"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Executive Summary

The Northern Cheyenne Tribe (NCT), located in Rosebud and Bighorn Counties in southeastern Montana was a recipient of a Department of Energy Renewable Energy Feasibility Study Grant under the "Renewable Energy Development on Tribal Lands FY2002" program. The NCT selected Distributed Generation Systems, Inc. (Disgen) of Lakewood, Colorado to manage the project at the direction of the Tribe. The study was scheduled to be completed in March 2004. However, the availability of long-term wind data, discovered after the initial award, has provided for the acceleration of the feasibility study. While customarily requiring one year of wind studies to qualify a site, the long-term data has made possible a correlation process that provides sufficient information to accelerate the schedule. The wind report, prepared by Mr. Ed McCarthy, is included as part of Tab #8 of this report, "Wind Resource Assessment."

The feasibility study included an examination of solar and biomass resources available on the NCT Reservation. Solar was deemed to be economically unattractive at this time and no further detailed analyses were performed. The NCT owns as saw mill which is not operational at this time. However, there is sufficient feedstock potential from the reservation and the Custer National Forest to support both the saw mill and a biomass power generation facility. The National Renewable Energy Laboratory (NREL) advisor suggested that a commercial use for waste heat is required to make such a project economically attractive. The inoperability of the saw mill and the lack of additional space for an ancillary commercial facility based on the waste heat rendered biomass as an infeasible opportunity currently.

In November 2002, Disgen arranged for the installation of a fifty meter (50m) meteorological (MET) tower in proximity to the now-selected project site. The correlation process, referred to above, compared the data from this tower to the long-term data collected as part of the environmental assessment of the 2250 Mw Colstrip coal-fired power plant twenty-six miles to the north. The correlation process resulted in expected wind speeds of 16.7 mph at a 65m hub height and an expected Capacity Factor of 34%. This data represents, in Disgen's experience, an economically competitive wind site for the Montana markets. Further, a National Renewable Energy Laboratory (NREL) MET tower (20m) was installed in the project area in February 2003. This tower provides additional assurances in the correlation process.

At the direction of the NCT, Disgen arranged for the acceleration of the Phase I Avian Study conducted by Western EcoSystems Technology Inc, (Western) of Cheyenne, Wyoming. The Phase I Avian Study is included in Tab #13. The Environmental Studies, identified no significant issues with birds or bats, but, as expected, recommended additional detailed studies to comply with the permitting requirements of the National Environmental Policy Act (NEPA). Disgen and NCT representatives have agreed with the US Fish & Wildlife Service (USF&WS) on the precise studies that will be required for future development of the a commercial wind facility.

The Preliminary Cultural Assessment was conducted by the Bureau of Indian Affairs (BIA) and identified no "significant cultural sites". The BIA letter is included in the Tab #13, Environmental Assessment. In order to comply with NEPA requirements, additional detailed physical studies have been defined for future pre-construction development. The NCT plans to conduct interviews with spiritual leaders to assess the verbal history and experience of the Tribal Elders. This specialty is referred to as "Ethnographics."

The electric service to the NCT is provided by Tongue River Electric Cooperative (TRECO). In discussions among the NCT, Disgen and TRECO, it was determined that a thirty megawatt (30Mw) wind facility could be interconnected to an existing sixty-nine thousand volt line (69kV) line running adjacent to the project area. Mr. Harold Hanson, Manager/ CEO of TRECO submitted a letter, included in Tab #10 indicating a willingness to work with the NCT to evaluate a future commercial project.

There are several potential purchasers of the energy produced by a future commercial project. These companies are all currently conducting business in Montana as power producers or retailers. Participants in the Colstrip Power Plant include PacifiCorp, Pennsylvania Power and Light, Puget Sound Power and Light, Avista, Portland General and Northwestern Energy (formerly Montana Power and Light). Each of these entities currently participates in renewable energy purchases and may be approached as potential power purchasers as the commercial project economics are finalized. In addition, Central Montana Generation and Transmission Cooperative, of which TRECO is a member, mayl be approached as well. Disgen has a business relationship in other states with PPM Energy, an unregulated affiliate of PacifiCorp and may, at the direction of the NCT, propose the project to PPM Energy as a potential purchaser of energy.

The economics of the project and the related power purchase price per kilowatt hour (kWh) will be finally determined after the assessment of the wind resource, the results of the environmental reviews, the results of the interconnection systems impact studies and the finance structure definition. However, based on the information available today, a budgetary estimate of the price per kWh can be reasonably determined. The project pro-forma model attached in Tab #7 is representative of an institutional finance model utilizing the Federal Production Tax Credit; which is currently not available pending action by the congress. This model results in a non-escalating price for energy of $0.0335 per kWh. The RUS option of financing has also be examined and provided to the Tribe as an alternative. It is probably in the Tribe's best interest to focus on the lowest cost per kWh to motivate the execution of a power purchase agreement. Preliminary analysis indicated the NCT may recognize $7.3 million in economic value over the life of the project.

While there is never any certainty as to the market for renewable energy in the future, it is the opinion of the Northern Cheyenne Tribe and Disgen that a future commercial wind project will be economically competitive with any other wind energy project being developed to serve the Montana market and has a several advantages. The NCT has a willing interconnection utility in TRECO. The project location allows all the participants in the Colstrip power plant an opportunity to participate in Native American wind project. Energy produced on Native American lands has public relations benefit to the purchasers and creates for these purchasers an important market differentiator. There already exists a separate market for the environmental attributes which may make the physical energy sale more attractive.

The project effort to date has provided the following significant information:

1. The project location is on Tribal Trust Land; benefiting the NCT.
2. The wind resource is sufficient for an economic wind project.
3. The preliminary environmental studies identified no significant impacts.
4. The local utility has indicated cooperativeness for interconnection.
5. Potential renewable energy power purchasers exist in the Montana market.
6. Potential project investors have been identified (Attachment "4")

“NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY”
Project Overview

The Northern Cheyenne Indian Tribe (NCT) is a Federally Recognized Sovereign Nation, located in Big Horn and Rosebud counties in southeastern Montana. The study assessed the feasibility of a commercial wind facility on lands selected and owned by the Northern Cheyenne Nation and examined the potential for the development of solar and biomass resources located on tribal lands The objectives of the feasibility assessment, and the subsequent wind project development, were to maximize the economic benefits to the Tribe and to identify potential employment for Tribal members through the development of renewable resources.

Distributed Generation Systems, Inc. (Disgen) of Lakewood, Colorado was selected by NCT as the contractor for the feasibility study.

The NCT, in conjunction with Disgen, selected a tribally-owned parcel of trust land for the feasibility study of a commercial wind facility. The property selected is east of Lame Deer, Montana, on the north side of US Hwy 212 and is depicted in the preliminary site plan in Fig, 1. The property consists of approximately 1900 acres. A fifty meter (50m) anemometer was installed in October 2002 as part of the Wind Energy Feasibility Grant awarded to the Northern Cheyenne Tribe. A twenty meter (20m) anemometer, provided by the National Renewable Energy Laboratory (NREL), was installed in the project area in February 2003. Corollary climatological data, including detailed wind data, has been collected since 1992 from four locations within, or bordering, the project area. This information has been collected as part of the environmental monitoring of the 2250 megawatt Colstrip coal fired power plant approximately twenty six miles (26 mi.) north of Lame Deer. Disgen’s meteorologist, Ed McCarthy analyzed this data and compared it to the data obtained from the meteorological towers and estimates a capacity factor for the project of approximately 34%, depending upon the wind turbine selected and its power curve. Mr. McCarthy’s report is included Tab #19. This correlation process is customary within the wind industry. The resulting capacity factor indicates that a commercial wind energy project is feasible in this location.

The electric utility providing service to the NCT Reservation is Tongue River Electric Cooperative (TRECO), located in Ashland, Montana on the eastern boundary of the reservation. Representatives from the Tribe and Disgen have met with Mr. Harold Hanson, General Manager and CEO of TRECO, who described the electrical system serving the reservation. The primary system is a 69,000 volt (69kV) three-phase line running from Colstrip south to Lame Deer, east to the community of Ashland and back to Colstrip. Mr. Hanson indicated that a 30Mw wind energy facility could be interconnected to the 69kV line which runs adjacent to the project area. It should be emphasized that an Interconnection Feasibility Study will be required to confirm Mr. Hanson’s opinion and an additional System Impact Study may be required.

Disgen, at the direction of the NCT and in compliance with the requirements of the current Wind Energy Feasibility Study grant, has arranged for the completion of the Phase I Avian Resource Assessment study. This study was conducted by Western EcoSystems Technology, Inc. (Western) of Cheyenne, Wyoming, a nationally recognized firm in this field and is included in Tab #13. There were no significant impacts identified. However, in order to meet the permitting requirements of NEPA for a future commercial wind project, a year long field study of the project area must be conducted. This study is required for either an Environmental Assessment or an Environmental Impact Statement under NEPA.

The National Historic Preservation Act (NHPA) and NEPA require a comprehensive cultural review, overseen by the Bureau of Indian Affairs (BIA). The customary BIA process is to conduct an on-site inspection of the property and integrate those findings with the catalogued "known significant cultural sites." The inspection and review of existing data must be done, or overseen by, a "BIA Permitted Contractor." However, the Northern Cheyenne and several other tribes have created Tribal Historical Preservation Offices (THPO) that require cultural studies to include oral interviews ("Ethnographic Studies") with Tribal Elders, conducted in the native language, by individuals that may not be BIA Permitted Contractors. These interviews are valuable and identify areas of concern other than physical evidence. The preliminary cultural examination did not discover significant cultural sites that would prohibit future development. A burial site was discovered and the site plans will avoid the sensitive area.

The feasibility assessment of this site supports the further pre-construction development of a 30 MW wind facility.

"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Objectives

Under this grant, the Northern Cheyenne Nation assessed the feasibility of renewable energy generation projects on Tribal Lands. The assessment included the resource potential of wind, solar and biomass technologies. The specific feasibility study objectives focus on the qualification of the selected site as a candidate for the development, financing, construction and operation of a commercial wind energy generation facility. In order for a wind plant to be developed, the site requires:

(i) a wind resource with an annual average wind speed in excess of thirteen miles per hour (13 mph),
(ii) an environmental assessment indicating no significant impact,
(iii) an electrical transmission capacity capable of accepting the energy from the project,
(iv) business and financing plans that demonstrate economic viability, and
(v) a resulting source of financing. The feasibility assessment will define the facts relative to these issues.

**“NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY”
Description of Activities Performed**

The Northern Cheyenne Nation, in conjunction with Disgen, selected a tribally owned parcel of land as the subject of the commercial wind facility feasibility assessment. The property selected will be located on Tribal Lands in Big Horn or Rosebud Counties in the State of Montana, near the community of Lame Deer. The property will consist of approximately 1.4 acres (250 ft. x 250 ft.), on which a 50-meter meteorological tower will be installed to gather wind data. Disgen, as the direction of the tribe conducted or created:

- A wind resource assessment sufficient to obtain financing;
  The Wind Resource Assessment Report is included in Tab #8
- A Phase I Avian resource assessment;
  The Phase One Environmental Assessment is included in Tab #8
- A preliminary cultural assessment;
  The Preliminary Cultural Assessment is included in Tab #8
- A review of local transmission capabilities;
  A discussion is included in Tab #10
- A preliminary set of project economic projections;
  A preliminary Pro-forma is included in Tab #7
- A quantification of solar and biomass resources on Tribal Lands;
  A discussion is included in Tab #8
- Options for Tribal employment and economic development; and
  A discussion is included in Tab #14
- An assessment of the local market for use or sale of the energy produced.
  A discussion is included in Tab #18

Statement of Work

The tribe will:

1) Assess the transmission capacity, capability and markets for a wind power energy project. Conduct, discussions with power purchasers and the Rural Utilities Service.
2) Provide a complete, in-depth assessment and report on wind resources available.
   a) Briefly assess and provide a brief report on the potential for development of solar and biomass power resources.
3) Assess and report on the potential environmental and cultural impacts of wind power development.
   a) Briefly assess and provide a brief report on the potential environmental and cultural impacts of solar and biomass power development.
4) Establish economic models for wind power development for Tribal consideration, including discussion of ownership options.
5) Define and report on economic, cultural and societal impacts on the Tribe of wind power development.
6) Prepare a business plan for wind power development (see description below).
7) Submit quarterly and final reports on all activities listed herein, including the business plan.

“NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY”
Conclusions and Recommendations

While there is never certainty as to the market for renewable energy in the future, it is the opinion of the Northern Cheyenne Tribe and Disgen that, based on the information collected from the feasibility study, a commercial wind energy facility contemplated on NCT Tribal Land will be economically competitive with any other wind energy project being developed to serve the Montana market. Such a project has a several advantages. The NCT has a willing interconnection utility in TRECO. The project location allows all the participants in the Colstrip power plant an opportunity to participate in Native American wind project. Energy produced on Native American lands has public relations benefit to the purchasers and creates for these purchasers an important market differentiator. There already exists a separate market for the environmental attributes which may make the physical energy sale more attractive.

The project effort to date has provided the following significant information:

7. The project location is on Tribal Trust Land; benefiting the NCT.
8. The wind resource is sufficient for an economic wind project.
9. The preliminary environmental studies identified no significant impacts.
10. The local utility has indicated cooperativeness for interconnection.
11. Potential renewable energy power purchasers exist in the Montana market.
12. Potential project investors have been identified

The NCT and Disgen recommend a continuing development of this candidate wind energy site and seek a development grant to support the pre-construction development process.

"NORTHERN CHEYENNE NATION WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Lessons Learned

Native American Cultural Issues: Integrating a commercial wind development process with the traditional values of the Northern Cheyenne People is an interesting challenge. While tribal traditionalists value greatly "Mother Earth" and therefore the environmental benefits arising from wind energy development, there is a conflict with excavating the earth for foundation construction and with the visual impact of large scale wind turbines. While non-Indians hardly ever comprehend adequately the verbal history of the many Native American cultures, it is critical that any tribal development of wind energy include intense study of the verbal history to the satisfaction of the People and their leaders.

Tribal Political Issues: The Northern Cheyenne are governed by an executive branch managed by a tribal-wide elected President, a Tribal Council elected by districts and a Tribal Court. Elections are held every two years and as much as a third of the Tribal Council members may change with each election. Consequently, the political process is continuously ongoing; which requires much greater communication with, and education of, tribal leaders. Communications with the body of tribal membership is very challenging, but critical due to a history of political activism. The communication and education processes must be directed by the tribe, not any well-meaning non-Indian. Failure to adequately plan for and conduct the membership communication programs leads to information by rumor which has partially motivated previous political activism.

Federal Government Oversight: The Northern Cheyenne Tribe has stated objectives of self-determination and sustainability. The Bureau of Indian Affairs has "Trust Responsibility." These two sets of criteria may conflict from time to time on procedural issues and must be considered when planning for wind energy development.

Financing Barriers: Native American Tribes are disadvantaged in financing of wind facilities because (a) they are non-tax paying entities that cannot utilize the Production Tax Credit (PTC) for wind energy and (b) they do not qualify for the alternative Renewable Energy Production Incentive (REPI) provided to other tax-exempt entities. In the 1992 National Energy Policy Act, the tribes simply seem to have been ignored.

Due to the political structure of the tribes and the justifiable focus on tribal sovereignty, non-Indian entities are concerned about investing in some tribal ventures. A limited waiver of tribal sovereignty will likely be required for third-party investment in tribal wind facilities. The waiver will probably focus on dispute resolution in federal courts.

Power Plant Climatological Data: The Colstrip Power Plant (2250 MW coal-fired) is located twenty-six (26) miles north of Lame Deer. The climatological stations for Colstrip located within the boundary of the Northern Cheyenne Reservation have provided valuable long-term wind data. This data, when correlated with the data collected from the meteorological tower installed as part of the feasibility study, provided for a much shorter time period in quantifying the wind resource.

Preliminary Wind Resource Assessment and Theoretical Energy Estimates

Northern Cheyenne Reservation, Montana

Prepared For:

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April, 2003

Table of Contents

1.0 Introduction and Summary

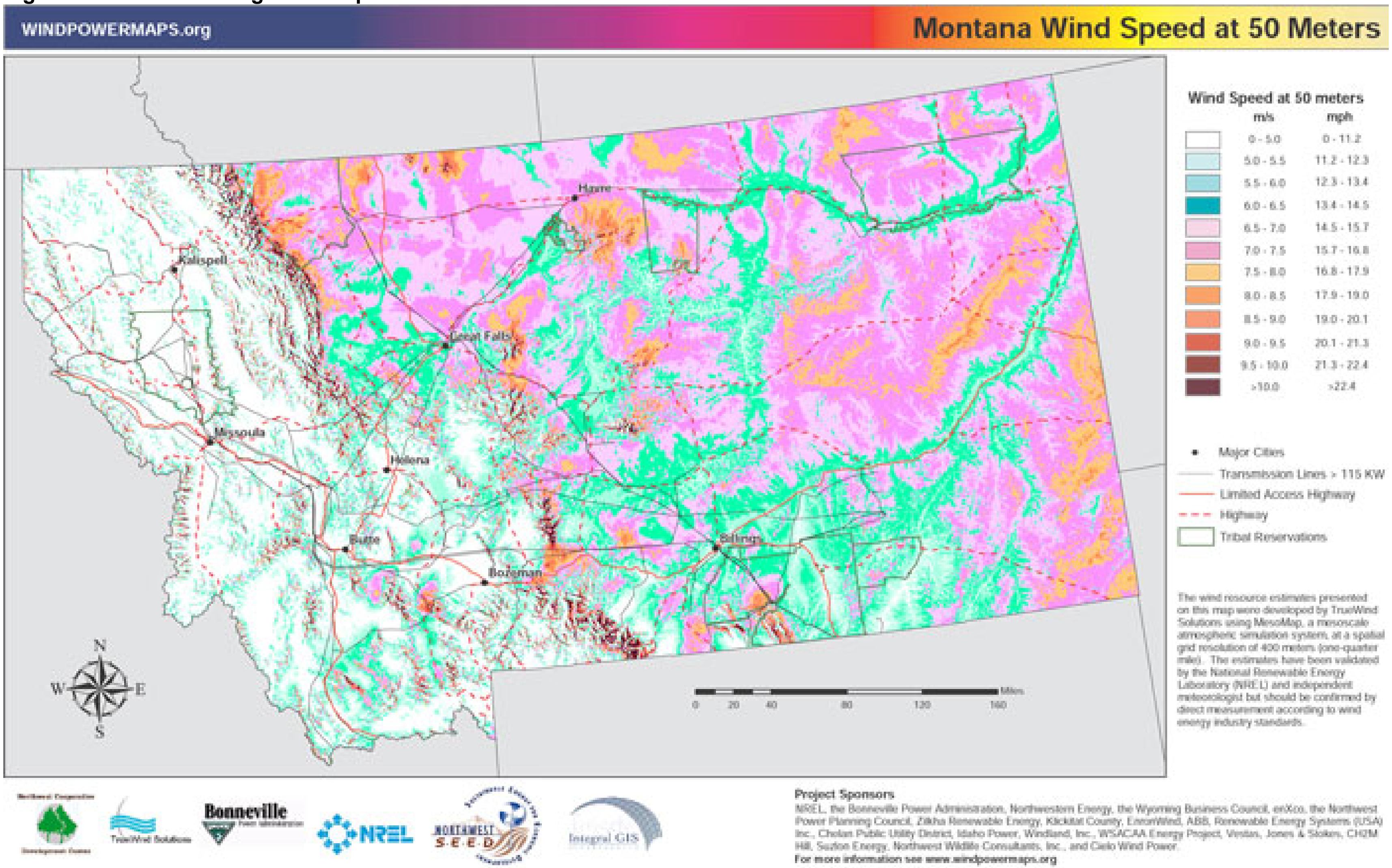
A preliminary wind resource assessment is prepared for a site known as Northern Cheyenne. This site is located in Southeastern Montana. A 50-meter meteorological tower was installed in November 2002 and is currently operating. One supplemental tower is also installed to gather additional wind data on the property. This preliminary wind resource assessment is based on historical wind data collected in the region.

The average wind speed projected for the Garfield Peak area at the 65 meter level is 18.1 mph; the average wind speed projected for an 80 meter level is 18.9 mph. A theoretical energy estimate, made for the GE 1.5MW turbine using these hub height wind speeds, indicates a gross capacity factor of 39% and 41%, respectively and a net capacity factor after losses of 34% and 35%, respectively.

2.0 Site Description

The site is located in southeastern Montana on the Northern Cheyenne Reservation. The general area consists of rolling hills and deep ravines. The land use is grazing and land cover is principally seasonal grasses. A few trees are evident in the lower elevation areas and in near ranches and cattle areas. A map depicting the annual average wind speed at 50 meters above ground level (agl) is presented in Figure 1.

Figure 1 – Annual Average Wind Speed in Montana at 50 Meters Above Ground Level



3.0 Meteorological Data

3.1 Data Sources

Meteorological data on the reservation are available from several sources. First, Montana Power Corporation operates three air quality stations on the reservation. These sites are Badger Peak, Garfield Peak, and Morningstar. Each site includes measurements of criteria air pollutants as well as wind speed and wind direction at 10 meters agl. Hourly wind speed and wind direction data are available from January 1, 1995 until December 31, 1999. Second, a Remote Automatic Weather Station (RAWS) site is located on Badger Peak. These data are collected principally for fire weather forecasting. The site is operated year round and hourly data area available. Data for a five year period from January 1998 until December 2002 are obtained from the Western Region Climate Center (WRCC) in Reno, Nevada. Finally, an on-site data collection program started in the late fall of 2002 with one 50-meter tower installed on the reservation and a second 20-meter tower installed in early January.

3.2 Climatology

The climatology for the Northern Cheyenne Reservation is based on the climatology for Billings, Montana (Table 1). The site is characterized has having cold dry winters and short, wet summers.

3.3 Air Quality Sites

Three air quality sites are located on the Northern Cheyenne Reservation:

Badger Peak	45.6483	106.5567	4,347 Feet
Garfield Peak	45.6031	106.4642	4,273 Feet
Morningstar	45.6681	1065189	4,311 Feet

The annual average wind speeds for the three air quality sites (Table 2) are 10.5 mph (4.7 mps) at Badger Peak, 14.0 mph (6.3 mps) at Garfield Peak, and 12.8 mph (5.7 mps) at Bright Star. The monthly average wind speeds are plotted in Figure 2, indicating the winter peak and the summer minimum. These data are collected at 10 meters agl. The mean hourly wind speeds at 10-meters agl for Garfield Peak are presented in Table 3.

Table 1 – Climatological Data for Billings, Montana

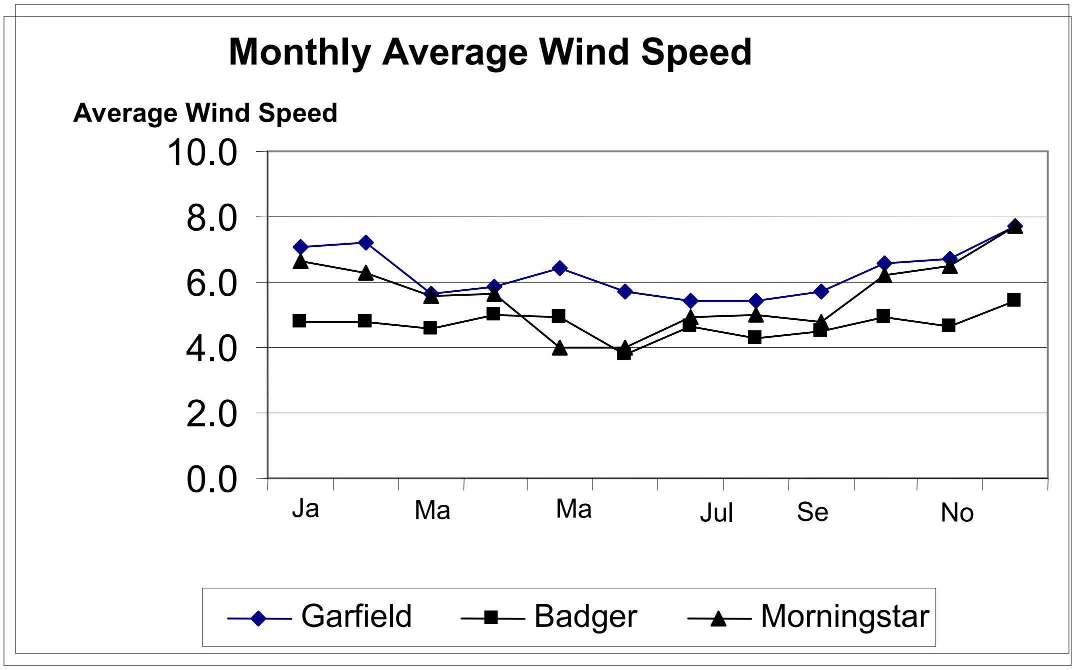
	(a)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE (Deg. F)														
Normals														
-Daily Maximum		31.8	38.6	45.8	57.1	66.7	77.6	86.7	84.7	71.6	60.6	44.5	34.4	58.3
-Daily Minimum		13.7	19.4	25.2	34.0	43.3	52.0	58.3	56.7	46.5	37.5	25.6	16.5	35.7
-Monthly		22.8	29.0	35.5	45.6	55.0	64.8	72.5	70.7	59.1	49.1	35.1	25.5	47.1
Extremes														
-Record Highest	61	68	72	79	92	96	105	106	105	103	90	77	69	106
-Year		1953	1961	1986	1939	1936	1984	1937	1961	1983	1992	1993	1980	JUL 1937
-Record Lowest	61	-30	-38	-19	-5	14	32	41	35	22	-7	-22	-32	-38
-Year		1937	1936	1989	1936	1954	1969	1972	1992	1984	1991	1959	1983	FEB 1936
NORMAL DEGREE DAYS														
Heating (base 65 Deg. F)		1308	1008	915	582	316	119	12	42	242	498	897	1225	7164
Cooling (base 65 Deg. F)		0	0	0	0	6	113	244	219	65	5	0	0	652
AV. STATION PRES. (mb)	23	890.8	890.9	888.6	889.4	889.1	889.9	891.8	891.9	892.5	892.1	890.6	890.7	890.7
PRECIPITATION (in.)														
Water Equivalent														
-Normal		0.90	0.64	1.16	1.74	2.57	1.99	0.94	1.01	1.36	1.14	0.84	0.79	15.08
-Maximum Monthly	61	2.35	1.77	2.70	4.42	7.71	7.64	5.08	3.50	4.99	3.80	2.34	2.00	7.71
-Year		1972	1978	1954	1955	1981	1944	1993	1965	1941	1971	1978	1973	MAY 1981
-Minimum Monthly	61	0.04	0.05	0.13	0.06	0.40	0.24	0.04	0.05	0.06	0.01	T	0.05	T
-Year		1941	1977	1936	1962	1993	1961	1988	1955	1964	1987	1954	1957	NOV 1954
-Maximum in 24 hrs	61	1.41	0.65	1.01	3.19	2.83	2.78	2.32	2.47	2.19	1.98	1.37	0.96	3.19
-Year		1972	1986	1973	1978	1952	1937	1993	1965	1966	1974	1959	1978	APR 1978
Snow, Ice Pellets, Hail														
-Maximum Monthly	61	27.7	22.4	27.6	42.3	15.6	2.0	0.4	T	9.3	23.1	25.2	28.8	42.3
-Year		1963	1978	1935	1955	1981	1950	1993	1992	1984	1949	1978	1955	APR 1955
-Maximum in 24 hrs	57	16.6	9.0	10.5	23.7	15.3	2.0	0.4	T	7.5	11.2	15.3	13.7	23.7
-Year		1972	1944	1964	1955	1981	1950	1993	1992	1983	1980	.1959	1978	APR 1955
WIND														
Mean Speed (mph)	56	13.0	12.2	11.4	11.4	10.7	10.1	9.5	9.5	10.2	11.0	12.1	13.0	11.2
Prevailing Direction through 1964		SW	SW	SW	SW	NE	SW	SW	SW	SW	SW	SW	WSW	SW
Fastest Mile														
-Direction(!!)	52	W	W	NW	NW	NN	NW	N	NW	NW	NW	NW	NW	NW
-Speed(mph)	52	66	72	61	72	68	79	73	69	61	68	63	66	79
-Year		1953	1963	1956	1947	1939	1968	1947	1983	1949	1949	1948	1953	JUN 1968
Peak Gust														
-Direction(!!)	12	NW	W	NW	NW	NW	W	32	NW	NW	31	SW	27	32
-Speed(mph)	12	59	62	52	59	60	54	71	69	61	64	58	70	71
-Date		1986	1988	1990	1987	1988	1987	1995	1986	1989	1995	1990	1995	JUL 1995

(a) - Length of Record in Years, although individual months may be missing.
0.* or * - The value is between 0.0 and 0.05.
Normals - Based on the 1961 - 1990 record period.
Extremes - Dates are the most recent occurrence.
Wind Dir.- Numerals show tens of degrees clockwise from true north. "00" indicates calm. Resultant Directions are given to whole degrees

Table 2. Monthly Average Wind Speeds (mps) for Badger Peak, Garfield Peak, and Bright Star.

Badger	1998	1999	2000	Average
Jan	4.6	5.1	4.6	4.8
Feb	4.7	6.0	3.7	4.8
Mar	3.9	5.0	4.8	4.6
Apr	4.7	5.1	5.2	5.0
May	4.8	5.1	4.8	4.9
Jun	4.8	4.4	2.1	3.8
Jul	4.5	4.8	4.6	4.7
Aug	4.3	4.3		4.3
Sep	4.3	4.6	4.6	4.5
Oct	5.1	4.8		5.0
Nov	4.6	4.7		4.6
Dec	5.4	5.5		5.4
Annual	4.6	4.9		4.7
Garfield	**1998**	**1999**	**2000**	**Average**
Jan	6.7	7.4		7.1
Feb	5.7	8.7		7.2
Mar	4.3	6.9	5.8	5.7
Apr	5.8	6.1	5.6	5.8
May	5.9	6.4	6.9	6.4
Jun	6.1	5.4		5.7
Jul	5.1	5.7		5.4
Aug	5.5	5.3		5.4
Sep	5.6	5.8		5.7
Oct	6.6	6.6		6.6
Nov	6.5	6.9		6.7
Dec	8.1	7.2		7.7
Annual	6.0	6.6		6.3
Bright Star	**1998**	**1999**	**2000**	**Average**
Jan	6.5	6.9	6.5	6.6
Feb	5.6	8.1	5.1	6.3
Mar	4.3	6.0	6.4	5.5
Apr	5.4	5.4	6.1	5.6
May	5.3	0.5	6.1	4.0
Jun	5.7	0.2	6.0	4.0
Jul	4.6	5.2	5.1	5.0
Aug	5.0	4.9		5.0
Sep	5.1	5.6	3.6	4.8
Oct	6.0	6.5		6.2
Nov	6.3	6.7		6.5
Dec	7.1	8.4		7.7
Annual	5.6	5.4		5.6

Figure 2 – Monthly Average Wind Speeds (mps) for Garfield Peak, Badger Peak, and Morningstar



3.4 Raws Site

The annual average wind speed for the RAWS site at Badger Peak, measured at 2 meters agl is 10.4 mph (4.6 mps). The mean hourly wind speeds are presented in Table 3. The time stamps for these data are Greenwich Mean Time (GMT) or Universal Time (UTC) which is -7 hours from local standard time. The diurnal trend in the RAWS data shows a nighttime maximum and a day time minimum which is typical of higher elevation sites

Table 3. Mean Hourly Wind Speeds for the Garfield Peak Air Quality Site.

MEAN HOURLY WIND SPEEDS

GARFIELD PEAK MONTANA
GARFIELD PEAK 10M WIND SPEED (MPH)

01/01/95 - 12/31/99

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	16.4	16.4	15.5	16.0	15.5	14.8	13.1	15.9	15.9	16.5	15.9	16.1	15.7
02	16.4	16.4	15.3	15.4	15.3	14.6	13.0	15.7	16.0	16.5	16.2	15.9	15.5
03	16.4	16.2	14.7	14.5	14.5	14.2	13.4	14.7	15.3	16.1	16.5	16.0	15.2
04	16.2	16.4	14.4	13.9	14.0	13.5	13.0	14.2	15.1	15.9	16.3	15.9	14.9
05	15.7	16.2	14.3	13.6	13.5	12.8	11.9	13.6	14.4	15.3	16.3	16.4	14.5
06	15.2	16.3	13.9	13.0	12.6	12.0	10.9	12.8	13.7	15.4	15.8	16.5	14.0
07	14.4	16.2	13.6	12.6	11.7	11.6	9.8	11.0	12.7	15.1	15.4	16.9	13.4
08	14.6	16.1	13.0	12.5	11.9	11.7	9.8	9.7	11.5	14.4	15.4	16.7	13.1
09	14.6	16.3	12.4	12.6	12.1	11.9	10.1	9.3	11.1	14.6	15.2	16.7	13.1
10	14.5	16.2	12.0	12.7	12.3	12.1	10.0	9.6	11.4	14.3	14.8	17.0	13.1
11	14.2	16.0	12.3	12.8	12.2	12.2	10.3	9.9	12.0	14.3	14.8	17.0	13.2
12	14.1	16.0	12.5	13.0	12.4	12.2	10.4	9.9	12.6	14.6	14.5	17.0	13.3
13	13.7	15.9	12.4	13.1	12.6	12.3	11.0	10.3	12.8	14.6	14.3	16.3	13.3
14	13.3	15.3	12.2	13.0	12.2	12.3	11.1	10.3	12.5	14.2	13.7	15.8	13.0
15	13.3	14.3	12.2	12.8	12.4	12.5	11.0	10.3	12.4	14.0	13.7	15.2	12.9
16	13.9	13.2	12.0	12.2	12.4	12.2	10.9	10.0	11.5	13.4	14.0	15.0	12.6
17	15.0	13.2	11.3	11.9	12.2	12.2	11.0	10.3	10.6	13.4	14.0	15.6	12.6
18	15.2	13.9	11.8	11.7	12.0	11.6	11.4	10.8	10.8	14.3	14.2	16.2	12.9
19	14.8	14.8	13.0	11.9	12.1	12.1	11.4	11.6	12.0	15.1	14.5	16.3	13.3
20	15.0	15.0	14.0	12.7	13.3	12.8	12.2	12.6	13.5	15.6	15.3	16.4	14.1
21	15.5	15.4	15.0	13.8	14.0	13.4	12.7	13.9	14.5	16.2	15.9	16.7	14.8
22	15.9	16.2	15.0	14.9	14.5	14.6	13.0	15.8	15.2	16.9	16.2	16.2	15.3

23	18.9	16.8	15.7	16.0	15.9	14.4	13.4	16.2	15.6	20.9	17.8	17.2	16.6
24	15.9	16.4	15.6	15.6	15.3	14.4	13.1	16.0	15.6	17.1	15.7	16.5	15.6
Mean	15.1	15.6	13.5	13.4	13.2	12.8	11.6	12.3	13.3	15.4	15.3	16.3	14.0
Good Hours	2945	2644	3611	3574	3689	3594	2976	2873	2690	3429	3377	3673	
Missing Hours	775	740	109	26	31	6	744	847	910	291	223	47	

39,075 Hours of Good Data 4,749 Hours Missing 89.2% Data Recovery

Table 4. Mean Hourly Wind Speeds for the Badger Peak RAWS Site (1998 – 2002). The time is recorded as GMT which is -07 hours from Local Standard Time (LST)

MEAN HOURLY WIND SPEEDS

BADGER PEAK MONTANA
2M WINDSPEED (MPH)

01/01/98 - 12/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	11.1	10.2	8.4	9.0	9.5	13.9	10.0	9.0	8.0	9.1	9.8	10.8	9.8
02	11.3	10.6	9.0	9.5	9.5	14.8	10.4	9.1	8.7	9.4	10.2	11.3	10.2
03	11.4	10.7	9.9	9.9	10.6	15.9	11.2	10.2	9.6	10.0	10.2	11.3	10.8
04	11.5	10.5	10.2	10.3	10.6	14.2	12.1	10.4	10.3	10.5	10.1	11.4	10.9
05	11.3	10.8	10.4	10.7	11.0	16.2	11.5	10.8	10.4	10.8	10.7	11.7	11.2
06	11.4	10.7	10.8	11.4	10.8	14.1	11.4	11.0	11.2	11.8	10.9	11.6	11.4
07	11.3	10.6	10.6	11.6	10.9	15.6	11.8	11.3	11.2	11.7	11.0	11.9	11.5
08	11.0	10.5	10.9	11.2	10.8	11.4	10.8	11.1	11.2	11.5	11.0	11.8	11.1
09	11.3	10.4	10.5	11.3	11.3	13.8	10.5	10.9	11.1	11.5	10.9	11.7	11.2
10	11.3	10.4	10.0	11.7	11.1	14.7	10.3	10.8	10.6	11.0	11.5	11.4	11.1
11	11.3	9.8	10.1	11.2	11.3	13.5	10.0	10.8	10.7	10.5	11.6	11.2	10.9
12	11.4	9.6	9.9	10.7	10.6	10.7	9.5	11.0	10.4	10.0	11.5	11.7	10.6
13	11.1	10.0	9.5	10.8	9.5	10.6	8.4	10.3	9.8	10.5	11.3	11.7	10.3
14	11.3	10.1	9.3	10.4	9.6	9.6	8.1	9.3	9.0	10.1	10.9	12.0	10.0
15	11.0	9.9	8.9	10.3	9.9	11.7	7.8	8.9	8.6	9.6	10.8	11.6	9.8
16	10.6	9.9	8.7	10.1	10.4	11.7	7.7	8.7	8.7	9.4	10.5	11.5	9.7
17	10.4	9.9	8.9	10.3	10.3	12.1	7.9	8.6	8.5	9.2	10.5	11.7	9.8
18	10.3	9.7	9.0	10.2	11.0	12.4	7.9	8.5	9.1	9.1	10.6	11.6	9.8
19	10.3	9.6	9.1	10.2	10.6	12.1	7.9	8.3	9.3	9.5	10.6	11.7	9.8
20	9.9	9.4	9.2	10.2	11.1	14.1	8.0	8.6	8.9	9.4	10.5	11.7	9.9

21	9.9	9.6	9.1	10.5	11.1	12.6	8.3	8.6	9.0	9.7	10.4	10.9	9.9
22	9.7	9.6	8.9	10.2	10.6	12.8	8.5	8.8	8.7	9.2	9.5	10.3	9.6
23	9.6	8.7	8.9	10.3	10.8	13.7	9.1	8.6	8.6	8.6	9.0	10.0	9.5
24	10.7	9.1	8.3	9.4	10.2	15.3	10.0	8.8	8.0	8.3	9.6	10.5	9.7
Mean	10.9	10.0	9.5	10.5	10.5	13.3	9.6	9.7	9.6	10.0	10.6	11.4	10.4
Good Hours	3556	2916	3270	2775	2875	2345	3511	3617	3473	3591	3507	2913	
Missing Hours	164	468	450	825	845	1255	209	103	127	129	93	807	

38,349 Hours of Good Data   5,475 Hours Missing   87.5% Data Recovery

3.5 On-Site Meteorological Monitoring Program

One primary tower was installed on Northern Cheyenne in November 2002. This 50-meter NRG Talltowers is instrumented with three levels of wind speed and two levels of wind direction. Maximum #40 anemometers and #200P wind directions sensors are used. The sensors are sampled once per second and hourly averages calculated using a NRG Systems 9300SA datalogger. The data are stored on flashcards which are removed for processing. A 20-meter tower is also installed on the reservation. This second tower was installed in January, 2003.

3.6 Wind Rose

Two wind roses which show the joint frequency of wind speed and wind direction are presented in Figures 3 (Badger Peak RAWS) and 4 (Garfield Peak AQ). The predominant wind directions appear to be south, southwest through west, and northwest.

3.4 Wind Shear

Wind shear is the change or increase in wind speed above ground level. The simple wind power law is expressed as:

$$U_2 = U1\ (Z_2/Z_1)^{\text{alpha}}$$

Where U_2 and U_1 are the wind speeds at the upper and lower levels, Z_2 and Z_1 are the upper and lower elevations, and alpha is the wind speed power law exponent. The typical value for the wind speed power law exponent is 0.14 (1/7 power law). Depending on terrain and surface roughness, the value may vary between 0.05 and 0.35. A conservative power law exponent of 0.14 is used in any hub height projections prepared in this report.

3.5 Projected Hub Height Wind Speeds

The hourly Garfield Peak Air Quality Site data are extrapolated to projected hub heights of 65 meter and 80 meters above ground level. A conservative power law exponent of 0.14 is used in these projections. These projections are presented in Tables 5 and 6. The estimated 65 meter annual average wind speed is 18.1 mph; the estimated 80 meter annual average wind speed is 18.9 mph.

3.6 Peak Wind Speed

The highest 3-second gust for the Northern Cheyenne site is estimated based on the peak wind speed information from the airport data collected at Billings, Montana. The peak wind speed measured at Billings, Montana over the period of record is 71 mph (31.7 mps). Selecting the highest value, 71 mph, and adjusting it from 7 meters (21 feet) to 80 meters (262 feet) above ground level using the wind speed power law and a power law exponent of 0.14 yields a peak wind speed of 99.7 mph (44.5 mps).

Figure 3 - Wind Rose for the Badger Peak RAWS Site. The number in the center, 12.2%, is the percentage of time the wind speeds are less than 5 mph.

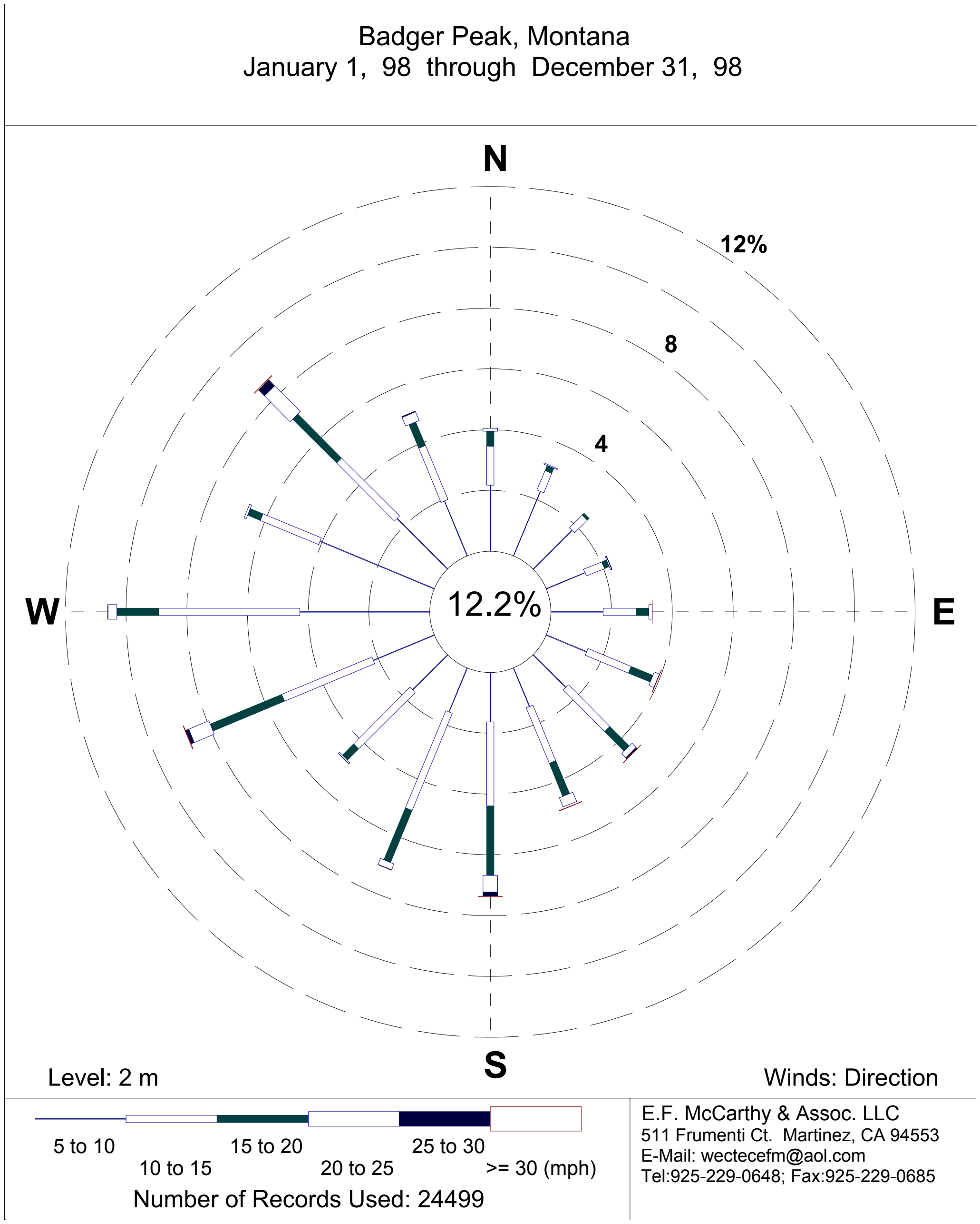


Figure 4 - **Wind Rose for the Garfield Peak AQ Site. The number in the center, 9.9%, is the percentage of time the wind speeds are less than 5 mph.**

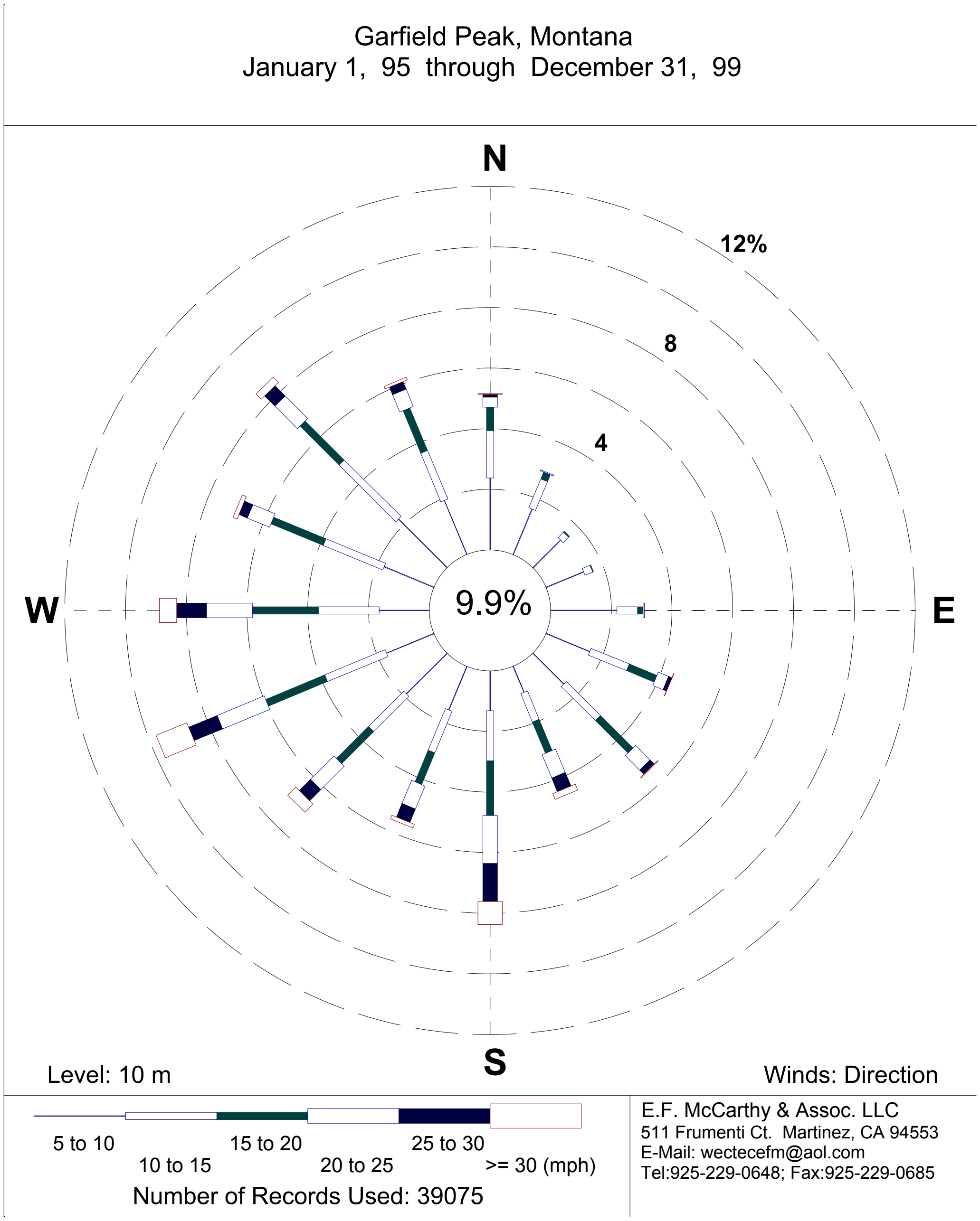


Table 5. Projected 65 Meter Wind Speeds (mph) for Garfield Peak.

MEAN HOURLY WIND SPEEDS

BADGER PEAK MONTANA
GARFIELD PK 65M WS (WS12 X 1.299) (MPH)

01/01/95 - 12/31/99

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	21.3	21.3	20.1	20.8	20.1	19.2	17.0	20.7	20.6	21.4	20.7	21.0	20.3
02	21.4	21.3	19.9	19.9	19.9	19.0	16.9	20.4	20.8	21.5	21.0	20.6	20.2
03	21.3	21.1	19.1	18.8	18.8	18.4	17.4	19.0	19.8	20.9	21.4	20.8	19.7
04	21.0	21.3	18.7	18.1	18.1	17.5	16.8	18.4	19.6	20.7	21.2	20.7	19.3
05	20.4	21.0	18.5	17.6	17.6	16.6	15.5	17.7	18.7	19.9	21.1	21.3	18.8
06	19.7	21.2	18.0	16.9	16.4	15.5	14.2	16.6	17.8	20.0	20.5	21.5	18.2
07	18.6	21.1	17.7	16.4	15.2	15.1	12.7	14.3	16.4	19.6	20.0	21.9	17.5
08	19.0	20.9	16.9	16.3	15.5	15.2	12.7	12.6	14.9	18.7	20.0	21.7	17.1
09	19.0	21.2	16.1	16.3	15.8	15.4	13.2	12.0	14.4	19.0	19.7	21.7	17.0
10	18.8	21.0	15.6	16.5	16.0	15.7	13.0	12.4	14.8	18.5	19.3	22.0	17.0
11	18.4	20.8	15.9	16.7	15.8	15.9	13.4	12.9	15.6	18.5	19.2	22.1	17.1
12	18.3	20.8	16.2	16.8	16.1	15.9	13.5	12.8	16.4	18.9	18.9	22.1	17.3
13	17.8	20.7	16.1	17.0	16.3	15.9	14.2	13.3	16.7	19.0	18.6	21.2	17.3
14	17.3	19.9	15.8	16.9	15.9	16.0	14.5	13.4	16.2	18.5	17.8	20.6	16.9
15	17.2	18.6	15.8	16.7	16.1	16.2	14.3	13.4	16.1	18.1	17.8	19.7	16.7
16	18.1	17.2	15.5	15.8	16.1	15.8	14.2	13.0	14.9	17.5	18.2	19.5	16.4
17	19.4	17.2	14.7	15.5	15.9	15.8	14.3	13.4	13.8	17.4	18.2	20.3	16.4
18	19.7	18.1	15.3	15.3	15.6	15.1	14.8	14.1	14.0	18.6	18.4	21.1	16.7
19	19.2	19.2	16.9	15.5	15.8	15.7	14.9	15.1	15.6	19.6	18.8	21.2	17.3

20	19.5	19.5	18.2	16.6	17.3	16.6	15.9	16.3	17.5	20.3	19.9	21.3	18.3
21	20.2	20.0	19.5	17.9	18.2	17.4	16.5	18.0	18.9	21.1	20.6	21.7	19.2
22	20.7	21.0	19.5	19.4	18.8	19.0	16.8	20.5	19.8	21.9	21.0	21.0	19.9
23	20.9	21.8	20.4	19.9	19.4	18.8	17.4	21.1	20.2	21.9	21.4	21.2	20.3
24	20.6	21.3	20.3	20.2	19.8	18.7	17.0	20.9	20.2	22.2	20.4	21.4	20.3
Mean	19.5	20.3	17.5	17.4	17.1	16.7	15.0	15.9	17.3	19.7	19.7	21.1	18.1
Good Hours	2943	2644	3611	3573	3688	3594	2976	2873	2690	3426	3376	3672	
Missing Hours	777	740	109	27	32	6	744	847	910	294	224	48	

39,066 Hours of Good Data 4,758 Hours Missing 89.1% Data Recovery

Table 6. Projected 65 Meter Wind Speeds (mph) for Garfield Peak.

MEAN HOURLY WIND SPEEDS

BADGER PEAK MONTANA
GARFIELD PK 80M WS (WS12 X 1.337) (MPH)

01/01/95 - 12/31/99

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	21.9	21.9	20.7	21.4	20.7	19.8	17.4	21.3	21.2	22.0	21.3	21.6	20.9
02	22.0	21.9	20.5	20.5	20.4	19.5	17.4	20.9	21.4	22.1	21.7	21.2	20.8
03	21.9	21.7	19.7	19.4	19.4	18.9	17.9	19.6	20.4	21.5	22.0	21.4	20.3
04	21.6	21.9	19.2	18.6	18.7	18.0	17.3	18.9	20.2	21.3	21.8	21.3	19.9
05	20.9	21.6	19.1	18.1	18.1	17.1	15.9	18.2	19.3	20.5	21.8	21.9	19.4
06	20.3	21.8	18.5	17.4	16.9	16.0	14.6	17.1	18.4	20.6	21.1	22.1	18.7
07	19.2	21.7	18.2	16.9	15.7	15.6	13.0	14.8	16.9	20.2	20.6	22.6	18.0
08	19.5	21.5	17.4	16.7	15.9	15.6	13.1	12.9	15.3	19.2	20.6	22.3	17.6
09	19.5	21.8	16.6	16.8	16.2	15.8	13.5	12.4	14.8	19.5	20.3	22.3	17.5
10	19.4	21.6	16.1	17.0	16.5	16.1	13.4	12.8	15.2	19.1	19.8	22.7	17.5
11	18.9	21.4	16.4	17.1	16.3	16.3	13.8	13.3	16.0	19.1	19.7	22.7	17.6
12	18.8	21.4	16.7	17.3	16.6	16.3	13.9	13.2	16.9	19.5	19.4	22.8	17.8
13	18.3	21.3	16.6	17.5	16.8	16.4	14.6	13.7	17.2	19.5	19.2	21.8	17.8
14	17.7	20.4	16.3	17.4	16.3	16.5	14.9	13.8	16.7	19.0	18.4	21.2	17.4
15	17.7	19.1	16.3	17.2	16.6	16.7	14.7	13.8	16.5	18.6	18.3	20.3	17.2
16	18.6	17.7	16.0	16.2	16.6	16.3	14.6	13.3	15.4	18.0	18.7	20.0	16.9
17	20.0	17.7	15.1	15.9	16.4	16.3	14.7	13.8	14.2	18.0	18.8	20.9	16.9
18	20.3	18.6	15.8	15.7	16.0	15.5	15.2	14.5	14.4	19.1	18.9	21.7	17.2
19	19.8	19.8	17.4	15.9	16.2	16.2	15.3	15.5	16.0	20.2	19.3	21.8	17.8
20	20.1	20.1	18.7	17.0	17.8	17.1	16.3	16.8	18.0	20.8	20.5	22.0	18.8
21	20.8	20.6	20.1	18.4	18.8	17.9	17.0	18.6	19.4	21.7	21.2	22.3	19.8

22	21.3	21.6	20.1	19.9	19.3	19.5	17.3	21.1	20.3	22.5	21.6	21.6	20.5
23	21.5	22.5	21.0	20.5	19.9	19.3	17.9	21.7	20.8	22.5	22.0	21.8	20.9
24	21.2	22.0	20.9	20.8	20.4	19.3	17.5	21.5	20.8	22.8	21.0	22.1	20.8
Mean	20.0	20.9	18.1	17.9	17.6	17.2	15.5	16.4	17.8	20.3	20.3	21.8	18.7
Good Hours	2943	2644	3611	3573	3688	3594	2976	2873	2690	3426	3376	3672	
Missing Hours	777	740	109	27	32	6	744	847	910	294	224	48	

39,066 Hours of Good Data 4,758 Hours Missing 89.1% Data Recovery

4.0 Wind Turbine Power Curve

The GE Wind 1.5 MW wind turbine (70M Rotor) is a three bladed, upwind, horizontal axis wind turbine employing variable pitch blade technology. The power curve for the GE Wind 1.5MW turbine for the Northern Cheyenne Site using an air density of 1.08 kg/m^3 is presented in Table 7.

Table 7 - GE Wind 70M Power Curve

Wind Speed (mps)	Power (kW)	Wind Speed (mps)	Power (kW)	Wind Speed (mps)	Power (kW)	Wind Speed (mps)	Power (kW)
4	28	10	946	16	1500	22	1500
5	87	11	1228	17	1500	23	1500
6	177	12	1420	18	1500	24	1500
7	299	13	1486	19	1500	25	1500
8	461	14	1500	20	1500	>25	0
9	676	15	1500	21	1500		

5.0 Annual Energy Estimate

5.1 Gross Annual Theoretical Energy Estimate

The wind speed frequency is combined with the GE Wind power curve to create the annual theoretical energy estimate for a single turbine. The theoretical gross energy output for the 70 meter GE Wind Turbine (1.5MW) on a 65 meter tower is 5,116,349kWh. The theoretical gross energy output for the 70 meter GE Wind Turbine (1.5MW) on an 80 meter tower is 5.331.350kWh.

5.2 Net Annual Theoretical Energy Estimate

The gross annual theoretical energy output is adjusted by various loss factors to estimate the actual or net energy delivered to the substation. These losses take into account the wind turbine out-of-service time associated with scheduled and unscheduled downtime, electrical line losses from the turbine to the substation, control system losses, array losses due to wake effects between adjoining turbines, and lost power associated with blade icing and blade soiling.

The annual net energy production for a single turbine is calculated using the following formula:

$$AEP_{net} = AEP_{gross} * (1- EL)$$

where AEP_{net} is the Annual Net Energy Production of the wind facility;

AEP_{gross} is the Annual Gross Energy Production of the wind facility;

EL is the product of individual energy losses (%);

EL is the product of the individual energy losses and is calculated as follows:

$$EL = 1-(1 - L_{array}) * (1 - L_{blade}) * (1 - L_{collect}) * (1 - L_{control}) * (1-Availability)$$

where L_{array} = Array losses

$L_{soiling}$ = Blade contamination losses

$L_{collect}$ = Collection system from turbine to grid

$L_{control}$ = Control, grid, and miscellaneous losses

Availability = Availability is the percentage of calendar time that the turbines are functional and ready to deliver power to the grid.

Table 8. Theoretical Energy Projection for a GE Wind Turbine (1.5MW) on a 65 Meter Tower.

THEORETICAL WIND TURBINE PRODUCTION 01/01/95 - 12/31/99

Wind: GARFIELD PK 65M WS (WS12 X 1.299)
BADGER PEAK MONTANA

Wind Speeds Multiplied By 1.00

Turbine: GE 1.5 SL (1500Kw)70M ROTOR 1.08KG/M**2

Rated at: 1500 kW at 30.0 MPH
Maximum Output: 1500 kW at 30.0 MPH

Status	MPH	Time hrs	Time %	Production KW-hrs	Production %
Below Cut-in	Under 10.0	9394	24.0		
Cut-in To Rated	10.1-30.0	24453	62.6	15,086,860	66.1
Rated To Cut-out	30.1-56.0	5155	13.2	7,729,956	33.9
Above Cut-out	Over 56.0	64	.2		
Contactor Closed		29608	75.8		

kW-hrs at Capacity / Total kW-hrs 33.9

hrs at Capacity / hrs of Operation 17.4

Mean Wind Speed 18.1 MPH

Energy Produced 22,816,810 kW-hrs

Annual Production Rate 5,116,349 kW-hrs

Capacity Factor .39

39066 hrs of Good Data 4758 hrs Missing 89.1% Data Recovery

Table 9. Theoretical Energy Projection for a GE Wind Turbine (1.5MW) on a 80 Meter Tower.

THEORETICAL WIND TURBINE PRODUCTION 01/01/95 - 12/31/99

Wind: GARFIELD PK 80M WS (WS12 X 1.337)
BADGER PEAK MONTANA

Wind Speeds Multiplied By 1.00

Turbine: GE 1.5 SL (1500Kw)70M ROTOR 1.08KG/M**2

Rated at: 1500 kW at 30.0 MPH
Maximum Output: 1500 kW at 30.0 MPH

Status	MPH	Time hrs	Time %	Production KW-hrs	Production %
Below Cut-in	Under 10.0	8961	22.9		
Cut-in To Rated	10.1-30.0	24353	62.3	15,286,850	64.3
Rated To Cut-out	30.1-56.0	5663	14.5	8,488,779	35.7
Above Cut-out	Over 56.0	89	.2		
Contactor Closed		30016	76.8		

kW-hrs at Capacity / Total kW-hrs 35.7

hrs at Capacity / hrs of Operation 18.9

Mean Wind Speed 18.7 MPH

Energy Produced 23,775,630 kW-hrs

Annual Production Rate 5,331,350 kW-hrs

Capacity Factor .41

39066 hrs of Good Data 4758 hrs Missing 89.1% Data Recovery

The loss factors assumed for this project include 3% for availability, 2% for electrical line losses, 7.5% for array and off-axis wind direction losses, 1% for turbulence and control, and 1% for blade contamination losses. The gross to net ratio is 0.862.

The calculated net energy production for a single turbine on a 65 meter tower using the loss factors presented above is 4,410,293kWh. The net capacity factor is 33.6%.

The calculated net energy production for a single turbine on a 80 meter tower using the loss factors presented above is 4,595,624kWh. The net capacity factor is 34.9%.

"NORTHERN CHEYENNE NATION WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Tribal Load Assessment and Export Markets

The Northern Cheyenne Tribe (NCT) is served exclusively by the Tongue River Rural Electric Cooperative (TRECO). The total load of TRECO is approximately fifteen megawatts (15 MW) with the majority of demand coming from the NCT. The largest loads on the system are the hospital, tribal headquarters, Dull Knife College, the casino and the Lame Deer School. Each of these facilities would benefit from an energy audit and the deployment of demand side management technologies. In addition an analysis of the existing loads of the local utility and the future requirements of that utility is being conducted. The analysis will provide the tribe with the necessary information to select a strategy of self supply and/or export supply. Based on the decisions and direction of the tribe, Disgen will engage the local utility or its wholesale electricity supply in order to discuss the potential of a power purchase agreement.

The NCT has decided to proceed with the development of a thirty megawatt (30 MW) wind project which will necessitate the exporting of the energy to a utility buyer. While the NCT wishes to consume some of the energy locally, the transmission system and the likely purchaser, i.e., a large utility, limits that possibility dramatically. The best method of the NCT providing this energy to its members is to sell the energy to Central Montana Generation and Transmission Cooperative and have its member TRECO supply it to the tribal members. This is a complicated transaction and will consume less than five megawatts (5 MW) of the planned capacity. Disgen will continue to define options for tribal consumption of the energy.

"NORTHERN CHEYENNE NATION WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Transmission and Interconnection Consideration

The interconnection of the potential wind facility will be to a 69 kV transmission line owned by Tongue River Rural Electric Cooperative (TRECO). The line runs through the project area. The TRECO general manager has been supportive of the feasibility study and provided a letter to that effect which is included in this report.

TRECO is a member of Central Montana Generation and Transmission Cooperative and receives all its power from the Colstrip 2250 MW coal fired power plant located 26 miles north of the Northern Cheyenne Reservation. The electrical service from Colstrip to TRECO is through a 69 kV system. TRECO is predominately a winter peaking system with approximately 15 MW at winter peak, so TRECO could not accept all the energy from the NCT Wind Facility. Consequently, the likely purchasers of the energy will be any of the utilities accepting power from Colstrip. These entities include (i) Puget Sound, (ii) Pennsylvania Power and Light, (iii) PacifiCorp, (iv) Northwestern Energy, (v) Avista Energy**, and (vi) Portland General Electric.** TRECO confirmed that 30 MW of wind can be added to its system without adversely affecting its operation.

The project collection system will consist of a 34.5 kV buried cable, interconnecting to a small substation adjacent to the transmission line stepping the voltage up to 69 kV. The interconnection will require a switch, relay, meter, and other equipment at the interconnect point.

The NCT would like to deliver at least some of the energy from a potential wind facility to its tribal members. However, the distance to Lame Deer from the proposed facility is approximately ten miles, so a contract with TRECO will be required to deliver the energy to the tribe. It is unknown whether such a contract is feasible.

"NORTHERN CHEYENNE NATION WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Technology Analysis

The Northern Cheyenne Tribe (NCT) and Distributed Generation Systems, Inc. (Disgen) examined three potential renewable technologies for deployment on the reservation; (i) biomass, (ii) solar (iii) pumped storage and (iv) wind.

Biomass: The NCT owns a sawmill that is not currently operational. The NCT would like to re-commission the sawmill from which a significant amount of wood waste would be created if a market for lumber exists. The sawmill was closed in the 1990s as a result of the import of wood products from Canada which depressed lumber prices in the US market. The wood waste would primarily be in the form of saw dust, very small particles. Disgen interviewed scientists at the National Renewable Energy Laboratory and was informed that power plants created solely for the production of electricity from biomass are not currently economically competitive. In addition, some of the more promising gasification biomass technologies cannot use fine particles such as sawdust for feedstock. In order to be competitive, biomass projects must produce electricity and have an economic use for the waste heat or is constructed to supply non-energy related materials such as pulp and paper products. A typical use for the waste heat is a greenhouse. At this time, the NCT is not planning to re-commission the sawmill but may do so in the future at which time the biomass option will be reconsidered.

Solar: For the most part, solar technologies have been relegated to special products due the relatively high cost of energy they produce. The only commercially competitive solar technology available currently is solar thermal which usually requires supplemental firing from a fossil fuel source such as natural gas. The NCT reservation does not have commercial natural gas service, so supplemental firing is not possible. Disgen continues to explore other emerging solar technologies for the benefit of the NCT.

Pumped storage: The NCT has water rights from the Tongue River flowing through the NCT Reservation and from Yellowtail Dam, located within the Crow Reservation to the west. The NCT also has as a key objective becoming energy independent, i.e., disconnecting from the grid if they so choose. In order to utilize the water resource and supply dispatchable energy, a pumped storage system integrated with a wind energy facility conceptually works, both technically and economically. Consequently, the NCT asked Disgen to begin the analysis and a candidate site has been identified, very close to the proposed wind project site. Disgen has conducted some preliminary technical and FERC permitting investigations and recommends that further analyses be done to define the economics. It is believed that a small pumped storage facility that is closed loop will not require a FERC license. Such a facility would provide the NCT significant flexibility in managing energy and would also provide the local utility, Tongue River Electric Cooperative (TRECO) with a demand-side management tool that may be able to manage demand, improve TRECO's load factor, and unload transmission line capacity. Disgen is continuing to refine this concept.

Wind energy: The NCT has access to long-term climatological data from three sets of instruments located on the reservation that monitor air quality as a result of the Colstrip Power located 26 miles north of the reservation. These data collection systems also recorded wind speed and direction for the past ten years. This data was used to select a project area about ten miles east of Lame Deer and north of US Highway 212. The initially installed fifty meter (50m) meteorological tower was relocated to the project area selected under this feasibility study grant and the wind data has averaged in excess of 16.0 miles per hour from November 2003 thru April 2004. This data is slightly less than the expectations of the meteorologist in his Wind Assessment Report included herein. However, a full year's data has not yet been collected and once collected, it is anticipated that the estimates will be reinforced.

"NORTHERN CHEYENNE NATION WIND-SOLAR-BIOMASS FEASIBILITY STUDY"

Economic Analysis

The economic analysis attached herein is created using the same project pro-forma models used for project financing within the wind industry. The assumptions integral to the models assume a third party taxable owner, not tribal non-taxable ownership. In order to obtain the lowest cost of energy and thereby compete economically in the marketplace, the Production Tax Credit (PTC) for wind energy as defined by the US Congress must be fully applied. That application requires an owner which has a significant federal tax liability and is not subject to the Alternative Minimum Tax (AMT). The PTC is not transferable and must be filed by the owner of the project.

Newly proposed tax legislation for wind energy contains a special provision for Native American owned facilities which allows the transfer of the PTC from the non-taxable tribe to another entity. This has tremendous value for the tribes and will facilitate greater economic development for the tribes.

Phase One Screening Report:

Northern Cheyenne Nation

Lame Deer Site

Rosebud County, Montana

April 23, 2003

Prepared for:

Disgen

Prepared by:

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INTRODUCTION:

Wind energy is one of the fastest growing sources of "green" energy in the U.S. However, wind plants can have negative effects on wildlife. Although studies have shown both the direct and indirect effects on wildlife by most wind plants to be minimal, state wildlife agencies, the U.S. Fish and Wildlife Service and environmental organizations have concern over the potential effects of wind plants on wildlife. State wildlife agencies and environmental organizations are concerned with issues such as critical wildlife habitat, avian fatalities and the disturbance or loss of unique plants and habitats. The U.S. Fish and Wildlife Service is charged with enforcing the Endangered Species Act, The Eagle Protection Act, and the Migratory Bird Treaty Act, and is concerned about impacts to migratory birds and listed species (candidate, proposed, threatened, or endangered). Currently, several wind power companies are conducting studies required by the described agencies.

When exploring potential wind plant sites, knowledge of potential wildlife issues would help the wind industry identify and avoid possible conflicts with wildlife and state and federal natural resource agencies. WEST, Inc was asked by Disgen to evaluate potential impacts to wildlife at a prospective wind plant site. The area is located northeast of Lame Deer within Rosebud County, Montana on the Northern Cheyenne Reservation (Figure 1). This report focuses on the following wildlife issues:

- Raptor Issues
    1. Identifying areas of potentially high nesting density
    2. Identifying areas of potentially high prey density
    3. Examine topography to determine the potential for high use and nest locations
    4. Determine the species likely to occur in the area
    5. Determine the potential for migratory pathways
- Candidate, Proposed, Threatened, Endangered or State Protected Species
    1. Identify the potential occurrence of federally listed or state protected species through existing literature and database searches
    2. Evaluate the suitability of habitat at wind plant sites for protected species
- State Wildlife Issues (using existing state wildlife agency information)
    1. Determine if site is considered a critical winter or parturition area or other highly valuable habitat
    2. Determine if area is considered a migratory route for game species
    3. Examine habitat during site visits to determine the potential for use by game or state protected species
- Unique habitat
    1. Evaluate the uniqueness of the site relative to the surrounding area. For example: wildlife might be fatally attracted to a desirable habitat (a rocky bluff) surrounded by undesirable areas (short-grass prairie)
    2. Determine the potential for sensitive or protected plants to occur on site through a habitat evaluation and a search of existing information

- Bats
  1. Determine the potential for bat deaths at the wind plant site. Proximity to potential feeding sites and hibernacula will be evaluated
  2. Determine species likely to occur in the area

- Avian Migratory Pathways

METHODS:

Biological resources within the project and evaluation areas were evaluated through a search of existing data and a site visit. The project and evaluation areas were visited on February 19, 2003 to evaluate habitat, potential for avian migratory pathways, and look for raptor nests, prey populations and other biological resources.

Several sources were used to identify biological resources within the project area, including a site visit, information obtained from the Billings office of the USFWS, requesting data from the Montana Natural Heritage Program, interviews with local experts and other sources of information (see Literature Cited). After biological resources within the project area were identified, we analyzed the potential for conflicts with the potential wind plant based upon baseline and mortality studies conducted at other wind plants throughout the U.S.

Study Area. The potential project area is located within T 2 S, R 43 E, Sec 17-20, 29-30 and T 2 S, R 42 E, Sec 24. We also evaluated a much larger area in the event the project was expanded, hereafter referred to as the evaluation area. The area evaluated for potential wildlife impacts includes land owned by the Northern Cheyenne east of Montana 39 and north of US 212 (Figure 2). Most of the evaluation area is characterized by relatively tall ridges dominated by open Ponderosa pine. Within the project area large areas of forest were recently burned and salvage logged, resulting in large openings within a forest matrix. Other habitat types are present within the evaluation area, including riparian areas, open sagebrush and grassland and cliffs. The Tounge River and associated mature cottonwood riparian areas are found on the eastern edge of the evaluation area. Open sagebrush and grassland habitats are also present in the eastern portion of the evaluation area.

RESULTS:

Raptor Issues

Nesting density and species breeding in area. Nesting habitat for raptors is present throughout the evaluation area, including open ponderosa pine forest, riparian areas and cliffs. Within two miles of the project area, most potential nesting habitat is limited to one area with some rock outcrops and cliffs (Figure 2), open ponderosa pine habitat and riparian areas along Greenleaf Creek and Stebins Creek (Figure 3). Potential nesting densities are difficult to assess and may depend largely on potential prey densities. Nesting densities of some species are likely to be higher on or near cliffs or riparian areas. Due to the presence of a variety of habitats, several species have the potential to nest within the evaluation area (Table 1).

Table 1. Raptor species potentially breeding within the evaluation area. Species distribution information is based on the Montana Bird Distribution Database (2003) and information obtained from the USFWS.

Species	**Habitat**
American kestrel (*Falco sparverius*)	Open habitats; Will nest in cliffs or snags
Prairie Falcon (*Falco mexicanus*)	Open habitats; Mostly nest in cliffs or rock outcrops and not likely to nest within the project area.
Merlin (*Falco columbarius*)	Open pine forest and open habitats; Nest within trees and old raptor or magpie nests
Bald Eagle (*Haliaeetus leucocephalus*)	Nesting and wintering habitat likely limited to Tounge River riparian area. No nesting habitat is present within the project area due to lack of large bodies of water
Golden Eagle (*Aquila chrysaetos*)	May nest in open forest, open habitats or cliffs
Osprey (*Pandion haliaetus*)	May nest along Tounge River riparian area
Red-tailed Hawk (*Buteo jamaicensis*)	Open forest or open habitats
Ferruginous Hawk (*Buteo regalis*)	Open habitats, not likely to nest within the project area.
Northern Harrier (*Circus cyaneus*)	Open habitats, not likely to nest within the project area.
Swainson's hawk (*Buteo swainsoni*	Open habitats, not likely to nest within the project area.
Cooper 's hawk (*Accipiter cooperii*)	Forested areas or riparian areas
Northern Goshawk (*Accipiter gentiles*)	Forested areas
Flammulated Owl (*Otus flammeolus*)	Forested areas
Great-horned Owl (*Bubo virginianus*)	Will nest in most habitats
Northern Saw-whet owl (*Aegolius funereus*)	Forested areas or riparian habitats
Short-eared owl (*Asio flammeus*)	Open habitats, not likely to nest within the project area
Burrowing Owl (*Athene cunicularia*)	Open areas, likely limited to prairie dog towns. Not likely to nest within the project area
Eastern Screech Owl (*Otus asio*)	Cottonwood riparian areas
Long-eared Owl (*Asio otus*)	Open habitats, not likely to nest within forest or project area

Potential for prey densities. Due to snow cover throughout most of the project area, it was difficult to evaluate the potential for prey densities. The potential exists for colonial species of rodents, such as ground squirrels, to occur within burned and other open habitats in the project area. One large black-tailed prairie dog town is present within the southeast portion of the evaluation area, approximately 3 – 4 miles from the project area. (Figure 2). Species such as golden eagle, red-tailed hawk, ferruginous hawk and burrowing owl may spend large amounts of time hunting within the prairie dog town. Burned areas within the project area may also provide habitat for relatively high densities of woodpeckers, such as the northern flicker and hairy woodpecker. Species such as Cooper's hawks and northern goshawks may be attracted to areas with relatively high densities of woodpeckers.

Does the topography of the site increase the potential for raptor use? At other wind plants located on prominent ridges with defined edges, raptors fly along the rim edges, using wind updrafts to maintain altitude while hunting, migrating or soaring. Turbines are often placed on prominent ridges, in order to use higher wind speeds and updrafts that raptors also use. The project area contains some prominent ridges, and the potential for raptors to use updrafts while hunting, soaring, or migrating through the area is high (Figure 4).

Federal and State Protected Species

According to the U.S. Fish and Wildlife Service (2003), four species listed under the Endangered Species Act are present within Rosebud County: bald eagle, black-footed ferret, and interior least tern. The black-tailed prairie dog is currently considered a candidate for listing under the endangered species act.

Bald Eagle. Bald eagles are documented as breeding along the Tounge River within the latilong of the evaluation area. Bald eagles may use the Tounge River and the associated riparian area adjacent to the evaluation area for nesting and winter habitat. The proposed project area is located approximately eight miles east of the Tounge River. It is highly unlikely that bald eagle nesting or winter roost habitat is present within the project area. However, bald eagles may also occasionally fly through the project area while hunting or migrating. The Bald eagle is currently listed as threatened under the Endangered Species Act.

Black-footed ferret. The black-footed ferret (*Mustela nigripes*) is listed as endangered under the Endangered Species Act. Black-footed ferrets rely on active prairie dog towns for food and shelter. One large black-tailed prairie dog town was observed within the southeast portion of the evaluation area. Since 1987, no populations of black-footed ferrets have been discovered in the wild, and it is highly unlikely that black-footed ferrets exist within the project area. Never the less, the potential exists for black-footed ferrets to occur within black-tailed prairie dog towns within the evaluation area. The project area occurs within open ponderosa pine habitat, and it is highly unlikely that black-tailed prairie dogs or black-footed ferrets occur within the project area.

Black-tailed prairie dog. Although considered as a candidate for listing under the Endangered Species Act, the black-tailed prairie dog (*Cynomys ludovicianus*) does not receive any special federal protection. However, impacts to black-tailed prairie dog towns may trigger potential effects to the black-footed ferret (see above paragraph). One black-tailed prairie dog town was observed during the site visit. The potential for black-tailed prairie dog towns is greatest in the eastern portion of the evaluation area where sagebrush and grassland habitats are present. Due to the presence of open ponderosa pine habitat, it is unlikely that black-tailed prairie dogs occur within the proposed project area.

Interior least tern. The interior population of the least tern (*Sterna antillarum*) is listed as endangered under the Endangered Species Act. The least tern breeds on bare sandbars associated with rivers and some reservoirs. In Montana, this species breeds well to the north of the proposed project area, but may pass through the area rarely as a transient or a migrant.

The Montana Fish Wildlife and Parks (MFWP) and the Montana Natural Heritage Program (MNHP) have created a list of Montana Animal Species of Concern (MASC) (Carlson 2003). The USFWS (2002) has also listed 24 birds of conservation concern which occur within the prairie and badland province. Most species on these lists are thought to be in decline throughout or within portions of their range or sufficient data are not present to determine population status. Most of the MASC species are not listed under the Endangered Species Act, rather, the purpose of the list is to bring attention to and increase monitoring of species which are declining or species which little is known concerning populations status or distribution. Some species on the MASC and the USFWS birds of conservation concern may migrate through or breed within the project area.

STATE WILDLIFE ISSUES AND UNIQUE HABITAT

State Wildlife Issues. We examined the potential for contentious state wildlife issues to occur within the project area by examining game species distribution data available from MFWP. The project occurs within the potential range of elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), sharp-tailed grouse (*Tympanuchus phasianellus*), Hungarian partridge (*Perdix perdix*), ring-necked pheasant (*Phasianus colchicus*), and wild turkey (*Meleagris gallopavo*). The project also occurs on the edge of the potential distribution for sage grouse (*Centrocercus urophasianus*).

State wildlife agencies often place a high priority on protecting habitats important to game species, particularly winter ranges and migration routes. The MFWP has mapped elk winter range as occurring within the project area (Figure 2). Within winter range designations, state agencies often place higher priorities on protecting areas designated as crucial. According to MFWP data, the elk winter range within the proposed project area is not designated as crucial. Due to relatively high hunting pressure on reservation lands, elk rarely occur within the designated winter area (S. Denson, MFWP, pers. comm.).

The sage grouse has recently been petitioned for listing as threatened or endangered under the Endangered Species Act by some environmental groups. State agencies often place a relatively high priority of protecting important sage grouse habitat, particularly lek sites. Although the proposed project area occurs just outside the MFWP mapped range for sage grouse, potential habitat for the species is present within the southeastern portion of the project area. The MFWP has no records of sage grouse leks within or bordering the evaluation area (S. Denson, MFWP, pers. comm.). Due to the presence of ponderosa pine habitat it is unlikely that sage grouse leks are present within the project area. There is a low probability that sage grouse leks may occur within sagebrush habitats within the evaluation area.

Unique Habitat. Because wildlife may be attracted to relatively unique habitats within a landscape, we assessed the relative uniqueness of the proposed project area. Many of the ridges within the proposed project area are located within open ponderosa pine habitats. This habitat type is found throughout much of the surrounding area, and likely does not pose an extraordinary attractant for wildlife. Less common habitats in the project are relatively more unique and provide habitat for a variety of species. These habitat types include riparian areas and cliffs or rocky outcrops.

We queried the Montana Natural Heritage Program (MNHP) database for rare plant and animal sightings within and surrounding the project area. The MNHP has no records of rare animals or plants within the project area, likely due to a lack of surveys on Northern Cheyenne land. Most MNHP records are located on public land where scientists can gain access for surveys. The MNHP has one record for a rare plant just north of Jimtown. Barr's milkvetch (*Astragalus barrii*) is species considered sensitive by the U.S. Forest Service and is on the BLM watch list. The plant was located within sandstone and shale outcrops within ponderosa pine forest (Figure 2).

BATS

Several species of bat may occur within the proposed project area, including little brown myotis (*Myotis lucifugus*), long-legged myotis (*Myotis volans*), northern myotis (*Myotis sptentrionalis*), long-eared myotis (*Myotis evotis*), California myotis (*Myotis californicus*), western small-footed myotis (*Myotis ciliolabrum*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), Townsend's big-eared bat (*Plecotus townsendii*), spotted bat (*Euderma maculatum*), big brown bat (*Eptesicus fuscus*), and pallid bat (*Antrozous pallidus*) (Genter and Jurist 1995). Bat habitat can be divided in to several types, including foraging areas, maternal and winter hibernacula. Species breeding within the project area will forage more often close to hibernacula sites. Potential hibernacula within the evaluation area include abandoned mines and snags. Due to recent burns within ponderosa forest, many snags which could serve as potential hibernacula are present within the project area. Abandoned mines are present within the evaluation area, but no known locations are present within the project area. Some bat species, including the Townsend's big-eared bat, have hibernacula within caves or abandoned mines. Several abandoned mines are present within and surrounding the evaluation area (Figure 2).

However, it should be noted that we do not know if these mine locations are suitable for bats, i.e. some mine entrances may be completely blocked, preventing entrance by bats. Other unevaluated factors may also influence use of mines by bats, including temperature and humidity.

No bat species within Montana receive federal protection. However, some species of resident or non-migratory bats are considered sensitive by the MNHP, including the Townsend's big-eared bat. Bat casualties are found more often than birds during carcass searches at some wind plants in the U.S. Most of the bat casualties at wind plants to date are migratory species which conduct long migrations between summer roosts and winter hibernacula such as hoary bats, silver-haired bats and eastern red bats. The high number of migratory bat deaths at wind plants may be related to the lack of echolocation during migration (Johnson 2003). Based on bat casualties found at other wind plants, it is likely that migrating hoary bats, silver-haired bats and eastern red bats will make up the majority of casualties within the proposed wind plant. Bat fatality rates may be similar to those at other wind plants in the U.S., ranging from 0.1 – 2.85 bats / turbine / year (Johnson et al. 2003).

BIRD MIGRATION

Many species of songbirds and waterfowl migrate at night and may collide with tall man-made structures. Large numbers of songbirds may collide with structures at lighted communication towers and buildings when foggy conditions and spring or fall migration coincide. Birds appear to become confused by the lights during foggy or low ceiling conditions, flying circles around lighted structures until they become exhausted or collide with the structure. To date, no large mortality events have been documented at wind plants in North America (Erickson et al. 2001). Some scientists suggest that many songbirds migrate above turbine height, reducing the risk of collision with wind turbines (Richardson 1998). However, preliminary results from Montana may indicate that more birds migrate within turbine blade heights than previously thought (R. Hazelwood, Montana USFWS, pers. comm.). Based upon the results of studies at other windplants, some migrating songbirds will collide with turbines, however, large mortality events similar to those witnessed at large communication towers are not expected.

McEneaney (1993) presents a very general map of bird migration corridors within the state of Montana. One of the corridors described as a major bird migration corridor appears to follow the Tounge River north through the state, and may include the proposed project area. By examining the topography of southeast Montana at a very small scale, it appears as if birds migrating along the front range of the Rocky Mountains may follow the Tounge River and associated valley when flying north and south (Figure 5). The degree to which birds, and in particular raptors will utilize ridges within the project area will depend largely on weather conditions and wind direction. Migrating raptors may utilize updrafts on ridges running north and south within the project. If the Tounge River is actually a major migratory corridor for raptors and songbirds, birds may follow ridgelines within the project area.

DISCUSSION:

Four issues may pose potential conflicts between wildlife and turbines: potential for raptor nests, threatened and endangered species, bats and a potential bird migration corridor (Table 2).

Existing and recently burned ponderosa pine provide potential nesting habitat for raptors in close proximity to ridges likely targeted for turbine placement. The presence of ponderosa pine may pose two potential conflicts 1) the presence of forest stands increases the amount of potential nesting habitat and may increase potential raptor nest densities and 2) the presence of ponderosa in close proximity to potential turbine locations may increase the amount of use of ridges targeted for development by some species of breeding raptors, such as northern goshawk and Cooper's hawk. Other important nesting habitats within the project area include cliff habitats and riparian area. The Tounge River and associated cottonwood riparian area provides excellent nesting habitat for raptors, including the bald eagle. Additionally, excellent hunting areas for many raptor species are present within prairie dog towns in the southeast portion of the project area. The current project area is located from 2 – 8 miles from the Tounge River, cliff habitats and prairie dog towns, decreasing the potential risk to breeding raptors within the project area.

The proposed project should pose relatively few conflicts with the Endangered Species Act. While bald eagles may occasionally fly through the project area, most nesting and winter habitat near the project area exists along the Tounge River. By placing turbines away from the Tounge River, potential impacts to bald eagles will be minimized. Black-tailed prairie dog towns are also present within the evaluation area. While prairie dogs currently receive no special protection under the Endangered Species Act, the towns may provide potential habitat for the black-footed ferret. If the proposed project area is moved, prairie dog towns will need to be mapped and evaluated for potential black-footed ferret habitat. Factors determining ferret habitat include town size and burrow density. If potentially affected towns meet ferret habitat requirements, the U.S. Fish and Wildlife Service may request black-footed ferret surveys be conducted on all affected prairie dog towns. However, it should be noted that it is highly unlikely that a wild population of black-footed ferret exists within Montana or anywhere within the U.S.

The presence of burned ponderosa pine forest and abandoned mines may increase potential use of the project area by resident bat species. Based on studies at other wind plants, most bat fatalities are migratory species which may not use echolocation during migration (Johnson 2003). However, it should be noted that we are unaware of any windplants located near well used hibernacula, such as abandoned mines. Overall, we feel the risk to resident bat species to be low, but the potential exists for increased resident bat fatalities if turbines are placed near well used hibernacula. It is likely the majority of bat fatalities will be comprised of hoary bats, red bats and silver-haired bats based on studies at other wind plants. These species inhabit forested areas. Due to the presence of ponderosa pine forest within the project area, potential fatality rates for these species may be within the upper range of observed bat mortalities documented at other wind sites.

The potential presence of a major migratory bird corridor may pose the largest potential conflict for the proposed project area. Increased use of ridges in the project area by raptors may potentially result in an increased number of potential fatalities. Other factors may also increase risk to raptors and other large birds, including topography and turbine placement. However, based on results at other windplants, no large mortality events of songbirds similar to those documented at large communication towers are expected.

It should be noted that the presence of a “major migratory corridor” was described within McEneaney (1993) on a very general map of Montana. The presence of a migratory corridor along the Tounge River and within the project area should be further investigated. If the proposed project proceeds, we recommend baseline studies be conducted to determine if the proposed project area is in fact heavily used by raptors and songbirds. McEneaney (1993) describes approximately half the state of Montana as a “major migratory corridor”, yet the author provides no definition or criteria for delineating these areas. It may be that the project area, while used by migrating raptors and other birds, does not receive high amounts of use relative to other areas in the state.

Well designed studies conducted before development can determine if the area receives increased use by raptors and songbirds. Surveys can also be used to identify raptor nest sites. The results of these studies may be used to site turbines away from high use areas and raptor nests and decrease the risk of fatalities. A similar approach was used at the Foote Creek Rim windplant in Carbon County, Wyoming. Pre-development studies identified areas that received high use by raptors and songbirds. Project developers placed turbines away from the high use areas, and documented fatality rates were much lower than those expected by U.S. Fish and Wildlife Service officials.

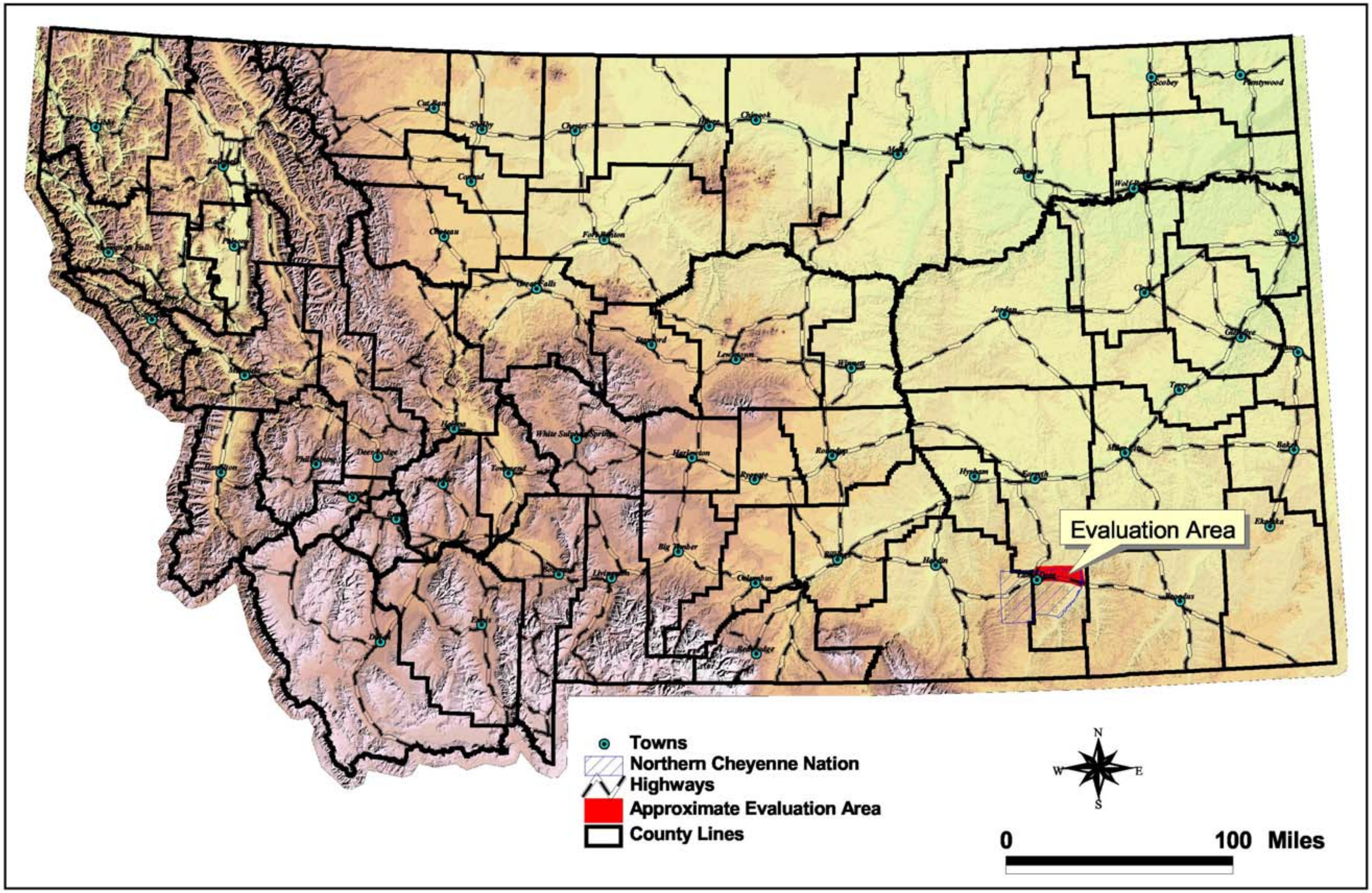

Figure 1. A map showing the approximate location of the evaluation area.

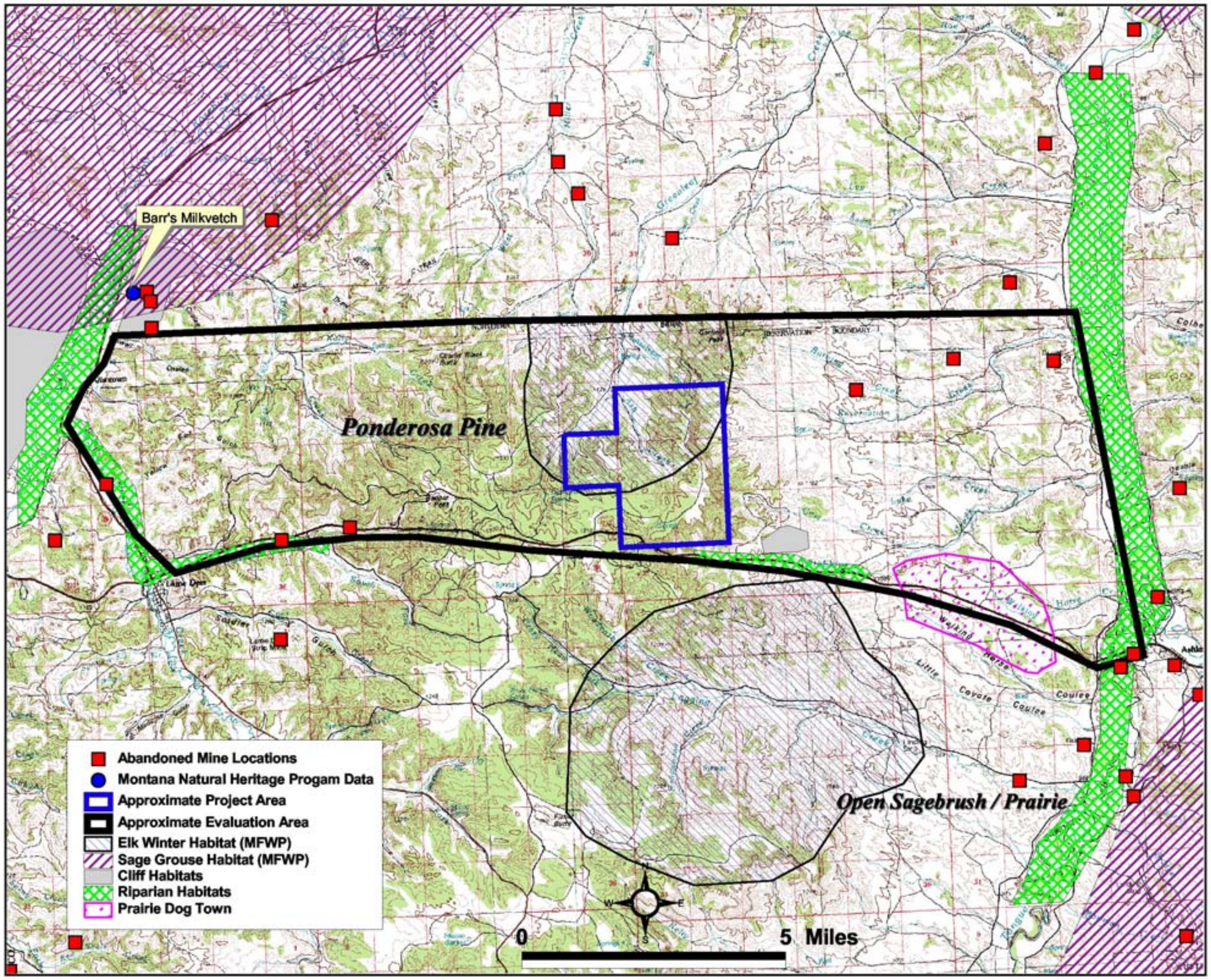

Figure 2. A map of the evaluation and project areas. Habitats shown on this map are incomplete, thus other riparian areas and cliffs may exist within the project or evaluation area.

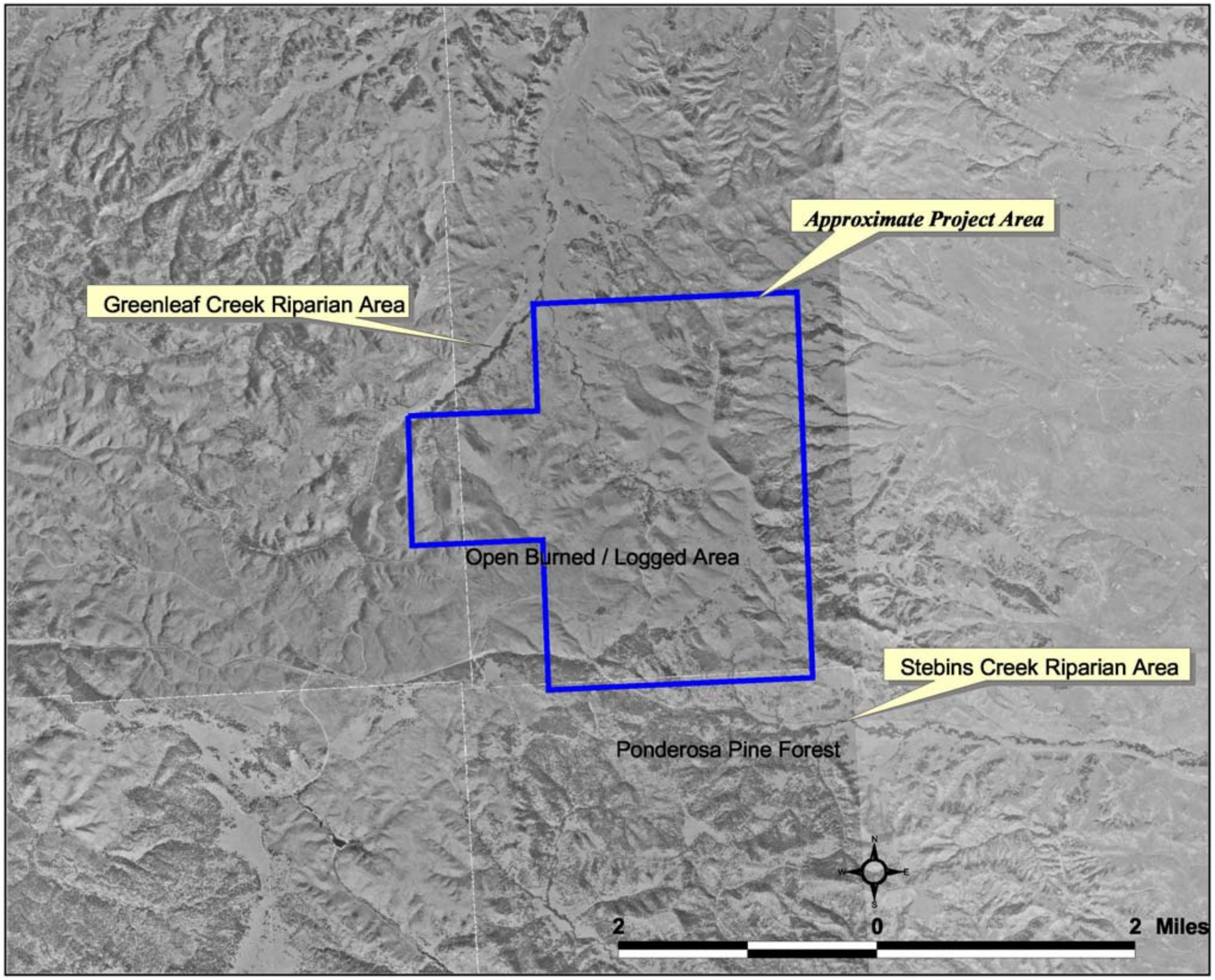

Figure 3. An aerial photo of the project area.

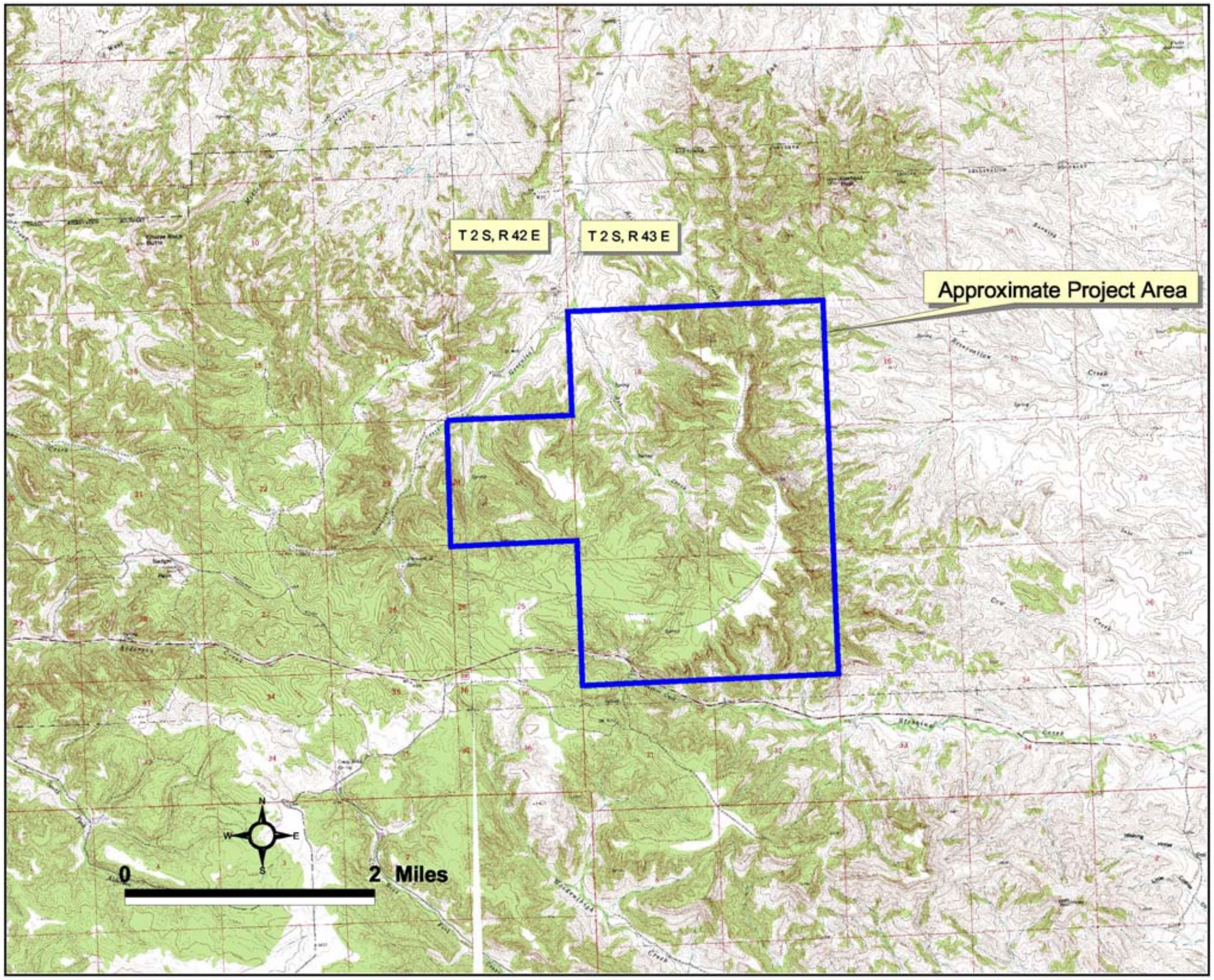

Figure 4. A topographic map of the project area.

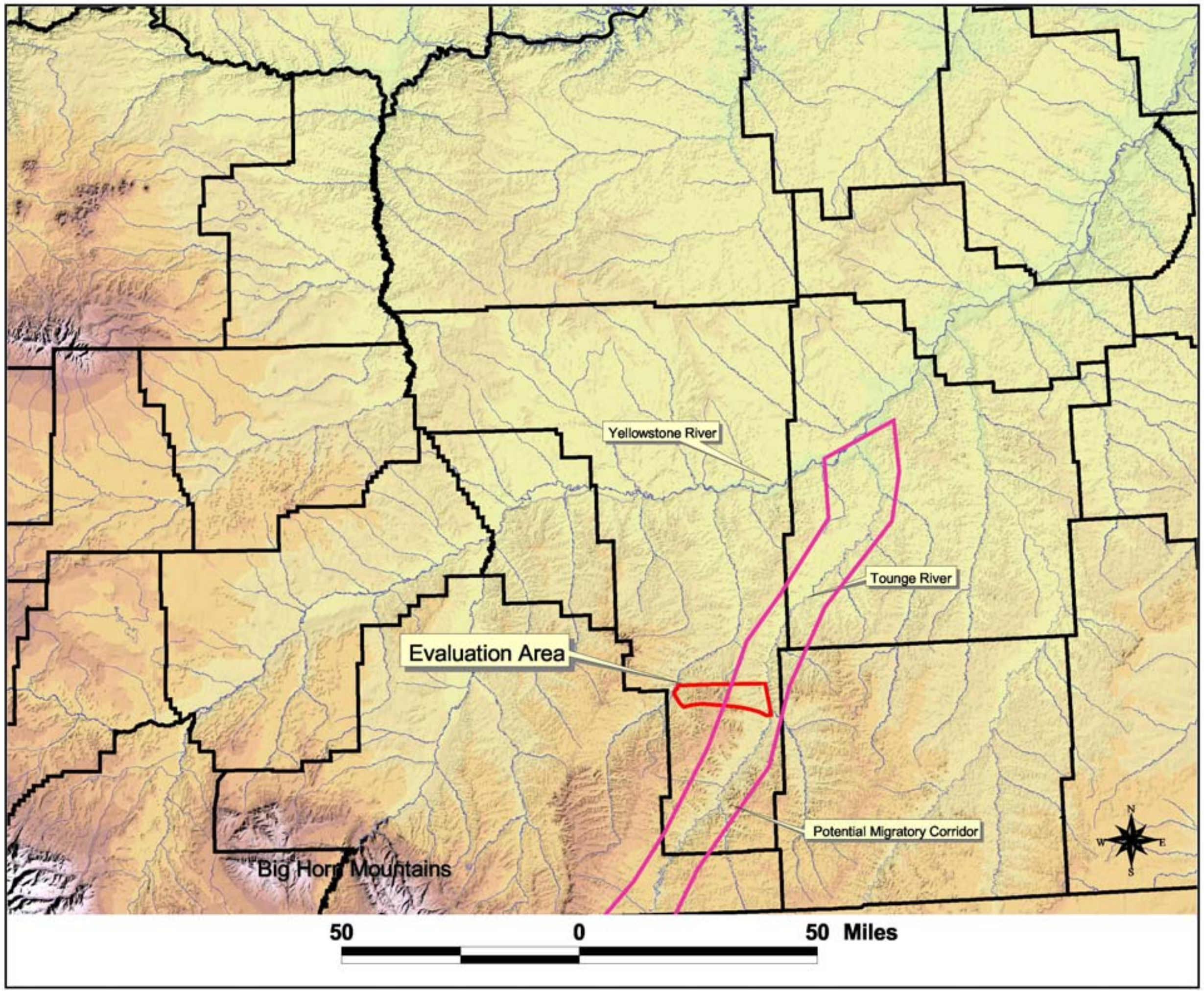

Figure 5. Potential migratory pathway near the proposed project area. Pathway location was derived from McEneaney (1993).

Table 2. A summary of the potential for wildlife conflicts in the proposed wind development area. VH = Very High, H = High, M = Medium, and L = Low.

Issue	VH	H	M	L	Notes
Potential for raptor nest sites [1]		✓			Due to presence of ponderosa pine in the project and evaluation area
Raptor flight potential		✓			Ridges within project area are well defined and raptors may use updrafts
Potential for raptor and songbird migratory pathway		✓			Based on McEneaney (1993). Presence should be verified.
Potential for raptor prey species[1]			✓		Prairie dog towns are present in eastern portion of project area.
Potential for protected species to occur[1]				✓	Low probability as long as project stays away from Tounge River and prairie dog towns
Potential for Big Game Issues[1]				✓	One elk winter range may be present
Uniqueness of habitat at wind plant				✓	Habitat within the project area is not unique
Potential for rare plants to occur			✓		One rare plant was documented within the evaluation area
Potential for use by bats		✓			Snags and mines provide potential hibernacula
Other issues			✓		

[1] Summarized for the project area as a whole but the habitat of the evaluation area varies throughout in its ability to support species of concern.

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"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Benefit Assessment

Description of Tribal Economic Benefits: The tribe will benefit economically from the deployment of renewable energy technologies in several ways. If the renewable resource is developed for sale of energy for the export market and the Project is owned by institutional investors, the Tribe will recognize economic benefits from jobs and the associated payroll, land lease payments, and Tribal taxes. In the example project pro-forma included in Tab 12 of this report, these values are approximately $7.3 million over the life of the project. If the tribe owns the renewable facility, then the economic gain normally realized by the owner of such a project will accrue to the tribe; although this increment is small compared to the value of the above items. It is the objective of both the tribe and Disgen that construction and operations and maintenance jobs created as a result of the project must awarded to tribal members. Such jobs are high quality (manufacturing equivalent) and long term. Further, a training program for tribal members will be established to fill such jobs as the opportunity for project expansion arises.

Environmental Benefits and Impacts: The environmental benefits will be determined by the number of kilowatt hours produced per year and the associated emissions avoided. Disgen will subsequently analyze the environmental impact based on the local electricity producers and the emissions history of those producers. Each kilowatt hour generated by a specific fossil fuel plant has an emission footprint. That data multiplied by the number of kilowatt hours produced by the renewable facility will result in a table of avoided emissions annually.

If properly sited, the renewable facility will have little, if any, adverse environmental impacts. However, if warranted, avian analyses may be conducted over several years and a noise assessment may be performed.

Culturally, tribes and their members take from nature only what is needed. Renewable technologies are at-one with the culture.

Socially, the greatest benefit will be derived form the creation of jobs and the expansion of the capabilities of the Sovereign Nation. Self sufficiency in electricity supply and the ability to serve an export market will do much to improve the economic status of the tribe and those economic benefits will accrue to the whole population.

Tribal Benefits: If and when the facility is constructed, the tribal benefits will be recorded in economic terms; the number of jobs created, the incremental cash flow to the tribe, the value of the energy purchases offset by the use of the renewable energy on the reservation. In addition, the educational benefits will be defined by the training programs and the graduates entering the wind industry, on tribal lands and off.

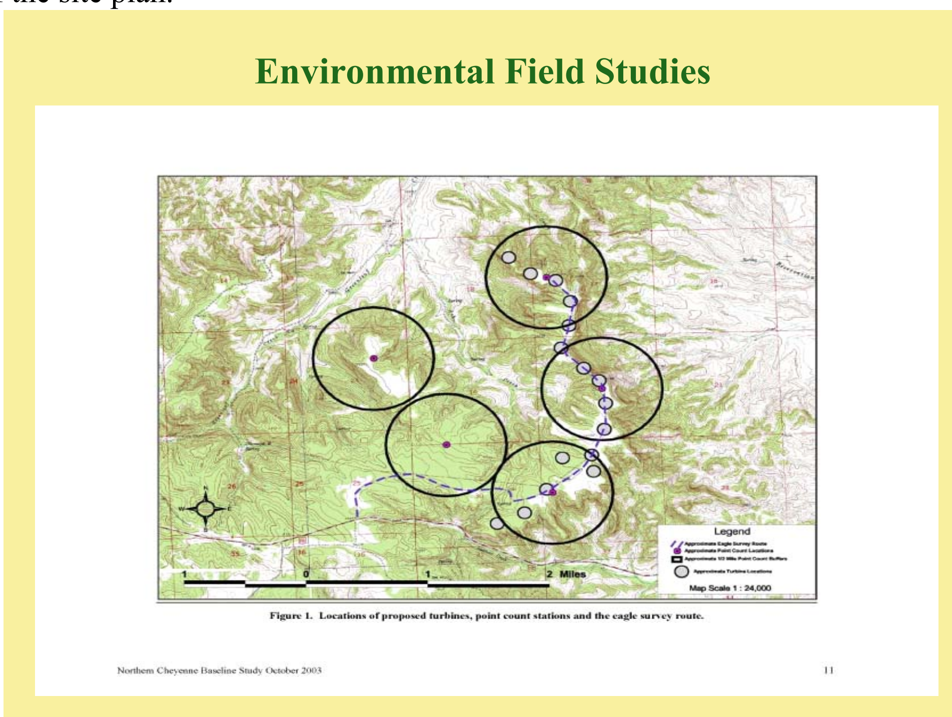
Potential Barriers and Plan of Mitigation: The single largest potential barrier is the possible unwillingness of any of the power purchasers in refusing to enter into the PPA. The PPA is the financeable asset and is the basis for obtaining financial commitments from investors. It is not possible to know at this early stage of development whether the markets two years hence will be motivating such purchases. The Tribe and Disgen will make every effort to motivate the buyers, but ultimately the decision on the PPA will reside with that buyer. Such is the risk of every renewable energy development. As the project is developed for export, the local utility may impose onerous wheeling rates as to render the project uneconomic. The resolution to these issues is negotiation between the parties to minimize the impact to each party. In addition, the emergence of the "Green Tags" market and national renewable portfolio standards will resolve most of these issues. These green tags and portfolio standards will allow the unbundling of the environmental attributes form the physical energy. The green tags will become the marketable asset and the physical energy will remain a commodity.

In the end, the only real showstoppers on renewable energy are (a) lack of resource, (b) lack of transmission and (c) lack of market.

“NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY”
Preliminary System Design

The Northern Cheyenne Tribe’s (NCT) wind project resulting from the feasibility study has been determined by the NCT to be thirty megawatts (30 MW). While the project area will accommodate a much larger project, the NCT has decided to focus on a smaller facility in order to utilize the existing transmission infrastructure to its fullest.

The wind turbine used to create a preliminary site plan is the GE Wind Energy 1.5 MW. A total of twenty (20) wind turbines have been located within the project area. This is a copy of the site plan.



The interconnection will be to the Tongue River Rural Electric Cooperative’s (TRECO) 69kV line running through the project area. TRECO has supported the project with preliminary transmission analyses. The likely purchaser of the energy will be an off-taker from the Colstrip Power Plant from which TRECO obtains its power.

The original meteorological tower was relocated from the south side of US Hwy 212 to the north side within the project area in November of 2003. In addition, an NREL 20 meter loaner tower was installed within the project area in February 2004.

The system design is consistent with all commercial wind facilities being developed domestically.

"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Tribal Training and Professional Development

During the feasibility study, tribal representatives from the Economic Development Committee, the Tribal Historical Preservation Office (THPO), the Tribal Fish and Game Department, the Tribal Land Commission and the Bureau of Indian Affairs participated in analyzing the location of the meteorological tower and conducting the archaeological analysis prior to installation of the tower.

The Tribal Administrator for the feasibility study learned the skills required to install, maintain and service the meteorological tower and to remove and reinstall the data cards from the datalogger. In addition, summary data has been analyzed and supplied to the administrator along with training in understanding the data.

The Tribal Administrator, the Department of Fish and Game and THPO have been involved in the detailed planning of the environmental studies and have participated in the studies. THPO has managed the cultural studies.

As the development phase of the project proceeds, the tribal membership will receive training through district meetings which will occur monthly during the development period.

"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Long Term Operating and Maintenance Planning

As a result of the feasibility study, the Northern Cheyenne Tribe (NCT) has submitted and was awarded a development grant by DOE for the pre-construction development of a 30 MW wind energy facility. The preliminary economics of that facility are included in Tab #12 of this report.

Imbedded in the economics are the costs to operate and maintain the facility. Theses costs are categorized as warranty, operations and maintenance and administration. For the GE Wind Energy 1.5 MW wind turbine, it is assumed the warranty cost is included for the first two years in the price of the wind turbine. While an additional three years of warranty may be purchased from the manufacture, such a purchase assumption is not included in this preliminary model.

The operations and maintenance (O&M) cost is assumed to be $20,000 per wind turbine per year escalating with inflation. It is now known this assumption is about 15% conservative. The O&M plan includes routine preventive maintenance which requires two visits per year and unscheduled maintenance as needed to correct any other issues. A project of this size is likely to employee two full time technicians. The unscheduled outages may require engineers to be dispatched to the site for resolution of the more technical problems.

Administration is the function of collecting operational data, creating invoices for energy sales, delivering those invoices to the energy purchaser and paying the bills of the project. In addition, quarterly performance reports will be submitted to the debt and equity providers for the project. This report will include actual versus forecast in energy output as well as a meteorologist's assessment of the output versus the actual wind resource available during that period. This is a task for one mid-level person with report review by a senior person. The budget is $30,000 per year escalating with inflation.

"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Plan for a Sustainable Renewable Energy Development Process

The Tribal Manager of the feasibility study is Joe Little Coyote. Joe requested Disgen's thoughts on an energy strategy that focuses on sustainability, energy independence, self-sufficiency and economic development. The following letter addresses these issues as they relate to the Northern Cheyenne Tribe (NCT) and its natural resources.

The NCT and Disgen are working together to investigate the implementation of this preliminary strategic energy plan.

DISGEN

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January 5, 2003

Joe Little Coyote
Tribal Planner, Economic Development Administration
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Dear Joe,

The tribal meetings over the past six weeks were very interesting and informative. I think we will get broad based support as we move forward and as we determine the best methods of communications with the people.

You asked me to think about an energy strategy that would provide self sufficiency, sustainability and economic development for the Northern Cheyenne Tribe (NCT). I have spent many hours thinking about this and the technologies that would be required to achieve such objectives. The following dialogue describes my preliminary thoughts on these issues and as time progresses I expect there will be additional refinement to these concepts. But, for the most part, these ideas provide the basics to achieve the objectives.

Base Load Supply

First and foremost, the NCT will need a base load source of energy in order to be self sufficient. Base load means that the electricity is available when it is needed. As you know, renewable energy sources such as wind and solar only deliver energy when the wind is blowing and the sun is shining. So these technologies do not meet the requirements of a base load source. Currently the base load source is the electricity provided by the Tongue River Electric Cooperative (TRECO).

Within the NCT Reservation, there are three technologies that could provide the base load requirements for the Tribe to become self sufficient. The timing for deployment of the technologies varies due to their current status of commercialization.

Pumped Hydro Storage: This technology has been around a long time and the economics are well understood. The high plateau running north-south within the reservation would seem to support this technology. The project would require a reservoir on the plateau and a second reservoir in the valley to the east. The water would be pumped from the base to the top using energy produced, preferably from renewable generation, and then released, as needed, to fall to the base, through a hydro-generation unit creating dispatchable energy for the Tribe's use. Dispatchable energy means that you can get it when you need it. The energy required to operate the pumping system could initially be purchased from TRECO during off-peak periods, probably at lower than normal rates. This technology has appeal due to the abundance of water available on the reservation.

Wood Products Biomass: This technology is also proven and well understood. It is not clear how much fuel is available in the area for this technology or for how long. However, the waste currently associated with the lumber mill and the opportunity to harvest the waste from the National Forest thinning program would seem to indicate that a sufficient fuel supply is available. Alternatively, fast growing trees have been developed by paper companies such that a "fuel crop" could be established on tribal land that would support a closed-loop biomass system. Closed Loop Biomass qualifies as a renewable resource under federal statutes and is therefore subject to the renewable energy credits, if they are ever enacted by Congress. The sixty (60) acres of tribally owned land adjacent to the lumber mill would probably support the biomass facility.

A large biomass facility will require fluidized bed technology. So, sizing the fuel supply and the energy needs of the Tribe will be critical in specifying and analyzing this opportunity.

<u>Community Power Corporation:</u> This small company is being funded by DOE and the California Energy Commission (CEC). It manufactures a 15kW wood waste gasification to electricity product that is being shipped internationally to support village power. All the economic supporters are very high on this system and it could possibly serve the district communities. The shortcoming is that the system is currently quite small and the company believes it will be limited to about 200kW units. The cost, in production will be about $1200 per kW which is similar to wind projects, but biomass will supply dispatchable energy.

<u>Greenhouse Potential:</u> A byproduct of the biomass plant would be waste heat. This heat could easily be captured and become the basis for a large greenhouse project that could supply fresh fruits and vegetables to the Tribe as well as create agricultural jobs for tribal

members. It might also be a source of sales to non-tribal parties. The CEDS Document appeared to tie poor diet to the increased rates of diabetes. This could be a partial solution to that problem.

Hydrogen Fuel Cells: This technology is probably five to ten years from being commercially operational. Commercially operational means that the technology is proven and that its economics make sense. There are a number of manufactures of fuel cells with the greatest emphasis being on transportation. However, there are several manufacturers focusing on electricity generation. The greatest barriers to commercialization are the costs of producing hydrogen, its storage and its transportation. Once commercially available, this technology could provide the energy needs of communities such as Lame Deer, Birney, Ashland and others. Currently, electrolysis is the preferred technology for converting electricity into hydrogen. Electrolysis is currently very expensive.

A commercially operational hydrogen creation process would solve the last remaining issue of intermittent renewable technologies such as wind and solar. It provides a method of storing the renewable electricity in a gas form to be delivered when the energy is in demand, rather than whenever the wind is blowing and the sun is shining. It has great economic value, if its own economic hurdles can be overcome.

A few of the American Wind Energy Association Conference proposed technical abstracts for presentation focus on hydrogen and wind energy. Disgen is a reviewer of the proposed abstracts and recommends the ones to be presented at the conference. Consequently, Disgen has an early insight into the status of this effort. Disgen is in contact with two of the leading technical groups working on this issue.

Summary of Base Load: Envision a wind energy generation facility that produces electricity when the wind blows. The wind generated electricity, through a very sophisticated control system, would (a) operate the pumps of the hydro storage system, (b) operate the electrolysis plant to produce hydrogen, (c) provide electricity in direct support of tribal needs or (d) provide energy for sale to the larger electric system. The priorities of these uses would need to be established, but the hydro system would probably take priority because of the flexibility it provides in supplying electricity on demand and its further ability to support electrolysis for hydrogen creation.

Further, consider the Wood Products Biomass system that would create dispatchable electricity. This electricity could be used to (a) operate the pumps for the hydro storage system. (b) operate the electrolysis plant to produce hydrogen, (c) provide electricity in direct support of tribal needs or (d) provide energy for sale to the larger electric system. So, biomass is a similar supply source as wind energy with one major exception; biomass is fully dispatchable, meaning it supplies electricity on demand. So, the biomass facility would operate as a backup system in the event there was no wind and the water resource was constrained.

As further backup, the Tribe could deploy a conventional reciprocating generator that would operate only on an emergency basis. This generator would be fueled either by fuel oil, propane, or perhaps hydrogen and would be designed to operate for a specific period at any given time. It would truly be used as an emergency backup only.

All of these systems, with the proper integration can deliver to the NCT self sufficiency and sustainability with very limited environmental impact.

The Wind Systems

The wind energy on NCT lands represents two opportunities for the Tribe; (1) a small project (<50 Mw) that will be owned and operated by the Tribe for its own benefit, or sale of energy to other parties and (2) a larger project for export of energy for sale to non-tribal parties. The larger project would most likely be greater than 100 Mw.

30 Mw Wind Project: If the energy from this project were used by the Tribe, either directly or within the integrated system described above, it could be financed under very attractive terms by the Rural Utilities Services (RUS), an agency of the US Department of Agriculture. The NCT would enter into a loan agreement with the RUS that would require repayment from the proceeds of any power purchase agreement (PPA) in which the Tribe has entered. Such an agreement could be between NCT Tribal entities. Under this scenario, the NCT would not be required to invest any of its limited resources to obtain the RUS loan and the loan would have limited recourse to the NCT. The limited recourse would be the payments from the PPA and the physical equipment. The NCT would not be risking any other economic proceeds. The best way to obtain the RUS financing would be to enter into a PPA with a Montana Rural Electric Cooperative. Such a PPA would be strongly favored by RUS. The existing transmission system is capable of accepting a project of this size according to TRECO.

An alternative way of financing such a project would be third party taxable investors. A taxable investor can utilize the Production Tax Credit (PTC) for wind systems as defined in the National Energy Policy Act of 1992. Only taxable entities can use the credit which is currently valued at $0.018 per kilowatt hour (kWh). The PTC is scheduled to expire at the end of 2003 unless Congress extends it; which is expected to happen. In this scenario, the NCT would not actually own the project, but would likely reap incremental economic benefits when compared to tribal ownership. The PTC runs for ten (10) years, and the Tribe could purchase the project at the end of that period, again through an RUS loan. This is the best economic scenario and leads to the lowest price of power and the best economics for the Tribe. It is also consistent with the technology development cycle for hydrogen generators and fuel cells. However, it may not be consistent with the near term objective of self determination.

150 MW Wind Project: A project of this size would not qualify for an RUS loan; therefore the NCT could not own this project, unless approximately $180 million dollars were available for investment from the Tribe. Additionally, the energy generated far exceeds the internal requirements of the NCT and would need to be sold under a long-term PPA to a large utility or power marketer. A large project would require an interconnection to the Colstrip Power Plant. This interconnection would require a transmission line, or an upgrade to an existing transmission line of approximately twenty-six (26) miles. Of course it would also require a long-term power purchase agreement from a creditworthy entity.

The Tribe would benefit through jobs, landowner payments and payments in lieu of taxes. The positive economic impact would be very large, but such a project would also require a limited waiver of sovereignty.

Energy Efficiency: This is the easiest of all the energy related economic opportunities. However, it will require significant data collecting and energy auditing. TRECO would probably be willing to assist in the data collection and in assessing the economic impact by installing energy efficiency technologies. Such technologies include (i) lighting systems, (ii) insulation systems, (iii) heating and air conditioning systems and (iv) control systems. All these, when combined can result in substantial energy savings.

Econergy: Disgen is creating an alliance with Econergy of Boulder, Colorado. This firm has many years experience in the analysis and design of energy efficient systems and is willing to participate with Disgen and the Tribes in the preparation of DOE Grant Applications that include the analyses. Disgen believes that Econergy will add a significant differentiator to further grant applications.

As a starting point in considering energy efficiency, Disgen proposes to examine the Tribe's procurement specification for housing and recommend changes to those specifications such that energy consumption is heavily weighted as selection criteria for design and construction.

Summary: The Northern Cheyenne Tribe has an abundance of energy related opportunities in which the objectives of self-sufficiency, sustainability and economic developments can be achieved. Disgen will be preparing, at the direction of the NCT, analyses for each of these opportunities and will present these opportunities for the Tribe's consideration. It seems clear that the synergies represented by these varying technologies are exceptional and that the impacts, both socially and economically, on the Tribal membership may be large.

Dale Osborn
Distributed Generation Systems, Inc.
6 January, 2003

"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Wind Resource Data

Preliminary Wind Resource Assessment and Theoretical Energy Estimates

Northern Cheyenne Reservation, Montana

Prepared For:

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April, 2003

Table of Contents

1.0 Introduction and Summary

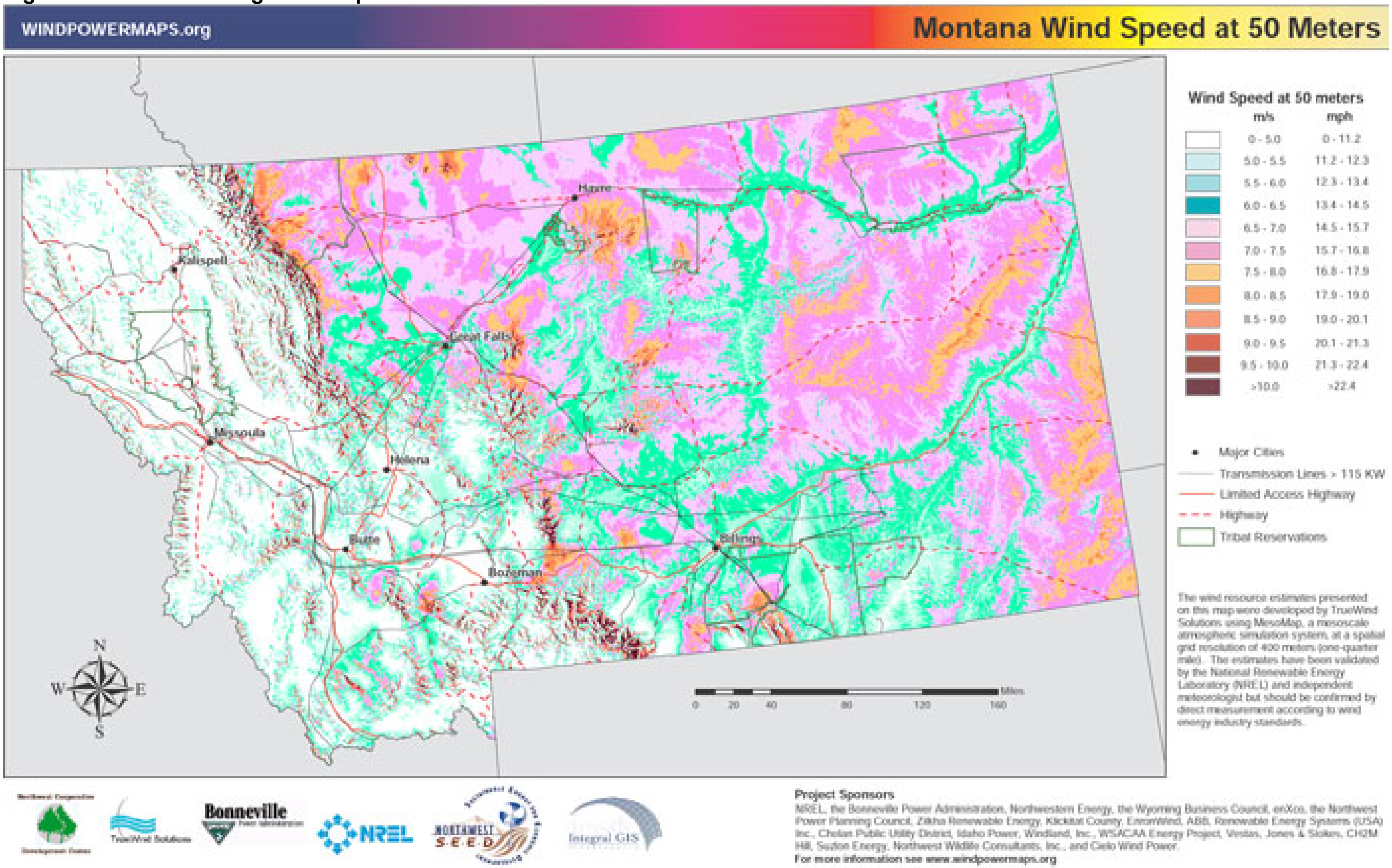
A preliminary wind resource assessment is prepared for a site known as Northern Cheyenne. This site is located in Southeastern Montana. A 50-meter meteorological tower was installed in November 2002 and is currently operating. One supplemental tower is also installed to gather additional wind data on the property. This preliminary wind resource assessment is based on historical wind data collected in the region.

The average wind speed projected for the Garfield Peak area at the 65 meter level is 18.1 mph; the average wind speed projected for an 80 meter level is 18.9 mph. A theoretical energy estimate, made for the GE 1.5MW turbine using these hub height wind speeds, indicates a gross capacity factor of 39% and 41%, respectively and a net capacity factor after losses of 34% and 35%, respectively.

2.0 Site Description

The site is located in southeastern Montana on the Northern Cheyenne Reservation. The general area consists of rolling hills and deep ravines. The land use is grazing and land cover is principally seasonal grasses. A few trees are evident in the lower elevation areas and in near ranches and cattle areas. A map depicting the annual average wind speed at 50 meters above ground level (agl) is presented in Figure 1.

Figure 1 – Annual Average Wind Speed in Montana at 50 Meters Above Ground Level



3.0 Meteorological Data

3.1 Data Sources

Meteorological data on the reservation are available from several sources. First, Montana Power Corporation operates three air quality stations on the reservation. These sites are Badger Peak, Garfield Peak, and Morningstar. Each site includes measurements of criteria air pollutants as well as wind speed and wind direction at 10 meters agl. Hourly wind speed and wind direction data are available from January 1, 1995 until December 31, 1999. Second, a Remote Automatic Weather Station (RAWS) site is located on Badger Peak. These data are collected principally for fire weather forecasting. The site is operated year round and hourly data area available. Data for a five year period from January 1998 until December 2002 are obtained from the Western Region Climate Center (WRCC) in Reno, Nevada. Finally, an on-site data collection program started in the late fall of 2002 with one 50-meter tower installed on the reservation and a second 20-meter tower installed in early January.

3.2 Climatology

The climatology for the Northern Cheyenne Reservation is based on the climatology for Billings, Montana (Table 1). The site is characterized has having cold dry winters and short, wet summers.

3.3 Air Quality Sites

Three air quality sites are located on the Northern Cheyenne Reservation:

Badger Peak	45.6483	106.5567	4,347 Feet
Garfield Peak	45.6031	106.4642	4,273 Feet
Morningstar	45.6681	1065189	4,311 Feet

The annual average wind speeds for the three air quality sites (Table 2) are 10.5 mph (4.7 mps) at Badger Peak, 14.0 mph (6.3 mps) at Garfield Peak, and 12.8 mph (5.7 mps) at Bright Star. The monthly average wind speeds are plotted in Figure 2, indicating the winter peak and the summer minimum. These data are collected at 10 meters agl. The mean hourly wind speeds at 10-meters agl for Garfield Peak are presented in Table 3.

Table 1 – Climatological Data for Billings, Montana

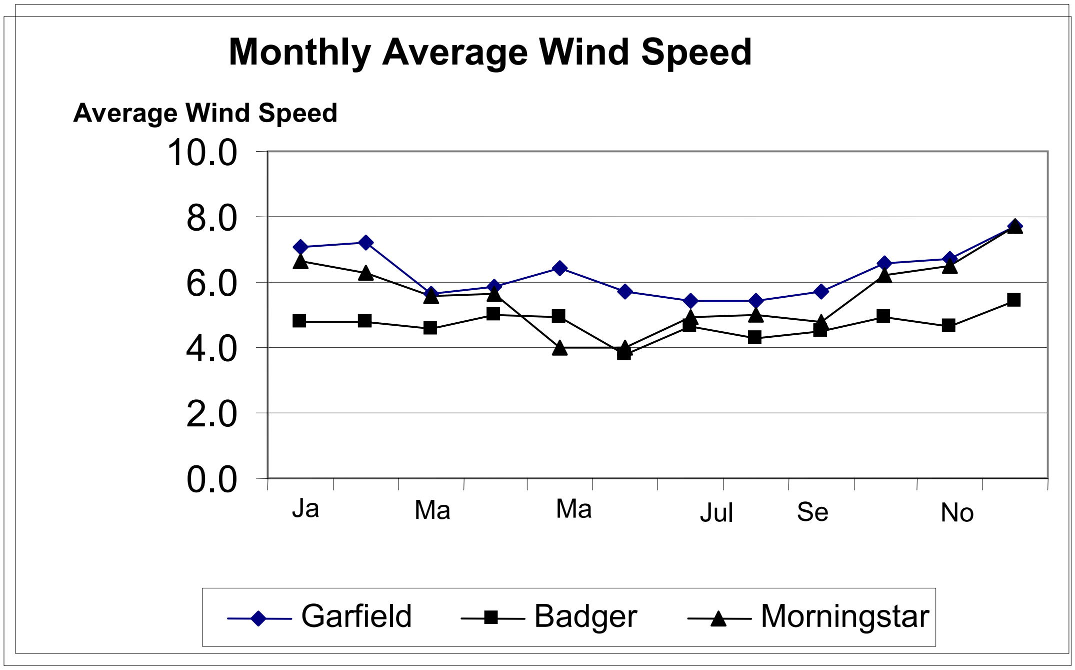
	(a)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE (Deg. F)														
Normals														
-Daily Maximum		31.8	38.6	45.8	57.1	66.7	77.6	86.7	84.7	71.6	60.6	44.5	34.4	58.3
-Daily Minimum		13.7	19.4	25.2	34.0	43.3	52.0	58.3	56.7	46.5	37.5	25.6	16.5	35.7
-Monthly		22.8	29.0	35.5	45.6	55.0	64.8	72.5	70.7	59.1	49.1	35.1	25.5	47.1
Extremes														
-Record Highest	61	68	72	79	92	96	105	106	105	103	90	77	69	106
-Year		1953	1961	1986	1939	1936	1984	1937	1961	1983	1992	1993	1980	JUL 1937
-Record Lowest	61	-30	-38	-19	-5	14	32	41	35	22	-7	-22	-32	-38
-Year		1937	1936	1989	1936	1954	1969	1972	1992	1984	1991	1959	1983	FEB 1936
NORMAL DEGREE DAYS														
Heating (base 65 Deg. F)		1308	1008	915	582	316	119	12	42	242	498	897	1225	7164
Cooling (base 65 Deg. F)		0	0	0	0	6	113	244	219	65	5	0	0	652
AV. STATION PRES. (mb)	23	890.8	890.9	888.6	889.4	889.1	889.9	891.8	891.9	892.5	892.1	890.6	890.7	890.7
PRECIPITATION (in.)														
Water Equivalent														
-Normal		0.90	0.64	1.16	1.74	2.57	1.99	0.94	1.01	1.36	1.14	0.84	0.79	15.08
-Maximum Monthly	61	2.35	1.77	2.70	4.42	7.71	7.64	5.08	3.50	4.99	3.80	2.34	2.00	7.71
-Year		1972	1978	1954	1955	1981	1944	1993	1965	1941	1971	1978	1973	MAY 1981
-Minimum Monthly	61	0.04	0.05	0.13	0.06	0.40	0.24	0.04	0.05	0.06	0.01	T	0.05	T
-Year		1941	1977	1936	1962	1993	1961	1988	1955	1964	1987	1954	1957	NOV 1954
-Maximum in 24 hrs	61	1.41	0.65	1.01	3.19	2.83	2.78	2.32	2.47	2.19	1.98	1.37	0.96	3.19
-Year		1972	1986	1973	1978	1952	1937	1993	1965	1966	1974	1959	1978	APR 1978
Snow, Ice Pellets, Hail														
-Maximum Monthly	61	27.7	22.4	27.6	42.3	15.6	2.0	0.4	T	9.3	23.1	25.2	28.8	42.3
-Year		1963	1978	1935	1955	1981	1950	1993	1992	1984	1949	1978	1955	APR 1955
-Maximum in 24 hrs	57	16.6	9.0	10.5	23.7	15.3	2.0	0.4	T	7.5	11.2	15.3	13.7	23.7
-Year		1972	1944	1964	1955	1981	1950	1993	1992	1983	1980	.1959	1978	APR 1955
WIND														
Mean Speed (mph)	56	13.0	12.2	11.4	11.4	10.7	10.1	9.5	9.5	10.2	11.0	12.1	13.0	11.2
Prevailing Direction														
through 1964		SW	SW	SW	SW	NE	SW	SW	SW	SW	SW	SW	WSW	SW
Fastest Mile														
-Direction(!!)	52	W	W	NW	NW	NN	NW	N	NW	NW	NW	NW	NW	NW
-Speed(mph)	52	66	72	61	72	68	79	73	69	61	68	63	66	79
-Year		1953	1963	1956	1947	1939	1968	1947	1983	1949	1949	1948	1953	JUN 1968
Peak Gust														
-Direction(!!)	12	NW	W	NW	NW	NW	W	32	NW	NW	31	SW	27	32
-Speed(mph)	12	59	62	52	59	60	54	71	69	61	64	58	70	71
-Date		1986	1988	1990	1987	1988	1987	1995	1986	1989	1995	1990	1995	JUL 1995

(a) - Length of Record in Years, although individual months may be missing.
0.* or * - The value is between 0.0 and 0.05.
Normals - Based on the 1961 - 1990 record period.
Extremes - Dates are the most recent occurrence.
Wind Dir.- Numerals show tens of degrees clockwise from true north. "00" indicates calm. Resultant Directions are given to whole degrees

Table 2. Monthly Average Wind Speeds (mps) for Badger Peak, Garfield Peak, and Bright Star.

Badger	1998	1999	2000	Average
Jan	4.6	5.1	4.6	4.8
Feb	4.7	6.0	3.7	4.8
Mar	3.9	5.0	4.8	4.6
Apr	4.7	5.1	5.2	5.0
May	4.8	5.1	4.8	4.9
Jun	4.8	4.4	2.1	3.8
Jul	4.5	4.8	4.6	4.7
Aug	4.3	4.3		4.3
Sep	4.3	4.6	4.6	4.5
Oct	5.1	4.8		5.0
Nov	4.6	4.7		4.6
Dec	5.4	5.5		5.4
Annual	4.6	4.9		4.7
Garfield	**1998**	**1999**	**2000**	**Average**
Jan	6.7	7.4		7.1
Feb	5.7	8.7		7.2
Mar	4.3	6.9	5.8	5.7
Apr	5.8	6.1	5.6	5.8
May	5.9	6.4	6.9	6.4
Jun	6.1	5.4		5.7
Jul	5.1	5.7		5.4
Aug	5.5	5.3		5.4
Sep	5.6	5.8		5.7
Oct	6.6	6.6		6.6
Nov	6.5	6.9		6.7
Dec	8.1	7.2		7.7
Annual	6.0	6.6		6.3
Bright Star	**1998**	**1999**	**2000**	**Average**
Jan	6.5	6.9	6.5	6.6
Feb	5.6	8.1	5.1	6.3
Mar	4.3	6.0	6.4	5.5
Apr	5.4	5.4	6.1	5.6
May	5.3	0.5	6.1	4.0
Jun	5.7	0.2	6.0	4.0
Jul	4.6	5.2	5.1	5.0
Aug	5.0	4.9		5.0
Sep	5.1	5.6	3.6	4.8
Oct	6.0	6.5		6.2
Nov	6.3	6.7		6.5
Dec	7.1	8.4		7.7
Annual	5.6	5.4		5.6

Figure 2 – Monthly Average Wind Speeds (mps) for Garfield Peak, Badger Peak, and Morningstar



3.4 Raws Site

The annual average wind speed for the RAWS site at Badger Peak, measured at 2 meters agl is 10.4 mph (4.6 mps). The mean hourly wind speeds are presented in Table 3. The time stamps for these data are Greenwich Mean Time (GMT) or Universal Time (UTC) which is -7 hours from local standard time. The diurnal trend in the RAWS data shows a nighttime maximum and a day time minimum which is typical of higher elevation sites

Table 3. Mean Hourly Wind Speeds for the Garfield Peak Air Quality Site.

MEAN HOURLY WIND SPEEDS

GARFIELD PEAK MONTANA
GARFIELD PEAK 10M WIND SPEED (MPH)

01/01/95 - 12/31/99

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	16.4	16.4	15.5	16.0	15.5	14.8	13.1	15.9	15.9	16.5	15.9	16.1	15.7
02	16.4	16.4	15.3	15.4	15.3	14.6	13.0	15.7	16.0	16.5	16.2	15.9	15.5
03	16.4	16.2	14.7	14.5	14.5	14.2	13.4	14.7	15.3	16.1	16.5	16.0	15.2
04	16.2	16.4	14.4	13.9	14.0	13.5	13.0	14.2	15.1	15.9	16.3	15.9	14.9
05	15.7	16.2	14.3	13.6	13.5	12.8	11.9	13.6	14.4	15.3	16.3	16.4	14.5
06	15.2	16.3	13.9	13.0	12.6	12.0	10.9	12.8	13.7	15.4	15.8	16.5	14.0
07	14.4	16.2	13.6	12.6	11.7	11.6	9.8	11.0	12.7	15.1	15.4	16.9	13.4
08	14.6	16.1	13.0	12.5	11.9	11.7	9.8	9.7	11.5	14.4	15.4	16.7	13.1
09	14.6	16.3	12.4	12.6	12.1	11.9	10.1	9.3	11.1	14.6	15.2	16.7	13.1
10	14.5	16.2	12.0	12.7	12.3	12.1	10.0	9.6	11.4	14.3	14.8	17.0	13.1
11	14.2	16.0	12.3	12.8	12.2	12.2	10.3	9.9	12.0	14.3	14.8	17.0	13.2
12	14.1	16.0	12.5	13.0	12.4	12.2	10.4	9.9	12.6	14.6	14.5	17.0	13.3
13	13.7	15.9	12.4	13.1	12.6	12.3	11.0	10.3	12.8	14.6	14.3	16.3	13.3
14	13.3	15.3	12.2	13.0	12.2	12.3	11.1	10.3	12.5	14.2	13.7	15.8	13.0
15	13.3	14.3	12.2	12.8	12.4	12.5	11.0	10.3	12.4	14.0	13.7	15.2	12.9
16	13.9	13.2	12.0	12.2	12.4	12.2	10.9	10.0	11.5	13.4	14.0	15.0	12.6
17	15.0	13.2	11.3	11.9	12.2	12.2	11.0	10.3	10.6	13.4	14.0	15.6	12.6
18	15.2	13.9	11.8	11.7	12.0	11.6	11.4	10.8	10.8	14.3	14.2	16.2	12.9
19	14.8	14.8	13.0	11.9	12.1	12.1	11.4	11.6	12.0	15.1	14.5	16.3	13.3
20	15.0	15.0	14.0	12.7	13.3	12.8	12.2	12.6	13.5	15.6	15.3	16.4	14.1
21	15.5	15.4	15.0	13.8	14.0	13.4	12.7	13.9	14.5	16.2	15.9	16.7	14.8
22	15.9	16.2	15.0	14.9	14.5	14.6	13.0	15.8	15.2	16.9	16.2	16.2	15.3

23	18.9	16.8	15.7	16.0	15.9	14.4	13.4	16.2	15.6	20.9	17.8	17.2	16.6
24	15.9	16.4	15.6	15.6	15.3	14.4	13.1	16.0	15.6	17.1	15.7	16.5	15.6
Mean	15.1	15.6	13.5	13.4	13.2	12.8	11.6	12.3	13.3	15.4	15.3	16.3	14.0
Good Hours	2945	2644	3611	3574	3689	3594	2976	2873	2690	3429	3377	3673	
Missing Hours	775	740	109	26	31	6	744	847	910	291	223	47	

39,075 Hours of Good Data   4,749 Hours Missing   89.2% Data Recovery

Table 4. Mean Hourly Wind Speeds for the Badger Peak RAWS Site (1998 – 2002). The time is recorded as GMT which is -07 hours from Local Standard Time (LST)

MEAN HOURLY WIND SPEEDS

BADGER PEAK MONTANA
2M WINDSPEED (MPH)

01/01/98 - 12/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	11.1	10.2	8.4	9.0	9.5	13.9	10.0	9.0	8.0	9.1	9.8	10.8	9.8
02	11.3	10.6	9.0	9.5	9.5	14.8	10.4	9.1	8.7	9.4	10.2	11.3	10.2
03	11.4	10.7	9.9	9.9	10.6	15.9	11.2	10.2	9.6	10.0	10.2	11.3	10.8
04	11.5	10.5	10.2	10.3	10.6	14.2	12.1	10.4	10.3	10.5	10.1	11.4	10.9
05	11.3	10.8	10.4	10.7	11.0	16.2	11.5	10.8	10.4	10.8	10.7	11.7	11.2
06	11.4	10.7	10.8	11.4	10.8	14.1	11.4	11.0	11.2	11.8	10.9	11.6	11.4
07	11.3	10.6	10.6	11.6	10.9	15.6	11.8	11.3	11.2	11.7	11.0	11.9	11.5
08	11.0	10.5	10.9	11.2	10.8	11.4	10.8	11.1	11.2	11.5	11.0	11.8	11.1
09	11.3	10.4	10.5	11.3	11.3	13.8	10.5	10.9	11.1	11.5	10.9	11.7	11.2
10	11.3	10.4	10.0	11.7	11.1	14.7	10.3	10.8	10.6	11.0	11.5	11.4	11.1
11	11.3	9.8	10.1	11.2	11.3	13.5	10.0	10.8	10.7	10.5	11.6	11.2	10.9
12	11.4	9.6	9.9	10.7	10.6	10.7	9.5	11.0	10.4	10.0	11.5	11.7	10.6
13	11.1	10.0	9.5	10.8	9.5	10.6	8.4	10.3	9.8	10.5	11.3	11.7	10.3
14	11.3	10.1	9.3	10.4	9.6	9.6	8.1	9.3	9.0	10.1	10.9	12.0	10.0
15	11.0	9.9	8.9	10.3	9.9	11.7	7.8	8.9	8.6	9.6	10.8	11.6	9.8
16	10.6	9.9	8.7	10.1	10.4	11.7	7.7	8.7	8.7	9.4	10.5	11.5	9.7
17	10.4	9.9	8.9	10.3	10.3	12.1	7.9	8.6	8.5	9.2	10.5	11.7	9.8
18	10.3	9.7	9.0	10.2	11.0	12.4	7.9	8.5	9.1	9.1	10.6	11.6	9.8
19	10.3	9.6	9.1	10.2	10.6	12.1	7.9	8.3	9.3	9.5	10.6	11.7	9.8
20	9.9	9.4	9.2	10.2	11.1	14.1	8.0	8.6	8.9	9.4	10.5	11.7	9.9

21	9.9	9.6	9.1	10.5	11.1	12.6	8.3	8.6	9.0	9.7	10.4	10.9	9.9
22	9.7	9.6	8.9	10.2	10.6	12.8	8.5	8.8	8.7	9.2	9.5	10.3	9.6
23	9.6	8.7	8.9	10.3	10.8	13.7	9.1	8.6	8.6	8.6	9.0	10.0	9.5
24	10.7	9.1	8.3	9.4	10.2	15.3	10.0	8.8	8.0	8.3	9.6	10.5	9.7
Mean	10.9	10.0	9.5	10.5	10.5	13.3	9.6	9.7	9.6	10.0	10.6	11.4	10.4
Good Hours	3556	2916	3270	2775	2875	2345	3511	3617	3473	3591	3507	2913	
Missing Hours	164	468	450	825	845	1255	209	103	127	129	93	807	

38,349 Hours of Good Data 5,475 Hours Missing 87.5% Data Recovery

3.5 On-Site Meteorological Monitoring Program

One primary tower was installed on Northern Cheyenne in November 2002. This 50-meter NRG Talltowers is instrumented with three levels of wind speed and two levels of wind direction. Maximum #40 anemometers and #200P wind directions sensors are used. The sensors are sampled once per second and hourly averages calculated using a NRG Systems 9300SA datalogger. The data are stored on flashcards which are removed for processing. A 20-meter tower is also installed on the reservation. This second tower was installed in January, 2003.

3.6 Wind Rose

Two wind roses which show the joint frequency of wind speed and wind direction are presented in Figures 3 (Badger Peak RAWS) and 4 (Garfield Peak AQ). The predominant wind directions appear to be south, southwest through west, and northwest.

3.4 Wind Shear

Wind shear is the change or increase in wind speed above ground level. The simple wind power law is expressed as:

$$U_2 = U1\ (Z_2/Z_1)^{\text{alpha}}$$

Where U_2 and U_1 are the wind speeds at the upper and lower levels, Z_2 and Z_1 are the upper and lower elevations, and alpha is the wind speed power law exponent. The typical value for the wind speed power law exponent is 0.14 (1/7 power law). Depending on terrain and surface roughness, the value may vary between 0.05 and 0.35. A conservative power law exponent of 0.14 is used in any hub height projections prepared in this report.

3.5 Projected Hub Height Wind Speeds

The hourly Garfield Peak Air Quality Site data are extrapolated to projected hub heights of 65 meter and 80 meters above ground level. A conservative power law exponent of 0.14 is used in these projections. These projections are presented in Tables 5 and 6. The estimated 65 meter annual average wind speed is 18.1 mph; the estimated 80 meter annual average wind speed is 18.9 mph.

3.6 Peak Wind Speed

The highest 3-second gust for the Northern Cheyenne site is estimated based on the peak wind speed information from the airport data collected at Billings, Montana. The peak wind speed measured at Billings, Montana over the period of record is 71 mph (31.7 mps). Selecting the highest value, 71 mph, and adjusting it from 7 meters (21 feet) to 80 meters (262 feet) above ground level using the wind speed power law and a power law exponent of 0.14 yields a peak wind speed of 99.7 mph (44.5 mps).

Figure 3 - Wind Rose for the Badger Peak RAWS Site. The number in the center, 12.2%, is the percentage of time the wind speeds are less than 5 mph.

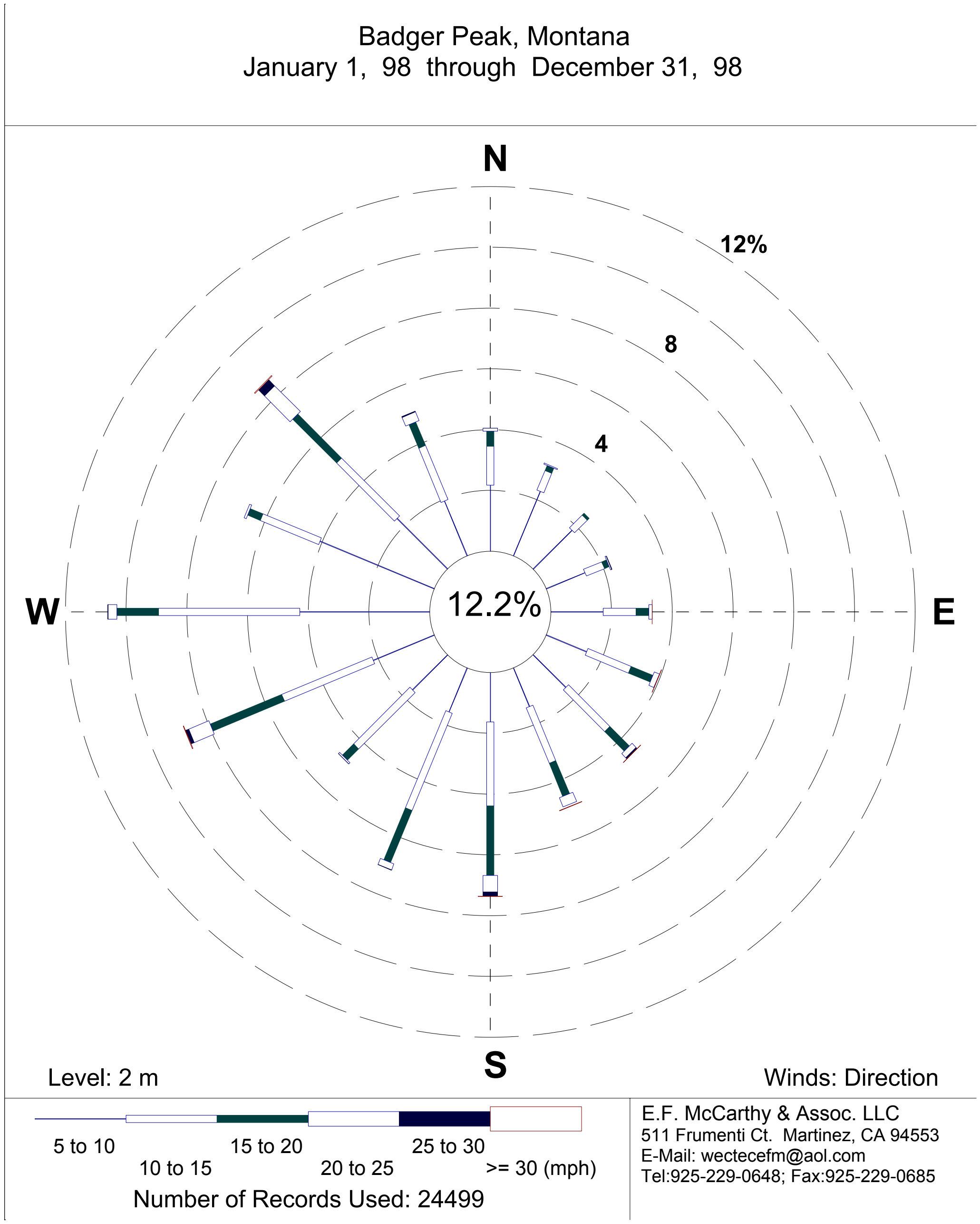


Figure 4 - **Wind Rose for the Garfield Peak AQ Site. The number in the center, 9.9%, is the percentage of time the wind speeds are less than 5 mph.**

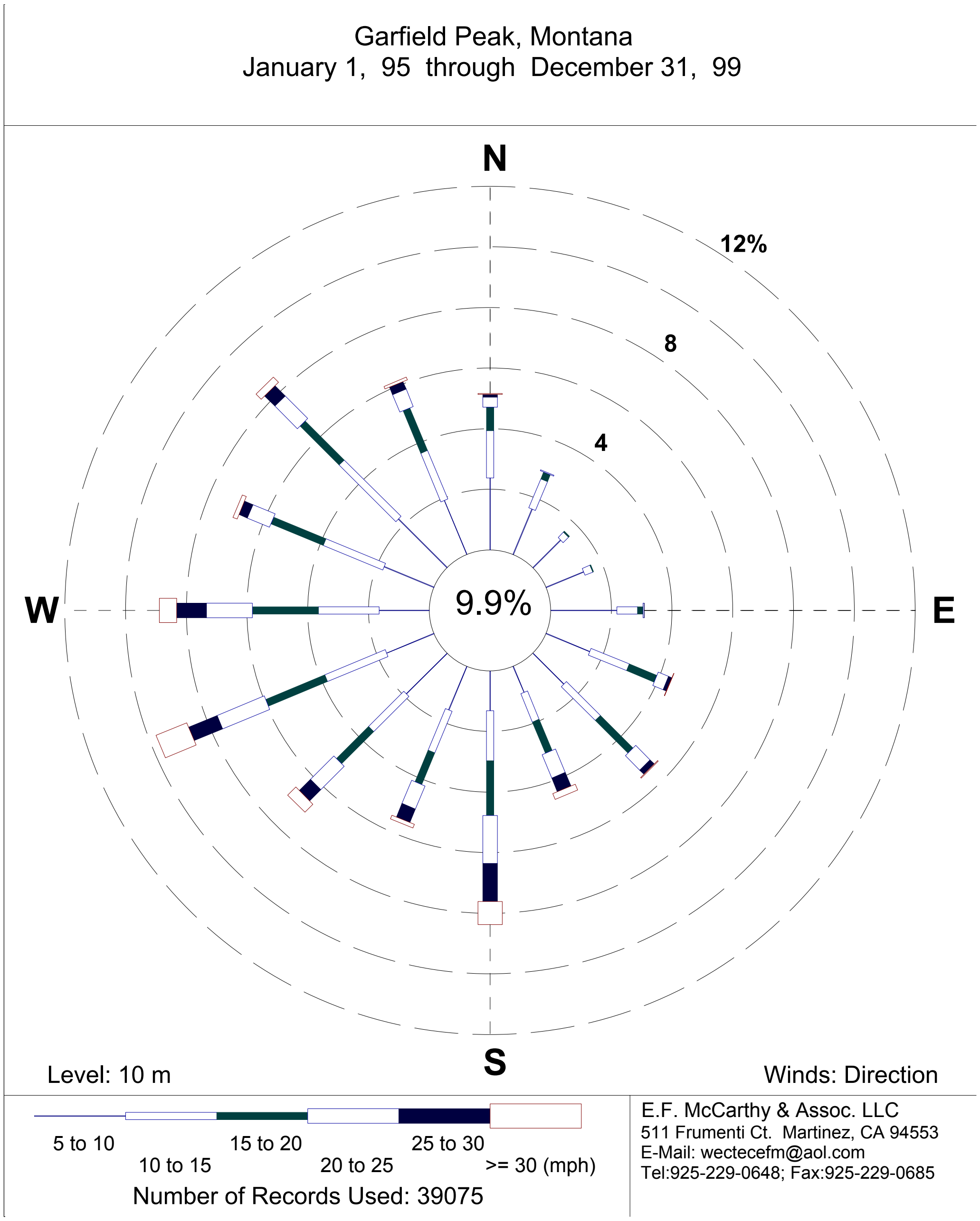


Table 5. Projected 65 Meter Wind Speeds (mph) for Garfield Peak.

MEAN HOURLY WIND SPEEDS

BADGER PEAK MONTANA
GARFIELD PK 65M WS (WS12 X 1.299) (MPH)

01/01/95 - 12/31/99

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	21.3	21.3	20.1	20.8	20.1	19.2	17.0	20.7	20.6	21.4	20.7	21.0	20.3
02	21.4	21.3	19.9	19.9	19.9	19.0	16.9	20.4	20.8	21.5	21.0	20.6	20.2
03	21.3	21.1	19.1	18.8	18.8	18.4	17.4	19.0	19.8	20.9	21.4	20.8	19.7
04	21.0	21.3	18.7	18.1	18.1	17.5	16.8	18.4	19.6	20.7	21.2	20.7	19.3
05	20.4	21.0	18.5	17.6	17.6	16.6	15.5	17.7	18.7	19.9	21.1	21.3	18.8
06	19.7	21.2	18.0	16.9	16.4	15.5	14.2	16.6	17.8	20.0	20.5	21.5	18.2
07	18.6	21.1	17.7	16.4	15.2	15.1	12.7	14.3	16.4	19.6	20.0	21.9	17.5
08	19.0	20.9	16.9	16.3	15.5	15.2	12.7	12.6	14.9	18.7	20.0	21.7	17.1
09	19.0	21.2	16.1	16.3	15.8	15.4	13.2	12.0	14.4	19.0	19.7	21.7	17.0
10	18.8	21.0	15.6	16.5	16.0	15.7	13.0	12.4	14.8	18.5	19.3	22.0	17.0
11	18.4	20.8	15.9	16.7	15.8	15.9	13.4	12.9	15.6	18.5	19.2	22.1	17.1
12	18.3	20.8	16.2	16.8	16.1	15.9	13.5	12.8	16.4	18.9	18.9	22.1	17.3
13	17.8	20.7	16.1	17.0	16.3	15.9	14.2	13.3	16.7	19.0	18.6	21.2	17.3
14	17.3	19.9	15.8	16.9	15.9	16.0	14.5	13.4	16.2	18.5	17.8	20.6	16.9
15	17.2	18.6	15.8	16.7	16.1	16.2	14.3	13.4	16.1	18.1	17.8	19.7	16.7
16	18.1	17.2	15.5	15.8	16.1	15.8	14.2	13.0	14.9	17.5	18.2	19.5	16.4
17	19.4	17.2	14.7	15.5	15.9	15.8	14.3	13.4	13.8	17.4	18.2	20.3	16.4
18	19.7	18.1	15.3	15.3	15.6	15.1	14.8	14.1	14.0	18.6	18.4	21.1	16.7
19	19.2	19.2	16.9	15.5	15.8	15.7	14.9	15.1	15.6	19.6	18.8	21.2	17.3

20	19.5	19.5	18.2	16.6	17.3	16.6	15.9	16.3	17.5	20.3	19.9	21.3	18.3
21	20.2	20.0	19.5	17.9	18.2	17.4	16.5	18.0	18.9	21.1	20.6	21.7	19.2
22	20.7	21.0	19.5	19.4	18.8	19.0	16.8	20.5	19.8	21.9	21.0	21.0	19.9
23	20.9	21.8	20.4	19.9	19.4	18.8	17.4	21.1	20.2	21.9	21.4	21.2	20.3
24	20.6	21.3	20.3	20.2	19.8	18.7	17.0	20.9	20.2	22.2	20.4	21.4	20.3
Mean	19.5	20.3	17.5	17.4	17.1	16.7	15.0	15.9	17.3	19.7	19.7	21.1	18.1
Good Hours	2943	2644	3611	3573	3688	3594	2976	2873	2690	3426	3376	3672	
Missing Hours	777	740	109	27	32	6	744	847	910	294	224	48	

39,066 Hours of Good Data 4,758 Hours Missing 89.1% Data Recovery

Table 6. Projected 65 Meter Wind Speeds (mph) for Garfield Peak.

MEAN HOURLY WIND SPEEDS

BADGER PEAK MONTANA
GARFIELD PK 80M WS (WS12 X 1.337) (MPH)

01/01/95 - 12/31/99

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	21.9	21.9	20.7	21.4	20.7	19.8	17.4	21.3	21.2	22.0	21.3	21.6	20.9
02	22.0	21.9	20.5	20.5	20.4	19.5	17.4	20.9	21.4	22.1	21.7	21.2	20.8
03	21.9	21.7	19.7	19.4	19.4	18.9	17.9	19.6	20.4	21.5	22.0	21.4	20.3
04	21.6	21.9	19.2	18.6	18.7	18.0	17.3	18.9	20.2	21.3	21.8	21.3	19.9
05	20.9	21.6	19.1	18.1	18.1	17.1	15.9	18.2	19.3	20.5	21.8	21.9	19.4
06	20.3	21.8	18.5	17.4	16.9	16.0	14.6	17.1	18.4	20.6	21.1	22.1	18.7
07	19.2	21.7	18.2	16.9	15.7	15.6	13.0	14.8	16.9	20.2	20.6	22.6	18.0
08	19.5	21.5	17.4	16.7	15.9	15.6	13.1	12.9	15.3	19.2	20.6	22.3	17.6
09	19.5	21.8	16.6	16.8	16.2	15.8	13.5	12.4	14.8	19.5	20.3	22.3	17.5
10	19.4	21.6	16.1	17.0	16.5	16.1	13.4	12.8	15.2	19.1	19.8	22.7	17.5
11	18.9	21.4	16.4	17.1	16.3	16.3	13.8	13.3	16.0	19.1	19.7	22.7	17.6
12	18.8	21.4	16.7	17.3	16.6	16.3	13.9	13.2	16.9	19.5	19.4	22.8	17.8
13	18.3	21.3	16.6	17.5	16.8	16.4	14.6	13.7	17.2	19.5	19.2	21.8	17.8
14	17.7	20.4	16.3	17.4	16.3	16.5	14.9	13.8	16.7	19.0	18.4	21.2	17.4
15	17.7	19.1	16.3	17.2	16.6	16.7	14.7	13.8	16.5	18.6	18.3	20.3	17.2
16	18.6	17.7	16.0	16.2	16.6	16.3	14.6	13.3	15.4	18.0	18.7	20.0	16.9
17	20.0	17.7	15.1	15.9	16.4	16.3	14.7	13.8	14.2	18.0	18.8	20.9	16.9
18	20.3	18.6	15.8	15.7	16.0	15.5	15.2	14.5	14.4	19.1	18.9	21.7	17.2
19	19.8	19.8	17.4	15.9	16.2	16.2	15.3	15.5	16.0	20.2	19.3	21.8	17.8
20	20.1	20.1	18.7	17.0	17.8	17.1	16.3	16.8	18.0	20.8	20.5	22.0	18.8
21	20.8	20.6	20.1	18.4	18.8	17.9	17.0	18.6	19.4	21.7	21.2	22.3	19.8

22	21.3	21.6	20.1	19.9	19.3	19.5	17.3	21.1	20.3	22.5	21.6	21.6	20.5
23	21.5	22.5	21.0	20.5	19.9	19.3	17.9	21.7	20.8	22.5	22.0	21.8	20.9
24	21.2	22.0	20.9	20.8	20.4	19.3	17.5	21.5	20.8	22.8	21.0	22.1	20.8
Mean	20.0	20.9	18.1	17.9	17.6	17.2	15.5	16.4	17.8	20.3	20.3	21.8	18.7
Good Hours	2943	2644	3611	3573	3688	3594	2976	2873	2690	3426	3376	3672	
Missing Hours	777	740	109	27	32	6	744	847	910	294	224	48	

39,066 Hours of Good Data   4,758 Hours Missing   89.1% Data Recovery

4.0 Wind Turbine Power Curve

The GE Wind 1.5 MW wind turbine (70M Rotor) is a three bladed, upwind, horizontal axis wind turbine employing variable pitch blade technology. The power curve for the GE Wind 1.5MW turbine for the Northern Cheyenne Site using an air density of 1.08 kg/m^3 is presented in Table 7.

Table 7 - GE Wind 70M Power Curve

Wind Speed (mps)	Power (kW)	Wind Speed (mps)	Power (kW)	Wind Speed (mps)	Power (kW)	Wind Speed (mps)	Power (kW)
4	28	10	946	16	1500	22	1500
5	87	11	1228	17	1500	23	1500
6	177	12	1420	18	1500	24	1500
7	299	13	1486	19	1500	25	1500
8	461	14	1500	20	1500	>25	0
9	676	15	1500	21	1500		

5.0 Annual Energy Estimate

5.1 Gross Annual Theoretical Energy Estimate

The wind speed frequency is combined with the GE Wind power curve to create the annual theoretical energy estimate for a single turbine. The theoretical gross energy output for the 70 meter GE Wind Turbine (1.5MW) on a 65 meter tower is 5,116,349kWh. The theoretical gross energy output for the 70 meter GE Wind Turbine (1.5MW) on an 80 meter tower is 5.331.350kWh.

5.2 Net Annual Theoretical Energy Estimate

The gross annual theoretical energy output is adjusted by various loss factors to estimate the actual or net energy delivered to the substation. These losses take into account the wind turbine out-of-service time associated with scheduled and unscheduled downtime, electrical line losses from the turbine to the substation, control system losses, array losses due to wake effects between adjoining turbines, and lost power associated with blade icing and blade soiling.

The annual net energy production for a single turbine is calculated using the following formula:

$$AEP_{net} = AEP_{gross} * (1- EL)$$

where AEP_{net} is the Annual Net Energy Production of the wind facility;

AEP_{gross} is the Annual Gross Energy Production of the wind facility;

EL is the product of individual energy losses (%);

EL is the product of the individual energy losses and is calculated as follows:

$$EL = 1-(1 - L_{array}) * (1 - L_{blade}) * (1 - L_{collect}) * (1 - L_{control}) * (1-Availability)$$

where L_{array} = Array losses

$L_{soiling}$ = Blade contamination losses

$L_{collect}$ = Collection system from turbine to grid

$L_{control}$ = Control, grid, and miscellaneous losses

Availability = Availability is the percentage of calendar time that the turbines are functional and ready to deliver power to the grid.

Table 8. Theoretical Energy Projection for a GE Wind Turbine (1.5MW) on a 65 Meter Tower.

```
THEORETICAL WIND TURBINE PRODUCTION          01/01/95 - 12/31/99

Wind:      GARFIELD PK 65M WS (WS12 X 1.299)
         BADGER PEAK MONTANA

         Wind Speeds Multiplied By  1.00

Turbine: GE 1.5 SL (1500Kw)70M ROTOR 1.08KG/M**2

         Rated at:        1500 kW at 30.0 MPH
         Maximum Output:  1500 kW at 30.0 MPH
```

Status	MPH	Time hrs	Time %	Production KW-hrs	Production %
Below Cut-in	Under 10.0	9394	24.0		
Cut-in To Rated	10.1-30.0	24453	62.6	15,086,860	66.1
Rated To Cut-out	30.1-56.0	5155	13.2	7,729,956	33.9
Above Cut-out	Over 56.0	64	.2		
Contactor Closed		29608	75.8		

```
kW-hrs at Capacity / Total kW-hrs    33.9

hrs at Capacity / hrs of Operation   17.4

Mean Wind Speed                      18.1 MPH

Energy Produced                22,816,810 kW-hrs


Annual Production Rate          5,116,349 kW-hrs

Capacity Factor                       .39


39066 hrs of Good Data   4758 hrs Missing     89.1% Data Recovery
```

Table 9. Theoretical Energy Projection for a GE Wind Turbine (1.5MW) on a 80 Meter Tower.

```
     THEORETICAL WIND TURBINE PRODUCTION            01/01/95 -
12/31/99

     Wind:      GARFIELD PK 80M WS (WS12 X 1.337)
              BADGER PEAK MONTANA

              Wind Speeds Multiplied By  1.00

     Turbine: GE 1.5 SL (1500Kw)70M ROTOR 1.08KG/M**2

              Rated at:        1500 kW at 30.0 MPH
              Maximum Output:  1500 kW at 30.0 MPH
```

Status	MPH	Time hrs	Time %	Production KW-hrs	Production %
Below Cut-in	Under 10.0	8961	22.9		
Cut-in To Rated	10.1-30.0	24353	62.3	15,286,850	64.3
Rated To Cut-out	30.1-56.0	5663	14.5	8,488,779	35.7
Above Cut-out	Over 56.0	89	.2		
Contactor Closed		30016	76.8		

```
     kW-hrs at Capacity / Total kW-hrs    35.7

     hrs at Capacity / hrs of Operation   18.9

     Mean Wind Speed                      18.7 MPH

     Energy Produced                23,775,630 kW-hrs

     Annual Production Rate          5,331,350 kW-hrs

     Capacity Factor                       .41

     39066 hrs of Good Data   4758 hrs Missing     89.1% Data Recovery
```

The loss factors assumed for this project include 3% for availability, 2% for electrical line losses, 7.5% for array and off-axis wind direction losses, 1% for turbulence and control, and 1% for blade contamination losses. The gross to net ratio is 0.862.

The calculated net energy production for a single turbine on a 65 meter tower using the loss factors presented above is 4,410,293kWh. The net capacity factor is 33.6%.

The calculated net energy production for a single turbine on a 80 meter tower using the loss factors presented above is 4,595,624kWh. The net capacity factor is 34.9%.

**"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Data Acquisition System**

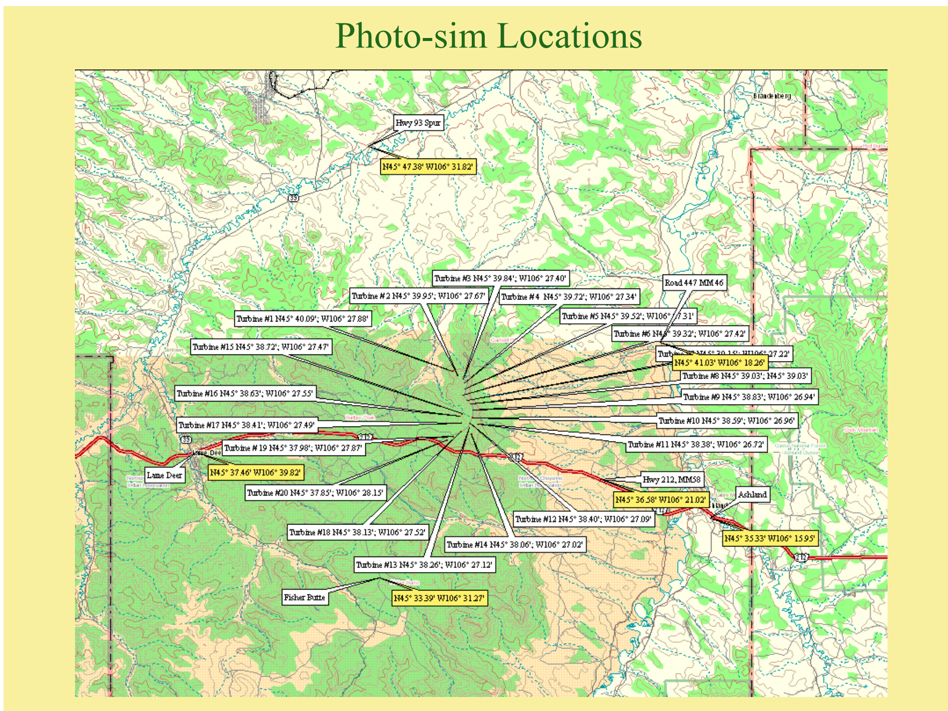
The Northern Cheyenne Tribe and Disgen selected as a meteorological (MET) tower the NRG 50 meter system. Due to lack of cellular service, the 9300 datalogger was substituted for the Symphony Cellular System. The 9300 logger has performed exceptionally well during the MET tower's initial installation and in its relocation to the project area in November of 2003.

The tower is instrumented with two wind speed sensors and one wind direction sensor at the 50 meter level, two wind speed sensors at the 40 meter level and one wind speed sensor and one wind direction sensor at the 30 meter level. Garfield Peak, which is at the northern end of the project area hosts a climatological research station as an ancillary emissions monitoring station for the coal-fired Colstrip Power Plant located twenty six (26) miles north of the reservation. This station has been operational since 1992, so the NCT enjoys an abundance of high quality wind data, at the 30 foot level, and temperature and humidity data as well. Consequently, the MET tower was not instrumented with temperature and humidity sensors.

The MET equipment is generic and does not come equipped with serial numbers. Upon completion of the wind studies, Disgen will retain the 9300 datalogger and replace it with a non-cellular Symphony System from NRG.

"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Site Description

The project area selected for final analysis is located approximately __ miles east of Lame Deer Montana on the north side of US Hwy 212 about two miles distant from the intersection of the high point of the highway. The elevation is ____ feet. The area is primarily used for grazing and contains tall pine trees interspersed with the area. There are no dwellings within several miles of the site. There is a 69 kV transmission line running on the south end of the project area. The area is depicted in the map below.



The area has been subjected to a forest fire in the past and does not contain dense stands of trees.

**"NORTHERN CHEYENNE NATION
WIND-SOLAR-BIOMASS FEASIBILITY STUDY"
Meteorological Tower Location**

The fifty meter (50m) meteorological tower was originally located on the south side of US Hwy 212 and was relocated to the project area in November 2003. The location of the relocated tower is:

45deg 30' 12"
W106deg 27' 24"
Elevation: 4220ft

Instrumentation:
50M 2 Anemometers, 1Vane
40M 2 Anemometers, 1Vane
30M 1 Anemometer