Memorandum

Date:	October 12, 2022
To:	Joanna Julian, Thompson-Dorfman Partners, LLC
From:	Philip Ault, Director of Noise and Air Quality
Subject:	Construction Noise Impacts Constraints Analysis for the Mallard Pointe Redevelopment Project

This memorandum summarizes the findings of a Construction Noise Impacts Constraints Analysis conducted by FirstCarbon Solutions (FCS) for the proposed Mallard Pointe Redevelopment Project (proposed project) located along Mallard Road, in Belvedere, California. Recommended measures to avoid or minimize potential project-related impacts to sensitive receptors in the project vicinity are included as appropriate.

PROJECT UNDERSTANDING

The proposed project would demolish 22 existing single-family residential units along Mallard Road and redevelop the 2.8-acre Mallard Pointe site in Belvedere, California. The site plan is provided in Attachment A.

CHARACTERISTICS OF NOISE

Noise is defined as unwanted sound. Sound levels are usually measured and expressed in decibels (dB), with 0 dB corresponding roughly to the threshold of hearing. Most of the sounds that we hear in the environment do not consist of a single frequency, but rather a broad band of frequencies, with each frequency differing in sound level. The intensities of each frequency add together to generate a sound. Noise is typically generated by transportation, specific land uses, and ongoing human activity.

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. A change of 3 dB is the lowest change that can be perceptible to the human ear in outdoor environments. While a change of 5 A-weighted decibel (dBA) is considered to be the minimum readily perceptible change to the human ear in outdoor environments.

Since the human ear is not equally sensitive to sound at all frequencies, the dBA was derived to relate noise to the sensitivity of humans, it gives greater weight to the frequencies of sound to which the human ear is most sensitive. The dBA sound level is the basis for a number of various sound level metrics, including the day/night sound level (L_{dn}) and the Community Noise Equivalent Level (CNEL), both of which represent how humans are more sensitive to sound at night. In addition, the equivalent continuous sound level (L_{eq}) is the average sound energy of time-varying noise over a sample period and L_{max} is the maximum instantaneous noise level occurring over a sample period.

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 1 shows typical noise levels of construction equipment as measured at a distance of 50 feet from the operating equipment.

Table 1: 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
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. August.

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 causes 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 to 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 2.

Table 2: 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

Construction Equipment	PPV at 25 Feet (inches/second)	rms Velocity in Decibels (VdB) at 25 Feet
Auger Drill Rig	0.051	82
Backhoe	0.051	82
Crane (Mobile)	0.051	82
Excavator	0.051	82
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
rms = root mean square
Source: Compilation of scientific and academic literature, generated by the Federal Transit Administration (FTA) and FHWA.

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 Federal Transit Administration (FTA) has also established industry accepted standards for vibration impact criteria and impact assessment. The FTA guidelines include thresholds for construction vibration impacts for various structural categories as shown in Table 3.

Table 3: 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

Building Category	PPV (in/sec)	Approximate VdB
Notes: PPV = peak particle velocity 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.		

REGULATORY FRAMEWORK

The City of Belvedere has established noise land use compatibility and noise performance standards in the Noise Element of the Belvedere General Plan 2030[1] and in the Belvedere Municipal Code.[2]

Belvedere General Plan

The City of Belvedere addresses construction-related noise in the Noise Element of the General Plan. The relevant noise policies and actions are listed below:

Policies

N-1-3 Minimize noise due to construction impacts.

N-1.3.1 Approval from the Building Permit and Planning Departments is required to be issued for all construction requirements in the City. The hours for construction shall continue to be limited from 8:00 a.m. to 5:00 p.m. Monday through Friday. The City Manager may, upon discretion, grant written exceptions to this condition whenever such work can be demonstrated to be necessary to protect the public's health and safety.

N-1.3.2 A noise control plan shall be reviewed as part of Design Review for all development applications involving pile driving or jack hammering.

N-1.4 Minimize noise generated from outdoor uses and events such as exterior speakers, spa and pool equipment, roof-mounted exhaust fans, emergency generators, multiple air conditioning units, exterior inclined elevators, as well as infrequent loud noises such as pile driving that can be disturbing to nearby homes.

N-1.4.5 Erratic loud noise sources such as pile driving shall conform to the City's mandated construction hours of 8:00 a.m. to 5:00 p.m. on weekdays, and shall not occur on weekends or City holidays.

Belvedere Municipal Code

The City's Municipal Code limits noise-generating construction and demolition activities, including material and equipment deliveries, to the hours between 8:00 a.m. and 5:00 p.m. on weekdays. Noise-generating construction and demolition activities are prohibited on weekends and City-recognized

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1 City of Belvedere. 2010. Belvedere General Plan 2030. June 9.

2 City of Belvedere. 2021. Belvedere Municipal Code (8.10 Noise). Website: https://www.cityofbelvedere.org/92/Belvedere-Municipal-Code. Accessed October 20, 2021.

holidays. The City Manager may, upon his discretion, grant written exceptions to this condition whenever such work can be demonstrated to be necessary to protect the public's health and safety.

CONSTRUCTION NOISE IMPACT ANALYSIS

Short-term Construction Impacts

Less than significant impact with mitigation incorporated. For purposes of this analysis, a significant impact would occur if construction activities would result in a substantial temporary increase in ambient noise levels outside of the City's permissible hours for noise producing construction activity. The City limits noise-generating construction and demolition activities to the hours between 8:00 a.m. and 5:00 p.m. on weekdays. Noise-generating construction and demolition activities are prohibited on weekends and City-recognized holidays.

Construction-related Traffic Noise

Noise impacts from construction activities associated with the proposed 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 impacts 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, 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 nose discussion above, is the lowest change that can be perceptible to the human ear in outdoor environments. According to the air quality modeling analysis prepared for the project,[3] the proposed project would generate a maximum of 71 daily trips (55 worker trips, and 16 vendor trips) during any phase of construction. According to the traffic analysis prepared for the proposed project,[4] there are 128 weekday daily trips generated by existing on-site uses. Therefore, project-related construction trips would not double the hourly traffic volumes along any roadway segment in the project vicinity. For these reasons, short-term intermittent noise from trucks would be minor when averaged over a longer time-period. Therefore, short-term construction-related noise impacts associated with worker commute and equipment transport to the project site would not exceed applicable significance thresholds and 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 noise levels are rarely steady in nature and, often, fluctuate depending on the

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3 FirstCarbon Solutions (FCS). 2022. Air Quality and Greenhouse Gas Emissions Analysis for the Mallard Point Improvement Project. October 14.
4 Parisi Transportation Consulting. 2021. Final Mallard Pointe Transportation Study; Belvedere, CA. December 13.

type and number of equipment being used at any given time. In addition, there could be times where large equipment is not operating and noise would be at or near normal ambient levels. Construction is completed in discrete steps, each of which has its own mix of equipment and 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.

The site preparation phase, which includes excavation and grading activities, 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.

Based on the construction equipment list detailed in the air quality analysis prepared for the proposed project, construction of the proposed project is expected to require the use of graders, scrapers, tractors, front-end loaders, and backhoes. Impact pile driving would not be used as a construction method for the proposed project. As shown in Table 1, the maximum noise level generated by a grader and scraper is 85 dBA L_{max} at 50 feet from this equipment. A front-end loader and backhoe generate maximum noise levels of 80 dBA L_{max} at 50 feet. And a tractor generates maximum noise levels of 84 dBA L_{max} at 50-feet.

A conservative but reasonable assumption is that this equipment would operate simultaneously and continuously over at least a 1-hour period in proximity of the closest existing residential receptors. This would be a reasonable worst-case assumption because work would move linearly over the project site as they perform their earthmoving operations, spending a relatively short amount of time adjacent to any one receptor.

The closest sensitive receptors to the proposed area of construction include single residences immediately south and west of the project's proposed construction footprint. The façade of this closest sensitive receptor would be located approximately 35 feet from the acoustic center of construction activity where multiple pieces of heavy construction equipment would potentially operate at the project site. At this distance, reasonable worst-case construction noise levels could range up to approximately 88 dBA L_{max}, intermittently, and could have an hourly average of up to 86 dBA L_{eq}, at the façade of the nearest sensitive receptor when multiple pieces of equipment operate simultaneously at the nearest center of construction activity. These reasonable worst-case conditions noise level calculations are included in Attachment B.

These noise levels would occur for only a short period during the site preparation phase of construction, as noise levels would drop off at a rate of 6 dB per doubling of distance as construction equipment moves across the site. For example, at a distance of 70-feet from the acoustic center of operating equipment, the reasonable worst-case combined noise level would be 82 dBA L_{max}, with a worst-case hourly average of 81 dBA L_{eq}. At a distance of 140-feet from the acoustic center of operating equipment, the reasonable worst-case combined noise level would be 76 dBA L_{max}, with a worst-case hourly average of 72 dBA L_{eq} (assuming multiple pieces of equipment operated simultaneously for a full hour in the same relative location). This is more than a 10 dBA reduction in noise levels compared to the worst-case noise levels when construction equipment could operate adjacent to the project boundaries. A 10-dBA reduction is perceived as the noise source being half as loud.

These noise levels would result in a temporary increase in ambient noise levels in the project vicinity that could result in annoyance or sleep disturbance of nearby sensitive receptors. However, the proposed project is required to comply with the City's Municipal Code standards restricting the permissible hours of construction. Compliance with the City's permissible hours of construction that limit such activities to daytime hours would ensure that construction activities would not result in substantial temporary increases in noise levels that would result in annoyance or sleep disturbance of nearby sensitive receptors, and potential construction noise impacts would be less than significant.

CONSTRUCTION VIBRATION IMPACT ANALYSIS

A significant impact would occur if the proposed project would generate groundborne vibration or groundborne noise levels in excess of established standards. For determining construction-related vibration impacts, the FTA Construction Vibration Impact Criteria are utilized. The FTA has established industry accepted standards for vibration impact assessment in its Transit Noise and Vibration Impact Assessment Manual, dated September 2018.

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. 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.

Although groundborne vibration can be felt outdoors, it is typically only an annoyance to people indoors where the associated effects such as the shaking of a building can be notable. When assessing annoyance from groundborne vibration, vibration is typically expressed as root mean square (rms) velocity in units of dBs of 1 microinch per second. To distinguish these vibration levels referenced in dBs from noise levels referenced in dBs, the unit is written as "VdB." In extreme cases, excessive groundborne vibration has the potential to cause structural damage to buildings. Common sources of groundborne vibration include construction activities such as blasting, pile driving and operating heavy earthmoving equipment. However, construction vibration impacts on building structures are generally assessed in terms of PPV. For the purposes of this analysis, project-related impacts are expressed in terms of PPV.

Short-term Construction Vibration Impacts

A significant impact would occur if project construction activities would generate groundborne vibration levels in excess of levels established by the FTA's Construction Vibration Impact Criteria for the receiving type of structure.

Impact pile driving would not be used as a construction method for the proposed project.. Therefore, of the variety of equipment used during construction, the small vibratory rollers that could be used in the site preparation phase of construction of the project would produce the greatest groundborne vibration levels. Small vibratory rollers produce groundborne vibration levels ranging up to 0.101 inch per second (in/sec) PPV at 25 feet from the operating equipment.

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 FTA Transit Noise and Vibration Impact Assessment Manual, an "n" value of 1.5 is recommended to calculate vibration propagation through typical soil conditions.[5]The nearest off-site structure to the proposed project construction footprint is the residence to the south of the project boundary perimeter. The nearest façade of this structure would be located approximately 20 feet from the nearest construction footprint where the heaviest construction equipment would potentially operate. At this distance, groundborne vibration levels would range up to 0.14 in/sec PPV from operation of the types of equipment that would produce the highest vibration levels. This is below the FTA's Construction Vibration Impact Criteria of 0.2 in/sec PPV for this type of structure.

Therefore, project construction activities would not generate groundborne vibration or groundborne noise levels in excess of established standards and impacts to off-site receptors would be less than significant.

SUMMARY

The analysis shows that compliance with the City's permissible hours of construction that limit such activities to daytime hours would ensure that project demolition and construction activities would not result in a temporary increase in ambient noise levels in the project vicinity that could result in annoyance or sleep disturbance of nearby sensitive receptors. In addition, the analysis shows that project demolition and construction activity would result in a less than significant groundborne vibration impacts on adjacent structures.

Sincerely,

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[5] Federal Transit Administration (FTA). 2018. Transit Noise and Vibration Impact Assessment Manual. September.

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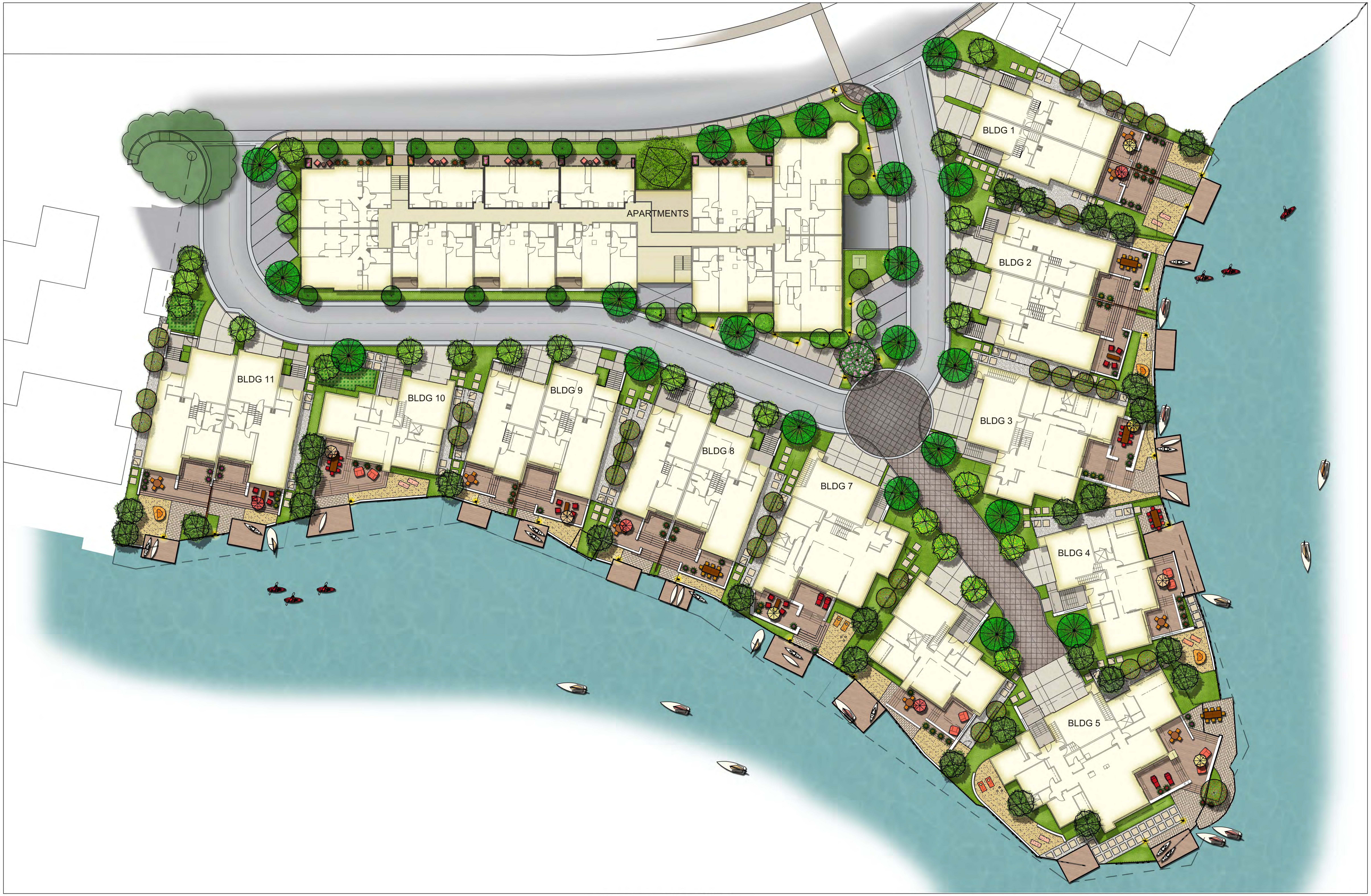
Attachment A: Site Plan
Attachment B: Noise Calculation Data

FIRSTCARBON SOLUTIONS
FCS INTERNATIONAL, INC.

Attachment A:
Site Plan



LANDSCAPE PLAN

October 5, 2021

Graphic Scale

1"=20'-0"

20' 10' 0 20' 40'

MALLARD POINTE

Belvedere, California

MALLARD POINTE 1951 LLC

Project Sponser

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FIRSTCARBON SOLUTIONS
FCS INTERNATIONAL, INC.

Attachment B: Noise Calculation Data

Reasonable Worst-Case Mobile Construction Activity Noise Calculation

Receptor:	Receiving residential property line	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[5]	Effect[2]	(dBA)[3]	Lmax	Leq	Energy
1	Grader	85	1	40	35	1	0	88.1	85.7	368778735.9
2	Scraper	80	1	40	85	1	0	75.4	69.1	8141664.97
3	Tractor	84	1	40	85	1	0	79.4	73.1	20450937.77
4	Front End Loader	80	1	40	85	1	0	75.4	69.1	8141664.97
5	Backhoe	80	1	40	85	1	0	75.4	69.1	8141664.97
6										
7										
8										
9										
10										
Notes:							Lmax[4]	88	Leq	86

[1] FHWA Acoustical Usage Factor - 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.
[5] Distance assumes one piece of equipment at the property line with other pieces of equipment in semi-circle equidistant from that same point.

Mobile Construction Activity Noise Calculation at 70-Feet

Receptor:	Receiving residential property line	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	70	1	0	82.1	76.6	46097341.98
2	Scraper	80	1	40	70	1	0	77.1	71.6	14577259.48
3	Tractor	84	1	40	70	1	0	81.1	75.6	36616420.28
4	Front End Loader	80	1	40	70	1	0	77.1	71.6	14577259.48
5	Backhoe	80	1	40	70	1	0	77.1	71.6	14577259.48
6										
7										
8										
9										
10										
Notes:							Lmax[4]	82	Leq	81

[1] FHWA Acoustical Usage Factor - 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.

Mobile Construction Activity Noise Calculation at 140-Feet

Receptor:	Receiving residential property line	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	140	1	0	76.1	67.6	5762167.748
2	Scraper	80	1	40	140	1	0	71.1	62.6	1822157.434
3	Tractor	84	1	40	140	1	0	75.1	66.6	4577052.536
4	Front End Loader	80	1	40	140	1	0	71.1	62.6	1822157.434
5	Backhoe	80	1	40	140	1	0	71.1	62.6	1822157.434
6										
7										
8										
9										
10										
Notes:							Lmax[4]	76	Leq	72

[1] FHWA Acoustical Usage Factor - 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.