SOUND TRANSIT LIGHT RAIL VIBRATION ISSUES AT THE UNIVERSITY OF WASHINGTON

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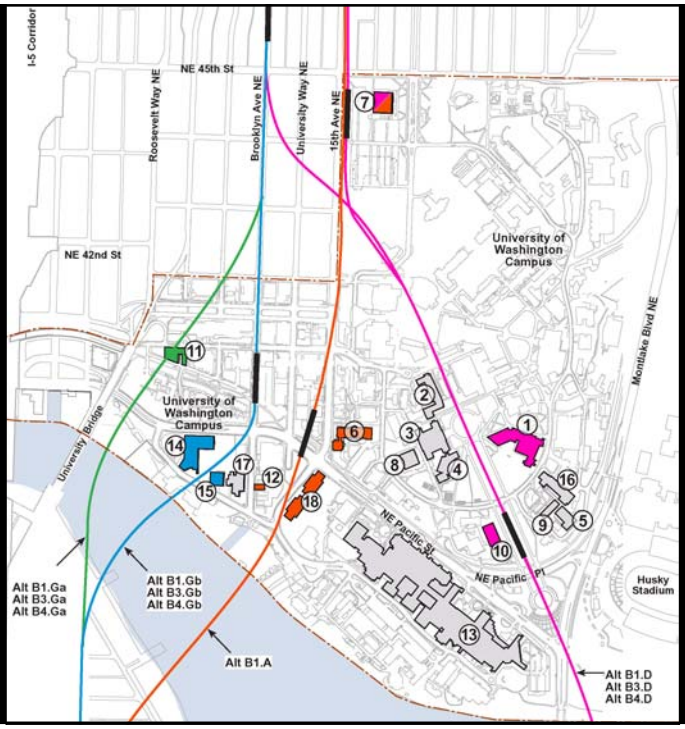
MODERN RESEARCH ENVIRONMENTS

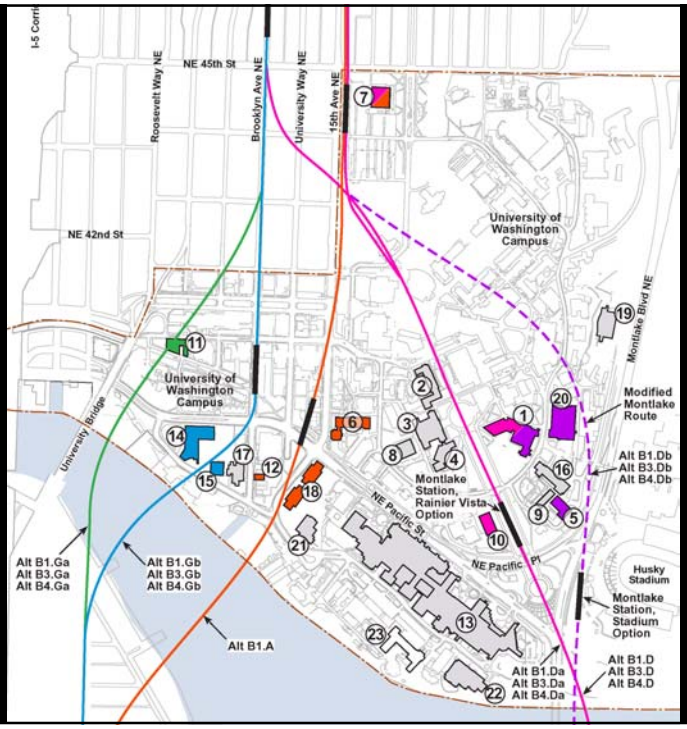
Highly Competitive

Attractiveness of Site

State-of-the-Art Research:

- Gravitation
- Semiconductor Research
- Nanotechnology





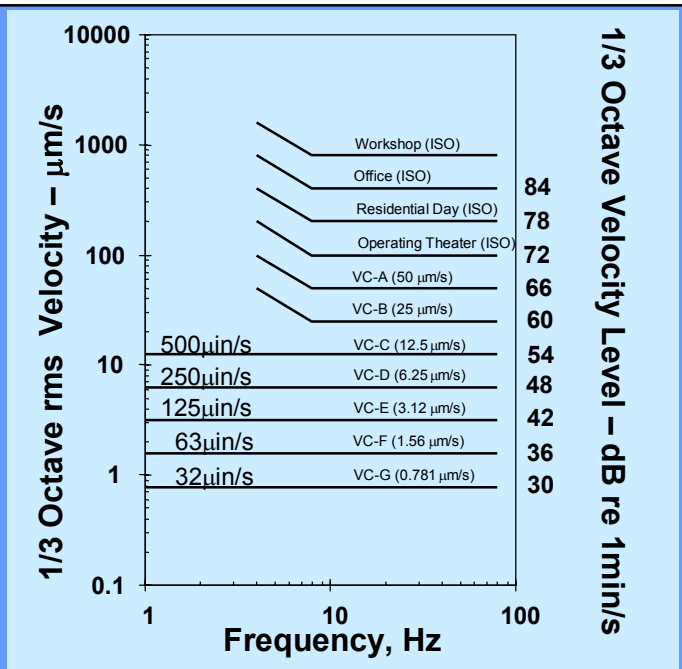
PRELIMINARY ENGINEERING

Discussion with UW
Vibration Design Criteria
Vibration Impact Evaluation
  LSR Testing at UW
  FDL Testing at San Jose
Mitigation

Criteria For Vibration Sensitive Activities

- FTA criterion is based on levels acceptable for most moderately sensitive equipment such as optical microscopes - 65 VdB.
- APTA Criteria for Vibration Sensitive Industrial or Research Laboratory – 70 to 60 dB
- ISO Criteria for Operating Theaters – 72 dB.
- Institute of Environmental Sciences (IES) – 66 to 42 dB.

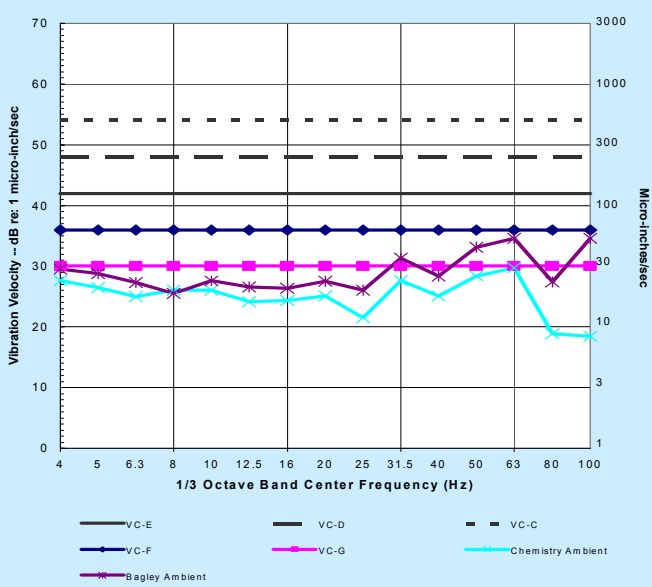
NEW IES CRITERIA



UW CRITERIA

"In order to preserve the ambient condition for current and future research activities on the UW campus, the UW wishes Sound Transit to design a train that limits the ST Vibration to be equal to or less than the measured ambient vibration spectra at each building foundation….. The train generated vibration levels should be expressed in terms of maximum amplitude per each 1/3 octave band frequency determined at the distance of closest approach for each building under consideration. Using these definitions, the UW requests that the train vibration levels be less than or equal to the current ambient vibration levels. This criteria needs to be met using source mitigation only."

UW Ambient and VC Levels



PREDICTION APPROACH

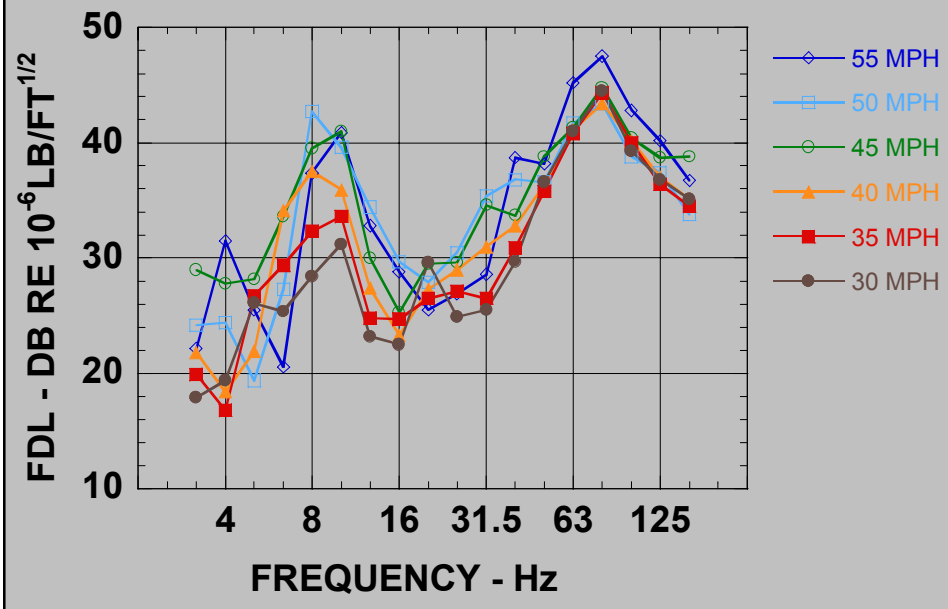
FTA Methodology – FDL, LSR

Lv = FDL + LSR

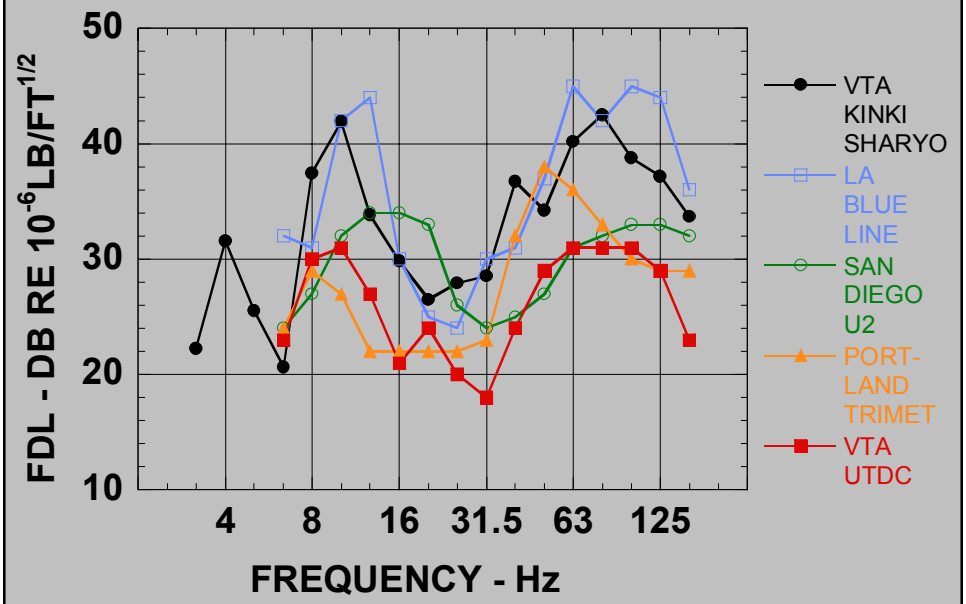
FDL = Force Density Level

LSR = Line Source Response

KINKI SHARYO FDL

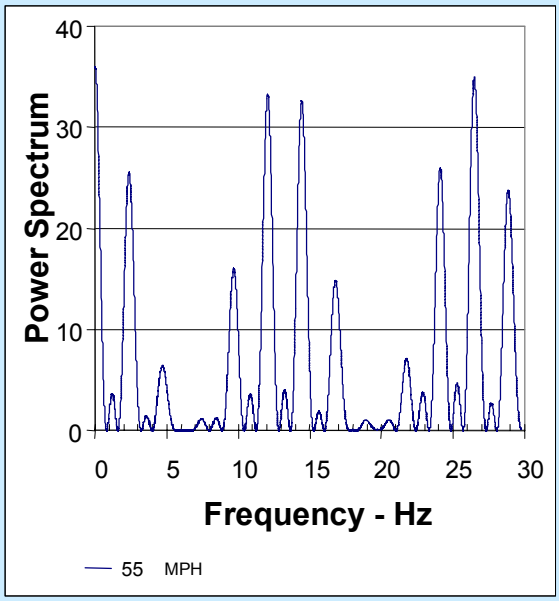


COMPARISON OF LIGHT RAIL FDL'S



SOUND TRANSIT PSTC / PARSONS BRINCKERHOFF WILSON IHRIG & ASSOCIATES

MODULATION ENVELOPE



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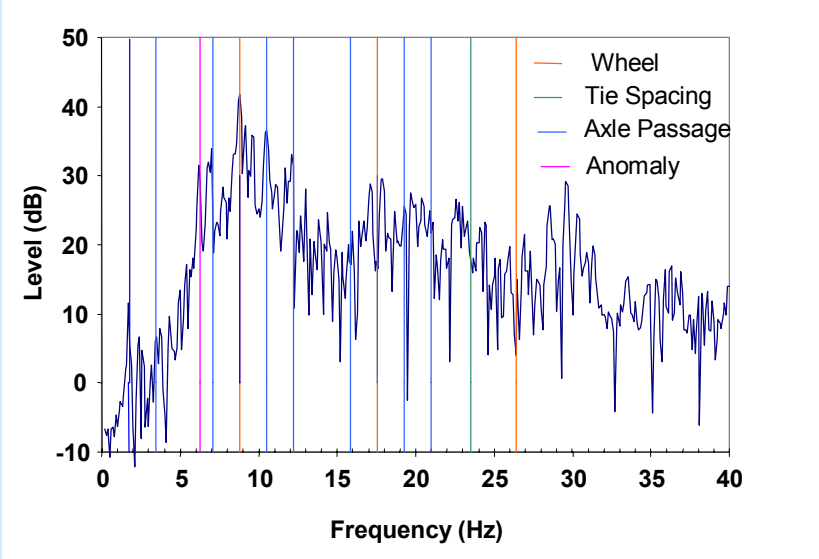
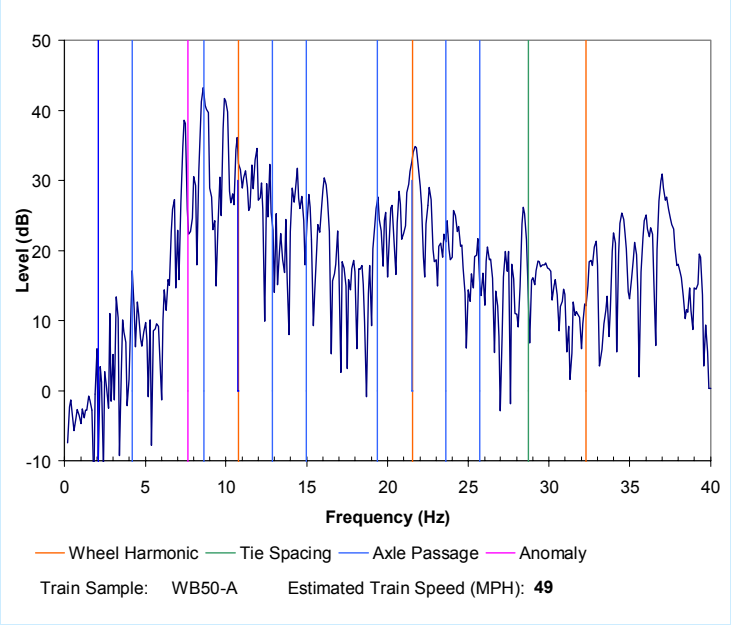
VIBRATION SPECTRUM – 40MPH

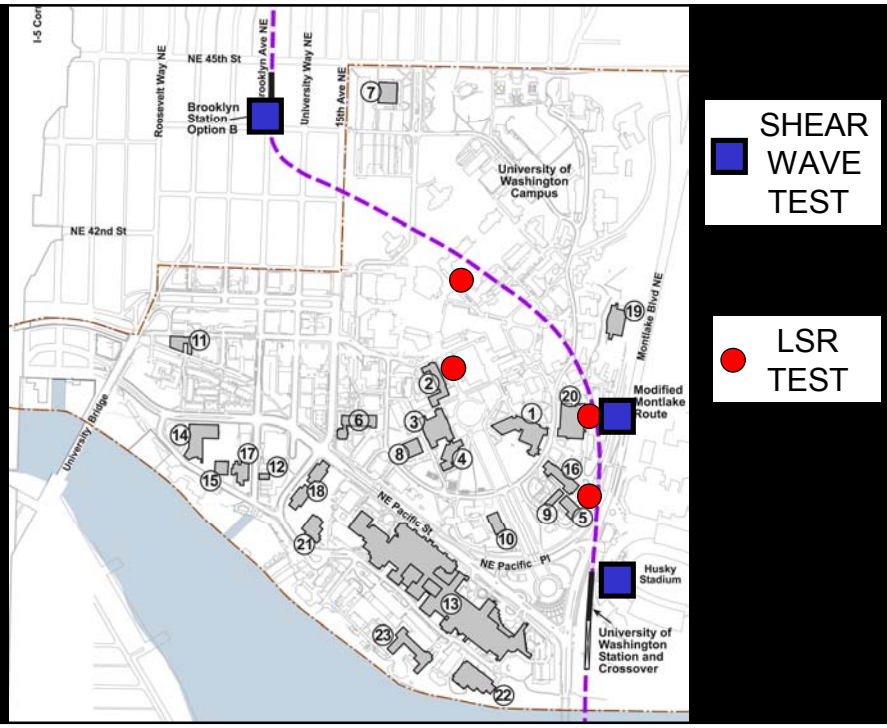


VIBRATION SPECTRUM – 49MPH



LSR ESTIMATION

- Borehole Impact Tests
- Vertical Seismic Velocity Surveys
- Numerical Modeling of Layered Soil
- Extrapolation to Large Offset

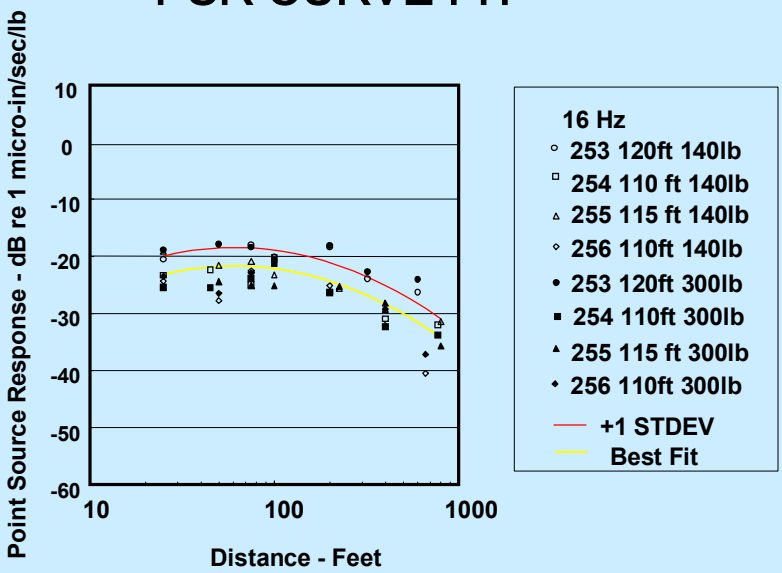



NB-254

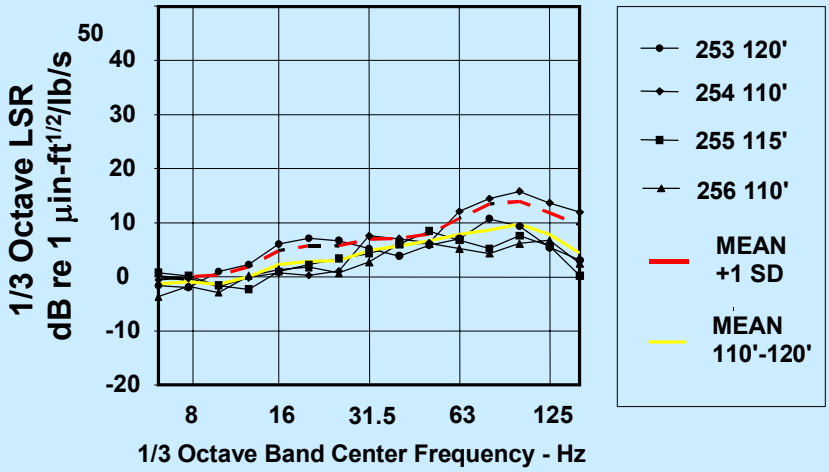

NB-255

BORE HOLE TEST

PSR CURVE FIT



LINE SOURCE RESPONSES



Vibration Velocity at 100 Feet from Track Center Line

Train Length=380 ft **Source Depth=110-120ft**

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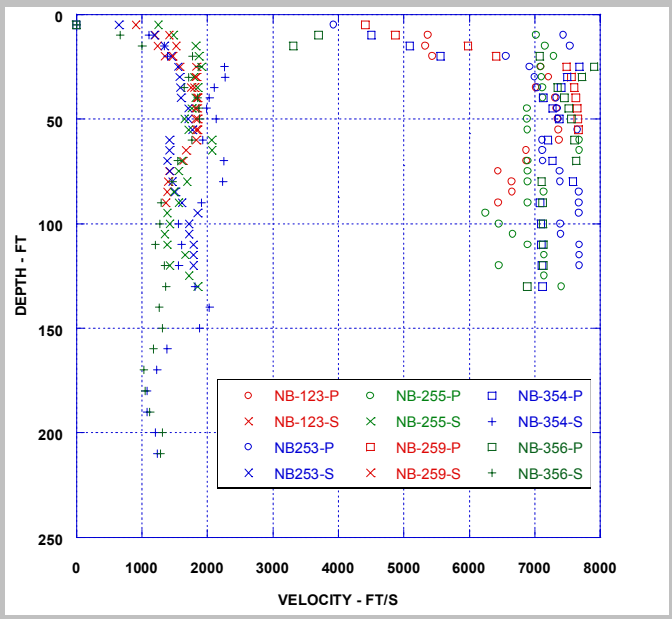
SEISMIC WAVE VELOCITIES



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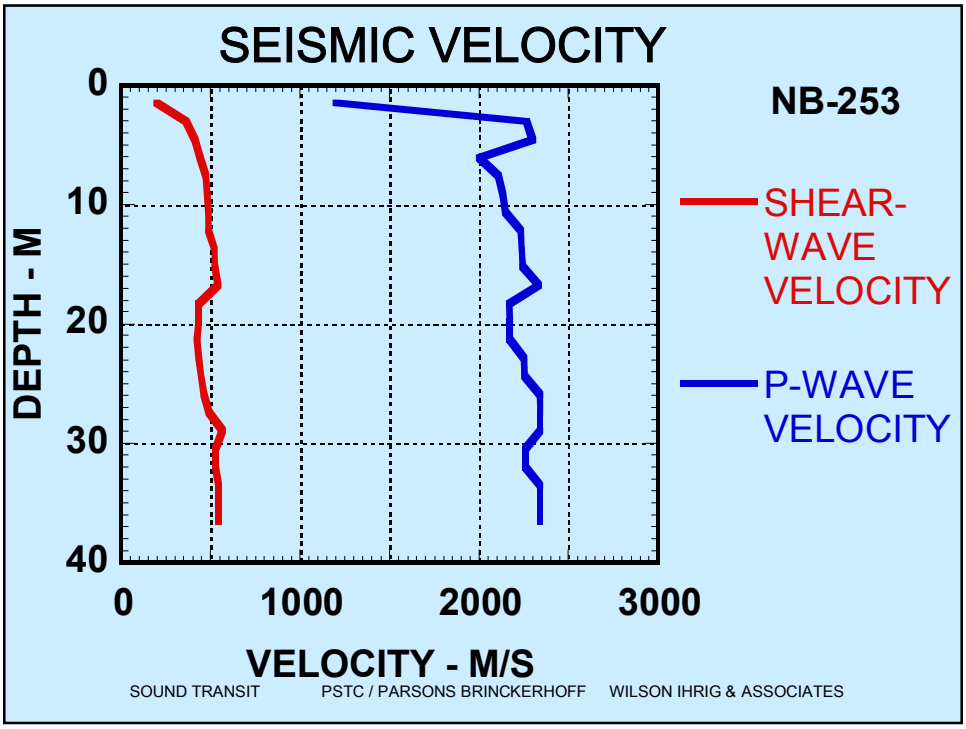
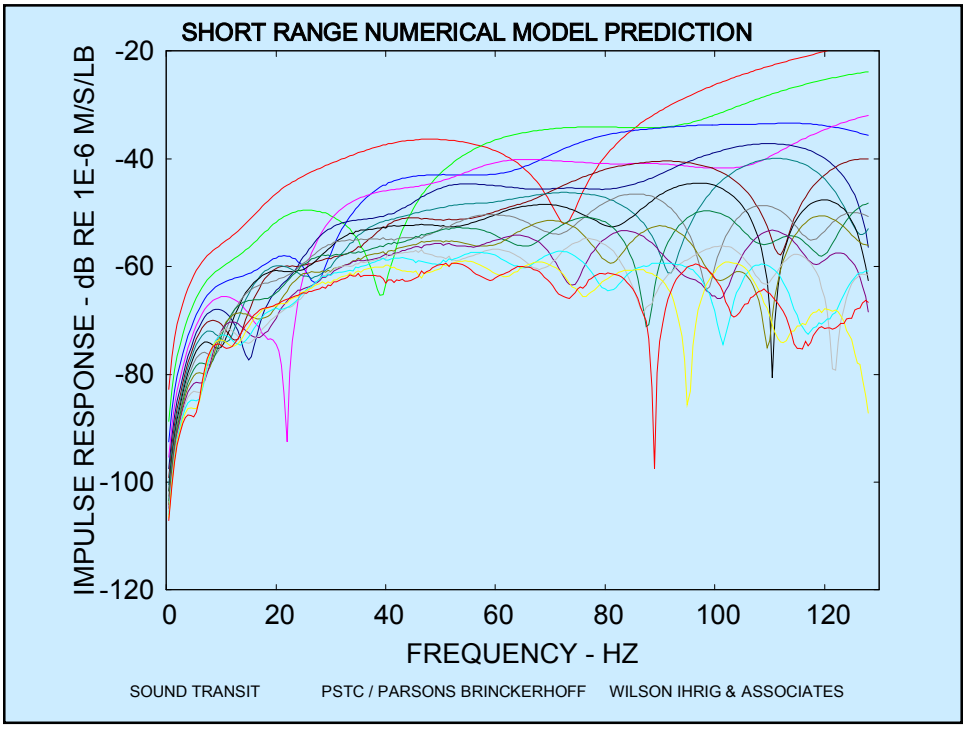
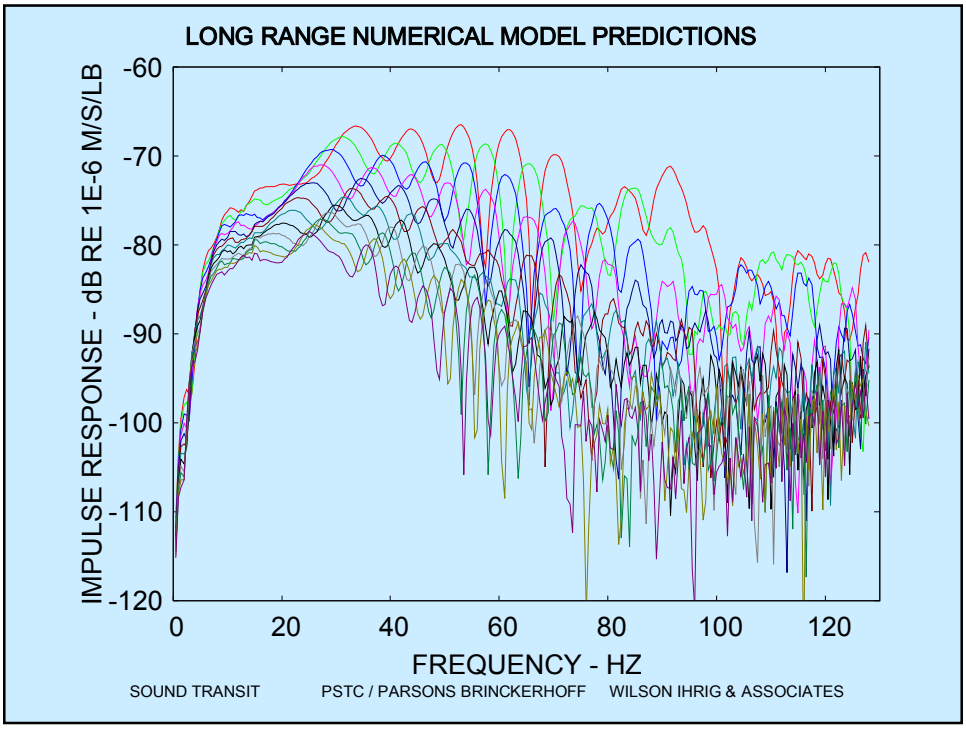
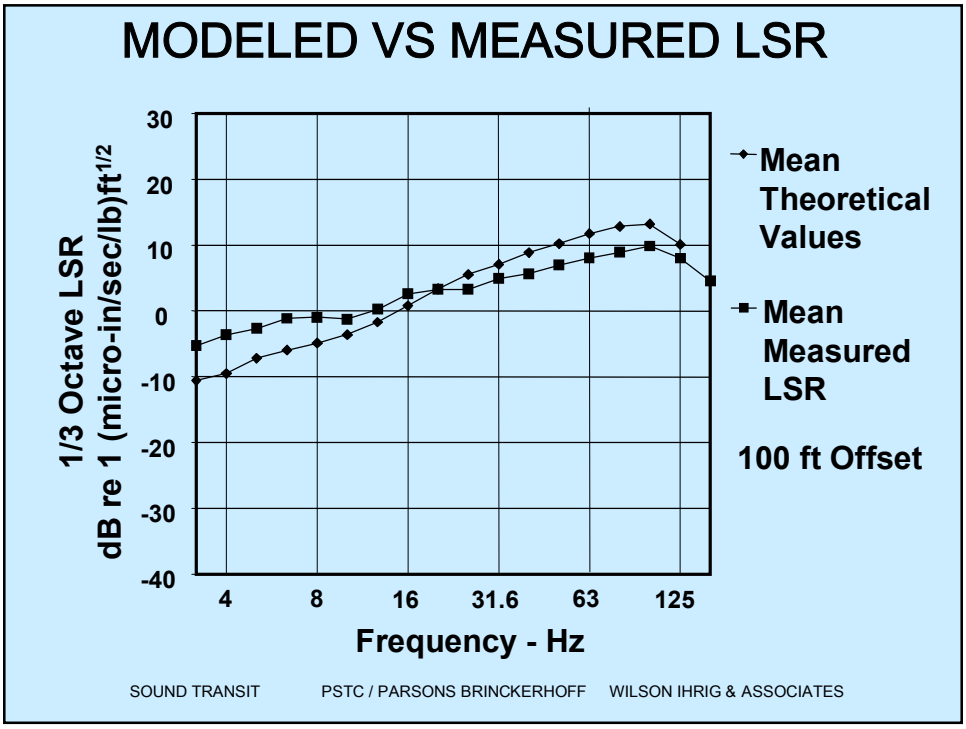
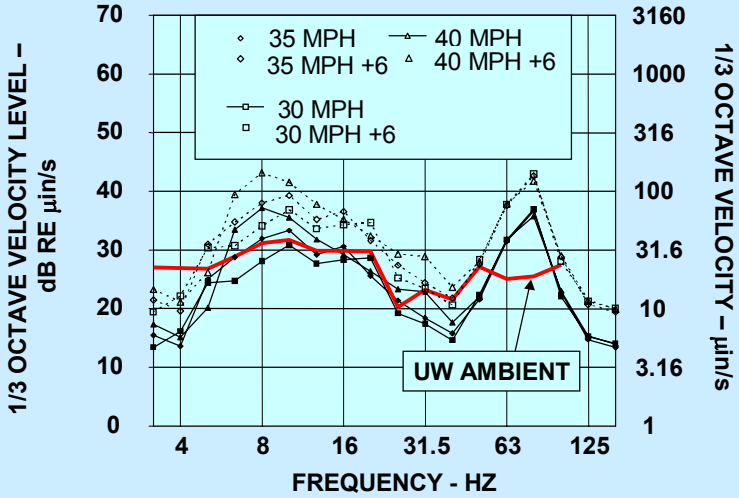

SEISMIC VELOCITY
NB-253
DEPTH - M
0
10
20
30
40
0
1000
2000
3000
VELOCITY - M/S
SHEAR-WAVE VELOCITY
P-WAVE VELOCITY
SOUND TRANSIT
PSTC / PARSONS BRINCKERHOFF
WILSON IHRIG & ASSOCIATES


SHORT RANGE NUMERICAL MODEL PREDICTION
IMPULSE RESPONSE - dB RE 1E-6 M/S/LB
-20
-40
-60
-80
-100
-120
0
20
40
60
80
100
120
FREQUENCY - HZ
SOUND TRANSIT
PSTC / PARSONS BRINCKERHOFF
WILSON IHRIG & ASSOCIATES


LONG RANGE NUMERICAL MODEL PREDICTIONS
IMPULSE RESPONSE - dB RE 1E-6 M/S/LB
-60
-70
-80
-90
-100
-110
-120
0
20
40
60
80
100
120
FREQUENCY - HZ
SOUND TRANSIT
PSTC / PARSONS BRINCKERHOFF
WILSON IHRIG & ASSOCIATES


MODELED VS MEASURED LSR
1/3 Octave LSR
dB re 1 (micro-in/sec/lb)ft1/2
30
20
10
0
-10
-20
-30
-40
4
8
16
31.6
63
125
Frequency - Hz
Mean Theoretical Values
Mean Measured LSR
100 ft Offset
SOUND TRANSIT
PSTC / PARSONS BRINCKERHOFF
WILSON IHRIG & ASSOCIATES

WILCOX HALL 30-40 MPH



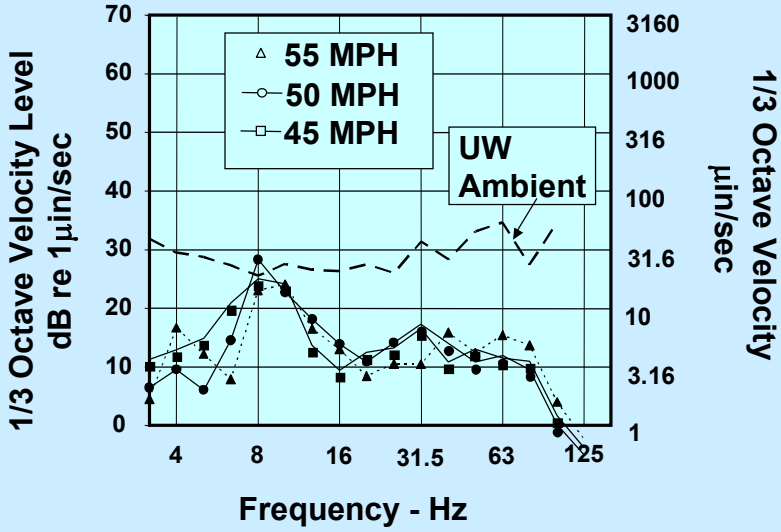
16 HZ FLOATING SLAB

GROUND SURFACE

110 FT OFFSET, 100 FT DEPTH

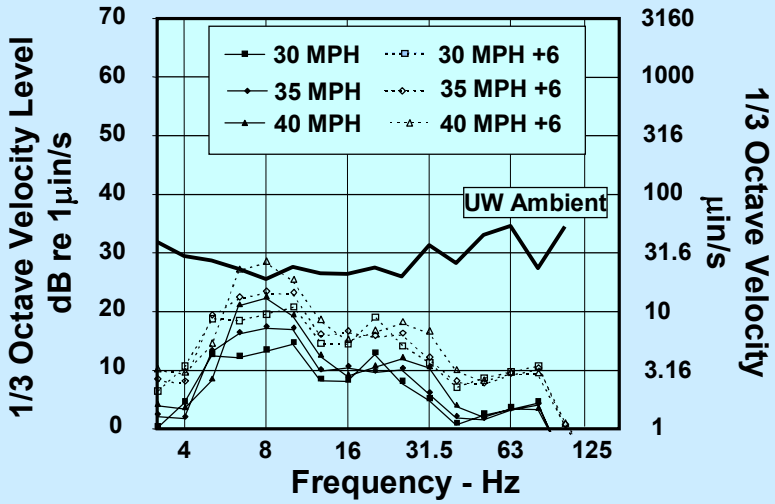
BAGLEY HALL 45-55 MPH

Ground Surface Vibration Velocity



BAGLEY HALL 30-40 MPH

Ground Surface Vibration Velocity



High Compliance Fastener **978 ft Offset, 120 ft Depth**

VIBRATION CONTROL PROVISIONS

Avoidance of Core Buildings
16Hz Floating Slab
Resilient Direct Fixation Fasteners
Moveable Point Frog
Speed Reduction
Single Train Operation
Wheel&Rail Maintenance
Monitoring

FINAL ENGINEERING

FDL Test of Sound Transit Vehicle
4Hz Floating Slab – GERB Spring
Rail Straightness
Long wave rail grinding
Wheel Runout
Wheel/Rail Profiles

CONCLUSION

Future
- Technological Research
- Increasing demand for transit

Prediction Methods
- Geophysical testing
- Modeling

Control
- Low Frequency Floating Slabs
- Rail Straightness
- Wheel Runout