Gradient Microclimate Engineering Inc.

August 17, 2009

Michael Agate, VP
Cannon Design
2170 Whitehaven Road
Grand Island, New York 14072

Dear Mr. Agate:

Re: Renovations / Additions to Science, Engineering and Technologies (SET) Building, SUNY Oswego
Preliminary Wind, Snow and Air Quality Assessment
***GmE* File Ref.: 09-030**

1. INTRODUCTON

In support of detailed design development, Gradient Microclimate Engineering Inc. (*GmE*) was retained by Cannon Design to undertake a qualitative design review for the planned expansion to the Science, Engineering and Technologies (SET) Building located at the State University College of New York at Oswego. The main goals of this review are to identify design or massing features that create pedestrian comfort concerns at grade; severe adverse snow drifting conditions, and possible exhaust re-entrainment problems at fresh air intakes or at operable windows. As well, an initial review will be performed relating to the wind energy potential of various rooftop areas. The current qualitative assessment will be followed with detailed wind tunnel testing to address these issues in quantitative terms. Figure 1 illustrates a site plan with building footprints.

The assessment is based on drawings received from Cannon Design, a recent site visit and a review of satellite imagery, supported with statistical analyses of available wind climate data available directly on the SUNY Oswego site. Relevant background information and results of our analysis are provided in this summary letter.

The future SET building represents the expansion of the current Piez Hall, located at the northeast end of the campus surrounded by buildings of similar height. The proposed expansion of Piez Hall comprises somewhat taller wings added to the east and south sides of the current building on adjacent parking and green spaces. Piez Hall currently consists of three storeys rising to a height of approximately 66 feet (') above grade. The new wings are four-storey sections rising to a height of 82' above grade. Access to the building is provided on the south and west elevations. A sidewalk canopy is provided along the north side of the south wing of the new addition leading to the main entrance. Four new laboratory exhaust stacks are provided on the south wing of the new additions. A generator exhaust stack and fresh air intake louvers are included on the east wing of the new additions. The existing fresh air intakes and four cooling towers will remain on the north wing of the existing roof facing an interior courtyard. Figure 1 illustrates a current site plan of the development.

2. BACKGROUND

The essential aspects of a wind analysis include: (i) consideration of the massing of the site, along with shape and orientation of the buildings; (ii) consideration of the statistical properties of the local wind climate. Integration of the first two elements provides site specific data for the assessments covered by this report including: (i) pedestrian wind comfort, (ii) snow drifting at grade, (iii) exhaust dispersion from key stacks, and (iv) wind energy generation.

Meteorological data from Piez Hall and Oswego Harbor, covering a period of 8 years and 5 years respectively, were analyzed to obtain separate statistical models of wind speed and direction for subsequent analysis. The data from Piez Hall were recorded every half hour, while the data from Oswego Harbor were recorded every 6 minutes. Inspection of annual and seasonal wind statistics for Oswego, presented in Figures 2a through 3b, shows the wind speeds at three probability levels (i.e. inner curve – once per month, middle curve – once per year, outer curve – once in ten years), as a function of wind direction. On an annual basis, the prominent wind directions are centered on the west quadrant and occur with substantial strength from the north. On a seasonal basis, the prominent wind directions continue to occur from the west quadrant, but vary substantially in specific form. The autumn and winter winds are strongest for most directions. The summer months display calmer winds for all directions. In wind engineering, wind direction represents the wind origin so that a north winds blows from north to south.

Physical features of the site which influence the wind environment include: the massing of surrounding buildings; the massing of the study site, as well as the shape and configuration of the study building itself. Development over time typically increases the density of buildings which provides greater shielding to wind and calmer wind conditions at grade. Increased building density provides shelter from the on-coming wind which lowers the average wind speed but creates increased turbulence (i.e. wind gusting). In terms of wind exposure, the proposed development is generally surrounded by low-rise buildings representing a suburban exposure, with water exposure from the northerly wind directions coming off Lake Ontario.

3. CRITERIA

Regarding wind comfort the criteria used by *GmE*, in-line with industry standards, ensure that pedestrian conditions are comfortable:

(i) for sitting, when the gust wind speed is less than or equal to 8.7 miles per hour (mph) for 70% of the time or more;

(ii) for standing and strolling, when the gust wind speed is less than or equal to 14 mph for 80% or more of the time;

(iii) for walking, when the gust wind speed is less than or equal to 19 mph for 80% or more of the time.

GmE uses gust wind speeds in the criteria because people are most sensitive to wind gusts rather than average wind speeds. It should be noted that these criteria are applied according to the intended use of the outdoor area. For example, an entrance to a building should be suited for walking, standing or strolling, but need not be suitable for sitting. Specific wind conditions for the proposed site are discussed in the following section.

Regarding dispersion of stack emissions, exhaust gas concentrations can be compared against available criteria, from the Environmental Protection Agency (EPA) and from the American Conference of Governmental Industrial Hygienists (ACGIH) among others, when specific contents of the emissions are known. For the present qualitative study, air quality will be guided on the basis of dimensionless dilution ratios which provide the factor by which an exhaust concentration is diluted between the source and the receiver. For example, a dilution of 500 indicates that the concentration from a particular source is reduced 500 times at the receiver. Dilution ratios greater than 500 are often required for common laboratory emissions for satisfactory performance. For more exotic gases or gases with low odor / health thresholds, dilution ratios approaching 2000 may be required. For highly intermittent sources, such as emergency generators, dilution ratios of 100 to 200 may be sufficient depending on common wind directions. The detailed wind tunnel study will provide accurate dilution ratios for each source – receiver combination.

Snow drifting severity is judged based on experience without the benefit of any specific criterion.

4. PEDESTRIAN WIND COMFORT PREDICTIONS AT GRADE

Based on foregoing information and review of architectural drawings, we foresee the following conditions at grade level:

(i) The pathway along the north side of the development is expected to be one of the windiest locations around the development due to its exposure to persistent west winds and north winds off Lake Ontario. Nonetheless, conditions are expected to be suitable for standing and strolling during the summer and suitable for walking during the remaining three seasons. These conditions are not expected to change as a result of the new additions.

(ii) The west side of the development is expected to experience moderately strong winds due to commonly occurring west and north winds, as well as due to funneling created by the new SET building and the existing Poucher Building. Wind conditions are expected to be suitable for walking during the three warmer seasons but may become unsuitable for walking on a regular basis during the winter months. This area is expected to require mitigation to achieve comfortable wind conditions for pedestrians on a year-round basis. Mitigation will be recommended, if required, based on the wind tunnel test results.

(iii) The main west-facing entrance at the recessed north side of the new south wing appears to be well protected for most wind directions. The canopy will further mitigate the downwash from west winds. As such, conditions at the main entrance are expected to be suitable for sitting or standing and strolling year round.

(iv) The recessed green space protected on three sides on the west side of the building is expected to experience calm conditions over much of the area similar to the main entrance. We expect that conditions will be suitable for sitting during the summer months, standing and strolling during the spring, autumn, and winter months.

(v) Wind conditions along the south elevation of the development including the area under the cantilever floor above, as well as the sidewalk and the entrance located at the southeast corner are expected to be moderately windy due to the unimpeded west winds passing over this area. We expect these locations to be suitable for standing or strolling during the summer and walking during the remaining seasons; conditions which are suitable for the location. Door operation may be adversely affected by the same strong winds. A solution to this problem would be either to use revolving doors, or provide a vestibule with two sets of doors designed so that both doors cannot be opened at once.

(vi) The east elevation of the SET building will be connected with a one storey link building to the existing Wilber Building. The placement of this area relative to the strong wind conditions and the added shielding provided by the two buildings and the link structure is likely to create moderately calm wind conditions on both the north and south sides of the link between the two buildings. Conditions are expected to be suitable for standing and strolling during the three warmer seasons and suitable for walking during the winter. However, pedestrian traffic is expected to be low in this area nonetheless.

(vii) Within the context of typical weather patterns, excluding severe local storm events such as thunderstorms, no dangerous or consistently strong wind conditions have been discovered anywhere on site on an annual basis.

5. SNOW DRIFTING

Common wind directions during snow storm events occur predominantly from the north and west. This section discusses potential impacts of excess snow accumulation on pedestrian use of the building and snow clearing operational considerations. This report addresses rooftop snow drifting only as it relates to the location of snow drifts. Calculation of snow loads is outside the scope of this study which is usually determined by the structural engineer based on code calculations. Based on the orientation of the building, and the massing of existing buildings, we expect the following conditions to exist at grade. In general terms, strong wind areas will be scoured clear of snow, whereas calm wind areas are expected to accumulate snow drifts. More specifically, supported by the comments in Section 4 above:

(i) North and west winds will tend to scour much of the snow away from the north side of the SET building, keeping it relatively clear of significant snow drifts.

(ii) The recessed lawn area on the west side of the SET building will likely see significant snow accumulations due to drifting from the roof and shelter from north and west winds, which may extend to the main entrance on the north side of the new south wing. In this case, the entrance will require regular snow clearing. Although the accumulations around the entrance are not expected to be severe, they are expected to occur frequently during the winter months.

(iii) West winds will create snow deposits over the street and pathways between the Poucher building and the SET building, which will be scoured to some degree by northwest and north winds. Snow is expected to accumulate with some consistency and depth along the entrance of the Poucher building, some of which will get drifted away by north winds towards the south and into the recessed lawn area on the west side of the SET building.

(iv) The same winds will deposit snow on the south elevation of the south wing of the new additions. The entrance on the southeast corner will likely see excess accumulations during most significant snow events arising from the east, which can be handled with regular snow clearing.

(v) However, the secondary entrance under the cantilever floors on the southwest end of the SET building is expected to be scoured clear of snow under most circumstances.

(vi) The east elevation of the SET building is expected to collect significant snow drifts on the south side of the link and less significant amounts on the north side.

(vii) Snow accumulations over the new higher roof of the SET building, on the east and south sides, are expected to be scoured off the roof under most circumstances, being retained only by the parapet height. A taller parapet will retain more snow on the roof which will reduce snow accumulations on adjacent lower roofs of the existing Piez Hall and the east side of the building at grade.

(viii) Snow accumulations are expected to increase on the lower roofs of the existing Piez Hall with the expansion to the new SET building due to the presence of the taller adjacent roofs of the new SET but also because of added constraints to drifting. The lowest central area of roof surrounded by the taller roofs of the SET building is expected to receive the largest amounts of snow accumulations.

(ix) ASCE 7-05 can be used to predict the snow loading created by these conditions.

Wind tunnel testing for snow drifting at grade will be conducted to assess the location of accumulations for common wind directions. While these tests are not intended to measure the actual snow depth, they are adequate to indicate extents and locations of snow drift zones.

6. WIND ENERGY ASSESSMENT

A wind energy demonstration project using wind turbines is being considered for the roof of the future SET building. As such, the purpose of this preliminary assessment, supported with wind tunnel measurements at a later time, is to select preferred locations for wind turbines on the roofs of the SET building which would generate the most electric energy from the wind.

In general terms, the SET building is well situated along the south shore of Lake Ontario, for wind energy generation, having favorable topography and little interference from surrounding taller buildings. According to available 8 year wind speed data recorded on the rooftop of the existing Piez building, wind speeds suitable for turbine operation occur nearly 80% of the time. The current placement of nine wind turbines illustrated on the north face of the penthouse above the Piez Hall portion of the SET building (Figures 4 and 5) would be unproductive for energy generation due to the following factors:

(i) The penthouse where the turbines are located shields winds from most directions, from east through southwest rotating clockwise as viewed from the top.

(ii) The shielding by the new wings of the SET building, which are 16 feet higher than the wind turbines, limits the amount of available wind energy for many wind directions.

(iii) Even for northerly winds, the placement of the turbines backed into the wall of the penthouse directs wind to flow over the penthouse instead of through the turbines to generate energy.

The best locations for the installation of wind turbines would be the highest building roof areas on the future SET building with the least amount of clutter by other equipment. The preferred locations for the given massing of the SET building are illustrated as points 1, 2 and 3 in Figure 5. Placement 4 would be the best choice if the wind turbines would have to be located on the roof of the existing Piez Hall. The influence of surrounding buildings on the placement of the turbines is insignificant due to their generally low heights and low density.

Placement of the wind turbines should be separated from any stacks, cooling towers or other rooftop equipment by at least five times the largest dimension (plan or elevation) of the objects. As such, considering the adverse effects from the four exhaust stacks on the top of the SET building and the preferred strong wind directions illustrated in Figure 2, the most likely preferred location for wind turbine installation will be location 1 at the east end of the high roof of the SET building. The second and third best choices will be points 3 and 2 respectively. It is also suggested to keep the spacing between turbines at least equal to their largest dimension (height and width) in order to maximize power generation from each unit. Furthermore, the best arrangement for multiple turbines would be in a straight line oriented approximately 45 degrees from north towards east. A grid arrangement of multiple turbines at the same elevation is not recommended as interior turbines would be shielded for all wind directions.

The wind data from the anemometer on the existing Piez building (Figure 6) includes the local wind acceleration effect over the building itself, as well as the influences from surrounding buildings. As such, the data available from this anemometer provides ideal information for predicting the electric power available from the wind at the location of the future SET building. Hence, based on 8 years of available recorded wind data, the energy available from the wind has been estimated assuming a typical turbine efficiency of 35% including mechanical power conversion, and mechanical transmission losses among others. It has also been assumed that the cut-in and cut-out wind speeds for typical turbine operation are 4 mph and 30 mph respectively.

Table 1 presents results of wind energy production based on the projected frontal area of a turbine in kilowatt-hours per square meters (kwh/m^2) per month of operation. Hence, for a given number of turbines of a given size, the total estimated power generation can be calculated. Alternately, the power required in the building can be used as a design target to select the number and size of turbines to deliver this power.

TABLE 1: PREDICTED WIND ENERGY GENERATON ON THE PIEZ BUILDING ROOF PER YEAR*

Year	kwh/m^2 Per Month	Year	kwh/m^2 Per Month
2001	33.2	2005	34.0
2002	35.4	2006	30.0
2003	36.7	2007	39.9
2004	32.5	2008	31.1
		Annual Average	34.1

NOTES: Values are KWH per square meter of effective blade sweeping area per month
Values assume that the turbine will be at the height of the current anemometer

*It is assumed in the calculation that wind is continuously blowing at an average wind speed between two consecutive measurements (30 minutes).

The estimated electric energy generation can be calculated by:

$$E = P \times S$$

Where E is output electric energy in kwh per month; P is the estimated annual average energy in kwh per square meter per month from Table 1; S is the swept area by wind turbine blades for either the horizontal axis wind turbine (HAWT) or the vertical axis wind turbine (VAWT).

As an example, if a diameter D= 4.9 ft (1.5 m) horizontal axis wind turbine (HAWT) is installed, the monthly energy capacity will be about:

$$E = P \times \pi D^2/4 = 34.1(\text{kwh/m}^2\text{/month}) \times \pi \times 1.5^2(\text{m})/4$$
$$=60.3 \text{ kwh per month}$$

i.e. 2 kwh per day, which can run thirty-six (36) 13w compact fluorescent lights (CFL) for 4 hours each day on average.

It is noteworthy that vertical axis wind turbines (VAWT) are inherently less efficient than the horizontal variety (HAWT) due the characteristics of vertical axis wind turbine (VAWT). Furthermore, the wind generator performace of VAWT will be also influenced more than HAWT by rapid wind speed gradient change near the building edges.

Detailed investigations will be undertaken in the next phase of the study using the wind tunnel and computer (CFD) analysis to determine the preferred placement of turbines for maximum energy generation, including recommended heights.

6. EXHAUST RE-ENTRAINMENT ASSESSMENT

In the absence of specific knowledge about chemicals in the exhaust stream, pollution levels from rooftop exhausts are considered in terms of dilution ratios. The dilution ratio for a given discharge represents the dimensionless ratio between the concentrations of any non-reactive chemical specie at the source, to the concentration of the same gaseous specie measured at the receiver. Figure 7 illustrates the roof plan with proposed exhaust stacks and fresh air intakes. Based on roof geometry, stack height and exhaust flow rates, theoretical estimates of dilution ratio at rooftop fresh air intakes and operable windows due to the new laboratory exhausts are presented in Table 2. It should be noted that these calculations are conservative as they cannot account for the complexities of wind flow and exhaust fan operation, all of which will be evaluated during the wind tunnel test phase of the work. In the meantime, the following guiding statements are presented.

(i) Worst case (lowest) dilution ratios[1] for the nearest fresh air intake, including operable windows from each of the four lab exhaust stacks, is expected to be 200 assuming that the chemical species is unchanging during its travel from the source to the receiver.

(ii) With these effective dilution ratios, moderate but frequent violations of health or odor criteria are expected to occur at the rooftop fresh air intakes and operable windows for some common chemicals, such as formaldehyde. However, significant violations are expected to occur for more exotic chemicals or chemicals with a low odor and health threshold, such as the Mercaptan family of chemicals.

(iii) Once the uses of the facility are known and specific chemicals identified, detailed analyses can be performed to confirm specific conditions.

(iv) Based on experience, dilution ratios of between 500 and 1000 are necessary to reduce the risk of contamination at fresh air intakes for most common chemicals. Exotic chemicals may require even higher dilution depending on odor or health thresholds.

[1] Worst case dilution ratio corresponds to least dilution and highest potential concentrations of a gaseous pollutant.

(v) The dilution ratio at the rooftop fresh air intakes and operable windows arising from the generator exhaust stack is expected to be approximately 200. Whereas this outcome is generally unacceptable for normal operations as indicated previously, the intermittent testing and emergency use of these fans makes the issue of exhaust re-entrainment a secondary priority during emergency scenarios.

(vi) The dilution ratio at the rooftop fresh air intakes arising from the cooling tower stack is expected to be approximately 10. This represents very poor dilution for the majority of gaseous pollutants present in exhaust air streams. While water vapor is not harmful to people, the impact on equipment can be detrimental at this dilution. Concerns may occur regarding corrosion of metal or control of humidity inside the SET building served by the fresh air intakes. If the water vapor contains trace contaminants these can be dealt with in the same way as for other sources when the concentration at the source is known.

(vii) The impact of the new laboratory exhausts and generator exhaust to the neighboring buildings is expected to be minor for common chemicals due to the distances involved, and the increased natural dilution. However, exotic gaseous chemicals species or those with low odor and health thresholds may cause problems for surrounding buildings as well.

(viii) Once the chemical species in the exhaust air can be quantified, precise contamination levels can be determined from dilution ratios and compared against accepted industry criteria.

Wind tunnel testing, as well as CFD modelling and simulation for exhaust dispersion studies will be conducted to obtain detailed information at fresh air intakes and other sensitive locations.

TABLE 2: DILUTION RATIO

Exhaust Sources	Fresh Air Intake 1	Fresh Air Intake 2	Nearest Operable Window
Generator Exhaust	3500	200	200
Cooling Tower	10	150	20
Exhaust Fan 1	1000	2000	200
Exhaust Fan 2	900	1500	200

7. SUMMARY AND FUTURE STEPS

Based on a qualitative analysis of site plans, building forms and local climate, we conclude that the pedestrian wind conditions around the proposed development site are expected to be moderate in most areas, suitable for standing and strolling much of time during the summer months, extending from late spring to early fall. The windiest location is expected to be at the northwest corner of the site, where conditions will remain suitable for walking much of the time on an annual basis. The recessed green space on the west side of the development are expected to be relatively calm on an annual basis and suitable for standing and strolling or sitting for much of the time during the spring, summer and autumn months. The canopy covered main entrance area will see calm wind much of the time on an annual basis.

Significant snow accumulations are expected to occur primarily around the entrance located at southwest corner of the new additions, over the recessed green spaces, and on the east side of the building. The additional snow accumulations predicted around this new building can be handled with moderate increase of existing snow maintenance capacity for the rest of the campus. A regular snow maintenance program will adequately protect pedestrians and users of the building. More specific information about snow locations will be determined based on wind tunnel testing.

Roof areas of the existing Piez Hall nearest to the expanded SET roofs will experience increased levels of snow accumulation. While the wind tunnel testing will identify the roof areas affected, these should be reviewed and designed by the structural engineer according to the requirements of ASCE 7-05.

The most suitable location for wind turbine installation will be the highest open areas on the rooftop of the SET building. The east end and west end of the added building roofs are the best potential candidates. Any installed turbines should be well separated from other roof equipment or prominent roof structure. Single row turbine installation aligned in the northeast-southwest direction with adequate spacing between turbines will assure the best performance.

Laboratory emissions through four dedicated roof stacks on the new additions are likely to create unacceptable levels of pollutants at rooftop fresh air intakes, from time to time, for common laboratory chemicals. Contamination from exotic chemical emissions or gaseous chemicals with low health and odor thresholds will be more frequent and acute. Similar results for the generator exhaust stack are of secondary importance due to the infrequent use of the stack. Common laboratory emissions are not likely to cause air quality problems for neighbouring buildings or grade levels pedestrian areas around the SET building. However, exotic or low health and odor threshold chemicals may produce excess levels at surrounding buildings. Water vapours from the cooling tower may be harmful to mechanical equipment and indoor environmental control at fresh air intake 1. Concerns may occur regarding corrosion of metal or control of humidity inside the SET building served by the fresh air intakes. If the water vapor contains trace contaminants, these can be dealt with in the same way as for other sources when the concentration at the source is known. These results will be studied by means of detailed wind tunnel testing.

The foregoing analysis and statements are based on experience and knowledge of wind flow patterns. While statements of the general conditions are expected to be reliable for the site as a whole, localized conditions being dependent on detailed features of the buildings, landscaping, and actual outdoor uses of the areas, are more difficult to predict. As a result, this assessment is intended to provide general guidance, but is not a substitute for wind tunnel testing. Wind tunnel testing for pedestrian level comfort, snow drifting at grade and over the roof of the building, and building laboratory exhaust re-entrainment will be conducted to provide detailed assessments.

This completes our preliminary desk top assessment. Please advise the undersigned of any questions or clarifications required.

Yours truly,

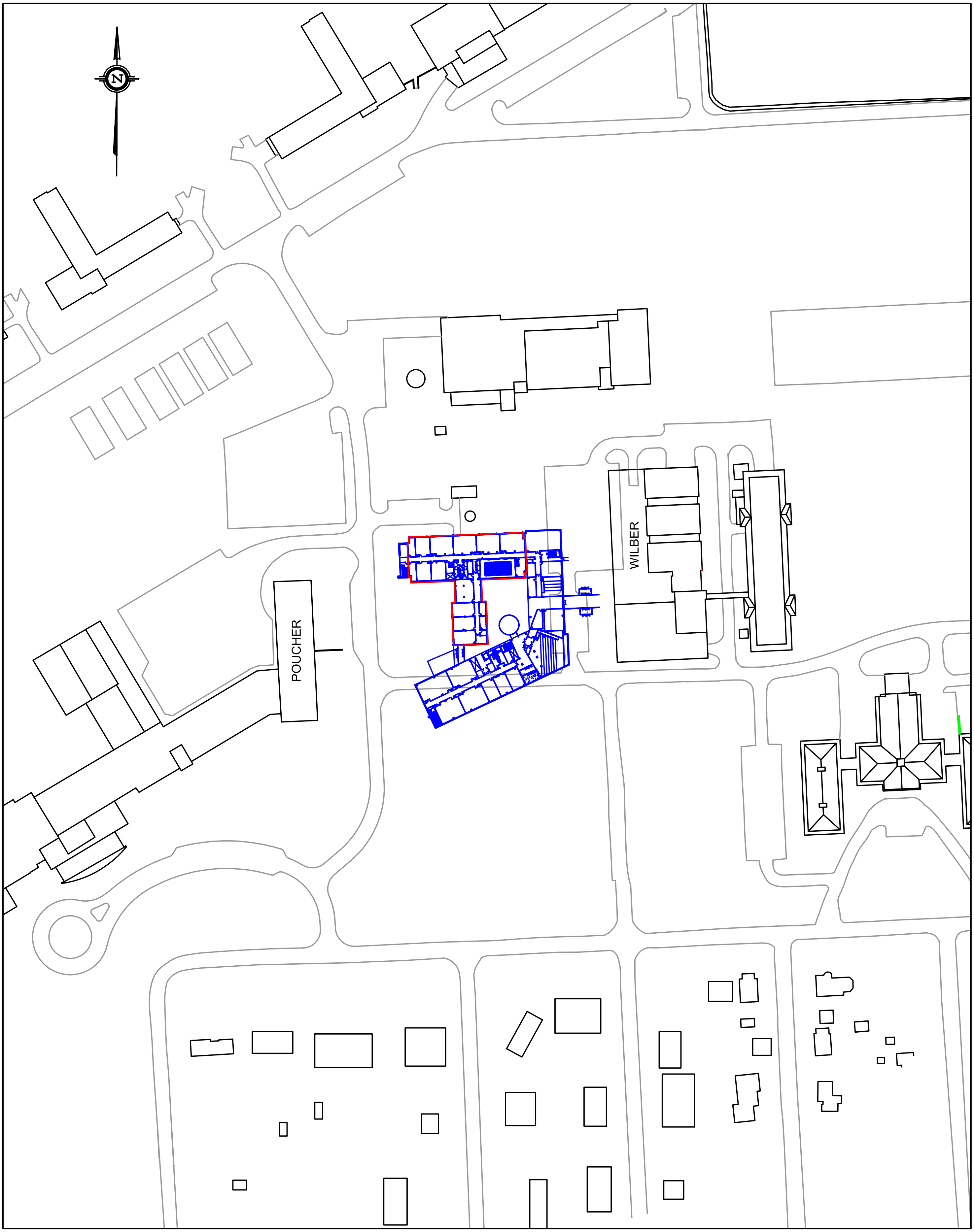
Gradient Microclimate Engineering Inc.

Lei Gong, PhD, P.Eng
Project Engineer

Vincent Ferraro, M.Eng., P.Eng.
Principal

Haiye Lou, PhD, EIT
Project Engineer

GmE 09-030



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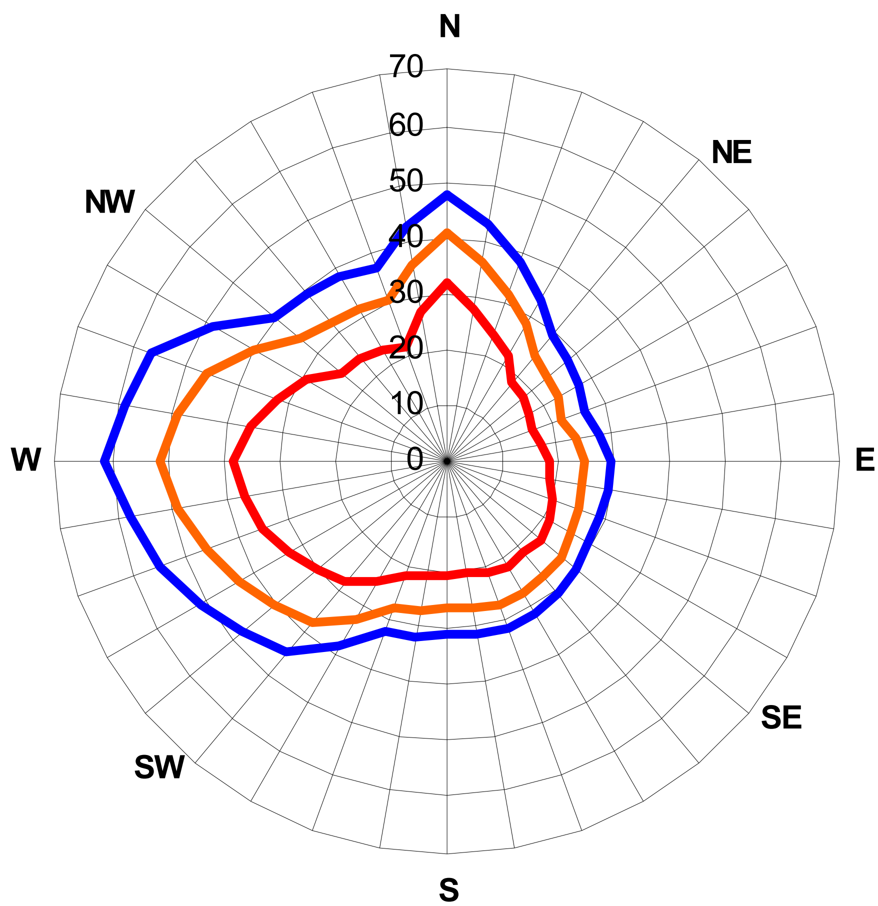
GmE Gradient Microclimate Engineering Inc

PROJECT SCIENCE, ENGINEERING AND TECHNOLOGIES (SET) BUILDING - DESKTOP STUDY		DESCRIPTION
SCALE 1:2500 (APPROX.)	DRAWING NO. GME09-030-DESKTOP-1	FIGURE 1: SITE LOCATION AND SURROUNDING CONTEXT
DATE AUGUST 17, 2009	DRAWN BY L.G.	



ANNUAL

Radial Distances Indicate Wind Speed in Miles per Hour (mph)

A Point Along The Innermost Contour Represents The Wind Speed Exceeded On Average 0.14% (once per month) Of The Time Within a 10° Sector Centered On That Direction. The Middle and Outermost Contours Represent Probability Levels of 0.01% (once per year) and 0.001% (once per 10 years) Respectively.

Figure 2a: Annual Distribution of Wind for Various Probability Levels at 33 Feet, SET building, State University of New York at Oswego, NY

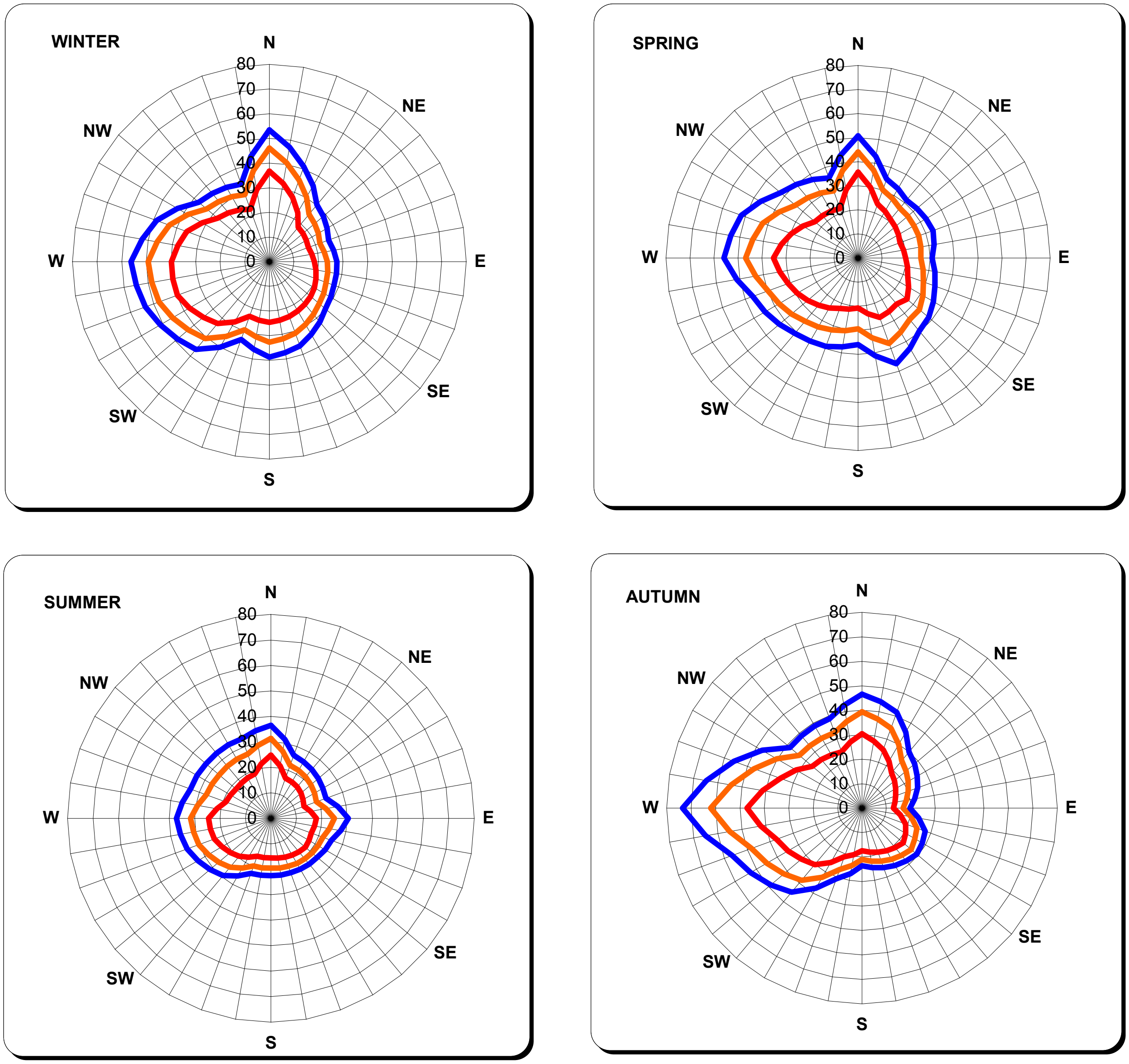


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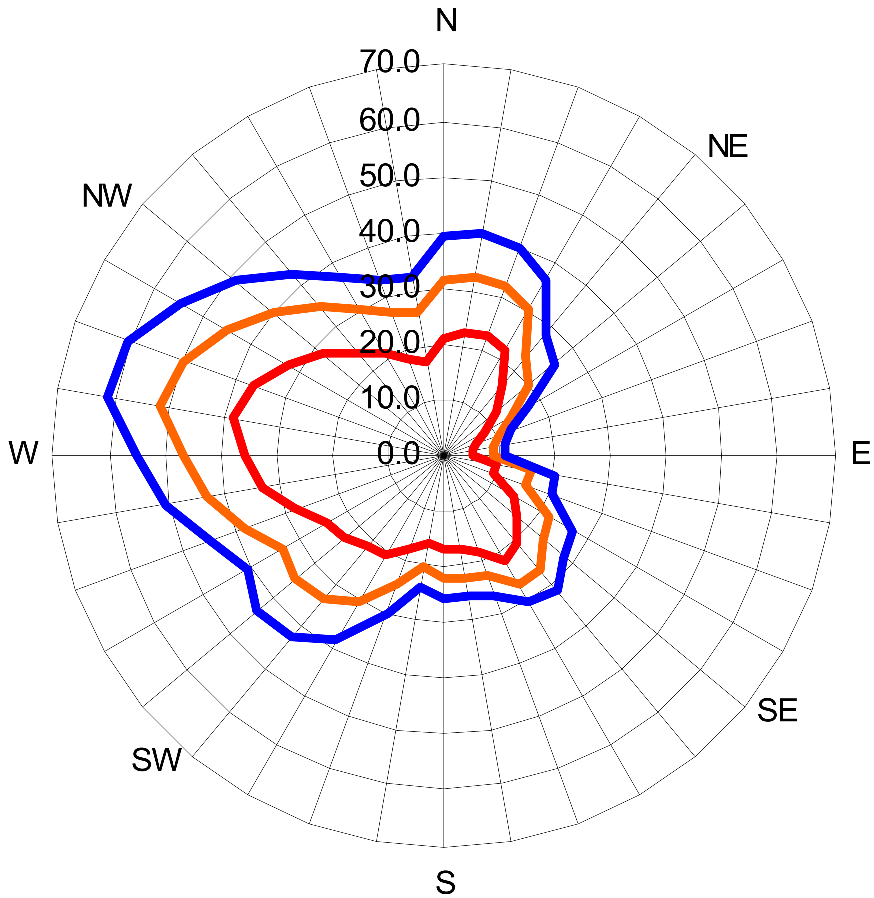
Figure 2b: Seasonal Distribution of Wind for Various Probability Levels at 33 Feet, SET building, State University of New York at Oswego, NY



ANNUAL

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Figure 3a: Annual Distribution of Wind for Various Probability Levels at 33 Feet, Oswego Harbor, NY

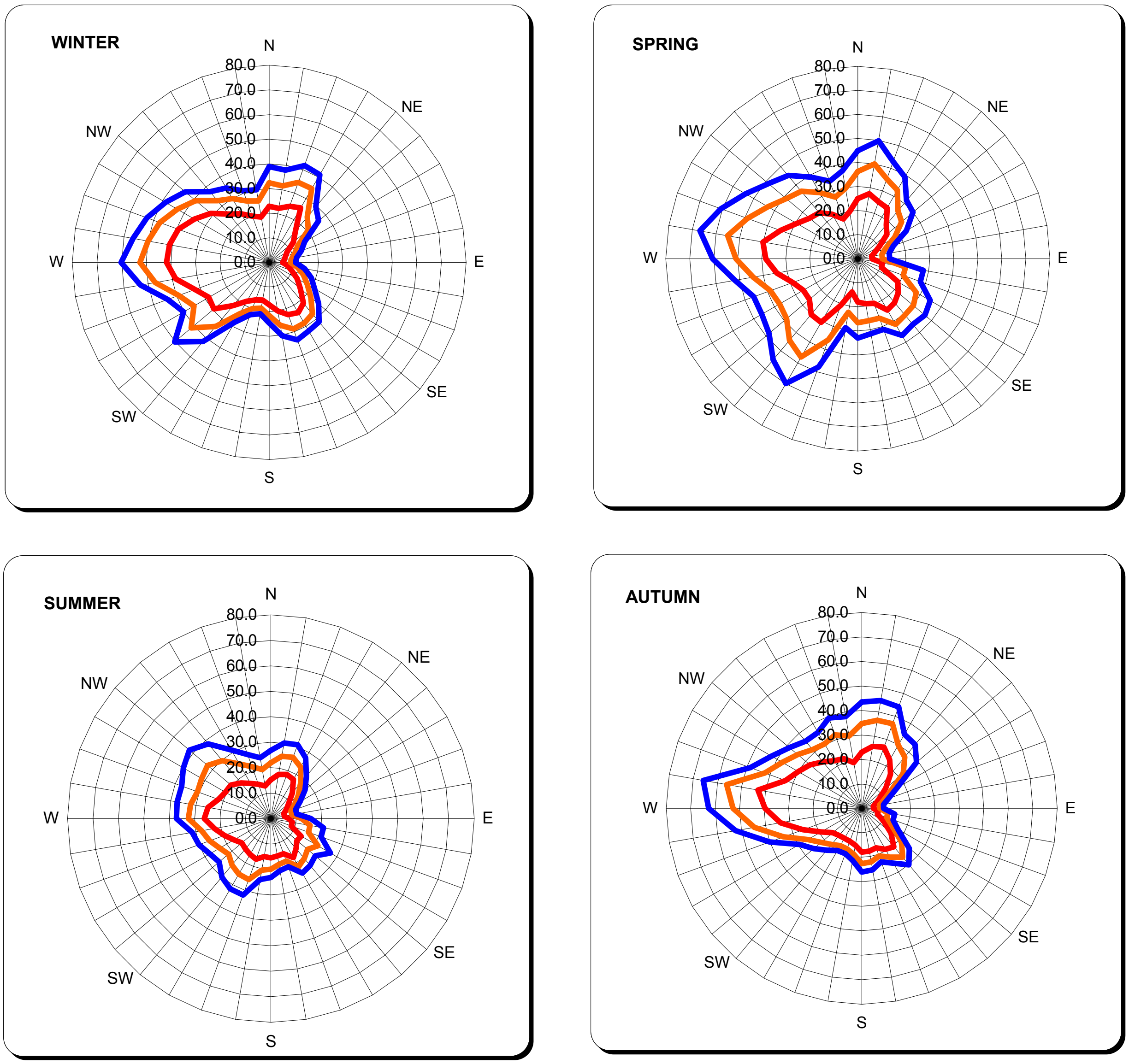

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Figure 3b: Seasonal Distribution of Wind for Various Probability Levels at 33 Feet, Oswego Harbor, NY

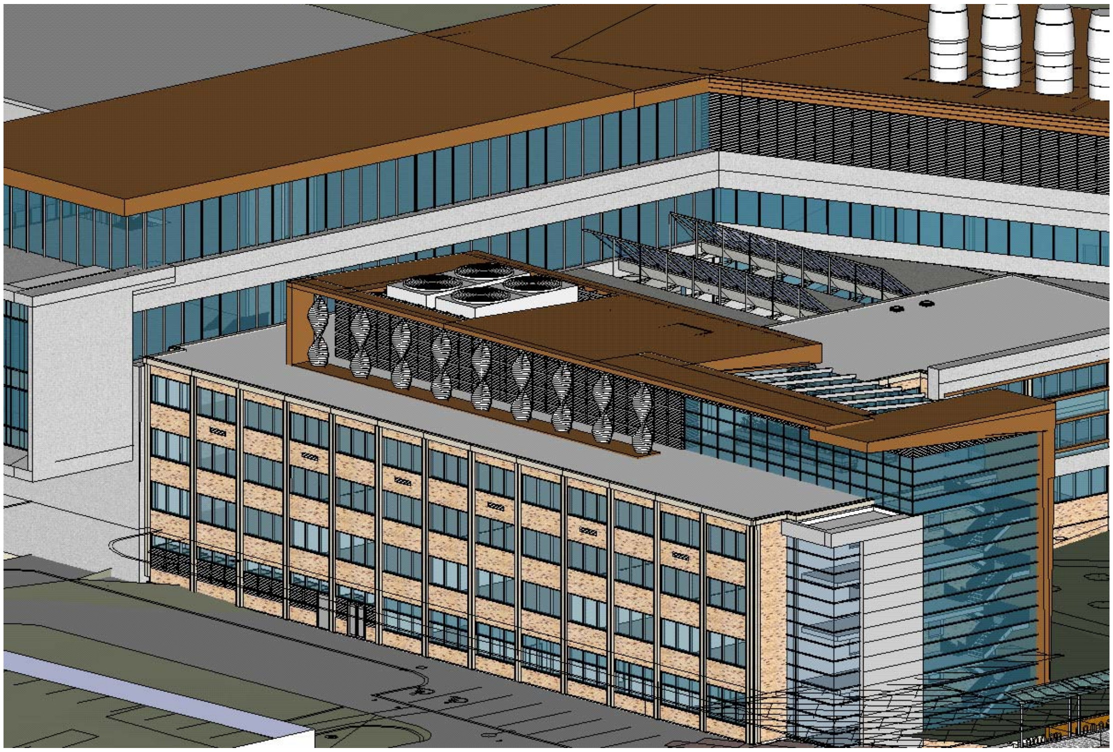


Figure 4: The Primary Designed Wind Turbine Installation Location

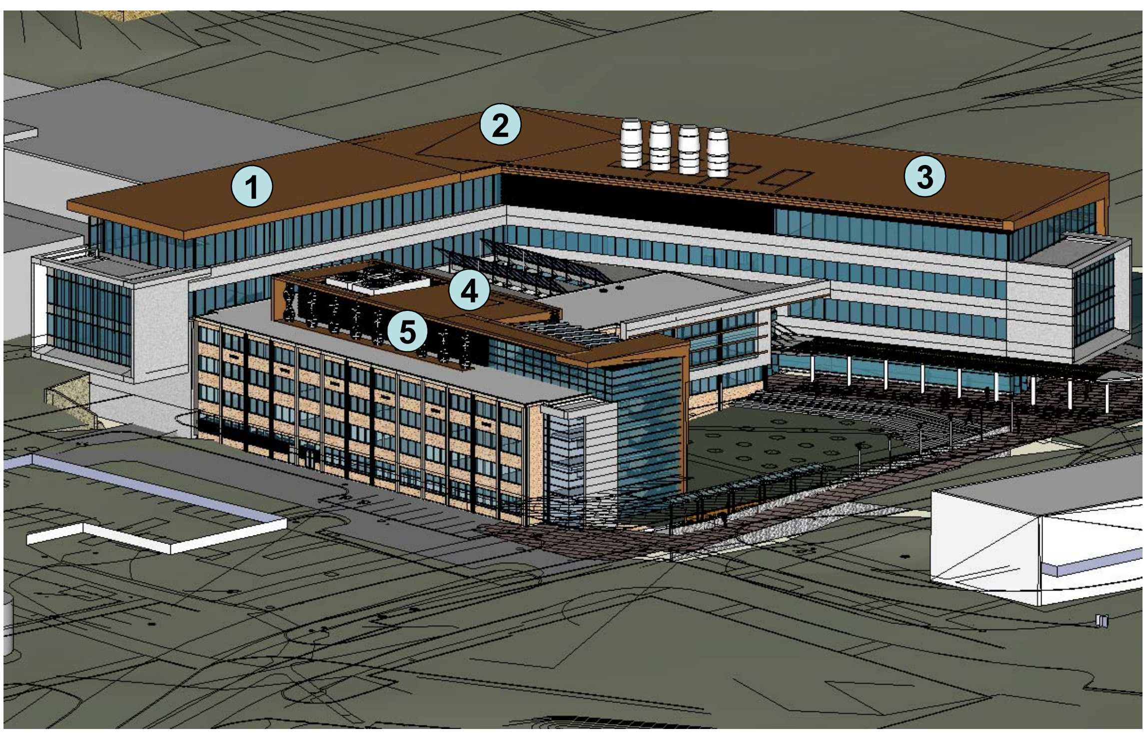


Figure 5: The Wind Turbine Installation Location Illustrations

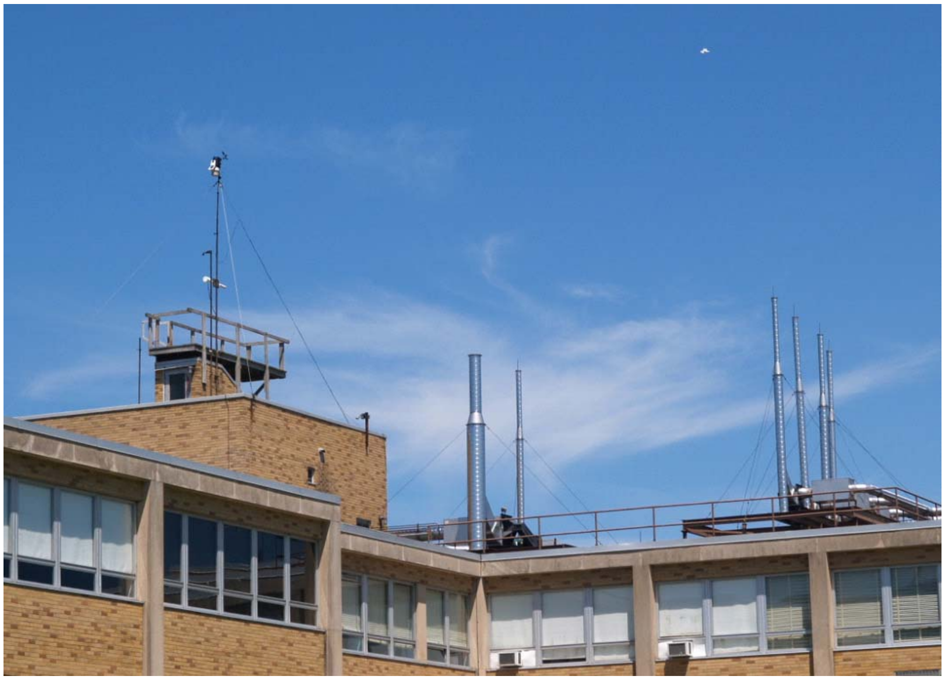
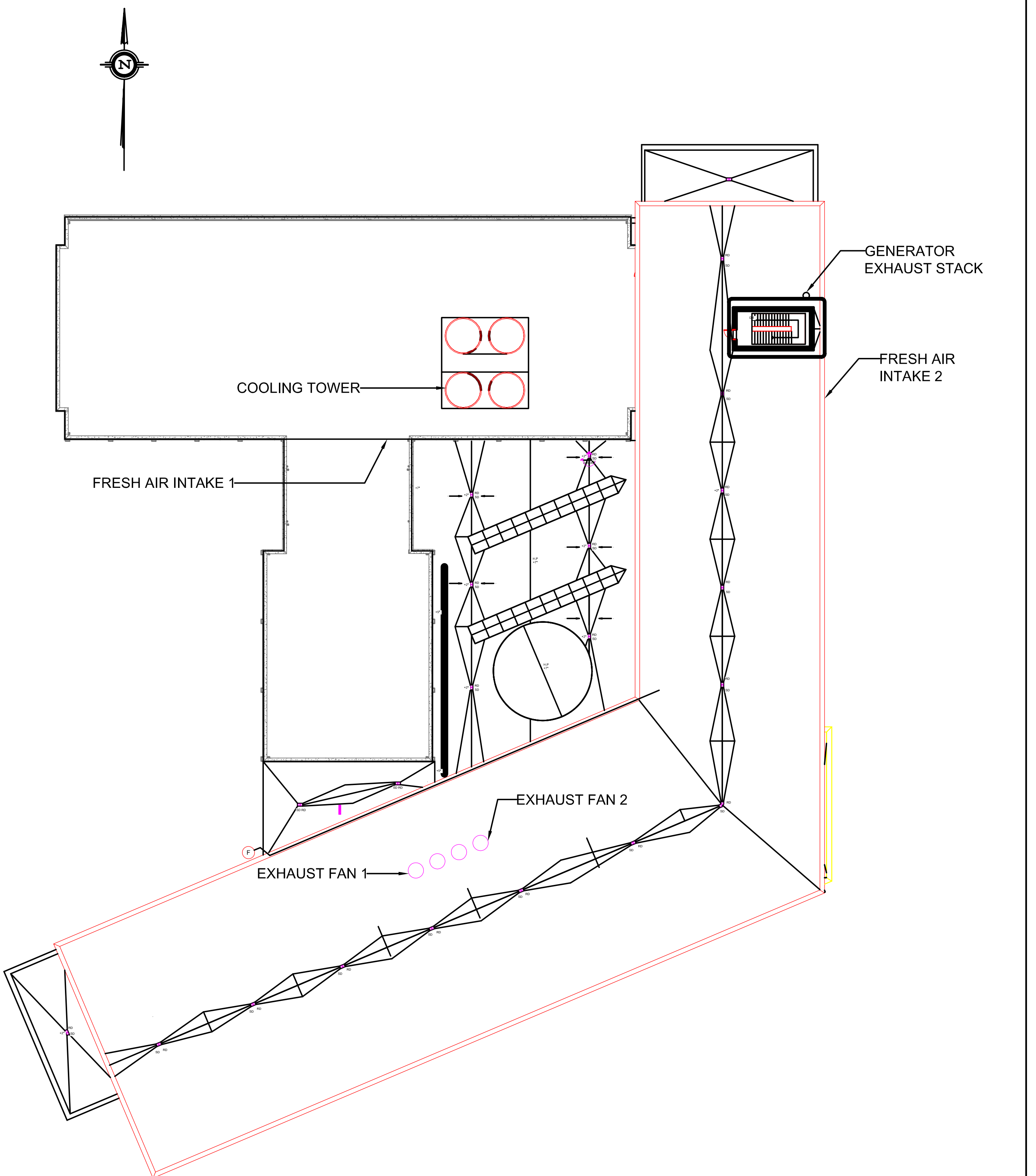


Figure 6: Anemometer on the Current SET Building



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PROJECT SCIENCE, ENGINEERING AND TECHNOLOGIES (SET) BUILDING - DESKTOP STUDY		DESCRIPTION
SCALE 1:600 (APPROX.)	DRAWING NO. GME09-030-DESKTOP-7	FIGURE 7: ROOF STACKS AND AIR INTAKES
DATE AUGUST 17, 2009	DRAWN BY L.G.	