Soundscape observations at the Judith King site (11-13 Dec 2025) and at the K-Mart site (22-24 Dec 2025)

Calibrated audio recordings were made at the Judith King property (Nelson Road at Royal Wolf Way), running from 4:56PM on Thursday,11 Dec 2025, until 11:08AM on Saturday, 13 Dec 2025 (approximately 42 hours). For comparison, a calibrated audio recording was also made at the former K-Mart property (N. 7th Avenue at Oak St.) from 4:56PM on Monday, 22 Dec 2025, until 11:16AM on Wednesday, 24 Dec 2025 (approximately 42 hours).

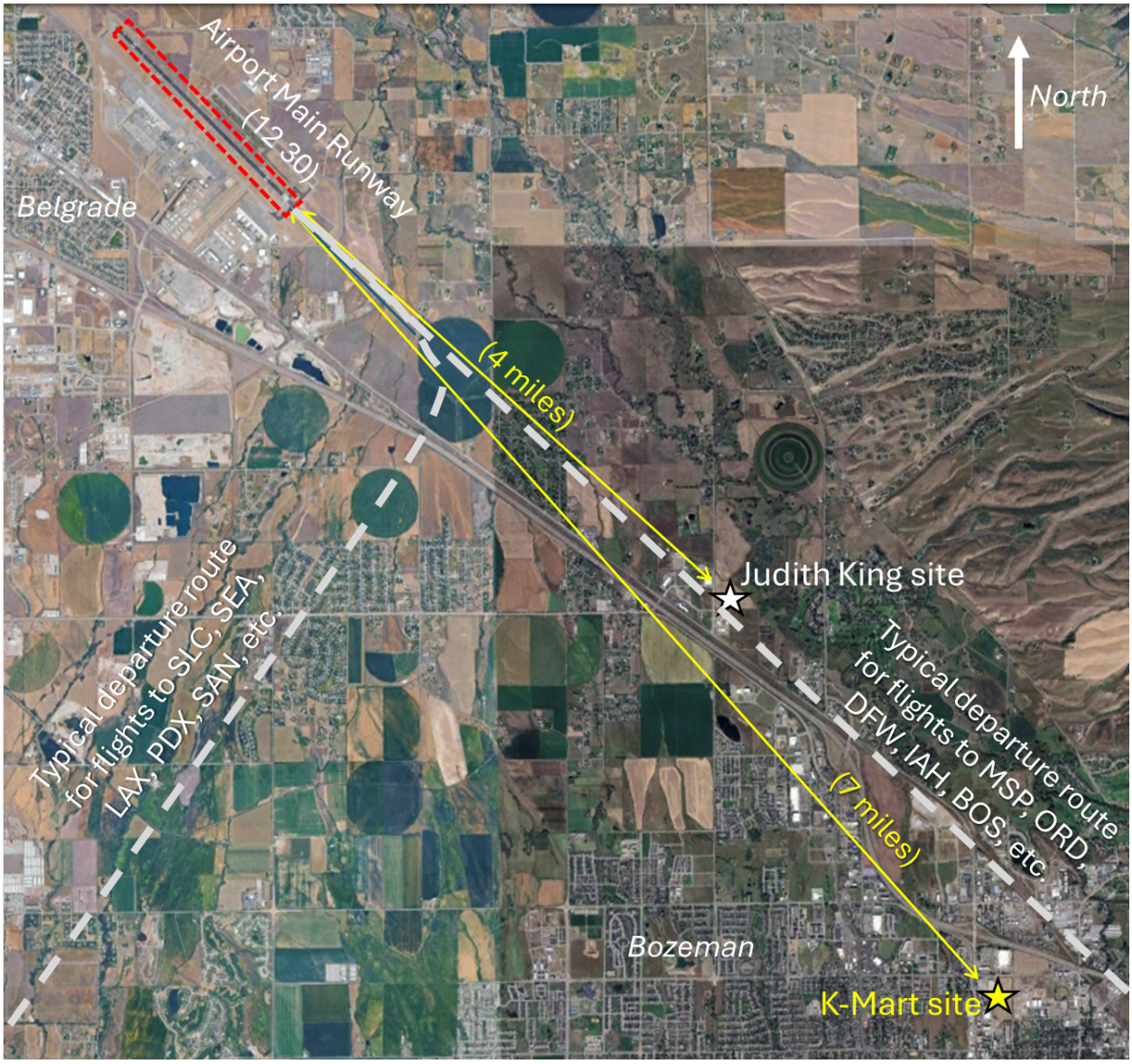

Figure 1: Map of the vicinity from northcentral Bozeman to Belgrade, with the location of the Judith King site, K-Mart site, and standard airport flight departure routes.

Summary

The soundscape at both sites comprises three main components: (1) ambient highway and road traffic noise, (2) railroad sounds, and (3) aircraft activity.

> *Sound levels are customarily expressed in decibels [dB]. Sound pressure level (SPL) expressed in decibels gives a logarithmic comparison of the observed sound to the threshold of hearing (quietest audible sound). SPL values typically vary between zero (just barely audible) and 100 (very, very loud), with common SPL readings of 25 dB for whispering, 50-60 for conversational speech, 90 dB for a loud passage during a symphony concert, and over 100 dB for extremely loud sounds like a gasoline-powered lawnmower or a jet engine. It is also customary to use a standard amplitude normalization called "A-weighting" to help mimic the fact that human ears are not equally sensitive to sounds at all frequencies. Audio levels measured with A-weighting are expressed as dBA. The readings given for the soundscape observations in this summary are given with dBA.*

Road traffic noise: Interstate 90 passes nearby to both sites, with the Judith King site also in proximity to street traffic on the Frontage Road and Nelson Road, and the K-Mart site in proximity to street traffic on N. 7th Ave. and W. Oak St., as well as sounds from the Gallatin County Fairgrounds.

Railroad noise: The rail corridor through north Bozeman passes within 0.2 miles of the Judith King site, and within 0.5 miles of the K-Mart site. The sound of the rolling stock is audible at both locations, and the sound of the required train horn at grade crossings is particularly distinct. Federal law mandates that the locomotive horn produce a sound level between 92 and 110 dBA SPL when measured 100 feet from the track. The sound level at the measurement sites is, of course, lower due to the distance from the horn, and also reduced somewhat due to attenuation because of barriers between the position of the locomotive and the microphone. Nevertheless, the sound of the horn is clear and distinct at both locations.

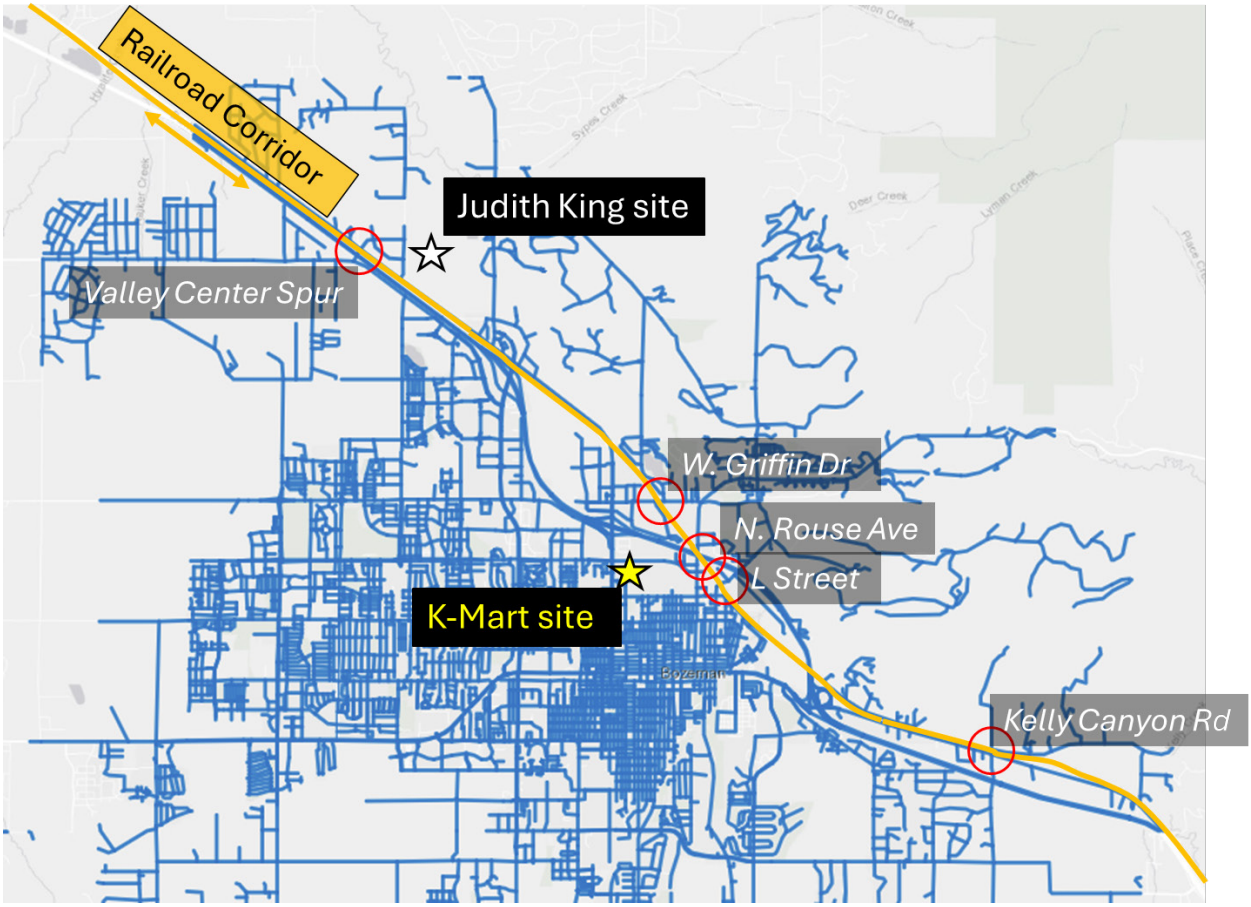

Figure 2: Railroad corridor through the Bozeman area, showing the grade crossings that have train horn signals in compliance with federal law. The locomotive engineer blows a signal sequence of {long, long, short, long} at least 15 seconds before the crossing.

Aircraft noise: Due to the runway configuration, jet aircraft using Bozeman Yellowstone International Airport (BZN) take off and land following customary trajectories that pass nearly directly above both sites. The direction of travel depends upon prevailing wind and the geographic location to which or from which the aircraft is traveling.

Judith King site summary

The typical background sound level at the Judith King site during the 42-hour observation period was 48 dBA. The loudest noise level observed at the Judith King site was 82 dBA briefly during an aircraft overflight from a jet plane taking off from Bozeman airport.

K-Mart site summary

At the K-Mart site, the typical average background sound level was 46 dBA. The loudest noise level observed at the K-Mart site was 79.9 dBA from a railroad locomotive horn. Typical aircraft overflight sound levels were 75 dBA at the K-Mart site.

Methods

The monitoring process used a Zoom F1 Field Recorder equipped with a small, lavalier-style electret condenser microphone. Recorder power was provided by a separate battery powerpack sufficient for 100+ hours. The digital recorder was configured for a 44.1 kHz audio sampling rate, monophonic (single channel), with storage as a 320 kbps MP3 file. A 1 kHz acoustical tone reading 94 decibels sound pressure level was recorded in the sound laboratory, then the system was brought to the recording site in a weatherproof container, with the microphone and windscreen mounted outside the enclosure. Upon completion of the recording interval, the system was retrieved from the recording site and brought back to the lab for analysis of the audio data.

The MP3 file was decoded, filtered for A-weighting, then processed to determine the RMS sound pressure with 30-second intervals. The resulting RMS pressure was converted to sound pressure level in decibels, using the known 94 dB calibration tone as the reference.

The Recording locations

Judith King site

The Judith King property is approximately 4 miles southeast of the main north-south runway (direction 12) of Bozeman Yellowstone International Airport (BZN). The soundscape at the site comprises three principal components: traffic noise from the nearby interstate and the adjacent Frontage Road and Nelson Road, the sound of railroad activity (locomotive and rolling stock, plus close and distant train horns), and the sound of aircraft landing and taking off from Bozeman airport.

Figure 3: Aerial view of the recording position at the Judith King site, showing the nearby roads, railroad line, and the grade crossing at Valley Center Spur.

The typical "background" sound pressure level (SPL) *peaks* at the site are about 55-60 decibels A-weighted (dBA), with the long-term background *average* of about 48 dBA. The primary audible characteristic of the ambient background sound is vehicle noise from I-90, which is audible essentially all of the time.

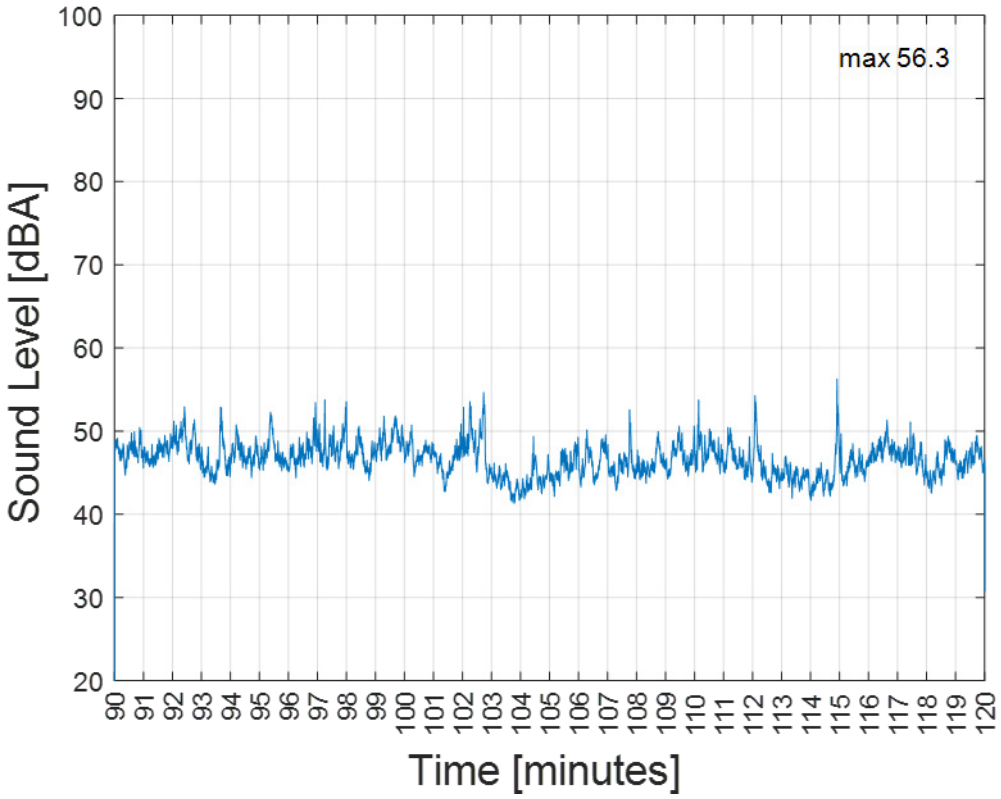

Figure 4: Typical example of the sound pressure level (30 second averages) of a 30 minute span at the Judith King site. The fluctuations are primarily due to changes in the vehicle traffic on the interstate and the nearby streets.

Railroad noise, and particularly the locomotive horn, peaked at about 76dBA at the Judith King site. Locomotives must blow their horn when approaching grade crossings, with the nearest grade crossing at Valley Center Spur Rd. Some trains have locomotives on both the front and the rear of the train. Only the lead locomotive blows its horn, but the sound level due to the engines tends to increase as the fore and aft locomotives pass by (see Figure 5).

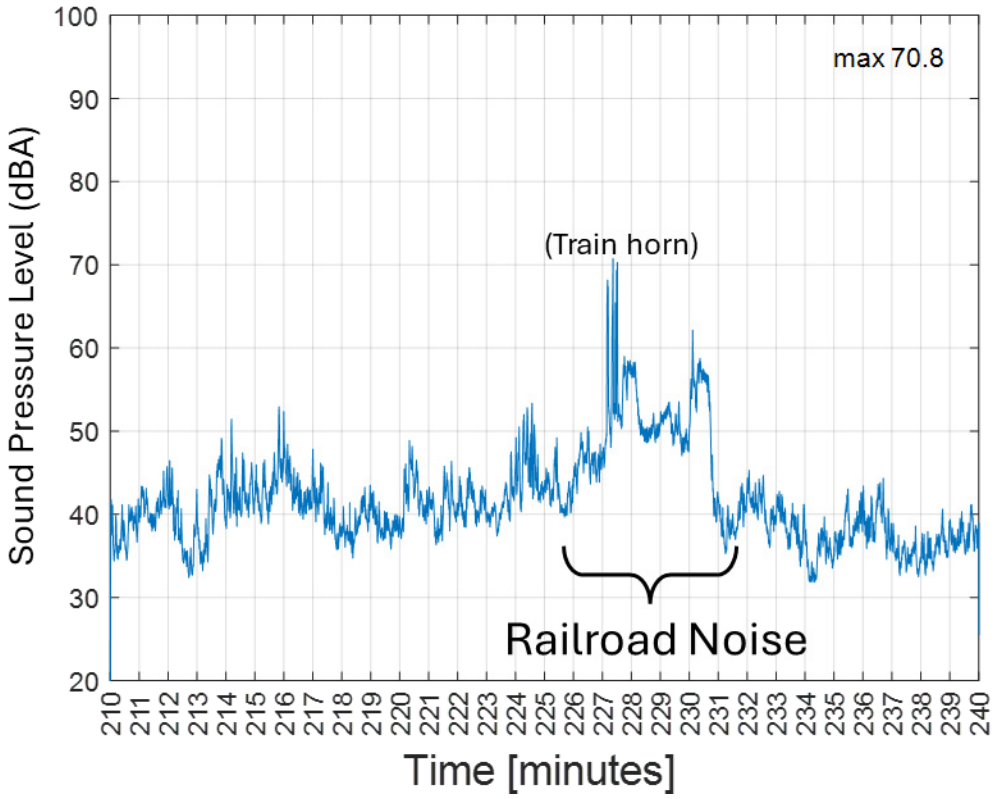

Figure 5: Typical example of a passing train from the Judith King site. The required "long, long, short, long" sequence of the train horn precedes the noise of the forward locomotives, then the sound of the rolling stock, then the engine sound of the rear locomotives.

When a passenger jet aircraft is taking off toward the southeast (runway 12)—traveling more or less directly over the microphone—the sound level at the site was observed to reach momentarily as high as 82 dBA.

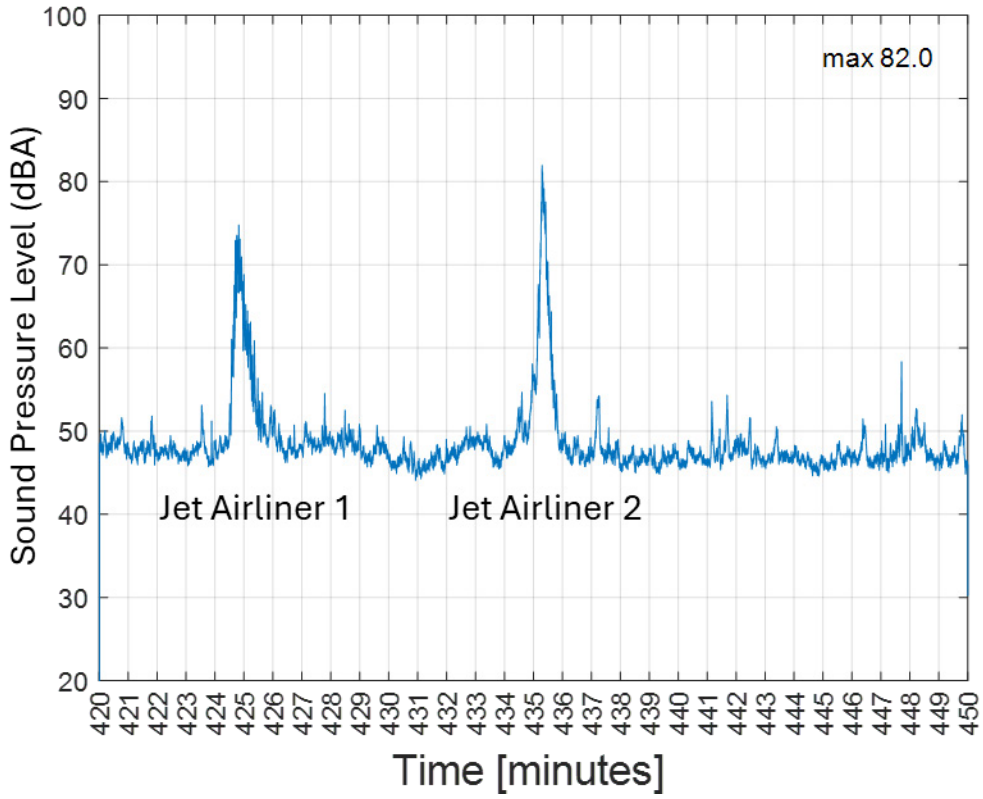

Figure 6: Example observation at the Judith King site of two successive jet aircraft departing on runway 12 from the Bozeman airport. Aircraft heading to destinations east of Bozeman, e.g., Minneapolis, Chicago, and Denver, use runway 12 when the wind direction is appropriate.

With the most common wind patterns, departing flights heading toward Minneapolis, Denver, Chicago, New York, Atlanta, Dallas, and other points to the east of Bozeman typically follow a path over the site, and therefore represent the highest noise levels observed at the site. Departing flights with destinations to the west of Bozeman, such as Seattle, Portland, Salt Lake City, Los Angeles, etc., typically turn south before reaching the site, and therefore contribute relatively low noise levels upon takeoff.

The time distribution of departing flights from BZN varies somewhat with time of year and day of the week, but most departures are between 5:00AM and 6:30PM.

K-Mart site

The former K-Mart property is near the intersection of N. 7th Avenue and W. Oak Street in north central Bozeman. Like the Judith King site, the soundscape at the K-Mart location comprises three principal components: traffic noise from the nearby interstate and the adjacent N 7th Ave. and W. Oak St., the sound of railroad activity (locomotive and rolling stock, plus close and distant train horns), and the sound of aircraft landing and taking off from Bozeman airport.

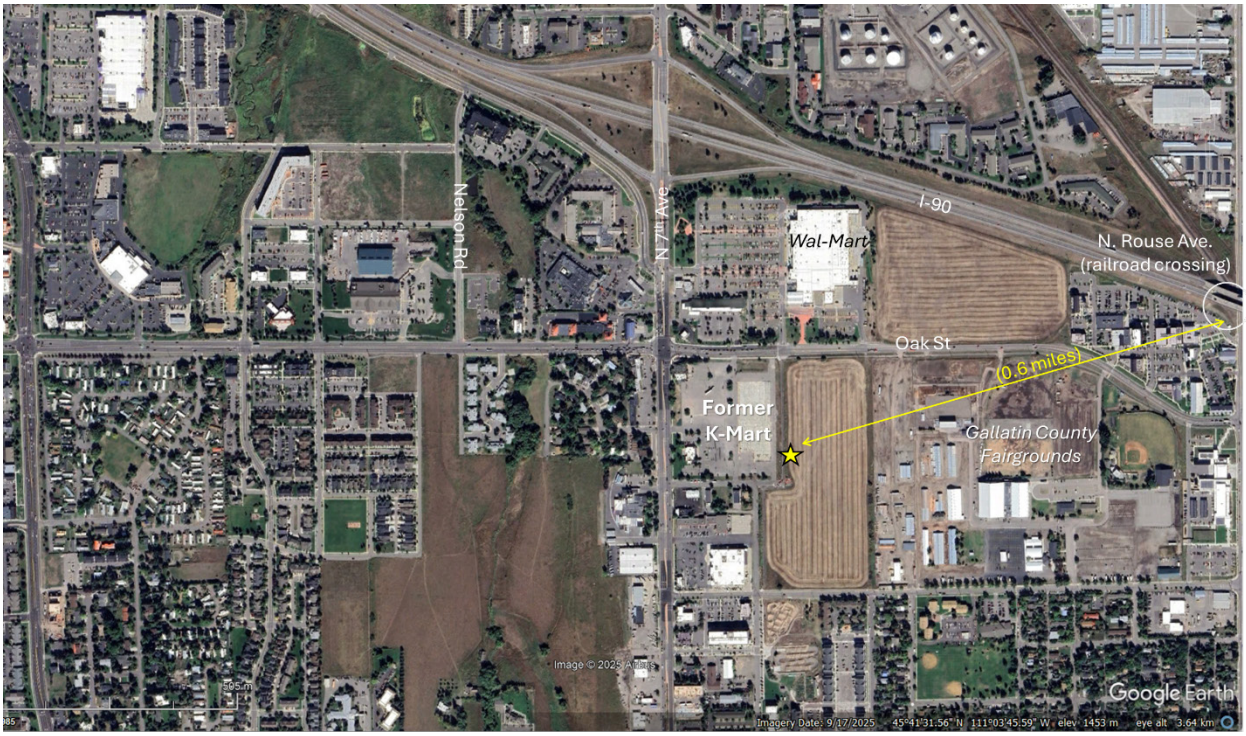

Figure 7: Aerial view of the recording position at the K-Mart site, showing the nearby roads, railroad line, and the grade crossing at N. Rouse Ave.

The typical "background" sound pressure level (SPL) peak at the K-Mart site is about 55-65 decibels A-weighted (dBA), with the long-term background average of about 45 dBA. The primary audible characteristic of the ambient background sound is vehicle noise from adjacent streets and I-90.

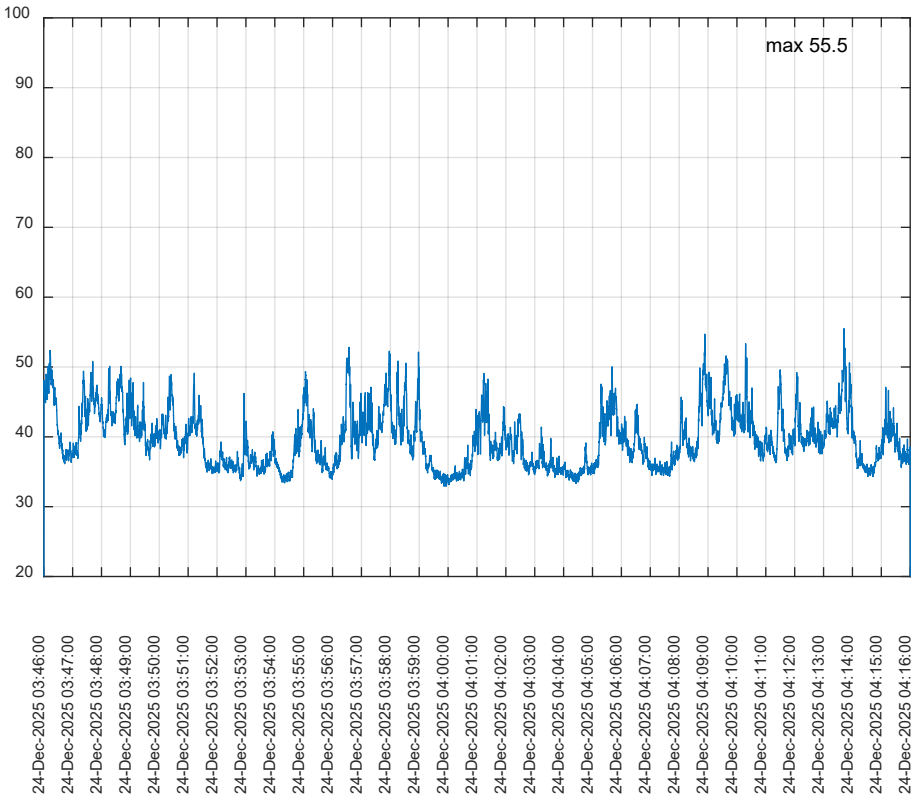

Figure 8: Typical example of the sound pressure level (30 second averages) of a 30 minute span at the K-Mart site. The fluctuations are primarily due to changes in the vehicle traffic on the interstate and the nearby streets.

Railroad locomotive noise horns peaked at about 74 dBA at the K-Mart site. Locomotive horns are more noticeable at the K-Mart site than at the Judith King site because of the three grade crossings relatively close to the site: L Street, N. Rouse, and W. Griffin. The result is that train horn sounds are heard several times for each passing train.

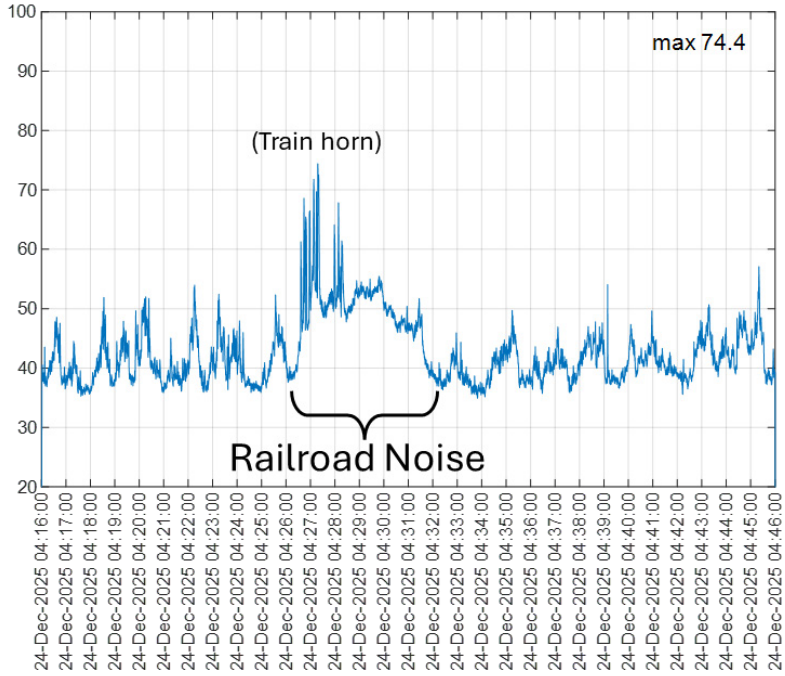

Figure 9: Typical example of a passing train from the K-Mart site. The train horn typically has several successive reports due to the sequence of nearby grade crossings (L Street, N. Rouse, W. Griffin).

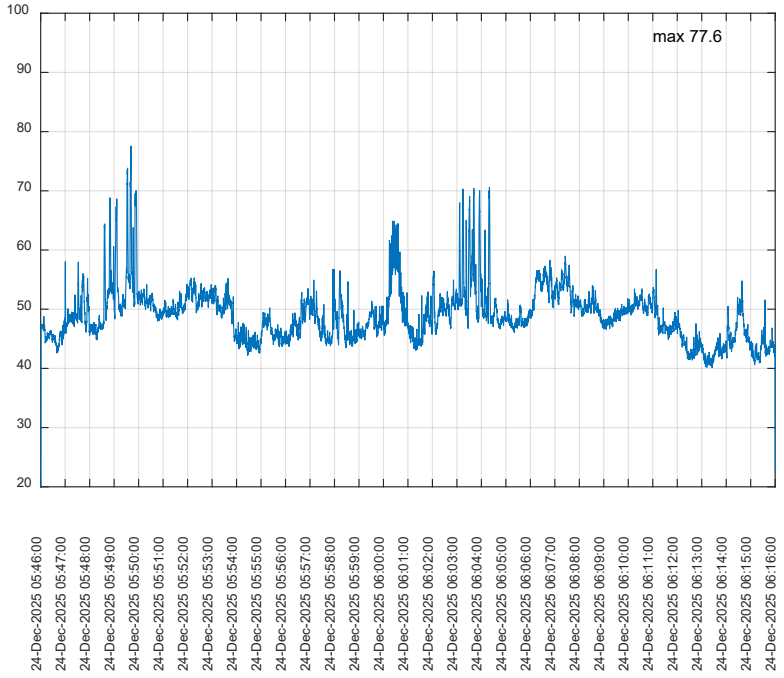

Figure 10: An example of a particularly loud train heard at the K-Mart site, followed by a jet flyover and another train.

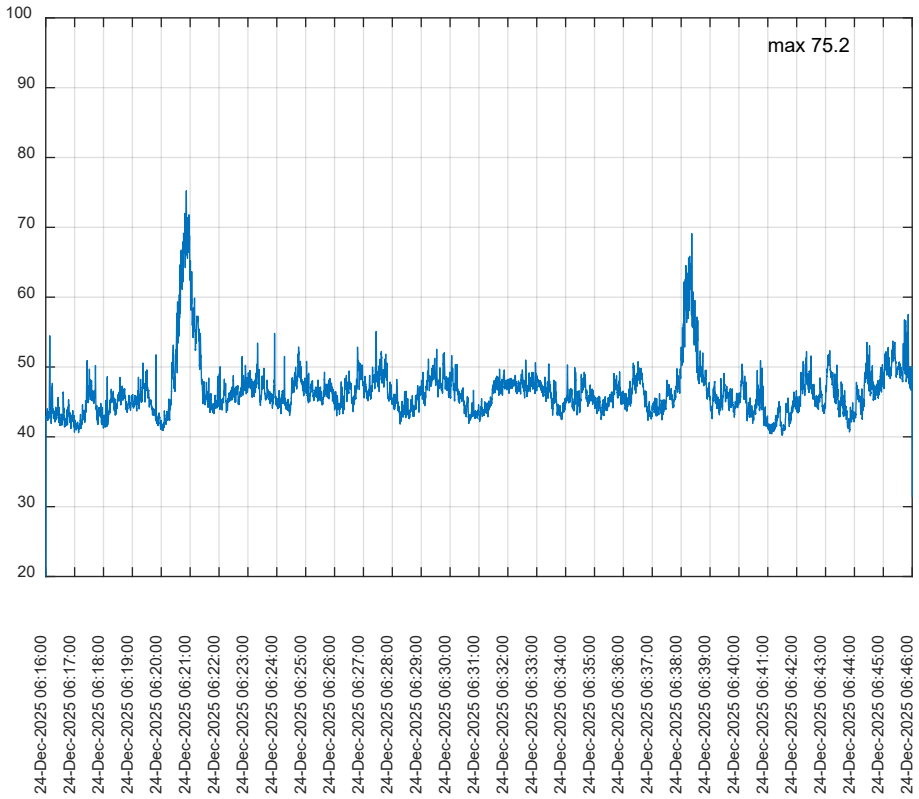

Figure 10: An example of two successive aircraft passing over the K-Mart site

Conclusion

The soundscape observations at the two sites provide both similarities and differences. Both locations have noticeable sound due to street traffic, railroad, and airplanes, with the loudest railroad sound levels slightly greater at the K-Mart location and the loudest aircraft sound levels slightly greater at the Judith King location.

For outdoor performances, the noise levels at both sites are sufficiently high to be undesirable. However, the loudest noise intrusions from aircraft and from train horns are relatively brief, lasting just 30-60 seconds in most cases. Some mitigation by landscaping berms and perhaps recognizing the issue and making good choices of the time-of-day of outdoor performances could be helpful.

For indoor performances, the sound levels observed at both sites seem not to be so high that reasonable architectural design of the building envelope, and choice of construction materials and acoustical sealing methods, should be able to eliminate audible sound infiltration from the ambient sources.