Ambient Noise Study
BC Oil and Gas Research and Innovation Society
Farmington Development Area
Phase 3 - Final Report
General Ambient – Non-Traffic

Prepared for:
BC Oil and Gas Research and Innovation Society

Prepared by:
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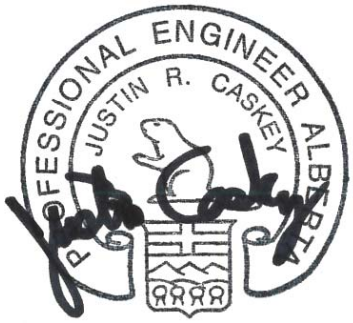
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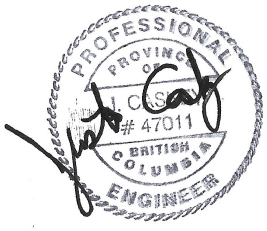

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Executive Summary

BC Oil and Gas Research and Innovation Society (BC OGRIS, the client) retained Patching Associates Acoustical Engineering Ltd. (PAAE) to conduct an ambient noise study for the areas away from Highway 97 or Regional Roadways in the Farmington Development Area (FDA), located NW of Dawson Creek, British Columbia.

The purpose of the sound survey is to quantify the ambient sound levels for the areas far from Highway 97 or Regional Roadways, which will provide data for consideration in a review of current noise regulations and associated permissible sound levels in B.C., and provide more targeted and specific information to optimize noise mitigation planning. This preliminary report outlines the results from Phase 3 related to the noise impact in the study area excluding the effects from the highway and local roads and outlines the results from monitoring in the studied local areas. To achieve this purpose two monitoring locations were selected and studied through noise monitoring in the Farmington Development Area. Each monitoring dataset was analysed to remove sound events near the microphone or other contamination and the residual data presented below represents the general ambient sound levels experienced in the monitoring areas studied. This represents sound levels without contribution from energy industry facilities.

Table A: Sound Monitor B Results

Measured Period	Measured Residual Leq (dBA)	Measured Hours	Wind Speed (kph)
Total Survey Period – Daytime (Sep 17-Oct 1)	52.7	179.3	12.5
Total Survey Period – Nighttime (Sep 17-Oct 1)	43.0	113.0	10.1
Total Survey Period – Daytime (Oct 29 -Nov 6)	41.6	110.7	10.1
Total Survey Period – Nighttime (Oct 29 -Nov 6)	35.8	71.7	9.7
BC OGC Current Assumed BSL (ASL) (dBA) - Daytime	50.0 (45.0)		
BC OGC Current Assumed BSL (ASL) (dBA) - Nighttime	40.0 (35.0)		

Table B: Sound Monitor E Results with Wind Conditions

Measured Period	Measured Residual Leq (dBA)	Measured Hours	Wind Speed (kph)
Total Survey Period - Daytime	41.6	158.0	14.3
Total Survey Period - Nighttime	34.8	95.4	10.8
BC OGC Current Assumed BSL (ASL) (dBA) - Daytime	50.0 (45.0)		
BC OGC Current Assumed BSL (ASL) (dBA) - Nighttime	40.0 (35.0)		

The key findings of the ambient noise study results are the following:

- The two receiver locations studied found that the acoustic environment included local traffic, fauna, wind and sounds of nature.
- Measured ambient sound levels for Monitor B and E ranged from 25.1 to 56.9 dBA during the measurement periods, many of the daytime and nighttime sound levels are higher than BC OGC current assumed ASL with moderate to strong wind conditions. There were several nights, during which the residual sound levels were lower than the BC OGC ASL with moderate to light wind conditions.
- Periods with high winds (>15 km/hr) demonstrate ambient sound levels 7-10 dBA above the BC OGC current assumed ASL. This suggests that wind induced sound may provide masking for industrial or traffic noise and thus qualify for A2 adjustments. Additional research is recommended to determine changes to wind induced sound from foliage (leaves) and ground cover (snow/grass) as well as receiver experienced (wind induced microphone noise) prior to developing general guidelines. In addition, periods without wind will not provide masking for industrial or traffic noise and this should be considered as a risk factor when planning noise mitigation measures for temporary activities.

Table of Contents

Acronyms

Acronym	Description
AADT	Average Annual Daily Traffic
AB	Alberta
AER	Alberta Energy Regulator
ASL	Ambient Sound Level
BSL	Basic Sound Level
dB	Decibel
dBA	A-Weighted Decibel
dBC	C-Weighted Decibel
dBZ	Z-Weighted Decibel or Linear Decibel
CSL	Comprehensive Sound Level
DIL	Dynamic Insertion Loss
ISO	International Organization for Standardization
L_{eq}	Energy Equivalent Sound Level
LFN	Low Frequency Noise
LSD	Legal Subdivision
NIA	Noise Impact Assessment
NC	Noise Control
NR	Noise Reduction
PSL	Permissible Sound Level
PWL	Sound Power Level
SPL	Sound Pressure Level
TL	Transmission Loss
UTM	Universal Transverse Mercator

Introduction

BC Oil and Gas Research and Innovation Society (BC OGRIS, the client) retained Patching Associates Acoustical Engineering Ltd. (PAAE) to conduct an ambient noise study for the areas away from Highway 97 or Regional Roadways in the Farmington Development Area (FDA), located NW of Dawson Creek, British Columbia.

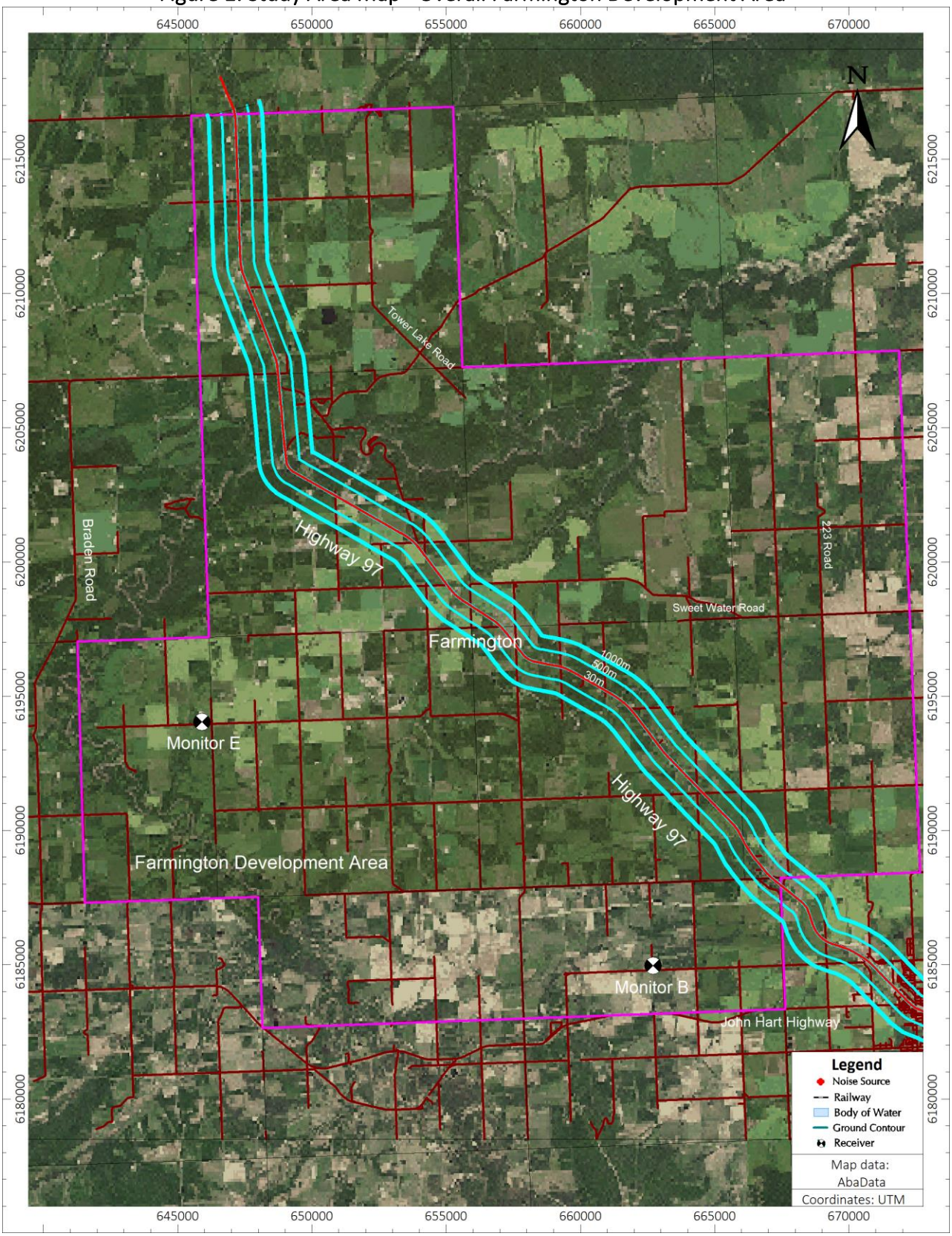
The purpose of the sound survey is to quantify the ambient sound levels for the areas far from Highway 97 or Regional Roadways, which will provide data for consideration in a review of current noise regulations and associated permissible sound levels in B.C., and provide more targeted and specific information to optimize noise mitigation planning. This preliminary report outlines the results from Phase 3 related to the noise impact in the study area excluding the effects from the highway and local roads and outlines the results from monitoring in the studied local areas. To achieve this purpose two monitoring locations were selected and studied through noise monitoring in the Farmington Development Area. Each monitoring dataset was analysed to remove sound events near the microphone and other contamination and the residual data presented below represents the general ambient sound levels experienced in the monitoring areas studied. This represents sound levels without contribution from energy industry facilities.

Study Area

The Farmington Development Area is located NW of Dawson Creek, British Columbia, setup by the BC OGC. The terrain cover is mainly rolling farmland with patches of tree.

Highway 97 traverses this area along a SE/NW orientation. John Hart Highway located just outside and along the south boundary of the Farmington Development Area. The two monitoring locations were selected to quantify the noise in the studied local areas, which are far enough to avoid the potential impact from Highway 97 and Regional Roadways. The overall Farmington area and the two selected sound monitoring locations denoted as Sound Monitor B and E, shown in Figure 1.

Figure 1: Study Area Map - Overall Farmington Development Area



Noise Criteria

Noise for energy related facilities is regulated through the BC OGC Noise Control Guideline (the Guideline). The Guideline sets the Permissible Sound Level (PSL), which is the limit that the Sound Pressure Level (SPL) emanating from the facilities in the study area plus the Ambient Sound Level (ASL) may not exceed over a specified period, as measured at specific locations of interest (the receivers). These allowable limits are dependent on the population density, proximity to heavily traveled transportation routes (motor vehicles, rail and aircraft) and other specified adjustments. The SPL is the sound level received at a specific location. The ASL is the average background sound level not attributable to energy industry facilities. The ASL is assumed to be 5 dBA below the PSL, as prescribed by the Guideline. The receivers are located at the residences existing within 1500 m of the subject facility, or else at the study area boundary.

The ambient sound level (ASL) is the average sound environment in a given area without contribution from any energy-related industry. This project aims to collect data for consideration in a review of noise regulations and associated permissible sound levels in B.C. Current regulations are based on research conducted in Alberta several decades ago that relied on approximate and simplified categories to establish permissible sound levels and compliance criteria for oil and gas activities.

The two survey locations B and E, have been selected to get representative conditions in this area, which are far away from the Highway 97 or Regional Roadways, and classified as the Category 1 for the Basic and Ambient Noise Levels definition, See Appendix B for the BSL and PSL calculations based on the Guideline.

Environmental noise level is typically not steady and continuous, but constantly varies over time. To account for the time-varying nature of environmental noise, a single number descriptor known as the energy equivalent sound level (L_{eq}) is used. The L_{eq} value, expressed in dBA, is the A-weighted equivalent-continuous sound level for the complete period of interest that has the same acoustic energy as the actual varying sound levels over the same time period. The use of this index permits the description of a varying sound level environment as a single number. As the L_{eq} is an “average” level, the measured sound level may exceed the criterion level for a short period, provided that the duration is limited. The L_{eq} value considers both the sound level and the length of time that the sound level occurs.

Methodology

The sound monitoring survey at each of the three locations was conducted with NTI XL2 Sound Level Meters. The microphones were mounted with windscreens to reduce the potential for wind-induced noise at the microphone. The sound level meters were calibrated at the beginning and confirmed after the survey with a Brüel & Kjær Model 4231 Sound Level Calibrator. Sound recording equipment recorded the sound for the whole period. These sound recordings were used to help identify the source of different noises. During the sound survey, continuous weather monitoring equipment recorded the wind speed, wind direction, temperature and humidity in the local study area.

Table 1 provides a summary of the major equipment used for this survey and the calibration dates for this equipment. Table 2 describes each monitoring location.

Table 1: Instrumentation Summary

Equipment	Manufacturer	**NetBox SN**	**XL2 SN**	**M2230 Transducer SN**	Calibration Date	Calibration Valid
Sound Level Meter NTI Kit B	NTI	FFJXM-SJNE9	A2A-16096-E0	5419	06/19/2019	Yes
Sound Level Meter NTI Kit E	NTI	CDZNZ- 7PPUV	A2A-16603-E0	8604	09/11/2019	Yes
Nomad Weather Station #3	Vaisala	-	R3530325	-	03/09/2019	Yes
Meter Calibrator 4231 #4	Bruel & Kjaer	-	2730772	-	23/05/2019	Yes

Table 2: Monitoring Locations

Equipment	Location	Description
Sound Level Meter and Weather Station	Sound Monitor B	• NTI Kit B • Approximately 160m north from 210 Road • Approximately 1770 m north from John Hart Highway • Approximately 5400m southwest from Highway 97 • Mic is 1.5 m above ground • For site photo, see Picture C1 in Appendix C
Sound Level Meter and Weather Station	Sound Monitor E	• NTI Kit E • Approximately 80m north from 216 Road • Approximately 280m south from facility site 1-25-79-18W6 • Approximately 6200 m east from Braden Road • Approximately 9800m southwest from Highway 97 • Mic is 1.5 m above ground • For site photo, see Picture C2 in Appendix C

Environmental Conditions

Environmental conditions of the area were recorded with a weather station installed by PAAE staff next to the sound monitor. Tables 3A and 3B summarize the weather measurement results for the daytime and nighttime periods during the survey period. The detailed records are presented in Appendix D.

Table 3A: Environmental Conditions (Weather Station – Monitor C)

Date (2019)	Average Speed (kph)	General Direction	General Description	Minutes of Audible Precipitation	Minutes of Valid Condition
Sep 17	3	NW	Light wind	0	270
Sep 17 - Sep 18	2	SSW	Light wind	0	540
Sep 18	9	SSW	Moderate wind	0	545
Sep 18 - Sep 19	17	SSW	Strong wind	0	0
Sep 19	21	SSW	Strong wind	0	0
Sep 19 - Sep 20	8	SW	Moderate wind	5	410
Sep 20	14	SSW	Moderate wind	0	155
Sep 20 - Sep 21	21	SSW	Strong wind	0	0
Sep 21	23	SSW	Strong wind	0	90
Sep 21 - Sep 22	14	SSW	Moderate wind	0	190
Sep 22	18	SSW	Strong wind	5	10
Sep 22 - Sep 23	16	SSW	Strong wind	0	40
Sep 23	18	SSW	Strong wind	0	115
Sep 23 - Sep 24	18	SSW	Strong wind	0	0
Sep 24	23	SSW	Strong wind	0	5
Sep 24 - Sep 25	11	SSW	Moderate wind	0	255
Sep 25	15	SSW	Strong wind	0	170
Sep 25 - Sep 26	13	SSW	Moderate wind	5	115
Sep 26	6	NW	Moderate wind	20	570
Sep 26 - Sep 27	7	N	Moderate wind	10	150
Sep 27	8	N	Moderate wind	0	295
Sep 27 - Sep 28	2	NNW	Light wind	0	535
Sep 28	5	NNE	Moderate wind	0	545
Sep 28 - Sep 29	2	SSE	Calm wind	0	540
Sep 29	9	SSE	Moderate wind	0	485
Sep 29 - Sep 30	6	SSE	Moderate wind	0	540
Sep 30	6	S	Moderate wind	0	805
Sep 30 - Oct 01	13	SSW	Moderate wind	0	200
Oct 01	13	SSW	Moderate wind	0	120

Table 3B: Environmental Conditions (Weather Station Located - Monitor B)

Date (2019)	Average Speed (kph)	General Direction	General Description	Minutes of Audible Precipitation	Minutes of Valid Condition
Oct 29	10	SSW	Moderate wind	0	5
Oct 29 - Oct 30	14	SSW	Moderate wind	0	25
Oct 30	27	SSW	Strong wind	0	0
Oct 30 - Oct 31	17	SSW	Strong wind	0	0
Oct 31	12	SSW	Moderate wind	0	65
Oct 31 - Nov 01	11	SSW	Moderate wind	0	0
Nov 01	12	SSW	Moderate wind	0	100
Nov 01 - Nov 02	18	SSW	Strong wind	0	0
Nov 02	12	SSW	Moderate wind	0	355
Nov 02 - Nov 03	5	NW	Moderate wind	5	470
Nov 03	3	ESE	Light wind	0	900
Nov 03 - Nov 04	2	SSE	Calm wind	0	540
Nov 04	3	SSE	Light wind	0	900
Nov 04 - Nov 05	4	NNE	Light wind	0	540
Nov 05	4	N	Light wind	0	900
Nov 05 - Nov 06	6	NNW	Moderate wind	0	520
Nov 06	6	N	Moderate wind	0	160

The survey results indicate that the daytime and nighttime periods from September 17 to October 1, 2019 have moderate to strong wind conditions for this survey, only a few days have light wind conditions. Wind data collected during the monitoring period has been used to create a wind rose experienced during the monitoring, which is shown in Figure 2A.

The survey results indicate that the daytime and nighttime periods from October 29 to November 6, 2019 have calm to strong wind conditions for this survey, the first half of this monitoring period have moderate to strong wind conditions. Wind data collected during the monitoring period has been used to create a wind rose during the monitoring, which is shown in Figure 2B.

Figure 2A: Wind Rose (September 17 to October 1, 2019)

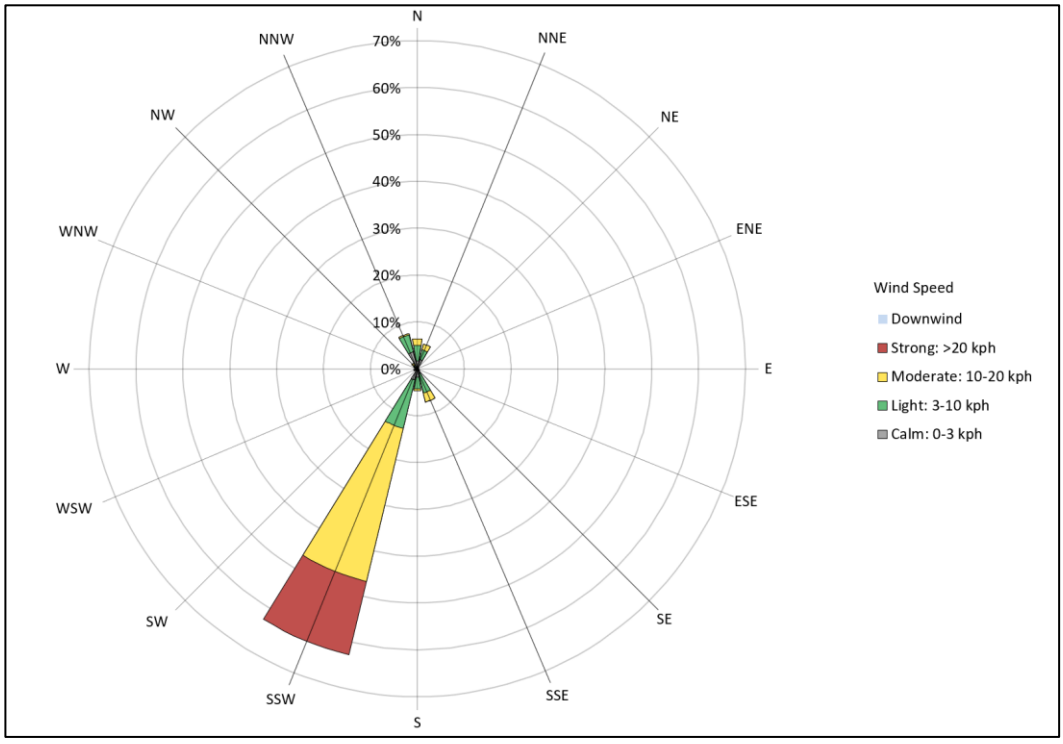
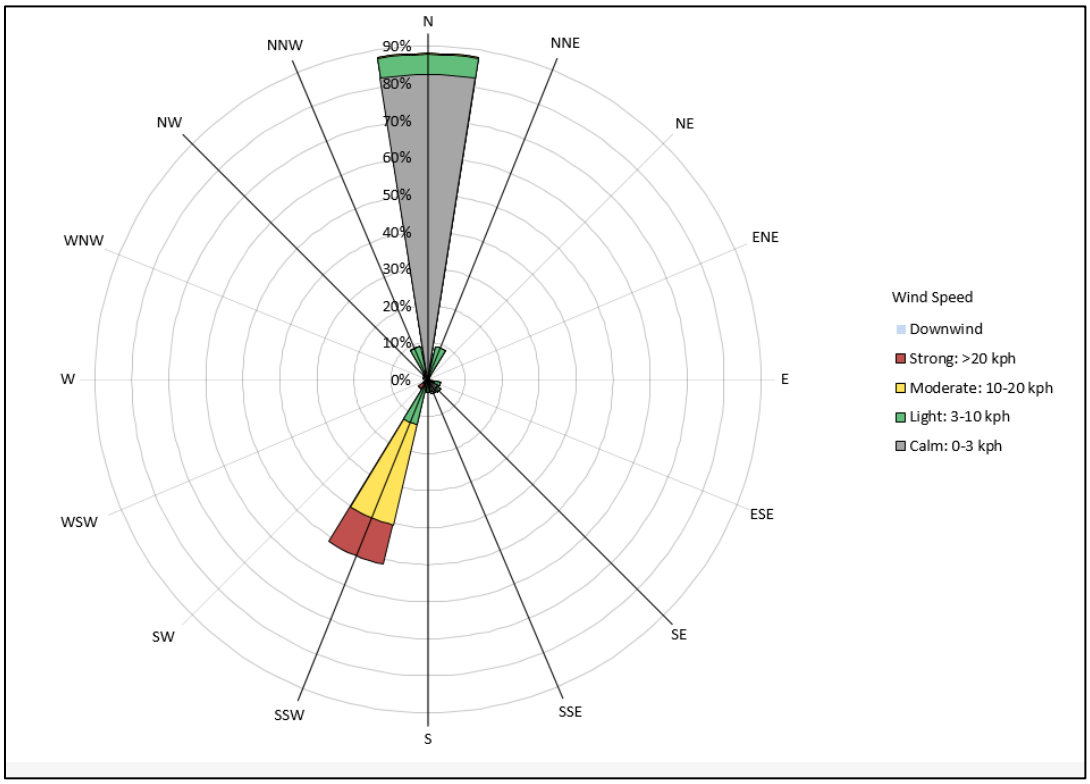


Figure 2B: Wind Rose (October 29 to November 9, 2019)



Results and Discussion

Sound Monitor B Measurement Locations

Sound Monitor B was located at approximately 160m north from 210 Road, 1770 m north from John Hart Highway and 5400m southwest from Highway 97.

Based on site observations during the survey and from the audio playback, the sound environment is dominated by sound from wind (nearby tree leaves), transportation and fauna and local activities. In this location distant highway noise is audible from time to time.

The detailed results including graphical presentation of the measured and residual levels are presented in Appendix E.

The survey results contained short-term sound events that are due to occasional noise events from local traffic, local activities and wind. Where possible, these short-term sounds were isolated from the measured comprehensive sound level data set resulting in the residual comprehensive sound level. Tables 4A and 4B and 4C summarize the comprehensive sound level measurement results for the monitoring based on daytime and nighttime periods.

Table 4A: Sound Monitor B Results

Period	Date (2019)	Measured Leq (dBA)	Measured Hours	Residual Leq (dBA)	Residual Hours
Day 01	Sep 17	73.5	10.0	33.7	8.4
Night 01	Sep 17 - Sep 18	33.2	9.0	32.9	8.4
Day 02	Sep 18	40.3	15.0	37.9	11.5
Night 02	Sep 18 - Sep 19	44.1	9.0	44.1	8.8
Day 03	Sep 19	53.1	15.0	52.7	14.4
Night 03	Sep 19 - Sep 20	42.0	9.0	42.0	8.4
Day 04	Sep 20	42.7	15.0	42.5	14.7
Night 04	Sep 20 - Sep 21	48.7	9.0	48.7	9.0
Day 05	Sep 21	54.9	15.0	54.9	14.9
Night 05	Sep 21 - Sep 22	57.6	9.0	45.9	6.6
Day 06	Sep 22	67.2	15.0	*-	0.0
Night 06	Sep 22 - Sep 23	65.3	9.0	*-	0.0
Day 07	Sep 23	77.7	15.0	48.7	4.7
Night 07	Sep 23 - Sep 24	47.3	9.0	47.3	9.0
Day 08	Sep 24	56.9	15.0	56.9	14.9
Night 08	Sep 24 - Sep 25	40.1	9.0	40.1	9.0
Day 09	Sep 25	44.6	15.0	44.6	15.0
Night 09	Sep 25 - Sep 26	44.8	9.0	44.8	9.0
Day 10	Sep 26	52.9	15.0	52.9	14.9
Night 10	Sep 26 - Sep 27	35.4	9.0	35.4	9.0
Day 11	Sep 27	38.6	15.0	38.2	14.7
Night 11	Sep 27 - Sep 28	32.1	9.0	31.8	8.9
Day 12	Sep 28	39.0	15.0	38.1	14.4
Night 12	Sep 28 - Sep 29	31.0	9.0	30.7	8.9
Day 13	Sep 29	41.4	15.0	39.1	14.4
Night 13	Sep 29 - Sep 30	32.5	9.0	32.5	9.0
Day 14	Sep 30	44.6	15.0	38.0	14.3
Night 14	Sep 30 - Oct 01	34.3	9.0	34.3	9.0
Day 15	Oct 01	45.4	15.0	40.0	4.5
BC OGC Current Assumed BSL (ASL) (dBA) - Daytime				50.0 (45.0)	
BC OGC Current Assumed BSL (ASL) (dBA) - Nighttime				40.0 (35.0)	

Note: * Data not available due to equipment malfunction.

Table 4B: Sound Monitor B Results

Period	Date (2019)	Measured Leq (dBA)	Measured Hours	Residual Leq (dBA)	Residual Hours
Day 01	Oct 29	75.1	4.0	35.7	3.7
Night 01	Oct 29 - Oct 30	38.7	9.0	38.7	9.0
Day 02	Oct 30	49.3	15.0	49.0	14.9
Night 02	Oct 30 - Oct 31	39.1	9.0	39.1	9.0
Day 03	Oct 31	43.6	15.0	36.7	14.7
Night 03	Oct 31 - Nov 01	31.7	9.0	31.7	9.0
Day 04	Nov 01	41.5	15.0	39.8	14.6
Night 04	Nov 01 - Nov 02	38.5	9.0	38.5	9.0
Day 05	Nov 02	41.5	15.0	38.1	13.7
Night 05	Nov 02 - Nov 03	29.9	9.0	29.9	9.0
Day 06	Nov 03	36.5	15.0	30.6	14.6
Night 06	Nov 03 - Nov 04	30.7	9.0	30.4	8.7
Day 07	Nov 04	42.6	15.0	34.4	14.2
Night 07	Nov 04 - Nov 05	34.9	9.0	34.9	9.0
Day 08	Nov 05	38.1	15.0	32.0	14.6
Night 08	Nov 05 - Nov 06	30.9	9.0	30.9	9.0
Day 09	Nov 06	47.6	15.0	38.6	5.6

Table 4C: Sound Monitor B Results

Measured Period	Measured Residual Leq (dBA)	Measured Hours	Wind Speed (kph)
Total Survey Period – Daytime (Sep 17-Oct 1)	52.7	179.3	12.5
Total Survey Period – Nighttime (Sep 17-Oct 1)	43.0	113.0	10.1
Total Survey Period – Daytime (Oct 29 -Nov 6)	41.6	110.7	10.1
Total Survey Period – Nighttime (Oct 29 -Nov 6)	35.8	71.7	9.7
BC OGC Current Assumed BSL (ASL) (dBA) - Daytime	50.0 (45.0)		
BC OGC Current Assumed BSL (ASL) (dBA) - Nighttime	40.0 (35.0)		

The results of the survey show that the acoustic environment was impacted by local traffic and wind noise during monitoring period. Based on site observations and audio recordings, the sources of sounds in the study area includes sounds from transportation (local road and highways), local activities (i.e., human and other local industrial related activities), fauna and weather and sounds of nature. Periods with high winds (>15 km/hr) demonstrate ambient sound levels 7-10 dBA above the BC OGC current assumed ASL. This suggests that wind induced sound may provide masking for industrial or traffic noise and thus qualify for A2 adjustments. Additional

research is recommended to determine changes to wind induced sound from foliage (leaves) and ground cover (snow/grass) as well as receiver experienced (wind induced microphone noise) prior to developing general guidelines. In addition, periods without wind will not provide masking for industrial or traffic noise and this should be considered as a risk factor when planning noise mitigation measures for temporary activities

The results indicate that the ambient sound pressure levels ranged from 30.7 to 56.9 dBA during the measurement period from September 17 to October 1, 2019 and from 29.9 to 49.0 dBA from October 29 to November 6, 2019, and most of the daytime and nighttime sound levels are higher than BC OGC current assumed ASL with moderate to strong wind conditions. There were several nights, during which the residual sound levels were lower than the BC OGC ASL with moderate to light wind conditions. Both average residual sound levels during daytime and nighttime periods September 17 to October 1, 2019 are higher than the BC OGC current assumed ASL during the monitoring period because of stronger wind conditions. The sound level results during the survey period included intermittent contamination from the strong wind conditions which rendered some data unreliable.

Sound Monitor E Measurement Location

Sound Monitor E was located approximately 80m north from 216 Road, 280m south from facility site 1-25-79-18W6, 6200 m east from Braden Road and 9800m southwest from Highway 97.

Based on site observations during the survey and from the audio playback, the sound environment was impacted by sound from wind, transportation and fauna and local activities. Contamination from the acoustic instrument internal noise was also present intermittently.

The detailed results including graphical presentation of the measured and residual levels are presented in Appendix F.

The survey results contained short-term sound events that are due to occasional noise events from local traffic, local activities and wind. Where possible, these short-term sounds were isolated from the measured comprehensive sound level data set resulting in the residual comprehensive sound level.

Table 5A summarizes the comprehensive sound level measurement results for the period of the survey based on daytime and nighttime periods. Table 5B also summarize the sound level measurement results for the period of the survey based on wind conditions.

Table 5A: Sound Monitor E Results

Period	Date (2019)	Measured Leq (dBA)	Measured Hours	Residual Leq (dBA)	Residual Hours
Day 01	Sep 17	74.6	6.8	30.8	3.5
Night 01	Sep 17 - Sep 18	29.6	9.0	26.7	8.2
Day 02	Sep 18	34.0	0.2	34.3	0.2
Night 02	Sep 18 - Sep 19	*-	0.0	-	0.0
Day 03	Sep 19	46.1	12.7	44.9	11.3
Night 03	Sep 19 - Sep 20	29.7	9.0	26.9	7.8
Day 04	Sep 20	37.1	15.0	35.3	13.3
Night 04	Sep 20 - Sep 21	42.0	9.0	42.0	9.0
Day 05	Sep 21	45.7	15.0	45.6	14.8
Night 05	Sep 21 - Sep 22	38.3	9.0	38.3	8.7
Day 06	Sep 22	40.9	15.0	37.3	13.5
Night 06	Sep 22 - Sep 23	29.3	9.0	28.0	8.8
Day 07	Sep 23	41.2	15.0	40.2	13.8
Night 07	Sep 23 - Sep 24	32.6	9.0	31.4	8.7
Day 08	Sep 24	40.8	15.0	40.8	15.0
Night 08	Sep 24 - Sep 25	33.7	9.0	31.2	8.7
Day 09	Sep 25	36.8	15.0	36.8	15.0
Night 09	Sep 25 - Sep 26	32.1	9.0	32.1	9.0
Day 10	Sep 26	46.0	15.0	46.0	15.0
Night 10	Sep 26 - Sep 27	35.0	9.0	35.0	9.0
Day 11	Sep 27	40.6	15.0	40.6	14.8
Night 11	Sep 27 - Sep 28	27.9	9.0	27.9	9.0
Day 12	Sep 28	35.6	14.4	35.6	14.2
Night 12	Sep 28 - Sep 29	*-	0.0	-	0.0
Day 13	Sep 29	37.8	13.6	36.4	11.9
Night 13	Sep 29 - Sep 30	30.8	9.0	25.1	8.5
Day 14	Sep 30	30.8	15.0	31.5	1.9
BC OGC Current Assumed BSL (ASL) (dBA) - Daytime		50.0 (45.0)			
BC OGC Current Assumed BSL (ASL) (dBA) - Nighttime		40.0 (35.0)			

Note: * Data not available due to equipment malfunction.

Table 5B: Sound Monitor E Results with Wind Conditions

Measured Period	Measured Residual Leq (dBA)	Measured Hours	Wind Speed (kph)
Total Survey Period - Daytime	41.6	158.0	14.3
Total Survey Period - Nighttime	34.8	95.4	10.8
BC OGC Current Assumed BSL (ASL) (dBA) - Daytime	50.0 (45.0)		
BC OGC Current Assumed BSL (ASL) (dBA) - Nighttime	40.0 (35.0)		

The results of the survey show that the acoustic environment was impacted by local traffic, local activities and wind noise during monitoring period. Facility to the north is not audible. Based on site observations and audio recordings, the sources of sounds in the study area includes sounds from transportation, local activities (i.e., human and other local industrial related activities), fauna and weather and sounds of nature. Periods with high winds (>15 km/hr) demonstrate ambient sound levels 7-10 dBA above the BC OGC current assumed ASL. This suggests that wind induced sound may provide masking for industrial or traffic noise and thus qualify for A2 adjustments. Additional research is recommended to determine changes to wind induced sound from foliage (leaves) and ground cover (snow/grass) as well as receiver experienced (wind induced microphone noise) prior to developing general guidelines. In addition, periods without wind will not provide masking for industrial or traffic noise and this should be considered as a risk factor when planning noise mitigation measures for temporary activities

The results indicate that the ambient sound pressure levels ranged from 25.1 to 46.0 dBA during measurement period, and most of the daytime and nighttime sound levels were generally lower than BC OGC current assumed BSL (ASL) at the monitoring location. There were two nights, during which the residual sound levels were higher than the BC OGC ASL with moderate to strong wind conditions. Both average residual sound levels during daytime and nighttime periods are lower than the BC OGC current assumed ASL during the monitoring period. The sound level results during the survey period included intermittent contamination from the strong wind conditions which rendered some data unreliable.

Conclusion

BC Oil and Gas Research and Innovation Society (BC OGRIS, the client) retained Patching Associates Acoustical Engineering Ltd. (PAAE) to conduct an ambient noise study for the areas away from Highway 97 or Regional Roadways in the Farmington Development Area (FDA), located NW of Dawson Creek, British Columbia.

The purpose of the sound survey is to quantify the ambient sound levels for the areas far from Highway 97 or Regional Roadways, which will provide data for consideration in a review of current noise regulations and associated permissible sound levels in B.C., and provide more targeted and specific information to optimize noise mitigation planning. This preliminary report outlines the results from Phase 3 related to the noise impact in the study area excluding the effects from the highway and local roads and outlines the results from monitoring in the studied local areas. To achieve this purpose two monitoring locations were selected and studied through noise monitoring in the Farmington Development Area. Each monitoring dataset was analysed to remove sound events

near the microphone and the residual data presented below represents the general ambient sound levels experienced in the monitoring areas studied. This represents sound levels without contribution from energy industry facilities.

The key findings of the ambient noise study results are the following:

- The two receiver locations studied found that the acoustic environment included local traffic, fauna, wind and sounds of nature.
- Measured ambient sound levels for Monitor B and E ranged from 25.1 to 56.9 dBA during the measurement periods, many of the daytime and nighttime sound levels are higher than BC OGC current assumed ASL with moderate to strong wind conditions. There were several nights, during which the residual sound levels were lower than the BC OGC ASL with moderate to light wind conditions.
- Periods with high winds (<15 km/hr) demonstrate ambient sound levels 7-10 dBA above the BC OGC current assumed ASL. This suggests that wind induced sound may provide masking for industrial or traffic noise and thus qualify for A2 adjustments. Additional research is recommended to determine changes to wind induced sound from foliage (leaves) and ground cover (snow/grass) as well as receiver experienced (wind induced microphone noise) prior to developing general guidelines. In addition, periods without wind will not provide masking for industrial or traffic noise and this should be considered as a risk factor when planning noise mitigation measures for temporary activities.

References

Alberta Utilities Commission (AUC) Rule 012: Noise Control (AUC 2013).

British Columbia Oil and Gas Commission (BC OGC) *British Columbia Noise Control Best Practices Guideline*. 2009. British Columbia, Canada.

International Organization for Standardization (ISO). 1993. *Standard 9613-1, Acoustics – Attenuation of Sound during Propagation Outdoors – Part 1: Calculation of Absorption of Sound by the Atmosphere*, Geneva Switzerland.

International Organization for Standardization (ISO) 1996. *Standard 9613-2, Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation*, Geneva Switzerland.

Natural Resources Canada: www.nrcan.gc.ca

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APPENDIX A

Technical Details Regarding
Sound Measurement and Analysis

Technical Details

Sound is the phenomena of vibrations transmitted through air, or other medium such as water or a building structure. The range of pressure amplitudes, intensities, and frequencies of the sound energy is very wide, and many specialized fields have developed using different ranges of these variables, such as room acoustics and medical ultrasound.

Due to the wide range of intensities, which are perceived as sound, standard engineering units become inconvenient. Sound levels are commonly measured on a logarithmic scale, with the level (in decibels, or dB) being proportional to ten times the common logarithm of the sound energy or intensity. Normal human hearing covers a range of about twelve to fourteen orders of magnitude in energy, from the threshold of hearing to the threshold of pain. On the decibel scale, the threshold of hearing is set as zero, written as 0 dB, while the threshold of pain varies between 120 to 140 dB. The most usual measure of sound is the sound pressure level (SPL), with 0 dB SPL set at 2.0×10^{-5} N/m^2 (also written 20 μPa), which corresponds to a sound intensity of 10^{-12} Watts/m^2 (or 1 picoWatt/m^2, written 1 pW/m^2).

Normal human hearing spans a frequency range from about 20 Hertz (Hz, or cycles per second) to about 20,000 Hz (written 20 kHz). However, the sensitivity of human hearing is not the same at all frequencies. To accommodate the variation in sensitivity, various frequency-weighting scales have been developed. The most common is the A-weighting scale, which is based on the sensitivity of human hearing at moderate levels; this scale reflects the low sensitivity to sounds of very high or very low frequencies. Sound levels measured on the A-weighted scale are written in A-weighted decibels, commonly shown as dBA or dB(A).

Human hearing becomes more sensitive to lower frequency sounds as the level of the sound increases. For this purpose, the C-weighing scale was developed to assess reaction to higher levels sounds. Although the C-weighting scale, or the sound level in dBC, is seldom used on its own, the levels in dBC and dBA are often used together to assess the significance of the low-frequency components of sound. In some cases, a limit is placed on the dBC level at a location in order to limit the amount of low-frequency noise.

When sound is measured using the A-weighting scale, the reading is often called the “Noise level”, to confirm that human sensitivity and reactions are being addressed. A table of some common noise sources and their associated noise levels are shown in the table below.

When the A-weighting scale is not used, the measurement is said to have a “linear” weighting, or to be unweighted, and may be called a “linear” level. As the linear reading is an accurate measurement of the physical (sound) pressure, the term “Sound Pressure Level”, or SPL, is usually (but not universally) reserved for unweighted measurements.

Noise is usually defined as “unwanted sound”, which indicates that it is not just the physical sound that is important, but also the human reaction to the sound that leads to the perception of sound as noise. It implies a judgment of the quality or quantity of sound experienced. As a human reaction to sound is involved, noise levels are usually given in A-weighted decibels (dBA). However, use of the C-weighting scale, usually in combination with the dBA level, is becoming more common as well. An alternate definition of noise is “sound made by somebody else”, which emphasizes that the ability to control the level of the sound alters the perception of noise.

Table A1: Noise Levels of Familiar Sources

Source Or Environment	Noise Level (dBA)
High Pressure Steam Venting To Atmosphere (3 m)	121
Steam Boiler (2 m)	90-95
Drilling Rig (10 m)	80-90
Pneumatic Drill (15 m)	85
Pump Jack (10 m)	68-72
Truck (15 m)	65-70
Business Office	65
Conversational Speech (1 m)	60
Light Auto Traffic (30 m)	50
Living Room	40
Library	35
Soft Whisper (5 m)	20-35

The single number A-weighted level is often inadequate for engineering purposes, although it does supply a good estimate of people's reaction to a noise environment. As noise sources, control measures, and materials differ in the frequency dependence of their noise responses or production, sound is measured with a narrower frequency bandwidth; the specific methodology varies with the application. For most work, the acoustic frequency range is divided into frequency bands where the center frequency of each band is twice the frequency of the next lower band; these are called "Octave" bands, as their frequency relation is called an "Octave" in music, where the field of acoustics has its roots. For more detailed work, the octave bands, and certain standard octave and 1/3 octave bands have been specified by international agreements.

Where the noise at the receiver is steady, it is easy to assess the noise level. However, both the production of noise at the source and the transmission of noise can vary with time; most noise levels are not constant, either because of the motion of the noise source (as in traffic noise), because the noise source itself varies, or because the transmission of sound to the receiver location is not steady as over long distances. This is almost always the case for environmental noise studies. Several single number descriptors have been developed and are used to assess noise in these conditions.

The most common is the measurement of the "equivalent continuous" sound level, or L_{eq}, which is the level of a hypothetical source of a constant level which would give the same total sound energy as is measured during the sampling period. This is the "energy" average noise level. Typical sampling periods are one hour, nighttime (9 hours) or one day (24 hours); the sampling period used must be reported when using this unit.

The greatest value of the L_{eq} is that the contributions of different sources to the total noise level can be assessed, or in a case where a new noise source is to be added to an existing environment, the total noise level from new and old sources can be easily calculated. It is also sensitive to short term high noise levels.

Statistical noise levels are sometimes used to assess an unsteady noise environment. They indicate the levels that are exceeded a fixed percentage of the measurement time period measured. For example, the 10^{th} percentile level, written L_{10}, is the levels exceeded 10% of the time; this level is a good measure of frequent noisy occurrences such as steady road traffic. The 90% level, L_{90}, is the level exceeded 90% of the time, and is the

background level, or noise floor. A steady noise source will modify the background level, while an intermittent noise source such as road or rail traffic will affect the short-term levels only.

One disadvantage with the L_{eq} measure, when used alone, is that nearby loud sources (e.g. dogs barking, or birds singing) can confuse the assessment of the situation when it is the noise from a distant plant that is the concern. For this reason, the equivalent level and the statistical levels can be used together to better understand the noise environment. One such indication is the difference between the L_{eq} and the L_{90} levels. A large difference between the L_{eq} and L_{90}, greater than 10 dB, indicates the intrusion of short-term noise events on the general background level. A small difference, less than 5 dB, indicates a very steady noise environment. If the L_{eq} value exceeds the L_{10} value this indicates the presence of significant short-term loud events.

For most noise measurement, instruments are adjusted so that the time response of the instrument is similar to the response of the human ear; this is the "Fast" setting. Measurement with the "Fast" setting therefore assesses the sound environment according to the way humans would hear it and react to it. Where the noise level varies substantially and an average level is wanted without the complexity of and L_{eq} or statistical measurement, the "Slow" setting is used on the sound level meter. The "Slow" setting is also typically used in industrial settings where hearing damage is a concern. Where the noise level changes very rapidly, for example due to impacts or detonations, the "Fast" and "Slow" settings do not respond quickly enough to assess the maximum levels, and the "Impulse" meter setting us used.

The Sound Power Level (abbreviated L_w, SWL or PWL) is the decibel equivalent of the total energy emitted from a source in the form of noise. The reference level for the sound power is 10^{-12} Watts, or 1 picoWatt (abbreviated pW). The sound power level is given by:

$$L_w, \text{SWL, PWL} = 10 \times \log_{10} (\text{Emitted Power} / 1\ \text{pW})\ \text{dB}$$

Therefore, a source emitting 1 Watt of power in the form of sound would have a sound power level of 120 dB. Sound power levels can be expressed in terms of frequency bands, an overall linear-weighted level or A-weighted, as is the case for sound pressure levels. However, sound power levels are inherent to the source of noise, whereas the sound pressure level is dependant on the source, but also on the distance from the source and other environmental factors.

Note that according to the acoustical literature (E.g. Noise Control Engineering from Bies and Hanson), the subjective effect of changes in SPL is as follows:

- A 3 dB change is "just perceptible".
- A 5 dB change is "clearly noticeable".
- A 10 dB change is "twice as loud or half as loud".
- A 20 dB change is "much louder or much quieter".

Table A2: Glossary

Term	Description
Average Annual Daily Traffic (AADT)	The total volume of vehicle traffic of a highway or road for a year divided by 365 days.
Alberta Energy Regulator (AER)	The Alberta Energy Regulator ensures the safe, efficient, orderly, and environmentally responsible development of hydrocarbon resources over their entire life cycle. This includes allocating and conserving water resources, managing public lands, and protecting the environment while providing economic benefits for all Albertans.
Ambient sound level (ASL)	The sound pressure level that is a composite of different airborne sounds from many sources far away from and near the point of measurement. The ASL does not include any energy-related industrial component and must be measured without it. The ASL is assumed to be 5 dBA below the determined PSL as per Rule 012.
A-weighted sound level (dBA)	The sound level as measured on a sound level meter using a setting that emphasizes the middle frequency components similar to the frequency response of the human ear at levels typical of rural backgrounds in mid frequencies.
Bands (full octave or 1/3 octave)	A series of electronic filters separate sound into discrete frequency bands, making it possible to know how sound energy is distributed as a function of frequency. Each octave band has a centre frequency that is double the centre frequency of the octave band preceding it. The 1/3 octave band analysis provides a finer breakdown of sound distribution as a function of frequency.
Cumulative SPL	The cumulative sound pressure level from the facilities and the ambient sound level.
Comprehensive Sound Level (CSL)	The sound level that is a composite of different airborne sounds from many sources far away from and near the point of measurement. The CSL does include industrial components and must be measured with them, but it should exclude abnormal noise events. The CSL is used to determine whether a facility is in compliance with the Directive.
Cumulative noise level	The sound level that is the total contribution of all industrial noise sources (existing and proposed) from EUB-regulated facilities at the receptor.
C-weighted sound level (dBC)	The C-weighting approximates the sensitivity of human hearing at industrial noise levels (above about 85 dBA). The C-weighted sound level (i.e., measured with the C-weighting) is more sensitive to sounds at low frequencies than the A-weighted sound level and is sometimes used to assess the low-frequency content of complex sound environments.
Daytime	Defined as the hours from 07:00 to 22:00.
Deferred facility	Facilities constructed and in operation prior to October 1988. These facilities do not have to demonstrate compliance in the absence of a complaint. This does not exempt them from the requirements but does recognize that they were potentially designed without the same considerations for noise as facilities approved after the date when the first comprehensive noise control directive (ID 88-1) was published and put into effect.
Directive 038: Noise Control	Directive 038: Noise Control states the requirements for noise control as they apply to all operations and facilities under the jurisdiction of the Alberta Energy and Utilities Board (EUB). The directive also provides background information and describes an approach to deal with noise problems. This directive is the fifth edition, superseding Interim Directive (ID) 99-8.
Energy equivalent sound level (Leq)	The average weighted sound level over a specified period of time. It is a single-number representation of the cumulative acoustical energy measured over a time interval. The time interval used should be specified in brackets following the Leq—e.g., Leq (9) is a 9-hour Leq. If a sound level is constant over the measurement period, the Leq will equal the constant sound level.
Emergency	An unplanned event requiring immediate action to prevent loss of life or property. Events occurring more than four times a year are not considered unplanned.
Facility SPL	The overall sound pressure level from all the facilities in the study area

Table A2: Glossary

Term	Description
Heavily Travelled Road	Generally includes highways and any other road where the average traffic count is at least 10 vehicles/hour over the nighttime period. It is acknowledged that highways are sometimes lightly travelled during the nighttime period, which is usually the period of greatest concern. The AER will use the 10 vehicles/hour criterion to determine whether highways qualify as heavily travelled during the nighttime period.
Low Frequency Noise (LFN)	Where a clear tone is present below and including 250Hz and the difference between the overall C-weighted sound level and the overall A-weighted sound level exceeds 20 dB.
Nighttime	Defined as the hours from 22:00 to 07:00.
Noise	Generally associated with the unwanted portion of sound.
Noise Impact Assessment (NIA)	An NIA identifies the expected sound level emanating from a facility as measured 15 m from the nearest or most impacted permanently or seasonally occupied dwelling. It also identifies what the permissible sound level is and how it was calculated.
Permanent facility	A facility that is in operation for more than two months.
Permissible Sound Level (SPL)	The maximum SPL that a facility must not exceed at receivers located within 1500 m from the subject facility fence line. The PSL for each receiver is determined as per section 2.1 of the Directive.
Receiver	The location of the residences existing in the NIA study area for which the SPL is determined. In the event that there are no residences existing in the study area, then hypothetical receivers are included at 1500 m from the subject facility fence line.
Representative conditions	Those conditions typical for an area and/or the nature of a complaint. For ASLs, these are conditions that portray the typical activities for the area, not the quietest time. For CSLs, these do not constitute absolute worst-case conditions or the exact conditions the complainant has highlighted if those conditions are not easily duplicated. Sound levels must be taken only when representative conditions exist; this may necessitate a survey of extensive duration (two or more consecutive nights).
Sound Power Level (PWL)	The sound level emitted. The decibel equivalent of the rate of energy (or power) emitted in the form of noise. The sound power level is given by: $PWL = 10 \times LOG_{10}\left(\frac{Sound\ as\ Power}{W_0}\right)$ Where $W_0 = 10^{-12}$ watts (or 1 pW)
Sound Pressure Level (SPL)	The sound level received. The decibel equivalent of the pressure of sound waves at a specific location, which is measured with a microphone. The sound pressure level is given by: $SPL = 10 \times LOG_{10}\left(\frac{Sound\ as\ Pressure}{P_0}\right)$ Where $P_0 = 2 \times 10^{-5}$ Pa (or 20 μPa)
Subject facility	The energy industry facility which is the object of the NIA.
Temporary facility	Any facility that will be in operation less than 60 days.
Tonal component	A pronounced peak clearly obvious within the sound level spectrum.

Appendix B: Permissible Sound Level Determination

BC OGC Noise Control Guideline: Permissible Sound Level Determination
Sound Monitors B and E

Basic Nighttime Sound Level

Proximity to Transportation	Dwelling Unit Density per ¼ Section of Land			Nighttime	Daytime
	1 - 8 Dwellings	9 - 160 Dwellings	>160 Dwellings		
Category 1	40	43	46	40	40
Category 2	45	48	51		
Category 3	50	53	56		
			Daytime Adjustment	N/A	10
			Basic Sound Levels	40	50

Class A Adjustments

Class	Reason for Adjustment	Value (dBA L_{eq})	Nighttime	Daytime
A1	Seasonal Adjustment (Wintertime Operation)	+5	N/A	N/A
A2	Ambient Monitoring Adjustment	-10 to +10	N/A	N/A
	Class Adjustment = Sum of A1 and A2 (as applicable), but not to exceed a maximum of 10 dBA L_{eq}			
		Total Class A Adjustments	0	0

Class B Adjustments

Class	Duration of Activity	Value (dBA L_{eq})	Nighttime	Daytime
B1	1 day	+15		
B2	7 days	+10		
B3	< or = to 60 days	+5		
B4	> 60 days	0	0	0
Class B Adjustment = one only of B1, B2, B3 or B4				
		Class B Adjustment	0	0
		PERMISSIBLE SOUND LEVEL (dBA)	**40**	**50**

Category 1: Dwelling units more than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.
Category 2: Dwelling units more than 30 m but less than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.
Category 3: Dwelling units less than 30 m from heavily travelled roads and/or rail lines and/or subject to frequent aircraft flyovers.

APPENDIX C

Photographs of Monitoring Locations and Equipment

Picture C1: Sound Monitor B and Weather Monitor Setup (North 20m from the 210 Road)

Picture C2: Sound Monitor E Setup
(80m north from 216 Road)


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APPENDIX D

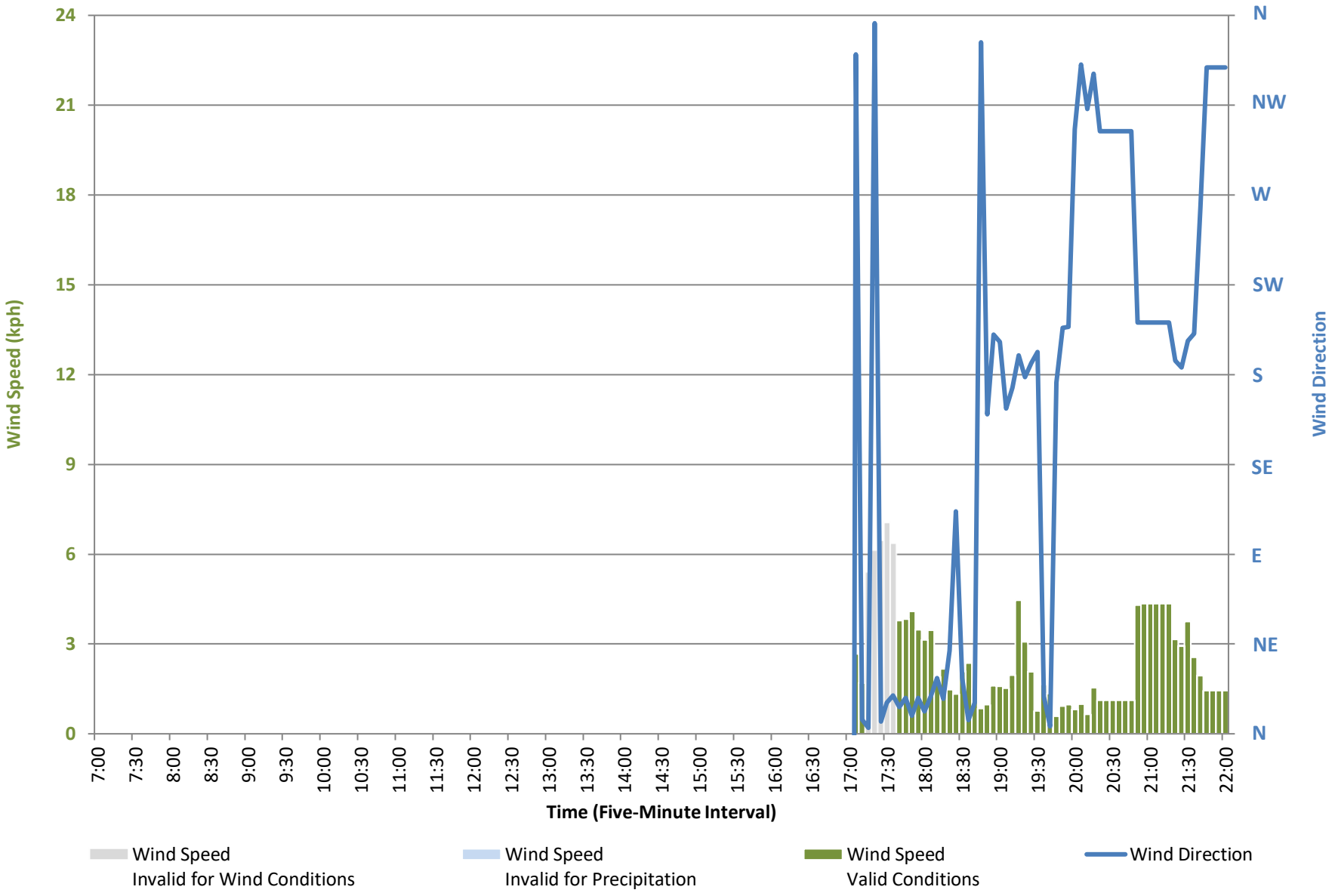
Weather Measurement Data

Table D: Weather Summary

Period	Date (2019)	Average Speed (kph)	Average Direction	Minutes of Audible Precipitation	Minutes of Downwind Conditions	Minutes of Valid Conditions	General Description	Period Valid
Day 01	Sep 17	3	NW	0	110	270	Light crosswind	Yes
Night 01	Sep 17 - Sep 18	2	SSW	0	375	540	Light downwind	Yes
Day 02	Sep 18	9	SSW	0	875	545	Moderate downwind	Yes
Night 02	Sep 18 - Sep 19	17	SSW	0	540	0	Strong downwind	No
Day 03	Sep 19	21	SSW	0	890	0	Strong downwind	No
Night 03	Sep 19 - Sep 20	8	SW	5	440	410	Moderate downwind	Yes
Day 04	Sep 20	14	SSW	0	870	155	Moderate downwind	No
Night 04	Sep 20 - Sep 21	21	SSW	0	540	0	Strong downwind	No
Day 05	Sep 21	23	SSW	0	875	90	Strong downwind	No
Night 05	Sep 21 - Sep 22	14	SSW	0	540	190	Moderate downwind	Yes
Day 06	Sep 22	18	SSW	5	900	10	Strong downwind	No
Night 06	Sep 22 - Sep 23	16	SSW	0	540	40	Strong downwind	No
Day 07	Sep 23	18	SSW	0	895	115	Strong downwind	No
Night 07	Sep 23 - Sep 24	18	SSW	0	540	0	Strong downwind	No
Day 08	Sep 24	23	SSW	0	800	5	Strong downwind	No
Night 08	Sep 24 - Sep 25	11	SSW	0	470	255	Moderate downwind	Yes
Day 09	Sep 25	15	SSW	0	855	170	Strong downwind	No
Night 09	Sep 25 - Sep 26	13	SSW	5	480	115	Moderate downwind	No
Day 10	Sep 26	6	NW	20	120	570	Moderate upwind	Yes
Night 10	Sep 26 - Sep 27	7	N	10	0	150	Moderate upwind	No
Day 11	Sep 27	8	N	0	20	295	Moderate upwind	Yes
Night 11	Sep 27 - Sep 28	2	NNW	0	80	535	Light upwind	Yes
Day 12	Sep 28	5	NNE	0	185	545	Moderate upwind	Yes
Night 12	Sep 28 - Sep 29	2	SSE	0	320	540	Calm wind	Yes
Day 13	Sep 29	9	SSE	0	680	485	Moderate downwind	Yes
Night 13	Sep 29 - Sep 30	6	SSE	0	540	540	Moderate downwind	Yes
Day 14	Sep 30	6	S	0	660	805	Moderate downwind	Yes
Night 14	Sep 30 - Oct 01	13	SSW	0	515	200	Moderate downwind	Yes
Day 15	Oct 01	13	SSW	0	515	120	Moderate downwind	No

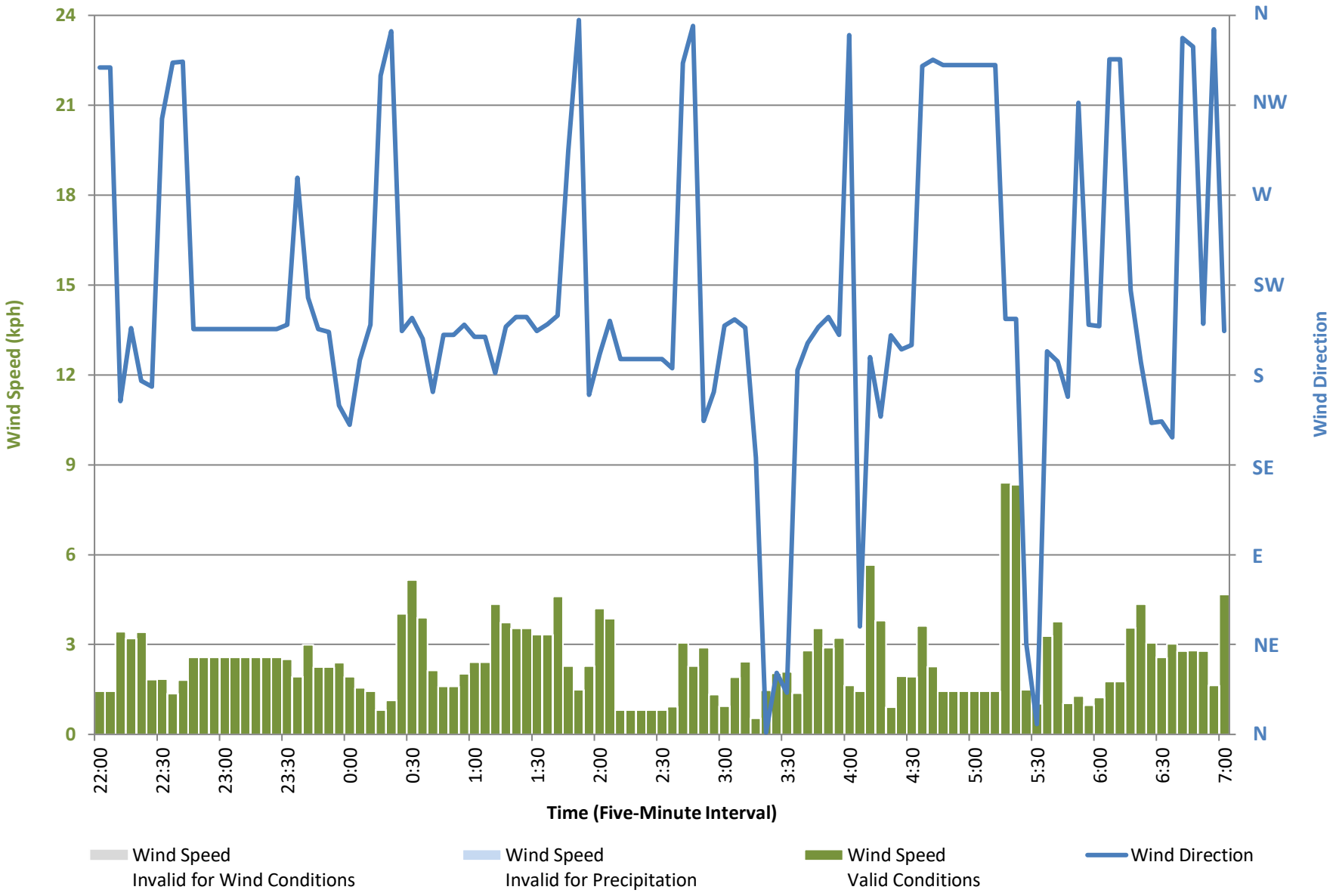
Weather Monitor Data

Figure D1 Day 1 Sep 17



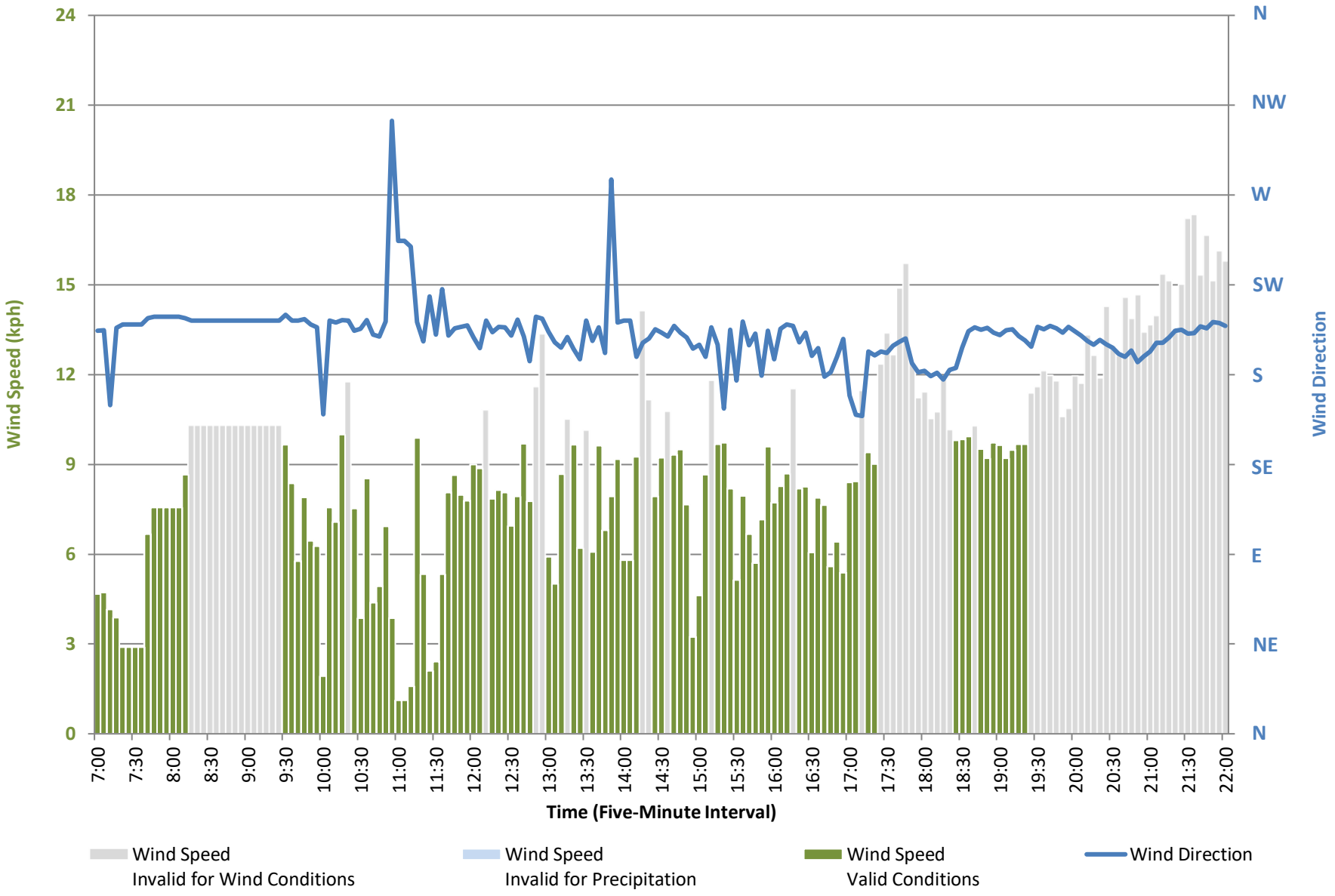
Weather Monitor Data

Figure D2 Night 1 Sep 17 - Sep 18



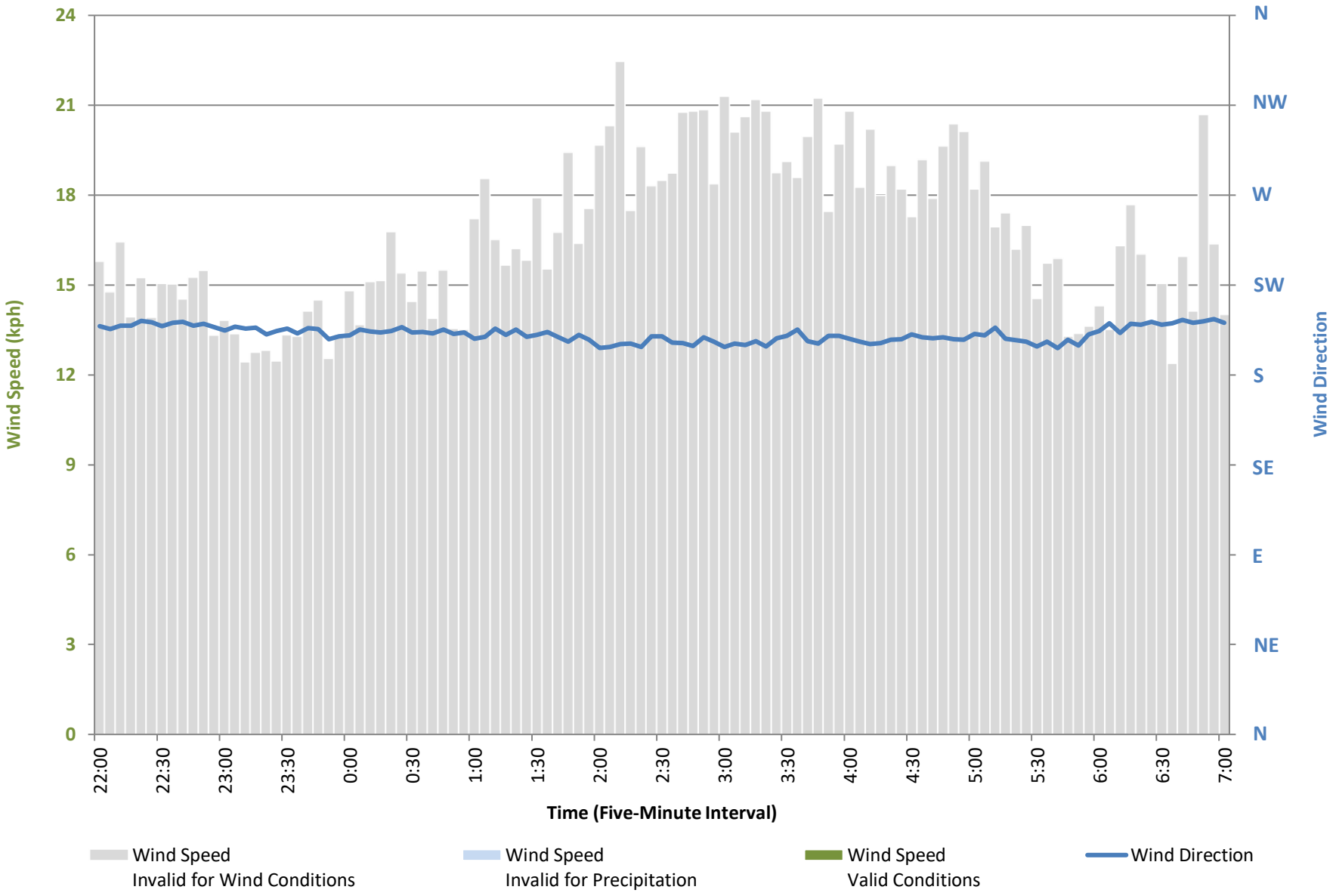
Weather Monitor Data

Figure D3 Day 2 Sep 18



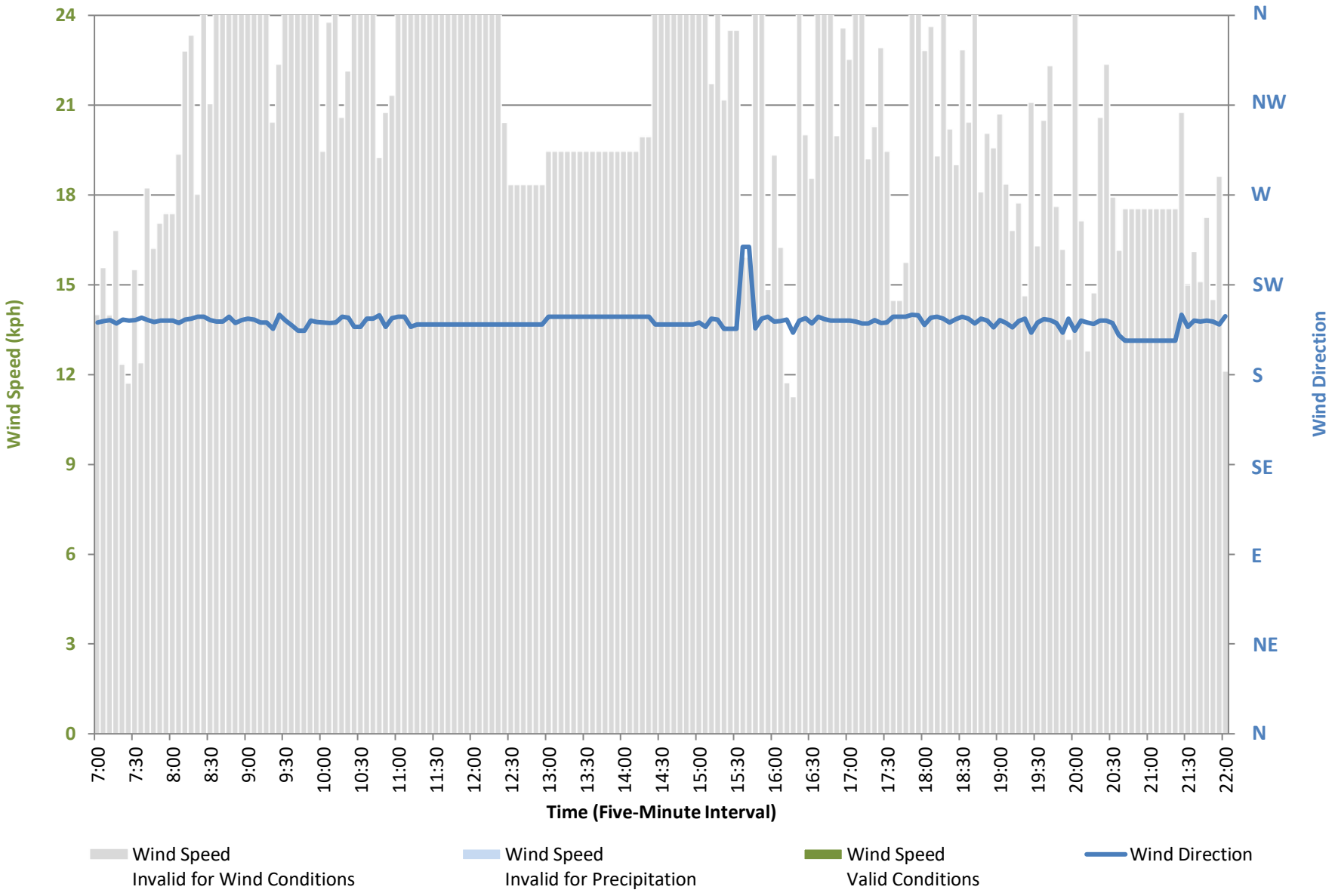
Weather Monitor Data

Figure D4 Night 2 Sep 18 - Sep 19



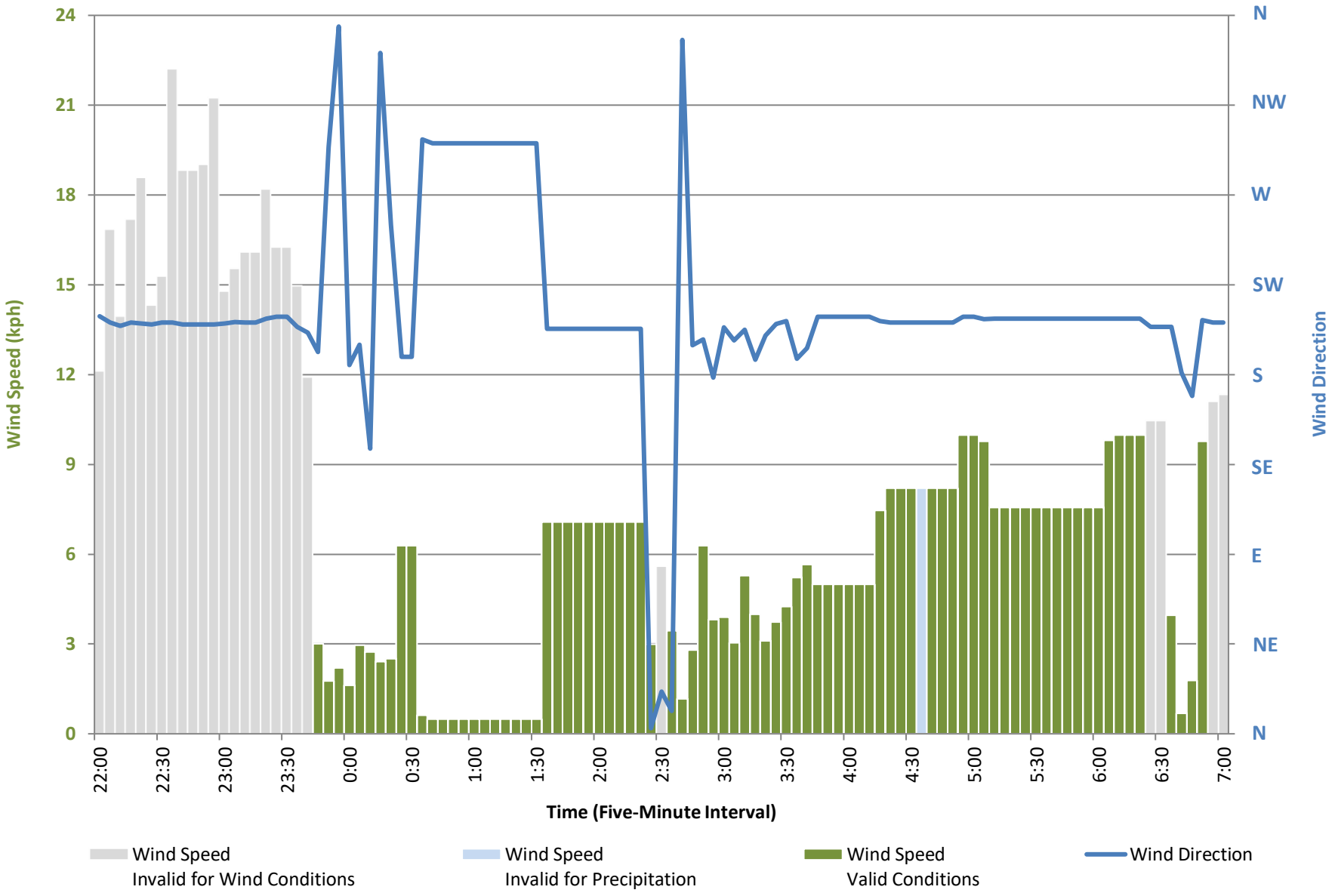
Weather Monitor Data

Figure D5 Day 3 Sep 19



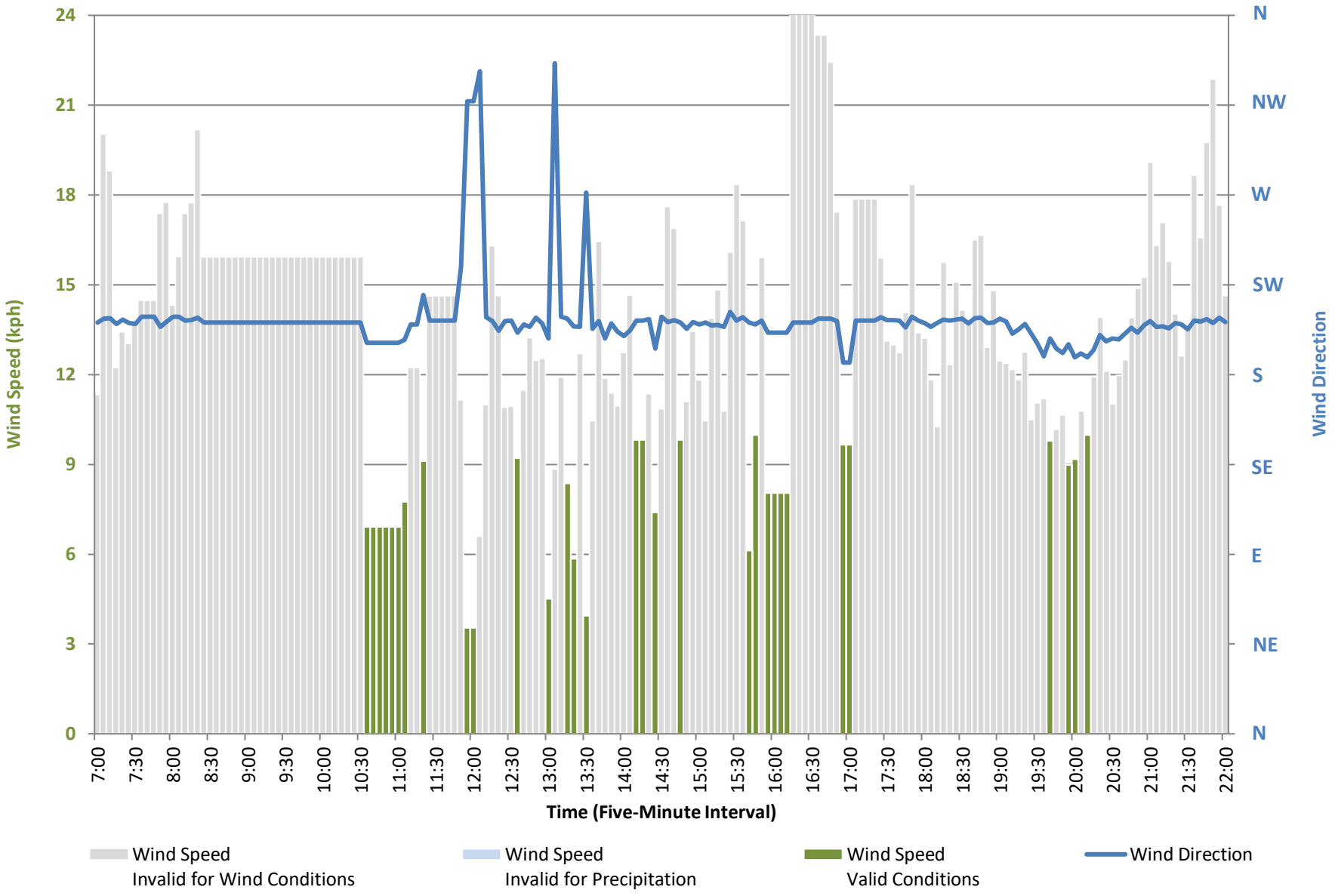
Weather Monitor Data

Figure D6 Night 3 Sep 19 - Sep 20



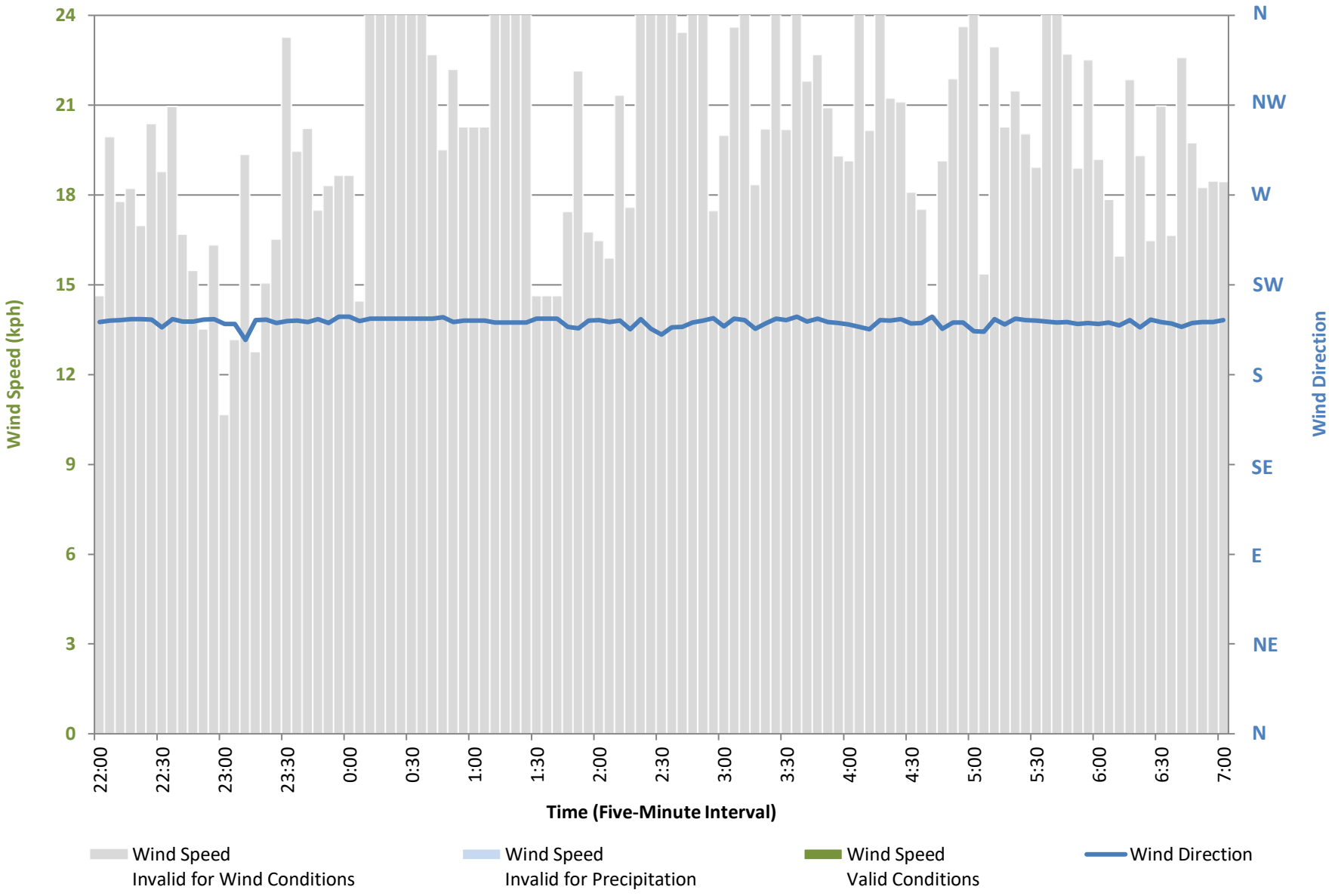
Weather Monitor Data

Figure D7 Day 4 Sep 20



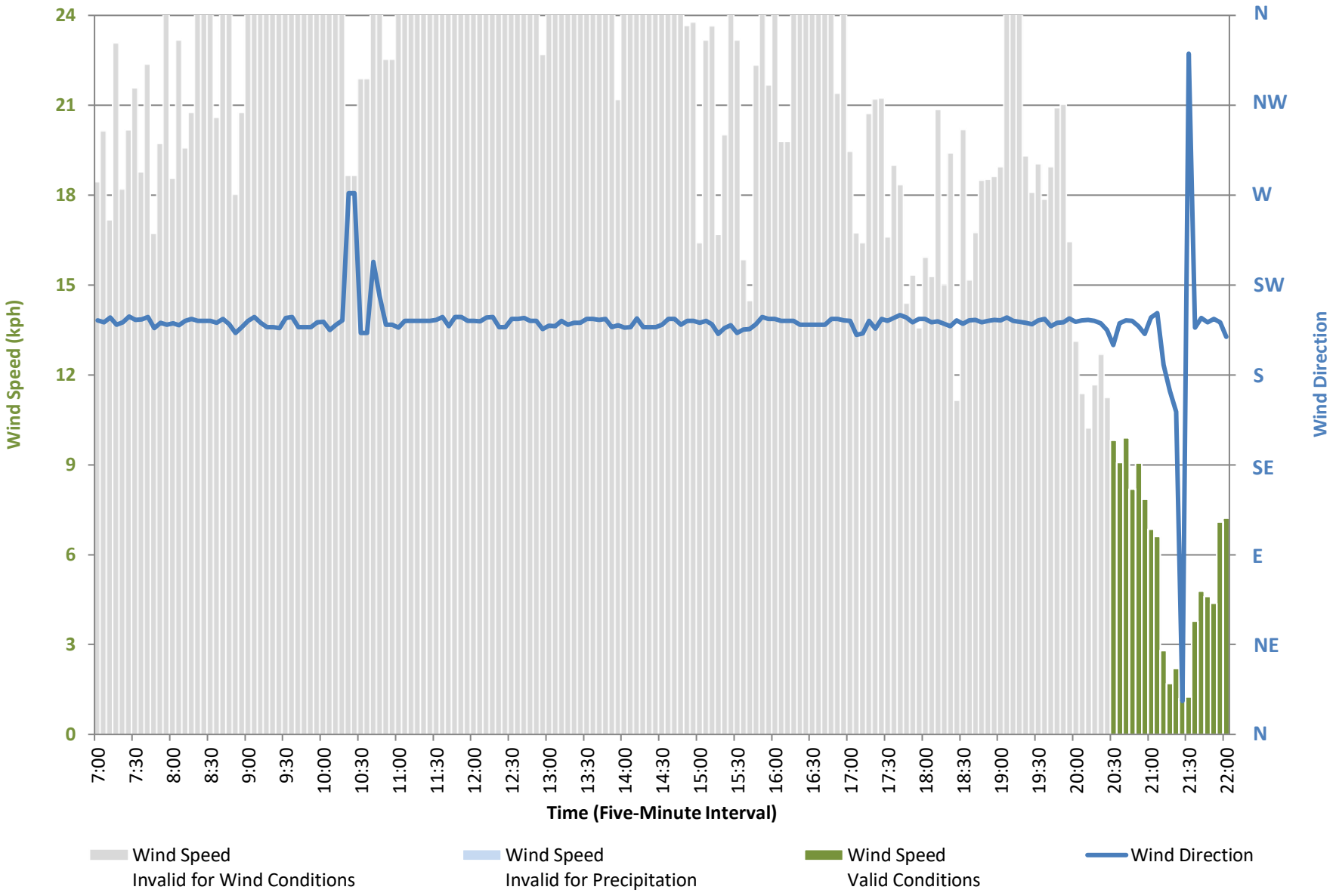
Weather Monitor Data

Figure D8 Night 4 Sep 20 - Sep 21



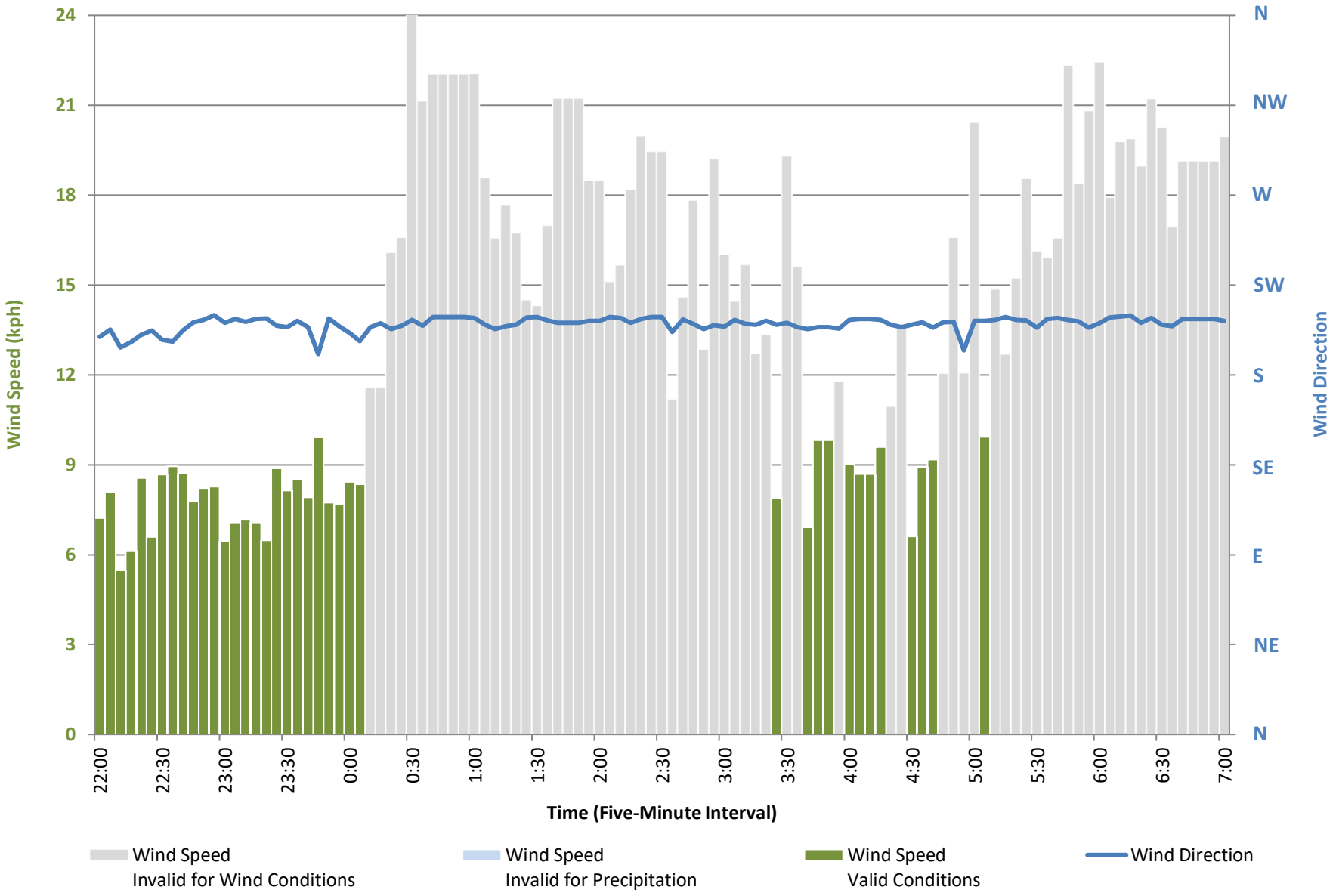
Weather Monitor Data

Figure D9 Day 5 Sep 21



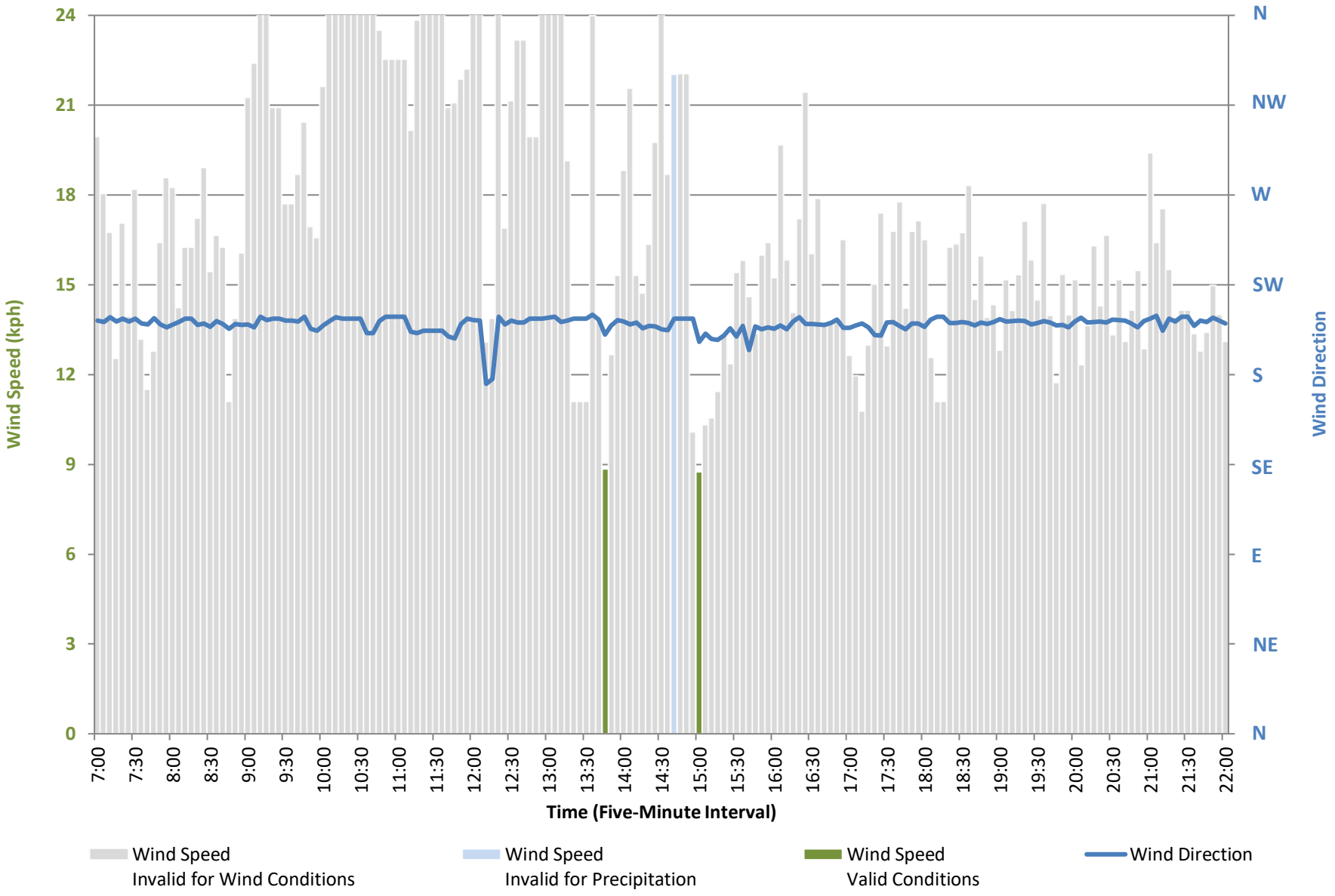
Weather Monitor Data

Figure D10 Night 5 Sep 21 - Sep 22



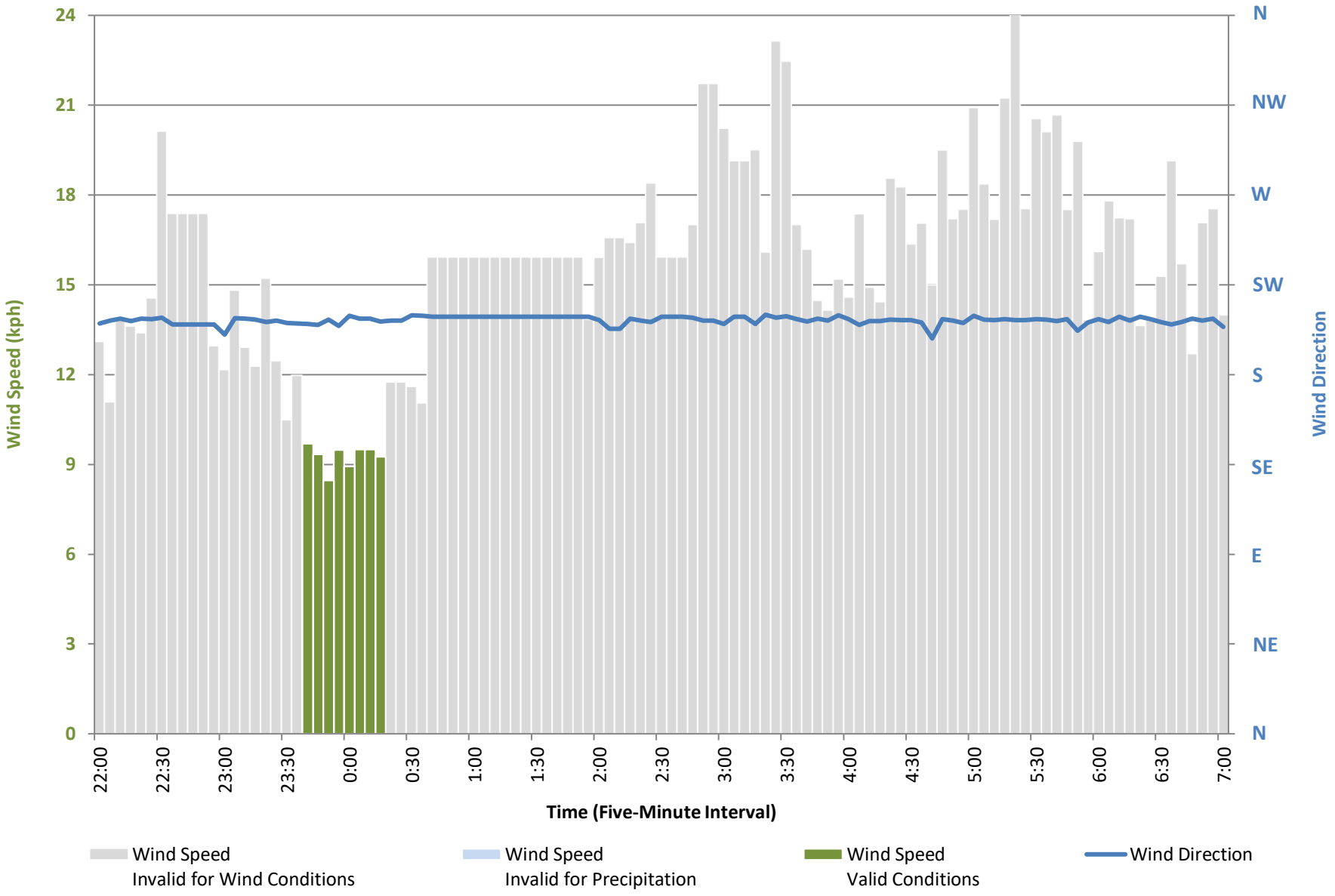
Weather Monitor Data

Figure D11 Day 6 Sep 22



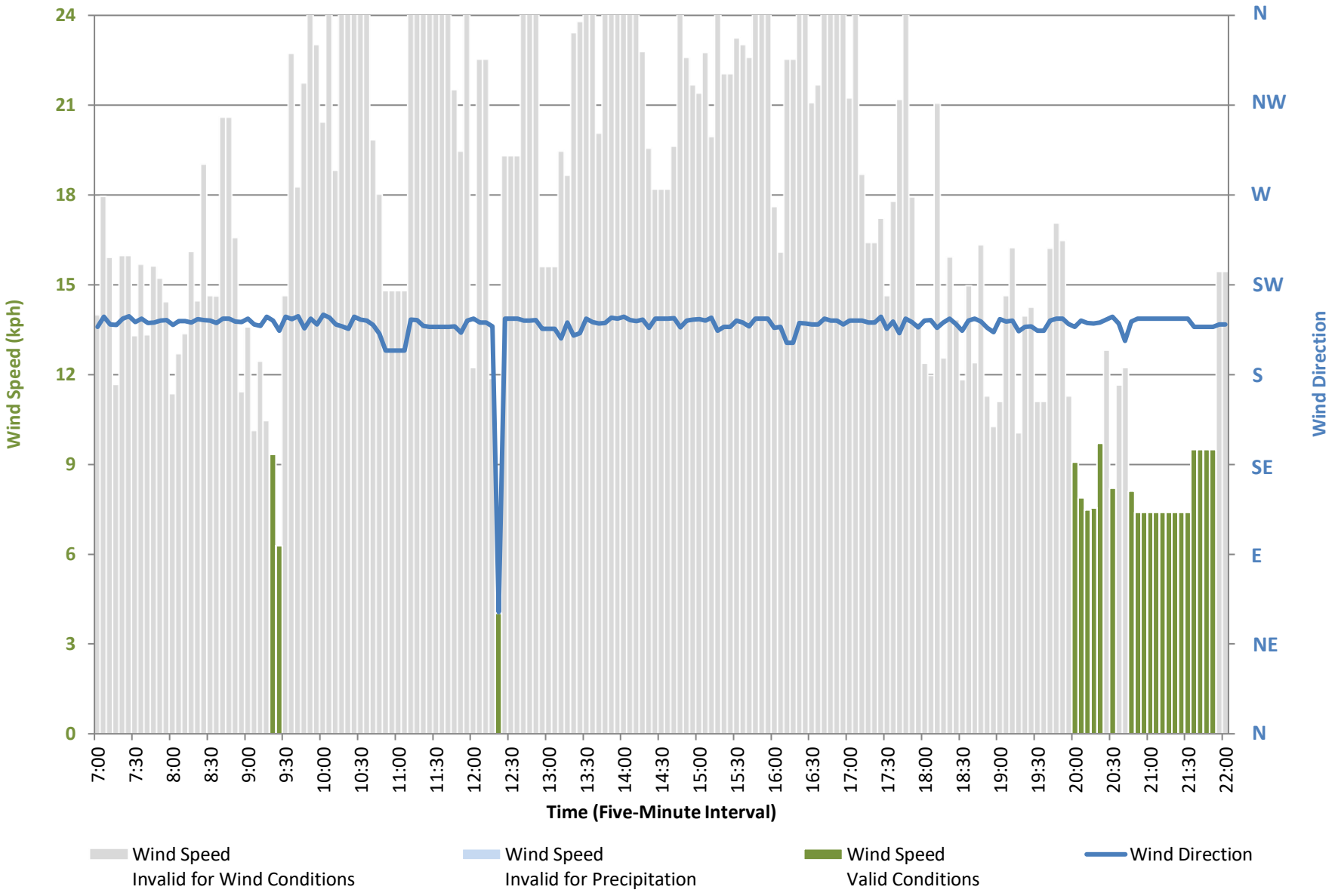
Weather Monitor Data

Figure D12 Night 6 Sep 22 - Sep 23



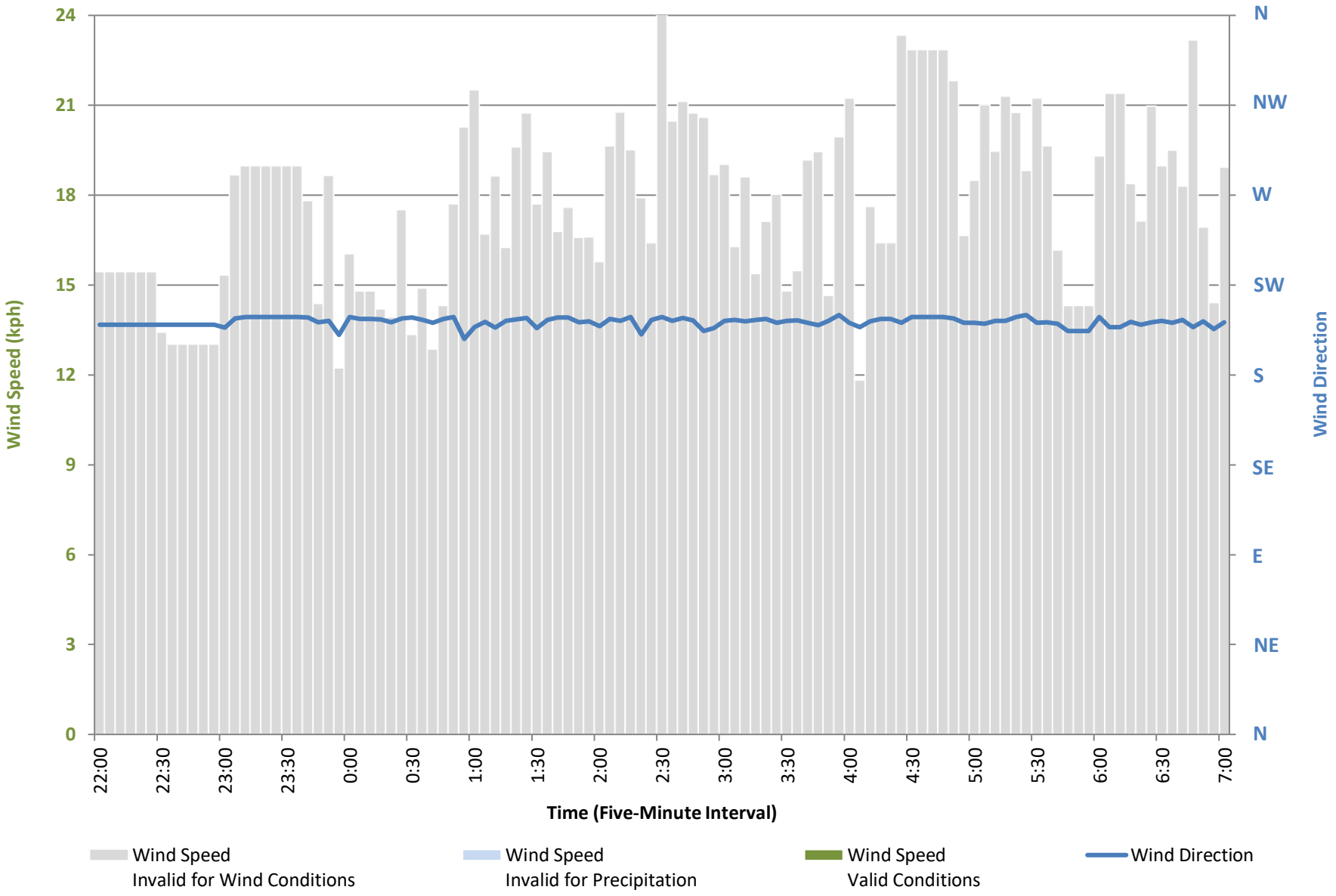
Weather Monitor Data

Figure D13 Day 7 Sep 23



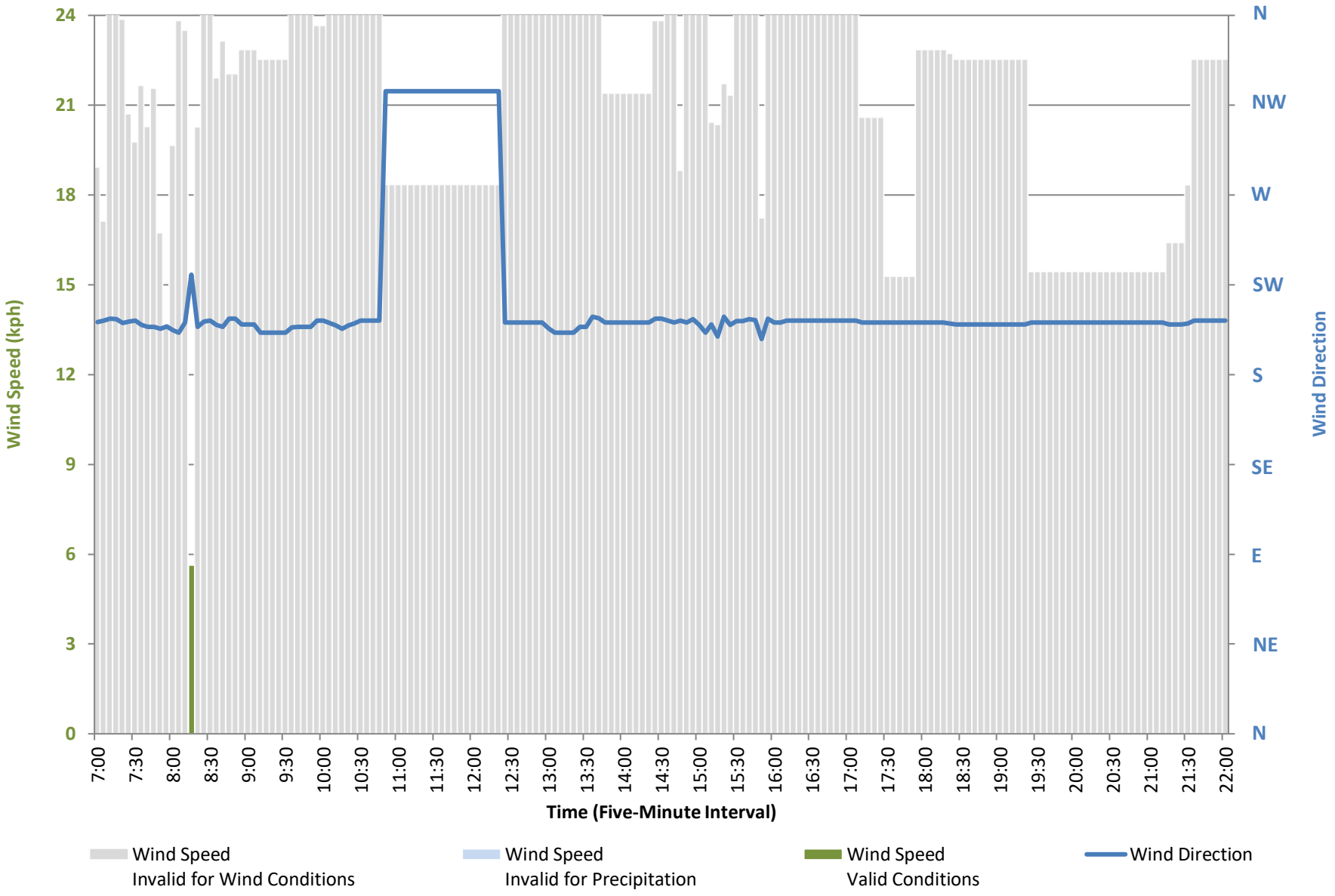
Weather Monitor Data

Figure D14 Night 7 Sep 23 - Sep 24



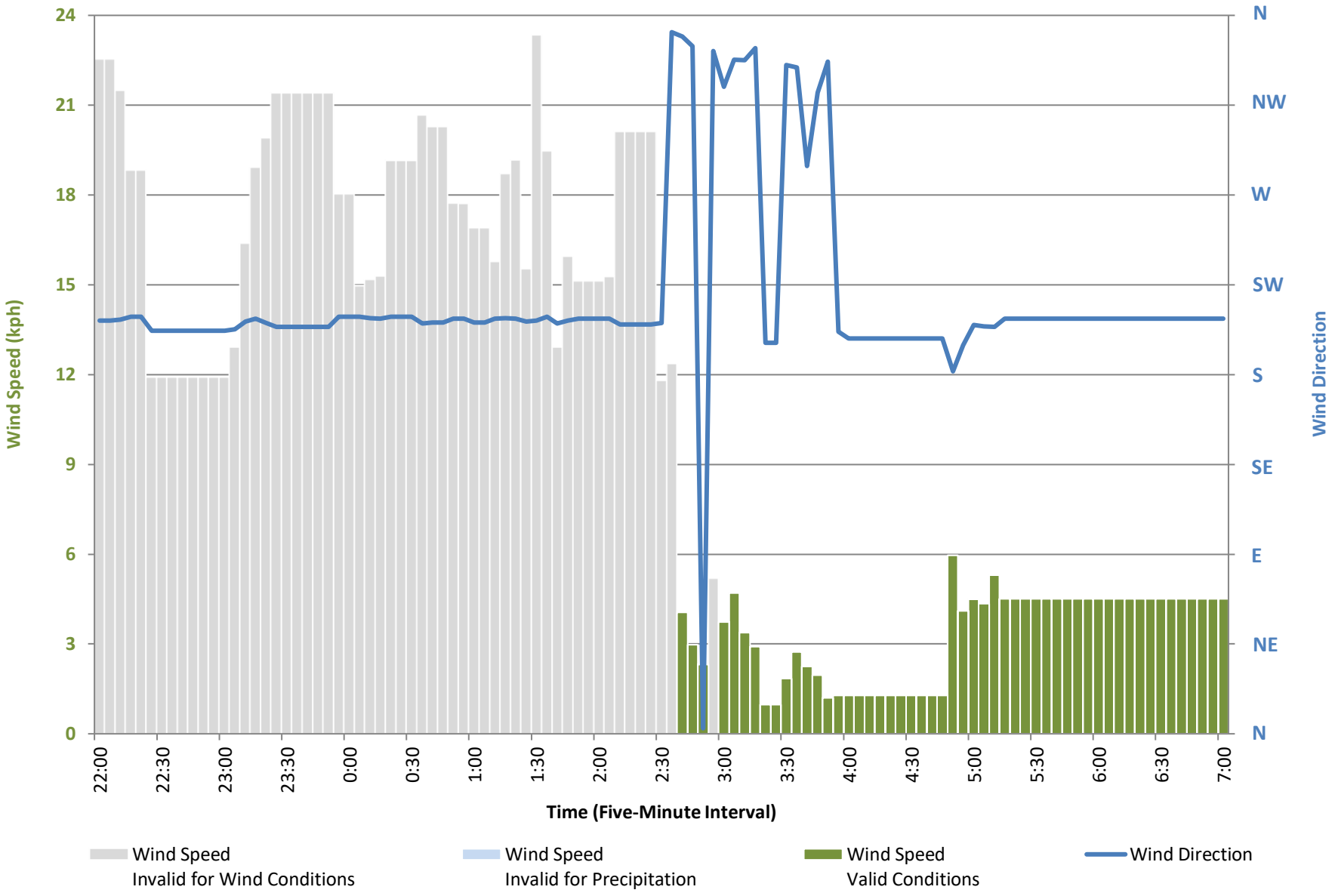
Weather Monitor Data

Figure D15 Day 8 Sep 24



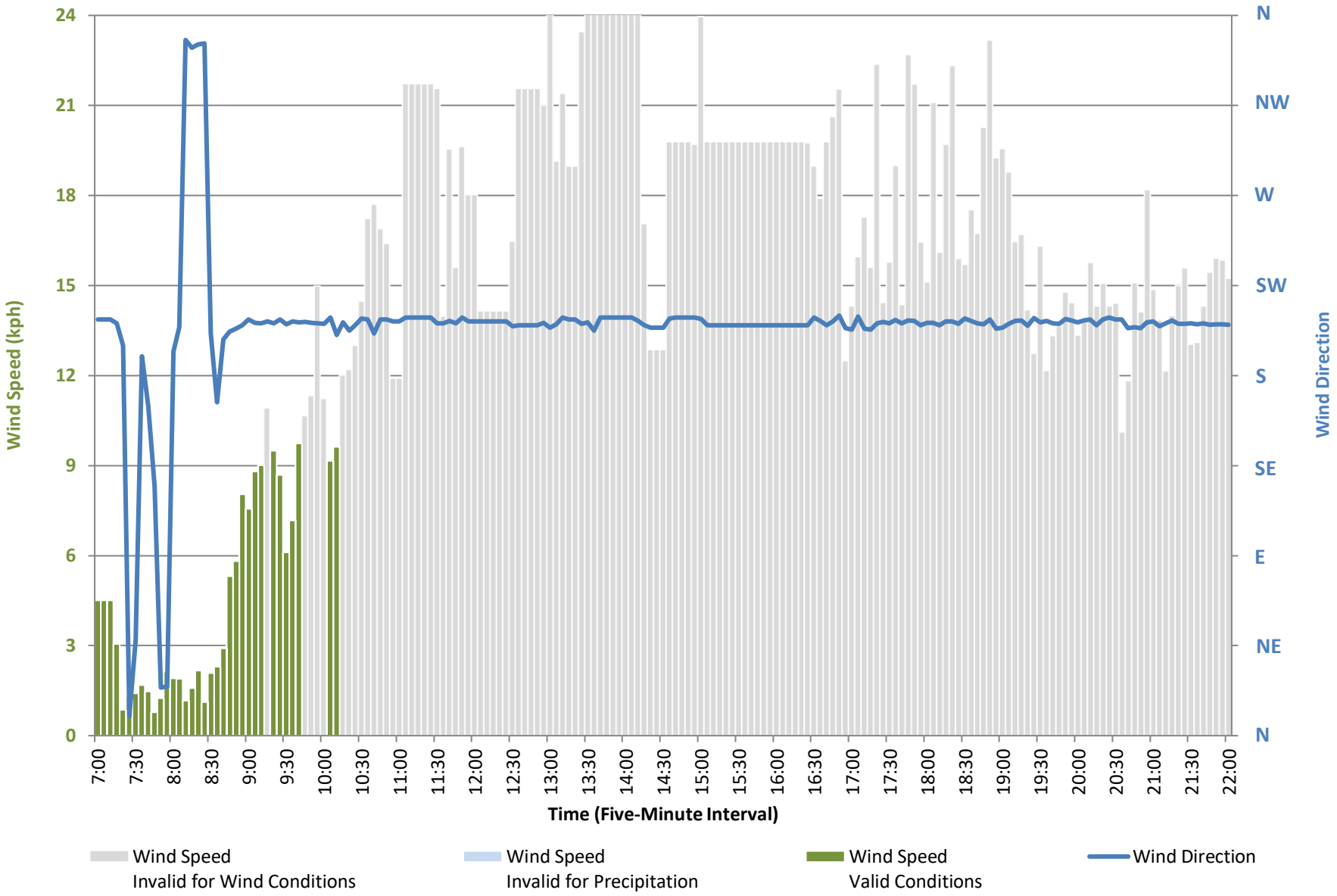
Weather Monitor Data

Figure D16 Night 8 Sep 24 - Sep 25



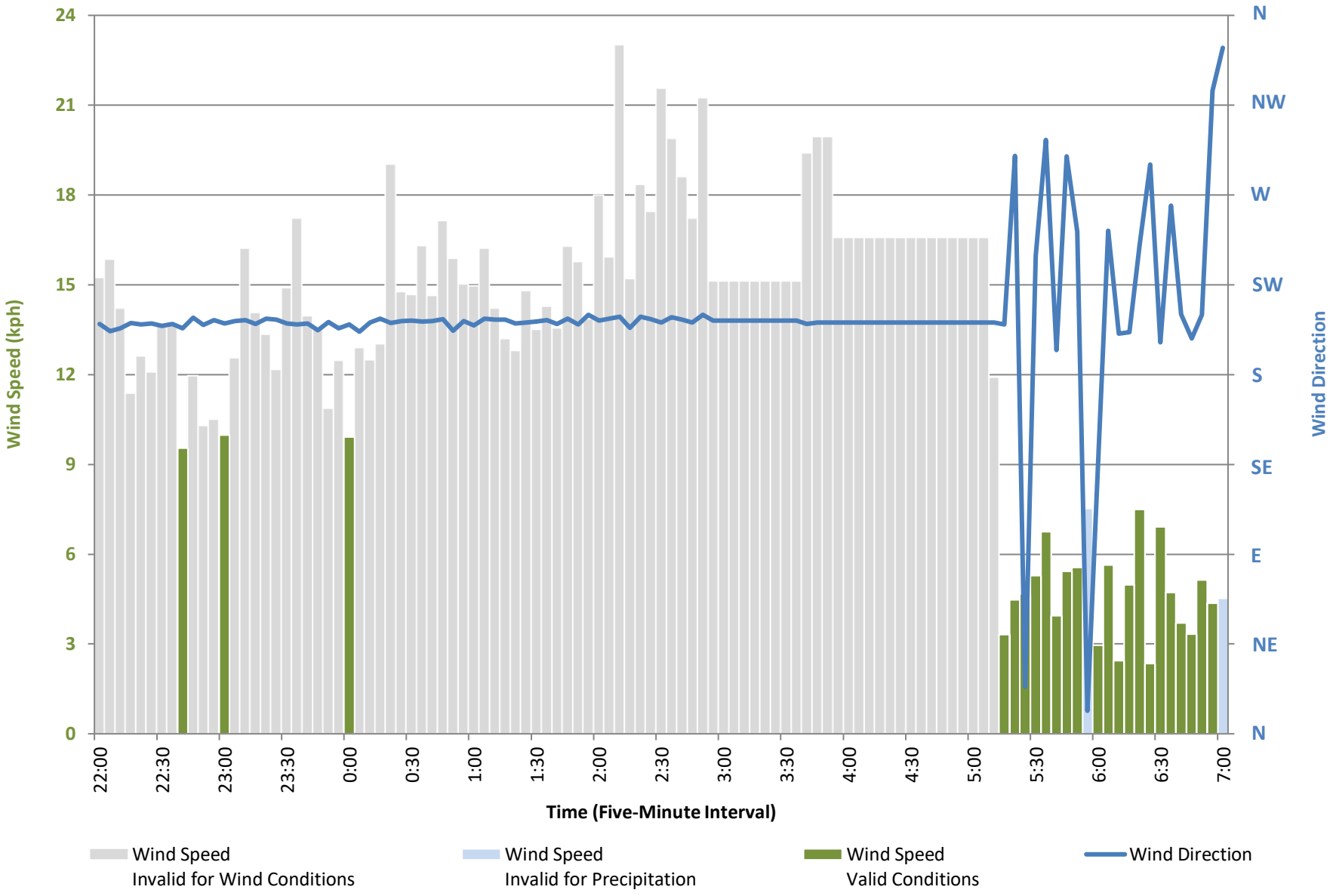
Weather Monitor Data

Figure D17 Day 9 Sep 25



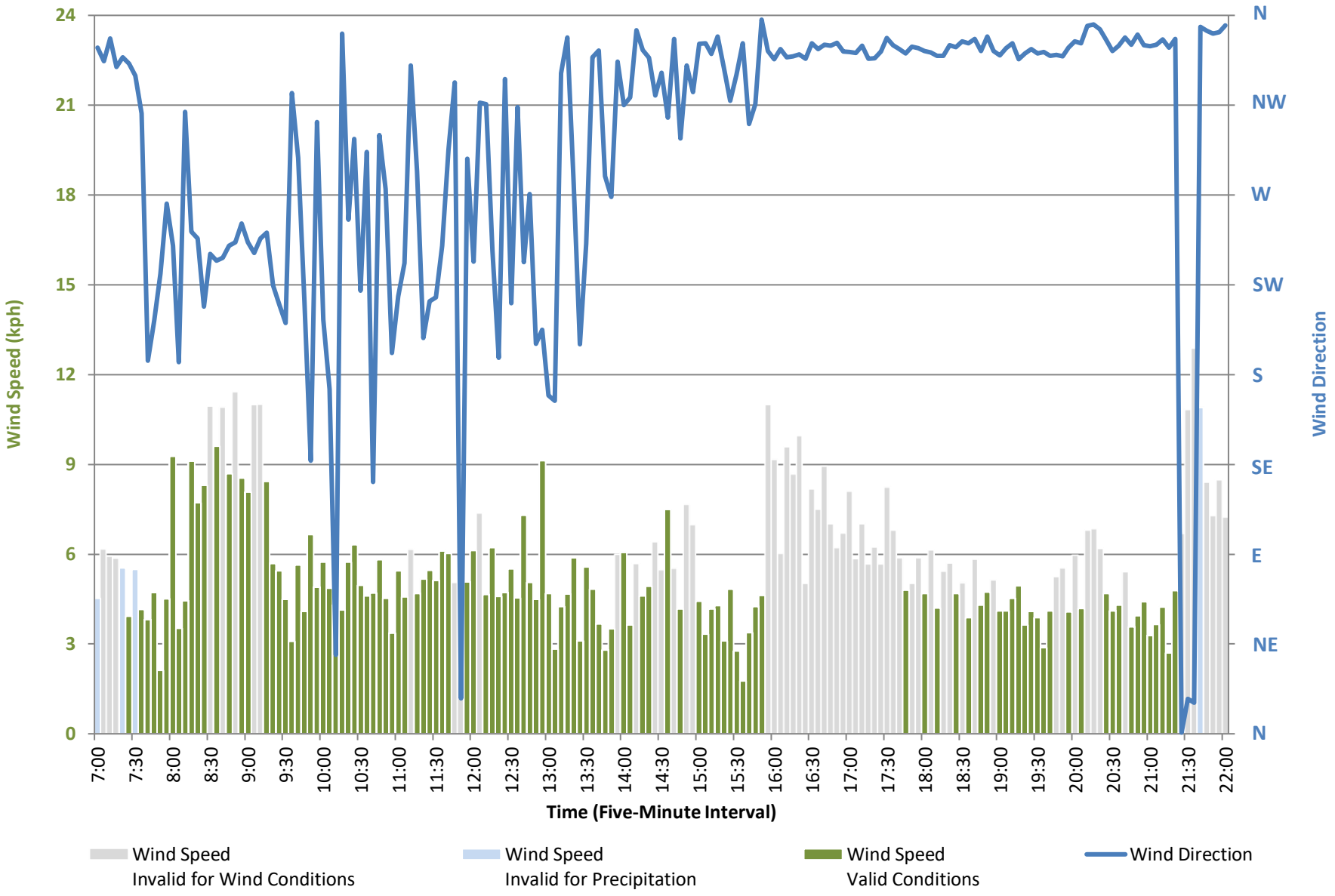
Weather Monitor Data

Figure D18 Night 9 Sep 25 - Sep 26



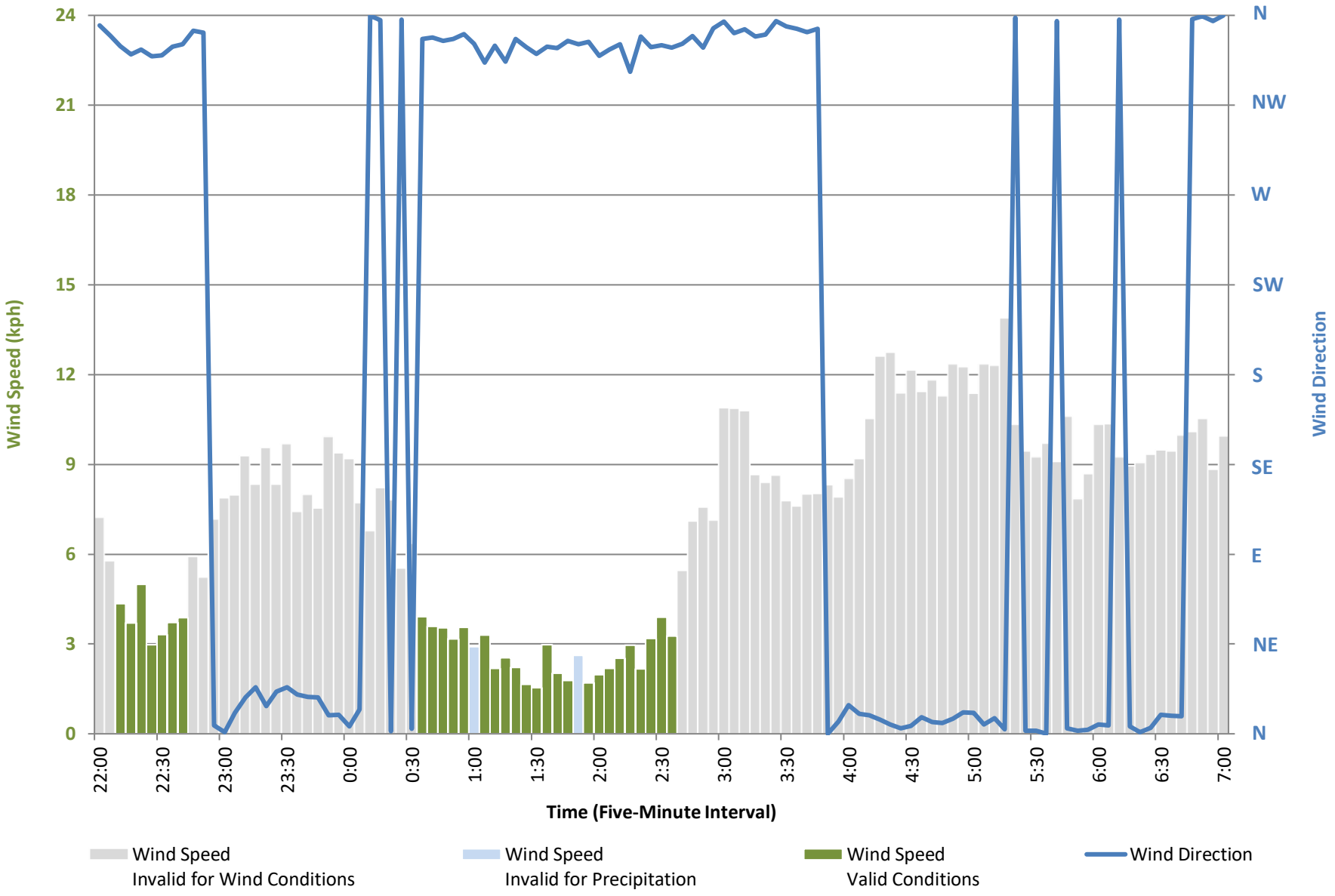
Weather Monitor Data

Figure D19 Day 10 Sep 26



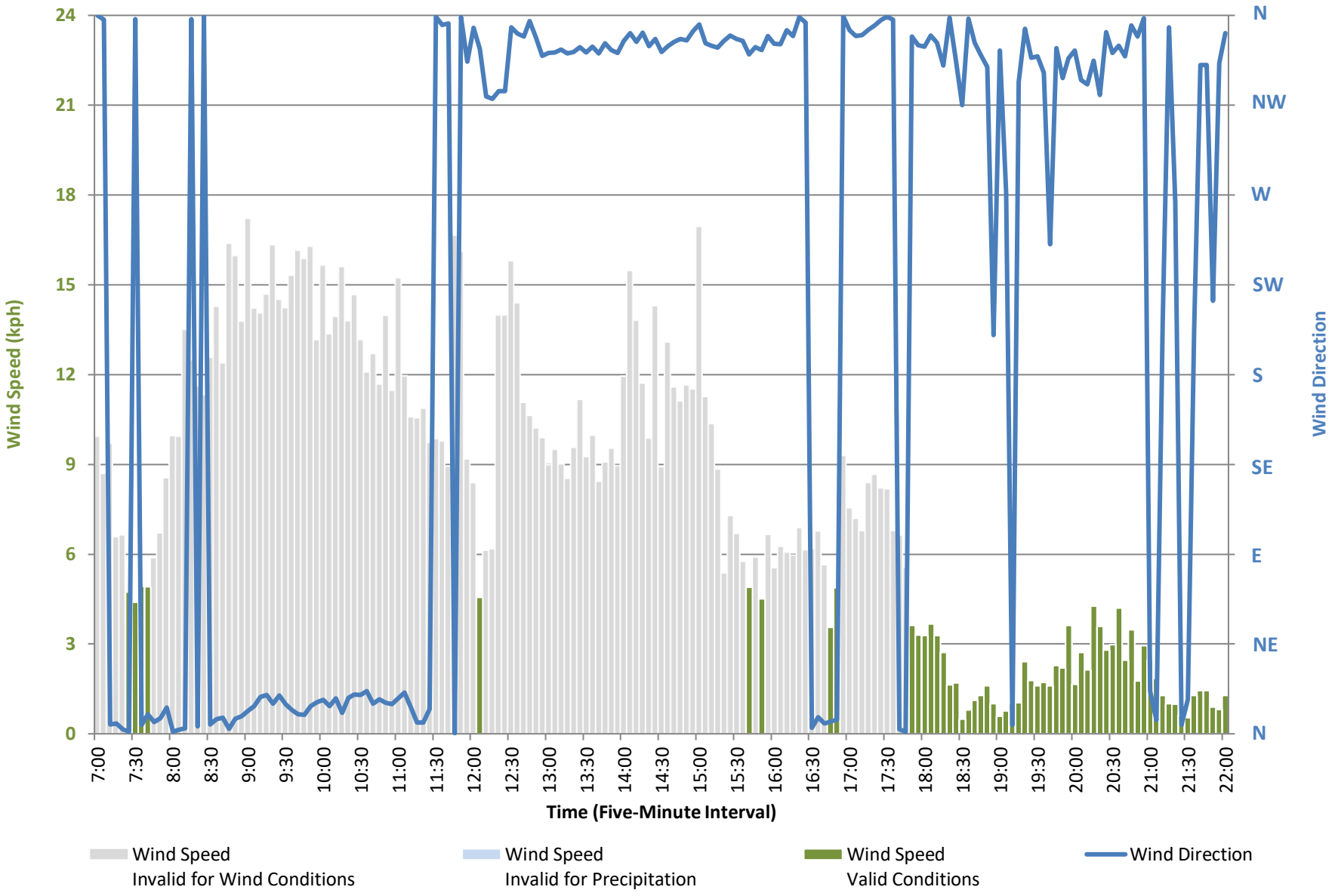
Weather Monitor Data

Figure D20 Night 10 Sep 26 - Sep 27



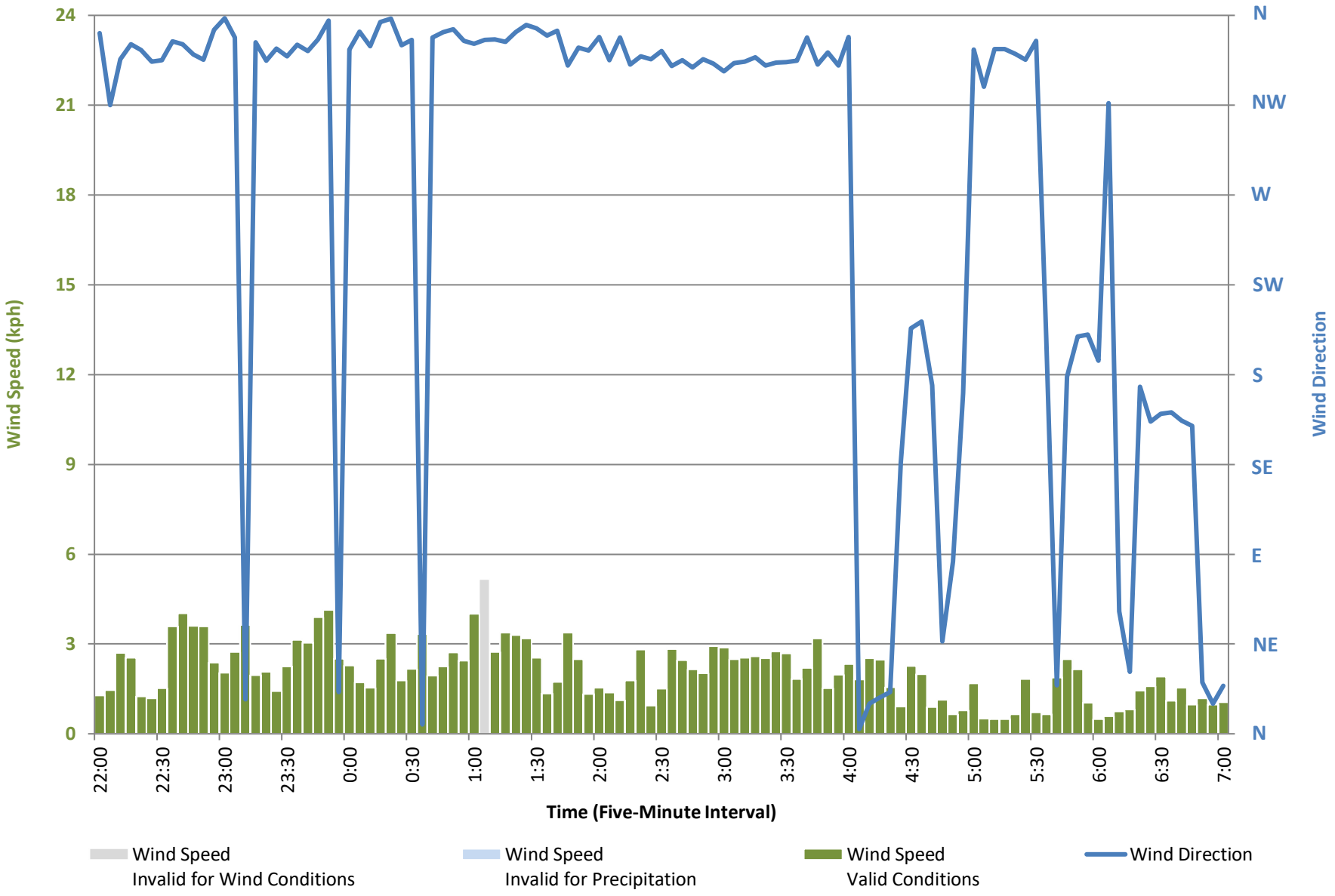
Weather Monitor Data

Figure D21 Day 11 Sep 27



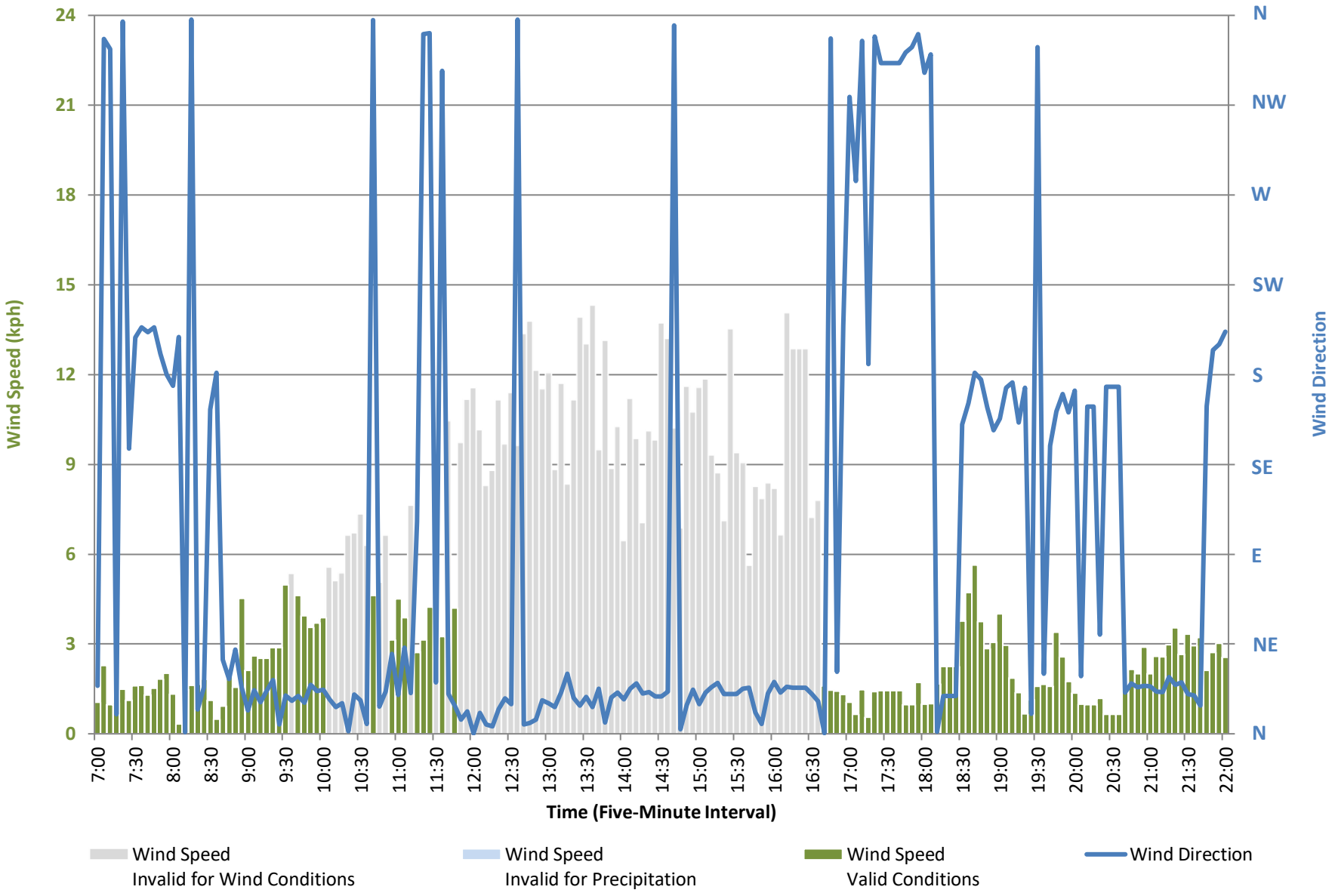
Weather Monitor Data

Figure D22 Night 11 Sep 27 - Sep 28



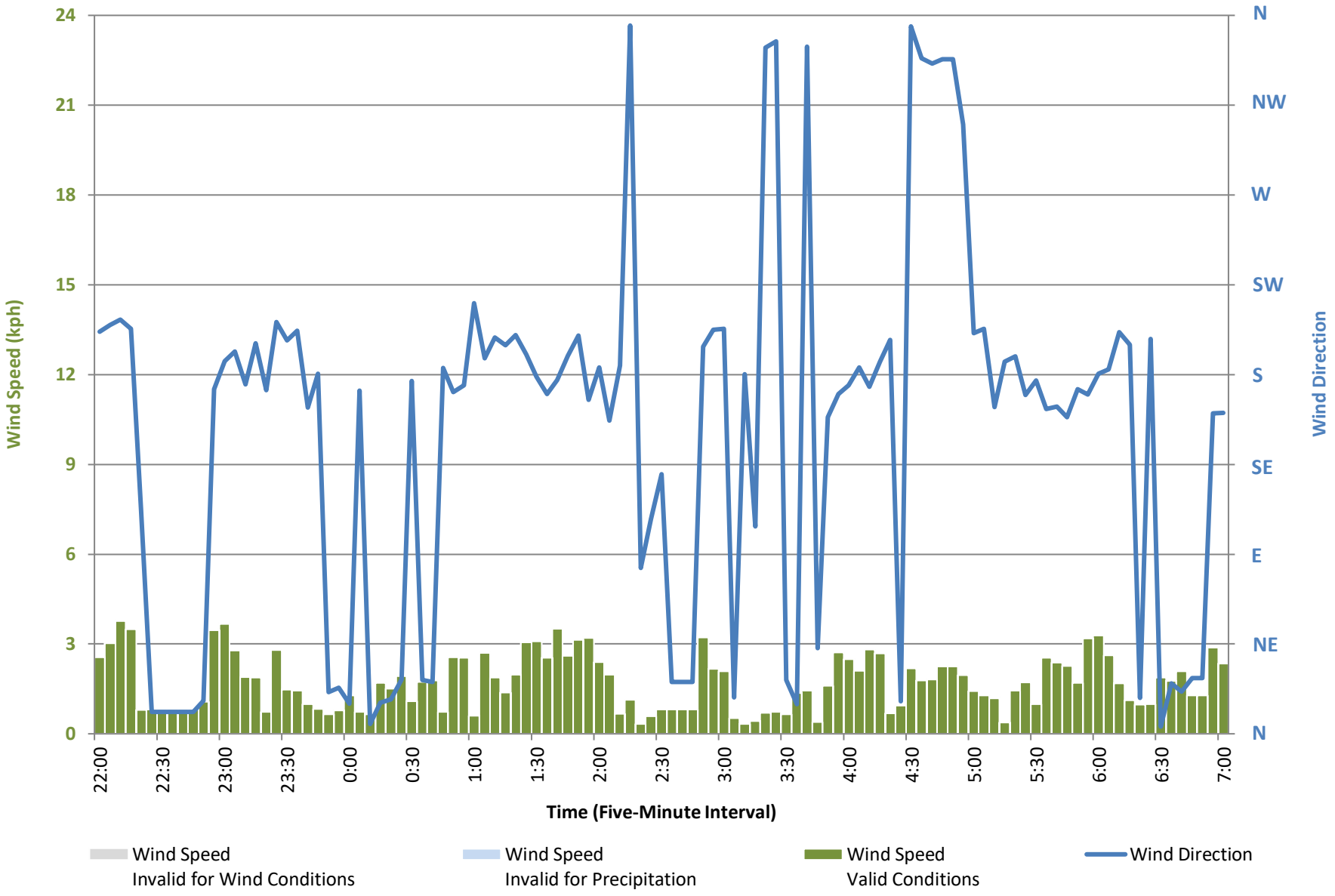
Weather Monitor Data

Figure D23 Day 12 Sep 28



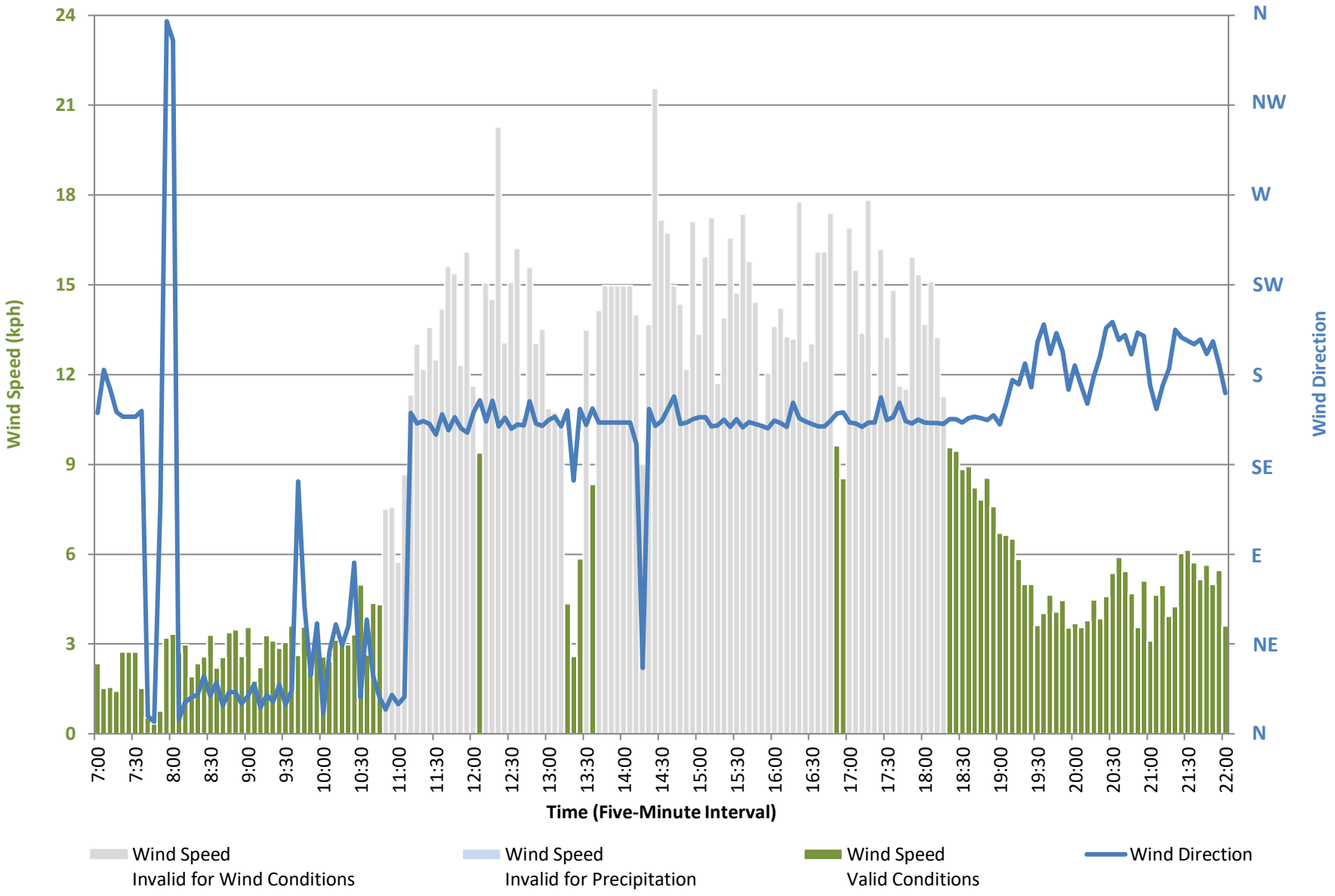
Weather Monitor Data

Figure D24 Night 12 Sep 28 - Sep 29



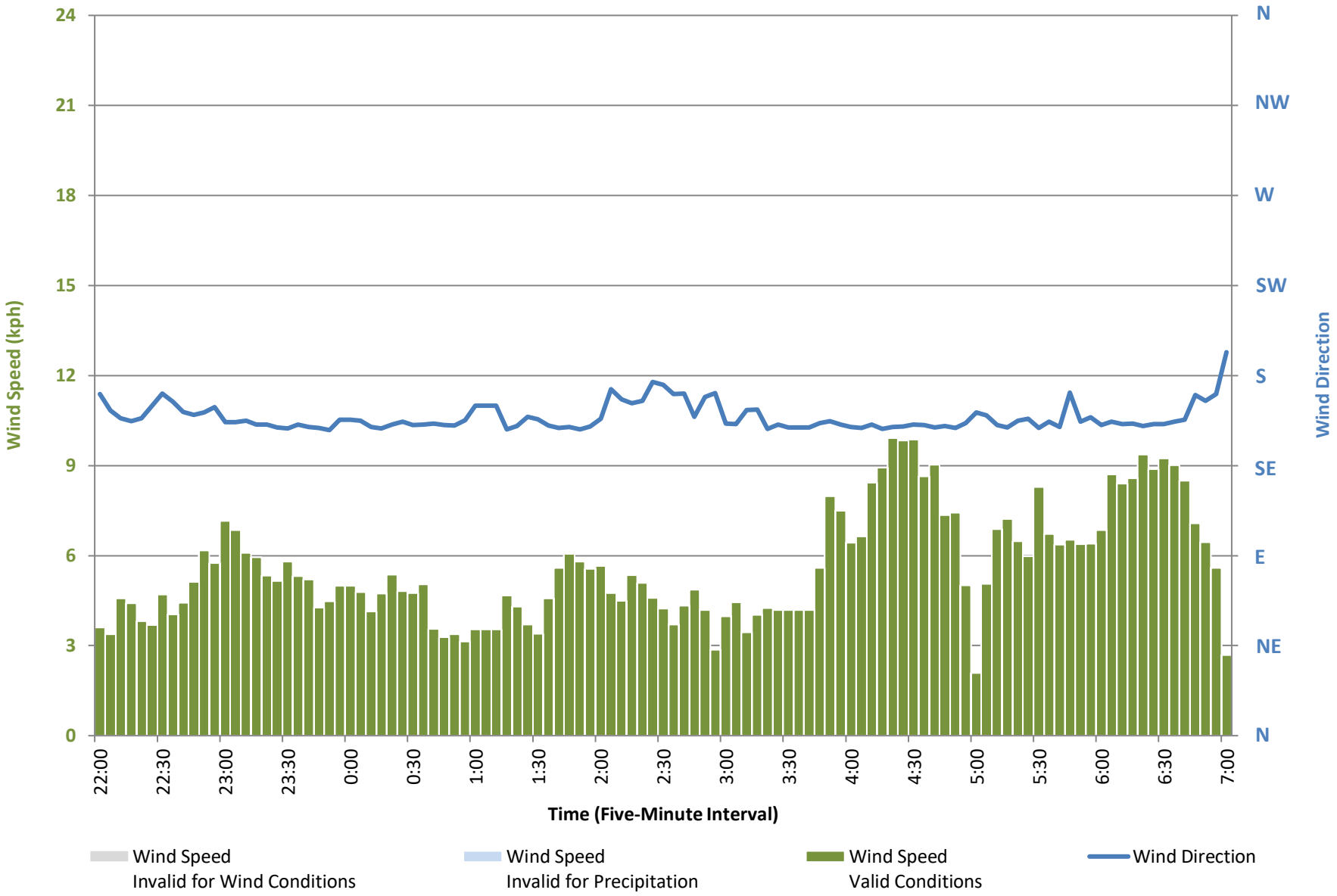
Weather Monitor Data

Figure D25 Day 13 Sep 29



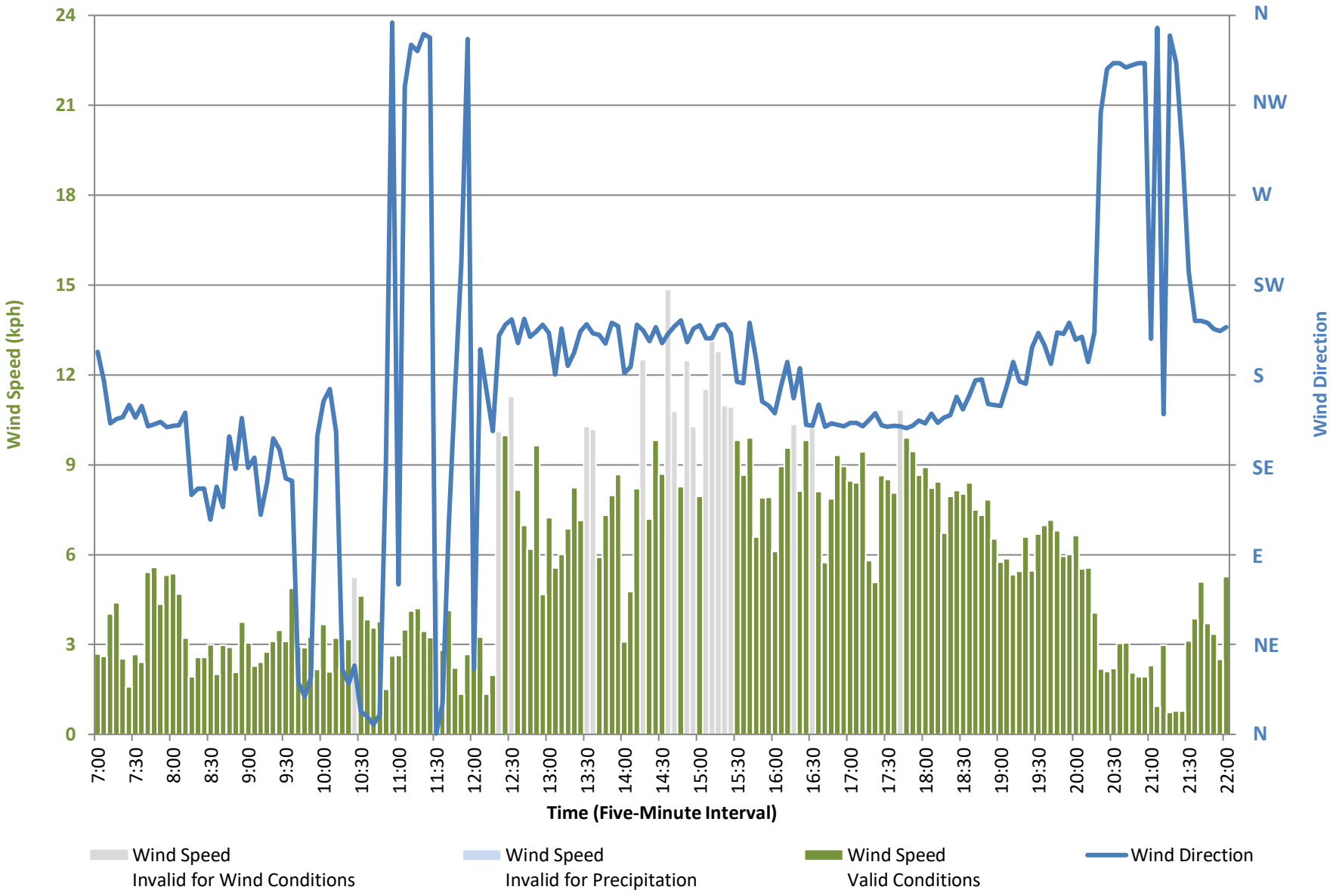
Weather Monitor Data

Figure D26 Night 13 Sep 29 - Sep 30



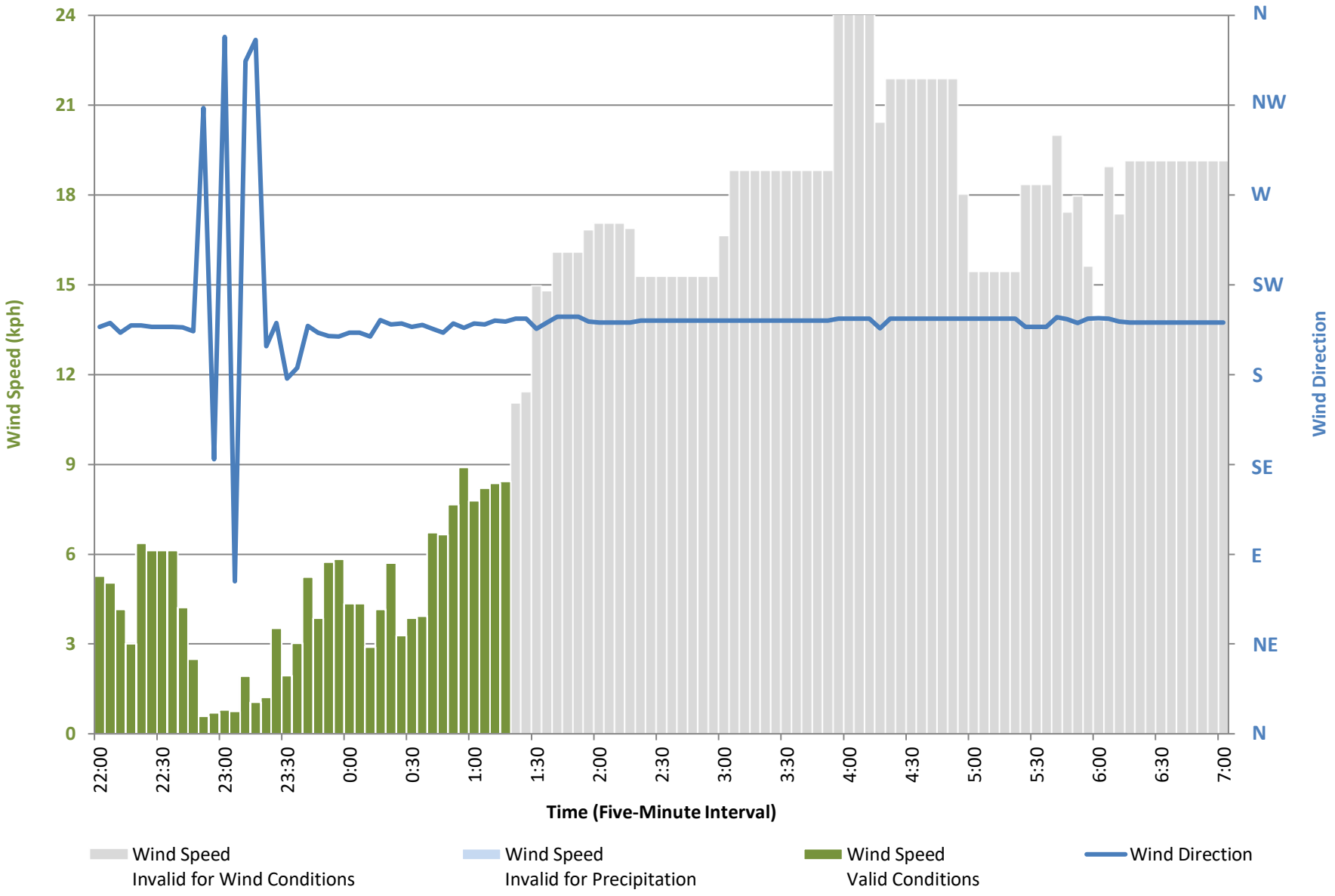
Weather Monitor Data

Figure D27 Day 14 Sep 30



Weather Monitor Data

Figure D28 Night 14 Sep 30 - Oct 01



Weather Monitor Data

Figure D29 Day 15 Oct 01

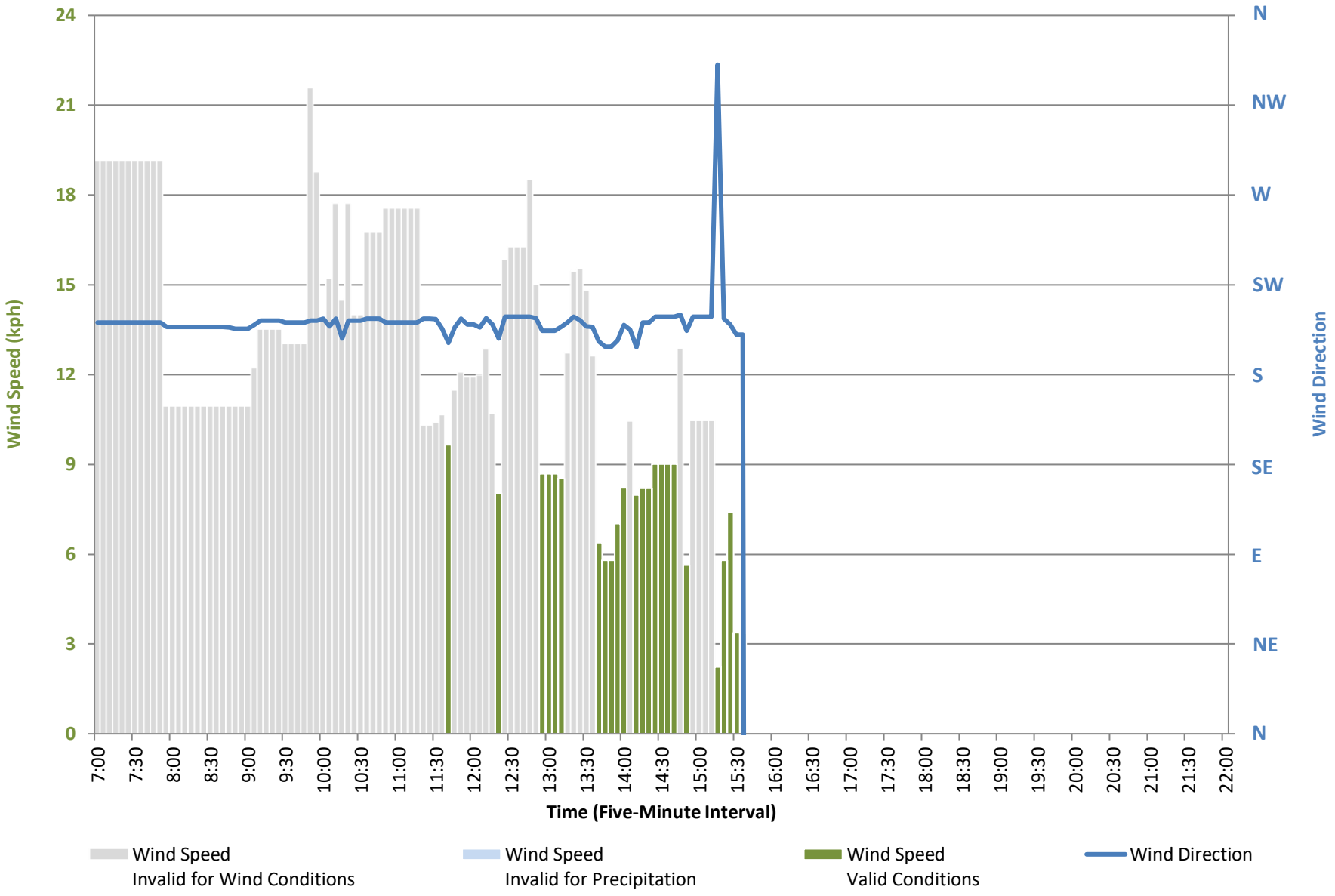
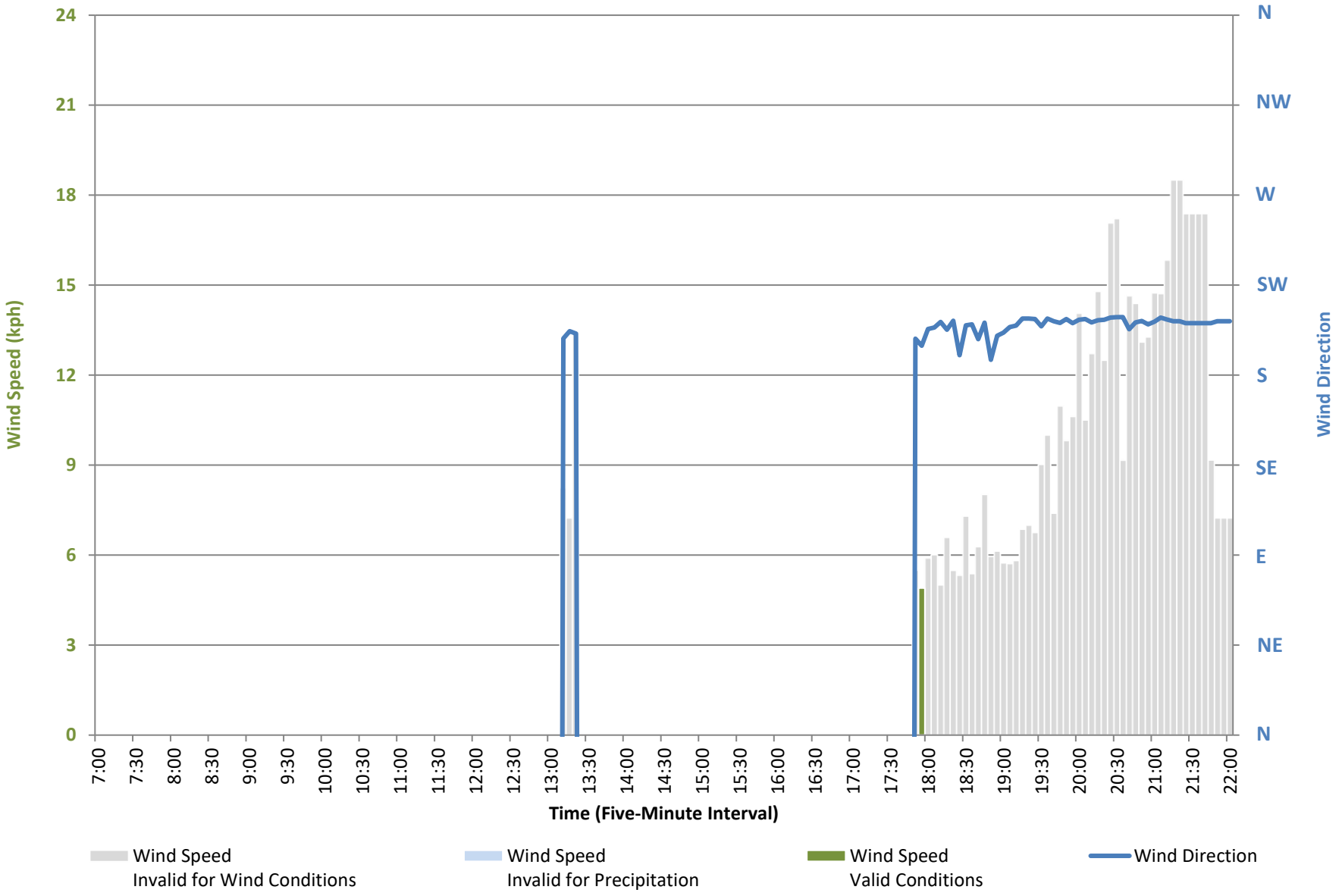


Table D: Weather Summary

Period	Date (2019)	Average Speed (kph)	Average Direction	Minutes of Audible Precipitation	Minutes of Downwind Conditions	Minutes of Valid Conditions	General Description	Period Valid
Day 01	Oct 29	10	SSW	0	0	5	Moderate wind	No
Night 01	Oct 29 - Oct 30	14	SSW	0	0	25	Moderate wind	No
Day 02	Oct 30	27	SSW	0	0	0	Strong wind	No
Night 02	Oct 30 - Oct 31	17	SSW	0	0	0	Strong wind	No
Day 03	Oct 31	12	SSW	0	0	65	Moderate wind	No
Night 03	Oct 31 - Nov 01	11	SSW	0	0	0	Moderate wind	No
Day 04	Nov 01	12	SSW	0	0	100	Moderate wind	No
Night 04	Nov 01 - Nov 02	18	SSW	0	0	0	Strong wind	No
Day 05	Nov 02	12	SSW	0	165	355	Moderate wind	Yes
Night 05	Nov 02 - Nov 03	5	NW	5	30	470	Moderate wind	Yes
Day 06	Nov 03	3	ESE	0	80	900	Light wind	Yes
Night 06	Nov 03 - Nov 04	2	SSE	0	10	540	Calm wind	Yes
Day 07	Nov 04	3	SSE	0	15	900	Light wind	Yes
Night 07	Nov 04 - Nov 05	4	NNE	0	395	540	Light wind	Yes
Day 08	Nov 05	4	N	0	555	900	Light wind	Yes
Night 08	Nov 05 - Nov 06	6	NNW	0	25	520	Moderate wind	Yes
Day 09	Nov 06	6	N	0	90	160	Moderate wind	No

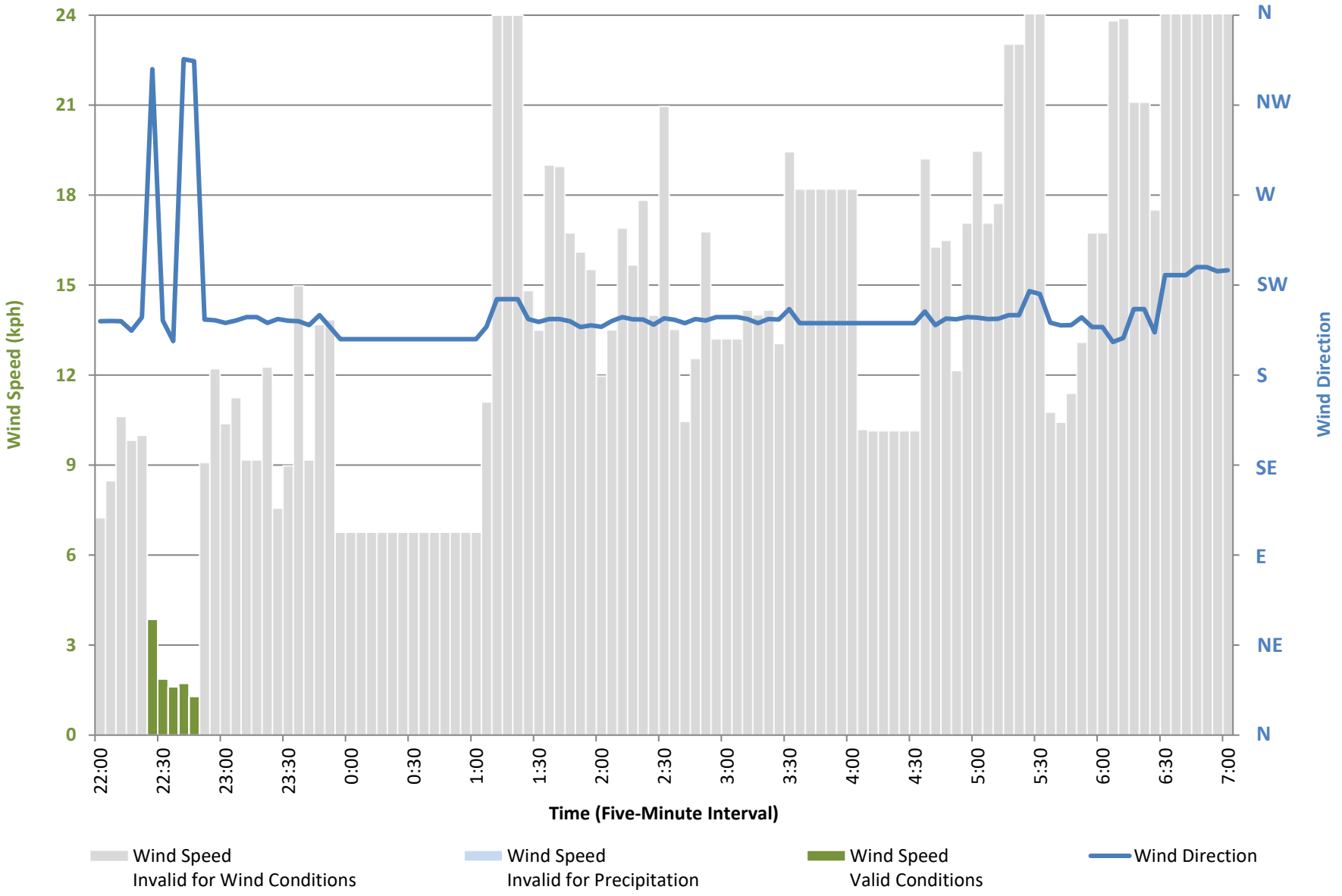
Weather Monitor Data

Figure D1 Day 1 Oct 29



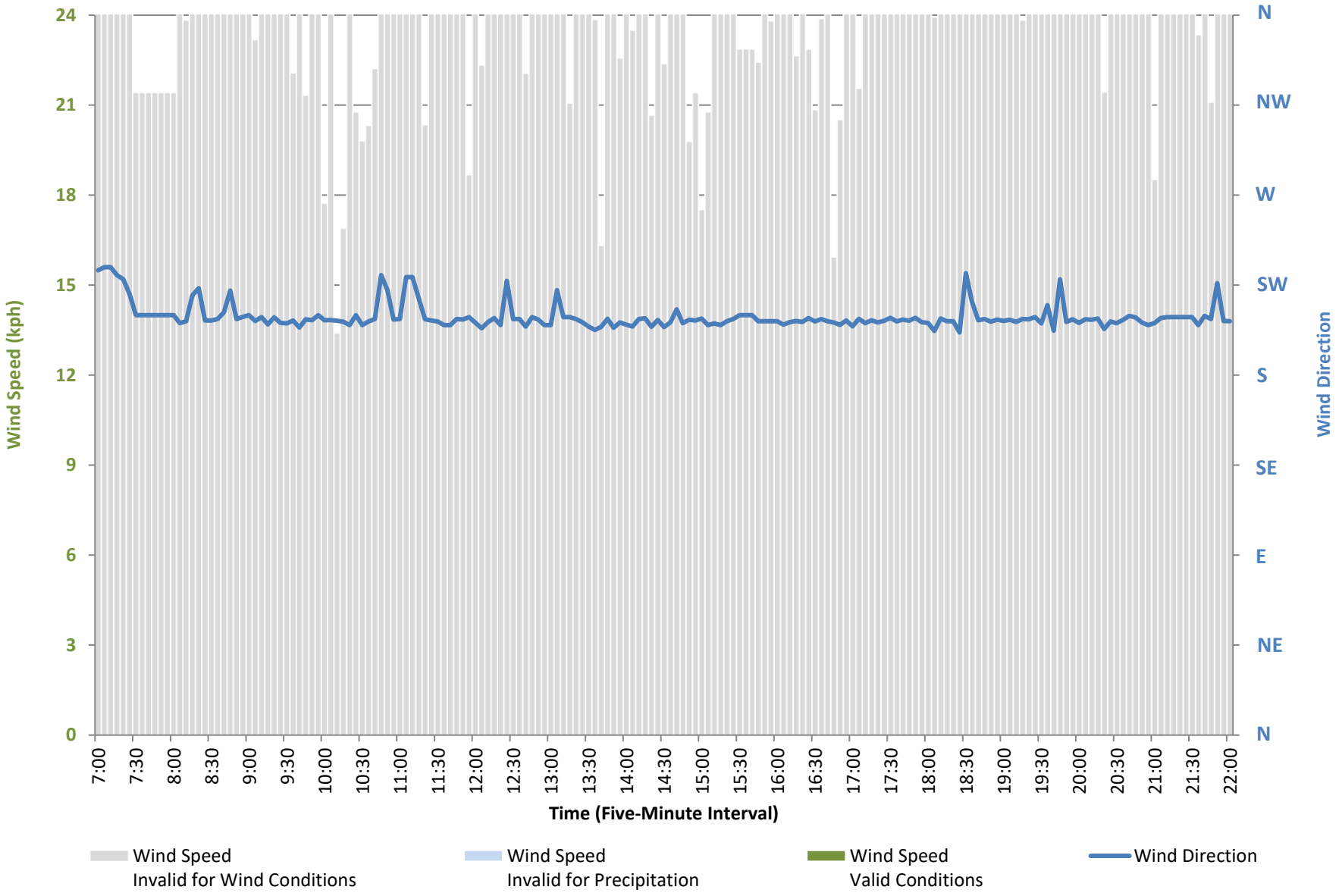
Weather Monitor Data

Figure D2 Night 1 Oct 29 - Oct 30



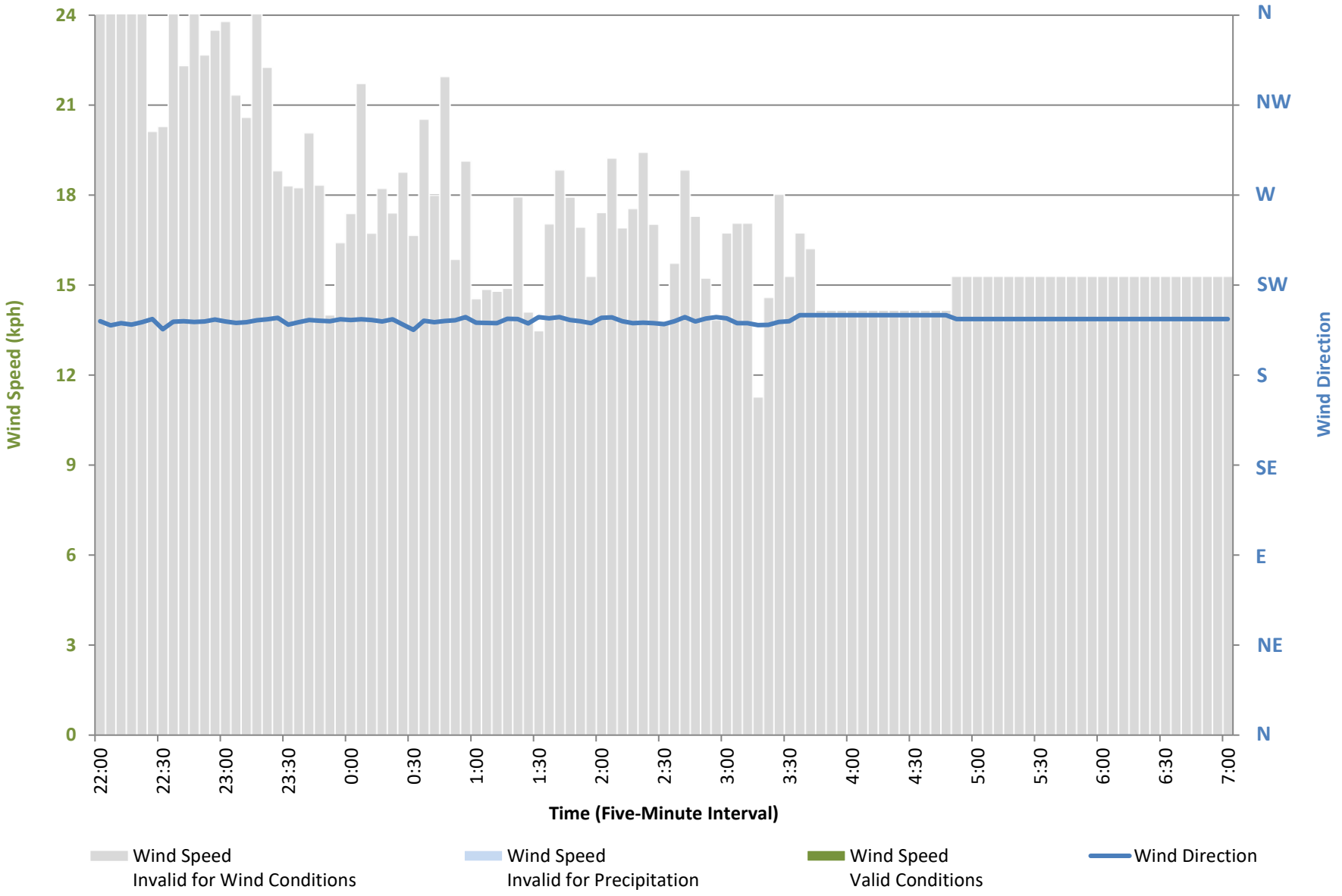
Weather Monitor Data

Figure D3 Day 2 Oct 30



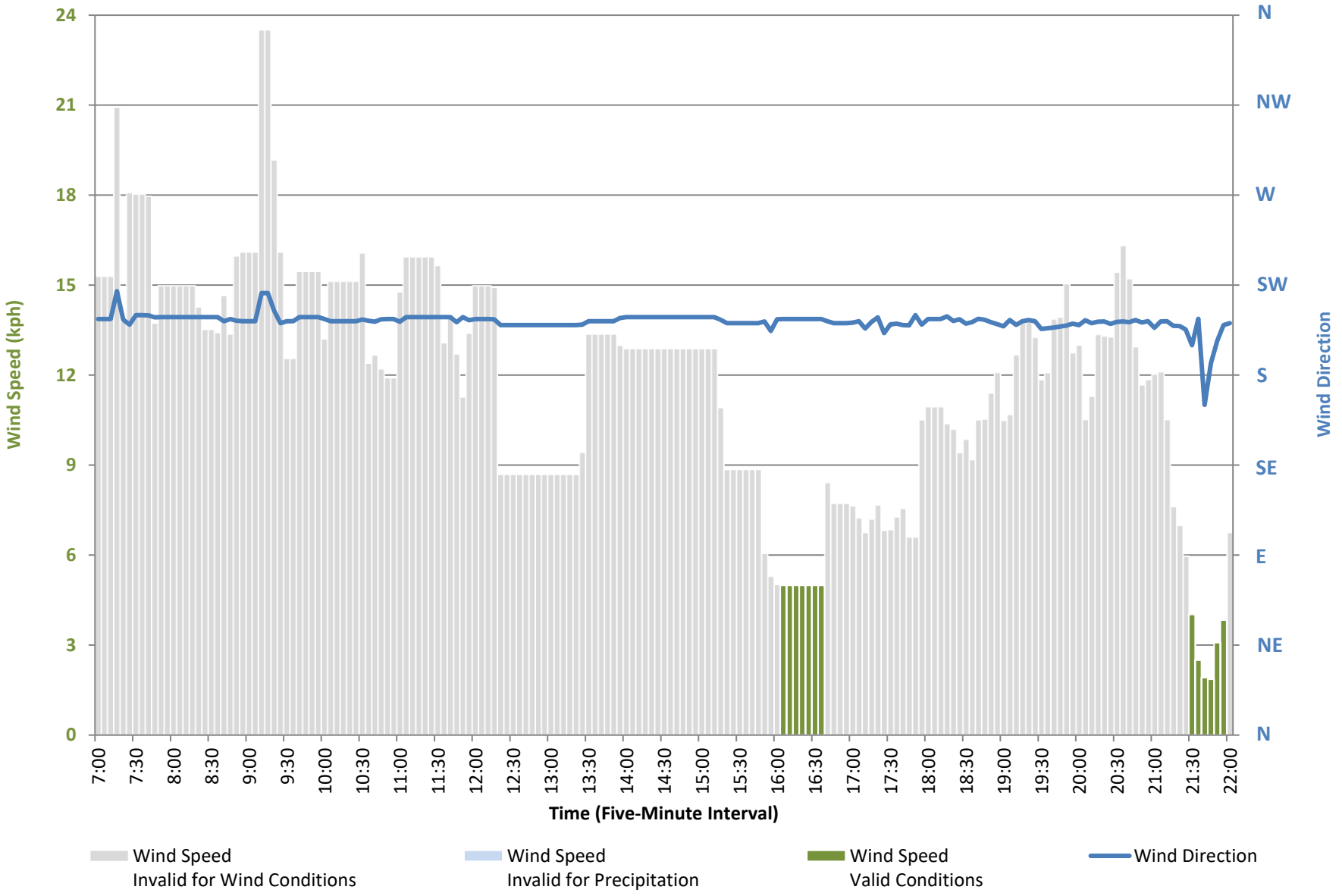
Weather Monitor Data

Figure D4 Night 2 Oct 30 - Oct 31



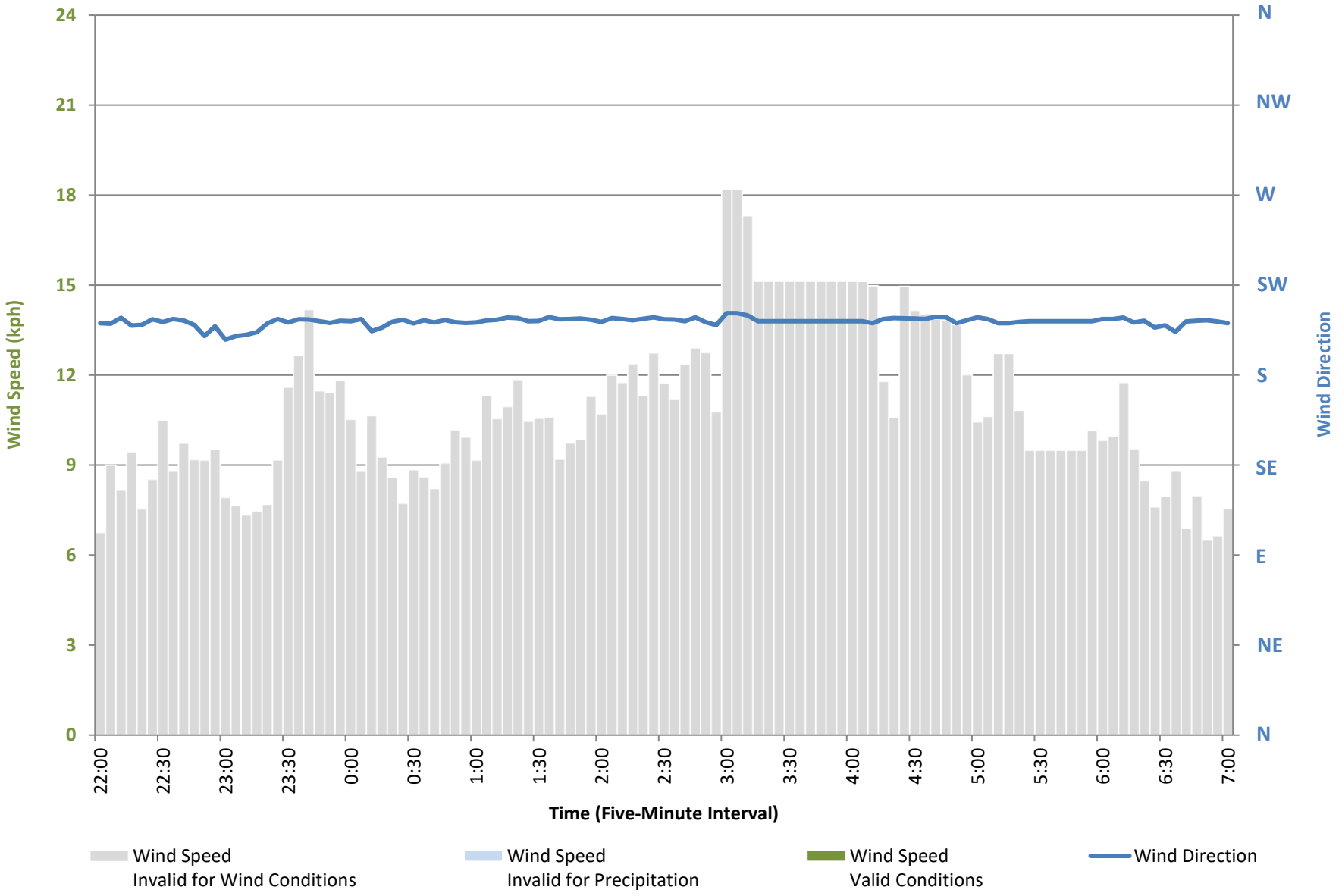
Weather Monitor Data

Figure D5 Day 3 Oct 31



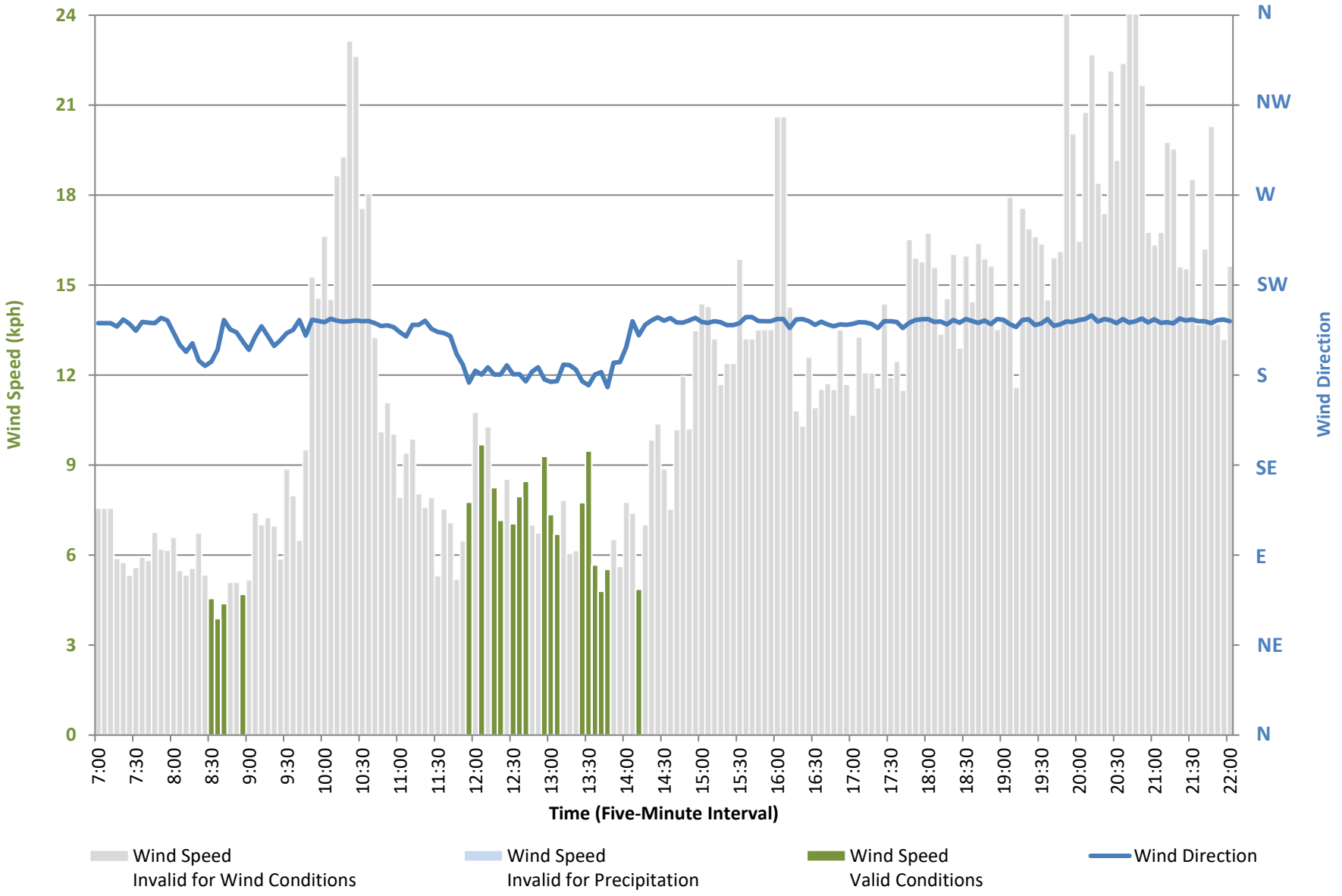
Weather Monitor Data

Figure D6 Night 3 Oct 31 - Nov 01



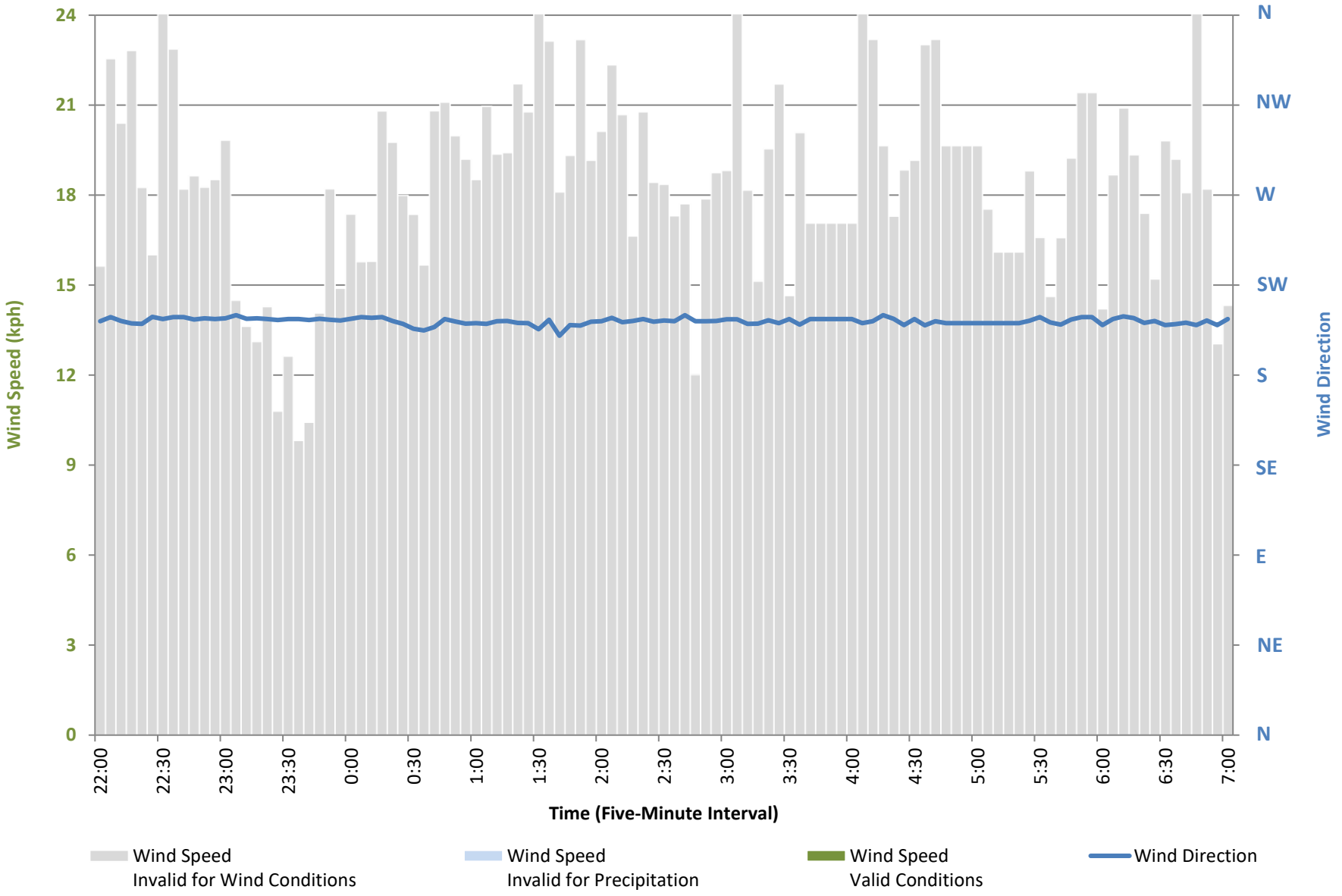
Weather Monitor Data

Figure D7 Day 4 Nov 01



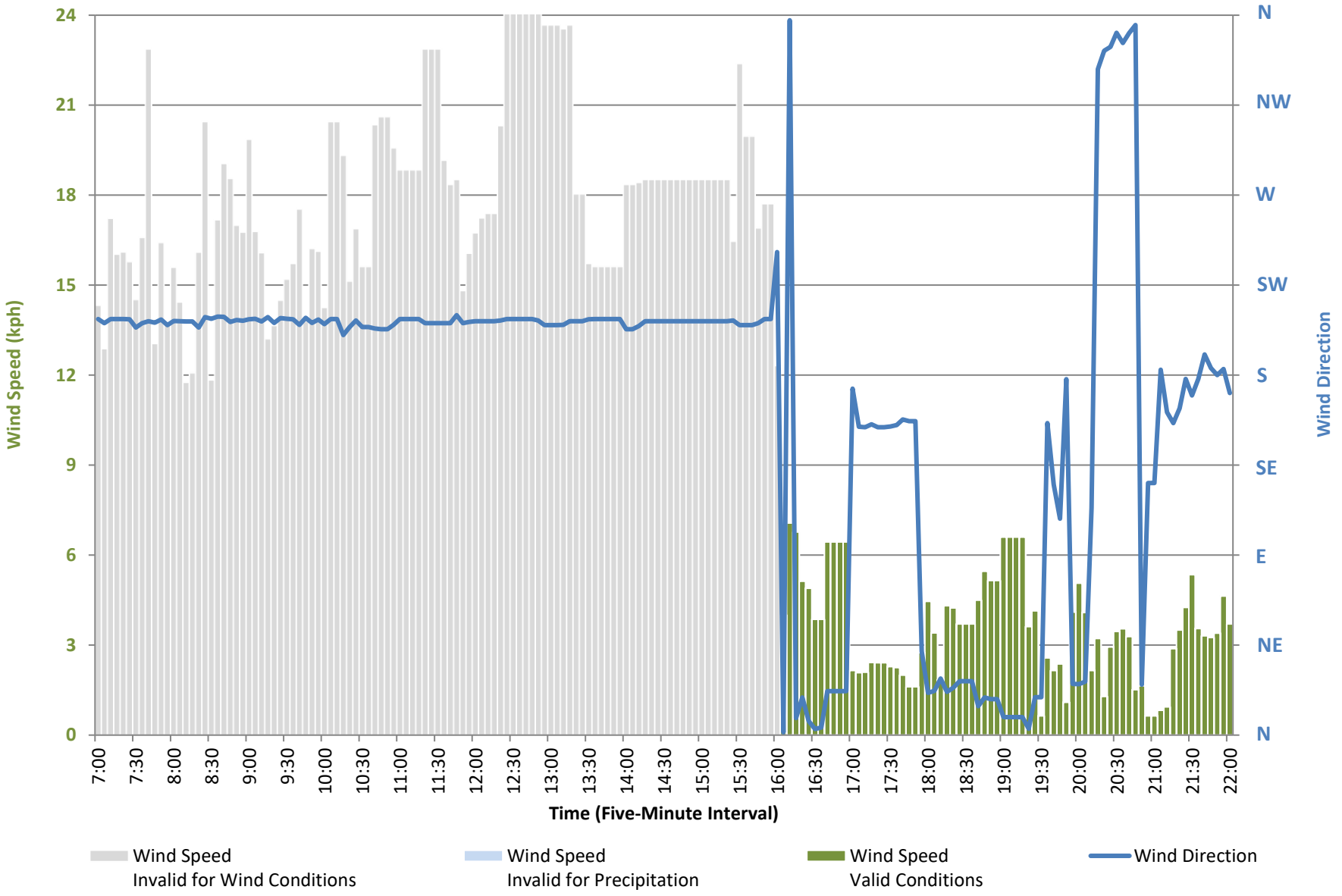
Weather Monitor Data

Figure D8 Night 4 Nov 01 - Nov 02



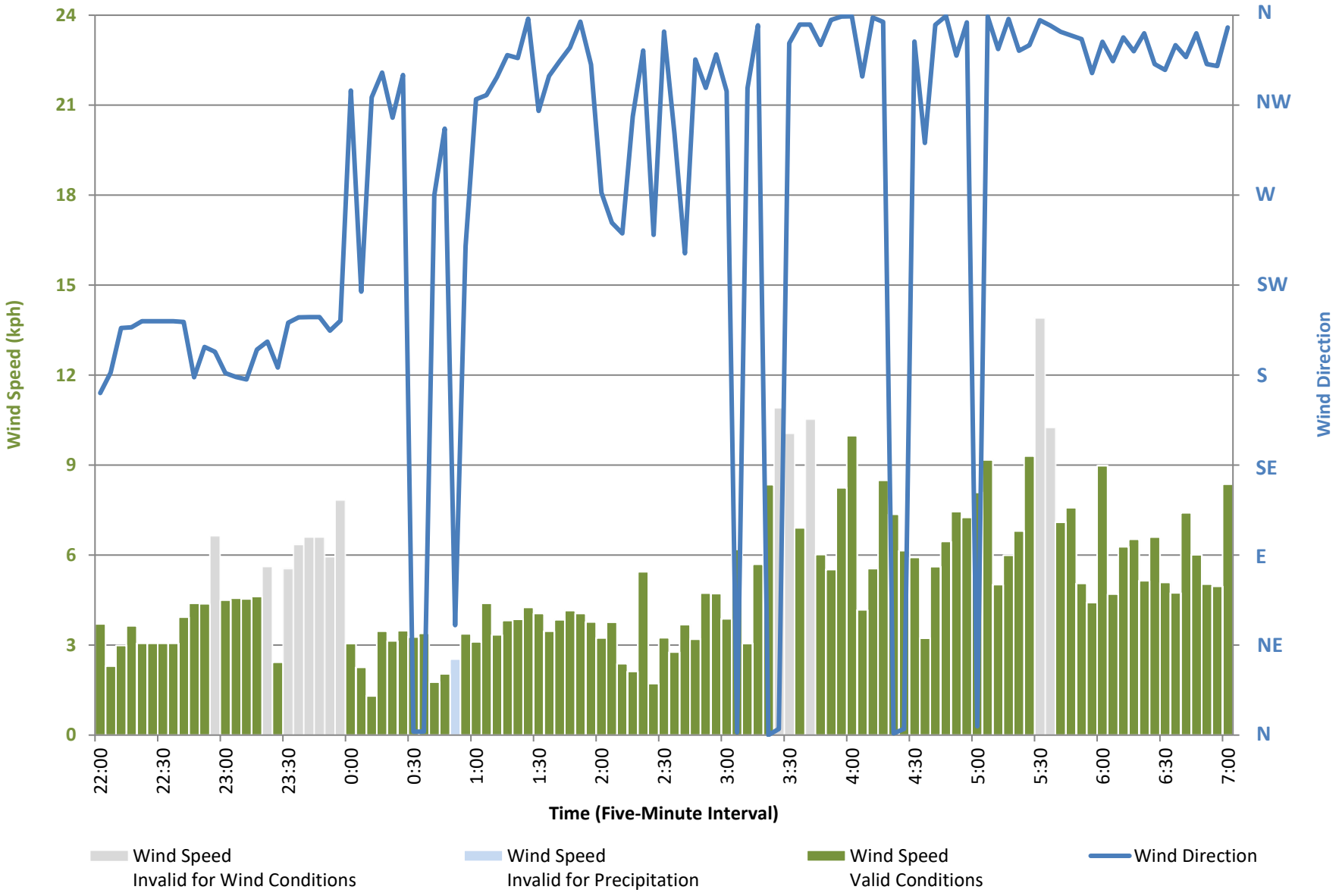
Weather Monitor Data

Figure D9 Day 5 Nov 02



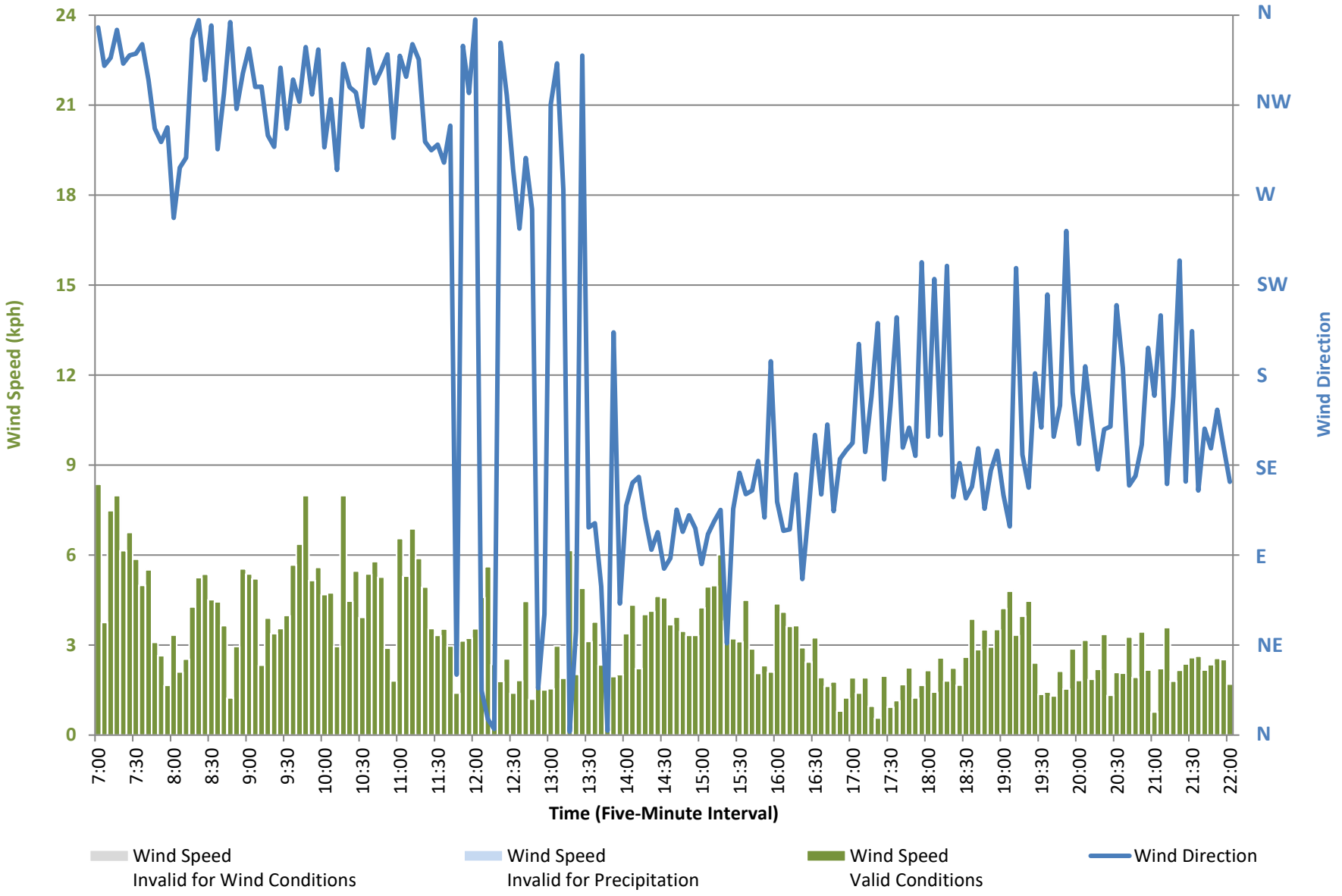
Weather Monitor Data

Figure D10 Night 5 Nov 02 - Nov 03



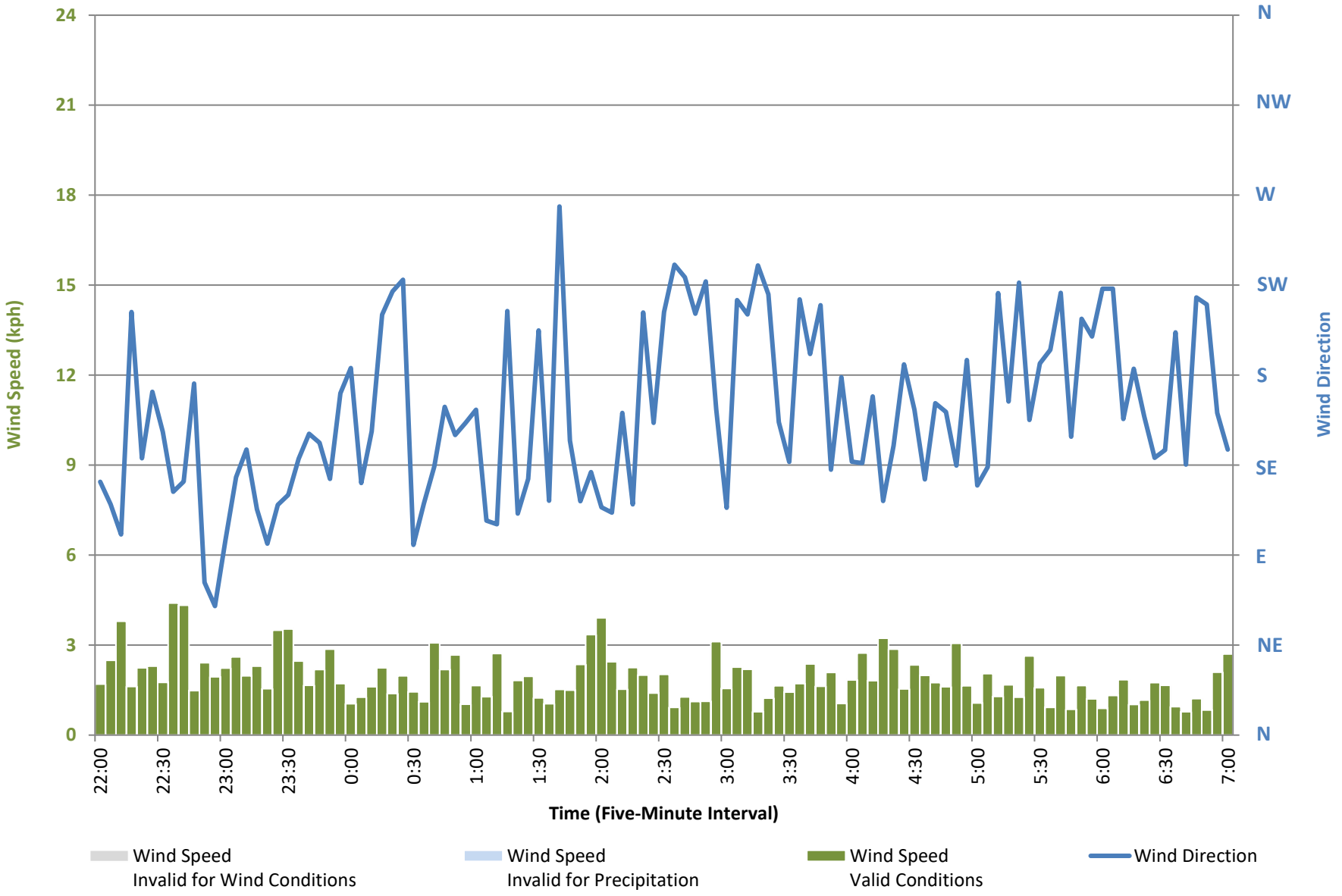
Weather Monitor Data

Figure D11 Day 6 Nov 03



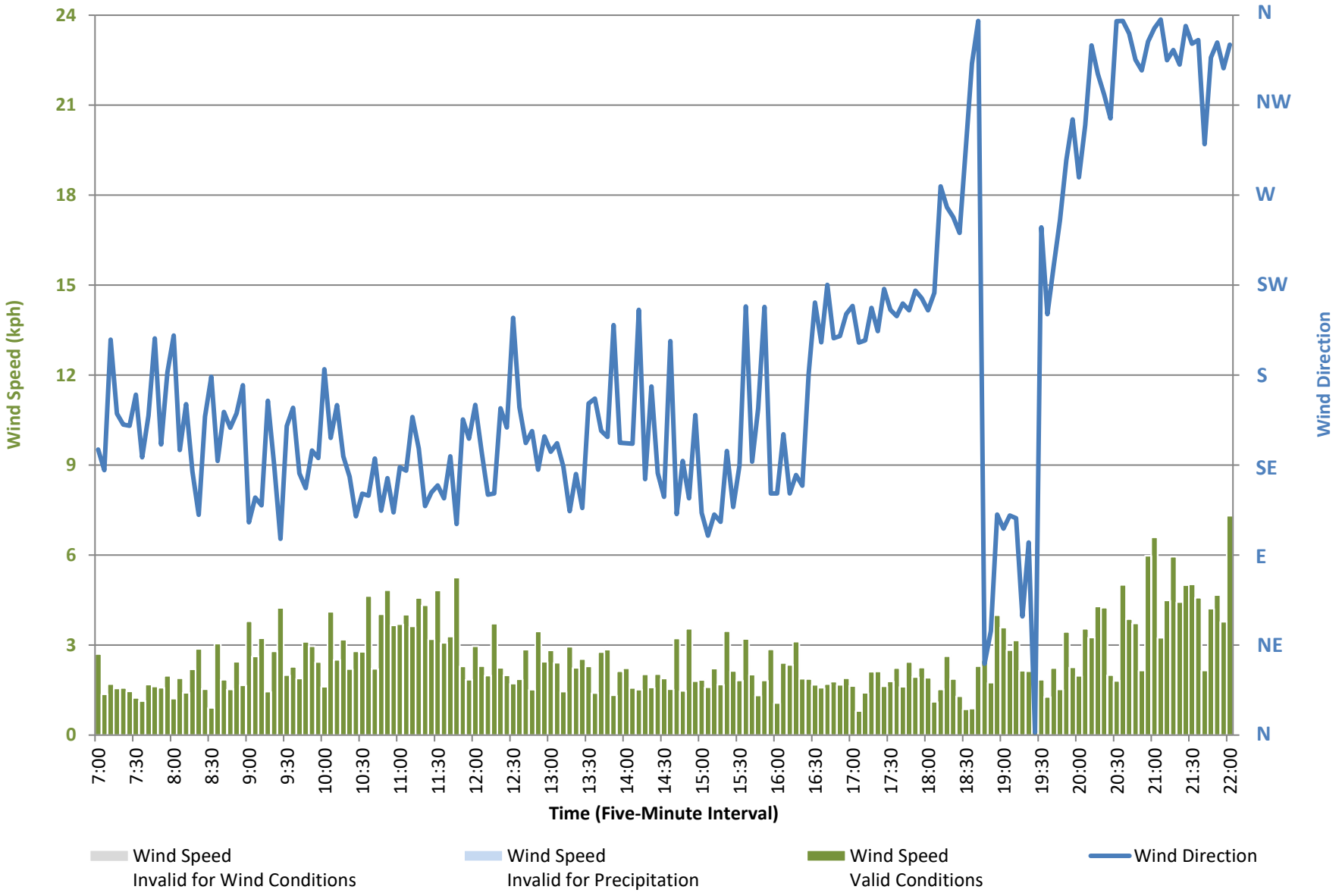
Weather Monitor Data

Figure D12 Night 6 Nov 03 - Nov 04



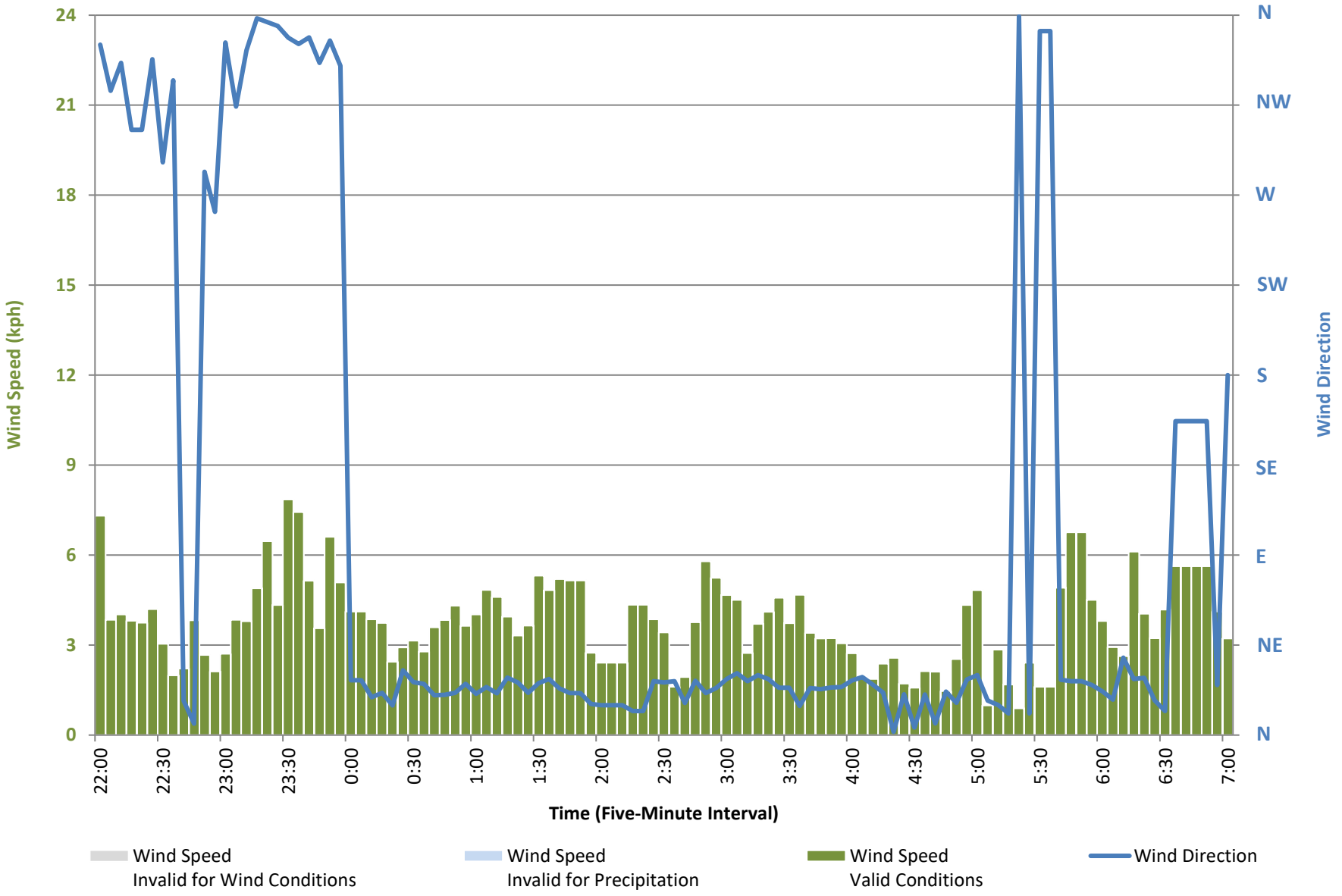
Weather Monitor Data

Figure D13 Day 7 Nov 04



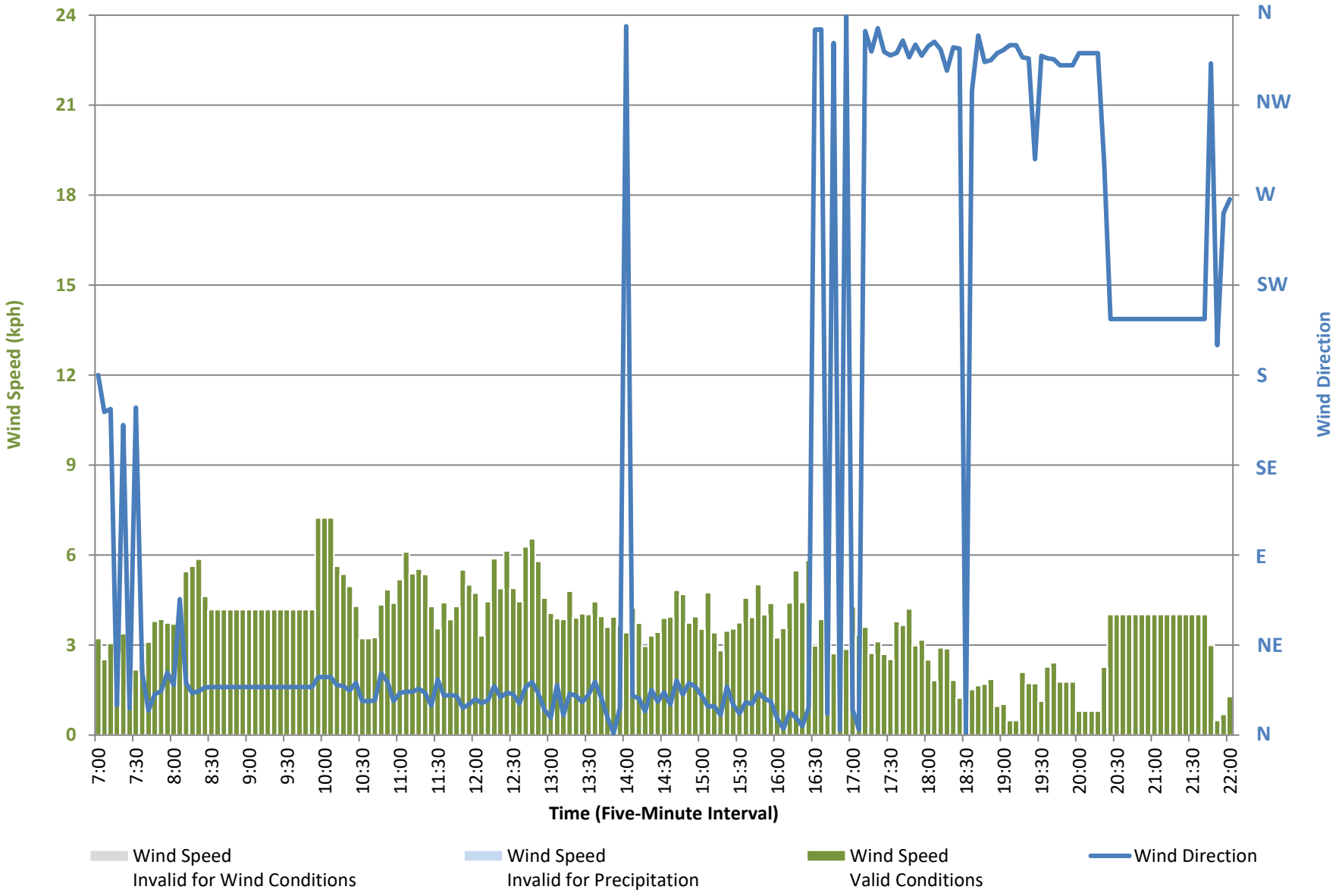
Weather Monitor Data

Figure D14 Night 7 Nov 04 - Nov 05



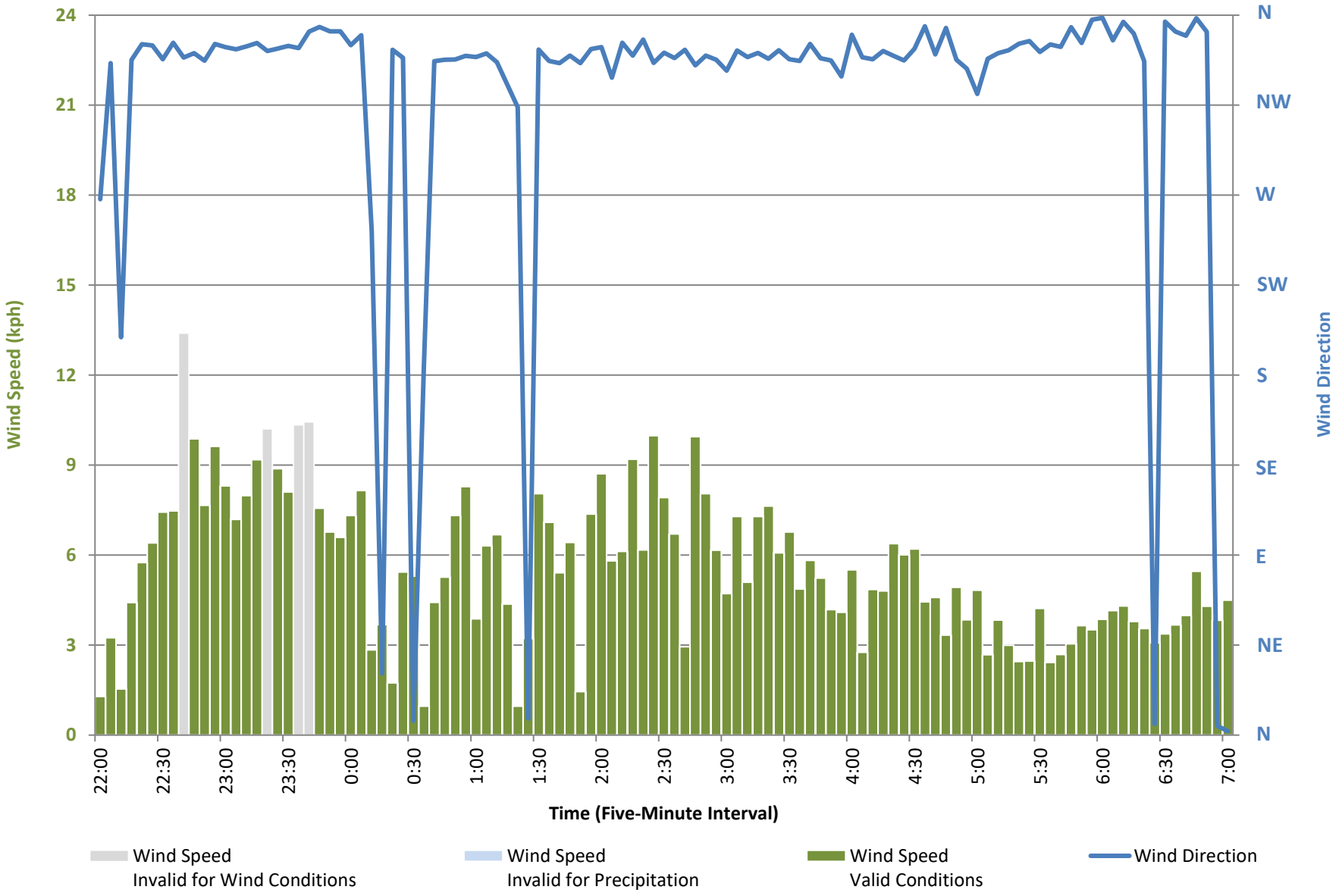
Weather Monitor Data

Figure D15 Day 8 Nov 05



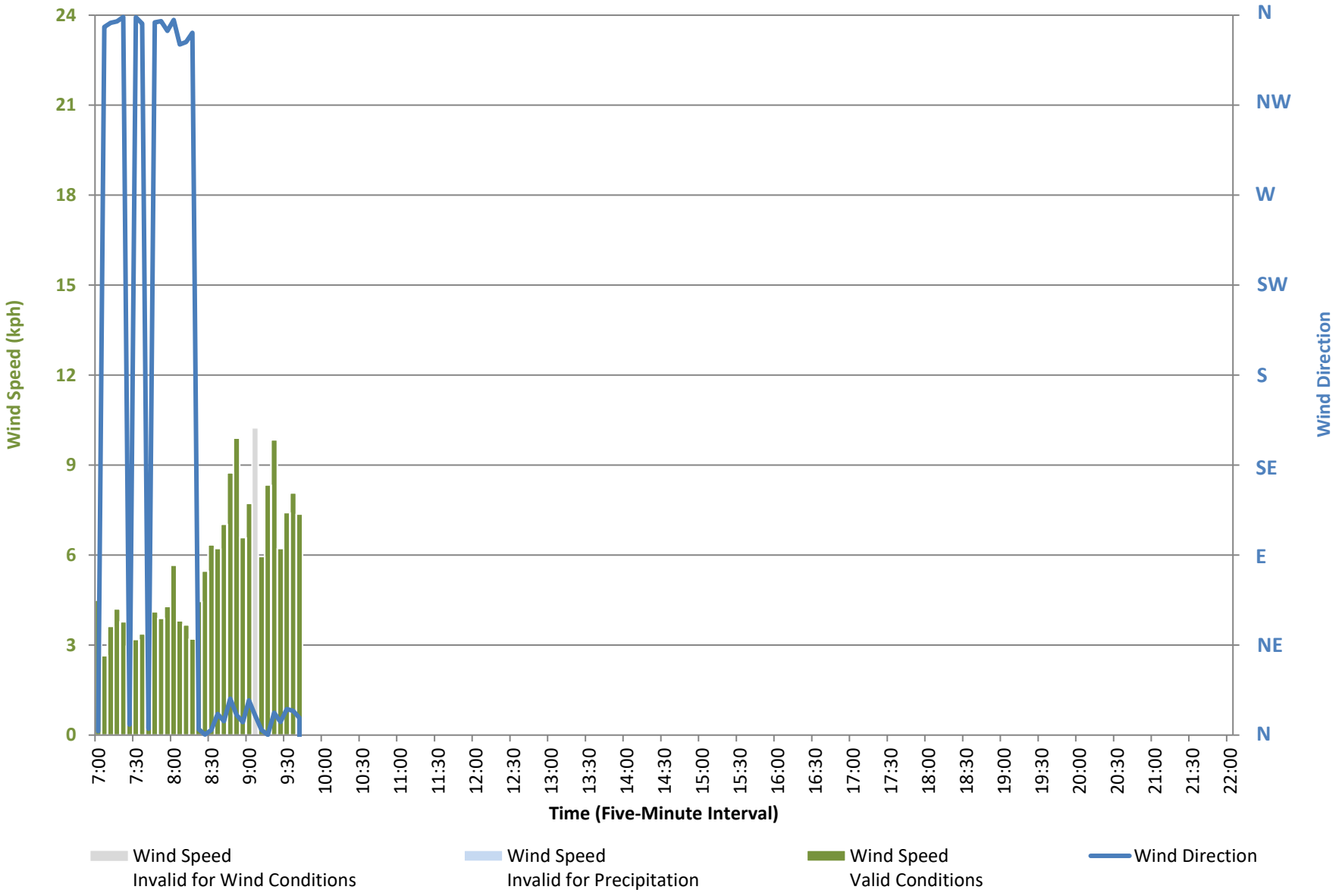
Weather Monitor Data

Figure D16 Night 8 Nov 05 - Nov 06



Weather Monitor Data

Figure D17 Day 9 Nov 06



APPENDIX E

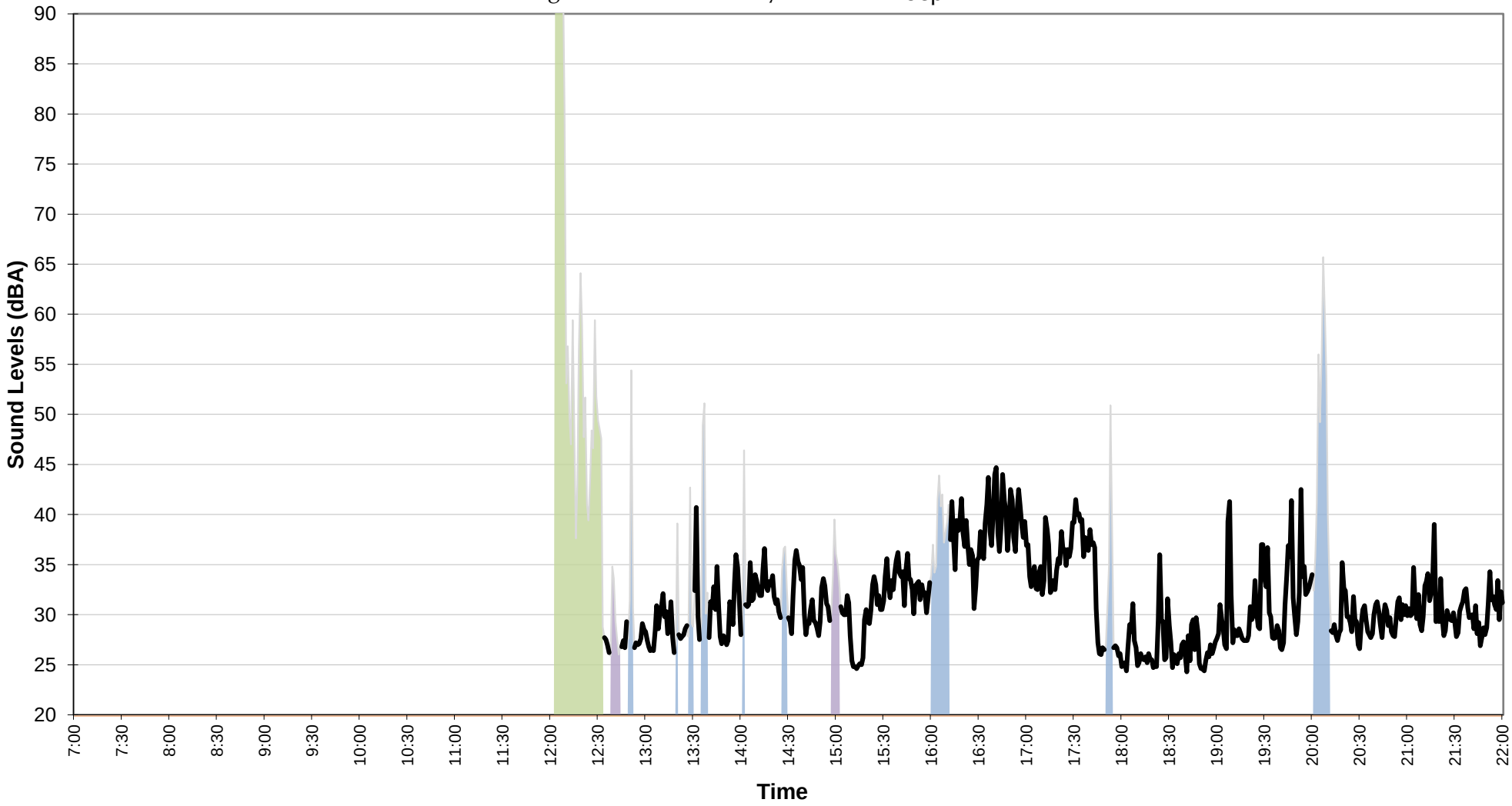
Sound Level Measurements
Sound Monitor B
160m north from 210 Road

Table E: Comprehensive Sound Survey - Monitor B

Period	Date (2019)	Measured Leq (dBA)	Measured Hours	Residual Leq (dBA)	Residual Hours
Day 01	Sep 17	73.5	10.0	33.7	8.4
Night 01	Sep 17 - Sep 18	33.2	9.0	32.9	8.4
Day 02	Sep 18	40.3	15.0	37.9	11.5
Night 02	Sep 18 - Sep 19	44.1	9.0	44.1	8.8
Day 03	Sep 19	53.1	15.0	52.7	14.4
Night 03	Sep 19 - Sep 20	42.0	9.0	42.0	8.4
Day 04	Sep 20	42.7	15.0	42.5	14.7
Night 04	Sep 20 - Sep 21	48.7	9.0	48.7	9.0
Day 05	Sep 21	54.9	15.0	54.9	14.9
Night 05	Sep 21 - Sep 22	57.6	9.0	45.9	6.6
Day 06	Sep 22	67.2	15.0	-	0.0
Night 06	Sep 22 - Sep 23	65.3	9.0	-	0.0
Day 07	Sep 23	77.7	15.0	48.7	4.7
Night 07	Sep 23 - Sep 24	47.3	9.0	47.3	9.0
Day 08	Sep 24	56.9	15.0	56.9	14.9
Night 08	Sep 24 - Sep 25	40.1	9.0	40.1	9.0
Day 09	Sep 25	44.6	15.0	44.6	15.0
Night 09	Sep 25 - Sep 26	44.8	9.0	44.8	9.0
Day 10	Sep 26	52.9	15.0	52.9	14.9
Night 10	Sep 26 - Sep 27	35.4	9.0	35.4	9.0
Day 11	Sep 27	38.6	15.0	38.2	14.7
Night 11	Sep 27 - Sep 28	32.1	9.0	31.8	8.9
Day 12	Sep 28	39.0	15.0	38.1	14.4
Night 12	Sep 28 - Sep 29	31.0	9.0	30.7	8.9
Day 13	Sep 29	41.4	15.0	39.1	14.4
Night 13	Sep 29 - Sep 30	32.5	9.0	32.5	9.0
Day 14	Sep 30	44.6	15.0	38.0	14.3
Night 14	Sep 30 - Oct 01	34.3	9.0	34.3	9.0
Day 15	Oct 01	45.4	15.0	40.0	4.5

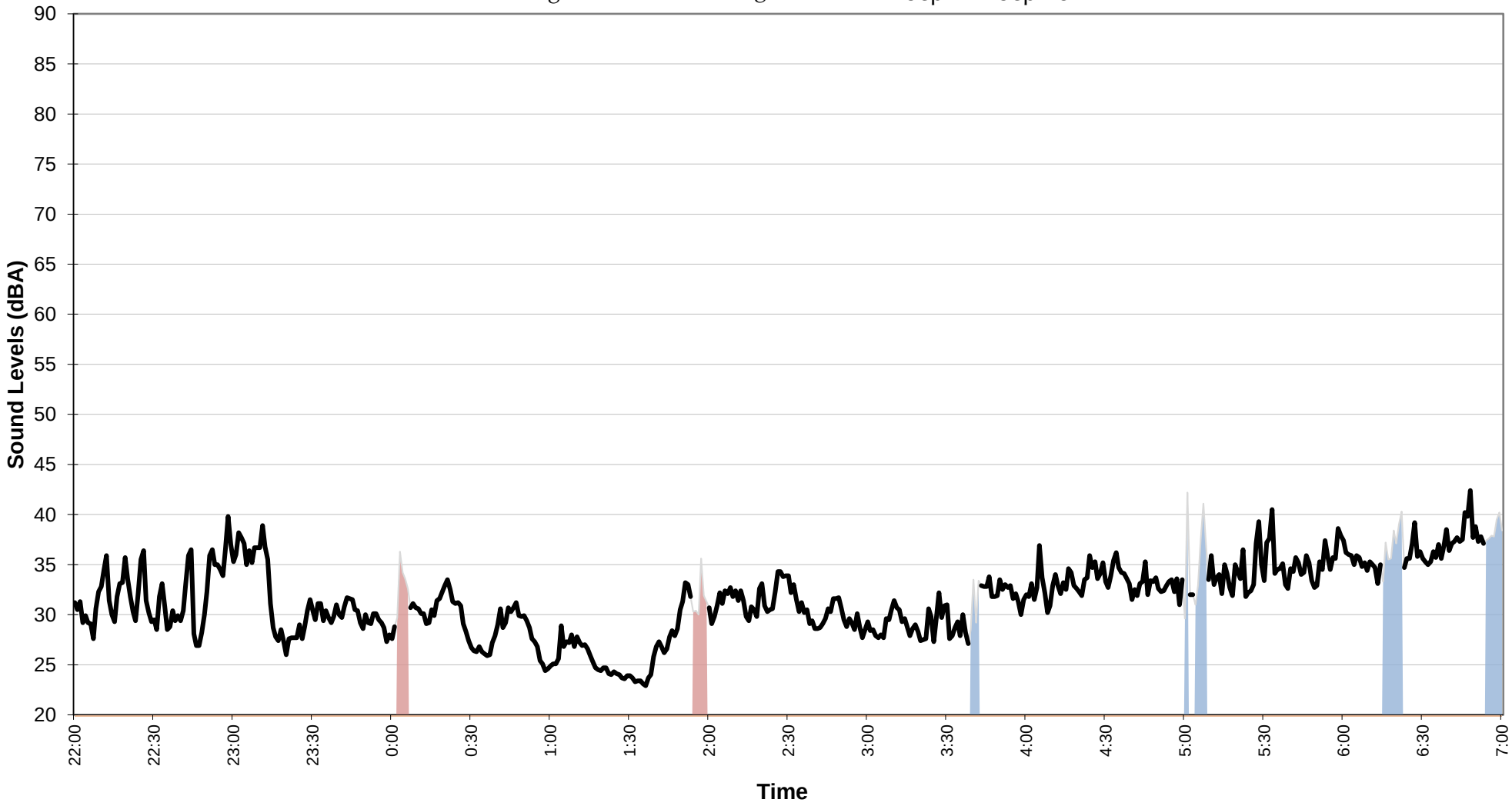
Comprehensive Sound Survey - Monitor B

Figure E1 Day 1 Sep 17



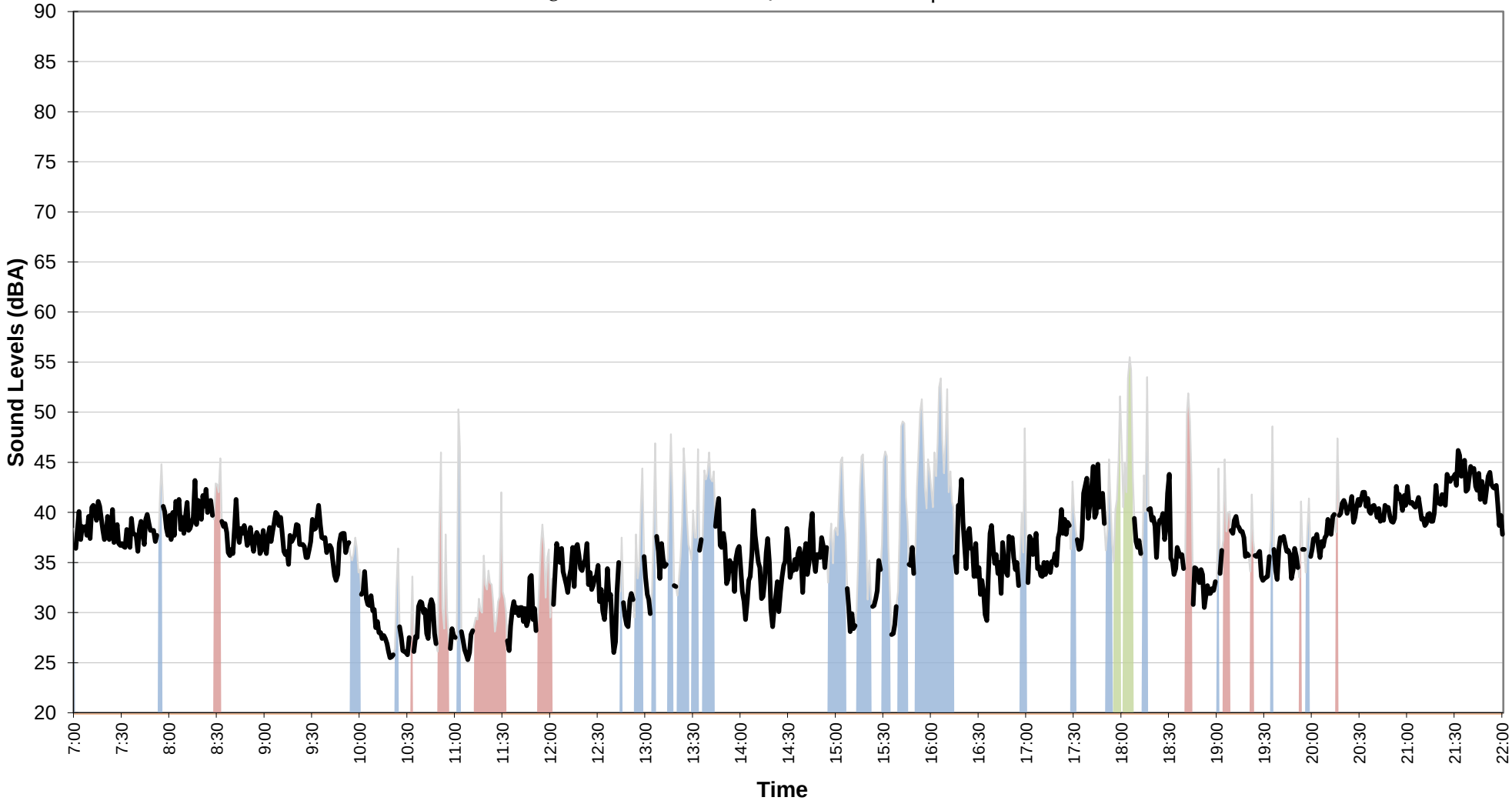
Comprehensive Sound Survey - Monitor B

Figure E2 Night 1 Sep 17 - Sep 18



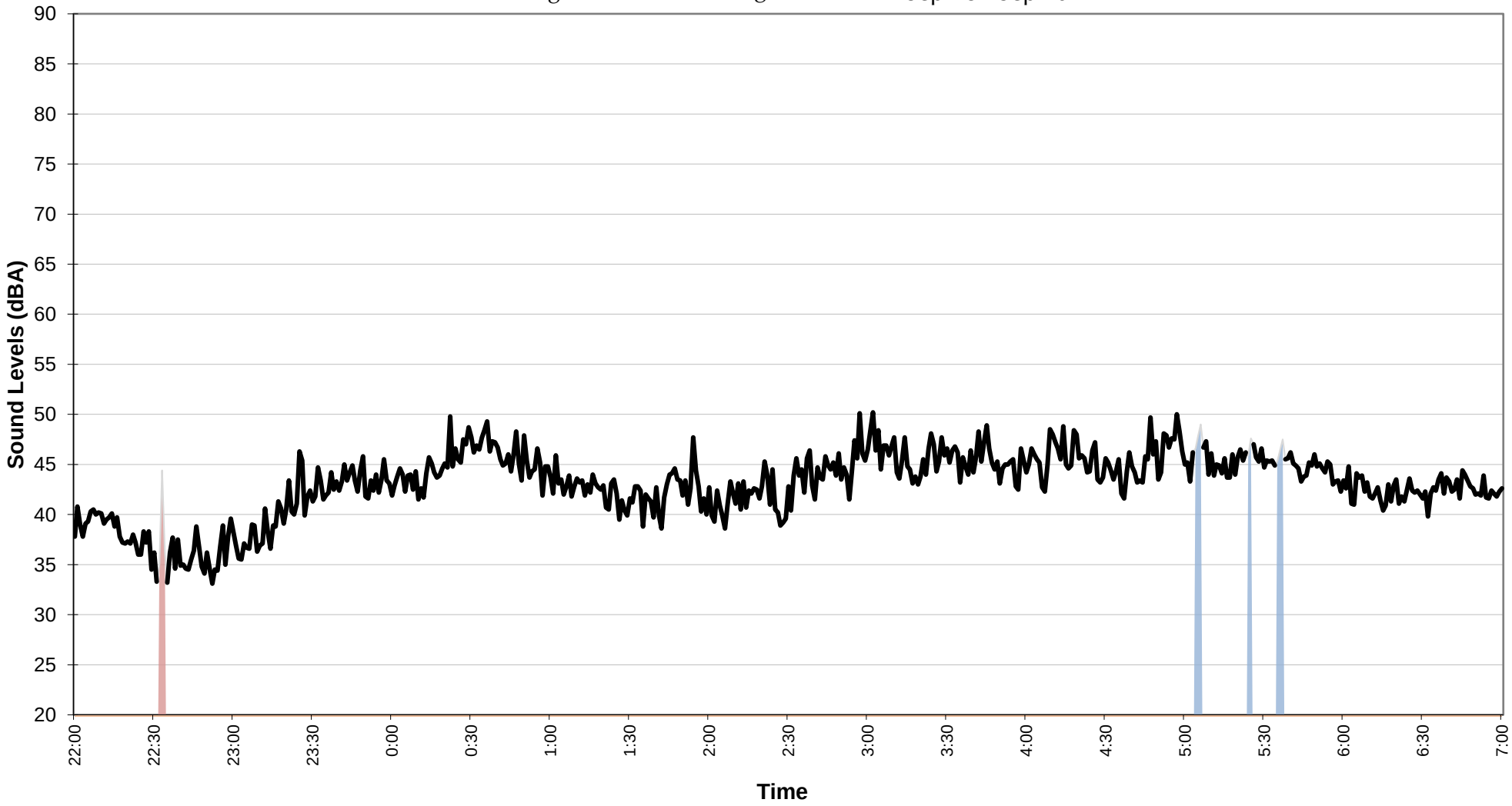
Comprehensive Sound Survey - Monitor B

Figure E3 Day 2 Sep 18



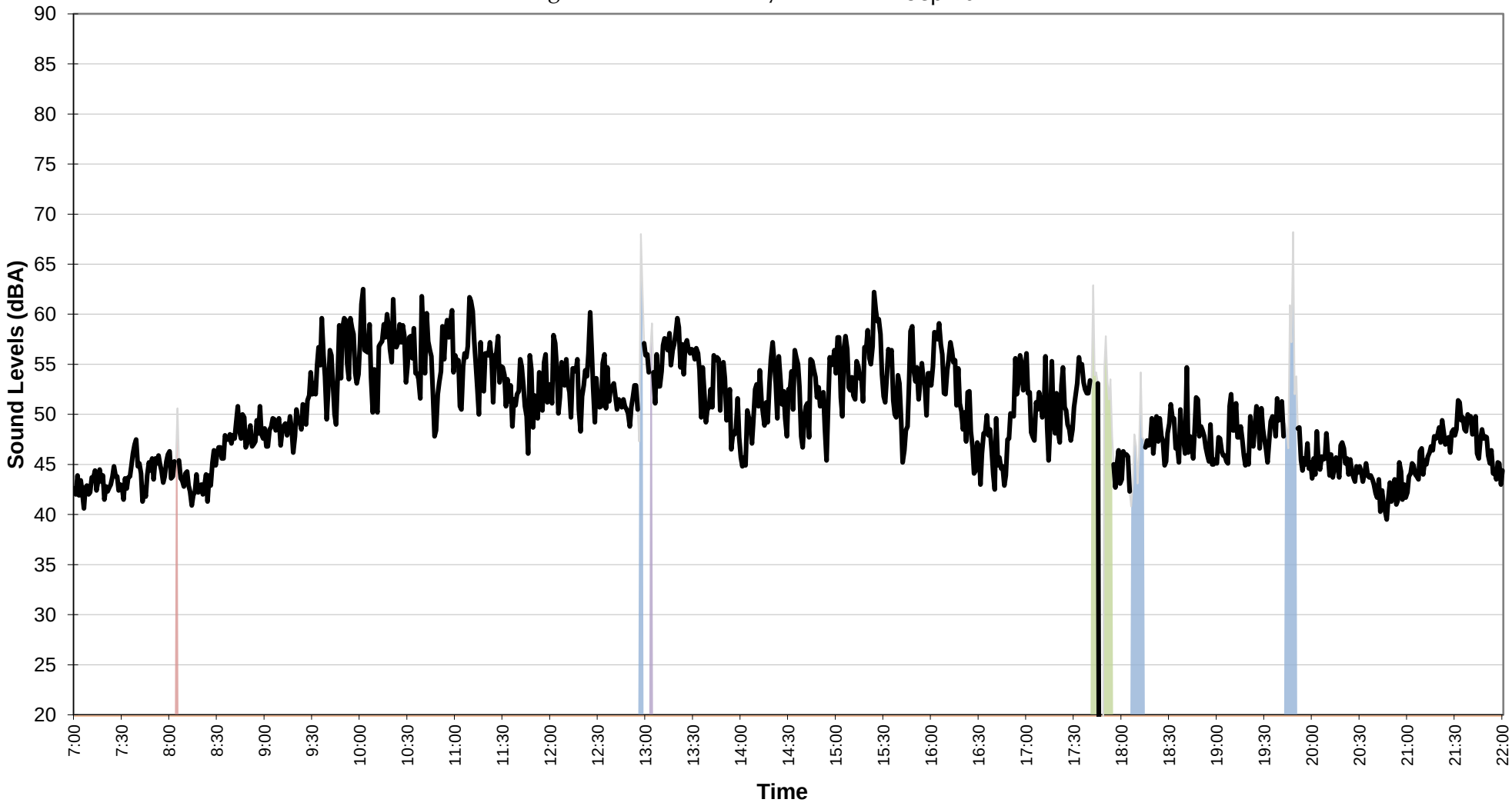
Comprehensive Sound Survey - Monitor B

Figure E4 Night 2 Sep 18 - Sep 19



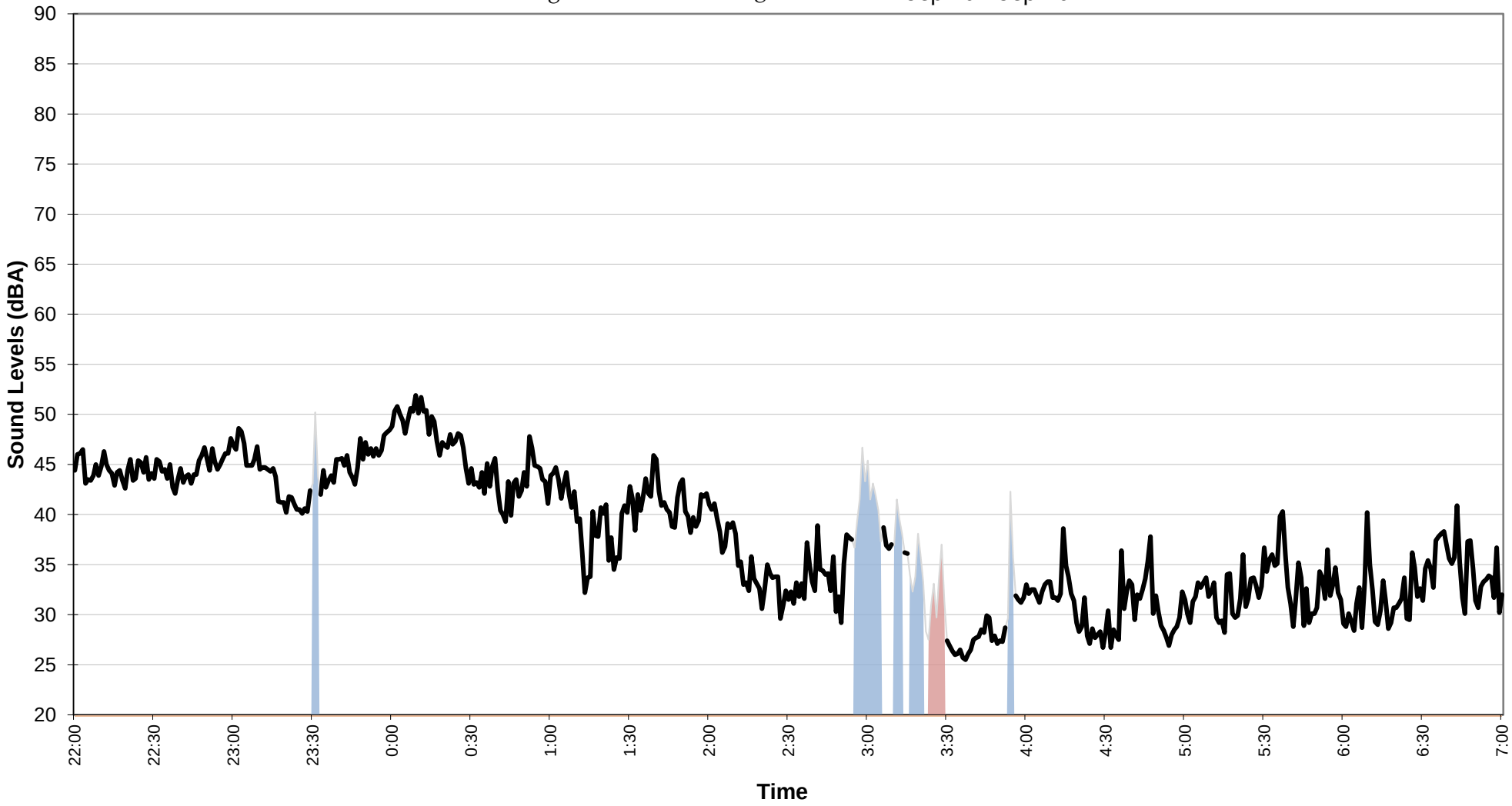
Comprehensive Sound Survey - Monitor B

Figure E5 Day 3 Sep 19



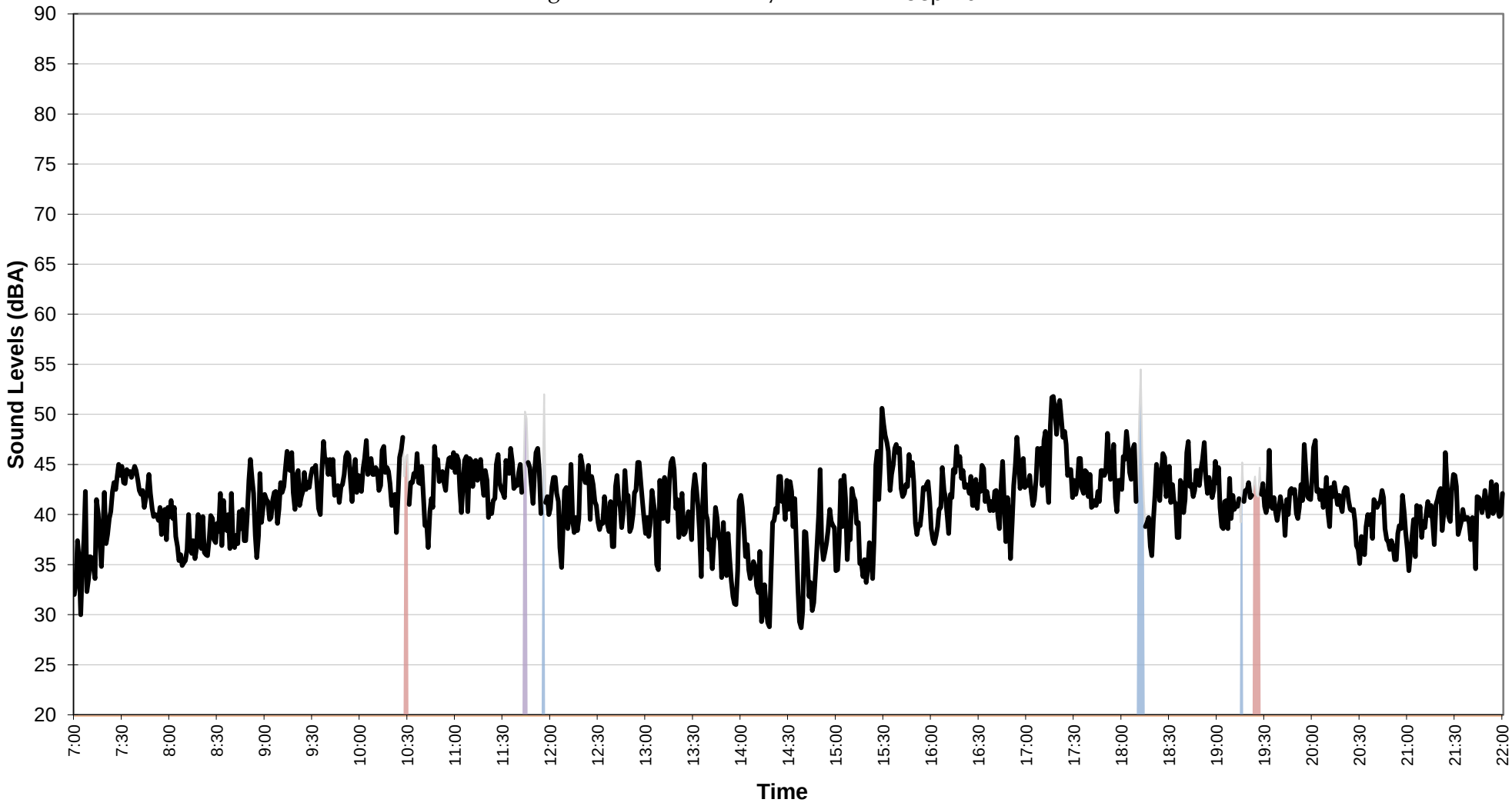
Comprehensive Sound Survey - Monitor B

Figure E6 Night 3 Sep 19 - Sep 20



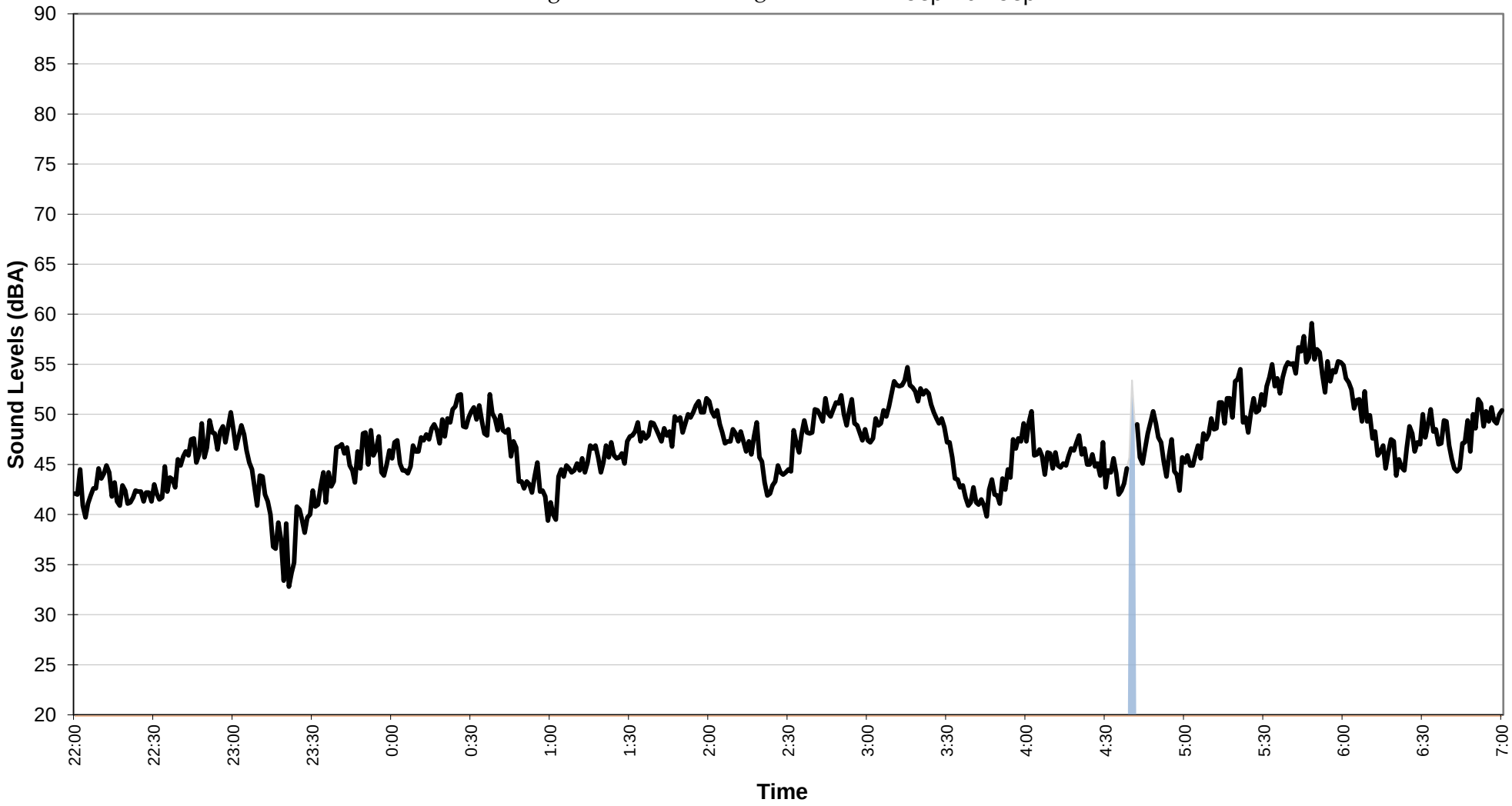
Comprehensive Sound Survey - Monitor B

Figure E7 Day 4 Sep 20



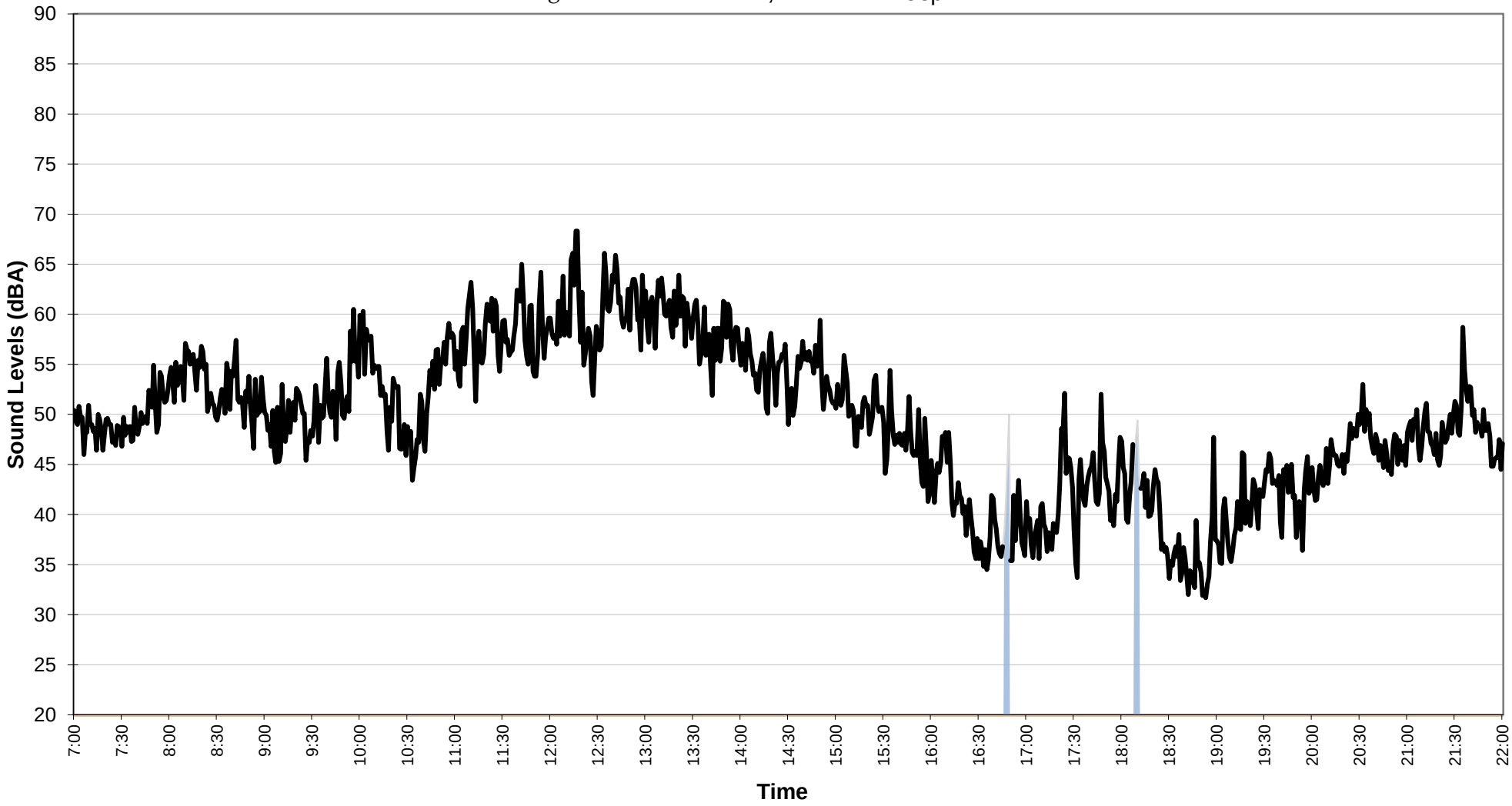
Comprehensive Sound Survey - Monitor B

Figure E8 Night 4 Sep 20 - Sep 21



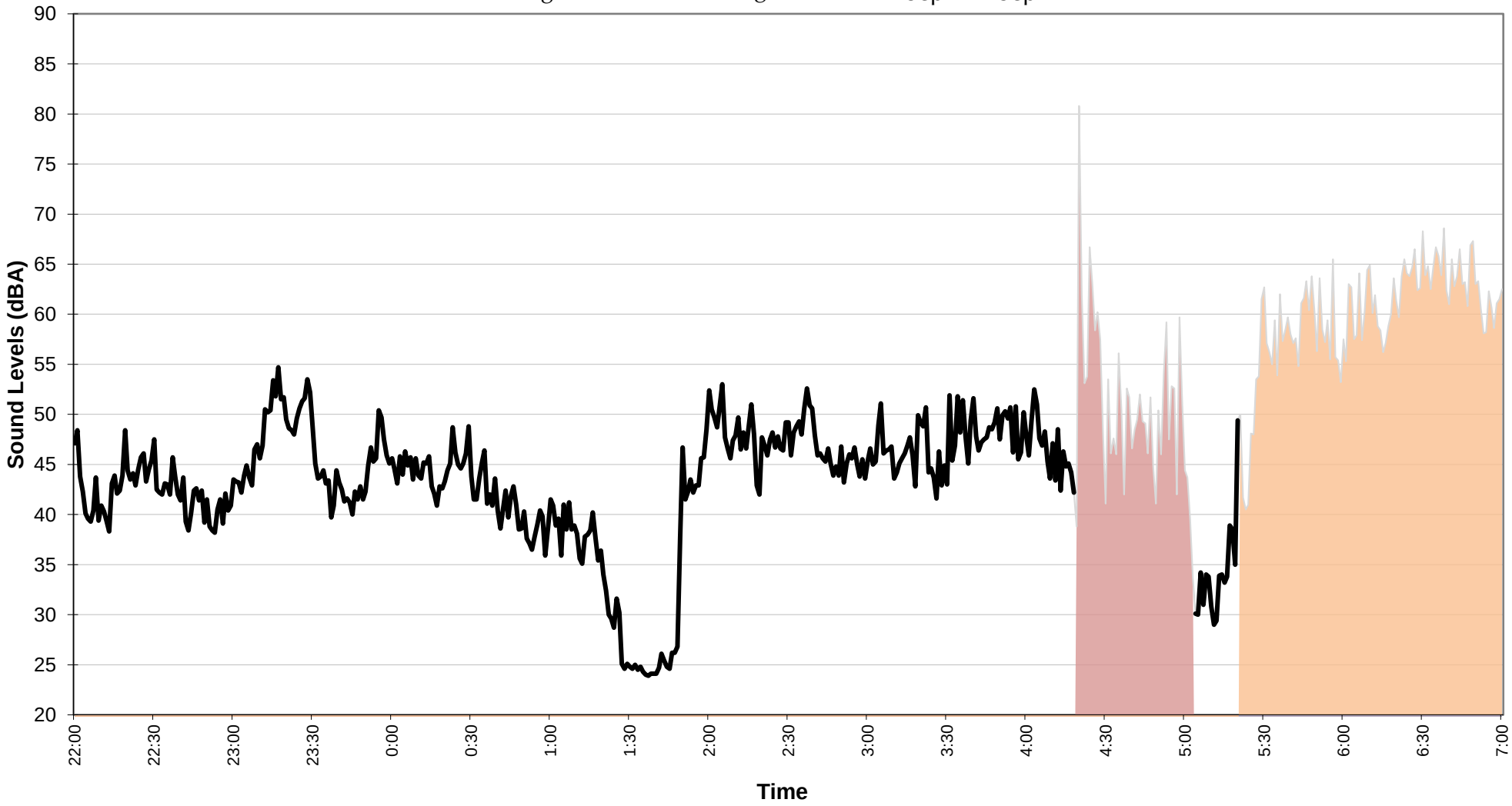
Comprehensive Sound Survey - Monitor B

Figure E9 Day 5 Sep 21



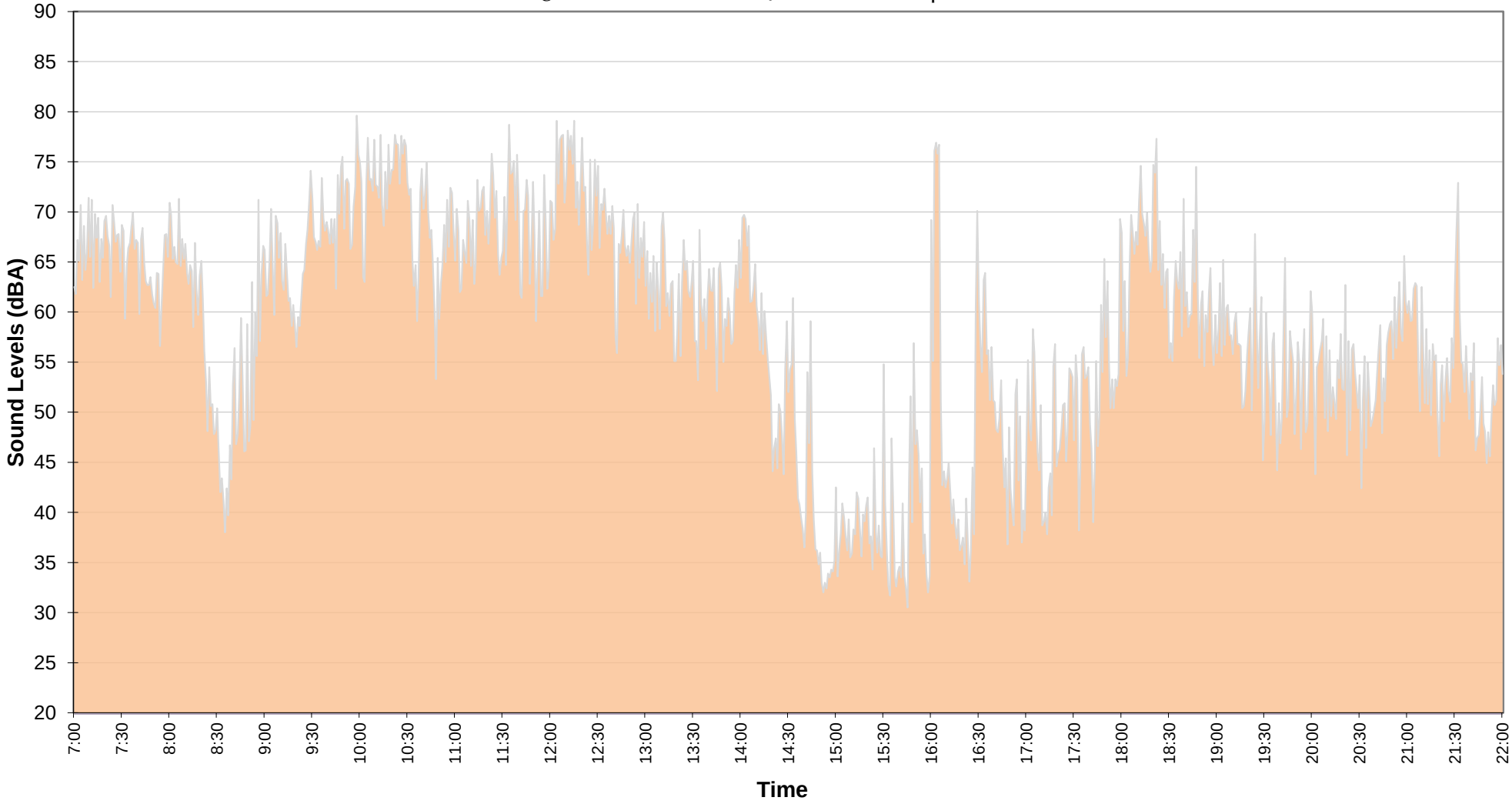
Comprehensive Sound Survey - Monitor B

Figure E10 Night 5 Sep 21 - Sep 22



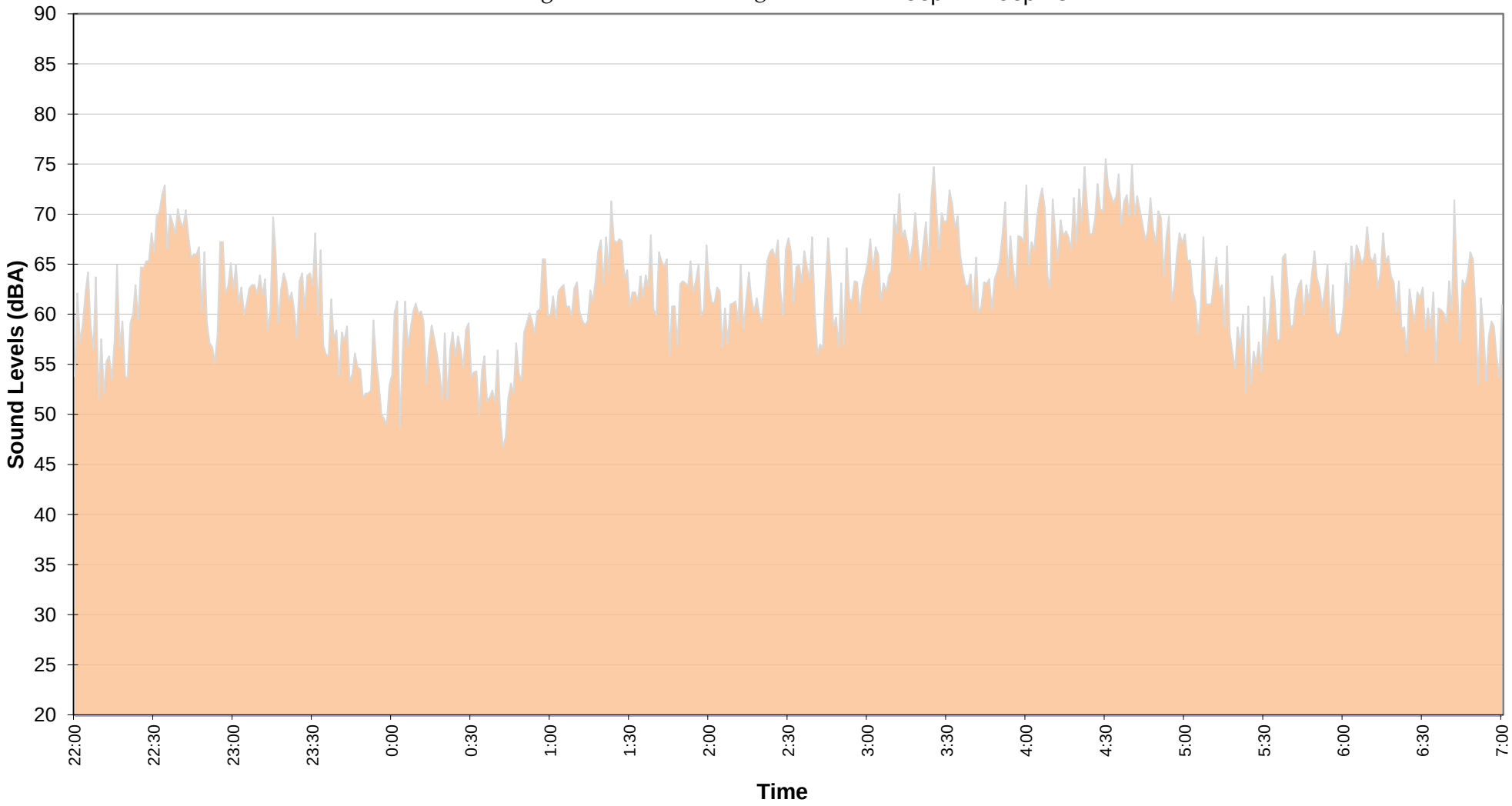
Comprehensive Sound Survey - Monitor B

Figure E11 Day 6 Sep 22



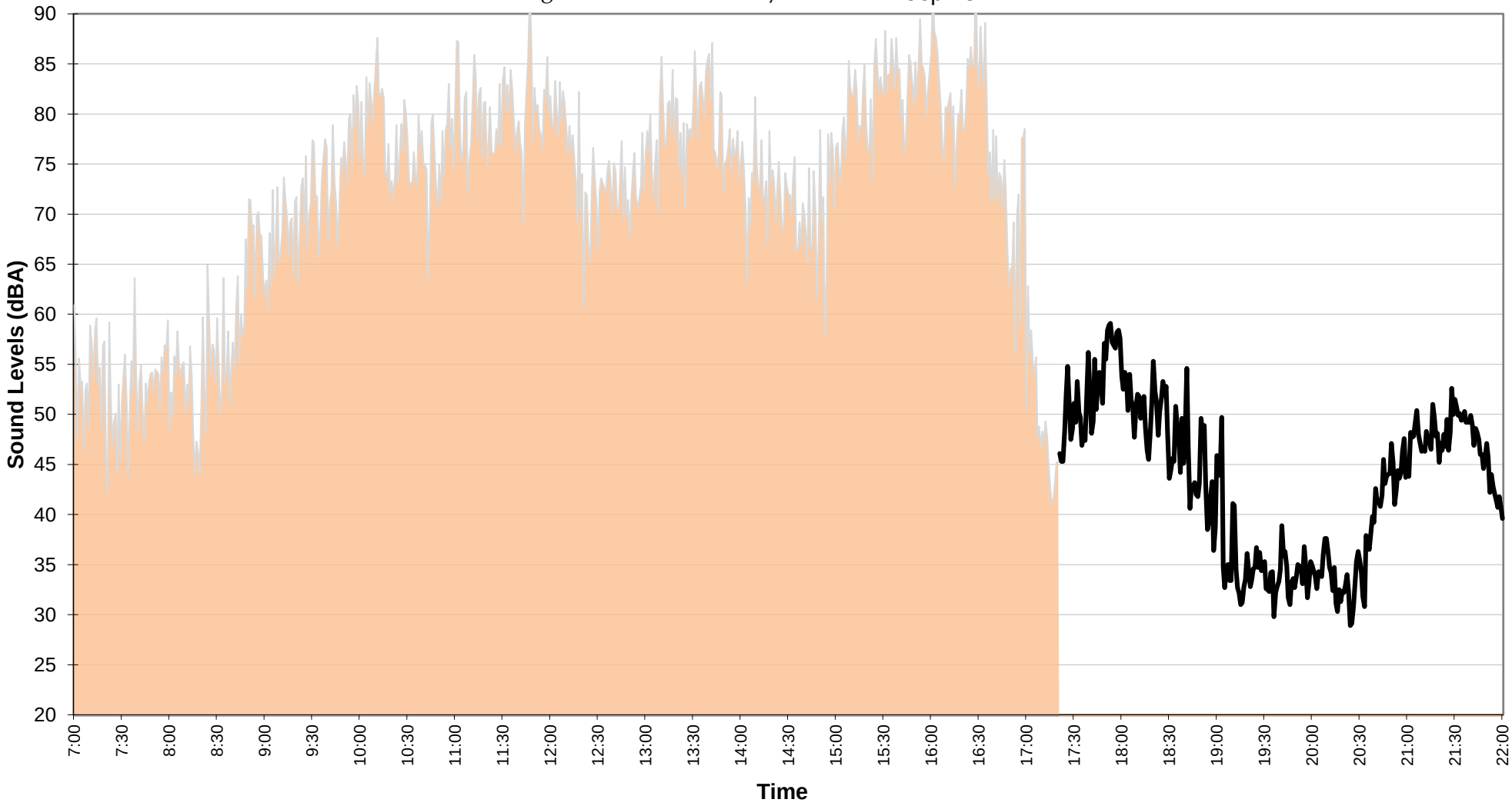
Comprehensive Sound Survey - Monitor B

Figure E12 Night 6 Sep 22 - Sep 23



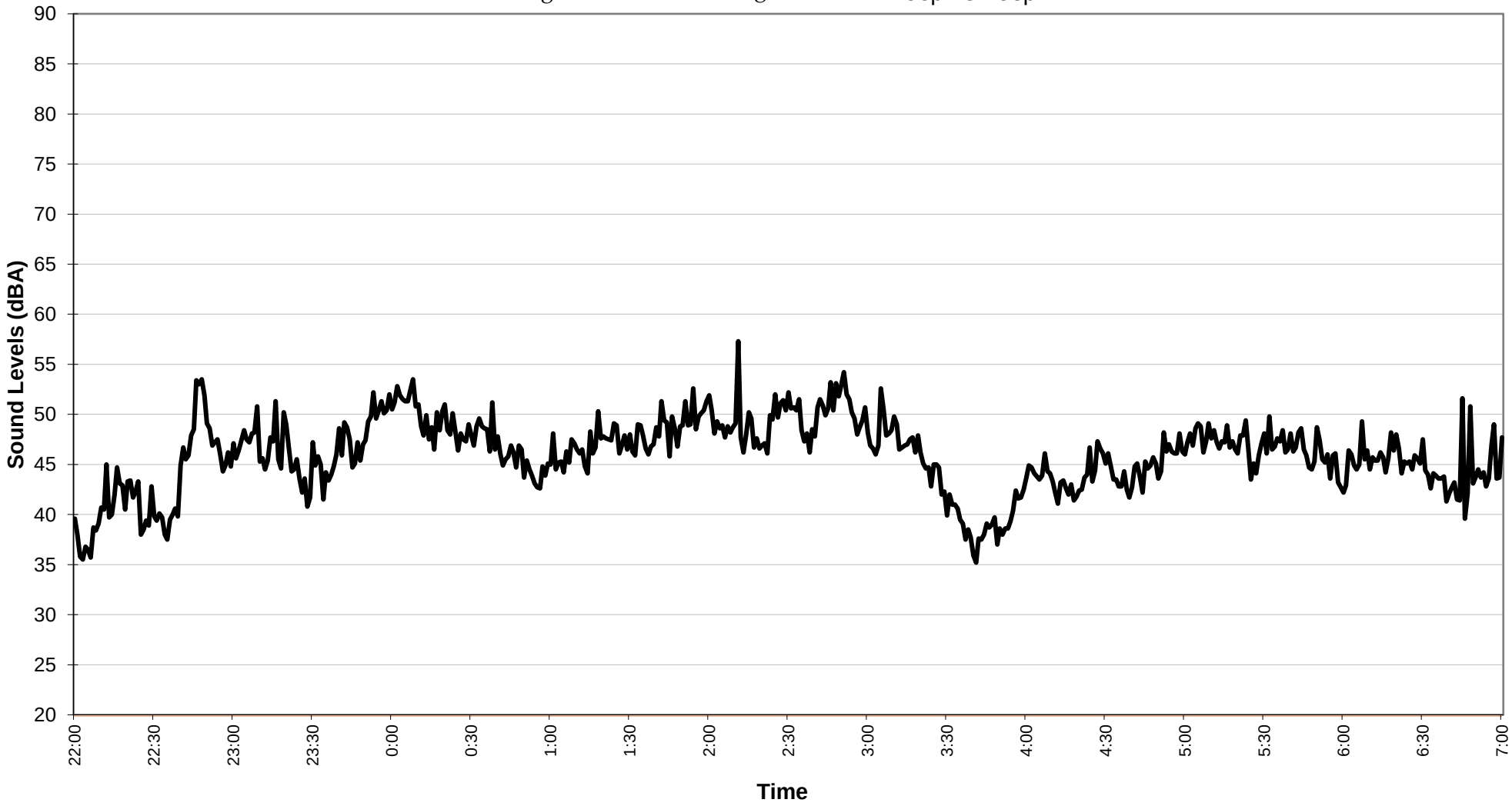
Comprehensive Sound Survey - Monitor B

Figure E13 Day 7 Sep 23



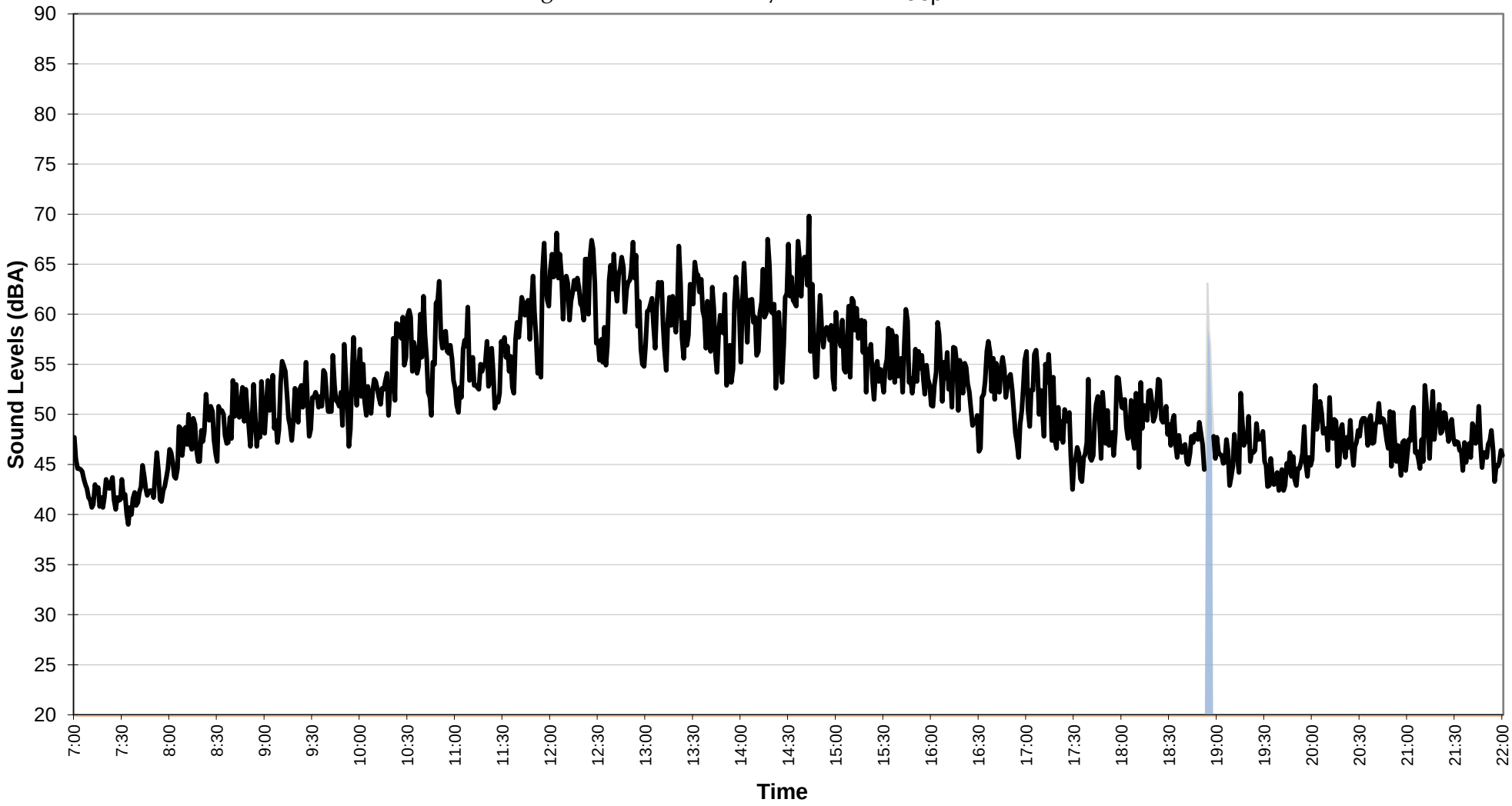
Comprehensive Sound Survey - Monitor B

Figure E14 Night 7 Sep 23 - Sep 24



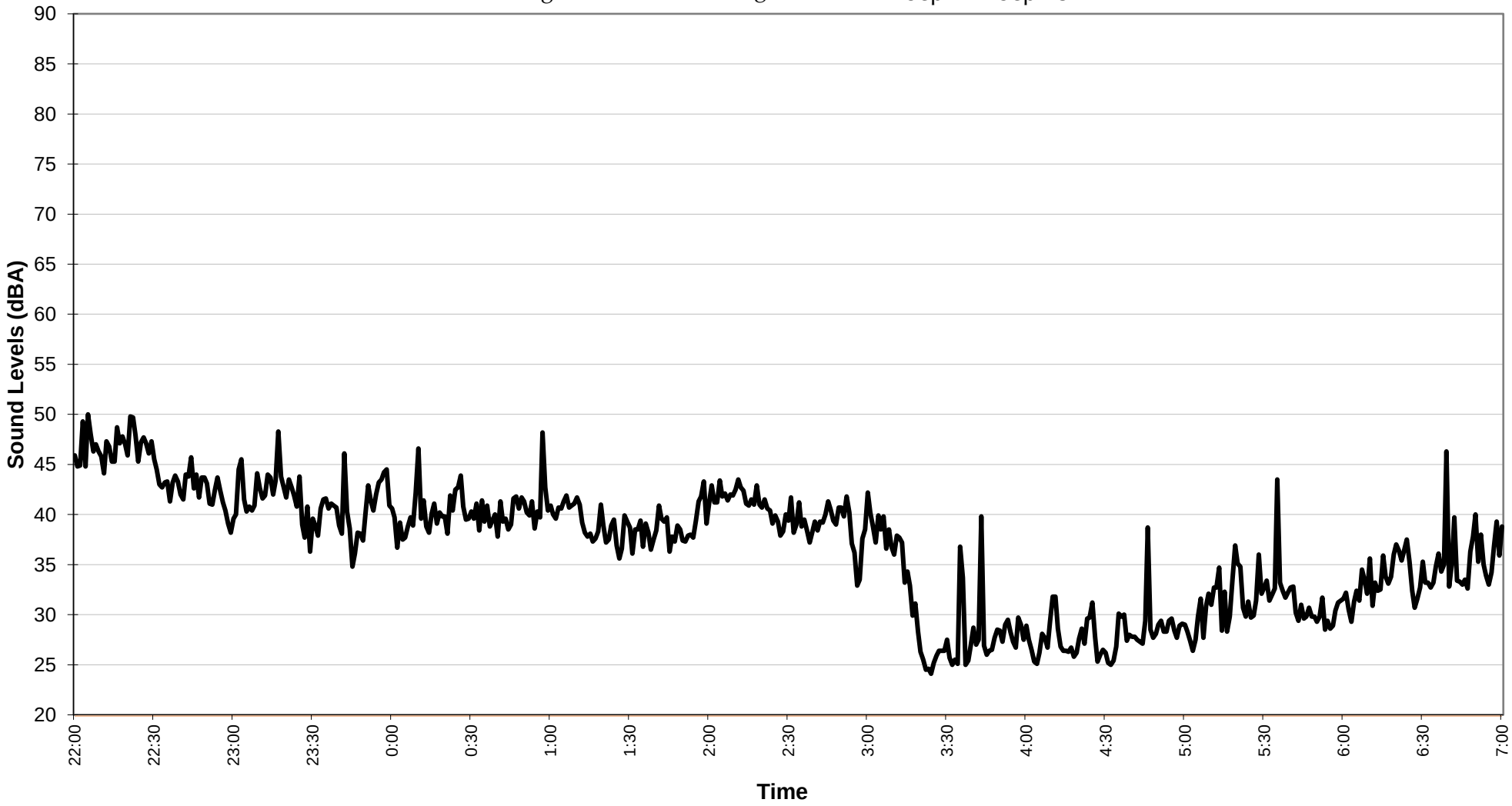
Comprehensive Sound Survey - Monitor B

Figure E15 Day 8 Sep 24



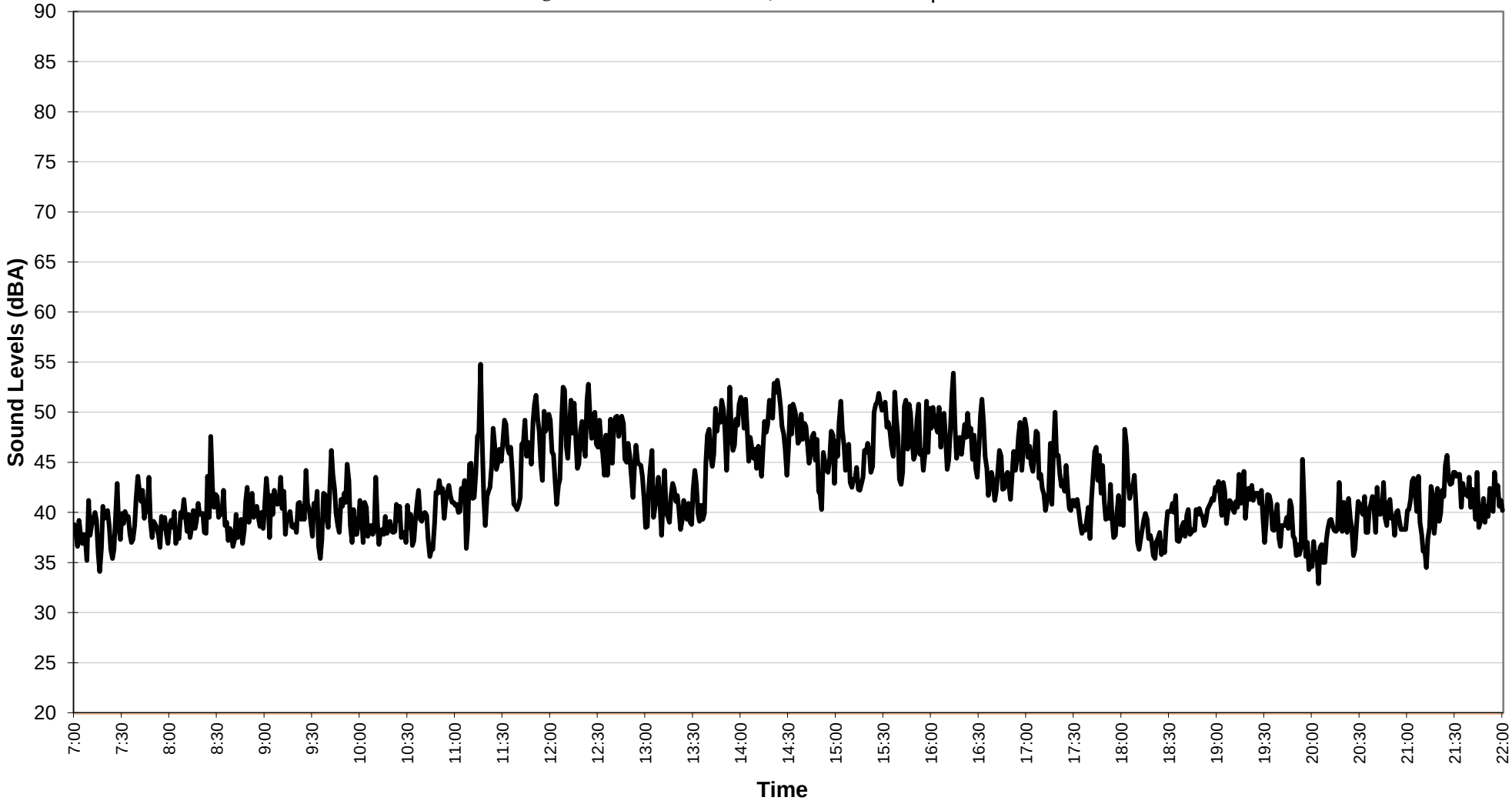
Comprehensive Sound Survey - Monitor B

Figure E16 Night 8 Sep 24 - Sep 25



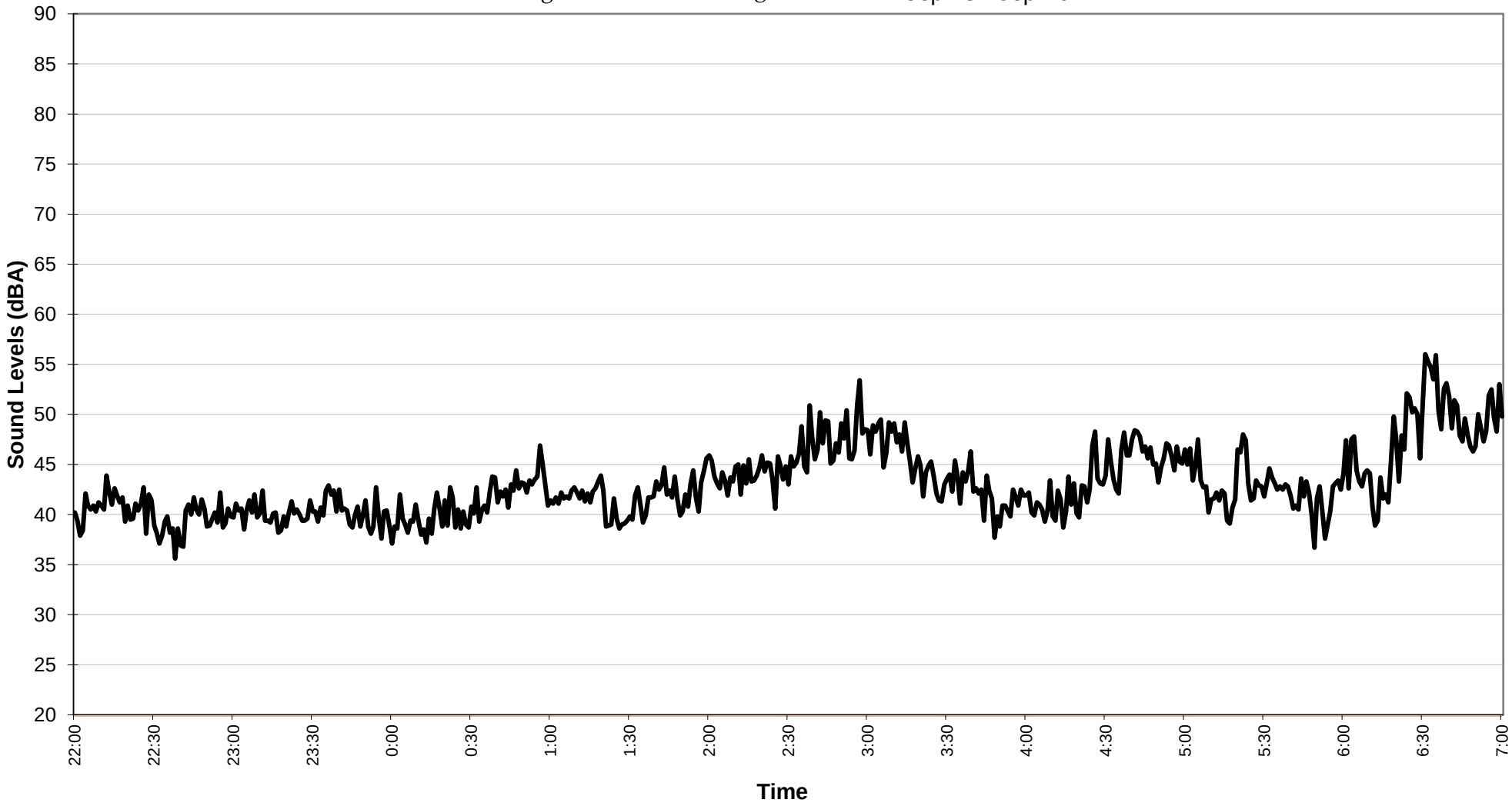
Comprehensive Sound Survey - Monitor B

Figure E17 Day 9 Sep 25



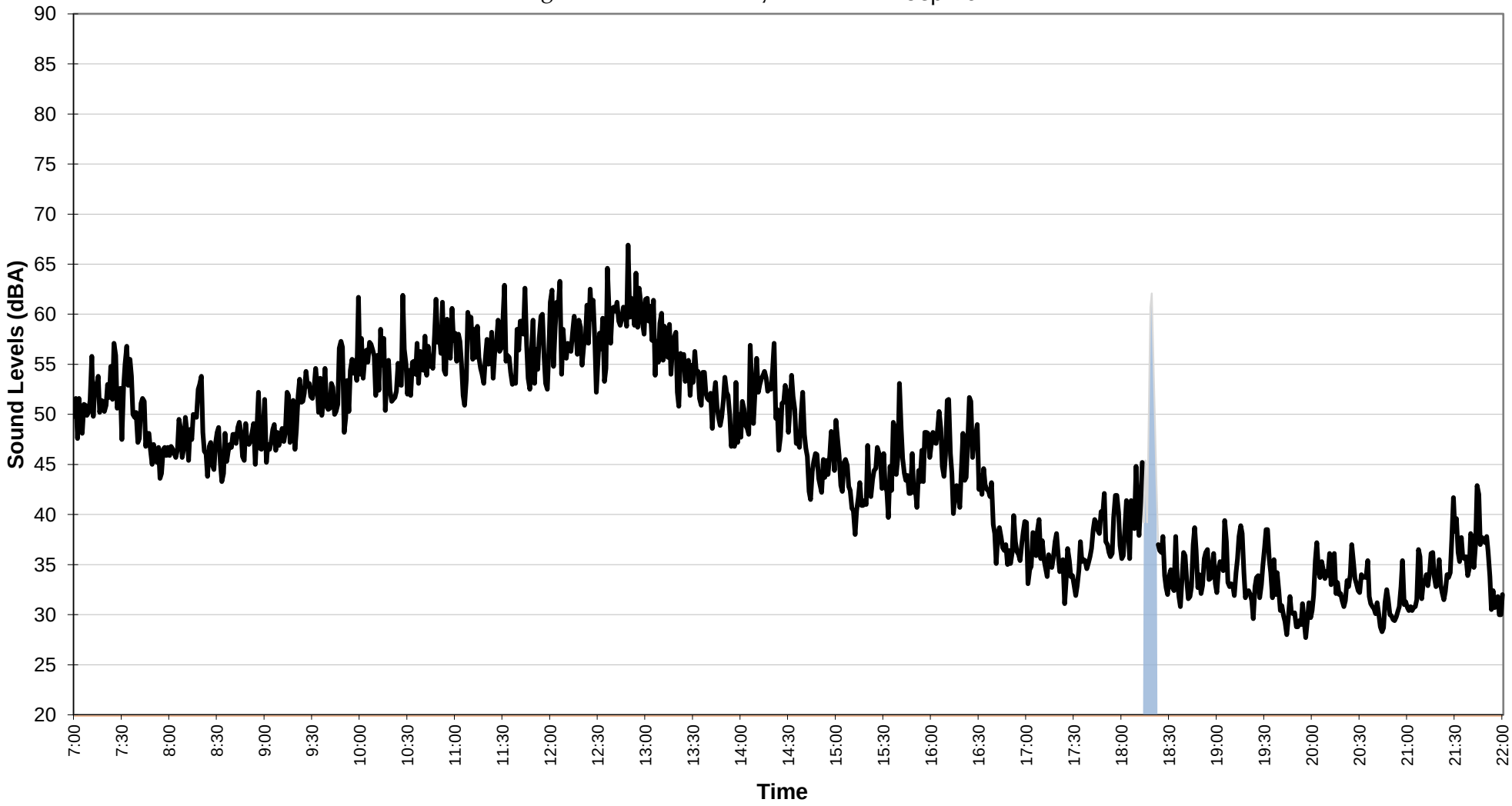
Comprehensive Sound Survey - Monitor B

Figure E18 Night 9 Sep 25 - Sep 26



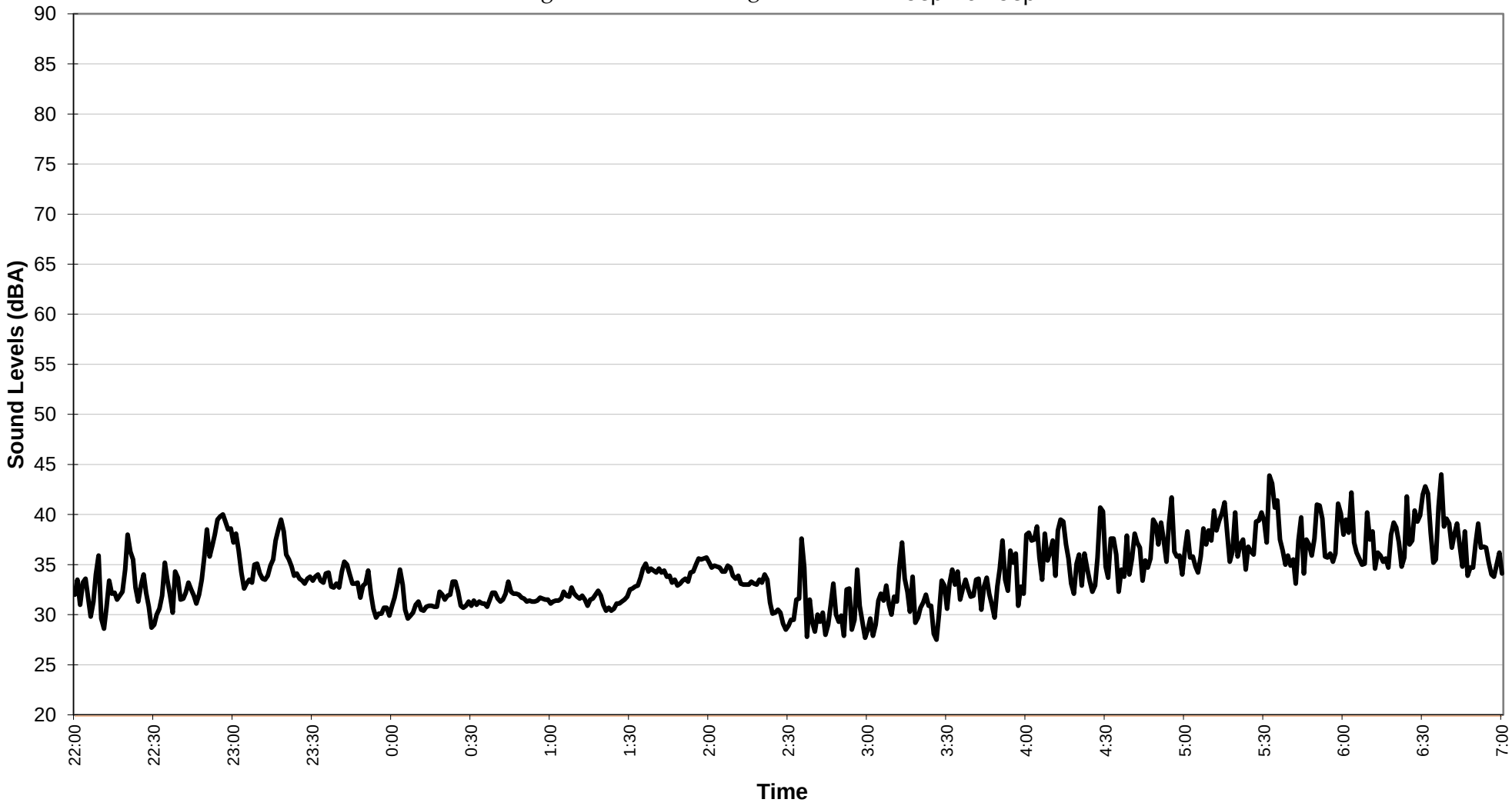
Comprehensive Sound Survey - Monitor B

Figure E19 Day 10 Sep 26



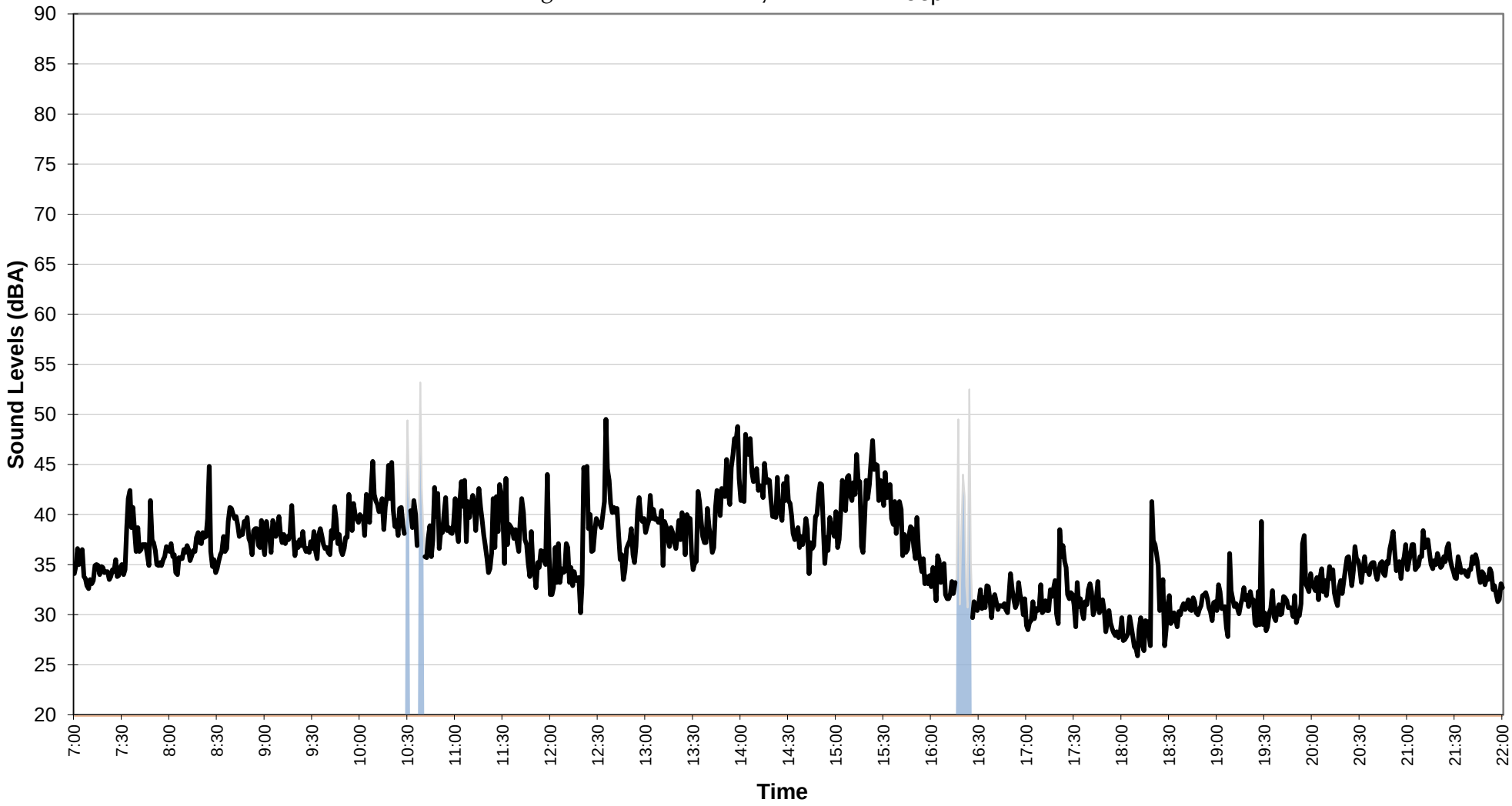
Comprehensive Sound Survey - Monitor B

Figure E20 Night 10 Sep 26 - Sep 27



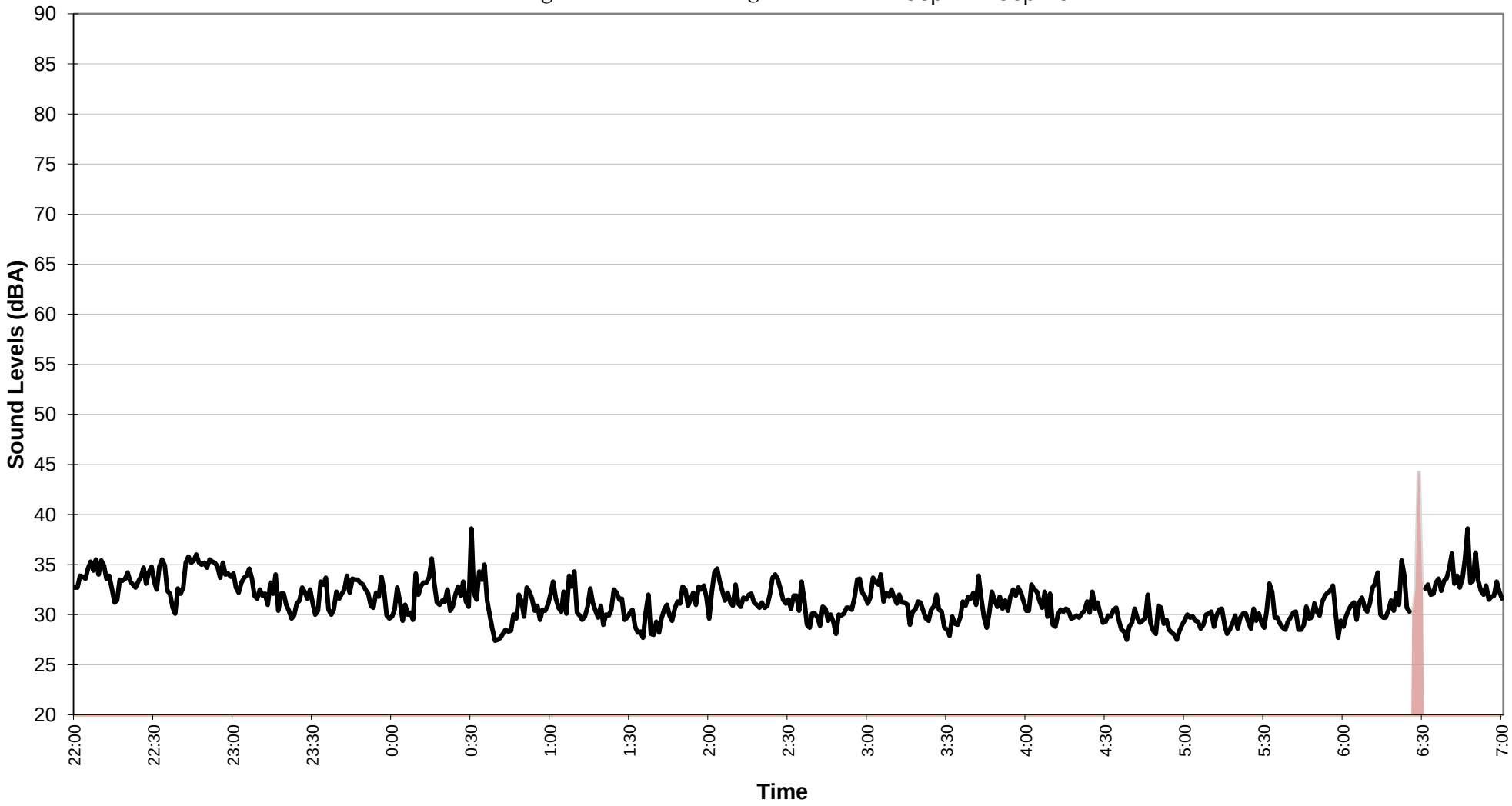
Comprehensive Sound Survey - Monitor B

Figure E21 Day 11 Sep 27



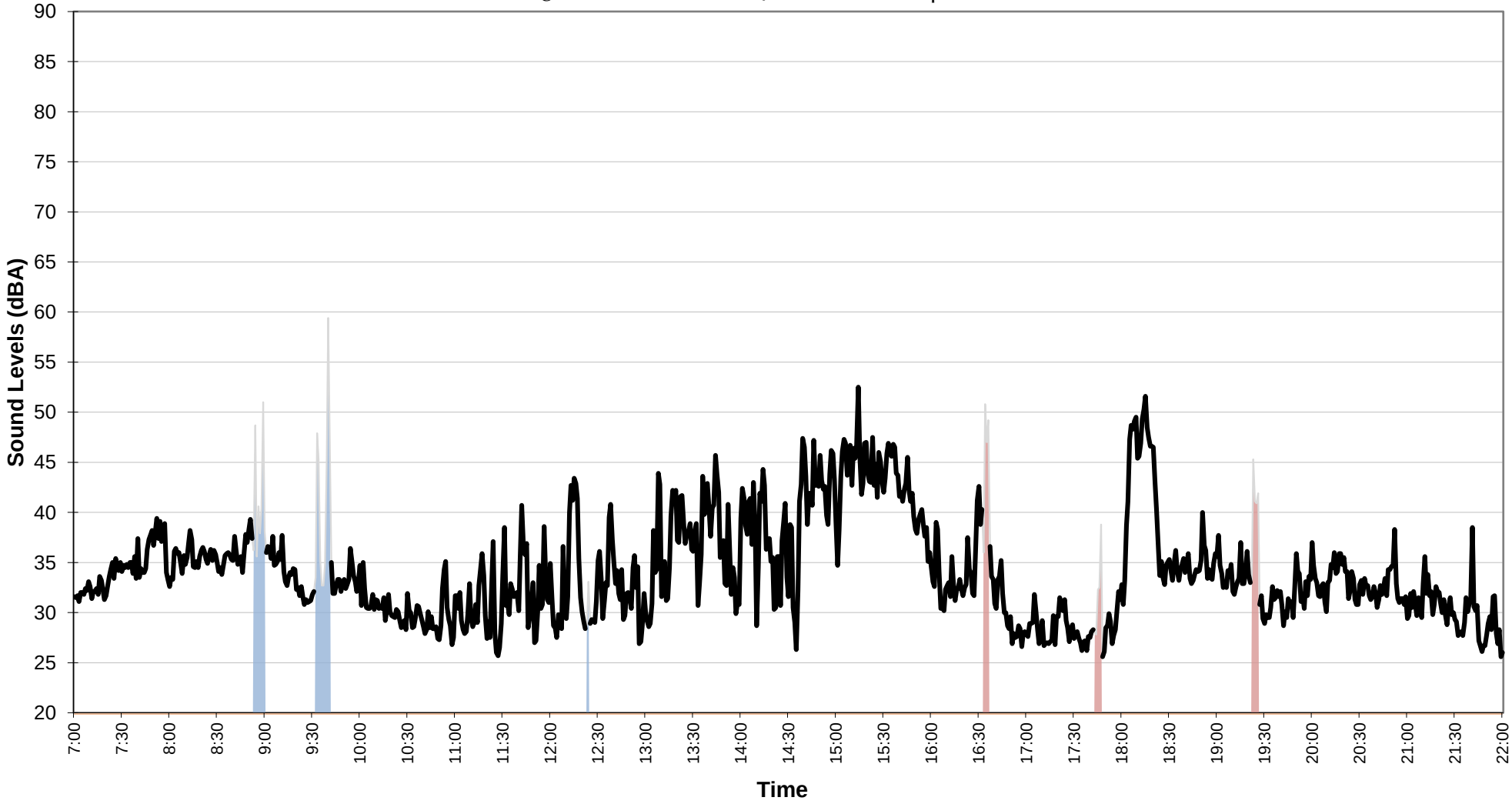
Comprehensive Sound Survey - Monitor B

Figure E22 Night 11 Sep 27 - Sep 28



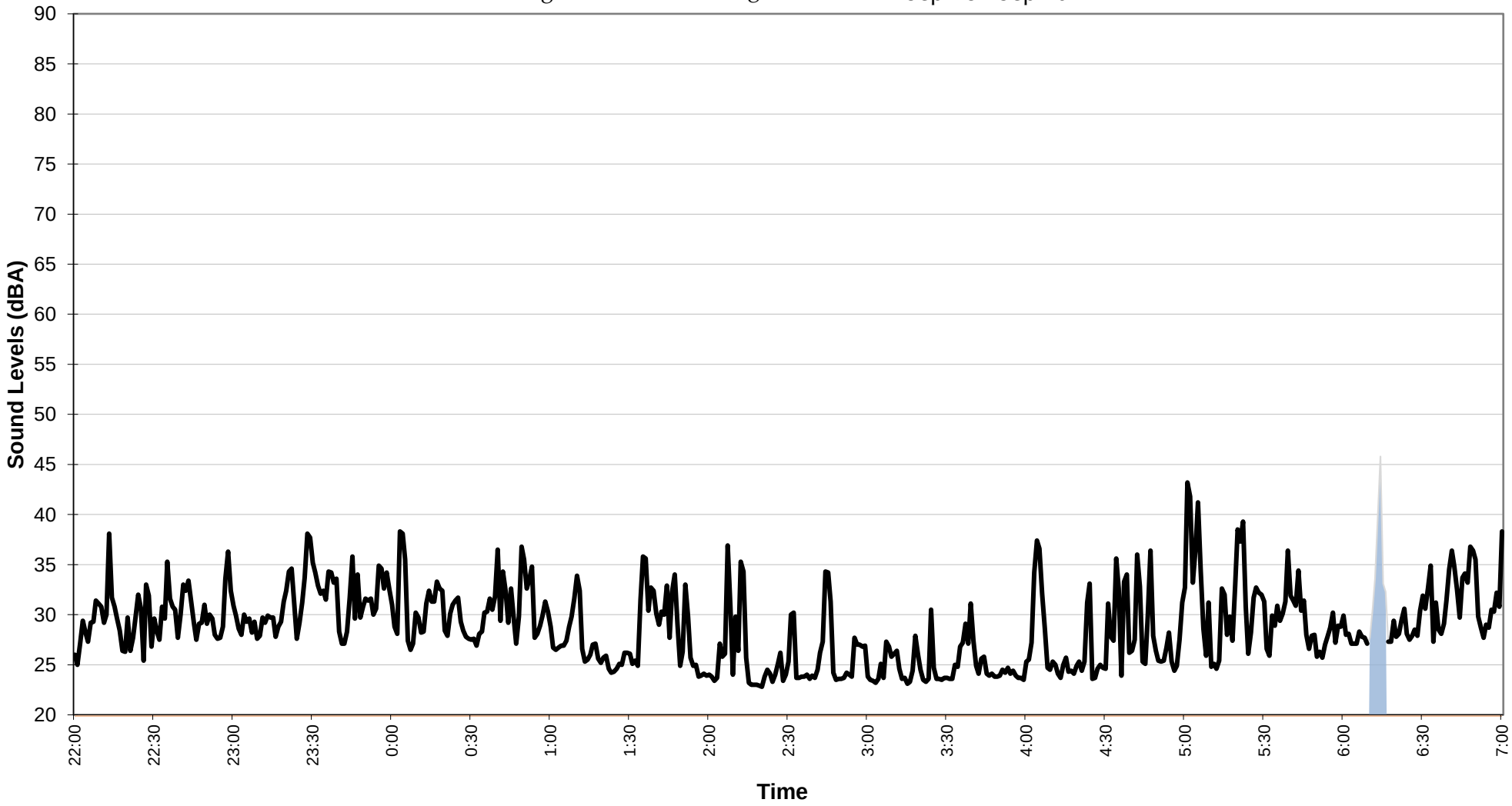
Comprehensive Sound Survey - Monitor B

Figure E23 Day 12 Sep 28



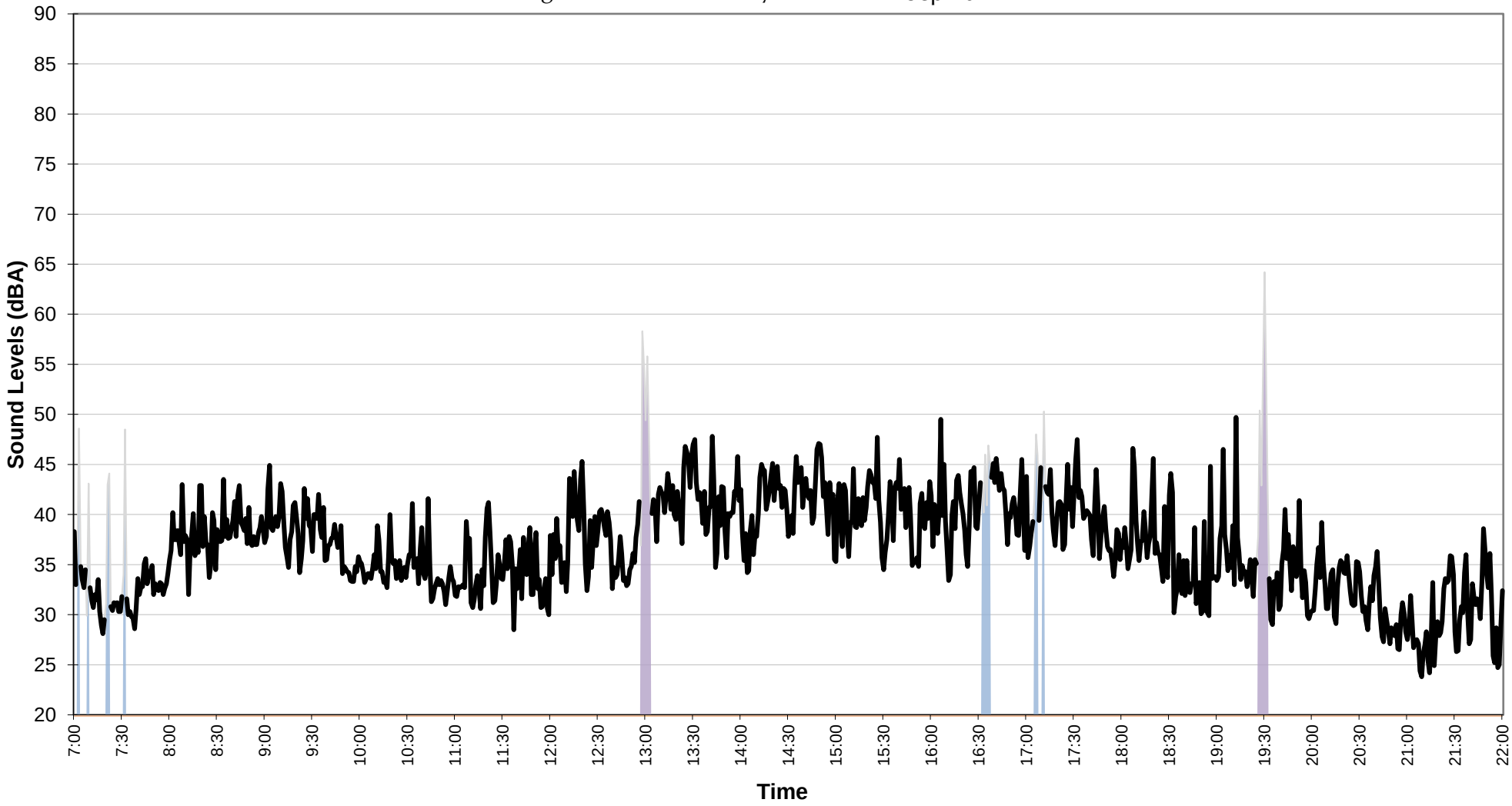
Comprehensive Sound Survey - Monitor B

Figure E24 Night 12 Sep 28 - Sep 29



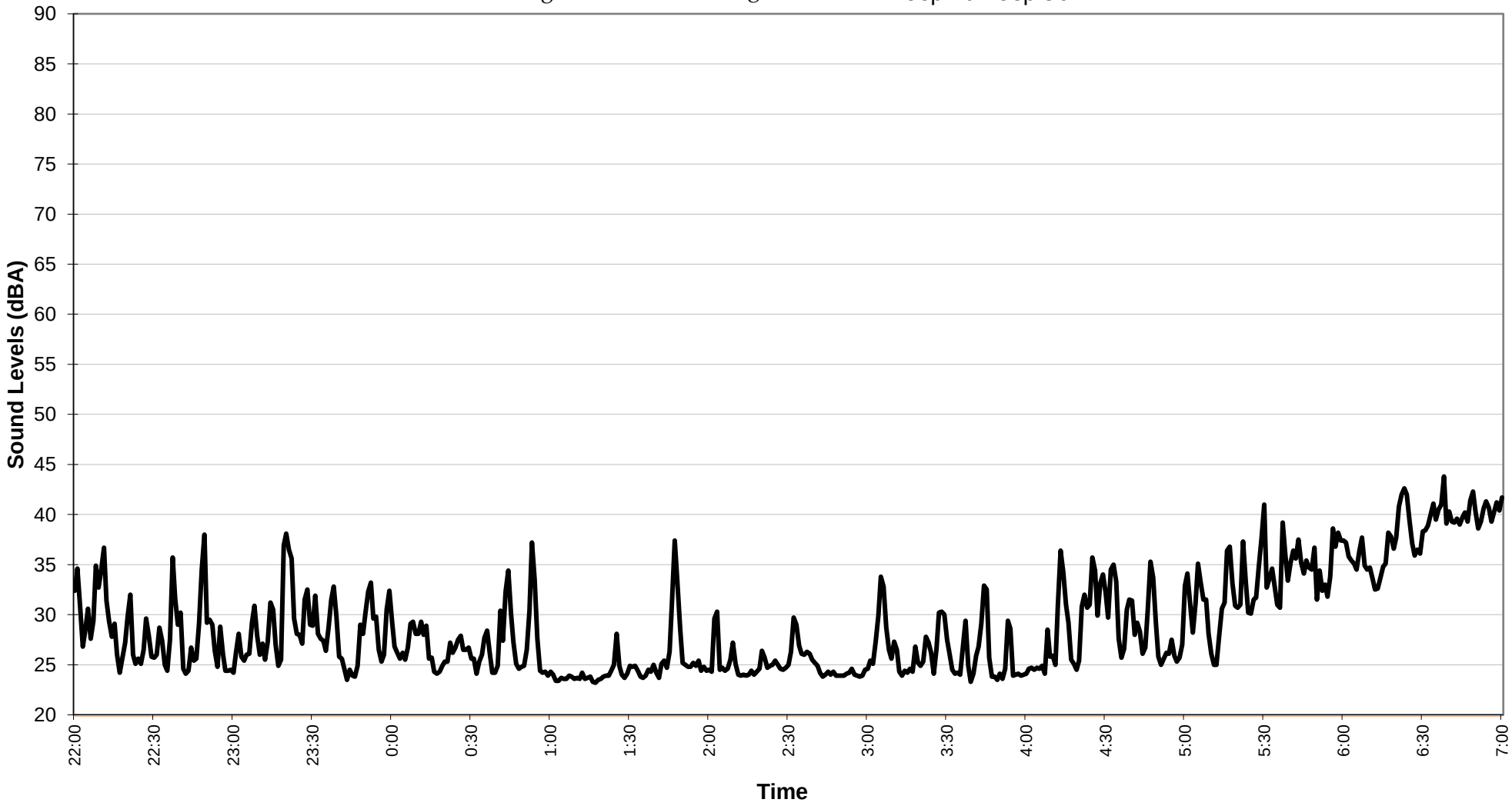
Comprehensive Sound Survey - Monitor B

Figure E25 Day 13 Sep 29



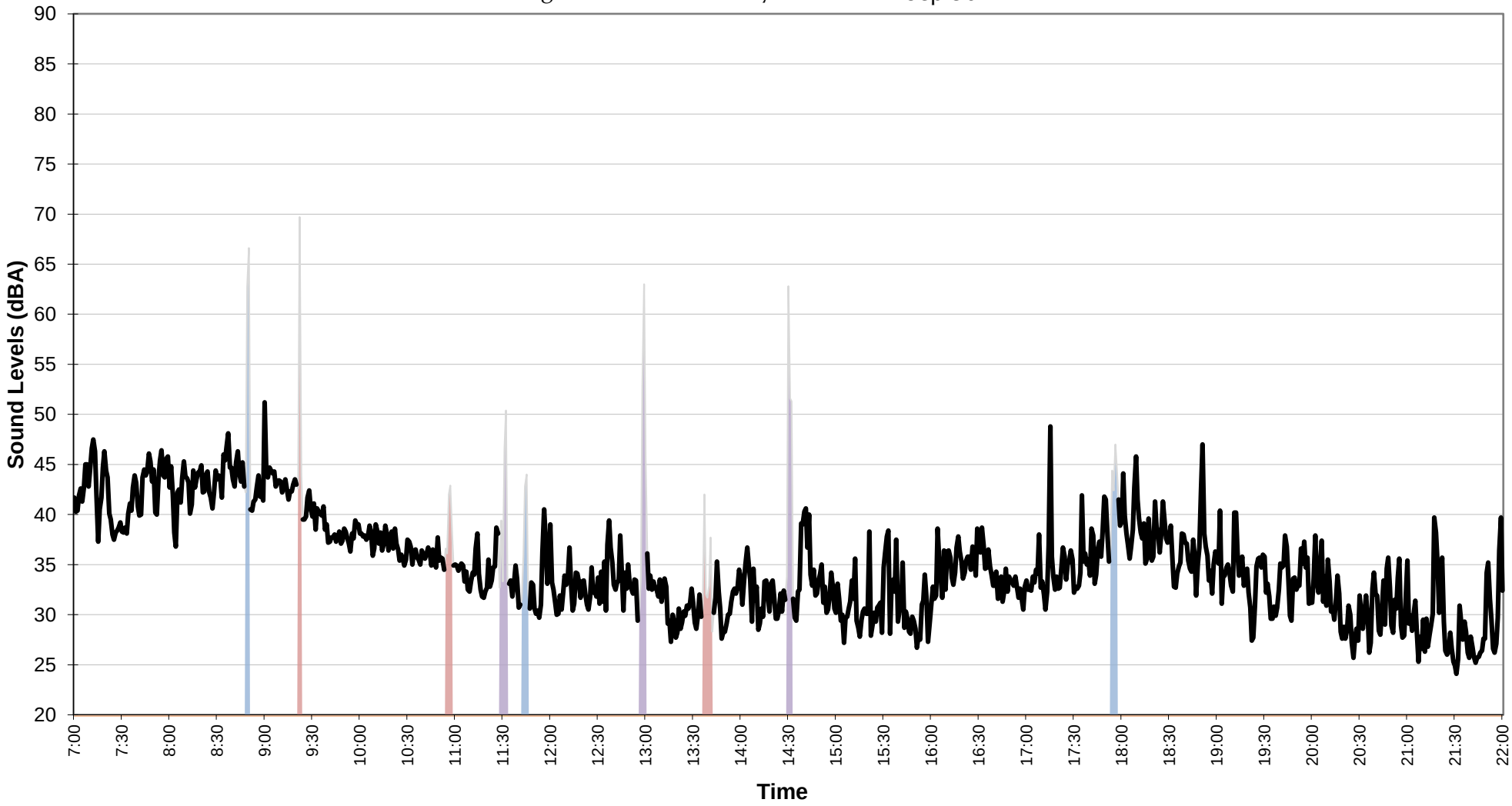
Comprehensive Sound Survey - Monitor B

Figure E26 Night 13 Sep 29 - Sep 30



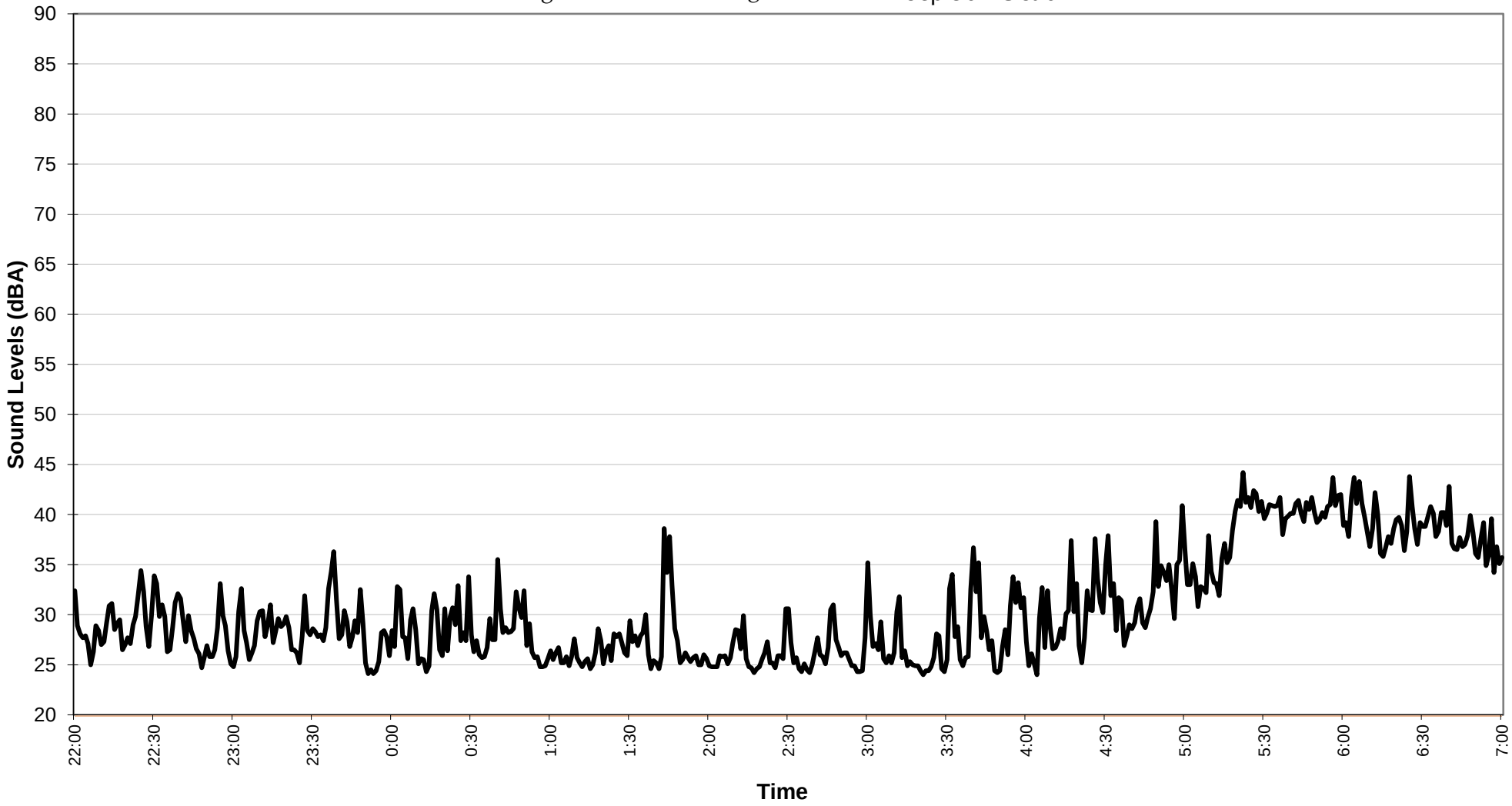
Comprehensive Sound Survey - Monitor B

Figure E27 Day 14 Sep 30



Comprehensive Sound Survey - Monitor B

Figure E28 Night 14 Sep 30 - Oct 01



Comprehensive Sound Survey - Monitor B

Figure E29 Day 15 Oct 01

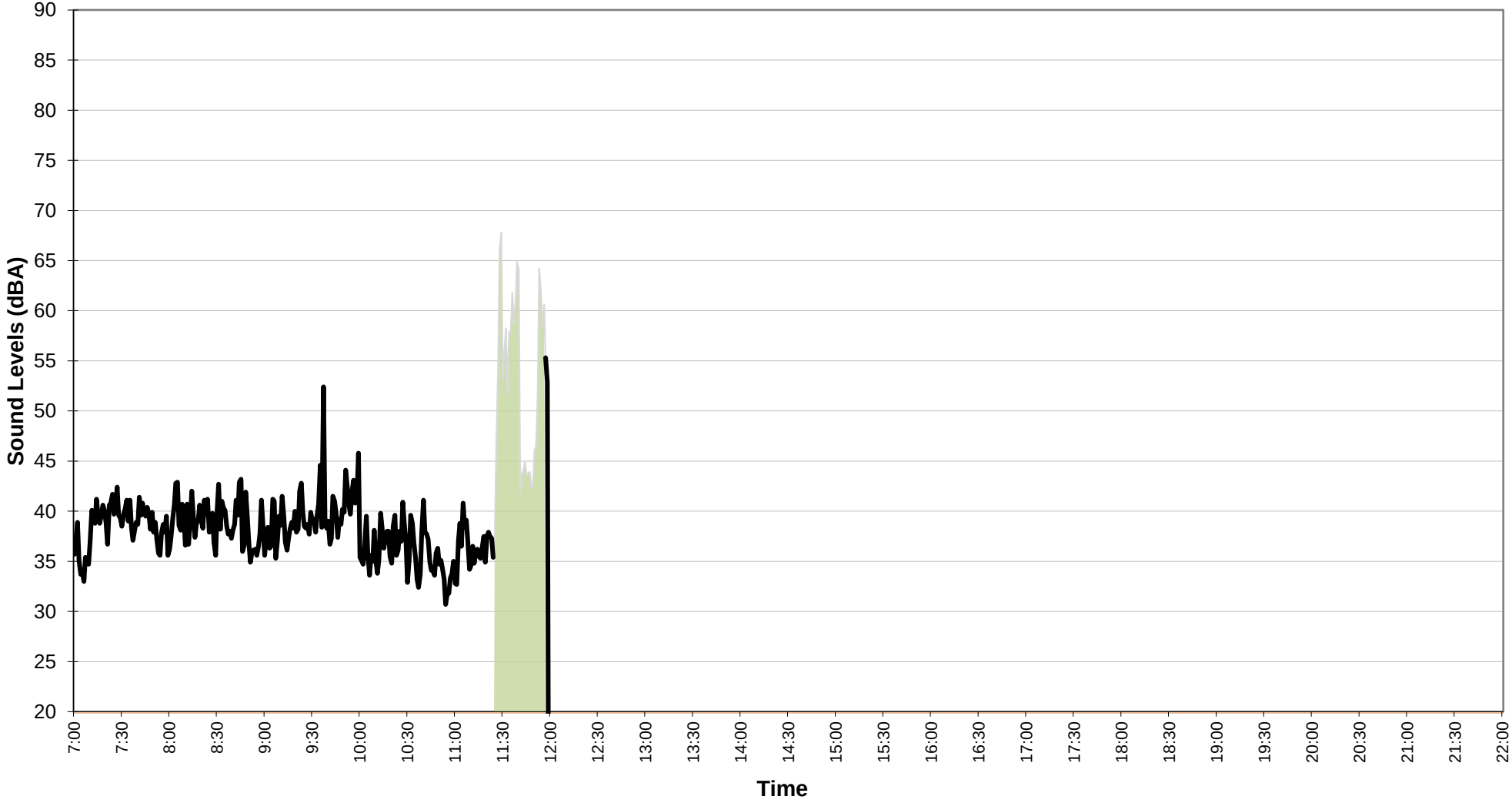
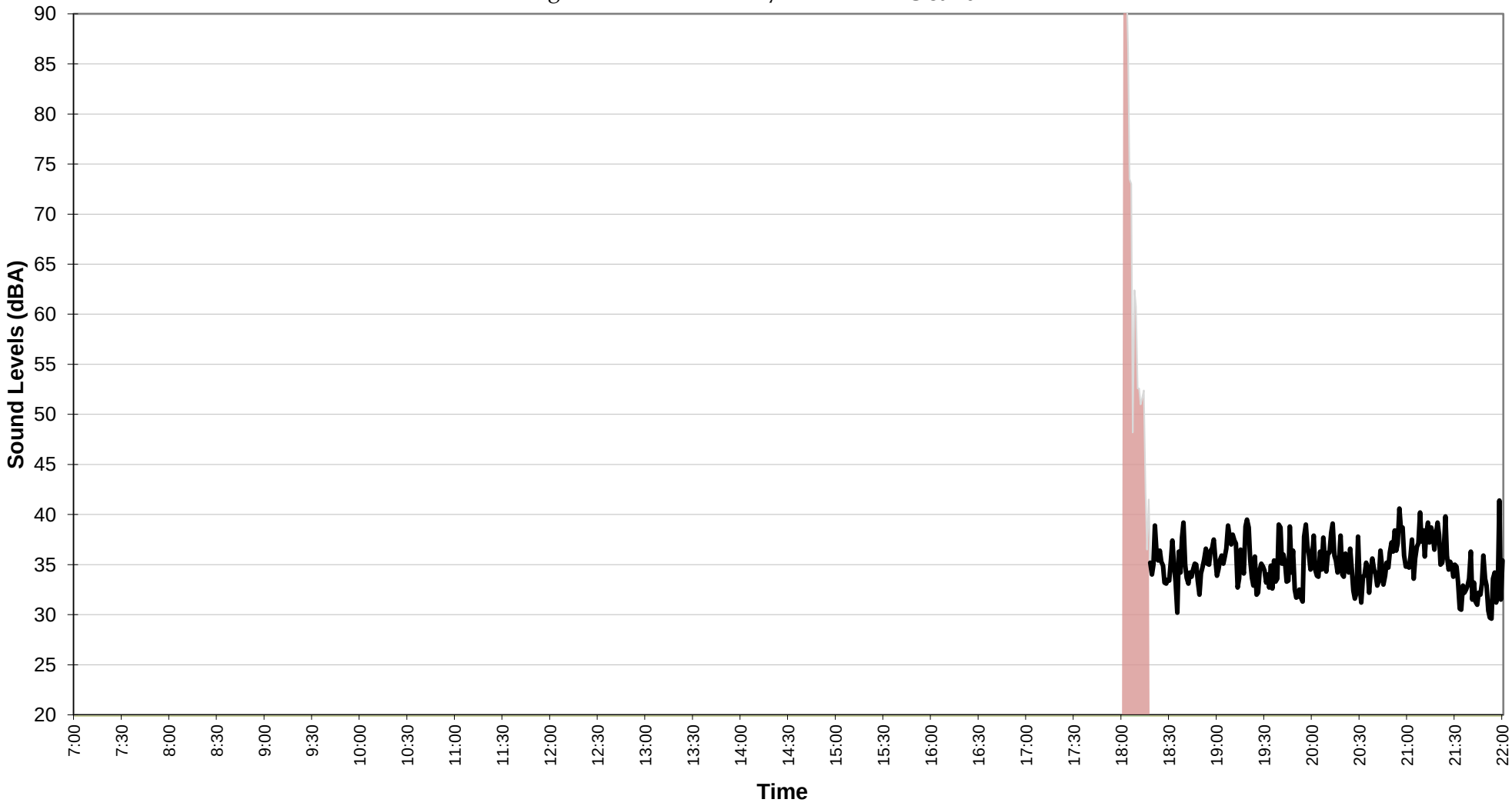


Table E: Comprehensive Sound Survey - Monitor B

Period	Date (2019)	Measured Leq (dBA)	Measured Hours	Residual Leq (dBA)	Residual Hours
Day 01	Oct 29	75.1	4.0	35.7	3.7
Night 01	Oct 29 - Oct 30	38.7	9.0	38.7	9.0
Day 02	Oct 30	49.3	15.0	49.0	14.9
Night 02	Oct 30 - Oct 31	39.1	9.0	39.1	9.0
Day 03	Oct 31	43.6	15.0	36.7	14.7
Night 03	Oct 31 - Nov 01	31.7	9.0	31.7	9.0
Day 04	Nov 01	41.5	15.0	39.8	14.6
Night 04	Nov 01 - Nov 02	38.5	9.0	38.5	9.0
Day 05	Nov 02	41.5	15.0	38.1	13.7
Night 05	Nov 02 - Nov 03	29.9	9.0	29.9	9.0
Day 06	Nov 03	36.5	15.0	30.6	14.6
Night 06	Nov 03 - Nov 04	30.7	9.0	30.4	8.7
Day 07	Nov 04	42.6	15.0	34.4	14.2
Night 07	Nov 04 - Nov 05	34.9	9.0	34.9	9.0
Day 08	Nov 05	38.1	15.0	32.0	14.6
Night 08	Nov 05 - Nov 06	30.9	9.0	30.9	9.0
Day 09	Nov 06	47.6	15.0	38.6	5.6

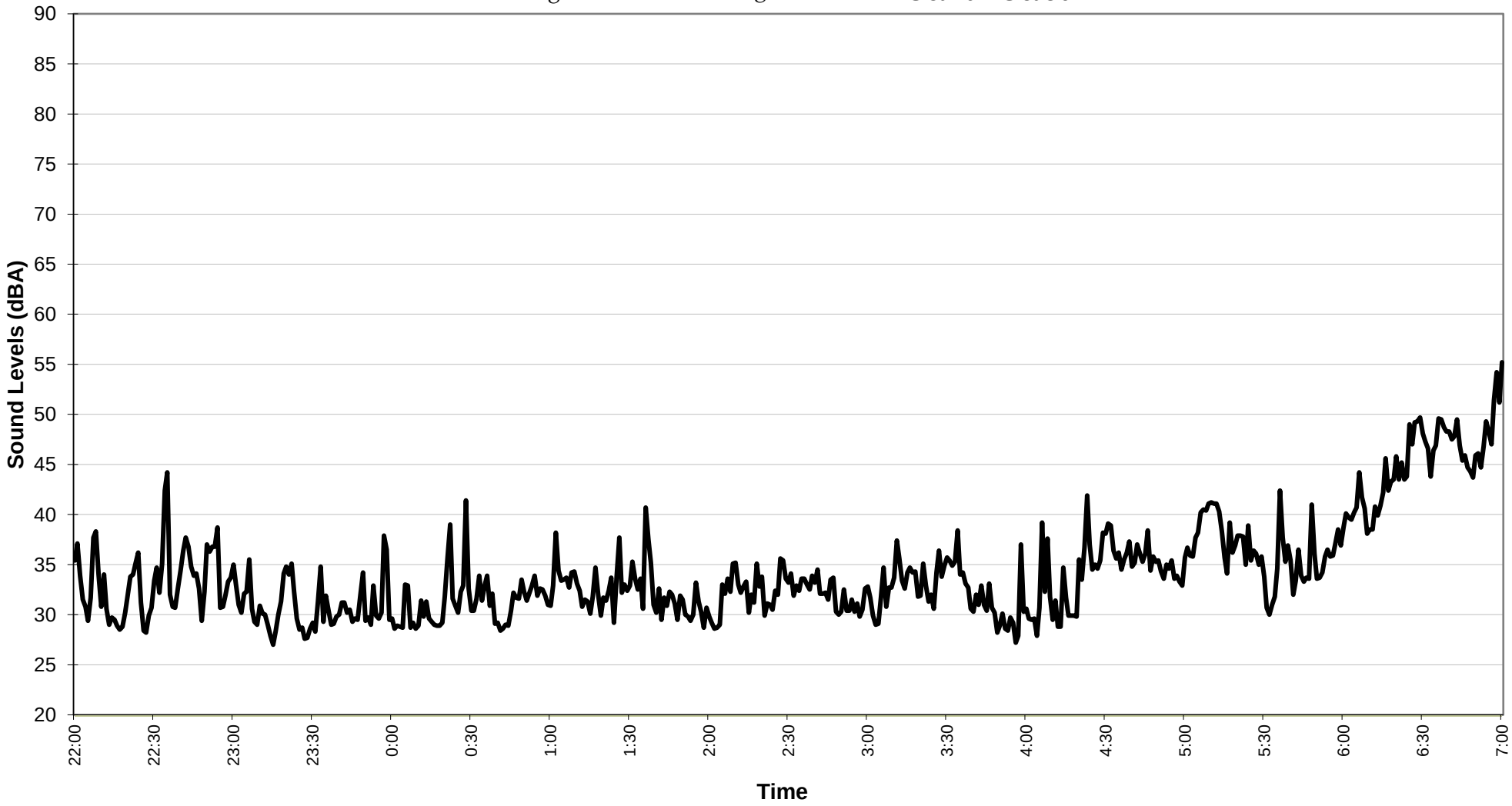
Comprehensive Sound Survey - Monitor B

Figure E1 Day 1 Oct 29



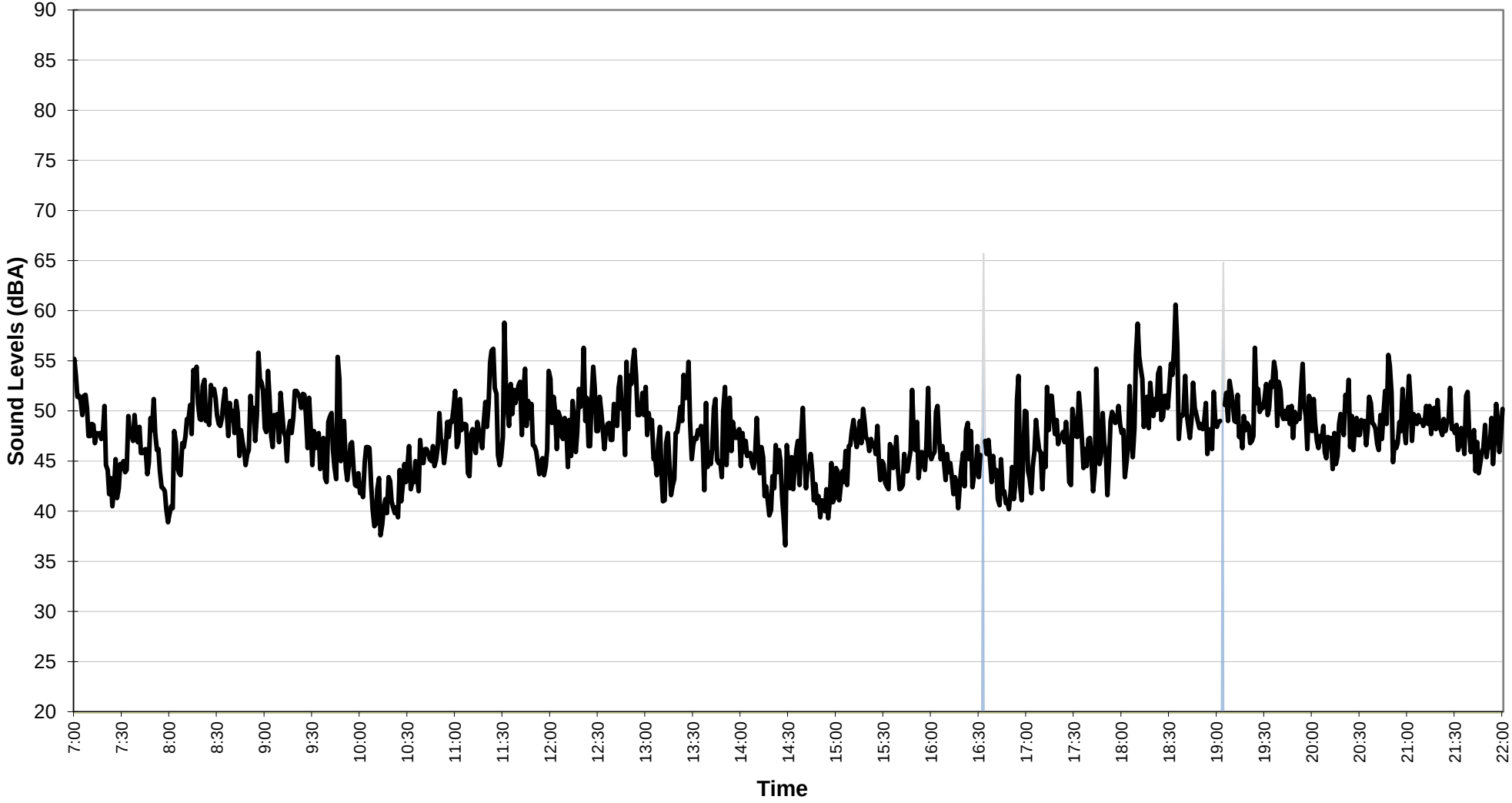
Comprehensive Sound Survey - Monitor B

Figure E2 Night 1 Oct 29 - Oct 30



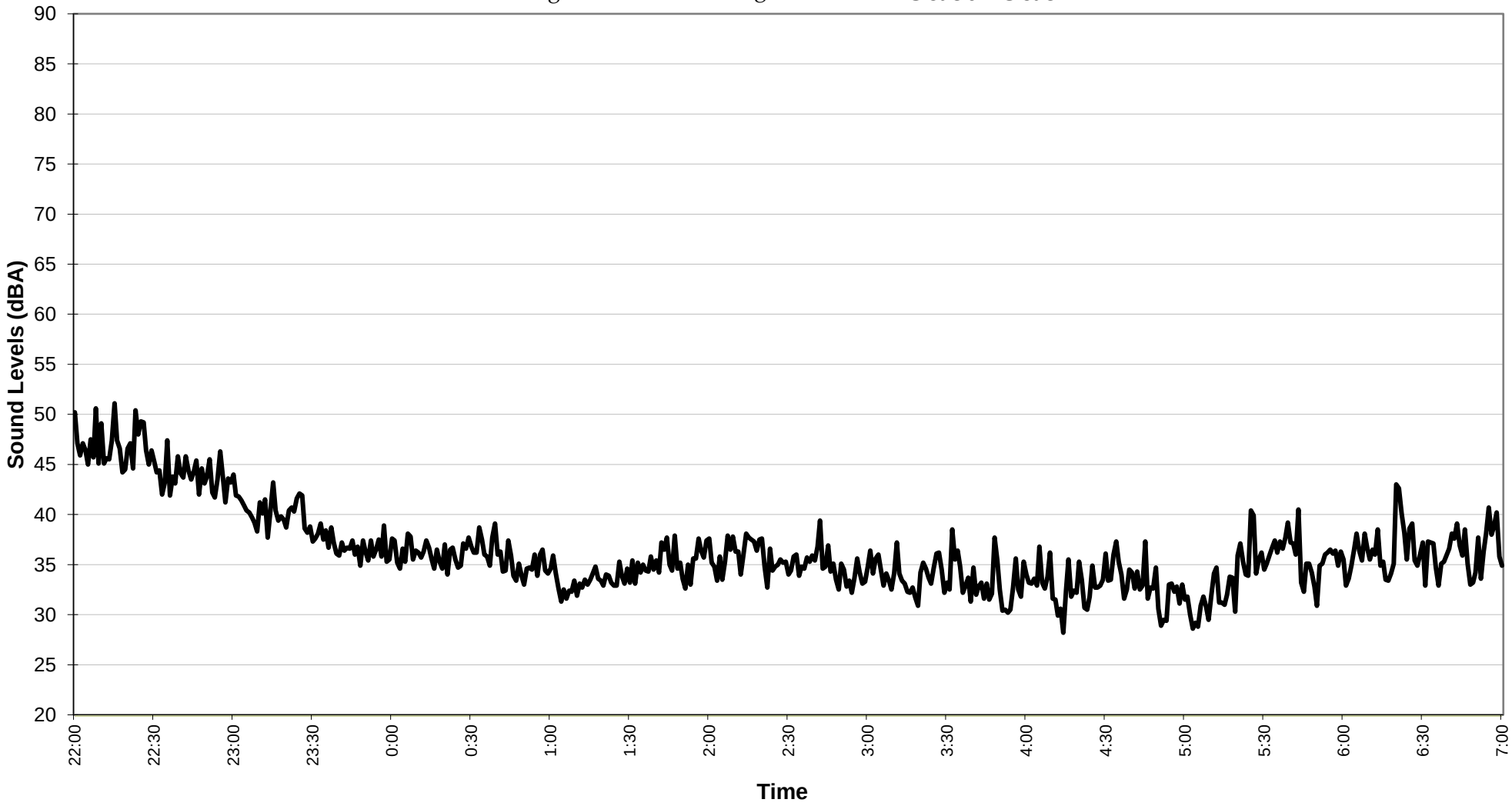
Comprehensive Sound Survey - Monitor B

Figure E3 Day 2 Oct 30



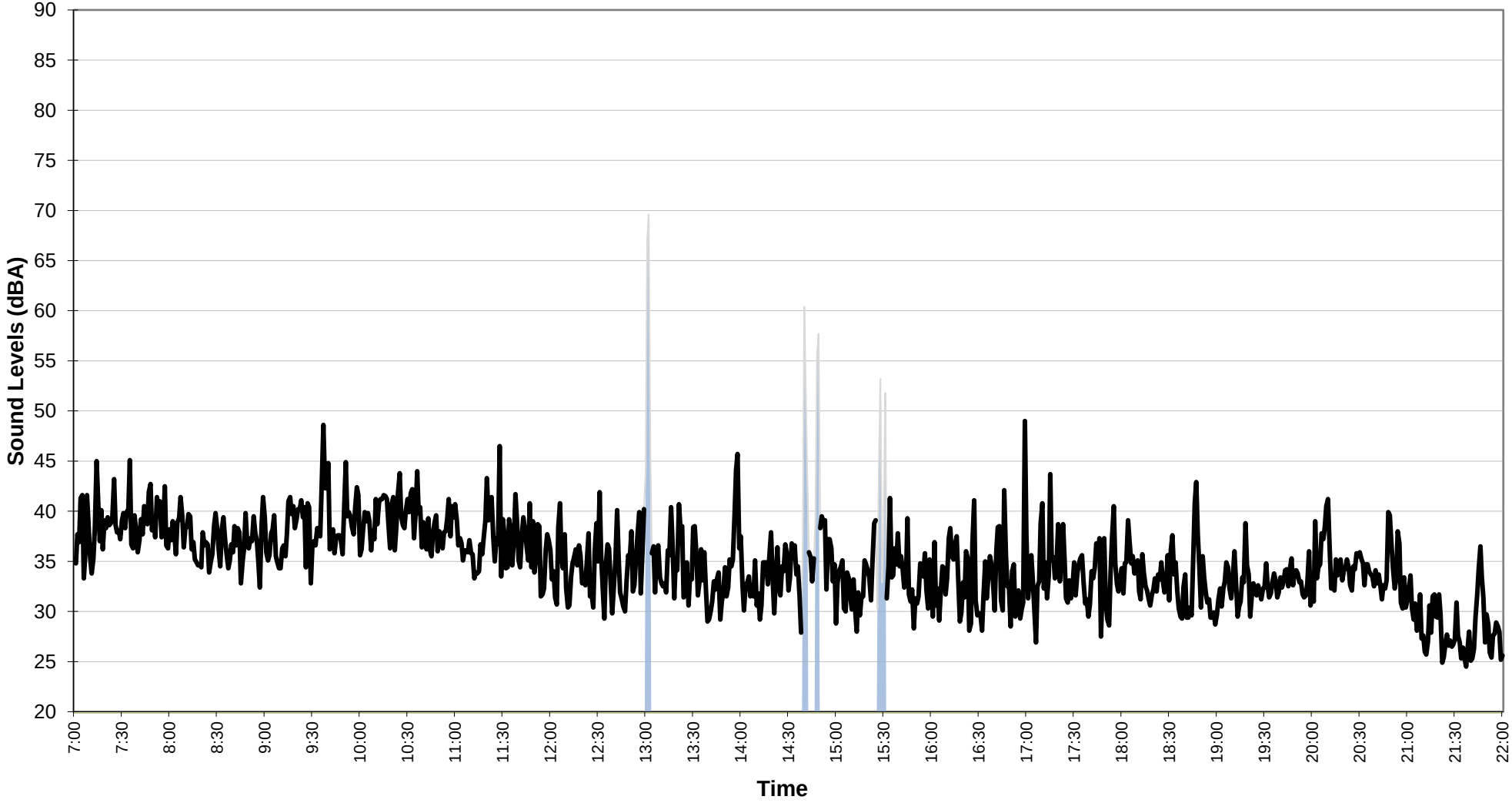
Comprehensive Sound Survey - Monitor B

Figure E4 Night 2 Oct 30 - Oct 31



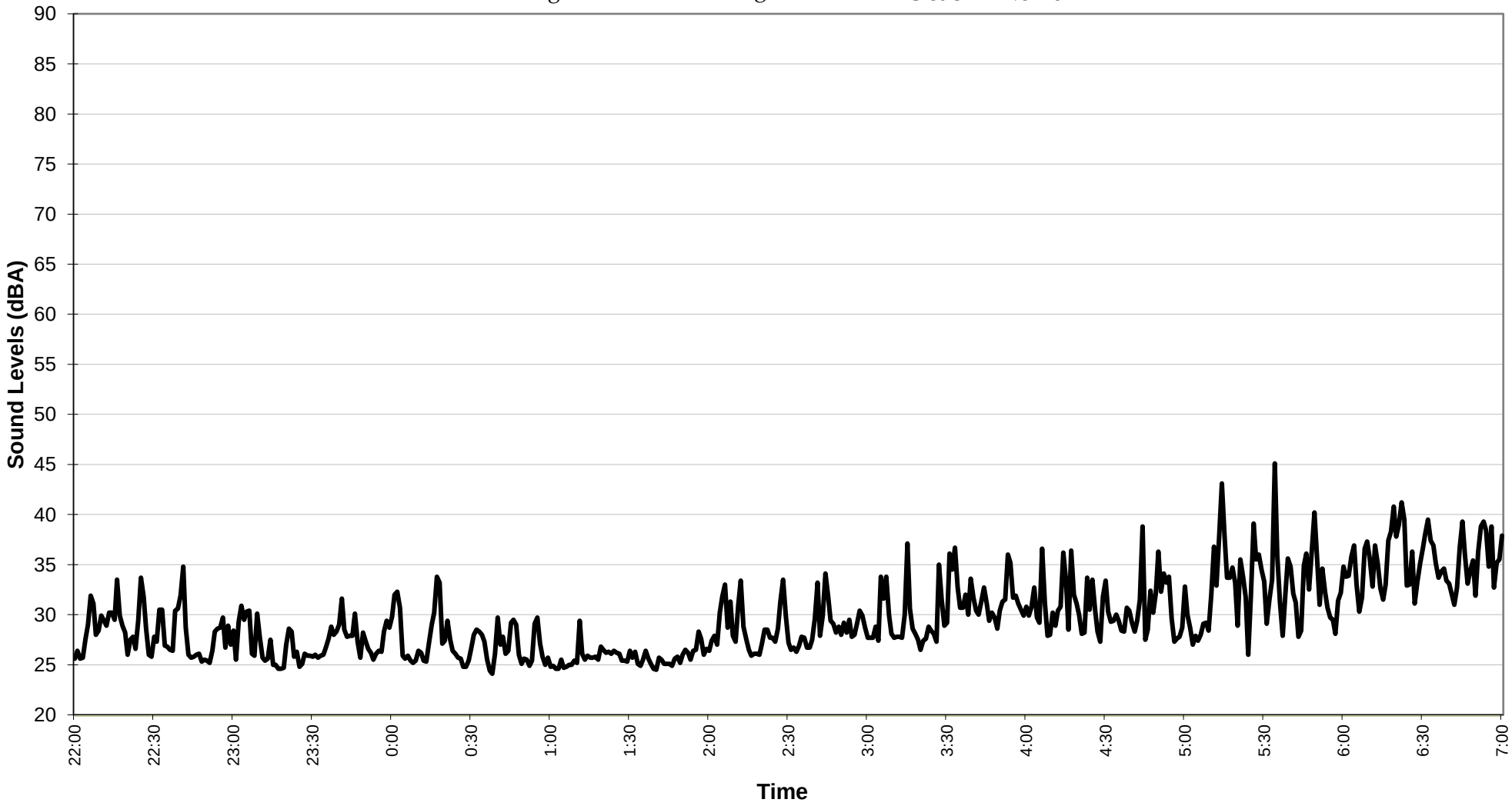
Comprehensive Sound Survey - Monitor B

Figure E5 Day 3 Oct 31



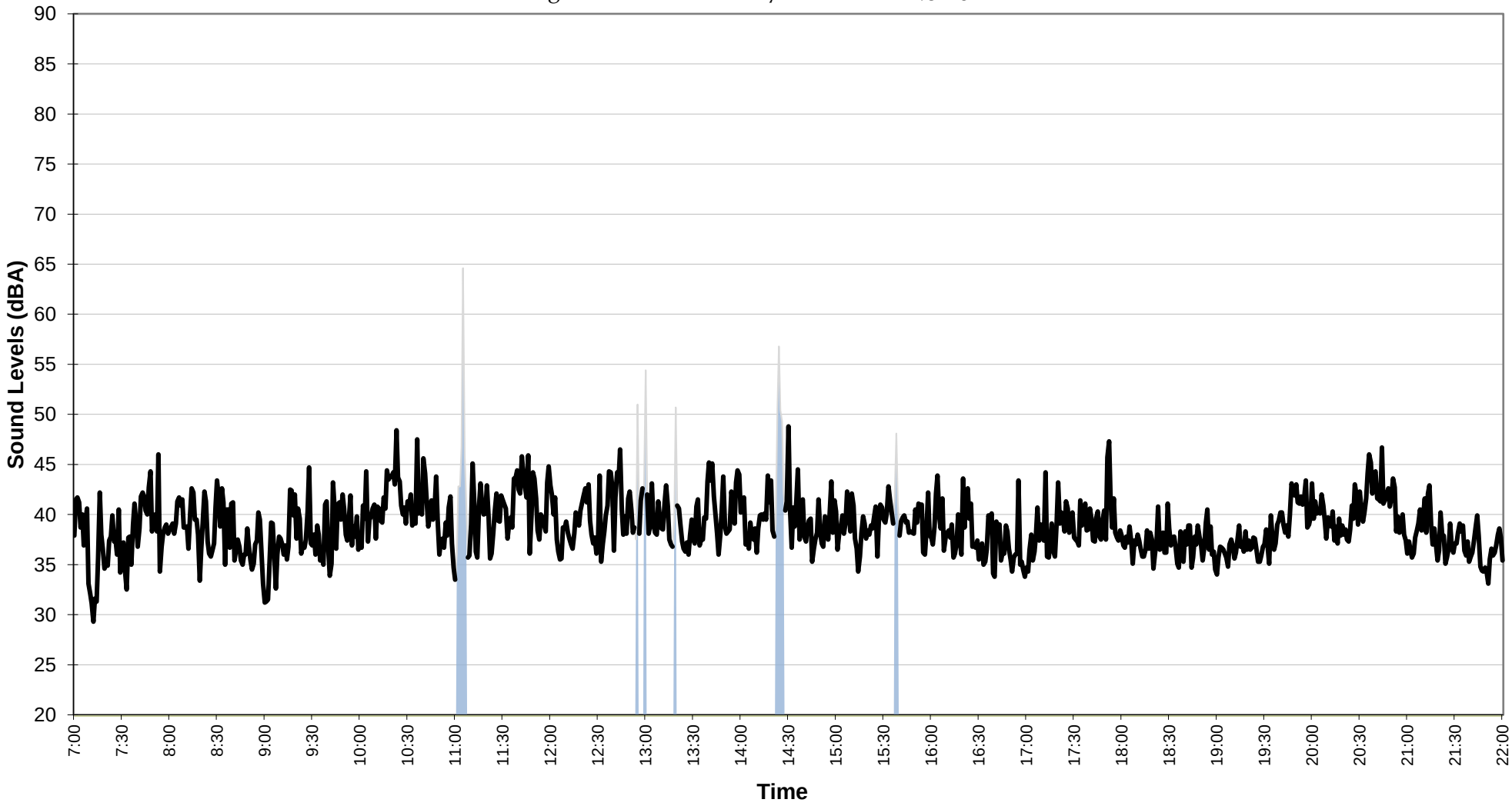
Comprehensive Sound Survey - Monitor B

Figure E6 Night 3 Oct 31 - Nov 01



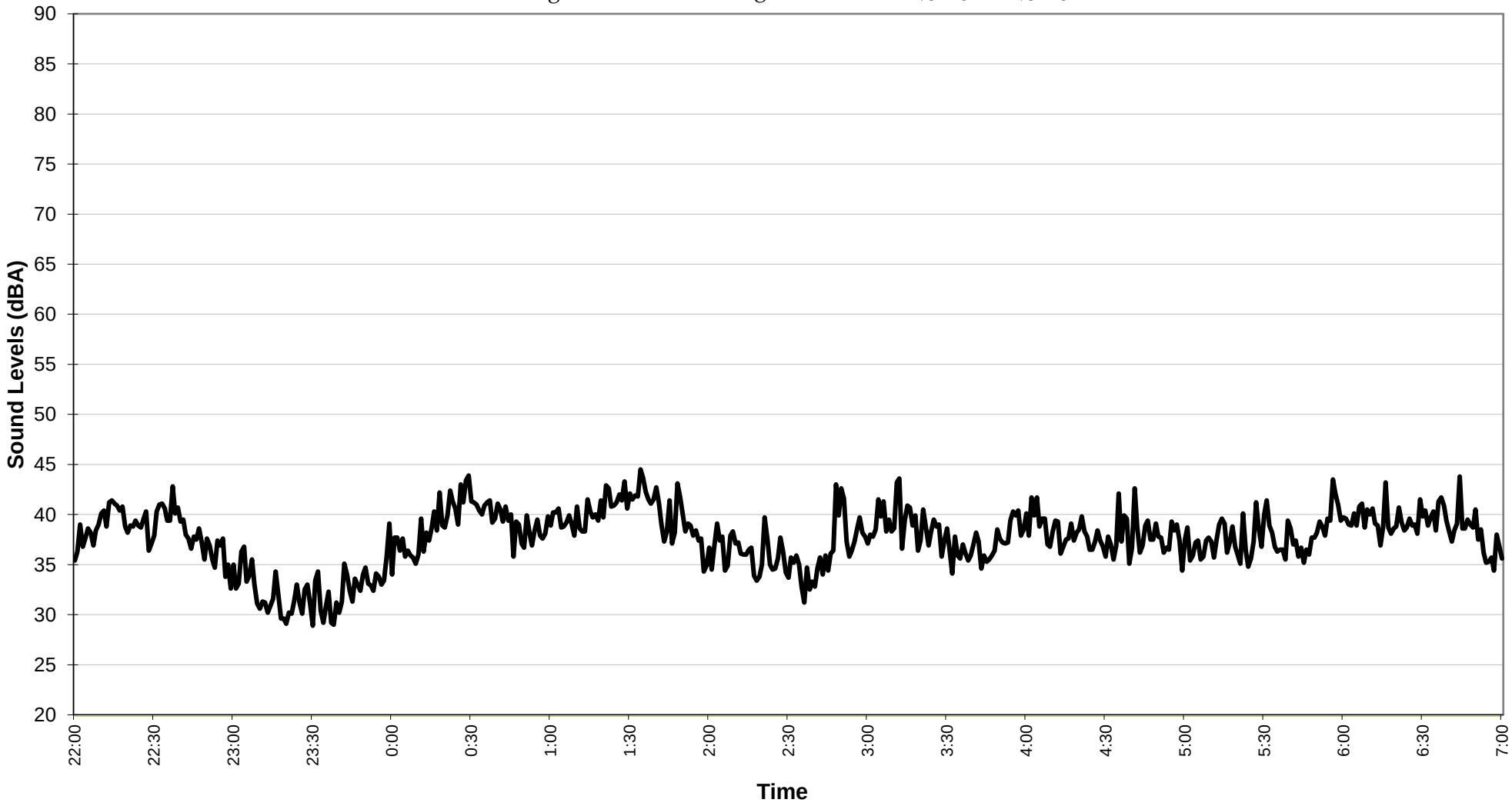
Comprehensive Sound Survey - Monitor B

Figure E7 Day 4 Nov 01



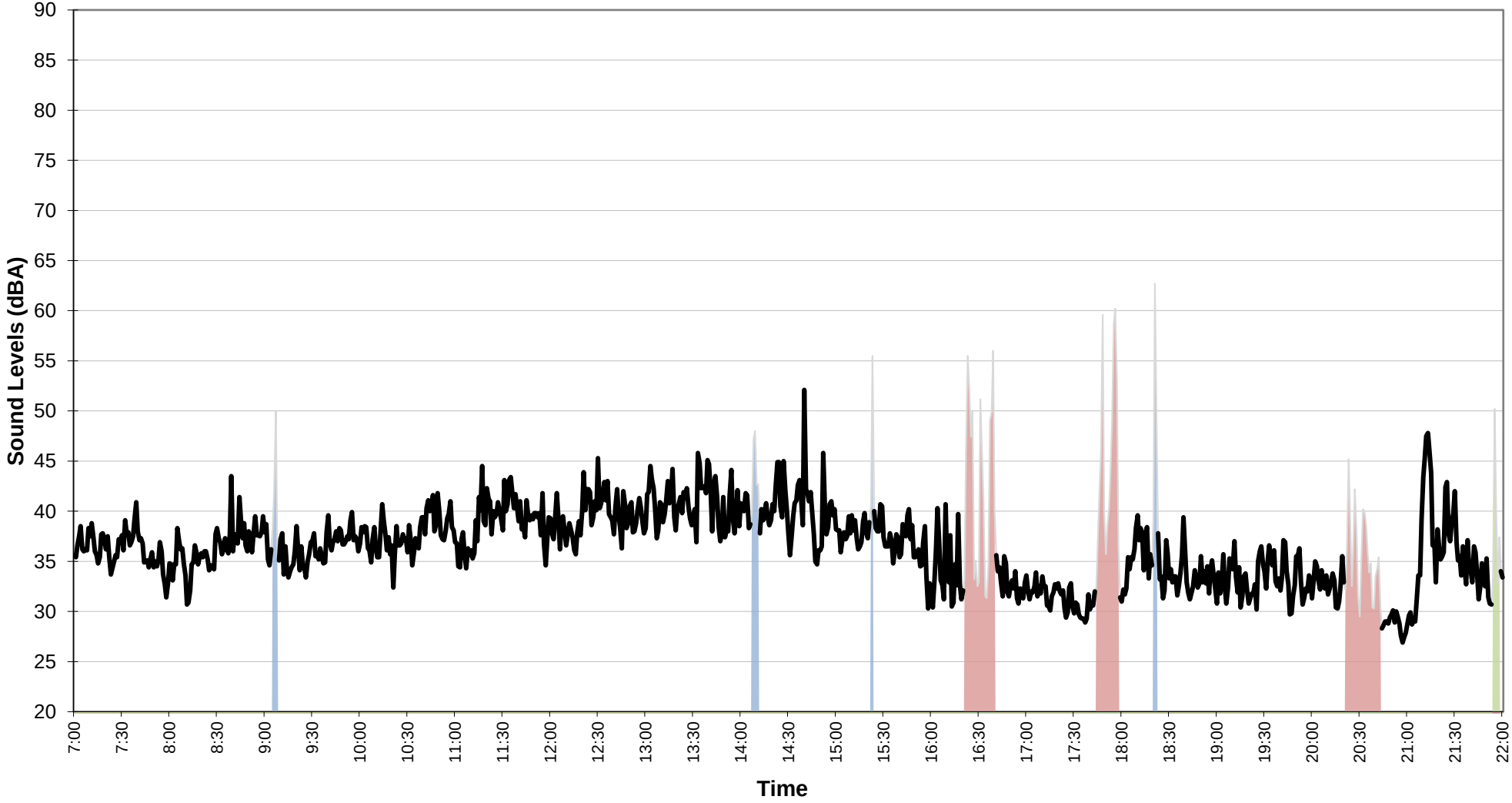
Comprehensive Sound Survey - Monitor B

Figure E8 Night 4 Nov 01 - Nov 02



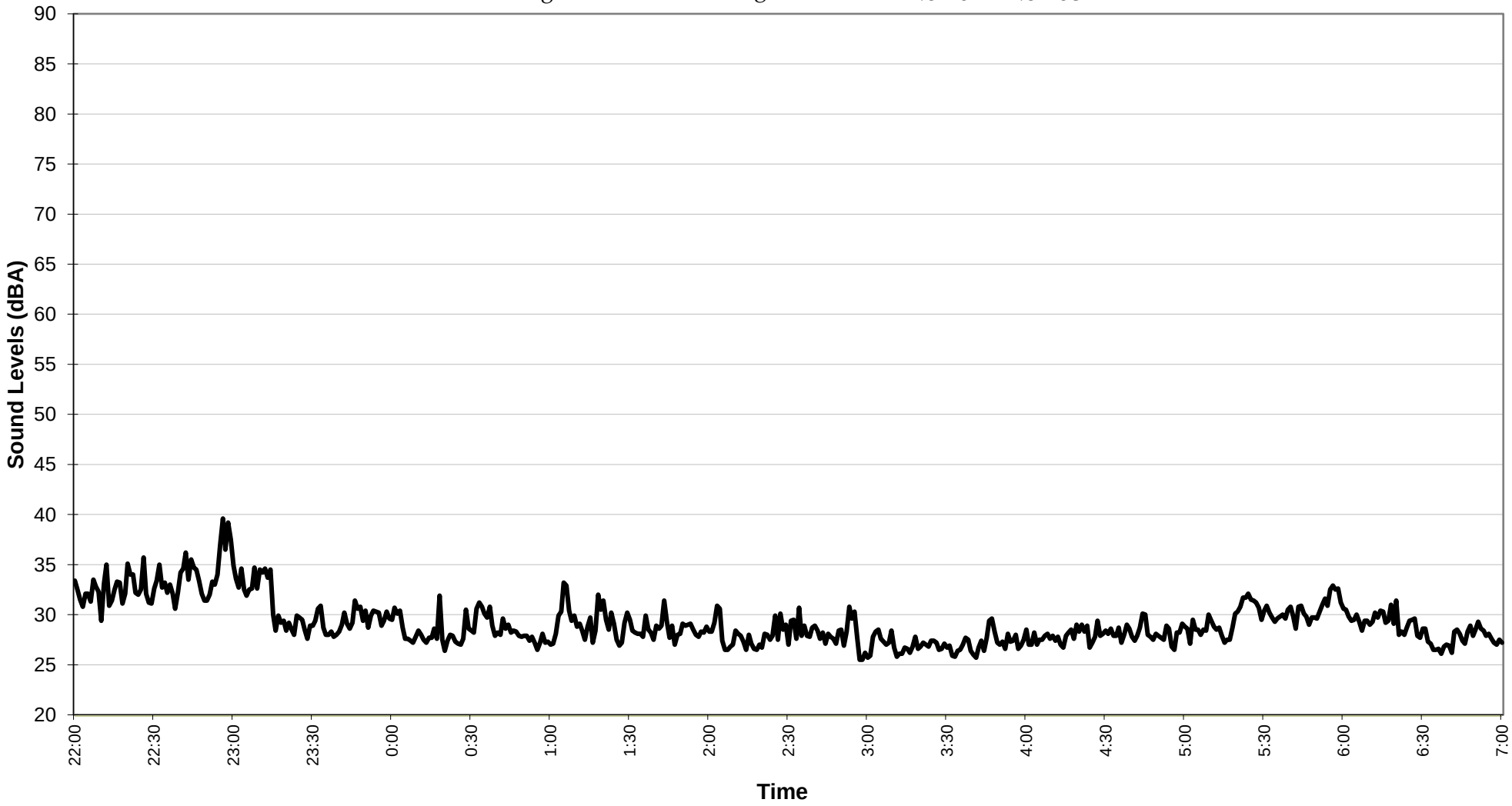
Comprehensive Sound Survey - Monitor B

Figure E9 Day 5 Nov 02



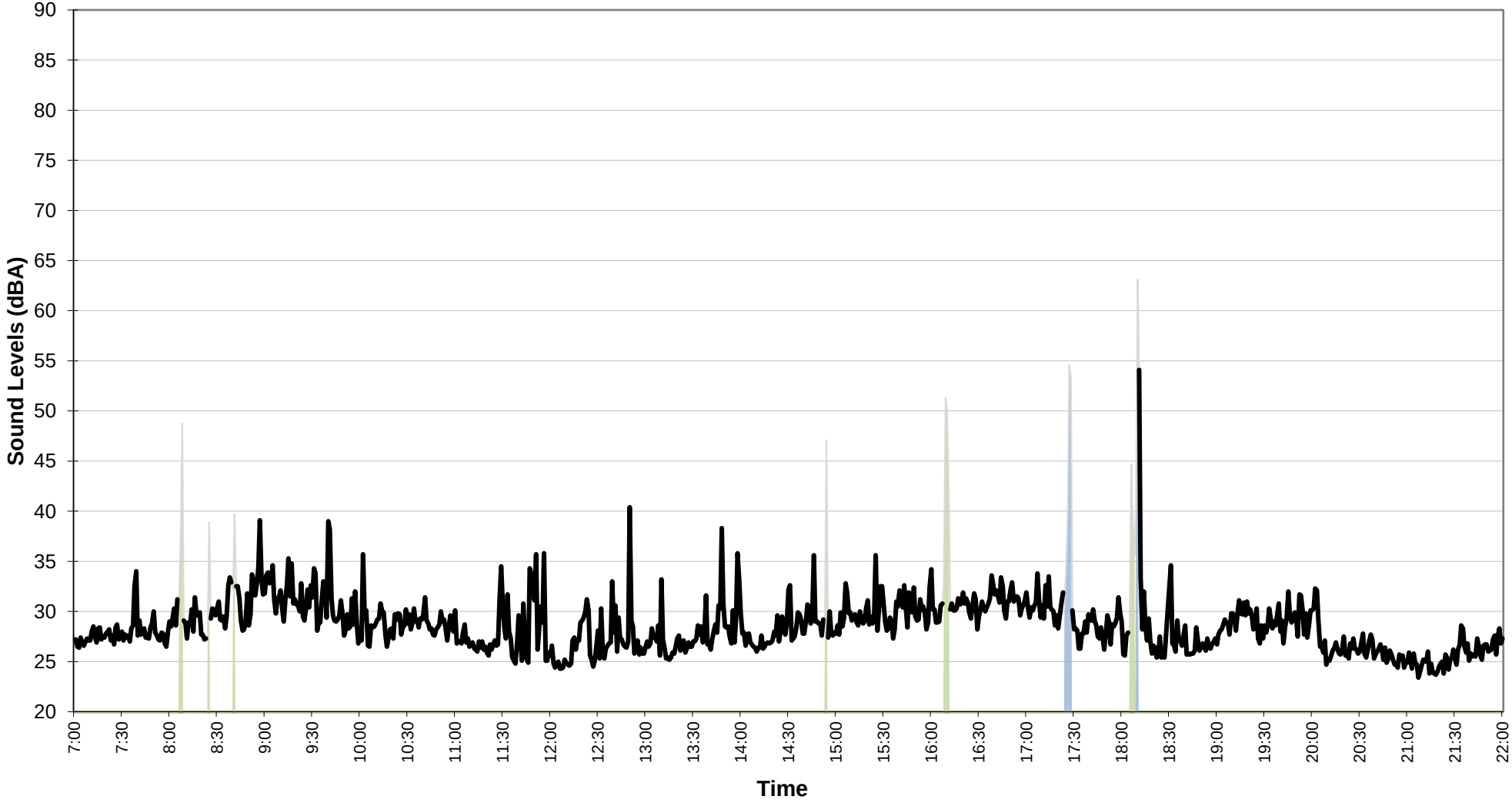
Comprehensive Sound Survey - Monitor B

Figure E10 Night 5 Nov 02 - Nov 03



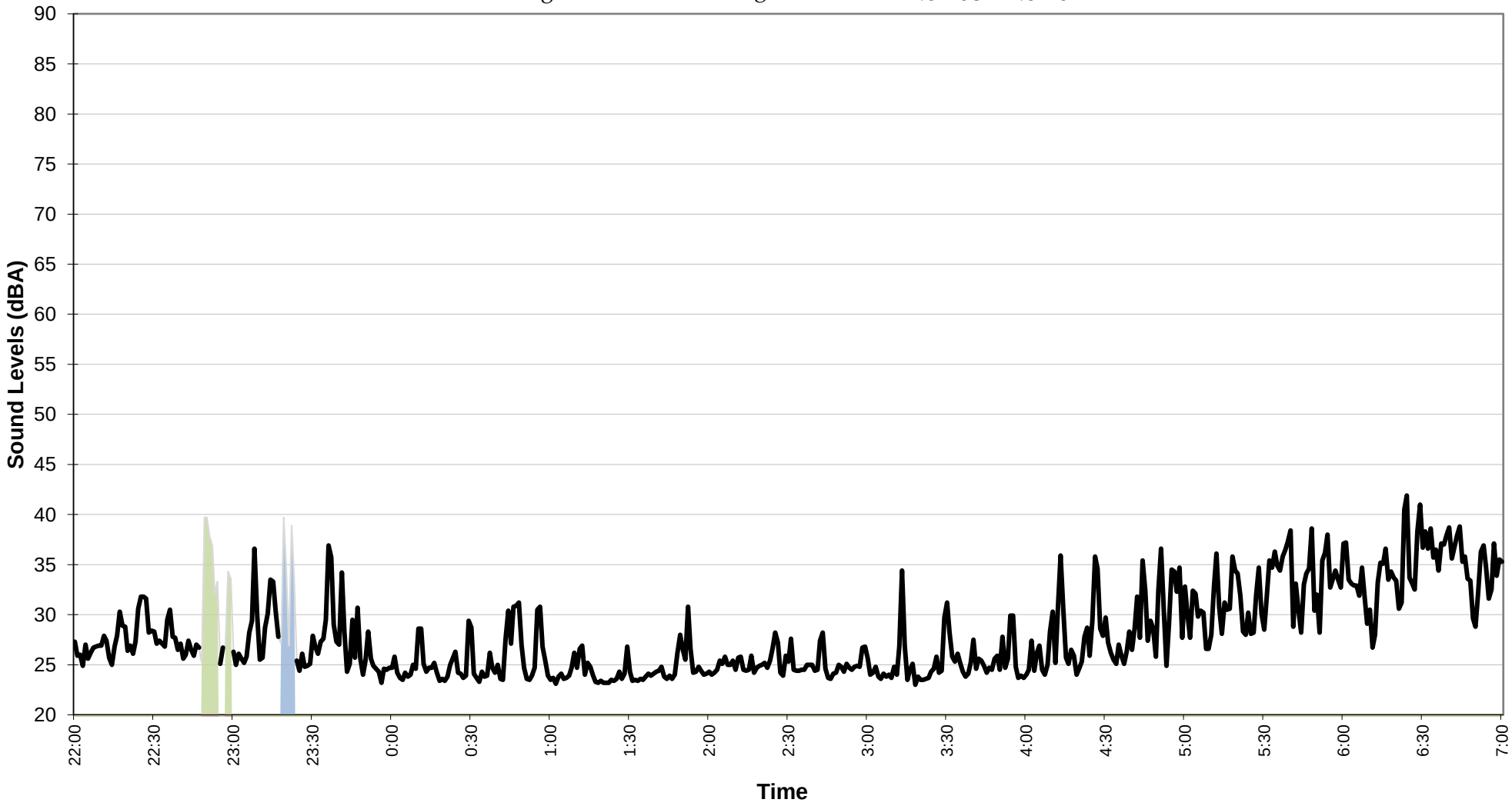
Comprehensive Sound Survey - Monitor B

Figure E11 Day 6 Nov 03



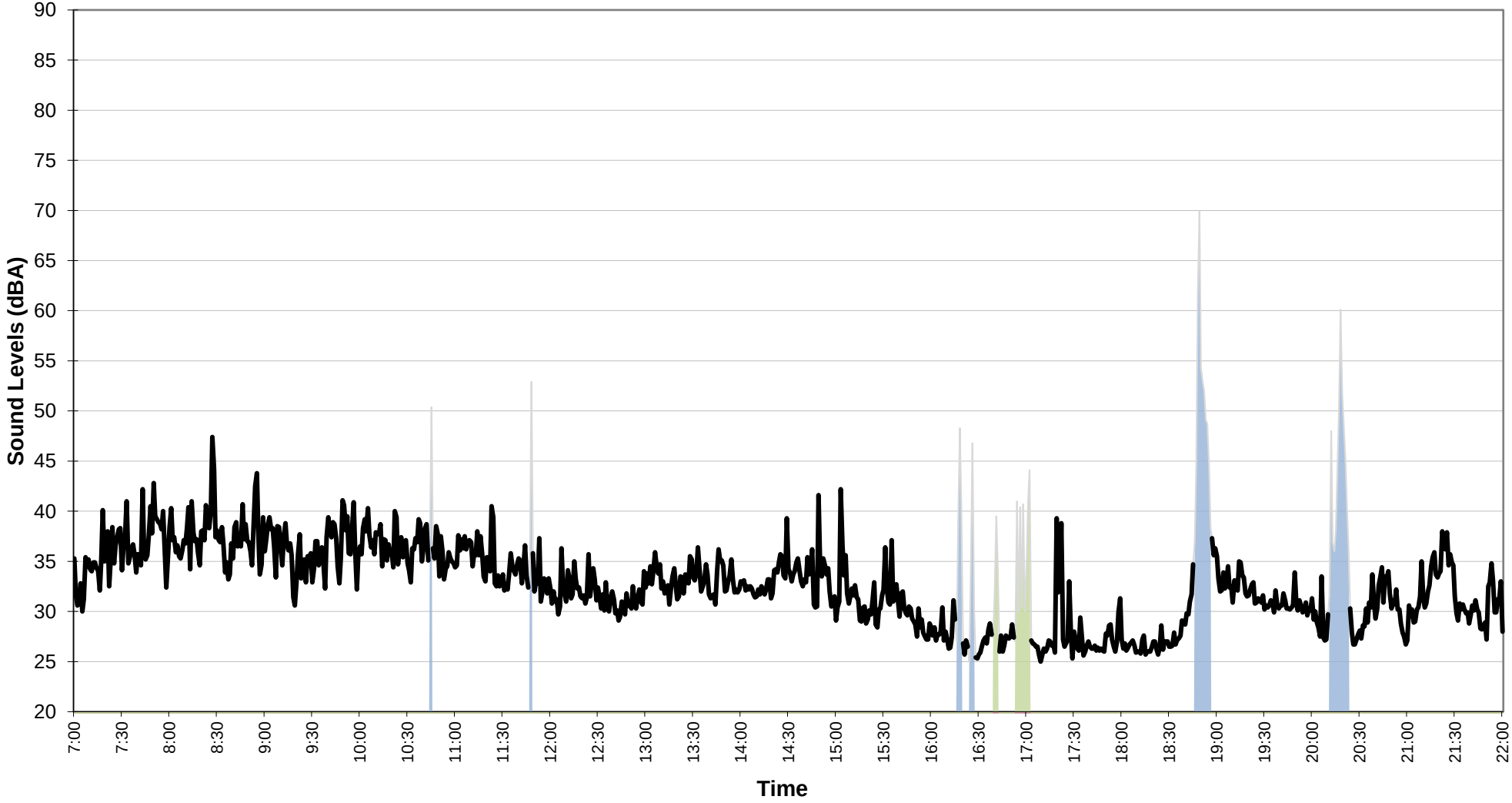
Comprehensive Sound Survey - Monitor B

Figure E12 Night 6 Nov 03 - Nov 04



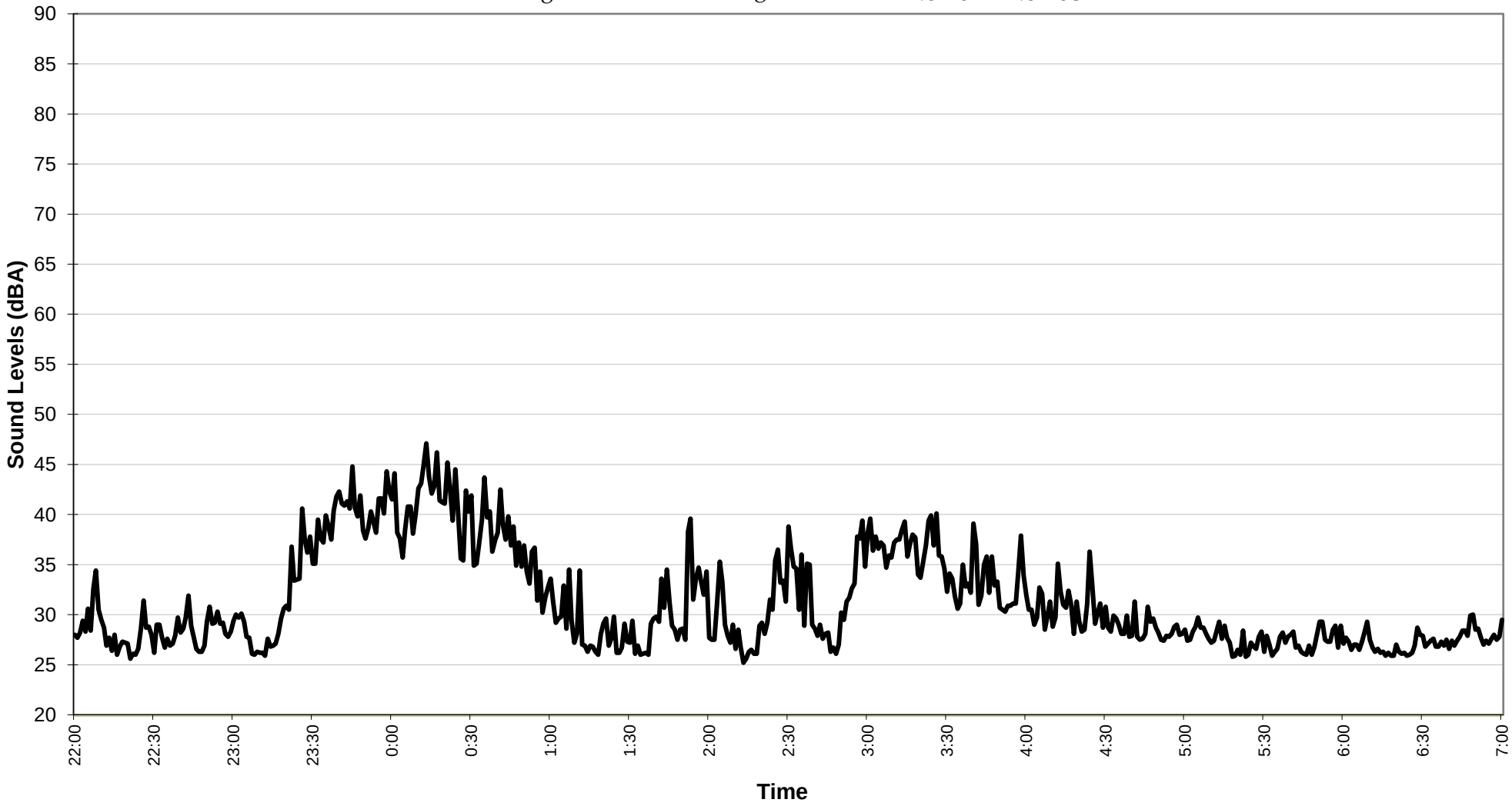
Comprehensive Sound Survey - Monitor B

Figure E13 Day 7 Nov 04



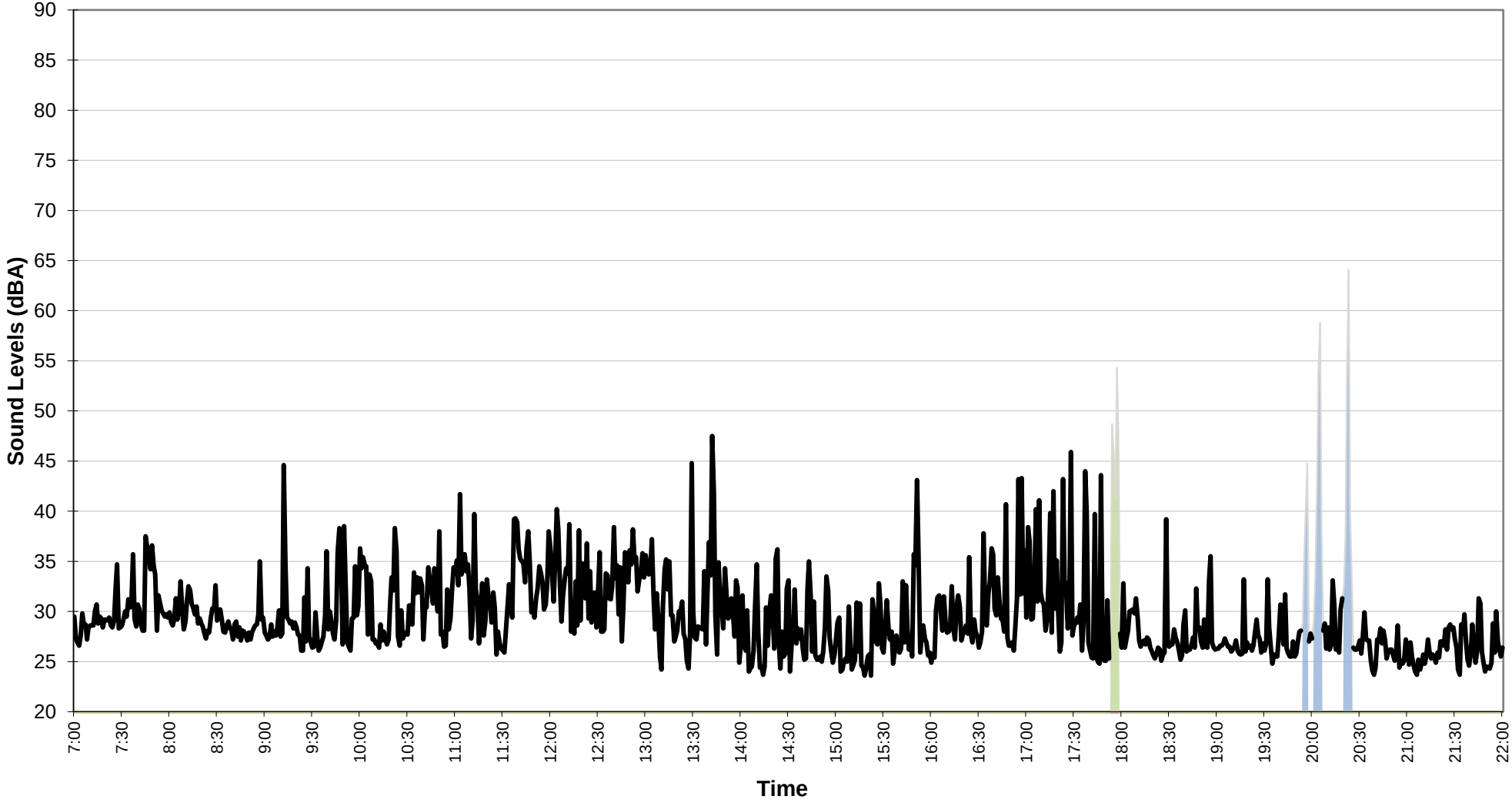
Comprehensive Sound Survey - Monitor B

Figure E14 Night 7 Nov 04 - Nov 05



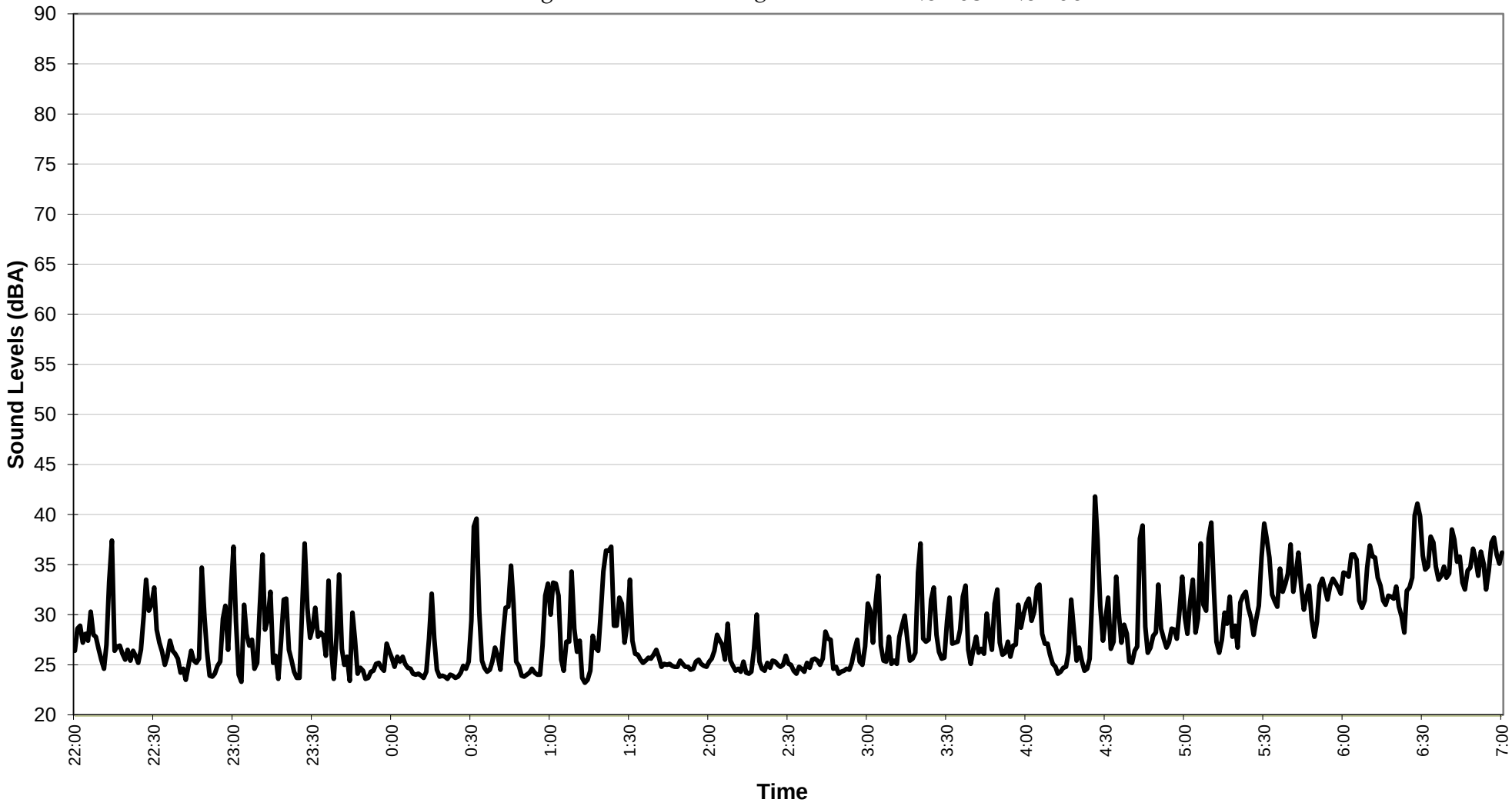
Comprehensive Sound Survey - Monitor B

Figure E15 Day 8 Nov 05



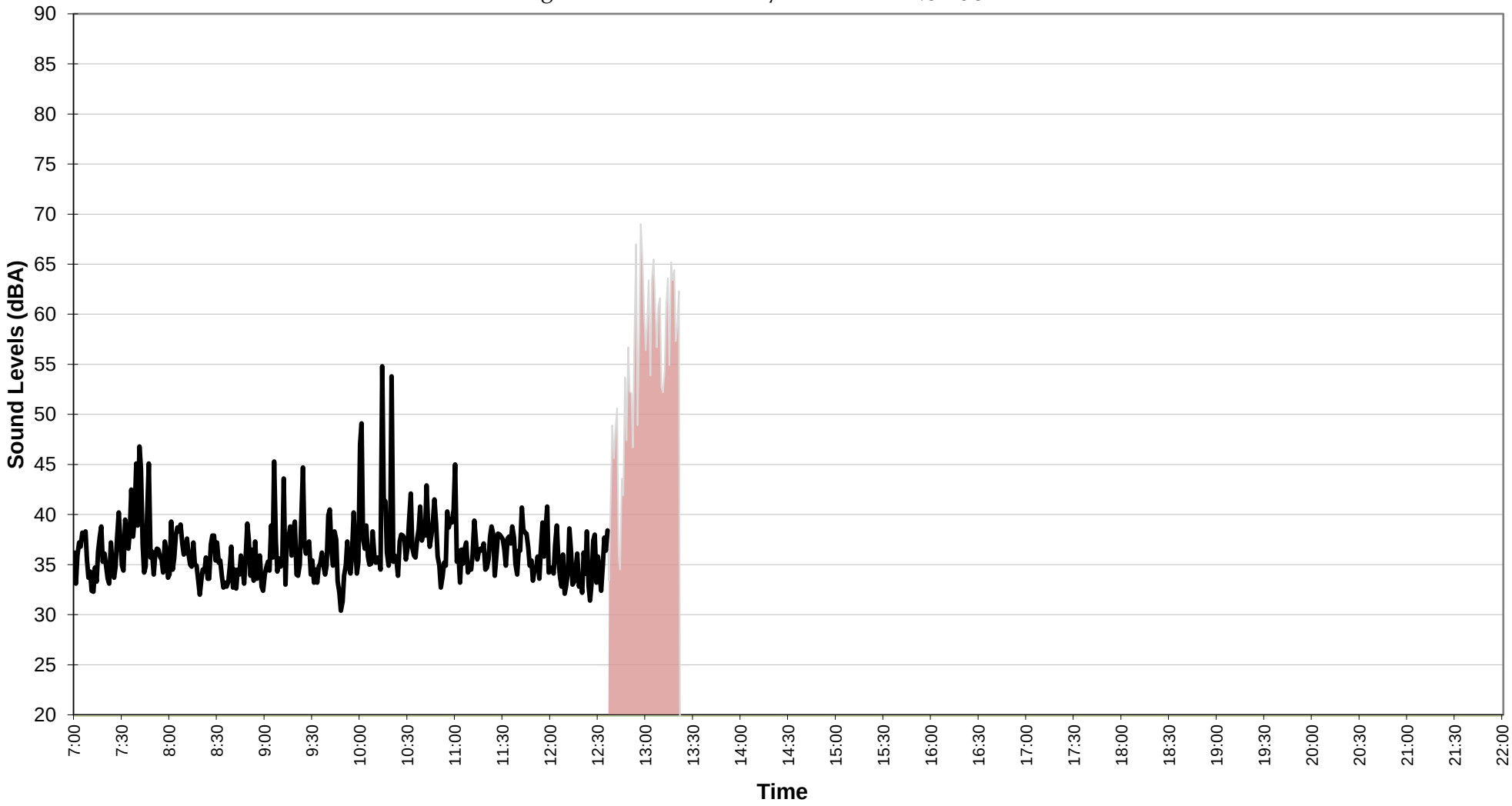
Comprehensive Sound Survey - Monitor B

Figure E16 Night 8 Nov 05 - Nov 06



Comprehensive Sound Survey - Monitor B

Figure E17 Day 9 Nov 06



APPENDIX F

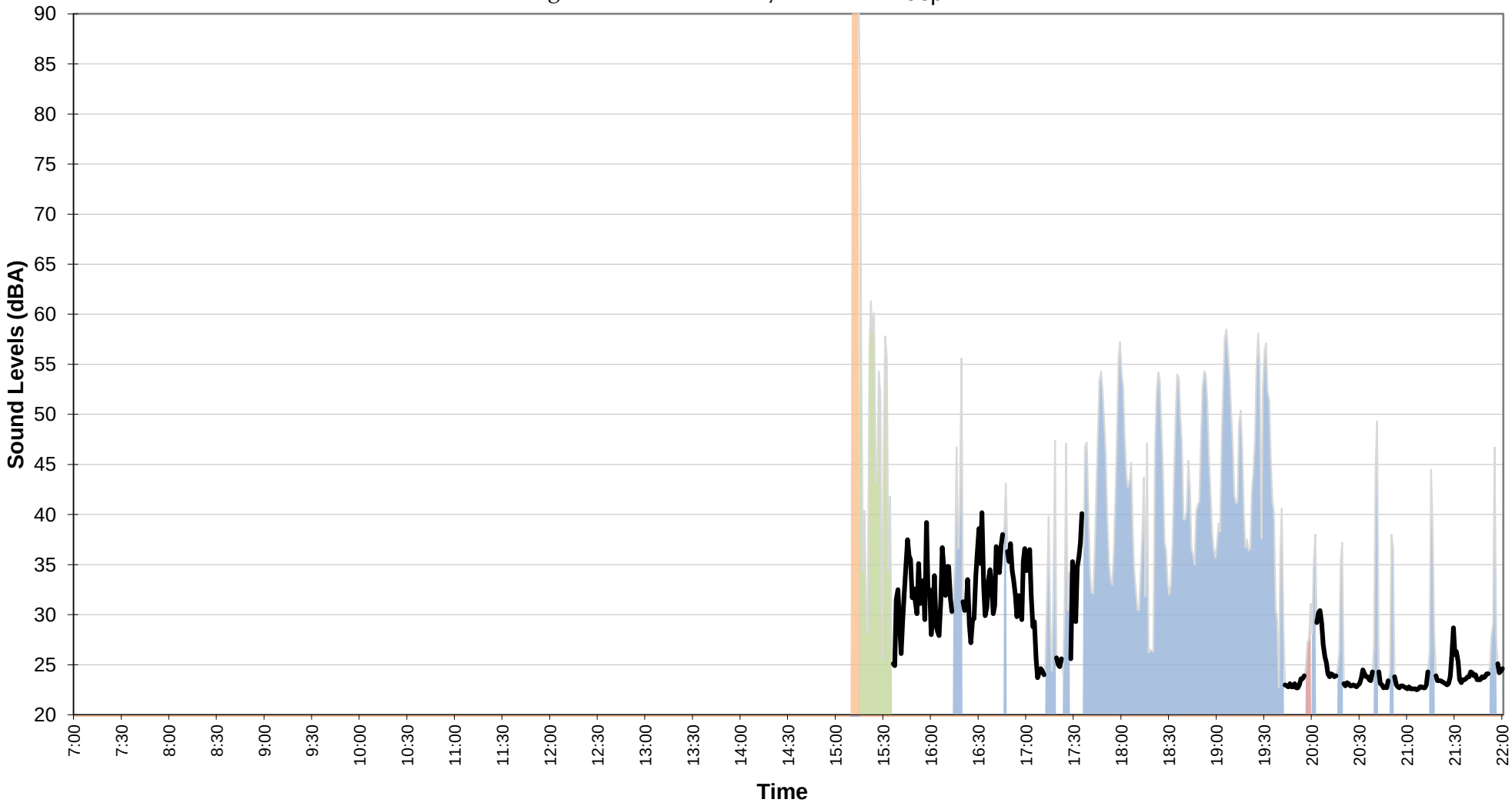
Sound Level Measurements
Sound Monitor E
80m north from 216 Road

Table F: Comprehensive Sound Survey - Monitor E

Period	Date (2019)	Measured Leq (dBA)	Measured Hours	Residual Leq (dBA)	Residual Hours
Day 01	Sep 17	74.6	6.8	30.8	3.5
Night 01	Sep 17 - Sep 18	29.6	9.0	26.7	8.2
Day 02	Sep 18	34.0	0.2	34.3	0.2
Night 02	Sep 18 - Sep 19	-	0.0	-	0.0
Day 03	Sep 19	46.1	12.7	44.9	11.3
Night 03	Sep 19 - Sep 20	29.7	9.0	26.9	7.8
Day 04	Sep 20	37.1	15.0	35.3	13.3
Night 04	Sep 20 - Sep 21	42.0	9.0	42.0	9.0
Day 05	Sep 21	45.7	15.0	45.6	14.8
Night 05	Sep 21 - Sep 22	38.3	9.0	38.3	8.7
Day 06	Sep 22	40.9	15.0	37.3	13.5
Night 06	Sep 22 - Sep 23	29.3	9.0	28.0	8.8
Day 07	Sep 23	41.2	15.0	40.2	13.8
Night 07	Sep 23 - Sep 24	32.6	9.0	31.4	8.7
Day 08	Sep 24	40.8	15.0	40.8	15.0
Night 08	Sep 24 - Sep 25	33.7	9.0	31.2	8.7
Day 09	Sep 25	36.8	15.0	36.8	15.0
Night 09	Sep 25 - Sep 26	32.1	9.0	32.1	9.0
Day 10	Sep 26	46.0	15.0	46.0	15.0
Night 10	Sep 26 - Sep 27	35.0	9.0	35.0	9.0
Day 11	Sep 27	40.6	15.0	40.6	14.8
Night 11	Sep 27 - Sep 28	27.9	9.0	27.9	9.0
Day 12	Sep 28	35.6	14.4	35.6	14.2
Night 12	Sep 28 - Sep 29	-	0.0	-	0.0
Day 13	Sep 29	37.8	13.6	36.4	11.9
Night 13	Sep 29 - Sep 30	30.8	9.0	25.1	8.5
Day 14	Sep 30	30.8	15.0	31.5	1.9

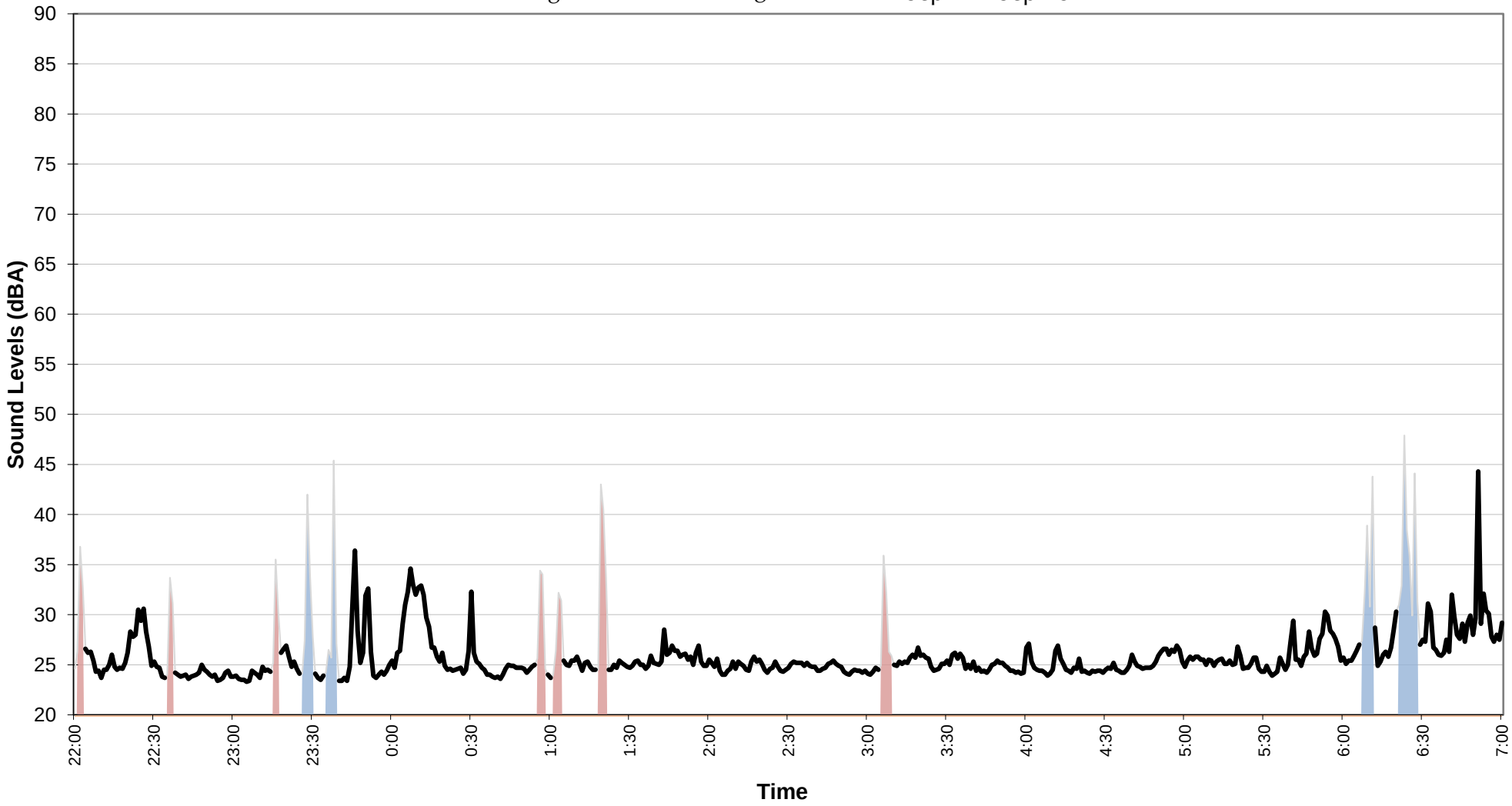
Comprehensive Sound Survey - Monitor E

Figure F1 Day 1 Sep 17



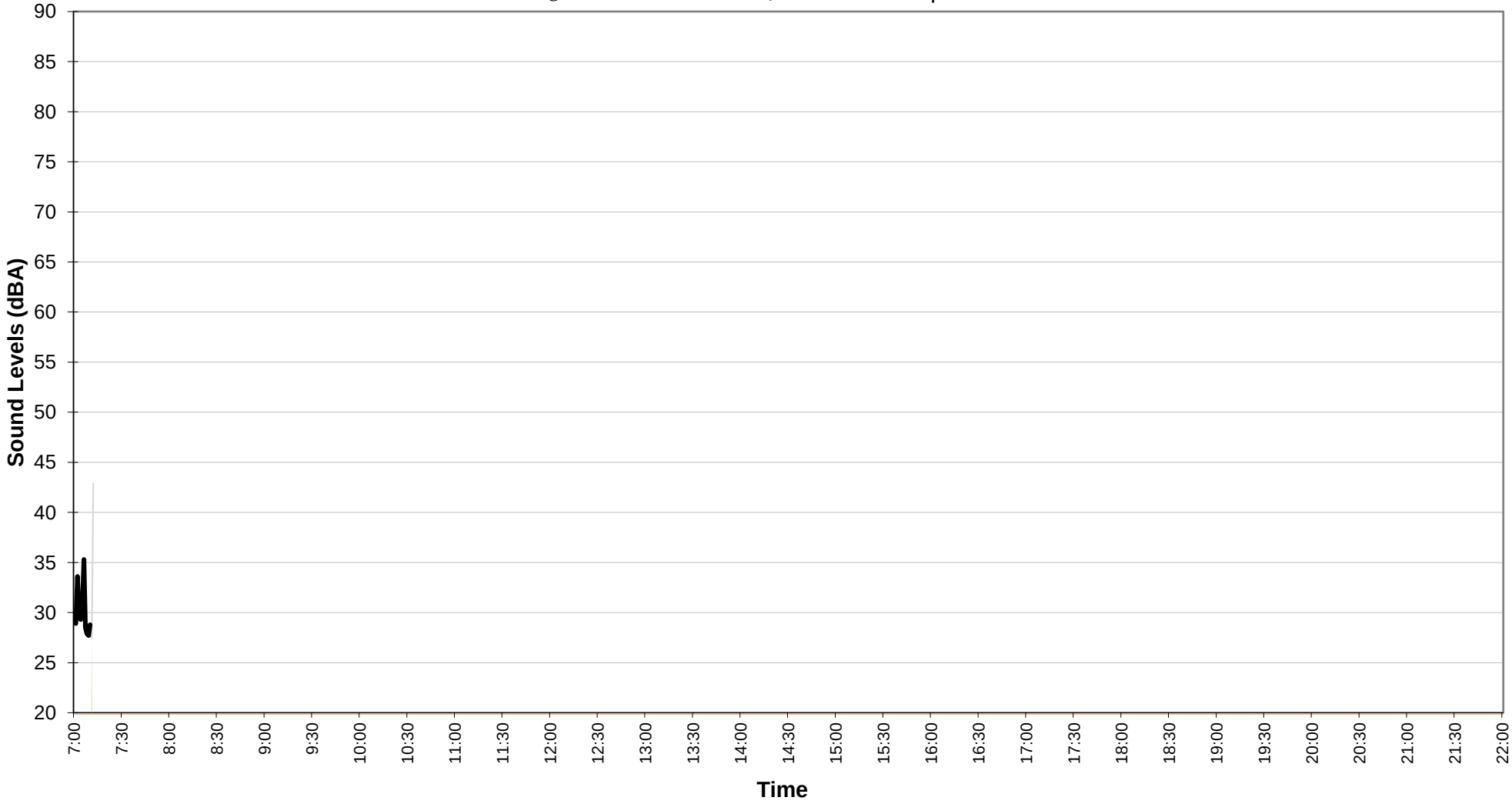
Comprehensive Sound Survey - Monitor E

Figure F2 Night 1 Sep 17 - Sep 18



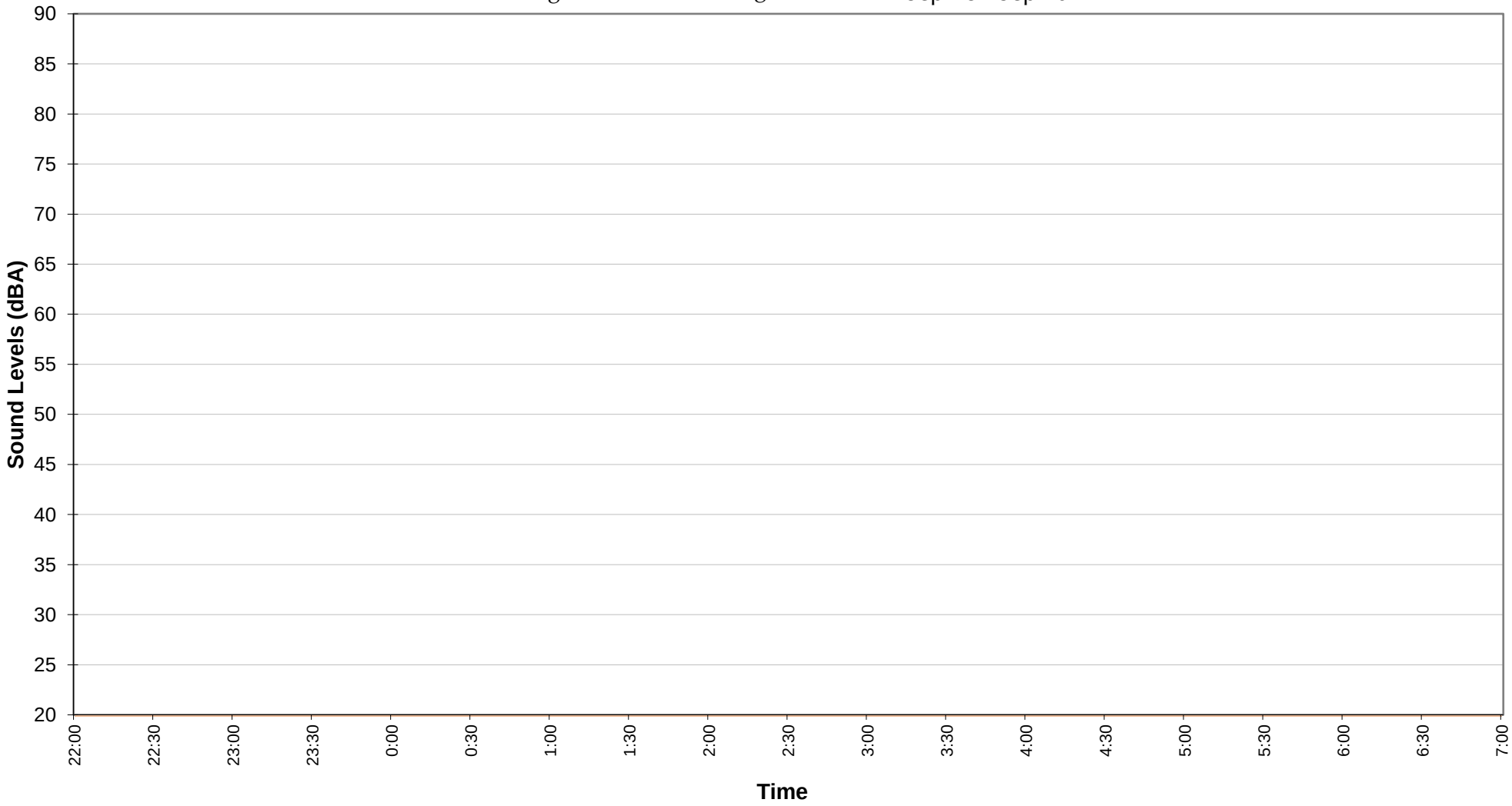
Comprehensive Sound Survey - Monitor E

Figure F3 Day 2 Sep 18



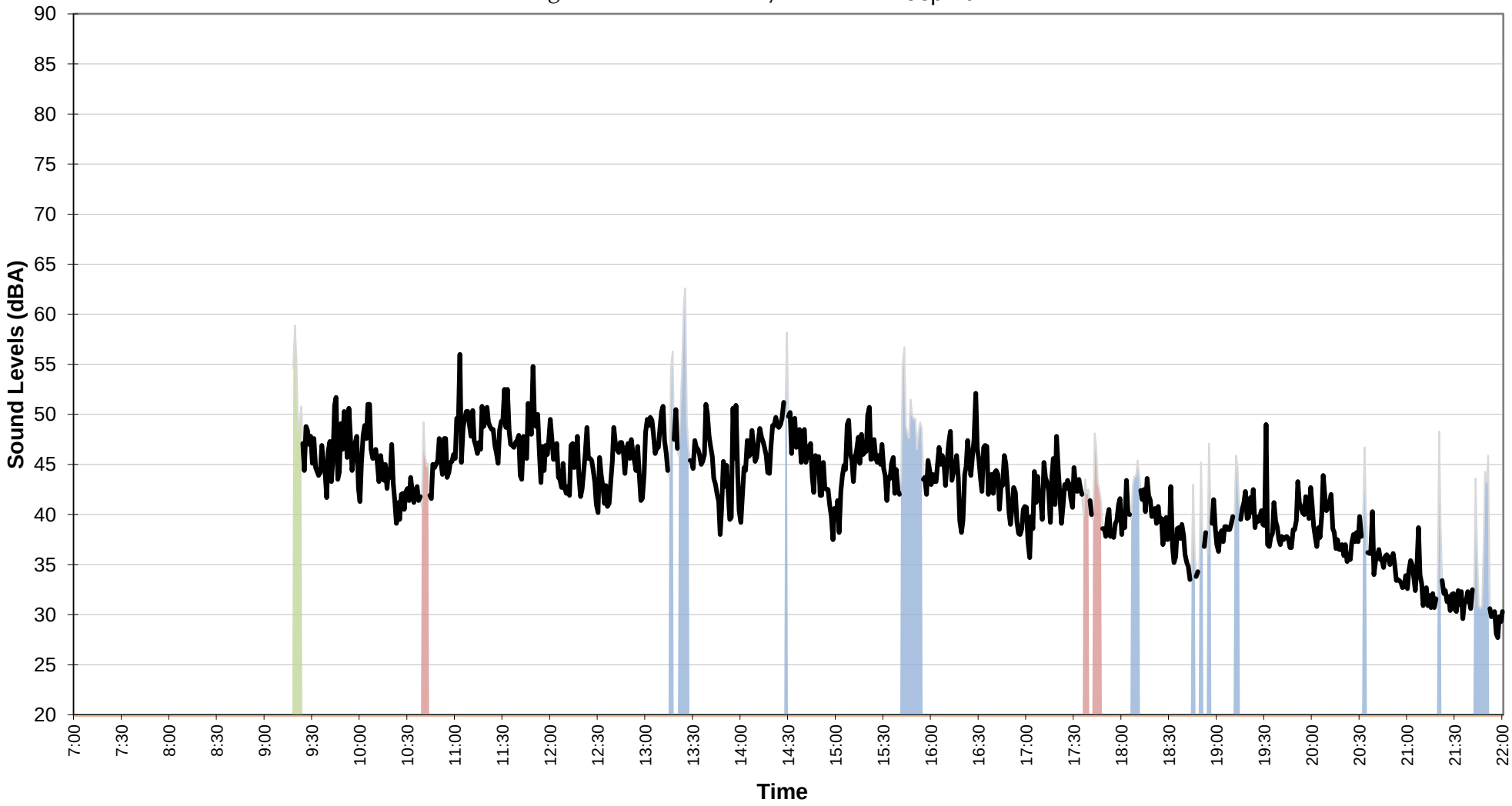
Comprehensive Sound Survey - Monitor E

Figure F4 Night 2 Sep 18 - Sep 19



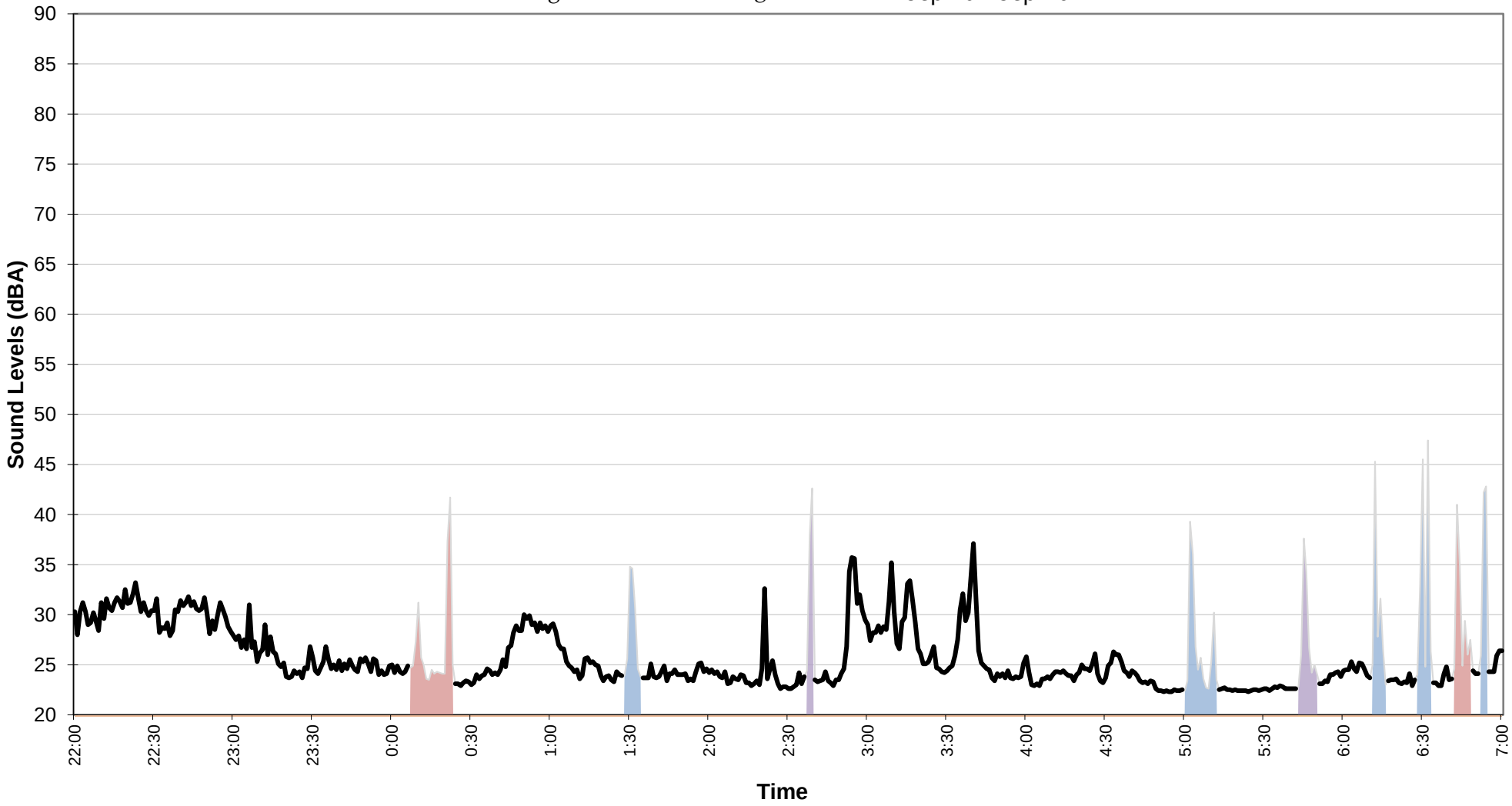
Comprehensive Sound Survey - Monitor E

Figure F5 Day 3 Sep 19



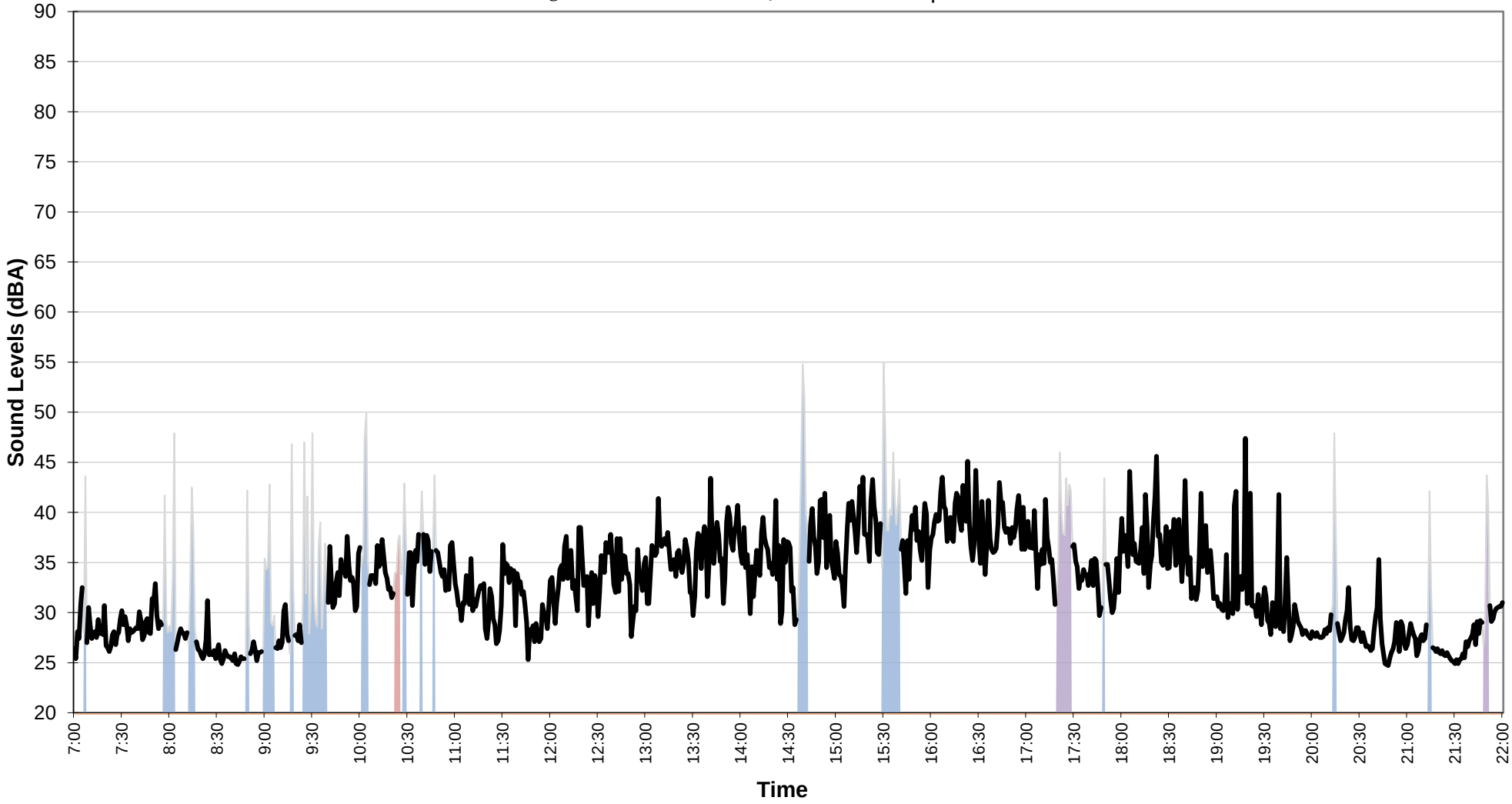
Comprehensive Sound Survey - Monitor E

Figure F6 Night 3 Sep 19 - Sep 20



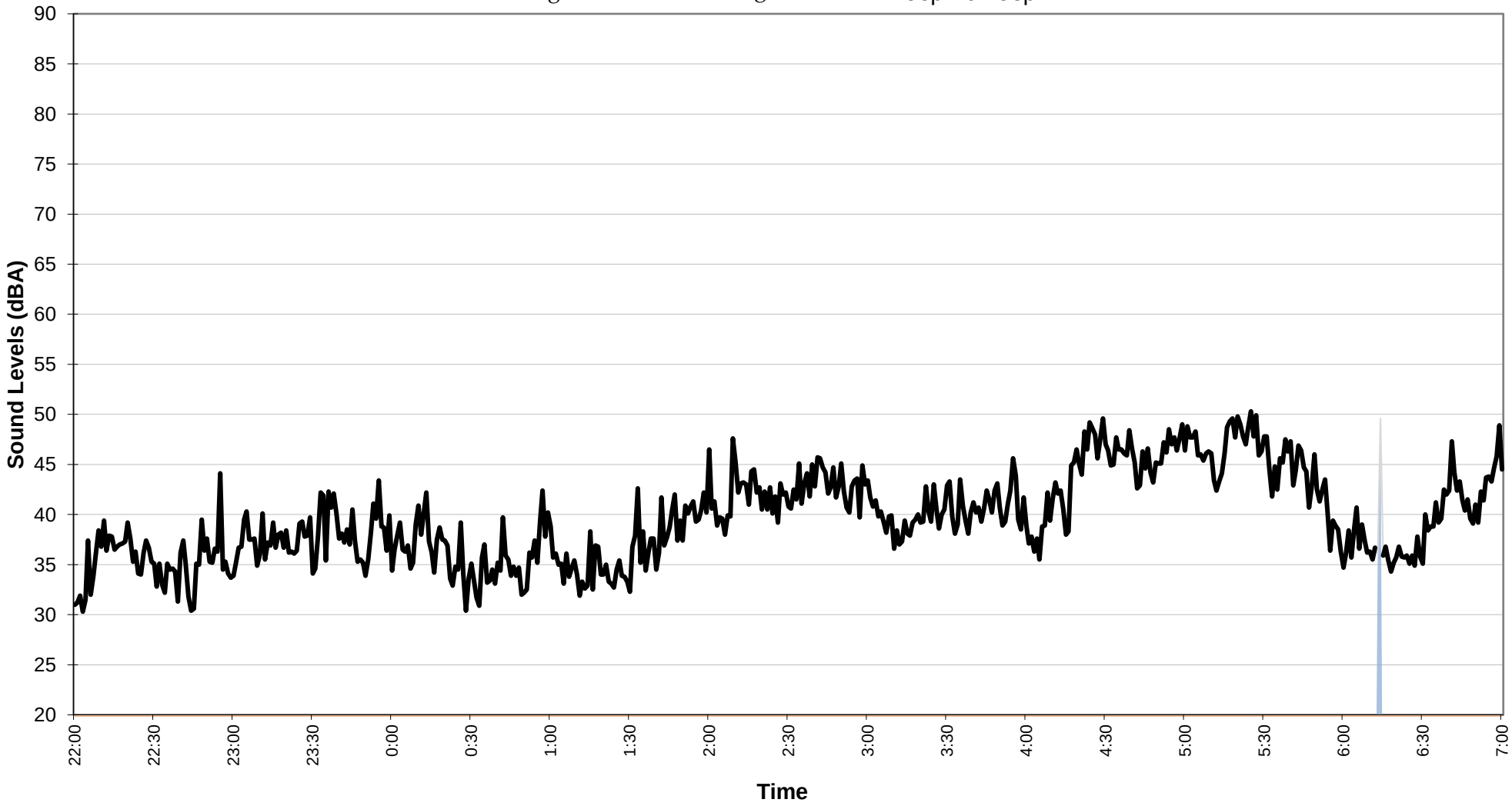
Comprehensive Sound Survey - Monitor E

Figure F7 Day 4 Sep 20



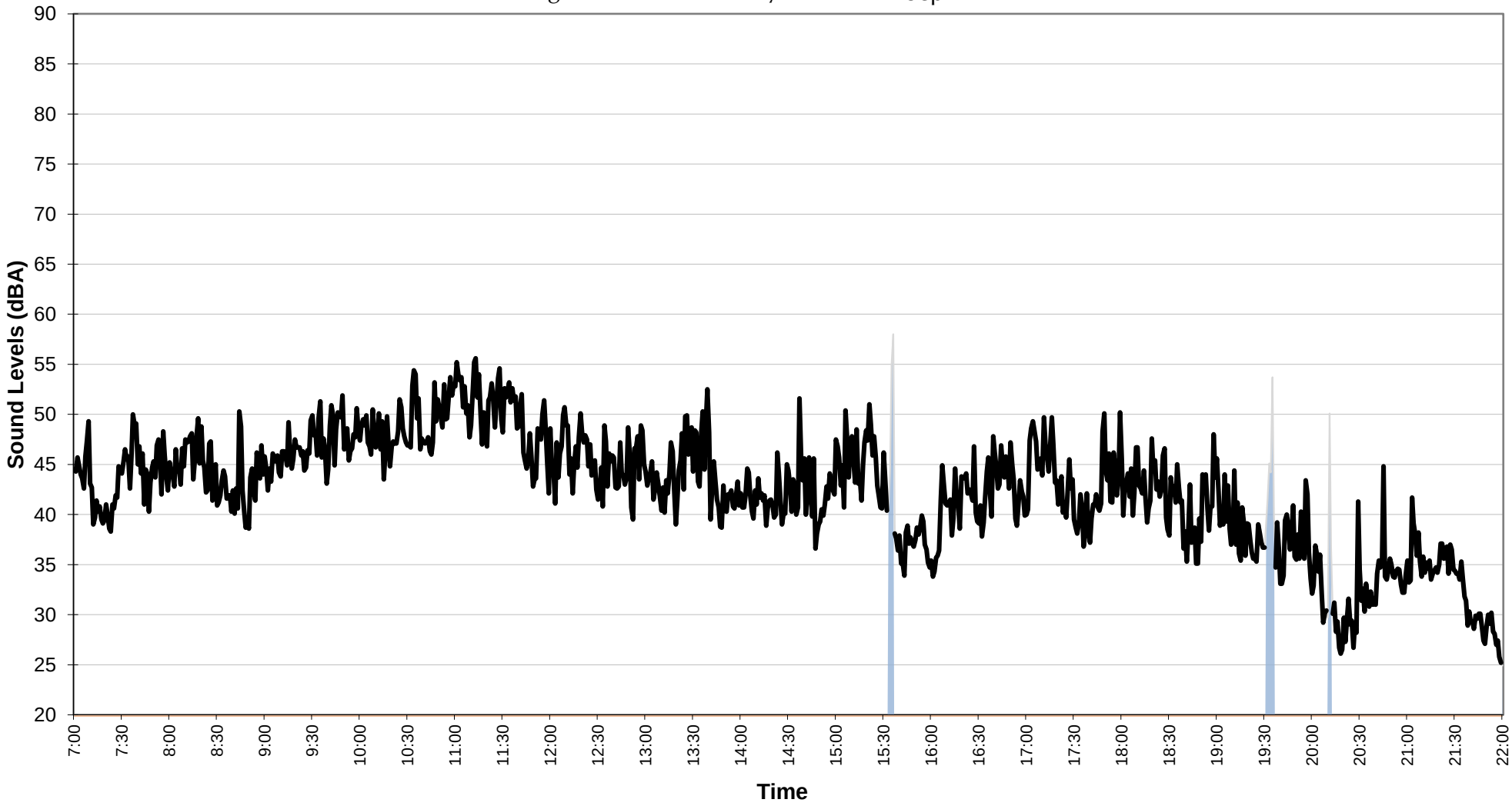
Comprehensive Sound Survey - Monitor E

Figure F8 Night 4 Sep 20 - Sep 21



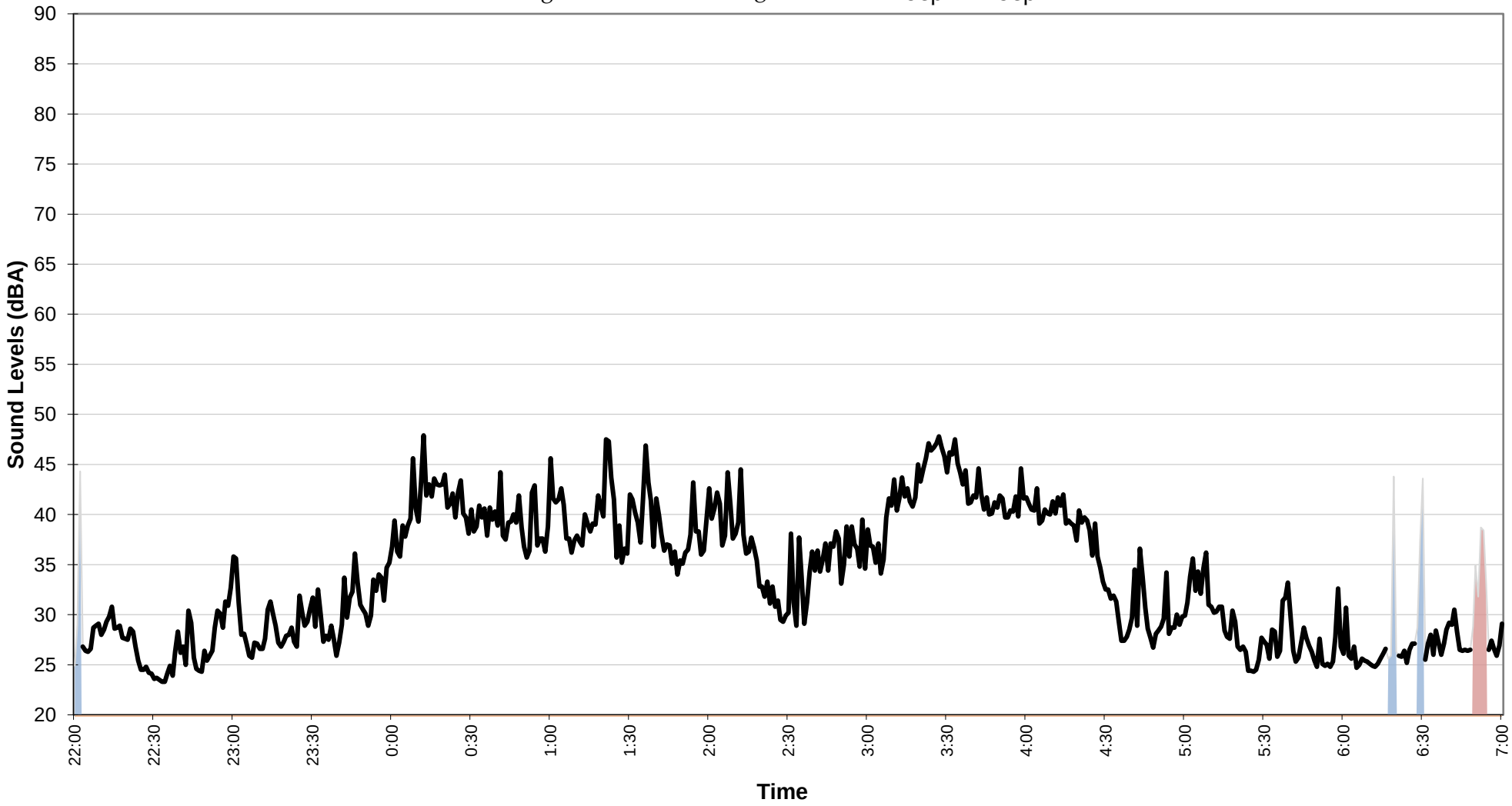
Comprehensive Sound Survey - Monitor E

Figure F9 Day 5 Sep 21



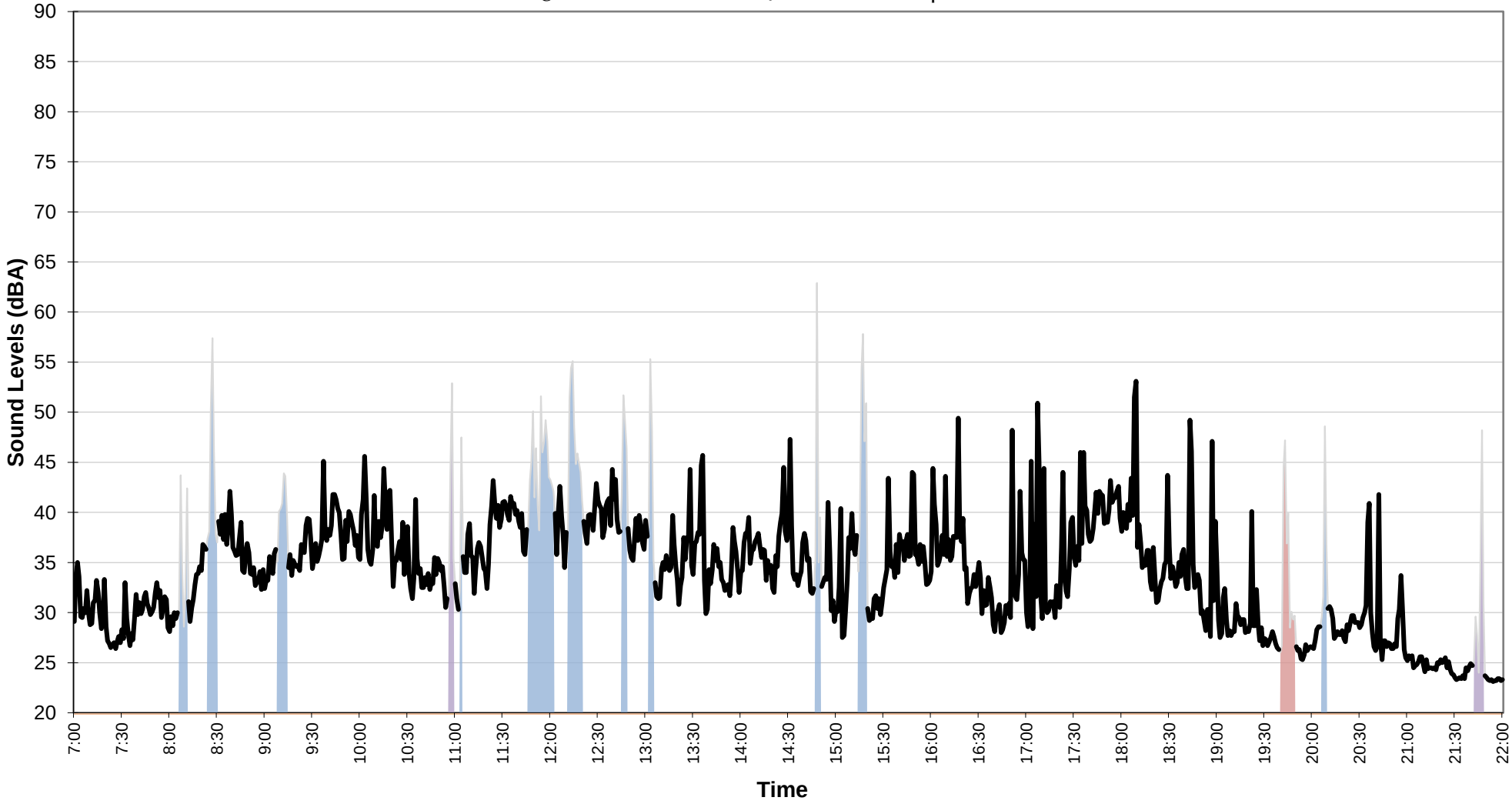
Comprehensive Sound Survey - Monitor E

Figure F10 Night 5 Sep 21 - Sep 22



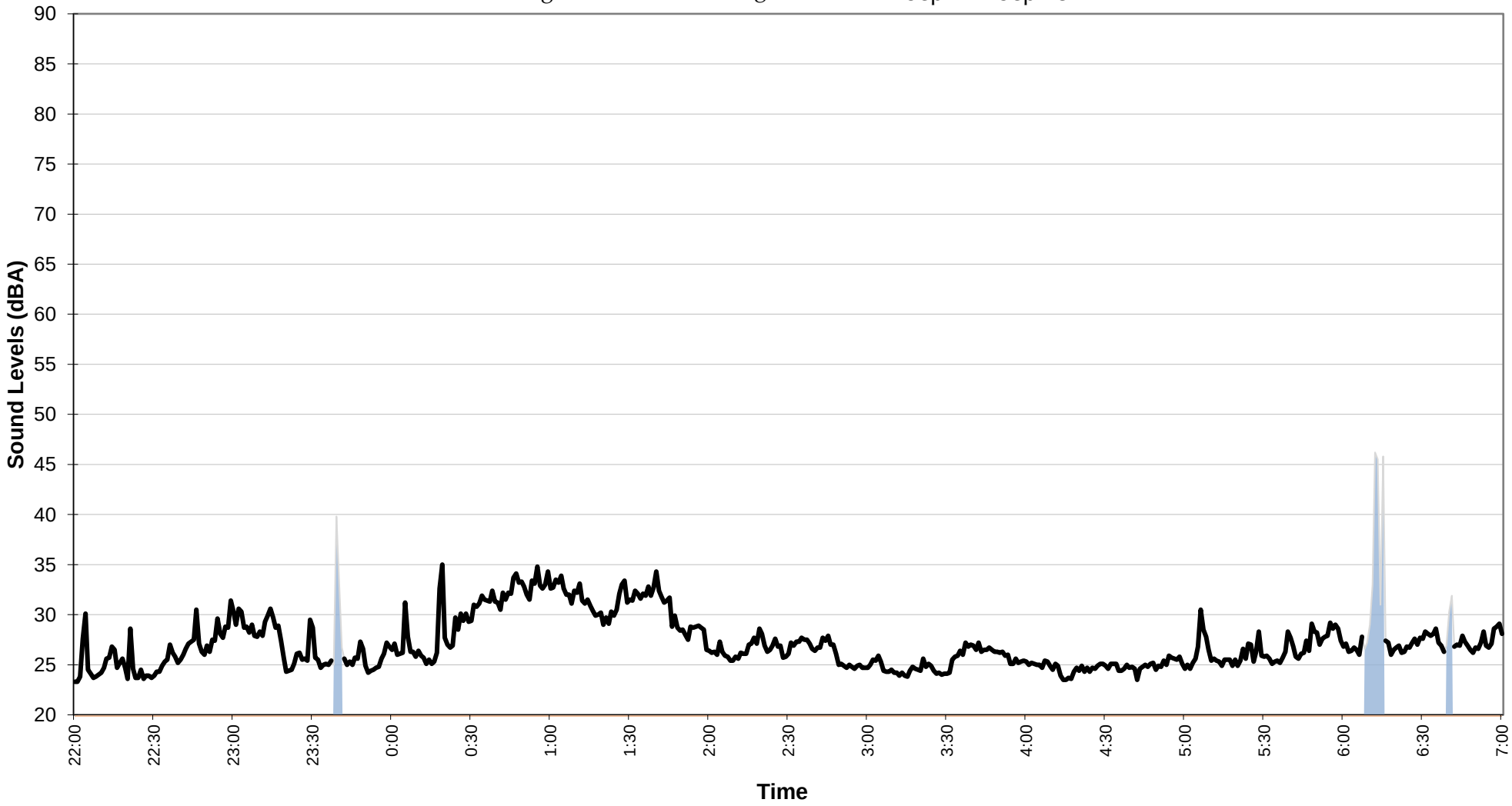
Comprehensive Sound Survey - Monitor E

Figure F11 Day 6 Sep 22



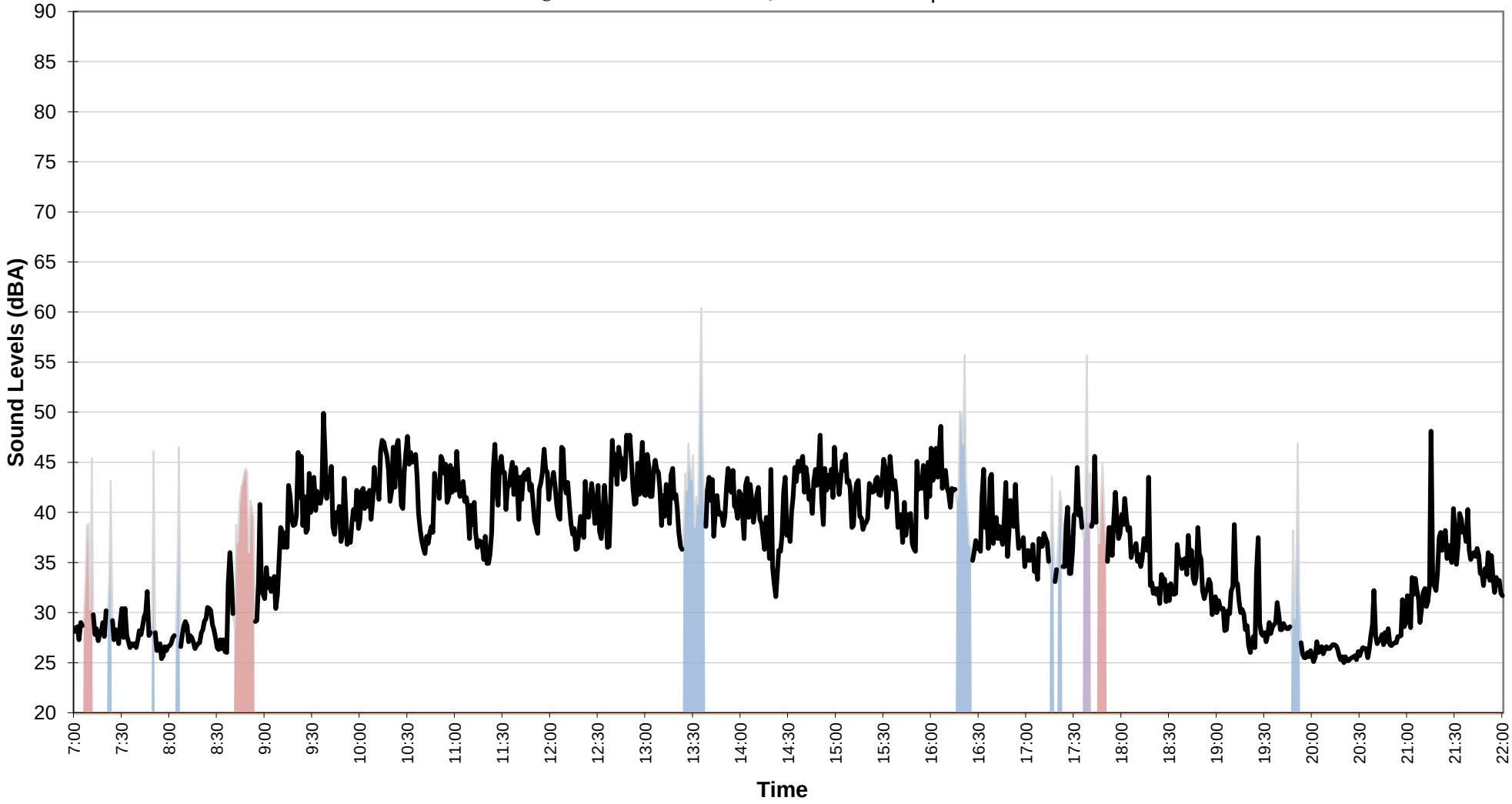
Comprehensive Sound Survey - Monitor E

Figure F12 Night 6 Sep 22 - Sep 23



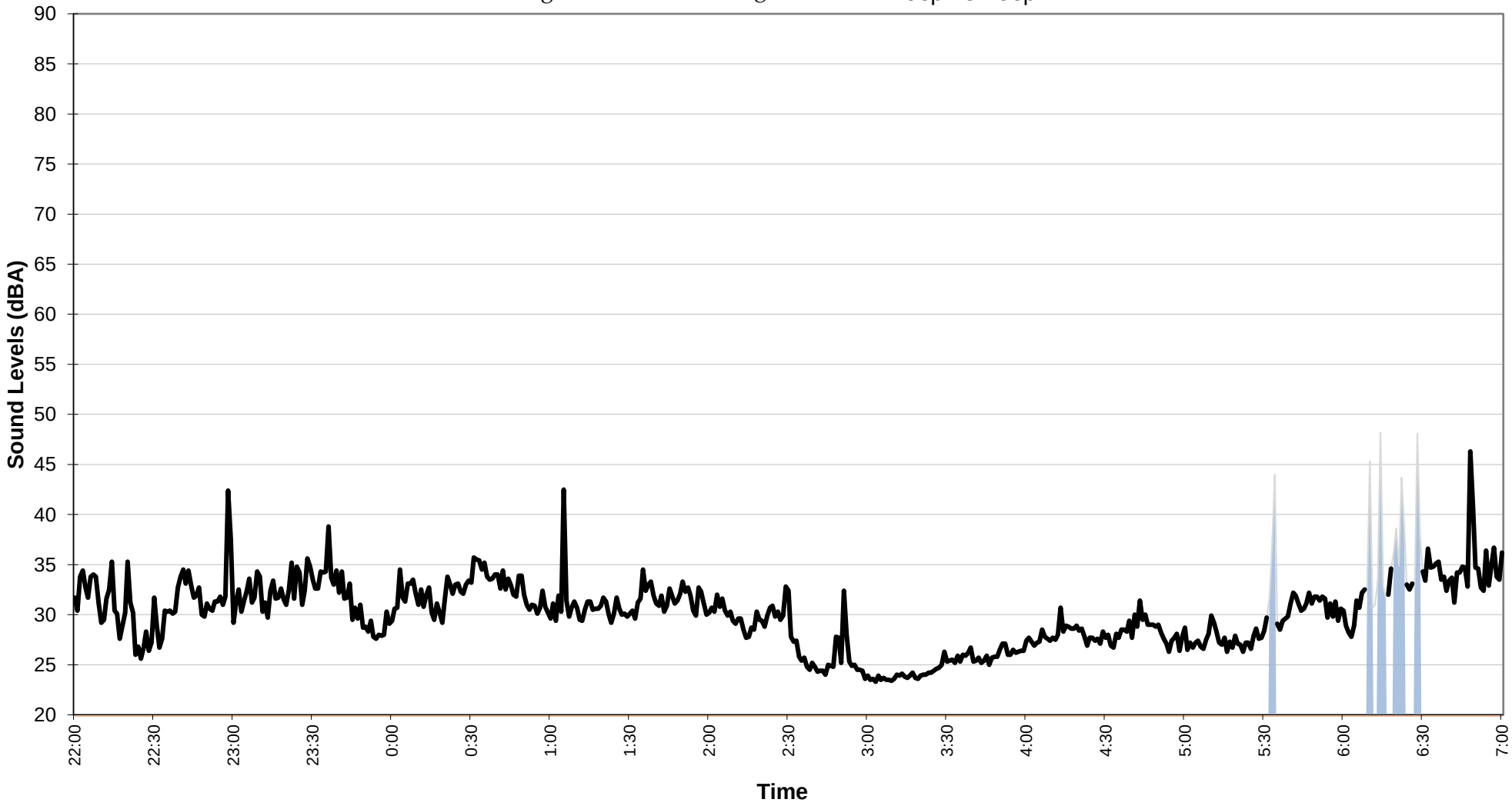
Comprehensive Sound Survey - Monitor E

Figure F13 Day 7 Sep 23



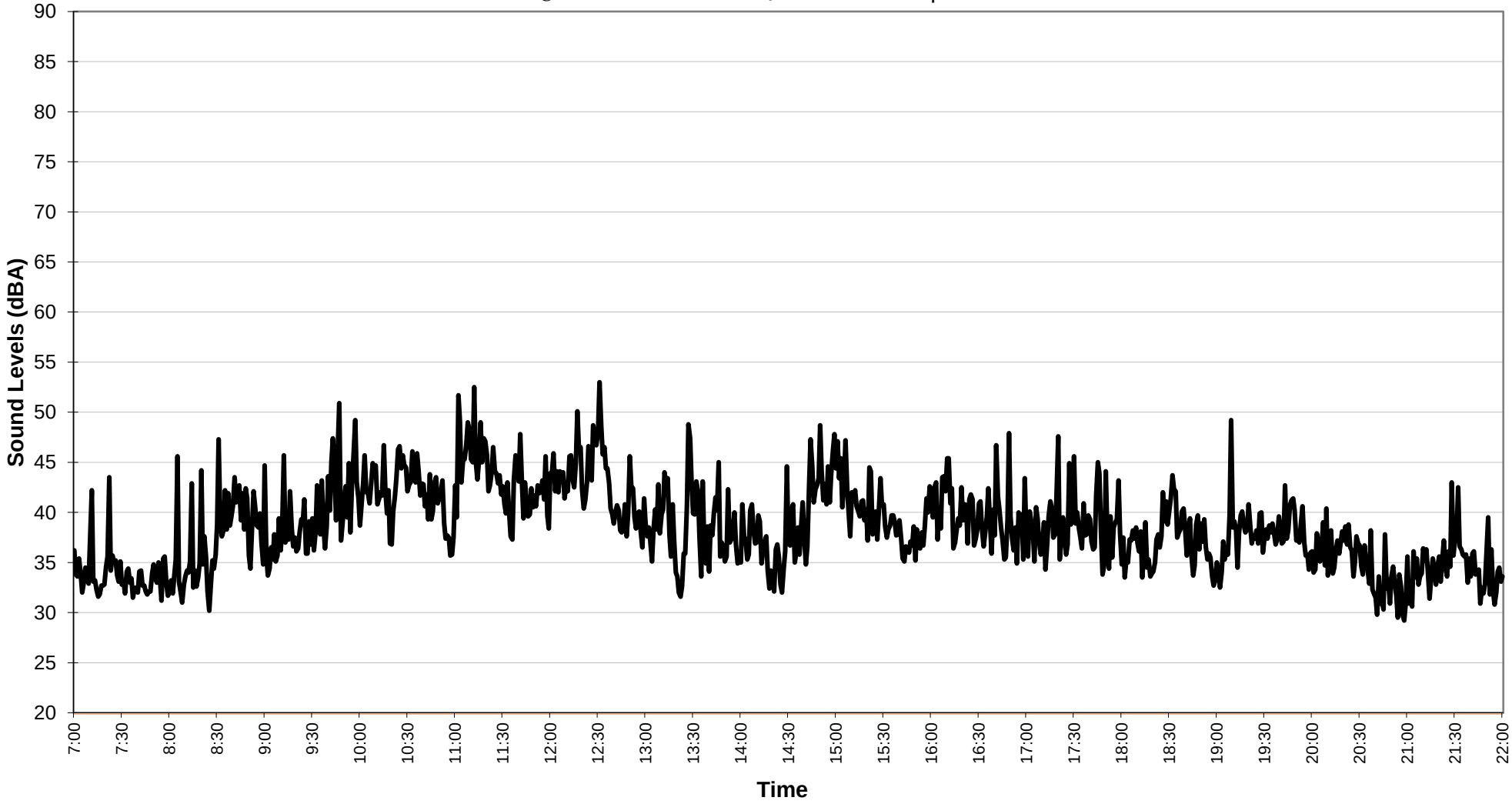
Comprehensive Sound Survey - Monitor E

Figure F14 Night 7 Sep 23 - Sep 24



Comprehensive Sound Survey - Monitor E

Figure F15 Day 8 Sep 24



Comprehensive Sound Survey - Monitor E

Figure F16 Night 8 Sep 24 - Sep 25

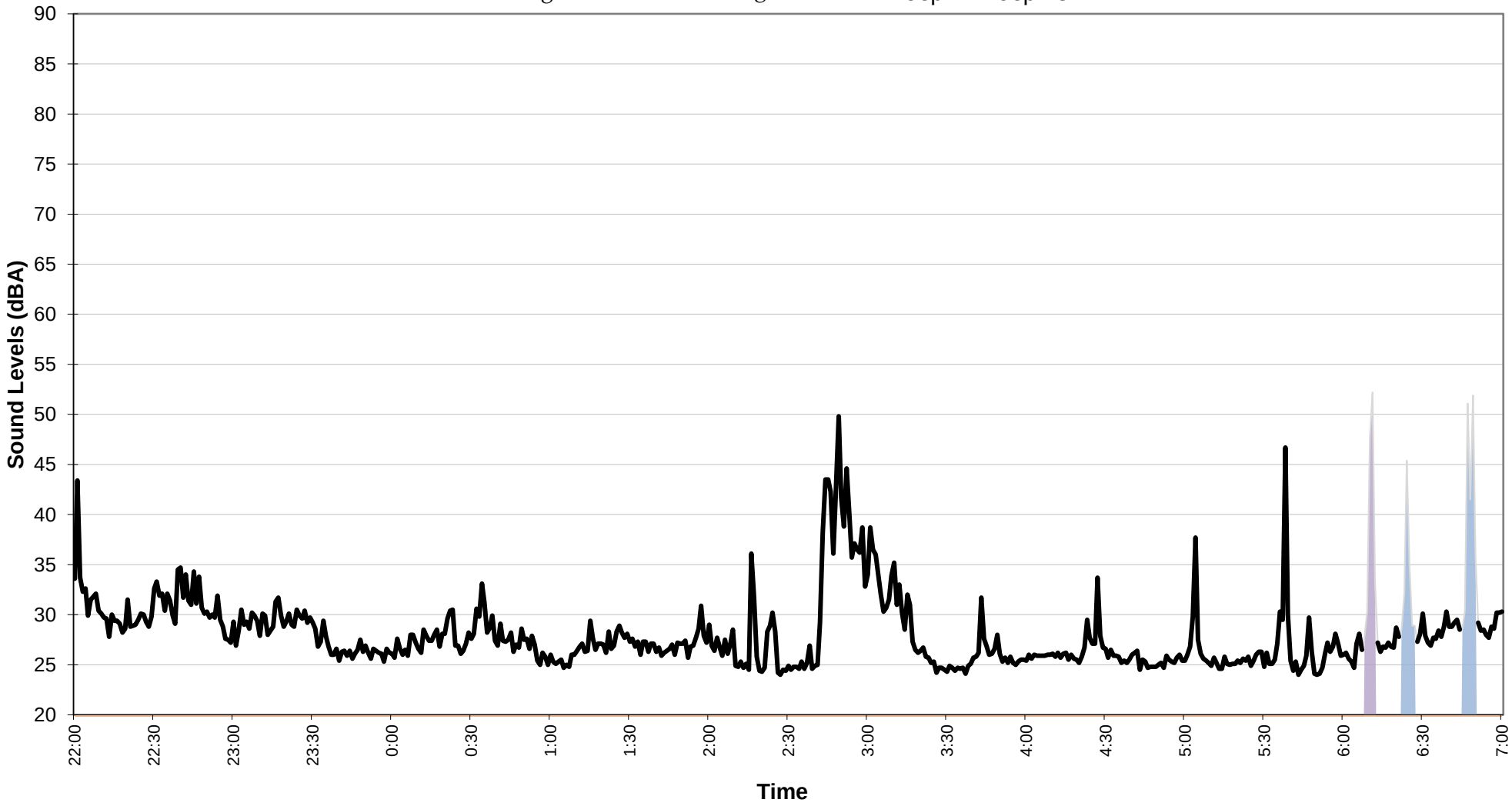


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Figure F17 Day 9 Sep 25

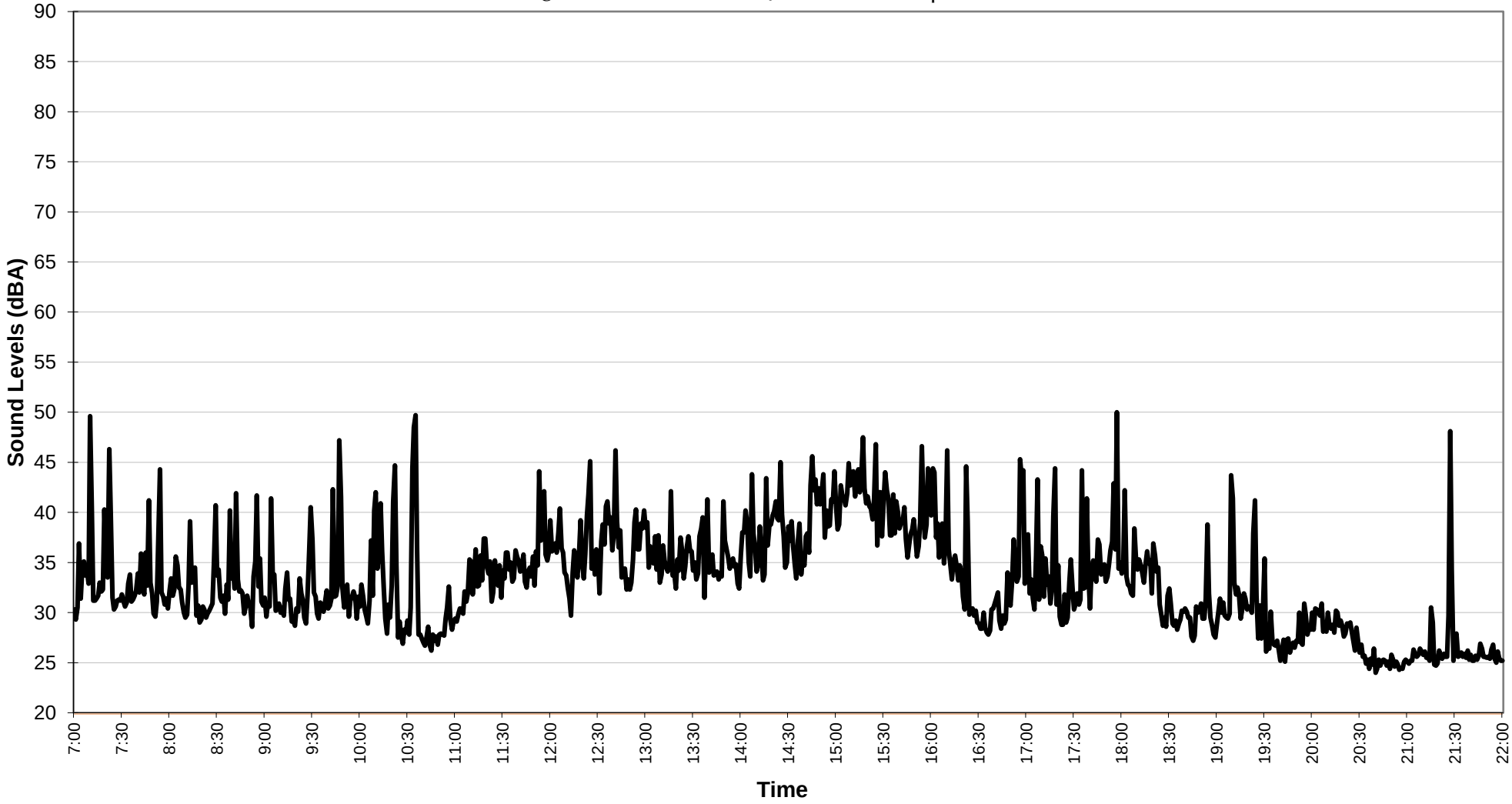

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Figure F18 Night 9 Sep 25 - Sep 26

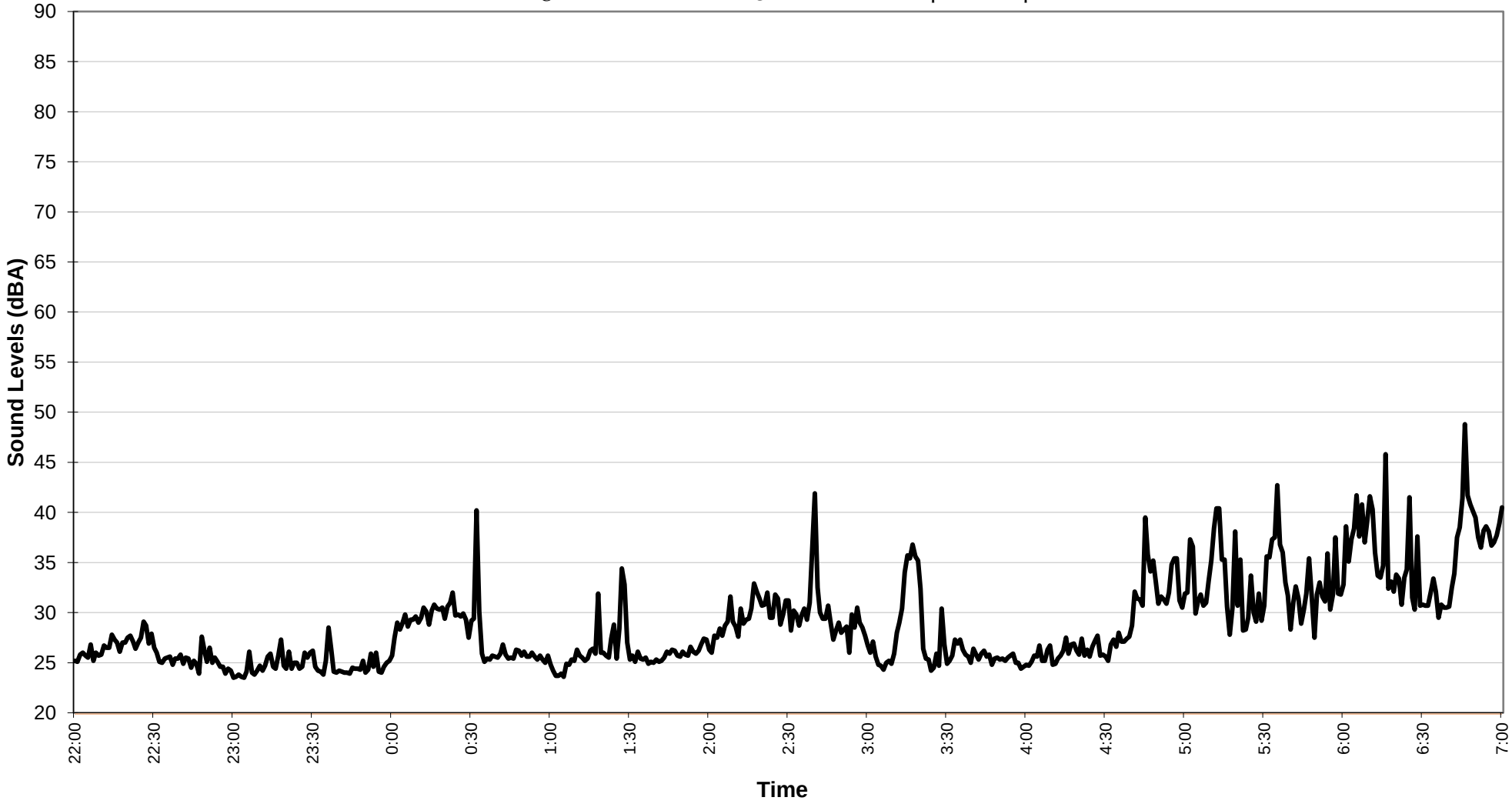

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Figure F19 Day 10 Sep 26

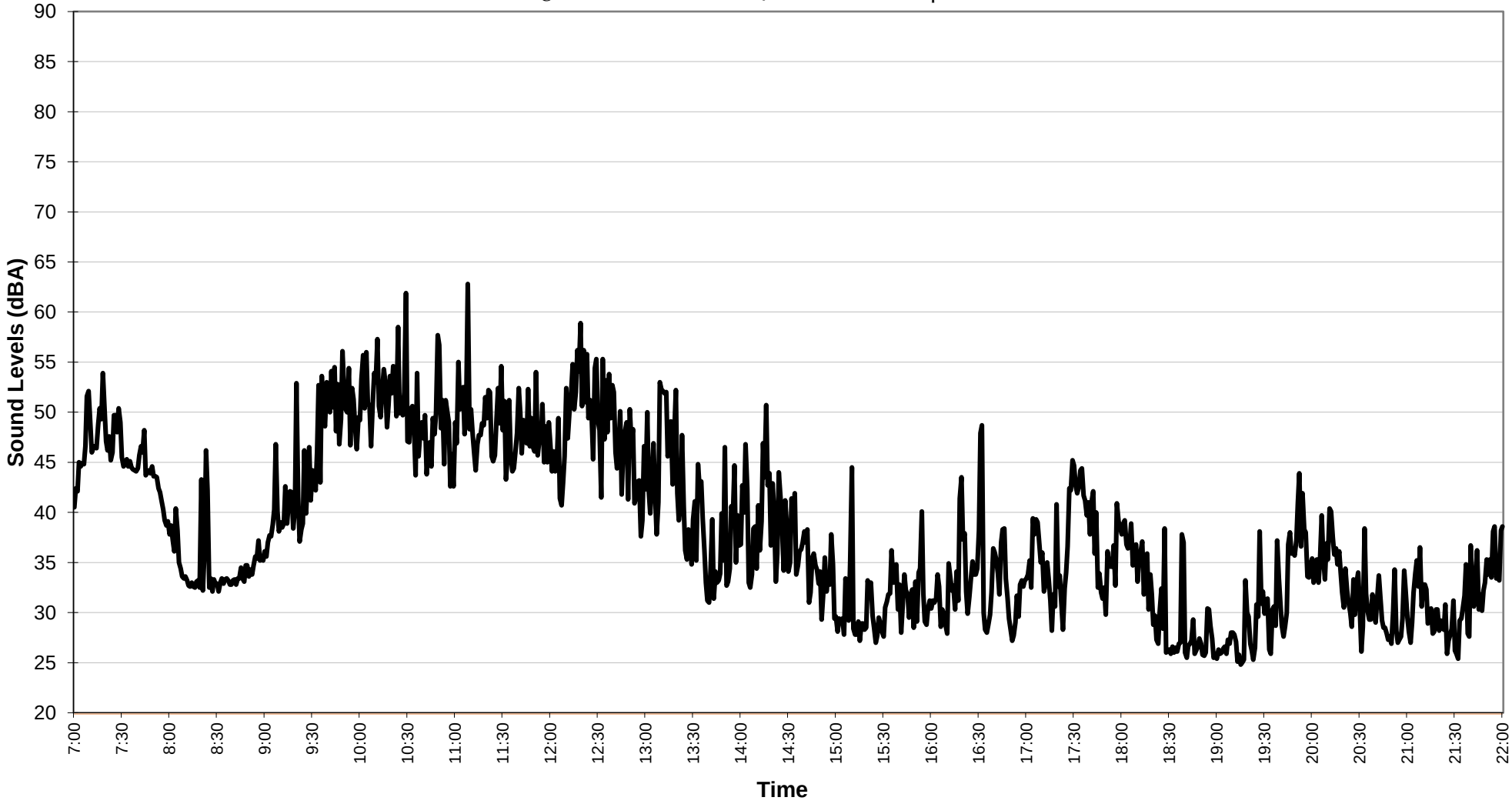

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Figure F20 Night 10 Sep 26 - Sep 27

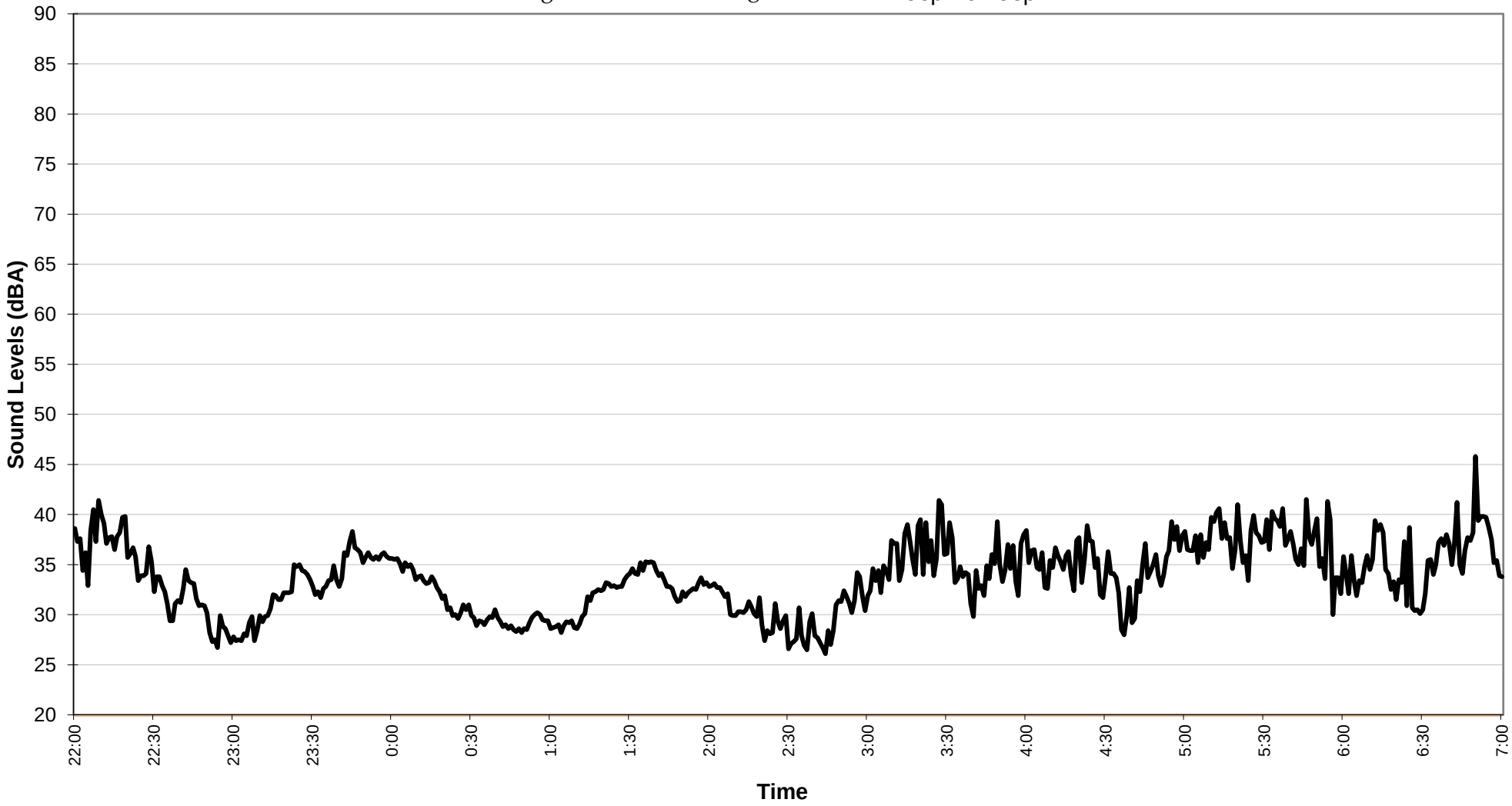

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Figure F21 Day 11 Sep 27

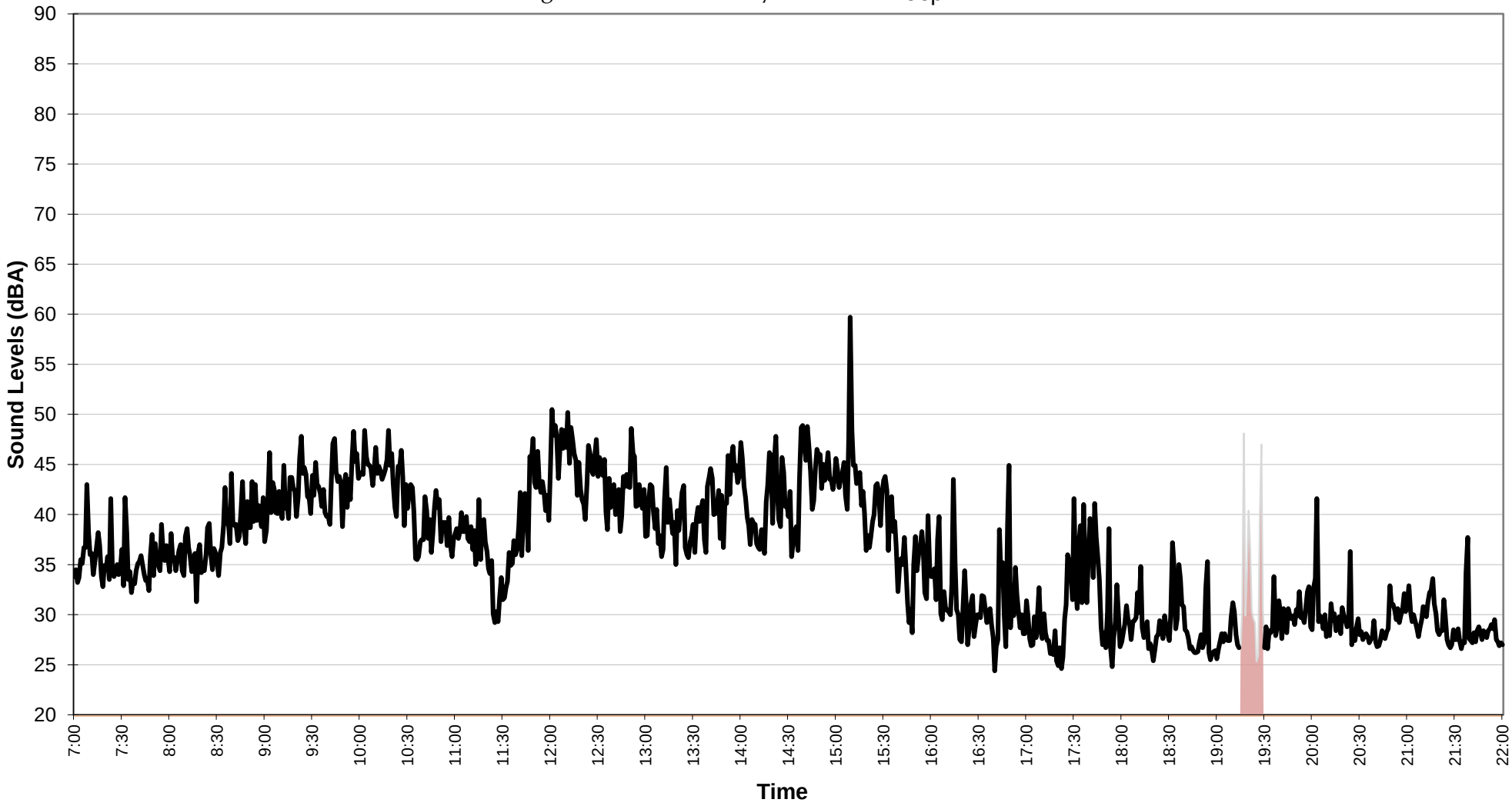

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Figure F22 Night 11 Sep 27 - Sep 28

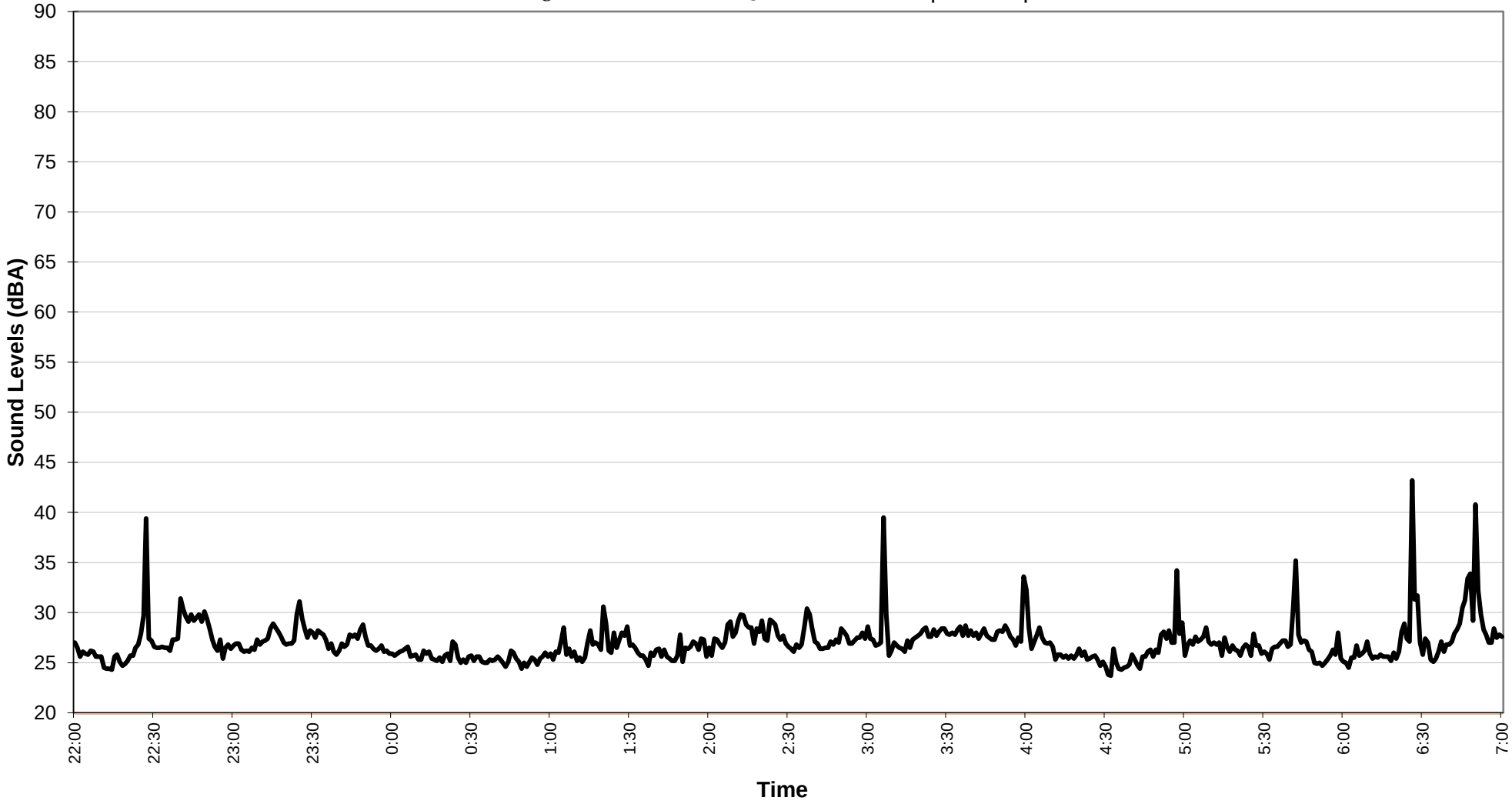

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Figure F23 Day 12 Sep 28

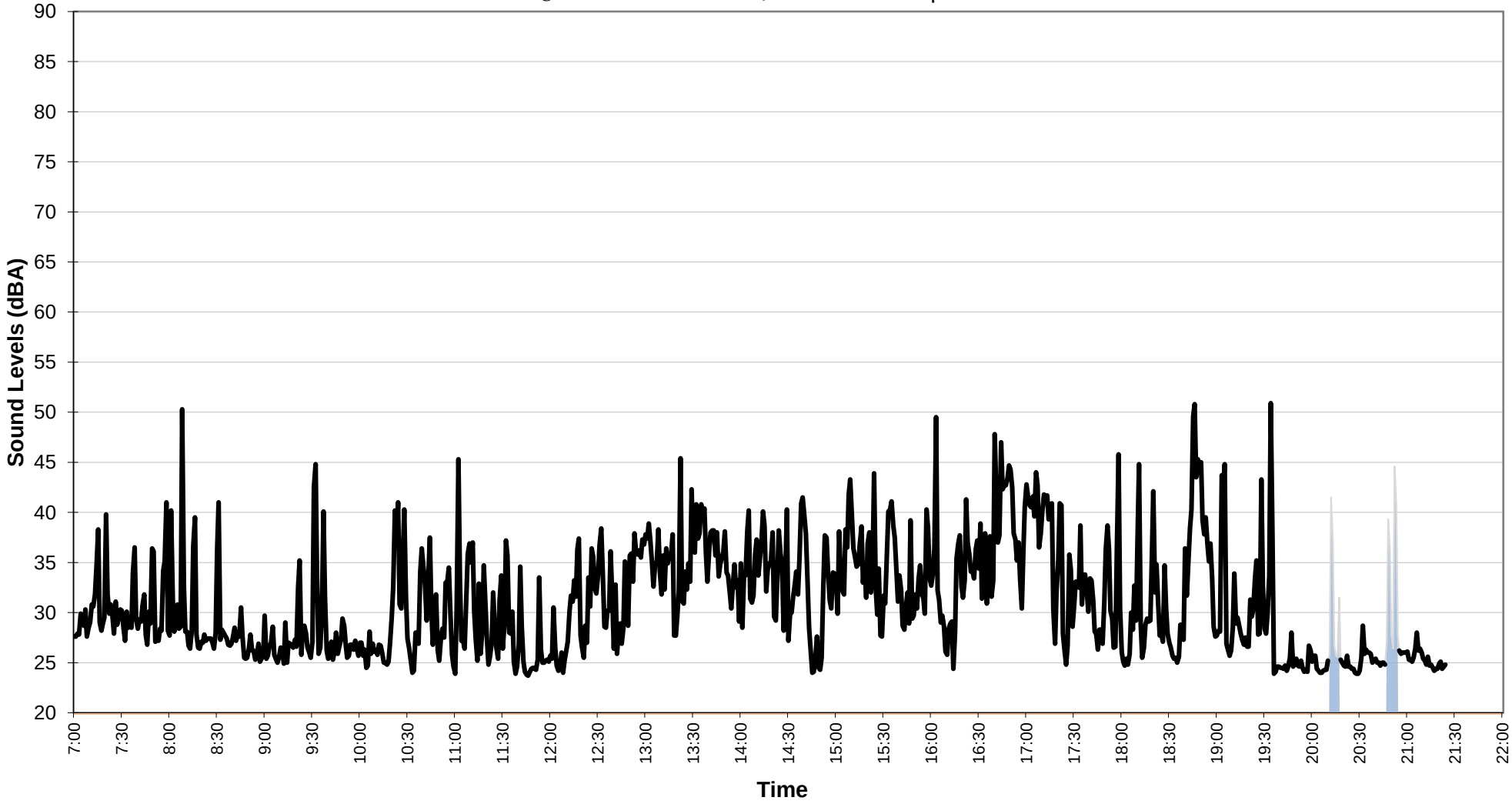

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Figure F24 Night 12 Sep 28 - Sep 29

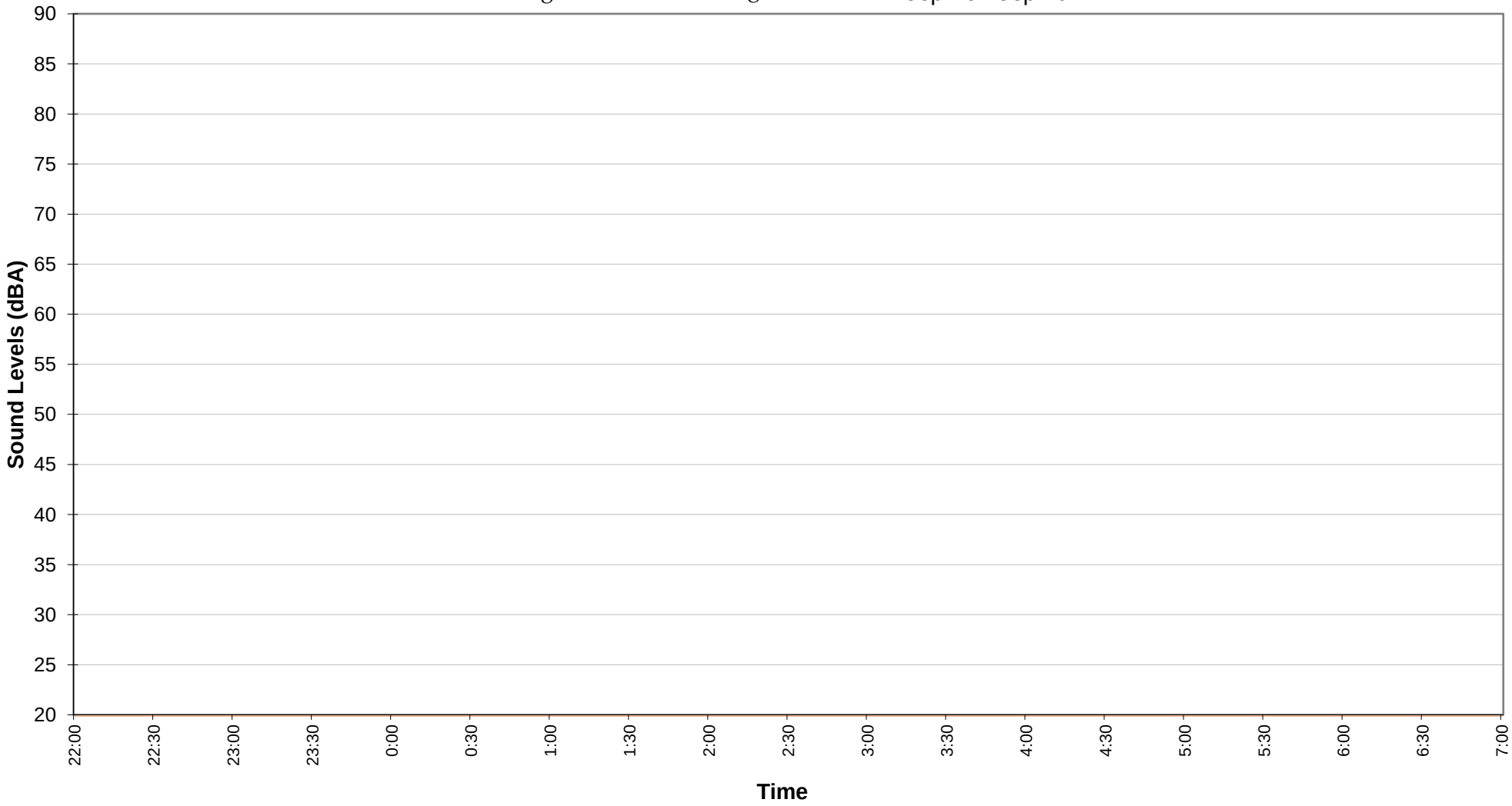

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Figure F25 Day 13 Sep 29

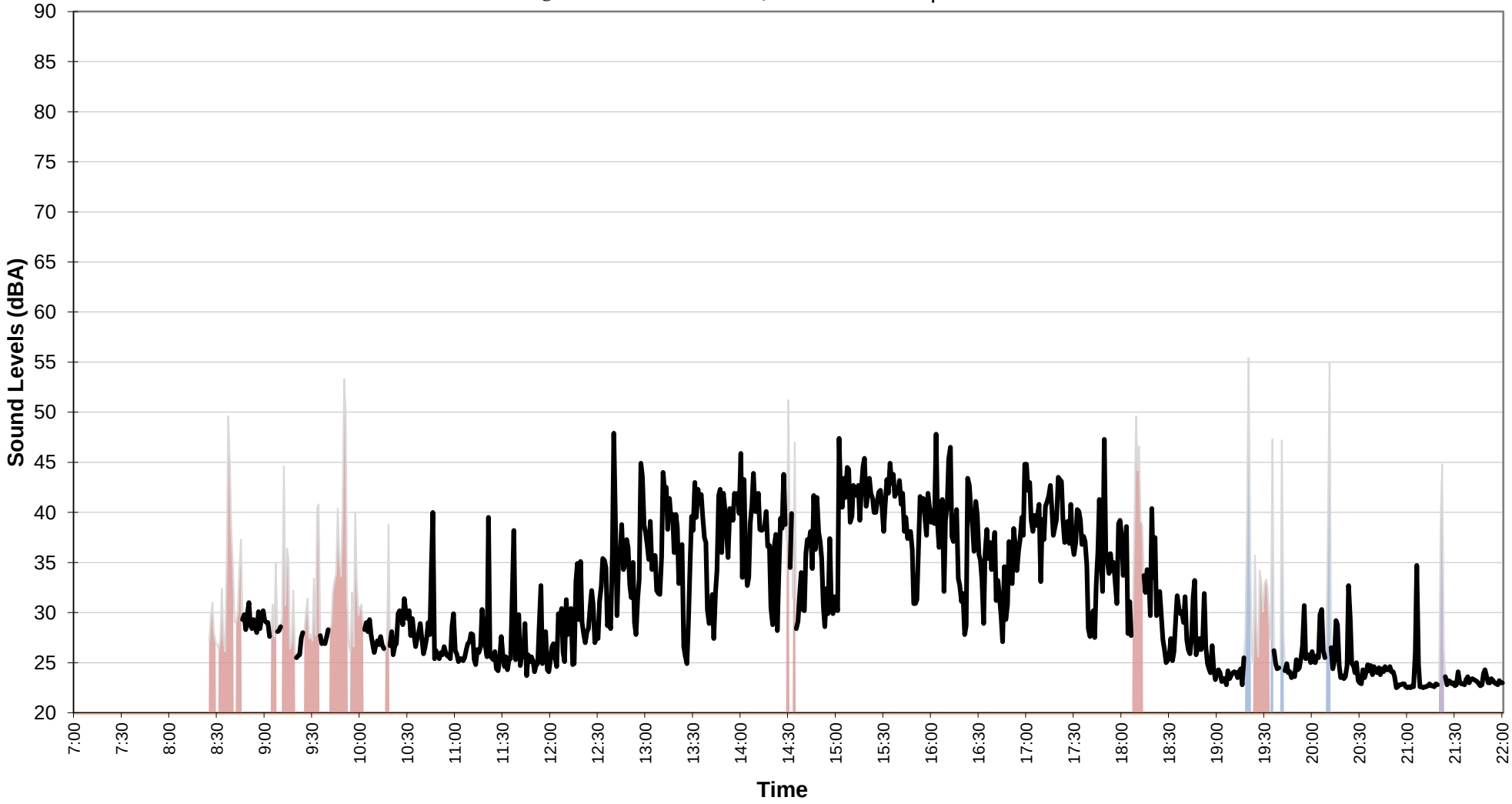

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Figure F26 Night 13 Sep 29 - Sep 30

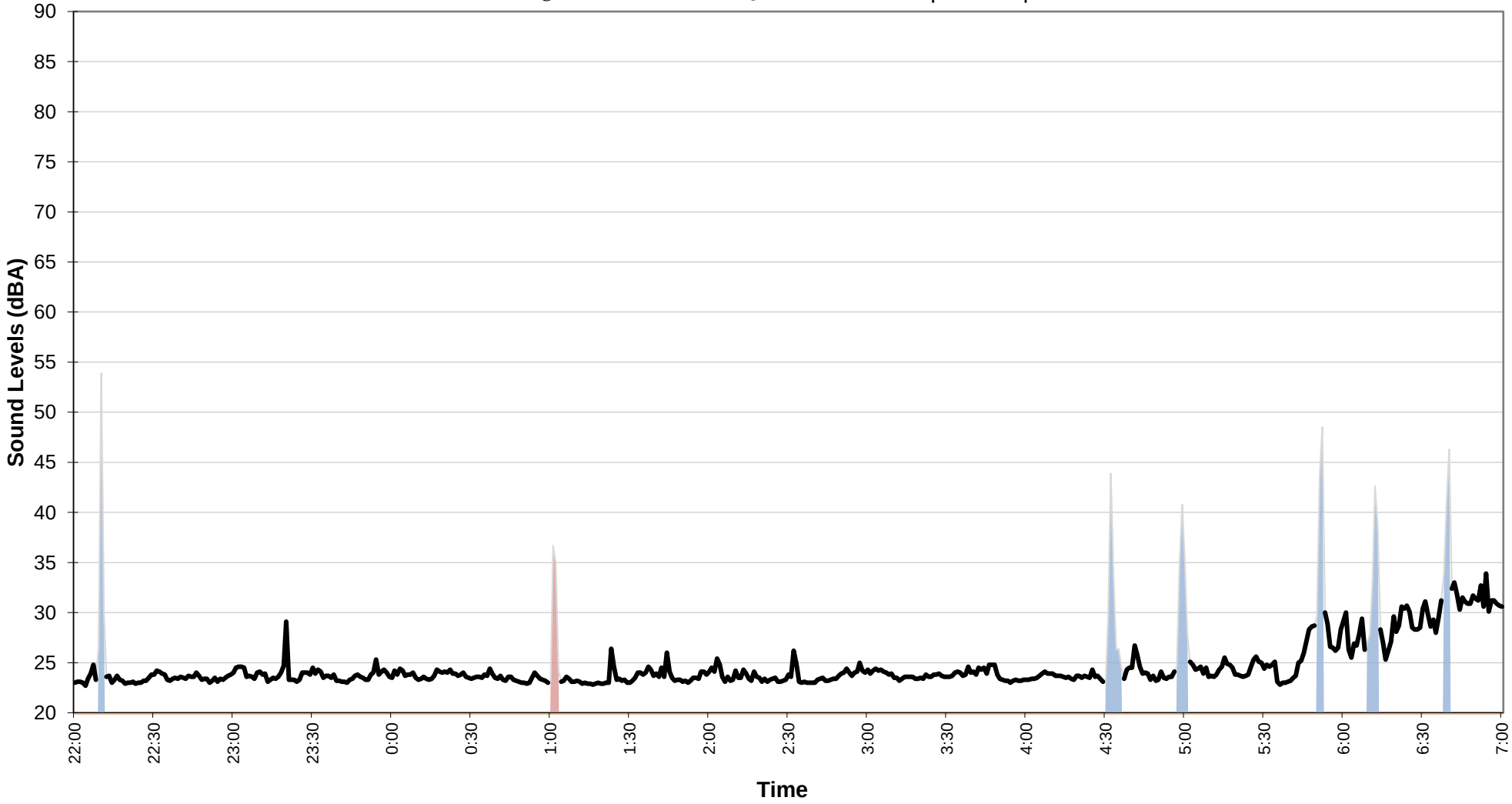

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Figure F27 Day 14 Sep 30