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TECHNICAL MEMORANDUM

To:	Michele Rodriguez SFO Airport/Community Roundtable Coordinator MRodriguez@smcgov.org
From:	Gene Reindel, Vice President
Date:	September 17, 2021
Subject:	Review of SFO Proposed Noise Monitoring System Thresholds – Phase 2
Reference:	HMMH Project Number 312310

As the SFO Airport/Community Roundtable noise consultant, the Roundtable requested HMMH review the proposed threshold noise levels provided in the Review of Remote Monitoring Terminal Thresholds-Phase 2 Report[1] referred to as "the Phase 2 Report" within this Technical Memorandum. The two reports (Phase 1 and Phase 2) included recommended threshold noise levels for the following 12 SFO Noise Monitoring Terminals (NMT) with the intent to request threshold noise level waivers from Caltrans:

Report	Site No.	Site Jurisdiction	Threshold Noise Level Recommendation (dB)	
			Daytime	Nighttime
Phase 2	**1**	San Bruno	**65**	**65**
Phase 2	**4**	South San Francisco	**62**	**60**
Phase 2	**5**	San Bruno	**63**	**61**
Phase 2	**6**	South San Francisco	**62**	**60**
Phase 1	**8**	Millbrae	**67**	**67**
Phase 1	**12**	Foster City	**62**	**62**
Phase 2	**14**	South San Francisco	**62**	**60**
Phase 1	**15**	South San Francisco	**60**	**60**
Phase 2	**16**	South San Francisco	**62**	**60**
Phase 2	**17**	South San Francisco	**62**	**60**
Phase 1	**18**	Daly City	**63**	**63**
Phase 1	**19**	Pacifica	**64**	**64**

As reported in our technical memorandum for the Phase 1 Report[2], Title 21 Noise Standards[3] requires the airport proprietor of a noise problem airport, for which SFO is designated by the County of San Mateo, is required to establish a noise monitoring program to validate the location of the noise impact boundary[4] as described in a monitoring plan approved by the department[5]. Due to the recent noise monitoring system upgrade, SFO must submit an updated monitoring plan for approval. The purpose of the noise monitoring plan is to ensure the noise measurements are within the accuracy required to validate the location of the noise impact boundary. Title 21 requires the noise impact boundary be determined, through measurements and/or modeling, and validated through noise measurements to within 1.5 dB. Title 21 ***Section 5032 Validation of the Noise Impact Boundary*** states, "The [NMT] locations shall be selected to facilitate locating the maximum extent (closure points) of the noise impact boundary when the contour extremities encompass incompatible land uses."

[1] Review of Remote Monitoring Terminal Thresholds, Report #2020-007, dated October 23, 2020.
[2] Review of Remote Monitoring Terminal Thresholds-Phase 2, dated June 21, 2021.
[3] State of California Department of Transportation (CalTrans) Division of Aeronautics, Title 21, Subchapter 6. Noise Standards, Register 90, No. 10—3-10-90.
[4] The noise impact boundary is the 65 CNEL contour, Title 21, Section 5012 Airport Noise Standard.
[5] Department of Transportation of the State of California.

1. Noise Monitoring Locations Required by Title 21

Due to the pandemic caused by COVID-19, SFO, along with many other U.S. airports, experienced a drastic reduction in the number of aircraft operations, which, in turn, resulted in a reduction in the size of the SFO 65 CNEL contour. Prior to the Pandemic, SFO, along with many other U.S. commercial service airports, had been experiencing record or near record numbers of aircraft operations. The pandemic provided an opportunity to evaluate a wide range of the extent of the SFO 65 CNEL contour. Figures 1 and 2 show the range of the 65 CNEL contour from the largest in recent history to the smallest in recent history, respectively, which are excerpted from the SFO Quarterly Noise Reports for 1st Quarter 2021 and the 4th quarter 2019 (prior to the pandemic).

To meet the Title 21 requirement to use noise monitoring locations "…to facilitate locating the maximum extent (closure points) of the noise impact boundary when the contour extremities encompass incompatible land uses", HMMH reviewed the two quarterly noise report 65 CNEL contours in Figures 1 and 2.

Given the change is size of the SFO 65 CNEL contour due to the pandemic, the area most affected by the change in the number of aircraft operations with incompatible land uses is to the west from the heavy and international flights departing SFO to the west, also known as "Gap Departures". Therefore, HMMH evaluated the NMT locations out the gap to account for the recently realized potential variation in the size of the 65 CNEL contour lobe to the west. The SFO NMT sites required to locate the maximum extent of the 65 CNEL contour lobe to the west include:

- Sites 1 and 4 during times of extremely low volume of aircraft operations (2020)
- Site 18 during a recent high volume of aircraft operations (2019)
- Sites 4 and/or 6 during times of aircraft operations between the low and high volumes of operations
- Site 19 in case SFO experiences higher volumes of aircraft operations than 2019 in the near future

In addition to the lobe to the west, SFO aircraft operations also produce 65 CNEL lobes to the north, south and east. While the 65 CNEL contour in recent years has not extended to Site 12 in Foster City, we suggest it is required to be certain, though measurements, whether the extent of the lobe to the east includes incompatible land uses. To monitor noise exposure from aircraft departing Runways 01R or 01L out into the Bay and then turning west over the peninsula, perhaps NMT Site 15 could also be included to locate the maximum extent of the 65 CNEL contour to determine whether it reaches the shoreline with areas of incompatible land uses. As documented in the Phase 1 report, Site 8 is unable to measure aircraft noise within 1.5 dB CNEL as required by Title 21 given the other noise sources in the area. Until a suitable site is located in Millbrae to determine the extent of the CNEL 65 contour south lobe behind the start-of-takeoff roll from aircraft departing Runways 01R and 01L, Site 8 will not meet Title 21 requirements.

Therefore, in our opinion, the SFO monitoring plan, to be approved by Caltrans in accordance with Title 21, should include up to the following eight (8) NMT sites to locate the maximum extent of the 65 CNEL contour in proximity to incompatible land uses:

- 1 San Bruno
- 4 South San Francisco
- 6 South San Francisco
- 8 Millbrae
- 15 South San Francisco
- 12 Foster City
- 18 Daly City
- 19 Pacifica

Note: As show in the table above on page 1 of this technical memorandum, SFO is requesting threshold noise level waivers for an additional 4 sites in proximity to the west lobe as well as each of the NMT locations HMMH suggests is required to meet the Title 21 requirement to locate the maximum extent of the 65 CNEL contour.

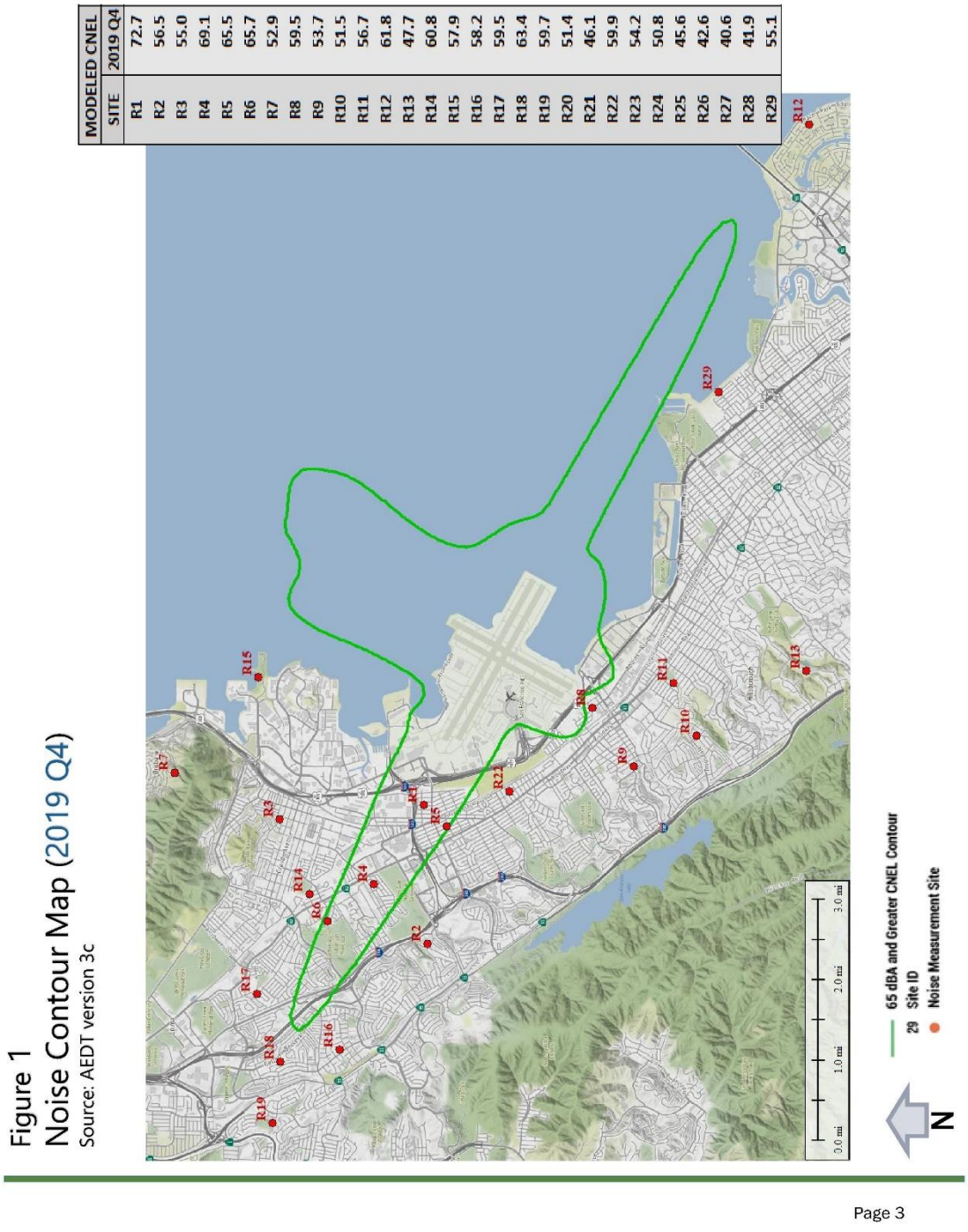

Figure 1: 65 CNEL Contour as Reported in the SFO Quarterly Noise Report for the 4th Quarter 2019

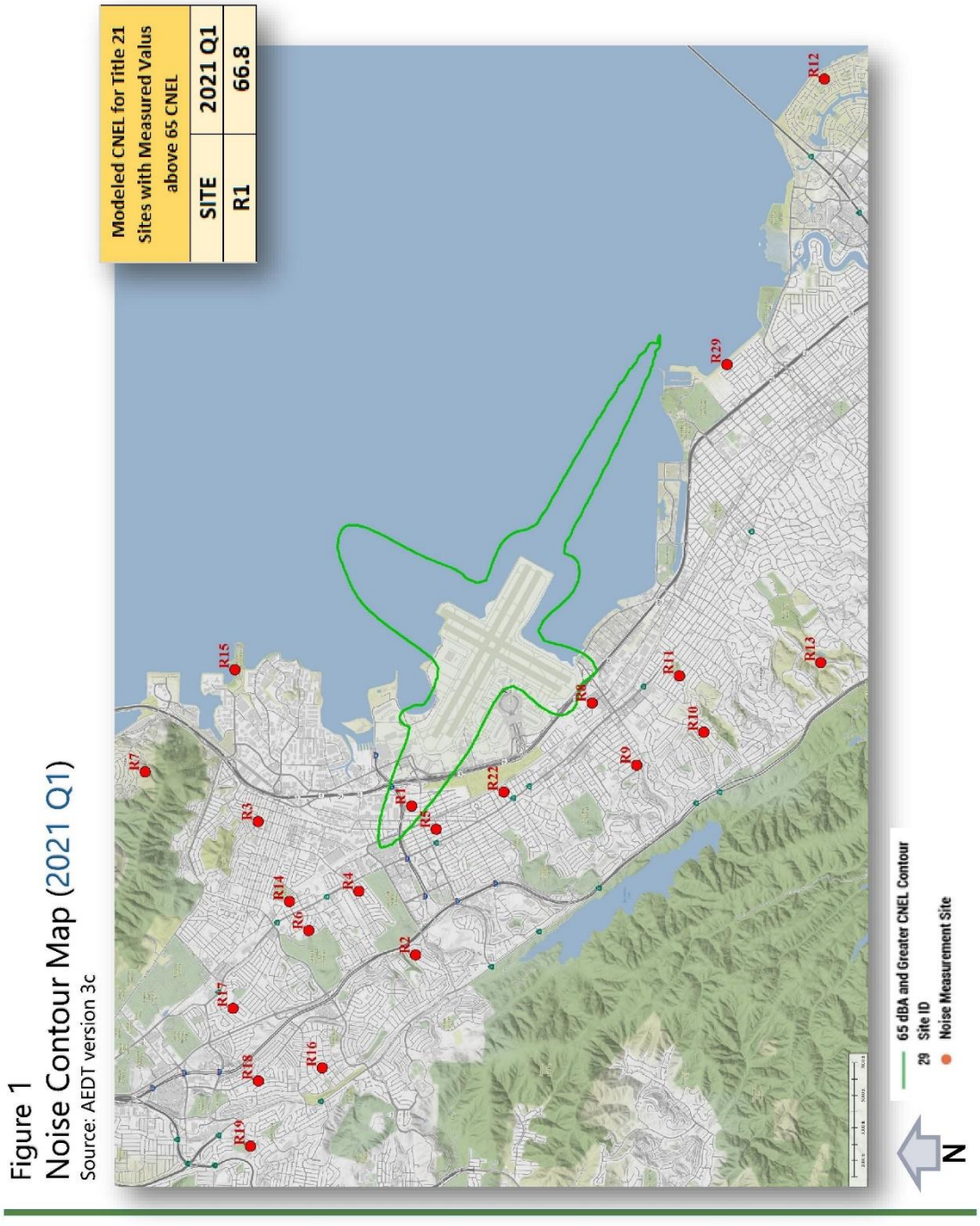

Figure 1
Noise Contour Map (2021 Q1)
Source: AEDT version 3c

Figure 2: 65 CNEL Contour as Reported in the SFO Quarterly Noise Report for the 1st Quarter 2021

2. Evaluation of the SFO Recommended Threshold Noise Levels

To meet Title 21 noise measurement accuracy requirements, the noise measurements used to validate the location of the 65 CNEL contour must report hourly noise levels from aircraft operations and calculate the resulting Community Noise Equivalent Level (CNEL) from aircraft operations to within 1.5 dB. It is our understanding that the SFO noise monitoring system determines aircraft noise events at each noise monitoring location by capturing noise events at the NMTs and determining which of the captured noise events were generated by aircraft operations. This determination is done through the correlation of noise events to aircraft operations in the vicinity of the NMT at the time of the noise event.

Noise events are generated when the measured noise level exceeds a threshold noise level. According to Title 21, the threshold noise level is to be 10 dB below the CNEL standard of 65 dB[6] or 55 dB. Title 21 allows for waivers to the 55-dB threshold noise level at noise monitoring sites where the airport proprietor demonstrates the accuracy of the CNEL from aircraft operations will remain within 1.5 dB. It is worth noting that Title 21 recommends noise monitors be located where the CNEL from sources other than aircraft in flight is equal to or less than 55 dB[7]; and that given the location of the 65 CNEL contour, such locations with low noise levels from non-aircraft sources is not possible. For example, the noise monitoring location to validate the 65 CNEL contour behind the start-of-takeoff roll from Runways 01R and 01L must adjacent to Highway 101 in Millbrae, which likely generates noise levels greater than 55 CNEL.

Therefore, the non-aircraft noise in the vicinity of the NMT is the critical component to how low the threshold noise level can be set to generate aircraft noise events. The Phase 2 Report defined ambient as 2 standard deviations over the average L90 measured over a specified time period within a 24-hour day using nearly three years of measured data (2019-2021) at each NMT. As shown in the figure below showing a typical aircraft noise event along with the ambient prior to and after the noise event, the threshold noise level must be above the "ambient" in order to generate noise events. If the threshold noise level is below the ambient, then a single noise event would result for the entire day as the measured noise is always above the threshold noise level, thus in essence generating no potential noise events to correlate to aircraft operations.

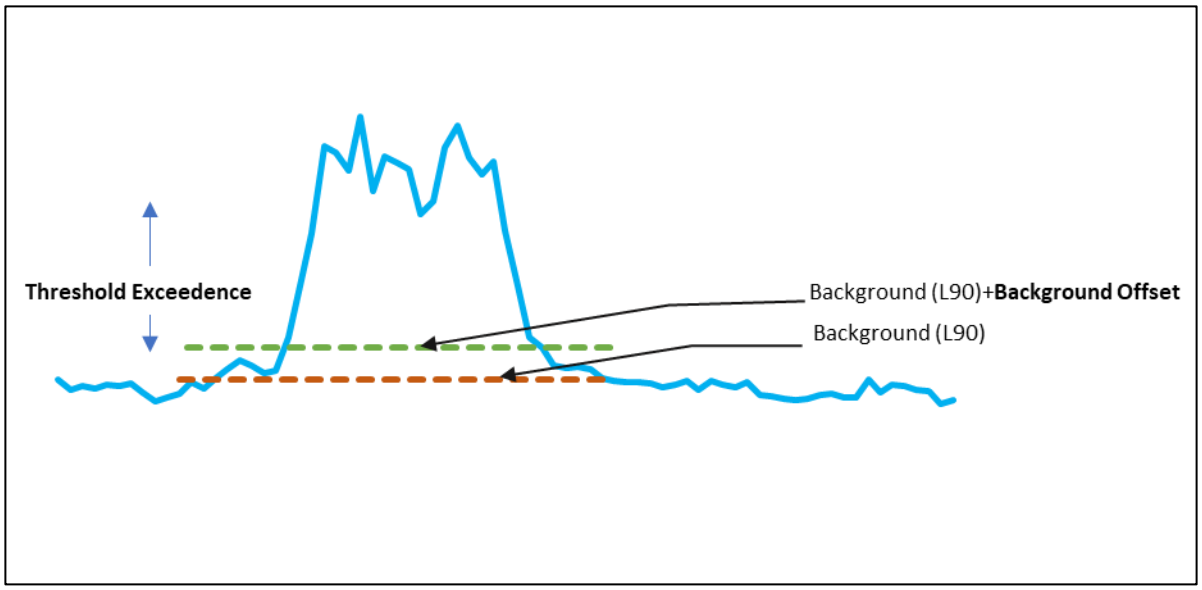

Figure 3: Typical Aircraft Noise Event, Background (Ambient), Background Offset, and Exceedence

[6] Title 21, Section 5001. Definitions., Paragraph (i) Hourly Noise Level.
[7] Title 21, Section 5072. Field Measurement Requirements.

The Phase 2 Report used NMT 4 as an example in calculating the ambient, which showed in Table 4 of the Phase 2 Report that the ambient is approximately 56 to 57 dB. Therefore, it would be nearly impossible to generate individual noise events with a threshold noise level of 55 dB as required in Title 21. To generate individual noise events the threshold noise level must be greater than the ambient. The level above the ambient is often known as the "background offset". Determining the background offset to generate noise events that can be correlated to aircraft is more of an art than a science as non-aircraft noise in the communities vary throughout the day. The methodology presented in the Phase 1 and Phase 2 reports seems sound and appropriate. It is important for SFO to evaluate the effectiveness of each NMT in generating noise events that can be correlated to aircraft noise after implementation of the threshold noise level and periodically, perhaps annually, to ensure the threshold noise levels remain effective in generating noise events; and to determine each NMT used to determine the locations of the extent of the 65 CNEL contour within 1.5 dB accuracy as required by Title 21.

3. Conclusions

HMMH finds the SFO-recommended threshold noise levels for the noise monitors as provided in the Phase 1 and Phase 2 reports as shown in the summary table on the first page of this technical memorandum to be appropriate at this time. We recommend that the threshold noise levels be evaluated immediately after approval by Caltrans using a couple months of data; and evaluate them on an annual basis to ensure the NMTs required to determine the extent of the 65 CNEL contour are measuring aircraft CNEL within 1.5 dB as required by Title 21.

HMMH was also asked to comment on the "duration" included in the Phase 2 Report, which was 60 seconds for the maximum duration of a single noise event. In addition to the threshold noise level, there are other noise event detection parameters. Three of the additional parameters are related to duration: (1) minimum duration above the threshold noise level in order to generate a noise event, (2) minimum duration below the threshold noise level before ending the noise event, and (3) maximum duration of a single noise event. Industry standard for aircraft noise detection is as follows and should be considered rules of thumb as each NMT and each airport could require different values as those shown here:

- Minimum duration above the threshold noise level: 5 seconds
- Minimum duration below the threshold noise level to end the event: 2 to 5 seconds
- Maximum duration of a single noise event: 60 seconds

It is worth noting that when the maximum duration above the threshold noise level is exceeded, the system ends one noise events and starts another noise event; and continues to create one-minute events until the measured noise level drops below the threshold noise level.