Using the Ground to Reduce Transportation Noise

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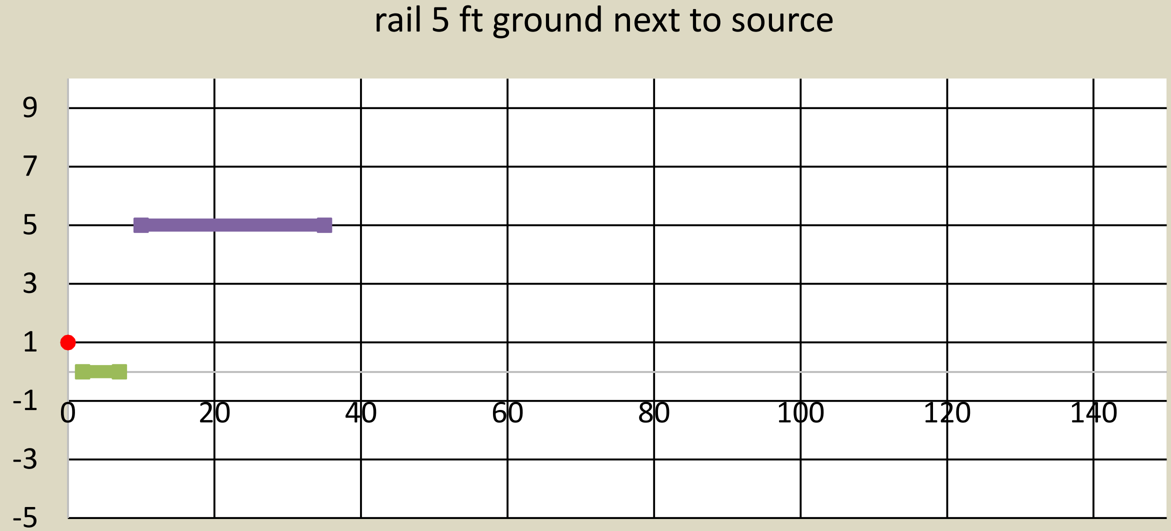
Why consider the ground?

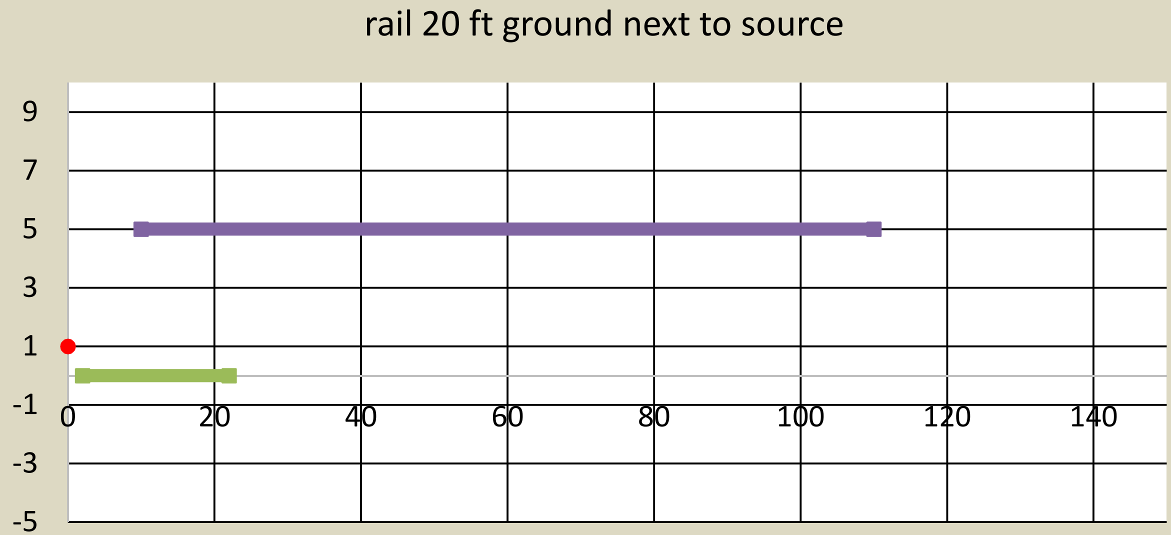
- Sound reducing effects could reduce or even eliminate noise impacts
- Another mitigation tool
- Multiple applications: highways, rail, airports?, spaceports?

Predicting region of influence

- Rail examples

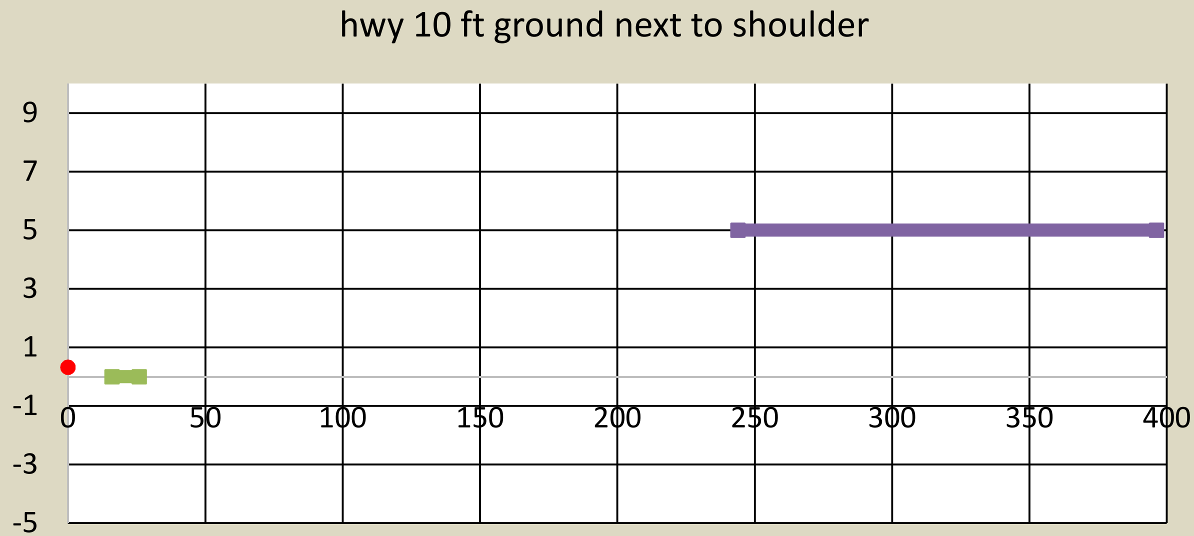
- Notes on width
  - o Wider ground zone = wider region of influence
  - o Need wide enough to influence first row receivers

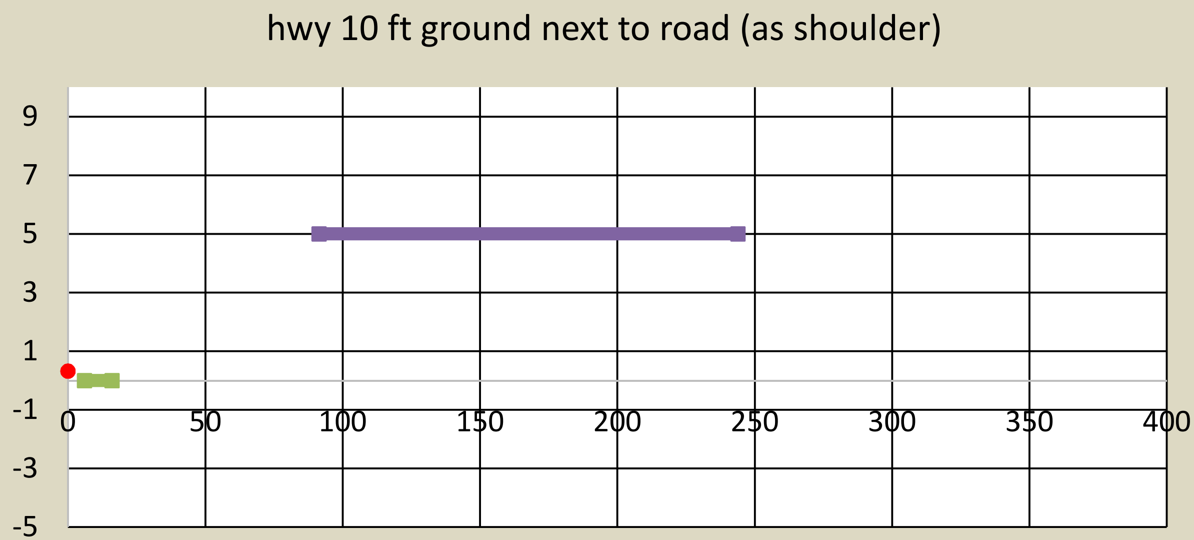




Predicting region of influence

- Highway examples
- Notes on placement
  - o For highways, shoulder may be ideal and/or the highway itself





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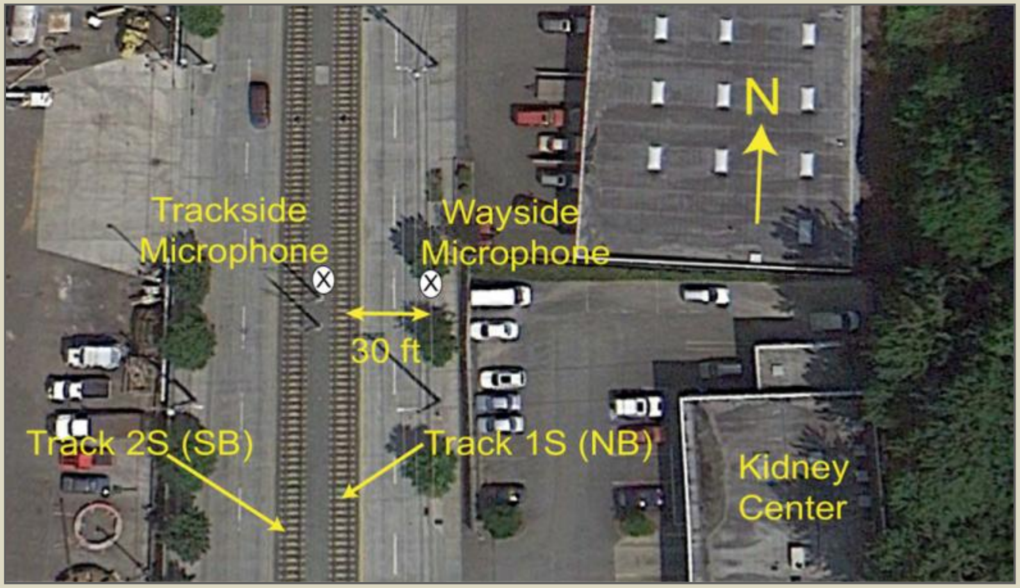
Rail

- What we know:
  - o Ballast provides noise reduction (FTA guidance 2006)
    - 3 dB at-grade
    - 5 dB on aerial structure
  - o Ballast is extremely sound absorptive (more than forest floor and powder snow) (Attenborough, et al., Predicting Outdoor Sound 2007)
  - o Measurements show ballast effect …

Rail (continued)

- ATS measurements near ballast & tie track
    - *Wayside* measured levels at a distance of 30 ft to NB track and 45 feet to SB track
        - NB track about 3.6 dB louder than SB track
        - Considering distance alone accounts for about 1.8 dB
        - Remaining 1.8-dB difference at least partially due to ballast



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Rail (continued)

- ATS measurements near ballast & tie track (continued)
    - *Trackside* measured levels at a distance of 7.5 ft to NB inside rail and 3.3 ft to SB inside rail
        - NB track about 7.5 dB quieter than SB track
        - Considering distance alone accounts for about 3.6 dB
        - Remaining 3.9-dB difference at least partially due to ballast
    - Note: Need to properly account for absorptive ground effects when normalizing to get meaningful single sound level for combined NB/SB trains – *may require measurements of the absorption*

Rail (continued)

- Is it possible to configure ballast to provide more noise reduction?
  - o Parameters that affect effectiveness
    - Width next to tracks
    - Depth (too shallow = reflections from underlying structure)

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Rail (continued)

- ANSI S1.18 measurements indicate …
  - o Comparing estimated depths of 6-8 inch, 24 inch, and 40 inch, more absorption provided with increasing depth
  - o Measured ballast EFR value below 10 cgs rayls (value for powder snow), where standard analysis does not apply
    - Literature states rail ballast = 0.2 cgs rayls!

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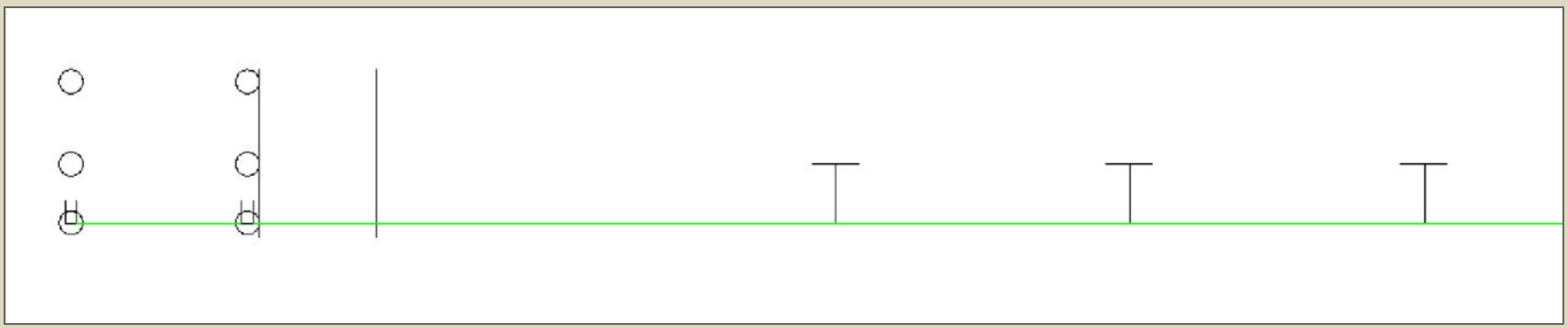
Rail (continued)

- “Rail” analysis using FHWA TNM
  - o Model
    - Autos for vehicle type (not exact rail source heights)
    - Default ground: reflective (pavement)
    - Ground zone of 10 cgs rayls (lowest in TNM) with varying width next to source



Rail (continued)

- “Rail” analysis using FHWA TNM (continued)
  - o Results
    - Replaced reflective surface with absorptive surface next to source with widths of 5, 10, and 20 ft
      - – 5 ft provided 6 dB reduction (150 ft)
      - – 10 ft provided 7 dB reduction (150 ft)
      - – 20 ft provided 8 dB reduction (150 ft)
    - If you already had ballast & tie track with 5-ft width ballast next to track, effect of widening would be …
      - – 1 dB additional reduction for 10 ft
      - – 2 dB additional reduction for 20 ft
  - o Could extend analysis to determine effect of absorptive surface between rails

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Rail (continued)

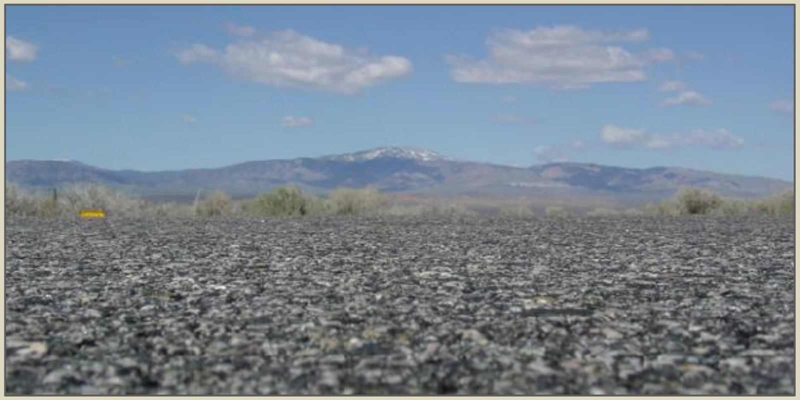
- One more interesting note
  - Ballast with small berm (15 inches) next to tracks can provide 10 dB reduction! (Attenborough, Inter-Noise 2005)

Highways

- What we know:
  - Sound-absorbing highway *pavements* can reduce sound as it propagates over the lanes (Rochat, TNM PEI Study; Rochat & Donavan, TRR 2013; Donavan, TRR 2014)
    - More lanes = greater effect
    - Theory/measured reduction of 2-4 dB wayside
  - Sound-absorbing *shoulders* can reduce sound (Staiano, TRB ADC40 2012)
    - 3 dB reduction possible with available pavements
    - 6 dB reduction possible with innovative designs
  - Brief TNM analysis showed sound-absorptive *right-of-way* provides little reduction, only about 1 dB compared to hard ground

Highways (continued)

- Ways to use the ground to reduce sound
  - Combine
    - Quieter, sound-absorbing pavement on highways to reduce source and propagating sound
    - Sound absorbing shoulders
  - Result
    - Likely to reduce the number of noise impacts
    - Has potential to meet 5 dB / 7 dB noise reduction requirements



Other modes?

- Aircraft
  - o Applies to ground noise
    - Airport: run-up and take-off
    - Spaceport: on or very near pad
    - Would not be effective as craft rises due to angle of incidence and community locations
  - o Absorptive ground zone would need to be strategically placed
  - o Would need to consider low frequency content of source

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Conclusions

- May be possible to reduce noise impacts with strategically placed ground zone, particularly in combination with other sound-reducing measures
- Absorptive ground shown to be effective for rail and highway; need to examine aircraft application
- Using ground to reduce transportation noise should be investigated further