



at only one position and therefore evidently associated with a local noise event are discarded. If the off-site levels are substantially dissimilar a design background level shall be derived from the available results in a manner deemed reasonable and appropriate by the test engineer and the rationale shall be clearly explained in the test report.

The design background level obtained from the off-site monitors shall be used to derive the project-only sound level at the on-site test locations through logarithmic subtraction of like quantities; for example, the L50 background level for a particular 10 minute time period shall be subtracted from the L50 level measured at each on-site position during that same time period. The general formula for this subtraction is as follows:

$$L_{p\text{Project}} = 10 \log [10^{(L_{p\text{Total}}/10)} - 10^{(L_{p\text{Background}}/10)}], \text{ dBA} \quad (1)$$

Where,

- $L_{p\text{Project}}$ = the sound pressure level associated exclusively with the project, dBA
- $L_{p\text{Total}}$ = the total measured sound level at an on-site receptor positions, dBA
- $L_{p\text{Background}}$ = the design background level derived from the off-site monitor data, dBA

However, this correction process is only relevant to samples recorded while the turbines were actually in operation and not necessarily to all samples; consequently, the data must be sifted to ignore all periods of calm winds. This can be accomplished by dealing only with data sets collected above the effective cut-in wind speed for the turbine model in question (bearing in mind whether that wind speed is measured at 10 m or hub height) or, more preferably, by comparing the measured data to a time history of project electrical output obtained from the SCADA, or project control system. For this latter option it is best to compare the operational output of the 2 or 3 units closest to each on-site measurement position rather than the total project output because this not only accurately defines the on and off times at each monitoring station but also may reveal that certain units were temporarily down for maintenance or due to some unexpected malfunction. The goal of the survey will be to measure during normal operating conditions with all or nearly all units functioning.

Because the proxy background level is, for practical reasons, an inexact estimation of the site-wide background level, there will usually be instances when the background level exceeds the total measured level at certain on-site positions. Under this circumstance, and when the background level is below but within 3 dB of the total level, the project-only sound level shall be considered indeterminate. The subtraction using Eqn. (1) above shall only be performed when the background level is between 3 and 10 dB below the total measured level. When this difference is greater than 10 dB the background level is inconsequential and no correction is needed.

6.0 Correction for Wind-induced Distortion

One of the principal errors in measuring wind turbine noise is false signal noise from wind blowing through the windscreen and over the microphone tip, which is manifested in the form of artificially elevated sound levels in the lower frequency bands. Some degree of distortion is

essentially inevitable in any measurement taken above ground level when the wind is blowing, even when using an extra-large windscreen as required for this survey.

The correction factors for a limited number of common windscreens have been developed through wind tunnel testing carried out by Hessler and Brandstätt in 2008¹ in which conventional ½" microphones fitted with an array of windscreens were subjected to known wind velocities in a massively silenced wind tunnel. The measured sound levels during each test were essentially a direct measure of the false-signal noise. Thus for a specific windscreen it is possible to estimate for any reasonable wind speed the overall A-weighted sound level of the distortion and then subtract it from the total measured level to reverse the error.

An example is shown in Figure 6.0.1 where the overall A-weighted level of self-noise is calculated as a function of wind speed and subtracted from the as-measured sound level. The plot is a three day detail of a wind turbine survey where oversized 175 mm (7") diameter treated windscreens (ACO Model WS7-80T) were used. This particular windscreen was found to be the best performer, in terms of minimizing wind-induced self-noise, in the wind tunnel study.

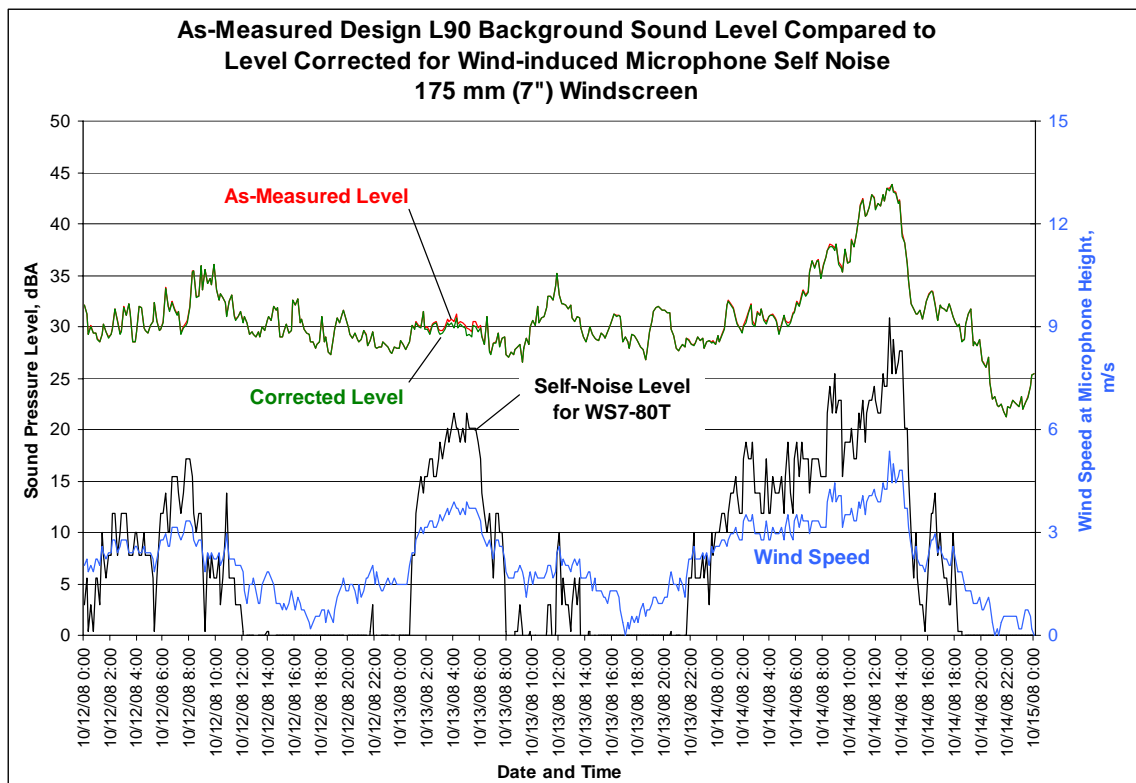


Figure 6.0.1

This plot shows the very typical result, at least where extra-large windscreens are used, that the correction is small and can almost be neglected when it comes to A-weighted sound levels.

¹ Hessler, G. F., Hessler, D. M., Brandstätt, P., Bay, K., "Experimental study to determine wind-induced noise and windscreen attenuation effects on microphone response for environmental wind turbine and other applications", *Noise Control Engineering Journal*, J.56, July-August 2008.



The overall level of self-generated noise for the WS7-80T windscreen recommended for this survey can be calculated, per Ref. 1, from the general expression:

$$L_{p,self} = 28.692 \ln(v) - 17.447, \text{ dB for } v > 1.5 \text{ m/s} \quad (2)$$

Where v is the average wind speed measured at the microphone in m/s. This value shall be taken from the 3 ft. anemometer on the temporary weather station set up one or more exposed positions on site.

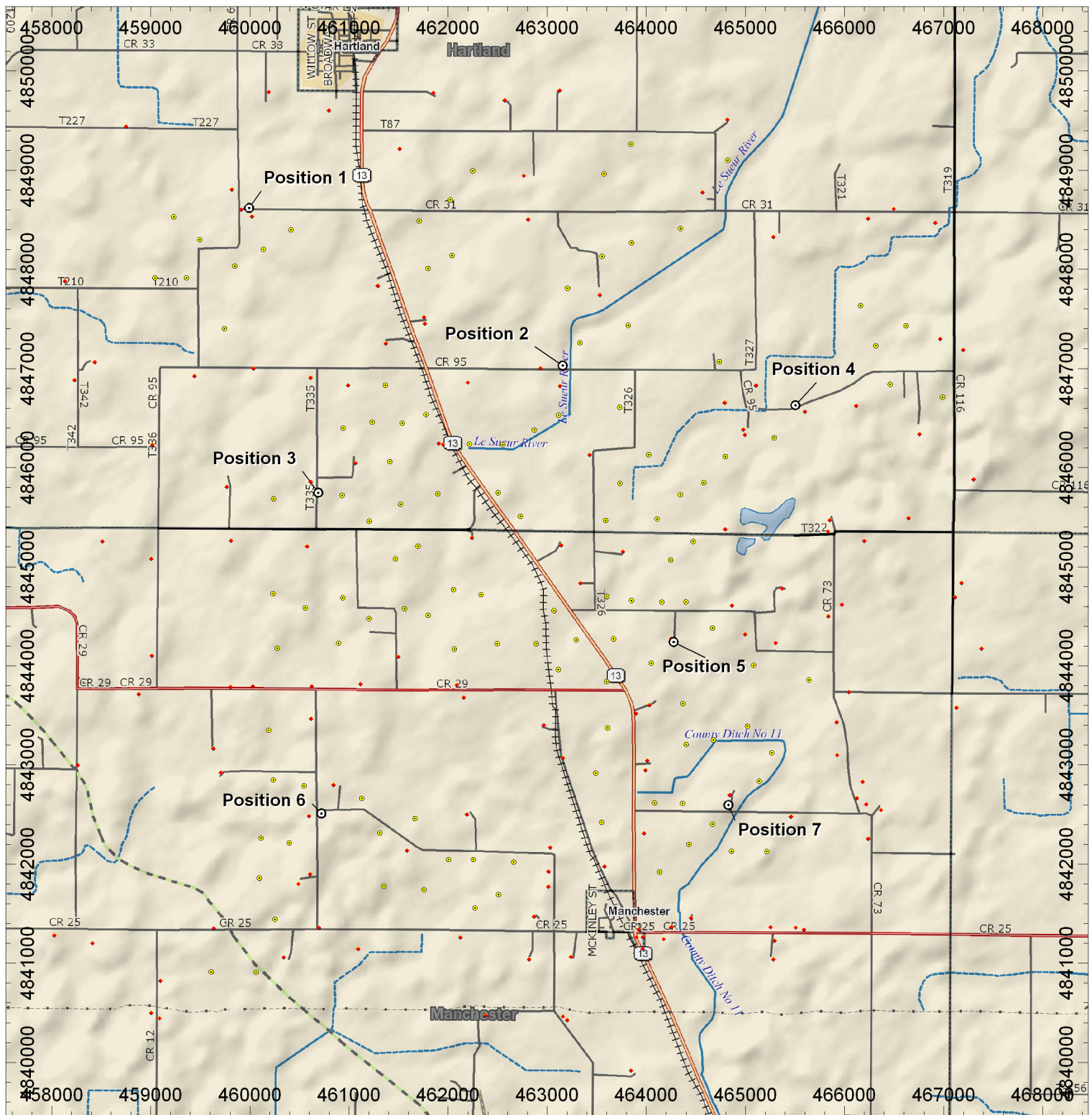
7.0 Compliance Determination

Once the on-site L10 and L50 sound levels have been corrected for spurious noise events, rain, background noise and microphone distortion the results shall be compared to the regulatory limits in Table 1.0.1. Spurious data points showing apparent noise excursions well above the mean are common in such surveys and it is often difficult or impossible to definitively ascribe these levels to the project. For example, a tractor many have been idling near a monitor station on a windy day creating the false impression that project noise was elevated at that location during that period. In order to reasonably allow for this possibility the project shall be considered in compliance with the regulatory limits if the corrected project-only is equal to or below the stated limits at least 95% of the time.

In the event that a clear result cannot be obtained from the L10 and L50 statistical measures the L90 level may be used. Experience with wind turbine surveys of this type suggests that it may be quite difficult to identify the project-only sound level from the L10 and L50 metrics because they are highly susceptible to contamination from spurious noise events and the background level may well be comparable in magnitude to the total measured level - making it impossible to subtract the two to derive the project-only level. The L90 statistical level, on the other hand, filters out such contamination and is the quantity that is normally used to measure long-term wind turbine project sound levels.

8.0 Reporting

A report shall be prepared summarizing the survey set up and methodology, data analysis and results. Any deviations from the protocol shall be explained along with the rationale for the alternate approach or interpretation. The report shall state whether the project was found to be in or out of the compliance with the applicable regulatory noise limits.



Scale in meters - Units are UTM NAD83 coordinates

Project: **Bent Tree Wind Park**

Prepared for: **Alliant**

Date: April 12, 2010

Drawing #: AA-Rev-B-1A-1

Description: **Graphic A**

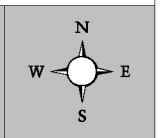
Sound Monitoring Positions

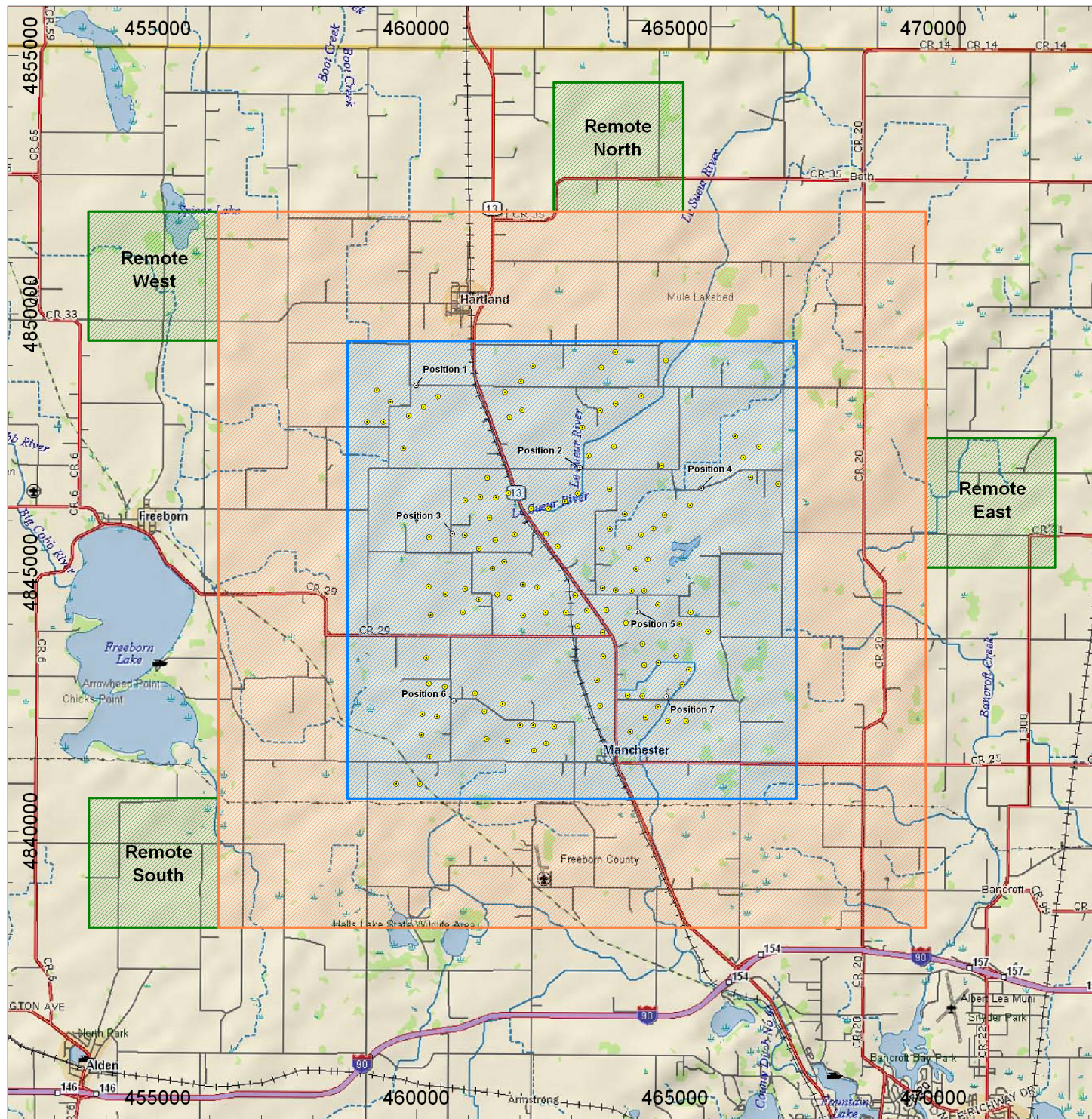
Legend:

- Sound Monitoring Location
- Turbine Location
- ◆ Nearby Residence

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 Haymarket VA, 20169
 www.hesslernoise.com
 (703) 753-2291 (703) 753-1602





Description:

Graphic B

Project Area and Potential Remote Ambient Measurement Location Areas

Project:

Bent Tree Wind Park

Drawing Number:

ABT-Rev-B-1B-1

Date:

December 6, 2010

Prepared for:

Alliant

Legend:

- Turbine Location
- Project Area
- Buffer Zone (@1.5 miles)
- Potential Remote Ambient Measurement Area

Hessler Associates, Inc.

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Acoustics Since 1976*

3862 Clifton Manor Place
Haymarket, VA 20169
(703) 753-1602
(703) 753-2291
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Border Scale in meters, units are UTM NAD83 coordinates



Appendix B

Survey Results – Positions 2 through 7



Position 2

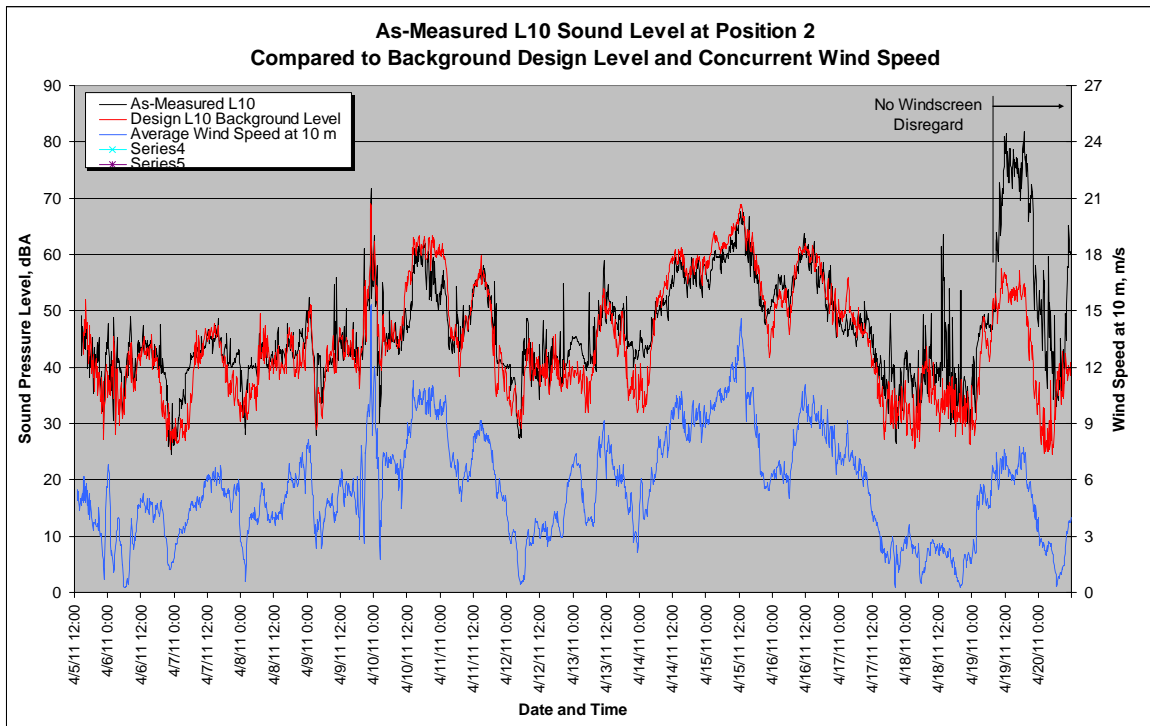


Figure B2-1

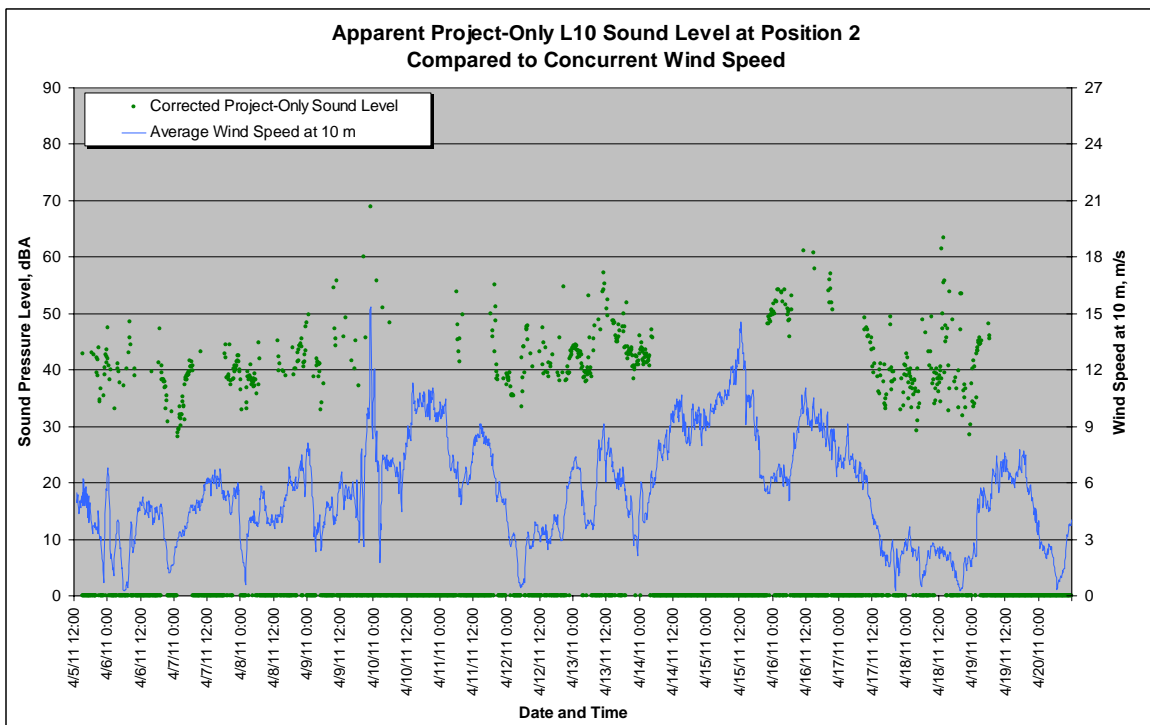


Figure B2-2

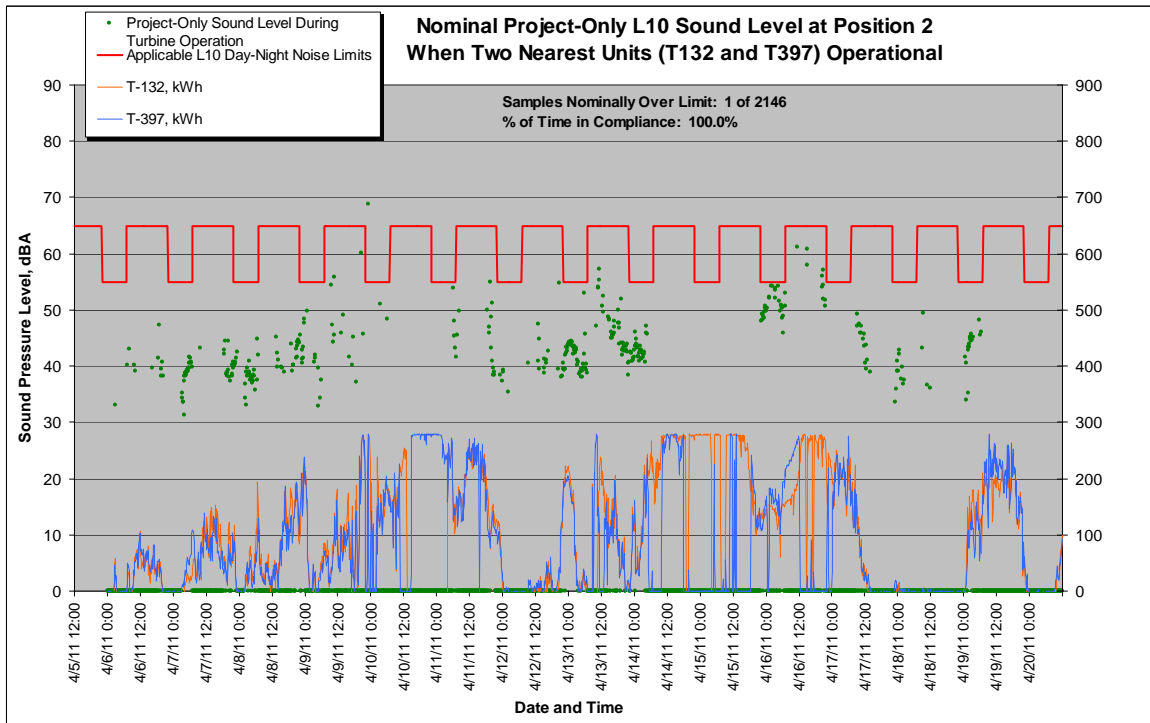


Figure B2-3

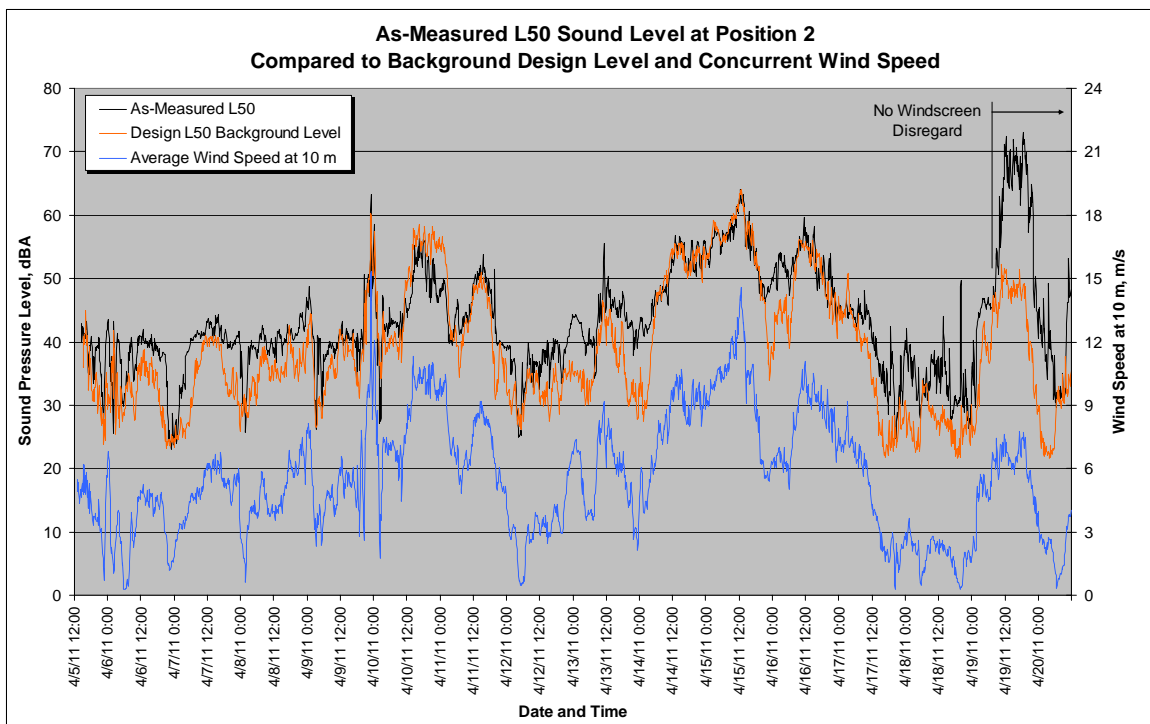


Figure B2-4

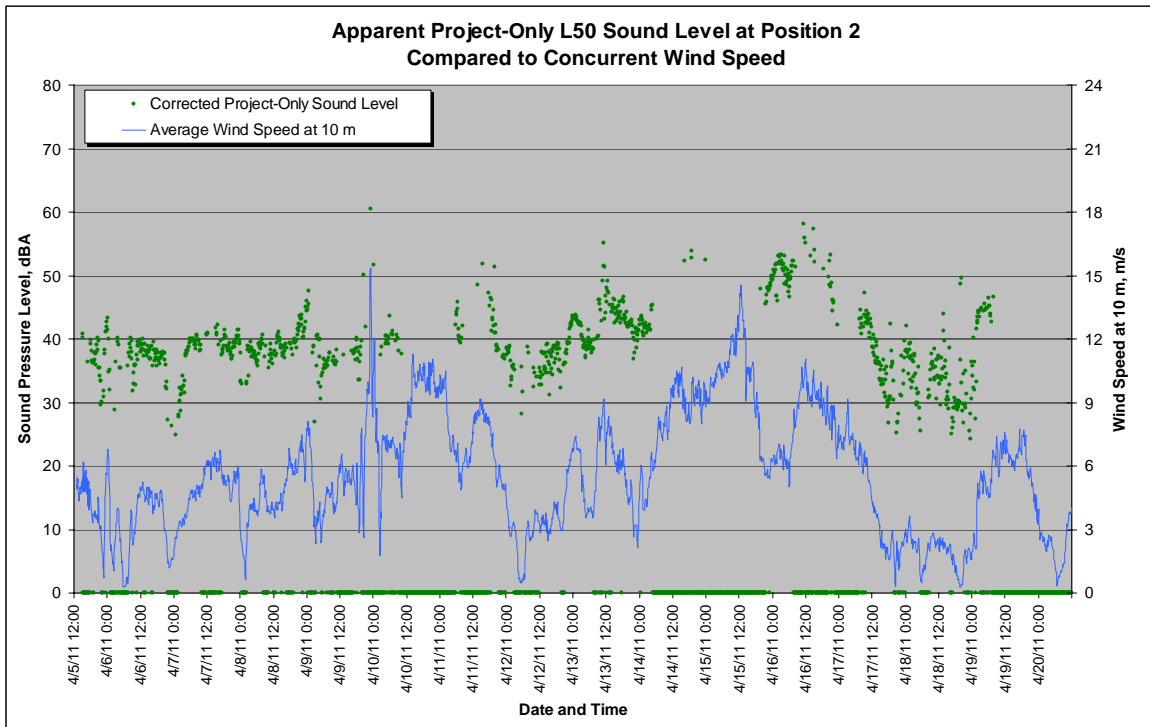


Figure B2-5

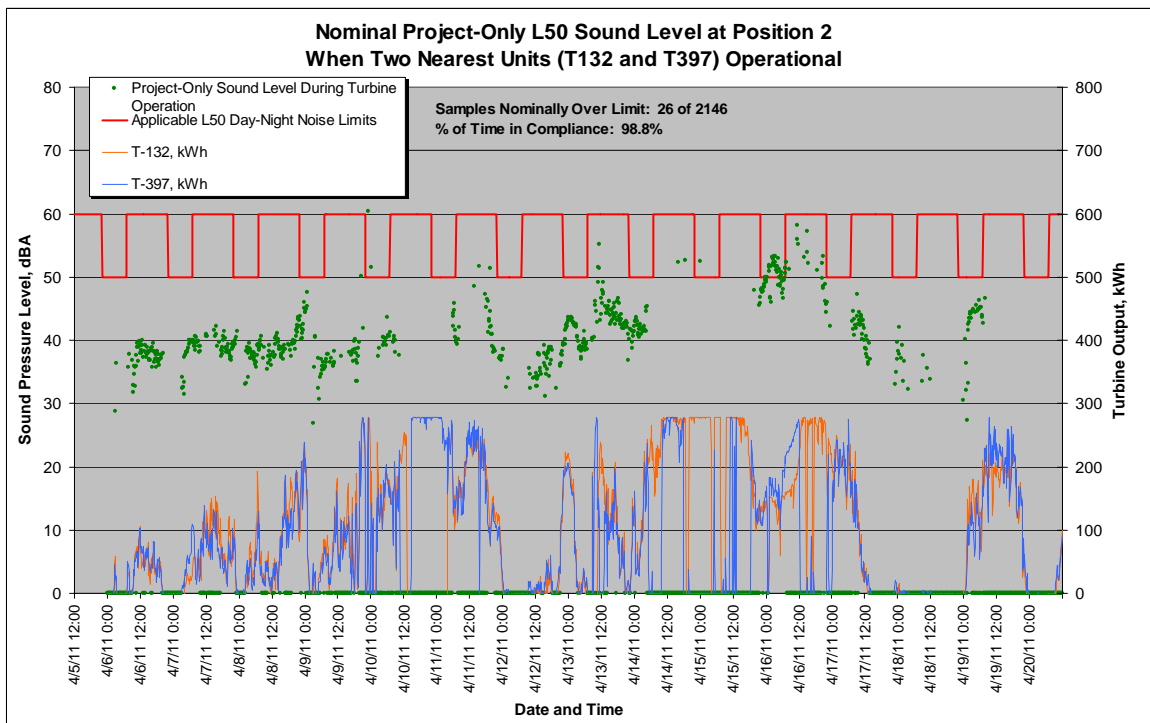


Figure B2-6

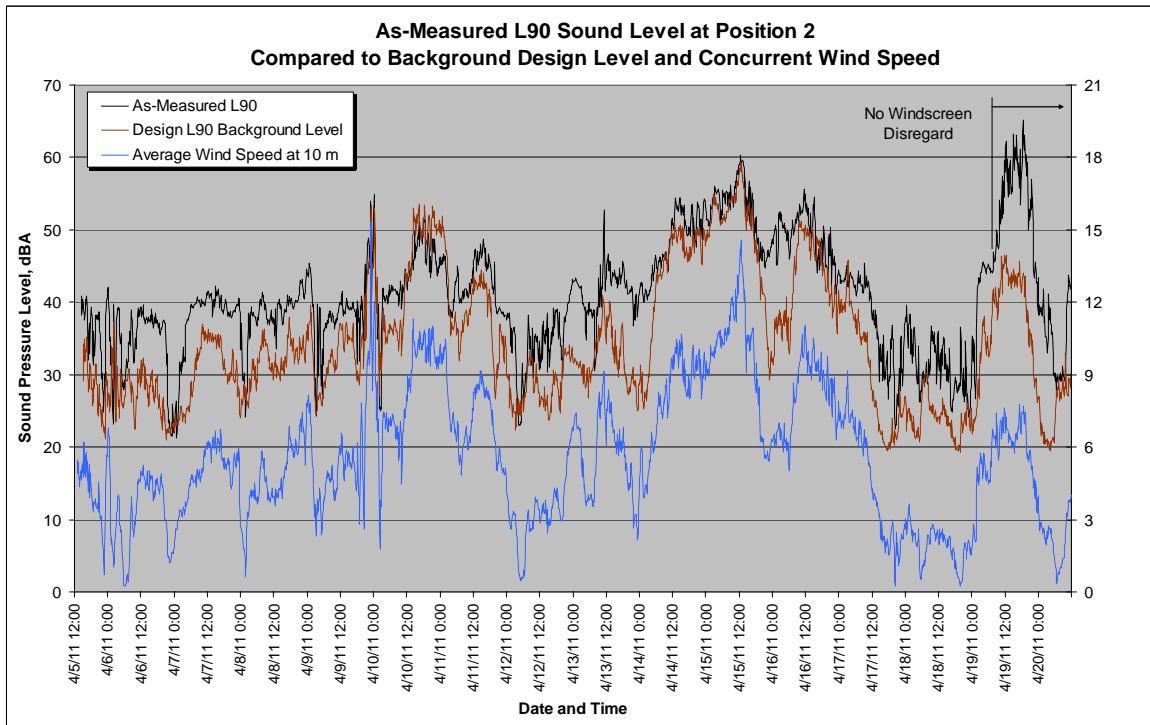


Figure B2-7

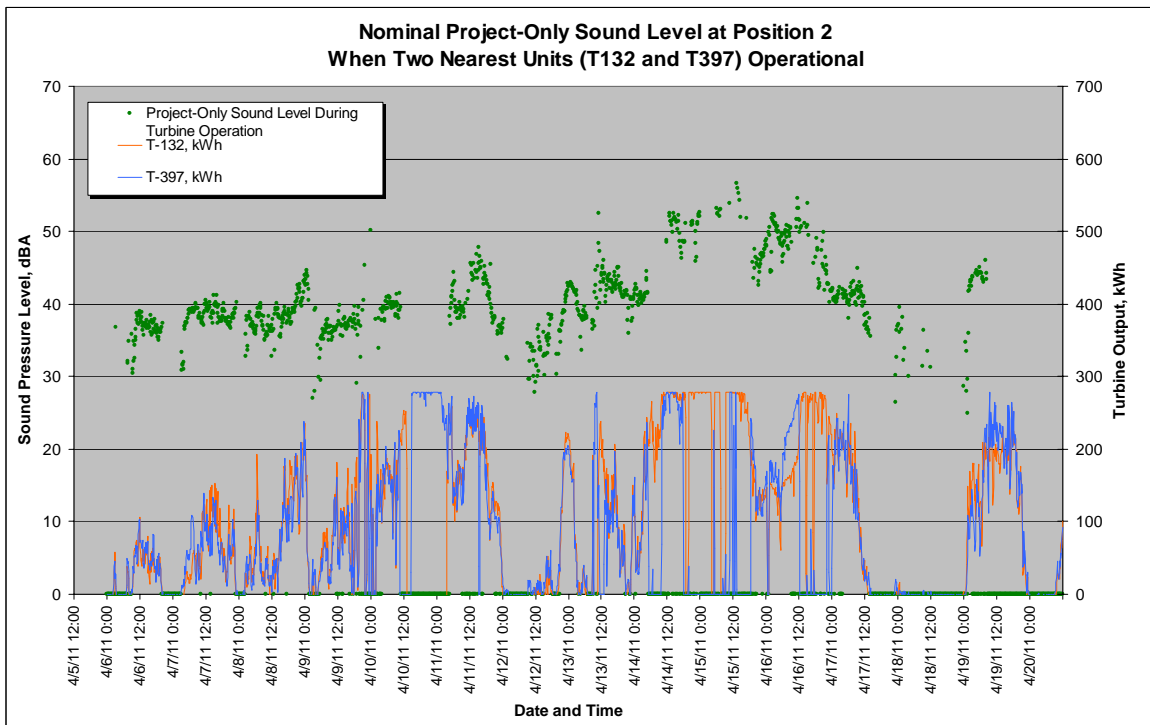


Figure B2-8

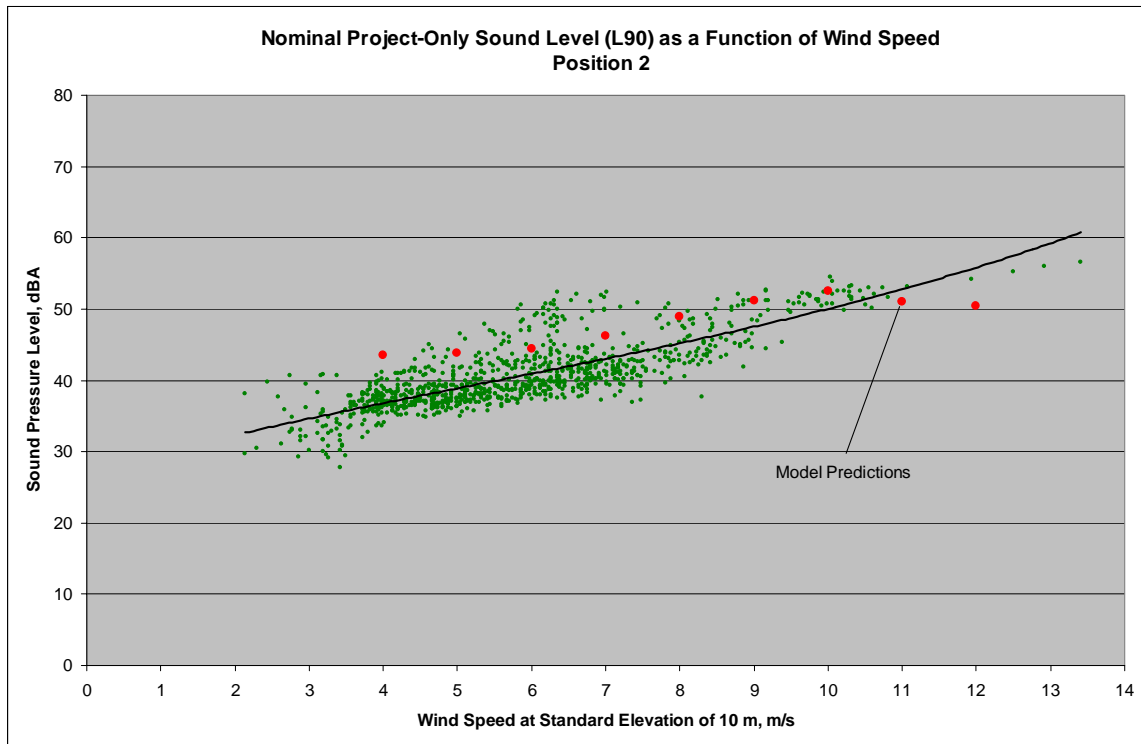


Figure B2-9

Position 3

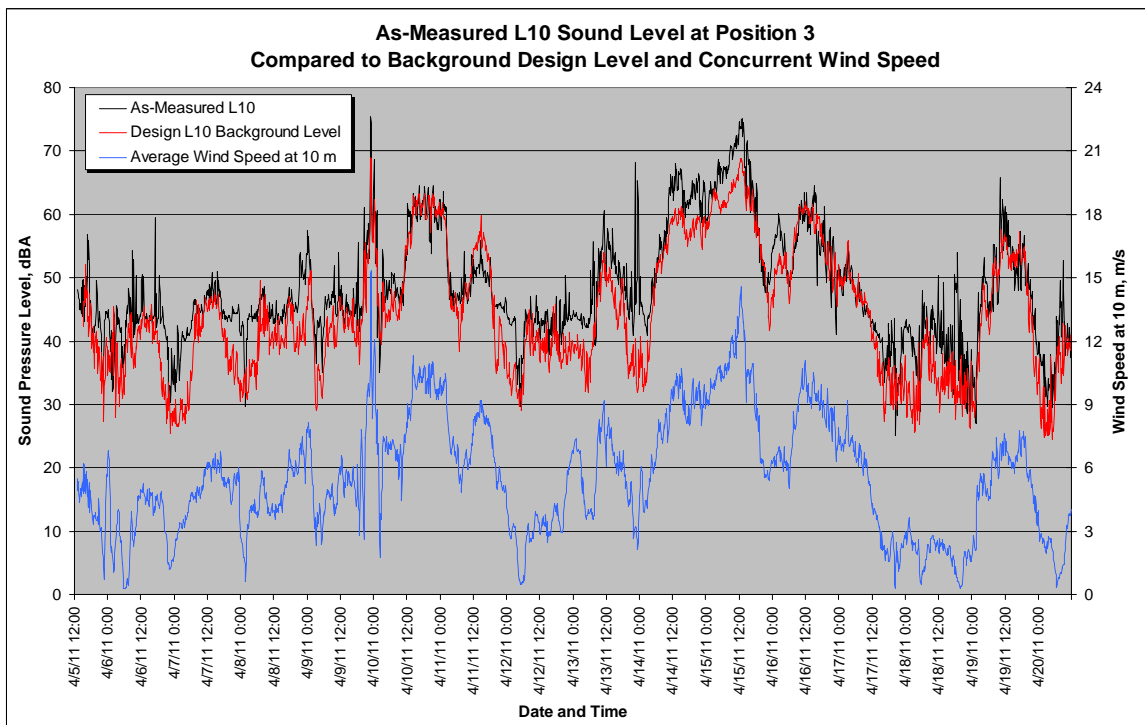


Figure B3-1

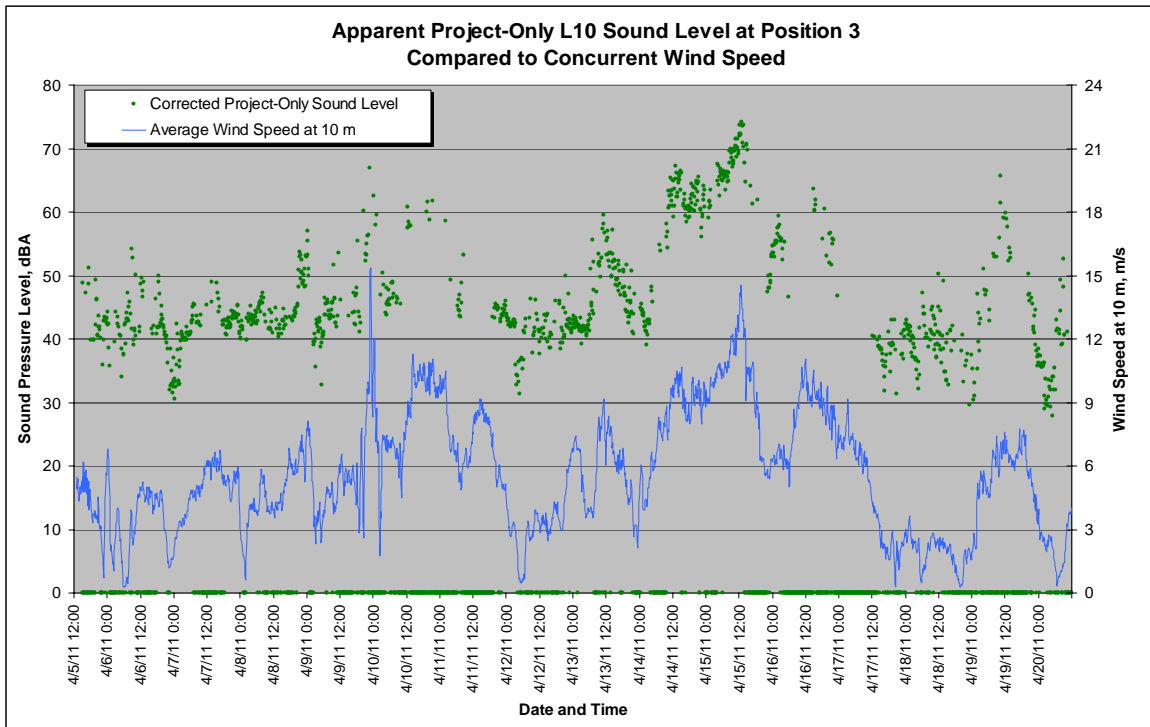


Figure B3-2

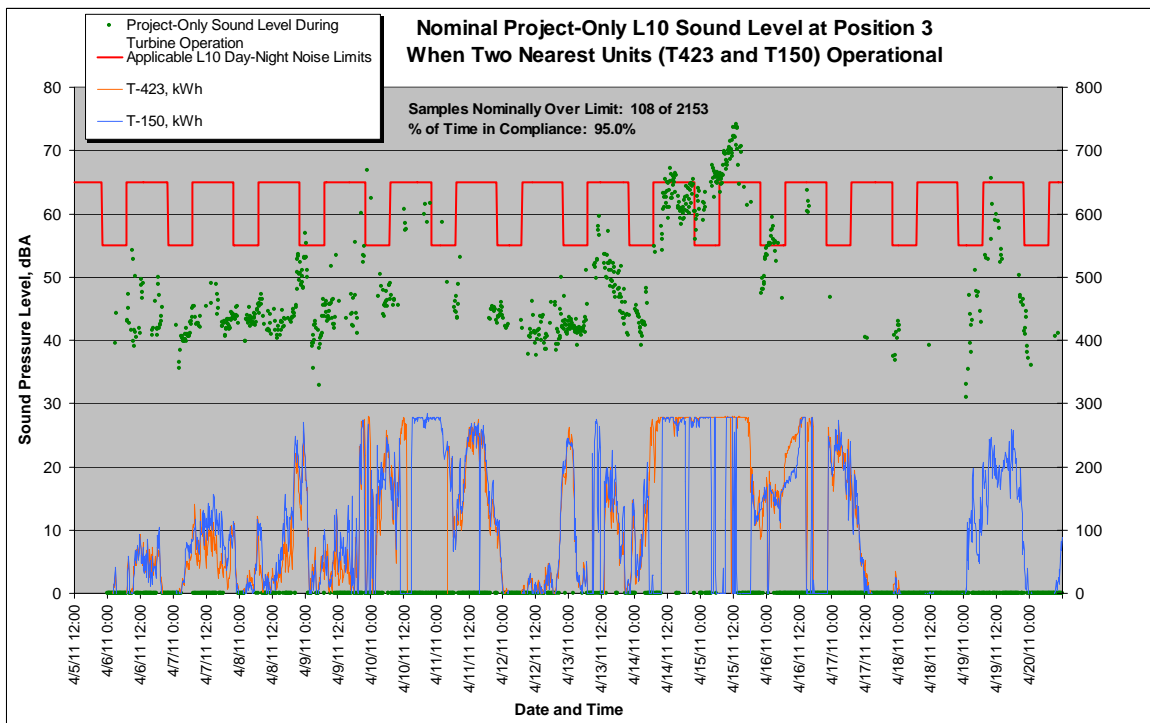


Figure B3-3

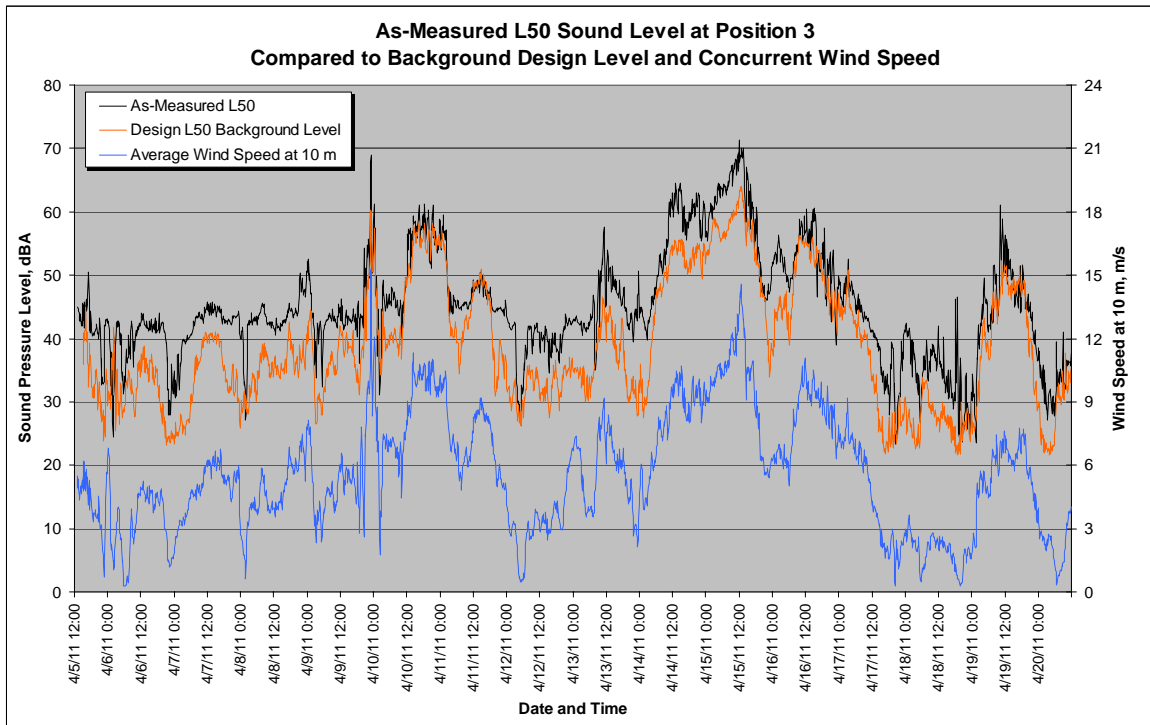


Figure B3-4

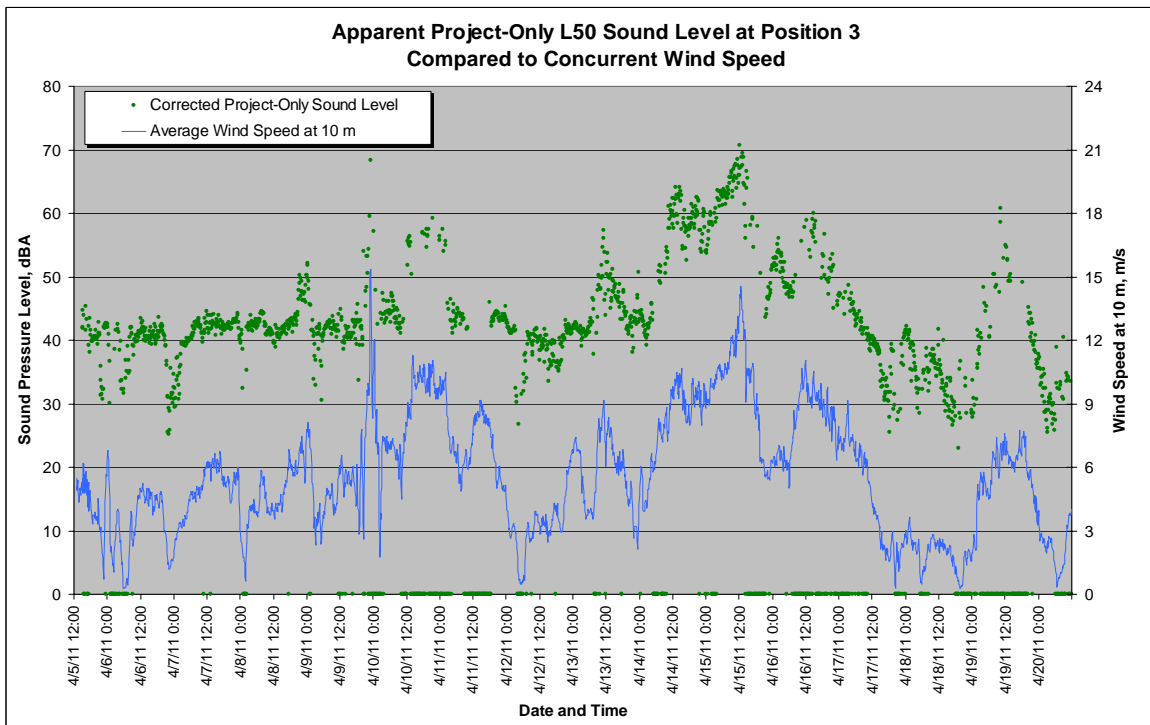


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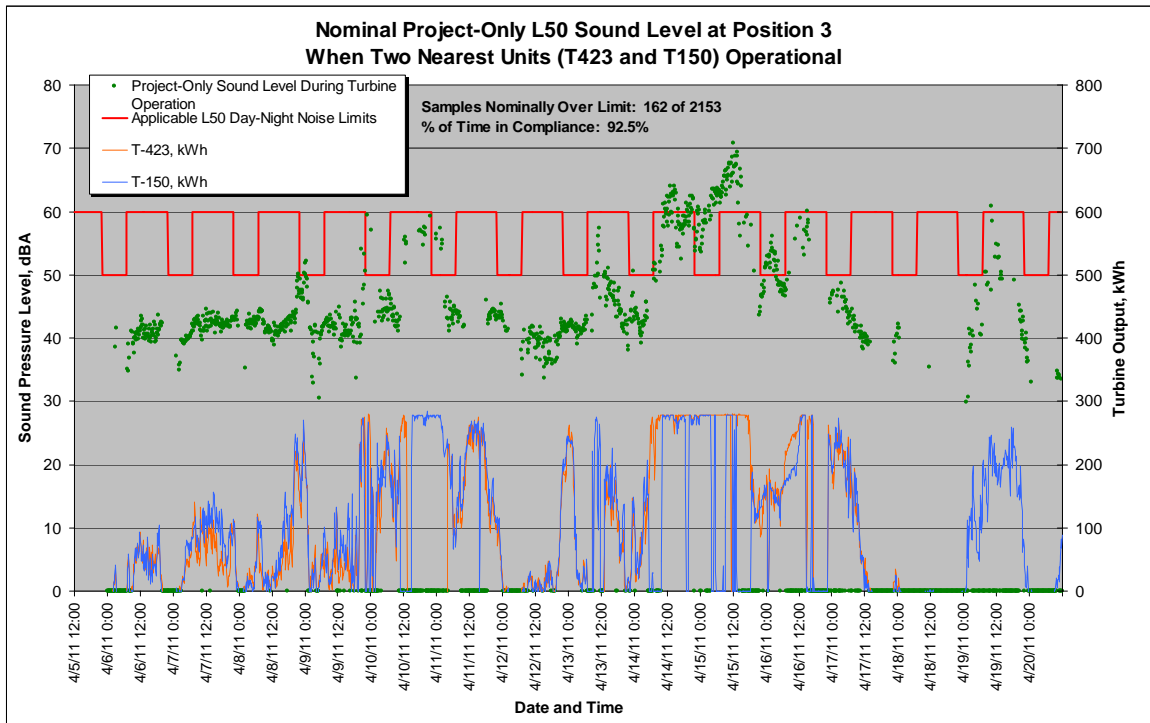


Figure B3-6

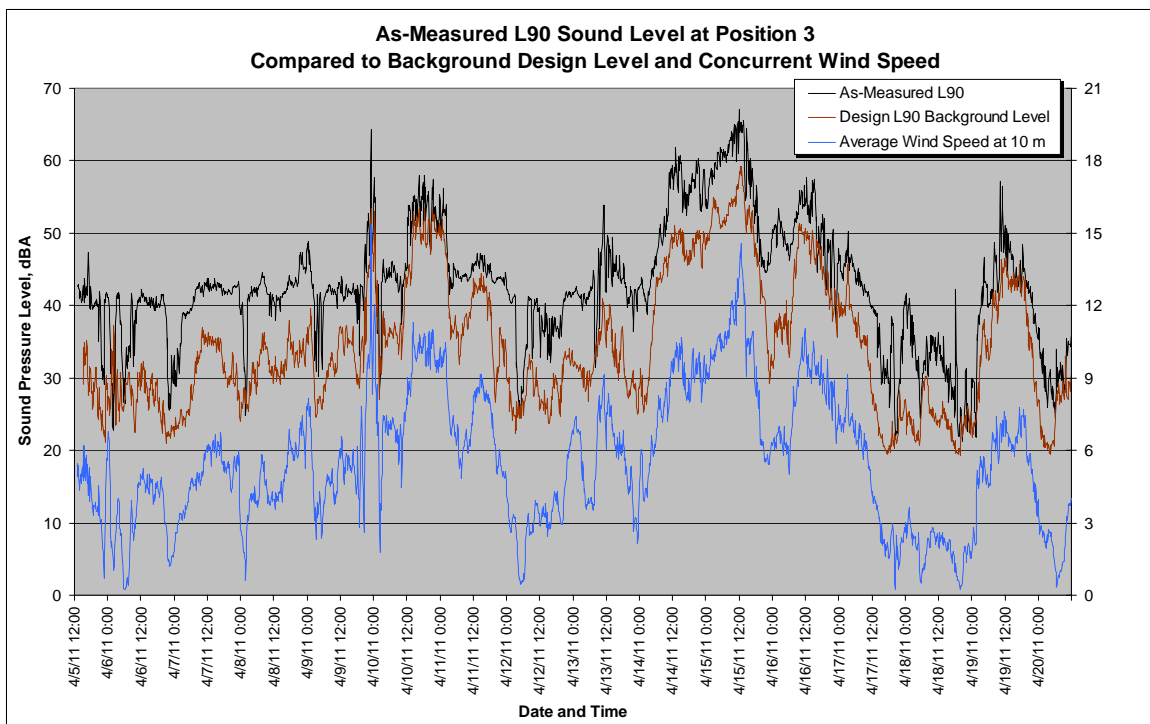


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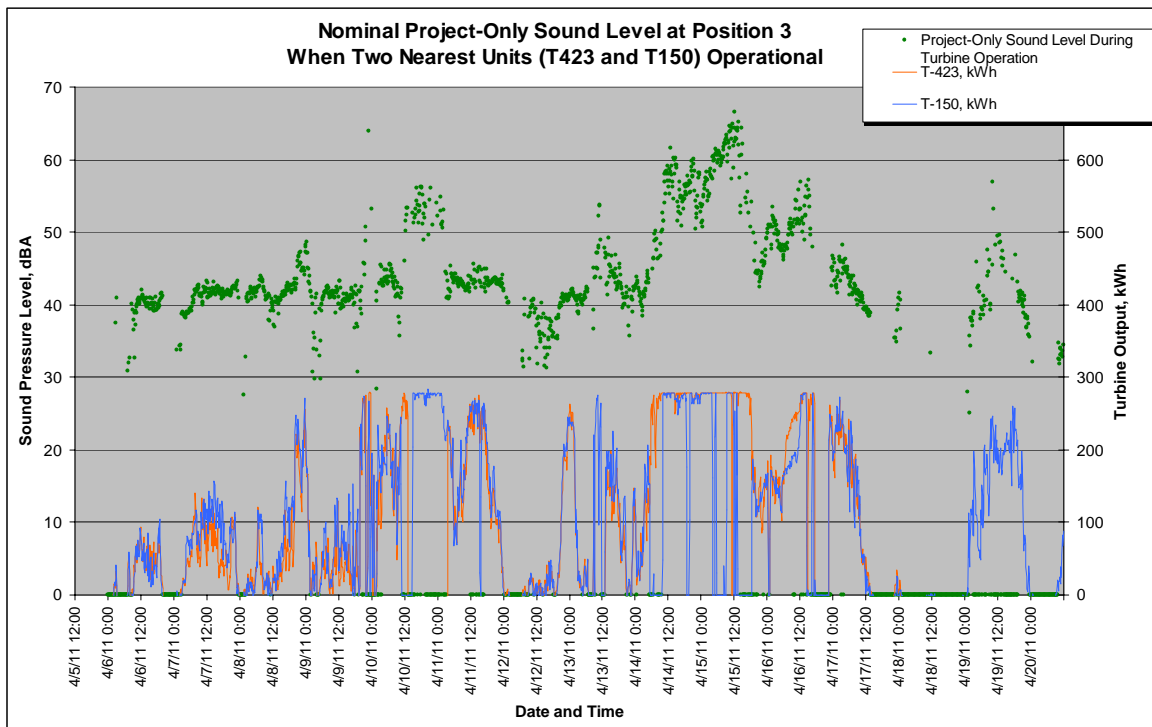


Figure B3-8

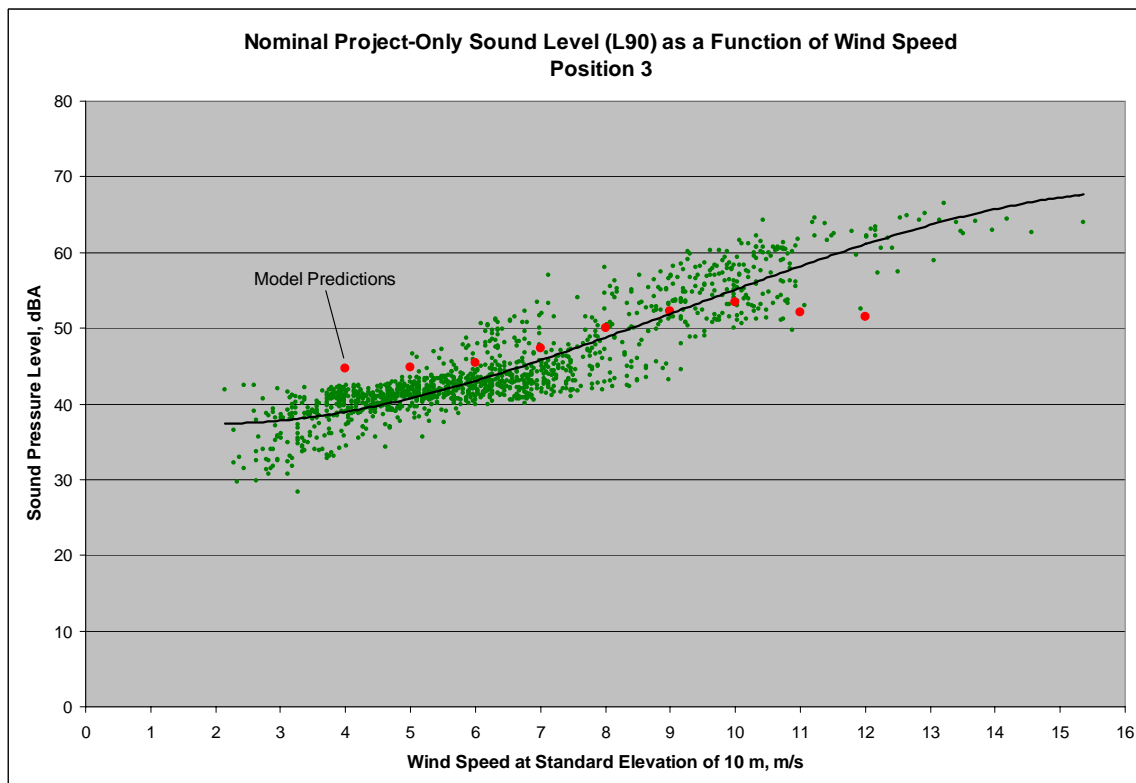


Figure B3-9

Position 4

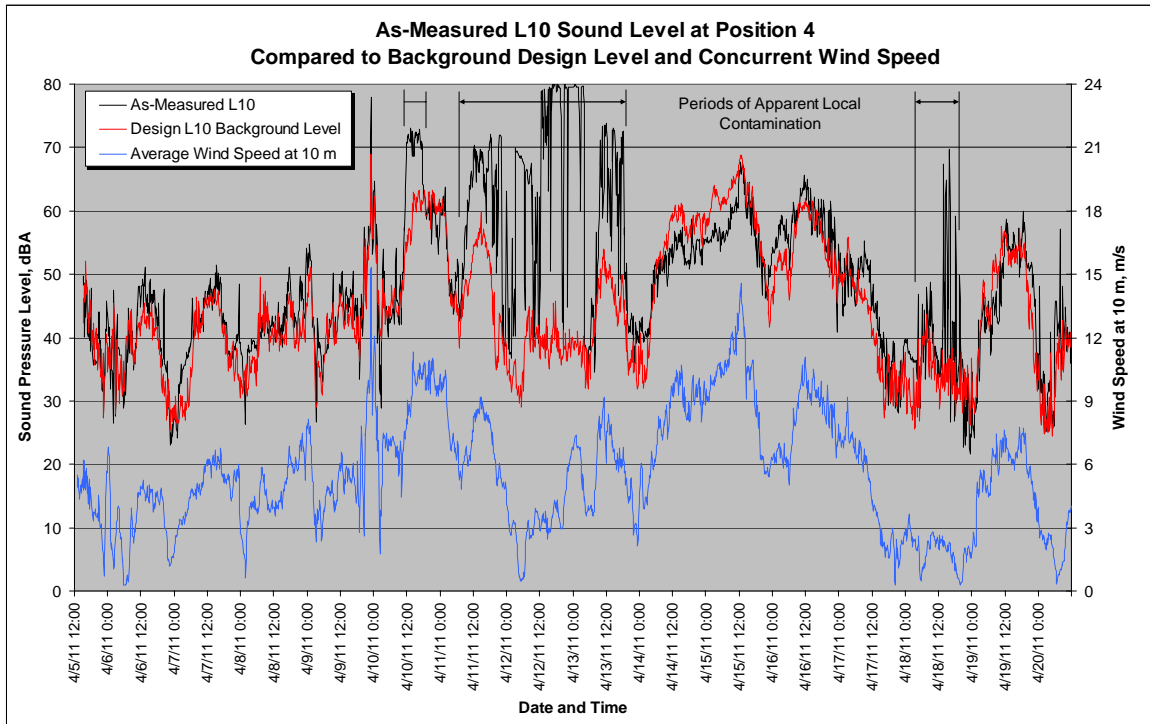


Figure B4-1

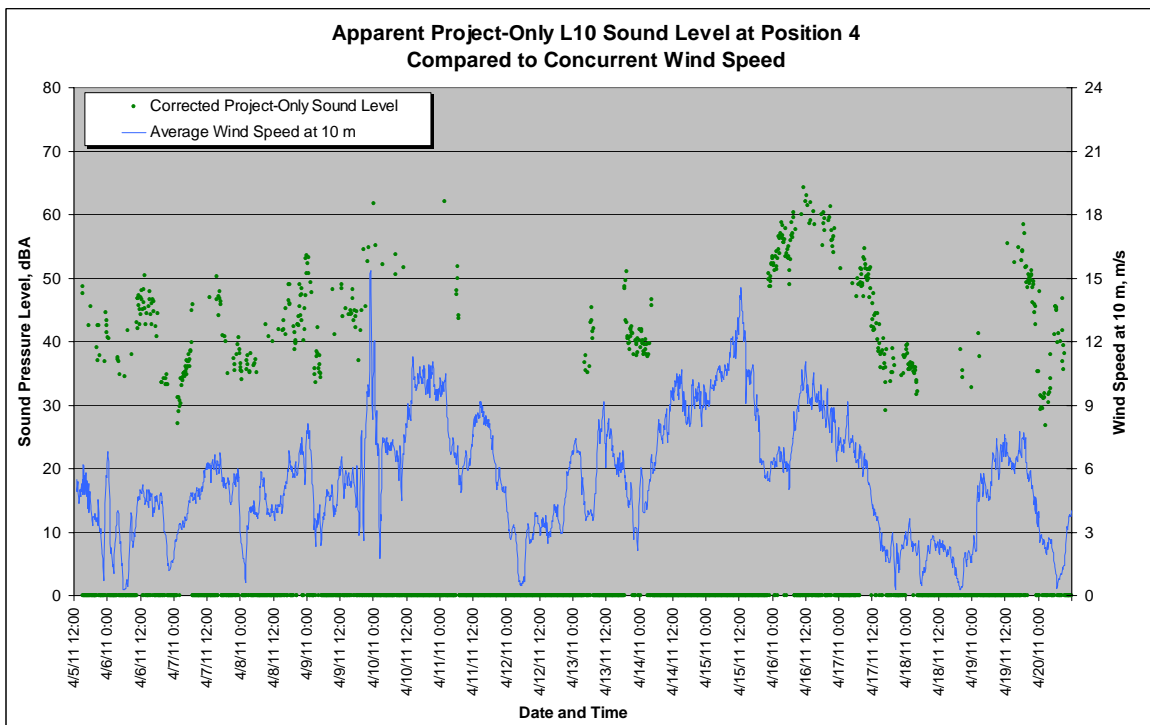


Figure B4-2

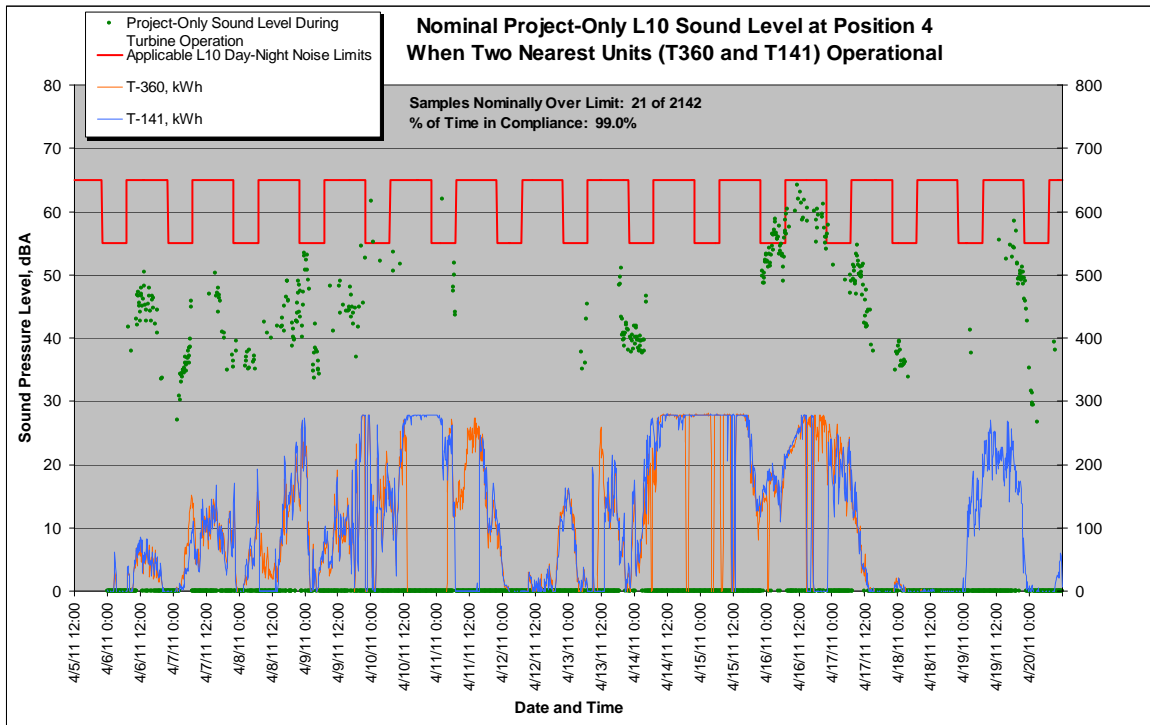


Figure B4-3

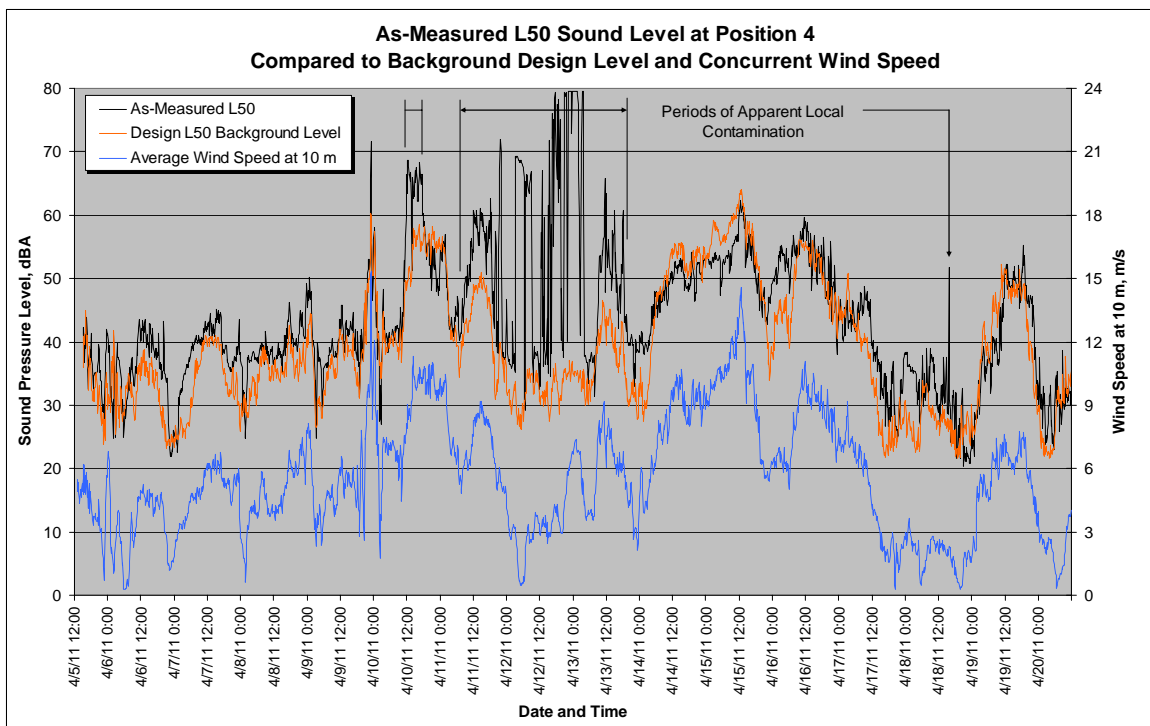


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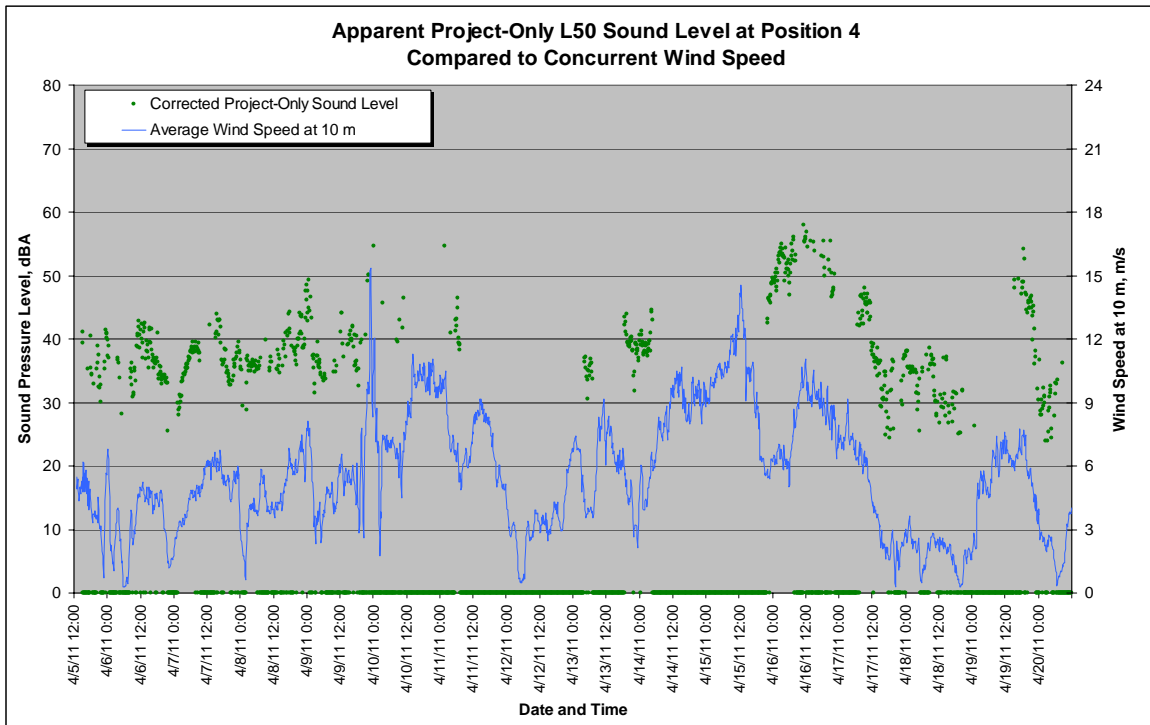


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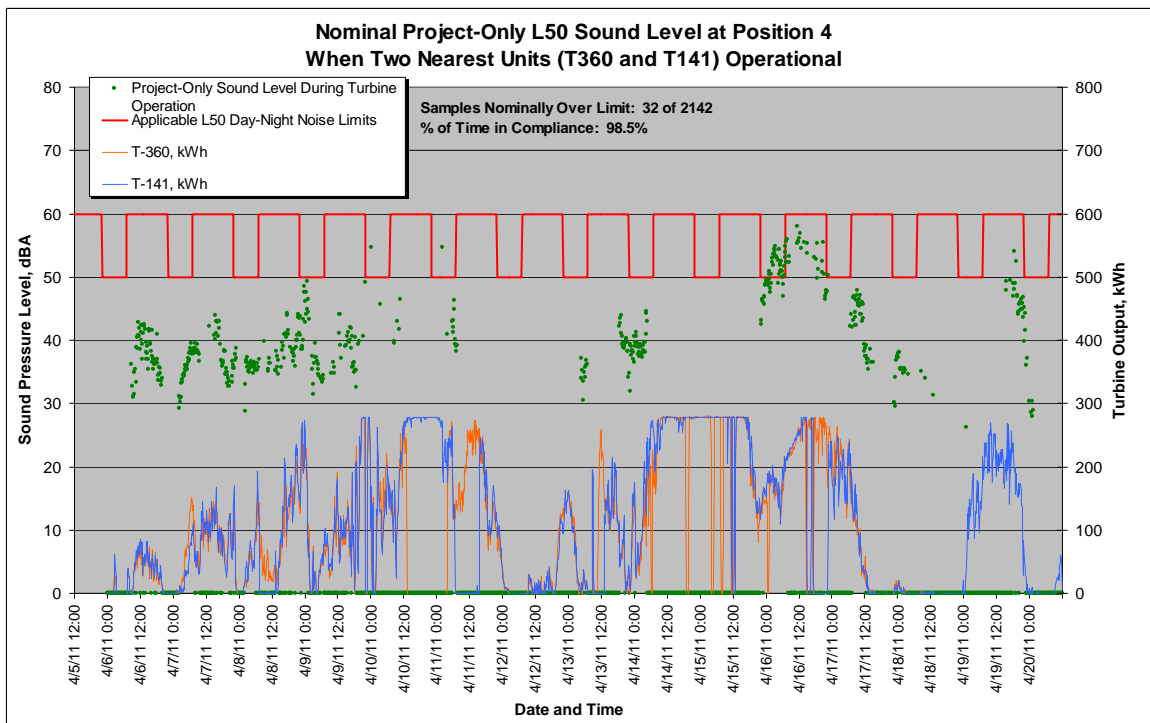


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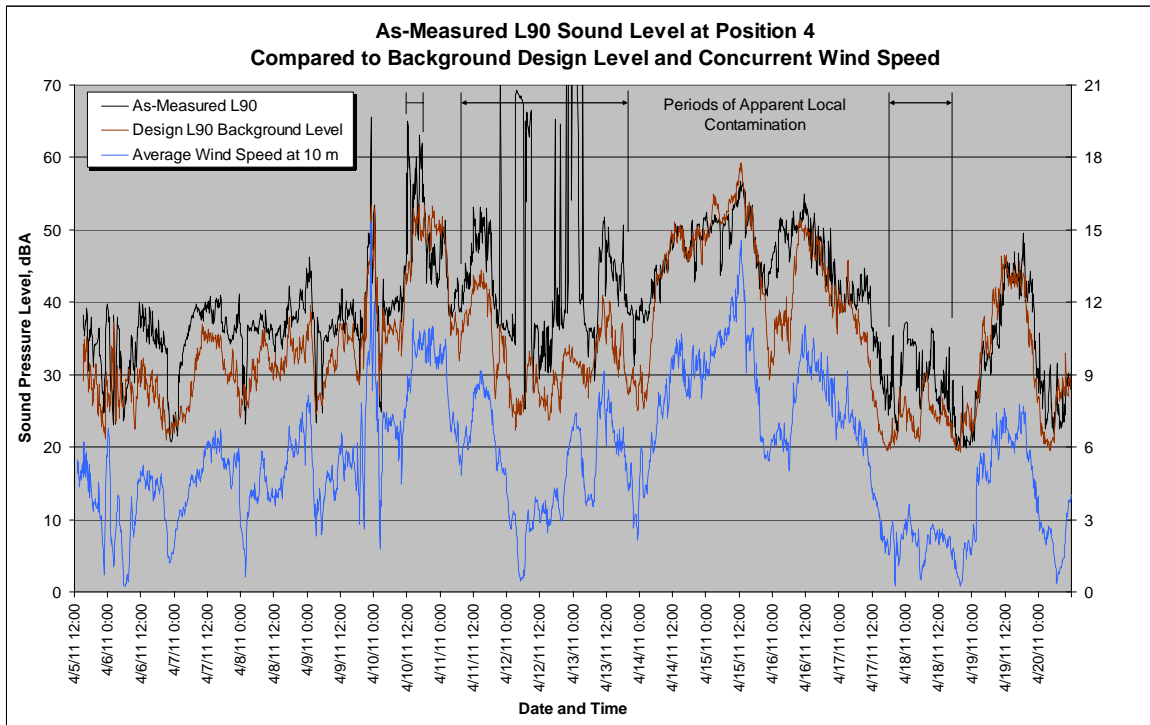


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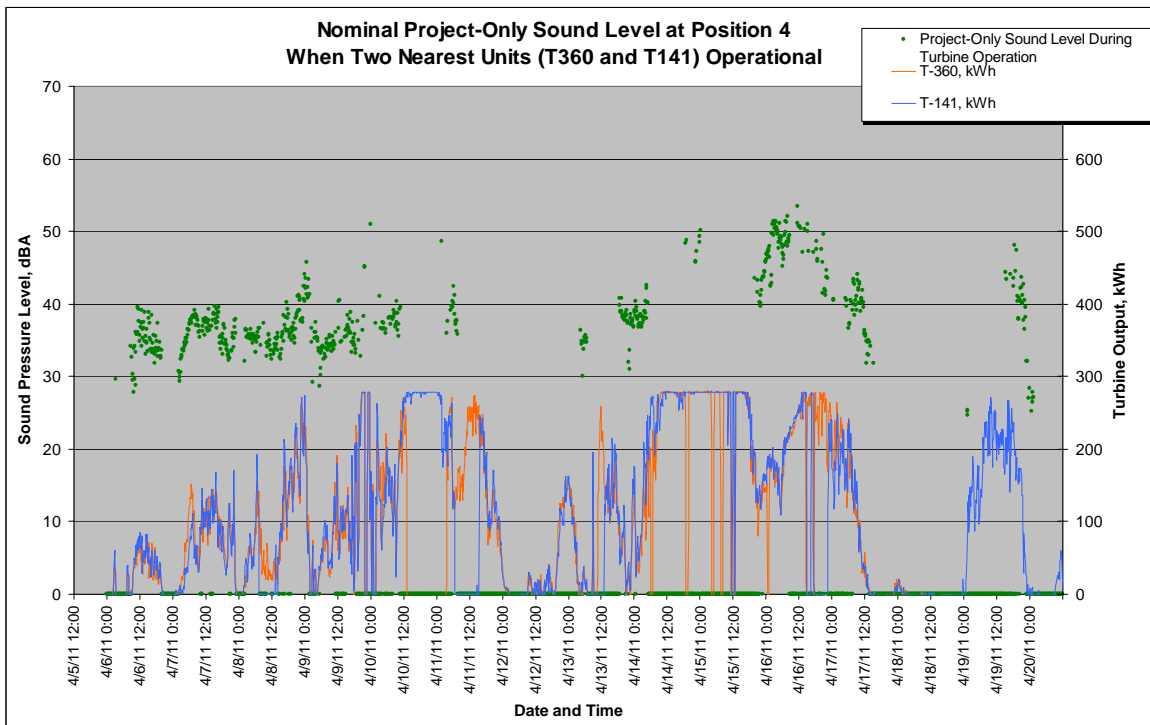


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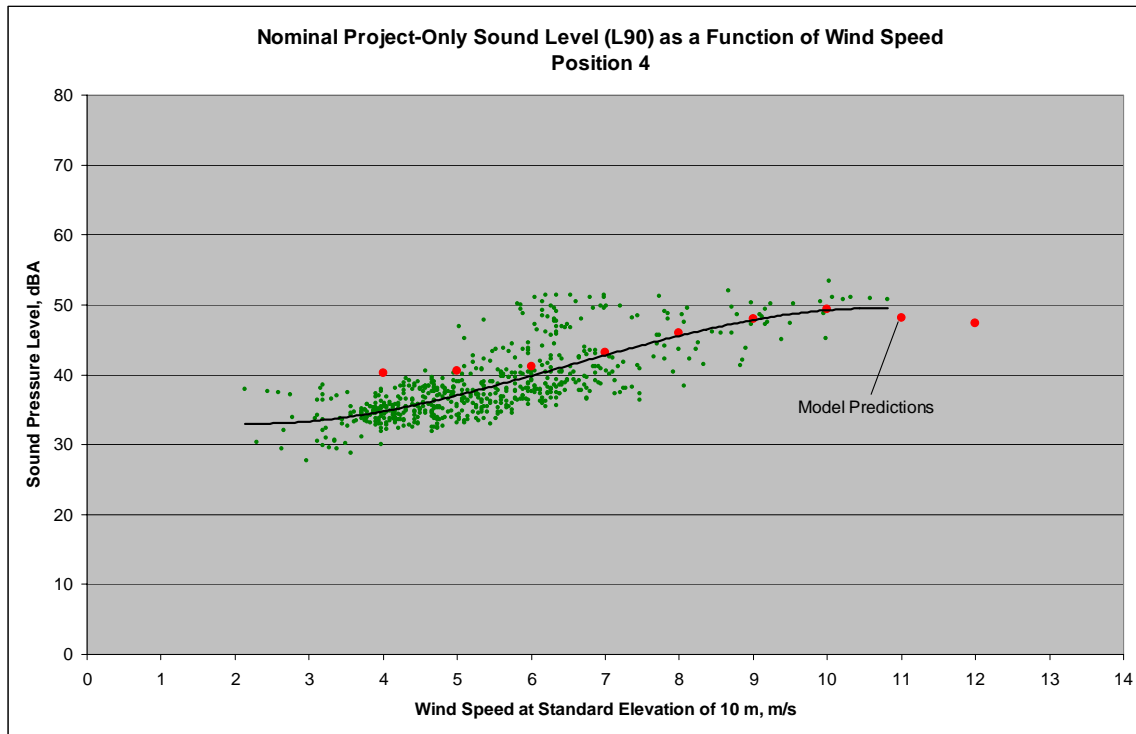


Figure B4-9

Position 5

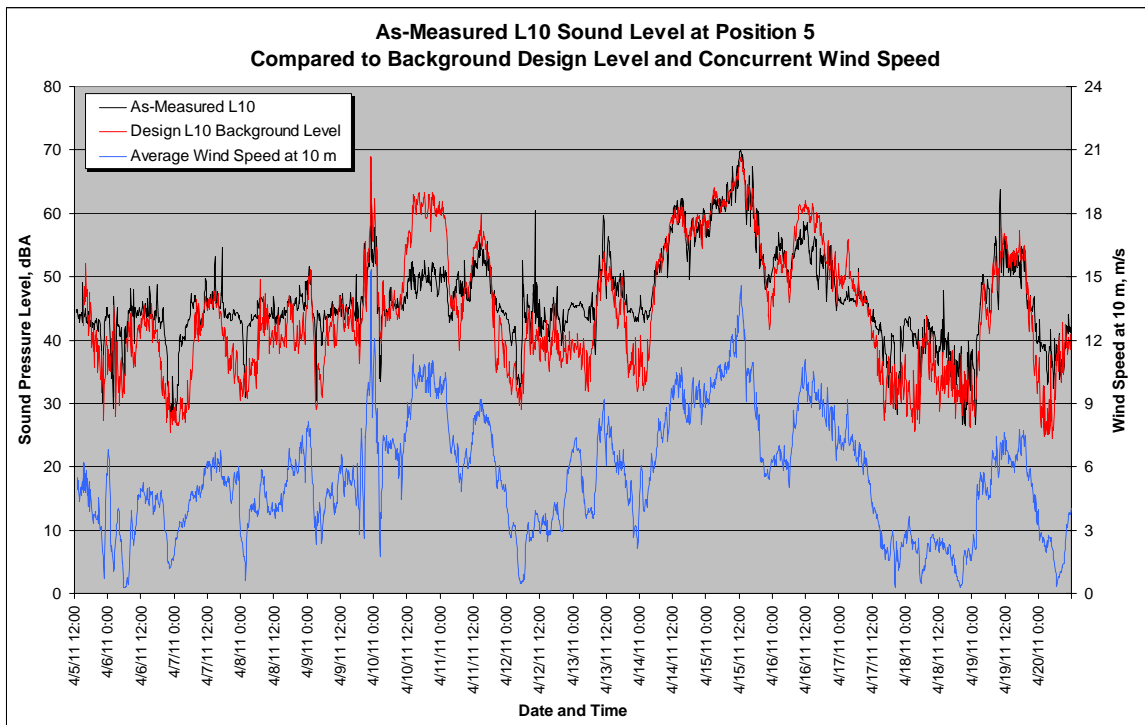


Figure B5-1

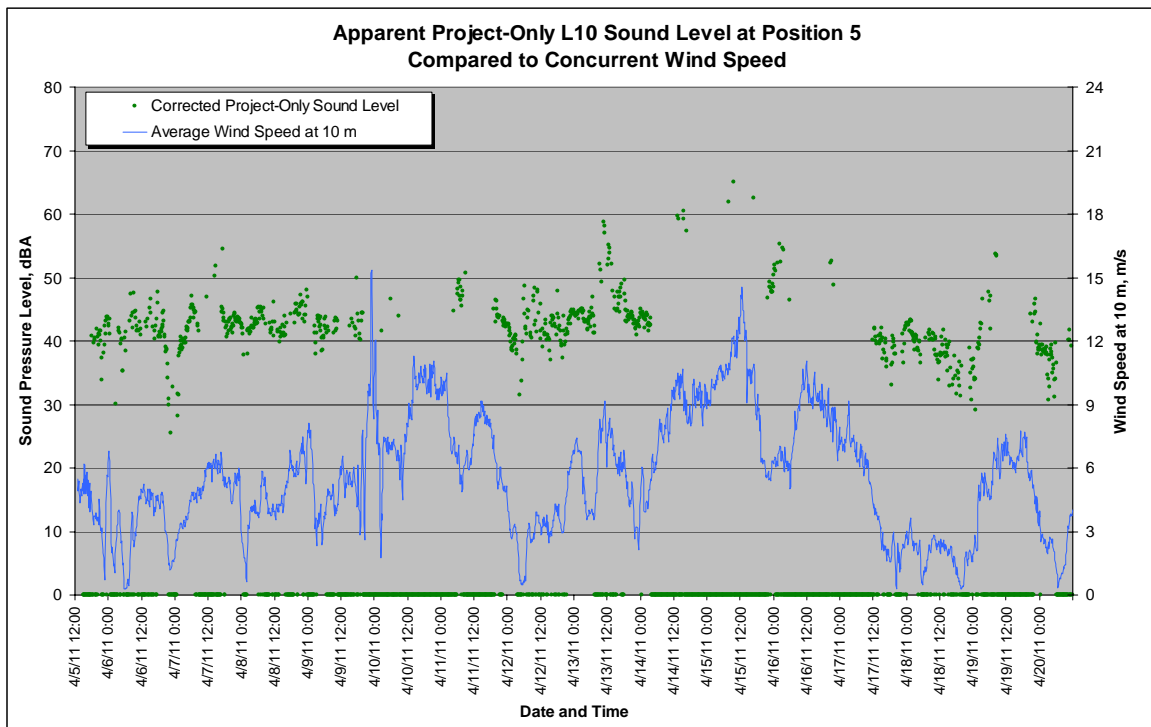


Figure B5-2

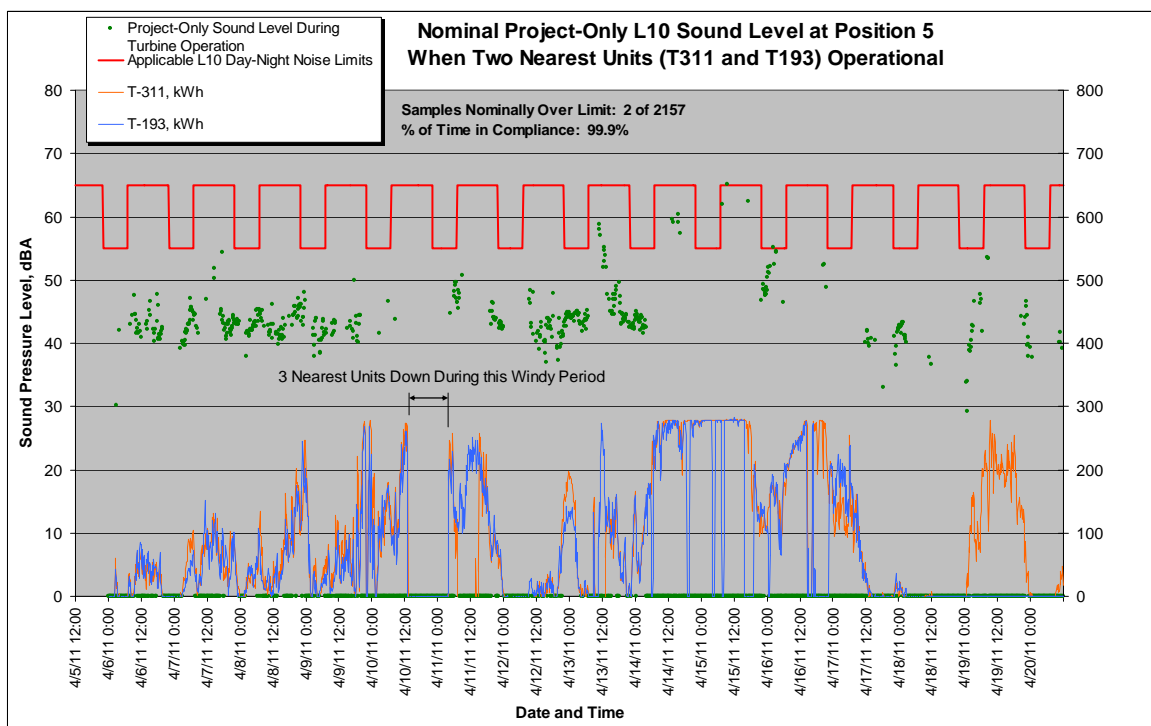


Figure B5-3

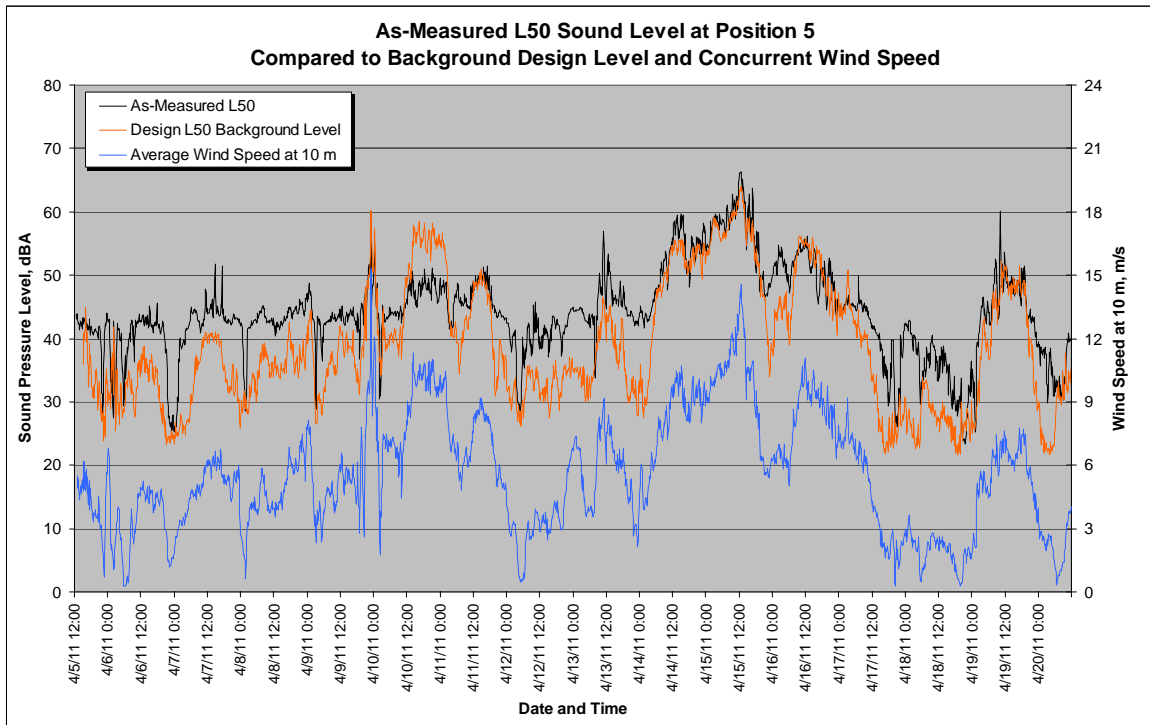


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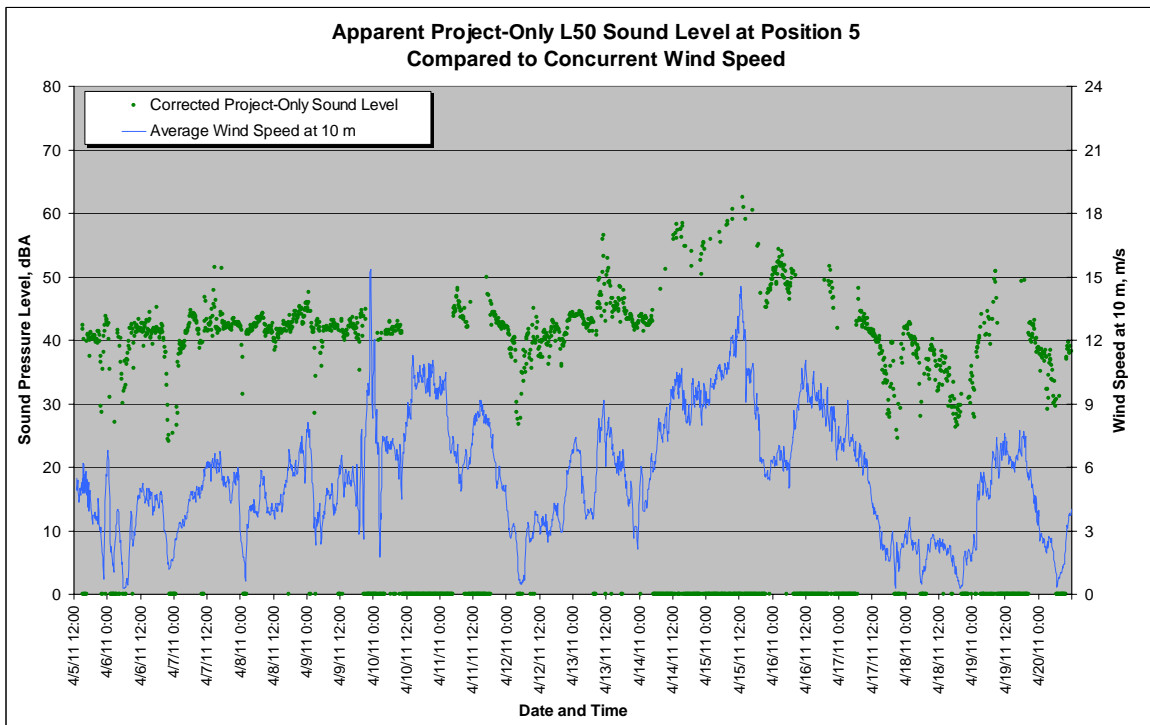


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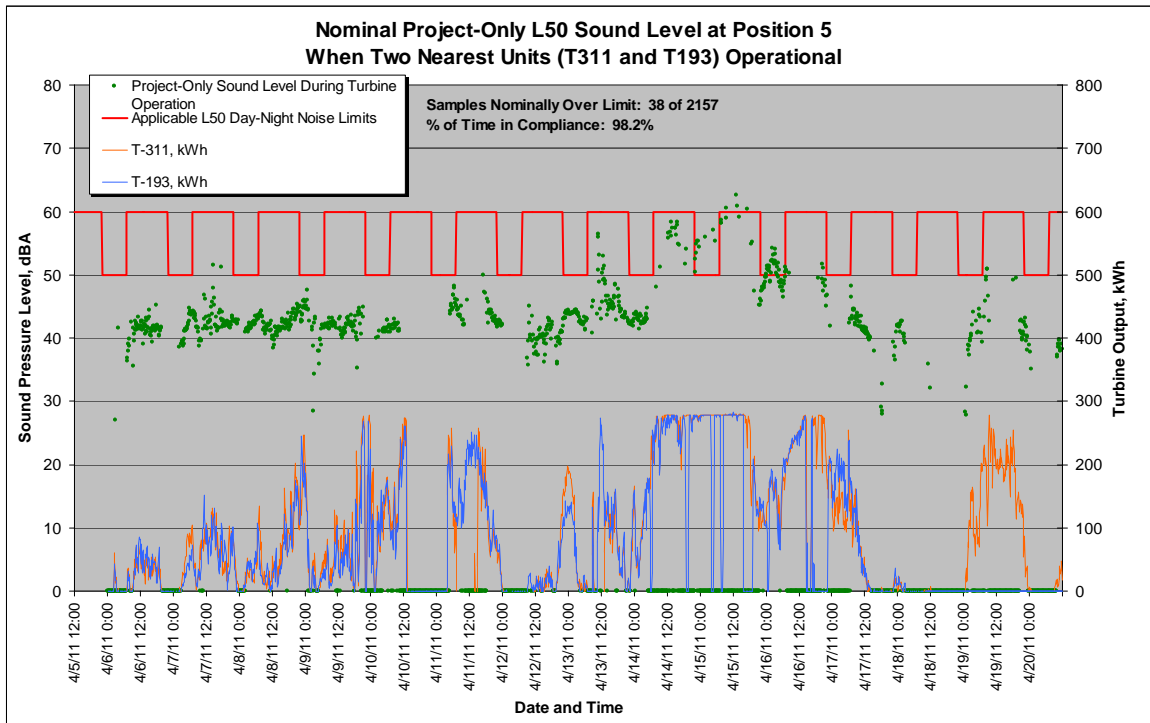


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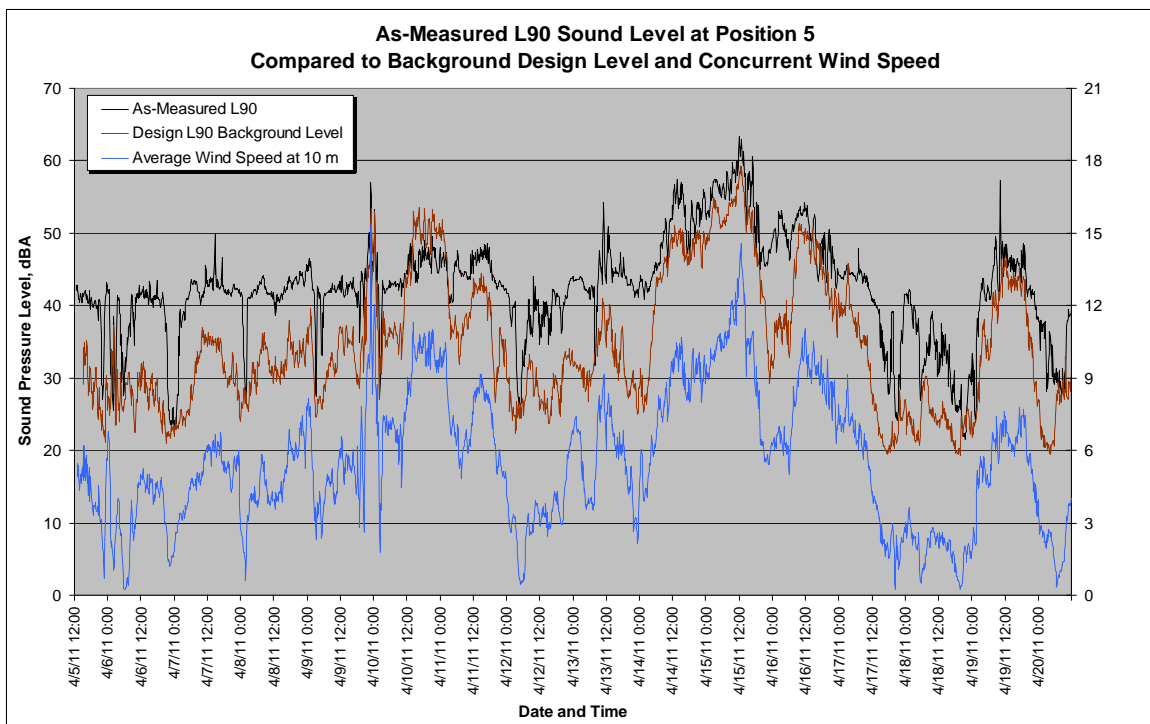


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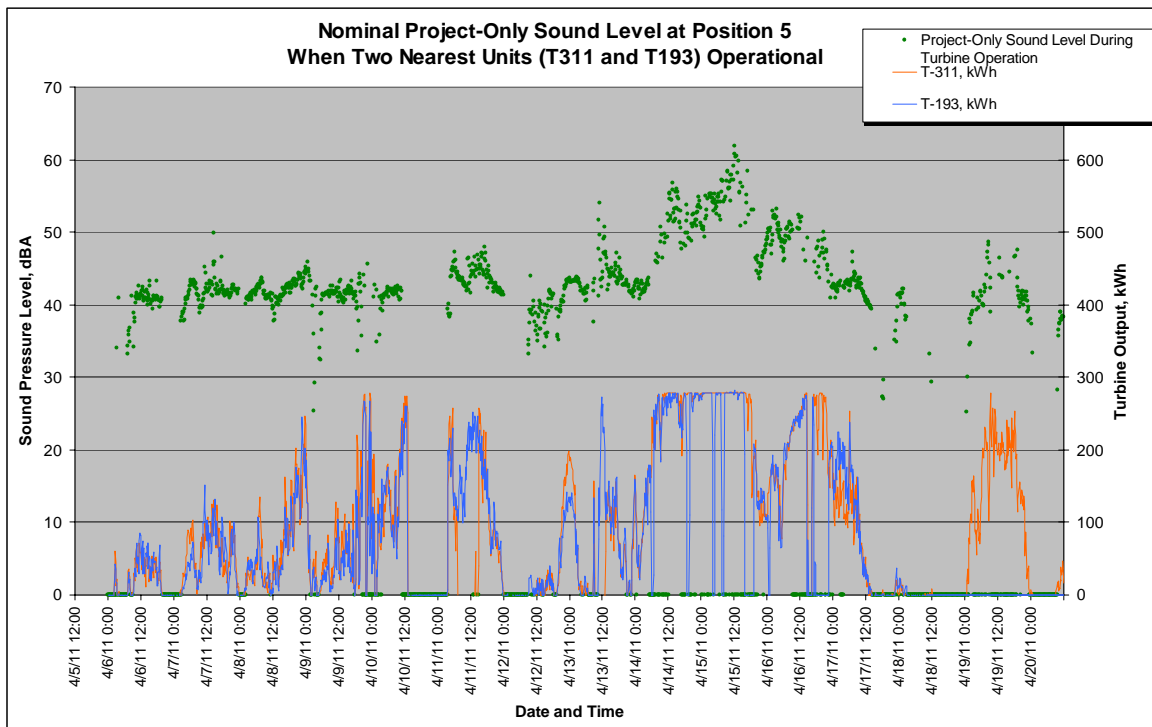


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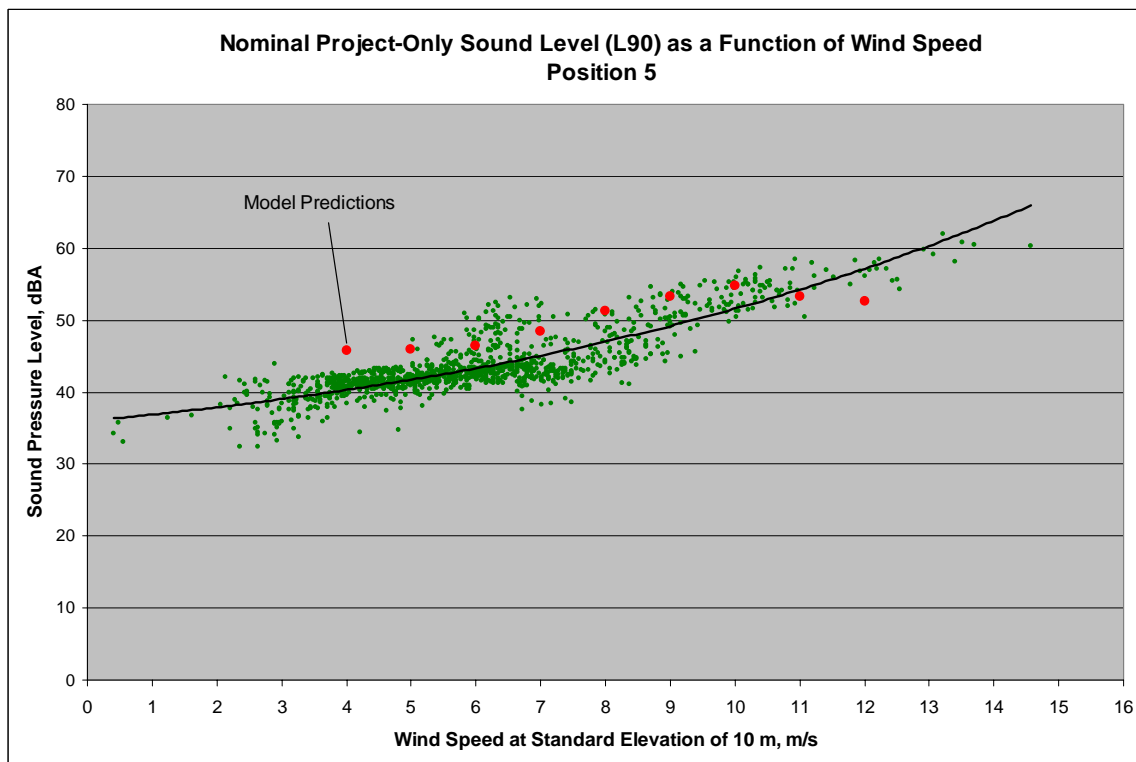


Figure B5-9

Position 6

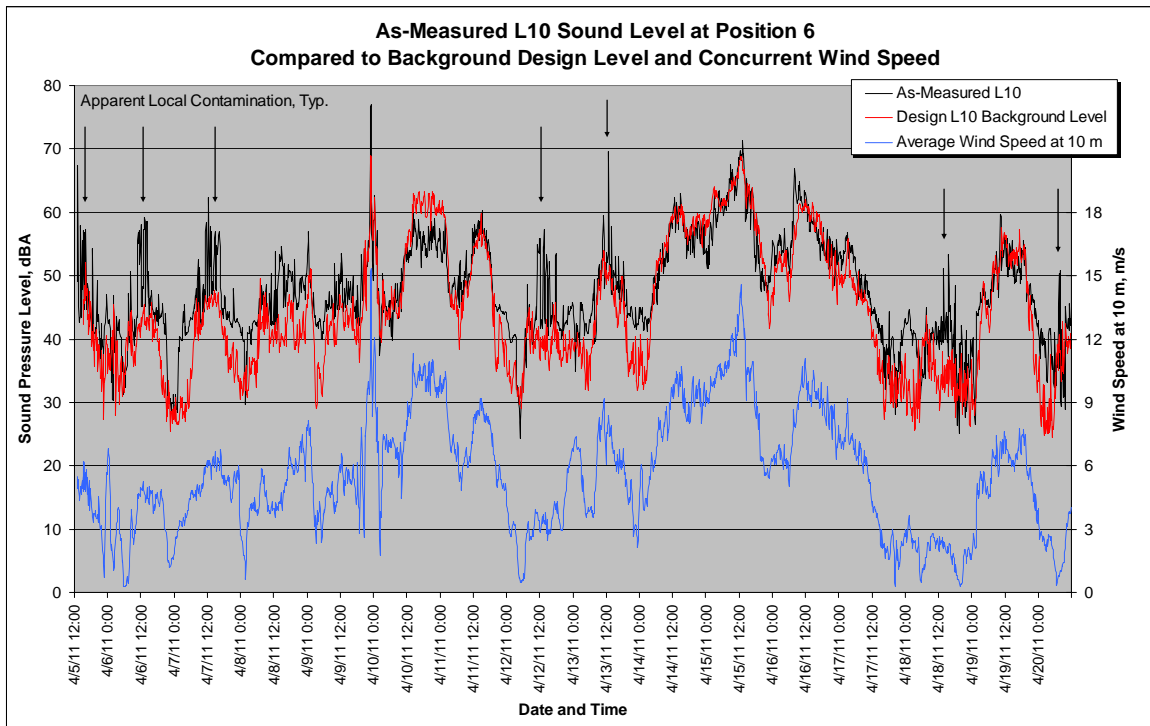


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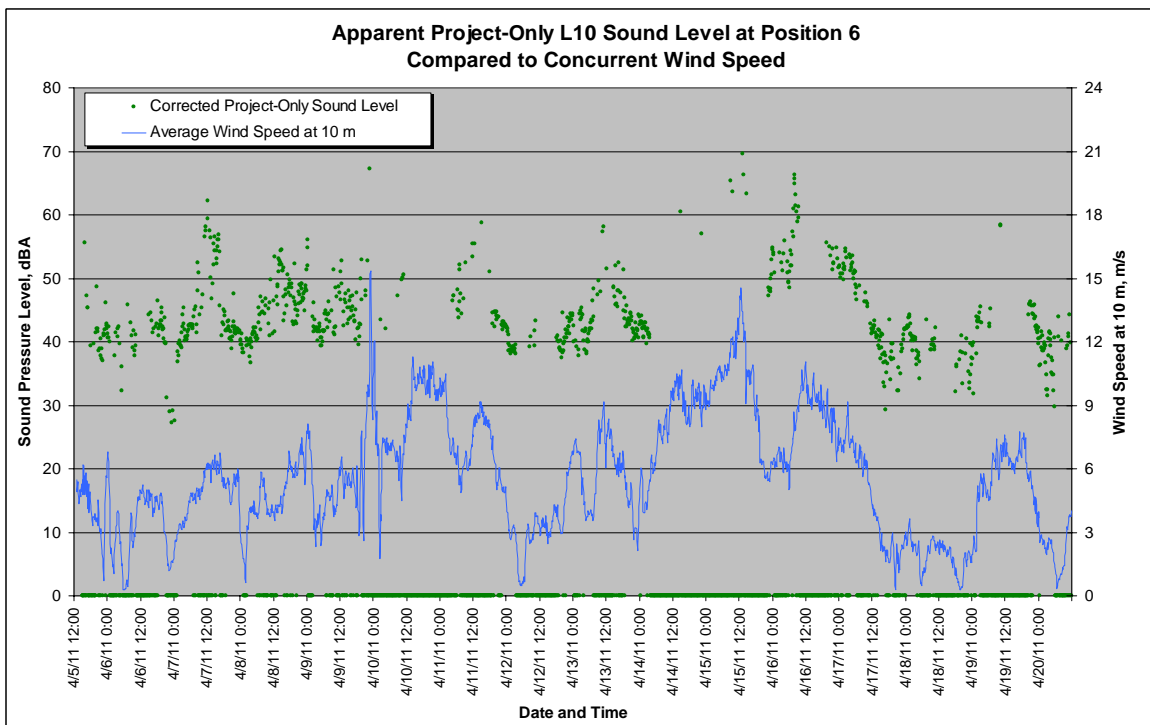


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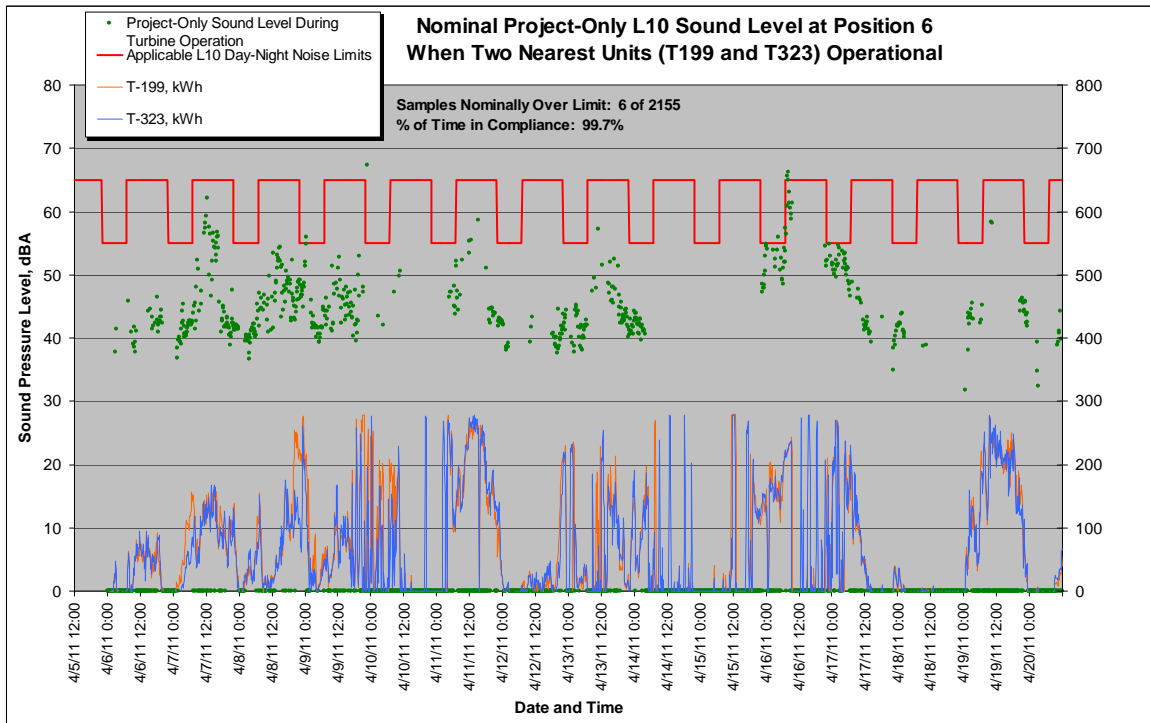


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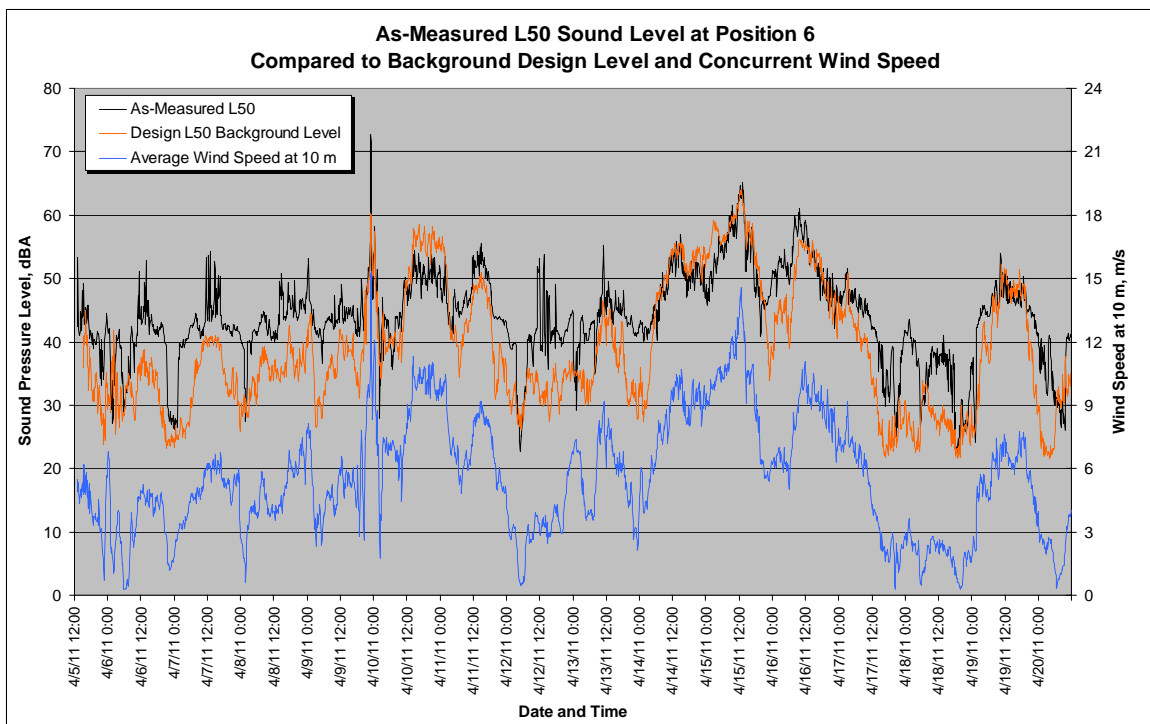


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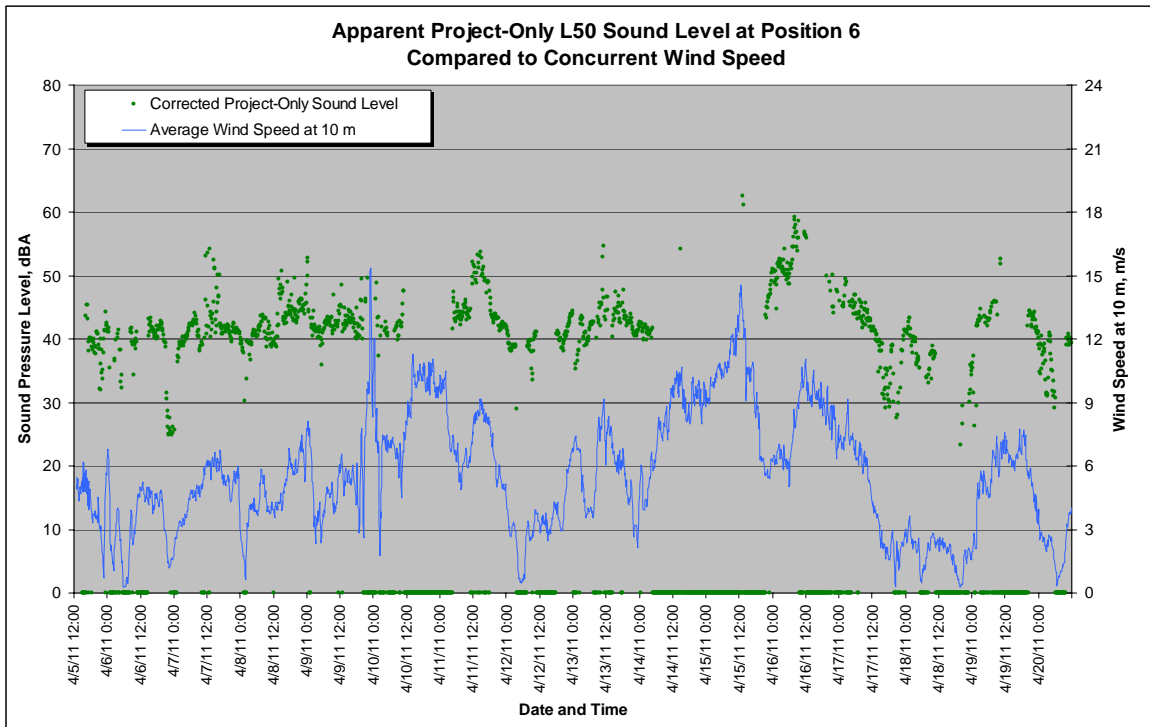


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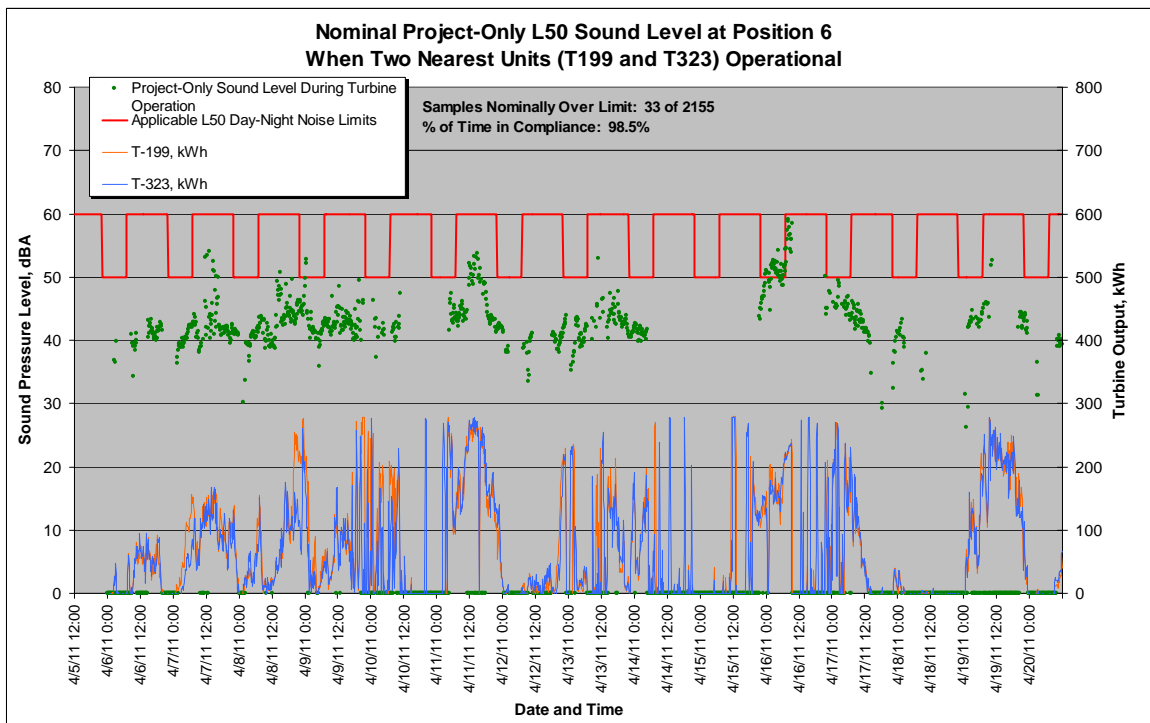


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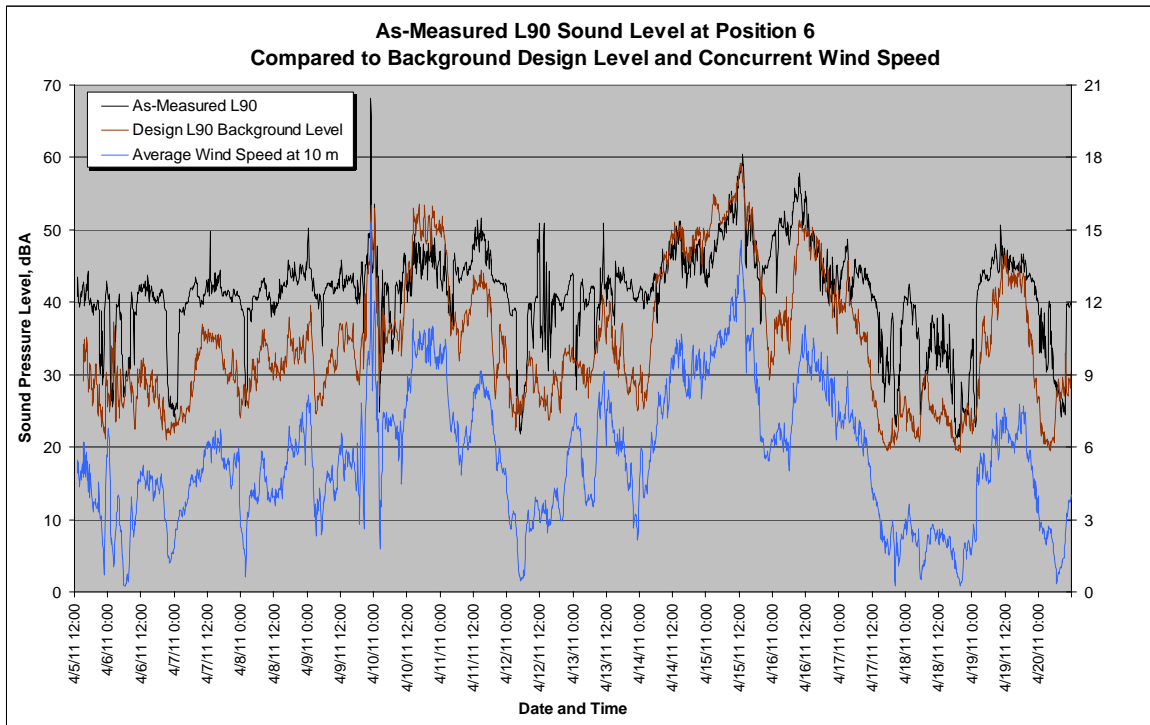


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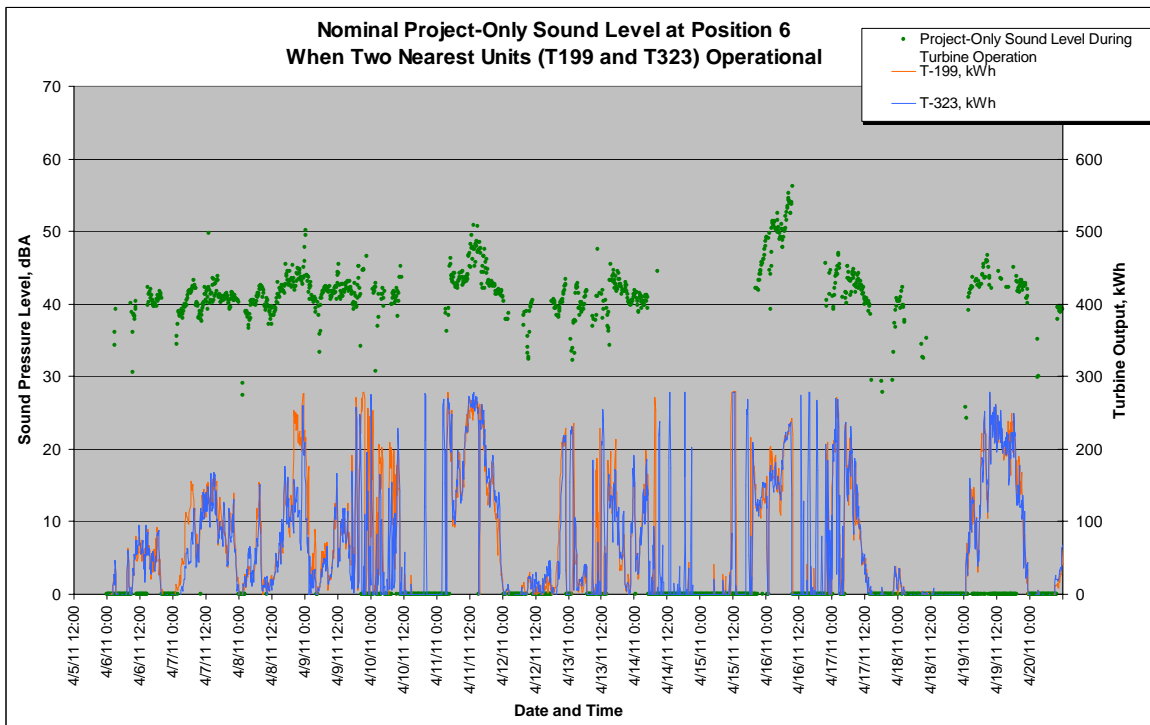


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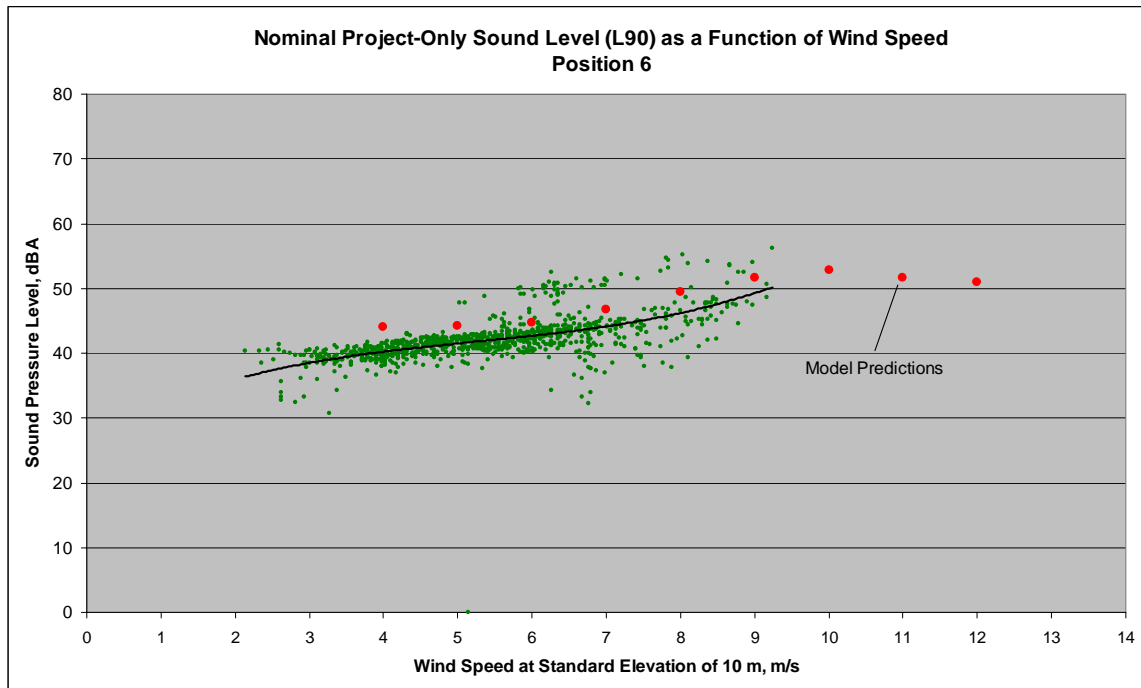


Figure B6-9

Position 7

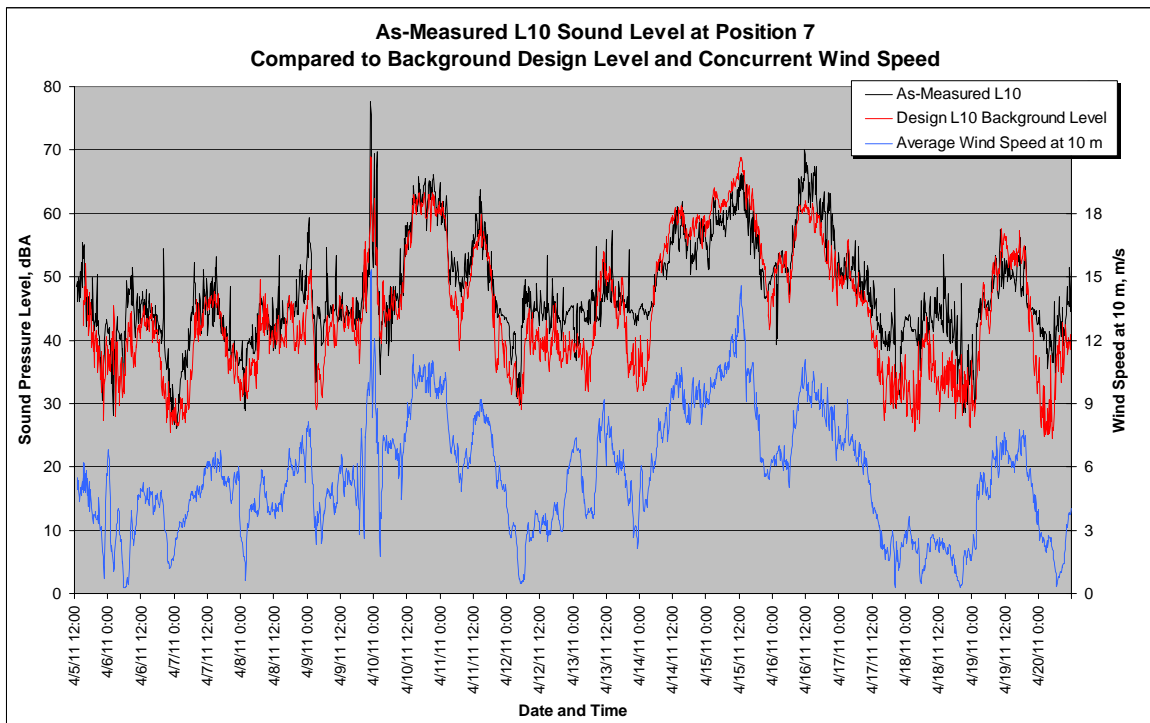


Figure B7-1

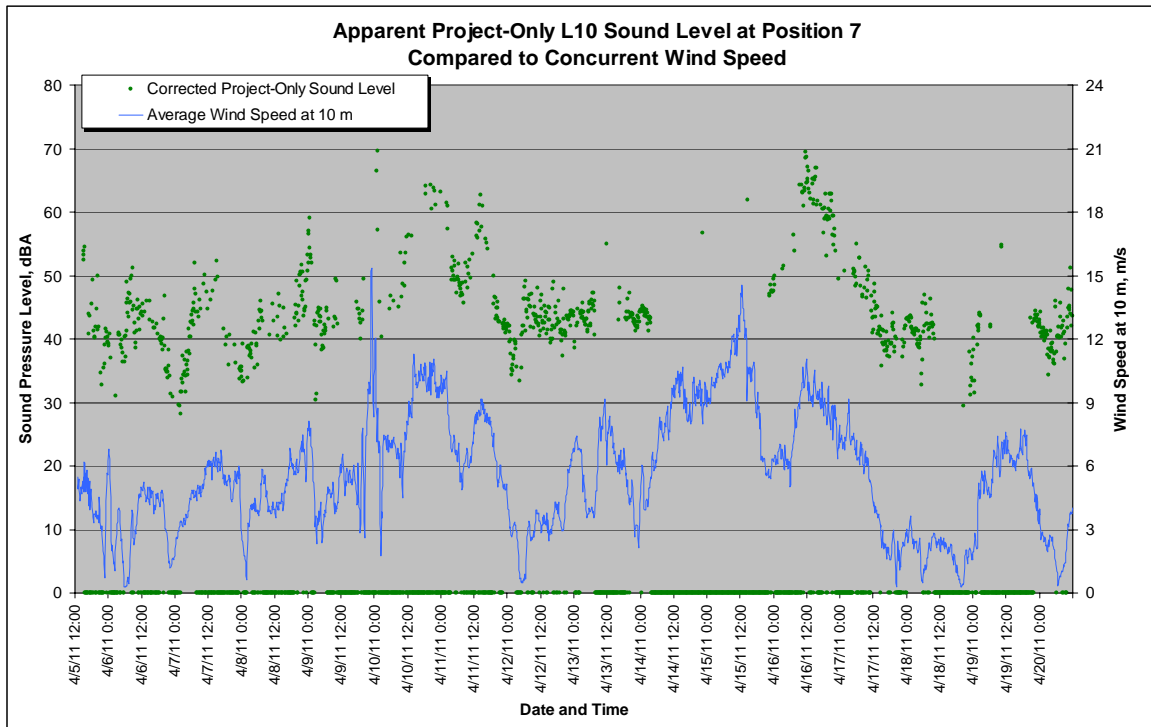


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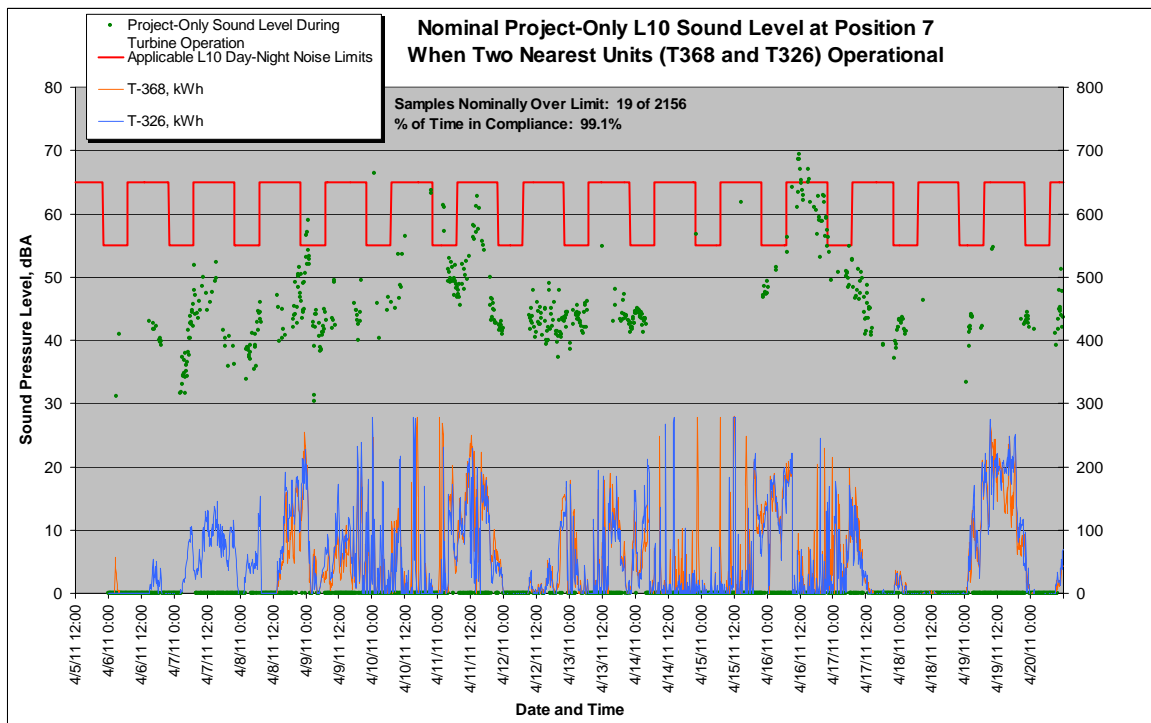


Figure B7-3

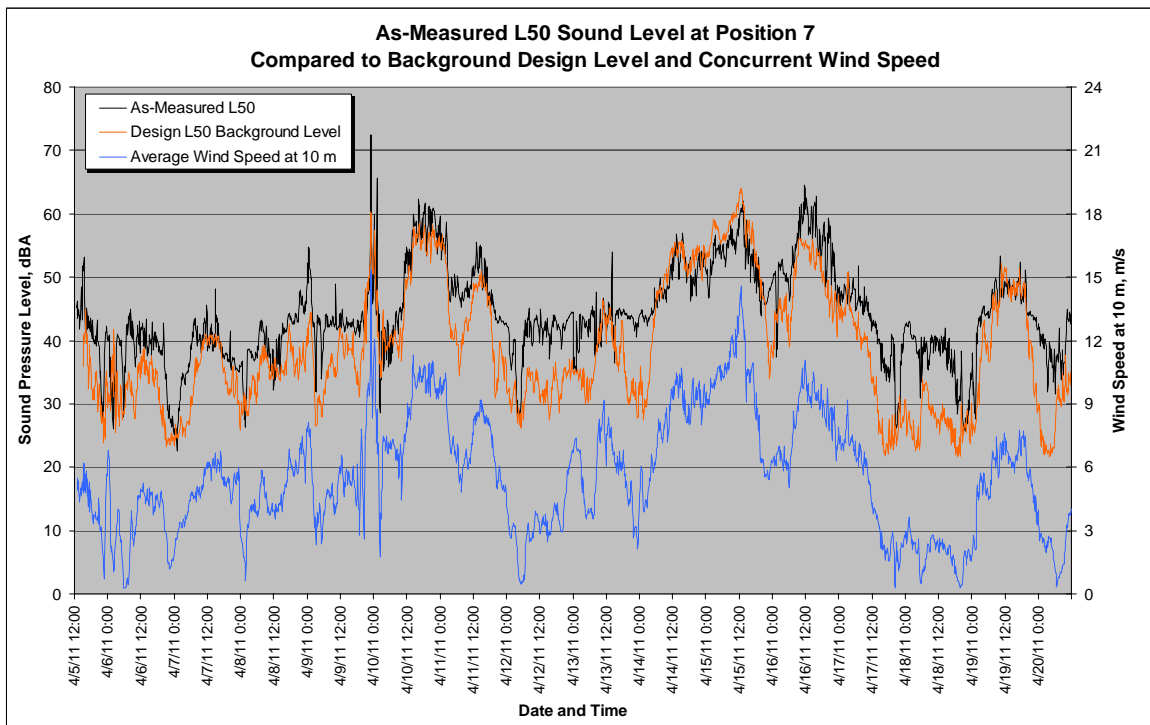


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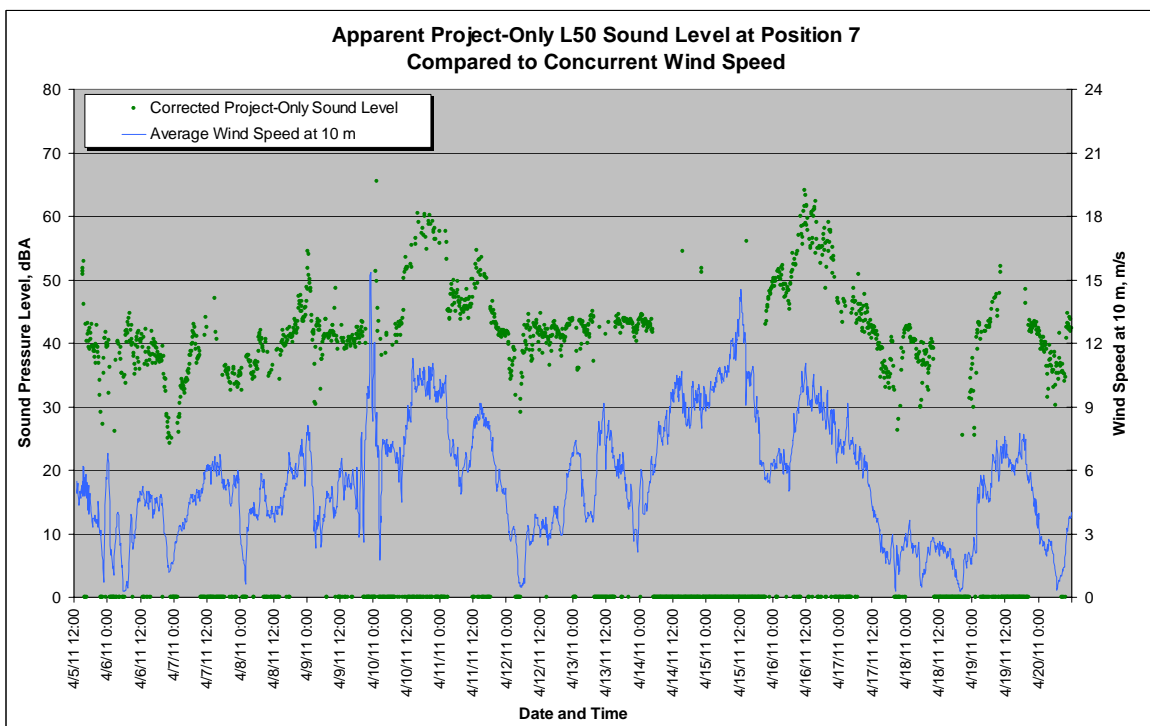


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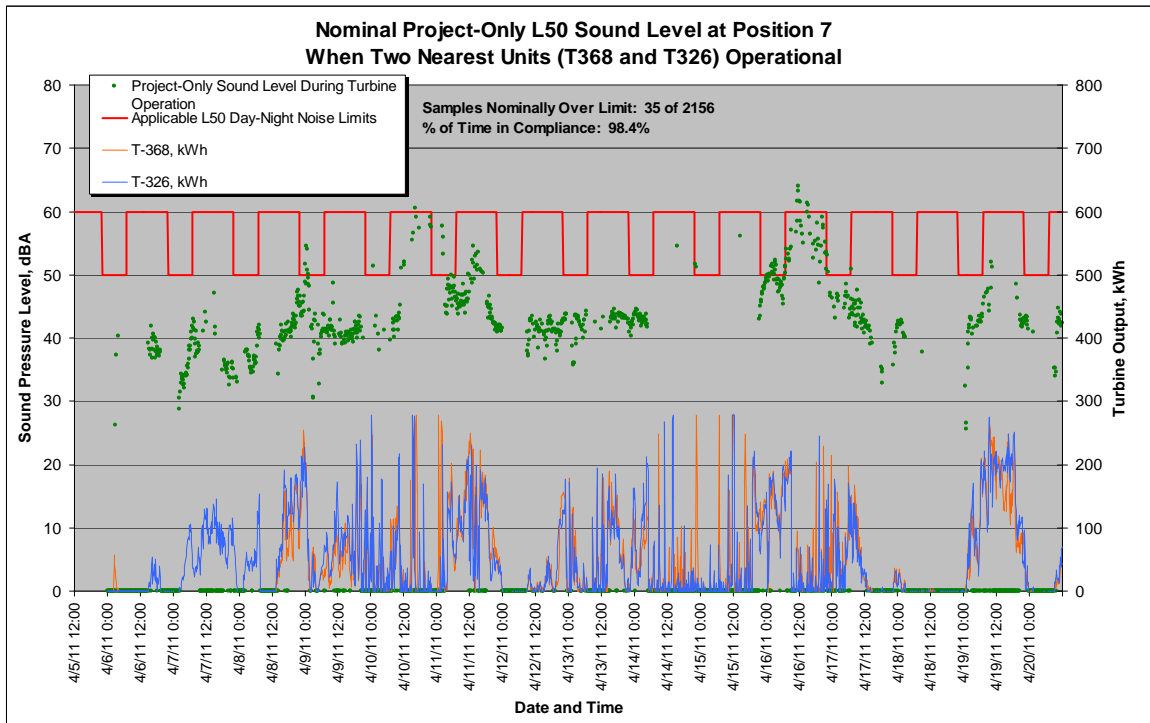


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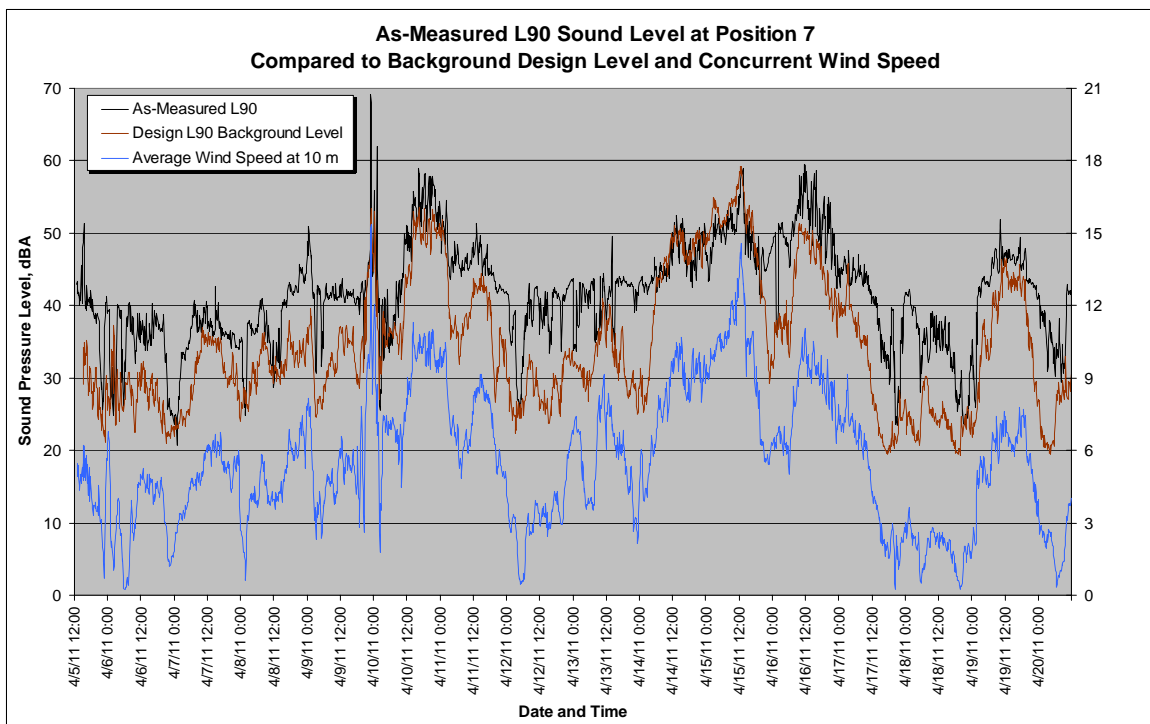


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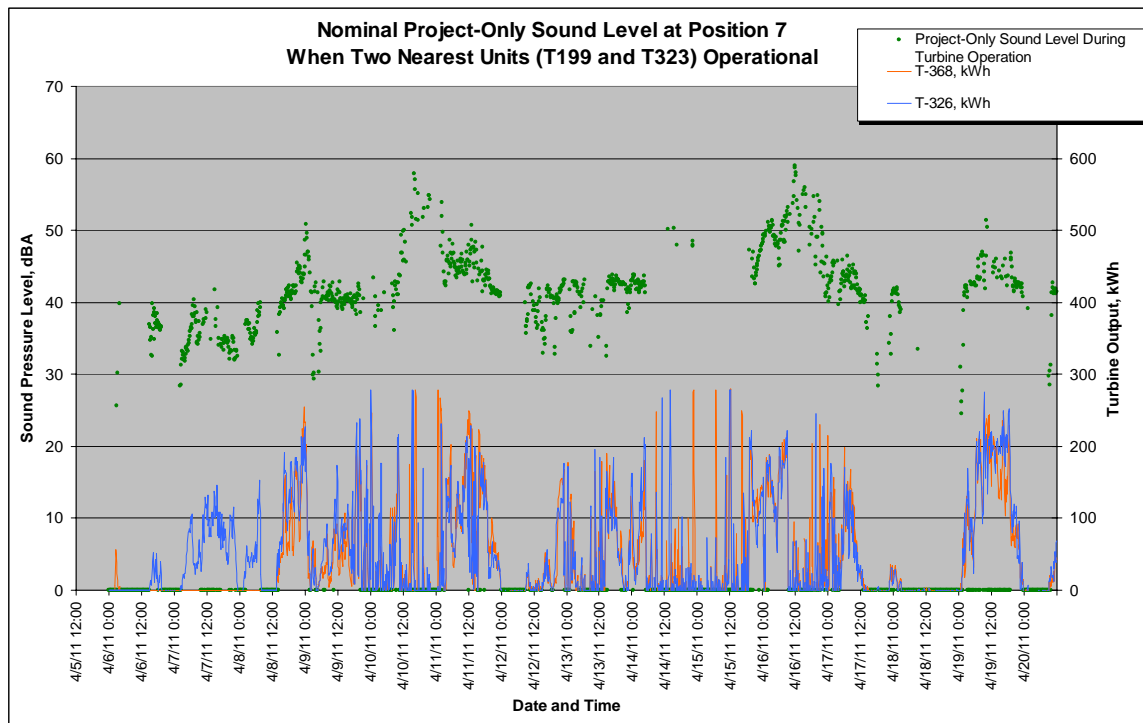


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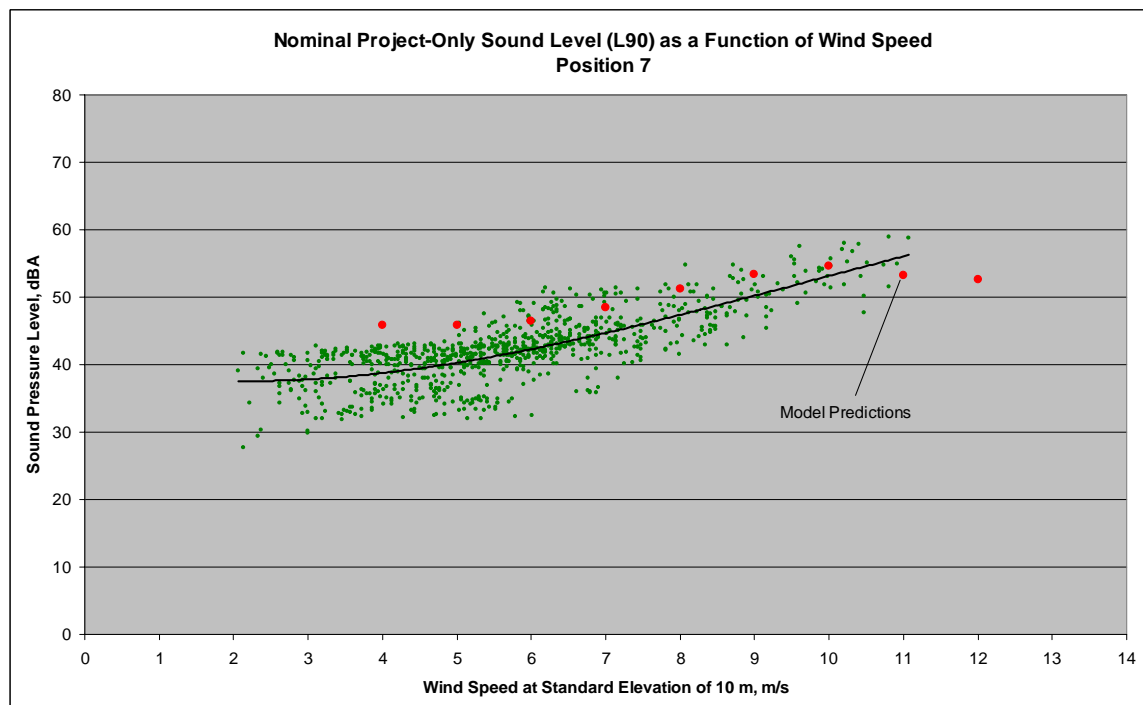


Figure B7-9