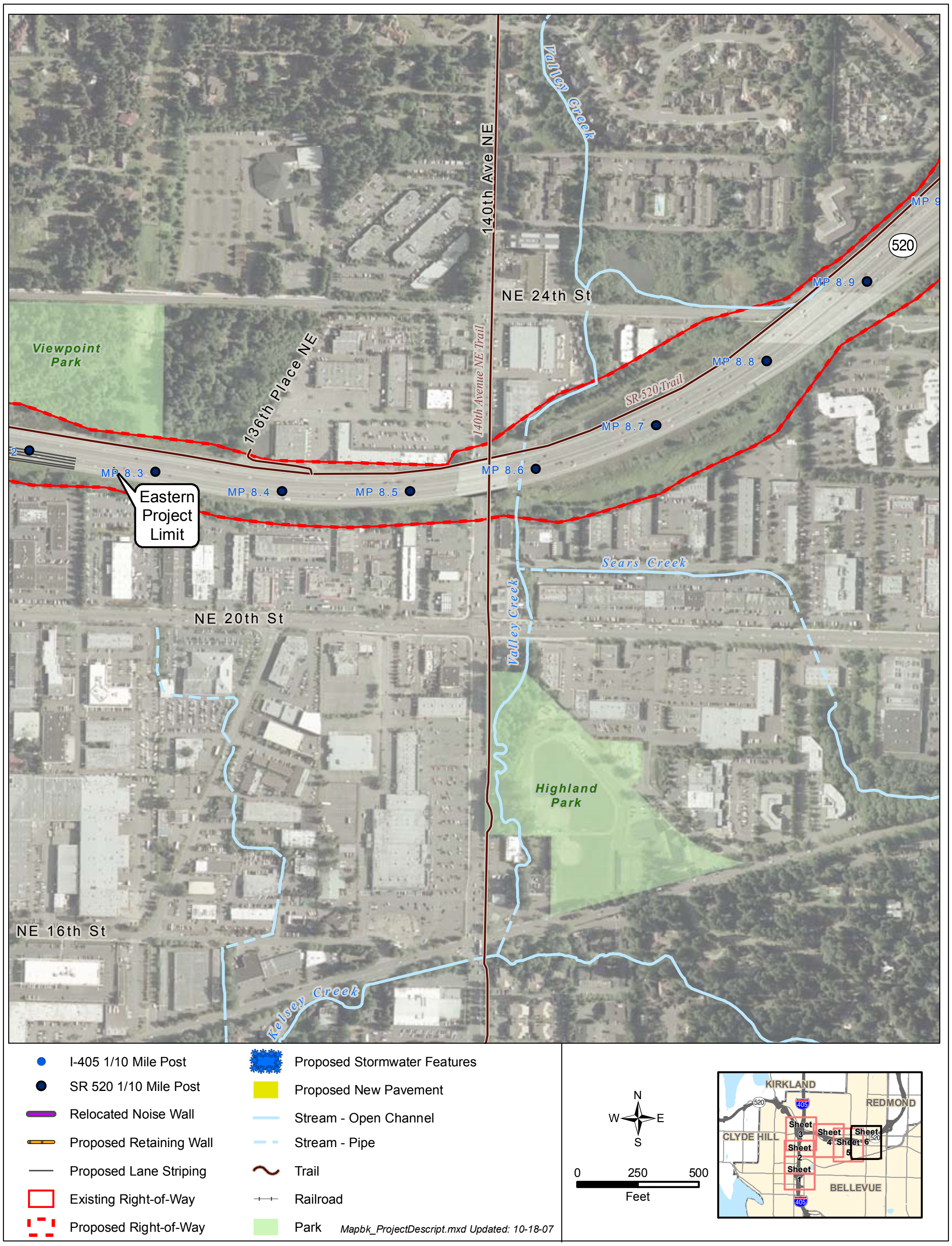
Exhibit 2-3: Project Features - Sheet 6 of 6



Construction Staging

Construction funding is currently available for only some of the proposed improvements in the Build Alternative. Consequently, the project will be constructed in stages. The funded first stage will include the northbound I-405 improvements, including the braided ramps, the NE 12th Street bridge reconstruction, and the northbound NE 10th Street on-ramp. Additionally, one of the three proposed collector-distributor lanes from northbound I-405 to eastbound SR 520 will be constructed. This collector-distributor lane will cross over the existing NE 124th Street on-ramp before merging with SR 520. Construction of these funded improvements is scheduled to begin in 2009 and will be completed in approximately 3 years.

The unfunded project improvements include the remaining two lanes of the three-lane collector-distributor system, improvements from southbound I-405 to the eastbound SR 520 collector-distributor, and the improvements from eastbound and westbound SR 520 to southbound I-405. Construction of these remaining improvements depends on when project funding becomes available.

Stormwater Management System Improvements

Stormwater for the I-405, NE 8th Street to SR 520 Improvement Project will be managed for both water quality and quantity using currently accepted best management practices (BMPs).

The I-405 Project Team is designing the stormwater management facilities to comply with the WSDOT *Highway Runoff Manual* (HRM),[1] M 31-16, and *Hydraulics Manual*,[2] M 23-03. The Department of Ecology has conditionally approved WSDOT's revised HRM for use as an equivalent approach to Ecology's *Stormwater Management Manual for Western Washington.*[3]

Runoff from existing paved surfaces on I-405 and SR 520 within the project limits is generally discharged to streams and ditches without treatment. The project will provide water quality treatment for all of the new impervious surfaces and a

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1 *WSDOT, 2006a.*

2 *WSDOT, 2006b.*

3 *Ecology, 2005.*

portion of the existing untreated impervious surfaces. Existing conveyance facilities will be modified as required to satisfy water quality treatment and flow control design standards noted above, while maintaining existing flow patterns to each of the receiving water bodies.

What are peak flows?
The maximum instantaneous rate of stormwater flow during a storm, usually in reference to a specific design storm event.

The I-405, NE 8th Street to SR 520 Improvement Project will also manage peak flows and duration in accordance with the WSDOT *Highway Runoff Manual*. The stormwater management facilities will also manage peak flows and durations in accordance with the HRM. Six new flow control facilities and one existing facility (constructed as part of the NE 10th Street Bridge Project) will be used to provide stormwater detention. The proposed locations of these facilities are shown in Exhibit 2-3.

Wetland and Stream Mitigation Sites

To compensate for the permanent effects on wetlands, WSDOT will provide mitigation at a wetland mitigation site that is about one mile southeast of the southern project limit. Mitigation at this site was approved as part of the I-405, Bellevue Nickel Improvement Project and has been constructed. The wetland mitigation site is within the boundaries of Kelsey Creek Park (Exhibit 2-1). The site is located north of the intersection of Richards Road SE and the Lake Hills Connector. The mitigation site is an upland area adjacent to a large wetland complex that will be transformed to an emergent wetland. Its wildlife habitat will be enhanced by constructing habitat structures and replanting adjacent upland areas with forest-type vegetation.

We will also mitigate for unavoidable effects on the unnamed tributary to Sturtevant Creek. The mitigation will be in-kind and will be located within WSDOT right-of-way on the east side of I-405 south of NE 4th Street (Exhibit 2-3). Stream mitigation for permanent effects to the unnamed tributary to Sturtevant Creek will occur at Sturtevant Creek and will be designed to meet specific goals. Stream mitigation goals include:

- Increased hydrologic connectivity with two small riparian wetlands;
- Increased fish rearing habitat; and
- Improved riparian buffer conditions.

WSDOT will meet these goals by installing large woody debris and other in-stream channel enhancements. The stream's buffer will be revegetated with plant species native to the area, and invasive vegetation will be removed.

We provide more detailed information about mitigation efforts planned in conjunction with the I-405, NE 8th Street to SR 520 Improvement Project in the Water Resources and Ecosystems Discipline Reports.

Does this project relate to any other improvements on I-405 or connecting highways?

In 1998, WSDOT joined with the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), Central Puget Sound Regional Transit Authority (Sound Transit), King County, and local governments to develop strategies to reduce traffic congestion and improve mobility in the I-405 corridor. In fall 2002, the combined efforts of these entities culminated in the I-405 Corridor Program NEPA/SEPA Final Environmental Impact Statement (EIS) and Record of Decision (ROD).

WSDOT created the I-405 Corridor Program as a comprehensive strategy to reduce congestion and improve mobility throughout the I-405 corridor. The corridor begins at the I-405/I-5 interchange in the city of Tukwila and extends northward 30 miles to the I-405/I-5 interchange in the city of Lynnwood. The program's purpose is to provide an efficient, integrated, and multimodal system of transportation solutions.

The I-405, NE 8th Street to SR 520 Improvement Project is one of several I-405 projects (see links to WSDOT's project-specific web pages at http://www.wsdot.wa.gov/projects/). Other projects along the I-405 corridor and connecting highways include:

- Renton Nickel Improvement Project, 1-5 to SR 169 (under construction)
- Renton to Bellevue Project, SR 169 to I-90 (proposed)
- South Bellevue Widening (112th Avenue SE to SE 8th Street) Project (under construction)
- NE 10th Street Bridge Crossing Project (under construction)

- SR 520 Bridge Replacement and HOV Project (proposed)
- SR 520 to I-5 Widening Project (proposed)

What are express toll lanes?

An express toll lane is a limited-access freeway lane that is actively managed through a variable toll system to regulate its use and thereby maintain express travel speeds and reliability. Toll prices rise or fall in real time as the lane approaches capacity or becomes less used. This ensures that traffic in the express toll lane remains flowing at express travel speeds of 45 to 60 miles per hour. Toll prices may differ for carpools, transit, motorcycles, and single-occupant vehicles. Tolls are collected electronically using overhead scanners that read a transponder inside the vehicle and automatically debit the operator's account.

In addition to improvements along I-405 and SR 520, WSDOT has planned projects on SR 167, I-90, and SR 522 as recorded in WSDOT's *Highway System Plan*.[4] This plan forecasts transportation needs for the next 20 years. The Metropolitan Transportation Plan for the central Puget Sound region, *Destination 2030*, revised in 2003, defines the region's action plan for the next 30 years.

The I-405 Corridor Program EIS identified possibilities to better manage the corridor through tolling. WSDOT could achieve this through the use of express toll lanes that would be managed through a variable toll system to regulate their use and thereby maintain express travel speeds and reliability. The footprint of the project identified in this document would not preclude implementation of express toll lanes. The freeway system would, however, operate differently if express toll lanes are used. If express toll lanes are to be implemented in the future, additional operational analysis and any necessary environmental documentation would be prepared. Therefore, an operational change to express toll lanes would be a future decision.

What is the No Build Alternative?

The No Build Alternative assumes the new NE 10th Street bridge across I-405 that is being constructed as part of another project will be in place. The No Build Alternative assumes that only routine activities such as road maintenance, repair, and minor safety improvements would take place over the next 20 years. The No Build Alternative does not include improvements that would increase roadway capacity, reduce congestion, or improve safety on I-405 or SR 520. For these reasons, it does not satisfy the project's purpose—to reduce congestion created by weaving traffic on I-405 and SR 520.

The No Build Alternative has been evaluated in this discipline report to establish a reference point for comparing the effects associated with the Build Alternative.

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[4] *WSDOT, 2007a.*

SECTION 3 STUDY APPROACH

This section defines sound and noise, sound-level descriptors, and what affects sound levels. It also describes project coordination and how the traffic noise study was performed.

What is the study area for this noise analysis and how was it determined?

The limits of the project extend north along I-405 from the vicinity of NE 4th Street to the north side of the I-405/SR 520 interchange. The project extends east along SR 520 from the west side of the I-405/SR 520 interchange to just west of 140th Avenue NE (see Exhibit 3-1). The noise study area for this project extends 500 feet from the pavement edge throughout the project limits.

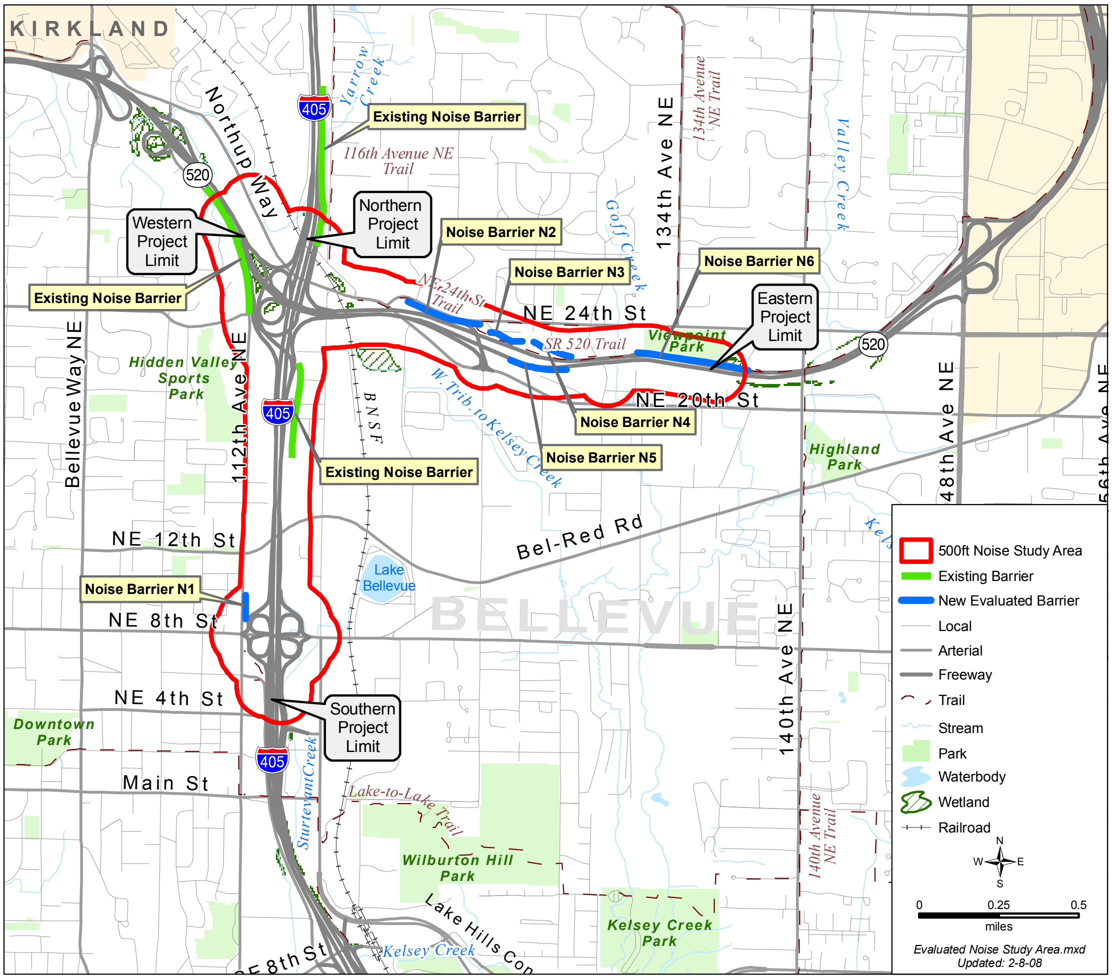
Land use in the study area varies. It is primarily commercial/industrial development with pockets of residential development, multi-family use, and parkland. Two existing noise walls are located parallel to I-405, and one is located parallel to SR 520 in some of the more densely populated residential areas. Exhibit 3-1 identifies the three existing noise barrier locations and six locations evaluated for noise barrier placement in Section 6 of this report. Terrain varies throughout the study area. Residences on either side of I-405 and SR 520 are located above and below the level of the highways.

What are sound and noise?

Sound is created when objects vibrate, resulting in a minute variation in surrounding atmospheric pressure called *sound pressure*. The human response to sound depends on the magnitude of a sound as a function of its frequency and time pattern.[5] Magnitude is a measure of sound energy in the air. Noise is unwanted sound.

[5] EPA, 1974.

Exhibit 3-1: Noise Study Area



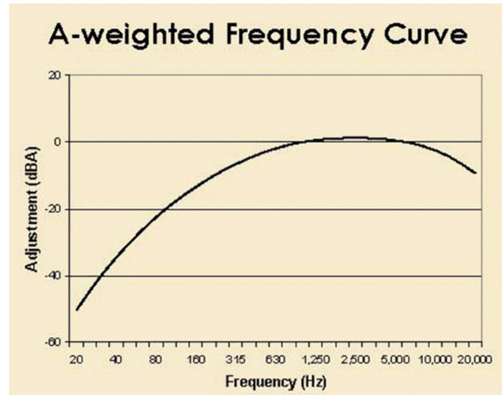
What is the Logarithm Scale?

A logarithm is the exponent that indicates the power to which a number must be raised to produce a given number.

For example: if $B^2 = N$, 2 is the logarithm of N (to the base B), or $10^2 = 100$ and the logarithm of 100 (to the base 10) = 2.

The range of magnitude, from the faintest to the loudest sound the ear can hear, is very large. The sound pressure near an airport runway is approximately one million times greater than a soft whisper. To accommodate this range, sound levels are expressed on a logarithmic scale in units called decibels (dB).

Humans respond to a sound's frequency or pitch. The human ear can very effectively perceive sounds with a frequency between approximately 500 and 5,000 hertz (Hz). Humans' ability to perceive sounds decreases outside this range.



Environmental sounds are composed of many frequencies, each occurring simultaneously at its own sound pressure level. Frequency weighting, which is applied electronically by a sound level meter, combines the overall sound frequency into one sound level that simulates how a typical person hears sounds. The commonly-used frequency weighting for environmental sounds is A-weighting (dBA), which is the most similar to how humans perceive sounds of low to moderate magnitude.

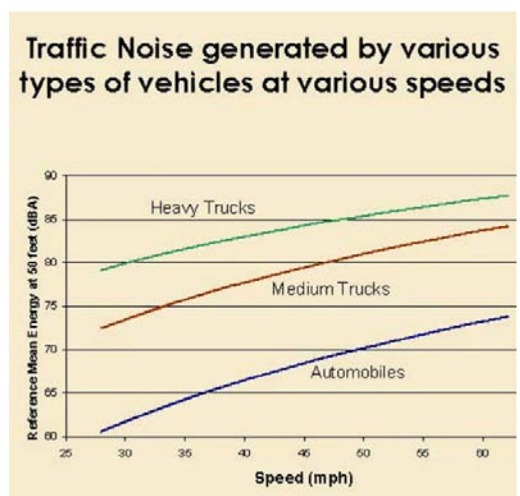
Loudness, in contrast to sound level, refers to how people subjectively perceive a sound. This varies from person to person, but most people judge the relative loudness of different sound levels similarly. The human ear can barely perceive a 3-dBA increase, but a 5- or 6-dBA increase is readily noticeable and appears as if the sound is about 1.5 times as loud. A 10-dBA increase appears to be a doubling in sound level to most listeners.

What are typical sound levels and what affects them?

Exhibit 3-2 presents typical A-weighted sound levels from various sources. The sound environments described, from a quiet whisper or light wind at 30 dBA to a jet takeoff at 120 dBA, demonstrate the great range of the human ear. A typical conversation is approximately 60 to 70 dBA.

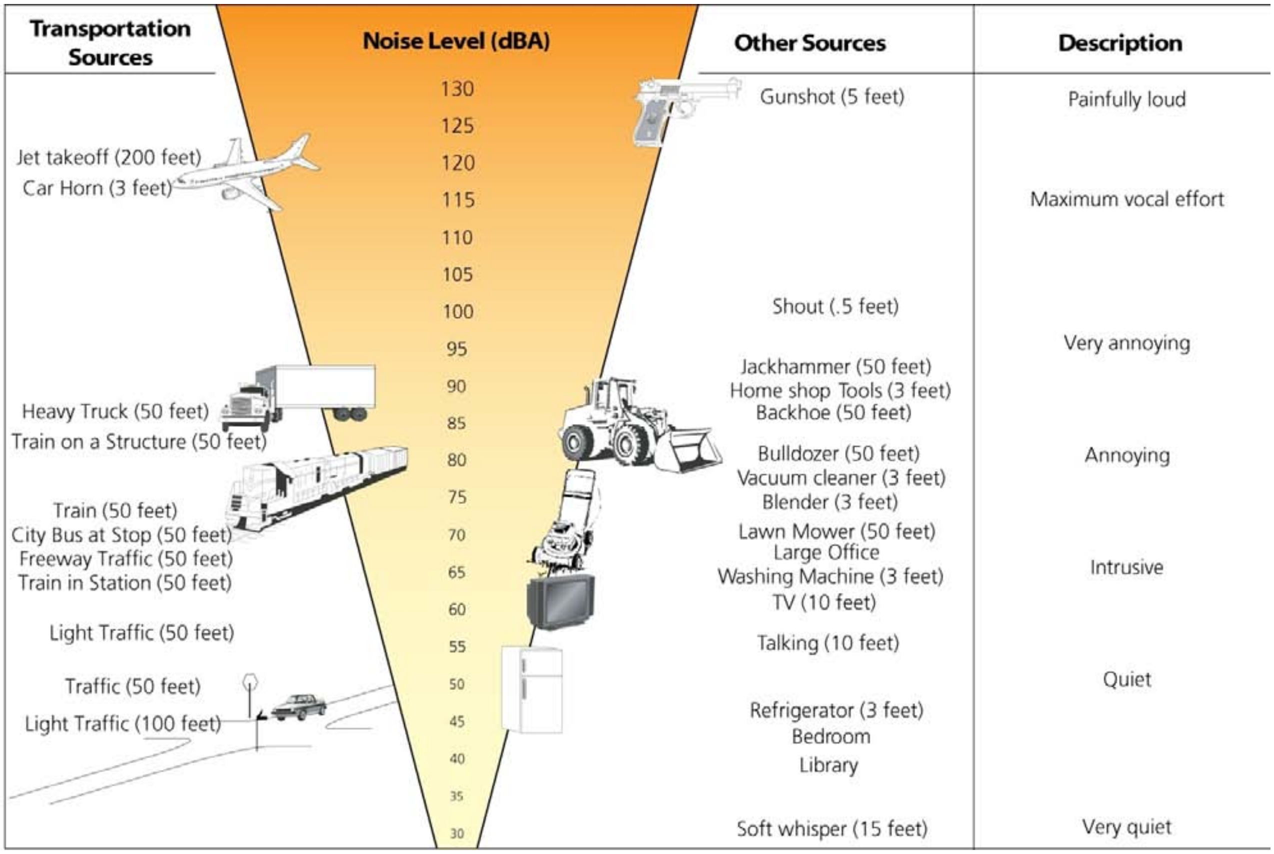
Sources of Sound

Because of the logarithmic decibel scale, a doubling of the number of sound sources (e.g., the number of cars operating on a roadway) increases sound levels by 3 dBA. As a result, a sound source emitting a sound level of 60 dBA combined with another sound source of 60 dBA yields a combined sound level of 63 dBA, not 120 dBA. A ten-fold increase in the number of sound sources adds 10 dBA.



Noise levels from traffic sources depend on volume, speed, and the type of vehicle. Generally, an increase in volume, speed, or vehicle size increases traffic noise levels. Vehicular noise is a combination of noises from the engine, exhaust,

Exhibit 3-2: Typical Noise Levels



and tires. Other conditions that affect the generation of traffic noise include defective mufflers, steep grades, and the roadway surface's material and condition.

The Effect of Distance

Sound levels decrease with distance from the source. For a line source such as a roadway, sound levels decrease 3 dBA over hard ground (concrete or asphalt, pavement) or 4.5 dBA over soft ground (grass) for every doubling of distance between the source and the receptor. For a point source such as construction sources, sound levels decrease between 6 and 7.5 dBA for every doubling of distance from the source.

The Effect of Terrain and Shielding

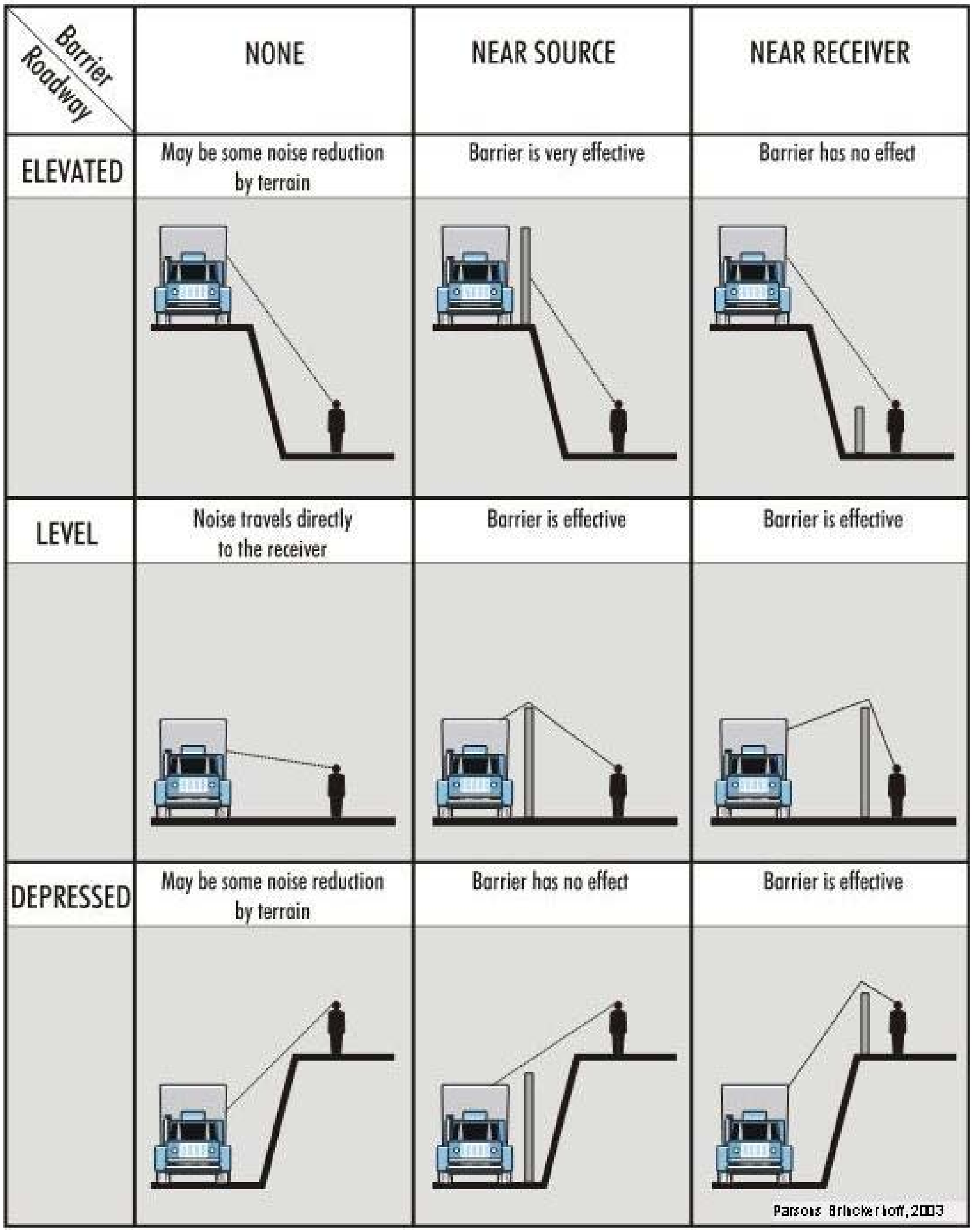
The propagation of sound can be greatly affected by terrain and the elevation of the receiver relative to the sound source shown in Exhibit 3-3. Depressed terrain dominates the project area.

Level ground is the simplest scenario: sound travels in a straight line-of-sight path between the source and receiver. If

What is Terrain?

Terrain describes the features of the land.

Exhibit 3-3: Noise Barrier Effectiveness

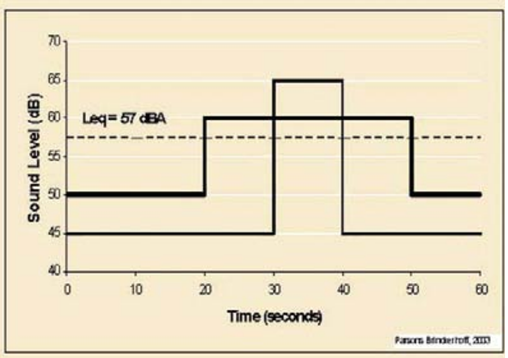


the sound source is depressed or the receiver is elevated, sound will generally travel directly to the receiver (see the bottom row of Exhibit 3-3). However, sound levels may be reduced if the terrain crests between the source and receiver, resulting in a partial sound wall near the receiver.

If the sound source is elevated or the receiver is depressed, sound may be reduced at the receiver by the edge of the roadway. Even a short wall, such as a solid concrete jersey-type safety barrier, can effectively block sound transmission between the source and receiver (see the top row of Exhibit 3-3). Breaking the line of sight between the receiver and the highest elevation of the sound source results in a noise reduction of approximately 5 dBA.

How are sound levels described?

Example of two sound patterns with the same L_{eq} (1 minute interval)



The equivalent sound level (Leq) is widely used to describe noise in human environments. The Leq is a measure of the average sound energy during a specified period of time. It is defined as the constant level that, over a given period of time, transmits the same amount of acoustical energy to the receiver as the actual time-varying sound. For example, two sounds, with one that contains twice as much energy but lasts only half as long as the other, can have the same Leq sound levels. Leq measured over a 1-hour period is the hourly Leq [Leq (h)]. This is used for highway noise effect and abatement analyses.

Short-term sound levels, such as from a single truck passing by, can be described by either the total sound energy (related to the Leq) or the highest instantaneous sound level that occurs during the event. The maximum sound level (Lmax) is the greatest short-duration sound level that occurs during a single event. Lmax is used to describe noise levels that cause speech interference and sleep disruption. In comparison, Lmin is the minimum sound level that occurs during a specified period of time.

What are the effects of loud noises?

What does Leq (24) refer to?

Leq (24) is the equivalent sound level measured over a period of 24 hours.

Prolonged exposure to high-intensity environmental noise directly affects human health by causing hearing loss. The U.S. Environmental Protection Agency (EPA) has established a protective level of 70 dBA Leq (24), below which hearing is conserved for exposure over a 40-year period.[6] Although scientific evidence is not currently conclusive, noise is suspected of causing or aggravating other diseases. Environmental noise indirectly affects human welfare by interfering with sleep, thought, and conversation. The FHWA noise abatement criteria (NAC) are based on speech interference, which is a well-documented effect that is relatively reproducible in human response studies. Noise can also disturb wildlife by disrupting communication, interfering with mating, and reducing the ability to obtain sufficient food, water, and cover.

What criteria are used to evaluate noise effects?

Operational Noise Standards

Noise regulations and guidelines are the basis for evaluating potential noise effects. For state and federally funded highway projects, traffic noise effects occur when predicted Leq (h) noise levels approach, meet, or exceed the NAC established by the FHWA, or substantially exceed existing noise levels.[7] Although the FHWA does not define the term "substantially exceed", WSDOT considers an increase of 10 dBA or more to be a substantial increase.[8]

The FHWA NAC specify exterior Leq (h) noise levels for various land activity categories, as shown in Exhibit 3-4. All exterior noise-sensitive uses within the project study area are Category B uses. WSDOT considers a noise effect to occur if predicted Leq (h) noise levels approach within 1 dBA of the NAC in Exhibit 3-4. Thus, if a noise level is 66 dBA or higher it will approach, meet, or exceed the FHWA NAC of 67 dBA for residences.

WSDOT defines severe traffic noise effects as levels that exceed 75 dBA outdoors in Category B areas. Severe noise effects also occur if as the result of a project, predicted future noise levels exceed existing levels by 15 dBA or more at noise-sensitive locations.

Exhibit 3-4: FHWA Noise Abatement Criteria

[6] EPA, 1974.

[7] U.S. Department of Transportation (DOT) Noise Abatement Council, 1982.

[8] WSDOT, 1999.

Activity Category	Leq (h) (dBA)	Description of Activity Category
A	57 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	–	Undeveloped lands.

Source: DOT, 1982.

The Washington State Department of Ecology (Ecology) regulates noise levels at neighboring properties' property lines (WAC Chapter 173-60-040). Traffic noise is exempt from property line noise limits, but these limits apply to construction noise during certain hours. The maximum permissible noise levels depend on the land uses of the source noise and the receiving property, as shown in Exhibit 3-5. King County has adopted the State of Washington's property line standards with King County Code, Chapter 12.88.020. The City of Bellevue regulates noise as a nuisance under the Bellevue Municipal Code, Chapter 9.18.

Exhibit 3-5: Maximum Permissible Environmental Noise Levels

EDNA[1] of Noise Source	Environmental Designation for Noise Abatement of Receiving Property (dBA)		
	Residential	Commercial	Industrial
Residential	55	57	60
Commercial	57	60	65
Industrial	60	65	70

[1] Environmental designation for noise abatement
Source: WAC 173-60-040.

The maximum permissible environmental noise level at residential receiving properties is reduced by 10 dBA between 10 p.m. and 7 a.m. Short-term exceedences above the permissible sound level are allowed. The maximum level may be exceeded by 5 dBA for a total of 15 minutes, by 10 dBA for a total of 5 minutes, or by 15 dBA for a total of 1.5 minutes during any one-hour period, as shown in Exhibit 3-6.

Exhibit 3-6: Allowed Exceedences of the Maximum Permissible Noise

Duration of Exceedence	Allowed Exceedence	Equivalent Leq (h) Increase
15 minutes	5 dBA	2 dBA
5 minutes	10 dBA	2 dBA
1.5 minutes	15 dBA	2 dBA

Source: WAC 173-60-040.

Considering the allowed short-term exceedences in Exhibit 3-6, the permissible hourly Leq is approximately 2 dBA higher than the values in Exhibit 3-5. For example, a noise level of 57 dBA for 45 minutes and 62 dBA for 15 minutes (57 dBA + 5 dBA exceedence) is permissible for noise from a commercial activity received by a residential property. This sound pattern has an Leq (h) of 59 dBA.

Construction Noise Standards

Construction noise from projects within the state of Washington is exempt from Ecology property line regulations during daytime hours, but regulations apply to construction noise during nighttime hours (10 p.m. to 7 a.m. on weekdays and 10 p.m. to 8 a.m. on weekends). Construction activities performed during nighttime hours may require noise variances from the City of Bellevue.

How was the noise study performed?

The project team measured ambient noise levels for 15-minute periods at 25 locations near the study area. The goal was to describe the existing noise environment, identify major noise sources in the study area, validate the noise model, and characterize the weekday background environmental noise levels. Appendix A presents the noise measurement results.

Measurement locations characterize the variety of noise conditions and represent other sensitive receptors near the proposed project. The team modeled existing (year 2005) and future noise levels for the No Build Alternative (year 2030) and the Build Alternative (design year 2030) at all of the 15-minute noise measurement locations. Existing and future noise levels were also modeled at 20 additional locations that may potentially be affected by the project. The team evaluated 2005 as the existing year to be consistent with the transportation analysis for the proposed project.

Traffic Noise Prediction

The project team used the FHWA Traffic Noise Model (TNM) Version 2.5 computer model[9] to predict Leq (h) traffic noise levels. TNM provides precise estimates of noise levels at discrete points, by considering interactions between different noise sources and topographical features. The model estimates acoustic intensity at a receiver location, calculated from a series of straight-line roadway sections. The team calculated noise emissions from each roadway section based on the number of automobiles, medium trucks, and heavy trucks per hour; vehicular speed; and the reference noise emission levels of an individual vehicle. TNM also considers the effects of intervening walls, topography, trees, and atmospheric absorption.

What affects traffic noise?

Small changes in vehicle speed have a greater effect on noise than small changes in traffic volume. Therefore, the loudest traffic noise levels are often not experienced during rush hour. During rush-hour traffic, traffic volumes increase and vehicle speeds decrease, resulting in lower traffic noise levels.

Noise from sources other than traffic is not included in these estimates. Therefore, when non-traffic noise such as aircraft noise is considerable in an area, TNM under-predicts the actual noise level. Because project effects only depend on changes in traffic noise levels, under-predicting the total environmental noise level does not affect the study's findings. The team used monitoring results to validate the existing TNM model.

The project team imported base maps and design files into the TNM package. The team digitized major roadways, topographical features, building rows, and sensitive receptors into the model, adding elevations from the 2-foot contour data. The team took elevations for planned improvements from design profiles, proposed cross-sections, and proposed cut-and-fill limits.

Analysis of Project Effects

The noise model is validated once the noise levels in the model are within 2 dBA of the noise measurements. Once the model is validated, an Existing Conditions TNM model is created. The project team based predicted noise levels on the loudest traffic hour of the day (when traffic volumes are high but not congested) to estimate worst-case noise levels. The loudest hour is also called the *peak hour*. The results of the Existing Conditions TNM model are located in Section 4 of this report. In areas where the noise measurements were during off-peak

[9] *FHWA, 2005.*

conditions, the Existing Conditions modeled noise levels are higher than the noise levels measured.

Existing peak-hour traffic analysis for the year 2005 shows that the traffic volumes on this portion of I-405 are at capacity part of the day. Congestion on I-405 in 2030 is expected to increase substantially and exceed the roadway's capacity for both the Build and No Build alternatives. For use in TNM, to represent the peak noise effect, the No Build Alternative assumed the same traffic volume on I-405 as the Existing Conditions model during the loudest hour. The Build Alternative added 1,750 vehicles to Existing Conditions loudest-hour traffic volumes on I-405 in areas where the braided ramp will be built. For SR 520 and other roadways in the study area, predicted future traffic volumes were used. This approach ensures that the loudest traffic hour is represented in the model, because small changes in vehicle speed have a greater effect on noise than small changes in traffic volume.

The project team based the traffic volumes and vehicle mix on the Transportation Discipline Report for the project. This is documented in Appendix B. The modeled sites represent similar receptors in the area, although noise levels at adjacent receptors may be different because of terrain or distance.

Noise Mitigation (Abatement) Analysis

The project team compared predicted noise levels to the FHWA NAC and counted the receptors affected by the Build Alternative. At receptors where noise levels were modeled to approach, meet, or exceed the NAC, the team evaluated mitigation measures to determine whether the reduced traffic noise will be substantial enough to warrant the cost of barrier construction, based on WSDOT feasibility and reasonableness criteria. A detailed discussion of WSDOT feasibility and reasonableness criteria is provided in the *Mitigation* section of this report. Noise barriers were evaluated using TNM in areas where adverse noise effects were predicted to result from the proposed project.

The project team evaluated the effectiveness of noise barriers at the outermost right-of-way boundary. The goal was to minimize the potential for future corridor roadway projects requiring their removal or relocation.

What circumstances constitute consideration of noise abatement?

Noise abatement is only considered where noise effects have been identified. WSDOT defines noise effects as effects that occur when predicted traffic noise levels approach within 1 dBA of, meet or exceed the noise abatement criterion (NAC) of 67 dBA, or when predicted design year traffic noise levels exceed existing noise levels by 10 or more dBA at residential properties.

How was construction noise analyzed?

The project team assessed construction noise using EPA reference levels, and based the analysis on noise levels from construction equipment typically used on this type of project. The team assessed noise levels at various distances from the construction site and evaluated potential measures to reduce disturbance caused by construction noise. The *Measures to Avoid or Minimize Effects* section of this report describes these measures.

What is vibration?

Vibration is a swinging motion that can be described in terms of displacement, velocity, or acceleration. Because the motion moves between two set points, there is no net movement. Velocity represents the speed of motion at a given moment, and acceleration is the speed's rate of change. The human body responds to the vibration's average speed of motion (velocity). A decibel notation is commonly used to notate this speed of motion (vibration velocity level). It is reported in decibels relative to a level of 1×10^{-6} inches per second and denoted as VdB.

In contrast to airborne noise, ground-borne vibration is not a phenomenon that most people experience every day. The background vibration velocity level in residential areas is usually 50 VdB or lower – well below the threshold of perception for humans, which is around 65 VdB. Most perceptible indoor vibration is caused by sources within buildings, such as the operation of mechanical equipment, movement of people, or slamming of doors. Although the perceptibility threshold is about 65 VdB, human response to vibration is not usually severe unless the vibration exceeds 70 VdB. This is a typical level 25 feet from a truck or bus lane, unless there are bumps in the road. There is potential for minor damage to fragile historic buildings at vibration levels greater than 100 VdB.

How was vibration analyzed?

Because roadway traffic with rubber tires generates low levels of vibration, construction activities are the most likely cause of noticeable vibration. Typical vibration levels for various construction activities were evaluated, to determine whether they have any potential to damage structures along the project. Specifically, the OHMC and GHC medical facilities were evaluated for effects from construction and future operation of the project.

What criteria are used to evaluate vibration effects?

No FHWA or state standards exist for vibration. The traditional view is that highway traffic and construction vibration pose no threat to buildings and structures, and that annoyance to people is no worse than other discomforts experienced from living near highways. The American National Standards Institute and the International Standards Organization have recommended floor vibration velocity limits for hospital operating theaters. The Institute of Environmental Science (IES) has published criteria for vibration-sensitive equipment and designated the following vibration criteria low to high curves: VC-A (2,000 micro-in/sec), VC-B (1,000 micro-in/sec), and VC-C (500 micro-in/sec), etc.

The building damage criteria for vibration vary with respect to the type of building involved. Vibration from vibratory sources (e.g., vibratory rollers and vibratory hammers) should be limited to a level that prevents architectural and structural damage.

Please see Appendix C (Draft Construction and Traffic Vibration Technical Report) for more detailed information.

SECTION 4 EXISTING CONDITIONS

Where are the modeled noise receptor locations?

The I-405 Team modeled existing noise levels at 45 locations to represent 307 residences. Traffic noise from I-405, SR 520, and local arterials is the dominant noise source in the study area. Periodic noise from aircrafts also exists in the study area.

The following odd-numbered exhibits (4-1 through 4-11) show existing noise levels for the 45 modeled receptors, and the even-numbered exhibits (4-2 through 4-12) show their corresponding locations. Note that some sites are shown on more than one exhibit to maintain consistency with project graphics. Appendix A discusses the noise measurements taken in the study area.

Exhibit 4-1, Sheet 1 of 6: Modeled Noise Levels at Receptors

			Future Modeled Noise Levels (dBA) without Additional Abatement	
Noise Receptor Number	**Total Residences Represented**	**Modeled Existing Noise Level (dBA)**	**2030 No Build**	**2030 I-405, NE 8th Street to SR 520 Improvement Project**
1*	Site acquired by WSDOT	**70**	N/A**	N/A**
2A***	3	**73**	**73**	**73**
2B***	13	**74**	**74**	**74**
3	4	58	58	58
4	1	**67**	**66**	**66**
5	7	**72**	**73**	**73**

*Text in **bold** indicates receptors that approach, meet or exceed the NAC of 67 dBA.*

**Sites analyzed as part of the NE 10th Street Project.*

***Not applicable*

****Modeled sites with the same number and different letters are located on different levels of the same multi-leveled building.*

Exhibit 4-2, Sheet 1 of 6: Modeled Noise Receptor Locations

Exhibit 4-3, Sheet 2 of 6: Modeled Noise Levels at Receptors

			Future Modeled Noise Levels (dBA) without Additional Abatement	
Noise Receptor Number	**Total Residences Represented**	**Modeled Existing Noise Level (dBA)**	**2030 No Build**	**2030 I-405, NE 8th Street to SR 520 Improvement Project**
1*	Site acquired by WSDOT	**70**	N/A**	N/A**
2A***	3	**73**	**73**	**73**
2B***	13	**74**	**74**	**74**
3	4	58	58	58
4	1	**67**	**66**	**66**
5	7	**72**	**73**	**73**
6	3	61	62	62
7	6	65	65	65
8	7	**69**	**69**	**69**
9	7	64	64	64
10*	4	**69**	**70**	N/A
11	2	62	63	**67**
12	4	65	65	**77**
13	3	60	60	**70**
14	3	64	64	**67**
15	1	63	63	**76**
16*	3	65	65	N/A
17	1	61	62	**72**
18	2	65	65	**74**
19	1	63	63	**69**
20	1	62	62	**68**

*Text in **bold** indicates receptors that approach, meet or exceed the NAC of 67 dBA.*

**Modeled sites will be acquired to build this project.*

*** Not applicable.*

****Modeled sites with the same number and different letters are located on different levels of the same multi-leveled building.*

Exhibit 4-4, Sheet 2 of 6: Modeled Noise Receptor Locations

Exhibit 4-5, Sheet 3 of 6: Modeled Noise Levels at Receptors

Noise Receptor Number	Total Residences Represented	Modeled Existing Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement: 2030 No Build	Future Modeled Noise Levels (dBA) without Additional Abatement: 2030 I-405, NE 8th Street to SR 520 Improvement Project
9	7	64	64	64
10*	4	**69**	**70**	N/A
11	2	62	63	**67**
12	4	65	65	**77**
13	3	60	60	**70**
14	3	64	64	**67**
15	1	63	63	**76**
16*	3	65	65	N/A
17	1	61	62	**72**
18	2	65	65	**74**
19	1	63	63	**69**
20	1	62	62	**68**
21	12	**69**	**69**	**69**
22	4	57	57	57
23	5	59	59	59
24	6	63	63	63
25	5	62	62	62
26	3	63	63	63
27	4	**68**	**69**	**69**
28	10	61	61	61
29	9	61	61	61
30	3	65	**66**	**66**

*Text in **bold** indicates receptors that approach, meet or exceed the NAC of 67 dBA.*
**Modeled sites will be acquired to build this project.*

Exhibit 4-6, Sheet 3 of 6: Modeled Noise Receptor Locations

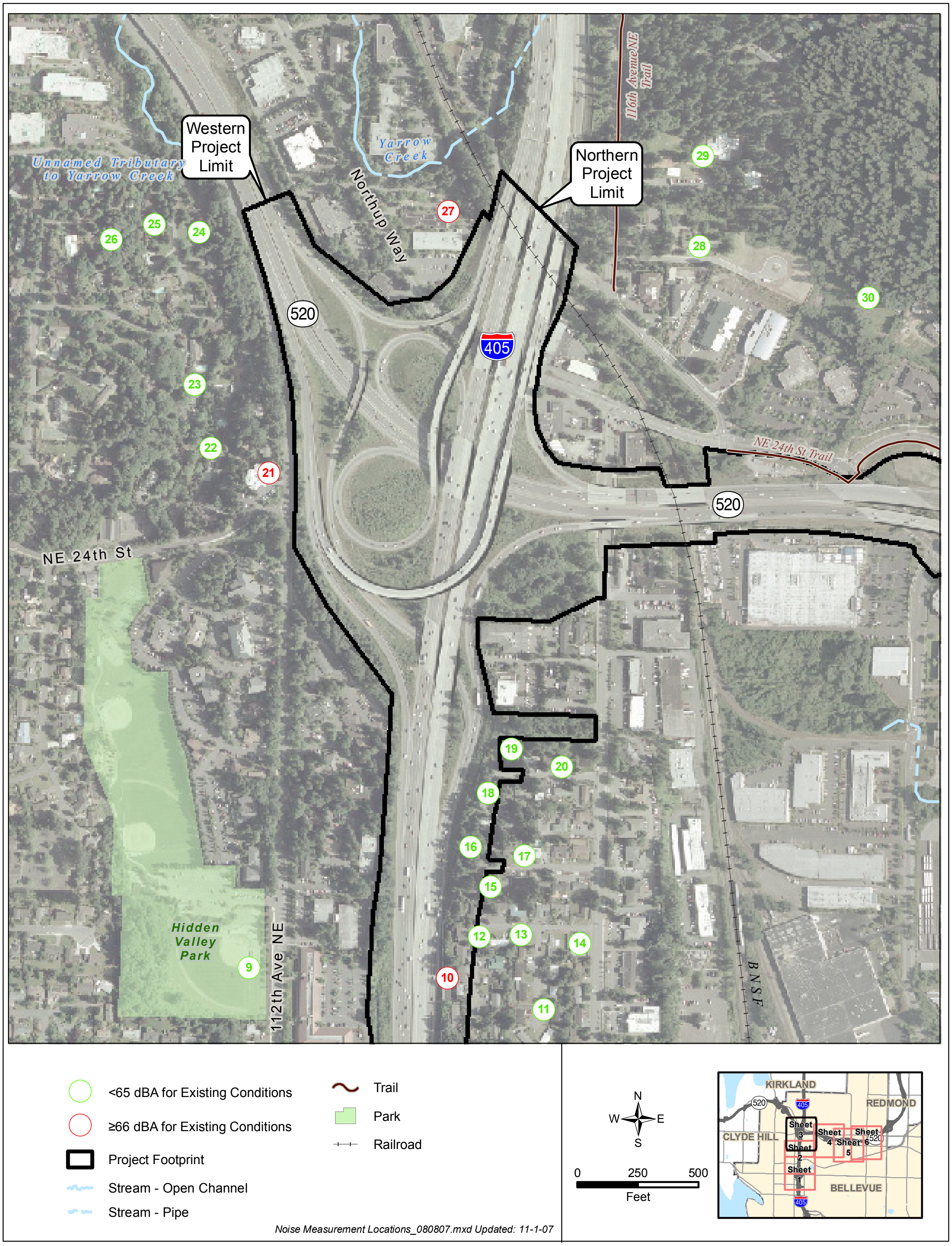


Exhibit 4-7, Sheet 4 of 6: Modeled Noise Levels at Receptors

Noise Receptor Number	Total Residences Represented	Modeled Existing Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement: 2030 No Build	Future Modeled Noise Levels (dBA) without Additional Abatement: 2030 I-405, NE 8th Street to SR 520 Improvement Project
30	3	65	**66**	**66**
31	3	**68**	**69**	**69**
32	3	64	64	65
33A*	5	60	61	62
33B*	5	64	65	65
33C*	5	65	**66**	**66**
34A*	4	**68**	**69**	**70**
34B*	4	**72**	**73**	**73**
34C*	4	**72**	**73**	**74**
35	8	65	**66**	**67**
36	7	62	63	63
37A*	8	**75**	**76**	**76**
37B*	8	**75**	**76**	**77**
37C*	8	**75**	**76**	**77**
38	3	63	64	65
39A*	5	**67**	**67**	**67**
39B*	5	**69**	**69**	**68**
40	5	**70**	**71**	**72**
41	3	59	60	60
42	4	59	60	60
43	9	61	63	62

*Text in **bold** indicates receptors that approach, meet or exceed the NAC of 67 dBA.*

**Modeled sites with the same number and different letters are located on different levels of the same multi-leveled building.*

Exhibit 4-8, Sheet 4 of 6: Modeled Noise Receptor Locations

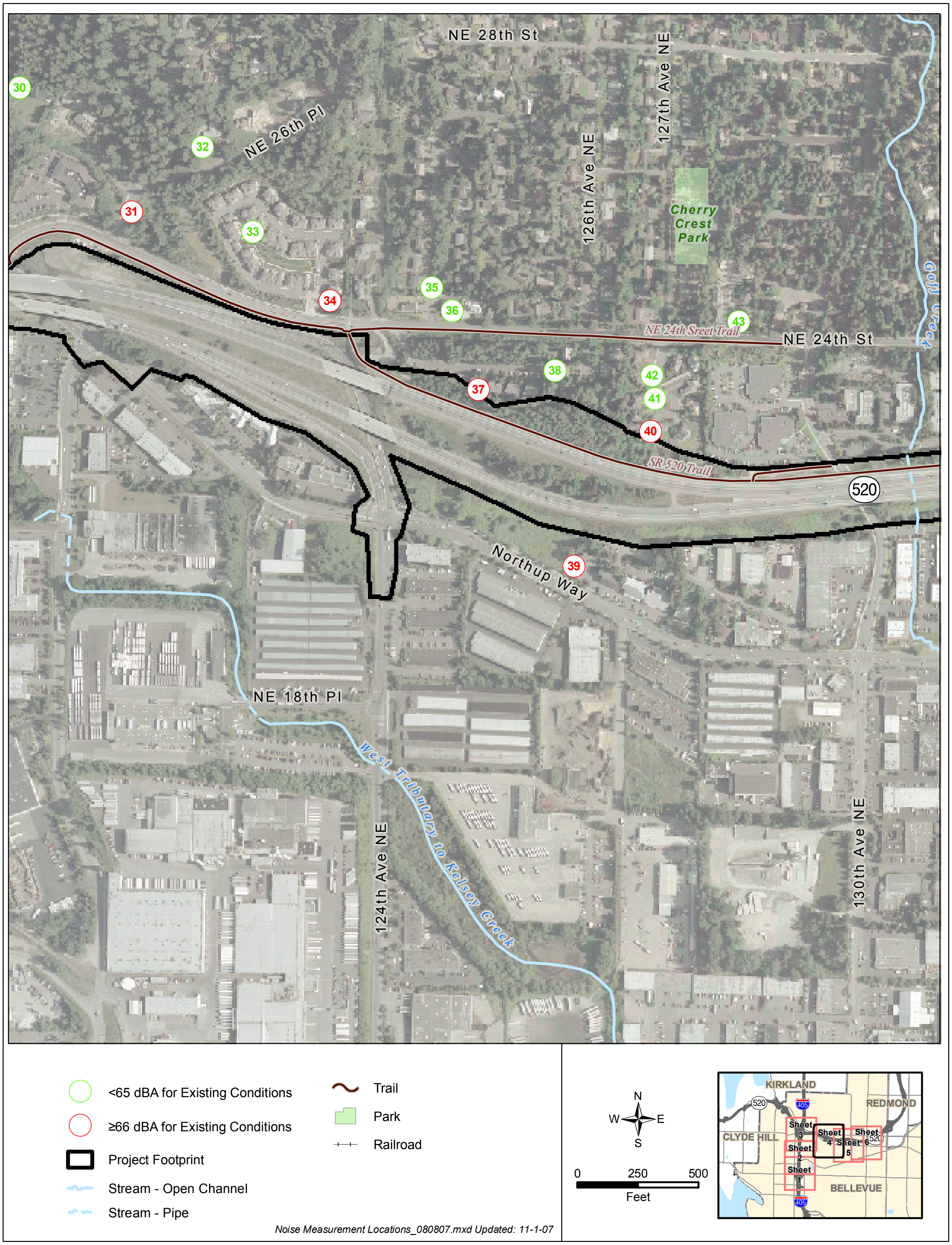


Exhibit 4-9, Sheet 5 of 6: Modeled Noise Levels at Receptors

			Future Modeled Noise Levels (dBA) without Additional Abatement	
Noise Receptor Number	**Total Residences Represented**	**Modeled Existing Noise Level (dBA)**	**2030 No Build**	**2030 I-405, NE 8th Street to SR 520 Improvement Project**
40	5	**70**	**71**	**72**
41	3	59	60	60
42	4	59	60	60
43	9	61	63	62
44	10	63	64	64
45	2	**67**	**68**	**69**

*Text in **bold** indicates receptors that approach, meet or exceed the NAC of 67 dBA.*

Exhibit 4-10, Sheet 5 of 6: Modeled Noise Receptor Locations

Exhibit 4-11, Sheet 6 of 6: Modeled Noise Levels at Receptors

			Future Modeled Noise Levels (dBA) without Additional Abatement	
Noise Receptor Number	**Total Residences Represented**	**Modeled Existing Noise Level (dBA)**	**2030 No Build**	**2030 I-405, NE 8th Street to SR 520 Improvement Project**
45	2	**67**	**68**	**69**

*Text in **bold** indicates receptors that approach, meet or exceed the NAC of 67 dBA.*

Exhibit 4-12, Sheet 6 of 6: Modeled Noise Receptor Locations

What are the modeled noise levels?

The project team used TNM to model noise levels for existing conditions in the study area, and levels ranged from 57 to 75 dBA. These levels range from typical suburban outdoor sound levels (between 50 to 60 dBA[10]) to very noisy levels (above 70 dBA) that are typical of locations within 100 feet of a busy freeway. Modeled noise levels at 20 of the 45 sites (representing 107 residences and one former hotel) currently approach, meet, or exceed the FHWA criteria of 67 dBA for existing conditions (see Exhibits 4-1 through 4-12).

These modeling results represent the loudest traffic hour of the day, when traffic volumes are high but not congested, so traffic speeds remain high.

[10] EPA, 1974.

SECTION 5 PROJECT EFFECTS

How will the project affect noise levels in the study area?

Build Alternative

Modeling for the Build Alternative indicates that noise levels will approach, meet, or exceed the NAC at 30 locations representing 137 residences. Existing noise levels approach, meet, or exceed FHWA criteria at 20 locations representing 107 residences and one former hotel.

No Build Alternative

Modeling for the No Build Alternative includes the NE 10th Street Bridge Project. Modeling indicates that noise levels will approach, meet, or exceed the NAC at 22 locations representing 123 residences. Existing noise levels approach, meet, or exceed the FHWA criteria at 20 locations representing 107 residences and one former hotel that has already been acquired to build the NE 10th Street Project.

How do the Existing Conditions, No Build, and Build Alternatives differ?

Existing noise levels approach, meet, or exceed the NAC at 20 locations representing the equivalent 107 residences.

Noise levels for the No Build Alternative are predicted to either stay the same, decrease by 1 dBA, or increase up to 2 dBA over existing conditions. Noise levels at 22 locations, including 123 residences, will approach, meet, or exceed the NAC for the No Build Alternative.

Noise levels for the Build Alternative were predicted to either stay the same, decrease by 1 dBA, or increase up to 13 dBA over existing conditions, depending on receptor location within the study area. Noise levels at 30 locations, including the 137 residences, will approach, meet, or exceed the NAC.

A former hotel was included in the existing conditions analysis. This hotel was recently acquired by WSDOT and will be converted into transportation use. Therefore it is not included in the No Build and Build alternatives analyses. Two locations that represent seven residences were included in the existing conditions and No Build Alternative analyses. These locations were not included in the Build Alternative analysis because these properties will be acquired to construct the project and will be converted into transportation use.

Will project construction affect noise levels?

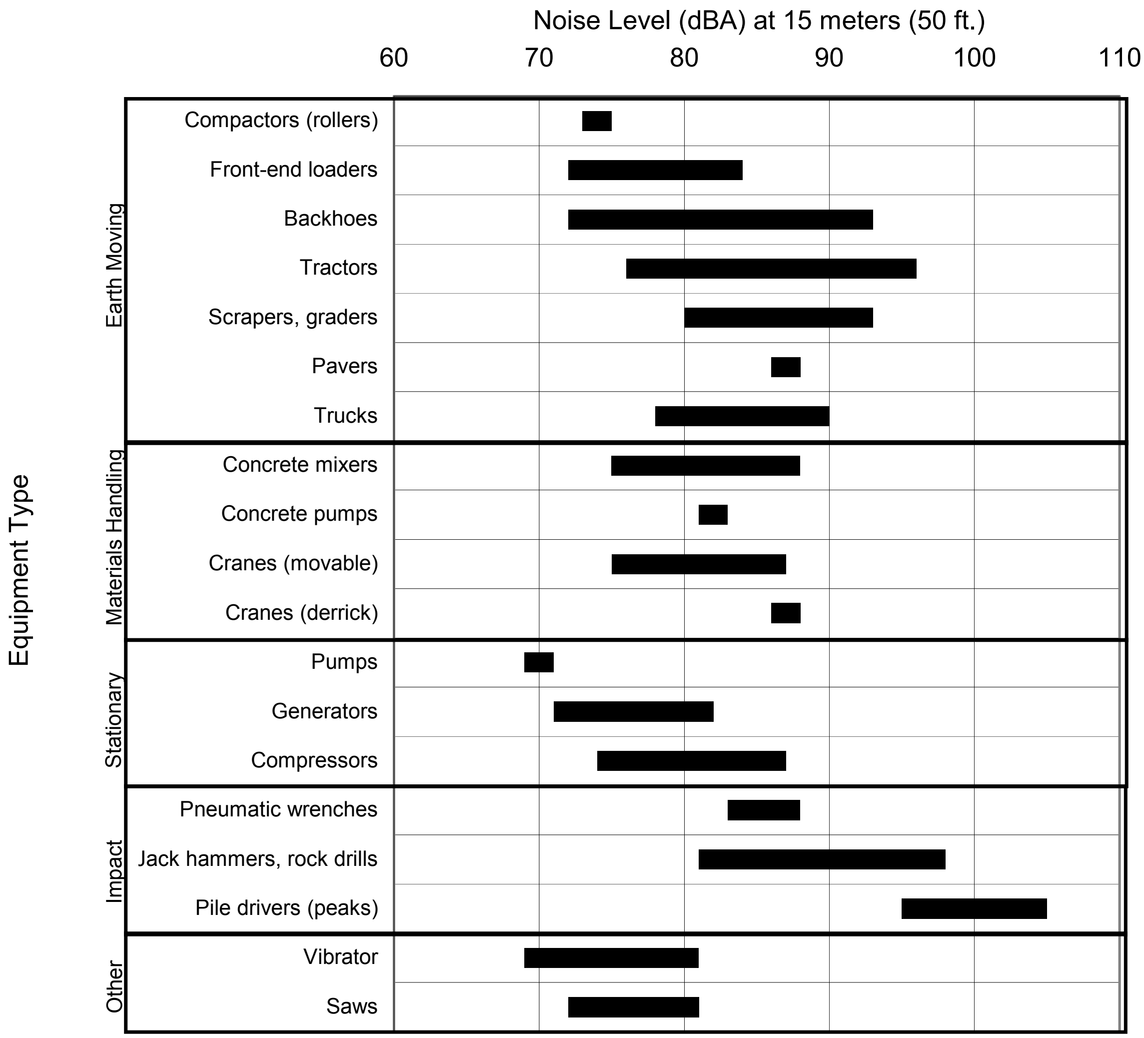
Construction activities will generate noise during the construction period. Construction will usually be carried out in several reasonably discrete steps, each with its own mix of equipment and its own noise characteristics. Roadway construction will involve clearing, cut-and-fill (grading) activities, removing old roadways, importing and compacting fill, paving, and pile driving.

What are the noise sources during construction?

The most prevalent noise source at construction sites will be the internal combustion engine. Engine-powered equipment includes earth-moving and compaction, material-handling and stationary equipment. Mobile equipment operates intermittently, with periods of high and low noise. Stationary equipment (e.g., generators and compressors) operates at sound levels that are fairly constant over time. Because trucks will be present during most construction phases and will not be confined to the active construction area, truck noise could affect more area residents. Other construction noise sources will include impact equipment and tools such as pile drivers. Impact tools could be pneumatically powered, hydraulic, or electric.

Construction noise will be intermittent. These noise levels will depend on the type, amount, and location of construction activities. The type of construction methods followed will establish maximum noise levels for the equipment used. The amount of construction activity will define how often noise will occur. The proximity of construction equipment to adjacent properties will affect the noise levels of the receptors. Maximum noise levels for construction equipment for the Build Alternative will be similar to the typical maximum levels presented in Exhibit 5-1.

Exhibit 5-1: Typical Construction Noise Levels



Source: EPA, 1971 and WSDOT, 1991.

What is the range of noise from construction equipment?

As shown in Exhibit 5-1, maximum noise levels from construction equipment will range from 69 to 106 dBA at 50 feet. Construction noise at residences farther away will decrease at a rate of 6 dBA per doubling of distance from the source. The number of maximum noise level occurrences will increase during construction, particularly during pile-driving activities. Because some equipment will be turned off, idling, or operating at less than full power at any time and because construction machinery is typically used to complete short-term tasks at any given location, average Leq noise levels

How does noise reduction change with distance?

Noise decreases at a rate of 6 dBA per doubling of distance. For example, if a jackhammer at 50 feet is 90 dBA, the noise generated from the jackhammer would decrease to 84 dBA at 100 feet.

during the day will be less than the maximum noise levels presented in Exhibit 5-1. The construction practices identified in the *Measures to Avoid or Minimize Effects* section of this report will help reduce construction noise levels.

What are the potential effects of vibration?

During operation, vibration levels will continue to be similar to those currently occurring in the study area. The observed vibration spectra at the closest distance to I-405 were all well below American National Standards Institute (ANSI), International Standards Organization (ISO), and Institute of Environmental Science (IES) VC-C criteria, with the exception of the 20 Hz maximum I/3 octave band level that was approximately 340 micro-inches per second at 17 feet from the I-405 right-of-way (as discussed further in Appendix C). The maximum vibration levels at 19, 44, and 57 feet from the I-405 right-of-way did not exceed the VC-C criteria. Since none of the operating theaters within the OHMC or GHC are within 17 feet of the I-405 right-of-way, there is no expected effect on hospital operating theaters, bench microscopes, and operating room microscopes.

Normal automobile and truck traffic running on a well-maintained pavement surface will not affect the sensitive uses such as operating theaters, surgical microscopes, or magnetic resonance imaging (MRI) at either the OHMC or GHC facilities. No substantial vibration effects will occur during operation.

During construction, various activities will create vibration. Heavy construction equipment such as large bulldozers and loaded trucks frequently generate between 85 and 87 VdB at 25 feet. Pile driving may generate between 104 and 112 VdB at 25 feet. The vibration energy from pile driving decreases to between 92 and 100 VdB at 100 feet. The potential for minor damage to fragile structures is limited to approximately 25 feet from most construction activities and 100 feet from pile driving. People will feel minor ground movement at greater distances, but because the construction activities are temporary and there is negligible potential for damage to fragile structures, this will not constitute a negative effect.

During construction, most of the OHMC and GHC campus will be affected by vibratory roller operations. The OHMC campus will also be affected during demolition of the NE 12th

Street Bridge and caisson drilling between NE 8th Street and NE 12th Street. The medical facilities that will be most affected are parts of the OHMC outpatient surgery at the ground floor of the existing Northwest Parking Garage, and the patient surgery area on the second floor of the existing Hospital Surgical Pavilion closest to I-405 as these facilities included activities sensitive to vibration. GHC medical facilities will not be affected by these construction activities. All other construction equipment and activities will generate lower levels of vibration. No substantial vibration effects are expected during construction.

Does the project have other effects that may be delayed or distant from the project?

An effect is considered to be indirect when it occurs later in time or farther removed from an original project action. Indirect effects may include those related to changes in land use patterns, population density or growth rate, and related effects on other natural systems.

The noise analysis for this project is based on the transportation demand forecasting model and includes the effects of unmet demand on the transportation system. By including unmet demand, the indirect effects of increased transportation capacity are included in the analysis.

The results of the noise analysis already reflect the potential delayed and distant effects of the I-405, NE 8th Street to SR 520 Improvement Project. The data presented in the even-numbered exhibits from Exhibit 4-2 to Exhibit 4-8 reflect modeled noise levels for the Build Alternative through 2030.

Were potential cumulative effects for noise and vibration considered?

The I-405 Team did not evaluate cumulative effects for this discipline report. A report of cumulative effects is not needed for every discipline studied for NEPA and SEPA documentation. The disciplines that were studied for cumulative effects are air quality, surface water and water quality, fisheries and aquatic habitat, and wetlands. The cumulative effects for these disciplines are presented in the Cumulative Effects Analysis Discipline Report.

SECTION 6 MEASURES TO AVOID OR MINIMIZE EFFECTS

WSDOT can control noise at three locations during construction: at noise sources with mufflers and quieter engines; along noise paths with barriers; and at receptors with insulation. Noise abatement is only necessary where frequent outdoor human use occurs and where a lower noise level will provide benefits.[11] WSDOT will control construction noise by incorporating avoidance and minimization measures into the project's construction specifications.

What measures will be taken to mitigate effects during construction?

Where practicable, WSDOT will reduce construction noise by installing mufflers on engines, using quiet equipment or construction methods, minimizing operation time, and locating equipment far from sensitive receptors. To reduce construction noise at nearby receptors, WSDOT will incorporate the following activities where practicable:

- As construction takes place in the area where the noise barrier is to be built, if possible, construct the proposed noise barrier before other construction activities begin;
- Limit the noisiest construction activities (e.g., pile driving) to between 7 a.m. and 10 p.m., to reduce construction noise levels during sensitive nighttime hours;
- Equip construction equipment engines with adequate mufflers, intake silencers, and engine enclosures to reduce their noise;
- Turn off construction equipment during prolonged periods of nonuse to eliminate noise;
- Where possible, locate stationary equipment away from residences to decrease noise;
- Require the use of Occupational Safety and Health Administration (OSHA)-approved ambient sound-sensing backup alarms to reduce disturbances from backup alarms during quiet periods.

[11] *DOT, 1982*

What measures will be taken to mitigate effects of operation?

FHWA regulations (23 CFR 772) specify that abatement (mitigation) measures must be evaluated when project noise effects are identified. For FHWA approval, all noise abatement measures that are determined to be feasible and reasonable must be incorporated into the project design, given local resident support.

A variety of mitigation methods can effectively reduce traffic noise levels. For example, methods to reduce noise generated from the project's long-term operation can include implementing traffic management measures, acquiring land as buffer zones, realigning the roadway, insulating a public use or non-profit institutional structures from noise, and constructing noise barriers or berms.

The project team evaluated these measures for their potential to reduce noise caused by the proposed project. This section summarizes the results of this evaluation. As this is a design-build project, a final determination of the size and placement of noise barriers or berms and the implementation of other noise-attenuating methods will take place during detailed project design. This determination will occur after an opportunity for public involvement and after approval at the local, state, and federal levels.

Traffic Management Measures

Traffic management measures include time restrictions or traffic control devices and signing. These measures help prohibit certain vehicle types (e.g., motorcycles and heavy trucks), modify speed limits, and implement exclusive lane designations.

Restricting vehicle types or lowering speed limits on I-405 could worsen congestion and is contrary to the facility's purpose. Land use controls could help reduce noise effects throughout the study area, although the area is largely built out. A Transportation System Management Plan, combined with increased transit facilities that encourage carpool and public transit use, will reduce vehicle trips and subsequently can reduce traffic noise. However, a 3-dBA decrease in traffic noise will require an approximately 50-percent reduction in traffic, which will not occur.

Land Acquisition for Noise Buffers or Barriers

Residential properties border I-405 in the study area. Acquiring land in this area will require the relocation of residents, which is an unreasonably expensive option for noise mitigation purposes.

Roadway Realignment

The project's horizontal alignment is defined by the proposed right-of-way. The vertical alignment is constrained by the need to provide clearance above and below roadway, railroad, and utility crossings. Lowering the I-405 mainline to provide noise reduction for some receptors will be prohibitively expensive and will only provide marginal improvement. Realigning the roadway could also increase noise levels at other receptors.

Noise Insulation of Buildings

Noise insulation of buildings could be feasible, but this remedy does not apply for commercial and residential structures, which constitute most uses within the study area.

Noise Barriers

Noise barriers include noise walls, berms, and buildings with uses that are not noise sensitive. A noise barrier's effectiveness is determined by its height and length and by site topography.

WSDOT evaluates many factors to determine whether barriers are feasible and/or reasonable. To be feasible, a barrier must be constructible in a location within WSDOT right-of-way that achieves a noise reduction of at least 7 dBA at one or more receptors, and must provide a reduction of at least 5 dBA at the majority of first-row receptors. The determination of reasonableness depends on the number of sensitive receptors benefited by at least a 3-dBA noise reduction, the barriers' cost effectiveness, and concerns such as aesthetics, safety, and the desires of nearby residents.

Noise barriers were evaluated in areas where noise levels were predicted to approach, meet, or exceed the NAC if the project is built. These areas included a large number of noise-sensitive receptors, closely grouped together to allow for a reasonable evaluation. Noise-sensitive areas that approach, meet or exceed the NAC were evaluated for noise barriers, except for McCormick Park (Receptor 4), the 7 residences represented by

Receptor 5 (located at 1233 112th Avenue NE), the 7 residences represented by Receptor 8 (located at the 1700 Block on 112th Avenue NE), and Megumi Preschool (Receptor 27).

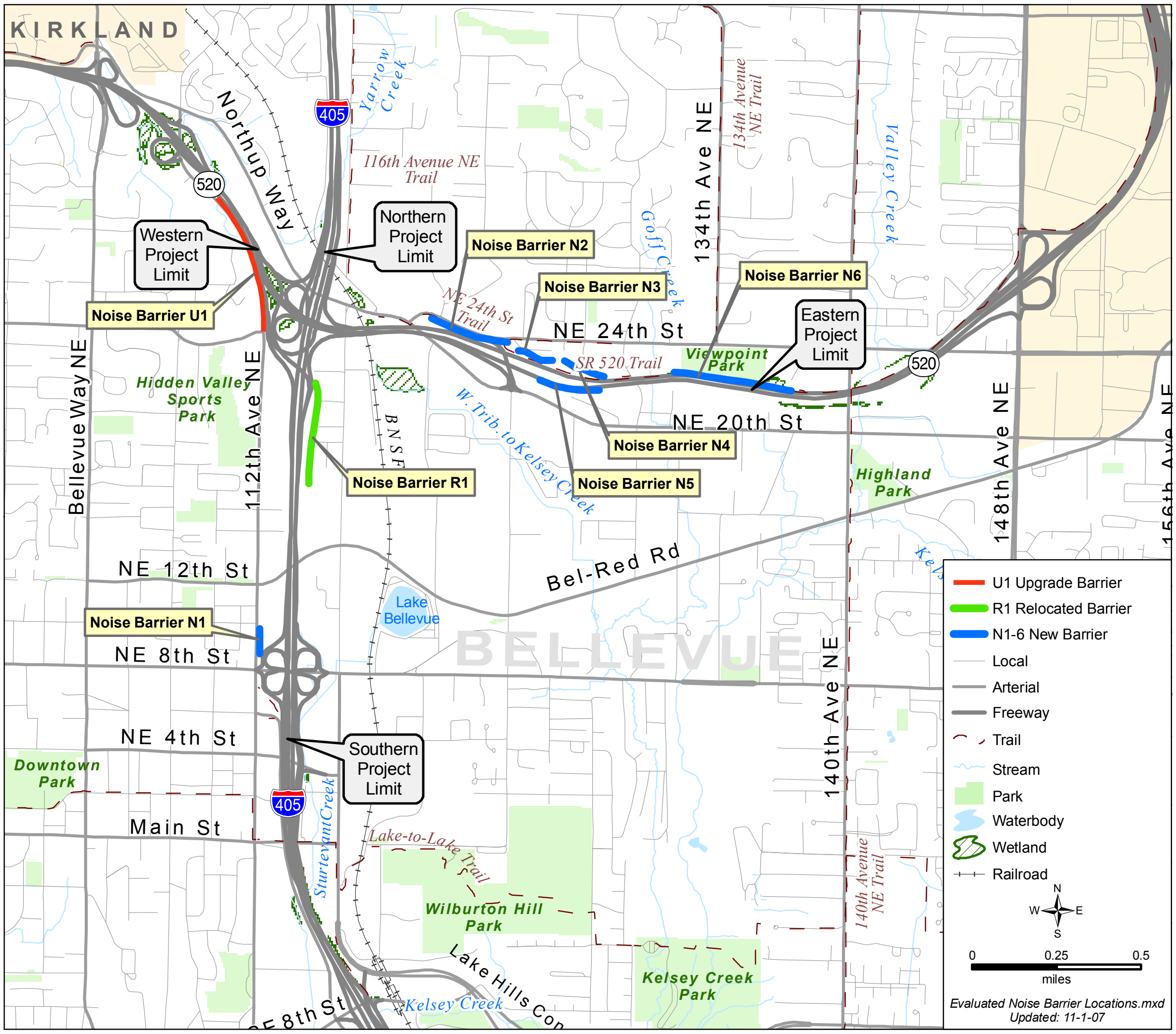
McCormick Park, and Receptors 5 and 8 are separated from the edge of I-405 pavement by nearly 500 feet, dense trees, buildings, 112th Avenue NE, and, in the case of McCormick Park, NE 12th Street. Thus, the majority of traffic noise experienced at these modeled sites is generated from 112th Avenue NE and, in the case of McCormick Park, NE 12th Street. Megumi Preschool is approximately 30 feet beneath the I-405/SR 520 interchange and experiences traffic noise from Northup Way. Based on their physical location in relation to I-405 and/or SR 520 and their primary traffic noise sources, noise mitigation from I-405 and/or SR 520 is not feasible for any of these noise-sensitive areas. (Receptor locations and noise levels are shown in Exhibits 4-2 through 4-9.)

McCormick Park, the 7 residences represented by Receptor 5, the 7 residences represented by Receptor 8, and Megumi Preschool all approach, meet or exceed the NAC under existing conditions at 67 dBA, 72 dBA, 69 dBA, and 68 dBA, respectively. McCormick Park experiences a 1-dBA decrease under the Build Alternative, so it experiences a noise level of 66 dBA. The 7 residences represented by Receptor 5 and the Megumi Preschool both experience a 1-dBA increase under the Build Alternative, so they experience a noise level of 73 dBA and 69 dBA, respectively. The noise level at the 7 residences represented by Receptor 8 is the same under existing conditions and the Build Alternative at 69 dBA.

Six new noise barriers, 1 replacement barrier and 1 upgrade barrier were evaluated for the project. One replacement barrier met the feasibility and reasonableness criteria for this project. Evaluated noise barrier locations are shown for Existing and No Build Conditions in Exhibit 6-1. Noise Barrier R1 already exists and will be moved to a new location under the Build Alternative due to realignment of the I-405 mainline and the I-405 northbound to SR 520 on-ramp.

This section summarizes the evaluation of each noise barrier. Refer to Appendix B for more detailed information.

Exhibit 6-1: Evaluated Noise Barriers



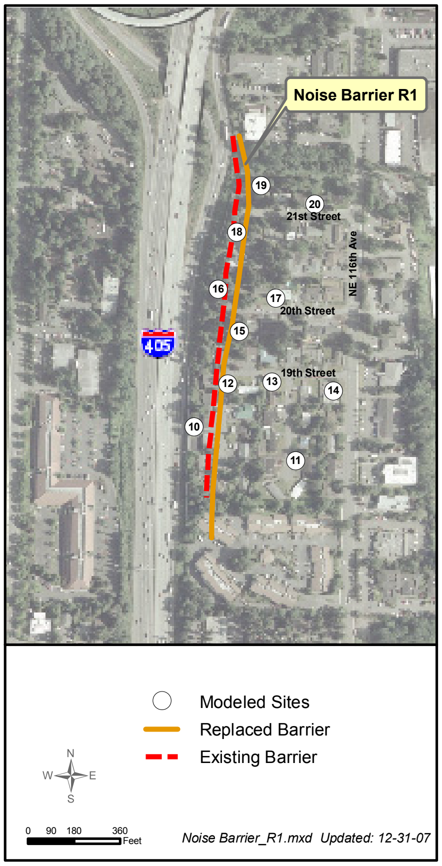
Noise Barrier N1 (Not Feasible)

The 989 Elements multi-family complex was evaluated for a noise barrier. This complex is located west of the I-405 southbound to NE 8th Street off-ramp, on the corner of NE 10th Street and 112th Avenue NE. Noise levels in the area of Noise Barrier N1 range from 73 to 74 dBA without a noise barrier.

The maximum reduction provided by Noise Barrier N1 is 1 dBA for the 13 residences represented by Modeled Site 2B. With a 24-foot-high wall, Noise Barrier N1 will not provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 2A and 2B (see Appendix B). This indicates that Noise Barrier N1 is not feasible.

The primary reason that Noise Barrier N1 will not reduce traffic noise in this area is because Modeled Sites 2A and 2B represent residences in a high-rise multi-family complex. A typical noise barrier cannot break the line-of-sight in such an instance.

Exhibit 6-2: Location of Barrier R1 Replacement



Noise Barrier R1 Replacement

The existing noise barrier that runs along the I-405 northbound to SR 520 on-ramp must be removed to make way for the new I-405 northbound to SR 520 on-ramp that is part of this project. This will cause noise levels at Modeled Sites 11, 12, 13, 14, 15, 17, 18, 19, and 20 to exceed the NAC. (Seven residences represented by Receptors 10 and 16 will be acquired for roadway realignment.) In accordance with WSDOT perpetuity standards, Noise Barrier R1 must be relocated to a position that provides residences behind the noise barrier with shielding effects that are comparable to those of the existing barrier. For this reason, the project team evaluated Noise Barrier R1 at its approximate original length of 1,585 feet and an average height of 20 feet (see Exhibit 6-3). The new location for Noise Barrier R1 is atop a planned retaining wall that is within 50 feet of its existing location and ranges 2 to 10 feet higher in elevation as this area is east of I-405 (see Exhibit 6-2). Elevations atop Noise Barrier R1 range from 235 feet at the southern end to 245 feet at the northern end with top of wall elevations reaching as high as 265 feet at central portions of the barrier. Noise levels in this area range from 67 to 77 dBA without a replacement barrier.

Maintaining similar dimensions as the existing noise barrier, Noise Barrier R1 provides comparable noise benefits provided by the existing barrier. At a height of 20 feet and a length of 1,585 feet, Noise Barrier R1 provides a maximum reduction of 16 dBA for the four first-row residences represented by Modeled Site 12. Three first-row residences represented by Modeled Sites 15 and 18 receive respective reductions of 15 and 13 dBA. The two remaining first-row residences in the area are represented by Modeled Site 19, which receives a 7-dBA reduction. Noise levels at all 18 remaining residences represented by Modeled Sites 11 through 15 and 17 through 20 are predicted to be below the NAC due to Noise Barrier R1's shielding effects.

Exhibit 6-3 presents the barrier area, planning level cost, and noise reduction provided by the relocated Noise Barrier R1.

Exhibit 6-3: Replacement Barrier Area for Noise Barrier R1 - 20 ft tall, 1,585 ft long

Modeled Site	Residences Represented	Leq (dBA)	Noise Level with Barrier (dBA)	Reduction (dBA)
11	2	67	64	3
12	4	77	61	16
13	3	70	60	10
14	3	67	64	3
15	1	76	61	15
17	1	72	62	10
18	2	74	61	13
19	1	69	62	7
20	1	68	62	6
Total Barrier Area (ft^2)			31,700	
Planning-Level Cost ($)			$1,692,780	

Increasing the height from 20 feet to 24 feet provided a maximum reduction of 1 dBA for the 5 residences represented by Modeled Sites 12 and 19. This modification to Noise Barrier R1 will not provide a noticeable reduction in I-405 traffic noise levels for any of the residences located behind Noise Barrier R1 in comparison to the 20-foot Noise Barrier R1 detailed above. For this reason, an upgrade to Noise Barrier R1 is not feasible. See Appendix B for additional height configuration analyses for Noise Barrier R1.

Noise Barrier U1 (Not Feasible)

The I-405, NE 8th Street to SR 520 Improvement Project will not affect the existing noise wall at location U1. However, future noise levels in the vicinity of Noise Barrier U1 were predicted to approach, meet, or exceed the NAC. For this reason, Noise Barrier U1 was evaluated for a height upgrade as part of this project. This noise barrier is currently approximately 22 feet tall and 2,257 feet long.

The project team evaluated increasing Noise Barrier U1's height by 8 feet. This upgrade will not provide any reduction in noise levels for the school and first-row residences that have a combined Residential Equivalency of 12 (see Appendix B) and are represented by Modeled Site 21. This upgrade will not provide a 7-dBA reduction in I-405 traffic noise levels for Modeled Site 21 (see Appendix B). This indicates that Noise Barrier U1 is not feasible.

The primary reason that Noise Barrier U1 will not reduce I-405 traffic noise in this area is that the existing noise barrier already provides maximized shielding effects. Modeled Site 21 is the only receptor in the area that approaches or exceeds the NAC. This is because it is located on the corner of 112th Avenue NE and NE 24th Street, which both generate local traffic noise that affects noise levels at Modeled Site 21.

Noise Barrier N2 (Feasible, Not Reasonable)

The Boulders at Pikes Peak Condominiums and a pocket of single-family residences northeast of the NE 24th Street/120th Avenue NE intersection were evaluated for a noise barrier. Noise Barrier N2 was evaluated along WSDOT right-of-way between the 124th Avenue NE to SR 520 westbound on-ramp and NE 24th Street. Noise levels in the area range from 63 to 73 dBA without a noise barrier.

At a height of 24 feet and length of 1,249 feet (an approximate area of 29,976 square feet), the maximum reduction provided by Noise Barrier N2 is 7 dBA at the eight first-row residences represented by Modeled Sites 34A and 34B. The four remaining first-row residences in the area are represented by Modeled Site 34C and receive a reduction of 4 dBA. Noise Barrier N2 meets WSDOT feasibility criteria, because a 7-dBA reduction is achieved and a reduction of 5 dBA or more is provided at 8 of the 12 first-row residences in the area.

The WSDOT allowable area for this barrier evaluation is 26,787 square feet, as shown in Exhibit 6-4. This indicates that Noise Barrier N2 is not reasonable (see Appendix B for additional analysis).

Noise Barrier N3 (Feasible, Not Reasonable)

The Cherry Crest Vista Condominium complex was evaluated for a noise barrier. Noise Barrier N3 was evaluated north of SR 520 along WSDOT right-of-way. Noise levels at outdoor use areas in the area range from 67 to 77 dBA without a noise barrier. Outdoor decks at the Cherry Vista Condominium complex are enclosed.

Exhibit 6-4: Allowed Barrier Area for Noise Barrier N2 – 24 ft tall, 1,249 ft long

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
30	3	66	0	66	0
31	3	69	2,715	65	4
33A	5	62	3,500	60	2
33B	5	65	3,500	61	4
33C	5	66	3,500	63	3
34A	4	70	3,892	63	7
34B	4	73	4,704	66	7
34C	4	74	4,976	70	4
Total Barrier Area (ft^2)			Allowed	Required	
			26,787	29,976	
Planning-Level Cost ($)			$1,430,426	$1,600,718	

At a height of 24 feet, the maximum reduction provided by Noise Barrier N3 is 15 dBA at the one first-row residence represented by Modeled Site 37A. Modeled Site 37B represents two additional first-row residences that achieve 5-dBA reductions. The remaining first-row residence in the area is represented by Modeled Site 37C and achieves a 1 dBA reduction. Noise Barrier N3 meets WSDOT feasibility criteria, because a 7-dBA reduction is achieved and a reduction of 5 dBA or more is provided at three out of four first-row residences in the area.

An area of approximately 13,481 square feet is required for Noise Barrier N3, at a height of 24 feet and a length of 562 feet. The WSDOT allowable area for this barrier evaluation is 4,362 square feet, as shown in Exhibit 6-5. This indicates that Noise Barrier N3 is not reasonable (see Appendix B for additional analysis).

Noise Barrier N4 (Feasible, Not Reasonable)

The pocket of single-family residences at the 2300 block of 127th Avenue NE was evaluated for a noise barrier. Noise Barrier N4 was evaluated north of SR 520 along WSDOT right-of-way. Noise levels in the area range from 60 to 72 dBA without a noise barrier.

Exhibit 6-5: Allowed Barrier Area for Noise Barrier N3 – 24 ft tall, 562 ft long

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
35	8	67	0	66	1
36	7	63	0	63	0
37A	1	77	1,454	62	15
37B	2	77	2,908	72	5
37C	1	77	0	76	1
38	3	65	0	65	1
Total Barrier Area (ft²)			Allowed	Required	
			4,362	13,481	
Planning-Level Cost ($)			$232,931	$719,885	

At a height of 12 feet, the maximum reduction provided by Noise Barrier N4 is 7 dBA at the 5 first-row residences represented by Modeled Site 40. Noise Barrier N4 meets WSDOT feasibility criteria, because a 7-dBA reduction is achieved and a reduction of 5 dBA or greater is provided at all 5 first-row residences in the area.

An area of approximately 7,260 square feet is required for Noise Barrier N4, at a height of 12 feet and a length of 605 feet. The WSDOT allowable area for this barrier evaluation is 5,545 square feet, as shown in Exhibit 6-6. This indicates that Noise Barrier N4 is not reasonable. See Appendix B for additional analysis showing that 16 foot and 20 foot N4 Noise Barrier designs did not achieve perceivable noise reduction at additional noise receptors.

Noise Barrier N5 (Not Feasible)

The Hi Lan apartment complex located south of SR 520 at 12628 Northup Way was evaluated for a noise barrier. Noise levels in the area range from 67 to 68 dBA without a noise barrier.

Exhibit 6-6: Allowed Barrier Area for Noise Barrier N4 – 12 ft tall, 605 ft long

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
40	5	72	5,545	65	7
41	3	60	0	60	0
42	4	60	0	60	0
43	9	62	0	62	0
Total Barrier Area (ft²)			Allowed	Required	
			5,545	7,260	
Planning-Level Cost ($)			$296,103	$387,684	

At a height of 24 feet, Noise Barrier N5 does not provide a reduction for any of the 10 residences represented by Modeled Sites 39A and 39B. Noise Barrier N5 is not feasible, because it does not provide a 7-dBA reduction in SR 520 traffic noise levels for the 10 residences represented by Modeled Sites 39A and 39B.

The primary reason that Noise Barrier N5 will not reduce SR 520 traffic noise in this area is that traffic generated from Northup Way greatly affects noise levels at Modeled Sites 39A and 39B. In addition, these sites already receive shielding from a hill between the apartment complex and SR 520.

Noise Barrier N6 (Not Feasible)

The Viewpoint Park area was evaluated for a noise barrier north of SR 520 along the WSDOT right-of-way. The noise level in the area is 69 dBA without a noise barrier.

The maximum reduction provided by Noise Barrier N6 is 3 dBA for the park represented by Modeled Site 45. With a 24-foot-high wall, Noise Barrier N6 will not provide a 7-dBA reduction in SR 520 traffic noise levels for the park represented by Modeled Site 45 (see Appendix B). This indicates that Noise Barrier N6 is not feasible.

The primary reason that Noise Barrier N6 will not reduce traffic noise in this area is that the WSDOT right-of-way line is located along SR 520, approximately 65 feet below Modeled Site 45.

How can the effects of vibration be minimized?

- Use static rollers rather than vibratory rollers for earthmoving and compaction activities adjacent to the

Overlake Hospital Medical Center to reduce effects on facilities with vibration-sensitive equipment;

- Coordinate demolition of the NE 12th Street Bridge foundations and earthmoving and compaction activities to occur outside the hours of scheduled theater operation or MRI activity at Overlake Hospital Medical Center; and
- Conduct vibration monitoring for construction activities occurring within 100 feet of a building housing vibration-sensitive equipment.

SECTION 7 UNAVOIDABLE ADVERSE EFFECTS

Does the project cause any substantial adverse effects that cannot be avoided?

For the Build Alternative, modeling indicates that noise levels will approach, meet, or exceed the NAC at 30 locations (representing 137 residences) without the recommended noise barrier. Twenty-one modeled sites that represent 119 residences will continue to experience noise levels that approach, meet, or exceed the NAC with the recommended noise barrier. None of these receptors experience substantial effects (an increase in noise levels of 10 or more dBA) or severe noise levels (80 or more dBA) with the recommended replacement barrier along the I-405 northbound to SR 520 on-ramp. The 24 residences represented by receptors 37A, 37B, and 37C experience Tier 2 substantial noise levels (noise levels between 75 and 79 dBA) under existing conditions and the No Build and Build alternatives due to their proximity to SR 520.

Noise Barrier N3 was evaluated in the vicinity of Modeled Sites 37A, 37B and 37C. Due to the terrain in the area, a 24-foot-tall wall is required for the 562-foot-long Noise Barrier N3 to meet WSDOT feasibility criteria. The resulting wall area of 13,488 square feet is considered unreasonable for the four residences with outdoor use in the area because they only have an allowable wall area of 4,362 square feet despite extra wall allowances. For this reason, the substantial noise levels Modeled Sites 37A, 37B, and 37C experience are unavoidable.

With appropriate mitigation to reduce construction noise, construction of the I-405, NE 8th Street to SR 520 Improvement Project will not cause any substantial unavoidable adverse noise effects. This is in accordance with FHWA guidance, which stipulates that temporary construction noise effects cannot be substantial.

During operation, vibration levels will continue to be similar to those currently occurring in the study area. During construction, most of the OHMC and GHC campus will be affected by vibratory roller operations. The OHMC campus will also be affected during demolition of the NE 12th Street Bridge and caisson drilling between NE 8th Street and NE 12th

Street. No substantial unavoidable adverse vibratory effects will occur during construction.

SECTION 8 REFERENCES

GIS Data Sources

Exhibit 2-1

WSDOT. 2006 – 2007. I-405 Staff; project limits.

Exhibit 2-3 – Sheets 1 through 6

WSDOT. 2006 – 2007. I-405 Staff; project limits, existing right-of-way, proposed right-of way, relocated noise wall, proposed retaining wall, proposed stormwater features, proposed new pavement.

Even-Numbered Exhibits 4-2 through 4-12

Parsons Brinckerhoff.
2006 – 2007 Parsons Brinckerhoff Staff; Noise Study Area and Modeled Noise Receptor Locations 1 thru 45.

Exhibits 6-1

Parsons Brinckerhoff.
2006 – 2007 Parsons Brinckerhoff Staff; Evaluated Noise Barriers. All data from base data referenced below.

Base Data

All GIS exhibits contain one or more of the following as base layers:

Geographic Data Technology, Inc. (GDT).
2005 GDT – Dynamap Transportation. April 2005.

King County Standard GIS Data Disk, extract June 2006:
2004 Cities with annexations.

2005 Open Water.

2006 Parks in King County. Data updated by I-405 staff to match data from city of Bellevue.

2005 Streams and Rivers. Data updated by I-405 staff to match fieldwork, 2002 LiDAR, and orthorectified aerial photography.

2005 Trails in King County. Data updated by I-405 staff to match fieldwork, 2002 LiDAR and orthorectified aerial photography.

United States Geological Survey (USGS).
2002 Color Aerial Photography. June 2002. *http://edc.usgs. gov/products/aerial/hiresortho.html*

Washington State Department of Transportation (WSDOT).
2001 Aerial photography program. March 2001.

1997 Spatial Data Catalog, Railroads.

Exhibit Subject Data Sources

Exhibit 3-1 through 3-3

WSDOT
2005 I-405, NE 8th Street to SR 520 Braided Crossing Project. Prepared by Parsons Brinckerhoff. Noise Background and Guidance.

Odd-Numbered Exhibits 4-1 through 4-11

Parsons Brinckerhoff.
2006 – 2007 Parsons Brinckerhoff Staff; Modeled Noise Levels at Receptors 1 thru 45.

Exhibit 5-1

WSDOT
2005 I-405, NE 8th Street to SR 520 Braided Crossing Project. Prepared by Parsons Brinckerhoff. Typical Construction Noise Levels.

Exhibit 6-3 through 6-6

WSDOT
2005 I-405, NE 8th Street to SR 520 Braided Crossing Project. Prepared by Parsons Brinckerhoff. Allowed Barrier Areas for Noise Barriers R1, N2, N3, and N4.

Text References and Verbal Communications

City of Bellevue
1999 Bellevue Municipal Code, Chapter 9.18, *Noise.* City of Bellevue, Washington, 1999.

I-405 Corridor Program
2008 Westby, Karl. *I-405, NE 8th Street to SR 520 Improvement Project Transportation Discipline Report*. Bellevue, Washington, 2008.

King County
1999 King County Code Title 12, Chapters 12.86-12.100. *Noise.* Seattle, Washington, 1999.

U.S. Department of Transportation (USDOT),
Federal Highway Administration (FHWA)

2005 FHWA *Traffic Noise Model Version 2.5.* Washington, D.C. 2005.

1998 *FHWA Traffic Noise Model User's Guide*. Washington, D.C., 1998.

1996 *Measurement of Highway Related Noise*. Washington, D.C., 1996.

1995 *Transit Noise and Vibration Impact Assessment*. Washington, D.C., 1995.

1982 *Procedures for Abatement of Highway Traffic Noise and Construction Noise*. Federal Aid Highway Program Manual, Volume 7, Chapter 7, Section 3. Washington, D.C., 1982.

1973 *Fundamentals and Abatement of Highway Traffic Noise*. Washington, D.C., 1973.

U.S. Environmental Protection Agency (EPA)

1974 *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*. Report Number 550/9-74-004. Washington, D.C., 1974.

1971 *Noise from Construction Equipment and Operations, Building Equipment and Home Appliances*. Washington, D.C., 1971.

Washington Administrative Code (WAC)

1999 WAC Chapter 173-60. *Maximum Environmental Noise Levels*. Olympia, Washington, 1999.

Washington State Department of Ecology (Ecology)

2005 Stormwater Management Manual for Western Washington. Available at: http://www.ecy.wa.gov/programs/wq/stormwater/manual.html.

Washington State Department of Transportation (WSDOT)

2007a 2007-2026 Highway System Plan, High Benefit Low Cost. Olympia, Washington. Available at: http://www.wsdot.wa.gov/planning/HSP.htm.

2006a *Highway Runoff Manual*. Publication M31-16. Olympia, Washington.

2006b *Hydraulics Manual*. Publication M23-03. Olympia, Washington.

2003 *Environmental Procedures Manual*. Olympia, Washington, 2003.

1999 *Traffic Noise Analysis and Abatement Policy and Procedures*. Olympia, Washington.

1987 Directive D22-22. *Noise Evaluation Procedures for Existing Highways*. Olympia, Washington, 1987.

APPENDIX A NOISE MEASUREMENT AND MODEL VALIDATION

Ambient noise levels were measured for 15-minute periods at 25 locations in the study area to describe the existing noise environment, identify major noise sources, validate the noise model, and characterize the weekday background environmental noise levels. Measurement locations characterize the variety of noise conditions and represent other sensitive receptors near the proposed project.

The FHWA Traffic Noise Model (TNM) Version 2.5 computer model (FHWA, 2004) was used to predict Leq (h) traffic noise levels. TNM is used to obtain precise noise level estimates at discrete points by considering interactions between different noise sources and the effects of topographical features on the noise level. This model estimates acoustic intensity at a receiver location, calculated from a series of straight-line roadway segments. Noise emissions from free-flowing traffic depend on the number of automobiles, medium trucks, and heavy trucks per hour; vehicular speed; and reference noise emission levels of an individual vehicle. TNM also considers the effects of intervening barriers, topography, trees, and atmospheric absorption. Noise from sources other than traffic is not included. Therefore, when non-traffic noise such as aircraft noise is considerable in an area, TNM under-predicts the actual noise level. Because project impacts only depend on traffic noise levels, under-predicting the total environmental noise level does not affect the study's findings. Noise monitoring results were used to validate the Existing Conditions TNM model.

The project team exported base maps and design files from Microstation as DXF files and imported them into the TNM package. Major roadways, topographical features, building rows, and sensitive receptors were digitized into the model. Elevations were added from the 2-foot contour data. Elevations for planned improvements were taken from design profiles, proposed cross-sections, and proposed cut-and-fill limits.

In the project area, 25 measured sites were chosen to represent noise-sensitive sites. Noise measurements lasting 15 minutes were taken at each of these 25 sites to estimate the Leq (h). The measured sites represent approximately 193 residences. For noise model calibration, traffic volumes were adjusted to match field counts during the time of day the noise measurements were taken. Additional topographical and geometrical detail was added to the TNM model until the model results at each of the 25 measurement sites were within 2 dBA of the measured levels for the model's validation run.

Once the validation run is calibrated, an Existing Conditions TNM model was created. The Existing Conditions TNM model predicted noise levels on the loudest traffic hour of the day (when traffic volumes are high but not congested) to estimate worst-case noise levels. The loudest hour is also called the *peak hour*. The results of the Existing Conditions TNM model are found in Section 4 of this report. In areas where the noise measurements were taken during off-peak conditions, the Existing Conditions modeled noise levels are higher than the noise levels measured.

Exhibit A-1: Summary of Noise Measurements

Receptor Number	Address	Date	Time	Leq
1*	Former Paragon Hotel, acquired by WSDOT	November 15, 2005	12:20 PM	69
2B	989 Elements Apartment #1506	March 27, 2007	12:29 PM	75.4
3*	10th Street Condo Outdoor Area	November 17, 2005	10:30 AM	58
5	1233 112th Avenue NE	September 27, 2006	11:23 AM	70.9
6	11217 NE 15th Street	September 27, 2006	10:15 AM	60.6
7	11051 NE 15th Street	September 27, 2006	10:35 AM	62.2
9	Hidden Valley Park	October 27, 2006	12:40 PM	60.1
10	1841 114th Avenue NE	September 27, 2006	12:55 PM	68.6
12	11409 114th Avenue NE	October 27, 2006	1:44 PM	64.1
13	1853 115th Avenue NE	October 27, 2006	1:44 PM	58.4
16	11410 20th Street NE	September 26, 2006	2:02 PM	65.8
18	11417 21st Avenue NE	October 27, 2006	2:35 PM	65.3
19	11418 21st Avenue NE	October 27, 2006	2:35 PM	62.3
21	2411 112th Avenue NE	October 27, 2006	12:00 PM	64.7
22	11074 NE 24th Street	October 27, 2006	11:55 AM	55.2
23	11021 NE 26th Place	October 27, 2006	11:00 AM	57.6
24	2640 110th Avenue NE	October 30, 2006	10:10 AM	60.3
25	2641 110th Avenue NE	October 30, 2006	10:28 AM	59.3
29	2820 116th Avenue NE	September 28, 2006	1:40 PM	61.0
31	2590 120th Avenue NE	September 28, 2006	12:15 PM	67.4
33A	12170 NE 24th Street at Boulder Condominiums	September 28, 2006	11:30 AM	59.3
34A	12262 NE 24th Street at Boulder Condominiums	September 28, 2006	11:56 AM	66.8
39A	Hi Lan Apartments	October 25, 2006	10:18 AM	66.4
43	12942 NE 24th Street	October 25, 2006	11:00 AM	60.0
44	2421 134th Avenue NE	October 30, 2006	12:13 PM	63.1

**Sites analyzed as part of the NE 10th Street Extension Project*

Description of Measurement Locations

The measurement represented by Receptor 1 is located at the former Paragon Hotel, facing east toward I-405. This measurement was taken approximately 100 feet from the western edge of I-405. Receptor 1 has a residential equivalency of 55.

The measurement represented by Receptor 2B is located on the balcony of apartment #1506 at the 989 Elements multi-family complex, facing east toward I-405. This measurement was taken approximately 450 feet from the western edge of I-405. Receptor 2B is representative of 13 residences.

The measurement represented by Receptor 3 is located at the corner of NE 11th Street and 111th Avenue NE, facing east toward I-405. This measurement was taken approximately 700 feet from the western edge of I-405, and approximately 350 feet from the project footprint. NE 10th Street and 112th Avenue NE were the dominant noise source at measurement sites. Receptor 3 is representative of condos with outdoor use, and has a residential equivalency of 4.

The measurement represented by Receptor 5 is located on the eastern edge of the front yard of 1233 112th Avenue NE, facing east toward 112th Avenue NE and I-405. This measurement was taken approximately 500 feet from the western edge of I-405. Receptor 5 is representative of seven residences.

The measurement represented by Receptor 6 is located in the back yard of 11217 NE 15th Street, facing east toward I-405. This measurement was taken approximately 300 feet from the western edge of I-405. Receptor 6 is representative of three residences.

The measurement represented by Receptor 7 is located on the edge of the front yard of 11051 NE 15th Street, facing east toward 112th Avenue NE and I-405. This measurement was taken approximately 560 feet from the western edge of I-405. Receptor 7 is representative of six residences.

The measurement represented by Receptor 9 is located on the edge of the eastern edge of the most southeastern baseball field at Hidden Valley Park, facing east toward 112th Avenue NE and I-405. This measurement was taken approximately 570 feet from the western edge of I-405. Receptor 9 has a residential equivalency of seven.

The measurement represented by Receptor 10 is located in the playground area of the daycare at 1841 114th Avenue NE, facing west toward I-405. This measurement was taken approximately 40 feet from the eastern edge of I-405. Receptor 10 has a residential equivalency of four.

The measurement represented by Receptor 12 is located on the western edge of the front yard of 11409 114th Avenue NE, facing west toward 114th Avenue NE and I-405. This measurement was taken approximately 150 feet from the western edge of I-405. Receptor 12 is representative of four residences.

The measurement represented by Receptor 13 is located on the northern edge of the back yard at 1853 115th Avenue NE, facing west toward I-405. This measurement was taken approximately 325 feet from the eastern edge of I-405. Receptor 13 is representative of five residences.

The measurement represented by Receptor 16 is located on the southern edge of the front yard of 11410 20th Street NE, facing west toward I-405. This measurement was taken approximately 90 feet from the eastern edge of I-405. Receptor 16 is representative of three first-row residences.

The measurement represented by Receptor 18 is located on the western edge of the front yard of 11417 NE 21st Avenue, facing west toward NE 21st Avenue and I-405. This measurement was taken approximately 115 feet from the eastern edge of the I-405 northbound to SR 520 on-ramp. Receptor 18 is representative of three first-row residences.

The measurement represented by Receptor 19 is located in the southwest corner of the back yard of 11418 NE 21st Avenue, facing west toward I-405. This measurement was taken approximately 155 feet from the eastern edge of the I-405 northbound to SR 520 on-ramp. Receptor 19 is representative of two residences.

The measurement represented by Receptor 21 is located in the southeastern most play area of the Montessori School at 2411 112th Avenue NE, facing 112th Avenue NE and I-405. This measurement was taken approximately 130 feet from the western edge of the SR 520 eastbound to I-405 southbound on-ramp. Receptor 21 has a residential equivalency of 12.

The measurement represented by Receptor 22 is located on the second-story balcony of 11074 NE 24th Street, facing east toward 112th Avenue NE and I-405. This measurement was taken approximately 375 feet from the western edge of the SR 520 eastbound to I-405 on-ramp. Receptor 22 is representative of four residences.

The measurement represented by Receptor 23 is located on the northern edge of the basketball court of 11021 NE 26th Place, facing east toward 112th Avenue NE and I-405. This measurement was taken approximately 415 feet from the western edge of the SR 520 eastbound to I-405 on-ramp. Receptor 23 is representative of five residences.

The measurement represented by Receptor 24 is located on the back patio of 2640 110th Avenue NE, facing east toward 112th Avenue NE and I-405. This measurement was taken approximately 190 feet from the western edge of I-405. Receptor 24 is representative of six residences.

The measurement represented by Receptor 25 is located on the eastern edge of the front yard of 2641 110th Avenue NE, facing east toward 110th Avenue NE, 112th Avenue NE, and I-405. This measurement was taken approximately 150 feet from the western edge of I-405. Receptor 25 is representative of five residences.

The measurement represented by Receptor 29 is located at 2820 116th Avenue NE, on the peak of a slope located east of the playing field at the Little School and west of the Little School's easternmost building, facing west toward 116th Avenue NE and I-405. This measurement was taken approximately 500 feet from the eastern edge of I-405. Receptor 29 has a residential equivalency of nine.

The measurement represented by Receptor 31 is located on the western edge of the front yard of 2590 120th Avenue NE, facing NE 24th Street and SR 520. This measurement was taken approximately 330 feet from the northern edge of SR 520. Receptor 31 is representative of three residences.

The measurement represented by Receptor 33A is located in the northwestern courtyard of Boulder Condominiums in front of the second-row building of 12170 NE 24th Street, facing NE 24th Street and SR 520. This measurement was taken approximately 350 feet from the northern edge of SR 520. Receptor 33A is representative of five residences.

The measurement represented by Receptor 34A is located in the southern yard of the 12262 NE 24th Street building in Boulder Condominiums, facing NE 24th Street and SR 520. This measurement was taken approximately 215 feet from the northern edge of SR 520. Receptor 34A is representative of four residences.

The measurement represented by Receptor 39A is located on the ground-level patio outside 12628 Northup Way, Unit 9 of Hi Lan Apartments, facing SR 520. This measurement was taken approximately 215 feet from the southern edge of SR 520. Receptor 39A is representative of five residences.

The measurement represented by Receptor 43 is located on the back patio of 12942 NE 24th Street, facing NE 24th Street, 130th Avenue NE, and SR 520. This measurement was taken approximately 660 feet from the northern edge of SR 520. Receptor 43 is representative of nine residences.

The measurement represented by Receptor 44 is located on the southwestern edge of the field associated with 2421 134th Avenue NE, facing NE 24th Street and SR 520. This measurement was taken approximately 615 feet from the northern edge of SR 520. Receptor 44 is representative of ten residences.

Validation Results

Exhibit A-2: Measured Noise Levels and Validation and Existing Traffic Noise Model (TNM) Outputs

Receptor Number	Address	Measured Leq	Validation Modeled Leq	Existing Modeled Leq
1	Site acquired by WSDOT	69.0	70	70
2B	989 Elements Apartment #1506	75.4	74	74
3	10th Street Condo Area	58.1	58	59
5	1233 112th Avenue NE	70.9	71	72
6	11217 NE 15th Street	60.6	60	61
7	11051 NE 15th Street	62.2	62	65
9	Hidden Valley Park	60.1	60	64
10	1841 114th Avenue NE	68.6	69	69
12	11409 114th Avenue NE	64.1	64	65
13	1853 115th Avenue NE	58.4	59	60
16	11410 20th Street NE	65.8	65	65
18	11417 21st Avenue NE	65.3	65	65
19	11418 21st Avenue NE	62.3	62	63
21	2411 112th Avenue NE	64.7	65	69
22	11074 NE 24th Street	55.2	55	57
23	11021 NE 26th Place	57.6	57	59
24	2640 110th Avenue NE	60.3	60	62
25	2641 110th Avenue NE	59.3	61	62
29	2820 116th Avenue NE	61.0	61	61
31	2590 120th Avenue NE	67.4	67	68
33A	12170 NE 24th Street at Boulder Condominiums	59.3	59	60
34A	12262 NE 24th Street at Boulder Condominiums	66.8	67	68
39A	Hi Lan Apartments	66.4	67	67
43	12942 NE 24th Street	60.0	60	61
44	2421 134th Avenue NE	63.1	63	63

In some instances, traffic volumes during noise measurements are not indicative of the loudest hour, as was the case during the measurements at Sites 21, 22, and 23. In this case, the measured noise levels for Sites 21, 22, and 23 are 1 to 4 dBA below the modeled loudest hour noise levels.

APPENDIX B NOISE BARRIER ANALYSIS

WSDOT evaluates many factors to determine whether barriers will be feasible and/or reasonable. To be feasible, a barrier must be constructible in a location that achieves a noise reduction of at least 7 dBA at one or more receptors, and a reduction of at least 5 dBA at most first-row receptors. Once a noise barrier is found to be feasible, WSDOT evaluates whether the noise barrier is reasonable.

To be reasonable, the noise barrier's surface area may not exceed the sum of the allowed barrier surface area per household. Exhibit B-1 summarizes the allowed area for each receptor that will benefit from a reduction of at least 3 dBA.

Exhibit B-1: Noise Mitigation Allowance

Design-Year Traffic Noise Decibel Level (dBA)	Noise Level Increase as a Result of the Project (dBA)	Allowed Barrier Surface Area Per Household in square meters (square feet)*	Allowed Cost Per Qualified Residence or Residential Equivalent
66		65.0 (700)	$37,380
67		71.3 (768)	$41,110
68		77.7 (836)	$44,640
69		84.0 (904)	$48,270
70		90.3 (972)	$51,900
71	10 (substantial, tier 1)	96.6 (1,040)	$55,530
72	11 (substantial, tier 1)	102.9 (1,108)	$59,160
73	12 (substantial, tier 1)	109.3 (1,176)	$62,790
74	13 (substantial, tier 1)	115.6 (1,244)	$66,420
75	14 (substantial, tier 1)	121.9 (1,312)	$70,060
76	15 (substantial, tier 2)	128.2 (1,380	$73,690

Source: WSDOT, 2006.
**For receptors that experience a reduction of at least 3 dBA*

Per WSDOT guidelines, the cost applied to all noise barriers is $53.40 per square foot. These costs represent a planning-level estimate. Once preliminary engineering of a noise barrier is completed, WSDOT's opinion of cost may differ considerably from the planning-level estimate depending on soil conditions, wall height, and integration into other structures.

Residential Equivalency

WSDOT calculates reasonableness based on the number of residences that benefit from a noise barrier. For noise-sensitive uses other than residences, a residential equivalency (RE) is calculated based on the usage factor and number of users (WSDOT, 1987).

Residences may be in use at all times, but many other facilities (e.g., schools) have specific hours of operation. The usage factor accounts for times of operation. Exhibit B-2 shows typical usage factors.

Exhibit B-2: WSDOT Established Usage Factors

Site	Hours/Day	Days/Week	Months/Year	Usage Factor
Homes	24	7	12	1
Apartments	24	7	12	1
Hospitals	24	7	12	1
Churches	6	3	12	0.11
Schools	10	5	9	0.22
Parks	10	5	5	0.17

An average household in Washington has three members, so the number of users for sites with uses other than residential is divided by three to convert to households. Exhibit B-3 presents the RE for receptors in the proposed project study area, which includes sensitive uses (other than single-family residences) that approach, meet, or exceed the NAC.

Exhibit B-3: Residential Equivalency

Noise Receptor	Activity Description	Number of Users	Usage Factor	Users to Households Factor	Residential Equivalency (RE)
4*	McCormick Park	25	0.17	0.33	1
9	Hidden Valley Park	125	0.17	0.33	7
10	Daycare	55	0.22	0.33	4
21	Bellevue Montessori School	165	0.22	0.33	12
27*	Megumi Preschool	55	0.22	0.33	4
29*	The Little School	125	0.22	0.33	9
45*	Viewpoint Park	35	0.17	0.33	2

**Number of users estimated due to unavailable or unsupplied data.*

The remainder of this section describes noise barriers where multiple barrier heights were evaluated. The proposed barriers' feasibility, reasonableness, and size are discussed.

Noise Barrier N1

Noise Barrier N1 is not feasible because, at a height of 24 feet and a length of 386 feet, it will not provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 2A and 2B.

Exhibit B-4: Allowed Barrier Area for Noise Barrier N1

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
2A	3	73	0	73	0
2B	13	74	0	73	1
Total Barrier Area (ft²)			Allowed	Required	
			0	9,264	
Planning-Level Cost ($)			$0	$494,698	

Noise Barrier R1

The existing noise barrier that runs along the I-405 northbound to SR 520 on-ramp must be removed to make way for the new I-405 northbound to SR 520 on-ramp that is part of this project. This will cause noise levels at Modeled Sites 11, 12, 13, 14, 15, 17, 18, 19, and 20 to exceed the NAC. (Seven residences represented by Receptors 10 and 16 will be acquired for roadway realignment.) In accordance with WSDOT perpetuity standards, Noise Barrier R1 must be relocated to a position that provides residences behind the noise barrier with shielding effects that are comparable to those of the existing barrier. For this reason, the project team evaluated Noise Barrier R1 at its approximate original length of 1,585 feet and an average height of 20 feet (see Exhibit B-5). The new location for Noise Barrier R1 is atop a planned retaining wall that is within 50 feet of its existing location and ranges 2 to 10 feet higher in elevation as this area is along a hillside east of I-405. Elevations atop Noise Barrier R1 range from 235 feet at the southern end to 245 feet at the northern end with top of wall elevations reaching as high as 265 feet at central portions of the barrier. Noise levels in this area range from 67 to 77 dBA without a replacement barrier.

Maintaining similar dimensions as the existing noise barrier, Noise Barrier R1 provides comparable noise benefits provided by the existing barrier. At a height of 20 feet and a length of 1,585 feet, Noise Barrier R1 provides a maximum reduction of 16 dBA for the four first-row residences represented by Modeled Site 12. Three first-row residences represented by Modeled Sites 15 and 18 receive respective reductions of 15 and 13 dBA. The two remaining first-row residences in the area are represented by Modeled Site 19, which receives a 7-dBA reduction. Noise levels at all 18 remaining residences represented by Modeled Sites 11 through 15 and 17 through 20 are predicted to be below the NAC due to Noise Barrier R1's shielding effects.

Exhibit B-5 presents the barrier area, planning level cost, and noise reduction provided by the 20 foot tall relocated Noise Barrier R1.

Increasing the height from 20 feet to 24 feet provided a maximum reduction of 1 dBA for the 5 residences represented by Modeled Sites 12 and 19. The modification of Noise Barrier R1 was not considered feasible because increasing its height from 20 feet to 24 feet will not provide a noticeable reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 11 through 15 and 17 through 20, as shown in Exhibit B-6.

Exhibit B-5: Barrier Area for Noise Barrier R1 - 20 ft tall, 1,585 ft long

Modeled Site	Residences Represented	Leq (dBA)	Noise Level with Barrier (dBA)	Reduction (dBA)
11	2	67	64	3
12	4	77	61	16
13	3	70	60	10
14	3	67	64	3
15	1	76	61	15
17	1	72	62	10
18	2	74	61	13
19	1	69	62	7
20	1	68	62	6
Total Barrier Area (ft^2)			31,700	
Planning-Level Cost ($)			$1,692,780	

Exhibit B-6: Barrier Area for Noise Barrier R1 - 24 ft tall, 1,585 ft long

Modeled Site	Residences Represented	Leq (dBA)	Noise Level with Barrier (dBA)	Reduction (dBA)
11	2	67	64	3
12	4	77	60	17
13	3	70	60	10
14	3	67	64	3
15	1	76	61	15
17	1	72	62	10
18	2	74	61	13
19	1	69	61	8
20	1	68	62	6
Total Barrier Area (ft^2)			38,000	
Planning-Level Cost ($)			$2,029,200	

Noise Barrier U1

Noise Barrier U1 is not feasible because a height increase of 8 feet over the existing height and a length of 2,257 feet will not provide any reduction in I-405 traffic noise levels for any of the 12 residential equivalents represented by Modeled Site 21 (see Exhibit B-7).

Noise Barrier N3

Noise Barrier N3 is feasible because at a height of 24 feet and a length of 562 feet, it provides a 15-dBA reduction in I-405 traffic noise levels for the first-row residence represented by Modeled Site 37A and a reduction of 5 or more dBA at two of the three remaining first-row residences in the area represented by Modeled Sites 37B (RE 2) and 37C (RE 1). Noise Barrier N3 is not

Exhibit B-7: Allowed Barrier Area for Noise Barrier U1

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
21	12	69	0	69	0
Total Barrier Area (ft²)			Allowed	Required	
			0	113,364	
Planning-Level Cost ($)			$0	$6,053,638	

reasonable at this height because it requires 13,481 square feet and is only allowed 4,362 square feet (see Exhibit 6-4 in the main body of this report and Exhibit B-9 which follows).

An additional height configuration was evaluated for Noise Barrier N3 to assess the effects that reducing the required wall area will have on feasibility and reasonableness (see Exhibit B-8). At a height of 20 feet, Noise Barrier N3 is not feasible because although it provides a maximum reduction of 14 dBA for the first-row residence represented by Modeled Site 37A, it no longer provides a reduction of 5 or more dBA for the majority of remaining first-row residences in the area represented by Modeled Sites 37B and 37C.

Exhibit B-8: Allowed Barrier Area for Noise Barrier N3 – Height: 20 feet

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
35	8	67	0	66	1
36	7	63	0	63	0
37A	1	77	1,454	63	14
37B	2	77	0	76	1
37C	1	77	0	77	0
38	3	65	0	65	0
Total Barrier Area (ft²)			Allowed	Required	
			1,454	11,234	
Planning-Level Cost ($)			$77,644	$599,896	

Exhibit B-9: Allowed Barrier Area for Noise Barrier N3 – Height: 24 feet

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
35	8	67	0	66	1
36	7	63	0	63	0
37A	1	77	1,454	62	15
37B	2	77	2,908	72	5
37C	1	77	0	76	1
38	3	65	0	65	0
Total Barrier Area (ft²)			Allowed	Required	
			4,362	13,481	
Planning-Level Cost ($)			$232,931	$719,885	

Noise Barrier N4

Noise Barrier N4 is feasible because, at a height of 12 feet and a length of 664 feet, it provides a 7-dBA reduction in I-405 traffic noise levels for all five first-row residences in its vicinity, represented by Modeled Site 40. Noise Barrier N4 is not reasonable at this height and length because the required area to provide this reduction is 7,968 square feet and the WSDOT allowable area is 5,545 square feet (see Exhibit B-10).

Noise Barrier N4 was evaluated at two additional height configurations to assess the possibility of providing further reductions (and subsequently increasing the WSDOT allowable area) for Modeled Site 40 and the 16 remaining residences in the area represented by Modeled Sites 41, 42 and 43. At a height of 16 feet, Noise Barrier N4 provides a reduction of 9 dBA at Modeled Site 40, but does not receive an increased allowable wall area. The required wall area for Noise Barrier N4 increases to 10,624 square feet at a height of 16 feet, indicating that this wall height is less reasonable than a wall height of 12 feet (see Exhibit B-11).

At a height of 20 feet, Noise Barrier N4 provides a reduction of 10 dBA at Modeled Site 40, but does not receive an increased allowable wall area (see Exhibit B-12). Noise Barrier N4's required wall area increases to 13,280 square feet at a height of 20 feet, indicating that this wall height is the least reasonable of all the evaluated heights for Noise Barrier N4.

Exhibit B-10: Noise Barrier N4 – Height: 12 feet

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
40	5	72	5,545	65	7
41	3	60	0	60	0
42	4	60	0	60	0
43	9	62	0	62	0
Total Barrier Area (ft²)			Allowed	Required	
			5,545	7,968	
Planning-Level Cost ($)			$296,103	$425,491	

Exhibit B-11: Allowed Barrier Area for Noise Barrier N4 – Height: 16 feet

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
40	5	72	5,545	63	9
41	3	60	0	60	0
42	4	60	0	60	0
43	9	62	0	62	0
Total Barrier Area (ft²)			Allowed	Required	
			5,545	10,624	
Planning-Level Cost ($)			$296,103	$567,322	

Exhibit B-12: Allowed Barrier Area for Noise Barrier N4 – Height: 20 feet

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
40	5	72	5,545	62	10
41	3	60	0	60	0
42	4	60	0	60	0
43	9	62	0	62	0
Total Barrier Area (ft²)			Allowed	Required	
			5,545	13,280	
Planning-Level Cost ($)			$296,103	$709,152	

Noise Barrier N5

Noise Barrier N5 is not feasible, because at a height of 24 feet and a length of 953 feet, it will not provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 39A and 39B.

Exhibit B-13: Allowed Barrier Area for Noise Barrier N5

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
39A	5	67	0	67	0
39B	5	68	0	68	0
Total Barrier Area (ft²)			Allowed	Required	
			0	22,872	
Planning-Level Cost ($)			$0	$1,221,365	

Noise Barrier N6

Noise Barrier N6 is not feasible, because at a height of 24 feet and a length of 1,854 feet, it will not provide a 7-dBA reduction in I-405 traffic noise levels for any of the residential equivalents represented by Modeled Sites 45.

Exhibit B-14: Allowed Barrier Area for Noise Barrier N6

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft²)	Noise Level with Barrier (dBA)	Reduction (dBA)
45	2	69	1,810	66	3
Total Barrier Area (ft²)			Allowed	Required	
			1,810	44,496	
Planning-Level Cost ($)			$96,654	$2,376,086	

APPENDIX C
DRAFT CONSTRUCTION AND TRAFFIC VIBRATION TECHNICAL REPORT

**I-405 NE 8TH STREET TO SR 520 BRAIDED CROSSING PROJECT
BELLEVUE, WASHINGTON**

DRAFT

CONSTRUCTION AND TRAFFIC VIBRATION TECHNICAL REPORT

Westbound I-405 NE 8th to NE 12th Street

Revision 1

December 2007

Prepared for:

**State of Washington Department of Transportation
U.S. Department of Transportation Federal Highway Administration**

Prepared by:

PB AMERICAS

EXECUTIVE SUMMARY

A study was prepared to assess the potential for vibration effects on the Overlake Hospital Medical Center (OHMC) and Group Health Cooperative (GHC) medical facilities from the construction and future operation of the I-405, NE 8th Street to SR 520 Braided Crossing Project (the Project). Both traffic vibration and temporary construction vibration are considered.

The study results indicate that the vibration generated by highway traffic, including trucks, would not affect the vibration-sensitive medical facilities at either OHMC or GHC. At the closest building to the I-405 right-of-way (ROW), general traffic vibration levels would not exceed the criteria for operating theaters and magnetic resonance imaging (MRIs). Surgical microscopes that are supported on adequate structures for controlling footfall-induced vibration would not be affected by highway traffic. No mitigation measures (other than construction of the road surface to highway standards for smoothness and maintenance) are needed to maintain an adequately low vibration environment for operating theaters, surgical microscopes, and MRIs.

Maximum levels of vibration generated by vibratory rollers during roadway construction and during demolition of the NE 12th Street Bridge foundation using hoe rams would exceed criteria for operating theaters up to 700 feet away. This is a worst-case scenario that assumes maximum ground vibration levels generated by this equipment and the highest sensitivity for surgical microscopes used in the operating suites. The higher the sensitivity of these microscopes, the more likely that they would have their own self-contained vibration isolation systems to control the effects of building vibration (e.g., footfalls inside and outside of the operating suites, rolling carts, and door slams). It is expected that most of the vibration-sensitive OHMC facilities may be affected by the vibratory roller operations and demolition of the NE 12th Street Bridge, depending on the sensitivity of these activities. The other construction activity that will occur between NE 8th and NE 12th is caisson drilling, which may only affect operating suites that are located 80 feet or closer to the drilling. These include parts of the OHMC outpatient surgery at the ground floor of the existing Northwest Parking Garage, and inpatient surgery on the second floor of the existing Hospital Surgical Pavilion closest to the I-405. The GHC medical facilities would not be affected by these construction activities. All other construction equipment and activities would generate lower levels of vibration and would not affect these operating suites.

The most effective mitigation measure is to ensure that construction vibration does not exceed levels that would interfere with the medical operations of the OHMC and GHC facilities. Because the surgical microscopes' vibration sensitivity and the construction vibration levels that would be generated and transmitted to the hospital buildings aren't known, a proactive mitigation approach will be required. This approach would involve: (1) scheduling construction activities such as demolition around critical hospital activities; (2) using static rollers rather than vibratory rollers between NE 8th Street and NE 12th Street; and (3) monitoring construction vibration levels at the sensitive hospital facilities located closest to the construction area.

INTRODUCTION

The vibration analysis presented in this report assesses the potential effects of construction of the I-405, NE 8th Street to SR 520 Braided Crossing Project (the Project) on the Overlake Hospital Medical Center (OHMC) and the Group Health Cooperative (GHC) facilities. Future traffic movements on the widened and relocated I-405 freeway are also evaluated. Elements of this study include:

- An inspection of the surgical suites, labs, testing equipment, and medical facilities that are in close proximity to the freeway and construction sites.
- Analysis of previous vibration measurements conducted for the OHMC Master Plan Environmental Impact Statement (EIS).
- Discussions with OHMC and GHC facilities staff to discuss the sensitivity of their medical equipment and activities that could be affected by construction.
- Selection of appropriate criterion for vibration-sensitive equipment and/or activities.
- Estimates of the maximum ground vibration levels resulting from relocating freeway lanes closer to the medical facilities.
- Estimates of the maximum ground vibration levels during construction at vibration-sensitive locations.
- Mitigation measures to control the vibration predicted to exceed the criteria.

PROJECT DESCRIPTION

The Project extends approximately 1.5 miles along I-405 (from NE 4th Street in Bellevue north to SR 520), and approximately 1.5 miles along SR 520 (from I-405 eastward to 134th Avenue NE). The Project's baseline condition assumes construction of the improvements that were environmentally cleared and permitted for the NE 10th Street Bridge Project across I-405. The Project's goal is to reduce congestion created by weaving traffic on I-405 and SR 520, by constructing grade-separated ramps (braids) and a collector-distributor lane (a lane that collects traffic from one roadway and deposits it onto another roadway). The Project's specific benefits are improved safety, reduced congestion, increased travel speeds during peak commuter hours, improved freight movement, and meaningful environmental improvements.

More specific to the OHMC and GHC medical facilities are the northbound I-405 to eastbound SR 520 improvements between NE 8th and NE 12th Streets. New grade-separated ramps would be constructed to eliminate the weave between the traffic entering northbound I-405 from NE 8th Street and traffic exiting I-405 to SR 520. This will result in traffic movements located closer to the OHMC and GHC medical facilities.

Overlake Hospital Medical Campus

The Overlake Hospital Medical Center (OHMC) campus is bordered by NE I2th Street on the north, NE 8th Street on the south, 116th Avenue NE on the east, and the I-405 freeway on the west.

In a meeting with Cary Given, Director of Facilities for the Overlake Medical Hospital Center, the general vibration sensitivity of the different facilities and medical activities throughout the campus were discussed. Concerns were expressed about microscopes used in surgical suites and eye surgery. Mr. Given followed up by providing a plan showing the surgical and laboratory areas that may be affected by vibration (Figure 1). The following OHMC campus locations are assessed in this study:

- Outpatient Surgery – ground floor of the existing Northwest Parking Garage
- Inpatient Surgery – second floor of the existing Hospital Surgical Pavilion
- Lab – ground floor of the existing Hospital Surgical Pavilion
- Pathology – second floor of the East Wing
- MRI – second floor of the existing Medical Office Building
- Outpatient Surgery Suites – third floor of the existing Medical Office Building
- MRI – in a trailer next to the North Parking Garage

Group Health Cooperative

In a meeting with GHC, it was determined that their new medical facilities now under construction would contain operating rooms and an MRI. However, because of the location of these facilities relative to I-405, they will not be impacted during construction of the Project.

UNDERSTANDING VIBRATION

Ground-borne vibration consists of oscillatory waves that propagate from the source through the ground to adjacent buildings. Although the vibration is sometimes noticeable outdoors, it is almost exclusively an indoor problem. Ground-borne vibration is different from airborne noise in that it is not a widespread environmental problem, for it is generally limited to localized areas near rail systems, construction sites, and some industrial operations. Road traffic rarely creates perceptible ground-borne vibration except when there are bumps, potholes, or other discontinuities in the road surface.

Vibration can be described in terms of the displacement, velocity, or acceleration of the oscillations. Ground-borne vibration is usually characterized in terms of the vibration velocity, because over the frequency ranges relevant to ground-borne vibration (about 1 to 200 Hz) both human and building response tend to be more proportional to velocity than to either displacement or acceleration. Vibration velocity is usually given in terms of either inches per second or decibels.

Construction vibration is characterized in terms of the root-mean-square (RMS) amplitude when either human annoyance or interference with sensitive equipment is concerned. RMS represents the average energy over a short time interval; typically, a one-second interval is used to evaluate human response to vibration. RMS vibration velocity is considered the best available measure of potential human annoyance from ground-borne vibration. Vibration measurements performed to monitor the potential for building damage from construction activities are usually in terms of peak particle velocity (PPV). The PPV represents the maximum instantaneous peak in the velocity of an object's vibratory motion about the equilibrium position. It is used to define the thresholds of potential building damage from vibration since it is more directly correlated to peak stresses in building components than RMS vibration. The relationship between PPV and RMS depends on the shape and duration of a specific waveform. The RMS amplitude is always less than the PPV, and in ground-borne vibration PPV amplitude is usually 2 to 5 times greater than RMS amplitude.

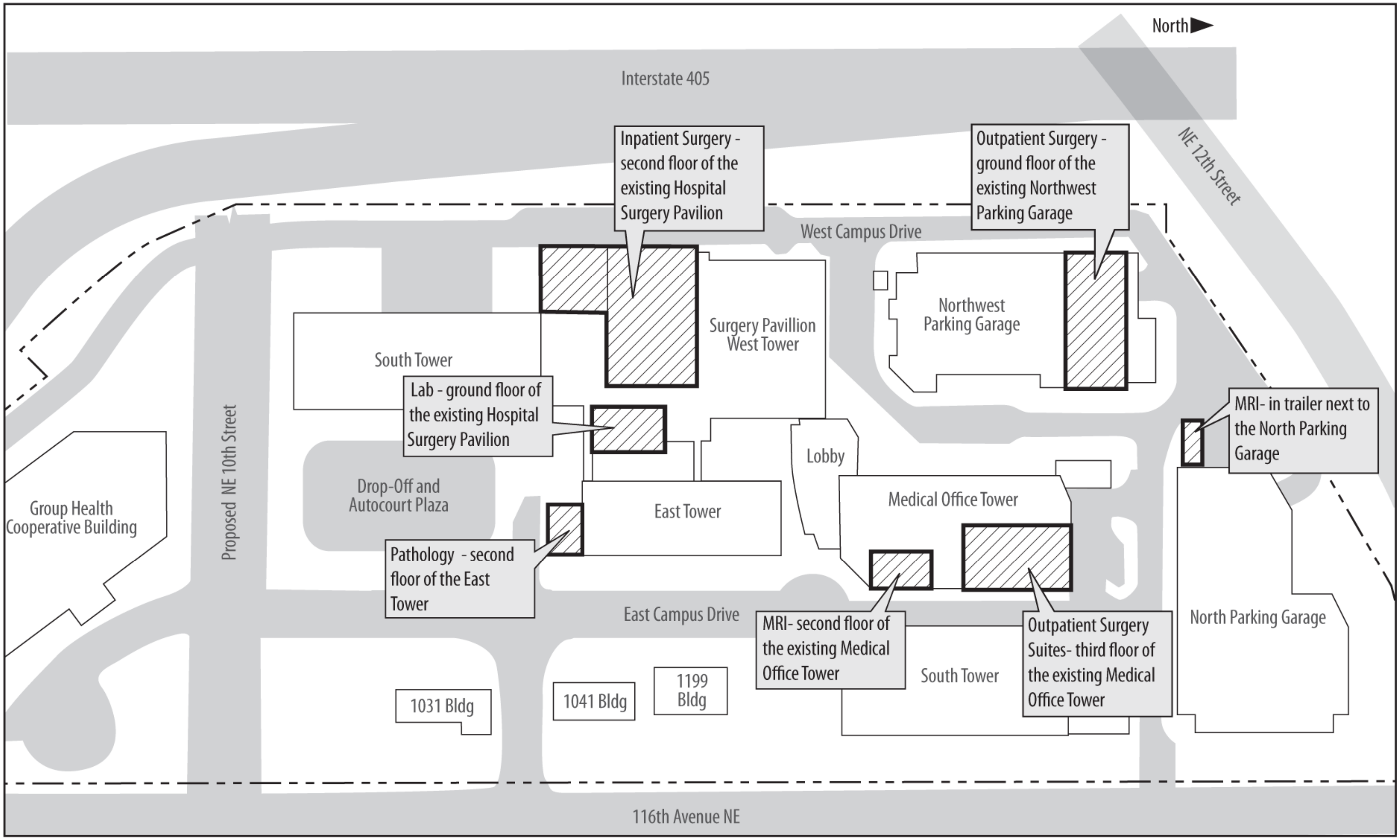


Figure 1. Overlake Hospital Medical Center (OHMC) – Vibration-Sensitive Locations

VIBRATION CRITERIA

No FHWA or state standards exist for vibration. The traditional view has been that highway traffic and construction vibration pose no threat to buildings and structures, and that annoyance to people is no worse than other discomforts experienced from living near highways. The American National Standards Institute (ANSI) Standard S3.29, "Guide to the Evaluation of Human Exposure to Vibration in Buildings," provides a floor vibration velocity limit for hospital operating theaters. The standard is 4,000 micro-inches per second (0.004 in/sec) or 2,800 micro-inches per second (0.0028 in/sec) root mean square velocity limit in any l/3 octave band at frequencies of 8 Hz and higher. This criterion is suitable for operating room theaters that are in use. The International Standards Organization (ISO) has also recommended a limit of 4,000 micro-inches per second for operating theaters.

Although the ANSI standard should be suitable for most conditions, additional criteria may be used for vibration-sensitive equipment that is not located on an upper floor of a building but located on slab on-grade, where floor vibration from footfalls would be minimized. The Institute of Environmental Science (IES) has published criteria for vibration-sensitive equipment and designated vibration criteria curves VC-A (2,000 micro-in/sec), VC-B (1,000 micro-in/sec), and VC-C (500 micro-in/sec), etc. The IES VC-A criterion applies to optical bench microscopes up to 400X and optical or microbalances. The VC-B criterion is appropriate for optical microscopes of 1000X. The VC-C standard is the most stringent, and is more than adequate for ceiling- and/or floor-mounted operating room microscopes that would be suspended from cantilevered arms and for MRIs.

The building damage criteria for vibration vary with respect to the type of building involved. Vibration from vibratory sources (e.g., vibratory rollers and vibratory hammers) should be limited to 0.2 in/sec peak particle velocity (0.1 in/sec rms vibration velocity). This limit is the threshold for architectural damage. Structural damage is expected to occur at levels ten times this threshold.

A summary of the vibration criteria discussed in this section is presented in Table 1.

TRAFFIC-GENERATED VIBRATION

As part of the Final EIS for the Overlake Hospital Master Plan (February 2005), Wilson, Ihrig & Associates, Inc. (WIA) took vibration measurements of I-405 highway traffic (including trucks) on the OHMC campus. Measurements conducted near I-405 were taken at two locations between 2 PM and 5 PM on January 26, 2005:

- 19 feet from the I-405 right-of-way (ROW), near the merge between the NE 8th Street to northbound I-405 on-ramp. A second channel was recorded simultaneously at 44 feet from the ROW. Numerous trucks traveling on the right-hand lane pass this location at the posted speed. Two or three trucks travel on the on-ramp.

- 75 feet north of the first measurement location, near the merge between the NE 8th Street to northbound I-405 on-ramp. Traffic was near full speed. Accelerometers were placed at 17 and 57 feet from the ROW. Numerous trucks traveling on the right-hand lane pass this location at speed. Two or three trucks traveled on the on-ramp.

The measured traffic vibration data is presented in l/3 octave band vibration velocity levels with the ANSI, ISO, and IES criteria curves in Figures 2 through 5. The Leq is the energy-mean level measured during the entire period. L1 is the level that occurs one percent of the time, and Lmax is the highest level found within any l/3 octave band during any single 1-second sample duration. The Lmax is thus an extreme measure of vibration, and is not necessarily

Table 1
Vibration Criteria

	Max Level - micro-inch/sec (dB)	Description of Use
Workshop (ISO)	32000 (90)	Distinctly feelable vibration. Appropriate to workshops and nonsensitive areas.
Office (ISO)	16000 (84)	Feelable vibration. Appropriate to offices and nonsensitive areas.
Residential Day (ISO)	8000 (78)	Barely feelable vibration. Appropriate to sleep areas in most instances. Probably adequate for computer equipment, probe test equipment and low-power (to 20X) microscopes.
Operating Theater (ISO & ANSI)	4000 (72)	Vibration not feelable. Suitable for sensitive sleep areas. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A	2000 (66)	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	1000 (60)	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	500 (54)	A good standard for most lithography and inspection equipment to 1 micron detail size.

Source: Institute of Environmental Sciences and Technology, "Considerations in Clean Room Design," RR-CC012.1, 1993.

representative of vibration effects, but is of interest in terms of the severity of individual transient events.

Levels of random, stationary vibration (e.g., vibration produced by distant automotive traffic) vary over a range represented by the energy-mean vibration level, or Leq. In this case, the energy-mean curve would be compared with the vibration criteria discussed previously and included in each of the figures. Where vibration is produced by relatively dense traffic located nearby, the energy mean would still be appropriate.

The criteria most appropriate for the vibration produced by occasional vehicle passbys (e.g., heavy trucks, door slams, and footfalls) is the level exceeded 1% of the time or 99% of the time the level is not exceeded. The maximum level is usually not used, because it could be influenced by other transient factors that are not due to the ground vibration of the vehicle passbys.

The observed vibration spectra at the closest distance to I-405 (Figure 2) were all below the ANSI, ISO, and IES VC-C criteria, with the exception of the 20 Hz maximum l/3 octave band

Figure 2. Measured Traffic Vibration Levels at 17 feet from I-405 ROW

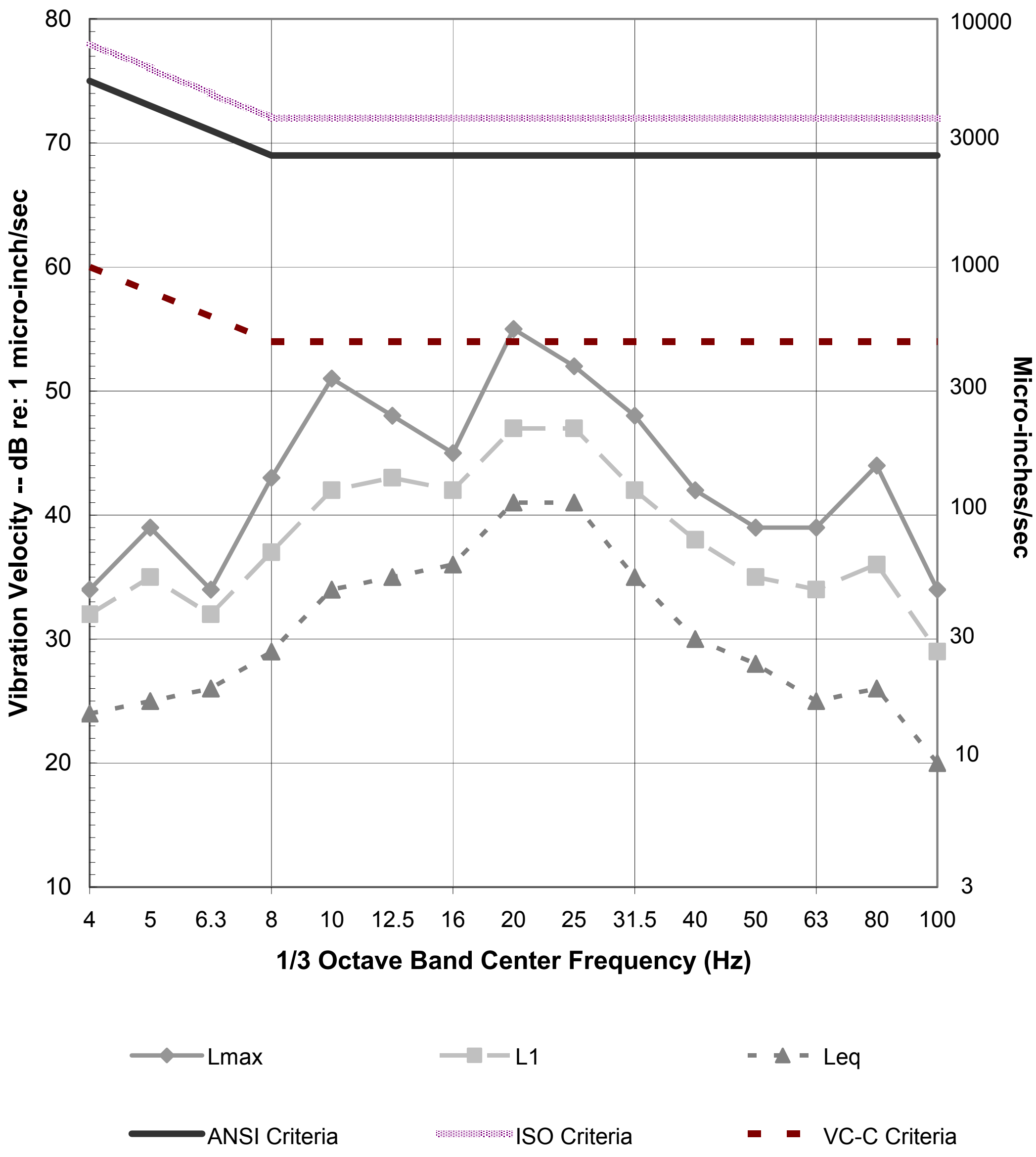
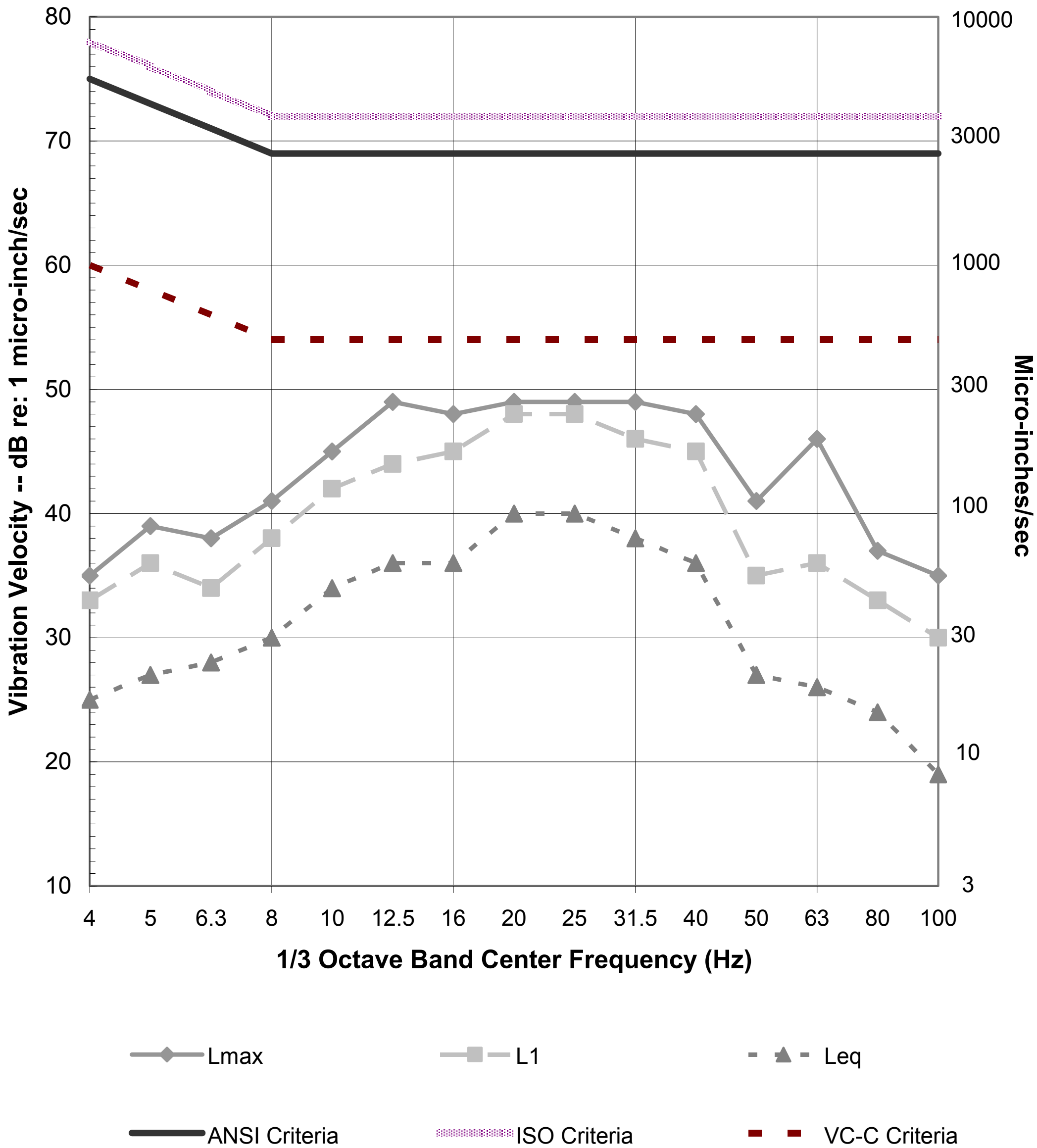


Figure 3. Measured Traffic Vibration Levels at 19 feet from I-405 ROW



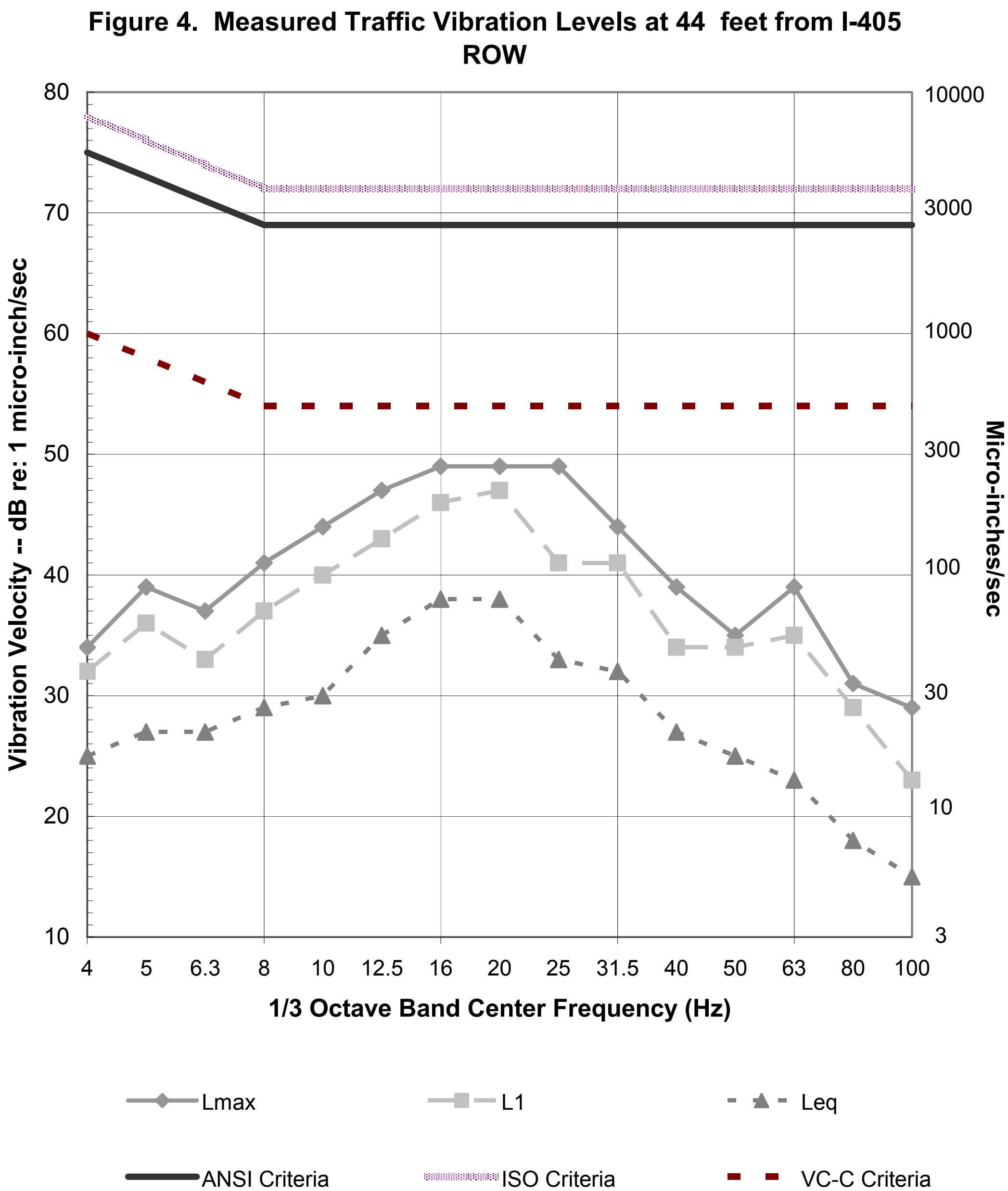
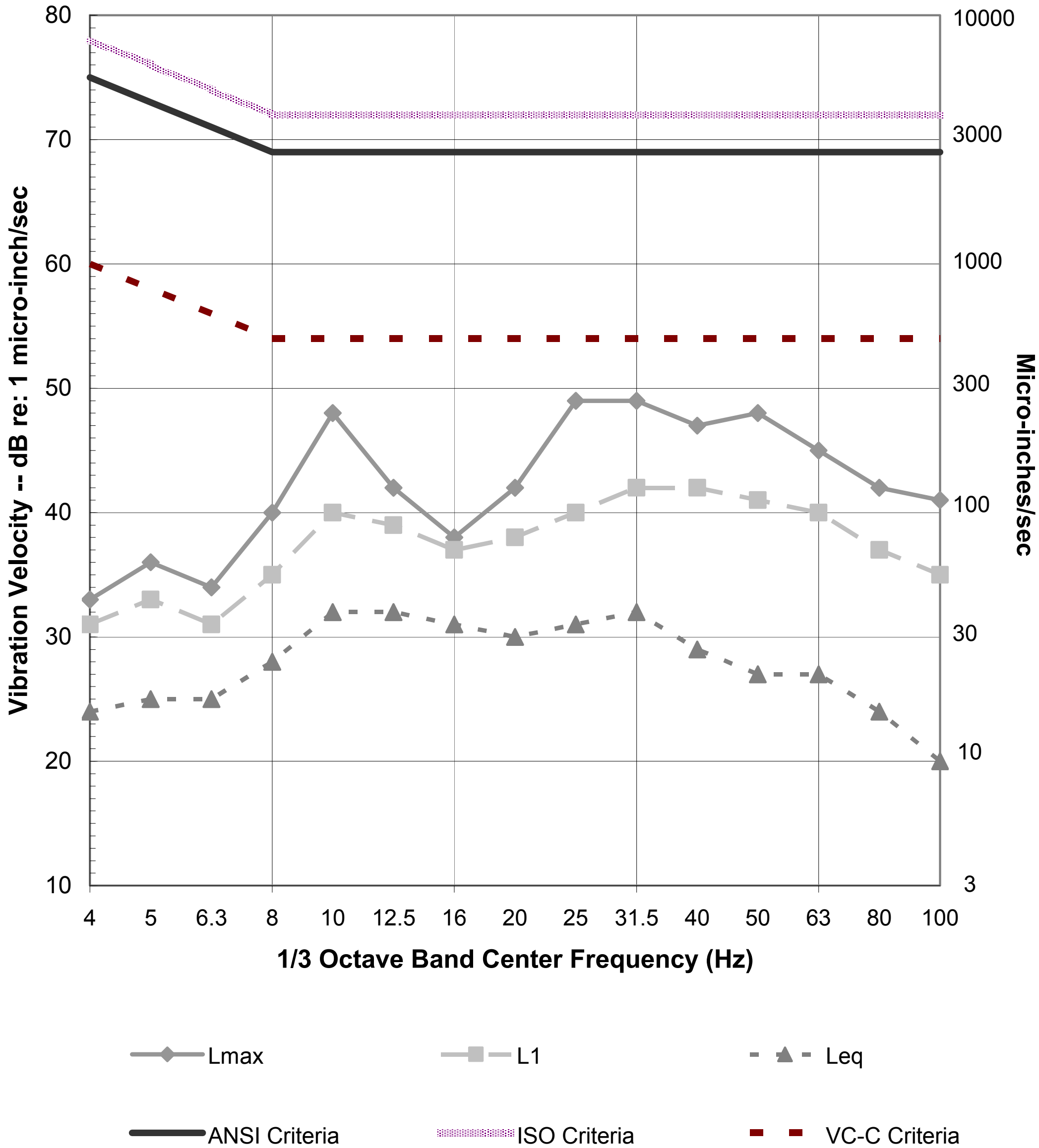


Figure 4. Measured Traffic Vibration Levels at 44 feet from I-405 ROW
80
70
60
50
40
30
20
10
10000
3000
1000
300
100
30
10
3
Vibration Velocity -- dB re: 1 micro-inch/sec
Micro-inches/sec
4
5
6.3
8
10
12.5
16
20
25
31.5
40
50
63
80
100
1/3 Octave Band Center Frequency (Hz)
Lmax
L1
Leq
ANSI Criteria
ISO Criteria
VC-C Criteria

Figure 5. Measured Traffic Vibration Levels at 57 feet from I-405 ROW



level that was approximately 340 micro-inches per second at 17 feet from the I-405 ROW (this did exceed the VC-C criteria). The maximum vibration levels at 19, 44, and 57 feet from the ROW did not exceed the VC-C criteria. Since none of the operating theaters are within 17 feet of the I-405 ROW, there is no expected effect on hospital operating theaters, bench microscopes, and operating room microscopes.

Roadway conditions are another variable that would influence traffic vibration. A rough road surface would produce higher levels of vibration than a smooth road surface. Potholes or speed bumps may produce significantly higher levels than those shown here. The foundations of the proposed buildings would tend to attenuate ground vibration transmitted into the structure by roughly 6 to 8 dB at higher frequencies, and less at lower frequencies.

Floor resonance amplification would tend to amplify vibration at the floor resonance frequency and at higher frequencies. Below resonance, little or no amplification would occur. The amount of amplification at resonance would depend on the floor's damping properties. As much as 6 to I0 dB of amplification might occur, much of which would be compensated by the foundation response.

CONSTRUCTION

Construction Activities

The study limits for construction are the northbound side of I-405 between NE 8th and NE 12th streets. The following is the sequence of construction that would occur directly adjoining the OHMC and GHC properties, with a general time estimate:

<u>Grade-Separated Northbound Ramps</u>

- Demolition of existing roadways and structure excavation
- Utility relocation – excavation and trenching over a 3-month period
- Drilled shafts for retaining walls – 3 to 6 months
- Excavation for the new grade-separated roadways – 2 to 3 months
- Cast-in-place concrete – 6 months
- At-grade roadway construction
- Finishing - lay asphalt and pavement

The following activities would have the potential of generating the highest levels of ground vibration during construction of the grade-separated northbound ramps:

- Demolition of existing roadways using an excavator with thumb and with crusher
- Drilling shafts for retaining walls using a drill rig
- Grading roadways using a vibratory roller

The level of vibration resulting from these activities would vary, depending on the size of the equipment and the soil and ground conditions where the equipment is used.

<u>NE 12th Street Bridge Replacement</u>

Demolition of the NE 12th Street Bridge is separate from construction of the grade-separated northbound ramps. Hoe rams will be used to remove the bridge foundations and vibratory rollers will be used for the at-grade roadway construction.

Construction Vibration

Construction vibration is considerably more difficult to characterize than highway traffic. The most significant sources of vibration would be vibratory compactors and impact equipment such as hoe rams. Both of these sources have the potential to produce ground vibration in excess of the IES criterion curves, and in excess of the ANSI S3.29 and ISO limits for operating theaters.

The WIA study in the Final EIS for the Overlake Hospital Master Plan (February 2005) presented peak particle velocity and rms velocity data for a vibratory roller. This data is summarized in Table 2. The rms magnitudes are calculated by dividing the peak particle velocity by the square root of two, or 1.4. Operation of a vibratory roller could produce vibration in excess of the VC-C criteria, and thus could affect the OHMC and GHC operating suites and MRIs. The ANSI and ISO criteria would be more appropriate for the other vibration-sensitive medical facilities, which may only be exceeded within 1,500 feet of the vibratory roller operations.

Table 2
Ground Vibration from a Vibratory Roller

Source Distance (feet)	Peak Particle Velocity (in/sec)	RMS Vibration Velocity (in/sec)
10	1.6	1.1
20	0.8	0.6
40	0.4	0.3
80	0.2	0.15
160	0.1	0.07
320	0.05	0.03
640	0.025	0.015
1280	0.0125	0.0075

Note: VC-C criterion is 0.0005 in/sec rms velocity level
An ANSI criterion is 0.004 in/sec rms velocity level

The estimates given in Table 2 indicate that peak particle velocities during vibratory rolling might exceed the threshold for architectural damage when occurring within a distance of 80 feet from a building foundation. Vibration should be monitored during vibratory rolling, and static roller compaction should be done to avoid exceeding 0.2 in/sec peak particle velocity.

Vibration from hoe rams during demolition of the NE 12th Street bridge foundation would be comparable in magnitude to vibratory rollers. The duration of the bridge demolition is limited to days rather than months for roadway construction when vibratory rollers are used for soil compaction. The other significant source of construction vibration is caisson drilling for the retaining walls at the OHMC property line. Vibration produced by haul trucks, dozers, and graders would produce lower levels of vibration compared to the measured levels from I-405 truck traffic presented in Figures 2 through 5. These construction activities would not present a significant vibration effect.

Estimates of construction vibration at the OHMC facilities that were identified as vibration-sensitive are presented in Table 3 for the most significant sources: vibratory roller and caisson drilling. These estimates indicate that the VC-C criteria for operating theaters would be exceeded during vibratory roller operations and within 100 feet of the caisson drilling. Hoe ram operations are not included in the estimates because of the limited duration of this activity, which may be mitigated through coordination and scheduling.

Table 3
Estimated Vibration Levels During Construction

Medical Activity	Location	Distance to I-405 ROW (ft)	RMS Vibration Velocity Level – in/sec	
			Vibratory Roller	**Caisson Drilling**
Outpatient Surgery	Ground floor of existing Northwest Parking Garage	40 to 120	**0.30 to 0.11**	**0.0111** to .0021
Inpatient Surgery	Second floor of existing Hospital Surgical Pavilion	30 to 160	**0.5 to 0.07**	**0.0170** to 0.0014
Lab	Ground floor of existing Hospital Surgical Pavilion	180 to 230	**0.065 to 0.05**	0.0012 to 0.0008
Pathology	Second floor of East Wing	275 to 325	**0.045 to 0.03**	0.0006 to 0.0005
MRI	Second floor of existing Medical Office Building	340	**0.03**	0.0004
Outpatient Surgery Suites	Third floor of existing Medical Office Building	310 to 350	**0.035 to 0.03**	0.0005 to 0.0004
Portable MRI	Trailer next to the North Parking Garage	220	**0.5**	0.0009

Notes: 1. Caisson drilling exceeds ANSI criteria at 100 feet or less
2. Vibratory roller exceeds ANSI criteria at 1,500 feet or less

Bolded values exceed the ANSI criteria of 0.004 in/sec

MITIGATION

Traffic Vibration

No vibration mitigation provisions would be needed. However, the road surface should be constructed to appropriate highway standards for smoothness. It should also be maintained in good condition to prevent potholes, washboard, or other significant imperfections in the road surface from developing.

Construction Vibration

The following mitigation measures may be considered to control construction-related vibration:

- A static roller should be used in lieu of a vibratory roller between NE 8th Street and NE 12th Street. A static roller would be less efficient than a vibratory roller for compacting soil, but should be acceptable as a compaction tool.
- Demolition of 12th Street Bridge foundation should be coordinated with and scheduled depending on operating room and MRI use.
- To avoid architectural building damage, foundation vibration should be monitored at the nearest structure during demolition of the bridge foundation or during vibratory roller operation within 100 feet of the structure.