Appendix B

Summer – Fall 2008 Passive Acoustic Monitoring Bat Survey Report

Summer-Fall 2008 Passive Acoustic Monitoring Bat Survey Report

for the Goddard Space Flight Center Wallops Flight Facility in Wallops Island, Virginia

Prepared for

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Executive Summary

The National Aeronautics and Space Administration (NASA) is evaluating the prospect of erecting up to two 1.5 megawatt (MW) wind generation turbines of approximately 119 meters (m; 388.8 feet), with associated underground electric power collection lines and new access roads, at the Goddard Space Flight Center Wallops Flight Facility in Wallops Island, Virginia (Project). The Project includes an interconnection with the existing NASA WFF electrical power distribution system, and the electricity generated by the wind turbines will only be used to power facilities at the WFF. The turbines are being considered by NASA as the primary component of a renewable energy initiative that will generate electricity to support operations at the WFF.

Stantec Consulting (Stantec) has acted as a consultant to Tetra Tech NUS Inc. (Tetra Tech) who is assisting NASA with environmental studies connected with the siting of the Project facilities. Stantec was contracted to conduct passive acoustic bat surveys in the Project area in order to document bat activity. The surveys were conducted in accordance with an avian and bat assessment study plan developed previously by NASA in June 2008, which was in part based on the Final Site-Wide Environmental Assessment completed in 2005.

Over the course of the fourteen week summer-fall survey period (July 15 through October 21, 2008), Anabat acoustic detectors collected 229 combined detector-nights of recordings. Four detectors were deployed throughout the Project area. Two detectors were placed in an existing 50 meter (164 feet) unguyed tower, which is located approximately 427 meter (1,400 feet) south of the southern-most wind turbine site, and two were situated on 10 meter (33 feet) poles in adjacent marshlands. Stantec deployed detectors at the beginning of the survey period, and NASA personnel were scheduled to download data on a bi-weekly basis. This data was then to be routinely submitted to Stantec for subsequent review, analysis, and interpretation. Stantec personnel then returned to the site at the end of the survey period to remove the detectors.

A total of 2,140 bat call sequences were recorded during the summer-fall sampling period. The mean detection rate of all detectors was 9.3 detections per detector-night. Habitat, landscape, location, and survey effort probably account for the observed differences in detection rates between detectors. Bat calls were identified to the lowest possible taxonomic level. These were then grouped into six guilds based on similarity in call characteristics between some species and the uncertainty in the ability of frequency division detectors to adequately provide information for this differentiation. The majority of calls (55.2%) were identified as “unknown” (all recorded sequences had too few pulses or pulses of poor quality to be distinguishable to guild). The guild with the most identifiable calls was that of the Red bat/Eastern pipistrelle, representing 27.9 percent of the recorded calls. There were few recorded calls identifiable as belonging to the hoary bat or Myotis guild.

When considering the level of activity documented at Wallops Island from July to October, it is important to acknowledge that numbers of recorded bat call sequences are not necessarily

correlated with number of bats in an area. Acoustic detectors do not allow for differentiation between a single bat making multiple passes and multiple bats each recorded a single time. Quantitative comparisons of detection rates among detectors, seasons, or habitats are not possible, nor are direct correlation with weather variables, or linking detection rates to bat abundance. General trends must be interpreted with caution due to the limitations of the sampling design used in this survey.

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1.0 Introduction

Despite the recent increase in general bat studies resulting from the growing wind-energy industry, most of the questions regarding risk to bats from wind turbines remain unanswered (Kunz *et al*. 2007a, 2007b). Mortality of eight bat species has been documented at wind energy facilities in the eastern United States (Kunz *et al*. 2007a), with most fatalities occurring during what is generally considered the fall migration period (August to November; Cryan 2003, Cryan and Brown 2007, Johnson *et al*. 2005). Species documented in the vicinity of wind turbines in the eastern U.S. include little brown myotis, northern myotis, eastern pipistrelle, seminole, hoary, silver-haired, red, and big brown bats. With the exception of eastern pipistrelles, the species killed most frequently—hoary, red, and silver-haired bat—are long-distance migrants, traveling dramatically greater migration distances than other North American species (Cryan 2003, Cryan *et al.* 2004, Cryan and Brown 2007, others).

Very little is understood about the behavior of migrating bats and the reasons behind their apparent susceptibility to collision with wind turbines. Throughout the scientific community a variety of hypotheses exist to explain this ecological concern. Several of these hypotheses suggest attraction of bat to wind turbines through (1) creation of linear habitat and/or potential roosts, (2) habitats and/or conditions favorable for foraging and high insect abundance, and (3) attraction through auditory cues. Other hypotheses indicate the possibility that turbines create an electromagnetic disorientation, or postulate that bats are unable to accurately determine wind turbine blade speed through echolocation. Further, it is unknown whether or not bats echolocate while migrating, and whether failure to echolocate could cause collision mortality, as bats are clearly able to avoid objects and maneuver rapidly while foraging (Kunz *et al*. 2007a).

In response to the potential risks apparently posed to nocturnal migrants, including bats, state and federal agencies typically require developers to survey their site to document the pre-construction level of bat activity in the area. To that end, this report has been prepared to review the findings of passive bat acoustic surveys conducted during the summer-fall of 2008 at the Goddard Space Flight Center Wallops Flight Facility in Wallops Island, Virginia (Project). Following is a brief description of the project; a review of the methods used to conduct scientific surveys and the results of those surveys. A discussion of those results is also presented.

1.1 PROJECT CONTEXT

The National Aeronautics and Space Administration (NASA) is evaluating the prospect of erecting up to two 1.5 megawatt (MW) wind generation turbines of approximately 119 meters (388.8 feet), with associated underground electric power collection lines and new access roads at the WFF in Wallops Island, Virginia. The Project includes an interconnection with the existing NASA WFF electrical power distribution system, and the electricity generated by the wind turbines will only be used to power facilities at the WFF. The turbines are being considered by NASA as the primary

component of a mandated renewable energy initiative that will generate electricity to support operations at the WFF.

Tetra Tech NUS, Inc. (Tetra Tech) contracted Stantec Consulting (Stantec) to conduct passive acoustic surveys during the summer-fall 2008 season to document bat activity patterns and species composition in the Project area. The surveys will provide data to help assess the potential risk for the proposed Project to impact bats. The scope of bat surveys was based on a combination of standard methods that have evolved within the wind power industry for pre-construction surveys, guidelines outlined by the study plan developed previously by NASA in June 2008, which was in part based on the Final Site Wide Environmental Assessment completed in 2005 (URS and EG&G 2005).

1.2 PROJECT AREA DESCRIPTION

The WFF lies within the Tidewater region of the embayed section of the Atlantic Coastal Plain Physiographic Province. Wallops Island is separated from the Main Base and Wallops Mainland by numerous inlets, marshes, bays, creeks, and tidal estuaries and is considered a barrier island; as such Wallops Island is subject to constant change due to ocean currents, wind erosion, and severe weather conditions. Wallops Island contains coastal primary sand dunes that serve as protective barriers from the effects of flooding and erosion caused by coastal storms. Habitats within the WFF area include dune systems, maritime forests, salt marshes, swamps, thickets, upland grasslands, and upland forests. Specifically, dune systems, maritime forest, and salt marsh are found on Wallops Island, and salt marsh, swamps, thickets, upland grasslands, and upland forest are found on Wallops Mainland and the Main Base (URS and EG&G 2005).

WFF is located in the climatic region known as the humid continental warm summer climate zone. Large temperature variations during the course of a single year and lesser variations in average monthly temperatures typify the region. The climate is tempered by the proximity of the Atlantic Ocean to the east and the Chesapeake Bay to the west. Also affecting the climate is an air current, know as the Labrador Current, which originates in the polar latitudes and moves southward along the Delmarva coastline. The current creates a wedge between the warm Gulf Stream offshore and the Atlantic coast (URS and EG&G 2005).

Wallops Island is technically zoned industrial by the state of Virginia. However, the island has been widely used over its history for a variety of government purposes. With the exception of the WWF facilities, the landscape adjacent to Wallops Island is predominantly agricultural or undeveloped. Rural residential areas, small villages, and businesses are scattered throughout the surroundings. The Town of Chincoteague, located approximately eight kilometers (5 miles) east of the Main Base on Chincoteague Island, Virginia, is the largest of the surrounding communities. Existing land uses at WFF include: administrative areas, fabrication areas, housing and recreation areas, institutional areas, separate operational areas, operations aircraft area, operations range, operations/explosive storage, Mid-Atlantic Regional Spaceport, and the Visitors Center Complex Area (URS and EG&G 2005).

In 1975, the Wallops Island National Wildlife Refuge was created when 151 hectare (373 acres) of land were transferred to the U.S. Fish and Wildlife Service (USFWS) from NASA. The refuge, comprised mainly of salt marsh and woodlands, is located east of Wattsville in Accomack County, Virginia, and is located 9.6 kilometers (6 miles) to the northeast of WFF. It contains habitat for a variety of species, including upland- and wetland-dependent migratory birds. A rare habitat, a sea-level fen, can also be found on the refuge. Sea-level fens are nutrient-poor, maritime seepage wetlands, confined to a few sites with an unusual combination of environmental conditions for the mid-Atlantic. Neotropical songbirds take advantage of the shelter and food that the forest can provide. Edge habitats, where two different habitats meet, are utilized by white-tailed deer, raccoons, and fox (USFWS 2008).

2.0 Acoustic Bat Survey

Fifteen species of bat occur in Virginia, based upon their normal geographical range. There are six *Myotis* species in Virginia including the gray bat (*Myotis grisescens*), little brown bat (*M. lucifugus*), northern long-eared bat (*M. septentrionalis*), Indiana bat (*M. sodalis*), eastern small-footed bat (*M. leibii*), and southeastern *Myotis* (*M. austroriparius*). Other species include silver-haired bat (*Lasionycteris noctivagans*), eastern pipistrelle (*Perimyotis* [=*Pipistrellus*] *subflavus*), big brown bat (*Eptesicus fuscus*), evening bat (*Nycticeius humeralis*), eastern red bat (*Lasiurus borealis*), hoary bat (*L. cinereus*), seminole bat (*L. seminolus*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) and the Virginia big-eared bat (*C. townsendii virginianus*) (BCI 2001). Of these the Indiana bat, gray bat, and Virginia big-eared bat are listed as federally endangered; Rafinesque's big-eared bat is listed as state endangered; and the eastern small-footed bat is a Species of Special Concern.

2.1 INTRODUCTION

Stantec conducted summer-fall 2008 field surveys to document activity patterns and species composition of bats in the Project area. The survey was designed to use passive acoustic monitoring Anabat detectors. Acoustic bat detectors allow for long-term monitoring of activity patterns of bats in a variety of habitats, including the air space approaching the rotor-swept zone of modern wind turbines. The acoustic bat survey at the proposed Wallops Island wind turbine site was designed to document bat activity patterns near the rotor zone of the proposed turbines and at a lower height in the open salt marsh habitat adjacent to the proposed wind turbine site. The acoustic survey was *not* intended to relate bat activity patterns to weather conditions in the Project area.

2.2 METHODS

2.2.1 Field Surveys

Anabat II detectors (Titley Electronics Pty Ltd.) were used for the duration of the summer-fall acoustic bat survey. Anabat detectors were selected based upon their widespread use for this

type of survey, their ability to be deployed for long periods of time, and their ability to detect a broad frequency range, which allows detection of all species of bats that could occur in the Project area. Each Anabat detector was coupled with CF Storage ZCAIM (Titley Electronics Pty Ltd.), which programmed the on/off times and stored data on removable 1 GB compact flash cards. Anabat detectors are frequency division detectors, dividing the frequency of ultrasonic calls made by bats by a factor of 16 so that they are audible to humans, then recording the bat calls for subsequent analysis. The audio sensitivity setting of each Anabat system was set at between six and seven (on a scale of one to ten) to maximize sensitivity while limiting ambient background noise and interference. The sensitivity of individual detectors was then tested using an ultrasonic Bat Chirp (Reno, NV) to ensure that the detectors would be able to detect bats up to a distance of at least 10 m (33 ft).

Detectors were powered by 12-volt batteries charged by solar panels. Each solar-powered Anabat system was deployed in a waterproof housing enabling the detector to record while unattended for the duration of the survey. The housing suspends the Anabat microphone downward to give maximum protection from precipitation. To compensate for the downward position, a reflector shield of smooth plastic is placed at a 45-degree angle directly below the microphone. The angled reflector allows the microphone to record the airspace horizontally surrounding the detector and is only slightly less sensitive than an unmodified Anabat unit. Maintenance visits were conducted by NASA personnel. Typical survey design anticipates detector checks approximately every two weeks to verify the condition of the detectors and download data to a computer for analysis. There was a slight deviation for this download schedule. Key to the download process is immediate processing of the data to ensure that active calls are being recorded and so that modifications to the equipment can occur.

Four detectors, deployed between July 15 and October 21, were programmed to record acoustic data between 19:00 and 07:00. On July 15, two detectors – North and South Marsh - were suspended 10 m (33 ft) above the ground on two poles located in the northern section of the Project area. The poles were positioned 250 m (820 ft) apart in an open salt marsh (Figure 1, Figure 2) in the locations of the proposed turbines. On July 30, two detectors were placed in an existing tower at a height of 50 m (164) at the southern end of the Project area (Figure 3).

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Figure No.
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Title
Bat Detector Location Map

10/28/2008

2.3 DATA ANALYSIS

Potential call files were extracted from data files using CFCread© software. The default settings for CFCread© were used during this file extraction process, as these settings are recommended for the calls that are characteristic of northeastern bats. This software screens all data recorded by the bat detector and extracts call files using a filter. Using the default settings for this initial screen also ensures comparability between data sets. Settings used by the filter include a max TBC (time between calls) of 5 seconds, a minimum line length of 5 milliseconds, and a smoothing factor of 50. The smoothing factor refers to whether or not adjacent pixels can be connected with a smooth line. The higher the smoothing factor, the less restrictive the filter is and the more noise files and poor quality call sequences are retained within the data set. A call is a single pulse of sound produced by a bat. A call sequence is a combination of two or more pulses recorded in a call file. Understanding the parameters of these settings is important in terms of determining when individual calls are classified as "unknown".

Following extraction of call files, each file was visually inspected to ensure that files created by static or some other form of interference that were still within the frequency range of eastern bats were not included in the data set. Bat calls typically include a series of pulses characteristic of normal flight or prey location ("search phase" calls) and capture periods (approach phase calls and feeding "buzzes") and on a sonogram look very different from static, which typically forms a diffuse band of dots at either a constant frequency or widely varying frequency, caused by wind, vibration, or other interference. Using these characteristics, bat call files are easily distinguished from non-bat files.

Bat call sequences were individually marked and categorized by species group, or "guild" based on visual comparison to reference calls. Qualitative visual comparison of recorded call sequences of sufficient length to reference libraries of bat calls allows for relatively accurate identification of bat species (O'Farrell *et al*. 1999, O'Farrell and Gannon 1999). A call sequence was considered of suitable quality and duration if the individual call pulses were "clean" (i.e., consisting of sharp, distinct lines) and at least five pulses were included within the sequence. Call sequences were classified to species whenever possible, based on criteria developed from review of reference calls collected by Chris Corben, the developer of the Anabat system, and other bat researchers. However, due to similarity of call signatures between several species, all classified calls have been categorized into six guilds[1] reflecting the bat community in the region of the Project area as follows:

- **Unknown (UNKN)** – All call sequences with too few pulses (less than five) or of poor quality (such as indistinct pulse characteristics or background static). These calls were further identified as either "high frequency unknown" (HFUN) for calls above 30-35 kHz or "low frequency unknown" (LFUN) for calls below 30-35 kHz;

[1] Gannon *et al.* 2003 categorized bats into guilds based upon similar minimum frequency and call shape. These guilds were: Unidentified, Myotis, LABO-PISU and EPFU-LANO-LACI. Stantec broke hoary bats out into a separate guild due to the importance of reporting activity patterns of migratory species in the context of wind energy development.

- **Myotid (MYSP)** – All bats of the genus *Myotis*. While there are some general characteristics believed to be distinctive for several of the species in this genus, these characteristics do not occur consistently enough for any one species to be relied upon at all times when using Anabat recordings;

- **Red bat/eastern pipistrelle (RBEP)** – Eastern red bats, eastern pipistrelles and evening bats. These three species can produce calls distinctive only to each species. However, significant overlap in the call pulse shape, frequency range, and slope can also occur.

- **Big brown/silver-haired bat (BBSH)** – Big brown and silver-haired bats. These species' call signatures commonly overlap and have therefore been included as one guild in this report.

- **Hoary bat (HB)** – Calls of hoary bats can usually be distinguished from those of big brown and silver-haired bats by minimum frequency extending to 20 kHz or below. Hoary bats are easily identified by calls varying in minimum frequency across a sequence.

- **BEB** – **Big-eared bat (BEB) –** Big-eared bats. Known as "whispering bats," these species emit low-intensity calls and listen for insect-generated sounds while foraging close to the ground; detecting calls of these bats is therefore difficult. Calls of big-eared bats are not easily confused with calls of any other species that may coexist in the Project area. The Project area lies within the distribution range of Rafinesque's big-eared bat (VDGIF c2008).

Since some species do sometimes produce calls unique only to that species, all calls were identified to the lowest possible taxonomic level before being grouped into the listed guilds. Tables and figures in the body of this report reflect those guilds. However, since species-specific identification did occur in some cases, each guild is also briefly discussed with respect to potential species composition of recorded call sequences.

Once all of the call files were identified and categorized in appropriate guilds, nightly tallies of detected calls were compiled. Mean detection rates (number of calls/detector-night) for the entire sampling period were calculated for each detector and for all detectors combined.

2.4 RESULTS

2.4.1 Detector Call Analysis

Detectors were deployed on July 15 (Marsh detectors) and July 30 (Tower detectors) and continued to record data through October 21, 2008, for a potential individual survey period of 99 nights for the Marsh detectors and 64 nights for the Tower detectors. The four detectors recorded data for a combined survey period of 229 detector-nights out of a potential combined period of 326 nights. The range of dates that each detector was deployed is summarized in Table 1. Some data gaps occurred due to power failures, CF card errors, and severe weather. Detectors were brought in from the field due to a hurricane between September 5 and 11.

Table 1. Summary of bat detector field survey effort and results

Location	Dates	# Nights	# Detector-Nights*	# Recorded sequences	Detection Rate **	Maximum # calls recorded ***
North Marsh	7/15-10/21	99	72	744	10.3	81
South Marsh	7/15-10/21	99	72	1143	15.9	170
Tower East	7/30-10/21	64	41	99	2.4	30
Tower West	7/30-10/21	64	44	154	3.5	34
Overall Results	**--**	***326***	***229***	***2140***	***9.3***	--

* Detector-night is a sampling unit during which a single detector is deployed overnight. On nights when two detectors are deployed, the sampling effort equals two detector-nights, etc.

** Number of bat passes recorded per detector-night.

*** Maximum number of bat passes recorded from any **single** detector for a 12-hour sampling period.

The four Wallops Island detectors recorded a total of 2,140 bat call sequences (Table 1). The mean detection rate for the four Wallops Island detectors was 9.3 sequences/detector-night (Table 1). Detection rates were highest at the South and North Marsh detectors (15.9 and 10.3 sequences/detector-night, respectively), followed by the Tower West (3.5 sequences/detector-night) and East (2.4 sequences/detector-night) detectors.

Nightly call volumes varied over the survey period (Figure 4). Call volumes peaked between August 13 and August 16, with the greatest number of sequences recorded on August 15 (n=223). Sequences within the RBEP, BBSH, UNKN and to a lesser extent HB guilds accounted for these peaks. On August 15, the majority of sequences identified to species belonged to eastern red bats (46.6 %, n=104). High frequency unknowns likely to be red bats or eastern pipistrelles accounted for 44.4% (n=99) of sequences recorded on August 15.

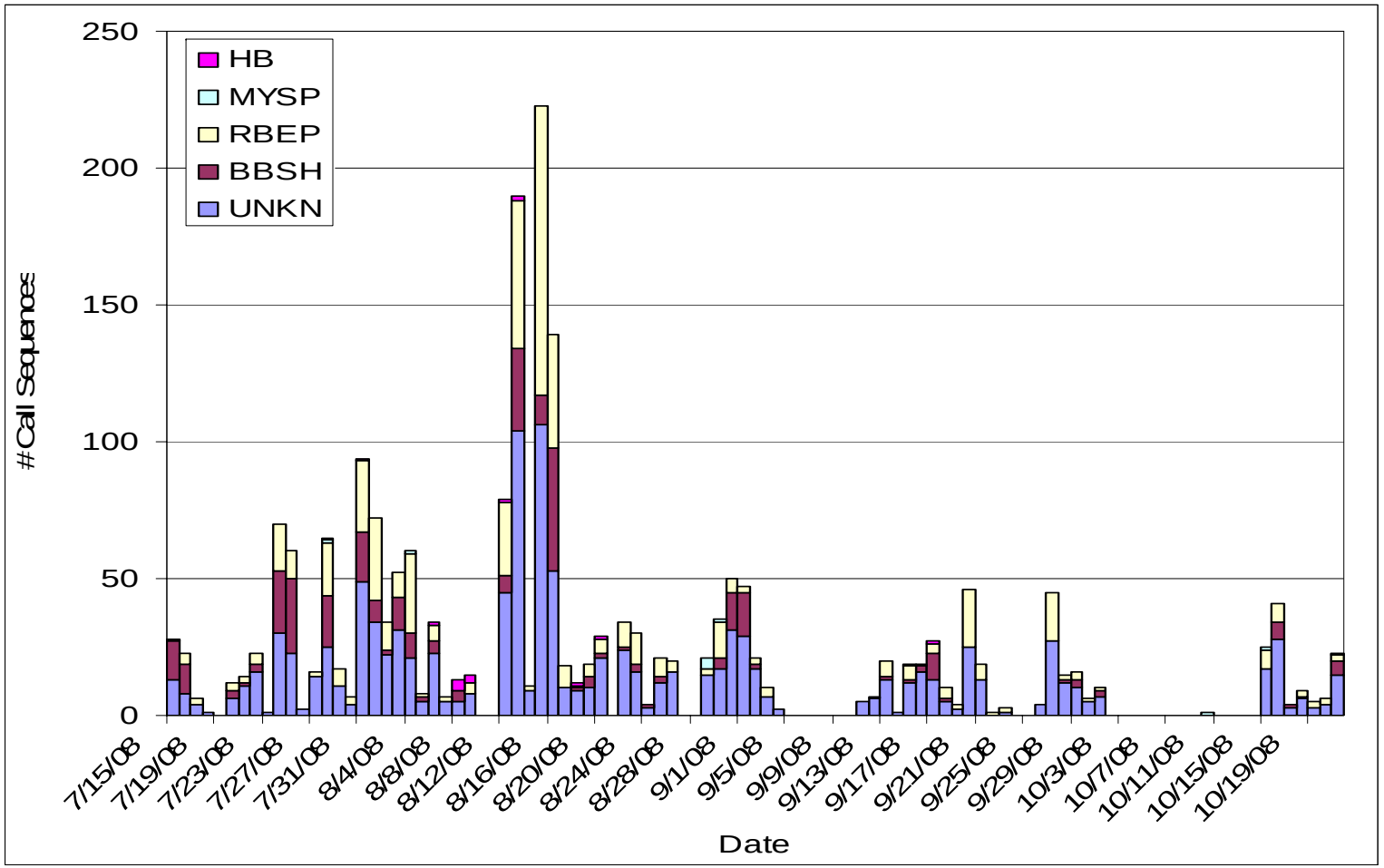

Figure 4. Total nightly bat call sequence detections by guild including hoary bat (HB), *Myotis spp.*(MYSP), eastern red bat/eastern pipistrelle/evening bat (RBEP), big brown/silver-haired bat (BBSH) and unknown (UNKN) guilds - Wallops Island Wind Project, summer-fall 2008.

When data from all four detectors were pooled, call volumes appeared to peak between 21:00 and 23:00. Call volumes tapered off toward dawn (Figure 5).

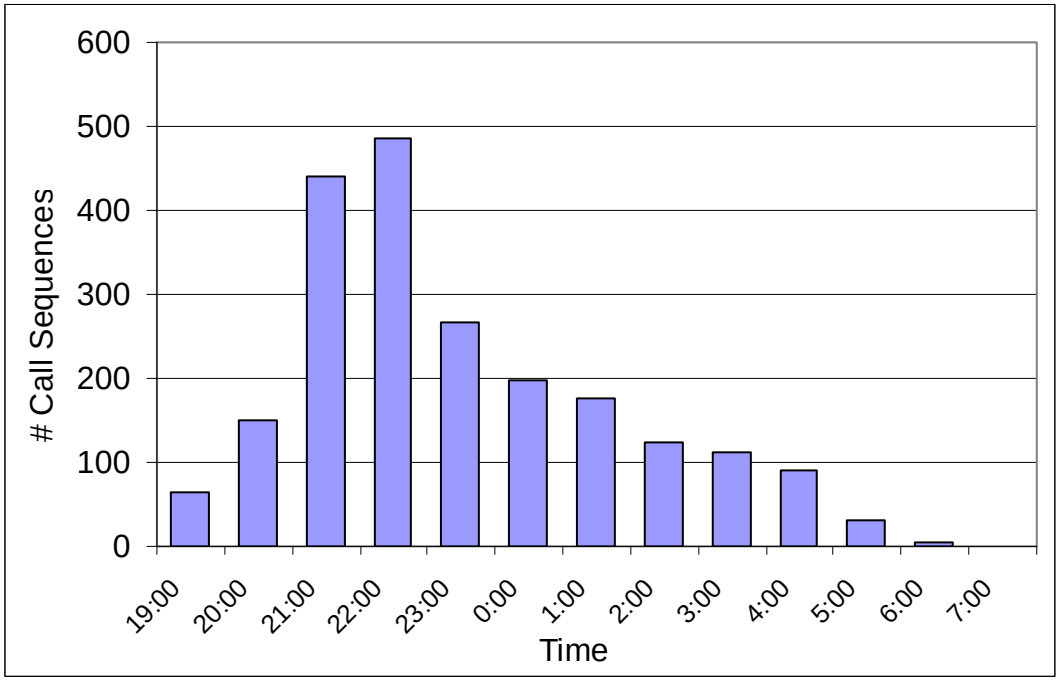

Figure 5. Hourly timing of call detections (n=2,140) at the Wallops Island Wind Project.

The majority of recorded call sequences (55.2%, n=1,181) were labeled as unknown (Table 2). Of these sequences, high frequency unknowns likely to be eastern red bats or eastern pipistrelles were most common (44.9%, n=960). Of the calls that were identified to species or guild, those of the RBEP guild were the most common (27.9%, n=596), followed by the species within the BBSH guild (15.7%, n=336), HB guild (0.8%, n=17) and MYSP guild (0.3%, n=10). Within the RBEP guild, eastern red bats accounted for 25.2% (n=540) of the 2,140 total sequences recorded at Wallops Island, followed by sequences just as likely belonging to red bats *or* eastern pipistrelles (2.5%, n=53) and eastern pipistrelles (0.1%, n=3). Within the BBSH guild, sequences just as likely belonging to big brown *or* silver-haired bats accounted for 10.8% (n=231) of the total sequences recorded, followed by those of big brown (4.4%, n=95) and silver-haired bats (0.5%, n=10).

Species composition differed only slightly between detector locations. Each of the Wallops Island detectors mainly recorded sequences of the RBEP and BBSH guilds, as well as high frequency unknowns likely belonging to species within the RBEP guild (Table 2). Unknown sequences likely to be eastern red bats and eastern red bats *or* eastern pipistrelles dominated at all detectors. Red bat/eastern pipistrelle guild sequences accounted for the majority of those identified to guild or species at all detectors except the North Marsh detector, where BBSH sequences were in slight majority over RBEP sequences. Overall, the majority of RBEP, and eastern red bat sequences in particular, were recorded at the Marsh detectors.

Table 2. Summary of the composition of recorded bat call sequences.

Detector	Guild					Total
	Hoary bat	Big brown/silver-haired bat	Red bat/ E. pipistrelle	Myotis	Unknown	
North Marsh	3	157	135	1	448	744
South Marsh	2	146	404	8	583	1,143
Tower East	4	14	17	0	64	99
Tower West	8	19	40	1	86	154
Total	***17***	***336***	***596***	***10***	***1,181***	***2,140***

Appendix A provides a series of tables with more specific information on the nightly timing, number, and species composition of recorded bat call sequences. Specifically, Appendix A Tables 1 through 4 provide information on the number of call sequences, by guild and suspected species, recorded at each detector and the weather conditions for that night. Results of acoustic surveys must be interpreted with caution. Considerable room for error exists in identification of bats based upon acoustic calls alone, especially if a site or regionally specific library of recorded reference calls is not available. Since a site specific or regional call libarary is not available, Stantec used its library of calls collected throughout the mid-Atlantic region as a baseline for comparison. Also, detection rates are not necessarily correlated with the actual numbers of bats in an area, because it is not possible to differentiate between individual bats (Hayes 2000). Stantec can provide NASA with a digital file of all acoustic calls, including all information about species identification and timing of calls from each detector on hourly and nightly basis, should that information be desired.

2.5 DISCUSSION

When data from all four Wallops Island detectors were pooled, bat activity appeared to peak in mid-August. Eastern red bats, high frequency unknown sequences mainly likely to be eastern red bats, and species within the BBSH guild primarily accounted for peaks in activity between August 13 and 16.

The majority of call sequences could not be identified to guild or species, however, due to short call sequences (less than five pulses) or poor call signature formation, often a result of bats flying at the edge of the detection zone of the detector or flying away from the microphone. The relatively small area sampled by bat detectors makes scenarios leading to un-identifiable call sequences common, but some information can still be gleaned from these recordings. The majority of unknown calls were high frequency unknowns likely to be eastern red bats or sequences just as likely belonging to eastern red bats as eastern pipistrelles. Low frequency unknowns were just as likely to be big brown as silver-haired bat sequences.

Bat activity appeared to vary by time of night, with peaks in activity occurring between 21:00 and 23:00. Patterns of bat activity within nights can vary, and anywhere from one to several peaks of activity have been documented. Several factors – such as sampling effort and detector location (e.g., Hayes 1997), and seasonal patterns in weather conditions, insect abundance and life history of bats (e.g., Anthony *et al.* 1981, Rautenbach 1996) may explain the overall nightly timing of bat activity. The unique factors associated with any acoustic bat survey with regard to effort, location, weather, prey abundance and other factors make it important to evaluate each dataset upon its own content.

The overall mean detection rate during the summer-fall 2008 survey period was 9.3 calls/detector-night. Summer-fall data in coastal marshland areas were not available for comparison with data from the Wallops Island survey. The fact that data recorded at the Wallops Island site were dominated by eastern red bat sequences and unknown sequences potentially belonging to eastern red bats is not surprising given seasonal distribution records for this species. When investigating the seasonal distribution of migratory tree-roosting bats in North America, Cryan (2003) suggested southward fall coastline migration (August-November) along the eastern seaboard may occur in eastern red bats[2]. However, it is important to keep in mind that although no call sequences recorded during this survey were definitively identified as those of evening bats, the possibility that this species may account for some of the sequences classified as eastern red bats does exist.

When considering the level of activity documented at the Wallops Island Project during the summer-fall 2008 acoustic survey, it is important to acknowledge that numbers of recorded bat call sequences are not necessarily correlated with number of bats in an area. Acoustic detectors do not allow for differentiation between a single bat making multiple passes and multiple bats each recorded a single time (Hayes 2000, Kunz *et al*. 2007). Similarly, acoustic interference can make detection of bats in certain areas difficult, lowering the estimate of acoustic activity. Furthermore, calls of some bats, such as Rafinesque's big-eared bat, are not as detectable as calls of other bats, limiting the inferences that can be made about the presence or absence of listed species. Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) is the only listed species likely to occur in region of the Project area and surrounding counties (BCI 2001). Although no call sequences likely belonging to Rafinesque's big-eared bats were detected, the bat's distribution range overlaps the location of the Project area, which may provide suitable habitat (VDGIF c2008). However, roosting and foraging data for this species are lacking (BCI 2001). This survey can neither confirm nor exclude the presence of Rafinesque's big-eared bat in the Project area. Despite the limitations of acoustic surveys, patterns in timing and species composition of recorded call sequences can be used to make inferences about seasonal activity of bats.

[2] Cryan (2003) collected distribution data from museum specimens. Seasonal distribution maps of migratory tree-roosting species were interpreted according to the seasonal presence or absence of these species in different geographic areas.

3.0 Literature Cited

Anthony E. L. P., M. H. Stack, T. H. Kunz. 1981. Night roosting and the nocturnal time budget of the little brown bat, *Myotis lucifugus*: Effects of reproductive status, prey density, and environmental conditions. Oecologia 51:151–6.

Arnett, E. B., 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.

Arnett, E. B., J. P. Hayes, and M. M. P. Huso. 2006. An evaluation of the use of acoustic monitoring to predict bat fatality at a proposed wind facility in south central Pennsylvania. An annual report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Bat Conservation International (BCI). 2001. Bats in Eastern Woodlands. Bat Conservation International, Austin, Texas.

Cryan, P.M. 2003. Seasonal distribution of migratory tree bats (*Lasiurus* and *Lasionycteris*) in North America. Journal of Mammalogy 84:579-593.

Cryan, P.M., M.A. Bogan, R.O. Rye, G.P. Landis, C.L. Kester. 2004. Stable hydrogen isotope analysis of bat hair as evidence for seasonal molt and long-distance migration. Journal of Mammalogy 85, 995–1001.

Cryan P.M. and A.C. Brown. 2007. Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. Biological Conservation, Vol 139, I-II.

Gannon, W.L., R.E. Sherwin, and S. Haywood. 2003. On the importance of articulating assumptions when conducting acoustic studies of habitat use by bats. Wild. Soc. Bull. 31 (1):45–61.

Hayes J. P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammalogy 78:514–24.

Hayes, J.P. 2000. Assumptions and practical considerations in the design and interpretation of echolocation-monitoring studies. Acta Chiropterologica 2(2):225-236.

Hayes, J.P. and J.C. Gruver. 2000. Vertical stratification of activity of bats in an old-growth forest in western Washington. Northwest Science, 74:102-108.

Johnson, G. D., M. K. Perlik, W. E. Erickson, and M. D. Strickland. 2005. Bat activity, composition, and collision mortality at a large wind plant in Minnesota. Wildlife Society Bulletin 32:1278–1288.

Kunz, T.H., E.B. Arnett, W.P. Erickson, A.R. Hoar, G.D. Johnson, R.P. Larkin, M.D. Strickland, R.W. Thresher, and M.D. Tuttle. 2007a. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5:315-324.

Kunz, T.H., E.B. Arnett, B.P. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, and J.M. Szewczak. 2007b. Assessing impacts of wind-energy development on nocturnally active birds and bats: A guidance document. Journal of Wildlife Management 71:2449-2486.

URS Group, Inc. (URS) and EG&G Technical Services (EG&G). 2005. Final Site-Wide Environmental Assessment for Wallops Flight Facility. Prepared for the National Aeronautics and Space Administration's (NASA) Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF), Wallops Island, Virginia. January 2005.

O'Farrell, M.J., and W.L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80(1):24–30.

O'Farrell, M.J., B.W. Miller, and W.L. Gannon. 1999. Qualitative identification of free-flying bats using the anabat detector. Journal of Mammalogy 80(1):11–23.

Rautenbach, I.L., Fenton, M.B. and Whiting, M.J. 1996. Bats in riverine forests and woodlands: a latitudinal transect in southern Africa. Canadian Journal of Zoology 74: 312-322.

Reynolds, D. S. 2006. Monitoring the potential impacts of a wind development site on bats in the Northeast. Journal of Wildlife Management 70(5):1219 – 1227.

Richardson, W.J. 1998. Bird migration and wind turbines: migration timing, flight behavior, and collision risk. Proceedings: National Avian-Wind Power Planning Meeting III, sponsored by Avian Workgroup of the National Wind Coord. Comm., June 2000.

U.S. Fish and Wildlife Service (USFWS) [Internet]. Wallops Island National Wildlife Refuge. (c2008; accessed on October 23, 2008). Available at: http://www.fws.gov/refuges/profiles/index.cfm?id=51571.

U.S. Fish and Wildlife Service (USFWS). 2007. Indiana Bat (Myotis sodalist) Draft Recovery Plan: First Revision. U.S. Fish and Wildlife Service, Fort Snelling, MN.

Virginia Department of Game and Inland Fisheries (VDGIF) [Internet]. Virginia Fish and Wildlife Information Service (c2008; accessed on October 28, 2008). Available at:

http://www.vafwis.org/fwis/booklet.html?Menu=_.County+Occurrence&bova=050034.

Appendix A

Bat survey results

Appendix A Table 1. Summary of acoustic bat data and weather during each survey night at the North Marsh detector - Summer-Fall 2008

		HB	BBSH			RBEP			MYSP	UNKN			
Night of	Operated Okay?	hoary bat	big brown bat	silver-haired bat	silver-haired/big brown	eastern pipistrelle	eastern red bat	pipistrelle/red bat	MYSP	high-frequency	low-frequency	unknown	Total
7/15/07	yes		1		5					5	4		**15**
7/16/07	yes		3		5		1			5	2		**16**
7/17/07	yes						2			2			**4**
7/18/07	yes												**0**
7/19/07	yes												**0**
7/20/07	yes				1		3			5	1		**10**
7/21/07	yes						2			4			**6**
7/22/07	yes						2			7	1		**10**
7/23/07	yes									1			**1**
7/24/07	yes		2	1	4		5			12	8		**32**
7/25/07	yes			1	10		2			2	9		**24**
7/26/07	yes									1			**1**
7/27/07	yes						1			4	1		**6**
7/28/07	yes		2		4		3			11	4		**24**
7/29/07	yes						1	1		2	1		**5**
7/30/07	yes									2			**2**
7/31/07	yes	1	2		5		5			21	5		**39**
8/1/07	yes				1		3			7	1		**12**
8/2/07	yes				1		4			9			**14**
8/3/07	yes		2		3		2	1		14	3		**25**
8/4/07	yes		1		2		3		1	6	2		**15**
8/5/07	no												**0**
8/6/07	no												**0**
8/7/07	no												**0**
8/8/07	no												**0**
8/9/07	no												**0**
8/10/07	no												**0**
8/11/07	no												**0**
8/12/07	yes		2		4		4			16	2		**28**
8/13/07	yes		5		8		6			23	4		**46**
8/14/07	yes						2			4			**6**
8/15/07	yes				3		16			32	2		**53**
8/16/07	yes		4		26		17	3		26	5		**81**
8/17/07	yes						3	1		4	1		**9**
8/18/07	yes												**0**
8/19/07	yes				2					3			**5**
8/20/07	yes	1			2		2			12	1		**18**
8/21/07	no												**0**
8/22/07	yes				1		2			11			**14**
8/23/07	yes				3		2			4			**9**
8/24/07	yes									2			**2**
8/25/07	yes									1			**1**
8/26/07	yes							1		7			**8**
8/27/07	yes												**0**
8/28/07	yes												**0**
8/29/07	yes									5			**5**
8/30/07	yes				1		5			6			**12**
8/31/07	yes		4		6		4			11	7		**32**
9/1/07	yes		9		4		1			10	3		**27**
9/2/07	yes						2			13			**15**
9/3/07	yes						1			3	1		**5**
9/4/07	yes												**0**
9/5/07	no												**0**
9/6/07	no												**0**
9/7/07	no												**0**
9/8/07	no												**0**
9/9/07	no												**0**
9/10/07	no												**0**
9/11/07	yes									1			**1**
9/12/07	yes									1			**1**
9/13/07	yes				1		4			6			**11**
9/14/07	yes												**0**
9/15/07	yes									1			**1**
9/16/07	yes		1				1			7	3		**12**
9/17/07	yes	1	1	1	2		3			5	2		**15**
9/18/07	yes		1				3			3			**7**
9/19/07	yes						1			1			**2**
9/20/07	yes									3			**3**
9/21/07	yes						1			2			**3**
9/22/07	yes												**0**
9/23/07	yes												**0**
9/24/07	yes												**0**
9/25/07	yes												**0**
9/26/07	yes									1			**1**
9/27/07	yes									1			**1**
9/28/07	yes				1		2			1			**4**
9/29/07	yes									2			**2**
9/30/07	yes						1			4			**5**
10/1/07	yes									1			**1**
10/2/07	no												**0**
10/3/07	no												**0**
10/4/07	no												**0**
10/5/07	no												**0**
10/6/07	no												**0**
10/7/07	no												**0**
10/8/07	no												**0**
10/9/07	no												**0**
10/10/07	no												**0**
10/11/07	no												**0**
10/12/07	no												**0**
10/13/07	no												**0**
10/14/07	no												**0**
10/15/07	yes									2			**2**
10/16/07	yes			2	3		4			9	2		**20**
10/17/07	yes				1					1			**2**
10/18/07	yes									1			**1**
10/19/07	yes						1			1			**2**
10/20/07	yes									2			**2**
10/21/07	yes			1	2		1			4			**8**
By Species		**3**	**40**	**6**	**111**	**0**	**128**	**7**	**1**	**373**	**75**	**0**	**744**
By Guild		**3**	**157**			**135**			**1**	**448**			
		HB	**BBSH**			**RBEP**			**MYSP**	**UNKN**			**Total**

Appendix A Table 2. Summary of acoustic bat data and weather during each survey night at the South Marsh detector - Summer-Fall 2008

		HB	BBSHHB			RBEP			MYSP	UNKN			
Night of	Operated Okay?	hoary bat	big brown bat	silver-haired bat	silver-haired/big brown	eastern pipistrelle	eastern red bat	pipistrelle/red bat	MYSP	high-frequency	low-frequency	unknown	Total
7/15/07	yes		2		6		1			2	2		**13**
7/16/07	yes		3				3				1		**7**
7/17/07	yes									1	1		**2**
7/18/07	yes									1			**1**
7/19/07	yes												**0**
7/20/07	yes		1		1								**2**
7/21/07	yes				1					6	1		**8**
7/22/07	yes		1		2		2			3	5		**13**
7/23/07	yes												**0**
7/24/07	yes		8		8		10	2		5	5		**38**
7/25/07	yes		6		10		6	2		7	5		**36**
7/26/07	yes									1			**1**
7/27/07	yes						1			8	1		**10**
7/28/07	yes	1	5		8	1	15		1	4	6		**41**
7/29/07	yes						3	1		6	2		**12**
7/30/07	yes						2			1			**3**
7/31/07	yes		2		6		13	3		10	4		**38**
8/1/07	yes				3		17	3		19	2		**44**
8/2/07	yes		1				5	1		13			**20**
8/3/07	yes		3		4		3	3		10	4		**27**
8/4/07	yes				6		23	3		12	1		**45**
8/5/07	no												**0**
8/6/07	no												**0**
8/7/07	no												**0**
8/8/07	no												**0**
8/9/07	no												**0**
8/10/07	no												**0**
8/11/07	no												**0**
8/12/07	yes						19			15	4		**38**
8/13/07	yes		1		6		45			54	8		**114**
8/14/07	yes									5			**5**
8/15/07	yes				8		88	2		67	5		**170**
8/16/07	yes		4		11		21			16	6		**58**
8/17/07	yes					1	2	1		4	1		**9**
8/18/07	yes	1			1			1		4	5		**12**
8/19/07	yes				2		5			2	5		**14**
8/20/07	yes						3			8			**11**
8/21/07	no												**0**
8/22/07	yes						5	1		12			**18**
8/23/07	yes						3	3		10	1		**17**
8/24/07	yes				1					1			**2**
8/25/07	yes				1		1			1			**3**
8/26/07	yes						3			9			**12**
8/27/07	yes												**0**
8/28/07	yes												**0**
8/29/07	yes						2		4	10			**16**
8/30/07	yes				3	1	6	1	1	9	2		**23**
8/31/07	yes		2		2		1			6	7		**18**
9/1/07	yes				3		1			7	9		**20**
9/2/07	yes		1		1					2	2		**6**
9/3/07	yes						1	1		3			**5**
9/4/07	yes									2			**2**
9/5/07	no												**0**
9/6/07	no												**0**
9/7/07	no												**0**
9/8/07	no												**0**
9/9/07	no												**0**
9/10/07	no												**0**
9/11/07	yes									2			**2**
9/12/07	yes									2		2	**4**
9/13/07	yes						1	1		1			**3**
9/14/07	yes												**0**
9/15/07	yes						3			4			**7**
9/16/07	yes				1					5		1	**7**
9/17/07	yes				6					2	3	1	**12**
9/18/07	yes						1			1		1	**3**
9/19/07	yes						1			1			**2**
9/20/07	yes						19	2		22			**43**
9/21/07	yes						5			11			**16**
9/22/07	yes						1						**1**
9/23/07	yes						1			1			**2**
9/24/07	yes												**0**
9/25/07	yes												**0**
9/26/07	yes									2			**2**
9/27/07	yes						5	13		26			**44**
9/28/07	yes									3	1	2	**6**
9/29/07	yes				2					1			**3**
9/30/07	yes									1			**1**
10/1/07	yes				2		1			4	1	1	**9**
10/2/07	no												**0**
10/3/07	no												**0**
10/4/07	no												**0**
10/5/07	no												**0**
10/6/07	no												**0**
10/7/07	no												**0**
10/8/07	no												**0**
10/9/07	no												**0**
10/10/07	no												**0**
10/11/07	no												**0**
10/12/07	no												**0**
10/13/07	no												**0**
10/14/07	no												**0**
10/15/07	yes						3		1	10			**14**
10/16/07	yes						3			6	3		**12**
10/17/07	yes										1		**1**
10/18/07	yes			1			2			3	2		**8**
10/19/07	yes									2			**2**
10/20/07	yes												**0**
10/21/07	yes						1		1	3			**5**
By Species		**2**	**40**	**1**	**105**	**3**	**357**	**44**	**8**	**469**	**106**	**8**	**1143**
By Guild		**2**	**146**			**404**			**8**	**583**			
		HB	**BBSH**			**RBEP**			**MYSP**	**UNKN**			**Total**

Appendix A Table 3. Summary of acoustic bat data and weather during each survey night at the Tower East detector – Summer-Fall 2008

		HB	BBSH			RBEP			MYSP	UNKN			
Night of	Operated Okay?	hoary bat	big brown bat	silver-haired bat	silver-haired/big brown	eastern pipistrelle	eastern red bat	pipistrelle/red bat	MYSP	high-frequency	low-frequency	unknown	Total
7/30/07	no												**0**
7/31/07	no												**0**
8/1/07	no												**0**
8/2/07	no												**0**
8/3/07	no												**0**
8/4/07	no												**0**
8/5/07	no												**0**
8/6/07	no												**0**
8/7/07	no												**0**
8/8/07	no												**0**
8/9/07	no												**0**
8/10/07	no												**0**
8/11/07	no												**0**
8/12/07	yes	1					4			6	2		**13**
8/13/07	yes	2	9		1		3			7	8		**30**
8/14/07	no												**0**
8/15/07	no												**0**
8/16/07	no												**0**
8/17/07	no												**0**
8/18/07	no												**0**
8/19/07	no												**0**
8/20/07	no												**0**
8/21/07	no												**0**
8/22/07	no												**0**
8/23/07	no												**0**
8/24/07	no												**0**
8/25/07	no												**0**
8/26/07	no												**0**
8/27/07	no												**0**
8/28/07	no												**0**
8/29/07	no												**0**
8/30/07	no												**0**
8/31/07	no												**0**
9/1/07	no												**0**
9/2/07	no												**0**
9/3/07	no												**0**
9/4/07	no												**0**
9/5/07	no												**0**
9/6/07	no												**0**
9/7/07	no												**0**
9/8/07	no												**0**
9/9/07	no												**0**
9/10/07	no												**0**
9/11/07	no									2			**2**
9/12/07	no						1			1			**2**
9/13/07	no									5	1		**6**
9/14/07	no									1			**1**
9/15/07	yes	1			1		1	1		6	1		**11**
9/16/07	no												**0**
9/17/07	no												**0**
9/18/07	no												**0**
9/19/07	no												**0**
9/20/07	no												**0**
9/21/07	no												**0**
9/22/07	no												**0**
9/23/07	no												**0**
9/24/07	no												**0**
9/25/07	no												**0**
9/26/07	no												**0**
9/27/07	no												**0**
9/28/07	no												**0**
9/29/07	no												**0**
9/30/07	no												**0**
10/1/07	no												**0**
10/2/07	no												**0**
10/3/07	no												**0**
10/4/07	no												**0**
10/5/07	no												**0**
10/6/07	no												**0**
10/7/07	no												**0**
10/8/07	no												**0**
10/9/07	no												**0**
10/10/07	no												**0**
10/11/07	no												**0**
10/12/07	no												**0**
10/13/07	no												**0**
10/14/07	no												**0**
10/15/07	yes						4			5			**9**
10/16/07	yes			1						7	1		**9**
10/17/07	yes										1		**1**
10/18/07	yes												**0**
10/19/07	yes						1						**1**
10/20/07	yes						2			2			**4**
10/21/07	yes			1	1					8			**0**
By Species		**4**	**9**	**2**	**3**	**0**	**16**	**1**	**0**	**50**	**14**	**0**	**99**
By Guild		**4**	**14**			**17**			**0**	**64**			**99**
		HB	**BBSH**			**RBEP**			**MYSP**	**UNKN**			**Total**

Appendix A Table 4. Summary of acoustic bat data and weather during each survey night at the Tower West detector – Summer-Fall 2008

		HB	BBSH			RBEP			MYSP	UNKN			
Night of	Operated Okay?	hoary bat	big brown bat	silver-haired bat	silver-haired/big brown	eastern pipistrelle	eastern red bat	pipistrelle/red bat	MYSP	high-frequency	low-frequency	unknown	Total
7/30/07	yes						1			1			**2**
7/31/07	yes		1		2		5			5	4		**17**
8/1/07	yes		1		3		7			4	1		**16**
8/2/07	yes												**0**
8/3/07	yes												**0**
8/4/07	yes												**0**
8/5/07	yes		1		1		1			4	1		**8**
8/6/07	yes	1	1		3		6			19	4		**34**
8/7/07	yes						2			3	2		**7**
8/8/07	yes	4	1		3					2	3		**13**
8/9/07	yes	3					4			5	3		**15**
8/10/07	yes												**0**
8/11/07	yes												**0**
8/12/07	yes												**0**
8/13/07	yes												**0**
8/14/07	yes												**0**
8/15/07	yes												**0**
8/16/07	yes												**0**
8/17/07	yes												**0**
8/18/07	yes												**0**
8/19/07	yes												**0**
8/20/07	yes												**0**
8/21/07	yes												**0**
8/22/07	yes						1			1			**2**
8/23/07	yes						3			1			**4**
8/24/07	yes												**0**
8/25/07	yes		1				6			10			**17**
8/26/07	n/o												**0**
8/27/07	no												**0**
8/28/07	no												**0**
8/29/07	no												**0**
8/30/07	no												**0**
8/31/07	no												**0**
9/1/07	no												**0**
9/2/07	no												**0**
9/3/07	no												**0**
9/4/07	no												**0**
9/5/07	no												**0**
9/6/07	no												**0**
9/7/07	no												**0**
9/8/07	no												**0**
9/9/07	no												**0**
9/10/07	no												**0**
9/11/07	no												**0**
9/12/07	no												**0**
9/13/07	no												**0**
9/14/07	no												**0**
9/15/07	no												**0**
9/16/07	no												**0**
9/17/07	no												**0**
9/18/07	no												**0**
9/19/07	no												**0**
9/20/07	no												**0**
9/21/07	no												**0**
9/22/07	yes												**0**
9/23/07	yes							1					**1**
9/24/07	yes												**0**
9/25/07	yes												**0**
9/26/07	yes									1			**1**
9/27/07	yes												**0**
9/28/07	yes									5			**5**
9/29/07	yes			1			3			7			**11**
9/30/07	yes												**0**
10/1/07	yes												**0**
10/2/07	no												**0**
10/3/07	no												**0**
10/4/07	no												**0**
10/5/07	no												**0**
10/6/07	no												**0**
10/7/07	no												**0**
10/8/07	no												**0**
10/9/07	yes												**0**
10/10/07	yes								1				**1**
10/11/07	yes												**0**
10/12/07	yes												**0**
10/13/07	yes												**0**
10/14/07	yes												**0**
10/15/07	no												**0**
10/16/07	no												**0**
10/17/07	no												**0**
10/18/07	no												**0**
10/19/07	no												**0**
10/20/07	no												**0**
10/21/07	no												**0**
By Species		**8**	**6**	**1**	**12**	**0**	**39**	**1**	**1**	**68**	**18**	**0**	**154**
By Guild		**8**	**19**			**40**			**1**	**86**			**154**
		HB	**BBSH**			**RBEP**			**MYSP**	**UNKN**			**Total**