NOISE & GROUNDBORNE VIBRATION IMPACT ANALYSIS

FOR

REEDLEY COLLEGE PERFORMING ARTS CENTER PROJECT

REEDLEY, CA

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

This report discusses the existing setting and identifies potential noise impacts associated with implementation of the proposed project. Noise mitigation measures are recommended where the project-generated noise levels would exceed applicable noise standards.

PROPOSED PROJECT SUMMARY

The project consists of the development of a performing arts center on approximately 4 acres within the northeast portion of the Reedley College campus in the City of Reedley. The site is located at the northwest corner of Reed Avenue and the northerly campus access road from Reed Avenue (see Figures 1 and 2). The proposed performing arts center building would include the following facilities: an auditorium with seating for 500-550 patrons; a 1,000 square-foot art gallery; an indoor lobby area configurable to accommodate up to 150 people as a sit-down dinner venue; a concessions area; a green room; a box office; a conference room; restrooms; and miscellaneous areas for storage and equipment. The project also includes an outdoor plaza that would function as a congregational area and may be used as an area for outdoor events and performances. The proposed site plan is depicted in Figure 3.

EXISTING SETTING

CONCEPTS AND TERMINOLOGY

ACOUSTIC FUNDAMENTALS

Noise is generally defined as sound that is loud, disagreeable, or unexpected. Sound is mechanical energy transmitted in the form of a wave because of a disturbance or vibration. Sound levels are described in terms of both amplitude and frequency.

Amplitude

Amplitude is defined as the difference between ambient air pressure and the peak pressure of the sound wave. Amplitude is measured in decibels (dB) on a logarithmic scale. For example, a 65 dB source of sound, such as a truck, when joined by another 65 dB source results in a sound amplitude of 68 dB, not 130 dB (i.e., doubling the source strength increases the sound pressure by 3 dB). Amplitude is interpreted by the ear as corresponding to different degrees of loudness. Laboratory measurements correlate a 10 dB increase in amplitude with a perceived doubling of loudness and establish a 3 dB change in amplitude as the minimum audible difference perceptible to the average person.

Frequency

The frequency of a sound is defined as the number of fluctuations of the pressure wave per second. The unit of frequency is the Hertz (Hz). One Hz equals one cycle per second. The human ear is not equally sensitive to sound of different frequencies. For instance, the human ear is more sensitive to sound in the higher portion of this range than in the lower and sound waves below 16 Hz or above 20,000 Hz cannot be heard at all. To approximate the sensitivity of the human ear to changes in frequency, environmental sound is usually measured in what is referred to as "A-weighted decibels" (dBA). On this scale, the normal range of human hearing extends from about 10 dBA to about 140 dBA (U.S. EPA 1971). Common community noise sources and associated noise levels, in dBA, are depicted in Figure 4.

Figure 1
Regional Location

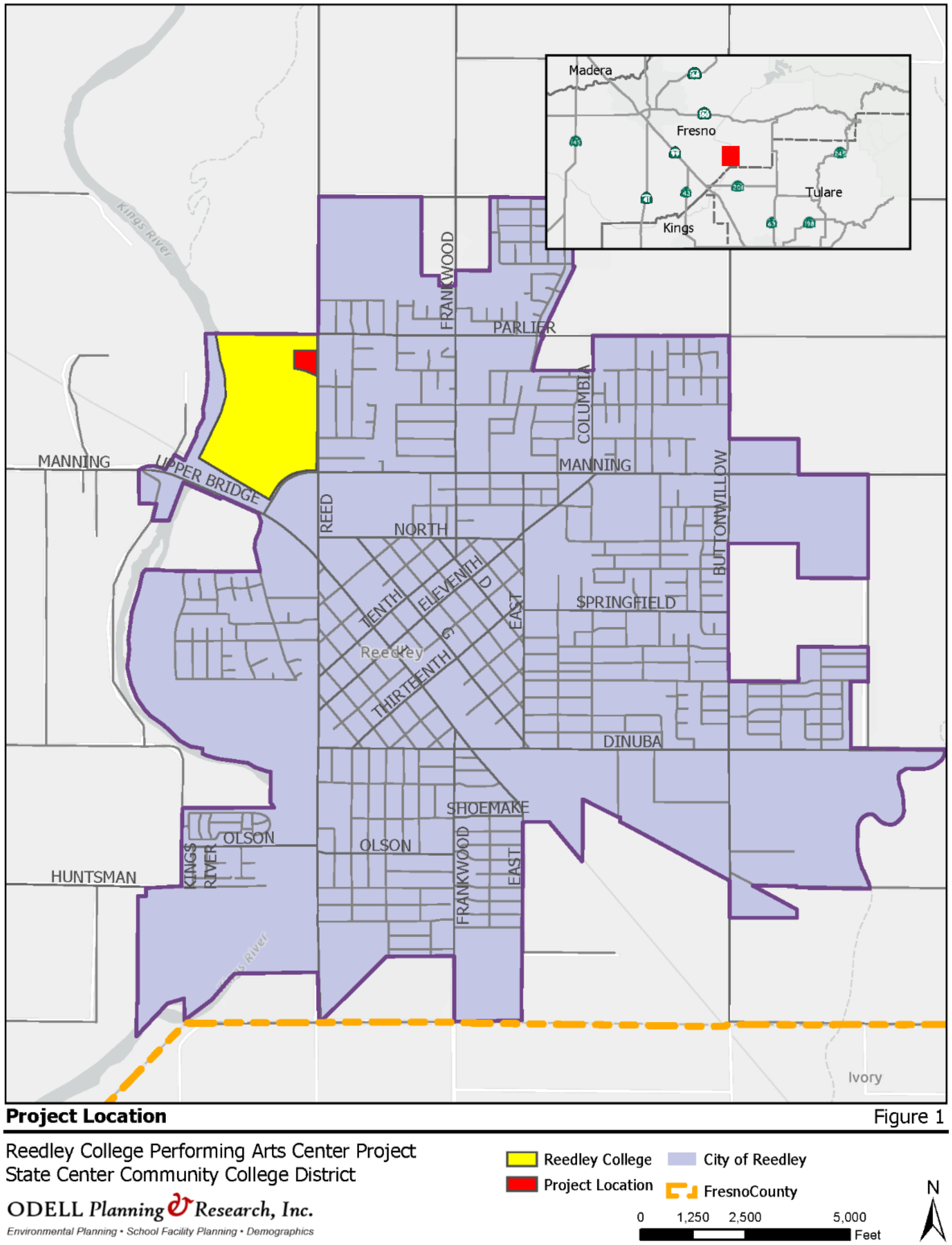


Image Source: OPR 2020

Figure 2
Project Site Location

Image Source: OPR 2020

Figure 3
Proposed Project Site Plan

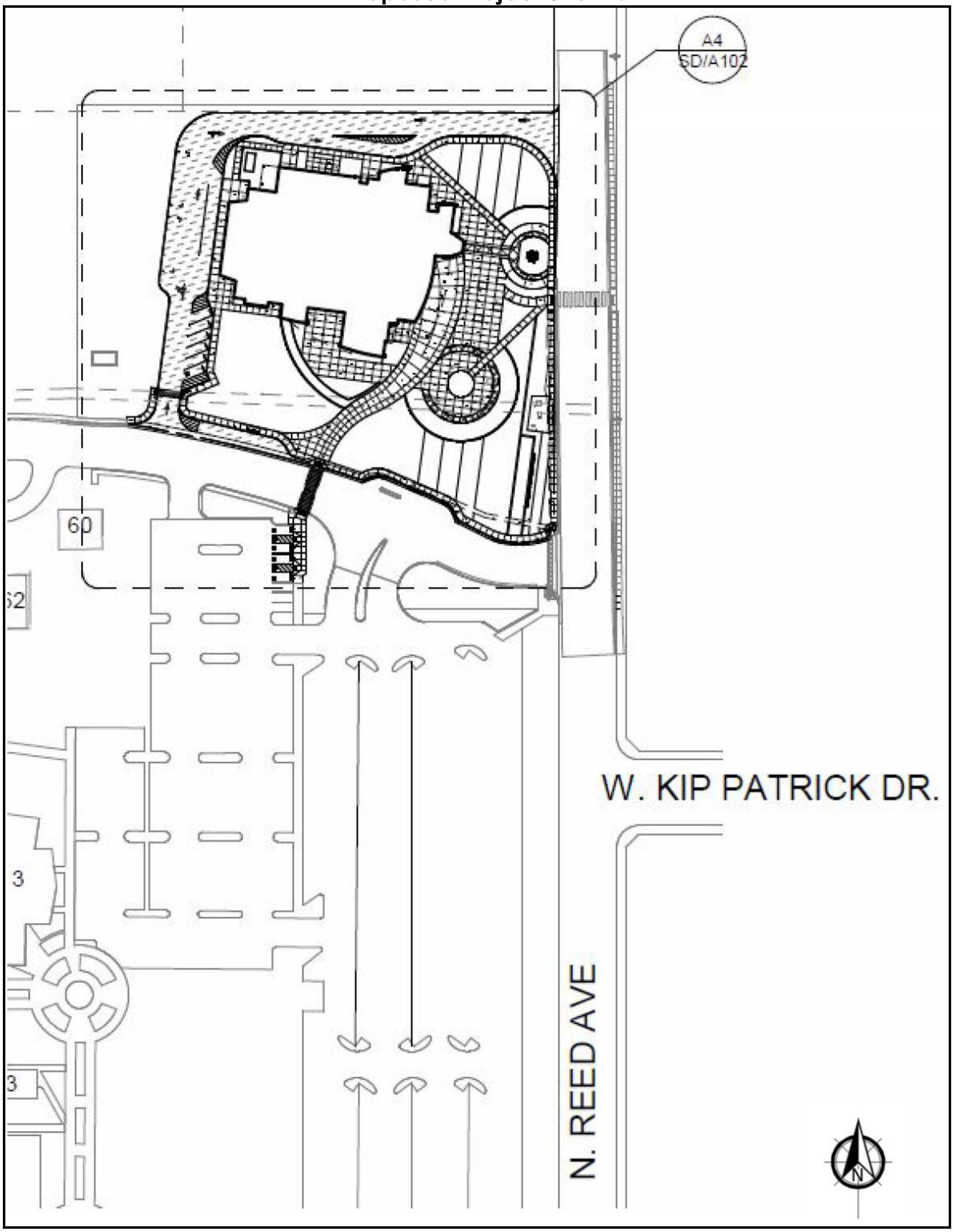
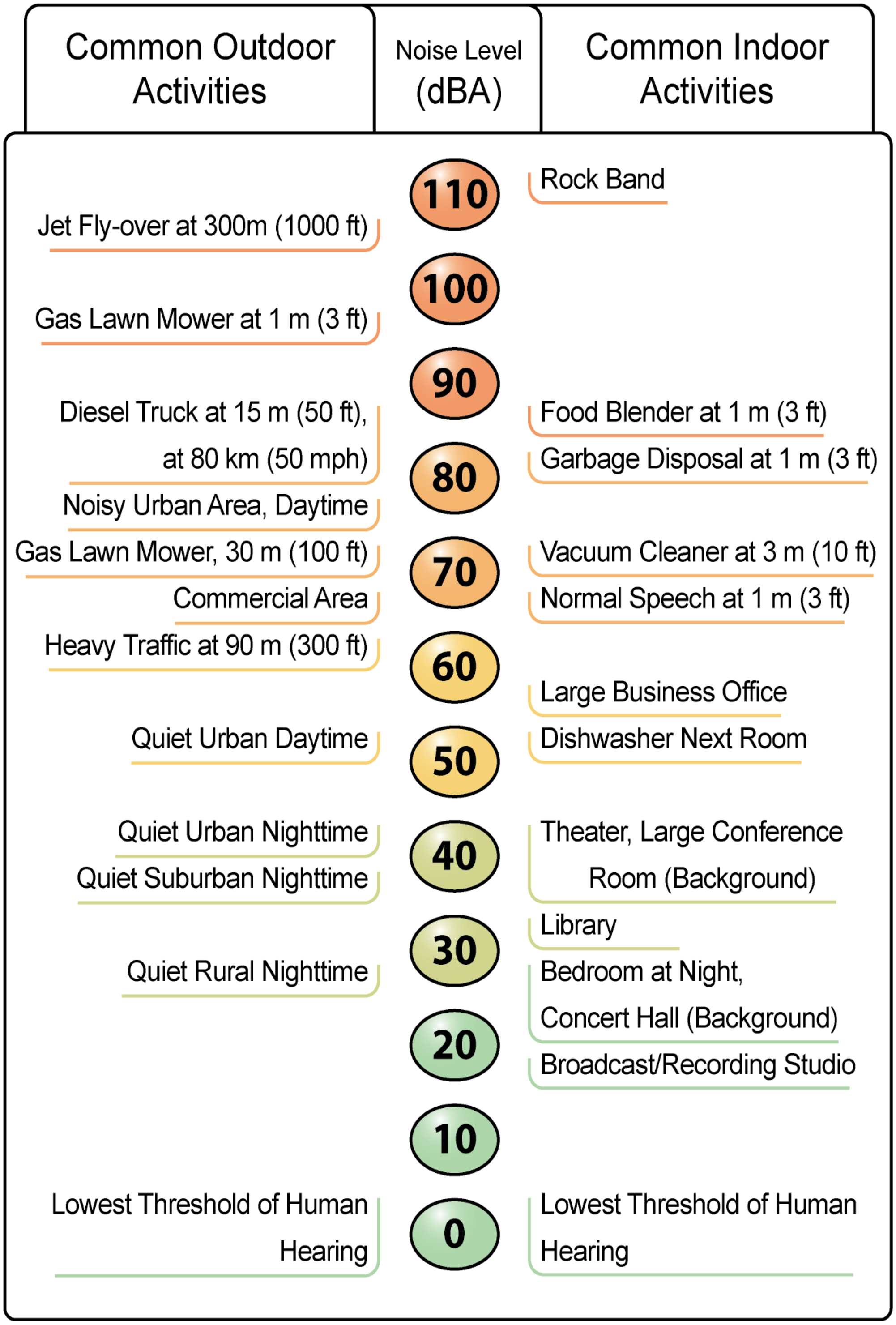


Image Source: JLB 2020

Figure 4
Common Noise Levels



Source: Caltrans 2020

Addition of Decibels

Because decibels are logarithmic units, sound levels cannot be added or subtracted through ordinary arithmetic. Under the decibel scale, a doubling of sound energy corresponds to a 3-dB increase. In other words, when two identical sources are each producing sound of the same loudness, the resulting sound level at a given distance would be 3 dB higher than one source under the same conditions. For example, if one automobile produces a sound level of 70 dB when it passes an observer, two cars passing simultaneously would not produce 140 dB; rather, they would combine to produce 73 dB. Under the decibel scale, three sources of equal loudness together would produce an increase of 5 dB.

Sound Propagation & Attenuation

Geometric Spreading

Sound from a localized source (i.e., a point source) propagates uniformly outward in a spherical pattern. The sound level decreases (attenuates) at a rate of approximately 6 decibels for each doubling of distance from a point source. Highways consist of several localized noise sources on a defined path, and hence can be treated as a line source, which approximates the effect of several point sources. Noise from a line source propagates outward in a cylindrical pattern, often referred to as cylindrical spreading. Sound levels attenuate at a rate of approximately 3 decibels for each doubling of distance from a line source, depending on ground surface characteristics. For acoustically hard sites (i.e., sites with a reflective surface between the source and the receiver, such as a parking lot or body of water,), no excess ground attenuation is assumed. For acoustically absorptive or soft sites (i.e., those sites with an absorptive ground surface between the source and the receiver, such as soft dirt, grass, or scattered bushes and trees), an excess ground-attenuation value of 1.5 decibels per doubling of distance is normally assumed. When added to the cylindrical spreading, the excess ground attenuation for soft surfaces results in an overall attenuation rate of 4.5 decibels per doubling of distance from the source.

Atmospheric Effects

Receptors located downwind from a source can be exposed to increased noise levels relative to calm conditions, whereas locations upwind can have lowered noise levels. Sound levels can be increased at large distances (e.g., more than 500 feet) from the highway due to atmospheric temperature inversion (i.e., increasing temperature with elevation). Other factors such as air temperature, humidity, and turbulence can also have significant effects.

Shielding by Natural or Human-Made Features

A large object or barrier in the path between a noise source and a receiver can substantially attenuate noise levels at the receiver. The amount of attenuation provided by shielding depends on the size of the object and the frequency content of the noise source. Natural terrain features (e.g., hills and dense woods) and human-made features (e.g., buildings and walls) can substantially reduce noise levels. Walls are often constructed between a source and a receiver specifically to reduce noise. A barrier that breaks the line of sight between a source and a receiver will typically result in minimum 5 dB of noise reduction. Taller barriers provide increased noise reduction.

Noise reductions afforded by building construction can vary depending on construction materials and techniques. Standard construction practices typically provide approximately 15 dBA exterior-to-interior noise reductions for building facades, with windows open, and approximately 20-30 dBA, with windows closed. With compliance with current Title 24 energy efficiency standards, which require increased building insulation and inclusion of an interior air ventilation system to allow windows on noise-impacted façades to remain closed, exterior-to-interior noise reductions typically average approximately 25 dBA. The absorptive characteristics of interior rooms, such as carpeted floors, draperies and furniture, can result in further reductions in interior noise.

NOISE DESCRIPTORS

The decibel scale alone does not adequately characterize how humans perceive noise. The dominant frequencies of a sound have a substantial effect on the human response to that sound. Although the intensity (energy per unit area) of the sound is a purely physical quantity, the loudness or human response is determined by the characteristics of the human ear.

Human hearing is limited in the range of audible frequencies as well as in the way it perceives the sound-pressure level in that range. In general, people are most sensitive to the frequency range of 1,000–8,000 Hz, and perceive sounds within that range better than sounds of the same amplitude in higher or lower frequencies. To approximate the response of the human ear, sound levels of individual frequency bands are weighted, depending on the human sensitivity to those frequencies, which is referred to as the "A-weighted" sound level (expressed in units of dBA). The A-weighting network approximates the frequency response of the average young ear when listening to most ordinary sounds. When people make judgments of the relative loudness or annoyance of a sound, their judgments correlate well with the A-scale sound levels of those sounds. Other weighting networks have been devised to address high noise levels or other special problems (e.g., B-, C-, and D-scales), but these scales are rarely used in conjunction with environmental noise.

The intensity of environmental noise fluctuates over time, and several descriptors of time-averaged noise levels are typically used. For the evaluation of environmental noise, the most commonly used descriptors are L_{eq}, L_{dn}, CNEL and SEL. The energy-equivalent noise level, L_{eq}, is a measure of the average energy content (intensity) of noise over any given period. Many communities use 24-hour descriptors of noise levels to regulate noise. The day-night average noise level, L_{dn}, is the 24-hour average of the noise intensity, with a 10-dBA "penalty" added for nighttime noise (10 p.m. to 7 a.m.) to account for the greater sensitivity to noise during this period. CNEL, the community equivalent noise level, is similar to L_{dn} but adds an additional 5-dBA penalty for evening noise (7 p.m. to 10 p.m.) Another descriptor that is commonly discussed is the single-event noise exposure level, also referred to as the sound-exposure level, expressed as SEL. The SEL describes a receiver's cumulative noise exposure from a single noise event, which is defined as an acoustical event of short duration (0.5 second), such as a backup beeper, the sound of an airplane traveling overhead, or a train whistle. Common noise level descriptors are summarized in Table 1.

HUMAN RESPONSE TO NOISE

The human response to environmental noise is subjective and varies considerably from individual to individual. Noise in the community has often been cited as a health problem, not in terms of actual physiological damage, such as hearing impairment, but in terms of inhibiting general well-being and contributing to undue stress and annoyance. The health effects of noise in the community arise from interference with human activities, including sleep, speech, recreation, and tasks that demand concentration or coordination. Hearing loss can occur at the highest noise intensity levels. When community noise interferes with human activities or contributes to stress, public annoyance with the noise source increases. The acceptability of noise and the threat to public well-being are the basis for land use planning policies preventing exposure to excessive community noise levels.

Table 1
Common Acoustical Descriptors

Descriptor	Definition
Energy Equivalent Noise Level (L_{eq})	The energy mean (average) noise level. The instantaneous noise levels during a specific period of time in dBA are converted to relative energy values. From the sum of the relative energy values, an average energy value (in dBA) is calculated.
Minimum Noise Level (L_{min})	The minimum instantaneous noise level during a specific period of time.
Maximum Noise Level (L_{max})	The maximum instantaneous noise level during a specific period of time.
Day-Night Average Noise Level (DNL or L_{dn})	The DNL was first recommended by the U.S. EPA in 1974 as a "simple, uniform and appropriate way" of measuring long term environmental noise. DNL takes into account both the frequency of occurrence and duration of all noise events during a 24-hour period with a 10 dBA "penalty" for noise events that occur between the more noise-sensitive hours of 10:00 p.m. and 7:00 a.m. In other words, 10 dBA is "added" to noise events that occur in the nighttime hours to account for increases sensitivity to noise during these hours.
Community Noise Equivalent Level (CNEL)	The CNEL is similar to the L_{dn} described above, but with an additional 5 dBA "penalty" added to noise events that occur between the hours of 7:00 p.m. to 10:00 p.m. The calculated CNEL is typically approximately 0.5 dBA higher than the calculated L_{dn}.
Sound Exposure Level (SEL)	The level of sound accumulated over a given time interval or event. Technically, the sound exposure level is the level of the time-integrated mean square A-weighted sound for a stated time interval or event, with a reference time of one second.

Unfortunately, there is no completely satisfactory way to measure the subjective effects of noise or of the corresponding reactions of annoyance and dissatisfaction. This is primarily because of the wide variation in individual thresholds of annoyance and habituation to noise over differing individual experiences with noise. Thus, an important way of determining a person's subjective reaction to a new noise is the comparison of it to the existing environment to which one has adapted: the so-called "ambient" environment. In general, the more a new noise exceeds the previously existing ambient noise level, the less acceptable the new noise will be judged. Regarding increases in A-weighted noise levels, knowledge of the following relationships will be helpful in understanding this analysis:

- Except in carefully controlled laboratory experiments, a change of 1 dB cannot be perceived by humans;
- Outside of the laboratory, a 3-dB change is considered a just-perceivable difference;

- A change in level of at least 5 dB is required before any noticeable change in community response would be expected. An increase of 5 dB is typically considered substantial;
- A 10-dB change is subjectively heard as an approximate doubling in loudness and would almost certainly cause an adverse change in community response.

Effects of Noise on Human Activities

The extent to which environmental noise is deemed to result in increased levels of annoyance, activity interference, and sleep disruption varies greatly from individual to individual depending on various factors, including the loudness or suddenness of the noise, the information value of the noise (e.g., aircraft overflights, child crying, fire alarm), and an individual's sleep state and sleep habits. Over time, adaptation to noise events and increased levels of noise may also occur. In terms of land use compatibility, environmental noise is often evaluated in terms of the potential for noise events to result in increased levels of annoyance, sleep disruption, or interference with speech communication, activities, and learning. Noise-related effects on human activities are discussed in more detail, as follows:

Speech Communication

For most noise-sensitive land uses, an interior noise level of 45 dB L_{eq} is typically identified for the protection of speech communication in order to provide for 100-percent intelligibility of speech sounds. Assuming a minimum 20-dB reduction in sound level between outdoors and indoors, with windows closed, this interior noise level of 45 dB L_{eq} would equate to an exterior noise level of 65 dBA L_{eq}. For outdoor voice communication, an exterior noise level of 60 dBA L_{eq} allows normal conversation at distances up to 2 meters with 95 percent sentence intelligibility (U.S. EPA 1974.) Based on this information, speech interference begins to become a problem when steady noise levels reach approximately 60 to 65 dBA. Within interior noise environments, an average-hourly background noise level of 45 dBA L_{eq} is typically recommended for noise-sensitive land uses, such as educational facilities.

Learning

Closely related to speech interference are the effects of noise on learning and, more broadly, on cognitive tasks. Recent studies have shown a strong relationship between noise and children's reading ability. Children's attention spans also appear to be adversely affected by noise. Adults are affected as well. Some studies indicate that, in a noisy environment, adults have increased difficulty accomplishing complex tasks. One of the issues associated with assessment of these effects is which noise metric correlates most closely with the impacts. For example, the average-daily noise level (i.e., CNEL/L_{dn}), which incorporates a nighttime weighting, may not be the best measure of noise impacts on schools given that operational activities are often limited to the daytime hours.

Various standards and recommended criteria have been developed to specifically address classroom noise. For instance, with regard to transportation sources, the California Department of Transportation has adopted abatement criteria that limit the maximum interior average-hourly noise level within classrooms, as well as other noise-sensitive interior uses, to 52 dBA L_{eq} (Caltrans 2020.) In June 2002, the American National Standards Institute, Inc. (ANSI) released a new classroom acoustics standard entitled Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools" (ANSI S12.60-2002). For schools exposed to intermittent background noise sources, such as airport and other transportation noise, the ANSI standards recommend that interior noise levels not exceed 40 dBA L_{eq} during the noisiest hour of the day. At present complying with the ANSI-recommended standard is voluntary in most locations.

Annoyance & Sleep Disruption

With regard to potential increases in annoyance, activity interference, and sleep disruption, land use compatibility determinations are typically based on the use of the cumulative noise exposure metrics (i.e., CNEL or L_{dn}). Perhaps the most comprehensive and widely accepted evaluation of the relationship between noise exposure and the extent of annoyance was one originally developed by Theodore J. Schultz in 1978. In 1978 the research findings of Theodore J. Schultz provided support for L_{dn} as the descriptor for environmental noise. Research conducted by Schultz identified a correlation between the cumulative noise exposure metric and individuals who were highly annoyed by transportation noise. The Schultz curve, expressing this correlation, became a basis for noise standards. When expressed graphically, this relationship is typically referred to as the Schultz curve. The Schultz curve indicates that approximately 13 percent of the population is highly annoyed at a noise level of 65 dBA L_{dn}. It also indicates that the percent of people describing themselves as being highly annoyed accelerates smoothly between 55 and 70 dBA L_{dn}. A noise level of 65 dBA L_{dn} is a commonly referenced dividing point between lower and higher rates of people describing themselves as being highly annoyed.

The Schultz curve and associated research became the basis for many of the noise criteria subsequently established for federal, state, and local entities. Most federal and state of California regulations and policies related to transportation noise sources establish a noise level of 65 dBA CNEL/L_{dn} as the basic limit of acceptable noise exposure for residential and other noise-sensitive land uses. For instance, with respect to aircraft noise, both the Federal Aviation Administration (FAA) and the State of California have identified a noise level of 65 dBA L_{dn} as the dividing point between normally compatible and normally incompatible residential land use generally applied for determination of land use compatibility. For noise-sensitive land uses exposed to aircraft noise, noise levels in excess of 65 dBA CNEL/L_{dn} are typically considered to result in a potentially significant increase in levels of annoyance.

Allowing for an average exterior-to-interior noise reduction of 20 dB, an exterior noise level of 65 dBA CNEL/L_{dn} would equate to an interior noise level of 45 dBA CNEL/L_{dn}. An interior noise level of 45 dB CNEL/L_{dn} is generally considered sufficient to protect against activity interference at most noise-sensitive land uses, including residential dwellings, and would also be sufficient to protect against sleep interference (U.S. EPA 1974.) Within California, the California Building Code establishes a noise level of 45 dBA CNEL as the maximum acceptable interior noise level for residential uses (other than detached single-family dwellings). Use of the 45 dBA CNEL threshold is further supported by recommendations provided in the State of California Office of Planning and Research's *General Plan Guidelines*, which recommend an interior noise level of 45 dB CNEL/L_{dn} as the maximum allowable interior noise level sufficient to permit "normal residential activity."

The cumulative noise exposure metric is currently the only noise metric for which there is a substantial body of research data and regulatory guidance defining the relationship between noise exposure, people's reactions, and land use compatibility. However, when evaluating environmental noise impacts involving intermittent noise events, such as aircraft overflights and train passbys, the use of cumulative noise metrics may not provide a thorough understanding of the resultant impact. The general public often finds it difficult to understand the relationship between intermittent noise events and cumulative noise exposure metrics. In such instances, supplemental use of other noise metrics, such as the L_{eq} or L_{max} descriptor, may be helpful as a means of increasing public understanding regarding the relationship between these metrics and the extent of the resultant noise impact.

AFFECTED ENVIRONMENT

NOISE-SENSITIVE LAND USES

Noise-sensitive land uses are generally considered to include those uses where noise exposure could result in health-related risks to individuals, as well as places where quiet is an essential element of their intended purpose. Residential dwellings are of primary concern because of the potential for increased and prolonged exposure of individuals to both interior and exterior noise levels. Additional land uses such as parks, historic sites, cemeteries, and recreation areas are also considered sensitive to increases in exterior noise levels. Schools, churches, hotels, libraries, and other places where low interior noise levels are essential are also considered noise-sensitive land uses.

Sensitive land uses located in the vicinity of the proposed project site consist primarily of residential land uses, which are generally located southeast of the project site, across Reed Avenue. The nearest residential land use is located approximately 90 feet southeast of the project site, adjacent to and east of Reed Avenue. Redeemer's Church is located approximately 175 feet east of the project site, across Reed Avenue.

AMBIENT NOISE ENVIRONMENT

To document existing ambient noise levels in the project area, short-term ambient noise measurements were conducted on September 18, 2019 using a Larson Davis Laboratories, Type I, Model 820 integrating sound-level meter. The meter was calibrated before use and is certified to be in compliance with ANSI specifications. Measured ambient daytime noise levels are summarized in Table 2. Measured daytime ambient noise levels ranged from approximately 58 dBA L_{eq} near the southern boundary of the project site, along College Driveway, to approximately 67 dBA L_{eq} near the eastern boundary of the project site, along Reed Avenue.

Based on the measurements conducted, average-hourly noise levels (in L_{eq}) within the project area are predominantly influenced by vehicle traffic on Reed Avenue. Existing transportation noise levels are discussed in greater detail, as follows:

Existing Transportation Noise

Roadway Traffic

The Federal Highway Administration (FHWA) Roadway Traffic Noise Prediction Model (FHWA RD77-108) was used to determine existing roadway traffic noise levels. The FHWA model used California vehicle reference noise factors for automobiles, medium trucks and heavy trucks, with consideration given to vehicle volume, speed, roadway configuration, distance to the receiver, and the acoustical characteristics of the site. Traffic data used in the modeling effort was obtained from the traffic analysis prepared for this project (JLB 2020).

Table 3 depicts predicted existing average-daily traffic noise levels (in CNEL/L_{dn}) at a distance of 50 feet from the near travel-lane centerline for major roadways within the project area. Based on the modeling conducted, predicted average-daily traffic noise levels in the project area range from approximately 55 to 63 dBA CNEL/L_{dn} at 50 feet from the near-travel-lane centerlines of area roadways.

Table 2
Summary of Measured Ambient Noise Levels

Location	Monitoring Period	Noise Levels (dBA)	
		L_{eq}	L_{max}
Reedley College Driveway. Approximately 300 feet west of Reed Avenue and 6 feet north of College Driveway.	09:00 – 09:10	58.0	74.1
Reed Avenue. Approximately 400 feet north of College Driveway and 18 feet east of Reed Avenue.	09:00 – 09:10	66.2	77.5
Reed Avenue. Approximately 25 feet north of College Driveway and 17 feet west of Reed Avenue.	09:00 – 09:10	67.1	80.1

Ambient noise measurements were conducted on September 18, 2019 using a Larson Davis Laboratories, Type I, Model 820 integrating sound-level meter.

Table 3
Existing Traffic Noise Levels

Segment	ADT	CNEL/L_{dn} at 50 Feet from Near-Travel-Lane Centerline
Reed Avenue, North of College Driveway	9,160	62.7
Reed Avenue, South of College Driveway	9,300	62.8
College Driveway	2,600	54.9

Traffic noise levels were calculated using the FHWA Roadway Traffic Noise Prediction Model (FHWA RD77-108). Based on data obtained from the traffic analysis prepared for this project. ADT volumes were calculated based on peak-hour traffic volumes assumes pk-hr volumes represent approximately ten percent of daily volumes.

ADT = Average Daily Traffic

Refer to Appendix A for modeling assumptions and results.

REGULATORY FRAMEWORK

NOISE

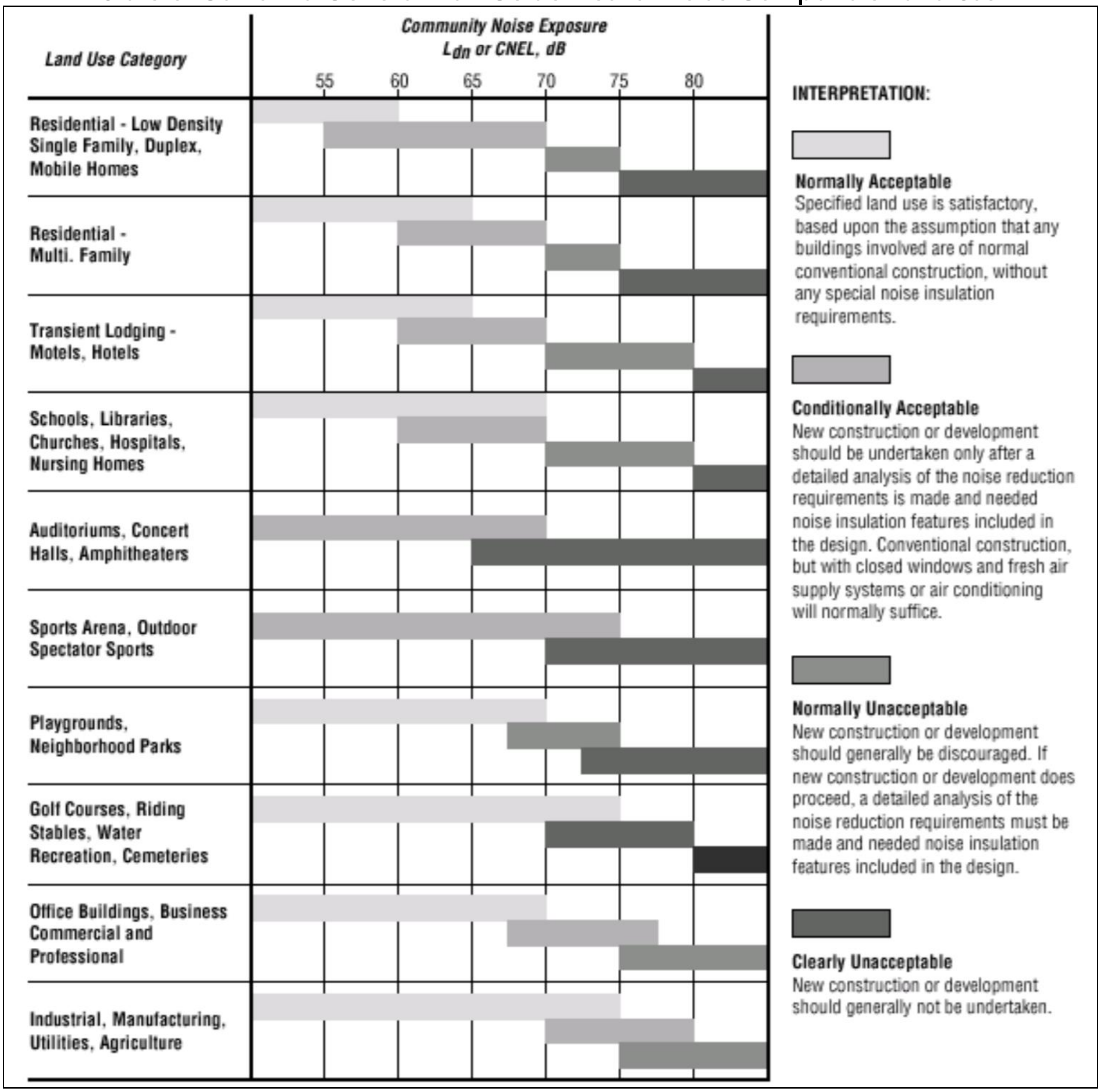
State of California

The State of California regulates vehicular and freeway noise affecting classrooms, sets standards for sound transmission and occupational noise control, and identifies noise insulation standards and airport noise/land-use compatibility criteria.

California General Plan Guidelines

The *State of California General Plan Guidelines*, published by the Governor's Office of Planning and Research (OPR 2017), also provides guidance for the acceptability of projects within specific CNEL/L_{dn} contours (refer to Figure 5). The guidelines also present adjustment factors that may be used in order to arrive at noise acceptability standards that reflect the noise control goals of the community, the particular community's sensitivity to noise, and the community's assessment of the relative importance of noise pollution. For auditoriums, the *State of California General Plan Guidelines* identify a "conditionally acceptable" exterior noise level of up to 70 dBA CNEL/L_{dn} provided necessary noise insulation features have been included in the design (OPR 2017).

Figure 5
State of California General Plan Guidelines for Noise Compatible Land Use



Source: OPR 2017

City of Reedley General Plan

The Reedley General Plan Noise Element includes noise standards for both transportation and non-transportation noise sources, which are used for determination of land use compatibility for new land uses. In accordance with General Plan policies, new noise-sensitive land uses impacted by existing or projected future transportation or stationary noise sources shall include mitigation measures so that resulting noise levels do not exceed these standards. The land use compatibility noise standards for transportation and non-transportation noise sources are summarized in Tables 4 and 5, respectively. As depicted, the exterior and interior noise level standards for sensitive land uses affected by transportation noise sources, which would include schools, is 60 dBA L_{dn} and 45 dBA L_{dn}, respectively. Exterior noise levels up to 65 dBA Ldn may be allowed provided practical noise-reduction measures have been applied and interior noise levels would be within acceptable levels. Noise generated by non-transportation sources are limited to exterior levels of 55 dBA L_{eq} and 70 dBA L_{max}.

Table 4
City of Reedley
Exterior Noise Exposure Standards for Transportation Noise Sources

	NOISE LEVEL STANDARDS (dBA L_{dn})	
	Noise Sensitive Land Use	**New Transportation Noise Sources**
Indoor	45	45
Outdoor	60	60

1. This table is applicable to noise sources created by either new development and/or new transportation projects.
2. Based on an evaluation of the existing condition and proposed project, the Community Development Director may allow exterior exposure up to 65 dB L_{dn} where practical application of construction practices has been used to mitigate exterior noise exposure.
Source: City of Reedley 2014

Table 5
City of Reedley
Exterior Noise Exposure Standards for Non-Transportation Noise Sources

	NOISE LEVEL STANDARDS (dBA)	
	DAYTIME (7 am - 10 pm)	**NIGHTTIME (10 pm – 7 am)**
Average Hourly (L_{eq})	55	50
Maximum (L_{max})	70	65

1. As determined within outdoor activity areas of existing or planned noise-sensitive uses, if outdoor activity area locations are unknown, the allowable noise exposure shall be determined at the property line of the noise sensitive use.
2. Based on an evaluation of the existing condition and proposed project, the Community Development Director may allow exterior exposure up to 65 dB DNL where practical application of construction practices has been used to mitigate exterior noise exposure.
Source: City of Reedley 2014

GROUNDBORNE VIBRATION

Vibration is like noise in that it involves a source, a transmission path, and a receiver. While vibration is related to noise, it differs in that noise is generally considered to be pressure waves transmitted through air, whereas vibration usually consists of the excitation of a structure or surface. As with noise, vibration consists of amplitude and frequency. A person's perception of the vibration will depend on their individual sensitivity to vibration, as well as the amplitude and frequency of the source and the response of the system which is vibrating. Vibration can be measured in terms of acceleration, velocity, or displacement. Measurements in terms of velocity are expressed as peak particle velocity (PPV) with units of inches per second (in/sec).

There are no federal, state, or local regulatory standards for groundborne vibration. However, Caltrans has developed vibration criteria based on potential structural damage risks and human annoyance. Caltrans-recommended criteria for the evaluation of groundborne vibration levels, with regard to structural damage and human annoyance, are summarized in Table 4. The criteria apply to continuous vibration sources, which include vehicle traffic and most construction activities. All damage criteria for buildings are in terms of ground motion at the buildings' foundations. No allowance is included for the amplifying effects of structural components (Caltrans 2013).

As indicated in Table 6, the threshold at which there is a risk to normal structures from continuous events is 0.3 in/sec PPV for older residential structures and 0.5 in/sec PPV for newer building construction. With regard to human perception, vibration levels would begin to become distinctly perceptible at levels of 0.04 in/sec PPV for continuous events. Continuous vibration levels are considered potentially annoying for people in buildings at levels of 0.2 in/sec PPV.

Table 6
Summary of Groundborne Vibration Levels and Potential Effects

Vibration Level (in/sec ppv)	Human Reaction	Effect on Buildings
0.006 - 0.019	Threshold of perception; possibility of intrusion.	Vibrations unlikely to cause damage of any type.
0.08	Vibrations readily perceptible.	Recommended upper level of the vibration to which ruins and ancient monuments should be subjected.
0.10	Level at which continuous vibrations begin to annoy people.	Virtually no risk of "architectural" damage to normal buildings.
0.20	Vibrations annoying to people in buildings (this agrees with the levels established for people standing on bridges and subjected to relatively short periods of vibrations).	Threshold at which there is a risk of "architectural" damage to fragile buildings.
0.3 - 0.6	Vibrations become distinctly perceptible at 0.04 in/sec ppv and considered unpleasant by people subjected to continuous vibrations and unacceptable to some people walking on bridges.	Potential risk of "architectural" damage may occur at levels above 0.3 in/sec ppv for older residential structures and above 0.5 in/sec ppv for newer structures.

The vibration levels are based on peak particle velocity in the vertical direction for continuous vibration sources, which includes most construction activities.
In/sec ppv = peak particle velocity in inches per second
Source: Caltrans 2013

IMPACTS AND MITIGATION MEASURES

METHODOLOGY

Short-Term Construction Noise

Short-term noise impacts associated with construction activities were analyzed based on typical construction equipment noise levels and distances to the nearest noise-sensitive land uses. Noise levels were predicted based on an average noise-attenuation rate of 6 dB per doubling of distance from the source.

Long-term Operational Noise

Traffic noise levels were calculated using the Federal Highway Administration (FHWA) roadway noise prediction model (FHWA-RD-77-108) based on California vehicle reference noise levels and traffic data obtained from the traffic analysis prepared for this project. Additional input data included day/night percentages of autos, medium and heavy trucks, vehicle speeds, ground attenuation factors, and roadway widths. The project's contribution to traffic noise levels along area roadways was determined by comparing the predicted noise levels with and without project-generated traffic.

Stationary source noise levels were calculated based on a combination of data obtained from existing literature, noise level measurements, and application of accepted noise prediction and sound propagation algorithms. Noise levels were predicted based on an average noise-attenuation rate of 6 dB per doubling of distance from the source. Predicted noise levels were compared to applicable City of Reedley noise standards for determination of impact significance.

The *CEQA Guidelines* do not define the levels at which temporary and permanent increases in ambient noise are considered "substantial." As discussed previously in this section, a noise level increase of 3 dBA is barely perceptible to most people, a 5 dBA increase is readily noticeable, and a difference of 10 dBA would be perceived as a doubling of loudness. For purposes of this analysis, a significant increase in ambient noise levels would be defined as an increase of 3 dBA, or greater.

Groundborne Vibration

The *CEQA Guidelines* also do not define the levels at which groundborne vibration levels would be considered excessive. For this reason, Caltrans' recommended groundborne vibration thresholds were used for the evaluation of impacts based on increased potential for structural damage and human annoyance, as identified in Table 6.

PROJECT IMPACTS

Impact Noise-A: ***Would the project result in the generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?***

Noise generated by the proposed project would occur during short-term construction and long-term operation. Noise-related impacts associated with short-term construction and long-term operations of the proposed project are discussed separately, as follows:

Short-term Construction Noise Levels

Construction noise typically occurs intermittently and varies depending upon the nature or phase (e.g., site preparation, grading, excavation, construction) of construction. Noise generated by construction equipment, including earth movers, material handlers, and portable generators, can reach high levels. Although noise ranges were found to be similar for all construction phases, the initial site preparation and grading/excavation phases, tend to involve the most equipment and result in the highest average-hourly noise levels.

Noise levels commonly associated with construction equipment are summarized in Table 7. As noted in Table 7, instantaneous noise levels (in dBA L_{max}) generated by individual pieces of construction equipment typically range from approximately 80 dBA to 85 dBA L_{max} at 50 feet (FTA 2006). Typical operating cycles may involve 2 minutes of full power, followed by 3 or 4 minutes at lower settings. Average-hourly noise levels for individual equipment generally range from approximately 73 to 82 dBA L_{eq}. Based on typical off-road equipment usage rates and assuming multiple pieces of equipment operating simultaneously within a localized area, such as soil excavation activities, average-hourly noise levels could reach levels of approximately 80 dBA L_{eq} at roughly 100 feet.

Table 7
Typical Construction Equipment Noise Levels

Equipment	Typical Noise Level (dBA) at 50 feet from Source	
	L_{max}	L_{eq}
Compactor, Concrete Vibratory Mixer	80	73
Backhoe/Front-End Loader, Air Compressor	80	76
Generator	82	79
Crane, Mobile	85	77
Jack Hammer, Roller	85	78
Dozer, Excavator, Grader, Concrete Mixer Truck	85	81
Paver, Pneumatic Tools	85	82
Sources: FTA 2006		

The City has not adopted noise standards that apply to short-term construction activities. However, based on screening noise criteria commonly recommended by federal agencies, construction activities would generally be considered to have a potentially significant impact if average-hourly daytime noise levels would exceed 80 dBA L_{eq} at noise-sensitive land uses, such as residential land uses (FTA 2006). Depending on the location and types of activities conducted, predicted noise levels at nearby existing or future planned residential land uses could potentially exceed 80 dBA L_{eq}. Furthermore, with regard to residential land uses, activities occurring during the more noise-sensitive evening and nighttime hours could result in increased levels of annoyance and potential sleep disruption. For these reasons, noise-generating construction activities would be considered to have a potentially significant short-term noise impact.

Mitigation Measure Noise-1: The following measures shall be implemented to reduce construction-generated noise levels:

a. Construction activities (excluding activities that would result in a safety concern to the public or construction workers) shall be limited to between the hours of 7:00 a.m. and 10:00 p.m. Construction activities shall be prohibited on Sundays and legal holidays.

b. Construction truck trips shall be scheduled, to the extent feasible, to occur during non-peak hours and truck haul routes shall be selected to minimize impacts to the nearby childcare center.
c. Construction equipment shall be properly maintained and equipped with noise-reduction intake and exhaust mufflers and engine shrouds, in accordance with manufacturers' recommendations. Equipment engine shrouds shall be closed during equipment operation.
d. Stationary construction equipment (e.g., portable power generators) should be located at the furthest distance possible from the nearby childcare center.
e. When not in use, all equipment shall be turned off and shall not be allowed to idle. Provide clear signage that posts this requirement for workers at the entrances to the site.

Significance After Mitigation

The use of mufflers and engine shrouds would reduce individual equipment noise levels by approximately 10 dBA. In addition, implementation of the above mitigation measures would limit construction activities to the less noise-sensitive periods of the day. With implementation of the above mitigation measures, this impact would be considered less than significant.

Long-term Operational Noise Levels

Potential long-term increases in noise associated with the proposed project would be primarily associated with the operation of building mechanical equipment, such as heating, ventilation, and air conditioning (HVAC) units, onsite events, and vehicle use along area roadways.

Building Maintenance & Mechanical Equipment

The proposed structure would include the use of building mechanical equipment, such as air conditioning units and exhaust fans. Building mechanical equipment (e.g., air conditioning units, exhaust fans) would typically be located within the structures, enclosed, or placed on rooftop areas away from direct public exposure. Exterior air conditioning units and exhaust fans can generate noise levels up to approximately 65 dBA L_{eq} at 10 feet. Based on this noise level and assuming a noise attenuation rate of 6 dB per doubling of distance from the source, predicted operational exterior noise levels at the nearby existing residential land uses and the place of worship would be approximately 35 dBA L_{eq}, or less. Predicted operational noise levels associated with building mechanical equipment would not exceed the City's exterior daytime and nighttime noise standards of 55 and 50 dBA L_{eq}, respectively. As a result, this impact would be considered less than significant.

Events

The proposed project would include the construction of an indoor auditorium and other smaller event areas (e.g., art gallery, dinner venue, conference room). The auditorium would seat approximately 500-550 patrons. Smaller venues, such as the dinner venue, would accommodate approximately 150 people, or less. The project also includes an outdoor plaza that would function as a congregational area and may be used as an area for outdoor events and performances. Potential noise impacts associated with interior and exterior events are discussed, as follows:

Interior Events

The loudest interior events are anticipated to occur within the proposed auditorium. Noise generated by interior performances, such as orchestras, can generate noise levels up to approximately 90 dBA L_{eq} at 50 feet. Based on this noise level and assuming a noise attenuation rate of 6 dB per doubling of distance from the source, and an average interior-to-exterior noise attenuation of 30 dBA (which is typical for newer buildings), predicted exterior noise levels at the outdoor activity area of the nearest residential land use would be approximately 44 dBA L_{eq}, or less, during interior events. Predicted noise levels at the outdoor activity areas of the nearest noise-sensitive land uses associated with proposed indoor events would not exceed the City's daytime or nighttime exterior noise standards of 55 and 50 dBA L_{eq}, respectively. Likewise, based on these same assumptions, predicted interior noise levels at the nearby place of worship would be approximately 20 dBA, or less, and would not exceed the commonly applied interior noise standard of 45 dBA L_{eq}. It is also important to note that during the daytime hours, noise levels generated by interior events would be largely masked by existing vehicle traffic noise levels along Reed Avenue and would be largely indiscernible at nearby noise-sensitive land uses. For these reasons, noise generated by interior events would be considered to have a less-than-significant impact.

Exterior Events

Based on noise measurements conducted for similar events, smaller venues, including those that would utilize amplified sound systems or live performances, typically generate noise levels up to approximately 75 dBA L_{eq} at 50 feet. Based on this noise level and assuming a noise attenuation rate of 6 dB per doubling of distance from the source, predicted exterior noise levels at the outdoor activity area of the nearest residential land use would be approximately 56 dBA L_{eq}. Predicted noise levels at the outdoor activity areas of the nearest noise-sensitive land uses associated with proposed outdoor events would exceed the City's daytime and nighttime exterior noise standards of 55 and 50 dBA L_{eq}, respectively. Based on these same assumptions, predicted interior noise levels at the nearby place of worship would be approximately 35 dBA L_{eq}, or less, which would not exceed the commonly applied interior noise standard of 45 dBA L_{eq}. Noise levels associated with outdoor events would be considered to have a potentially-significant impact.

Mitigation Measure Noise-2: The following measures shall be implemented to reduce noise levels associated with outdoor events:

a. Outdoor events shall be limited to between the hours of 7:00 a.m. and 10:00 p.m.

b. If outdoor events involving the use of amplified sound systems or live performances are proposed along the eastern façade of the proposed structure, a noise barrier shall be constructed sufficient to block the line of sight between onsite outdoor event areas and nearby existing residential land uses. The barrier shall be constructed to a minimum height of 6 feet above ground level. The barrier shall be constructed of masonry block, or material of similar density and usage, with no visible air gaps at the base of the barrier or between construction materials/components.

Significance After Mitigation

With mitigation, outdoor events would be limited to the less noise-sensitive periods of the day. The construction of a sound barrier would reduce event noise levels by approximately 5 dBA. With mitigation, predicted noise levels at the outdoor activity areas of the nearest residential land uses would be approximately 51 dBA L_{eq}, or less. During the daytime hours, mitigated operational noise levels would be largely masked by vehicle traffic on Reed Avenue and would not be projected to exceed the City's exterior noise standard of 55 dBA L_{eq}. With implementation of the above mitigation measures, this impact would be considered less than significant.

Roadway Traffic

Existing Conditions

Predicted existing traffic noise levels, with and without implementation of proposed project, are summarized in Table 8. In comparison to existing traffic noise levels, the proposed project would result in a predicted increase in traffic noise levels of 0.3 dB along Reed Avenue. Predicted increases in traffic noise levels along College Driveway in the vicinity of the project site would be approximately 2.0 dBA. Implementation of the proposed project would not result in a significant increase (i.e., 3 dBA, or greater) in existing traffic noise levels along area roadways.

Near-term Conditions

Predicted existing traffic noise levels, with and without implementation of proposed project, are summarized in Table 9. In comparison to existing traffic noise levels, the proposed project would result in a predicted increase in traffic noise levels of 0.3 dB along Reed Avenue. Predicted increases in traffic noise levels along College Driveway in the vicinity of the project site would be approximately 2.0 dBA. Implementation of the proposed project would not result in a significant increase (i.e., 3 dBA, or greater) in near-term traffic noise levels along area roadways.

Future Cumulative Conditions

Predicted existing traffic noise levels, with and without implementation of proposed project, are summarized in Table 10. In comparison to existing traffic noise levels, the proposed project would result in a predicted increase in traffic noise levels of 0.3 dB along Reed Avenue. Predicted increases in traffic noise levels along College Driveway in the vicinity of the project site would be approximately 2.0 dBA. Implementation of the proposed project would not result in a significant increase (i.e., 3 dBA, or greater) in future cumulative traffic noise levels along area roadways.

Table 8
Predicted Increases in Existing Traffic Noise Levels

Roadway Segment	Predicted Noise Level at 50 feet from Centerline of Near Travel Lane (dBA CNEL/L_{dn})[1]			
	Existing Without Project	Existing With Project	Difference[2]	Significant?[3]
Reed Avenue, North of College Driveway	62.7	63.1	0.3	No
Reed Avenue, Sourth of College Driveway	62.8	63.3	0.5	No
College Driveway	54.9	56.9	2.0	No

1. Traffic noise levels were calculated using the FHWA roadway noise prediction model (FHWA-RD-77-108), based on data obtained from the traffic analysis prepared for this project. Assumes no natural or man-made shielding (e.g., vegetation, berms, walls, buildings).
2. Difference in noise levels reflects the incremental increase attributable to the proposed project.
3. Significant increase is defined as an increase of 3 dBA, or greater.

Table 9
Predicted Increases in Near-Term Traffic Noise Levels

Roadway Segment	Predicted Noise Level at 50 feet from Centerline of Near Travel Lane (dBA CNEL/L_{dn})[1]			
	Existing Without Project	Existing With Project	Difference[2]	Significant?[3]
Reed Avenue, North of College Driveway	63.3	63.5	0.2	No
Reed Avenue, Sourth of College Driveway	63.7	64.0	0.4	No
College Driveway	55.1	57.0	1.9	No

1. Traffic noise levels were calculated using the FHWA roadway noise prediction model (FHWA-RD-77-108), based on data obtained from the traffic analysis prepared for this project. Assumes no natural or man-made shielding (e.g., vegetation, berms, walls, buildings).
2. Difference in noise levels reflects the incremental increase attributable to the proposed project.
3. Significant increase is defined as an increase of 3 dBA, or greater.

Table 10
Predicted Increases in Future Cumulative Traffic Noise Levels

Roadway Segment	Predicted Noise Level at 50 feet from Centerline of Near Travel Lane (dBA CNEL/L_{dn})[1]			
	Future Without Project	Future With Project	Difference[2]	Significant?[3]
Reed Avenue, North of College Driveway	65.2	65.3	0.1	No
Reed Avenue, Sourth of College Driveway	65.4	65.7	0.3	No
College Driveway	56.7	56.8	0.2	No

1. Traffic noise levels were calculated using the FHWA roadway noise prediction model (FHWA-RD-77-108), based on data obtained from the traffic analysis prepared for this project. Assumes no natural or man-made shielding (e.g., vegetation, berms, walls, buildings).
2. Difference in noise levels reflects the incremental increase attributable to the proposed project.
3. Significant increase is defined as an increase of 3 dBA, or greater.

As noted earlier in this report, changes in ambient noise levels of approximately 3 dBA, or less, are typically not discernible to the human ear and would not be considered to result in a significant impact. Implementation of the proposed project would not result in a significant increase (i.e., 3 dBA, or greater) in traffic noise levels along primarily affected roadways. As a result, this impact would be considered less than significant.

Land Use Compatibility

As noted earlier in the report, auditorium land uses are typically considered "conditionally acceptable" within noise environments up to 70 dBA CNEL/L_{dn} (refer to Figure 5). Under future cumulative conditions, with project-generated vehicle traffic included, the predicted 70 dBA CNEL/L_{dn} noise contour for Reed Avenue and College Driveway would not extend beyond the roadway right of ways. Under future cumulative-plus-project conditions, predicted traffic noise levels at the proposed structure would be approximately 63 dBA CNEL, or less. Predicted exterior noise levels would not exceed the "conditionally acceptable" exterior noise standard of 70 dBA CNEL/L_{dn}. This impact is considered less than significant.

Impact Noise-B. Would the project result in the generation of excessive groundborne vibration or groundborne noise levels?

Long-term operational activities associated with the proposed project would not involve the use of any equipment or processes that would result in potentially significant levels of ground vibration. Increases in groundborne vibration levels attributable to the proposed project would be primarily associated with short-term construction-related activities. Construction activities associated with the proposed improvements would likely require the use of various off-road equipment, such as tractors, concrete mixers, and haul trucks. The use of major groundborne vibration-generating construction equipment, such as pile drivers, are not anticipated to be required for this project.

Vibration levels associated with representative construction equipment are summarized in Table 11. As depicted, vibration levels generated by construction equipment would be approximately 0.089 in/sec ppv, or less, at 25 feet. Predicted vibration levels at the nearest existing structures would not be anticipated to exceed commonly applied criteria for structural damage or human annoyance (i.e., 0.5 and 0.2 in/sec ppv, respectively). In addition, no fragile or historic structures have been identified in the project area. As a result, this impact would be considered less than significant.

Table 11
Representative Vibration Source Levels for Construction Equipment

Equipment	Peak Particle Velocity at 25 Feet (In/Sec)
Large Bulldozer	0.089
Loaded Truck	0.076
Jackhammer	0.035
Small Bulldozer	0.003
Source: FTA 2006, Caltrans 2004	

Impact Noise-C. For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

The nearest airport in the project vicinity is the Reedley Municipal Airport, approximately 3.6 miles north of the project site. The proposed project is not located within the projected 60 dBA CNEL/L_{dn} noise contours of this airport (City of Reedley 2014). No private airstrips were identified within two miles of the project site. Implementation of the proposed project would not result in the exposure of sensitive receptors to aircraft noise levels nor would the proposed project affect airport operations. This impact is considered less than significant.

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APPENDIX A
Noise Prediction Modeling & Supportive Documentation

PREDICTED TRAFFIC NOISE MODELING

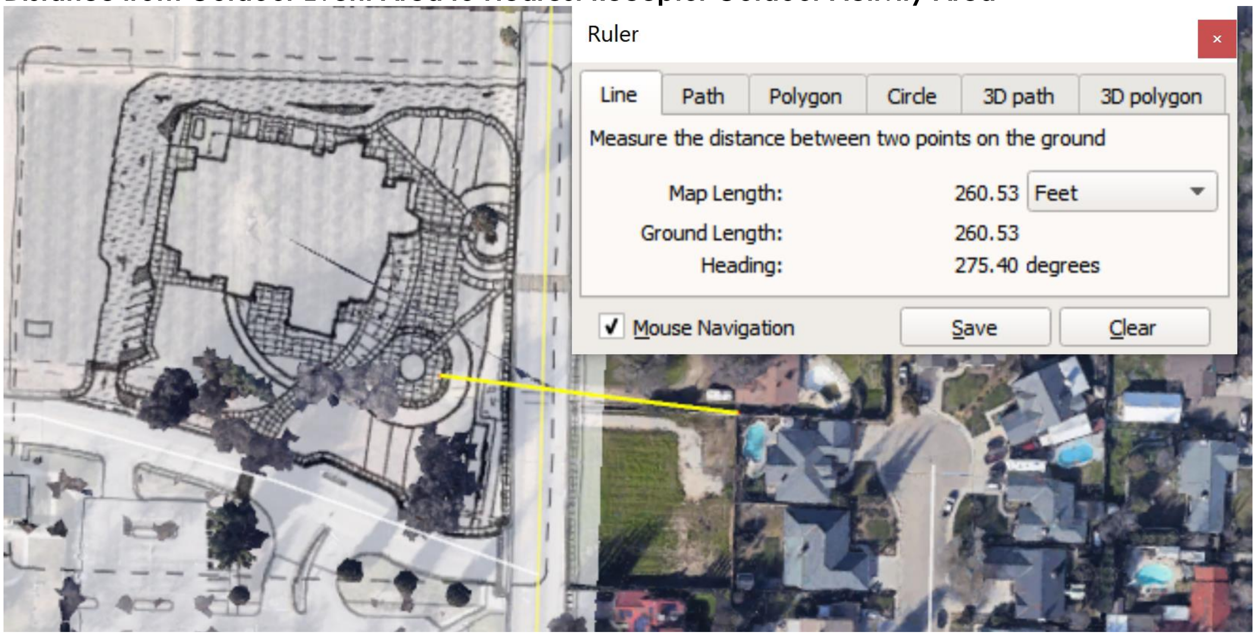
	SPEED	EXISTING	EX+P	NEAR-TERM	NT+P	CUMULATIVE	CUM+P
Reed Avenue, North of College Driveway	35	9160	9790	11330	10780	16060	16620
Reed Avenue, South of College Driveway	35	9300	10310	11330	12340	17000	18010
College Driveway	25	2600	4120	2740	4260	3920	4070

PREDICTED TRAFFIC NOISE LEVELS

		CNEL AT 50' FROM NTLCL	DISTANCE TO CONTOURS 70	65	60	55
EXISTING						
Reed Avenue, North of College Driveway	9160	62.74	WR	WR	101	216
Reed Avenue, South of College Driveway	9300	62.8	WR	WR	102	218
College Driveway	2600	54.88	WR	WR	WR	55
EX+P						
Reed Avenue, North of College Driveway	9790	63.06	WR	WR	106	225
Reed Avenue, South of College Driveway	10310	63.25	WR	53	110	233
College Driveway	4120	56.87	WR	WR	WR	75
NEAR-TERM						
Reed Avenue, North of College Driveway	10330	63.3	WR	53	110	237
Reed Avenue, South of College Driveway	11330	63.66	WR	56	116	248
College Driveway	2740	55.1	WR	WR	WR	57
NT+P						
Reed Avenue, North of College Driveway	10780	63.45	WR	55	113	240
Reed Avenue, South of College Driveway	12340	64.03	WR	59	123	263
College Driveway	4260	57.02	WR	WR	WR	76
CUMULATIVE						
Reed Avenue, North of College Driveway	16060	65.18	WR	70	146	313
Reed Avenue, South of College Driveway	17000	65.42	WR	72	152	325
College Driveway	3920	56.66	WR	WR	WR	72
CUM+P						
Reed Avenue, North of College Driveway	16620	65.33	WR	71	150	320
Reed Avenue, South of College Driveway	18010	65.67	WR	75	158	338
College Driveway	4070	56.82	WR	WR	WR	74

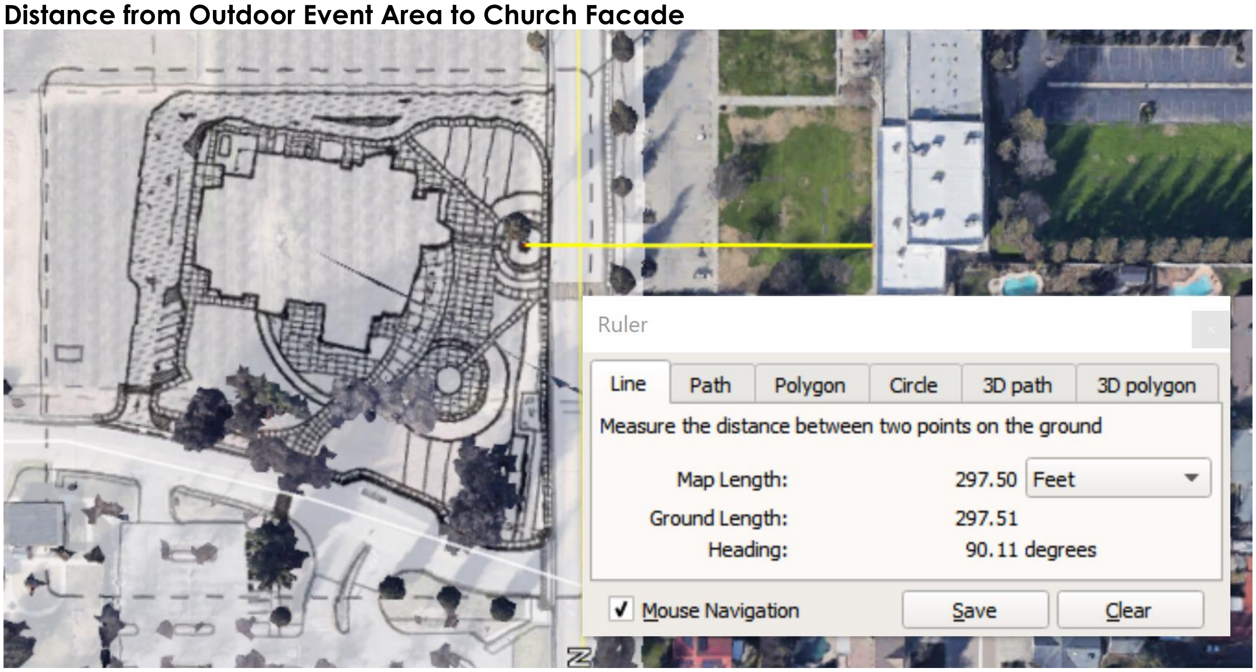
	CNEL AT 50' FROM NTLCL EXISTING	EX+P	INCREASE
Reed Avenue, North of College Driveway	62.7	63.1	0.3
Reed Avenue, South of College Driveway	62.8	63.3	0.5
College Driveway	54.9	56.9	2.0
	NEAR-TERM	NT+P	INCREASE
Reed Avenue, North of College Driveway	63.3	63.5	0.2
Reed Avenue, South of College Driveway	63.7	64.0	0.4
College Driveway	55.1	57.0	1.9
	CUMULATIVE	CUM+P	INCREASE
Reed Avenue, North of College Driveway	65.2	65.3	0.1
Reed Avenue, South of College Driveway	65.4	65.7	0.3
College Driveway	56.7	56.8	0.2

Distance from Outdoor Event Area to Nearest Receptor Outdoor Activity Area



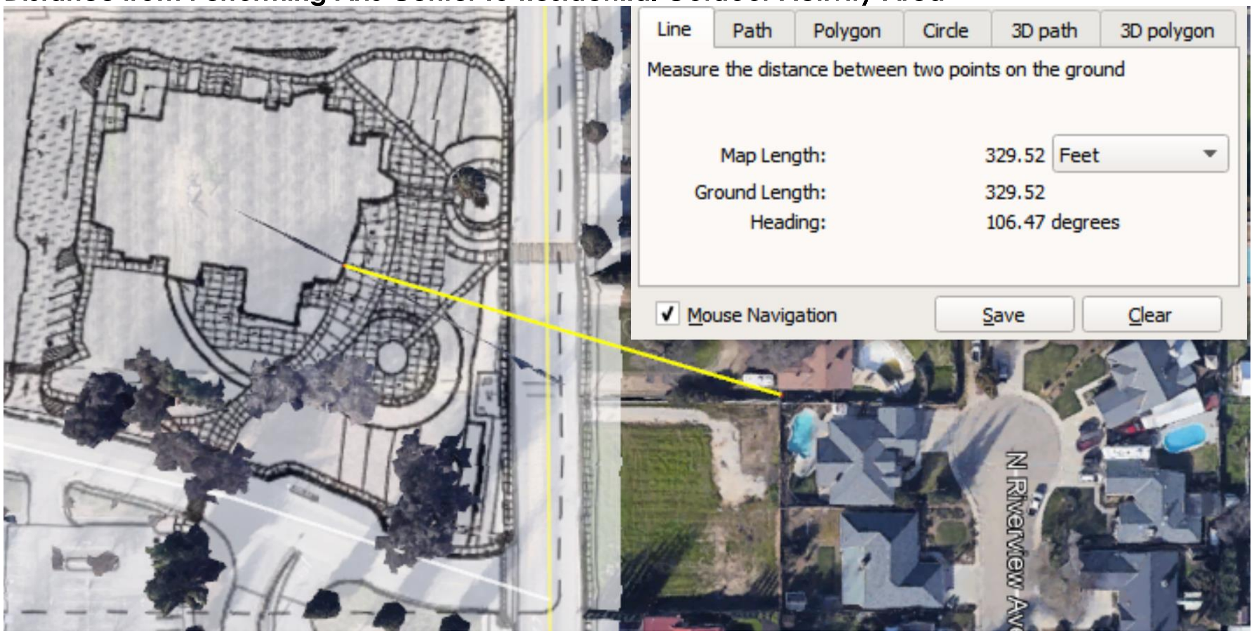
Reference Noise Level: 75 dBA Leq (Amplified Music)
Noise Shielding: 5 dB (Fencing)
Predicted Exterior Noise Level at Receptor: 56 dBA Leq

Distance from Outdoor Event Area to Church Facade



Reference Noise Level: 75 dBA Leq (Amplified Music)
Noise Shielding: 0
Predicted Exterior Noise Level at Receptor: 60 dBA Leq
Exterior-to-Interior Noise Reduction (older structure): 25 dB
Predicted Interior Noise Level at Receptor: 35 dBA Leq

Distance from Performing Arts Center to Residential Outdoor Activity Area



Reference Noise Level for Interior Noise Events: 90 dBA Leq (Symphony Orchestra Performance)
Interior-to-Exterior Noise Reduction (newer structure): 30 dB
Predicted Noise Level at Nearest Outdoor Activity Area: 44 dBA Leq