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Subject: Sunset Amphitheater, Broken Arrow
Environmental Noise Assessment – Draft

Dear Bob,

In this document we summarize our current environmental noise assessment for the development of the Sunset Amphitheater in Broken Arrow, OK.

Please let us know if you or the municipality have any questions.

Yours Sincerely,

A handwritten signature in black ink that reads "MATT MAHON".

Matt Mahon
Partner, LSTN Consultants

CC: Ken Andria, LSTN

1 BACKGROUND

- Notes Live (Notes) is developing the Sunset Amphitheater in Broken Arrow, Wagoner County, OK at a site east of the Creek Turnpike, north of Events Park, west of Rosewood Elementary, and south of the Union Pacific railroad.
- Notes is engaging with the community and seeking relevant planning approvals. As part of that effort, Notes has requested that LSTN provide an environmental noise assessment.
- This document summarizes our current environmental noise assessment.

2 NOISE CODE

We understand that the noise code for Broken Arrow, OK is captured in the Code of Ordinances. We expect that the Broken Arrow ordinances supersede any the Wagoner County or Oklahoma State ordinances, but this should be confirmed. Relevant clauses from Broken Arrow's ordinances are reproduced below for convenience, though refer to the Code of Ordinance for any official reading.

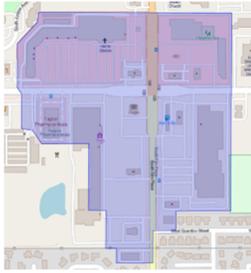
Sec. 16-12. – Disturbing the peace; disorderly conduct.

- (a) *It shall be unlawful for any person at any time to willfully or maliciously disturb the public peace or quietude by creating any noise of such character or duration so as to be loud and unnecessary to a person of ordinary sensibilities. Such noises shall include, but not be limited to, the following:*
- (1) *The sounding of a horn or a similar signal device on any vehicle, except as a danger signal;*
 - (2) *The playing of any television, radio, phonograph, tape recorder, CD player or any musical instrument in any manner or at such volume, that annoys or disturbs the peace and quiet of any person within another dwelling;*
 - (3) *Allowing any animal within the person's custody or control to habitually bark, howl, yelp, roar or make similar noises;*
 - (4) *Discharging the exhaust of any internal combustion engine or motor vehicle, except through a muffler or other device which will effectively prevent loud or explosive noises;*
 - (5) *Construction activities to include the erection, excavation, demolition, alteration or repair of any building, land clearing, land grading, or road and utility construction, or other construction-related activities except in case of a public emergency or in the interest of public safety;*
 - (6) *For purposes of this section, the creation of any of the above noises between the hours of 10:00 p.m. and 7:00 a.m. Sunday through Thursday and the hours of 11:00 p.m. and 7:00 a.m. Friday and Saturday in such a manner as to be plainly audible at a distance of 50 feet from the exterior of the building, structure or vehicle within which the sound originates shall be prima facie evidence of a violation of this section. However, the fact that the above noises were created between 7:00 a.m. and 10:00 p.m. Sunday through Thursday and the hours of 7:00 a.m. and 11:00 p.m. Friday and Saturday is not a defense to prosecution under this section.*
 - (7) *Noises between the hours of 10:00 p.m. and 2:00 a.m. on every Friday and Saturday for the following geographical locations within the Broken Arrow municipal limits shall not be deemed violations of the disturbing the peace ordinance and shall not be deemed a violation of this section. Enforcement of this subsection shall be initiated by citizen complaint. The specific geographical locations exempt from the disturbing the peace ordinance on the dates and times referred to in this subsection are as follows:*
 - (i) *The Rose District/downtown area, specially noted as follows:*

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(ii) New Orleans Square Overlay District, specifically noted as follows:



(b) It shall be unlawful for any person to perform disorderly conduct in any public place or in any private dwelling or office occupied by the victim of such conduct. For purposes of this section, disorderly conduct shall include, and not be limited to:

- (1) Yelling, shouting or singing on the public streets between the hours of 11:00 p.m. and 7:00 a.m., or at any other time or place where the acts are performed so as to annoy or disturb the occupants of any dwelling, or in such a way as to disturb the occupants of schools, churches, hospitals or similar institutions; provided, that the building or grounds of the schools, churches, hospitals or similar institutions must display conspicuous signs which are legible from the public streets, indicating the nature of the facility.
- (2) Using abusive, violent or otherwise threatening language, whether the language is addressed to the party who is disturbed or addressed to some other persons. "Threatening language" includes threats to kill, threats to do bodily harm or injury, threats to destroy the property of another, the issuance of challenges to fight or the brandishing of firearms, or language likely to incite a breach of peace or an assault.
- (3) Interrupting or disrupting any lawful assembly of people, except as may be required by a public danger.
- (4) Initiating or conducting a fight through any form of actual combat.

(c) The following uses shall be exempt from this section:

- (1) Noise of safety signals and warning devices.
- (2) Noises resulting from any authorized emergency vehicle, when responding to an emergency.
- (3) Noises resulting from the provision of municipal or other governmental services.
- (4) Any noise resulting from activities of a temporary duration which is permitted by law and/or for which a waiver has been granted by the city council.
- (5) Parades and public gatherings for which a special waiver has been issued by the city council.
- (6) Bells, chimes, carillons while being used for religious purposes or in conjunction with religious services, or for national celebrations or public holidays. The city council expressly finds this

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exemption to be a reasonable accommodation to protected expressive activity yet lacking unnecessary governmental entanglements.

(7) Lawn maintenance equipment when it is functional within manufacturer's specifications and with all mufflers and noise-reducing equipment in use and in properly operating condition, when used between the hours of 8:00 a.m. and 9:00 p.m.

(8) Nonamplified crowd noises or band noises resulting from the activities such as those planned by day care centers, schools, and governmental or community groups.

(9) Amplified announcements, or electronically amplified announcements at athletic or similar special events from 8:00 a.m. to the following 12:01 a.m.

(10) Noises from electric generators during a state of emergency when declared by the mayor pursuant to section 20-3.

(d) Any person convicted of violating subsection (a) or (b) shall be punished by a fine not less than \$50.00 nor more than \$100.00.

Noise Code Interpretation

We interpret clause 16-12(a)2 to be relevant for amplified music such as is expected at the venue. Thus, the noise code's obligation is to avoid annoying or disturbing the peace and quiet of a person in a nearby dwelling. There are no specific noise level limits that would objectively exceed the noise code—just a prohibition on noise that is considered loud and unnecessary to a normal person.

The noise code indicates that some noise after 10pm Sunday through Thursday and after 11pm Friday and Saturday receives some special attention, though it does not specifically apply to amplified music.

The code anticipates the following potential exemptions from the noise code, which may be appropriate for the venue:

- Any noise resulting from activities of a temporary duration which is permitted by law and/or for which a waiver has been granted by the city council.
- Parades and public gatherings for which a special waiver has been issued by the city council.

To avoid subjective or capricious interpretation of the noise code, we would recommend seeking approval from the city council for waivers for events that meet reasonable and objective noise limits.

Note violation seems only to be subject to modest fine and violation does not appear to be subject to injunctive relief, though this should be confirmed.

3 VENUE PROGRAMMING AND SOUND SYSTEM CHARACTERIZATION

To clarify the expected environmental impact of the venue, we here characterize the expected use of the venue and its proposed sound system.

The noise levels expected to be generated at the amphitheater during events will relate to two primary factors:

- The types of events produced
- The types of sound systems used

Notes propose to operate an amphitheater that will host live musical performances. The venue may host stand-alone productions and events but will primarily host tours that travel between similar venues to different regions.

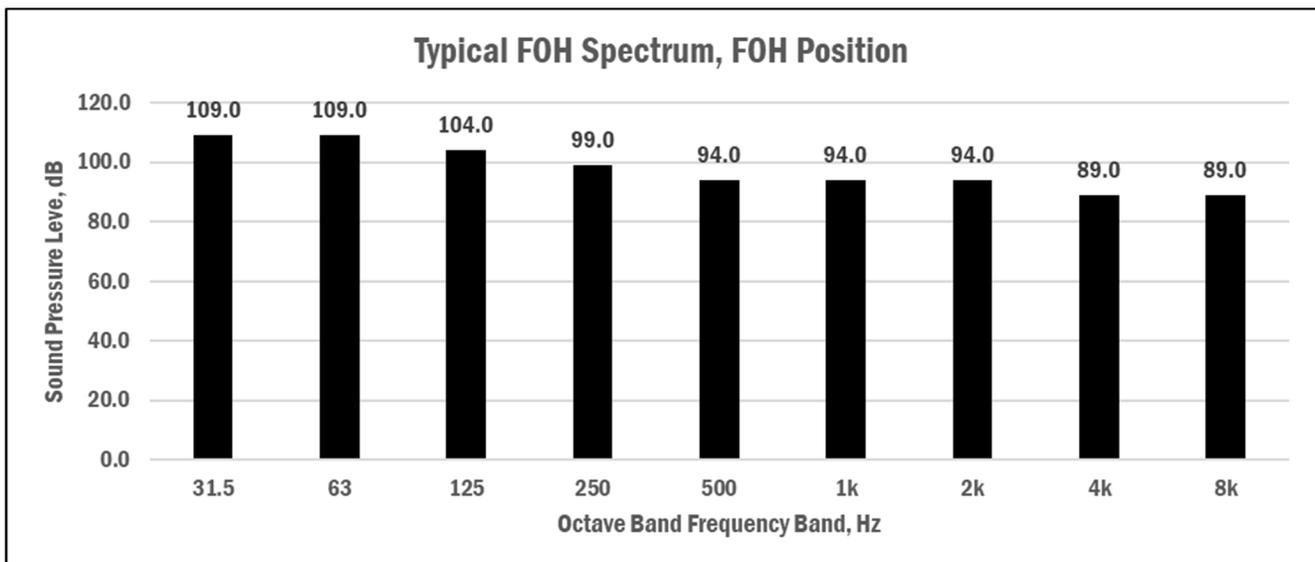
For an idea of the programming for such a venue, consider the recent performers at the popular Red Rocks Amphitheatre outside of Denver, CO, reproduced here. The performances include a mix of Rock, Pop, Hip Hop, Electronic, and Folk genres.

Such performances rely on sound systems to amplify/reinforce sound produced on stage for the audience. The music performed is typically broad spectrum, i.e. it includes sounds across the audible frequency spectrum.

The level and spectrum of sound varies temporally throughout a performance and will differ broadly between different performance types (e.g. Electronic and Hip Hop performances typically have more low frequency sound than folk music).

Despite significant variation, we can make reasonable assumptions about the typical frequency spectrum and sound level produced for typical events to facilitate estimating environmental noise. The spectrum below corresponds to 100dB(A) of broadband sound, which would be a reasonable level for a performance to reinforce at the front of house (FOH) mix position, ~100ft from the stage. Note, these would be common levels to hit periodically during a single song (not average levels).

APR 27	Ludacris / Nelly at Red Rocks Amphitheatre Ludacris Nelly Fat Joe
APR 28	Trevor Hall / Citizen Cope at Red Rocks Amphitheatre Trevor Hall Citizen Cope Rising Appalachia Gone Gone Beyond
APR 30	Sublime With Rome at Red Rocks Amphitheatre Sublime With Rome GZA Katastro
MAY 1	Tech N9ne at Red Rocks Amphitheatre Tech N9ne Joey Cool X-Raided Mayday!
MAY 2	"A Prairie Home Companion Revival" at Red Rocks Amphitheatre "A Prairie Home Companion Revival" Garrison Keillor Brad Paisley Elvin Bishop
MAY 3	Jason Isbell & The 400 Unit at Red Rocks Amphitheatre Jason Isbell & The 400 Unit Waxahatchee
MAY 4	Jason Isbell & The 400 Unit at Red Rocks Amphitheatre Jason Isbell & The 400 Unit Waxahatchee
MAY 5	Hippie Sabotage at Red Rocks Amphitheatre Hippie Sabotage Two Feet Sebastian Paul
MAY 6	Brantley Gilbert at Red Rocks Amphitheatre Brantley Gilbert
MAY 7	Brantley Gilbert at Red Rocks Amphitheatre Brantley Gilbert



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It is typical for acts touring venues of this type to travel with a main sound system which would be deployed to each side of the stage.



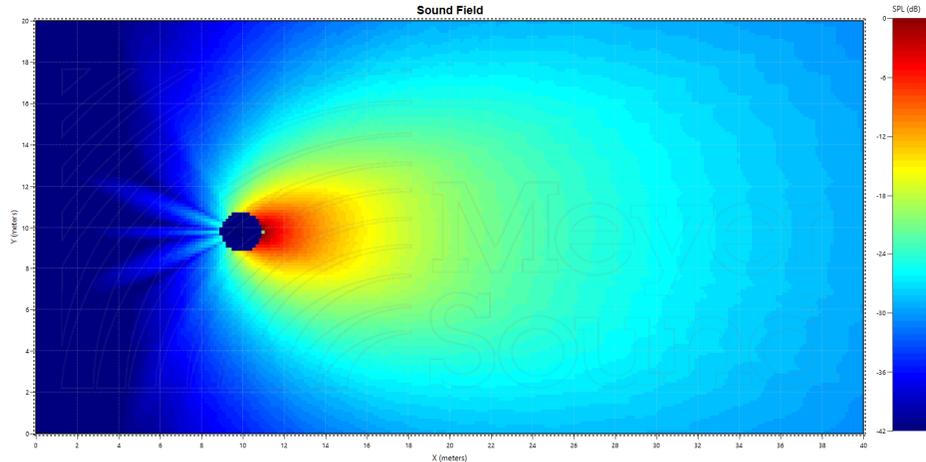
Tours typically deploy line array-type main loudspeakers. Line arrays consist of individual loudspeaker cabinets that are arrayed vertically together, as shown above.

Subwoofers are often hung in vertical arrays as shown in the left two images above. But sometimes they are stage-stacked as shown on the right.

The primary function of a sound system is to provide adequate sound level to the audience. Sound should also be consistent across the audience, i.e. not too loud at the front and too quiet at the back.

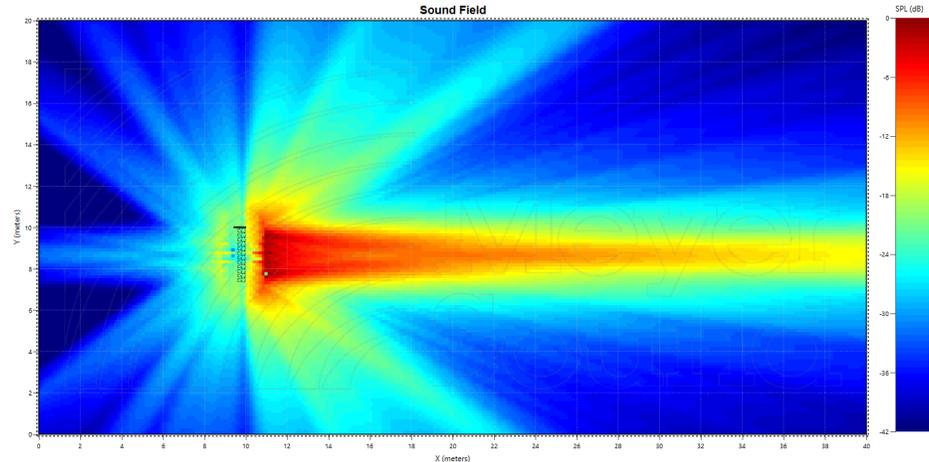
In addition to sound power output, a core characteristic of loudspeakers is directivity—How much sound energy the loudspeaker emits in different directions.

The physical design of line array loudspeakers inherently provides wide, even coverage over typical festival and amphitheater audience areas and limits noise spill in other directions.



Typical Horizontal Line Array Directivity

Note the line array's ability to limit sound emissions in the vertical plane to the axis of the loudspeaker—Little sound is “wasted” off axis. Though tours carry line array loudspeakers with different manufacturers, detailed specifications, and quantities, in practice the variation between typical line arrays is not significant.



Typical Vertical Line Array Directivity

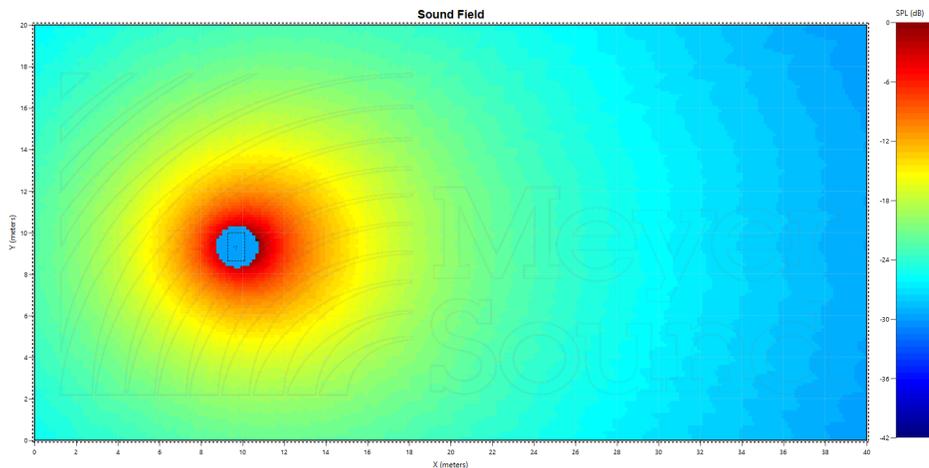
The analysis presented here was based on a Meyer LEO-M loudspeakers and is representative of all common touring line arrays (D&B, L'Acoustics, JBL, EAW, Nexo, Clair, etc)

Subwoofer systems have greater variation in their physical deployment (as shown in the photos above) and in their interior construction that can impact their directivity.

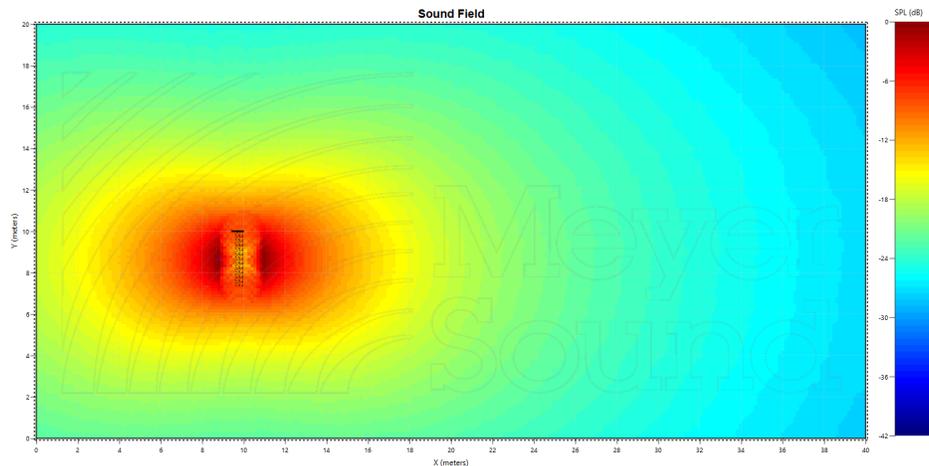
A basic individual subwoofer is effectively omnidirectional (in the vertical and horizontal planes).

When you array basic subwoofers vertically (like the line array loudspeakers), the subwoofer array exhibits pattern control in the vertical direction. In plan, the directivity is effectively unchanged.

Cardioid directivity for subwoofers can be accomplished with either inherently cardioid subwoofer cabinets or by reorienting subwoofer cabinets in array. There is significant variation on the methods to achieve cardioid subwoofer directivity.



Typical Omnidirectional Subwoofer Directivity



Vertical Array Subwoofer Directivity

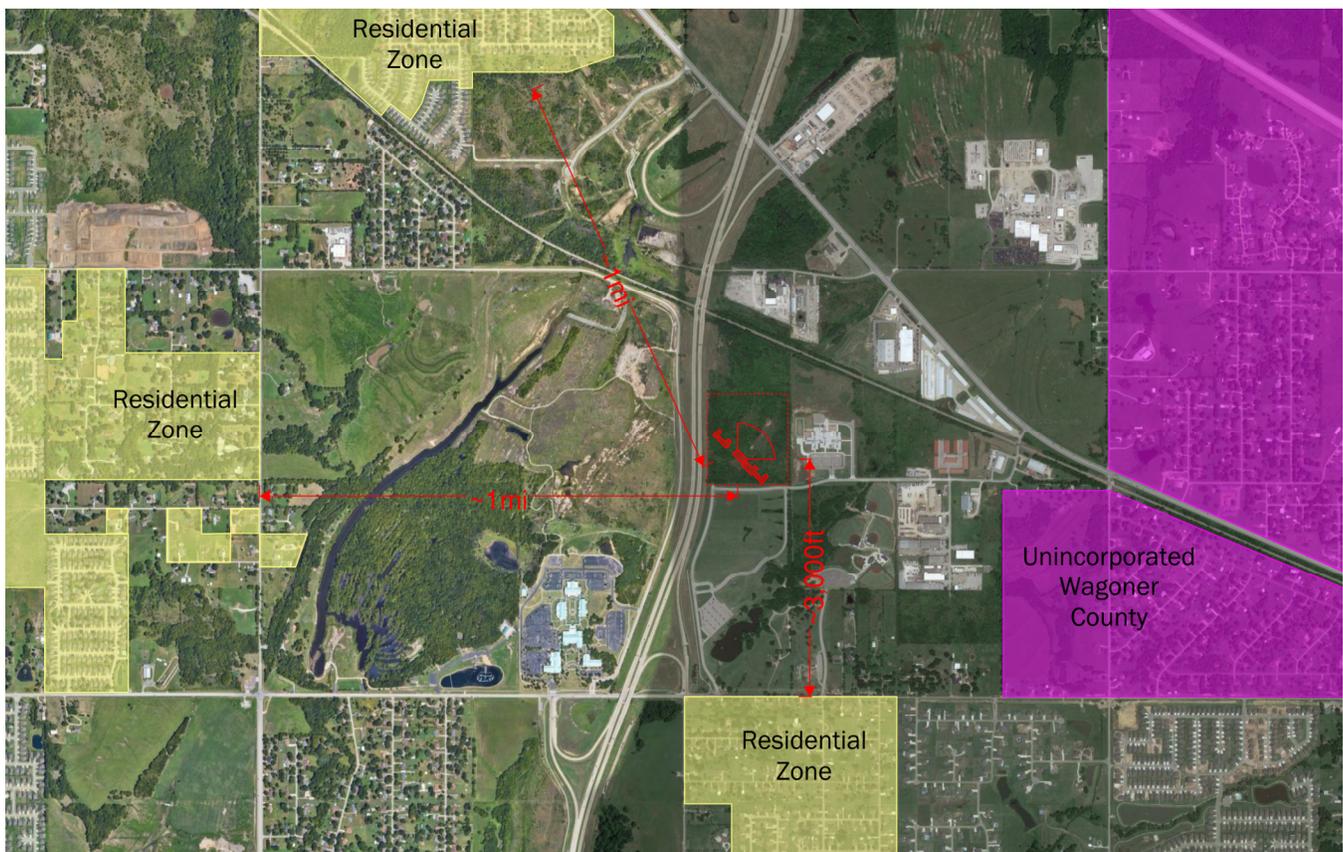
4 ENVIRONMENTAL NOISE MITIGATION

Incorporating mitigation measures can help reduce environmental noise. Noise emissions to the surrounding environment can be mitigated the following factors:

- Physical Mitigation
- Electroacoustic Mitigation
- Operational Mitigation

Physical Mitigation

The proposed amphitheater is located in Broken Arrow, OK at a site east of the Creek Turnpike, north of Events Park, west of Rosewood Elementary, and south of the Union Pacific railroad. The land immediately surrounding the site is zoned agricultural, though actual use appears varied. Most residential zoned development appears to be approximately 1mi distant from site—The closest residential development appears to be on the south-side of New Orleans St, approximately 3,000ft to the south.



The site's location adjacent to the turnpike and railroad employs good planning practice—the site and surroundings are already impacted by road and rail noise. The natural terrain is generally flat, but the raised rake of the seating bowl will reduce noise emissions toward the north-east

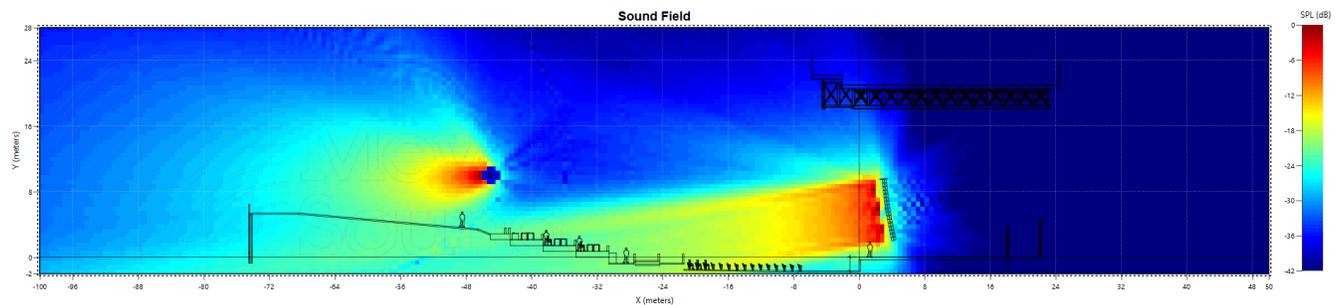
The stage has been oriented such that loudspeakers will fire north east, towards existing industrial land use.

Electroacoustic Mitigation

The types of loudspeakers typically used for performances demonstrate inherent benefits for the control of environmental noise:

- Sound from line arrays is vertically controlled to allow directing sound to the audience, without sending sound higher vertically or beyond the venue footprint horizontally. This will reduce noise emissions from the amphitheater to the north and east.
- Some subwoofer systems may be deployed in configurations to affect a cardioid directivity. This will reduce low frequency noise spill to the rear of the stage.

To further reduce sound system noise spill, the design proposes to incorporate house delay loudspeaker clusters that would be located at the front of the rear seating section (as illustrated in the conceptual mapping below). By using delay clusters, all loudspeakers (main loudspeakers at stage and delay clusters) may be operated at a lower overall sound power thus reducing overall noise emissions.



Aggregate Effect

The Physical and Electroacoustic mitigation measures described above are expected to reduce environmental noise emissions from the amphitheater, particularly toward the south, east and west. In the table below, we summarize initial analysis of the benefits of the physical and electroacoustic mitigation measures.

South of New Orleans St ~3,000ft S	Decibels (dB) at Octave Band Center Frequency (Hz)									Overall
	32	63	125	250	500	1k	2k	4k	8k	
FOH Mix Position	109	109	104	99	94	94	94	89	89	100dB(A)
Without Mitigation	79	79	74	68	62	60	57	39	0	66dB(A)
With Physical and Electroacoustic Mitigation	79	77	69	57	44	40	24	4	0	56dB(A)

These results are typical for outdoor amphitheaters—High frequency sounds are well attenuated by loudspeaker orientation and directivity, barriers, and air absorption at reasonable distances from the amphitheater. Low frequency sounds are the hardest to reduce at distance.

In our experience, these are reasonable noise emission levels from an amphitheater. Given the subjective language in the relevant noise code, we recommend these results be reviewed with the relevant authorities.

Operational Mitigation

In addition to the physical and electroacoustic mitigation described in the preceding sections, we propose that the amphitheater should adopt additional operational mitigations strategies. These are appropriate both as a good faith effort as a member of the community and to address the limitations of the physical and electroacoustic mitigation strategies:

- Some productions may be inclined to operate sound systems at noise levels in excess of our assumed spectrum.
- Weather events (wind, temperature inversions) may cause noise emissions in excess of those estimated here.

As such, the following specific operational mitigation strategies have been developed with Notes:

<p>Operating Hours</p>	<ul style="list-style-type: none"> • Sunday through Thursday <ul style="list-style-type: none"> • Events would typically occur during the evening. • Performances would typically begin between 7-8pm. • Sound check would begin after 3pm. • Performances would end not later than 10:30pm. • Friday and Saturday <ul style="list-style-type: none"> • Events would typically occur during the afternoon and evening. • Performances would typically begin between 3-8pm. • Sound check would begin after 12pm. • Performances would end not later than 11:00pm.
<p>Controls on Touring Sound Systems</p>	<ul style="list-style-type: none"> • The main loudspeakers of touring sound systems are expected to be line-array type. • The main loudspeakers and subwoofers would be rigged no higher than 40ft above stage. • Where practical, subwoofers can be arrayed to provide low frequency directivity. • Performances are expected to make use of permanently installed delay cluster loudspeakers. Main loudspeakers would be rigged and aimed only to serve the lower, seated sections.
<p>Noise Monitoring and Performance Controls</p>	<p>The amphitheater is expected to establish operational maximum sound levels for performances and if performances exceed these levels, active steps would be taken to reduce noise levels.</p> <ul style="list-style-type: none"> • Noise monitoring would be conducted during performances at the FOH mix position. The noise limits are expected as follows: <ul style="list-style-type: none"> • Broadband noise levels measured at the FOH mix position exceeding 105dB(A), L10 in any 30 minute period. • Should noise levels exceed those documented above, the venue operator would promptly inform the event production team and instruct the event production team to reduce noise levels to a level appropriate to maintain the requirements. • Event production teams are expected to be obligated by their contracts to comply with the venue operator’s directions and may be subject to prematurely terminating events if the performance remains out of compliance.

5 NEXT STEPS

We propose the assessment here be reviewed with the relevant authorities. Following relevant approvals, we expect to further develop the details of these mitigation strategies into the architectural design for the project.