2007 Spring, Summer, and Fall Post-construction Bird and Bat Mortality Study at the Mars Hill Wind Farm, Maine

Prepared For:

UPC Wind Management, LLC
102 Tuttle Road
Cumberland, ME 04021

Prepared By:

Stantec Consulting, formerly Woodlot Alternatives, Inc.
30 Park Drive
Topsham, ME 04086

January 2008

Executive Summary

Construction for the Mars Hill Wind Farm in Maine was approved by the Maine Department of Environmental Protection in 2004. As proposed by Evergreen Wind Power, LLC, post-construction monitoring is being conducted to determine if the project presents an unreasonable adverse impact on wildlife. The post-construction monitoring protocol was developed in consultation with the Maine Department of Inland Fisheries and Wildlife, and the 2007 bird and bat mortality surveys represent the first of the two years of post-construction wildlife monitoring.

The 28 turbines of the Mars Hill Wind Farm were operational as of March 27, 2007. The GE 1.5 sle turbines have a maximum height of 119 meters (m) (389 ft) for the tower and the blade-tip height combined. Ten of the 28 turbines are lit with FAA approved lighting.

During the first year of operation, bird and bat mortality surveys were conducted for six weeks during the spring (April 23 to June 3), four weeks in the late-summer (July 15 to August 12), and for six weeks in the fall (August 13 to September 23). Mortality surveys involved both standardized searches conducted according to Maine Department of Inland Fisheries and Wildlife approved protocols, as well as supplemental surveys conducted voluntarily by UPC Wind Management, LLC as a means of validating the results of standardized searches. During each survey session (spring, summer, and fall), 2 randomly selected turbines were searched everyday, all 28 turbines were searched once every 7 days (typically over a period of 4 days), and a meteorological tower and a communication tower on-site were also searched once a week. Surveys consisted of standardized searches of transects (6 to 8 m apart [20 to 26 ft]) created within the cleared and leveled lay-down areas surrounding each turbine. During surveys, any intact carcasses or evidence of scavenged birds or bats found were documented. At the end of each survey session, a subset of the turbines (19.6 = average number of turbines searched per session) was searched by a surveyor with a dog on a leash. Additional fatalities found by hikers or maintenance personnel were recorded as incidental findings.

A total of six bird fatalities were documented during the 2007 standardized searches (four during the spring and two during the fall survey session). There were 3 incidental findings of bird fatalities (1 prior to initiation of the spring survey, 1 during the spring survey, and 1 prior to initiation of the summer survey), and 13 bird fatalities were found during the dog searches (2 during the spring, 4 during the summer, and 7 during the fall survey session), with an overall total of 22 birds found during the study year. The bird found before the spring surveys during transect set-up had been run-over in the road. Due to its relatively far distance from the nearest turbine (71 m [233 ft]) and its location on the access road, it was difficult to determine the actual cause of death. Another incidental finding during the spring survey session was also found in the road (41 m [134 ft] from the nearest turbine); therefore, the actual cause of death was unknown. However, these birds' deaths were attributed to operation of wind farm.

All birds found were songbird species. Warbler species, blackburnian warbler (*Dendroica fusca*), and golden-crowned kinglet (*Regulus satrapa*) represented 45 percent (N=10), 9 percent (N=2), and 9 percent (N=2) of all detected bird fatalities, respectively. There were no state endangered or threatened, or state bird species of special concern found during the 2007 surveys. Results indicate that bird fatalities were dispersed throughout the survey period and likely involved both resident and migrant songbird species (Appendix B Table 2). Therefore, bird fatalities were believed to occur during both small-scale and localized resident bird movements, as well as during nighttime migration movements. The average distance of bird fatalities from the turbines was 35 m (115 ft) (including the two fatalities found in the road for which the actual cause of death was undetermined).

A total of 24 bats were recovered for the study year: 2 bat carcasses were recovered during the 2007 standardized searches (one during the spring surveys and one during the fall surveys); two incidental bat findings, both during the summer surveys; one bat was found within the cleared and leveled lay-down area (36 m from the turbine) during an extended survey plot search during the summer survey session; and 19 bat fatalities were recovered during dog searches (15 during the summer survey session and 4 during the fall survey session). Silver-haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinereus*), little brown bat (*Myotis lucifugus*), and eastern red bat (*Lasiurus borealis*) accounted for 38 percent (N=9), 21 percent (N=5), 17 percent (N=4), 13 percent (N=3) of all detected bat fatalities, respectively. The majority of bat fatalities (63% were found moderately or heavily decomposed) were recovered during dog searches at the end of the summer survey session. The bat fatalities included three state species of special concern: silver-haired bat, hoary bat, and eastern red bat. The timing of the majority of bat fatalities occurred between late-July and August. These results are consistent with the findings of other studies suggesting that bats are at greatest risk of collision during the late-summer dispersal periods. The average distance of bat fatalities from the turbines was 21 m (69 ft).

Fatalities were detected—either during standard surveys, dog searches, or incidentally—at 22 of the 28 turbines. Of the turbines that experienced fatalities, most yielded 1 to 2 fatalities with the exceptions of turbines 3 (6 fatalities), 8 (4 fatalities), 12 (3 fatalities), 17 (4 fatalities), 20 (3 fatalities), and 26 (4 fatalities). For all detected fatalities including results from incidental, dog searches, and extended survey plot searches, the average number of fatalities at lit turbines was 1.4 and the average number of fatalities at unlit turbines was 1.8.

No fatalities were detected under the met or communication towers that were searched throughout the study period. However, there were three bird fatalities found in the turbine clearings that were in proximity to a communication tower as well as a turbine: a bird found 37 m (121 ft) from a communication tower was also 59 m (193 ft) from turbine 26; a different bird found 51 m (167 ft) from the same tower was 40 m (131 ft) from turbine 26; and, a bird found 72 m (236 ft) from a communication tower was 73 m (239 ft) from turbine 12. Two of these birds had been scavenged and their original location may have been different from where they were detected. Due to the close proximity of the communication towers to some of the turbines, the actual source of mortality of these carcasses was difficult to determine.

Migration activity ranged from moderate to heavy on those nights that NEXRAD migration data was available to compare to nights during which bird or bat mortality events were known to occur. Of those nights during which bat fatalities occurred, winds ranged from calm to light during both clear and overcast conditions. Bird fatalities occurred during a range of weather conditions from clear to overcast/mist conditions with calm to moderate winds.

To investigate the number of fatalities that may occur outside of the average search plot area, extended plot searches (plot diameter of 238 m [780 ft]) were conducted during each of the survey sessions. During the extended search plots, 1 bat was found 36 m (118 ft) from turbine 2. No birds or bats were found outside of the cleared and leveled turbine search plots during the extended plot surveys.

To account for the number of carcasses removed by scavengers, a scavenger removal trial was conducted during each survey session. Bird and bat carcasses found during mortality searches, and house mice (*Mus musculus*) when bat carcasses were unavailable, were placed at different turbines throughout the project area. The status of the carcasses was periodically monitored. One fresh bird fatality was not collected and left out during the fall survey session to reduce the bias of human handling or freezing in scavenger activity. If carcasses were scavenged, it was noted whether they were totally removed from the site or if feathers or other parts of carcasses were still detectable for a surveyor. Data was pooled among the seasons to calculate the percent of bird and bat/mouse carcasses that were completely removed during the

trial period and were therefore undetectable. The scavenger removal trials determined that 87 percent of bird carcasses and 33 percent of bat carcasses were not scavenged between weekly search intervals; 87 percent of bird carcasses and 50 percent of bat carcasses were not scavenged during daily search intervals; and 40 percent of bird carcasses and 33 percent of the bat/mouse carcasses were not scavenged during the 2-week trial period.

Bird and bat carcasses were also placed among turbine plots once during each survey session for searcher efficiency trials. Data from the survey sessions was pooled to calculate a searcher efficiency rate for birds and for bats. The surveyor detected 56 percent of the trial bird carcasses and 50 percent of the trial bat carcasses. A single searcher efficiency trial was conducted for the surveyor with a dog. The results for bird and bat carcasses were pooled for this trial, resulting in an overall search efficiency of 67 percent of the carcasses.

The results of the scavenger carcass removal and the searcher efficiency trials, the proportion of turbines searched during weekly or daily searches, as well as the number of bird or bat carcasses found, were used to calculate an estimated total of bird and bat fatalities per turbine per study year (fatalities/turbine/study year). The weekly surveys resulted in an estimated total of 12.32 bird fatalities per study year (±3.78) with 0.44 birds/turbine/study year. For weekly surveys, the estimated total number of bat fatalities was 12.1 per study year (±0.59) with 0.43 bats/turbine/study year. The results of daily searches indicated a total estimated number of 29.32 birds per study year (±34) with 1.04 birds/turbine/study year, and an estimated total of 57.14 total bats per study year (±32.4) with 2.04 bats/turbine/study year.

A single searcher efficiency trial, the percent of carcasses scavenged, the average number of turbines searched per survey session, and the number of carcasses found during the dog searches, were used to calculate a separate estimate of the total bird and bat fatalities. A total of 69.2 birds per study year (±29.7) with 2.47 birds/turbine/year; and 122.5 total bats per study year (±62.9) with 4.37 bats/turbine/year were estimated. Survey effort varied among the standardized searches and the dog surveys; therefore, the results should not be taken out of context. However, the discrepancies between the results of daily and weekly standard searches and dog searches, as well as the differences in searcher efficiency between a single surveyor and a surveyor with a dog, indicate that modifications to the mortality survey protocol for 2008 may be worth considering, particularly as re-vegetation progresses on-site. Decreasing the transect width from 5 to 6 m (20 – 26 ft) down to 3 to 4 m (10 – 13 ft) would likely increase searcher efficiency. The more standard use of dogs may also increase searcher efficiency. The use of radar or dogs may increase the probability of detecting carcasses during extended plot searches. Increasing the number of turbines searched daily may help narrow down the weather conditions during which birds and bats are at increased risk of collision. Finally, extending fall surveys into mid-October may be appropriate to assess mortality through the migration period.

The timing of the peak number of bird and bat fatalities at Mars Hill during the 2007 survey period is similar to that found during other studies in the U.S. The majority of bat species found during fatality searches at Mars Hill is also consistent with the species of bat commonly found during searches at other wind farms. However, the rates of bird and bat fatalities found at Mars Hill during the first year of monitoring were generally much lower than the results of other existing wind farms in the eastern U.S. There were no State Threatened or Endangered species of bird found during the first year of fatality searches. The two species of songbird that experienced multiple fatalities (2 total of each species), golden-crowned kinglet and blackburnian warbler, have stable regional populations. Bat species of special concern, including silver-haired bat, eastern red bat, and hoary bat, were found during fatality searches at Mars Hill; however, the estimate of total bat mortality was low compared to other wind farms in the East. The results of the first year of monitoring suggest that bird and bat mortality due to the project does not represent an unreasonable adverse impact to wildlife.

Table of Contents

1.0 INTRODUCTION 1
1.1 Project Context 1
1.2 Project Area Description 2
1.3 Study Area 4
2.0 METHODS 4
2.1 Standardized Searches 4
2.2 Extended Plot Searches 5
2.3 Incidental Findings 6
2.4 Dog Searches 6
2.5 Searcher Efficiency Trials 6
2.6 Scavenger Removal Trials 7
2.7 Statistical Analysis 7
2.8 Weather and NEXRAD Migration Data Comparisons 8
3.0 RESULTS 9
3.1 Standardized Searches 9
3.2 Extended Plot Searches 11
3.3 Incidental Findings 11
3.4 Dog Searches 11
3.5 Searcher Efficiency Trials 12
3.6 Scavenger removal trials 12
3.7 Statistical Analysis 12
4.0 DISCUSSION 14
4.1 Carcass Species Composition 14
4.2 Spatial Analysis 15
4.3 Temporal Analysis 23
4.4 NEXRAD Migration Data and Weather Correlations 24
4.5 Statistical Analysis 26
4.6 Comparison of Results with Other Studies 26
5.0 CONCLUSIONS AND FUTURE STUDIES 28
6.0 LITERATURE CITED 30

List of Appendices

Appendix A Wildlife Casualty Monitoring Protocol
Appendix B Table 1 Dates of bird and bat mortality surveys at the Mars Hill Wind Farm 2007
Table 2 Bird fatalities found at the Mars Hill Wind Farm 2007
Table 3 Bat fatalities found at the Mars Hill Wind Farm 2007
Table 4 NEXRAD migration data during Mars Hill Wind Farm mortality surveys 2007

List of Tables

Table 1 Example schedule for a four or six week survey session during 2007 bird and bat mortality surveys
Table 2 Total transect length and total search area per turbine plot
Table 3 Results of weekly and daily turbine searches and dog searches at the Mars Hill Wind Farm 2007
Table 4 Total search area compared to the total number of fatalities detected per turbine
Table 5 Comparison of known dates of mortality events with NEXRAD migration data and weather
Table 6 Comparison of bird and bat mortality at existing wind farms in the U.S.

List of Figures

Figure 1 Project Location Map
Figure 2 Example of extended plot search area and methods
Figure 3 NEXRAD reflectivity image with no migration activity
Figure 4 NEXRAD reflectivity image with light migration activity
Figure 5 NEXRAD reflectivity image with heavy migration activity
Figure 6 Bird and Bat Fatality Maps
Figure 7 Ridge Profile Fatality Map
Figure 8 Total search area compared to the total number of fatalities at each turbine

1.0 Introduction

In compliance with a condition of the Department of Environmental Protection (DEP) permit approving construction of the Mars Hill Wind Farm, a two-year post-construction wildlife monitoring project was initiated in April 2007. The objective of the study is to investigate if unpredicted and unreasonable adverse impacts on wildlife are resulting from development of the project. The 2007 bird and bat mortality survey conducted by Woodlot Alternatives, Inc. (Woodlot)[1] represents the first of the two years of post-construction wildlife monitoring.

Birds and bats are known to collide with tall man-made structures including communication towers, buildings, and wind turbines. Emerging evidence suggests that bats may be at greatest risk of collision during periods of low cloud cover and calm wind speeds, often after the passing of storm fronts (Kunz *et al.* 2007). Birds may be at greater risk of collision with tall structures when weather conditions reduce visibility (Crawford 1981; Avery *et al.* 1976, 1977).

A review of existing mortality studies indicated that bat mortality in the U.S. ranged from 0 to 63.9 bats per turbine per year (bats/turbine/year) (Kerlinger 2002, 2006; GAO 2005; Arnett 2005; Fiedler *et al.* 2007). The Buffalo Mountain facility in Tennessee observed rates among the highest reported in the U.S. at 63.9 bats/turbine/year (1,149 total bats) (Fiedler *et al.* 2007). Locations in the Appalachian Mountains observed mortality as high as 38 bats/turbine per a 6-week study period (1,364 to 1,980 total bats) (Arnett 2005). Another recent study in New York documented 11.39 to 20.31 bats/turbine/year (1,367-2,437 total bats) (Jain *et al.* 2007). Raptor mortality in the U.S. has been low at wind farms with modern turbine models, ranging from 0 to 0.07 raptors/turbine/year (Erickson *et al.* 2002, GAO 2005). Nocturnal migrant songbird fatalities at most existing wind farms have also been relatively low, despite the high reported number of collisions of nocturnal migrants with large, lit and guyed communication towers (typically greater than 153 m [500 ft]) in the U.S. (Jain *et al.* 2007). The number of reported songbird fatalities associated with wind farms in the U.S. has ranged from 0 to 9.48 fatalities/turbine/year (GAO 2005, National Research Council 2007, Jain *et al.* 2007).

To assess the level of mortality of birds and bats resulting from the Mars Hill Wind Farm, a bird and bat mortality study was initiated in April 2007, approximately one month after the start of operation of the facility. Another purpose of this first year of study was to assess the effectiveness of the current protocol (included as Appendix A) in determining wildlife impacts at the Mars Hill Wind Farm and to determine if adjustments should be made to the 2008 protocol.

Mortality surveys were conducted for six weeks during the spring (April 23 to June 3), four weeks in the late-summer (July 15 to August 12), and six weeks in the fall (August 13 to September 23). The spring and fall survey sessions were designated to include the peak migration periods of birds, and the late-summer session was designated to include the peak period of bat dispersal. A second year of monitoring is scheduled to take place during the spring, summer, and fall of 2008.

1.1 Project Context

The Mars Hill Wind Farm is located on the Mars Hill ridge-top in Aroostook County, Maine (Figure 1). The wind farm became operational as of March 27, 2007. The facility consists of 28 GE 1.5 sle turbines that have a maximum tower and rotor blade-tip height of 119 meters (m) (389 ft). The turbines have a

[1] Field work and subsequent report filings performed prior to October 1, 2007, were done so as Woodlot Alternatives, Inc. On October 1, 2007, Woodlot Alternatives, Inc. was acquired by Stantec Consulting Services Inc.

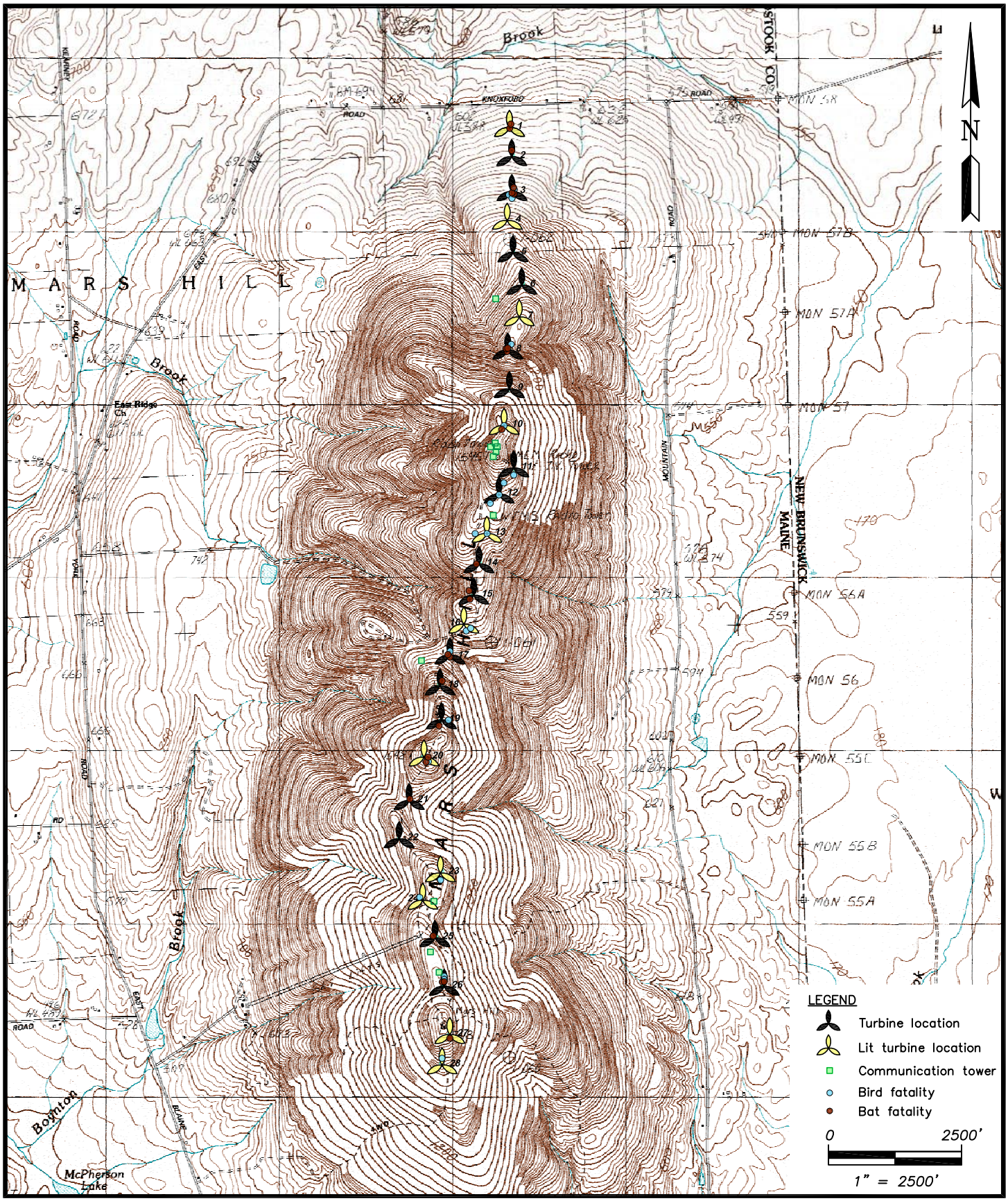
maximum rotor-blade diameter of 77 m (252 ft). A total of 10 of the 28 turbines (turbines 1, 5, 7, 10, 13, 16, 20, 23, 27, and 28) are lit by L-864 red flashing FAA lighting. The wind speed at which the turbines cut-in is 3.5 m/s and the turbines cut-out at a maximum wind speed of 25 m/s.

The Big Rock Ski Area is located at the south end of the Mars Hill ridgeline. There are five freestanding and one guyed communication towers located on the northern end of the ridge, and one free standing and three guyed communication towers positioned along the southern part of the ridge (Figure 1). The communication tower heights range from approximately 10 m (33 ft) to greater than 400 m (1311 ft) and three are equipped with lighting. There is one meteorological (met) tower located along the north end of the ridge, and one met tower at the south end, both of which are unlit. There is a hiking trail that follows the ridge, and ATV use is permitted along portions of the access roads of the ridgeline.

1.2 Project Area Description

The project area occurs in the Aroostook Lowlands Biophysical Region of Maine in the northeast region of the State, bordering New Brunswick, Canada. The Aroostook Lowlands Biophysical Region is relatively low in elevation except for a few mountains over 244 m (800 ft) above sea level (asl), including Mars Hill at 533 m (1,748 ft). Others include Number Nine Mountain at 499 m (1,638 ft) and Squa Pan Mountain at 366 m (1,200 ft). The climate is relatively uniform throughout the region, with the highest average temperature in July of 77 ºF and an average low temperature in January of -1 ºF. The growing season ranges from 95 to 110 days long and the average annual precipitation is approximately 71 centimeters (cm) (38”). Northern hardwoods are the dominant forests in the region (McMahon 1990).

Within the project area, elevations range from 486 m (1,595 ft) on the north end of Mars Hill to 533 m (1,748 ft) on the south end. Ridge top habitat in this area consist of northern hardwood forests dominated by sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), American beech (*Fagus grandifolia*), and quaking aspen (*Populus tremuloides*). American beech, striped maple (*Acer pensylvanicum*), and hobblebush (*Viburnum lantanoides*) are the dominant understory species. Lower elevation habitat is mainly the same as ridge top habitat except paper birch (*Betula papyrifera*) is more evident in the canopy and forested and scrub-shrub wetlands are common. The landscape surrounding Mars Hill is mainly agricultural, which includes mostly potato, cabbage, and broccoli fields.



PREPARED BY:

Stantec

WOODLOT

107123-F001-Mortality_Loc.dwg

SHEET TITLE:

Project Location Map

PROJECT:

Mars Hill Wind Farm
Mars Hill, Maine

DATE: Jan. 11, 2008

SCALE: 1"=2500'

PROJ. NO.: 107123

FIGURE:

1

1.3 Study Area

Turbine lay-down areas with a typical diameter of 76 m (250 ft) were created during construction of the project. Cleared areas and steep side slopes have since been covered with crushed stone. Since construction of the project, the cleared flat areas have been hayed and seeded with grass. During the summer 2007 surveys, grass began to grow in several plots and by the time of the fall surveys, the grass had grown in all plots, with some patches of grass several inches high. The northern-most turbines, turbine plots 1 to 4, occur in old field (grassland) or partially forested and grassland habitats. The habitat surrounding the remaining turbine plots is mainly characterized by northern hardwood forest.

Roughly half of the turbines are centered within the cleared and leveled areas while the remaining turbines are positioned near the edge of the clearings. Therefore, the area under a turbine equivalent to the distance between the ground and the maximum rotor-swept zone (119 m [389 ft]) may fall over cleared and leveled areas, as well as sections of access road, forest, grassland, scrub-shrub, or steep terrain. Although 76 m (250 ft) is a typical turbine plot diameter, where a turbine is located at the edge of a plot, a cleared area may extend as far as 100 m (328 ft) from a side of the tower, and less than 10 m (33 ft) on the side closest to forest edge.

2.0 Methods

2.1 Standardized Searches

Bird and bat mortality surveys were conducted for six weeks during the spring (April 23 to June 3), four weeks in the late-summer (July 15 to August 12), and for six weeks in the fall (August 13 to September 23). Although fatalities may occur at distances from the turbine tower equal to or greater than the distance between the ground and the maximum blade-tip swept area (119 m [389 ft] at Mars Hill), it was determined during protocol development that survey effort would focus on the cleared and leveled turbine lay-down areas due to the significantly greater difficulty of searching steep and forested terrain. Other mortality studies have used reduced search areas for similar reasons. Mitigating this issue is the fact that other studies have found that the majority of bird and bat fatalities occur within half the maximum distance from the tip height to the ground (Arnett 2005). Other studies suggest that greater than 80 percent of fatalities occur within 40 m of towers. In this study, although the typical turbine plot diameter is 76 m (250 ft), some turbine plot cleared and leveled areas are greater, allowing for carcass searches extending as far as 100 m (328 ft) from the side of a tower in some locations.

Search transects were established under all 28 turbines during the weekend of April 19 to 20, 2007. Depending on the size of the cleared turbine plot, 7 to 14 transects were established within the cleared and level turbine lay-down areas. Transects were oriented north to south and were spaced 6-8 m apart (20 to 26 ft). The start and end points of each transect were marked along the edge of the plot (on rocks or trees or with flags).

During each survey session (seasonal 4 week or 6 week period), 2 randomly selected turbines were searched every day and all 28 turbines were searched once every 7 days (typically over a period of 4 days). The two turbines to be searched daily and the order of turbines to be searched weekly during each survey session were determined by a random sequence generator. The open area under the communication tower located at the top of the Big Rock Ski Area near turbine 24 was searched weekly throughout the three survey sessions. The area cleared under the met tower located near turbine 6 was searched weekly during the spring and summer survey session, and the cleared area under the met tower

near turbine 18 was searched weekly during the fall survey session. Table 1 provides an example of a weekly schedule during one of the 4-week or 6-week survey sessions.

Table 1. Example schedule for a 4 or 6 week survey session during 2007 bird and bat mortality surveys

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
10,17,12,6,27, 23,7,11	**10,17**,14,3**,**19, 20,18,26,1	**10,17,**22,4,5, 24,8,2	**10,17**,21,28,9,16, 25,15,13	**10,17,** communication tower and met tower	**10,17**	**10,17**

A local individual from the town of Westfield, the town north of Mars Hill, conducted the majority of the daily and weekly turbine searches. The individual was recommended by Maine Department of Environmental Protection and was trained by Woodlot biologists during transect set-up. During a turbine plot search, the surveyor would walk at a rate of 45 to 60 m (148-197 ft) per minute, searching on both sides of a transect out to 3 to 4 m (10-13 ft) for bird or bat fatalities. Any fatalities found along transects or found as the surveyor walked the 6 to 8 m (20-26 ft) widths between transects at the north and south ends of the plots, were documented.

Intact bird or bat carcasses or remnants of scavenged carcasses (a cluster of feathers, or a patch of skin and bone) were documented as fatalities. If a carcass was found, the surveyor used a range finder to determine the carcass' distance from the nearest turbine (or communication tower). The surveyor would take a compass reading of the carcass from the turbine in order to determine the carcass' location. Multiple pictures would be taken of a carcass for positive identification. The date, time, the previous night's weather, the turbine number, and any notes were recorded, including the age of decomposition of the carcass (previous night, 2 to 3 days, 4 to 7 days, 7 to14 days, greater than 2 weeks, scavenged), or if the carcass was found in a turbine plot or along the access road,. The carcasses were collected and frozen (except for one fresh carcass involved in scavenger removal trial). To the extent possible, casualties believed to be associated with the wind farm were distinguished from those believed to be associated with communication tower or vehicle collision or as natural sources of mortality.

2.2 Extended Plot Searches

Two turbine plots with an extended search area (238 m [780 ft] diameter) were searched during each survey session to determine the number of fatalities that may occur outside of the typical search plot diameter of 76 m (250 ft). The turbines for the extended searches were chosen according to practicality of survey. For example, the turbines where the extended search diameter may occur over dangerously steep terrain were excluded from the searches. Turbines throughout the project area that occur in both grassland and forested areas were included in the study.

A Woodlot biologist conducted the extended plot searches each survey session. The biologist used a hand-held GPS to maintain a maximum distance of 119 m (389 ft) from the tower base while searching an extended area outside of the cleared and leveled turbine plot. Outside of the cleared and leveled standard search area, the biologist walked along transects spaced roughly 6-8 m (20-26 ft) apart, surveying the area by zigzagging at approximately the same pace as the standardized searches (Figure 2). The area within the cleared turbine plot was then searched according to the standardized protocol. Extended search plots were conducted in addition to weekly standard searches. Any carcasses found were documented and collected according to standardized search protocol. Findings are reported separately from the results of the standardized searches.

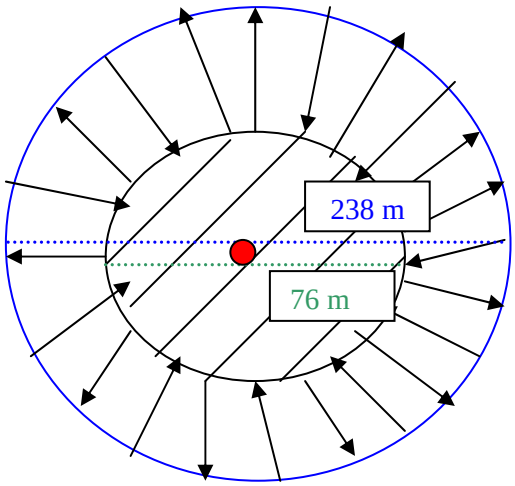


Figure 2. Example of extended plot search area and methods (not to scale).

2.3 Incidental Findings

Any fatalities found by maintenance personnel, hikers, or surveyors outside of the standardized searches were documented and collected according to the standardized protocol. These findings were reported as incidental.

2.4 Dog Searches

At the end of each survey session, a subset of turbines was searched by a Woodlot biologist with a dog (Siberian husky) on a 1-m (4-ft) leash. The biologist searched according to the standardized protocol by walking the designated transects, allowing the dog to stop or move toward a carcass it detected along a transect. Findings were recorded according to the standardized protocol and it was noted whether the biologist or the dog had first detected the carcass. During the final week of a survey session, the dog searches were generally conducted in place of standardized searches at a subset of turbines and also included turbines that had been searched previously that week by the surveyor alone. Incidental findings and the findings of dog searches were reported separately from the results of the standardized searches.

2.5 Searcher Efficiency Trials

During each survey session, a searcher efficiency trial unannounced to the surveyor was conducted to estimate the percent of bird and bat carcasses that may go undetected during standardized searches. For the trials, a Woodlot biologist left out carcasses early in the morning at turbines scheduled to be searched that day. Carcasses were marked with pink leg tape, unnoticeable to the surveyor until the carcass was in hand, so that the surveyor would be able to distinguish trial carcasses. Small and medium sized songbird and bat carcasses found during surveys at varying stages of decomposition were placed during trials[2]. Carcasses were placed at random within search plots. As the surveyor searched turbines according to the standard protocol, carcasses found during the trial were collected. After the test, the Woodlot biologist or the surveyor (informed by the biologist) collected those trial carcasses not found and the biologist determined the number of carcasses recovered by the surveyor.

[2] Additional small and medium sized songbirds, and one small owl, were provided by Maine Audubon Society.

2.6 Scavenger Removal Trials

During each survey session, a scavenger removal trial was conducted to estimate the percent of carcasses removed by scavengers between the 1-day and 7-day search intervals. Bird carcasses, including small and medium songbird carcasses, one small owl, and bat carcasses (fresh to aged 2 to 3 days) were used. When bat carcasses were not available, house mice (*Mus musculus*) were placed as a small mammal substitute. Carcasses were marked by a nearby flag or colored leg tape to distinguish trial birds and bats from new fatalities. Carcasses were left out either along the edge of search plots or within search plots throughout the project area in the late-afternoon or evening.

The status of the carcasses was monitored daily for the next five days, then on days 7, 10, and 14. If a carcass showed evidence of scavenging, it was noted if the carcass was completely removed (scavenged/removed), or if feathers or parts of the carcass were still evident to the surveyor (scavenged/detectable). Jain *et al.* 2007 noted that the period between carcass fall and discovery is approximately half the actual search cycle, rounded up. Therefore, the status of the carcasses on the day equivalent to the average time between impact and discovery was noted (day 1 for turbines searched daily, day 4 for turbines searched weekly). If a carcass remained unscavenged on day 14, or if the carcass was scavenged but remained detectable to the surveyor, it was documented as not removed and was collected.

During the fall, any fresh carcasses found were marked by a nearby flag, were left in place, and were monitored according to the above schedule to minimize bias created by human handling of carcasses.

2.7 Statistical Analysis

The estimated total number of bird and bat wind farm-related fatalities is influenced by the total number of birds and bats found, the proportion of turbines searched, the percent of carcasses found by the surveyor, the percent of carcasses removed by scavengers, and the percent of carcasses that may occur outside of the standard search plot area. Statistical analyses were modeled after Jain *et al.* 2007.

There were no carcasses found outside of the standard search plot areas during the extended plot surveys; therefore, there were no data to account for the percent of carcasses that may occur outside of the standard search areas. The results of each survey sessions' scavenger trials were pooled for bird and bat carcasses. The analysis considered the percent of placed birds that were totally removed by scavengers and were therefore, no longer detectable by a surveyor. The results of each survey sessions' searcher efficiency trails were also pooled for bird and bat carcasses. The searcher efficiency rate was based on the total number of carcasses found divided by the total number of carcasses placed.

An estimate of the total mortality that occurred at Mars Hill ($\hat{c}$) was calculated for weekly and daily and for dog searches based on the number of carcasses found during the type of survey (C), the proportion of turbines searched (Ps), the percent of carcasses not removed by scavengers after the average number of days between potential impact and discovery for each search interval (Sc), and the percent of carcasses found by the surveyor (Se).

$$\hat{C} = \frac{C}{Sc \times Se \times Ps}$$

The variance was calculated as described by Jain *et al*. 2007.

$$\mathrm{Var}(\hat{C}) = \hat{C}^2 \times \left[\frac{\mathrm{var\ C}}{\mathrm{C}^2} + \frac{\mathrm{var}(Sc \times Se)}{(Sc \times Se)^2} \right]$$

The standard deviation was then calculated based on the square root of the variance divided by the square root of the number of searched turbines, multiplied by a factor of 95 percent confidence intervals.

2.8 Weather and NEXRAD Migration Data Comparisons

Weather data was downloaded from www.weatherunderground.com (Houlton, Maine) to examine the relationship between weather and mortality events. Weather data from the previous night was reported for those fatalities found fresh in order to isolate specific weather events that may have been associated with mortality.

NEXRAD radar images from the National Weather Service station in Houlton, Maine, were compiled for the duration of the mortality survey period. These radar images were used to compare nights of heavy migration in the area with mortality events at Mars Hill. NEXRAD is a long range Doppler radar that detects the reflectivity of objects (and precipitation) in the sky, as well as velocity of those objects. It cannot be used to individually track birds but can be used to interpret large-scale bird migration patterns (Gauthreaux and Belser 1998).

Nightly samples of reflectivity and velocity images were obtained from the National Oceanic and Atmospheric Administration website[3] and visually assessed to determine the overall intensity of nightly migration. Each night was qualitatively categorized by a Woodlot biologist as: 1) no migration (very low activity or rainy nights); 2) light migration; or 3) heavy migration. These determinations were based on the color-coded strength of the radar reflectance data, velocity and direction, and wind data. The images selected for this assessment were generally timed to be from two to four hours after sunset.

For data interpretation purposes, bird migration is discernable from most precipitation, unless the weather system is a large, slow moving front that remains over the weather observation station in excess of six to eight hours. However, bird activity was detected on some nights when rain occurred periodically. On those nights, radar reflectivity patterns indicative of migrating birds were observed forming and then dissolving during those periods between rain events. Nights exhibiting these conditions were given a classification of light migration activity.

Figures 3, 4, and 5 provide examples of NEXRAD radar reflectivity images for nights with no, light, or heavy migration activity.

[3] http://www.nws.noaa.gov

Figure 3. NEXRAD reflectivity image with no migration activity (rain)

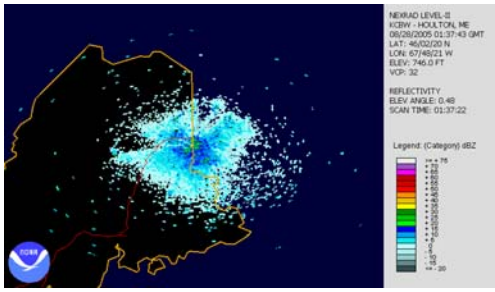


Figure 4. NEXRAD reflectivity image with light migration activity

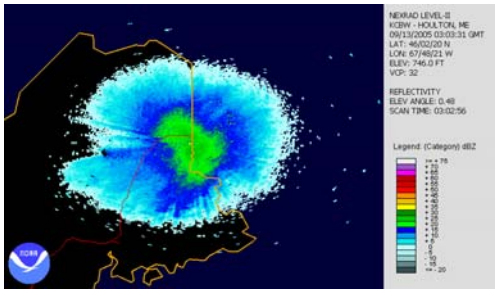


Figure 5. NEXRAD reflectivity image with heavy migration activity (green area)

Once the NEXRAD images were analyzed, the nights during which mortality events occurred at Mars Hill were compared with those same nights of NEXRAD data. Additionally, the remainder of the nightly NEXRAD data was summarized to identify the proportion of nights with light and heavy migration during the mortality survey sessions at Mars Hill.

3.0 Results

3.1 Standardized Searches

Standardized searches occurred in the spring from April 23 to June 3, in the summer from July 15-August 12, and in the fall from August 13 to September 23 (Appendix B Table 1 shows the dates turbines, met, and communication towers were searched). The turbines scheduled to be searched on May 11 (turbines 2, 6, 11, 13, 16, 18, 21, 23, and 25) were not surveyed due to logistical constraints. However, turbines 21, 23, 25 were searched the next day. Turbines 4, 5, 6, 10, 17, 20, and 22 were not searched on the designated date, June 3, as a result of scheduling complications. Otherwise, all turbines were searched once a week and two turbines were searched daily during the survey sessions according to the

standardized protocol except when standardized searches were replaced with dog searches (see Appendix B Table 1).

Table 2 shows the total area searched (total transect length x transect width) per turbine, and the percent of the cleared area per turbine that was searched. Approximately 40 percent of the cleared area at each turbine was searched.

Table 2. Total transect length and total search area per turbine plot

Turbine #	Total transect length (m)	Total area searched (total length of transects x 8 m width) (sq. m)	Total plot area (sq. m)	% of total plot area searched
1	879	7033	17425	40%
2	625	4997	12787	39%
3	543	4345	11150	39%
4	570	4559	11399	40%
5	778	6224	15746	40%
6	460	3677	9317	39%
7	476	3810	9520	40%
8	468	3742	9572	39%
9	485	3876	9742	40%
10	518	4140	10420	40%
11	630	5040	12098	42%
12	872	6980	16719	42%
13	485	3876	9742	40%
14	485	3876	9742	40%
15	758	6062	14891	41%
16	521	4171	10467	40%
17	591	4725	11637	41%
18	778	6227	15384	40%
19	521	4171	10467	40%
20	491	3930	9923	40%
21	466	3726	9400	40%
22	665	5319	13399	40%
23	648	5188	12969	40%
24	640	5120	12728	40%
25	914	7314	18180	40%
26	895	7160	18180	39%
27	855	6836	16961	40%
28	774	6194	15364	40%
Total	**17790**	**142317**	**355329**	**40%**

A total of 6 bird fatalities were found during the 2007 standardized searches (4 during the spring and 2 during the fall survey session) (see Appendix B Table 2). The number of bird fatalities found during standardized searches peaked during the spring migration session, accounting for 67 percent of the fatalities. During standardized surveys, a little brown bat (*Myotis lucifugus*) (fresh fatality from the previous night) was found during the spring survey session and a silver-haired bat (*Lasionycteris noctivagans*) (aged greater than 2 weeks from the time of mortality) was found during the fall survey session (see Appendix B Table 3 for a list of bat fatalities).

Because incidental findings, the results of dog searches, and the one bat found in the standard plot area during an extended plot search, represent a substantial portion of the mortality data, these results are included in the spatial and temporal analysis of detected mortalities. The results of the spatial analysis are reported in the Discussion and include:

- the location of fatalities in the project area;
- the location of the fatalities at specific turbines (lit and unlit turbines); and
- the average distance of bird and bat fatalities from towers.

The temporal analysis, also reported in the Discussion, includes the timing of the majority of bird and bat fatalities, and a comparison of the timing of fatalities with weather and NEXRAD migration data.

3.2 Extended Plot Searches

An extended survey plot search (238 m [780 ft] diameter plot) was conducted at two different turbines during each survey session. During the spring, turbines 1 and 20 were searched on May 17; in the summer, turbines 2 and 15 were searched on August 2; and in the fall, turbines 1 and 2 were searched on September 9. Habitats searched included the cleared and leveled areas, as well as sections of access road, forest, grassland, scrub-shrub, and areas of reasonably steep terrain.

No fatalities were found outside of the cleared and leveled search plots during the extended plot searches. One silver-haired bat was found within the standard search plot area at turbine 2 during the summer extended plot search. The bat was 36 m [118 ft] from the tower.

3.3 Incidental Findings

There were three incidental bird carcass findings. A hairy woodpecker (*Picoides villosus*) was found in the access road during transect set-up the weekend before surveys were initiated. The bird had been run-over and was 71 m [233 ft] from turbine 12. A second bird was also found in the road by maintenance personnel during spring surveys (41 m [134 ft] from the nearest turbine). It is unknown whether these birds first collided with turbines or were hit by a vehicle; however, their deaths were attributed to the wind farm. The third bird was found by maintenance personnel in between the spring and summer survey sessions.

Two bats were incidentally found during the summer survey session. One bat was found by hikers and pointed out to the surveyor that was on-site, and one bat was found by the dog while walking through a turbine plot after a dog search had been completed.

3.4 Dog Searches

There were 13 bird fatalities found during the dog searches: two during the spring; four during the summer; and seven during the fall survey session. Fifty-four percent of surveyor with dog bird findings occurred in the fall, while 31 percent occurred in the summer, and 15 percent occurred in the spring. It should be noted that only 8 of the 28 turbines were searched with a dog in the spring, 23 were searched with a dog in the summer, and all turbines were searched with a dog in the fall.

There were 19 bat fatalities recovered during dog searches: 15 during the summer survey session and 4 during the fall survey session. Seventy-nine percent of surveyor with dog bat findings were recovered at the end of the summer survey session over a timeframe of three days (8/10 to 8/12); however, 63 percent

of these 15 total bats were heavily or moderately decomposed (over 4 to 7 days or 2 weeks or greater) and therefore do not represent an isolated window of mortality.

3.5 Searcher Efficiency Trials

A searcher efficiency trial was set-up during each survey session. Due to a foot injury, the surveyor could not complete the spring trial. Therefore, an additional trial was conducted in the fall. The summer trial was conducted on August 2, the first fall trial was conducted on September 7, and the second fall trial was conducted on September 20. The results of the trials were pooled among the survey sessions for birds and bats. Of a total of 12 bats placed, the surveyor found 6 (50%). Of nine total birds placed, the surveyor found five (56%).

A single searcher efficiency trial using a total of 9 carcasses was set-up for the surveyor searching with the dog. Five of 8 bats placed and 1 of 1 bird placed were found; resulting in an overall efficiency rate of 67 percent.

3.6 Scavenger removal trials

A scavenger removal trial was conducted during each of the survey sessions. A total of six to seven carcasses were left out during each trial period. During the trial periods, carcasses were distributed at two or three different turbines. Turbines included in the trials were distributed throughout the project area (turbines 2, 6, 10, 11, 12, 17, 20, and 28) to account for variability in scavenging among sites.

The results of the three survey sessions were pooled for birds and bats. In total, 14 birds that had been previously frozen were left out, and 1 bird that was found as a fresh fatality at turbine 3 was left in place for the trial period. Four house mice and two bats (previously frozen) were left out.

Of those birds that were scavenged during the 14-day trial period, the average number of days before the birds were scavenged was 7.5 days. Of the 11 birds that exhibited evidence of scavenging, 5 remained detectable by a surveyor as feathers or part of the carcass remained evident. Therefore, 40 percent of the trial birds were documented as not removed by scavengers during the 2 week trial period. Four of the six placed small mammals (67%) were completely removed. The four mice used in the trial were removed at an average number of 1.5 days. The two bats remained after the 14-day trial period; therefore, 33 percent of the bat/mouse carcasses were not scavenged or were still detectable by a surveyor during the 2-week trial period. Eighty-seven percent of bird carcasses and 33 percent of bat carcasses were not scavenged between weekly search intervals (day 4), and 87 percent of bird carcasses and 50 percent of bat carcasses were not scavenged during daily search intervals (day 1).

3.7 Statistical Analysis

Table 3 summarizes the results of the statistical analysis. The weekly surveys resulted in an estimated total number of bird fatalities at 12.32 per study year (±3.78) with 0.44 birds/turbine/study year. For weekly surveys, the estimated total number of bat fatalities was 12.12 per study year (±0.59) with 0.43 bats/turbine/study year.

The results of daily searches indicated an estimated total of 29.32 birds per study year (±34) with 1.04 birds/turbine/study year and an estimated total of 57.14 bats per study year (±32.4) with 2.04 bats/turbine/study year.

The results of the dog searches (based on a single searcher efficiency trial) indicated an estimated total of 69.2 birds per study year (±29.7) with 2.47 birds/turbine/year and an estimated total of 122.5 bats per study year (±62.9) with 4.37 bats/turbine/year.

Table 3. Results of standard weekly and daily searches and dog searches at Mars Hill 2007

Standard Weekly Surveys		
Correction factors	**Birds**	**Bats**
# found (C)	6	2
% carcasses remaining after 4 days (average # days between potential impact and discovery, rounded up) (Sc)	87%	33%
searcher efficiency (Se)	56%	50%
proportion of towers searched weekly (Ps)	100%	100%
Adjusted total fatalities per study year	**12.32**	**12.12**
95% CI (±)	3.78	0.59
Adjusted total fatalities per/turbine/study year	**0.44**	**0.43**
Standard Daily Surveys		
Correction factors	**Birds**	**Bats**
# found (C)	1	1
% carcasses remaining after 1 day (average # days between potential impact and discovery, rounded up) (Sc)	87%	50%
searcher efficiency (Se)	56%	50%
proportion of towers searched daily (Ps)	7%	7%
Adjusted total fatalities per study year	**29.32**	**57.14**
95% CI (±)	34	32.4
Adjusted total fatalities per/turbine/study year	**1.04**	**2.04**
Dog surveys (1 survey session per season)		
Correction factors	**Birds**	**Bats**
# found (C)	13	19
% scavenger trial carcasses remaining after 14 days (Sc)	40%	33%
searcher efficiency (Se)	67%	67%
proportion of towers searched (average # turbines per session) (Ps)	70%	70%
Adjusted total fatalities per study year	**69.2**	**122.5**
95% CI (±)	29.7	62.9
Adjusted total fatalities per/turbine/study year	**2.47**	**4.37**

4.0 Discussion

4.1 Carcass Species Composition

Bird species found during standard surveys, incidental findings, or during dog searches consisted of songbird species. Warbler species, blackburnian warbler (*Dendroica fusca*), and golden-crowned kinglet (*Regulus satrapa*) represented 45 percent (N=10), 9 percent (N=2), and 9 percent (N=2) of all detected bird fatalities, respectively. For birds, there were no state endangered or threatened or state species of special concern found during the 2007 mortality surveys.

Silver-haired bat, hoary bat (*Lasiurus cinereus*), little brown bat, and eastern red bat (*Lasiurus borealis*) accounted for 38 percent (N=9), 21 percent (N=5), 17 percent (N=4), and 13 percent (N=3) of all detected

bat fatalities, respectively. Bat fatalities included three state species of special concern: silver-haired bat; hoary bat; and eastern red bat.

Pre-construction Survey Information

Of the 25 bat call sequences detected during pre-construction stationary acoustical surveys conducted from August 31 to September 21, 2005, 36 percent were big brown bat (*Eptesicus fuscus*), 16 percent were *Myotis* species, 16 were silver-haired bat, 8 percent were eastern red bat, 8 percent were hoary bat, and 16 percent of the calls were classified as unknown due to the poor quality of the recordings (Woodlot 2006). Of the 103 calls detected during the roving bat surveys from September 6 to September 14, 2005, 91 percent were identified as *Myotis* species, 4 percent as big brown bats, 3 percent as unknown, and 2 percent as hoary bats. During the 2005 surveys, bats were detected in a variety of habitat types, including field edges, road edges, power line corridors, pond shores, and open fields. Bats were detected more frequently in the lower elevation habitats surrounding Mars Hill than in habitats along the ridge-top itself. Interestingly, big brown bat, the species most frequently detected during the stationary acoustical pre-construction surveys was not found during mortality searches. This may support the findings of previous mortality surveys that long-distance migratory species are more susceptible to collision as the most commonly detected species during pre-construction experienced no known mortality at Mars Hill, or it may suggest that acoustics surveys are better adept at detecting certain species than others.

All birds that were identifiable to species found during mortality searches were detected during the morning bird migration stop-over surveys conducted in fall 2005 and spring 2006 at Mars Hill, except for blackburnian warbler (Woodlot 2006a, 2006b). Two blackburnian warblers were detected during the 2007 mortality surveys (5/18/07 and 6/21/07). This species is a resident breeder. Bird carcasses were found during the summer (including red-eyed vireo [*Vireo olivaceus*], red crossbill [*Loxia curvirostra*], and blackburnian warbler). Based on the stage of decomposition of carcasses, it was estimated that some of the fatalities occurred during the summer (Appendix B Table 2). The data suggest that both resident and migrant birds are susceptible to collision at Mars Hill.

4.2 Spatial Analysis

The results of the spatial analysis include fatalities documented during standardized searches, incidental findings, the limited results of extended plot searches, and dog searches. Fatalities were detected at all turbines in the project area except for turbines 4, 5, 6, 7, 9, and 22 (see Figure 6a-d). Of the turbines that experienced fatalities, most yielded 1 to 2 fatalities with the exceptions of turbines 3 (6 fatalities), 8 (4 fatalities), 12 (3 fatalities), 17 (4 fatalities), 20 (3 fatalities), and 26 (4 fatalities).

Fatalities occurred at turbines throughout the project area. There were a few turbines that experienced relatively higher numbers of fatalities (turbines 3, 8, 17, 23, and 26). These turbines occur in different habitats (grassland/forest edge and forested ridgeline) (Figure 6a-d). No observable trends are evident when comparing the habitats or topographical characteristics of locations at which the fatalities occurred (Figure 6a-d, Figure 7). Additionally, there are no correlations between the total search area and the number of fatalities at individual turbines (Table 4, Figure 8). There were no fatalities detected under the met towers or communication towers that were searched weekly throughout the study period.

PREPARED BY:

Stantec

WOODLOT

107123-F000-Mortality.dwg

SHEET TITLE:

Bird and Bat Fatality Map

PROJECT:

Mars Hill Wind Farm
Mars Hill, Maine

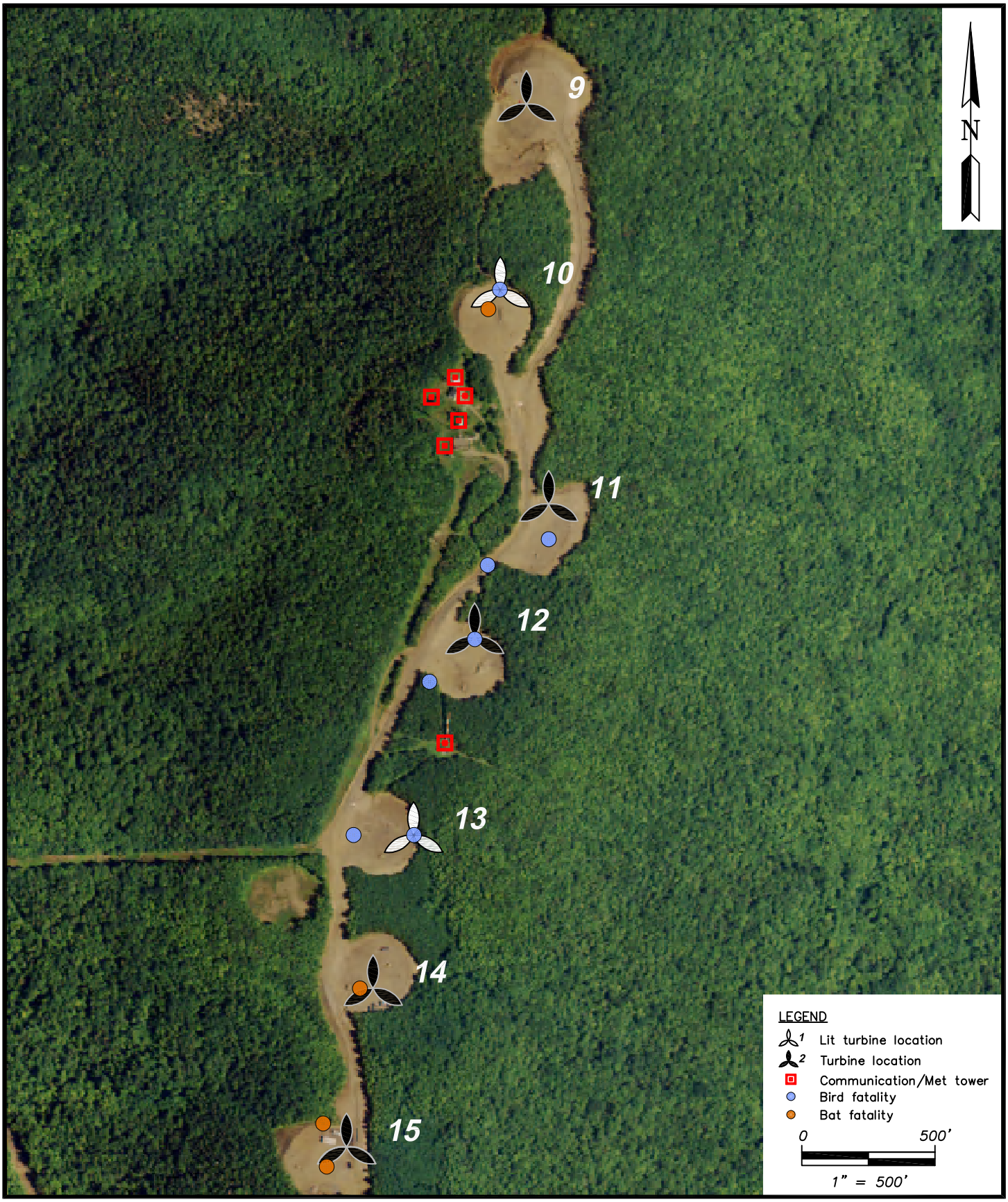
DATE: Jan. 11, 2008

SCALE: 1"=500'

PROJ. NO.: 107123

FIGURE:

6a



PREPARED BY:

Stantec

WOODLOT

107123-F000-Mortality.dwg

SHEET TITLE:

Bird and Bat Fatality Map

PROJECT:

Mars Hill Wind Farm
Mars Hill, Maine

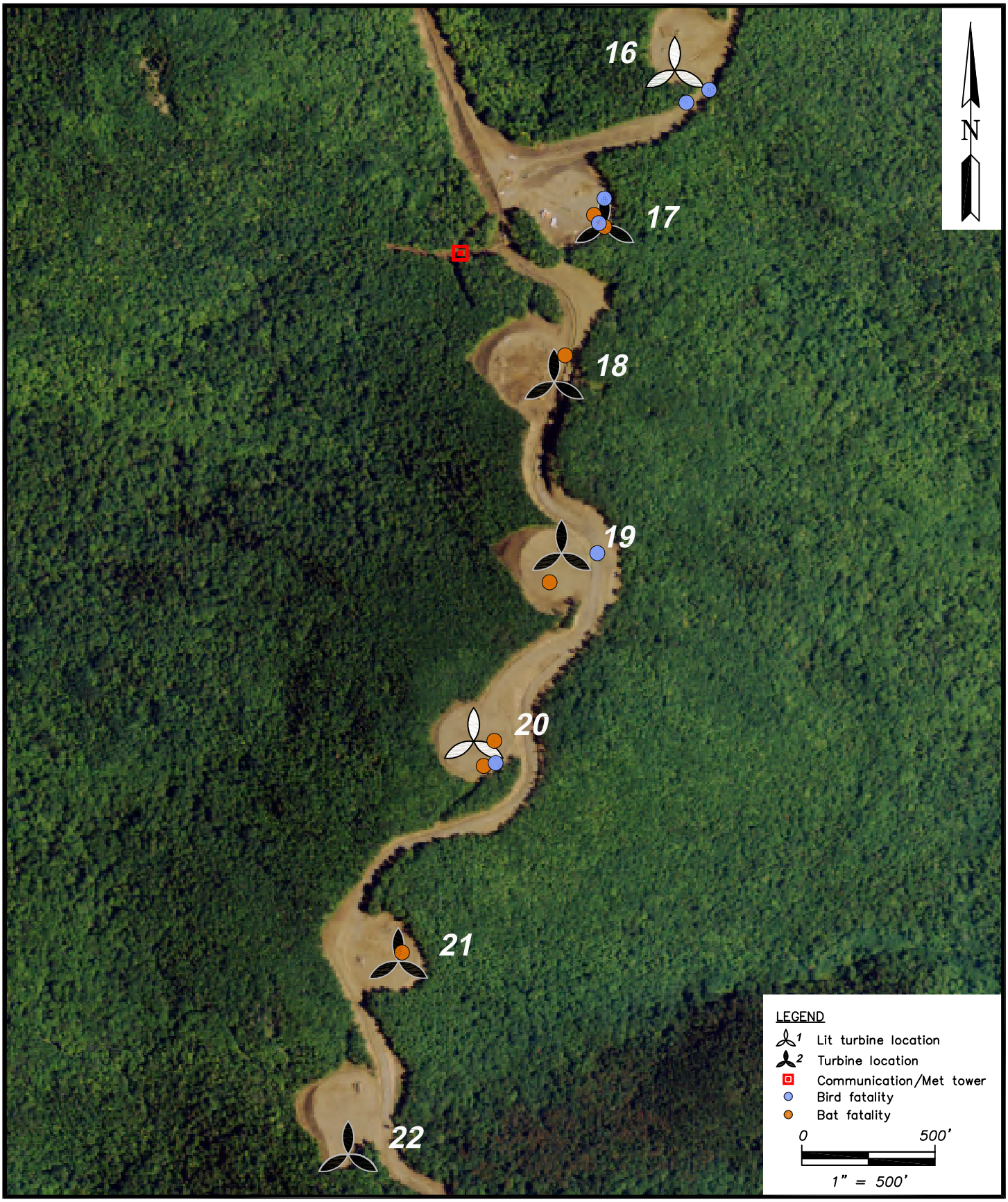
DATE: Jan. 11, 2008

SCALE: 1"=500'

PROJ. NO.: 107123

FIGURE:

6b



PREPARED BY:

Stantec

WOODLOT

107123-F000-Mortality.dwg

SHEET TITLE:

Bird and Bat Fatality Map

PROJECT:

Mars Hill Wind Farm
Mars Hill, Maine

DATE: Jan. 11, 2008

SCALE: 1"=500'

PROJ. NO.: 107123

FIGURE:

6c

PREPARED BY:

Stantec

WOODLOT

107123-F000-Mortality.dwg

SHEET TITLE:

Bird and Bat Fatality Map

PROJECT:

Mars Hill Wind Farm
Mars Hill, Maine

DATE: Jan. 11, 2008

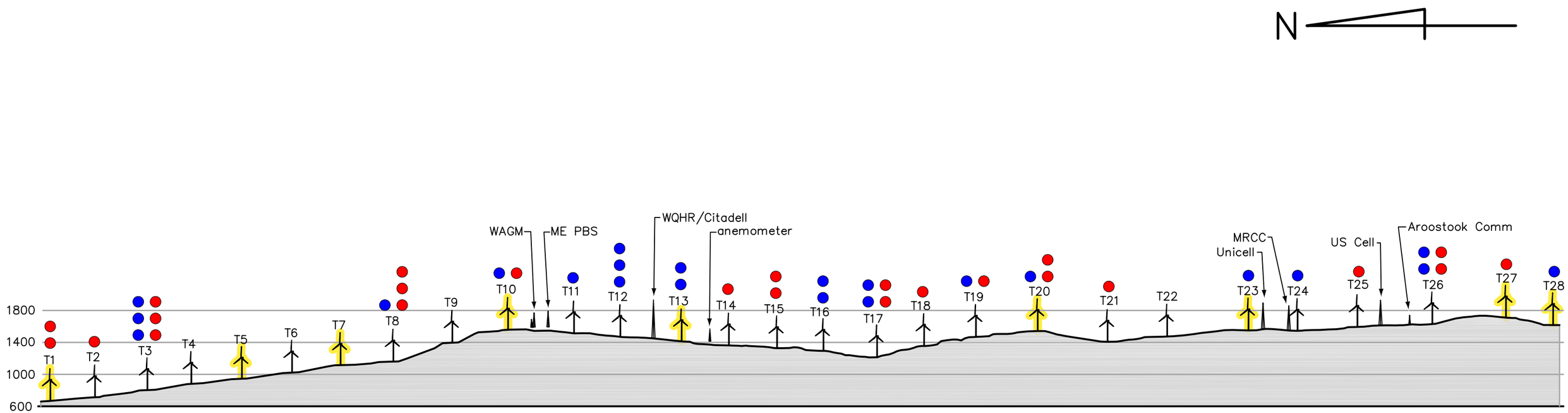
SCALE: 1"=500'

PROJ. NO.: 107123

FIGURE:

6d

Figure 7
Ridge Profile Fatality Map



Legend

- 1 Bird Fatality
- 1 Bat Fatality
- Lit Turbine

0' 1200' 2400'

SCALE: FEET

Mars Hill Wind Farm
Mars Hill, Maine

1/11/2008 107123 Mars Hill Fatalities.ai

Stantec

WOODLOT

Table 4. Total search area compared to the total number of fatalities detected per turbine

Turbine #	Total area searched (total length of transects x 8 m width) (sq. m)	# total bird fatalities	# total bat fatalities	total # fatalities
1	7033	0	2	2
2	4997	0	1	1
3	4345	3	3	6
4	4559	0	0	0
5	6224	0	0	0
6	3677	0	0	0
7	3810	0	0	0
8	3742	1	3	4
9	3876	0	0	0
10	4140	1	1	2
11	5040	1	0	1
12	6980	3	0	3
13	3876	2	0	2
14	3876	0	1	1
15	6062	0	2	2
16	4171	2	0	2
17	4725	2	2	4
18	6227	0	1	1
19	4171	1	1	2
20	3930	1	2	3
21	3726	0	1	1
22	5319	0	0	0
23	5188	1	0	1
24	5120	1	0	1
25	7314	0	1	1
26	7160	2	2	4
27	6836	0	1	1
28	6194	1	0	1

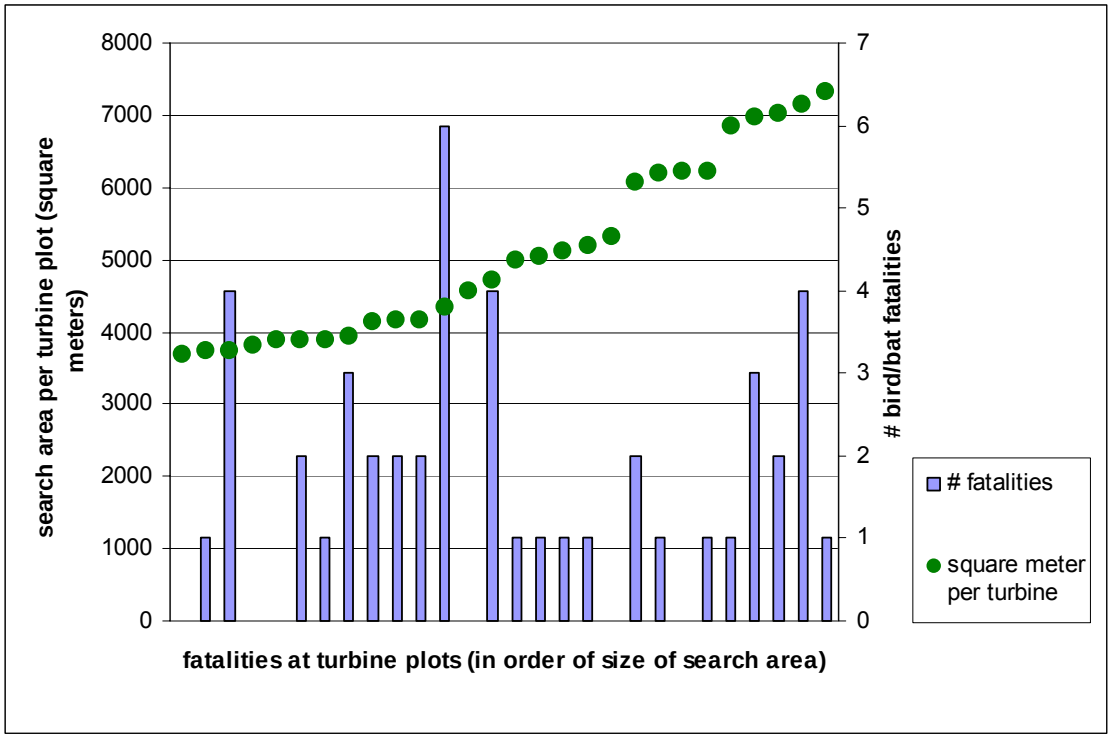


Figure 8. Total search area compared to the total number of fatalities at each turbine.

Statistical analysis resulted in variable estimates of total mortality between weekly and daily searches. For example, analysis indicated an estimate of 12.12 total bats per study year based on weekly searches and 57.14 total bats per study year based on the findings of daily searches. The difference in the results of the analysis are likely a reflection of the small sample size of the turbines that were searched daily, as well as the low number of carcasses found overall during the standard searches. It may be more useful to search more turbines daily, because the results of daily searches of two turbines per survey session may not accurately represent the variability in the number of fatalities at different turbines throughout the project area.

The 10 FAA lit turbines at Mars Hill are turbines 1, 5, 7, 10, 13, 16, 20, 23, 27, and 28. The average number of fatalities detected during standard surveys at lit turbines was 0.3, and the average number of fatalities detected during standard surveys at unlit turbines was also 0.3. For all detected fatalities, including results from incidental, dog searches, and extended survey plot searches, the average number of fatalities at lit turbines was 1.4 and the average number of fatalities at unlit turbine was 1.8. However, the results between lit and unlit turbines based on all detected fatalities should be interpreted with caution as survey effort varied between turbines for the different survey types. If the FAA lighting was an attractant to nocturnal migrating birds, the proportion of fatalities at lit turbines would be greater. The limited data suggest that FAA lighting on the 10 turbines at Mars Hill does not result in an evident increase in mortality of birds or bats. These results are consistent with those of other available studies (Jain *et al.* 2007, Arnett 2005). The substantially higher numbers of fatalities observed at lit communication towers (at heights greater than 305 m [1,000 ft]) in the U.S. may be influenced by the greater heights of the towers, the guy wires, or the steady-burning lights mounted on many towers (Jain *et al.* 2007), verses the pulsing lights on wind turbines. Whether the lights positioned directly above the wind tower doors that often remain lit at night have any effect on foraging bats or migrating birds has not been investigated at Mars Hill, but could be considered in future studies.

During the 2007 surveys, no fatalities were detected at the communication towers or met towers on-site. However, there were three bird fatalities found in the turbine clearings that were relatively close to both a communication tower and a turbine: a bird was found 37 m [121 ft] from a communication tower and was 59 m (193 ft) from turbine 26; a bird found 51 m (167 ft) from the same communication tower was 40 m (131 ft) from turbine 26; and, a bird found 72 m (236 ft) from a communication tower was 73 m (239 ft)from turbine 12. Two of these birds had been scavenged and their original location may have been different from where they were found. The actual cause of mortality of these carcasses was difficult to determine due to the close proximity of the communication towers to some of the turbines. However, the carcasses were found in turbine clearings at distances from the turbines close to the maximum distance from blade-tip height to the ground. Therefore, the fatalities were attributed to the wind farm. It should be noted that only the areas under the guy lines and at the base of the communication towers are cleared; therefore, detection of carcasses is more difficult near these towers than within the cleared plots of the turbines.

Analysis of the distance of birds and bats from the turbines included fatalities that were found scavenged and may have been moved from their original location. The average distance of bird fatalities from the turbines was 35 m (115 ft) (including the 2 fatalities for which the actual cause of death was undetermined). The maximum and minimum detected distance of a bird fatality from a tower was 73 m (239 ft) and 1.2 m (4 ft), respectively. The average distance of bat fatalities from the turbines was 21 m (69 ft). The closest distance of a bat fatality from a turbine was 1.5 m (4.9 ft) and the furthest detected distance was 38 m (125 ft).

Analysis of the compass direction of documented fatalities from the turbines indicated that the majority (44%) of carcasses were found generally north of the towers. Fatalities found generally south of the towers represented 42% of all fatalities; fatalities found east of the towers represented 3%; and fatalities found west of the towers represented 3%.

No carcasses were found outside of cleared and leveled search plot areas. This is consistent with other studies that the majority of carcasses fall within closer proximity to the towers. Studies at Mountaineer, West Virginia, and Myersdale, Pennsylvania, determined that approximately 80 percent of fatalities are found within half the maximum distance from the height of the blade-tip to the ground (roughly 40 m) (Arnett 2005). At the Maple Ridge Wind Power Project in New York, the fall distances were evaluated for 69 birds, of which 80 percent were within 60 m (197 ft) of the tower; and the distances were evaluated for 74 bats of which 80 percent were within 40 m (131 ft), and 98 percent were within 60 m (Jain *et al*. 2007). However, these results may also reflect the difficulties in recovering carcasses in areas of forest, thick scrub-shrub, or tall grass.

4.3 Temporal Analysis

Bird fatalities are believed to occur during both small-scale and localized resident bird movements, as well as during nighttime migration movements because fatalities occurred during peak migration periods and during the breeding season (Appendix B Table 2). Thirty-six percent of all detected bird fatalities occurred in the spring, 23 percent occurred in the summer, and 41 percent occurred in the fall. Because findings from the dog searches represented a substantial portion of the detected fatalities (59%), it should be noted that only 8 of the 28 turbines were searched in the spring with a dog, 23 were searched in the summer with a dog, and all turbines were searched in the fall with a dog during one survey period per survey session (a dog search period was either one day or occurred over the course of three days).

Four percent of all bats detected were found during the spring survey. Seventy-five percent of all detected bats were found during the summer, 95 percent of which were found during dog searches over a period of three days (8/10 to 8/12). However, 63 percent of the 15 total bats found over the three-day

period were heavily or moderately decomposed (over 4 to 7 days, or 2 weeks or greater) and therefore do not reflect an isolated window of mortality.

The timing of the peak numbers of bat fatalities were believed to occur during the mid-to-late summer migration period (the actual dates of the majority of fatalities were unknown as many were found moderately to heavily decomposed). The timing of the majority of fatalities are consistent with other studies: a mortality study at the Maple Ridge Wind Power Project in New York found that 69.9 percent of bat fatalities occurred between July 1 and August 31 (Jain *et al.* 2007); a study at the Buffalo Mountain Wind Farm in Tennessee documented 69 percent of bat mortality between late-August and early-September (Fiedler *et al*. 2007); and, at the Mountaineer facility in West Virginia, a 6 week period from July 31 to September 11, observed a high mortality rate of 38 bats/turbine/study period (Arnett 2005). The findings at Mars Hill support the theory that most bat collisions occur during the mid-to-late summer dispersal period, and that long-distance migratory species (hoary bat, silver-haired bat, and red bat) are at a greater risk of collision.

4.4 *NEXRAD Migration Data and Weather Correlations*

The nights during which mortality events were known to occur at Mars Hill were compared with those same nights of NEXRAD data. A total of 100 nights of NEXRAD data were available during the 2007 mortality study period. Some migration activity occurred on all nights for which NEXRAD data was available during the mortality study period, with nights ranging from light, moderate, or heavy, or when periods of rain restricted analysis. Of the total 100 nights with available migration data, migration activity was classified as heavy on 35 nights, 22 nights of moderate activity, 32 nights of light activity, and 7 nights when periods of rain restricted analysis (Appendix B Table 4).

Due to the overall low number of fatalities and the limited number of fatalities found fresh, there is little mortality data to correlate to NEXRAD data and weather events. Table 5 shows the dates of fresh to relatively fresh fatalities with a summary of weather and NEXRAD data. The limited data suggests that mortality events generally occurred on nights characterized as moderate to heavy and heavy migration, and on one night with light migration and rain (Table 5). Bat fatalities generally occurred on clear to partly cloudy nights with calm to light winds. Bird collisions appeared to occur during a variety of weather conditions, including clear to overcast or misting conditions and nights with calm to 11.5 mph winds.

Table 5. Comparison of known dates of mortality events with NEXRAD migration data and weather

Night of Mortality	# Fatalities	Age of Decomposition	NEXRAD Migration Classification	Weather*
4/22/2007	1 bird	fresh	not available	mostly clear, 43-53ºF, 9-11.5 mph, SSW winds
5/12/2007	1 bat	fresh	heavy	clear to partly cloudy, 28.9-48.9ºF, calm wind
5/17/2007	2 birds	fresh	light/rain	mist/overcast to clear, 28-42ºF, calm to 9.2 mph ESE winds
6/2/2007	1 bird	fresh	not available	partly cloudy to overcast, 46-63ºF, calm to 6.9 mph SW changing to NE winds
8/1/2007	1 bat	fresh	heavy	overcast to clear, 62-75ºF, calm to 6.9 mph SSE winds
8/10/2007	1 bat	fresh	heavy	clear, 55-69ºF, calm to 5.8 mph SW winds
8/11/2007	1 bat	fresh	heavy	clear, 51-75ºF, calm to 5.8 mph NNW
8/7-8/11/2007	7 bats	2-3 days	heavy to moderate	partly cloudy to clear, 53 to 75ºF, calm to 18 mph variable winds
9/1/2007	1 bird	fresh	not available	clear, 39.9-48.9ºF, calm wind
9/19-9/21/2007	1 bat	2-3 days	moderate to heavy	clear, 41-63ºF, calm to 5.8 mph SSE winds

*Weather data was obtained for Houlton, Maine at www.weatherunderground.com

The results of the scavenger removal trials at Mars Hill indicate that small mammal carcasses remain, on average, for a period of 1.5 days; and that 67 percent of bat/mice carcasses were removed during the trial period and were no longer detectable by observers. However, 63 percent of the 15 total bats found by the surveyor with a dog over a 3-day period were heavily or moderately decomposed (over 4 to 7 days, or two weeks or greater). These findings suggest that the scavenger removal rates, mainly determined by the use of mice (4 of 6 total carcasses used in the trials), may not accurately reflect the scavenging rates of bats at Mars Hill. The two bats that were used in the trials were not scavenged within the 14-day trial period. Additionally, 38 percent of all bats found were aged over 4 to 7 days, and 42 percent were relatively fresh (fresh to aged 2 to 3 days). A greater number of fresh bat carcasses should be used in scavenger removal trials in the future to better investigate bat scavenging activity at Mars Hill.

Observations of potential scavengers occurred throughout the study period. A group of four American crows (*Corvus brachyrhynchos*) were seen at the base of one of the northern turbines during the summer survey session. A red fox (*Vulpes vulpes*) was seen with a prey item in its mouth at the northern end of the project during the summer surveys. Coyote (*Canis latrans*) scat was found within turbine plots throughout the project area throughout the study period. Other studies indicate that scavenger activity and scavenger species composition varies between wind farm sites. The level of scavenging at a site may also change over time (Arnett 2005).

Rates of searcher efficiency at other study sites have been variable and are likely dependent on the level of vegetation at a particular site as well as the size of the carcasses used in trials. Searcher efficiency for bat carcasses at Mountaineer, West Virginia, and at Meyersdale, Pennsylvania, was 44 percent and 25 percent, respectively (Arnett 2005). At Nine Canyon, Washington, searcher efficiency for small carcasses was 44 percent and 78 percent for large carcasses (Erickson 2003). Searcher efficiency at the Maple Ridge Wind Power Project in New York was 100 percent for large bird carcasses, 56 percent for small and medium sized birds, and 51 percent for bats (Jain *et al*. 2007). The Mars Hill searcher efficiency

results were very similar to those of Maple Ridge with searcher efficiency at 50 percent for bats and 56 percent for birds (small to medium sized songbirds and one small owl).

The results of a single surveyor with dog searcher efficiency trial indicate a search efficiency rate (for bat and small bird carcasses combined) of 67 percent. The surveyor with dog found a total of four decomposed carcasses during three survey sessions at turbines that had been searched previously those weeks by the surveyor alone: one bird was found decomposed two weeks or greater on August 10 at a turbine that had been searched the previous day by the surveyor alone; one bird decomposed greater than two weeks was found at a turbine that was surveyed the previous day; one bird was found decomposed four to seven days on August 12 at a turbine that was searched on August 9; one scavenged bird was found on September 21 at a turbine that had been searched by the surveyor alone the previous day.

The results of searcher efficiency trials with dogs indicate dog-human teams consistently found a higher percent of carcasses at trial sites at Mountaineer, WV and Myersdale, PA. Human-dog teams found 65 to 100 percent of trial carcasses, while humans alone found 38 to 59 percent at low to high visibility trial sites. The human-dog teams found 40 to 50 percent of carcasses at very low visibility sites, while humans alone found 0 to 10 percent at very low visibility sites (Arnett 2005). It should be noted that the methods of searching with a dog at Mars Hill varied from the human-dog team search methods at other sites. At Mars Hill, the dog remained on leash as the surveyor and dog walked transects. In Arnett's trials, the human walked the transects and the unleashed dogs were allowed to quarter the entire 10 m (33 ft) search area for each transect.

4.5 *Statistical Analysis*

The overall total numbers of birds and bats found during the study year (during incidental, standard, and dog searches) indicate that the statistical analysis is unsuitable for estimating the total mortality. More birds and bats were found during the study period (22 total birds and 24 total bats) than were estimated based on the results of the standard weekly searches (12 total birds and 12 total bats). Additionally, the statistical analysis may not fully account for stochastic events (variable weather conditions, variable migration patterns, variable annual regional populations) that may result in fewer or greater fatalities among study years.

The accuracy of the results of the statistical analysis may be improved by increasing searcher efficiency and scavenger removal trial effort. More carcasses, particularly bat carcasses, should be used in future trials. The availability of fresh carcasses is the limiting factor for scavenger removal trials. To the extent possible, carcasses found fresh during searches should be left in place and monitored according to the scavenger removal trial protocol in order to reduce the bias of human handling. Additionally, changes to the current standard search protocol may be necessary to increase accuracy of results (see 5.0 Conclusions and future studies).

4.6 Comparison of Results with Other Studies

The results of standard weekly searches indicate that bat mortality at the Mars Hill Wind Farm (0.43 bats/turbine/study year) is well below that observed at existing facilities in the U.S. (Table 6). However, the results of standard daily searches and dog searches indicate that bat mortality at Mars Hill (2.04 to 4.37 bats/turbine/study year) may be more comparable to existing facilities that have reported relatively low bat mortality including Top of Iowa (10.17 bats/turbine/year), or Nine Canyon in Washington (3.21 bats/turbine/year).

Table 6. Comparison of bird and bat mortality at existing wind farms in the U.S.

Site	habitat type (# turbines)	Dates surveyed	# bats found during surveys (incidental)	Estimated total bat fatalities/turbine/year	# birds found during surveys (incidental)	Estimated fatalities/turbine /year	Reference
Mountaineer, WV	forested ridgeline (44)	31 July- 11 Sept 2004	398 (68)	38/t/yr (1364-1980)	15 (n/a)	n/a	Arnett *et al.* 2005
Myersdale, PA	forested ridgeline (20)	2 Aug-13 Sept 2004	262 (37)	25/t/yr (400-660)	13 (4)	n/a	Arnett *et al.* 2005
Somerset County, PA	agricultural (8)	2000 (12 months)	0	n/a	0	n/a	Kerlinger 2006
Maple Ridge, NY	woodland, grassland, agricultural (120)	17 June- 15 Nov 2006	326 (58)	11.39-20.31bats/t/yr (1367-2437.2)	123 (15)	3.10-9.48/t/yr (372-1138)	Jain *et al.* 2007
Searsburg, VT	forested (11)	30 June - 18 Oct 1997	0	n/a	0	n/a	Kerlinger 2002
Top of Iowa, IA	agricultural (89)	24 March- 10 Dec 2004	44 (n/a)	10.17/t/yr (905)	5 (n/a)	0.9/t/yr (80)	Koford 2005
Nine Canyon, WA	grass and shrubland (37)	Sept 2002- August 2003	27 (n/a)	3.21/t/yr (118.8)	38 (n/a)	3.59/t/yr (132.8)	Erickson 2003
Buffalo Mtn, TN	open/shrubland (18)	April- Dec 2005	243 (14)	63.9/t/yr (1,149)	9 (2)	1.8/t/yr (111.6)	Fiedler *et al.* 2007
Mars Hill, ME	forested ridgeline (28)	23 April- 3 June, 15 July-23 Sept 2007	22 (2)	0.43/t/yr-4.4/t/yr (12.1-122.5)	19 (3)	0.44-2.5/t/yr (26.8-69.2)	*this report*

The results of standard weekly searches indicate that bird mortality at Mars Hill (0.44 birds/turbine/study year) is well below that observed at other facilities in the U.S. (Table 6). However, statistical analysis of standard daily searches and dog searches (1.04 to 2.47 birds/turbine/study year) indicate that bird mortality may be comparable to sites with relatively low bird mortality including Buffalo Mountain, Tennessee (1.8 birds/turbine/year) or Maple Ridge, New York (3.10 to 9.48 birds/turbine per year).

The majority of mortality studies (with the exception of Arnett 2005) have not incorporated the results of dog searches into the estimate of total bird and bat mortality. The Mars Hill estimates for total bird and bat mortality are comparable to those sites that have demonstrated low mortality estimates, even though the use of dog searches results in finding a greater number of carcasses.

5.0 Conclusions and Future Studies

The results of the initial year of monitoring suggest that there are no unreasonable adverse impacts to avian species resulting from the wind farm. The estimated total avian mortality during the 2007 standard weekly surveys at the Mars Hill Wind Farm, 12.32 total birds (29.32 total birds for daily searches), represents a low impact to regional bird populations. The limited results of dog searches also indicate a low estimated total mortality per study year (69.2 total birds), even when compared to other wind farms that have not employed dogs in mortality searches. Out of all detected birds (including incidental and dog searches), blackburnian warbler (N=2) and golden-crowned kinglet (N=2) were the only species that experienced more than one fatality at Mars Hill in 2007. Breeding Bird Surveys (BBS) from 1966 to 2002 indicate a stable population of blackburnian warbler (Morse 2004). BBS data for golden-crowned kinglet in eastern states and Canadian provinces have shown population increases, despite population declines in some western states (Ingold and Galati 1997). No avian species of conservation concern were found during the mortality searches.

The results of the initial year of monitoring suggest that the Mars Hill Wind Farm presents no unreasonable adverse impacts to bat species. The two bat species most commonly detected during the 2007 mortality study at Mars Hill were State species of special concern: silver-haired bat and hoary bat. Hoary bats, silver-haired bats, and eastern red bats (the long-distance migratory species), as well as little brown bats, have also been most commonly found during mortality searches at other wind farms (Jain *et al.* 2007, Arnett 2005). Bat species have low reproductive rates and therefore may be more susceptible to cumulative impacts resulting from fatalities at wind farms and other sources of human induced mortality. The estimated total bat mortality detected during the 2007 standard weekly surveys, 12.12 total bats (57.14 total bats for daily searches), represents a relatively low number of bat fatalities. The limited dog searches also indicate a relatively low estimated total mortality per study period (122.5 total bats), even when compared to other sites that have not employed dogs in mortality estimates. Updated bat population estimates as well as the numbers of bats impacted by pesticides, collisions with communication towers, as well as other sources of human induced mortality are required to put the number of bat collisions with wind turbines into perspective (Kunz *et al.* 2007).

Year 2 protocol recommendations

A comparison of the results of statistical analyses of standard weekly searches, standard daily searches, and limited dog searches indicate variable numbers of fatalities/turbine/study year between daily and weekly standard searches, as well as dog searches. The variability among the results of search intervals and survey types suggests that adjustments to the current protocol may be appropriate.

As the revegetation process progresses under the turbines at Mars Hill in Year 2, carcass detectability will likely decrease. Therefore, decreasing the distance between transects from 6-8 m (20-26 ft), down to 3-4

m (10-13 ft) is an option for improving efficiency. The more standard use of dogs during searches is another option for improving search efficiency, given the higher searcher efficiency rate of the surveyor with dog team at Mars Hill and the higher efficiency of dogs searching in densely vegetated areas in other studies.

To increase searcher efficiency during the extended plot searches, it may be worth decreasing the search transect width to 3-4 m (10-13 ft), as during standard searches; although given the much larger area and lower detectability, the limited results may not be worth the considerable extra effort. Conducting the searches with dogs may increase the probability of detecting carcasses outside of the cleared and level search areas. Increased survey effort could provide greater confidence in assessing the percentage of birds that occur outside of the cleared and leveled turbine plots.

Extending the fall surveys into mid-October for the 2008 surveys may be worth considering as many avian species continue to migrate through this time period. For example, the pre-construction radar surveys conducted from September 1 to October 12, 2005, recorded a peak passage rate on October 8 (Woodlot 2006a). The 2007 spring survey period is apparently sufficient as the spring pre-construction radar survey conducted from April 20 to June 4, 2006, recorded a peak passage rate on May 28 (Woodlot 2006b). The 2007 summer survey time frame appears appropriate to cover the peak bat dispersal period.

The appropriate search interval at a site depends upon several factors, including the level of scavenger activity and the specific questions that need to be addressed at the site (A. Jain personal communication). Scavenger activity of bird and bat carcasses appears to be similar between daily and weekly search intervals: 87 percent of bird carcasses remained detectable to the surveyor for both weekly and daily search intervals; and 33 percent and 50 percent of bat/mice carcasses remained detectable to the surveyor for weekly and daily search intervals, respectively. Further, a large portion of the carcasses that were found during searches were scavenged yet were still detectable by surveyors. Therefore, daily searches may not be necessary at Mars Hill if the objective is to estimate the total mortality resulting from the wind farm for the purpose of determining whether the level of wildlife impact is reasonable.

6.0 Literature Cited

Arnett, E.B., technical editor. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Avery, M.L., P.F. Spring, and J.F. Cassel. 1976. The effects of a tall tower on nocturnal bird migration – A portable ceilometer study. Auk. 93(2):281-291.

Avery, M.L., P.F. Spring, and J.F. Cassel. 1977. Weather influences on nocturnal bird mortality at a North Dakota tower. Wilson Bulletin. 89(2):291-299.

Crawford, R.L. 1981. Bird kills at a lighted man-made structure: often on nights close to a full moon. Amer. Birds. 35:913-914.

Erickson, W., G. Johnson, D. Young, D. Strickland, R. Good, M. Bourassa, K. Bay, and K. Sernk. 2002. Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments. Prepared for Bonneville Power Administration.

Erickson, W. 2003. Nine Canyon Wind Power Project Avian and Bat Monitoring Report September 2002 – August 2003. Prepared for Nine Canyon Technical Advisory Committee Energy Northwest, October 2003.

Fiedler, J.K., T.H. Henry, R.D. Tankersley, and C.P. Nicholson 2007. Results of Bat and Bird Mortality Monitoring at the Expanded Buffalo Mountain Windfarm, 2005 June 28, 2007. Prepared for Tennessee Valley Authority.

GAO (Government Accountability Office). 2005. Wind Power: Impacts on wildlife and government responsibilities for regulating development and protecting wildlife. Report to congressional requesters, September 2005.

Gauthreaux, S.A., Jr. and C.G. Belser. 1998. Displays of Bird Movements on the WSR-88D: Patterns and Quantification. American Meteorological Society. 13:453-464.

Ingold, J.L., and R. Galati. 1997. Golden-crowned Kinglet (*Regulus satrapa*). *In* The Birds of North America, No. 301 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual Report for the Maple Ridge Wind Power Project Postconstruction Bird and Bat Fatality Study – 2006 FINAL REPORT June 25, 2007. Prepared for PPM Energy and Horizon Energy and Technical Advisory Committee (TAC for the Maple Ridge Project Study).

Jones, J., editor. 2006. Methodologies for evaluating bird and bat interactions with wind turbines in Maine Draft: April 12, 2006. Compiled by Maine Audubon in collaboration with the Maine Windpower Advisory Group, Maine Department of Inland Fisheries and Wildlife, and Wildlife Windpower Siting Committee.

Kerlinger, P. 2002. An Assessment of the Impacts of Green Mountain Power Corporation's Wind Power Facility on Breeding and Migrating Birds in Searsburg, Vermont, July 1996 – July 1998. Prepared for the Vermont Department of Public Service Montpelier, Vermont.

Kerlinger, P. 2006. Supplement to the Phase I Avian Risk Assessment and Breeding Bird Study for the Deerfield Wind Project, Bennington County, Vermont. Prepared for Deerfield Wind, LLC.

Koford, R., A. Jain, G. Zenner, and A. Hancock. 2005. Avian Mortality Associated with the Top of Iowa Wind Farm Progress Report 2004 February 2, 2005.

Kunz, T.H., E.B. Arnett, W.P. Erickson, A.R. Hoar, G.D. Johnson, R.P. Larkin, M.D. Stickland, R.W. Thresher, and M.D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research, needs, and hypotheses. Front Ecol Environ 2007; 5(6): 315-324.

McMahon. J. 1990. *The Biophysical Regions of Maine: Patterns in the Landscape and Vegetation.* University of Maine, Orono, ME.

Morse, D.H. 2004. Blackburnian Warbler (*Dendroica fusca*). The Birds of North America Online. (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved from The Birds of North American Online database: http://bna.birds.cornell.edu/BNA/account/Blackburnian_Warbler/.

National Research Council of the National Academies. 2007. Environmental Impacts of Wind-Energy Projects. Committee on Environmental Impacts of Wind Energy Projects Board on Environmental Studies and Toxicology Division on Earth and Life Studies. Available at http://www.nap.edu/catalog/11935.html

Woodlot Alternatives, Inc. 2006a. A Fall 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Mars Hill Wind Farm in Mars Hill, Maine. Prepared for Evergreen Windpower, LLC.

Woodlot Alternatives, Inc. 2006b. A Spring 2006 Radar, Visual, and Acoustic Survey of Bird Migration at the Mars Hill Wind Farm in Mars Hill, Maine. Prepared for Evergreen Windpower, LLC.

Appendix A

Wildlife Casualty Monitoring Protocol

Wildlife Casualty Monitoring Protocol

Mars Hill Wind Farm
Evergreen Windpower, LLC
November 2006

Objective

The objective of wildlife casualty monitoring is to document injuries and fatalities of birds and bats during peak migration periods, as a basis for the Maine Department of Environmental Protection (DEP) in consultation with the Maine Department of Inland Fisheries & Wildlife (IF&W) to determine whether the Mars Hill Wind Farm is causing an unreasonable impact to wildlife.

Background

As stipulated in Finding 6 of the DEP Order L-21635-TH-B-N dated June 1, 2004, Evergreen Windpower, LLC agreed to fund a post-construction monitoring study for a maximum of two years at a level of up to $50,000 per year. The studies shall be specifically focused on assessing possible impacts of the project, and may include bird mortality searches or studies, computer modeling of impact probabilities, and assessment of best techniques for assessing impacts of windpower sites. Monitoring will distinguish impacts of the project from those caused by the existing telecommunications towers on the project site.

Prior to operation of the wind turbines, the final parameters of the monitoring study, which must be designed by the applicant in consultation with IF&W, must be submitted to the Department for review and approval. The project is currently in the advanced stages of construction, and operation is scheduled to begin by the end of December, 2006.

Development of the post-construction monitoring protocol has benefited from the input of IF&W staff, the University of Maine Cooperative Extension Unit, and Maine Audubon Society. Three meetings were held between November 2005 and February 2006 to discuss the permitting requirements, study objectives and possible approaches. At the most recent meeting on February 14, 2006, general agreement was reached on the elements of the protocol. This document incorporates comments provided at the meetings, and represents Evergreen's final protocol, submitted for DEP approval.

Sources consulted in preparing this protocol include the draft guidance of the Maine Wind Power Advisory Group (Hodgman and Jones unpublished manuscript), which included contributions by several recognized experts in the field of wind energy and wildlife interaction. Additional experts were consulted directly, including Bob Gritzki and Karen Kronner at Northwest Wildlife Consultants, Inc. (NWC), and Dr. Paul

Kerlinger of Curry & Kerlinger. NWC provides fatality assessment services at numerous projects in the northwestern United States, several of which are widely cited (*e.g.*, Erickson *et al.* 2004b, 2003 and 2000, Johnson *et al.* 2000a and 2000b). Dr. Kerlinger oversaw the initial fatality monitoring studies at the Mountaineer facility in West Virginia and at Searsburg, VT, and has overseen a recent study of fatalities at telecommunications towers in the Midwest. Other recent studies of bird and bat fatalities at wind power projects in the U.S. and Europe were reviewed with regard to methods and search techniques (*e.g.*, Arnett 2005, Kerns and Kerlinger 2004, Barrios and Rodriguez 2004, de Lucas et al. 2004, Krewitt and Nitchs 2003 and Osborn et al. 2000).

Proposed Monitoring Protocol

The proposed monitoring protocol includes:

1) Standardized searches during periods of peak spring and fall bird migration, and during the late summer bat migration period;

2) Searcher efficiency trials to estimate the percentage of carcasses found by searchers; and

3) Carcass removal trials to estimate the length of time that carcasses remain in the field for possible detection.

Monitoring will entail regular, systematic searches of the area beneath turbines and at least one lighted and guyed telecommunications tower by trained technicians. Turbines will be monitored on a rotating basis, i.e., a subset of turbines will be searched on any given day, but all turbines will be searched over the course of each survey period. Monitoring will be conducted for the first two years of operation, with three survey periods each year: two centered on the peak avian migration periods in the spring and fall, and one in late summer to represent the dispersal/migration period when bat fatalities are most likely to occur.

Plot Sizes

Fatalities may be found at considerable distances from the base of the turbine, *e.g.*, at distances equal to or greater than the total height of the turbine and rotor, commonly in the range of 300-400 feet (Erickson *et al.* 2004b, 2003 and 2000, Johnson *et al.* 2000a and 2000b, Gritski and Kronner, pers. comm., Kerlinger pers. comm.). The GE 1.5sle turbines being erected at Mars Hill have a maximum structural height of approximately 119 m (389 ft) for the tower and rotor combined. Extending outward from the base this distance would yield a plot size significantly larger than the laydown area that was cleared and leveled for each turbine (typical diameter 250 feet, some less). For example, a square plot based on the full tower height would measure approximately 780 feet on a side. Plots of this size at Mars Hill would include substantial areas of forest cover and, at many locations, dangerously steep terrain. In comparison, many of the published studies

conducted at existing projects in the western U.S. are situated in relatively level agricultural landscapes, where searches are not hindered by terrain or tree cover. Yet even under ideal conditions, NWC biologists have advised that conducting repeated searches of such large areas on foot is labor-intensive and logistically challenging (Bob Gritski, pers. comm.).

As noted by Erickson and Jones (unpublished) in the draft Maine guidelines, conducting searches at this level of intensity may simply be impractical in hilly and forested terrain. For similar reasons, Kerns et al. (2005) scaled down their search areas to suit existing site constraints. Offsetting this problem somewhat is the fact that most fatalities are being found much closer to the turbines. For example, working at the Meyersdale project in Pennsylvania, Kerns and Kerlinger (2004) reported that the majority of bird and bat fatalities were found within about 30m of the turbine bases, and Kerns et al. (2005) reported >80 percent of bat fatalities within 40m of turbines at Meyersdale, PA and Mountaineer, WV. The NEG Micon 1.5 MW wind turbines at Meyersdale and Mountaineer are similar in size to those being constructed at Mars Hill.

In light of the above, options for tailoring the monitoring methods at Mars Hill to suit local conditions were discussed with IF&W and U. Maine at the February 14, 2006 meeting:

1) Focusing monitoring on the cleared and leveled laydown areas and applying a correction factor to account for fatalities that fall outside of the smaller search plots. A similar approach was used by Kerns et al. (2005), and has been suggested in the draft Maine guidance (Erickson in prep.).

2) Increasing the area of clearing at selected turbines to facilitate searches (while this may be possible, it was not contemplated during permitting and would require DEP approval);

Cooperators at the meeting agreed that Option 1 should be incorporated into the protocol for Mars Hill, and that Option 2 was not desirable.

The attached schematic shows the final grading plans for a typical portion of the Mars Hill project (Figure 1). These are pre-construction plans and therefore may not fully reflect as-built conditions for all areas. However, they illustrate the arrangement and sizes of the turbine laydown areas to be searched.

Plot Selection

The laydown areas of all turbines will be searched on a rotating basis over the course of each survey period. Approximately seven areas (25 percent) will be searched on any

given round. In addition, at least one telecommunications tower will be searched per round.

Search Timing and Frequency

Systematic searches will be conducted roughly twice per week for up to six weeks during peak spring and fall avian migration periods, for a total of at least 12 searches per season. Searches during the summer bat season will occur roughly twice per week over a four week period, for a minimum of eight surveys. A minimum of 32 surveys will be conducted each year (2007 and 2008). Searches may be timed to coincide with specific events such as big migration nights (clear skies, favorable winds) or alternatively to represent moonless nights or cloudy, foggy or low cloud ceiling conditions.

Standardized Searches

Plots will be searched by walking parallel transects at regular intervals. Initially, transects will be set at 6-8 meters apart in the area to be searched. A searcher will walk at a rate of approximately 45-60 meters a minute along each transect, searching on both sides out to 3-4 meters for casualties. Depending upon whether casualties are found, it should take an average of 60-90 minutes to search each plot and then travel to the next. All casualties will be documented on standardized field forms, located with GPS, photographed and, if a listed species, collected and reported.

Searcher Efficiency Trials (SEEF)

SEEF trials will be conducted in the same area as the searches to estimate the percentage of avian/bat fatalities that are found by searchers. One SEEF trial will be conducted during each season (i.e., one spring, one summer, one fall). Approximately six carcasses will be used for each trial, two each of rock dove, house sparrow, and bat (as available – alternative species may be substituted). Searcher efficiency will be estimated by habitat type, (gravel, grassland, shrubs, etc., as applicable) and taxon/size class. Estimates of searcher efficiency will be used to adjust for detection bias using methods similar to Kerns et al. (2005).

Personnel conducting carcass searches will not be told when or where trials will be conducted. All carcasses will be placed at random locations prior to the carcass search on the same day, and each trial carcass will be discreetly marked so it can be identified when found.

Carcass Removal Trials

One carcass removal trial will be conducted during each season (i.e., one spring, one fall), independently of the SEEF trials. The objective will be to estimate the percentage of avian/bat fatalities that disappear from study plots due to scavengers. Estimates of carcass removal will be used to adjust the number of carcasses found, correcting for removal bias.

For each trial, approximately six carcasses (species composition as noted for SEEF trials), will be placed out near search plots (but not in plots to avoid contamination from blowing feathers, etc.). All birds will be checked on days 1, 2, 3, 4, 5, 7, 10, and 14, or until all evidence of the carcass is absent. On day 14, all carcasses, feathers or parts will be retrieved and properly discarded.

Reporting

A report will be provided after each season summarizing methods and results of monitoring. The estimate of the total number of wind turbine-related fatalities will be based on three components: 1) observed number of carcasses, 2) searcher efficiency expressed as the proportion of trial carcasses found by searchers, and 3) removal rates expressed as the length of time a carcass remains in the study area and is available for detection by searchers, and possibly factors such as the 4) proportion of casualties likely to land or move outside the plot (such as forested portions beyond the cleared area surround turbines), 5) an estimate of the number of carcasses found by observers where cause of death could not be attributed to wind energy development. Calculation methods are presented in Kerns et al. (2005) and in Appendix II of Hodgman and Jones (unpublished).

LITERATURE CITED

Arnett, E. B., technical editor. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Barrios, L. and A. Rodriguez. 2004. Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines. Journal of Applied Ecology 41:72-81.

De Lucas, M., G. F. E. Janss, and M. Ferrier. 2004. The effects of a wind farm on birds in a migration point: the Straight of Gibraltar. Biodiversity and Conservation 13:395-407.

Erickson, W.P. In preparation. Methodologies for Studies of Avian and Bat Fatalities. In: Methodologies for evaluating bird and bat interactions with wind turbines in Maine. T. Hodgman and J. Jones, Eds. Maine Wind Power Advisory Group, January 11, 2006 Draft.

Erickson, W.P., J. Kerns, E. Arnett and M. Tuttle. 2004a. Bat fatality monitoring methods, fall 2004, Mountaineer and Meyersdale. National Wind Coordinating

Committee, Onshore Wildlife Interactions with Wind Developments: Research Meeting V, November 3-4, 2004, Landsdowne, VA. Resolve, Inc., Washington, D.C.

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2004b. Stateline Wind Project Wildlife Monitoring Final Report, July 2001 – December 2003. Technical report peer-reviewed by and submitted to FPL Energy, the Oregon Energy Facility Siting Council, and the Stateline Technical Advisory Committee.

Erickson, W.P., B. Gritski, and K. Kronner, 2003. Nine Canyon Wind Power Project Avian and Bat Monitoring Annual Report. Technical report submitted to Energy Northwest and the Nine Canyon Technical Advisory Committee.

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000. Avian and bat mortality associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 study year. Technical Report prepared by WEST, Inc. for Umatilla County Department of Resource Services and Development, Pendleton, Oregon. 21pp.

Hodgman, T. and J. Jones, Eds. Unpublished draft manuscript. Methodologies for evaluating bird and bat interactions with wind turbines in Maine. Maine Wind Power Advisory Group, January 11, 2006 Draft.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd and D.A. Shepherd. 2000a. Avian Monitoring Studies at the Buffalo Ridge, Minnesota Wind Resource Area: Results of a 4-year study. Technical Report prepared for by WEST, Inc. for Xcel Energy, Minneapolis, MN. 262 pp.

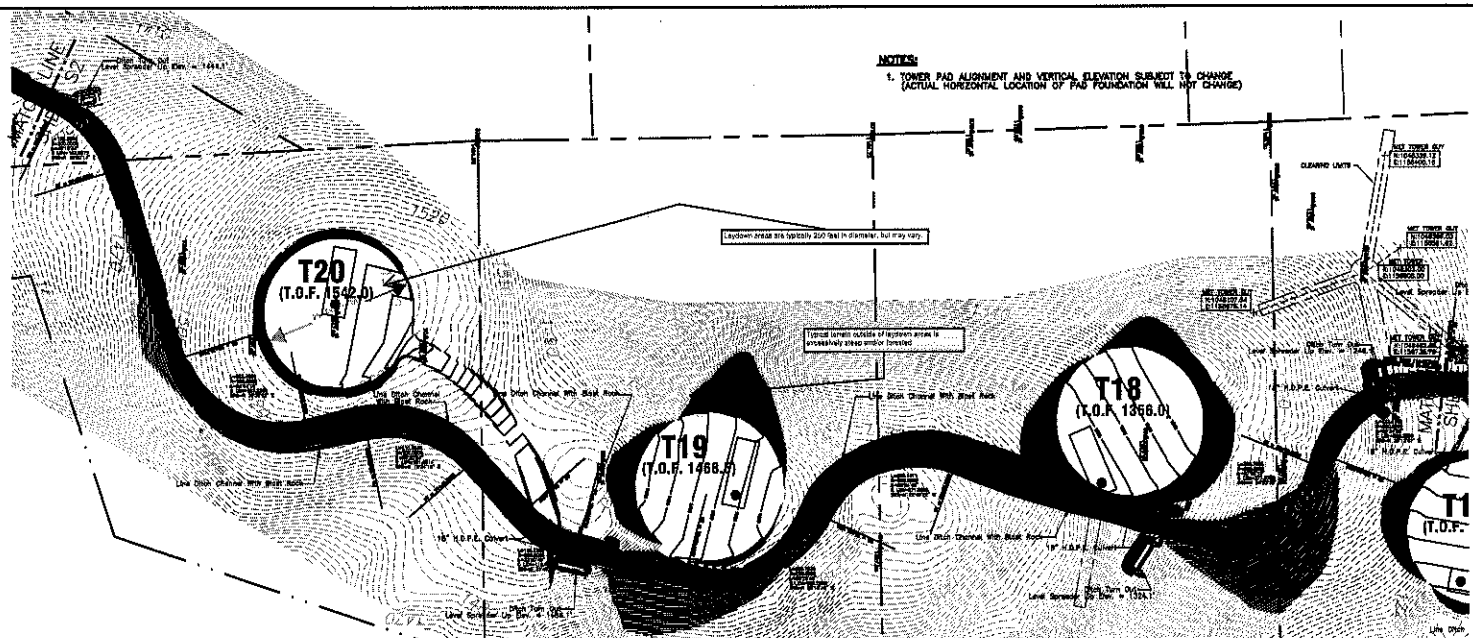
Johnson, G.D., D.P. Young, Jr., W.P. Erickson, M.D. Strickland, R.E. Good and P. Becker. 2000b. Avian and bat mortality associated with Phase I of the Foote Creek Rim Wind Power Project, Carbon County, Wyoming: November 1, 1998 – October 31, 1999. Tech. Report prepared by WEST for SeaWest Energy Corporation and Bureau of Land Management. 32 pp.

Kerns, J., W. P. Erickson and E. B. Arnett. 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia. Pages 24-95 in E. B. Arnett, technical editor, Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Kerns, J. and P. Kerlinger. 2004. A study of bird and bat collision fatalities at the MWEC Wind Energy Center, Tucker County, West Virginia: annual report for 2003. Technical report prepared by Curry and Kerlinger, LLC for FPL Energy and MWEC Wind Energy Center Technical Review Committee.

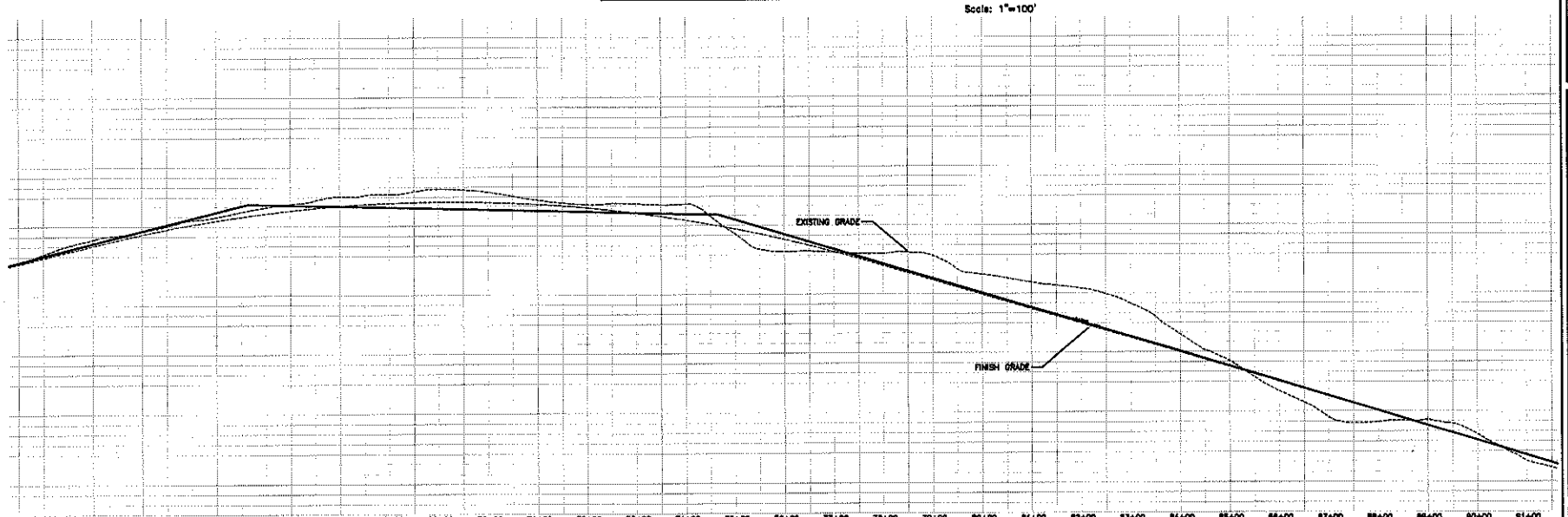
Krewitt, W. and J. Nitsch. 2003. The potential for electricity generation from on-shore wind energy under the constraints of nature conservation: a case study for two regions in Germany. Renewable Energy 28:1645-1655.

Osborn, R. G., K. F. Higgins, R., E. R. Usgaard, C. D. Dieter, and R. D. Neiger. 2000. Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota. American Midland Naturalist 143:41-52.



SOUTH STRING ROAD PLAN

Scale: 1"=100'



PROFILE

Scale: 1"=100' Hor.
1"=50' Vert.

SARGENT CORPORATION

1	7-14-06	REVISED FOR CLIENT COMMENTS	SCT/DAW
0	7-7-06	ISSUED FOR CLIENT REVIEW	SCT/DAW

DRAWING FILE NO. 8.8
DATE JULY 25, 2006
SCALE AS NOTED
DRAWN
PROJECTED
CHECKED BY
APPROVED

MARS HILL WIND POWER PROJECT

EVERGREEN WINDPOWER, LLC, C/O LIPPO WIND MANAGEMENT, LLC.

PROJECT LOCATION
MARS HILL, MAINE

DRAWING DESCRIPTION
SOUTH ROAD PLAN AND PROFILE
STATION 80+50 THRU 91+00

PROJECT NO.
53690E

ENGINEER

JAMES W. SEWALL COMPANY
ENGINEERS, SURVEYORS
RESOURCE CONSULTANTS
1535 OLD BRADLEY ROAD
O.D. BANGOR, MAINE 04468
(207) 827-4456

PHASE
-

DRAWING NO.
S3

Appendix B

Table 1 **Dates of bird and bat mortality surveys at the Mars Hill Wind Farm 2007**
Table 2 **Bird fatalities found at the Mars Hill Wind Farm 2007**
Table 3 **Bat fatalities found at the Mars Hill Wind Farm 2007**
Table 4 **NEXRAD migration data during Mars Hill Wind Farm mortality surveys 2007**

Appendix B Table 1. Dates of bird and bat mortality surveys at the Mars Hill Wind Farm 2007

Spring			Summer			Fall		
Date	**Turbines searched**	**Survey Type**	**Date**	**Turbines searched**	**Survey Type**	**Date**	**Turbines searched**	**Survey Type**
23-Apr	2, 6, 7, 9, 19, 24, 27, 28	Standard	15-Jul	10, 17, 21, 28, 9, 16, 25, 15, 13	Standard	13-Aug	1, 4, 11, 12, 19, 20, 21, 26	Standard
24-Apr	2, 6, 11, 13, 16, 18, 21, 23, 25	Standard	16-Jul	10, 17, communication tower near turbine 24 and met tower near turbine 6	Standard	14-Aug	8, 10, 12, 13, 14, 16, 17, 20, 22	Standard
25-Apr	1, 2, 6, 8, 12, 14, 15, 26	Standard	17-Jul	10, 17	Standard	15-Aug	2, 7, 9, 12, 15, 18, 20, 24, 27	Standard
26-Apr	2, 3, 4, 5, 6, 10, 17, 20, 22	Standard	18-Jul	10, 17	Standard	16-Aug	3, 5, 6, 12, 20, 23, 25, 28	Standard
27-Apr	2, 6, communication tower near turbine 24 and met tower near turbine 6	Standard	19-Jul	10, 17, 12, 6, 27, 23, 7, 11	Standard	17-Aug	12, 20, communication tower near turbine 24 and met tower near turbine 18	Standard
28-Apr	2, 6	Standard	20-Jul	10, 17, 14, 3, 19, 20, 18, 26, 1	Standard	18-Aug	12, 20	Standard
29-Apr	2, 6	Standard	21-Jul	10, 17, 22, 4, 5, 24, 8, 2	Standard	19-Aug	12, 20	Standard
30-Apr	2, 6, communication tower near turbine 24 and met tower near turbine 6	Standard	22-Jul	10, 17, 21, 28, 9, 16, 25, 15, 13	Standard	20-Aug	12, 20, communication tower near turbine 24 and met tower near turbine 18	Standard
1-May	2, 6	Standard	23-Jul	10, 17, communication tower near turbine 24 and met tower near turbine 6	Standard	21-Aug	12, 20	Standard
2-May	2, 6	Standard	24-Jul	10, 17	Standard	22-Aug	12, 20	Standard
3-May	2, 6, 7, 9, 19, 24, 27, 28	Standard	25-Jul	10, 17	Standard	23-Aug	1, 4, 11, 12, 19, 20, 21, 26	Standard
4-May	2, 6, 11, 13, 16, 18, 21, 23, 25	Standard	26-Jul	10, 17, 12, 6, 27, 23, 7, 11	Standard	24-Aug	8, 10, 12, 13, 14, 16, 17, 20, 22	Standard
5-May	1, 2, 6, 8, 12, 14, 15, 26	Standard	27-Jul	10, 17, 14, 3, 19, 20, 18, 26, 1	Standard	25-Aug	2, 7, 9, 12, 15, 18, 20, 24, 27	Standard
6-May	2, 3, 4, 5, 6, 10, 17, 20, 22	Standard	28-Jul	10, 17, 22, 4, 5, 24, 8, 2	Standard	26-Aug	3, 5, 6, 12, 20, 23, 25, 28	Standard
7-May	2, 6, communication tower near turbine 24 and met tower near turbine 6	Standard	29-Jul	10, 17, 21, 28, 9, 16, 25, 15, 13	Standard	27-Aug	12, 20, communication tower near turbine 24 and met tower near turbine 18	Standard
8-May	2, 6	Standard	30-Jul	10, 17, communication tower near turbine 24 and met tower near turbine 6	Standard	28-Aug	12, 20	Standard
9-May	2, 6	Standard	31-Jul	10, 17	Standard	29-Aug	12, 20	Standard
10-May	2, 6, 7, 9, 19, 24, 27, 28	Standard	1-Aug	10, 17	Standard	30-Aug	1, 4, 11, 12, 19, 20, 21, 26	Standard
11-May	no survey due to transportation issue	Standard	2-Aug	10, 17, 12, 6, 27, 23, 7, 11	Standard	31-Aug	8, 10, 12, 13, 14, 16, 17, 20, 22	Standard
12-May	1, 2, 6, 8, 12, 14, 15, 26, 21, 23, 25	Standard	2-Aug	2, 15	Extended plot	1-Sep	2, 7, 9, 12, 15, 18, 20, 24, 27	Standard
13-May	2, 3, 4, 5, 6, 10, 17, 20, 22	Standard	3-Aug	10, 17, 14, 3, 19, 20, 18, 26, 1	Standard	2-Sep	3, 5, 6, 12, 20, 23, 25, 28	Standard
14-May	2, 6, communication tower near turbine 24 and met tower near turbine 6	Standard	4-Aug	10, 17, 22, 4, 5, 24, 8, 2	Standard	3-Sep	12, 20, communication tower near turbine 24 and met tower near turbine 18	Standard
15-May	2, 6	Standard	5-Aug	10, 17, 21, 28, 9, 16, 25, 15, 13	Standard	4-Sep	12, 20	Standard
16-May	2, 6	Standard	6-Aug	10, 17, communication tower near turbine 24 and met tower near turbine 6	Standard	5-Sep	12, 20	Standard
17-May	2, 6, 7, 9, 19, 24, 27, 28	Standard	7-Aug	10, 17	Standard	6-Sep	1, 4, 11, 12, 19, 20, 21, 26	Standard
17-May	1, 20	Extended plo	8-Aug	10, 17	Standard	7-Sep	8, 10, 12, 13, 14, 16, 17, 20, 22	Standard
18-May	2, 6, 11, 13, 16, 18, 21, 23, 25	Standard	9-Aug	10, 17, 12, 6, 27, 23, 7, 11	Standard	8-Sep	2, 7, 9, 12, 15, 18, 20, 24, 27	Standard
19-May	1, 2, 6, 8, 12, 14, 15, 26	Standard	10-Aug	10, 17, 14, 19, 20, 18, 26, 1	Dog searches	9-Sep	3, 5, 6, 12, 20, 23, 25, 28	Standard
20-May	2, 3, 4, 5, 6, 10, 17, 20, 22	Standard	11-Aug	10, 17, 3, 4, 5, 24, 8, 2, 6, 7, met tower near 6	Dog searches	9-Sep	1, 2	Extended plot
21-May	2, 6, communication tower near turbine 24 and met tower near turbine 6	Standard	11-Aug	27, 28, 12, 9, 22	Standard	10-Sep	12, 20, communication tower near turbine 24 and met tower near turbine 18	Standard
22-May	2, 6	Standard	12-Aug	10, 17, 21, 16, 25, 15, 13, 11, 23	Dog searches	11-Sep	12, 20	Standard
23-May	2, 6	Standard				12-Sep	12, 20	Standard
24-May	2, 6, 7, 9, 19, 24, 27, 28	Standard				13-Sep	1, 4, 11, 12, 19, 20, 21, 26	Standard
25-May	2, 6, 11, 13, 16, 18, 21, 23, 25	Standard				14-Sep	8, 10, 12, 13, 14, 16, 17, 20, 22	Standard
26-May	1, 2, 6, 8, 12, 14, 15, 26	Standard				15-Sep	2, 7, 9, 12, 15, 18, 20, 24, 27	Standard
27-May	2, 3, 4, 5, 6, 10, 17, 20, 22	Standard				16-Sep	3, 5, 6, 12, 20, 23, 25, 28	Standard
28-May	2, 6, communication tower near turbine 24 and met tower near turbine 6	Standard				17-Sep	12, 20, communication tower near turbine 24 and met tower near turbine 18	Standard
29-May	2, 6	Standard				18-Sep	12, 20	Standard
30-May	2, 6	Standard				19-Sep	12, 20	Standard
31-May	2, 6, 7, 9, 19, 24, 27, 28	Standard				20-Sep	1, 4, 11, 19, 21, 26	Standard
1-Jun	2, 6, 11, 13, 16, 18, 21, 23, 25	Standard				20-Sep	8, 10, 12, 13, 14, 16, 17, 20, 22	Dog searches
2-Jun	1, 2, 6, 8, 12, 14, 15, 26	Dog searches				21-Sep	2, 7, 9, 12, communication tower near tubine 12 and met tower near turbine 18, 18, 20, 24, 27, 28, 26, 25, 23, 21, 19	Dog searches
3-Jun	2, 3 (short survey due to injury)	Standard				22-Sep	1, 3, 4, 5, 6, 11, 12, 20	Dog searches
						23-Sep	12, 20	Standard

Appendix B Table 2. Bird fatalities at the Mars Hill Wind Farm 2007

Survey Type or Incidental	Common Name	Scientific Name	Date	Time	Turbine #	Distance (m) from tower	Compass Direction From Tower	# of Days Decomposed
Incidental	hairy woodpecker	*Picoides villosus*	4/20/2007	9:30 AM	12	71	22.5 N	2-3
Incidental	white-throated sparrow	*Zonotrichia albicollis*	4/23/2007	3:30 PM	19	41	East	fresh
Standard	golden-crowned kinglet	*Regulus satrapa*	4/24/2007	3:20 PM	23	40	due south	4-7
Standard	black-throated green warbler	*Dendroica virens*	5/18/2007	12:15 PM	16	46	120 SE	fresh
Standard	blackburnian warbler	*Dendroica fusca*	5/18/2007	12:30 PM	16	40	160 SE	fresh
w/ dog	warbler sp.	n/a	6/2/2007	4:45 PM	12	73	SW	scavenged
w/ dog	golden-crowned kinglet	*Regulus satrapa*	6/2/2007	5:15 PM	26	59	N	2 weeks+
Standard	ovenbird	*Seiurus aurocapillus*	6/3/2007	10:30 AM	3	38	S	fresh
Incidental	blackburnian warbler	*Dendroica fusca*	6/21/2007	n/a	13	1	E	2 weeks+
w/ dog	unidentified songbird	n/a	8/10/2007	3:46 PM	20	36	SE	scavenged
w/ dog	red crossbill	*Loxia curvirostra*	8/10/2007	5:23 PM	17	7	WNW	2 weeks+
w/ dog	red-eyed vireo	*Vireo olivaceus*	8/10/2007	6:53 PM	10	1.2	under stairs to tower	2 weeks+
w/ dog	bay-breasted warbler	*Dendroica castanea*	8/12/2007	10:37 AM	11	40	S	4-7
Standard	warbler sp.	n/a	8/16/2007	3:45 PM	12	3	S	2 weeks+
Standard	veery	*Catharus fuscescens*	9/2/2007	3:00 PM	3	25	SW	fresh
w/ dog	warbler sp.	n/a	9/20/2007	10:00 AM	8	40	NNE 30	scavenged
w/ dog	unidentified songbird	n/a	9/20/2007	12:00 PM	13	68	W	scavenged
w/ dog	unidentified songbird	n/a	9/20/2007	1:00 PM	17	31	N	scavenged
w/ dog	warbler sp.	n/a	9/21/2007	10:45 AM	24	26	NW	scavenged
w/ dog	warbler sp.	n/a	9/21/2007	12:24 PM	28	39	N	scavenged
w/ dog	unidentified songbird	n/a	9/21/2007	1:56 PM	26	40	N	scavenged
w/ dog	unidentified songbird	n/a	9/22/2007	6:55 AM	3	19	NE	4-7

Appendix B Table 3. Bat fatalities at the Mars Hill Wind Farm 2007

Survey Type or Incidental	Common Name	Scientific Name	Date	Time	Turbine #	Distance (m) From Tower	Compass Direction From Tower	# of Days Decomposed
Standard	little brown bat	*Myotis lucifugus*	5/13/2007	9:00 AM	3	7	S	fresh
extended plot survey	silver-haired bat	*Lasionycteris noctivagans*	8/2/2007	9:51 AM	2	36	N	fresh
w/ dog	unidentified bat	n/a	8/10/2007	2:20 PM	26	28	NNW	scavenged
Incidental	eastern red bat	*Lasiurus borealis*	8/10/2007	2:53 PM	26	28	N	2-3
w/ dog	unidentified bat	n/a	8/10/2007	3:31 PM	20	24	E	scavenged
w/ dog	hoary bat	*Lasiurus cinereus*	8/10/2007	3:59 AM	20	31	SSE	scavenged
w/ dog	silver-haired bat	*Lasionycteris noctivagans*	8/10/2007	4:24 PM	19	36	SSW	4-7
w/ dog	hoary bat	*Lasiurus cinereus*	8/10/2007	5:58 PM	14	15	W	4-7
w/ dog	hoary bat	*Lasiurus cinereus*	8/10/2007	7:31 PM	1	22	NNE	2 weeks+
w/ dog	silver-haired bat	*Lasionycteris noctivagans*	8/10/2007	7:37 PM	1	3.6	SSE	2-3
w/ dog	little brown bat	*Myotis lucifugus*	8/11/2007	7:09 AM	3	26	NNE	fresh
w/ dog	little brown bat	*Myotis lucifugus*	8/11/2007	9:08 AM	8	8	SSW	4-7
w/ dog	silver-haired bat	*Lasionycteris noctivagans*	8/11/2007	9:11 AM	8	12	N	2-3
w/ dog	silver-haired bat	*Lasionycteris noctivagans*	8/11/2007	9:21 AM	8	14	NW	2-3
Incidental	hoary bat	*Lasiurus cinereus*	8/11/2007	12:16 PM	27	20	S	2-3
w/ dog	silver-haired bat	*Lasionycteris noctivagans*	8/12/2007	6:40 AM	25	15	NW	2-3
w/ dog	little brown bat	*Myotis lucifugus*	8/12/2007	7:26 AM	21	11	NNE	fresh
w/ dog	unidentified bat	n/a	8/12/2007	8:46 AM	15	32	SW	scavenged
w/ dog	silver-haired bat	*Lasionycteris noctivagans*	8/12/2007	8:55 AM	15	38	NW	4-7
Standard	silver-haired bat	*Lasionycteris noctivagans*	8/14/2007	5:00 PM	17	1.5	S	2 weeks+
w/ dog	silver-haired bat	*Lasionycteris noctivagans*	9/20/2007	11:00 AM	10	27	SSW 210	2 weeks+
w/ dog	hoary bat	*Lasiurus cinereus*	9/20/2007	2:00 PM	17	17	NW	2 weeks+
w/ dog	eastern red bat	*Lasiurus borealis*	9/21/2007	9:30 AM	18	33	NNE 23	2 weeks+
w/ dog	eastern red bat	*Lasiurus borealis*	9/22/2007	6:50 AM	3	18	SE	2-3

Appendix B Table 4. NEXRAD migration data during Mars Hill mortality surveys 2007

Spring			Summer			Fall		
Night of	Level of Migration	Rain Events	Night of	Level of Migration	Rain Events	Night of	Level of Migration	Rain Events
04/22/07	not available		07/15/07	light	rain	08/13/07	moderate	rain
04/23/07	not available		07/16/07	heavy		08/14/07	moderate	rain
04/24/07	light		07/17/07	moderate		08/15/07	moderate	
04/25/07	light		07/18/07	rain	rain	08/16/07	moderate	
04/26/07	heavy	rain	07/19/07	rain	rain	08/17/07	rain	
04/27/07	light	rain	07/20/07	moderate	rain	08/18/07	moderate	
04/28/07	light	rain	07/21/07	moderate		08/19/07	heavy	
04/29/07	light	rain	07/22/07	heavy		08/20/07	heavy	
04/30/07	rain		07/23/07	moderate		08/21/07	heavy	
05/01/07	heavy		07/24/07	moderate		08/22/07	heavy	
05/02/07	light		07/25/07	moderate		08/23/07	rain	rain
05/03/07	light		07/26/07	moderate		08/24/07	light	rain
05/04/07	light		07/27/07	light	rain	08/25/07	light	rain
05/05/07	light	rain	07/28/07	rain	rain	08/26/07	heavy	
05/06/07	light		07/29/07	moderate	rain	08/27/07	heavy	
05/07/07	light	rain	07/30/07	heavy		08/28/07	heavy	
05/08/07	heavy		07/31/07	moderate		08/29/07	not available	
05/09/07	light	rain	08/01/07	heavy	rain	08/30/07	not available	
05/10/07	light	rain	08/02/07	light	rain	08/31/07	not available	
05/11/07	light	rain	08/03/07	light	rain	09/01/07	not available	
05/12/07	heavy		08/04/07	moderate		09/02/07	not available	
05/13/07	light		08/05/07	heavy		09/03/07	heavy	
05/14/07	heavy	rain	08/06/07	moderate	rain	09/04/07	heavy	
05/15/07	light	rain	08/07/07	heavy		09/05/07	heavy	
05/16/07	rain		08/08/07	moderate	rain	09/06/07	moderate	
05/17/07	light	rain	08/09/07	heavy		09/07/07	not available	
05/18/07	rain		08/10/07	heavy		09/08/07	not available	
05/19/07	light	rain	08/11/07	heavy		09/09/07	not available	
05/20/07	light	rain	08/12/07	rain	rain	09/10/07	moderate	rain
05/21/07	light					09/11/07	rain	rain
05/22/07	heavy					09/12/07	heavy	
05/23/07	heavy					09/13/07	heavy	
05/24/07	not available					09/14/07	moderate	rain
05/25/07	heavy					09/15/07	moderate	
05/26/07	light					09/16/07	heavy	
05/27/07	rain					09/17/07	heavy	
05/28/07	light					09/18/07	heavy	
05/29/07	light					09/19/07	moderate	
05/30/07	light					09/20/07	heavy	
05/31/07	heavy					09/21/07	heavy	
06/01/07	light	rain				09/22/07	light	
06/02/07	not available							