I-405, Tukwila to Renton Improvement Project (I-5 to SR 169 – Phase 2)

INTERSTATE 405 **Corridor Program**

Congestion Relief & Bus Rapid Transit Projects

NOISE DISCIPLINE REPORT

December 2007

Washington State Department of Transportation

U.S. Department of Transportation
Federal Highway Administration

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SUMMARY

In order to relieve congestion, WSDOT is proposing to construct the I-405, Tukwila to Renton Improvement Project (I-5 to SR 169 – Phase 2), referred to in this document as the Tukwila to Renton Project. The I-405 Team noise specialists considered the project's effect on noise to understand the potential effect of traffic and construction noise on public health and welfare.

Study Approach

Noise levels were measured at 18 locations in the study area, during the loudest hours of the day when traffic volumes are high but not congested. These measurements were used to validate the Existing Conditions (year 2005) computer model generated with the Federal Highway Administration (FHWA)'s Traffic Noise Model (TNM) Version 2.5.

Noise levels for the 18 measured locations and 46 modeled-only locations, which were chosen to represent noise sensitive sites in the study area, were predicted for the Baseline Conditions (year 2014), No Build Alternative (year 2030), and Build Alternative (design year 2030) computer models using TNM. I-405 noise specialists also used relevant design files, traffic volumes, and vehicle mixes based on the *Tukwila to Renton Project Transportation Discipline Report* (WSDOT, 2007) to create the noise models for this project. The results of the No Build and Build Alternatives models were compared to the Baseline Conditions model in order to determine project effects.

All noise-sensitive locations within the Tukwila to Renton Project study area are residential and public use buildings or outdoor recreational areas, which fall under the noise abatement criterion (NAC) of 67 A-weighted decibels (dBA). Noise specialists evaluated mitigation measures at receptors where noise levels were modeled to approach within 1 dBA of or exceed the NAC. They used WSDOT feasibility and reasonability criteria to determine whether the reduction in traffic noise will be substantial enough to warrant the cost of constructing or replacing noise barriers.

Baseline Conditions

Baseline conditions (year 2014) incorporate the effects of the Renton Nickel Improvement Project. Under these conditions,

some study area locations already approach, meet, or exceed the NAC for sensitive receptors. Locations that currently approach, meet, or exceed 67 dBA include approximately 98 residences, 2 hotels, 6 parks, and 3 trails. Eleven of these residences and the 2 hotels exceed the NAC because of noise from local traffic on Main Avenue S, S Grady Way, Benson Road S, N 3rd Avenue, the SR 169/N 3rd Avenue connector, and/or SR 169.

Baseline conditions include a noise wall called Noise Barrier East 5. This noise wall was constructed as part of the Renton Nickel Improvement Project, which is assumed to be included in the baseline condition for the Tukwila to Renton Project. Retaining walls, limited jersey barriers, and topography also shield some residential areas.

Project Effects

The Tukwila to Renton Project will increase noise levels throughout the entire study area, primarily affecting residences in the Renton Hill and Talbot Hill neighborhoods. Noise levels will grow over time, with an increase of 0 to 12 dBA by the year 2030.

If this project is built, WSDOT will acquire 30 noise-affected residences and one park as right-of-way for the roadway project. With the project in place, 92 residences, 1 library, and 1 park will go from being below the NAC to being at or above the NAC. Added to the 98 residences, 2 hotels, 5 parks, and 3 trails that are already at or above the NAC, a total of 190 residences, 2 hotels, 1 library, 6 parks, and 3 trails are predicted to experience noise levels at or above the NAC of 66 dBA set for residences in 2030.

If this project is not built, no additional receptors will approach, meet, or exceed the NAC. Under the No Build Alternative, the 98 residences, 2 hotels, 6 parks, and 3 trails that already approach, meet, or exceed the NAC will continue to experience noise levels that approach, meet or exceed the NAC in 2030.

Construction activities will generate noise during this project's construction period. Construction will usually be carried out in several steps, each with its own mix of equipment and its own noise characteristics. Adverse effects may result from construction noise levels generated by heavy equipment,

including heavy trucks, excavators, jackhammers, and pile drivers. However, this noise will be temporary, occurring only in specific areas of the construction zone during specific times of the construction.

Measures to Avoid or Minimize Effects

Noise Barrier East 5 was built under the Renton Nickel Improvement Project and will be relocated to a new location with the Tukwila to Renton Project. In its new location, Noise Barrier East 5 will not provide noise level reductions over baseline conditions for the five receptors that represent 32 residences in the Talbot Hill area. These residences will actually experience an increased noise level due to the Tukwila to Renton Project, although the magnitude of this increase will be minimized by the shielding effects of the replacement noise barrier. Upgraded noise barrier designs were evaluated in an attempt to reduce noise in the area of Noise Barrier East 5. However, additional noise barrier height and length did not noticeably reduce noise levels and did not meet WSDOT criteria for feasibility.

Two new noise barriers meet WSDOT criteria for placement along the Tukwila to Renton Project. Noise Barrier 8 is planned for construction along the WSDOT right-of-way line east of Benson Road S and southeast of I-405, near the Berkshire Apartments. At a height of 20 feet, Noise Barrier 8 would reduce the number of residences that experience noise levels that approach, meet, or exceed the NAC from 27 to 5 residences in the area behind Noise Barrier 8.

Noise Barriers 10A and 10B were evaluated together as a system. The barrier system is planned for construction atop a retaining wall from Renton Avenue S to the end of Mill Avenue S. At a height of 14 to 20 feet and 20 feet respectively, Noise Barriers 10A and 10B would reduce the number of residences that experience noise levels that approach, meet, or exceed the NAC from 76 to 29 residences in the area behind the two barriers.

As for construction, noise will be reduced where practicable by using enclosures or walls to surround noisy equipment, installing mufflers on engines, using quiet equipment and/or construction methods, minimizing operation time, and locating stationary equipment far from sensitive receptors such as residences.

Unavoidable Adverse Effects

For the Build Alternative, noise levels will approach, meet, or exceed the NAC at 36 locations (representing 121 residences, 2 hotels, 1 library, 6 parks, and 3 trails) with the relocated Noise Barrier East 5, and new Noise Barrier 8 and Noise Barrier 10. Noise Receptor Sites 22, 25, 26, 30, 31, 34, and Freeway Park are planned for acquisition by the I-405, Tukwila to Renton Improvement Project. The Tukwila to Renton Project will not cause any substantial increases in noise.

Construction of the Tukwila to Renton Project will not cause any substantial unavoidable adverse noise impacts, per the FHWA guidance stipulating that temporary construction noise effects are not substantial.

ACRONYMS AND ABBREVIATIONS

Term	Meaning
CFR	Code of Federal Regulations
dB	decibels
dBA	A-weighted decibels
Ecology	Washington State Department of Ecology
EDNA	Environmental Designation for Noise Abatement
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
Hz	hertz
HOV	High-Occupancy Vehicle
I	interstate
L_{dn}	day/night sound level
L_{eq}	equivalent A-weighted sound level
$L_{eh}(h)$	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* represents the percentage of time the sound level is exceeded
NAC	Noise Abatement Criteria
RE	Residential Equivalency
SEL	Sound Exposure Level
SR	State Route
TNM	Traffic Noise Model
USDOT	U.S. Department of Transportation
VdB	velocity decibels
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

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GLOSSARY

Term	Meaning
A-weight	A standard frequency weighting that simulates how humans perceive sound (dBA).
ambient noise	The totality of noise associated with a given environment, encompassing sounds from many sources near and far.
calibration	Adjustment of the noise measurement system so the measured sound level agrees with a reference sound level.
calibration check	A check of a noise meter for variations between the measured sound level and a reference level; no adjustment is made to the noise monitoring system.
decibel (dB)	A logarithmic-based unit of measure of sound pressure.
duration	The length of time of an event.
energy average	The average of two or more acoustic energies expressed on a common decibel logarithmic scale.
equivalent sound level (L_{eq})	The equivalent steady-state sound level in A-weighted decibels for a stated period of time, which contains the same acoustic energy as the actual time-varying sound level for the same period of time.
hertz (Hz)	A unit of frequency measured in cycles per second.
L_{max}	Maximum sound level, in decibels. This is the maximum value of the noise level that occurs during a single event.
L_{min}	Minimum sound level, in decibels. This is the minimum value of the noise level that occurs during a single event.
L_n	The A-weighted sound level, in decibels, that is exceeded *n* percent of the time in a given interval. For example, L_{10} is the A-weighted sound level exceeded 10 percent of the time over the given interval (usually 1 hour).
logarithm	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. Also abbreviated to "log".
noise level	The sound pressure level, measured using a meter with an "A" frequency weighting and reported as dBA.
peak	The maximum sound level during a given time interval when the normal frequency and time weighting is not used.

Term	Meaning
Sound Exposure (SE)	A measure of the total sound energy of the actual sound during a given time interval. Unlike the Sound Exposure Level, it is not expressed in decibels, but in units of Pascal-squared seconds.
Sound Exposure Level (SEL)	The level of a steady one-second-long sound that contains the same energy as the actual (varied) sound over the total measurement duration. SEL is expressed in decibels. SEL is related to L_{eq}, but all the energy is compressed within a one-second period as opposed to being spread over a stated period of time.
sound pressure level or noise level	A noise measurement that uses an A-weighting to modify the frequency response of the measuring instrument, so that it more closely mimics the human ear's frequency characteristics.

SECTION 1 INTRODUCTION

What are the primary features of the Tukwila to Renton Project?

WSDOT is proposing to construct the I-405, Tukwila to Renton Improvement Project (I-5 to SR 169 – Phase 2), referred to as the Tukwila to Renton Project, to relieve congestion. The Tukwila to Renton Project extends approximately four and one half miles along Interstate 405 (I-405), from I-5 to State Route 169 (SR 169), and approximately two miles along SR 167, from I-405 to SW 43rd Street. The project will:

- Add capacity to both I-405 and SR 167.
- Replace bridges over the Green River and Cedar River and add one new bridge over the Green River.
- Improve the SR 181 and SR 169 interchanges.
- Reconstruct the SR 167 interchange consisting of new general-purpose direct-connector ramp from southbound I-405 to southbound SR 167, HOV direct-connector ramps from northbound SR 167 to northbound I-405 and from southbound I-405 to southbound SR 167, and a split-diamond interchange at Lind Avenue and Talbot Road with connecting frontage roads.
- Replace the two local street accesses to Renton Hill.

These improvements represent the second phase of the I-405 Corridor Program for this portion of I-405. The first phase consists of improvements in the Renton Nickel Improvement Project.

Why do we consider noise as we plan this project?

Sound is an element of daily life that when perceived as unpleasant, unwanted, or disturbingly loud, is called *noise*. The I-405 Team's noise specialists considered the effects of noise in order to understand the potential effect of traffic and construction noise on public health and welfare. Federal regulations (23 CFR 772) and WSDOT noise abatement criteria (NAC) require a noise analysis for projects that add capacity to a highway or when a highway is realigned.

Are you new to reading noise reports?

Environmental disciplines generally have vocabularies all their own. We encourage readers who are new to noise-related terminology to invest a few minutes now reviewing the Glossary and the list of Acronyms and Abbreviations in the preceding sections. An understanding of the A-weighted decibel (dBA) and the Equivalent A-weighted sound level (L_{eq}) will be especially helpful in following our analysis of this important environmental element.

Additional travel lanes on I-405 and higher peak-hour speeds that result from reduced congestion could increase perceived noise levels at sensitive receptors, such as residences and parks in the study area. This noise analysis determines whether mitigation measures such as noise barriers are warranted to buffer noise-sensitive areas from the roadway.

What are the key points from this report?

Under baseline conditions, some places in the study area already exceed the NAC, including approximately 98 residences, 2 hotels, 6 parks, and 3 trails. Eleven of these residences and 2 hotels exceed the NAC because of noise generated from local traffic on Main Avenue S, S Grady Way, Benson Road S, NE 3rd Avenue, the SR 169/NE 3rd Avenue connector, and/or SR 169.

If the project is built, noise levels will increase primarily at residences in the Renton Hill and Talbot Hill neighborhoods. For the most part, noise levels will grow over time with an increase of 0 to 12 dBA L_{eq} by the year 2030. Some sensitive receptors in the western portion of the study area, representing 16 residences and 1 trail, will experience noise-level reductions of 1 to 6 dBA L_{eq} by the year 2030, yet will still be at or above the NAC. Freeway Park, also a sensitive receptor, will be removed by the project along with 30 potentially noise-sensitive residences in the Talbot Hill neighborhood and at the Berkshire Apartments.

If this project is built, 92 residences, 1 park, and 1 library will go from being below the NAC to being at or above the NAC. Added to the 98 residences, 2 hotels, 5 parks, and 3 trails that are already at or above the NAC under baseline conditions, a total of 190 future residences, 2 hotels, 6 parks, 3 trails, and 1 library are predicted to experience noise levels at or above the NAC of 67 dBA set for residences in 2030.

What measures are proposed to avoid or reduce impacts?

Noise Barrier East 5, which was built under the Renton Nickel Improvement Project, will be relocated to a new location with the Tukwila to Renton Project. In its new location, Noise Barrier East 5 will not provide noise level reductions over baseline conditions for the five receptors that represent 32 residences in the Talbot Hill area. These residences will

experience additional noise effects, although the magnitude of these effects will be minimized by the shielding effects of the replacement noise barrier.

Two new noise barriers meet WSDOT criteria for placement along the Tukwila to Renton Project. Noise Barrier 8 is planned for construction along the WSDOT right-of-way line east of Benson Road S and southeast of I-405, near the Berkshire Apartments. Without the Tukwila to Renton Project, noise levels behind Noise Barrier 8 range from 54 to 71 dBA. At a height of 20 feet, Noise Barrier 8 would reduce the number of residences that experience noise levels that approach, meet, or exceed the NAC with the project from 27 to 5 residences in the area behind Noise Barrier 8.

Noise Barriers 10A and 10B were evaluated together as a system. The barrier system is planned for construction atop a retaining wall from Renton Avenue S to the end of Mill Avenue S. At a height of 14 to 20 feet and 20 feet respectively, Noise Barriers 10A and 10B would reduce the number of residences that experience noise levels that approach, meet, or exceed the NAC from 76 to 29 residences in the area behind the two barriers.

What will happen if we adopt the No Build Alternative?

If this project is not built, no additional residences will approach, meet, or exceed the NAC (the equivalent sound level of 67 dBA) until at least the year 2030. The 98 residences, 2 hotels, 6 parks, and 3 trails that already approach, meet, or exceed the NAC will continue to do so until at least 2030.

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SECTION 2 PROJECT DESCRIPTION

What is the intent of the Tukwila to Renton Project?

WSDOT is proposing to construct the I-405, Tukwila to Renton Improvement Project (I-5 to SR 169 – Phase 2), referred to as the Tukwila to Renton Project, to relieve congestion. Relieving congestion will benefit the public by:

- Lowering the number of accidents thus improving safety.
- Increasing overall speeds through this section of freeway.
- Improving response times for emergency service vehicles using I-405.
- Improving access to and from I-405 and local circulation.

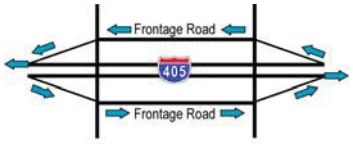
The Tukwila to Renton Project extends approximately four and one half miles along I-405, from I-5 to SR 169, and approximately two miles along SR 167, from I-405 to SW 43rd Street. The project adds capacity to both I-405 and SR 167; improves the SR 181 and SR 169 interchanges; reconstructs the SR 167 interchange consisting of a split-diamond interchange at Lind Avenue and Talbot Road with connecting frontage roads, general-purpose direct-connector ramp from I-405 to SR 167 southbound, and high-occupancy vehicle (HOV) direct-connector ramps from SR 167 northbound to I-405 northbound and from I-405 southbound to SR 167 southbound. These improvements are detailed in the following section.

What are the details of the Tukwila to Renton Project?

The Tukwila to Renton Project improvements are described from west to east (northbound) along the study area on the following pages. These improvements are also illustrated on Exhibits 2-1 through 2-15.

What is a split-diamond interchange?

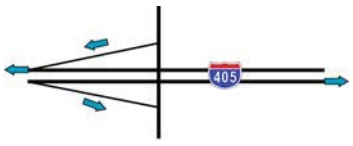
This interchange type consists of two half-diamond interchanges at arterials. These are connected by two, one-way frontage roads. Traffic enters and exits the freeway at the two arterials, creating an elongated diamond configuration as shown.



Split Diamond

What is a half-diamond interchange?

It is an interchange where traffic exits or enters the freeway in one direction. This creates a triangular or half-diamond configuration as shown.



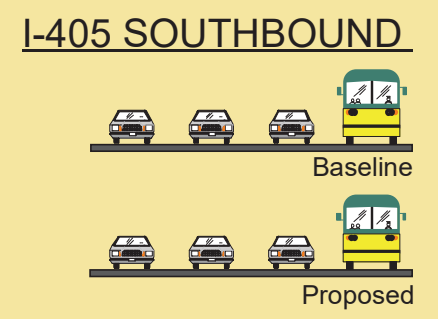
Half Diamond

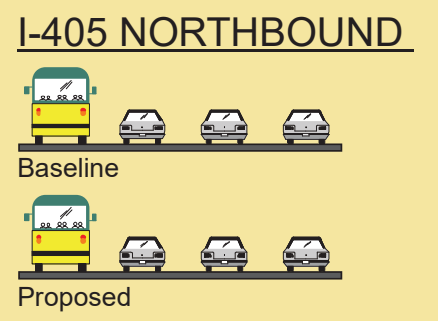
Exhibit 2-1: Project Features, Sheet 1

I-405 from I-5 to East of SR 181

For this portion of the project, WSDOT will:

- Remove the existing northbound I-405 Tukwila Parkway on-ramp. See Exhibits 2-2 and 2-3 for where the project will provide a new on-ramp.
- Realign I-405 mainline slightly to the south beginning just west of the existing northbound I-405 Tukwila Parkway on-ramp to the SR 181 interchange as shown in Exhibits 2-1 and 2-2.





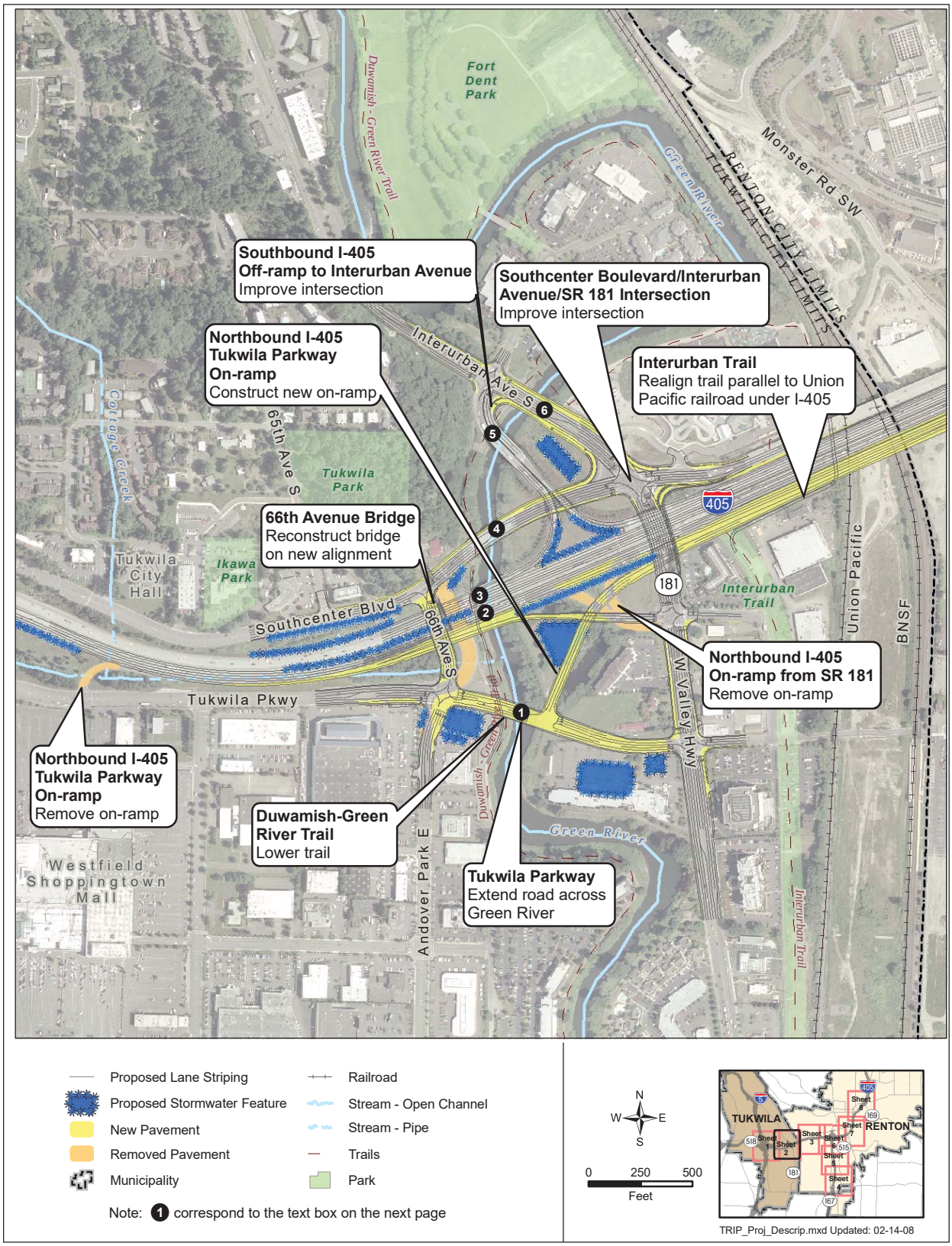
The project will not change capacity along this section

What are baseline conditions for this project?

Baseline conditions describe the site conditions just before construction of the project begins. This can include the build conditions of earlier phased projects that are already approved and funded and expected to be complete before the next project begins. Baseline provides an important point of comparison for understanding the effects of the proposed build alternative.

For the Tukwila to Renton Project, the baseline condition assumes that the Renton Nickel Improvement Project has been completed.

Exhibit 2-2: Project Features, Sheet 2



I-405 at SR 181 Interchange

WSDOT designed the improvements in Exhibits 2-2 and 2-3 to improve freeway and local travel in this area. WSDOT will:

- Improve the SR 181 interchange:
  - Remove the existing SR 181 on-ramp to northbound I-405.
  - Extend Tukwila Parkway from the intersection with 66th Avenue east over the Green River to SR 181.
  - Construct new northbound I-405 on-ramp from Tukwila Parkway just east of the new crossing over the Green River (replaces the two existing on-ramps).
  - Reconstruct the 66th Avenue S bridge over I-405 on a new alignment to the west and reconstruct the intersections with Southcenter Boulevard and Tukwila Parkway.
  - Reconstruct the off-ramp from northbound I-405 to SR 181.
  - Improve local arterials within the interchange area such as Southcenter Boulevard and Interurban Avenue.
- Reconstruct five bridges and build one new bridge over the Green River.
- Lower the Duwamish-Green River Trail.
- Reconstruct the I-405 structures over SR 181.
- Realign the Interurban Trail.

What bridge construction will occur over the Green River?

❶ Tukwila Parkway Bridge (new)

❷ Northbound I-405 Bridge

❸ Southbound I-405 Bridge

❹ Southcenter Boulevard Bridge

❺ Off-Ramp Bridge from southbound I-405.

❻ Interurban Avenue Bridge

See Exhibit 2-2 for the bridge locations.

Exhibit 2-3: SR 181 Interchange Improvements

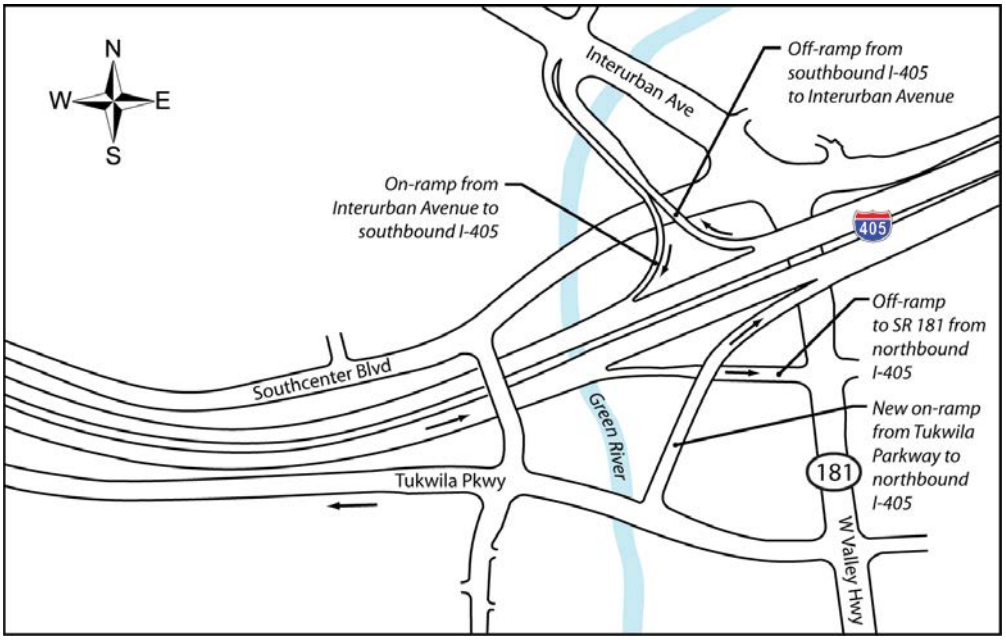
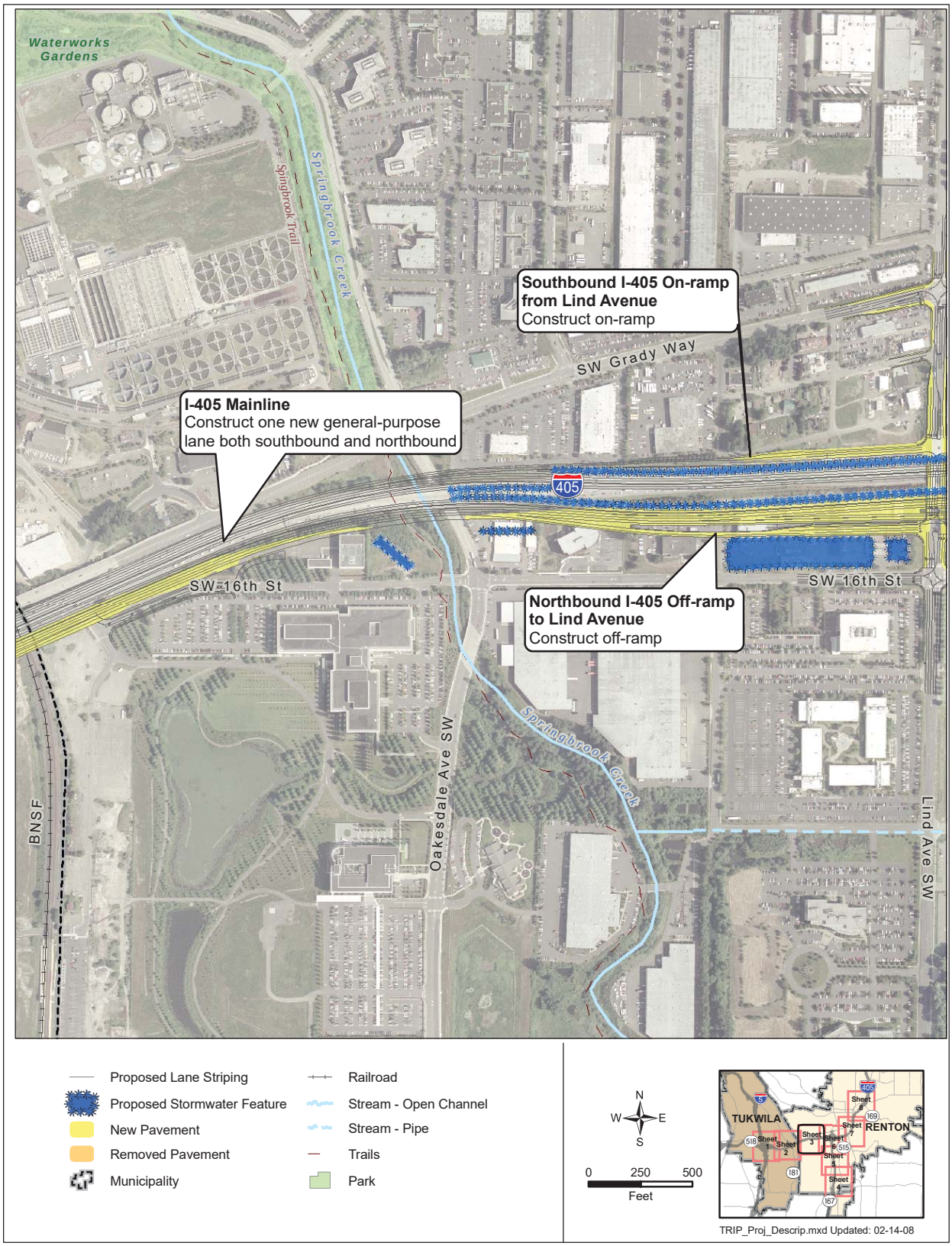


Exhibit 2-4: Project Features, Sheet 3



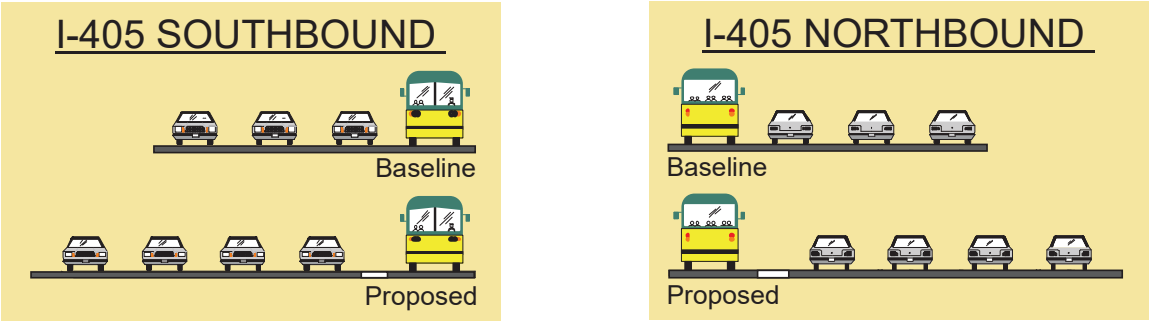
I-405 from East of SR 181 to SR 167 Interchange

From the SR 181 interchange east, WSDOT will realign I-405 to the south. This will:

- Provide a smooth transition onto the new Springbrook Creek/Oakesdale Avenue bridge that was constructed under the Renton Nickel Improvement Project.
- Minimize effects on SW Grady Way and businesses north of I-405.

In addition to realigning I-405, WSDOT will:

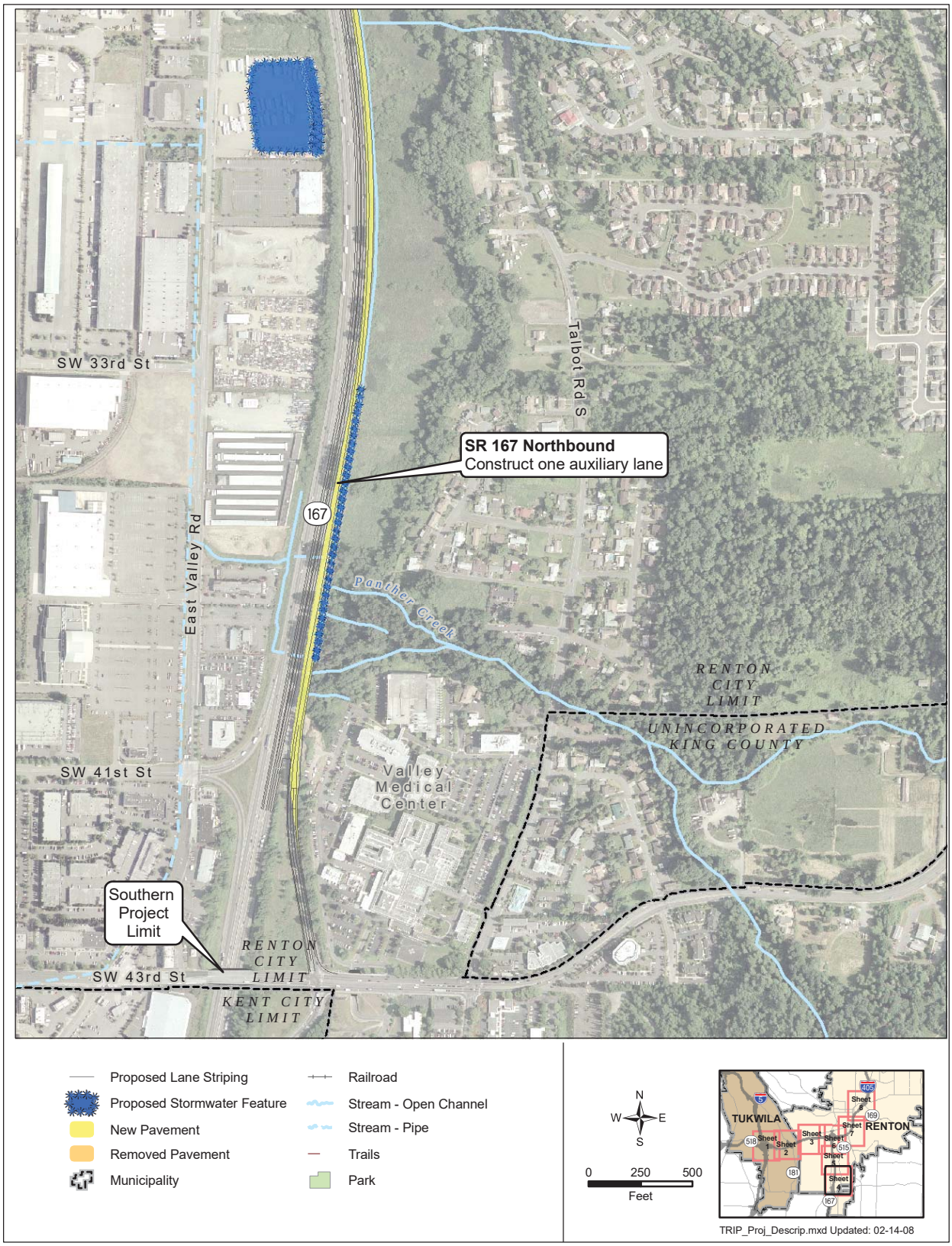
- Construct one additional general-purpose lane in both directions on I-405 from SR 181 through SR 167.
- Stripe lanes to provide a buffer between HOV and general-purpose lanes along I-405.



Project improvements will add capacity to I-405 for both southbound and northbound traffic and will provide a buffer between the HOV lane and the general-purpose lanes

- Stripe the bridges over Springbrook Creek/Oakesdale Avenue to provide five lanes in both directions.
- Reconstruct I-405 structures over the Burlington Northern Santa Fe (BNSF) and Union Pacific railroads.
- Construct a half-diamond interchange at Lind Avenue (see sidebar on page 2-1).

Exhibit 2-5: Project Features, Sheet 4

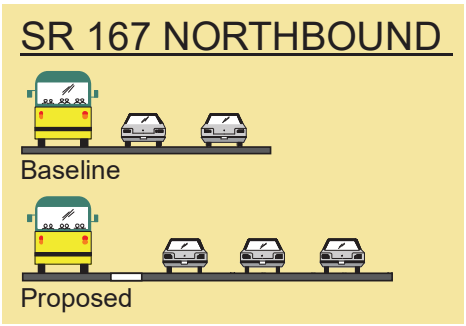


SR 167 from SW 43rd Street On-ramp North to SW 27th Street

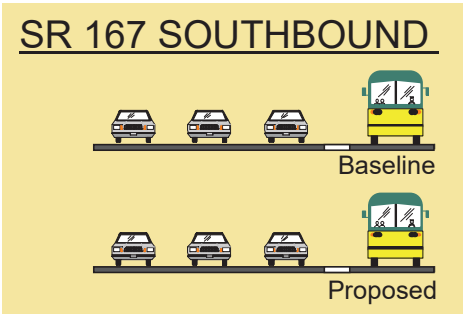
In this area, WSDOT will:

- Construct an auxiliary lane on northbound SR 167 from SW 43rd Street to SW 27th Street.
- Stripe lanes to provide a buffer between HOV and general-purpose lanes along northbound SR 167.

As shown on Exhibit 2-5, the new northbound lane will be added north of the SW 43rd Street on-ramp. This will improve the ability of traffic to merge onto SR 167 and increase capacity along this stretch. To minimize effects on the streams and wetlands along SR 167, WSDOT has used retaining walls instead of fill slopes.



Project improvements will add capacity to northbound SR 167 and will provide a buffer between the HOV lane and the general-purpose lanes



The project will not affect the southbound lanes of SR 167

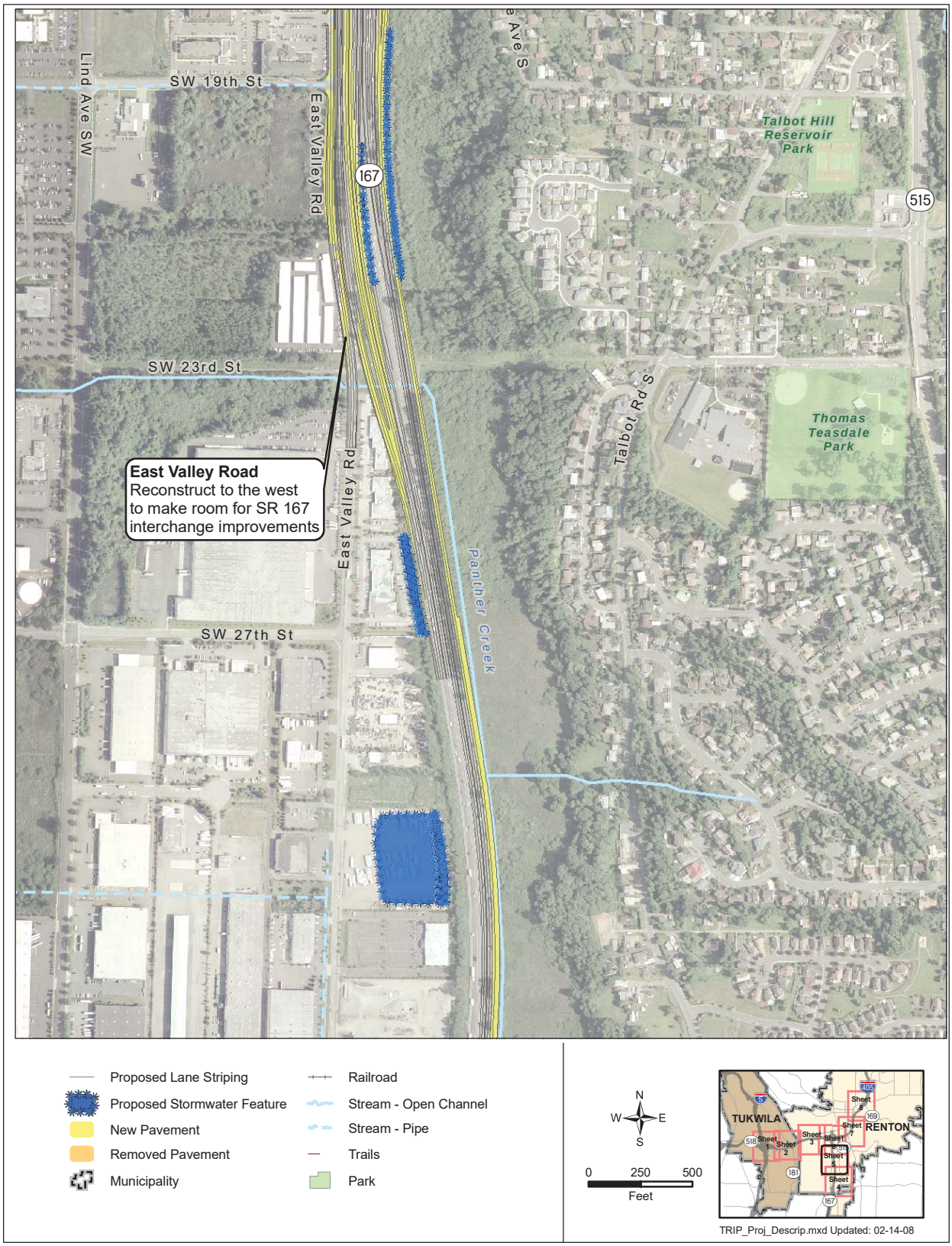
What is an auxiliary lane?

An auxiliary lane is a lane added between interchanges—from one on-ramp to the next off-ramp. It is dedicated to traffic entering and leaving the freeway and provides motorists with more time and extra room to accelerate or decelerate and merge when getting on and off the freeway.

The signs below show how an auxiliary lane changes how an on-ramp operates.

Existing Proposed

Exhibit 2-6: Project Features, Sheet 5

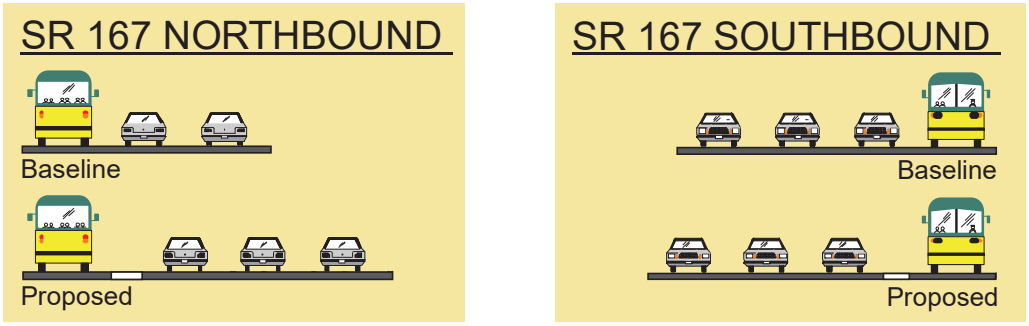


SR 167 from SW 27th Street to I-405

Along this section of SR 167, the project will:

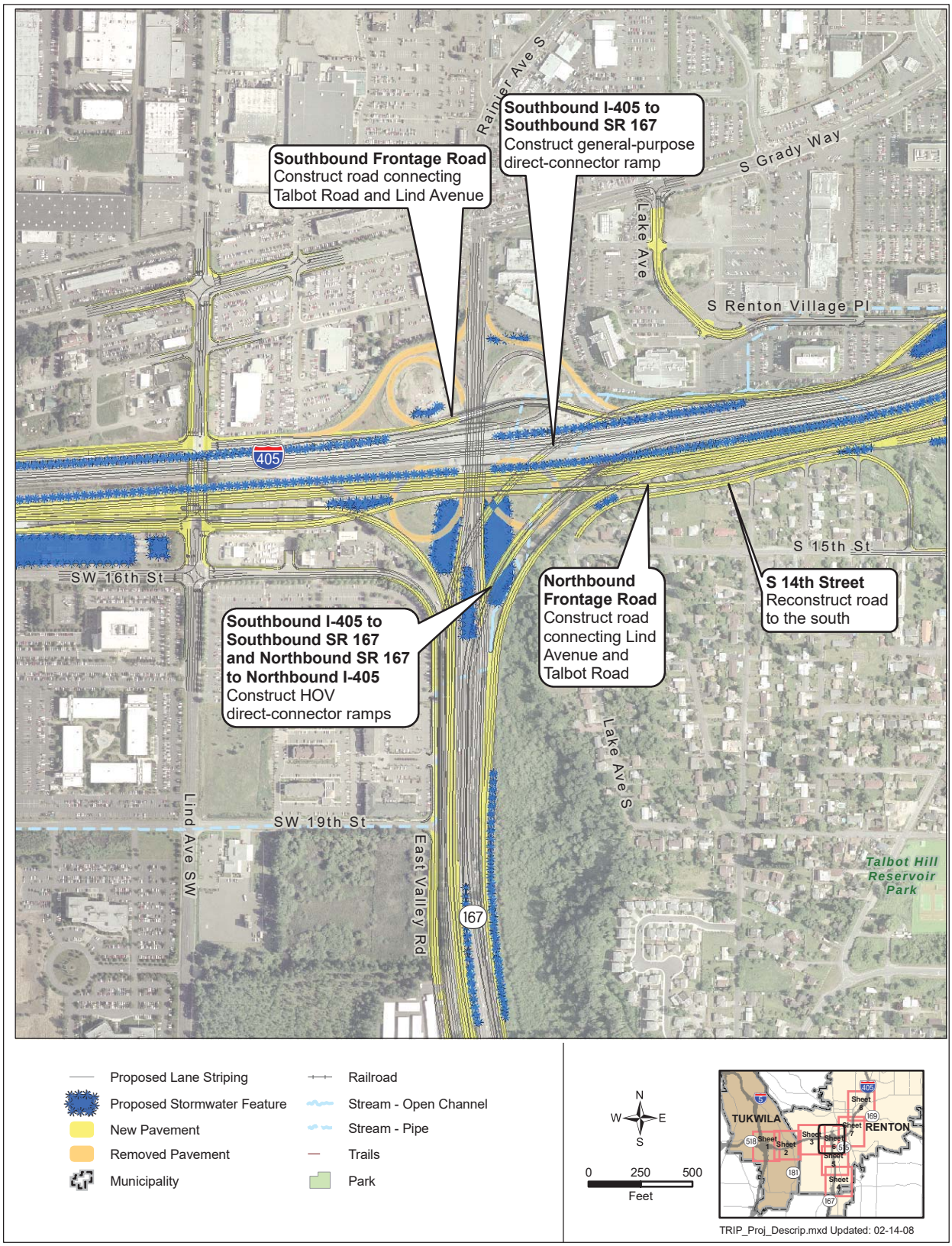
- Reconstruct SR 167 between SW 27th Street and I-405 to accommodate the reconstructed SR 167 interchange as shown on Exhibits 2-7 to 2-9.
- Reconstruct East Valley Road to the west of its current alignment between SW 23rd Street and SW 16th Street to accommodate the reconstructed SR 167 interchange.
- Stripe lanes to provide a buffer between HOV and general-purpose lanes along SR 167.
- Construct an auxiliary lane on northbound SR 167 from SW 27th Street to I-405.

WSDOT has designed the improvements in this area to the west as much as possible to minimize effects on the Panther Creek wetlands while also limiting the effects on businesses west of SR 167. To further minimize the area needed to accommodate the improvements, the new southbound I-405 to southbound SR 167 direct-connector ramp will be built over local street and freeway improvements as shown on Exhibit 2-9. WSDOT also used design features such as retaining walls to minimize the area needed for improvements.



Project improvements will add capacity to northbound SR 167 and will provide a buffer between the HOV lane and the general-purpose lanes in both the northbound and southbound directions of SR 167

Exhibit 2-7: Project Features, Sheet 6



I-405 Interchange with SR 167

Within the I-405/SR 167 interchange, the project will improve freeway to freeway access and local access.

Freeway to Freeway Access

To improve access, WSDOT will:

- Construct a general-purpose direct-connector ramp from southbound I-405 to southbound SR 167, replacing the existing loop ramp.
- Reconstruct exterior ramps from northbound I-405 to southbound SR 167 and from northbound SR 167 to northbound I-405, replacing the existing ramps. This project will also add a general-purpose lane to both ramps.
- Construct HOV direct-connector ramps from southbound I-405 to southbound SR 167 and from northbound SR 167 to northbound I-405.
- Maintain existing loop ramp from northbound SR 167 to southbound I-405.

Exhibit 2-8 focuses on the freeway to freeway interchange improvements and Exhibit 2-9 presents how these improvements will look.

Exhibit 2-8: Freeway to Freeway Ramps in Reconstructed I-405/SR 167 Interchange

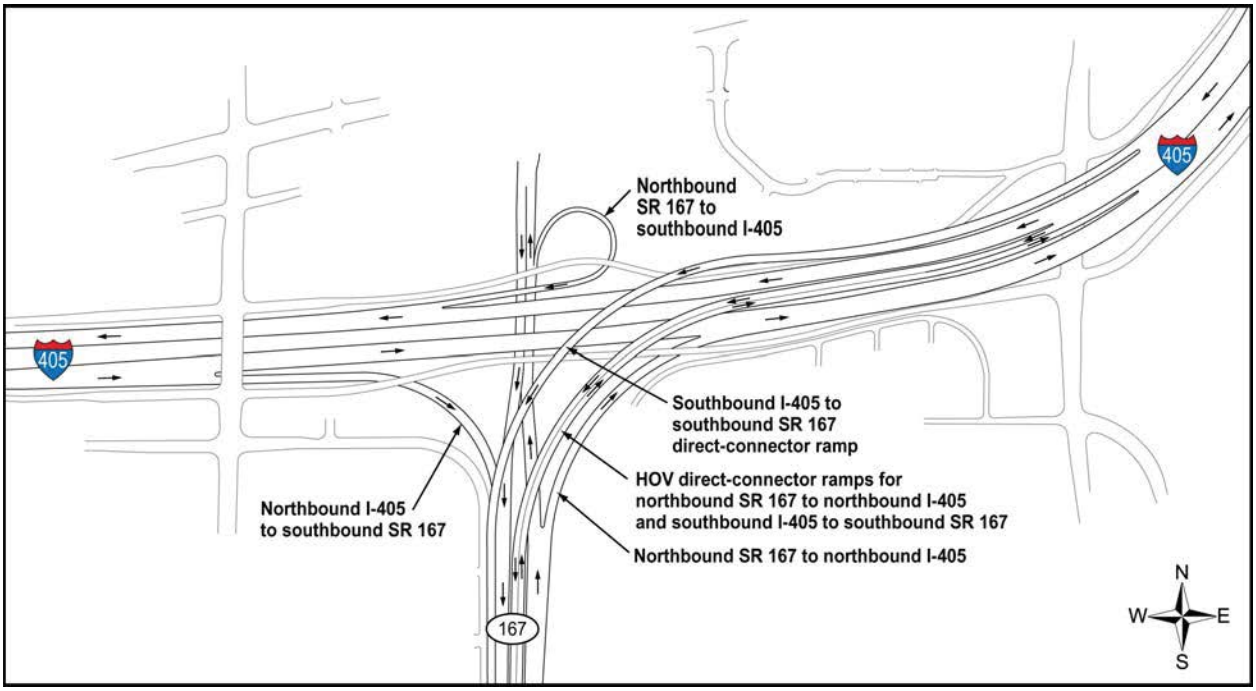


Exhibit 2-9: Rendering of I-405/SR 167 Interchange Improvements

Local Access

WSDOT will improve local access at the SR 167 interchange. The improvements will:

- Construct a split-diamond interchange at Lind Avenue and Talbot Road (SR 515). See Exhibits 2-10 and 2-11.
- Construct southbound and northbound frontage roads connecting Lind Avenue and Talbot Road. The southbound frontage road will reuse the existing I-405 to SR 167 southbound bridge.
- Reconstruct the Lind Avenue bridge over I-405.
- Reconstruct the I-405 structures over Talbot Road.
- Improve local street intersections.
- Provide new connection to Grady Way from S Renton Village Place.

Exhibit 2-10: Split-diamond Interchange at Lind Avenue and Talbot Road

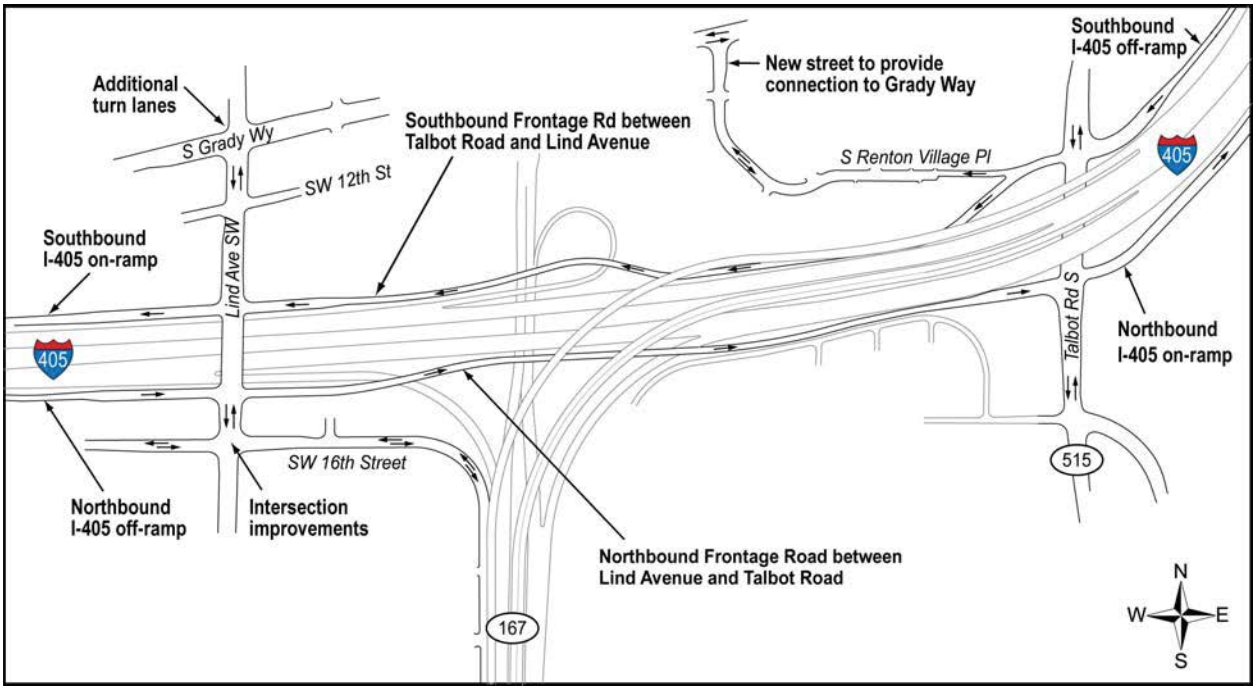
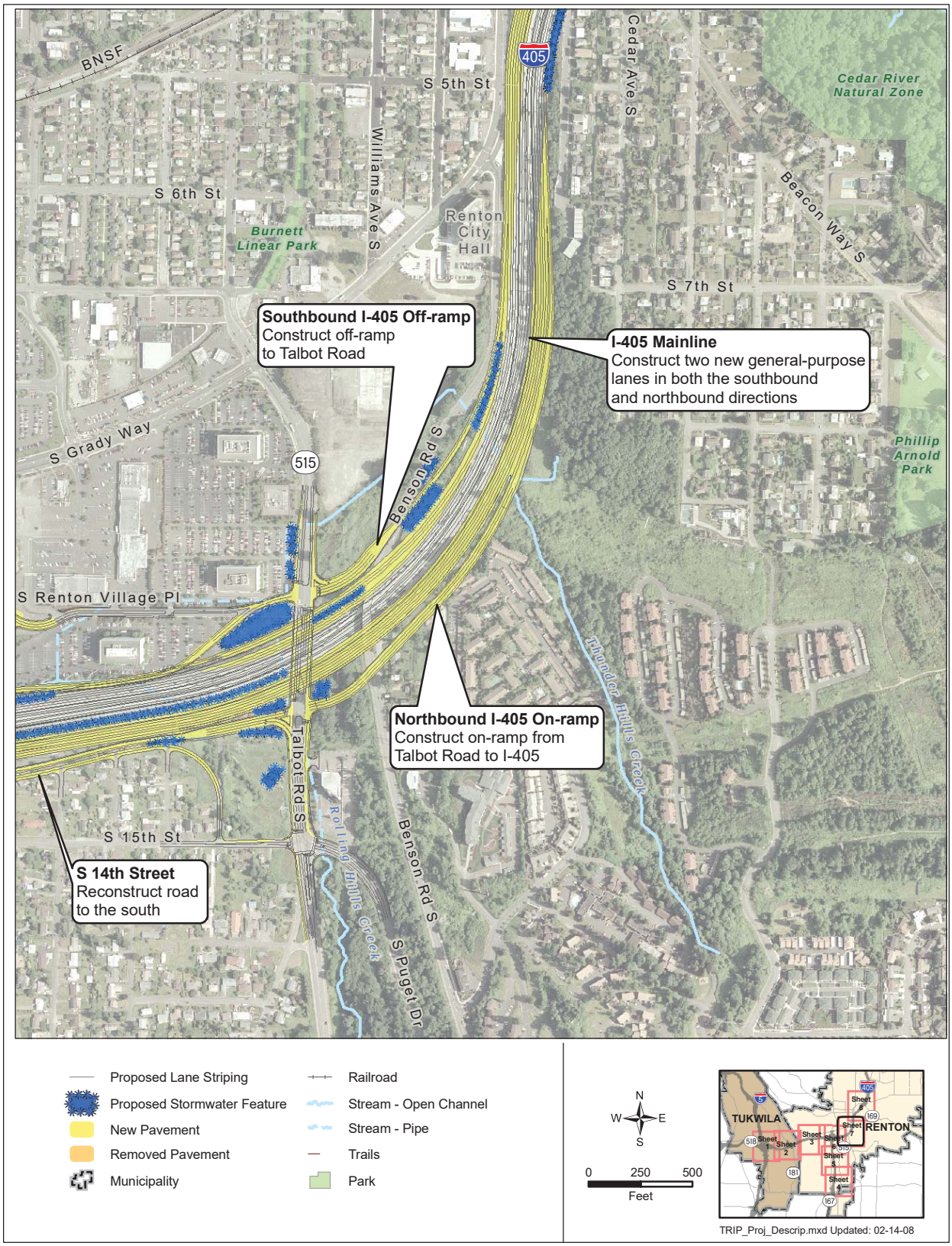


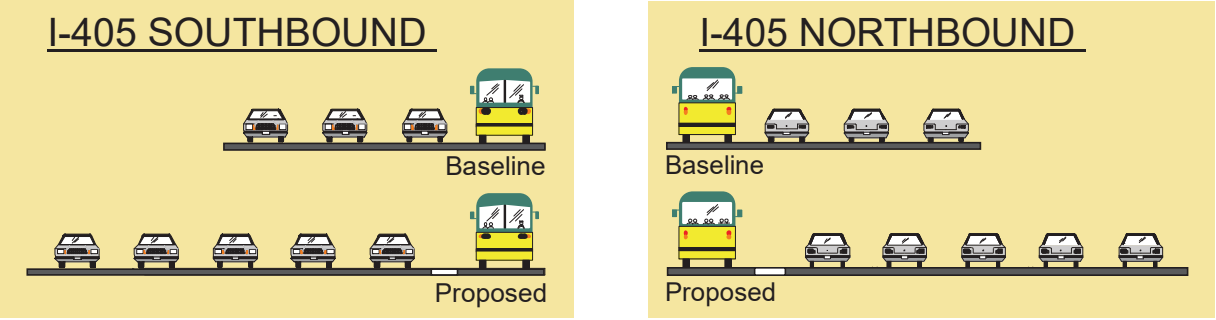
Exhibit 2-11: Project Features, Sheet 7



I-405 from East of SR 167 Interchange to North of S 5th Street

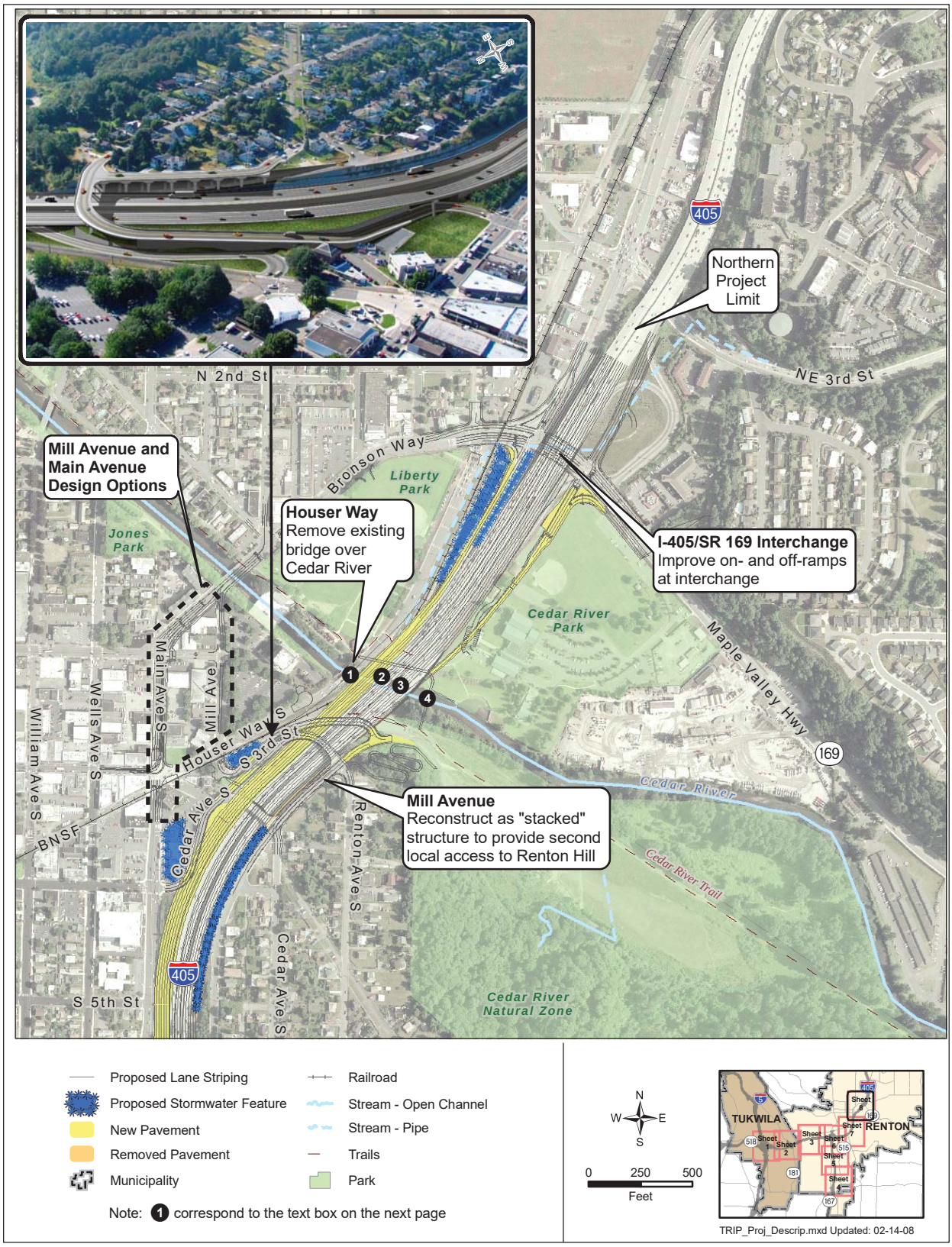
For the section of I-405 that extends from the SR 167 interchange past Renton City Hall as shown on Exhibit 2-11, WSDOT will:

- Construct two additional lanes in both directions on I-405 from SR 167 through SR 169.
- Stripe lanes to provide a buffer between HOV and general-purpose lanes along I-405.
- Construct a new half-diamond interchange at Talbot Road as shown on Exhibit 2-10.
- Reconstruct S 14th Street south of its existing location.



Project improvements will add capacity to I-405 for both southbound and northbound traffic and will provide a buffer between the HOV lane and the general-purpose lanes

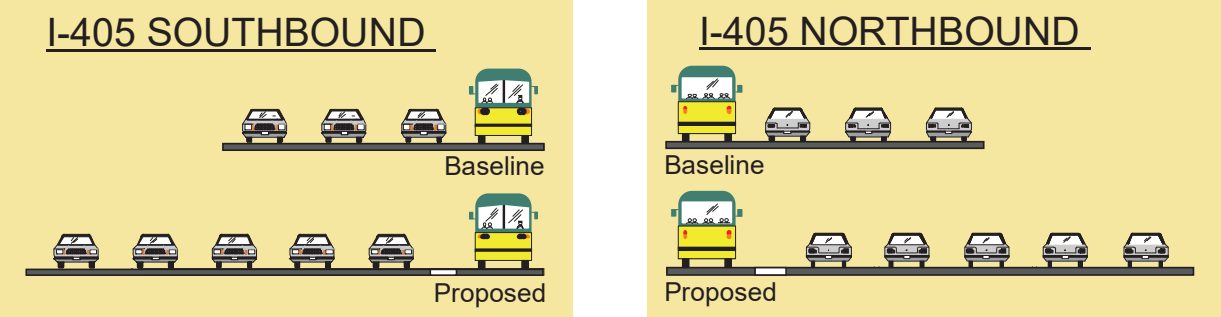
Exhibit 2-12: Project Features, Sheet 8



I-405 from S 5th Street to SR 169

This last portion of the Tukwila to Renton Project crosses the Cedar River to the SR 169 interchange. In this section, WSDOT will:

- Construct two additional lanes in both directions on I-405 from SR 167 through SR 169.
- Stripe lanes to provide a buffer between HOV and general-purpose lanes along I-405.



Project improvements will add capacity to I-405 for both southbound and northbound traffic and will provide a buffer between the HOV lane and the general-purpose lanes

- Cantilever the I-405 structures over Main Avenue.
- Reconstruct three bridges over the Cedar River: southbound I-405, northbound I-405, and a pedestrian bridge.
- Relocate the Burlington Northern Santa Fe railroad bridge.
- Close Houser Way south of the Cedar River north to Bronson Way and remove the bridge over the Cedar River.
- Reroute northbound traffic to Bronson Way, which will be striped to accommodate the new traffic pattern.
- Reconstruct two local street accesses to Renton Hill.

What bridge construction will occur over the Cedar River?

❶ Burlington Northern Santa Fe Railroad Bridge

❷ Southbound I-405 Bridge

❸ Northbound I-405 Bridge

❹ Pedestrian Bridge

See Exhibit 2-12 for the bridge locations.

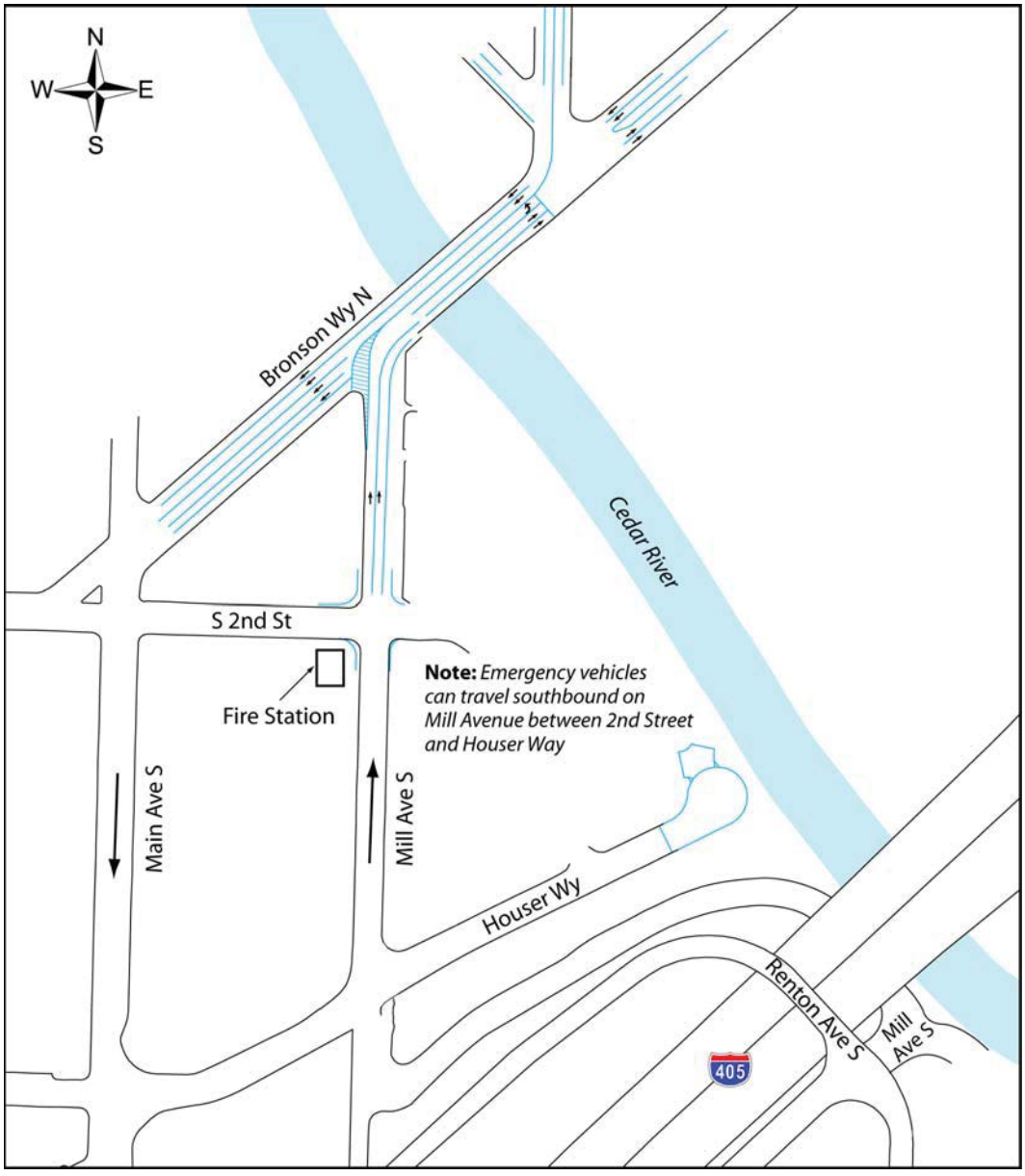
To accommodate the I-405 improvements, the Tukwila to Renton Project also required rerouting traffic from Houser Way and changing access to Renton Hill. These improvements are discussed on the following pages.

Mill Avenue and Main Avenue Design Options

To accommodate widening I-405 over the Cedar River, the Houser Way bridge will be closed. WSDOT worked closely with the City of Renton to develop the most acceptable and feasible solution for redirecting traffic coming from south of Houser Way. For northbound traffic within Renton south of the Cedar River, two design options are being considered:

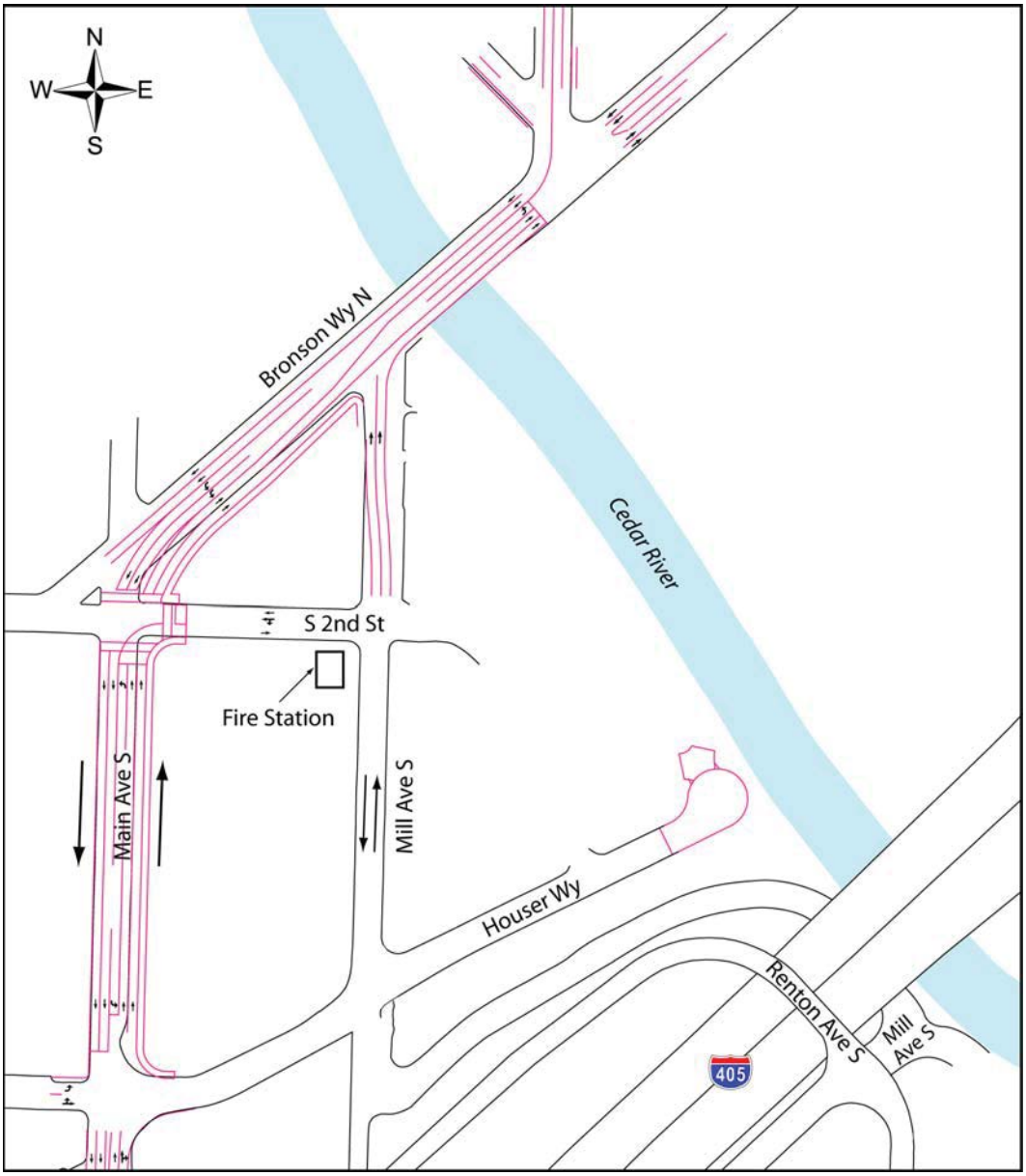
- The first option stripes Mill Avenue as a one-way street to provide two lanes northbound from the intersection of Houser Way and Mill Avenue to Bronson Way (see Exhibit 2-13).

Exhibit 2-13: Mill Avenue Design Option for Local Access to Bronson Way



- The second option leaves Mill Avenue as a two-way street up to the intersection with 2nd Street where it will be striped for one-way traffic northbound and reconfigures Main Avenue, a one-way street southbound, to provide two-way traffic. Main Avenue would be widened and striped for two-way traffic to provide access from the south to Bronson Way (see Exhibit 2-14).

Exhibit 2-14: Main Avenue Design Option for Local Access to Bronson Way

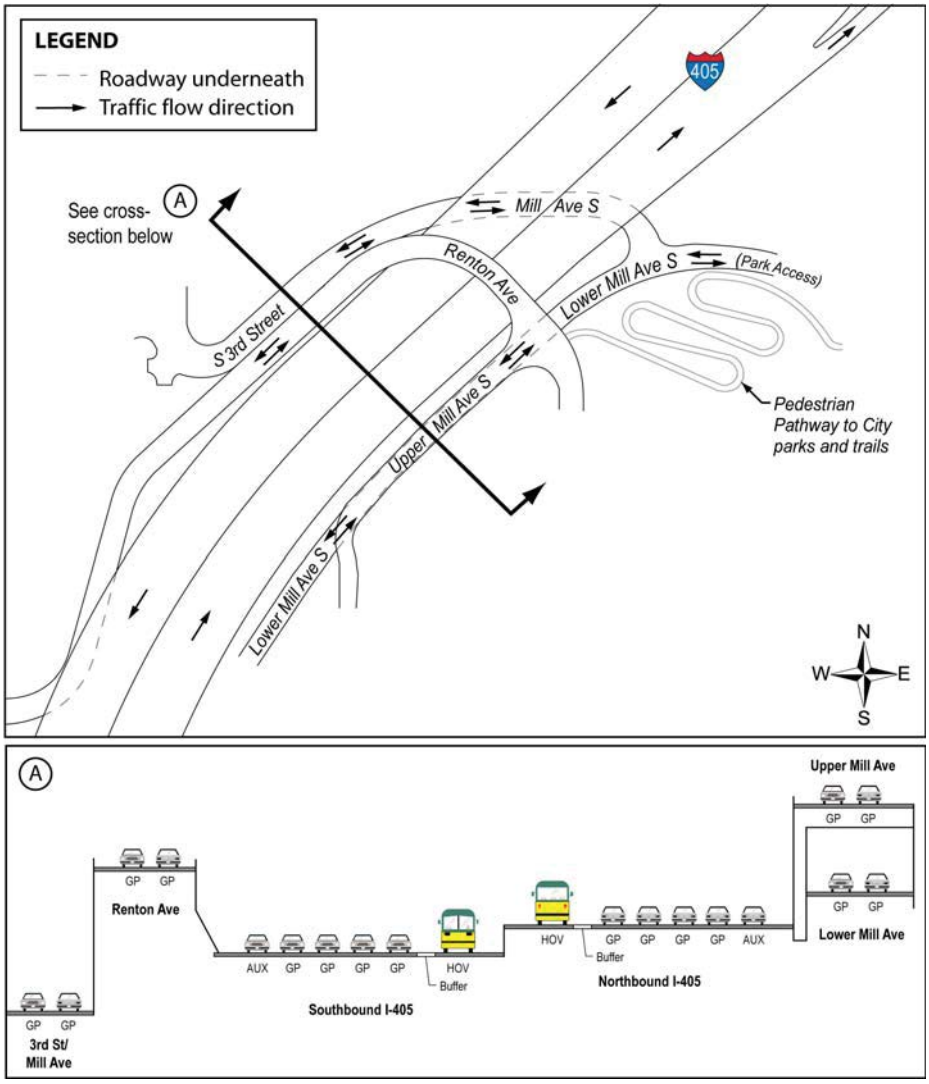


Changes to Renton Hill Access

As shown in the inset on Exhibit 2-12, the Renton Hill Access will be changed to accommodate the widening of I-405. These changes are detailed in Exhibit 2-15 below. WSDOT will:

- Reconstruct the Renton Avenue bridge over I-405 and realign the north end to intersect with Main Avenue rather than Houser Way as it currently does.
- Reconstruct Mill Avenue as a stacked structure that also provides access to Renton Hill as shown in Exhibit 2-15.
- Remove the existing Cedar Avenue bridge.
- Construct a pedestrian pathway connecting residents on Renton Hill to the City's parks and trails.

Exhibit 2-15: New Local Access for Renton Hill



What are the construction methods and schedule for implementation?

Construction Methods

The Tukwila to Renton Project will use different methods to construct the various project elements. The main approaches to construction for this project are described below.

At-grade Construction

At-grade construction, which occurs on the same elevation as the existing lanes, will be staged to minimize traffic delays and detours. One method would shift lanes toward the median. WSDOT then would place a concrete barrier to provide a work zone outside of the roadway. A second method would build the entire new section, then shift traffic to the new portion and reconstruct the existing section. Staging allows construction to occur safely without closing lanes for the duration of construction.

Bridge Construction

Bridge construction will generally occur in multiple stages to minimize traffic delays and detours. The following describes a typical staging approach for bridge construction on I-405 that will be used where practicable. As the first step, traffic is shifted toward the I-405 median, and the existing lanes and shoulders are narrowed slightly. This approach allows widening of the existing structure or construction of the new bridge, depending on the design, to occur on the outside of the roadway. Next, traffic is shifted onto the new bridge area. If the bridge is being replaced rather than simply widened, the old structure is demolished after traffic is shifted to the new bridge.

Road Closures

Some road closures will be necessary to construct various improvements. WSDOT will notify local agencies, public services, utilities, and the general public prior to any temporary road closures and will clearly mark detour routes. As much as possible, closures will be scheduled during times that will have the least impact on the traveling public.

Traffic Control

WSDOT will work with local agencies to develop detours as needed during construction. Prior to starting construction, WSDOT will develop a traffic control plan. The plan's primary objectives will be to provide a safe facility, to streamline the construction schedule, and to minimize reductions to existing traffic capacity. To lessen effects on traffic, the duration of activities will be minimized and reductions in capacity will be limited and will be targeted to a period when they will have the least effect.

Schedule

Because the I-405 Corridor Program master plan configuration is very expensive, WSDOT will implement the improvements in phases as funding becomes available. The Tukwila to Renton Project represents Phase 2 for this section of I-405. This discipline report assumes a baseline condition where the Phase 1 improvements, Renton Nickel Improvement Project, have been completed prior to the start of Phase 2.

Construction of the entire Tukwila to Renton Project is expected to be spread over several years as funding becomes available. For this reason, construction activity will not be constant throughout the entire study area and the duration will vary depending on the improvement being constructed.

The first element of the Tukwila to Renton Project that is proposed for construction is the SR 515 Interchange Project. This portion is funded through the 2005 Transportation Partnership Account (TPA). This Tukwila to Renton project element will construct a half-diamond interchange on I-405 at Talbot Road (SR 515). Construction of this element is scheduled to begin in autumn of 2008. The remaining elements of the Tukwila to Renton Project are unfunded at this time.

To complete the master plan for I-405 from I-5 to SR 169, additional work will need to be accomplished in this area.

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

The Tukwila to Renton Project is part of a comprehensive program to address the congestion problems in the I-405 corridor. WSDOT worked with the Federal Highway

Administration (FHWA), Federal Transit Administration, Central Puget Sound Regional Transit Authority, King County, and local governments to develop strategies to reduce traffic congestion and improve mobility along the I-405 corridor. The I-405 Corridor Program Environmental Impact Statement (EIS) and Record of Decision (ROD), published in 2002, document these strategies. The selected alternative has become known as the master plan.

WSDOT is constructing the master plan as funding becomes available. For the southern end of I-405 extending from I-5 to SR 169, the Renton Nickel Improvement Project was Phase 1. This phase was largely funded by the statewide transportation-funding plan called the "nickel package," which was approved by the Washington State Legislature in 2003. In 2005, the legislature passed a second funding package, TPA. It also provided funding for the Renton Nickel Improvement Project. Construction of the Renton Nickel Improvement Project began in 2007 and will be completed by 2011.

The other I-405 projects that relate to the Tukwila to Renton Project address the sections north of SR 169 to the end of I-405 at I-5 in Lynnwood. Of these projects, the first stage for the Kirkland area of I-405 is currently under construction. The first stage for Bellevue, SE 112th Street to SE 8th Street, began construction in 2007. As each successive project becomes operational, the public will benefit from the improved traffic movement, safety, and capacity along the I-405 corridor.

Another related project is the HOT Lanes Pilot Project on SR 167. This project will convert the existing HOV lanes to High-Occupancy Toll (HOT) lanes between Auburn and Renton. HOT lanes will better manage the SR 167 corridor traffic demand through tolling. The Tukwila to Renton Project will tie into the HOT lanes project.

In addition, some local agencies are working on projects that will tie into the work on I-405. For example, the City of Renton is proposing to reconstruct Rainier Avenue S, in particular, improving local access and circulation to the interchange with I-405 and SR 167.

As well as the road projects discussed above, WSDOT and the City of Renton are constructing the Springbrook Creek Wetland and Habitat Mitigation Bank. This project will create

a large wetland complex that will provide mitigation credits to multiple projects including the Tukwila to Renton Project.

What is the No Build Alternative?

The No Build Alternative assumes that the improvements associated with the Renton Nickel Improvement Project are constructed as does the baseline condition. Only routine activities such as road maintenance, repair, and safety improvements would be expected to take place between 2014 and 2030. This alternative does not include improvements that would increase roadway capacity or reduce congestion beyond baseline conditions. For these reasons, it does not satisfy the project's purpose to reduce congestion on I-405 between I-5 in Tukwila and SR 169 in Renton.

The No Build Alternative has been evaluated in this discipline report as a comparison for the effects associated with the Build Alternative.

SECTION 3 STUDY APPROACH

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

What are sound and noise?

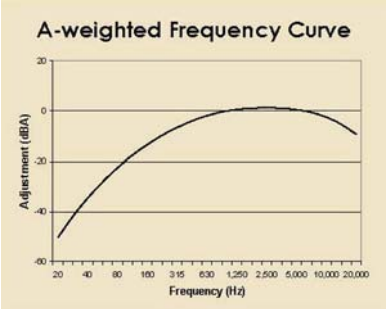
Sound is created when objects vibrate, resulting in a minute variation in surrounding atmospheric pressure called *sound pressure*. The human response to sound depends on the magnitude of a sound as a function of its frequency and time pattern.[1] *Magnitude* is a measure of sound energy in the air. Noise is unwanted sound.

What is the logarithm scale?

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 between sound levels similarly. The human ear can barely perceive a

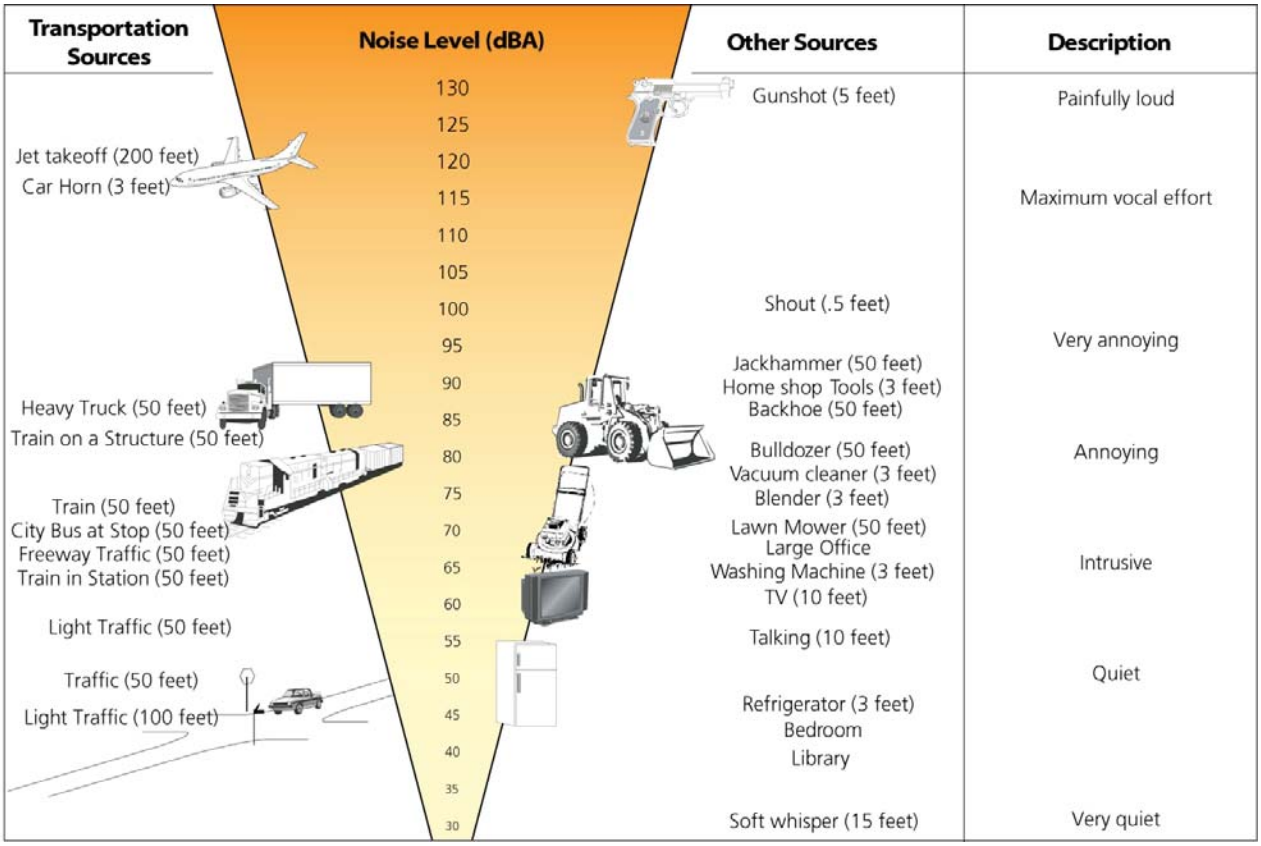
[1] *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety.* Report Number 550/9-74-004. EPA, 1974.

3-dBA increase, but a 5- or 6-dBA increase is readily noticeable and appears as if the sound is about one and one-half 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 3-1 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 human ear's great range. A typical conversation ranges from 60 to 70 dBA.

Exhibit 3-1: Typical Noise Levels



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. A ten-fold increase in the number of sound sources adds 10 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).

Noise levels from traffic sources depend on volume, speed, and vehicle type. An increase in volume, speed, or vehicle size generally increases traffic noise levels. Vehicular noise is a combination of noises from engines, exhaust, and tires. Defective mufflers, steep grades, and roadway surface materials and conditions also affect the generation of traffic noise.

Traffic Noise generated by various types of vehicles at various speeds

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 point sources 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, as shown in Exhibit 3-2. Depressed terrain dominates the study area.

What is a receiver?

A *receiver* is the location at which noise is measured (e.g., a residence, school, park, or church).

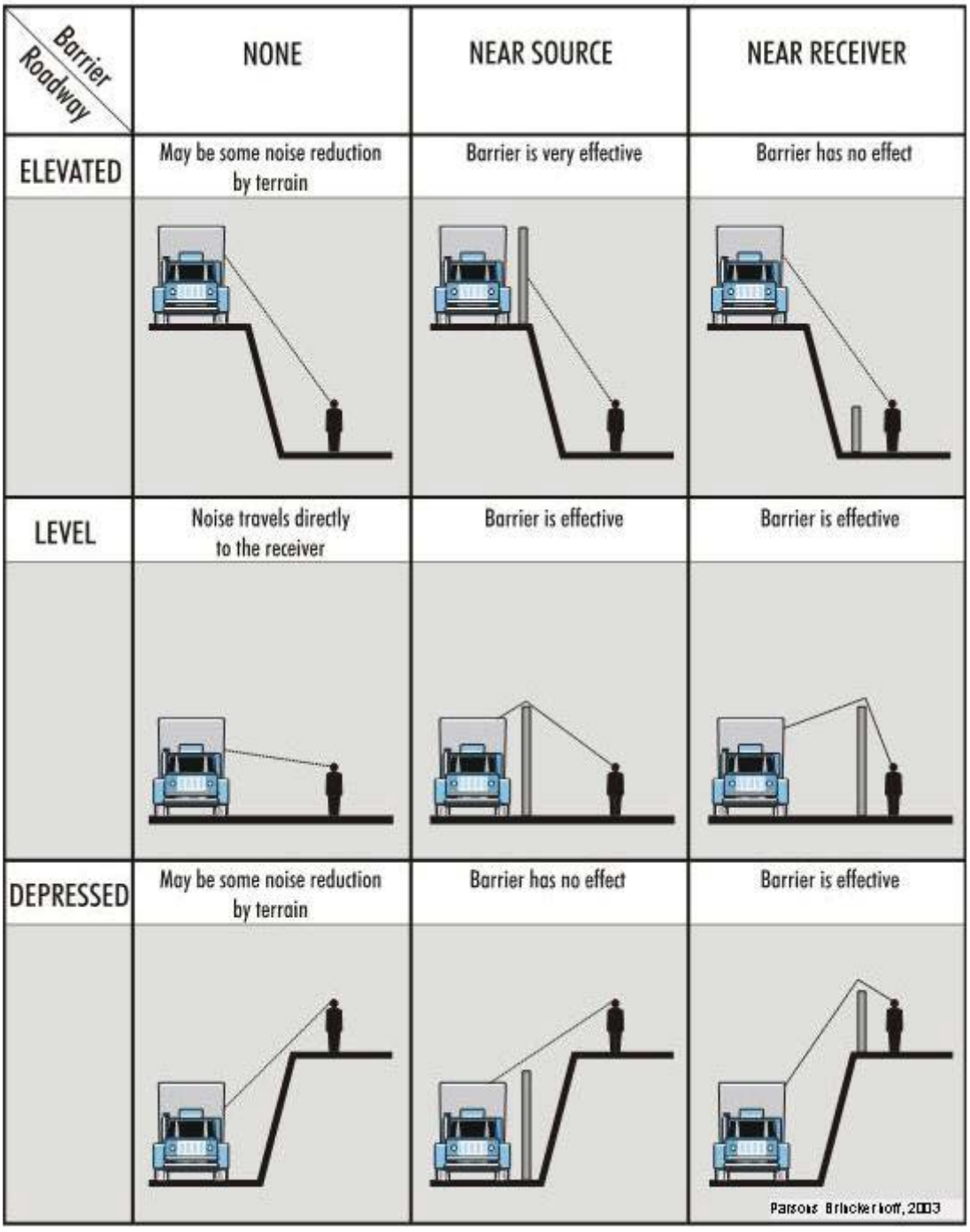
Level ground is the simplest scenario: sound travels in a straight line-of-sight path between the source and receiver. As shown in the bottom row of Exhibit 3-2, if the sound source is depressed or the receiver is elevated, sound will generally travel directly to the receiver. However, sound levels may be reduced if the terrain crests between the source and receiver and creates a partial sound wall near the receiver.

What is terrain?

Terrain is a term used to describe land features.

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 safety barrier can effectively block sound transmission between the source and receiver (see the top row of Exhibit 3-2). If the line of sight between the receiver and the highest elevation of the sound source is broken, a noise reduction of approximately 5 dBA results.

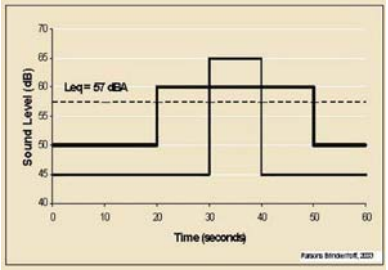
Exhibit 3-2: Noise Barrier Effectiveness



How are sound levels described?

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

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



What are the effects of loud noises?

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 L_{eq}(24). This protective sound level is set to conserve hearing for 40 years of exposure.[2]

What does L_{eq} (24) refer to?

L_{eq} (24) is the equivalent sound level measured over a period of 24 hours.

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 Federal Highway Administration (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 project coordination was performed?

The I-405 Team coordinated with federal, state, and local agencies and community members. Scoping meetings were held specifically for the Tukwila to Renton Project and general neighborhood meetings were held for the I-405 corridor program. This included consulting with FHWA, the City of Tukwila, and the City of Renton, and participation in community meetings with local residents. Residents received project information and provided input on the project and potential noise monitoring locations.

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[2] *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. EPA 1974.

What criteria are used to evaluate the project's potential effects on the acoustical environment?

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 L_{eq}(h) noise levels approach, meet, or exceed the FHWA NAC or substantially exceed existing noise levels.[3] Although the FHWA does not define "substantially exceed", WSDOT considers an increase of 10 to 14 dBA to be a Tier 1 substantial increase and an increase of 15 to 29 dBA to be a Tier 2 substantial increase.[4]

The FHWA NAC specify exterior and interior L_{eq}(h) noise levels for various land activity categories, as shown in Exhibit 3-3. All exterior noise-sensitive uses within the study area are Category B uses. WSDOT considers a noise impact to occur if predicted L_{eq}(h) noise levels approach within 1 dBA of the NAC listed in Exhibit 3-3. Therefore, if a noise level is 66 dBA or higher it approaches the FHWA NAC of 67 dBA for residences.

WSDOT defines severe traffic noise impacts as 80 dBA or more for Category B areas, or 30 dBA or more over existing traffic noise levels. Substantial noise levels are classified as Tier 1 (10 to 14 dBA over existing traffic noise levels) and Tier 2 (15 to 29 dBA over existing traffic noise levels), or as total highway noise levels between 76 and 79 dBA.

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[3] *Procedures for Abatement of Highway Traffic Noise and Construction Noise. Federal-Aid Highway Program Manual.* Volume 7, Chapter 7, Section 3. Washington, D.C. U.S. Department of Transportation, 1982, Noise Abatement Council.

[4] *Traffic Noise Analysis and Abatement Policy and Procedures.* Olympia, Washington. WSDOT, 2006.

Exhibit 3-3: FHWA Noise Abatement Criteria

Activity Category	L_{eq}(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.
D	–	Undeveloped lands.

Source: USDOT, 1982.

The Washington State Department of Ecology (Ecology) regulates noise levels at property lines of neighboring properties (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 both the source noise and receiving property, as shown in Exhibit 3-4. King County, the City of Renton, and the City of Tukwila have adopted the State of Washington's property line standards with King County Code 12.88.020; Renton Municipal Code, Title 8, Chapter 7, Section 8-7-2; and Tukwila Municipal Code, Chapter 8.22.

Exhibit 3-4: Maximum Permissible Environmental Noise Levels

EDNA[1] of Noise Source	EDNA of Receiving Property		
	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 1-hour period, as shown in Exhibit 3-5.

Exhibit 3-5: Allowed Exceedences of the Maximum Permissible Noise

Duration of Exceedence	Allowed Exceedence	Statistical Descriptor	Equivalent L_{eq}(h) Increase
15 minutes	5 dBA	L_{25}	2 dBA
5 minutes	10 dBA	L_{8}	2 dBA
1.5 minutes	15 dBA	$L_{2.5}$	2 dBA

Source: WAC 173-60-040.

Considering the allowed short-term exceedences in Exhibit 3-5, the permissible hourly L_{eq} is approximately 2 dBA higher than the values in Exhibit 3-4. For example, a noise level of 57 dBA for 45 minutes and 62 dBA for 15 minutes (57 dBA + a 5-dBA exceedence) is permissible for noise from a commercial activity received by a residential property. This sound pattern has a L_{eq} (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. weekdays and 10 p.m. to 8 a.m. weekends). Performance of construction activities during nighttime hours will require noise variances from the City of Renton and the City of Tukwila.

How was the noise study performed?

Ambient noise levels were measured for 15-minute periods at 15 locations near the study area. These measurements help 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 describes the results of these measurements.

Measurement locations characterize the variety of noise conditions and represent other sensitive receptors near the proposed project. Baseline (year 2014) and future noise levels for the No Build (year 2030) and Build (design year 2030) alternatives were modeled at all of the 15-minute noise measurement locations. These noise levels were also modeled at 46 additional locations that may potentially be affected by the project. 2005 was evaluated as the existing year to be consistent with this project's transportation analysis. 2014 was evaluated as the baseline year to correspond with a completed Renton Nickel Improvement Project.

Traffic Noise Prediction

The FHWA Traffic Noise Model (TNM) Version 2.5 computer model[5] was used to predict $L_{eq}(h)$ traffic noise levels. TNM provides precise estimates of noise levels at discrete points, by considering interactions between different noise sources and topographical features. This model estimates acoustic intensity at receiver locations, calculated from a series of straight-line roadway sections. Noise emissions from each roadway are calculated 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.

Why don't the highest noise levels occur during rush hour?

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, vehicle speeds decrease and traffic volumes increase, resulting in lower traffic noise levels.

Noise from sources other than traffic is not included. When non-traffic noise such as aircraft noise is considerable in an area, TNM under-predicts the actual noise level. Because the project effects only depend on traffic noise levels, under-predicting the total environmental noise level does not affect the study's findings.

The I-405 Team's noise specialists imported base maps and design files into the TNM package. Major roadways, topographical features, buildings, and sensitive receptors were digitized into the model. Elevations for the area surrounding the project 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.

[5] FHWA, 2005.

Analysis of Project Effects

Predicted noise levels were based on the loudest traffic hour of the day (when volumes are high but not congested) to estimate worst-case noise levels.

Traffic analysis for the year 2005 shows that existing traffic volumes on this portion of I-405 are at capacity for part of the day. I-405 traffic volumes in 2030 are expected to increase over existing volumes and will be at or near the roadway's capacity for the Build and No Build alternatives.

For use in TNM, the No Build Alternative assumed the same traffic volume on I-405 as the Baseline Conditions model during the loudest hour. The Build Alternative added 1,750 vehicles to baseline conditions loudest-hour traffic volumes on I-405 in areas where an extra lane will be built. For 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 Build Alternative noise model included all project elements including: bridge replacements and additions; improvements to the SR 181, SR 167, and SR 169 interchanges; construction of a split diamond interchange at Lind Avenue and Talbot Road; general-purpose direct access between southbound I-405 and southbound SR 167; HOV direct access between SR 167 and I-405; and the replacement of Cedar and Renton Avenues on Renton Hill.

The traffic volumes and vehicle mix were based on the *Tukwila to Renton Project Transportation Discipline Report*.[6] The modeled sites represented similar receptors in the area, although noise levels at adjacent receptors may be different because of terrain or distance.

What is WSDOT's Noise Abatement Criteria (NAC) level?

Noise levels approach, meet, or exceed the noise abatement criteria (NAC) at 66 dBA. Noise mitigation must be evaluated when noise levels reach 66 dBA.

Noise Mitigation Analysis

The I-405 Team's noise specialists 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, noise specialists evaluated whether mitigation measures could reduce traffic noise substantially enough to warrant the cost of barrier construction. This evaluation was based on WSDOT

[6] *I-405, Tukwila to Renton Project Transportation Discipline Report,* WSDOT, 2007.

feasibility and reasonableness criteria (a detailed discussion of WSDOT feasibility and reasonableness criteria is provided in the *Measures to Avoid or Minimize Effects* section of this report). Noise barriers were evaluated using TNM in all areas where noise effects predicted to result from this project could be mitigated by a noise barrier.

The I-405 Team's noise specialists evaluated the effectiveness of noise barriers at the outermost boundary of the right-of-way.

How was construction noise analyzed?

Construction noise was assessed using EPA reference levels. The analysis was based on noise levels from construction equipment typically used on this type of project. Noise levels were assessed at various distances from the construction site. Potential measures to reduce disturbance caused by construction noise were evaluated and are described in the *Measures to Avoid or Minimize Effects* section of this report.

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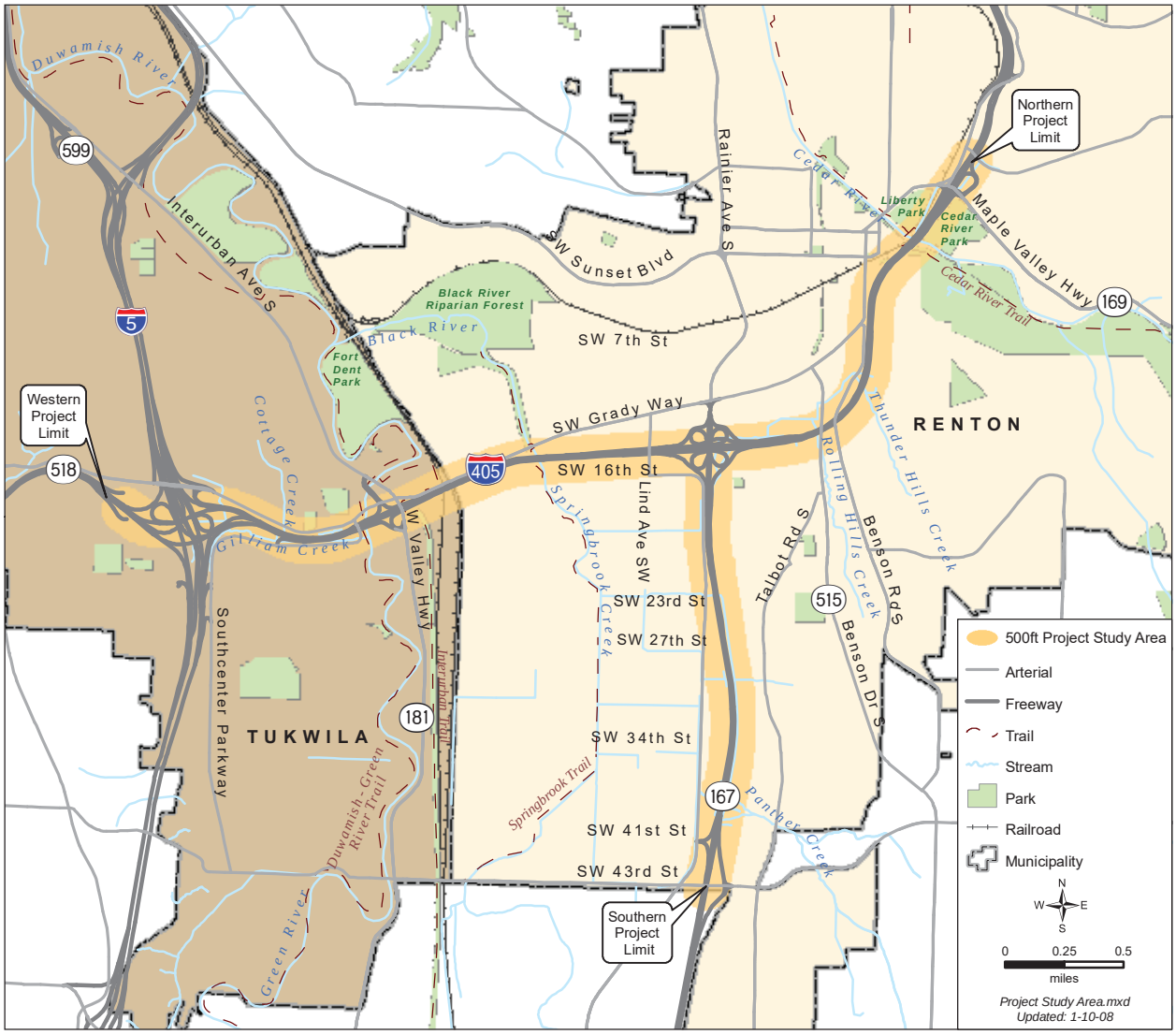
SECTION 4 BASELINE CONDITIONS

What is the study area for the noise analysis?

The Tukwila to Renton Project extends from the vicinity of the I-405/I-5 interchange north to the I-405/SR 169 interchange; south from the I-405/SR 167 interchange to the SW 43rd Street; and north and south of I-405 along SR 181, Lind Avenue SW, Talbot Road S (SR 515), Bronson Way, SR 169/Maple Valley Road, and east-west improvements along Tukwila Parkway and Southcenter Boulevard. The study area for the noise analysis extends approximately 500 feet from the project limits (see Exhibit 4-1).

Exhibit 4-1: Noise Study Area



For a detailed description of land use in the study area please refer to the Land Use Discipline Report.

The Renton Hill neighborhood primarily consists of single-family residences with limited multi-family units, and is located well above the elevation of I-405. The hillside and I-405 retaining walls shield a portion of the I-405 noise.

Most residents in the Talbot Hill neighborhood are located above the elevation of the I-405/SR 167 interchange. However, some residents are located at or below the I-405 elevation. Single-family residences are the primary land use throughout this neighborhood. The closest residences are located approximately 100 feet from I-405, between SR 167 and Talbot Road.

Several multi-family residential buildings are also located above I-405 north and east of the I-405/I-5 interchange. Residences west of Main Avenue S are below the elevation of I-405.

Park and recreation land located within the study area include Liberty Park, Veteran's Park, Cedar River Park and Trail, Freeway Park, Ikawa Park, Tukwila Park, Springbrook Trail, Interurban Trail, and Duwamish-Green River Trail. Additional information on these resources can be found in the *Social, Public Services, and Utilities Technical Memorandum*[7] and *Section 4(f) Evaluation Discipline Report*[8] for this project.

One noise barrier is located in the study area as a result of the Renton Nickel Improvement Project. This noise barrier is located along the southern I-405 right-of-way, placed north of S 14th Street from Talbot Road S to the S 14th Street/S 15th Street intersection. Retaining walls, limited jersey barriers, and topography shield some other residential areas from I-405 traffic noise

[7] *I-405, Tukwila to Renton Project Social, Public Services, and Utilities Technical Memorandum, WSDOT, 2007.*

[8] *I-405, Tukwila to Renton Project Section 4(f) Evaluation Discipline Report, WSDOT, 2007.*

Where are the modeled noise receptor locations?

Baseline noise levels were modeled at 64 locations that represent 339 residences, 2 hotels, 8 parks, 3 trails, 1 aquatic center, and 1 library. Traffic noise is the dominant noise source in the study area, with periodic air and rail noise.

The modeled noise levels of all 64 sensitive receptors are shown on even-numbered Exhibits 4-2 through 4-14 on the following pages. Odd-numbered Exhibits 4-3 through 4-15 show the locations of all 64 modeled sensitive receptors. Discussions and descriptions of noise measurements locations and procedures taken in the study area are included in Appendix A.

What are baseline conditions?

Baseline conditions describe what will exist in the future after a project that has already been approved and funded is completed. The baseline condition is a snapshot of expected conditions. It provides an important point of comparison for understanding the effects of the proposed Build Alternative.

For the Tukwila to Renton Project, the baseline condition assumes that the Renton Nickel Improvement Project has been completed.

Exhibit 4-2: Modeled Noise Levels at Receptors, as shown on Sheet 1 of 7

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
1	Ikawa Park	1	**70**	**70**	**71**
2	Tukwila Park	3	**66**	**66**	**67**
3	Duwamish-Green River Trail	1	**72**	**72**	**73**
4	Family Fun Center	10	**71**	**71**	**69**
5	Interurban Trail	3	**74**	**74**	**68**

Values in **BOLD** approach, meet, or exceed the NAC

Exhibit 4-3: Modeled Noise Receptor Locations, Sheet 1 of 7

Exhibit 4-4: Modeled Noise Levels at Receptors, as shown on Sheet 2 of 7

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
6	Springbrook Trail	1*	**74**	**74**	**70**

Values in **BOLD** approach, meet, or exceed the NAC
* Exhibit B-3 in Appendix B describes the residential equivalency of users at Receptor 6, Springbrook Trail

Exhibit 4-5: Modeled Noise Receptor Locations, Sheet 2 of 7

Exhibit 4-6: Modeled Noise Levels at Receptors, as shown on Sheet 3 of 7

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
7	Residence at SW 13th St.	3	**68**	**68**	**67**
8	Residence at 1503 Lake Ave. S	5	**67**	**67**	**69**
9	Residence at 1514 Lake Ave. S	3	64	64	**67**
10	Residence at Lake Ave. S	5	**67**	**67**	**68**
11	Residence at Lake Ave. S	4	63	63	65
12	Residence at Lake Ave. S	6	**66**	**66**	**67**
13	Residence at Lake Ave. S	6	64	64	65
14	Residence at Davis Ave. S	8	65	65	**67**
15	Residence at Davis Ave. S	6	59	59	61
22	Residence at 301 S 14th St.	8	62	62	N/A
23	Residence at S 15th St.	5	63	63	**72**
24	Residence at Shattuck Ave. S	6	63	63	**70**
25	Residence at Whitworth Ave. S	5	62	62	N/A
26	Residence at S 14th St.	3	63	63	N/A
27	Residence at Whitworth Ave. S	6	63	63	**68**
28	Residence at Morris Ave. S	8	64	64	**69**
29	Residence at Smithers Ave. S	7	65	65	**70**
30	Residence at 1306 Smithers Ave. S	2	63	63	N/A

Values in **BOLD** approach, meet, or exceed the NAC
N/A indicates that property is acquired by WSDOT for right-of-way

Exhibit 4-7: Modeled Noise Receptor Locations, Sheet 3 of 7

Exhibit 4-8: Modeled Noise Levels at Receptors, as shown on Sheet 4 of 7

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
13	Residence at Lake Ave. S	6	64	64	65
14	Residence at Davis Ave. S	8	65	65	**67**
15	Residence at Davis Ave. S	6	59	59	61
16	Residence at Talbot Crest Dr. S	14	63	63	65
17	Residence at Talbot Crest Dr. S	14	56	56	58
18	Residence at Talbot Rd. S	5	63	63	64
19	Residence at Talbot Rd. S	3	65	65	**66**

Values in **BOLD** approach, meet, or exceed the NAC

Exhibit 4-9: Modeled Noise Receptor Locations, Sheet 4 of 7

Exhibit 4-10: Modeled Noise Levels at Receptors, as shown on Sheet 5 of 7

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
18	Residence at Talbot Rd. S	5	63	63	64
19	Residence at Talbot Rd. S	3	65	65	**66**
20	Residence at 3521 Shattuck Ave. S	10	65	65	**66**
21	Residence at 402 S 36th St.	9	60	60	61

Values in **BOLD** approach, meet, or exceed the NAC

Exhibit 4-11: Modeled Noise Receptor Locations, Sheet 5 of 7

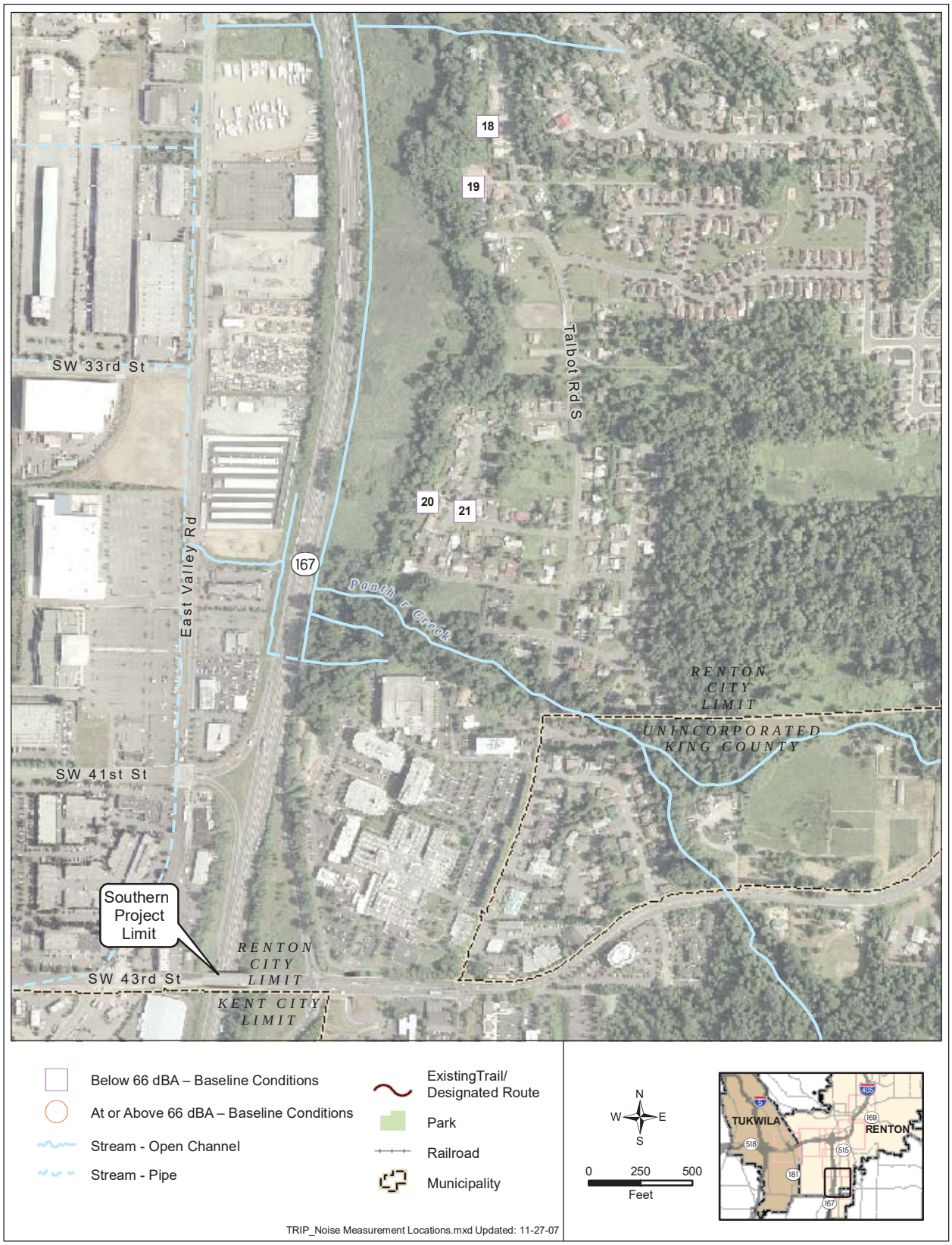


Exhibit 4-12: Modeled Noise Levels at Receptors, as shown on Sheet 6 of 7

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
24	Residence at Shattuck Ave. S	6	63	63	**74**
25	Residence at Whitworth Ave. S	5	62	62	N/A
26	Residence at S 14th St.	3	63	63	N/A
27	Residence at Whitworth Ave. S	6	63	63	**70**
28	Residence at Morris Ave. S	8	64	64	**73**
29	Residence at Smithers Ave. S	7	65	65	**73**
30	Residence at 1306 Smithers Ave. S	2	63	63	N/A
31	Residence at Benson Rd. S	5	65	65	N/A
32A	Residence at 1114 Benson Rd. S	2	**67**	**67**	**71**
32B	Residence at 1114 Benson Rd. S	3	65	65	**69**
33A	Berkshire Apartments Bldg. L (facing I-405)	4	62	62	**66**
33A(2)	Berkshire Apartments Bldg. L (facing I-405) – second story	4	**67**	**67**	**71**
33B	Berkshire Apartments Bldg. L (opposite I-405)	4	53	54	54
33B(2)	Berkshire Apartments Bldg. L (opposite I-405) - second story	4	53	54	54
33C	Berkshire Apartments Bldg K (opposite I-405)	3	54	54	55
33C(2)	Berkshire Apartments Bldg K – (opposite I-405) – second story	3	55	55	56
33D	Berkshire Apartments Bldg K (facing I-405)	3	63	63	65
33D(2)	Berkshire Apartments Bldg K – (facing I-405) - second story	3	**67**	**67**	**69**
33E	Berkshire Apartments Bldg N	3	54	54	55

Exhibit 4-12: Modeled Noise Levels at Receptors, as shown on Sheet 6 of 7 (continued)

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
33E(2)	Berkshire Apartments Bldg N – second story	3	55	55	57
33F	Berkshire Apartments Bldg J	3	61	62	64
33F(2)	Berkshire Apartments Bldg J – second story	3	**66**	**66**	**67**
33G	Berkshire Apartments Bldg I	4	63	63	**66**
33G(2)	Berkshire Apartments Bldg I – second story	4	**66**	**66**	**68**
34	Berkshire Apartments Bldg. Q	4	65	65	N/A
35A	Residence at Renton Ave. S	3	63	63	65
35B	Residence at Renton Ave. S	3	64	64	**66**
35C	Residence at Renton Ave. S	3	**67**	**67**	**71**
35D	Residence at Renton Ave. S	3	**66**	**66**	**70**
36	Residence at Cedar Ave. S	7	**67**	**67**	**71**
37A	Residence at 518 Cedar Ave. S	4	59	59	62
37B	Residence at 518 Cedar Ave. S	4	61	61	64
38A	Residence at 520 Mill Ave. S	3	**74**	**74**	**75**
38B	Residence at 520 Mill Ave. S	2	**72**	**72**	**73**
38C	Residence at 520 Mill Ave. S	2	**74**	**74**	**75**
38D	Residence at 520 Mill Ave. S	3	**73**	**73**	**74**
38E	Residence at 520 Mill Ave. S	3	**75**	**75**	**76**
38F	Residence at 520 Mill Ave. S	3	**76**	**76**	**77**

Exhibit 4-12: Modeled Noise Levels at Receptors, as shown on Sheet 6 of 7 (continued)

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
39A	Residence at Cedar Ave. S	2	65	65	**68**
39B	Residence at Cedar Ave. S	3	64	64	**67**
39C	Residence at Cedar Ave. S	5	62	62	65
40	Residence at 509 S Main St.	3	**73**	**73**	**74**
41	Residence at 522 Well Ave. S	7	64	64	65
42A	Residence at Mill Ave. S	1	**70**	**70**	**74**
42B	Residence at Mill Ave. S	4	**68**	**68**	**72**
42C	Second-Story Residence at Mill Ave. S	2	**71**	**71**	**75**
42D	Third-Story Residence at Mill Ave. S	2	**73**	**73**	**77**
42E	Residence at Mill Ave. S	2	**68**	**68**	**72**
42F	Second-Story Residence at Mill Ave. S	2	**71**	**71**	**75**
42G	Third-Story Residence at Mill Ave. S	2	**73**	**73**	**77**
42H	Fourth-Story Residence at Mill Ave. S	2	**74**	**74**	**78**
43A	Residence at 412 Mill Ave. S	3	**70**	**70**	**71**
43B	Second-Story Residence at 412 Mill Ave. S	2	**75**	**75**	**76**
43C	Third-Story Residence at 412 Mill Ave. S	2	**76**	**76**	**77**
43D	Residence at 412 Mill Ave. S	2	**70**	**70**	**71**
44A	Residence at Cedar Ave. S	3	62	62	**68**
44B	Residence at Cedar Ave. S	2	63	63	**69**
44C	Residence at Cedar Ave. S	2	61	61	**67**
45A	Residence at Cedar Ave S	3	59	59	65
45B	Residence at Cedar Ave. S	4	55	55	61

Values in **BOLD** approach, meet, or exceed the NAC
N/A indicates that property is acquired by WSDOT for right-of-way

Exhibit 4-13: Modeled Noise Receptor Locations, Sheet 6 of 7

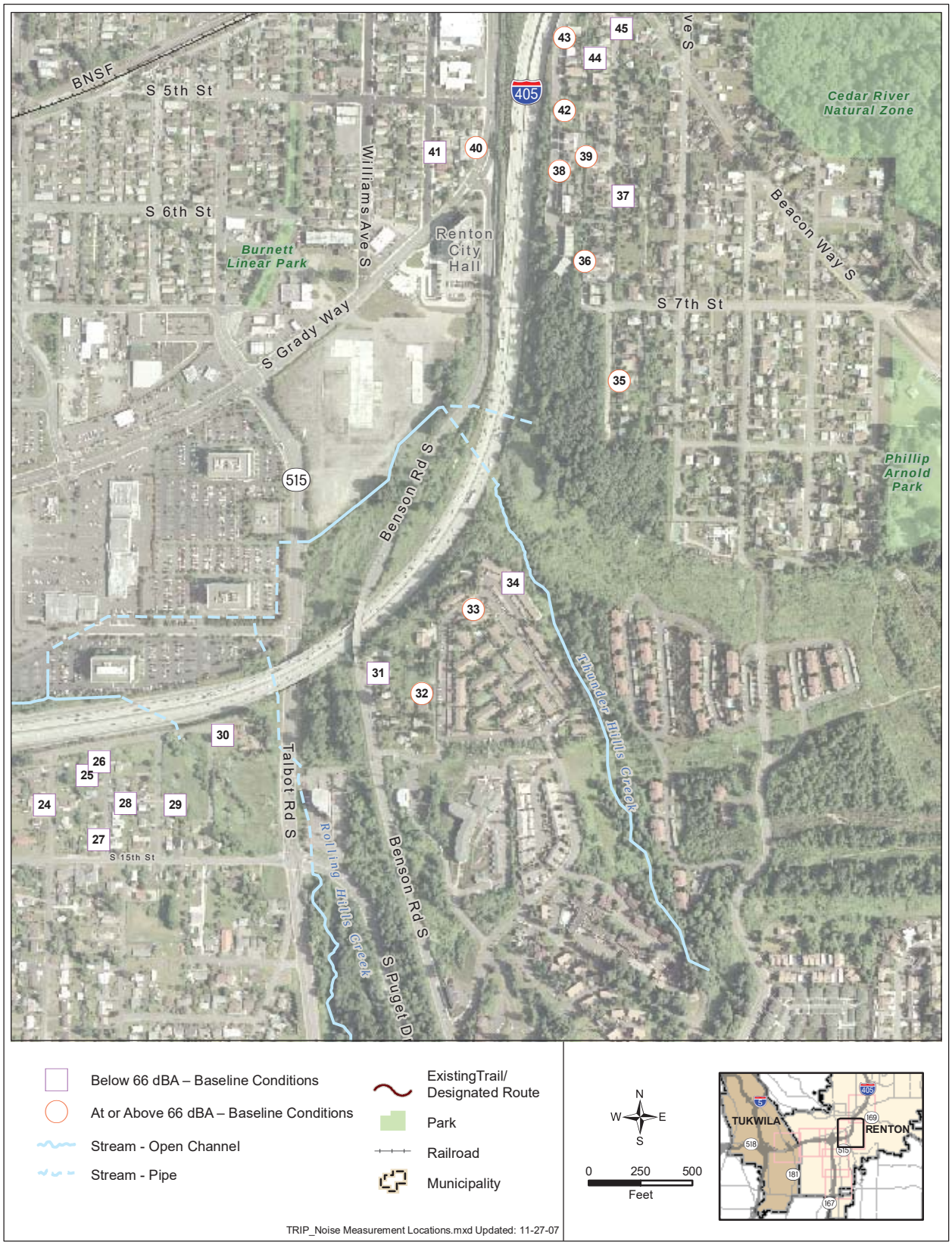


Exhibit 4-14: Modeled Noise Levels at Receptors, as shown on Sheet 7 of 7

Noise Receptor Number	Activity Description	Total Residences Represented	Modeled Baseline Noise Level (dBA)	Future Modeled Noise Levels (dBA) without Additional Abatement	
				2030 No Build	2030 Tukwila to Renton Project
42A	Residence at Mill Ave. S	1	**70**	**70**	**74**
42B	Residence at Mill Ave. S	4	**68**	**68**	**72**
42C	Second-story Residence at Mill Ave. S	2	**71**	**71**	**75**
42D	Third-story Residence at Mill Ave. S	2	**73**	**73**	**77**
42E	Residence at Mill Ave. S	2	**68**	**68**	**72**
42F	Second-story Residence at Mill Ave. S	2	**71**	**71**	**75**
42G	Third-Story Residence at Mill Ave. S	2	**73**	**73**	**77**
42H	Fourth-story Residence at Mill Ave. S	2	**74**	**74**	**78**
43A	Residence at 412 Mill Ave. S	3	**70**	**70**	**71**
43B	Second-story Residence at 412 Mill Ave. S	2	**75**	**75**	**76**
43C	Third-story Residence at 412 Mill Ave. S	2	**76**	**76**	**77**
43D	Residence at 412 Mill Ave. S	2	**70**	**70**	**71**
44A	Residence at Cedar Ave. S	3	62	62	**68**
44B	Residence at Cedar Ave. S	2	63	63	**69**
44C	Residence at Cedar Ave. S	2	61	61	**67**
45A	Residence at Cedar Ave. S	3	59	59	65
45B	Residence at Cedar Ave. S	4	55	55	61
46A	Residence at Beacon Way S	3	64	64	**67**
46B	Residence at Beacon Way S	1	**66**	**66**	**69**
46C	Residence at Beacon Way S	2	65	65	**68**
47A	Residence at Beacon Way S	3	58	58	62
47B	Residence at Beacon Way S	4	57	57	61
48	Veteran's Park	1	**69**	**69**	**70**
49	Freeway Park	1	**76**	**76**	N/A
50A	Residence at Mill Ave. S	2	**67**	**67**	**71**
50B	Residence at Mill Ave. S	3	63	63	**67**
51A	Residence at Renton Ave. S	2	**66**	**66**	**69**
51B	Residence at Renton Ave. S	2	63	63	**66**
52	Cedar River Park – trail, picnic, recreational open space, beach area	5	63	63	**67**
53	Liberty Park – playground	1	**68**	**68**	**69**
54	Renton Public Library	Library	65	65	**67**
55*	Liberty Park – furthest baseball field in outfield and tennis court	3	64	64	65
56*	Liberty Park – baseball field, stands, and basketball court	3	**69**	**69**	**69**
57*	Cedar River Park – soccer field and baseball field	3	**71**	**71**	**73**
58	Aquatic Center	Aquatic Center	63	63	63
59	Single-Family Residence	1	64	64	65
60	Silver Cloud Inn	Hotel	**71**	**71**	**71**
61	Hotel	Hotel	**74**	**74**	**74**

Values in **BOLD** approach, meet, or exceed the NAC
* Measurements were taken as part of the I-405 Renton to Bellevue Project, but were analyzed as part of the Tukwila to Renton Project
N/A indicates that property is acquired by WSDOT for right-of-way

Exhibit 4-15: Modeled Noise Receptor Locations, Sheet 7 of 7

What are the modeled noise levels?

Noise levels for baseline conditions in the study area were modeled using TNM, and levels ranged between 56 and 76 dBA. These levels range from typical suburban outdoor sound levels (from 50 to 60 dBA[9]) to very noisy levels (above 70 dBA), which is typical of locations within 100 feet of a busy freeway. Noise levels at 28 sites, representing an equivalent of 98 residences, 2 hotels, 6 parks and 3 trails, were modeled to approach, meet, or exceed the FHWA criteria of 67 dBA for baseline conditions.

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

[9] *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. EPA, 1974.

SECTION 5 PROJECT EFFECTS

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 40 locations representing an equivalent of 190 residences, 2 hotels, 1 library, 6 parks, and 3 trails. Noise levels at 28 locations representing 98 residences, 2 hotels, 6 parks, and 3 trails approach, meet, or exceed the NAC criteria under baseline conditions.

Noise level results are the same for both the Main Street and Mill Avenue design options. Therefore, regardless of the design option selected, overall noise levels for the Build Alternative will not change.

Two new noise barriers are planned for construction as a part of the Tukwila to Renton Project. Noise Barrier 8 is planned for construction along the WSDOT right-of-way line east of Benson Road S and southeast of I-405, near the Berkshire Apartments. Noise Barriers 10A and 10B work together as a system and will be constructed atop a retaining wall from Renton Avenue S to the edge of Mill Avenue S. A discussion of Noise Barriers 8 and 10 is located in Section 6 of this report.

No Build Alternative

Modeling for the No Build Alternative indicates that noise levels will not approach, meet, or exceed the NAC at any additional locations. This means that noise levels for the No Build Alternative and baseline conditions are the same; they approach, meet, or exceed FHWA criteria at 28 locations representing an equivalent of 98 residences, 2 hotels, 6 parks, and 3 trails.

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

Baseline conditions indicate that noise levels at 28 locations including 98 residences, 2 hotels, 6 parks, and 3 trails approach, meet, or exceed the NAC. Noise levels for the No Build Alternative are predicted to be the same as noise levels under baseline conditions.

Noise levels for the Build Alternative were predicted to increase by 0 to 12 dBA over baseline conditions at residences in the study area. Noise levels at 40 locations, including 190 residences, 2 hotels, 1 library, 6 parks, and 3 trails, will approach, meet, or exceed the NAC. These levels remain constant despite the effects of relocating Noise Barrier East 5. The number of residences that experience noise levels that approach, meet, or exceed the NAC would be reduced from 190 to 121 with construction of Noise Barrier 8 and Noise Barrier 10, which are included in the Build Alternative.

Six locations that represent 25 potentially noise-sensitive residences and 1 park (located primarily in the Talbot Hill neighborhood and at the Berkshire Apartments) were included in baseline 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 to transportation use.

Will project construction temporarily affect noise levels?

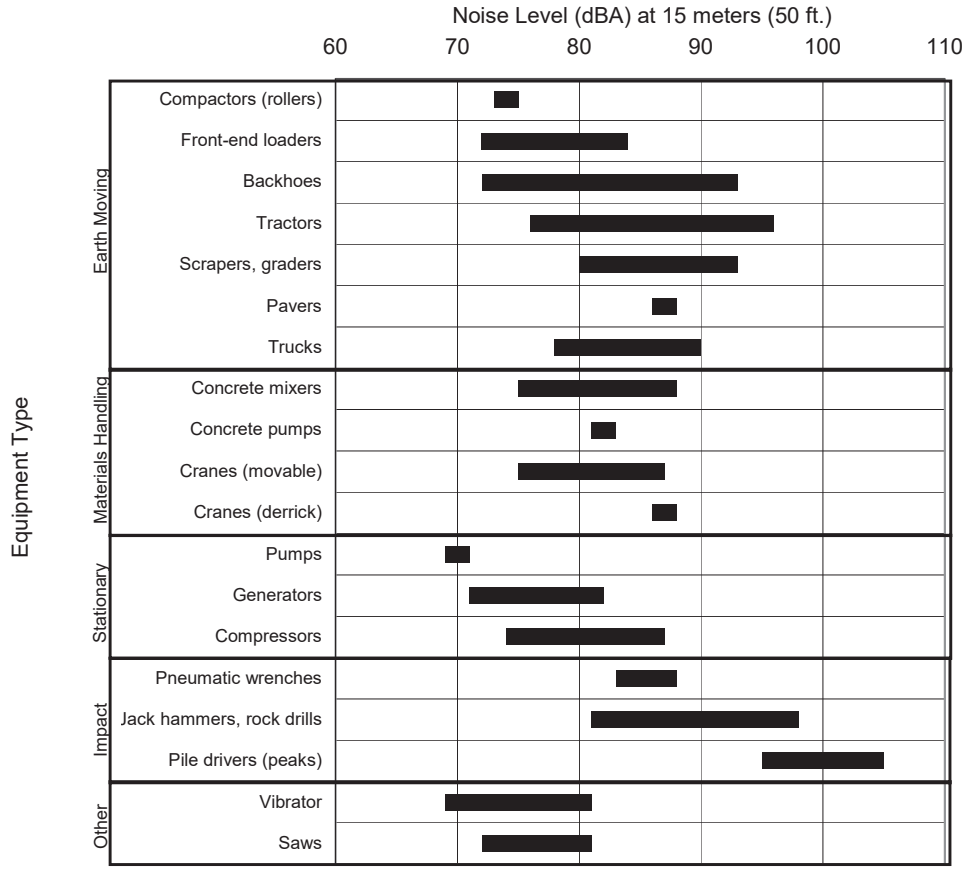
Construction activities will generate noise during the construction period. Construction will usually be carried out in stages, each with its own mix of equipment and its own noise characteristics. Roadway construction will involve clearing, cut-and-fill (grading) activities, removing old roadways, importing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

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, such as generators and compressors, operates at fairly constant sound levels 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.

Did noise specialists consider this project's cumulative noise effects?

The 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, Aquatic Resources, and Wetlands. The cumulative effects for these disciplines are presented in the *Cumulative Effects Analysis Technical Memorandum*. (WSDOT, 2007)

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 L_{eq} noise levels 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.

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

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 capacity constraints on the transportation system. By including the vehicles that are not moving efficiently through the transportation system, 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 Tukwila to Renton Project. The data presented in the even-numbered exhibits from Exhibit 4-2 to Exhibit 4-14 reflect modeled noise levels for the Build Alternative through 2030.

SECTION 6 MEASURES TO AVOID OR MINIMIZE EFFECTS

WSDOT can control noise at three locations: 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 human use occurs and where a lower noise level will provide benefits (USDOT, 1982).

How will effects from construction noise be minimized?

Where practicable, WSDOT will reduce construction noise by using enclosures or walls to surround noisy equipment, installing mufflers on engines, using quiet equipment or construction methods, minimizing operation time, and locating stationary 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;
- Locate stationary equipment away from residences to decrease noise;
- Construct temporary noise barriers or curtains around stationary equipment that must be located near residences, to decrease noise levels at nearby sensitive receptors; and
- Require use of Occupational Safety and Health Administration (OSHA)-approved ambient sound-sensing backup alarms, to reduce disturbances from backup alarms during quiet periods.

How can effects from traffic noise be minimized?

FHWA regulations (23 CFR 772) specify that when the project team identifies noise effects, they must evaluate abatement (mitigation) measures to reduce these effects. For FHWA approval, the project team must incorporate all noise abatement measures that they determine to be feasible and reasonable into the project design, including the opinions of local residences regarding the mitigation measures.

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, noise-insulating public use or non-profit institutional structures, and constructing noise barriers or berms.

The I-405 Team's noise specialists evaluated these measures for their potential to reduce noise caused by the proposed project. This section summarizes the results of this evaluation. 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 of noise mitigation strategy at the local, state, and/or 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. Limiting the introduction of new sensitive noise receptors near the study area could help reduce noise effects, 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 reduce traffic noise. However, a 3-dBA decrease in traffic noise will require an approximately 50 percent reduction in traffic, which is highly unlikely.

Land Acquisition for Noise Buffers or Barriers

Residential properties border I-405 in the study area. Acquiring land in this area would require relocating residents, and often presents an unreasonably expensive option for noise mitigation purposes.

Roadway Realignment

The project's horizontal alignment is defined to minimize impacts to property owners and environmental sensitive areas. 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 to some receptors will be prohibitively expensive and will provide only 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 insulation is provided primarily for public facilities.

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 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 most first-row receptors. Determination of reasonableness depends on: the number of sensitive receptors benefited by a reduction in noise of at least 3 dBA; the cost effectiveness of the barriers to provide noise reduction within the allowable area determined by the number of benefited receivers; 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 Ikawa Park, Tukwila Park, Duwamish-Green River Trail, Interurban Trail, Springbrook Trail, Freeway Park, and Veteran's Park. Based on their physical location in relation to I-405, noise mitigation from I-405 is not feasible in these noise-sensitive areas. The absence of a large number of noise-sensitive receptors in these areas will also prevent them from meeting WSDOT's reasonableness criteria. Receptor locations and noise levels are shown in Exhibits 4-2 through 4-15.

Due to ramp reconfigurations and subsequent elevation changes in the study area, noise modeling results for the Build Alternative predict decreased noise levels for the 10 residences represented by a family fun center, as well as for the Interurban and Springbrook trails. Baseline noise levels are 71 dBA for the family fun center and 74 dBA for each of the trails, and are predicted to be 69 dBA, 68 dBA, and 70 dBA respectively for the Build Alternative. Therefore, a reduction in noise levels occurs in these locations even without a noise barrier. While these areas are eligible for mitigation, they are not areas where noise mitigation efforts can noticeably lower noise levels at a cost per benefited user that satisfies WSDOT criteria for reasonableness.

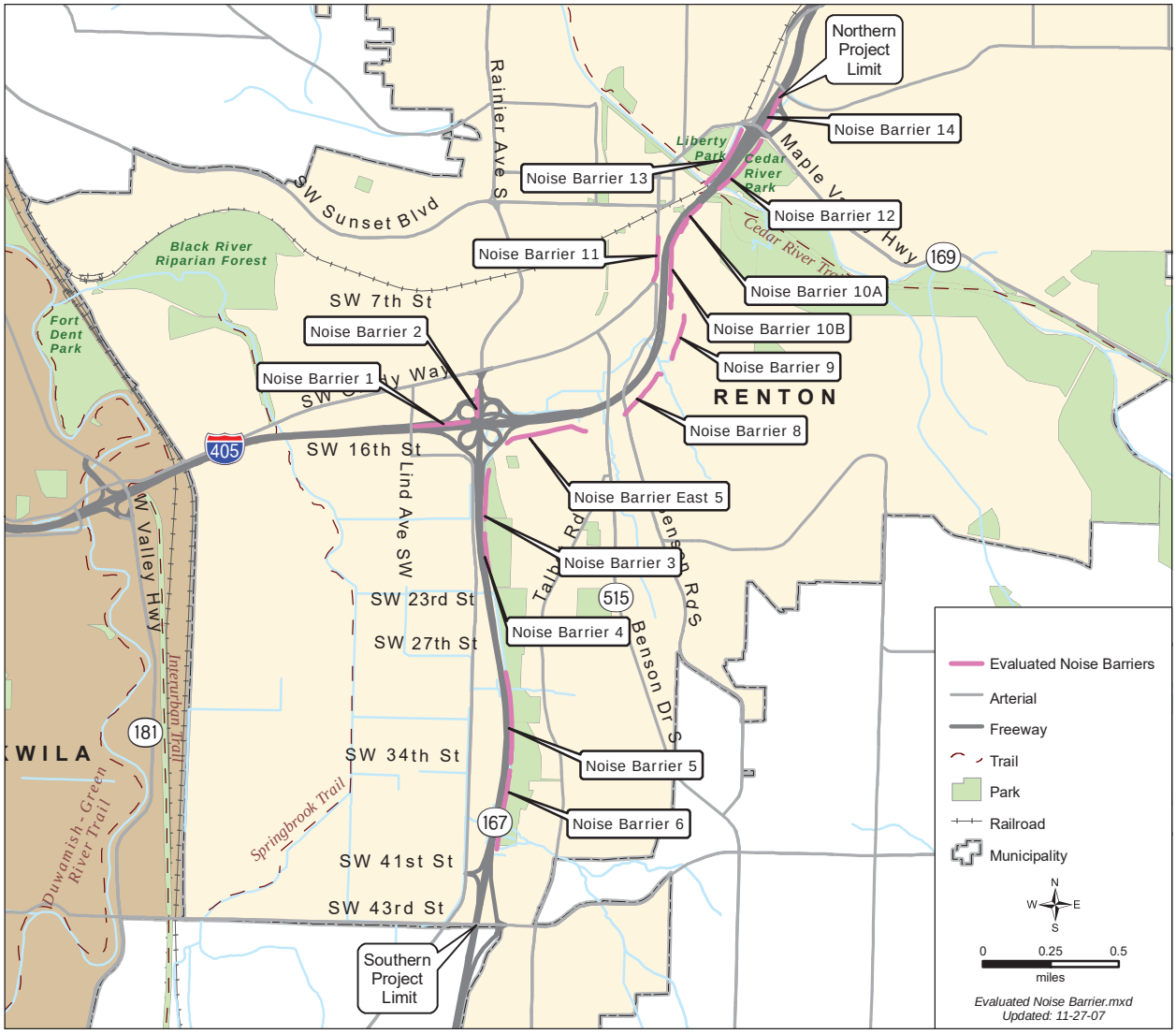
Ikawa Park, Tukwila Park, and Duwamish-Green River Trail all exceed the NAC under baseline conditions at 70 dBA, 66 dBA and 72 dBA, respectively. These locations each experience a 1-dBA increase due to increased traffic volume under the Build Alternative, putting them at 71 dBA, 67 dBA, and 73 dBA, respectively. These areas are not areas where noise mitigation efforts can noticeably lower noise levels at a cost per benefited user that satisfies WSDOT criteria for reasonableness.

Veteran's Park is predicted to experience a 1-dBA increase in noise levels, from 69 dBA under baseline conditions to 70 dBA for the Build Alternative. Further noise analysis of Freeway Park is not relevant, because Build Alternative improvements will require its acquisition. These are also areas where noise mitigation efforts cannot noticeably lower noise levels at a cost per benefited user that satisfies WSDOT criteria for reasonableness.

Fourteen noise barriers were evaluated for the Tukwila to Renton Project. Evaluated noise barrier locations are shown in Exhibit 6-1. Noise Barrier East 5 already exists under baseline conditions, from construction of the Renton Nickel Improvement Project. This barrier is included in the baseline conditions and No Build Alternative, and will be moved to a new location under the Build Alternative due to reconfiguration of the I-405 mainline and the I-405/SR 167 interchange.

Two new noise barriers are planned for construction as a part of the Tukwila to Renton Project. Noise Barrier 8 is planned for construction along the WSDOT right-of-way line east of

Exhibit 6-1: Evaluated Noise Barriers



Benson Road S and southeast of I-405, near the Berkshire Apartments. Noise Barriers 10A and 10B, which work together as a single system, will be constructed atop a retaining wall from Renton Avenue S to the edge of Mill Avenue S to reduce residential noise levels on Renton Hill.

This section summarizes the evaluation of each noise barrier. Refer to Appendix B for more detailed information on the noise barrier evaluation. Noise Barrier East 5, Noise Barrier 8, and Noise Barrier 9 were evaluated further as part of the redesigned SR 515/I-405 half-diamond interchange. This analysis is presented in Appendix C.

Noise Barrier 1 (Not Feasible)

Single-family residences in the area northwest of the I-405/SR 167 interchange were evaluated for a noise barrier. This noise barrier was evaluated along the southern edge of the new southbound frontage road between the eastern edge of Lind Avenue and the western edge of SR 167. The noise level predicted at the sensitive receptor site in this area is 67 dBA without a barrier.

The maximum reduction achieved was 2 dBA for the three residences represented by Modeled Site 7. Noise Barrier 1 will not provide a 7-dBA reduction in I-405 and SR 167 traffic noise levels with a 28-foot-high wall. For this reason, Noise Barrier 1 is not feasible.

The predicted effects of Noise Barrier 1 were combined with the effects of Noise Barrier 2, as shown in Appendix B. However, even when combined these noise barriers could not achieve a 7-dBA reduction with a 28-foot-high wall in order to meet WSDOT's feasibility criteria.

Noise Barrier 2 (Not Feasible)

Single-family residences in the area northwest of the I-405/SR 167 interchange were evaluated for a second noise barrier, in addition to Noise Barrier 1. This noise barrier was evaluated along the western edge of SR 167, just north of the new southbound frontage road. The noise level predicted at the sensitive receptor site in this area is 67 dBA without a barrier.

The maximum reduction was 3 dBA for the three residences represented by Modeled Site 7. Noise Barrier 2 will not provide a 7-dBA reduction in I-405 and SR 167 traffic noise

levels with a 28-foot-high wall. For this reason, Noise Barrier 2 is not feasible.

The predicted effects of Noise Barrier 2 were combined with the effects of Noise Barrier 1, as shown in Appendix B. However, even when combined these noise barriers could not achieve a 7-dBA reduction with a 28-foot-high wall in order to meet WSDOT's feasibility criteria.

Noise Barrier 3 (Not Feasible)

The area southeast of the I-405/SR 167 interchange, along the eastern edge of the SR 167 northbound general-purpose off-ramp to northbound I-405, was evaluated for a noise barrier. Noise levels in the area of Noise Barrier 3 range from 65 dBA to 67 dBA without a noise barrier.

The maximum reduction provided by Noise Barrier 3 is 2 dBA for the five residences represented by Modeled Site 10. With a 28-foot-high-wall, Noise Barrier 3 will not provide a 7-dBA reduction in I-405 and SR 167 traffic noise levels for any of the residences represented by Modeled Sites 10, 11, 12, and 13 (see Appendix B). For this reason, Noise Barrier 3 is not feasible.

Noise Barrier 4 (Not Feasible)

The area southeast of the SR 167 northbound general-purpose off-ramp to northbound I-405 was evaluated for a noise barrier. The noise barrier was evaluated along the eastern edge of SR 167. Noise levels in the area of Noise Barrier 4 range from 61 dBA to 67 dBA without a noise barrier.

Noise Barrier 4 did not provide a measurable reduction in noise levels for this area. With a 28-foot-high wall, Noise Barrier 4 will not provide a 7-dBA reduction in I-405 and SR 167 traffic noise levels for any of the residences represented by Modeled Sites 14 and 15 (see Appendix B). For this reason, Noise Barrier 4 is not feasible.

Noise Barrier 5 (Not Feasible)

A pocket of single-family residences on Talbot Road S, south of the I-405/SR 167 interchange and east of SR 167, were evaluated for a noise barrier. This noise barrier was evaluated along the eastern edge of SR 167. Noise levels in the area of Noise Barrier 5 range from 64 dBA to 66 dBA without a noise barrier.

The maximum reduction provided by Noise Barrier 5 is 5 dBA for the five residences represented by Modeled Site 18 and for the three residences represented by Modeled Site 19. With a 28-foot-high wall, Noise Barrier 5 will not provide a 7-dBA reduction in SR 167 traffic noise levels for any of the residences represented by Modeled Sites 18 and 19 (see Appendix B). For this reason, Noise Barrier 5 is not feasible.

Noise Barrier 6 (Not Feasible)

A pocket of single-family residences on Shattuck Avenue S and S 36th Street, south of the I-405/SR 167 interchange and east of SR 167, were evaluated for a noise barrier. This noise barrier was evaluated along the eastern edge of SR 167. Noise levels in the area of Noise Barrier 6 range from 61 dBA to 66 dBA.

The maximum reduction provided by Noise Barrier 6 was 6 dBA for the 15 residences represented by Modeled Site 20. With a 28-foot-high wall, Noise Barrier 6 will not provide a 7-dBA reduction in SR 167 traffic noise levels for any of the residences represented by Modeled Sites 20 and 21 (see Appendix B). For this reason, Noise Barrier 6 is not feasible.

Renton Nickel Noise Barrier East 5 Modification

Noise Barrier East 5 was built under the Renton Nickel Improvement Project and will be relocated as a part of the Tukwila to Renton Project. Noise Barrier East 5 will be relocated south of the existing S 14th Street, directly southeast of the I-405/ SR 167 interchange (see Exhibit 6-2 below). The noise barrier will run along the eastern edge of the SR 167

Exhibit 6-2: Renton Nickel Noise Barrier East 5 Modification

northbound general-purpose off-ramp to I-405 northbound and the southern edge of the proposed northbound frontage road, beginning west of the S 15th Street/Lake Avenue intersection atop Talbot Hill and ending just west of the old Smithers Avenue S.

In accordance with WSDOT perpetuity standards, Noise Barrier East 5 must be relocated to a position that provides residences in the Talbot Hill area with shielding effects that are comparable to those of Noise Barrier East 5 in its original position. Noise Barrier East 5 will have the same approximate dimensions as it does under the Renton Nickel Improvement Project. However, it will be approximately 100 feet shorter in length because the two potentially noise-sensitive residences in the area to the east of the old Smithers Avenue S will be acquired for an interim construction stage which is addressed in Appendix C. The length of Noise Barrier East 5 will be approximately 1,608 feet and it will remain at a height of 18 feet.

Modifications to Noise Barrier East 5 were evaluated. Noise levels in this area range from 67 dBA to 72 dBA under the Build Alternative.

Increasing the height from 18 feet to 24 feet provided a maximum reduction of 2 dBA for the 21 residences represented by Modeled Sites 24, 28, and 29. This modification to Noise Barrier East 5 will not provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 23, 24, 27, 28, and 29 (see Appendix B). For this reason, an upgrade to Noise Barrier East 5 is not feasible.

Noise Barrier 8 (Feasible, Reasonable)

The area just east of Benson Road S and continuing atop the hillside adjacent to the Berkshire Apartments was evaluated for a noise barrier (see Exhibit 6-3). This noise barrier was evaluated along the new WSDOT right-of-way line from Benson Road S, continuing north to approximately 200 feet beyond the Berkshire Apartment property. Noise levels in the area of Noise Barrier 8 range from 54 dBA to 71 dBA.

Exhibit 6-3: Location of Noise Barrier 8

Planned acquisitions for the SR 515/I-405 half-diamond interchange include two apartment buildings within the Berkshire Apartment complex and full or partial acquisitions of several single-family residential parcels, including some residential structures along I-405 and Benson Road S.

At a height of 20 feet, Noise Barrier 8 provides a maximum noise reduction of 12 dBA for four second-floor residences represented by Modeled Site 33A(2). Modeled Sites 32A, 33A, and 33D represent all nine first-row residences, which experience a reduction of 5 dBA or more. Receptors 33A(2), 33D(2), 33F, 33F(2), 33G, and 33G(2)—representing 21 ground-floor and second-floor residences—are predicted to achieve reductions that range from 3 dBA to 12 dBA.

Noise Barrier 8 meets WSDOT feasibility criteria at a height of 20 feet, because a 7-dBA reduction is achieved and a reduction of 5 dBA or greater is provided at most first-row residences. An area of approximately 21,911 square feet and a length of 1,096 feet are required for Noise Barrier 8 at this height. Noise Barrier 8 would force utility line relocation in the area north of the Berkshire Apartments. Utility relocations costs of $40,000 are including in the evaluation of reasonableness shown in Exhibit 6-4. Based on the WSDOT mitigation allowance, the allowable area that the residences in the vicinity of Noise Barrier 8 can receive is 24,406 square feet, as shown in Exhibit 6-4. The optimal barrier height for Noise Barrier 8 is 20 feet.

Exhibit 6-4: Allowed Barrier Area for Noise Barrier 8 – 20 feet tall

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
32A	2	71	2,080	66	5
32B	3	69	0	67	2
33A	4	66	2,800	57	9
33A(2)	4	71	4,160	59	12
33B	4	54	0	52	2
33B(2)	4	54	0	53	1
33C	3	56	0	55	1
33C(2)	3	58	0	56	2
33D	3	65	2,100	56	9
33D(2)	3	69	2,712	61	8
33E	3	55	0	54	1
33E(2)	3	57	0	55	2
33F	3	64	2,100	59	5
33F(2)	3	67	2,304	62	5
33G	4	66	2,800	63	3
33G(2)	4	68	3,344	65	3
TOTAL Barrier Area (ft^2)			24,400	21,911	
Utility Relocation Cost ($)			--	40,000	
Planning-Level Cost ($)			$1,302,960	$1,170,047 + $40,000 = $1,210,047	

Additional barrier heights were evaluated in Appendix C.

Noise Barrier 9 (Feasible, Not Reasonable)

A pocket of single-family residences located on Renton Avenue S, southeast of the southern limit of Mill Avenue S, were evaluated for a noise barrier. This noise barrier was evaluated along the WSDOT right-of-way line east of I-405. The residences in this area are located at a much higher elevation than the I-405 lanes. Noise levels predicted at the sensitive receptor sites in this area range from 65 to 71 dBA without a barrier.

The maximum reduction provided by Noise Barrier 9 was 8 dBA for the three residences represented by Modeled Site

35D. As shown in Exhibit 6-5, at this barrier height Noise Barrier 9 meets WSDOT feasibility criteria, because a 7-dBA noise reduction is experienced at Modeled Sites 35B and 35D and 9 of the 12 first-row residences represented by Modeled Sites 35B, 35C, and 35D achieve at least a 5-dBA noise reduction. At a height of 16 feet, an area of approximately 11,584 square feet and a length of 724 feet is required for Noise Barrier 9. Based on the WSDOT mitigation allowance, the allowable area that residences in the vicinity of Noise Barrier 9 can receive is 10,236 square feet. Because the allowable area is less than the area needed for the shortest barrier in both height (16 feet) and length (724 feet), Noise Barrier 9 is not considered to be reasonable.

Exhibit 6-5: Noise Barrier 9 – 16 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
35A	3	65	2,100	62	3
35B	3	66	2,100	59	7
35C	3	71	3,120	66	5
35D	3	70	2,916	62	8
Total Barrier Area (ft^2)			10,236	11,584	
Planning-Level Cost ($)			$546,602	$618,586	

*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.

Additional barrier heights were evaluated in Appendix C.

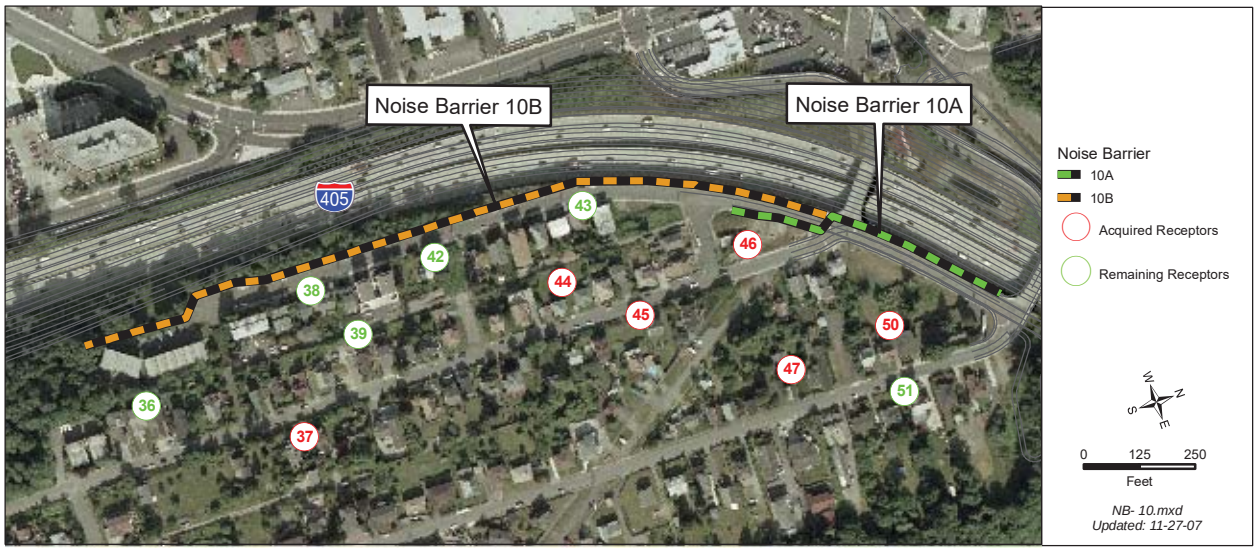
Noise Barriers 10A and 10B (Feasible, Reasonable)

The area from Renton Avenue S to the edge of Mill Avenue S was evaluated for placement of a noise barrier. Due to changing topography near the intersection of S 4th Avenue and Mill Avenue S, Noise Barrier 10 was divided into two barriers, 10A and 10B; the two barriers are evaluated together as they work as a system to collectively reduce noise levels at receptors located behind them. Noise Barrier 10 separates at Cedar Avenue S and becomes Noise Barrier 10A to the north and Noise Barrier 10B to the south. Noise Barrier 10A sits at the top of the stacked structure and overlaps with Noise Barrier 10B where the upper and lower roadway structure

begins (see Exhibit 2-12 for a visual of the proposed stacked road structure). Noise Barrier 10B follows Mill Avenue to the bottom of the new stacked road structure. This area is shown in Exhibit 6-6. Noise levels in the area range from 63 dBA to 78 dBA.

At heights of 14 to 20 feet and 20 feet respectively, Noise Barriers 10A and 10B provide a maximum noise reduction of 13 dBA for two second-floor residences represented by Modeled Site 43B. Modeled Sites 38A, 38B, 38D, 42A, 42B, 42E, 43A, 43D, 46B, and 46C represent 23 of the 31 first-row residences, which experience a reduction of 5 dBA or more. Modeled Sites 46A, 50A, and 50B, which represent the 8 remaining first-row residences in the vicinity of Noise Barriers 10A and 10B, experience between 0 dBA and 1-dBA reductions. Receptors 37B, 38C, 38E, 38F, 39A, 39B, 39C, 42C, 42D, 42F, 42G, 42H, 43B, 43C, 44A, 44B, 44C, 45A, and 45B—representing 50 ground-floor, second-floor, third-floor, and fourth-floor residences—are predicted to achieve reductions that range from 4 dBA to 13 dBA.

Exhibit 6-6: Location of Noise Barriers 10A and 10B



Noise Barriers 10A and 10B meet WSDOT feasibility criteria at heights of 14 to 20 feet and 20 feet respectively, because a 7-dBA reduction is achieved and a reduction of 5 dBA or greater is provided at most first-row residences. A total area of approximately 48,115 square feet and a total length of 2,453 feet are required for Noise Barriers 10A and 10B at the specified heights. Based on the WSDOT mitigation allowance,

the allowable area that the residences in the vicinity of Noise Barrier 10 can receive is 77,688 square feet, as shown in Exhibit 6-7.

Portions of both Noise Barriers 10A and 10B will have to be located atop existing and planned retaining walls that separate I-405 from Renton Hill. This will require additional construction techniques and engineering to support the barrier. The additional cost of construction is estimated to be $600,000.

As shown in Exhibit 6-7, Noise Barriers 10A and 10B meet WSDOT criteria for reasonableness after adding non-typical construction costs for building portions of both noise barriers on retaining walls. Exhibit 6-7 provides information on the total barrier area allowed, based on the noise reduction provided to receptors and the total barrier area for the design of both noise barriers. The planning-level cost presented is calculated by multiplying the total barrier area by $53.40, which is the standard cost per square foot for noise barrier construction.

Additional barrier height evaluations are presented in Appendix B.

Exhibit 6-7: Allowed Barrier Area for Noise Barrier 10

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
37A	4	62	0	60	2
37B	4	64	2,800	57	7
38A	3	75	3,936	64	11
38B	2	73	2,352	62	11
38C	2	75	2,624	65	10
38D	3	74	3,732	64	10
38E	3	76	4,140	69	7
38F	3	77	4,344	73	4
39A	2	68	1,808	63	5
39B	3	67	2,304	59	8
39C	5	65	3,500	60	5
42A	1	74	1,244	63	11
42B	4	72	4,432	62	10
42C	2	75	2,624	63	12
42D	2	77	2,896	65	12
42E	2	72	2,216	62	10
42F	2	75	2,624	63	12
42G	2	77	2,896	67	10
42H	2	78	3,032	72	6
43A	3	71	3,120	63	8
43B	2	76	2,760	63	13
43C	2	77	2,896	65	12
43D	2	71	2,080	62	9
44A	3	68	2,508	60	8
44B	2	69	1,808	59	10
44C	2	67	1,536	58	9
45A	3	65	2,100	61	4
45B	4	61	2,800	57	4
46A	3	67	0	66	1
46B	1	69	904	61	8
46C	2	68	1,672	60	8
47A	3	62	0	60	2
47B	4	61	0	60	1
50A	2	71	0	71	0
50B	3	67	0	67	0
51A	2	69	0	69	0
51B	2	66	0	66	0
Barrier 10A Area (ft^2)			-	34,727	
Barrier 10B Area (ft^2)			-	13,388	
TOTAL Barrier Area (ft^2)			77,688	48,115	
Planning-Level Cost ($)			$4,148,539	$2,569,341 + $600,000 = $3,169,341	

Noise Barrier 11 (Not Feasible)

The area around the Main Avenue S/S Grady Way/Benson Road S intersection was evaluated for a noise barrier. This noise barrier was evaluated from the southernmost point of Main Avenue S, north along its eastern edge and ending south of the Main Avenue S/Cedar Avenue intersection. Noise levels in this area range from 65 dBA to 74 dBA without a barrier.

Noise Barrier 11 will not provide any measurable noise reduction in I-405 traffic noise levels at noise receptor sites in the area with a 28-foot-high wall (see Appendix B). For this reason, Noise Barrier 11 is not feasible.

The primary reason that Noise Barrier 11 did not reduce noise levels in this area is because most of the noise experienced by the residences represented by Modeled Sites 40 and 41 comes from Main Avenue S, S Grady Way, and Benson Road S.

Noise Barrier 12 (Feasible, Not Reasonable)

The Cedar River Park area was evaluated for a noise barrier. This noise barrier was evaluated along the eastern edge of the northbound I-405 to SR 169 off-ramp, between the I-405 Cedar River Bridge and SR 169. Noise levels in this area range from 63 dBA to 73 dBA without a barrier.

At a height of 10 feet, Noise Barrier 12 provides a maximum noise reduction of 7 dBA for Modeled Site 57, which represents the soccer and baseball fields in Cedar River Park and has a Residential Equivalency (RE) of 6 first-row residences (see Exhibits B-2 and B-3 in Appendix B for an explanation of how RE is determined.) Modeled Site 58 represents an aquatic center, has an RE of 10, and experiences a 1-dBA reduction. Modeled Site 52, which represents the trails, picnic areas, recreational open space, and beach areas in Cedar River Park, has an RE of 3 and experiences a 2-dBA noise reduction.

Noise Barrier 12 meets WSDOT feasibility criteria at a height of 10 feet, because a 7-dBA reduction is achieved and a 5-dBA reduction or greater is provided for all first-row residential equivalents. An area of approximately 12,500 square feet (length of 1,250 feet) is required for Noise Barrier 12 at this height. Based on WSDOT mitigation allowance, the allowable area that the residences in the vicinity of Noise Barrier 12 can receive is 7,056 square feet, as shown in Exhibit 6-8. Because

of this, Noise Barrier 12 is not reasonable. Additional barrier height evaluations are presented in Appendix B.

Exhibit 6-8: Allowed Barrier Area for Noise Barrier 12

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
52	3	67	0	65	2
57	6	73	7,056	66	7
58	10	63	0	62	1
TOTAL Barrier Area (ft^2)			7,056	12,500	
Planning-Level Cost ($)			$376,790	$667,500	

Noise Barrier 13 (Feasible, Not Reasonable)

The Liberty Park area was evaluated for a noise barrier along the eastern edge of Houser Way S, beginning north of the Cedar River and ending along the western edge of the entrance to the SR 169/Sunset Boulevard to southbound I-405 on-ramp. Noise levels in this area range from 65 dBA to 69 dBA without a barrier.

The maximum reduction provided by Noise Barrier 13 is 7 dBA at Modeled Site 56, which represents the baseball field, stands, and basketball court at Liberty Park. This park is a first-row receptor with an RE of 6. Modeled Site 53 represents the skateboard facility at Liberty Park and is also a first-row receptor. This modeled site has an RE of 1 and achieves a 3-dBA reduction. Modeled Sites 54 and 55 have REs of 15 and 1 respectively and each experience 3-dBA reductions. These sites respectively represent the Renton Public Library and the tennis courts and baseball field furthest from I-405 in Liberty Park.

Noise Barrier 13 meets WSDOT feasibility criteria at a height of 28 feet, because a 7-dBA reduction is achieved, a reduction of 5 dBA or greater is provided at 6 of the 7 first-row residential equivalents, and all receptors in the vicinity achieve reductions of 3 or more dBA. An area of approximately 35,280 square feet and a length of 1,260 feet are required for Noise Barrier 13 at this height. Based on WSDOT mitigation allowance, the allowable area that the sites in the vicinity of Noise Barrier 13 can receive is 18,585 square feet, as

shown in Exhibit 6-9. This indicates that Noise Barrier 13 is not reasonable.

At a height of 28 feet, Noise Barrier 13 will exceed the 24-foot-maximum height of a typically constructed noise barrier. Additional construction techniques and engineering will be needed to support the barrier. This will increase the costs of the barrier and enhance the unreasonableness of Noise Barrier 13. (Note: Additional costs are not included in Exhibit 6-9.)

Exhibit 6-9: Allowed Barrier Area for Noise Barrier 13

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
53	1	69	905	66	3
54	15	67	11,550	64	3
55	1	65	700	62	3
56	6	69	5,430	62	7
TOTAL Barrier Area (ft^2)			18,585	35,280	
Planning-Level Cost ($)			$992,439	$1,883,952	

*Planning-level cost is based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.

Noise Barrier 14 (Not Feasible)

The area northeast of the I-405/SR 169 interchange and southeast of NE 3rd Avenue was evaluated for a noise barrier. Noise Barrier 14 was evaluated along the western edge of the SR 169/NE 3rd Avenue connector. Noise levels in this area range from 65 dBA to 74 dBA.

The maximum noise reduction provided by Noise Barrier 14 is 3 dBA at Modeled Site 61, which represents a hotel. With a 28-foot-high wall, Noise Barrier 14 will not provide a 7-dBA reduction in I-405 and SR 169 traffic noise levels for any of the sites represented in the area (see Appendix B). For this reason, Noise Barrier 14 is not feasible.

The primary reason that Noise Barrier 14 did not reduce traffic noise in this area is because most of the noise experienced by residences represented by Modeled Sites 59, 60, and 61 comes from NE 3rd Avenue, the SR 169/NE 3rd Avenue connector, and SR 169.

SECTION 7 VIBRATION

What is vibration?

Vibration is an oscillatory motion that can be described in terms of displacement, velocity, or acceleration. Because the motion is oscillatory, no net movement of the vibration element occurs, and the average of any of the motion descriptors is zero. For vibration, velocity represents the instantaneous speed of the motion and acceleration is the speed's rate of change.

The human body responds to the vibration velocity's average amplitude. A vibration decibel notation is commonly used to describe vibration. The vibration velocity level is reported in decibels relative to a level of $1x10^{-6}$ inches per second and is 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 human perception (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 significant 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. Minor damage to fragile historic buildings can occur at vibration levels over 100 VdB.

How is vibration analyzed?

Because roadway traffic with rubber tires generates low levels of vibration, construction activities are the most likely cause of noticeable vibration. The I-405 Team's noise specialists evaluated typical vibration levels for various construction activities, to determine whether structures along I-405 could be potentially damaged.

What are the potential effects of vibration?

During operation, vibration levels will be similar to those currently occurring in the study area. No substantial vibration effects will occur.

During construction, various activities will create vibration. Heavy construction equipment (e.g., large bulldozers and loaded trucks) frequently generates 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 an impact.

A laser eye surgery facility, sensitive to vibrations, is located along Lind Avenue. Vibration impacts are not anticipated at this site because this facility will be acquired. No additional facilities or structures were identified as being sensitive to vibration.

How can the potential effects be minimized?

Construction crews may not conduct pile driving within 100 feet of fragile structures or sensitive vibratory uses. Large bulldozers and vibratory rollers may be operated over 25 feet from fragile structures or areas with sensitive uses. No fragile structures are expected to be affected by the Tukwila to Renton Project.

SECTION 8 UNAVOIDABLE ADVERSE EFFECTS

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

For the Build Alternative, noise levels will approach, meet, or exceed the NAC at 35 locations (representing 116 residences, 2 hotels, 1 library, 6 parks, and 3 trails) with the relocated Noise Barrier East 5, and new Noise Barrier 8 and Noise Barrier 10. Noise Receptor Sites 22, 25, 26, 30, 31, 34, and Freeway Park are planned for acquisition by the project. The Tukwila to Renton Project will not cause any substantial increases in noise.

The Tukwila to Renton Project will not cause any substantial unavoidable adverse noise effects from construction, per FHWA guidance stipulating that temporary construction noise effects are not substantial.

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SECTION 9 REFERENCES

GIS data sources

Odd-Numbered Exhibits 4-1 through 4-15

Parsons Brinckerhoff.

2006 – 2007 Parsons Brinckerhoff Staff; Noise Study Area and Modeled Noise Receptor Locations 1 thru 7.

Exhibits 6-1 and 6-2

Parsons Brinckerhoff.

2006 – 2007 Parsons Brinckerhoff Staff; Evaluated Noise Barriers.

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 cities of Renton and Tukwila.

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 3-5

WSDOT

2005 I-405 Renton Nickel Improvement Project, I-5 to SR 169. Prepared by Parsons Brinckerhoff. Noise Background and Guidance.

Even-Numbered Exhibits 4-2 through 4-14

Parsons Brinckerhoff.

2006 – 2007 Parsons Brinckerhoff Staff; Modeled Noise Levels at Receptors 1 thru 7.

Exhibit 5-1

WSDOT

2005 I-405 Renton Nickel Improvement Project, I-5 to SR 169. Prepared by Parsons Brinckerhoff. Typical Construction Noise Levels.

Exhibit 6-3 through 6-6

WSDOT

2005 I-405 Renton Nickel Improvement Project, I-5 to SR 169. Prepared by Parsons Brinckerhoff. Allowed Barrier Areas for Noise Barriers 10, 12, and 13.

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

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. USDOT FHWA.

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1971 Noise from Construction Equipment and Operations, Building Equipment and Home Appliances. Washington, D.C. U.S. EPA.

Washington Administrative Code (WAC)

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

Washington State Department of Transportation (WSDOT)

2007 Tukwila to Renton Project Social, Public Services, and Utilities Technical Memorandum. Prepared by David Evans and Associates.

2007 Tukwila to Renton Project Section 4(f) Evaluation Discipline Report. Prepared by Osborn Pacific Consulting, Inc.

2007 Tukwila to Renton Project Cumulative Effects Analysis Discipline Report. Prepared by HDR, Inc.

2007 Tukwila to Renton Project Transportation Discipline Report. Prepared by Mirai Associates.

2006 Traffic Noise Analysis and Abatement Policy and Procedures. Olympia, Washington. WSDOT.

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APPENDIX A
NOISE MEASUREMENT AND MODEL VALIDATION DATA

I. Noise Measurement and Model Validation

Ambient noise levels were measured for 15-minute periods at 18 locations near the study area to describe the existing noise environment, identify major noise sources in the study area, validate the noise model, and characterize weekday background environmental noise levels. Measurement locations characterize the variety of noise conditions and represent other sensitive receptors near the proposed project.

The I-405 Team's noise specialists exported base maps and design files from MicroStation as DXF files and imported them into the TNM package. Major roadways, topographical features, buildings, and sensitive receptors from the MicroStation files were digitized into the TNM. 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.

Eighteen measured sites were chosen to represent noise-sensitive sites in the study area. Fifteen-minute noise measurements were taken at each of these 18 sites to estimate the $L_{eq}(h)$, as shown in Exhibit A-1. The measured sites represent approximately 77 single-family residences and multi-family units, 1 park, and 1 library. For noise model validation, traffic volumes were adjusted to match field counts during the time of day the noise measurement occurred. Additional topographical and geometrical detail was added to the TNM model, until the model results at each of the 18 measurement sites were within 2 dBA of the measured levels for the model's validation run.

The following hotels were not considered in the noise analysis due to the lack of ground-floor outdoor use: the Renton Travel Lodge, Springhill Suites Marriot, Hilton Garden Hotel, and Larkspur Landing (all located west of SR 167); and the Hampton Inn and Homestead Studio Suites Hotel (located south of I-405 at SR 181). Noise levels at outdoor use areas at the Nelson House, located south of I-405 at SR 181, are predicted to be below the NAC with the project. The Holiday Inn, located northeast of the I-405/SR 167 interchange, has an outdoor use area in the center of the building, but this area was not considered in the noise analysis because traffic noise levels from I-405 were observed to be well below the NAC. The Best Western Inn South Center will be acquired.

Valley Medical Center was visited during field activities. Traffic noise levels at this medical center were observed to be well below the NAC during field reconnaissance activities.

Exhibit A-1: Noise Measurement Summary

Receptor Number	Location	Date	Time	Leq
8	1503 Lake Avenue S	March 10, 2005	2:10 PM	68.1
9	1514 Lake Avenue S	March 10, 2005	2:10 PM	61.5
20	3521 Shattuck Avenue S	March 10, 2005	1:25 PM	66.8
21	402 S 36th Street	March 10, 2005	1:25 PM	58.7
22	301 S 14th Street	March 8, 2005	10:05 AM	68.8
30	1306 Smithers Avenue S	March 8, 2005	2:00 PM	70.4
32	1114 Benson Road S	March 22, 2005	12:45 PM	69.7
33	Berkshire Apartments (Bldg. P)	March 22, 2005	12:10 PM	68.0
37	518 Cedar Avenue S	March 8, 2005	2:30 PM	59.4
38	520 Mill Avenue S	March 8, 2005	11:15 AM	67.7
40	509 S Main Street	March 8, 2005	11:35 AM	72.0
41	522 Well Avenue S	March 22, 2005	11:15 AM	60.7
43	412 Mill Avenue S	March 8, 2005	3:25 PM	65.9
49	Freeway Park	March 22, 2005	10:15 AM	73.9
54	Renton Public Library	March 22, 2005	10:40 AM	63.8
55*	Liberty Park	November 3, 2003	11:30 AM	65.0
56*	Liberty Park	November 3, 2003	11:30 AM	68.0
57*	Cedar River Park	November 3, 2003	12:09 PM	68.0

* Sites were analyzed as a part of the I-405 Renton to Bellevue Project

II. Description of Measurement Locations

The measurement represented by Receptor 8 is located in the backyard of the property at 1503 Lake Avenue S, facing SR 167. The measurement was taken approximately 300 feet from the eastern edge of the SR 167 off-ramp to northbound I-405. Receptor 8 is located approximately 50 feet above the elevation of the nearest SR 167/I-405 interchange roadways. Receptor 8 is representative of five residences.

The measurement represented by Receptor 9 is located in the front yard of the property at 1514 Lake Avenue S, facing SR 167. The measurement was taken approximately 500 feet from the eastern edge of SR 167 and approximately 60 feet higher than the nearest SR 167/I-405 interchange roadways. Receptor 9 is representative of 3 residences.

The measurement represented by Receptor 20 is located in the backyard of the property at 3521 Shattuck Avenue S, facing SR 167. The measurement was taken approximately 500 feet from the eastern edge of SR 167. Receptor 20 is representative of 10 residences.

The measurement represented by Receptor 21 is located in the front yard of the property at 402 S 36th Street, facing SR 167. The measurement was taken approximately 650 feet from the eastern edge of SR 167. Receptor 21 is representative of 9 residences.

The measurement represented by Receptor 22 is located in the front yard of the property at 301 S 14th Street, facing I-405. The measurement was taken approximately 100 feet from the southern edge of I-405 and approximately 45 feet above two I-405 northbound on-ramps. Receptor 22 is representative of 8 residences.

The measurement represented by Receptor 30 is located in the front yard of the property at 1306 Smithers Avenue S, facing I-405. The measurement was taken approximately 50 feet from the southern edge of I-405 and is one of the nearest properties to I-405 along the study area. Receptor 30 is representative of 2 residences.

The measurement represented by Receptor 32 is located in the side yard of the property at 1114 Benson Road S, facing I-405. The measurement was taken approximately 400 feet from the southeastern edge of I-405. Receptor 32 is representative of 4 residences.

The measurement represented by Receptor 33 is located at a ground-floor outdoor use area at building P of the Berkshire Apartments at 1300 Eagle Ridge Drive S. The measurement was taken approximately 200 feet from the eastern edge of I-405, in the grassy lawn west of the building facing I-405. Receptor 33 is representative of 6 ground-floor apartment units and an adjacent single-family residence.

The measurement represented by Receptor 37 is located in an elevated front yard and swimming pool area on the first-floor ground-level of a single-family residence on the property at 518 Cedar Avenue S, facing I-405. The measurement was taken approximately 400 feet from the eastern edge of I-405. This receptor is located approximately 45 feet above I-405 and is partially shielded by the retaining wall alongside I-405. Receptor 37 is representative of 10 residences.

The measurement represented by Receptor 38 is located in an elevated front yard on the first-floor ground level of a single-family residence on the property at 520 Mill Avenue S, facing I-405. The measurement was taken approximately 100 feet from the eastern edge of I-405. This receptor is located approximately 30 feet above I-405 and is partially shielded by the retaining wall alongside I-405. Receptor 38 is representative of 5 residences.

The measurement represented by Receptor 40 is located in front of the property at 509 Main Avenue S. The measurement was taken approximately 150 feet from the western edge of I-405. Receptor 40 is representative of 3 residences.

The measurement represented by Receptor 41 is located in the backyard of the property at 522 Well Avenue S. The measurement was taken approximately 300 feet from the western edge of I-405. Receptor 41 is representative of 7 residences.

The measurement represented by Receptor 43 is located in the front yard of the property facing I-405 at 412 Mill Avenue S. The measurement was taken approximately 75 feet from the eastern edge of I-405. This receptor is located approximately 30 feet above I-405 and is partially shielded by the retaining wall separating the Renton Hill neighborhood from I-405. Receptor 43 is representative of 7 residences.

The measurement represented by Receptor 49 is located at Freeway Park, just west of I-405 between the Renton Avenue S and Cedar Avenue S underpasses at I-405. The measurement

was taken approximately 30 feet from the western edge of I-405, in the center of the benched area facing I-405. Receptor 49 is representative of 1 residential equivalent unit (see Exhibit B-3 in Appendix B).

The measurement represented by Receptor 54 is located at the Renton Public Library at 100 Mill Avenue S. The measurement was taken approximately 500 feet from the western edge of I-405, on the Cedar River Bridge just outside the library entrance. Receptor 54 is representative of 10 residential equivalent units (see Exhibit B-3 in Appendix B).

III. Validation Results

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

Receptor Number	Address	Measured Leq	Modeled Leq
8	1503 Lake Avenue S	68.1	69
9	1514 Lake Avenue S	61.5	63
20	3521 Shattuck Avenue S	66.8	67
21	402 S 36th Street	58.7	59
22	301 S 14th Street	68.8	68
30	1306 Smithers Avenue S	70.4	71
32	1114 Benson Road S	69.7	69
33	Berkshire Apartments (Bldg. P)	68.0	68
37	518 Cedar Avenue S	59.4	59
38	520 Mill Avenue S	67.7	68
40	509 S Main Street	72.0	71
41	522 Well Avenue S	60.7	62
43	412 Mill Avenue S	65.9	66
49	Freeway Park	73.9	74
54	Renton Public Library	63.8	64
55*	Liberty Park	65.0	65
56*	Liberty Park	68.0	69
57*	Cedar River Park	68.0	68

* Sites were analyzed as a part of the I-405 Renton to Bellevue Project

Exhibit A-2 shows that measured values are all within 2 dBA of the modeled values for each site. These results validate the model.

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. For noise levels above 74 dBA, the allowed barrier surface area per household increases by 70 square feet per-dBA increase.

Exhibit B-1: Noise Mitigation Allowance

Design-Year Traffic Noise Decibel Level	Allowed Barrier Surface Area per Household in Square Meters (square feet)*
66 dBA	65.0 (700)
67 dBA	71.5 (770)
68 dBA	77.7 (837)
69 dBA	84.0 (905)
70 dBA	90.5 (973)
71 dBA	96.7 (1,041)
72 dBA	103.0 (1,109)
73 dBA	109.2 (1,176)
74 dBA	115.5 (1,244)

Source: WAC, 1999

*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. This cost represents 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.

I. 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

In Washington an average household has three members, so for sites with other than residential uses, the number of users is divided by three to convert to households. Exhibit B-3 presents the RE for receptors in the proposed 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)
1	Ikawa Park	10[1]	0.17	0.33	1
2	Tukwila Park	50[1]	0.17	0.33	3
3	Duwamish-Green River Trail	10[1]	0.17	0.33	1
4	Family Fun Center	180[2]	0.17	0.33	10
5	Interurban Trail	50[1]	0.17	0.33	3
6	Springbrook Trail	10[1]	0.17	0.33	1
48	Veteran's Park	10[1]	0.17	0.33	1
49	Freeway Park	10[1]	0.17	0.33	1
52	Cedar River Park – trail, picnic, recreational open space, beach area	50[1]	0.17	0.33	3
53	Liberty Park – skateboard facility	20[1]	0.17	0.33	1
54	Renton Public Library	210[2]	0.22	0.33	15
55*	Liberty Park – furthest baseball field in outfield and tennis court	10[1]	0.17	0.33	1
56*	Liberty Park – baseball field, stands, and basketball court	108[1]	0.17	0.33	6
57*	Cedar River Park – soccer field and baseball field	108[1]	0.17	0.33	6
58	Aquatic Center	180[2]	0.17	0.33	10

[1] The number of users was estimated because user data were not available from the Renton Parks Department.

[2] The estimated average number of users at any one time while the facility is open.

*Measurements were taken as part of the I-405 Renton to Bellevue Project, but were analyzed as part of the I-405 Tukwila to Renton Project

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

Noise Barriers 1 and 2

Noise Barrier 1 was not considered feasible because it will not be possible to provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Site 7 with a wall of 28 feet in height and 1,190 feet in length, as shown in Exhibit B-4.

Noise Barrier 2 was not considered feasible because it will not be possible to provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Site 7 with a wall of 28 feet in height and 731 feet in length, as shown in Exhibit B-5.

The predicted effects of Noise Barrier 1 were combined with those of Noise Barrier 2 to enhance the possibility of a feasible noise wall in the area. The barrier analysis of Noise Barrier 1 and Noise Barrier 2 was not considered feasible, because it will not be possible to provide a 7-dBA reduction for the residences represented by Modeled Site 7, as shown in Exhibit B-6.

Exhibit B-4: Noise Barrier 1 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
7	3	67	0	65	2
Total Barrier Area (ft^2)			0	33,320	
Planning-Level Cost ($)			$0	$1,779,288	
*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.					

Exhibit B-5: Noise Barrier 2 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
7	3	67	2,310	64	3
Total Barrier Area (ft^2)			2,310	20,468	
Planning-Level Cost ($)			$123,354	$1,092,991	
*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.					

Exhibit B-6: Noise Barrier 1 – 28 feet tall and Noise Barrier 2 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
7	3	67	2,310	61	6
Total Barrier Area (ft^2)			2,310	53,788	
Planning-Level Cost ($)			$123,354	$2,872,279	
*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.					

Noise Barrier 3

Noise Barrier 3 was not considered feasible because it will not be possible to provide a 7-dBA reduction in I-405 and SR 167 traffic noise levels for any of the residences represented by Modeled Sites 10, 11, 12 and 13 with a wall of 28 feet in height and 975 feet in length, as shown in Exhibit B-7.

Exhibit B-7: Noise Barrier 3 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
10	5	68	0	66	2
11	4	65	0	65	0
12	6	67	0	66	1
13	6	65	0	64	1
Total Barrier Area (ft^2)			0	27,300	
Planning-Level Cost ($)			$0	$1,457,820	

*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.

Noise Barrier 4

Noise Barrier 4 was not considered feasible because it will not be possible to provide a 7-dBA reduction in SR 167 traffic noise levels for any of the residences represented by Modeled Sites 14 and 15 with a wall of 28 feet in height and 800 feet in length, as shown in Exhibit B-8.

Exhibit B-8: Noise Barrier 4 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
14	8	67	0	67	0
15	6	61	0	61	0
Total Barrier Area (ft^2)			0	22,400	
Planning-Level Cost ($)			$0	$1,196,160	

*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.

Noise Barrier 5

Noise Barrier 5 was not considered feasible because it will not be possible to provide a 7-dBA reduction in SR 167 traffic noise levels for any of the residences represented by Modeled Sites 18 and 19 with a wall of 28 feet in height and 1,760 feet in length, as shown in Exhibit B-9.

Exhibit B-9: Noise Barrier 5 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
18	5	64	3,500	59	5
19	3	66	2,100	61	5
Total Barrier Area (ft^2)			5,600	49,280	
Planning-Level Cost ($)			$299,040	$2,631,552	
*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.					

Noise Barrier 6

Noise Barrier 6 was not considered feasible because it will not be possible to provide a 7-dBA reduction in SR 167 traffic noise levels for any of the residences represented by Modeled Sites 20 and 21 with a wall of 28 feet in height and 1,585 feet in length, as shown in Exhibit B-10.

Exhibit B-10: Noise Barrier 6 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
20	10	66	7,000	60	6
21	9	61	6,300	57	4
Total Barrier Area (ft^2)			13,300	44,380	
Planning-Level Cost ($)			$710,220	$2,369,892	
*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.					

Renton Nickel Noise Barrier East 5 Modification

The modification of Renton Nickel Noise Barrier East 5 was not considered feasible because increasing its height from 18 feet to 24 feet will not provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 23, 24, 27, 28, and 29, as shown in Exhibit B-11.

Exhibit B-11: Noise Barrier East 5 – 24 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier Modification	Reduction (dBA)
23	5	63	0	62	1
24	6	63	0	61	2
27	6	63	0	63	0
28	8	64	0	62	2
29	7	63	0	61	2
Total Barrier Area (ft^2)			0	33,930	
Planning-Level Cost ($)			$0	$1,811,862	

Noise Barrier 8

The evaluation of Noise Barrier 8 is discussed in the SR 515/I-405 Interchange Technical Memorandum included in Appendix C.

Noise Barrier 9

The evaluation of Noise Barrier 9 is discussed in the SR 515/I-405 Interchange Technical Memorandum included in Appendix C.

Noise Barrier 10

The area from Renton Avenue S to the edge of Mill Avenue S was evaluated for placement of a noise barrier. Due to changing topography near the intersection of S 4th Avenue and Mill Avenue S, Noise Barrier 10 was divided into two barriers, 10A and 10B; the two barriers are evaluated together as they work as a system to collectively reduce noise levels at receptors located behind them. Noise Barrier 10 separates at Cedar Avenue S and becomes Noise Barrier 10A to the north and Noise Barrier 10B to the south. Noise Barrier 10A sits at the top of the stacked structure and overlaps with Noise Barrier 10B where the upper and lower roadway structure begins (see Exhibit 2-12 for a visual of the proposed stacked road structure). Noise Barrier 10B follows Mill Avenue to the bottom of the new stacked road structure. This area is shown in Exhibit 6-6. Noise levels in the area range from 63 dBA to 78 dBA (see Chapter 6 in the main body of this report).

As discussed in the main body of this report and presented in Exhibit 6-7, Noise Barriers 10A and 10B are recommended at heights of 14 to 20 feet and 20 feet respectively. At these heights, the two barriers collectively meet WSDOT feasibility criteria, because a 7-dBA reduction is achieved and a reduction of 5 dBA or greater is provided at most first-row residences. A total area of approximately 48,115 square feet and a total length of 2,453 feet are required for Noise Barriers 10A and 10B at the specified heights. Based on the WSDOT mitigation allowance, the allowable area that the residences in the vicinity of Noise Barrier 10 can receive is 77,688 square feet, as shown in Exhibit 6-7 (Chapter 6).

Portions of both Noise Barriers 10A and 10B will have to be located atop existing and planned retaining walls that separate I-405 from Renton Hill. This will require additional construction techniques and engineering to support the barrier. The additional cost of construction is estimated to be $600,000.

As shown in Exhibit 6-7, Noise Barriers 10A and 10B meet WSDOT criteria for reasonableness after adding non-typical construction costs of building portions of both noise barriers on retaining walls. Exhibit 6-7 provides information on the total barrier area allowed, based on the noise reduction provided to receptors and the total barrier area for the design of both noise barriers. The planning-level cost presented is calculated by multiplying the total barrier area by $53.40, which is the cost per square foot for noise barrier construction.

At a height of 12 feet, Noise Barriers 10A and 10B provide a maximum noise reduction of 10 dBA for two second-floor residences represented by Modeled Site 43B. Modeled Sites 38A, 38B, 42A, 42B, 42E, 43A, 43D, 46B, and 46C represent 20 of the 31 first-row residences that experience

a reduction of 5 dBA or more. Modeled Sites 38A, 46A, 50A, and 50B, which represent the 11 remaining first-row residences in the vicinity of Noise Barriers 10A and 10B, experience 0 dBA to 4-dBA reductions respectively. Receptors 38C, 38E, 39B, 39C, 42C, 42D, 42F, 42G, 42H, 43B, 43C, 44A, 44B, 44C, and 45A—representing 33 ground-floor, second-floor, third-floor, and fourth-floor residences—are predicted to achieve reductions that range from 3 dBA to 10 dBA.

Noise Barriers 10A and 10B collectively meet WSDOT feasibility criteria at heights of 12 feet each, because a 7-dBA reduction is achieved and a reduction of 5 dBA or greater is provided at most first-row residences. A total area of approximately 29,439 square feet and a total length of 2,453 feet are required for Noise Barriers 10A and 10B at this height. Based on the WSDOT mitigation allowance, the allowable area that the residences in the vicinity of Noise Barriers 10A and 10B can receive is 68,736 square feet, as shown in Exhibit B-12. The large amount of allowable wall area that remains available at the height of 12 feet indicates that additional noise reduction may be available by increasing each barrier's height.

Exhibit B-12: Noise Barrier 10 – 12 feet tall

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
37A	4	62	0	61	1
37B	4	64	2,800	61	3
38A	3	75	3,936	69	6
38B	2	73	2,352	66	7
38C	2	75	2,624	71	4
38D	3	74	3,732	70	4
38E	3	76	4,140	73	3
38F	3	77	0	75	2
39A	2	68	0	68	0
39B	3	67	2,304	64	3
39C	5	65	3,500	61	4
42A	1	74	1,244	66	8
42B	4	72	4,432	64	8
42C	2	75	2,624	66	9
42D	2	77	2,896	73	4
42E	2	72	2,216	64	8
42F	2	75	2,624	68	7
42G	2	77	2,896	73	4
42H	2	78	3,032	74	4
43A	3	71	3,120	65	6
43B	2	76	2,760	66	10
43C	2	77	2,896	73	4
43D	2	71	2,080	64	7
44A	3	68	2,508	64	4
44B	2	69	1,808	62	7
44C	2	67	1,536	62	5

Exhibit B-12: Noise Barrier 10 – 12 feet tall

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
45A	3	65	2,100	62	3
45B	4	61	0	60	1
46A	3	67	0	67	0
46B	1	69	904	63	6
46C	2	68	1,672	62	6
47A	3	62	0	61	1
47B	4	61	0	61	0
50A	2	71	0	71	0
50B	3	67	0	67	0
51A	2	69	0	69	0
51B	2	66	0	66	0
Barrier 10A Area (ft^2)			--	21,406	
Barrier 10B Area (ft^2)			--	8,033	
TOTAL Barrier Area (ft^2)			68,736	29,439	
Planning-Level Cost ($)			$3,670,502	$1,572,043 + $600,000 = $2,172,043	

At heights of 28 feet respectively, Noise Barriers 10A and 10B provide a maximum noise reduction of 15 dBA for six second-floor and third-floor residences represented by Modeled Sites 42C, 42D, and 43C. Modeled Sites 38A, 38B, 38D, 42A, 42B, 42E, 43A, 43D, 46B, and 46C represent 23 of the 31 first-row residences that experience a reduction of 5 dBA or more. Modeled Sites 46A, 50A, and 50B—representing the eight remaining first-row residences in the vicinity of Noise Barriers 10A and 10B—experience reductions of 0 to 1 dBA. Receptors 37A, 37B, 38C, 38E, 38F, 39A, 39B, 39C, 42C, 42D, 42F, 42G, 42H, 43B, 43C, 44A, 44B, 44C, 45A, and 45B—representing 54 ground-floor, second-floor, third-floor, and fourth-floor residences—are predicted to achieve reductions that range from 3 dBA to 15 dBA.

Noise Barriers 10A and 10B meet WSDOT feasibility criteria at a height of 28 feet, because a 7-dBA reduction is achieved and a reduction of 5 dBA or greater is provided at most first-row residences. A total area of approximately 68,690 square feet and a total length of 2,453 feet are required for Noise Barriers 10A and 10B at this height. Based on the WSDOT mitigation allowance, the allowable area that the residences in the vicinity of Noise Barriers 10A and 10B can receive is 80,468 square feet, as shown in Exhibit B-13. A 2-dBA average reduction is predicted per benefited receiver with the 28-foot barrier design, compared to the 20-foot barrier design. Only eight additional residences experience noise levels below the NAC when comparing the 28-foot height to the 20-foot height. The 28-foot height design also adds only four additional benefited receivers compared to the 20-foot height design for Noise Barriers 10A and 10B.

Exhibit B-13: Noise Barrier 10 – 28 feet tall

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
37A	4	62	2,800	59	3
37B	4	64	2,800	56	8
38A	3	75	3,936	62	13
38B	2	73	2,352	60	13
38C	2	75	2,624	62	13
38D	3	74	3,732	61	13
38E	3	76	4,140	64	12
38F	3	77	4,344	69	8
39A	2	68	1,808	60	8
39B	3	67	2,304	57	10
39C	5	65	3,500	59	6
42A	1	74	1,244	61	13
42B	4	72	4,432	61	11
42C	2	75	2,624	60	15
42D	2	77	2,896	62	15
42E	2	72	2,216	60	12
42F	2	75	2,624	61	14
42G	2	77	2,896	62	15
42H	2	78	3,032	66	12
43A	3	71	3,120	62	9
43B	2	76	2,760	62	14
43C	2	77	2,896	62	15
43D	2	71	2,080	61	10
44A	3	68	2,508	58	10
44B	2	69	1,808	58	11
44C	2	67	1,536	56	11
45A	3	65	2,100	60	5
45B	4	61	2,800	56	5
46A	3	67	0	65	2
46B	1	69	904	60	9
46C	2	68	1,672	59	9
47A	3	62	0	60	2
47B	4	61	0	59	2
50A	2	71	0	71	0
50B	3	67	0	66	1
51A	2	69	0	68	1
51B	2	66	0	66	0
Barrier 10A Area (ft^2)			--	49,947	
Barrier 10B Area (ft^2)			--	18,743	
TOTAL Barrier Area (ft^2)			80,488	68,690	
Planning-Level Cost ($)			$4,298,059	$3,668,046 + $600,000 = $4,268,046	

Noise Barrier 11

Noise Barrier 11 was not considered feasible because it is not possible to provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 40 and 41 with a wall of 28 feet in height and 846 feet in length (as shown in Exhibit B-14).

Exhibit B-14: Noise Barrier 11 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
40	3	74	0	74	0
41	7	65	0	65	0
Total Barrier Area (ft^2)			0	23,688	
Planning-Level Cost ($)			$0	$1,264,939	

*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.

Noise Barrier 12

Noise Barrier 12 is approximately 1,250 feet in length. A minimum height of 10 feet is necessary to meet WSDOT feasibility criteria and providing a 7-dBA reduction (and a reduction of 5 dBA or greater) for all first-row residential equivalents in the area, which are represented by Modeled Site 57.

As discussed in the main body of this report and presented in Exhibit 6-8 (and in Exhibit B-15 for comparison purposes), Noise Barrier 12 is unreasonable at a height of 10 feet because it requires an area of approximately 12,500 square feet. This far exceeds the 7,056 square feet of allowable area that residences in the vicinity of Noise Barrier 12 can receive.

Noise Barrier 12 was evaluated for two additional configurations (see Exhibits B-16 and B-17). At heights of 14 feet and 18 feet, Noise Barrier 12 meets WSDOT feasibility criteria by providing a 7-dBA reduction (and a reduction of 5 dBA or greater) for all first-row residential equivalents in the area, which are represented by Modeled Site 57.

The allowable wall area for Noise Barrier 12 at heights of 14 feet and 18 feet is the same: 7,056 square feet. The required area for a 14-foot-tall wall and an 18-foot-tall wall respectively increase to 17,500 and 22,500 square feet (which is over the 12,500 square feet required for a height of 10 feet). This indicates that these wall heights will be even more unreasonable than a 10-foot wall for Noise Barrier 12.

Exhibit B-15: Noise Barrier 12 – 10 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
52	3	67	0	65	2
57	6	73	7,056	66	7
58	10	63	0	62	1
Total Barrier Area (ft^2)			7,056	12,500	
Planning-Level Cost ($)			$376,790	$667,500	

Exhibit B-16: Noise Barrier 12 – 14 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
52	3	67	0	65	2
57	6	73	7,056	64	9
58	10	63	0	62	1
Total Barrier Area (ft^2)			7,056	17,500	
Planning-Level Cost ($)			$376,790	$934,500	

Exhibit B-17: Noise Barrier 12 – 18 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
52	3	67	0	65	2
57	6	73	7,056	64	9
58	10	63	0	62	1
Total Barrier Area (ft^2)			7,056	22,500	
Planning-Level Cost ($)			$376,790	$1,201,500	

Noise Barrier 13

Noise Barrier 13 was not considered feasible because it is not possible to provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 53, 54, 55 and 56 with a wall of 24 feet in height and 1,260 feet in length. This is discussed in the main body of the report (see Exhibit 6-9) and shown in Exhibit B-18.

Noise Barrier 13 was evaluated for one additional configuration (see Exhibit B-19). At a height of 28 feet, Noise Barrier 13 is considered feasible because it provides a 7-dBA reduction in I-405 traffic noise levels for residences represented by Modeled Site 56; however, at this height Noise Barrier 13 is 35,280 square feet, which is nearly twice the allowable barrier area of 18,585 square feet.

Exhibit B-18: Noise Barrier 13 – 24 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
53	1	69	905	66	3
54	15	67	0	65	2
55	1	65	700	62	3
56	6	69	5,430	63	6
Total Barrier Area (ft^2)			7,035	30,240	
Planning-Level Cost ($)			$375,669	$1,614,816	

Exhibit B-19: Noise Barrier 13 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
53	1	69	905	66	3
54	15	67	11,550	64	3
55	1	65	700	62	3
56	6	69	5,430	62	7
Total Barrier Area (ft^2)			18,585	35,280	
Planning-Level Cost ($)			$992,439	$1,883,952	

Noise Barrier 14

Noise Barrier 14 was not considered feasible because it is not possible to provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 59, 60, and 61 with a wall of 28 feet in height and 750 feet in length (as shown in Exhibit B-20).

Exhibit B-20: Noise Barrier 14 – 28 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
59	1	65	0	64	1
60	1	71	0	70	1
61	1	74	1,244	71	3
Total Barrier Area (ft^2)			1,244	21,000	
Planning-Level Cost ($)			$66,430	$1,121,400	

*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.

APPENDIX C
SR 515 IMPROVEMENT PROJECT NOISE ANALYSIS

DATE: September 27, 2007

TO: Karen Comings, I-405 Project Team

FROM: Patrick Romero, I-405 Project Team

RE: Interstate 405, Tukwila to Renton Improvement Project (1-5 to SR 169 – Phase 2), SR 515 Improvement Project – Supplemental Noise Analysis

CC: File

This technical memorandum presents the findings for the noise analysis of communities located near design modifications for the SR 515/I-405 half-diamond interchange. The noise levels experienced by residences located behind Noise Barrier East 5B (located southeast of the I-405/SR 167 interchange), Noise Barrier 8 (located near the Berkshire Apartments, east of the SR 515/I-405 interchange), and Noise Barrier 9 (located near the Defoor Property, east of I-405 along Renton Hill) are evaluated in these areas.

Findings presented in this technical memorandum detail the modification to Noise Barrier East 5 resulting from the SR 515/I-405 half-diamond interchange. Findings also include the evaluation of Noise Barrier 8, which satisfies WSDOT criteria for a feasible and reasonable noise barrier, and Noise Barrier 9, which is feasible but does not satisfy WSDOT criteria for a reasonable noise barrier.

Renton Nickel Noise Barrier East 5B Modification

Noise Barrier East 5 is planned for construction as part of the Renton Nickel Improvement Project. The SR 515/I-405 interchange improvements make modifications to Noise Barrier East 5 necessary. The modified Noise Barrier East 5 is renamed Noise Barrier East 5B. Noise Barrier East 5B is located along the southern right-of-way of I-405 along S 14th Street beginning approximately 250 feet west of SR 515 to the east and ending west of the S 14th Street/S 15th Street intersection atop Talbot Hill (see Exhibit C-1 below). Noise levels in the vicinity of Noise Barrier East 5B were predicted to range between 66 and 72 dBA without a noise barrier.

Exhibit C-1: Renton Nickel Noise Barrier East 5B Modification

In accordance with WSDOT perpetuity standards, Noise Barrier East 5B must be relocated to a position that provides residences in the Talbot Hill area with shielding effects that are comparable to those of Noise Barrier East 5 in its original position. Noise Barrier East 5B will have the same 18-foot height as was originally designed. However, it will be approximately 300 feet shorter because two potentially noise-sensitive residences in the area to the east of the old Smithers Avenue S will be acquired for an interim construction stage. The length of Noise Barrier East 5B will be approximately 1,860 feet and it will remain at a height of 18 feet.

Shortening the length by 300 feet off the eastern end of Noise Barrier 5B does not change noise reductions initially provided by Noise Barrier 5 at the remaining residences located behind Noise Barrier 5B.

Increasing the height of Noise Barrier 5B from 18 feet to 24 feet provided a maximum reduction of 2 dBA for the 21 residences represented by Modeled Sites 24, 28, and 29. This modification to Noise Barrier East 5B will not provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 23, 24, 27, 28, and 29 (see Appendix B). For this reason, an upgrade to Noise Barrier East 5B is not feasible.

The modification of Renton Nickel Noise Barrier East 5B was not considered feasible because increasing its height from 18 feet to 24 feet will not provide a 7-dBA reduction in I-405 traffic noise levels for any of the residences represented by Modeled Sites 23, 24, 27, 28, and 29, as shown in Exhibit C-2.

Exhibit C-2: Noise Barrier East 5B – 24 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier Modification	Reduction (dBA)
23	5	63	0	61	2
24	6	63	0	62	1
27	6	63	0	62	1
28	8	64	0	63	1
29	7	63	0	61	2
Total Barrier Area (ft^2)			0	43,526	
Planning-Level Cost ($)			$0	$2,324,288	

Noise Barrier 8 (Feasible, Reasonable)

The area just east of Benson Road S and continuing atop the hillside adjacent to the Berkshire Apartments was evaluated for a noise barrier (see Exhibit C-3). This noise barrier was evaluated along the new WSDOT right-of-way line from Benson Road S, continuing north to approximately 200 feet beyond the Berkshire Apartment property. Noise levels in the area of Noise Barrier 8 range from 54 dBA to 71 dBA.

It is important to note that acquisitions are anticipated for the design of the SR 515/I-405 half-diamond interchange. Planned acquisitions include two apartment buildings within the Berkshire Apartment complex and full or partial acquisitions of several single-family residential parcels, including some residential structures along I-405 and Benson Road S.

Exhibit C-3: Location of Noise Barrier 8

At a height of 20 feet, Noise Barrier 8 provides a maximum noise reduction of 12 dBA for four second-floor residences represented by Modeled Site 33A(2). Modeled Sites 32A, 33A, and 33D represent all nine first-row residences, which experience a reduction of 5 dBA or more.

Receptors 33A(2), 33D(2), 33F, 33F(2), 33G, and 33G(2)—representing 21 ground-floor and second-floor residences—are predicted to achieve reductions that range from 3 dBA to 12 dBA.

Noise Barrier 8 meets WSDOT feasibility criteria at a height of 20 feet, because a 7-dBA reduction is achieved and a reduction of 5 dBA or greater is provided at most first-row residences. An area of approximately 21,911 square feet and a length of 1,096 feet are required for Noise Barrier 8 at this height. Noise Barrier 8 would force utility line relocation in the area north of the Berkshire Apartments. Utility relocation costs of $40,000 are included in the evaluation of reasonableness shown in Exhibit C-4. Based on the WSDOT mitigation allowance, the allowable area that the residences in the vicinity of Noise Barrier 8 can receive is 24,406 square feet, as shown in Exhibit C-4. The optimal barrier height for Noise Barrier 8 is 20 feet.

Exhibit C-4: Allowed Barrier Area for Noise Barrier 8 – 20 feet tall

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
32A	2	71	2,080	66	5
32B	3	69	0	67	2
33A	4	66	2,800	57	9
33A(2)	4	71	4,160	59	12
33B	4	54	0	52	2
33B(2)	4	54	0	53	1
33C	3	56	0	55	1
33C(2)	3	58	0	56	2
33D	3	65	2,100	56	9
33D(2)	3	69	2,712	61	8
33E	3	55	0	54	1
33E(2)	3	57	0	55	2
33F	3	64	2,100	59	5
33F(2)	3	67	2,304	62	5
33G	4	66	2,800	63	3
33G(2)	4	68	3,344	65	3
TOTAL Barrier Area (ft^2)			24,400	21,911	
Utility Relocation Cost ($)			--	40,000	
Planning-Level Cost ($)			$1,302,960	$1,170,047 + $40,000 = $1,210,047	

Additional barrier heights were evaluated to determine the optimal barrier height and potential noise reduction. At a height of 12 feet, Noise Barrier 8 provides a maximum noise reduction of 8 dBA for four ground-floor residences represented by Modeled Site 33A. Modeled Sites 32A and 33D represent the remaining five first-row residences, which all experience a reduction of

5 dBA or more. Receptors 33A(2), 33D(2), 33F, and 33F(2)—representing 13 ground-floor and second-floor residences—are predicted to achieve reductions that range from 3 dBA to 7 dBA.

Noise Barrier 8 meets WSDOT feasibility criteria at a height of 12 feet, because a 7-dBA reduction is achieved and a reduction of 5 dBA or greater is provided at most first-row residences. An area of approximately 13,147 square feet and a length of 1,096 feet are required for Noise Barrier 8 at this height. Utility relocation costs of $40,000 are included in the evaluation of reasonableness shown in Exhibit C-5. Based on the WSDOT mitigation allowance, the allowable area that the residences in the vicinity of Noise Barrier 8 can receive is 18,256 square feet, as shown in Exhibit C-5. The large amount of allowable wall area that remains available at the height of 12 feet indicates that additional noise reduction may be available by increasing the height of the barrier.

Exhibit C-5: Allowed Barrier Area for Noise Barrier 8 – 12 feet tall

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
32A	2	71	2,080	68	3
32B	3	69	0	68	1
33A	4	66	2,800	58	8
33A(2)	4	71	4,160	64	7
33B	4	54	0	53	1
33B(2)	4	54	0	53	1
33C	3	56	0	55	1
33C(2)	3	58	0	58	0
33D	3	65	2,100	60	5
33D(2)	3	69	2,712	64	5
33E	3	55	0	54	1
33E(2)	3	57	0	57	0
33F	3	64	2,100	61	3
33F(2)	3	67	2,304	64	3
33G	4	66	0	64	2
33G(2)	4	68	0	66	2
TOTAL Barrier Area (ft^2)			18,256	13,147	
Utility Relocation Cost ($)			--	40,000	
Planning-Level Cost ($)			$974,870	$702,050 + $40,000 = $742,050	

As shown in Exhibit C-6, Noise Barrier 8 was also evaluated at a height of 24 feet. As shown in Exhibit C-6, at a height of 24 feet Noise Barrier 8 meets WSDOT criteria for feasibility, because a 7 dBA noise reduction is experienced at several modeled sites and because all nine of the first-

row residences represented by Modeled Sites 32A, 33A, and 33D achieve at least a 5 dBA noise reduction.

At a height of 24 feet, an area of approximately 26,293 square feet and a length of 1,096 feet are required for Noise Barrier 8. Utility relocation costs of $40,000 are included in the evaluation of reasonableness shown in Exhibit C-6. Based on the WSDOT mitigation allowance, the allowable area that the residences in the vicinity of Noise Barrier 8 can receive is 24,406 square feet. Because the allowable area is less than the area needed for a 24-foot-tall barrier, the 24-foot height is not considered reasonable for Noise Barrier 8. A 0-to-1-dBA reduction is predicted per benefited receiver with the 24-foot barrier design, compared to the 20-foot barrier design. Only two additional residences experience noise levels below the NAC when comparing the 24-foot height to the 20-foot height.

Exhibit C-6: Allowed Barrier Area for Noise Barrier 8 – 24 feet tall

Modeled Site	Residences Represented	L_{eq} (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier (dBA)	Reduction (dBA)
32A	2	71	2,080	65	6
32B	3	69	0	67	2
33A	4	66	3,072	56	10
33A(2)	4	71	4,160	58	13
33B	4	54	0	52	2
33B(2)	4	54	0	53	1
33C	3	56	0	55	1
33C(2)	3	58	0	56	2
33D	3	65	2,100	55	10
33D(2)	3	69	2,712	58	9
33E	3	55	0	54	1
33E(2)	3	57	0	55	2
33F	3	64	2,100	57	7
33F(2)	3	67	2,304	61	6
33G	4	66	2,800	62	4
33G(2)	4	68	3,344	64	4
TOTAL Barrier Area (ft^2)			24,400	26,293	
Utility Relocation Cost ($)			--	40,000	
Planning-Level Cost ($)			$1,302,960	$1,404,046 + $40,000 = $1,444,046	

Noise Barrier 9 (Feasible, Not Reasonable)

A pocket of single-family residences located on Renton Avenue S, southeast of the southern limit of Mill Avenue S, were evaluated for a noise barrier. This noise barrier was evaluated

along the WSDOT right-of-way line east of I-405. The residences in this area are located at a much higher elevation than the I-405 lanes. Noise levels predicted at the sensitive receptor sites in this area range from 65 to 71 dBA without a barrier.

The maximum reduction provided by Noise Barrier 9 was 8 dBA for the three residences represented by Modeled Site 35D. As shown in Exhibit C-7, at a height of 16 feet Noise Barrier 9 meets WSDOT feasibility criteria, because a 7 dBA noise reduction is experienced at Modeled Sites 35B and 35D and 9 of the 12 first-row residences represented by Modeled Sites 35B, 35C, and 35D achieve at least a 5 dBA noise reduction. At a height of 16 feet, an area of approximately 11,584 square feet and a length of 724 feet is required for Noise Barrier 9. Based on the WSDOT mitigation allowance, the allowable area that residences in the vicinity of Noise Barrier 9 can receive is 10,236 square feet. Because the allowable area is less than the area needed for the shortest barrier in both height (16 feet) and length (724 feet), Noise Barrier 9 is not considered to be reasonable.

Exhibit C-7: Noise Barrier 9 – 16 feet tall

Modeled Site	Residences Represented	Leq (dBA)	Allowed Barrier Area (ft^2)	Noise Level with Barrier	Reduction (dBA)
35A	3	65	2,100	62	3
35B	3	66	2,100	59	7
35C	3	71	3,120	66	5
35D	3	70	2,916	62	8
Total Barrier Area (ft^2)			10,236	11,584	
Planning-Level Cost ($)			$546,602	$618,586	

*Planning-level cost based on typical construction techniques and engineering for noise barriers with a maximum height of 24 feet.