Bus Rapid Transit

I-405 corridor

Noise and Vibration Technical Memorandum

September 2020

SoundTransit

Consultant Quality Control Form

Version	Title	Date	Originator/ Drafted by	Reviewed by	Approved by	Notes, as required
0	I-405 BRT Noise and Vibration Technical Memorandum – Draft	December 9, 2019	Steven Wolf	Larissa King Rawlins (Task Lead) Ed Reynolds (tech edit) Sandi Wise (QC Review)	Chris Wellander	Initial Issue
1	I-405 BRT Noise and Vibration Technical Memorandum – Second Draft	February 26, 2020	Steven Wolf	Larissa King Rawlins (Task Lead) Ed Reynolds (tech edit) Sandi Wise (QC Review)	Chris Wellander	Second draft for ST review
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6	I-405 BRT Noise and Vibration Technical Memorandum	August 22, 2020	Larissa King Rawlins (Task Lead)	Ed Reynolds (tech edit) Sandi Wise (QC Review)	Chris Wellander	Revised final version in response to ST and WSDOT comments

Version	Title	Date	Originator/ Drafted by	Reviewed by	Approved by	Notes, as required
7	I-405 BRT Noise and Vibration Technical Memorandum	September 11, 2020	Larissa King Rawlins (Task Lead)	Ed Reynolds (tech edit) Sandi Wise (QC Review)	Chris Wellander	Final review and revisions before publishing

Summary

This Noise and Vibration Technical Memorandum assesses the potential noise and vibration effects of the proposed I-405 Bus Rapid Transit (BRT) project on existing noise-sensitive land uses. The Federal Transit Administration (FTA) General Noise and Vibration Assessment was used to predict noise and vibration levels from transit-related project components, such as BRT stations, park-and-ride lots and garages, and transit centers. The Federal Highway Administration (FHWA) Noise Abatement Criteria, as implemented by the Washington State Department of Transportation (WSDOT), were used to predict traffic noise at locations where roadway modifications are proposed. Noise-sensitive land uses were identified using Geographic Information System data, assessor's parcel maps, and aerial photos, and were verified through field work.

Construction of the project would result in temporary noise and vibration from the use of heavy equipment and machinery. Pile driving, which would produce the highest levels of noise and vibration at sensitive receivers, may occur to construct the foundations of the park-and-ride garages at the South Renton Transit Center and Kingsgate Park-and-Ride Garage. Prior to the start of construction, the contractor would develop a Noise Control Plan demonstrating how the local noise limits can be achieved. Once the project is constructed, vibration effects would not be noticeable since the rubber tires and suspension systems of the buses provide vibration isolation that minimizes groundborne vibration.

Based on the FTA General Noise Assessment, there were no future transit noise and vibration impacts predicted at noise-sensitive land uses and vibration-sensitive buildings near the project components. Mitigation measures would not be required.

Predicted noise from park-and-ride lots and garages and transit centers, which would not be in the public right-of-way, would not exceed the Washington Administrative Code Maximum Environmental Noise Levels at adjoining residential land uses.

Proposed roadway improvements at project components would not create a new line of sight to a sensitive receiver, would not substantially change the vertical or horizontal roadway alignment, and would result in minimal to no change to overall traffic volumes. Therefore, based on WSDOT policy, the roadway improvements do not require a FHWA traffic noise abatement analysis.

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Acronyms and Abbreviations

BMC	Burien Municipal Code
BRT	bus rapid transit
CFR	Code of Federal Regulations
dB	decibel
dBA	A-weighted decibel
EDNA	Environmental Designations for Noise Abatement
ETL	electronic toll lanes
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
in/sec	inches per second
L_{dn}	day/night sound level
L_{eq}	equivalent noise level
L_{max}	maximum noise level
mph	miles per hour
PPV	peak particle velocity
Project	I-405 Bus Rapid Transit Project
SR	State Route
ST	Sound Transit
TNM	Traffic Noise Model
TSP	transit signal priority
VdB	decibel notation
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

1 INTRODUCTION

1.1 Overview

The I-405 Bus Rapid Transit (BRT) Project would provide BRT service, primarily operating in managed and bus-only lanes within the I-405 and State Route (SR) 518 corridors for 37 miles between Lynnwood and Burien. The project alignment as well as proposed transit stations and park-and-ride garages are shown in **Figure 1-1**. The new BRT service is planned to operate as two high-capacity transit lines, inter-connecting at the Bellevue Transit Center near the future Bellevue Downtown Link light rail station. The north BRT line would operate between the Bellevue Transit Center and the Lynnwood City Center transit center, and the south BRT line would operate between the Bellevue Transit Center and the Burien Transit Center. Together, the I-405 BRT lines (north and south) would serve 11 stations, including one new transit center in Renton and one new park-and-ride garage in Kirkland. In addition, a park-and-ride lot would be constructed to increase park-and-ride capacity in the I-405 corridor (NE 44th Street, Renton).

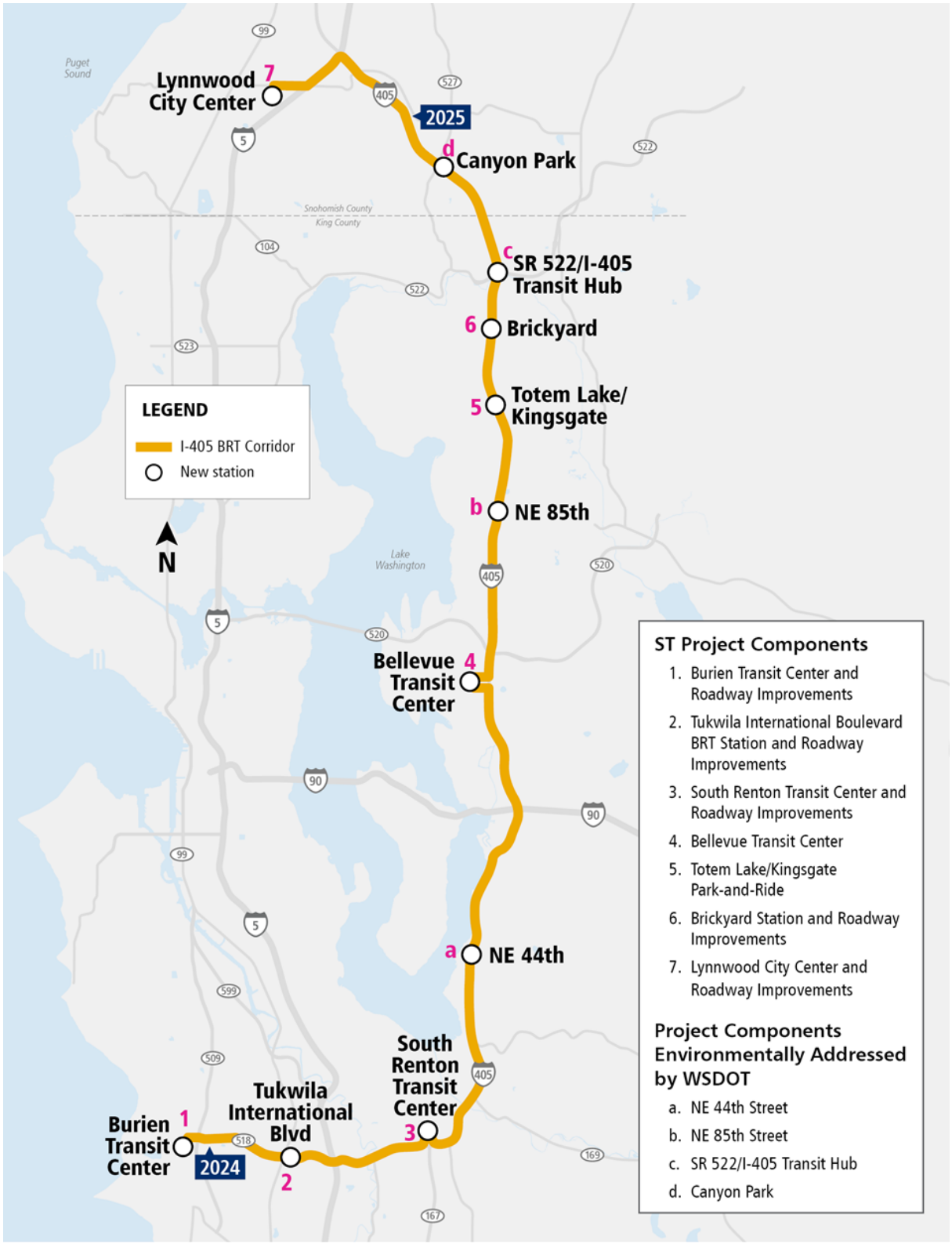
In large part, the project would operate in express toll lanes (ETLs) along I-405, including segments of existing ETLs and segments of ETLs that the Washington State Department of Transportation (WSDOT) will construct between Bellevue and Tukwila (WSDOT 2018) and between the Canyon Park and Brickyard Stations. Along SR 518, the project would operate primarily in general-purpose lanes, with bus-only lanes approaching and leaving the BRT station. Buses would move along local arterial roads to access transit facilities in Burien, Renton, Bellevue, and Lynnwood. It should be noted that WSDOT, in partnership with Sound Transit, has completed the environmental analysis, including noise and vibration, for the:

- NE 44th Street Station and Park-and-Ride
- NE 85th Street Station
- SR 522/I-405 Transit Hub
- Canyon Park Station

This document does not provide any additional information about these four locations.

Figure 1-1 shows all BRT project components, including the four locations with environmental analysis completed by WSDOT, for reference, and also shows the following project components for which Sound Transit is completing environmental analysis and which are discussed in this memorandum:

- Burien Transit Center and Roadway Improvements
- Tukwila International Boulevard BRT Station and Roadway Improvements
- South Renton Transit Center and Roadway Improvements
- Bellevue Transit Center and Off-site Layover
- Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage
- Brickyard Station and Roadway Improvements
- Lynnwood City Center Transit Station BRT and Roadway Improvements



SOURCE: Sound Transit 2020

Figure 1-1 I-405 Bus Rapid Transit Project

1.2 Purpose of technical memorandum

The purpose of this technical memorandum is to assess future noise and vibration effects on noise-sensitive land uses near project components as a result of the construction and operation of the proposed I-405 BRT Project. The potential project effects are noise from BRT operations at proposed bus stations, transit centers, and park-and-ride lots and garages and from roadway modifications.

The Federal Transit Administration (FTA) General Noise Assessment was used to predict transit noise levels from BRT operations at project components. The Federal Highway Administration (FHWA) Noise Abatement Criteria, as implemented by WSDOT, was used to predict traffic noise at project components where roadway modifications are proposed. Noise-sensitive land uses were identified using Geographic Information System (GIS) data, assessor's parcel maps, aerial photos and were verified through field work.

2 PROJECT DESCRIPTION

2.1 I-405 BRT operations

The new BRT service is planned to operate as two high-capacity transit lines, inter-connecting at the Bellevue Transit Center near the future Bellevue Downtown Link light rail station. The north BRT line would operate between the Bellevue Transit Center and the Lynnwood City Center transit center, and the south BRT line would operate between the Bellevue Transit Center and the Burien Transit Center. BRT service would have 10-minute headways during peak periods and 15-minute headways the remainder of the day and on weekends. Assuming a similar pattern to the Sound Transit Express and Sound Transit service standards, peak periods would be from 6 a.m. to 9 a.m. and from 3 p.m. to 6 p.m. on weekdays. During peak periods when travel time has more variation, the level of bus service could vary to maintain 10-minute headway service. The span of service would be 19 hours on weekdays and Saturday and up to 17 hours on Sundays.

2.2 Project components

All project components would include a proposed BRT-branded (Stride) uniquely identifiable pylon (decorative column) at the transit station to alert BRT riders to the service access point. The pylon may be internally illuminated to be identifiable in the evening and during hours of less light. In addition, all project components would likely include ticket vending machines (TVMs), security cameras and real-time bus information signs at stations for passengers. These are considered to be standard elements for all project components.

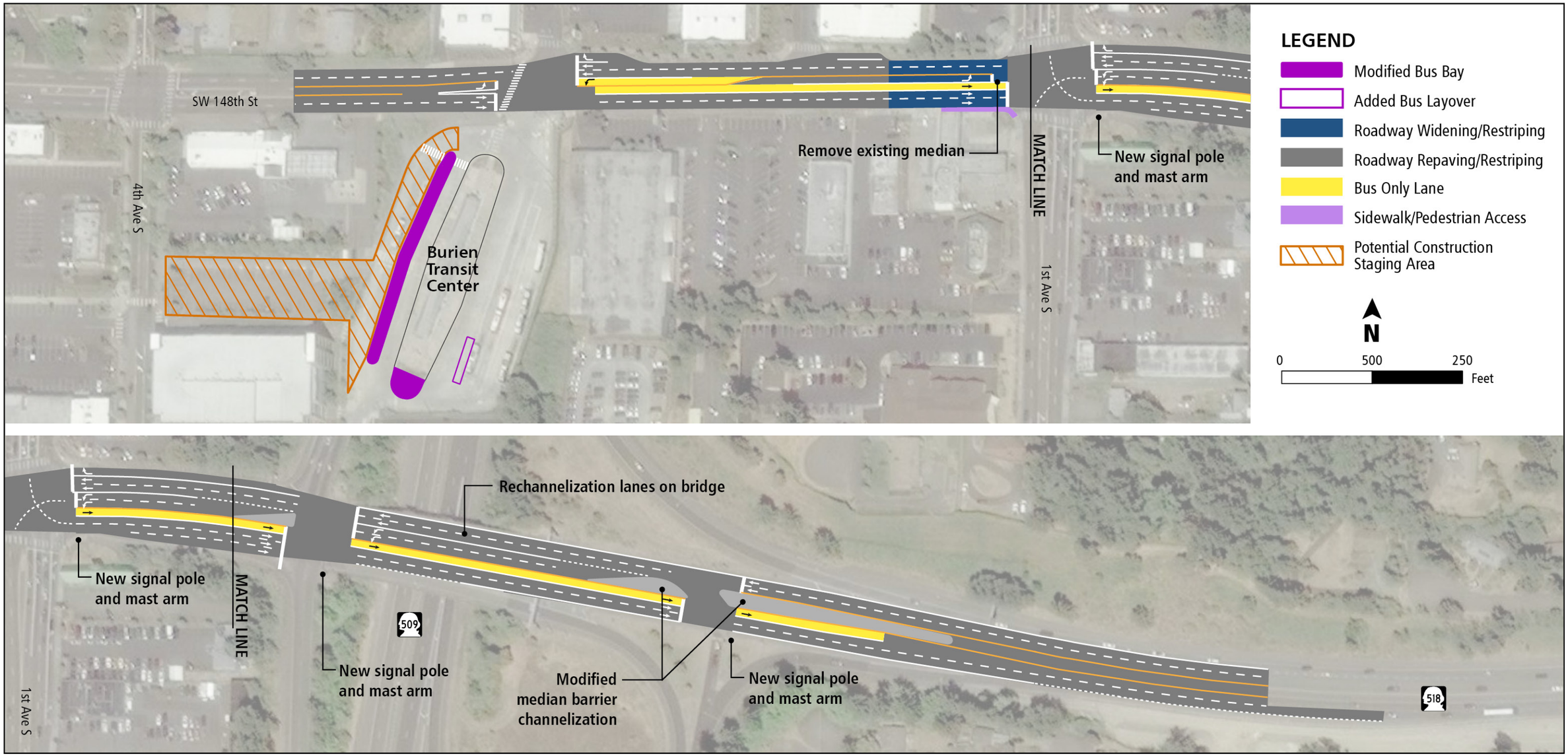
2.2.1 Burien Transit Center and Roadway Improvements

Figure 2-1 provides a graphic representation of the proposed Burien Transit Center and associated Roadway Improvements.

To access the Burien Transit Center, westbound vehicles would turn left into the existing transit center driveway access, circulate south around the main transit center island and then west to the west transit center island. Within the Burien Transit Center, the existing main transit center island would be extended approximately 20 feet south to provide additional bus bay capacity; the height of this transit center island would remain at 6 inches. The west transit center island would be reconstructed to provide 9-inch-high platforms and would be lengthened to the south approximately 60 feet and to the north approximately 50 feet; the northern portion would also be shifted slightly to be angled to the east. The BRT service would use the northern portion of the west transit center island. The station would include a BRT-branded shelter and benches, in addition to the amenities at all project component stations.

New crosswalks may be added at the northern end of the west transit center island, one connecting the pedestrian path from the sidewalk on SW 148th Street to the west transit center island and a second extending east to connect to the main transit center island. The BRT vehicles would use the layover area in the Burien Transit Center. This project component may add one layover space to the southwest portion of the existing layover area. To exit the Burien Transit Center, BRT vehicles would circulate around the transit center islands to the existing driveway access and then turn right to travel eastbound on SW 148th Street.

To improve transit speed and reliability, a bus-only lane would be added east of the transit center entrance for eastbound buses along SW 148th Street that would extend east across the SR 509/SR 518 interchange and along SR 518 for approximately 400 feet. For westbound buses, a new bus-only left-turn pocket would be added beginning approximately 240 feet east of the transit center driveway access. Between 1st Avenue S and the Burien Transit Center, the bus-only lane and the bus-only left-turn pocket on SW 148th Street would be accommodated by converting the center two-way turn lane and, in the southeast section, slightly widening the existing roadway. Between the Burien Transit Center and 1st Avenue S, driveways would become right-in/right-out only. To accommodate the eastbound bus-only lane on the SR 518 bridge over SR 509, the existing lane striping would be rechannelized. Transit signal priority (TSP) would be added to the existing traffic signals at the intersection of SW 148th Street and 1st Avenue S, at the intersection of SW 148th Street and the SR 509 southbound on- and off-ramps, and at the intersection of SR 518.



SOURCE: Sound Transit 2020

Figure 2-1 Burien Transit Center and Roadway Improvements

2.2.1.1 Utilities and connections

Anticipated utilities needed to serve the BRT station include electric power, communications, and possibly water, which would be connected to utilities currently available in the transit center site or within SW 148th Street.

For this project component, all stormwater would be collected underground and detention would be provided as required. For the Burien Transit Center, flow control and water quality treatment would meet the requirements of the *King County Surface Water Design Manual* (King County 2016) and agreements between the King County Metro Transit Division, the property owner, and the City of Burien Public Works Department. Roadway modifications to SW 148th Street would comply with City of Burien requirements, which follow the *King County Surface Water Design Manual*, for flow control and water quality treatment. Stormwater facilities would ultimately tie into the existing conveyance systems. For the roadway modifications along SR 518, stormwater would meet the requirements of WSDOT's *Highway Runoff Manual* (WSDOT 2019) for flow control and water quality treatment. Stormwater facilities also would ultimately tie into the existing conveyance systems.

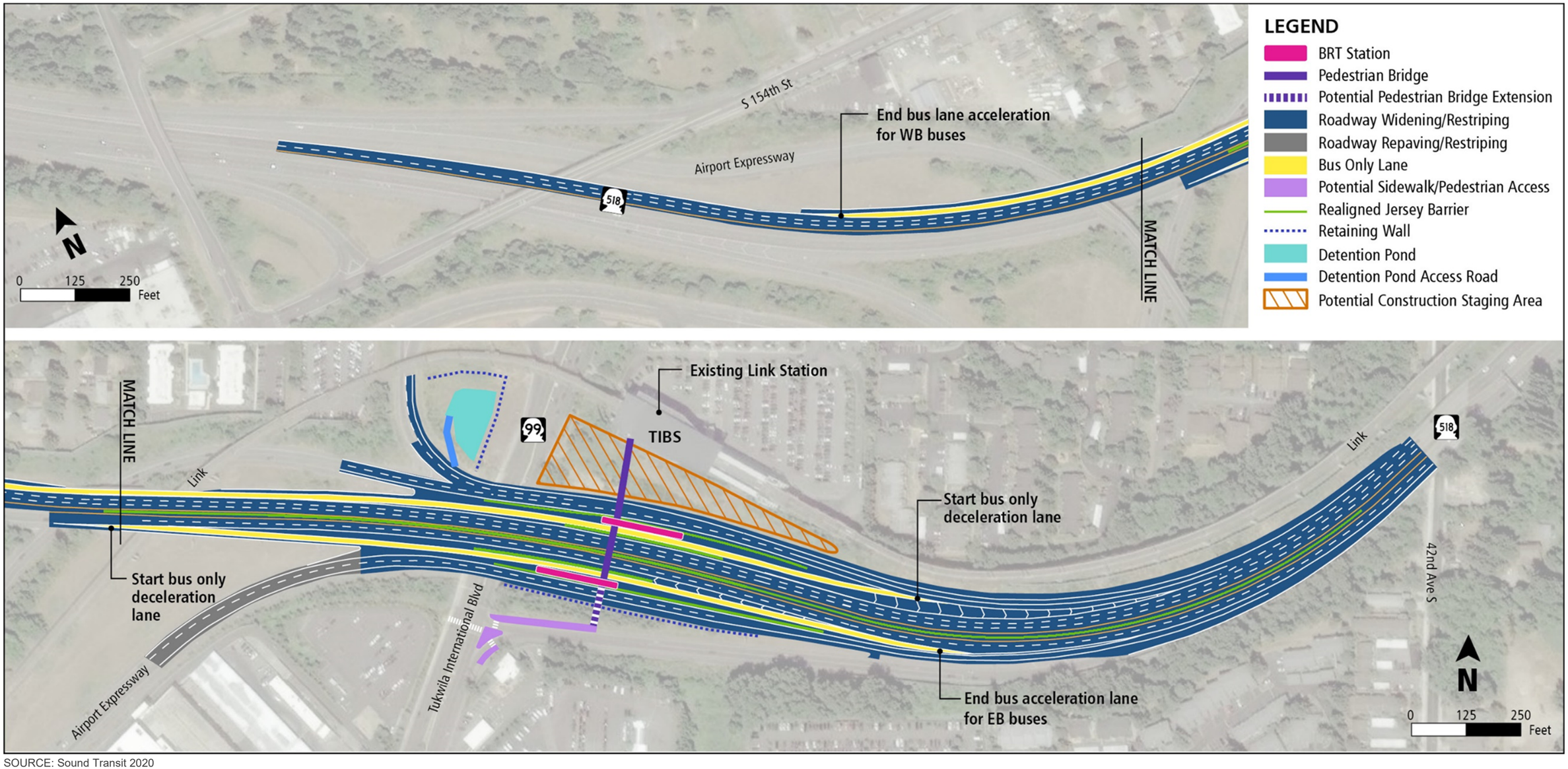
2.2.1.2 Site work

It is anticipated that the contractor would stage the necessary construction equipment and materials within the Burien Transit Center, including potentially using adjacent parking areas also owned by King County Metro.

2.2.2 Tukwila International Boulevard BRT Station and Roadway Improvements

Figure 2-2 provides a graphic representation of the proposed Tukwila International Boulevard BRT Station, the new pedestrian bridge, and associated roadway improvements. The proposed BRT station would be accessed by a new pedestrian bridge that would be constructed from the mezzanine level of the Tukwila International Boulevard Link light rail station and extended south across SR 518, connecting to the eastbound and westbound BRT station platforms. The walking surface of the pedestrian bridge would be level with the mezzanine floor level of the Link station and roughly level with the existing Tukwila International Boulevard bridge over SR 518. From the pedestrian bridge, access down to each BRT station platform would be provided by stairs and an elevator. The pedestrian bridge is also anticipated to extend to the south and connect at grade to an existing sidewalk on the eastbound on-ramp to SR 518 that connects to sidewalks on Tukwila International Boulevard.

The proposed BRT station (eastbound and westbound station platforms) would be located at-grade within the SR 518 right-of-way in an existing area between the SR 518 travel lanes and the on- and off-ramps to SR 518. In addition to the standard elements, the BRT station would include a branded shelter, benches, and raised platforms (approximately 9 inches) for level or near-level passenger boarding. Approaching both the east and westbound BRT station platforms, bus-only lanes would be added (for a total length of approximately 1,900 feet eastbound and 2,800 feet westbound) to allow BRT vehicles to safely decelerate to pick up/drop off at the station platform and accelerate from the station platforms and merge back onto SR 518 with general-purpose traffic. The addition of these bus-only lanes would require realigning the center jersey barrier, regrading, and repaving a portion of the existing SR 518 travel lanes and ramps to and from the interchange of SR 518 with Tukwila International Boulevard. In the westbound direction, the bus-only lane would also require widening the existing westbound SR 518 bridge that passes over the SR 518 off-ramp heading south to Airport Expressway.



SOURCE: Sound Transit 2020

Figure 2-2 Tukwila International Boulevard BRT Station and Roadway Improvements

A new retaining wall for fill would be constructed along the west side of the eastbound bus-only deceleration lane for approximately 900 feet, with a maximum height of 6 feet. On the south side of SR 518, adjacent to eastbound SR 518, there would be a new retaining wall for a length of approximately 730 feet, with a maximum height between 10 and 15 feet.

2.2.2.1 Utilities and connections

Anticipated utilities needed to serve the BRT station include electric power, communications, and possibly water, which would be connected to utilities currently available in or near SR 518 right-of-way.

Additionally, a stormwater detention facility would be constructed inside the westbound SR 518 off-ramp loop. The detention pond would include an adjacent retaining wall with a maximum height of 11 feet. Stormwater would be collected underground and detention would be provided as required. Flow control and water quality treatment would be provided as required by WSDOT's *Highway Runoff Manual* (WSDOT 2019), and stormwater facilities would ultimately tie into the existing conveyance systems.

2.2.2.2 Site work

During construction, dewatering is anticipated near the Tukwila International Boulevard BRT Station area for construction of new retaining walls.

For this project component, the contractor would be expected to stage the necessary construction equipment and materials within the existing right-of-way for SR 518, likely in the area between westbound SR 518 and the existing Tukwila International Boulevard Link light rail station, outside of the active travel lanes and the on- and off-ramps.

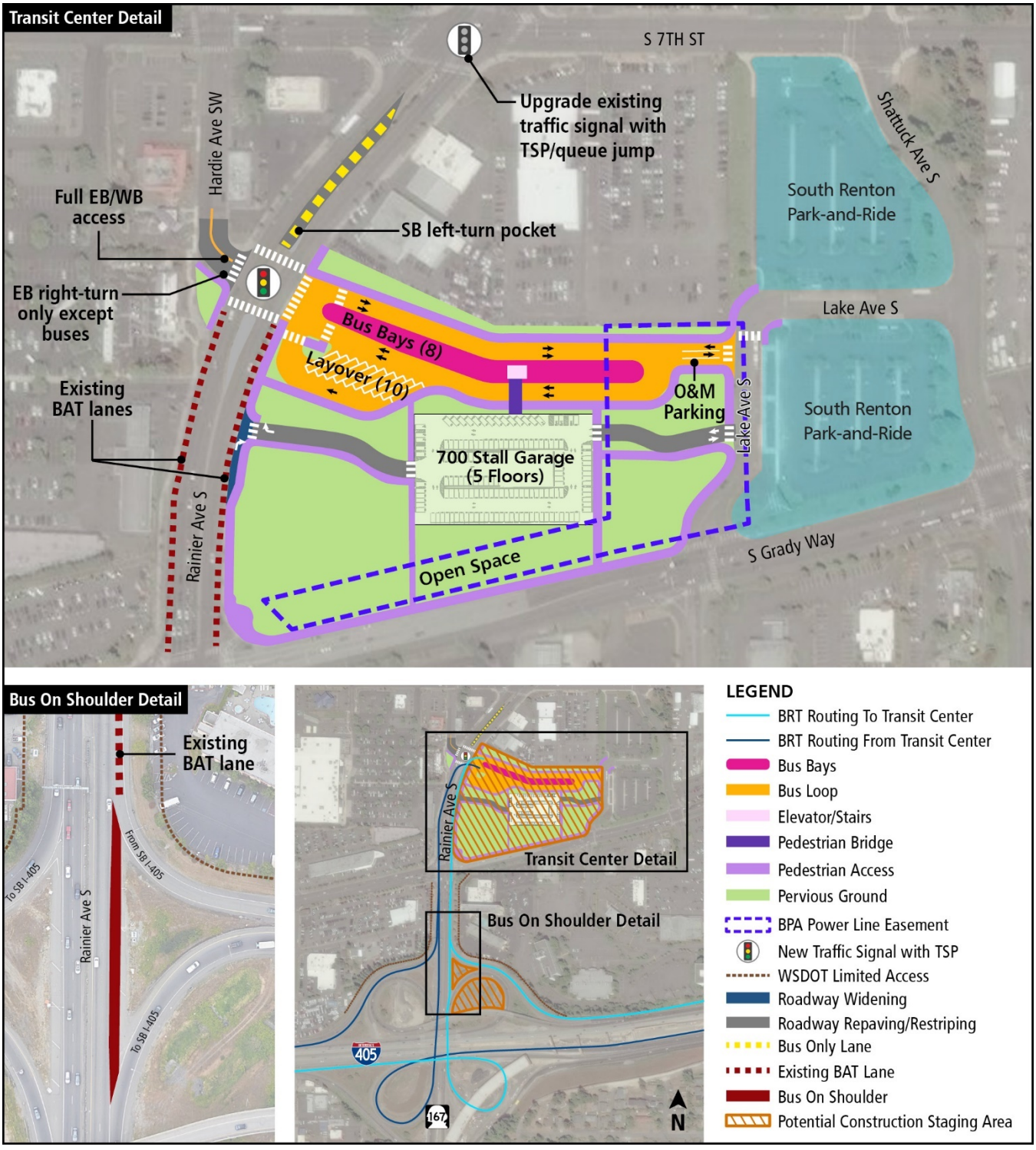
2.2.3 South Renton Transit Center and Roadway Improvements

Figure 2-3 provides a graphic representation of the proposed South Renton Transit Center and Roadway Improvements.

The South Renton Transit Center would be located on the north side of I-405, in the northeast corner of the intersection of S Grady Way and Rainier Avenue S. This new transit facility would be developed on an 8.3-acre site. Facilities at the South Renton Transit Center would include the following:

- A new transit center island with eight 120-foot active bus bays with operational space provided for both BRT and other bus transit service (operated by King County Metro, with the assumption that they will use 6 active bays) using this facility. In addition to the standard elements, the BRT station in the transit center island could include a branded BRT shelter (if the entire transit center island is covered by a single, large shelter there would only be the pylon) and 9-inch raised platforms for near-level passenger boarding.

- Ten bus layover bays in the bus loop area.



SOURCE: Sound Transit 2020

Figure 2-3 South Renton Transit Center and Roadway Improvements

- A 700-stall, 5-floor park-and-ride garage with drop-off and pick-up stalls on the first floor. Access to the park-and-ride garage would be from a separate right-turn-only entrance and exit from Rainier Avenue S, located south of the access to the transit center bus loop. A second access to the park-and-ride garage would be from Lake Avenue S; this access would not be restricted to right-in/right-out turns.

- From the third floor of the park-and-ride garage, a pedestrian bridge would potentially connect the garage to a staircase and elevator connecting to the middle of the transit center island.

- Pedestrian access to the transit center site would be from the existing and reconstructed sidewalks along Rainier Avenue S and S Grady Way. A new sidewalk would be constructed along the eastern side of the transit center, along the frontage of Lake Avenue S. Pedestrian sidewalks would also be constructed within the transit center site along the north and south sides of the bus loop, from Rainier Avenue S and Lake Avenue S to the park-and-ride garage, from S Grady Way north into the site, and between the park-and-ride garage and the bus loop.

To access the South Renton Transit Center from I-405, BRT vehicles heading in a westerly direction (southbound) on I-405 would use the exit onto SR 167 N/Rainier Avenue S into an existing northbound, curbside business access and transit (BAT) lane. BRT buses would stay in the existing BAT lane across S Grady Way along Rainier Avenue S. BRT vehicles heading in an easterly direction (northbound) on I-405 would access the South Renton Transit Center using the existing exit onto SR 167 N/Rainier Avenue S. To improve transit speed and reliability, northbound BRT vehicles would use a new short section of a bus-only, bus-on-shoulder lane on northbound SR 167 that would be constructed starting at the existing loop ramp from SR 167 to southbound I-405 and extending north approximately 200 feet to connect with the existing BAT lane.

Once across S Grady Way, BRT vehicles heading northbound would turn right into the transit center's bus loop from a new signalized intersection at Rainier Avenue S and Hardie Avenue SW. This new intersection would also be the exit point for buses leaving the transit center and would be the primary ingress and egress location for the buses. Within this intersection, the existing raised, landscaped median in Rainier Avenue S would be removed to allow for turning movements, and crosswalks would be provided at each of the four roadway crossings. North of this intersection, the existing center median within Rainier Avenue S would be removed for a new southbound bus-only left-turn pocket that would allow buses to turn left into the transit center; a small section of a center median may remain at the southern end of the bus-only left-turn pocket. At the connection to Rainier Avenue S, Hardie Avenue SW would be reconstructed to realign the southbound lane adjacent to the northbound lane. This shift would require removing the northern portion of an existing raised, landscaped island. In place of the existing southbound lane on Hardie Avenue SW, a landscaped curb would be constructed, connecting with the remaining portion of the existing island. For general-purpose traffic, the southbound lane on Hardie Avenue SW would be right-turn only. Buses on Hardie Avenue SW would be able to travel through the intersection into the transit center.

A secondary bus access into the transit center's bus loop would be from the east side of the site from Lake Avenue S. This secondary access would also provide connectivity to the bus bays and layover spaces at the existing South Renton Park-and-Ride located just east of the South Renton Transit Center. Access from Lake Avenue S provides bus circulation and access from S

Grady Way, Shattuck Avenue S, and S 7th Street. Parking for operation and maintenance vehicles would be located parallel to the Lake Avenue S access to the bus loop.

In the southern portion (adjacent to S Grady Way) and the eastern portion of the site (adjacent to Lake Avenue S) there is an existing Bonneville Power Administration power line easement. Along the south boundary, the easement is approximately 100 feet in width. In the eastern portion of the site the easement is approximately 200 feet in width. Prior to the start of construction, Sound Transit would coordinate with the Bonneville Power Administration, and utility providers as needed, to ensure construction activities would not interfere with their facilities and service. Once constructed, the transit facilities would not alter, affect, or interfere with this existing 240 kilovolt transmission line across the site. The easement area under the transmission lines would primarily be green space (where existing pavement would be removed) or would consist of ground-level improvements, such as the driveway into the park-and-ride garage off of Lake Avenue S and the eastern portion of the transit loop. In addition, the existing sculpture located at the northeast corner of the intersection of Rainier Avenue S and S Grady Way, adjacent to the southwest corner of the transit center site, would remain.

BRT vehicles leaving the South Renton Transit Center would turn left onto Rainier Avenue S into an existing, southbound curbside BAT lane and then onto either northbound or southbound I-405 using existing on-ramps. Signal-timing improvements would be made, including adding TSP to the traffic signal at the intersection of S Grady Way and southbound SR 167 and at Rainier Avenue S and SW 7th Street.

2.2.3.1 Utilities and connections

Anticipated utilities to serve this project component include electric power (transmission and distribution), storm drainage, sanitary sewer, water, public agency telecommunications, and commercial telecommunications. Electric power and telecommunications would be tied into utilities currently available near the project component, such as either from S Grady Way or Rainier Avenue S. Electrical service would be coordinated with the local electrical service provider (Puget Sound Energy) who would extend service to the site. Construction within the existing power line easement would be limited to equipment that would not interfere with the high voltage, overhead power lines. Potential conflicts may exist between existing utilities and structure foundations, which would require relocating the existing utilities.

For this project component, stormwater within the transit center site would be collected underground and detention would be provided either above grade or below grade as required. Currently, three compost amended biofiltration swales are proposed on-site upstream of existing catch basins and would tie into the existing catch basins. Flow control and water quality treatment would be provided as required by the *City of Renton Surface Water Design Manual* (City of Renton 2017). Stormwater facilities would ultimately tie into existing conveyance systems. Within the Rainier Avenue S/SR 167 right-of-way, stormwater would be collected underground and detention would be provided either above grade or below grade as required. Flow control and water quality treatment would be provided as required by WSDOT's *Highway Runoff Manual* (WSDOT 2019), and stormwater facilities would tie into the existing conveyance systems.

2.2.3.2 Site work

For construction of the South Renton Transit Center, the contractor would likely stage the necessary equipment and materials on the site. For construction of the bus-on-shoulder lane along SR 167, the contractor may stage equipment and materials in the area to the east of SR 167, within the existing, unpaved right-of-way for I-405.

Dewatering is potentially anticipated at the South Renton Transit Center depending on the type of foundation used for the parking garage.

Prior to construction, the existing buildings on-site would be removed and properly disposed of and on-site remediation would be completed as identified in the Phase II Environmental Site Assessment (Shannon & Wilson 2018). The site would be cleared and graded as needed for the proposed transit center features and to provide adequate drainage.

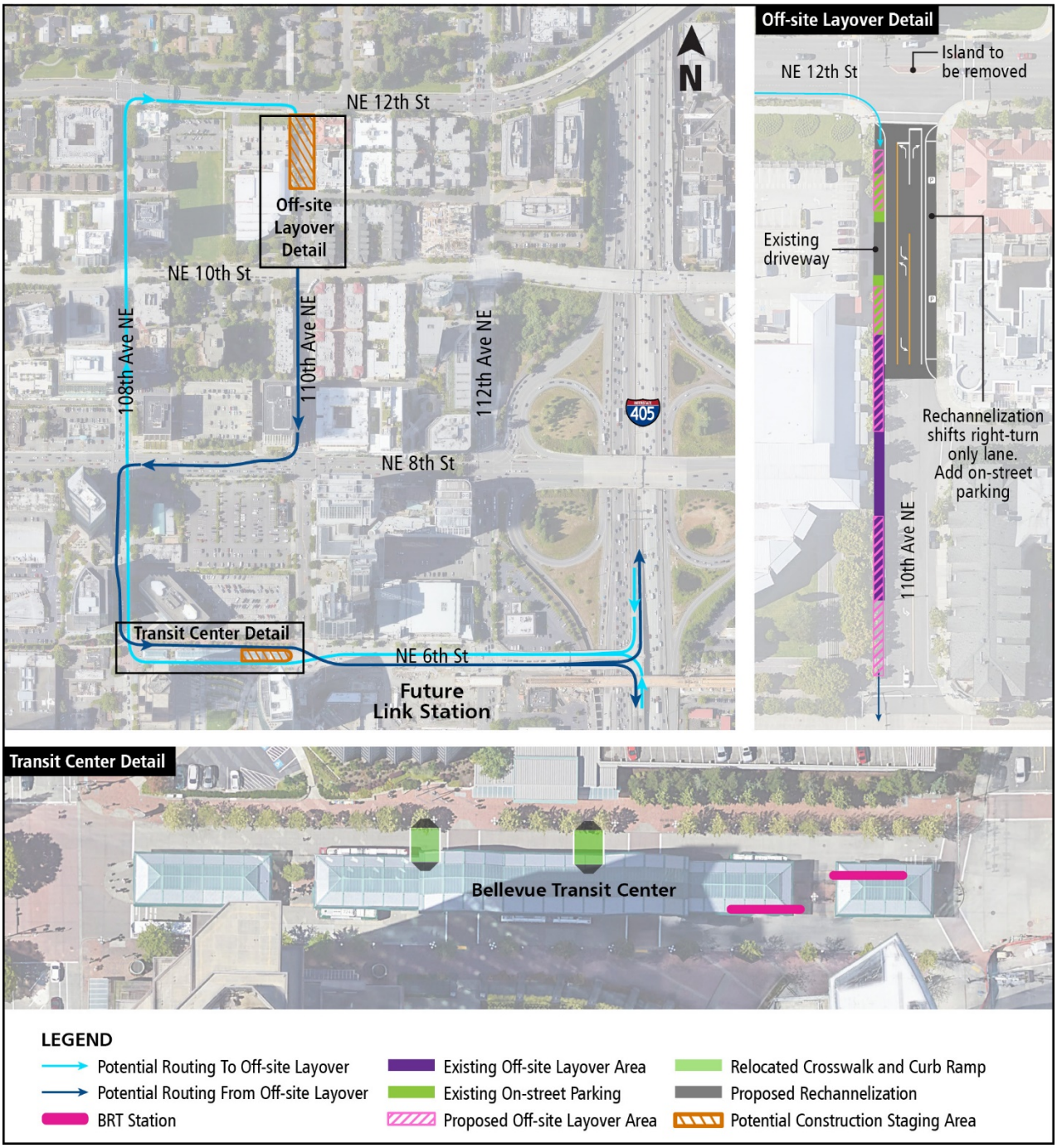
Concrete paving would be used for all driveways and bus and large maintenance vehicle parking areas. Limited areas of asphalt paving would be provided in areas trafficked by personal vehicles. A retaining wall with a maximum height of 5 feet would be constructed along the northern edge of the site. The site would be equipped with lighting to support operations and as needed for security. Landscaping would be provided in designated areas and in accordance with City of Renton requirements, including regulations relating to maintenance and irrigation.

2.2.4 Bellevue Transit Center and Off-site Layover

Figure 2-4 provides a graphic representation of the proposed Bellevue Transit Center improvements, off-site layover space, and potential BRT routing to and from the improvements and I-405.

At the Bellevue Transit Center, two existing bus bays would be modified with the standard station elements for the BRT service. The existing height of the transit center island would remain, as would the shelter over the transit center island; a BRT-branded pylon would be installed to identify the bays used for the BRT service. On the north side of the transit center island, two existing crosswalks across NE 6th Street would be relocated (shifted slightly west from their current locations). To maintain Americans with Disability Act accessibility at these relocated crosswalks, the existing curb ramps on the transit center island and on the north side of NE 6th Street would be re-graded. This regrading would be coordinated with the City of Bellevue's Downtown Bellevue Exceptional Intermodal Connections project to raise the intersections east and west of the transit center (City of Bellevue 2020).

The BRT vehicles would have on-street layover along 110th Avenue NE in front of the Bellevue Library, which is less than one-half mile north of the transit center. To access the layover space from the transit center, BRT vehicles would be anticipated to turn right onto 108th Avenue NE, then right onto NE 12th Street, and then right onto 110th Avenue NE.



SOURCE: Sound Transit 2020

Figure 2-4 Bellevue Transit Center and Off-site Layover

In the northern portion of 110th Avenue NE, the roadway cross-section would be modified. On the west side of 110th Avenue NE the existing on-street parking would be removed to provide additional bus layover capacity north and south of the existing driveway into the library parking garage. The one existing southbound through lane would remain. In the northbound direction, the rechannelization includes shifting the right-turn-only lane slightly west to provide on-street parking spaces along the east side of the street to replace what was removed along the west side of the street. Through re-striping, the existing painted median would be replaced with a left-turn-only pocket from 110th Avenue NE to NE 12th Street. No changes to the existing sidewalks are proposed. The existing raised island in the middle of the intersection of 110th Avenue NE and NE 12th Street would be removed. In the southern portion of 110th Avenue NE, the existing bus layover space just north of NE 10th Street would remain.

From the layover space, BRT vehicles would be anticipated to access the Bellevue Transit Center by heading south on 110th Avenue NE, turning right onto NE 8th Street, left onto 108th Avenue NE, and then left onto NE 6th Street into the transit center.

2.2.4.1 Utilities and connections

Anticipated utilities needed to serve the BRT station include electric power, communications, and possibly water, which would be connected to utilities currently available in the transit center site.

For this project component, flow control and water quality treatment would be provided as required by the City of Bellevue. Stormwater would ultimately tie into the existing conveyance systems. For the work at the Bellevue Transit Center, the contractor would likely stage the necessary equipment and materials all within the existing transit center.

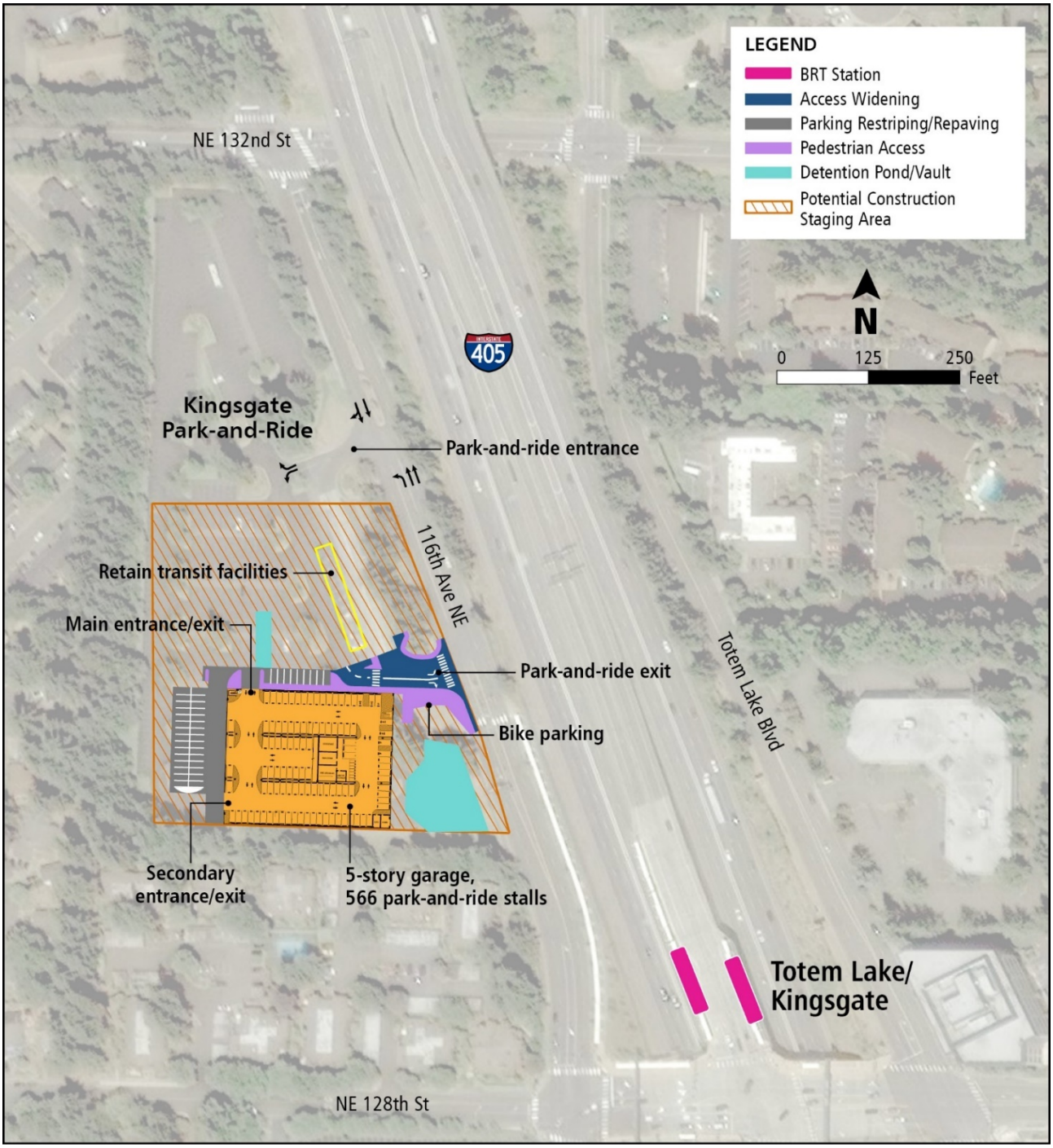
2.2.4.2 Site work

For the layover area, construction staging would be expected within the existing right-of-way for 110th Avenue NE. Off-site staging areas are not anticipated.

2.2.5 Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage

Figure 2-5 provides a graphic representation of the proposed Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage.

The existing Totem Lake Freeway Station is located on the in-line direct access ramps that extend from the center of I-405 up to the NE 128th Street overcrossing of I-405 (on the north side of NE 128th Street). For the Totem Lake/Kingsgate BRT Station, one bay of each existing station pair would be transformed into a BRT station with the standard station elements. TVMs may be installed at the station platform or they may just be located at the Kingsgate Park-and-Ride Garage. At this station, the existing 6-inch height of the platforms and the existing shelter over the station platforms would remain. TSP would be added at the intersection of the in-line ramp terminal and NE 128th Street.



SOURCE: Sound Transit 2020

Figure 2-5 Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage

The existing Kingsgate Park-and-Ride lot is located west of the Totem Lake/Kingsgate Station along 116th Avenue NE. The Kingsgate Park-and-Ride site is approximately 8 acres in size and consists of 502 surface park-and-ride spaces and an existing bus transit loop currently used by Sound Transit express routes, several King County Metro routes, and one Community Transit route. The site is owned by WSDOT, considered to be right-of-way for I-405, and is operated and maintained by King County Metro.

This project component includes adding 400 park-and-ride spaces at the Kingsgate site by constructing a garage structure in the southern portion of the existing surface park-and-ride lot to create a total of approximately 900 park-and-ride spaces on the site. Sound Transit would construct a 5-story park-and-ride garage with approximately 566 park-and-ride stalls. The 566 park-and-ride stalls would replace 166 surface park-and-ride spaces that would be displaced by the garage and would provide an additional 400 park-and-ride spaces. The park-and-ride garage would be equipped with lighting to support operations and as needed for safety and security. Landscaping would be provided in designated areas in accordance with City of Kirkland and Sound Transit requirements, including maintenance and irrigation. Security cameras are anticipated to be used in the vicinity of the garage structure.

Access to the Kingsgate site would continue to be through two driveways from 116th Avenue NE, and the existing on-site circulation would not change. The northern driveway along 116th Avenue NE would remain as is and would continue to be the only entrance to the park-and-ride lot, with vehicles southbound on 116th Avenue NE turning right and vehicles northbound on 116th Avenue NE turning left. To access the park-and-ride garage, vehicles from 116th Avenue NE would use this northern driveway and then circulate through the surface park-and-ride aisles to the main garage entrance/exit on the northwest corner of the structure or the secondary access on the southwest corner of the structure.

Vehicles exiting the garage would turn right immediately past the proposed single row of park-and-ride stalls located along the northern side of the garage, drive along the aisle, and exit the site using the southern driveway to 116th Avenue NE. The existing southern driveway would be shifted slightly north to accommodate the garage structure. This shift in the driveway location would result in a slight modification to the existing bus loop, located just north, that uses this driveway. The existing bus loop would remain on-site. The two lanes of this driveway would continue to be one right-turn-only and one left-turn-only to exit the site. Asphalt paving would be provided in areas trafficked by personal vehicles. Additional work within the Kingsgate site includes providing sidewalks for pedestrian access from 116th Avenue NE along the north side of the garage to the main entrance. This sidewalk would connect to the existing crosswalk across 116th Avenue NE to the covered walkway along the east side that continues south and then east to connect to the Totem Lake/Kingsgate Station.

2.2.5.1 Utilities and connections

Anticipated utilities to serve this project component include electric power (transmission and distribution), storm drainage, sanitary sewer, water, public agency telecommunications, and commercial telecommunications. Electric power and telecommunications would be tied into utilities currently available near the project component. Electrical service would be coordinated with the local electrical service provider (Puget Sound Energy) who would extend service to the site from 116th Avenue NE. Potential conflicts may exist between existing utilities and the proposed garage structure foundation, which would require relocation of the existing utilities.

For this project component (both the Totem Lake Station and the Kingsgate Park-and-Ride Garage), stormwater would be collected underground and detention would be provided either above grade or below grade as required. Stormwater management facilities would include modifications to the existing detention pond in the southeast corner of the site, a bioretention swale along the south side of the garage, and a detention vault that would be located underground, below the surface park-and-ride stalls (**Figure 2-5**). Flow control and water quality treatment would be provided as required by WSDOT's *Highway Runoff Manual* (WSDOT 2019). Stormwater would ultimately tie into the existing conveyance systems.

2.2.5.2 Site work

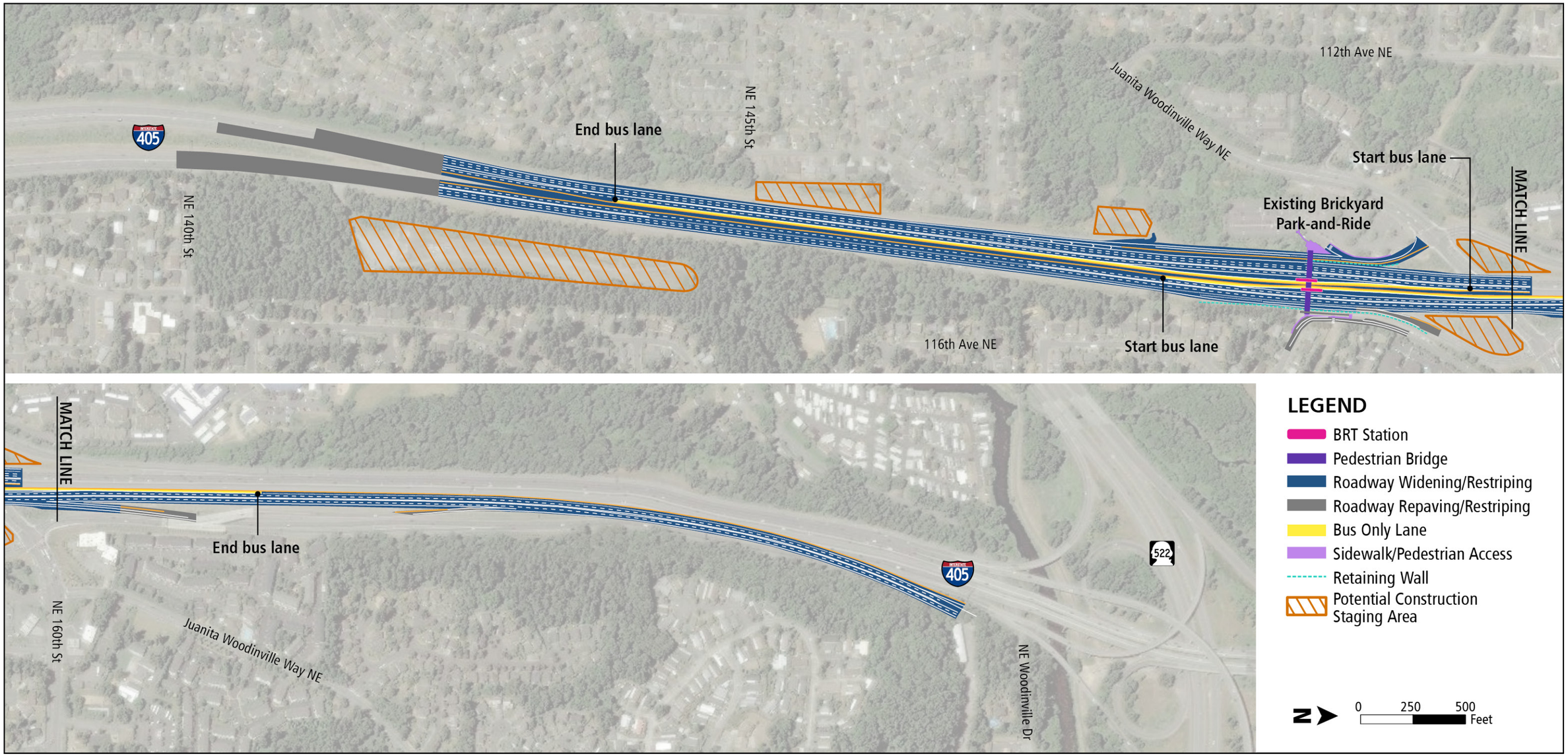
For the work at the Totem Lake Station and the Kingsgate Park-and-Ride, the contractor would likely stage the necessary equipment and materials on the Kingsgate site. The Kingsgate Park-and-Ride lot was constructed with FHWA funds. A requirement of this funding is to maintain the existing 502 park-and-ride stalls associated with the lot. During construction of the Kingsgate Park-and-Ride Garage, a number of the existing surface stalls within the footprint of the garage and areas needed for construction staging would be inaccessible. Prior to construction, nearby temporary parking spaces would be identified for use as temporary replacement parking during construction. These temporary parking spaces are anticipated to be from existing, nearby properties with underused parking that could be leased through temporary construction easements.

Prior to construction, the southern portion of the Kingsgate Park-and-Ride lot where the garage would be located would be cleared of existing trees/vegetation and pavement, and would be graded as needed for the garage structure and the drainage vault. The existing trees along the southern and western site boundary would remain, as would the existing raised berm along the western site boundary.

Concrete paving would be used for all driveways and bus and large maintenance vehicle parking areas. Asphalt paving would be provided in areas trafficked by personal vehicles. The park-and-ride garage would be equipped with lighting to support operations and as needed for safety and security. Landscaping would be provided in designated areas in accordance with City of Kirkland requirements, including maintenance and irrigation.

2.2.6 Brickyard Station and Roadway Improvements

Figure 2-6 provides a graphic representation of the proposed Brickyard Station, the new pedestrian bridge, and associated roadway improvements.



SOURCE: Sound Transit 2020

Figure 2-6 Brickyard Station and Roadway Improvements

The proposed new BRT station (northbound and southbound station platforms) would be located at-grade within the center of the I-405 roadway and right-of-way. A bus-only lane would be added in both the northbound and southbound direction (for a total length of approximately 4,000 feet southbound and 3,000 feet northbound), to allow BRT vehicles to safely decelerate to pick up/drop off at the BRT station platform and to accelerate from the station platforms and merge into I-405 traffic. The addition of these northbound and southbound bus-only lanes and the BRT station platforms would require realigning and widening the existing I-405 roadway to the east and west. The BRT station would include a branded shelter, benches, and raised platforms for level or near-level passenger boarding, in addition to the standard elements.

A pedestrian bridge over I-405 would connect the two BRT station platforms and would connect the BRT station to the Brickyard Park-and-Ride lot to the west. Between the I-405 roadway surface and the bottom of the pedestrian bridge, the proposed vertical clearance would be approximately 17.5 feet. From each BRT station platform, access to the pedestrian bridge would be provided by stairs and at least one elevator. Stairs and an elevator would be provided from the pedestrian bridge to access the Brickyard Park-and-Ride lot. Although funding is not currently available, WSDOT, Bothell, Kirkland, and Sound Transit are currently considering an extension of this pedestrian bridge to the east side of I-405, with a stairway and ramp, and possibly an elevator, connecting over the existing noise wall alongside I-405 to 116th Avenue NE.

2.2.6.1 Utilities and connections

Anticipated utilities needed to serve the BRT station include electric power, public agency telecommunications and commercial telecommunications, and water, which would be tied into utilities currently available near the project component.

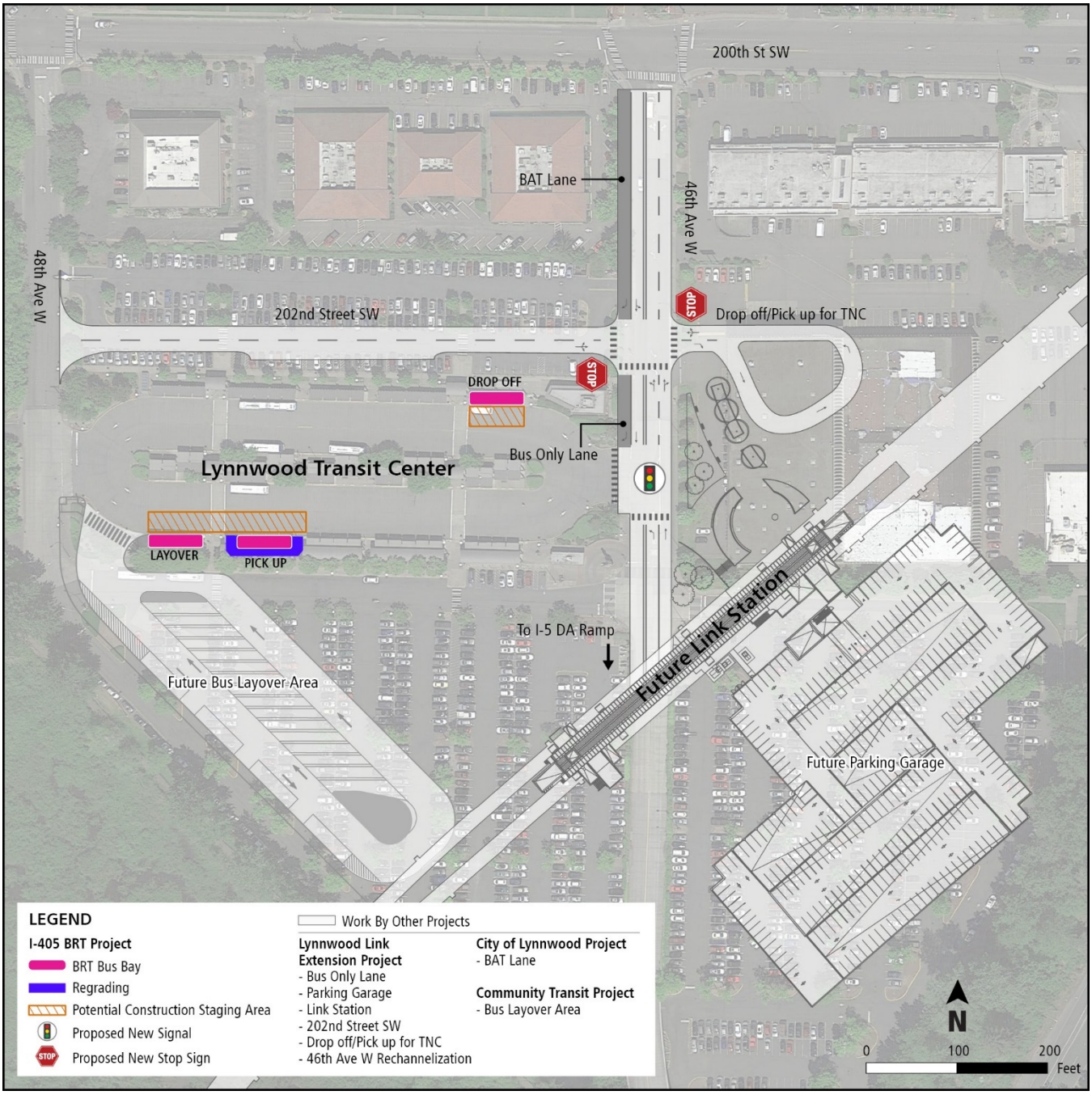
Stormwater would be collected underground and detention would be provided as required. Flow control and water quality treatment would be provided as required by WSDOT's *Highway Runoff Manual* (WSDOT 2019), and stormwater facilities would ultimately tie into the existing conveyance systems. Near the BRT station platforms, where the I-405 widening would be greatest, new noise walls may be needed along the east side of I-405. A new retaining wall would be constructed along the west side of I-405 for approximately 1,110 feet in the northbound direction and 465 feet in the southbound direction, with a maximum height of 6 feet, from the pedestrian bridge north along the I-405 on-ramp from Juanita Woodinville Way NE.

2.2.6.2 Site work

For this project component, the contractor would be expected to stage the necessary construction equipment and materials within the existing right-of-way for I-405 and, potentially, the Brickyard Park-and-Ride lot.

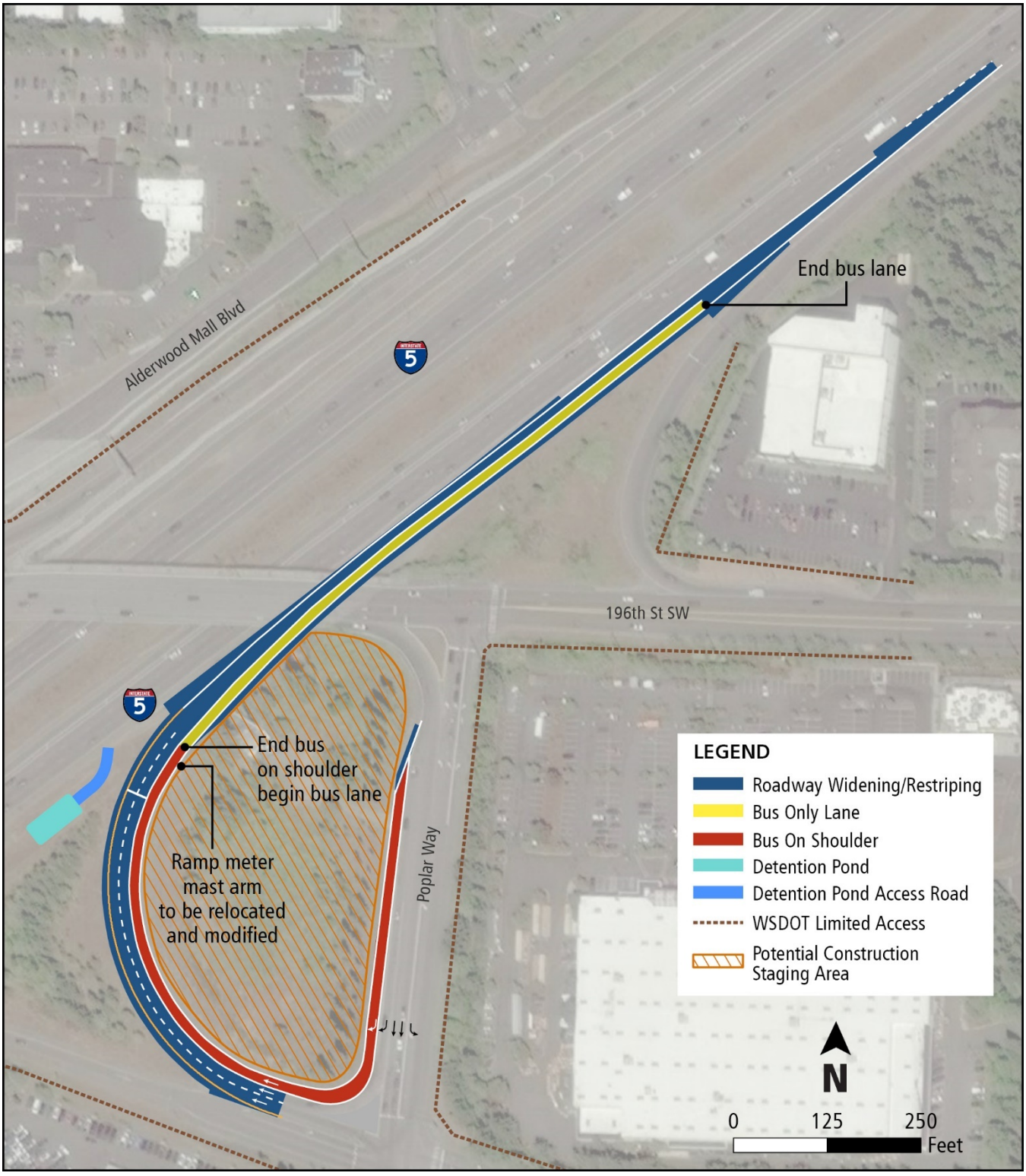
2.2.7 Lynnwood City Center Transit Station BRT and Roadway Improvements

Figure 2-7 provides a graphic representation of the proposed Lynnwood City Center Transit Station BRT and Roadway Improvements. **Figure 2-7** also shows the Lynnwood Link light rail station, transit center bus layover area, and roadway improvements that will be constructed as part of Sound Transit's Lynnwood Link Extension project. **Figure 2-8** shows the proposed roadway improvements that would be constructed as part of the I-405 BRT Project on Poplar Way and the loop ramp onto I-5 northbound.



SOURCE: Sound Transit 2020

Figure 2-7 Lynnwood City Center Transit Station BRT and Roadway Improvements



SOURCE: Sound Transit 2020

Figure 2-8 Lynnwood City Center Transit Station BRT and Roadway Improvements: Poplar Way Loop Ramp Roadway Improvements

BRT buses would access the Lynnwood City Center Transit Station by using the existing Alderwood Mall Boulevard exit from I-5 south, traveling along 196th Street SW, turning left at 44th Avenue W, right at 200th Street SW, left onto 46th Avenue W, and then into the transit center. Along this routing, TSP would be added to existing traffic signals. To improve access to and from the transit center, modifications would be made at two intersections along 46th Avenue W. The first intersection, just north of the transit center, would include two northbound and two southbound lanes with stop signs controlling the east and west legs of the intersection. The second intersection, at the entrance to the transit center, would be modified to include a new traffic signal and to include crosswalks.

At the existing Lynnwood City Center Transit Station, one bay in the northeast portion of the transit center loop would be modified to accommodate the BRT service as a drop-off bay with a 6 to 9 inch curb height. In the southwest portion of the transit center loop, one bay would be modified to accommodate BRT pick up and one bay would be converted to a layover space. At the BRT pick-up bay, in addition to the standard station elements, the platform and adjacent area would be re-graded for near-level passenger boarding. The existing shelters over the bays would remain.

Leaving the transit center, BRT vehicles would follow the same routing to 196th Street SW and then would use the Poplar Way on-ramp to access I-5 north and then I-405 south. Along Poplar Way (south of 196th Street SW) and the I-5 northbound on-ramp, the roadway and ramp would be widened for a bus-only bus-on-shoulder lane for BRT vehicles to use to bypass congestion.

Leaving the transit center, BRT vehicles would follow the same routing to 196th Street SW and then would use the Poplar Way on-ramp to access I-5 north and then I-405 south. Along Poplar Way (south of 196th Street SW) and the I-5 northbound on-ramp, the roadway and ramp would be widened for a bus-only lane for BRT vehicles to use to bypass congestion. The existing ramp meter mast arm would be relocated and modified.

2.2.7.1 Utilities and connections

Anticipated utilities include electric power, storm drainage, public agency telecommunications, and commercial telecommunications. Electric power and telecommunications would be tied into utilities currently available near the project component.

At the Lynnwood Transit Center, stormwater would be collected underground and detention would be provided as required. Flow control and water quality treatment would be provided as required by the *Washington State Department of Ecology Stormwater Management Manual for Western Washington* (Ecology 2019). Stormwater would ultimately tie into the existing conveyance systems. For the Poplar Way ramp modifications, stormwater flow control and water quality treatment would be provided as required by WSDOT's *Highway Runoff Manual* (WSDOT 2019).

2.2.7.2 Site work

For construction at the Lynnwood City Center Transit Station, the contractor would likely stage the necessary equipment and materials within the transit center. For construction of the bus-only lane along Poplar Way and the I-5 on-ramp, the contractor may stage equipment and materials in the existing, unpaved right-of-way within the center of the Poplar Way loop ramp onto I-5.

3 METHODOLOGY

3.1 Noise and vibration fundamentals

The following provides information on some fundamental concepts and terminology used in this noise and vibration assessment.

3.1.1 Noise

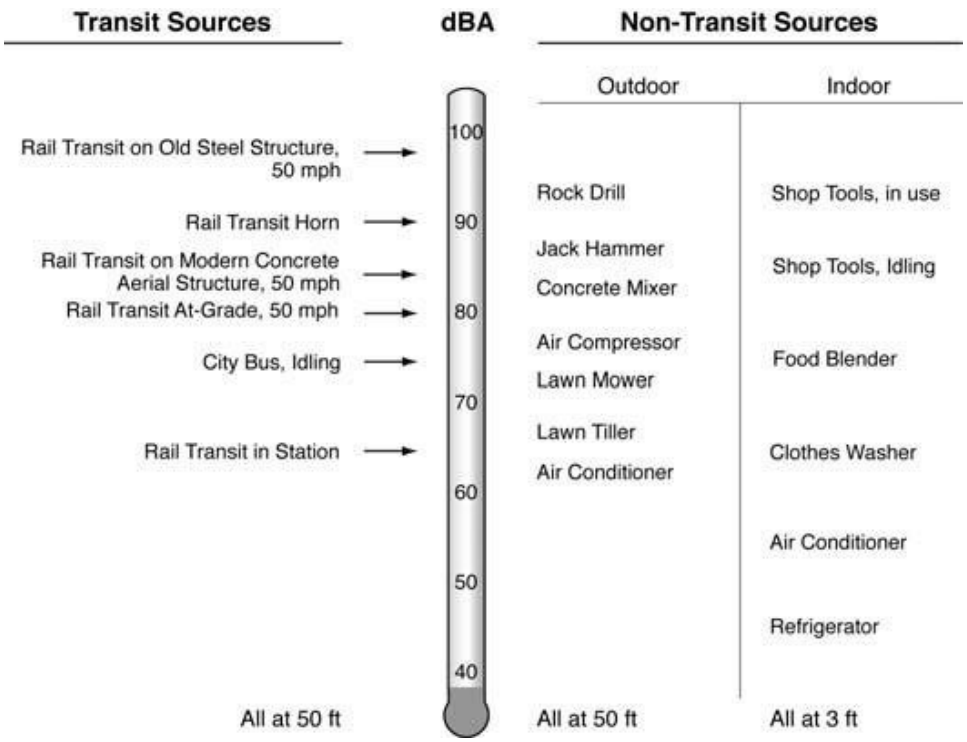
Noise is defined as unwanted sound; it is measured in terms of sound pressure level and is usually expressed in decibels (dB). The human ear is less sensitive to higher and lower frequencies than it is to midrange frequencies. To provide a measurement meaningful to humans, a weighting system was developed that reduces the sound level of higher and lower frequency sounds, similar to what the human ear does. This filtering system is used in virtually all noise ordinances. Measurements taken with this "A-weighted" filter are referred to as "dBA" readings.

The two primary noise measurement descriptors used to assess noise impacts from traffic and transit projects are the L_{eq}, and the L_{dn}:

- L_{eq}: The equivalent sound level (L_{eq}) is the level of a constant sound for a specified period of time that has the same sound energy as an actual fluctuating noise over the same period of time. The peak-hour L_{eq} is used for all traffic and transit noise analyses at locations with daytime use, such as schools and libraries. The Washington State Administrative Maximum Environmental Noise Levels are interpreted to mean a 1-hour L_{eq} and not the maximum sound level (L_{max}).

- L_{dn}: The day-night sound level (L_{dn}) is a L_{eq} over a 24-hour period, with 10 dBA added to nighttime sound levels (between 10 p.m. and 7 a.m.) as a penalty to account for the greater sensitivity and lower background sound levels during this time.

The L_{dn} is the primary noise-level descriptor for the assessment of FTA transit noise at sensitive noise receivers. Typical A-weighted sound levels are presented in **Figure 3-1**. The L_{eq} is used by FHWA to assess peak-hour traffic noise and is the primary noise-level descriptor for the Washington State administrative assessment.



SOURCE: FTA 2018

Figure 3-1 Typical A-weighted sound levels

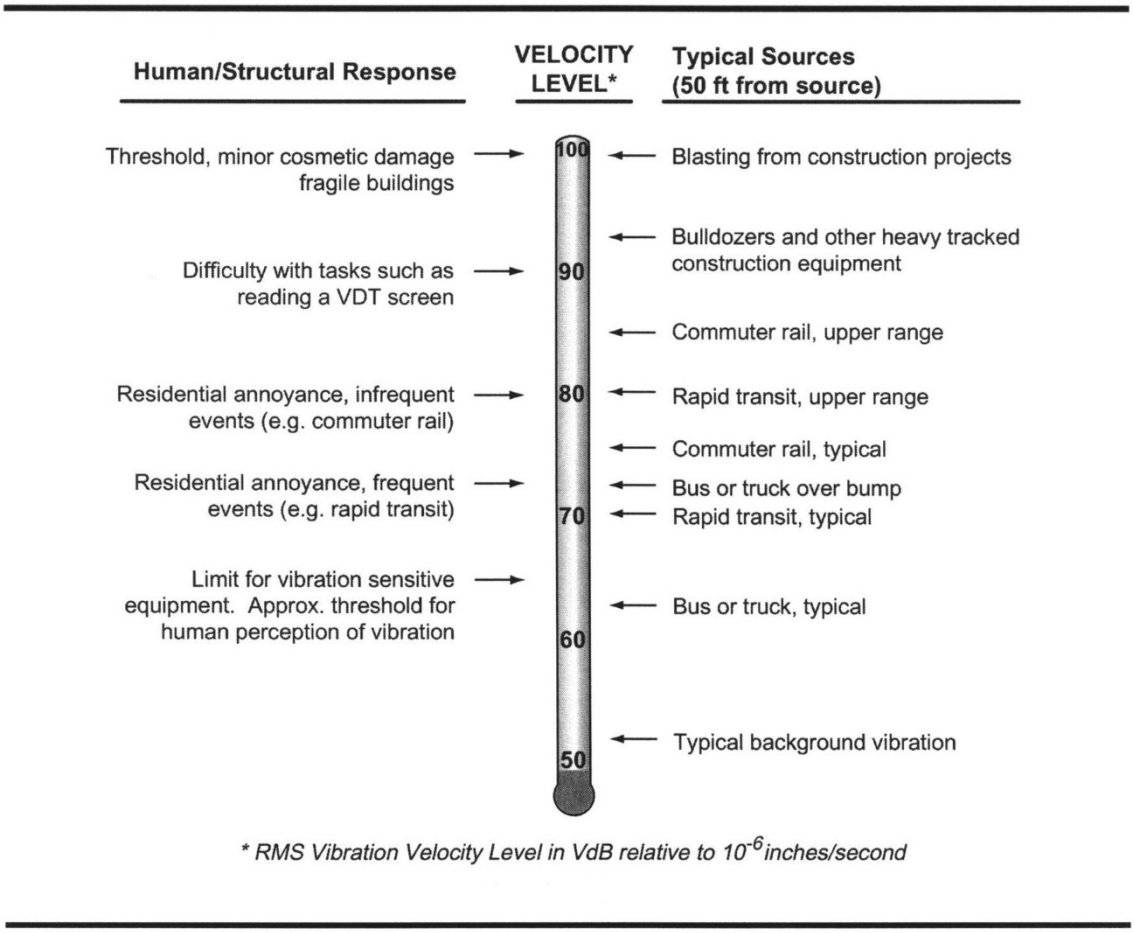
3.1.2 Vibration

Because the rubber tires and suspension systems of buses provide vibration isolation, it is unusual for them to cause noticeable groundborne vibration or groundborne noise. With bus-related vibration, such as rattling of adjacent building windows that may be noticed by building occupants, the cause is almost always airborne noise and directly related to running surface conditions such as potholes, bumps, expansion joints, or other discontinuities in the road surface (usually resolved by smoothing the discontinuities). The two types of vibration impacts that may occur when buses operate over poor road surface conditions are:

- Groundborne vibration: The movement of the ground (vibration can be experienced either outdoors or indoors)
- Groundborne noise: Noise generated by the movement of room surfaces, such as walls, resulting from vibration of a building (groundborne noise can only be experienced indoors)

Groundborne vibration can be described in terms of displacement, velocity, or acceleration when evaluating impacts from transit projects. Groundborne noise occurs as a perceptible rumble and is caused by the noise radiated from the vibration of room surfaces. Vibration above certain levels can damage buildings, disrupt sensitive operations, and cause annoyance to humans within buildings. The response of humans, buildings, and equipment to vibration is most accurately described using velocity or acceleration. Vibration velocity is used by the FTA as the primary measurement to evaluate the effects of vibration.

Figure 3-2 illustrates typical groundborne vibration velocity levels for common sources as well as thresholds for human and structural response to groundborne vibration. As shown, the range of interest is from approximately 50 vibration velocity decibels (VdB) to 100 VdB (i.e., from imperceptible background vibration to the threshold of damage to structures). Although the threshold of human perception to vibration is approximately 65 VdB, annoyance does not usually occur unless the vibration exceeds 70 VdB.



SOURCE: FTA 2018

Figure 3-2 Typical levels of ground vibration

3.2 Regulatory requirements

The guidance presented in the FTA 2018 *Transit Noise and Vibration Impact Assessment* was used to predict and assess the potential transit noise and vibration effects in areas where BRT operations would occur, such as bus-only lanes. FHWA's Title 23 of Code of Federal Regulations (CFR) Part 772, *Procedures for Abatement of Highway Traffic Noise and Construction Noise*, as implemented by WSDOT, was used to assess the potential traffic noise effects from proposed roadway modifications. The potential effects of construction were assessed using local agency noise ordinances.

3.2.1 Federal

FTA criteria were applied to the project components. The FTA criteria found in the FTA guidance are the primary noise and vibration criteria by which transit-specific noise and vibration impacts are identified by FTA. The FTA guidance provides performance standards or thresholds for project elements where only transit would operate, including BRT operations and associated ancillary and support elements such as stations, park-and-ride lots and garages, and transit centers.

The FTA criteria are also used to consider highway elements of a transit project if:

- FTA is the lead agency
- The main purpose of the project is transit-related and not highway-related and alternatives considered do not include reconstructing or widening an existing highway
- No federal-aid highway funds are used for the project

The FHWA traffic noise impact criteria defined in 23 CFR 772 were applied in locations where roadway modifications would occur. Projected traffic noise levels are calculated using FHWA's Traffic Noise Model (TNM), version 2.5.

3.2.2 State

3.2.2.1 WSDOT

WSDOT is responsible for implementing FHWA regulation 23 CFR 772 in Washington state. Specific procedures to follow in applying the federal code are identified in WSDOT's *Traffic Noise Analysis and Abatement Policy and Procedures* (WSDOT 2011). Based on Appendix 5 of WSDOT's noise procedures, the project does not propose roadway modifications that would create a new line of sight to a sensitive receiver, substantially change the vertical or horizontal roadway alignment, or result in a change to overall traffic volumes. Therefore, based on WSDOT policy, the roadway improvements do not require a FHWA traffic noise abatement analysis.

3.2.2.2 Washington state noise control ordinance

In Chapter 173-60 of the Washington Administrative Code (WAC), the Department of Ecology has adopted Maximum Environmental Noise Levels for residential, commercial, industrial and construction areas. However, WAC 173-60-110 states that:

> *The department conceives the function of noise abatement and control to be primarily the role of local government and intends actively to encourage local government to adopt measures for noise abatement and control. Wherever such measures are made effective and are being actively enforced, the department does not intend to engage directly in enforcement activities.*

The WAC noise control ordinance applies (together with local noise regulations) to construction, and industrial, commercial, and residential noise sources. This ordinance exempts mobile noise sources, including freight rail, aircraft in flight, and vehicles traveling in public right-of-way, as

well as safety warning devices (e.g., bells). For stationary noise sources, with noises originating from outside public roadways and rights-of-way, the Washington State Noise Control Ordinance defines three different Environmental Designations for Noise Abatement (EDNAs) based on land use (summarized for this study as residential, commercial, and industrial) and states the maximum noise levels for each, as shown in **Table 3-1**. The WAC noise regulations are taken from Chapter 173-60, WAC, Maximum Environmental Noise Levels, 2000 (WAC 2000). The regulations define the maximum allowable noise level from one EDNA to another EDNA.

The WAC property line noise standards are used to assess potential noise impacts from park-and-ride lots and garages and transit noise sources that are not in the public right-of-way to adjoining residential uses. They are not used to assess potential impacts from the future BRT and traffic operations. The FTA noise criteria and FHWA Noise Abatement Criteria are used to assess the bus and traffic operation noise levels and impacts of the project.

Although the WAC does not define the maximum noise-level descriptor, the EDNA allowable noise levels are interpreted to mean a 1-hour L_{eq}. For example, the noise caused by a park-and-ride garage or lot, both considered a commercial property, must be less than a L_{eq} of 57 dBA at the closest residential property line. From 10 p.m. to 7 a.m., the maximum allowable sound levels shown in **Table 3-1** are reduced by 10 dBA in Class A EDNAs (residential zones). The WAC contains short-term exemptions to the property line noise standards, as shown in **Table 3-1**, based on the minutes per hour that the noise limit is exceeded. These exceedances are outlined in **Table 3-2**.

Table 3-1 Washington State noise control regulation

EDNA Source of Noise	EDNA Receiver of Noise (Maximum Allowable Sound Level, L_{eq} dBA[1])		
	Residential	Commercial	Industrial
Class A Residential	55	57	60
Class B Commercial	57	60	65
Class C Industrial	60	65	70

SOURCE: Washington Administrative Code Chapter 173-60-040
NOTES: dBA = A-weighted decibel; EDNA = Environmental Designation for Noise Abatement
1 Between 10 p.m. and 7 a.m., the levels given above are reduced by 10 dBA in Class A EDNAs. Maximum allowable noise levels are interpreted to mean a 1-hour L_{eq}.

Table 3-2 Washington State exemptions for short-term noise exceedances

Minutes Per Hour	Adjustment to Maximum Sound Level
15	+5 dBA
5	+10 dBA
1.5	+15 dBA

SOURCE: Washington Administrative Code Chapter 173-60-040
NOTES: dBA = A-weighted decibel

Sounds received in Class A EDNAs that originate from construction sites are exempt from the limits of the WAC regulations during normal daytime hours (7 a.m. to 10 p.m.). If construction is performed during the nighttime, the contractor must still meet the WAC noise-level requirements for sounds received in Class A EDNAs, as presented in **Table 3-1**, or obtain a noise variance from the governing jurisdiction.

The WAC also contains a set of construction-specific allowable noise-level limits. These construction noise regulations are organized by type of noise and, among other things, include criteria for backup safety alarms and haul trucks. Sounds created by backup alarms are exempt, except between 10 p.m. and 7 a.m. when “beep-beep” backup alarms are essentially prohibited by the WAC in urban areas and would be replaced with smart backup alarms, which automatically adjust the alarm level based on the background level or switch off backup alarms and replace with spotters. This criterion is included because, just like noise from construction activities, noise from backup beepers would exceed the WAC nighttime criteria, even with the allowable exceedance, at large distances from the construction site.

Maximum permissible sound levels for haul trucks on public roadways are limited to 86 dBA for speeds of 35 miles per hour (mph) or less, and 90 dBA for speeds over 35 mph when measured at 50 feet (Chapter 173-62, WAC).

3.2.3 Local

Applicable local noise regulations are identified in the noise ordinance for the city where the project component is located.

Local city noise ordinances outline regulations to control construction noise and are primarily the same for all project components. Construction noise is limited to Monday through Friday between 7 a.m. and 8 p.m. and Saturday from 9 a.m. to 6 p.m. Construction noise is prohibited on Sunday and major holidays. The exception is the City of Bellevue where construction noise is allowed only on weekdays from 7:00 a.m. to 6:00 p.m. Certain construction noise activities are exempt, including freeway, highway, or arterial construction and improvements. Construction noise outside the allowable hours would require approval of a variance from the local jurisdiction.

3.3 Construction

3.3.1 Noise

Construction of the project would require the use of heavy equipment that generates relatively high noise levels. FTA reference noise levels were used to predict construction noise for a variety of construction operations based on a compilation of empirical data and the application of acoustical propagation formulas. The FTA uses a database of noise levels for common pieces of construction equipment that would be expected to be used during construction of the project (FTA 2018). Variables that can be adjusted are distance from equipment to receiver, shielding, and equipment usage rates. Construction noise levels were predicted as they would typically occur at the closest residential receivers. See **Table 5-1** for typical construction noise levels.

3.3.2 Vibration

Construction vibration was analyzed to evaluate the potential for damage to structures. To evaluate potential vibration effects during construction, the FTA's recommendation on damage risk vibration levels was used because there are no state, county, or city vibration regulations. Annoyance from groundborne noise and vibration is generally not an issue because of the short-term duration of most construction activities unless there is a vibration sensitive land use nearby, like a lab with an magnetic resonance imaging machine. No vibration sensitive land uses were noted in the area, so this is not included in this assessment.

The parameter normally used to assess potential construction vibration effects to structures is the peak particle velocity (PPV), which is the maximum velocity recorded during a particular event, such as from a jackhammer. The FTA's recommended limits for construction vibration for four building categories are as follows:

- Reinforced concrete, steel, or timber: 0.5 inch per second (in./sec) PPV
- Engineered concrete and masonry: 0.3 in./sec PPV
- Nonengineered timber and masonry buildings: 0.2 in./sec PPV
- Buildings extremely susceptible to vibration damage (such as ruins or ancient monuments): 0.12 in./sec PPV

3.4 Operations

3.4.1 Transit noise

Existing measured noise levels were used to predict the L_{dn} and peak-hour L_{eq} for receivers used in the noise analysis. The L_{dn} is a 24-hour energy average noise level used to determine impacts where nighttime sensitive land use exists, such as residences, hotels and motels, and hospitals. The peak-hour L_{eq} is used to determine noise impacts for institutional land use, such as schools, libraries, or churches. All noise levels are A-weighted to account for the hearing response of humans and referred to as sound levels in decibels (dBA).

The criteria in the FTA Manual (2018) are founded on well-documented research on community reaction to noise and are based on changes in noise exposure using a sliding scale. The amount of change in the overall noise environment that the transit project is allowed to make is reduced with increasing levels of existing noise. The FTA noise impact criteria group noise-sensitive land uses into the following three categories:

- Category 1: Tracts of land where quiet is an essential element in their intended purposes. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with considerable outdoor use. Also included are recording studios and concert halls.
- Category 2: Residences and buildings where people normally sleep. This category includes residences, hospitals, and hotels where nighttime sensitivity is assumed to be of utmost importance.

- Category 3: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities may also be considered to be in this category. Certain historical sites and parks are also included.

The L_{dn} is used to characterize noise exposure for residential areas (Category 2), and the peak 1-hour L_{eq} is used to evaluate effects from other noise-sensitive land uses such as schools, libraries, and other noise-sensitive daytime uses (Categories 1 and 3) during project operation. There are no FTA impact criteria for commercial uses, such as offices, retail, or restaurants.

Two levels of impact are included in the FTA criteria. The interpretations of these two levels of impact are summarized below:

- Severe: Project-generated noise in this range is likely to cause a high level of community annoyance. Noise mitigation must be considered for severe impacts unless extenuating circumstances prevent mitigation.

- Moderate: Project-generated noise in this range is considered to cause impact at the threshold of measurable annoyance. Mitigation should be considered at this level of impact based on project specifics and details concerning the affected properties.

Note that Sound Transit mitigates both Severe and Moderate impacts unless there is not reasonable or feasible mitigation available. The FTA noise impact criteria are provided in **Figure 3-3**, which shows the existing noise exposure and the project noise exposure that would result in either a moderate or severe impact. The future noise exposure, which is not shown in the figure, would be the combination of the existing noise exposure and the additional noise exposure caused by the BRT project.

Noise from BRT operations was modeled using the FTA General Noise Assessment described in the FTA Manual. Inputs to the model were based on the operating plan, speed, and distances to the noise-sensitive land uses.

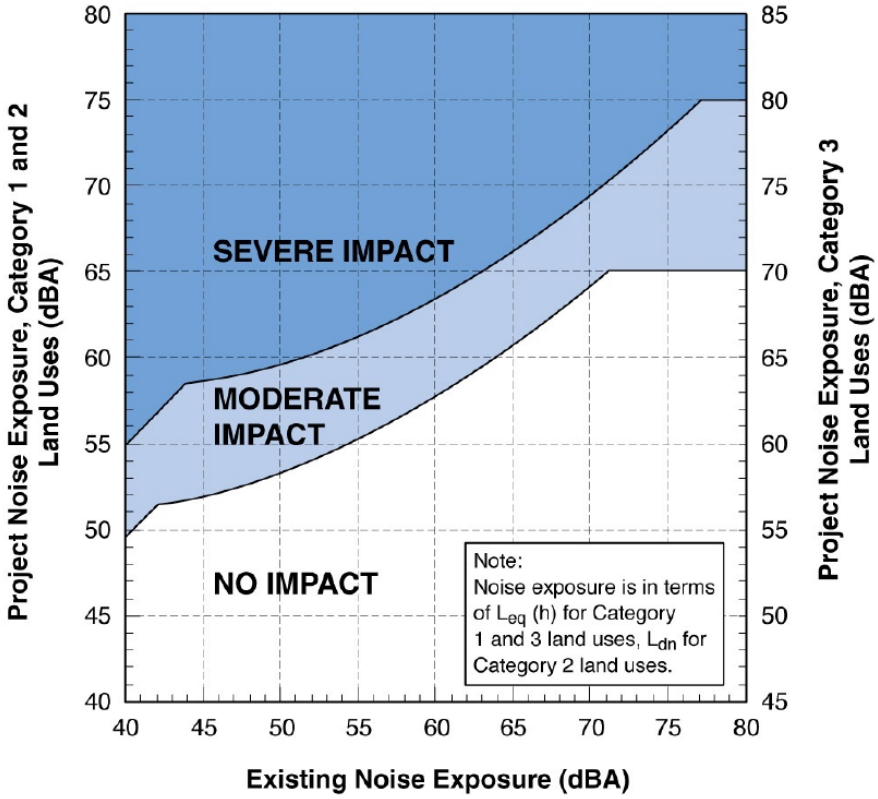


Figure 3-3 FTA Noise Impact Criteria

3.4.2 Traffic noise

The traffic noise impact criteria against which the project traffic noise levels were evaluated are taken from CFR Title 23, Part 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise. The criterion applicable for residences, churches, schools, recreational uses, and similar areas is an exterior L_{eq} that approaches or exceeds 67 dBA. The criterion applicable for other developed lands, such as commercial and industrial uses, is an exterior L_{eq} that approaches or exceeds 72 dBA. The FHWA states that a substantial increase in traffic noise levels can also result in a noise impact. Finally, the FHWA allows the state departments of transportation to define the terms “approach” and “substantial increase” in their local regulations.

Under WSDOT policy implementing FHWA regulations, a traffic noise impact would occur if projected noise levels approach within 1 dB of the FHWA criteria; therefore, a residential impact occurs at 66 dBA L_{eq} and a commercial impact at 71 dBA L_{eq}. WSDOT also considers a 10-dB increase in noise a substantial increase impact, regardless of the existing noise level. A summary of the FHWA noise regulations is provided in **Table 3-3**.

Table 3-3 Noise Abatement Criteria by land use category

Activity category	Activity Criteria in hourly L_{eq} (dBA)		Evaluation location	Activity description
	FHWA NAC	WSDOT NAC		
A	57	56	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[1]	67	66	Exterior	Residential (single- and multi-family units)
C[1]	67	66	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day-care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or non-profit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings
D	52	51	Interior	Auditoriums, day-care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or non-profit institutional structures, radio studios, recording studios, schools, and television studios
E[1]	72	71	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in Activity Category A to D or F
F	--	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	--	--	--	Undeveloped lands that are not permitted

SOURCE: FHWA 2004
NOTES: [1] Includes undeveloped lands permitted for this activity category
dBA = A-weighted decibel; FHWA = Federal Highway Administration; NAC = Noise Abatement Criteria; L_{eq} = equivalent noise level; WSDOT = Washington State Department of Transportation

3.4.3 Vibration

The FTA vibration impact criteria are based on the maximum vibration level as a transit vehicle passes. The FTA vibration thresholds do not specifically account for existing vibration because it is very rare that even substantial volumes of vehicular traffic, including trucks and buses, would generate perceptible ground vibration unless there are irregularities in the roadway surface such as potholes or wide expansion joints.

The FTA Manual (2018) provides two sets of criteria: one based on the overall vibration velocity level for use in a General Vibration Impact Assessment and one based on the maximum vibration level in any 1/3-octave band (the band maximum level) for use with a Detailed Vibration Assessment.

4 AFFECTED ENVIRONMENT

This section summarizes land uses sensitive to noise and vibration located along the project corridor, as well as existing noise levels measured for the I-405 project analysis.

Land uses sensitive to noise and buildings potentially sensitive to construction vibration were identified through site reconnaissance, aerial maps, and GIS. Noise measurement locations were selected to best represent existing noise levels at the closest residential receiver to project improvements. **Figure 4-1** through **Figure 4-7** show where the existing noise levels were measured. The results of the existing 24-hour measurements are presented in **Table 4-1**.

Table 4-1 24-hour existing noise-level measurements

Site	Project component	Location	L_{dn}, dBA	Peak-hour L_{eq} (h), dBA	Time of peak-hour L_{eq} (h)	Date of measurement	Reference figure
1	Burien Transit Center and Roadway Improvements	14654 3rd Ave SW, Burien	60	62	9:00 AM	9/16/2019	Figure 4-1
2		14652 4th Ave S, Burien	69	69	8:00 AM	9/16/2019	Figure 4-1
3		14839 4th Ave S, Burien	66	66	8:00 AM	9/16/2019	
4	Tukwila International Boulevard BRT Station and Roadway Improvements	15432 30th Ave S, SeaTac	66	61	7:00 PM	9/16/2019	Figure 4-2
5		15440 40th Ave S, Tukwila	70	66	8:00 AM	9/17/2019	Figure 4-2
6		15603 42nd Ave S, Tukwila	71	66	12:00 PM	9/17/2019	Figure 4-2
7	South Renton Transit Center and Roadway Improvements	1 S Grady Way, Renton	72	68	6:00 PM	9/17/2019	Figure 4-3
8	Bellevue Transit Center and Off-site Layover	Library Square apartments, 11004 NE 11th St, Bellevue	72	74	7:00 AM	2/4/2020	Figure 4-4
9	Totem Lake/ Kingsgate Station and Kingsgate Park-and-Ride Garage	Southern boundary of Kingsgate site, near the Country Trace Condos, 11414 NE 128th St, Kirkland	68	65	2:00 PM	9/19/2019	Figure 4-5
10	Brickyard Station and Roadway Improvements	Braewood Condos, 15300 112th Ave NE, Bothell	75	74	11:00 AM	2/4/2020	Figure 4-6

Site	Project component	Location	L_{dn}, dBA	Peak-hour L_{eq} (h), dBA	Time of peak-hour L_{eq} (h)	Date of measurement	Reference figure
11	Lynnwood City Center Transit Station BRT and Roadway Improvements	Lynnwood Transit Center – 20100 48th Ave W, Lynnwood	67	66	3:00 PM	9/19/2019	Figure 4-7

SOURCE: Sound Transit 2019

4.1 Project components – BRT transit features

Existing noise measurements were taken near the following BRT transit features of the project components:

Burien Transit Center and Roadway Improvements – Sites 1, 2, and 3 (Figure 4-1): A new BRT station platform and a bus-only lane are proposed at this location. Land use around the station location is mostly parking lots and retail shops. The nearest homes are located at the intersection of 4th Avenue SW and SW 148th Street. These homes are represented by Site 1. A L_{dn} of 60 dBA and a peak-hour $L_{eq(h)}$ of 62 dBA at 9:00 a.m. were measured in the front yard of the home. The home is located approximately 109 feet from the property line of the station, 210 feet from the bus entrance to the station, and 320 feet from the center of the station.

Tukwila International Boulevard BRT Station and Roadway Improvements – Sites 4, 5, and 6 (Figure 4-2): Additional bus-only lanes on SR 518 are proposed to allow BRT vehicles to travel to and from the Tukwila International Boulevard BRT Station and into SR 518 traffic. Between 38th Lane S and 24th Avenue S, the land use is industrial, retail, and airport-related uses, with the exception of the area between 32nd Avenue S and 29th Avenue S, north of SR 518, which is residential. Site 4 represents this area, with a measured L_{dn} of 66 dBA and a peak-hour $L_{eq(h)}$ of 61 dBA at 7:00 p.m. Between 42nd Avenue S and 38th Lane S the residential land use is within 100 to 120 feet of SR 518 with sound walls on both sides of SR 518. Noise measurements were taken at Site 5 to represent the homes to the north of SR 518 and at Site 6 to represent homes to the south. A L_{dn} of 70 dBA was measured on the north side (Site 5), with a peak-hour $L_{eq(h)}$ of 66 dBA at 8:00 a.m. A L_{dn} of 71 dBA was measured on the south side (Site 6), with a peak-hour $L_{eq(h)}$ of 66 dBA at 12:00 p.m.

South Renton Transit Center and Roadway Improvements – Site 7 (Figure 4-3): A new transit center island with 8 active bus bays and a 700-stall park-and-ride garage is proposed at this location along with a bus-on-shoulder lane. The land use along Rainer Avenue S is mostly parking lots and retail centers. The Holiday Inn Seattle-Renton is located north of I-405 and east of Rainer Avenue S. The hotel is represented by Site 7, where a L_{dn} of 72 dBA was measured with a peak-hour $L_{eq(h)}$ of 68 dBA at 6:00 p.m.

Bellevue Transit Center and Off-site Layover – Site 8 (Figure 4-4): The Bellevue Transit Center is an existing facility in a downtown urban area. The closest noise-sensitive land use that could be affected by the changes in the transit center is the Bravern Condominiums at 688 110th Avenue NE, which is located approximately 110 feet east of the transit center. The bus layover area is located on 110th Avenue NE in front the Bellevue Public Library. The closest noise-sensitive receiver to the layover area is the Library Square Apartments at 11004 NE 11th Street, which is located along the east side of 110th Avenue NE, across from the library. A L_{dn} of 72 dBA and a peak-hour L_{eq} of 74 dBA at 7:00 a.m. were measured at Site 8 which represents these residential land uses.

Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage – Site 9 (Figure 4-5): Improvements at this location include a BRT station in the center of I-405 and a park-and-ride garage on the existing Kingsgate Park-and-Ride lot. South and west of the proposed park-and-ride garage there are residential land uses, including the Country Trace Condominiums located along the southern boundary of the Kingsgate Park-and-Ride lot. A L_{dn} of 68 dBA and a peak-hour $L_{eq(h)}$ of 65 dBA at 2:00 p.m. were measured at Site 9 which represents the residential land uses on the west side of I-405. Land uses east of I-405 are office and retail.

Brickyard Station and Roadway Improvements – Site 10 (Figure 4-6): Proposed improvements at this location include bus-only lanes on I-405 to allow BRT vehicles to travel to and from the BRT Station and into I-405 traffic. The noise measurement site (Site 10) is located adjacent to the Braewood Condominiums at 15300 112th Avenue NE. A L_{dn} of 75 dBA and a peak-hour $L_{eq(h)}$ of 74 dBA at 11:00 a.m. were measured. The Willina Ranch apartments at 15515 Juanita Woodinville Way NE are located to the north.

Lynnwood City Center Transit Station BRT and Roadway Improvements – Site 11 (Figure 4-7): A BRT station and layover area and roadway improvements would be constructed at the Lynnwood City Center transit center and a bus-only lane would be constructed along Poplar Way and the I-5 Poplar Way on-ramp. Land uses along the routes to access the BRT station in the transit center are commercial and retail. A few residential areas are near the proposed BRT station, the closest of which is to the west across 48th Avenue W, with other residences located north of 200th Street near the bus route and along 200th Street SW and 46th Avenue W. The Lynnwood Transit Center measurement, Site 11, represents the noise levels for the residential area around the BRT station, with a measured L_{dn} of 67 dBA and a peak-hour $L_{eq(h)}$ of 66 dBA at 3:00 p.m.

4.2 Project components – Roadway improvements

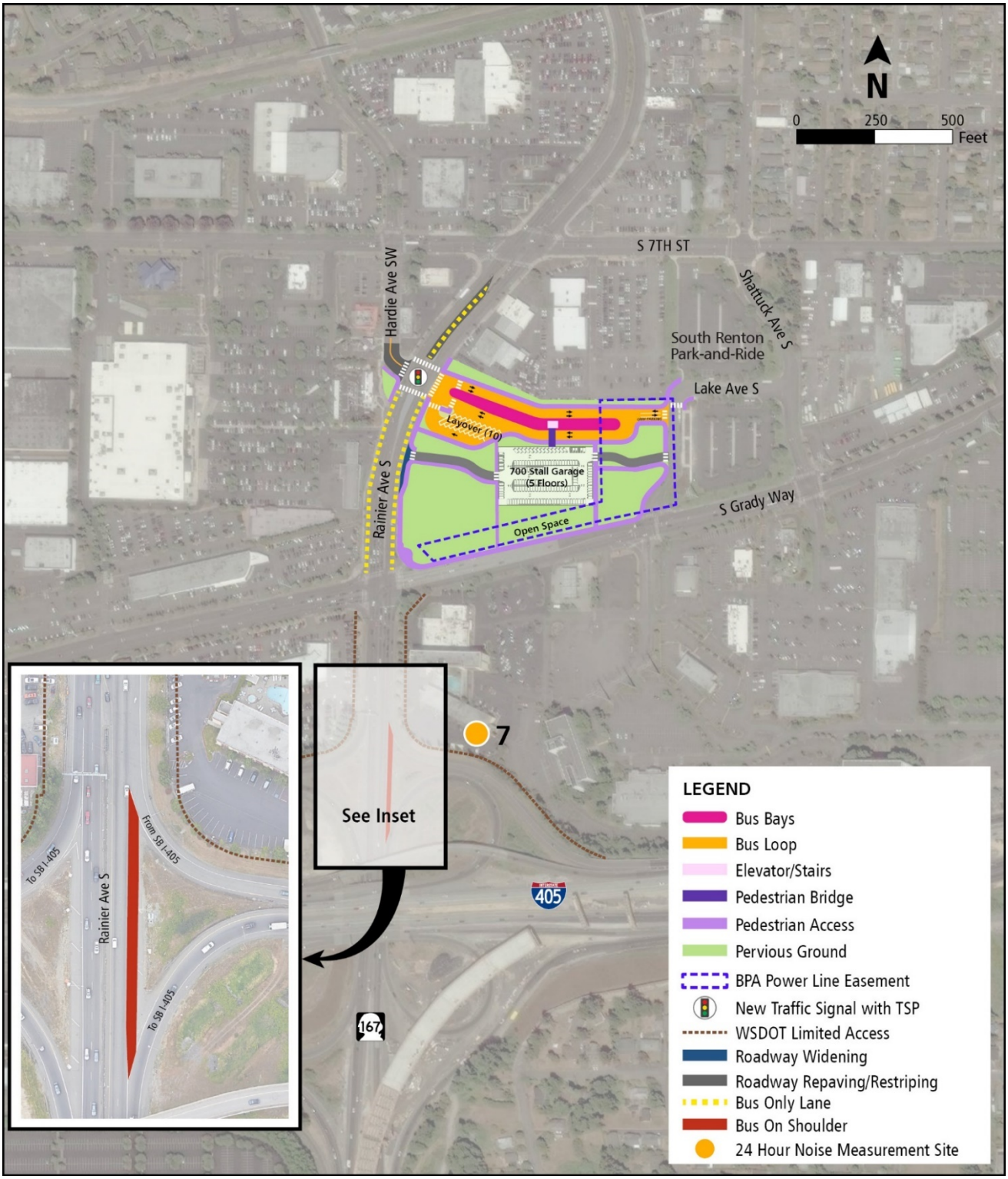
Roadway improvements are proposed as part of the Burien Transit Center, Tukwila International Boulevard BRT Station, South Renton Transit Center, Brickyard Station, and Lynnwood City Center Transit Station project components. These roadway improvements would not substantially change the vertical or horizontal roadway alignments (i.e., compared to the existing condition, the roadway improvements would not result in a vertical change that would create a new line of sight to the receiver and would not result in a horizontal change that would halve the distance between the roadway and the receiver) and would result in a minimal to no change to overall traffic volumes. Based on WSDOT's *Traffic Noise Analysis and Abatement Policy and Procedures* (WSDOT 2011), these improvements do not require a FHWA traffic noise abatement analysis. Therefore, existing noise measurements near the proposed roadway improvements were not presented.

SOURCE: Sound Transit 2020

Figure 4-1 Burien Transit Center and Roadway Improvements – Measurement sites 1, 2, and 3

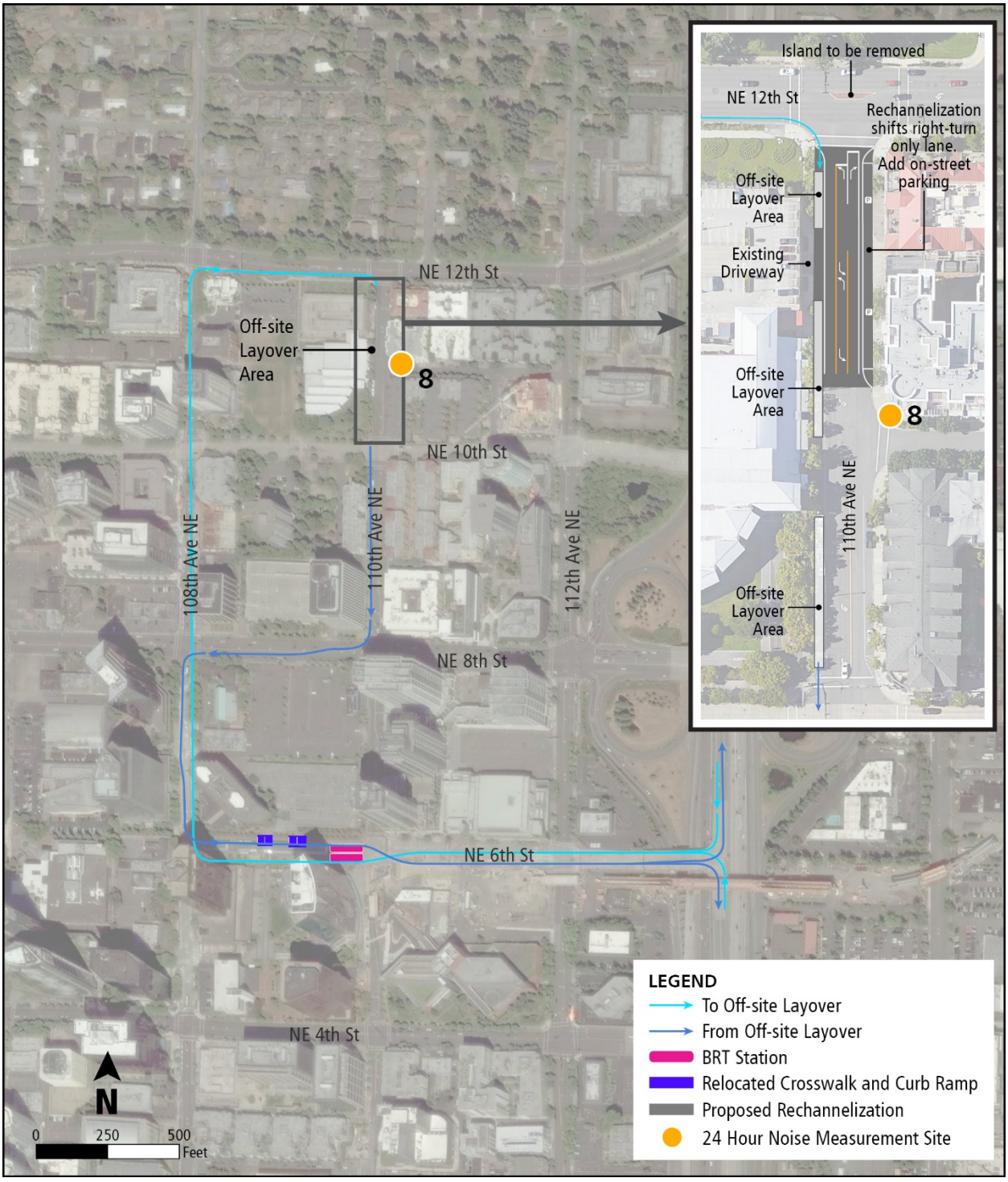
SOURCE: Sound Transit 2020

Figure 4-2 Tukwila International Boulevard BRT Station and Roadway Improvements – Measurement sites 4, 5, and 6



SOURCE: Sound Transit 2020

Figure 4-3 South Renton Transit Center and Roadway Improvements – Measurement site 7



SOURCE: Sound Transit 2020

Figure 4-4 Bellevue Transit Center and Off-site Layover – Measurement site 8

SOURCE: Sound Transit 2020

Figure 4-5 Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage – Measurement site 9

SOURCE: Sound Transit 2020

Figure 4-6 Brickyard Station and Roadway Improvements – Measurement site 10

SOURCE: Sound Transit 2020

Figure 4-7 Lynnwood City Center Transit Station BRT and Roadway Improvements – Measurement site 11

5 ENVIRONMENTAL IMPACTS

The discussion of likely impacts is divided into short-term construction impacts and long-term BRT and traffic operation impacts. As described in Section 3, noise impacts for the areas of BRT bus-only operations were determined using FTA guidance, and the noise impacts for the roadway modifications were determined using WSDOT/FHWA policy and procedures. Vibration from buses was not analyzed because their rubber tires and suspension systems provide vibration isolation and, therefore, no vibration impacts are anticipated during operation of the BRT service.

5.1 Construction

At all of the project components, the following construction activities could occur for the BRT station or roadway work:

- General Contractor mobilization, including locating existing utilities, installation of temporary utilities, etc.
- Install temporary construction fencing
- Install required temporary erosion and sediment control and stormwater pollution prevention and management measures, including truck wash down area
- Install protection measures for existing features, such as trees, to be retained
- Prepare lay down and staging areas for use
- Survey and stake the work areas
- Clear and grub the work areas
- Rough grade and update stormwater management as required
- Install underground and aboveground utilities
- Install stormwater detention and water quality treatment facilities
- Prepare station platform and equipment pad, including removing soils and importing on-site fill as recommended by the geotechnical report
- Conduct final grading
- Install paving in the transit center
- Install primary electrical systems, including lighting
- Tie in permanent driveways
- Construct right-of-way modifications

- Install roadway pavement and striping
- Install permanent signage
- Remove temporary construction fencing
- General Contractor demobilization

In addition, for the park-and-ride garage structures at the South Renton Transit Center and the Kingsgate Park-and-Ride Garage, the following additional construction activities are anticipated:

- Demolish existing buildings on the site (South Renton Transit Center only)
- Install building foundation systems. This could include drilling or driving piles as needed for deep foundations if used, as well as excavating, forming, and pouring any shallow foundations and grade beams
- Prepare building pad. This could include further removal of existing dirt or importing of fill or on-site fill treatment as recommended by the geotechnical report
- Install under-slab vapor-barrier system
- Pour building ground-floor slabs
- Install building framing system. This would include forming, pouring concrete framing members and concrete slabs, and stressing post-tensioned framing members
- Install garage floor drains and fire sprinkler system
- Install pedestrian bridge and stair/elevator tower (South Renton Transit Center only)
- Install finished exterior façade system and roofing systems
- Build out interior, including interior walls, finishes, ceilings, fixtures, plumbing systems, electrical systems, heating/ventilation/air conditioning systems, and fire suppression systems

5.1.1 Noise

Project construction noise would be temporary and intermittent and would cease once construction is complete. **Table 5-1** presents typical construction equipment that would be expected to be used for this project. Representative equipment noise levels are based on the typical construction equipment such as bulldozers, graders, and trucks that are expected to be used for this project. Estimated sound levels from construction activities as a function of distance are shown in **Table 5-2** and are based on calculated point-source attenuation over hard (i.e., acoustically reflective) ground. They represent the worst-case noise level at a distance of 50 feet and could be up to 101 dBA L_{eq} (1-hour) with pile driving and 85 dBA L_{eq} (1-hour) for other typical construction equipment such as bulldozers and graders.

Table 5-1 Typical construction equipment noise levels

Equipment	Typical noise level 50 feet from source, dBA
Air Compressor	80
Backhoe	80
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Concrete Vibrator	76
Crane, Mobile	83
Dozer	85
Generator	82
Grader	85
Loader	80
Paver	85
Pile Driving	101
Pneumatic Tool	85
Pump	77
Roller	85
Saw	76
Scarifier	83
Scraper	85
Shovel	82
Truck	84

SOURCE: FTA 2018

Table 5-2 Predicted construction noise at nearest receivers to project components

Project component	Distance between source and closest receiver (feet)	Typical construction noise levels, (dBA L_{eq} (1-hour))	Typical pile driving noise levels, (dBA L_{eq} (1-hour))
Burien Transit Center and Roadway Improvements	109	79	N/A
Tukwila International Boulevard BRT Station and Roadway Improvements	100	80	N/A
South Renton Transit Center and Roadway Improvements	90	81	96
Bellevue Transit Center and Off-site Layover	60	84	N/A
Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage	60	84	99
Brickyard Station and Roadway Improvements	470	67	N/A
Lynnwood City Center Transit Station BRT and Roadway Improvements	80	82	N/A

SOURCE: Sound Transit 2020
NOTES: Calculations are based on FTA methodology (2018). Calculations do not include the effects, if any, of local shielding from walls, topography, or other barriers that may reduce sound levels further.
L_{eq} (1-hour) = hourly-equivalent sound level (over 1 hour); dBA = A-weighted decibel; FTA = Federal Transit Administration
N/A = Not applicable. Pile driving is not applicable to this project component.

Construction work would generally occur between 7:00 a.m. and 10:00 p.m., Monday through Friday, and generally between 7:00 a.m. and 6:00 p.m. in the City of Bellevue. During these times, construction work is exempt from the WAC and local code. A variance would need to be obtained for construction during regulated weekend and nighttime hours.

5.1.2 Vibration

Construction of the project would result in temporary vibration from the use of heavy equipment and machinery. Annoyance from groundborne noise and vibration is generally not an issue because of the short-term duration of most construction activities; the main concern is potential damage to buildings.

As shown in **Table 5-3**, vibration levels from typical construction equipment may vary depending on equipment used and ground conditions. Pile driving, if used, would generate the highest level of vibration. Vibration levels from pile driving at 60 feet would not exceed the FTA building damage risk criterion of 0.20 in/sec PPV for nonengineered and masonry buildings (see Section 3.3.2). No buildings fall into other categories. Other construction equipment, such as vibratory rollers and bulldozers, would not exceed the 0.20 in/sec PPV damage risk criteria.

Table 5-3 Predicted construction vibration at nearest receivers to project components

Project component	Distance to nearest receiver (feet)	Bulldozer	Vibratory roller	Pile driving	Damage risk criteria
		PPV[2]	PPV[2]	PPV[2]	PPV[1]
Burien Transit Center and Roadway Improvements	109	0.010	0.023	N/A	0.20
Tukwila International Boulevard BRT Station and Roadway Improvements	100	0.011	0.026	N/A	0.20
South Renton Transit Center and Roadway Improvements	90	0.013	0.031	0.094	0.20
Bellevue Transit Center and Off-site Layover	60	0.024	0.056	N/A	0.20
Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage	60	0.024	0.056	0.173	0.20
Brickyard Station and Roadway Improvements	470	0.001	0.003	N/A	0.20
Lynnwood City Center Transit Station BRT and Roadway Improvements	80	0.016	0.037	N/A	0.20

SOURCE: FTA 2018
NOTES: [1] FTA damage risk criterion based on nonengineered timber and masonry buildings.
[2] PPV = peak particle velocity – inches/second
N/A = Not applicable. Pile driving is not applicable to this project component.

5.2 Operations

5.2.1 Transit noise

Transit operational noise was evaluated at noise-sensitive land uses near the project components using the FTA General Assessment. These sources of transit noise include bus operations on dedicated bus lanes, park-and-ride lots and garages, and bus idling at transit stations.

The proposed operations for the I-405 BRT Project are headways of 10 minutes during peak periods and 15 minutes the remainder of the day and on weekends. AM and PM peak periods have 10-minute headways with 6 hours of peak (total) and 6 buses per hour in 2 directions for a total of 72 peak-period buses. There are 13 non-peak hours of 4 buses per hour in 2 directions for a total of 104 non-peak-period buses. Combined, this results in 176 buses on the corridor per weekday (including both northbound and southbound trips). The proposed span of service for the I-405 BRT Project is shown in **Table 5-4**.

Table 5-4 Span of service for I-405 BRT

	Daily hours
Weekdays	19 hours
Saturdays	19 hours
Sundays	17 hours

SOURCE: Sound Transit 2019
NOTE: BRT = bus rapid transit

For each project component, **Table 5-5** presents the results of the FTA General Noise Assessment modeling of noise levels from BRT operations at the closest noise-sensitive land uses/receiver. **Table 5-6** presents the predicted park-and-ride garage and lot noise levels. Following these tables is a brief discussion of the noise levels and impacts from BRT operations for each project component.

Table 5-5 Noise levels from BRT operations at each project component

Project component	Noise prediction site	Location	Existing noise level, L_{dn}, dBA	Project noise level, L_{dn}, dBA	FTA moderate/ severe impact threshold, L_{dn}, dBA	Impact (Y/N)	Graphic of the noise prediction sites
Burien Transit Center and Roadway Improvements, including bus-only lanes	1	14654 3rd Ave SW, Burien	60	57	58/64	N	Figure 4-1
Tukwila International Boulevard BRT Station and Roadway Improvements	6	15603 42nd Ave S, Tukwila	71	54	66/71	N	Figure 4-2
South Renton Transit Center and Roadway Improvements, including bus-only lane	7	1 S Grady Way, Renton	72	57	66/72	N	Figure 4-3

Project component	Noise prediction site	Location	Existing noise level, L_{dn}, dBA	Project noise level, L_{dn}, dBA	FTA moderate/ severe impact threshold, L_{dn}, dBA	Impact (Y/N)	Graphic of the noise prediction sites
Bellevue Transit Center and Off-site Layover	8	Off-site Layover - Library Square apartments, 11004 NE 11th St, Bellevue	72	56	66/72	N	Figure 4-4
		Bellevue Transit Center - Bravern Condominiums, 688 110th Ave NE, Bellevue		52	66/72	N	Figure 4-4
Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage	9	Southern boundary of Kingsgate site, near the Country Trace Condos, 11414 NE 128th St, Kirkland	68	57	63/69	N	Figure 4-5
Brickyard Station and Roadway Improvements	10	Braewood Condos, 15300 112th Ave NE, Bothell	75	44	66/74	N	Figure 4-6
Lynnwood City Center Transit Station BRT and Roadway Improvements, including bus-only lane	11	20100 48th Ave W, Lynnwood	67	60	63/68	N	Figure 4-7

SOURCE: Sound Transit 2019
NOTES: BRT = bus rapid transit; dBA = A-weighted decibel; FTA = Federal Transit Administration; L_{dn} = day/night sound level; N = no; Y = yes

Table 5-6 Predicted park-and-ride garage and lot noise levels

Receiver location	Existing one-hour average noise level, dBA	Predicted noise levels	WAC noise impact threshold	Impact (Y/N)
Burien Transit Center	Daytime L_{eq}= 64 dBA	Daytime L_{eq}= 52 dBA	Daytime L_{eq}=57 dBA	N
	Nighttime Leq= 58 dBA	Nighttime L_{eq}=46 dBA	Nighttime L_{eq}=47 dBA	N
South Renton Transit Center	Daytime L_{eq}= 66 dBA	Daytime L_{eq}= 51 dBA	Daytime L_{eq}=57 dBA	N
	Nighttime Leq= 58 dBA	Nighttime L_{eq}=46 dBA	Nighttime L_{eq}=47 dBA	N
Bellevue Transit Center	Daytime L_{eq}= 71 dBA	Daytime L_{eq}= 51 dBA	Daytime L_{eq}=57 dBA	N
	Nighttime Leq= 61 dBA	Nighttime L_{eq}=46 dBA	Nighttime L_{eq}=47 dBA	N
Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage	Daytime L_{eq}=63 dBA	Daytime L_{eq}=43 dBA	Daytime L_{eq}=57 dBA	N
	Nighttime Leq= 56 dBA	Nighttime L_{eq}=39 dBA	Nighttime L_{eq}=47 dBA	N
Lynnwood City Center Transit Station	Daytime L_{eq}= 64 dBA	Daytime L_{eq}= 51 dBA	Daytime L_{eq}=57 dBA	N
	Nighttime Leq= 58 dBA	Nighttime L_{eq}=45 dBA	Nighttime L_{eq}=47 dBA	N

SOURCE: Sound Transit 2020
NOTES: dBA = A-weighted decibels; L_{eq} = equivalent noise level, Y/N = yes/no; WAC = Washington Administrative Code

5.2.1.1 Burien Transit Center and Roadway Improvements

With this project component transit-related noise would occur at the proposed BRT station in the existing Burien Transit Center and along the bus-only lanes. Typical noise from buses entering and leaving the transit center and BRT station would include noise from tires, propulsion motors, and other auxiliary equipment on the vehicles which are predicted to be a L_{dn} of 57 dBA. The noise levels generated by the BRT vehicles operating at the Burien Transit Center would not exceed the FTA noise impact criteria (58 dBA for a moderate impact and 64 dBA for a severe impact) and would be below the existing ambient noise level of a L_{dn} of 60 dBA. The transit center noise levels are predicted to be a L_{eq} of 52 dBA during the day and 46 dBA at night, which is below the WAC noise impact threshold for commercial noise sources adjoining a residential use, which are an L_{eq} of 57 dBA for daytime and an L_{eq} of 47 dBA for nighttime (**Table 5-6**).

5.2.1.2 Tukwila International Boulevard BRT Station and Roadway Improvements

With this project component transit-related noise would occur at the BRT freeway station platforms and along the bus-only lanes. Typical noise from buses entering and leaving the BRT freeway station platforms would include noise from tires, propulsion motors, and other auxiliary equipment on the vehicles which are predicted to be a L_{dn} of 54 dBA. The noise levels generated by the BRT vehicles would not exceed the existing noise levels, which are a L_{dn} of 71 dBA, and would not exceed the FTA noise impact criteria (66 dBA for a moderate impact and 71 dBA for a severe impact). Additionally, there are no noise-sensitive land uses within FTA's screening distance from this project component. The nearest residence is 200 feet from any planned roadway improvement. On the south side, the residences are above SR 518, and the closest residence is 260 feet from the proposed roadway improvements.

5.2.1.3 South Renton Transit Center and Roadway Improvements

With this project component transit-related noise would occur at the proposed park-and-ride garage, transit center, and the bus-only lanes. With regard to the proposed park-and-ride garage, typical parking lot sources of noise would include vehicle engine noise, opening and closing of car doors, and people talking. Typical noise from buses entering and leaving the transit center would include noise from tires, propulsion motors, and other auxiliary equipment on the vehicles, which is predicted to be a L_{dn} of 57 dBA at the nearest noise-sensitive receiver. This is well below the existing measured noise level of a L_{dn} of 72 dBA and would not exceed the FTA noise impact criteria (66 dBA for a moderate impact and 72 dBA for a severe impact). The park-and-ride garage noise level (L_{eq} of 51 dBA daytime and 46 dBA nighttime) is predicted to be below the WAC noise impact threshold for commercial noise sources adjoining a residential use of a L_{eq} of 57 dBA for daytime and a L_{eq} of 47 dBA for nighttime (**Table 5-6**).

5.2.1.4 Bellevue Transit Center and Off-site Layover

With this project component transit-related noise would occur at the proposed BRT station at the existing Bellevue Transit Center and at the proposed off-site layover location along the east side of the Bellevue Library. Typical noise from buses entering and leaving the transit center and layover area would include noise from tires, propulsion motors, air conditioning, and other auxiliary equipment on the vehicles. At the Bellevue Transit Center transit noise is predicted to be a L_{dn} of 52 dBA at the nearest noise-sensitive receiver, the Bravern Condominiums at 688 110th Avenue NE. This is well below the existing measured noise level at this location, which is a L_{dn} of 72 dBA, and would not exceed either the FTA noise impact criteria (66 dBA for a moderate impact and 72 dBA for a severe impact).

The bus layover area is located on 110th Avenue NE in front the Bellevue Public Library, across the street from the Library Square Apartments at 11004 NE 11th Street. Noise from bus operations at the layover site is predicted to be a L_{dn} of 56 dBA at the Library Square Apartments, which is the closest residential location. This is well below the existing measured noise level at this location, which is a L_{dn} of 72 dBA, and would not exceed the FTA noise impact criteria (66 dBA for a moderate impact and 72 dBA for a severe impact).

5.2.1.5 Totem Lake/Kingsgate Station and Kingsgate Park-and-Ride Garage

At the existing Totem Lake Freeway Station, both the northbound and southbound bus stop locations would have one bus bay modified for a BRT station. This project component would also include a park-and-ride garage structure in the southern portion of the existing park-and-ride lot adding 400 park-and-ride spaces.

Transit-related noise from BRT operations would be generated at both the proposed BRT station and the park-and-ride garage. Typical noise from buses entering and leaving the BRT station would include noise from tires, propulsion motors, and other auxiliary equipment on the vehicles, which are predicted to be a L_{dn} of 57 dBA at the nearest noise-sensitive receiver, below the existing measured noise level of a L_{dn} of 68 dBA and would not exceed the FTA noise impact criteria (63 dBA for a moderate impact and 69 dBA for a severe impact).

At the Kingsgate Park-and-Ride Garage, typical parking lot sources of noise would include vehicle engine noise, opening and closing of car doors, and people talking. The predicted project noise level of the BRT operations entering and exiting the park-and-ride garage is a L_{eq}

of 43 dBA during the day and 39 dBA at night. The park-and-ride garage noise levels are predicted to be below the WAC noise impact threshold for commercial noise sources adjoining a residential use of a L_{eq} of 57 dBA for daytime and a L_{eq} of 47 dBA for nighttime (**Table 5-6**).

5.2.1.6 Brickyard Station and Roadway Improvements

With this project component transit-related noise would occur at the BRT freeway station platforms and along the bus-only lanes. Typical noise from buses entering and leaving the BRT freeway station platforms would include noise from tires, propulsion motors, and other auxiliary equipment on the vehicles, which are predicted to be a L_{dn} of 44 dBA. The noise levels generated by the BRT vehicles would not exceed the existing noise levels, which were measured at a L_{dn} of 75 dBA, and would not exceed the FTA noise impact criteria (66 dBA for a moderate impact and 74 dBA for a severe impact).

5.2.1.7 Lynnwood City Center Transit Station BRT and Roadway Improvements

With this project component transit-related noise would occur at the proposed BRT station at the existing Lynnwood City Center transit center and the bus-on-shoulder and bus-only lane along the Poplar Way on-ramp to I-5. Typical noise from buses entering and leaving the transit center would include noise from tires, propulsion motors, and other auxiliary equipment on the vehicles. These noise levels are predicted to be a L_{dn} of 60 dBA at the nearest noise-sensitive receiver, which is below the existing noise levels measured at a L_{dn} of 67 dBA, and would not exceed the FTA noise impact criteria (63 dBA for a moderate impact and 68 dBA for a severe impact). The transit center noise levels are predicted to be below the WAC noise impact threshold for commercial noise sources adjoining a residential use, which are an L_{eq} of 57 dBA for daytime and an L_{eq} of 47 dBA for nighttime (**Table 5-6**).

5.2.2 Traffic Noise

For each project component with roadway improvements the traffic noise levels and impacts are discussed below.

5.2.2.1 Burien Transit Center and Roadway Improvements

Roadway improvements at the Burien Transit Center, which would improve transit speed and reliability, would include a bus-only lane for eastbound buses along SW 148th Street, extending east across the SR 509/SR 518 interchange and along SR 518 for approximately 400 feet. For westbound buses, a bus-only left-turn pocket would be added along SW 148th Street between 1st Avenue S and the Burien Transit Center. These bus-only lanes would not create a new line of sight to the receiver, would not substantially change the vertical or horizontal roadway alignment, and would result in minimal to no change to overall traffic volumes on the roadway; therefore, no change to overall traffic noise levels is expected. Based on the WSDOT guidance, these improvements would not require a FHWA traffic noise abatement analysis.

5.2.2.2 Tukwila International Boulevard BRT Station and Roadway Improvements

Roadway improvements at the Tukwila International Boulevard BRT Station would add bus-only lanes to the inside of both eastbound and westbound SR 518, providing for pull-out stops in both directions at the station. These bus-only lanes would require realigning the center jersey

barrier along the highway median and widening SR 518 by regrading and repaving portions of the existing SR 518 travel lanes and ramps. In the westbound direction, the bus-only lane would also require widening the existing westbound SR 518 bridge that passes over the SR 518 off-ramp heading south to the Airport Expressway. These bus-only lanes would not create a new line of sight to the receiver, would not substantially change the vertical or horizontal roadway alignment, and would result in minimal to no change to overall traffic volumes on the roadway; therefore, no change to overall traffic noise levels is expected. Based on the WSDOT guidance, these improvements would not require a FHWA traffic noise abatement analysis.

5.2.2.3 South Renton Transit Center and Roadway Improvements

Roadway improvements at the South Renton Transit Center would include a new short section of a bus-on-shoulder lane that would start north of I-405 and extend to connect to the existing BAT lane on Rainier Avenue S. TSP would be added to the traffic signal owned by the City of Renton at the intersection of S Grady Way and Rainier Avenue S. A new signalized intersection would be constructed at Rainier Avenue S and Hardie Avenue SW. At the connection with Rainier Avenue S, Hardie Avenue SW would be reconstructed to realign the northbound and southbound lanes to be adjacent. North of this new intersection, the existing center median within Rainier Avenue S would be converted to a new southbound bus-only left-turn pocket to allow buses to turn left into the transit center. These bus-only lanes would not create a new line of sight to the receiver, would not substantially change the vertical or horizontal roadway alignment, and would result in minimal to no change to overall traffic volumes on the roadway; therefore, no change to overall traffic noise levels is expected. Based on the WSDOT guidance, these improvements would not require a FHWA traffic noise abatement analysis.

5.2.2.4 Brickyard Station and Roadway Improvements

Roadway improvements include bus-only lanes within I-405 that would be added to the approaches of both the northbound and southbound stations. The addition of these bus-only lanes and the BRT station platforms would require widening the existing I-405 roadway to the east and west. These bus-only lanes would not create a new line of sight to the receiver, would not substantially change the vertical or horizontal roadway alignment, and would result in minimal to no change to overall traffic volumes on the roadway; therefore, no change to overall traffic noise levels is expected. Based on the WSDOT guidance, these improvements would not require a FHWA traffic noise abatement analysis.

5.2.2.5 Lynnwood City Center Transit Station BRT and Roadway Improvements

The roadway improvements along Poplar Way would allow bus-only traffic on the inside shoulder of the loop on-ramp. While these improvements add an outside lane, it is for buses only and the bus traffic that would be added is farther from noise-sensitive receivers and would be traveling at reduced speeds of 35 mph to make the turn on the loop ramp. These bus-only lanes would not create a new line of sight to the receiver, would not substantially change the vertical or horizontal roadway alignment, and would result in minimal to no change to overall traffic volumes on the roadway; therefore, no change to overall traffic noise levels is expected. Based on the WSDOT guidance, these improvements would not require a FHWA traffic noise abatement analysis.

5.2.3 Vibration

Because the rubber tires and suspension systems of buses provide vibration isolation, it is unusual for buses to cause noticeable groundborne vibration or groundborne noise problems. For most issues with bus-related vibration, such as rattling of windows, the cause is almost always airborne noise and directly related to running surface conditions such as potholes, bumps, expansion joints, or other discontinuities in the road surface (usually resolved by smoothing the discontinuities). Existing and future vehicles such as buses, trucks, and automobiles generated by the proposed project are not anticipated to generate perceptible levels of vibration at surrounding land uses. As such, no vibration impacts are anticipated during operation of the BRT service.

6 MITIGATION MEASURES

6.1 Construction mitigation

The contractor will develop a Noise Control Plan demonstrating how the local noise limits can be achieved. The Noise Control Plan must be approved by either Sound Transit or WSDOT prior to initiating construction. If construction is planned during nighttime hours from 10:00 p.m. and 7:00 a.m., Sundays or legal holidays, the contractor would need to obtain a noise variance. The exception is the City of Bellevue where a noise variance would be required for construction from 6:00 p.m. to 7:00 a.m. Construction noise-reducing methods that may be implemented, as necessary, include the following:

- Use low-noise emission equipment
- Use broadband backup warning devices on all vehicles
- Implement noise-deadening measures for truck loading and operations
- Conduct monitoring and maintenance of equipment to meet noise limits
- Use acoustic enclosures, shields, or shrouds for equipment and facilities
- Install high-grade engine exhaust silencers and engine-casing sound insulation
- Minimize the use of generators
- Use movable noise barriers at the source of the construction activity
- Use drilled piles in lieu of impact piles or limit the time of day the activity could occur for potential pile driving for the foundations of the South Renton Transit Center and Kingsgate Park-and-Ride garage.

6.1.1 Vibration

Building damage from construction vibration is not anticipated from the project due to the type of construction and distance between the site and any nearest receivers; therefore, no mitigation is anticipated to be needed.

6.2 Operations mitigation

Based on the FTA General Noise Assessment, future BRT operational noise levels at the noise-sensitive land uses near BRT transit project components are not expected to result in a noise impact. Mitigation measures would not be required.

As design continues for the Tukwila International Boulevard BRT Station, the Totem Lake/Kingsgate BRT Station, and the Brickyard BRT Station, which would be located in or directly above the SR 518 or I-405 roadway, noise levels at the BRT station platforms would be evaluated for compliance with Sound Transit's criteria of a 1 hour L_{eq} noise limit of 72 dBA for traffic noise exposure for patrons at the station platform and design would incorporate noise minimization features as needed.

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