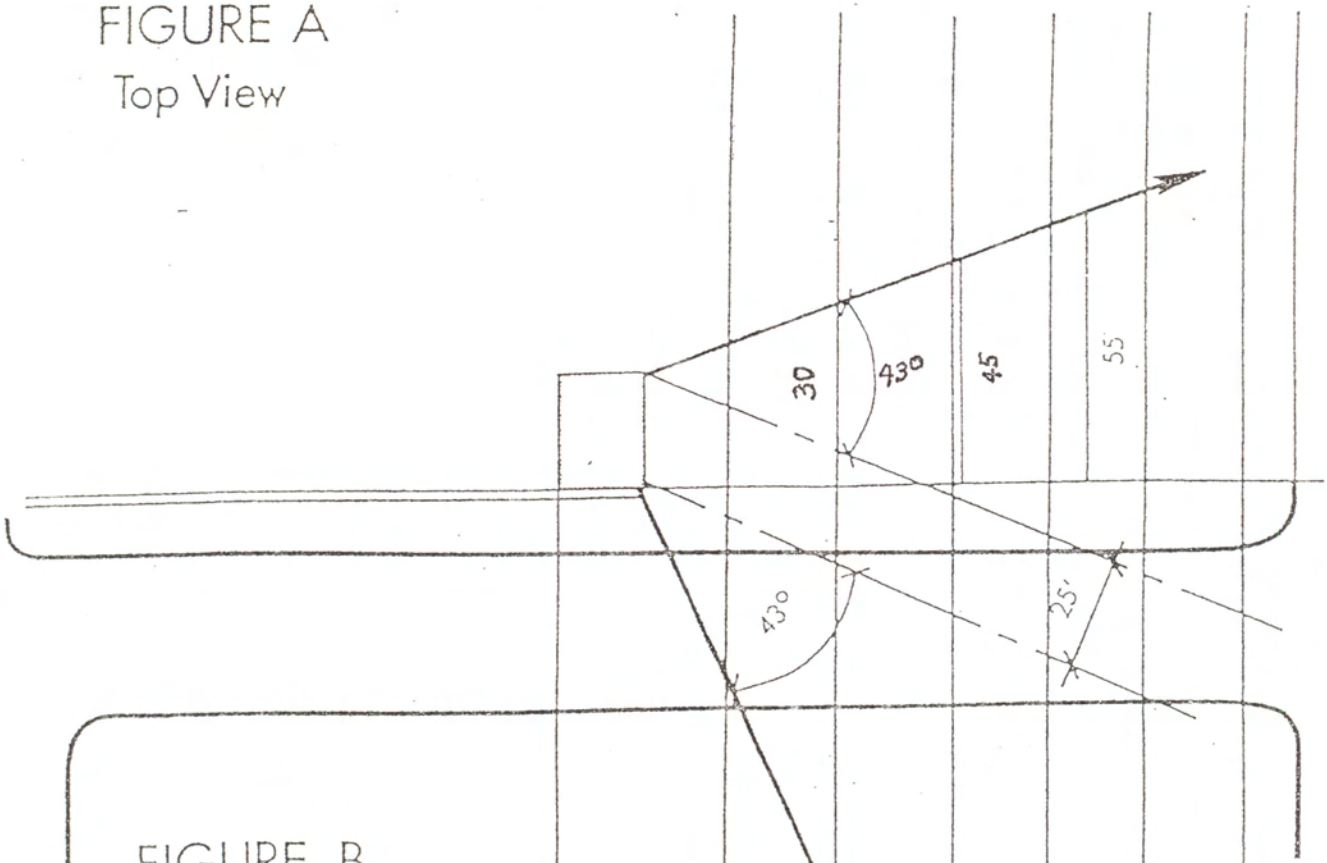
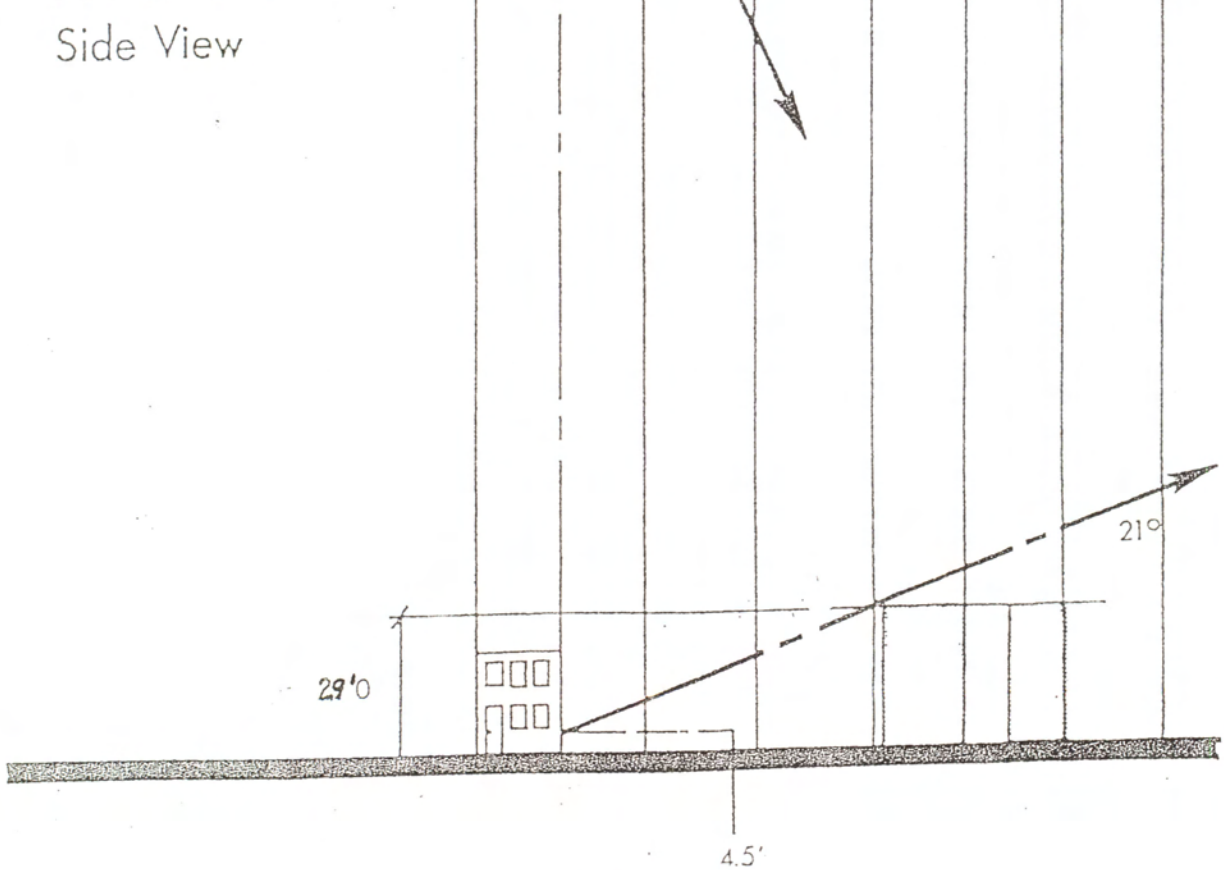


FIGURE B
Side View



MODEL SOLAR PLANE EASEMENT

Explanation

The model solar easement is intended as a proposal for easement drafting. Since the substantive law in each state may vary, no representation or legal opinion is made as to enforceability of this proposal. Use of the form without further legal research or competent legal advice tailored to the specific circumstances is not recommended.

The model solar easement attaches to the land. Therefore, it may be created without the existence of actual solar energy systems. Since easements run with the land, are transferable as interest in land, and should be permanently identifiable, this is the preferred approach. Some efforts have been made to describe solar easement from collector locations. Although the model solar easement could be easily adaptable to such an approach, the solar collector itself must then be defined and permanent.

Property owners securing solar easement should first determine over which neighboring properties easements are desirable, considering property lines, topography, and future use. The dominant property to which the solar easement attaches and confers benefits shall be called the "Solar Lot." The description of the solar easement granted the solar lot generally will not change. Only the names of the grantors and legal descriptions of the grantor's servient property will vary.

Review the model solar easement and accompanying figures before beginning preparation of a solar easement. Decide approximately what area of the solar lot (including airspace) is to be provided direct solar access. Rough sketching is helpful. As the collector is elevated from ground level, the solar easement burdens on grantor's servient properties decrease. Most solar easements will be designed for roof-top collectors with an elevated base line running due east or west coincident with the base of the solar collectors, and side lanes projecting from the base line at angles that provide designed protection.

Proposed Form

The following directions refer to the model solar easement in the pages following. Complete the blanks in the model solar easement proposal as follows:

1) *Insert names of owners of property over which solar easement will pass (Grantors).*

(2) *Set out legal description of Grantor's property over which solar easement will pass.*

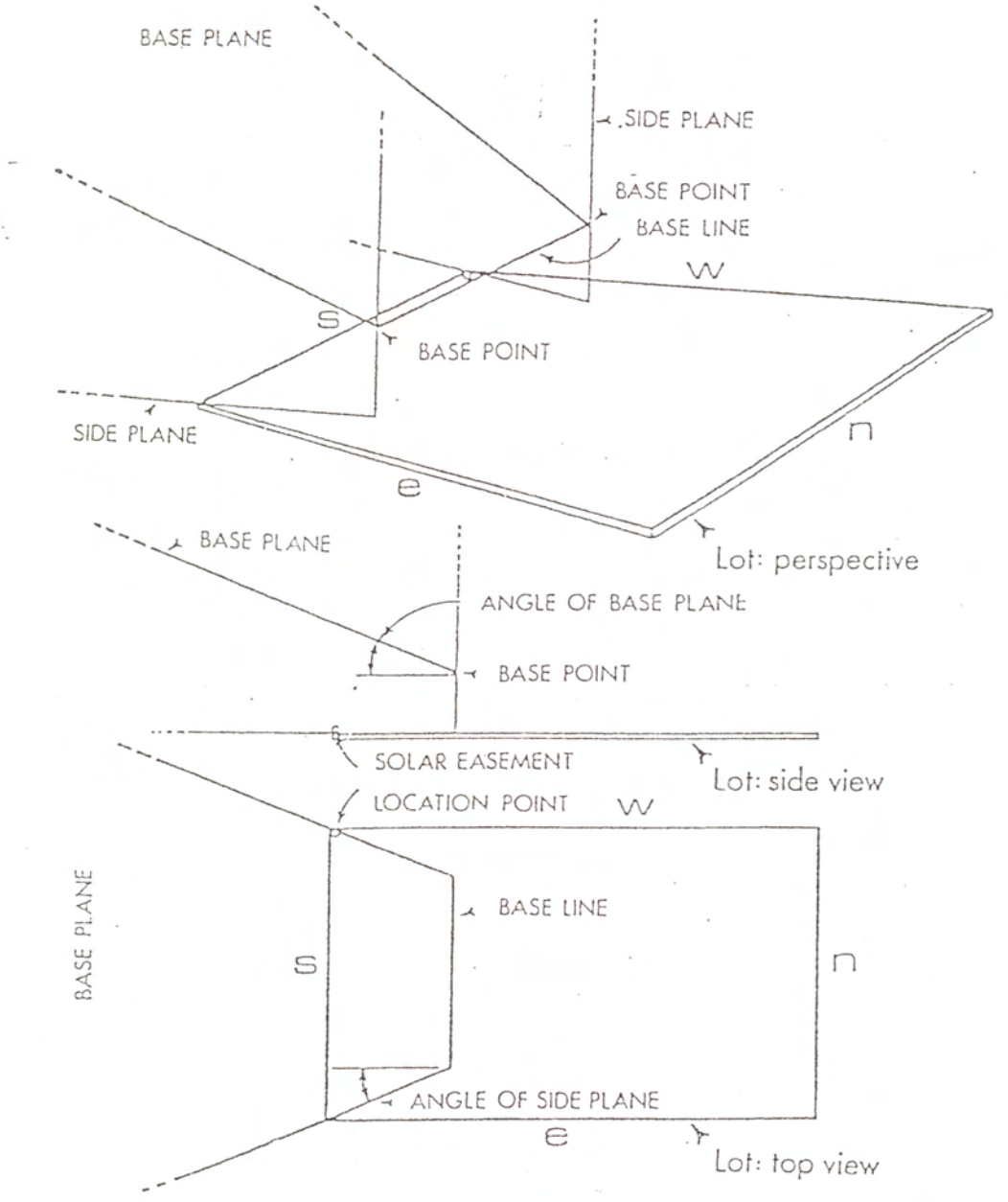


FIGURE C SOLAR PLANE EASEMENT: PERSPECTIVE (UPPER FIGURE), SIDE VIEW (MIDDLE FIGURE), AND TOP VIEW (LOWER FIGURE)

Illustrates solar easement location point, base point, base line, base plane, angle of base plane, side plane, and angle of side plane.

(3) Insert names of owners of solar lot (Grantees).

(4) Set out legal description of solar lot.

(5) Select a solar easement location point. It is important that the vertical distance be measured from a permanent, identifiable point of reference, since development or construction could change ground level elevation on some portions of the lot, thus changing the elevation of the solar easement. The United States Coast and Geodetic Survey (commonly referred to as USGS) has established benchmarks throughout the United States maintained by the Department of Interior. They are brass caps set in concrete with identified sea level elevation and location, generally at every section corner in cities, making such a pin within one-half mile of any lot. Any governmental entity maintaining a public works function has established benchmarks of latitude, longitude and elevation at locations creating identifiable elevation points within several hundred feet of any lot. Such permanently established benchmarks may be used as a solar easement location point.

An alternative is to establish a relative elevation of zero on the property itself by permanently placing a benchmark in concrete at grade surface level, or identified on a building foundation or other permanent location so that it will not be disturbed in the future. Such a benchmark may easily be made by pouring concrete in a hole and placing a nail, pin, or other such identifiable permanent mark in the top surface. All elevations may then be taken from this permanent point without involving complex calculations or costly surveying. If a relative benchmark is used, tie back into an identifiable elevation is possible.

(6) The beginning point is best located in the southwesterly (or southeasterly) corner of the solar lot. From this point, describe a path to a point on the solar lot vertically under the westerly (or easterly) most point of the base line. Then project vertically a fixed distance to a point which shall be the base point.

(7) Describe a horizontal line extending east (or west) from the base point. The line generally needs to be no longer than the horizontal length of the proposed solar collectors. It will generally be within the lot setback requirements.

(8) Describe an angle (or angles) which generally will be the horizontal angle the sun travels (azimuth) from the time you wish protection to begin, until 12 noon. The same angle would then protect for the same time period after twelve (12) noon. If different morning and afternoon protection times are desirable, two (2) different angles

(azimuths) must be used.

(9) Describe an angle which generally will be some average of the vertical sun angle (altitude) on December 21st (winter solstice) at the latitude of the solar lot during the protected hours. The farthest time from noon will be the smallest angle.

SOLAR EASEMENT

(PROPOSED FORM)

(1) *A Good Neighbor*, *hereinafter called Grantor, is the owner of the following described property:*

(2) *(Insert Legal Description of Grantor's Property).*

Now therefore, in consideration on One Dollar ($1.00) and other good and valuable considerations, the receipt of which is hereby acknowledged, Grantor does hereby grant, bargain, sell and convey unto

(3) *Sonny Sunright*, *hereinafter called the Grantee, an easement and right-of-way for access to direct sunlight in the airspace above the surface of Grantor's property extending to an infinite height and described as follows:*

(4) *(Solar Lot - Shall mean the lot benefited and owned by the Grantee)*

Lot 1, Block 1, Sunnyside Estates .

(5) *(Solar Easement Location Point - Shall mean a permanent, identifiable point of reference.)*

In this Solar Easement, the Soar Easement location point shall be:
The concrete benchmark located at the southwesterly corner of the Solar Lot, which is three feet higher in elevation than the U.S.G.S. Benchmark at the SW corner of Section X, Township Y, Range Z

(6) *(Base Point - Shall mean a point in space above the Solar Lot.)*

In this Solar Easement, Base Point shall be located as follows:
Beginning at the southwesterly corner of the Solar Lot, thence easterly along the southerly lot line eight feet, thence angle north 20 feet, then angle 90 degrees vertically ten feet above the Solar Easement Location Point to the Base Point.

(7) *(Base Line - Shall mean the horizontal line created by extending Base Point east or west.)*

In this Solar Easement, Base Point shall be located as follows:
A horizontal line extending east from the Base Point 30 feet.

(8) Side Planes - Shall be the planes created from each end of the Base Line by the vertical projection of a horizontal line from the east end of the Base Line extending south (8) - 30 degrees east, and from the west end of the Base Line extending south (8) - 30 degrees west.

(9) Base Plane shall mean the lowest boundary plane of the Solar Lot. In this Solar Easement, Base Plane shall be a plane extending upward southerly from the Base Line at an angle of (9) - 22 degrees from the horizontal.

Solar Easement - The Solar Easement shall be that airspace above that portion of the Base Plane lying between the two Side Planes.

No tree, building or other obstruction of any kind or nature shall be allowed to encroach within the airspace described. This Solar Easement is an interest in land, shall run with the land benefited and burdened and shall terminate only on the conditions stated herein or as provided by law. This Solar Easement may be enforced by an action for injunctive relief, damages, or both, plus reasonable attorney's fees and costs for enforcement. This Easement shall be binding on the heirs, successors and assigns of all parties.

IN WITNESS HEREOF, the Grantor has hereunto set his hand and seal this _____ day of _____, 20___.

By: _____
Grantor

STATE OF _____
) ss
COUNTY OF _____)

On this the _____ day of _____, 20___, before me personally appeared _____, known to me to be the persons whose names are subscribed to the within instrument and acknowledged that they executed the same for the purposes therein contained.

Witness my hand and official seal.

My Commission Expires: _____
Notary Public