2101748

PARADIGM LAND DESIGN LLC
GPO@ParadigmLand.US • (520) 664-4304

TO: Town of Oro Valley
Community & Economic Development Dept.
11000 N La Cañada Dr.
Oro Valley, AZ 85737

DATE: 7/10/2021

PROJECT: La Cañada & Naranja, NE Corner Retail/Office Development

PROJECT #: 20aza01

SUBJECT: Conditional Use Permit Request for Drive-Thru Use

Approximately 2.8 acres of land at the northwest corner of the intersection of La Canada Drive and Naranja Drive is proposed for development of a neighborhood-scale retail and office complex. The project is anticipated to include a mix of retail shops, offices and a restaurant including drive-thru service. All proposed uses are permitted by existing zoning, although the drive-thru element of the restaurant requires a Conditional Use Permit. As such, we submit this request for approval of said permit concurrently with the review and approval of the Conceptual Site Plan package for the overall development. Below are the criteria for evaluating Conditional Use Permits as stated in Section 22.5 of the Oro Valley Zoning Code, along with responses to each criterion.

1. That the granting of such conditional use permit will not be materially detrimental to the public health, safety, or welfare. In arriving at this determination, the factors which shall be considered shall include the following:

   a. Damage or nuisance arising from noise, smoke, odor, dust, vibration or illumination;

      ✓ ***Of the potential nuisances listed, the proposed drive-thru use could only create noise impacts to surrounding properties. Attached to this letter is a noise study prepared by Spendiarian & Willis Acoustics & Noise Control LLC. The study analyzed existing noise levels and also modeled potential noise impacts based on the proposed drive-thru speaker location. The study concluded modern, well designed, and intentionally located drive-thru kiosks will not have an adverse effect on nearby homeowners.***

   b. Hazard to persons and property from possible explosion, contamination, fire or flood;

      ✓ ***None.***

   c. Unusual volume or character of traffic.

      ✓ ***Attached to this letter is a traffic impact study prepared by M Esparza Engineering LLC. The study analyzed existing traffic levels and also modeled potential traffic impacts of the proposed development based on industry-standard trip generation rates from the Institute of Transportation Engineering. Admittedly, drive-thru lanes do tend to create traffic levels***

above typical restaurant uses. However, most vehicular trips "generated" by a restaurant drive-thru lane are considered "pass-by" visits rather than "destination" visits, meaning that most of those cars will already have been on the roadway system anyway. For perspective, the entire proposed development is expected to generate just over one car per minute during rush-hour, whereas the surrounding roadway system can easily accommodate hundreds of vehicles per hour. The study concluded that the existing nearby roadway system can accommodate the development without causing existing levels of service to drop below acceptable levels.

Additionally, drive-thru restaurants experience their peak traffic generation during the weekday lunch and dinner hours, which corresponds to when the project's office uses will be generating less traffic. Thus, actual traffic generation is less than a simple sum of the "peak" traffic expected from each proposed land use.

2. That the characteristics of the proposed use are reasonably compatible with the types of use permitted in the surrounding area and sufficient mitigation measures are employed to minimize impact on adjoining properties.

   - ✓ ***As previously stated, the development's proposed retail/office and restaurant uses are already permitted by existing zoning. Those uses were established by the Canada Hills PAD decades ago and have proven to be compatible with the PAD's surrounding residential areas. For example, the shopping center across Lambert from the subject property, and also the centers at the northwest, northeast, and southeast corners of La Canada and Lambert all have the same zoning as the subject property and have developed compatibly with surrounding areas. Two of the aforementioned corners already feature drive-thru uses.***

3. That the proposed use is consistent with the goals and policies of the general plan.

   - ✓ ***This neighborhood-scale development supports a number of General Plan goals and policies. For example:***

     - ***3.4.D. – This project will help Oro Valley to be a community with a wide range of services, amenities, shopping, and dining opportunities that meet the needs of current and future residents.***

     - ***3.6.CC.6. – This project will be an inviting, walkable, and attractive commercial gathering place right across the street from the Oro Valley Library.***

     - ***3.6.CC.8. – This infill project will help complete the original Canada Hills PAD vision of fostering complete neighborhoods with easy access to commercial areas offering amenities and services for residents' daily needs.***

- ***5.5.LU.5. – As part of the overall Canada Hills PAD, this commercial property has been situated at the intersection of two arterial roadways, and already features open space areas along its northern and western edges to soften the transition from commercial to residential land use.***

- ***5.5.LU.6. – This neighborhood-scale infill development helps maintain OV's neighborly character.***

- ***5.5.LU.8. – Responsible development of this small commercial property continues to fulfil the original vision of the Canada Hills PAD, which is a mixed-use master plan encompassing over a square mile of Oro Valley.***

- ***5.7.DG.1. – The developer will fund their fair share of any new infrastructure is required to offset the impacts of this development.***

- ***5.8.I.10. – This development's central, infill location is extremely accessible by pedestrians and bicyclists. In fact, multi-use paths already exist along the property's eastern and southern roadway frontages.***

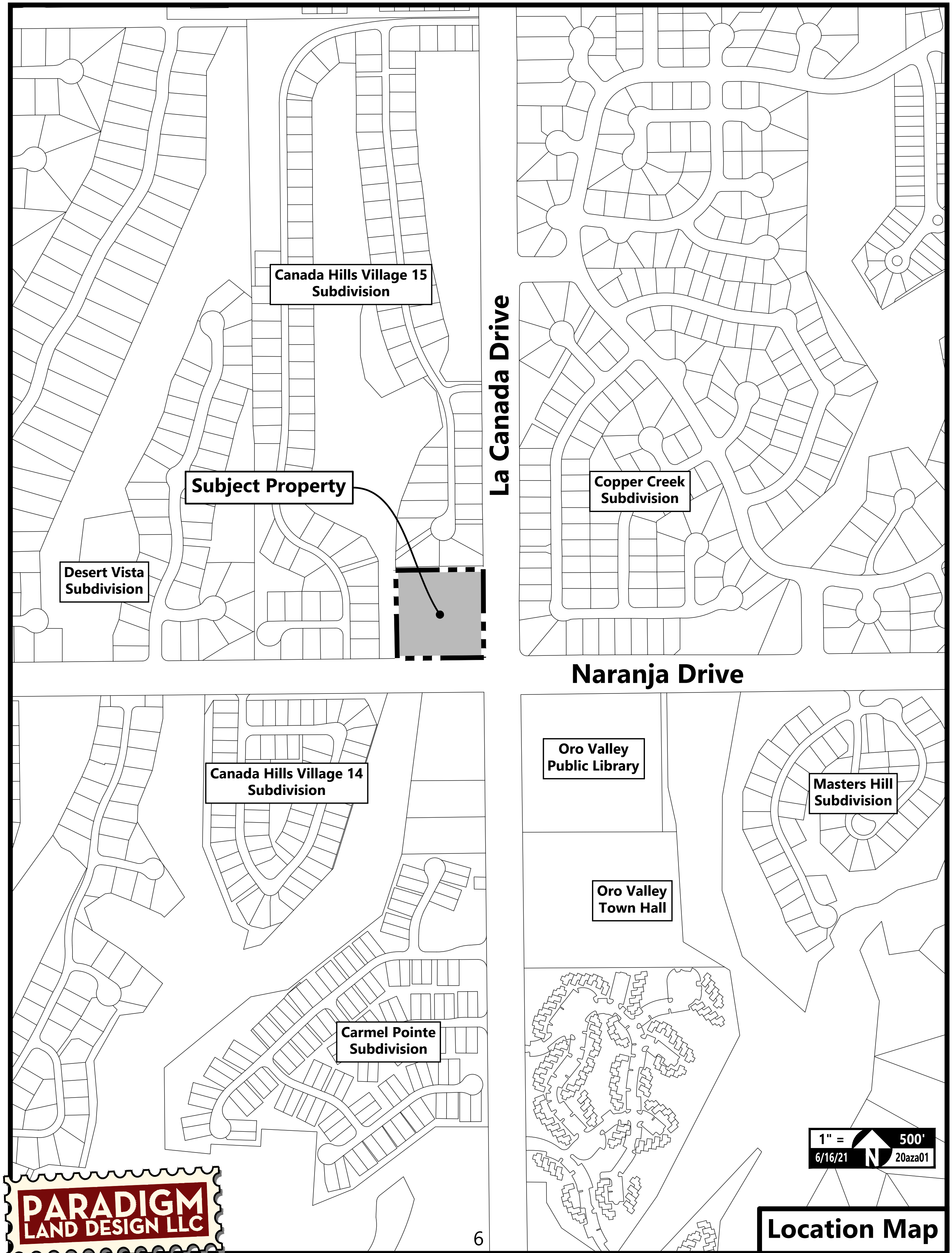
4. That the hours of operation of the proposed use will not adversely impact neighboring properties.

   ✓ ***The hours of operation will not adversely impact neighboring properties.***

The proposed drive-thru use will not have an adverse impact on nearby homeowners or on public infrastructure. Rather, it will add to Oro Valley's growing choice of conveniently located eateries. We appreciate your consideration of this request. Please do not hesitate to contact me with any questions.

Sincerely,

Paul Oland



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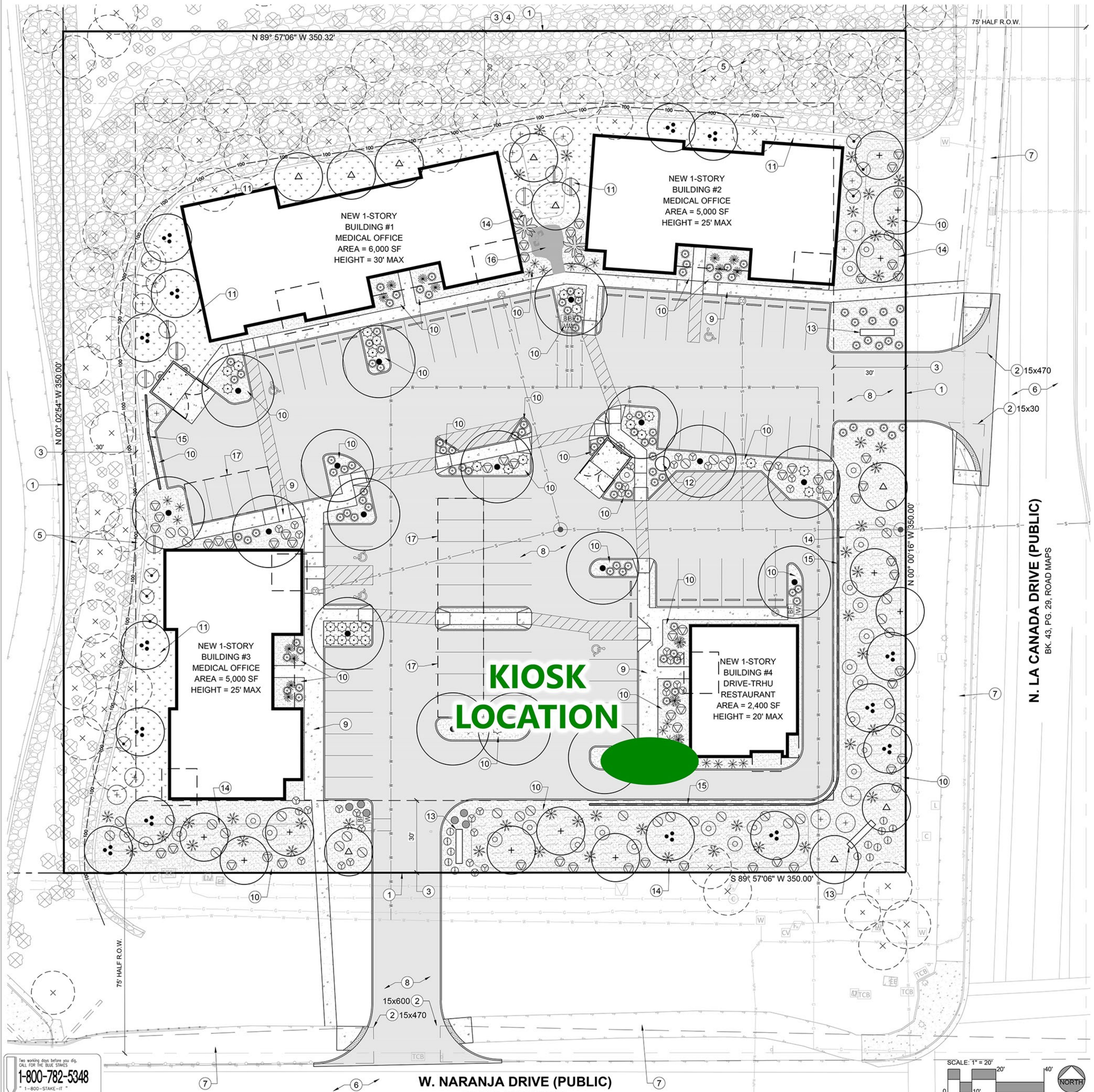

CONCEPTUAL LANDSCAPE LEGEND

Furnish and install landscape material per plans, details and specifications. All plant material to meet ANA specifications and be of sound health and appearance.

Trees	Size	Qty
Native tree	salvage	3
	48" box	1
	36" box	6
	24" box	4
Native hybrid buffer yard tree	24" box 1.5" caliper	11
Native hybrid tree	24" box 1.5" caliper	9
Parking lot shade tree	24" box 1.5" caliper	17
Existing tree to remain in place		

Shrubs / Ground Covers	Size	Qty
Large native shrub	5 gallon	15
Large native shrub	5 gallon	26
Medium shrub	5 gallon	38
Medium shrub	5 gallon	62
Large native shrub	5 gallon	7
Large native shrub	5 gallon	7
Small ground cover	1 gallon	13
Small ground cover	1 gallon	102
Small ground cover	5 gallon	6
Existing shrub/accent to remain in place, typ.		

Vines	Size	Qty
Flowering vine	5 gallon	3

Cacti / Succulents	Size	Qty
Large cacti accent	5 gallon	--
Large accent	24" box specimen	3
Medium accent	5 gallon	44
Small accent	5 gallon	36
Medium accent	5 gallon	32
Small accent	5 gallon	12
Small cacti accent	5 gallon	--
Small accent	5 gallon	17
Medium accent	5 gallon	2

GROUND COVER MATERIAL LEGEND

Furnish and install all material per plans, details, and specs.

Decorative rock 01
- type: screened rock
- size: 1/2"
- color: coco brown - pioneer materials
- depth: 2"
- notes: install in all landscape planting areas as indicated on plans

Decorative rock 02
- type: rip rap
- size: 3 - 6"
- color: santa fe brown
- depth: 6"
- notes: refer to civil paving plans, details and specifications

Decorative rock 03
- type: stabilized decomposed granite
- size: 1/4" minus
- color: palomino gold
- depth: 3"
- notes: stabilizer solutions stabilizer® w/ 15lbs of stabilizer® per ton of aggregate

Hydro-seed - mix 1

20 lbs pure live seed - refer to specs.

Botanical Name	Common Name	lbs/ac
Ambrosia deltoidea	*triangle-leaf bursage*	2.0
Acacia constricta	*whitethorn acacia*	1.0
Calliandra eriophylla	*fairy duster*	1.0
Encelia farinosa	*brittlebush*	1.0
Baileya multiradiata	*desert marigold*	1.0
Cassia covesii	*desert senna*	2.0
Psilostrophe cooperi	*paper flower*	1.0
Zinnia pumila	*desert zinnia*	1.0
Aristida purpurea	*purple three-awn*	1.0
Bouteloua curtipendula	*side-oats grama*	1.0
Muhlenbergia porteri	*bush muhly*	2.0
Sporobolus cryptandrus	*sand dropseed*	1.0
Eschscholzia mexicana	*mexican poppy*	1.0
Evolvulus arizonicus	*arizona blue eyes*	1.0
Lupinus sparisflorus	*desert lupine*	2.0
Penstemon parryi	*parry penstemon*	1.0

LANDSCAPE KEY NOTES

1. Property line
2. Sight visibility triangle
3. 30' buffer yard 'b'
4. Existing public 30' drainage easement per bk. 43, pg. 29
5. Existing grouted rip rap drainage channel
6. Existing pavement
7. Existing multi-use path
8. Pavement - refer to civil
9. Concrete sidewalk - refer to civil
10. Decorative rock 01 - all landscape areas, typ.
11. Hydro-seed mix 1 - desert seed mix
12. Public art - by others
13. Monument sign - by others
14. Water harvesting basin - 6" depressed landscape area, refer to civil plans for finish grades
15. Masonry screen wall
16. Courtyard patio - stabilized dg
17. Parking shade canopy

owner/developer:
LA CANADA/NARANJA LLC
PO BOX 57037
TUCSON, ARIZONA 85732
attn: C/0 PAUL OLAND
ph: (520) 664-4304
email: gpo@paradigmland.us

ARC STUDIOS
3117 E. Flower Street
Tucson, Arizona 85716
phone: 520.882.9655
www.arcstudiosinc.com
landscape architecture . urban design
environmental services . irrigation design

site address:
1440 WEST NARANJA DRIVE
ORO VALLEY, ARIZONA 85737

legal description:
A PORTION OF LAND IN THE SE 1/4 OF THE SE 1/4 OF SECTION 03, T12S, R13E, G&SRB&M, TOWN OF ORO VALLEY, PIMA COUNTY, ARIZONA
A.P.N. 224-10-002B

REGISTERED LANDSCAPE ARCHITECT
CERTIFICATE NO.
39813
ERIC R.
BARRETT
06/21
Date Signed
ARIZONA USA
EXPIRES 9/30/2021

case number:
xx.xx.xx
ref. number:
xx.xx.xx

date:
2021.06.29

project # -
01-20080

Refer to specifications for additional information on policies, performances, and products.

project description:
CONCEPTUAL LANDSCAPE PLAN
for NWC LA CANADA / NARANJA

LANDSCAPE PLAN

L2.0

2 of 2 Sheets

June 22, 2021

Town of Oro Valley
11000 N. La Canada Drive
Oro Valley AZ 85737

Re: La Canada & Naranja NW Corner
Conditional Use Permit Request

To Whom it May Concern:

This letter shall serve as authorization for Paradigm Land Design LLC to represent La Canada Naranja LLC in the application for a variance affecting the property referenced above.

La Canada Naranja LLC

Signature: Robert Schwartz

Printed Name: Robert Schwartz

Title: Owner

4.0 SUPPLEMENTARY DOCUMENTS

4.1 ADDITIONAL NOTIFICATION

In addition to the Town of Oro Valley (the "Town"), there may be other jurisdictions affecting development of this property. If a property developer waits until late in the development process to contact other pertinent governmental agencies or bodies, additional expense and time in coordination, redesign and development may be a result. Examples of other governmental agencies and/or bodies that may have overlapping jurisdiction over this property include but are not limited to the following:

Federal: The United States Department of the Interior, Fish and Wildlife Service is responsible for Endangered Species Act compliance, etc. Please note, habitat has been designated with the Town.

U.S Fish and Wildlife Field Division
2321 W. Royal Palm Rd., Suite 103
Phoenix, AZ 85021-4951
Phone (602) 640-2720 Fax (602) 620-2730

The United States Corps of Engineers: This agency is responsible for management of jurisdictional waters, etc. Section 404 consultations may be required on properties that contain washes.

U.S. Army Corps of Engineers
5205 E. Comanche
Davis Monthan AFB
Tucson, AZ 85707
Phone (520) 584-4486 Fax (520) 584-4497

State: Arizona Department of Environmental Quality: This agency has multiple responsibilities. Please contact directly for further information.

ADEQ
1110 W. Washington Street
Phoenix, AZ 85007
(602) 771-2300

County: Pima County Department of Environmental Quality: This agency has multiple responsibilities. Please contact directly for further information.

PDEQ
201 N. Stone Avenue, 2nd Floor
Tucson, AZ 85701
(520) 740-6520

Please be advised, issuance of a permit **DOES NOT,** nor should it be construed, to imply compliance with Federal, State or County regulations. If you have any questions concerning your responsibilities under federal law, please contact the applicable agency.

APPLICANT NAME: Paul Oland
CONTACT PHONE AND ADDRESS: 520-664-4304 7090 N Oracle Road #178-193
SITE LOCATION: 1440 W Naranja Drive
PROPOSED USE: Commercial / Retail

Applicant Signature Date 6-21-21

Case/File Number ____________

Preliminary Noise Assessment of Drive-through Kiosk

La Cañada Drive and Naranja Drive

Prepared for

La Cañada Naranja LLC

Project Manager
Bob Schwartz

Lance Willis, PhD

R. 0, July 9, 2021

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1. Summary

This report is a preliminary assessment of the noise impact of a drive-through kiosk at La Cañada Drive and Naranja Drive with respect to Section 25.1 of the Oro Valley Zoning Code. In the daytime use case, kiosk sound levels were found to decrease faster than and fall below the roadway noise levels at the adjacent properties. In the nighttime use case, kiosk sound pressure levels were found to meet the limits in Table 25-1.A of the Zoning Code. Overall the operation of a drive-through kiosk on the proposed site is compatible with surround land uses. Recommendations are made to meet the acoustical performance analysis given in this document.

2. Site Summary

2.1 Proposed Site Development

A commercial retail and office center is proposed for a vacant lot at the corner of La Cañada Drive and Naranja Drive (see Figure 2.1). The project will consist of four stand alone buildings hosting office space and a restaurant. Of interest for acoustical analysis is the drive-through kiosk planned for the restaurant located in the building closest to the intersection.

2.2 Area Summary

The land uses surrounding the proposed site are shown in Figure 2.2. There are single family homes to the east, west, southwest, and north. To the south and southeast are commercial uses.

The homes to the east are located on top of a bluff approximately 20 above the elevation of the proposed site. Figure 2.3 shows the view from the approximate location of the planned restaurant. There is a privacy wall at the back of the home lots; however, it is not high enough to shield the upper level windows of the houses.

2.3 Zoning

Zoning in the area is shown in Figure 2.4 [Pima County ArcGIS Online <https://pimamaps.pima.gov/geoapps/main>]. The proposed site and adjacent properties to north, west, and south are zoned PAD, Planned Area Development. To the east is zone R-4, Townhouse Residential. Farther to the west is a neighborhood zoned R1-7, Single-Family Residential.

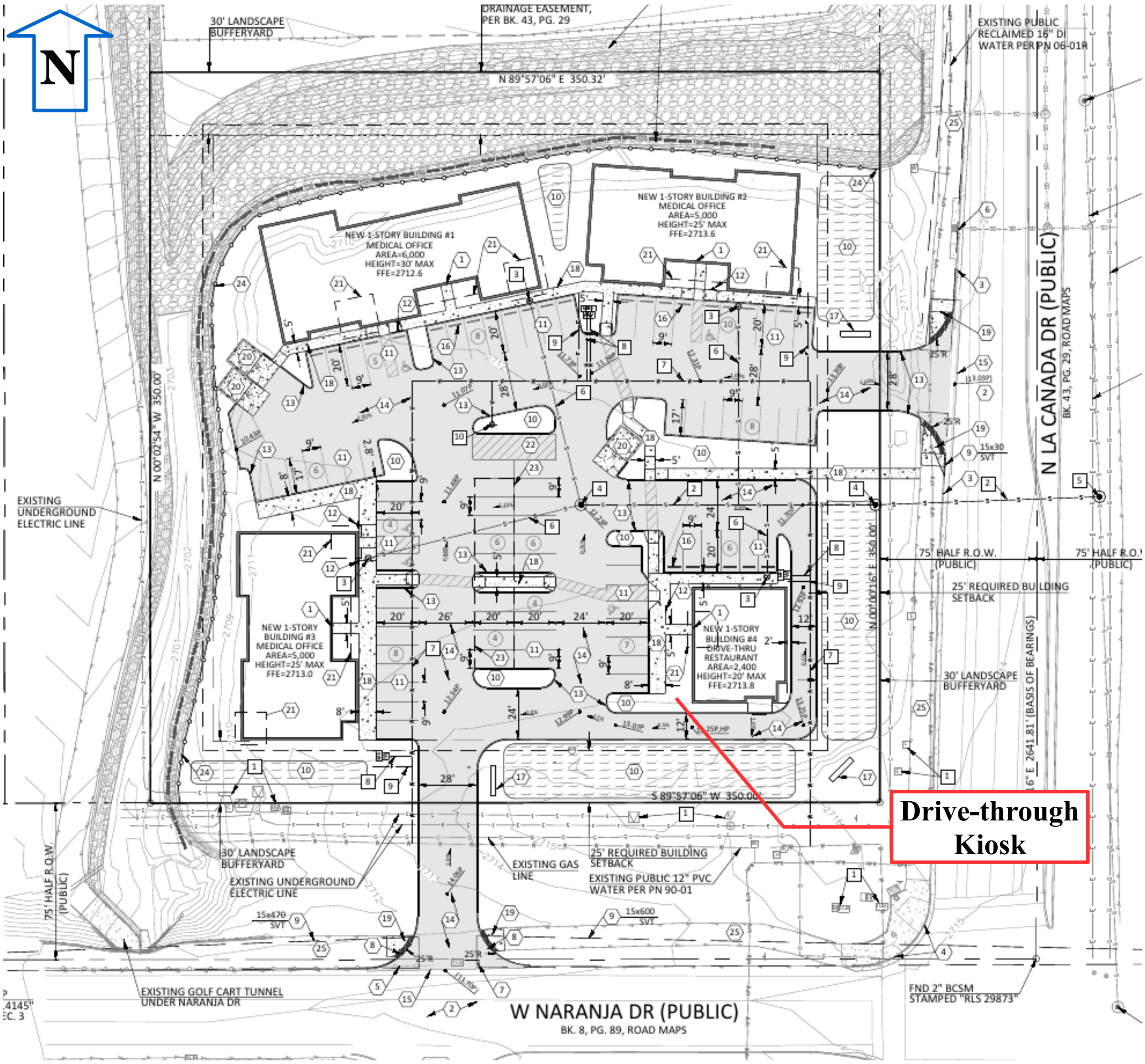


Figure 2.1. Proposed Site Plan

Figure 2.2. Proposed Site and Surrounding Area

Figure 2.3. Houses to East Across La Cañada Drive as Seen from Restaurant Site

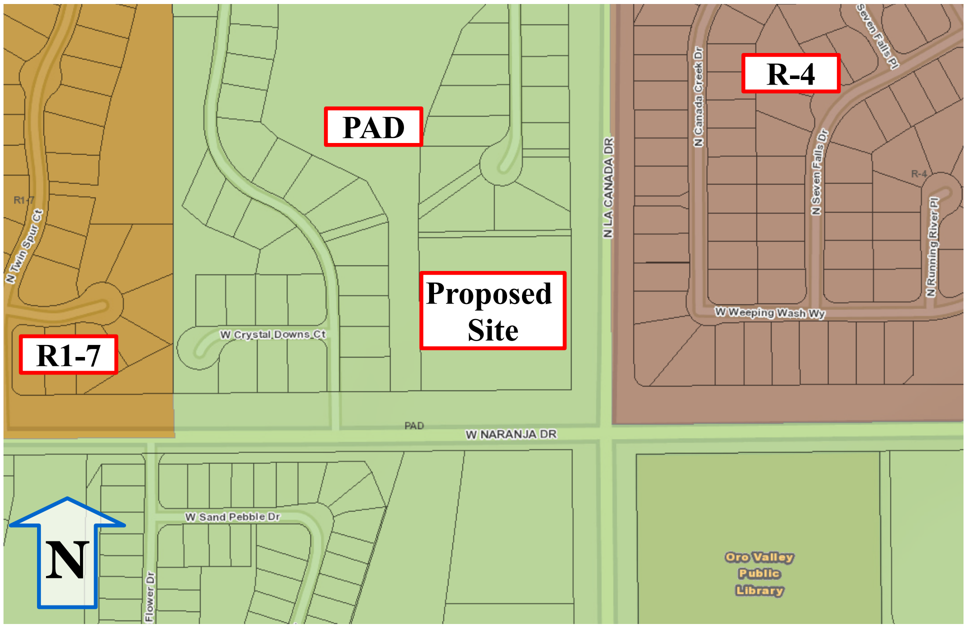


Figure 2.4. Zoning

3. Site Plan Analysis

3.1 Methodology

The acoustical site model has been constructed using the iNoise package version 2021.0 developed by DGMR. The sound propagation model is ISO 9613. This software conforms with the ISO/TR 17534-3 quality standard for implementing the ISO 9613 Part 2 outdoor sound propagation model.

3.2 Kiosk Sound Source

The restaurant in the southeast corner of the proposed site will have a drive-through kiosk. The tenant and equipment used for the kiosk is not known at this time. This analysis will therefore focus on a typical well designed drive-through utilizing sound reproduction equipment manufactured for this purpose.

3.2.1 Location

In order to take advantage of the shielding provided by the restaurant building, both for the homes to the east and to improve speech communication between the kiosk and drive-through customer in regard to roadway noise from La Cañada Drive, the kiosk will be located on the west side of the restaurant as indicated in Figure 2.1. The loudspeaker has been placed 3 feet above grade, 10 feet from the west facade of the restaurant, and 5 feet from the customer in the drive-through lane.

3.2.2 Use Cases

A well designed kiosk will often have an automated gain control (AGC) function to adjust the output of the loudspeaker based on the background noise level. The AGC reduces the amount of sound produced at times when the background noise is low such as during nighttime hours. This is useful for kiosks located in areas where there is a large variation in background noise at different times of day such near a highway.

This leads to two use cases. One is when the loudspeaker volume is determined relative to the background noise level. The other is when the background noise is not a factor and the kiosk output is set to achieve a normal conversation level.

In the former case, the equivalent-continuous sound pressure level, LAeq, will be set at 15 dBA above the background noise level. This is a common setting for good speech communication in the presence of noise. In the latter case, LAeq will be set to a sound pressure level of 65 dBA at the customer position.

3.2.3 Zoning Code Requirements

The Oro Valley Zoning Code Section 25.1 gives specific recommendations for maximum allowable sound pressure levels according to receiving land use, time of day, and the characteristics of the sound produced. Speech is considered regular impulsive sound. All equivalent-continuous levels will be adjusted by 5 dBA. Neither the restaurant employee speaking or the loudspeaker used will produce noticeable sound in the 16, 31.5, or 63 Hz octave bands. The one minute level limits will therefore not apply in this application.

The level limits in Table 25-1.A of the Code that apply are the one hour average limits and maximum sound limits. These limits are adjusted upward in the presence of background noise levels that exceed the limits. This will apply in the use case where the kiosk level is set 15 dBA above the roadway noise. Here the concern will be whether the one hour average and maximum sound pressure levels exceed the background noise level at the adjacent properties or whether they are masked by it.

3.2.4 Source Characteristics

Since the frequency response of the sound reproduction system is not known, an ANSI S3.5 normal effort speech spectrum will be used for the loudspeaker. Table 3.1 shows the unadjusted and unweighted octave band speech sound pressure levels that will serve as the starting point for the source model.

Octave Band (Hz)	Sound Pressure Level (dB)
125	48.10
250	56.86
500	59.09
1000	54.09
2000	48.77
4000	43.48
8000	37.03

Table 3.1. Normal Effort Speech Levels

The loudspeaker enclosure is also not known. A cardioid directivity pattern with a 10 dB rear null will be assumed as shown in Figure 3.1. The loudspeaker faces south.

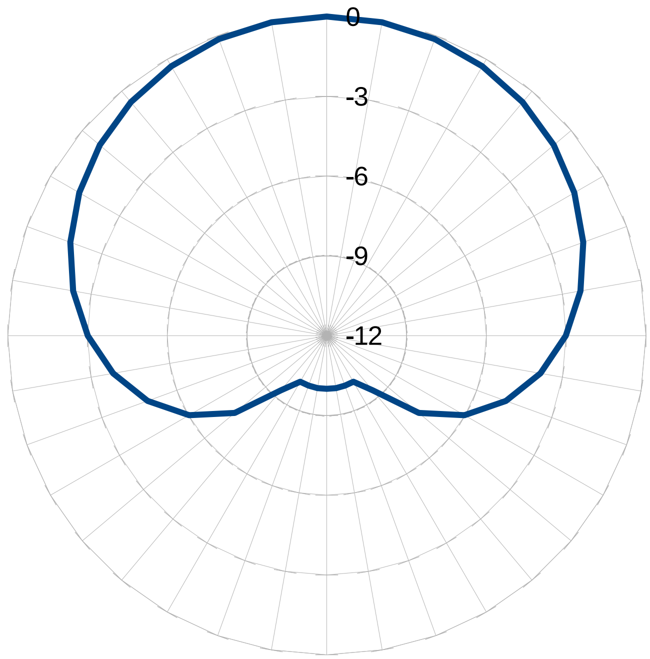


Figure 3.1. Kiosk Directivity Pattern

The relative difference in LAeq and LAmax will be assumed to be 15 dBA. This is a conservative estimate of the fast exponential time weighted speech crest factor and does not take into account a number of factors that will tend to decrease the level difference. These may include power compression by the loudspeaker driver and audio compression in the signal processing (not including the AGC).

Other undefined factors that will tend to reduce the amount of sound leaving the property include the directivity of kiosk and obstacles, mainly the customer's vehicle, that will block sound and reduce the directivity.

3.3 The Model Space

Figure 3.2 gives an overview of the acoustical model. The drive-through kiosk is located on the west side of the restaurant building. Four receiver field points have been selected to verify sound pressure levels at nearby homes. These are at:

- 1381 W Weeping Wash Way
- 1393 W Weeping Wash Way
- 11182 N Sand Pointe drive
- 11240 N Scioto Ave

The heights of the receivers on Weeping Wash Way are at 16 feet above grade to evaluate the sound reaching the upper level windows of these houses. The others are at 5 feet above grade.

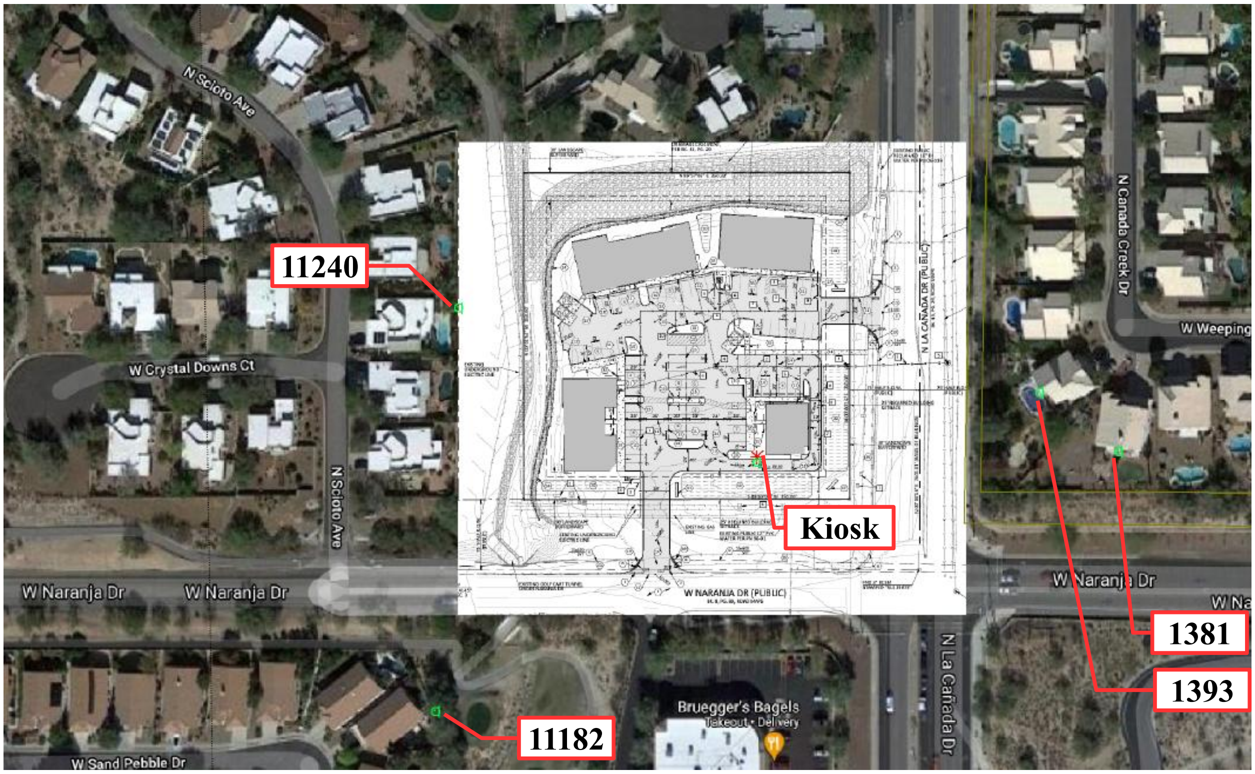
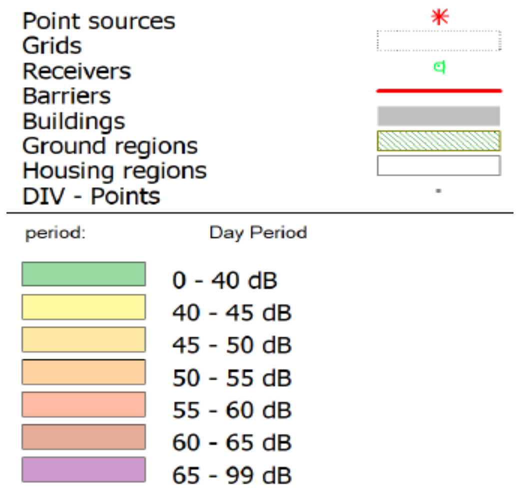


Figure 3.2. Model View

3.4 Sound Pressure Level Contour Maps

Sound pressure level contours in the figures below are displayed in 5 dBA increments. The legend identifying the map symbols is in Figure 3.3. All sound pressure levels are A-weighted. Sound walls are labeled as barriers in the iNoise software. The height of the grid points is 5 feet above grade.



igure 3.3. Legend for Sound Pressure Level Contour Maps

3.5 Low Background Noise Use Case

In the kiosk use case where background noise levels do not interfere with speech intelligibility, a normal conversation level at the customer vehicle is sufficient. Sound pressure level contours for LAmax are shown in Figure 3.4. The adjusted average levels will be 10 dBA lower.

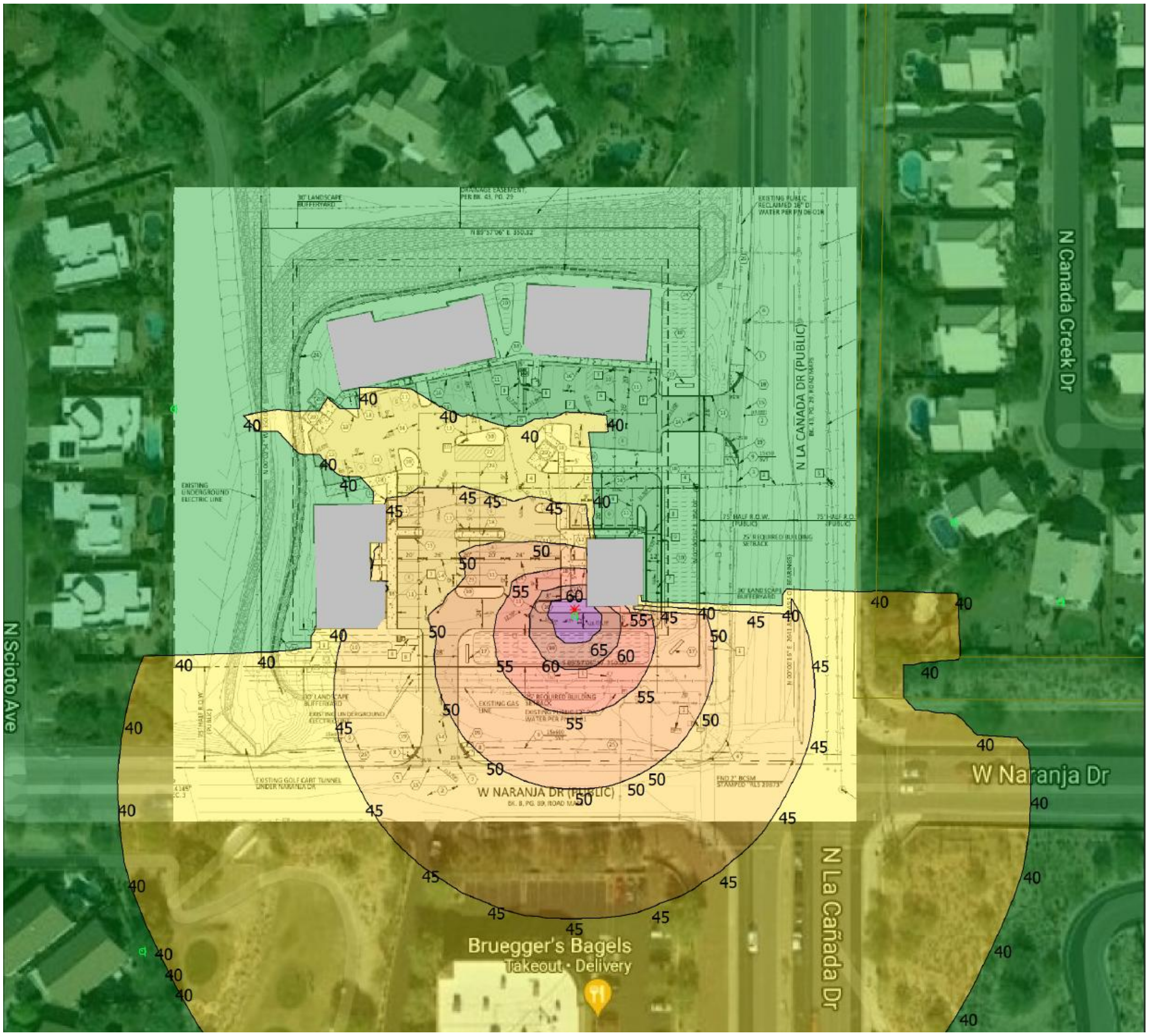


Figure 3.4. LAmax Sound Pressure Level Contours with No Background Noise

As can seen in the above figure and in Table 3.2 below, with moderate kiosk settings the adjusted average (LAeq) and maximum (LAmax) sound pressure levels are below the nighttime limits of 45 and 65 dBA respectively for single family residences in Table 25-1.A of the Code. The sound levels also meet the Code requirements of 65 dBA LAeq and 85 dBA LAmax for the commercial land use to the south of the drive-through.

Location	Height Above Grade (ft)	Adjusted One Hour Average Level (LAeq, dBA)	Maximum Sound Level (LAmax, dBA)
1381 W Weeping Wash Way	16	28.0	38.0
1393 W Weeping Wash Way	16	17.0	27.0
11182 N Sand Pointe drive	5	29.8	39.8
11240 N Scioto Ave	5	20.6	30.6

Table 3.2. Sound Pressure Levels at Adjacent Residential Uses

3.6 Use Case with Road Noise Interference

Acoustical measurements of the roadway noise have not been performed on the proposed site to quantify the background noise levels throughout the day. This part of the analysis will look at the difference between ambient and background sound pressure levels as defined in the Zoning Code at the adjacent properties when the road noise drives the kiosk output to higher levels.

Roadway line sources have been added to the acoustical model. According to the PAG Travel Data and Forecasting website <https://pag.public.ms2soft.com/tcds/tsearch.asp?loc=Pag&mod=>, La Cañada Drive has a daily traffic count of 16,384 vehicles while Naranja Drive has a daily count of 10,885. This is a sound power level difference of 1.8 dBA. The total sound power of the road sources has been set arbitrarily since no measurements are available.

The LAeq of the kiosk at the customer vehicle has been set 15 dBA higher than the road noise at the same location. The adjusted LAeq of the kiosk is 5 dBA higher than this level and the LAmax 15 dBA higher. Figure 3.5 shows the combined roadway LAeq and kiosk LAmax sound pressure levels. The kiosk can be seen to exceed the roadway noise near the restaurant; however, the sound level of a line source decreases by 3 dB with every doubling of distance from the centerline of the roadway. The kiosk is a point source whose sound level decreases 6 dB with every doubling of distance. For this reason the LAmax level of the kiosk falls below the LAeq of the roadways by the time it gets to the adjacent homes.

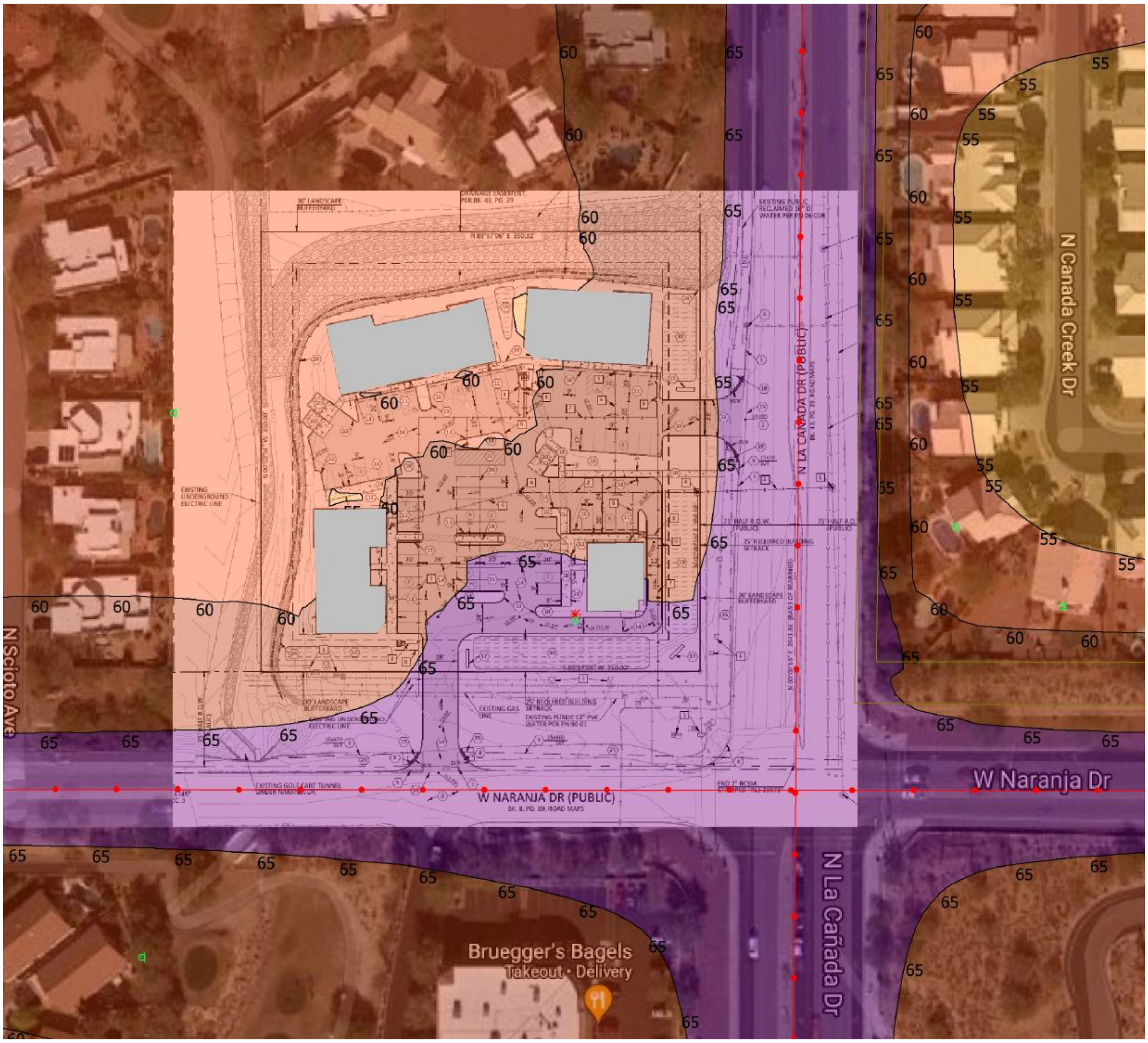


Figure 3.5. LAmax Sound Pressure Level Contours with Roadway Noise

Table 3.3 lists the differences in sound pressure level of the kiosk with respect to the roadway noise at the nearest houses. At each location both the average and maximum kiosk sound levels are less than the roadway noise and would therefore not be measurable.

Location	Adjusted One Hour Average Level Difference (LAeq, dBA)	Maximum Sound Level Difference (LAmax, dBA)
1381 W Weeping Wash Way	-19.7	-9.7
1393 W Weeping Wash Way	-29.4	-19.4
11182 N Sand Pointe drive	-18.5	-8.5
11240 N Scioto Ave	-24.1	-14.1

Table 3.3. Kiosk Sound Pressure Levels at Adjacent Residential Uses in Comparison to Roadway Noise

4. Conclusions and Recommendations

A preliminary investigation of the noise impact of a drive-through kiosk at La Cañada Drive and Naranja Drive has been carried out for two use cases. In one case, for daytime hours, the kiosk loudspeaker must overcome the background noise created by the two adjacent roadways. In the other use case for nighttime hours, moderate conversational sound pressure levels produced by the kiosk were evaluated against the sound pressure level limits in Section 25.1 of the Oro Valley Zoning Code. In the daytime use case, kiosk sound levels were found to decrease faster than and fall below the roadway noise levels at the adjacent properties. In the nighttime use case kiosk sound pressure levels were found to meet the limits in Table 25-1.A of the Code.

The analysis in this report assumes a well designed drive-through kiosk. If the kiosk is operated during evening or nighttime hours an automated gain control (AGC) system may be needed to reduce the kiosk sound level when the background noise level decreases. Placement of the kiosk on the east side of the restaurant is not recommended.

The following are guidelines for minimizing the noise impact of the loudspeaker on the surrounding area and optimizing communication with the customer.

- Place loudspeakers as close as possible to the customer in order to reduce the required amplification for necessary for good communication.
- Avoid placing the kiosk on a curve that will force the vehicle farther away from the loudspeaker.
- Aim the loudspeaker away from noise sensitive areas and avoid directing sound upward.
- To the degree possible, locate kiosks so as to utilize vehicles, buildings, and other structures to block the line of sight from the loudspeakers to noise sensitive areas. A menu board or wall can also be used for this purpose.
- Adjust the loudspeaker volume to the minimum necessary for good communication. In most applications, this should not be more than 15 dBA above the background noise level at the customer's vehicle (including the customer's vehicle).
- If necessary, such as may be the case for kiosks that are operated into the evening or nighttime hours, use an automatic gain control (AGC) amplifier to power the loudspeaker. This will reduce the gain to the loudspeaker during times of lower background noise level.
- Don't place the kiosk in a location with high background noise levels that will require increasing the loudspeaker volume for effective communication.

Not all of these measures may be necessary for a specific application or kiosk design. Ultimately the amplification of the loudspeakers will have to be limited as necessary to comply with the sound pressure level limits set in the Oro Valley Zoning Code. The above recommendations will reduce the amount of amplification necessary for effective communication and minimize the amount of sound going toward noise sensitive land uses.

Finally, this is a preliminary analysis performed without any specific equipment in mind. The final kiosk design should be reviewed before installation to ensure it meets the recommendations and estimated performance provided in this document.

Appendix

A1. Glossary of Acoustical Terms and Abbreviations

A1.1 Abbreviations

AI: articulation index

ASEL: A-weighted sound exposure level

ASTC: apparent sound transmission class

dB: decibel

DNL: day - night level

FSTC: field sound transmission class

Hz: Hertz

IIC: impact insulation class

kHz: kilohertz

L_{eq}, LA_{eq}, LC_{eq}: equivalent sound pressure level

NC: noise criteria

NIC: noise isolation class

NIPTS: noise induced permanent threshold shift

NR: noise reduction

Pa: Pascal

POE: probable occupant evaluation (see room criteria)

PTS: permanent threshold shift

PWL: sound power level

QAI: quality assessment index (see room criteria)

RC: room criteria

RT_{60}: reverberation time

SEL: sound exposure level

SII: speech interference index

SIL: speech interference level

SLM: sound level meter

SPI: speech privacy index

SPL: sound pressure level

STI: speech transmission index

TTS: temporary threshold shift

A1.2 Terms

A-weighting: see frequency weighting

absorption coefficient: see sound absorption coefficient

acoustical coupler: a cavity of predetermined shape and volume used for the calibration of earphones or microphones in conjunction with a calibrated microphone adapted to measure the sound pressure developed within the cavity

anechoic room: a room whose boundaries absorb practically all of the sound incident thereon, thereby providing essentially freefield conditions

articulation index (AI): a number (ranging from 0 to 1) which is a measure of the intelligibility of speech- the higher the number the greater the intelligibility. This metric has been replaced by the Speech Intelligibility Index (SII) defined in ANSI S3.5.

average sound level: see equivalent continuous sound level

background noise: the total noise from all sound sources other than a particular sound that is of interest

band: a subsection of the frequency spectrum

C-weighting: see frequency weighting

coupler: see acoustical coupler

day-night level (DNL): the 24 hour equivalent (average) A-weighted sound pressure level. A 10 dBA penalty is incurred between the hours of 10:00 PM and 7:00 AM. The DNL system has been adopted by the U.S. Department of Housing and Urban Development, the Department of Defense, and the Federal Aviation Administration.

decibel (dB): a unit of level which denotes the ratio between two quantities that are proportional to power; the number of decibels is 10 times the common logarithm (base 10) of this ratio.

diffuse field: a sound field which has statistically uniform energy density and in which the directions of propagation of the sound waves are randomly distributed. In a practical sense, the sound pressure levels at all points in the room are nearly the same except near the room boundaries and a sound wave reaching a given point in the room is equally likely to arrive from all directions.

direct sound: sound which reaches a given location in a direct line from the source without any reflections.

equivalent continuous sound level (L_{eq}): the level of steady sound which, in a stated time period and at a stated location, has the same sound energy as the time varying sound. If frequency weighting is applied, the equivalent continuous sound level may be designated LA_{eq} to indicate A-weighting or LC_{eq} to indicate C-weighting, etc. See also frequency weighting.

field sound transmission class (FSTC): a single number rating similar to sound transmission class (STC), except that the transmission loss values used to derive this class are measured in the field. FSTC ratings are typically lower than STC ratings which are measured under laboratory conditions.

flanking path: A wall or floor/ceiling construction that permits sound to be transmitted along its surface; or any opening, which permits the direct transmission of sound through the air.

freefield: a sound field in which the boundaries have negligible effect over the frequency range of interest.

frequency: the number of times that a waveform repeats itself in a given period of time, usually one second, i.e. the number of cycles per second). Unit: Hz.

frequency weighting: a prescribed frequency dependent attenuation or amplification applied to measured sound data usually intended to better approximate the sensation of loudness in a human listener. For example, A, B, and C weighting approximate the frequency dependent shape of the equal loudness contours for soft, moderate, and loud sounds.

Hertz (Hz): unit of frequency, cycles per second.

impact insulation class (IIC): a single number metric used to compare the effectiveness of floor-ceiling assemblies in providing reduction of impact-generated sounds such as footsteps. This rating is derived from values of normalized impact sound pressure levels in accordance with ASTM E492.

insertion loss: the reduction in sound level at the location of the receiver when a noise reduction measure such as a barrier, attenuator, muffler, etc. is inserted into the transmission path between the source and receiver. Unit: dB.

level: the logarithm of the ratio of a given quantity to the reference quantity of the same kind. Levels represent physical quantities such as sound pressure on a logarithmic scale and are therefore expressed in decibels. Unit: dB.

loudness: that attribute of auditory sensation in terms of which sounds may be ordered on a scale extending from soft to loud. Unit: sone.

masking: the process by which the threshold of hearing for one sound is raised by the presence of another sound.

noise criteria (NC): a single number criteria for the HVAC or mechanical noise level in a room derived from measured octave band data. The octave bands are weighted to de-emphasize low frequencies because the human ear is least sensitive to these frequencies. This metric is not valid for outdoor measurements.

noise induced permanent threshold shift (NIPTS): the permanent hearing loss resulting from noise exposure.

noise isolation class (NIC): a single number rating derived from measured values of noise reduction between two enclosed spaces that are connected by one or more paths. This rating is not adjusted or normalized to a standard reverberation time.

noise reduction (NR): the difference in sound pressure level between any two points along the path of sound propagation, e.g. the difference in level between the interior and exterior of a building where the sound level inside is due only to exterior noise.

octave: the frequency interval between two tones whose frequency ratio is 2.

omnidirectional microphone: a microphone whose response is independent of the direction of the incident sound wave.

Pascal (Pa): a unit of pressure. 1 Pascal = 1 Newton per square meter ($1 N / m^2$).

permanent threshold shift (PTS): a permanent increase in the threshold of hearing at a given frequency.

point source: a source that radiates sound as if from a single point.

receiver: a person (or persons) or equipment which is affected by sound.

refraction: (1) the phenomenon by which the direction of propagation of a sound wave is changed as a result of a spatial variation is the speed of sound. (2) The angular change in direction of a sound wave as it passes obliquely from one medium to another having different sound speed.

reverberation time (RT_{60}): of an enclosure, for a sound of a given frequency or frequency band, the time that is required for the sound pressure level in the enclosure to decrease by 60 dB after the source has stopped. Unit: second.

room criteria (RC, RC Mark II): an octave band metric for evaluating HVAC noise inside a room. RC is a two dimensional metric consisting of a curve number that is the arithmetic average of the 500, 1000, and 2000 Hz octave band sound pressure levels and a qualitative descriptor identifying the character of the sound spectrum. The descriptor can be (N) for neutral, (LF) for low frequency dominance (rumble), (MF) for midfrequency dominance (roar), and (HF) for high frequency dominance (hiss). In addition, acoustically induced vibration can be designated by (LFV_B) for moderate, but perceptible vibration and (LFV_A) for clearly perceptible vibration. As an example, the maximum RC prerequisite for LEED is designated as RC 37(N) indicating curve number 37 with a neutral spectrum.

Further, two intermediary metrics are used in calculating the room criteria. The quality assessment index (QAI) is a measure of the deviation from the given RC curve. The probable occupant evaluation (POE) is based on the magnitude of the QAI and can be 'Acceptable,' 'Marginal,' or Objectionable.'

Sabin: a unit of measure of sound absorption; a measure of sound absorption of a surface. It is the equivalent of 1 square foot of a perfectly absorbing surface; a metric Sabin is the equivalent of 1 square meter of a perfectly absorbing surface.

sone: the unit of loudness. One sone is the loudness of a pure tone presented frontally at a frequency of 1000 Hz and a sound pressure level of 40 dB referenced to 20 micropascals.

sound absorption coefficient (α): ideally, the fraction of diffusely incident sound power that is absorbed (or otherwise not reflected) by a material or surface.

sound exposure level (SEL): over a stated time period or event, 10 times the logarithm base 10 of the ratio of the time integral of the sound pressure squared to the product of the reference sound pressure, 20 μPa, squared and the reference time, one second. This quantity is used to characterize single events of short duration where the averaged level (L_{eq}) is inadequate.

sound level meter (SLM): an instrument that is used to measure sound level, with a standard frequency weighting and standard exponentially weighted time averaging.

sound power level (PWL): the total acoustical power emitted from a sound source expressed in decibels relative to 10^{-12} Watts.

sound pressure level (SPL): the acoustical pressure amplitude expressed in decibels relative to 20 micropascals.

sound transmission class (STC): a single number rating used to compare sound insulation properties of walls, floors, ceilings, windows, or doors. See also field sound transmission class.

speech intelligibility index (SII): metric defined under ANSI S3.5 to quantifiy the intelligibility of speech under adverse listening conditions such as noise masking, spectral filtering, and reverberation. The SII is defined for a scale of 0 to 1 where values greater than 0.75 indicate good communication and values below 0.45 indicate generally poor communication conditions.

speech intelligibility test: a procedure that measures the portion of test items (such as syllables, monosyllabic words, or sentences) that are heard correctly.

speech interference level (SIL): an index for assessing the interference effects of noise on the intelligibility of speech, derived from measurements of the background noise level of contiguous octave bands; i.e. the arithmetic average of the octave band sound levels for the bands centered at 500, 1000, 2000, and 4000 Hz (four band method) or the corresponding average for the octave bands centered at 500, 1000, and 2000 Hz (three band method). If other octave bands are used they must be specified. Unit: dB.

speech privacy index (SPI): The SPI is essentially the opposite of the speech intelligibility index and is defined as 1 - SII and usually represented as a percentage. An SPI above 80% is considered normal privacy while an SPI above 95% would meet the requirements of confidential privacy.

speech transmission index (STI): an index for rating the intelligibility of speech that takes both noise and reverberation into account.

temporary threshold shift (TTS): a temporary increase in the threshold of hearing at a given frequency.

threshold of hearing: for a given listener, the minimum sound pressure level of a specified sound that is capable of evoking an auditory sensation. The sound reaching the ears from other sources is assumed negligible.

transducer: a device designed to receive an input signal of a given kind and to furnish an output signal of a different kind in such a manner that the desired characteristics of the input signal appear in the output signal. For example, a microphone takes an acoustic pressure as an input and produces an electrical voltage as an output that is direct proportion to the instantaneous acoustic pressure amplitude. Other common examples in noise measurement would be a loudspeaker, accelerometer, or laser Doppler vibrometer (LDV).

transmission loss: the reduction in sound level from one side of a partition to the other.

wavelength: the distance a sound wave travels in the time it takes to complete one cycle.

weighting: see frequency weighting

A2. General Acoustics

Sound Pressure Level (SPL)

Sound is small, rapidly varying perturbations of atmospheric pressure with respect to the slowly changing ambient pressure. The ambient pressure is measured with a barometer while the small acoustic perturbations are measured with a microphone.

The unit of sound pressure is the Pascal (Pa). However, due to the wide range of acoustic amplitudes that can be heard by the human ear, sound pressure is normally expressed on a logarithmic scale having units of decibels (dB). Sound pressure expressed this way is known as the sound pressure level (SPL) and has the following relation to sound pressure.

$$SPL = 20\log_{10}\left(\frac{p}{p_{ref}}\right) \tag{A2.1}$$

Here p is the sound pressure in Pascals. p_{ref} is a reference pressure, the threshold of hearing at 1000 Hertz (Hz), 20×10^{-6} Pa.

A-Weighting

The above formulation of SPL is a purely physical quantity. Due to the nonlinear and frequency dependent characteristics of the human ear it does not always correlate well with the perception of loudness. To improve the correlation for noise assessment purposes, a frequency weighting is often applied called A-weighting. The A-weighting function is based on listening tests in which human subjects adjusted tones throughout a range of frequencies to have equal loudness compared to a tone having an SPL of 40 dB at 1000 Hz. Figure A2.1 shows equal loudness contours according to ISO 226.

Thus applying A-weighting to measured sound pressures more closely represents the frequency response of the human ear for low to moderate amplitude sound. Sound pressure levels that have been A-weighted are denoted by the symbol, dBA. Figure A2.2 shows the A frequency weighting and several other common weightings.

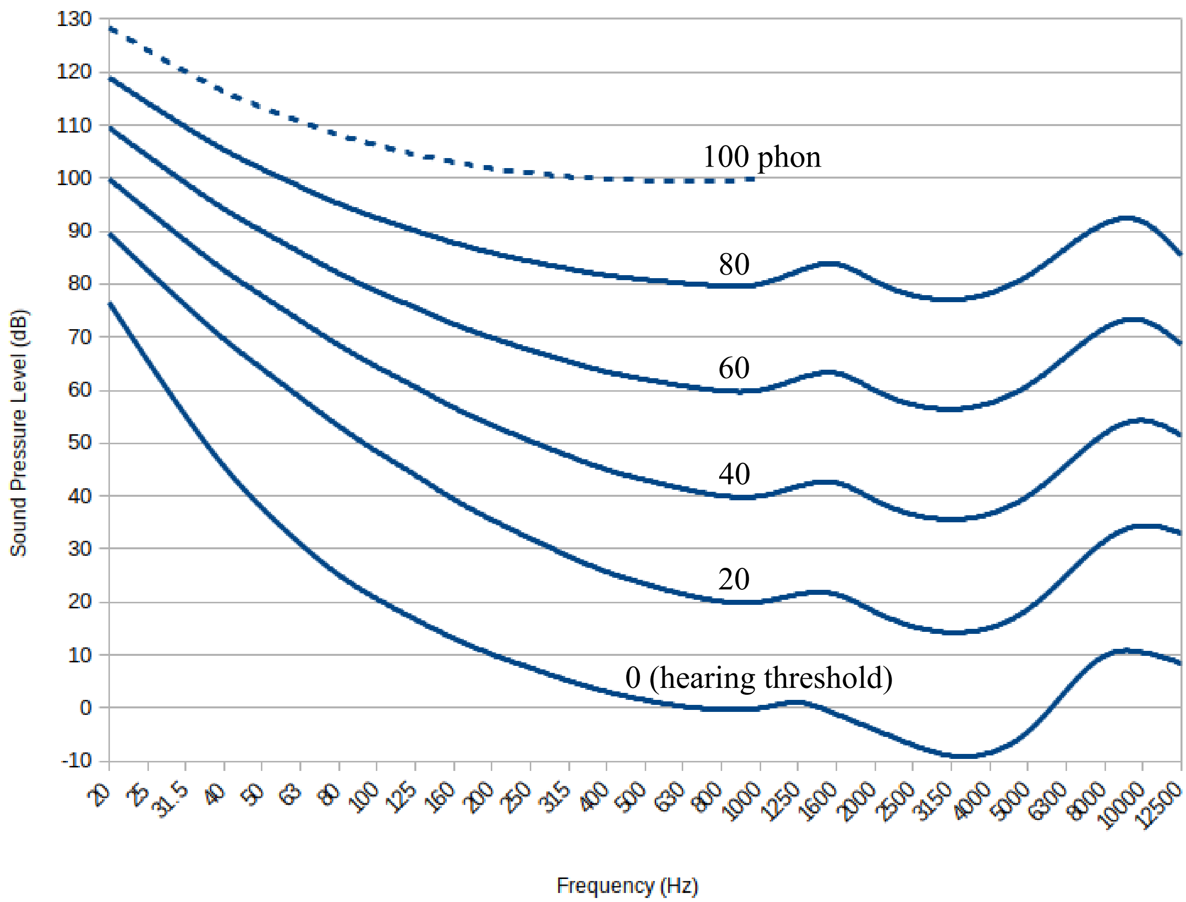


Figure A2.1. ISO 226 Equal Loudness Contours

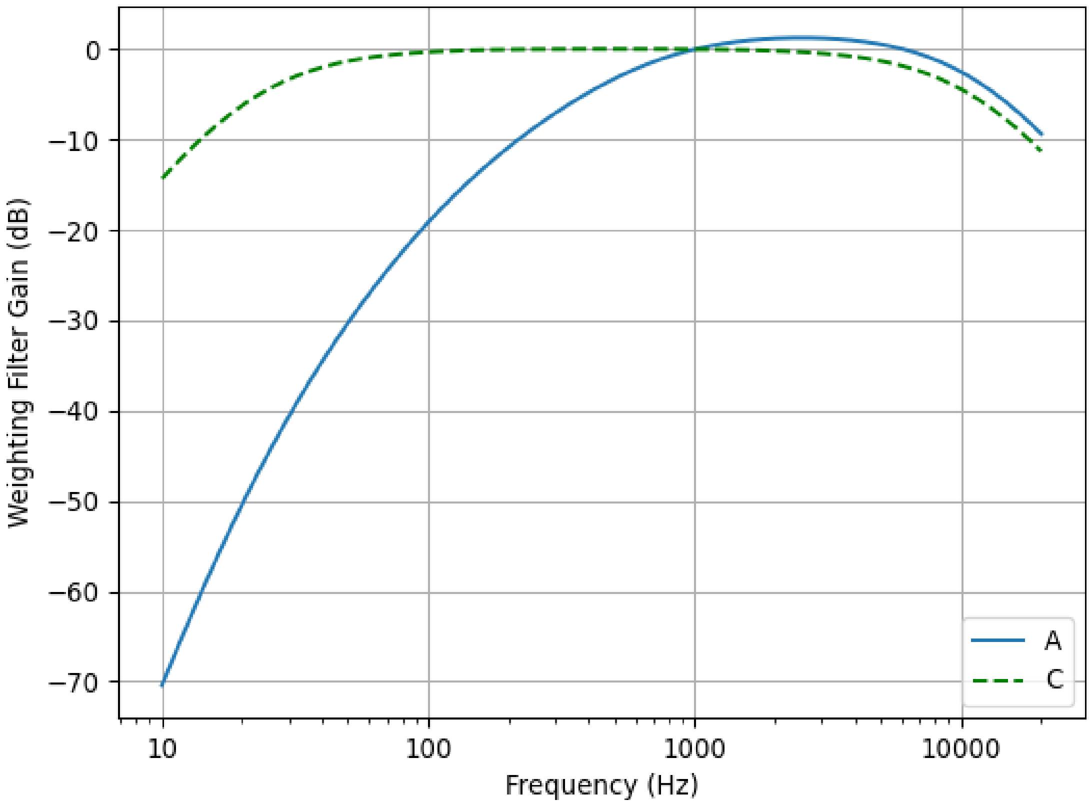


Figure A2.2. Frequency Weighting Filter Curves

The Perception of Sound

The most basic descriptions of sound are loudness (amplitude) and pitch (frequency). The frequency range of human hearing is roughly 20 to 20,000 Hz, although most people can not hear this full range because high frequencies are lost as a natural part of aging and other factors such as illness and exposure to high levels of noise that may cause permanent hearing loss.

Amplitude Attenuation with Distance

Sound originating from a small point source will spread spherically in all directions, absent any nearby surfaces. The conservation of energy requires the sound pressure spreading out from such a source to decrease by half with each doubling of distance. This is known as the inverse square law and is demonstrated in Table A2.1 and Figure A2.3.

Distance from Source (ft)	SPL (dBA)	SPL Loss Relative to 10 ft
10	90	
20	84	6
40	78	12
80	72	18
160	66	24
320	60	30

Table A2.1. Decrease of SPL with Distance Due to Spherical Spreading

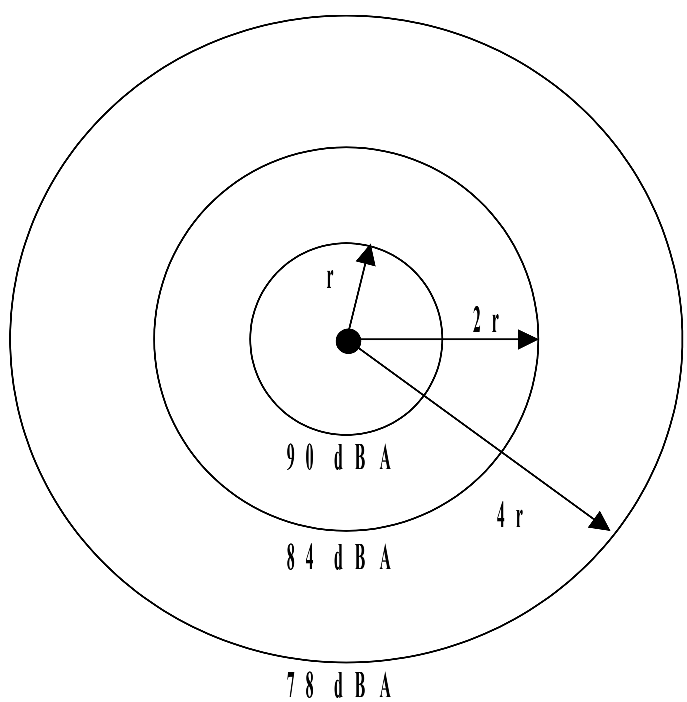


Figure A2.3. Decrease of SPL with Distance Due to Spherical Spreading

Adding Decibels

Summing the contributions from multiple sound sources to obtain the total SPL is *not* done simply by adding the decibel levels because SPL is a logarithmic quantity.

Imagine a fan produces a moderate SPL of 65 dBA at 6 feet. If a second identical fan were turned on the resulting SPL would not be 130 dBA. This would be equivalent to a commercial jetliner taking off at close range.

The correct method of adding the SPL from each source is to sum the acoustic power produced by each source. This implies that each time the number of sources having equal SPL is doubled, the SPL will increase by 3 dBA. Therefore, in the example with two fans, the correct total SPL would be 68 dBA. More examples with multiple sources producing equal SPL are shown in Figure A2.4.

$$65 \text{ dBA} + 65 \text{ dBA} \neq 130 \text{ dBA} \quad \textbf{WRONG} \tag{A2.2}$$

$$65 \text{ dBA} + 65 \text{ dBA} = 68 \text{ dBA} \quad \textbf{RIGHT} \tag{A2.3}$$

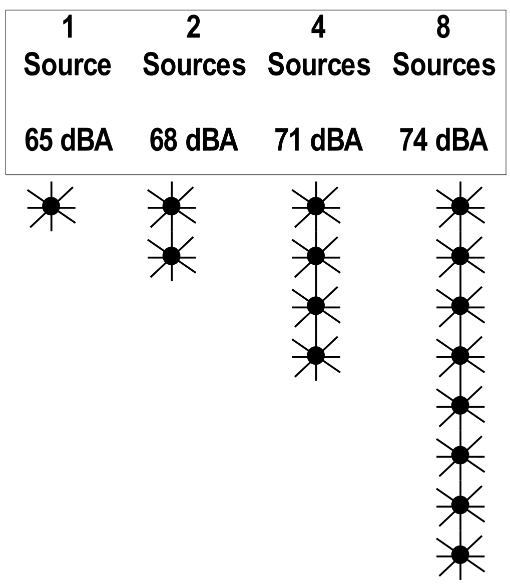


Figure A2.4. Total SPL from Multiple Sources with Equal SPL Output

Further Reading

Bruel and Kjaer, “Measuring Sound.” Covers topics in this appendix in more detail. Available on the Bruel and Kjaer website, www.bkhome.com. Find this and other primers under the library section of the site.

Cyril M. Harris, Ed. Handbook of Acoustical Measurements and Noise Control, 3rd Edition. Acoustical Society of America, Melville, NY, 1998.