TRB ADC 40 Summer Meeting, Minneapolis

Estimating long-term noise levels from short-term noise measurements and a long term reference location

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AECOM

Or...

How I learned to stop worrying and love the Long Term Reference Method!

Introduction

Why is this method needed?

- Many noise analyses may require determination of long-term noise metrics (such 24-hour Leq, Ldn, CNEL, etc.).
- Conducting actual long-term measurements at all analysis locations may present challenging issues regarding cost, security and property access.
- The presented method, when applied with appropriate assumptions and limitations, addresses the above issues.
- And way not?

The Long-Term Reference Method (LTRM)

- The long-term reference method (LTRM) is simply a method by which long-term (LT) noise levels can be estimated from short-term (ST) measurements by comparing the ST measurement values to measured values for the same period as a nearby LT reference measurement location and then applying the difference to the LT measured values at the reference location.

- While the method is simple to apply, the noise environmental and dominant noise sources must be judged to be similar to those experienced at the LT reference location.

LTRM - Basic Technique (1/4)

1. LT Measurements (reference location):

- Identify a limited number of representative LT sound measurement locations within the study area and conduct continuous 24-hour measurements at these locations.
- The number of LT measurement locations would vary by size of study area and the number and proximity of dominant noise sources.

LTRM - Basic Technique (2/4)

2. ST Measurements (receiver locations):

- While the LT measurements are running, conduct a set of ST sound measurements (typically between 15 and 30 minutes each) within an area represented of the long term measurement and which is assumed to be affected by the same dominant sound sources and daily variation in sound levels.

- The number of ST measurements per representative LT measurement may vary according to study area size and site characteristics, but typically not more than four or five locations.

- Both LT and ST measurement should be conducted with discrete, synchronized measurement intervals of one or five minutes each.

LTRM - Basic Technique (3/4)

3. Calculate LT Metrics

- Once measurements are complete, calculate the desired 24-hour metric values for the LT locations (24-hour, Leq, Ldn, CNEL, etc.).

4. Calculate ST Leq for ST and LT locations

- For each ST measurement location, calculate the Leq value for the ST measurement period, as well as the corresponding simultaneous Leq value at the associated LT measurement locations for the same time period.

LTRM - Basic Technique (4/4)

5. Calculate Delta.

- Calculate the arithmetic difference (or delta) between the simultaneous ST measurement values for the LT and ST locations.

6. Scale LT metric by Delta

- Apply the difference between the measured ST values at the ST and LT locations to the calculated LT 24-hour metric to determine the estimated 24-hour value at the ST location.

LTRM - Basic Technique

This process may be expressed by the following formula, for an estimated $Leq_{(24\text{-hr})}$ value:

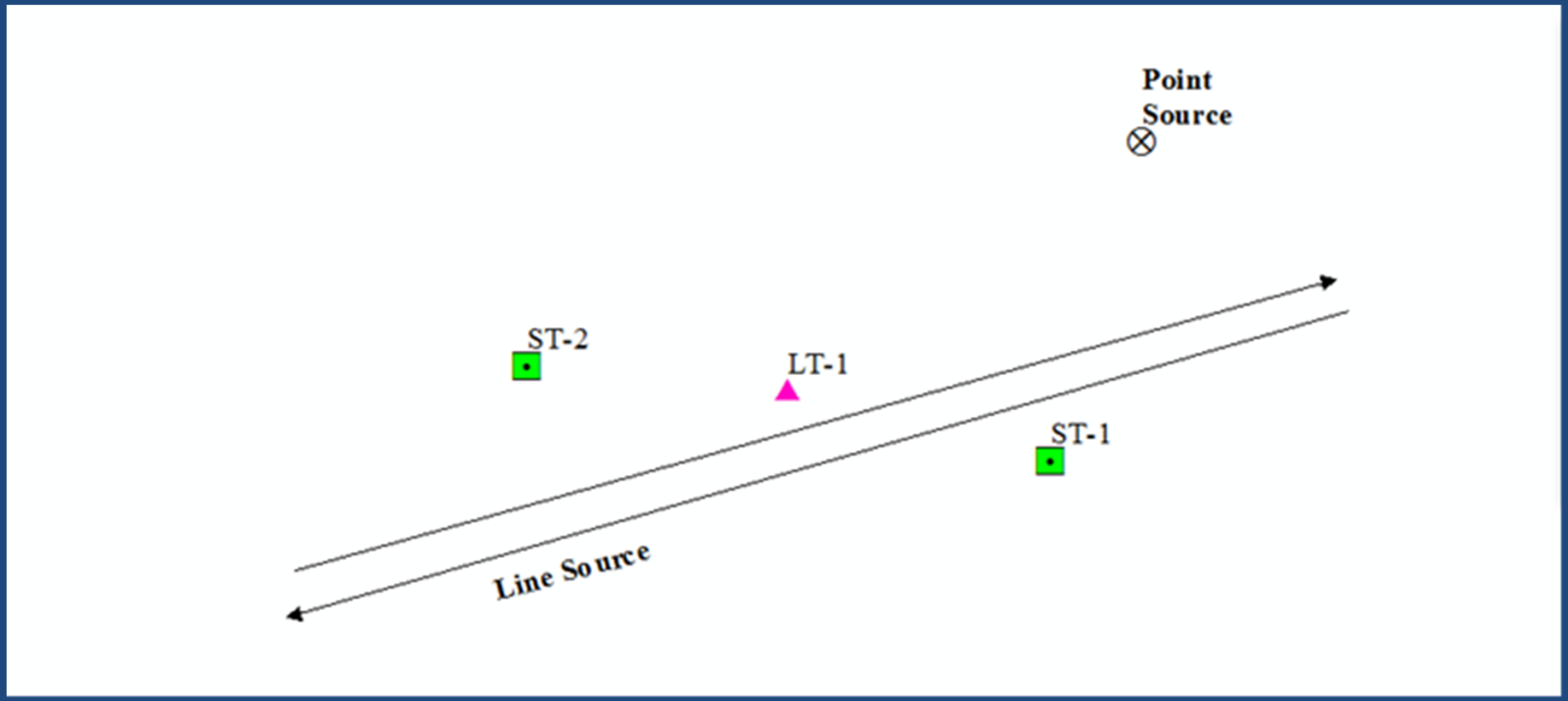
$$Leq_{(24\text{-hr})}(ST) = Leq_{(24\text{-hr})}(LT) + [Leq_{(20\text{-min})}(ST) - Leq_{(20\text{-min})}(LT)]$$

Where:

$Leq_{(24\text{-hr})}(ST)$ is the LTRM estimated 24-hour Leq at the ST location
$Leq_{(24\text{-hr})}(LT)$ is the measured 24-hour Leq at the LT location
$Leq_{(20\text{-min})}(ST)$ is the measured 20-minute Leq at the ST location
$Leq_{(20\text{-min})}(LT)$ is the measured 20-minute Leq at the LT location measured at the same time

LTRM – Simple Example

For the simple case shown below, consider one LT and two ST measurement locations, all exposed to a highway and another nearby point source.



LTRM – Simple Example

For this example, for a ST location: ST-1 taken between 9:00 and 9:15 am and be compared to the same period at a nearby LT reference location (LT-1) and then that difference can be applied to the measured LT value. This is then repeated for each ST measurement.

Measurement location ID	LT-1	ST-1	ST-2
Measurement period	9:00 am to 9:00 am	10:00 to 10:20 am (P1)	11:00 to 11:20 am (P2)
Measurement duration	24 hour	20 minute	20 minute
Measured $Leq_{(24\text{-}hr)}$	67.5 dBA	--	--
Measured $Leq_{(20\text{-}min)}$, (P1)	69.4 dBA	68.2 dBA	--
Measured $Leq_{(20\text{-}min)}$, (P2)	69.2 dBA	--	64.8 dBA
Leq delta (LT minus ST)	--	1.2	4.4
Estimated $Leq_{(24\text{-}hr)}$ (Measured LT Leq – delta)	--	66.3 dBA	63.1 dBA

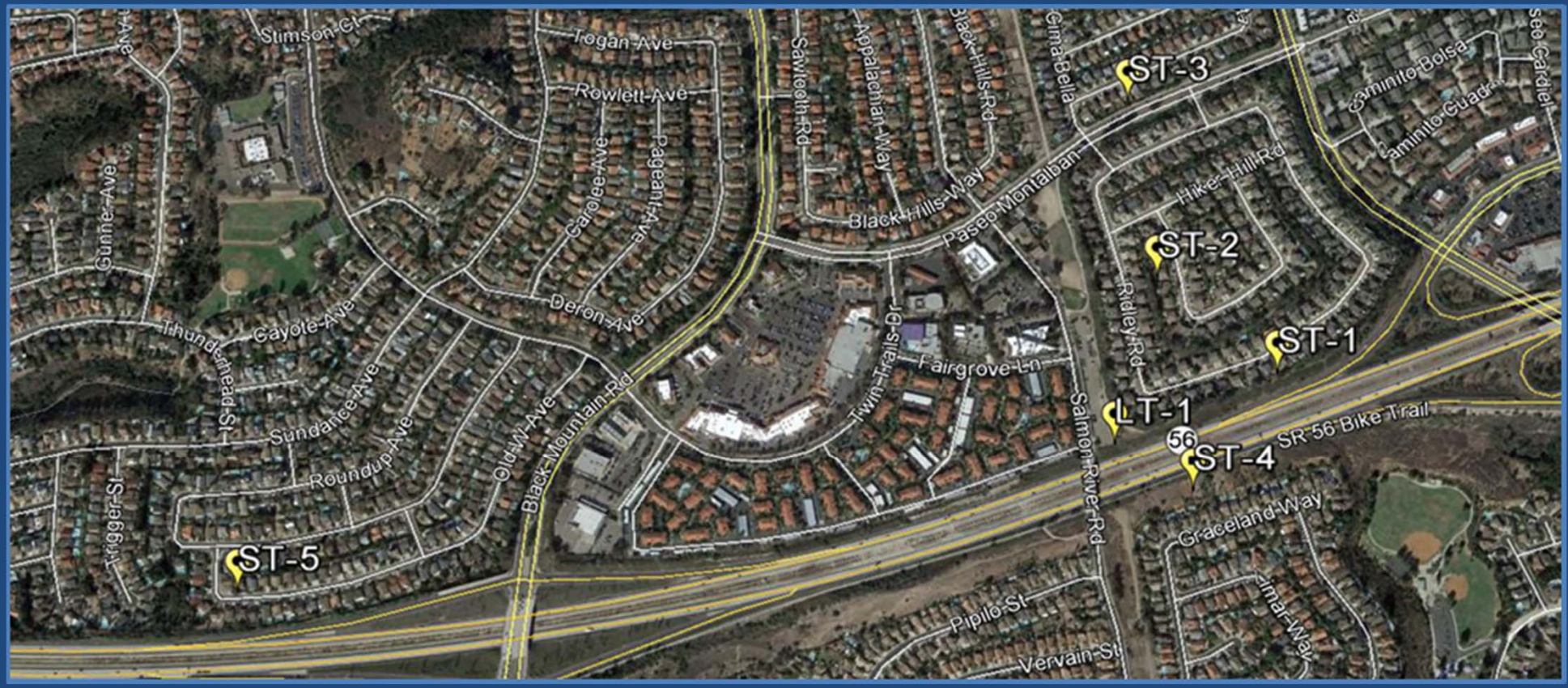
LTRM – Assumptions and Limitations

- Similar noise environment
- Similar dominant noise sources
- Similar variation in daily noise levels

LTRM Validation Methodology

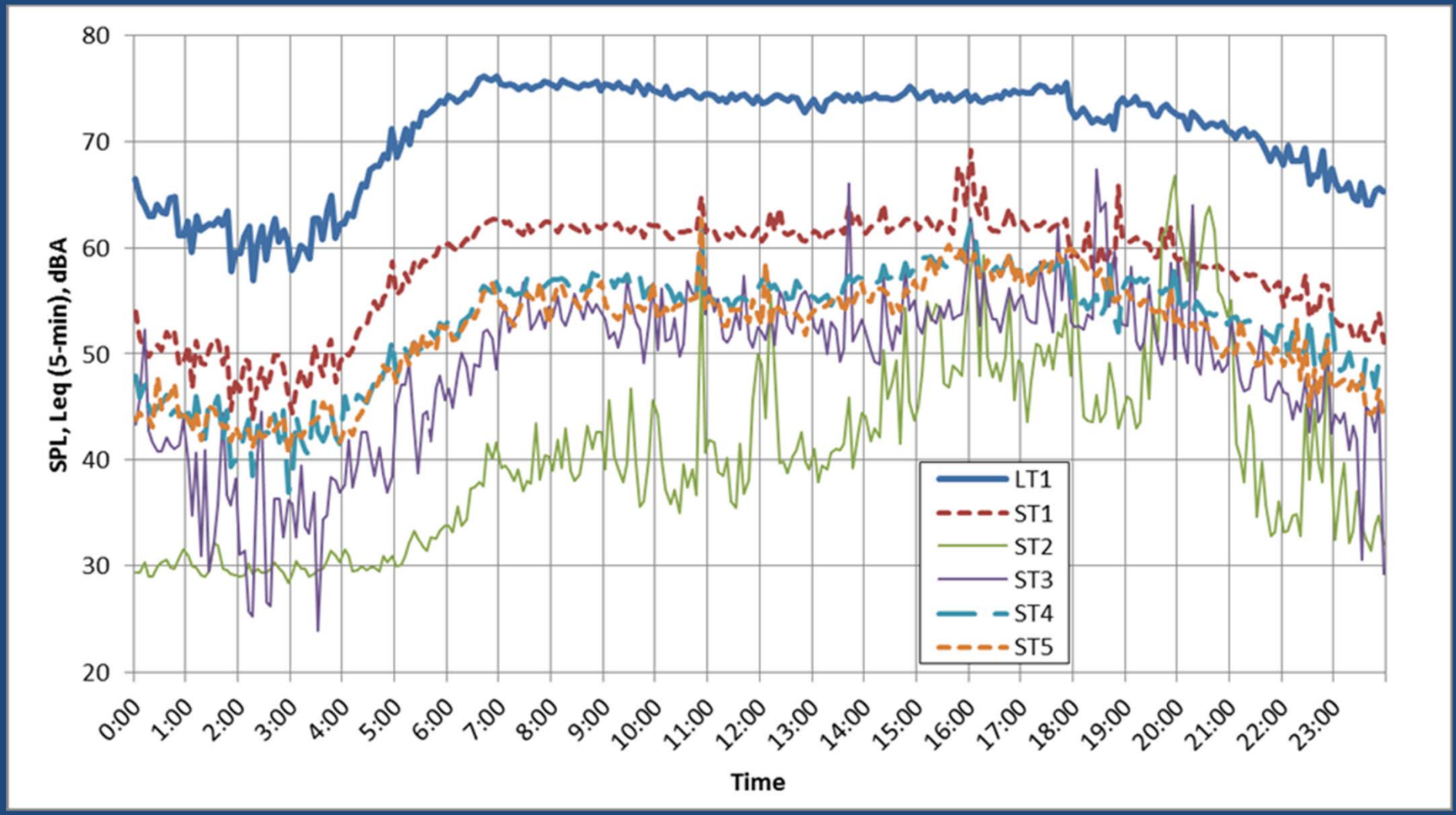
- Conduct a small scale test with a typical LT reference measurement location and several ST measurement locations.
- For validation, conduct “ST” measurements for a full 24-hour period.
- Compare LTRM estimated LT values at ST measurement locations to actual LT values measured at those same locations.
- Evaluate the quality of the LTRM estimates to the actual LT values.

LTRM Validation Test Set-up



LT and ST Validation Measurement Locations

Validation Measurement Results



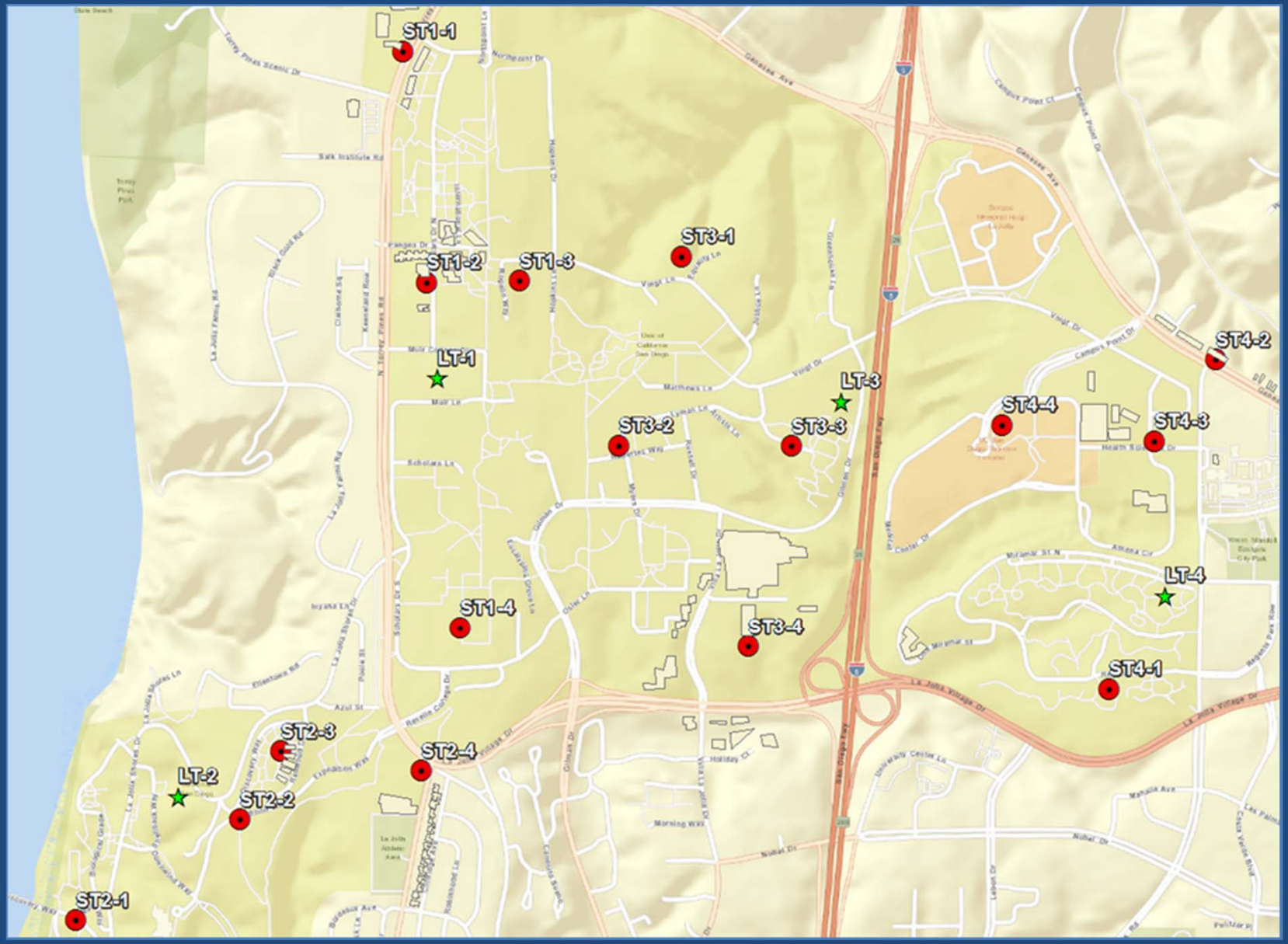
Validation measurement data for all LT and ST locations

Validation Test Results

Estimated and actual CNEL values at all locations

Measurement Location	ST1	ST2	ST3	ST4	ST5
ST measurement period	9:00-9:20	10:00-10:20	11:00-11:20	12:00-12:20	13:00-13:20
ST measured ST level	62.2	40.6	54.6	56.7	54.3
LT measured ST level	75.3	74.6	74.2	73.9	73.4
LT-ST delta	13.1	34.1	19.6	17.2	19.1
LT CNEL (measured)	76.9	76.9	76.9	76.9	76.9
ST CNEL (LTRM estimated)	63.8	42.8	57.3	59.7	57.7
ST CNEL (measured)	63.9	55.1	55.8	58.4	57.5
Error (measured - estimated)	0.1	12.3	-1.5	-1.3	-0.2
Result	Excellent	Poor	Good	Good	Excellent

Wide Scale Application Case Study



Case Study Results

Location	Duration	ST time	ST level	LT Level	LT-ST delta	CNEL
LT-1	24-hr	--	--	--	--	46.4
ST1-1	30-min	11:10-11:35	64.0	50.0	14.0	60.4
ST1-2	30-min	12:00-12:30	64.9	63.5	1.4	47.8
ST1-3	30-min	10:25-10:50	47.8	50.8	-3.1	43.4
ST1-4	30-min	12:50-13:20	51.7	52.5	-0.8	45.6
LT-2	24-hr	--	--	--	--	48.2
ST2-1	30-min	16:45-17:15	60.7	53.4	7.3	55.5
ST2-2	30-min	15:55-16:25	57.8	56.9	0.9	49.1
ST2-3	30-min	15:15-45:45	48.3	56.2	-7.9	40.3
ST2-4	30-min	17:35-18:05	64.1	52.8	11.3	59.5
LT-3	24-hr	--	--	--	--	55.5
ST3-1	30-min	13:05-13:35	54.3	61.2	-6.9	48.6
ST3-2	30-min	14:45-15:15	60.3	61.6	-1.4	54.1
ST3-3	30-min	15:45-16:15	65.6	60.8	4.7	60.3
ST3-4	30-min	16:30-17:00	54.1	59.5	-5.4	50.1
LT-4	24-hr	--	--	--	--	44.9
ST4-1	30-min	17:20-17:50	55.3	55.1	0.2	45.1
ST4-2	30-min	11:10-11:40	65.7	56.7	9.1	54.0
ST4-3	30-min	10:25-10:55	62.1	55.7	6.4	51.3
ST4-4	30-min	12:00-12:30	56.4	50.1	6.3	51.2

Use for Determining Loudest Hour

- For highway noise projects 24-hour metrics are not usually required.
- However, a long-term reference measurement can still be helpful to empirically determine the loudest hour and to identify periods when noise levels are reduced by traffic congestion or to estimate loudest hour levels in a similar manner.
- If desired, the LTRM may be used to estimate loudest hour levels at representative ST measurement locations.

Conclusions

- The LTRM is a convenient method to estimate LT noise metrics with a limited number of LT measurements.
- Observe recommended limits and assumptions and everything will be awesome!
- Always carry a small trash container in your car.

Questions?

I-94 “Shipping Container”” Noise barrier, Minneapolis, MN