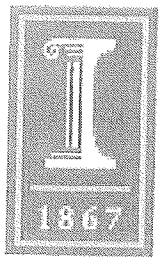
The University of Illinois at Urbana-Champaign



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Wind Turbine Feasibility Study

September 28, 2005

Prepared by:

Navigant Consulting, Inc.
175 W. Jackson, Suite 500
Chicago, IL 60604

www.navigantconsulting.com

NAVIGANT CONSULTING

Wind Siting Basics

A discussion of the basic concepts used in siting one or more WTG will help in the ensuing discussion of site selection. Siting an individual 1.5 MW WTG will require less than one acre of land to be removed from agricultural production for the access road and foundation pad. Setbacks to other turbines increases the area required to 70-100 acres, but the remaining land underneath can all be farmed. Either three or four units may require somewhere between a quarter-section and half-section (160 to 320 acres), smaller 0.9 MW machines may be used.

Up to eleven 1.5 MW machines on a section of land (640 acres) are installed in sites in the Midwest, but at this spacing the units will "steal" wind from each other, and overall array efficiency goes down. Land and/or cost considerations usually drive this configuration. For a commercial sized wind farm, spacing between WTGs will vary between 500 to 750 feet if a single row of WTGs is used. If multiple rows were to be used, about one-quarter mile would be need between rows, with the predominate wind perpendicular to the rows.

Other siting guidelines are contained in the draft, Model Ordinance Regulating the Siting of Wind Energy Conversion Systems in Illinois (2003). It covers the typical siting concerns of noise, setbacks, design, etc that one would expect. UIUC has a copy of this document.

Due to the nature of UIUC's underground distribution system in the South Farms area, which almost exactly copies a commercial wind farm's underground generation collection system, it is not necessary that all units be located in the same area. However, if the University wishes to study the effects of multiple wind turbines, on for instance crop production, it may wish to site the turbines in one area.

Lastly, wind speed is important. Wind capture is a function of the wind speed cubed (fourth power). Speed increase with height above the terrain. Thus small changes in elevation can have significant benefits. What may appear to be a small knoll of 10-15 feet could increase wind capture by a few percentage points. This is reflected in the capacity factor ("CF") of the wind farm, which is the estimated (or actual) net power production (MWhrs) divided by the maximum that could be produced (rated capacity in MW times hours).

Overall, Illinois is classified as a Class 3 wind resource, which is considered a low wind region (Attachment 1). Certain areas of the State, however, have average winds speeds at the upper end of Class 3. Champaign does not appear in the upper range, although the map is not very detailed. Wind studies are performed by installing on-site metrological towers (minimum of 50 meters),

Executive Summary

In June 2005, Navigant Consulting Inc ("NCI") was engaged by the University of Illinois at Urbana-Champaign ("UIUC") to conduct a wind turbine-generator ("WTG") fatal flaw analysis for siting up to four WTG on property owned by UIUC in the South Farms area. The need for this study was driven by a $2/student-semester fee that has been collected over the past two school years. The $300,000 collected so far would allow the generation or purchase of renewable energy by UIUC.

The results of this study will be used by UIUC to prepare an application to the Illinois Clean Energy Community Foundation ("ICECF") which can provide loans and grants to assist with the development and ownership of projects of this type.

There were no fatal flaws that would exclude the entire South Farms area from installation of a one or more WTG. However, some areas will provide a better fit than others. Two separate half sections (320 acres each) of land owned by the University are good candidates to site one or more WTGs. One of these sites, located along Philo Road south of Curtis Road and north of Church Road, provides the best combination of elevation, impact on present research use, access the transmission grid, and distance from residences and airport runways.

Results of a base case analysis with UIUC ownership and $1.05 million of assistance from the students and ICEFC, shows a bus-bar cost of about 3.1¢/kWh for the estimated 3.5 million kWhrs/yr production from a single 1.5 MW WTG, using a reasonable estimate for the expected winds speeds in this part of Illinois. The actual price, however, is highly dependent on the actual construction cost, the amount of assistance received and the wind capture of the project.

Task Definition

The following tasks were defined:

1) Perform a fatal flaw analysis to site either one or multiple WTGs somewhere in the South Farm area, or if not feasible, to suggest additional locations.

2) Develop a preliminary economic analysis of the WTG bus-bar electric costs. Explore third-party ownership possibilities, or other project structures that could reduce UIUC costs. Examine and evaluate other small WTG projects for "lessons learned".

3) Complete the studies and submit a report with an objective to allow the UIUC time to prepare a grant for submission to the ICECF for funding in 2006, which requires an outline summarizing the project in mid-July 2005.

The determination of what structures are allowed and where is unique to each airport. In general discussions with airport personnel, the closer and object is to the approach of the end of any runway the greater scrutiny the application will receive. The further to the side of a runway, the greater the likelihood the height and location will be approved.

Table 1
Site Matrix

	Site A	Site B	Site C	Site D
Location	SWof Windsor & Race	SE of Windsor and First	East of First between Church and Airport	West of Philo between Curtis and Church
Present and Future Uses	The area is presently used by ACES. There are orchards and forests on the property.	The are two - 300 foot tall WILL radio towers in the area The remaining area is in agriculture.	The area is in agriculture, however there is an on-going research study on the effects of elevated carbon dioxide on crop production	The area is in agriculture. There is an underground piping system for disposing of manure that may require some piping and procedural changes.
Residential Proximity	Park district to the east, Yankee Ridge subdivision to the south-east, large numbers of residences to the northeast.	Residences within the quarter-section on the west, commercial to the northeast	Scattered farm homes within a half mile.	Scattered farm homes to the east, Yankee Ridge subdivision about one-half mile to the northwest. Large development about one mile northeast
Electrical Interconnection	About one mile of new underground cable would be required.	On-site	~1-1/2 mi of underground cable would be needed, Soybean Research could be added to UIUC system.	About three quarters of a mile of new underground cable will be required.
Elevation, Power Production	700-710' ASL; area for 2 or 3 WTG	740-750' ASL; could probably only site one WTG	700-710' ASL; area for 4 or more WTG	730-335' ASL; area for up to 4 WTG
Airport Issues	A little less than 4 miles to end of closest runway, but about 10° angle.	A little over 3 miles to end of closest runway, but dead on angle.	A little over 2 miles to end of closest of two runways, but at 45° angle.	Depending on location +/-4 miles to end of closest runway, but about 25° to 45° angle.

The primary concern expressed by airport personnel was interference with flight paths for instrument approaches and missed landings. Sites farther from the airport have lesser concerns. Therefore, sites A and B should require the most study, because of possible impacts on instrument flight paths and missed landing flight paths. Site C may have some concerns because it lies the closest to the airport of all the sites. Site D, may not have any problems, and is the most desirable of the proposed locations. Only the detailed study as required by the FAA can fully answer the question of whether WTGs can be installed in this area, but the preliminary review is encouraging.

Endangered Species – There are no recorded instances of the collection of any specific Threatened or Endangered Species within Champaign County. As of January 2005, the Indiana bat (Myotis sodalis) potentially occurs in all Illinois Counties. We would not expect to see Threatened and/or Endangered Species as an issue in this area.

Avian – WTGs are tall moving structures that can reach 400 feet to the tip of the moving blades. All of Illinois is located within the Mississippi Flyway for migratory birds. The major location of the flyway is much further west. The are no large swamps or nature conservation areas of located near the proposed area. We would not expect to see migratory birds as an issue at this site.

There have been instances of avian (birds and bats) mortality at wind farms. The industry is addressing the issue and it is still not well understood. Further studies are underway. We would expect this issue to come up as comments are made by those that oppose WTGs.

Zoning – As an agency of the State government, the UIUC is not required to obtain zoning approval from local municipal or county governments. Incorporated entities with filed master development plans do have jurisdiction over private development which takes place within one and one-half miles for their boundaries. The majority of the area reviewed is controlled by Champaign County, but depending on the location may lie within the jurisdictional limits for private development for the Cities of Champaign, Urbana, and/or Savoy.

Initial discussions between the UIUC and these municipal governments have revealed no strong opposition to the project, but a preference to locate away from residential areas was expressed. Of the four sites evaluated, site D (Philo Rd) appears to best meet this request.

As discussed elsewhere in this study, the ultimate ownership of the project could impact what approvals and permits would be required. There is nothing to stop the UIUC from proceeding without involving the local government, however, lack of their involvement could preclude optimizing the financials of the project by the involvement of private individuals or companies at a later date.

Residential Proximity – Siting guidelines allow placing WTGs up to the maximum height (tower plus blades) times 1.1 to an occupied residence with landowner permission, otherwise the minimum distance should be 1,000 feet, or further if required to meet noise or shadow requirements.

WTGs are extremely tall structures that are visible on the horizon for miles. The reaction of homeowners can span the range of "they are pretty to look at" to "they are a blight on the horizon". The negative concerns typically fall back on the effect on property values. The Renewable Energy Policy Project funded a study entitled, "The Effect of Wind Development on Local Property Values" in 2004 that determined there was no appreciable affect on property values surrounding wind farms. UIUC should expect this is issue to be brought up, but it should not affect siting in the South Farms areas

Elevation, Power Production – Individual WTG's should be sited on the highest available terrain, without severely impacting the performance of nearby turbines. The recent growth of tower height from 65 m a few years ago, the an industry standard of 80 m today, is driven by the quest for higher average wind speeds. As previously stated power increases with the cube of the wind speed. Therefore seemingly minor increases in height can have dramatic effects on power production. It will usually pay off in the long run to pay for additional roads and cabling to achieve a higher overall height.

Ralf Möller (College of ACES) extrapolated data from a 10 m tower located near First and Airport Roads to 70 and 80 m WTG hub heights. Data from the November 2003 to May 2005 time period show an average gross capacity factor of about 27%, which would drop to around a 26.5% net capacity factor after all losses are accounted for. For a General Electric ("GE") 1.5 MW WTG, this would translate into about 3,500 MWh of production per year. If UIUC wishes to determine a more detailed forecast, the actual long term estimated capacity factor can be developed by using data from Willard Airport, and correlating with the site data.

Microwave beam paths – For siting multiple WTGs, microwave beam paths can sometimes be an issue if they bisect the farm. For an individual WTG, it can usually be moved to take the rotating blades out of the beam path. Prior to siting the WTG(s) UIUC should contract to have a beam study performed.

Interconnection – The generator located within the nacelle at the top of the tower produces power at 600 or 900 volts. The power would be transmitted down the tower through cables, and then the voltage is increased through a transformer to the UIUC system distribution voltage of 13.8kV. In recent years, the system has been expanded underground south of the main campus. One leg runs south along First Street and presently terminates at Curtis Street. The eastern leg ends east of Race Street, slightly north of Church Street. The long-term plan is to loop the two legs together to strengthen the system.

Discussions with Karl Miller of Henneman, indicate that each leg can transmit up to 10 MW of electricity at 13.8 kV. No fatal flaws were found that would preclude installing multiple WTG on the UIUC distribution system in the South Farms area.

Locations away from the UIUC campus were not evaluated due to the increased cost to move the power over third party transmission lines, and increased transformer and transmission losses.

Technical priority of sites – From a technical standpoint for a single WTG, sites A and D provide the best elevation (and potential power production). Of these two sites, A would have the shortest interconnection. Both are beyond 20,000 feet from the runways, and would provide the lowest expected impact on airport operations. Site A is slightly higher, and should provide the highest power production of the four sites.

For multiple WTGs in one area, sites C and D are best, with D providing the highest power production potential of these two. Site A does lie close to numerous residences. This factor should be taken it account as the UIUC decides where to place the WTG(s), and would tend to again favor Philo Rd (site D).

Ownership Structures and Issues

There are various ownership structures available to the UIUC. The simplest would be for the University to construct and own the project, and consume the power. Other ownership structures would involve private ownership, from either individuals (though a limited partnership) or from a corporation.

Private – PTCs are presently available through the end of 2007 as part of the recently signed Energy Bill of 2005. They provide a 1.9¢/kWh benefit to any owner of a WTG that pays federal income taxes and sells the power to a third party. It is indexed for inflation and would be available for 10 years after start of operations.

Typically a corporation is an optimal owner instead of an individual, because the corporate tax rate is 38.5%, most individuals are at a lower rate, and a large tax credit such as provided by the PTC may push them into alternate minimum taxes. Companies such as John Deere have expressed an interest in owning wind projects serving customers that cannot take advantage of the tax credits. Under this arrangement, a power purchase agreement would obligate the UIUC to buy the output and renewable attributes from the project.

Some disadvantages of utilizing a private ownership structure are that no tax-exempt financing can be used, the credit worthiness of the owner is important,

local municipalities have to issue permits, and the ICECF usually does not contribute capital to private projects. Private entities do pay property taxes, which should fall in the range of $7-10,000 per WTG. This would be more than off-set by the reduced cost due to full utilization of the PTCs.

UIUC - For entities that do not pay taxes, a REPI is an option. It is similar to a PTC and consists of a payment by the federal government to a public entity which has installed a WTG. It is priced similar to the PTC, but does not include the "gross-up" for a pre-tax benefit. Thus, the REPI will always be disadvantaged in comparison to the PTC by the tax rate (38.5% for corporations). This is off-set, however, but the absence of property taxes -- and in the end the REPI and PTC prices are almost equal.

The REPI is included in annual allocations from Congress, therefore there is always the risk not enough funding will be made, as shown in this excerpt from the Congressional Budget Office Cost Estimate, June 9, 2005,

> "The REPI program currently provides cash payments to public utilities and electric cooperatives that generate energy using renewable sources. The payment is based on the annual kilowatt-hours of electricity generated using qualified renewable energy sources. Section 202 would reauthorize the REPI program for an additional 20 years, and make Indian tribes eligible for the program. Annual funding appropriated for the program has not kept pace with applications for payment from eligible utilities. Specifically, eligible utilities have generated electricity from renewable resources since 1994 in an amount that qualifies for about $76 million in REPI payments that have not been appropriated. Based on information from DOE, CBO estimates that fully funding this program, including the backlog of applications, would cost $70 million in 2006 and $163 million over the 2006-2010 period."

Therefore, although an analysis including a REPI is performed as part pf this report, it is highly unlikely complete funding will be available.

Hybrid -- One other structure to consider would be to bring in a private owner for the first ten years (to maximize PTC utilization), and then have the University assume ownership in year eleven. The contribution from the students would be used to decrease the upfront capital cost. Discussions with the ICECF has indicated that although they have not funded a deal like this, they would consider an offer to pay an option payment upfront to allow the UIUC to assume ownership after ten years thus decreasing project construction cost.

DISCUSSION OF OTHER PROJECTS

There are two projects of a similar nature that have been completed in the past few years that can be used for comparison. The common data is contained in the following table..

	Project	
Owner	IL Rural El. Coop	Carlton College
Location	Western Illinois	SE Minnesota
Size, MW	1.65	1.65
Manufacturer	NEG-Micon	NEG-Micon
Cost ("all-in"), millions	$1.887	$1.95
Elevation, ft ASL	~825	315
Est. Capacity Factor	~30%	~30%
Tower Height, m	70	70
Interconnection, kV	12	13.8
Commercial Date	May 2005	September 2004
$/kW, see notes	$1,143	$1,818

Notes: The Illinois Rural Electric Cooperative performed all their own design for interconnection, and upgraded some distribution lines in the area. It is not clear if these costs were included in the total. Both projects received grants to decrease the installed cost.

FINANCIAL ANALYSIS

Based on the other similar projects, an economic model was developed and run. The base case assumed a 26.5% capacity factor, and a $1,333/kW construction cost, based on a $2 million total cost for a GE 1.5 MW WTG (single WTG). Costs have been estimated at slightly higher prices than similar projects quoted mainly due to increased steel costs, inflation, and higher prices charged by manufacturers due to high demand for units in 2005. Please note that UIUC that these costs are merely estimates. The WTG market prices are highly volatile, and there is great demand of WTGs. Prices may change from the numbers used here.

Reducing this number by $250k will give an indication of the reduction in power cost that can be achieved with grants or contributions. The calculations are fairly linear, so they can be easily extrapolated for purposes of this study.

O&M data was obtained from GE. Property taxes for private party ownership were estimated from similar projects in Illinois (about $9,000/year/WTG) and only applied to the PTC cases. No local payments were assumed for the UIUC

ownership case. Three different ownership cases were run, private party ownership with PTC, UIUC ownership with REPI, and UIUC ownership with no per third-party assistance.

The capacity factor was varied to 24% and 29% which should span the range of expected production. Results in cents/kWh are contained on the following table. All runs were solved to a 9% IRR, which is equivalent to an 11 year payback. This is typical of returns expected in the industry.

	Power Cost, ¢/kWh		
Ownership/Type	Private/PTC	UIUC/REPI*	UIUC/None
Base, C.F. @ 26.5%	4.0	4.0	5.6
Capital Cost down $250k	3.3	3.5	5.0
C.F. @ 24%	4.7	4.6	6.2
C.F. @ 29%	3.5	3.6	5.1

* if available

As expected the private ownership option will provide a power cost that is on average 1.5¢/kWh lower than if UIUC owns the project. Translating the capital cost number shows that a $50k change in capital cost will change the power price by 0.12¢/kWh. Thus, including a buy-down assistance of $330k from the students, and $750k from ICECF at a 26.5% C.F., would result in a power cost of a little over 3.1¢/kWh with UIUC contributing $950k.

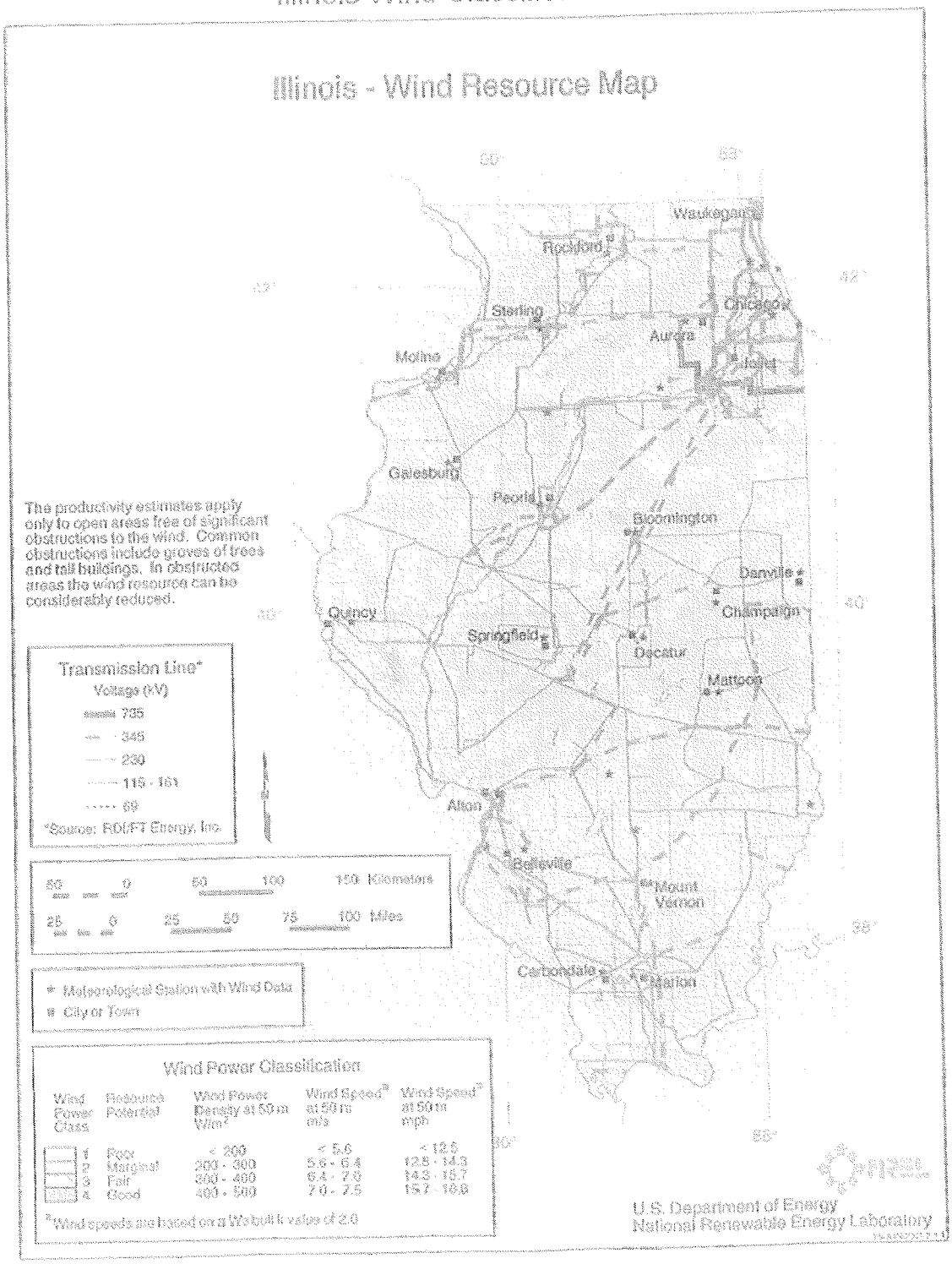
Installing multiple units may decrease these prices slightly, but probably by no more than 5%. Economies of scale for wind farms do not significantly reduce costs until 20 to 25 units are installed. Increasing the project size to 3.0 MW by installing two 1.5 MW WTGs will increase the average net construction cost ($1,000/kW) due to spreading the buy-down assistance over more units. Average power cost would be expected to about 4.2¢/kWh. Installing multiple WTGs (say four 900 kW) will increase power cost by about 5-10% due to the loss of economies of scale in manufacturing, erection, and startup.

CONCLUSION

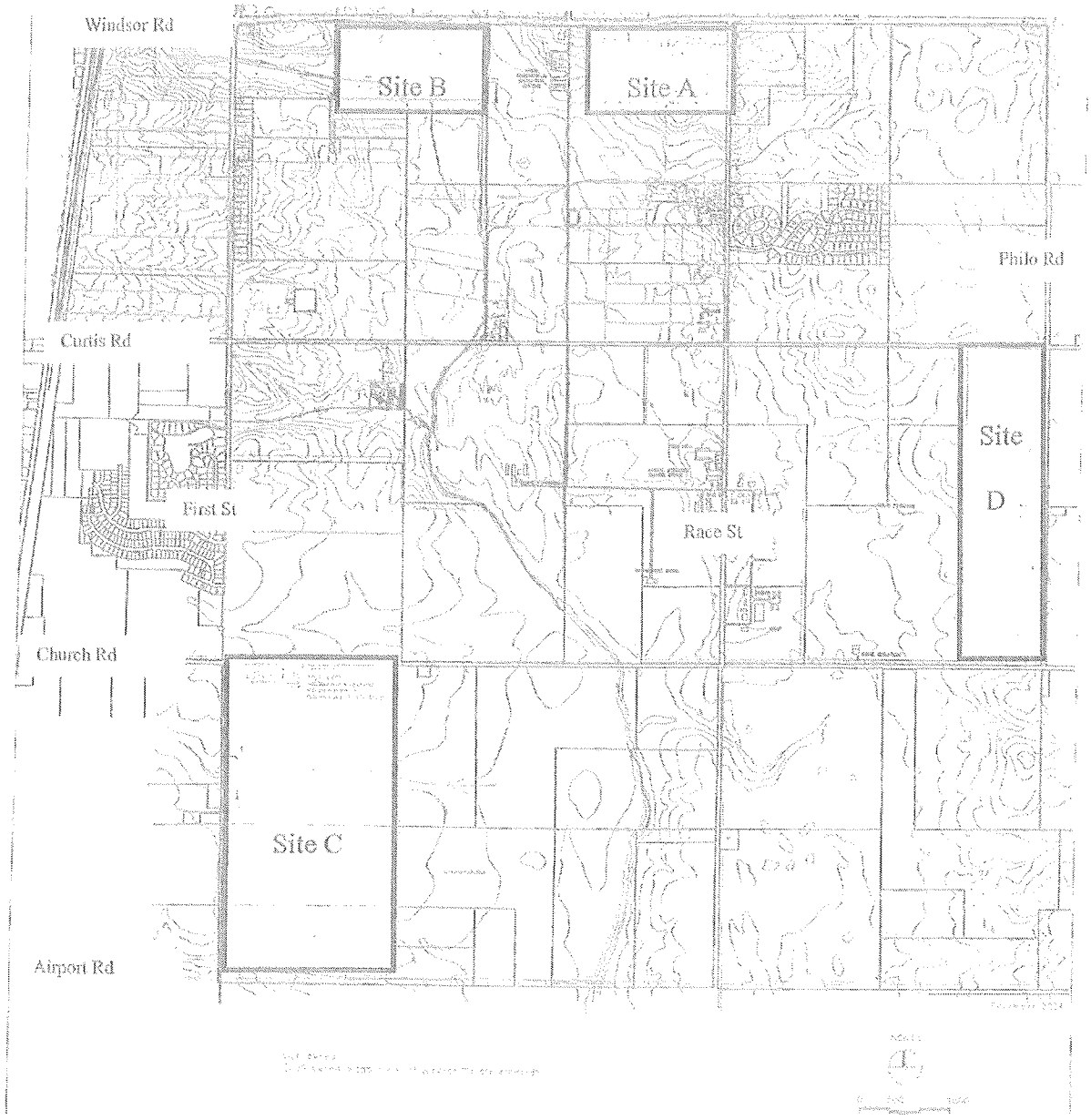
There are no fatal flaws that would prevent the installation of one or more WTG on the UIUC campus in the South Farms area. Depending on the ownership structure chosen and actual wind resource captured, power costs will be in the range of 3.5¢/kWh to 6.2¢/kWh. Third party contributions can significantly lower these values.

The best site evaluated is in Site D, about 500 feet south Curtis Rd, and 500 feet east of Philo Rd. As shown on the photograph in Attachment 4, there is a small knoll in the area that should provide the highest power production on the Philo Rd site. Additional WTGs could be added incrementally to the south, because the elevation tends to fall off in that direction.

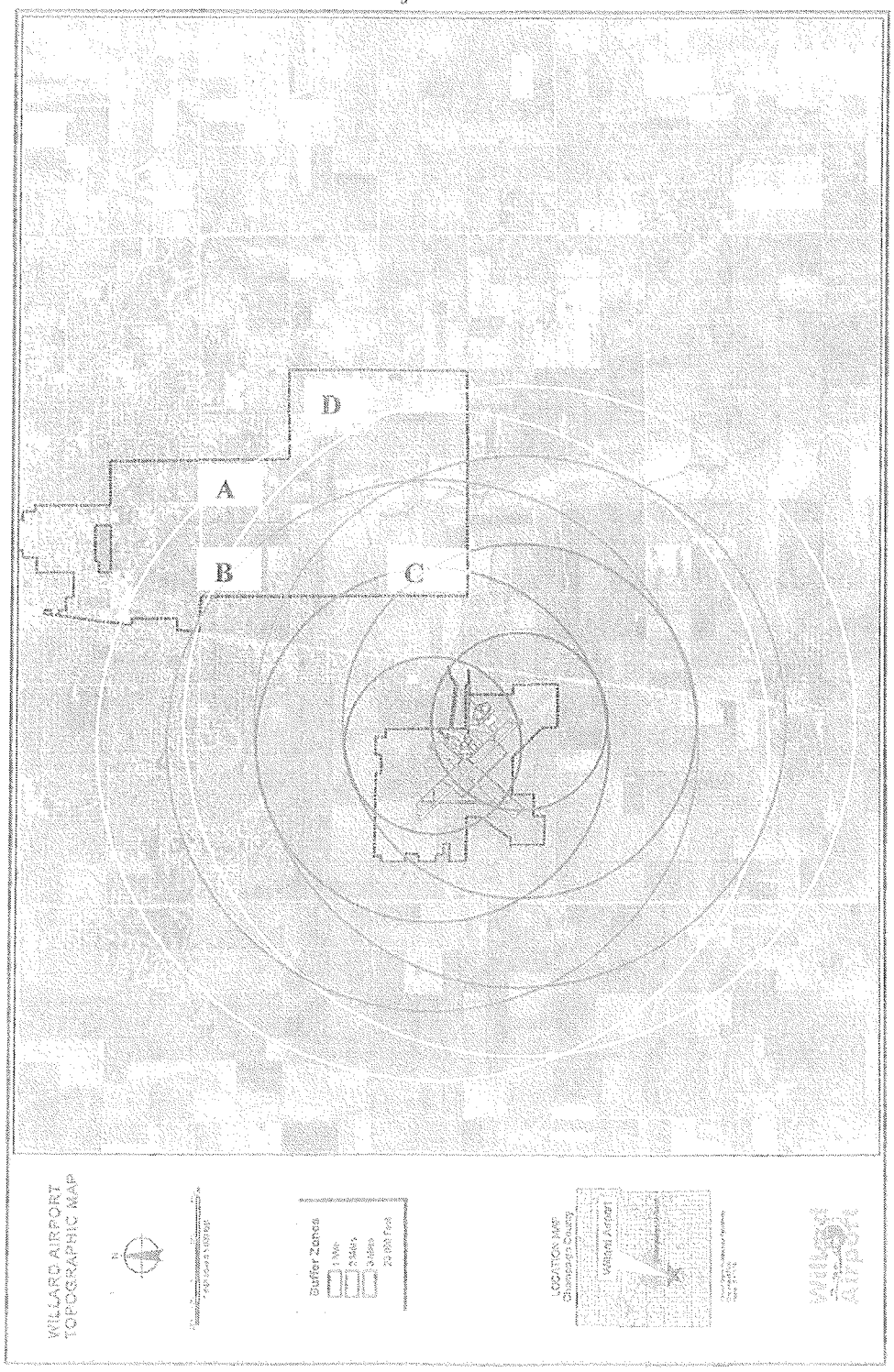
Attachment 1
Illinois Wind Classifications



Attachment 2
South Farms Sites Evaluated



Attachment 3
Runway Buffer Zones



Attachment 4
Corner of Philo and Curtis Roads looking Southwest