

URBAN DESIGN

SUN/SHADOW STUDY TERMS OF REFERENCE

1. Purpose

To ensure that new development fits harmoniously into its existing and planned context and to adequately limit any resulting shadowing, a Sun/Shadow Study is required.

A Sun/Shadow Study is a technical document that provides a visual model and written description of the potential impact of shadows cast by a proposed development on the subject lands and surroundings including residential areas, outdoor common amenity areas (such as children's play areas, school yards, tot lots and amenity areas associated with seniors' residences, long-term care facilities, commercial and employment areas, and cemeteries) and the public realm (sidewalks, open spaces, public parks and plazas).

A Sun/Shadow Study, submitted as part of a development application, complements the City's development review process by demonstrating the potential shadow impacts of the proposal on the subject site and surroundings at various times of day throughout the year.

2. When is a Sun/Shadow Study required?

A Sun/Shadow Study must be submitted as part of a development application for an Official Plan Amendment, Zoning Bylaw Amendment or Site Plan Approval for proposals over 6-storeys or 20 m in height.

Sun/Shadow tests may also be requested for developments lower than 6-storeys or 20 m, in particular on rezoning applications, where additional height is applied for near shadow-sensitive areas (including adjacent residential properties, public parks, school yards, cemeteries, etc.).

3. Test Dates and Times

Sun/Shadow tests are required for June 21, September 21 and December 21 at **Solar Noon** (SN) and the even hours between 1.5 hours after **sunrise** to 1.5 hours before **sunset**.

Time Zone: Eastern

Standard Time: UT - 5 hours (applies on Dec 21)

Daylight Time: UT - 4 hours (applies on Jun 21 and Sep 21)

(UT denotes **Universal Time** i.e. Greenwich Mean Time)

Sun Angle Data is provided in Tables 1 to 3 in the Attachments. Additional dates and times may be required at the discretion of the City.

4. Submission Requirements

Sun/Shadow testing of alternative building massing may be required during the application review process to assist in decision-making regarding how to limit negative sun/shadow impacts.

When the massing of an application has been agreed to, a final Sun/Shadow Study will be required and prepared to the following standards.

The shadow diagrams should clearly indicate the following:

- a) North arrow (with grid to **true north** adjustment indicated), scale bar and legend;
- b) Development site;
- c) Property boundaries;
- d) Building footprints and mass within the Study Area;
- e) Streets; and,
- f) Nearby public parks, amenity spaces, cemeteries and/or publicly accessible open spaces.

Shadow diagrams will contain two parts, the first showing the existing condition and the second showing the proposed development within the existing context. The existing context should include other approved but not built buildings (e.g. approved rezoning and site plan applications) within the Study Area; these should be differentiated graphically from the proposal and the built context. See Figure 4 in the Attachments for the Sun/Shadow Study Colour Code to be used.

The diagrams should show the proposed development within the area context to a distance adequate to show the shadow reach during the requested test times, namely 4x the building height to the north, 3x to the east and west, and 1x the building height to the south (i.e. the Study Area). (Shadows from existing buildings further south should be included if they fall within the Study Area.)

The diagrams should highlight the incremental ground level shadows of the proposed development. **Incremental shadows** are those shadows over and above existing shadows, shadows from approved unbuilt buildings, and as-of-right zoning shadows for the subject site.

Base plan GIS mapping including building footprints, contours, roads, curbs, sidewalks, public parks, etc., is available from the City of Brampton and should be used in the preparation of the Sun/Shadow Study. See <https://geohub.brampton.ca/pages/data>.

The Sun/Shadow Study should be completed by a licensed design professional, such as an architect, engineer, or planner, with experience in this field.

5. Written Summary

In addition to the shadow diagrams, the Sun/Shadow Study must include a written summary of the potential shadow impacts of the proposed development. This should describe how the shadow criteria have been met and include a description of any mitigating features that have been incorporated into the site and building design. If applicable, a description and assessment of shadow-sensitive locations/uses not meeting the shadow criteria must be included.

Incremental shadows do not necessarily result in an adverse or undue impact. To be adversely impacted, the space incrementally shadowed must first of all be shadow-sensitive, and secondly, the duration and extent of shadowing must be such that it affects the utility of the space.

In reviewing any identified impacts, also take into consideration the existing and planned land use context outlined in Brampton Plan (e.g., an established low density residential area versus an area where land use changes are planned). Each proposal will be evaluated on its own merit.

6. Deliverables

- a) One digital copy of the Sun/Shadow Study is to be provided with the Urban Design Brief in the same format.
- b) A digital massing model of the proposed building, preferably in SketchUp. See Terms of Reference for 3D Models at the following link:
<https://www.brampton.ca/EN/Business/planning-development/DevelopmentApplicationGuidelines/3D%20Model%20Terms%20of%20Reference%20-Final.pdf>

7. Evaluation Criteria

These criteria focus on the pedestrian level and ground-related uses. While sunlight on windows can be expected for a few hours per day, there is no guarantee to direct sunlight unless that right is vested in the Official Plan or Zoning By-Law. Access to daylight, however, is provided by ensuring adequate separation between buildings and by setbacks stipulated in Zoning By-Laws.

Adequate sunlight, that meets the criteria described below, should be ensured on:

a) Private Personal Amenity Areas

Incremental shadows shall not exceed one hour in duration on residential private outdoor amenity areas.

The criterion for 'adequate sunlight' is met in this case if there is shadow impact for no more than two consecutive hourly test times within the space between the exterior wall of a dwelling that abuts the amenity space and the line of impact assessment ("No Impact Zone"), on Jun 21 and Sep 21. (Note: Mar 21 shadow patterns are similar to those on Sep 21 but occur 14 minutes later.)

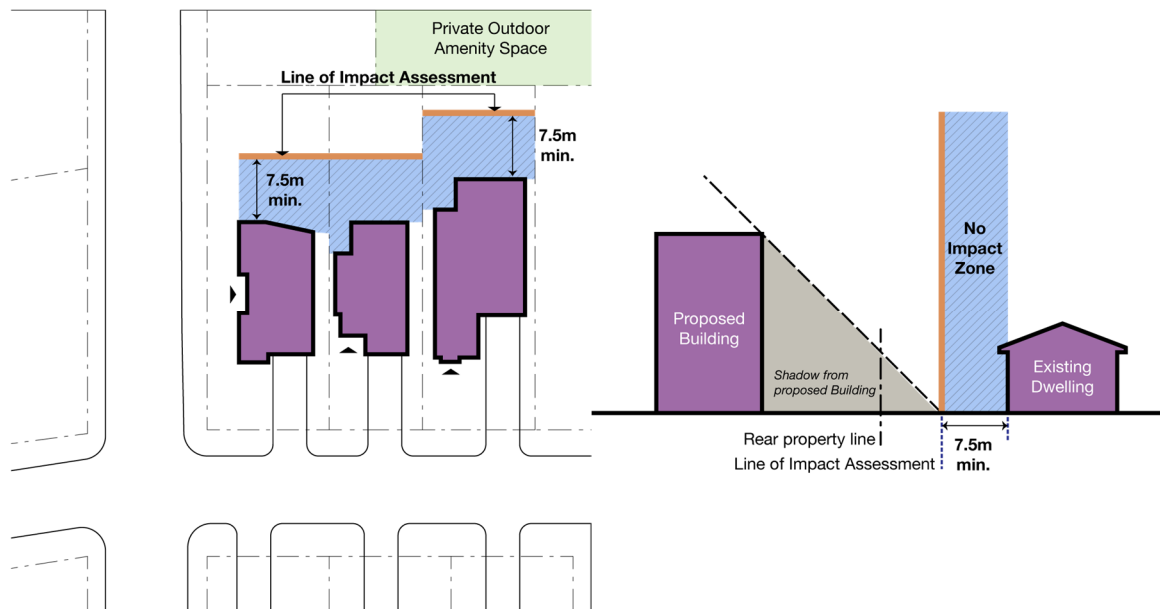
The line of impact assessment shall be a line 7.5 m minimum from the rear wall or other exterior wall of the dwelling that abuts private amenity space. See Figure 1.

Incremental shadows shall not result in less than 2 hours of sunlight. Where less than 2 hours of sunlight already exists within the "No Impact Zone", no **incremental shadow** may be added.

Balconies are not considered "Private Personal Amenity Areas" unless they are:

- i) the only outdoor living area available to the occupants,
- ii) unenclosed, and
- iii) a minimum of 4 m deep.

Figure 1 - Shadow Impact on Private Personal Amenity Areas



b) Outdoor Common Amenity Areas

Outdoor Common Amenity Areas include shadow-sensitive activity areas such as:

- i) areas where children play – such as school yards, tot lots, and public park features such as sandboxes, wading pools, etc., and
- ii) areas associated with seniors' residences, long-term care facilities, commercial and employment areas, and cemeteries.

A commonly used sun access goal for publicly accessible play areas and public park features is a 50/50 sun/shade balance during times of primary use. This allows for at least 50% of the area to be in full sunlight during the period of use. Alternatively, the 50/50 goal can be achieved by ensuring full sun on the sensitive area for 50% of the time.

Incremental shadows from proposed developments should allow for full sun at least half the time on areas where children play, or an average of at least 50% sun coverage all the time on Jun 21, Sep 21 and Dec 21.

The above applies to areas associated with seniors' residences, long-term care facilities, commercial and employment areas, and cemeteries on Jun 21 and Sep 21.

If the prime periods of use can be identified (e.g. recess/lunch times at schools, daycares, etc.) the above need apply only to those periods.

This criterion applies to offsite Public Open Spaces, Privately Owned Public Space (POPS), Strata Parks, Outdoor Common Amenity Areas, and Private Personal Amenity Areas as well as Outdoor Common Amenity Areas that are part of the proposed development. The criterion is met if the **Sun Access Factor** is at least 50%, or 0.5, on each test date.

See Attachments for details regarding the calculation of **Sun Access Factors**.

c) Public Realm

The Public Realm includes sidewalks, open spaces, public parks and plazas. These should be protected to extend their use during the shoulder seasons (spring and fall).

Sidewalks

New developments should ensure adequate sun on the opposite sidewalk in mixed-use, commercial, employment and high-density residential areas.

This is achieved by limiting the street wall height to 80% of the right-of-way width and by applying minimum standards to the tower portions of buildings including tower separation minimums, setback minimums and floorplate maximums to minimize shadowing. Minimum setbacks and setbacks are stipulated in other City planning policies, however, more stringent requirements for tower placement and floorplate size may be imposed on a site-specific basis in consultation with City staff.

Where minimum standards noted above are not met (e.g. street wall height, tower separation, setbacks, floorplates, etc.) staff will review the shadow impacts on sidewalks on a site-specific basis.

Public Open Spaces, Public Parks and Plazas

Public open spaces, public parks and plazas require a **Sun Access Factor** of 0.5 on Sep 21. (See Attachments for the SAF calculation method.)

d) Community gardens, and turf and flower gardens in public parks

Adequate sun should be provided during the growing season from March to October by providing at least 6 hours of direct sun on Sep 21.

This criterion is met if full sun is provided on any 7 hourly test times on Sep 21.

June 2024

Attachments

Sun Angles for Brampton shadow studies

Angles are based on City of Brampton City Hall latitude and longitude.

- **Latitude** 43° 41' 05" North (43.6847° North)
- **Longitude** 79° 45' 35" West (79.7597° West).

Time Zone: Eastern

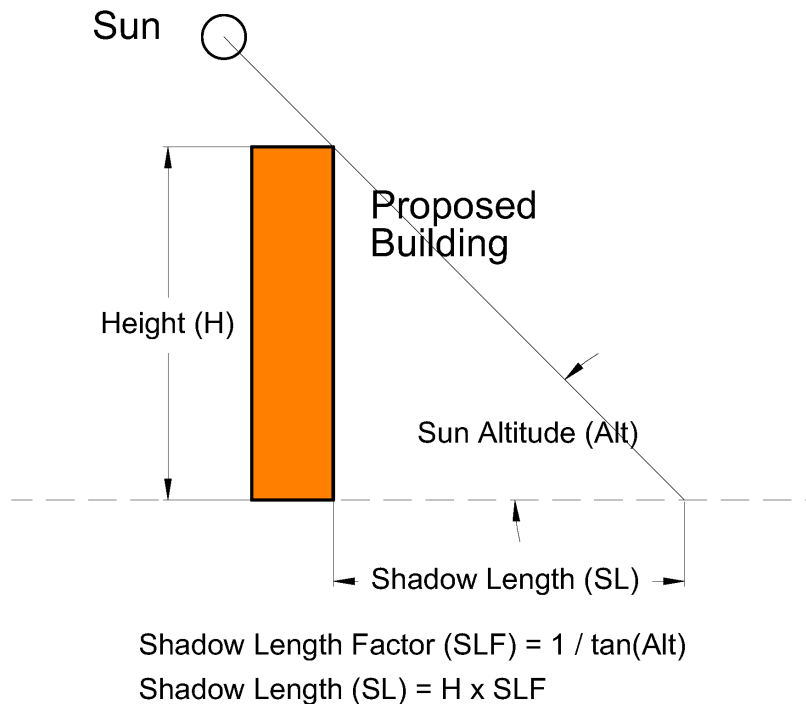
Standard Time: UT - 5 hours (applies on Dec 21)

Daylight Time: UT - 4 hours (applies on Jun 21 and Sep 21)

UT denotes **Universal Time** i.e. Greenwich Mean Time

Multiply building height by **Shadow Length Factor (SLF)** to determine shadow length as follows: Shadow Length = Building Height x **SLF**. See Figure 2.

Figure 2 – Determining Shadow Length



See Tables 1 to 3, Brampton Sun Angle Data, for **SLF** values.

Table 1 - Brampton Sun Angle Data – Jun 21

Shadow Direction and Length			
Date	Azimuth	SLF	Comments
21-Jun	(dec. deg.)	(ratio length/height)	
Local Time EDT			
5:37	235.7		Rise (for info only)
7:07			Rise + 1.5 hr (for info only)
8:00	258.75	2.3791	test time
9:00	268.49	1.5072	test time
10:00	279.49	1.0223	test time
11:00	293.50	0.7065	test time
12:00	314.07	0.4919	test time
13:00	346.33	0.3779	test time
13:21	0.00	0.3689	test time (SN)
14:00	24.81	0.3997	test time
15:00	53.18	0.5475	test time
16:00	71.23	0.7900	test time
17:00	84.06	1.1460	test time
18:00	94.54	1.7129	test time
19:00	104.12	2.8101	test time
19:34			Set - 1.5 hr (for info only)
21:04	124.3		Set (for info only)

Table 2 - Brampton Sun Angle Data – Sep 21

Shadow Direction and Length			
Date	Azimuth	SLF	Comments
21-Sep	(dec. deg.)	(ratio length/height)	
Local Time EDT			
7:05	268.4		Rise (for info only)
8:35			Rise + 1.5 hr (for info only)
9:00	288.95	2.8119	test time
10:00	301.46	1.7765	test time
11:00	316.40	1.2889	test time
12:00	334.56	1.0370	test time
13:00	355.61	0.9407	test time
13:12	0.00	0.9380	test time (SN)
14:00	17.25	0.9823	test time
15:00	36.69	1.1686	test time
16:00	52.83	1.5463	test time
17:00	66.17	2.2964	test time
17:48			Set - 1.5 hr (for info only)
19:18	91.4		Set (for info only)

Table 3 - Brampton Sun Angle Data – Dec 21

Date 21-Dec Local Time EST	Shadow Direction and Length		Comments
	Azimuth (dec. deg.)	SLF (ratio length/height)	
7:49	302.4		Rise (for info only)
9:19			Rise + 1.5 hr (for info only)
10:00	327.49	3.5170	test time
11:00	341.10	2.6631	test time
12:00	355.72	2.3831	test time
12:17	0.00	2.3697	test time (SN)
13:00	10.59	2.4547	test time
14:00	24.85	2.9279	test time
15:00	37.91	4.2619	test time
15:15			Set - 1.5 hr (for info only)
16:45	57.6		Set (for info only)

Note: Shadow **azimuth** measured clockwise in decimal degrees from **true north**.

Adjustment between Grid North and (Solar) True North

The grid coordinate system used in Brampton’s Open Data GIS mapping (<https://geohub.brampton.ca/pages/data>) is referenced to UTM Zone 17, NAD83. Since shadow studies are referenced to (Solar) **True North**, a rotational adjustment must be made to align the shadows with **True North**.

For the latitude and longitude coordinates used to generate the Sun Angle Data in Tables 1 to 3, **True North** lies 0.8567° west (i.e. counter-clockwise) of Grid North (i.e. the north direction in the City’s mapping).

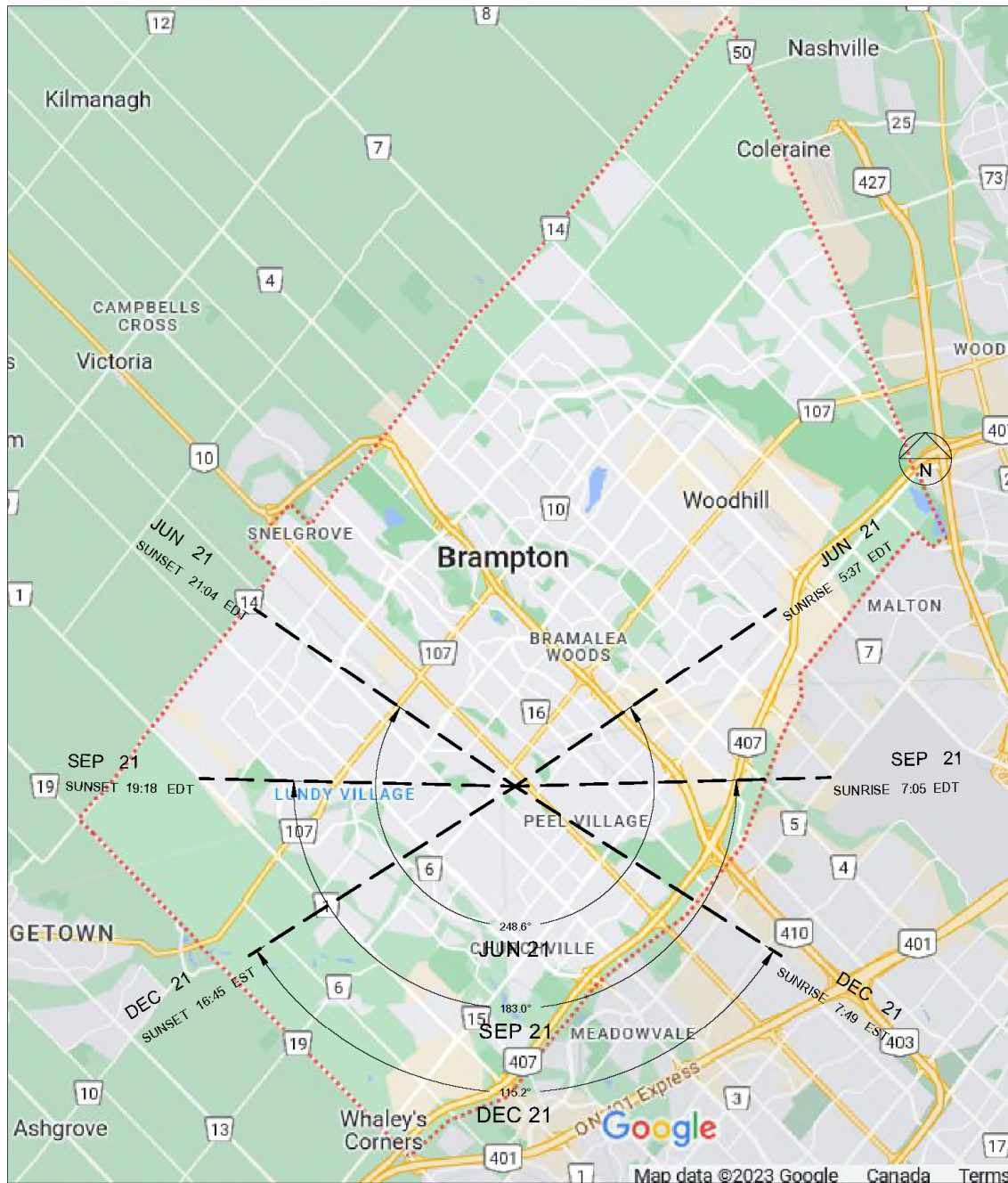
For other latitudes and longitudes (e.g. site specific), the tables do not apply and the azimuth adjustment can be provided by an Ontario Land Surveyor.

The rotational adjustment must be shown and labelled in the north arrow.

Calculating Sun Access Factors

- i) Measure the total area (A_T) of the space or feature
- ii) Measure the area in sunshine ($AS_{h1}, AS_{h2}, AS_{h3} \dots AS_{hn}$) for each hourly test time (h1, h2, etc.) (not including **Solar Noon**).
- iii) Find the average area in sun for each hourly period ($AS_{hp1}, AS_{hp2}, AS_{hp3}, \text{etc.}$).
- iv) Find the overall average area in sun for each test date (AS_{ave}) by adding the AS_{hp} values and dividing by the number of hourly periods on that date
- v) **Sun Access Factor** for each test date = AS_{ave} / A_T
- vi) For example, a test date with 10 hourly test times (h1-10) includes 9 hourly periods (hp).
- vii) $AS_{ave} = (AS_{hp1} + AS_{hp2} + AS_{hp3} + \dots + AS_{hp10}) / 9$
- viii) Finally, $SAF = AS_{ave} / A_T$







Figure 3 – Seasonal Sun Rise/Set Angles and Times - Brampton



SEASONAL SOLAR ANGLE RANGE

BRAMPTON: 43° 41' 05" North, 79° 45' 35" West

Figure 4 – Sun/Shadow Study Colour Code – Colour-Blind Friendly

Layer Colours for Sun/Shadow Study Drawings		(RGB) and HEX Values
1. Existing shadow (includes existing, as-of-right on subject site, and approved unbuilt)		
2. Proposed shadow outline*		
3. As-of-right zoning shadow outline*		(245,121,58) #F5793A
4. Incremental ground level shadow*		(133,192,249) #85C0F9
5. Approved unbuilt building footprint		(169,90,161) #A95AA1
6. Open spaces (Shadow sensitive areas)		(63,171,23) #3FAB17

*NOTE: Shadows are to be drawn at ground level.

Definitions

Altitude - the vertical angular distance, measured in degrees, between the horizon and the centre of the sun's disk (positive above horizon).

Azimuth - the bearing, or direction of the sun, as viewed by an observer, measured in degrees clockwise from **true north** (e.g. North = 0°, East = 90°, South = 180°, West = 270°).

Daylight Saving Time (or **Daylight Time**) - **Standard Time** adjusted by adding 1 hour. Starting in 2007, **daylight time** begins in North America on the second Sunday in March and ends on the first Sunday in November. (On the second Sunday in March, clocks are set ahead one hour at 2:00 a.m. local **Standard Time**, which becomes 3:00 a.m. local **daylight time**. On the first Sunday in November, clocks are set back one hour at 2:00 a.m. local **daylight time**, which becomes 1:00 a.m. local **Standard Time**.)

Declination - the angular distance, measured in degrees, between the celestial equator and the direction of the observer to sun. It is equivalent to **latitude**. By convention, when the sun lies north of the equator, **declination** is positive (Mar 21 to Sep 21); similarly, south of the equator is negative (Sep 21 to Mar 21). Maximum of +23.5° occurs about Jun 21; minimum of -23.5° occurs about Dec 21.

Equation of Time - also known as the "Sundial Correction", this time correction factor takes into account the variations in the earth's velocity as it travels through its elliptical orbit.

Hour Angle - the angle between an observer's **meridian** and the sun's **meridian**. Measured from south; west of south is positive, east is negative.

Incremental Shadows - net new shadows over and above all existing building shadows and as-of-right shadows from the approved zoning massing envelope for the subject site along with shadows from approved but not yet built buildings.

Latitude - the angular distance, measured in degrees, between the equator and an observer's location. North of the equator is positive; south is negative.

Local Civil Time - **Standard Time** corrected for one's actual location based on **Longitude** east or west of the **Time Zone's** central **Meridian**. (Correction applied at the rate of 4 minutes per degree.)

Local Time - local watch time (**Standard Time** or **Daylight Saving Time**).

Longitude - the angular distance, measured in degrees, between the **Prime Meridian** (0 degrees **Longitude** at Greenwich, England) and an observer's location. West of Greenwich is negative; east is positive.

Meridian - a line of **Longitude**.

Prime Meridian - Longitude “zero” which runs through Greenwich, England.

Shadow Length Factor (SLF) - ratio of shadow length to object height. It is the factor by which to multiply an object’s height to find its shadow length. ($SLF = 1 / \tan \text{Altitude}$)

Solar Noon - local time at which the sun crosses the local **Meridian**. At **Solar Noon** the sun is due south and reaches its peak. It is approximately the midpoint between **Sunrise** and **Sunset**.

Standard Time - the time within a specified **time zone**. Usually varies from Greenwich Mean Time (GMT) by an even number of hours. (e.g. EST = UT - 5)

Sun Access Factor (SAF) – the ratio of sun duration over a given area expressed in percent (e.g. a 50% **sun access factor** can mean 50% sun coverage 100% of the time, or 100% sun coverage 50% of the time).

Sunrise/Sunset Time - local time at which the upper edge of the sun’s disk appears on the horizon. The time takes into account average refraction conditions (34 arc minutes) and half the sun’s diameter (16 arc minutes).

Time Zone - a 15° wide zone within which all watch times are the same for the sake of convenience. Each zone represents one hour, and they are measured in about 15° increments east and west from the **Prime Meridian**, which is the centre of the first zone. (The central **meridians** of some sample **time zones** occur at **longitudes** 15, 30, 45, 60, 75 degrees west, etc. Brampton lies in the Eastern **Standard Time** Zone centred on **longitude** 75° west. Since each 15 degrees represents one hour, EST is 5 hours behind Greenwich Mean Time.)

True North - is the direction along Earth's surface towards the **True North Pole**. All lines of **longitude** point **True North**.

True North Pole - is the north end of the imaginary rotational axis of the Earth. All lines of **longitude** converge at the **True North Pole**.

True Solar Time - Local Civil Time + Equation of Time.

Universal Time (UT) – commonly used synonym for Greenwich Mean Time (GMT).

References

- A. Toronto Development Guide – Sun/Shadow Study Terms of Reference (City of Toronto, June 2022)
- B. Urban Design Terms of Reference – Standards for Shadow Studies (City of Mississauga, February 2023)
- C. Development Application Guidelines - Shadow Impact Analysis (Town of Oakville, December 2017)
- D. Shadow Study Guidelines and Terms of Reference (City of Burlington, June 2020)
- E. Development Application Guidelines - Sun Shadow Study (City of Hamilton, October 2022)
- F. Downtown Urban Design Guidelines, Section 1.1.18 Shadow Impacts (City of St. Catharines, 2012)
- G. Urban Design Manual, Part 4.0 Site Plan Review Guidelines, Section K - Shadow Study Criteria (City of Waterloo)
- H. Sun and Shadow Study Terms of Reference (City of Guelph, May 2019)
- I. Shadow Impact Analysis Guidelines (Town of Milton, November 2019)
- J. Zoning By-law and Official Plan Amendment Application (City of Cambridge, December 2017)
- K. Terms of Reference: Sun and Shadow Study (Town of Caledon, July 2023)
- L. Terms of Reference: Sun/Shadow Study (City of Vaughan)
- M. Sun & Shadow Study Terms of Reference (Town of Richmond Hill, January 2022)
- N. Sun & Shadow Study Terms of Reference (Town of Markham, February 2023)
- O. Site Plan Application Process Manual - Shadow Impact Study Guidelines (Town of Newmarket, March 2023)
- P. Application for Site Plan Approval – General Information and Procedures - Shadow Study Guidelines (Town of Whitby, April 2015)
- Q. Terms of Reference - Shadow Analysis (City of Ottawa)
- R. Brampton Official Plan – Final Draft (September 2023)
- S. Tall Building Design Guideline - Second Draft (City of Brampton, September 16, 2022)
- T. Cityplan '91 Report Number 25 - Sun, Wind, and Pedestrian Comfort – A Study of Toronto's Central Area (Bosselmann, Arens, Dunker & Wright, April 1991)
- U. Sun Easements to Parks – Implications for Planning and Zoning Toronto's Central Area (Wight & Hoinkes, June 1992)
- V. Decisions of the Ontario Municipal Board
- W. Environmental Noise Guideline – Stationary and Transportation Sources – Approval and Planning (MECP Publication NPC-300, Aug 2013 ver. #22)