Appendix F:
Noise Modeling Analysis

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April 20, 2016

Mr. Doyle Heaton
DRG Builders, Inc.
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VIA Email: doyle@drgbuilders.com, cort@munsellecivil.com

SUBJECT: Environmental Noise Assessment
The Oaks at Foss Creek Residential Development, Healdsburg CA

Dear Mr. Heaton:
This report presents the results of the environmental noise and vibration assessment conducted for the proposed single and multi-family residential development for your proposed Oaks at Foss Creek residential development at 111, 155, and 157 Chiquita Road in Healdsburg, CA. Vehicular traffic on Highway 101 west of the site and future freight and commuter rail service on the adjacent Northwestern Pacific (NWP) railroad line at the western edge of the site are the primary sources of noise affecting the project site. This study evaluates the compatibility of the proposed single-family residential uses proposed with the future noise environment at the project site. Included in the report is a summary of applicable noise and vibration regulations, the results of a noise monitor survey, an evaluation of the site's existing and future noise and vibration exposure with respect to applicable standards, and recommendations to mitigate noise and vibration impacts on the proposed project. Persons not familiar with environmental noise analysis are referred to Appendix A for additional discussion.

REGULATORY BACKGROUND

The City of Healdsburg has established plans and policies designed to limit noise exposure at noise sensitive single family residential land uses that are relevant to the proposed project. These plans and policies are contained in the City of Healdsburg General Plan (1). Considering the close proximity of site development to the NWP rail line where SMART passenger and freight rail services are proposed in the near future, sleep disturbance criteria related have been used in this document to address maximum interior noise levels within the project that may result in significant sleep disturbance (2). Vibration impact criteria proposed by the Federal Transit Administration (FTA) have been used in this document to address impacts from potential ground-borne vibration at the project (3).

1. ***City of Healdsburg General Plan.*** The City of Healdsburg has established plans and policies designed to limit noise exposure at noise sensitive single residential land uses that are relevant to the proposed project. These plans and policies are contained in the Safety Element of the City of Healdsburg's 2030 General Plan. The following noise goals, policies, and measures are relevant to the proposed project:

GOAL S-G Protection of residents and other sensitive noise receptors from the harmful effects of excessive noise.

Policies

S-G-1 New development shall not be approved unless it is generally consistent with the Land Use Compatibility for Community Noise Environments guidelines contained in General Plan Figure 10 (see Table 1) and it is demonstrated that the new development will not violate the City's ordinance regulating excessive noise.

S-G-2 The City will require the inclusion of design techniques in new construction that minimize noise impacts, including building location and orientation, building design features, and placement of noise-tolerant components (i.e., parking, utility areas, and maintenance facilities) between noise sources and the sensitive receptor areas where necessary to meet the Land Use Compatibility for Community Noise Environments guidelines contained in General Plan.

S-G-5 The City will work to minimize noise impacts related to passenger or freight rail service.

Table 1: Healdsburg GP (Figure 10) Noise and Land Use Compatibility

Land Use Category	Community Noise Exposure (dBA, L_{dn})			
	Normally Acceptable[1]	Conditionally Acceptable[2]	Normally Unacceptable[3]	Clearly Unacceptable[4]
Residential-Single-family, duplex, mobile home	≤60[5]	55–70	70–75	75+
Residential-Multi-family	≤65[6]	60–70	70–75	75+
Residential-Interior	≤45	---	---	---
Transient lodging - Motel, hotel	<65	60–70	70–80	80+
School, library, church, hospital, nursing home	<70	60–70	70–80	80+
Auditorium	---	<70	65+	---
Sports arena, outdoor spectator sports	---	<75	70+	---
Playground, neighborhood park	<70	---	67.5–75	72.5+
Golf course, cemetery	<75	---	70–80	80+
Commercial-retail, office, service	<70	67.5–77.5	75+	---
Industrial, utility, agriculture	<75	70–80	75+	---

Notes:

1. Specified land use is satisfactory based on the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.
2. New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and after needed noise insulation features are included in the design. Conventional construction, but with closed windows and fresh-air supply systems or air conditioning, will normally suffice.
3. New construction or development should generally be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design. Outdoor areas must be shielded.
4. New construction or development should generally not be undertaken.
5. Outdoor private use areas
6. Outdoor active use areas, excluding balconies

Implementation Measures

S-16 Require a noise study, including field noise measurements, for any proposed project that would place a potentially-intrusive noise source near an existing noise-sensitive use or place a noise-sensitive land use near an existing or potentially-intrusive noise source such as a freeway, arterial street or railroad.

S-19 Work with entities providing passenger or freight rail service to utilize equipment and operate in a manner that minimizes noise impacts to the community to the maximum

feasible extent. Seek the installation of supplementary safety measures at highway-rail grade crossings in order to apply for Quiet Zones in the city.

S-20 Where necessary, require the provision of sound-proofing and other similar noise-attenuating measures in residential development when proximate to noise sources.

S-23 Use the Federal Transit Administration vibration impact criteria to evaluate the land use compatibility of sensitive uses proposed along the railroad using the best available information (without active railroad operations) or site-specific analyses (with active railroad operations). Developers of sensitive uses shall demonstrate that potential impacts of existing or potential vibration have been minimized to the maximum feasible extent.

S-25 Where construction occurs that would result in a potentially-significant impact on noise-sensitive uses, require use of noise-reducing measures that may include the following:

a. Equip internal combustion engine-driven equipment with intake and exhaust mufflers that are in good condition and are appropriate for the equipment.
b. Locate stationary noise-generating equipment as far as possible from sensitive receptors in the vicinity.
c. Utilize "quiet" air compressors and other stationary noise sources where technology exists.
d. Erect temporary noise control blanket barriers in a manner to shield noise sensitive uses.
e. Control noise levels from workers' amplified music so that sounds are not audible sensitive receptors in the vicinity.
f. Designate a "disturbance coordinator" responsible for responding to complaints about project construction noise and taking reasonable measures to correct the problem. Conspicuously post a telephone number for the disturbance coordinator at the construction site and include it in any notice sent to neighbors regarding the construction schedule.

2. Supplemental Annoyance and Sleep Disturbance Criteria

Though the City noise criteria is typically sufficient to achieve an acceptable interior noise environment with common environmental noise source, when dealing with loud intermittent noise sources, such as the sounding of train horns near railroad tracks, the achievement of an L_{dn} of 45 dBA within homes may still result in maximum noise levels within interiors great enough to result in significant sleep disturbance and resident annoyance. Studies have been undertaken to determine the effect of short-term maximum noise levels on these issues. The conclusions of the studies related to the sleep disturbance typically give a probability of sleep disturbance related to the maximum noise level of the event at the sleep location and the duration of the event. A review of these data shows that limiting maximum noise levels to 55 dBA within bedrooms will limit the probability of waking the future residents of the homes at the subject project when trains pass the site to less than five percent per occurrence[1]. Therefore, though this is not a City or State requirement, I&R recommends the adoption of additional interior sound level criteria limiting maximum noise levels to 55 dBA within bedrooms of the homes adjacent to rail lines. To limit annoyance and disturbance of non-sleeping residents, we recommend limiting maximum noise levels to 60 dBA in other residential living areas of these homes.

[1] Kryter Karl D., The effects of Noise on Man, Second Edition, Academic Press, Inc. London, 1985, p.444-446

3. Groundborne Vibration

The City of Healdsburg has not identified quantifiable vibration limits that can be used to evaluate the compatibility of land uses with the expected vibration environment, however the Safety Element of the General Plan does direct the use of the Federal Transit Administration (FTA) vibration impact criteria to evaluate the land use compatibility along railroad lines. The FTA[2] vibration impact criteria has been developed to assess vibration impacts associated with rapid transit projects based on maximum overall levels for a single event. The criteria for groundborne vibration impact are shown in Table 1. Note that there are criteria for frequent events (more than 70 events per day), occasional (between 30 and 70 events per day) and infrequent events (less than 30 events per day).

Table 2: Groundborne Vibration Impact Criteria

Land Use Category	Vibration Impact Limits (VdB re: 1 µin./sec, RMS)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events [3]
Category 1: Buildings where low ambient is essential for interior operations	65 VdB[4]	65 VdB[4]	65 VdB[4]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB
Category 3: Institutional land uses with primarily daytime use	75 VdB	78 VdB	83 VdB

Notes: 1. "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events per day. This category includes most commuter rail systems.
4. This limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes.

EXISTING NOISE ENVIRONMENT

The project site is located west of Highway 101and the commercial entrance to the Simi Winery (identified as Montepuliciano Road), north of Chiquita Road, and east of the NWP railroad line and Healdsburg Avenue (see Figure 1). The primary noise source on the project site is vehicular traffic on Hwy 101, which is elevated as it passes the site. Occasional traffic on Chiquita Road and truck passbys on Montepuliciano Road along the distant traffic on Healdsburg Avenue also contribute to the noise environment, however the day/night average noise levels throughout to site is dominated by highway traffic.

To evaluate the existing noise environment on the project site two long term noise measurements were conducted between 10 am on Wednesday, April 6th, 2016 and 7 am on Friday April 8rd 2013 to establish the daily trend in ambient noise levels on the site. These measurement locations are shown as LT-1 and LT-2 in Figure 1.

The first long-term noise measurement, LT-1, was made about 12 feet above grade near the western edge of the of the site approximately 36 feet east of the Montepuliciano Road centerline and 560 feet north of the Chiquita Road centerline. Chart 1, following, presents a summary of the long-term noise monitoring data at this measurement location.

A review of Chart 1 shows that during this long-term measurement, hourly average noise levels ranged from 57 to 63 dBA L_{eq} during the day and from 52 to 61 dBA L_{eq} at night, with an

[2]U.S. Department of Transportation, Federal Transit Administration, Transit Noise and Vibration Impact Assessment, May 2006, FTA-VA-90-1003-06.

average daytime L_{eq} of 61 dBA and an average nighttime L_{eq} of 55 dBA. The overall and daily average day-night average noise levels (L_{dn}) measured at this site was 64 dBA. The dominant noise source at this site was Hwy 101 Traffic, with isolated maximum noise levels of 79 to 80 dBA from passing trucks and loud vehicles on Montepuliciano Road.

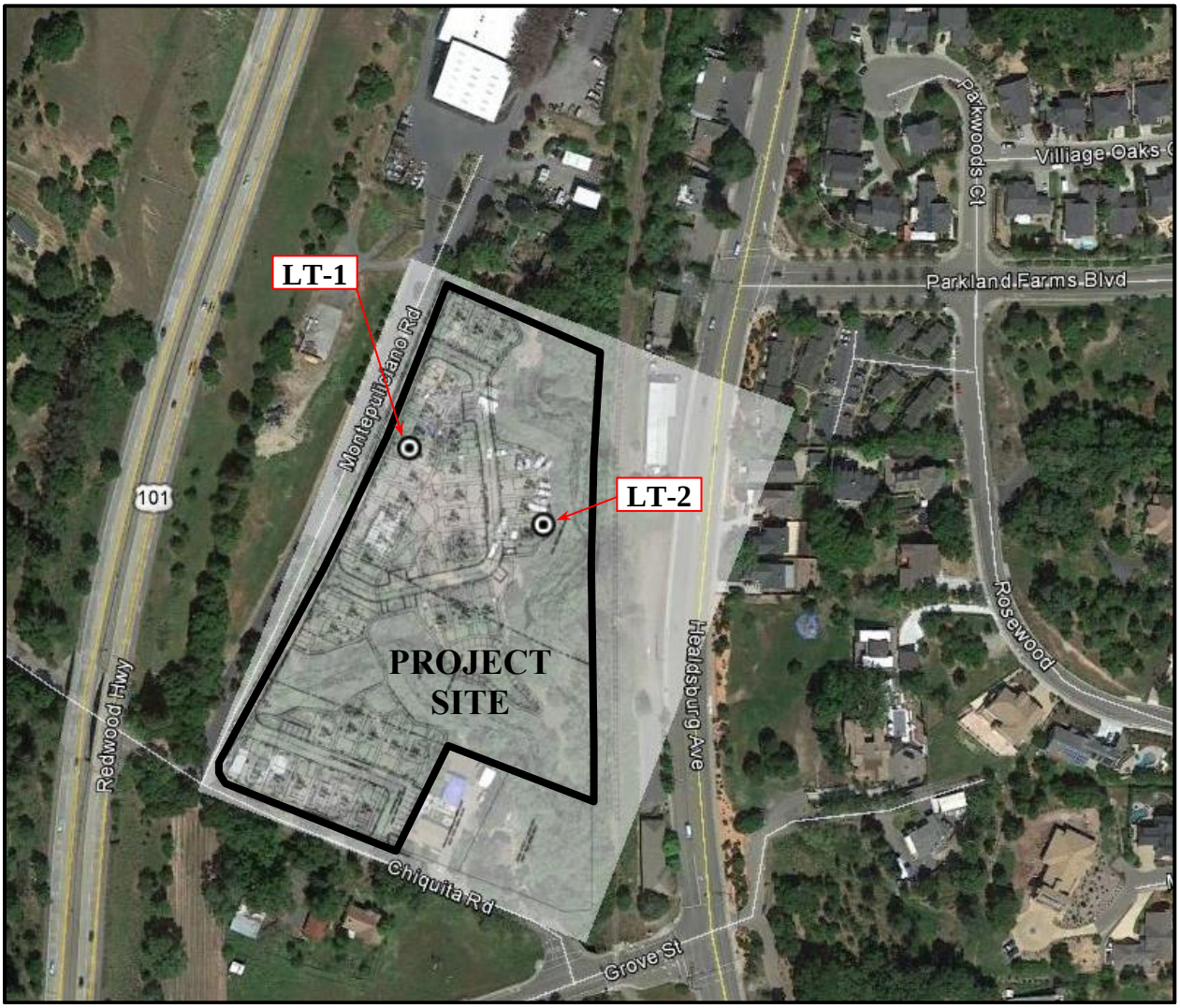


Figure 1: Aerial Photo with Project Site and Noise Measurement Locations

The second long-term noise measurement, LT-2, was made about 6 feet above grade near the eastern edge of the of the site development area approximately 550 feet north of the Chiquita Road centerline and 110 and 325 feet east of the respective centerlines of the NWP railroad line and Healdsburg Avenue. Chart 2, following, presents a summary of the long-term noise monitoring data at this measurement location.

A review of Chart 2 shows that during this long-term measurement, hourly average noise levels ranged from 50 to 56 dBA L_{eq} during the day and from 45 to 56 dBA L_{eq} at night, with an average daytime L_{eq} of 54 dBA and an average nighttime L_{eq} of 49 dBA. The overall and daily average day-night average noise levels (L_{dn}) measured at this site was 57 dBA. The dominant noise source at this site was also Hwy 101 Traffic, with isolated maximum noise levels of 74 dBA from loud vehicles on Montepuliciano Road, and 67 dBA from airplane overflights and barking dogs.

Chart 1: Measured Noise Levels at LT-1

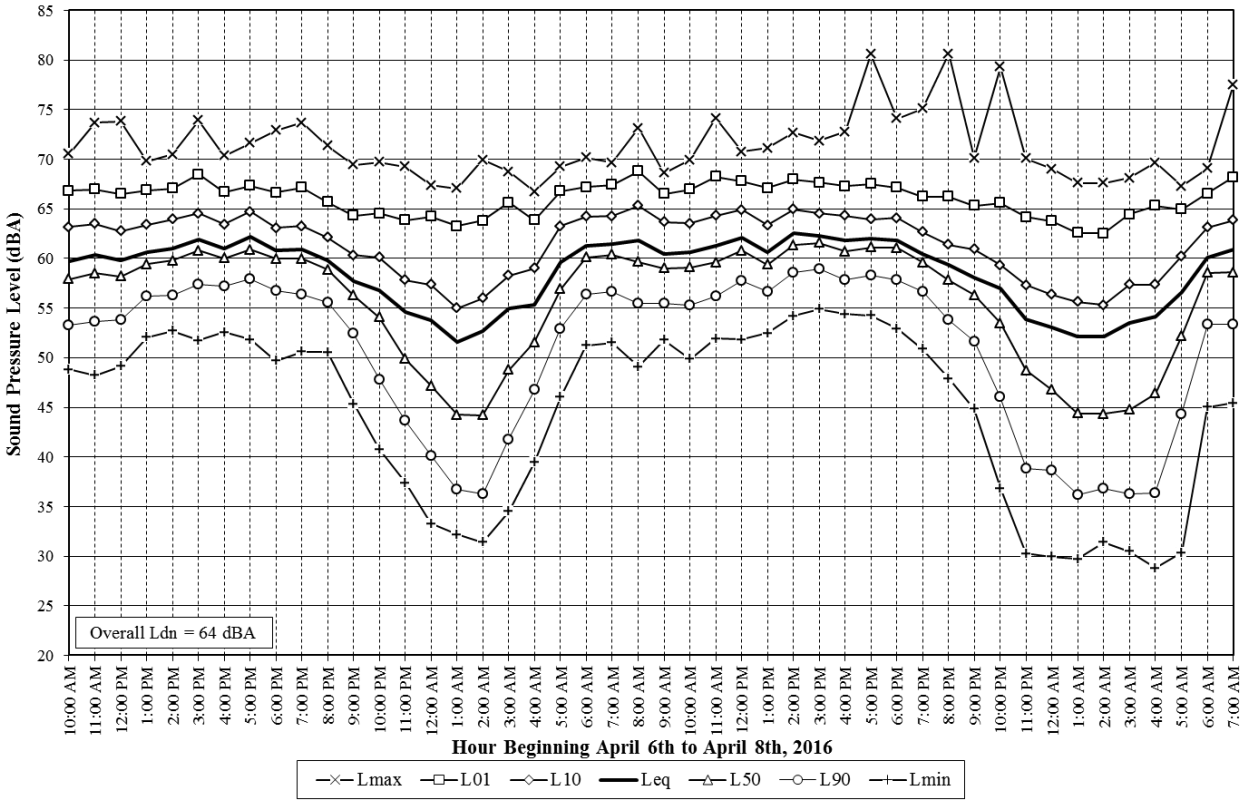
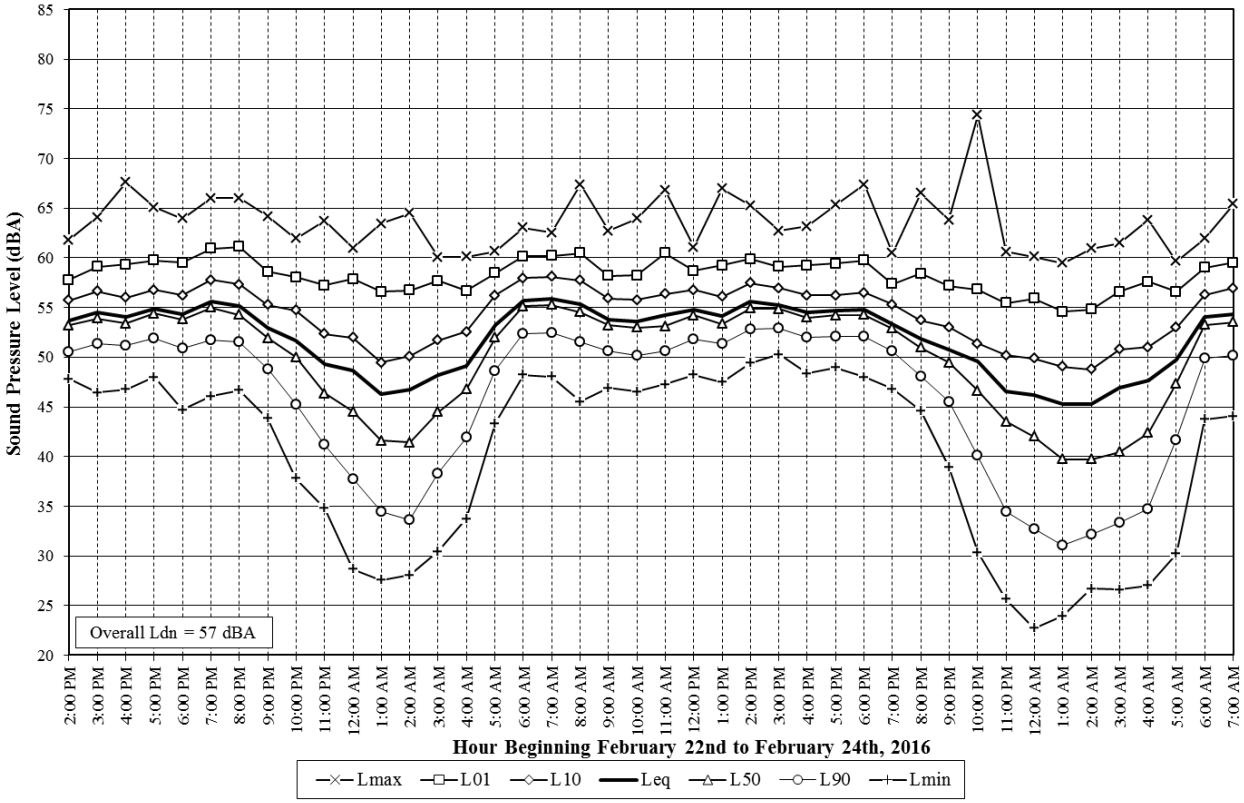


Chart 2: Measured Noise Levels at LT-2



FUTURE NOISE ENVIRONMENT

Roadway Traffic Noise

The future environmental noise levels on the site due to highway and roadway traffic are likely to increase with future increases in highway traffic. Assuming an annual growth rate of between 1% and 2% per year, traffic noise levels in the area would be expected to increase by a maximum of 2 dB L_{dn} over the next 20 years. This would result in future traffic noise levels on the site ranging from between 66 dBA L_{dn} on the western portion of the site (closest to Highway 101) to 59 dBA L_{dn} on the eastern portion of the site (furthest from Highway 101).

Railroad Noise

Under future conditions the NWP railroad line at the western edge is planned to carry commuter and freight rail operations. The March 2008 Draft Supplemental EIR for the SMART project indicate that weekday passenger service would involve twelve round trips per day and weekend passenger service would involve four round trips per day. The Draft Supplemental also notes that the NCRA's proposed freight service would add up to six freight train pass-bys per day between Novato and Santa Rosa and four freight train pass-bys per day north of Santa Rosa. The six pass-bys per day would be generated by three NCRA freight trains: two with two locomotives and up to 60 rail cars, and one train of up to 25 rail cars.

Estimates in the Draft Supplemental EIR indicate that with four to six freight pass-bys per day running at 50 mph, the estimated cumulative noise levels is 59 dB Ldn at 100 feet. This estimate assume that the freight operations do not occur at night (between the hours of 10:00 p.m. and 7:00 a.m.). The Draft Supplemental EIR notes that with one night-time freight operation the noise level will increase to "over 68 dBA L_{dn} within 50 feet of the tracks." Considering that the rail line is mostly single-track and most of the passenger train operations will occur during the day, i.e., between 7:00 a.m. and 10:00 p.m., at least some night-time freight operations could be expected along this rail line.

The average day/night noise levels discussed above deals with average noise exposure, however the sounding of train horns in the vicinity of grade crossings and the engines of passing trains result in high maximum noise levels during train passbys which can cause daytime interruption and/or sleep disturbance. Train operators are required by the State to sound warning horns within ¼- mile from at-grade road crossings, which in this case would occur when southbound locomotives are alongside the development. Information provided in the Draft EIR for the SMART project indicates that the train horns could produce maximum noise levels of approximately 100 dBA at 100 feet sideline distance from the track and the engines of passing trains can produce maximum noise levels of up to 85 dBA at 100 feet from the track

One of the noise mitigation measures in the 2005 Draft and 2006 Final EIR for the SMART project was to obtain Quiet Zone designations at grade crossings in residential areas. Quiet Zones are segments of rail lines where crews are exempt from regularly sounding the train horns at grade crossings. However, the 2005 Draft EIR also noted that since the FRA (Federal Railroad Administration) "has final jurisdiction over Quiet Zone applications, SMART cannot commit to Quiet Zone implementation. SMART has committed to work with any local jurisdictions wishing to be designated Quiet Zones to cooperatively meet the requirements for designation."

One of the main issues determining whether or not Quiet Zones will be implemented at specific locations is likely to be funding, as there might not be sufficient funds available for all locations where the local jurisdictions apply for Quiet Zones. Thus, it cannot be assumed that a Quiet Zone will be implemented at the Chiquita Road grade crossing. Based on the uncertainty related to Quiet Zone implementation, two estimates of the future noise exposure levels along the NWP

rail line at the proposed development have been developed.

To calculate the noise contours adjacent to the NWP rail line with and without Quiet Zone implementation, we have used the FRA Grade Crossing Noise Model. As model inputs, the SMART trains were assumed to run on 30-minute intervals between 6:00 AM to 9:00 AM (during the morning commute) and between 5:00 PM and 8:00 PM (during the evening commute), with trains running less frequently during the daytime hours. Additionally, one daily north-bound freight train and one daily north-bound commuter train are assumed to pass the site between the hours of 10:00 p.m. and 7:00 a.m.

Using this model we have determined that homes on lots closest to the rail line (lots 25 through 28, between 115 to 135 feet from the track centerline), will be exposed to a future L_{dn} of between 63 to 65 dBA with Quiet Zone implementation, and an L_{dn} of between 66 to 68 dBA without Quiet Zone implementation. In addition to these average noise exposure levels, facades of residences on these lots facing the rail line will also be exposed to maximum noise levels of between 81 to 84 dBA from engine noise with Quiet Zone implementation, and to maximum noise levels of between 97 to 99 dBA, from horns of southbound trains approaching the grade crossing, without Quiet Zone implementation.

Railroad Induced Vibration

Based on data in the SMART EIR documents for freight and commuter rail passbys, the ground vibration at 115 feet from the rail track centerline (the approximate setback of the closest proposed residence) could be 79 VdB due to freight rail passbys and would be below 71 VdB due to SMART commuter rail operations.

NOISE ASSESSMENT

EXTERIOR NOISE

Based on the above discussions and a review of the project site plan (see Figure 2), portions of all residential lots on the project site would be exposed to environmental noise levels of between 64 dBA to 68 dBA L_{dn} due to noise from either Hwy 101 traffic or future rail operations. As such the project site would be considered "conditionally acceptable" for residential use. The project site plan does, however, show a central open area where traffic and rail noise would be shielded by the structures of intervening homes, such that environmental noise in this area can be expected to meet the City's "normally acceptable" limit 60 dBA L_{dn}. The project site design also incorporates easements across lot lines to create private side yard open spaces for each home. Based on a review of the lot layouts and residence placements, the side yards of Lots 2 through 10, 17, 21, 22, 23, and 30 will be shielded by the home structures such that environmental noise in the private open spaces of these homes can be expected to meet the City's "normally acceptable" limit 60 dBA L_{dn}. The private side yard and central open areas where the 60 dBA L_{dn} limit is expected to be met without mitigation are shown in Figure 2.

EXTERIOR NOISE MITIGATION MEASURES

To provide some noise protected useable private open space at the homes on lots other than those listed above, and shown in Figure 2, 6 foot high side yard noise barriers between adjacent residences and/or at the side yard frontages. The approximate location of these noise barriers is shown in Figure 3, attached. To be effective as a noise barrier, these walls should be built without cracks or gaps in the face or large or continuous gaps at the base and have a minimum surface weight of 3.0 lbs. per sq. ft. Acceptable materials include, a wood framed stucco faced wall or a solid wood wall.

For a wood wall to meet these requirements we typically recommend that a homogenous sheet material, such as 3/4" plywood, be used as a backing for typical 1" thick (nominal) wood fence slats. Using the plywood ensures the continued effectiveness of the barrier with age, since wood slats alone have a tendency to warp and separate with age allowing gaps to form and the barrier effect of the wall to diminish. A variety of other materials may be used for the barrier wall as long as the above minimum surface weight and gap-sealing specifications for noise attenuation are met.

INTERIOR NOISE

The future noise environment at the project site would continue to result from vehicular traffic but with the use of the NWP rail line for SMART commuter and freight service, rail traffic would also be a major source of noise on the project site.

As discussed above, the facades of the homes on lots 25 to 28, closest to the rail line, facing the tracks would be exposed to an L_{dn} of between 66 to 68 dBA without Quiet Zone implementation and an L_{dn} of between 63 to 65 dBA with Quiet Zone implementation. Additionally, without Quiet Zone implementation the facades of these homes will be exposed to maximum sound levels of between 97 to 99 dBA when trains approaching the Chiquita Road grade crossing sound their horns. With Quiet Zone implementation maximum sound levels at these facades would be 81 to 84 dBA due to the engine noise of passing trains.

Based on a consideration of typical building techniques and exterior door and window percentages for single family residences, exterior noise levels can be expected to be reduced within the residential interiors by between 24 to 27 dBA when standard thermal insulating windows and weather sealed doors are closed. When these windows or doors are open the noise attenuation from exterior to interior is typically reduced by 10 to 12 dBA, such that for this project we would expect exterior to interior noise reduction to be between 12 to 17 dBA with open windows and/or doors.

Based on this exterior to interior noise attenuation, interior L_{dn} levels in the rooms of the residences on lots 25 to 28 facing the NWP rail line with or without Quiet Zone implementation will be below City's interior noise level criteria for residential uses of 45 dBA when standard thermal insulating windows and weather sealed doors are closed for the purpose of noise control. However, the 45 dBA L_{dn} will be exceeded when windows at these or other homes on the site are open with or without Quiet Zone implementation. Additionally, maximum noise levels due to engine passbys (without horns sounding) in the residences on these lots and any others which face or are perpendicular to the rail line would be above the 55 dBA L_{max} sleep disturbance criteria with or without Quiet Zone implementation.

INTERIOR NOISE MITIGATION MEASURES:

1. **Mechanical Ventilation:** All residences will require mechanical ventilation to allow the windows to remain closed at the residents' option as the interior noise standards would not be met with open windows. In our experience a standard central air conditioning system or a central heating system equipped with a 'summer switch' which allows the fan to circulate air without furnace operation in each residence requiring mechanical ventilation will provide a habitable interior environment and thus meet the building code requirement referenced above.

2. **Exterior Walls:** Though the proposed exterior assemblies of the residences have not been reviewed, based on a consideration of typical building techniques, we expect the exterior wall construction of the homes to be single width wood stud walls (2x4 or 2x6) with fiberglass insulation, a single layer of gypsum board attached to the inside of the studs, and 3-coat stucco or wood or cementitious plank siding over wood or gypsum sheathing at the exterior face. A review of available test data for such assemblies indicates that this exterior wall assembly would have an STC rating of between 46[3] and 39[4]. As discussed above with the currently proposed exterior window, door and wall percentages, such exterior wall assemblies would allow the City's interior 45 dBA L_{dn} standard to be met with closed windows and doors. However, the use of this standard exterior wall construction and non-acoustically rated exterior windows and doors may result in maximum instantaneous noise (L_{max}) levels within bedrooms exceeding the 55 dBA sleep disturbance criteria and L_{max} levels in other living spaces which exceed the 60 dBA annoyance/disturbance criteria <u>with or without</u> Quiet Zone implementation, requiring mitigation to meet these standards.

   To reduce maximum noise levels to acceptable levels, exterior wall upgrade 1 or 2, below, are recommended for use for all exterior walls which are facing or perpendicular to the rail line.

   <u>Wall Upgrade 1:</u>

   EXTERIOR: 3-coat Stucco.
   CAVITY: 2x4 wood studs with 3 ½" thick sound attenuation blankets in the cavity.
   INTERIOR: 1 layer of 5/8" gypsum board on ½" resilient channels spaced horizontally at 24"o.c.
   This upgraded exterior wall would have laboratory STC rating of 57[5]

   <u>Wall Upgrade 2:</u>

   EXTERIOR: Wood/cementitious plank siding over wood or gypsum sheathing.
   CAVITY: 2x4 wood studs with 3 ½" thick sound attenuation blankets in the cavity.
   INTERIOR: 2 layers of 5/8" gypsum board on ½" resilient channels spaced horizontally at 24"o.c.
   This upgraded exterior wall would have laboratory STC rating of 56[6]

3. **Exterior Windows:** Standard exterior windows and doors with mechanical ventilation will be sufficient to reduce interior noise levels within the residences facing away from and without any direct views of passing trains on the NWP rail line. However, based on the use of the one of the exterior wall upgrades as discussed in Mitigation 2, above, and typical window and door areas as a percentage of exterior wall areas in residential construction, sound rated windows and doors at the exterior windows and doors at residential facades facing or perpendicular to the NWP rail line will be required to reduce maximum interior noise levels to those considered acceptable for residential use <u>with</u> or <u>without</u> Quiet Zone implementation. The estimated sound ratings of these windows and doors are presented following:
   a. <u>With Quiet Zone Implementation (i.e. no horns sounded at the grade crossing):</u> With either of the exterior wall upgrades, windows with a minimum STC rating of 30 and doors with a minimum STC rating of 26 will likely be needed to reduce interior

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[3] Based on Building Partition Sound Transmission Test no.W-50-71published by the U.S. National Bureau of Standards.
[4] Based on laboratory test NRC #66 in section 1.2.1.5.5.5 of the Catalog of STC and IIC Ratings for the Wall and Floor/Ceiling Assemblies published by the California Office of Noise Control (referred to as the CONC).
[5] Based on Building Partition Sound Transmission Test no.W-52-71published by the U.S. National Bureau of Standards.
[6] Based on similar laboratory test OCF W-5-69 in section 1.2.2.2.4.2 of the CONC.

maximum levels due to train engine noise to meet the 55 dBA L_{max} sleep disturbance standard in bedrooms and the 60 dBA L_{max} annoyance/disturbance standard in other living spaces.

b. Without Quiet Zone Implementation (i.e. horns sounded at the grade crossing): With the use of either of the exterior wall upgrades, windows with a minimum STC rating of 45 and doors with a minimum STC rating of 35 likely be needed to reduce interior maximum levels due to train horn noise to meet the 55 dBA L_{max} sleep disturbance standard in bedrooms and the 60 dBA L_{max} annoyance/disturbance standard in other living spaces.

An alternate approach could be to use secondary windows on the inside of STC 30 to 32 windows (exterior wall upgrades) such as that from 'Soundproof Windows' or equal (see Figure 2 for a conceptual drawing). This secondary window should be spaced 2 to 4 inches back from the exterior window. Using this type of secondary window has been shown increase the effective STC rating of the window assembly by up to 20 points[7].

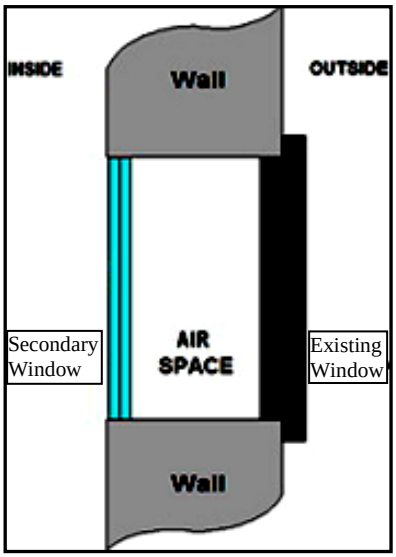

Figure 2: Secondary glazing

Additionally, because the timeline of the full use of the rail line is unclear, and the question of whether or not a Quiet Zone will be implemented at the Chiquita Road grade crossing is in doubt, it might a reasonable approach to initially provide STC 30 windows and subsequently install secondary windows in the higher-noise areas if needed, particularly if no decision has been made on the implementation of a Quiet Zone at the time when the design of the project needs to be finalized.

This concludes our environmental noise assessment conducted for the proposed Oaks at Foss Creek single and multi-family residential development at 111, 155, and 157 Chiquita Road in Healdsburg, CA. If you have any questions or comments regarding this analysis, please do not hesitate to call.

Sincerely,

Fred M. Svinth, INCE, Assoc, AIA
Senior Consultant, Principal
Illingworth & Rodkin, Inc.

Figure 3: Site Plan showing Noise Protected Areas and Exterior Noise Mitigation
Attachment A: Fundamental Concepts of Environmental Acoustics

[7] See Sound test data on the Sound Proof windows site at http://www.soundproofwindows.com/architect/specs/STC-Results-Soundproof-Windows.pdf

Figure 2: Site Plan showing Noise Protected Areas and Exterior Noise Mitigation

APPENDIX A:
FUNDAMENTAL CONCEPTS OF ENVIRONMENTAL ACOUSTICS

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. The objectionable nature of sound may be caused by either its *pitch* or its loudness. *Pitch* is the height or depth of a tone or sound, depending on the relative rapidity (frequency) of the vibrations by which it is produced. Higher pitched signals sound louder to humans than sounds with a lower pitch. *Loudness* is intensity of sound waves combined with the reception characteristics of the ear. Intensity may be compared with the height of an ocean wave in that it is a measure of the amplitude of the sound wave.

In addition to the concepts of pitch and loudness, there are several noise measurement scales that are used to describe noise in a particular location. *A decibel (dB)* is a unit of measurement that indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its intensity. Each 10-decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities. Technical terms are defined in Table 1. There are several methods of characterizing sound. The most common in California is the *A-weighted sound level or dBA.* This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Representative outdoor and indoor noise levels in units of dBA are shown in Table 2.

Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This energy-equivalent sound/noise descriptor is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration.

The scientific instrument used to measure noise is the sound level meter. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various computer models are used to predict environmental noise levels from sources, such as roadways and airports. The accuracy of the predicted models depends upon the distance the receptor is from the noise source. Close to the noise source, the models are accurate to within about plus or minus 1 to 2 dBA.

Since the sensitivity to noise increases during the evening and at night -- because excessive noise interferes with the ability to sleep -- 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The *Community Noise Equivalent Level, CNEL,* is a measure of the cumulative noise exposure in a community, with a 5 dB penalty added to evening (7:00 pm - 10:00 pm) and a 10 dB addition to nocturnal (10:00 pm - 7:00 am) noise levels. The *Day/Night Average Sound Level, Ldn,* is essentially the same as CNEL, with the exception that the evening time period is dropped and all occurrences during this three-hour period are grouped into the daytime period.

TERM	DEFINITIONS
Decibel, dB	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure, which is 20 micropascals (20 micronewtons per square meter).
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise. All sound levels in this report are A-weighted, unless reported otherwise.
L_{01}, L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period.
Day/Night Noise Level, L_{dn}	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.
L_{max}, L_{min}	The maximum and minimum A-weighted noise level during the measurement period.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

Definitions Of Acoustical Terms Table 1

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At a Given Distance From Noise Source	A-Weighted Sound Level in Decibels	Noise Environments	Subjective Impression
	140		
Civil Defense Siren (100')	130		Pain Threshold
Jet Takeoff (200')	120	Rock Music Concert	
	110		Very Loud
Diesel Pile Driver (100')	100	Boiler Room Printing Press Plant	
	90		
Freight Cars (50') Pneumatic Drill (50') Freeway (100')	80	In Kitchen With Garbage Disposal Running	Moderately Loud
Vacuum Cleaner (10')	70	Data Processing Center	
	60	Department Store	
Light Traffic (100') Large Transformer (200')	50	Private Business Office	Quiet
	40	Quiet Bedroom	
Soft Whisper (5')	30	Recording Studio	
	20		Threshold of Hearing
	10		
	0		

Typical Sound Levels Measured In The Environment And Industry	Table 2

ILLINGWORTH & RODKIN, INC./Acoustical Engineer

Effects of Noise

Sleep and Speech Interference: The thresholds for speech interference indoors are about 45 dBA if the noise is steady and above 55 dBA if the noise is fluctuating. Outdoors the thresholds are about 15 dBA higher. Steady noise of sufficient intensity; above 35 dBA, and fluctuating noise levels above about 45 dBA have been shown to affect sleep. Interior residential standards for multi-family dwellings are set by the State of California at 45 dBA Ldn. Typically, the highest steady traffic noise level during the daytime is about equal to the Ldn and nighttime levels are 10 dBA lower. The standard is designed for sleep and speech protection and most jurisdictions apply the same criterion for

all residential uses. Typical structural attenuation is 12-17 dBA with open windows. With closed windows in good condition, the noise attenuation factor is around 20 dBA for an older structure and 25 dBA for a newer dwelling. Sleep and speech interference is therefore possible when exterior noise levels are about 57-62 dBA Ldn with open windows and 65-70 dBA Ldn if the windows are closed. Levels of 55-60 dBA are common along collector streets and secondary arterials, while 65-70 dBA is a typical value for a primary/major arterial. Levels of 75-80 dBA are normal noise levels at the first row of development outside a freeway right-of-way. In order to achieve an acceptable interior noise environment, bedrooms facing secondary roadways need to be able to have their windows closed, those facing major roadways and freeways typically need special glass windows.

Annoyance: Attitude surveys are used for measuring the annoyance felt in a community for noises intruding into homes or affecting outdoor activity areas. In these surveys, it was determined that the causes for annoyance include interference with speech, radio and television, house vibrations, and interference with sleep and rest. The Ldn as a measure of noise has been found to provide a valid correlation of noise level and the percentage of people annoyed. People have been asked to judge the annoyance caused by aircraft noise and ground transportation noise. There continues to be disagreement about the relative annoyance of these different sources. When measuring the percentage of the population highly annoyed, the threshold for ground vehicle noise is about 55 dBA Ldn. At an Ldn of about 60 dBA, approximately 2 percent of the population is highly annoyed. When the Ldn increases to 70 dBA, the percentage of the population highly annoyed increases to about 12 percent of the population. There is, therefore, an increase of about 1 percent per dBA between an Ldn of 60-70 dBA. Between an Ldn of 70-80 dBA, each decibel increase increases by about 2 percent the percentage of the population highly annoyed. People appear to respond more adversely to aircraft noise. When the Ldn is 60 dBA, approximately 10 percent of the population is believed to be highly annoyed. Each decibel increase to 70 dBA adds about 2 percentage points to the number of people highly annoyed. Above 70 dBA, each decibel increase results in about a 3 percent increase in the percentage of the population highly annoyed.