Appendix F

Noise and Vibration Technical Memorandum

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MEMORANDUM

To:	Greg Keppler, PE, Vista Irrigation District
From:	Connor Burke, Dudek
Subject:	Vista Irrigation District – E Reservoir Project, Noise and Vibration Technical Memorandum
Date:	January 17, 2020
cc:	Mark Storm, Dudek
Attachment(s):	Figures 1–3 A – Construction Noise Modeling Input/Output Worksheets B – Operation Noise Modeling Input/Output Worksheets

Dudek is pleased to submit this predictive noise impact assessment to assist the Vista Irrigation District with initial environmental planning requirements for the proposed E Reservoir Project (project) in the County of San Diego (County).

This memorandum estimates potential noise and vibration impacts from construction and operation of the project in accordance with the California Environmental Quality Act (CEQA) Guidelines.

The contents and organization of this memorandum are as follows: project description, environmental setting, regulatory setting, noise and vibration impacts assessment, conclusions, and references cited.

1 Project Description

Project Location

The proposed project would be located on a 1.88-acre parcel of land located within Section 16 of Township 11 South, Range 3 West of the San Marcos, CA 7.5' United States Geological Survey (USGS) Topographic Quadrangle Map (Figure 1, Project Vicinity). The project site, a one-parcel property (APN: 174-240-33) is located at 2330 Edgehill Road in unincorporated land in the County of San Diego (County) east of the City of Vista (City) in the northern portion of San Diego County—please see Figure 1, Project Vicinity; and Figure 2, Project Location.

Project Description

In accordance with its 2017 Potable Water Master Plan, the Vista Irrigation District (VID or District) is proposing the replacement of the existing oval shaped, partially buried, 1.5 million gallon (MG) E Reservoir with a new reservoir and construction of a new pump station (proposed project) on the existing site. The new reservoir would increase storage capacity and provide the VID with a facility that meets applicable current codes and standards. The new pump station would provide a redundant water supply to higher-pressure zones within the VID's service area when disruptions occur to primary water supplies.

The project would require the demolition of the existing E Reservoir and accessory facilities. Within a similar footprint, the proposed project would construct a cast-in-place hexagonal shaped structure that would increase the onsite capacity to approximately 2.92 MG, which is a 1.42 MG net increase. The hexagonal shape would allow for more easily maintained water quality. The proposed project would also construct a new water pump station. The pumps, control panel, and other electric and SCADA equipment would be housed in an above ground structure with approximate dimensions of 20-feet by 38-feet that would match the architectural features of the existing adjacent pressure reducing station (PRS) facility.

2 Environmental Setting

2.1 Noise Characteristics and Terminology

Pressure fluctuations, traveling as waves through air from an emission source of vibrational energy, exert a force perceived by the human ear as sound. Sound pressure level (often referred to generally as “sound level” or “noise level”) is expressed by way of a logarithmic scale in decibels (dB) that represent magnitude of these air pressure waves with respect to the threshold of average healthy human hearing. The human ear is more sensitive to middle and higher frequencies (those usually associated with speech) of the audible spectrum, especially when the noise levels are quieter; thus, a frequency-dependent decibel weighting system called the “A” scale was developed to mimic this human hearing frequency response. The A-weighted dB scale is typically used for quantifying typical environmental sound levels and is described in units of “dBA” to distinguish the values from “flat” or unweighted dB values. In a manner similar to the scaling of temperature on a thermometer, Table 1 provides examples of common indoor and outdoor sound sources having A-weighted levels that “line-up” with the listed dB values.

Table 1. Typical Sound Levels in the Environment and Industry

Common Outdoor Activities	Noise Level (dB)	Common Indoor Activities
—	110	Rock band
Jet flyover at 300 meters (1,000 feet)	100	—
Gas lawn mower at 1 meter (3 feet)	90	—
Diesel truck at 15 meters (50 feet), at 80 kph (50 mph)	80	Food blender at 1 meter (3 feet)
		Garbage disposal at 1 meter (3 feet)
Noisy urban area, daytime	70	Vacuum cleaner at 3 meters (10 feet)
gas lawn mower at 30 meters (100 feet)		
Commercial area	60	Normal speech at 1 meter (3 feet)
Heavy traffic at 90 meters (300 feet)		
Quiet urban daytime	50	Large business office
		Dishwasher, next room
Quiet urban nighttime	40	Theater, large conference room (background)
Quiet suburban nighttime	30	Library
Quiet rural night time	20	Bedroom at night, concert hall (background)

Table 1. Typical Sound Levels in the Environment and Industry

Common Outdoor Activities	Noise Level (dB)	Common Indoor Activities
—	10	Broadcast/recording studio
Lowest threshold of human hearing	0	Lowest threshold of human hearing

Source: Caltrans 2013a.
Notes: kph = kilometers per hour; mph = miles per hour

The equivalent noise level (L_{eq}), also referred to as the energy-average sound level, is a single number representing the fluctuating sound level in decibels (dB) over a specified period of time. In other words, L_{eq} is a constant value considered equivalent to what is actually a time-varying fluctuating sound level. Community noise sources tend to vary continuously, being the amalgam of many sound emission sources at various distances with respect to a listener position. Many acoustical contributors to a perceived or measured overall outdoor sound level are indistinct and thus aggregate into what is usually called the "background" sound environment. This background, added to perceptibly dominant acoustical contributors (i.e., those that are the loudest and/or closest to the listener position) constitutes the overall "ambient" sound that a sound level meter can detect with its microphone and quantify as a dB level.

Noise levels are generally higher during the daytime and early evening when traffic (including airplanes), commercial, and industrial activity is the greatest. However, noise sources experienced during nighttime hours when background levels are generally lower can be potentially more conspicuous and irritating to the receiver. In order to evaluate noise in a way that considers periodic fluctuations experienced throughout the day and night, a concept termed "community noise equivalent level" (CNEL) was developed. The CNEL scale represents a time-weighted 24-hour average noise level based on the A-weighted equivalent (L_{eq}) sound level. But more than merely a 24-hour L_{eq}, CNEL accounts for the increased noise sensitivity during the evening hours (7 p.m. to 10 p.m.) and nighttime hours (10 p.m. to 7 a.m.) by adding 5 dB to the hourly average sound levels occurring during the evening hours and 10 dB to the hourly average sound levels occurring during nighttime hours. Day-night sound level (L_{dn}) is a comparable 24-hour metric, but differs from CNEL in that it only adds the 10 dB to nighttime hours (i.e., the "evening" hours from 7 p.m. to 10 p.m. are treated as daytime hours that are not adjusted).

2.1.2 Exterior Noise Distance Attenuation

Noise sources are largely classified in two forms: 1) point sources, such as stationary equipment or a group of construction vehicles and equipment working within a spatially limited area at a given time; and 2) line sources, such as a roadway with a large number of pass-by sources (motor vehicles). Sound generated by a point source typically diminishes (attenuates) at a rate of 6.0 dBA for each doubling of distance from the source to the receptor at acoustically "hard" sites and at a rate of 7.5 dBA for each doubling of distance from source to receptor at acoustically "soft" sites. These attenuation rates would also be expected for sound propagation away from a horizontal area source, which can be approximated as a single point such as the geographic center of the area. By comparison, sound generated by a line source (such as a roadway) typically attenuates at a rate of 3.0 dBA for each doubling of distance from the source to the receptor at acoustically "hard" sites and at a rate of 4.5 dBA for each doubling of distance from source to receptor at acoustically "soft" sites.

Sound levels can also be attenuated by man-made or natural barriers. For the purpose of a sound attenuation discussion, hard, smooth, or otherwise acoustically reflective surfaces do not provide any excess ground-effect attenuation and are characteristic of sealed asphalt roads, bodies of water, and hard-packed soils. An acoustically soft or absorptive surface, on the other hand, is exemplified by fresh-fallen snow, tilled soils, or thickly-vegetated ground cover.

2.1.3 Vibration

Vibration is an oscillatory motion through a solid medium in which the motion's amplitude can be described in terms of displacement, velocity, or acceleration. Vibration can be a serious concern, causing buildings to shake and rumbling sounds to be heard. In contrast to noise, vibration is not a common environmental problem. It is unusual for vibration from sources such as buses and trucks to be perceptible, even in locations close to major roads. Some common sources of vibration are trains, buses on rough roads, and construction activities, such as blasting, pile driving, and heavy earthmoving equipment.

Several different descriptors are used to quantify vibration. Peak particle velocity (PPV) is defined as the maximum instantaneous peak of the vibration signal. PPV is most frequently used to describe vibration impacts to buildings and is usually measured in inches per second (ips). The root mean square (RMS) amplitude is most frequently used to describe the effect of vibration on the human body and is defined as the average of the squared amplitude of the signal. Decibel notation (VdB) is commonly used to describe RMS amplitude with respect to a reference quantity. The decibel notation acts to compress, and thus make more convenient for presentation and discussion purposes, the range of numbers required to describe vibration.

High levels of vibration may cause risk of or actual damage to buildings. However, most people consider vibration to be an annoyance that can affect concentration or disturb sleep. In addition, high levels of vibration can interfere with processes or equipment that are highly sensitive to vibration (e.g., electron microscopes). Most perceptible indoor vibration is caused by sources within buildings, such as operation of mechanical equipment, movement of people, or slamming of doors. Typical outdoor sources of perceptible vibration are construction equipment, steel-wheeled trains, and traffic on rough roads. If the roadway is smooth, which means there are little or no bumps that could cause a slight wheel drop or other force impulse, the vibration from traffic is rarely perceptible.

2.1.4 Sensitive Receptors

Noise- and vibration-sensitive land uses are locations where people reside or where the presence of unwanted sound and/or vibration could adversely affect the use of the land. Residences, schools, hospitals, guest lodging, libraries, and some passive recreation areas would be considered noise and vibration sensitive and may warrant unique measures for protection from intruding noise.

Sensitive receptors near the project site include existing single-family residential uses to the south, west, and north, the closest of which are located approximately 35 feet from the project site boundary. These sensitive receptors represent the nearest residential land uses with the potential to be impacted by construction and operation of the proposed project. Additional sensitive receptors are located farther from the project site in the surrounding community and would be less impacted by noise and vibration levels than the above-listed sensitive receptors.

2.3 Existing Noise Conditions

Noise level measurements were conducted on and near the project site on November 5, 2019 to characterize and quantify a representative sample of the existing outdoor ambient sound environment. Table 2 provides the location, date, and time for the sound pressure level (SPL) measurements collected with a Rion NL-52 sound level meter (SLM) equipped with a 0.5-inch, pre-polarized condenser microphone and connected pre-amplifier. The SLM meets the current American National Standards Institute (ANSI) standard for a Type 1 (Precision) sound level meter. The accuracy of the SLM was verified in the field using a reference signal-generating calibrator before and after the SPL measurements; and, the measurements were conducted with the microphone positioned approximately 5 feet above the ground.

Table 2. Measured Existing Outdoor Ambient Noise Levels

Receptors	Location	Date & Time	L_{eq} (dBA)	L_{max} (dBA)
ST1	Eastern property line	2019-11-05, 09:00 AM to 09:15 AM	37.0	49.5
ST2	West of existing pump house at southern property line	2019-11-05, 09:35 AM to 09:50 AM	40.8	55.2
ST3	Western property line	2019-11-05, 09:20 AM to 09:35 AM	36.6	53.4
ST4	Adjacent from existing reservoir, south of Edgehill Road	2019-11-05, 10:00 AM to 10:15 AM	42.1	58.7

Notes: L_{eq} = equivalent continuous sound level (time-averaged sound level); L_{max} = maximum sound level during the measurement interval; dBA = A-weighted decibels.

Four (4) short-term SPL measurement locations (ST) that represent the existing noise-sensitive receivers were selected on and near the project site. These locations are depicted as receivers ST1–ST4 on Figure 3, Noise Measurement Locations. The measured energy-averaged (L_{eq}) and maximum (L_{max}) noise levels are provided in Table 2. The primary noise sources at the sites identified in Table 2 consisted of birds; distant roadway traffic; distant aviation traffic, and rustling leaves. As shown in Table 2, the measured sound levels ranged from approximately 37 dBA L_{eq} at ST1 to 42.1 dBA L_{eq} at ST4.

3 Regulatory Setting

Federal

Environmental Protection Agency

As described in its "Levels Document" (EPA 1974) and referenced or used by several federal agencies and many other state and local jurisdictions, the U.S. Environmental Protection Agency (EPA) considers 55 dBA day-night sound level (L_{dn}) as a threshold for outdoor noise at the exterior of an existing residential receiver. For continuous sources of noise, such as the operating pumps considered in this assessment, the per-hour sound limit translated from this L_{dn} metric would be 48.6 dBA L_{eq}. While not a regulatory limit that would apply to this project, this sound metric serves as guidance for consideration.

Federal Transit Administration

In its *Transit Noise and Vibration Impact Assessment* guidance manual, the Federal Transit Administration (FTA) recommends a daytime construction noise level threshold of 80 dBA L_{eq} over an 8-hour period (FTA 2006) at community residences when detailed construction noise assessments are performed to evaluate potential project impacts. Although this FTA guidance is not a regulation, it can serve as a quantified standard in the absence of such applicable limits at the state and local jurisdictional levels.

With respect to vibration velocity thresholds for building damage risk, the aforementioned FTA guidance manual suggests that 0.2 ips PPV is appropriate for construction-attributed vibration, where the receiving building category is "non-engineered timber and masonry buildings" that likely resemble the features of the existing residences near the project site.

State

California Department of Transportation (Caltrans)

In its *Transportation and Construction Vibration Guidance Manual*, the California Department of Transportation (Caltrans) presents a variety of industry-recommended thresholds for vibration velocity expressed as PPV, which are summarized and reproduced in Table 3.

Table 3. Selected Caltrans Recommended Vibration Velocity Thresholds

Receptor Type	Land Use or Receptor Description	Vibration Velocity for *Continuous* Source (PPV ips)	Vibration Velocity for *Transient* or *Single-Event* Source (PPV ips)	Source Note
Building Occupant	"Annoying" Human Response	0.2 (e.g., from traffic)	n/a	A
Building Occupant	"Strongly Perceptible" Human Response	n/a	0.9	B
Building Structure	"Relatively old residential structures in poor condition"	n/a	1 (single blast); 0.5 (repeated blasts)	C

Notes:
A = Transportation and Construction Vibration Guidance Manual (Caltrans 2013b), Table 5.
B = Transportation and Construction Vibration Guidance Manual (Caltrans 2013b), Table 6.
C = Transportation and Construction Vibration Guidance Manual (Caltrans 2013b), Table 9.

Local

The proposed project site is located within an unincorporated portion of the County of San Diego (County). The County of San Diego has adopted various noise policies and standards contained within the County's General Plan Noise Element and the County Noise Ordinance.

County of San Diego General Plan, Noise Element

The County's General Plan Noise Element (Noise Element) establishes noise and land use compatibility standards and outlines goals and policies to achieve these standards. The Noise Element characterizes the noise environment in the County and provides the context for the County's noise/land use compatibility guidelines and standards. The Noise Element also describes the County's goals for achieving the standards and introduces policies designed to implement the goals. Under implementation of the General Plan, the County would use the Noise Compatibility Guidelines to determine the compatibility of land uses when evaluating proposed development projects. The Noise

Compatibility Guidelines indicate ranges of compatibility and are intended to be flexible enough to apply to a range of projects and environments.

A land use located in an area identified as "acceptable" indicates that standard construction methods would attenuate exterior noise to an acceptable indoor noise level and that people can carry out outdoor activities with minimal noise interference. Land uses that fall into the "conditionally acceptable" noise environment should have an acoustical study that considers the type of noise source, the sensitivity of the noise receptor, and the degree to which the noise source has the potential to interfere with sleep, speech, or other activities characteristic of the land use. For land uses indicated as "conditionally acceptable," structures must be able to attenuate the exterior noise to the indoor noise level as indicated in the Noise Compatibility Guidelines. For land uses where the exterior noise levels fall within the "unacceptable" range, new construction generally should not be undertaken (San Diego County 2011a).

San Diego County Code of Regulatory Ordinances Title 3, Division 6, Chapter 4, Sections 36.401–36.435, Noise Ordinance

The Noise Ordinance establishes prohibitions for disturbing, excessive, or offensive noise as well as provisions such as sound level limits for the purpose of securing and promoting the public health, comfort, safety, peace, and quiet for its citizens. Planned compliance with sound level limits and other specific parts of the ordinance allows presumption that the noise is not disturbing, excessive, or offensive. Limits are specified depending on the zoning placed on a property (e.g., varying densities and intensities of residential, industrial, and commercial zones). Where two adjacent properties have different zones, the sound level limit at a location on a boundary between two properties is the arithmetic mean of the respective limits for the two zones, except for extractive industries. It is unlawful for any person to cause or allow the creation of any noise that exceeds the applicable limits of the Noise Ordinance at any point on or beyond the boundaries of the property on which the sound is produced. Table 4 lists the sound level limits for the County.

Table 4. San Diego County Noise Ordinance Sound Level Limits

Zone	Applicable Limit 1-Hour Average Sound Level (dB)		
	7 a.m. to 7 p.m.	7 p.m. to 10 p.m.	10 p.m. to 7 a.m.
(1) RS, RD, RR, RMH, A70, A72, S80, S81, S87, S90, S92, RV, and RU with a density of less than 11 dwelling units per acre	50	50	45
(2) RRO, RC, RM, S86, V5 and RV and RU with a density of 11 or more dwelling units per acre	55	55	50
(3) S94, V4, all other commercial zones.	60	60	55
(4) V1, V2	60	55	see below
V1	60	55	55
V2	60	55	50
V3	70	70	65
(5) M50, M52, M54	70	70	70
(6) S82, M56 and M58	75	75	75
(7) S88 (see note 4 below)			

Source: County of San Diego 2011

Notes:
RS, RD, RM, RR, RU, RV, RRO, RMH, RU = Residential uses; A70, A72 = Agricultural uses; S80, S81, S82, S87, S90 = Open space uses, ecological resource areas, or holding area uses; S92 = General rural uses; RC = Residential/commercial uses; S86 = parking uses; V1, V2, V3, V4, V5 = Village uses; M50, M52, M54, M56, M58 = Manufacturing and industrial uses; S88 = Special planning area uses.

1 If the measured ambient level exceeds the applicable limit noted in the table, the allowable 1-hour average sound level will be the ambient noise level. The ambient noise level will be measured when the alleged noise violation source is not operating.

2 The sound-level limit at a location on a boundary between two zoning districts is the arithmetic mean of the respective limits for the two districts; provided, however, that the 1-hour average sound-level limit applicable to extractive industries, including but not limited to borrow pits and mines, will be 75 dB at the property line, regardless of the zone where the extractive industry is actually located.

3 Fixed-location, public utility distribution or transmission facilities located on or adjacent to a property line shall be subject to the noise-level limits of this section, measured at or beyond 6 feet from the boundary of the easement upon which the equipment is located.

4 S88 zones are Specific Planning Areas, which allow different uses. The sound level limits present in Table 2 that apply in an S88 zone depend on the use being made of the property. The limits in Table 2, subsection (1) apply to a property with a residential, agricultural, or civic use. The limits in subsection (3) apply to a property with a commercial use. The limits in subsection (5) apply to a property with an industrial use that would only be allowed in an M50, M52, or M54 zone. The limits in subsection (6) apply to all property with an extractive use or a use that would only be allowed in an M56 or M58 zone.

Section 36.408 of the Noise Ordinance sets limits on the time of day and days of the week that construction can occur, as well as setting noise limits for construction activities. In summary, the Noise Ordinance prohibits operating construction equipment on the following days and times:

- Mondays through Saturdays except between the hours of 7:00 a.m. and 7:00 p.m.
- Sundays or a holiday. A holiday means January 1st, the last Monday in May, July 4th, the first Monday in September, December 25th and any day appointed by the President as a special national holiday or the Governor of the State as a special State holiday.

In addition, Section 36.409 requires that between the hours of 7:00 a.m. and 7:00 p.m., no equipment shall be operated so as to cause an 8-hour average construction noise level in excess of 75 dBA when measured at the boundary line of the property where the noise source is located, or on any occupied property where the noise is being received.

In addition to the general limitations on sound levels in section 36.404 and the limitations on construction equipment in section 36.409, the following additional sound level limitations shall apply:

a) Except for emergency work or work on a public road project, no person shall produce or cause to be produced an impulsive noise that exceeds the maximum sound level shown in Table 36.410A, when measured at the boundary line of the property where the noise source is located or on any occupied property where the noise is received, for 25 percent of the minutes in the measurement period, as described in subsection (c) below. The maximum sound level depends on the use being made of the occupied property. The uses in Table 5 are as described in the County Zoning Ordinance.

Table 5. Maximum Sound Level (Impulsive) Measured at Occupied Property in Decibels (dBA)

Occupied Property Use	Decibels (dBA)
Residential, village zoning or civic use	82
Agricultural, commercial or industrial use	85

(b) Except for emergency work, no person working on a public road project shall produce or cause to be produced an impulsive noise that exceeds the maximum sound level shown in Table 4, when measured at the boundary line of the property where the noise source is located or on any occupied property where the noise is received, for 25 percent of the minutes in the measurement period, as described in subsection (c) below. The maximum sound level depends on the use being made of the occupied property. The uses in Table 4 are as described in the County Zoning Ordinance.

4 Noise and Vibration Impacts Assessment

4.1 Thresholds of Significance

The following significance criteria are based on Appendix G of the California Environmental Quality Act Guidelines (14 CCR 15000 et seq.) and will be used to determine the significance of potential noise impacts. Impacts related to noise would be significant if the proposed project would result in the following:

a. 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
b. Generation of excessive groundborne vibration or groundborne noise levels
c. Expose people residing or working in the project area to excessive noise levels (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 2 miles of a public airport or public use airport)

Per California Government Code Section 53091(d) and 53091(e), the project is exempt from the provisions of the County's Zoning Ordinance, and the County cannot prohibit the location or construction of facilities for the production, generation, storage, treatment, or transmission of water, wastewater, or electrical energy. Because the District is an independent local agency, it is not required to comply with County of San Diego requirements; however, a combination of the summarized regulations and standards as described in Section 3 (Regulatory Setting) of this analysis serves as suggested criteria against which potential noise and vibration impacts can be assessed in the following section.

5 Impact Discussion

a) Would the project result in 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?

Short-Term Construction

Conventional Construction Activities

Construction noise and vibration are temporary phenomena, and their levels can vary from hour to hour and day to day depending on the equipment in use, the operations being performed, and the distance between the source and receptor.

Equipment that would be in use during construction would include, in part, backhoes, loaders, cranes, forklifts, pavers, rollers, a rock drill rig, impact hammer, and air compressors. The typical maximum noise levels for various pieces of construction equipment at a distance of 50 feet are presented in Table 6. Note that the equipment noise levels presented in Table 6 are maximum noise levels (L_{max}). Typically, construction equipment operates in alternating cycles of full power and low power, producing average noise levels less than the maximum noise level. The average sound level of construction activity also depends on the amount of time that the equipment operates and the intensity of construction activities during that time.

Table 6. Construction Equipment Maximum Noise Levels

Equipment Type	Typical Equipment (dBA at 50 Feet)
Backhoe	78
Compressor (air)	78
Crane	81
Excavator	81
Flat bed truck	74
Front-end loader	79
Impact Hammer	90
Man lift	75
Paver	77
Rock Drill	81
Roller	80
Welder / torch	73

Source: FHWA 2006.
Notes: dBA = A-weighted decibels.

Construction noise in a well-defined area typically attenuates at approximately 6 dB per doubling of distance. Project construction would take place both near and far from adjacent, existing noise-sensitive uses. For example, construction near the western project boundary would take place within approximately 35 feet of existing residences, but during construction of other project components, construction would be further away from these noise-sensitive receptors. Most construction activities associated with the proposed project would occur at distances of approximately 100 feet or more from existing noise-sensitive uses, which represents activities both near and far from any one receiver, as is typical for construction projects.

Aggregate noise emission from proposed project construction activities, broken down by sequential phase, was predicted at two distances to the nearest existing noise-sensitive receptor: 1) from the nearest position of the construction site boundary and 2) from the geographic center of the construction site, which serves as the time-averaged location or geographic *acoustical centroid* of active construction equipment for the phase under study. The intent of the former distance is to help evaluate anticipated construction noise from a limited quantity of equipment or vehicle activity expected to be at the boundary for some period of time, which would be most appropriate for phases such as site preparation, demolition, or paving. The latter distance is used in a manner similar to the general assessment technique as described in the FTA guidance for construction noise assessment, when the location of individual equipment for a given construction phase is uncertain over some extent of (or the entirety of) the construction site area. Because of this uncertainty, all the equipment for a construction phase is assumed to operate—on average—from the acoustical centroid. Table 7 summarizes these two distances to the apparent closest noise-sensitive receptor for each of the seven sequential construction phases. At the site boundary, this analysis assumes that up to only one piece of equipment of each listed type per phase will be involved in the construction activity for a limited portion of the 8-hour period. In other words, at such proximity, the operating equipment cannot “stack” or crowd the vicinity and still operate. For the acoustical centroid case, which intends to be a geographic average position for all equipment during the indicated phase, this analysis assumes that the equipment may be operating up to all 8 hours per day.

Table 7. Estimated Distances between Phase Activities and the Nearest Noise-sensitive Receptors

Construction Phase (and Equipment Types Involved)	Approximate Distance from Nearest Noise-Sensitive Receptor to *Construction Site Boundary* (Feet)	Approximate Distance from Nearest Noise-Sensitive Receptor to *Acoustical Centroid of Site* (Feet)
Demolition (backhoe, excavator, front end loader)	60	100
Site preparation (excavator, backhoe, front-end loader, rock drill, impact hammer)	50	100
Pump Station Construction (crane, flat bed truck, man lift, welder/torch)	50	100
Paving (paver, roller)	50	100
Reservoir Construction (backhoe, excavator, front end loader)	35	100
Piping (excavator)	50	100
Architectural finishes (air compressor)	50	100

A Microsoft Excel–based noise prediction model emulating and using reference data from the Federal Highway Administration Roadway Construction Noise Model (RCNM) (FHWA 2008) was used to estimate construction noise levels at the nearest occupied noise-sensitive land use. (Although the RCNM was funded and promulgated by the Federal Highway Administration, it is often used for non-roadway projects, because the same types of construction equipment used for roadway projects are often used for other types of construction.) Input variables for the predictive modeling consist of the equipment type and number of each (e.g., two graders, a loader, a tractor), the duty cycle for each piece of equipment (e.g., percentage of time within a specific time period, such as an hour, when the equipment is expected to operate at full power or capacity and thus make noise at a level comparable to what is presented in Table 6), and the distance from the noise-sensitive receiver to the construction zone. The predictive model also considers how many hours that equipment may be on site and operating (or idling) within an established work shift. Conservatively, no topographical or structural shielding was assumed in the modeling. The RCNM has default duty-cycle values for the various pieces of equipment, which were derived from an extensive study of typical construction activity patterns. Those default duty-cycle values were used for this noise analysis, which is detailed in Attachment A, Construction Noise Model Input and Output Data, and produce the predicted results displayed in Table 7.

Table 8. Construction Noise Model Results Summary

Construction Phase	Estimated Construction Noise Level at Representative Locations (8-hour L_{eq} dBA)	
	Construction Site Boundary	Acoustical Centroid of Site
Demolition	78.4	75.7
Site Preparation and Grading	85.1	79.1
Pump Station Construction	76.5	70.5
Paving	76.5	72.1
Reservoir Construction	79.1	76.0
Piping	77.0	71.0
Architectural Coating	74.0	68.0

Notes: L_{eq} = equivalent continuous sound level (time-averaged sound level); dBA = A-weighted decibel.

As presented in Table 8, the construction noise levels are predicted to have an 8-hour L_{eq} value as high as 85 dBA at the nearest existing residences when site preparation and grading activities take place.

On an average construction workday, heavy equipment will be operating sporadically throughout the project site and more frequently away from the southernmost edge of the site. At more typical distances closer to the center of the project site (approximately 100 feet from the nearest existing residence), construction noise levels are estimated to range from approximately 68 dBA L_{eq} to 79 dBA L_{eq} at the nearest existing residence.

Although nearby off-site residences would be exposed to elevated construction noise levels, the increased noise levels would typically be relatively short term It is anticipated that construction activities associated with the proposed project would take place primarily within the allowable hours of the County of San Diego (7:00 a.m. and 7:00 p.m. Monday through Saturday), and would not occur at any time on Sunday or on national holidays. In the event that construction is required to extend beyond these times, extended hours permits would be required and would be obtained by the Client.

As previously mentioned in Section 4, the Vista Irrigation District is a local agency that is not required to comply with the County's thresholds, such as the 75 dBA 8-hour L_{eq} identified in Section 3. For this reason, the FTA guidance-based standard was adopted herein for purposes of this environmental impact assessment. However, as best practice, VID would aim for compliance with County noise standards. Therefore, because the prediction results presented in Table 8 indicate that noise from conventional construction activities attributed to the project would exceed the County's 8-hour L_{eq} threshold for most of the activity phases and exceed the FTA threshold at the nearest existing residential receivers when site grading and preparation occurs, implementation of common noise-reducing construction activity best practices listed below in mitigation measure M-NOI-1 would be recommended. If these measures are implemented properly by the District or its contractors, conventional construction noise impacts would be considered less than significant.

M-NOI-1. Construction Noise Reduction

The Vista Irrigation District and/or its construction contractor shall comply with the following measures during construction:

1. Construction activities shall not occur between the hours of 7:00 p.m. and 7:00 a.m. Monday through Saturdays, or on Sundays or national holidays. In the event that construction is required to extend beyond these times, extended hours permits shall be required.
2. Equipment (e.g., portable generators) shall be shielded from sensitive uses using local temporary noise barriers or enclosures or shall otherwise be designed or configured to minimize noise at nearby noise-sensitive receptors.
3. All noise-producing equipment and vehicles using internal combustion engines should be equipped with mufflers; air-inlet silencers, where appropriate; and any other shrouds, shields, or other noise-reducing features in good operating condition that meet or exceed original factory specification. Mobile or fixed "package" equipment (e.g., arc-welders, air compressors) should be equipped with shrouds and noise control features that are readily available for that type of equipment.
4. All mobile or fixed noise-producing equipment used on the project facilities that are regulated for noise output by a local, state, or federal agency should comply with such regulation while in the course of project activity.
5. Idling equipment should be kept to a minimum and moved as far as practicable from noise-sensitive land uses.
6. Electrically powered equipment should be used instead of pneumatic or internal-combustion-powered equipment, where feasible.
7. Material stockpiles and mobile equipment staging, parking, and maintenance areas should be located as far as practicable from noise-sensitive receptors.
8. The use of noise-producing signals, including horns, whistles, alarms, and bells, should be for safety warning purposes only.
9. Residences within 500 feet of the construction site should be notified of the construction schedule in writing at least 3 calendar days prior to construction. The District or its contractor(s) shall designate a

noise disturbance point of contact who would be responsible for responding to complaints regarding construction noise. The point of contact should make reasonable effort to investigate the cause of the complaint and, if indeed related to construction noise attributed to the project, see that reasonable measures are implemented to help address the problem. A contact number for the noise disturbance point of contact should be conspicuously placed on construction site fences and written into the construction notification schedule sent to nearby residences.

The net noise reduction effectiveness of these listed practices would vary with the equipment in use, the original condition of the equipment, the specific locations of the noise source and receiver, etc. By way of example, halving equipment engine idling time could reduce—over the course of a measurement period—noise levels from idling equipment by 3 dB. Positioning of large trailers or storage containers onsite, so that they occlude the line of sight between the noise-producing idling equipment and a receptor could yield an additional 3 to 5 dB of noise reduction. Collectively, proper application of multiple listed practices under M-NOI-1 would be expected to result in a substantial decrease in construction noise, and under the right conditions could also yield compliance with the County standard (i.e., per Section 36.409) of 75 dBA 8-hour L_{eq}. Therefore, with respect to federal guidance consistency, the anticipated impact from construction noise would be considered **less than significant with mitigation incorporated.**

Blasting

Based on the known presence of hard rock at the project site, there is a high likelihood that rock excavation would be required during the site preparation and grading phase. Rock excavation methods would generally consist of non-explosive techniques, such as rock breaking attachments (both with and without pre-drilling), hydro-fracturing, or expansive chemical agents. Although potential noise from these rock excavation activities has been included in the preceding predictive analysis of conventional construction equipment, there is some potential that these methods would be unable to excavate the underlying rock and limited blasting would be required. Because of this potential, the analysis presented in this report conservatively assumes blasting would be required.

Blasting typically involves drilling a series of boreholes, placing explosives (the “charge”) in each hole, then topping the charge with fill material to help confine the blast. These multiple holes are typically arranged so as to yield optimal fracturing of the rock strata and thus allow gravity to subsequently collapse or “implode” the volume of rock in as safe and controlled manner as possible after detonation. Post-detonation material can then be further broken down to manageable size and hauled away with conventional construction equipment and vehicles.

By limiting the amount of charge in each hole, and detonating each charge successively with a time delay, the blasting contractor can limit the total energy released at any single time, which in turn reduces the airborne noise L_{max} and groundborne vibration energy associated with each individual detonated charge.

If required, no more than one blast per day would occur during construction activities. To keep groundborne vibration magnitude from each charge-delayed detonation at a peak particle velocity (PPV) that does not exceed the single-event threshold of 1 ips for residential structures, per Caltrans guidance, Table 9 presents the preliminarily determined maximum charge weights with respect to the nearest eastern and western residential receptors. Table 9 also displays the predicted A-weighted L_{max} for each detonated charge, under a fully-confined condition, using mathematical expressions and typical parameters provided by the Blasting and Explosives Quick Reference Guide (Dyno Nobel 2010).

Table 9. Preliminary Blasting Charge Weights and Predicted L_{max} Values

Nearest Receiving Residential Structure	Per-Detonation Charge Weight (lbs)	Single Charge Detonation Airborne Sound Pressure Level (SPL, dBA Lmax)	Single Charge Detonation Peak Particle Velocity (PPV, inches per second)
West (75 feet distance to expected closest detonation)	1.56	105	0.992
East (130 feet distance to expected closest detonation)	4.62	104	0.994

With a blast expected to loosen up to 2,000 cubic yards of material, and assuming a powder factor of 0.5, the total quantity of successive detonations would vary with the charge weight but result in an estimated 8-hour L_{eq} of 85 to 91 dBA using the values in Table 9 as a guide. Hence, and for informational purposes, noise from the blast at these indicated distances could exceed the County's standard.

M-NOI-2. Blasting Plan

Blasting for rock excavation shall only be used by the contractor upon receipt of approval by Vista Irrigation District and after other non-explosive techniques have been exhausted, such as rock breaking attachments (both with and without pre-drilling), hydro-fracturing, and expansive chemical agents. If blasting is required for rock excavation, the District or its contractor will prepare a blasting plan that will reduce impacts associated with construction-related noise, drilling operations and vibrations related to blasting. The blasting plan will be site specific, based on general and exact locations of required blasting and the results of a project-specific geotechnical investigation. The blasting plan will include a description of the planned blasting methods, an inventory of receptors potentially affected by the planned blasting, and calculations to determine the area affected by the planned blasting. Noise calculations in the blasting plan will account for blasting activities and all supplemental construction equipment. The final blasting plan and pre-blast survey shall meet the requirements provided below.

- Prior to blasting, a qualified geotechnical professional shall inspect and document the existing conditions of facades and other visible structural features or elements of the nearest residential buildings. Should this inspector determine that some structural features or elements appear fragile or otherwise potentially sensitive to vibration damage caused by the anticipated blasting activity, the maximum per-delay charge weights and other related blast parameters shall be re-evaluated to establish appropriate quantified limits.
- All blasting shall be performed by a blast contractor and blasting personnel licensed to operate per appropriate regulatory agencies.
- Each blast shall be monitored and recorded with an air-blast overpressure monitor and groundborne vibration accelerometer that is located outside the closest residence to the blast. This data shall be recorded, and a post-blast summary report shall be prepared and be available for public review or distribution as necessary.

- Blasting shall not exceed 1 ips PPV (transient or single-event), or a lower PPV determined by the aforesaid inspector upon completion of the pre-blast inspection, at the façade of the nearest occupied residence
- To ensure that potentially impacted residents are informed, the applicant will provide notice by mail to all property owners within 500 feet of the project at least 1 week prior to a scheduled blasting event.
- Drilling operations associated with blasting preparations shall be performed in a manner consistent with adherence to guidance that emulates Sections 36.408, 36.409, and 36.410 of the San Diego County Code Noise Ordinance.

Long-Term Operational Impacts

On-Site Mechanical Noise Levels

Operating pump station equipment would have the potential to create noise impacts. The proposed new pump station would provide redundant water supply and would have a capacity of 3,000 gallons per minute to meet peak hour expectations during maximum-day demand conditions. The pump station would consist of skid-mounted multi-stage vertical pumps with aboveground headers. The pumps would be housed in an aboveground structure that would match the architectural features of the existing PRS facility. The pump station structure would also house the pump station control panel, electrical panels, and SCADA equipment for the site. The station would be approximately 20 feet by 38 feet with a height of 14 feet. It would be constructed of a 12-inch, cast-in-place concrete floor with an 8- to 12-inch concrete masonry wall. Additionally, the roof would be composed of sloped composite shingles supported by wood trusses and plywood sheathing, with a 20-pounds-per-square-foot load limit. The pump station would also include outside air intake louvers on one of the walls and a roof-mounted ventilation fan to remove heat generated by the pump equipment. Access to the structure would be provided through two entry points: a single standard solid personnel door, and a 14-foot-wide and 12-foot-tall insulated roll-up door.

Prediction of pump noise propagation from the new pump station structure under typical expected operating conditions utilized techniques based on International Organization of Standardization (ISO) 9613-2 (ISO 1996) and included the following key calculation parameters and assumptions:

- The “long wall” of the new pump station features the 12-inch thick concrete masonry unit (CMU) wall, penetrated by the aforesaid roll-up door (comparable to an Alpine Insul-Sound model), personnel door, and a twelve square-foot outside air intake housing an Industrial Acoustics 12”-deep “S-12” model acoustical louver (or comparable product).
- The “short wall” is an 8-inch thick CMU wall with no penetrations.
- The sloped roof features a roof hatch, through which vertical pump equipment may be drawn or lowered.
- The interior is ventilated with a Loren Cook model 180ACRUB (3/4 HP) roof-mounted fan that yields 3,000 cubic feet per minute (cfm) at 0.875 inches water gauge (iwg) of static pressure.
- To reduce reverberation (i.e., the build-up of noise) within the enclosed volume housing multiple operating pumps, the interior wall surfaces should feature at least a cumulative quantity of 320 square feet of 2-inch thick (minimum), 3 pounds per cubic foot density (minimum), acoustically absorptive insulation (e.g., Owens-Corning 703 insulation, or pre-fabricated panels composed of similarly-performing media). The equipment-facing side of the ceiling should also feature a total of 320 square feet of similar acoustically absorptive media that has a noise reduction coefficient (NRC) of 0.7 or better.

With the design of the new pump station reflecting these above-listed features, two alternatives for the structural footprint were considered and resulted in predicted operation noise levels at the indicated project property lines as presented in Table 10. Details of the new pump station operation noise assessment appear in Attachment B.

Table 10: Predicted Pump Station Operation Noise Levels

Pump Station Building Orientation	Receiving Property Line	Noise Level (dBA)
Alt 1 B	South Boundary	44.2
	West Boundary	35.3
Alt 1 B Alternate Pump station location	South Boundary	38.1
	West Boundary	42.7

As shown in Table 10, estimated noise levels during typical operation would range from approximately 35.3 to 44.2 dBA and thus comply with the County's noise standards of 45 dBA hourly L_{eq} during nighttime hours (10:00 p.m. through 7:00 a.m.). These predicted levels are also below the suggested hourly L_{eq} limit of 48.6 dBA, based on EPA guidance. Hence, no further noise mitigation would be needed, and impact from operation noise would be considered less than significant.

Operation noise contribution to the outdoor sound environment from the valve vault, an enclosed volume, and buried new piping and fittings would be expected to have a less than significant impact.

b) ***Would the project result in generation of excessive groundborne vibration or groundborne noise levels?***

Construction activities may expose persons to excessive groundborne vibration or groundborne noise, causing a potentially significant impact. Caltrans has collected groundborne vibration information related to construction activities (Caltrans 2013b). Information from Caltrans indicates that continuous vibrations with a PPV of approximately 0.2 ips is considered annoying. For context, heavier pieces of construction equipment, such as a vibratory roller that may be expected on the project site as part of the paving phase, have peak particle velocities of 0.21 ips PPV at a reference distance of 25 feet (DOT 2006).

Groundborne vibration attenuates rapidly, even over short distances. The attenuation of groundborne vibration as it propagates from source to receptor through intervening soils and rock strata can be estimated with expressions found in FTA and Caltrans guidance. By way of example, for the aforementioned roller operating on site and as close as the western project boundary (i.e., 35 feet from the nearest receiving sensitive land use) the estimated vibration velocity level would be less than 0.13 ips per the equation as follows (FTA 2006):

$$PPV_{rcvr} = PPV_{ref} * (25/D)^{1.5} = 0.127 = 0.21 * (25/35)^{1.5}$$

In the above equation, PPV_{rcvr} is the predicted vibration velocity at the receiver position, PPV_{ref} is the reference value at 25 feet from the vibration source (the roller), and D is the actual horizontal distance to the receiver. Therefore, at this predicted PPV magnitude, the impact of vibration-induced annoyance to occupants of nearby existing homes would be less than significant.

Construction vibration, at sufficiently high levels, can also present a building damage risk. However, the predicted 0.13 ips PPV at the nearest residential receiver 35 feet away from onsite operation of the roller during paving would not surpass the guidance limit of 0.2 to 0.3 ips PPV for preventing damage to residential structures (Caltrans 2013b). Because the predicted vibration level at 35 feet is less than both the annoyance and building damage risk thresholds, vibration from project conventional construction activities is considered less than significant.

Once operational, the proposed project would not be expected to feature major onsite producers of groundborne vibration. Anticipated mechanical systems like pumps are designed and manufactured to feature rotating components (e.g., impellers) that are well-balanced with isolated vibration within or external to the equipment casings. On this basis, potential vibration impacts due to proposed project operation would be less than significant.

Blasting Vibration

Although conventional construction equipment using mechanical means for earth-moving are not expected to yield vibration velocity levels that exceed applicable standards, potential blasting activities represent a separate category of vibration assessment. The project may require blasting to facilitate excavation in areas where competent bedrock occurs at depths that make mechanical excavation difficult. The right-most column in Table 9 presents the estimated per-detonation PPV that would be received at each of the indicated residential receptors. Under such parameters, the blast vibration magnitudes would be compatible with Caltrans guidance limits for single-event or “transient” events. However, to help ensure that vibration from the blasting associated with project excavation would not cause undue temporary annoyance and minimize damage risk to the receiving structures, proper implementation of the Blasting Plan introduced as M-NOI-2 is recommended to help render vibration-related environmental impacts temporary and **less than significant with mitigation**.

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?***

There are no private airstrips within the vicinity of the project site. The closest airport to the project site is the McClellan Palomar Airport, approximately 7 miles southwest of the site. The project site is not located within any noise contours and would therefore not expose people residing or working in the project area to excessive noise levels. Impacts from aviation overflight noise exposure would be **less than significant**.

6 Conclusions

Based upon the project-attributed operation and construction noise and vibration analysis presented herein, predicted sound and vibration levels are anticipated to be less than significant with application of proper mitigation.

We trust that this technical memorandum meets your Project needs with the County. Should you have any questions or require additional information, please do not hesitate to contact Mark Storm at (760) 479-4297, mstorm@dudek.com; or, Connor Burke at (760) 479-4272, cburke@dudek.com.

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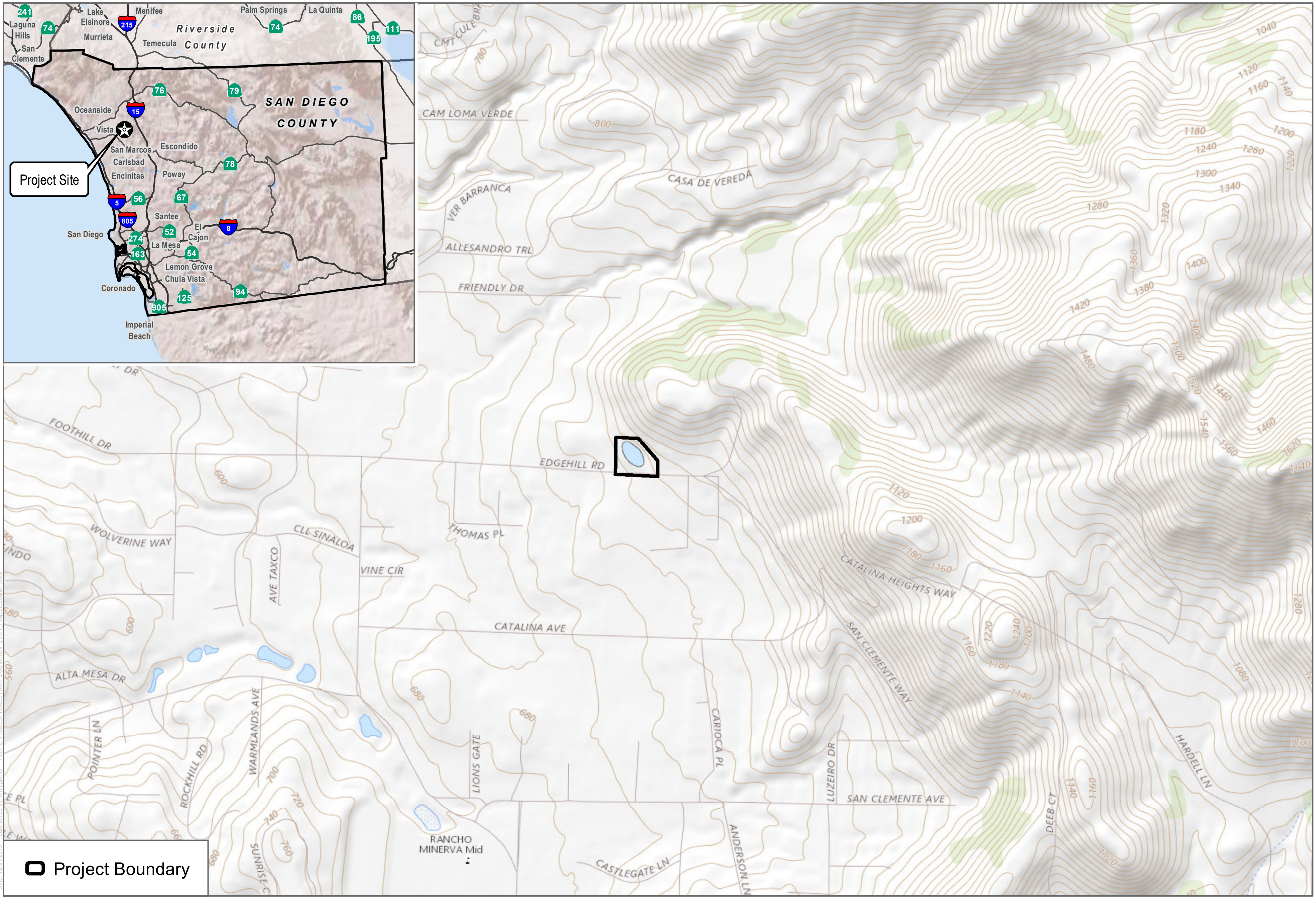

SOURCE: USGS 7.5-minute Quadrangle

DUDEK

0 500 1,000 Feet

FIGURE 1

Project Vicinity

Vista Irrigation District E Reservoir and Pump Station

SOURCE: SANGIS 2017

DUDEK

0 200 400 Feet

FIGURE 2

Project Location

Vista Irrigation District E Reservoir and Pump Station

SOURCE: ESRI 2019

DUDEK

0 100 200 Feet

FIGURE 3

Noise Measurement Locations

Vista Irrigation District E Reservoir and Pump Station

Attachment A

Construction Noise Modeling Input/Output Worksheets

To User: bordered cells are inputs, unbordered cells have formulae

noise level limit for construction phase, per FTA guidance for residential receptors = 80
allowable hours over which Leq is to be averaged (example: 8 for County of San Diego, FTA guidance) = 8

Construction Phase	FHWA RCNM Equipment Type	Total Equipment Qty	AUF % (from FHWA RCNM)	Reference Lmax @ 50 ft. from FHWA RCNM	Client Equipment Description, Data Source and/or Notes	Source to NSR Distance (ft.)	Distance-Adjusted Lmax	Allowable Operation Time (hours)	Allowable Operation Time (minutes)	Predicted 8-hour Leq
Demolition	Backhoe	1	40	78		60	76.4	8	480	72
	Excavator	1	40	81		60	79.4	8	480	75
	Front End Loader	1	40	79		60	77.4	6	360	72
							Total for Demolition Phase:			**78.4**
Site Preparation and Grading	Excavator	1	40	81		50	81.0	8	480	77
	Backhoe	1	40	78		50	78.0	8	480	74
	Front End Loader	1	40	79		50	79.0	6	360	74
	Rock Drill	1	20	81		50	81.0	8	480	74
	Mounted Impact Hammer (hoe ram)	1	20	90		50	90.0	8	480	83
						Total for Site Preparation and Grading Phase:				**85.1**
Pump Station Construction	Crane	1	16	81		50	81.0	8	480	73
	Flat bed truck	1	40	74		50	74.0	8	480	70
	Man Lift	1	20	75		50	75.0	8	480	68
	Welder / Torch	1	40	73		50	73.0	8	480	69
						Total for Pump Station Construction Phase:				**76.5**
Paving	Paver	1	50	77		50	77.0	8	480	74
	Roller	1	20	80		50	80.0	8	480	73
							Total for Paving Phase:			**76.5**
Reservoir Construction	Backhoe	1	40	78		35	81.1	3	180	73
	Excavator	1	40	81		35	84.1	3	180	76
	Front End Loader	1	40	79		35	82.1	3	180	74
						Total for Reservoir Construction Phase:				**79.1**
Piping	Excavator	1	40	81		50	81.0	8	480	77
							Total for Piping Phase:			**77.0**
Architectural Coating	Compressor (air)	1	40	78		50	78.0	8	480	74
						Total for Architectural Coating Phase:				**74.0**

To User: bordered cells are inputs, unbordered cells have formulae

noise level limit for construction phase, per FTA guidance for residential receptors = 80

allowable hours over which Leq is to be averaged (example: 8 for County of San Diego, FTA guidance) = 8

Construction Phase	FHWA RCNM Equipment Type	Total Equipment Qty	AUF % (from FHWA RCNM)	Reference Lmax @ 50 ft. from FHWA RCNM	Client Equipment Description, Data Source and/or Notes	Source to NSR Distance (ft.)	Distance-Adjusted Lmax	Allowable Operation Time (hours)	Allowable Operation Time (minutes)	Predicted 8-hour Leq
Demolition	Backhoe	1	40	78		100	72.0	8	480	68
	Excavator	2	40	81		100	75.0	8	480	74
	Front End Loader	1	40	79		100	73.0	6	360	68
								Total for Demolition Phase:		**75.7**
Site Preparation and Grading	Excavator	1	40	81		100	75.0	8	480	71
	Backhoe	1	40	78		100	72.0	8	480	68
	Front End Loader	1	40	79		100	73.0	6	360	68
	Rock Drill	1	20	81		100	75.0	8	480	68
	Mounted Impact Hammer (hoe ram)	1	20	90		100	84.0	8	480	77
								Total for Site Preparation and Grading Phase:		**79.1**
Pump Station Construction	Crane	1	16	81		100	75.0	8	480	67
	Flat bed truck	1	40	74		100	68.0	8	480	64
	Man Lift	1	20	75		100	69.0	8	480	62
	Welder / Torch	1	40	73		100	67.0	8	480	63
								Total for Pump Station Construction Phase:		**70.5**
Paving	Paver	1	50	77		100	71.0	8	480	68
	Roller	2	20	80		100	74.0	8	480	70
								Total for Paving Phase:		**72.1**
Reservoir Construction	Backhoe	1	40	78		100	72.0	8	480	68
	Excavator	2	40	81		100	75.0	8	480	74
	Front End Loader	1	40	79		100	73.0	8	480	69
								Total for Reservoir Construction Phase:		**76.0**
Piping	Excavator	1	40	81		100	75.0	8	480	71
								Total for Piping Phase:		**71.0**
Architectural Coating	Compressor (air)	1	40	78		100	72.0	8	480	68
								Total for Architectural Coating Phase:		**68.0**

Attachment B

Operation Noise Modeling Input/Output Worksheets

below from Bies & Hansen, *Engineering Noise Control* , 2nd ed. (1996), Section 11.6 and Table 11.0

input for your pump:

			Unweighted OBCF PWL (dB)												rpm	kW	
OBCF (Hz)	kW	rpm	*31.5*	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	Notes			3550	37.3	**<-- User: enter these two values!**
			13	12	11	9	9	6	9	13	19						
	< 75kW	3000-3600	83	84	85	87	87	90	87	83	77		72	10	3000	3600	
		1600-1800											75	10	1600	1800	
		1000-1500											70	10	1000	1500	
		450-900											68	10	450	900	
	> 75kW	3000-3600											86	3	3000	3600	
		1600-1800											89	3	1600	1800	
		1000-1500											84	3	1000	1500	
		450-900											82	3	450	900	
			83	84	85	87	87	90	87	83	77	values for other worksheets					**<-- User: these are accessed by other sheets**

Horsepower to kW conversion

37.3

Scenario: painted CMU	% cover	Square Feet (SF)	L	W	H	Vol. (m)	125	250	500	1000	2000	4000	NRC	Notes
				room dimensions in feet					Octave Band Center Frequency (Hz)					
			20	26	13	191								
									Acoustical Absorption Coefficients (α)					
Abs. Coeff - walls, treated	0%	0	20	26	13		0.63	0.56	0.95	0.79	0.60	0.35	0.73	Owens-Corning 703, 2" thick, 3 pcf, FRK lined, on wall; http://www.bobgolds.com/AbsorptionCoefficients.htm
Abs. Coeff - walls, untreated	100%	1196					0.1	0.05	0.06	0.07	0.09	0.08	0.07	I
Abs. Coeff - ceiling, treated	0%	0	20	26			0.63	0.56	0.95	0.79	0.60	0.35	0.73	Owens-Corning 703, 2" thick, 3 pcf, FRK lined, on wall; http://www.bobgolds.com/AbsorptionCoefficients.htm
Abs. Coeff - ceiling, untreated	100%	520					0.05	0.1	0.01	0.1	0.07	0.02	0.07	II
Abs. Coeff - floor, treated	0%	0	20	26			0.01	0.05	0.1	0.2	0.45	0.65	0.20	Egan, p. 52, #36 (indoor-outdoor carpet)
Abs. Coeff - floor, untreated	100%	520					0.01	0.01	0.02	0.02	0.02	0.02	0.02	III
Total Square Footage TREATED	0%	0												
Total Square Footage UNTREATED	100%	2236												
TOTAL SQUARE FOOTAGE		2236					0.07	0.05	0.04	0.07	0.07	0.05	0.06	average absorption coefficient
									Sabins (A)					
Abs. Coeff - walls, treated							0	0	0	0	0	0		
Abs. Coeff - walls, untreated							120	60	72	84	108	96		
Abs. Coeff - ceiling, treated							0	0	0	0	0	0		
Abs. Coeff - ceiling, untreated							26	52	5	52	36	10		
Abs. Coeff - floor, untreated							5	5	10	10	10	10		
Total Sabins per OBCF							151	117	87	146	154	116		

Notes:

I painted concrete block (Egan, p. 52, #4)
II steel (Egan, p. 52, #15)
III concrete floor (Egan, p. 52, #15)
NRC = noise reduction coefficient

Scenario: 2" fill w/ FSK liner*	% cover	Square Feet (SF)	L	W	H	Vol. (m)	125	250	500	1000	2000	4000	NRC	Notes
				room dimensions in feet					Octave Band Center Frequency (Hz)					
									Acoustical Absorption Coefficients (α)					
Abs. Coeff - walls, treated	27%	320	20	26	13		0.63	0.56	0.95	0.79	0.60	0.35	0.73	Owens-Corning 703, 2" thick, 3 pcf, FRK lined, on wall; http://www.bobgolds.com/AbsorptionCoefficients.htm
Abs. Coeff - walls, untreated	73%	876					0.1	0.05	0.06	0.07	0.09	0.08	0.07	I
Abs. Coeff - ceiling, treated	62%	320	20	26			0.63	0.56	0.95	0.79	0.60	0.35	0.73	Owens-Corning 703, 2" thick, 3 pcf, FRK lined, on wall; http://www.bobgolds.com/AbsorptionCoefficients.htm
Abs. Coeff - ceiling, untreated	38%	200					0.05	0.1	0.01	0.1	0.07	0.02	0.07	II
Abs. Coeff - floor, treated	0%	0	20	26			0.01	0.05	0.1	0.2	0.45	0.65	0.20	Egan, p. 52, #36 (indoor-outdoor carpet)
Abs. Coeff - floor, untreated	100%	520					0.01	0.01	0.02	0.02	0.02	0.02	0.02	III
Total Square Footage TREATED	29%	640												
Total Square Footage UNTREATED	71%	1596												
TOTAL SF		2236					0.23	0.19	0.30	0.27	0.22	0.14	0.24	average absorption coefficient
									Sabins (A)					
Abs. Coeff - walls, treated							202	179	304	253	192	112		
Abs. Coeff - walls, untreated							88	44	53	61	79	70		
Abs. Coeff - ceiling, treated							202	179	304	253	192	112		
Abs. Coeff - ceiling, untreated							10	20	2	20	14	4		
Abs. Coeff - floor, treated							0	0	0	0	0	0		
Abs. Coeff - floor, untreated							5	5	10	10	10	10		
Total Sabins per OBCF							506	427	673	597	487	308		
estimated noise reduction (NR, dB)							**5.3**	**5.6**	**8.9**	**6.1**	**5.0**	**4.2**		

Notes:
*the FSK-lined 2"-thick, 3 pcf glass could be placed behind standard 23% open area perforated metal or comparable acoustically-transparent protective porous screen.

*Booster Pump Building, **long wall*** | *12" hollow CMU*

25 = approx. STC

	qty	width	height	Square feet	
material or element #1				288.25	12" hollow CMU
material or element #2	1	14	12	168	Rollup door
material or element #3	1	3	7.25	21.75	single solid door
material or element #4	1	3	4	12	Acoustical Louver
total surface		35	14	490	arbitrary total surface area

	125	250	500	1000	2000	4000
6inch	37	36	42	49	55	58
8inch	39	38	44	51	57	60
12inch	43	42	48	55	61	64

Octave Band Center Frequency (OBCF, Hz)

TL Data Source		125	250	500	1000	2000	4000	
Harris, Noise Control in Buildings, Appx. 5.2c*	12" hollow CMU	43	42	48	55	61	64	STC is 50 per referenced 48 psf block, but this link suggests STC should be 55 for grout-filled 8" thick: http://www.ncma-br.org/pdfs/5/TEK%2013-01C.pdf
*+ 5dB to adjust for STC up 5 points for grout-filled	material #1 τ	5E-05	6.3E-05	1.6E-05	3.2E-06	7.9E-07	4E-07	
Alpine Insul-Sound roll-up door (or comparable)	Rollup door	20	23	24	31	43	50	https://3xg3ng2xwa8629t6fg2h7vu9-wpengine.netdna-ssl.com/wp-content/uploads/2011/04/Insulsound-sound.jpg
	material #2 τ	0.01	0.00501	0.00398	0.00079	5E-05	0.00001	
Egan, Architectural Acoustics, p. 205, line 46	single solid door	24	23	29	31	24	40	
	material #3 τ	0.00398	0.00501	0.00126	0.00079	0.00398	0.0001	
https://www.iacacoustics.com/acoustic-louvers.html	Acoustical Louver	7	10	12	18	18	14	based on SL-12 model
	material #4 τ	0.19953	0.1	0.0631	0.01585	0.01585	0.03981	
	composite TL	21	24	25	32	32	30	

*Booster Pump Building, **short wall*** | *8" hollow CMU*

44 = approx. STC

	qty	width	height	Square feet	
material or element #1				280	8" hollow CMU
material or element #2				0	n/a
material or element #3				0	single solid door
material or element #4				0	n/a
total surface		20	14	280	arbitrary total surface area

Octave Band Center Frequency (OBCF, Hz)

TL Data Source		125	250	500	1000	2000	4000	
Harris, Noise Control in Buildings, Appx. 5.2c*	8" hollow CMU	39	38	44	51	57	60	STC is 50 per referenced 48 psf block, but this link suggests STC should be 55 for grout-filled 8" thick: http://www.ncma-br.org/pdfs/5/TEK%2013-01C.pdf
*+ 5dB to adjust for STC up 5 points for grout-filled	material #1 τ	0.00013	0.00016	4E-05	7.9E-06	2E-06	1E-06	
	n/a							
	material #2 τ	1	1	1	1	1	1	
Egan, Architectural Acoustics, p. 205, line 46	single solid door	24	23	29	31	24	40	
	material #3 τ	0.00398	0.00501	0.00126	0.00079	0.00398	0.0001	
	n/a	0	0	0	0	0	0	
	material #4 τ	1	1	1	1	1	1	
	composite TL	39	38	44	51	57	60	

Pump Room, Roof *exhaust duct in roof*

26 = approx. STC

	qty	width	height	Square feet	
material or element #1				695.9811	insulated metal deck roof assembly
material or element #2	1	1.5	1.5	2.25	18"x18" roof hatch
material or element #3	1	1.33	1.33	1.7689	16" x 16" exhaust fan duct penetration
material or element #4				0	n/a
total surface		35	20	700	arbitrary total surface area

Octave Band Center Frequency (OBCF, Hz)

TL Data Source		125	250	500	1000	2000	4000	
see link: STC 32 roof assembly (insulated metal deck)	insulated metal deck roof assembly	29	33	37	44	55	63	http://therm-all.com/wp-content/uploads/2018/09/NAIMA-Fact-Sheet-58-Acoustical-Performance-of-Metal-Building-Insulation.pdf
	material #1 τ	0.00126	0.0005	0.0002	4E-05	3.2E-06	5E-07	
	18"x18" roof hatch	15	21	27	33	38	39	assume comparable to 1/16"-thick sheet steel per Universal Silencer Application Handbook, pg. 166, Appx. XIV
	material #2 τ	0.03162	0.00794	0.002	0.0005	0.00016	0.00013	
	16" x 16" exhaust fan duct penetration	0	0	0	0	0	0	
	material #3 τ	1	1	1	1	1	1	
	n/a	0	0	0	0	0	0	
	material #4 τ	1	1	1	1	1	1	
	composite TL	24	25	26	26	26	26	

Alt 1B ***Pump Room, South*** *Façade* — *12" hollow CMU*

Octave Band Center Frequency (OBCF, Hz)	125	250	500	1000	2000	4000	overall	Notes					
A-weighting adjustments	16	9	3	0	-1	-1							
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM			5	*number of pumps	
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2					
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied					
Wall radiation term ("C")	17	17	17	17	17	17		square feet of radiating wall	490	ft^2			
TL of room wall	21	24	25	32	32	30		see "pump_compTL_walls" worksheet, assumes ***long wall*** and 12" acoustical louver installed					
Distance attenuation	24	24	24	24	24	24		distance from façade to receptor	55	ft	3.28	ft	reference distance
Directivity	0	0	0	0	0	0		south façade facing southern receptor, so these values represent no directivity loss					
Intervening Barrier	0	0	0	0	0	0							
Air absorption	0.0	0.0	0.0	0.1	0.1	0.3		from Beranek and Ver, NaVCE					
Ground absorption	0.0	0.0	0.0	0.0	0.0	0.0		from Beranek and Ver, NaVCE (also ISO 9613-2)	5	ft			average of height of source and height of receiver
predicted SPL (dBA)	29	35	36	38	37	35	**44**						

Alt 1B ***Pump Room, West*** *Façade* — *8" hollow CMU*

Octave Band Center Frequency (OBCF, Hz)	125	250	500	1000	2000	4000	overall	Notes					
A-weighting adjustments	16	9	3	0	-1	-1							
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM					
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2					
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied					
Wall radiation term ("C")	14	14	14	14	14	14		square feet of radiating wall	280	ft^2			
TL of room wall	39	38	44	51	57	60		see "pump_compTL_walls" worksheet, assumes ***short wall***					
Distance attenuation	27	27	27	27	27	27		distance from façade to receptor	70	ft	3.28	ft	reference distance
Directivity	5	5	5	5	5	5		west façade isn't facing the southern receptor, so these values represent directivity loss					
Intervening Barrier	0	0	0	0	0	0							
Air absorption	0	0	0	0	0	0		from Beranek and Ver, NaVCE					
Ground absorption	0.0	0.0	0.0	0.0	0.0	0.0		from Beranek and Ver, NaVCE (also ISO 9613-2)	5	ft			average of height of source and height of receiver
predicted SPL (dBA)	1	11	8	9	2	-4	**15**						

Alt 1b ***Pump Room, Roof***

Octave Band Center Frequency (OBCF, Hz)	125	250	500	1000	2000	4000	overall	Notes					
A-weighting adjustments	16	9	3	0	-1	-1							
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM					
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2					
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied					
Wall radiation term ("C")	18	18	18	18	18	18		square feet of radiating wall	700	ft^2			
Comp TL of roof	24	24	25	32	32	30		see "pump_compTL_roof" worksheet					
Distance attenuation	27	27	27	27	27	27		distance from roof midpoint to receptor	70	ft	3.28	ft	reference distance
Directivity	7	8	9	10	11	12		IAC handbook, 90 degrees					
Intervening Barrier	0	0	0	0	0	0							
Air absorption	0	0	0	0	0	0		from Beranek and Ver, NaVCE					
Ground absorption	0.0	0.0	0.0	0.0	0.0	0.0		from Beranek and Ver, NaVCE (also ISO 9613-2)	5	ft			average of height of source and height of receiver
predicted SPL (dBA)	18	26	26	28	25	23	**33**						

44.0 =logsum of all three sound paths (both facades and the roof)

Alt 1B Pump Room, South Façade — *12" hollow CMU*

	125	250	500	1000	2000	4000	overall	Notes		
A-weighting adjustments	16	9	3	0	-1	-1				
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		5 *number of pumps
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	17	17	17	17	17	17		square feet of radiating wall	490 ft²	
TL of room wall	21	24	25	32	32	30		see "pump_compTL_walls" worksheet, assumes ***long wall*** and 12" acoustical louver installed		
Distance attenuation	28	28	28	28	28	28		distance from façade to receptor	85 ft	3.28 ft reference distance
Directivity	5	5	5	5	5	5		south façade not facing southern receptor, so these values represent directivity loss		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0.0	0.0	0.1	0.1	0.2	0.5		from Beranek and Ver, NaVCE		
Ground absorption	1.4	1.4	1.4	1.4	1.4	1.4		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	19	25	26	28	26	25	**33**			

Octave Band Center Frequency (OBCF, Hz)

Alt 1B Pump Room, West Façade — *8" hollow CMU*

	125	250	500	1000	2000	4000	overall	Notes		
A-weighting adjustments	16	9	3	0	-1	-1				
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	14	14	14	14	14	14		square feet of radiating wall	280 ft²	
TL of room wall	39	38	44	51	57	60		see "pump_compTL_walls" worksheet, assumes ***short wall***		
Distance attenuation	26	26	26	26	26	26		distance from façade to receptor	65 ft	3.28 ft reference distance
Directivity	0	0	0	0	0	0		west façade is facing the southern receptor, so these values represent no directivity loss		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0	0	0	0	0	1		from Beranek and Ver, NaVCE		
Ground absorption	1.4	1.4	1.4	1.4	1.4	1.4		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	6	15	12	14	7	0	**19**			

Octave Band Center Frequency (OBCF, Hz)

Alt 1b Pump Room, Roof

	125	250	500	1000	2000	4000	overall	Notes		
A-weighting adjustments	16	9	3	0	-1	-1				
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	18	18	18	18	18	18		square feet of radiating wall	700 ft²	
Comp TL of roof	24	24	25	32	32	30		see "pump_compTL_roof" worksheet		
Distance attenuation	28	28	28	28	28	28		distance from roof midpoint to receptor	85 ft	3.28 ft reference distance
Directivity	7	8	9	10	11	12		IAC handbook, 90 degrees		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0	0	0	0	0	1		from Beranek and Ver, NaVCE		
Ground absorption	1.4	1.4	1.4	1.4	1.4	1.4		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	15	23	23	25	22	20	**30**			

Octave Band Center Frequency (OBCF, Hz)

35.1 =logsum of all three sound paths (both facades and the roof)

Alt 3 ***Pump Room, west*** *Façade*										
12" hollow CMU	16	9	3	0	-1	-1		A-weighting adjustments		
	Octave Band Center Frequency (OBCF, Hz)									
	125	250	500	1000	2000	4000	overall	Notes		
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		5 *number of pumps
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	17	17	17	17	17	17		square feet of radiating wall	490 ft^2	
TL of room wall	21	24	25	32	32	30		see "pump_compTL_walls" worksheet, assumes ***long wall*** and 12" acoustical louver installed		
Distance attenuation	27	27	27	27	27	27		distance from façade to receptor	70 ft	3.28 ft reference distance
Directivity	5	5	5	5	5	5		west façade not facing southern receptor, so these values represent directivity loss		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0.0	0.0	0.0	0.1	0.2	0.4		from Beranek and Ver, NaVCE		
Ground absorption	0.4	0.4	0.4	0.4	0.4	0.4		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	22	27	28	31	29	28	**36**			

Alt 3 ***Pump Room, south*** *Façade*										
8" hollow CMU	16	9	3	0	-1	-1		A-weighting adjustments		
	Octave Band Center Frequency (OBCF, Hz)									
	125	250	500	1000	2000	4000	overall	Notes		
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	14	14	14	14	14	14		square feet of radiating wall	280 ft^2	
TL of room wall	39	38	44	51	57	60		see "pump_compTL_walls" worksheet, assumes ***short wall***		
Distance attenuation	24	24	24	24	24	24		distance from façade to receptor	55 ft	3.28 ft reference distance
Directivity	0	0	0	0	0	0		south façade is facing the southern receptor, so these values represent no directivity loss		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0	0	0	0	0	0		from Beranek and Ver, NaVCE		
Ground absorption	0.4	0.4	0.4	0.4	0.4	0.4		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	8	18	14	16	9	3	**22**			

Alt 1b ***Pump Room, Roof***										
	16	9	3	0	-1	-1		A-weighting adjustments		
	Octave Band Center Frequency (OBCF, Hz)									
	125	250	500	1000	2000	4000	overall	Notes		
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	18	18	18	18	18	18		square feet of radiating wall	700 ft^2	
Comp TL of roof	24	24	25	32	32	30		see "pump_compTL_roof" worksheet		
Distance attenuation	27	27	27	27	27	27		distance from roof midpoint to receptor	70 ft	3.28 ft reference distance
Directivity	7	8	9	10	11	12		IAC handbook, 90 degrees		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0	0	0	0	0	0		from Beranek and Ver, NaVCE		
Ground absorption	0.4	0.4	0.4	0.4	0.4	0.4		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	18	26	26	27	25	22	**33**			

37.9 =logsum of all three sound paths (both facades and the roof)

Alt 1B* Pump Room, west *Façade — *12" hollow CMU*

	125	250	500	1000	2000	4000	overall	Notes		
A-weighting adjustments	16	9	3	0	-1	-1				
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		5 *number of pumps
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	17	17	17	17	17	17		square feet of radiating wall	490 ft^2	
TL of room wall	21	24	25	32	32	30		see "pump_compTL_walls" worksheet, assumes ***long wall*** and 12" acoustical louver installed		
Distance attenuation	26	26	26	26	26	26		distance from façade to receptor	65 ft	3.28 ft reference distance
Directivity	0	0	0	0	0	0		west façade facing southern receptor, so these values represent no directivity loss		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0.0	0.0	0.0	0.1	0.2	0.4		from Beranek and Ver, NaVCE		
Ground absorption	0.0	0.0	0.0	0.0	0.0	0.0		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	28	33	34	37	35	34	**42**			

Octave Band Center Frequency (OBCF, Hz)

Alt 1B* Pump Room, south *Façade — *8" hollow CMU*

	125	250	500	1000	2000	4000	overall	Notes		
A-weighting adjustments	16	9	3	0	-1	-1				
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	14	14	14	14	14	14		square feet of radiating wall	280 ft^2	
TL of room wall	39	38	44	51	57	60		see "pump_compTL_walls" worksheet, assumes ***short wall***		
Distance attenuation	28	28	28	28	28	28		distance from façade to receptor	85 ft	3.28 ft reference distance
Directivity	5	5	5	5	5	5		south façade is facing the southern receptor, so these values represent directivity loss		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0	0	0	0	0	0		from Beranek and Ver, NaVCE		
Ground absorption	0.0	0.0	0.0	0.0	0.0	0.0		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	0	9	6	8	1	-6	**13**			

Octave Band Center Frequency (OBCF, Hz)

***Alt 1b* Pump Room, Roof**

	125	250	500	1000	2000	4000	overall	Notes		
A-weighting adjustments	16	9	3	0	-1	-1				
3000 gpm pumps (5 running at once)	84	86	86	89	86	82	94	SPL unweighted dB at 1m, calc'd from "pump_ref" based on individual pump power and RPM		
Room volume term, without absorption	5	5	5	5	5	5		from EEPENG, Table 6.2		
Room absorption	5	6	9	6	5	4		see "pump_abs_calcs" worksheet, assumes interior treatment applied		
Wall radiation term ("C")	18	18	18	18	18	18		square feet of radiating wall	700 ft^2	
Comp TL of roof	24	24	25	32	32	30		see "pump_compTL_roof" worksheet		
Distance attenuation	28	28	28	28	28	28		distance from roof midpoint to receptor	85 ft	3.28
Directivity	7	8	9	10	11	12		IAC handbook, 90 degrees		
Intervening Barrier	0	0	0	0	0	0				
Air absorption	0	0	0	0	0	0		from Beranek and Ver, NaVCE		
Ground absorption	0.0	0.0	0.0	0.0	0.0	0.0		from Beranek and Ver, NaVCE (also ISO 9613-2)	5 ft	average of height of source and height of receiver
predicted SPL (dBA)	17	25	25	26	23	21	**31**			

Octave Band Center Frequency (OBCF, Hz)

42.5 =logsum of all three sound paths (both facades and the roof)