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Prescott Park Arts Festival
Sound Level Monitoring Report
June 16, 2019 – July 27, 2019

Prepared by
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for
The City of Portsmouth, NH

Introduction

Reuter Associates, LLC is under contract with the City of Portsmouth, NH to provide monitoring of sound levels during events at the city-owned facility. The Prescott Park Arts Festival (PPAF), a non-profit arts and education organization, is the principal tenant of the Park, and presents musical theater, concerts, and other events throughout the summer season.

The two goals for monitoring sound levels throughout the season are to maintain consistency in sound level emission between events (both theater and concerts) and to create a continuous record of sound levels for the entire season to document compliance with established standards in the PPAF's license agreement with the City and develop mitigation strategies and policies for future seasons.

To support this goal, a sound monitoring system has been designed and installed at the Park. Data generated from the system will result in regular reports (approximately every two weeks) throughout the performance season and be posted on the City's website.

This system, originally installed in June 2017, continuously monitors and records the sound pressure level at a fixed outdoor microphone, and provides visual feedback in real time to the sound engineer in the form of an arrangement of lights that provide a warning when sound levels exceed preset thresholds. By observing the lights during performances, the sound engineer is easily able to maintain sound levels that are consistent throughout the performance, across performances, and even across multiple engineers.

Background

This year is the third year the City has carried out sound monitoring in the Park. As in 2018, costs for the monitoring were shared with the Prescott Park Arts Festival in accordance with the adopted License Agreement. Data and reports from last year's monitoring efforts contributed to public policy discussions including the resulting recommendation to continue monitoring in subsequent seasons.

In addition to sound monitoring, the 2017 scope of work included an assessment of the sound system design, geared towards ensuring both adequate coverage of the audience area while minimizing off site sound impacts. Several of these have been subsequently implemented.

Terminology

Measurement and analysis of sound is a complex subject with a good deal of proprietary terminology. The definitions below are intended to help clarify the contents of this report, but are by no means comprehensive.

Decibel (dB)– Sound pressure is a fluctuation above and below the steady-state atmospheric pressure, and is typically measured in pascals (force/area). However, humans perceive changes in sound pressure on a logarithmic scale rather than a linear scale. To generate equal intervals of change in perceived loudness, exponential increases in pressure are necessary. As such, instead of comparing sound pressures in pascals, a pair of sound pressure measurements can be compared using the decibel scale, which provides a consistent measure of perceived change in amplitude between the measured values. For reference, a change of 3 dB is considered the just noticeable difference (JND) for humans, 5 dB represents a clearly audible change, and 10 dB is perceived by most people to be twice (or half) as loud.

Sound Pressure Level (SPL) - The decibel is, by definition, a comparative measure. However, it has been adapted for use as an absolute measure of sound level by comparing a measured pressure to the threshold of human hearing. This is known as sound pressure level (SPL). Sound level meters measure sound pressure level directly, and the reported value represent the amplitude (loudness) of the sound relative to the threshold of hearing.

Frequency Weighting – While sound pressure level is based on the threshold of human hearing, the threshold of hearing is frequency dependent. In simple terms, the threshold of hearing for low (bass) frequencies is much higher (requiring more SPL) than that for higher frequencies (such as speech). Human hearing acuity is frequency-dependent throughout the dynamic range (soft to loud) of hearing. Measuring overall sound pressure level without any regard for relative acuity at different frequencies yields meaningless data when the goal is to assess human perception and response.

To correct for this, weighting curves are applied to measured data before calculating the overall level. These filters compensate for relative acuity. Two such curves are in common use: A-weighting and C-weighting. A-weighting de-emphasizes low (bass) frequencies more than C-weighting, and is used in nearly all assessment of noise impacts. C-weighting is used in a few specific applications, among them monitoring of outdoor concert noise with significant low-frequency content.

When sound pressure level is measured with frequency weighting applied, the dB is followed by a letter indicating the weighting, i.e. **dBA** or **dBC**. If no weighting has been used, this it indicated by using dBZ, for “zero weighting”, but this is unusual.

Equivalent Sound Level (Leq or L_{EQ}) – Sound pressure level fluctuates rapidly. If levels are to be measured over time, an interval of time must be chosen for each discrete measurement. However small this interval, sound pressure level will likely have fluctuated somewhat within the interval. The equivalent sound level is the theoretical constant sound pressure level that would contain the same amount of energy as the actual fluctuating level. It is therefore considered an energy average. To avoid the necessary exponential math, it is easiest to think of Leq as the average sound level during the interval.

If Leq is measured at a particular interval, these data can be used to calculate the Leq of any longer interval, provided the data are continuous. For example, a 1-minute Leq can be calculated from sixty 1-second Leq values. A 24-hour Leq can be calculated from 24 1-hour Leq values (or 86,400 1-second values).

While other statistics are often calculated to analyze the nature of fluctuating sound levels, Leq has been shown to be most useful in predicting annoyance and other impacts on humans from noise in the environment. It is therefore the only metric used in this study.

Sound Level Limits

Limits for sound pressure levels from events at Prescott Park were utilized in 2017 and were subsequently formally established through the 2018 and 2019 license agreements between the PPAF and the City of Portsmouth.

When mixing live music, the sound reinforcement system (the loudspeakers, amplifiers, and other associated components) must be able to overcome the direct sound emanating from the instruments on stage. If it is not possible to accomplish this, the engineer will not have control over the mix. For a full band with drums and guitar amplifiers onstage, this level is routinely in the 85 to 90 dBA range at a distance comparable to the front of house location at Prescott Park. For this reason, a limit of 90 dBA has been used since the 2017 season.

As noted in the Terminology section above, C-weighting (dBC) is sometimes used for monitoring of live music. C-weighting is more sensitive to low frequencies (bass, etc.) than A-weighting, and C-weighted levels are typically higher than A-weighted levels for rock/pop music. C-weighting may be useful for some of the concerts staged at the park, but A-weighting is more appropriate for musical theater and lightly orchestrated folk and similar music, which makes up much of the summer schedule. For these reasons, A-weighting has been used for monitoring and feedback.

Visual Feedback

The sound level monitor at Prescott Park continuously measures and logs 1-second Leq values. These data are used in real time to calculate longer Leq values, and to control the stoplight-style visual feedback system.

Sound pressure levels associated with music fluctuate rapidly, making it somewhat impractical to use the nearly instantaneous 1-second Leq to monitor the overall sound level of a performance. A longer Leq is more useful. This can be described as a sliding average, or smoothing function. This is used for the first level of warning, the yellow light.

The red light is used to warn of instantaneous levels that exceed a higher threshold, indicating a more severe exceedance of the limit.

The triggers for the lights have been set as follows:

Green – neither condition below is true (target sound level range)
Yellow – 5-second Leq exceeds 90 dBA
Red – 1-second Leq exceeds 95 dBA

Sound engineers have been instructed to respond as follows:

Yellow – Gradually reduce overall level until green illuminates.
Red – Immediately reduce overall level by at least 5 dB until green illuminates.

Under most circumstances, the yellow light will already have been on if the red light comes on, but there are situations where both could illuminate simultaneously.

Event Data

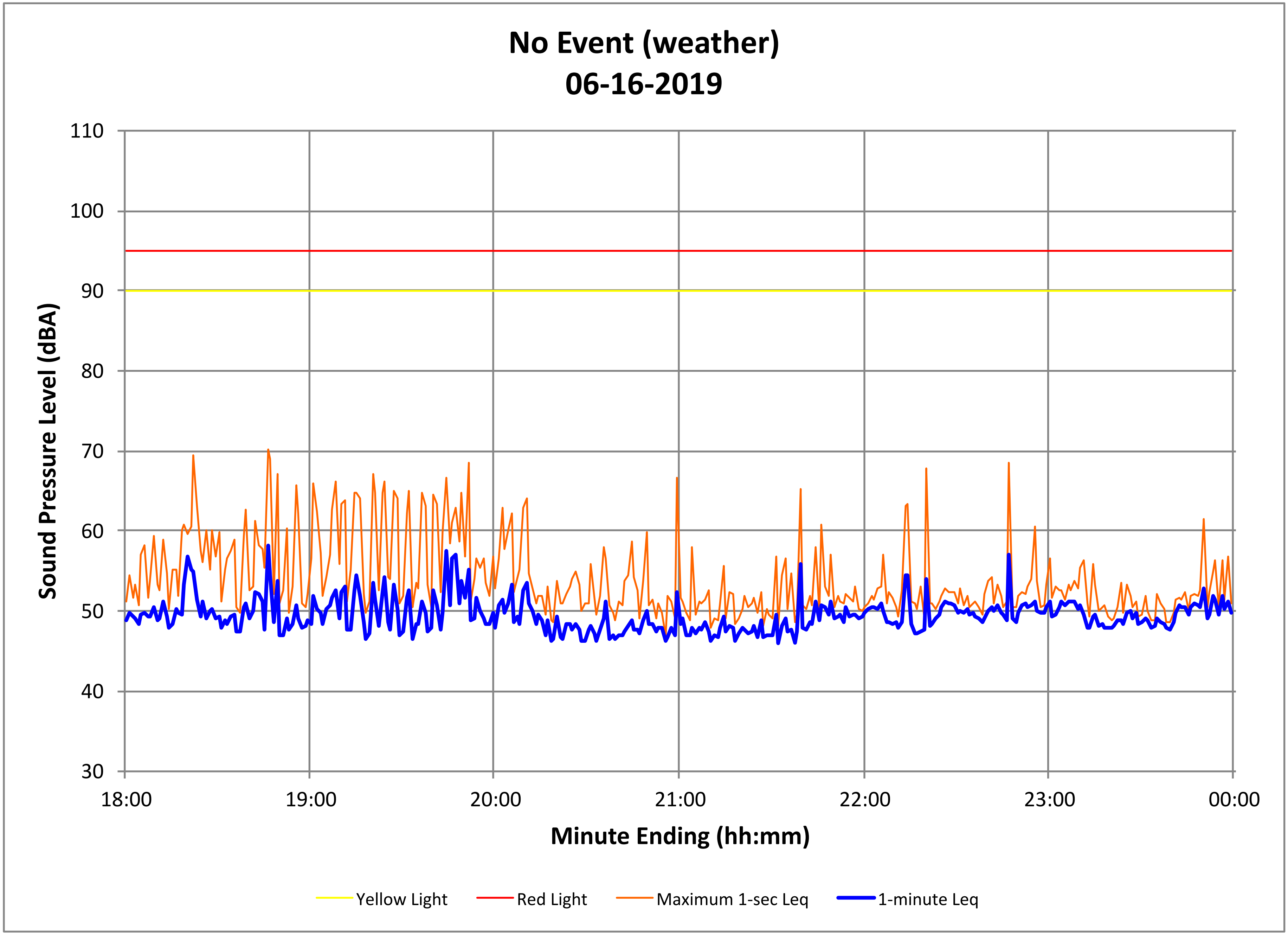
The attached Appendix A provides plots of sound levels versus time from 6 pm to midnight for each night between June 16th and July 27th. Nights without events have been included for clarity and comparison.

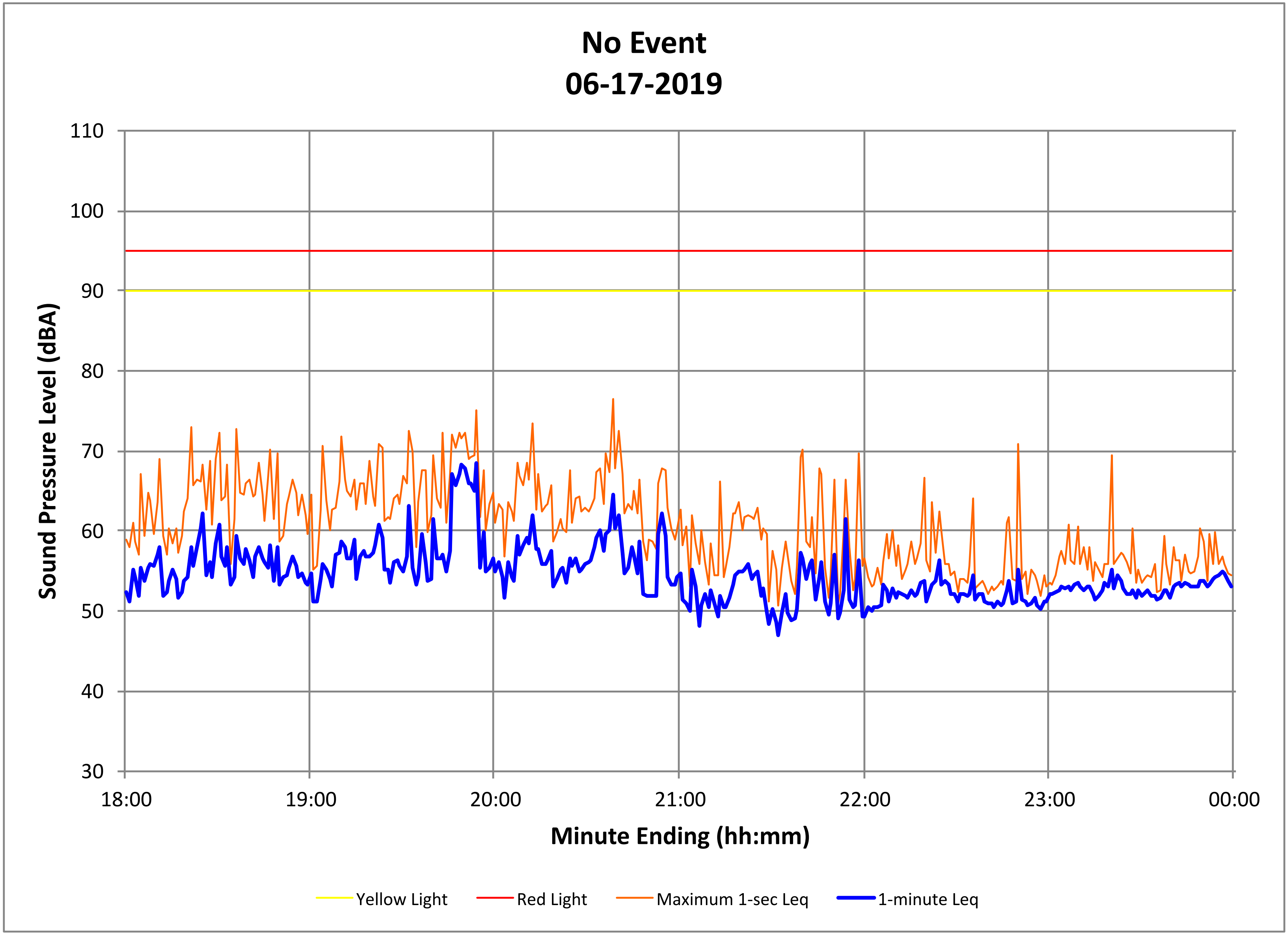
The lines plotted are both A-weighted sound pressure level in 1-minute intervals, as plotting six hours of data in 1-second intervals makes the plot difficult to interpret. The 1-second data are available for further analysis.

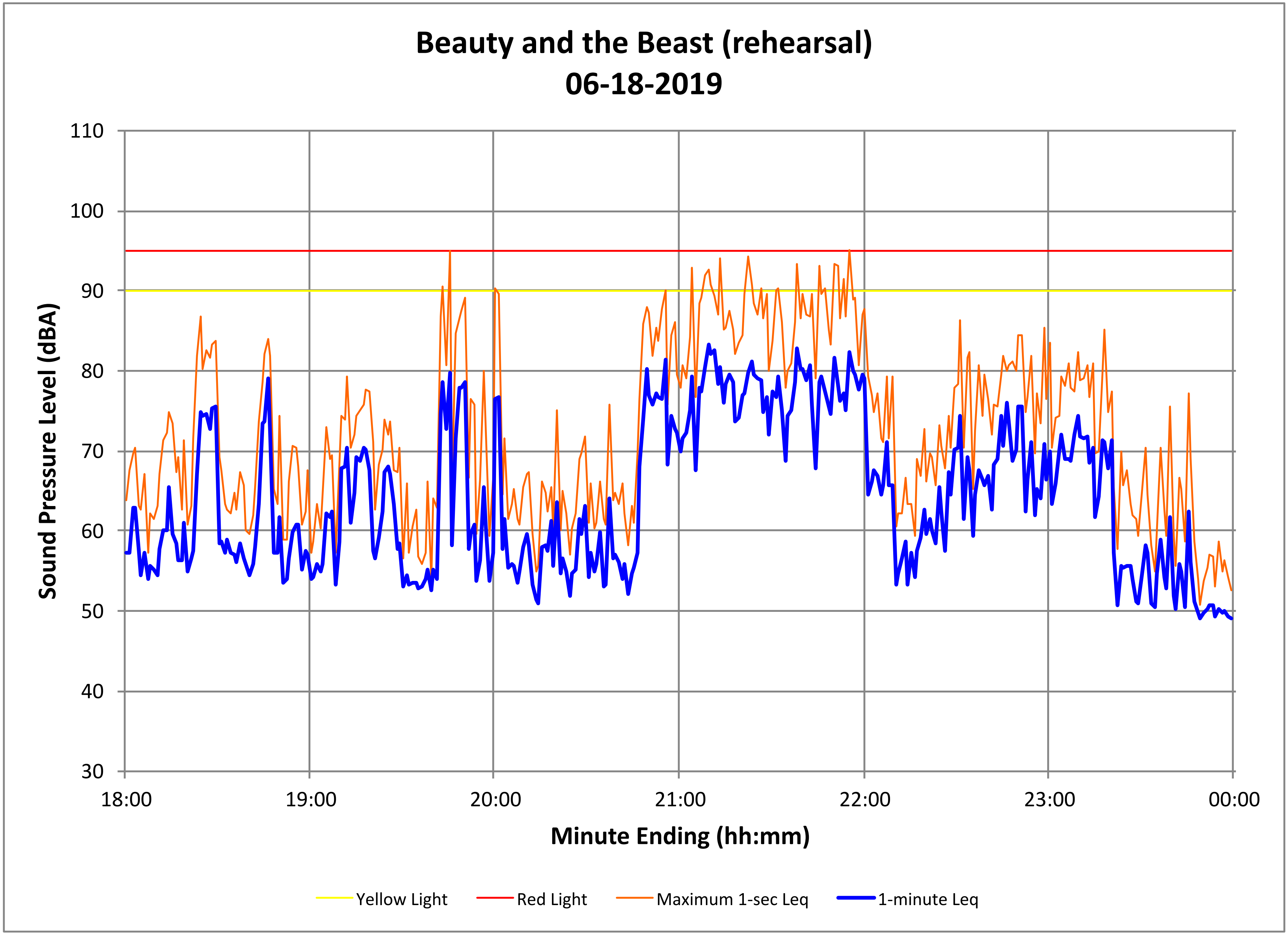
1-minute Leq – The Leq over the minute ending at the data point
Maximum 1-second Leq – The maximum 1-second Leq measured during this minute
Also included are lines indicating the yellow and red light thresholds.

As annoyance is known to correlate with Leq, the 1-minute Leq is the more useful of these. However, the maximum 1-second Leq during each minute provides a better indicator of whether the 95-dBA red lamp was illuminated.

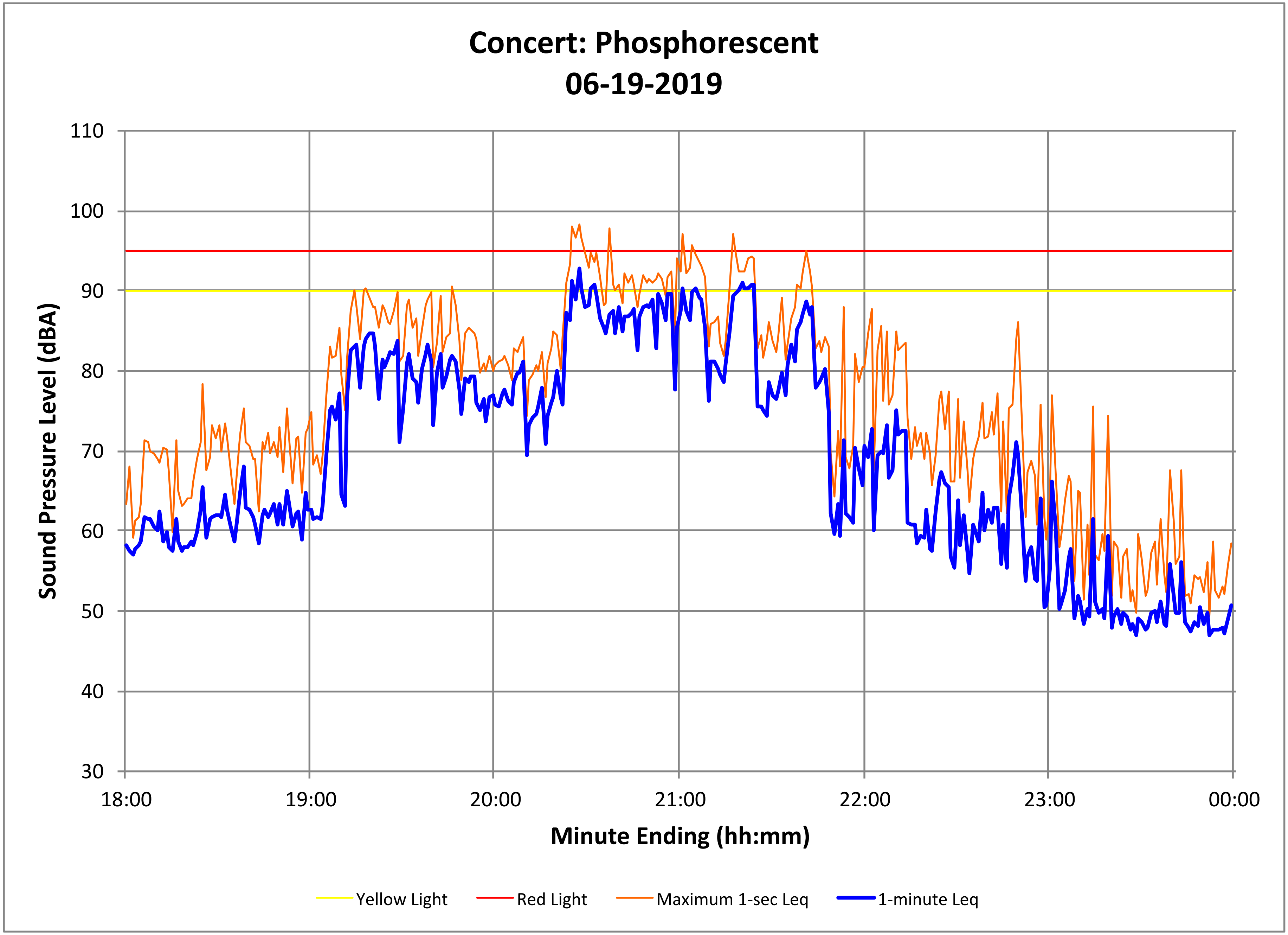
Appendix A
Sound Monitor Data


No Event (weather)
06-16-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

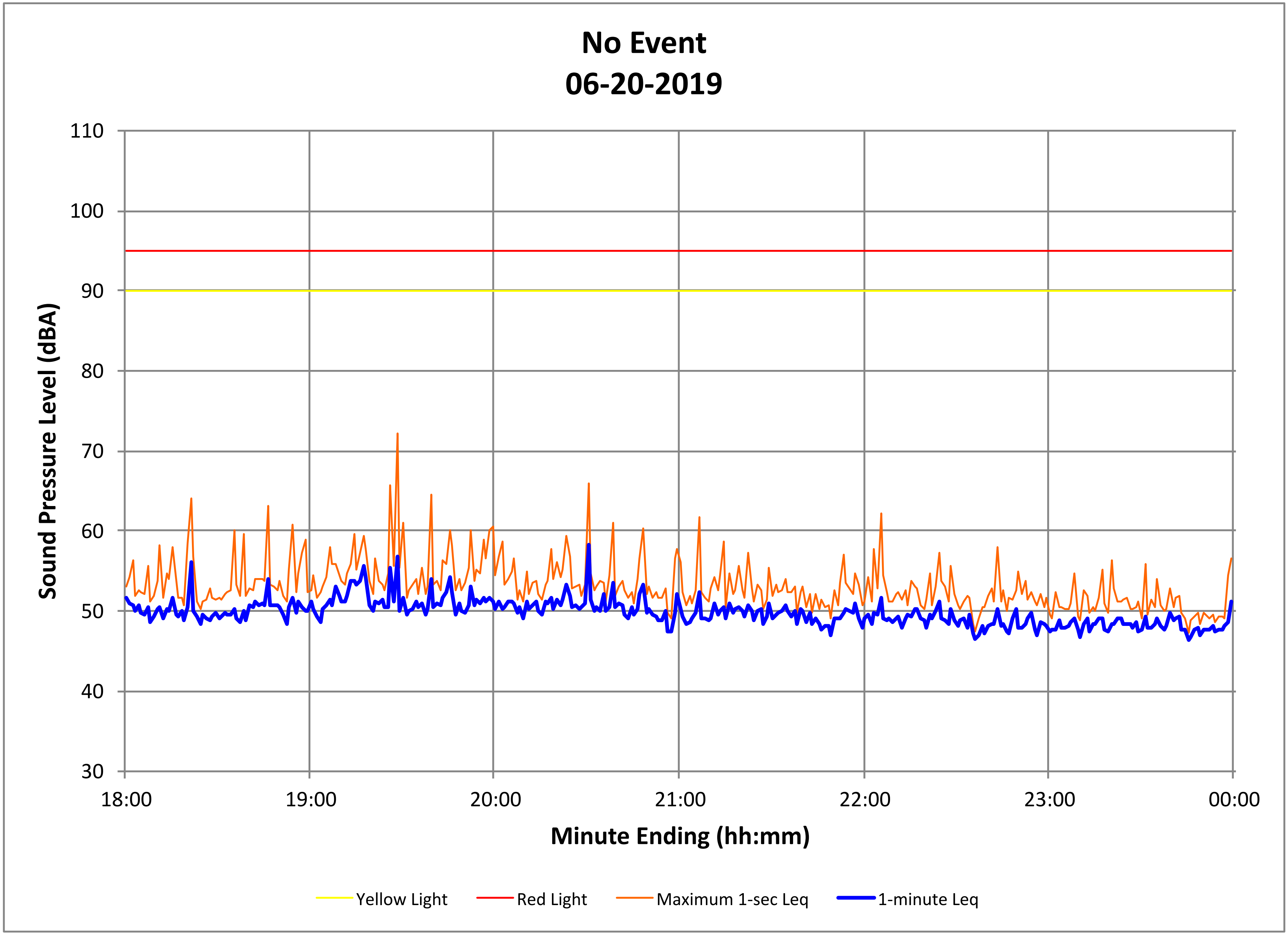

No Event
06-17-2019
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

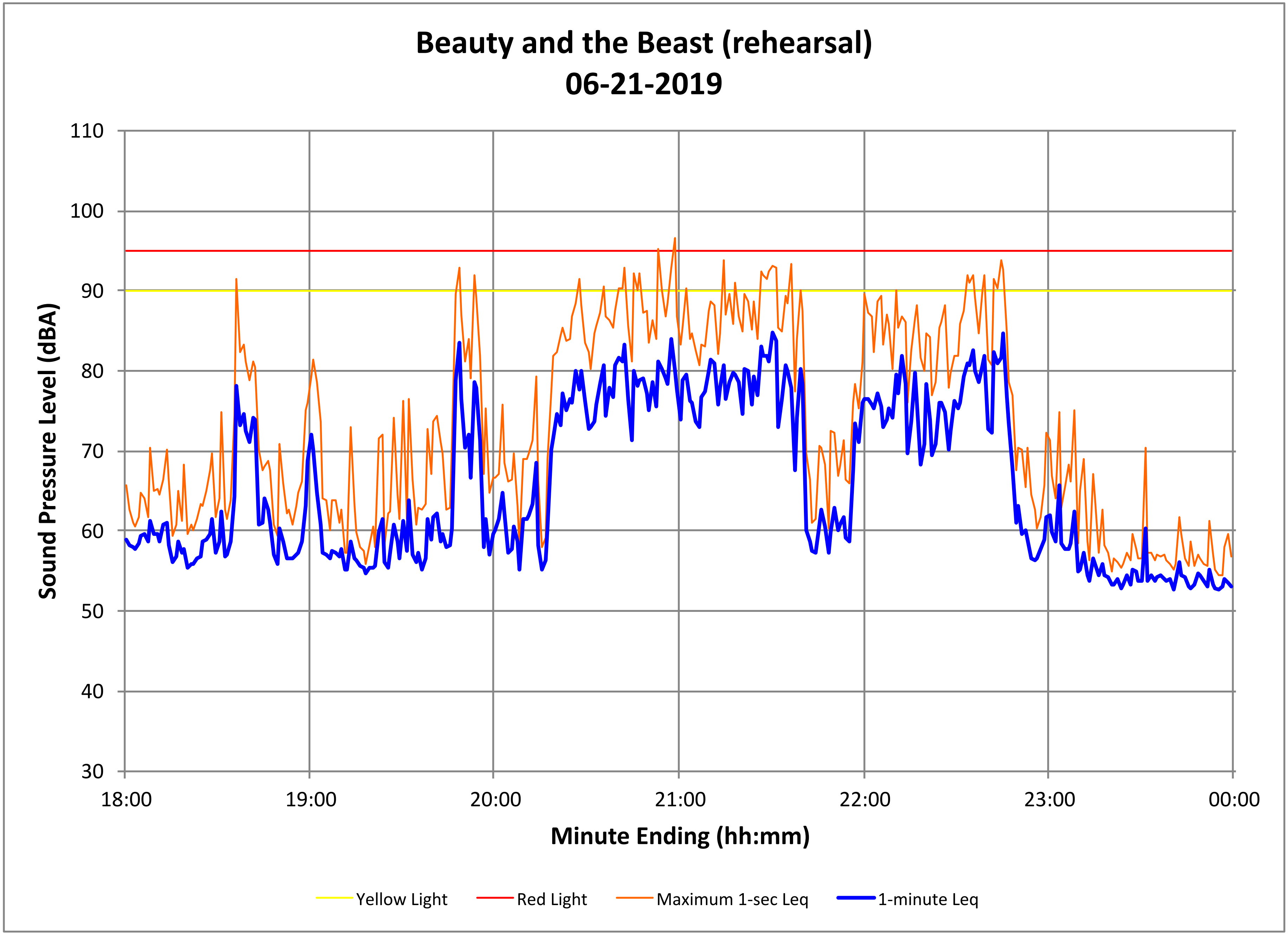


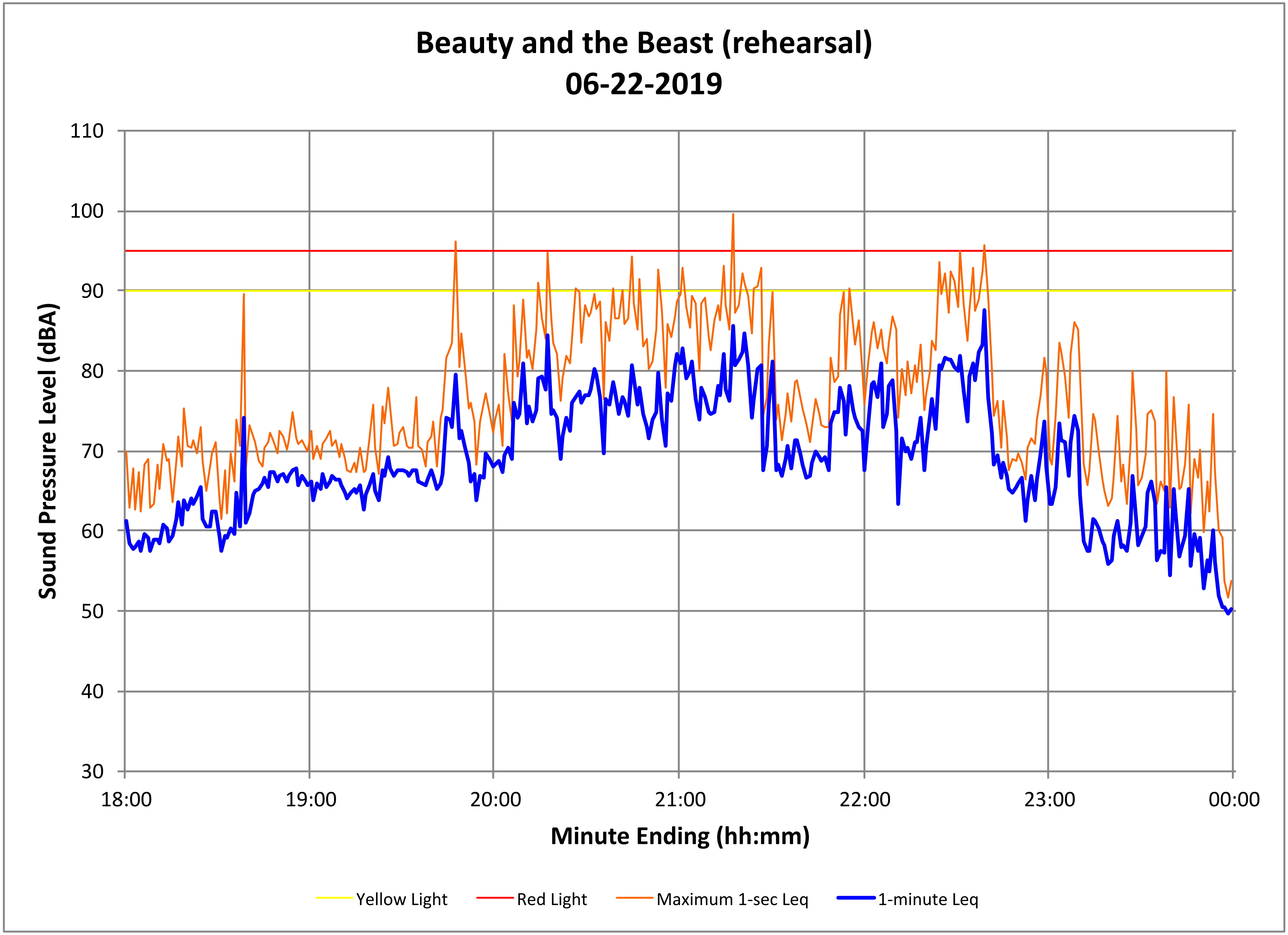
Beauty and the Beast (rehearsal)
06-18-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

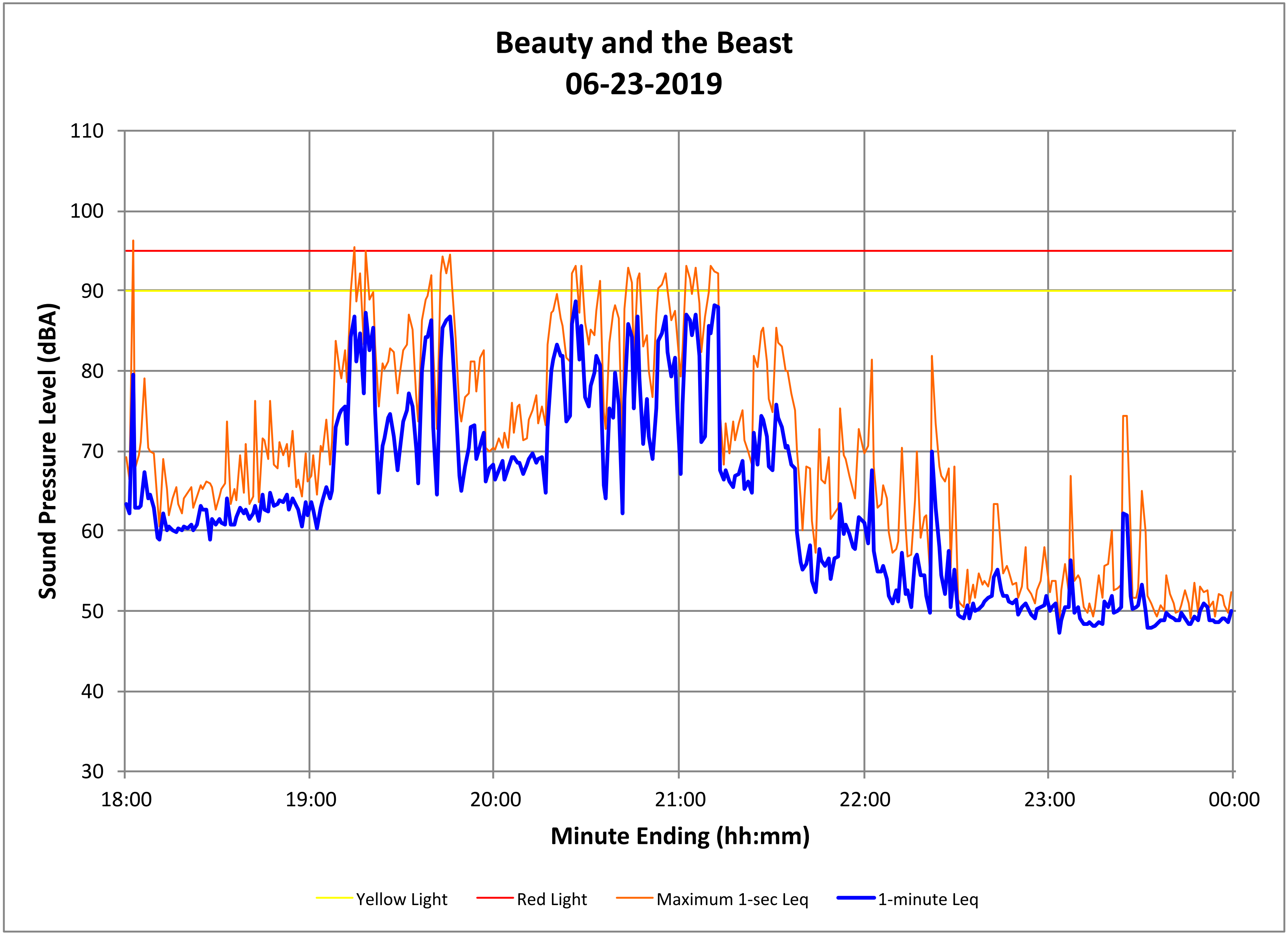


Concert: Phosphorescent
06-19-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

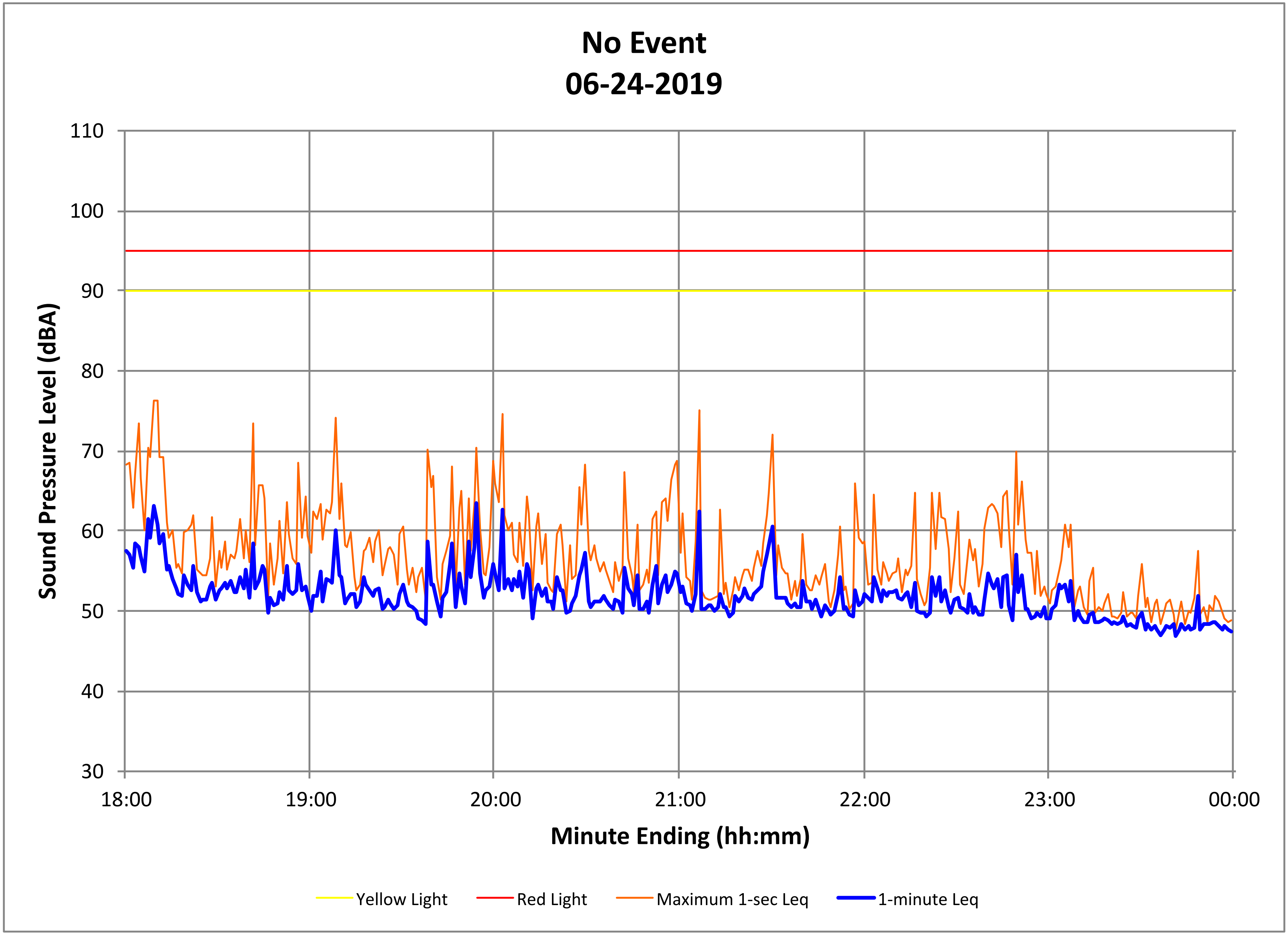

No Event
06-20-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq


Beauty and the Beast (rehearsal)
06-21-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

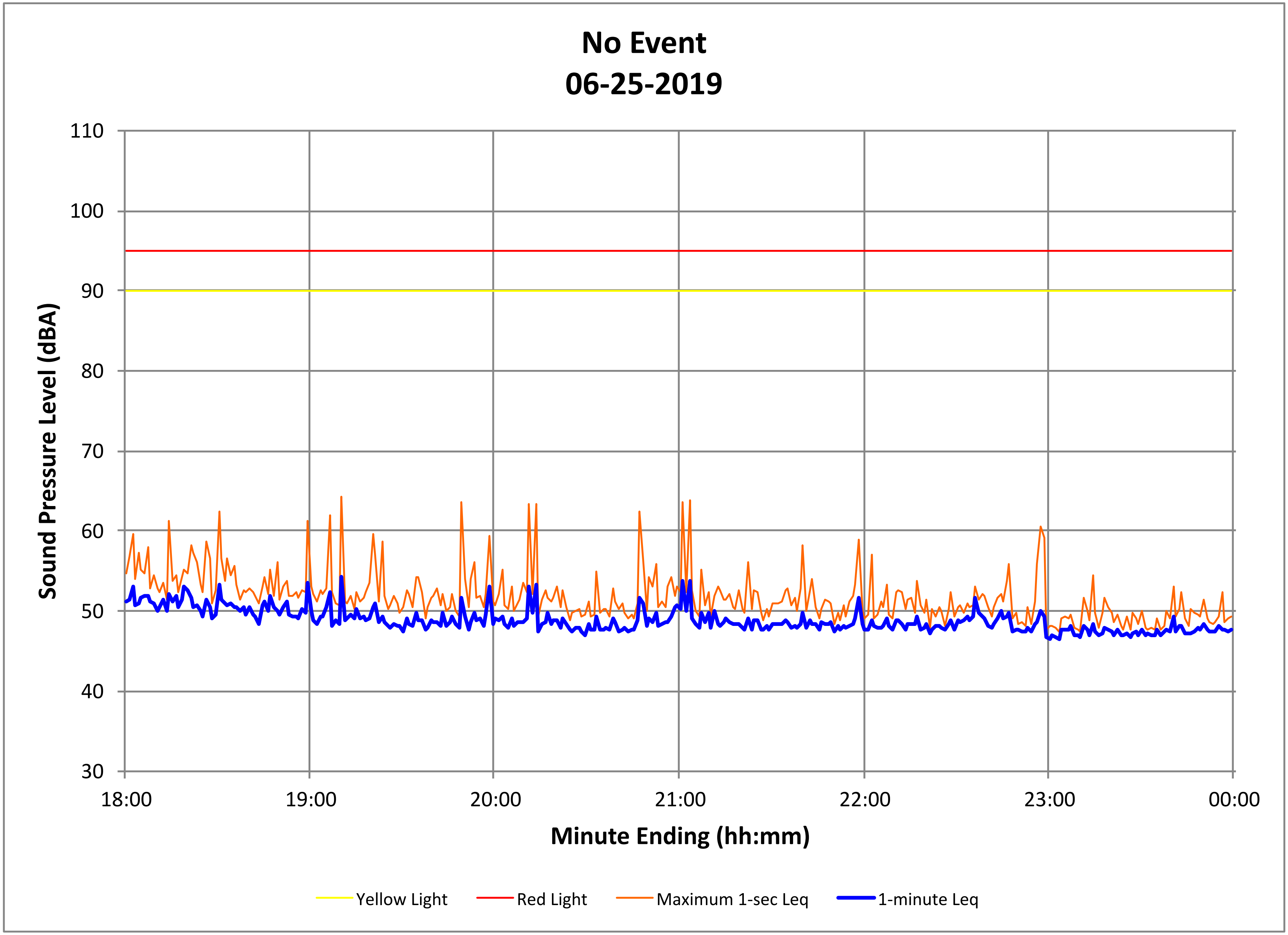

Beauty and the Beast (rehearsal)
06-22-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



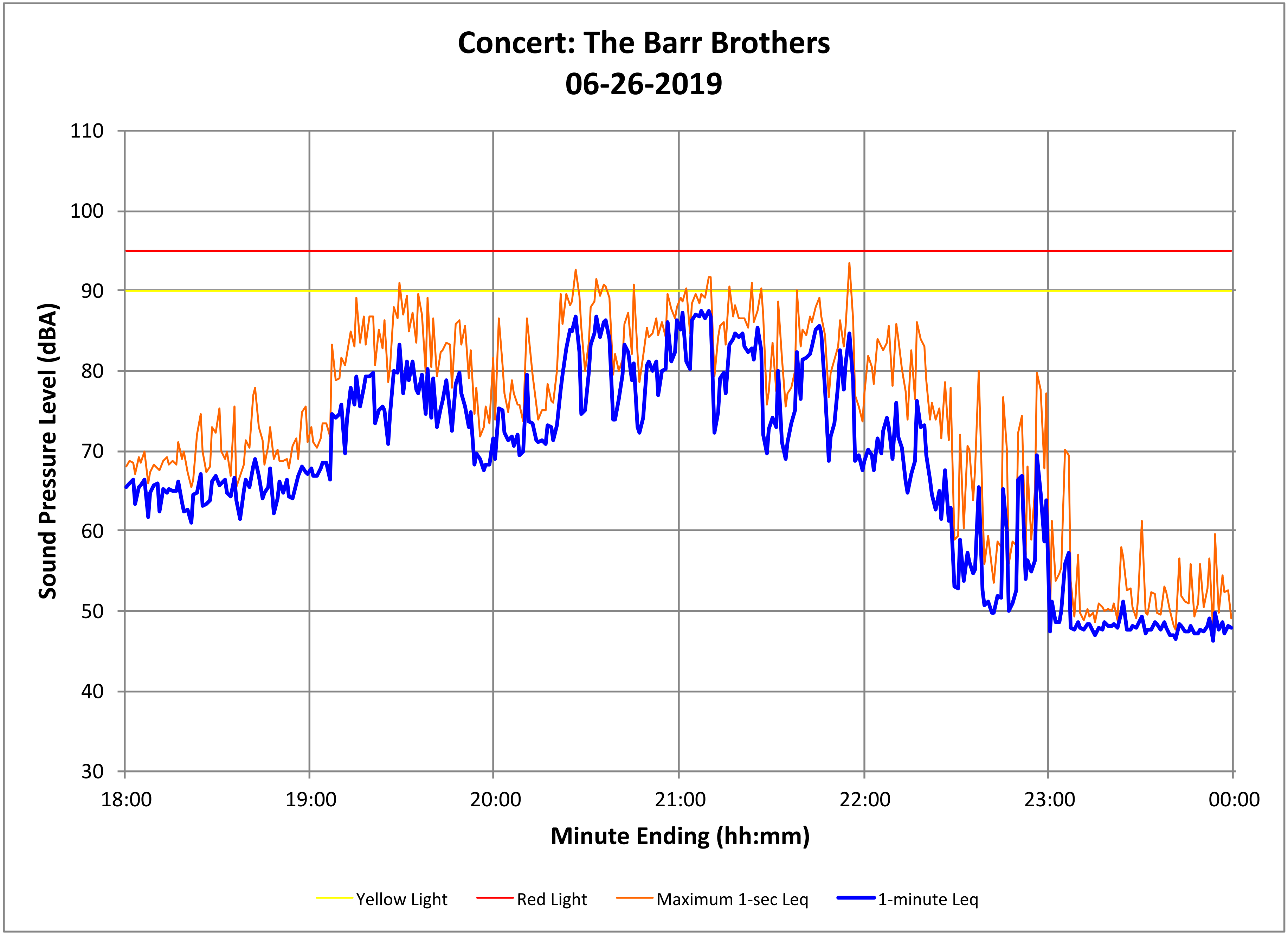
Beauty and the Beast
06-23-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



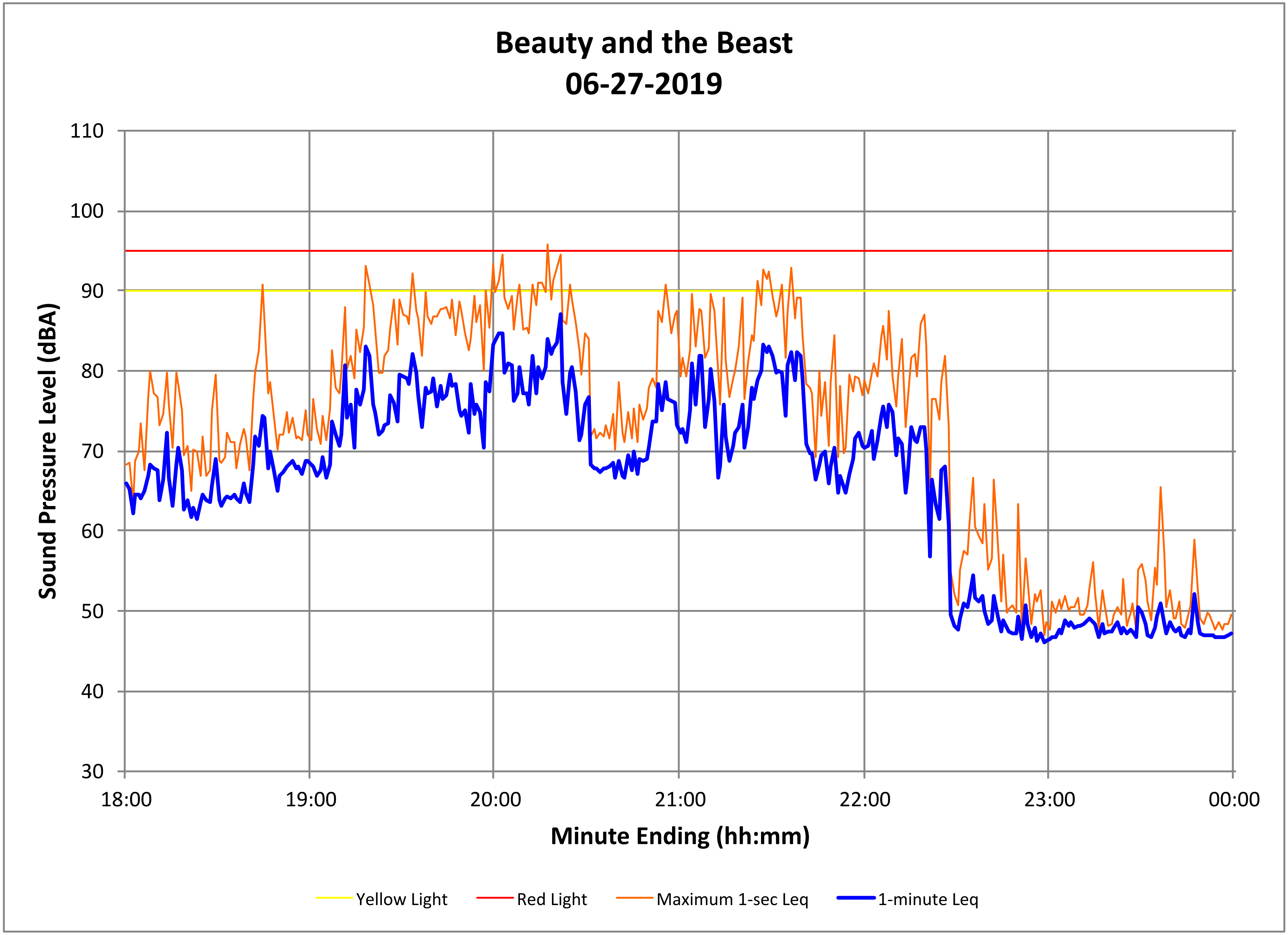
No Event
06-24-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



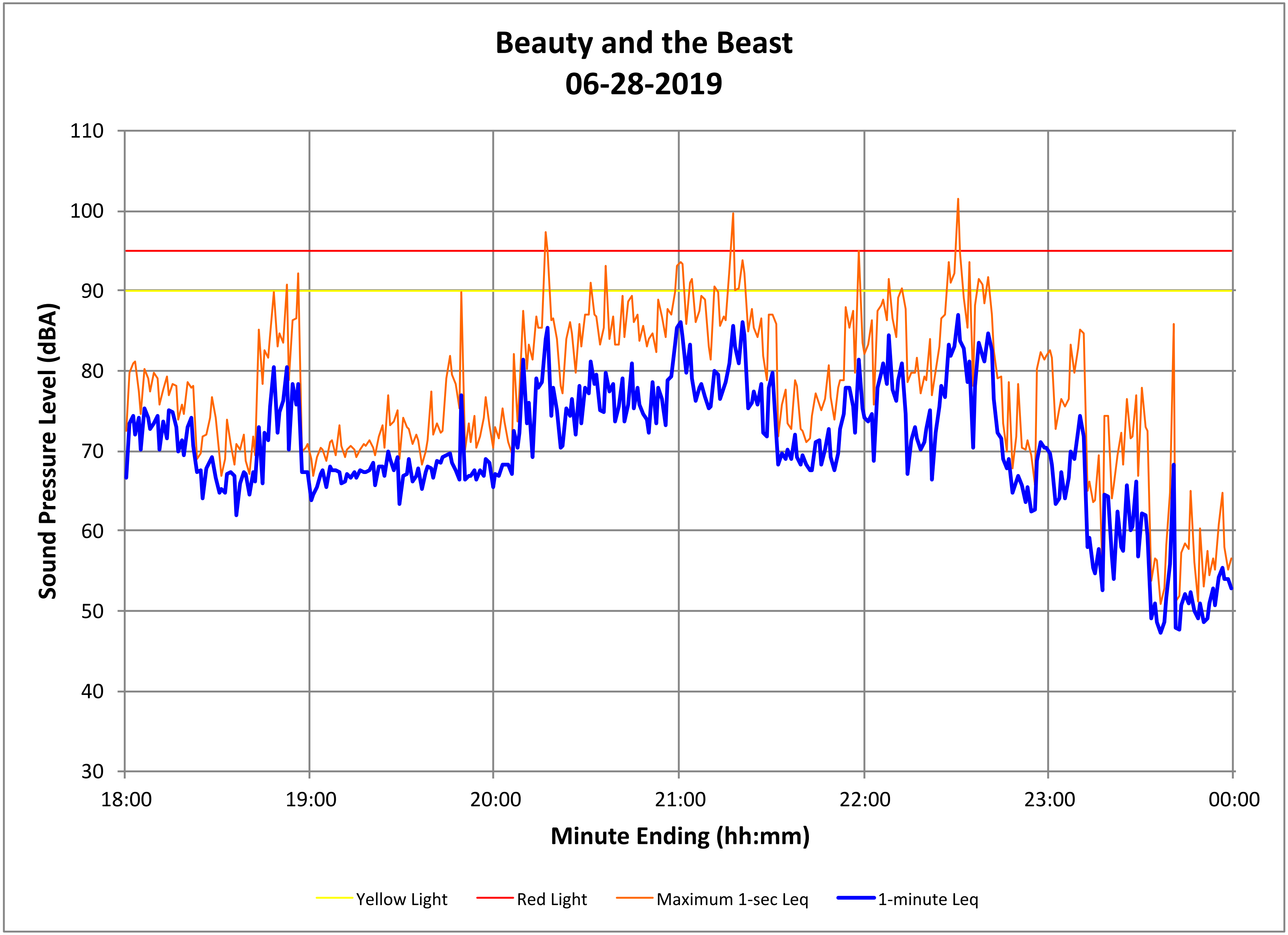
No Event
06-25-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



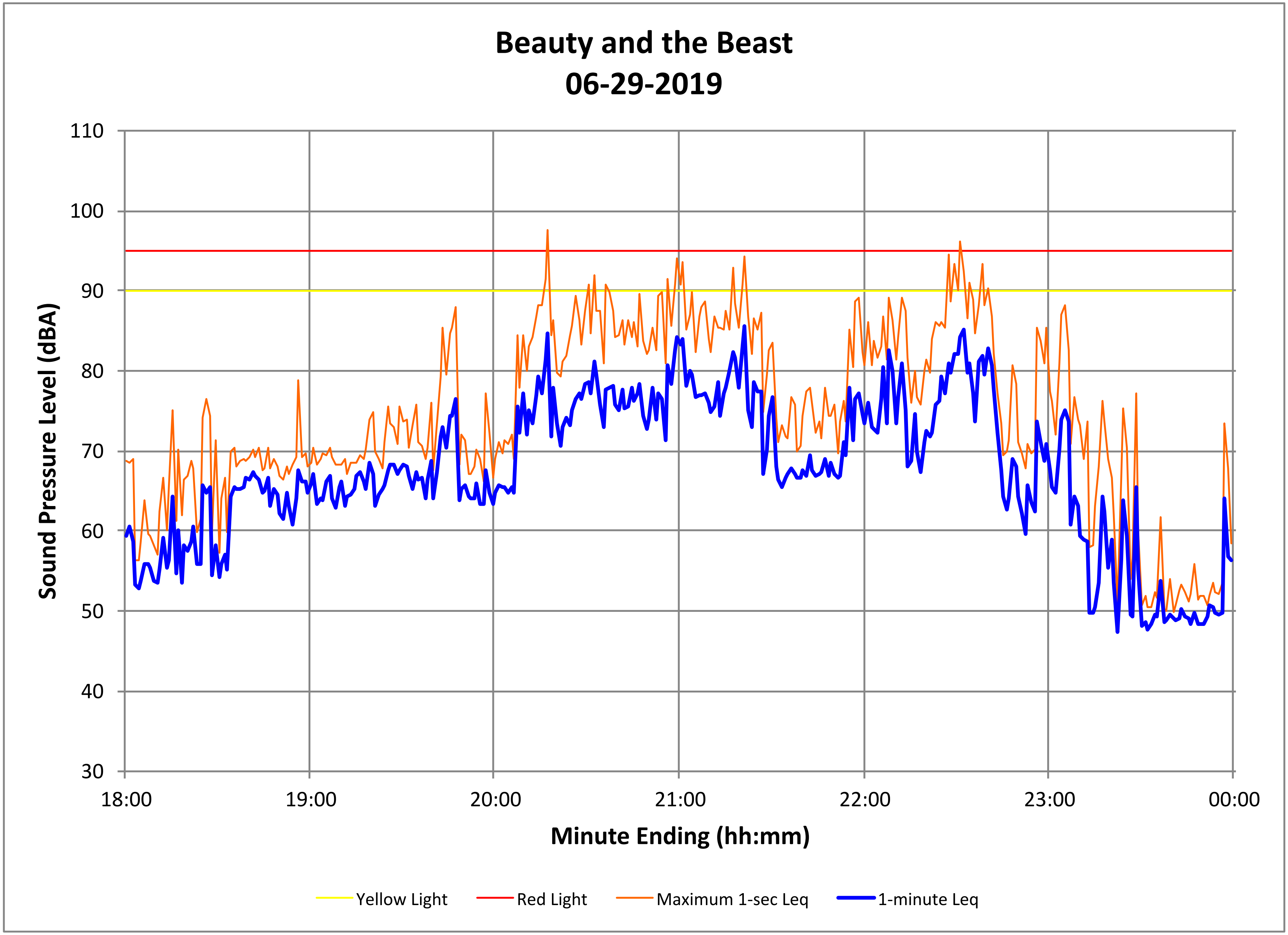
Concert: The Barr Brothers
06-26-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

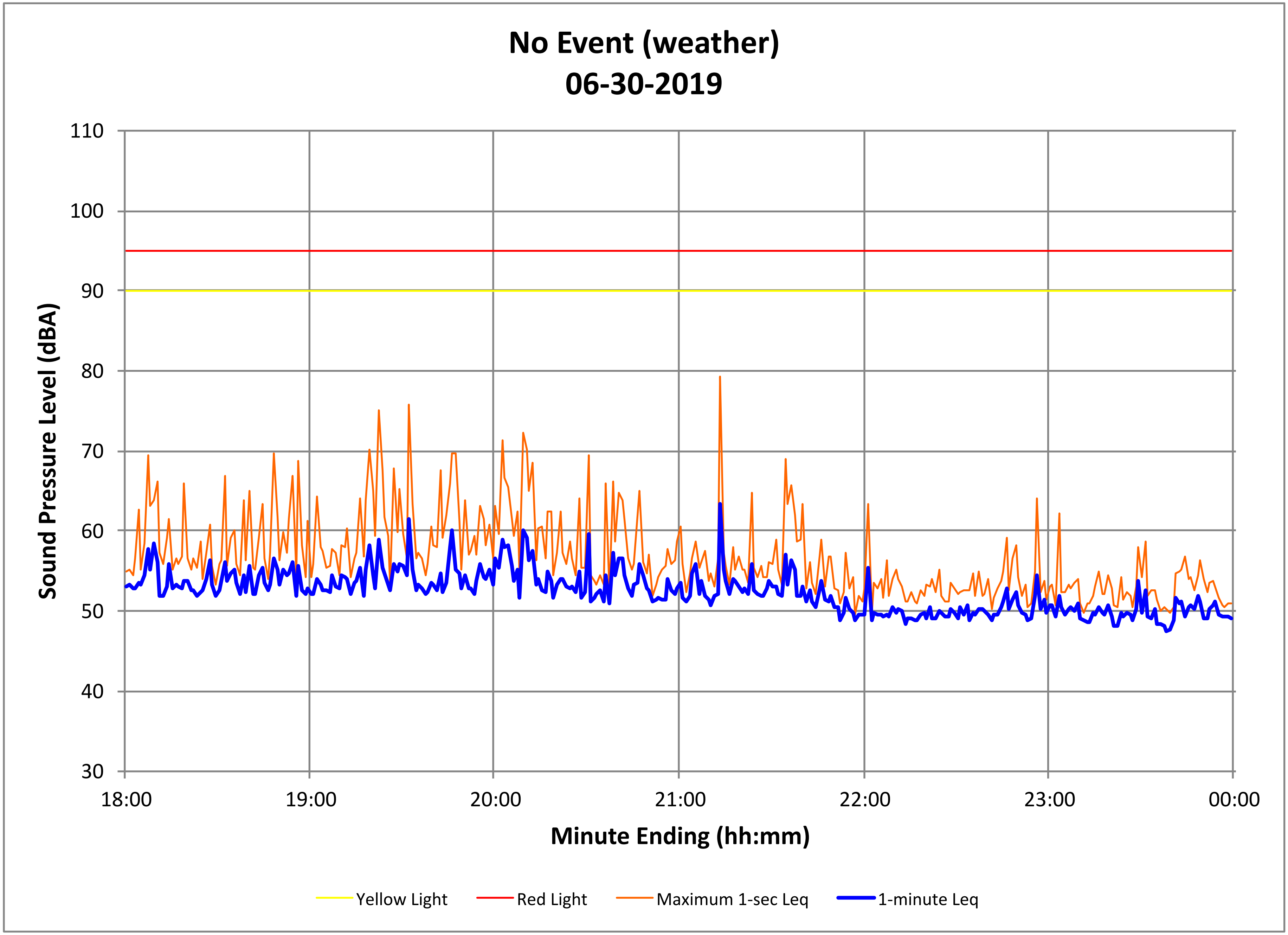


Beauty and the Beast
06-27-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

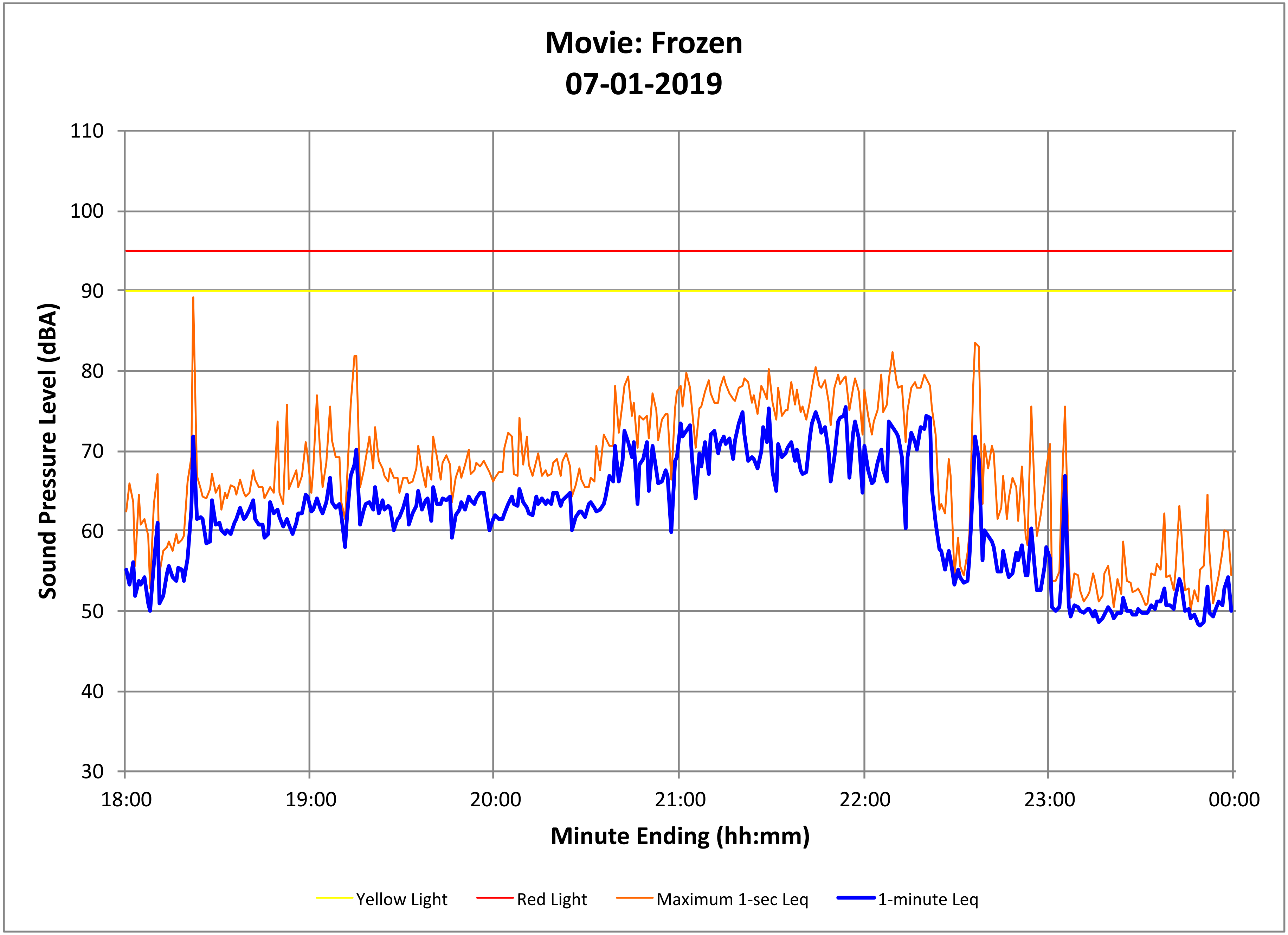


Beauty and the Beast
06-28-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

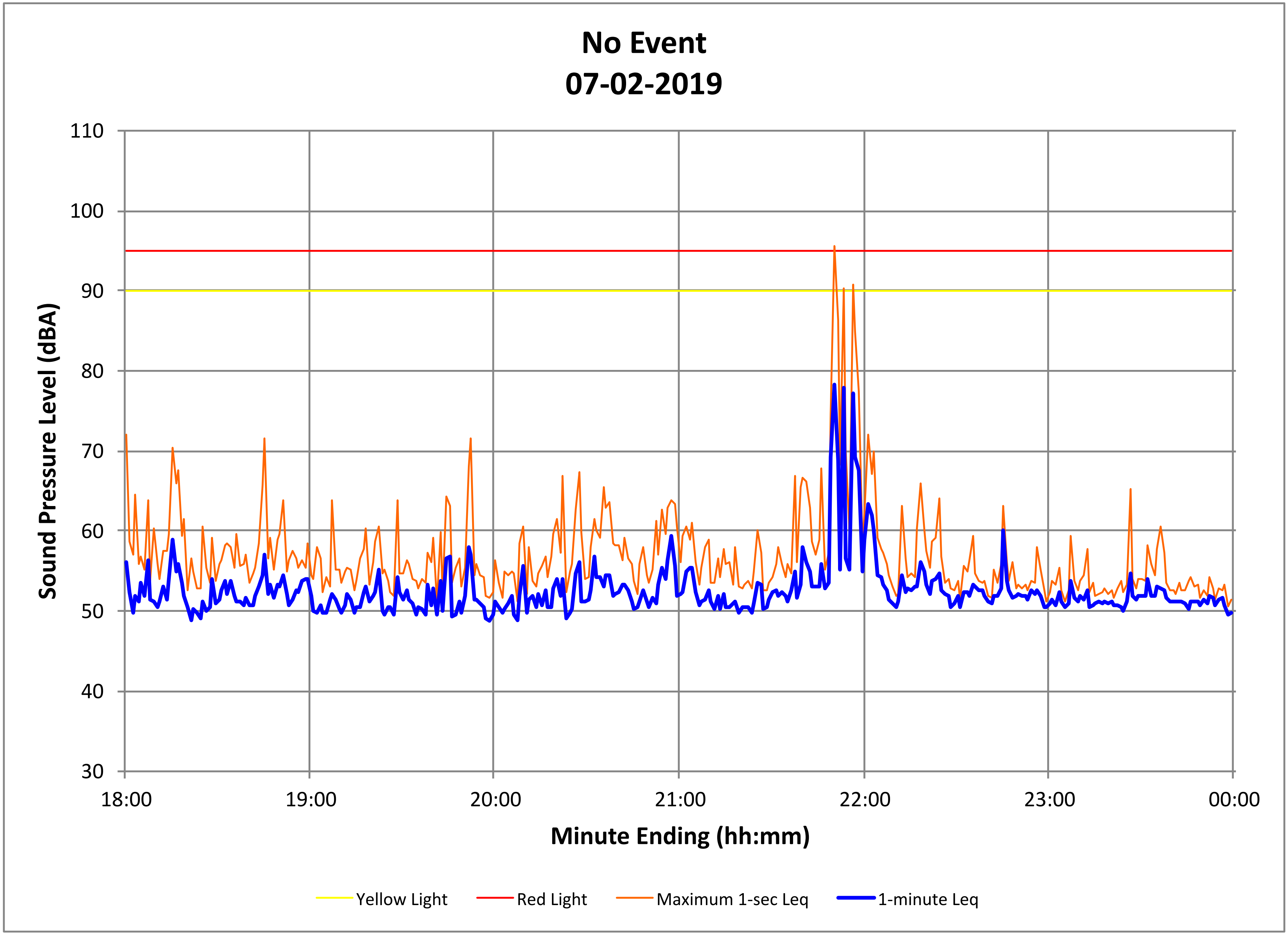

Beauty and the Beast
06-29-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

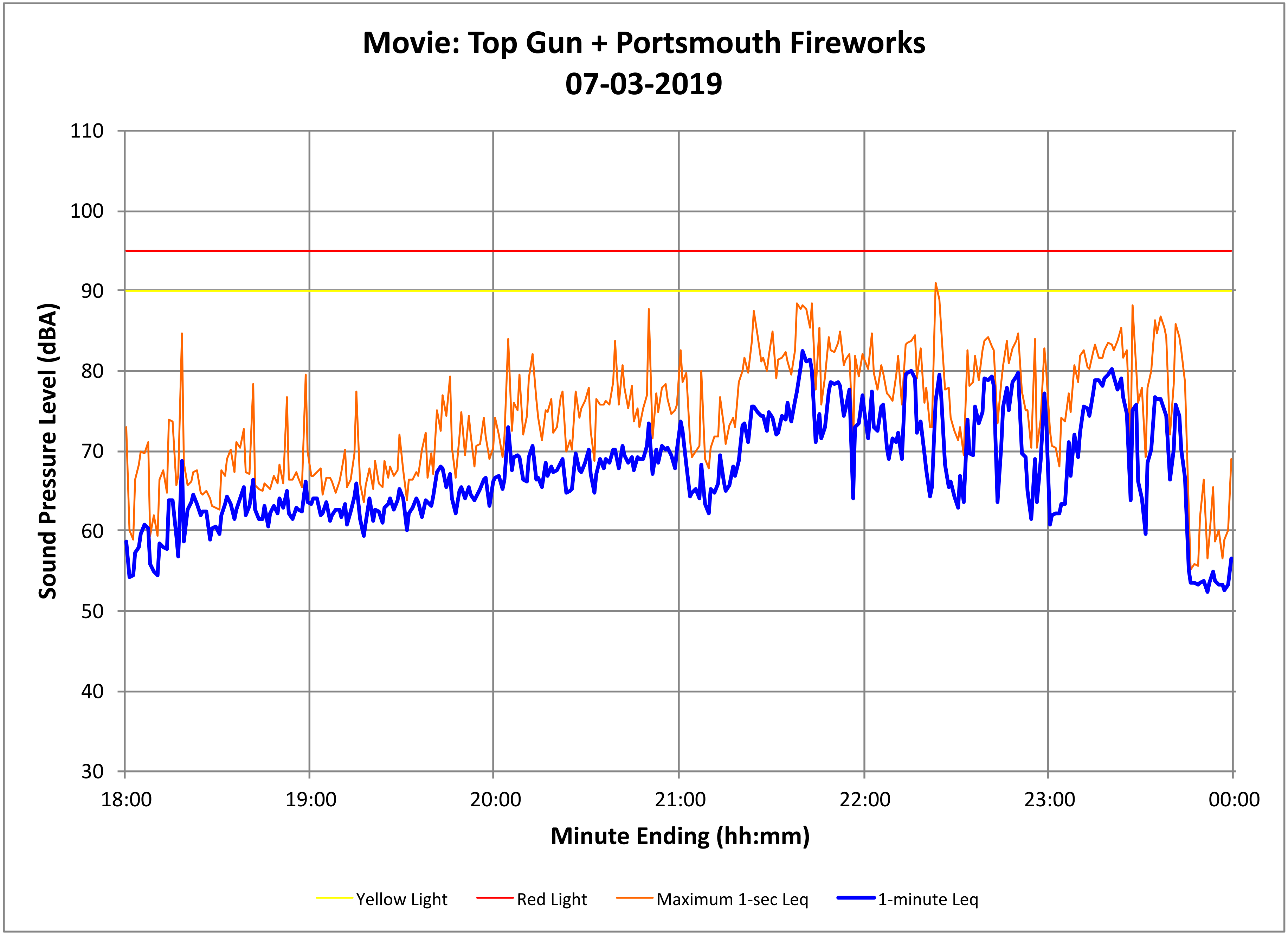


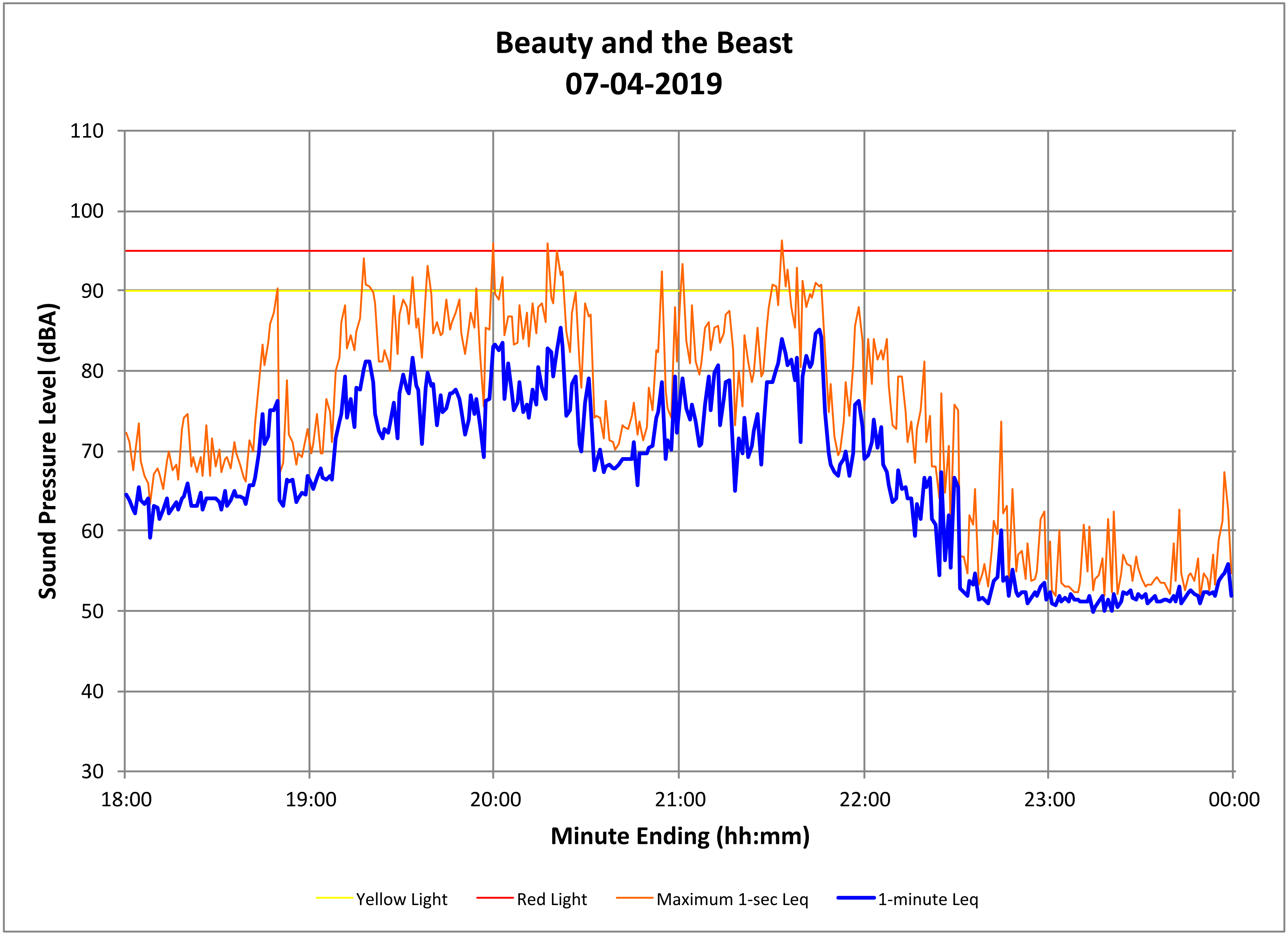
No Event (weather)
06-30-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



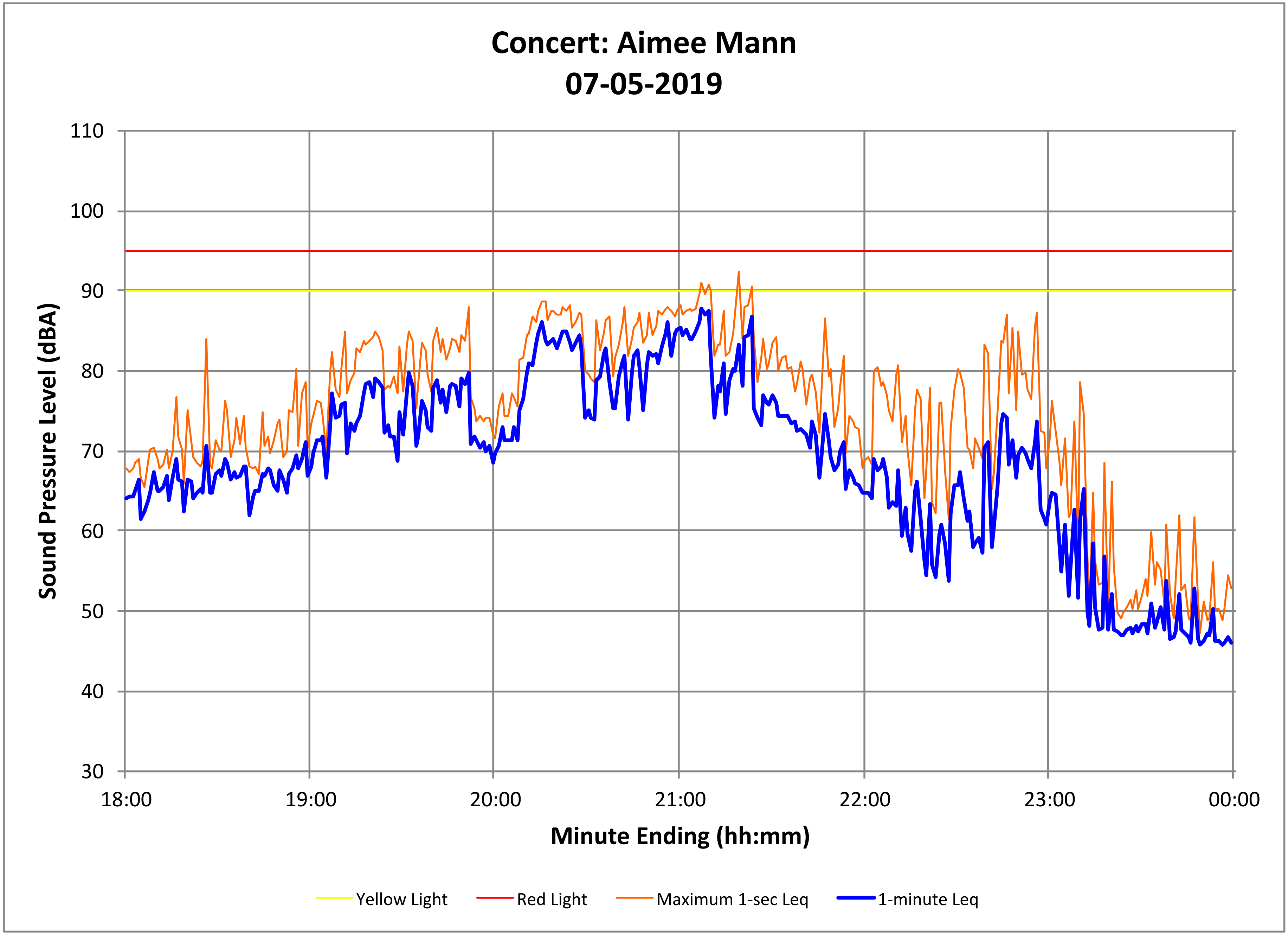
Movie: Frozen
07-01-2019
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq


No Event
07-02-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

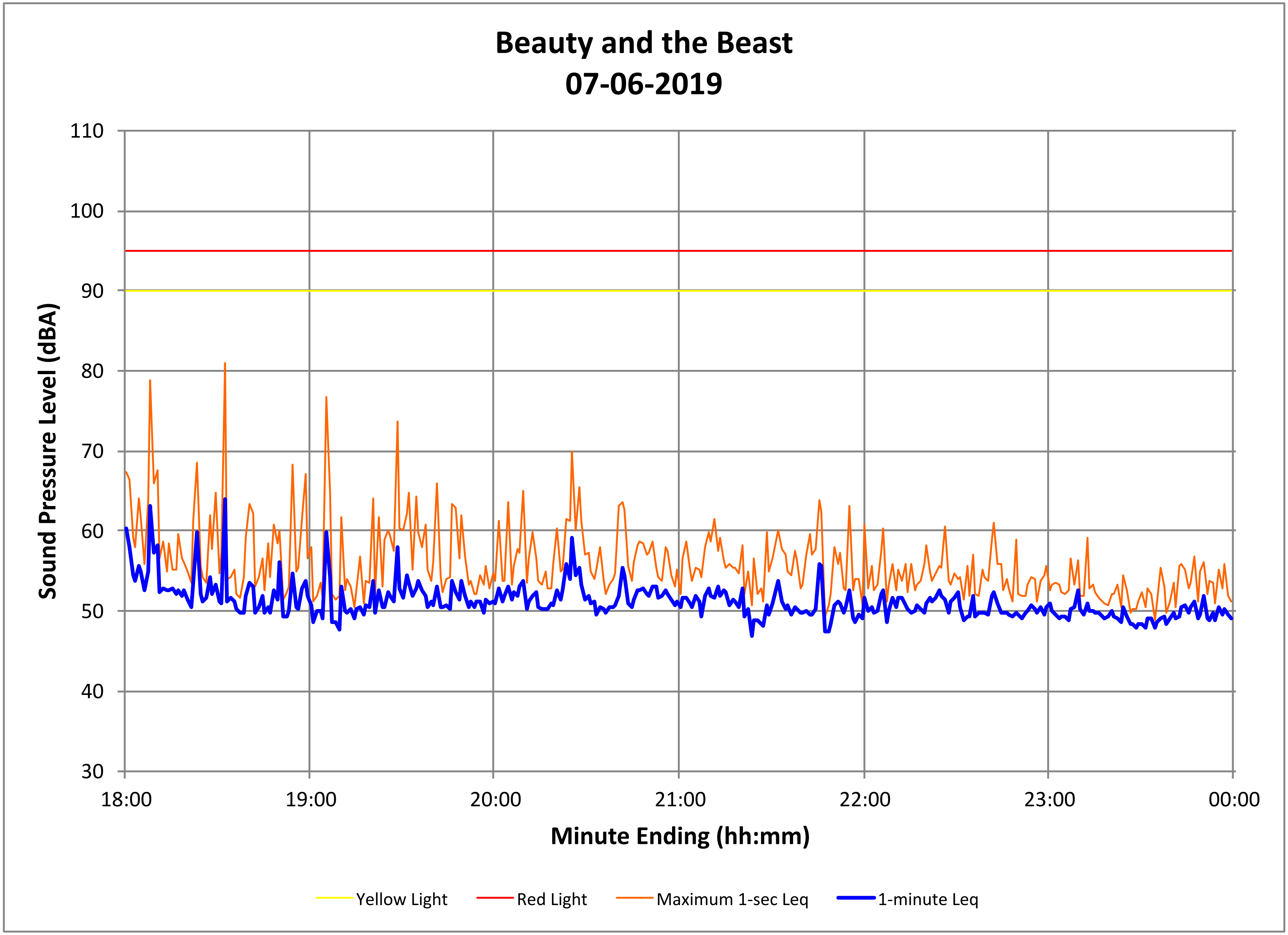

Movie: Top Gun + Portsmouth Fireworks
07-03-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

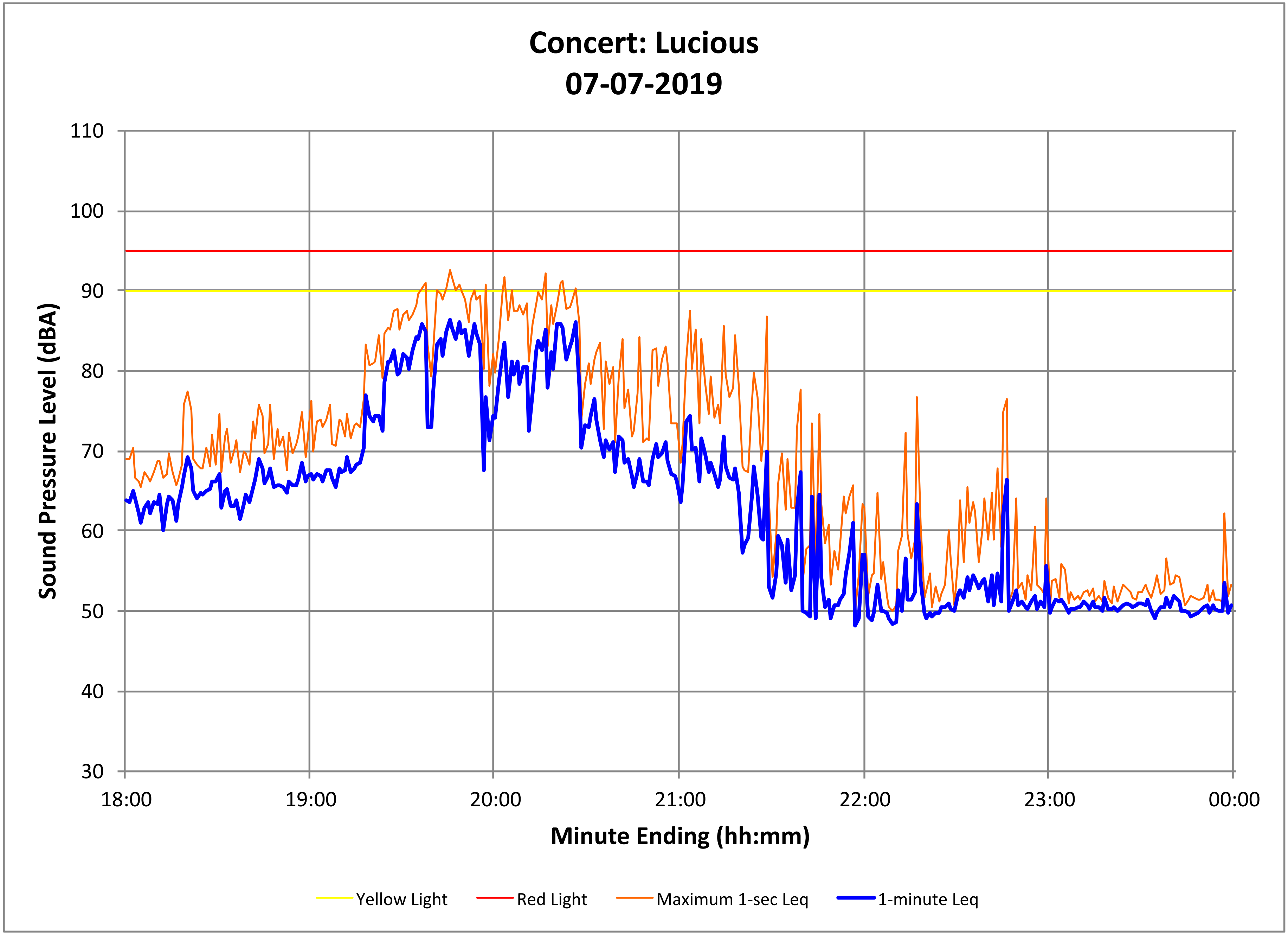


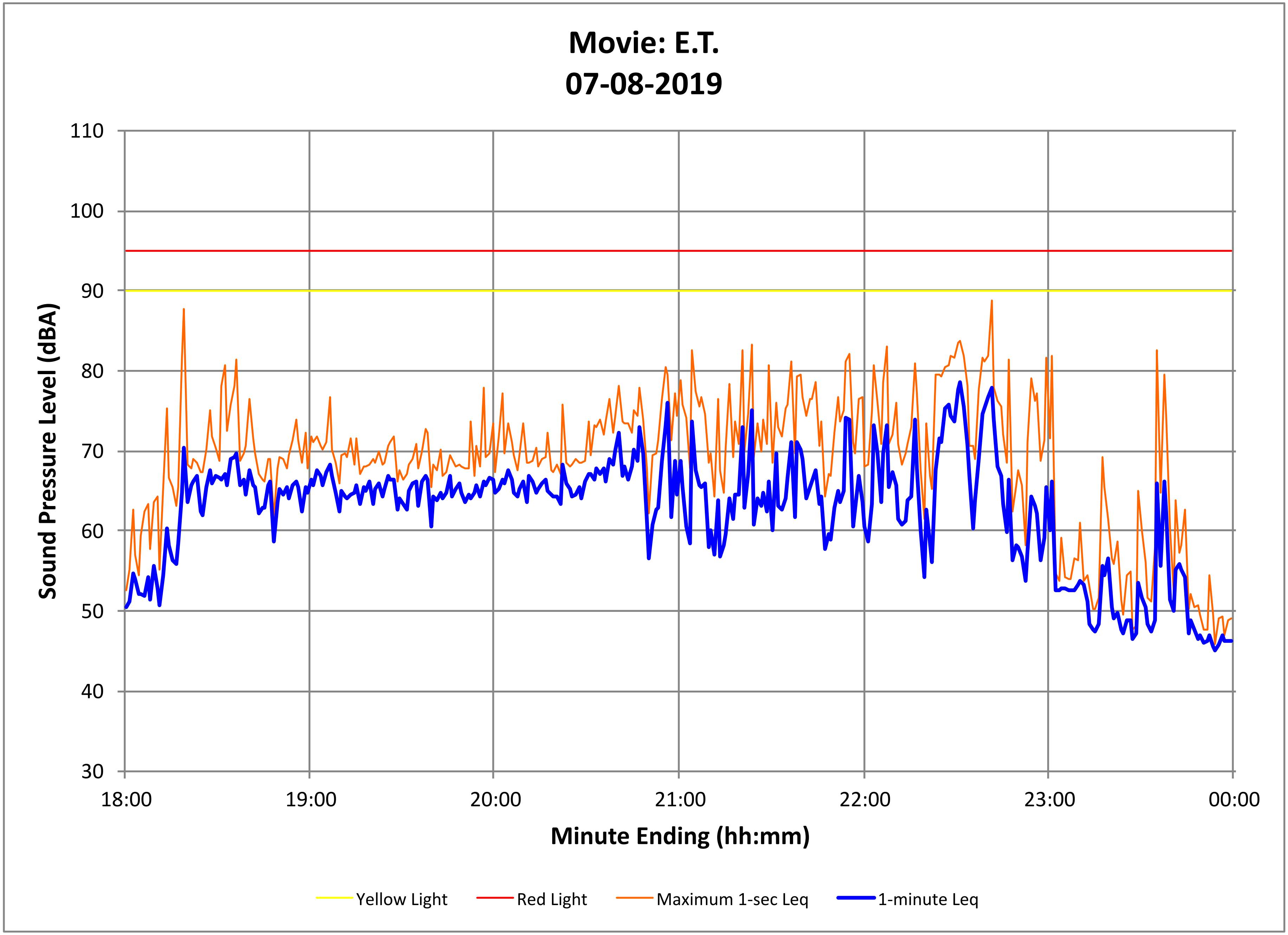
Beauty and the Beast
07-04-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



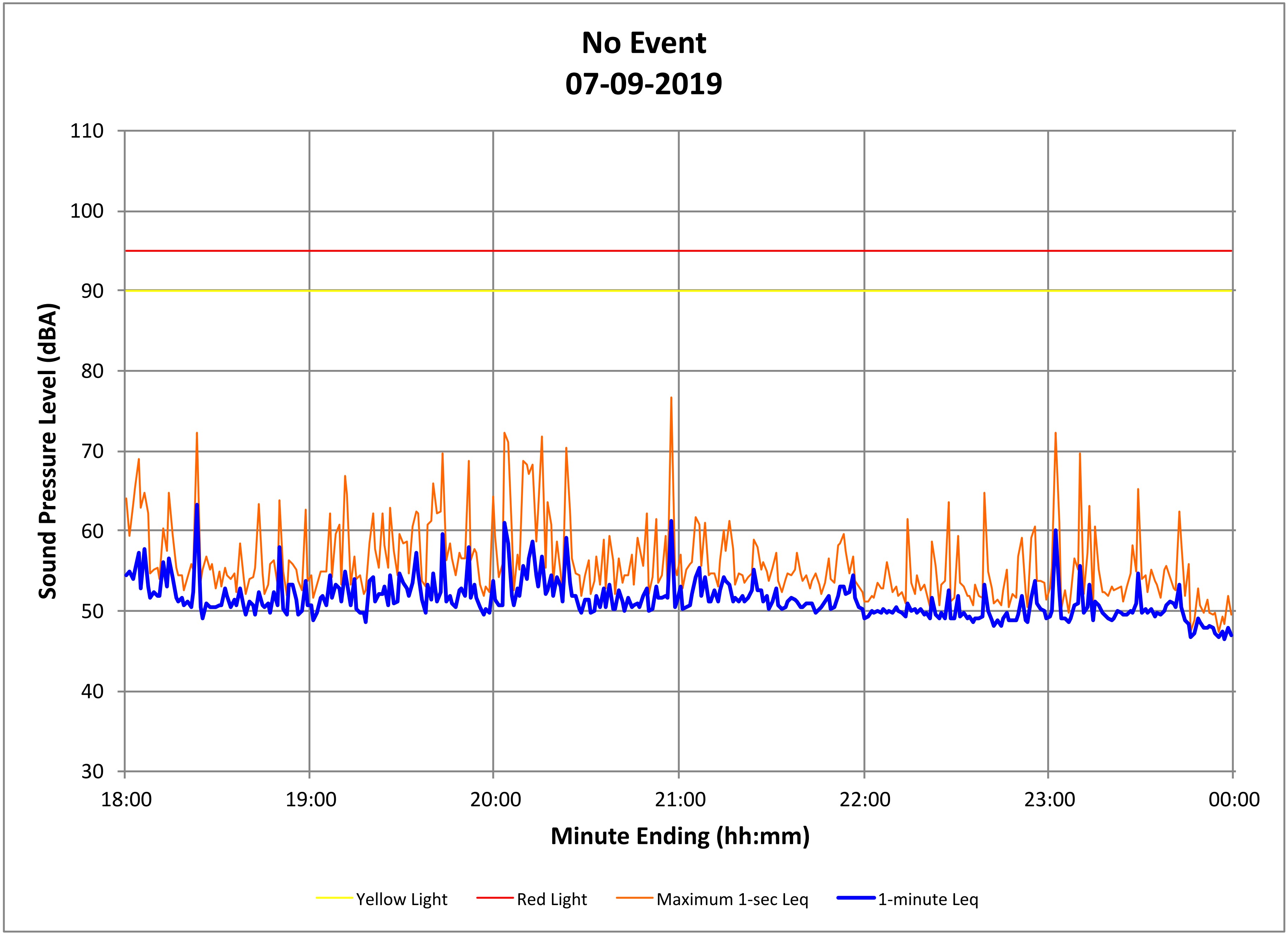
Concert: Aimee Mann
07-05-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq


Beauty and the Beast
07-06-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

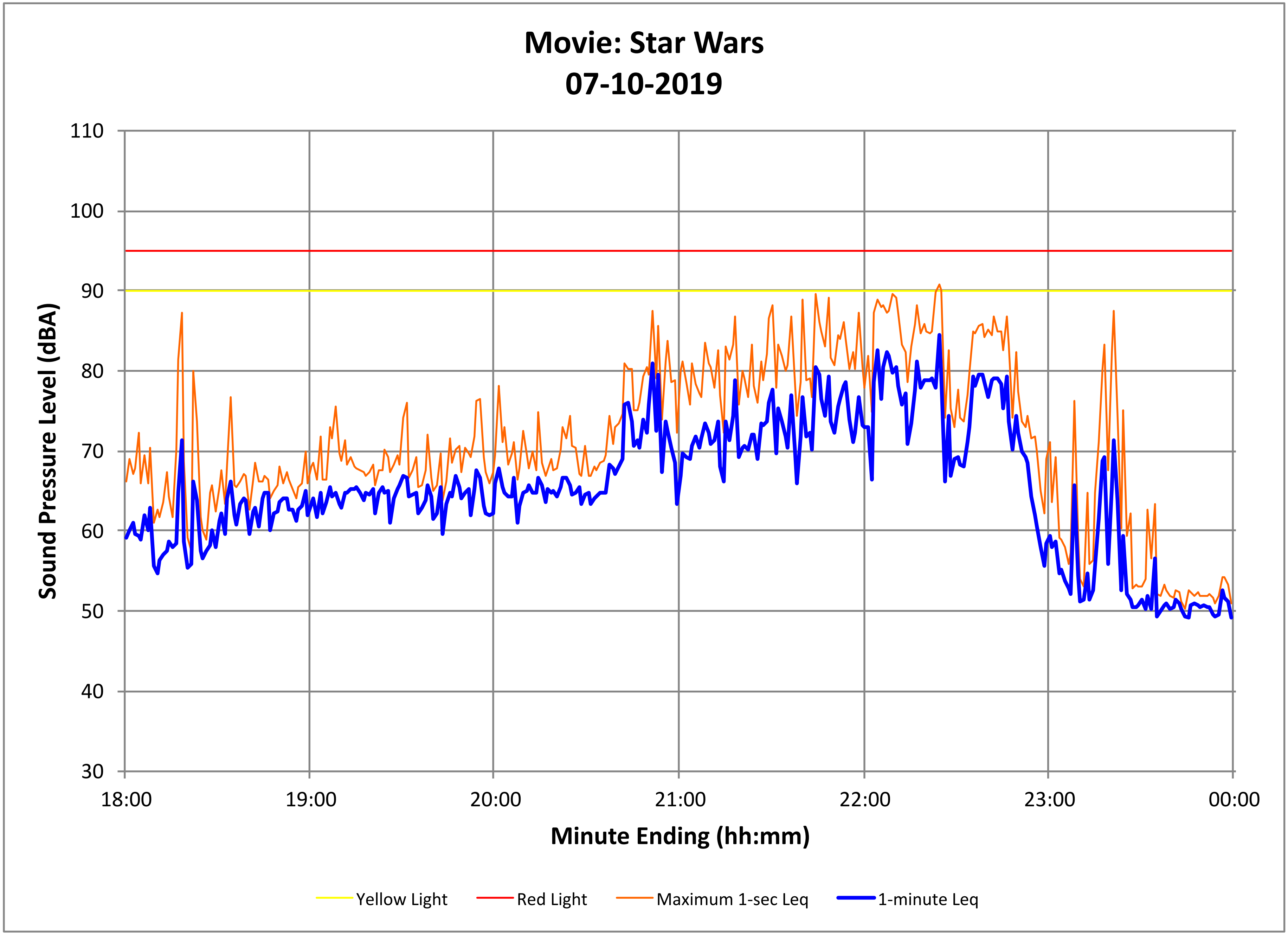

Concert: Lucious
07-07-2019
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

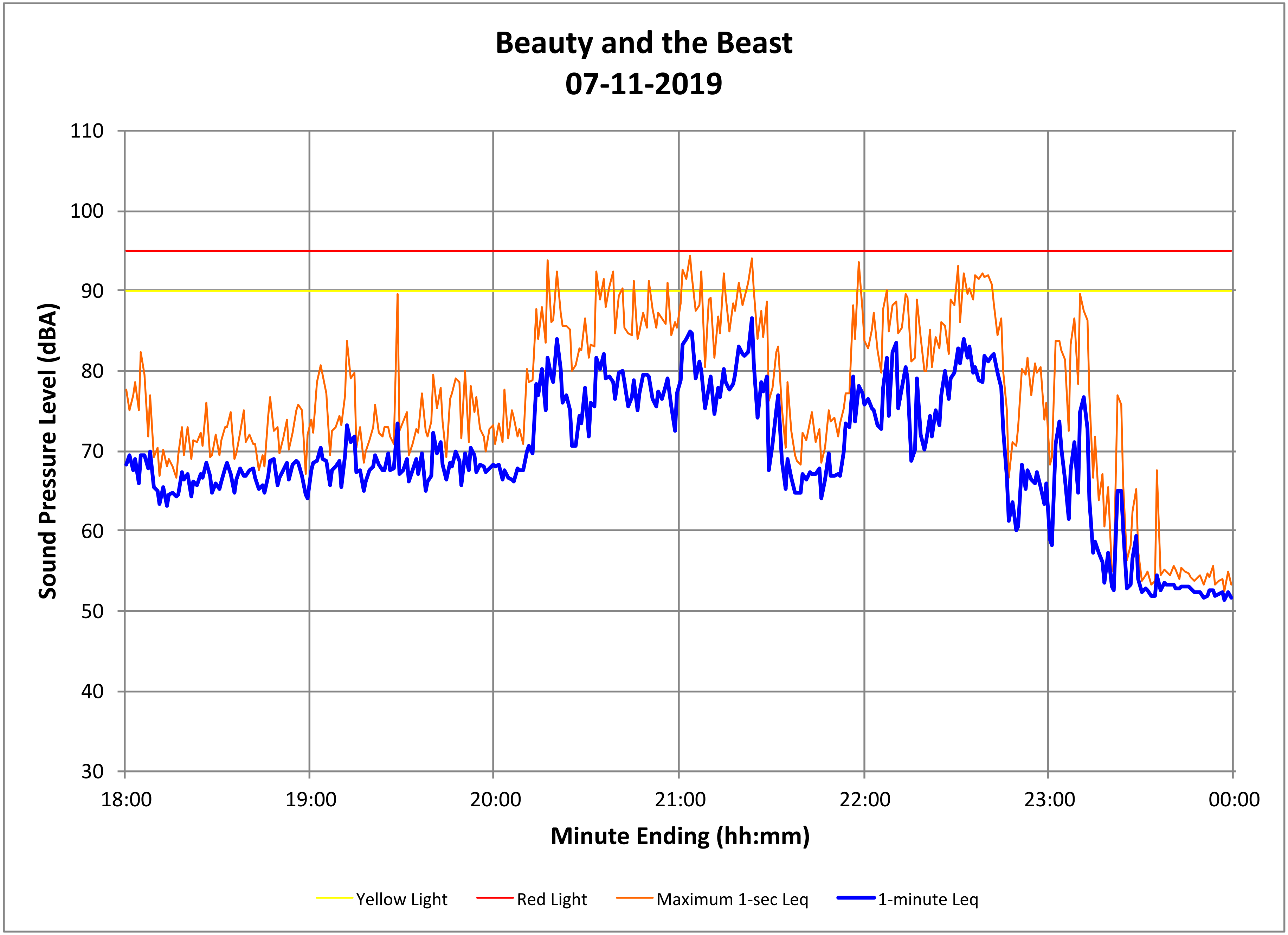


Movie: E.T.
07-08-2019
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

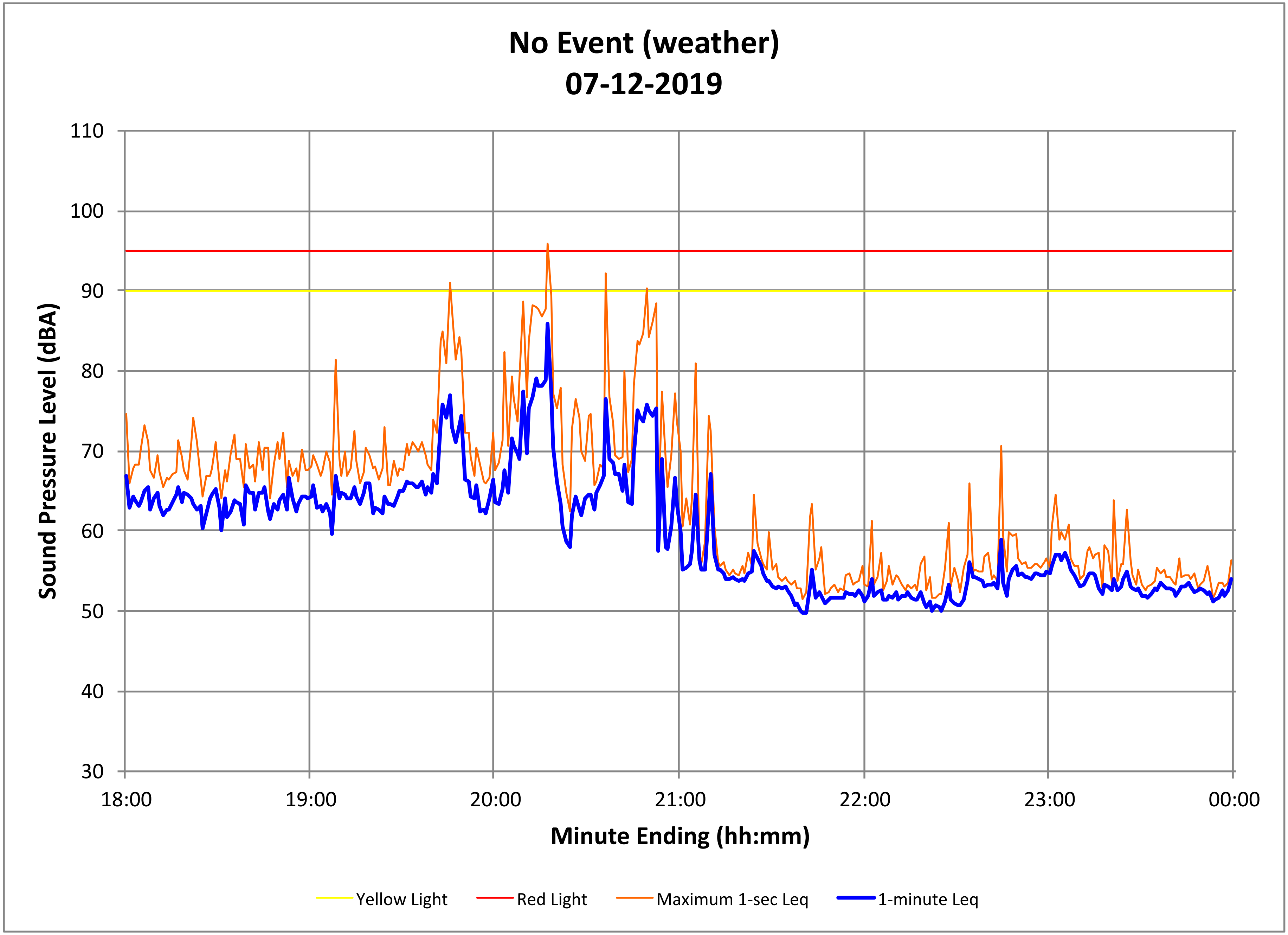


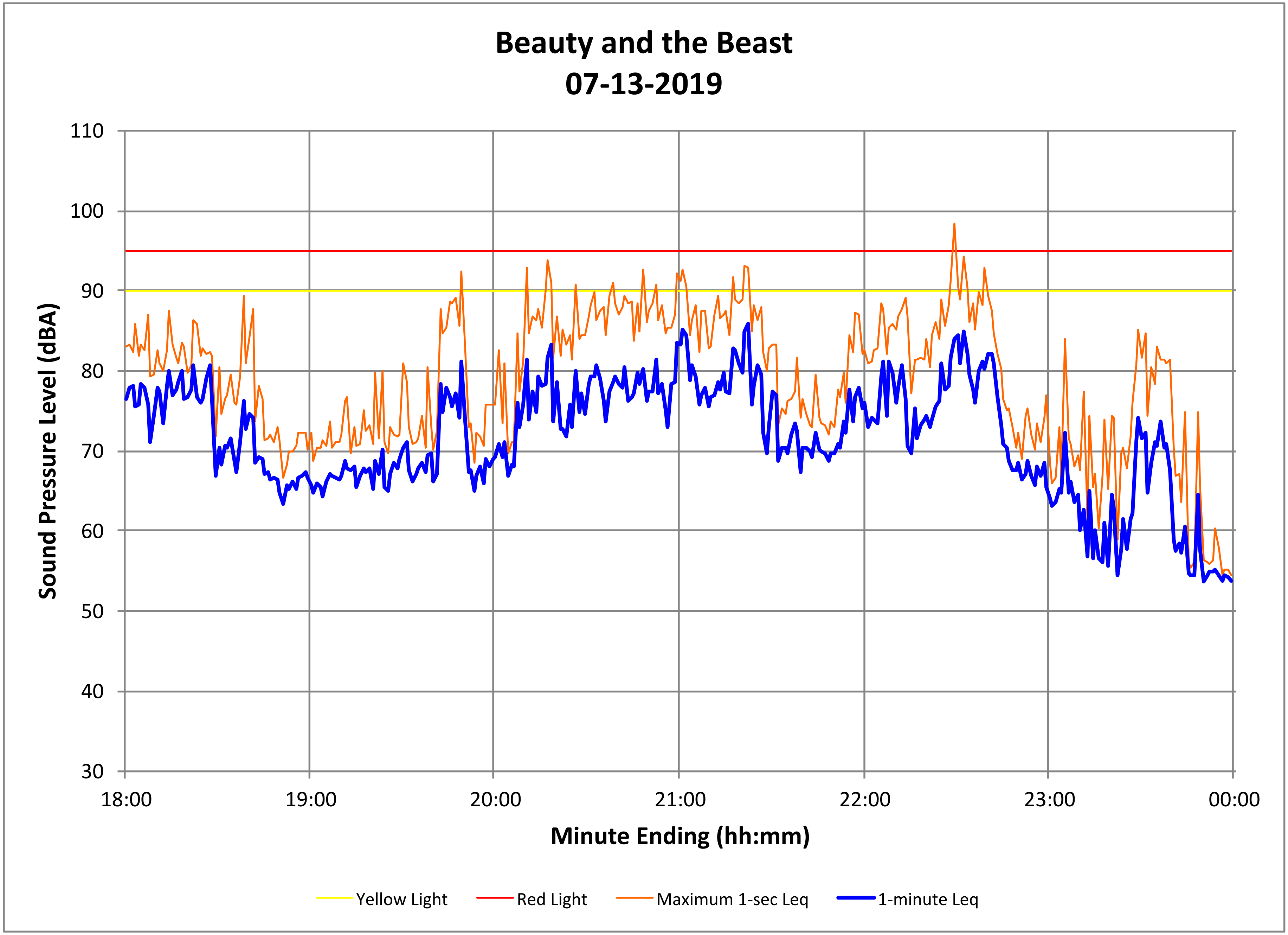
No Event
07-09-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

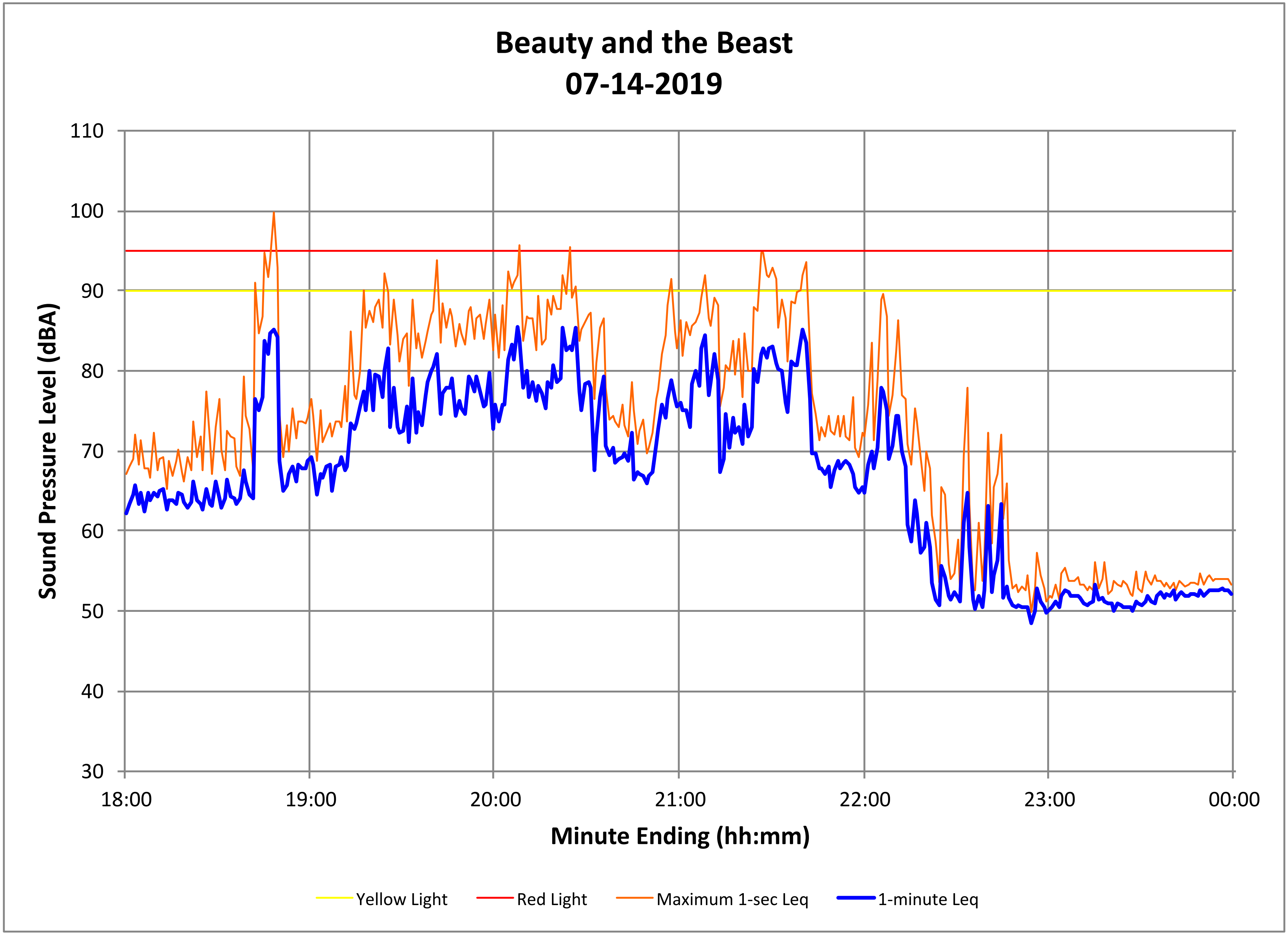

Movie: Star Wars
07-10-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

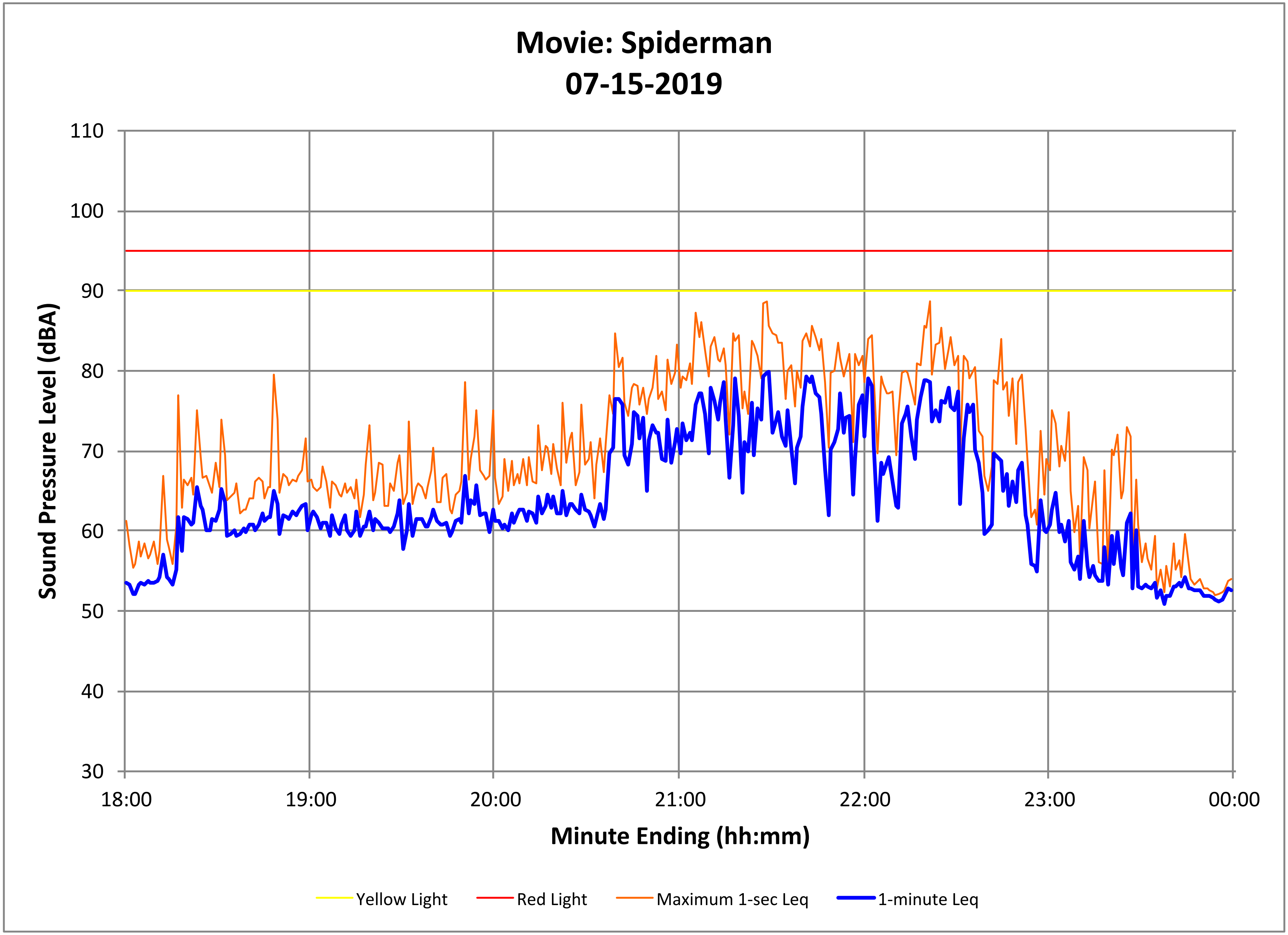


Beauty and the Beast
07-11-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

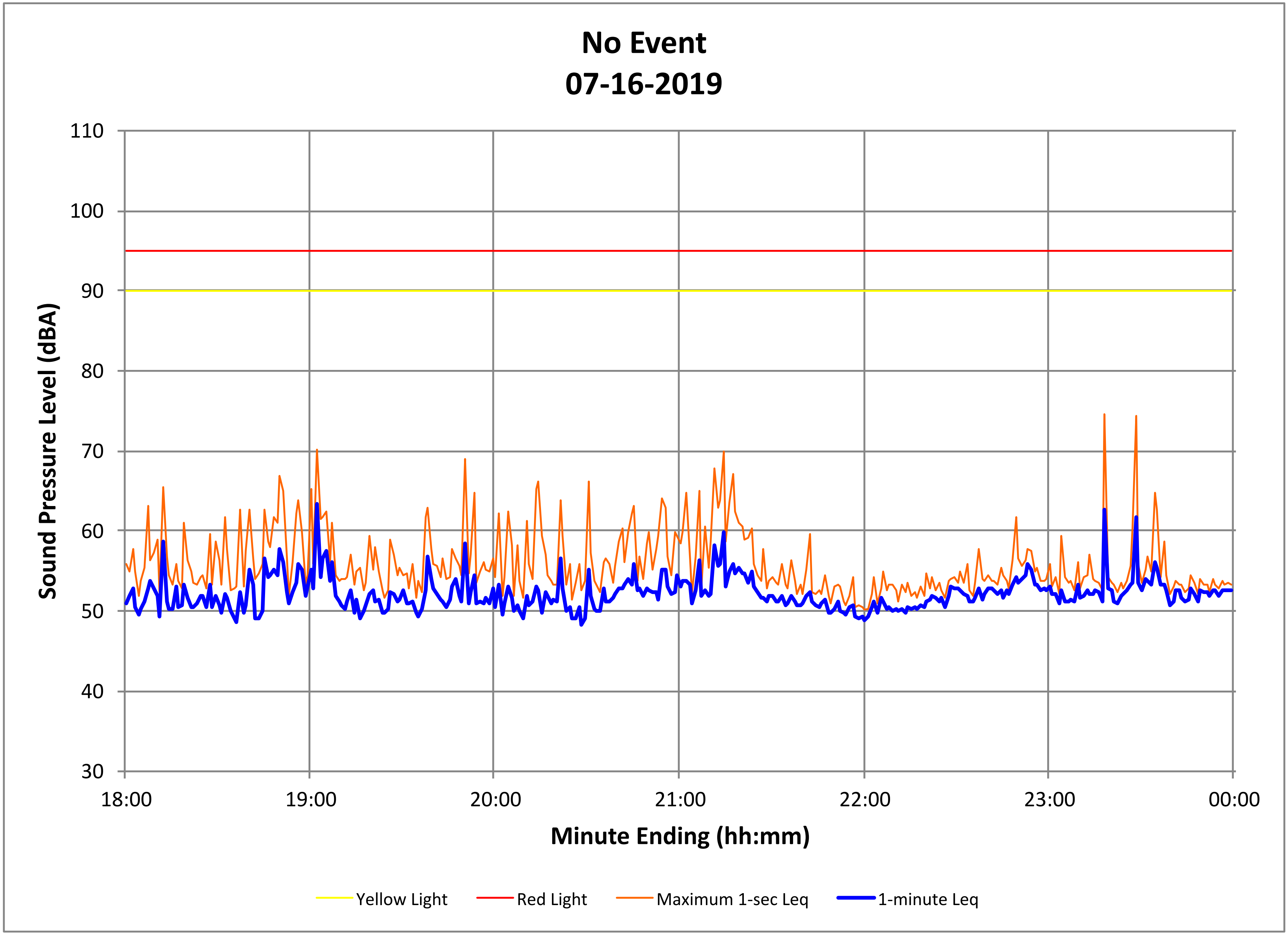

No Event (weather)
07-12-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

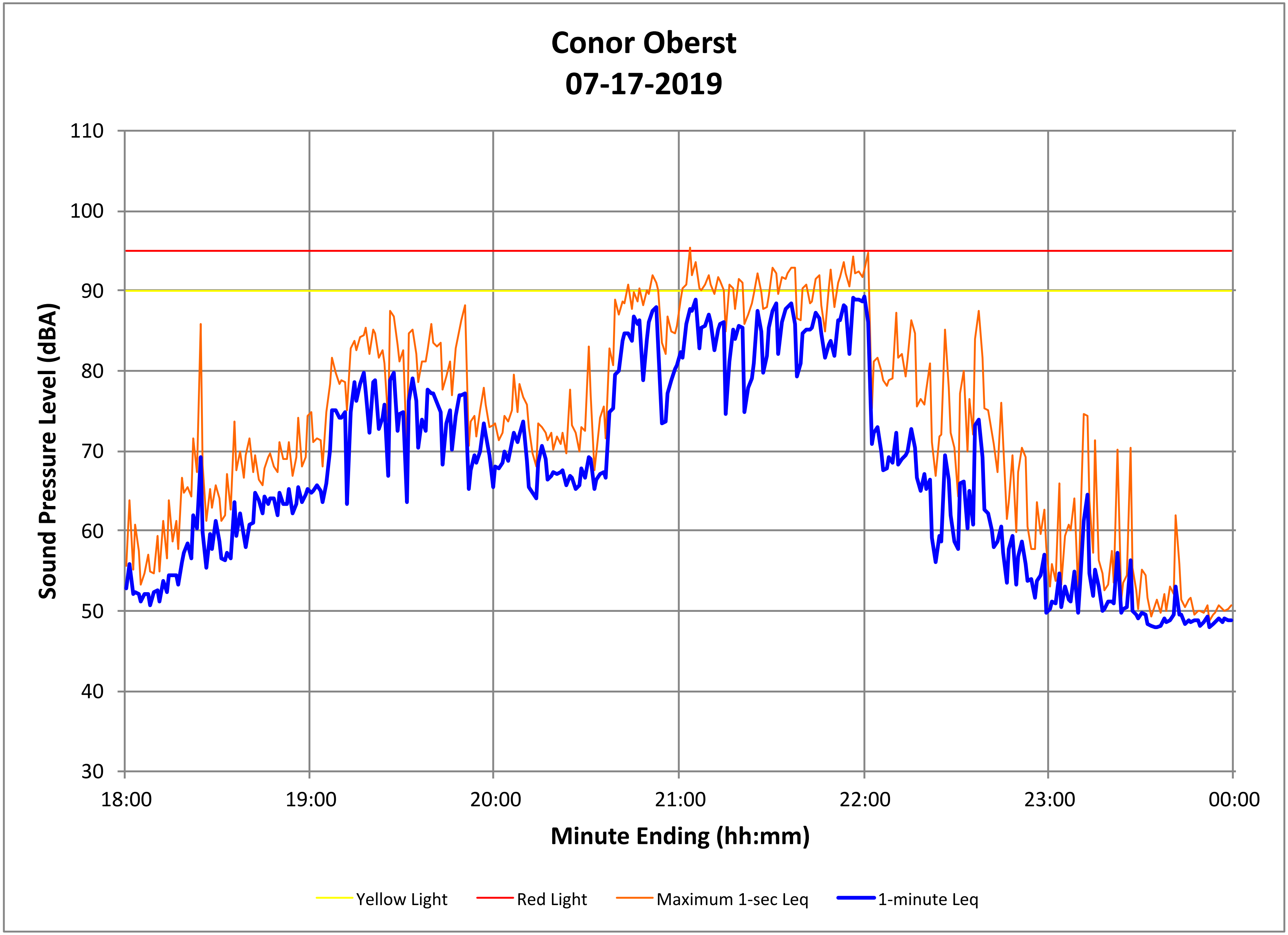

Beauty and the Beast
07-13-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq


Beauty and the Beast
07-14-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

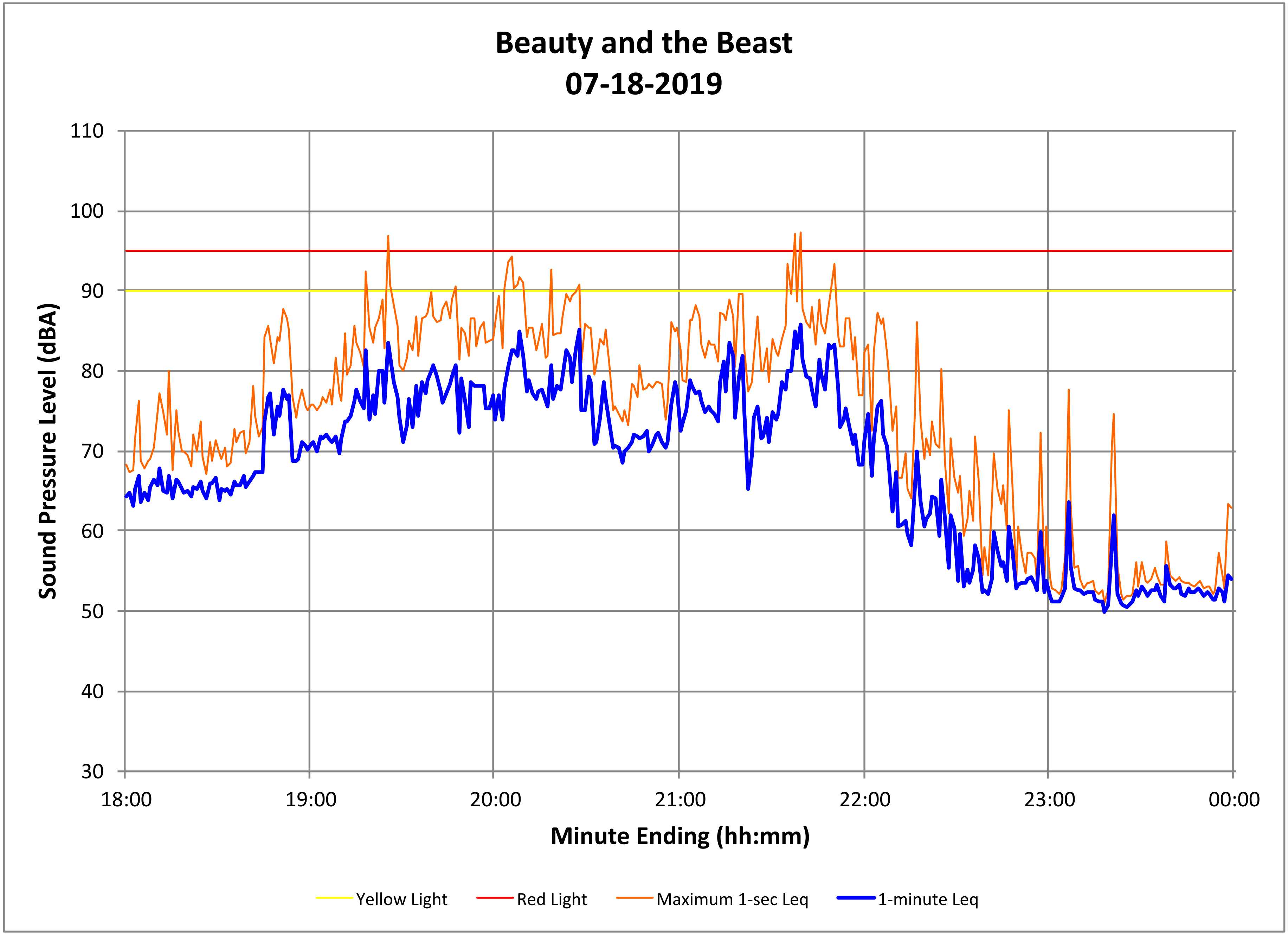


Movie: Spiderman
07-15-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

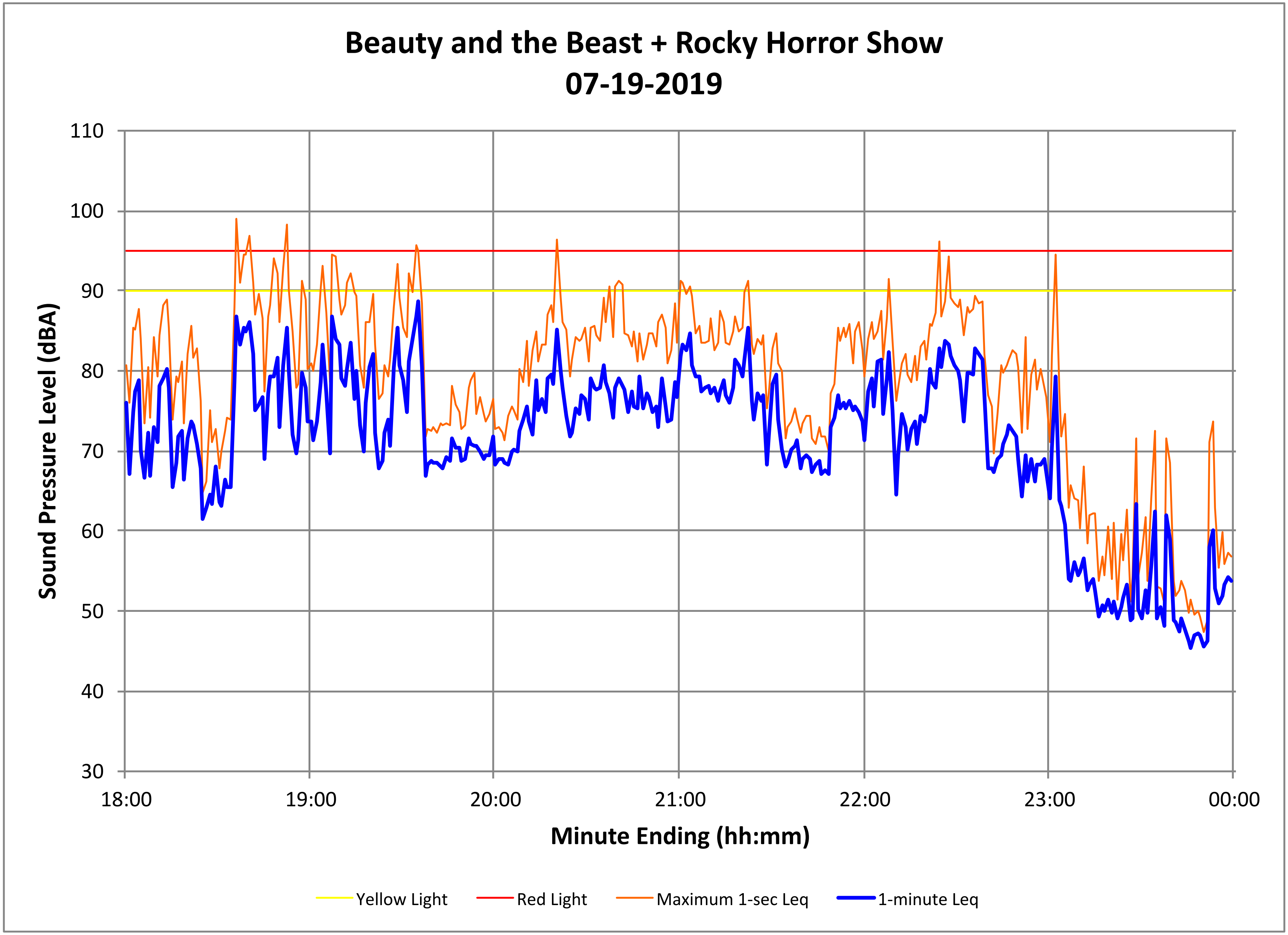

No Event
07-16-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

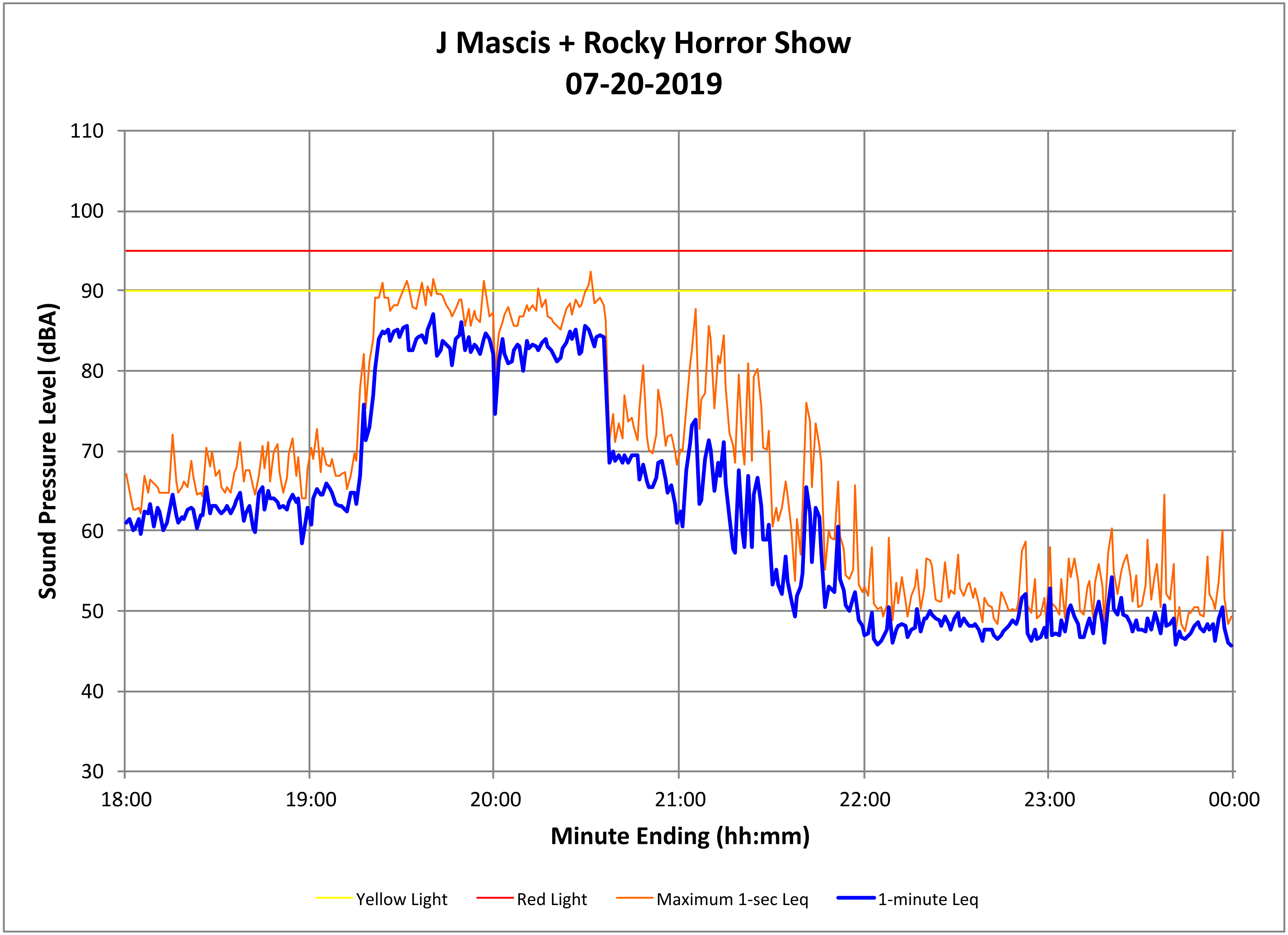


Conor Oberst
07-17-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

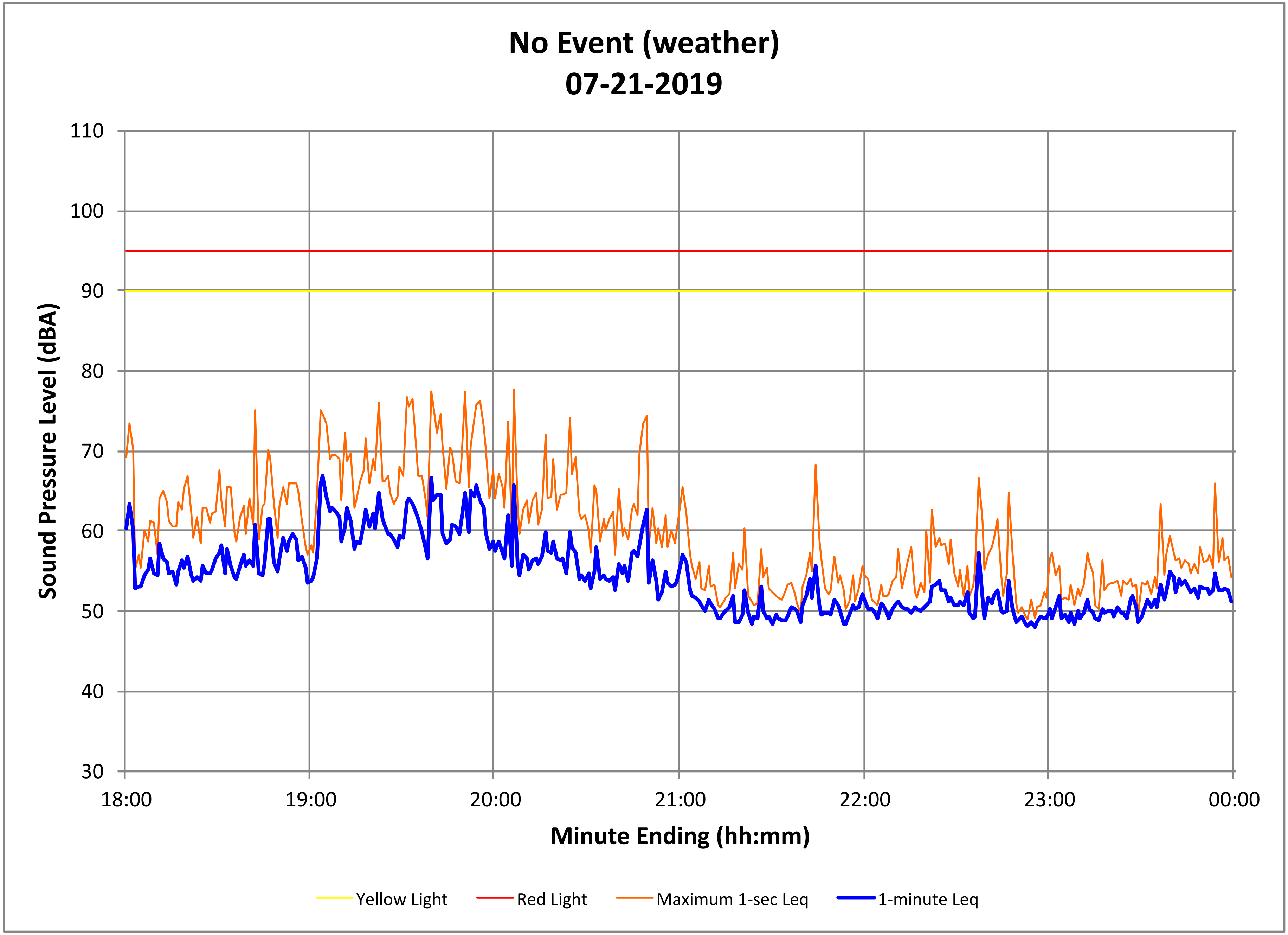


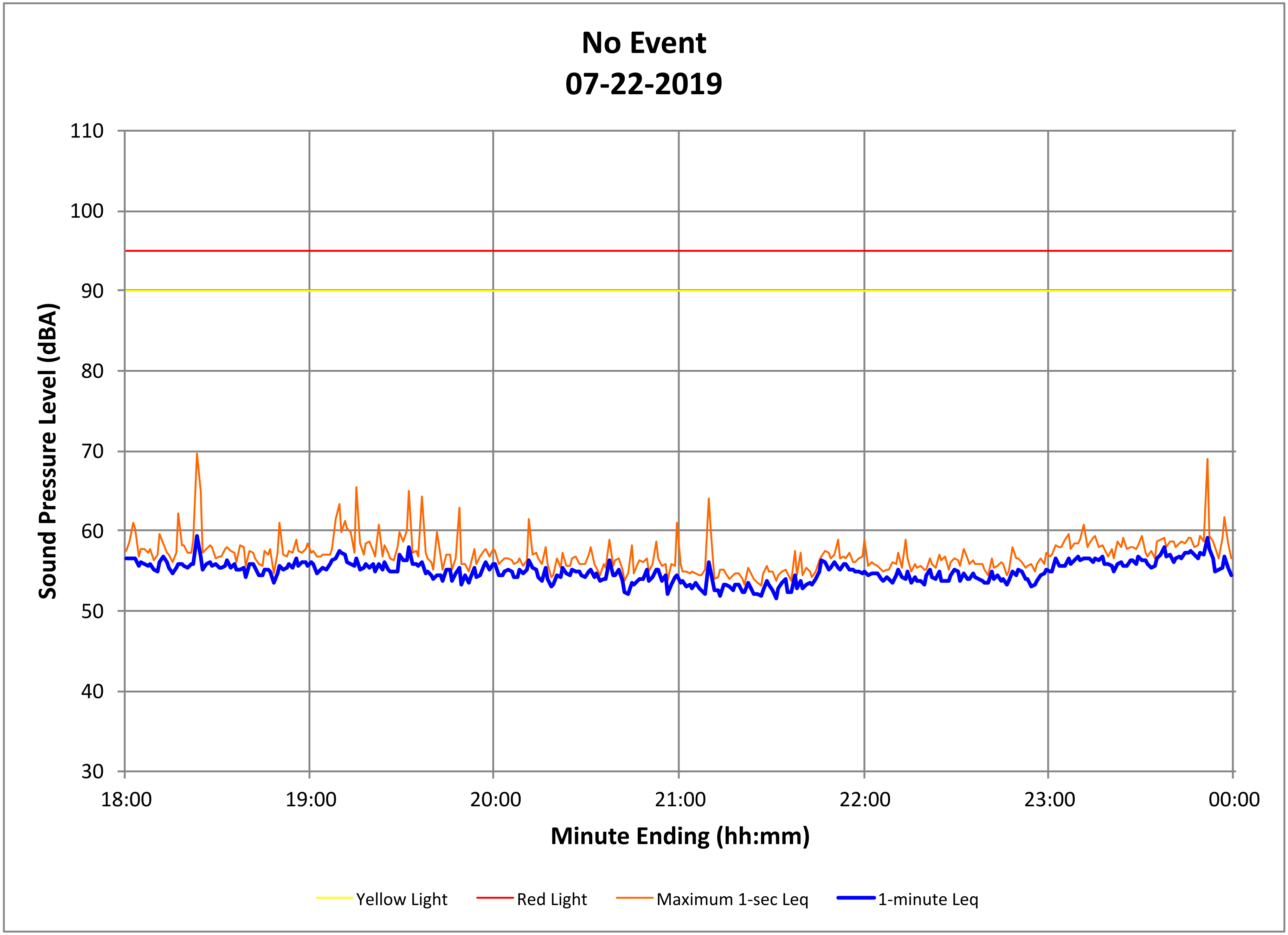
Beauty and the Beast
07-18-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

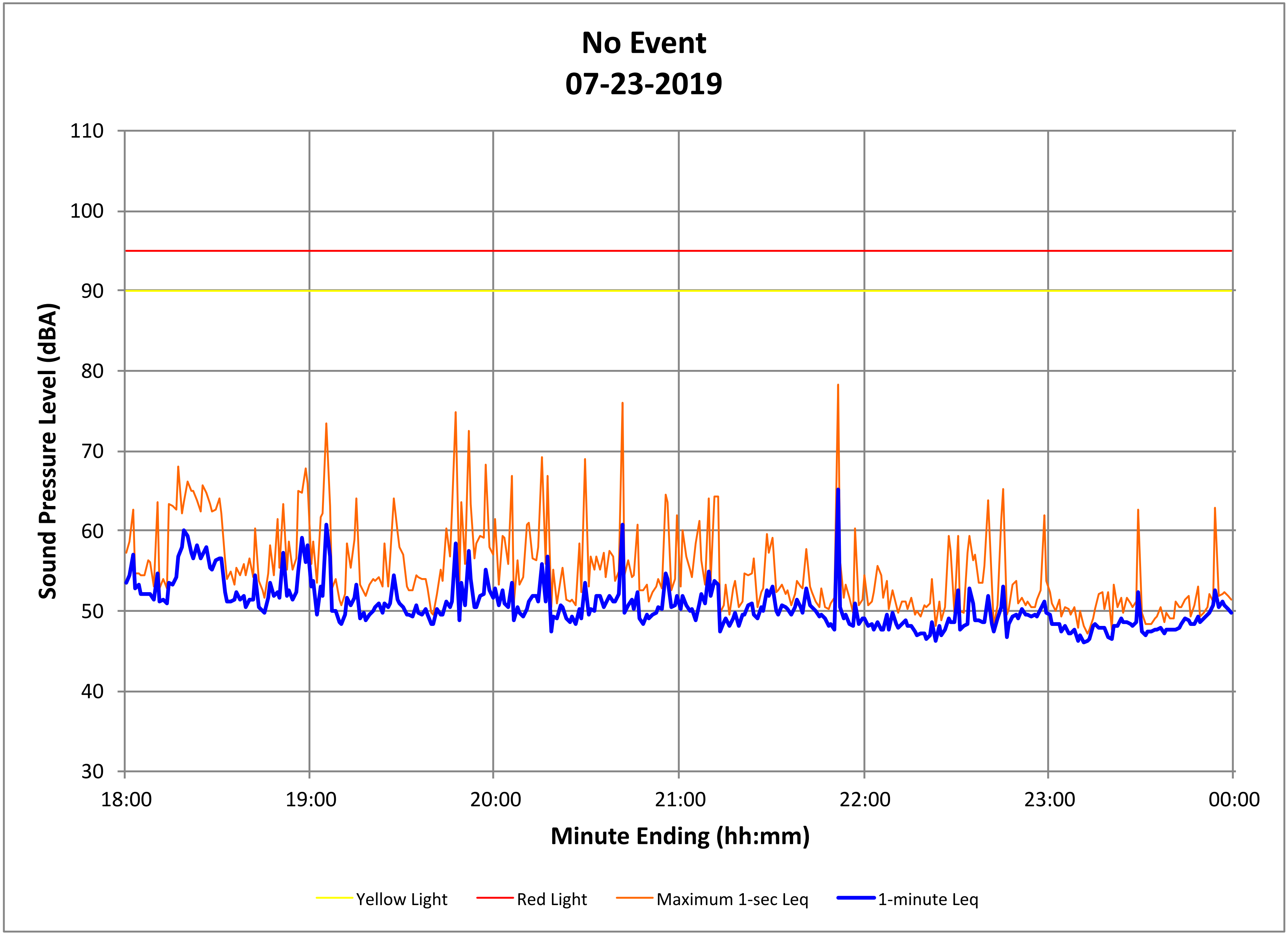

Beauty and the Beast + Rocky Horror Show
07-19-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

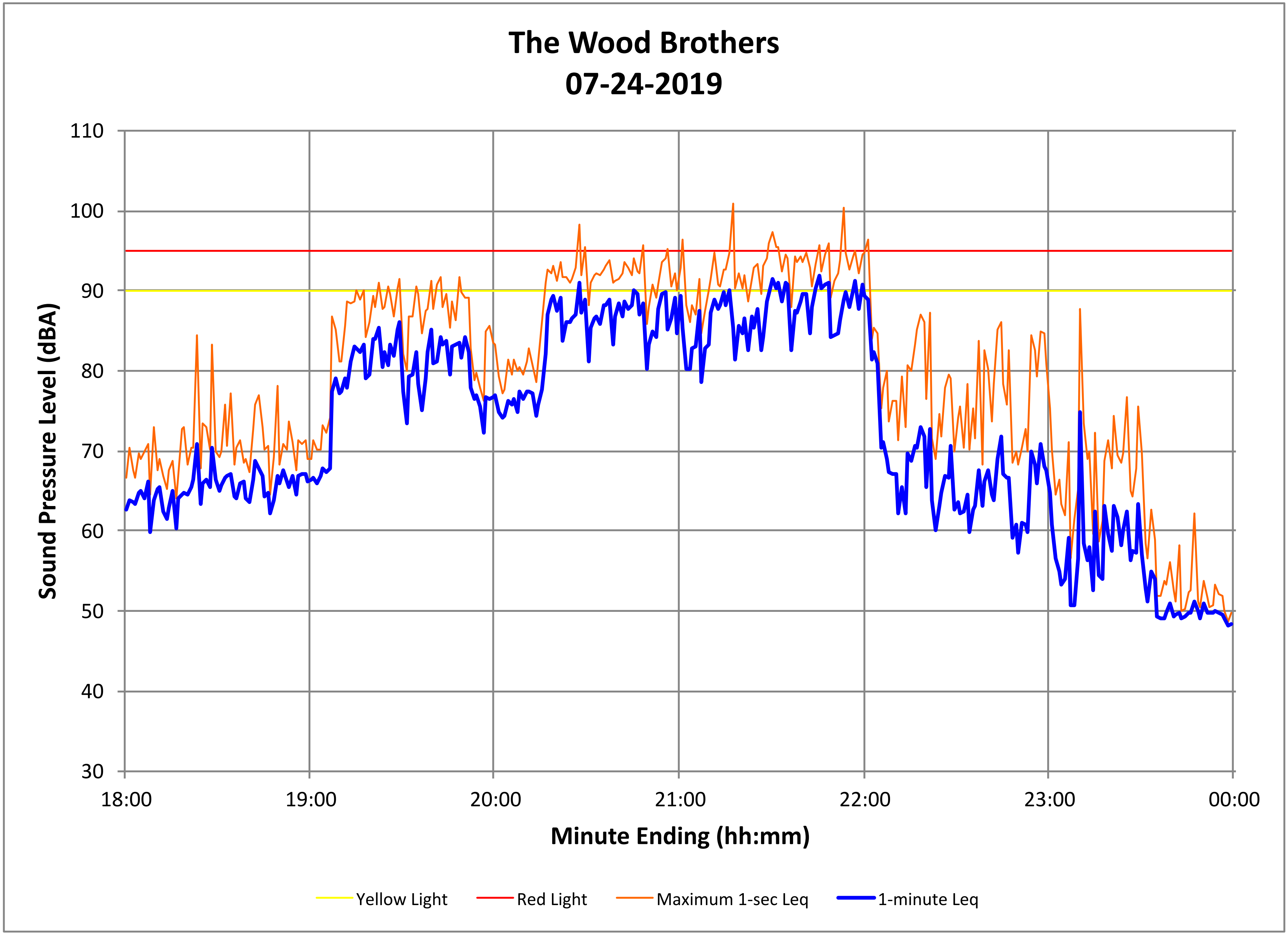


J Mascis + Rocky Horror Show
07-20-2019
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

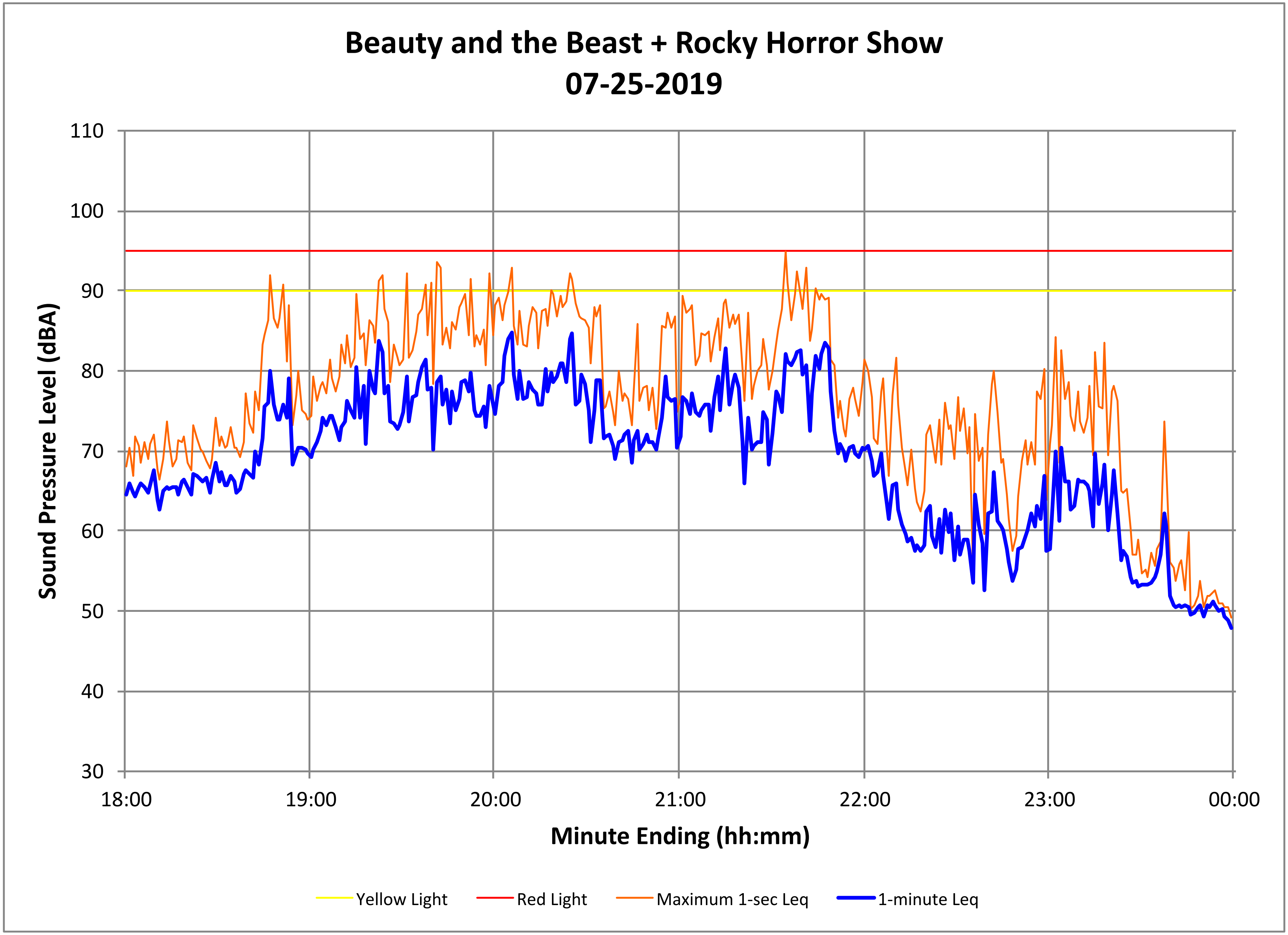

No Event (weather)
07-21-2019
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq


No Event
07-22-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq

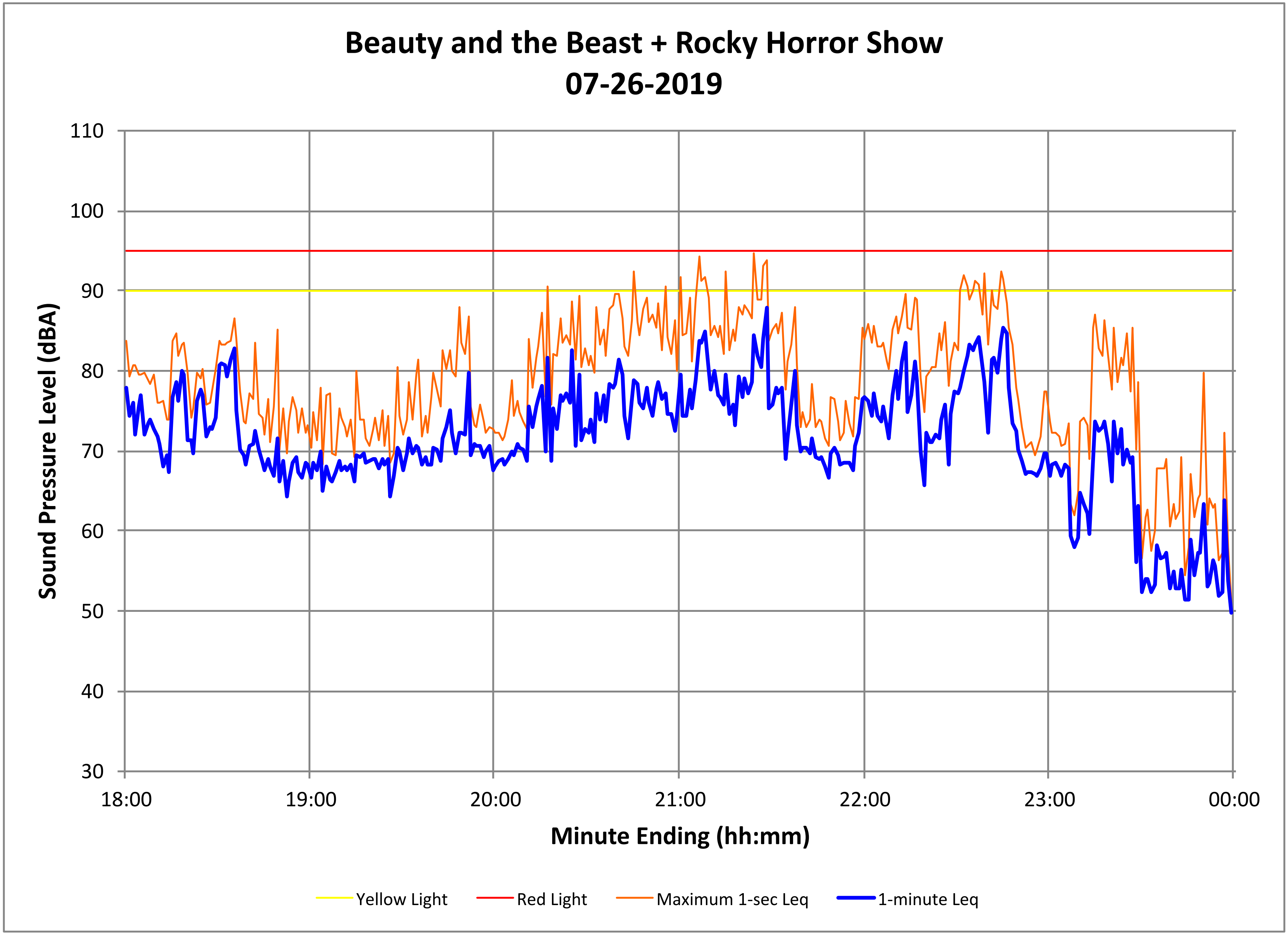

No Event
07-23-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



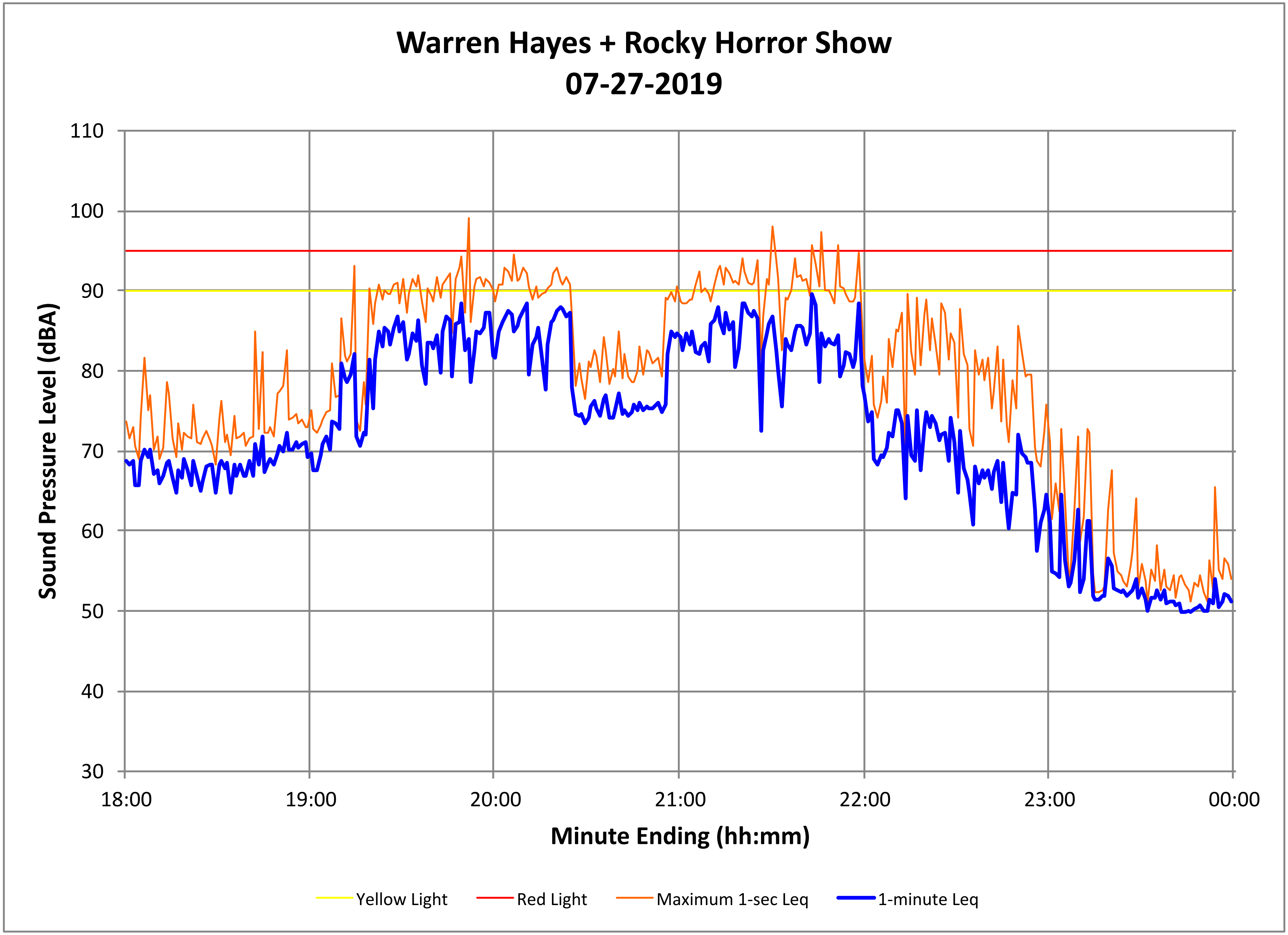
The Wood Brothers
07-24-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



Beauty and the Beast + Rocky Horror Show
07-25-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq



Beauty and the Beast + Rocky Horror Show
07-26-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq


Warren Hayes + Rocky Horror Show
07-27-2019
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Yellow Light
Red Light
Maximum 1-sec Leq
1-minute Leq