
***SCITUATE WIND COMPLIANCE SOUND
MONITORING STUDY***

SCITUATE, MASSACHUSETTS

June 2015

**SCITUATE WIND
COMPLIANCE SOUND MONITORING
STUDY**

SCITUATE, MASSACHUSETTS

Prepared for:

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EXECUTIVE SUMMARY

Tech Environmental, Inc. (Tech) performed a compliance sound monitoring study for the Sinovel SL1500 1.5-MW wind turbine (80-meter hub height) owned by Scituate Wind, LLC (Scituate Wind) at 161 Driftway adjacent to the Scituate Wastewater Treatment Plant. The primary goal of this work is to verify that the turbine complies with the Massachusetts Department of Environmental Protection's (MassDEP) Noise Policy and the Department's current compliance monitoring approach adopted for wind turbine projects (turbine-ON L_{max} compared to turbine-OFF L_{90}). Tech also performed a secondary compliance evaluation (turbine-ON L_{90} compared to turbine-OFF L_{90}). This report presents the monitoring locations, monitoring procedures, data analyses and results.

Tech prepared a sound monitoring protocol that was approved by the Scituate Board of Health (BoH) and the MassDEP that was later modified by the BoH based on the results of this first round of sound testing performed in August 2013. The BoH ruled that the results of the first round of testing were not sufficient since the sampling conditions were not representative of maximum wind turbine power output. Although the first round test results are not based on a maximum power production scenario, they are valid for a low power production sound event. Tech has included the August 2013 results in this report for purposes of completeness.

After reviewing the results of the second round of sound testing performed in March 2014, the BoH instructed Scituate Wind and Tech that future sound compliance monitoring should capture a southwest wind event when hub wind speeds are between the August 2013 and the March 2014 measurements (i.e., 5 to 11 meters/second). In addition, the BoH eliminated the need to capture sound levels for both low and high tide events.

In advance of each sampling event, Tech notified the BoH, Scituate Wind and residents at whose properties monitoring was to be conducted. Tech performed four rounds of sound monitoring over a 22-month period from August 2013 to May 2015. Sound monitoring was performed to collect ambient turbine OFF and turbine ON sound level measurements at the following monitoring locations:

- 151 Driftway (Closest Residence)
- 56 Moorland Road (East of Turbine)
- 122 Gilson Road (East of Turbine)
- 149 Gilson Road (East of Turbine)
- 127 Gilson Road (East of Turbine)

The results in this report include sound sampling conducted on four nights during the quiet late evening and overnight hours. Since the sound monitoring was attended, the study was able to focus directly on sound from the wind turbine and remove any measurements in which sound levels were dominated by other sources of sound. Note that the MassDEP compliance monitoring approach for wind turbines does not eliminate all noise contamination (peak or continuous) from the turbine-ON levels, and thus, the sound levels from Scituate Wind are over-stated by this method.

Sound monitoring was performed for four turbine-operating scenarios:

1. **Light west wind condition and low power production:** Average hub height wind speeds ranged from 4.5 to 5.5 m/s (10.1 to 12.3 mph); average power production ranged from 225.7 to 416.3 kW (15-28% of maximum power production), and average 10-meter wind speeds ranged from 0 to 1.3 m/s (0 to 3 mph). The tide was low.
2. **Light south-southwest wind, inversion condition and low- to mid-range power production:** Average hub height wind speeds ranged from 3.8 to 7.8 m/s (8.5 to 17.5 mph); average power production ranged from 157.6 to 950.2 kW (11-63% of maximum power production), and average 10-meter wind speeds ranged from 0 to 1.6 m/s (0 to 3.5 mph). Sampling occurred during an intermediate tide event (low to high).
3. **Moderate southwest wind condition and mid-range power production:** Average hub height wind speeds ranged from 10.4 to 11.3 m/s (23.3 to 25.2 mph); average power production ranged from 827.5 kW to 1,047.8 kW (55-70% of maximum power production), and average 10-meter wind speeds ranged from 4.7 m/s to 6.7 m/s (10.4 to 15.0 mph). The tide was high.
4. **Strong southwest wind condition and maximum power production:** Average hub height wind speeds ranged from 10.2 to 12.9 m/s (22.8 to 28.9 mph); average power production ranged from 1420.5 to 1518.0 kW (95-101% of maximum power production), and average 10-meter wind speeds ranged from 3.6 to 6.7 m/s (8 to 15 mph). The tide was high.

Table 1 presents a summary of the sound monitoring results including wind, tide cycle and turbine production data for each sampling round. For the four turbine operating scenarios, Tech collected 120 (five-minute) measurements (60 with turbine-ON and 60 with turbine-OFF). A comparison of the L_{\max} -to- L_{90} for the four sampling rounds reveal that the incremental change in sound levels ranged from NA to 9.0 dBA and the comparison of the L_{90} -to- L_{90} for the four sampling round reveal that the incremental change in sound levels ranged from 0.5 to 7.2 dBA. The results reveal that all 60 turbine-ON measurements comply with the MassDEP 10 dB(A) above ambient sound limit, pursuant to 310 CMR 7.10. In addition, results of the octave band analysis demonstrate that operation of the wind turbine does not contribute to a pure tone condition under any of the four sampling conditions.

A compliance sound monitoring study was performed for the Scituate Wind turbine under four different wind and turbine power production conditions and under three different tidal conditions (low, intermediate and high). The results confirm that Scituate Wind fully complies with all requirements of the MassDEP Noise Policy.

TABLE 1

SUMMARY OF SOUND MONITORING RESULTS

WIND, TIDE and TURBINE POWER PRODUCTION															
Parameters	August 14-15, 2013 Sampling			March 15, 2014 Sampling			June 3, 2014 Sampling			May 5, 2015 Sampling			All Sampling Rounds		
Turbine-ON Hub Height Wind Speed	4.5 to 5.5 m/s (10.1 to 12.3 mph)			10.2 to 12.9 m/s (22.8 to 28.9 mph)			3.8 to 7.8 m/s (8.5 to 17.5 mph)			10.4 to 11.3 m/s (23.3 to 25.2 mph)			3.8-12.9 m/s (8.5 to 28.9 mph)		
10-Meter Wind Speed Range	0 to 1.3 m/s (0 to 3 mph)			3.6 to 6.7 m/s (8 to 15 mph)			0 to 1.6 m/s (0 to 3.5 mph)			4.7 to 6.7 m/s (10.4 to 15.0 mph)			0 to 6.7 m/s (0 to 15 mph)		
Wind Direction	Westerly ⁽¹⁾			South-Southwest ⁽²⁾			South-Southwest ⁽²⁾			Southwest ⁽¹⁾			West, South-Southwest, Southwest		
Tide Condition	Low			High			Intermediate			High			Low, High, Intermediate		
Turbine-ON Production	225.7-416.3 kW; (15-28% of max. power)			1420.5 -1,518.0 kW; (95-101% of max. power)			157.6-950.2 kW; (11-63% of max. power)			827.5-1,047.8 kW; (55-70% of max. power)			157.6-1518.0 kW		
L _{max} to L ₉₀ COMPARISON															
Residential Location	August 14-15, 2013 Sampling			March 15, 2014 Sampling			June 3, 2014 Sampling			May 5, 2015 Sampling			All Sampling Rounds		
	5-Minute Ambient L ₉₀ Level (Turbine OFF)	1-Second L _{max} Level (Turbine ON)	Net Increase	5-Minute Ambient L ₉₀ Level (Turbine OFF)	1-Second L _{max} Level (Turbine ON)	Net Increase	5-Minute Ambient L ₉₀ Level (Turbine OFF)	1-Second L _{max} Level (Turbine ON)	Net Increase	5-Minute Ambient L ₉₀ Level (Turbine OFF)	1-Second L _{max} Level (Turbine ON)	Net Increase	Minimum Net Increase	Maximum Net Increase	
#151 Driftway	49.0	50.5	1.5	44.8	51.8	7.0	41.2	47.0	5.8	42.2	51.2	9.0	1.5	9.0	
#56 Moorland Road	34.8	38.7	3.9	47.3	NA	NA	36.8	40.6	3.8	46.0	48.1	2.1	NA	3.9	
#149 Gilson Road	33.6	35.2	1.6	40.5	45.9	5.4	36.0	42.5	6.5	42.5	43.6	1.1	1.1	6.5	
#122 Gilson Road	31.2	34.5	3.3	41.7	43.9	2.2	37.1	42.7	5.6	40.2	42.4	2.2	2.2	5.6	
#127 Gilson Road	35.3	36.4	1.1	38.0	43.0	5.0	38.4	42.5	4.1	40.6	NA	NA	NA	5.0	
L ₉₀ to L ₉₀ COMPARISON															
Residential Location	August 14-15, 2013 Sampling			March 15, 2014 Sampling			June 3, 2014 Sampling			May 5, 2015 Sampling			All Sampling Rounds		
	5-Minute Ambient L ₉₀ Level (Turbine OFF)	5-Minute L ₉₀ Level (Turbine ON)	Net Increase	5-Minute Ambient L ₉₀ Level (Turbine OFF)	5-Minute L ₉₀ Level (Turbine ON)	Net Increase	5-Minute Ambient L ₉₀ Level (Turbine OFF)	5-Minute L ₉₀ Level (Turbine ON)	Net Increase	5-Minute Ambient L ₉₀ Level (Turbine OFF)	5-Minute L ₉₀ Level (Turbine ON)	Net Increase	Minimum Net Increase	Maximum Net Increase	
#151 Driftway	49.0	49.9	0.9	44.8	50.9	6.1	41.2	44.9	3.7	42.2	49.4	7.2	0.9	7.2	
#56 Moorland Road	34.8	37.6	2.8	47.3	NA	NA	36.8	38.0	1.2	46.0	48.4	2.4	NA	2.8	
#149 Gilson Road	33.6	35.2	1.6	40.5	43.7	3.2	36.0	39.9	3.9	42.5	43.2	0.7	0.7	3.9	
#122 Gilson Road	31.2	33.0	1.8	41.7	42.2	0.5	37.1	40.6	3.5	40.2	42.7	2.5	0.5	3.5	
#127 Gilson Road	35.3	35.9	0.6	38.0	42.0	4.0	38.4	41.7	3.3	40.6	NA	NA	NA	4.0	
⁽¹⁾ 10 meter wind speed and direction from Marshfield Airport															
⁽²⁾ 10 meter wind speed and direction from NWS Plymouth Airport as Marshfield Airport data not available															
NA = Turbine was inaudible above background noise during the sampling period.															

1.0 INTRODUCTION

On January 28, 2013, the Scituate Board of Health (BoH) requested that Scituate Wind, LLC (Scituate Wind) undertake an acoustical study regarding the wind turbine installed by Scituate Wind at 161 Driftway on property of the Town Wastewater Treatment Plant. On March 28, 2013, the BoH selected Tech Environmental, Inc (Tech) in Waltham, MA to perform an unbiased and independent sound monitoring study to determine whether the Scituate Wind turbine conforms with the provisions of the Massachusetts Department of Environmental Protection Division of Air Quality Noise Regulations (310 CMR 7.10).

Tech prepared a sound monitoring protocol, dated April 3, 2013¹ that was approved by the BoH and the MassDEP^{2,3}. At the September 11, 2013 Scituate BoH meeting, the BoH modified the sound compliance monitoring approach based on the results of the first round of sound testing performed on August 14 and 15, 2013 and comments from neighbors as follows:

- Sample southwest and not west wind events for monitoring locations east of the turbine.
- Sampling should not commence before midnight.
- The turbine needs to be producing a minimum of 60% (900 kilowatts) power production at midnight to proceed with the sound testing. If the turbine is not at that power production level, then the sound test is cancelled for that night.

After reviewing the results of the second round of sound testing performed on March 15, 2014, the BoH instructed Scituate Wind and Tech that future sound compliance monitoring should capture a southwest wind event when hub wind speeds are between the August 2013 and the March 2014 measurements (i.e., 5 to 11 meters/second). In addition, given the difficulty of capturing the exact wind conditions requested by the neighborhood, the BoH eliminated the need to capture sound levels for both low and high tide events.

¹Tech Environmental, Inc. Sound Monitoring Protocol for the Scituate Wind Turbine, April 2, 2013.

² Scituate BoH email to MassDEP filing the Sound Monitoring Protocol for the Scituate Wind Turbine for review on April 11, 2013.

³Marc Wolman, MassDEP, Sound Monitoring Protocol for the Scituate Wind Turbine, April 26, 2013.

The results in this report include sound sampling conducted on four nights during the quiet late evening and overnight hours. Since the sound monitoring was attended, the study was able to focus directly on sound from the wind turbine and remove any measurements that could be caused by other sources of sound. Sound monitoring was performed for four turbine-operating scenarios:

1. **Light west wind condition and low power production:** Average hub height wind speeds ranged from 4.5 to 5.5 m/s (10.1 to 12.3 mph); average power production ranged from 225.7 to 416.3 kW (15-28% of maximum power production), and average 10-meter wind speeds ranged from 0 to 1.3 m/s (0 to 3 mph). The tide was low.
2. **Light south-southwest wind, inversion condition and low- to mid-range power production:** Average hub height wind speeds ranged from 3.8 to 7.8 m/s (8.5 to 17.5 mph); average power production ranged from 157.6 to 950.2 kW (11-63% of maximum power production), and average 10-meter wind speeds ranged from 0 to 1.6 m/s (0 to 3.5 mph). Sampling occurred during an intermediate tide event (low to high).
3. **Moderate southwest wind condition and mid-range power production:** Average hub height wind speeds ranged from 10.4 to 11.3 m/s (23.3 to 25.2 mph); average power production ranged from 827.5 kW to 1,047.8 kW (55-70% of maximum power production), and average 10-meter wind speeds ranged from 4.7 m/s to 6.7 m/s (10.4 to 15.0 mph). The tide was high.
4. **Strong southwest wind condition and maximum power production:** Average hub height wind speeds ranged from 10.2 to 12.9 m/s (22.8 to 28.9 mph); average power production ranged from 1420.5 to 1518.0 kW (95-101% of maximum power production), and average 10-meter wind speeds ranged from 3.6 to 6.7 m/s (8 to 15 mph). The tide was high.

The results of the compliance sound study documented in this report are specific to the Scituate Wind turbine operating under the weather conditions described above.

The report is divided into seven sections and three appendices. Section 1 presents an introduction describing the compliance sound study. Section 2.0 describes the MassDEP Noise Policy. Section 3.0 presents the sound monitoring locations. Section 4.0 describes the sound monitoring methodology and Section 5.0 presents the data analysis approach. Section 6.0 presents the sound monitoring results and Section 7.0 presents our conclusions. Appendix A provides an example field log sheet. Appendix B provides the turbine-ON L_{\max} -to- L_{90} summary graphs and Appendix C presents the turbine power production and hub height wind speed graphs.

2.0 MASSACHUSETTS DEP NOISE POLICY

The MassDEP regulates noise through 310 CMR 7.10, "Air Pollution Control". In these regulations, "air contaminant" is defined to include sound, and a condition of "air pollution" includes the presence of an air contaminant in such concentration and duration as to "cause a nuisance" or "unreasonably interfere with the comfortable enjoyment of life and property."

Regulation 7.10 prohibits "unnecessary emissions" of noise. The MassDEP Noise Policy (Policy Statement 90-001, February 1, 1990) interprets a violation of this noise regulation to have occurred if the source causes either:

- (1) An increase in the broadband sound pressure level of more than 10 A-weighted decibels (dBA) above the ambient, or
- (2) A "pure tone" condition.

The ambient background level is defined as the background sound level that is exceeded 90 percent of the time (L_{90}) level, as measured during equipment operating hours. A "pure tone" condition occurs when any octave band sound pressure level exceeds both of the two adjacent octave band sound pressure levels by 3 dB or more. These criteria are measured at the property line and the nearest inhabited residence.

Consistent with recent wind turbine sound compliance testing performed by MassDEP, the L_{\max} to L_{90} method was used for this sound compliance monitoring program. See Section 4.0 for a detailed description of the L_{\max} to L_{90} monitoring methodology.

3.0 SOUND MONITORING LOCATIONS



Tech collected ambient (turbine-OFF) and turbine ON sound level measurements on four nights at five locations downwind and generally to the east of the turbine over a 22-month period. The sound monitoring protocol required sound testing for an east wind condition to measure the turbine sound levels for a downwind location west of the turbine (ML6 – 1 Ladds Way). However, as stated in Section 1.0, after the first two rounds of sound sampling, the BoH instructed Scituate Wind and Tech that future sound compliance monitoring should capture southwest wind events, which eliminated the east-wind sampling event and effectively eliminated the ML6 monitoring location.

Table 2 presents the sound monitoring locations and Figure 1 shows these locations on an aerial photograph. Tech contacted each resident where sound monitoring was to take place and received approval to access their properties during each sampling round.

TABLE 2
SOUND MONITORING LOCATIONS

Location No.	Address	Monitoring Location	Latitude	Longitude	Elevation (ft)
ML1	151 Driftway	Front lawn area, west of the residence about 15 feet back from the tree line	42° 10' 36''	70° 43' 38''	32
ML2	56 Moorland Road	Grassy side yard area, 50 feet southwest of the residence	42° 10' 21''	70° 43' 06''	12
ML3	122 Gilson Road	Back yard area, 50 feet west of the residence	42° 10' 41''	70° 43' 03''	53
ML4	149 Gilson Road	Front lawn area, at the corner of Gilson Road and Driftway	42° 10' 35''	70° 43' 02''	50
ML5	127 Gilson Road	Front lawn at end of driveway area	42° 10' 41''	70° 43' 00''	61

Legend

-  Wind Turbine
-  Sound Monitoring Locations



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Figure 1

Sound Monitoring Locations
For the Scituate Wind Turbine
Scituate, MA

4.0 MONITORING METHODOLOGY

This section describes the sound monitoring equipment and sampling procedures implemented for the sound monitoring program.

An ANSI Type 1 (precision) real-time sound analyzer (Bruel & Kjaer 2250) was used to record A-weighted (dBA) broadband sound pressure levels and 10 whole octave band frequencies (16 to 16,000 Hertz) un-weighted linear (dBZ) sound levels at the five residential locations during the first three sampling rounds. Both a B&K 2250 and a Larson Davis Model 831 sound analyzers were used during the fourth sampling round when there were two acoustic engineers collecting sound level measurements. In addition, the B&K 2250 sound analyzer was also setup to collect sound recordings of each turbine-ON measurement. The recording format is 16-bit wave files (extension .wav), which were downloaded onto a PC at Tech's office to be played back afterwards to identify the maximum one-second turbine sound levels.

The sound analyzers were calibrated both before and after each sampling night. Consistent with ANSI Standard S12.9-1993/Part 3, the microphone height was between 1 and 2 meters (m) (3.3 and 6.6 feet) above ground and the microphone was located 7.5 m (25 feet) or farther from any reflecting surface. The microphones were kept at least 1.5 m (5 feet) from any small-dimension reflecting object such as a tree, post, or vegetation. The analyzers were tripod mounted and equipped with a 178-mm (7 inch) wind screen to reduce wind interference across the microphone. The analyzers were set to collect one-second measurements at slow response⁴. Sound measurements were collected during the quietest overnight hours of 11:00 p.m. to 4:00 a.m. The start time of the sampling round was changed to 12:00 a.m. after the first round of sound testing in August 2013.

⁴ The MassDEP requires that the sound meter be set at slow response.

Tech collected alternating series of turbine-ON and turbine-OFF measurements under the following three criteria:

1. No precipitation fell during the monitoring period;
2. Wind directions would generally place the identified residential properties downwind of the turbine – winds from the west and southwest for the East locations; and
3. Wind speeds at the 80-m hub height were consistently above the 3.5 m/s (8 mph) cut-in speed and average wind speeds ranged from 4.5 m/s (10.1 mph) up to 12.9 m/s (28.9 mph) when the turbine was operating during the sound monitoring program. In addition, 10-meter wind speeds ranged from calm to 6.7 m/s (15 mph) during the sound monitoring program.

Tech obtained hub-height wind speed data from Scituate Wind. The 10-meter wind speed and weather data were obtained from the nearest National Weather Service (NWS) station at the Marshfield and Plymouth airports.

As part of the initial sound monitoring protocol, Tech was to monitor tidal cycles based on Scituate Harbor tide charts⁵. Based on guidance provided by the BoH, the nights with a minimum high tide height of 11 feet that would occur during 12:00 a.m. to 4:00 a.m., \pm 1 hour would be targeted for high tide sampling events. Given the difficulty of capturing the wind conditions requested by the neighborhood, the BoH eliminated the need to capture low and high tides for each wind direction after the March 15, 2014 sampling event.

For the purposes of completing the sound monitoring during the quietest hours of the night (12:00 a.m. – 4:00 a.m., \pm 1 hour) at all locations, and consistent with the MassDEP wind turbine monitoring procedures, sampling with the turbine-ON and the turbine-OFF was implemented. Tech collected A-weighted broadband and un-weighted whole octave band measurements with the turbine on and off. Each round of testing at a monitoring location consisted of six measurements as follows: OFF, OFF, OFF, ON, ON, ON. Four sets of turbine-ON and turbine-OFF nighttime measurements were made at five monitoring locations downwind and east of the turbine. Over the four nights of sampling at monitoring locations ML1 through ML5, a total of 24 measurements per location were collected, (12 with the turbine ON and 12 with the turbine OFF).

The MassDEP monitoring method used for recent wind turbine monitoring programs is based on a maximum sound level (turbine-ON L_{max}) to a baseline (turbine-OFF L_{90}) sound level comparison to determine compliance with the MassDEP Noise Policy. MassDEP's monitoring method calls for an acoustic engineer to record A-weighted one-second sound levels on slow response (L_{AS}) shown on the analyzer screen. Every five seconds, the acoustic engineer records this number on field log sheets and selects the highest value over each sample period with the turbine-ON. The arithmetic average of the three highest decibel values represents the L_{max} with the turbine-ON. A similar approach is used to define background sound with the turbine-OFF. L_{AS} sound levels are recorded on log sheets every five seconds and the lowest 10 percent one-second value in each three sample period represents the lowest L_{90} background sound level with the turbine-OFF. In other words, if 180 measurements are taken over three periods, the 18th lowest value represents the L_{90} level used for comparison to the L_{max} . To be consistent with MassDEP's approach, Tech collected one-second L_{eq} ⁶ sound levels that were stored in the analyzer. The L_{eq} sound levels correlate closely to the L_{AS} for wind turbine sound measurements.

The lowest L_{90} sound level measured at each location during the three sample periods with the turbine OFF was used to represent background conditions. In addition to the measurements discussed above, Tech also recorded L_{max} , L_{eq} and L_{90} sound levels for each sampling period for both the turbine-ON and turbine-OFF intervals.

The sound analyzer was set to measure L_{eq} octave band sound levels over each period with turbine-ON. These octave band measurements were used to determine if the wind turbine produces a pure tone.

⁵ <http://ma.us harbors.com/monthly-tides/Massachusetts-Boston%20Harbor,South%20Shore/Scituate%20Harbor>

⁶ The equivalent sound level L_{eq} is the steady-state sound level over a period of time that has the same acoustic energy as the fluctuating sounds that actually occurred during that same period. It is commonly referred to as the energy-average sound level and it includes in its measure all of the sound we hear.

5.0 DATA ANALYSIS

After each sound monitoring event, Tech downloaded the measurements from the B&K sound analyzer to a PC for storage and analysis. As outlined in Section 4.0, the sound analyzers measured A-weighted and whole octave band sound levels from 16 Hz to 20,000 Hz, and logged statistical data (L_{eq} , L_{90} , L_{50} , and L_{10}) for five-minute periods. Consistent with the MassDEP monitoring method, the Tech acoustic engineer flagged other sound sources (e.g., local traffic, leaves rustling, dogs barking, wind gusts, etc.) on data log sheets. (A copy of a log sheet is presented in Appendix A.) Tech discarded one-second measurements with audible noise contamination from the data set before determining the L_{max} sound level. Upon review of the sound recordings and field log sheets, Tech selected the highest one-second L_{eq} sound levels recorded by the sound analyzer for each sample period with the turbine-ON and averaged them to calculate an L_{max} sound level. The data from this screening process were summarized in the turbine-ON L_{max} to L_{90} sound graphs presented in Appendix B. To understand the contribution of the wind turbine to sound levels in each hour, the analysis also examined whether the residences were downwind of the nearest wind turbine for a given hour and the operating level of the turbine. Tech obtained the hub-height power production and wind speed data from Scituate Wind for comparison to ensure that the turbine was operating properly and to screen out any gusty wind conditions that would erroneously increase the apparent sound from the wind turbine. Appendix C presents turbine power production and hub height wind speed graphs for each sampling round.

6.0 SOUND MONITORING RESULTS

Tech performed sound monitoring on four separate nights: August 14-15, 2013, March 15, 2014, June 3, 2014 and May 5, 2015, over a 22-month period. This section of the report presents the results of the broadband and octave band sound measurements for each sampling event.

6.1 Broadband Sounds

The monitoring results presented below presents a comparison of MassDEP's current compliance approach for wind turbine projects (L_{\max} - L_{90}).

Scenario 1: August 14-15, 2014 - Light West Wind Condition and Low Power Production

On the night of Wednesday, August 14, 2013 and into the early morning hours of Thursday, August 15, 2013, sound compliance measurements were made at the five locations between 11:08 p.m. and 2:37 a.m. The tide was low during the sampling event. Weather conditions were favorable for sound monitoring with surface wind speeds as measured at the National Weather Service (NWS) meteorological station located at the airport in Marshfield, MA ranging from 0 to 1.3 m/s (0 to 3 mph) from the west. Skies were clear and the temperatures ranged from 55 to 61°F. The average turbine hub height wind speeds ranged from 4.5 to 5.5 m/s (8.5 to 12.9 mph) and the average power production ranged from 225.7 to 416.3 kW, which is equivalent to 15.0 to 27.8 percent of the turbine's 1500 kW capacity during the turbine-ON measurements. Table 3 presents a summary of the turbine power production and hub height wind speed data. Appendix C presents turbine power production and hub height wind speed data for the entire sampling event.

Tech's acoustic engineer was accompanied by Mr. Gordon Deane (Scituate Wind) to turn the turbine on and off and, for most of the sampling event, Mr. David Dardi (a neighborhood representative from 122 Gilson Road). Wind speed conditions were lower than predicted, but the turbine was operating above cut-in wind speed of 3.5 m/s, and the wind speeds at the surface were near calm. At the start of the sampling, power production was around 200 kW. Although conditions were not ideal for capturing maximum turbine power output and sound levels, it appeared these weather conditions are coincident with times when neighbors complained the most about the turbine noise (i.e., temperature inversion with the turbine operating and calm conditions at the surface). The sampling

proceeded at the first location at 151 Driftway with the expectation that hub height wind speeds and power production would increase as the testing proceed through the night.

Table 4 shows that the lowest background L_{90} sound levels with the turbine-OFF ranged from 31.2 dBA at 122 Gilson Road to 49.0 dBA at 151 Driftway. These sound levels represent the lowest of the three five-minute averages at each monitoring location. Background human and natural sound sources observed at each monitoring location included cars passing by along Driftway and other nearby roadways, aircraft flyovers and insect noise, especially at 151 Driftway. In addition, the Town's wastewater treatment plant operations could be heard at 151 Driftway. Appendix B presents summary graphs of the all the turbine-OFF one-second sound levels.

The highest one-second L_{max} sound levels with the turbine-ON ranged from 34.5 dBA at 122 Gilson Road to 50.5 dBA at 151 Driftway. The incremental change in sound levels ranged from 1.1 dBA at 127 Gilson Road to 3.9 dBA at 56 Moorland Road. These sound level increases are below the MassDEP Noise Policy's 10-dBA allowable incremental change (See Table 4). Appendix B presents summary graphs of the all the turbine-ON one-second sound levels.

Tech also performed a secondary compliance evaluation (L_{90} to L_{90}) with and without the Turbine-ON for comparison purposes. The five-minute L_{90} sound levels with the turbine-ON ranged from 33.0 dBA at 122 Gilson Road to 49.9 dBA at 151 Driftway. The incremental change in sound levels ranged from 0.6 dBA at 127 Gilson Road to 2.8 dBA at 56 Moorland Road. These sound level increases are below the MassDEP Noise Policy's 10-dBA allowable incremental change (See Table 5).

After reviewing the results of the first round of sampling, the BoH decided that the test results were not sufficient since the sampling conditions were not representative of a maximum wind turbine power output. Although the test results are not based on a maximum power production scenario, they are valid for a low-power production sound event. Tech included the first round results in this report for purposes of completeness.

As discussed in Section 1.0, the BoH modified the sound compliance monitoring approach because the first round of sound testing did not capture a turbine maximum power or sound level condition, and established criteria as to when Tech should proceed with a sampling event. Tech implemented these changes in the next three rounds of sampling.

TABLE 3

**TURBINE-ON POWER PRODUCTION AND HUB HEIGHT WIND SPEED SUMMARY
FOR THE SCITUATE WIND TURBINE
AUGUST 14-15, 2013**

Residential Location	Sampling Time (hrs, min, sec) (Turbine-ON)	Average Power Production (kW)	Percent of Max. Power Production (%)	Average Hub Height Wind Speed (m/s)
ML1 - 151 Driftway	23:08:59 – 23:26:46	282.3	18.8	4.8
ML2 - 56 Moorland Road	00:26:10 – 00:44:54	303.3	20.2	5.1
ML3- 149 Gilson Road	00:52:48 – 01:12:52	225.7	15.0	4.5
ML 4 - 122 Gilson Road	02:00:48 – 02:17:04	328.6	21.9	5.0
ML5 - 127 Gilson Road	02:20:34 – 02:36:57	416.3	27.8	5.5

TABLE 4
L_{max} to L₉₀ COMPARISON
FOR THE SCITUATE WIND TURBINE (dBA)
AUGUST 14-15, 2013

Residential Location	Five-minute Ambient L₉₀ Level (Turbine-OFF)	One-second L_{max} Level (Turbine-ON)	Net Increase
ML1 - 151 Driftway	49.0	50.5	1.5
ML2 - 56 Moorland Road	34.8	38.7	3.9
ML3- 149 Gilson Road	33.6	35.2	1.6
ML 4 - 122 Gilson Road	31.2	34.5	3.3
ML5 - 127 Gilson Road	35.3	36.4	1.1

Note: DEP Noise Policy limits the increase in the ambient level to 10 dBA.

4. During these compliance tests, three five-minute samples were taken with the turbine-ON, and three five-minute samples were taken with the turbine-OFF. The turbine-OFF value is the lowest of the three five-minute L₉₀ levels, and the turbine-ON value is the average of the three five-minute L_{max} levels.
5. Average hub height wind speeds ranged from 4.5 to 5.5 m/s (10.1 to 12.3 mph) during turbine-ON measurements.
6. Average 10-meter wind speeds ranged from 0 to 1.3 m/s (0 to 3 mph) from the westerly direction based on Marshfield Airport wind data.
7. Sampling was performed during a low-tide event.

TABLE 5
L₉₀ to L₉₀ COMPARISON
FOR THE SCITUATE WIND TURBINE (dBA)
AUGUST 14-15, 2013

Residential Location	Five-minute Ambient L₉₀ Level (Turbine-OFF)	Five-minute Average L₉₀ Level (Turbine-ON)	Net Increase
ML1 - 151 Driftway	49.0	49.9	0.9
ML2 - 56 Moorland Road	34.8	37.6	2.8
ML3- 149 Gilson Road	33.6	35.2	1.6
ML4 - 122 Gilson Road	31.2	33.0	1.8
ML5 - 127 Gilson Road	35.3	35.9	0.6

Note: DEP Noise Policy limits the increase in the ambient level to 10 dBA.

1. During these compliance tests, three five-minute samples were taken with the turbine-ON, and three five-minute samples were taken with the turbine-OFF. The turbine-OFF value is the lowest of the three five-minute L₉₀ levels, and the turbine-ON value is the average of the three five-minute L₉₀ levels.
2. Average hub height wind speeds ranged from 4.5 to 5.5 m/s (10.1 to 12.3 mph) during turbine-ON measurements.
3. Average 10-meter wind speeds ranged from 0 to 1.3 m/s (0 to 3 mph) from the westerly direction based on Marshfield Airport wind data.
4. Sampling was performed during a low-tide event.

Scenario 4: March 15, 2014 - Strong Southwest Wind Condition and Maximum Power Production

On Saturday, March 15, 2014, sound measurements were made at the five monitoring locations between 12:05 a.m. and 3:11 a.m. The sampling was conducted during high tide. Weather conditions were favorable for sound monitoring with surface wind speeds as measured at the NWS station located at the airport in Plymouth, MA ranging from 3.6 to 6.7 m/s (8 to 15 mph) from the south-southwesterly direction. The Marshfield Airport NWS was unavailable. Skies were clear and the temperature ranged from 38 to 39°F. The average turbine hub height wind speeds ranged from 10.2 to 12.9 m/s (22.8 to 28.9 mph) and the average power production ranged from 1420.5 to 1518.0 kW, which is equivalent to 94.7 to 101.2 percent during the turbine-ON measurements. Table 6 presents a summary of the turbine power production and hub height wind speed data. Appendix C presents turbine power production and hub height wind speed data for the entire sampling event.

Tech's acoustic engineer was accompanied by Mr. Gordon Deane for this sampling event. At the start of the sampling, power production was around 1,500 kW. It was an excellent night to capture the high power production and maximum sound level condition. Hub height wind speed and turbine power production were steady and consistent throughout the sampling event. Tech's acoustic engineer began sampling at 151 Driftway and finished at 122 Gilson Road. Tech's acoustic engineer observed that the wind turbine could be heard at 151 Driftway, but it became more difficult to discern the further away he moved from the turbine location. In particular, the turbine was inaudible above background noise during the sampling period at 56 Moorland Road. This was likely due to its distance from the turbine, approximately 3,000 feet away, and that it was not directly downwind during a southwest wind condition.

Table 7 shows that the lowest background L_{90} sound levels with the turbine-OFF ranged from 38.0 dBA at 127 Gilson Road to 47.3 dBA at 56 Moorland Road. These sound levels represent the lowest of the three five-minute L_{90} levels at each monitoring location. Background human and natural sound sources observed at each monitoring location included cars passing by along Driftway, aircraft flyovers, trees branches swaying in the wind and wind gusts. Appendix B presents summary graphs of the all the turbine-OFF one-second sound levels.

The highest one-second L_{max} sound levels with the turbine-ON ranged from 43.0 dBA at 127 Gilson Road to 51.8 dBA at 151 Driftway. Wind turbine sound levels were inaudible above background noise during the sampling period at 56 Moorland Road. The incremental change in sound levels at locations where the turbine was audible ranged from 2.2 dBA at 122 Gilson Road to 7.0 dBA at 151 Driftway. These sound level increases are below the MassDEP Noise Policy's 10-dBA allowable incremental change (See Table 7). Appendix B presents summary graphs of the all the turbine-ON one-second sound levels.

Tech also performed a secondary compliance evaluation (L_{90} to L_{90}) with and without the Turbine-ON. The five-minute L_{90} sound levels with the turbine-ON ranged from 42.0 dBA at 127 Gilson Road to 50.9 dBA at 151 Driftway. Wind turbine sound levels were inaudible above background noise during the sampling period at 56 Moorland Road, and therefore, no turbine-ON sound levels could be determined. The incremental change in sound levels at locations where the turbine was audible ranged from 0.5 dBA at 122 Gilson Road to 6.1 dBA at 151 Driftway. These sound level increases are below the MassDEP Noise Policy's 10-dBA allowable incremental change (See Table 8).

TABLE 6

**TURBINE-ON POWER PRODUCTION AND HUB HEIGHT WIND SPEED SUMMARY
FOR THE SCITUATE WIND TURBINE
MARCH 15, 2014**

Residential Location	Sampling Time (hrs, min, sec) (Turbine ON)	Average Power Production (kW)	Percent of Max. Power Production (%)	Average Hub Height Wind Speed (m/s)
ML1 - 151 Driftway	00:05:43 – 00:22:53	1,517.4	101.2	12.9
ML2 - 56 Moorland Road	01:13:37 – 01:31:55	1,518.0	101.2	11.8
ML3- 149 Gilson Road	01:37:51 – 01:54:07	1,515.1	101.0	10.8
ML4 - 122 Gilson Road	02:36:34 – 02:52:50	1,475.1	98.3	10.2
ML5 - 127 Gilson Road	02:55:10 – 03:11:18	1,420.5	94.7	10.2

TABLE 7
L_{max} to L₉₀ COMPARISON
FOR THE SCITUATE WIND TURBINE (dBA)
MARCH 15, 2014

Residential Location	Five-minute Ambient L₉₀ Level (Turbine-OFF)	One-second L_{max} Level (Turbine-ON)	Net Increase
ML1 - 151 Driftway	44.8	51.8	7.0
ML2 - 56 Moorland Road	47.3	NA	NA
ML3- 149 Gilson Road	40.5	45.9	5.4
ML4 - 122 Gilson Road	41.7	43.9	2.2
ML5 - 127 Gilson Road	38.0	43.0	5.0

Note: DEP Noise Policy limits the increase in the ambient level to 10 dBA.

1. During these compliance tests, three five-minute samples were taken with the turbine-ON, and three five-minute samples were taken with the turbine-OFF. The turbine-OFF value is the lowest of the three five-minute L₉₀ levels, and the turbine-ON value is the average of the three five-minute L_{max} levels.
2. Average hub height wind speeds ranged from 10.2 to 12.9 m/s (22.8 to 28.9 mph) during turbine-ON measurements.
3. Hourly 10-meter wind speeds ranged from 3.6 to 6.7 m/s (8 to 15 mph) from the south-southwesterly direction based on NWS Plymouth Airport wind data. Marshfield Airport wind data was unavailable
4. Sampling was performed during a high-tide event.
5. NA = Turbine was inaudible above background noise during the sampling period.

TABLE 8
L₉₀ to L₉₀ COMPARISON
FOR THE SCITUATE WIND TURBINE (dBA)
MARCH 15, 2014

Residential Location	Five-minute Ambient L₉₀ Level (Turbine-OFF)	Five-minute Average L₉₀ Level (Turbine-ON)	Net Increase
ML1 - 151 Driftway	44.8	50.9	6.1
ML2 - 56 Moorland Road	47.3	NA	NA
ML3- 149 Gilson Road	40.5	43.7	3.2
ML4 - 122 Gilson Road	41.7	42.2	0.5
ML5 - 127 Gilson Road	38.0	42.0	4.0

Note: DEP Noise Policy limits the increase in the ambient level to 10 dBA.

6. During these compliance tests, three five-minute samples were taken with the turbine-ON, and three five-minute samples were taken with the turbine-OFF. The turbine-OFF value is the lowest of the three five-minute L₉₀ levels, and the turbine-ON value is the average of the three five-minute L₉₀ levels.
7. Average hub height wind speeds ranged from 10.2 to 12.9 m/s (22.8 to 28.9 mph) during turbine-ON measurements.
8. Hourly 10-meter wind speeds ranged from 3.6 to 6.7 m/s (8 to 15 mph) from the south-southwesterly direction based on NWS Plymouth Airport wind data. Marshfield Airport wind data was unavailable
9. Sampling was performed during a high-tide event.
10. NA = Turbine was inaudible above background noise during the sampling period.

Scenario 2: June 3, 2014 - Light South-Southwest Wind, Inversion Condition and Low- to Mid-Range Power Production

On Tuesday, June 3, 2014, sound measurements were made at the five monitoring locations between 12:01 a.m. and 3:27 a.m. The sampling was conducted during an intermediate tide event with low tide occurring at 9:26 p.m., approximately 2.5 hours prior to the start of the sampling round. Weather conditions were favorable for sound monitoring with surface wind speeds as measured at the NWS station located at the airport in Plymouth, MA ranging from 0 to 1.6 m/s (0 to 3.5 mph) from a south-southwesterly direction. The Marshfield Airport NWS was unavailable. Skies were clear and the temperature ranged from 54 to 56°F. The average turbine hub height wind speeds ranged from 3.8 to 7.8 m/s (8.5 to 17.5 mph) and the average power production ranged from 157.6 to 950.2 kW, which is equivalent to 10.5 to 63.3 percent during the turbine ON measurements. Table 9 presents a summary of the turbine power production and hub height wind speed data. Appendix C presents turbine power production and hub height wind speed data for the entire sampling event.

At the start of the sampling, power production was around 1,000 kW. It appeared to be an excellent night to capture mid-range power production and maximum sound levels, with light winds at the surface and hub height wind speeds of 8 m/s or greater. A review of upper air sounding data from Chatham, MA showed a temperature inversion condition was occurring during the start of the sampling program^{7, 8}.

Tech's acoustic engineer⁹ began sampling at 127 Gilson Road and for the first three monitoring locations power production and hub height wind speeds were good, but they were declining over time (See Table 9). Once the acoustic engineer had arrived at 151 Driftway around 2:00 a.m., average power production was below 300 kW and the average hub height wind speed was 5 m/s. Although power production and wind speeds were continuing to decrease, the noise sampling continued at 151 Driftway since it was possible power production and wind speeds could increase.

⁷ A temperature inversion in the atmosphere occurs when temperature, instead of falling, increases with height above the ground. An inversion acts like a lid, keeping normal convective overturning of the atmosphere from penetrating through the inversion and normally leading to higher sound levels at the surface. Wind speeds can be calm or light below the inversion and wind speeds above the inversion increases with height.

⁸ University of Wyoming, <http://weather.uwyo.edu>, downloaded June 5, 2014.

⁹ Turning the turbine on and off was done remotely by Mr. Sumul Shah of Scituate Wind

Upon completing the sampling at 151 Driftway, power production and hub height wind speeds were continuing to decrease. However, the acoustic engineer finished the sampling round at the last location (56 Moorland Road) to collect a complete sampling round.

Table 10 shows that the lowest background L_{90} sound levels with the turbine-OFF ranged from 36.0 dBA at 149 Gilson Road to 41.2 dBA at 151 Driftway. These sound levels represent the lowest of the three five-minute L_{90} levels at each monitoring location. Background human and natural sound sources observed at each monitoring location included cars passing by along Driftway, aircraft flyovers and insect noise. In addition, the Town's wastewater treatment plant operations could be heard at 151 Driftway. Appendix B presents summary graphs of the all the turbine-OFF one-second sound levels.

The highest one-second L_{max} sound levels with the turbine-ON ranged from 40.6 dBA at 56 Moorland Road to 47.0 dBA at 151 Driftway. The incremental change in sound levels ranged from 3.8 dBA at 56 Moorland Road to 6.5 dBA at 149 Gilson Road. These sound level increases are below the MassDEP Noise Policy's 10-dBA allowable incremental change (See Table 10). Appendix B presents summary graphs of the all the turbine-ON one-second sound levels.

Tech also performed a secondary compliance evaluation (L_{90} to L_{90}) with and without the Turbine-ON. The five-minute L_{90} sound levels with the turbine-ON ranged from 38.0 dBA at 56 Moorland Road to 44.9 dBA at 151 Driftway. The incremental change in sound levels ranged from 1.2 dBA at 56 Moorland Road to 3.9 dBA at 149 Gilson Road. These sound level increases are below the MassDEP Noise Policy's 10-dBA allowable incremental change (See Table 11).

TABLE 9**TURBINE-ON POWER PRODUCTION AND HUB HEIGHT WIND SPEED SUMMARY
FOR THE SCITUATE WIND TURBINE
JUNE 3, 2014**

Residential Location	Sampling Time (hrs, min, sec) (Turbine-ON)	Average Power Production (kW)	Percent of Max. Power Production (%)	Average Hub Height Wind Speed (m/s)
ML1 - 151 Driftway	02:10:55 – 02:26:39	285.2	19.0	5.0
ML2 - 56 Moorland Road	03:11:56 – 03:27:39	157.6	10.5	3.8
ML3- 149 Gilson Road	01:18:09 – 01:34:17	621.5	41.4	6.5
ML4 - 122 Gilson Road	00:57:08 – 01:13:03	784.0	52.2	7.2
ML5 - 127 Gilson Road	00:01:14 – 00:17:15	950.2	63.3	7.8

TABLE 10
L_{max} to L₉₀ COMPARISON
FOR THE SCITUATE WIND PROJECT (dBA)
JUNE 3, 2014

Residential Location	Five-minute Ambient L₉₀ Level (Turbine-OFF)	One-second L_{max} Level (Turbine-ON)	Net Increase
ML1 - 151 Driftway	41.2	47.0	5.8
ML2 - 56 Moorland Road	36.8	40.6	3.8
ML3- 149 Gilson Road	36.0	42.5	6.5
ML4 - 122 Gilson Road	37.1	42.7	5.6
ML5 - 127 Gilson Road	38.4	42.5	4.1

Note: DEP Noise Policy limits the increase in the ambient level to 10 dBA.

1. During these compliance tests, three five-minute samples were taken with the turbine-ON, and three five-minute samples were taken with the turbine-OFF. The turbine-OFF value is the lowest of the three five-minute L₉₀ levels, and the turbine-ON value is the average of the three five-minute L_{max} levels.
2. Average hub height wind speeds ranged from 3.8 to 7.8 m/s (8.5 to 17.5 mph) during turbine-ON measurements.
3. Hourly 10-meter wind speeds ranged from 0 to 1.6 m/s (0 to 3.5 mph) from a south-southwesterly direction based on NWS Plymouth Airport wind data. Marshfield Airport ind data was unavailable.
4. Sampling was performed during an intermediate-tide event.

TABLE 11
L₉₀ to L₉₀ COMPARISON
FOR THE SCITUATE WIND PROJECT (dBA)
JUNE 3, 2014

Residential Location	Five-minute Ambient L₉₀ Level (Turbine-OFF)	Five-minute Average L₉₀ Level (Turbine-ON)	Net Increase
ML1 - 151 Driftway	41.2	44.9	3.7
ML2 - 56 Moorland Road	36.8	38.0	1.2
ML3- 149 Gilson Road	36.0	39.9	3.9
ML 4 - 122 Gilson Road	37.1	40.6	3.5
ML5 - 127 Gilson Road	38.4	41.7	3.3

Note: DEP Noise Policy limits the increase in the ambient level to 10 dBA.

5. During these compliance tests, three five-minute samples were taken with the turbine-ON, and three five-minute samples were taken with the turbine-OFF. The turbine-OFF value is the lowest of the three five-minute L₉₀ levels, and the turbine-ON value is the average of the three five-minute L₉₀ levels.
6. Average hub height wind speeds ranged from 3.8 to 7.8 m/s (8.5 to 17.5 mph) during turbine-ON measurements.
7. Hourly 10-meter wind speeds ranged from 0 to 1.6 m/s (0 to 3.5 mph) from a south-southwesterly direction based on NWS Plymouth Airport wind data. Marshfield Airport wind data was unavailable.
8. Sampling was performed during an intermediate-tide event.

Scenario 3: May 5, 2015 - Moderate Southwest Wind Condition and Mid-Range Power Production

On Tuesday, May 5, 2015, sound measurements were collected at the five monitoring locations between 12:01 a.m. and 2:20 a.m. The sampling was conducted during a high-tide event. At the start of the sampling, power production was around 1,100 kW. Tech had two acoustic engineers perform the sound test to expedite the collection of sound data when the turbine was operating at mid-range power production. One engineer began sampling at 151 Driftway and the second engineer began sampling at 56 Moorland Road. In addition, Mr. Gordon Deane accompanied Tech's acoustic engineers for this sampling event. Throughout the sampling round, turbine operations and hub height wind speeds were good for capturing sound levels generated for a mid-range power production event (See Table 12). Winds were from the southwest throughout the sampling period and 10-meter wind speeds ranged from 4.7 m/s to 6.7 m/s (10.4 to 15.0 mph) as measured at the NWS Marshfield Airport station. Skies were clear and the temperature ranged from 64 to 66°F. The average turbine hub height wind speeds ranged from 10.4 m/s to 11.3 m/s (23.3 mph to 25.2 mph) and the average power production ranged from 827.5 kW to 1,047.8 kW, which is equivalent to 55.1 to 69.9 percent during the turbine-ON measurements. Table 12 presents a summary of the turbine power production and hub height wind speed data. Appendix C presents turbine power production and hub height wind speed data for the entire sampling event.

Table 13 shows that the lowest background L_{90} sound levels with the turbine-OFF ranged from 40.2 dBA at 122 Gilson Road to 46.0 dBA at 56 Moorland Road. These sound levels represent the lowest of the three five-minute averages at each monitoring location. Background human and natural sound sources observed at each monitoring location included cars passing by along Driftway and other local roadways, aircraft flyovers and insect noise. In addition, the Town's wastewater treatment plant operations could be heard at 151 Driftway. Appendix B presents summary graphs of the all the turbine-OFF one-second sound levels.

The highest one-second L_{max} sound levels with the turbine-ON ranged from 42.4 dBA at 122 Gilson Road to 51.2 dBA at 151 Driftway. Wind turbine sound levels were inaudible above background noise during the sampling period at 127 Gilson Road. The incremental change in sound levels ranged from 1.1 dBA at 149 Gilson Road to 9.0 dBA at 151 Driftway. These sound level increases

are below the MassDEP Noise Policy’s 10-dBA allowable incremental change (See Table 13). Appendix B presents summary graphs of the all the turbine-ON one-second sound levels.

Tech also performed a secondary compliance evaluation (L_{90} to L_{90}) with and without the Turbine-ON for comparison purposes. The five-minute L_{90} sound levels with the turbine-ON ranged from 42.7 at 122 Gilson Road to 49.4 dBA at 151 Driftway. Wind turbine sound levels were inaudible above background noise during the sampling period at 127 Gilson Road, and therefore, no turbine-ON sound level could be determined. The incremental change in sound levels at locations where the turbine was audible ranged from 0.7 dBA at 149 Gilson Road to 7.2 dBA at 151 Driftway. These sound level increases are below the MassDEP Noise Policy’s 10-dBA allowable incremental change (See Table 14).

TABLE 12

**TURBINE-ON POWER PRODUCTION AND HUB HEIGHT WIND SPEED SUMMARY
FOR THE SCITUATE WIND TURBINE
MAY 5, 2015**

Residential Location	Sampling Time (hrs, min, sec) (Turbine-ON)	Average Power Production (kW)	Percent of Max. Power Production (%)	Average Hub Height Wind Speed (m/s)
ML1 - 151 Driftway	00:00 – 0:020	1,047.8	69.9	11.3
ML2 - 56 Moorland Road	00:00 – 0:020	1,047.8	69.9	11.3
ML3- 149 Gilson Road	01:20 – 01:40	911.0	60.7	10.7
ML 4 - 122 Gilson Road	01:42 – 02:02	827.5	55.1	10.4
ML5 - 127 Gilson Road	01:20 – 01:40	911.0	60.7	10.7

TABLE 13
L_{max} to L₉₀ COMPARISON
FOR THE SCITUATE WIND PROJECT (dBA)
MAY 5, 2015

Residential Location	Five-minute Ambient L₉₀ Level (Turbine-OFF)	One-second L_{max} Level (Turbine-ON)	Net Increase
#151 Driftway	41.2	51.2	9.0
#56 Moorland Road	46.0	48.1	2.1
#149 Gilson Road	42.5	43.6	1.1
#122 Gilson Road	40.2	42.4	2.2
#127 Gilson Road	40.6	NA	NA

Note: DEP Noise Policy limits the increase in the ambient level to 10 dBA.

1. During these compliance tests, three five-minute samples were taken with the turbine-ON, and three five-minute samples were taken with the turbine-OFF. The turbine-OFF value is the lowest of the three five-minute L₉₀ levels, and the turbine-ON value is the average of the three five-minute L_{max} levels.
2. Average hub height wind speeds ranged from 10.4 to 11.3 m/s (23.3 to 25.2 mph) from a southwest direction.
3. Hourly 10-meter wind speeds ranged from 4.7 to 6.7 m/s (10.4 to 15.0 mph) from a southwest direction based on NWS Marshfield Airport wind data.
4. Sampling was performed during a high-tide event.
5. NA = Turbine was inaudible above background noise during the sampling period.

TABLE 14
L₉₀ to L₉₀ COMPARISON
FOR THE SCITUATE WIND PROJECT (dBA)
MAY 5, 2015

Residential Location	Five-minute Ambient L₉₀ Level (Turbine-OFF)	Five-minute Average L₉₀ Level (Turbine-ON)	Net Increase
#151 Driftway	42.2	49.4	7.2
#56 Moorland Road	46.0	48.4	2.4
#149 Gilson Road	42.5	43.2	0.7
#122 Gilson Road	40.2	42.7	2.5
#127 Gilson Road	40.6	NA	NA

Note: DEP Noise Policy limits the increase in the ambient level to 10 dBA.

1. During these compliance tests, three five-minute samples were taken with the turbine-ON, and three five-minute samples were taken with the turbine-OFF. The turbine-OFF value is the lowest of the three five-minute L₉₀ levels, and the turbine-ON value is the average of the three five-minute L₉₀ levels.
2. Average hub height wind speeds ranged from 6.1 to 16.0 m/s (13.6 to 35.8 mph) from a southwest direction.
3. Hourly 10-meter wind speeds ranged from 4.7 to 6.7 m/s (10.4 to 15.0 mph) from a southwest direction based on NWS Marshfield Airport wind data.
4. Sampling was performed during a high-tide event.
5. NA = Turbine was inaudible above background noise during the sampling period.

6.2 Octave Band Sounds

Tech collected whole octave band frequency (16 to 16,000 Hertz (Hz)) sound levels at the five residence locations for three sampling events using the B&K 2250 sound analyzer and the B&K 2250 and LD 831 sound analyzers during the fourth sampling event. The assessment of pure tone when measuring wind turbine sound is complicated by the sound contribution of the wind, which contributes to the tonal quality of sound, especially at higher wind speeds. Tech reviewed center octave band L_{eq} readings and turbine power levels for all the turbine-ON measurements and selected those measurements when the turbine was producing the highest power production to assess whether the turbine was creating a pure tone.

Tonal sounds were recorded at octave band center frequencies of 63 and 4,000 Hz at 151 Driftway during the first round of monitoring (August 14 and 15, 2013). However, when compared turbine-OFF measurements were analyzed, the same pure tones were found. The 63 Hz pure tone is attributed to the Town's Wastewater Treatment Plant and the 4,000 Hz pure tone was attributed to high pitch insect noise. A more pronounced pure tone at 63 Hz was measured at 151 Driftway during the third round of monitoring (June 3, 2014). Again, this pure tone was attributed to the "humming" sound from the Wastewater Treatment Plant. For the other two sampling events (March 15, 2014 and May 5, 2015), no pure tones were measured.

The operation of the wind turbine did not produce a pure tone under the conditions tested, and therefore, complies with the 310 CMR 7.10.

7.0 CONCLUSIONS

A compliance sound monitoring study was performed for the Scituate Wind turbine under four different wind and turbine power production conditions and under three different tidal conditions (low, intermediate and high). For the four turbine operating scenarios, Tech collected 120 (five-minute) measurements (60 with the turbine-ON and 60 with the turbine-OFF). The results reveal that all 60 turbine-ON measurements comply with the MassDEP 10 dB(A) above ambient sound limit, pursuant to 310 CMR 7.10. In addition, results of the octave band analysis demonstrate that operation of the wind turbine does not contribute to a pure tone condition under the sampling conditions.

In conclusion, the results confirm that Scituate Wind fully complies with all requirements of the MassDEP Noise Policy.

APPENDIX A

EXAMPLE FIELD LOG SHEET

Monitoring Location: 56 Moorland Rd ML#2

Larson Davis Project #: 132

Weather Conditions:

Turbine: ON OFF

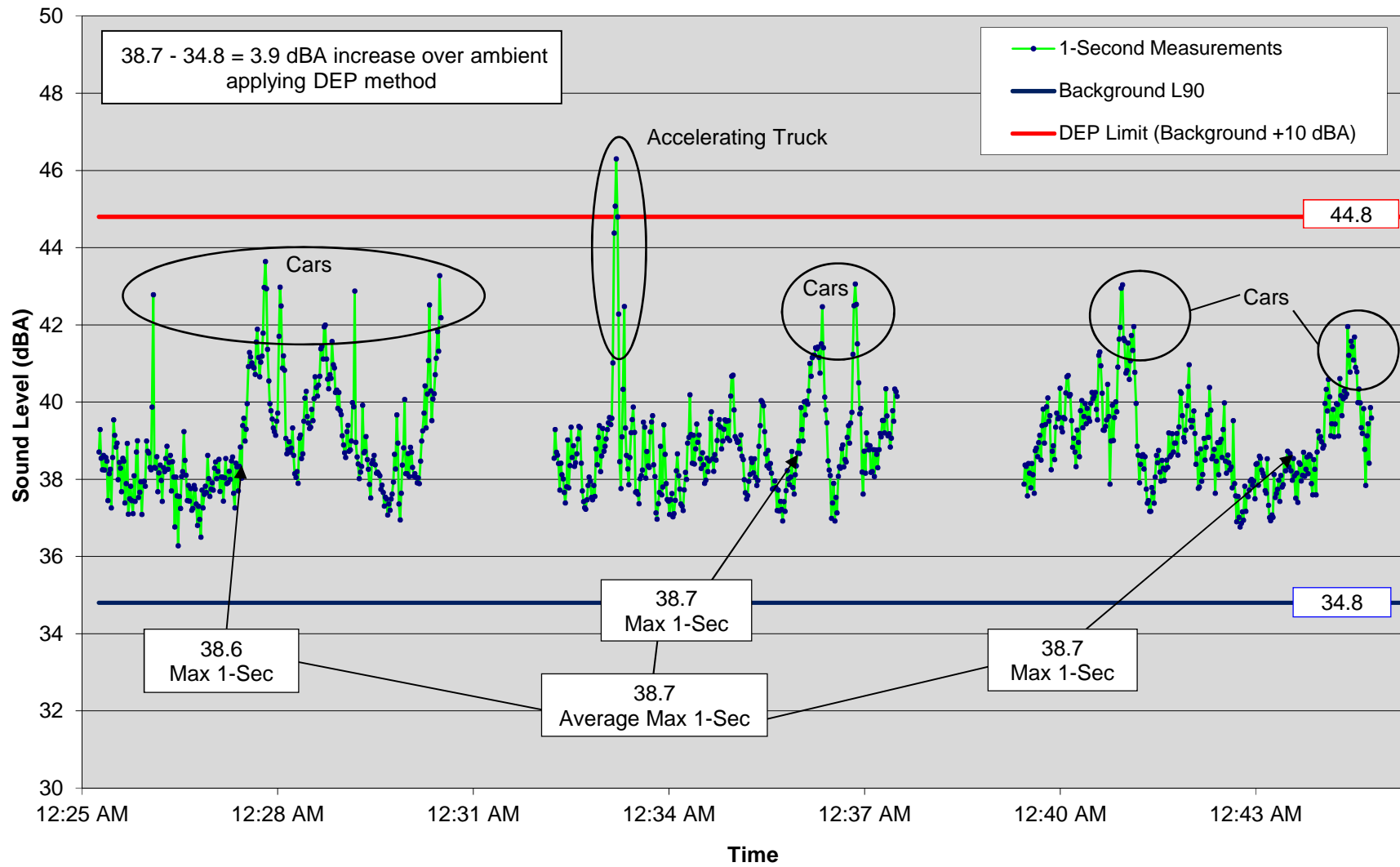
Time Period	Accepted	Car	Wind	Other	Notes
0:00 - 0:05			✓	✓	
0:05 - 0:10					
0:10 - 0:15			✓		
0:15 - 0:20			✓		
0:20 - 0:25				✓	
0:25 - 0:30				✓	
0:30 - 0:35			✓		
0:35 - 0:40				✓	
0:40 - 0:45				✓	chime flagpole
0:45 - 0:50			✓	✓	
0:50 - 0:55				✓	
0:55 - 1:00				✓	
1:00 - 1:05				✓	
1:05 - 1:10			✓		
1:10 - 1:15				✓	
1:15 - 1:20				✓	
1:20 - 1:25			✓		
1:25 - 1:30			✓		
1:30 - 1:35				✓	
1:35 - 1:40			✓		
1:40 - 1:45			✓		
1:45 - 1:50			✓	✓	
1:50 - 1:55			✓	✓	
1:55 - 2:00				✓	
2:00 - 2:05				✓	
2:05 - 2:10			✓		
2:10 - 2:15				✓	
2:15 - 2:20			✓		
2:20 - 2:25			✓		
2:25 - 2:30			✓		
2:30 - 2:35				✓	
2:35 - 2:40			✓		
2:40 - 2:45			✓		
2:45 - 2:50			✓		
2:50 - 2:55			✓		
2:55 - 3:00			✓		
3:00 - 3:05				✓	
3:05 - 3:10				✓	
3:10 - 3:15			✓		
3:15 - 3:20			✓		
3:20 - 3:25			✓		
3:25 - 3:30			✓		
3:30 - 3:35				✓	
3:35 - 3:40				✓	
3:40 - 3:45			✓		
3:45 - 3:50			✓		
3:50 - 3:55			✓		
3:55 - 4:00			✓		
4:00 - 4:05			✓		
4:05 - 4:10			✓		
4:10 - 4:15			✓		
4:15 - 4:20			✓		
4:20 - 4:25			✓		
4:25 - 4:30				✓	
4:30 - 4:35			✓	✓	
4:35 - 4:40			✓		
4:40 - 4:45				✓	
4:45 - 4:50				✓	
4:50 - 4:55				✓	
4:55 - 5:00				✓	
5:00 - 5:05					
5:05 - 5:10					
5:10 - 5:15					
5:15 - 5:20					
5:20 - 5:25					
5:25 - 5:30					

APPENDIX B

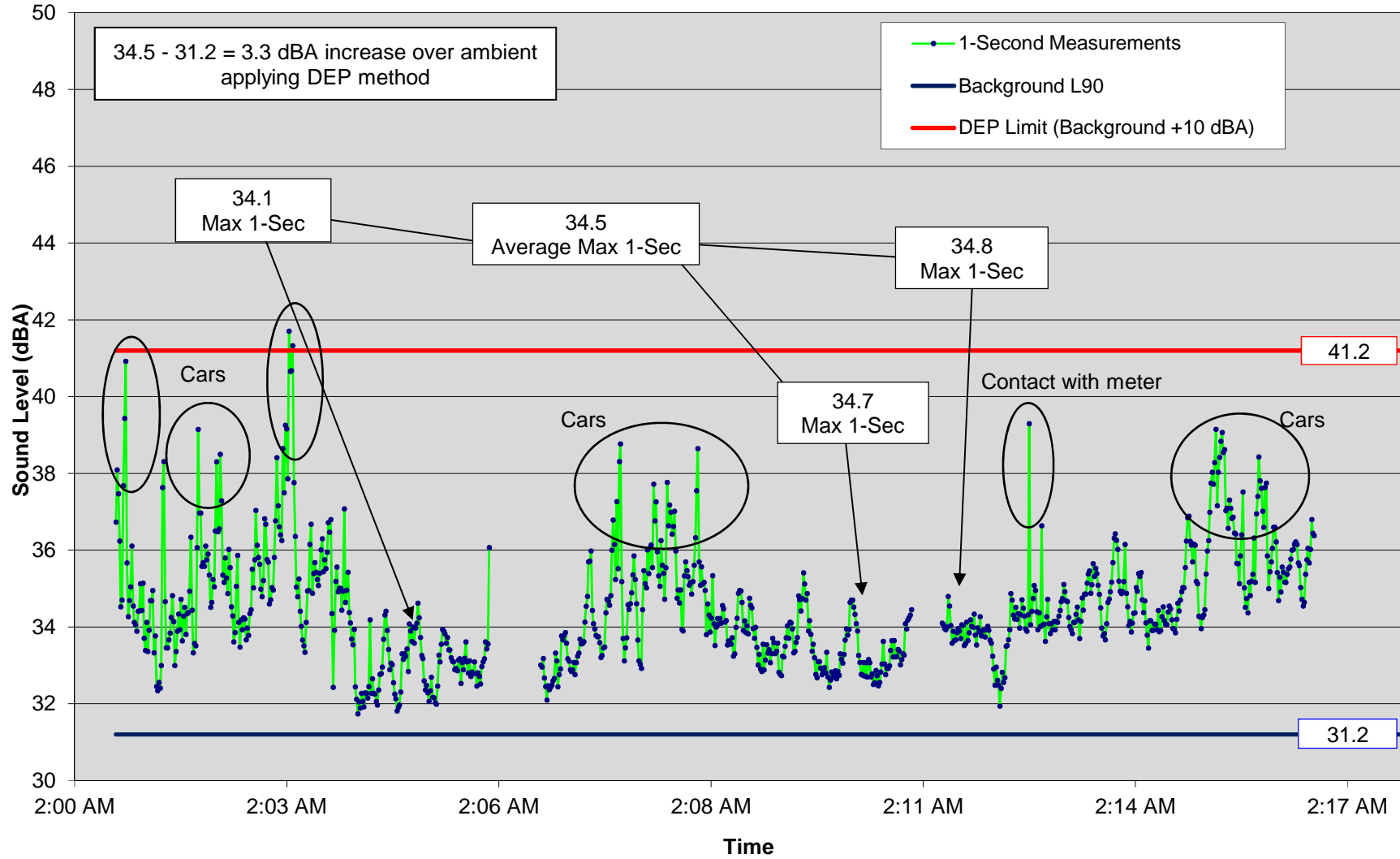
TURBINE-ON AND TURBINE-OFF SUMMARY GRAPHS

Turbine-ON Graphs

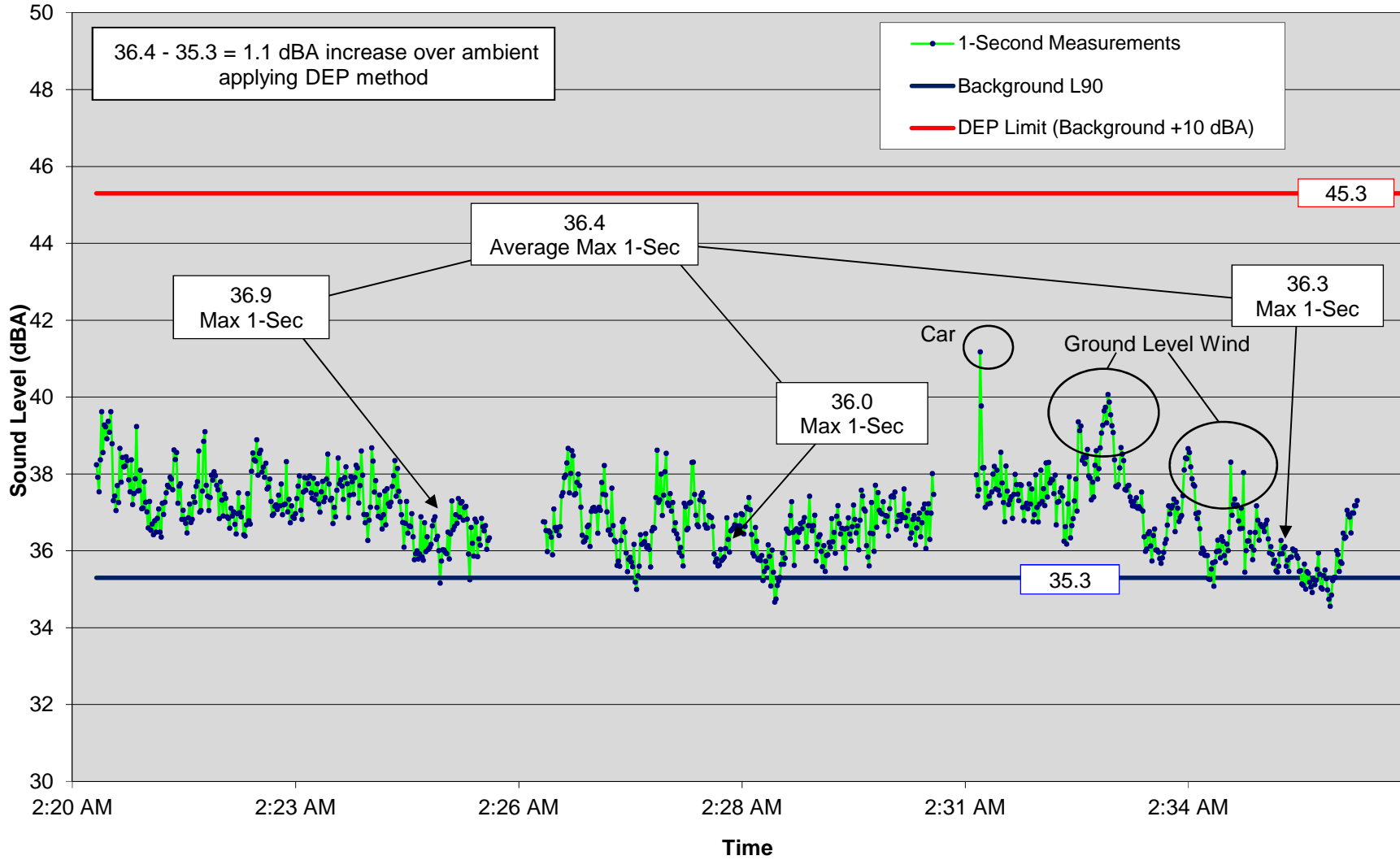
1-Second Sound Levels at 56 Moorland Road With Turbine Operating August 15, 2013



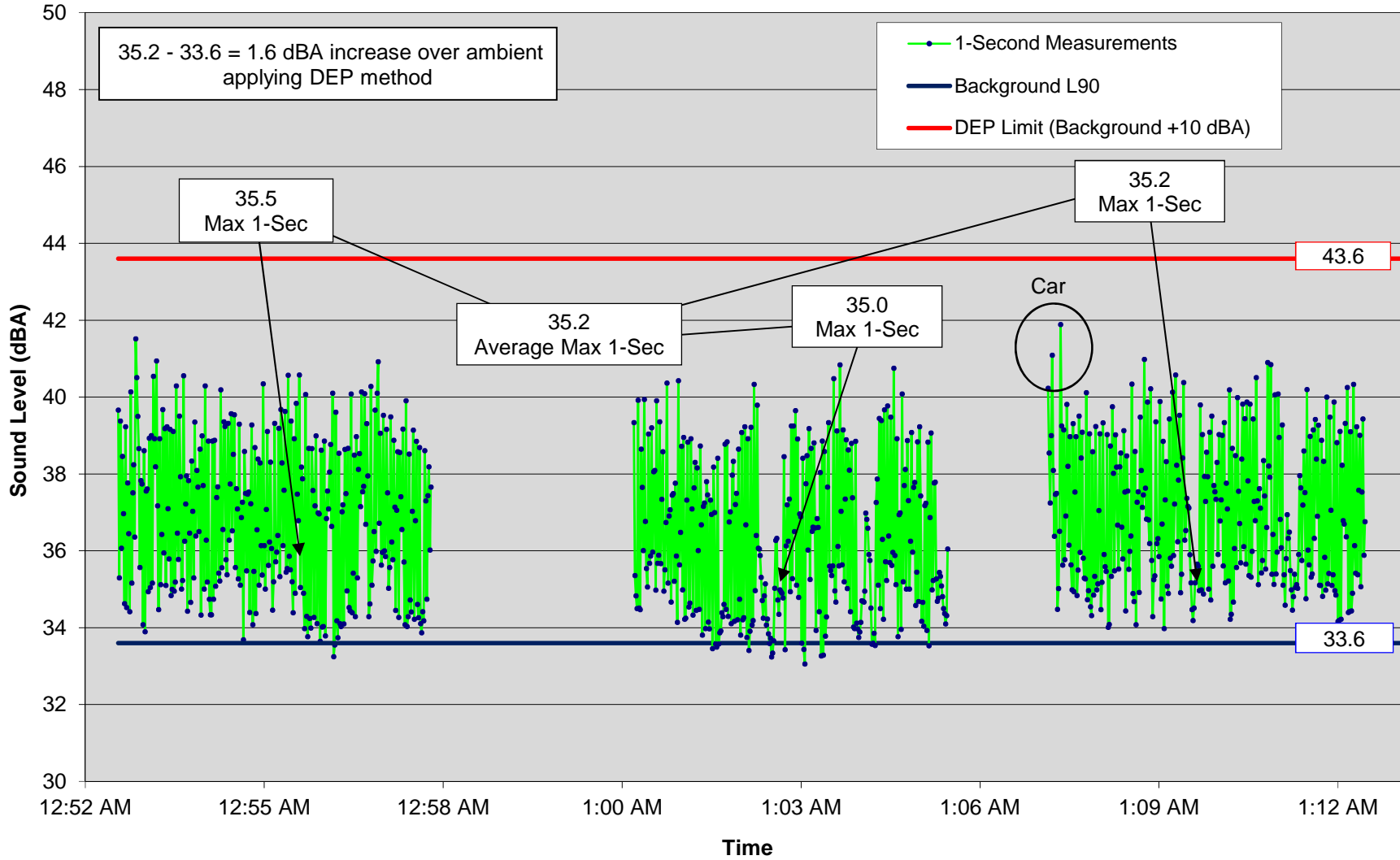
1-Second Sound Levels at 122 Gilson Road With Turbine Operating August 15, 2013



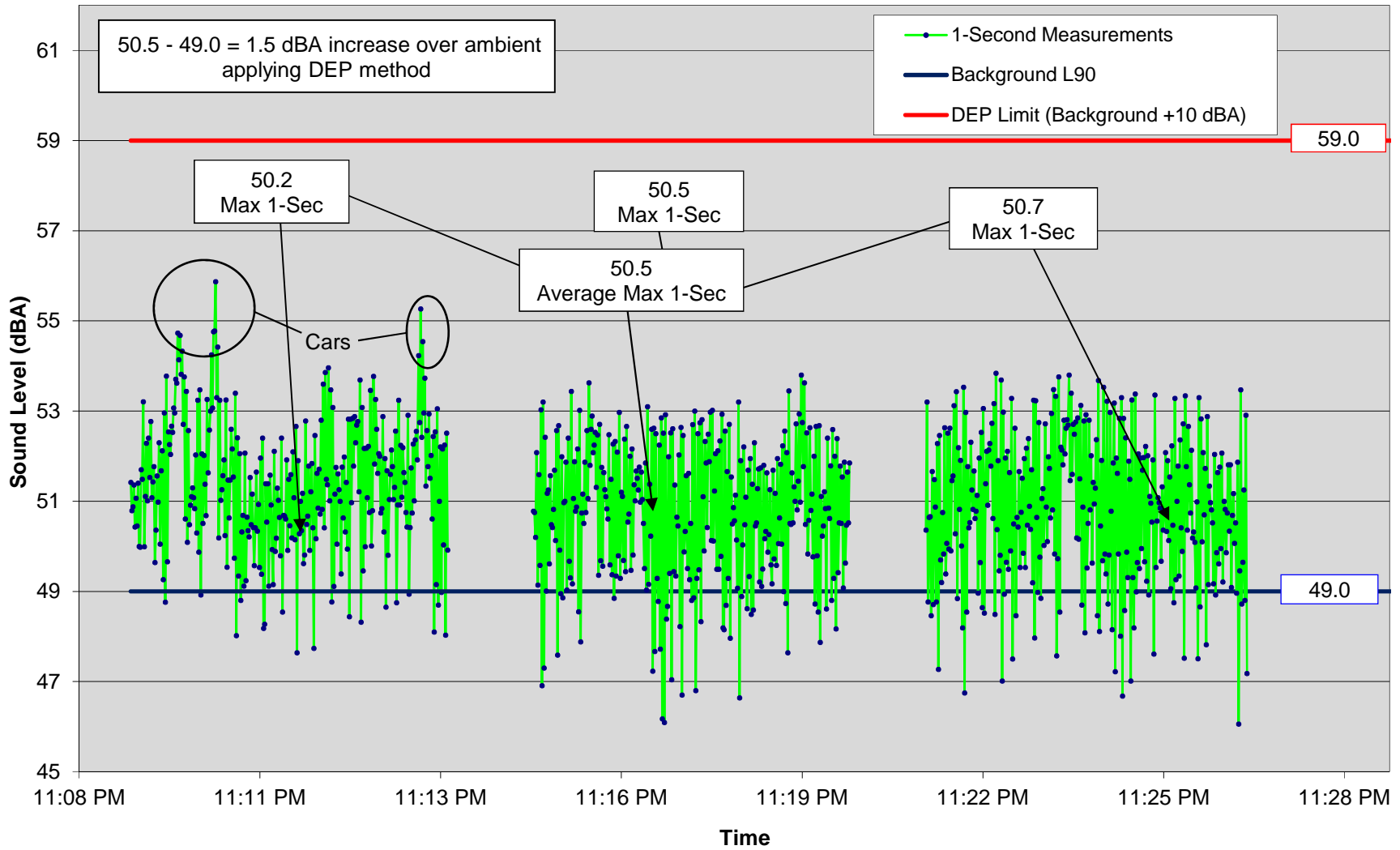
1-Second Sound Levels at 127 Gilson Road With Turbine Operating August 15, 2013



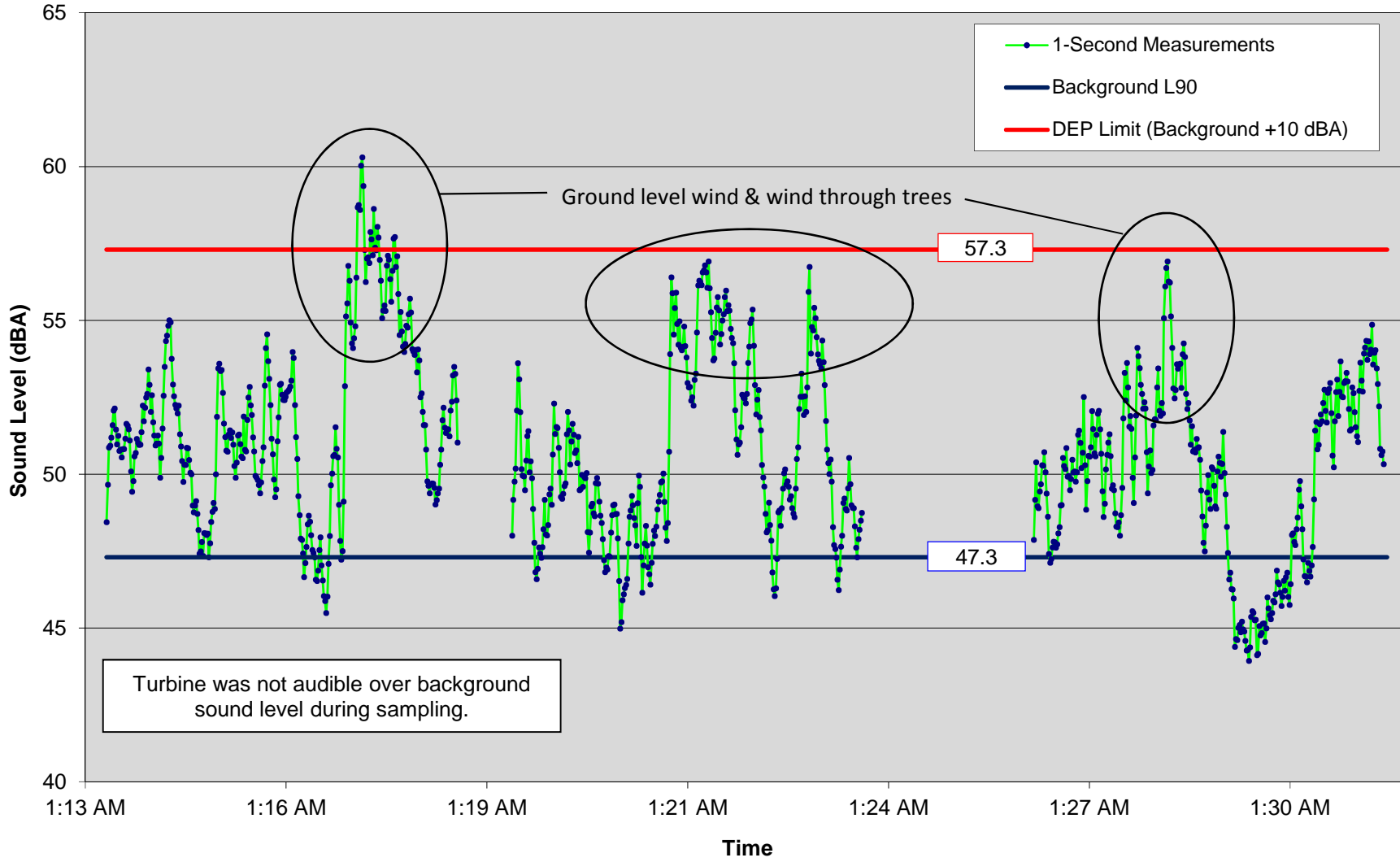
1-Second Sound Levels at 149 Gilson Road With Turbine Operating August 15, 2013



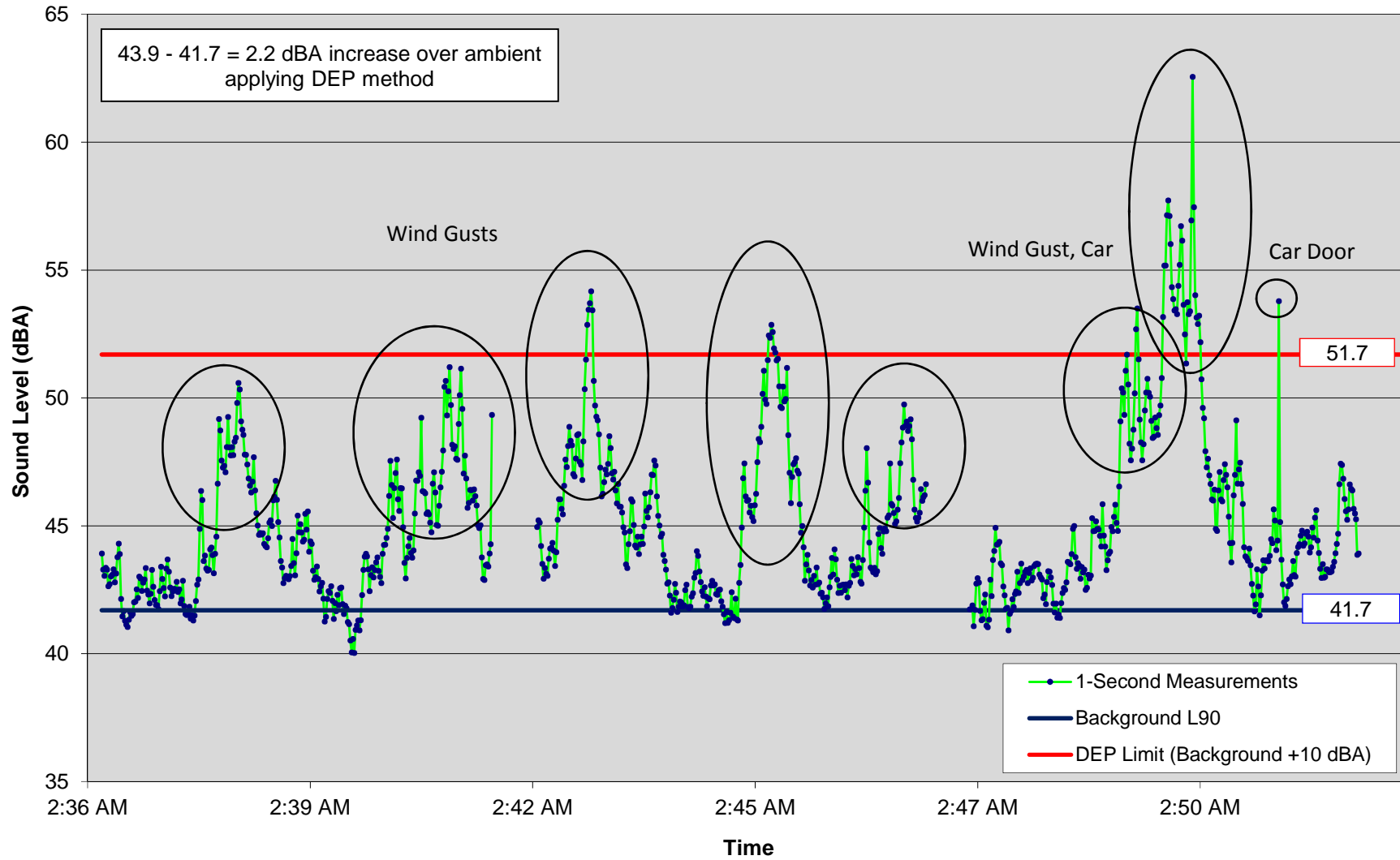
1-Second Sound Levels at 151 Driftway With Turbine Operating August 15, 2013



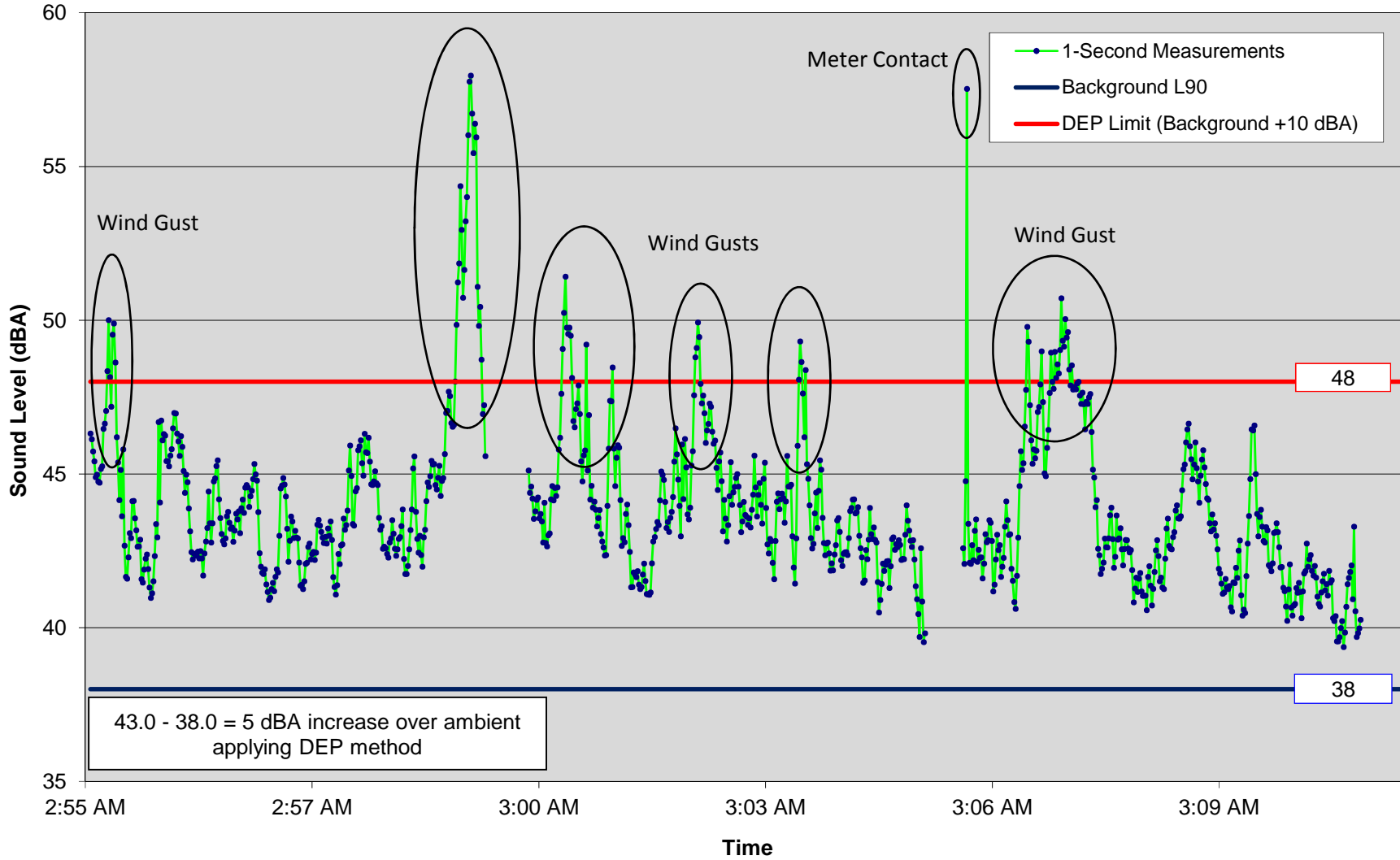
1-Second Sound Levels at 56 Moorland Road With Turbine Operating March 15, 2014



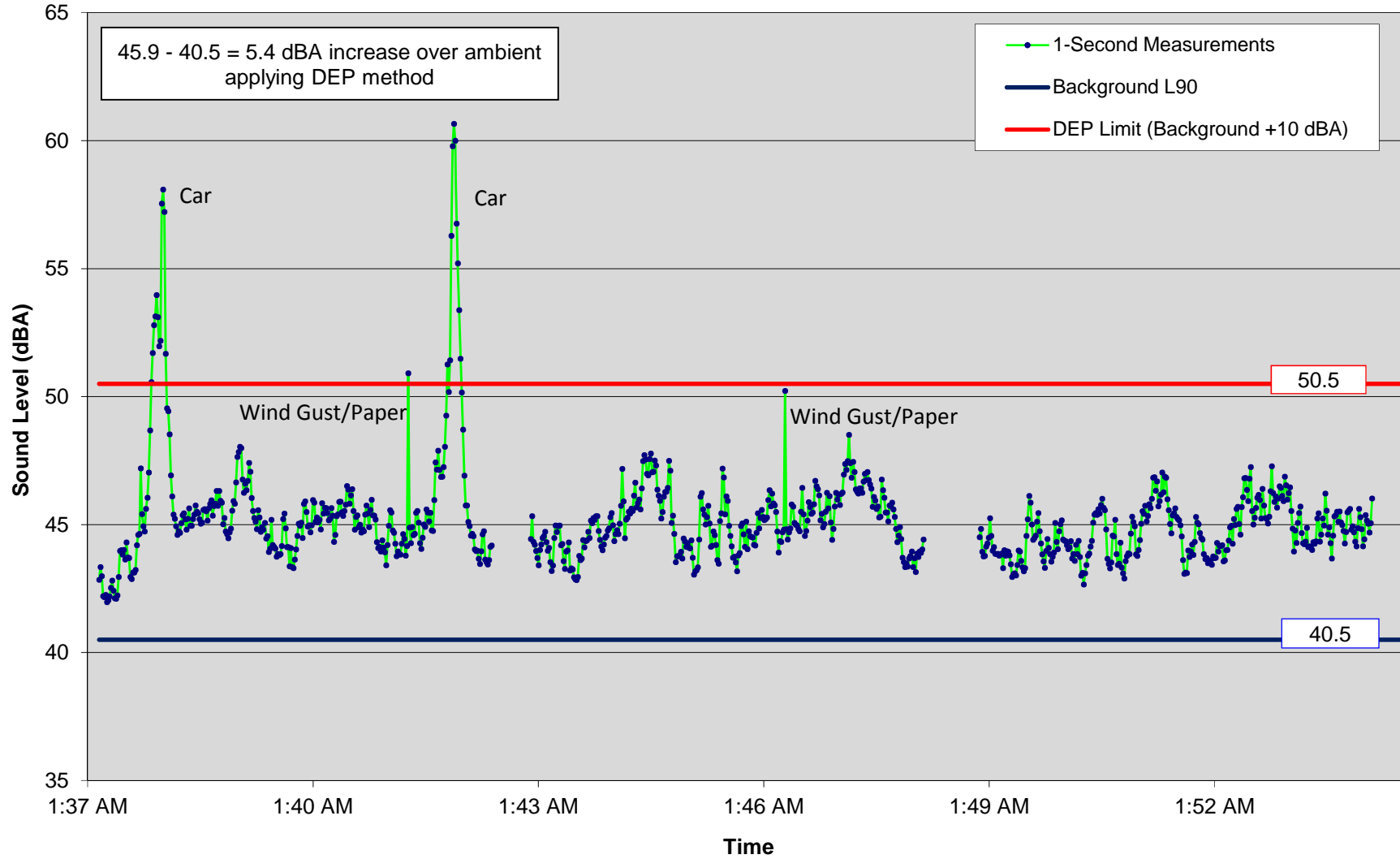
1-Second Sound Levels at 122 Gilson Road With Turbine Operating March 15, 2014



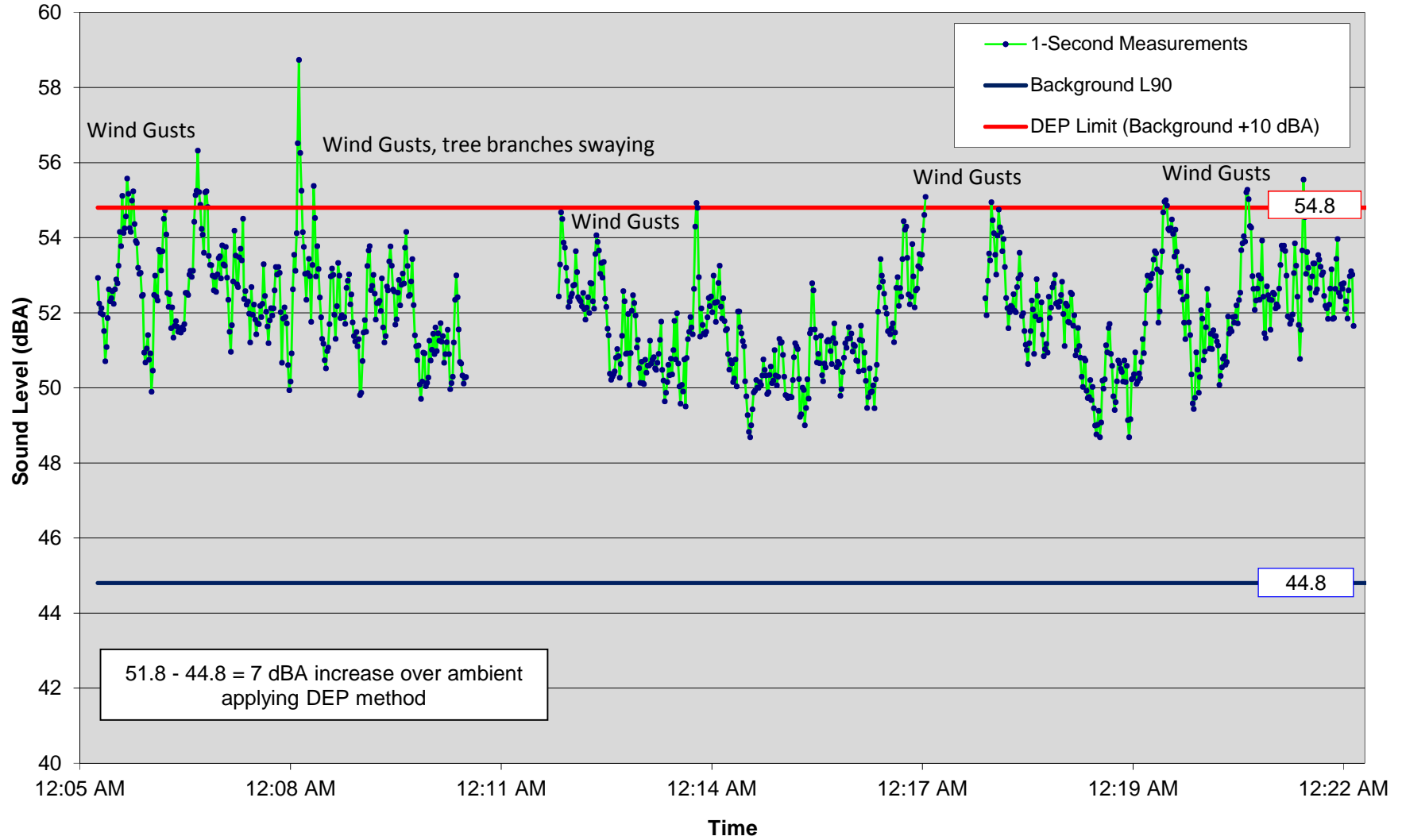
1-Second Sound Levels at 127 Gilson Road With Turbine Operating March 15, 2014



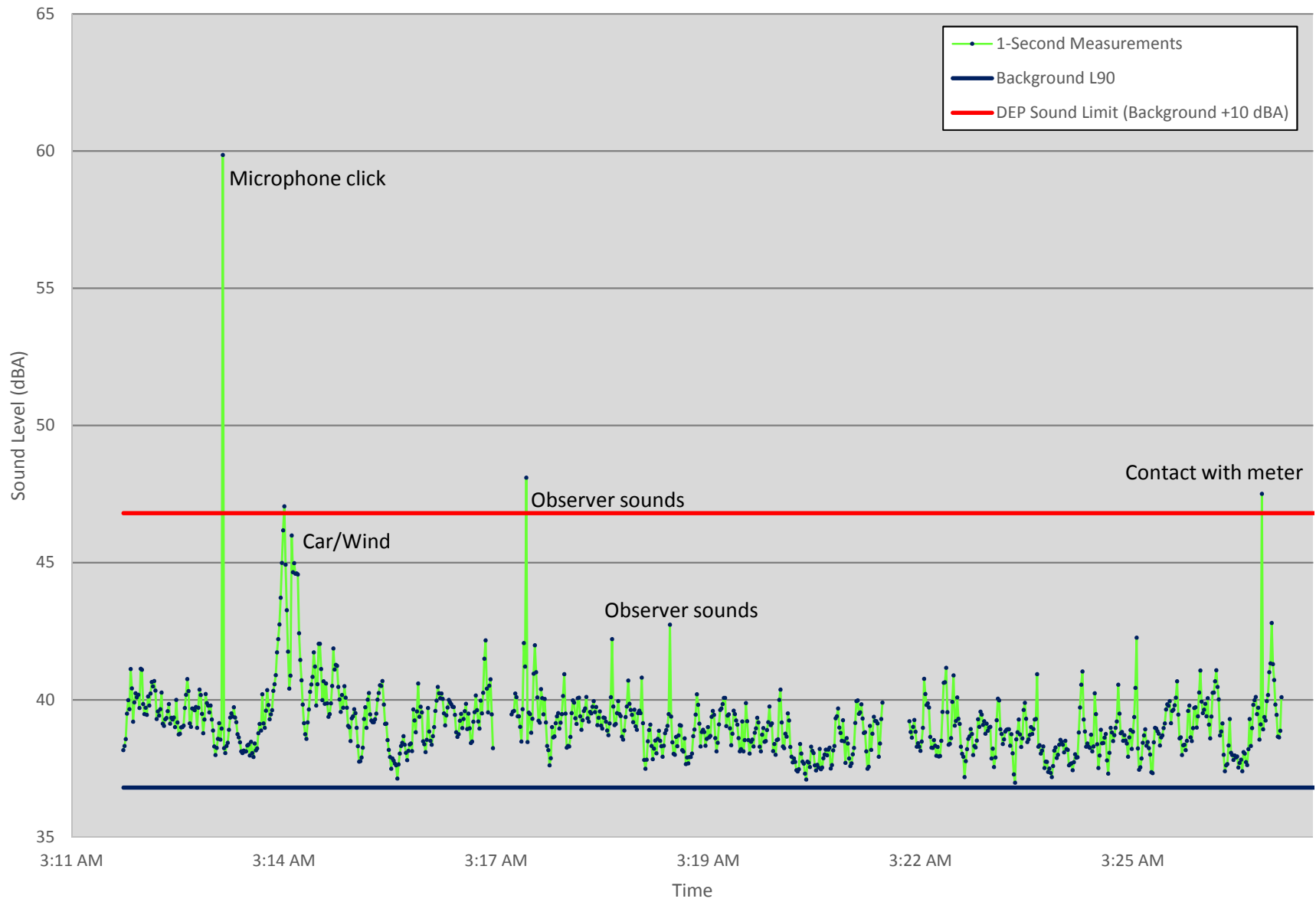
1-Second Sound Levels at 149 Gilson Road With Turbine Operating March 15, 2014



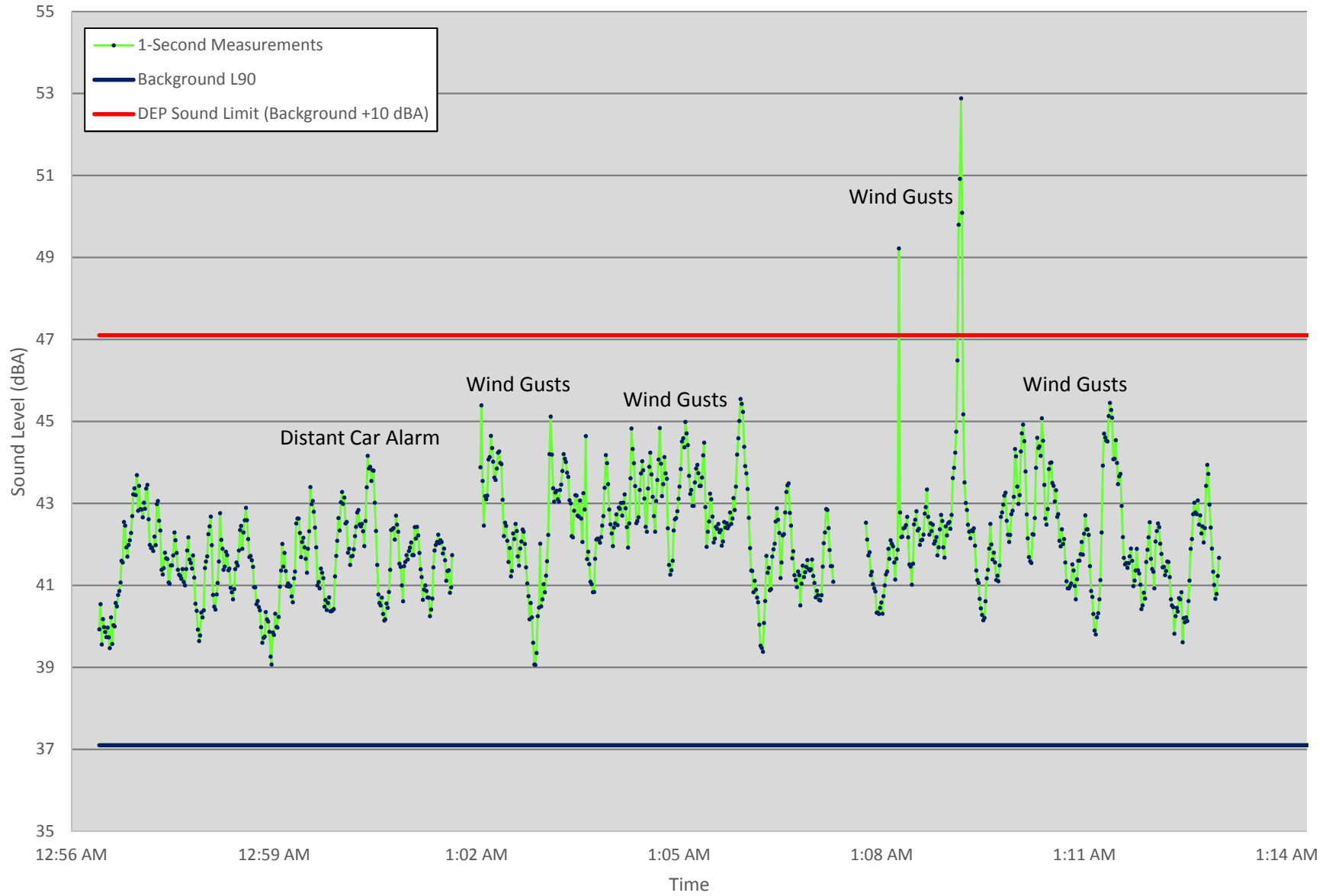
1-Second Sound Levels at 151 Driftway With Turbine Operating March 15, 2014



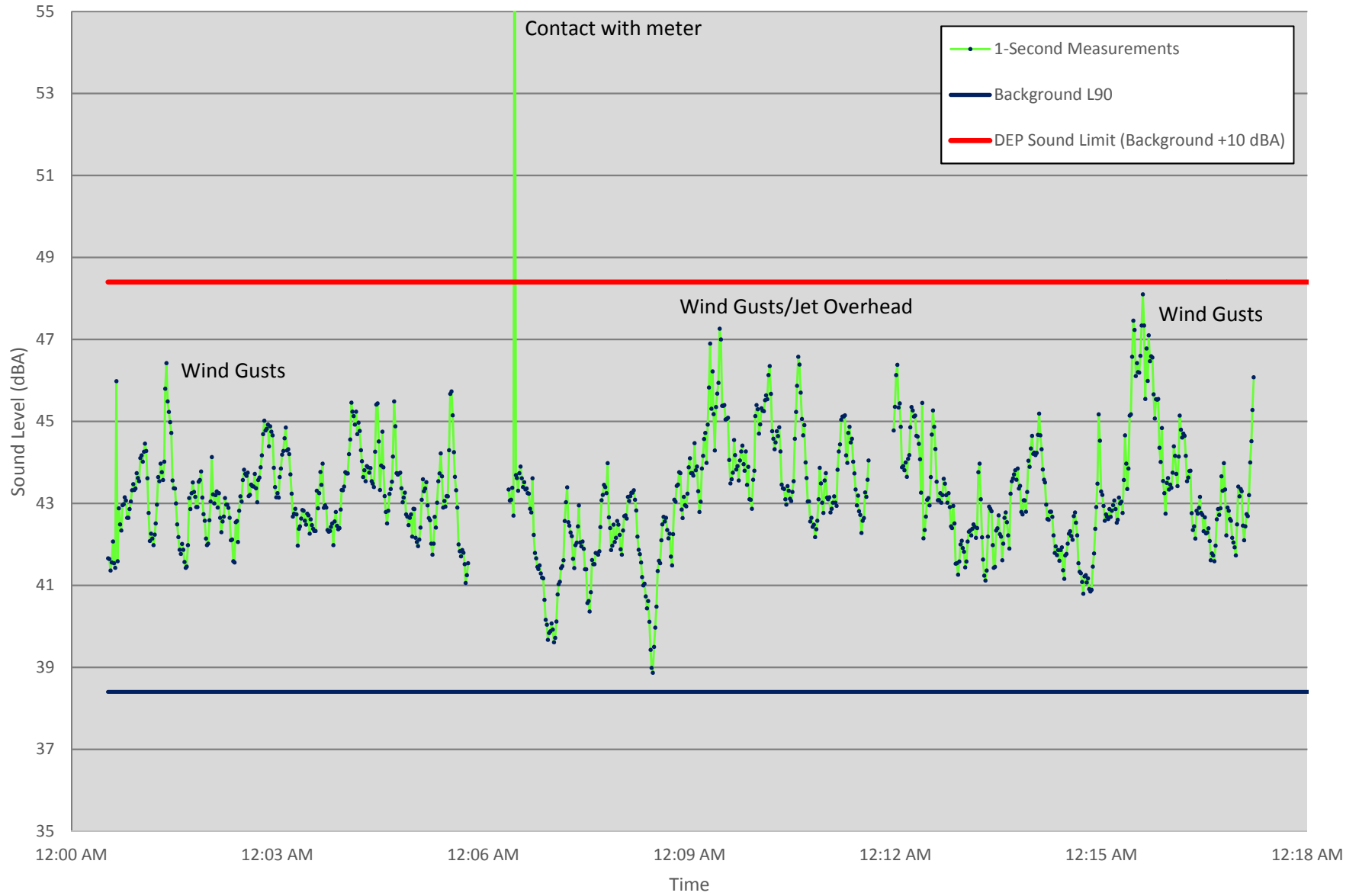
1-Second Sound Levels at 56 Moorland Road With Turbine Operating June 3, 2014



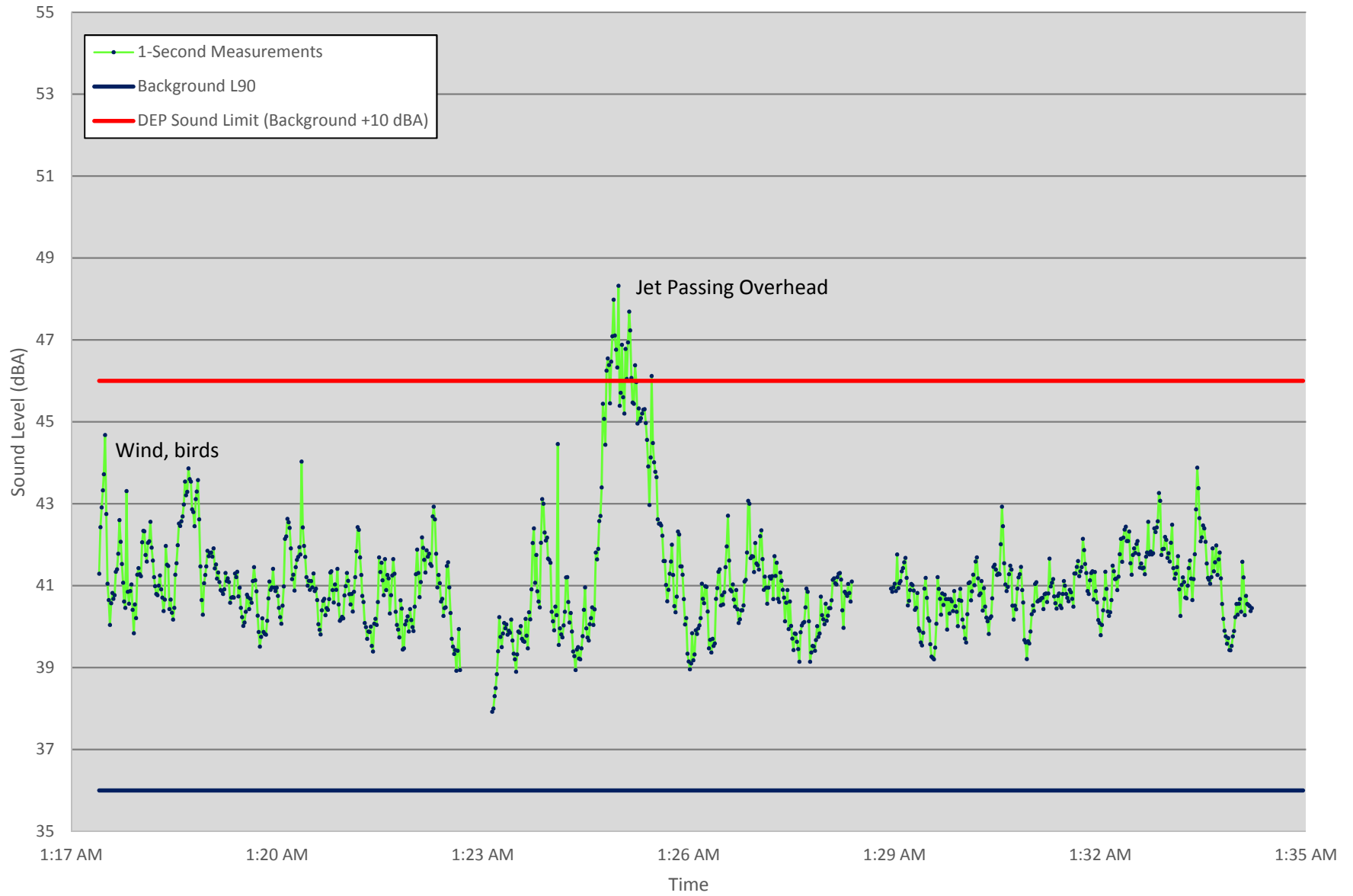
1-Second Sound Levels at 122 Gilson Road With Turbine Operating June 3, 2014



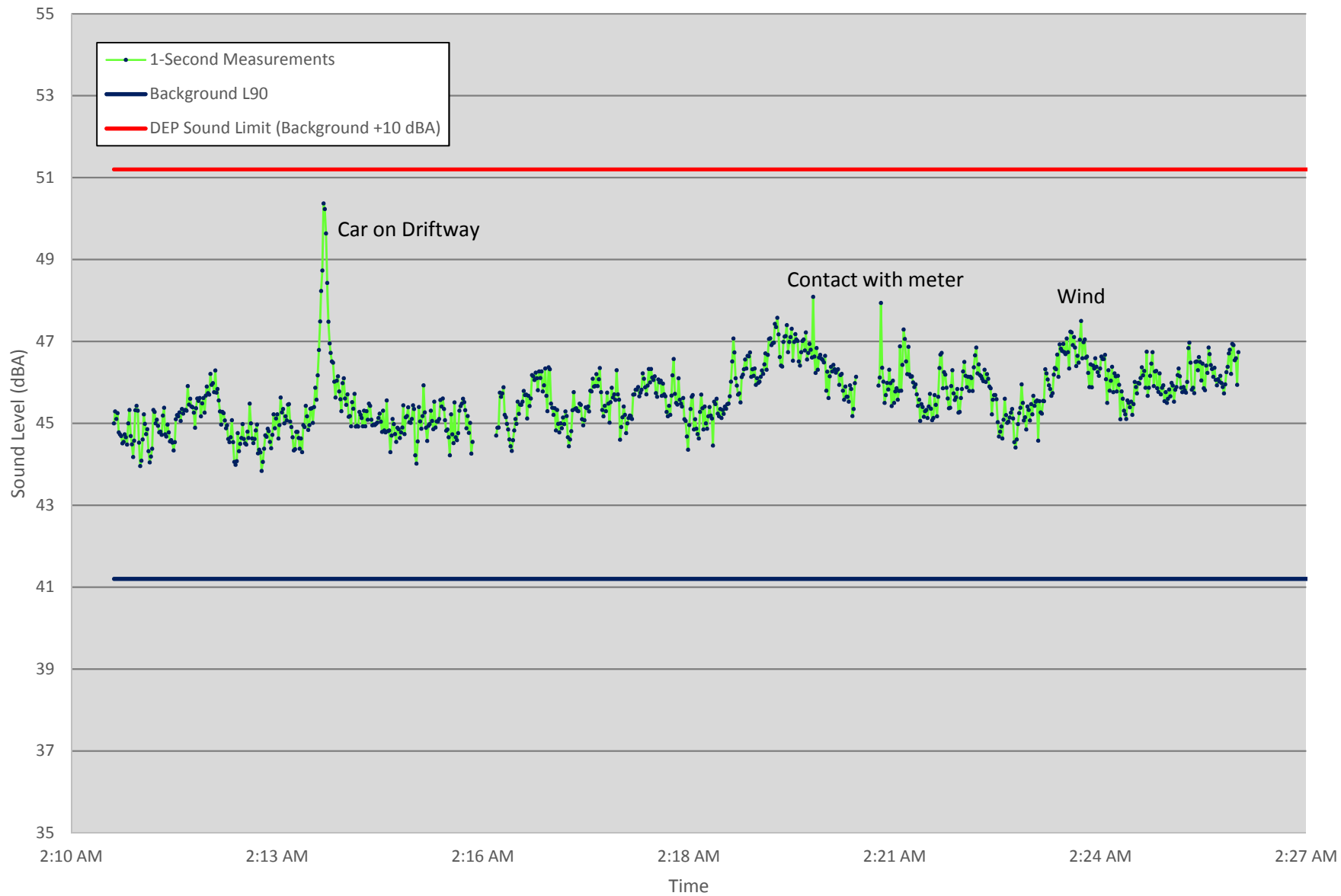
1-Second Sound Levels at 127 Gilson Road With Turbine Operating June 3, 2014



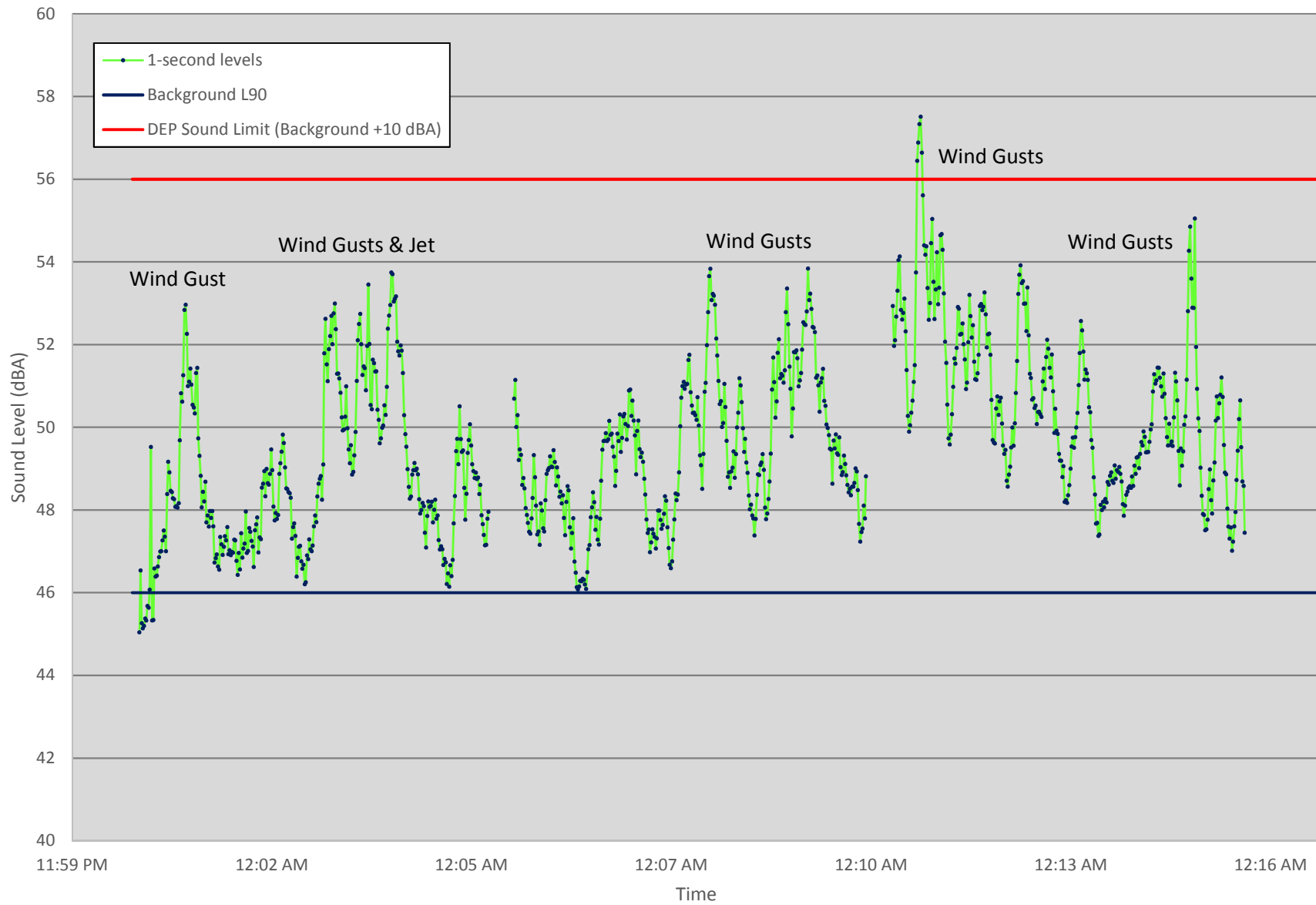
1-Second Sound Levels at 149 Gilson Road With Turbine Operating June 3, 2014



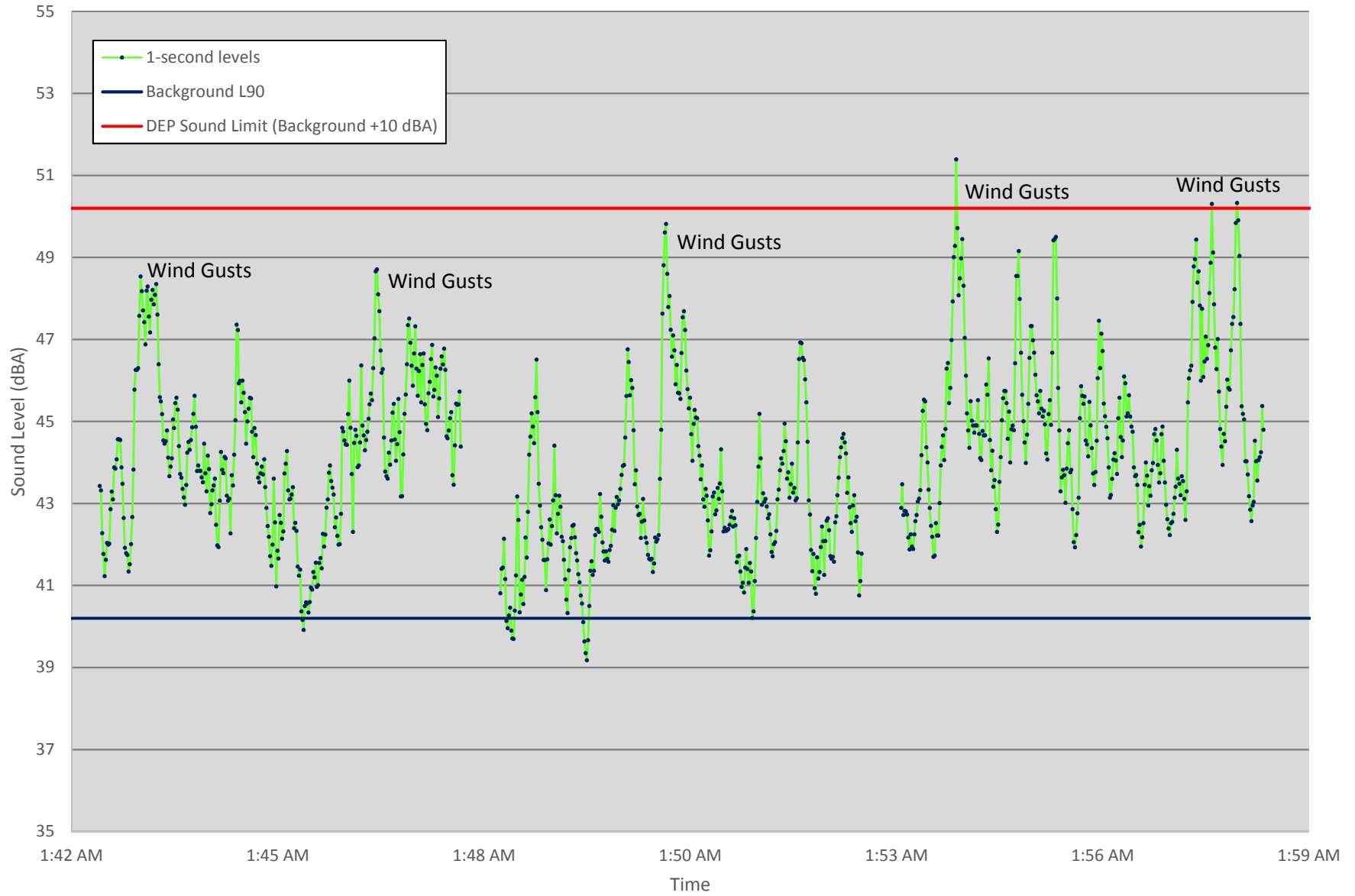
1-Second Sound Levels at 151 Driftway With Turbine Operating June 3, 2014



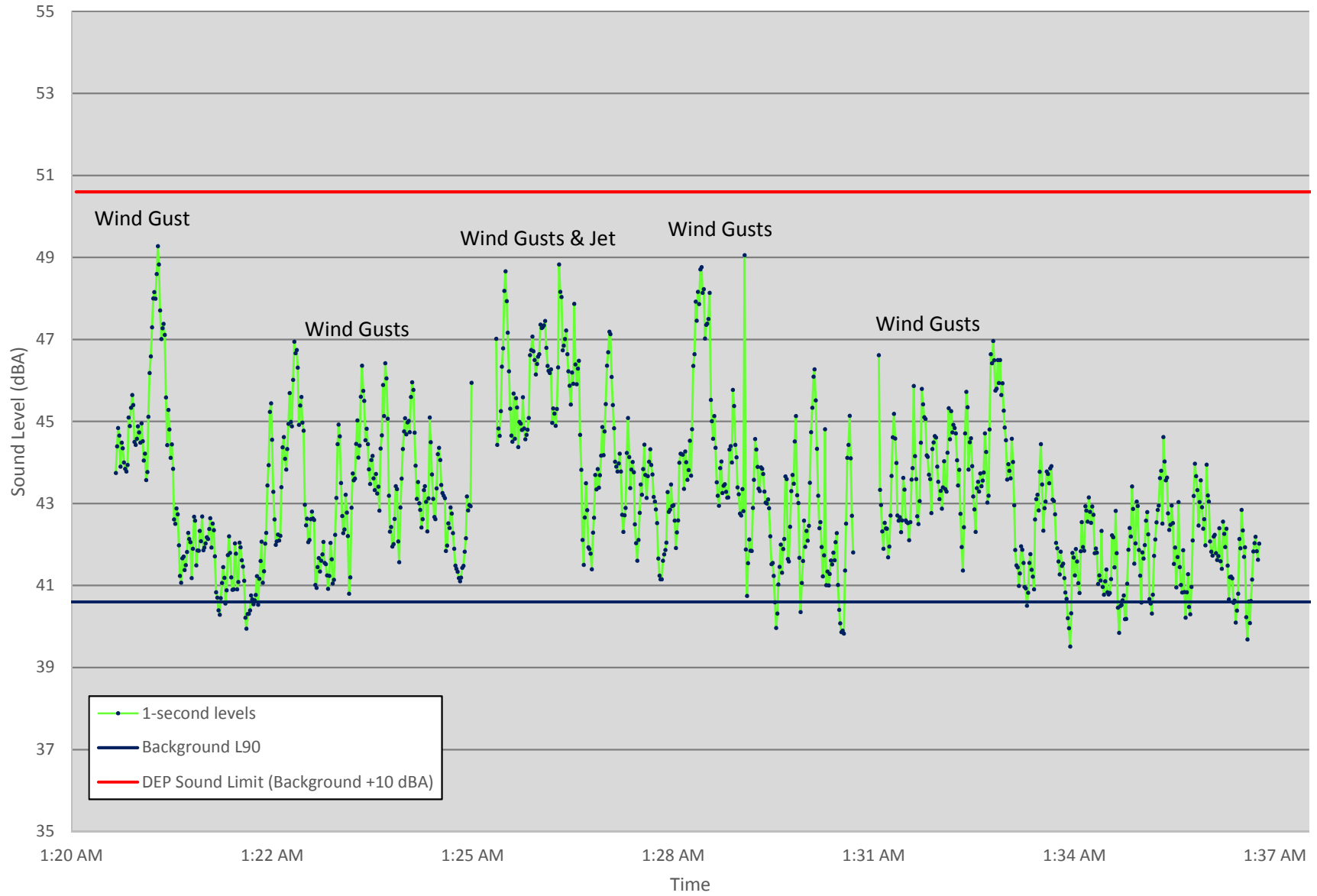
1-Second Sound Levels at 56 Moorland Road With Turbine Operating May 5, 2015



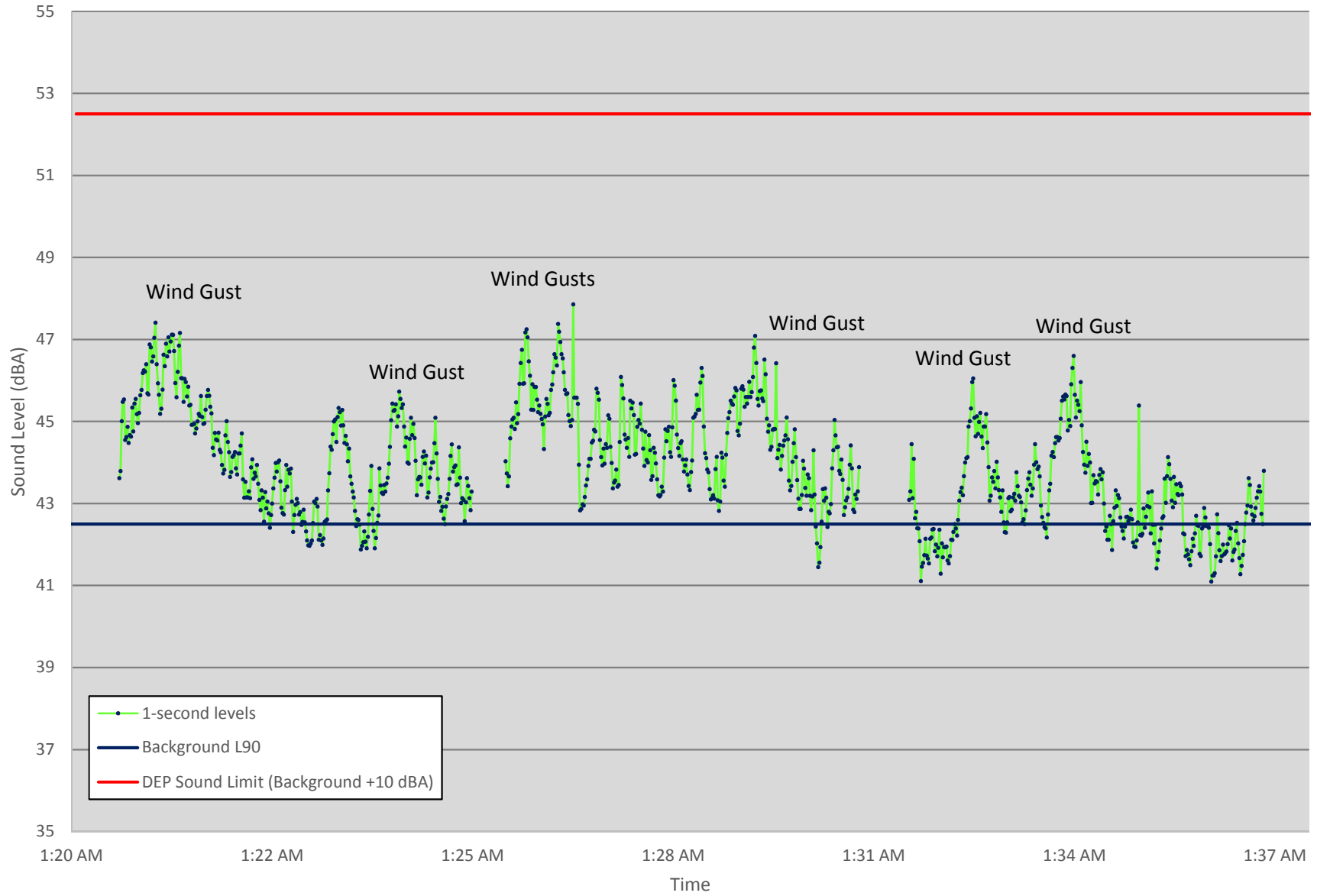
1-Second Sound Levels at 122 Gilson Road With Turbine Operating May 5, 2015



1-Second Sound Levels at 127 Gilson With Turbine Operating May 5, 2015



1-Second Sound Levels at 149 Gilson With Turbine Operating May 5, 2015

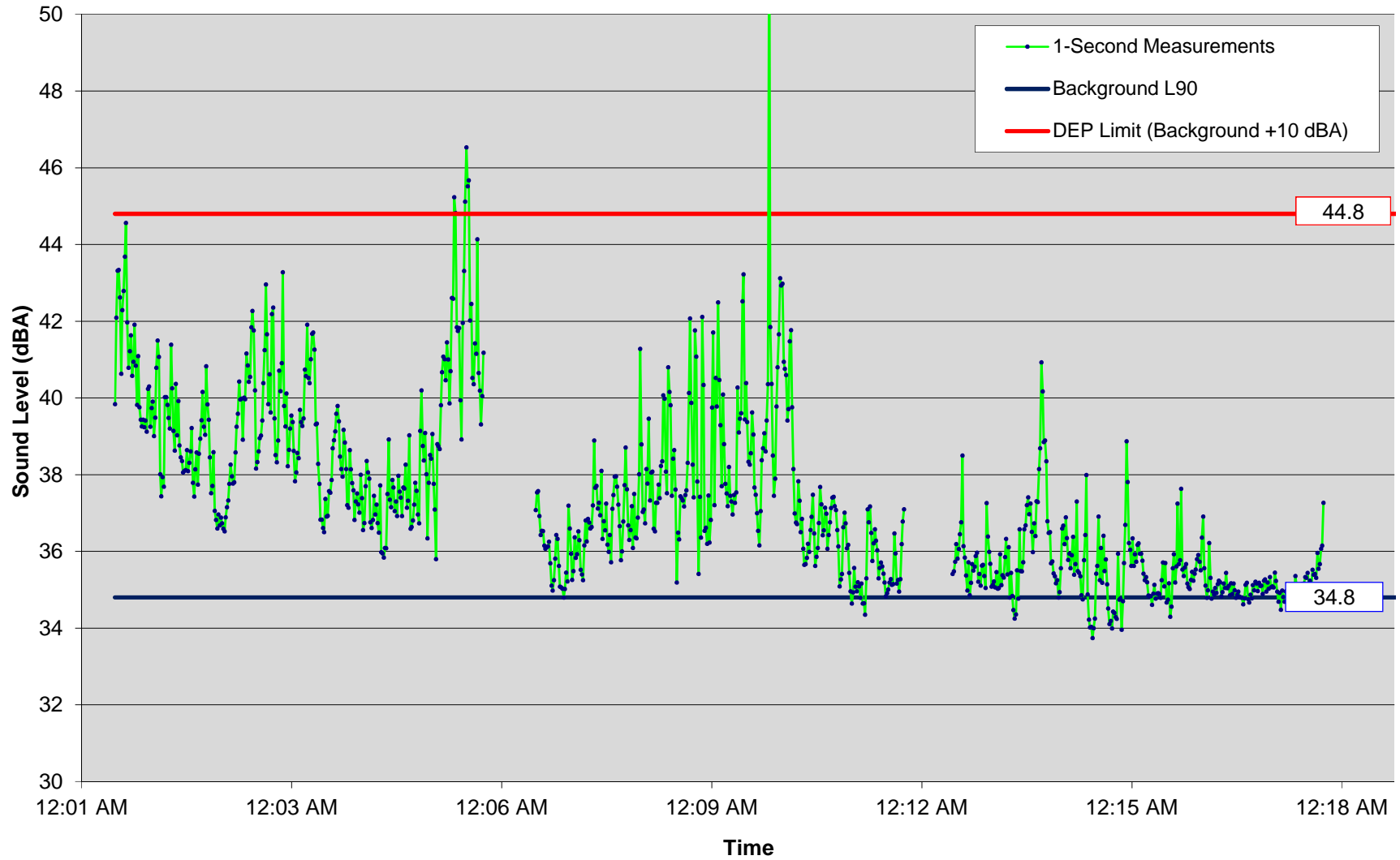


1-Second Sound Levels at 151 Driftway With Turbine Operating June 3, 2014

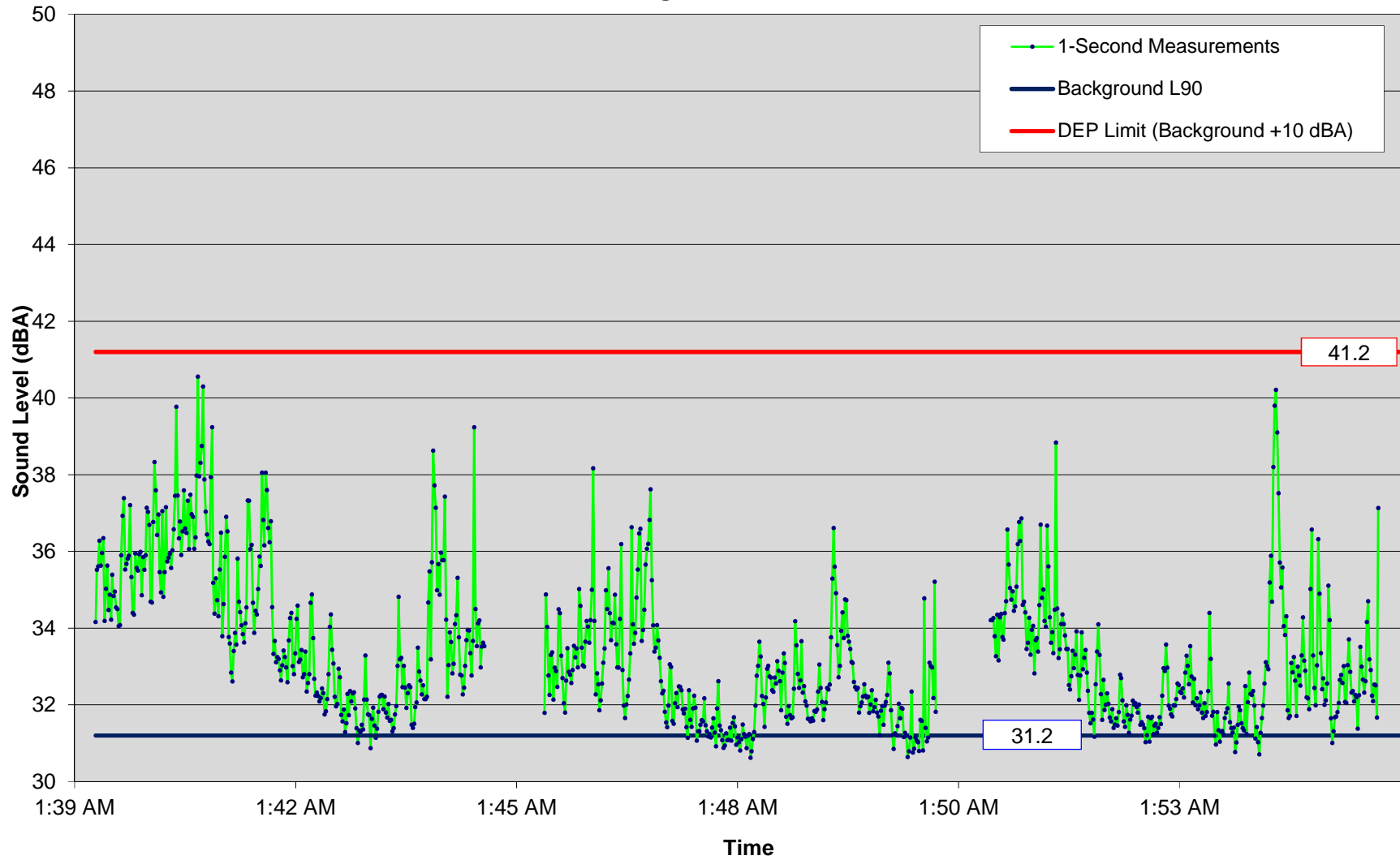


Turbine-OFF Graphs

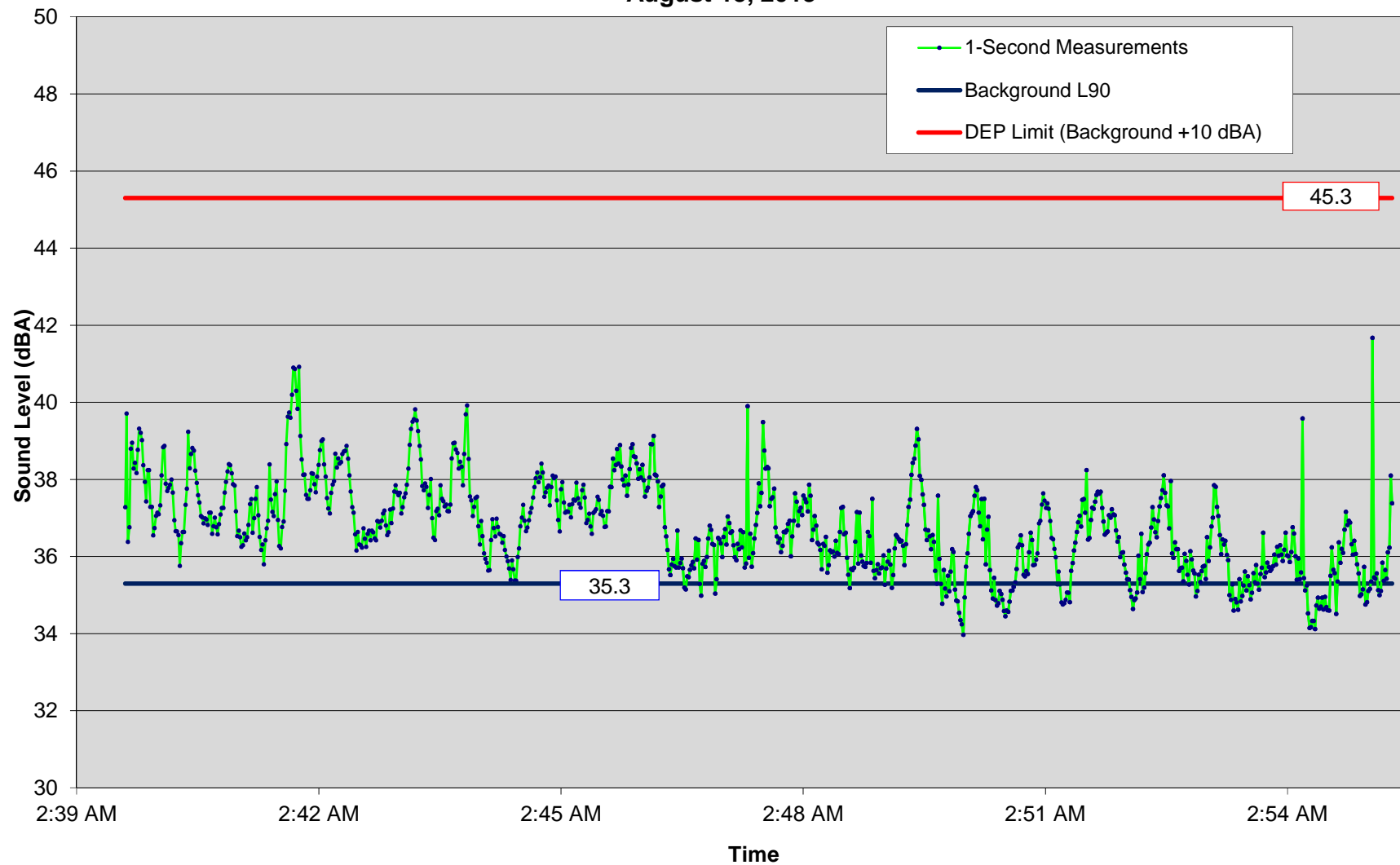
1-Second Sound Levels at 56 Moorland Road Without Turbine Operating August 15, 2013



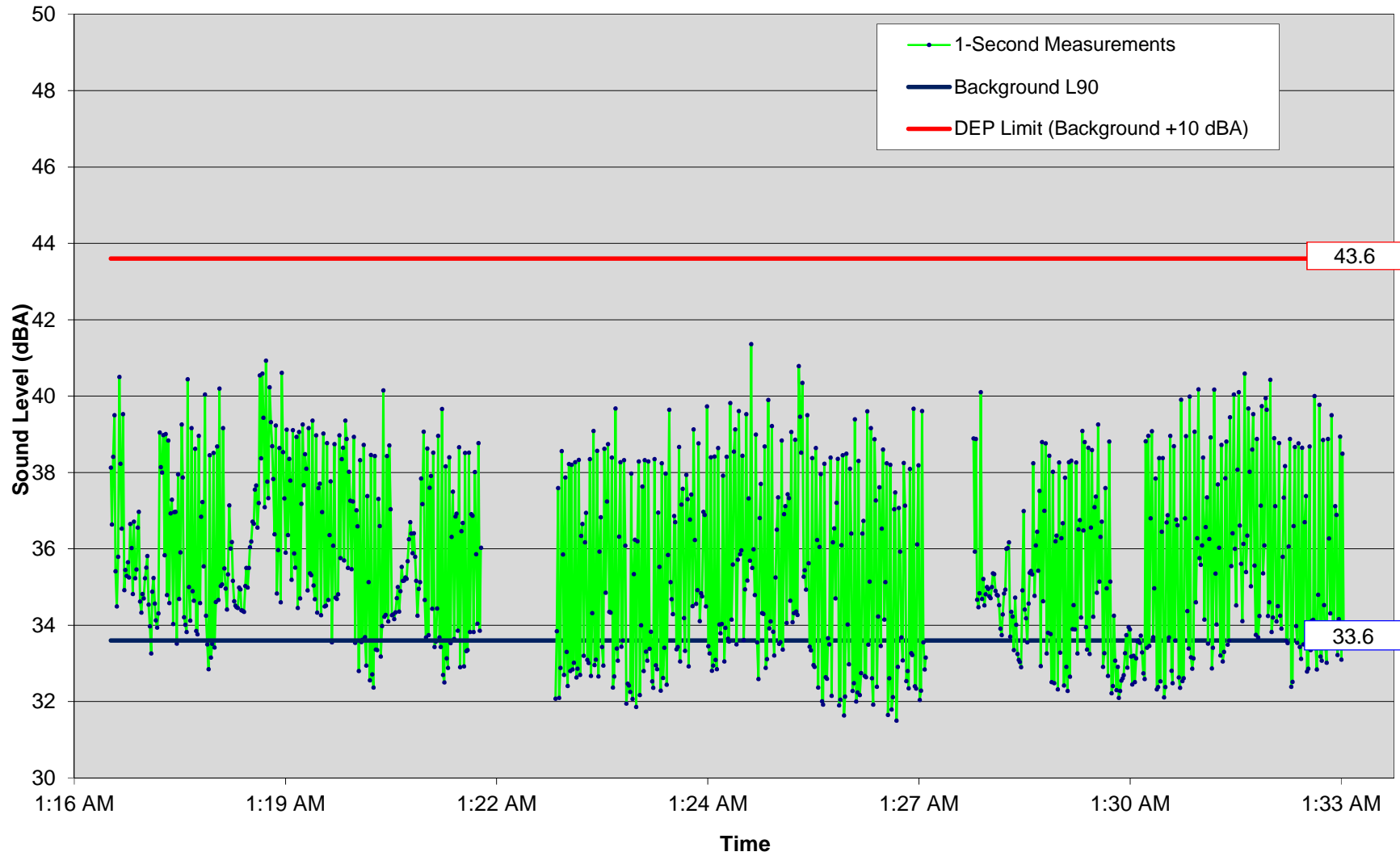
**1-Second Sound Levels at 122 Gilson Road Without Turbine Operating
August 15, 2013**



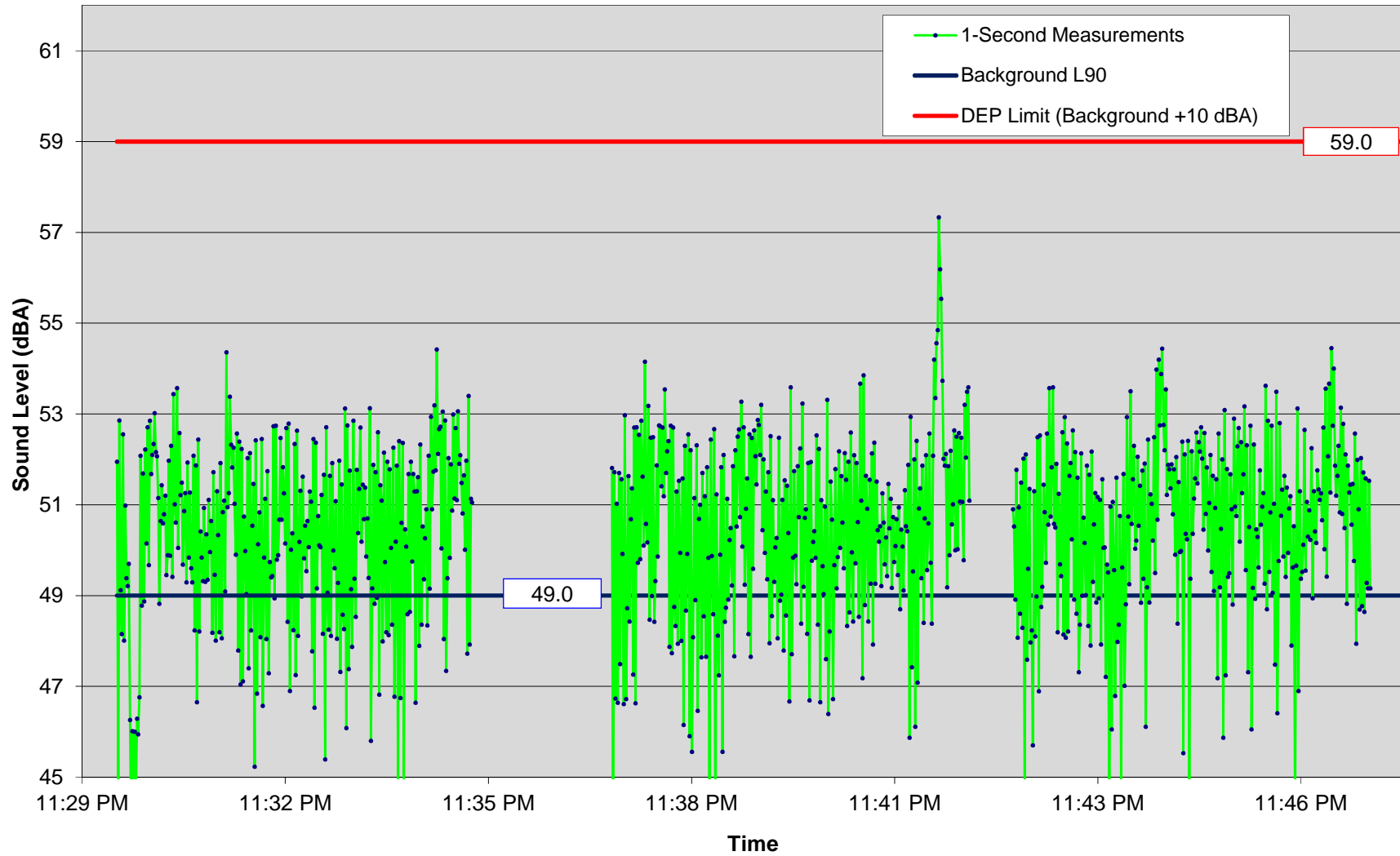
1-Second Sound Levels At 127 Gilson Road Without Turbine Operating August 15, 2013



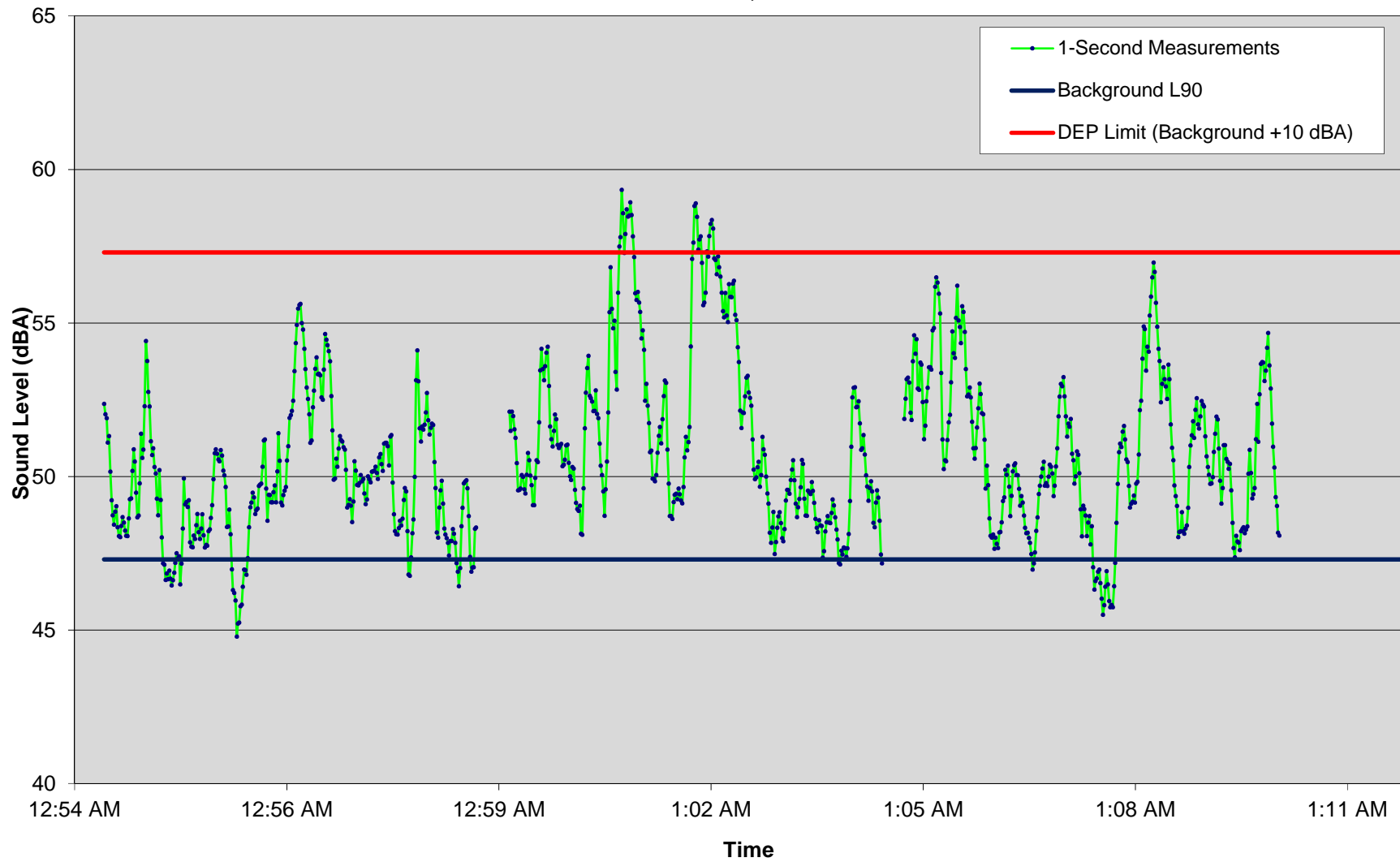
1-Second Sound Levels At 149 Gilson Road Without Turbine Operating August 15, 2013



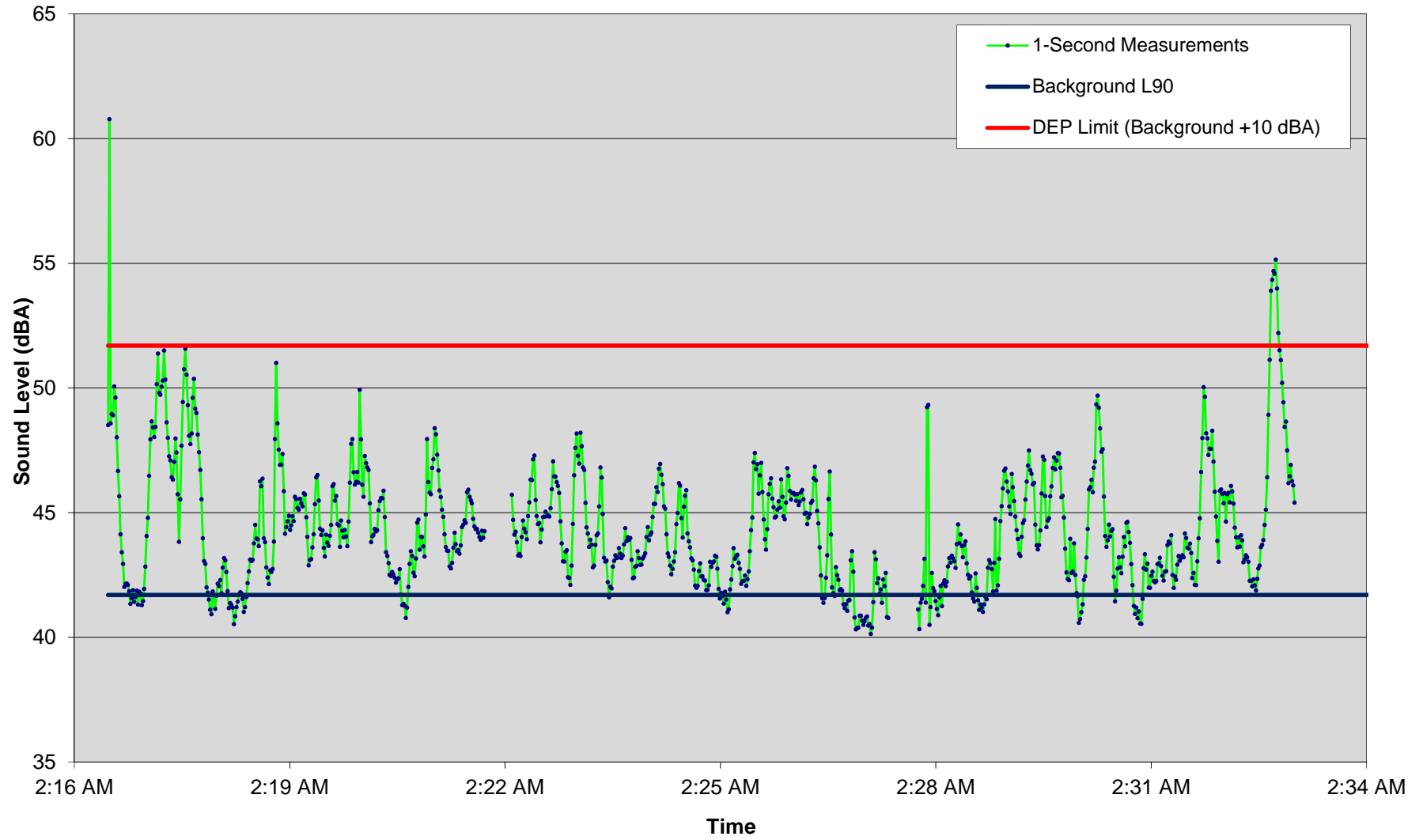
1-Second Sound Levels At 151 Driftway Without Turbine Operating August 14, 2013



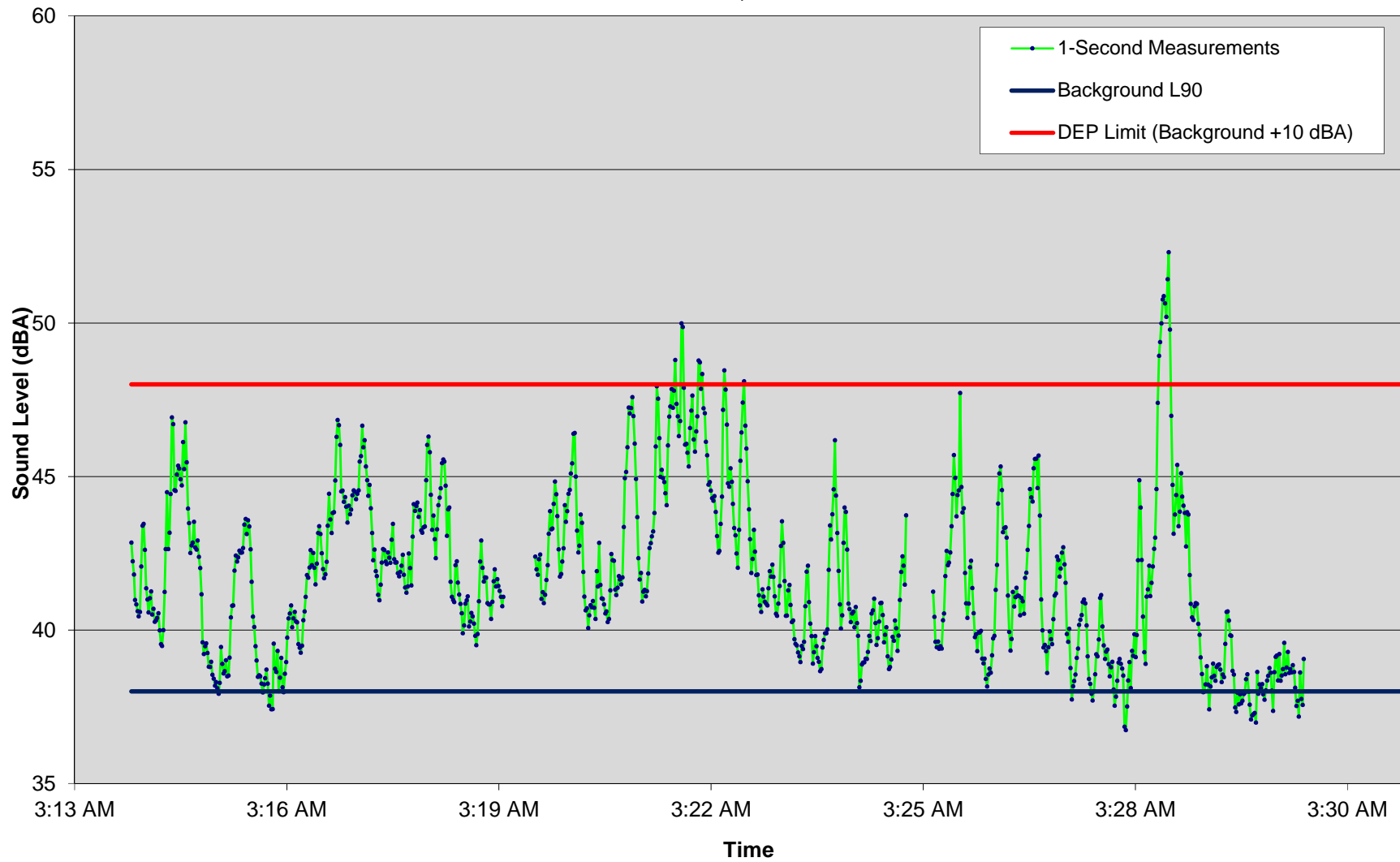
1-Second Sound Levels at 56 Moorland Road Without Turbine Operating March 15, 2014



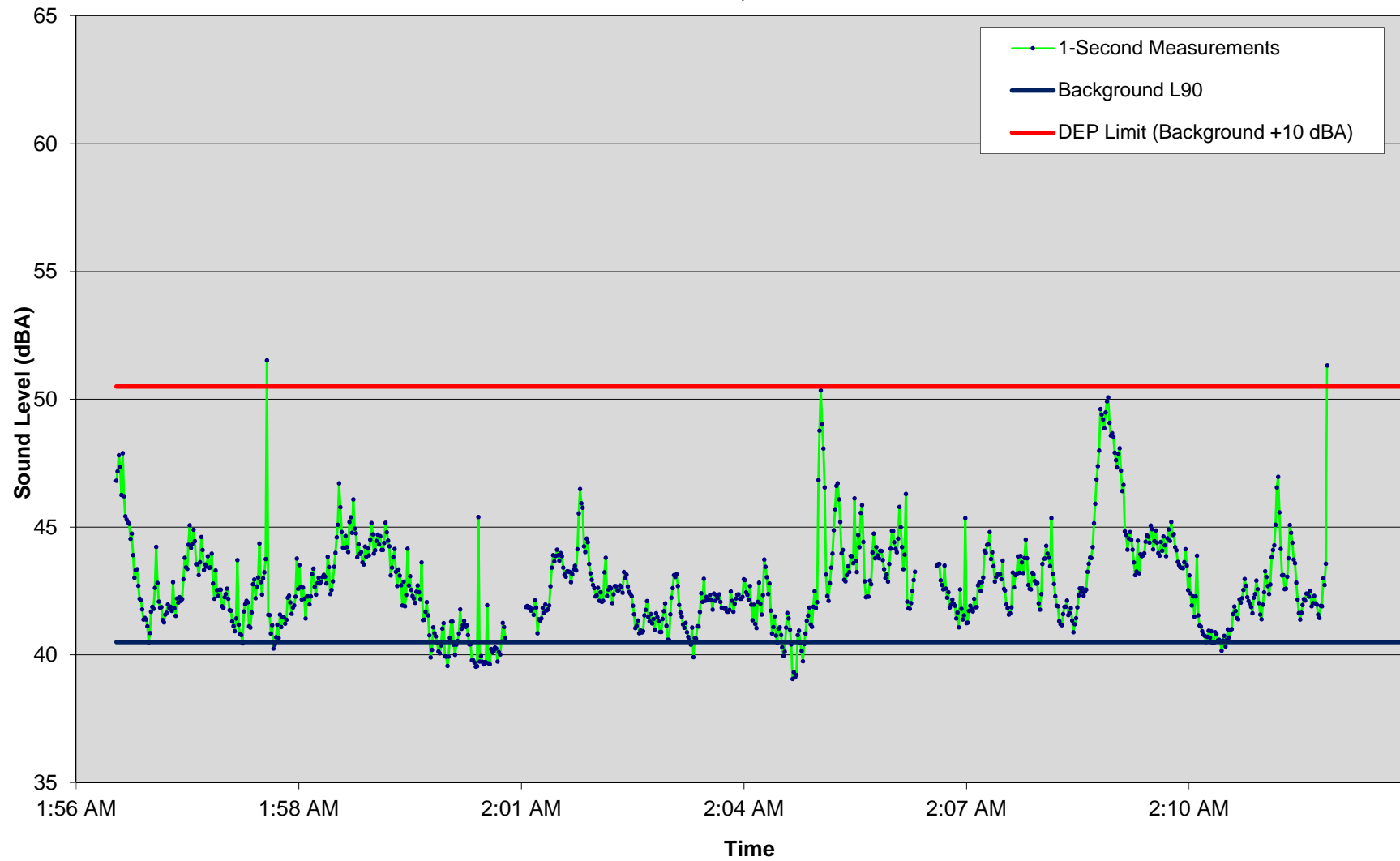
**1-Second Sound Levels at 122 Gilson Road Without Turbine Operating
March 15, 2014**



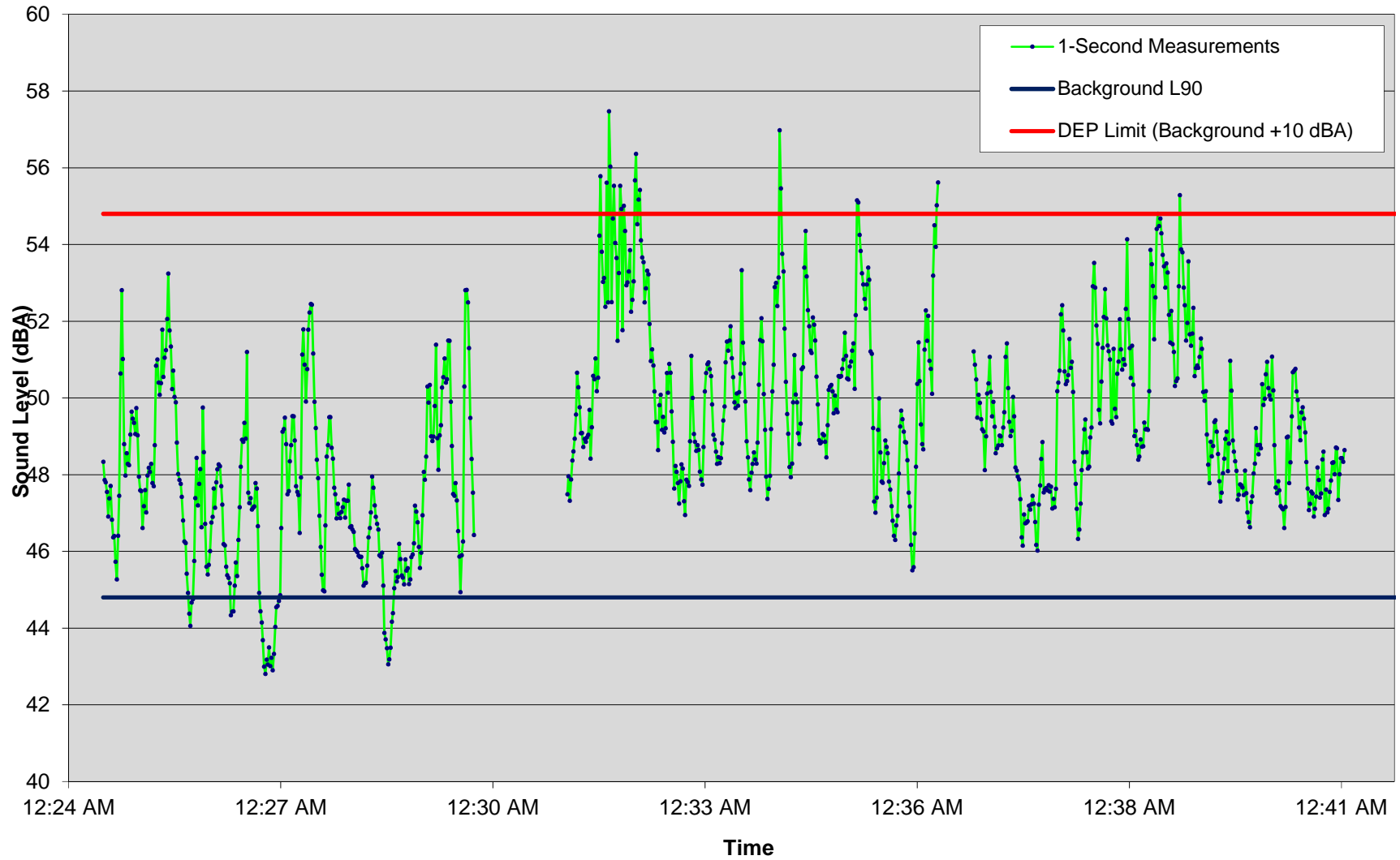
1-Second Sound Levels at 127 Gilson Road Without Turbine Operating
March 15, 2014



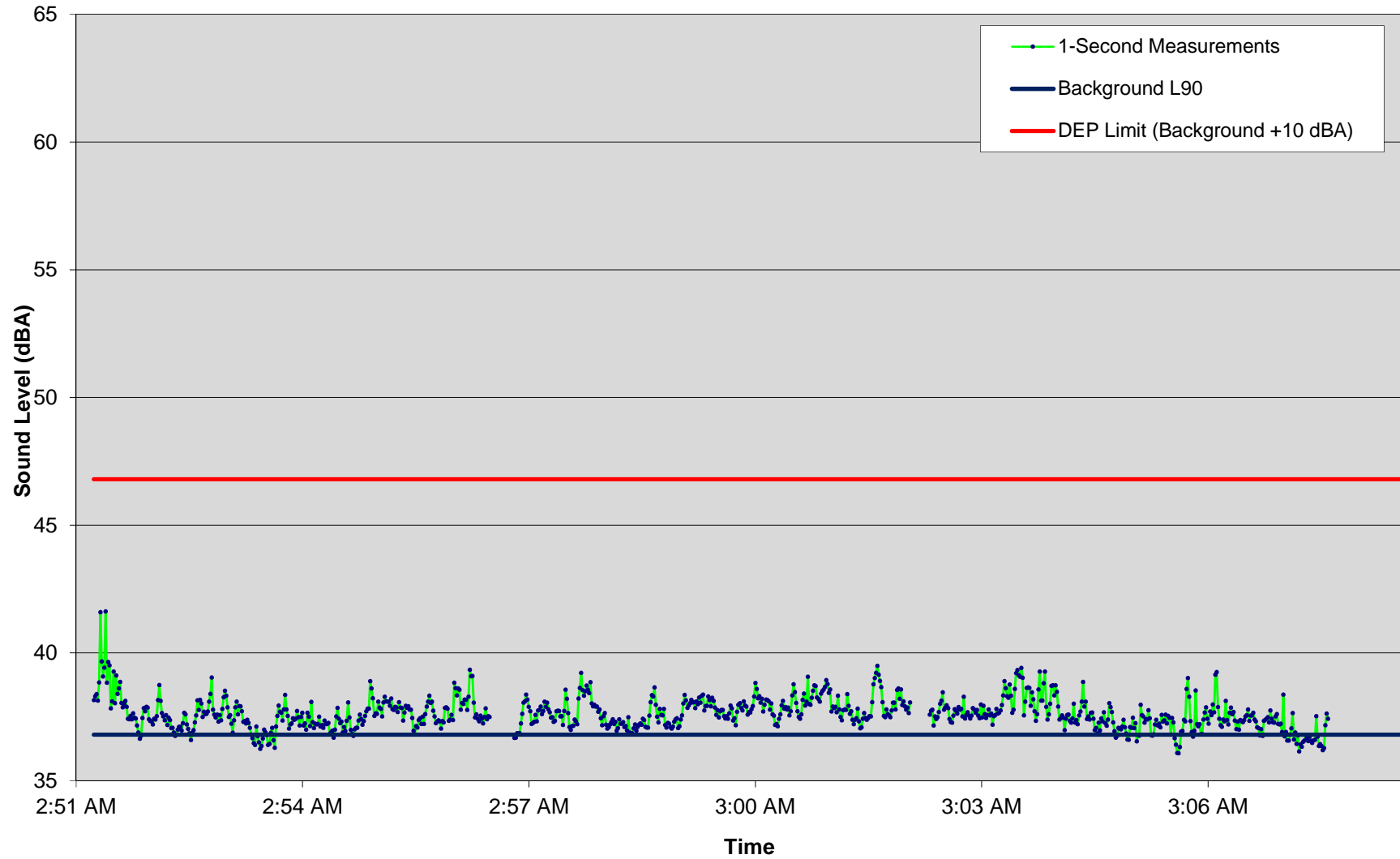
**1-Second Sound Levels at 149 Gilson Road Without Turbine Operating
March 15, 2014**



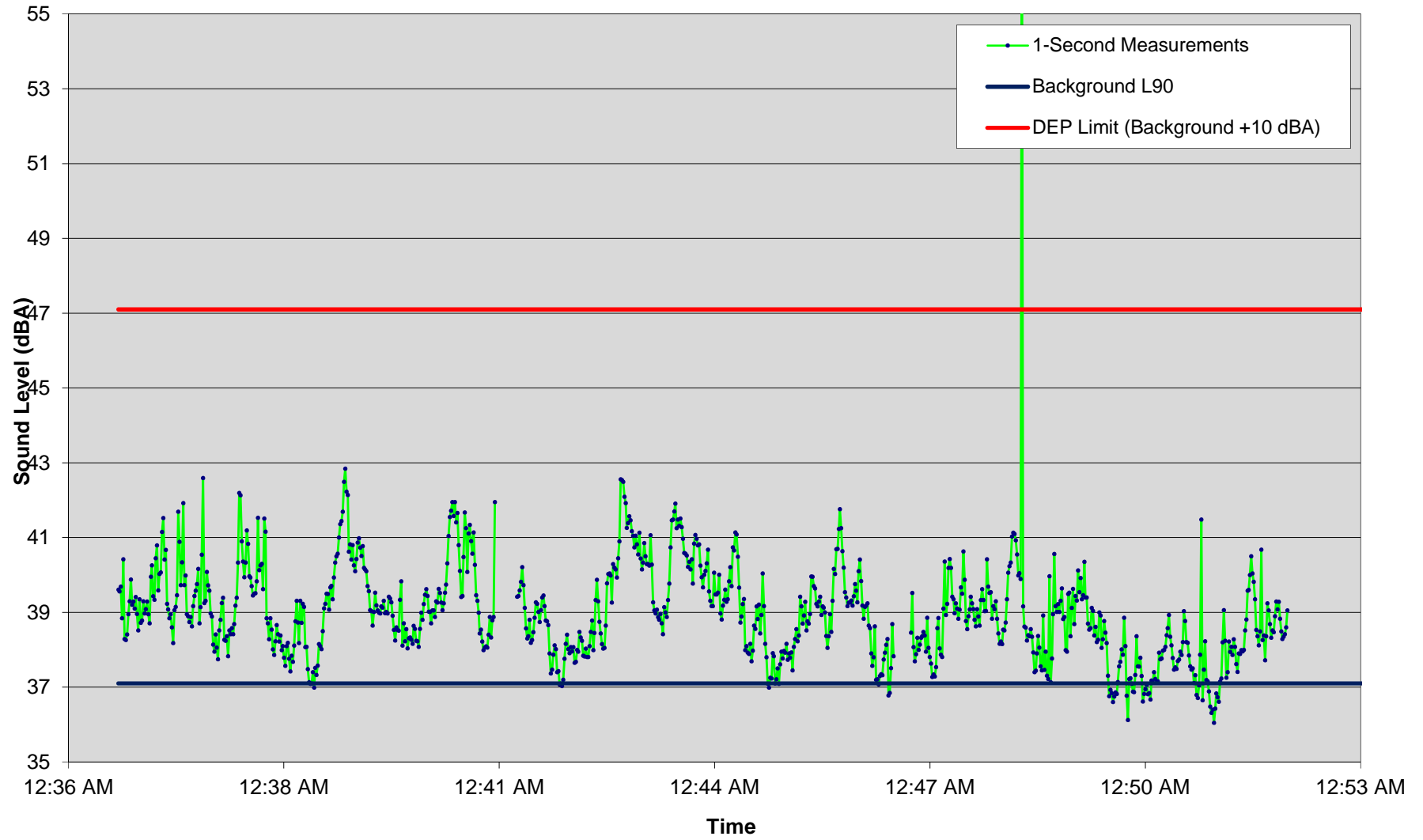
1-Second Sound Levels at 151 Driftway Without Turbine Operating
March 15, 2014



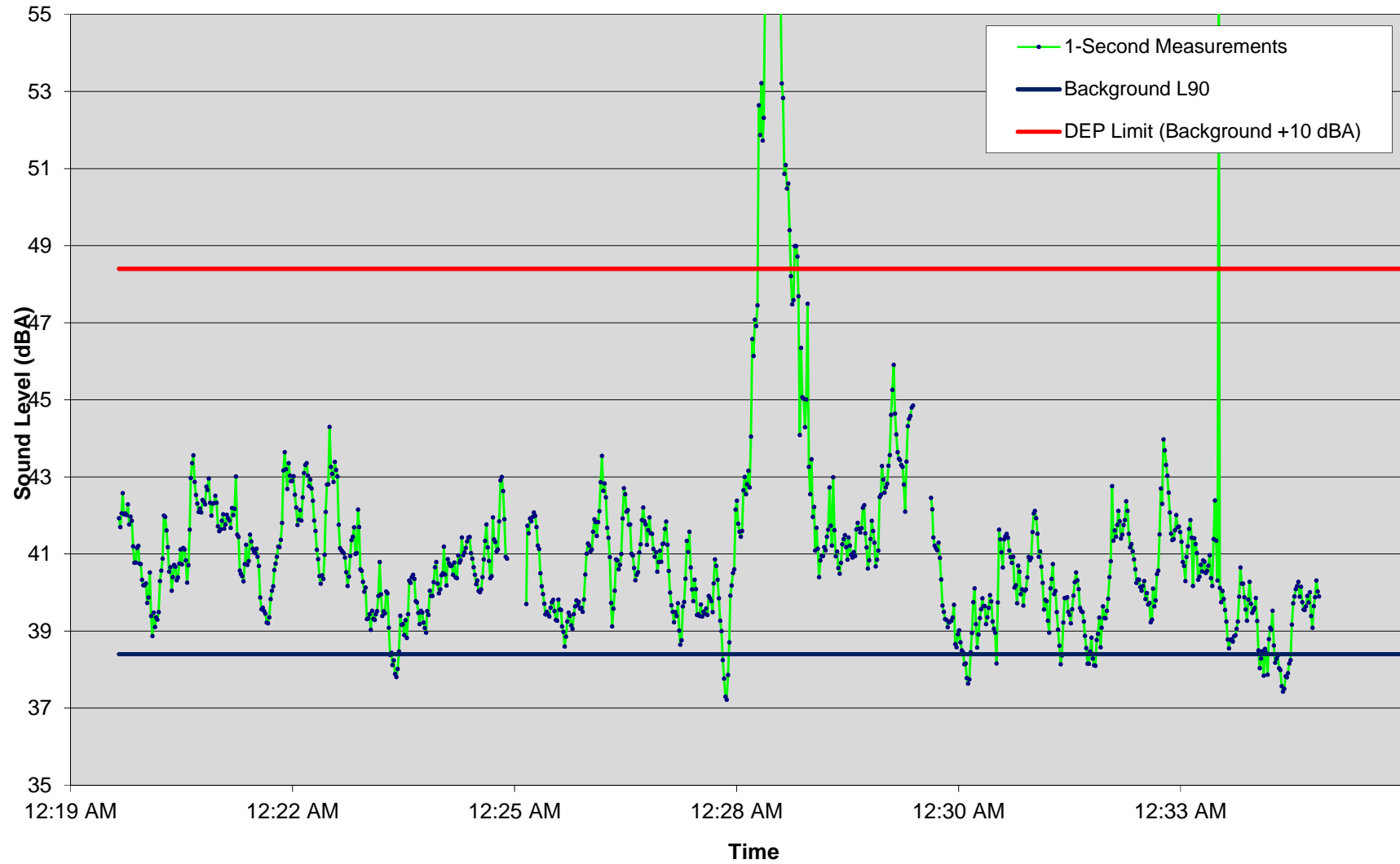
**1-Second Sound Levels at 56 Moorland Road Without Turbine Operating
June 3, 2014**



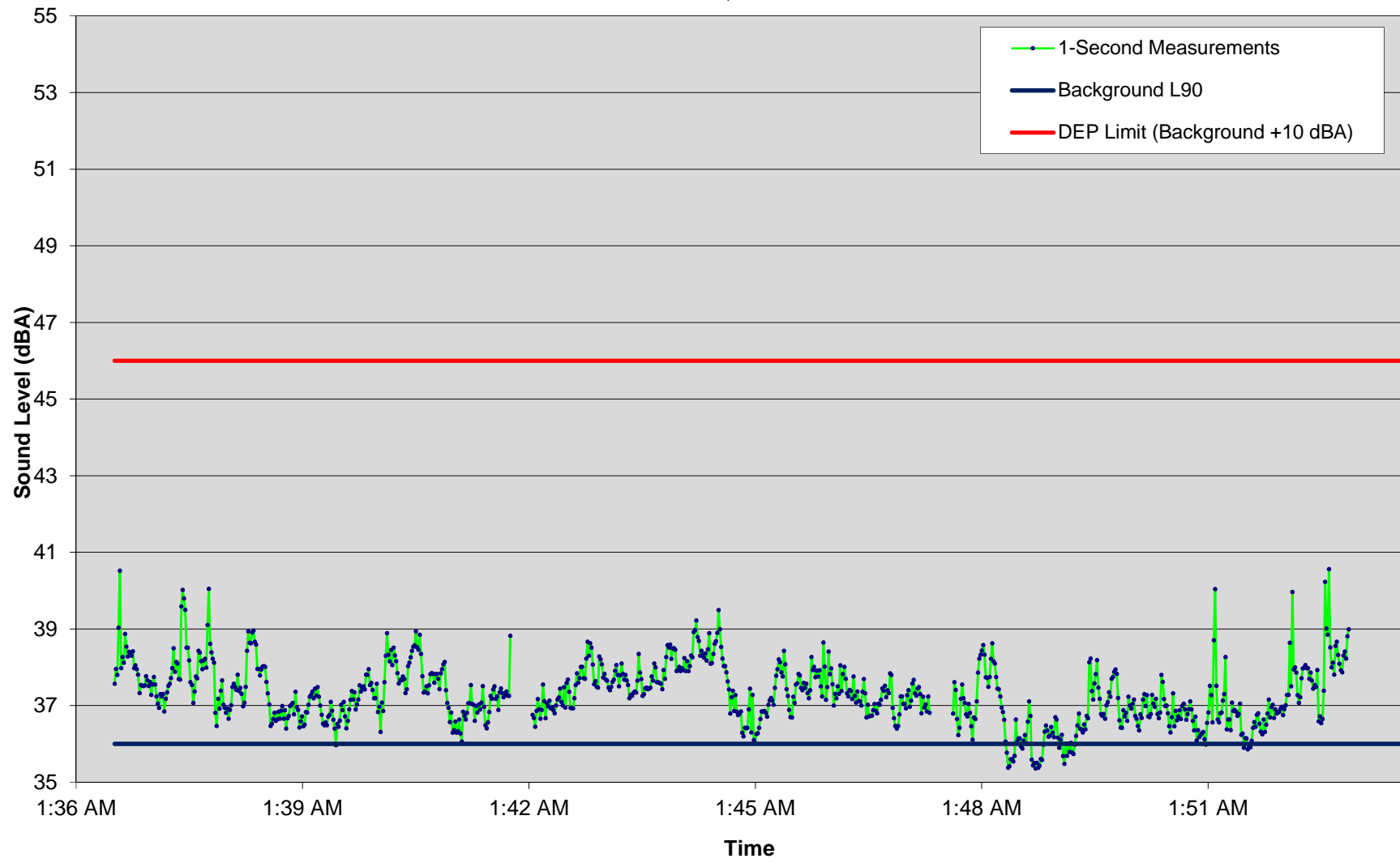
1-Second Sound Levels at 122 Gilson Road Without Turbine Operating
June 3, 2014



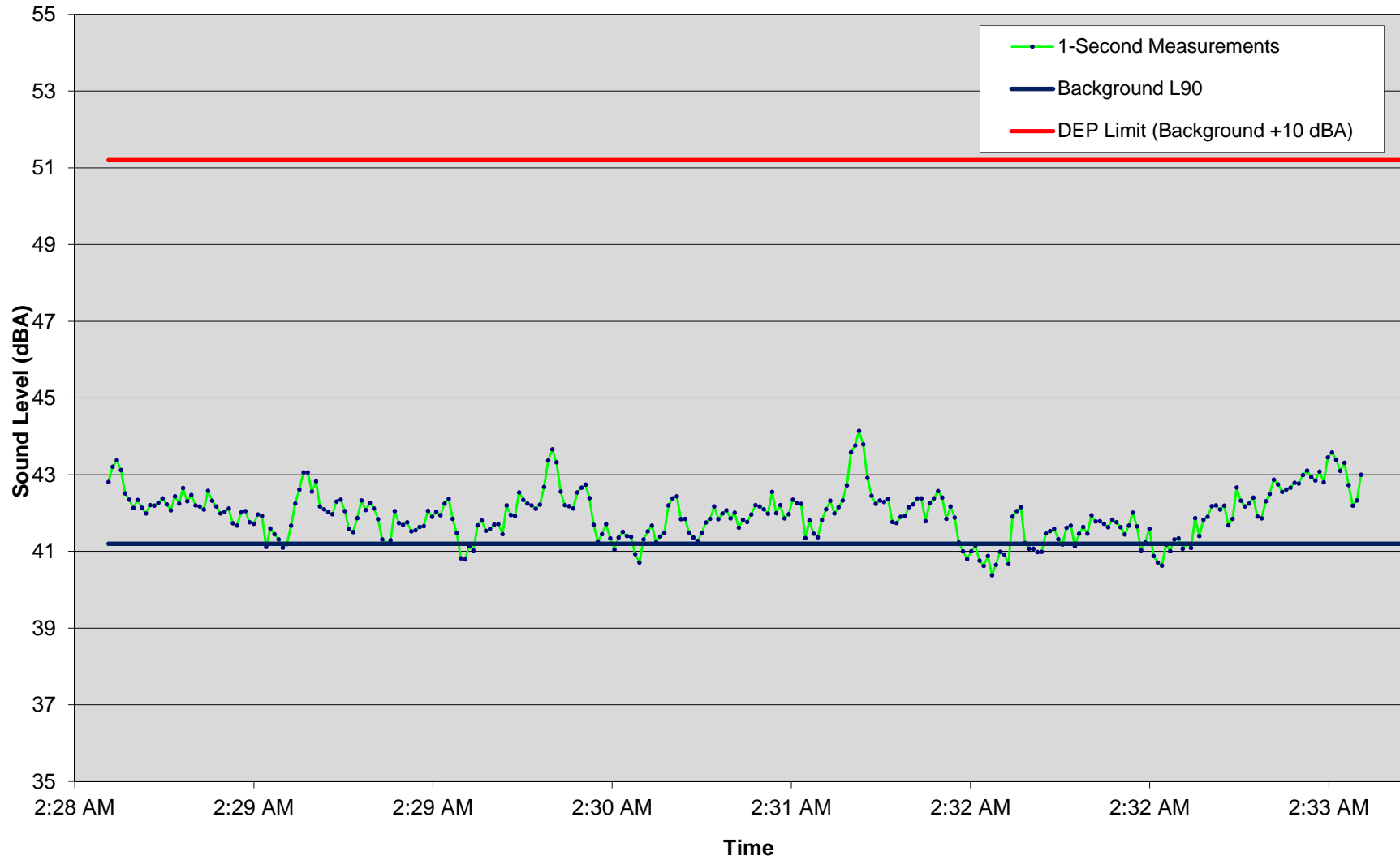
1-Second Sound Levels at 127 Gilson Road Without Turbine Operating
June 3, 2014



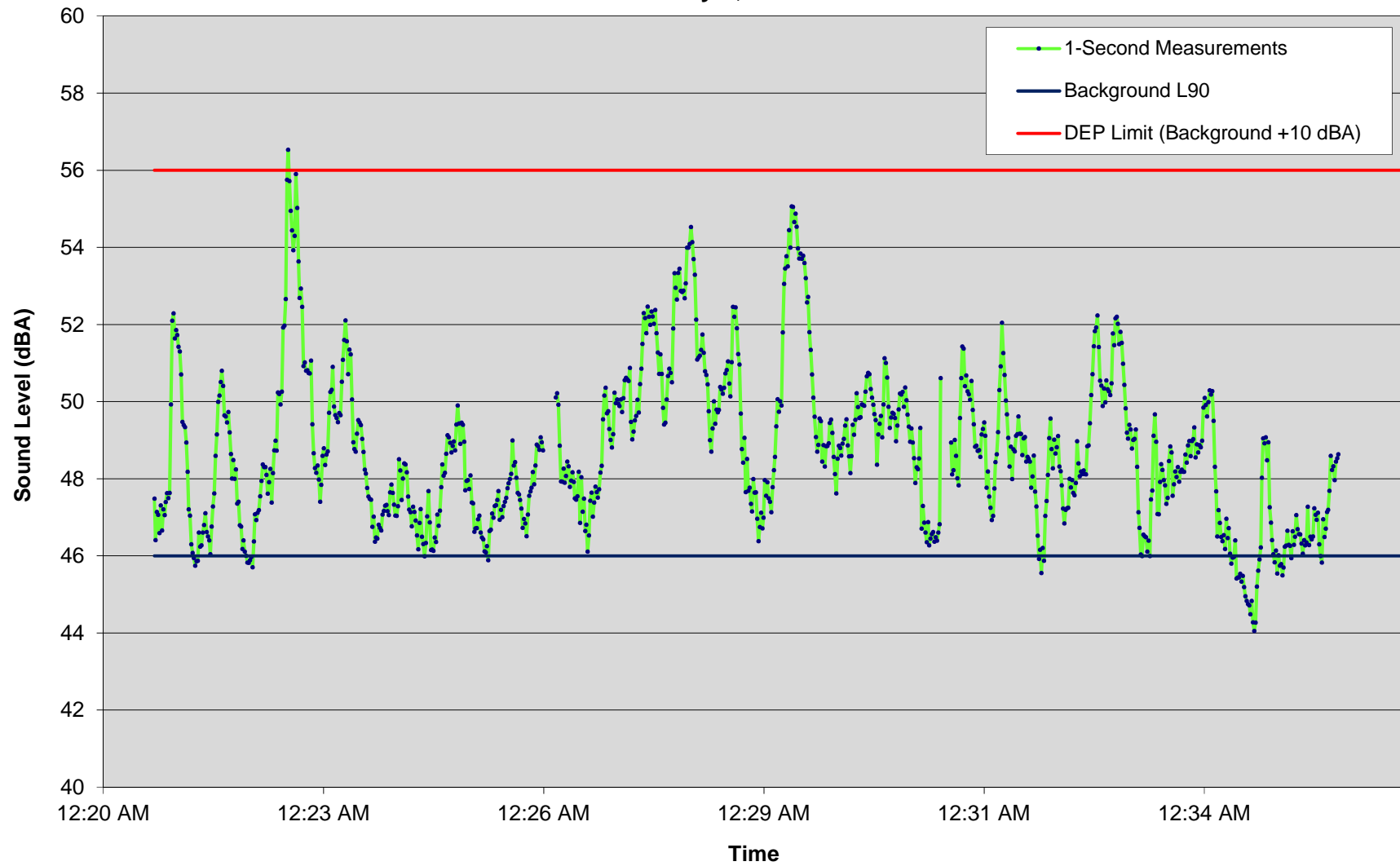
**1-Second Sound Levels at 149 Gilson Road Without Turbine Operating
June 3, 2014**



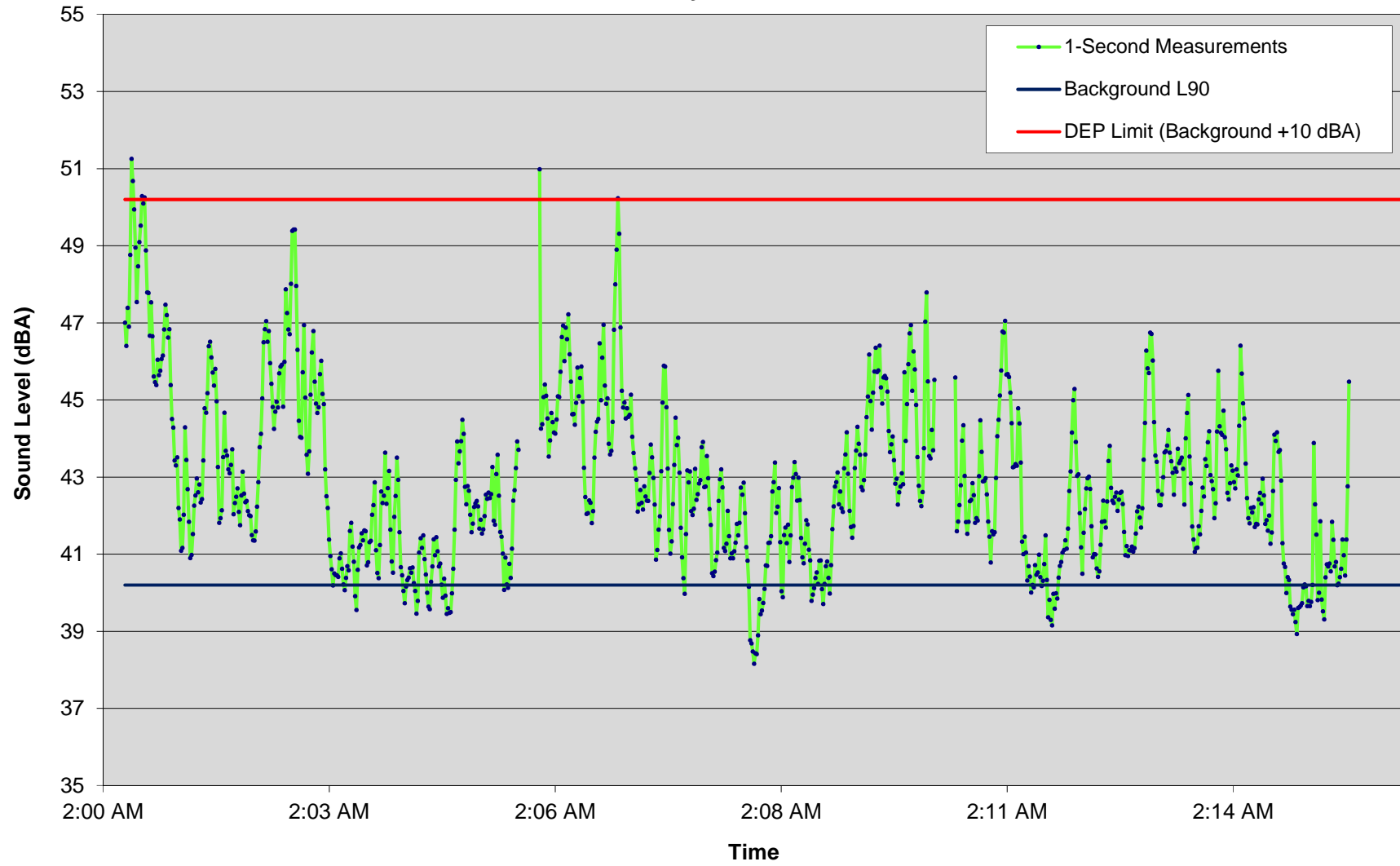
**1-Second Sound Levels at 151 Driftway Without Turbine Operating
June 3, 2014**



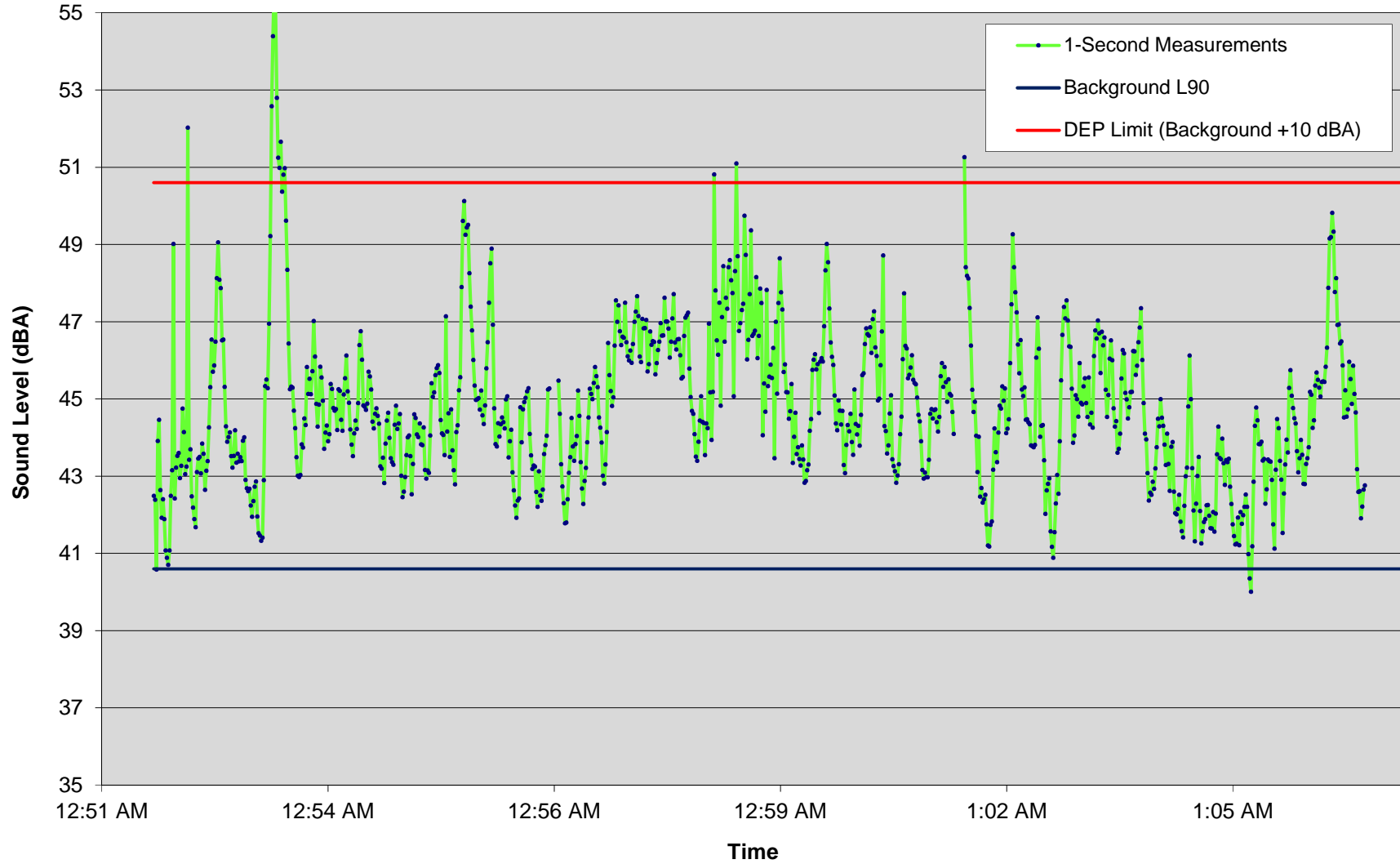
1-Second Sound Levels at 56 Moorland Road Without Turbine Operating May 5, 2015



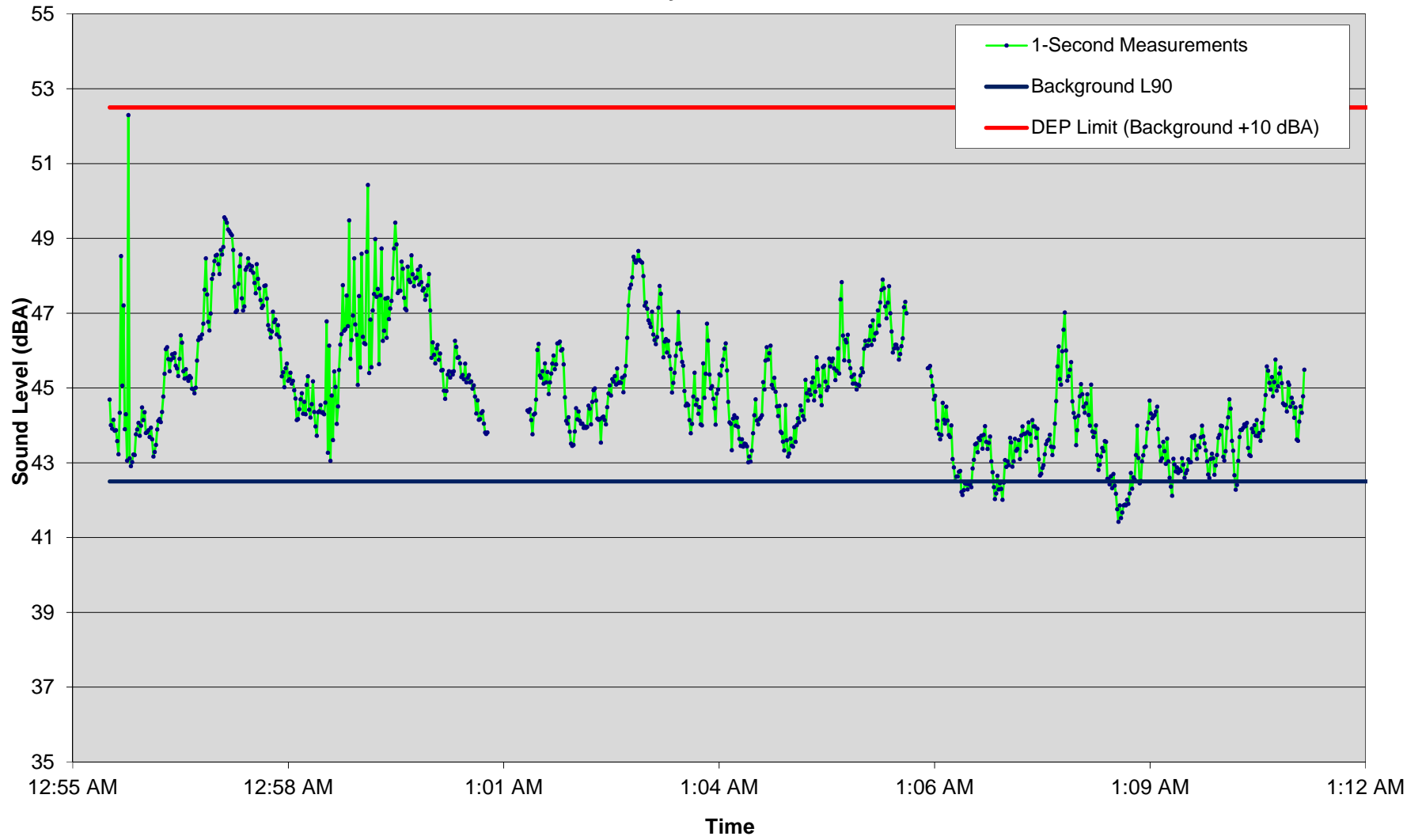
**1-Second Sound Levels at 122 Gilson Road Without Turbine Operating
May 5, 2015**



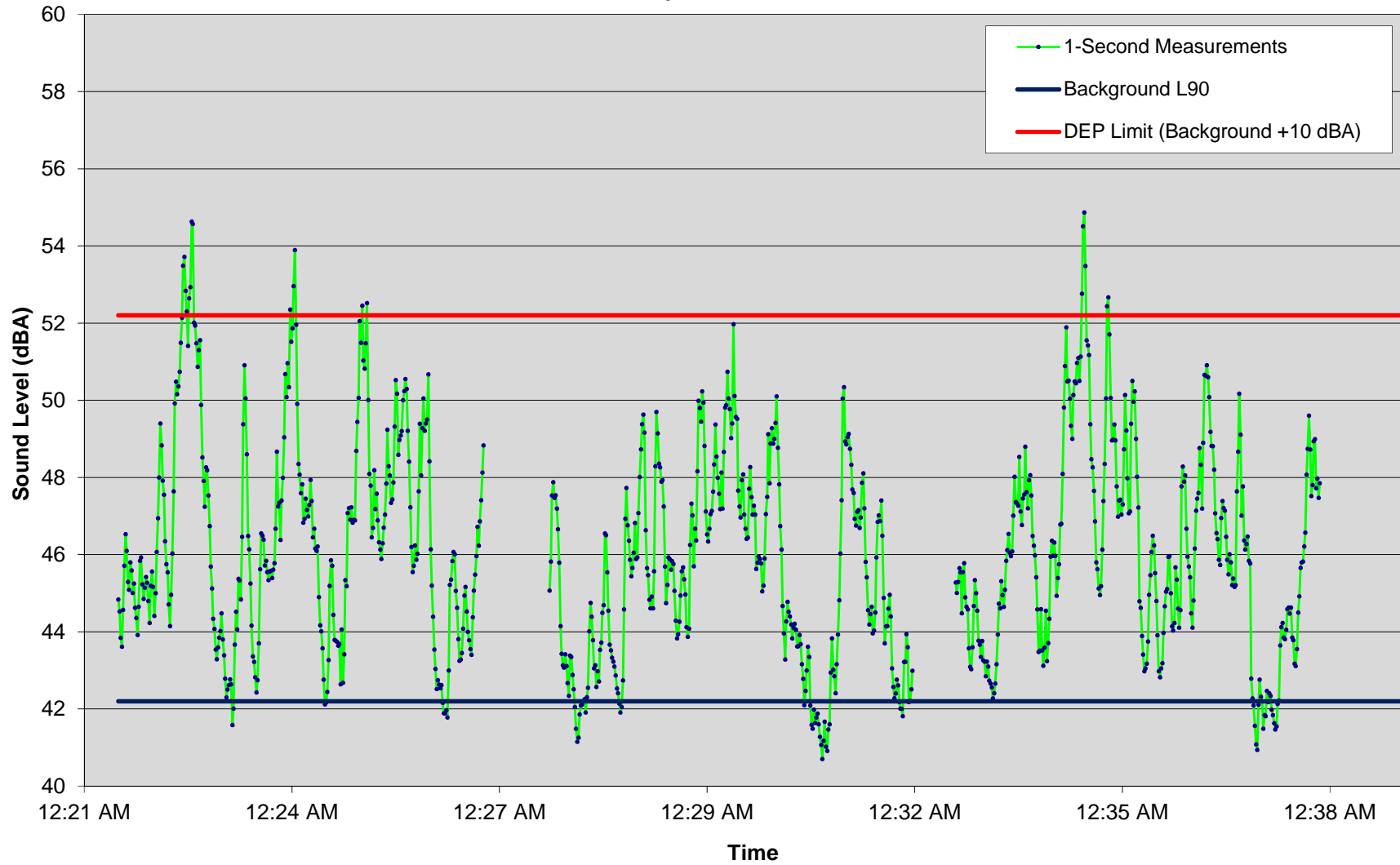
**1-Second Sound Levels at 127 Gilson Road Without Turbine Operating
May 5, 2015**



**1-Second Sound Levels at 149 Gilson Road Without Turbine Operating
May 5, 2015**



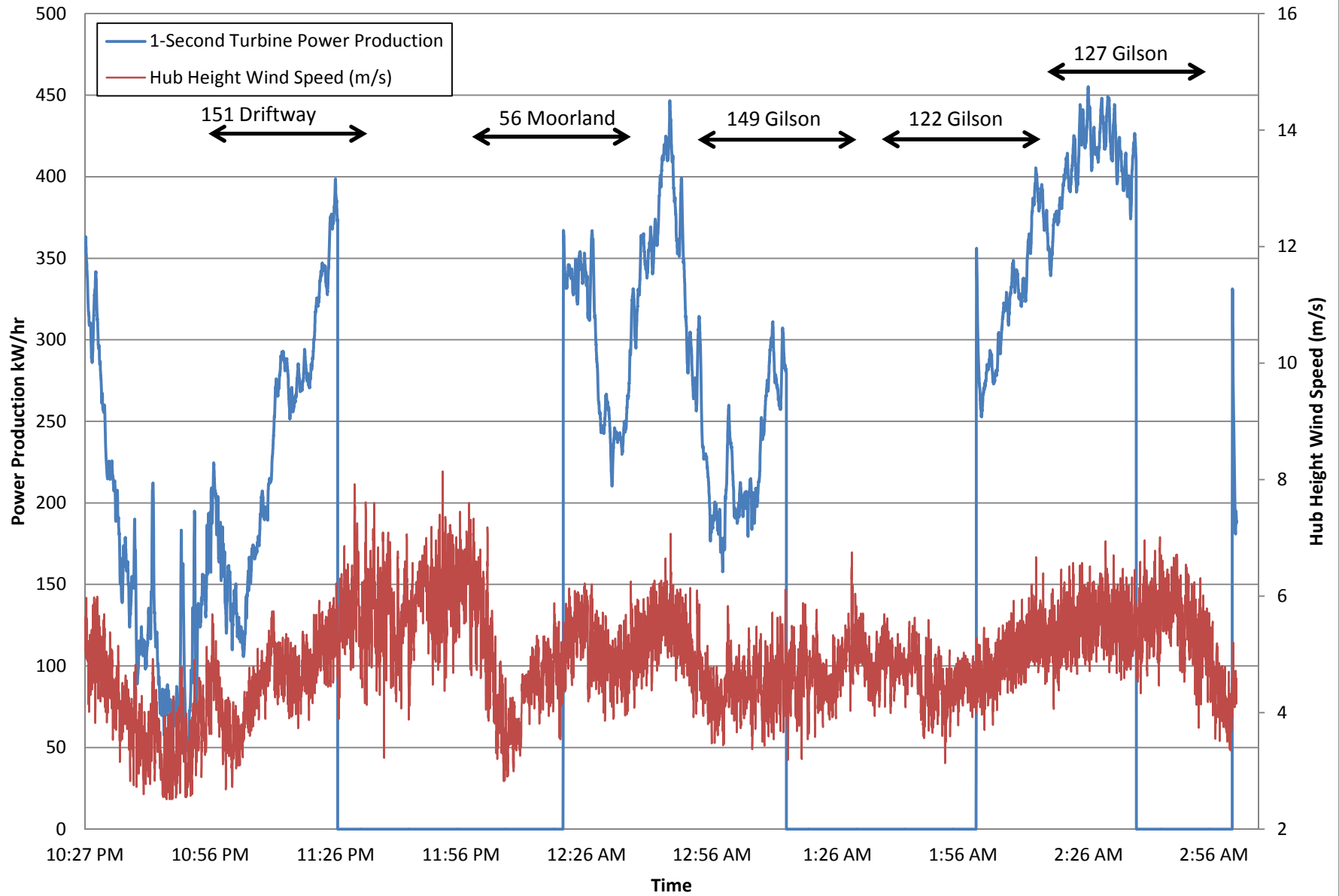
1-Second Sound Levels at 151 Driftway Without Turbine Operating May 5, 2015



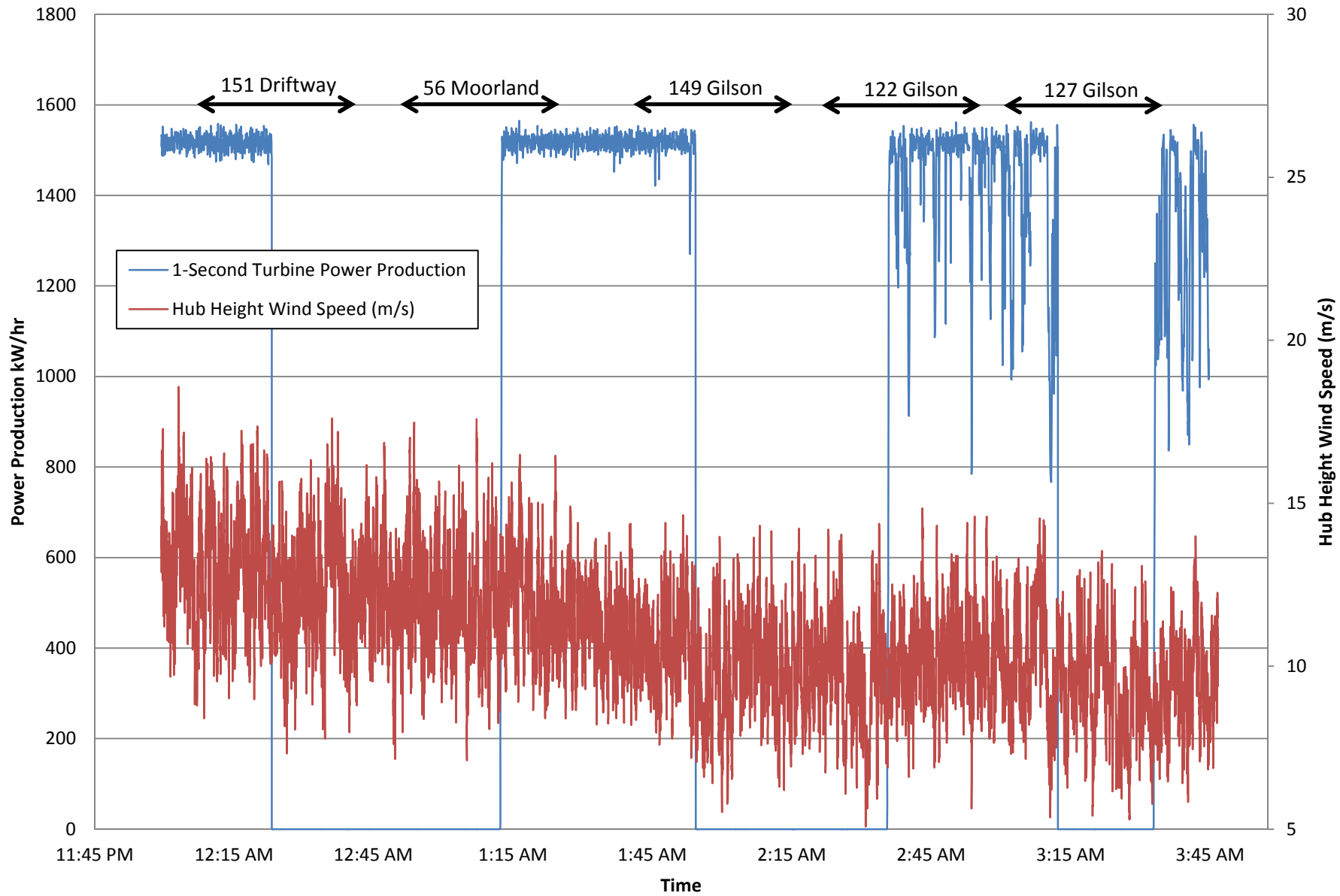
APPENDIX C

TURBINE POWER PRODUCTION AND HUB HEIGHT WIND SPEED GRAPHS

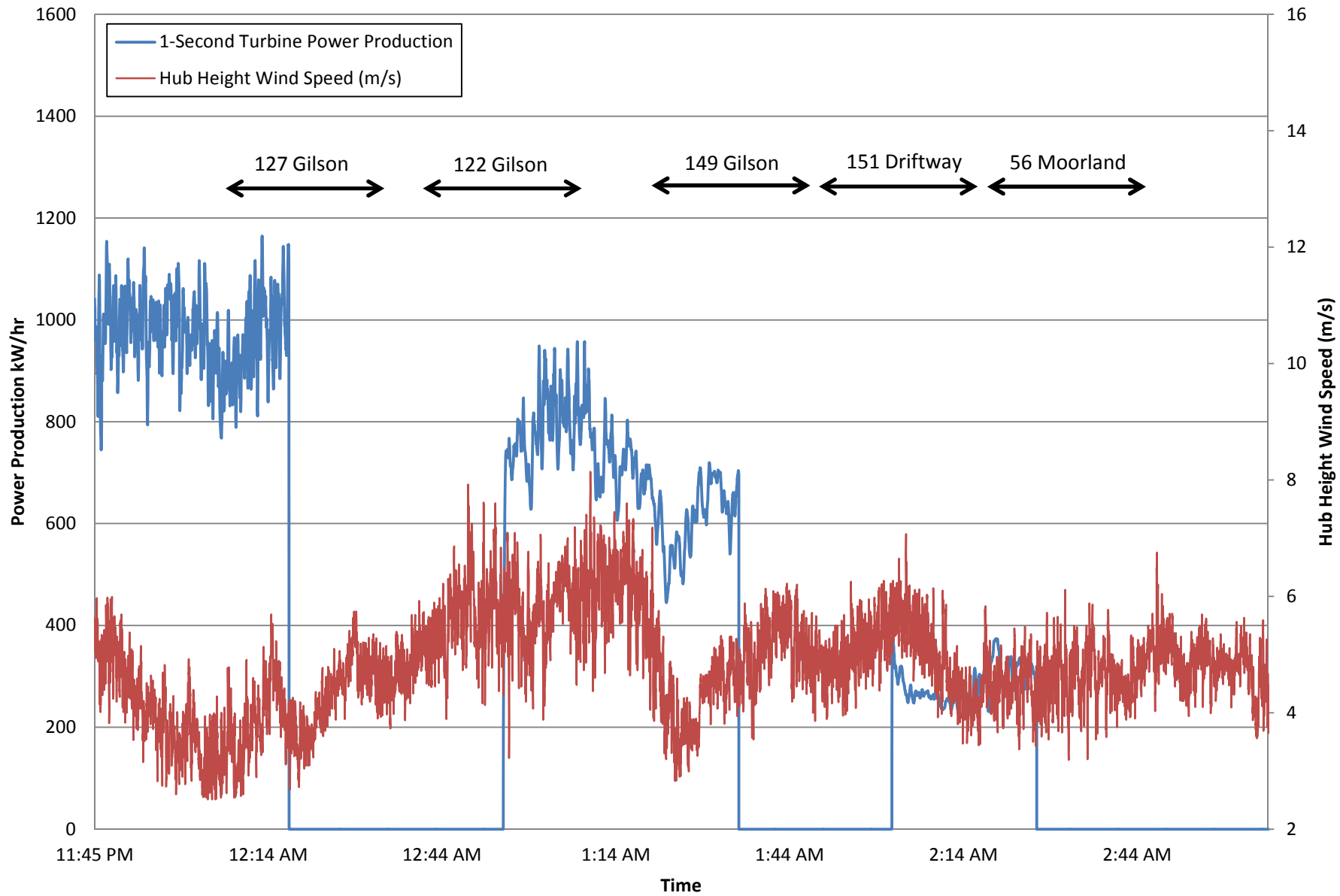
Turbine Power Production And Hub Height Wind Speed During Acoustic Sampling August 14-15, 2013



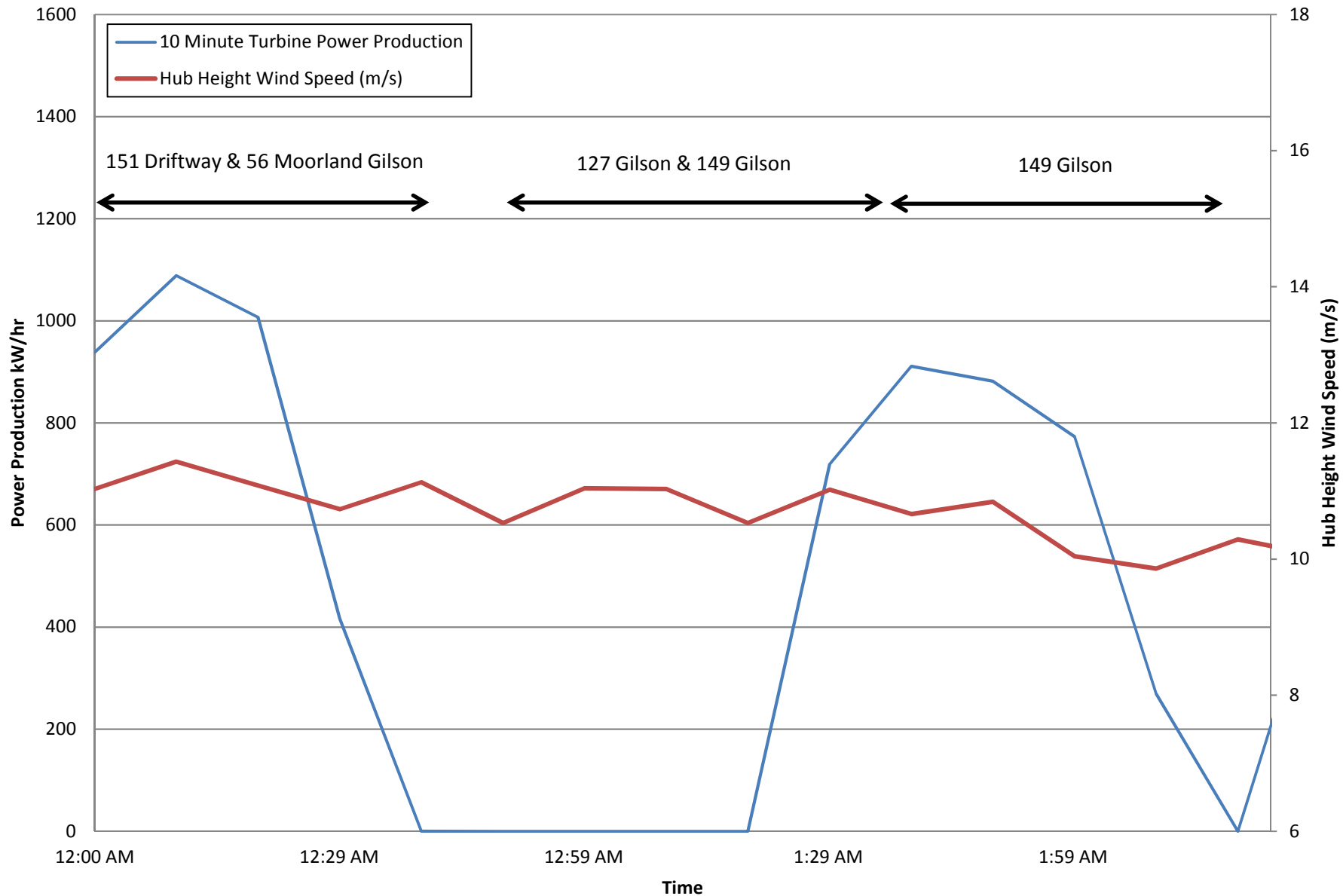
Turbine Power Production And Hub Height Wind Speed During Acoustic Sampling March 15, 2014



Turbine Power Production And Hub Height Wind Speed During Acoustic Sampling June 3, 2014



Turbine Power Production And Hub Height Wind Speed During Acoustic Sampling May 5, 2015



*Two sound meters and staff were present for this round of sampling, allowing for simultaneous monitoring at two locations.

**Turbine data only logged 10-minute intervals during this monitoring event.