2025 JUN 24
Isolating Source Contributions

David A. Nelson
Fellow, Institute of Noise Control Engineering
Principal Consultant
Nelson Acoustics
www.nelsonacoustical.com

Methods for Isolating the Source

- Measurements and Mathematics:
  - Measure the “neighborhood residual” - everything but the Source
  - Measure the “total sound” – everything including the Source
  - Use decibel subtraction to determine the Source contribution
    - Note: the level difference must be ≥ 3 dB to do the subtraction per ANSI standard
- Behind Barrier
  - Estimate the neighborhood residual by measuring behind the residence or other structure that blocks the Source
- Similar Neighborhood
  - Estimate the neighborhood residual by measuring at the same distance from a nearby roadway but much farther from the Source

Summary

Source	Method	LpA,eq	LpC,eq	31.5	63	125	250	500	1000	2000	4000	8000	
Hornbaker	Behind Barrier, Location A	OK	OK	OK	OK	+4	OK	OK	+7	+6	+2	---	Data Center out of compliance
Hornbaker	Behind Barrier Location B	OK	OK	---	---	OK	OK	OK	OK	OK	OK	---	Secondary sources ruled out
Wellington Glen	Behind Barrier	OK	OK	OK	OK	---	OK	OK	---	OK	---	---	< 3 dB differences
Novant Hospital	Along Roadway	OK	OK	OK	OK	OK	OK	+0	+1	OK	---	---	Just out of compliance - may be traffic
Marsteller School	Along Roadway	OK	OK	OK	OK	OK	OK	OK	OK	OK	+12	+8	Bugs, otherwise Compliant
10224 Winged Elm	Backyard - Frontyard	OK	OK	OK	+2	+1	OK	+0	+2	OK	OK	---	Data Center out of compliance
10224 Winged Elm	Along Roadway vs Frontyard	OK	OK	OK	+2	+1	OK	+0	+2	OK	---	---	Data Center out of compliance
10224 Winged Elm	Property Line - Frontyard	OK	OK	OK	+1	+1	OK	+0	OK	---	OK	---	Property Line levels < Backyard Levels
10224 Winged Elm	6/25/12 Backyard vs Frontyard	+4	+5	OK	+4	+9	+12	+8	+1	OK	OK	OK	Data Center out of compliance

KEY:	
OK	Source ≤ Criterion
---	Source not measurable
+X	Source > Criterion by X dB
	Out of Compliance
	Biogenic Noise ("Bugs")

Hornbaker

Level Difference < 3

Source	Description	Start Time	LpA,eq	LpC,eq	LpF,50 31.5	63	125	250	500	1000	2000	4000	8000
Hornbaker	Property Line, South End of Bldg	6/10/25 00:54	49	63	61	59	57	48	42	44	40	35	24
Hornbaker	Behind Barrier	6/10/25 01:08	45	61	58	57	55	46	39	38	34	31	27
	Net Apparent Source Contribution		46	59	57	54	54	43	39	43	39	33	---
		Night Criterion	**47**	**60**	**63**	**55**	**50**	**45**	**40**	**36**	**33**	**31**	**30**
		Compliance Status	**OK**	**OK**	**OK**	**OK**	**+4**	**OK**	**OK**	**+7**	**+6**	**+2**	---

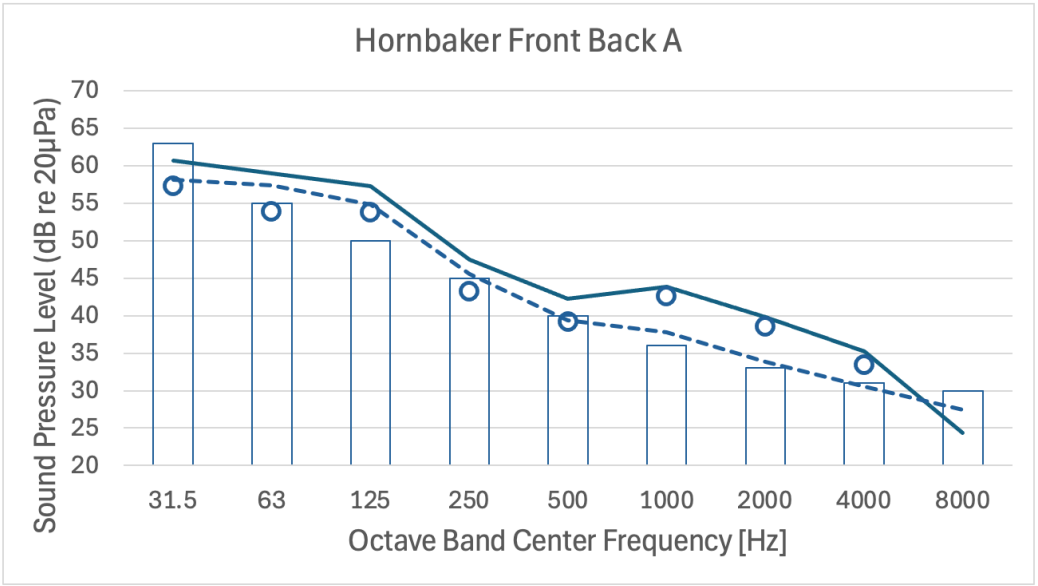
Total Sound (solid line)

Residual Sound (dashed line)

Apparent Source Contribution (circles)

Criterion (bars)

If circle > bar, out of compliance

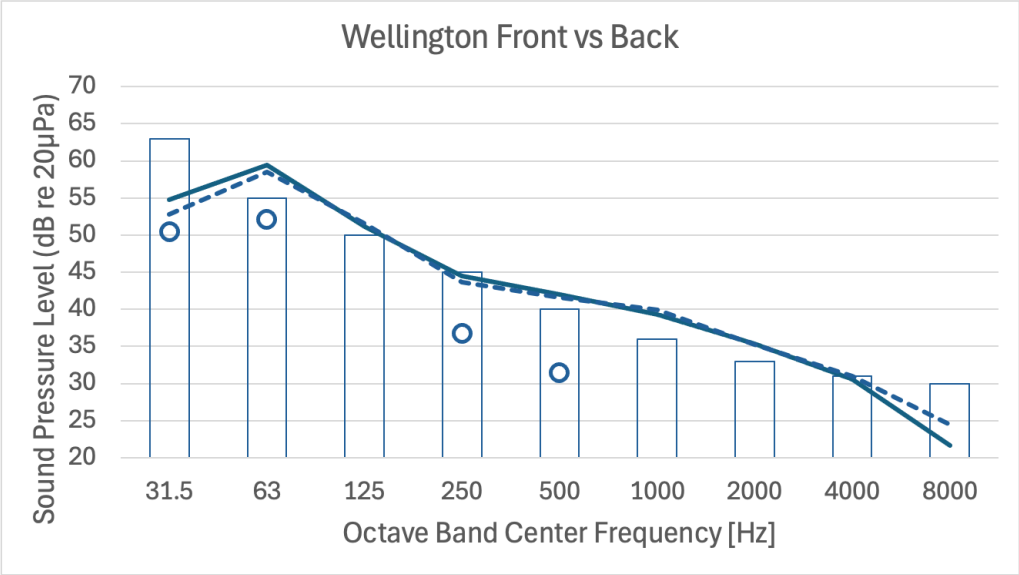


Wellington Glen (Iron Mountain)

					LpF,50								
Source	**Description**	**Start Time**	**LpA,eq**	**LpC,eq**	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Wellington Glen	Facing Data Center	6/10/25 01:54	46	61	55	59	51	45	42	39	35	31	22
Wellington Glen	In Courtyard	6/10/25 02:06	45	60	53	59	52	44	42	40	35	31	25
	Net Apparent Source Contribution		34	51	50	52	---	37	31	---	19	---	---
		Night Criterion	**47**	**60**	**63**	**55**	**50**	**45**	**40**	**36**	**33**	**31**	**30**
		Compliance Status	**OK**	**OK**	**OK**	**OK**	**---**	**OK**	**OK**	**---**	**OK**	**---**	**---**

All Level differences < 3 dB
Source contribution not accurate
In compliance at the moment

However past measurements indicated a strong low-frequency tone that would have been out of compliance



Novant Hospital

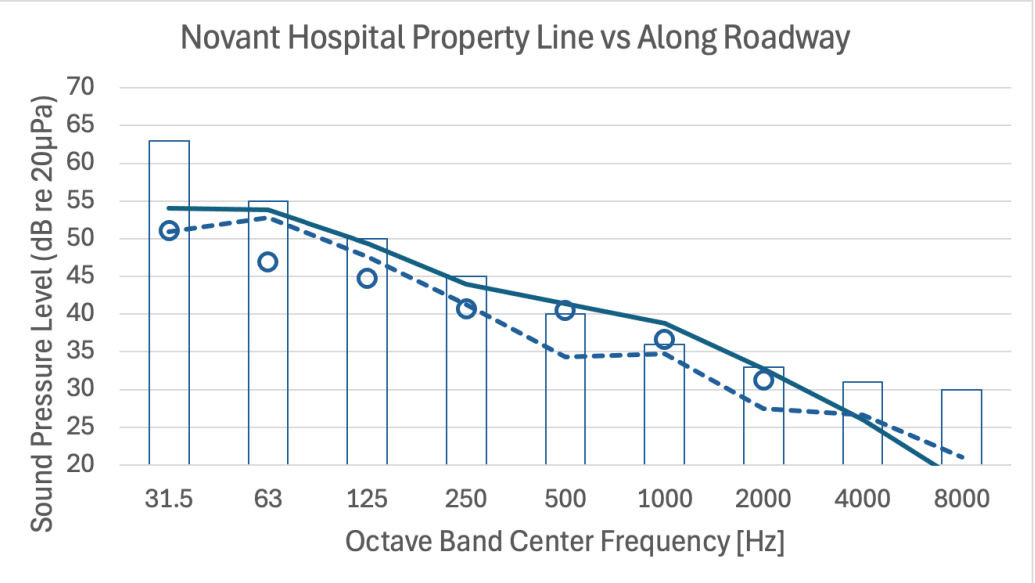
Source	Description	Start Time	LpA,eq	LpC,eq	LpF,50 31.5	63	125	250	500	1000	2000	4000	8000
Novant Health	Property Line	6/10/25 02:47	45	58	54	54	49	44	41	39	33	26	18
Novant Health	Along Highway similar Distance	6/10/25 02:32	40	55	51	53	48	41	34	35	27	27	21
	Net Apparent Source Contribution		43	53	51	47	45	41	40	37	31	---	---
		Night Criterion	**47**	**60**	**63**	**55**	**50**	**45**	**40**	**36**	**33**	**31**	**30**
		Compliance Status	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**+0**	**+1**	**OK**	---	---

Large distance to along highway point

Several roadways in the area

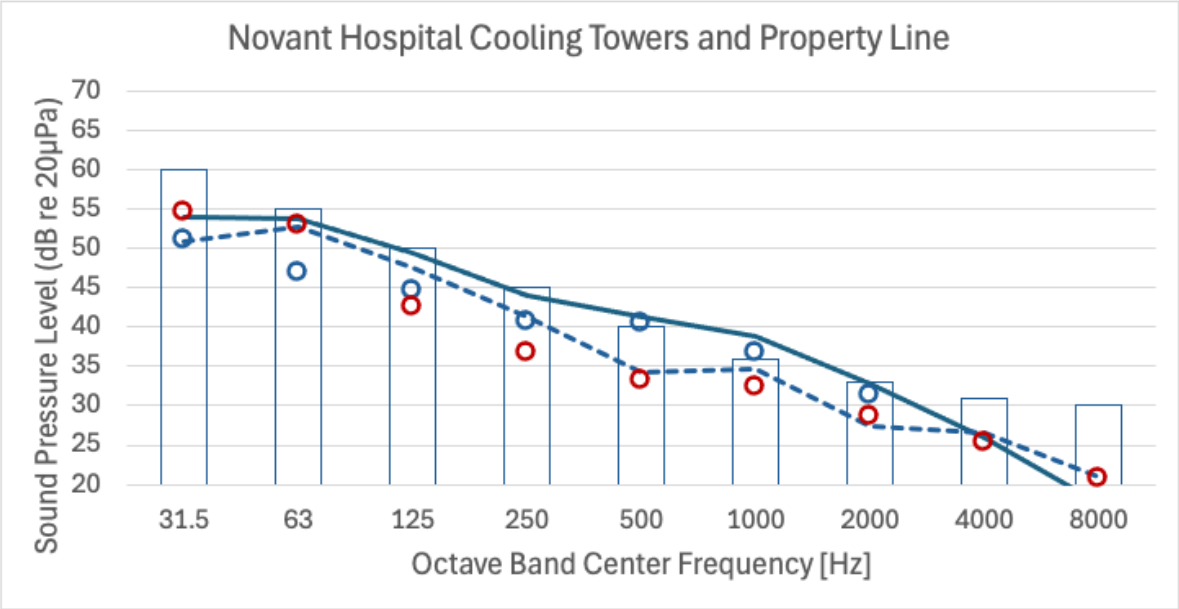
The Total sound at the property line may include “extra” traffic noise not included in the residual

Additional measurements recommended



Novant Hospital – extrapolate from cooling towers

- A measurement relatively near the Cooling Towers
- Extrapolate to property line
  - Buildings and other potential noise sources nearby
- Cooling Tower contribution estimate in red circles
- Cooling Tower does not appear to be the source of the 500 and 1000 Hz exceedance



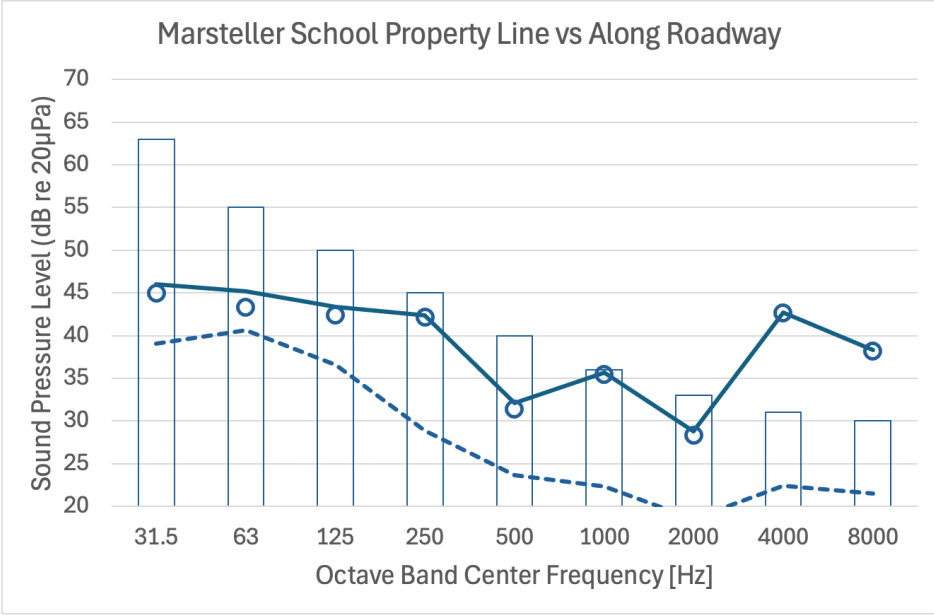
Marsteller School rooftop HVAC equipment

					LpF,50									
Source	**Description**	**Start Time**	**LpA,eq**	**LpC,eq**	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**LpA',50**
Marsteller School	Property Line beside water tower	6/10/25 03:39	46	51	46	45	43	42	32	36	29	43	38	39
Marsteller School	Across Road similar distance	6/10/25 03:24	31	44	39	41	37	29	24	22	19	22	22	27
	Net Apparent Source Contribution		46	50	45	43	42	42	31	35	28	43	38	
		Night Criterion	**47**	**60**	**63**	**55**	**50**	**45**	**40**	**36**	**33**	**31**	**30**	
		Compliance Status	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**+12**	**+8**	

Significant bugs in 4000 and 8000
possibly 1000 as well

Surprisingly low levels for residual

In compliance at all remaining bands



10224 Winged Elm – Backyard at Ground Level

					LpF,50								
Source	**Description**	**Start Time**	**LpA,50**	**LpC,50**	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
AWS DC	Backyard 10224 Winged Elm Cir	6/12/25 04:06	44	60	57	58	52	44	42	40	30	18	13
Along Roadway	GlenCrest and SunnySlope	6/12/25 03:25	40	53	48	52	46	39	37	35	29	26	22
	Net Apparent Source Contribution		42	59	57	57	51	42	40	38	20	---	---
		Night Criterion	**47**	**60**	**63**	**55**	**50**	**45**	**40**	**36**	**33**	**31**	**30**
		Compliance Status	**OK**	**OK**	**OK**	**+2**	**+1**	**OK**	**+0**	**+2**	**OK**	**---**	**---**

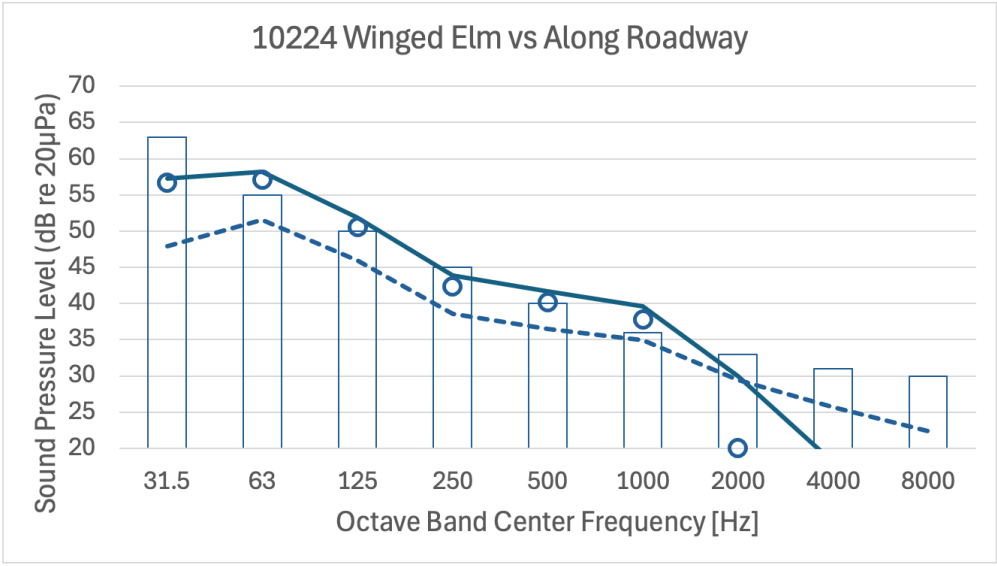
Behind Barrier and Along Roadway methods gave identical results

VRE was active during measurement

VRE 90 Hz tone and harmonics removed by signal processing

Other VRE noises may remain

Re-measurement recommended



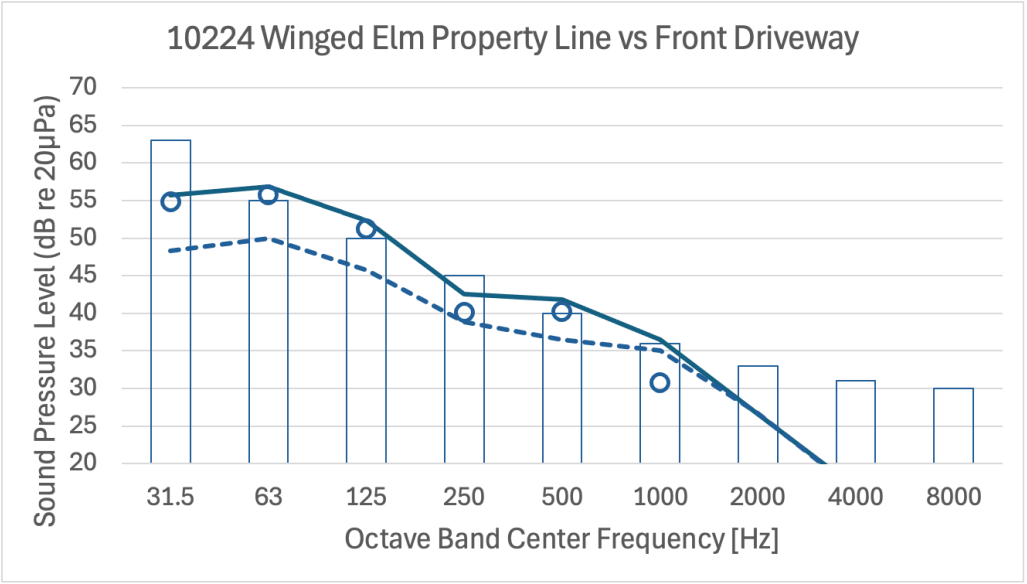
10224 Winged Elm – Property Line

Source	Description	Start Time	LpA,50	LpC,50	LpF,50 31.5	63	125	250	500	1000	2000	4000	8000
AWS DC	Property Line	6/12/25 03:55	43	59	56	57	52	43	42	36	27	17	13
AWS DC	Front Driveway 10224 Winged Elm Cir	6/12/25 03:42	39	53	48	50	46	39	36	35	27	16	13
	Net Apparent Source Contribution		41	58	55	56	51	40	40	31	---	5	---
		Night Criterion	**47**	**60**	**63**	**55**	**50**	**45**	**40**	**36**	**33**	**31**	**30**
		Compliance Status	**OK**	**OK**	**OK**	**+1**	**+1**	**OK**	**+0**	**OK**	**---**	**OK**	**---**

Property Line levels < Backyard Levels
despite lesser distance

Suggests acoustic shadow of building reducing levels of rooftop equipment

Recommend re-measurement 25’ from back of house at height of 2nd story window



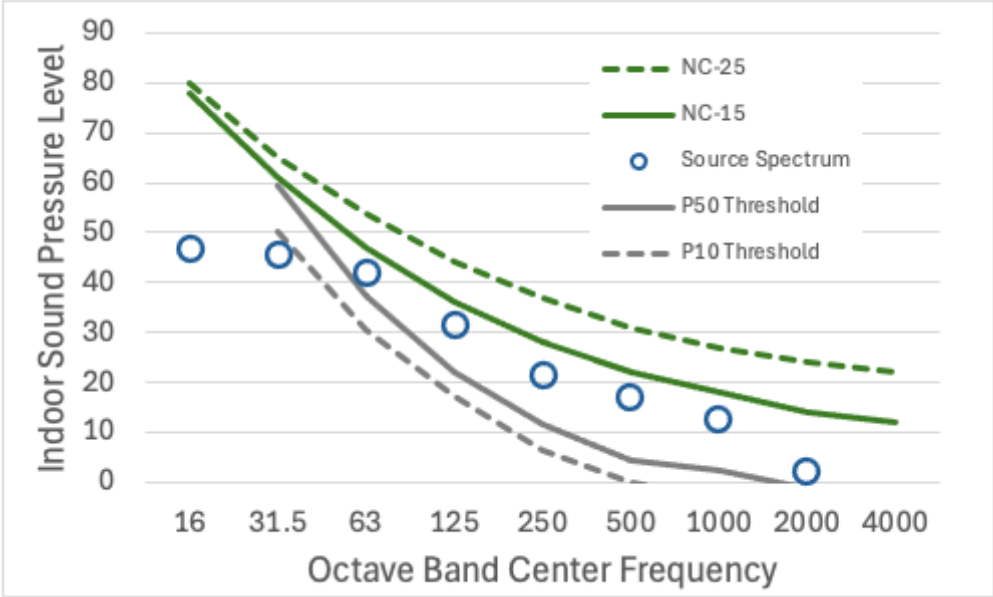
Est'd Sound Levels indoors 10224 Winged Elm 6/12

- Start from Source sound levels
  - $L_{pA,outdoor} \approx 42$, below WHO recommendation of 45
- Subtract typical noise reduction (NR) of wood-frame residence
- Evaluate interior sound spectrum
  - $L_{pA.indoor} \approx 21$, well below WHO recommendation of 30
  - NC rating is below 15, which is appropriate for broadcast studios
  - NC 25 is considered compatible with residential bedrooms

	16	31.5	63	125	250	500	1000	2000	4000	A	C	NC
Source Contribution	55	57	57	51	42	40	38	27	13			
Typical House NR	8	11	15	19	21	23	25	25	25			
Net Indoors	47	46	42	32	21	17	13	2	-12	21	46	11

Audibility of Interior Levels 6/12

- The “average” listener (P50) would be able to detect the presence of the sound at 63 Hz and above in an otherwise silent background
- Sensitive listeners (P10) might also be able to detect the 31.5 Hz band as well (depending on spectrum)
- The difference between sound levels with and without the source would also be detectable



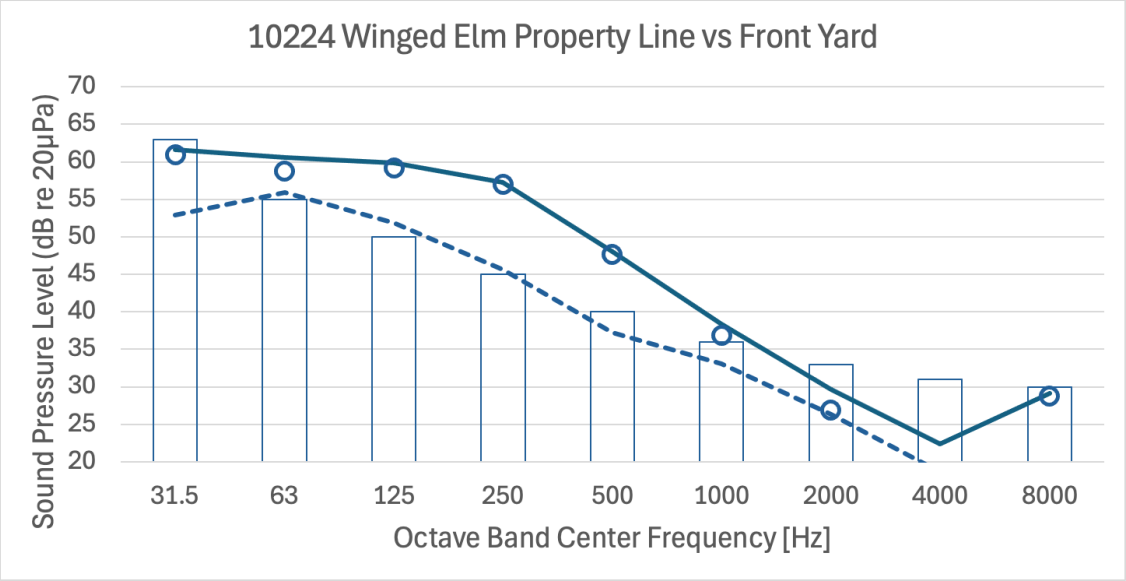
6/25 AM Testing 10224 Winged Elm

Source	Description	Start Time		LpA,50	LpC,50	LpF,50 31.5	63	125	250	500	1000	2000	4000	8000
AWS DC + ?	Backyard Elevated 10224 Winged Elm (		6/25/25 01:46	51	66	62	61	60	57	48	38	30	22	29
AWS DC + ?	Front Driveway 10224 Winged Elm Cir		6/25/25 02:01	42	58	53	56	52	46	37	33	26	19	17
	Net Apparent Source Contribution			51	65	61	59	59	57	48	37	27	20	29
			Night Criterion	**47**	**60**	**63**	**55**	**50**	**45**	**40**	**36**	**33**	**31**	**30**
			Compliance Status	**+4**	**+5**	**OK**	**+4**	**+9**	**+12**	**+8**	**+1**	**OK**	**OK**	**OK**

Backyard measurement elevated 15’

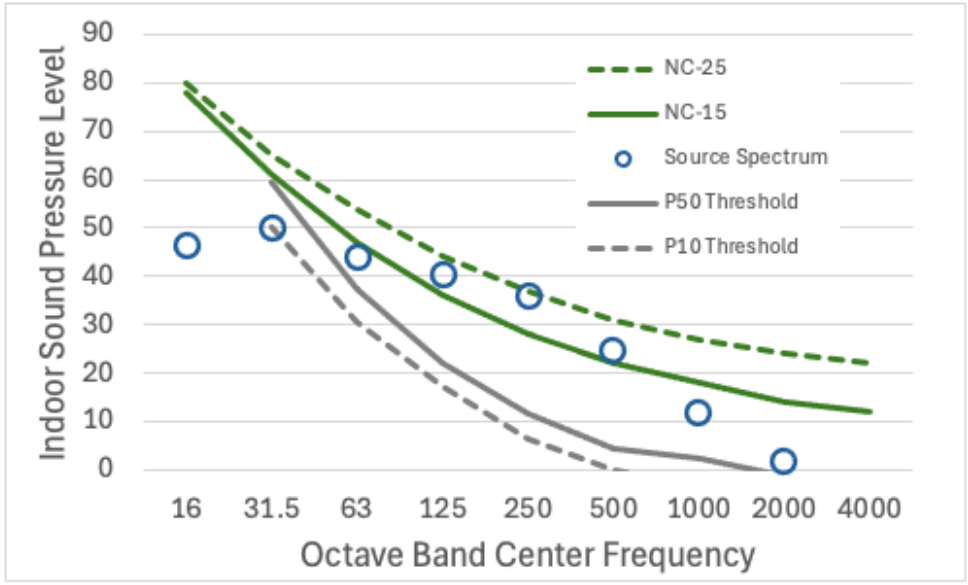
AC unit off

Hot, humid weather – expect high fan speeds at an air-cooled data center



Audibility Indoors 6/25

	16	31.5	63	125	250	500	1000	2000	4000	A	C	NC
Source Contribution	55	61	59	59	57	48	37	27	20			
Typical House NR	8	11	15	19	21	23	25	25	25			
Net Indoors	47	50	44	40	36	25	12	2	-5	30	50	24



Effect of Interior Levels

- Outdoor levels are well below those needed to create perceptible structural vibration
  - Even when combined with the neighborhood residual
- Example reasons why these levels could nevertheless be experienced as “loud”:
  - A listener has involuntarily learned to focus on it
  - A listener has exceptionally sensitive hearing
  - Structural resonances are present:
    - in walls, can increase sound levels particularly in the 16 Hz band
    - in windows, can increase sound levels up to and including the 125 Hz band
  - Room acoustic resonances are present:
    - can increase tonal sound levels from the 31.5 Hz to the 125 Hz band, inclusive