Appendix H:
Noise Impact Analysis

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Noise Impact Analysis Report
Masson Estates Project
City of Saratoga, Santa Clara County, California

Prepared for:
City of Saratoga
Planning Division
13777 Fruitvale Avenue
Saratoga, CA 95070
408.868.1200

Contact: Christopher Riordan, Senior Planner

Prepared by:
FirstCarbon Solutions
2999 Oak Road, Suite 250
Walnut Creek, CA 94597
888.826.5814

Contact: Philip Ault, Director of Noise and Air Quality

Date: June 10, 2024

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Table of Contents

Acronyms and Abbreviations ..... **v**

Section 1: Introduction **1**
1.1 - Purpose of Analysis and Study Objectives 1
1.2 - Project Summary 1

Section 2: Noise and Vibration Fundamentals **9**
2.1 - Characteristics of Noise 9
2.2 - Characteristics of Groundborne Vibration and Noise 13

Section 3: Regulatory Setting **17**
3.1 - Federal Regulations 17
3.2 - State Regulations 18
3.3 - Local Regulations 19

Section 4: Existing Noise Conditions **23**

Section 5: Thresholds of Significance and Impact Analysis **25**
5.1 - Thresholds of Significance 25
5.2 - Substantial Noise Increase in Excess of Standards 25
5.3 - Groundborne Vibration/Noise Levels 29
5.4 - Noise Levels from Airport Activity 30

Appendix A: Noise Measurement Data

Appendix B: Noise Modeling Data

List of Tables

Table 1: Sound Terminology 11
Table 2: Typical Construction Equipment Maximum Noise Levels, L_{max} 12
Table 3: Vibration Levels of Construction Equipment 14
Table 4: Summary of EPA Recommended Noise Levels to Protect Public Welfare 17
Table 5: Federal Transit Administration Construction Vibration Impact Criteria 18
Table 6: New Development Land-Use Compatibility Guidelines 19
Table 7: Existing Ambient Noise Levels in the Project Vicinity 23

List of Exhibits

Exhibit 1: Regional Location Map 3
Exhibit 2: Local Vicinity Map 5
Exhibit 3: Site Plan 7

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ACRONYMS AND ABBREVIATIONS

ADT	Average Daily Traffic
Caltrans	California Department of Transportation
CBC	California Building Standards Code
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CNEL	Community Noise Equivalent Level
dB	decibel
dBA	A-weighted decibel
DNL	Day-Night Level
EPA	United States Environmental Protection Agency
FCS	FirstCarbon Solutions
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
L_{dn}	day/night average sound level
L_{eq}	equivalent sound level
L_{max}	maximum noise level
L_{min}	minimum noise level
MM	Mitigation Measure
PPV	peak particle velocity
rms	root mean square
USGS	United States Geological Survey
VdB	vibration in decibels

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SECTION 1: INTRODUCTION

1.1 - Purpose of Analysis and Study Objectives

This Noise Impact Analysis has been prepared by FirstCarbon Solutions (FCS) to determine the off-site and on-site noise impacts associated with the proposed Masson Estates Project (proposed project). The following is provided in this report:

- A description of the study area, project site, and proposed project.
- Information regarding the fundamentals of noise and vibration.
- A description of the local noise and vibration guidelines and standards.
- A description of the existing noise environment.
- An analysis of the potential short-term, construction-related noise and vibration impacts from the proposed project.
- An analysis of long-term, operations-related noise and vibration impacts from the proposed project.

1.2 - Project Summary

1.2.1 - Site Location

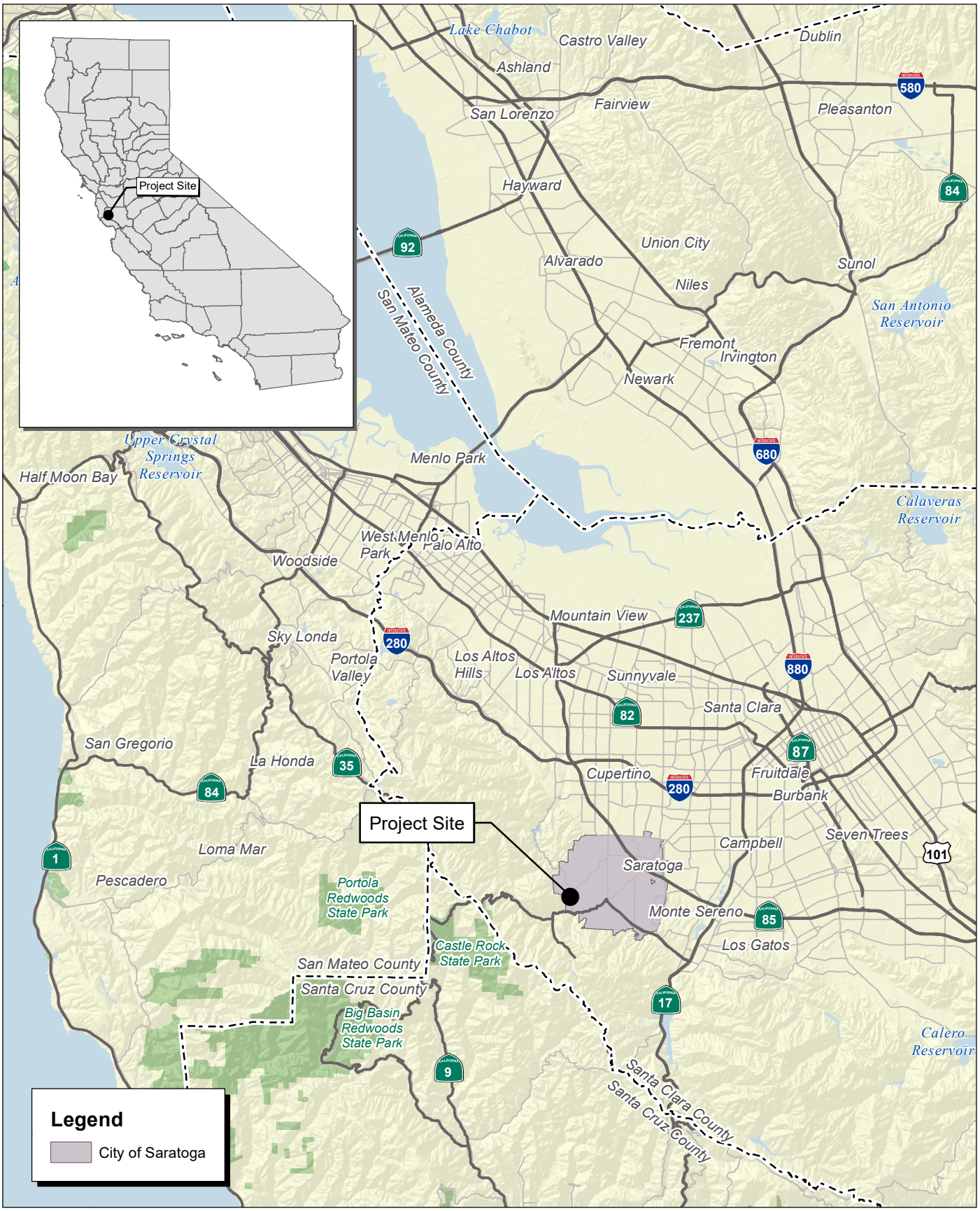
The project site is located in the western portion of the City of Saratoga (City), east of The Mountain Winery along Pierce Road (Exhibit 1). The Mountain Winery is an event venue that provides wine tasting and dining, private events and events open to the public, and concerts in a 2,500-seat outdoor amphitheater.

The project site is surrounded by low-density hillside residential uses to the north, east, and south, and by Mountain Winery to the west. The project site is approximately 72.45 acres. Regional access to the site is available off State Route (SR) 9 from the south via Pierce Road. SR-85 also provides regional access from the north via Saratoga Sunnyvale Road. The project site consists of one parcel, Assessor's Parcel Number (APN) 503-46-005.

1.2.2 - Project Description

The project applicant, Chateau Masson, LLC proposes to subdivide the 72.45-acre parcel and develop 25 homes and related infrastructure. Development would be focused in the northern 18.38 acre portion of the parcel (Development Area); the southern 54.06 portion would remain undeveloped with the exception of emergency access roads (Remainder Area) (Exhibit 2). Homes would consist of two to three stories. The proposed project would also include improvements to the existing emergency access road (Exhibit 3).

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Source: Census 2000 Data, The California Spatial Information Library (CaSIL).

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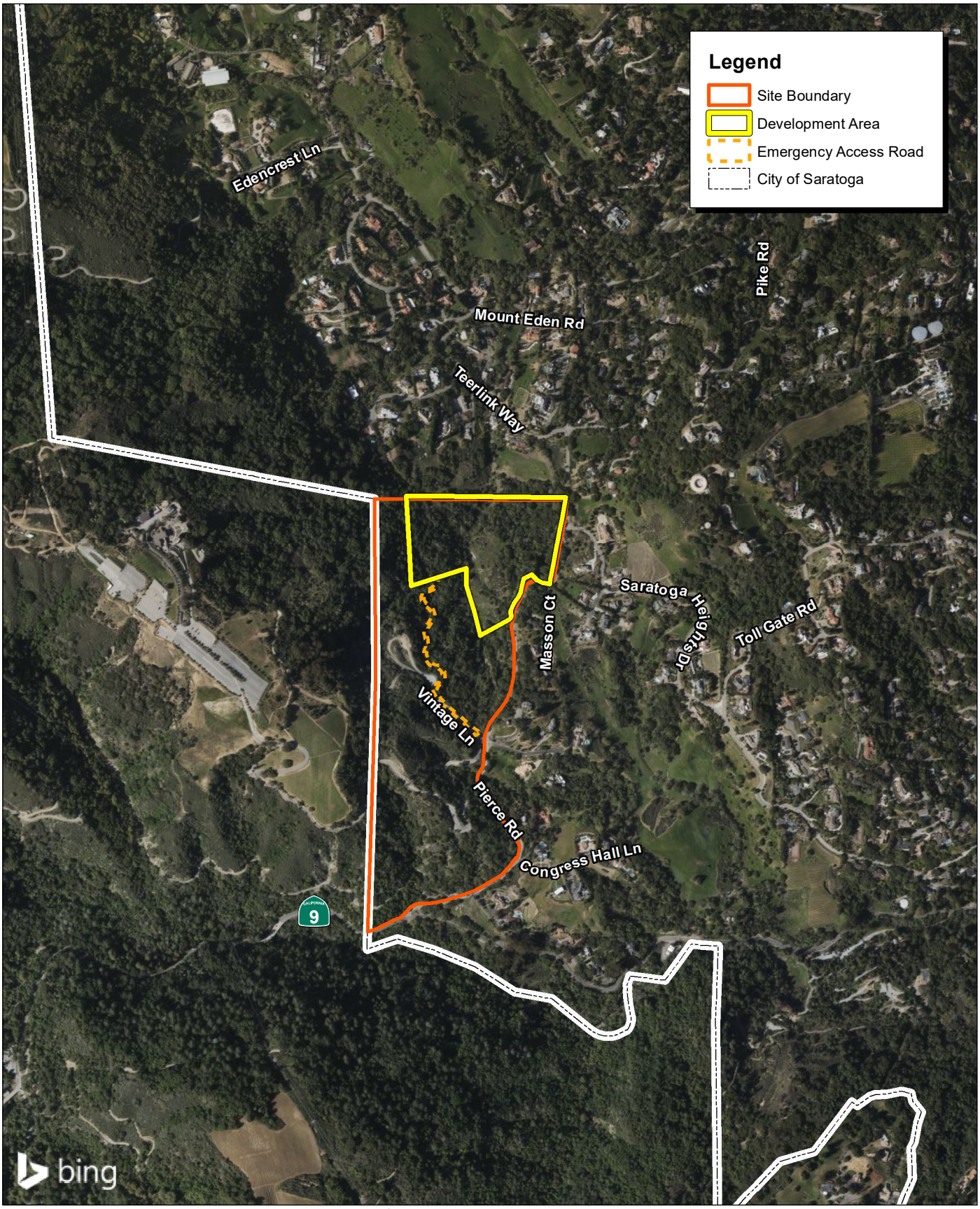
5 2.5 0 5 Miles

Exhibit 1
Regional Location Map

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CITY OF SARATOGA
MASSON ESTATES PROJECT
NOISE IMPACT ANALYSIS

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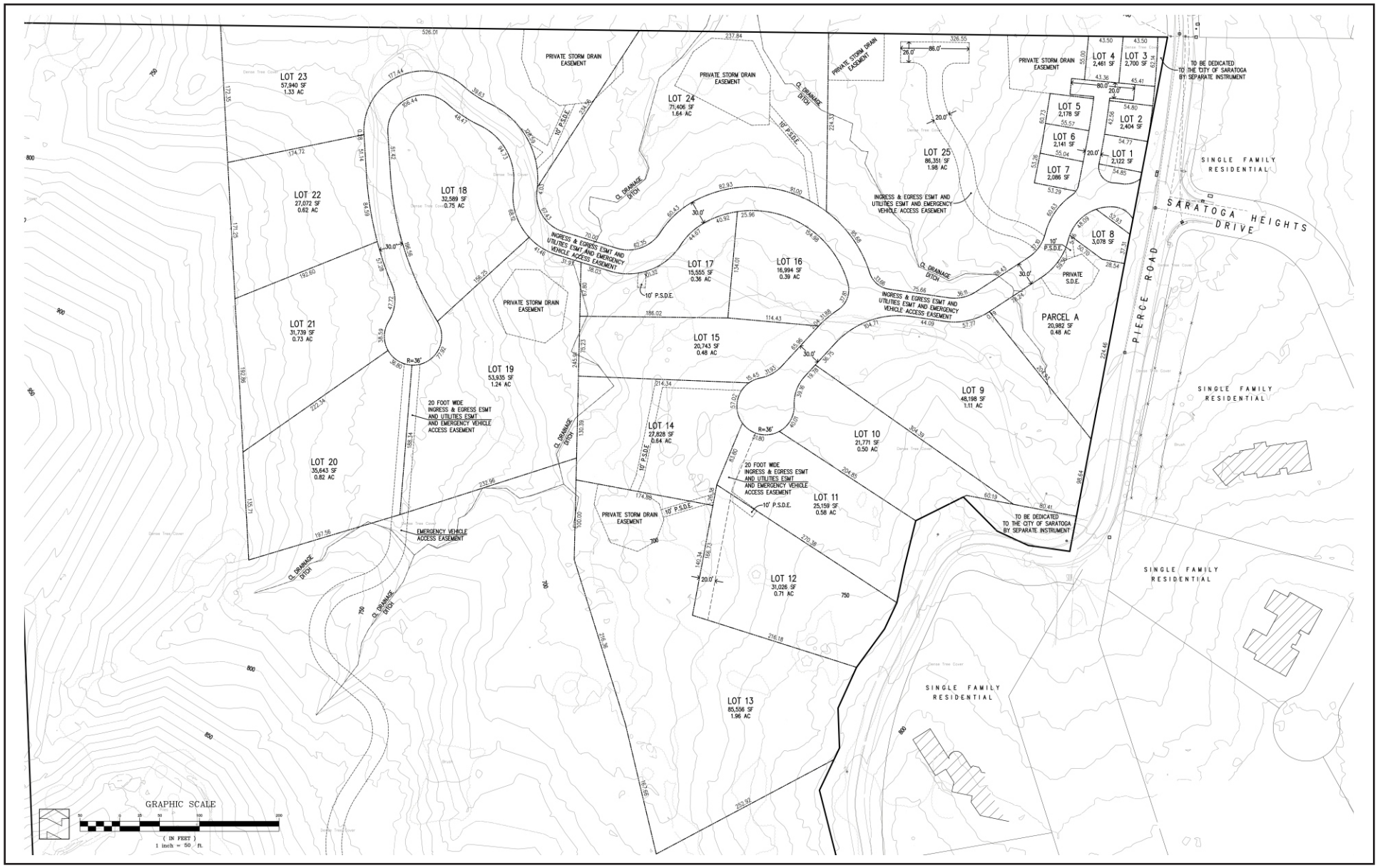
Source: Bing Aerial Imagery. Hanna-Brunetti Civil Engineers, 02/2024.

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1,000 500 0 1,000 Feet

Exhibit 2
Local Vicinity Map

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Source: Hanna-Brunetti. 12/2023.

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Exhibit 3
Site Plan

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SECTION 2: NOISE AND VIBRATION FUNDAMENTALS

2.1 - Characteristics of Noise

Noise is generally defined as unwanted or objectionable sound. Sound becomes unwanted when it interferes with normal activities, when it causes actual physical harm, or when it has adverse effects on health. The effects of noise on people can include general annoyance, interference with speech communication, sleep disturbance, and in the extreme, hearing impairment. Noise effects can be caused by pitch or loudness. *Pitch* is the number of complete vibrations or cycles per second of a wave that result in the range of tone from high to low; higher-pitched sounds are louder to humans than lower-pitched sounds. *Loudness* is the intensity or amplitude of sound.

Sound is produced by the vibration of sound pressure waves in the air. Sound pressure levels are used to measure the intensity of sound and are described in terms of decibels. The decibel (dB) is a logarithmic unit, which expresses the ratio of the sound pressure level being measured to a standard reference level. The 0 point on the dB scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Changes of 3 dB or less are only perceptible in laboratory environments. Audible increases in noise levels generally refer to a change of 3 dB or more, as this level has been found to be barely perceptible to the human ear in outdoor environments. Only audible changes in existing ambient or background noise levels are considered potentially significant.

The human ear is not equally sensitive to all frequencies within the audible sound spectrum, so sound pressure level measurements can be weighted to better represent frequency-based sensitivity of average healthy human hearing. One such specific “filtering” of sound is called “A-weighting.” A-weighted decibels (dBA) approximate the subjective response of the human ear to a broad frequency noise source by discriminating against very low and very high frequencies of the audible spectrum. They are adjusted to reflect only those frequencies that are audible to the human ear. Because decibels are logarithmic units, they cannot be added or subtracted by ordinary arithmetic means. For example, if one noise source produces a noise level of 70 dB, the addition of another noise source with the same noise level would not produce 140 dB; rather, they would combine to produce a noise level of 73 dB.

As noise spreads from a source, it loses energy so that the farther away the noise receiver is from the noise source, the lower the perceived noise level. Noise levels diminish or attenuate as distance from the source increases based on an inverse square rule, depending on how the noise source is physically configured. Noise levels from a single-point source, such as a single piece of construction equipment at ground level, attenuate at a rate of 6 dB for each doubling of distance (between the single-point source of noise and the noise-sensitive receptor of concern). Heavily traveled roads with few gaps in traffic behave as continuous line sources and attenuate roughly at a rate of 3 dB per doubling of distance.

2.1.1 - Noise Descriptors

There are many ways to rate noise for various time periods, but an appropriate rating of ambient noise affecting humans also accounts for the annoying effects of sound. Equivalent continuous sound level (L_{eq}) is the total sound energy of time-varying noise over a sample period. However, the predominant rating scales for human communities in the State of California are the L_{eq} and Community Noise Equivalent Level (CNEL) or the day/night average sound level (L_{dn}) based on dBA. CNEL is the time-varying noise over a 24-hour period, with a 5 dBA weighting factor applied to the hourly L_{eq} for noises occurring from 7:00 p.m. to 10:00 p.m. (defined as relaxation hours) and a 10 dBA weighting factor applied to noise occurring from 10:00 p.m. to 7:00 a.m. (defined as sleeping hours). L_{dn} is similar to the CNEL scale but without the adjustment for events occurring during the evening hours. CNEL and L_{dn} are within 1 dBA of each other and are normally exchangeable. The noise adjustments are added to the noise events occurring during the more sensitive hours.

Other noise rating scales of importance when assessing the annoyance factor include the maximum noise level (L_{max}), which is the highest exponential time-averaged sound level that occurs during a stated time period. The noise environments discussed in this analysis are specified in terms of maximum levels denoted by L_{max} for short-term noise impacts. L_{max} reflects peak operating conditions and addresses the annoying aspects of intermittent noise.

2.1.2 - Noise Propagation

From the noise source to the receiver, noise changes both in level and frequency spectrum. The most obvious is the decrease in noise as the distance from the source increases. The manner in which noise reduces with distance depends on whether the source is a point or line source, as well as ground absorption, atmospheric conditions (wind, temperature gradients, and humidity) and refraction, and shielding by natural and manmade features. Sound from point sources, such as an air conditioning condenser, a piece of construction equipment, or an idling truck, radiates uniformly outward as it travels away from the source in a spherical pattern.

The attenuation or sound drop-off rate is dependent on the conditions of the land between the noise source and receiver. To account for this ground-effect attenuation (absorption), two types of site conditions are commonly used in noise models: soft-site and hard-site conditions. Soft-site conditions account for the sound propagation loss over natural surfaces such as normal earth and ground vegetation. For point sources, a drop-off rate of 7.5 dBA per each doubling of the distance (dBA/DD) is typically observed over soft ground with landscaping, as compared with a 6 dBA/DD drop-off rate over hard ground such as asphalt, concrete, stone, and very hard packed earth. For line sources, such as traffic noise on a roadway, a 4.5 dBA/DD is typically observed for soft-site conditions compared to the 3 dBA/DD drop-off rate for hard-site conditions. Table 1 briefly defines these measurement descriptors and other sound terminology used in this section.

Table 1: Sound Terminology

Term	Definition
Sound	A vibratory disturbance created by a vibrating object which, when transmitted by pressure waves through a medium such as air, can be detected by a receiving mechanism such as the human ear or a microphone.
Noise	Sound that is loud, unpleasant, unexpected, or otherwise undesirable.
Ambient Noise	The composite of noise from all sources near and far in a given environment.
Decibel (dB)	A unitless measure of sound on a logarithmic scale, which represents the squared ratio of sound pressure amplitude to a reference sound pressure. The reference pressure is 20 micropascals, representing the threshold of human hearing (0 dB).
A-Weighted Decibel (dBA)	An overall frequency-weighted sound level that approximates the frequency response of the human ear.
Equivalent Noise Level (L_{eq})	The average sound energy occurring over a specified time period. In effect, L_{eq} is the steady-state sound level that in a stated period would contain the same acoustical energy as the time-varying sound that actually occurs during the same period.
Maximum and Minimum Noise Levels (L_{max} and L_{min})	The maximum or minimum instantaneous sound level measured during a measurement period.
Day-Night Level (DNL or L_{dn})	The energy average of the A-weighted sound levels occurring during a 24-hour period, with 10 dB added to the A-weighted sound levels occurring between 10:00 p.m. and 7:00 a.m. (nighttime).
Community Noise Equivalent Level (CNEL)	The energy average of the A-weighted sound levels occurring during a 24-hour period, with 5 dB added to the A-weighted sound levels occurring between 7:00 p.m. and 10:00 p.m. and 10 dB added to the A-weighted sound levels occurring between 10:00 p.m. and 7:00 a.m.
Source: Data compiled by FirstCarbon Solutions (FCS) 2024.	

2.1.3 - Traffic Noise

The level of traffic noise depends on the three primary factors: (1) the volume of the traffic, (2) the speed of the traffic, and (3) the number of trucks in the flow of traffic. Generally, the loudness of traffic noise is increased by heavier traffic volumes, higher speeds, and greater number of trucks. Vehicle noise is a combination of the noise produced by the engine, exhaust, and tires. Because of the logarithmic nature of noise levels, a doubling of the traffic volume (assuming that the speed and

truck mix do not change) results in a noise level increase of 3 dBA. Based on the Federal Highway Administration (FHWA) community noise assessment criteria, this change is "barely perceptible." For reference, a doubling of perceived noise levels would require an increase of approximately 10 dBA. The truck mix on a given roadway also has an effect on community noise levels. As the number of heavy trucks increases and becomes a larger percentage of the vehicle mix, adjacent noise levels increase.

2.1.4 - Stationary Noise

A stationary noise producer is any entity in a fixed location that emits noise. Examples of stationary noise sources include machinery, engines, energy production, and other mechanical or powered equipment and activities such as loading and unloading or public assembly that may occur at commercial, industrial, manufacturing, or institutional facilities. Furthermore, while noise generated by the use of motor vehicles over public roads is preempted from local regulation, the use of these vehicles is considered a stationary noise source when operated on private property such as at a construction site, a truck terminal, or warehousing facility.

The effects of stationary noise depend on factors such as characteristics of the equipment and operations, distance and pathway between the generator and receptor, and weather. Stationary noise sources may be regulated at the point of manufacture (e.g., equipment or engines), with limitations on the hours of operation, or with provision of intervening structures, barriers, or topography.

Construction activities are a common source of stationary noise. Construction-period noise levels are higher than background ambient noise levels but eventually cease once construction is complete. Construction is performed in discrete 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 on each construction site and, therefore, would change the noise levels 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 2 shows typical noise levels of construction equipment as measured at a distance of 50 feet from the operating equipment.

Table 2: Typical Construction Equipment Maximum Noise Levels, L_{max}

Type of Equipment	Impact Device? (Yes/No)	Specification Maximum Sound Levels for Analysis (dBA at 50 feet)
Impact Pile Driver	Yes	95
Auger Drill Rig	No	85
Vibratory Pile Driver	No	95
Jackhammers	Yes	85
Pneumatic Tools	No	85
Pumps	No	77
Scrapers	No	85

Type of Equipment	Impact Device? (Yes/No)	Specification Maximum Sound Levels for Analysis (dBA at 50 feet)
Cranes	No	85
Portable Generators	No	82
Rollers	No	85
Bulldozers	No	85
Tractors	No	84
Front-end Loaders	No	80
Backhoe	No	80
Excavators	No	85
Graders	No	85
Air Compressors	No	80
Dump Truck	No	84
Concrete Mixer Truck	No	85
Pickup Truck	No	55

Notes:
dBA = A-weighted decibel
Source: Federal Highway Administration (FHWA). 2006. Highway Construction Noise Handbook.

2.1.5 - Noise from Multiple Sources

Because sound pressure levels in decibels are based on a logarithmic scale, they cannot be added or subtracted in the usual arithmetical way. Therefore, sound pressure levels in decibels are logarithmically added on an energy summation basis. In other words, adding a new noise source to an existing noise source, both producing noise at the same level, will not double the noise level. Instead, if the difference between two noise sources is 10 dBA or more, the louder noise source will dominate, and the resultant noise level will be equal to the noise level of the louder source. In general, if the difference between two noise sources is 0–1 dBA, the resultant noise level will be 3 dBA higher than the louder noise source, or both sources if they are equal. If the difference between two noise sources is 2–3 dBA, the resultant noise level will be 2 dBA above the louder noise source. If the difference between two noise sources is 4–10 dBA, the resultant noise level will be 1 dBA higher than the louder noise source.

2.2 - Characteristics of Groundborne Vibration and Noise

Groundborne vibration consists of rapidly fluctuating motion through a solid medium, specifically the ground, which has an average motion of zero and in which the motion's amplitude can be described in terms of displacement, velocity, or acceleration. The effects of groundborne vibration typically only cause a nuisance to people, but in extreme cases, excessive groundborne vibration has the potential to cause structural damage to buildings. Although groundborne vibration can be felt outdoors, it is typically only an annoyance to people indoors where the associated effects of the

shaking of a building can be notable. Groundborne noise is an effect of groundborne vibration and only exists indoors, since it is produced from noise radiated from the motion of the walls and floors of a room and may also consist of the rattling of windows or dishes on shelves.

Several different methods are used to quantify vibration amplitude such as the maximum instantaneous peak in the vibrations velocity, which is known as the peak particle velocity (PPV) or the root mean square (rms) amplitude of the vibration velocity. Because of the typically small amplitudes of vibrations, vibration velocity is often expressed in decibels—denoted as LV—and is based on the reference quantity of 1 microinch per second. To distinguish these vibration levels referenced in decibels from noise levels referenced in decibels, the unit is written as "VdB."

Although groundborne vibration can be felt outdoors, it is typically only an annoyance to people indoors where the associated effects of the shaking of a building can be notable. When assessing annoyance from groundborne vibration, vibration is typically expressed as rms velocity in units of decibels of 1 microinch per second, with the unit written in VdB. Typically, developed areas are continuously affected by vibration velocities of 50 VdB or lower. Human perception of vibration starts at levels as low as 67 VdB. Annoyance due to vibration in residential settings starts at approximately 70 VdB.

Off-site sources that may produce perceptible vibrations are usually caused by construction equipment, steel-wheeled trains, and traffic on rough roads, while smooth roads rarely produce perceptible groundborne noise or vibration. Construction activities, such as blasting, pile driving and operating heavy earthmoving equipment, are common sources of groundborne vibration. Construction vibration impacts on building structures are generally assessed in terms of PPV. Typical vibration source levels from construction equipment are shown in Table 3.

Table 3: Vibration Levels of Construction Equipment

Construction Equipment	PPV at 25 feet (inches/second)	rms Velocity in Decibels (VdB) at 25 feet
Water Trucks	0.001	57
Scraper	0.002	58
Bulldozer—small	0.003	58
Jackhammer	0.035	79
Concrete Mixer	0.046	81
Concrete Pump	0.046	81
Paver	0.046	81
Pickup Truck	0.046	81
Auger Drill Rig	0.051	82
Backhoe	0.051	82
Crane (Mobile)	0.051	82
Excavator	0.051	82

Construction Equipment	PPV at 25 feet (inches/second)	rms Velocity in Decibels (VdB) at 25 feet
Grader	0.051	82
Loader	0.051	82
Loaded Trucks	0.076	86
Bulldozer—large	0.089	87
Caisson drilling	0.089	87
Vibratory Roller–small	0.101	88
Compactor	0.138	90
Clam shovel drop	0.202	94
Vibratory Roller–large	0.210	94
Pile Driver (impact-typical)	0.644	104
Pile Driver (impact-upper range)	1.518	112

Notes:
PPV = peak particle velocity
Source: Compilation of scientific and academic literature, generated by the Federal Transit Administration (FTA) and Federal Highway Administration (FHWA).

The propagation of groundborne vibration is not as simple to model as airborne noise. This is because noise in the air travels through a relatively uniform medium, while groundborne vibrations travel through the earth, which may contain significant geological differences. Factors that influence groundborne vibration include:

- **Vibration source:** Type of activity or equipment, such as impact or mobile, and depth of vibration source.
- **Vibration path:** Soil type, rock layers, soil layering, depth to water table, and frost depth.
- **Vibration receiver:** Foundation type, building construction, and acoustical absorption.

Among these factors that influence groundborne vibration, there are significant differences in the vibration characteristics when the source is underground compared to at the ground surface. In addition, soil conditions are known to have a strong influence on the levels of groundborne vibration. Among the most important factors are the stiffness and internal damping of the soil and the depth of bedrock. Vibration propagation is more efficient in stiff clay soils than in loose sandy soils, and shallow rock seems to concentrate the vibration energy close to the surface and can result in groundborne vibration problems at a large distance from the source. Factors such as layering of the soil and depth to the water table can have significant effects on the propagation of groundborne vibration. Soft, loose, sandy soils tend to attenuate more vibration energy than hard, rocky materials. Vibration propagation through groundwater is more efficient than through sandy soils. There are three main types of vibration propagation: surface, compression, and shear waves. Surface waves, or Rayleigh waves, travel along the ground's surface. These waves carry most of their energy along an

expanding circular wave front, similar to ripples produced by throwing a rock into a pool of water. P-waves, or compression waves, are body waves that carry their energy along an expanding spherical wave front. The particle motion in these waves is longitudinal (i.e., in a "push-pull" fashion). P-waves are analogous to airborne sound waves. S-waves, or shear waves, are also body waves that carry energy along an expanding spherical wave front. However, unlike P-waves, the particle motion is transverse, or side-to-side and perpendicular to the direction of propagation.

As vibration waves propagate from a source, the vibration energy decreases in a logarithmic nature and the vibration levels typically decrease by 6 VdB per doubling of the distance from the vibration source. As stated above, this drop-off rate can vary greatly depending on the soil type, but it has been shown to be effective enough for screening purposes, in order to identify potential vibration impacts that may need to be studied through actual field tests. The vibration level (calculated below as "PPV") at a distance from a point source can generally be calculated using the vibration reference equation:

$$PPV = PPV_{ref} * (25/D)^n \text{ (in/sec)}$$

Where:

PPV_{ref} = reference measurement at 25 feet from vibration source
D = distance from equipment to property line
n = vibration attenuation rate through ground

According to Section 7 of the Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment Manual, an "n" value of 1.5 is recommended to calculate vibration propagation through typical soil conditions.[1]

[1] Federal Transit Administration (FTA). 2018. Transit Noise and Vibration Impact Assessment Manual. Website: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/118131/transit-noise-and-vibration-impact-assessment-manual-fta-report-no-0123_0.pdf. Accessed March 26, 2024.

SECTION 3: REGULATORY SETTING

3.1 - Federal Regulations

3.1.1 - United States Environmental Protection Agency

In 1972, Congress enacted the Noise Control Act.[2] This act authorized the United States Environmental Protection Agency (EPA) to publish descriptive data on the effects of noise and establish levels of sound "requisite to protect the public welfare with an adequate margin of safety." These levels are separated into health (hearing loss levels) and welfare (annoyance levels) categories, as shown in Table 4. The EPA cautions that these identified levels are not standards because they do not take into account the cost or feasibility of the levels.

For protection against hearing loss, 96 percent of the population would be protected if sound levels are less than or equal to an $L_{eq(24)}$ of 70 dBA. The EPA activity and interference guidelines are designed to ensure reliable speech communication at about 5 feet in the outdoor environment. For outdoor and indoor environments, interference with activity and annoyance should not occur if levels are below 55 dBA and 45 dBA, respectively.

Table 4: Summary of EPA Recommended Noise Levels to Protect Public Welfare

Effect	Level	Area
Hearing loss	$L_{eq}(24) \leq 70$ dB	All areas
Outdoor activity interference and annoyance	$L_{dn} \leq 55$ dB	Outdoors in residential areas, farms, and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq}(24) \leq 55$ dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{eq} \leq 45$ dB	Indoor residential areas.
	$L_{eq}(24) \leq 45$ dB	Other indoor areas with human activities such as schools, etc.

Notes:
dB = decibel
L_{eq} = equivalent sound level
L_{dn} = day/night average sound level
(24) signifies an L_{eq} duration of 24 hours.
Source: United States Environmental Protection Agency (EPA). 1978. Protective Noise Levels, EPA 550/9-79-100.

[2] GovInfo. 2024. Noise Control Act Of 1972. Website: https://www.govinfo.gov/content/pkg/COMPS-888/pdf/COMPS-888.pdf. Accessed March 26, 2024.

3.1.2 - Federal Transit Administration

The FTA has established industry accepted standards for vibration impact criteria and impact assessment. These guidelines are published in its Transit Noise and Vibration Impact Assessment Manual.[3] The FTA guidelines include thresholds for construction vibration impacts for various structural categories as shown in Table 5.

Table 5: Federal Transit Administration Construction Vibration Impact Criteria

Building Category	PPV (in/sec)	Approximate VdB
I. Reinforced—Concrete, Steel, or Timber (no plaster)	0.5	102
II. Engineered Concrete and Masonry (no plaster)	0.3	98
III. Non-engineered Timber and Masonry Buildings	0.2	94
IV. Buildings Extremely Susceptible to Vibration Damage	0.12	90

Notes:
PPV = peak particle velocity
rms = root mean square
VdB = vibration measured as rms velocity in decibels of 1 microinch per second
Source: Federal Transit Administration (FTA). 2018. Transit Noise and Vibration Impact Assessment Manual. September.

In addition, FTA has identified construction noise thresholds in the Transit Noise and Vibration Impact Assessment Manual, which limit daytime construction noise to 80 dBA L_{eq} at residential land uses, 85 dBA L_{eq} at commercial uses and to 90 dBA L_{eq} at industrial land uses.

3.2 - State Regulations

3.2.1 - California General Plan Guidelines

Established in 1973, the California Department of Health Services Office of Noise Control was instrumental in developing regularity tools to control and abate noise for use by local agencies. One significant model is the "Land Use Compatibility for Community Noise Environments Matrix," which allows the local jurisdiction to delineate compatibility of sensitive uses with various incremental levels of noise.[4]

Government Code Section 65302 mandates that the legislative body of each county and city in California adopt a noise element as part of its comprehensive general plan. The local noise element must recognize the land use compatibility guidelines published by the State Department of Health Services. The guidelines rank noise/land use compatibility in terms of normally acceptable, conditionally acceptable, normally unacceptable, and clearly unacceptable. The project is also subject to review under the State of California Environmental Quality Act (CEQA). Appendix G of the

[3] Federal Transit Administration (FTA). 2018. Transit Noise and Vibration Impact Assessment Manual. Website: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/118131/transit-noise-and-vibration-impact-assessment-manual-fta-report-no-0123_0.pdf. Accessed March 26, 2024.

[4] California Department of Health Services Office of Noise Control. Land Use Compatibility for Community Noise Environments Matrix. 1976.

CEQA Guidelines provides impact thresholds for potential noise and vibration impacts. The City of Saratoga had developed its own CEQA thresholds, which are listed in the Thresholds of Significance section below.

3.2.2 - California Building Standards Code

The State of California has established noise insulation standards for new hotels, motels, apartment houses, and dwellings (other than single-family detached housing). These requirements are provided in the 2022 California Building Standards Code (CBC) (California Code of Regulations [CCR] Title 24). As provided in the CBC, the noise insulation standards set forth an interior standard of 45 dBA CNEL as measured from within the structure's interior. Title 24 standards are typically enforced by local jurisdictions through the building permit application process.

3.2.3 - Assembly Bill 1307

Assembly Bill (AB) 1307 went into effect January 1, 2024. This bill clarifies that "for residential projects, the effects of noise generated by project occupants and their guests on human beings is not a significant effect on the environment." Therefore, this analysis does not address potential noise impacts from future occupants and their guests on sensitive receptors in the project vicinity.

3.3 - Local Regulations

The project site is located in the City of Saratoga. The City addresses noise in the City of Saratoga General Plan 2040 (General Plan),[5] and in the City of Saratoga Municipal Code (Municipal Code).[6]

3.3.1 - City of Saratoga General Plan 2040

The Noise Element of the General Plan provides goals and policies to guide compatible land uses and the incorporation of noise attenuation measures for new uses to protect people living and working in the City from an excessive noise environment.

Land Use Compatibility (Exterior Noise Impacts)

The City has established the following exterior noise land use compatibility guidelines, summarized in Table 6 (Table NE-2 in the General Plan) that are considered environmentally acceptable for approval of new single-family residential development in the City of Saratoga.

Table 6: New Development Land-Use Compatibility Guidelines

Land Use Category	Normally Acceptable*
Residential–Single-Family	Up to 60 dBA

[5] City of Saratoga. General Plan Update. 2024. General Plan 2040 Noise Section. Website: https://www.saratoga.ca.us/DocumentCenter/View/4868/Noise-Element_FINAL. Accessed April 25, 2024.

[6] Municode Library. 2024. Saratoga, CA. Website: https://library.municode.com/ca/saratoga/codes/code_of_ordinances. Accessed April 29, 2024.

Land Use Category	Normally Acceptable*
Notes: Sound levels above are as measured at the exterior of the proposed location of the new development (e.g., residential unit, commercial building, etc.) rather than at the property boundary of the source or the property to be developed. Refer to Table LU-1 (Land-Use Element) for detailed descriptions of land use categories and land uses for which these guidelines apply. These guidelines are derived from the California Department of Health Services, Guidelines for the Preparation and Content of the Noise Element of the General Plan, 2003. The State Guidelines have been modified to reflect standards for the City of Saratoga. ***Normally Acceptable** – Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction. There are no special noise insulation requirements.	

Goals, Policies, and Implementations

The following are applicable policies contained in the City of Saratoga General Plan.

Goal N-2 **Promote land-use compatibility by addressing noise exposure from existing noise sources.**

N-2.1 An acoustical analysis is to be conducted for proposed Residential and Quasi-Public development where the existing noise level exceeds Outdoor DNL 60 dB to determine measures needed to reduce noise impacts to meet City noise standards.

N-2.2 New residential development shall be designed and constructed to provide an interior noise level of DNL 45 dB or less in habitable rooms (due to outdoor sources).

N-2.3 Residential outdoor open space intended for use and enjoyment shall be designed to meet Outdoor DNL 60 dB. This policy does not apply to private exterior balconies. Where this level cannot feasibly be met by incorporating reasonable measures, such as strategic site layout and noise barriers, DNL 65 dB may be approved.

Goal N-3 **Promote land-use compatibility by addressing noise exposure from new noise sources.**

N-3.1 Changes in use and development shall be reviewed for noise impacts to neighboring land uses.

N-**3.2** New development shall be required to utilize appropriate measures to reduce noise impacts to the adopted noise standards; and acoustical analysis may be required by the approving authority.

3.3.2 - City of Saratoga Municipal Code

The City establishes noise standards for hours of construction in Municipal Code Section 7-30.060. According to this section, construction activity shall be limited to the hours of 7:30 a.m. and 6:00 p.m. daily, Monday through Friday. Saturday hours of construction shall be 9:00 a.m. and 5:00 p.m.

Construction activities shall be prohibited on Sundays and weekday holidays, with the exception of the following:

(1) Residential construction activities that do not require a City permit, or which are authorized by a valid City permit and do not exceed 50 percent of the existing main or accessory structure, may be conducted between the hours of 9:00 a.m. and 5:00 p.m. on Sundays and weekday holidays.

7-30.040 Noise standards

(a) Except as otherwise provided in Paragraph (b) of this Section, all uses and developments shall comply with the following noise standards for the various land uses and times of day as indicated below. No person shall cause, produce, or allow to be produced any noise that exceeds these noise standards at any point outside the property boundary on which the noise is generated.

Maximum Permissible Outdoor Noise Levels Generated dBA						
	Daytime (7:00 a.m. to 7:00 p.m.)		Evening (7:00 p.m. to 10:00 p.m.)		Nighttime (10:00 p.m. to 7:00 a.m.)	
Land Use	Average L_{eq}	Maximum L_{max}	Average L_{eq}	Maximum L_{max}	Average L_{eq}	Maximum L_{max}
Residential (single and multi-family)	55	65	45	55	40	50

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SECTION 4: EXISTING NOISE CONDITIONS

The project site is located within the City of Saratoga in Santa Clara County, California. Surrounding the project site are low-density hillside residential uses to the north, east, and south, and by Mountain Winery to the west. The project site is located in a relatively quiet area, and the primary noise sources audible on the project site are vehicles on adjacent roadways.

The existing noise environment in the project vicinity was documented through ambient noise monitoring. Three short-term noise measurements (15 minutes each) were taken on Thursday, March 21, 2024. The short-term noise measurements were taken between approximately 12:35 p.m. and 2:20 p.m. The noise measurement data sheets are provided in Appendix A of this report.

The short-term noise measurements taken at the project site are summarized in Table 7. The noise measurements indicate that daytime ambient noise levels range from 40.1 dBA to 59.1 dBA L_{eq} adjacent to nearby residential land uses and roadways in the project vicinity. The noise technician observed that the dominant noise source in the project vicinity is traffic noise from the Saratoga Heights Drive/Pierce Road intersection, which runs along the northeast boundary of the project site.

Table 7: Existing Ambient Noise Levels in the Project Vicinity

Site Location	Location Description	dBA	Primary Noise Sources
ST-1	Pierce Road, Saratoga Heights Drive intersection.	59.1 L_{eq}	Adjacent roadway, vehicles, wildlife.
ST-2	Along Pierce Road, across from Masson Court.	54.6 L_{eq}	Adjacent roadway, vehicles, wildlife.
ST-3	Central western boundary.	40.1 L_{eq}	Wildlife

Notes:
dBA = A-weighted decibel
L_{eq} = equivalent sound level
Source: FirstCarbon Solutions (FCS). 2024.

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SECTION 5: THRESHOLDS OF SIGNIFICANCE AND IMPACT ANALYSIS

5.1 - Thresholds of Significance

According to CEQA Guidelines Appendix G, to determine whether impacts related to noise and vibration are significant environmental effects, the following questions are analyzed and evaluated.

Would the proposed project:

a) Generate a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?

b) Generate excessive groundborne vibration or groundborne noise levels?

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

5.2 - Substantial Noise Increase in Excess of Standards

5.2.1 - Construction Noise Impacts

For the purposes of this analysis, a significant impact would occur if construction activities would result in a substantial temporary increase in ambient noise levels in excess of the City's applicable noise standards. A significant impact would occur if construction activities do not comply with Section 7-30.060 of the Municipal Code, limiting general construction activities to 7:30 a.m. to 6:00 p.m. daily, Monday through Friday; to 9:00 a.m. to 5:00 p.m. on Saturday; and no construction activity on Sundays or public holidays. The only exception to these restrictions is for residential construction activities that do not require a City permit, or which are authorized by a valid City permit and do not exceed 50 percent of the existing main or accessory structure; such activities may be conducted between the hours of 9:00 a.m. and 5:00 p.m. on Sundays and weekday holidays. However, the proposed project does not meet the terms of this exception.

Since the City has not defined what would determine a substantial increase in noise levels due to construction, this analysis has utilized the following standard.

- Where existing noise levels are 60 dBA L_{dn} or less at the outdoor activity areas of noise-sensitive uses, a +5 dBA increase in average daily ambient noise levels will be considered significant.
- Where existing noise levels are greater than 60 dBA L_{dn} and up to 65 dBA L_{dn} at the outdoor activity areas of noise-sensitive uses, a +3 dBA increase in average daily ambient noise levels will be considered significant.

- Where existing noise levels are greater than 65 dBA L_{dn} at the outdoor activity areas of noise-sensitive uses, a +1.5 dBA increase in average daily ambient noise levels will be considered significant.

Documented existing noise levels on the project site range from 40.1 dBA to 59.1 dBA L_{eq}, which included all transportation and non-transportation noise sources in the project vicinity. Therefore, based on the existing noise environment, a greater than 5 dBA increase in average daytime ambient noise levels due to construction activity would be considered a significant impact.

Construction-related Traffic Noise

Noise impacts from construction activities associated with the project would be a function of the noise generated by construction equipment, equipment location, sensitivity of nearby land uses, and the timing and duration of the construction activities. One type of short-term noise impact that could occur during project construction would result from the increase in traffic flow on local streets, associated with the transport of workers, equipment, and materials to and from the project site. The transport of workers and construction equipment and materials to the project site would incrementally increase noise levels on access roads leading to the site. Because workers and construction equipment would use existing routes, noise from passing trucks would be similar to existing vehicle-generated noise on these local roadways. Typically, a doubling of the Average Daily Traffic (ADT) hourly volumes on a roadway segment is required in order to result in an increase of 3 dBA in traffic noise levels; which, as discussed in the characteristics of noise discussion above, is the lowest change that can be perceptible to the human ear in outdoor environments. Because the proposed project's average daily trips would represent a small fraction of daily traffic on access roadways, they would not be capable of doubling traffic volumes along surrounding roadways and causing 3 dBA noise increases. For this reason, short-term intermittent noise from construction trips would not be expected to result in a perceptible increase in hourly or daily average traffic noise levels in the project vicinity. Therefore, short-term construction-related noise impacts associated with the transportation of workers and equipment to the project site would be less than significant.

Construction Equipment Operational Noise

The second type of short-term noise impact is related to noise generated during construction on the project site. Construction is completed in discrete 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 on the site and, therefore, the noise levels surrounding the site 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. Typical operating cycles for these types of construction equipment may involve 1 or 2 minutes of full power operation followed by 3 or 4 minutes at lower power settings. Impact equipment, such as impact pile drivers, are not expected to be used during construction of this project. This noise impact analysis focuses on analyzing the loudest phase of construction.

The site preparation phase, which includes excavation and grading of the site, tends to generate the highest noise levels because the noisiest construction equipment is earthmoving equipment.

Earthmoving equipment includes excavating machinery and compacting equipment, such as bulldozers, draglines, backhoes, front loaders, roller compactors, scrapers, and graders. Typical operating cycles for these types of construction equipment may involve 1 or 2 minutes of full power operation followed by 3 or 4 minutes at lower power settings.

Construction of the proposed project is expected to require the use of a variety of equipment, the loudest being a grader, excavator, and bulldozer, all of which generate maximum reference noise levels of 85 dBA L_{max} at 50 feet.

The closest noise-sensitive receptor to the project site is a single-family residential home located northeast of the project site located approximately 225 feet north of the project site boundary, east of Pierce Road, and 315 feet away from the nearest acoustic center of construction activity. At this distance, reasonable worst-case construction noise levels would attenuate to 61 dBA L_{eq}. However, reasonable worst-case construction noise levels would occur only periodically throughout the day as construction equipment operates along the nearest project boundaries. As noted previously, documented ambient noise levels range up to 59.1 L_{eq} along Pierce Road. Therefore, the proposed project would not result in a substantial increase of 5 dBA or greater above existing background ambient noise levels as measured at the nearest sensitive receptor.

The proposed project would comply with the City's restrictions on hours of construction activity; therefore, it would not result in any temporary increase in nighttime noise levels that could result in annoyance or sleep disturbance of nearby receptor. In addition, project construction activity would not result in a 5 dBA or greater increase in average daily ambient noise levels as measured at the outdoor active use area of the nearest residential receptor. Therefore, project construction noise impacts would be less than significant.

5.2.2 - Mobile Source Operational Noise Impacts

As discussed in the City of Saratoga General Plan 2040, under the Noise section, a significant impact would occur if a project doubled the existing traffic volume on a roadway, which would increase the ambient noise level by approximately 3 dBA.[7] The City's existing (2019) ADT volumes on key roadway segments that included Pierce Road, range from about 3,400 to 36,000 vehicles per day. As presented in Table IV.J-3 of the *Saratoga Housing And Safety Elements, and 2040 General Plan Updates EIR*, these traffic volumes generate outdoor DNL noise levels ranging from about 60 to 72 dBA at 50 feet from the roadways. Therefore, at the minimum, an increase of about 3,400 vehicles per day would be required to result in a 3 dBA increase in ambient noise levels along the key roadway segments in the planning area. FCS calculated the project trip generation numbers based on the Institute of Transportation Engineers Trip Generation Manual 11th Edition. The trip generation data sheets are provided in Appendix B of this report. The proposed 25 single-family homes at the maximum daily rate of 9.43 documented in the Institute of Transportation Engineers (ITE) manual would generate approximately 235.75 average daily trips. Therefore, the proposed project would not double average daily trips on Pierce Road adjacent to the project site and therefore would not generate 3 dBA increase in traffic noise levels. Therefore, the proposed project would not result in a

[7] City of Saratoga. General Plan Update. 2024. General Plan 2040 Noise Section. Website: https://www.saratoga.ca.us/DocumentCenter/View/4868/Noise-Element_FINAL. Accessed April 25, 2024.

substantial permanent increase in ambient noise levels from project-generated traffic trips, and mobile source operational noise impacts would be less than significant.

5.2.3 - Stationary Source Operational Noise Impacts

A significant impact would occur if operational noise levels generated by stationary noise sources at the project site would result in a substantial permanent increase in ambient noise levels in excess of any of the noise performance thresholds established in the City's Municipal Code. The City's most restrictive noise performance standard identified in Municipal Code Section 7-30.040 is 40 dBA L_{eq} during nighttime hours as measured at the project site boundary on which the noise is generated.

Mechanical Ventilation Equipment

Implementation of the proposed project would include operation of new mechanical ventilation equipment. Noise levels for residential-grade mechanical ventilation equipment systems range up to approximately 70 dBA L_{eq} at a distance of 3 feet.

The proposed project would have residential-grade mechanical ventilation equipment for each proposed residential unit. Proposed mechanical ventilation equipment could be located as close as 20 feet from the project boundary. At this distance, resulting noise levels would attenuate to 44 dBA L_{eq}. The noise calculation sheet is provided in Appendix B of this report.

These noise levels would exceed the City's nighttime noise performance standard of 40 dBA L_{eq}. Therefore, mitigation would be required to ensure that noise levels from mechanical ventilation equipment would not exceed the City's nighttime noise performance standard. Implementation of quieter models, or solid (no vertical or horizontal gaps) shielding around the units, or solid fencing at the property line, or setbacks of a minimum of 28 feet from the property line would ensure that mechanical ventilation equipment operational noise levels would be reduced to meet the City's most restrictive noise performance standard of 40 dBA L_{eq}.

Therefore, implementation of Mitigation Measure (MM) NOI-1 would ensure that mechanical ventilation equipment operational noise levels would not result in a substantial permanent increase in ambient noise levels in excess of any of the City's noise performance thresholds and would represent a less than significant impact.

Mitigation Measures

MM NOI-1 Mechanical Ventilation Equipment Noise Reduction Measured

- Prior to issuance of building permits, the applicant shall identify on project plan sets documentation that proposed mechanical ventilation equipment would not exceed the City's noise performance standard of 40 dBA L_{eq} as measured at the nearest project property line on which the equipment is located. This documentation can take the form of one of, or a combination of, the following, or similar, measures:
  - Identification of the noise rating for the equipment as being rated at 60 dBA or lower as measured at approximately 3 feet.

- Identification of solid shielding around proposed mechanical ventilation equipment to block the line of sight to the property's boundaries.
- Identification of solid fencing on the property that has a minimum surface weight of 4 pounds per square foot and no vertical or horizontal gaps.
- Identification that proposed equipment is located greater than 28 feet from any property boundary.

Implementation of this measure would ensure that mechanical ventilation equipment operational noise levels would not exceed the City's most restrictive noise performance standard, and the impact would be reduced to less than significant.

5.3 - Groundborne Vibration/Noise Levels

This section analyzes both construction and operational groundborne vibration and noise impacts. Groundborne vibrations consist of rapidly fluctuating motions within the ground that have an average motion of zero. Vibrating objects in contact with the ground radiate vibration waves through various soil and rock strata to the foundations of nearby buildings. Groundborne noise is generated when vibrating building components radiate sound, or noise generated by groundborne vibration. In general, if groundborne vibration levels do not exceed levels considered to be perceptible, then groundborne noise levels would not be perceptible in most interior environments. Therefore, this analysis focuses on determining exceedances of groundborne vibration levels.

The City has not adopted criteria for groundborne vibration impacts. Therefore, for the purposes of this analysis, the FTA's guidelines for vibration impacts are used to determine potential significant construction and operational-related vibration impacts.

5.3.1 - Short-term Construction Vibration Impacts

A significant impact would occur if existing structures at the project site or in the project vicinity would be exposed to excessive groundborne vibration levels.

Of the variety of equipment used during construction, the large vibratory rollers that are anticipated to be used in the construction of internal roadways for the project would produce the greatest groundborne vibration levels. Large vibratory rollers produce groundborne vibration levels ranging up to 0.201 in/sec PPV at 25 feet from the operating equipment.

The nearest off-site receptor to the project site is the residential building located east of the project site. The façade of this building would be located approximately 260 feet from the nearest construction footprint where the large vibratory rollers would potentially operate. At this distance, groundborne vibration levels would range up to 0.006 PPV from operation of the types of equipment that would produce the highest vibration levels. This is well below the FTA's construction vibration damage criteria of 0.2 PPV for this type of structure. Therefore, the impact to off-site receptors from short-term groundborne vibration associated with construction would be less than significant.

5.3.2 - Operational Vibration Impacts

Implementation of the proposed project would not include any permanent sources that would expose persons in the project vicinity to groundborne vibration levels that could be perceptible without instruments at any existing sensitive land use in the project vicinity. In addition, there are no existing significant permanent sources of groundborne vibration in the project vicinity to which the proposed project would be exposed. Therefore, project operational groundborne vibration level impacts would be considered less than significant.

5.4 - Noise Levels from Airport Activity

A significant impact would occur if the project would expose people residing or working in the project area to excessive noise levels for a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport.

The project site is not located within the vicinity of a private airstrip. The nearest public airport to the project site is San José Mineta International Airport, located approximately 9.3 miles northeast of the project site. Because of the distance to the airport and the orientation of the runways, the project site lies outside of the 60 dBA CNEL noise contours of the airport. Therefore, implementation of the project would not expose persons residing or working in the project vicinity to noise levels from airport activity that would be in excess of normally acceptable standards for the proposed land use development, and no impact would occur.

Appendix A:
Noise Measurement Data

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NOISE MEASUREMENT SURVEY

Site Number: ST1 Date: 3/21/24 Time: From 12:55 To 1:10

Site Location: Pierce & Saratoga Heights drives, corner of

Primary Noise Sources: Adjacent Roadway, Cars, wildlife.

Measurement Results

	dBA
L_{eq}	59.1
L_{max}	76.5
L_{min}	30.4
L_{peak}	
L_5	64.8
L_{10}	58.1
L_{50}	39
L_{90}	33.2
SEL	

Observed Noise Sources/Events

Time	Noise Source/Event	dBA

Comments:

Equipment:

Settings: A-Weighted ☐ Other ☐

Measured Difference: 0.05 dBA

Slow ☐ Fast ☐ Windscreen ☑

Atmospheric Conditions:

Maximum Wind Velocity (mph)	Average Wind Velocity (mph)	Temperature (F)	Relative Humidity (%)	
3 mph	3 mph	65° F	60%	

Comments:

NOISE MEASUREMENT SURVEY

Site Number: ST2 Date: 3/21/24 Time: From 12:35 To 12:50

Site Location: Along Pierce Rd, across from Masson CT

Primary Noise Sources: Adjacent Roadway, Cars, Wildlife.

Measurement Results

	dBA
L_{eq}	54.6
L_{max}	74.1
L_{min}	28.4
L_{peak}	
L_5	59.4
L_{10}	54.3
L_{50}	40.6
L_{90}	33.2
SEL	

Observed Noise Sources/Events

Time	Noise Source/Event	dBA

Comments: Spikes in noise levels can be attributed to cars driving by.

Equipment: _____

Settings: A-Weighted ☐ Other ☐ _____

Measured Difference: 0.05 dBA

Slow ☐ Fast ☐ Windscreen ☑

Atmospheric Conditions:

Maximum Wind Velocity (mph)	Average Wind Velocity (mph)	Temperature (F)	Relative Humidity (%)	
	3 mph	64 °F	61 %	
Comments:	Measure Diff. 0.05DBA			

NOISE MEASUREMENT SURVEY

Site Number: ST3 Date: 3/21/24 Time: From 2:085 To 2:20

Site Location: central western boundary - see Sarah's recommendation

Primary Noise Sources: Wildlife

Measurement Results

	dBA
L_{eq}	40.1
L_{max}	58
L_{min}	31.7
L_{peak}	
L_5	44.8
L_{10}	42.2
L_{50}	36.5
L_{90}	33.2
SEL	

Observed Noise Sources/Events

Time	Noise Source/Event	dBA

Comments:

Equipment:

Settings: A-Weighted ☐ Other ☐

Measured Difference: -0.2 dBA

Slow ☐ Fast ☐ Windscreen ☑

Atmospheric Conditions:

Maximum Wind Velocity (mph)	Average Wind Velocity (mph)	Temperature (F)	Relative Humidity (%)
4mph	4 mph	67°F	56 %

Comments:

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Appendix B:
Noise Modeling Data

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Mobile Construction Activity Noise Calculation

Receptor:	Receiving residential receptor	Noise Level Calculation Prior to Implementation of Noise Attenuation Requirements								
		Reference (dBA) 50 ft		Usage	Distance to	Ground	Shielding	Calculated (dBA)		
No.	Equipment Description	Lmax	Quantity	factor[1]	Receptor	Effect[2]	(dBA)[3]	Lmax	Leq	Energy
1	Grader	85	1	40	315	1	0	69.0	57.0	505869.3222
2	Excavator	85	1	40	365	1	0	67.7	55.1	325155.7295
3	Dozer	85	1	40	415	1	0	66.6	53.4	221220.6755
4	Front End Loader	80	1	40	465	1	0	60.6	47.0	49729.16255
5	Backhoe	80	1	40	515	1	0	59.7	45.6	36605.66637
6										
7										
8										
9										
10										
							Lmax[4]	69	Leq	61

Notes:

[1] Percentage of time activity occurs each hour

[2] Soft ground terrain between project site and receptor.

[3] Shielding due to terrain or structures

[4] Calculated Lmax is the Loudest value.

Residential Grade Mechanical Equipment

Receptor:	Nearest Property Line	Noise Level Calculation Prior to Implementation of Noise Attenuation Requirements								
		Reference (dBA) 3 ft		Usage	Distance to	Ground	Shielding	Calculated (dBA)		
No.	Equipment Description	Lmax	Quantity	factor[1]	Property Line	Effect[2]	(dBA)[3]	Lmax	Leq	Energy
1	Commercial grade mechanical ventilation equipment	70	1	80	20	1	0	53.5	44.3	27000
2										
3										
4										
5										
6										
7										
8										
9										
10										
									Leq	44

Notes:
[1] Percentage of time activity occurs each hour
[2] Soft ground terrain between project site and receptor.
[3] Shielding due to structural/soundwall shielding

Land Use: 210
Single-Family Detached Housing

Description

A single-family detached housing site includes any single-family detached home on an individual lot. A typical site surveyed is a suburban subdivision.

Specialized Land Use

Data have been submitted for several single-family detached housing developments with homes that are commonly referred to as patio homes. A patio home is a detached housing unit that is located on a small lot with little (or no) front or back yard. In some subdivisions, communal maintenance of outside grounds is provided for the patio homes. The three patio home sites total 299 dwelling units with overall weighted average trip generation rates of 5.35 vehicle trips per dwelling unit for weekday, 0.26 for the AM adjacent street peak hour, and 0.47 for the PM adjacent street peak hour. These patio home rates based on a small sample of sites are lower than those for single-family detached housing (Land Use 210), lower than those for single-family attached housing (Land Use 251), and higher than those for senior adult housing -- single-family (Land Use 251). Further analysis of this housing type will be conducted in a future edition of *Trip Generation Manual*.

Additional Data

The technical appendices provide supporting information on time-of-day distributions for this land use. The appendices can be accessed through either the ITETripGen web app or the trip generation resource page on the ITE website (https://www.ite.org/technical-resources/topics/trip-and-parking-generation/).

For 30 of the study sites, data on the number of residents and number of household vehicles are available. The overall averages for the 30 sites are 3.6 residents per dwelling unit and 1.5 vehicles per dwelling unit.

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in Arizona, California, Connecticut, Delaware, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Minnesota, Montana, New Jersey, North Carolina, Ohio, Ontario (CAN), Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Vermont, Virginia, and West Virginia.

Source Numbers

100, 105, 114, 126, 157, 167, 177, 197, 207, 211, 217, 267, 275, 293, 300, 319, 320, 356, 357, 367, 384, 387, 407, 435, 522, 550, 552, 579, 598, 601, 603, 614, 637, 711, 716, 720, 728, 735, 868, 869, 903, 925, 936, 1005, 1007, 1008, 1010, 1033, 1066, 1077,1078, 1079

Single-Family Detached Housing
(210)

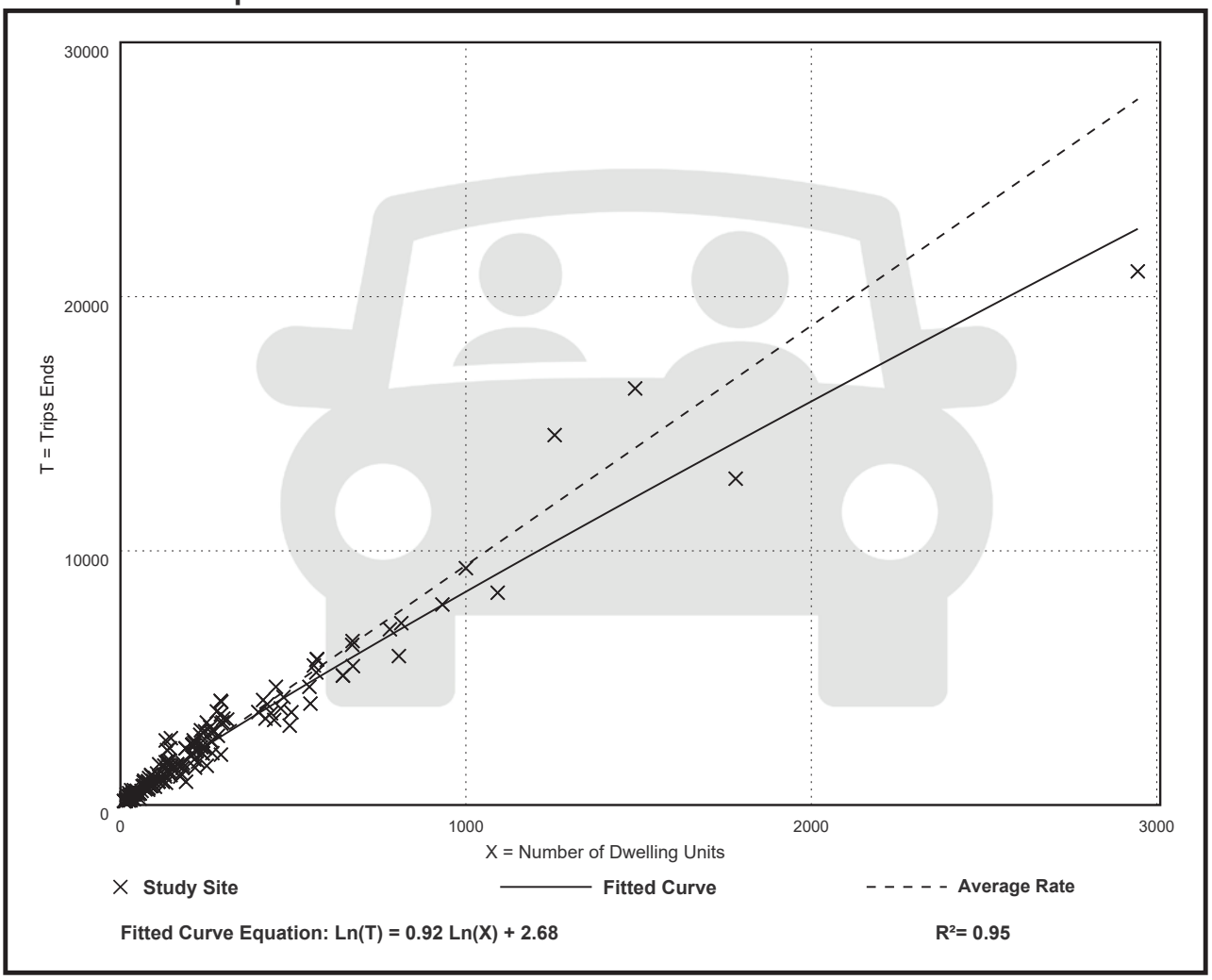
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 174
Avg. Num. of Dwelling Units: 246
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
9.43	4.45 - 22.61	2.13

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.92 Ln(X) + 2.68

R^2= 0.95

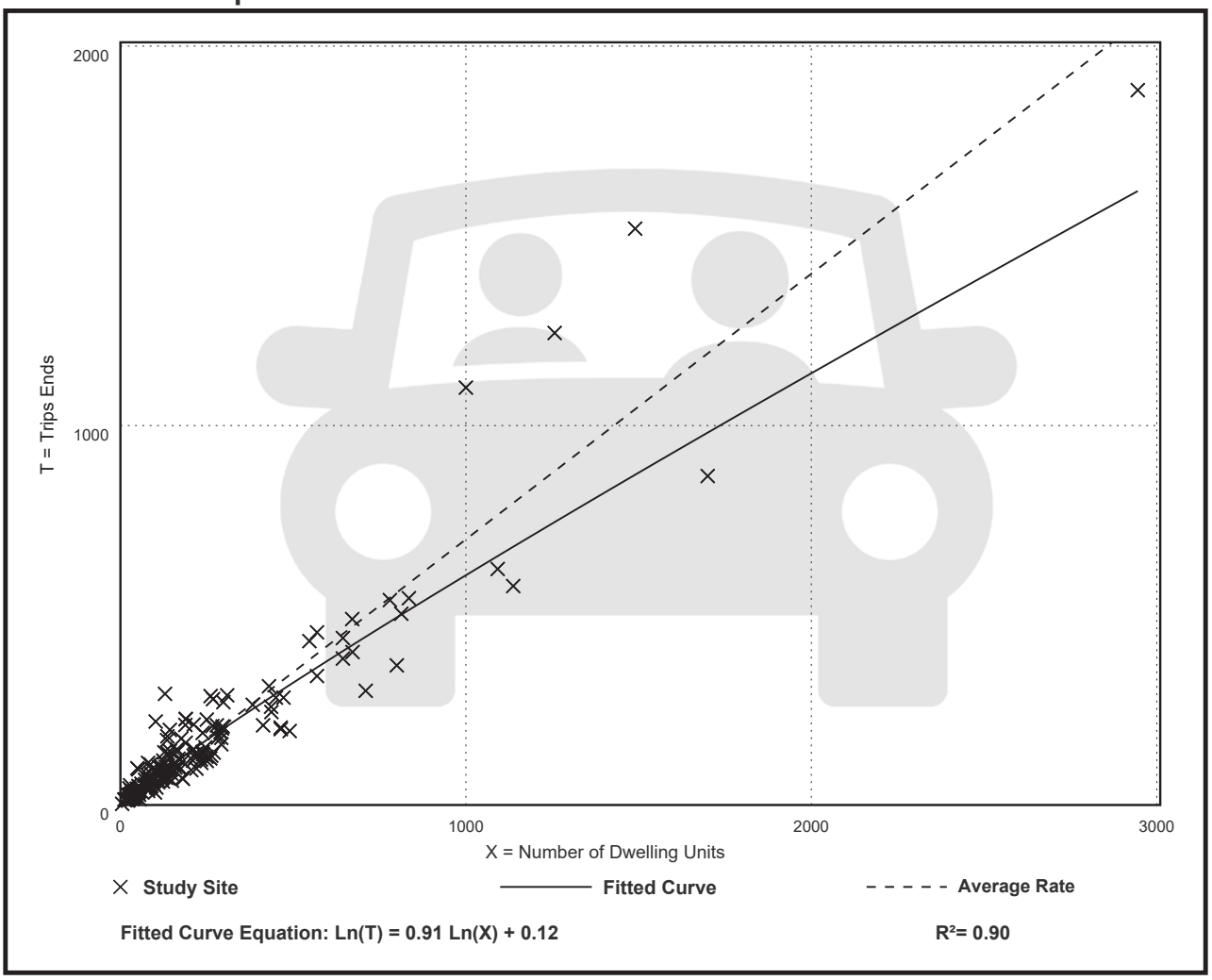
Single-Family Detached Housing
(210)

Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: General Urban/Suburban
Number of Studies: 192
Avg. Num. of Dwelling Units: 226
Directional Distribution: 26% entering, 74% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.70	0.27 - 2.27	0.24

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.91 Ln(X) + 0.12

R^2= 0.90

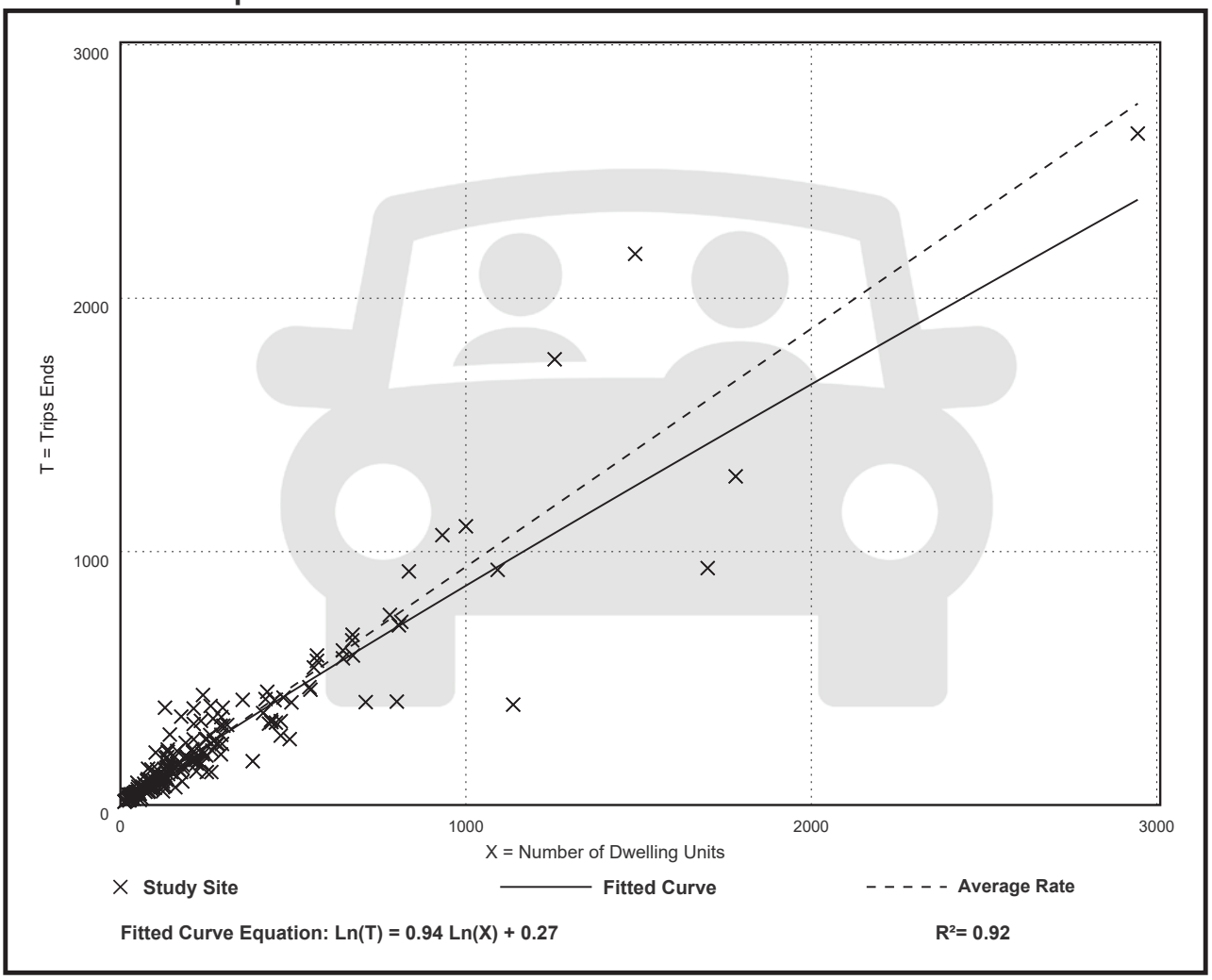
Single-Family Detached Housing
(210)

Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: General Urban/Suburban
Number of Studies: 208
Avg. Num. of Dwelling Units: 248
Directional Distribution: 63% entering, 37% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.94	0.35 - 2.98	0.31

Data Plot and Equation



Single-Family Detached Housing
(210)

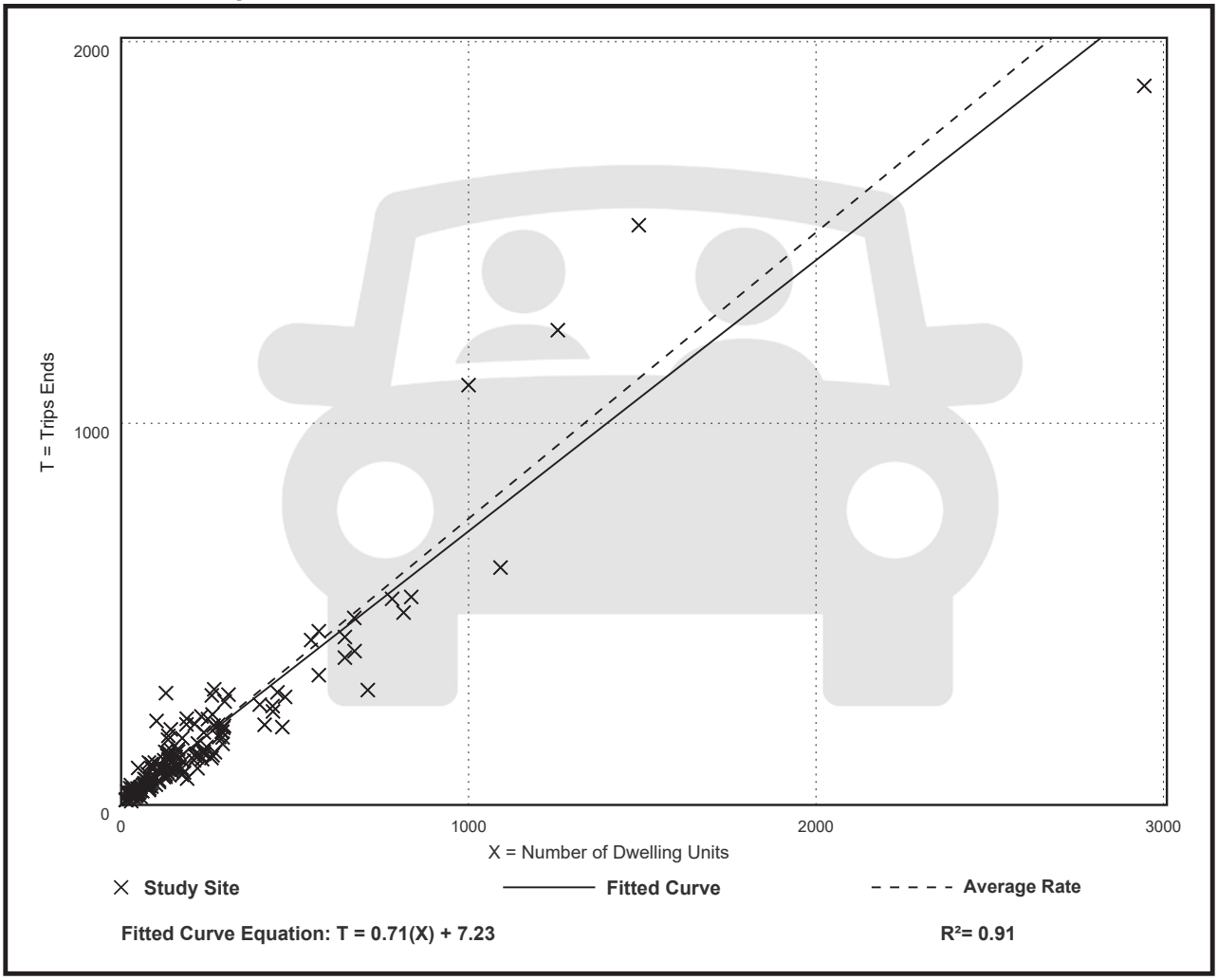
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
AM Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 169
Avg. Num. of Dwelling Units: 217
Directional Distribution: 26% entering, 74% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.75	0.34 - 2.27	0.25

Data Plot and Equation



Fitted Curve Equation: T = 0.71(X) + 7.23

R^2= 0.91

Single-Family Detached Housing
(210)

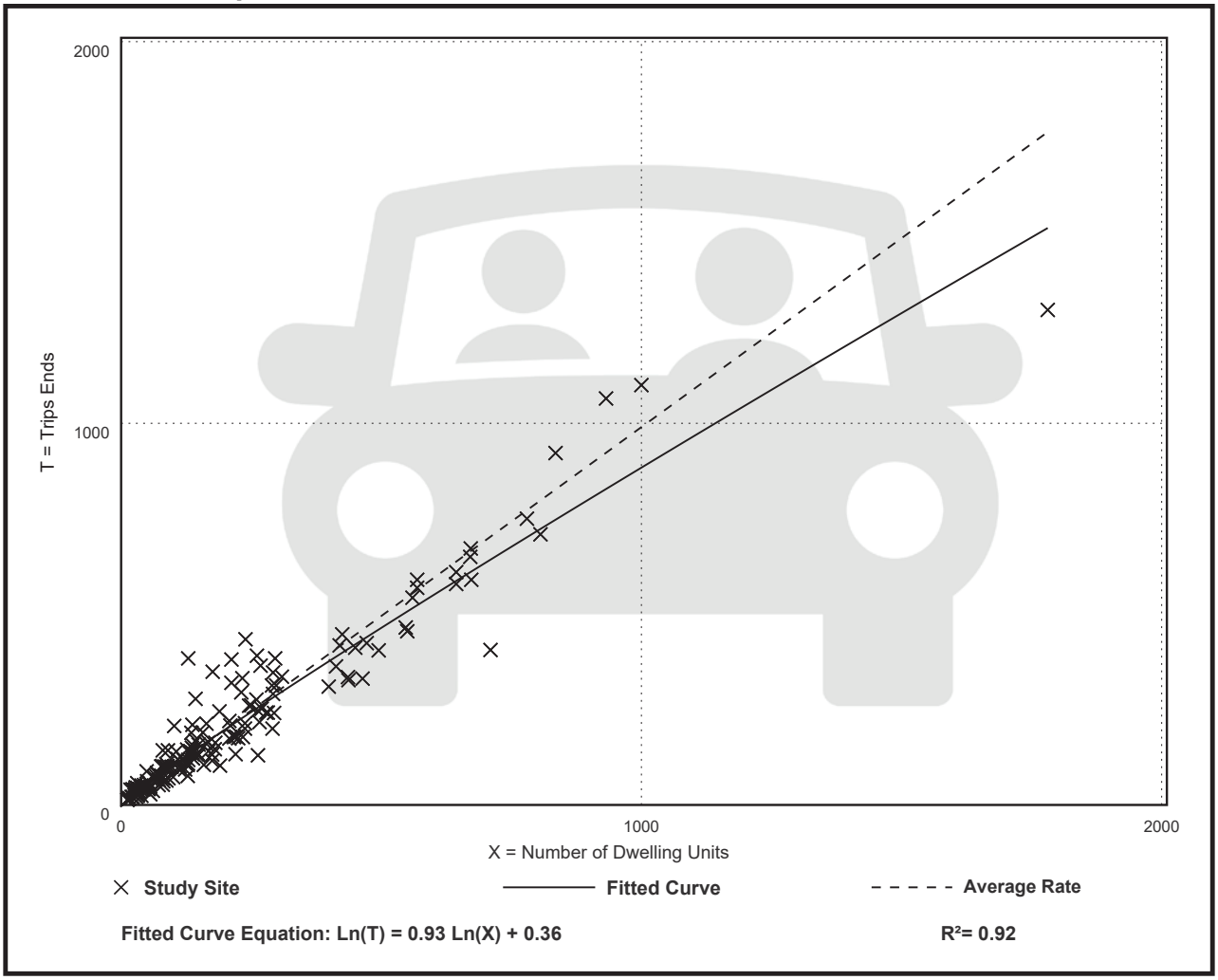
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
PM Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 178
Avg. Num. of Dwelling Units: 203
Directional Distribution: 64% entering, 36% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.99	0.49 - 2.98	0.28

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.93 Ln(X) + 0.36

R^2= 0.92

Single-Family Detached Housing
(210)

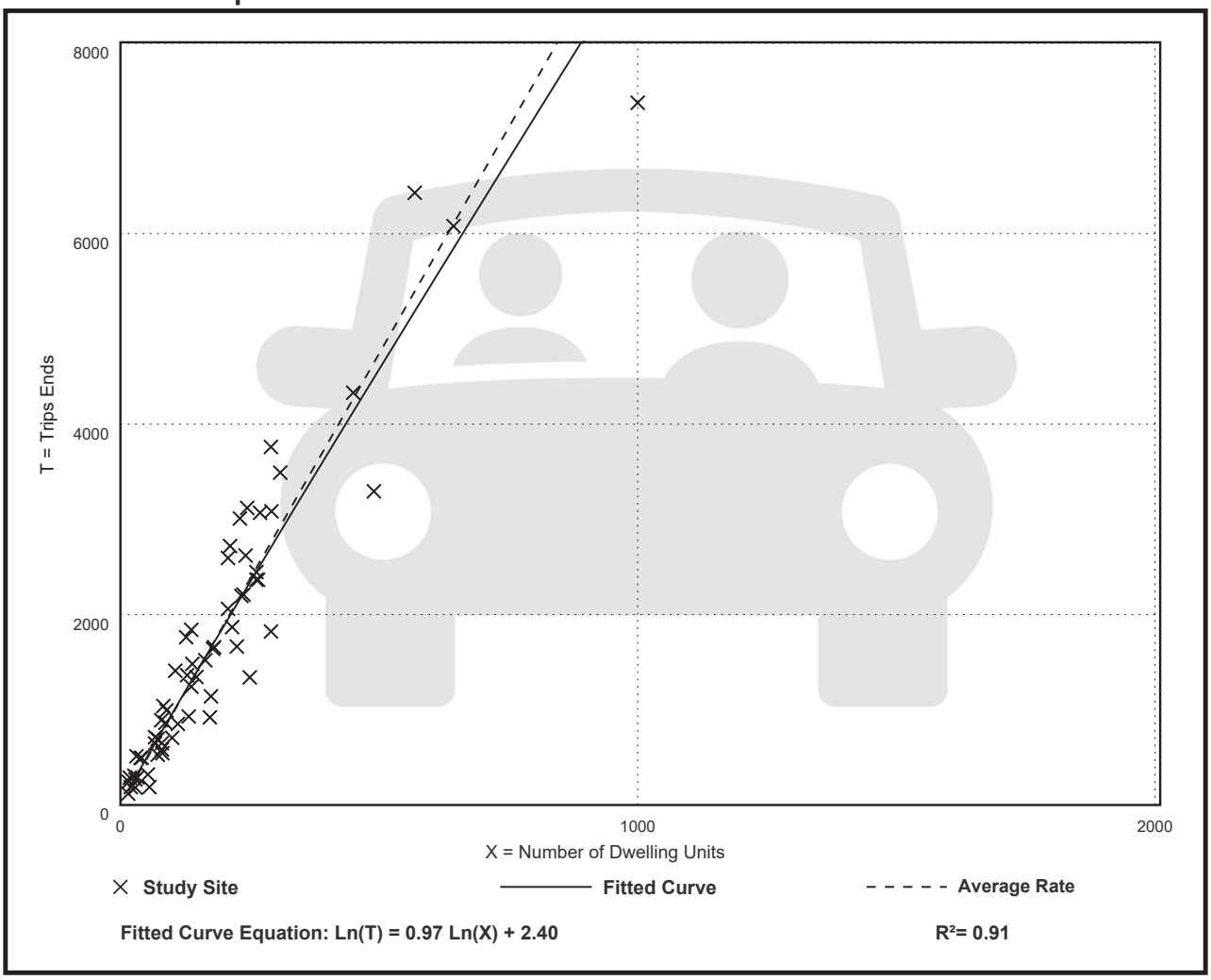
Vehicle Trip Ends vs: Dwelling Units
On a: Saturday

Setting/Location: General Urban/Suburban
Number of Studies: 63
Avg. Num. of Dwelling Units: 179
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
9.48	3.36 - 16.52	2.26

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.97 Ln(X) + 2.40

R^2= 0.91

Single-Family Detached Housing
(210)

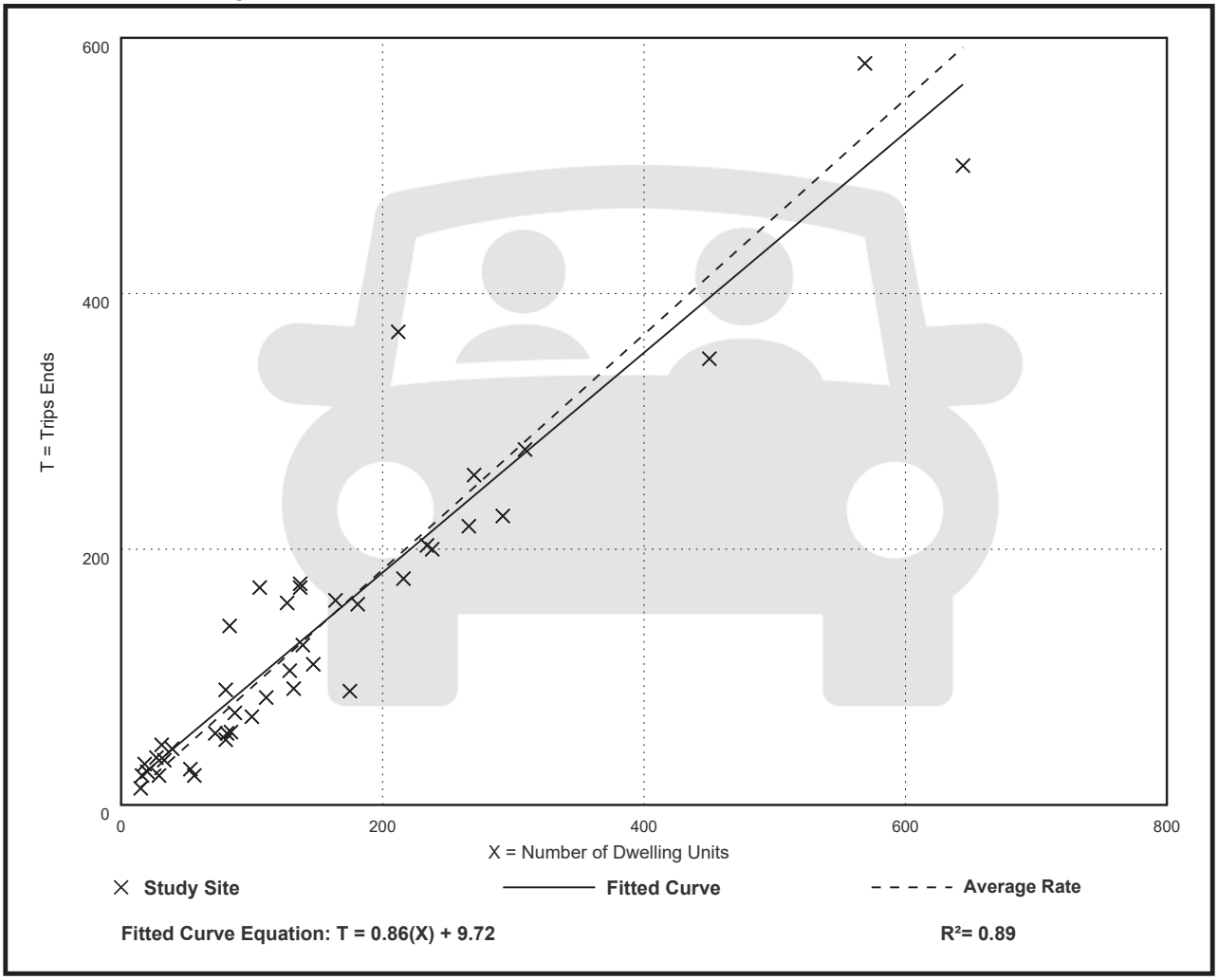
Vehicle Trip Ends vs: Dwelling Units
On a: Saturday, Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 42
Avg. Num. of Dwelling Units: 152
Directional Distribution: 54% entering, 46% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.92	0.41 - 1.78	0.27

Data Plot and Equation



Fitted Curve Equation: T = 0.86(X) + 9.72

R^2= 0.89

Single-Family Detached Housing
(210)

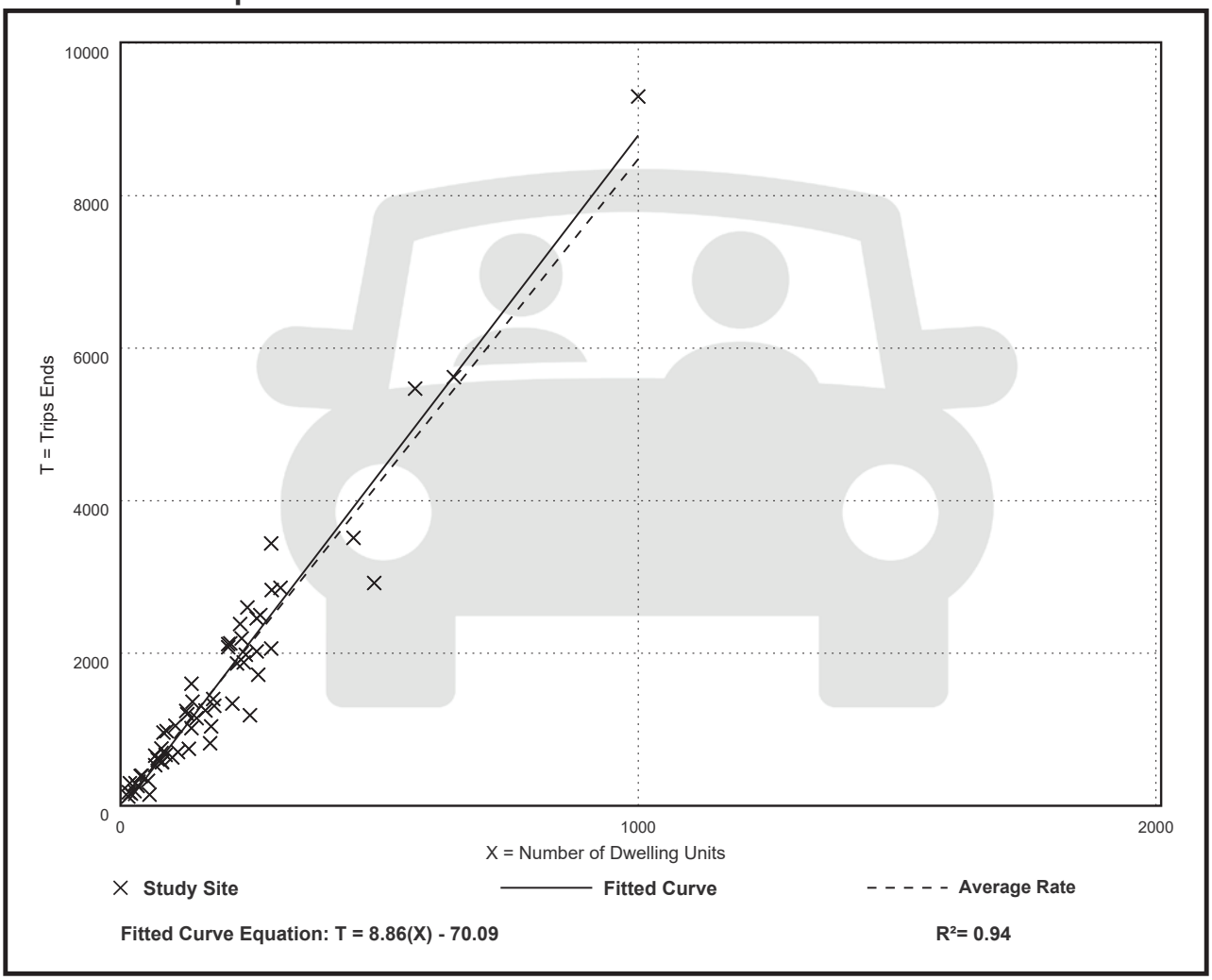
Vehicle Trip Ends vs: Dwelling Units
On a: Sunday

Setting/Location: General Urban/Suburban
Number of Studies: 60
Avg. Num. of Dwelling Units: 186
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
8.48	2.61 - 16.44	1.74

Data Plot and Equation



Fitted Curve Equation: T = 8.86(X) - 70.09

R^2= 0.94

Single-Family Detached Housing
(210)

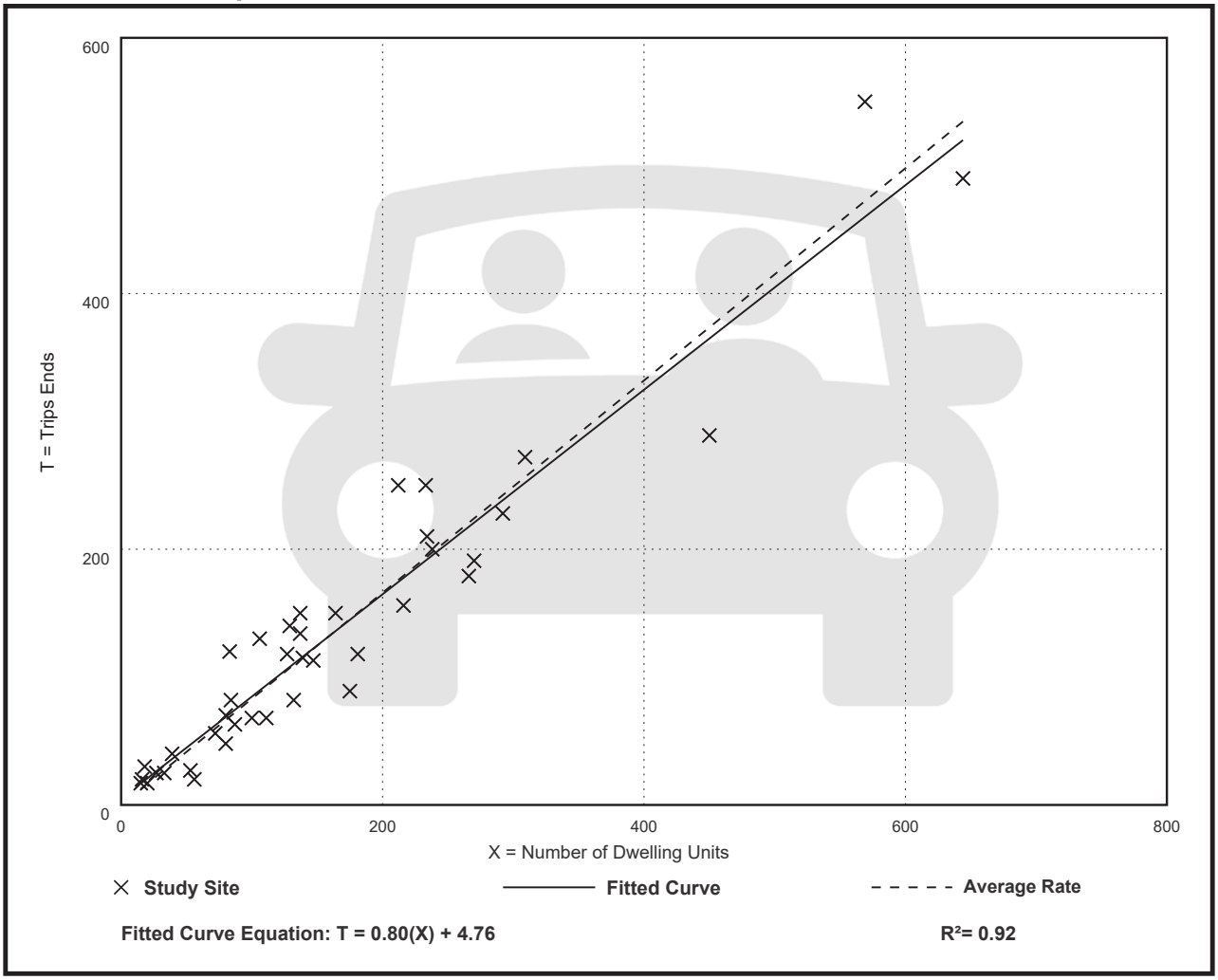
Vehicle Trip Ends vs: Dwelling Units
On a: Sunday, Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 40
Avg. Num. of Dwelling Units: 162
Directional Distribution: 53% entering, 47% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.83	0.36 - 1.67	0.19

Data Plot and Equation



Fitted Curve Equation: T = 0.80(X) + 4.76

R^2= 0.92

Single-Family Detached Housing
(210)

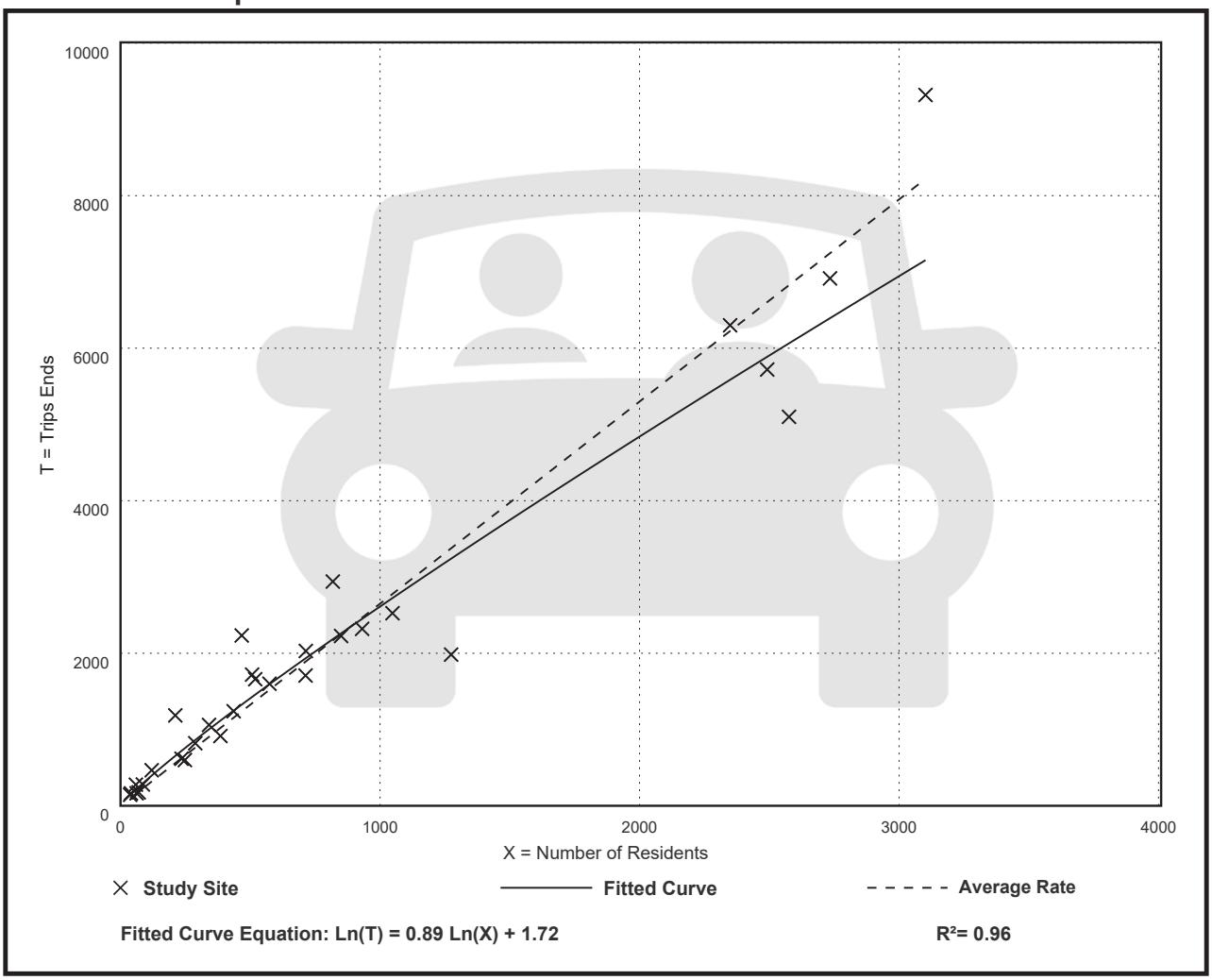
Vehicle Trip Ends vs: Residents
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 30
Avg. Num. of Residents: 810
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
2.65	1.56 - 5.62	0.64

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.89 Ln(X) + 1.72

R^2= 0.96

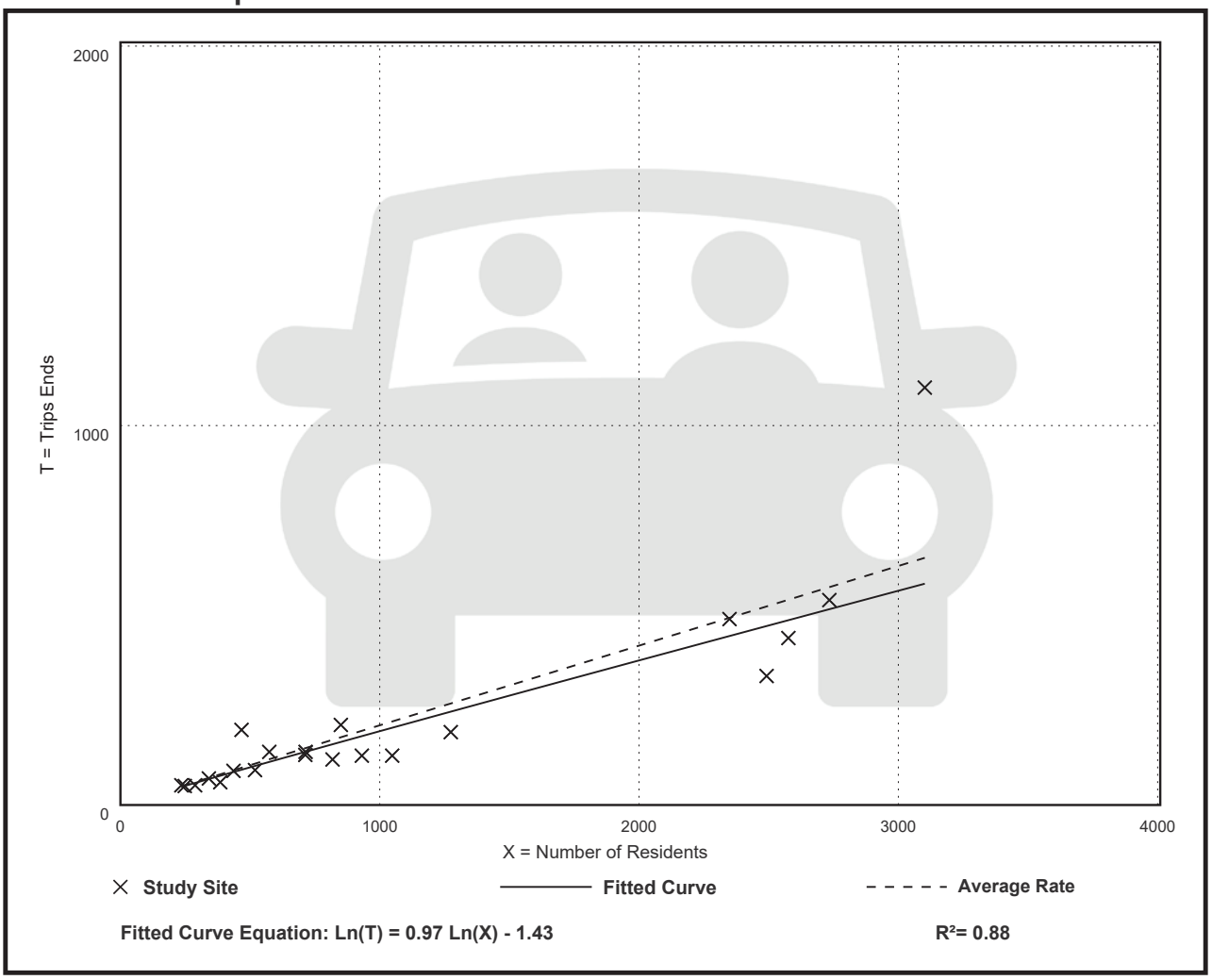
Single-Family Detached Housing
(210)

Vehicle Trip Ends vs: Residents
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: General Urban/Suburban
Number of Studies: 21
Avg. Num. of Residents: 1100
Directional Distribution: 31% entering, 69% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
0.21	0.12 - 0.42	0.08

Data Plot and Equation



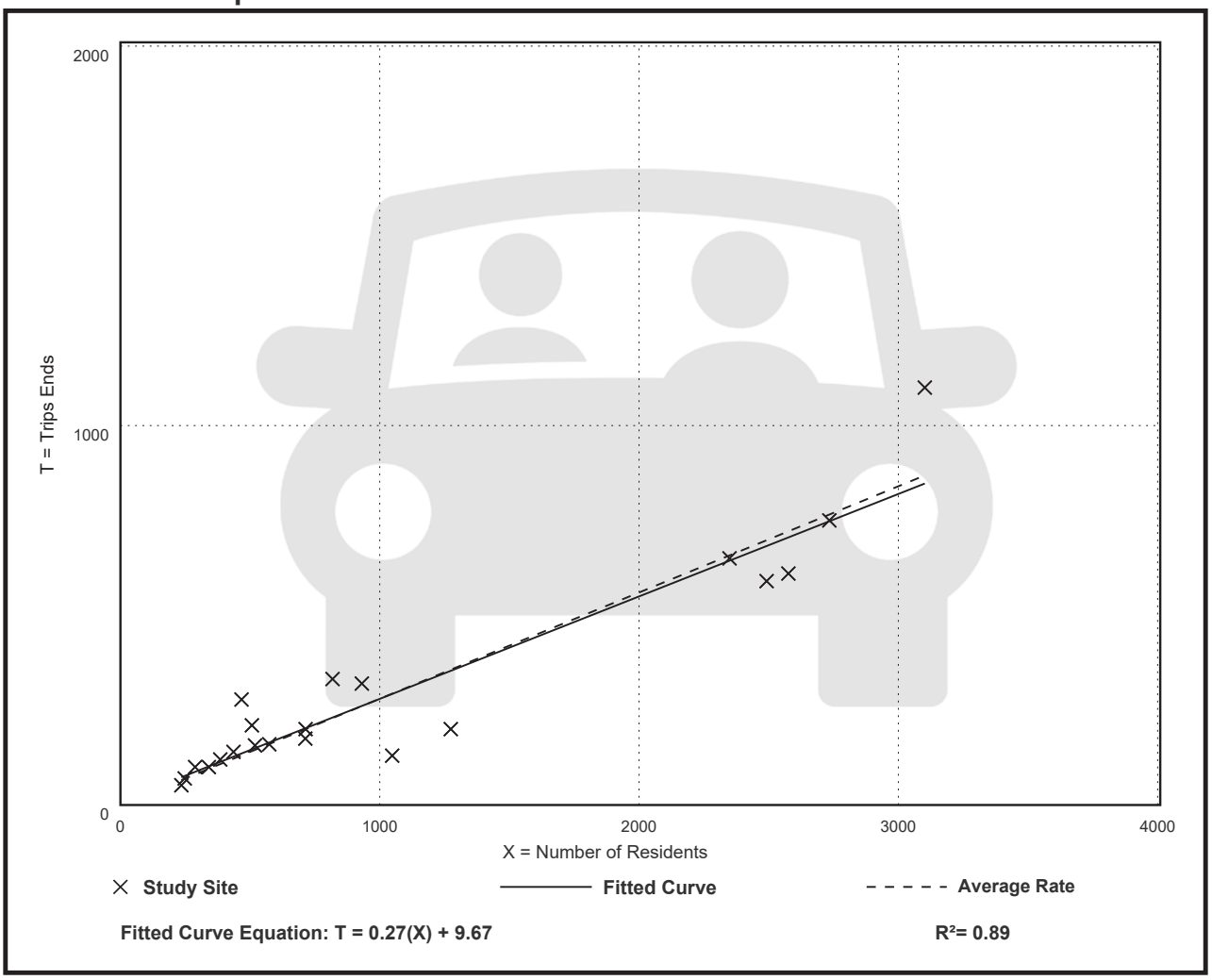
Single-Family Detached Housing
(210)

Vehicle Trip Ends vs: Residents
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: General Urban/Suburban
Number of Studies: 21
Avg. Num. of Residents: 1083
Directional Distribution: 66% entering, 34% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
0.28	0.12 - 0.60	0.08

Data Plot and Equation



Single-Family Detached Housing
(210)

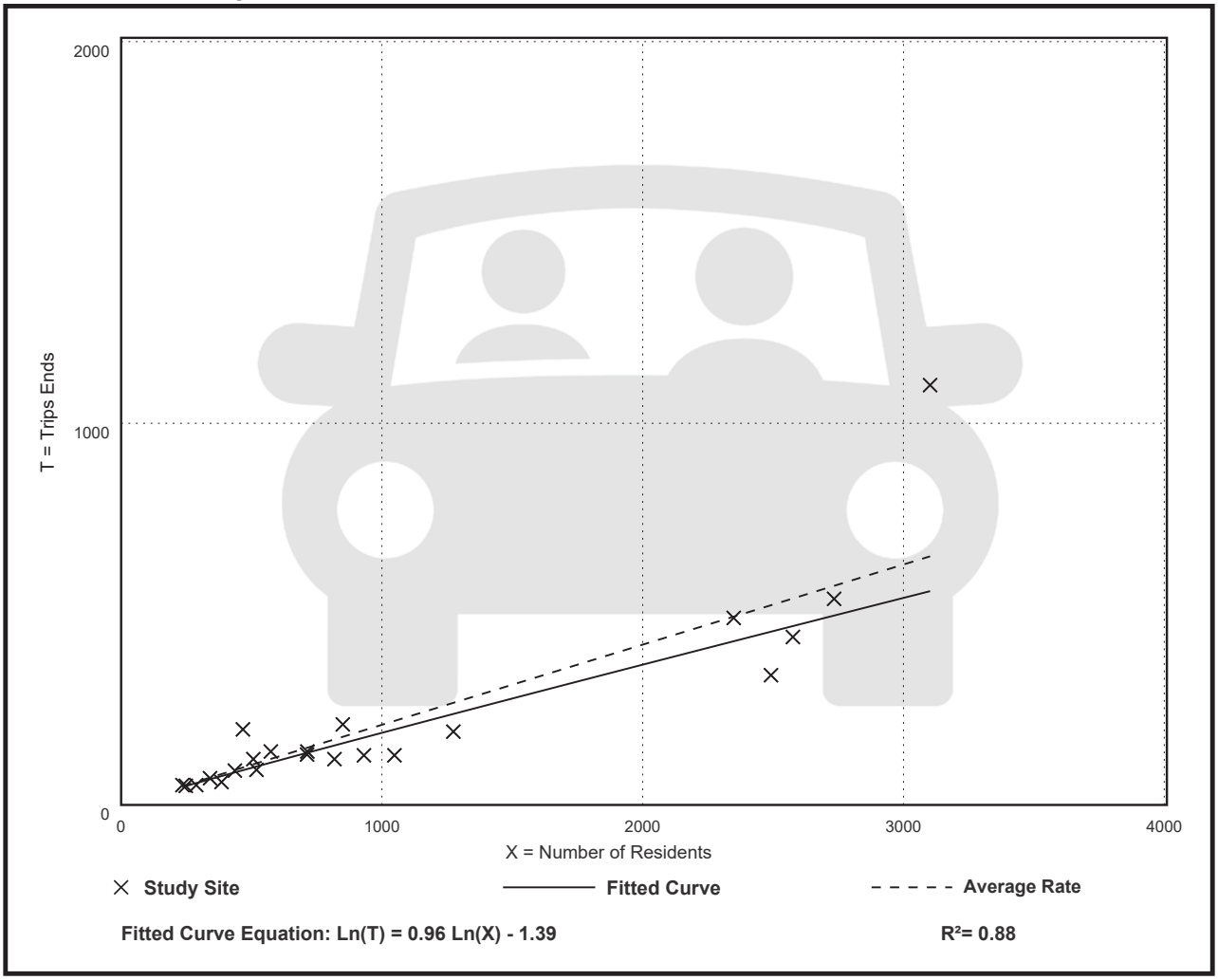
Vehicle Trip Ends vs: Residents
On a: Weekday,
AM Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 22
Avg. Num. of Residents: 1073
Directional Distribution: 30% entering, 70% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
0.21	0.12 - 0.42	0.08

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.96 Ln(X) - 1.39

R^2= 0.88

Single-Family Detached Housing
(210)

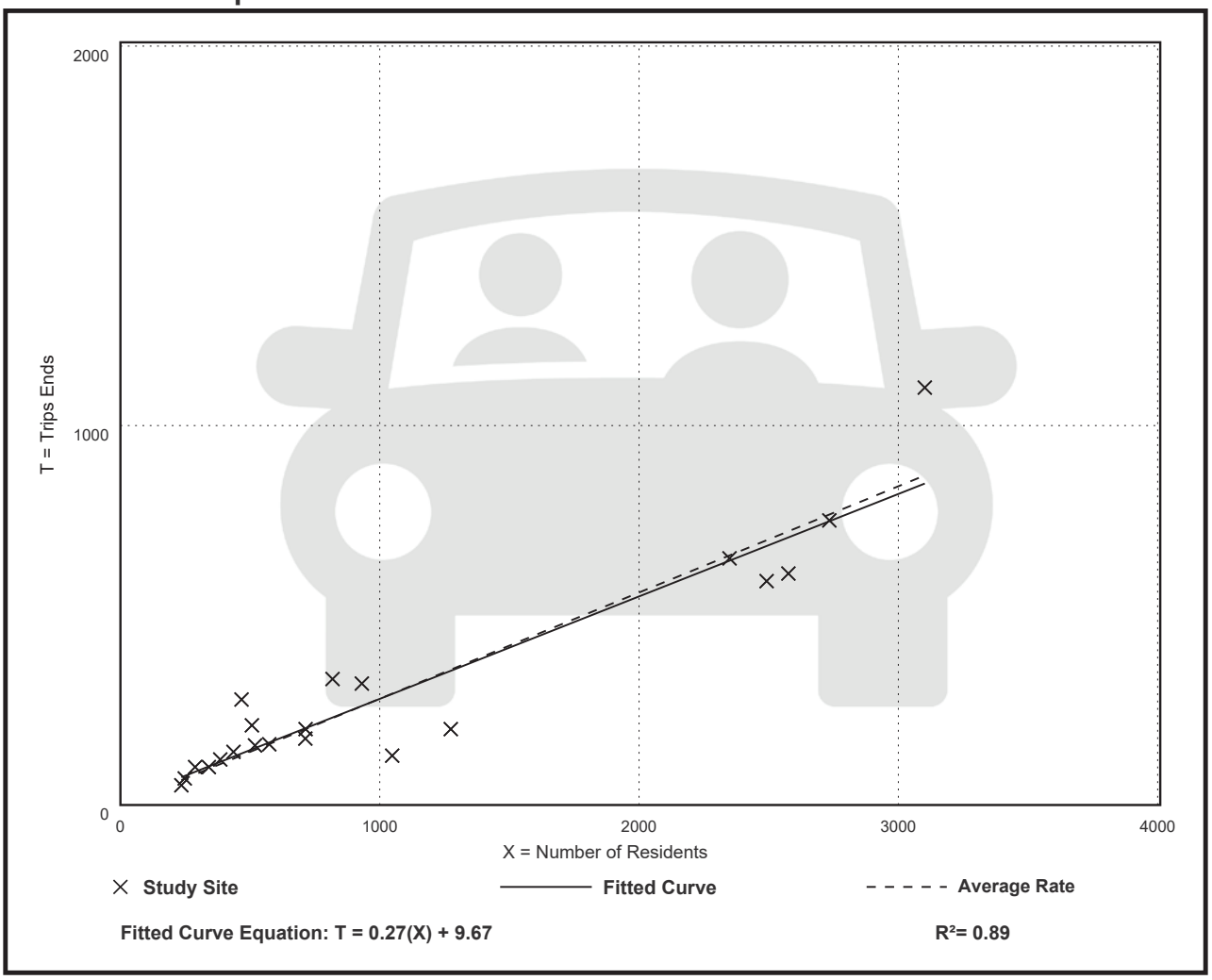
Vehicle Trip Ends vs: Residents
On a: Weekday,
PM Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 21
Avg. Num. of Residents: 1083
Directional Distribution: 66% entering, 34% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
0.28	0.12 - 0.60	0.08

Data Plot and Equation



Fitted Curve Equation: T = 0.27(X) + 9.67

R^2= 0.89

Single-Family Detached Housing
(210)

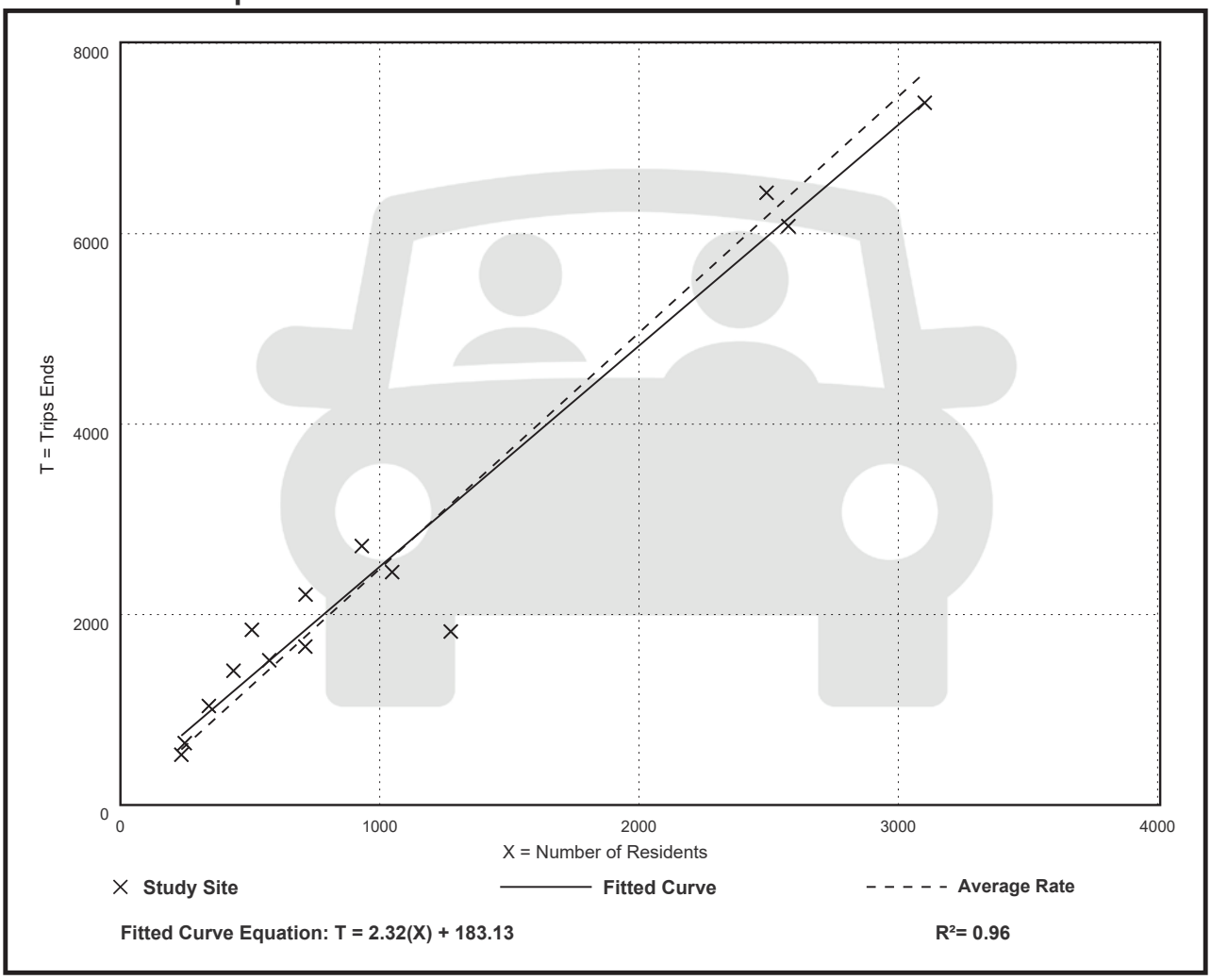
Vehicle Trip Ends vs: Residents
On a: Saturday

Setting/Location: General Urban/Suburban
Number of Studies: 14
Avg. Num. of Residents: 1085
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
2.48	1.43 - 3.63	0.46

Data Plot and Equation



Fitted Curve Equation: T = 2.32(X) + 183.13

R^2= 0.96

Single-Family Detached Housing
(210)

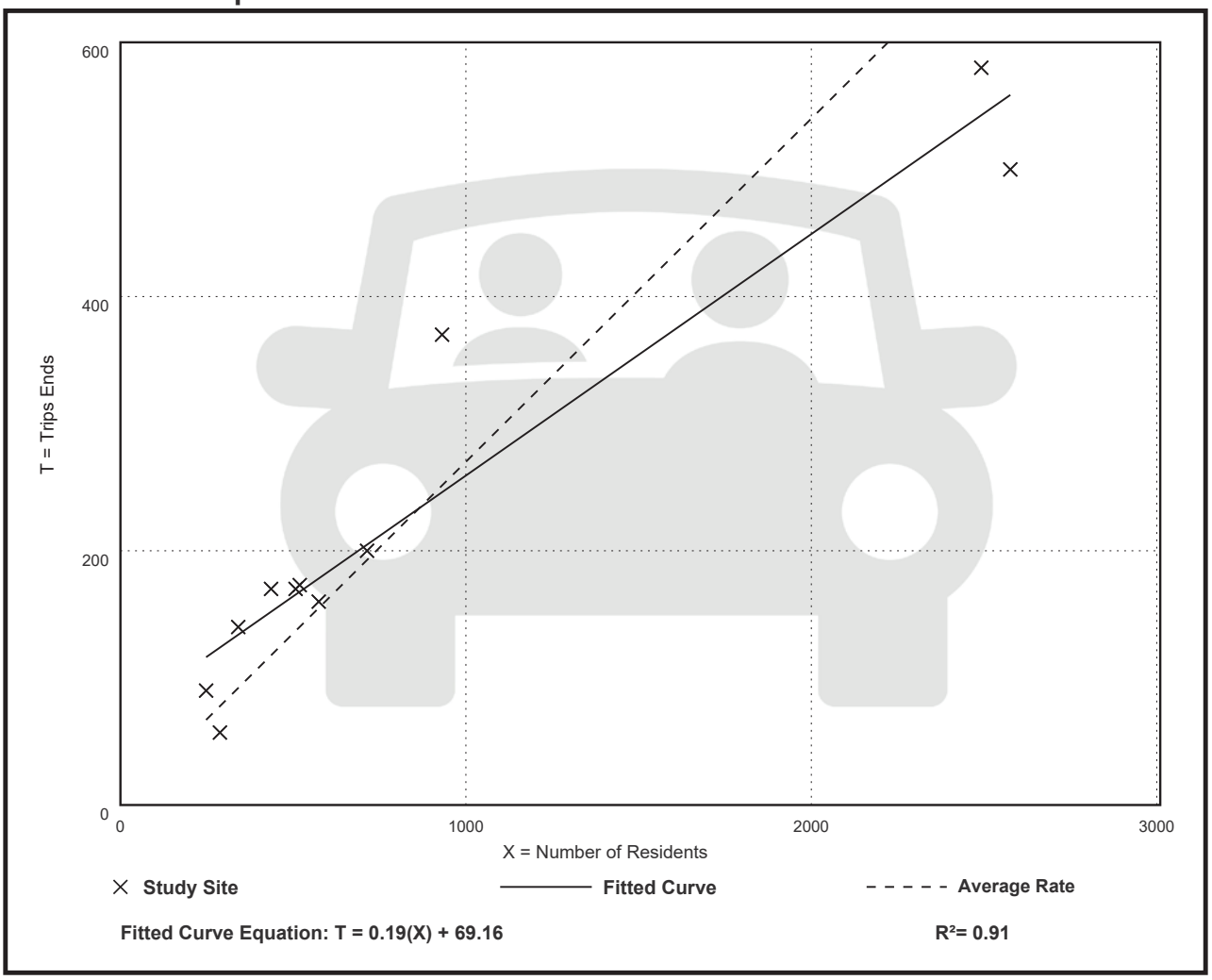
Vehicle Trip Ends vs: Residents
On a: Saturday, Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 11
Avg. Num. of Residents: 875
Directional Distribution: 54% entering, 46% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
0.27	0.19 - 0.41	0.08

Data Plot and Equation



Fitted Curve Equation: T = 0.19(X) + 69.16

R^2= 0.91

Single-Family Detached Housing
(210)

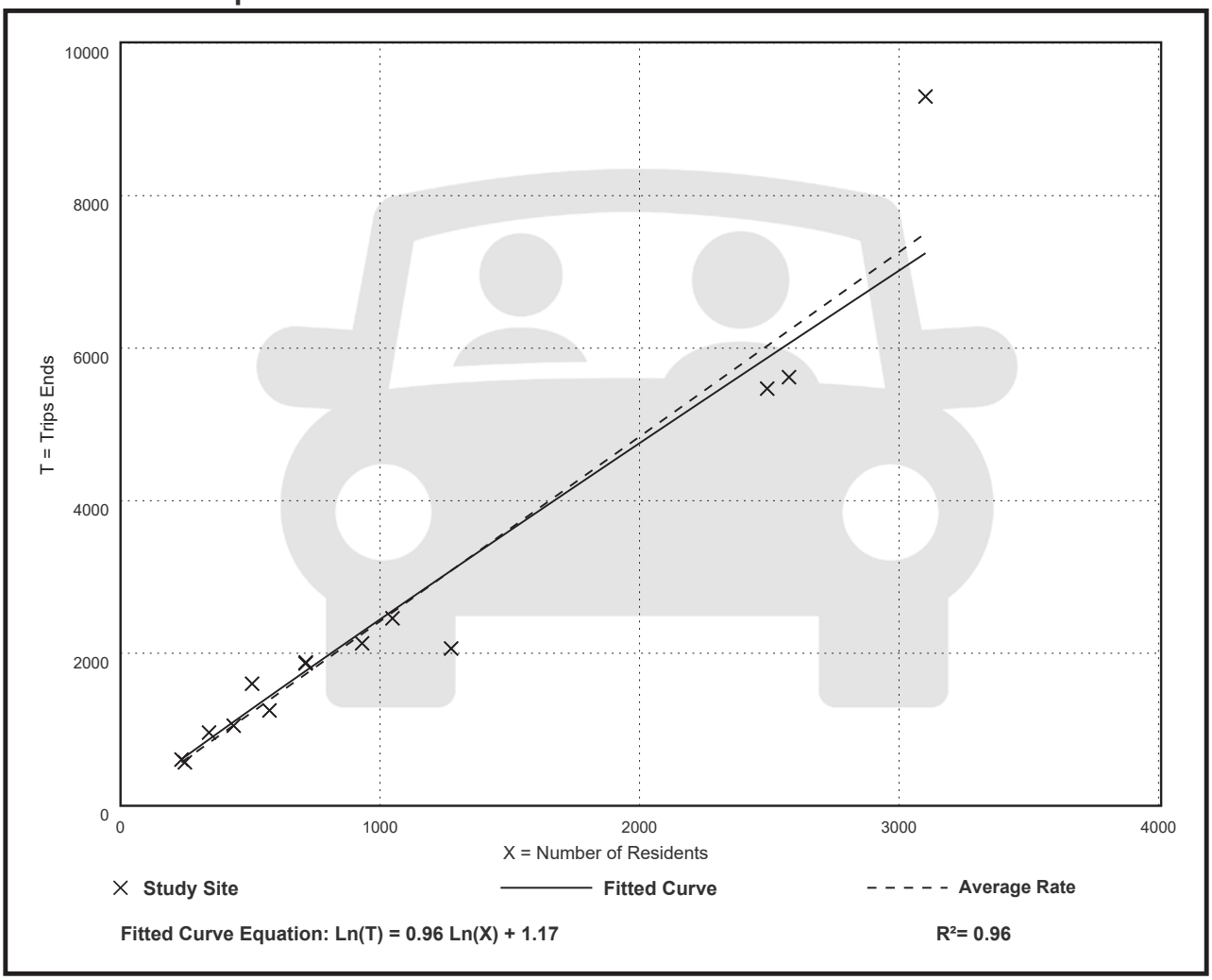
Vehicle Trip Ends vs: Residents
On a: Sunday

Setting/Location: General Urban/Suburban
Number of Studies: 14
Avg. Num. of Residents: 1085
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
2.42	1.62 - 3.16	0.43

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.96 Ln(X) + 1.17

R^2= 0.96

Single-Family Detached Housing
(210)

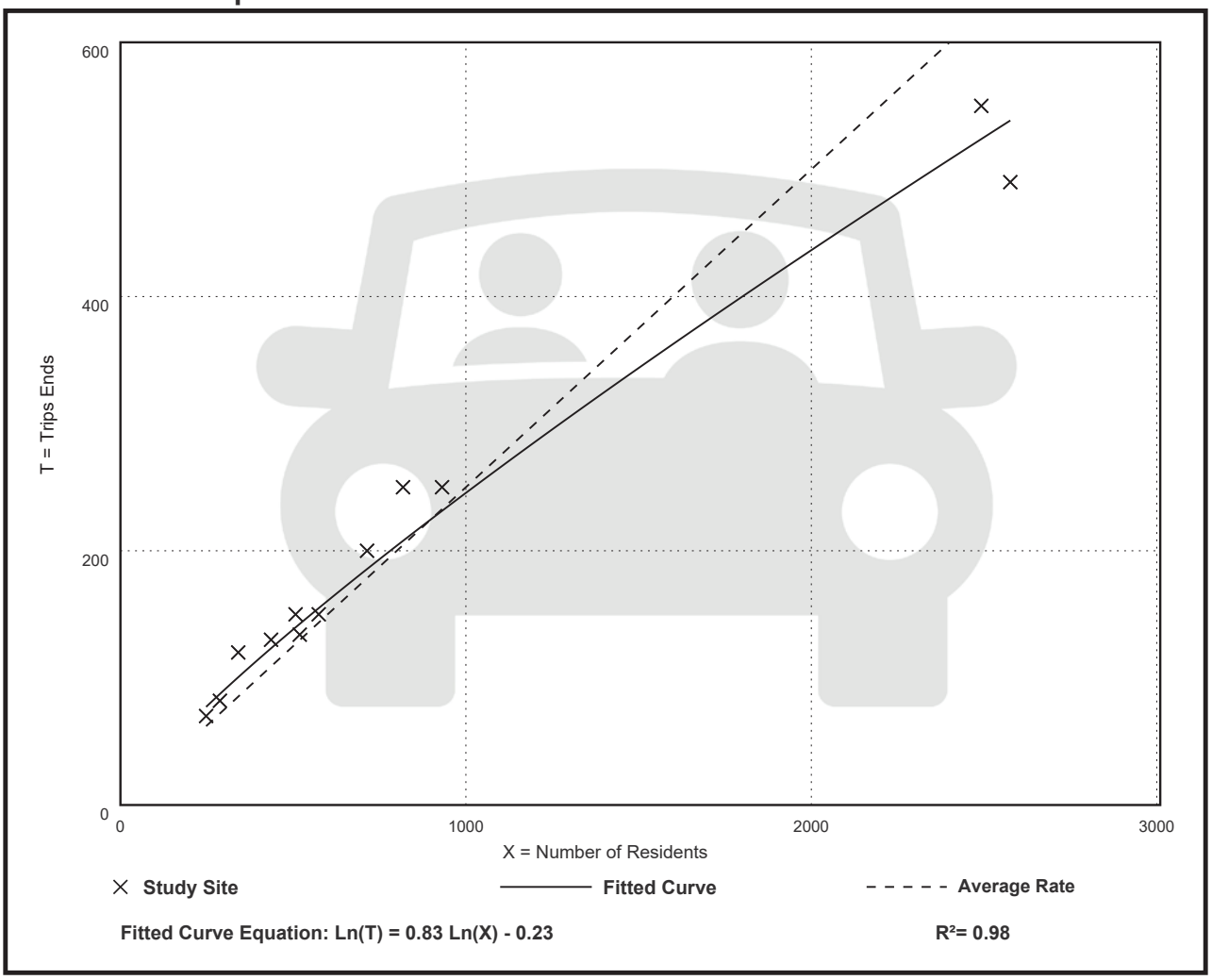
Vehicle Trip Ends vs: Residents
On a: Sunday, Peak Hour of Generator

Setting/Location: General Urban/Suburban
Number of Studies: 12
Avg. Num. of Residents: 870
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Resident

Average Rate	Range of Rates	Standard Deviation
0.25	0.19 - 0.35	0.05

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.83 Ln(X) - 0.23

R^2= 0.98

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