AIRBORNE AND UNDERWATER SOUND STUDY

This report describes the methods and results of modeling undertaken to quantify airborne and underwater sound levels generated from construction and operation of the proposed Louisiana International Terminal Project (Project). The study also includes the results of an ambient sound survey conducted at land-based receptors near the Project site to determine existing sound conditions. While this report presents the results of airborne and underwater modeling, it does not discuss the findings or assess its impact on land-based receptors and marine wildlife. This report does not assess the impact of increased offsite truck traffic sound.

1. BACKGROUND

This section provides background information useful to understand the methodology and results of airborne and underwater sound modeling. This includes a description of airborne and underwater sound metrics, criteria, existing conditions, area of potential impacts, prediction methods, and results.

2. AIRBORNE AND UNDERWATER SOUND METRICS

Sound levels and human sensitivity to sound vary over time; for example, a nuisance sound (noise) generated during the night may be perceived as a greater disturbance than the same sound generated during the day. Evaluation of the sound environment is therefore based on measurements of sound exposure over time to characterize cumulative sound. Two measures used to measure time-varying sound exposure are the 24-hour equivalent sound level (L_{eq}) and day-night sound level (L_{dn}). The L_{eq} is the level of steady sound with the same total (equivalent) energy as the time-varying sound, averaged over a 24-hour period. The L_{dn} is the L_{eq}, weighted to account for people's greater sensitivity to nighttime sound by adding 10 dBA between the hours of 10:00 p.m. and 7:00 a.m.

Table 1 demonstrates relative sound levels, measured in dBA, of common sounds in the environment. The human ear's threshold of perceptible sound level change is considered to be 3 dBA; 5 dBA is clearly noticeable to the human ear, and 10 dBA is perceived as a doubling of sound (Bies, D.A., Hansen C.H. and Howard C.Q 2018).

Table 1
Sound Levels of Common Sound Sources

Common Sound Source	Sound Level (dBA)
Threshold of pain	140
Jet taking off (180 feet away)	130
Operating heavy equipment	120
Night club (with music)	110
Construction site	100
Boiler room	90
Freight train (90 feet away)	80
Classroom chatter	70
Conversation (3 feet away)	60
Urban residence	50

Table 1 Sound Levels of Common Sound Sources	
Common Sound Source	**Sound Level (dBA)**
Soft whisper (4.5 feet away)	40
North Rim of Grand Canyon	30
Silent study room	20
Threshold of human hearing (1,000 Hz)	0
Source: U.S. Department of Labor 2016	

Sound levels in water may be unweighted or referenced to a species-specific hearing threshold at a given frequency (similar to A-weighting for human hearing). For example, generalized frequency weighting for various hearing groups of marine mammals is referred to as M-weighting (Southall et al. 2007). The M-weighting functions de-emphasize frequencies that are near the lower and upper frequency end of the estimated hearing range, where sound levels must be higher to result in the same auditory impact. A recent study by Finneran (2016) suggested revisions to both the M-weighting functions and the functional hearing groups developed by Southall et al. (2007) to account for new research findings. The revisions consisted of expanding the upper hearing range of low-frequency cetaceans and splitting pinnipeds into two families. NOAA Fisheries incorporated recommendations from Finneran (2016) into its Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NOAA Fisheries 2016; NOAA Fisheries 2018).

The sound pressure level (SPL) is a measure of the pressure component of sound. It can be presented in multiple ways. Common metrics include root mean square (RMS) SPL, instantaneous peak sound pressure level (Peak SPL), and sound exposure level (SEL). The RMS SPL is a measure of the average or effective pressure over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalization, or the passage of a vessel. It is also expressed in “dB re 1 μPa”. Events spread out in time have a lower RMS SPL than short duration events with the same total acoustic energy density (NOAA Fisheries 2016; NOAA Fisheries 2018). The Peak SPL is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal. It is expressed in dB re 1 μPa to indicate that it is measured relative to a fixed reference pressure. At high intensities, peak pressure level can be a valid criterion for assessing whether a sound is potentially injurious; however, because the Peak SPL does not account for the duration of an acoustic event, it is a poor indicator of perceived loudness (NOAA Fisheries 2016; NOAA Fisheries 2018). Because non-impulsive sound (for example, vibratory pile driving) does not contain rapid rise times, Peak SPL is typically reserved for impulsive sound (for example, impact pile driving, explosives). The SEL is a measure of the total acoustic energy contained in one or more acoustic events. It represents a measure of the total sound energy to which an organism at that location would be exposed and is expressed in dB re 1 $\mu Pa^2 \cdot s$. The SEL differs from the SPL in that it considers the duration of the signal. The SEL is a cumulative metric if it is calculated over a fixed time period that encompasses multiple acoustic events (NOAA Fisheries 2016; NOAA Fisheries 2018).

3. AIRBORNE AND UNDERWATER SOUND CRITERIA

There are no federal regulations that limit overall environmental (airborne) sound levels; however, several federal agencies have published guidelines and policies for sound levels. USEPA guidance indicates that a L_{dn} of 55 dBA (which is equivalent to a continuous sound level of 48.6 dBA) protects the public from indoor and outdoor activity sound interference (USEPA 1974). However, these criteria do not constitute enforceable federal regulations or standards. The USEPA has since delegated regulatory authority to local entities.

The Federal Highway Administration (FHWA) has developed noise abatement criteria as hourly L_{eq} sound levels that provide a benchmark to assess the level at which roadway traffic sound levels become a source of annoyance at different land use types. These criteria are published in 23 CFR 772 and presented in Table 2. The FHWA requires that states establish noise abatement criteria at least 1 dBA below the FHWA criteria. Consistent with this requirement, the State of Louisiana Department of Transportation and Development's (DOTD) noise policy dictates that traffic sound impacts occur when sound levels are equal to or greater than 1 dBA below the FHWA Noise Abatement Criteria, or when sound levels exceed the existing sound levels at any sensitive receptor by 10 dBA (DOTD 2021). Table 2 includes the activity categories and their respective hourly equivalent steady-state sound level (hourly L_{eq} dBA) value, per FHWA and DOTD guidelines. Notably, however, FHWA and DOTD hourly noise abatement criteria do not apply to construction activities.

Table 2
FHWA and DOTD Noise Abatement Criteria Hourly A-weighted Sound Level Decibels

Activity Category	FHWA Hourly L_{eq} (dBA)	Evaluation Location	Activity Description	DOTD Sound Level Hourly L_{eq} (dBA)
A	57	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.	56
B	67	Exterior	Residential (includes undeveloped lands permitted for residential).	66
C	67	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings. (Includes undeveloped lands permitted for these activities).	66
D	52	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional	51

Table 2
FHWA and DOTD Noise Abatement Criteria Hourly A-weighted Sound Level Decibels

Activity Category	FHWA Hourly L_{eq} (dBA)	Evaluation Location	Activity Description	DOTD Sound Level Hourly L_{eq} (dBA)
			structures, radio studios, recording studios, schools, and television studios.	
E	72	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A through D or F. (Includes undeveloped lands permitted for these activities).	71
F	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.	N/A
G	--	--	Undeveloped lands that are not permitted.	N/A

Source: 23 CFR 772; DOTD 2021

Underwater sound is often assessed against criteria derived from NOAA Fisheries and U.S. policy and published scientific literature. Table 3 presents a summary of NOAA Fisheries (2016; 2018) injury (permanent threshold shift [PTS] onset) and behavioral response criteria for marine mammals for impulsive (for example, pile driving) and non-impulsive (for example, vessel movement) sounds. Table 4 presents a summary of the Popper et al. (2014) injury criteria for fish and turtles for impulsive sounds. No data are available for non-impulsive or continuous sounds. In addition, there is limited data regarding fish and turtle behavioral responses to sound levels below those expected to cause injury. For this study, the behavioral response criteria for impulsive sounds for fish and turtles were assumed to be 150 dB RMS SPL (Washington State Department of Transportation [WSDOT]) 2020) and 166 dB RMS SPL, respectively (McCauley et al. 2000).

Table 3
NOAA Fisheries Injury and Behavioral Response Criteria for Marine Mammals

Hearing Group	PTS onset, Peak SPL (dB re 1µPa) [a]	PTS onset, SELcum,24hr (dB re 1 µPa2s) [a]		Behavioral Response, RMS SPL (dB re 1µPa) [b]	
	Impulsive	Impulsive	Non-impulsive	Impulsive	Impulsive
Low-frequency cetaceans	219	183	199	160	120
Mid-frequency cetaceans	230	185	198	160	120
High-frequency cetaceans	203	155	173	160	120
Phocid pinnipeds (in water)	218	185	201	160	120

Table 3 NOAA Fisheries Injury and Behavioral Response Criteria for Marine Mammals					
Hearing Group	**PTS onset, Peak SPL (dB re 1µPa) [a]**	**PTS onset, SELcum,24hr (dB re 1 µPa2s) [a]**		**Behavioral Response, RMS SPL (dB re 1µPa) [b]**	
	Impulsive	**Impulsive**	**Non-impulsive**	**Impulsive**	**Impulsive**
Otariid pinnipeds (in water)	232	203	219	160	120

[a] Source: NOAA Fisheries 2016, 2018; Finneran 2016

[b] Federal Register: Volume 70, Number 7 (January 11, 2005)

PTS = permanent threshold shift; SPL = sound pressure level; dB re 1 µPa = decibels relative to 1 microPascal; SEL24h (or SELcum) = cumulative sound exposure level; dB re 1 µPa2s = decibels relative to 1 microPascal squared normalized to 1 second, RMS = root mean squared

Table 4 Injury and Behavioral Response Criteria for Fish and Turtles						
Hearing Group	**PTS onset, Peak SPL (dB re 1µPa) [a]**		**PTS onset, SEL_{cum}, 24hr (dB re 1 µPa2s) [a]**		**Behavioral Response, RMS SPL (dB re 1µPa) [b]**	
	Impulsive	**Non-Impulsive**	**Impulsive**	**Non-impulsive**	**Impulsive**	**Non-Impulsive**
Fish: no swim bladder (particle motion detection)	213	No data	219	No data	150[b]	No data
Fish: swim bladder is not involved in hearing (particle motion detection)	207	No data	210	No data	150[b]	No data
Fish: swim bladder involved in hearing (primarily pressure detection)	207	No data	207	No data	150[b]	No data

Table 4 Injury and Behavioral Response Criteria for Fish and Turtles						
Hearing Group	**PTS onset, Peak SPL (dB re 1µPa) [a]**		**PTS onset, SEL_{cum}, 24hr (dB re 1 µPa2s) [a]**		**Behavioral Response, RMS SPL (dB re 1µPa) [b]**	
	Impulsive	**Non-Impulsive**	**Impulsive**	**Non-impulsive**	**Impulsive**	**Non-Impulsive**
Turtles	207	No data	210	No data	166[c]	No data

[a] Source: Popper et al. 2014
[b] Source: WSDOT 2020
[c] Source: McCauley et al. 2000
PTS = permanent threshold shift; SPL = sound pressure level; dB re 1 µPa = decibels relative to 1 microPascal; SEL24h (or SELcum) = cumulative sound exposure level; dB re 1 µPa2s = decibels relative to 1 microPascal squared normalized to 1 second, RMS = root mean squared

4. EXISTING CONDITIONS

The ambient sound level comprises the total sound generated within a specific environment, including natural and anthropogenic sounds. The magnitude and frequency of ambient sound at any specific location is variable in time, and that variation may be due to changing weather conditions, seasonal changes in vegetative cover, and, in developed areas, daily traffic patterns. Existing sources of sound in the vicinity of the Project site include local roadway traffic (LA 47, LA 46, and LA 39), vessels (including boats and ships on the Mississippi River) in open water areas, and natural sounds such as wildlife vocalizations.

General land uses in the Project site and vicinity consist of open water, wetlands, agricultural, open land, forest land, and developed land. The Project would be constructed mainly on large private undeveloped land near existing road and rail traffic and surrounded by the land uses described above.

Noise-sensitive areas (NSAs) or "receptors" are those locations which, because of their use by people, may be more susceptible to sound impacts. NSAs include residences, churches, schools, cemeteries, and recreational areas. Table 5 identifies 12 NSAs nearest to the Project footprint based on a review of aerial imagery. See Figure 1 for a map of the NSA locations (R1 to R12).

Table 5 Nearest NSAs to the Project Facilities		
Proposed Project Feature	**Parish**	**Approximate Distance and Direction from nearest NSA Receptors (R)[a,b]**
Wharf and Riverside Elements	St. Bernard	• R1 - Residences on LA 46 – 690 feet southeast • R2 - Residences on C St. – 1,050 feet northeast • R3 - Merrick Cemetery and Violet Park/Playground– 850 feet east-northeast • R10 - A Studio in the Woods – 3,200 feet west • R11 – Audubon Wilderness Park – 2,900 feet west

Table 5 Nearest NSAs to the Project Facilities		
Proposed Project Feature	**Parish**	**Approximate Distance and Direction from nearest NSA Receptors (R)[a,b]**
		• R12 – W. Smith Junior Elementary School -1,110 feet east
Container Terminal – Landside Elements	St. Bernard	• R1 - LA 46 - 775 feet south-southwest • R2 - Residences on C St. - 890 feet north • R3 - Merrick Cemetery and Violet Park/Playground– 530 feet north • R4 - Residences on Reunion Drive (eastern portion) – 1,220 feet south • R12 – W. Smith Junior Elementary School – 350 feet north
Rail Yard	St. Bernard	• R5 - Residences on Reunion Drive (western portion) – 1,600 feet south • R6 - Residences on 4th Street – 2,130 feet northwest • R7 - Church on Louis Elam Street - 2,800 feet northwest • R8 - Church on Canal Street – 3,200 feet northwest • R9 - Residences on Packenham Road – 2,400 feet northwest
Truck Waiting Area	St. Bernard	• R5 - Residences on Reunion Drive (western portion) – 3,400 feet south • R6 - Residences on 4th Street – 2,130 feet northwest • R7 - Church on Louis Elam Street – 2,800 feet northwest • R8 - Church on Canal Street – 3,200 feet northwest • R9 - Residences on Packenham Road – 3,650 feet northwest
Terminal Access Road	St. Bernard	• R5 - Residences on Reunion Drive (western portion) – 2700 feet south • R6 - Residences on 4th Street – 1,860 feet west • R7 - Church on Louis Elam Street -1,550 feet northwest • R8 - Church on Canal Street – 1,790 feet northwest • R9 - Residences on Packenham Road – 1,650 feet northwest
Railroad Relocation	St. Bernard	• R1 - Residences on LA 46 – 580 feet south • R2 -Residences on C Street - 480 feet east • R3 - Merrick Cemetery and Violet Park/Playground – 425 feet east • R4 – Residences on Reunion Drive (eastern portion) - 720 feet south • R5 – Residences on Reunion Drive (western portion) – 710 feet south
E. St. Bernard Hwy (LA 46) Relocation	St. Bernard	• R1- Residences on LA 46 – 230 feet west • R2 - Residences on C Street - 360 feet east • R3 - Merrick Cemetery and Violet Park/Playground– 300 feet east

Table 5
Nearest NSAs to the Project Facilities

Proposed Project Feature	Parish	Approximate Distance and Direction from nearest NSA Receptors (R)[a,b]
		• R12 – W. Smith Junior Elementary School – 700 feet east
Terminal Pump Station	St. Bernard	• R6 - Residences on 4th Street – 4,720 feet west • R7 - Church on Louis Elam Street – 4,945 feet west • R8 - Church on Canal Street – 5,210 feet west • R9 – Residences on Packenham Road – 4,900 feet west

[a] Distances are based on the nearest distance to the closest edge of each proposed Project feature.

[b] W. Smith Junior Elementary School and Violet Park/Playground are within the Project site boundary. Merrick Cemetery is outside the site boundary. The Port anticipates the relocation of Violet Park/Playground, relocation of W. Smith Elementary School, and acquisition of the school site by the Port, no later than the beginning of Phase 3 construction

Figure 1. Locations of NSA Receptors and Measurement Positions

On March 12-14, 2024, Arcadis conducted a noise survey during which sound level measurements were taken near 11 of the 12 NSAs (R1 to R11) identified in Figure 1. The green dots in Figure 1 denote both the NSA points and sound measurement locations. At each location, one-hour measurements were taken during the daytime (between 11:30 a.m. and 6:30 p.m.) and 30-minute measurements were taken at nighttime (between 10:00 p.m. and 1:00 a.m.). These sound measurements were taken to establish baseline conditions at nearest NSAs to the proposed Project; it does not cover all NSAs associated with increased offsite road traffic during Project operations.

On October 29 through November 4, 2024, Terracon conducted a noise survey at four positions around W. Smith Junior Elementary School (R12) located within the Project site. Two of the measurement positions were in front of the school near LA 46 and the other two positions were at the back of the school. Most of the measurements were taken between 6:00 a.m. and 6:00 p.m. The measured sound levels at the four positions were analyzed and separated into daytime levels (7:00 a.m.-6:00 p.m.) and nighttime levels (6:00 a.m. – 7:00 a.m.) and averaged to determine the existing noise levels at the school.

A-weighted equivalent sound level measurements (Leq) were taken with a fully calibrated TSI® Quest SoundPro DL Type 1 sound level meter. The instrument was equipped with a microphone and wind shield to avoid/reduce wind-induced sound. The instrument was set to a slow response rate and calibrated using an acoustic calibrator before and after the measurement period. All sound level measurements were made with instruments that conforms to the American National Standards Institute (ANSI) specifications for sound level meters (ANSI S1.4 1983 (R2006)). All instruments are maintained with National Bureau of Standards traceable calibrations, per the manufacturers' standards.

Weather conditions were calm and conducive for sound measurements, with clear to mostly cloudy conditions during the day and clear to partly cloudy conditions at night. Ambient temperatures ranged from 69 to 72 degrees Fahrenheit during the day and 60 to 68 degrees Fahrenheit at night. Relative humidity ranged from 57 to 76 percent during the day and 69 to 89 percent at night. Average wind speed during the day ranged from 4 to 10 miles per hour, primarily in a southeast to south-southeast direction. At night, average wind speed ranged from 3 to 8 miles per hour, primarily in a southeast to south-southeast direction. No precipitation occurred during the survey.

The primary sources of sound observed during the survey are vehicle traffic on nearby highways, particularly LA 46 (mostly cars, some trucks, buses, and motorcycles), airplane flyovers, dogs barking, and a child playing outside.

A summary of the existing Leq sound levels measured at the NSAs during daytime and nighttime is presented in Table 6. The results show that existing sound levels at all NSAs except R1, are below the hourly sound limits for FHWA and DOTD (see Table 2 for the Project sound criteria)[1].

[1] Existing sound levels at all NSAs except R1 are also below the daytime and nighttime sound limits for St. Bernard Parish (65 dBA daytime limit and 60 dBA nighttime limit). The existing sound levels at R1 exceed the daytime and nighttime sound limits for St. Bernard Parish due to the proximity of the location to LA 46

Table 6
Measured Existing Sound Levels at Nearest NSAs (March 12-14, 2024)

NSA	Daytime Measurements		Nighttime Measurements	
	Time	Leq (dBA)	Time	Leq (dBA)
R1	4:05 p.m. - 5:05 p.m.	73.8	10:58 p.m. - 11:28 p.m.	63.0
R2	2:51 p.m. - 3:51 p.m.	63.3	11:41 p.m. - 12:11 a.m.	57.9
R3	2:51 p.m. - 3:51 p.m.	61.7	11:41 p.m. - 12:11 a.m.	56.7
R4	2:30 p.m. - 3:30 p.m.	50.8	11:36 p.m. - 12:06 a.m.	43.6
R5	2:34 p.m. - 3:34 p.m.	53.2	11:39 p.m. - 12:09 a.m.	44.7
R6	4:03 p.m. - 5:03 p.m.	61.3	10:54 p.m. - 11:24 p.m.	49.4
R7	5:20 p.m. - 6:20 p.m.	57.0	10:14 p.m. - 10:44 p.m.	46.4
R8	5:15 p.m. - 6:16 p.m.	53.7	10:13 p.m. - 10:43 p.m.	46.3
R9	3:48 p.m. - 4:48 p.m.	64.8	12:18 p.m. - 12:48 a.m.	53.9
R10	11:27 a.m. - 12:27 p.m.	61.7	10:02 p.m. - 10:32 p.m.	50.5
R11	11:30 a.m. - 12:30 p.m.	60.9	10:01 p.m. - 10:31 p.m.	51.3
R12	7:00 a.m. – 6:00 p.m.	61.6 [a]	6:00 a.m. - 7:00 a.m.	56.7 [b]

Notes: NSA = Noise Sensitive Area; dBA = A-weighted decibel; NSA type (R1 to R12) described in Table 5

[a] The 61.6 dBA is an average of the daytime sound levels taken at the four positions around the school. The daytime measurement at two positions in front of the school near LA 46 range from 65 to 69 dBA. At the other two positions at the back of the school (further away from LA 46), daytime measurements range from 53 to 60 dBA.

[b] The 56.7 dBA is an average of the nighttime sound levels taken at the four positions around the school. The nighttime measurement at two positions in front of the school near LA 46 range from 55 to 70 dBA. At the other two positions at the back of the school (further away from LA 46), nighttime measurements range from 48 to 53 dBA.

Ambient underwater sound levels represent sound from natural sources such as wind-driven waves, storms, fish, tidal currents, and vocalizing marine mammals. When anthropogenic sources are added to ambient sound sources, underwater sound levels increase. The extent and duration of increase is variable in time and space and dependent upon the individual and cumulative anthropogenic source types. Measurements of baseline ambient underwater sound in the Project vicinity are not available. However, in the Mississippi River, sources of anthropogenic underwater sound include small fishing and recreational vessels, as well as large commercial vessels (for example, oil tankers and container ships), pile driving, and dredging.

As with airborne sound, ambient underwater sound is variable over time due to changes in the intensity and abundance of sound sources. Biological sounds associated with a host of marine mammals, fishes, and invertebrates can generate broadband sound in the frequency range of about 10 to 10,000 Hz (Discovery of Sound in the Sea [DOSITS] 2023). Most underwater sound in the 20 to 500 Hz range is due to distant shipping, rather than natural sources; vessel traffic generates low-frequency sounds that can travel considerable distances. Ambient sound in the mid-frequency range of 500 to 100,000 Hz is primarily due to sound from breaking waves; the intensity of sound in this frequency range increases with wind speed. Higher frequency sounds (greater than 100,000 Hz) are primarily generated by thermal sound, which is the sound of the random motion of water molecules (DOSITS 2023).

The predominant freshwater habitat in the Project vicinity, the Mississippi River, provides habitat for multiple fish species. Threatened and/or endangered species of marine mammals, reptiles, and fishes that could be affected by underwater sound at or near the Project site are listed below:

- West Indian Manatee (threatened) – marine mammal (sirenian) with hearing sensitivities comparable to mid-frequency cetaceans (150 Hz – 160 kHz);
- Alligator snapping turtle (proposed threatened) – reptile, freshwater turtle; and
- Pallid sturgeon (endangered) – fish.

Low-frequency cetaceans, high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds have not been seen near the Project site; therefore, sound impacts on the hearing of these marine mammals are not addressed in this study.

5. AREA OF POTENTIAL IMPACTS AND TYPE OF PROJECT-RELATED SOUNDS

The area of potential impacts for evaluation of construction impacts on ambient sound includes the immediate vicinity (within 1 mile) of the Project footprint because construction activities would be highly localized, and sound attenuates with increasing distance from the source. NSAs such as residences, cemetery, churches, schools, an art/forest preservation studio, and a wilderness park near the Project footprint have the greatest potential to be affected by construction and operational sound. The NSAs nearest to each proposed Project feature are identified in Table 5 and Figure 1. Operational sound impacts would be limited to the immediate vicinity (within 1-mile) of the container terminal and wharf. The Project is expected to add lots of truck traffic to nearby roadways; however, impacts of offsite truck traffic sound are not discussed in this study.

The area of potential impacts for evaluation of construction and operation impacts on underwater sound levels and marine life that may be affected by sound are defined as effect distances or isopleths; these are distances in which sound would exceed a threshold protective of marine and aquatic species. Effect distances were determined as applicable for marine mammals, turtles, and fish using estimated sound levels for pile driving, dredging, and transiting vessels. The effect distances are described for each of the sources in section 7.

Construction activities within the Project footprint would include clearing and grading associated with site preparation, materials and equipment delivery, and installation of the container terminal structures and wharf (for example, pile driving). The most prevalent sound-generating equipment and activity during construction of the Project is anticipated to be pile driving, back-up alarms, dump trucks slapping their tailgates, engine sound, tracked equipment sound, and compression release engine brakes (“jake brakes”)

Operation of the Project would produce sound from multiple sources, including container trucks, freight trains, and cargo handling equipment (dock side/wharf crane and rubber-tired gantry crane safety alarms, forklifts/side picks/top handlers, and yard tractors). The most common sound from the container terminal would be train cars banging, railcar wheel and track squeal, back-up alarms, containers banging as they are set down, and trucks using their compression release engine brakes ("jake brakes").

The primary sources of operational underwater sound would be large container vessels and barges with tugboats transiting the Mississippi River and at berth with auxiliary engines running; therefore, operational sound impacts would be limited to the immediate vicinity of the vessels during transit and at berth.

6. Airborne Sound Prediction Method

Sound modeling during Project construction and operation was performed using Cadna/A (Computer Aided Sound Abatement), the leading software for calculation, presentation, assessment, and prediction of environmental sound. The software was developed by DataKustik Gmbh and it implements International Organization for Standardization (ISO) 9613-2 international standard for sound propagation (Acoustics – Attenuation of Sound during Propagation Outdoors – Part 2: General Method of Calculation) (ISO 1996). All calculations assumed favorable conditions for sound propagation per ISO 9613-2, corresponding to a moderate, well-developed ground-based temperature inversion, as might occur on a calm, clear night, or equivalently downwind propagation. The model assumed a temperature of 10 degrees Celsius and relative humidity of 70 percent and meteorological conditions favorable to sound propagation per ISO 9613, that is, each source propagates maximum sound level in all directions at all times (downward propagation). This will likely overpredict upwind sound levels. No meteorological correction was added to the results.

Terrain and attenuation from ground absorption can have a significant impact on sound transmission. Elevation contours for the modeling domain were directly imported into Cadna/A, which allowed for consideration of terrain shielding where appropriate. For areas with foliage, the average height of tree canopy was assumed to be 24 feet. A ground absorption coefficient of 0.5 (that is, 50 percent soft ground and 50 percent hard ground) was assumed for areas modeled within 1 mile of the construction footprint, except for hard reflecting surfaces such as the Mississippi River (water body), where a ground absorption coefficient of 0.0 was assumed.

The calculation height for the NSAs were executed at 5 feet above ground level, to represent the average height of an adult human ear for standard sound modeling purposes. Construction and operation equipment types, sound levels at a reference distance, and sources of data are provided in Section 8, Results.

7. Underwater Sound Prediction Method

NOAA Fisheries User Spreadsheet Tool (NOAA Fisheries 2020) was used to estimate effect distances (that is, isopleths or the distance in which sound levels exceed PTS onset thresholds) for anticipated in-water activities on mid-frequency cetaceans (including manatees). To account for the differences in audible bandwidth amongst cetacean groups, the effect distances for onset of PTS injury were calculated using the Practical Spreading Loss model and accounted for NOAA Fisheries' suggested default auditory weighting factor adjustments for the broadband sources (impact and vibratory pile driving, dredging, and vessel transiting).

The Practical Spreading Loss model is defined by the formula:

TL = 15 Log (R1/R2)

Where:

R1 is the range or distance in meters at which transmission loss is estimated;

R2 is the range or distance in meters of the known or measured sound level; and

TL is the transmission loss or change in sound level (dB) between R1 and R2.

Consequently, the effect distance, R1, to Peak SPL thresholds for onset of PTS injury or to RMS SPL thresholds for behavioral disturbance to marine mammals are calculated based on practical spreading as follows:

$$R1 = R2*10^{((\text{Source Level} - \text{Sound Threshold Level})/15)}$$

For fish and turtles, the effect distances where thresholds for injury (Peak SPL and SELcum) and behavioral disturbance (RMS SPL) may be exceeded are calculated based on practical spreading using the same formula above for cetaceans. Unlike marine mammals, fish and turtles are not sensitive to variations in sound frequency, so the effect distance calculations do not account for auditory weighting factors. In general, the effect distance to the threshold level for marine and aquatic species increases as the SELcum increases (that is, number of strikes increases). However, when the received sound level of a single strike decreases below 150 dB (effective quiet), the accumulated energy from multiple strikes would not contribute to injury regardless of the number of strikes (WSDOT 2020). Therefore, effective quiet establishes the distance beyond which no adverse effect is expected. The distance, R1, to effective quiet is calculated as follows:

$$R1 = R2*10^{((\text{Source SEL (single strike)} - 150)/15)}$$

Other parameters that influence the propagation and attenuation of sound underwater such as geoacoustic properties of the seabed and sound speed profile are not accounted for in this sound analysis; hence the practical spreading calculations are conservative.

8. RESULTS

8.1. Construction Impacts Related to Airborne Sound

Construction of the proposed Project facilities, both riverside and land side elements, would result in temporary airborne sound increase in the immediate vicinity of the construction area. Sound from construction activities varies greatly depending on the type and model of construction equipment, the operations being performed, and the overall condition of the equipment. Construction of the Project facilities would occur in several phases over the analysis period, and the construction equipment necessary for each stage of construction would differ.

Construction equipment would be operated intermittently over that period. Most riverside construction activities and most landside construction activities would be limited to daytime hours when ambient/existing sound levels are already elevated and when people are less likely to detect increases in sound levels. Most riverside and landside construction activities are expected to occur on a 12-hour daily schedule between 7:00 a.m. and 7:00 p.m., Monday to Saturday, with some work occurring on Sundays. Some riverside and landside construction equipment, particularly river sand harvesting equipment, would be operated intermittently over the construction period, 24 hours each day, Monday to Saturday.

Pile driving activities and construction equipment operation would be primary sources of airborne sound over the Project construction period. Construction impacts are expected to be greatest near the wharf and ramp structures, where large pile driving hammers would be used. Large pile drivers would also be used during construction of the landside elements. Pile driving would be conducted using both impact and vibratory hammers; impact hammers produce impulsive (short, intense) sound, while vibratory hammers produce non-impulsive continuous sound while in use. Construction of the wharf and ramps would include using an impact hammer to drive 24-inch and 36-inch square concrete piles. A vibratory hammer would be used to install steel piles for a temporary construction trestle, and an impact hammer would be used to proof test the trestle piles. There would be limited-to-no nighttime (10:00 p.m. to 7:00 a.m.) construction at the wharf and riverside portions of the ramps. During construction of the landside elements, certain construction equipment would operate 24 hours a day, including marine equipment (tugboat, derrick barge) needed for sand harvesting, smaller pile drivers, asphalt delivery trucks and pavers, concrete delivery and pump trucks, generators, portable light plants, water pumps, sweepers, conveyors, rollers, some trucks, some crawler tractors, and some excavators. Table 7 provides equipment sound level at 50 feet that would be used to construct the wharf and ramps (river side elements) during the daytime (7:00 a.m-7:00 p.m.). Table 7 does not include sand harvesting equipment which will be used near the riverside during construction of the wharf; however, addition of noise from sand harvesting equipment is not expected to change the modeled construction levels at the wharf and riverside area. As indicated above, the dominant sources of noise would be large pile driving hammers (maximum noise level of 101 dBA at 50 feet; see Table 7) used during construction of the wharf and ramp structures. Table 8 and Table 9 provide equipment sound levels at 50 feet that would be used to construct the container terminal (land side elements) during the daytime and nighttime, respectively. Table 8 and Table 9 exclude equipment associated with construction of the 25-acre pond, rail support yard, and drainage pump station. Noise associated with construction of these areas would be less than noise from pile driving and other heavy equipment, and as such, are not expected to change the modeled construction levels for landside elements. For construction equipment where measured sound levels were unavailable, sound level information for similar equipment types was assumed.

The Project would be constructed and operated in three phases: Phase 1, Phase 2, and Phase 3. Phase 1 may be further grouped into Phase 1A and 1B, but these subgroupings would not affect the construction sound analysis. The primary differences between the three phases are described below:

Phase 1: The first phase of the Project includes construction and operation of the down-river portion of the container yards, two ramps over the Mississippi River levee for wharf access, and approximately 2,604 linear feet of wharf structure, and other terminal features such as a stormwater drainage system, terminal ingress/egress on LA 39, administrative and operations buildings, parking, and a rail support and intermodal yards.

Phase 2: The second phase of the Project includes construction and operation of an additional container yard area with more container stacking cranes, additional empty container yards with more side pick forklifts. Phase 2 would not include additional wharf or ramp construction.

Phase 3: The third phase of the Project includes construction and operation of remaining container yard areas with more container stacking cranes, completion of the third wharf access ramp resulting in a total of three ramps, and construction of approximately 1,004 linear feet of additional wharf structure, totaling approximately 3,608 linear feet of wharf structure. The Port anticipates the relocation of Violet Park/Playground, and the relocation of W. Smith Elementary School and acquisition of the school site by the Port, no later than the beginning of Phase 3 construction.

Predicted construction sound levels at the NSAs are presented in Table 10 (Daytime Construction Sound) and Table 11 (Nighttime Construction Sound), respectively. The predicted daytime and nighttime sound contours for all construction phases are depicted in Figures 2 through 7.

Table 7
Equipment Sound Levels for Wharf and Ramp Construction During Daytime

Equipment Description	Number of Units	Actual Measured Maximum Sound Level at 50 feet (Lmax, dBA) [a]	Acoustical Use Factor [b]	Predicted Sound Level at 50 feet (Leq, dBA) [c]
Bridge Deck Finisher - Bidwell (30 hp)	1	77	50	74.0
Bidwell High Density Paver (30 hp)	1	77	50	74.0
78–84-inch Single Drum / Combo / Vibro (Roller) (120 hp)	1	80	20	73.0
815 Compactor (120 hp)	1	83	20	76.0
Portable Light Plant (Generator<25 kVA) (30 hp)	12	73	50	80.8
Self-Contained Pre-Drilling Machine (150 hp)	1	84	20	77.0
36-39 mt (CAT 330,336) (300 hp)	2	81	40	80.0
Hydraulic Concrete Saw w/Blade in op. (12 hp)	2	90	20	86.0
Pile Cutter w/Power Pack (385 hp)	1	90	20	83.0
Mixer 10 cy Hydraulic Agitator (240 hp)	2	80	50	80.0
Conc/Grout Pump (40 hp)	2	81	20	77.0
Soil Stabilizer 650 (600 hp)	1	74	50	71.0
Cat 140 Grader (250 hp)	1	85	40	81.0

Table 7
Equipment Sound Levels for Wharf and Ramp Construction During Daytime

Equipment Description	Number of Units	Actual Measured Maximum Sound Level at 50 feet (Lmax, dBA) [a]	Acoustical Use Factor [b]	Predicted Sound Level at 50 feet (Leq, dBA) [c]
Small Water Truck (200 hp)	1	74	40	70.0
Forklift 16,000-20,000 lb. Straight Mast (160 hp)	3	75	20	72.8
30,000 lb. Extendable Forklift (200 hp)	3	75	20	72.8
Mid-Size Loader Backhoe (Cat 446D 4x4) (100 hp)	1	78	40	74.0
Cat D3 LGP, D4 LGP / JD 450 LGP (200 hp)	2	82	40	81.0
Cat D6R / JD 850 (200 hp)	2	82	40	81.0
Transport Truck - Tractor Only (450 hp)	1	84	40	80.0
60' Manlift (85 hp)	6	75	20	75.8
80' Manlift (85 hp)	6	75	20	75.8
Generator (<25 kVA) (60 hp)	6	73	50	77.8
185 cfm Air Compressor (43 hp)	6	78	40	81.8
400 - 450 Amp Diesel Welder (40 hp)	6	74	40	77.8
Pickup Truck/Sedan (300 hp)	15	75	40	82.8
Diesel Pile Hammer D160 w/ Leads/Spotter Comb.	1	101	20	94.0
Diesel Pile Hammer D100 w/ Leads/Spotter Comb.	1	101	20	94.0
Pneu/Hyd Hammer w/ Leads/Spotter Comb.	1	101	20	94.0
APE 400 Vibratory Pile Hammer 13,000 in-lb. (1200 hp)	1	101	20	94.0
APE 200 Vibratory Pile Hammer (1000 hp)	1	101	20	94.0
Rough Terrain Crane 60-69 ton (220 hp)	1	81	16	73.0
175–225-ton Lattice Crawler Crane (300 hp)	1	81	16	73.0
300–330-ton Lattice Crawler Crane (500 hp)	3	81	16	77.8
Hydraulic All Terrain Crane < 50 ton (200 hp)	1	81	16	73.0
Total[d]				**101.7**
Total for Phases 1 only[e]				**101.7**
Total for Phase 2 only[f]				**98.7**
Total for Phase 3 only[g]				**98.7**

Table 7
Equipment Sound Levels for Wharf and Ramp Construction During Daytime

Equipment Description	Number of Units	Actual Measured Maximum Sound Level at 50 feet (Lmax, dBA) [a]	Acoustical Use Factor [b]	Predicted Sound Level at 50 feet (Leq, dBA) [c]

Notes:

Lmax = maximum A-weighted sound level during a measurement period, Leq = average equivalent sound level, dBA = A-weighted decibel, hp = horsepower; mt = metric ton; cy = cubic yard, kVA = kilo volt ampere; cfm = cubic feet per minute; in-lb. = inch-pound;

[a] Source: FHWA 2006, WSDOT 2020 (soil stabilizer/mud recycler only); reference sound level is based on one unit of equipment.

[b] Acoustical use factor is a percentage of time during a construction sound operation that a piece of construction equipment is operating at full power.

[c] Leq = Lmax – 20 x Log (D/50) + 10 x Log (U.F. in percent/100) + 10 x Log (# of units), where D is distance to receiver location, U.F is acoustical use factor, and # of units is number of units of each equipment type operating simultaneously.

[d] Total Leq level was based on the logarithmic sum of sound levels for individual construction equipment.

[e] Assume Phase 1 sound level is same as total riverside construction sound.

[f] Assume Phase 2 sound level is one-half of total riverside construction sound.

[g] Assume Phase 3 sound level is one-half of total riverside construction sound.

Table 8
Equipment Sound Levels for Container Terminal Construction During Daytime

Equipment Description	Number of Units	Actual Measured Maximum Sound Level at 50 feet (Lmax, dBA) [a]	Acoustical Use Factor [b]	Predicted Sound Level at 50 feet (Leq, dBA) [c]
Pickup Truck (225 hp)	41	75	40	87.1
Maintenance Truck (350 hp)	6	74	40	77.8
Large Mechanic Truck (400 hp)	2	74	40	73.0
Large Water Truck (400 hp)	8	74	40	79.1
Boom Truck Large Tandem Axle >12 ton (400 hp)	1	76	40	72.0
Flatbed Truck - F450 (350 hp)	1	74	40	70.0
Transport Truck - Tractor Only (450 hp)	2	84	40	83.0
Attenuator Crash Truck (350 hp)	1	74	40	70.0
Cat D3 LGP, D4 LGP / JD 450 LGP Dozer (200 hp)	1	82	40	78.0
Cat D5 LGP / JD 550 LGP Dozer (200 hp)	1	82	40	78.0
Cat D6R / JD 850 Dozer (250 hp)	25	82	40	92.0
Cat D8 / JD 1050 Dozer (400 hp)	1	82	40	78.0

Table 8
Equipment Sound Levels for Container Terminal Construction During Daytime

Equipment Description	Number of Units	Actual Measured Maximum Sound Level at 50 feet (Lmax, dBA) [a]	Acoustical Use Factor [b]	Predicted Sound Level at 50 feet (Leq, dBA) [c]
Mid-Size Loader Backhoe (Cat 446D 4x4) (100 hp)	1	78	40	74.0
Large Loader Backhoe (JD-710 G 4x4) (100 hp)	1	78	40	74.0
Medium Farm Tractor / 4440 (100 hp)	3	84	40	84.8
Motor Grader	11	85	40	91.4
1-5 mt (Mini Ex 301.5-305) Excavator (30 hp)	4	81	40	83.0
10-19 mt (SM EX 312 - 318) Excavator (50 hp)	2	81	40	80.0
30-35 mt (328,329) Excavator (150 hp)	1	81	40	77.0
36-39 mt (CAT 330, 336) Excavator (300 hp)	2	81	40	80.0
40-49 mt (345,350) Excavator (400 hp)	11	81	40	87.4
78–84-inch Single Drum / Smooth / Vibro (Roller) (120 hp)	12	80	20	83.8
Rough Terrain Crane 60-69 ton (220 hp)	4	81	16	79.1
300–330-ton Lattice Crawler Crane (500 hp)	3	81	16	77.8
Hyd. All Terrain Crane 70-75 ton (200 hp)	1	81	16	73.0
Articulated Dump Truck 40 ton (420 hp)	30	76	40	86.8
185 CFM Air Compressor - Diesel (40 hp)	3	78	40	78.8
400-450 Amp Diesel Welder (40 hp)	6	74	40	77.8
1-24 kW Generator (30 hp)	1	73	50	70.0
Portable Light Plant (Generator) (15 hp)	21	73	50	83.2
6-inch Centrifugal Water Pump (30 hp)	15	77	50	85.8
18-inch Godwin Water Pump (150 hp)	5	77	50	81.0
Road Broom (Vacuum Street Sweeper) (50 hp)	5	80	10	77.0
Conveyor (100 hp)	2	N/A	N/A	73.4
Cat 950, IT62, JD644, WA250, L120 Loader (200 hp)	4	79	40	81.0
Cat 966, JA744, WA500, L150 Loader (250 hp)	8	79	40	84.1
Skid Steer - Track Loader (50 hp)	4	79	40	81.0
60-foot Manlift (85 hp)	5	75	20	75.0
80-foot Manlift (85 hp)	2	75	20	71.0
Diesel Pile Hammer, 107,000 ft-lb Imp Energy (300 hp)	1	101	20	94.0
Diesel Pile Hammer, 69,000 ft-lb Imp Energy (200 hp)	2	101	20	97.0
Vibratory Pile Hammer 6,500 in-lb. (180 hp)	2	101	20	97.0

Table 8
Equipment Sound Levels for Container Terminal Construction During Daytime

Equipment Description	Number of Units	Actual Measured Maximum Sound Level at 50 feet (Lmax, dBA) [a]	Acoustical Use Factor [b]	Predicted Sound Level at 50 feet (Leq, dBA) [c]
Vibratory Pile Hammer 4,400 in-lb. (140 hp)	2	101	20	97.0
Wick drain installer (200 hp)	5	84	20	84.0
Barge Unloader (500 hp)	1	N/A	N/A	73.4
Asphalt Paver (150 hp)	1	77	50	74.0
Batch Plant and Concrete Pump (550 hp)	2	83	15	77.8
Total[d]				**104.1**
Total for Phases 1 only[e]				**104.1**
Total for Phase 2 only[f]				**101.1**
Total for Phase 3 only[g]				**101.1**

Notes:

Lmax = maximum A-weighted sound level, Leq = average equivalent sound level, dBA = A-weighted decibel, hp = horsepower, in-lb. = inch-pound; ft-lb =foot-pound; N/A = not applicable

[a] Source: FHWA 2006, WSDOT 2020 (conveyor/barge unloader only); reference sound level is based on one unit of equipment.

[b] Acoustical use factor is a percentage of time during a construction sound operation that a piece of construction equipment is operating at full power.

[c] Leq = Lmax – 20 x Log (D/50) + 10 x Log (U.F. in percent/100) + 10 x Log (# of units), where D is distance to receiver location, U.F is acoustical use factor, and # of units is number of units of each equipment type operating simultaneously.

[d] Total Leq level was based on the logarithmic sum of sound levels for individual construction equipment.

[e] Assume Phase 1 sound level is same as total landside construction sound.

[f] Assume Phase 2 sound level is one-half of total landside construction sound.

[g] Assume Phase 3 sound level is one-half of total landside construction sound.

Table 9
Equipment Sound Levels for Container Terminal Construction During Nighttime

Equipment Description	Number of Units	Actual Measured Maximum Sound Level at 50 feet (Lmax, dBA) [a]	Acoustical Use Factor [b]	Predicted Sound Level at 50 feet (Leq, dBA) [c]
Maintenance Truck (350 hp)	6	74	40	77.8
Large Mechanic Truck (400 hp)	2	74	40	73.0
Attenuator Crash Truck (350 hp)	1	74	40	70.0
Cat D6R / JD 850 Dozer (250 hp)	25	82	40	92.0
Cat D8 / JD 1050 Dozer (400 hp)	1	82	40	78.0

Table 9 Equipment Sound Levels for Container Terminal Construction During Nighttime				
Equipment Description	**Number of Units**	**Actual Measured Maximum Sound Level at 50 feet (Lmax, dBA) [a]**	**Acoustical Use Factor [b]**	**Predicted Sound Level at 50 feet (Leq, dBA) [c]**
36 to 39 mt (CAT 330, 336) Excavator (300 hp)	2	81	40	80.0
40 to 49 mt (345,350) Excavator (400 hp)	11	81	40	87.4
78-to-84-inch Single Drum / Smooth / Vibro (Roller) (120 hp)	12	80	20	83.8
1 - 24 kW Generator (30 hp)	1	73	50	70.0
Portable Light Plant (Generator) (15 hp)	21	73	50	83.2
6" Centrifugal Water Pump (30 hp)	15	77	50	85.8
18" Godwin Water Pump (150 hp)	5	77	50	81.0
Road Broom (Vacuum Street Sweeper) (50 hp)	5	80	10	77.0
Conveyor (100 hp)	2	N/A	N/A	73.4
Barge Unloader (500 hp)	1	N/A	N/A	73.4
Asphalt Paver (150 hp)	1	77	50	74.0
Batch Plant and Concrete Pump (550 hp)	2	83	15	77.8
Total[d]				**95.5**
Total for Phases 1 only[e]				**95.5**
Total for Phase 2 only[f]				**92.5**
Total for Phase 3 only[g]				**92.5**

Notes:

Lmax = maximum A-weighted sound level, Leq = average equivalent sound level, dBA = A-weighted decibel, hp = horsepower, mt = metric tons, kW = kilowatt; N/A = not applicable

[a] Source: FHWA 2006, BSI 2014 (conveyor/barge loader only); reference sound level is based on one unit of equipment.

[b] Acoustical use factor is a percentage of time during a construction sound operation that a piece of construction equipment is operating at full power.

[c] Leq = Lmax – 20 x Log (D/50) + 10 x Log (U.F. in percent/100) + 10 x Log (# of units), where D is distance to receiver location, U.F is acoustical use factor, and # of units is number of units of each equipment type operating simultaneously.

[d] Total Leq level was based on the logarithmic sum of sound levels for individual construction equipment.

[e] Assume Phase 1 sound level is same as total landside construction sound.

[f] Assume Phase 2 sound level is one-half of total landside construction sound.

[g] Assume Phase 3 sound level is one-half of total landside construction sound.

Table 10 Daytime Construction Sound Modeling Results at Nearest NSAs (dBA)[a]				
NSA ID	**NSA Type**	**Phase 1**	**Phase 2**	**Phase 3**
R1	Residence	72	57	62

Table 10
Daytime Construction Sound Modeling Results at Nearest NSAs (dBA)[a]

NSA ID	NSA Type	Phase 1	Phase 2	Phase 3
R2	Residence	68	60	73
R3	Cemetery and Park/Playground	70	64	78[b]
R4	Residence	66	57	60
R5	Residence	65	55	58
R6	Residence	67	60	64
R7	Church	67	60	65
R8	Church	65	58	64
R9	Residence	62	53	58
R10	A Studio in the Woods	57	46	54
R11	Audubon Wilderness Park	61	48	57
R12	W. Smith Junior Elementary School	73	72	--[b]

Note:
[a] Daytime construction sound levels were predicted using Cadna/A modeling software. The predicted sound levels at each NSA location does not include existing sound levels at the NSAs. As a result, predicted sound levels at NSAs further away (for example, R10 and R11) are less than existing sound levels, which is dominated by LA 46.
[b] The Port anticipates the relocation of Violet Park/Playground, and the relocation of W. Smith Elementary School and acquisition of the school site by the Port, no later than the beginning of Phase 3 construction. Merrick Cemetery is just outside the site boundary and as such, would not be relocated.

Table 11
Nighttime Construction Sound Modeling Results at Nearest NSAs (dBA)[a]

NSA ID	NSA Type	Phase 1	Phase 2	Phase 3
R1	Residence	58	49	52
R2	Residence	55	52	58
R3	Cemetery and Park/Playground	58	55	62[b]
R4	Residence	55	48	50
R5	Residence	54	47	48
R6	Residence	57	51	52
R7	Church	56	51	54
R8	Church	55	50	52
R9	Residence	52	45	45
R10	A Studio in the Woods	43	38	40
R11	Audubon Wilderness Park	45	40	43
R12	W. Smith Junior Elementary School	64	64	--[b]

Note:
[a] Nighttime construction sound levels were predicted using Cadna/A modeling software. The predicted sound levels at each NSA location does not include existing sound levels at the NSAs. As a result, predicted sound

Table 11
Nighttime Construction Sound Modeling Results at Nearest NSAs (dBA)[a]

NSA ID	NSA Type	Phase 1	Phase 2	Phase 3
levels at NSAs further away (for example, R10 and R11) are less than existing sound levels, which is dominated by LA 46. [b] The Port anticipates the relocation of Violet Park/Playground, and the relocation of W. Smith Elementary School and acquisition of the school site by the Port, no later than the beginning of Phase 3 construction. Merrick Cemetery is just outside the site boundary and as such, would not be relocated.				

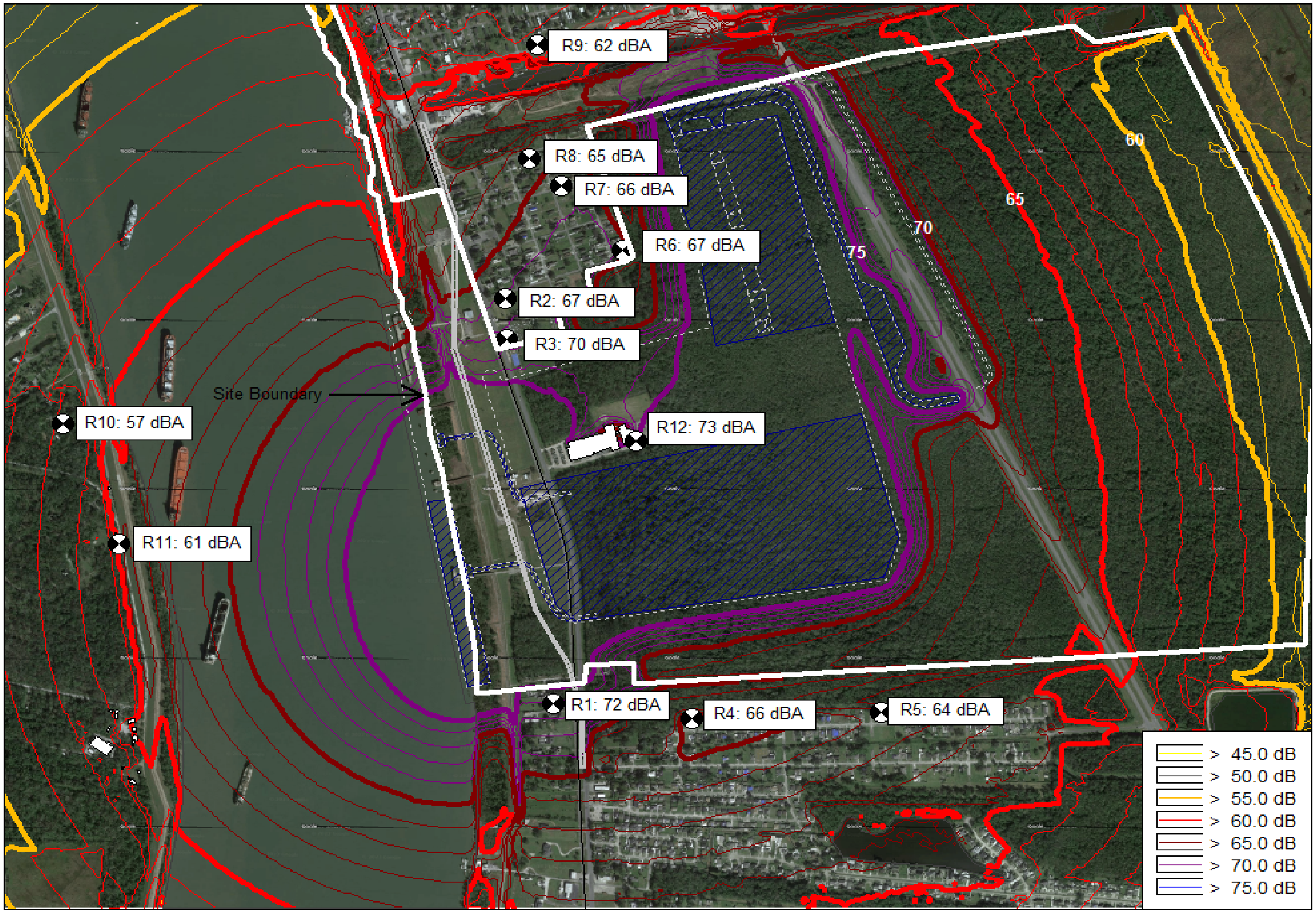

Figure 2. Airborne Sound Contours During Phase 1 Daytime Construction

Figure 3. Airborne Sound Contours During Phase 2 Daytime Construction

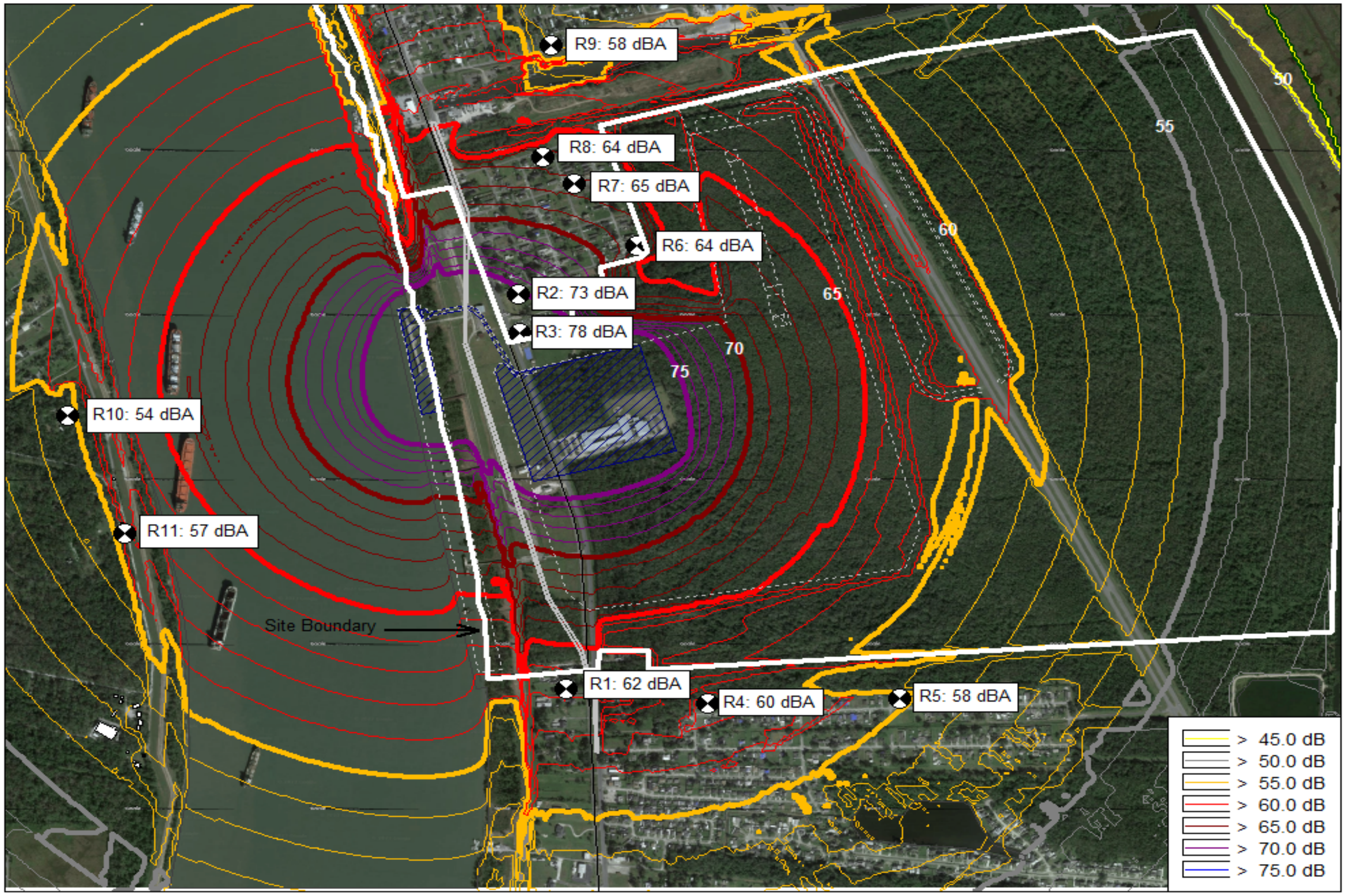

Figure 4. Airborne Sound Contours During Phase 3 Daytime Construction

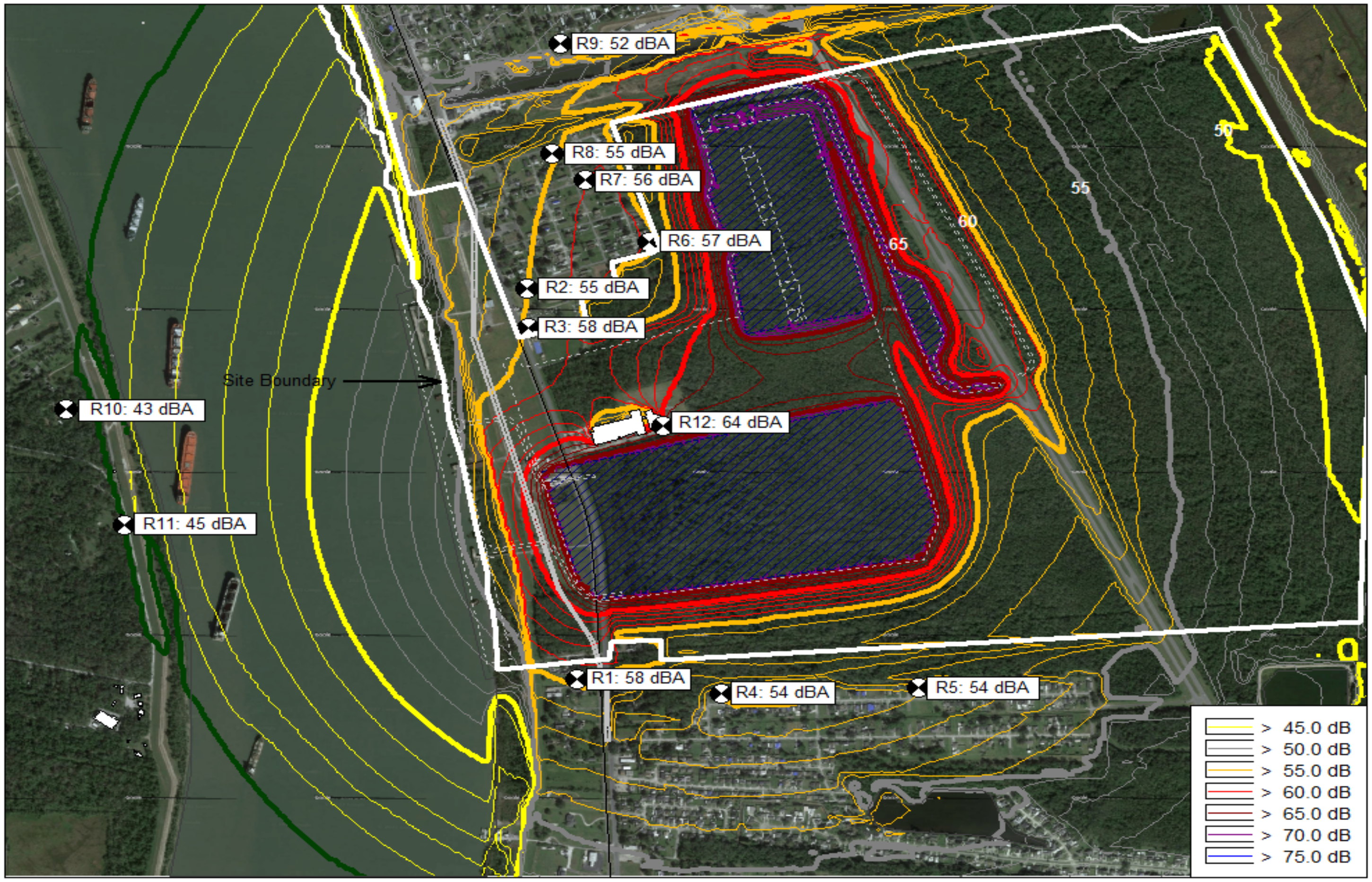

Figure 5. Airborne Sound Contours During Phase 1 Nighttime Construction

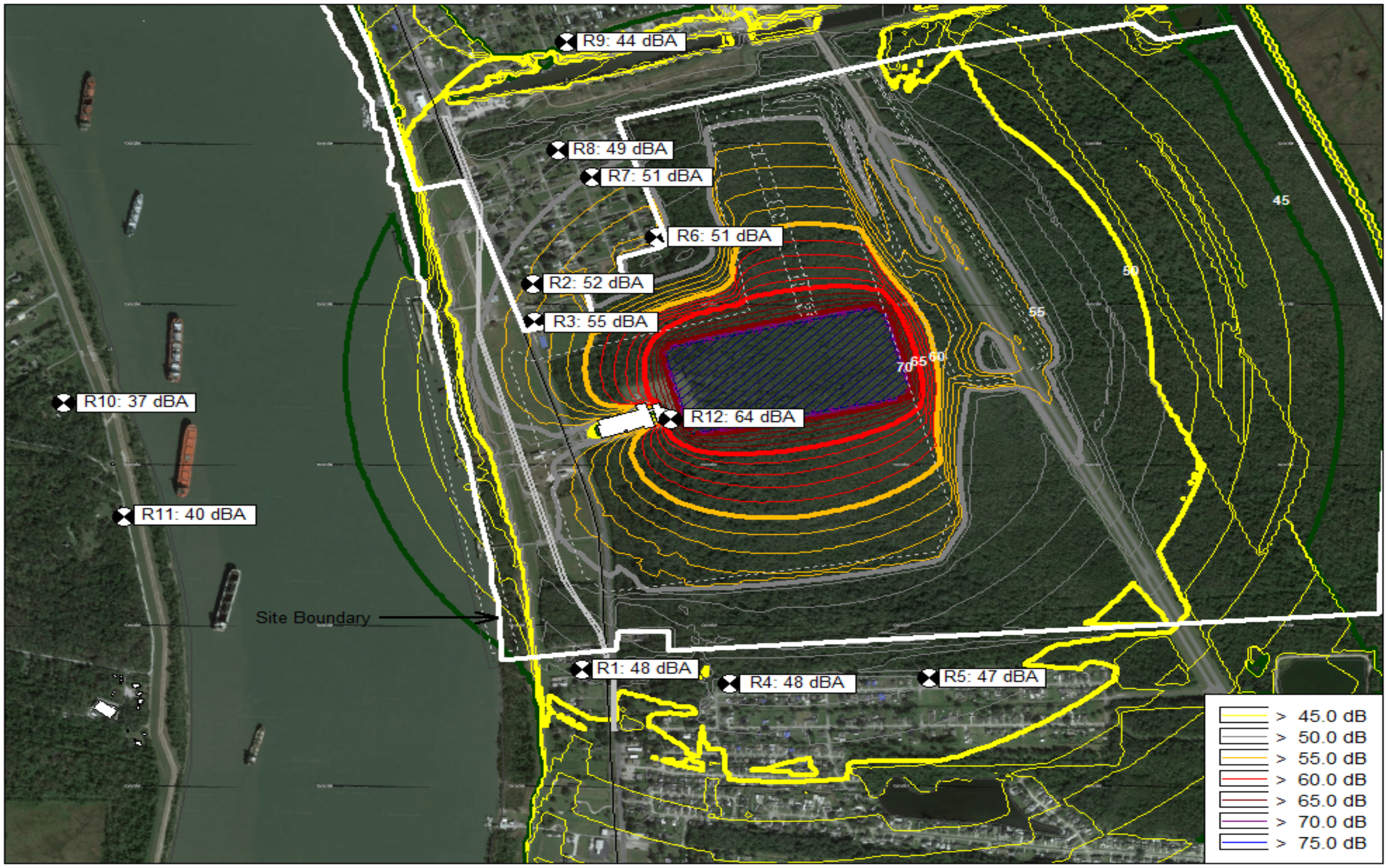

Figure 6. Airborne Sound Contours During Phase 2 Nighttime Construction

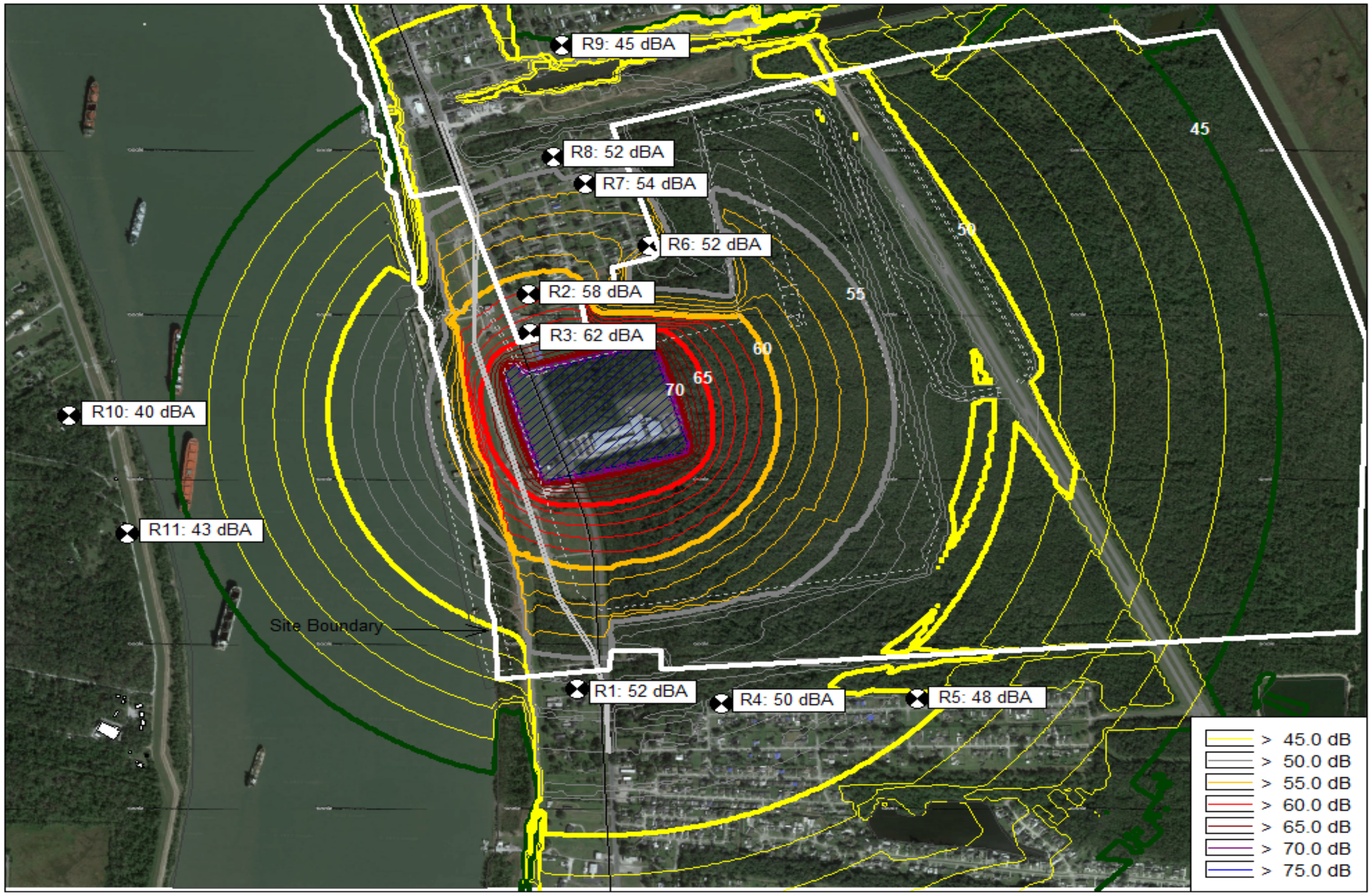

Figure 7. Airborne Sound Contours During Phase 3 Nighttime Construction

Sound would also be generated by vessels used for construction of the Project, including tugs, scows, and barges used to transport construction materials and equipment. Dredging would occur on the western side of the Mississippi River for the ship turning basin. This would allow deep-draft container vessels clearance to turn around and go back down to the Gulf. Airborne sound contribution from the dredger, tugs, scows, and barges would likely be consistent with other vessel activity in the Project vicinity, such as barges and other commercial vessels traveling along the Mississippi River; therefore, impacts would be minor.

8.2. Construction Impacts Related to Underwater Sound

The Project could produce underwater sound from construction activities including pile driving, dredging, and the transit of Project-related vessels. Pile driving activities may include both impact pile driving and vibratory pile driving. Dredging may occur on the western side of the Mississippi River for the ship turning basin.

Project activities that may cause underwater sound are listed in Table 12, including source levels at a reference distance, type of sound, number of piles driven per day, number of strikes per pile (impact), and duration to drive a single pile (vibratory). Table 13 through Table 15 identify the distance at which calculated sound levels from the in-water activities would attenuate to the effects levels of mid-frequency cetaceans (including the West Indian Manatee), fish, and turtles.

Table 12
Estimated Sound Levels from Underwater Sound Sources

Underwater Sound Sources	Type of Sound	Number of Piles Driven Per Day (Estimated)	Number of Strikes Per Pile (Impact) or Duration to Drive a Single Pile (Vibratory)	Average Sound Levels (dB)		
				Peak SPL	RMS SPL	SEL
42-inch spun cast impact pile[a] (at 33 feet)	Impulsive	4	2000 strikes	210	194	184
42-inch steel batter impact pile[a] (at 33 feet)	Impulsive	4	2400 strikes	210	194	184
36-inch steel trestle vibratory pile[b] (at 33 feet)	Non-impulsive	8	100 minutes	180	170	170
36-inch steel trestle impact pile to proof test the trestle piles[b] (at 33 feet)	Impulsive	8	500 strikes	210	193	183
12-inch H-type vibratory pile for templates (pile installation)[b] (at 33 feet)	Non-impulsive	12	60 minutes	165	150	150
12-inch H-type vibratory pile for templates (pile removal)[b] (at 33 feet)	Non-impulsive	12	30 minutes	165	150	150
Dredger[c] (at 3.3 feet)	Non-impulsive	N/A	N/A	N/A	175	N/A
Small vessel transiting [d] (at 3.3 feet)	Non-impulsive	N/A	N/A	N/A	180	N/A

Table 12
Estimated Sound Levels from Underwater Sound Sources

Underwater Sound Sources	Type of Sound	Number of Piles Driven Per Day (Estimated)	Number of Strikes Per Pile (Impact) or Duration to Drive a Single Pile (Vibratory)	Average Sound Levels (dB)		
				Peak SPL	RMS SPL	SEL

Notes:

dB = decibel

Peak = peak sound pressure level (re: 1 µPa), unweighted

RMS SPL = root-mean-square sound pressure level (re: 1 µPa), unweighted

SEL = sound exposure level per strike or pulse (re: 1 $\mu Pa^2 s$), weighted according to functional hearing group

N/A = not available

[a] The wharf design is expected to change to all 36-inch and 24-inch square concrete piles. However, the 42-inch spun cast impact pile and 42-inch steel batter impact piles assumed for the construction sound analysis are more conservative than the 36-inch or 24-inch square concrete piles. If the smaller-diameter piles are used, underwater sound impacts to marine animals would be less.

[b] Data obtained from “Compendium of Pile Driving Sound Data” (Caltrans, 2007).

[c] A specific method of dredging has not yet been determined. Assumed reference source level values for a cutter suction dredger at a distance of 3.3 feet (ERDC 2019); dredger assumed to operate continuously for 24-hours.

[d] Assumed reference source levels for small boats and ships at a distance of 3.3 feet (ERDC 2019); small vessels would operate as needed.

Table 13
Estimated Effect Distances from Underwater Sounds for Mid-Frequency Cetaceans (including Manatees) During Project Construction

Source of Underwater Sound	Effect Distance (Feet) for Project-related Underwater Sounds[a,b]		
	Injury		Behavioral Disturbance
	SELcum	Peak SPL	RMS SPL
42-inch spun cast impact pile[d]	543	N/A	6,061
42-inch steel batter impact pile[d]	630	N/A	6,061
36-inch steel trestle vibratory pile	45	N/A	15,224[c]
36-inch steel trestle impact pile to proof test the trestle piles	40	N/A	5,198
12-inch H-type vibratory pile for templates (pile installation)	2	N/A	707
12-inch H-type vibratory pile for templates (pile removal)	1	N/A	707
Dredger (24-hour duration)	9	N/A	3,280

Table 13
Estimated Effect Distances from Underwater Sounds for Mid-Frequency Cetaceans (including Manatees) During Project Construction

Source of Underwater Sound	Effect Distance (Feet) for Project-related Underwater Sounds[a,b]		
	Injury		Behavioral Disturbance
	SELcum	Peak SPL	RMS SPL
Small vessel transiting at less than 15 knots	0	N/A	7,067

Notes:
N/A = not applicable
SELcum = cumulative sound exposure level (re: 1 μPa^{2}s), weighted according to functional hearing group
Peak SPL = peak sound pressure level (re: 1 μPa), unweighted
RMS SPL = root-mean-square sound pressure (re: 1 μPa), unweighted

[a] Effect distances for permanent threshold injury (SELcum and Peak SPL) to mid-frequency cetaceans, including manatees, were calculated using the NOAA Fisheries User Spreadsheet Tool (NOAA Fisheries 2020).

[b] Effect distances for behavioral disturbance (RMS SPL) to mid-frequency cetaceans, including manatees, were calculated using the Practical Spreading Loss model.

[c] A practical distance for behavioral effects is anticipated to be no more than 2 miles given the presence of landforms that block sound transmission (WSDOT 2020).
[d.] The wharf design is expected to change to 36-inch and 24-inch square concrete piles. However, the 42-inch spun cast impact pile and 42-inch steel batter impact pile assumed for the construction sound analysis are more conservative than the 36-inch or 24-inch square concrete piles. If the smaller-diameter piles are used, underwater sound impacts to marine animals would be less.

Table 14
Estimated Effect Distances from Underwater Sounds for Fish During Project Construction

Source of Underwater Sound	Effect Distance (Feet) for Project-related Underwater Sounds[a,b]		
	Injury		Behavioral Disturbance
	Peak SPL	SELcum	RMS SPL
Fish: no swim bladder (particle motion detection)			
42-inch spun cast impact pile[d]	21	61	28,132[c]
42-inch steel batter impact pile[d]	21	69	28,132[c]
36-inch steel trestle vibratory pile	0	6	707
36-inch steel trestle impact pile to proof test the trestle piles	21	33	24,129[c]
12-inch H-type vibratory pile for templates (pile installation)	0	0	33
12-inch H-type vibratory pile for templates (pile removal)	0	0	33

Table 14
Estimated Effect Distances from Underwater Sounds for Fish During Project Construction

Source of Underwater Sound	Effect Distance (Feet) for Project-related Underwater Sounds[a,b]		
	Injury		Behavioral Disturbance
	Peak SPL	SELcum	RMS SPL
Dredger	N/A	N/A	N/A
Small vessel transiting	N/A	N/A	N/A
Fish: swim bladder is not involved in hearing (particle motion detection)			
42-inch spun cast impact pile[d]	52	522	28,132[c]
42-inch steel batter impact pile[d]	52	434	28,132[c]
36-inch steel trestle vibratory pile	1	233	707
36-inch steel trestle impact pile to proof test the trestle piles	52	131	24,129[c]
12-inch H-type vibratory pile for templates (pile installation)	0	57	33
12-inch H-type vibratory pile for templates (pile removal)	0	36	33
Dredger	N/A	N/A	N/A
Small vessel transiting	N/A	N/A	N/A
Fish: swim bladder involved in hearing (primarily pressure detection)			
42-inch spun cast impact pile[d]	52	828	28,132[c]
42-inch steel batter impact pile[d]	52	688	28,132[c]
36-inch steel trestle vibratory pile	1	370	707
36-inch steel trestle impact pile to proof test the trestle piles	52	208	24,129[c]
12-inch H-type vibratory pile for templates (pile installation)	0	90	33
12-inch H-type vibratory pile for templates (pile removal)	0	57	33
Dredger	N/A	N/A	N/A
Small vessel transiting	N/A	N/A	N/A

Notes:
N/A = not applicable; there are no sound thresholds for fish exposed to non-impulsive sound sources such as dredgers and vessels.
Peak SPL = peak sound pressure level (re: 1 µPa)
SELcum = cumulative sound exposure level (re: 1 $\mu Pa^2 s$)
RMS SPL = root-mean-square sound pressure (re: 1 µPa)

[a] Effect distances for injury (Peak SPL and SELcum) and behavioral disturbances (RMS SPL) to fish were calculated using the Practical Spreading Loss model.

[b] This calculation assumes that single strike SELs < 150 dB do not accumulate to cause injury to fish (Effective Quiet) (WSDOT 2020).
[c] A practical distance for behavioral effects is anticipated to be no more than 2 miles given the presence of landforms that block sound transmission (WSDOT 2020).
[d.] The wharf design is expected to change to 36-inch and 24-inch square concrete piles. However, the 42-inch spun cast impact pile and 42-inch steel batter impact pile assumed for the construction sound analysis are more conservative than the 36-inch or 24-inch square concrete piles. If the smaller-diameter piles are used,

Table 14
Estimated Effect Distances from Underwater Sounds for Fish During Project Construction

Source of Underwater Sound	Effect Distance (Feet) for Project-related Underwater Sounds[a,b]		
	Injury		Behavioral Disturbance
	Peak SPL	SELcum	RMS SPL
underwater sound impacts to marine animals would be less.			

Table 15
Estimated Effect Distances from Underwater Sounds for Turtles During Project Construction

Source of Underwater Sound	Effect Distance (Feet) for Project-related Underwater Sounds[a]		
	Injury		Behavioral Disturbance
	Peak SPL	SELcum	RMS SPL
42-inch spun cast impact pile[d]	52	242	2,413
42-inch steel batter impact pile[d]	52	274	2,413
36-inch steel trestle vibratory pile	1	23	61
36-inch steel trestle impact pile to proof test the trestle piles	52	131	2,070
12-inch H-type vibratory pile for templates (pile installation)	0	1	3
12-inch H-type vibratory pile for templates (pile removal)	0	0	3
Dredger	N/A	N/A	N/A
Small vessel transiting	N/A	N/A	N/A

Notes:
N/A = not applicable; there are no sound thresholds for turtles exposed to non-impulsive sound sources such as dredgers and vessels.
Peak SPL = peak sound pressure level (re: 1 µPa)
SELcum = cumulative sound exposure level (re: 1 $\mu Pa^2 s$)
RMS SPL = root-mean-square sound pressure (re: 1 µPa)
[a] Effect distances for injury (Peak SPL and SELcum) and behavioral disturbances (RMS SPL) to turtles were calculated using the Practical Spreading Loss model.
[d.] The wharf design is expected to change to 36-inch and 24-inch square concrete piles. However, the 42-inch spun cast impact pile and 42-inch steel batter impact pile assumed for the construction sound analysis are more conservative than the 36-inch or 24-inch square concrete piles. If the smaller-diameter piles are used, underwater sound impacts to marine animals would be less.

8.3. Operation Impacts Related to Airborne Sound

Operation of the Project would produce sound from multiple sources, including container trucks, freight trains, and cargo handling equipment (dock side/wharf crane and rubber-tired gantry crane safety alarms, forklifts/side picks/top handlers, and yard tractors). The most common sound from the container terminal would be train cars banging, railcar wheel and track squeal, back-up alarms, containers banging as they are set down, and trucks using their compression release engine brakes (“jake brakes”).

The container terminal also includes a large backup natural-gas-fired or diesel generator (or several smaller backup generators strategically placed inside the terminal) which would operate only during power outages and for peak shaving on local utility grid. The drainage pump station will have three diesel engine-driven pumps that will run continuously anytime stormwater pumping is required. The pump station also includes a small diesel generator that would only run during power outages. As a conservative measure, the model assumed the backup generators on the terminal and the small diesel-fired generator at the pump station would operate continuously 24 hours per day. Table 16 provides sound levels of equipment expected to be used during container terminal operation. The table also includes source location and description, source type and height, operating times, and source data.

Table 16
Operation Equipment Sound Levels (per Unit)

Source Location	Source Description	Source Type	Height (feet)	Operating Times	A-weighted PWL (dBA)	A-weighted SPL at 50 feet (dBA)	Data Source
Internal Terminal Track to Mainline Track	Freight Car (8,000 foot-long) at 15 mph	Railway	15.5	24 hours/day		See note a	Cadna/A (FTA/FRA Standard)
	Freight Locomotive (4,400 hp; Diesel-Powered)	Railway	15.5	24 hours/day		See note b	Cadna/A (FTA/FRA Standard)
Intermodal Yard and Support Tracks	Freight Locomotive (2,000 hp; Diesel-Powered)	Railway	15.5	24 hours/day		See note c	Cadna/A (FTA/FRA Standard)
Main Circulation Routes	Over-the-Road Diesel Truck Circulation	Road	13.1	7 am-5 pm		See note d	Cadna/A (TNM Standard)
Wharf to Container Yard and Container Yard to Intermodal Railyards	Terminal Tractor (Diesel-Powered)	Line	11.3	24 hours/day	104.0[e]		Khoo, I-Hung and Nguyen, Tang-Hung 2013
Railyard	Gantry Cranes (Rail-mounted)	Area	84.0	7 am-5 pm	109.9		Khoo, I-Hung and Nguyen, Tang-Hung 2013
Container Yard (x4)	Automated Stacking Crane	Area	84.0	24 hours/day	98.7		Marshall Day Acoustics 2019
Empty Container Yard (x3)	Side Pick/ Forklift	Area	20.0	7 am-5 pm	111.2		Khoo, I-Hung and Nguyen, Tang-Hung 2013

Table 16
Operation Equipment Sound Levels (per Unit)

Source Location	Source Description	Source Type	Height (feet)	Operating Times	A-weighted PWL (dBA)	A-weighted SPL at 50 feet (dBA)	Data Source
Queuing Area	Over-the-Road diesel Trucks Idling	Area	13.1	7 am-5 pm	88.8		Marshall Day Acoustics 2019
Truck Waiting Area	Over-the-Road diesel Trucks Idling	Area	13.1	6 am-5 pm	88.8		Marshall Day Acoustics 2019
Pump Station	Pump (500 hp, diesel-engine driven) (x3)	Point	27.9	24 hours/day	99.0[f]		Cadna/A Ref. Manual, Ch. 11 (Undated)
	Small Backup Diesel Generator (assumed 80 kW)	Point	2.4	Emergency	90.2		Bies, D.A., Hansen C.H. and Howard C.Q 2018, Ch. 10
Main Electrical Substation	Transformer (67 MVA)	Point	13.0	24 hours/day	97.6		Cadna/A Ref. Manual, Ch. 11 (Undated)
	Large Backup Generator (2 MVA; Natural-Gas-fired or diesel)	Point	7.8	Emergency	103.2[g]		Bies, D.A., Hansen C.H. and Howard C.Q 2018, Ch. 10
Container Repair Station (Exclude indoor sources such as drill presses and sheet metal preparation)	Welder	Point	6.6	7 am-5 pm		70.0	FHWA 2006
	Shear/Cutter	Point	13.1	7 am-5 pm		92.0	FHWA 2006
	Grinder	Point	6.6	7 am-5 pm		66.0	WSDOT 2020
	Container Flipping (loud boom)	Point	5.0	7 am-5 pm	114.2		Marshall Day Acoustics 2019
	Forklift at Container Repair Shop	Point	20.0	7 am-5 pm	111.2		Khoo, I-Hung & Nguyen, Tang-Hung 2013
Wharf	Ship-to-Shore Cranes (All Electric)	Area	121.4	24 hours/day	98.1		Marshall Day Acoustics 2019
	16,000 TEU Ship Running Onboard Generators	Point	52.0	24 hours/day	95.1	76.3	Technalia Research & Innovation 2018
	Barge Tug, Engine Idling	Point	13.1	24 hours/day		87.0	Epsilon Associates, Inc. 2006

Table 16
Operation Equipment Sound Levels (per Unit)

Source Location	Source Description	Source Type	Height (feet)	Operating Times	A-weighted PWL (dBA)	A-weighted SPL at 50 feet (dBA)	Data Source

Notes:

dBA = A-weight decibel; PWL = sound power level, SPL = sound pressure level, mph = miles per hour; hp = horsepower; cfs = cubic feet per second; MVA = mega voltage ampere; TEU = twenty-foot equivalent unit; kW = kilowatt.

[a] Calculated in Cadna/A using FTA/FRA Standard; model input includes three 8000-foot-long trains at 15 mph (2 daytime, 1 nighttime)

[b] Calculated in Cadna/A using FTA/FRA Standard; model inputs include two locomotives per train (6 locomotives total; 4 in the day, and 2 at night), locomotive length of 90 feet, speed of 15 mph, and throttle setting of 8.

[c] Calculated in Cadna/A using FTA/FRA Standard; model inputs include two locomotives (1 locomotive during the day and 1 at night), locomotive length of 90 feet, speed of 15 mph, and throttle setting of 8.

[d] Calculated in Cadna/A using TNM Standard; model inputs include 478 peak hour truck trips and truck speed of 15 mph.

[e] Assumed 80 percent drive-by between container yards and over the ramps to the wharf; other 20 percent from eastern container yard to the intermodal railyard.

[f] Calculated based on a 1500 hp propeller pump; includes 10 dBA reduction from enclosure and exhaust muffler.

[g] Based on a 1500 revolutions per minute speed and 1.6 megawatts rated capacity (0.8 power factor); operated only during power outages and for peak shaving. As a conservation measure, the model assumed the backup generator would operate continuously 24 hours per day.

Sound modeling during Project operation was performed using the Cadna/A sound calculation software, the same modeling software program used for the Project construction and the same methodology was utilized.

The nearest NSAs from the Project operations include residences, churches, cemetery, park/playground, an elementary school, art/forest preservation studio, and a wilderness park in the town of Violet, which are within 1 mile from the Project footprint. The calculation height for the NSAs were executed at 5 feet above ground level, to represent the average height of an adult human ear for standard sound modeling purposes. Operation sound levels were predicted for the identified NSAs in the Cadna/A sound modeling program using the equipment sound levels shown in Table 16 and the model input parameters described above. Total estimated Leq sound levels from Project operations during daytime (7:00 a.m. to 10 p.m.; all equipment in Table 16) and nighttime (10 p.m. to 7:00 a.m.; equipment with operating times of 24 hours per day only) were modeled as point, area, line, road, and railway sources in Cadna/A. The analysis conservatively assumes that all equipment used during operation of the container terminal would be operating concurrently. Hourly operation sound modeling results at nearest NSAs are presented in Table 17 and depicted in Figures 8 through 10. The dBA contour lines are depicted by different colors in Figures 8 through 10. For example, the 65 dBA and 45 dBA contours are depicted by the red and green lines, respectively.

Once the construction is complete, there would be additional noise due to the shift in roadway geometry, added roadways, and additional traffic generated due to the Project. However, traffic noise impact due to the increase in vehicular traffic during Project operations was not assessed in this study.

Table 17
Hourly Operation Sound Modeling Results at Nearest NSAs (dBA)[a]

NSA ID	NSA Type	Phase 1	Phase 2	Phase 3
R1	Residence	54	54	55
R2	Residence	56	56	58
R3	Cemetery and Park/Playground	58	58	62[b]
R4	Residence	53	53	54
R5	Residence	53	53	54
R6	Residence	60	59	61
R7	Church	59	59	60
R8	Church	57	57	58
R9	Residence	53	53	54
R10	(A Studio in the Woods)	42	42	43
R11	(Audubon Wilderness Park)	43	44	45
R12	W. Smith Junior Elementary School	66	65	--[b]

Note:
[a] Hourly operation sound levels were predicted using Cadna/A modeling software. The predicted sound levels at each NSA location does not include existing sound levels at the NSAs. As a result, predicted sound levels at NSAs further away (for example, R10 and R11) are less than existing sound levels, which is dominated by LA 46.
[b] The Port anticipates the relocation of Violet Park/Playground, and the relocation of W. Smith Elementary School and acquisition of the school site by the Port, no later than the beginning of Phase 3 construction. Merrick Cemetery is just outside the site boundary and as such, would not be relocated.

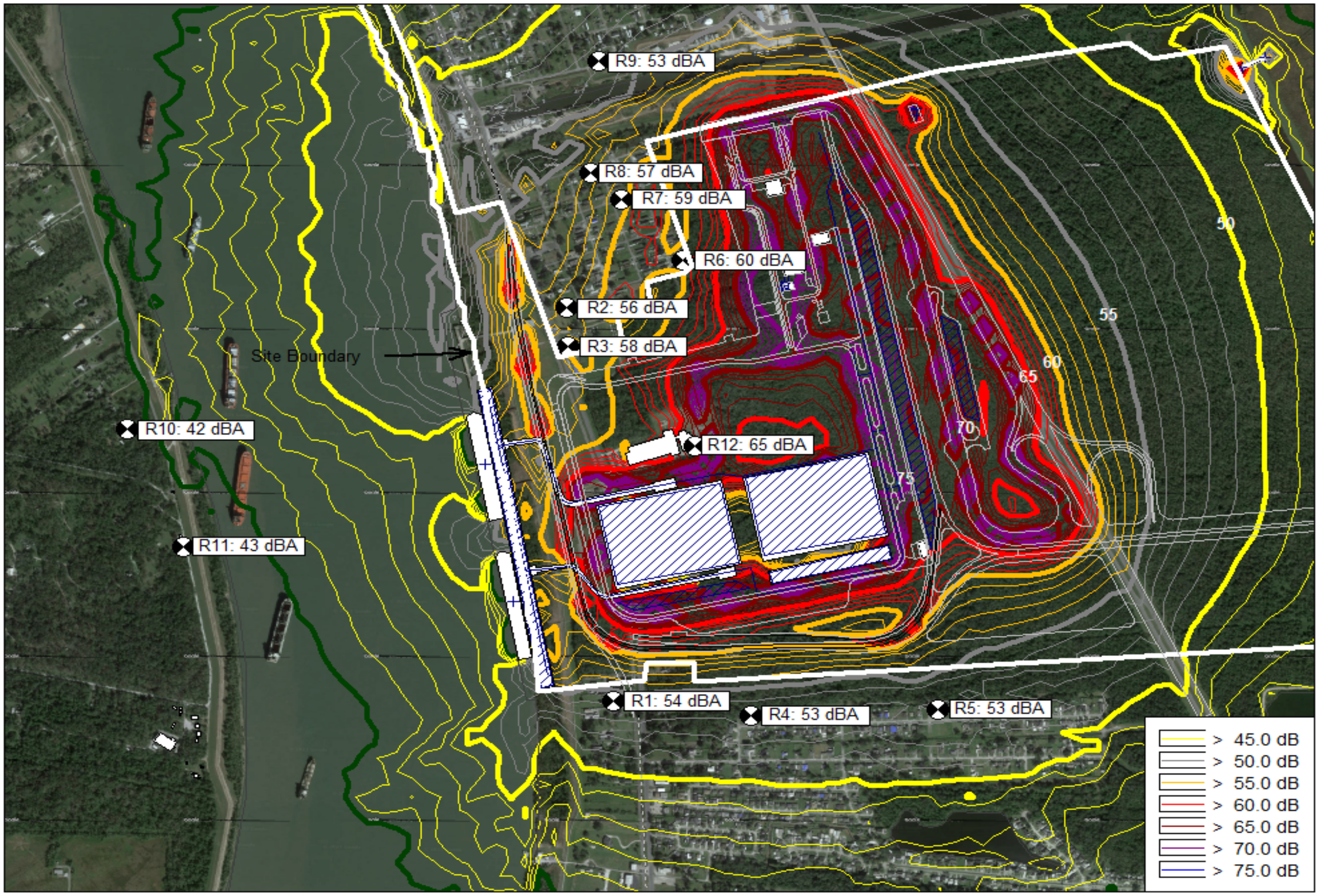

Figure 8. Hourly Airborne Sound Contours During Phase 1 Operation (Daytime or Nighttime)

Figure 9. Hourly Airborne Sound Contours During Phase 2 Operation (Daytime or Nighttime)

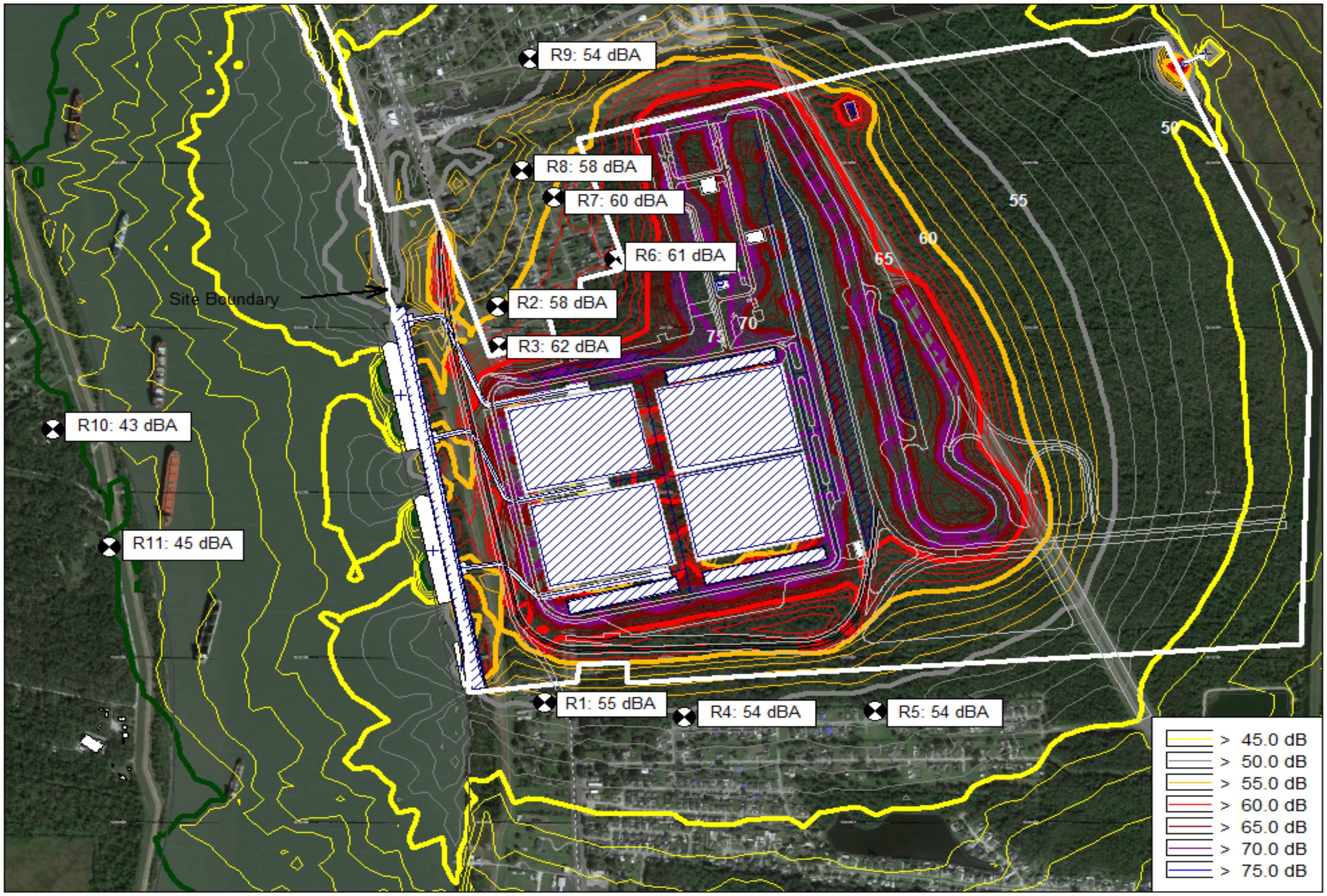

Figure 10. Hourly Airborne Sound Contours During Phase 2 Operation (Daytime or Nighttime)

8.4. Operation Impacts Related to Underwater Sound

The primary source of underwater sound associated with the operation of the Project is the movement of large container vessels, barge vessels, and support tugs (non-impulsive sound). Marine wildlife would likely experience behavioral impacts, such as temporary avoidance of the area; however, there would be no auditory injury on any marine wildlife and the marine wildlife are expected to resume normal activity when the vessels leave the platform. Furthermore, the marine wildlife in the Project site and vicinity is already accustomed to underwater sound sources from existing vessel movements in the designated navigation channels in the Mississippi River. Therefore, vessel movements during Project operations would have a negligible impact on underwater sound.

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