U. S. Department of Transportation
Federal Highway Administration

April 2018

I-405, Downtown Bellevue Vicinity Express Toll Lanes Project (MP 11.9 to 14.6)

Attachment C: Noise Discipline Report

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EXHIBITS

SUMMARY

This discipline report was prepared in support of the *I-405, Downtown Bellevue Vicinity Express Toll Lanes Project (MP 11.9 to 14.6)* (the Project) *Environmental Assessment (*EA*)*. This report evaluates the environmental effects of the proposed improvements on Interstate 405 (I-405) from milepost (MP) 11.9 to milepost 14.6 in support of the EA.

The Project is part of a comprehensive strategy identified in the 2002 *I-405 Corridor Program Final Environmental Impact Statement* (EIS) and subsequent Federal Highway Administration (FHWA) *Record of Decision* to reduce traffic congestion and improve mobility along I-405. The Project is needed because travelers on I-405 face one of the most congested routes in the state, particularly during peak travel times.

Noise Environment

In the study area for the Project, land use consists of mainly commercial and a mix of single family and multifamily residential properties. The noise study area for the Project extends 400 feet from the pavement edge throughout the project limits.

The Washington State Department of Transportation (WSDOT) compared the predicted peak-hour noise levels to the FHWA Noise Abatement Criteria (NAC) to determine whether there will be future noise impacts with the Project.

Listed below are existing noise levels in 2016, 2045 noise levels without the Project, and predicted noise levels with the Project in 2045, the design year.

- Existing (2016) noise levels in the study area are between 53 and 78 dBA. Due to the traffic data availability, we selected 2016 for the existing year.
- In 2045, without the Project, noise levels are predicted to increase to between 54 and 75 dBA.
- In 2045, with the Project, noise levels are predicted to increase to between 54 and 75 dBA, which is the same as without the Project.

Noise Impacts of the Project

The analysis of noise impacts in the noise study area that would result from the Project is based on a comparison of future sound levels to the existing levels and applicable criteria. Construction noise impacts are based on the maximum noise levels of construction equipment published by the U.S. Environmental Protection Agency (EPA) (EPA 1971).

WSDOT used the FHWA NAC to evaluate traffic noise impacts. Traffic noise levels are predicted at sensitive receivers based on projected future traffic operations using FHWA Traffic Noise Model (TNM) version 2.5. Abatement measures that may be taken to avoid or reduce potential noise impacts are discussed where appropriate.

WSDOT evaluated the noise study area for the presence of receivers sensitive to traffic noise. We modeled 40 receivers to identify current and future noise impacts under the Project and No Build condition, then compared the predicted peak-hour noise levels to the FHWAs NAC to determine if the Project would result in traffic noise impacts.

This noise analysis revealed that six receivers currently approach or exceed the FHWA NAC of 66 dBA Leq (equivalent sound pressure level in A-weighted decibels). The analysis of future modeled No Build conditions predicts an increase to 7 receivers without the Project due to a slight increase in traffic noise levels. With the Project, WSDOT expects to approach or exceed the NAC of 66 dBA at 7 receiver locations, which is the same as the No Build predicted condition by 2045 without noise abatement.

Considered Abatement

Exhibit 1 summarizes the existing and predicted noise conditions at the modeled locations, and Exhibit 2 lists the five existing noise walls evaluated for the Project.

Exhibit 1. Noise Impacts and Abatement

Condition	Construction Noise	Operational Impacts	Abatement Measures
Existing 2016 (pm peak)	None.	Noise levels exceeded 66 dBA NAC at 6 locations.	None required.
2045 No Build (pm peak)	None.	Noise levels exceeded 66 dBA NAC at 7 locations.	None required.
2045 Build (pm peak)	Nearby receivers could experience temporary noise impacts during construction. Potential nighttime construction would require a noise variance from the local jurisdiction.	Noise levels exceeded 66 dBA NAC at 7 locations.	None required.

Exhibit 2. Walls Evaluated for the Project

Current Study Walls	Current Wall Status
Existing Wall East 18A	Existing wall
Existing Wall East 18B	Existing wall
Existing Wall West 8	Existing wall
Existing Wall East 19	Existing wall
Existing Wall R1	Existing wall

The noise study area for the Project extends 400 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 developments. With the Project, noise levels are projected to stay about the same as existing conditions in 2016, or increase by 1 or 2 dBA. The modeling results show that a hospital and hotel are predicted to be at or above the noise impact level with the Project. Future predicted noise levels for the hospital and hotel with no outdoor areas of frequent human use are 75 dBA and 71 dBA, respectively. Because there are no outdoor use areas at the hospital and hotel, we considered the interior noise impact levels under Category D. To determine the interior noise levels using the exterior modeled values, we subtracted 25 dBA from the future predicted noise levels of 75 dBA and 71 dBA. This results in interior noise levels of 50 dBA and 46 dBA, respectively, which are below the impact level of 51 dBA for Category D (FHWA 2010) land use. Therefore, evaluation of noise abatement is not required for these properties.

SECTION 1 INTRODUCTION

This Noise Discipline Report was prepared in support of the *I-405, Downtown Bellevue Vicinity Express Toll Lanes Project (MP 11.9 to 14.6)* (the Project) *Environmental Assessment* (EA). This report evaluates the environmental effects of proposed improvements on Interstate 405 (I-405) from milepost (MP) 11.9 to 14.6 in support of the EA.

SECTION 2 PROJECT DESCRIPTION

What improvements are proposed with the Project?

The Project would extend along I-405 approximately 2.7 miles from just north of the I-90 interchange (MP 11.9) to north of the NE 6th Street interchange (MP 14.6). The Project proposes the following improvements by mile posts, as shown in Exhibit 2-1, sheets 1 and 2:

- **Northbound I-405, I-90 to NE 6th Street (MP 11.9 to 13.7) –** Develop approximately 1.6 miles of new lane in the northbound direction by widening or restriping I-405 from MP 11.9 to 13.5. In this same section of I-405, convert the existing HOV lane to an ETL. The new lane coupled with the existing HOV lane would create a dual ETL. Between MP 13.5 and 13.7, convert the existing HOV lane to an ETL. The ETL would connect to the existing ETLs from downtown Bellevue to Lynnwood. Westward expansion of I-405 is proposed south of SE 8th Street, and eastward expansion is proposed north of SE 8th Street.
- **Southbound I-405, I-90 to NE 6th Street (MP 11.9 to 13.7) –** From MP 11.9 to 12.5, reconfigure the existing outside HOV lane to the inner roadway and convert both of the existing HOV lanes to ETLs. From MP 12.5 to 13.5, develop a new lane by widening or restriping. This new lane coupled with the existing HOV lane would result in a dual ETL south of NE 4th Street. Between MP 13.5 and 13.7, convert the existing HOV lane to an ETL. The ETL would connect to the existing ETLs from downtown Bellevue to Lynnwood. Where new pavement is needed, eastward expansion is proposed.
- **I-405 Eastside Rail Corridor Overpass (MP 12.4) –** Build a new northbound I-405 bridge structure adjacent to the existing I-405 structure over the Eastside Rail Corridor Regional Trail. The new structure would carry the two ETLs and the GP lanes would remain on the existing structure.
- **Eastside Rail Corridor Regional Trail (MP 12.09 to 12.49) –** Construct a new bridge for nonmotorized

travel over southbound I-405 near MP 12.15. Build a section of nonmotorized trail to connect with the Eastside Rail Corridor Regional Trail.

- **SE 8th Street Interchange (MP 12.78) –** Widen the northbound I-405 overpass over SE 8th Street.
- **Main Street Overpass (MP 13.31) –** Reconstruct the Main Street bridge (photo on right) over I-405.
- **Northbound I-405 to SR 520 Ramp (MP 14.6) –** Widen the existing northbound off-ramp to SR 520 from two lanes to three lanes for approximately 600 feet beginning where the NE 10th Street on-ramp merges onto the I-405 ramp.
- **Stormwater –** Build new flow control and runoff treatment facilities.
- **Other Improvements –** Provide pavement markings, drainage improvements, permanent signing, illumination, intelligent transportation systems, barriers, and tolling gantries.
- **Context Sensitive Solutions –** Incorporate CSS to enhance mobility, safety, the natural and built environment, and aesthetics throughout the Project corridor.
- **Property Acquisitions –** Acquire portions of five commercial and public properties to accommodate the Project.
- **Minimization Measures –** Implement avoidance and minimization measures or compensate for unavoidable effects on the environment, as described in Chapter 6, Measures to Avoid or Minimize Effects.

Existing Main Street Overpass

What are Context Sensitive Solutions?

The *Context Sensitive Solutions (CSS)* process is a model for transportation project development that has received much discussion and broad acceptance. Its essence is that a proposed transportation project must be planned not only for its physical aspects and road serving specific transportation objectives, but also for its effects on the aesthetic, social, economic, and natural environment, as well as the needs, constraints, and opportunities in a larger community setting.

Exhibit 2-1. Project Improvements, Sheet 1 of 2

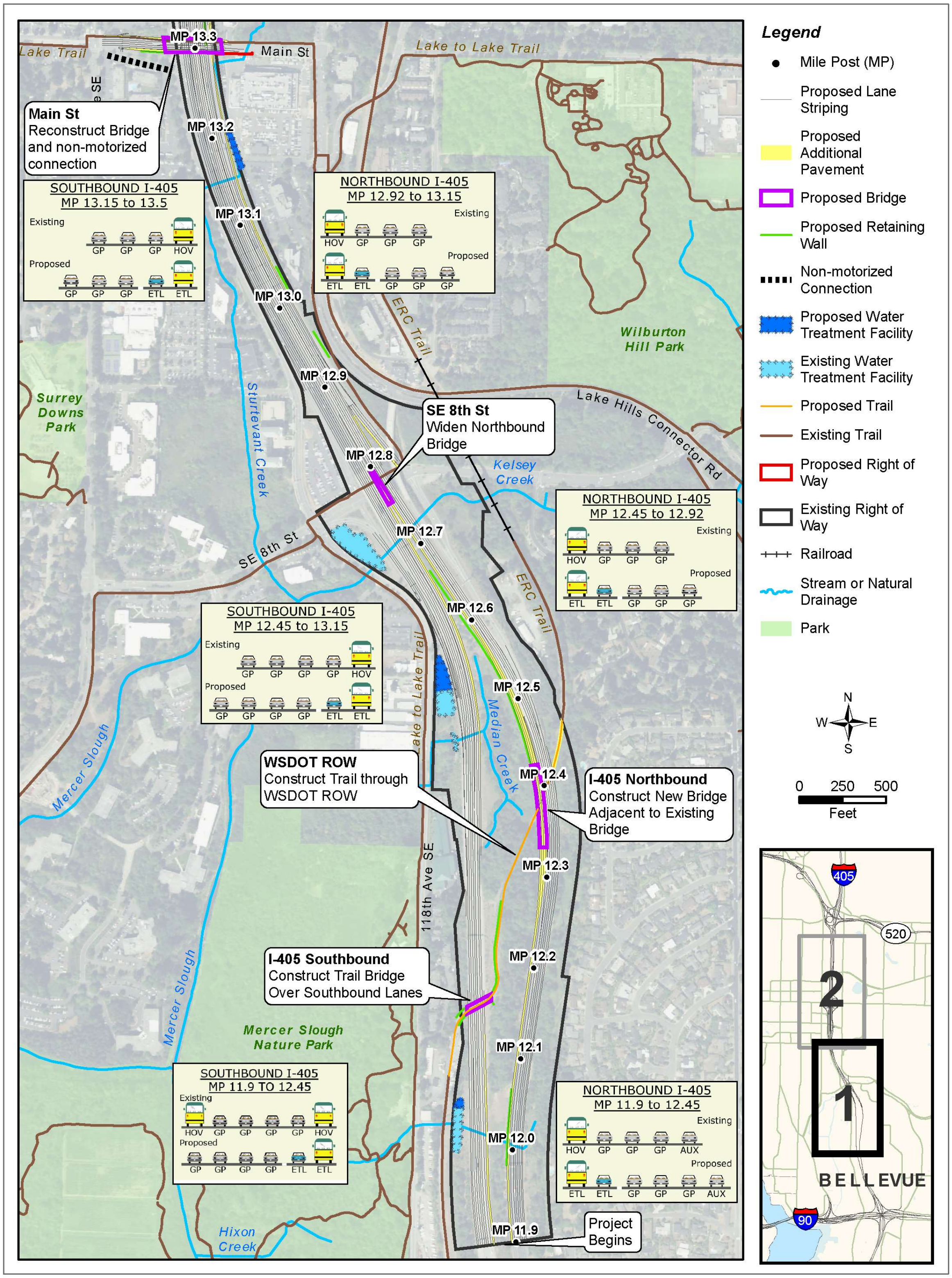
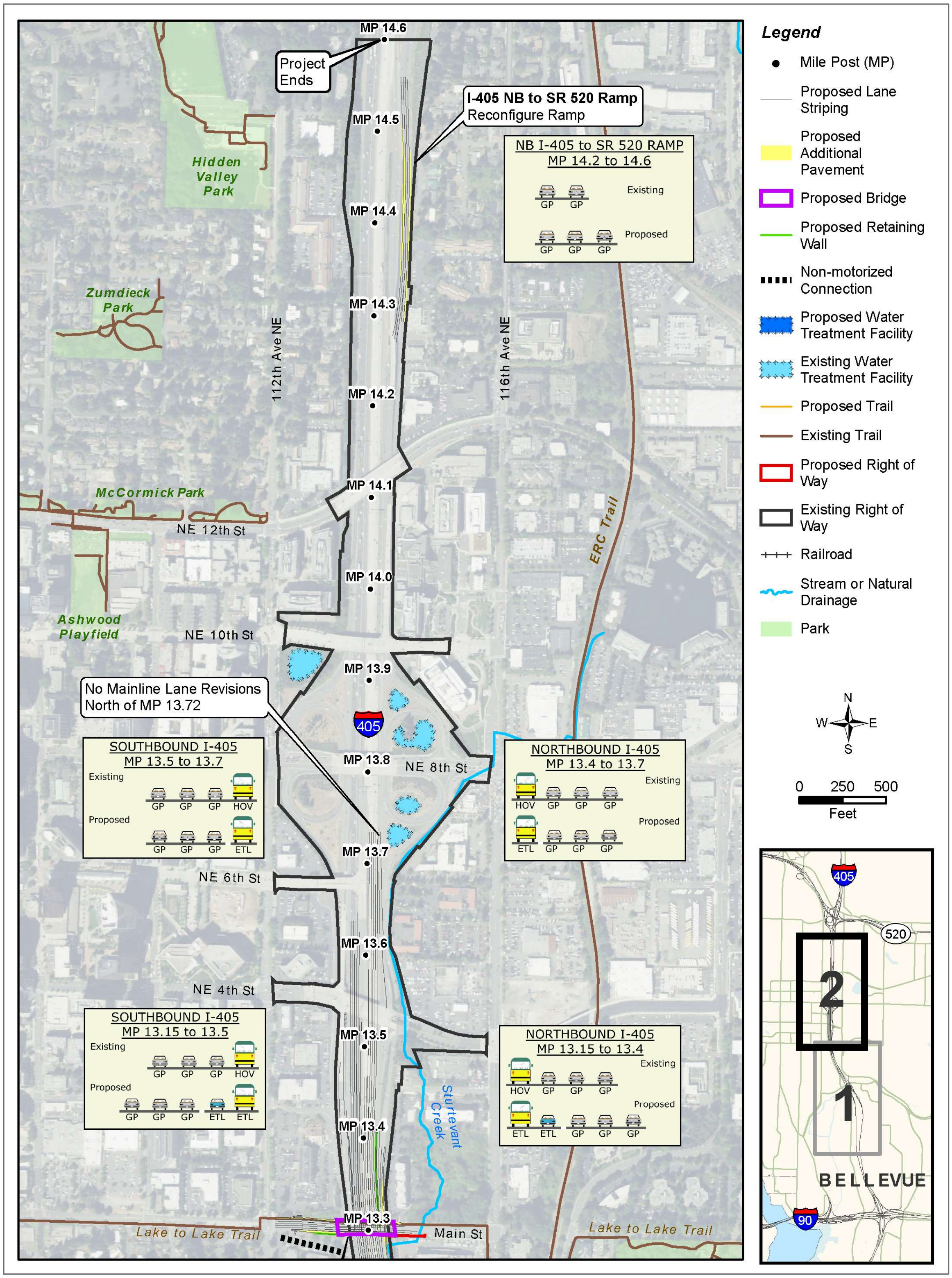


Exhibit 2-1. Project Improvements, Sheet 2 of 2



How would the express toll lanes work?

At this time, the Washington State Transportation Commission (WSTC) has not established operational hours, user exemptions, occupancy requirements, and operating parameters for ETLs proposed with the Project. WSTC would set operational requirements for the ETLs prior to opening day. For this analysis, we assumed the requirements for the current I-405, Bellevue to Lynnwood ETL system would be used for the Project. These assumptions, listed below, represent the most recent operating guidance from the WSTC for ETLs:

- **Limited Access –** The system would have designated entry and exit points, with a buffer between the ETLs and the GP lanes. These access points would vary in length, depending on the location.
- **Dynamic and Destination Pricing –** The I-405 ETL system would use both dynamic and destination pricing to determine a driver's toll at the time they enter the ETL. With *dynamic pricing*, toll rates vary based on congestion within the corridor to maintain performance. Electronic signs are used to communicate the current toll rate for drivers. Toll rates are updated every few minutes, but the driver's price is set when they enter the system. With *destination pricing*, the toll is based on the driver's destination. Toll signs show up to three toll rates for different toll zones, or destinations. Drivers pay the rate they see upon entering the ETLs to reach their destination, even if they see a different toll rate for their destination further down the road. When both pricing approaches are used together, it means the toll that drivers pay is based both on the congestion in the corridor and the distance they are traveling.
- **Operating Hours and *Good To Go!* Passes –** The ETL system is expected to operate from 5 a.m. to 7 p.m. on weekdays, with the system toll-free and open to all at other hours and on major holidays. Transit, HOVs, and motorcycles would need to have a *Good To Go!* pass to use the ETLs for free during operating hours. Eligible HOV users would

How does dynamic pricing work?

Electronic monitors along the roadway measure real-time information on speed, congestion, and number of vehicles in the *express toll lanes (ETLs)*. This information is used to determine whether tolls go up or down to optimize lane use.

As the ETLs become congested, toll rates increase, and as congestion decreases, toll rates decrease. The use of dynamic pricing allows the lanes to operate with high volumes, but avoid becoming congested.

When would tolls be charged to use the ETLs?

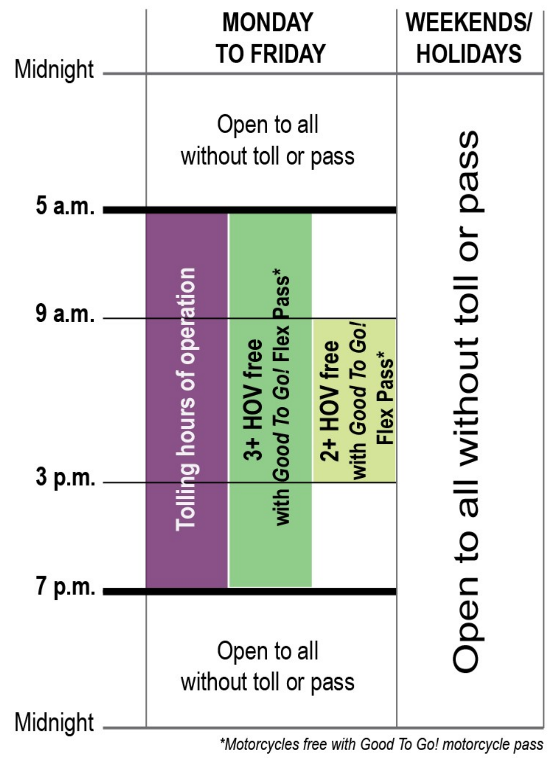
It is assumed the ETLs would operate from 5 a.m. to 7 p.m. on weekdays. At all other times and major holidays, the lanes would be free and open to all without a *Good To Go!* pass.

During operating hours:

- **SOVs** would pay a toll to use the lanes.
- **Transit, HOV 3+, and Motorcycles** would travel for free with a *Good To Go!* pass.
- **HOV 2+** would travel for free from 9 a.m. to 3 p.m. with a *Good To Go!* pass. From 5 a.m. to 9 a.m. and 3 p.m. to 7 p.m. HOV2+ would pay a toll to use the ETLs with or without a *Good To Go!* pass.
- **Large vehicles** over 10,000 pounds gross vehicle weight would not be able to use the ETLs at any time.

be required to set the *Good To Go!* pass to the HOV mode to avoid charges. SOVs could choose to pay a toll to use the ETLs during operating hours with or without a *Good To Go!* pass.

- **Occupancy Requirements –** During the peak periods (weekdays from 5 a.m. to 9 a.m. and 3 p.m. to 7 p.m.), transit vehicles and carpools with three or more persons (HOV 3+) would be able to use the lanes for free with a *Good To Go!* pass. From 9 a.m. to 3 p.m., the system would be open toll-free to those with two or more passengers with a *Good To Go!* pass. Motorcycles ride toll-free in the ETLs with a *Good To Go!* pass.
- **Vehicle Weight –** Vehicles over 10,000 pounds gross vehicle weight will be prohibited, which is consistent with HOV lane restrictions throughout Washington.
- **Electronic Tolling –** Payments will be made via electronic tolling with a *Good To Go!* pass. For drivers who choose not to use a *Good To Go!* Pass, WSDOT offers optional photo billing (pay by mail) for an extra fee.



How would tolling revenue be used?

Federal law and state law provide specific requirements on how toll revenues can be used. Federal law regarding the use of toll revenues is contained in 23 United States Code (USC) Section 129 (a)(3). This law states that all toll revenues received from operation of the toll facility are used only for such things as debt service, a reasonable return on investment for any private financers of the Project, operations and maintenance costs, and payments associated with any public–private partnership agreements.

In addition to these federal requirements, the Revised Code of Washington (RCW) 47.56.820 requires that all revenue from an eligible toll facility must be used only to construct, improve, preserve, maintain, manage, or operate the eligible toll facility on or in which the revenue is collected. Similar to the federal law, expenditures of toll revenues must be approved by the

Legislature and must be used only to cover operations and maintenance costs; to repay debt, interest and other financing costs; and to make improvements to the eligible toll facilities.

As required by state law, all toll revenue generated from the Project ETLs would be used to construct, improve, preserve, maintain, manage, or operate the I-405 corridor.

What is the Project construction schedule?

Construction of the Project is expected to last up to 5 years beginning in 2019 and ending in 2024.

SECTION 3 METHODOLOGY

Background Information on Noise

Type 1 Trigger for Noise Analysis

A traffic noise analysis is required by law (23 Code of Federal Regulation [CFR] 772) for federally funded projects and required by WSDOT policy (WSDOT 2011) for other funded projects that meet the following criteria:

- Involve construction of a new highway on a new alignment.
- Significantly change the horizontal or vertical alignment.
- Increase the number of through-traffic lanes on an existing highway.
- Alter terrain to create new line-of-sight to traffic for noise-sensitive receivers.

The Project proposes to increase the number of through-traffic lanes on an existing highway to address safety and improve mobility. Implementation of this project would construct an additional lane in both directions, which is a Type 1 trigger for a traffic noise analysis.

Definition of Sound

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 (EPA 1974). Magnitude is a measure of the physical sound energy in the air. The range of magnitude the ear can hear, from the faintest to the loudest sound, is so large that sound pressure is expressed on a logarithmic scale in units called decibels (dB). Loudness refers to how people subjectively judge a sound and how it varies between people.

Sound is measured using the logarithmic decibel scale, so that doubling the number of noise sources, such as the number of cars on a roadway, increases the sound level by 3 dBA. Therefore, when you combine two sources emitting 60 dBA, the combined sound level is 63 dBA, not 120 dBA. The human ear can barely perceive a 3-dBA increase, while a 5-dBA increase is about 1.5 times as loud and readily noticed. A

10-dBA increase appears to be a doubling in noise level to most listeners. A tenfold increase in the number of noise sources will add 10 dBA.

In addition to magnitude, humans also respond to a sound's frequency or pitch. The human ear is very effective at perceiving frequencies between 1,000 and 5,000 hertz (Hz), with less efficiency outside this range. Environmental noise is composed of many frequencies. A-weighting (dBA) of sound levels is a filter applied electronically by a sound level meter that combines the many frequencies into one sound level that simulates how an average person hears sounds.

Definition of Noise

Noise is unwanted or unpleasant sound. Noise is a subjective term because, as described previously, sound levels are perceived differently by different people. Magnitudes of typical noise levels are presented in Exhibit 3-1.

Traffic Noise Sources

An increase in traffic volumes, vehicle speeds, or the amount of heavy trucks increases traffic noise levels. Traffic noise is a combination of noises from the engine, exhaust, and tires. Defective mufflers, truck compression braking on steep grades, the terrain and vegetation near the roadway, shielding by barriers and buildings, and the distance from the road can also contribute to minimizing the traffic noise heard from traffic on roadway.

Exhibit 3-1. Typical Noise Levels

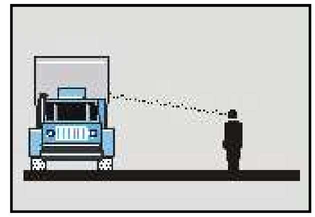
Transportation Noise Sources	Noise Level (dBA)	Other Sources	Description
-	130	50-horsepower siren (100 feet)	Painfully loud
Jet takeoff (200 feet)	120	Thunder	
Car horn (3 feet)	110	Rock band	
Jet takeoff (2,000 feet)	100	Shout (0.5 foot)	Very annoying
Heavy truck (50 feet)	90	Jack hammer (50 feet)	Hearing loss with prolonged exposure
Train on structure (50 feet)	85	Backhoe (50 feet)	
City bus passing (50 feet)	80	Bulldozer (50 feet)	Annoying
Train (50 feet)	75	Blender (3 feet)	
City bus at stop (50 feet)	70	Vacuum cleaner (3 feet)	
Freeway traffic (50 feet)		Lawn mower (50 feet)	
Train in station (50 feet)	65	Washing machine (3 feet)	Intrusive
Light traffic (50 feet)	60	TV (10 feet)	
-		Talking (3 feet)	
Light traffic (100 feet)	50	Flowing stream	Quiet

Source: FTA 1995

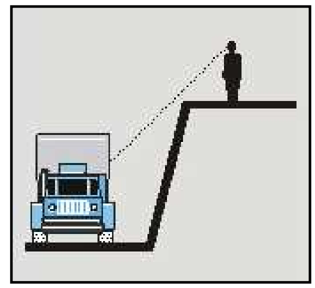
Sound Propagation

Sound propagation, or how far the sound travels, is affected by the terrain and the elevation of the receiver relative to the noise source. Breaking the line of sight between the receiver and the noise source can reduce noise levels. Listed below are examples of sound propagation pathways.

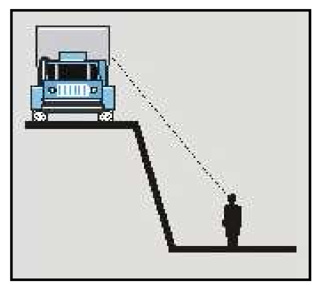
- Level ground – Noise travels in a straight path between the source and receiver.
- Depressed source/elevated receiver – Terrain may act like a partial noise barrier and reduce noise levels if it crests between the source and receiver.
- Elevated source/depressed receiver – The edge of the roadway may act as a partial noise barrier. Even a short barrier, like a concrete safety barrier, can reduce the noise level.



Level Ground



Depressed Source / Elevated Receiver



Elevated Source/Depressed Receiver

Line and Point Sources

Noise levels decrease with distance from the source. For a line source, like a highway, noise levels decrease 3 dBA for every doubling of distance, e.g., from 66 dB at 50 feet to 63 dB at 100 feet, between the source and the receiver over hard ground (concrete, pavement), or 4.5 dBA over soft ground (grass). For point sources, like most construction noise, the levels decrease between 6 and 7.5 dBA for every doubling of distance, depending on ground hardness.

Effects of Noise

The FHWA NAC are based on speech interference, which is a well-documented impact that is relatively reproducible in human response studies. Environmental noise indirectly affects human welfare by interfering with sleep, thought, and conversation. Prolonged exposure to very high levels of environmental noise can cause hearing loss, and EPA has established a protective level 70 dBA equivalent sound level (L_{eq}) (24) (USEPA 1974) for hearing loss.

Noise Level Descriptors

The L_{eq} is a measure of the average noise level during a specified period. A 1-hour period, or hourly L_{eq} (L_{eq}h]), is used to measure highway noise. L_{eq} is a measure of total noise during a time period that places more emphasis on occasional high noise levels that accompany general background noise levels. For example, if you have two different sounds, and one contains twice as much energy but lasts only half as long as the other, the two would have the same L_{eq} noise levels.

Either the total noise energy or the highest instantaneous noise level can describe short-term noise levels, such as those from a single truck passing by. The sound exposure level (SEL) is a measure of total sound energy from an event and is useful in determining what the L_{eq} would be over a period when several noise events occur. L_{max} is the maximum sound level that occurs during a single event and is related to impacts on speech interference and sleep disruption. L_{min} is the minimum sound level during a period of time.

The variation of sound levels recorded during a measurement period is represented by L_n, where "n" is the percent of time that a sound level is exceeded. For example, the L_{10} level is the noise level that is exceeded 10 percent of the time. Sound varies in the environment and people will generally find a higher, but constant, sound level more tolerable than a quiet background level interrupted by higher sound level events. For example, steady traffic noise from a highway is normally less bothersome than occasional aircraft flyovers in an otherwise quiet area.

Noise Regulations and Impact Criteria

Traffic noise impacts occur when predicted L_{eq} (h) noise levels approach or exceed the FHWA NAC, or substantially exceed existing noise levels (FHWA 1982). WSDOT considers a noise impact to occur if predicted L_{eq} (h) noise levels approach within 1 dBA of the NAC. The FHWA NAC specify exterior L_{eq} (h) noise levels for various land activity categories as described in Exhibit 3-2. WSDOT also considers an increase of 10 dBA or more to be a substantial increase and constitute a traffic noise impact. See Appendix B, Traffic Noise Analysis and Abatement Process.

Exhibit 3-2. FHWA Noise Abatement Criteria by Land Use

Activity Category	L_{eq}(h)[a] at Evaluation Location (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. For example, Arlington National Cemetery.
B	67 (exterior)	Residential (single- and multifamily units).
C	67 (exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, daycare centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52 (interior)	Auditoriums, daycare centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E	72 (exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A–D or F. Includes undeveloped land permitted for these activities.
F	-	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	-	Undeveloped lands that are not permitted.

[a] L_{eq} (h) are A-weighted (dBA) hourly equivalent steady state sound levels used for impact determination and are not design standards for abatement.

Construction Noise Level Limits

Traffic and construction noise are exempt from the Washington Administrative Code (WAC) property line noise limits during daytime hours, but noise limits still apply to construction noise at night. Noise levels shown in Exhibit 3-3 apply only to construction noise at residential properties between 10:00 p.m. and 7:00 a.m. At night, construction noise must meet Washington State Department of Ecology property line regulations (WAC 173-60-040) that set limits based on the Environmental Designation for Noise Abatement (EDNA) of the land use: residential (Class A), commercial (Class B), and industrial (Class C).

Allowable nighttime (10:00 p.m. to 7:00 a.m.) noise levels at Class A receiving properties (residential) are reduced by 10 dBA (WAC 173-60).

Exhibit 3-3. Maximum Permissible Environmental Noise Levels

	EDNA of Receiving Property (dBA)		
EDNA of Noise Source	**Class A**	**Class B**	**Class C**
Class A	55	57	60
Class B	57	60	65
Class C	60	65	70

Short-term exceedance of the sound levels in Exhibit 3-3 is allowed. During any one-hour period, the maximum level may be exceeded by:

- 5 dBA for a total of 15 minutes
- 10 dBA for a total of 5 minutes
- 15 dBA for a total of 1.5 minutes (WAC 173-60-040)

The allowed exceptions are defined by the percentage of time a given level is exceeded. For example, L_{25} is the noise level exceeded 15 minutes during an hour. Therefore, the permissible L_{25} would be 5 dBA greater than the values in Exhibit 3-3, if the noise level is below the permissible level for the rest of the hour and never exceeds the permissible level by more than 5 dBA.

Noise Study Area

Land use in the study area is primarily commercial development at intersections. Between the Interstate 90 (I-90) interchange and the Eastside Rail Corridor Regional Trail, the land to the east is higher than I-405. From the Eastside Rail Corridor Regional Trail bridge to the northern project limits, the freeway is higher than the land to the east. On the west, the land is about the same level as I-405. Land use adjacent to the highway in this area is primarily commercial.

This noise study analyzes traffic noise effects up to 400 feet from the edge of the pavement on both sides of I-405 throughout the Project corridor. A simple "straight-line" noise model (FHWA-approved preliminary traffic noise screening analysis) was developed to predict the distance to where traffic noise levels drops below impact levels, and we determined that distance was 400 feet from the edge of pavement. The model used the existing measured noise and the future projected traffic volumes to predict noise impacts where a substantial noise level increase of 10 dBA or more would occur. The study area then extends to the limits of noise impacts, where there would be a future noise level of 66 dBA or less in 2045. See Appendix B, Traffic Noise Analysis and Abatement Process.

Traffic Noise Measurement and Validation

Ambient sound levels were measured to describe the existing noise environment, identify major noise sources in the study area, and validate the noise model. Noise measurements were collected out to 400 feet from the roadway to confirm the straight-line model predictions, as well as validate the model out to just beyond the 66-dBA contour.

We collected 15-minute L_{eq} measurements at locations representative of sound level environments within the study area during free-flowing traffic conditions. FHWA allows 15-minute L_{eq} measurements to represent the hourly L_{eq} (h). These traffic noise measurements are not a representation of "average" existing noise levels.

To ensure that the noise model used to predict traffic noise impacts accurately reflects the sound levels in the noise study area, we constructed a model using the same traffic volumes, speed, and vehicle types that were present during the sound level measurements. Modeled values must be within ±2.0 dBA of the measured levels to validate the model.

We used TNM version 2.5 (2004) to validate and predict future L_{eq} (h) traffic noise levels. TNM calculates precise estimates of noise levels at discrete points. The model estimates the sound levels from a series of straight-line roadway segments. TNM also considers the effects of existing barriers, topography, vegetation, and atmospheric absorption. Noise from sources other than traffic is not included. When nontraffic noise is present, such as aircraft noise, TNM will under-predict the actual noise level. To ensure the model does not under-predict, noise measurements are paused to avoid interference of other noise sources. To create the model, design files outlining major roadways, topographical features, and sensitive receivers were imported into the TNM model as background features and the corresponding values were entered manually. We used aerial photographs and site visits to verify site conditions.

Exhibit 3-4 lists the validation locations and the comparison of measured to modeled values for the Project. The analysis included noise measurements taken at eight sites chosen to represent noise-sensitive sites in the study area. We took 15-minute noise measurements at each location and used the measured noise levels to validate the noise model as described earlier in this section. For noise model validation, we entered traffic volumes in the noise model to match field counts during the time of day of the noise measurement.

Exhibit 3-4. Noise Model Validation – I-405, Downtown Bellevue Vicinity Express Toll Lane Project (MP 11.9 to 14.6)

Site #	Measured Receiver Location	Date	Start Time	Measured L_{eq} (dBA)	Modeled L_{eq} (dBA)	Difference (dBA)
V57	1692 118th AVE SE	8/13/2015	11:20 am	64.1	65.0	0.7
V58	1421 121st AVE SE	8/12/2015	11:00 am	61.8	61.1	1.3
V59	11715 SE 5th Street	8/12/2015	11:25 am	67.5	68.3	-0.8
V60	605 114th AVE SE	8/13/2015	11:00 am	65.6	64.3	-0.4
V61	300 112th AVE SE	8/12/2015	2:40 pm	67.0	67.4	0.6
V62	11211 Main Street	8/12/2015	2:15 pm	66.0	65.0	0.2
V63	11400 Main Street	8/12/2015	12:35 pm	71.0	70.8	-1.9
V64	100 112th AVE NE	8/12/2015	1: 50 pm	65.8	67.7	-0.9

We added additional topographical and geometrical detail to the TNM model until the modeled noise levels at each of the 65 measurement sites were at 2 dBA or less of the measured level. The noise levels at all 65 measured sites were modeled using TNM. These sites were at 2 dBA or less of the measured values, which indicates that the model accurately represented site conditions.

Exhibits 3-5 and 3-6 show the measured receivers' locations. In these exhibits, measured receivers are denoted by the letter V followed by a number.

Exhibit 3-5. Traffic Noise Measurement Locations – Model 6 (SE 21st Street to SE 6th Street Vicinity)

Exhibit 3-6. Traffic Noise Measurement Locations – Model 6 (SE 6th Street Vicinity to NE 12th Street)

SECTION 4 PROJECT EFFECTS

FHWA requirements and WSDOT policy dictate that noise studies assess properties adjacent to highway projects that may be potentially affected by traffic noise. Primary consideration must be given to areas of frequent outdoor human use, such as residences with yards, decks, or patios. Parks and schools with outdoor play areas also warrant primary consideration of potential noise impacts. This section presents the results of noise modeling for current and future traffic noise levels in the study area.

Operational Traffic Noise

The study area was assessed for areas of frequent outdoor human use, such as residences with yards, decks, or patios and parks and schools with outdoor play areas, at or above the WSDOT noise impact level in the following conditions.

- Existing conditions (2016) traffic noise impacts—at a hospital and a hotel.
- No Build conditions (2045) traffic noise impacts—at a hospital and a hotel.
- Build conditions (2045) traffic noise impacts—at a hospital and a hotel.

Exhibit 4-1 shows the existing, No Build, and Build traffic noise levels for 2016 for all eight modeled receivers in the study area. We added 32 additional receivers to the TNM model to represent properties along the existing alignment. Exhibit 4-1 also identifies the location of the modeled sites labeled with numbers preceded by the letter M. We input existing PM peak-hour traffic data and ran the TNM model. The TNM noise model predicted loudest-hour noise levels using PM peak-hour traffic conditions, where peak-hour traffic would operate at or near the speed limit. To estimate worst-case noise levels, where peak-hour traffic volumes cause a substantial reduction in speed, we modeled the highest traffic volume that would travel at or near the speed limit. Appendix B, Traffic Noise Analysis and Abatement Process, documents the traffic volumes and vehicle mix near the study area. In addition to the measured sites, the noise model included additional receivers to provide additional information in areas not fully described by the measurement sites.

Existing Noise Level (Year 2016)

With existing conditions, one commercial property and one hospital was modeled at or above the WSDOT noise impact level.

Design Year Traffic Noise Level—No Build (Year 2045)

Under No Build in 2045, noise levels are predicted to increase by about 1 to 2 dBA over the 2016 existing noise levels (Exhibit 4-1). The modeling results show that the hospital and hotel discussed previously for existing conditions are predicted to be at or above the noise impact level under 2045 No Build conditions. The actual maximum noise level increases may be less than the predicted increase because congestion may reduce traffic speeds during peak traffic hours.

Design Year Traffic Noise Level—Build (Year 2045)

With the Project, noise levels are predicted to stay about the same as the existing traffic or increase by 1 or 2 dBA over existing noise levels in the study area. The modeling results show that a hospital and a hotel are predicted to be at or above the noise impact level under 2045 Build conditions.

These two properties are predicted to approach or exceed the impact level with the Build condition. Future predicted noise levels for the hospital and hotel are 75 dBA and 71 dBA, respectively. Because there are no outdoor use areas at the hospital and hotel, we must consider the interior noise impact levels under Category D. To determine the interior noise levels using the exterior modeled values, we subtracted 25 dBA from the future predicted noise levels of 75 dBA and 71 dBA, assuming a structure with masonry walls and closed windows based on the WSDOT noise policy (WSDOT 2011). This results in interior noise levels of 50 dBA and 46 dBA, respectively, which are below the impact level of 51 dBA for Category D (FHWA 2010) land use. Therefore, evaluation of noise abatement is not required for these properties.

Exhibit 4-1. Modeled Noise Results for Model 6 and 7 – SE 22nd Street Vicinity to SR 520

Site #	Location[a]	Dwelling Units	Existing (2016) L_{eq} (dBA)	No Build (2045) L_{eq} (dBA)	Build (2045) L_{eq} (dBA)	Build vs Existing (dB)	Build vs No Build (dB)
V57	Residential property	1	64	65	65	1	0
V58	Residential property	10	62	63	63	1	0
V60	Commercial property (Marriot Res)	1	64	65	64	0	-1
V59	Commercial property	1	68	69	69	1	0
V61	Commercial property (Hilton Hotel, Pool)	Pool	67	68	69	2	1
V62	Commercial property (Red Lion Hotel)	Hotel	65	66	66	1	0
V63[b]	Commercial property (Extended stay)	Hotel	**71**	**72**	**71**	0	-1
V64	Commercial property (Sheraton) Hotel)	Hotel	67	68	68	1	0
6M100	Residential property	1	63	64	64	1	0
6M101	Residential property	3	60	62	62	2	1
6M103	Residential property	2	59	60	60	1	0
6M112	Residential property	3	57	58	57	0	-1
6M113	Residential property	3	60	61	61	1	0
6M114	Residential property	2	55	57	56	1	-1
6M115	Residential property	3	53	54	54	1	0
6M116	Residential property	9	59	60	60	1	0
6M117	Residential property	3	64	65	65	1	0
6M118	Residential property	4	55	57	56	1	-1
6M119	Residential property	5	57	58	58	1	0
6M120	Residential property	6	55	56	56	1	0
6M121	Residential property	5	61	62	62	1	0
6M122	Residential property	4	61	62	62	1	0

Exhibit 4-1. Modeled Noise Results for Model 6 and 7 – SE 22nd Street Vicinity to SR 520

Site #	Location[a]	Dwelling Units	Existing (2016) L_{eq} (dBA)	No Build (2045) L_{eq} (dBA)	Build (2045) L_{eq} (dBA)	Build vs Existing (dB)	Build vs No Build (dB)
6M123	Residential property	2	59	60	60	1	0
6M124	Residential property	1	61	62	61	0	-1
6M125	Residential property	3	59	60	60	1	0
6M126	Residential property	4	64	65	65	1	0
6M130	Residential property	2	61	63	62	1	-1
6M132	Residential property	2	63	64	64	1	0
7M4	Hospital[b]	Hospital	**74**	**75**	**75**	1	0
7M7	Residential property	4	61	61	61	0	0
7M12	Residential property	4	62	63	63	1	0
7M13	Residential property	4	65	63	63	-2	0
7M14	Residential property	5	60	60	60	0	0
7M15	Residential property	4	64	64	64	0	0
7M16	Residential property	4	63	63	63	0	0
7M18	Residential property	6	61	61	61	0	0
7M19	Residential property	3	65	63	63	-2	0
7M20	Residential property	2	63	63	63	0	0
7M21	Residential property	3	62	62	62	0	0
7M25	Commercial property	Hotel	68	68	68	0	0

Bold numbers represent noise levels at or above WSDOT impact levels.
The letter “V” represents validation sites and the letter “M” represents modeled sites.
[a.] See Exhibits 5-2 through 5-4.
[b.] Category D. Subtract 25 dB to determine the interior noise level (FHWA 2010).

SECTION 5 TRAFFIC NOISE ABATEMENT

Recommendation for Traffic Noise Abatement

For the Project, no noise walls were evaluated. Future predicted noise levels for the hospital and the hotel use are 75 dBA and 71 dBA, respectively. However, these facilities do not have outdoor use areas; therefore, interior noise levels must be considered under Category D. When interior noise levels were considered, these sites were expected to be below FHWA's interior noise impact level of 51 dBA under Category D. Therefore, evaluation of noise abatement is not required. Exhibits 5-2 through 5-4 show existing noise wall locations.

Background

Noise abatement is considered only where there is (1) an expected noise level of 66 dBA or higher in the design year Build condition, (2) an increase of 10 dBA over existing conditions for land use categories A, B, C, and D as defined in Exhibit 3-2, or (3) 71 dBA or higher for land use Category E. If such a situation exists, abatement is considered only where frequent human use occurs and where a lower noise level would have benefits (FHWA 1982). Noise levels can be reduced by the following types of abatement:

- Traffic management, such as restrictions on the types of vehicles and the time they may use a certain roadway.
- Change in vertical or horizontal alignment of the roadway.
- Acquisition of property.
- Construction of noise barriers, such as noise walls.

Abatement was considered for the traffic noise impacts related to the Project. Some of the modeled noise levels approach or exceed the WSDOT and FHWA NAC levels. We modeled increases between the existing and Build conditions.

Abatement must be both feasible and reasonable for it to be recommended for construction.

Feasibility

Feasibility is a combination of acoustic and engineering considerations. WSDOT evaluates many factors to determine whether noise walls will be feasible. All of the following must occur for abatement (e.g., noise barrier) to be considered feasible:

- Abatement must be physically constructible.
- The majority of first-row affected receivers (closest to the roadway) must obtain a minimum 5 dBA of noise reduction because of abatement (insertion loss), thus ensuring that every reasonable effort will be made to assess outdoor use areas as appropriate.

Reasonableness

When noise abatement is determined feasible, we assess whether the abatement is reasonable. WSDOT will only construct noise walls, or other types of abatement, if they have been determined reasonable after thoroughly evaluating the criteria below.

The reasonableness criteria of a noise barrier depend on the noise level at the sensitive receivers that will benefit from the barrier. To be reasonable, the proposed wall must be cost-effective and it must also meet the design goal for noise reduction. The noise barrier area may not exceed the sum of the total allowed area per household, for all households that will benefit by at least 5 dBA, and 7 dBA at one location, because of the barrier. The allowed area per household is a function of the predicted future noise level during the loudest hour. For receivers other than single-family residences, WSDOT calculates a residential equivalency (RE).

Cost Effectiveness

The cost of noise abatement sufficient to provide at least the minimum feasible noise reductions must be equal to or less than the allowable cost of abatement for each noise wall location analyzed. Based on noise wall costs from 2007 to 2010, the current average cost in Washington is $51.61 per square foot. The cost is applied to the allowed wall surface area (square feet) to generate the allowable cost per qualified resident, as described in Exhibit 5-1.

Either wall square footage or cost can be used to evaluate cost effectiveness, unless costs for the wall will exceed the cost of a standard design noise wall; then cost must be used to compare the wall cost to the allowable cost.

Exhibit 5-1. Reasonableness Allowances for Noise Walls

Design Year Traffic Sound Decibel Level (dBA)	Noise Level Increase Because of a Transportation Project (dBA)[a]	Allowed Wall Surface Area per Qualified Residence or Residential Equivalent (square feet)	Allowed Cost per Qualified Residence or Residential Equivalent [b]
66		700	$36,127
67		768	$39,636
68		836	$43,146
69		904	$46,655
70		972	$50,165
7 1	10 (substantial, step 1)[c]	1,040	$53,674
72	11 (substantial, step 1)	1,108	$57,184
73	12 (substantial, step 1)	1,176	$60,693
74	13 (substantial, step 1)	1,244	$64,203
75	14 (substantial, step 1)	1,312	$67,712
76	15 (substantial, step 2)[d]	1,380	$71,222

[a] If the noise level increases 10 dBA or more as the result of a project (Column B), follow the allowed wall surface and cost for the level of increase in Column C and D, respectively, in lieu of the total design year sound decibel level in Column A. For total highway-related sound levels at 76 or more dBA or if the Project results in an increase of 15 or more decibels, continue increasing the allowance at the rate provided herein unless circumstances determined on a case-by-case basis require a methodology for determining the allowance.

[b] Current costs are based on $51.61 per square foot constructed cost developed in 2011.

[c] Step 1 – when the noise levels are 10 to 14 dBA over future No Build conditions traffic noise as a result of a transportation project.

[d] Step 2 – when the noise levels are 15 or more dBA over existing traffic noise because of the transportation project (or total highway-related noise levels are between 76 and 79 decibels). Additional consideration for abatement may be considered under these circumstances.

Design Goal Achievement

The design goal for abatement on all transportation projects for reasonableness is at least 7 dBA of reduction for at least one first-row receiver. Noise walls cannot be recommended if they do not achieve the design goal. In addition to the design goal requirement, WSDOT makes a reasonable effort to get 10 dBA or greater insertion loss (noise reduction) at first-row receivers for all projects where abatement is recommended.

All the following reasonableness evaluation exhibits in this report describe the allowable cost per receiver and the cost of the minimum barrier size to achieve the design goal.

Residential Equivalency

WSDOT calculates reasonableness based on the number of residences that would benefit from a noise wall. For noise-sensitive uses other than residences, we calculate an RE of the users based on the usage factor and number of users, per WSDOT's *Traffic Noise Policy and Procedures* (WSDOT 2011). Residences are assumed to be in use at all times, but many other facilities such as schools have specific hours of operation. The usage factor accounts for the times of operation. Appendix C, Residential Equivalency, shows typical usage factors. In Washington, the average household has three members, so for sites with other than residential uses, the number of users is multiplied by a usage factor and divided by three to convert to equivalent households. Appendix C, Residential Equivalency, presents the residential equivalency for receivers in the noise study area that include sensitive uses (other than single-family residences) that approached or exceeded the NAC.

Exhibit 5-2. Existing Noise Wall Alignments –SE 22nd Street Vicinity to SE 8th Street Vicinity

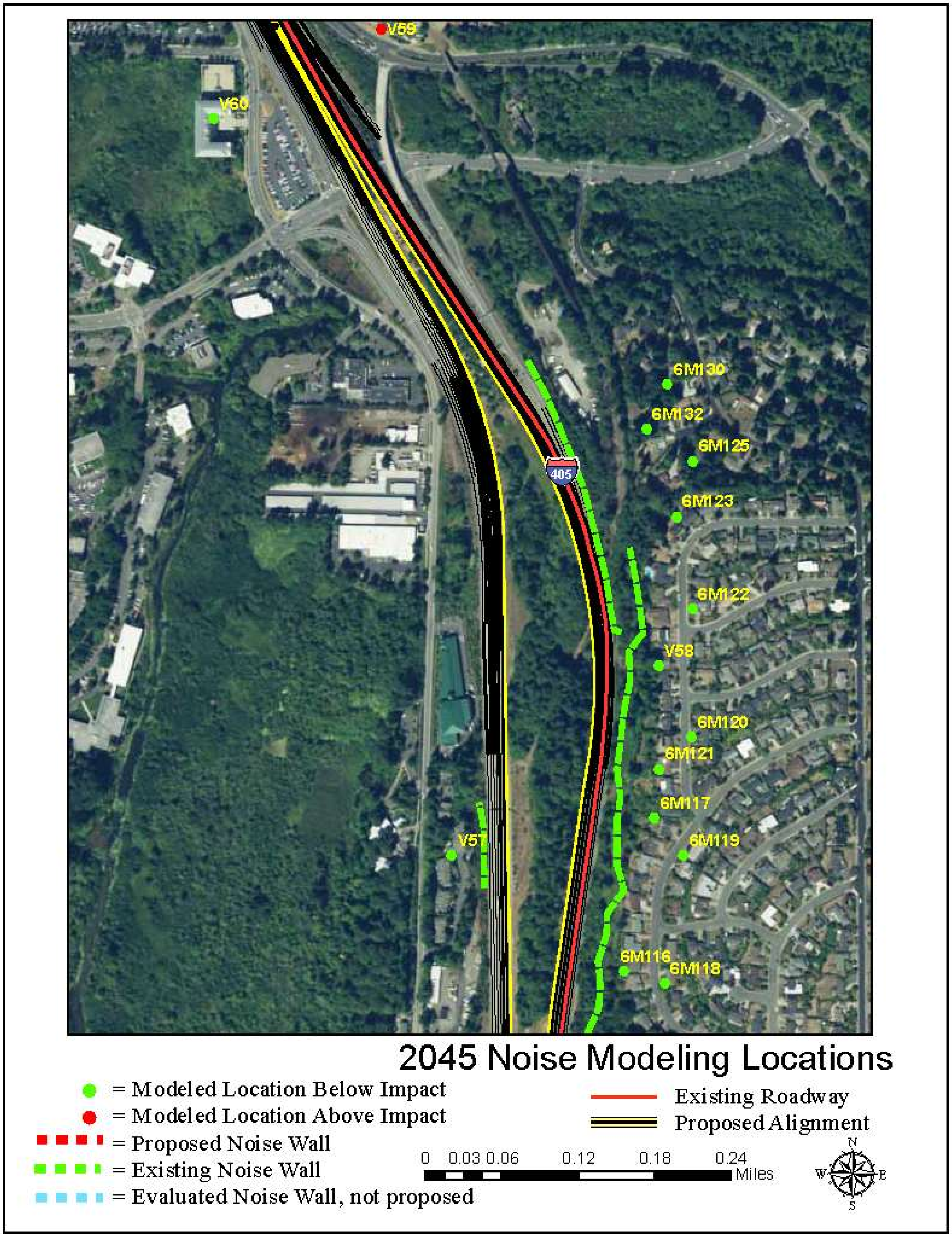


Exhibit 5-3. Existing Noise Wall Alignments –SE 8th Street Vicinity to NE 8th Street Vicinity

Exhibit 5-4. Existing Noise Wall Alignments –NE 8th Street Vicinity to SR 520

SECTION 6 CONSTRUCTION NOISE

Construction Noise Background

Construction creates temporary noise and is usually carried out in reasonably discrete steps, each with its own mix of equipment and noise characteristics. For example, roadway construction typically involves demolition, construction, and paving.

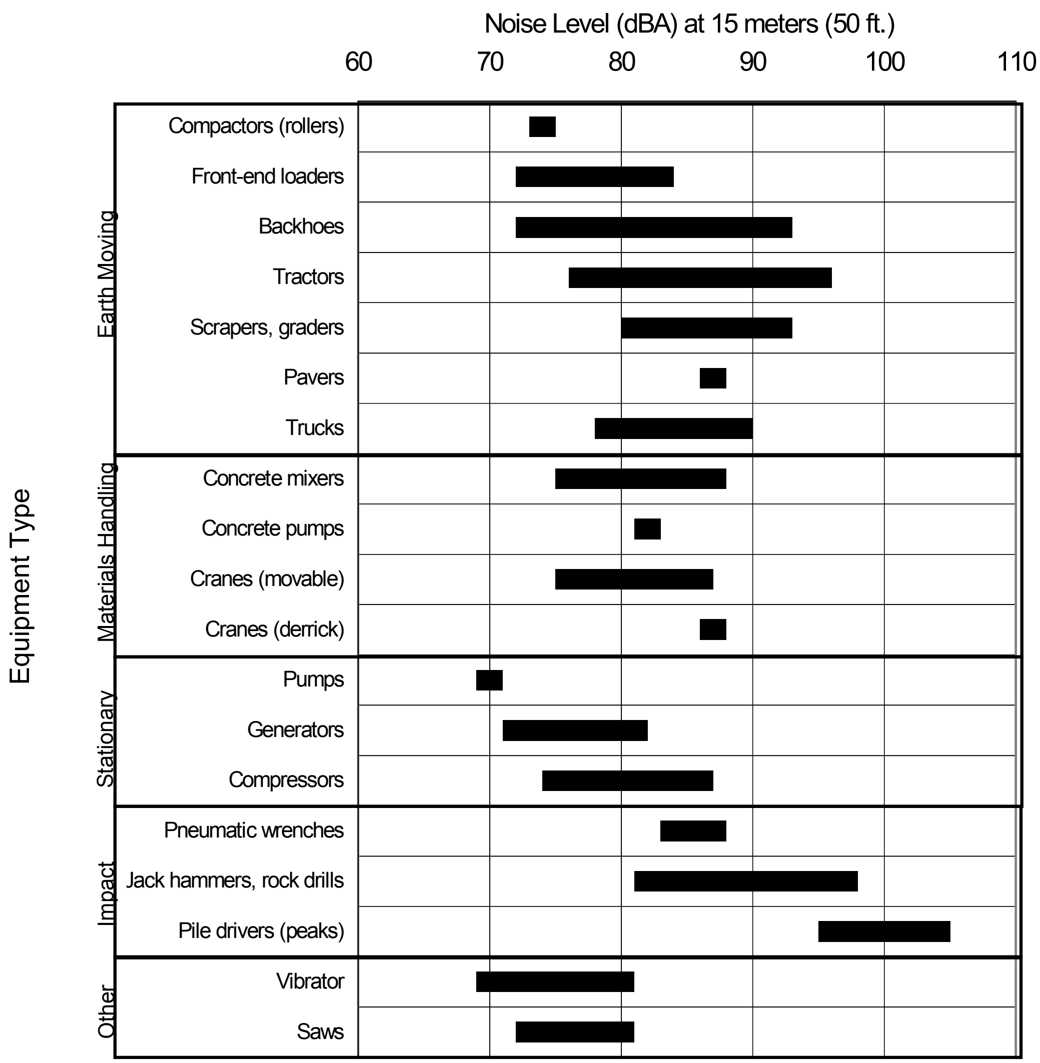
The most constant noise source at construction sites is usually engine noise. Mobile equipment generally operates intermittently or in cycles of operation, while stationary equipment, such as generators and compressors, generally operates at constant sound levels. Trucks are present during most phases of construction and are not confined to the Project site, so noise from trucks may affect more receivers than other construction noise. Other common noise sources typically include impact equipment, which could be pneumatic, hydraulic, or electric-powered.

Noise levels during the construction period depend on the following type, amount, and location of construction activities:

- The type of construction methods establishes the maximum noise levels.
- The amount of construction activity establishes how often certain construction noises occur throughout the day.
- The location of construction equipment relative to adjacent properties determines the effect of distance in reducing construction noise levels.

The maximum noise levels of construction equipment are expected to be similar to the maximum construction equipment noise levels presented in Exhibit 6-1 and typically range from 69 to 106 dBA at 50 feet. As a point source, construction noise decreases by 6 dBA per doubling of distance from the source moving away from the equipment. The various pieces of equipment are almost never operating simultaneously at full power, and some would be turned off, idling, or operating at less than full power at any time. Therefore, the average L_{eq} noise levels would be less than aggregate of the maximum noise levels in Exhibit 6-1.

Exhibit 6-1. Construction Equipment Noise Ranges



Source: EPA, 1971 and WSDOT, 1991.

Construction Noise Variance for Night Work

Construction noise is exempt from state and local property line regulations during daytime hours. If nighttime construction is required for the Project, WSDOT will apply for variances or exemptions from local noise ordinances for the night work. Such noise variances or exemptions require construction noise abatement measures that vary by jurisdiction.

Construction Noise Abatement

To reduce construction noise at nearby receptors, the following measures will be incorporated, where practicable, into construction plans and specifications:

- WSDOT will equip construction equipment engines with mufflers, intake silencers, and engine enclosures, as appropriate.
- WSDOT will turn off construction equipment during prolonged periods of nonuse to reduce noise.
- WSDOT will locate stationary equipment away from receiving properties to decrease noise.
- WSDOT will maintain all equipment and train their equipment operators in good practices to reduce noise levels.
- WSDOT will use Occupational Safety and Health Act-approved ambient sound-sensing backup alarms that could reduce disturbances from backup alarms during quieter periods.

SECTION 7 REFERENCES

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APPENDIX A ACRONYMS AND ABBREVIATIONS

Acronym	Meaning
ADA	Americans with Disabilities Act
ANE	Air, Noise, and Energy (Program)
CAD	computer-aided drafting
dB	decibels
dBA	A-weighted decibel
DOT	Department of Transportation
EA	Environmental Assessment
EDNA	Environmental Designation for Noise Abatement
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ETL	express toll lane
FHWA	Federal Highway Administration
Ft^2	square foot
GP	general purpose
HOT	high-occupancy toll
Hz	hertz
HOV	high-occupancy vehicle
I-405	Interstate 405
I-90	Interstate 90
L_{dn}	day/night sound level
L_{eq}	equivalent A-weighted sound level
$L_{eq}(h)$	equivalent A-weighted sound level averaged hourly
L_{max}	maximum sound level during a period of time
L_{min}	minimum sound level during a period of time
L_n	n representing the percentage of time the sound level exceeded
MP	milepost
NAC	Noise Abatement Criteria
NEPA	National Environmental Policy Act
RE	residential equivalency
SEL	sound exposure level
SOV	single-occupant vehicle

Acronym	Meaning
SR	State Route
TNM	traffic noise model
USDOT	U.S. Department of Transportation
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation
WSTC	Washington State Transportation Commission

APPENDIX B TRAFFIC NOISE ANALYSIS AND ABATEMENT PROCESS

When are noise reports and/or recommendations final?

The noise abatement process, from preparation of a noise wall to the final noise wall design (or decision not to build), can be confusing. The following process attempts to provide some clarification to project teams and outlines a recommended "standard" process, but acknowledges that variations to this process are likely because of the differences between projects.

Environmental Discipline Reports

The noise analyst works with the project team to model project elements affecting noise that include traffic, topography, and the location of noise-sensitive receivers. If traffic noise impacts are discovered through modeling, then abatement is evaluated.

Abatement is compared to the feasibility (constructability, effectiveness) and reasonableness (allowable barrier size/cost) for a standard project. If abatement is feasible and reasonable, the report recommends the optimal (cost to benefit) noise barrier.

After completion of the above, the traffic noise discipline report can be finalized.

Design Phase

The design phase steps described below and the Public Involvement steps described in the following section may be incorporated before the discipline report is finalized.

The project office reviews the recommended noise wall height and horizontal alignment to determine if there are any conflicts that were not realized when the discipline report was prepared.

If conflicts from utilities, steep slopes, etc. are present, the project team provides the details and costs of the conflicts to the noise analyst. The noise analyst will then add any additional ("but for" the noise wall) costs to the reasonableness evaluation. If noise wall costs, including accommodation of conflicts, are still less than the allowable costs for the noise wall, the barrier height and/or alignment are reevaluated and a new barrier will be recommended. If barrier costs plus the new costs exceed the allowable costs, the barrier may not be recommended by the WSDOT Air, Noise, and Energy (ANE) Program.

If a noise wall is recommended, the ANE Program will review and confirm noise wall dimensions throughout the design process.

Public Involvement

If noise abatement is recommended in the Traffic Noise Discipline Report, public outreach to determine public desires for abatement must occur. The noise wall discussion may be introduced to the public before the design phase, but should happen after the noise wall alignment, height, and length (or other abatement description) is established so that people can understand any impacts of the noise wall (or other abatement) on their community.

The final determination whether to construct a noise wall or other abatement that the traffic noise analysis recommends cannot be made until public outreach has occurred.

Final Steps

Any updates to the Traffic Noise Discipline Report to clarify changes that occurred during the design phase or from public involvement can be made at the project engineering office's discretion. An addendum or supplementary memorandum to clarify changes can also be added to the discipline report or project file.

The noise wall is constructed or a letter from the ANE Program is added to the project file clarifying why a noise wall was not constructed.

Modeled Traffic Volumes

Exhibit B-1. Modeled Hourly Traffic Volumes for Existing and Future No Build and Build Conditions

I-405 between:		2045 Build AM - 5:30 AM to 6:30 AM			2045 Build PM - 2PM to 3PM			Existing AM - 5:30 AM to 6:30 AM			Existing PM - 2PM to 3PM		
South	North	Northbound	Southbound	Total	Northbound	Southbound	Total	Northbound	Southbound	Total	Northbound	Southbound	Total
I-90	SE 8th	9032	6948	15980	9314	9158	18472	5765	4419	10184	6813	6570	13383
SE 8th	NE 4th/8th	8746	7329	16075	9462	9165	18627	5298	4603	9901	6674	6555	13229

Exhibit B-2. Modeled Hourly Traffic Volumes for Existing and Future No Build and Build Conditions

I-405 between:	2045 Build AM - 5:30 AM to 6:30 AM	2045 Build PM - 2PM to 3PM	Existing AM - 5:30 AM to 6:30 AM	Existing PM - 2PM to 3PM
North	Northbound	Southbound	Total	Northbound
NB NE 4/8th Off	1319	1525	1087	1265

Notes: The hours used in this table represent the projected highest volume that could use the corridor when closest to free-flow conditions.

Higher volumes are projected in hours closer to the peak period of the two analysis periods; however, congestion within the corridor limits the actual volume that can get through.

AM: These volumes are in the beginning of the 6-hour analysis period, as most of the congestion had not build up yet along the corridor. Also, according to existing counts, the highest volumes were observed in the NB direction in the early hours of the peak period.

PM: These volumes are the first hour of the 6-hour analysis period, as the highest congestion has not started at this time to limit the through volume.

Exhibit B-3. Modeled Hourly Traffic Volumes for Existing and Future No Build and Build Conditions

I-405 between:		2045 Build AM - Truck %			2045 Build PM - Truck %			Existing AM - Truck %			Existing PM - Truck %		
South	North	Northbound	Southbound	Total	Northbound	Southbound	Total	Northbound	Southbound	Total	Northbound	Southbound	Total
I-90	SE 8th	8	8	8	4	5	4	7	6	7	5	5	5
SE 8th	NE 4th/8th	8	8	8	4	4	4	7	6	7	5	5	5

Notes:

Truck Percentages reported are the 6-Hour average percentage.

APPENDIX C RESIDENTIAL EQUIVALENCY

WSDOT calculates reasonableness based on the number of residences that benefit from a noise wall. For noise-sensitive uses other than residences, a residential equivalency (RE) of the users 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 such as schools have specific hours of operation. The usage factor accounts for the times of operation. Exhibit C-1 shows typical usage factors. In Washington, the average household has three members, so for sites use other than residential, the usage factor is multiplied by the number of users and then divided by three to convert to an equivalent number of households.

Exhibit C-1 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
Trails	12	7	5	0.17