Markham Street Extension Project
Riverside County, California

Noise and Vibration Study Report

Prepared for

Riverside County Transportation Department
4080 Lemon Street
Riverside, California 92501

Prepared by

A/E Tech LLC
Laguna Woods, California

February 27, 2023

Summary

The County of Riverside Transportation Department is proposing improvements to Markham Street by extending the roadway between Roosevelt Street and Wood Road for approximately 1.3 miles in the community of Woodcrest in Riverside County, California. The purpose of the Markham Street Extension Project (Project) is to improve traffic circulation systems within the community. Markham Street, in its ultimate classification, is designated as a secondary highway per the Riverside County General Plan (2015). The Project would construct a roadway section consisting of one lane in each direction, Class II bike lanes, and a sidewalk on the south side of Markham Street.

The purpose of this Noise and Vibration Study Report is to evaluate the noise effects of the Project at the exterior activity areas of noise-sensitive properties located in the vicinity of the Project. The analysis includes assessment of existing noise exposure through on-site noise measurements and noise modeling, development of a noise model of the Project area that accurately estimates traffic noise levels at exterior areas of concern, and determining whether the Project would result in significant noise and vibration impacts at the study locations due to traffic.

As part of the noise study, short-term (15 minutes in duration) and 24-hour noise measurements were taken at a total of eight representative locations throughout the Project area. Traffic counts were conducted concurrently with the traffic noise measurements at one location (ST06) for use in calibrating the Traffic Noise Model (TNM) files developed for the noise study. Deviations between measured and modeled noise levels found in the model validation process were found to be within ±2 A-weighted decibels (dBA). This indicates acceptable agreement between the modeled and measured noise levels. Comparison of measured and modeled noise levels and the related field traffic counts are presented in Table 6-2 and Appendix A-1 of this report, respectively.

Community Noise Equivalent Level (CNEL) and noisiest-hour traffic noise levels during AM and PM peak traffic periods were analyzed at a total of 24 exterior activity locations within noise-sensitive properties in the vicinity of the Project. Baseline and future noise levels were quantified using onsite noise measurements and modeling of traffic noise by the Federal Highway Administration (FHWA) TNM version 2.5. The noise analysis locations are shown in Figure 6-1 and modeled noise levels are presented in Table B-1 through Table B-3 of this Noise Study Report.

Existing noise levels are assessed based on a combination of noise levels measured in the field and modeled noise levels. Worst-hour traffic noise levels in the AM peak traffic hour (L_{eq}[h]) were found to be 43 to 57 dBA at the modeled locations. Existing PM peak-hour noise levels

were determined to be between 44 to 57 dBA, and existing CNEL values were found to be between 44 to 58 dBA at the selected noise modeling locations throughout the Project area.

Under the Horizon Year (2046) No-Build condition, AM peak-hour traffic noise levels at exterior areas of noise-sensitive properties are predicted to range between 43 to 58 dBA, while PM peak-hour noise levels are estimated to be between 44 to 59 dBA. Horizon Year (2046) No-Build condition traffic CNEL values at the same noise-sensitive locations are calculated to be 47 to 58 dBA.

Under the Horizon Year (2046) Build condition, AM peak-hour traffic noise levels at exterior areas of noise-sensitive properties are predicted to range between 48 to 63 dBA, while PM peak-hour noise levels are estimated to be between 51 to 64 dBA. Horizon Year (2046) Build condition traffic CNEL values at the modeled noise-sensitive locations are predicted to be in the range of 52 to 65 dBA.

Table S-1 below summarizes the modeled Existing Year (2021) No-Build condition and the Horizon Year (2046) No-Build and Build condition traffic CNEL at exterior locations of receptors representing nearby noise-sensitive land uses in the Project area.

Table S-1. Existing Year (No-Build) Condition and Predicted Horizon Year (2046) No-Build and Build Condition Traffic CNEL

Receptor I.D.	Land Use[1]	Existing Year (2021) Noise Level CNEL, dBA[2]	Horizon Year (2046) No-Build Condition CNEL, dBA[2]	Horizon Year (2046) Build Condition CNEL, dBA[2]	Build Condition Minus Existing Noise Level CNEL, dBA[2]	Riverside County Exterior Noise Standard CNEL, dBA[2]	Impact Type[3]
M1	RES	44	48	59	15	65	NONE
M2	RES	45	48	60	15	65	NONE
M3	RES	45	49	61	16	65	NONE
M4	RES	46	47	59	13	65	NONE
M5	RES	50	50	52	2	65	NONE
M6	RES	50	50	54	4	65	NONE
M7	RES	50	50	52	2	65	NONE
M8	RES	50	50	52	2	65	NONE
M9	RES	50	50	59	9	65	NONE
M10	RES	50	50	64	14	65	NONE
M11	RES	50	50	62	12	65	NONE
M12	RES	50	50	61	11	65	NONE
M13	RES	50	50	53	3	65	NONE
M14	RES	50	50	60	10	65	NONE
M15	RES	50	50	64	14	65	NONE
M16	RES	50	50	65	15	65	NONE

Table S-1. Existing Year (No-Build) Condition and Predicted Horizon Year (2046) No-Build and Build Condition Traffic CNEL

Receptor I.D.	Land Use[1]	Existing Year (2021) Noise Level CNEL, dBA[2]	Horizon Year (2046) No-Build Condition CNEL, dBA[2]	Horizon Year (2046) Build Condition CNEL, dBA[2]	Build Condition Minus Existing Noise Level CNEL, dBA[2]	Riverside County Exterior Noise Standard CNEL, dBA[2]	Impact Type[3]
M17	RES	50	50	63	13	65	NONE
M18	RES	50	50	59	9	65	NONE
M19	RES	52	53	55	3	65	NONE
M20	RES	55	55	55	-0-	65	NONE
M21	RES	58	58	60	2	65	NONE
M22	RES	54	55	57	3	65	NONE
M23	RES	57	58	60	3	65	NONE
M24	SCH	52	53	55	3	65	NONE

Notes:

1 - Land Use: RES = Residential , SCH = School
2 - CNEL is A-weighted, 24-hour equivalent noise level in decibels.
3 - NONE = No impact. Does not exceed County's 65 dBA CNEL in exterior areas.

Based on the results of Horizon Year (2046) Build condition, traffic noise level calculations, exterior noise levels at the nearest noise-sensitive receptors along the Project corridor are expected to be in compliance with the County's exterior noise standard of 65 dBA CNEL.

Areas where there are noticeable changes in 24-hour traffic noise levels between the Horizon Year (2046) No-Build and Build conditions, are at the residential parcels located along Markham Street, west of Roosevelt Street, and parcels of land closest to Markham Street, between Roosevelt Street and Wood Road. Changes in CNEL under the Horizon Year (2046) Build condition, relative to Existing Year (2021) condition noise levels at these locations range between 9 to 16 dBA.

At other noise-sensitive locations along the north side of Markham Street and on both sides of Markham Street, east of Wood Road, Project-related increases in traffic noise levels between the Horizon Year (2046) No-Build and Build conditions would be between zero and 4 dBA, which are considered to be no change, or barely perceptible.

Project construction would result in occasional occurrence of maximum noise levels from loudest activities, which include grading and paving activities. Maximum construction noise levels at the nearest homes located along Markham Street would approach 90 dBA. To minimize exposure of the local community to construction noise, it is recommended that noise generating construction activities be confined to the daytime hours, as required by the County ordinance, equipment be outfitted with effective mufflers, and construction staging areas be placed as far away from inhabited noise-sensitive structures as possible. Detailed construction noise minimization measures are outlined in Section 8.1 of this report.

Groundborne vibration due to Project construction would potentially result in significant impacts in terms of human annoyance when heavy construction machinery, such as large bulldozers and vibratory rollers, are operated in close proximity (less than 25 feet) to existing residential buildings. To mitigate construction vibration to levels less than significant, it is recommended that pneumatic (or static) rollers and lighter earth moving equipment be utilized for construction in areas that are closer than 25 feet from existing residential structures (see Section 8.1).

Table of Contents

Appendix

List of Figures

List of Tables

List of Abbreviated Terms

°F	degrees Fahrenheit
ADA	Americans with Disabilities Act
ANSI	American National Standard Institute
APN	Assessor's Parcel Number
CAD	computer-aided design
Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CNEL	Community Noise Equivalent Level
dB	decibel
dBA	A-weighted decibels
FHWA	Federal Highway Administration
Hz	Hertz
in/sec	inches per second
IEC	International Electrotechnical Commission
kHz	kilohertz
L_{dn}	Day-Night Level
L_{eq}	Equivalent Sound Level
L_{eq}(h)	hourly equivalent sound level
L_{max}	Maximum Sound Level
µPa	micro-Pascal
mph	miles per hour
NAC	noise abatement criteria
NVSR	Noise and Vibration Study Report
PPA	peak particle acceleration
PPV	peak particle velocity
Protocol	2011 Caltrans Traffic Noise Analysis Protocol
SEL	Sound Exposure Level
SLM	sound level meter
SPL	sound pressure level
TeNS	Caltrans Technical Noise Supplement
TNM	FHWA Traffic Noise Model

Chapter 1 Introduction

The County of Riverside Transportation Department (County) is proposing improvements to Markham Street by extending the roadway between Roosevelt Street and Wood Road for approximately 1.3 miles in the community of Woodcrest in Riverside County, California. Figure 1-1 shows the ocation of the Markham Street Extension Project (Project).

The purpose of the Project is to improve traffic circulation systems within the community. Markham Street, in its ultimate classification, is designated as a secondary highway per the Riverside County General Plan (2015). The Project would construct a roadway section consisting of one lane in each direction, Class II bike lanes, and a sidewalk on the south side of Markham Street. The Project is subject to the requirements of the California Environmental Quality Act (CEQA). The County will serve as the CEQA lead for the proposed Project.

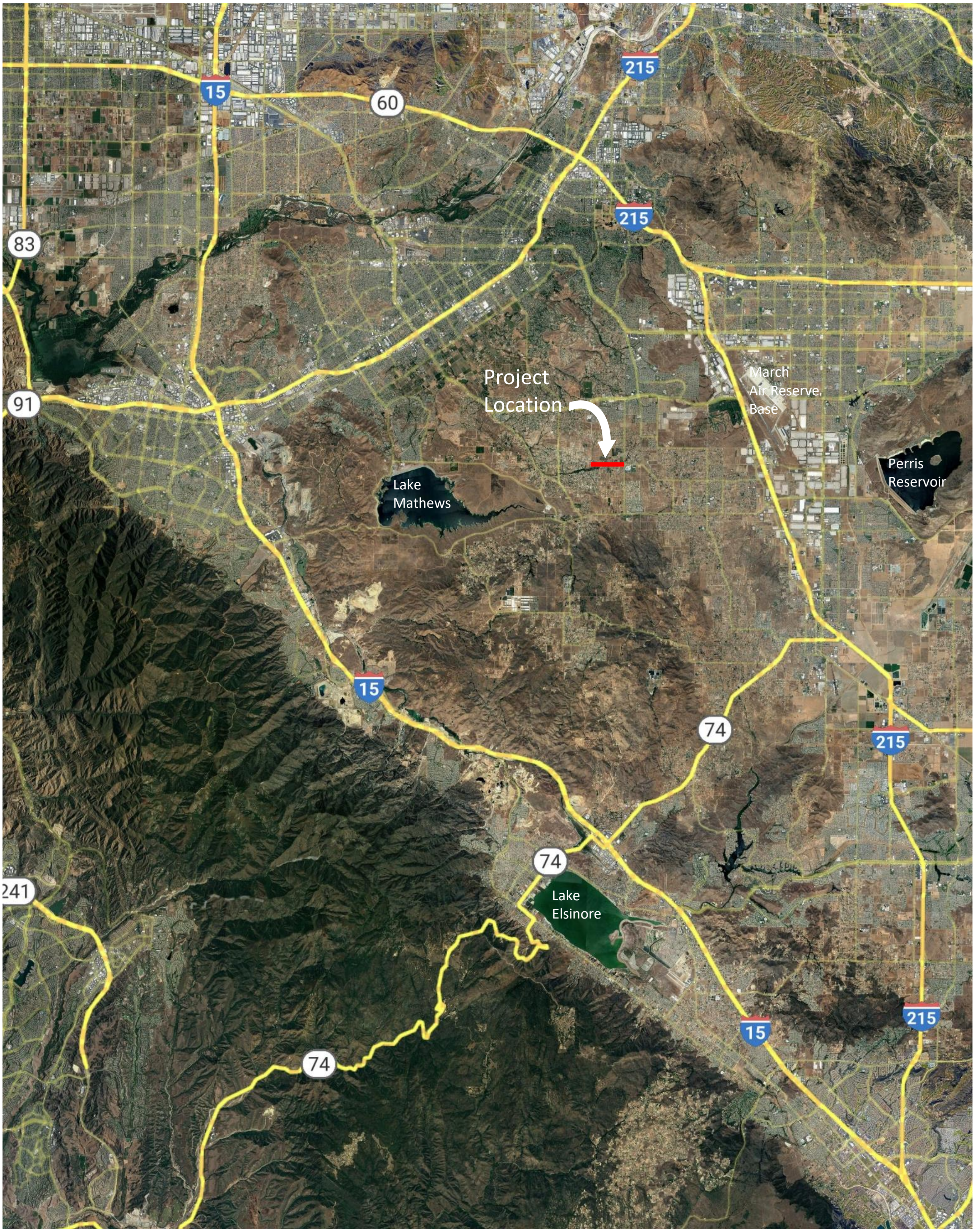
1.1 Purpose of the Noise and Vibration Study Report

The purpose of this Noise and Vibration Study Report (NVSR) is to evaluate existing ambient noise conditions at representative exterior areas of noise-sensitive land uses in the vicinity of the Project through on-site noise measurements, and develop a traffic noise model of the Project area that accurately estimates future traffic noise levels. Traffic noise levels are evaluated in terms of the highest morning and afternoon (AM and PM) peak-hour noise levels and the Community Noise Equivalent Level (CNEL) based on the Existing Year (2021) and Horizon Year (2046) No-Build and Build traffic conditions.

The report assesses whether Existing Year (2021) or Horizon Year (2046) Build condition noise levels exceed the local (County) noise standard at any of the residential and school land uses in the Project area, compares the Existing Year (2021) noise levels to Horizon Year (2046) noise levels under No-Build and Build conditions, and determines whether the Project would result in noise levels that exceed the applicable local noise criteria under the Horizon Year (2046) Build condition. If any locations are found where significant noise impacts are identified, noise mitigation in the form of noise barriers would be evaluated to determine whether such mitigation would be practical in reducing noise impacts to below significant.

In terms of temporary construction noise effects, the NVSR presents typical noise and vibration levels from roadway construction activities, highest noise and vibration levels that may be expected from Project construction at noise-sensitive locations nearest to the Project, and noise and vibration control measures that should be implemented during construction.

Figure 1-1
Project Vicinity Map
Markham Street Extension Project



TECH
Noise & Vibration

Chapter 2 Project Description

2.1 Existing Condition

The proposed Project is located between the intersection of Markham Street and Roosevelt Street and the intersection of Wood Road and Markham Street. Each of these intersections have been partially developed as part of previous roadway work. Markham Street, west of Roosevelt Street and east of Wood Road, has been improved to meet the secondary street classification standards. However, Markham Street, east of Roosevelt Street, is an unpaved dirt road and is not accessible from the Markham Street and Roosevelt Street intersection. There is an existing metal beam guardrail that blocks access to the dirt road segment of Markham Street. From the intersection of Wood Road to the west, Markham Street has been paved with a 20-foot-wide asphalt surface to provide access to the existing properties for a distance of 2,500 feet. Along this paved section, driveways to the existing properties have been set back to allow for roadway widening. The unpaved dirt road on the west-end of the Project extends approximately 0.5 mile to the east where it ties into the exiting paved roadway. Additionally, smaller street intersections, including Oran Drive, Birch Street, Cedar Street, and James Kenny Road connect to Markham Street within the Project area.

The Project is located in a semi-rural area with residential, commercial, and institutional land uses throughout the area. Adjacent properties along this roadway segment consist of vacant land, single-family homes, business properties, and water district properties utilized for a sewer-lift station and water-pumping station. Existing utilities consist of an overhead power line, water lines, a gas line, and communication lines.

2.2 Proposed Project

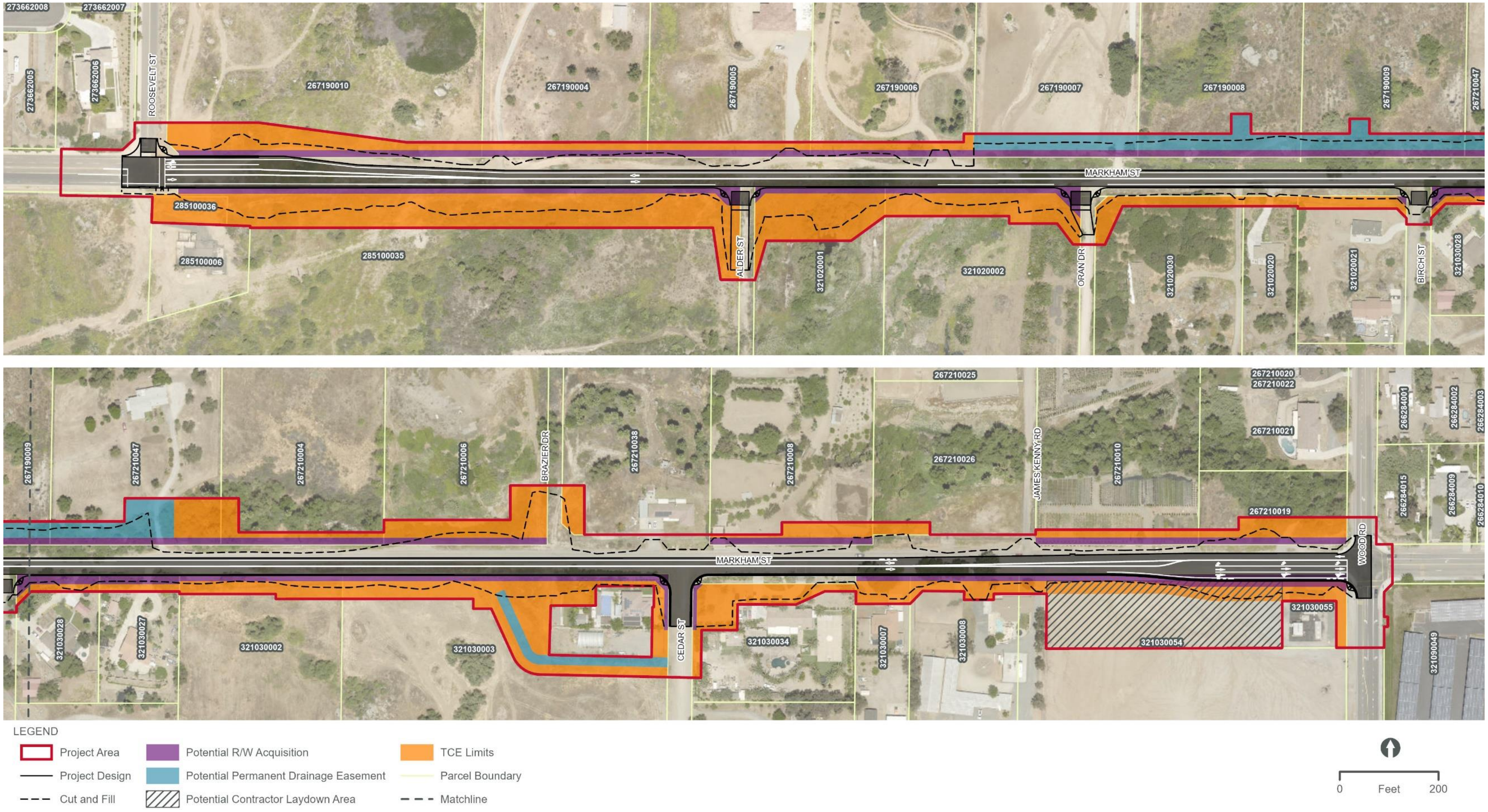
The proposed Project would add one additional travel lane in each direction for approximately 1.3 miles along Markham Street, between Roosevelt Street and Wood Road. Roadway improvements would include two 12-foot-wide travel lanes (one in each direction), with a 5-foot-wide westbound and 6-foot-wide eastbound Class II bike lane. The northern edge of the roadway would have an 8-foot-wide unpaved shoulder, and the southern edge of the roadway would include curb and gutters, a 6-foot-wide sidewalk, and a 6-foot-wide parkway.

Traffic signal improvements would be required at the Markham Street and Wood Road intersection to accommodate the extended roadway and the addition of a dedicated eastbound left-turn lane, a dedicated eastbound through lane, and a shared-through and right-turn lane. The Markham Street and Roosevelt Street intersection would remain as a stop-controlled intersection. The four smaller intersections (Oran Drive, Birch Street, Cedar Street, and James Kenny Road) would require roadway modifications to develop curb returns and Americans with Disabilities Act (ADA)-compliant pedestrian accessible ramps to tie into the existing roadways, and the intersections would be stop controlled. Existing property driveways would be modified to connect to new roadway improvements. Drainage improvements would include storm drain piping along the roadway and the addition of culverts to direct storm-flow drainage across the roadway. Existing utilities that may require relocations or modifications to accommodate the roadway extension include water, gas, electrical, and telephone lines. In addition, traffic restriping west of Roosevelt Street would be needed to transition from the existing roadway to the new extended roadway.

Construction of the proposed Project would require partial acquisition, temporary construction easements, and drainage easements, as shown on Figure 2-1. In addition, a construction staging area could be located on a vacant parcel south of Markham Street and west of Wood Road in the southeastern portion of the Project area (Assessor's Parcel Number [APN] 321-030-054). The use of this parcel for staging would require a temporary construction easement and the parcel would be returned to preconstruction condition upon completion of the proposed Project.

Figure 2-1 shows the planned roadway modifications to be implemented by the Project.

Figure 2-1
Proposed Markham Street Extension Project



Chapter 3 Fundamentals of Noise and Vibration

The following is a brief discussion of fundamental traffic noise concepts.

3.1 Sound, Noise, and Acoustics

Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a liquid or gaseous medium (e.g., air) to a hearing organ, such as a human ear. Noise is defined as loud, unexpected, or annoying sound.

In the science of acoustics, the fundamental model consists of a sound (or noise) source, a receptor, and the propagation path between the two. The loudness of the noise source and obstructions or atmospheric factors that affect the propagation path to the receptor determine the sound level and the characteristics of the noise perceived by the receptor. The field of acoustics deals primarily with the propagation and control of sound.

3.2 Frequency

Continuous sound can be described by frequency (pitch) and amplitude (loudness). A low-frequency sound is perceived as low in pitch. Frequency is expressed in terms of cycles per second, or Hertz (Hz) (e.g., a frequency of 250 cycles per second is referred to as 250 Hz). High frequencies are sometimes more conveniently expressed in kilohertz (kHz), or thousands of Hertz. The audible frequency range for humans is generally between 20 Hz and 20,000 Hz.

3.3 Sound-Pressure Levels and Decibels

The amplitude of pressure waves generated by a sound source determines the loudness of that source. Sound pressure amplitude is measured in micropascals (µPa). One µPa is approximately one hundred billionth (0.00000000001) of normal atmospheric pressure. Sound pressure amplitudes for different kinds of noise environments can range from less than 100 to 100,000,000 µPa. Because of this huge range of values, sound is rarely expressed in terms of µPa. Instead, a logarithmic scale is used to describe sound-pressure level (SPL) in terms of decibels (dB). The threshold of hearing for young people is about 0 dB, which corresponds to 20 µPa.

3.4 Addition of Decibels

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

3.5 A-Weighted Decibels

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

Human hearing is limited in the range of audible frequencies as well as in the way it perceives the SPL in that range. In general, people are most sensitive to the frequency range of 1,000–8,000 Hz, and perceive sounds within that range better than sounds of the same amplitude in higher or lower frequencies. To approximate the response of the human ear, sound levels of individual frequency bands are weighted, depending on the human sensitivity to those frequencies. Then, an “A-weighted” sound level (expressed in units of dBA) can be computed based on this information.

The A-weighting network approximates the frequency response of the average young ear when listening to most ordinary sounds. When people make judgments regarding the relative loudness or annoyance of a sound, their judgments correlate well with the A-scale sound levels of those sounds. Other weighting networks have been devised to address high noise levels or other special problems (e.g., B-, C-, and D-scales), but these scales are rarely used in conjunction with highway traffic noise. Noise levels for traffic noise reports are typically reported in terms of A-weighted decibels, or dBA. Table 3-1 describes typical A-weighted noise levels for various noise sources.

3.6 Human Response to Changes in Noise Levels

As discussed above, a doubling of sound energy results in a 3 dBA increase in sound. However, assuming a sound-level change measured with precise instrumentation, the subjective human perception of a doubling of loudness will usually be different from what is measured.

Table 3-1. Typical A-Weighted Noise Levels

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	— 110 —	Rock band
Jet fly-over at 1000 feet		
	— 100 —	
Gas lawn mower at 3 feet		
	— 90 —	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	— 80 —	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	— 70 —	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	— 60 —	
		Large business office
Quiet urban daytime	— 50 —	Dishwasher in next room
Quiet urban nighttime	— 40 —	Theater, large conference room (background)
Quiet suburban nighttime		
	— 30 —	Library
Quiet rural nighttime		Bedroom at night, concert
	— 20 —	
		Broadcast/recording studio
	— 10 —	
Lowest threshold of human hearing	— 0 —	Lowest threshold of human hearing

Source: Caltrans 2013a.

Under controlled conditions in an acoustical laboratory, the trained, healthy human ear is able to discern 1 dBA changes in sound levels when exposed to steady, single-frequency ("pure-tone") signals in the mid-frequency range (1,000–8,000 Hz). In typical noisy environments, changes in noise of 1 to 2 dBA are generally not perceptible. However, it is widely accepted that:

- People are able to begin to detect sound level increases of 3 dBA in typical noisy environments.
- A 5 dBA increase is generally perceived as a distinctly noticeable increase.
- A 10 dBA increase is generally perceived as a doubling of loudness.

Therefore, a doubling of sound energy (e.g., doubling the volume of traffic on a highway), resulting in a 3 dBA increase in sound, would generally be perceived as barely detectable.

3.7 Noise Descriptors

Noise in our daily environment fluctuates over time. Some fluctuations are minor, but some are substantial. Some noise levels occur in regular patterns, but others are random. Some noise levels fluctuate rapidly, but others change slowly. Some noise levels vary widely, but others are relatively constant. Various noise descriptors have been developed to describe time-varying noise levels. The following are the noise descriptors most commonly used in traffic noise analysis.

- **Equivalent Sound Level (L_{eq}):** L_{eq} represents an average of the sound energy occurring over a specified period. In effect, L_{eq} is the steady-state sound level containing the same acoustical energy as the time-varying sound that actually occurs during the same period. The one-hour A-weighted equivalent sound level (L_{eq}[h]) is the energy average of A-weighted sound levels occurring during a one-hour period.
- **Minimum Sound Level (L_{min}):** L_{min} is the lowest instantaneous sound level measured during a specified period.
- **Maximum Sound Level (L_{max}):** L_{max} is the highest instantaneous sound level measured during a specified period.
- **Day-Night Level (L_{dn}):** L_{dn} is the energy average of A-weighted sound levels occurring over a 24-hour period, with a 10 dBA penalty applied to A-weighted sound levels occurring during nighttime hours between 10:00 PM and 7:00 AM
- **Community Noise Equivalent Level (CNEL):** Similar to L_{dn}, CNEL is the energy average of the A-weighted sound levels occurring over a 24-hour period, with a 10 dBA penalty applied to A-weighted sound levels occurring during the nighttime hours between 10:00 PM and 7:00 AM and a 5 dBA penalty applied to the A-weighted sound levels occurring during evening hours between 7:00 PM and 10:00 PM
- **Statistical Noise Level (L_n):** The noise level that is exceeded “n” percent of the time during the measurement period. For example, L_{90} is the level that is exceeded 90 percent of the time.

3.8 Sound Propagation

When sound propagates over a distance, it changes in level and frequency content. The manner in which noise reduces with distance depends on the factors below.

3.8.1 Geometric Spreading

Sound from a localized source (i.e., a point source) propagates uniformly outward in a spherical pattern. The sound level attenuates (or decreases) at a rate of 6 dBA for each doubling of distance from a point source. Highways consist of several localized noise sources on a defined path and, hence, can be treated as a line source, which approximates the effect of several point sources. Noise from a line source propagates outward in a cylindrical pattern, often referred to as cylindrical spreading. Sound levels attenuate at a rate of 3 dBA for each doubling of distance from a line source.

3.8.2 Ground Absorption

The propagation path of noise from a highway to a receptor is usually very close to the ground. Noise attenuation from ground absorption and reflective-wave canceling adds to the attenuation associated with geometric spreading. Traditionally, the excess attenuation has also been expressed in terms of attenuation per doubling of distance. This approximation is usually sufficiently accurate for distances of less than 200 feet. For acoustically hard sites (i.e., sites with a reflective surface between the source and the receptor, such as a parking lot or body of water), no excess ground attenuation is assumed. For acoustically absorptive or soft sites (i.e., those sites with an absorptive ground surface between the source and the receptor, such as soft dirt, grass, or scattered bushes and trees), an excess ground-attenuation value of 1.5 dBA per doubling of distance is normally assumed. When added to the cylindrical spreading, the excess ground attenuation results in an overall drop-off rate of 4.5 dBA per doubling of distance.

3.8.3 Atmospheric Effects

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

3.8.4 Shielding by Natural or Human-made Features

A large object or barrier in the path between a noise source and a receptor can substantially attenuate noise levels at the receptor. The amount of attenuation provided by shielding depends on the size of the object and the frequency content of the noise source. Natural terrain features (e.g., hills and dense woods) and human-made features (e.g., buildings and walls) can substantially reduce noise levels. Walls are often constructed between a source and a receptor specifically to reduce noise. A barrier that breaks the line of sight between a source and a receptor will typically result in at least 5 dBA of noise reduction. Taller barriers provide increased noise reduction. Vegetation between the highway and receptor is rarely effective in reducing noise because it does not create a solid barrier.

3.9 Vibration

When the ground is subject to vibration from a source, such as heavy construction machinery, a disturbance propagates away from the vibration source. The ground vibration waves created are similar to those that propagate in water when a stone is dropped into the water.

When the ground is subject to vibratory impact, vibration waves propagate outward from the source of impact. These waves encounter an increasingly large volume of material in the ground as they travel outward, and the energy density in each wave decreases with distance from the source. This decrease in energy density and the associated decrease in displacement amplitude is called spreading loss (or vibration attenuation).

The quantities that are used to describe vibratory motion include displacement, velocity, and acceleration. In describing vibration in the ground and in structures, the concepts of particle displacement, velocity, and acceleration are used to describe how the ground or structure responds to excitation. Vibratory motion is commonly described by identifying the peak particle velocity (PPV) or peak particle acceleration (PPA). Velocity is measured in inches per second (in/sec) or millimeters per second (mm/sec).

Soil and subsurface conditions are known to have a strong influence on the levels of ground-borne vibration. Among the most important factors are the stiffness and internal damping of the soil and the depth to bedrock. Experience with ground-borne vibration is that vibration propagation is more efficient in stiff clay soils, and shallow rock seems to concentrate the vibration energy close to the surface and can result in ground-borne vibration problems at large distances from the source. Factors such as layering of the soil and depth to water table can have significant effects on the propagation of ground-borne vibration.

When the ground surfaces of the excitation source and the receiver are at different elevations, much of the vibration energy carried through waves causing surface displacement of the ground dissipates. This results in weaker vibratory motion at the receiver than if the receiver were at the same elevation as the source.

In residential areas, the background vibration velocity approximately 0.0013 in/sec PPV. This level is well below the vibration velocity level that is readily perceptible to humans, which is 0.08 in/sec PPV. A vibration velocity level of 0.1 in/sec PPV is considered to be the threshold of annoyance for many people (Caltrans, 2013).

Chapter 4 Local, State, and Federal Noise and Vibration Regulations and Policies

4.1 Federal Regulations

4.1.1 23 CFR 772

Procedures for preparing operational and construction noise studies and evaluating noise abatement considered for federal and federal-aid highway projects are provided under 23 CFR 772. Traffic noise impacts, as defined in 23 CFR 772.5, occur when the predicted noise level in the design year approaches or exceeds the NAC specified in 23 CFR 772 or a predicted noise level substantially exceeds the existing noise level (a “substantial” noise increase). However, 23 CFR 772 does not specifically define the terms “substantial increase” or “approach”; these criteria are defined in the Protocol, as described in the following section.

Table 4-1 summarizes the NAC corresponding to various land use activity categories. Activity categories and related traffic noise impacts are based on the actual or permitted land use in a given area.

Table 4-1. Activity Categories and Noise Abatement Criteria (23 CFR 772)

Activity Category	Activity $L_{eq}(h)$[1]	Evaluation Location	Description of Activities
A	57	Exterior	Lands where serenity and quiet have extraordinary significance and the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[2]	67	Exterior	Residential.
C[2]	67	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E	72	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in A–D or F.
F			Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G			Undeveloped lands that are not permitted.

[1] The $L_{eq}(h)$ activity criteria values are for impact determination only and are not design standards for noise abatement measures. All values are A-weighted decibels (dBA).
[2] Includes undeveloped lands permitted for this activity category.

Noise-sensitive receptors located in the vicinity of the Project are residential (Activity Category B) and school (Activity Category C). Therefore, a NAC of 67 dB hourly L_{eq} would be applied to these locations.

4.2 State Regulations and Policies

4.2.1 Traffic Noise Analysis Protocol

The California Department of Transportation (Caltrans) Traffic Noise Analysis Protocol (the Protocol) specifies the policies, procedures, and practices to be used by agencies that sponsor new construction or reconstruction of federal or federal-aid highway projects. The Protocol defines a noise increase as *substantial* when the predicted noise levels with project implementation exceed existing noise levels by 12 dBA or more. The Protocol also states that a sound level approaches the NAC when the sound level is within 1 dBA of the NAC identified in 23 CFR 772 (e.g., 66 dBA is considered to be approaching the NAC of 67 dBA but 65 dBA is not).

The Caltrans Technical Noise Supplement (TeNS) provides detailed technical guidance for the evaluation of highway traffic noise. This includes field measurement methods, noise modeling methods, and report preparation guidance.

4.2.2 Section 216 of the California Streets and Highways Code

Section 216 of the California Streets and Highways Code relates to the noise effects of a proposed freeway project on public and private elementary and secondary schools. Under this code, a noise impact occurs if, as a result of a proposed roadway project, noise levels exceed 52 dBA L_{eq}(h) in classrooms, libraries, multipurpose rooms, or interior spaces of public or private elementary or secondary schools. This requirement does not replace the “approach or exceed” NAC criterion for FHWA Activity Category E for classroom interiors, but it is a requirement that must be addressed in addition to the requirements of 23 CFR 772.

If a project results in a noise impact under this code, noise abatement must be provided to reduce classroom noise to a level that is at or below 52 dBA L_{eq}(h). If the noise levels generated from freeway and roadway sources exceed 52 dBA L_{eq}(h) prior to construction of the proposed freeway project, then noise abatement must be provided to reduce the noise to the level that existed prior to construction of the project.

4.2.3 Caltrans Vibration Guidelines

The State of California has not adopted statewide standards or regulations for evaluating vibration or groundborne noise impacts. However, the *Caltrans Transportation and Construction Vibration Guidance Manual* recommends certain thresholds for assessment of groundborne vibration impacts from construction of roadway improvement projects. Table 4-2 lists the vibration building damage criteria for six general categories of buildings. These criteria are expressed in terms of PPV, which is the maximum instantaneous positive or negative peak of the vibration signal, often used in monitoring of construction vibration (such as blasting) since it is related to the stresses that are experienced by buildings.

Table 4-2. Groundborne Vibration Building Damage Thresholds

Structure and Condition	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.20	0.10
Historic and some old buildings	0.50	0.25
Older residential structures	0.50	0.30
New residential structures	1.00	0.50
Modern industrial/commercial buildings	2.00	0.50

Note:
- PPV = Peak particle velocity; in/sec = inches per second
- Transient sources create a single isolated vibration event, such as blasting or drop balls.
- Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

Source: Caltrans, 2013

Table 4-3 shows human annoyance thresholds due to vibration that are recommended by Caltrans for assessment of vibration impacts.

Table 4-3. Groundborne Vibration Potential Annoyance Thresholds

Human Response	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Barely perceptible	0.04	0.01
Distinctly perceptible	0.25	0.04
Strongly perceptible	0.90	0.10
Severe	2.00	0.40

Note:
- PPV = Peak particle velocity; in/sec = inches per second
- Transient sources create a single isolated vibration event, such as blasting or drop balls.
- Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

Source: Caltrans, 2013

4.3 Local Regulations and Policies

4.3.1 Riverside County General Plan

Riverside County General Plan (Riverside County, 2015) in its Chapter 7, Noise Element, establishes land use compatibility criteria in terms of the Day-Night Noise Level (L_{dn}) or Community Noise Exposure Level (CNEL) for various land uses, including residential. The County in Table N-1 of the General Plan has adopted land use compatibility thresholds for various land uses. For single-family homes, the County regards exterior noise levels up to 60 dBA CNEL as "Normally Acceptable" while the threshold for multi-family homes under this category is 65 dBA CNEL. For single-family homes, an exterior CNEL of 70 dBA is "Conditionally Acceptable," so long as needed sound insulation features are included in the building design (see Table 4-4 below).

Table 4-4 Riverside County Land Use Noise Compatibility Guidelines

Land Use Category	Normally Acceptable[1] (dBA, CNEL/L_{dn})	Conditionally Acceptable[2] (dBA, CNEL/L_{dn})	Normally Unacceptable[3] (dBA, CNEL/L_{dn})	Clearly Unacceptable[4] (dBA, CNEL/L_{dn})
Residential – Low Density Single Family, Duplex, Mobile Homes	50-60	55-70	70-75	75-85
Residential – Multiple Family	50-65	60-70	70-75	75-85
Transient Lodging – Motels, Hotels	50-65	60-70	70-75	75-85
Schools, Libraries, Churches, Hospitals, Nursing Homes	50-70	60-70	70-80	80-85
Auditoriums, Concert Halls, Amphitheaters	N/A	50-75	70-85	N/A
Sports Arenas, Outdoor Spectator Sports	N/A	50-75	70-85	N/A
Playgrounds, Neighborhood Parks	50-70	N/A	67.5-75	72.5-85

Table 4-4 Riverside County Land Use Noise Compatibility Guidelines

Land Use Category	Normally Acceptable[1] (dBA, CNEL/L_{dn})	Conditionally Acceptable[2] (dBA, CNEL/L_{dn})	Normally Unacceptable[3] (dBA, CNEL/L_{dn})	Clearly Unacceptable[4] (dBA, CNEL/L_{dn})
Golf Courses, Riding Stables, Water Recreation, Cemeteries	50-70	N/A	70-80	80-85
Office Buildings, Business Commercial and Professional	50-70	67.5-72.5	N/A	75-85
Industrial, Manufacturing, Utilities, Agriculture	50-75	70-80	N/A	75-85

Notes:

1. Normally Acceptable: Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.
2. Conditionally Acceptable: New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features included in the design. Conventional construction, but with closed windows and fresh air supply systems or air conditioning will normally suffice. Outdoor environment will seem noisy.
3. Normally Unacceptable: New Construction or development should be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made with needed noise insulation features included in the design. Outdoor areas must be shielded.
4. Clearly Unacceptable: New construction or development should generally not be undertaken. Construction posts to make indoor environment acceptable would be prohibitive and the outdoor environment would not be usable.

N/A: Not Applicable

Source: County of Riverside General Plan, 2015

Policy N 1.3 of the County's General Plan considers various land uses including residential, schools, libraries, hospitals and others as noise-sensitive and discourages locating these uses in areas in excess of 65 dBA CNEL. Therefore, this threshold is regarded as the County's noise standard for exterior activity areas of residential uses.

Furthermore, the Noise Element of the General Plan, Appendix I-1 (County of Riverside, 2015) states that "interior noise levels in residential dwellings shall not exceed 45 dBA L_{dn} (or CNEL) and exterior noise levels shall not exceed 65 dBA L_{dn} (or CNEL) for transportation noise receptors" (pg. 65 of Appendix I-1).

For stationary noise sources, Appendix I-1 of the General Plan states that "during hours of 7 A.M. to 10 P.M. and 10 P.M. to 7 A.M., the noise levels shall not exceed 65 and 45 dBA weighted ten minute Leq, respectively, as projected to any portion of a lot with occupied residence."

4.3.2 Riverside County Code of Ordinances

Ordinance No. 847 of the County of Riverside Code of Ordinances, Noise Regulation, outlines the County's approach to management and prevention of noise-generating activities that the County may find harmful to the community health, safety, and general welfare. The Code specifies maximum noise level limits of 55 dBA for daytime hours (7:00 AM to 10:00 PM) and 45 dBA for nighttime (10:00 PM to 7:00 AM) for exterior areas of noise-sensitive land uses, including residential uses.

The County also lists activities that would be exempt from its provisions. Such exemption includes private construction projects located within one-quarter of a mile from an inhabited dwelling, provided that:

1. Construction does not occur between the hours of 6:00 PM and 6:00 AM during the months of June through September, and
2. Construction does not occur between the hours of 6:00 PM and 7:00 AM during the months of October through May.

Chapter 5 Study Methods and Procedures

5.1 Methods for Selecting Noise Measurement and Modeling Receptor Locations

As indicated previously, the land uses subject to this noise study are noise-sensitive land uses along the Project corridor. A field investigation was conducted to identify representative locations within land uses in the vicinity of the Project.

The focus of this noise analysis is on locations of frequent human use within properties along Markham Street between Roosevelt Street and Wood Road and at existing noise-sensitive locations west of Markham Street and Roosevelt Street intersection and east of Markham Street and Wood Road intersection.

A combination of short-term and long-term (24-hour) noise measurements were used to quantify existing (baseline) noise conditions throughout the Project study area. Additionally, one short-term location near the intersection of Markham Street and Wood Road was used to validate/calibrate the traffic noise model developed for the noise study.

Additional non-measurement locations were also selected for noise modeling to gain a more complete understanding of the existing and predicted future noise environment in the Project area.

5.2 Field Measurement Procedures

A field noise study was conducted in accordance with recommended procedures in the Caltrans TeNS. The noise measurements were conducted using a Rion Model NL-52 Type 1 sound-level meter (SLM) equipped with a Rion UC-59 ½" microphone, a Rion Model NL-42 Type 2 SLM equipped with a Rion UC-52 ½" microphone, and a Brüel & Kjaer (B&K) Model 2238 Type 1 SLM equipped with a B&K Type 4188 ½" microphone. These sound levels meters are classified as Type 1 and Type 2 (precision-grade) instruments, as defined in the American National Standard Institute (ANSI) specification S1.4-1984 and the International Electrotechnical Commission (IEC) publications 804 and 651. The meters were set to the “slow” time-response mode and A-weighting filter network. Field calibration of the meters was checked before and after each measurement using a Rion Model NC-74 calibrator (serial number 35157442).

The following is a summary of the procedures that were used to collect short-term and long-tem sound level data.

5.2.1 Short-Term Noise Measurements

Short-term noise measurements were taken at six locations at exterior areas of residential locations, or nearby acoustically equivalent locations, where residents typically spend most of their time during outdoor activities. Short-term noise monitoring was conducted at the selected measurement locations within the noise study area on May 3 and May 4, 2022. The noise study area includes noise-sensitive land uses along Markham Street west of Roosevelt Street through sensitive areas east of Wood Road. The short-term noise measurement locations are shown in Figure 5-1 as locations ST01 through ST06. The short-term noise monitoring included two 15-minute measurements at each of the measurement locations. Sound levels collected during the measurement periods were measured with the digital integrating SLM and documented manually on field data sheets. Dominant noise sources observed and other relevant measurement conditions were also identified and logged manually on the field data sheets.

At Site ST06, where traffic noise measurements were conducted, traffic at the intersection of Markham Street and Wood Road was videotaped. The relevant traffic data from each of the two short-term measurements at this location were later classified and counted using the video recordings obtained in the field. In order to input the traffic data into the Traffic Noise Model (TNM), vehicles were classified as automobiles, medium-duty trucks, and heavy-duty trucks. An automobile is defined as a vehicle with two axles and four tires that is designed to carry primarily passengers. Small vans and light trucks are included in this category. Medium-duty trucks include all cargo vehicles with two axles and six tires. Heavy-duty trucks include all vehicles with three or more axles. Average vehicle speeds were estimated using vehicle speed data observed in the field during the noise measurement periods.

Temperature, wind speed, and humidity were recorded manually using a Kestrel Model 2500 portable weather station during the short-term monitoring.

5.2.2 Long-Term Noise Measurements

Long-term (24-hour) noise monitoring measurements were conducted at two locations designated as LT01 and LT02 on Figure 5-1. Following are brief descriptions of the noise monitoring locations:

LT01: This 24-hour noise monitoring site is near the residential building located at 18180 Markham Street within APN-267-190-004. The purpose of choosing this site is to capture day and night noise levels representative of the existing residences along the north side of Markham Street that are relatively far from the roadway.

LT02: This 24-hour noise monitoring site is located within the backyard of the home located at 18049 Birch Street (APN-321-020-021), and represents background noise levels in areas along the south side of Markham Street at relatively close distances to the roadway.

Figure 5-1
Noise Measurement Locations
Markham Street Extension Project

5.3 Traffic Noise Level Prediction Methods

Traffic noise levels were predicted using the FHWA TNM, version 2.5. This computer model is based on FHWA reports FHWA-PD-96-009 and FHWA-PD-96-010 (FHWA 1998a, 1998b). Key geometric inputs for the TNM were ground type and the locations of roadways, shielding features (e.g., topography and buildings), noise barriers, and receptors. Three-dimensional representations of these inputs were developed using Microstation computer-aided design (CAD) files provided by the project engineer. The CAD files include the existing roadway alignments by individual lanes, topographic contours, building locations and heights, vegetation, and other physical features. MicroStation software was used to digitize the geometric inputs into TNM version 2.5.

To validate the accuracy of the noise model, TNM version 2.5 was used to compare measured traffic noise levels with modeled noise levels at the traffic noise measurement location (Site ST06). Counted traffic volumes during each of the two measurement periods were normalized to one-hour volumes. Modeled and measured sound levels at the traffic noise measurement location were then compared to determine the accuracy of the model and whether a calibration adjustment was necessary. The results of calibration modeling are described in Chapter 6 of this report.

For analysis of the highest noise hours and CNEL under the existing roadway conditions, existing hourly traffic counts for the 24-hour period on September 23, 2021 were examined (HDR, February 2022). The highest AM and PM hourly traffic values were found to occur between 7:00 to 8:00 AM in the morning and 4:00 to 5:00 PM in the afternoon.

The existing study segment is a two-lane Collector Highway and consists of a rural paved road and a dirt road which ends east of Roosevelt Street. The intent of the Project is to develop Markham Street to its interim roadway classification, which is a Collector Highway per Riverside County standards. Appendix I-1 of the County's General Plan lists the distribution of traffic by vehicle category (automobiles, medium trucks, and heavy trucks) over a 24 hour period (Riverside County, 2015). For CNEL, the assumed traffic distribution was used, and the average equivalent traffic volume for the 24-hour period was derived, with volumes during evening hours (7:00 PM to 10:00 PM) multiplied by a factor of 3 and the nighttime (10:00 PM to 7:00 AM) traffic volumes multiplied by a factor of 10. Appendix A-2 shows the existing (2021) peak-hour and equivalent 24-hour traffic volumes used in this noise analysis[1].

Similarly, for Horizon Year (2046) No-Build and Build condition traffic scenarios, AM and PM peak hour traffic data were obtained from the Supplemental Traffic Impact Assessment

---

[1] Existing noise environment in this NVSR has been based upon 2021 traffic data and on-site noise measurements conducted in May 2022. Traffic conditions during the noise measurement periods are expected to be similar to the 2021 traffic volumes used in the traffic noise model.

Memorandum (HDR, November 2022), and input into the noise models developed for each scenario. For CNEL calculations, the 24-hour distribution of traffic was applied to the forecast average daily traffic (ADT), and the resultant traffic volumes were input into the noise model. Appendix A-3 and Appendix A-4 summarize the traffic volumes and assumptions used for modeling the highest noise hours and CNEL at the selected modeling locations under the Horizon Year (2046) No-Build and Build conditions, respectively.

5.4 Construction Noise

For assessment of temporary noise exposure during the construction of the Project, reference construction equipment noise levels were utilized in estimating maximum noise levels during construction at nearby noise-sensitive land uses. Reference noise levels were obtained from the FHWA publication related to roadway construction noise (FHWA, 2006). For estimation of maximum noise levels during construction, a point noise source attenuation factor of 6 dBA per doubling of distance was applied to construction equipment noise levels in conjunction with distances to the nearest noise-sensitive receptors to the Project.

5.5 Construction Vibration

For estimation of ground-borne vibration levels at the nearest residential structures in the vicinity of the Project site due to Project construction, reference vibration levels were obtained from the Caltrans Transportation and Construction Vibration Guidance Manual (Caltrans, 2013). Local ground vibration attenuation rate was based on the assumption of competent soil in the Project area. Ground vibration attenuation rate was then applied to reference vibration levels from construction machinery to predict the levels of construction vibration at the nearest residential structures to the Project area. Estimated construction vibration levels are compared with applicable building damage and human perceptibility criteria to determine Project vibration impacts at neighboring receptors.

Chapter 6 Existing Noise Environment

6.1 Existing Noise-Sensitive Receptors

Existing noise-sensitive locations along the Project corridor include outdoor activity areas of existing residential land uses along Markham Street and Citrus Hill High School, located at the southeast corner of Markham Street and Wood Road intersection at 18150 Wood Road. A number of analysis locations were chosen as representative outdoor locations at noise-sensitive properties in the vicinity of the Project (see Figure 5-1).

6.2 Noise Measurement Results

The existing noise environment in the Project area is characterized below according to the short-term and 24-hour noise monitoring data that were collected in the field and estimated existing AM and PM peak-hour noise levels and CNEL values using the noise model developed for this NVSR.

6.2.1 Short-Term Noise Measurements

Short-term noise measurements were conducted at six locations along the Project corridor on May 3 and May 4, 2022. The short-term noise monitoring locations are shown as Sites ST01 through ST06 on Figure 5-1. Table 6-1 summarizes the results of the short-term noise monitoring conducted in the Project area. The table shows the measurement location address, start time, date, and duration; and the measured L_{eq}, L_{min}, L_{90}, and L_{max}.

During short-term measurements, wind speeds ranged from 0 to 8 miles per hour (mph), temperatures ranged from 68 to 85 degrees Fahrenheit (°F), and relative humidity was between 35 to 57 percent.

Simultaneous traffic counts were conducted during the short-term noise measurements at Site ST06 located at the east end of the Project area, where traffic dominates the noise environment, in order to calibrate the TNM model to be developed for the noise study area. Field traffic count results are summarized in Appendix A-1 of this NVSR.

TABLE 6-1

Summary of Measured Short-Term Noise Levels (dBA)
Markham Street Extension Project
Riverside County, California

Measurement Location		Date	Start Time	Duration (minutes)	Measured Sound Level (dBA)			
					L_{eq}	L_{min}	L_{90}	L_{max}
ST01	17971 Timberview Dr. (APN-273-662-006)	5/3/2022	9:56 AM	15	44.2	37.3	38.5	59.4
			10:11 AM	15	44.6	35.9	37.0	61.3
ST02	18263 Markham St. (APN-321-020-020)	5/3/2022	10:50 AM	15	42.6	37.8	39.0	60.3
			11:05 AM	15	47.1	37.6	38.0	61.3
ST03	North property line (APN-321-030-002)	5/3/2022	12:56 PM	15	51.9	36.1	38.0	89.4
			1:11 PM	15	46.6	36.0	38.5	85.2
ST04	18750 Markham St. (APN-267-210-038)	5/4/2022	11:24 AM	15	52.6	48.0	50.0	65.0
			11:39 AM	15	54.9	50.0	50.5	70.9
ST05	18765 Markham St. (APN-321-030-007)	5/3/2022	2:07 PM	15	55.8	37.0	39.0	75.0
			2:22 PM	15	47.0	37.3	39.5	60.6
ST06	19010 Markham St. (APN-266-284-015)	5/4/2022	9:56 AM	15	62.2	50.4	52.5	77.5
			10:11 AM	15	63.2	51.0	53.5	77.6

Notes:

- Leq: Equivalent average sound level
- Lmin: Minimum measured sound level
- L90: Sound level exceeded 90% of the time
- Lmax: Maximum measured sound level

Source: A/E Tech LLC

6.2.2 Long-Term Noise Measurements

Long-term noise measurements were conducted at two locations using the Type 1 sound level meters described in the prior chapter. The monitoring locations are shown as LT01 and LT02 on Figure 5-1. The purpose of these measurements was to describe variations in sound levels throughout the day, rather than absolute sound levels at a specific receptor of concern. The long-term sound level data at each location were collected over one 24-hour period.

Table 6-2 and Table 6-3 summarize the results of the long-term noise monitoring at LT01 and LT02, respectively. The average sound level (Leq(h)) measured at LT01 was 46 dBA during the 7:00 AM hour and 49 dBA during the 4:00 PM hour. The measured CNEL at this location was 50 dBA.

At Site LT02, the measured CNEL was approximately 58 dBA, while the average noise levels during the 7:00 AM and 4:00 PM hours were about 60 dBA and 65 dBA, respectively.

TABLE 6-2

24-hour Noise Monitoring Results
Site LT01: 18180 Markham Street
May 3-4, 2022

Measurement Start Time		Measured Sound Levels, dBA		
		L_{eq}	L_{min}	L_{max}
May 3, 2022	10:00 AM	44.8	37.5	70.0
	11:00 AM	45.8	37.2	65.8
	12:00 PM	49.7	35.1	69.5
	1:00 PM	56.6	33.3	76.9
	2:00 PM	48.5	32.9	71.0
	3:00 PM	48.3	33.1	73.0
	4:00 PM	49.4	35.2	75.7
	5:00 PM	49.4	34.3	74.2
	6:00 PM	45.9	35.9	71.3
	7:00 PM	45.3	35.8	65.1
	8:00 PM	40.8	36.0	56.7
	9:00 PM	41.7	35.8	59.8
	10:00 PM	38.8	33.2	53.7
	11:00 PM	36.0	31.9	57.9
May 4, 2022	12:00 AM	37.7	31.6	51.2
	1:00 AM	36.4	30.6	50.1
	2:00 AM	37.4	32.0	49.0
	3:00 AM	37.4	34.7	49.8
	4:00 AM	39.3	35.5	47.3
	5:00 AM	45.0	37.3	58.5
	6:00 AM	46.9	41.3	63.8
	7:00 AM	46.0	41.5	58.7
	8:00 AM	48.4	38.7	72.9
	9:00 AM	52.4	35.5	75.1
CNEL		**50.3 dBA**		

Source: A/E Tech LLC

TABLE 6-3

24-hour Noise Monitoring Results
Site LT02: 18049 Birch Street
May 3-4, 2022

Measurement Start Time		Measured Sound Levels, dBA		
		L_{eq}	L_{min}	L_{max}
May 3, 2022	12:00 PM	52.3	35.4	72.8
	1:00 PM	49.1	33.5	67.4
	2:00 PM	55.2	34.4	75.2
	3:00 PM	54.0	35.7	83.4
	4:00 PM	64.8	35.6	98.1
	5:00 PM	52.8	35.3	82.1
	6:00 PM	46.2	35.2	71.1
	7:00 PM	58.5	34.7	87.5
	8:00 PM	45.5	34.7	68.7
	9:00 PM	43.0	33.1	63.1
	10:00 PM	38.8	31.6	59.8
	11:00 PM	36.5	29.8	65.0
May 4, 2022	12:00 AM	38.0	29.6	60.3
	1:00 AM	38.7	31.6	64.4
	2:00 AM	38.4	31.1	61.8
	3:00 AM	38.0	33.7	59.1
	4:00 AM	44.0	34.1	66.4
	5:00 AM	45.2	37.0	67.3
	6:00 AM	57.7	42.3	83.4
	7:00 AM	59.9	43.3	86.5
	8:00 AM	58.2	39.1	85.1
	9:00 AM	55.0	35.7	78.3
	10:00 AM	52.8	35.6	81.8
	11:00 AM	53.5	38.3	76.2
CNEL		**58.1 dBA**		

Source: A/E Tech LLC

6.3 Traffic Noise Model Calibration

TNM version 2.5 was used to compare measured traffic noise levels with modeled noise levels at short-term field measurement location ST06, using the traffic count data collected at the time of the noise measurements (see Appendix A-1). Table 6-4 compares measured and modeled noise levels at this measurement location. Agreement (within 2 dBA) was achieved between the measured and modeled results. Therefore, the noise model is used without adjustment to predict traffic noise levels in the Project area.

TABLE 6-4

Comparison of Measured and Modeled Traffic Noise Levels (dBA)
Markham Street Extension Project

Measurement Site	Date	Start Time	Measured Sound Level (dBA)	Modeled Sound Level (dBA)	Measured minus Modeled (dBA)
ST06	5/4/2022	9:56 AM	62.2	61.0	1.2
		10:11 AM	63.2	63.4	-0.2

Source: A/E Tech LLC

6.4 Existing Traffic Noise Levels

Existing noise levels were assessed at 24 locations throughout the Project area using a combination of onsite noise measurements and traffic noise modeling. The selected noise analysis locations are summarized in Table 6-5 and shown as locations M01 through M24 in Figures 6-1A through 6-1D. The noise analysis locations represent outdoor activity areas within residential land uses along the Project corridor and at the closest building setback within the Citrus Hill High School (Site M24).

Quantification of existing noise levels is done in terms of the highest hourly traffic noise levels (i.e., AM and PM peak hour L_{eq}) and CNEL. For receivers in areas where existing traffic movements are scarce (i.e., areas west of Roosevelt Street and areas between Roosevelt Street and Wood Road), the field noise measurement results were used to estimate the existing noise levels. At locations near the intersection of Markham Street and Wood Road, traffic noise levels were evaluated through TNM noise modeling.

TABLE 6-5
Noise Analysis Locations
Markham Street Extension Project

Modeling Location	Address	Land Use	Parcel Number
M01	17843 Timberview Drive	RES	APN-273-662-003
M02	17875 Timberview Drive	RES	APN-273-662-004
M03	17939 Timberview Drive	RES	APN-273-662-005
M04	17971 Timberview Drive	RES	APN-273-662-006
M05	18180 Markham Street	RES	APN-267-190-004
M06	18240 Markham Street	RES	APN-267-190-005
M07	18300 Markham Street	RES	APN-267-190-006
M08	18350 Markham Street	RES	APN-267-190-007
M09	18263 Markham Street	RES	APN-321-020-020
M10	18049 Birch Street	RES	APN-321-020-021
M11	18345 Markham Street	RES	APN-321-030-028
M12	18385 Markham Street	RES	APN-321-030-027
M13	18540 Markham Street	RES	APN-267-210-047
M14	18075 Cedar Street	RES	APN-321-030-003
M15	18750 Markham Street	RES	APN-267-210-038
M16	18759 Markham Street	RES	APN-321-030-034
M17	18765 Markham Street	RES	APN-321-030-007
M18	18811 Markham Street	RES	APN-321-030-008
M19	17959 Wood Road	RES	APN-267-210-021
M20	19010 Markham Street	RES	APN-266-284-015
M21	19044 Markham Street	RES	APN-266-284-010
M22	19076 Markham Street	RES	APN-266-284-012
M23	19096 Markham Street	RES	APN-266-284-013
M24	18150 Wood Road	SCH	APN-321-090-049

Notes:

Land Use: RES=Residential, SCH=School

Figure 6-1A
Traffic Noise Analysis Locations
Markham Street Extension Project

M## Noise Modeling Location

ST## Short-term Noise Measurement Location

LT## 24-hour Noise Measurement Location

TECH Noise & Vibration

Figure 6-1B
Traffic Noise Analysis Locations
Markham Street Extension Project

M## Noise Modeling Location

ST## Short-term Noise Measurement Location

LT## 24-hour Noise Measurement Location

Figure 6-1C
Traffic Noise Analysis Locations
Markham Street Extension Project

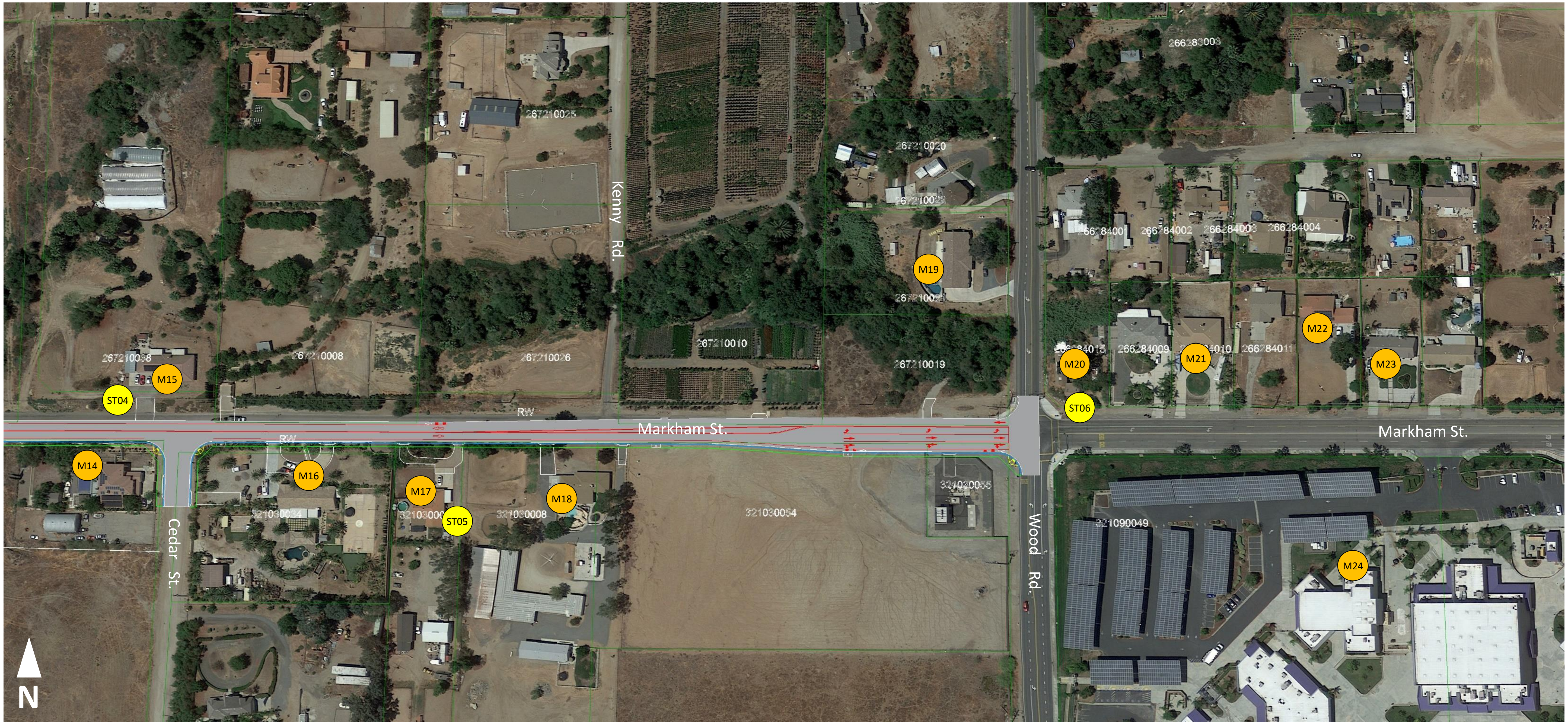
M## Noise Modeling Location

ST## Short-term Noise Measurement Location

LT## 24-hour Noise Measurement Location

TECH Noise & Vibration

Figure 6-1D
Traffic Noise Analysis Locations
Markham Street Extension Project



M## Noise Modeling Location

ST## Short-term Noise Measurement Location

LT## 24-hour Noise Measurement Location

The traffic data for the roadways used in the noise model for assessment of existing traffic noise levels are presented in Appendix A-2.

AM peak-hour, PM peak-hour, and CNEL values due to vehicular traffic at the analyzed receptors under existing conditions are listed in Appendix B, in Table B-1, Table B-2, and Table B-3, respectively. As shown in Table B-1, existing AM peak-hour traffic noise levels at exterior activity areas within nearby noise-sensitive properties are between 43 and 57 dBA Leq(h). Table B-2 shows that existing PM peak-hour traffic noise levels are between 44 and 57 dBA. None of the existing highest hour noise levels at the selected noise receptors approach or exceed the Caltrans NAC of 67 dBA hourly Leq(h).

Existing CNEL values at outdoor activity areas of homes were also estimated using the noise measurement results and results of the traffic noise model developed for the Project area. As shown in Table B-3, the existing CNEL values at the modeled receptor locations in the vicinity of the Project range between 44 dBA and 58 dBA. Existing CNEL values do not exceed the County’s exterior noise criterion of 65 dBA CNEL at any of the representative analyzed locations.

Chapter 7 Future Noise and Vibration Environment and Potential Project Impacts

Potential Project noise effects on the surrounding environment are evaluated in terms of temporary construction noise and long-term noise effects resulting from vehicular traffic on the proposed Markham Street extension.

7.1 Construction Noise

During construction of the Project, noise from construction activities may intermittently dominate the noise environment in the immediate area of construction. Riverside County Ordinance No. 847 exempts public construction activities from its noise limits between the hours of 7:00 AM to 6:00 PM on weekdays and Saturdays (except holidays) during the months of October through May, and between the hours of 6:00 AM to 6:00 PM on weekdays and Saturdays (except holidays) during the months of June through September. It is anticipated that the proposed Project would adhere to the exempted hours. However, for purposes of this NVSR, loudest noise levels from construction are estimated at the nearest noise-sensitive locations to construction activities.

Two types of short-term noise impacts would occur during Project construction. The first type would be from construction crew commutes and the transport of construction equipment and materials to the Project site, which would incrementally raise noise levels on access roads leading to the Project site. The pieces of heavy equipment for grading and construction activities would be moved on site, would remain for the duration of each construction phase, and would not add to the daily traffic volume in the Project vicinity. A high single-event noise exposure potential at a maximum level of 87 dBA L_{max} from trucks passing at 50 feet would exist. However, the projected construction traffic would be minimal when compared with existing traffic volumes on Wood Road and other affected paved streets in the area. Therefore, the associated noise level changes would be transitory and not be perceptible. Construction-related worker commutes and equipment transport noise impacts would be short-term and would not be adverse.

The second type of short-term noise impact would be from construction activities. Construction is performed in distinct steps, each of which has its own mix of equipment and consequently its own noise characteristics. These various sequential phases would change the character of the noise generated and the noise levels along the Project alignment as construction progresses. Despite the variety in the type and size of construction equipment, similarities in the dominant noise sources and patterns of operation allow construction-related noise ranges to be categorized by work phase.

Table 7-1 is a listing of typical noise levels from commonly used equipment during construction of road improvement projects at a reference distance of 50 feet from the equipment. Typical noise levels at 50 feet from an active construction area could reach 90 dBA L_{max} during the noisiest construction phases. The site preparation phase, which includes clearing and grubbing, asphalt demolition, and grading, tends to generate the highest noise levels because the noisiest construction equipment include pavement breakers and saws and earthmoving equipment. Earthmoving equipment includes excavation machinery such as backhoes, bulldozers, and front loaders. Earthmoving and compacting equipment includes compactors, scrapers, and graders. Typical operating cycles for these types of construction equipment may involve one or two minutes of full-power operation followed by three or four minutes at lower power settings.

TABLE 7-1
Reference Construction Equipment Noise Levels

Equipment Type	Actual L_{max} at 50 Feet (dBA)
Backhoe	78
Bulldozer	82
Compactor	83
Concrete Mixer	79
Concrete Pump	81
Concrete Saw	90
Crane, Mobile	81
Dump Truck	76
Excavator	81
Forklift	75
Grader	85
Loader	79
Pavement Breaker	90
Paver	77
Pump	81
Roller	80
Scraper	85
Sweeper	80
Tractor	84
Flatbed Truck	74
Welder	74

Source: Federal Highway Administration, 2006

During the site preparation phase, construction equipment would operate in close proximity to the residential structures nearest to Markham Street. Some of these structures are located at distances as close as 50 feet or closer to the construction machinery. Therefore, maximum noise levels from the equipment could approach 90 dBA at the nearest homes. Such levels would exceed the County's allowable daytime standard of 65 dBA maximum noise level for stationary equipment, and are therefore considered to be significant impacts.

7.2 Construction Vibration

Although the County of Riverside has not established any specific vibration criteria, the Caltrans vibration guidelines (see Section 4.2.3) are used in this study to assess potential vibration impacts due to construction of the Project.

Project construction is expected to generate temporary groundborne vibration in the immediate vicinity of certain construction activities. Groundborne vibration could cause human annoyance and potential building damage. Typical construction equipment with the potential to create groundborne vibration include pile drivers, vibratory rollers, large bulldozers, loaded trucks, jackhammers, and small bulldozers. Of these pieces of equipment, only pile drivers would not be used for construction of the Project.

Primary factors affecting the level of attenuation of vibration in the ground include the type and intensity of vibration at the source and the type of soil through which vibratory force propagates. Table 7-2 presents reference vibration levels in terms of PPV from the types of equipment to be utilized in construction of the Project. The soil type at the Project site is assumed to be competent soil type, which generally includes sandy clays, silty clays, gravel, silts, or weathered rock.

TABLE 7-2
Vibration Source Amplitudes for Construction Equipment

Equipment Type	Reference PPV at 25 ft. (in/sec)
Vibratory roller	0.210
Large bulldozer	0.089
Loaded trucks	0.076
Jackhammer	0.035
Small bulldozer	0.003

Note:
- PPV = Peak particle velocity; in/sec = inches per second

Source: Caltrans, 2013

As seen in Table 7-2, the highest vibration levels are generated by vibratory rollers and large bulldozers. Rollers are planned to be utilized during the roadway excavation, imported borrow, placement of aggregate base, and asphalt paving phases of construction. During these phases, the vibratory rollers could operate as close as 40 feet from the existing residential buildings near the intersection of Markham Street and Cedar Street. At such distances, vibration levels from vibratory rollers are estimated to reach 0.11 in/sec PPV. This level is below the building damage threshold of 0.30 in/sec PPV for older residential buildings.

Large bulldozers would be utilized during the clearing and grubbing, asphalt demolition, and roadway excavation phases. Such equipment would potentially operate at distances of 25 feet or closer to the nearest residential structures. Vibration levels from large bulldozers at these distances would be 0.089 in/sec PPV or higher. These levels would be below the threshold of damage to older residential buildings.

In terms of potential impacts related to human annoyance, vibration levels inside the nearest residential buildings to Project construction were calculated. Since annoyance from ground-borne vibration is an indoor phenomenon, coupling effects of building structures on vibration levels were considered for estimating vibration velocities inside the buildings. Estimated vibration levels inside buildings from the closest operating bulldozers (at 25 feet) would be 0.04 in/sec PPV. A vibratory roller would generate a vibration level of approximately 0.049 in/sec PPV inside the nearest building (at a distance of 40 feet). These groundborne vibration levels would be distinctly perceptible to occupants of buildings in respective proximities to the bulldozers and vibratory rollers. Therefore, utilization of these equipment in close proximity to the existing residential buildings would result in significant impacts.

7.3 Horizon Year (2046) No-Build Noise Environment

Horizon Year (2046) forecast peak hour and equivalent 24-hour traffic data were inputted into the TNM model developed for the No-Build condition. Table B-1 and Table B-2 in Appendix B summarize traffic noise modeling results for AM and PM peak-hour traffic under the future No-Build conditions, respectively. Table B-3 shows the predicted future CNEL at representative exterior noise-sensitive locations in the vicinity of the Project under the No-Build condition.

Analyzed results in Table B-1 and Table B-2 indicate that predicted traffic noise levels for AM and PM peak-hour traffic conditions would be between 43 dBA to 59 dBA L_{eq}(h) at outdoor locations of noise-sensitive receptors. Horizon Year No-Build traffic noise levels over a typical 24-hour period would be 48 dBA to 58 dBA CNEL. Similar to existing conditions, Horizon Year (2046) No-Build noise levels would not exceed the County criterion of 65 dBA CNEL at any of the analyzed locations.

Horizon Year (2046) No-Build condition traffic noise levels at exterior activity areas of noise-sensitive properties near the Project would be approximately zero to 2 dBA above existing noise levels during peak hour traffic, and zero to 4 dBA above existing noise levels over a typical 24-

hour period. Such changes would be imperceptible or barely perceptible to persons with normal hearing (see Section 3.6 for a narrative of human response to changes in noise levels).

7.4 Horizon Year (2046) Build Noise Environment

The proposed roadway geometry under the Project Build condition was used to create the Build condition traffic noise model. The Horizon Year (2046) peak hour and 24-hour traffic volumes under the Build condition were inputted into the model. The noise modeling results are summarized in Tables B-1 through B-3 of Appendix B.

As shown in Tables B-1 and B-2, the future peak-hour traffic noise L_{eq} is predicted to be between 48 to 63 dBA during the AM peak hour and 51 to 64 dBA during the PM peak hour at exterior areas of noise-sensitive receptors in the vicinity of the Project. Therefore, peak-hour traffic noise levels would not approach or exceed the State NAC of 67 dBA L_{eq}(h) at any of the analyzed receptor locations. Increases in hourly noise levels due to the Project would be between 6 to 17 dBA in residential areas west of Roosevelt Street and residences adjoining Markham Street between Roosevelt Street and Wood Road. Such increases in hourly noise levels would be clearly noticeable to residents. At residential structures farther away from Markham Street (generally along the north side of the roadway), increases in hourly traffic noise levels would be in the range of 2 to 5 dBA, which is considered barely noticeable. In areas east of Wood Road, increases in hourly noise levels would be between zero and 2 dBA, which would be relatively imperceptible.

Horizon Year (2046) traffic CNEL values under the Build condition would be 52 to 65 dBA at locations representing the nearest noise-sensitive uses in the vicinity of the Project. Such levels would be in compliance with the County’s exterior noise criterion of 65 dBA CNEL for residential land uses. In terms of the County’s interior noise standard of 45 dBA CNEL, today’s residential construction is expected to provide at least 20 to 25 dBA outdoor-to-indoor noise reduction with windows closed (meaning that air conditioning is provided in the homes adjoining the Project corridor). Therefore, the long-term operation of the Project would not cause interior noise levels within the residential structures to exceed 45 dBA CNEL. Therefore, Project exterior and interior noise impacts are not considered to be significant.

Increases in CNEL due to the Project under the Build condition would be between 13 to 16 dBA within the backyards of first row of homes along Markham Street west of Roosevelt Street. Such changes would be noticeable.

At exterior activity areas of homes north of Markham Street between Roosevelt Street and Wood Road (M05 through M08 and M13), Project implementation of the Build condition would result in traffic CNEL increases of 2 to 4 dBA. Such changes in noise levels would be barely perceptible.

At receptor locations along the south side of Markham Street between Roosevelt Street and Wood Road (M09 through M12 and M14 through M18), the Project under the Build condition, would result in increases of 9 to 15 dBA in CNEL over existing conditions. Such changes would be clearly noticeable.

At noise-sensitive locations adjoining Markham Street east of Wood Road and those along Wood Road, increases in CNEL due to the Project under the Build condition would be in the range of zero to 3 dBA. Such increases would not be noticeable to the noise-sensitive receptors in these areas.

Chapter 8 Avoidance, Minimization, and/or Mitigation Measures

8.1 Construction

Noise levels from construction equipment and activities could exceed the background sound levels in the Project area. Therefore, the following short-term (construction) avoidance/minimization measures, N-1 through N-11, would be required to avoid and minimize the community exposure to construction noise impacts:

N-1: Limit roadway construction activities to the exempted daytime hours in the Riverside County Code, Ordinance No. 847, which are 6:00 AM to 6:00 PM during the months of June through September and 7:00 AM to 6:00 PM during the months of October through May (except weekends and holidays).

N-2: All construction equipment should be outfitted with manufacture-recommended mufflers and silencers.

N-3: Staging and delivery areas should be located as far as feasible from existing residences.

N-4: Material hauling and deliveries should be coordinated by the construction contractor to reduce the potential of trucks waiting to unload for protracted periods of time.

N-5: To the extent feasible, hydraulic equipment should be used instead of pneumatic impact tools, and electric powered equipment should be used instead of diesel powered equipment.

N-6: For smaller equipment (such as air compressors and small pumps), line powered (electric) equipment should be used to the extent feasible.

N-7: Maintaining equipment in an idling mode should be minimized.

N-8: Stationary noise sources (e.g., generators and air compressors) should be located as far from sensitive receptors as possible, and they should be muffled and enclosed within temporary sheds, or insulation barriers, or other measures shall be incorporated to the extent feasible.

N-9: Signs shall be posted at the job site(s), within the construction zones, and along queueing lanes (if any) to reinforce the prohibition of unnecessary engine idling. All other equipment shall be turned off if not in use for more than 5 minutes. The construction manager shall be responsible for enforcing this.

N-10: At least 21 days prior to the start of construction activities, all neighboring residents within 300 feet of the Project site shall be notified of the planned construction activities. The notification shall include a brief description of the Project, the activities that would occur, the hours when construction would occur, and the construction period's overall duration. The notification shall include the telephone numbers of the County's and contractor's authorized representatives that are assigned to respond in the event of a noise complaint.

N-11: At least 10 days prior to the start of construction activities, a sign shall be posted at the job site, clearly visible to the public, that includes permitted construction days and hours, as well as the telephone numbers of the County's and contractor's authorized representatives that are assigned to respond in the event of a noise complaint. If the authorized contractor's representative receives a complaint, they shall investigate, take appropriate corrective action, and report the action to the County. The sign will have a minimum dimension of 48 inches wide by 24 inches high. The sign will be placed 5 feet above ground level.

Based on the vibration analysis results, construction of the Project would result in significant vibration impacts at residential land uses in the immediate vicinity of the Project. Such impacts would be due to the use of vibratory rollers and large bulldozers in very close proximity to neighboring residential buildings during construction. The following construction vibration measures are recommended in order to reduce construction vibration to less than significant levels:

N-12: If paving activities occur within 25 feet of off-site buildings or structures, a pneumatic or static roller shall be used in lieu of a vibratory roller.

N-13: Grading and earthwork activities within 25 feet of adjacent residential structures shall be conducted with off-road equipment that is limited to 100 horsepower or less.

Furthermore, proper timely notices of scheduled construction activities to local residents as recommended above for construction noise mitigation would be important in managing expectations and minimizing the potential for complaints.

8.2 Operation

Horizon Year (2046) Build location traffic noise levels at exterior locations of the nearest noise-sensitive properties along the Project corridor are predicted to be in compliance with the County of Riverside exterior noise standard of 65 dBA CNEL for residential and school land uses. Therefore, long-term noise avoidance, minimization, or mitigation measures would not be required for the Project.

Chapter 9 References

California Department of Transportation. 2011. *Traffic Noise Analysis Protocol for New Highway Construction, Reconstruction, and Retrofit Barrier Projects.* May. Sacramento, CA. Available at: http://www.dot.ca.gov/hq/env/noise/pub/ca_tnap_may2011.pdf.

———. 2013a. *Technical Noise Supplement*. September. Sacramento, CA: Environmental Program, Noise, Air Quality, and Hazardous Waste Management Office. Sacramento, CA. Available at: http://www.dot.ca.gov/hq/env/noise/pub/TeNS_Sept_2013B.pdf.

______. 2013. Transportation and Construction Vibration Guidance Manual. September 2013.

———. 2016. *Highway Design Manual*. September. Available at: http://www.dot.ca.gov/hq/oppd/hdm/pdf/english/HDM_Complete_16Dec2016.pdf.

County of Riverside. 2015. Noise Element of the General Plan, December 2015. Available at: https://planning.rctlma.org/Portals/14/genplan/general_Plan_2017/elements/OCT17/Ch07_Noise_120815.pdf?ver=2017-10-11-102104-080

———. 2015. General Plan Appendix I-1: Noise Element Data, December. Available at: https://planning.rctlma.org/Portals/14/genplan/general_plan_2016/appendices/Appendix%20I-1_120815.pdf?ver=2016-04-01-142032-867

______. Riverside County Code of Ordinances. Ordinance No. 847. Available at: http://www.rivcocob.org/ords/800/847.pdf

Federal Highway Administration. 1998a. Traffic Noise Model, Version 1.0 User's Guide. January. FHWA-PD-96-009. Washington D.C.: Available at: http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/old_versions/tnm_version_10/users_guide/tnm10usersguide.pdf.

———. 1998b. Traffic Noise Model, Version 1.0. February. FHWA-PD-96-010. Washington D.C.: Available at: http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/old_versions/tnm_version_10/tech_manual/tnm10techmanual.pdf.

———. 2011. Highway Traffic Noise: Analysis and Abatement Guidance. December. Washington D.C. FHWA-HEP-10-025. Available at: http://www.fhwa.dot.gov/environment/noise/regulations_and_guidance/analysis_and_abatement_guidance/revguidance.pdf.

______. 2006. Roadway Construction Noise Model. February 15, 2006. Available at: http://www.fhwa.dot.gov/environment/noise/construction_noise/rcnm/rcnm.cfm

HDR. 2022. *Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum*, February 2022.

———. 2022. *Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum*, November 2022.

This page intentionally left blank.

Appendix A Traffic Data

A-1: Hourly Traffic Count Data during Noise Measurements

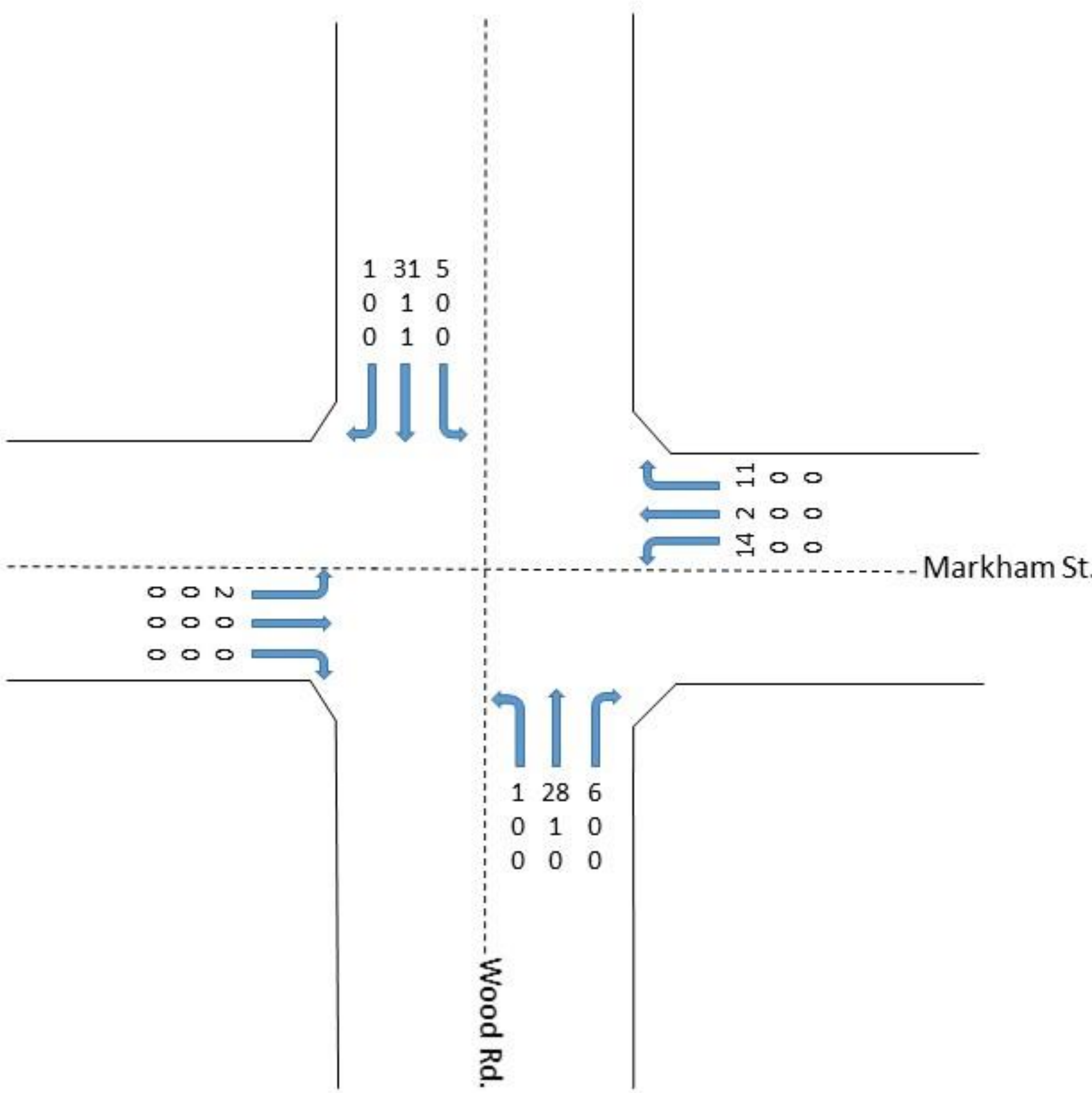
A-2: Existing Year (2021) Traffic Volumes

A-3: Horizon Year (2046) No-Build Traffic Volumes

A-4: Horizon Year (2046) Build Traffic Volumes

A-1

Noise Measurement Traffic Counts
May 4, 2022 – 9:56 a.m. – 10:11 a.m.
(15-minute Duration)



Legend:
- # Automobiles
- # Medium Trucks
- # Heavy Trucks

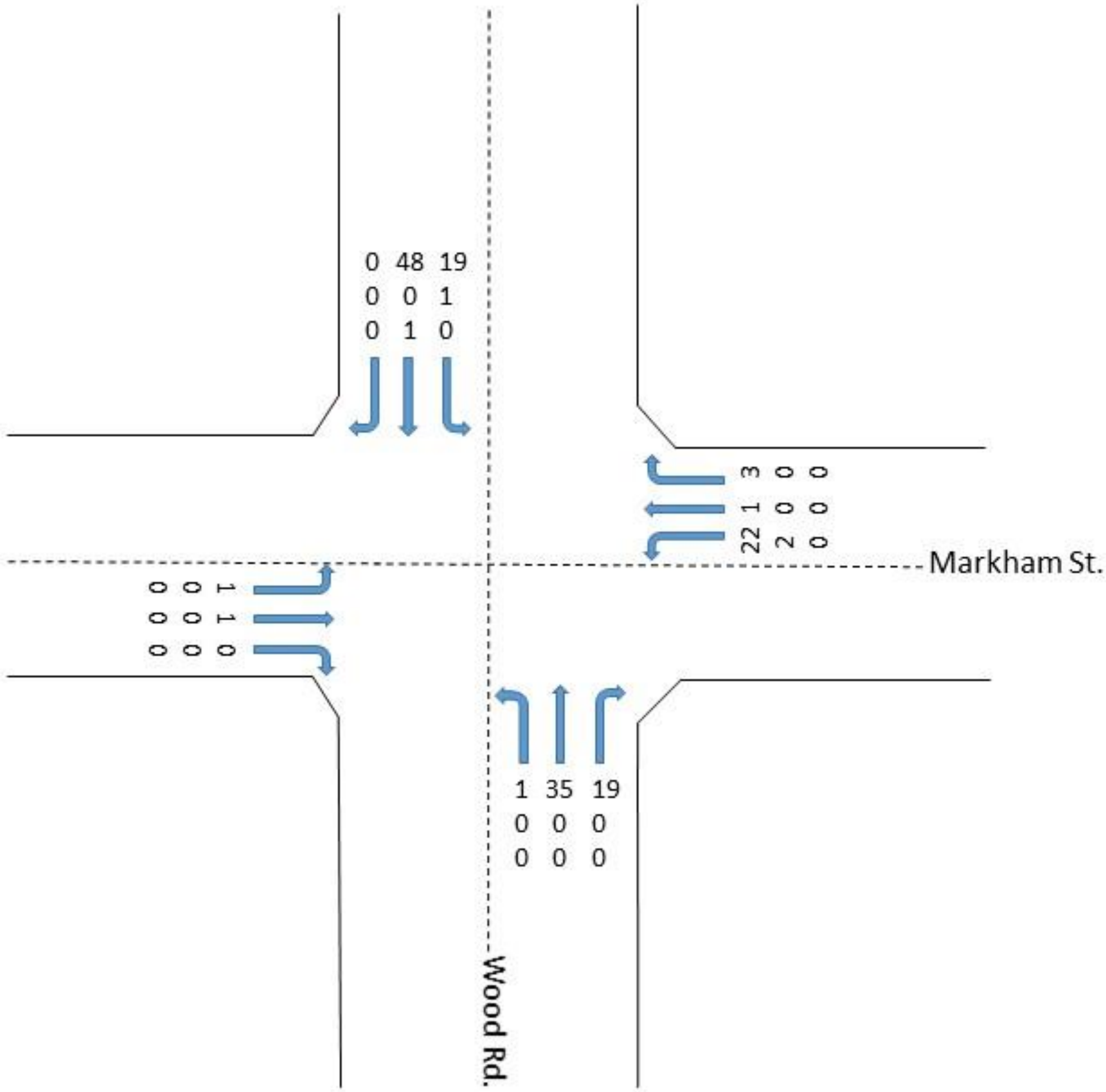
Source: A/E Tech LLC, May 4, 2022

A-1 (Cont'd)

Noise Measurement Traffic Counts

May 4, 2022 – 10:11 a.m. – 10:26 a.m.

(15-minute Duration)



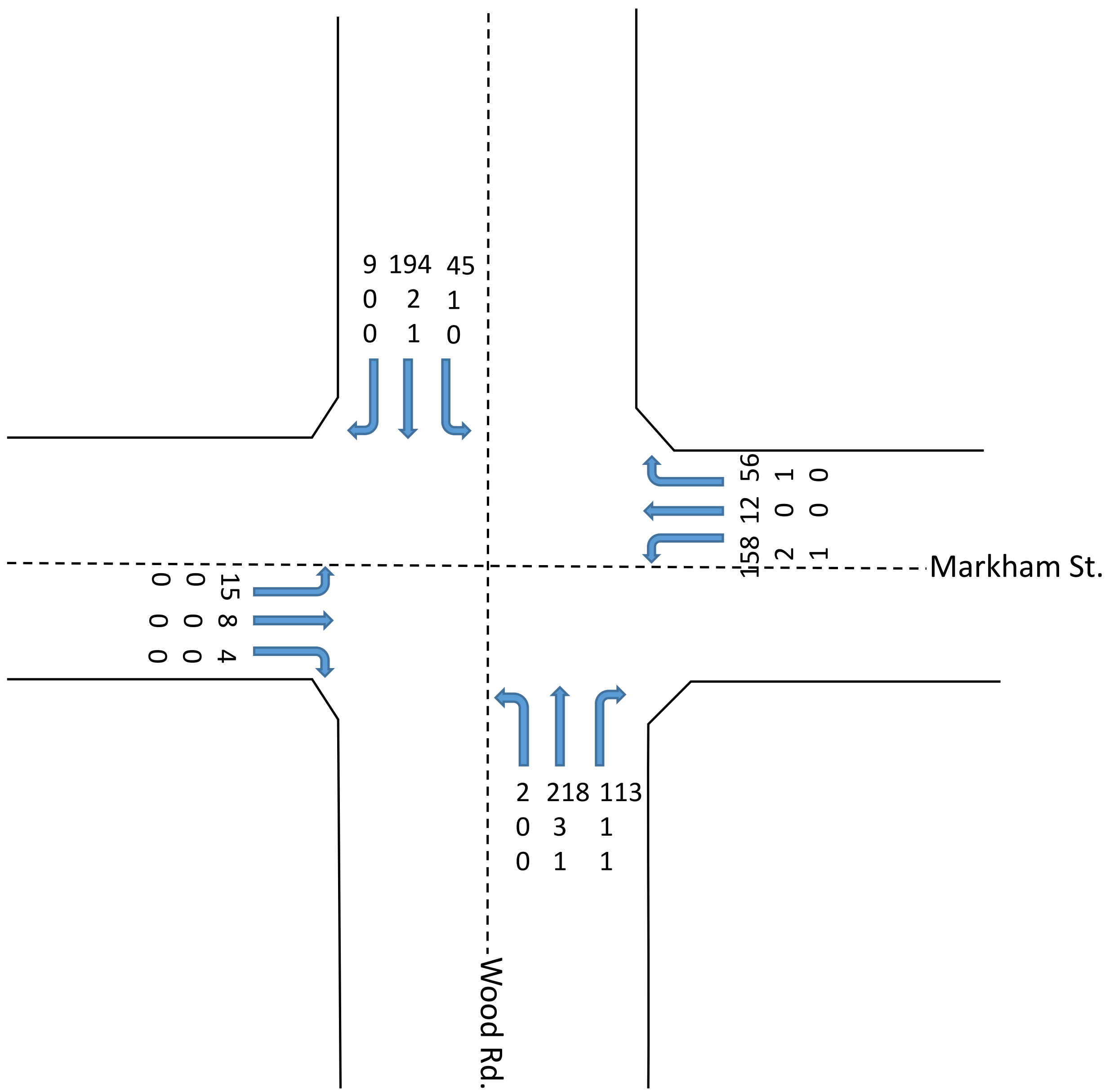
Legend:

- # Automobiles
- # Medium Trucks
- # Heavy Trucks

Source: A/E Tech LLC, May 4, 2022

A-2. Existing (2021) Traffic Volumes

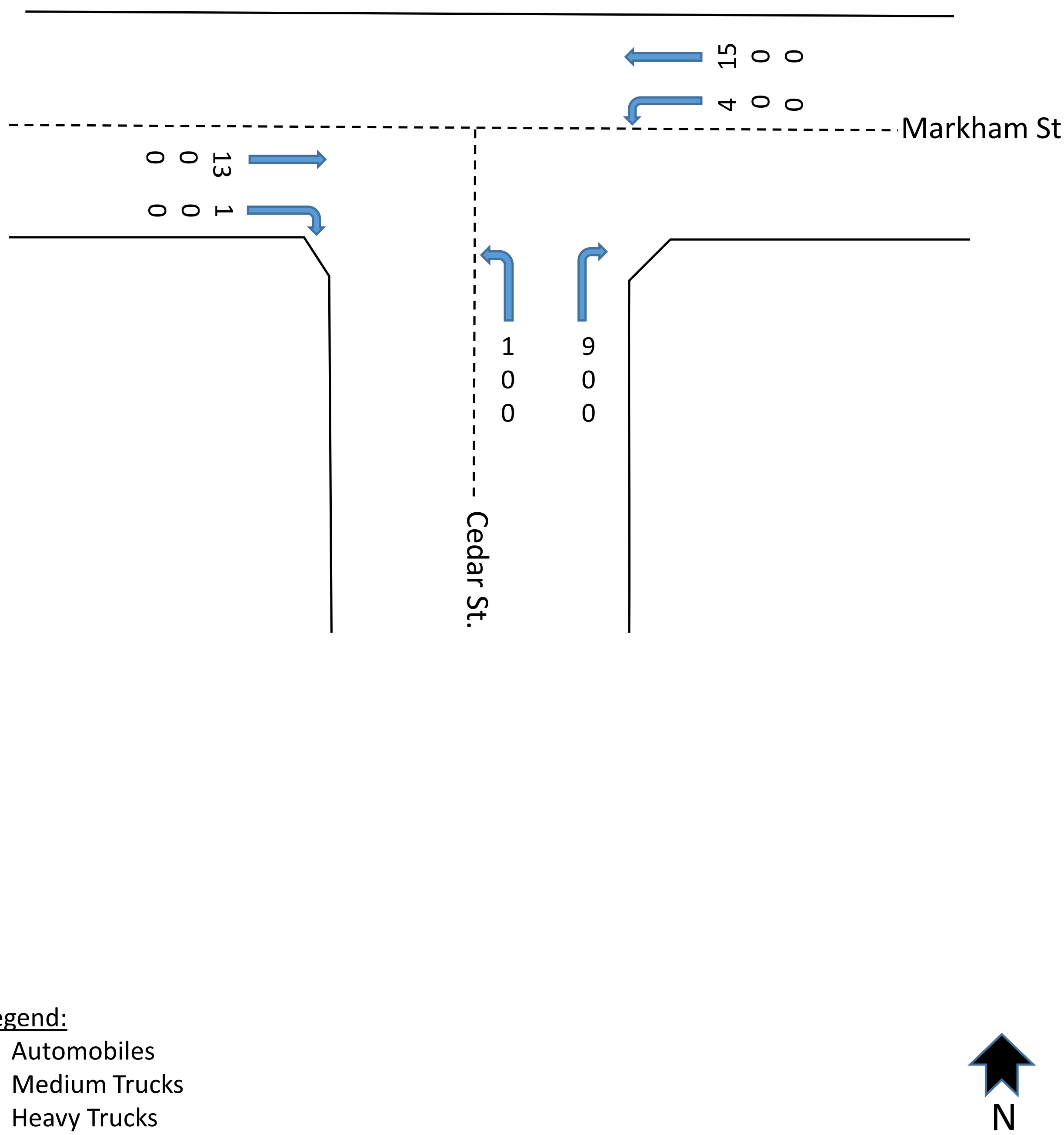
Existing (2021) AM Peak Hour Traffic Volumes
Markham Street/Wood Road Intersection



Legend:
Automobiles
Medium Trucks
Heavy Trucks

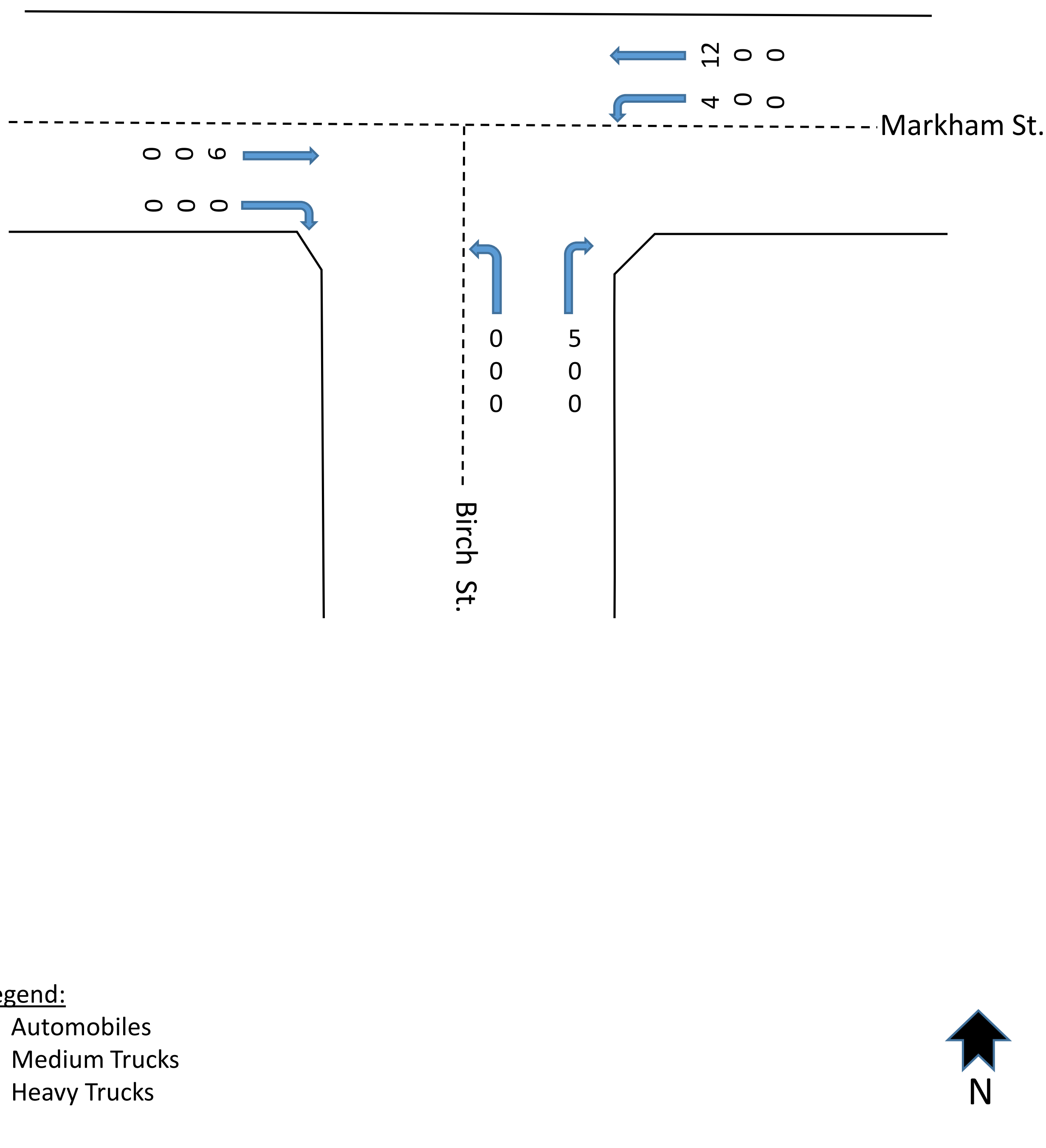
Source: HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 16, 2022

Existing (2021) AM Peak Hour Traffic Volumes
Markham Street/Cedar Street Intersection



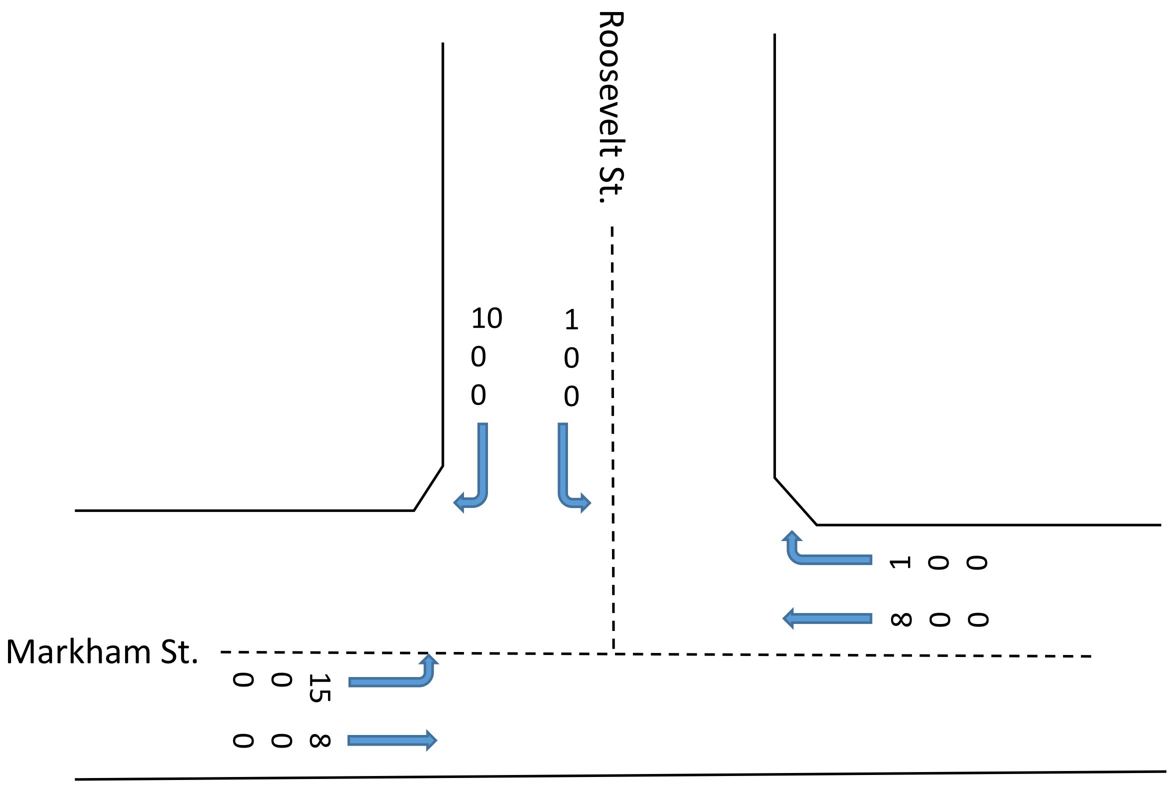
Source: HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 16, 2022

Existing (2021) AM Peak Hour Traffic Volumes
Markham Street/Birch Street Intersection



Source: HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 16, 2022

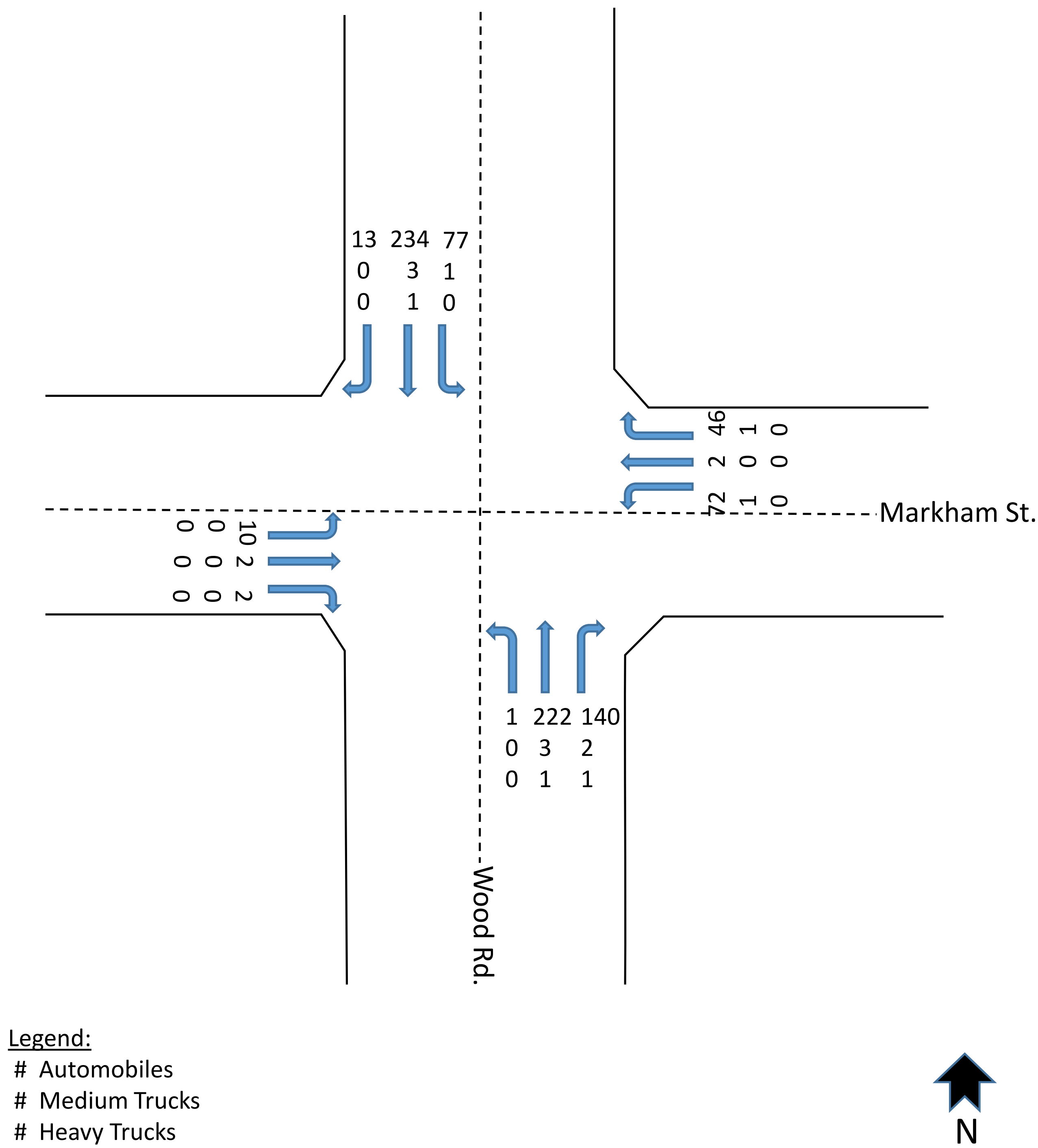
Existing (2021) AM Peak Hour Traffic Volumes
Markham Street/Roosevelt Street Intersection



Legend:
\# Automobiles
\# Medium Trucks
\# Heavy Trucks

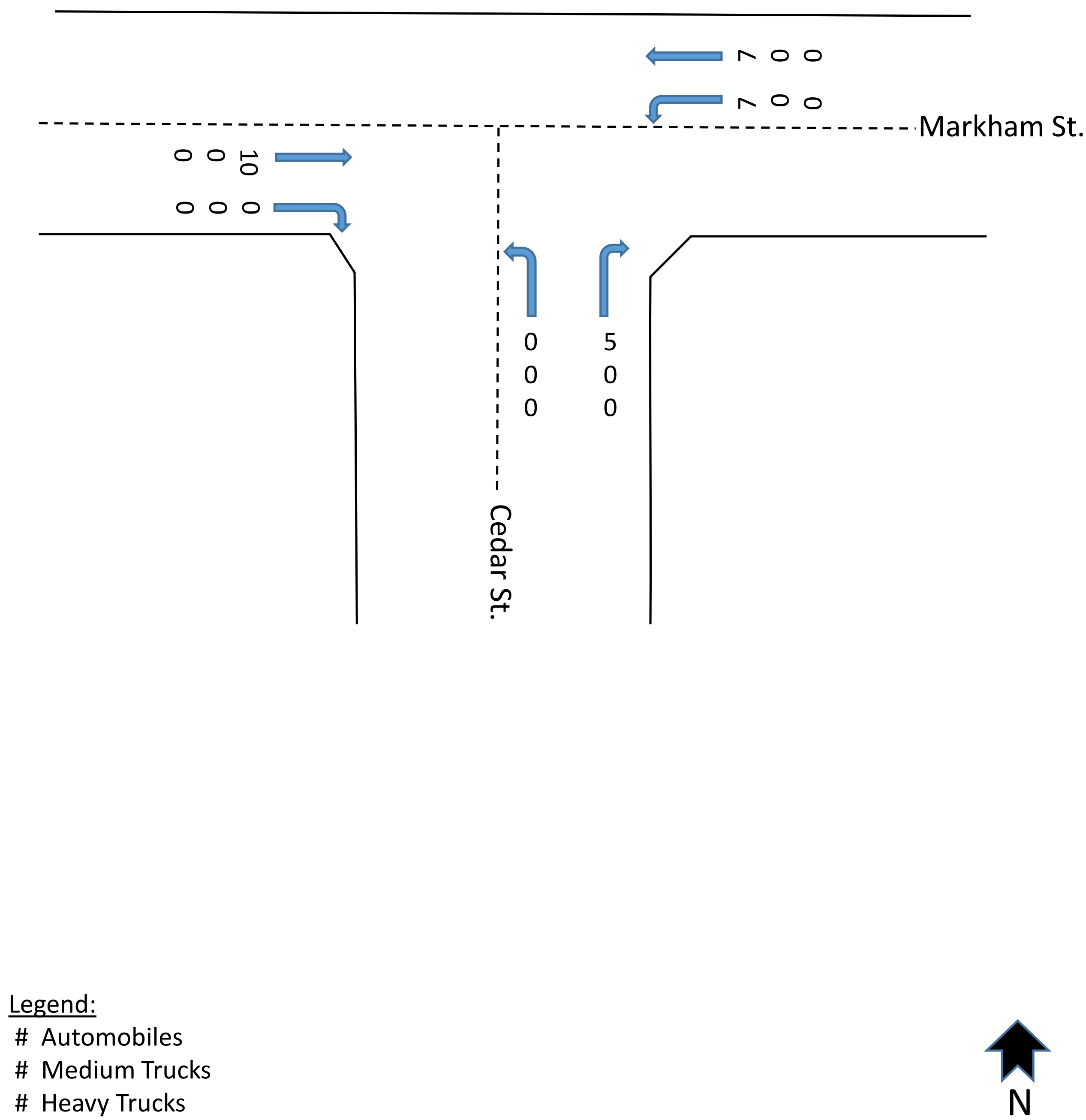
Source: HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 16, 2022

Existing (2021) PM Peak Hour Traffic Volumes
Markham Street/Wood Road Intersection



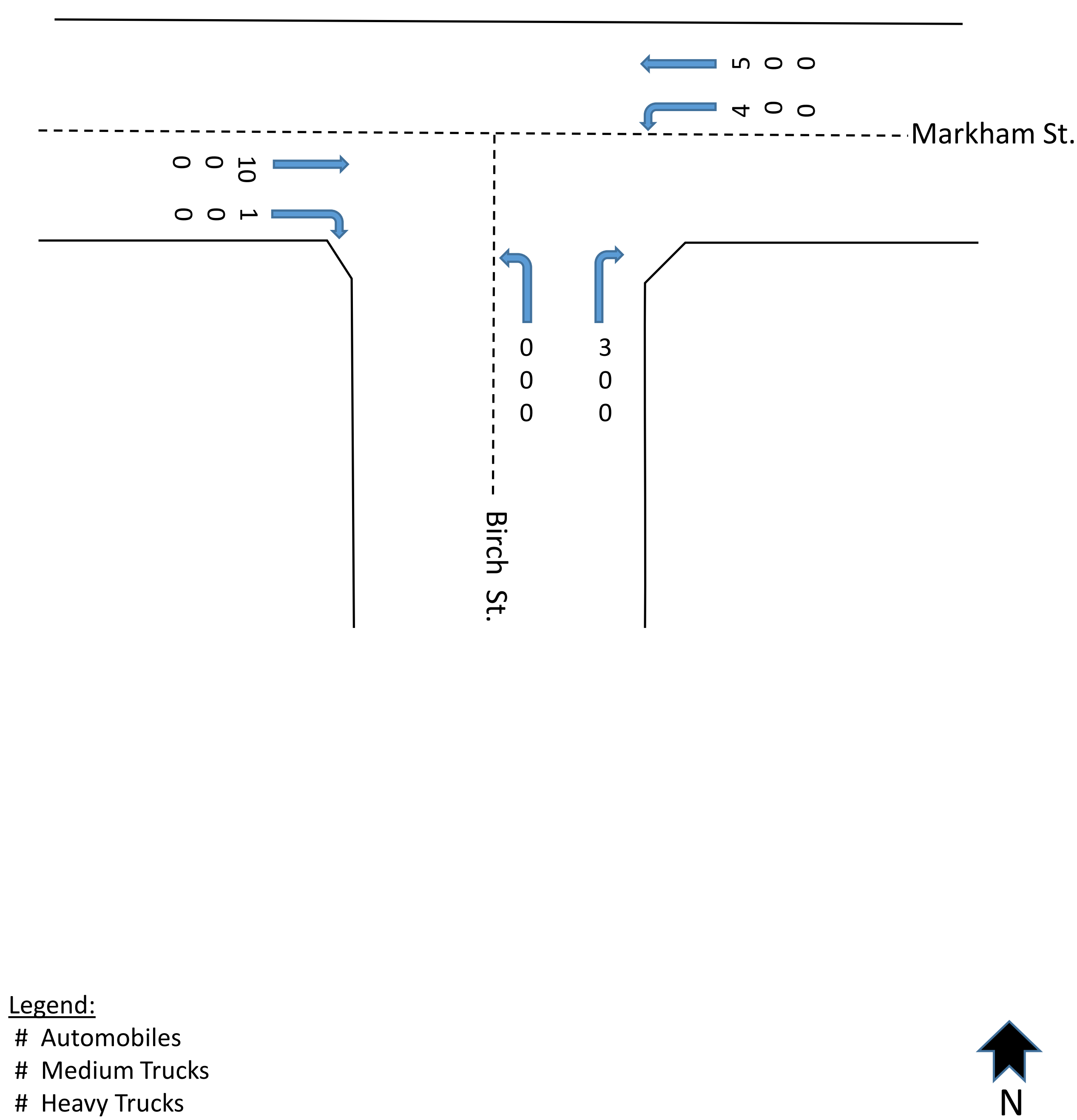
Source: HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 16, 2022

Existing (2021) PM Peak Hour Traffic Volumes
Markham Street/Cedar Street Intersection



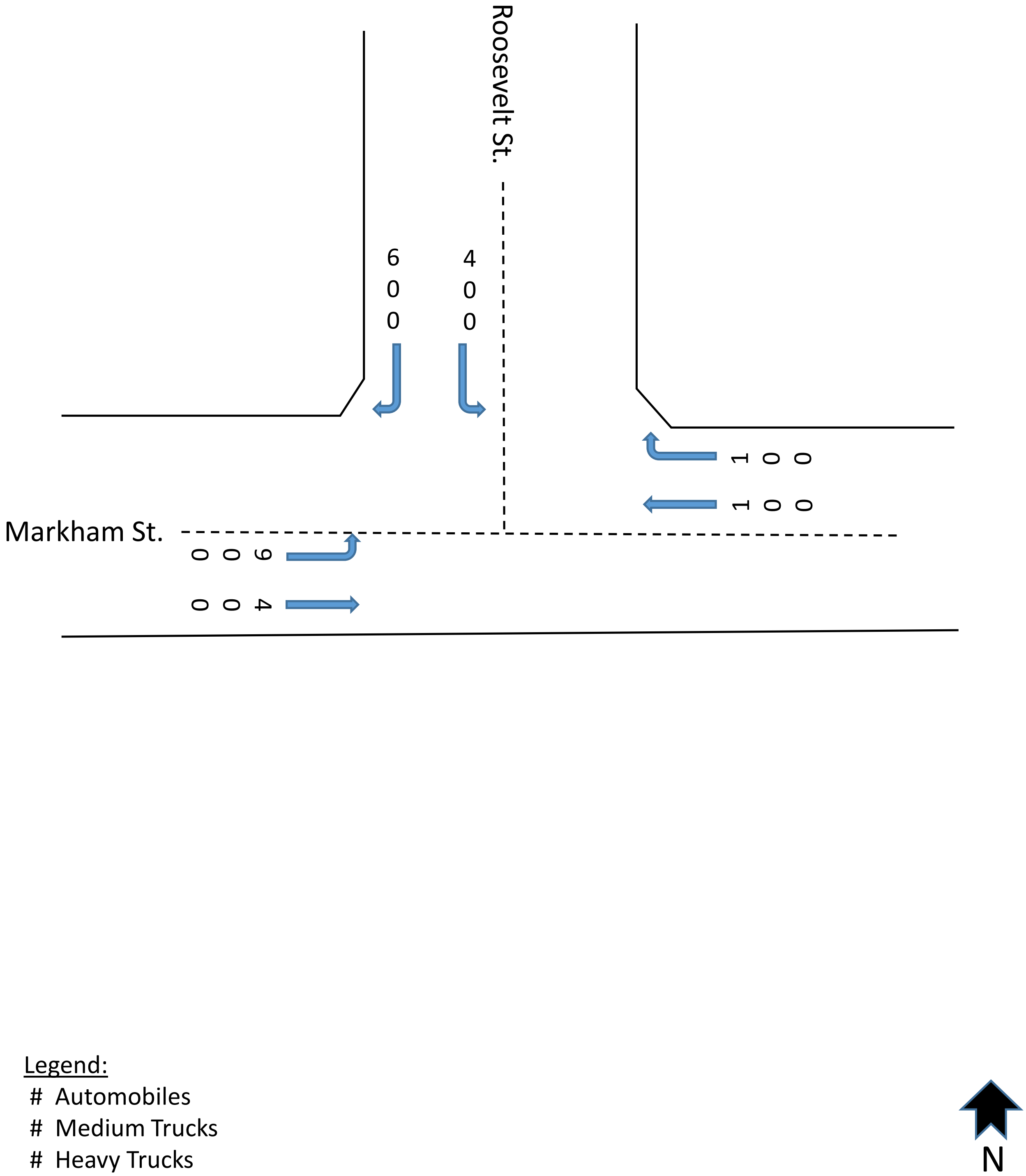
Source: HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 16, 2022

Existing (2021) PM Peak Hour Traffic Volumes
Markham Street/Birch Street Intersection



Source: HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 16, 2022

Existing (2021) PM Peak Hour Traffic Volumes
Markham Street/Roosevelt Street Intersection



Legend:
- # Automobiles
- # Medium Trucks
- # Heavy Trucks

Source: HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 16, 2022

Existing (2021) ADT Volumes

Markham Street - West of Roosevelt Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	178	135	25	19
Medium Truck	3	2	0	2
Heavy Truck	1	1	0	1

Markham Street - Roosevelt Street to Wood Road

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	489	369	68	51
Medium Truck	9	5	0	5
Heavy Truck	4	2	0	2

Markham Street - East of Wood Road

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	2,896	2,188	404	304
Medium Truck	55	27	1	27
Heavy Truck	22	10	1	10

Roosevelt Street - North of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	128	96	18	13
Medium Truck	2	1	0	1
Heavy Truck	1	0	0	0

Wood Road - North of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	6,156	4,651	859	646
Medium Truck	116	57	3	57
Heavy Truck	47	22	3	22

Wood Road - South of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	6,500	4,911	907	682
Medium Truck	123	60	3	60
Heavy Truck	49	23	3	23

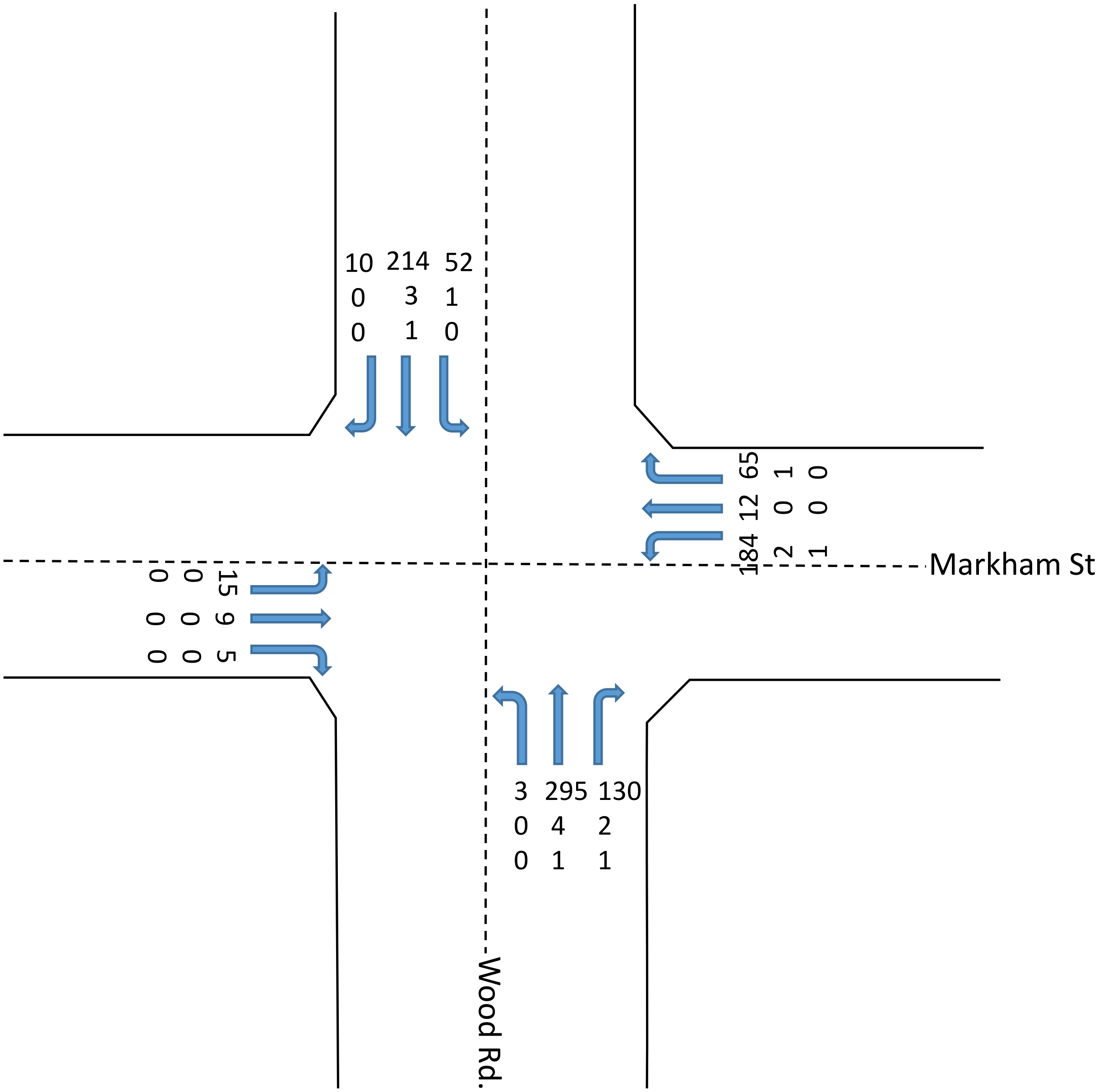
Sources:

County of Riverside, General Plan Appendix I: Noise Element Technical Data, December 2015

HDR, Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum, February 2022

A-3. Horizon Year (2046) No Build Traffic Volumes

Year 2046 No Build AM Peak Hour Traffic Volumes
Markham Street/Wood Road Intersection

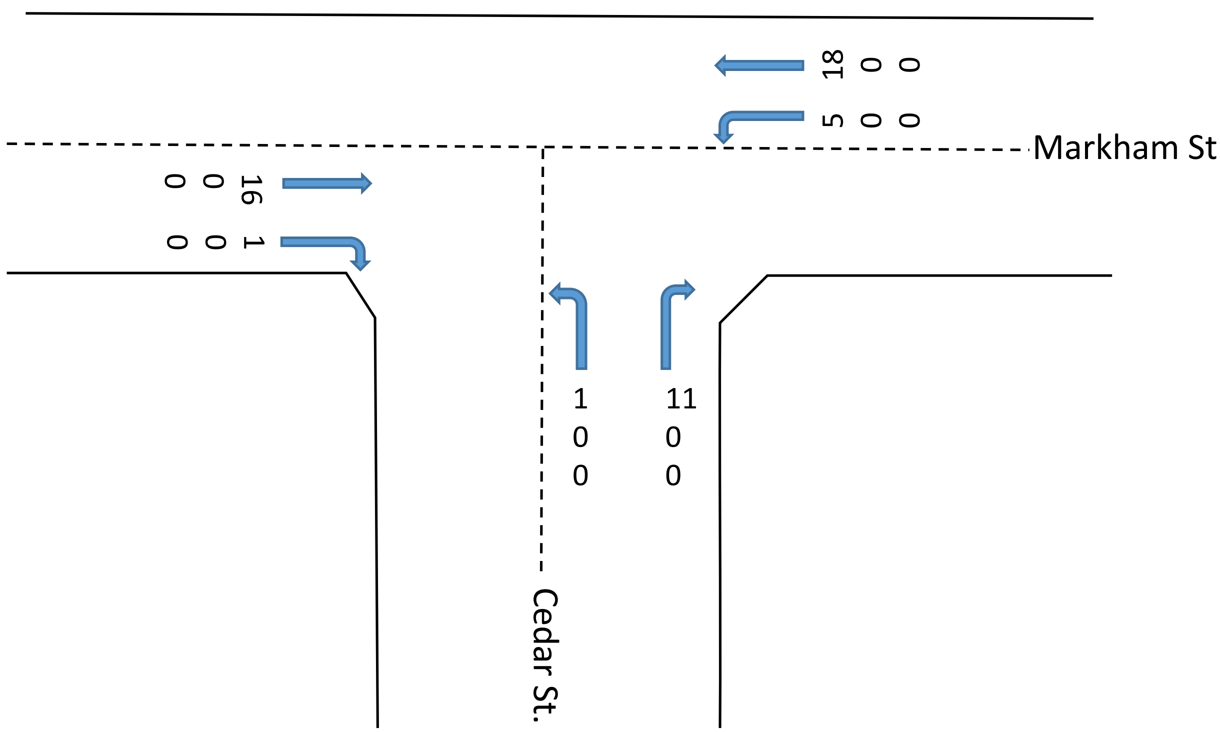


Legend:
Automobiles
Medium Trucks
Heavy Trucks

N

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

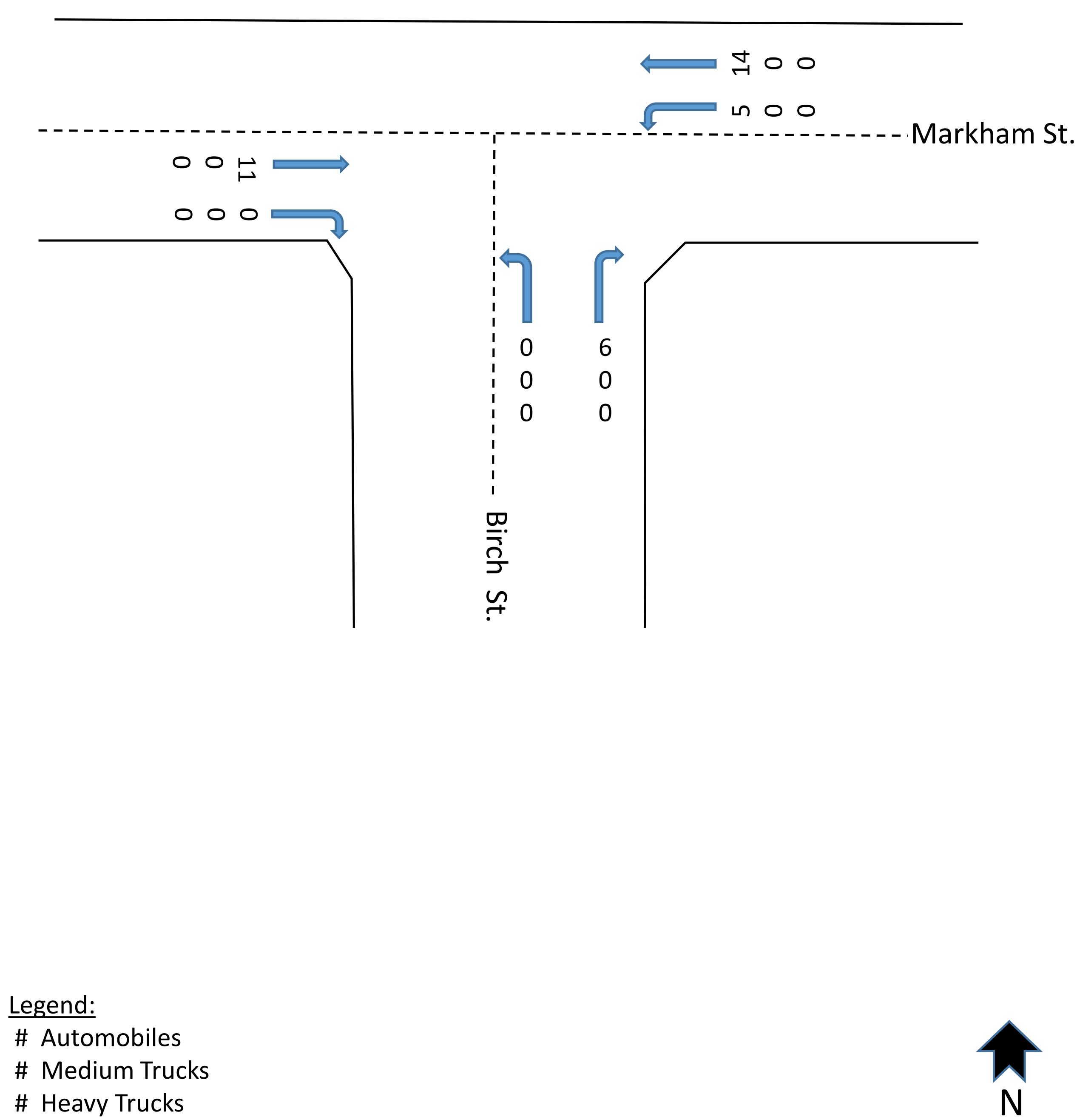
Year 2046 No Build AM Peak Hour Traffic Volumes
Markham Street/Cedar Street Intersection



Legend:
Automobiles
Medium Trucks
Heavy Trucks

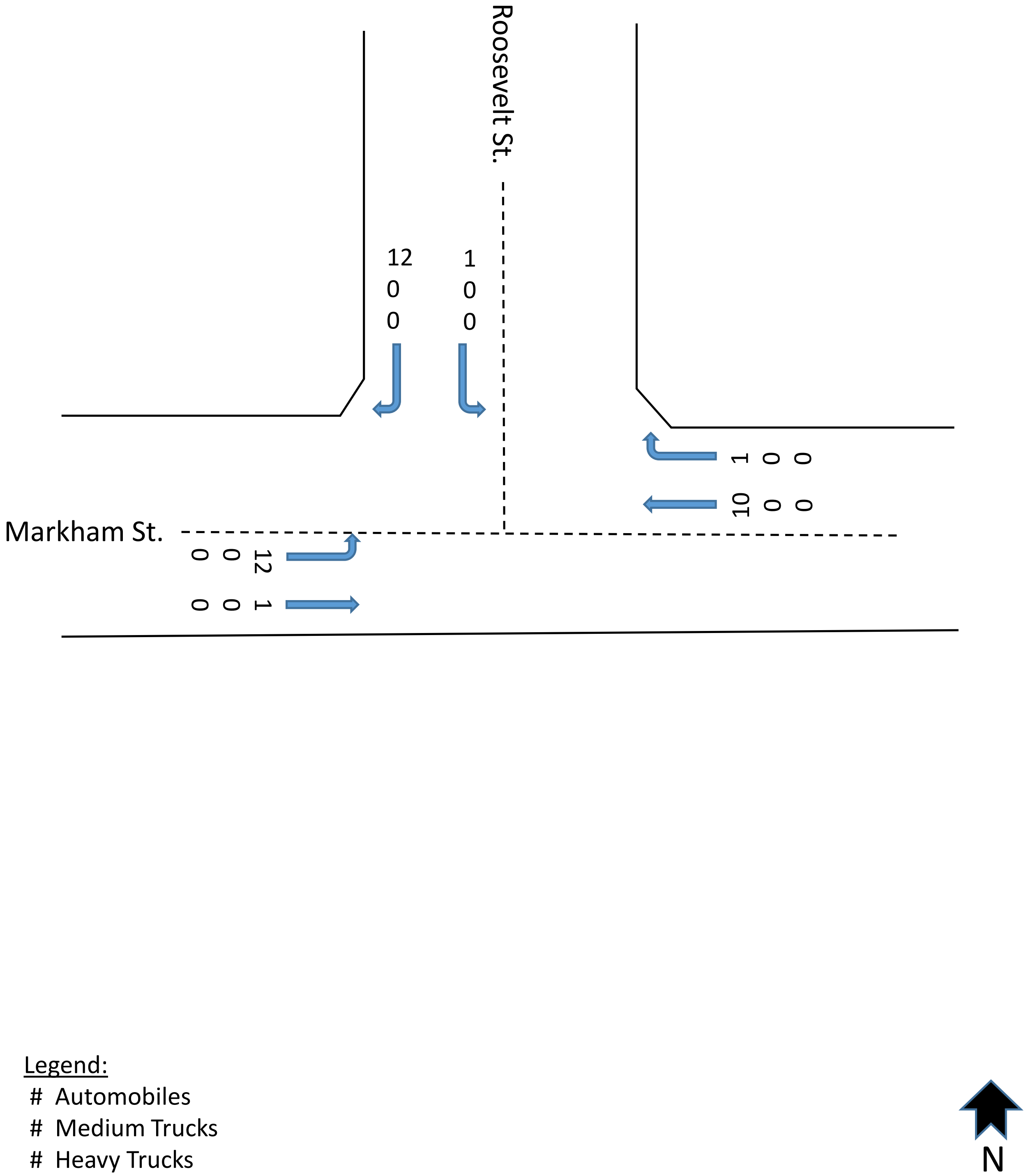
Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 No Build AM Peak Hour Traffic Volumes
Markham Street/Birch Street Intersection



Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

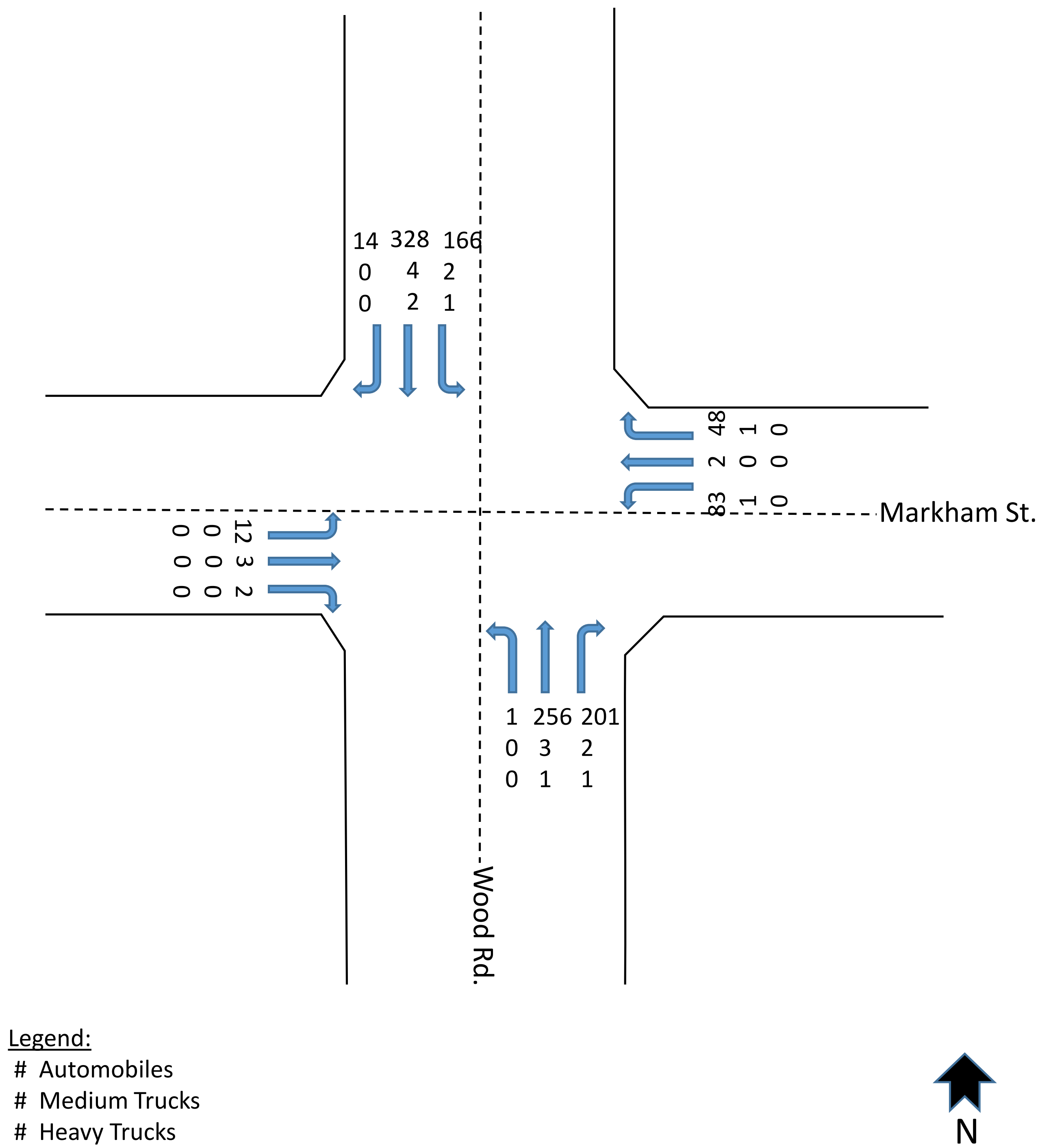
Year 2046 No Build AM Peak Hour Traffic Volumes
Markham Street/Roosevelt Street Intersection



Legend:
Automobiles
Medium Trucks
Heavy Trucks

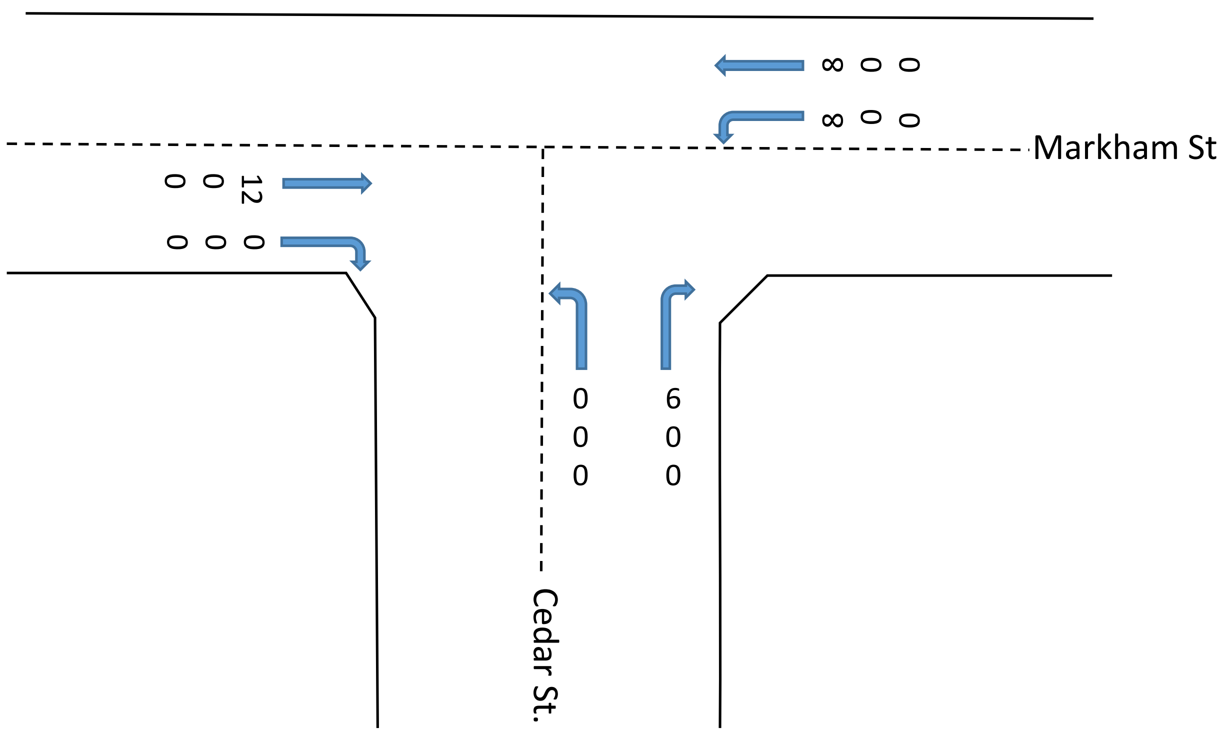
Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 No Build PM Peak Hour Traffic Volumes
Markham Street/Wood Road Intersection



Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

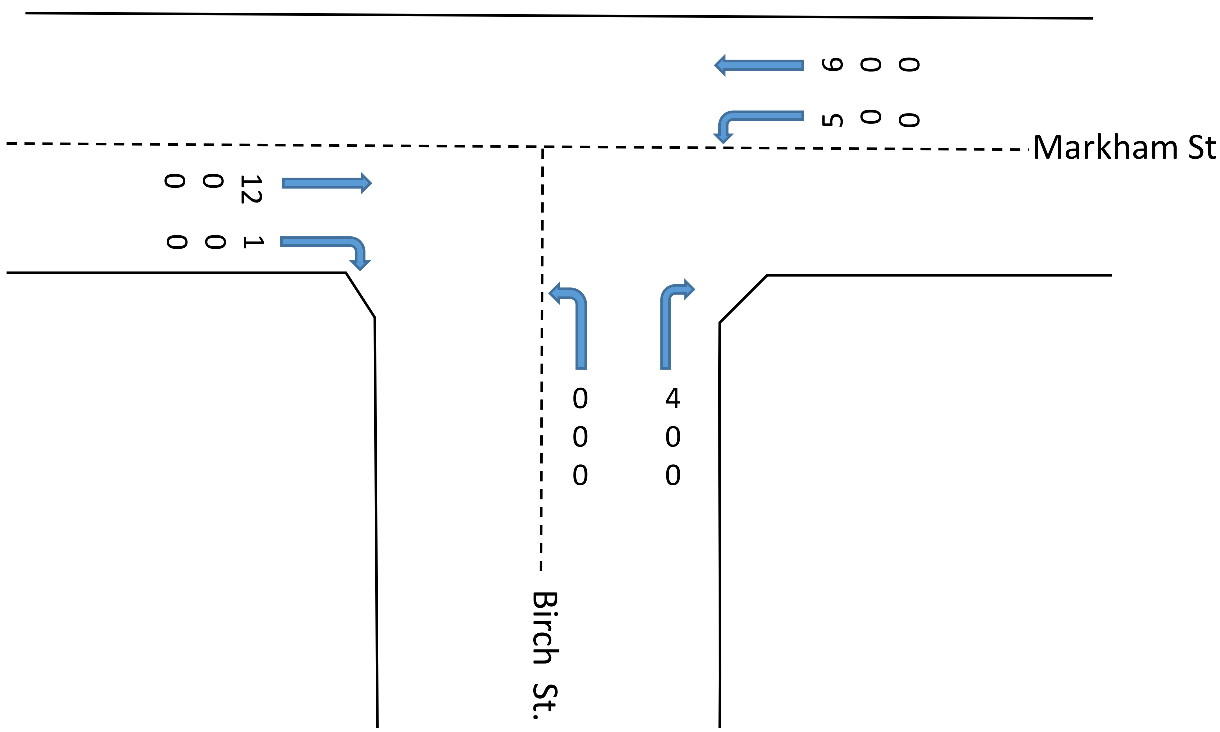
Year 2046 No Build PM Peak Hour Traffic Volumes
Markham Street/Cedar Street Intersection



Legend:
Automobiles
Medium Trucks
Heavy Trucks

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 No Build PM Peak Hour Traffic Volumes
Markham Street/Birch Street Intersection

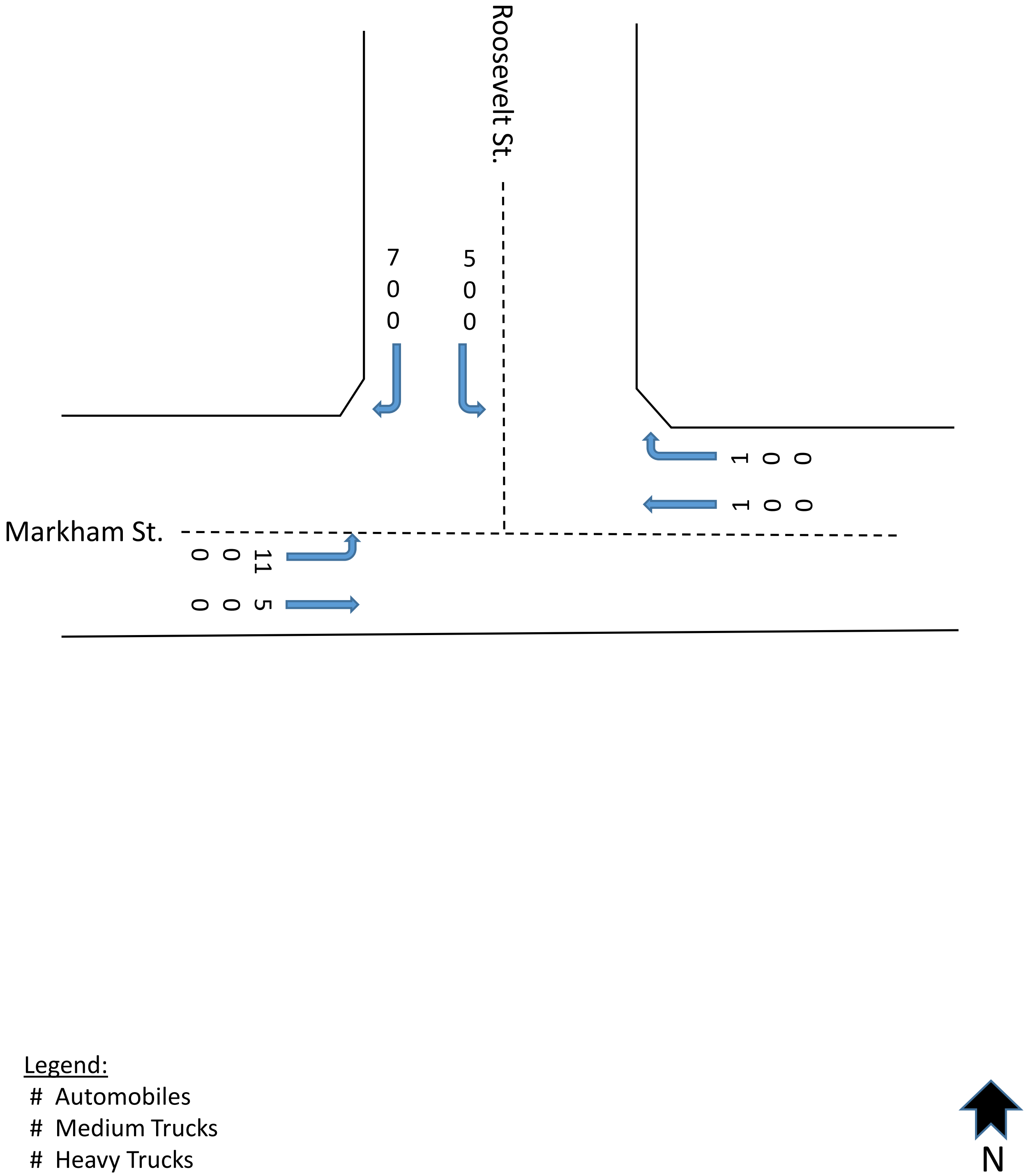


Legend:
Automobiles
Medium Trucks
Heavy Trucks

N

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 No Build PM Peak Hour Traffic Volumes
Markham Street/Roosevelt Street Intersection



Legend:
- # Automobiles
- # Medium Trucks
- # Heavy Trucks

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 No Build ADT Volumes

Markham Street - West of Roosevelt Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	347	262	48	36
Medium Truck	7	3	0	3
Heavy Truck	3	1	0	1

Markham Street - Roosevelt Street to Wood Road

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	544	411	76	57
Medium Truck	10	5	0	5
Heavy Truck	4	2	0	2

Markham Street - East of Wood Road

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	2,961	2,237	413	311
Medium Truck	56	27	1	27
Heavy Truck	22	11	1	11

Roosevelt Street - North of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	142	107	20	15
Medium Truck	3	1	0	1
Heavy Truck	1	1	0	1

Wood Road - North of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	6,608	4,992	922	693
Medium Truck	125	61	3	61
Heavy Truck	50	24	3	24

Wood Road - South of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	7,533	5,691	1,052	790
Medium Truck	142	70	3	70
Heavy Truck	57	27	3	27

Sources:

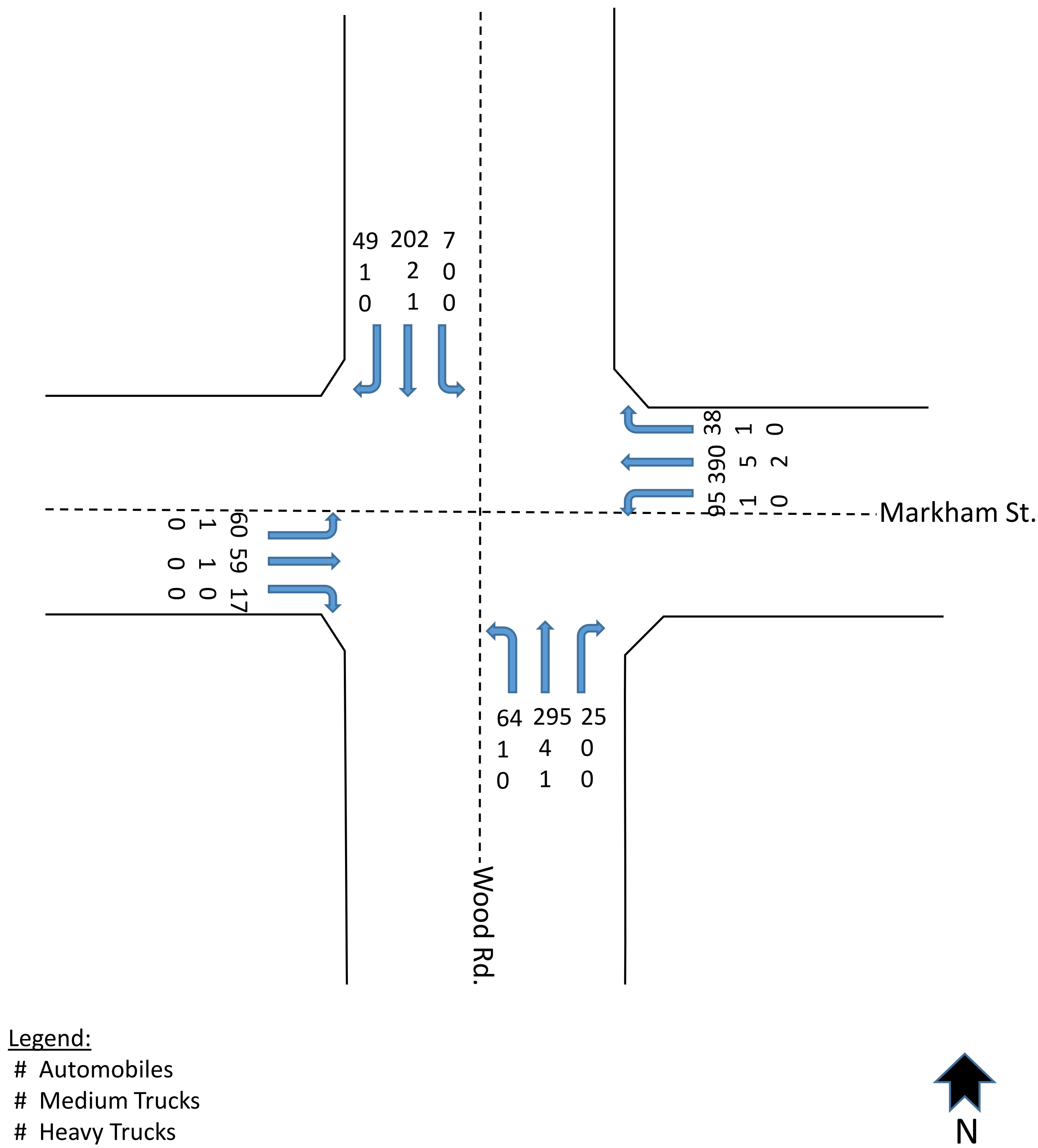
County of Riverside, *General Plan Appendix I: Noise Element Technical Data* , December 2015

HDR, *Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum* , February 2022

HDR, *Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum* , November 2022

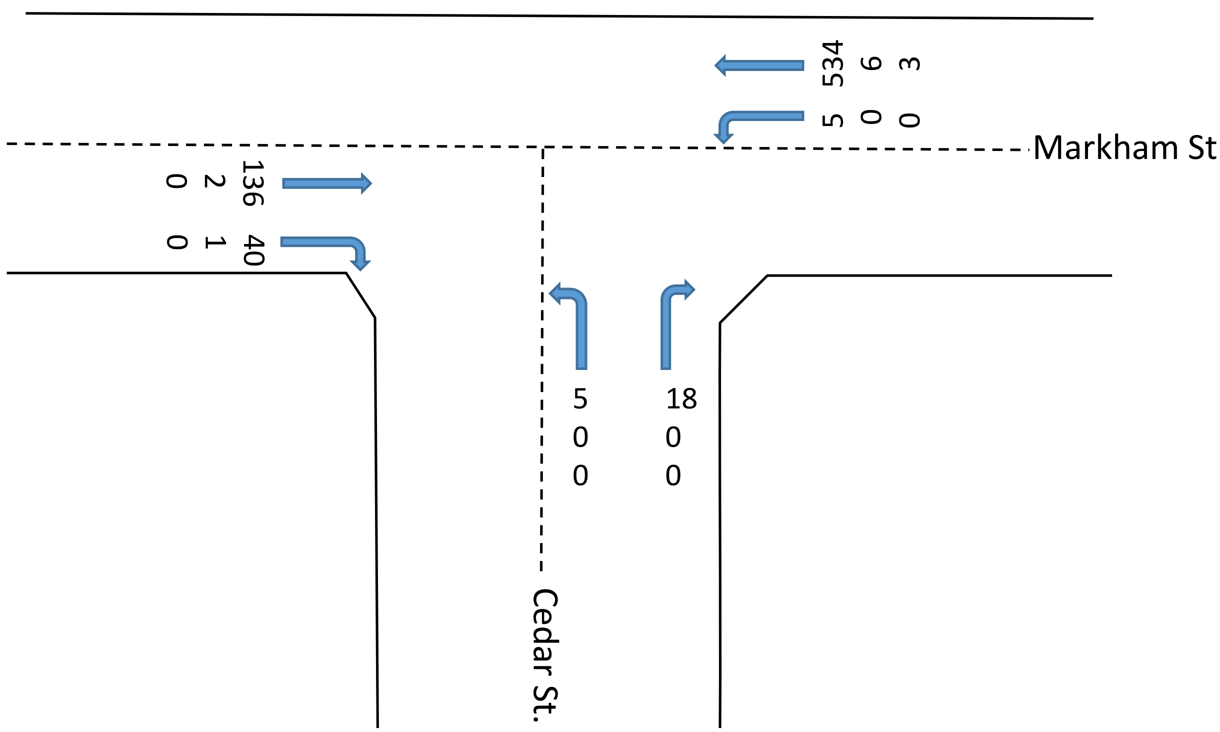
A-4. Horizon Year (2046) Build Traffic Volumes

Year 2046 Build AM Peak Hour Traffic Volumes
Markham Street/Wood Road Intersection



Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

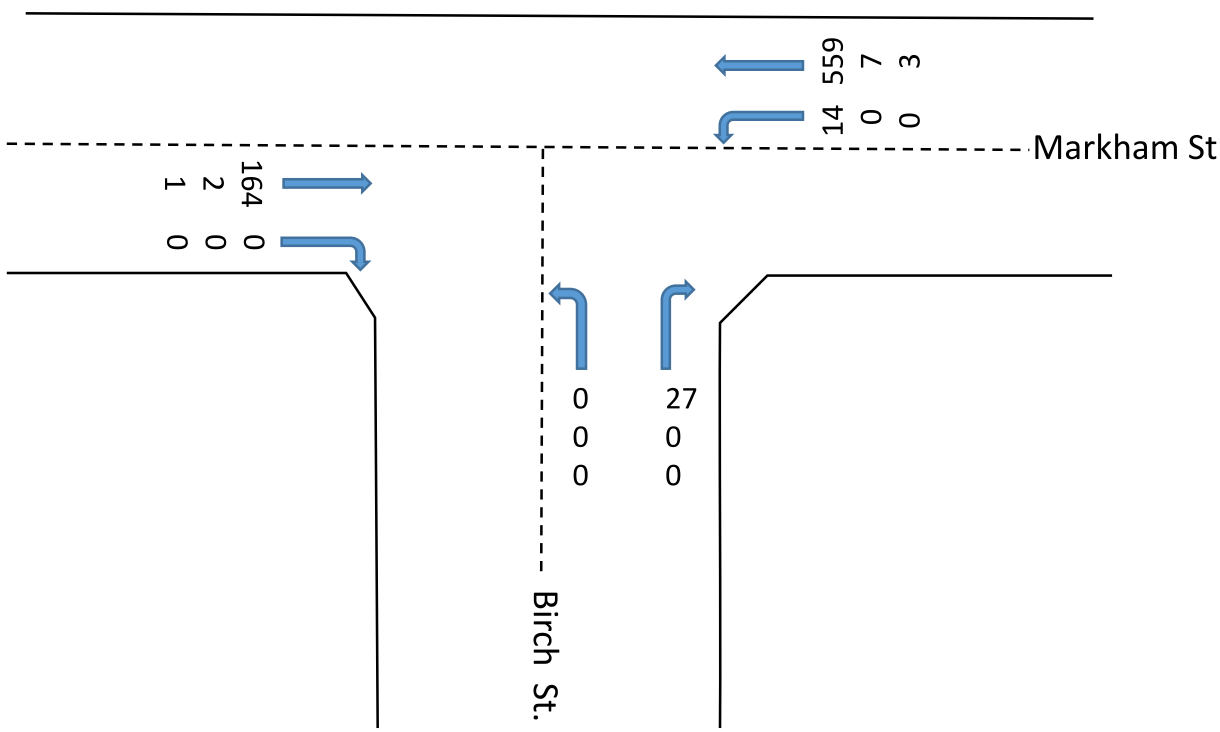
Year 2046 Build AM Peak Hour Traffic Volumes
Markham Street/Cedar Street Intersection



Legend:
Automobiles
Medium Trucks
Heavy Trucks

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 Build AM Peak Hour Traffic Volumes
Markham Street/Birch Street Intersection

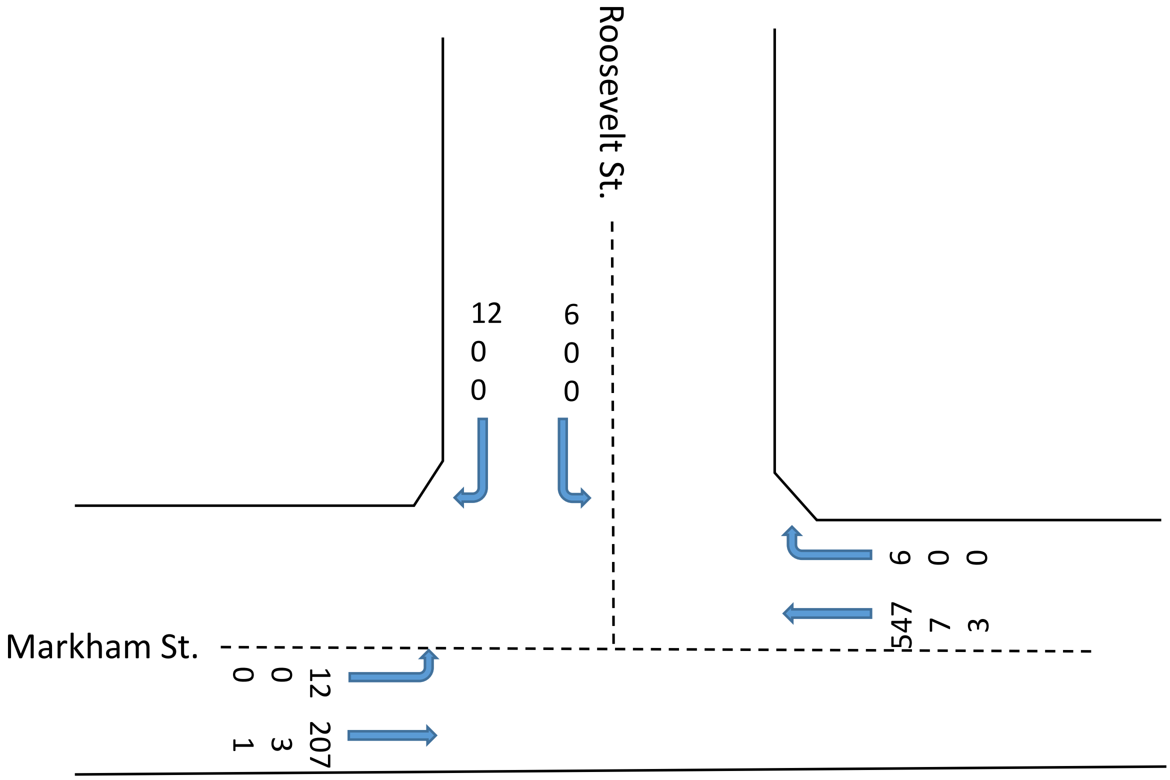


Legend:
Automobiles
Medium Trucks
Heavy Trucks

N

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 Build AM Peak Hour Traffic Volumes
Markham Street/Roosevelt Street Intersection

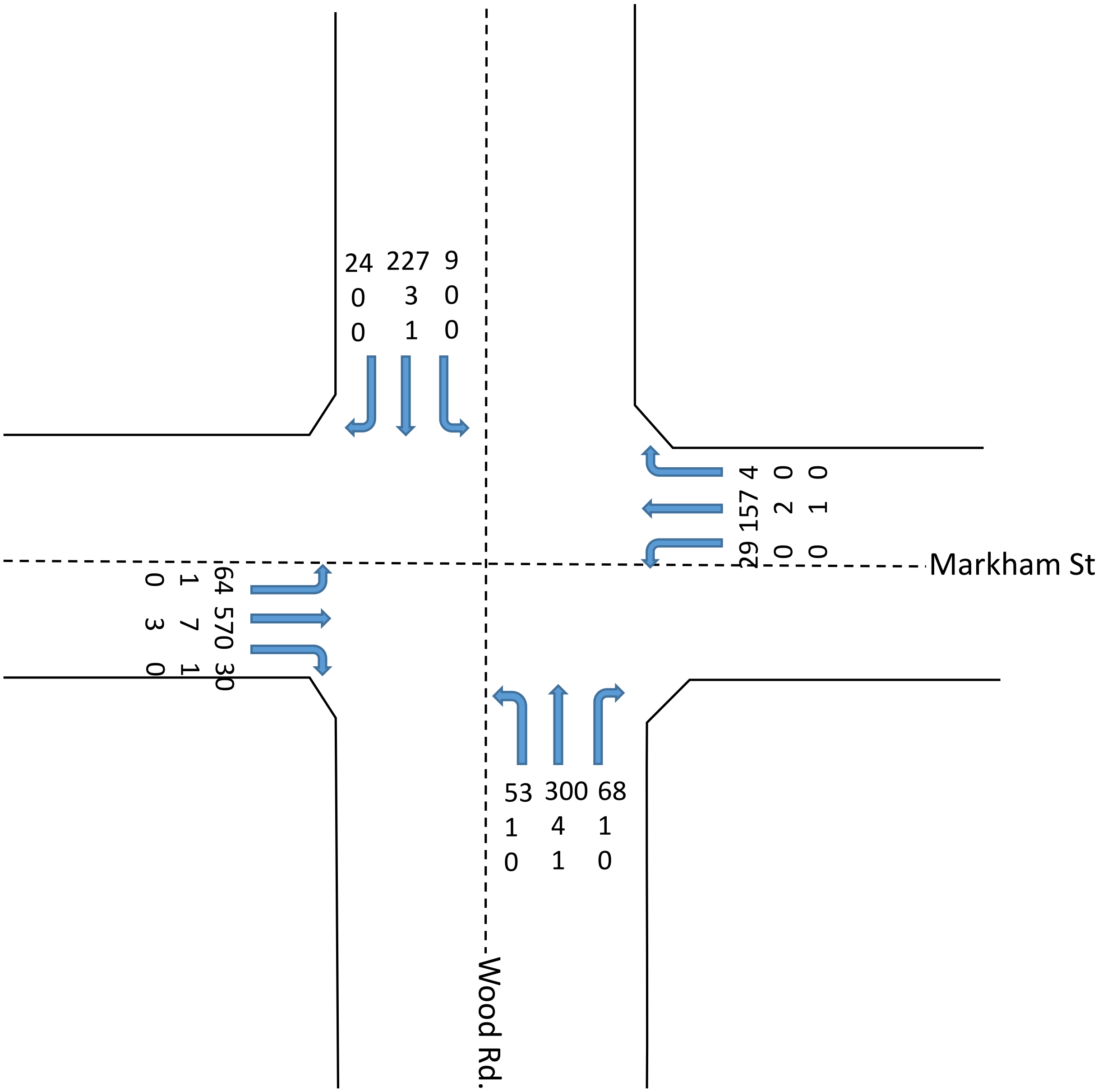


Legend:
\# Automobiles
\# Medium Trucks
\# Heavy Trucks

N

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

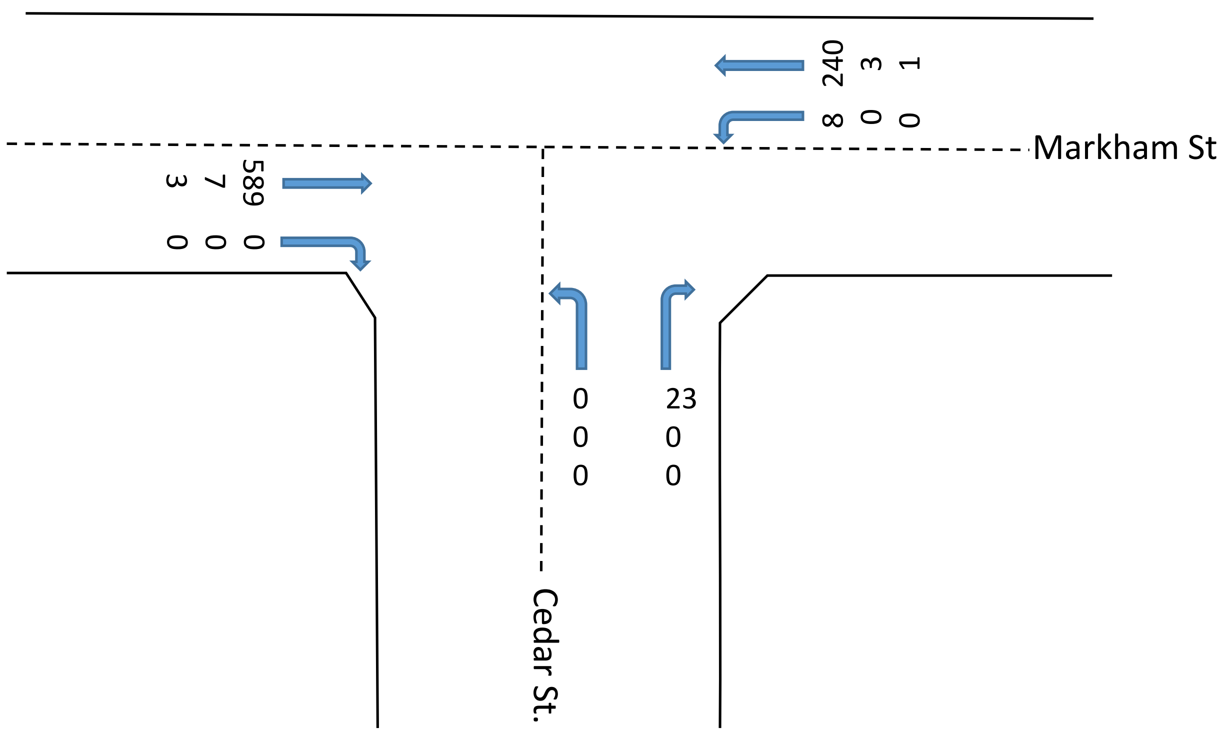
Year 2046 Build PM Peak Hour Traffic Volumes
Markham Street/Wood Road Intersection



Legend:
- # Automobiles
- # Medium Trucks
- # Heavy Trucks

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 Build PM Peak Hour Traffic Volumes
Markham Street/Cedar Street Intersection

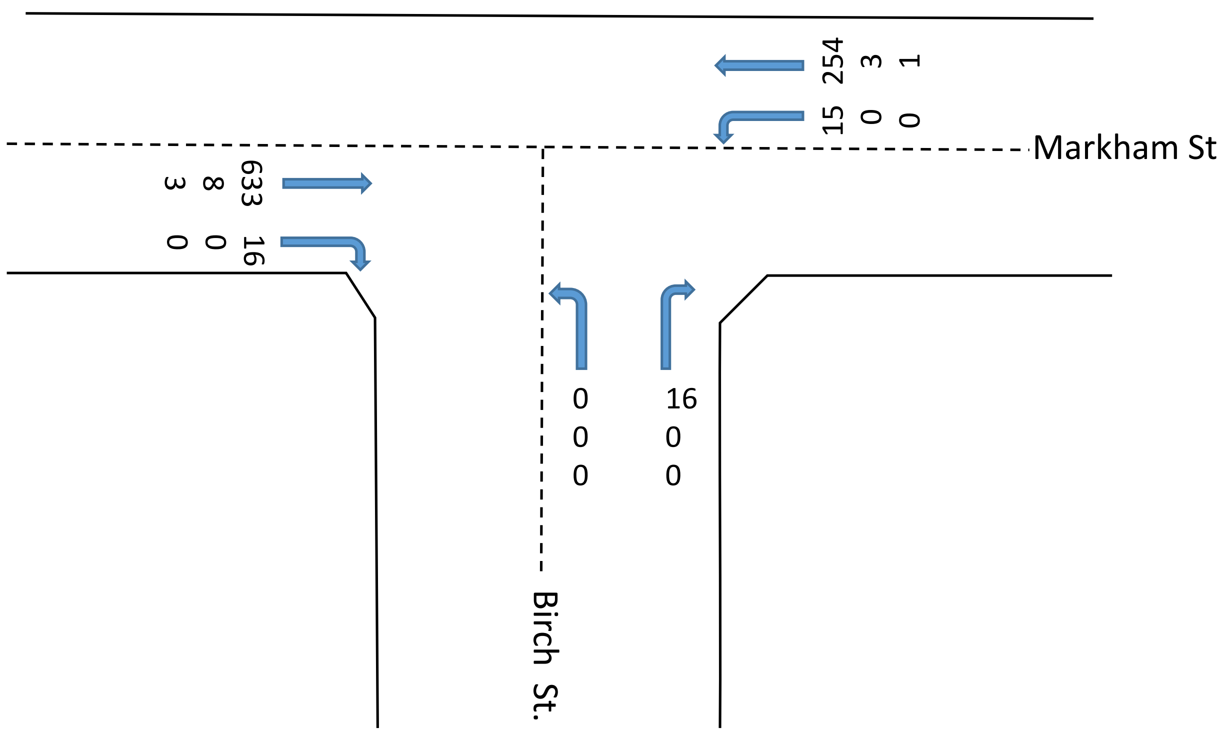


Legend:
Automobiles
Medium Trucks
Heavy Trucks

N

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

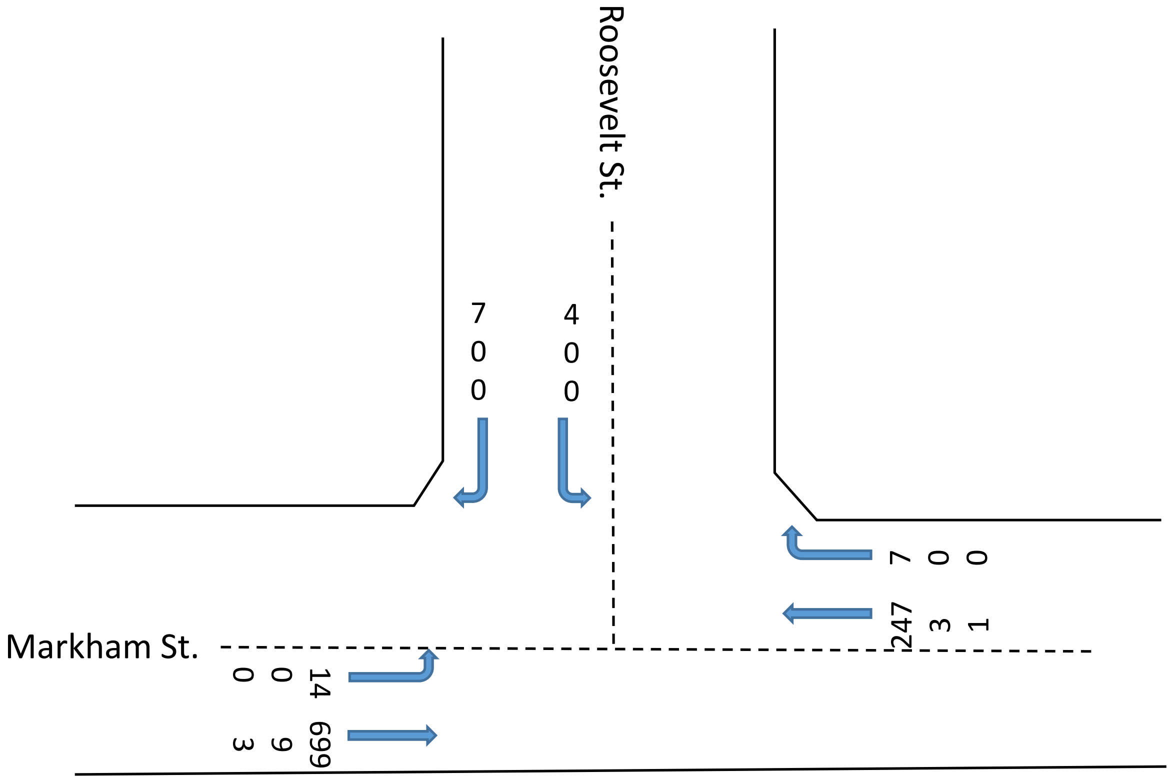
Year 2046 Build PM Peak Hour Traffic Volumes
Markham Street/Birch Street Intersection



Legend:
- # Automobiles
- # Medium Trucks
- # Heavy Trucks

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 Build PM Peak Hour Traffic Volumes
Markham Street/Roosevelt Street Intersection



Legend:
- # Automobiles
- # Medium Trucks
- # Heavy Trucks

N

Source: HDR, Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum, November 18, 2022

Year 2046 Build ADT Volumes

Markham Street - West of Roosevelt Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	5,315	4,016	742	558
Medium Truck	100	49	2	49
Heavy Truck	40	19	2	19

Markham Street - Roosevelt Street to Wood Road

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	7,615	5,753	1,063	799
Medium Truck	144	70	3	70
Heavy Truck	58	27	3	27

Markham Street - East of Wood Road

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	5,207	3,934	727	546
Medium Truck	98	48	2	48
Heavy Truck	40	19	2	19

Roosevelt Street - North of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	190	144	27	20
Medium Truck	4	2	0	2
Heavy Truck	1	1	0	1

Wood Road - North of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	4,970	3,755	694	521
Medium Truck	94	46	2	46
Heavy Truck	38	18	2	18

Wood Road - South of Markham Street

VEHICLE	OVERALL	DAY	EVENING	NIGHT
Auto	6,575	4,967	918	690
Medium Truck	124	61	3	61
Heavy Truck	50	24	3	24

Sources:

County of Riverside, *General Plan Appendix I: Noise Element Technical Data*, December 2015

HDR, *Markham Street Roadway Improvement Project Traffic Impact Assessment Technical Memorandum*, February 2022

HDR, *Markham Street Extension Project Updated Years 2026/2046 Forecasts Technical Memorandum*, November 2022

Appendix B Highest Hourly Noise Levels and CNEL Values

Table B-1. Existing Year (2021) and Horizon Year (2046) No-Build and Build Condition AM Peak Hour Noise Levels

Receptor I.D.	Land Use[1]	Existing Year (2021) Noise Level Leq(h), dBA[2]	Horizon Year (2046) No Build Leq(h), dBA[2]	Horizon Year (2046) Build Leq(h), dBA[2]	No-Build Condition Minus Existing Year (2021) Condition Noise Level Leq(h), dBA[2]	Build Condition Minus Existing Year (2021) Condition Noise Level Leq(h), dBA[2]
M01	RES	46	46	61	-0-	15
M02	RES	46	47	61	1	15
M03	RES	47	48	62	1	15
M04	RES	46	47	60	1	14
M05	RES	46	46	50	-0-	4
M06	RES	46	46	51	-0-	5
M07	RES	46	46	49	-0-	3
M08	RES	46	46	48	-0-	2
M09	RES	43	43	58	-0-	15
M10	RES	43	43	63	-0-	20
M11	RES	47	47	61	-0-	14
M12	RES	47	47	60	-0-	13
M13	RES	46	46	51	-0-	5
M14	RES	53	53	59	-0-	6
M15	RES	53	53	63	-0-	10
M16	RES	47	47	63	-0-	16
M17	RES	47	47	61	-0-	14
M18	RES	47	47	57	-0-	10
M19	RES	50	51	53	1	3
M20	RES	54	54	54	-0-	-0-
M21	RES	57	57	57	-0-	-0-
M22	RES	54	54	54	-0-	-0-
M23	RES	57	58	57	1	-0-
M24	SCH	51	52	52	1	1

Notes:

1 - Land Use: RES = Residential, SCH = School

2 - Leq(h) is A-weighted, peak hour noise level in decibels.

Table B-2. Existing Year (2021) and Horizon Year (2046) No-Build and Build Condition PM Peak Hour Noise Levels

Receptor I.D.	Land Use[1]	Existing Year (2021) Noise Level Leq(h), dBA[2]	Horizon Year (2046) No-Build Condition Leq(h), dBA[2]	Horizon Year (2046) Build Condition Leq(h), dBA[2]	No-Build Condition Minus Existing Year (2021) Condition Noise Level Leq(h), dBA[2]	Build Condition Minus Existing Year (2021) Condition Noise Level Leq(h), dBA[2]
M01	RES	44	44	61	-0-	17
M02	RES	44	45	61	1	17
M03	RES	45	45	62	-0-	17
M04	RES	45	46	60	1	15
M05	RES	49	49	52	-0-	3
M06	RES	49	49	53	-0-	4
M07	RES	49	49	51	-0-	2
M08	RES	49	49	51	-0-	2
M09	RES	47	47	59	-0-	12
M10	RES	47	47	64	-0-	17
M11	RES	47	47	62	-0-	15
M12	RES	47	47	61	-0-	14
M13	RES	46	46	51	-0-	5
M14	RES	53	53	60	-0-	7
M15	RES	53	53	63	-0-	10
M16	RES	47	47	64	-0-	17
M17	RES	47	47	63	-0-	16
M18	RES	47	47	58	-0-	11
M19	RES	51	52	54	1	3
M20	RES	54	55	56	1	2
M21	RES	57	59	61	2	4
M22	RES	54	56	58	2	4
M23	RES	57	59	62	2	5
M24	SCH	52	54	55	2	3

Notes:

1 - Land Use: RES - Residential , SCH - School

2 - Leq(h) is A-weighted, peak hour noise level in decibels.

Table B-3. Existing Year (2021) and Horizon Year (2046) CNEL

Receptor I.D.	Land Use[1]	Existing Year (2021) Noise Level CNEL, dBA[2]	Horizon Year (2046) No-Build Condition CNEL, dBA[2]	Horizon Year (2046) Build Condition CNEL, dBA[2]	Build Condition Minus Existing Year (2021) Noise Level CNEL, dBA[2]	Riverside County Exterior Noise Standard CNEL, dBA[2]	Impact Type[3]
M01	RES	44	48	59	15	65	NONE
M02	RES	45	48	60	15	65	NONE
M03	RES	45	49	61	16	65	NONE
M04	RES	46	47	59	13	65	NONE
M05	RES	50	50	52	2	65	NONE
M06	RES	50	50	54	4	65	NONE
M07	RES	50	50	52	2	65	NONE
M08	RES	50	50	52	2	65	NONE
M09	RES	50	50	59	9	65	NONE
M10	RES	50	50	64	14	65	NONE
M11	RES	50	50	62	12	65	NONE
M12	RES	50	50	61	11	65	NONE
M13	RES	50	50	53	3	65	NONE
M14	RES	50	50	60	10	65	NONE
M15	RES	50	50	64	14	65	NONE
M16	RES	50	50	65	15	65	NONE
M17	RES	50	50	63	13	65	NONE
M18	RES	50	50	59	9	65	NONE
M19	RES	52	53	55	3	65	NONE
M20	RES	55	55	55	-0-	65	NONE
M21	RES	58	58	60	2	65	NONE
M22	RES	54	55	57	3	65	NONE
M23	RES	57	58	60	3	65	NONE
M24	SCH	52	53	55	3	65	NONE

Notes:

1 - Land Use: RES = Residential , SCH = School

2 - CNEL is A-weighted, 24-hour equivalent noise level in decibels.

3 - NONE = No impact. Does not exceed County's 65 dBA CNEL in exterior areas.

Appendix C Supplemental Data

C-1: Field Noise Data Sheets

C-2: Noise Measurement Photographs

C-3: Sound Level Meter Calibration Records

C-1: Field Noise Data Sheets

Field Noise Measurement Data Sheet

Project: Markham St. Extension Project			By: F. Farhang		Date: 5/3/2022
Measurement Address: 17971 Timberview (Markham St. fence)					Site No: ST01
Sound Level Meter: B&K 2238	Mic: B&K 4188		Preamp: ZC 0026		Calibrator: Rion NC-74
Serial #: 2106267	1891268		—		35157442

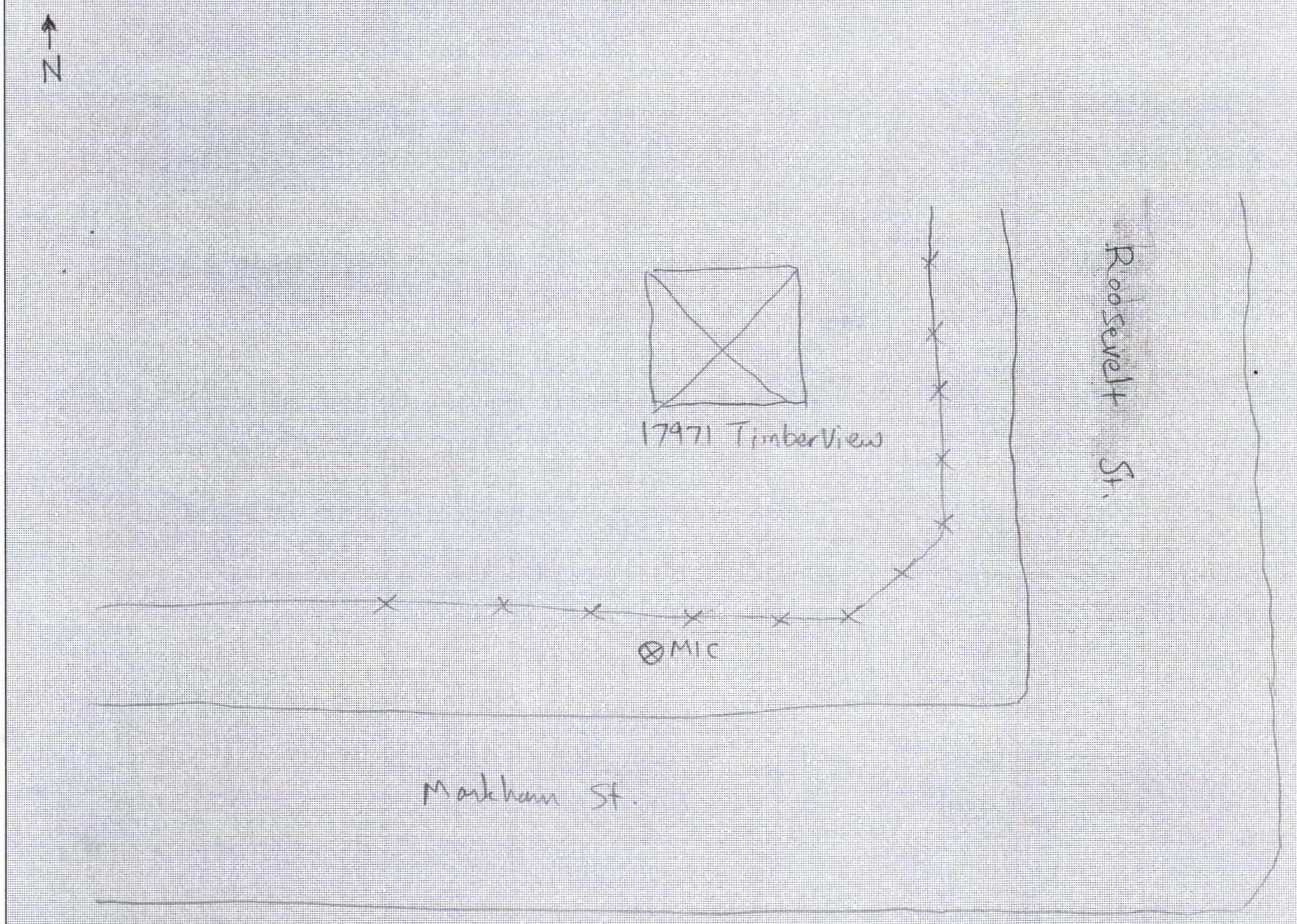
Weather Conditions:

Skies: Mostly cloudy Temp: 68-72 °F RH: 48-57 % Wind Speed: 1-6 mph Dir: NE

Meter Settings: Response Slow Weighting A

Date	Start Time	End Time	L_{eq}	L_{min}	L_{max}	L_{10}	L_{25}	L_{50}	L_{90}	Notes
5/3/22	9:56	10:11	44.2	37.3	59.4	45.0	41.5	40.0	38.5	Distant AC, dogs, moving
"	10:11	10:26	44.6	35.9	61.3	45.5	41.5	39.0	37.0	" 4 cars

Site Sketch:



Field Noise Measurement Data Sheet

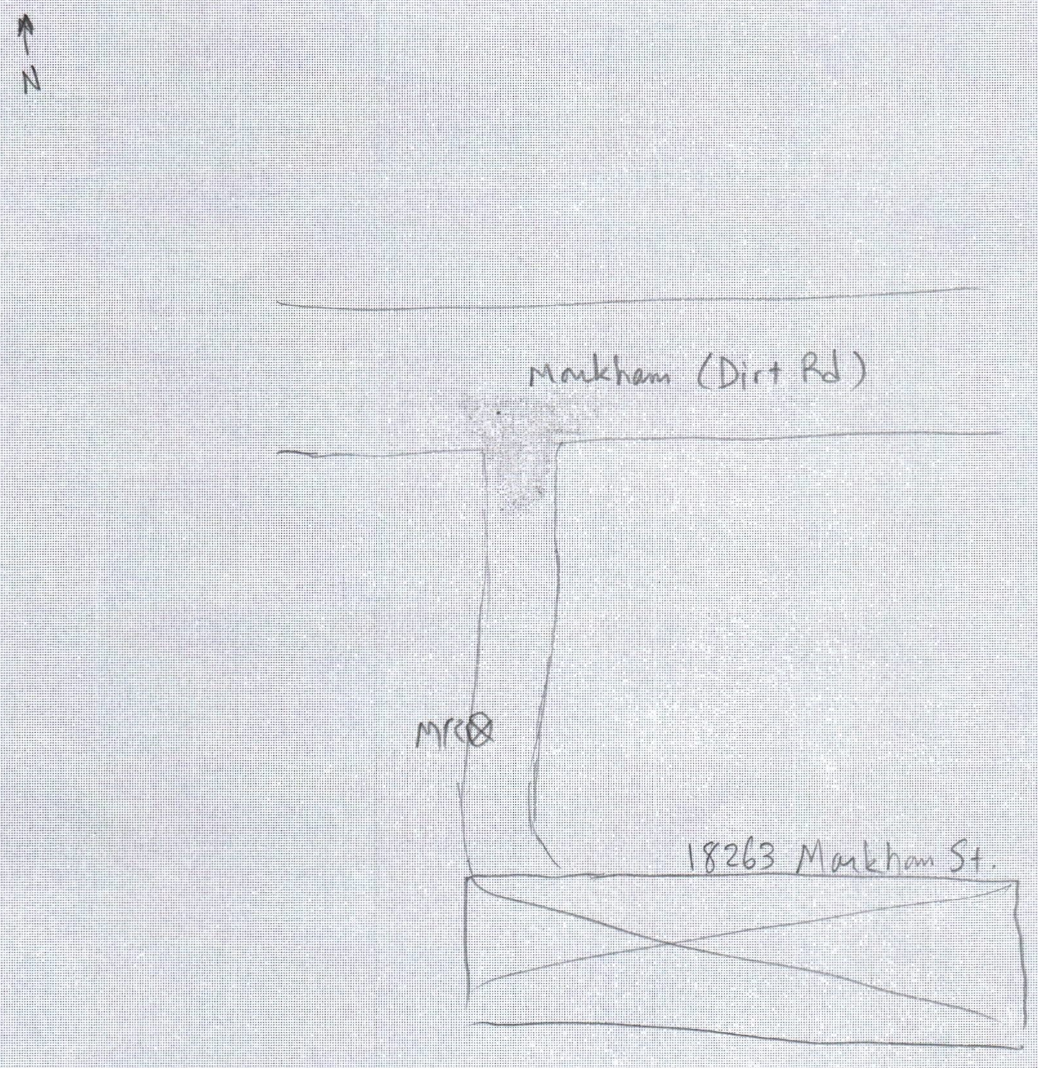
Project: Markham St. Extension Project		By: F. Farhang	Date: 5/3/2022
Measurement Address: 18263 Markham St.			Site No: ST02
Sound Level Meter: B&K 2238	Mic: B&K 4188	Preamp: ZC 0026	Calibrator: Rion NC-74
Serial #: 2106267	1891268	—	35157442

Weather Conditions:
Skies: Cloudy Temp: 75 °F RH: 55 % Wind Speed: 1-4 mph Dir: NE

Meter Settings: Response Slow Weighting A

Date	Start Time	End Time	L_{eq}	L_{min}	L_{max}	L_{10}	L_{25}	L_{50}	L_{90}	Notes
5/3/2022	10:50	11:05	42.6	37.8	60.3	44.0	41.5	40.5	39.0	Birds, Dist. dogs, Pickup Passby
//	11:05	11:20	47.1	37.6	61.3	49.5	43.0	40.0	38.0	Heli to the east (11:09) Dist AC Overflight (11:16)

Site Sketch:



Field Noise Measurement Data Sheet

Project: Markham St. Extension Project	By: F. Farhang	Date: 5/3/2022
Measurement Address: APN 321-030-002 (North fenceline)		Site No: ST03

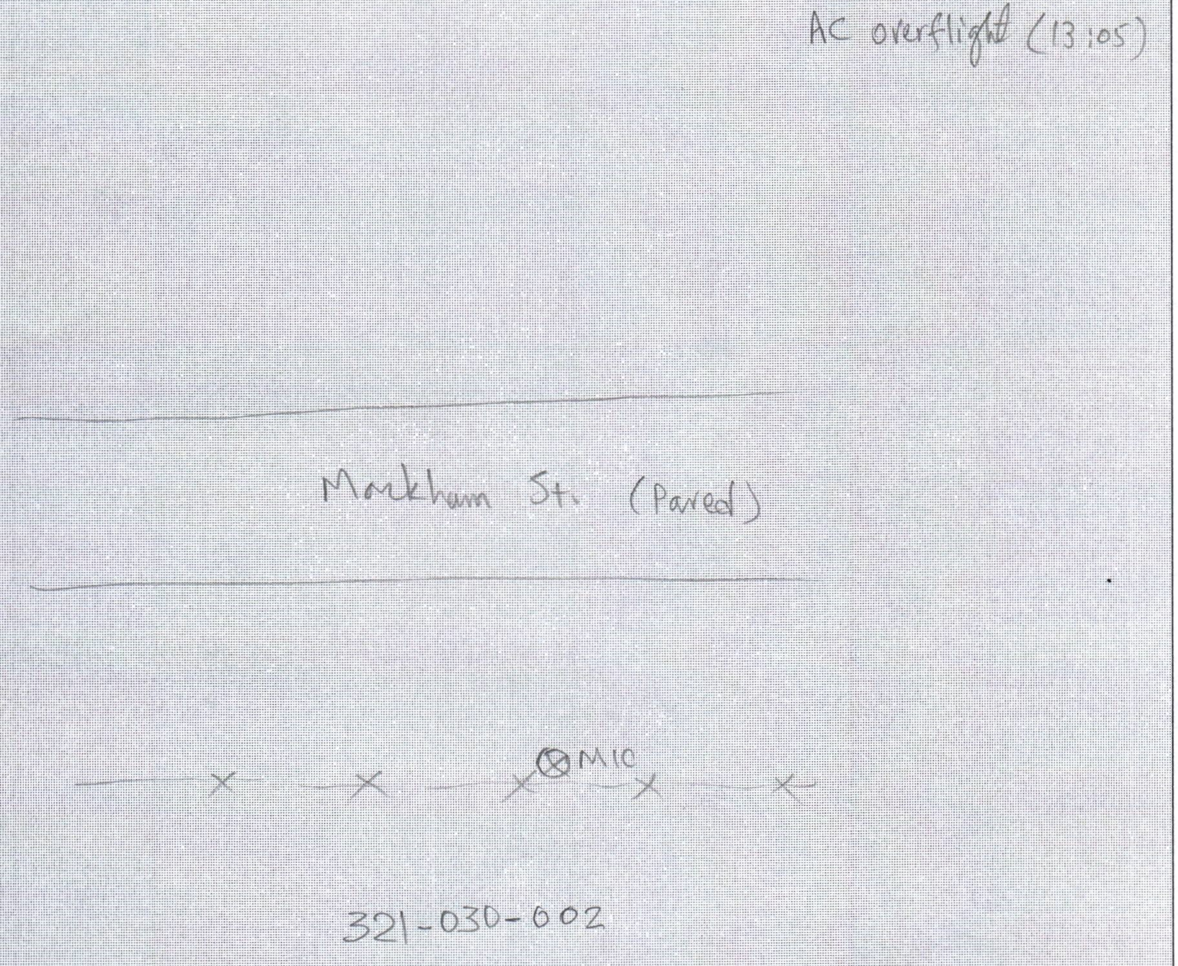
Sound Level Meter: B&K 2238	Mic: B&K 4188	Preamp: ZC 0026	Calibrator: Rion NC-74
Serial #: 2106267	1891268	—	35157442

Weather Conditions:
Skies: Clear Temp: 81 °F RH: 38 % Wind Speed: 0-4 mph Dir: SE

Meter Settings: Response Slow Weighting A

Date	Start Time	End Time	L_{eq}	L_{min}	L_{max}	L_{10}	L_{25}	L_{50}	L_{90}	Notes
5/3/22	12:56	13:11	51.9	36.1	69.2	51.0	43.0	40.0	38.0	Mil. AC overflight, car on
〃	13:11	13:26	46.6	36.0	65.8	45.5	43.0	41.0	38.5	Markham, Birds

Site Sketch:



Field Noise Measurement Data Sheet

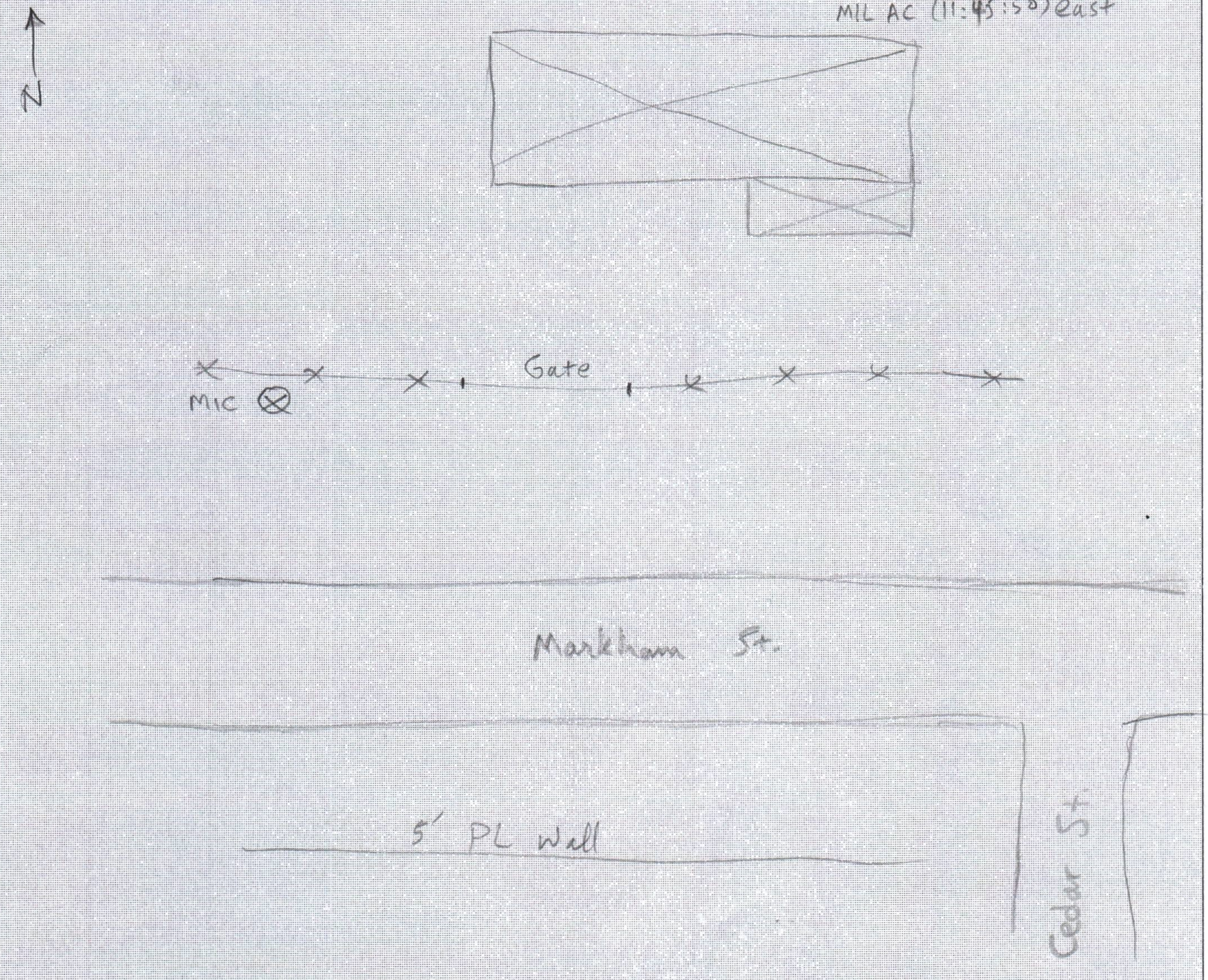
Project: Markham St. Extension Project		By: FFarhang	Date: 5/4/2022
Measurement Address: 18750 Markham St. (Front fence)			Site No: ST04
Sound Level Meter: B&K 2238	Mic: B&K 4188	Preamp: ZC 0026	Calibrator: Rion NC-74
Serial #: 2106267	1891268	—	35157442

Weather Conditions:
Skies: Clear Temp: 80-85 °F RH: 35 % Wind Speed: 1-6 mph Dir: NW

Meter Settings: Response Slow Weighting A

Date	Start Time	End Time	L_{eq}	L_{min}	L_{max}	L_{10}	L_{25}	L_{50}	L_{90}	Notes
5/4/2022	11:24	11:39	52.6	48.0	65.0	53.5	51.5	51.0	50.0	AC off (11:25:35) (11:30:40)
〃	11:39	11:54	54.9	50.0	70.9	55.0	51.5	51.0	50.5	Cars on Markham 2-3 Birds, distant work AC (11:40:50), Car (8) MIL AC (11:45:50) east

Site Sketch:



Field Noise Measurement Data Sheet

Project: Markham St. Extension Project		By: F. Farhang	Date: 5/3/22
Measurement Address: 18765 Markham St. (backyard Setback)			Site No: ST05
Sound Level Meter: B&K 2238	Mic: B&K 4188	Preamp: ZC 0026	Calibrator: Rion NC-74
Serial #: 2106267	1891268	—	35157442

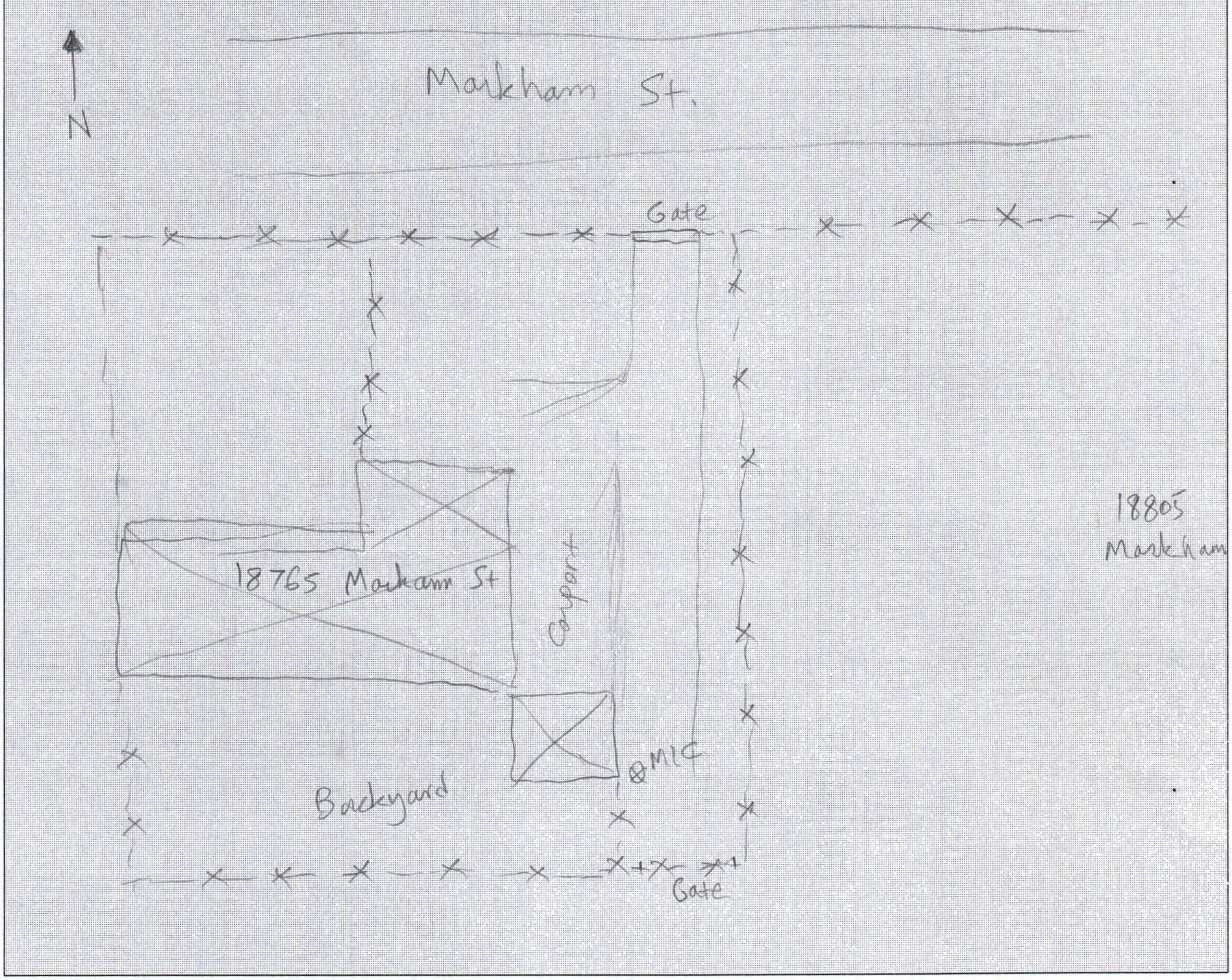
Weather Conditions:

Skies: clear Temp: 75 °F RH: 45 % Wind Speed: 3-8 mph Dir: SSE

Meter Settings: Response Slow Weighting A

Date	Start Time	End Time	L_{eq}	L_{min}	L_{max}	L_{10}	L_{25}	L_{50}	L_{90}	Notes
5/3/22	14:07	14:22	55.8	37.0	75.0	54.5	48.5	44.0	39.0	MIL AC (14:08) (14:20)
〃	14:22	14:37	47.0	37.3	60.6	49.5	47.0	44.0	39.5	Heli (SW)(14:21:20) Birds, rooster, Cars AC (14:26:45)

Site Sketch:



Field Noise Measurement Data Sheet

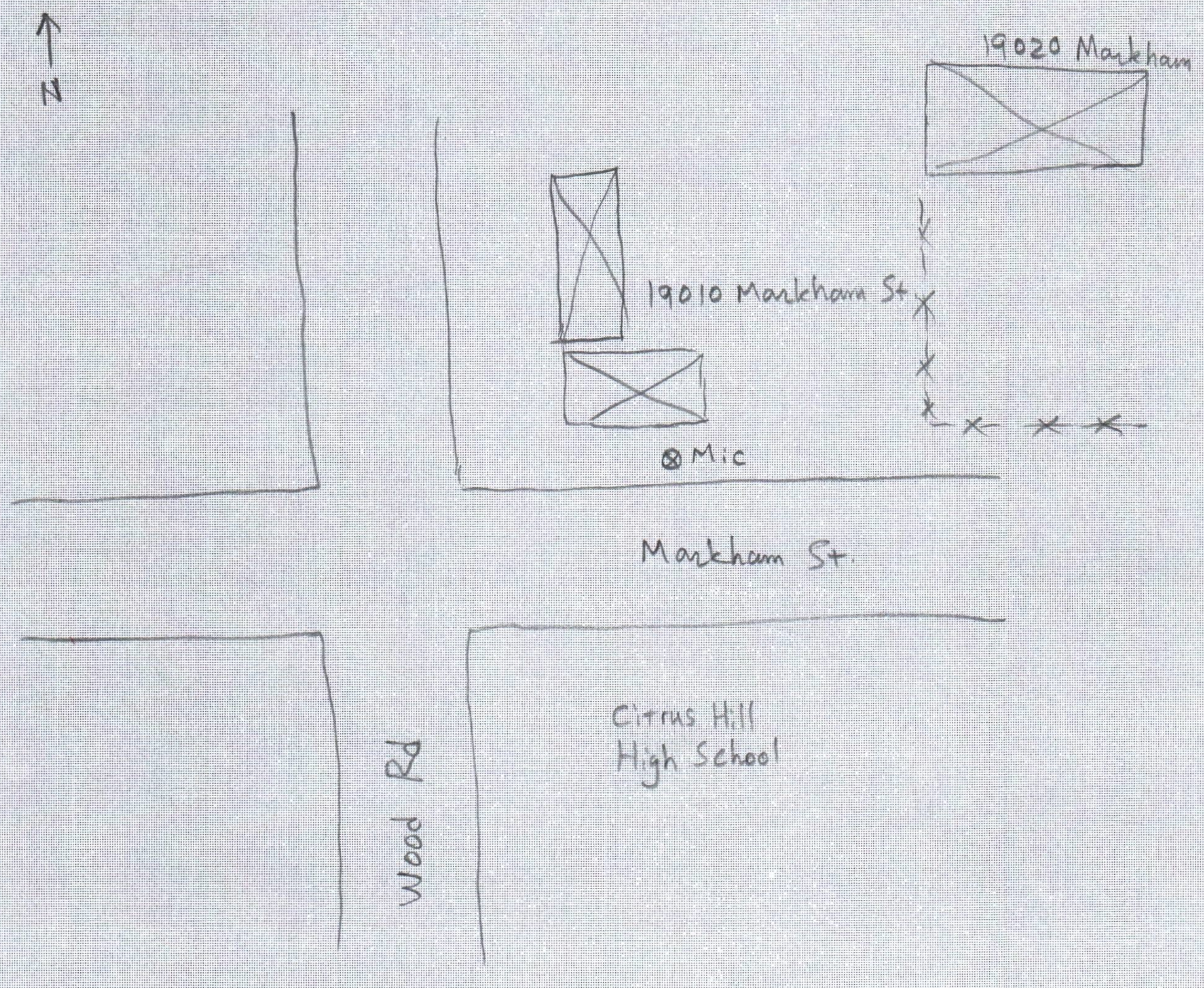
Project: Markham St. Extension Project		By: F. Farhang	Date: 5/4/2022
Measurement Address: 19010 Markham St.			Site No: ST06
Sound Level Meter: B&K 2238	Mic: B&K 4188	Preamp: ZC 0026	Calibrator: Rion NC-74
Serial #: 2106267	1891268	—	35157442

Weather Conditions:
Skies: Clear Temp: 75-80 °F RH: 35 % Wind Speed: 1-3 mph Dir: S

Meter Settings: Response Slow Weighting A

Date	Start Time	End Time	L_{eq}	L_{min}	L_{max}	L_{10}	L_{25}	L_{50}	L_{90}	Notes
5/4/22	9:56	10:11	62.2	50.4	77.5	65.0	61.0	56.5	52.5	Traffic on Markham St
〃	10:11	10:26	63.2	51.0	77.6	66.0	63.0	59.5	53.5	& Wood Rd.

Site Sketch:



C-2: Noise Measurement Photographs

Noise Measurement Photographs at Site LT01

Looking East

Looking South

Looking West

Looking North

Noise Measurement Photographs at Site ST01

Looking East

Looking South

Looking West

Looking North

Noise Measurement Photographs at Site ST02

Looking East

Looking South

Looking West

Looking North

Noise Measurement Photographs at Site ST03

Looking East

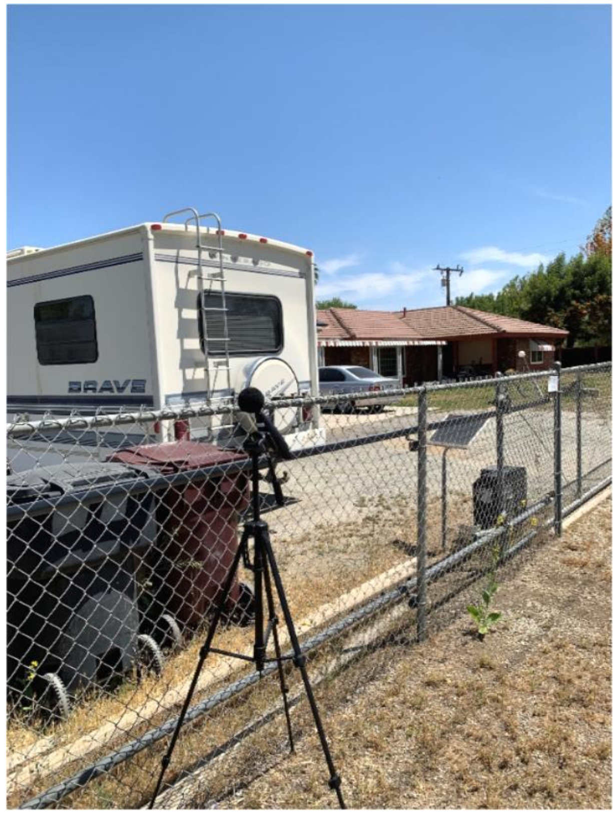
Looking South

Looking West

Looking North

Noise Measurement Photographs at Site ST04

Looking East



Looking Northeast

Looking West

Looking North

Noise Measurement Photographs at Site ST05

Looking East

Looking South

Looking West

Looking North

Noise Measurement Photographs at Site ST06

Looking East

Looking South

Looking West

Looking North

C-3. Sound Level Meter Calibration Records

CERTIFICATE OF CALIBRATION
26994-1
FOR RION MODEL
NL-52 SOUND LEVEL METER

Model **NL-52** Serial No. **01054269**
ID No. **N/A**

Microphone **UC-59** Serial No. **08733**
Preamplifier **NH-25** Serial No. **54342**

Customer: **A/E Tech**
Laguna Woods, CA 92637 P.O. No. **Credit Card**

was tested and met Rion specifications at the points tested and as outlined in ANSI S1.4-1983 (R2006) Type 1; IEC 61672-2002 Class1; 60651-2001 Type 1

on **22 MAR 2022** **BY HAROLD LYNCH**
Service Manager

As received and as left condition: Within Specifications.
Re-calibration due on: **22 MAR 2023**

Certified References*

Mfg.	Type	Serial No.	Cal Date	Due Date
B&K	1051	1777523	28 SEP 2021	28 SEP 2022
B&K	2636	1423390	03 JAN 2022	03 JAN 2023
B&K	4226	3274134	30 NOV 2021	30 NOV 2022
B&K	4231	1770857	09 SEP 2021	09 SEP 2022
HP	34401A	MY45023668	25 JAN 2022	25 JAN 2023
HP	3458A	2823A07179	21 AUG 2021	21 AUG 2022

Calibration System operates in conformance to ANSI/ NCSL Z540-1, 1994 and ISO 17025, ISO 9001:2015 Certification NQA No. 11252
*References are traceable to NIST (National Institute of Standards and Technology).

Note: For calibration data see enclosed pages.
The data represent both "as found" and "as left" conditions.

Reference Test Procedure: **ACCT Procedure General SLM Version 1.0.2.**

Temperature	Relative Humidity	Barometric Pressure
23°C	**29**%	**992.41** hPa

Signed

ODIN METROLOGY, INC.
CALIBRATION OF SOUND & VIBRATION INSTRUMENTATION
3533 OLD CONEJO ROAD, SUITE 125 THOUSAND OAKS CA 91320
PHONE: (805) 375-0830 FAX: (805) 375-0405

Odin Metrology, Inc.
Calibration of Sound & Vibration Instruments

Certificate Number: **26994-2**

Certificate of Calibration for RION 1/2" Free-field Microphone

This calibration is performed by comparison with measurement reference standard microphone:

REFERENCE STANDARDS	
Type No.	4134/UA0825
Serial No.	1866524
Calibrated by	DANAK
Cal Date	23 SEP 2021
Due Date	23 SEP 2023

a) Estimated uncertainty of comparison: ± **0.05** dB
b) Estimated uncertainty of reference microphone: ± **0.04** dB
c) Total uncertainty: $\sqrt{a^2 + b^2}$ = ± **0.064** dB
d) Expanded uncertainty (coverage factor *k* = 2 for 95% confidence level): = ± **0.13** dB

Type no.	**UC-59**
Serial no.	**08733**
With preamplifier type no.	**N/A**
Preamplifier Serial no.	**N/A**
Submitted by	**A/E Tech** **Laguna Woods, CA 92637**
Purchase order no.	**Credit Card**
Asset no.	**N/A**

PERFORMANCE DATA		
Open circuit sensitivity at 1,013 hPa, 23°C, 50% RH, 251.2 Hz	**-26.96**	dB re 1 V/Pa
	44.86	mV/Pa
System sensitivity (with preamplifier) at 251.2 Hz	**N/A**	dB re 1 V/Pa
	N/A	mV/Pa

UC-59# 08733 free field frequency response with multitone calibrator 4226:

31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	12.5 kHz	16 kHz
0.0	0.0	0.0	REF	0.0	+0.1	+0.2	+0.2	-0.2	-0.6	-0.4

Note: this data can not be used to update the specifications for the microphone. It is only listed to indicate compliance to specifications. Tolerance is ± 2 dB.

Calibration performed by [signature]

Harold Lynch, Service Manager

CONDITION OF TEST		
Ambient Pressure	**991.71**	hPa
Temperature	**23**	°C
Relative Humidity	**30**	%
Polarization Voltage	**0**	V
Frequency	**251.2**	Hz
Date of Calibration	**21 MAR 2022**	
Re-calibration due on	**21 MAR 2023**	

ODIN METROLOGY, INC.
3533 OLD CONEJO ROAD, SUITE 125
THOUSAND OAKS, CA 91320
PHONE: (805) 375-0830; FAX: (805) 375-0405

The calibration data is both "as found" and "as final." At the time of calibration this microphone was found to be **within** the manufacturer's specifications. Calibration Procedure: **OM-P-1008-Microphone Rev. 1.2 20130618.**

This calibration is traceable to DANAK/DPLA No. **M2.10-1478-2.1** and through inter-laboratory comparisons to NIST Test Number: **683/289533-17.** *See page 2 Traceability.

CERTIFICATE OF CALIBRATION
26994-5
FOR RION MODEL
NL-42 SOUND LEVEL METER

Model **NL-42** | Serial No. **00697402**
ID No. **N/A**

Microphone **UC-52** | Serial No. **181605**
Preamplifier **NH-24** | Serial No. **98415**

Customer: **A/E Tech**
Laguna Woods, CA 92637

P.O. No. **Credit Card**

was tested and met Rion specifications at the points tested and as outlined in ANSI S1.4-1983 Type 2; IEC 61672-2002 Class 2

on **21 MAR 2022** BY **HAROLD LYNCH**
Service Manager

As received and as left condition: Within Specifications.
Re-calibration due on: **21 MAR 2023**

Certified References*

Mfg.	Type	Serial No.	Cal Date	Due Date
B&K	1051	1777523	28 SEP 2021	28 SEP 2022
B&K	2636	1423390	03 JAN 2022	03 JAN 2023
B&K	4226	3274134	30 NOV 2021	30 NOV 2022
B&K	4231	1770857	09 SEP 2021	09 SEP 2022
HP	34401A	MY45023668	25 JAN 2022	25 JAN 2023
HP	3458A	2823A07179	21 AUG 2021	21 AUG 2022

Calibration System operates in conformance to ANSI/ NCSL Z540-1, 1994 and ISO 17025, ISO 9001:2015 Certification NQA No. 11252
*References are traceable to NIST (National Institute of Standards and Technology).

Note: For calibration data see enclosed pages.
The data represent both "as found" and "as left" conditions.

Reference Test Procedure: **ACCT Procedure General SLM Version 1.0.2.**

Temperature	Relative Humidity	Barometric Pressure
23°C	**30** %	**991.71** hPa

Signed Harold Lynch

ODIN METROLOGY, INC.
CALIBRATION OF SOUND & VIBRATION INSTRUMENTATION
3533 OLD CONEJO ROAD, SUITE 125 THOUSAND OAKS CA 91320
PHONE: (805) 375-0830 FAX: (805) 375-0405

Odin Metrology, Inc.
Calibration of Sound & Vibration Instruments

Certificate Number: **26994-6**

Certificate of Calibration for RION 1/2" Free-field Microphone

This calibration is performed by comparison with measurement reference standard microphone:

Reference Standards	
Type No.	4134/UA0825
Serial No.	1866524
Calibrated by	DANAK
Cal Date	23 SEP 2021
Due Date	23 SEP 2023

a) Estimated uncertainty of comparison: ± **0.05** dB
b) Estimated uncertainty of reference microphone: ± **0.04** dB
c) Total uncertainty: $\sqrt{a^2+b^2}$ = ± **0.064** dB
d) Expanded uncertainty (coverage factor k = 2 for 95% confidence level): = ± **0.13** dB

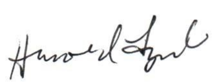
Type no.	**UC-52**
Serial no.	**181605**
With preamplifier type no.	**N/A**
Preamplifier Serial no.	**N/A**
Submitted by	**A/E Tech** **Laguna Woods, CA 92637**
Purchase order no.	**Credit Card**
Asset no.	**N/A**

Performance Data		
Open circuit sensitivity at 1,013 hPa, 23°C, 50% RH, 251.2 Hz	**-32.23**	dB re 1 V/Pa
	24.45	mV/Pa
System sensitivity (with preamplifier) at 251.2 Hz	**N/A**	dB re 1 V/Pa
	N/A	mV/Pa

UC-52# 181605 free field frequency response with multitone calibrator 4226:

31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	12.5 kHz
+0.5	+0.3	+0.1	REF	+0.1	+0.1	+0.1	+0.1	-0.7	+0.5

Note: this data can not be used to update the specifications for the microphone. It is only listed to indicate compliance to specifications. Tolerance is ± 2 dB.

Calibration performed by 

Harold Lynch, Service Manager

Condition of Test		
Ambient Pressure	**991.71**	hPa
Temperature	**23**	°C
Relative Humidity	**30**	%
Polarization Voltage	**0**	V
Frequency	**251.2**	Hz
Date of Calibration	**21 MAR 2022**	
Re-calibration due on	**21 MAR 2023**	

ODIN METROLOGY, INC.
3533 OLD CONEJO ROAD, SUITE 125
THOUSAND OAKS, CA 91320
PHONE: (805) 375-0830; FAX: (805) 375-0405

The calibration data is both "as found" and "as final." At the time of calibration this microphone was found to be **within** the manufacturer's specifications. Calibration Procedure: **OM-P-1008-Microphone Rev. 1.2 20130618.**

This calibration is traceable to DANAK/DPLA No. **M2.10-1478-2.1** and through inter-laboratory comparisons to NIST Test Number: **683/289533-17.** *See page 2 Traceability.

Certificate Number: **26994-3**

Certificate of Calibration for Rion Sound Level Calibrator

This calibration is performed by comparison with measurement reference standard pistonphones:

Type No.	4228	4228
Serial No.	1793011	1504084
Calibrated by	HL	HL
Cal Date	19 NOV 2021	19 NOV 2021
Due Date	19 NOV 2022	19 NOV 2022

a) Estimated uncertainty of comparison: ± **0.05** dB
b) Estimated uncertainty of calibration service for standard pistonphone: ± **0.06** dB
c) Total uncertainty: $\sqrt{a^2+b^2}$ = ± **0.08** dB
d) Expanded uncertainty (coverage factor k = 2 for 95% confidence level): = ± **0.16** dB

This acoustic calibrator has been calibrated using standards with values traceable to the National Institute of Standards and Technology. This calibration is traceable to NIST Test Number **683/289533-17.**

Condition of Test		
Ambient Pressure	**992.41**	hPa
Temperature	**23**	°C
Relative Humidity	**29**	%
Date of Calibration	**22 MAR 2022**	
Re-calibration due on	**22 MAR 2023**	

The calibration of this acoustic calibrator was performed using a test system conforming to the requirements of ANSI/NCSLZ540-1, 1994, ISO 17025, and ISO 9001:2015, Certification NQA No. 11252.

Calibration procedure: **OM-P-1001-Acoustic_Calibrator, Rev. 1.0 20130522.**

Calibration performed by [signature]

Harold Lynch, Service Manager

Calibrator type **NC-74**
Serial no. **35157442**
Submitted by **A/E Tech**
Laguna Woods, CA 92637
Purchase order no. **Credit Card**
Asset no. **N/A**

This calibrator has been found to perform **within** the specifications listed below at the normalized conditions stated.

SPL produced in coupler terminated by a loading volume of 1.333 cm^3	94.0 ± 0.3 dB
Frequency	1,000 Hz ± 20 Hz
Distortion	No manufacturer specs
At 1,013 hPa, 23°C, and 65% relative humidity	

Performance as Received		
Frequency	**1001.2**	Hz
SPL	**93.90**	dB
Distortion	**0.3**	%
Battery Voltage	**1.55**	V

Was adjustment performed? **No**
Were batteries replaced? **No**

Final Performance		
Frequency	**1001.2**	Hz
SPL	**93.90**	dB
Distortion	**0.3**	%

Following the final calibration measurements, a quality test with a Brüel & Kjær 1/2" microphone type 4134 was inserted into a Rion ½"" adapter. The test measured the SPL as: **94.12 dB**.

Note: This calibrator was **within** manufacturer's specifications as received.

Odin Metrology, Inc.
3533 Old Conejo Road, Suite 125
Thousand Oaks, CA 91320
Phone: (805) 375-0830; Fax: (805) 375-0405

CERTIFICATE OF CALIBRATION
OM20220118-1
FOR BRÜEL & KJÆR
SOUND LEVEL METER

Model **2238** Serial No. **2106267**
ID No. **N/A**
With Microphone Model **4188** Serial No. **1891268**

Customer: **Odin Metrology, Inc.**
Thousand Oaks, CA 91320 P.O. No. **N/A**

was tested and met factory specifications at the points tested and as outlined in ANSI S1.4-1983 Type 1; IEC 651-1979 Type 1; IEC-61672-3:2006 Class 1

on **18 JAN 2022** BY **HAROLD LYNCH**
Service Manager

As received and as left condition: Within Specification.
Re-calibration due on: **18 JAN 2023**

Certified References*

Mfg.	Type	Serial No.	Cal Date	Due Date
B&K	1051	1777523	28 SEP 2021	28 SEP 2022
B&K	2636	1423390	03 JAN 2022	03 JAN 2023
B&K	4226	3274134	30 NOV 2021	30 NOV 2022
B&K	4231	1770857	09 SEP 2021	09 SEP 2022
HP	34401A	MY45023668	28 JAN 2021	28 JAN 2022
HP	3458A	2823A07179	21 AUG 2021	21 AUG 2022

Performed in Compliance with ANSI, NCSL Z-540-1, 1994
and ISO 17025, ISO 9001:2015 Certification NQA No. 11252
*References are traceable to NIST (National Institute of Standards and Technology).

Note: For calibration data see enclosed pages.
The data represent both "as found" and "as left" condition.

Reference Test Procedure: **ACCT Procedure 2238 Version 2.1.0.** (Rev. Aug 2013)
Brüel & Kjær Factory Service Instructions: **2238**

Temperature	Relative Humidity	Barometric Pressure
23°C	**37** %	**991.51** hPa

Signed: [signature]

ODIN METROLOGY, INC.
CALIBRATION OF BRÜEL & KJÆR INSTRUMENTS
3533 OLD CONEJO ROAD, SUITE 125 THOUSAND OAKS CA 91320
PHONE: (805) 375-0830 FAX: (805) 375-0405

Odin Metrology, Inc.
Calibration of Sound & Vibration Instruments

Certificate Number: **OM20210119-1**

Certificate of Calibration for
Brüel & Kjær 1/2" Free-field Microphone

This calibration is performed by comparison with measurement reference standard microphone:

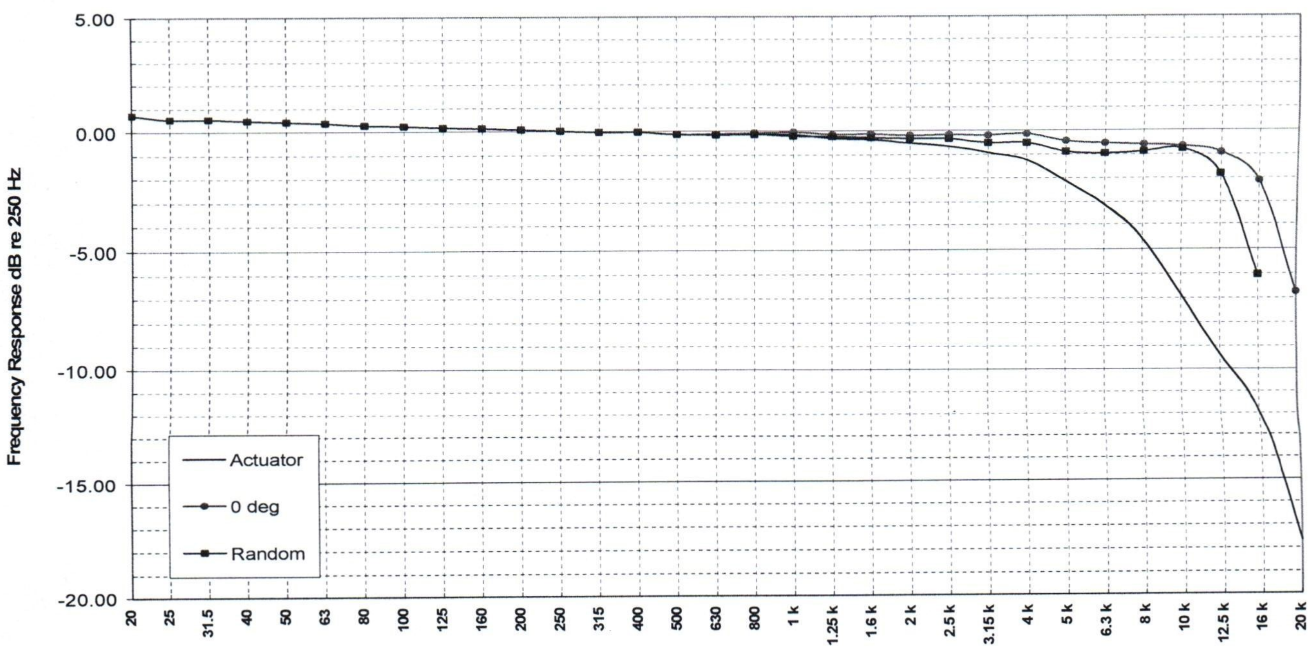
Reference Standards	
Type No.	4134/UA0825
Serial No.	1866524
Calibrated by	DANAK
Cal Date	23 SEP 2021
Due Date	23 SEP 2023

a) Estimated uncertainty of comparison: ± **0.05** dB
b) Estimated uncertainty of reference microphone: ± **0.04** dB
c) Total uncertainty: $\sqrt{a^2+b^2}$ = ± **0.064** dB
d) Expanded uncertainty (coverage factor k = 2 for 95% confidence level): = ± **0.13** dB

Type no.	**4188**
Serial no.	**1891268**
With preamplifier type no.	**N/A**
Preamplifier Serial no.	**N/A**
Submitted by	**Odin Metrology, Inc.** **Thousand Oaks, CA 91320**
Purchase order no.	**N/A**
Asset no.	**N/A**

Performance Data		
Open circuit sensitivity at 1,013 hPa, 23°C, 50% RH, 251.2 Hz	**-29.91**	dB re 1 V/Pa
	31.95	mV/Pa
Open circuit correction factor K_o	**3.9**	dB
System sensitivity (with preamplifier) at 251.2 Hz	**N/A**	dB re 1 V/Pa
	N/A	mV/Pa
Correction factor K	**N/A**	dB

Microphone Frequency Response Type 4188
S/N 1891268 : Measured 19 Jan 2022



Calibration performed by

Harold Lynch, Service Manager

Condition of Test		
Ambient Pressure	**995.23**	hPa
Temperature	**23**	°C
Relative Humidity	**38**	%
Polarization Voltage	**0**	V
Frequency	**251.2**	Hz
Date of Calibration	**19 JAN 2022**	
Re-calibration due on	**19 JAN 2023**	

ODIN METROLOGY, INC.
3533 OLD CONEJO ROAD, SUITE 125
THOUSAND OAKS, CA 91320
PHONE: (805) 375-0830; FAX: (805) 375-0405

The calibration data is both "as found" and "as final." At the time of calibration this microphone was found to be **within** the manufacturer's specifications.
Calibration Procedure: **OM-P-1008-Microphone Rev. 1.2 20130618.**

This calibration is traceable to DANAK/DPLA No. **M2.10-1478-2.1** and through inter-laboratory comparisons to NIST Test Number: **683/289533-17.** *See page 2 Traceability.