Chapter 4
Environmental Impacts and Mitigation

This chapter describes the existing conditions for a wide variety of environmental resources within the Plan area based on readily available information. Each section also describes the laws and regulations applicable to each resource, and potential long-term and construction-related impacts for the Current Plan Alternative and the Potential Plan Modifications Alternative described in Chapter 2. This Final Supplemental Environmental Impact Statement (SEIS) identifies alternatives and analyzes their potential impacts at a level of detail consistent with and appropriate for the broad, plan-level issues being addressed in the Long-Range Plan Update. To the extent possible, impacts would be mitigated in accordance with established local, state, and federal requirements as appropriate and Sound Transit's Environmental Policy (Sound Transit 2004b) and Sustainability Initiative (Sound Transit 2007). Potential mitigation measures for impacts are also discussed.

For purposes of analyzing impacts for the Current Plan Alternative, corridor sections were generally not evaluated if they are currently (1) in operation, (2) in final design or construction, or (3) in (or currently undergoing) project-level environmental review. These are corridor sections that have already been subject to environmental review and have been advanced or implemented as part of *Sound Move* or Sound Transit 2 (ST2). Recognizing that additional transit support facilities in these corridor sections may be warranted in the future, this Final SEIS does broadly evaluate development of new infill stations, park-and-rides, operations and maintenance facilities, additional tracks, and other representative projects that could be implemented within these corridors. However, for the Current Plan Alternative, the impact analysis in this chapter focuses primarily on potential impacts that could occur within the remaining corridor sections—those that have not yet advanced into project-level design and environmental review. These remaining corridors are listed in Table 2-1 through Table 2-4 and shown on Figure 2-7.

Corridors analyzed in this chapter for the Potential Plan Modifications Alternative are listed in Table 2-5 through Table 2-8 and shown in Figure 2-9 and Figure 2-10.

Impacts of the two alternatives are assessed in either qualitative or quantitative terms. Much of the quantitative analysis was done using techniques that are common in transportation analyses, including air quality modeling and energy consumption modeling. The sections of this chapter for Air Quality (4.2) and Energy (4.6) provide additional information on the data modeling and assessment methodology used.

Some resources in this chapter were assessed more qualitatively, with the discussion informed by geographic information systems (GIS) data acquired from federal, state, county, city, and other municipal sources. In some cases, GIS data were used solely to map resources and describe their location relative to the transit corridors being studied (e.g., earth, public

services and utilities). In other cases, GIS data were used to quantify environmental resources within a study area that varied in width depending on transit mode and the resource being analyzed. This provided an inventory of previously identified resources within the study area for each transit corridor. The inventory does not represent an estimate of the number of resources (such as parks and recreation facilities or wetlands) that would be impacted if a corridor were implemented. Instead, it was used as an indication of the relative concentration of resources within various corridors.

Regional express bus and streetcar corridors were not evaluated using GIS because they would generally operate within an existing roadway. Corridors that are identified as "HCT" (high-capacity transit) but do not specify mode would ultimately be either light rail or bus rapid transit (BRT). Therefore, potential impacts for these corridors were analyzed as if they were either light rail or BRT using the study area widths for each mode as described below.

The resources that were quantified using GIS data are described below along with the study area widths that were used for each resource.

Noise and vibration

- **Light rail—**Study area width of approximately 350 feet on each side of the corridor's centerline (or 700-foot total width). This study area was based on the Federal Transit Administration's (FTA) screening distances for noise assessments.
- **Commuter rail—**Study area width of approximately 750 feet on each side of the corridor's centerline (or 1,500-foot total corridor width). This study area was based on FTA's screening distances for noise assessments.
- **Bus rapid transit—**Study area width of approximately 500 feet on each side of an existing roadway corridor's centerline (or 1,000-foot total width). This study area was based on FTA's screening distances for noise assessments.

Water quality and hydrology, ecosystems, parks and recreation, and historic and cultural resources

- **Light rail—**Study area width of approximately one-half mile on each side of the corridor's centerline (or 1-mile total width). This relatively wide study area was used because (1) light rail corridors are not well defined at this stage of planning and potential alternative alignments, if considered in future project-level environmental reviews, could reasonably be accommodated within this broader area, and (2) the extent of right-of-way required for light rail could be greater than that needed for other modes.
- **Commuter rail—**Study area width of approximately 100 feet on each side of the corridor's centerline (or 200-foot total width). This width was used because commuter rail corridors would generally operate in existing rail corridors and would accommodate additional track, platforms, or other rail elements.

  Exception: Corridor 20 (Sounder line between Lakewood and Parkland) in the Potential Plan Modifications Alternative, which was suggested as a new commuter rail line. There is no existing rail line in this corridor; therefore, it was analyzed using a width of approximately one-half mile on each side of the corridor's centerline, similar to light rail.

- **Bus rapid transit—**Study area width of approximately 100 feet on each side of an existing roadway corridor's centerline (or 200-foot total width). For purposes of analyzing impacts for BRT that operate in exclusive bus lanes, this Final SEIS assumes development of exclusive BRT lanes adjacent to existing roadways by adding one lane in each direction.

  Exception: Corridor 30 (BRT route along Madison Street in Seattle from Colman Dock to 23rd Street) was not analyzed using GIS data because it was assumed this BRT route largely would be located within existing roadway facilities. Impacts to these resources could occur in this corridor but they are not expected to be significant.

Environmental health (Hazardous materials)

- **Light rail—**Study area width of approximately one-half mile on each side of the corridor's centerline (or 1-mile total width). This study area width was used to be consistent with Sound Transit project-level environmental documents.

- **Commuter rail—**Study area width of approximately one-eighth mile on each side of the corridor's centerline (or one-quarter mile total width). This is consistent with other Sound Transit documents.

  Exception: Corridor 20 (Sounder line between Lakewood and Parkland) in the Potential Plan Modifications Alternative, which was suggested as a new commuter rail line. There is no existing rail line in this corridor; therefore, it was analyzed using a width of approximately one-half mile on each side of the corridor's centerline, similar to light rail.

- **Bus rapid transit—**Study area width of approximately one-eighth mile on each side of an existing roadway corridor's centerline (or one-quarter mile total width). This is consistent with other Sound Transit documents.

  Exception: Corridor 30 (BRT route along Madison Street in Seattle from Colman Dock to 23rd Street) was not analyzed using GIS data because it is assumed this BRT route largely would be located within existing roadway facilities. Impacts from hazardous materials could occur in this corridor but they are not expected to be significant.

4.1 Earth

This section describes existing geologic conditions in the Plan area and potential geologic impacts and mitigation measures for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, the potential impacts are qualitatively described based on broadly defined corridor locations. The study area for these corridors varies in width depending on mode as described in the introduction to this chapter.

4.1.1 Regulatory environment

Washington State's Growth Management Act (Chapter 36.70A RCW) requires all cities and counties to identify critical areas within their jurisdictions and formulate development regulations for their protection. The act defines geologically hazardous areas as those that are susceptible to erosion, sliding, earthquakes, or other geological events; these areas are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns.

4.1.2 Affected environment

General geology

The central Puget Sound region lies in a glacially scoured basin between mountains to the east and the west. The landscape is a series of north-south trending ridges separated by deep troughs occupied by marine waters, lakes, streams, and rivers.

Most surface and shallow subsurface soils were deposited during the most recent glaciation. These deposits, from oldest to youngest, generally include the following:

- Lakebed sediments (silts and clays)
- Deposits from glacial runoff (sands and gravels)
- Glacial till (very dense mixture of gravel, sand, silt, and clay)

Relatively recent (less than 10,000 years old) stream deposits and artificial fill are also present in many places.

The Plan area includes geologically hazardous areas. These areas are associated with slide, erosion, settlement, liquefaction, and seismic hazards and are presented in the Long-term impacts sections for each alternative below. Geologic hazard areas are often designated *sensitive areas* and could be subject to additional restrictions and permitting requirements. Steep slopes in the area are conducive to landslides. Unconsolidated lakebed deposits and peats are prone to settlement. Strong lateral stresses in hard silt and clay adversely affect construction of retaining walls and underground facilities. Underground facilities could also be adversely affected by water-bearing sand and gravel.

Slide hazard areas

Slide hazards in the Plan area are associated with steep slopes or loose soils made unstable by geologic or human-generated conditions. Factors that can contribute to slope instability include over-steepening of natural slopes; constructed fills consisting of loose, wet, or saturated fill soils; and the presence of groundwater in soils. These conditions can also decrease soil stability by decreasing friction between soil particles in coarse-grained deposits

and by creating excess pressure in fine-grained deposits that are poorly drained. Slope stability is also influenced by seismic activity, which is discussed in further detail below.

Relatively small steep slope/slide hazard areas are found throughout the Plan area. Larger areas are found along the Puget Sound shoreline; in the cities of Seattle, Shoreline, Issaquah, and Burien; and along the shores of Commencement Bay.

Erosion is greater on slopes and can occur through either wind or water action. The rate of erosion also depends on soil type, vegetative cover, and topographic position.

Seismic hazard areas

Seismic hazard conditions often occur in valleys and areas of constructed fill. Relatively small seismic/liquefaction areas are found throughout the Plan area. Seismic/liquefaction areas occur along the Puget Sound shoreline in Snohomish County; in the city of Seattle and near the cities of Woodinville, Auburn, and Sumner; along the shoreline of Lake Sammamish; along the Cedar River near Renton; from the city of Tukwila, south to Orting; and in the large area in Pierce County between Mount Rainier and Commencement Bay.

Seismic hazard areas

Areas that are subject to severe risk of earthquake damage as a result of seismically induced settlement, soil liquefaction, or landslides.

Researchers warn that earthquakes pose a serious threat to life and property in the Puget Sound region. According to a study by the Federal Emergency Management Agency (FEMA), Washington State has the second highest risk of economic loss caused by earthquakes in the nation, behind only California (FEMA 2008). More than 1,000 earthquakes occur in the state annually. Washington has a record of at least 20 damaging earthquakes during the past 125 years (DNR 2014a). The greatest damage is usually near an earthquake's origin, although damage to structures depends on many factors, such as the type of construction, distance from the epicenter, and type of soil beneath the structure.

In the Pacific Northwest, there are multiple sources for earthquakes, including the Cascadia Subduction Zone and shallow crustal fault zones. Subduction zone earthquakes tend to be large and can exceed magnitude 9.0. The geologic record suggests that five or six subduction zone events may have occurred over the last 3,500 years; the most recent was about 300 years ago (PNSN 2002).

Cascadia Subduction Zone

A convergence zone between the Juan de Fuca and North American plates (the Juan de Fuca plate is sliding below the North American plate) located about 50 miles off the coasts of British Columbia, Washington, Oregon, and northern California.

Crustal fault zones

Areas where sections or layers of rock are moving past each other.

In Washington, there are three types of earthquakes:

Intraplate or Benioff Zone—These earthquakes occur in the subducting Juan de Fuca plate at depths of 16 to 62 miles.

Shallow Crustal—These earthquakes occur within about 17 miles of the surface.

Subduction Zone (Interplate)—These earthquakes occur along the interface between tectonic plates.

The most prominent local earthquake in recent years—the magnitude 6.8 Nisqually earthquake of 2001—was an intraplate (Benioff) zone event associated with the Cascadia Subduction Zone. The Nisqually earthquake was located about 10.5 miles northeast of Olympia at a depth of 32.25 miles (PNSN 2014).

The Seattle Fault zone, which runs east-west from Issaquah to Bremerton, is a shallow crustal fault zone. Evidence suggests that a major earthquake occurred about 1,100 years ago on the Seattle Fault. Researchers speculate that the Seattle Fault could produce earthquakes on the order of magnitude 7.0; however, the

recurrence interval of such earthquakes is anticipated to be infrequent (thousands of years). Other faults occur in Snohomish County between Lynnwood and Everett and near the southern part of the Plan area near Mount Rainier.

4.1.3 Long-term impacts

Long-term impacts to the existing geology of the Plan area could result from new excavation slopes and new earth fills associated with potential transit improvements. Slopes that have been steepened to meet alignment requirements pose a risk of insufficient long-term stability. New earth fills for structures could lead to long-term settlement of soft soils below and adjacent to new construction which in turn could lead to settlement of buildings, and damage to roadways or buried utilities.

Other long-term effects would be related to geologic hazards that already exist, including steep slopes, erosion, landslides, seismicity, and soft soils. For example, there could be the risk of seismic events during the period of operation, and this risk could result in other related geologic hazards, such as liquefaction and seismic-induced slope failures. Both the Current Plan Alternative and the Potential Plan Modifications Alternative include some corridors that could operate in areas with steep slopes. Existing steep slopes are susceptible to erosion or landslides, such as along the Puget Sound shoreline where Sound Transit operates Sounder commuter rail service between Seattle and Everett. Landslides could damage transit facilities and interrupt operations. Landslides can be triggered by a seismic event, natural stabilization processes, water pressure changes due to excessive rainfall, or where construction traverses or cuts into a steep slope.

The Draft *Sound Transit Climate Risk Reduction Project* (FTA 2013b) identified mudslide activity as a potential impact for alignments near the shoreline, such as the rail tracks adjacent to the Puget Sound shoreline. Slides could also occur in other areas with steep slopes or loose soils. Slides could lead to transit delays, service disruptions, and damage to Sound Transit facilities and infrastructure. The Plan area could be subjected to earthquake shaking and is considered to have a moderate-to-high seismic risk. Both the Current Plan Alternative and the Potential Plan Modifications Alternative include north-south transit corridors that would cross active faults as well as corridors with soils prone to liquefaction (particularly fill soils, tidal flats, and other unconsolidated deposits). Earthquake-induced soil liquefaction could result in a loss of soil strength, settlement, lateral spreading, and landslides. The magnitude of soil movement and loss of strength is a function of many factors, including soil thickness, soil quality, groundwater level, and the magnitude and location of the seismic event. Some of the corridors in both alternatives are also in areas where earthquake-induced tsunamis could occur, although most corridors are considerably inland and not at risk.

Under both alternatives, the design of new transit facilities (or renovation and upgrading of existing facilities) would comply with all applicable building codes and current or updated seismic code requirements. In general, new transit facilities would be more likely to survive earthquake impacts than older existing transportation infrastructure built to less stringent seismic standards.

Current Plan Alternative

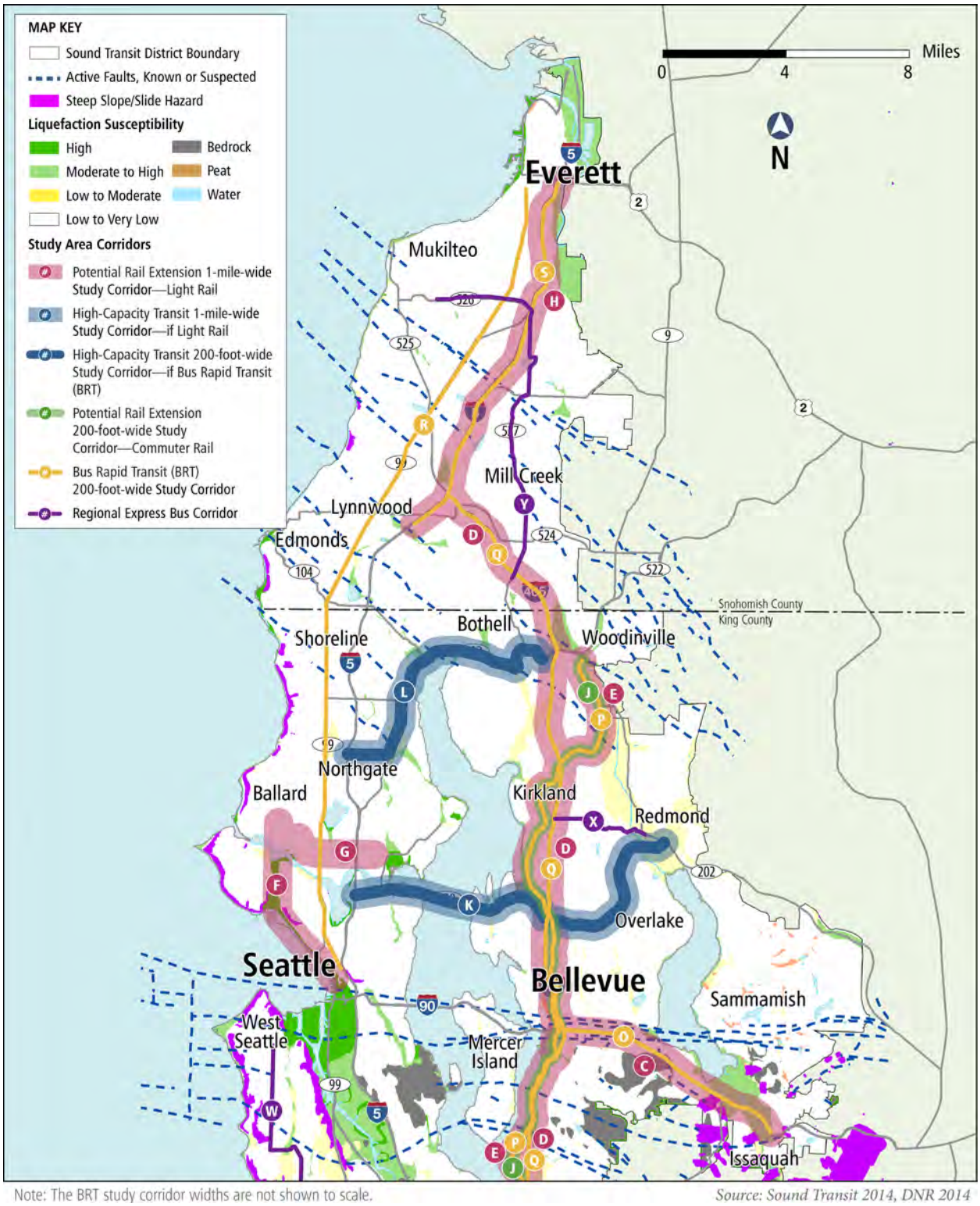
Figure 4-1 and Figure 4-2 depict the geologic hazard areas in relation to the Current Plan Alternative corridors, including areas categorized by Snohomish, King, and Pierce Counties as steep slope/slide hazard areas, seismic/liquefaction areas, and fault lines, based on recent GIS data from the three counties and the Washington State Department of Natural Resources, Geology and Earth Resources Division. The potential impacts of the Current Plan Alternative are discussed by mode below.

Light rail

Insufficient stability of steep slopes and retaining structures could endanger light rail facilities, light rail passengers, and neighboring properties, as well as support facilities such as operations and maintenance facilities and park-and-ride facilities. The Current Plan Alternative study corridor C includes areas of steep slopes, which are primarily located in Issaquah. In addition to the steep slope/slide hazard areas shown in Figure 4-1, portions of the Eastside Rail Corridor (light rail corridor E) traverse areas of high landslide hazard, as identified in City of Kirkland landslide areas data (City of Kirkland 2014). The overall risk from steep slopes and retaining structures is low because Sound Transit would evaluate these risks during future project-level design and propose preventive measures, such as retaining structures, to minimize risks.

Light rail alignments would have at-grade, elevated (including bridges), or belowground profiles. Elevated guideway structures, light rail stations, operation and maintenance facilities, and parking facilities would likely require shallow foundations or drilled shaft foundations. New earth fills could also be used in some areas to support new structures. Excavation of slopes along light rail corridors could also require retaining structures. New structures and fills could cause increased loads on the soil and could result in settlement of soft soils or erosion depending on ground conditions. Light rail operations are not likely to result in vibrations that would increase the potential for landslides.

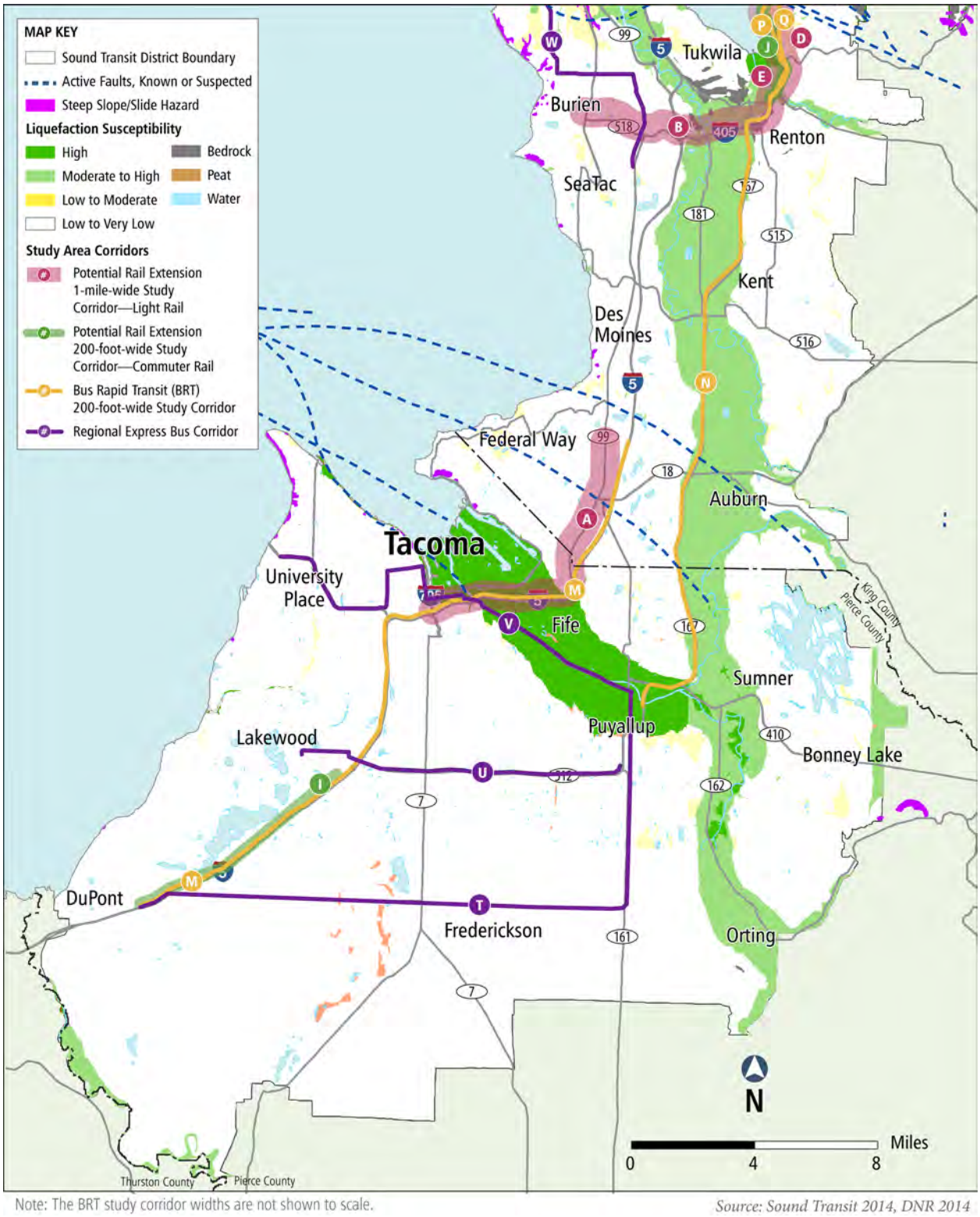
Study corridors A, B, and C of the Current Plan Alternative all have areas of soil with moderate-to-high and high liquefaction susceptibility. Seismic activity could impact light rail operations if light rail facilities were damaged in an earthquake. At-grade segments, stations, and support facilities would be more susceptible to liquefaction-induced damage than elevated and belowground elements because elevated guideways are typically supported on piles that are founded below the liquefaction-prone soils. Below-ground bored tunnels are generally deep and often lower in elevation than liquefaction-prone soils; cut-and-cover tunnels are generally shallower and may occur in areas of liquefaction-prone soils. However, more detailed evaluations would be conducted during project-level environmental review and design to assess whether liquefaction or land-sliding would be expected to occur and assess the impacts on the light rail elements, including tunnels. Study corridors C, F, and G could include potential tunnels in parts of the corridors.



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2014, DNR 2014

Figure 4-1. Geologic hazards for Current Plan Alternative study corridors—north



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2014, DNR 2014

Figure 4-2. Geologic hazards for Current Plan Alternative study corridors—south

Commuter rail

Within study corridor I there are no steep slopes and the soil is classified as having low to very low liquefaction susceptibility. Study corridor J traverses areas of high landslide hazards in Kirkland (City of Kirkland 2014), though the soil is classified as having low to very low liquefaction susceptibility. If new tracks are added along Everett-Seattle-Tacoma-Lakewood Commuter rail lines already in operation, they could occur in areas with steep slopes or in a liquefaction hazard area. For example, mudslides have occurred multiple times in the last few years south of Everett, Edmonds, and Mukilteo, causing cancelations in Sounder service.

Seismic activity could impact commuter rail operations if rail facilities were damaged in an earthquake. Similar to light rail, ground-borne vibrations from commuter rail trains are not likely to increase the potential for landslides. Commuter rail would be mainly at-grade, although some sections could be elevated, belowground, or on bridge segments. If infill stations and track or capacity improvements were added along the existing Sounder route, they could be located in areas of steep slopes or high liquefaction susceptibility.

Regional express bus/bus rapid transit

Additional regional express bus service (corridors T through Y) operating on existing roadways where buses currently operate would have little to no potential to generate impacts to steep slopes. Regional Express study corridor V is located within the Puyallup River area where the soil is classified as having moderate–to-high and high liquefaction susceptibility. BRT operating in exclusive rights-of-way, such as bus-only lanes, would most likely be at-grade and adjacent to existing roadway corridors. Elevated, belowground, and bridge segments could occur in some areas. In the Current Plan Alternative, BRT and regional express bus study corridors M, N, O, and V are located within areas where the soil is classified as having moderate–to-high and high liquefaction susceptibility. In particular, BRT study corridor N, traversing the Kent Valley, and regional express bus study corridor V, traversing the Puyallup River basin, have the largest area of moderate-to-high and high liquefaction susceptibility.

Seismic activity could impact both regional express and BRT operations because the roadways and facilities they use could be damaged in a seismic event. Depending on the extent of seismic damage, buses could be detoured around damaged areas, and temporary repairs to at-grade pavement could be accomplished quickly. Similarly, bus corridors operating in steep slope areas could be affected by landslides, although many of the corridors are along major freeways that are not abutting steep slopes.

High-capacity transit (mode not specified)

Corridors K and L, both identified as HCT corridors in the 2005 Long-Range Plan, also could be selected as light rail or BRT corridors. If selected for light rail, impacts generally would be similar to those described for the other light rail corridors. If selected as BRT, the impacts generally would be similar to those described for the other BRT corridors. However, neither of these corridors is in an area of steep slopes or high liquefaction susceptibility. Study corridor K includes a potential short tunnel west of

Lake Washington, which would have similar soil liquefaction concerns as described for light rail under the Current Plan Alternative.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have the same types of geologic impacts as those described above for the Current Plan Alternative. However, as a result of the additional corridors in the Potential Plan Modifications Alternative, the overall geologic impacts and risks could be greater than those in the Current Plan Alternative. Figure 4-3 and Figure 4-4 depict the geologic hazard areas in relation to the Potential Plan Modifications Alternative corridors, including areas categorized by Snohomish, King, and Pierce Counties as steep slope/slide hazard areas, seismic/liquefaction areas, and fault lines, based on recent GIS data from the three counties. The potential impacts of the Current Plan Alternative are discussed by mode below.

Light rail

The types of impacts that could occur would be similar to the light rail impacts discussed under the Current Plan Alternative. Light rail study corridors 2, 7, 9, 10, 11, and 12 all have areas of soil with moderate-to-high and high liquefaction susceptibility, with 7 traversing the Kent Valley having the largest area of moderate-to-high and high liquefaction susceptibility.

Commuter rail

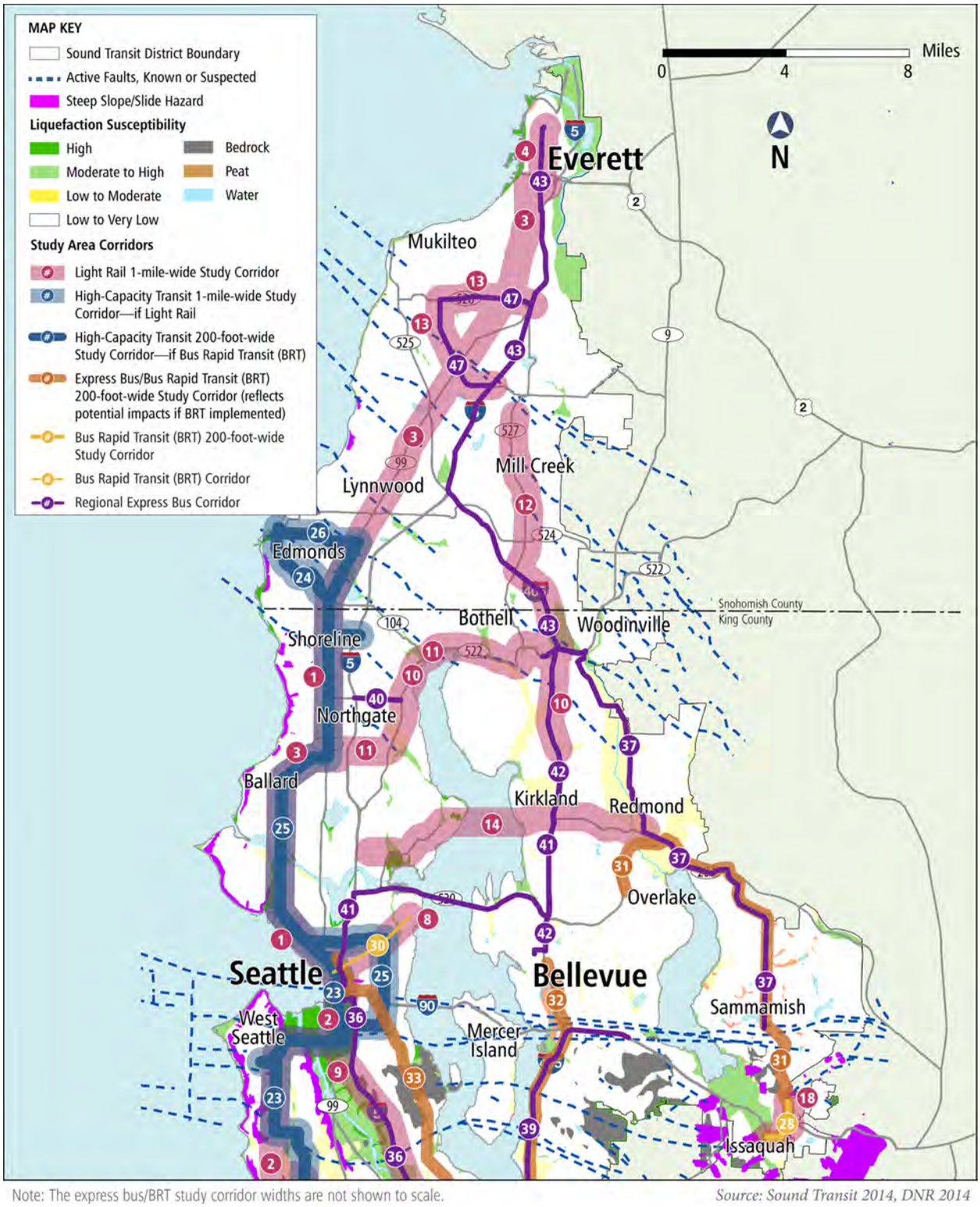
The types of impacts that could occur would be similar to the commuter rail alignments discussed under the Current Plan Alternative. While steep slopes are not common within the commuter rail study corridors (19 through 21), commuter rail study corridor 19 is almost entirely located within an area having soils classified as moderate-to-high and high liquefaction susceptibility.

Regional express bus/bus rapid transit

Additional regional express bus/BRT service (corridors 27 through 47) operating on existing roadways where buses currently operate would have little potential to generate impacts to steep slopes. The types of impacts that could occur would be similar to those discussed for regional express bus/BRT under the Current Plan Alternative. Regional Express bus/BRT study area corridors 29, 33 and 34 are all located in areas with soils classified as moderate-to-high and high liquefaction susceptibility.

Streetcar

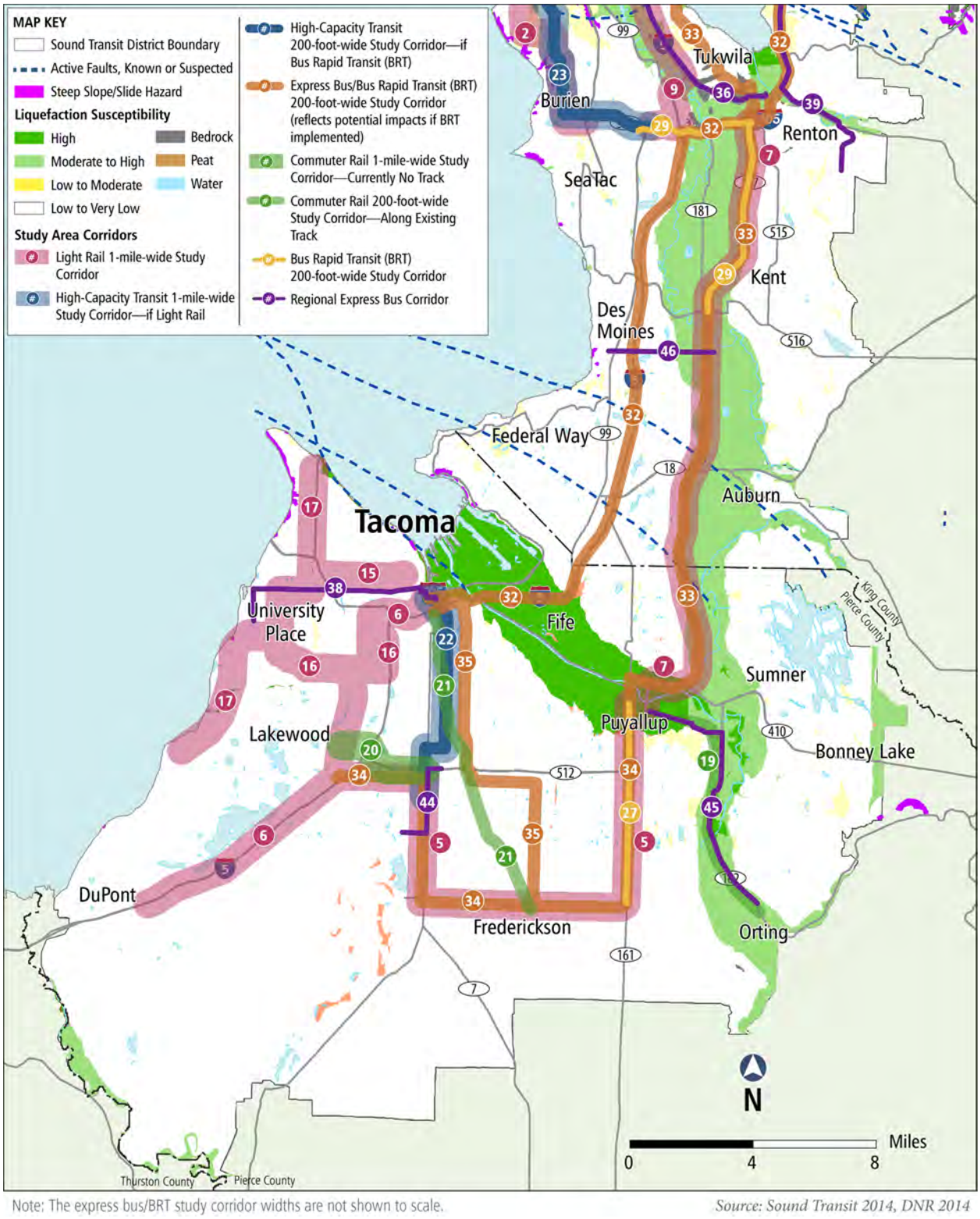
Since most streetcars would operate at-grade and within or adjacent to existing roadway rights-of-way, impacts would be similar to either BRT or at-grade light rail. Those lines that extend from downtown Seattle north are in areas of liquefaction susceptibility. There could be a risk of seismic events during operation, and this risk could result in other related geologic hazards, such as liquefaction and seismic-induced slope failures. Streetcar facilities, such as tracks and passenger stops, would have similar impacts as BRT and regional express bus facilities and are generally located in or adjacent to existing roadways. A streetcar in the ERC corridor would have similar impacts as discussed for at-grade portions of corridors E and J under the Current Plan Alternative.



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2014, DNR 2014

Figure 4-3. Geologic hazards for Potential Plan Modifications Alternative study corridors—north



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2014, DNR 2014

Figure 4-4. Geologic hazards for Potential Plan Modifications Alternative study corridors—south

High-capacity transit (mode not specified)

Corridors 22 through 26, all identified as HCT corridors, could be selected as light rail or BRT. If selected as light rail, impacts generally would be similar to those described for the other light rail corridors. If selected as BRT, impacts generally would be similar to those described for the other BRT corridors.

4.1.4 Construction impacts

Construction activities for both alternatives could cause a number of geological and soils-related short-term impacts, including erosion, hillside slumping, and settlement of nearby buildings or other infrastructure as described below.

Current Plan Alternative

Construction of at-grade and elevated alignments, as well as new stations or support facilities, could cause erosion impacts associated with vegetation removal, fill placement, cutting into the toe of slopes, and removal or stockpiling of spoils, especially if cut-and-fill techniques are required. The severity of potential erosion would depend on the quantity of vegetation removed, site topography, the volume of soils stockpiled, and mitigation measures. Soils disturbed during construction would be revegetated and would not experience long-term erosion impacts.

Excavations for foundations and belowground construction of tunnels and underground facilities could also result in temporary geologic impacts. Excavation, if not supported correctly, could result in failure and collapse of adjacent ground. Settlement of nearby structures and roadways could occur due to vibrations, dewatering of excavations below the groundwater table, or stockpiling of excavated material. This would be of particular concern near large structures and in sand and gravel, fill, and lake and stream deposits. Excavation for the installation of elevated light-rail column foundations would have similar impacts, but would be much less in extent because column foundations are only needed approximately every 100 feet.

Tunnel construction would create spoils and a potential for erosion. Soils could settle during dewatering and result in movement of structures near the excavation. A portion of excavated material could be contaminated and would therefore need to be properly treated or disposed of (for hazardous materials, see Section 4.7). Cut-and-cover tunnels would include large areas of disturbance along the length of the tunnel, while bored tunnels would limit disturbance to the portal, shaft, and station areas; however, settling could occur along the entire length with either construction method. Tunnels could be located in portions of study corridors C, F, G, and K.

Commuter rail improvements are not expected to involve substantial amounts of excavation because they would occur in existing rail corridors. However, new or expanded track sections, stations, and park-and-ride facility construction could require some excavation and therefore result in earth impacts.

Similar to commuter rail, new regional express bus routes are not expected to involve substantial amounts of excavation, although bus stops, transit centers, access ramps, and park-and-ride facility construction would require some excavation and earth impacts. If new

exclusive BRT lanes or transitways were required, the same types of profile-specific impacts as discussed for at-grade light rail could occur.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar construction impacts as those described above for the Current Plan Alternative. Tunnel sections could be located in portions of study corridors 2 and 14. The Potential Plan Modifications Alternative could involve additional construction activity in the region as a result of the additional corridors under consideration. Therefore, overall temporary impacts during construction could be slightly greater for the Potential Plan Modifications Alternative.

4.1.5 Potential mitigation measures

Geologic conditions would be studied in more detail during project-level planning and environmental review, and some impacts could likely be avoided by adjusting alignments. Where alignments could not be changed, potential problem areas would be identified and mitigated during design and construction. Design of all transit-related infrastructure would meet applicable local, state, and federal codes for retaining structures, settlement prevention, and earthquake safety. For both alternatives, the severity or frequency of the hazard or impact could be avoided or minimized by using conventional design and construction methods.

Long-term erosion and landslide impacts would be addressed through mitigation. The potential impacts of surface settlement, subsurface settlement, and other ground movements could be minimized by ground modification (grouting, freezing, removal of unsuitable materials, etc.) and structural modification (deep foundations, underpinning, spanning deposits, etc.). Designs would meet regulatory requirements for erosion control; best management practices (BMP) would be applied; and soil improvements could be implemented in some cases. In addition, facilities would be designed to minimize potential seismic effects and to counteract potential liquefaction through various means of support.

Settlement

New earth fills may be needed in some areas to meet grade requirements for transitways, stations, and other support facilities. The fill would cause new earth loads on the existing soil, which could lead to settlement of soft soil. Additional geotechnical assessment during final design would identify the location of soft soils that are prone to settlement. Where found, soft soils could either be replaced or ground improvement techniques could be used to prevent long-term settlement. Depending on the location, another potential mitigation measure would be to use lightweight fill rather than normal earth fill. Monitoring could identify settlement of compressible soils beneath retaining structures and fill areas and periodic maintenance of the new structures would minimize impacts. Utilities or other structures adjacent to new facilities could also settle as a result of increased loads. In areas where settlement-prone soils exist, mitigation measures would be used to minimize the impact of settlement.

Lightweight fill

Examples of lightweight fill include extruded polystyrene (geofoam) or cellular concrete.

During construction, methods to help minimize soil settlement during dewatering include:

- Controlling changes in groundwater elevation near critical structures
- Using sheetpile barrier systems to control the horizontal extent of groundwater withdrawal
- Installing deep foundation systems to support structures

Landslides

For landslides and steep slopes, mitigation is required only if construction of an alternative traverses or cuts into existing steep slope/landslide hazard areas, removes vegetation from existing steep slopes, or is in such close proximity to an existing steep slope/landslide hazard that construction could impact the slope or vice versa. Potential mitigation measures include the following:

- Locating new facilities away from unstable slopes
- Improving the soil
- Limiting clearing and grading
- Using an engineered structure (retaining wall)
- Re-grading the slope to an allowable inclination
- Installing drainage improvements
- Re-vegetating to protect soils from erosion

Potential ground movements would be monitored during construction, and adequate support to adjacent structures would be provided. Permanent slopes would be designed and constructed with adequate safety factors. Where facilities are located next to unstable slopes, a slide warning system could be used to detect landslides.

Spoils stockpiling and erosion

Generally, any construction would create the potential for erosion. While underground construction could generate large volumes of spoils, aboveground construction could create a greater surface of exposed soil. Potential impacts include erosion to exposed soil at stockpile and disposal sites. Disposal of spoils would depend upon whether the spoils are clean or contaminated, the type of soil (coarse-grained or fine-grained), soil moisture content, regional demand for fill soils at the time construction is undertaken, availability of disposal sites, and other factors.

To control erosion during construction, contractors would employ standard mitigation measures within the construction limits. Best management practices would be used as necessary. These mitigation measures would be approved by the local jurisdictions and would reduce the amount of silt-laden runoff leaving the construction site, minimize dust, and reduce erosion. Use of clean fill soils containing little or no silt and clay could also help reduce erosion potential.

Seismic events

The Plan area is within a seismically active zone. New structures, such as guideways, tunnels, light rail stations, support systems, and retaining structures, including retained fills or cuts, would be designed to meet Sound Transit's Design Criteria, the latest federal and state seismic and environmental requirements, and state and local building codes. These standards

are required to minimize long-term risks to the system and the public and are based on the occurrence of a very rare seismic event.

4.1.6 Significant unavoidable adverse impacts

Significant unavoidable adverse earth impacts are not anticipated. Facility design for future actions would include standard BMPs, meet current design standards, and consider geologic and seismic hazards that affect construction and operations.

4.2 Air quality

This section describes the existing air quality conditions (2011) and the potential future (2040) regional air quality impacts and benefits, including greenhouse gas emissions, of the Current Plan Alternative and the Potential Plan Modifications Alternative in the Plan area. To assess air quality effects, both alternatives are also compared to future ST2 buildout conditions, meaning that only those projects in the ST2 System Plan are implemented in 2040. This section also describes potential localized air quality impacts where the Current Plan Alternative and the Potential Plan Modifications Alternative could increase traffic volumes and congestion within the transportation system.

4.2.1 Regulatory environment

Air quality in the Puget Sound region is regulated by the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and the Puget Sound Clean Air Agency (PSCAA).

Under the authority of the Clean Air Act (CAA), EPA has identified several air pollutants as pollutants of concern nationwide and has established National Ambient Air Quality Standards (NAAQS) (EPA 2011b). Pollutants that have applicable standards are known as criteria pollutants and include carbon monoxide (CO), particulate matter less than 10 micrometers in size (PM_{10}), particulate matter less than 2.5 micrometers in size ($PM_{2.5}$), ozone (O_3), sulfur dioxide (SO_2), lead (Pb), and nitrogen dioxide (NO_2). The NAAQS specify maximum allowable concentrations for these criteria pollutants. Washington State and the PSCAA have also adopted these standards; in addition, they have established a standard for total suspended particulates (TSP) (Table 4-1).

Areas that meet the NAAQS for pollutants of concern are deemed *attainment areas;* areas not in compliance with the NAAQS are deemed *nonattainment areas;* and areas that were formerly classified as nonattainment areas but have since demonstrated attainment with the NAAQS are classified as *maintenance areas*. Under federal and state air quality statutes and regulations, maintenance and nonattainment areas must demonstrate that proposed transportation activities—plans, programs, and projects—do not cause new, or contribute to existing, air quality problems. EPA also regulates mobile source air toxic (MSAT) pollutants.

Greenhouse gas emissions are federally regulated for large industrial sources. To date, no national standards have been established regarding greenhouse gases nor has EPA established criteria or thresholds for ambient greenhouse gas emissions pursuant to its authority to establish motor vehicle emission standards for carbon dioxide (CO_2) under the Clean Air Act. Federal guidance regarding greenhouse gas emissions from other sources is currently under development. As a result, Sound Transit is analyzing greenhouse gas emissions in a manner consistent with best practices and its own policies.

Table 4-1. Ambient air quality standards

Pollutant	National primary standard	Washington State and PSCAA regional standard
CO (carbon monoxide)		
1-hour average (not to be exceeded more than once per year)	35 ppm	35 ppm
8-hour average (not to be exceeded more than once per year)	9 ppm	9 ppm
PM_{10}		
24-hour average (not to be exceeded more than once per year on average over 3 years)	150 µg/m^3	150 µg/m^3
$PM_{2.5}$		
Annual (annual mean, averaged over 3 years)	12 µg/m^3	12 µg/m^3
24-hour average concentration (98th percentile averaged over 3 years)	35 µg/m^3	35 µg/m^3
Total suspended particulates		
Annual arithmetic mean	NS	60 µg/m^3
24-hour average concentration (not to be exceeded more than once per year)	NS	150 µg/m^3
O_3 (ozone)		
8-hour average (annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years)	0.075 ppm	0.075 ppm
SO_2 (sulfur dioxide)		
1-hour average (99th percentile of 1-hour daily maximum concentrations, averaged over 3 years)	75 ppb	75 ppb
3-hour average (not to be exceeded more than once per year)	0.5 ppm	0.5 ppm
24-hour average (not to be exceeded more than once per year)	NS	0.14 ppm
Annual average (not to be exceeded)	NS	0.02 ppm
NO_2 (nitrogen dioxide)		
1-hour average (98th percentile averaged over 3 years)	100 ppb	100 ppb
Annual (annual mean)	53 ppb	53 ppb
Pb (lead)		
Rolling 3-month average (not to be exceeded)	0.15 µg/m^3	0.15 µg/m^3

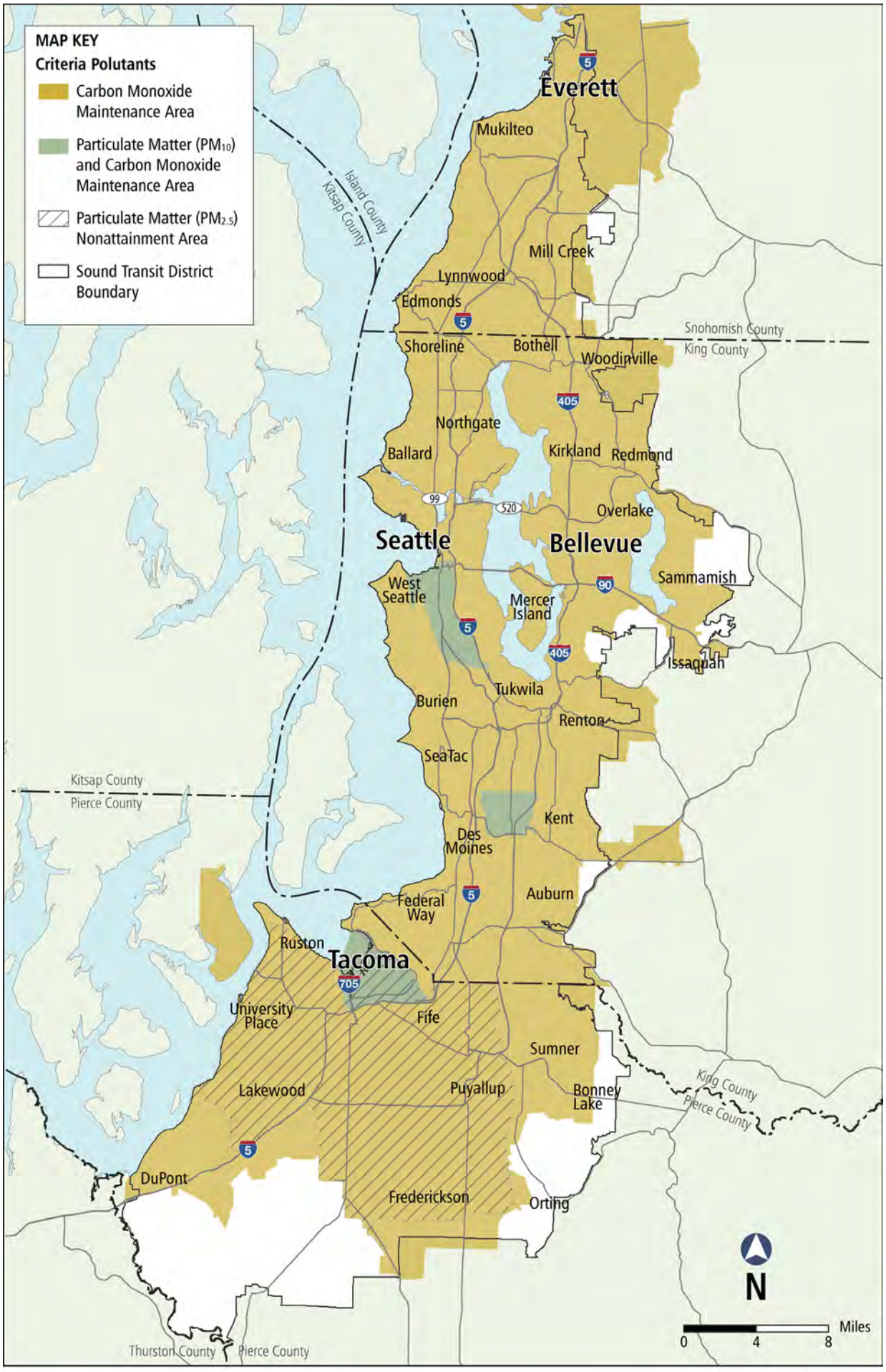
Sources: EPA 2011b; Chapter 173-474 WAC

The 8-hour ozone standard of 0.075 ppm (effective in 2008) replaces (for the most part) the previous 1-hour standard of 0.08 ppm.

µg/m3 = micrograms per cubic meter; NS = no standard established; ppb = parts per billion; ppm = parts per million

4.2.2 Affected environment

Most of the region is designated as a maintenance area for CO, and some locations in Seattle, Tacoma, and Kent are also maintenance areas for PM_{10} (Figure 4-5). While the region is currently designated as being in attainment with the federal standards for the other criteria pollutants, the South Tacoma (Wapato Hills/Puyallup River Valley) area in Pierce County violated the $PM_{2.5}$ standard and was designated a nonattainment area in December 2009 (Figure 4-5). The primary source of $PM_{2.5}$ emissions in this area is the burning of wood in winter, although mobile sources also represent a portion of $PM_{2.5}$ emissions (PSRC 2010).



Source: PSRC 2011

Figure 4-5. Air quality maintenance and nonattainment areas

Pollutants of concern

Motor vehicles are generally the largest contributors of air pollution from transportation sources. The main criteria pollutants emitted from motor vehicles are CO, PM_{10}, $PM_{2.5}$, and ozone precursors—volatile organic compounds and oxides of nitrogen (NO_x). Greenhouse gases and air toxic emissions are also pollutants of concern. This subsection discusses the effects of the main pollutants of concern on public health and the environment.

Carbon monoxide

CO is a colorless and odorless gas that interferes with the transfer of oxygen to the brain. It is emitted almost exclusively from the incomplete combustion of fossil fuels. Prolonged exposure to high levels of CO can cause headaches, drowsiness, loss of equilibrium, or heart disease. CO concentrations can vary greatly over relatively short distances. Relatively high concentrations are typically found near congested intersections, along heavily used roadways carrying slow-moving traffic, and in areas where atmospheric dispersion is inhibited by urban "street canyon" conditions.

Particulate matter

Particulate pollution is composed of solid particles or liquid droplets that are small enough to remain suspended in the air. Of particular concern are those particles that are smaller than, or equal to, PM_{10} and $PM_{2.5}$ (Figure 4-6). Particulates can include smoke, soot, dust, salts, acids, and metals. Particulate pollution also forms when gases emitted from motor vehicles react in the atmosphere.

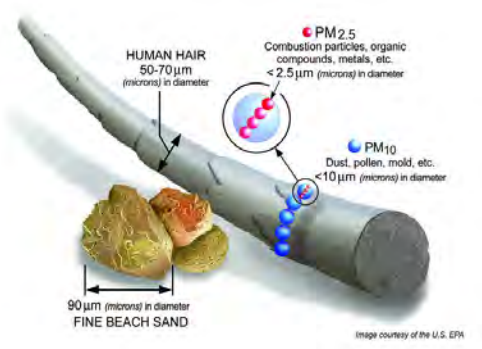


Figure 4-6. Particulate matter size

When inhaled, these particles can damage the respiratory tract. Particles between 2.5 and 10 micrometers in diameter tend to collect in the upper portion of the respiratory system, whereas particles 2.5 micrometers or less in diameter are so tiny that they can penetrate deeper into the lungs and damage lung tissue.

Ozone

Ozone is a colorless toxic gas that enters the bloodstream and interferes with the transfer of oxygen. It also damages plants by inhibiting their growth. Although ozone is not directly emitted, it forms in the atmosphere through a chemical reaction between reactive volatile organic compounds and NO_x. Ozone is also produced from industrial sources and automobile emissions.

Mobile source air toxic pollutants

In addition to the criteria pollutants for which there are NAAQS, the EPA regulates air toxics. Toxic air pollutants are those pollutants known or suspected to cause cancer or other serious health effects. Most air toxics originate from human-made sources, including on-road mobile sources, non-road mobile sources (e.g., airplanes), area sources (e.g., dry cleaners), and stationary sources (e.g., factories or refineries). EPA has identified seven priority MSAT pollutants.

Greenhouse gases

Greenhouse gases are gases that trap heat in the atmosphere. These gases are necessary because they keep the planet's surface warmer than it would be otherwise. As their

concentrations increase, however, the Earth's temperature rises. Vehicles emit a variety of gases during their operation; some of these are greenhouse gases. The greenhouse gases associated with transportation are water vapor, CO_2, methane (CH_4), and NO_2.

Nationally, the transportation sector (including on-road vehicles, construction activities, airplanes, and boats) accounts for almost 30 percent of total domestic CO_2 emissions, and the electricity sector accounts for almost 35 percent. In Washington State, the transportation sector accounts for nearly 50 percent of emissions (Figure 4-7). This larger percentage associated with transportation, as compared to the rest of the nation, is due to the relatively low greenhouse gas emission rate associated with electricity production in Washington (only 20 percent of total CO_2); this lower greenhouse gas emission rate is a result of the state's use of renewable energy, such as hydropower.

Greenhouse gas emissions are normally presented as the total CO_2 equivalent (CO_{2e}) released. The CO_{2e} emissions take into account the global warming potential of several different pollutants, including CO_2, CH_4, and nitrous oxide (N_2O).

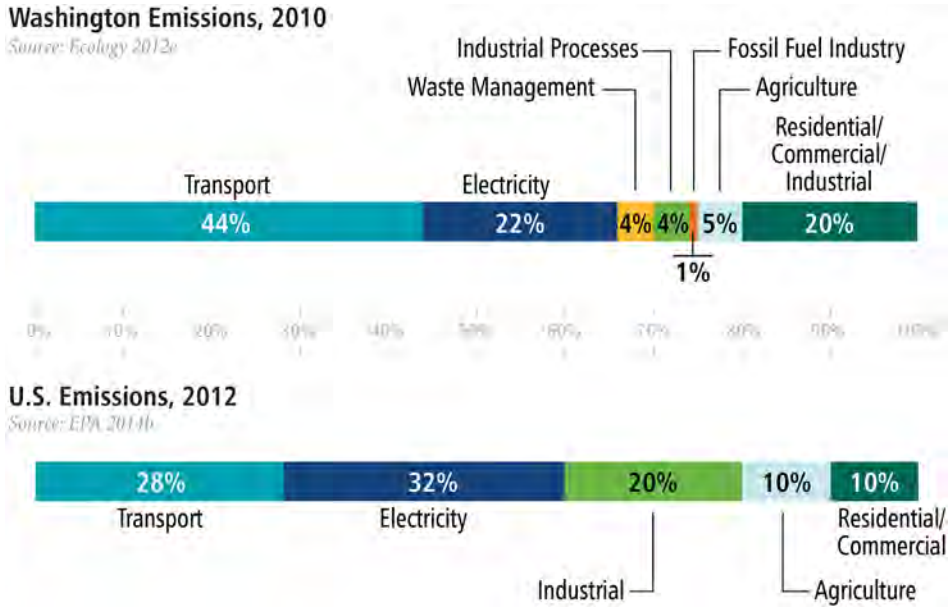


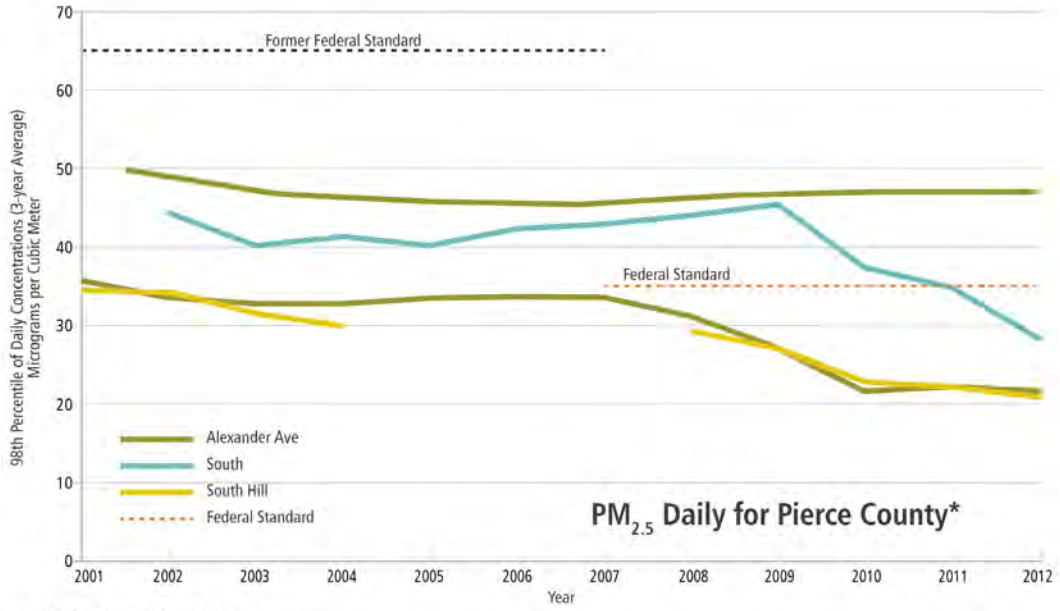
Figure 4-7. Greenhouse gas emissions by sector

Air pollution trends

Regional air pollution trends have generally followed national patterns over the last 20 years. While the average weekday vehicle miles traveled in the central Puget Sound region has increased from 36 million in 1980 to 80 million in 2009 (PSRC 2010a), pollutant emissions associated with transportation sources have decreased. Emissions of CO, sulfur oxides, and lead are well below the NAAQS in the region and have been for many years. CO is the criteria pollutant most closely tied to transportation; the maximum measured CO concentrations have decreased considerably as a result of greater vehicle fuel efficiency and EPA's national control programs. Other transportation-related pollutants have followed similar but less pronounced trends.

Emissions of fine particulates have been a concern in recent years. Pierce County violated the $PM_{2.5}$ standard and was subsequently designated nonattainment; ozone levels also

exceeded the new federal standard. Figure 4-8 shows the fine particulate concentrations in Pierce County. The region is currently designated as being in attainment with the federal standards for the other criteria pollutants.



Source: Puget Sound Clean Air Agency
Note: All South Hill data are FRM (Federal Reference Method) from 2000-2012. Alexander Ave data are from 1999-2002 and nephelometer from 2003-2012. South Hill data are FRM from 1999-2002 and nephelometer from 2003-2004 and 2006-2012; incomplete nephelometer data was collected from South Hill in 2005.
**Three-year average of the 98th percentile of daily concentrations reference and continuous methods.*

Figure 4-8. Daily $PM_{2.5}$ for Pierce County

PSRC recently updated the regional emission analysis, which evaluated the air quality conditions for the $PM_{2.5}$ nonattainment and PM_{10} and CO maintenance areas for *Transportation 2040*, the current metropolitan transportation plan for the central Puget Sound region through 2040. PSRC evaluated CO and $PM_{2.5}$. NO_x is considered a precursor to $PM_{2.5}$; therefore, NO_x emissions were addressed as part of $PM_{2.5}$. Monitored PM_{10} levels are roughly one-third of the PM_{10} NAAQS with steady declines; as a result, PM_{10} areas will no longer be required to compare to regional limits. As shown in Table 4-2, the emissions analysis of the projects and programs in *Transportation 2040* are within the established limits for CO, $PM_{2.5}$, and NO_x. A large decrease in emissions from motor vehicles is expected between current conditions and 2030 due to the implementation of EPA's national control programs. After 2030, emissions from motor vehicles would continue to decrease but at a less dramatic rate. However, coupled with the growth in vehicle miles traveled during this time period, overall emissions could gradually increase, as demonstrated by the slight increase in CO emissions between 2030 and 2040 (PSRC 2014b). The *Transportation 2040* emissions analysis did not take into account recent and likely future updates to EPA's fuel economy and emission standards. Other state and federal legislation also could reduce future emission rates. As such, overall emissions could be lower.

Table 4-2. *Transportation 2040* air pollutant emission projections

	CO (tons per day)	$PM_{2.5}$ (pounds per day)	NO_x (pounds per day)
Emissions budget	2,512[1]	3,002[2]	71,5982
2020 forecast	1,139	1,823	37,729
2030 forecast	944	1,200	19,015
2040 forecast	959	1,082	14,174

Source: Transportation 2040 Update Appendix E: Regional Air Quality Conformity Analysis 2014

[1] CO motor vehicle emissions budget as identified in the updated CO maintenance plan, effective September 7, 2004

[2] $PM_{2.5}$ and NO_x motor vehicle emissions budgets as identified in the revision to the Washington State Implementation Plan, effective October 21, 2013

In 2008, the Washington State Legislature put into law the state's greenhouse gas emissions reduction requirements (RCW 70.235.020) and statewide goals to reduce annual per capita vehicle miles traveled (RCW 47.01.440), which supports the reduction of greenhouse gas emissions. Ecology's projection of Washington State's greenhouse gas emissions between 2009 and 2020 predicts emissions will only grow 3 percent as a result of state and federal policies in place right now. Over the same period, state population is expected to increase 14 percent. Between 2020 and 2035, greenhouse gas emissions are projected to grow an additional 10 percent. State and federal policies are projected to slow the growth in emissions from all energy use sectors and thus greenhouse gas emissions (Ecology 2010).

4.2.3 Long-term impacts

Regional impacts

Both the Current Plan Alternative and the Potential Plan Modifications Alternative are predicted to reduce regional greenhouse gas emissions in 2040 as compared to the ST2 buildout conditions in 2040, and are expected to demonstrate this same effect on regional criteria pollutants. By providing alternatives to driving, both alternatives would help reduce regional vehicle miles traveled by automobiles and trucks, thereby reducing overall regional pollutant emissions. Both the Current Plan Alternative and the Potential Plan Modifications Alternative would help meet Washington State's goals to reduce annual per capita vehicle miles traveled and would support the reduction of greenhouse gas emissions.

The small reduction (less than 1 percent) in total vehicle miles traveled (Table 4-3) with the Current Plan Alternative compared to the 2040 ST2 buildout could result in a similar reduction in regional pollutant emission. An additional small reduction in total vehicle miles traveled with the Potential Plan Modifications Alternative could result in an additional reduction in regional pollutant emissions for the Potential Plan Modifications Alternative compared to the Current Plan Alternative and the 2040 ST2 buildout of between 0.5 and 1.5 percent. Because of the slight decrease in vehicle miles traveled, emissions levels for CO, $PM_{2.5}$, and NO_x likely would remain below the emissions budgets under both the Potential Plan Modifications Alternative and the Current Plan Alternative.

Future MSAT emissions likely would be lower than present levels as a result of EPA's national control programs. Based on an FHWA analysis using EPA's Motor Vehicle Emission Simulator (MOVES) model version 2010b, even if vehicle-miles travelled increases by 102 percent as assumed from 2010 to 2050, a combined reduction of 83 percent in the total

annual emissions for the priority MSAT is projected for the same time period as a result of improved emission technology in on-road vehicles (FHWA's 2012 Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA). The 0.5 to 1.5 percent reduction in total vehicle miles traveled with the Potential Plan Modifications Alternative or the Current Plan Alternative compared to the 2040 ST2 buildout could result in a comparable reduction in regional MSAT emissions.

Sound Transit published a Sustainability Plan in 2011 that builds on the 2007 Sustainability Initiative. According to the Sustainability Plan, Sound Transit would integrate efficient operating practices at existing and new facilities and maximize intermodal transit connections in order to reduce automobile vehicle miles traveled. Implementation of the Sustainability Plan would reduce energy consumption and thus greenhouse gas emissions. Because potential transit improvements would affect on-road vehicles within the Plan area, as well as light rail, commuter rail, and regional express bus/BRT, greenhouse gas emissions of these sources have been evaluated.

Greenhouse gas emissions for light rail were developed using emission factors from local electricity vendors (Sound Transit 2014). Sound Transit's future long-term targets for electricity use would be carbon neutral (Sound Transit 2011). As such, actual light rail greenhouse gas emissions could be much lower.

Greenhouse gas emissions for commuter rail and buses were developed using EPA's Emission Factors for Greenhouse Gas Inventories (EPA 2011a). Greenhouse gas emissions for highway and road vehicles were developed using EPA's MOVES. PSRC provided regionally specific MOVES input files, and national defaults were used when regionally specific inputs were not available. EPA's Emission Factors for Greenhouse Gas Inventories and MOVES do not take into account recent and likely future updates to EPA's fuel economy and emission standards. Other state and federal legislation also could reduce future emission rates. As such, actual future greenhouse gas emissions from commuter rail, buses, and highway and road vehicle emissions could be lower.

Even with a roughly 25 percent increase in overall transportation vehicle miles traveled for all alternatives in 2040 compared to existing conditions, greenhouse gas emissions are expected to increase by only three to four percent between 2011 and 2040 as a result of improved fuel efficiency and future emissions standards (Table 4-3). Once EPA's Emission Factors for Greenhouse Gas Inventories and MOVES are updated with the new standards, future modeled 2040 greenhouse gas emissions would likely be lower.

Total transportation greenhouse gas emissions under the Current Plan Alternative would be lower than the ST2 buildout (Table 4-4). Total transportation greenhouse gas emissions under the Potential Plan Modifications Alternative would be lower than the Current Plan Alternative and the ST2 buildout (Table 4-4). Overall, the Potential Plan Modifications Alternative would result in the smallest total greenhouse gas emissions in the Sound Transit district because it would shift the greatest number of trips from single-occupancy vehicles to transit use. The Current Plan Alternative and the Potential Plan Modifications Alternative would reduce vehicle miles traveled and greenhouse gas emissions as compared to the ST2 buildout.

Table 4-3. Daily transportation greenhouse gas emissions

Mode	2011 existing		2040 ST2 buildout		2040 Current Plan Alternative		2040 Potential Plan Modifications Alternative	
	Vehicle miles traveled[4]	Daily CO_{2e} emissions (metric tons)	Vehicle miles traveled[4]	Daily CO_{2e} emissions (metric tons)	Vehicle miles traveled[4]	Daily CO_{2e} emissions (metric tons)	Vehicle miles traveled[4]	Daily CO_{2e} emissions (metric tons)
Commuter rail[1]	970	7	1,400	10	1,680	11	2,380	16
Light rail[2]	4,430	4	17,900	39	38,100	105	80,510	182
Sound Transit buses[1]	53,200	148	43,400	121	73,100	203	60,500	168
Non-transit highway and road vehicles[1,3]	79,435,205	41,271	99,865,404	42,827	99,033,864	42,470	98, 264,900	42,141
Total	79,493,805	41,430	99,928,104	42,997	99,146,744	42,789	98,408,290	42,507

[1] The emission calculations do not take into account recent and likely future updates to EPA's fuel economy and emission standards. Other state and federal legislation also could reduce future emission rates. As such, actual 2040 greenhouse gas emissions could be lower.

[2] Sound Transit's future long-term targets for electricity use would be carbon neutral (Sound Transit 2011). As such, actual 2040 light rail greenhouse gas emissions could be lower.

[3] Non-transit highway and road vehicles include autos, light trucks, medium trucks, and heavy trucks.

[4] See Section 3.5.2, Highway and road operations, in Chapter 3, Transportation, for more details on the vehicle miles traveled data.

Table 4-4. Total greenhouse gas emissions for forecast year 2040

	2040 ST2 buildout (metric tons)	2040 Current Plan Alternative (metric tons)	2040 Potential Plan Modifications Alternative (metric tons)
Daily CO_{2e}	42,997	42,789	42,507
Daily CO_{2e} reduction compared to ST2 buildout	Not applicable	208	490
Annual CO_{2e} reduction compared to ST2 buildout	Not applicable	75,920	178,850

Localized impacts

The Potential Plan Modifications Alternative and the Current Plan Alternative could have localized traffic impacts that increase localized pollutant concentrations. CO and $PM_{2.5}$ concentrations can vary greatly over relatively short distances. The highest concentrations are typically found near congested intersections, along heavily used roadways carrying slow-moving traffic, and in areas where atmospheric dispersion is inhibited by urban "street canyon" conditions. Potential localized air quality effects would be further evaluated as appropriate during project-level environmental review in CO and $PM_{2.5}$ maintenance and nonattainment areas (Figure 4-5). While there could be localized air quality impacts as a result of implementing elements of the Current Plan and Potential Plan Modifications Alternatives, no exceedances of ambient air quality standards are anticipated based on data from similar locations in the Puget Sound region.

At-grade light rail alignments could include at-grade crossings of intersections, which could increase traffic congestion. Elevated light rail alignments could also result in arterial modifications and could eliminate some two-way left-turn lanes. Increased traffic congestion and roadway changes could create localized air quality effects. New stations with park-and-ride facilities, as well as the expansion of park-and-ride capacity, and potential tunnel portals and vents could also result in localized traffic and air quality impacts. This could be particularly true near interim and permanent end-of-the-line stations, which could serve as collectors for the system and could attract additional automobile and transit traffic.

Increased commuter rail services with the Current Plan Alternative and the Potential Plan Modifications Alternative could cause a moderate to substantial increase in automobile traffic at some stations during train arrivals and departures at peak hours. This increase in traffic could increase congestion. As discussed for light rail, new stations with park-and-ride facilities, as well as the expansion of park-and-ride capacity with the Current Plan Alternative and the Potential Plan Modifications Alternative could also result in localized traffic and air quality impacts.

New regional express bus/BRT service with the Current Plan Alternative and the Potential Plan Modifications Alternative could result in new bus transit centers and potential expansion of existing bus transit centers and park-and-ride facilities. As discussed for light rail and commuter rail, these stations could increase congestion and localized air quality impacts as a result of the additional traffic generated by the park-and-ride facilities.

Streetcars operate in mixed traffic and at-grade on surface streets. The impact of streetcar lines could result in limiting left-turn movements and in localized air quality impacts.

Systemwide, the 0.5 to 1.5 percent reductions in regional vehicle miles traveled (Table 4-3) with the Potential Plan Modifications Alternative and the Current Plan Alternative compared to the ST2 buildout could result in comparable localized reductions in congestion on local roadways and at congested intersections, which would reduce localized emissions. Further evaluation of potential localized air quality impacts, as well as potential mitigation measures, would be conducted as appropriate in project-level planning and environmental review for each of the elements that could be part of the Current Plan Alternative and the Potential Plan Modifications Alternative.

4.2.4 Construction impacts

Construction-related air quality effects resulting from the Current Plan Alternative and the Potential Plan Modifications Alternative would be similar; however, the Potential Plan Modifications Alternative could involve additional construction activity in the region because of the additional corridors under consideration. As a result, overall temporary construction impacts could be slightly greater for the Potential Plan Modifications Alternative.

Construction-related air quality effects could result primarily from emissions from heavy-duty construction equipment (e.g., bulldozers, backhoes, and cranes), diesel-fueled mobile sources (e.g., trucks, brooms, and sweepers), diesel- and gasoline-fueled generators, and on-site and off-site project-related vehicles (e.g., service trucks and pickups).

Fugitive PM_{10} emissions are associated with land clearing, ground excavation, grading, cut-and-fill operations, and structure erection. PM_{10} emissions would vary from day to day, depending on the level of activity, specific operations, and weather conditions. Fugitive PM_{10} emissions from construction activities could be noticeable if uncontrolled. Mud and particulates from trucks could also be of concern if construction trucks are routed through streets near sensitive land uses (e.g., residences, schools, and parks).

Heavy trucks and construction equipment powered by gasoline and diesel engines would also generate $PM_{2.5}$, CO, and NO_x in exhaust emissions. If construction traffic and lane closures increase congestion and reduce the speed of other vehicles in the area, emissions could temporarily increase during delays. The effects would generally be limited to the immediate area in which the congestion occurs.

Some construction phases (particularly those involving paving operations using asphalt) could result in short-term odors, which could be detectable to some people near the site and would be diluted as distance from the site increases.

The generation of greenhouse gas emissions is directly related to the amount of fossil fuel burned. During construction, greenhouse gas emissions would be generated by diesel engines used to power the majority of the construction equipment.

4.2.5 Potential mitigation measures

Regionally, both the Current Plan Alternative and the Potential Plan Modifications Alternative are predicted to reduce criteria pollutant and greenhouse gas emissions in 2040 as compared to the ST2 buildout conditions in 2040. Because no long-term adverse air quality impacts are expected, no mitigation measures would be necessary. Potential localized air quality effects are not expected to exceed air quality standards and would be further evaluated as appropriate during project-level and environmental reviews in CO and $PM_{2.5}$ maintenance and nonattainment areas.

Consistent with PSCAA requirements, Sound Transit would use BMPs to prevent and reduce fugitive dust resulting from construction activities. The following mitigation measures could be used, as necessary and in accordance with standard practice, to control PM_{10}, $PM_{2.5}$, and emissions of CO and NO_x during construction. Several of these measures could also reduce greenhouse gas emissions:

- Spray exposed soil with a dust-control agent, such as water, as necessary to reduce emissions of PM_{10} and deposition of particulate matter
- Cover all transported loads of soils and wet materials before transport or provide adequate freeboard (i.e., space from the top of the material to the top of the truck) to reduce PM_{10} and deposition of particulates during transport
- Provide wheel washes to reduce dust and mud that would be carried offsite by vehicles in order to decrease particulate matter on area roadways
- Remove the dust and mud that are deposited on paved, public roads
- Route and schedule high volumes of construction traffic, where practical, to reduce additional congestion during peak travel periods and reduce emissions of CO, NO_x, and CO_{2e}
- Require appropriate emission-control devices on all construction equipment powered by gasoline or diesel fuel in order to reduce CO and NO_x emissions in vehicular exhaust
- Use well-maintained heavy equipment to reduce CO and NO_x emissions, which could also reduce greenhouse gas emissions
- Cover, install mulch, or plant vegetation as soon as practical after grading to reduce windblown particulates in the area
- Encourage contractors to employ emission-reduction technologies and practices for both on-road and off-road equipment and vehicles (e.g., retrofit equipment with diesel control technology or use ultra-low sulfur diesel)
- Implement a restriction on the time construction trucks may idle (e.g., no longer than 5 minutes)
- Locate construction equipment and truck staging zones away from sensitive receptors, as practicable, and in consideration of other factors, such as noise

All mitigation measures would comply with local regulations governing air quality, including those for controlling fugitive dust during construction.

Conformity statement

The Plan area includes a nonattainment area for $PM_{2.5}$ and maintenance areas for CO and PM_{10}. Revised state implementation plans must comply with the project-level conformity criteria described in the EPA Conformity Rule and with Chapter 173-420 WAC. Sound Transit will complete project-level conformity determinations on individual projects during project-level environmental reviews for those projects that are advanced as part of a future system plan.

The conformity requirements are that transportation activities should not:

- Cause or contribute to any new violation of the NAAQS
- Increase the frequency or severity of any existing violation of the NAAQS
- Delay the timely attainment of the NAAQS

Determinations of conformity are made on the regional level by PSRC in cooperation with Ecology and other jurisdictions. PSRC has previously found the *Transportation 2040* plan (which includes the Current Plan Alternative) to conform with the state implementation plan. Inclusion in *Transportation 2040* and a formal finding of conformity with the state implementation plan is anticipated by the PSRC Transportation Policy Board if the Sound Transit Board adopts all or part of the Potential Plan Modifications Alternative as part of its updated Long-Range Plan. A finding of conformity with the state implementation plan is expected to follow.

4.2.6 Significant unavoidable adverse impacts

No significant unavoidable adverse impacts to air quality are expected from the Current Plan Alternative or the Potential Plan Modifications Alternative. Implementation of the Current Plan Alternative and the Potential Plan Modifications Alternative could provide an overall benefit to regional air quality due to the reduction in vehicle trips and miles traveled.

4.3 Noise and vibration

Transit systems produce noise and vibration during construction and operation. This section describes potential noise and vibration impacts and mitigation measures for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, the potential impacts are qualitatively described based on broadly defined corridor locations. For the noise and vibration impact analyses, the study area for these corridors varies by mode and was defined by the impact screening distances for each mode as provided in FTA guidelines on corridor-level transit noise and vibration impact assessments (FTA 2006). While the number of residential parcels within the study area for each corridor is provided, it does not represent the number of parcels that would be impacted if a corridor were implemented. It may, however, reflect the relative concentration of noise-sensitive receptors along the various corridors. The actual number of residential parcels affected, the anticipated level of potential impacts, and measures to avoid and minimize those impacts would be determined during future project-level planning and environmental reviews.

4.3.1 Regulatory environment

Noise and vibration are forms of energy that travel through matter and are readily perceptible to people. Because they are readily perceived, they are often among the greatest concerns for communities surrounding transit projects.

Noise

The human ear can perceive a large range of sound magnitude (loudness) over a broad frequency (pitch in music) range. To account for this sensitivity, sound levels are measured on a logarithmic decibel scale with a frequency weighting applied to account for sensitivity of the human ear. Sound level is reported in units of A-weighted decibels (dBA).

Noise terminology

A-weighted decibels (dBA) are a unit of measure of sound energy that accounts for human perception of sound frequency.

The maximum sound level (L_{max}) is the highest sound level experienced over a period of time.

The equivalent sound level (L_{eq}) is the total sound energy averaged over a specified period of time.

The hourly L_{eq} ($L_{eq(h)}$) is averaged over 1 hour.

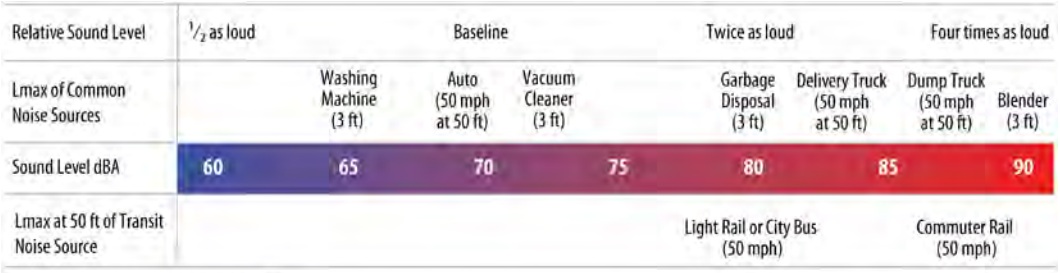
The day/night sound level (L_{dn}) is a measure of the entire daily sound environment with 10 dBA added to sound that occurs between 10 p.m. and 7 a.m. to recognize that nighttime noise is more bothersome than daytime noise.

Human hearing is not linear with sound energy. Most individuals can perceive a 3-dBA increase in sound levels, while a 5-dBA increase is obvious and a 10-dBA increase is a doubling of perceived loudness.

Sound levels decrease with distance from the source or if a barrier is placed between the source and the receiver. Doubling the distance from the source of a sound reduces the magnitude of the sound by between 3.5 and 8 dBA depending on the nature of the source and the ground over which the sound travels. Figure 4-9 provides the L_{max} sound levels for several transit sources at 50 feet along with those of common noise sources at various distances for comparison.

FTA guidelines evaluate noise impacts based on the noise sensitivity of the land use, the existing sound environment, and the source of the noise. The FTA transit noise impact criteria shown in Figure 4-10 are applicable for most transit sources. Under the FTA transit noise impact criteria, the louder the existing sound environment, the less a project is allowed to increase the total noise level. A new transit project would create a noise impact if the noise exposure from the project falls in either the moderate or severe impact area, as depicted in Figure 4-10, that corresponds to the existing environmetal noise level in the area. The land use categories referenced in Figure 4-10, which include more sensitive residential uses and less sensitive insititutional uses, are described in Table 4-5.

FTA has developed screening distances, which represent the greatest distance at which various types of projects would generate noise impacts. These distances are useful both to determine the boundaries of a noise analysis and as an evaluating tool to compare projects at a corridor-level. Applicable screening distances are included in Table 4-6.



Sources: EPA 1971, EPA 1974, FTA 2006

Figure 4-9. Typical sound levels

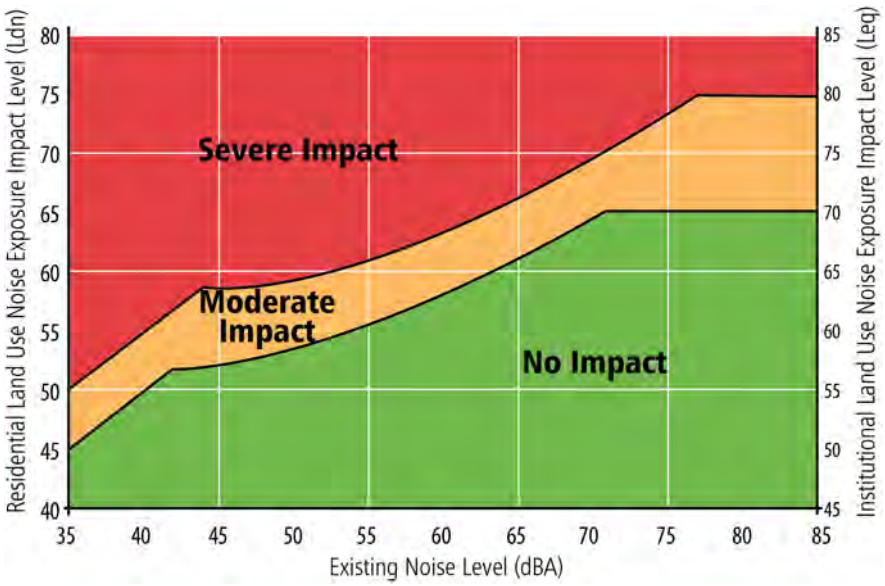


Figure 4-10. FTA noise impact criteria for transit projects

Table 4-5. Land use categories for transit noise impact criteria

Category	Metric	Description of category
1	$L_{eq(h)}$ (dBA)	Tracts of land where quiet is an essential element in their intended purpose—This category includes lands set aside for serenity and quiet, land uses such as outdoor amphitheaters and concert pavilions, and National Historic Landmarks with substantial outdoor use.
2	L_{dn} (dBA)	Residences and buildings where people normally sleep—This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	$L_{eq(h)}$ (dBA)	Institutional land uses with primary daytime and evening use—This category includes schools, libraries, and churches where it is important to consider interference with such activities as speech, meditation, and concentration on reading material. Buildings with interior spaces where quiet is important, such as medical offices, conference rooms, recording studios, and concert halls, fall into this category. It also includes places for meditation or study associated with cemeteries, monuments, and museums. Certain historical sites, parks, and recreational facilities are also included.

Source: FTA 2006

Table 4-6. FTA screening distances for noise assessments

Type of project	Maximum screening distance
Commuter rail	750 feet
Commuter rail station or crossing with horn	1,600 feet
Light rail transit	350 feet
BRT operating on busway	500 feet

Noise impacts from transit projects that are integrated with highways, such as BRT projects, are evaluated using the Federal Highway Administration (FHWA) noise abatement criteria. This approach considers the transit noise cumulatively with the other traffic noise. Unlike the FTA transit noise impact criteria, which consider the existing sound environment, the FHWA criteria are absolute levels. A criterion of 67 dBA $L_{eq(h)}$ is applicable to most noise-sensitive activities, including residences, hotels, schools, libraries, hospitals, and other similar land uses.

Local noise regulations apply to construction noise and noise from stationary sources, such as park-and-ride facilities and maintenance facilities. Most of the jurisdictions in the Plan area have adopted noise-control ordinances based on the Washington State Noise Control Ordinance (Chapter 173-60 WAC). The ordinance includes property-line noise limits that range between 55 and 70 dBA during daytime hours and between 45 and 60 dBA at night, depending on land use or zoning. Short-term exceedances are allowed, and most construction activities are exempt during weekday daytime hours.

Vibration

Vibration is an oscillatory (back-and-forth) motion caused by energy traveling through a solid. Vibration from transit projects mostly occurs during operation of rail transit or during construction of any type of project. People's perception of vibration relates more closely to the velocity of the vibration in the solid than to the displacement or acceleration of the material; therefore, vibration levels are evaluated as a vibration velocity. Vibration level is a function of the source, the path the vibration travels through various solid materials, and the distance between the source and receiver.

Most individuals can perceive vibration levels greater than about 65 VdB and become annoyed by frequent or persistent events greater than about 75 VdB when sedentary. Figure 4-11 shows vibration levels for common vibration sources.

FTA guidelines evaluate vibration impacts based on the frequency of events and vibration sensitivity of the land use. Table 4-7 summarizes the general ground-borne vibration criteria applicable for considering disturbance impacts from transit system operation. Hospitals, recording studios, and certain research laboratories are examples of vibration land use category 1 uses. Table 4-8 summarizes the construction vibration damage criteria.

Vibration terminology

Peak particle velocity (PPV) is the maximum instantaneous velocity at which matter moves while vibrating. It is analogous to an Lmax noise level. The potential for vibration damage is related to PPV level, which is measured in inches per second.

The velocity level (Lv) is a root-mean-square average of the particle velocity over a time period. It is analogous to a Leq noise level. People's response to vibration relates to Lv, which is measured in vibration decibel units (VdB).

Ground-borne noise

Low-frequency noise that is generated when a structure is excited by vibration energy traveling through the ground.

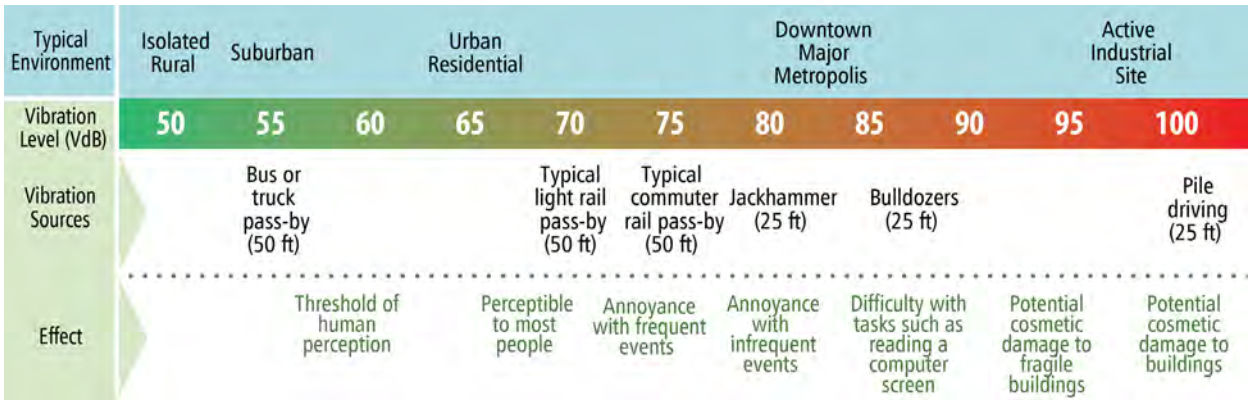


Figure 4-11. Typical vibration levels

Table 4-7. Ground-borne vibration criteria

Land use category	Impact levels	
	Frequent events	Infrequent events
1: Buildings where low ambient vibration is essential for interior operations	65 VdB	65 VdB
2: Residences and buildings where people normally sleep	72 VdB	80 VdB
3: Institutional land uses with primarily daytime use	75 VdB	83 VdB

Source: FTA 2006

Frequent events are more than 70 vibration events per day. Infrequent events are fewer than 70.

Table 4-8. Construction vibration damage criteria

Building category	Peak particle velocity
I: Reinforced-concrete, steel, or timber (no plaster)	0.5 in/sec
II: Engineered concrete and masonry (no plaster)	0.3 in/sec
III: Non-engineered timber and masonry buildings	0.2 in/sec
IV: Buildings extremely susceptible to vibration damage	0.12 in/sec

Source: FTA 2006

Vibration from trains can excite nearby buildings, generating low-frequency noise inside the buildings. This phenomenon, referred to as ground-borne noise, can be bothersome in situations such as tunnels where the direct noise from the rail-transit source is not audible.

4.3.2 Affected environment

Background noise and vibration levels vary widely in the environment. Transportation sources, including transit, contribute a substantial portion of the noise and vibration experienced in an urban environment.

Noise

The noise level in an environment tracks closely with the density of population and transportation noise sources (Figure 4-12). Areas within 500 feet of highways and railroad lines tend to be dominated by those sources, often with L_{dn} levels greater than 55 dBA. Areas within 100 feet of a freeway often have L_{dn} levels greater than 70 dBA (Figure 4-13). Noise levels measured in the Plan area (Table 4-9) are consistent with the typical levels shown in Figure 4-12 and Figure 4-13. No noise category 1 land uses (Table 4-5) have been identified within 500 feet of any study corridors.

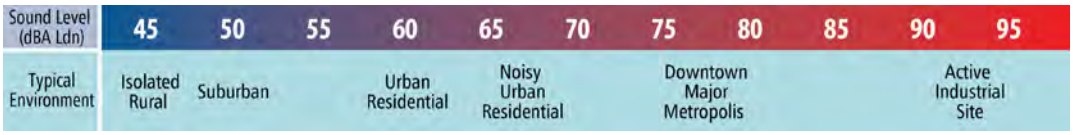


Figure 4-12. Typical sound environments

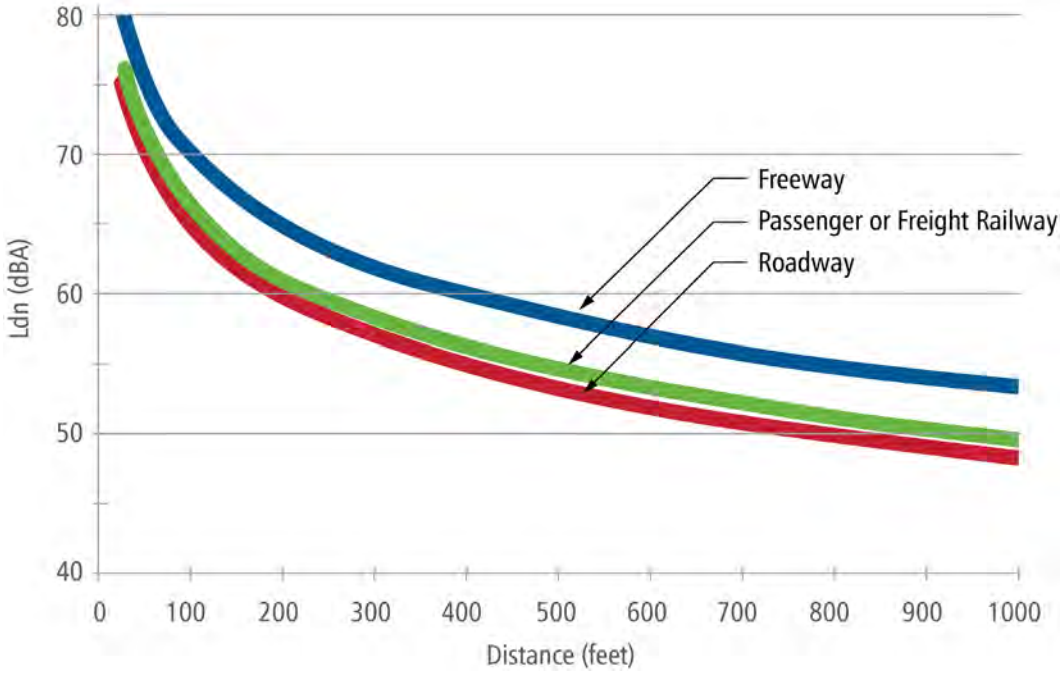


Figure 4-13. Typical noise levels (L_{dn}) near transportation facilities

Table 4-9. Range of measured existing noise levels along corridors for Sound Transit projects

Project	Minimum measured L_{dn}	Maximum measured L_{dn}
Central Link (Sound Transit 1999)	61 dBA	76 dBA
Tacoma Link (Sound Transit 1999)	64 dBA	74 dBA
Everett–Seattle Commuter Rail (Sound Transit 1999)	58 dBA	70 dBA
East Link (Sound Transit 2011)	53 dBA	70 dBA
Lynnwood Link (Sound Transit 2013)	57 dBA	81 dBA

Measured noise levels prior to the project being constructed and operated.

Vibration

Ambient ground-borne vibration levels are localized to the immediate vicinity of vibration sources but still reflect the level of activity in an area (Figure 4-11). Low-level vibration is generated in all transportation corridors, but it only becomes a concern if it annoys people or damages property. Noticeable ambient ground-borne noise occurs rarely because most vibration sources strong enough to generate ground-borne noise also directly generate noise levels sufficient to mask the ground-borne component.

4.3.3 Long-term impacts

With planned growth in the Plan area, transportation noise and vibration will increase under the Current Plan Alternative and the Potential Plan Modifications Alternative. Expanded transit coverage generates localized noise and vibration but reduces single-occupant vehicle use, a substantial component of freeway and local roadway noise.

Noise

The Current Plan Alternative and the Potential Plan Modifications Alternative would increase transit service in the Plan area. Typical L_{dn} levels experienced near transit facilities and services are shown in Figure 4-14. The facilities and services shown in Figure 4-14 are described in Table 4-10. In addition to noise from moving transit vehicles, warning bells and horns are used on light rail and commuter rail vehicles at stations and at-grade crossings. Stationary noise sources would include warning bells at at-grade crossings, station announcements, traction power substations, park-and-ride facilities, and both bus and rail maintenance and storage facilities. Infill stations, park-and-ride lots, and other supporting facilities added to increase capacity on existing lines would also generate noise similar to that evaluated in the study corridors. Commuter rail has the highest L_{max} noise levels of all transit modes; however, it has L_{dn} levels lower than light rail and bus modes because it operates infrequently, with the highest service occurring during the peak commute hours in the peak directions.

The corridor-level analysis completed following FTA guidelines indicates operational noise impacts would likely occur within 60 to 175 feet of new service and could extend to between 500 and 1,000 feet adjacent to at-grade rail crossings where crossing bells or horns are sounded.

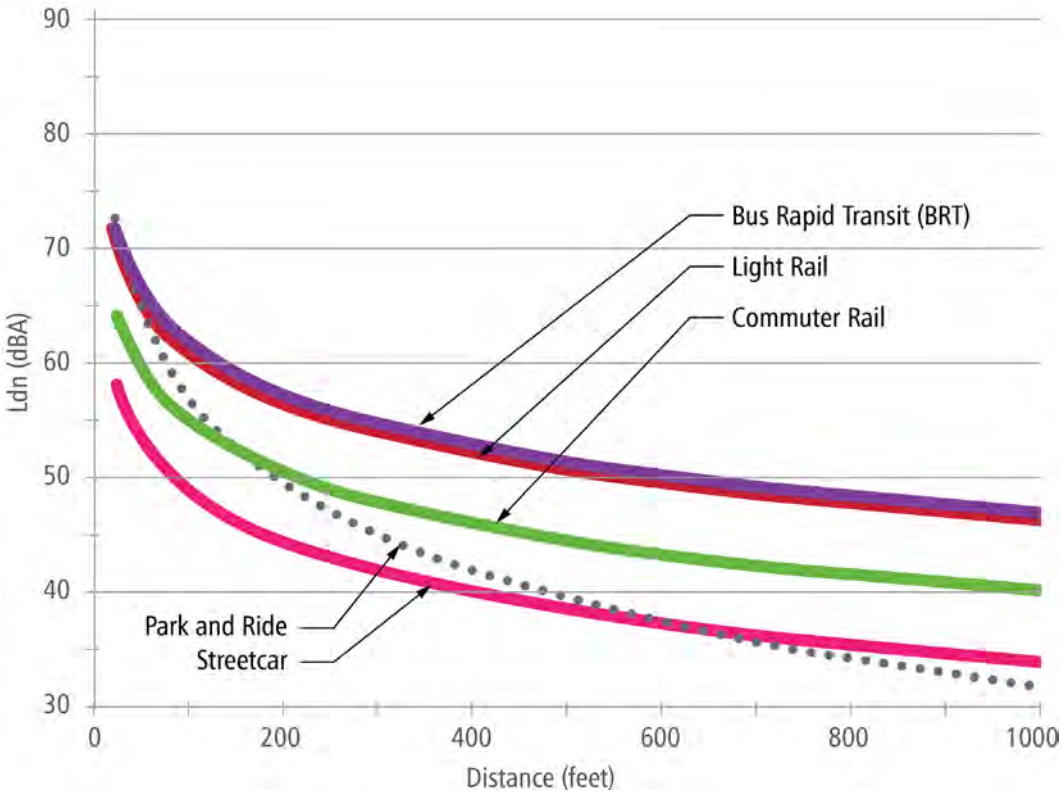


Figure 4-14. Typical noise levels near transit facilities

Table 4-10. Noise modeling assumptions reflected in Figure 4-14

Facility	Assumptions
Light rail extension line	Four-car trains operating at 55 mph every 12 minutes during the day and every 30 minutes at night in each direction
Commuter rail	One train with a single locomotive and 10 carriages operating at 55 mph each hour during the day in each direction
BRT	Buses operating at 55 mph every 12 minutes during the day and every 30 minutes at night in each direction
Streetcar	Single streetcar operating at 25 mph every 10 minutes during the day and every 30 minutes at night in each direction
Park-and-ride	500 auto capacity served by 12 buses per hour during the day and 2 buses per hour at night

Current Plan Alternative

The Current Plan Alternative includes light rail, commuter rail, and BRT. Operation of each of these modes would generate noise. Noise impacts would not extend beyond the FTA screening distances for the Current Plan Alternative corridors. Table 4-11 lists the number of residential parcels within the screening distances (Table 4-6) for each study corridor as defined by FTA. These numbers do not represent an estimate of the number of parcels that would experience noise impacts if a corridor were implemented. They may, however, indicate the relative concentration of noise-sensitive receivers near various corridors.

Light rail

Light rail operation would typically generate 62 dBA L_{dn} at 100 feet from the tracks and 52 dBA L_{dn} at 500 feet (Figure 4-14). Typical noise levels in neighborhoods where Sound Transit has added light rail are between 60 and 70 dBA L_{dn} (Table 4-9); therefore, noise impacts would typically occur at residences closer than 175 feet from light rail tracks in quieter neighborhoods and 60 feet in louder neighborhoods. The number of residential parcels within the screening distance of each light rail corridor is presented in Table 4-11. Potential noise impacts would occur only at a fraction of those parcels.

Although study corridor D along the I-405 corridor from Renton to Lynnwood is one of the longest corridors for the Current Plan Alternative, it has relatively low concentration of adjacent parcels when compared to other corridors. For example, looking at the number of parcels per mile, corridor G between Ballard and the University of Washington has the greatest density of development and is therefore likely to result in more noise impacts on a per mile basis than other corridors. At the other end of the scale, study corridor C along I-90 between Bellevue and Issaquah includes the fewest total residential parcels and the fewest parcels per corridor mile. Overall, the differences between corridors reflect the relative distance covered and the density of development in areas served by each corridor.

Noise impacts from stations and traction power substations are within the screening distances used to develop Table 4-11. Any portion of study corridors C, F, and G that are constructed in tunnels would not generate direct noise impacts. Noise from a 500-space park-and-ride facility would be 57 dBA L_{dn} at 100 feet and 39 dBA L_{dn} at 500 feet (Figure 4-14).

Table 4-11. Residential parcels for Current Plan Alternative study corridors

ID	Corridor location	Approximate length of corridor (miles)	Number of residential parcels within screening distance[1]
Potential rail extensions, assumed light rail: screening distance 350 feet each side of corridor centerline			
A	Tacoma to Federal Way	10	282
B	Burien to Renton	8	322
C[2]	Bellevue to Issaquah along I-90	10	231
D	Renton to Lynnwood along I-405	28	1,917
E	Renton to Woodinville along Eastside Rail Corridor	22	1,392
F[2]	Downtown Seattle to Ballard	6	508
G[2]	Ballard to UW	4	1,645
H	Lynnwood to Everett	13	1,216
Total residential parcels within screening distance of light rail study corridors[3]			6,990
Potential rail extensions, assumed commuter rail: screening distance 750 feet each side of corridor centerline			
I	DuPont to Lakewood	8	561
J	Renton to Woodinville along Eastside Rail Corridor	22	3,393
Total residential parcels within screening distance of commuter rail study corridors[3]			3,953
High-capacity transit (HCT) (mode not specified): screening distance 350 feet each side of corridor centerline if light rail/500 feet each side of corridor centerline if BRT			
K[2]	UW to Redmond via SR 520	13	Light rail: 485 BRT: 820
L	Northgate to Bothell	9	Light rail: 1,274 BRT: 1,945
Total residential parcels within screening distance of high-capacity transit study corridors[3]			Light rail: 1,759 BRT: 2,765
Bus rapid transit (BRT): screening distance 500 feet each side of corridor centerline			
M	Federal Way to DuPont along I-5	25	943
N	Renton to Puyallup along SR 167	21	740
O	Bellevue to Issaquah along I-90	10	418
P	Renton to Woodinville along Eastside Rail Corridor	22	2,089
Q	Renton to Lynnwood along I-405	28	3,213
R	Seattle to Everett along SR 99	27	8,035
S	Lynnwood to Everett along I-5	13	2,016
Regional express bus			
T-Y	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS	—	—
Total residential parcels within screening distance of bus study corridors[3]			17,001

[1] These numbers do not represent an estimate of the number of parcels that would experience noise impacts if a corridor were implemented; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

[3] Numbers include residential parcels where only a portion of the property is within the study corridor. Some residential parcels may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.

Commuter rail

As described previously, commuter rail has the highest L_{max} noise levels of all transit modes; however, it has L_{dn} levels substantially lower than other modes because it operates infrequently, with the highest service occurring mainly during the peak commute hours in the peak directions (Figure 4-14). Commuter rail service would typically generate 56 dBA L_{dn} at 100 feet from the tracks and 45 dBA L_{dn} at 500 feet. At new at-grade crossings where train horns are used, train horn noise would add 73 dBA at 100 feet from the new at-grade crossing and 59 dBA L_{dn} at 500 feet. In an area with an existing L_{dn} of 60 dBA, noise impacts would occur at residences closer than 60 feet from commuter rail lines and 600 feet from at-grade crossings or stations where train horns are used. The number of parcels within the screening distance for commuter rail corridors is presented in Table 4-11. Only a fraction of these parcels would experience noise impacts, with the greatest noise impacts occurring in the vicinity of at-grade crossings where the locomotives sound their horns. In general, the Eastside Rail Corridor (corridor J) has a relatively high density of development and is therefore more likely to result in noise impacts. Because the screening distance for commuter rail is greater than light rail, the total number of parcels potentially affected by noise is substantially larger for commuter rail than for light rail in the same corridor (light rail corridor E).

Park-and-ride facilities would have similar noise impacts to those in light rail corridors, depending on size.

Regional express bus/bus rapid transit

Additional regional express bus service (corridors T through Y) operating on existing roadways where buses currently operate would have little potential to generate new noise impacts. BRT lines would typically generate 62 dBA L_{dn} at 100 feet from the roadway and 51 dBA L_{dn} at 500 feet (Figure 4-14). BRT and regional express bus service is generally provided on or adjacent to existing freeways and major arterials where the existing L_{dn} noise levels are typically in the range of 70 dBA. Noise impacts would typically occur at residences closer than 60 feet from BRT and regional express bus lines. These noise impacts would occur in the corridors considered in Table 4-11 and would occur at a fraction of the parcels within the study corridors. Overall, based on the total number of residential parcels within study corridors, the highest potential for noise impacts would occur for study corridor R following SR 99 and the fewest for study corridor O, which reflects the relative distance covered, areas served by each corridor, and density of development along the corridors.

BRT noise levels

BRT, because it requires more buses to provide similar capacity as light rail transit, generates more noise than light rail transit for a similar number of passengers served.

Park-and-ride facilities would have similar noise impacts as light rail, depending on size.

High-capacity transit (mode not specified)

Corridors K and L, both HCT corridors, could be selected as either light rail or BRT corridors. The screening distance results in Table 4-11 include both mode options. The greater number of potential noise impacts associated with the BRT mode compared to light rail reflects operation of BRT on a new, exclusive alignment not currently in use by

traffic. If a portion of study corridor K were constructed in a tunnel west of Lake Washington, it would not generate direct noise impacts. Corridor L would have a higher potential for noise impacts than corridor K, which reflects its proximity to residential land uses.

Potential Plan Modifications Alternative

In general, long-term impacts resulting from the Potential Plan Modifications Alternative would be similar to those described for the Current Plan Alternative. Because of the additional corridors in the Potential Plan Modifications Alternative, the potential for noise impacts could be greater than those in the Current Plan Alternative if all of the modifications were implemented.

Similar to the Current Plan Alternative, noise impacts would not extend beyond the FTA screening distances for the Potential Plan Modifications Alternative corridors. Table 4-12 lists the number of residential parcels within screening distance of the corridors. These numbers do not represent an estimate of the number of parcels that would experience noise impacts if a corridor were implemented. They may, however, indicate the relative concentration of noise-sensitive resources near various corridors.

Table 4-12. Residential parcels for Potential Plan Modifications Alternative study corridors

ID	Corridor location	Approximate length of corridor (miles)	Number of residential parcels [1]
Potential rail extensions, assumed light rail: screening distance 350 feet each side of corridor centerline			
1	Downtown Seattle to Magnolia/Ballard to Shoreline Community College	12	2,015
2[2]	Downtown Seattle to West Seattle/Burien	13	2,575
3	Ballard to Everett Station via Shoreline Community College, Aurora Village, Lynnwood	24	4,754
4	Everett to North Everett	2	373
5	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	1,912
6	DuPont to downtown Tacoma via Lakewood, Tacoma Mall	16	733
7	Puyallup/Sumner to Renton via SR 167	21	438
8	Downtown Seattle along Madison Street	3	825
9	Tukwila to SODO via Duwamish industrial area	11	202
10	North Kirkland or University of Washington Bothell to Northgate via SR 522	13	1,503
11	Ballard to Bothell via Northgate	13	2,724
12	Mill Creek, connecting to Eastside Rail Corridor	8	1,266
13	Lynnwood to Everett, serving Southwest Everett Industrial Center (Paine Field and Boeing)	7	1,446
14[2]	UW to Sand Point to Kirkland to Redmond	10	901
15	Downtown Tacoma to Tacoma Community College	3	940
16	Tacoma Mall to University Place	6	1,030
17	Steilacoom to Ruston via University Place	12	2,332
18	Issaquah to Issaquah Highlands	2	131
Total residential parcels within screening distance of light rail study corridors[3]			21,888
Potential rail extensions, assumed commuter rail: screening distance 750 feet each side of corridor centerline			
19	Puyallup/Sumner to Orting	8	1,394
20	Lakewood to Parkland	3	676
21	Tacoma to Frederickson	10	2,936
Total residential parcels within screening distance of commuter rail study corridors[3]			5,006

Table 4-12. Residential parcels for Potential Plan Modifications Alternative study corridors (continued)

ID	Corridor location	Approximate length of corridor (miles)	Number of residential parcels [1]
High-capacity transit (HCT) (mode not specified): screening distance 350 feet each side of corridor centerline if light rail / 500 feet each side of corridor centerline if BRT			
22	Downtown Tacoma to Parkland	8	Light rail: 1,464 BRT: 2,141
23	Tukwila Sounder station to downtown Seattle via Sea-Tac Airport, Burien, West Seattle	15	Light rail: 2,472 BRT: 3,713
24	Downtown Seattle to Edmonds via Ballard, Shoreline Community College	19	Light rail: 3,588 BRT: 5,675
25	West Seattle to Ballard via Central District, Queen Anne	14	Light rail: 2,389 BRT: 3,673
26	Edmonds to Lynnwood Link	5	Light rail: 1,675 BRT: 2,296
Total residential parcels within screening distance of high-capacity transit study corridors[3]			Light rail: 10,916 BRT: 16,197
Bus rapid transit (BRT): screening distance 500 feet each side of corridor centerline			
27	Puyallup vicinity, notably along Meridian Avenue	6	680
28	Issaquah to Issaquah Highlands	2	198
29	Kent to Sea-Tac Airport	11	387
30	Downtown Seattle along Madison Street	2	690
Regional express bus/BRT (mode not specified): screening distance 500 feet each side of corridor centerline			
31	Issaquah Highlands to Overlake via Sammamish, Redmond	14	1,246
32	Tacoma to Bellevue	34	4,325
33	Puyallup to downtown Seattle via Kent, Rainier Valley	35	2,588
34	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	2,818
35	Tacoma to Frederickson	13	1,759
Regional express bus			
36-47	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS	—	—
Total residential parcels within screening distance of bus study corridors[3]			13,768

[1] These numbers do not represent an estimate of the number of parcels that would experience noise impacts if a corridor were implemented; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

[3] Numbers include residential parcels where only a portion of the property is within the study corridor. Some residential parcels may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.

Noise levels for individual modes would be the same as described for the Current Plan Alternative. The noise impacts would be within the study corridors considered in Table 4-12 and would occur at a fraction of the parcels listed. The greatest potential for noise impacts per mile of service would occur in transit corridors that have the highest residential density and in corridors where the mode of service creates noise that extends the farthest into the community. Overall, the greatest number of residential parcels within the noise screening distances for each mode per mile of corridor occurs in light rail study corridors 2, 3, 11 and 15; commuter rail corridor 21; HCT corridors 24 and 26 when operated as light rail, and HCT study corridors 22 through 26 when operated as BRT. These corridors would have the highest potential for noise impacts. Any portion of light rail corridor 2 between downtown Seattle, West Seattle, and Burien or light rail corridor 14 between Sand Point and Kirkland that is constructed in a tunnel would not generate direct noise impacts.

The greater number of potential noise impacts associated with BRT compared to light rail operating in corridors 22 through 26 reflects operation of BRT on a new, exclusive alignment not currently in use by traffic. If BRT service were added on an existing roadway, the number of parcels affected by noise would be more similar to the assessment for light rail.

In addition to services provided in the Current Plan Alternative, the Potential Plan Modifications Alternative would include streetcar service, which is quieter than light rail and BRT service because it operates at lower speeds. As a result, noise from a streetcar operating at 25 mph generates 49 dBA L_{dn} at 100 feet from the tracks and 38 dBA L_{dn} at 500 feet when operating on 10-minute headways (six trains each direction per hour) during the day and averaging 30-minute headways between 10 p.m. and 7 a.m. (Figure 4-14). With the exception of the ERC, streetcar service would generally operate in urban areas where the existing L_{dn} noise levels are typically in the range of 70 dBA, and the streetcar service would not generate noise impacts except where warning bells are used.

Vibration

Vibration impacts from rail lines can extend up to 200 feet from commuter rail tracks or 150 feet from light rail; however, they generally extend a fraction of this distance. Bus projects rarely create vibration impacts because they operate on rubber tires, but impacts can extend up to 50 feet from the roadway. Rail transit generates higher levels of vibration than buses because the vehicles are heavier and have less dampening, or dissipation of vibrating energy. Typical vibration levels experienced near transit facilities and services are shown in Figure 4-15.

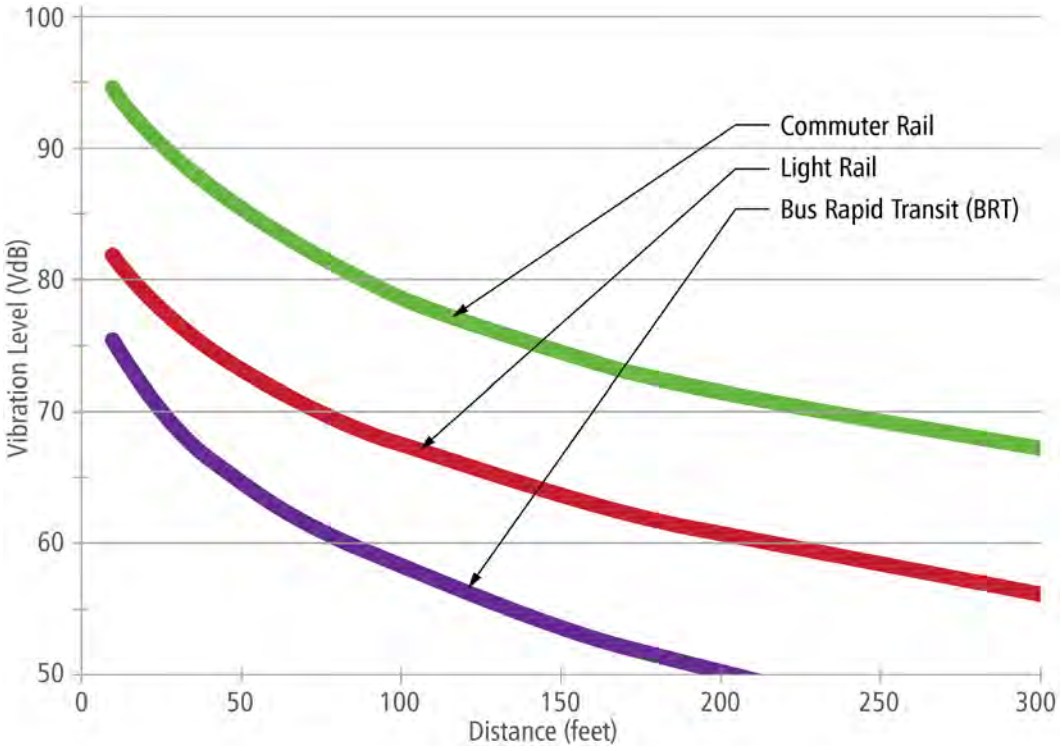


Figure 4-15. Typical vibration levels near transit facilities

Current Plan Alternative

Residences within 50 feet of new light rail lines could experience vibration impacts. Vibration levels are lower for elevated track sections, which generally cause fewer impacts. In addition, light rail corridors that are operated in a tunnel could generate ground-borne vibration impacts within adjacent buildings. Corridors G and K include the University of Washington campus, which houses numerous vibration-sensitive research facilities.

Commuter rail operations are generally less frequent; therefore, a higher maximum vibration level would be acceptable than for light rail operations. Vibration impacts, such as rattling of windows and perceptible floor movement, generally could occur at residences within about 80 feet of the tracks. New commuter rail service is proposed on existing tracks that currently carry passenger or freight service. The frequency of vibration impacts could increase, but the magnitude of vibration events would not.

Additional regional express bus service (corridors R through W) and BRT operating on existing roadways where buses currently operate would have little potential to generate vibration impacts.

Potential Plan Modifications Alternative

In general, long-term vibration impacts resulting from the Potential Plan Modifications Alternative would be similar to those described for the Current Plan Alternative. Because of the additional light rail corridors in particular, the number of vibration impacts could be greater than those in the Current Plan Alternative. The corridors would add the same vibration sources described for the Current Plan Alternative in new areas. Corridor 14, connecting the University of Washington campus to Kirkland and Redmond, would potentially impact vibration-sensitive research facilities at UW. Any portion of light rail study corridors 2 or 14 that operate in a tunnel could generate ground-borne vibration impacts within adjacent buildings. Additional regional express bus service (corridors 36 through 47) operating on existing roadways where buses currently operate would have little to no potential to generate vibration impacts; BRT would also have no potential for vibration impacts.

4.3.4 Construction impacts

Construction generates both noise and vibration, which may cause localized temporary impacts. Construction impacts resulting from the Current Plan Alternative and the Potential Plan Modifications Alternative would be similar; however, the Potential Plan Modifications Alternative could involve additional construction activity in the region because of the additional corridors under consideration. As a result, overall temporary construction impacts could be slightly greater for the Potential Plan Modifications Alternative.

Noise

Construction-related noise would be produced by impact equipment, earthmoving equipment, pneumatic tools, generators, concrete pumps, and similar equipment (Figure 4-16). State and local ordinances regulate construction noise, and contractors would be required to adhere to these regulations. Nighttime or weekend construction, which is often required to maintain weekday traffic access and capacity, requires noise permits or variances from local jurisdictions. The permits or variances place specific limits on what activities are acceptable during nighttime or weekend hours.

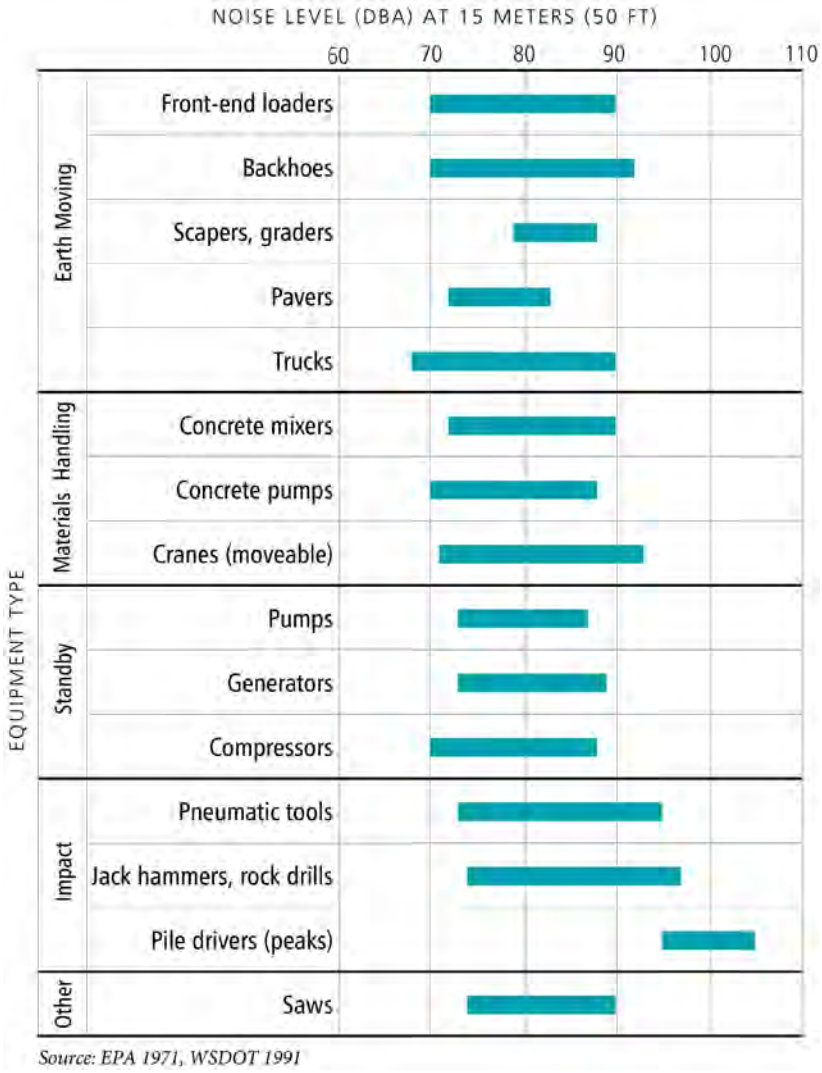


Figure 4-16. Typical construction equipment noise levels

Construction noise is temporary and occurs over a limited period of time in any single location but it can be disruptive to nearby residents. Impacts would be similar for both the Current Plan Alternative and the Potential Plan Modifications Alternative, differing only in the specific locations and time periods of disruption.

Vibration

Construction vibration is a concern regarding potential damage to structures (Table 4-8). Short-term annoyance is typically not considered an impact for construction vibration because the activities are temporary. Construction equipment produces a wide range of vibration energy (Table 4-13). Construction vibration impacts are localized and are dependent on the equipment being used, local soil conditions, and the fragility of nearby structures. Pile driving creates the greatest potential for vibration damage during construction. Depending on soil conditions, pile driving can result in high short-term vibration levels reaching a peak-particle velocity of 0.5 inch per second at 50 feet. Pile driving conducted at more than 100 feet from most buildings would not cause damage. Other construction equipment produces lower vibration levels. Impacts would be similar for both the Current Plan Alternative and the Potential Plan Modifications Alternative, differing only in the specific locations and time periods of disruption.

Table 4-13. Typical vibration velocities from construction equipment at 25 feet

Project	Peak particle velocity (in/sec)
Pile driving	0.6–1.5
Vibratory roller	0.6
Clam shovel drop	0.2
Large bulldozer	0.09
Jackhammer	0.04

Source: FTA 2006

Tunneling does not produce vibration at levels that would cause damage, but it may generate noticeable vibration and ground-borne noise in certain soil conditions. Tunneling may also cause settling, which is addressed in Section 4.1.

4.3.5 Potential mitigation measures

Noise and vibration can be controlled at the source, along the noise or vibration path (between the source and the receiver), and at the receiver. Noise and vibration mitigation is provided when a project would create impacts above the applicable federal, state, and local criteria and the mitigation is feasible and reasonable to provide. Sound Transit's Light Rail Noise Mitigation Policy (Sound Transit 2004a) establishes policies intended to guide the mitigation of noise impacts associated with light rail project components.

Operational noise mitigation

Because mitigation at the source and along the path benefit all nearby receivers, including outdoor uses, it is preferable to control noise before it reaches a sensitive receiver. Sound insulation of individual properties is used only when other options are not effective. The following measures can be effective in various situations:

- Acquire or designate land as buffer zones or for construction of noise barriers or berms
- Place roadways, tracks, and cross-over track and switches away from residential and other noise-sensitive uses
- Design, construct, and maintain buses to minimize engine and exhaust noise and roadways to minimize noise and bumps
- Design, construct, and maintain rail vehicles to minimize noise and wheel flats, including selecting appropriate wheel types and profiles

- Design tracks to minimize wheel squeal, corrugation, roughness, and gaps; use welded track where appropriate; and provide lubrication where squeal cannot otherwise be avoided
- Design and operate audible warning devices such as train and way side horns and bells to the minimum level necessary for safety purposes
- Construct noise barriers or berms
- Provide noise insulation to buildings where no other method would be effective

Operational vibration mitigation

Vibration impacts are very location and source specific. They are most efficiently controlled at or near the source. Many measures to reduce noise, such as placing tracks and crossovers away from residential and other noise-sensitive uses and maintenance of tracks and rail vehicles, are also effective at reducing vibration. In addition to these measures, track sub-base and support structures can be designed to reduce vibration transmission at critical frequencies.

Construction noise mitigation

Construction noise disruption and annoyance can be managed in several ways, including design considerations and project layouts, sequencing and timing of construction, using alternative construction methods and equipment, and ensuring that contractors follow good practices to reduce construction noise. Specific options that fall into these categories include the following:

- Use ambient-sensing broadband backup alarms on construction equipment
- Place staging areas and stationary equipment away from residences
- Construct noise barriers early to provide noise shielding during later construction activities
- Combine and conduct noisy activities as quickly and efficiently as possible, even if it results in higher absolute noise levels as long as the overall duration of noise disturbance is substantially reduced
- Minimize nighttime construction in residential areas
- Replace pile driving and other impact activities when practical
- Keep neighbors informed of what to expect and when disturbing nighttime noise is scheduled to occur
- As required, seek the appropriate noise variance from local jurisdiction for nighttime construction

Construction vibration mitigation

The most effective measures to reduce construction vibration levels relate to the size, type, and amount of equipment being operated. Replacing pile driving and other impact equipment with alternate methods when near vibration-sensitive locations is the most effective mitigation measure. Other approaches that may be taken on a case-by-case basis include

operating vibration-producing equipment as far from sensitive sites as possible, avoiding bumps on construction access roads that trucks hit at high speed, using the fewest and smallest pieces of construction equipment that can efficiently complete each task near sensitive sites, and avoiding vibratory rollers and compactors. The hours and duration of these activities can also be restricted to times when vibration is less noticeable.

4.3.6 Significant unavoidable adverse impacts

Significant adverse noise and vibration impacts can be mitigated or avoided for most plan elements under the Current Plan Alternative and the Potential Plan Modifications Alternative. However, some adverse noise and vibration impacts could occur with both alternatives. Some construction impacts are unavoidable and may be significant in some locations.

4.4 Water quality and hydrology

This section describes existing major watersheds, streams, floodplains, and water quality in the Plan area and potential impacts and mitigation for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, the potential impacts are qualitatively described based on broadly defined study corridor locations. For the impact analysis, the study area for these corridors varies in width by mode as described in the introduction to this chapter. The number of water resources within these study areas does not represent the number of resources that would be impacted if a corridor were implemented. Instead, it provides a comparison of the relative concentration of resources within various corridors. The actual number of water resources affected, the anticipated level of potential impacts, and measures to avoid and minimize impacts would be determined during future project-level planning and environmental reviews.

4.4.1 Regulatory environment

A number of federal, state, and local water-related regulations, permits, and approval processes could apply to transit improvements under the Current Plan Alternative and the Potential Plan Modifications Alternative.

Federal

The Clean Water Act (33 USC 1251 et seq.) is the federal law regulating the direct discharge of pollutants to water resources. The Clean Water Act requires all states to report on the health of all of their waters. Historically, this has been in a "biennial water quality" report, or the 305(b) report, which has then been used to develop the "threatened and impaired waters" list, or the 303(d) list. Both the 305(b) report and the 303(d) list are submitted for EPA approval every two years (EPA 2012).

Categories 4 and 5 will be discussed in this report and referred to as the "listed threatened and impaired waters." Within this list, the Category 5 list identifies "polluted waters that require a total maximum daily load (TMDL) or other water quality improvement (WQI) project. This is the list of impaired water bodies traditionally known as the 303(d) list. Placement in this category means that Ecology has data showing that the water quality standards have been violated for one or more pollutants and there is no TMDL or pollution control plan. TMDLs or other approved WQI projects are required for the water bodies in this category.

The Category 4 waters are identified as "polluted waters that do not require a TMDL: waters that have pollution problems that are being solved in one of three ways:

- **Category 4a—**has a TMDL
- **Category 4b—**has a pollution control program
- **Category 4c—**is impaired by a non-pollutant" (Ecology 2013)

Under Section 404 of the Clean Water Act, a U.S. Army Corps of Engineers Section 404 permit would be required for any discharge of dredge or fill material into waters of the United States, which includes streams and rivers. Under Section 402 of this act, a National Pollutant Discharge Elimination System (NPDES) permit could be required during construction for any discharge of pollutants into waters of the U.S. Some support facilities could require an NPDES Industrial Stormwater General permit for operation. Permitted discharges must also satisfy discharge permit requirements under state water pollution control requirements (Chapter 90.48 RCW).

Aquifer recharge areas

Areas defined as having a critical effect on recharging groundwater used for potable water supplies. These groundwater areas could also be at risk of contamination from land use activities.

Impervious surface

Artificial structures such as pavements (roads, sidewalks, driveways, and parking lots) that are covered by impenetrable materials such as asphalt and concrete.

Wellhead protection areas

Wellhead protection area boundaries are the maximum distance from which a contaminant could reach a public water system well within 10 years of travel through the ground.

In addition, a U.S. Army Corps of Engineers Section 10 permit would be required for any work in navigable waters of the U.S. in accordance with Section 10 of the Rivers and Harbors Act. For construction of new bridges over navigable waters (or modifications to an existing bridge), a U.S. Coast Guard Bridge Permit would also be required under the General Bridge Act of 1946 (also referred to as a Section 9 Permit as they were once approved under Section 9 of the Rivers and Harbors Act).

FEMA has mapped numerous 100-year and 500-year floodplains within the Plan area's sub-watersheds. The provisions of the National Flood Insurance Program apply to areas, typically for the 100-year flood, identified in FEMA's floodplain maps and managed at the county level to reduce flood risk.

The Safe Drinking Water Act (42 USC 300f to 300j-26) authorizes EPA to designate sole source aquifers, which are the principal source of drinking water for a given area. EPA reviews all federally funded projects that have the potential to contaminate a designated sole source aquifer.

State

Ecology regulates discharges to surface waters within the state. *Water Quality Standards for Groundwaters of the State of Washington* (Chapter 173-200 WAC) sets rules for the quality of groundwater in Washington. In addition, Ecology has developed the Critical Aquifer Recharge Ordinance to help local jurisdictions manage aquifers used as sources of drinking water. Ecology has also developed the *Ecology Stormwater Management Manual for Western Washington* (Ecology Stormwater Manual) to provide guidance for surface water management during both the construction and operational phases of a project, including flow control and water quality treatment (Ecology 2012a). Parking facilities and other pollutant-generating impervious surfaces would have stormwater treatment to ensure compliance with applicable regulations. Ecology has established minimum state requirements for floodplain

management and provides oversight and approval of local ordinances that regulate development in floodplains.

The Washington Department of Fish and Wildlife (WDFW) issues hydraulic approval permits for any project that would require work within the ordinary high water mark of streams and sets guidelines for in-water work periods and BMPs. The Shoreline Management Act defines shorelines of statewide significance among marine areas, streams and rivers, and lakes where specific priority uses are preferred.

Snohomish, King, and Pierce Counties

Each county and local jurisdiction is required to adopt the standards outlined in the Ecology Stormwater Manual as a minimum or develop equivalent standards for stormwater management.

In addition, local county health departments regulate the numerous critical aquifer recharge and wellhead protection areas that exist within the Plan area. Within critical aquifer recharge and wellhead protection areas, counties typically regulate the amount of impervious surface that can be added by new development.

The county and local governments require the flood storage and conveyance capacity of mapped flood zones to be maintained. In addition, they prohibit certain types of construction and activities in flood zones, require preservation of wetlands or other natural flood storage features, and require flood-proofing for construction.

4.4.2 Affected environment

This water resources analysis considered watersheds and stream basins within the Plan area.

Natural water bodies

Ecology developed Water Resource Inventory Areas (WRIA) as part of a system to organize the major watersheds in the state. WRIAs comprise watersheds (with their smaller sub-watersheds and sub-basins) that are drained by perennial and intermittent streams, seeps, wetlands, and man-made drainage systems.

Water Resource Inventory Areas (WRIA) located within Plan area

- WRIA 7: Snohomish
- WRIA 8: Cedar-Sammamish
- WRIA 9: Duwamish-Green
- WRIA 10: Puyallup-White
- WRIA 11: Nisqually
- WRIA 12: Chambers-Clover

Water bodies within the Plan area are classified (as Category 1 through 5) by Ecology's most recent marine Water Quality Assessment as required by the Clean Water Act and approved by EPA on December 21, 2012. Water bodies identified as impaired are discussed for each WRIA in the sections below.

All major water bodies in the Plan area, including all rivers, streams, and creeks discussed below, are designated by Ecology for protection for salmon habitat, recreational uses, water supply, and other miscellaneous uses.

Water Resource Inventory Area 7: Snohomish

Within the Plan area, WRIA 7 includes Possession Sound, which is located at the mouth of the Snohomish River, as well as the Snohomish River. Ecology has listed Possession Sound on the Category 4a list for dioxin and on the Category 5 list for several impairments. Ecology has also placed the Snohomish River, which is downstream of the Plan area but feeds into Possession Sound, on this list for several impairments. The Snohomish River is on the Category 4a list for dissolved oxygen.

WRIA 7: Snohomish

Drains 1,800 square miles. The major surface-water resources in this watershed are the Snoqualmie and Skokomish Rivers. They converge to form the Snohomish River, about 20 miles upstream of Puget Sound.

WRIA 8: Cedar-Sammamish

Drains about 700 square miles and spans the largest urbanized area within the state of Washington. Water bodies in WRIA 8 include Lake Union, Lake Sammamish, and Lake Washington; the Sammamish and Cedar Rivers; and Bear, Evans, Issaquah, Coal, and Kelsey Creeks.

WRIA 9: Duwamish-Green

Covers 500 square miles and includes the Duwamish River, Black River, Lower Green River, and Elliott Bay sub-watersheds.

WRIA 10: Puyallup-White

Covers nearly 1,065 square miles, and originates on the slopes of Mount Rainier. It includes the Puyallup River, White River, and Hylebos Creek sub-watersheds.

Water Resource Inventory Area 8: Cedar-Sammamish

The WRIA 8 sub-watersheds in the Plan area are in the highly developed area in and around Seattle and are primarily tributaries of Northern and Central Puget Sound, Lake Union, Lake Sammamish, Lake Washington, or the Sammamish River. Ecology has listed most of these water bodies (with the exception of Evans Creek) on the Category 5 list (Ecology 2012b). The most common water quality problems are dissolved oxygen, fecal coliform, and temperature. Notably, Lake Union is listed as a Category 5 water body, containing fecal coliform, total phosphorous, lead, and aldrin (a pesticide). Evans Creek is listed on the Category 4a list for dissolved oxygen, fecal coliform, and temperature, and Issaquah Creek is listed under Category 4a for fecal coliform. Puget Sound, Lake Union, and Lake Washington are all on the Category 4c list for invasive exotic species.

Water Resource Inventory Area 9: Duwamish-Green

EPA classifies about 20 to 50 percent of the riparian habitat in the Duwamish-Green system as forested and about 20 to 50 percent as urban/agricultural. Within the Plan area, however, much of the riparian habitat in the lower Green River has been channelized for flood control and much of the riparian corridor along the Duwamish waterway is heavily industrialized. Ecology has listed most of these water bodies on the Category 5 list, with the most common water quality problems being dissolved oxygen and fecal coliform. However, the Duwamish River contains polychlorinated biphenyls, polycyclic aromatic hydrocarbons, chlorinated dioxins and furans, arsenic, and other metals, such as pesticides and phthalates (Ecology 2012b, 2012d). The Green River is on the Category 4a list for temperature and ammonia-N, and on the Category 4c list for large woody debris. South-central Puget Sound is also on the Category 4c list for fish and shellfish habitat.

Water Resource Inventory Area 10: Puyallup-White

Both the Puyallup River and Hylebos Creek are tributaries of Commencement Bay. Most of the eastern half of the WRIA is forested; the lower watershed within the Plan area is a mix of agricultural, residential, urban, and industrial areas. Ecology has identified water quality problems in a number of the streams/rivers in WRIA 10. Additionally, Commencement Bay contains dissolved oxygen, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, dieldrin, DDT, and chlorinated pesticides, and phthalates (Ecology 2012). The White River and Salmon Creek are both listed on the

Category 4a list for fecal coliform, and Wapato Creek and the White River are listed on the Category 4c list for in-stream flow.

Water Resource Inventory Area 11: Nisqually

The lower Nisqually Watershed is one of the most intensely farmed basins in western Washington (Ecology 2012c). The Nisqually River is not identified on Ecology's Category 5 list, but is listed on the Category 4c list for invasive exotic species and on the Category 4a list for fecal coliform.

Water Resource Inventory Area 12: Chambers-Clover

This watershed includes approximately the western half of the City of Tacoma, as well as several other cities and towns. McChord Air Force Base and part of Fort Lewis occupy a large portion of the central and southern part of the basin. Ecology has identified water quality problems in WRIA 12 on a number of streams and rivers within the study corridor, the most common of which is fecal coliform. Chambers Creek is identified on the Category 4a list for copper.

WRIA 11: Nisqually

Only has one sub-watershed within the Plan area, the lower Nisqually River sub-watershed, which includes the Nisqually River near its mouth, and numerous tributary creeks and streams.

WRIA 12: Chambers-Clover

Covers approximately 180 square miles and includes the Chambers-Clover Creek Basin and the small drainages of Sequalitchew (including American Lake and Murray Creek) and Puget Creek.

Shorelines

Snohomish, King, and Pierce Counties are the regulating authorities for designated shorelines in the Plan area, including shorelines of statewide significance, as designated by Ecology. Several lakes, rivers, and streams in the Plan area are designated as shorelines of the state, with several having shorelines of statewide significance, including Lake Washington, Lake Sammamish, the Green River, and the Puyallup River (Appendix C) (Title 173 WAC).

Floodplains

FEMA has mapped extensive 100-year floodplains associated with various waterways:

- WRIA 7: Snohomish River adjacent to the eastern portion of the Plan area.
- WRIA 8: Bear Creek and North Creek at their confluence with the Sammamish River; the mouth of the Cedar River and at the mouths of May, Issaquah, and Tibbetts Creeks (at high flows, the floodwaters from Tibbetts and Issaquah Creeks are connected).
- WRIA 9: Most of the Green River and portions of the Black River; Hylebos Creek, and the Puyallup River. FEMA has also mapped a narrow floodplain along certain reaches of Des Moines Creek.
- WRIA 11: Nisqually River.
- WRIA 12: Clover Creek.

Groundwater resources

Groundwater is found at relatively shallow depths (typically 25 to 50 feet below ground) in the Plan area. In addition, in several locations groundwater is much closer to the surface, such as in floodplains and wetlands. Principal aquifers consist of glacial drift or alluvium, with depths to water of 25 to 50 feet in the glacial drift and less than 25 feet in alluvial aquifers. Alluvial aquifers are found along the principal rivers in the region.

EPA has designated the following sole-source aquifers within the Plan area: Cross Valley, Cedar Valley, and Central Pierce County Aquifers (see Appendix C). The Cross Valley Aquifer is located in WRIA 8 and is approximately 4 miles wide, extending southeast from Mill Creek for roughly 11 miles. The Cedar Valley Aquifer is located in WRIA 8 and extends approximately 1 mile out in either direction of the Cedar River, then widens at the mouth of the river adjacent to Lake Washington. The Central Pierce County Aquifer is located in WRIAs 10, 11, and 12, and extends across the entire Plan area from the Puyallup River to the Nisqually River.

In most areas, groundwater quality meets drinking water standards. The most common water quality problems are high iron and manganese concentrations. Groundwater in some areas, such as near Superfund sites, has been contaminated by heavy metals, hydrocarbons, solvents, or other toxic pollutants. For a discussion regarding Superfund sites, refer to Section 4.7.

Climate change

The potential impacts of climate change would be considered during project-level planning. Based on Sound Transit's Draft *Climate Risk Reduction Project* (FTA 2013a), sea-level rise and localized flooding could impact transit infrastructure and operations near the shoreline or in low-lying areas. Figure 4-17 illustrates two values of sea-level rise: 22 inches and 50 inches. These values are both within the range of projections for the latter half of the century that are used by Seattle Public Utilities for scenario planning (SPU 2014) and were selected to be consistent with the approach used by Washington State Department of Transportation (WSDOT) for its *Climate Impacts Vulnerability Assessment* (WSDOT 2011). Low-lying areas have a higher potential to experience flooding and inundation that could lead to transit delays, service disruptions, and damage to Sound Transit facilities and infrastructure. Similar impacts could also occur along rivers where rising sea level and increased rainfall and runoff could affect the floodplain and stream levels. Areas at risk for rising sea levels and localized flooding resulting from climate change are shown in Figure 4-17 and generally coincide with areas that are in 100-year floodplains. However, if climate change were to exacerbate localized flooding in the future, flood-prone areas may be more closely represented by the mapped FEMA 500-year floodplains, which are typically the same as or larger than the mapped 100-year floodplains.

Source: Sound Transit 2013

Figure 4-17. Areas susceptible to sea level rise

4.4.3 Long-term impacts

WRIAs, protected use designations, threatened and impaired waters listings, and sole-source aquifer locations for water bodies that could be impacted either by the Current Plan Alternative or the Potential Plan Modifications Alternative are summarized in Appendix C.

Best management practices

A BMP is an action or structure that reduces or prevents pollutants from entering stormwater or treats stormwater to reduce possible degradation of water quality. BMPs, such as stormwater filtration devices, detention basins, and landscaping areas, reduce impacts of high water flow-rates and pollutant loads.

Operation of transit and support facilities included in any of the corridors that comprise the two alternatives is not expected to contribute to the types of pollutants that the threatened and impaired waters are listed for or pollutants that typically impact groundwater, which include aldrin, ammonia, bacteria, dissolved oxygen, lead, pH, temperature, total phosphorus, iron, and manganese. However, transit and support facilities may contribute to sediment, heavy metals, and hydrocarbons. Each of these can impact surface waters when carried to streams and other natural water bodies through stormwater runoff. In addition, heavy metals and hydrocarbons can adversely impact aquifers when mixed with runoff that soaks through the soil.

Developments or projects that fall within designated categories or above size thresholds identified by Ecology as potentially posing risks to surface and ground water bodies, including transit improvements, are required to use operation and construction BMPs to avoid or minimize impacts as part of their permitting. The design and permit requirements for the Current Plan Alternative and the Potential Plan Modifications Alternative could include stormwater management, conveyance design, water quality treatment, and flow control BMPs for discharges to surface and ground waters from the corridor area. Sound Transit's Sustainability Plan emphasizes water conservation and low impact development to improve water quality. This policy emphasizes the use of design features, BMPs, on-site natural approaches, and native plantings to reduce pollutant runoff. To avoid or minimize impacts to receiving waters, runoff would be treated to remove pollutants before discharging to surface waters or soaking into the ground.

New impervious surfaces have been linked to increases in the frequency of peak flow rates and the volume of stormwater runoff. Both of these could increase stream bed depth and bank erosion as a result of implementation of the Current Plan Alternative or the Potential Plan Modifications Alternative, particularly in steep stream reaches. The amount of new impervious surface would vary by mode, as described below. Eroded sediment can be deposited as the stream slope decreases, which could lead to drainage problems and local flooding. However, the overall risk to water bodies by increased impervious surfaces would be relatively minor compared to the current amount of impervious surfaces that exist in the Plan area.

Risks to water quality are also posed by new impervious surfaces that generate pollutants. Pollutant-generating impervious surfaces are a source of pollutants in stormwater runoff that reaches streams, wetlands, and groundwater and generally include areas subject to vehicle use, industrial activities, and materials storage where stormwater runoff could erode or seep through the materials. If treatment prior to discharge is not provided, runoff from pollutant-generating impervious surfaces could impact the beneficial uses of the receiving water. The

overall change in the amount of pollutant-generating impervious surfaces from the Current Plan Alternative or the Potential Plan Modifications Alternative would be relatively minor compared to the current amount of pollutant-generating impervious surfaces that exist in the Plan area.

The Snohomish River, Sammamish River, Duwamish River, Black River, Green River, Springbrook Springs, Mill Creek, White River, Hylebos Creek, Puyallup River, and Nisqually River (as well as several smaller creeks) all have floodplains that extend beyond their banks in the vicinity of the Current Plan Alternative and the Potential Plan Modifications Alternative. Risks to stream and floodplain hydraulics are increased in locations where the Current Plan Alternative or the Potential Plan Modifications Alternative would be located in a floodplain or stream channel through the construction of fill or bridges. Fill within a floodplain could impede flood flows and increase the risk of flooding. This, in turn, could result in upstream and downstream stream bed erosion and bank erosion. State and local jurisdictions require fill within floodplains to be offset by the creation of additional floodplain storage within the same area.

The Current Plan Alternative and the Potential Plan Modifications Alternative include stream crossings. If new culverts or culvert extensions would be required, they could decrease the flow capacity of the stream and increase erosion and sediment buildup at the culvert location. Culvert additions or modifications would be required to adhere to state design standards for stream crossings.

Current Plan Alternative

The Current Plan Alternative could impact water quality in locations where pollution-generating impervious surfaces are added, and where water or floodplain crossings are necessary. The Current Plan Alternative could create new pollutant-generating impervious surfaces in the form of busways or roadway widening to support BRT, new parking areas, bus holding areas, and maintenance facilities. In these locations, runoff could contain a higher pollutant concentration discharged to BMPs, which could increase required long-term maintenance. An increase in impervious area could also increase the rate of runoff during storm events.

Table 4-14 summarizes the number of water resources, including the number of threatened and impaired waters, within the study area for each of the corridors; these resources are shown in Figure 4-18 and Figure 4-19. Because light rail corridors have the widest study area, the total number of resources within light rail corridors is higher than for other modes. The numbers are provided only to allow for a comparison of the relative concentration of resources near various corridors.

Table 4-14. Streams, floodplains, sole-source aquifers, and Category 4- and 5-listed waters for Current Plan Alternative study corridors

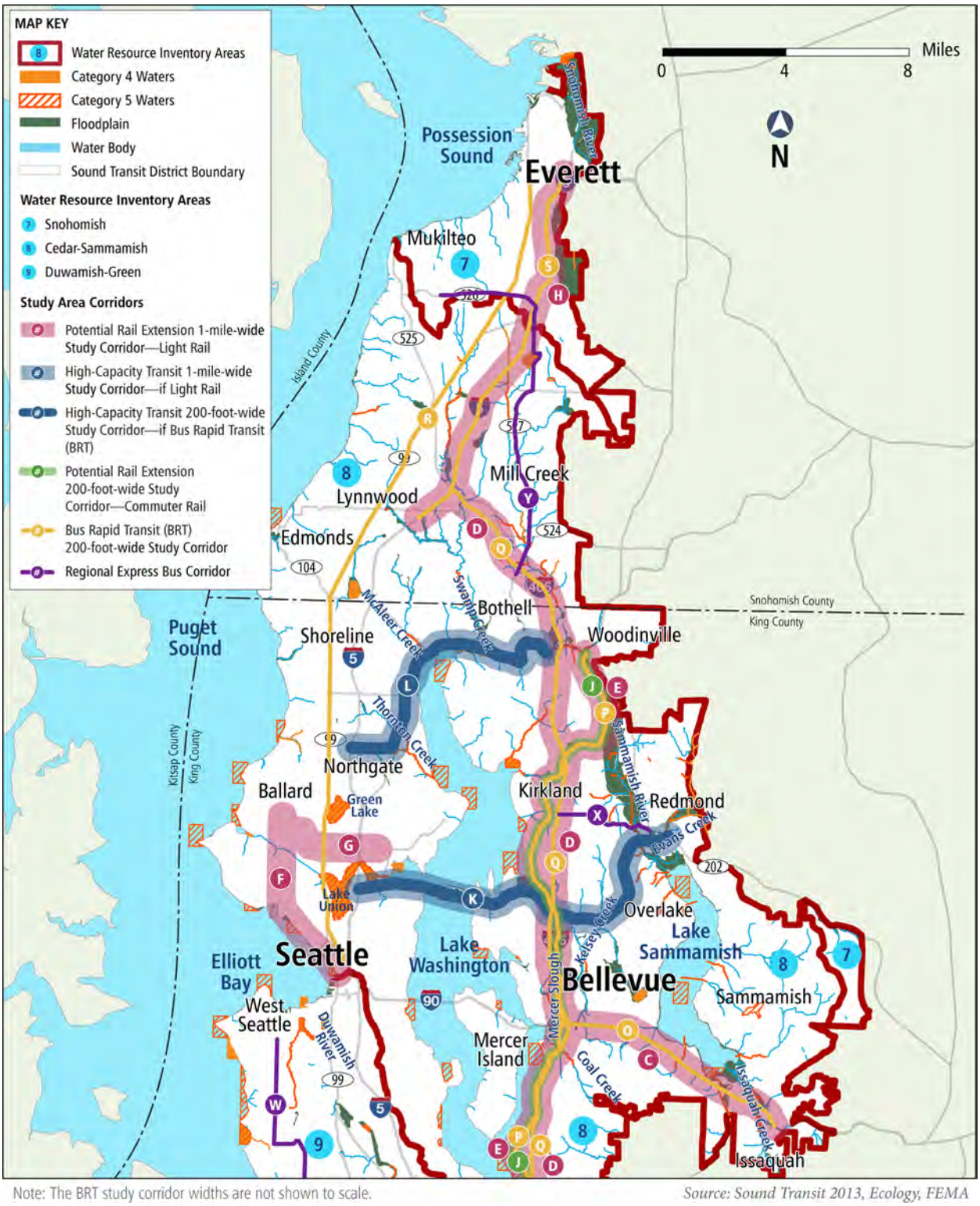
ID	Current Plan Alternative corridor location	Approximate length of corridor (miles)	Number of streams in corridor[1]	Floodplains (Zone A) present?	Sole-source aquifer present?	Number of Category 4 listed waters[1,2]	Number of Category 5 listed waters[1,2]
Potential rail extensions, assumed light rail: 1-mile-wide study area							
A	Tacoma to Federal Way	10	9	yes	yes	4	5
B	Burien to Renton	8	9	yes	yes	1	3
C[3]	Bellevue to Issaquah along I-90	10	25	yes	no	8	7
D	Renton to Lynnwood along I-405	28	47	yes	yes	8	13
E	Renton to Woodinville along Eastside Rail Corridor	22	30	yes	yes	1	11
F[3]	Downtown Seattle to Ballard	6	1	yes	no	0	1
G[3]	Ballard to UW	4	0	no	no	1	1
H	Lynnwood to Everett	13	16	yes	no	4	3
Total waters within potential light rail extensions study corridors[4]			97	—	—	27	32
Potential rail extensions, assumed commuter rail: 200-foot-wide study area							
I	DuPont to Lakewood	8	2	yes	yes	0	1
J	Renton to Woodinville along Eastside Rail Corridor	22	13	yes	yes	0	4
Total waters within potential commuter rail extensions study corridors[4]			15	—	—	0	5
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail/200-foot-wide study area if BRT							
K[3]	UW to Redmond via SR 520	13	Light rail: 16 BRT: 10	Light rail: yes BRT: yes	Light rail: no BRT: no	Light rail: 6 BRT: 4	Light rail: 9 BRT: 4
L	Northgate to Bothell	9	Light rail: 19 BRT: 7	Light rail: yes BRT: yes	Light rail: no BRT: no	Light rail: 3 BRT: 1	Light rail: 9 BRT: 4
Total waters within potential HCT study corridors[4]			Light rail: 35 BRT: 17	—	—	Light rail: 9 BRT: 5	Light rail: 16 BRT: 7
Bus rapid transit (BRT): 200-foot-wide study area							
M	Federal Way to DuPont along I-5	25	6	yes	yes	1	1
N	Renton to Puyallup along SR 167	21	25	yes	yes	0	1
O	Bellevue to Issaquah along I-90	10	9	yes	no	4	3
P	Renton to Woodinville along Eastside Rail Corridor	22	14	yes	yes	0	4
Q	Renton to Lynnwood along I-405	28	19	yes	yes	1	5
R	Seattle to Everett along SR 99	27	3	no	no	3	3
S	Lynnwood to Everett along I-5	13	2	yes	no	1	0
Regional express bus							
T-Y	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS						
Total waters within potential bus study areas[4]			74	—	—	10	13

[1] These numbers do not represent an estimate of the water resources that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] These numbers include all listed water bodies, including marine, lakes, and streams, within the study area.

[3] Portions of these corridors could be constructed in tunnels.

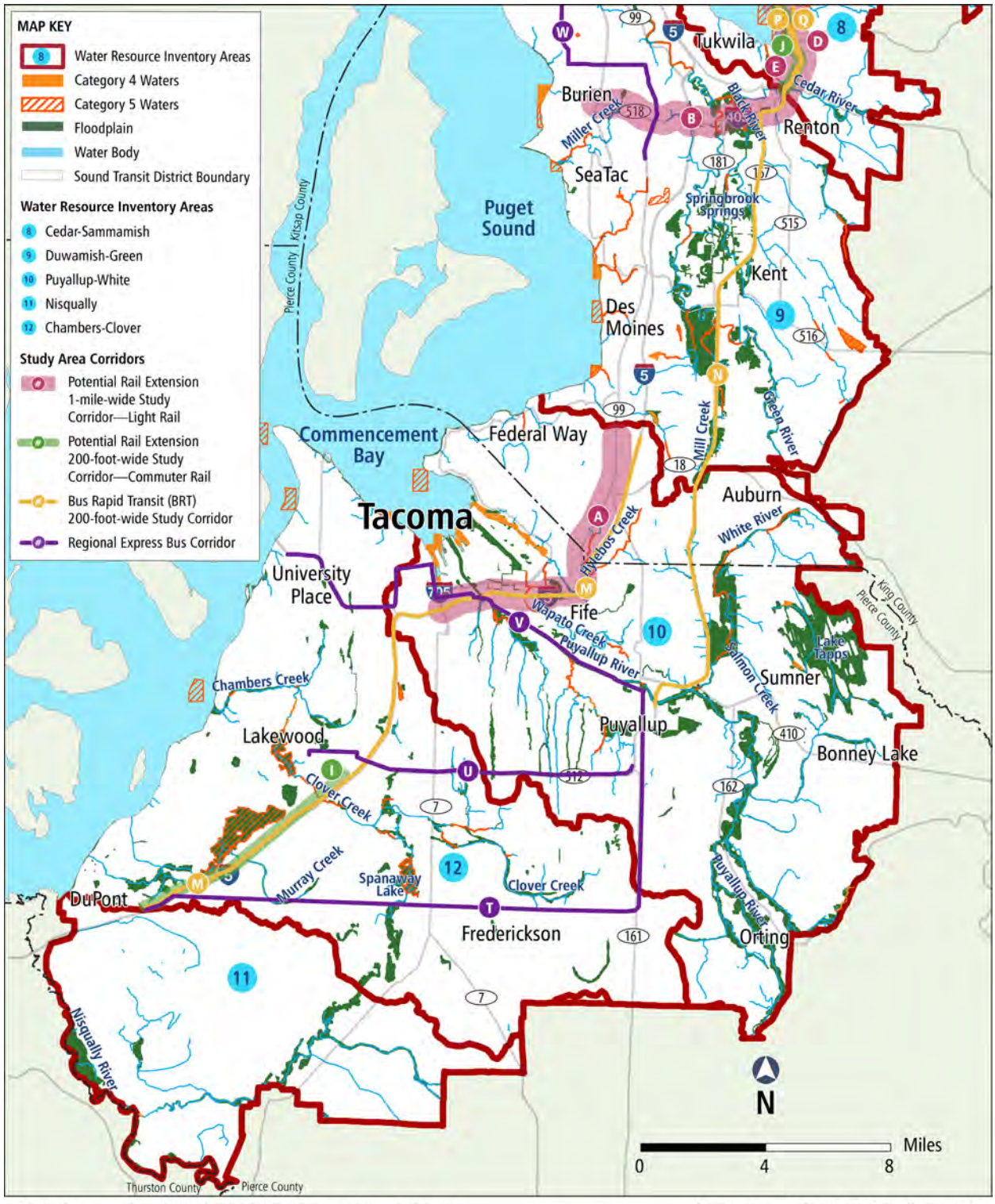
[4] Numbers include resources where only a portion of the resource is within the study corridor. Some water resources may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013, Ecology, FEMA

Figure 4-18. Water Resource Inventory Areas for Current Plan Alternative study corridors—north



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013, Ecology, FEMA

Figure 4-19. Water Resource Inventory Areas for Current Plan Alternative study corridors—south

Light rail

Light rail projects would create new impervious surfaces that could increase stormwater runoff rates, volumes and pollutant loads. At-grade light rail tracks constructed on tie and ballast are considered impervious surfaces. For elevated tracks, the surface is considered impervious if stormwater runoff collects into a conveyance system or concentrates by any other method. If the track is elevated but stormwater is not collected or concentrated (i.e. stormwater runoff drips off the edges), then the surface directly below the tracks determines whether it is impervious or not. Light rail could be constructed over or within existing impervious area footprints and could redirect runoff from those impervious surfaces rather than create additional impervious surfaces Operation of light rail alone is not a pollution-generating activity. Non-pollution generating impervious surfaces associated with light rail facilities include tracks, guide-ways, and stations. Where light rail track crosses a roadway or shares traffic lanes it is considered a pollution generating surface. If traffic lanes are converted to light rail tracks and are no longer used for motorized traffic, the converted lanes would no longer generate pollution. Therefore, the potential long-term impacts to water resources are most likely to occur in light rail corridors where new impervious surfaces are created.

Potential long-term impacts could also be related to impervious surfaces for supporting facilities, such as park and rides, traction power substations, and operations and maintenance facilities, and where floodplains would be filled.

Light rail corridors could have at-grade, elevated (including bridges), or below ground facilities. Study corridor D could cross the greatest number of streams, although given the width of the study corridor many streams could potentially be avoided. Below ground facilities would not come in contact with runoff and would be less likely to have long-term water quality impacts. If fill or new bridges are required adjacent to or over water bodies, these risks could increase. Opportunities for maintaining floodplain connectivity can be greater with elevated corridors than with at-grade corridors.

Study corridors C and H include large areas of floodplains along Lake Sammamish and the Snohomish River; study corridors B and E are located in a concentrated area of multiple floodplains; and a portion of study corridor A contains a few concentrated mid-sized floodplains. Although floodplains are located in the Plan area, light rail corridors would be designed to avoid or minimize structural placement in floodplains. Corridors in areas at risk for rising sea levels include study corridor H in Everett near the Snohomish River, study corridor F along Elliott Bay, and study corridor A in Tacoma along the Puyallup River and Hylebos Creek (Figure 4-17). Other corridors that contain existing floodplains are potentially at risk for increased local flooding as a result of climate change.

Study corridors C, F, and G could include tunnels in part of the corridor. Except at the portals, tunnel sections would not affect water quality or hydrology during operation.

The water resources identified within each light rail study corridor in Table 4-14 are within a broad corridor, which would contain the light rail alignment. These resources would be considered, and to the extent possible avoided, when establishing the final alignment; therefore, the number of impacts would be less than indicated by the number of resources within the study area.

Commuter rail

The commuter rail corridors in the Current Plan Alternative would largely operate on existing tracks but could require additional tracks to provide capacity for additional service in the existing corridors. Tracks on ballast and ties are considered an impervious surface that would not allow stormwater to percolate into the underlying soil. These corridors are adjacent to floodplain areas but generally avoid them. New commuter rail facilities, such as new stations, infill stations, and park-and-ride facilities in new or existing corridors, could also create new impervious surfaces. In some cases, existing stream crossings could be replaced or expanded.

Regional express bus/bus rapid transit

BRT corridors would operate on existing roadways or in additional lanes adjacent to existing roadways to accommodate higher performing BRT that operates within its exclusive right-of-way. New roadways, access ramps, stations, park-and-ride facilities, or other improvements could be required for BRT systems. Water quality and runoff volume impacts would occur as a result of new impervious surfaces where additional and expanded roadway facilities would be needed. Water pollutant loadings in runoff would increase where bus volumes increase on existing streets. Additional regional express bus routes using existing facilities where buses currently operate would have little potential to generate additional impacts aside from increased pollutant loadings.

Study corridor S from Lynnwood to Everett is adjacent to a large floodplain area associated with the Snohomish River, as is study corridor O along I-90 which crosses Issaquah Creek. Corridor M traverses an area in Tacoma that could be at risk for inundation as a result of rising sea levels affecting the Puyallup River. Other corridors that contain existing floodplains are potentially at risk for increased local flooding as a result of climate change.

High-capacity transit (mode not specified)

Study corridors K and L both HCT corridors, could be selected as either light rail or BRT corridors. If implemented as light rail, the facility would not generate pollution; however, the trackbed could be considered impervious. The potential for water quality impacts would generally be low. Depending on the location of an alignment, the number of stream and floodplain crossings for light rail in these corridors could be comparable to that of BRT or somewhat greater since light rail requires a larger footprint. For elevated sections of light rail, streams and floodplains could be completely avoided unless piers have to be placed in stream.

For BRT corridors, construction of additional lanes on existing highways could require extension of culverts or bridges at existing crossings. In addition, new lanes for BRT would generate pollutants on either existing or new impervious surfaces.

Study corridor K, whether selected for light rail or BRT, includes large floodplain areas associated with the Sammamish River. If implemented as light rail, the alignment could include a tunnel west of Lake Washington and avoid impacts to water resources through that section.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar impacts as those described for the Current Plan Alternative. However, because of the additional corridors in the Potential Plan Modifications Alternative, the impacts to water resources could be greater than those in the Current Plan Alternative. Table 4-15 summarizes the number of water resources, including the number of listed threatened and impaired waters, within the study area for each of the transit corridors; these resources are shown in Figure 4-20 and Figure 4-21. These numbers do not represent an estimate of the number of resources that would be affected if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors. Operation of the range of transportation improvements included in the Potential Plan Modifications Alternative is not expected to contribute to the types of pollutants that these threatened and impaired waters are listed for, which typically include bacteria, copper, dissolved oxygen, mercury, pH, temperature, and total phosphorus.

Light rail

The long-term impacts to water resources from light rail with the Potential Plan Modifications Alternative would be similar to those described for the Current Plan Alternative, including impacts from infill facilities. Study corridor 7 has the greatest total number of stream crossings; however, study corridors 12 and 18 have high concentrations of streams based on the number of streams in these study corridors per mile. In the northern portion of the Plan area, the study corridors generally avoid large floodplains. Study corridor 12 contains smaller but linear floodplains that extend almost the entire length of the study corridor. In the vicinity of Tukwila, study corridors 2 and 9 are in the vicinity of the Duwamish River and associated floodplains. The potential for impacts to floodplains is highest along SR 167 from the vicinity of Tukwila to Sumner where a high concentration of floodplains is located within study corridor 7. Corridors that contain existing floodplains are also potentially at risk for increased local flooding as a result of climate change.

Study corridor 14 would begin near Lake Union and would cross Lake Washington, the Sammamish River and its associated floodplains, and extend to Lake Sammamish. Each of these waterbodies is on the threatened and impaired waters list. Construction of this corridor would include a bridge or a tunnel for the crossing at Lake Washington. This particular corridor would potentially have higher impacts to water quality due to the additional crossings of large waterbodies where none currently exist.

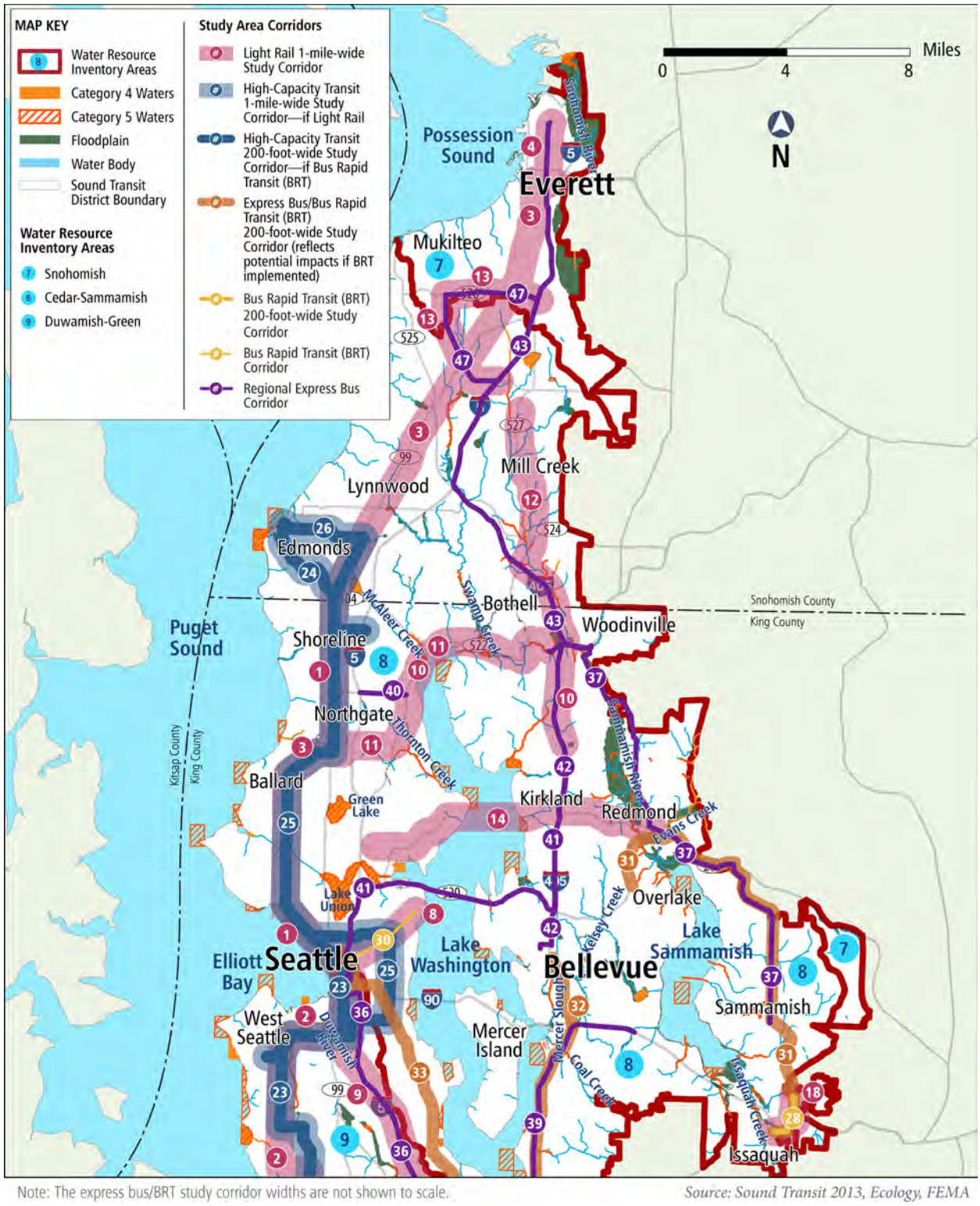
Table 4-15. Streams, floodplains, sole-source aquifers, and Category 4- and 5-listed waters for Potential Plan Modifications Alternative study corridors

ID	Potential Plan Modifications Alternative corridor location	Approximate length of corridor (miles)	Number of streams in corridor[1]	Floodplains (Zone A) present?	Sole-source aquifer present?	Number of Category 4 listed waters[1,2]	Number of Category 5 listed waters[1,2]
Potential rail extensions, assumed light rail: 1-mile-wide study area							
1	Downtown Seattle to Magnolia/Ballard to Shoreline Community College	12	3	yes	no	1	1
2[3]	Downtown Seattle to West Seattle/Burien	13	4	yes	no	2	5
3	Ballard to Everett Station via Shoreline Community College, Aurora Village, Lynnwood	24	12	yes	no	3	6
4	Everett to North Everett	2	0	no	no	0	0
5	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	10	yes	yes	1	3
6	DuPont to downtown Tacoma via Lakewood, Tacoma Mall	16	8	yes	yes	1	2
7	Puyallup/Sumner to Renton via SR 167	21	33	yes	yes	0	4
8	Downtown Seattle along Madison Street	3	0	yes	no	0	1
9	Tukwila to SODO via Duwamish industrial area	11	6	yes	no	1	3
10	North Kirkland or University of Washington Bothell to Northgate via SR 522	13	22	yes	no	2	10
11	Ballard to Bothell via Northgate	13	20	yes	no	3	9
12	Mill Creek, connecting to Eastside Rail Corridor	8	27	yes	no	6	6
13	Lynnwood to Everett, serving Southwest Everett Industrial Center (Paine Field and Boeing)	7	7	yes	no	2	2
14[3]	UW to Sand Point to Kirkland to Redmond	10	13	yes	no	1	4
15	Downtown Tacoma to Tacoma Community College	3	0	yes	yes	0	0
16	Tacoma Mall to University Place	6	1	yes	yes	1	1
17	Steilacoom to Ruston via University Place	12	8	yes	yes	0	2
18	Issaquah to Issaquah Highlands	2	9	yes	no	2	1
Total waters within potential light rail extensions study corridors[4]			152	—	—	17	36

Table 4-15. Streams, floodplains, sole-source aquifers, and Category 4- and 5-listed waters for Potential Plan Modifications Alternative study corridors (continued)

ID	Potential Plan Modifications Alternative corridor location	Approximate length of corridor (miles)	Number of streams in corridor[1]	Floodplains (Zone A) present?	Sole-source aquifer present?	Number of Category 4 listed waters[1,2]	Number of Category 5 listed waters[1,2]
Potential rail extensions, assumed commuter rail: 1-mile-wide study area new track/200-foot-wide study area existing track							
19	Puyallup/Sumner to Orting	8	4	yes	yes	0	0
20	Lakewood to Parkland	3	0	yes	yes	0	0
21	Tacoma to Frederickson	10	4	yes	yes	0	1
Total waters within potential commuter rail extensions study corridors[4]			8	—	—	0	1
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail/200-foot-wide study area if BRT							
22	Downtown Tacoma to Parkland	8	Light rail: 3 BRT: 0	Light rail: yes BRT: no	Light rail: yes BRT: yes	Light rail: 1 BRT: 0	Light rail: 0 BRT: 0
23	Tukwila Sounder station to downtown Seattle via Sea-Tac Airport, Burien,	15	Light rail: 6 BRT: 2	Light rail: yes BRT: yes	Light rail: no BRT: no	Light rail: 1 BRT: 1	Light rail: 5 BRT: 2
24	Downtown Seattle to Edmonds via Ballard, Shoreline Community College	19	Light rail: 8 BRT: 2	Light rail: yes BRT: yes	Light rail: no BRT: no	Light rail: 3 BRT: 0	Light rail: 3 BRT: 1
25	West Seattle to Ballard via Central District, Queen Anne	14	Light rail: 2 BRT: 1	Light rail: yes BRT: no	Light rail: no BRT: no	Light rail: 1 BRT: 1	Light rail: 4 BRT: 2
26	Edmonds to Lynnwood Link	5	Light rail: 5 BRT: 1	Light rail: yes BRT: yes	Light rail: no BRT: no	Light rail: 1 BRT: 0	Light rail: 1 BRT: 0
Total waters within potential high capacity transit study corridors[4]			Light rail: 19 BRT: 6	—	—	Light rail: 5 BRT: 1	Light rail: 7 BRT: 3
Bus rapid transit (BRT): 200-foot-wide study area							
27	Puyallup vicinity, notably along Meridian Avenue	6	0	no	yes	0	0
28	Issaquah to Issaquah Highlands	2	1	no	no	0	0
29	Kent to Sea-Tac Airport	11	10	yes	yes	1	2
30[5]	Downtown Seattle along Madison Street	—	—	—	—	—	—
Regional express bus/BRT (mode not specified): 200-foot-wide study area							
31	Issaquah Highlands to Overlake via Sammamish, Redmond	14	9	yes	no	3	1
32	Tacoma to Bellevue	34	18	yes	yes	2	5
33	Puyallup to downtown Seattle via Kent, Rainier Valley	35	23	yes	yes	0	2
34	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	1	yes	yes	0	0
35	Tacoma to Frederickson	13	4	yes	yes	0	0
Regional express bus							
36-47	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS						
Total waters within potential bus study corridors[4]			59	—	—	5	7

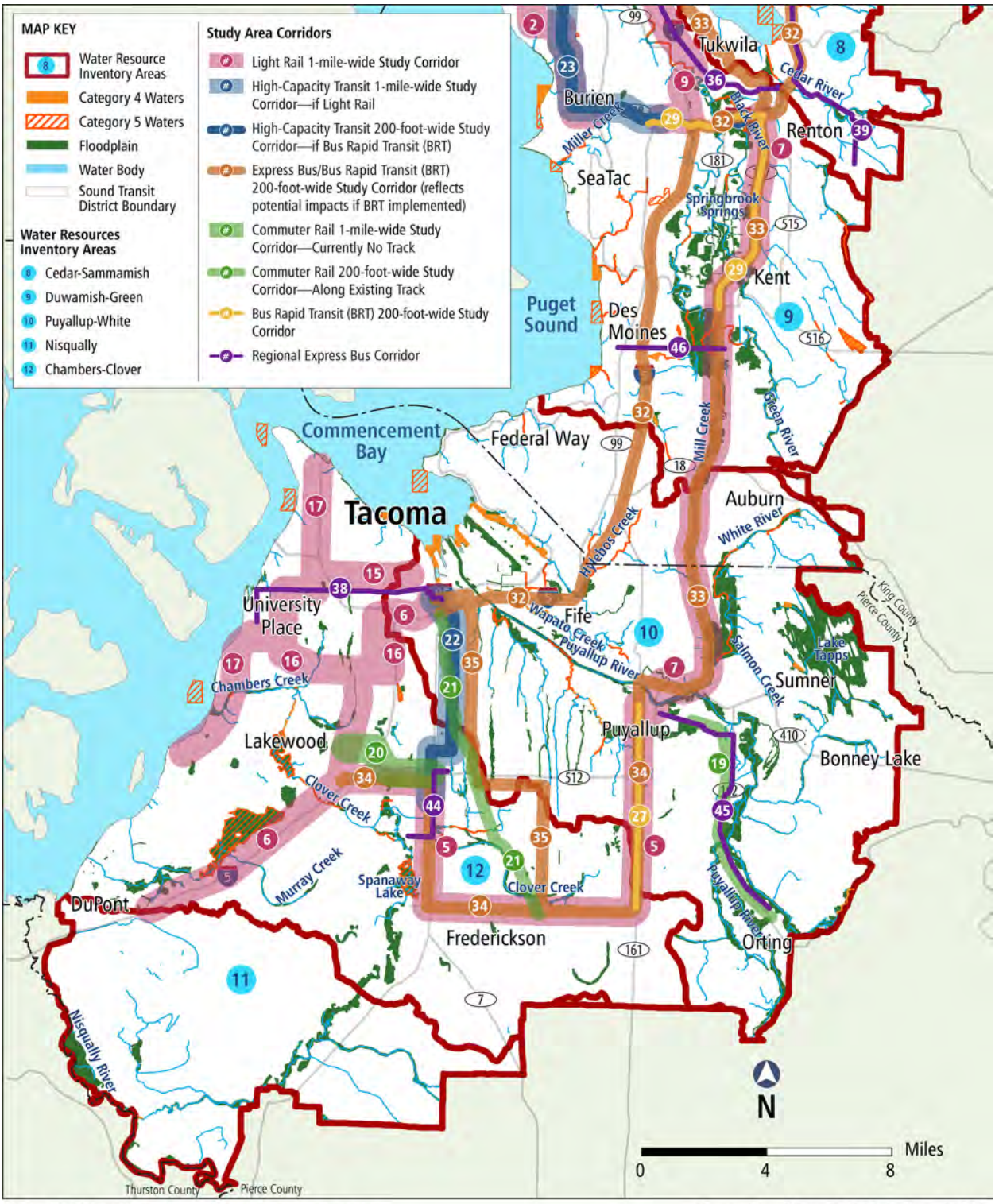
[1] These numbers do not represent an estimate of the water resources that would be impacted; however, they may indicate the relative concentration of resources near various corridors.
[2] These numbers include all listed water bodies, including marine, lakes, and streams, within the corridor.
[3] Portions of these corridors could be constructed in tunnels.
[4] Numbers include resources where only a portion of the resource is within the study corridor. Some water resources may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.
[5] Corridor 30 is BRT and is assumed to use existing roadway facilities in this location so was not analyzed using GIS. Impacts to water resources could occur in this corridor but they are not expected to be significant.



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013, Ecology, FEMA

Figure 4-20. Water Resource Inventory Areas for Potential Plan Modifications Alternative study corridors—north



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013, Ecology, FEMA

Figure 4-21. Water Resource Inventory Areas for Potential Plan Modifications Alternative study corridors—south

Many areas at risk for inundation from rising sea levels associated with climate change occur along the Puget Sound shoreline. Corridors in areas at risk for rising sea levels are as follows:

- Study corridor 3 and 4 in Everett near the Snohomish River
- Study corridors 1, 2, 9, 15, and 17 along the Puget Sound shoreline
- Study corridor 2, along the Puget Sound shoreline and the Duwamish Waterway
- Study corridors 6, 15, and 17 near the Port of Tacoma

As with the Current Plan Alternative, the water resources identified within each light rail study corridor in Table 4-15 are within a broad corridor, which would contain the light rail alignment. These resources would be considered, and to the extent possible avoided, when establishing the final alignment; therefore, the number of impacts would be less than indicated by the number of resources within the study corridor.

Commuter rail

As with the Current Plan Alternative, commuter rail service generally includes new operations along existing rail corridors where Sound Transit does not currently operate. The exception to this is corridor 20 where no rail tracks exist. New or modified rail stations and associated facilities could be needed in new or existing corridors.

Study corridor 19 is adjacent to a large linear floodplain associated with the Puyallup River tributaries and, for a few small lengths, crosses them. The corridor for a new line between Lakewood and Parkland (study corridor 20) includes a small floodplain area that is not currently crossed by any tracks. Study corridor 21 includes a small floodplain for a short length in its southern area. If constructed within the floodplains, these corridors could change the floodplain hydraulics, although study corridors 19 and 21 are along existing rail lines and may not require additional construction in floodplains. Fill within a floodplain could also impede flood flows and increase the risk of flooding. During design, efforts would be made to avoid floodplains; state and local jurisdictions require that fill within floodplains be offset by creation of additional floodplain storage within the same area.

Regional express bus/bus rapid transit

As with the Current Plan Alternative, BRT corridors would likely be located in existing roadways or in additional lanes adjacent to existing roadways. New roadways, stations, park-and-ride facilities, or other facilities could also be required for BRT systems. Impacts on water quality and runoff volume would occur as a result of adding additional impervious surface where new and expanded roadway facilities would be needed. Water pollutant loadings in runoff that could reach surface and ground waters would increase where bus volumes increase on existing streets.

Study corridor 32 generally follows I-5 and I-405 from the vicinity of Tacoma to Bellevue, and study corridor 33 generally follows SR 167 and Rainier Avenue S. from the vicinity of Puyallup to downtown Seattle via Kent and Rainier Valley. These BRT corridors are located near some larger floodplain areas and also cross multiple streams and creeks. These corridors are also potentially at risk for increased local flooding as a result of climate change. Additional regional express bus routes using existing facilities

where buses currently operate would have little potential to generate additional impacts to floodplain areas.

Study corridor 32 in Tacoma near the Puyallup River is in an area at risk for rising sea levels. Study corridors 38 (University Place to Titlow Beach to downtown Tacoma) is also in an area at risk for rising sea levels.

Streetcar

The potential for streetcar corridors to cause long-term impacts on water resources would be minimal because streetcar corridors would generally be located in existing roadways in densely developed urban areas, such as Seattle. Because these corridors would not result in additional impervious surfaces, there would be little to no impact to groundwater or stormwater runoff. In addition, because of existing development in these areas, it is likely that water resources have already been modified and, therefore, there would be no long-term impacts to water resources as a result of streetcar corridors. If a streetcar is operated in the Eastside Rail Corridor, the impacts to water resources would be similar to light rail operating in the same corridor.

High-capacity transit (mode not specified)

Study corridors 22 through 26, all HCT corridors, could be selected as either light rail or BRT corridors. If selected as light rail, the corridors would not generate pollution; however, if constructed on tie and ballast, the trackbed would be considered impervious. If selected as light rail, these corridors could cross more streams and floodplains than if they were selected as BRT. However, because they would not generate pollutants and could be constructed in a manner that would minimize the creation of impervious surfaces, the potential for impacts would be low. Study corridors 24 and 25 extend through the Northgate area, adjacent to Lake Union, which is listed as a threatened and impaired water. Study corridor 24 crosses a smaller floodplain in its northern portion, and study corridor 23 crosses a mid-sized floodplain along Miller Creek in its southern portion. These corridors are also potentially at risk for increased local flooding as a result of climate change.

Corridors in areas at risk for rising sea levels are as follows:

- Study corridor 24 along the Puget Sound shoreline
- Study corridors 23 and 25 along the Puget Sound shoreline and the Duwamish Waterway

4.4.4 Construction impacts

Construction-related impacts to water resources under the Current Plan Alternative and the Potential Plan Modifications Alternative would be temporary and controlled through the implementation of required BMPs, as determined through the permitting process.

Construction effects on surface water could result from the types of earthwork, concrete work, paving, stockpiling, material transport, and storm drainage utility work associated with the Current Plan Alternative or the Potential Plan Modifications Alternative. Clearing, grading, and stockpiling, particularly in locations adjacent to streams or wetlands, could temporarily increase turbidity caused by erosion of disturbed soil areas or soil stockpiles and stormwater runoff transporting silt and sediment to receiving waters.

Erosion of sediment and other contaminants could increase turbidity and affect other water quality parameters, such as the amount of oxygen available in the water. In addition, the acidity in surface water could increase if runoff comes in contact with curing concrete. The tires of construction vehicles could carry soil onto roadways, which could then enter ditches or streams. In addition, equipment leaks or spills from construction machinery, which is most likely to occur at construction staging areas, could also affect the water quality of nearby surface and ground water resources if uncontained. Construction of retaining walls or tunnels would likely require temporary dewatering. The water resulting from the dewatering process would be treated or detained, as needed, prior to discharge to control risks such as increased turbidity or erosion to surface receiving waters.

A Construction Stormwater Pollution Prevention Plan would likely include measures to address:

- Temporary erosion and sediment control
- Spill prevention, control, and countermeasures
- Concrete containment and disposal
- Dewatering
- Fugitive dust

Construction of culvert extensions, culvert replacements, and bridges could result in unavoidable temporary impacts where stream diversions and other in-water work occur in streams that flow year-round. In-water work could increase turbidity and impact water quality to an extent that cannot fully be controlled by BMPs. However, the risk of construction-related impacts on water resources would be controlled and impacts would be minimized by complying with the NPDES Construction Stormwater General Permit process, the WDFW Hydraulic Project Approval (as required), and applicable guidance manuals. Sound Transit would develop and implement a Construction Stormwater Pollution Prevention Plan for most transit improvements included in each alternative, as applicable, which would serve as the overall construction stormwater management plan.

The prevention plans would develop site-specific BMPs, operating procedures, and monitoring protocols intended to control risks and minimize impacts to water quality during construction.

Current Plan Alternative

Construction of light rail facilities would typically be the most intensive of all the modes because of their scale; therefore, construction of light rail would have the greatest potential for temporary construction impacts to surface water resources as described above. If in-water work is needed at water crossings, temporary impacts to water quality would likely occur that could be difficult to entirely control through BMPs.

Construction BMPs

Water quality impacts during construction could be substantially reduced or eliminated by implementing temporary erosion and sediment control BMPs. Examples of temporary erosion and sediment control BMPs include cover measures, perimeter protection, and sediment ponds.

The commuter rail corridors in the Current Plan Alternative would operate within existing rail corridors, although some new construction could be required for new tracks, stations, and supporting facilities. Commuter rail study corridors A and P likely would require new construction within small areas of floodplains, but with proper construction methods and BMPs, it is expected that construction could be managed and impacts to the floodplain would be avoided or minimized.

BRT corridors could require the construction of additional roadway lanes, or park-and-ride facilities. These facilities could result in the same types of temporary impacts to surface water resources described above, but to a lesser extent than light rail because of the smaller scale of work that would be required. The majority of BRT corridors likely would use existing road crossings of water bodies; therefore, they are expected to result in fewer temporary construction impacts compared to light rail corridors. Any BRT corridors that require new crossings would have impacts similar to or slightly greater than light rail crossings, as the width of roadway bridges would be greater than for light rail bridges.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar construction risks and impacts as those described for the Current Plan Alternative. However, because of the additional corridors in the Potential Plan Modifications Alternative (most notably, study corridor 14 across Lake Washington), impacts to water resources could be greater than those in the Current Plan Alternative. As a result, overall construction-related risks and temporary impacts to surface water resources would be greater for the Potential Plan Modifications Alternative.

Streetcar facilities could require construction within existing roadways. These corridors generally exist in highly developed areas where water resources have likely already been modified from their natural condition (i.e., placed in pipes or otherwise channelized). Therefore, the potential for additional impacts during construction is expected to be minimal. If selected, streetcar construction in the Eastside Rail Corridor would be similar to light rail in the same corridor.

4.4.5 Potential mitigation measures

Improvements in all study corridors would be designed to avoid or minimize potential adverse effects as reasonable and practical.

During project-level planning, facilities would be sited to avoid or minimize the filling of wetlands, streams, and floodplains to the extent practical. The effect of potential future water levels would be considered during design for facilities in areas susceptible to sea level rise and increased local flooding. Because BMPs included in the Current Plan Alternative and the Potential Plan Modifications Alternative would be implemented in accordance with the applicable regulations and permit conditions, no additional long-term mitigation would be required for stormwater runoff. Consistent with Sound Transit's Sustainability Initiative, low impact development to improve water quality is a preferred method for mitigating storm water impacts and would be implemented where appropriate and practical.

During construction, the Current Plan Alternative and the Potential Plan Modifications Alternative would meet all applicable requirements for managing runoff, limiting erosion, preventing spills, and phasing activities to fall within required construction windows. Water quality impacts associated with in-water or over-water work would also be minimized through BMPs, such as limiting the duration of in-water or over-water construction, reducing sediment disturbance using stream diversion structures, and capturing as much mobilized sediment as possible.

4.4.6 Significant unavoidable adverse impacts

Significant adverse impacts to water quality could be mitigated or avoided for most plan elements under the Current Plan Alternative and the Potential Plan Modifications Alternative. However, temporary unavoidable impacts to surface water quality and hydrology could occur during construction.

4.5 Ecosystems

This section describes the ecosystems in the Plan area and potential impacts and mitigation for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, the potential impacts are qualitatively described based on broadly defined corridor locations. For the impact analysis, the study area for these corridors varies in width depending on mode as described in the introduction to this chapter. While the number of ecosystem resources within the study area for each corridor is provided, it does not represent the number of resources that would be impacted if a corridor were implemented. The actual number of ecosystem resources affected, the anticipated level of potential impacts, and measures to avoid and minimize impacts would be determined during future project-level planning and environmental reviews.

Ecosystem resources in the Plan area

- Vegetation
- Wetlands
- Streams, lakes, and other water bodies
- Fish and aquatic species and their habitat
- Terrestrial wildlife and their habitat

4.5.1 Regulatory environment

The Current Plan Alternative and the Potential Plan Modifications Alternative would comply with a wide range of regulations, plans, and policies that have been established to protect ecosystem resources. Many regulations require approval procedures, such as the issuance of environmental permits, before project implementation; others require agency consultation.

The primary relevant federal and state regulations include the Endangered Species Act (ESA), the Clean Water Act, the Shoreline Management Act, and the Hydraulic Project Approval permitting program (Chapter 77.55 RCW). Permits and approvals related to these and other federal and state ecosystem-related regulations are included in Table 4-16.

Additional information regarding policies and regulations related to stormwater is provided in Section 4.4.

Local critical areas ordinances and other ecosystem-related municipal regulations and policies would also likely govern activities associated with the Current Plan Alternative or the Potential Plan Modifications Alternative. In many cases, these ordinances and policies supplement national and state regulations. Habitats and features typically protected in these local ordinances and policies include erosion-prone areas, wetlands, streams, riparian corridors, and habitats for threatened and endangered species.

Fish species are of particular concern—most prominently salmon and trout. The Plan area falls within the usual and accustomed fishing areas of federally recognized tribes with treaty rights, including harvesting fish free of state interference (subject to conservation principles) and co-managing the fishery resource. Sound Transit routinely addresses potential effects on fish and fish habitat in project-level analyses and coordinates with potentially affected tribes.

Table 4-16. Potential ecosystem-related permits, approvals, and processes

Permit or approval	Trigger	Approving agency	Approval criteria
National Environmental Policy Act (review)	Federal nexus (either federal funding or project requires federal permits)	Depends on federal nexus	Consideration of the environmental impacts for proposed federal actions and reasonable alternatives to those actions
Endangered Species Act (consultation)	Needed for projects with federal nexus that may impact any listed species	Lead federal agency initiates consultation with USFWS and NMFS	No jeopardy to the continued existence of federally listed threatened or endangered species
Bald and Golden Eagle Protection Act (permit)	Needed for projects that may impact bald or golden eagles	USFWS	Compliance with measures to avoid, minimize, or mitigate for detrimental effects on the regional eagle population
Migratory Bird Treaty Act and Federal Executive Order 13186 (coordination)	Needed for projects that may take active nests, eggs, or nestlings	USFWS	Demonstration of a valid justification for take
Essential Fish Habitat (consultation)	Needed for projects with federal nexus that may adversely affect Essential Fish Habitat, as identified in the Magnuson-Stevens Fishery Conservation and Management Act	Lead federal agency initiates consultation with NMFS	Avoidance, mitigation, or offsetting of project impacts on Essential Fish Habitat
Fish and Wildlife Coordination Act (consultation)	Needed for projects with a federal nexus that may affect a stream or body of water	USFWS, NMFS, WDFW	Consultation includes disclosure of proposed action, potential effects, and mitigation; any recommendations from USFWS, NMFS, or WDFW are not binding, but lead agency must give them full consideration
Clean Water Act Section 404 Nationwide Permit or Individual Permit	Placing a structure, excavating (including land clearing), or discharging dredged or fill material in Waters of the U.S., including wetlands	U.S. Army Corps of Engineers	Protection of water quality; no significant degradation to waters
Clean Water Act Section 402 National Pollutant Discharge Elimination System (permit)	Work that involves discharge of pollutants into Waters of the U.S.	Ecology	Permitted discharges must satisfy discharge permit requirements under Section 402 of the Clean Water Act and Chapter 90.48 RCW
Clean Water Act Section 401 Water Quality Certification	An activity involving a discharge into Waters of the U.S. authorized by a federal permit	Ecology	Protection of water quality; adherence to water quality standards (Clean Water Act, state water quality laws, and any other state aquatic protection requirements)
Coastal Zone Management Act Consistency Determination	Conducting projects in Washington's 15 coastal counties by federal agencies or applying for certain federal permits or funding	Federal permitting agency or Ecology	Compliance with state and federal Clean Water Act, Clean Air Act, SEPA, Shoreline Management Act, and energy facility site evaluation criteria
Section 9 of the Rivers and Harbors Act (permit)	Prohibits the obstruction of navigable waterways by bridge construction or replacement	U.S. Coast Guard	Avoidance of obstruction of navigable waterways, NEPA compliance, Coastal Zone Management Certification, and water quality certification (401)
Section 10 of the Rivers and Harbors Act (permit)	Placement of structures and discharge of material in navigable waters of the U.S., including wetlands; typical activities include boat docks, floats, buoys, etc.	U.S. Army Corps of Engineers	Avoidance of obstruction or alteration of navigable waters of the U.S., unless a permit from the Corps of Engineers has been granted
State Environmental Policy Act (review)	State and local agency decisions	Sound Transit	Consideration of the environmental impacts for proposed state actions and reasonable alternatives to those actions
Hydraulic Project Approval (permit)	Work that uses, diverts, obstructs, or changes the natural flow or bed of state waters	WDFW	No harm to listed species or their habitat; overall goal is no project or cumulative impacts to fish and wildlife
Shoreline Substantial Development Permit (Shoreline Management Act)	Activities occurring in the shoreline zone whose value is above the minimum dollar threshold	Local jurisdiction (city or county) and Ecology	Permitted use identified in the Shoreline Master Program; if project includes only minor shoreline development, a letter of exemption, conditional use permit, or variance may be appropriate
Critical Areas Ordinance Compliance	Impacts to critical areas or their buffers (e.g., wetlands, streams, geologically hazardous areas and steep slopes, and fish and wildlife habitat conservation areas)	Local jurisdiction (city or county)	Project compliance with city and county codes

Ecology = Washington State Department of Ecology; NEPA = National Environmental Policy Act; NMFS = National Marine Fisheries Service; SEPA = Washington State Environmental Policy Act; USFWS = U.S. Fish and Wildlife Service; WDFW = Washington State Department of Fish and Wildlife

4.5.2 Affected environment

Ecosystems in the Plan area have been altered to varying degrees, with the greatest alterations occurring in areas of urban, commercial, or residential development. In many developed areas, ecosystems have been substantially modified from pre-settlement conditions, resulting in fragmented and low-quality habitat. These environments support native and nonnative fish, wildlife, and plant species adapted to urban conditions. However, the Plan area also contains relatively undeveloped areas that provide higher-quality habitat.

The largest relatively undeveloped area occurs at the southern extreme of the Plan area, largely within the Joint Base Lewis-McChord military installation. These lands contain rare oak woodland and glacial outwash prairie habitats, as well as conifer and mixed conifer-hardwood forests. Other higher-quality habitat areas in the Plan area include rivers (e.g., Sammamish River, Cedar River, Green/Duwamish River, and Puyallup River), streams, lakes (e.g., Lake Washington and Lake Sammamish), and wetlands. These habitats support regionally important native fish, wildlife, and plant species, including species listed under the ESA.

Regionally important ecosystem resources

This analysis considered regionally important habitats within the Plan area, as identified by three primary resources involved in conservation actions in Washington State:

- **Washington State Department of Fish and Wildlife (WDFW)—**Priority Habitats and Species Program (WDFW 2008)
- **Washington State Department of Natural Resources (DNR)—**Natural Heritage Program (DNR 2007)
- **Willamette Valley–Puget Trough–Georgia Basin Ecoregional Assessment—**Priority Conservation Areas (Floberg et al. 2004)

The locations of regionally important ecosystem resources relative to the study corridors for the Current Plan Alternative and the Potential Plan Modifications Alternative are shown in Section 4.5.3. WDFW priority habitats, including wetlands and fish-bearing streams and other water bodies, are distributed throughout the Plan area. High-quality native ecosystems and priority conservation areas are found primarily in the eastern, southeastern, and southern extremes of the Plan area, particularly in and near the Joint Base Lewis-McChord military installation. The tables in Appendix D list the priority habitats, high-quality native ecosystems, and priority conservation areas that have been identified within the Plan area.

Table 4-17 lists several species that are either listed, proposed for listing, or candidates for listing under the ESA. These species are of particular concern because (1) their listing status indicates heightened management concern, (2) Section 7 of the ESA requires additional scrutiny of projects authorized, funded, or carried out by

WDFW Priority Habitats

WDFW defines priority habitats as those habitat types or elements with unique or significant value to a diverse assemblage of species.

DNR High-quality Native Ecosystems

Through the Natural Heritage Program, DNR collects and distributes information about native ecosystems and rare species, using a vegetation-based classification system to identify high-quality native ecosystems and relatively undisturbed wetlands. These are found primarily in the eastern, southeastern, and southern extremes of the Plan area, particularly in and near the Joint Base Lewis-McChord military installation.

Priority Conservation Areas

The Nature Conservancy and WDFW jointly developed the Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment in 2004. The assessment used a prioritization process to identify important places for conserving native species and ecosystems in the region. These are found primarily in the eastern, southeastern, and southern extremes of the Plan area, particularly in and near the Joint Base Lewis-McChord military installation.

federal agencies, and (3) local critical ordinances include measures to protect areas that have a primary association with endangered, threatened, and sensitive species. Many of the streams, lakes, and nearshore marine areas in the Plan area have been designated or proposed as critical habitat for ESA-listed species. State-listed and other species that are management priorities for WDFW are identified in Appendix D, along with Natural Heritage Program rare plant species.

Table 4-17. Species listed, proposed for listing, or candidates for listing under the Endangered Species Act

Common name	Scientific name	Status
Fish		
Bull trout	*Salvelinus confluentus*	Threatened
Chinook salmon	*Oncorhynchus tshawytscha*	Threatened
Steelhead	*Oncorhynchus mykiss*	Threatened
Bocaccio rockfish*	*Sebastes paucispinis*	Endangered
Canary rockfish*	*Sebastes pinniger*	Threatened
Yelloweye rockfish*	*Sebastes ruberrimus*	Threatened
Eulachon*	*Thaleichthys pacificus*	Threatened
Birds		
Marbled murrelet*	*Brachyramphus marmoratus*	Threatened
Streaked horned lark	*Eremophila alpestris strigata*	Threatened
Yellow-billed cuckoo	*Coccyzus americanus*	Proposed Threatened
Mammals		
Pacific fisher	*Martes pennanti*	Candidate
Roy Prairie (Mazama) pocket gopher	*Thomomys mazama glacialis*	Threatened
Southern resident killer whale*	*Orcinus orca*	Endangered
Amphibians		
Oregon spotted frog	*Rana pretiosa*	Threatened
Invertebrates		
Taylor's checkerspot butterfly	*Euphydryas editha taylori*	Endangered
Plants		
Marsh sandwort	*Arenaria paludicola*	Endangered
Golden paintbrush	*Castilleja levisecta*	Threatened
Water howellia	*Howellia aquatilis*	Threatened

Sources: NMFS 2014, USFWS 2014

*Species found primarily in marine habitats in the Plan area.

4.5.3 Long-term impacts

Potential long-term impacts associated with implementing either the Current Plan Alternative or the Potential Plan Modifications Alternative can be grouped into six general categories:

- Habitat loss or degradation from clearing of vegetation, shading of vegetation, and filling of wetlands
- Habitat fragmentation from establishment of facilities in otherwise intact habitat
- Disturbance of fish and wildlife caused by noise, light, and human activity associated with facility operations
- Impediments to fish movement from the presence of culverts or structures in aquatic areas

- Habitat impacts from alteration of hydrology and water quality changes
- Pollution associated with facility operations

These impacts are expected to be greatest in areas where activities would occur within higher-quality habitats (e.g., lakes, rivers, streams, wetlands, and tracts of undeveloped or moderately developed land).

Current Plan Alternative

Under the Current Plan Alternative, implementing any of the modes could remove, degrade, or fragment habitat; fill wetlands; disturb fish and wildlife; or affect fish movement or fish passage. Table 4-18 identifies the number of ecosystem resources that fall within the study areas for each corridor. In addition, see Table 4-14 for the number of streams that cross each corridor. The number of resources shown in these tables does not represent an estimate of the number of regionally important ecosystem resources that would be affected if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors. Figure 4-22 and Figure 4-23 depict the locations of the regionally important ecosystem resources relative to the Current Plan Alternative study corridors.

Light rail

Elements of the light rail system most likely to affect ecosystem resources include at-grade and elevated guideways, stations, park-and-ride facilities, traction power substations, passing or storage tracks, stormwater treatment facilities, and operations and maintenance facilities. Study corridors C, F, and G could include potential tunnels in parts of the corridors. Belowground facilities would be less likely to have long-term impacts, depending on the construction approach. Vent shafts, portals, and other support facilities for tunnels or belowground stations could affect ecosystem resources at the surface.

Clearing and ground disturbance for the construction of at-grade corridors and associated facilities could permanently remove or degrade existing vegetation, introduce or spread invasive weeds, alter wetlands, and disturb sensitive wildlife species. Elevated facilities could shade vegetation, thereby impacting wildlife habitat, wetlands, and other ecosystem resources.

If new over-water structures are needed in light rail corridors, some shading and loss of river bank or in-stream habitat could occur. For elevated guideways, the placement of structures over existing fish passage barriers could potentially preclude the replacement of those barriers in the future. Installing new culverts or lengthening existing culverts or modifying stream channels to accommodate light rail corridors that cross fish-bearing streams could impede access by fish to suitable habitat upstream. Conversely, many stream crossings may include new culverts or bridge structures that are designed to allow fish passage. Fish passage conditions could even be improved at some locations if existing fish passage barriers are replaced with open-bottom culverts or other structures that more closely resemble natural conditions.

Table 4-18. Ecosystem resources for Current Plan Alternative study corridors

ID	Current Plan Alternative study corridor location	Approximate length of corridor (miles)	Wetlands (acres)[1]	Number of WDFW priority habitat areas[1]	Number of Washington Natural Heritage Program high-quality native ecosystems[1]	Number of Ecoregional Assessment Priority conservation areas[1]
Potential rail extensions, assumed light rail: 1-mile-wide study area						
A	Tacoma to Federal Way	10	330	6	5	0
B	Burien to Renton	8	111	8	0	0
C[2]	Bellevue to Issaquah along I-90	10	438	13	0	3
D	Renton to Lynnwood along I-405	28	785	15	0	0
E	Renton to Woodinville along Eastside Rail Corridor	22	560	13	0	0
F[2]	Downtown Seattle to Ballard	6	18	3	0	0
G[2]	Ballard to UW	4	0.08	1	0	0
H	Lynnwood to Everett	13	591	14	0	0
Total resource areas within potential light rail extension study corridors[3]			2,834	53	5	3
Potential rail extension, assumed commuter rail: 200-foot-wide study area						
I	DuPont to Lakewood	8	0	0	0	0
J	Renton to Woodinville along Eastside Rail Corridor	22	2.4	2	0	0
Total resources within potential commuter rail extensions study corridors[3]			2.4	2	0	0
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail / 200-foot-wide study area if BRT						
K[2]	UW to Redmond via SR 520	13	Light rail: 246 BRT: 9.4	Light rail: 24 BRT: 5	Light rail: 0 BRT: 0	Light rail: 0 BRT: 0
L	Northgate to Bothell	9	Light rail: 238 BRT: 0.9	Light rail: 7 BRT: 1	Light rail: 0 BRT: 0	Light rail: 0 BRT: 0
Total resource areas within high-capacity transit study corridors[3]			Light rail: 484 BRT: 10.3	Light rail: 29 BRT: 6	Light rail: 0 BRT: 0	Light rail: 0 BRT: 0

Table 4-18. Ecosystem resources for Current Plan Alternative study corridors (continued)

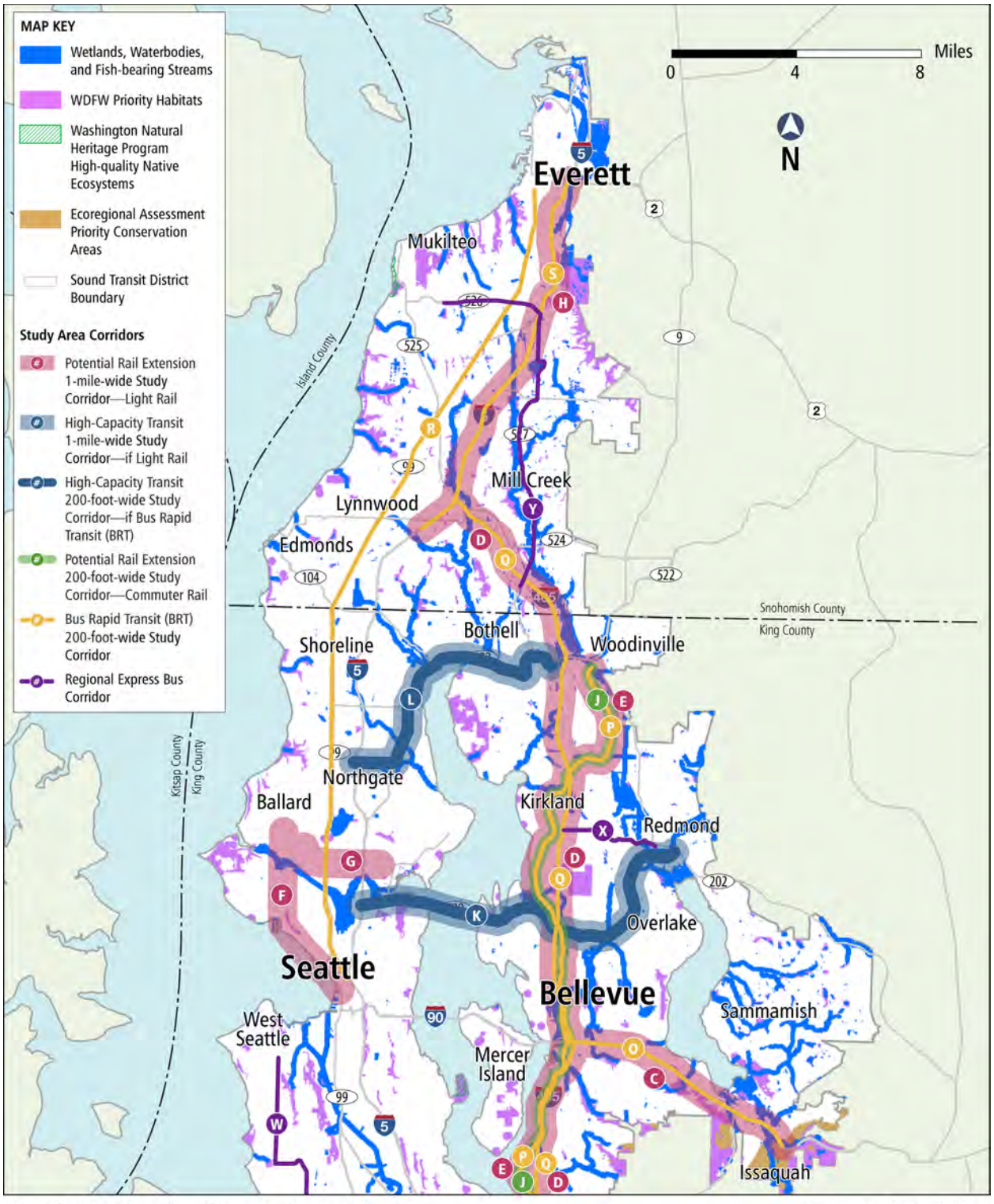
ID	Current Plan Alternative study corridor location	Approximate length of corridor (miles)	Wetlands (acres)[1]	Number of WDFW priority habitat areas[1]	Number of Washington Natural Heritage Program high-quality native ecosystems[1]	Number of Ecoregional Assessment Priority conservation areas[1]
Bus rapid transit (BRT): 200-foot-wide study area						
M	Federal Way to DuPont along I-5	25	1.4	2	0	0
N	Renton to Puyallup along SR 167	21	13	7	0	0
O	Bellevue to Issaquah along I-90	10	1.2	2	0	1
P	Renton to Woodinville along Eastside Rail Corridor	22	2.4	2	0	0
Q	Renton to Lynnwood along I-405	28	0.9	1	0	0
R	Seattle to Everett along SR 99	27	0.2	4	0	0
S	Lynnwood to Everett along I-5	13	0	0	0	0
Regional express bus						
T-Y	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS					
Total resource areas within bus study corridors[2]			19	16	0	1

Sources: WDFW 2014; DNR 2014c; The Nature Conservancy 2011a

[1] These numbers do not represent an estimate of the number of resource areas that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

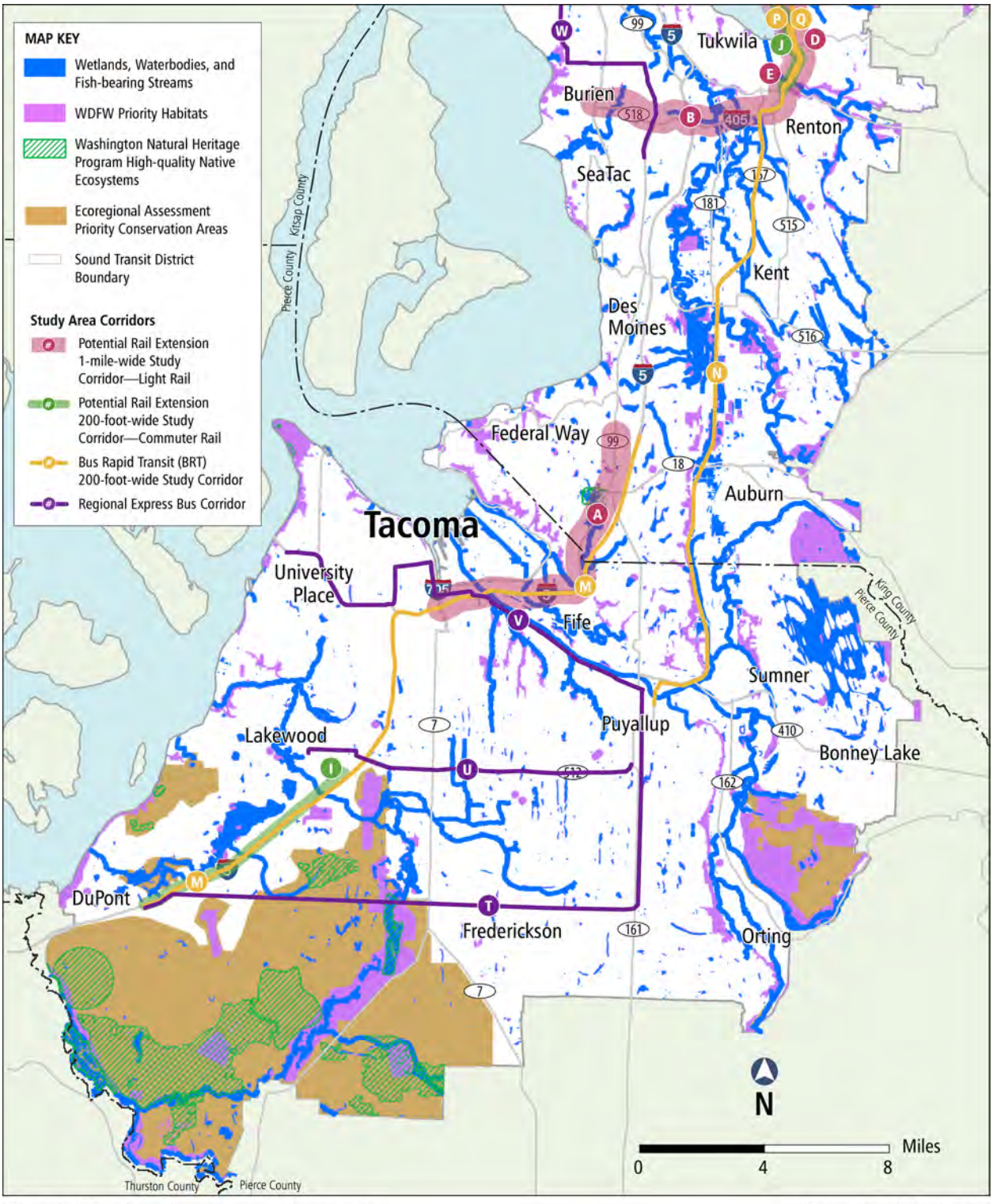
[3] Numbers include resource areas where only a portion of the resource is within the study corridor. Some resource areas may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-22. Regionally important ecosystem resources for Current Plan Alternative study corridors—north



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-23. Regionally important ecosystem resources for Current Plan Alternative study corridors—south

The following light rail study corridors overlap areas with relatively high densities of regionally important ecosystem resources, as indicated by the presence of Natural Heritage Program high-quality native ecosystems, Ecoregional Assessment priority conservation areas, major lakes or rivers, or concentrations of WDFW priority habitat areas (including wetlands and water bodies) (Figure 4-22 and Figure 4-23), with study corridors A and C having the greatest number of regionally important ecosystems:

- **A (Tacoma to Federal Way)—**Puyallup River; wetland complexes and high-quality native ecosystems along Hylebos Creek
- **B (Burien to Renton)—**Green River; Cedar River
- **C (Bellevue to Issaquah)—**Mercer Slough; open space and priority conservation areas near Cougar Mountain and Issaquah Creek
- **D (Renton to Lynnwood along I-405)—**Sammamish River; Mercer Slough; May Creek; Cedar River; wetland complexes along North Creek and Swamp Creek
- **E (Renton to Woodinville along Eastside Rail Corridor)—**Sammamish River; Mercer Slough; May Creek; Cedar River
- **H (Lynnwood to Everett)—**Open space areas and wetland complexes along the lower Snohomish River; wetland complexes along Swamp Creek

Corridor A has the highest concentration of high-quality native ecosystems, priority habitat areas, and priority conservation areas. Corridors C and H have the highest concentration of wetlands.

The number of resources identified within each study corridor in Table 4-18 is within a broad corridor that would contain the light rail alignment. These resources would be considered—and avoided to the extent possible—when establishing the final alignment; therefore, the number of impacts would be less than indicated by the number of resources within the study corridors.

Commuter rail

Potential long-term adverse effects associated with commuter rail service include the loss and degradation of ecosystem resources at new or modified rail stations and associated facilities or where new track is required within expanded railroad rights-of-way along existing or new corridors. The study corridor for the potential rail extension from Renton to Woodinville along the eastside rail corridor (study corridor J) crosses the Sammamish River and the Cedar River and runs alongside Lake Washington at several locations; the study corridor for the extension from DuPont to Lakewood (study corridor I) does not include any areas with relatively high densities of regionally important ecosystem resources (Figure 4-22 and Figure 4-23).

Regional express bus/bus rapid transit

Additional regional express bus routes using existing facilities where buses currently operate would have little potential to generate additional impacts. BRT corridors would operate on existing roadways or in additional lanes adjacent to existing roadways. New roadways, access ramps, stations, park-and-ride facilities, or other improvements could be required for some BRT systems. Ecosystem impacts similar to those identified for

light rail and for commuter rail could occur where new and expanded roadways and facilities are needed.

The following BRT study corridors overlap areas with densities of regionally important ecosystem resources (Figure 4-22 and Figure 4-23):

- **M (Federal Way to DuPont along I-5)—**Puyallup River
- **N (Renton to Puyallup along SR 167)—**Wetland complexes along Panther Creek and in the Kent Valley; Green River; Puyallup River
- **O (Bellevue to Issaquah along I-90)—**Mercer Slough; priority conservation area near Issaquah Creek
- **Q (Renton to Lynnwood along I-405)—**Wetland complexes along North Creek and Swamp Creek; Sammamish River; Cedar River
- **R (Seattle to Everett along SR 99)—**Green Lake; Lake Union

High-capacity transit (mode not specified)

Corridors K and L, both HCT corridors, could be selected as either light rail or BRT corridors. Regardless of mode, corridor K (University of Washington (UW) to Redmond via SR 520) intersects portions of the Sammamish River, Lake Washington, and Lake Union (Portage Bay). If implemented as light rail, impacts to ecosystem resources within corridor K could be slightly higher than the impacts of BRT. However, these impacts could be reduced by elevating or burying light rail segments. For example, study corridor K, if selected for light rail, could include a tunnel west of Lake Washington.

The wider light rail study area for corridor L (Northgate to Bothell) includes portions of the Sammamish River and Lake Washington, as well as wetland complexes along the Sammamish River and lower Swamp Creek, which are not in the BRT study area. Overall, light rail in corridor L could result in greater impacts to ecosystem resources than BRT in the same corridor depending on the final alignment and profile of the light rail facility.

These resources would be considered—and to the extent possible avoided—when establishing the final alignment; therefore, the number of impacts would be less than indicated by the number of resources within study corridor L when evaluated for light rail.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar impacts as those described for the Current Plan Alternative. However, because of the additional corridors included in the Potential Plan Modifications Alternative, impacts to ecosystem resources could be greater than those for the Current Plan Alternative. Table 4-19 identifies the number of these resources that fall within the study areas for each corridor. These numbers do not represent an estimate of the number of resources that would be affected if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors. Figure 4-24 and Figure 4-25 depict the locations of the regionally important ecosystem resources relative to the Potential Plan Modifications Alternative study corridors.

Table 4-19. Ecosystem resource areas for Potential Plan Modifications Alternative study corridors

ID	Potential Plan Modifications Alternative study corridor location	Approximate length of corridor (miles)	Wetlands (acres)[1]	Number of WDFW priority habitat areas[1]	Number of Washington Natural Heritage Program high-quality native ecosystems[1]	Number of Ecoregional Assessment Priority conservation areas[1]
Potential rail extensions, assumed light rail: 1-mile-wide study area						
1	Downtown Seattle to Magnolia/Ballard to Shoreline Community College	12	59	6	0	0
2[2]	Downtown Seattle to West Seattle/Burien	13	81	14	0	0
3	Ballard to Everett Station via Shoreline Community College, Aurora Village, Lynnwood	24	226	16	0	0
4	Everett to North Everett	2	7	1	0	0
5	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	253	9	0	1
6	DuPont to downtown Tacoma via Lakewood, Tacoma Mall	16	420	11	0	1
7	Puyallup/Sumner to Renton via SR 167	21	1,189	16	0	0
8	Downtown Seattle along Madison Street	3	6	2	0	0
9	Tukwila to SODO via Duwamish industrial area	11	98	5	0	0
10	North Kirkland or University of Washington Bothell to Northgate via SR 522	13	312	7	0	0
11	Ballard to Bothell via Northgate	13	254	8	0	0
12	Mill Creek, connecting to Eastside Rail Corridor	8	724	9	0	0
13	Lynnwood to Everett, serving Southwest Everett Industrial Center (Paine Field and Boeing)	7	79	8	0	0
14[2]	UW to Sand Point to Kirkland to Redmond	10	1,284	14	0	0
15	Downtown Tacoma to Tacoma Community College	3	7	1	0	0
16	Tacoma Mall to University Place	6	27	3	0	0
17	Steilacoom to Ruston via University Place	12	452	17	0	2
18	Issaquah to Issaquah Highlands	2	10	3	0	3
Total resource areas within light rail study corridors[3]			5,169	108	0	7
Potential rail extensions, assumed commuter rail: 1-mile-wide study area new track / 200-foot-wide study area existing track						
19	Puyallup/Sumner to Orting	8	5	3	0	0
20	Lakewood to Parkland	3	69	5	0	1
21	Tacoma to Frederickson	10	1	1	0	0
Total resource areas within commuter rail study corridors[3]			75	8	0	1

Table 4-19. Ecosystem resource areas for Potential Plan Modifications Alternative study corridors (continued)

ID	Potential Plan Modifications Alternative study corridor location	Approximate length of corridor (miles)	Wetlands (acres)[1]	Number of WDFW priority habitat areas[1]	Number of Washington Natural Heritage Program high-quality native ecosystems[1]	Number of Ecoregional Assessment Priority conservation areas[1]
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail / 200-foot-wide study area if BRT						
22	Downtown Tacoma to Parkland	8	Light rail: 60 BRT: 1	Light rail: 1 BRT: 1	Light rail: 0 BRT: 0	Light rail: 0 BRT: 0
23	Tukwila Sounder station to downtown Seattle via Sea-Tac Airport, Burien, West Seattle	15	Light rail: 85 BRT: 0.5	Light rail: 15 BRT: 3	Light rail: 0 BRT: 0	Light rail: 0 BRT: 0
24	Downtown Seattle to Edmonds via Ballard, Shoreline Community College	19	Light rail: 136 BRT: 0.2	Light rail: 14 BRT: 1	Light rail: 0 BRT: 0	Light rail: 1 BRT: 1
25	West Seattle to Ballard via Central District, Queen Anne	14	Light rail: 34 BRT: 0.01	Light rail: 16 BRT: 4	Light rail: 0 BRT: 0	Light rail: 0 BRT: 0
26	Edmonds to Lynnwood Link	5	Light rail: 255 BRT: 0.6	Light rail: 14 BRT: 1	Light rail: 0 BRT: 0	Light rail: 1 BRT: 0
Total resource areas within high-capacity transit study corridors[3]			Light rail: 495 BRT: 2.1	Light rail: 41 BRT: 9	Light rail: 0 BRT: 0	Light rail: 1 BRT: 1
Bus rapid transit (BRT): 200-foot-wide study area						
27	Puyallup vicinity, notably along Meridian Avenue	6	0.04	0	0	0
28	Issaquah to Issaquah Highlands	2	0	2	0	2
29	Kent to Sea-Tac Airport	11	5.4	1	0	0
30[4]	Downtown Seattle along Madison Street	—	—	—	—	—
Regional express bus/BRT (mode not specified): 200-foot-wide study area						
31	Issaquah Highlands to Overlake via Sammamish, Redmond	14	1	3	0	0
32	Tacoma to Bellevue	34	2.5	1	0	0
33	Puyallup to downtown Seattle via Kent, Rainier Valley	35	28	9	0	0
34	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	2	2	0	1
35	Tacoma to Frederickson	13	3	3	0	0
Regional express bus						
36-47	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS					
Total resource areas within bus study corridors[3]			41.8	16	0	3

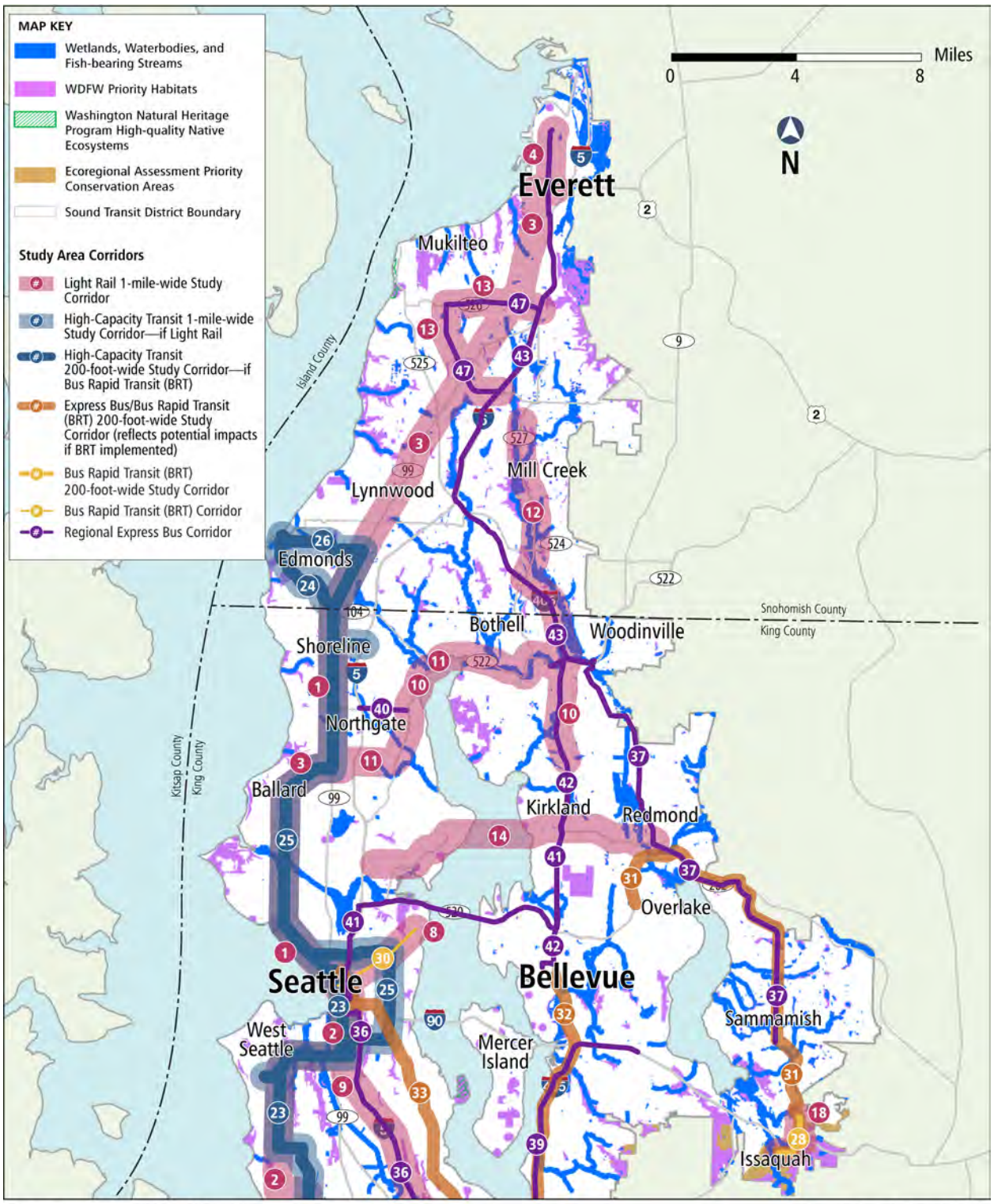
Sources: WDFW 2014; DNR 2014c; The Nature Conservancy 2011a

[1] These numbers do not represent an estimate of the number of resource areas that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

[3] Numbers include resource areas where only a portion of the resource is within the study corridor. Some resource areas may be within more than one study corridor; therefore, the number of resources within each study corridor may may be greater than the total for all study corridors combined.

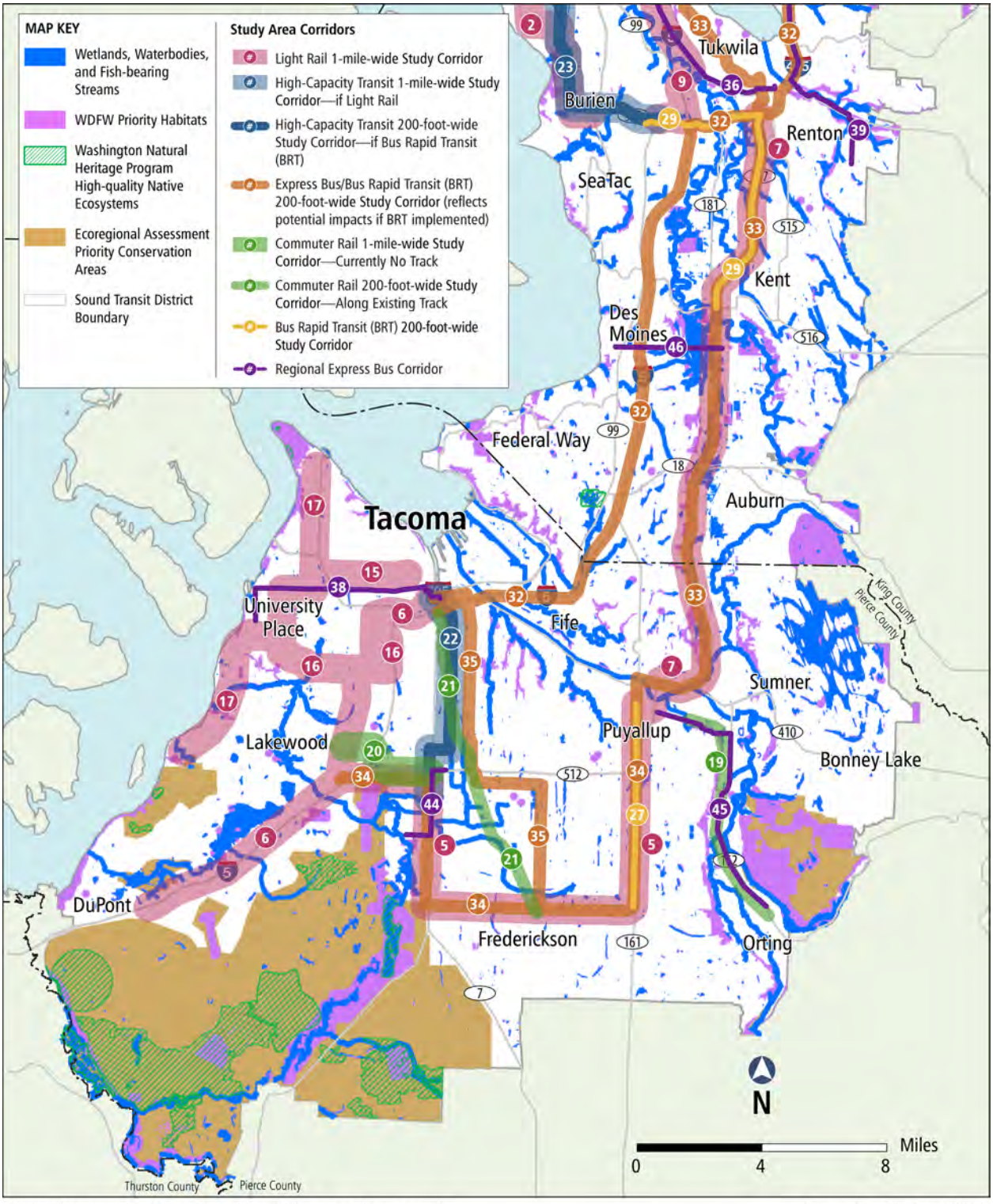
[4] Corridor 30 is BRT and is assumed to use existing roadway facilities in this location so was not analyzed using GIS. Impacts to ecosystems could occur in this corridor but they are not expected to be significant.



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-24. Regionally important ecosystem resources for Potential Plan Modifications Alternative study corridors—north



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-25. Regionally important ecosystem resources for Potential Plan Modifications Alternative study corridors—south

Light rail

As with the Current Plan Alternative, at-grade and elevated light rail guideways, stations, park-and-ride facilities, traction power substations, passing or storage tracks, stormwater treatment facilities, and operations and maintenance facilities could affect ecosystem resources. The following light rail study corridors overlap areas with relatively high densities of regionally important ecosystem resources (Figure 4-24, Figure 4-25, and Table 4-19), with study corridors 7 and 14 having the greatest number of wetlands and study corridors 14, 17, and 18 having the greatest concentrations of regionally important ecosystems:

- **2 (Downtown Seattle to West Seattle/Burien)—**Elliott Bay; Duwamish Waterway; green spaces along Longfellow Creek; Salmon Creek ravine; forested areas in Seahurst Park. This corridor includes potential tunnel sections
- **5 (Lakewood to Spanaway to Frederickson to South Hill to Puyallup)—**Joint Base Lewis-McChord priority conservation area; Spanaway Lake; Clover Creek
- **6 (DuPont to downtown Tacoma via Lakewood, Tacoma Mall)—**American Lake; Murray Creek; Sequalitchew Creek and associated wetlands; Sequalitchew Marshes priority conservation area
- **7 (Puyallup/Sumner to Renton via SR 167)—**Green River; White River; Puyallup River; Mill Creek; various wetland complexes
- **10 (North Kirkland or University of Washington Bothell to Northgate via SR 522)—**Lake Washington; Sammamish River; wetland complexes along Swamp Creek and North Creek
- **11 (Ballard to Bothell via North gate)—**Lake Washington; Sammamish River; wetland complexes along Swamp Creek and North Creek
- **12 (Mill Creek, connecting to Eastside Rail Corridor)—**Wetland complexes along North Creek; Sammamish River
- **14 (UW to Sand Point to Kirkland to Redmond)—**Lake Washington; Sammamish River; including a crossing of Lake Washington that could be either a bridge or tunnel
- **17 (Steilacoom to Ruston via University Place)—**West Tacoma open space areas; Chambers Creek and associated open space areas; Solo Point-Farrell Marsh priority conservation area
- **18 (Issaquah to Issaquah Highlands)—**Tiger Mountain priority habitat area; East Fork and North Fork Issaquah Creek; Issaquah Creek priority conservation area

Study areas for corridors 7 and 14 having the greatest total number of wetlands and the highest concentration of wetlands (wetlands per mile) than any other corridors included in the Current Plan Alternative or Potential Plan Modifications Alternative. Corridors 7 and 17 have the greatest number of regionally important ecosystems.

As described for the Current Plan Alternative, the resources identified within each study area in Table 4-19 are within a broad corridor that would contain the light rail alignment. These resources would be considered—and to the extent possible avoided—when establishing the final alignment; therefore, the number of impacts would be less than indicated by the number of resources within the study corridor.

Commuter rail

As with the Current Plan Alternative, commuter rail service generally includes new operations on existing tracks (with the exception of corridor 20) with new or modified rail stations and associated facilities. A portion of the Joint Base Lewis-McChord priority conservation area falls within the 1-mile-wide study area for a new line between Lakewood and Parkland (study corridor 20). The 200-foot-wide study area for the potential line from Puyallup to Orting (study corridor 19) crosses the Puyallup River (Figure 4-25).

Regional express bus/bus rapid transit

As with the Current Plan Alternative, regional express bus routes using existing facilities where buses currently operate would have little potential to generate additional impacts. BRT corridors would operate on existing roadways or in additional lanes adjacent to existing roadways. New roadways, access ramps, stations, park-and-ride facilities, or other improvements could be required for some BRT systems. Ecosystem impacts similar to those identified for light rail and commuter rail could occur where new and expanded roadways and facilities are needed. The following BRT study corridors overlap areas with relatively high densities of regionally important ecosystem resources (Figure 4-24, Figure 4-25, and Table 4-19):

- **28 (Issaquah to Issaquah Highlands)—**East Fork Issaquah Creek; Issaquah Creek priority conservation area
- **29 (Kent to Sea-Tac Airport)—**Green River; wetland complexes along Panther Creek
- **33 (Puyallup to downtown Seattle via Kent, Rainier Valley)—**Lower Green River wetland complexes; candidate open space areas in Pierce County; Puyallup River
- **34 (Lakewood to Spanaway to Frederickson to South Hill to Puyallup)—**Joint Base Lewis-McChord priority conservation area; Clover Creek

Streetcar

The potential for streetcar service to result in long-term impacts on regionally important ecosystem resources would be minimal because streetcar lines would generally be located in existing roadways in densely developed urban areas, such as Seattle. These areas support few if any at-surface fish-bearing streams, large wetlands, priority habitats, high-quality native ecosystems, or priority conservation areas. If a streetcar is operated in the Eastside Rail Corridor, the impacts to ecosystems would be similar to light rail operating in the same corridor.

High-capacity transit (mode not specified)

Study corridors 22 through 26, all HCT corridors, could be selected as either light rail or BRT corridors. Regardless of mode, corridor 23 (Tukwila Sounder Station to Burien and downtown Seattle via Sea-Tac Airport and West Seattle) intersects the Duwamish Waterway, Longfellow Creek, and the Salmon Creek ravine. The wider study corridor for light rail also includes portions of Elliott Bay, green spaces along Longfellow Creek, and Seahurst Park (Figure 4-24 and Figure 4-25).

Regardless of mode, corridor 24 (downtown Seattle to Edmonds via Ballard and Shoreline Community College) intersects the West Queen Anne greenbelt, the Lake Washington Ship Canal, and a nearshore marine priority conservation area at Edmonds Point. The wider study corridor for light rail also includes portions of Elliott Bay and forested areas near Carkeek Park (Figure 4-24).

Regardless of mode, corridor 25 (West Seattle to Ballard via Central District and Queen Anne) intersects the Duwamish Waterway, the East Duwamish greenbelt, and the Lake Washington Ship Canal. The wider study corridor for light rail also includes portions of Elliott Bay and the green spaces along Longfellow Creek (Figure 4-24).

Regardless of mode, corridor 26 (Edmonds to Lynnwood Link) intersects Shelleberger Creek and the Edmonds Wildlife Sanctuary. The wider study corridor for light rail also includes portions of Puget Sound (Figure 4-24).

If implemented as light rail, potential impacts to ecosystem resources within any of these corridors could be higher than the impacts of BRT. Impacts could be reduced by elevating light rail segments over sensitive areas. In all corridors, these resources would be considered—and to the extent possible avoided—when establishing the final alignment; therefore, the number of impacts would be less than indicated by the number of resources within study corridors when evaluated for light rail.

4.5.4 Construction impacts

Under the Current Plan Alternative or the Potential Plan Modifications Alternative, potential construction-related impacts to ecosystems and natural resources could include the following:

- Short-term habitat loss and wildlife impacts from clearing vegetation in construction staging areas and temporary site grading and filling for access
- Impacts to migratory birds or their eggs through destruction of active nests while clearing vegetation
- Short-term habitat loss and impacts to aquatic species (including ESA-listed fish) as a result of construction in, over, or near water (e.g., bridges, guideway columns, and culvert installation or replacement)
- Disturbance of wildlife from noise, light, and activity associated with construction
- Pollution, erosion, and water quality changes resulting from runoff from construction areas

Construction impacts are expected to be greatest in areas with the higher-quality habitats identified in the discussion of long-term impacts. Construction staging areas could require clearing vegetation and trees in less urban areas. Specific impacts and mitigation for individual transit improvements associated with the Current Plan Alternative or the Potential Plan Modifications Alternative would be determined in conjunction with future project-level planning and environmental review.

Current Plan Alternative

Where in-water work would be needed for the light rail corridors, impacts to fish could occur. For belowground construction, tunnel boring or mining would have fewer impacts to surface habitat than cut-and-cover construction. Construction of the Current Plan Alternative could affect the high-quality habitat areas identified in the discussion of long-term impacts above. The areas with the greatest potential for construction-related impacts within each study corridor would be the same as described under long-term impacts.

The commuter rail corridors in the Current Plan Alternative would operate within existing rail corridors, although some new construction could be required for new track, stations, and supporting facilities. Compared to light rail, construction-related impacts associated with commuter rail would occur in a smaller area. Impacts to ecosystem resources would thus be similar in nature but less than the potential impacts described for light rail corridors.

Regional express buses would operate in existing high-occupancy vehicle (HOV) lanes. They would result in limited construction-related impacts related to construction of additional roadway lanes or access ramps, stations, or park-and-ride facilities. These facilities could result in similar types of temporary impacts to ecosystem resources as described above, but to a lesser extent than light rail because of the smaller scale of work that would be required. If new roadways or roadway widening would be required, impacts similar to those described for light rail could occur.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar construction impacts as those described for the Current Plan Alternative. However, the Potential Plan Modifications Alternative could involve additional construction activity in the region because of the additional corridors under consideration. As a result, overall temporary impacts to ecosystems could be slightly greater for the Potential Plan Modifications Alternative. As noted for the Current Plan Alternative, the areas with the greatest potential for construction-related impacts within each study corridor would be the same as described under long-term impacts.

The installation of streetcar facilities, such as tracks, could disturb existing roadways. The potential for this construction to impact regionally important ecosystem resources would be minimal because streetcar lines would generally be located in existing roadways in densely developed urban areas, such as Seattle. With the exception of the Eastside Rail Corridor, these areas support few, if any, at-surface fish-bearing streams, large wetlands, priority habitats, high-quality native ecosystems, or priority conservation areas.

4.5.5 Potential mitigation measures

Sound Transit would mitigate impacts on ecosystem resources in accordance with the mitigation requirements established by the regulations described in Section 4.5.1. Mitigation

for ecosystem impacts is based on a hierarchy of avoiding, minimizing, and compensating for unavoidable impacts. In addition, Sound Transit's Sustainability Initiative (Sound Transit 2007) directs the agency to implement ecosystem mitigation measures to the maximum extent practicable. Specifically, Sound Transit is directed to avoid impacts to environmentally sensitive resources and to provide adequate mitigation to ensure there is no net loss of ecosystem function and acreage as a result of agency projects.

For the development of any individual corridor, Sound Transit would avoid, to the extent practicable, impacts on ecosystem resources by adjusting alignments and site design for new facilities. Where constraints exist, potential ecosystem impact areas would be identified and mitigated during design and construction.

Further, for development of any of the corridors, Sound Transit would comply with standard BMPs and applicable federal, state, and local mitigation requirements during design, construction, and post-construction activities.

Possible measures to minimize and mitigate construction and long-term impacts could include the following:

- Minimize the size of areas cleared of vegetation (e.g., construction staging areas, temporary site grading, and filling for access) and replant the areas with native vegetation following construction (to the extent practicable)
- Avoid construction activities near key locations for wildlife species that are sensitive to disturbance (e.g., active nest sites of great blue herons, bald eagles, red-tailed hawks, and other species of federal, state, or local importance)
- Design fish-passable structures (e.g., bridges or stream simulation-designed culverts) when modifying existing fish-bearing stream crossings or creating new crossings
- Design structures over existing fish passage barriers so as not to preclude replacement of such barriers in the future
- Locate permanent facilities and construction staging areas away from wetlands, creeks, and other higher-quality habitats (to the extent practicable)
- Establish time-of-year restrictions on clearing activities and, as appropriate, conduct pre-construction surveys to determine the presence of migratory bird nests; during construction, minimize the extent of vegetation clearing and establish buffer zones around active nests as appropriate
- Enhance remaining habitat in select priority areas and consider acquiring other lands for habitat restoration or enhancement
- Compensate for unavoidable permanent impacts to wetlands through the use of available approved mitigation banks, in-lieu fee programs, or project-specific mitigation developed by Sound Transit (e.g., wetland creation, restoration, and enhancement)

4.5.6 Significant unavoidable adverse impacts

Significant adverse impacts to ecosystem resources could be mitigated or avoided for most plan elements under the Current Plan Alternative and the Potential Plan Modifications

Alternative. However, temporary unavoidable impacts to ecosystem resources could occur during construction.

4.6 Energy

This section describes existing transportation-related energy consumption (2011) and the potential future (2040) impacts or benefits on energy consumption for the Current Plan Alternative and the Potential Plan Modifications Alternative. Relative to energy consumption, both alternatives are also compared to future ST2 buildout conditions, meaning that only those projects in the ST2 System Plan are implemented in 2040.

4.6.1 Affected environment

The affected environment focuses on existing and planned transportation-related energy use in the Plan area, which reflects the four-county central Puget Sound region (Snohomish, King, Pierce, and Kitsap Counties). As shown in Figure 4-26, transportation energy accounted for the largest percentage of energy consumption in Washington State for the year 2011 (EIA 2013). Gasoline and diesel fuels are the primary energy sources used by automobiles, buses, and trucks. Some transit vehicles, such as trolley buses and light rail trains, and a small percentage of automobiles operate on electricity. Petroleum supplied 46 percent of Washington's primary energy needs in 2011(Commerce 2013).

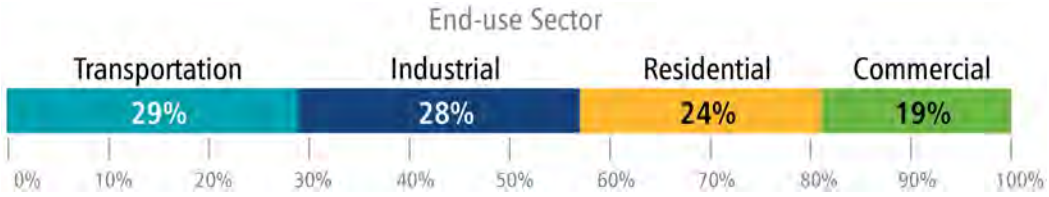


Figure 4-26. Washington State energy consumption by end-use sector, 2011

In 2011, Washington was the nation's leading producer of electricity from hydroelectric sources and produced 29 percent of the nation's net hydroelectric generation. In addition, Washington State was ranked sixth in the nation in net generation of electricity from wind energy in 2011 (EIA 2013).

Energy use is often expressed in terms of a standard measure known as the British thermal units (Btu). One Btu is the heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

Because potential transit improvements would reduce on-road vehicles within the Plan area, as well as increase Sound Transit light rail, commuter rail, and regional express bus/BRT use, the existing energy consumption of these sources has been evaluated. See Section 3, Transportation, for more details on the transit improvement. The Current Plan Alternative and the Potential Plan Modifications Alternative would not affect public transportation provided by other agencies; therefore, energy consumption from other public transportation agencies is not included in this analysis. Energy consumption per mile for Sound Transit vehicles is listed in Table 4-20 along with the estimated 2011 energy consumption based on vehicle miles travelled. Additional details regarding the other agencies that provide public transportation and the transportation system network used in travel demand forecasting are provided in Appendix K.

Table 4-20. Existing daily Sound Transit vehicle energy consumption in the Plan area

Mode	Btu/vehicle mile[1]	2011 daily vehicle miles traveled	2011 daily energy consumption (million Btu)
Light rail	64,585	4,430	286
Commuter rail	92,474	970	90
Regional express bus/BRT	37,718	53,200	2,007
Total Sound Transit energy consumption			2,383

[1] *Source: Transportation Energy Data Book, Edition 32, Table 2.12 (2013)*

Energy consumption for passenger vehicles was developed using EPA's MOVES model version 2010b (released in June 2012). PSRC provided regionally specific MOVES input files, and national defaults were used when regionally specific inputs were not available. Passenger vehicle miles traveled and associated energy consumption are listed in Table 4-21. Total transit and passenger vehicle energy consumption for 2011 is shown in Table 4-22. As shown in this table, passenger vehicles are the largest source of transportation energy consumption within the Plan area.

Energy consumption from Sound Transit vehicles represents 0.4 percent of total on-road vehicle energy consumption in the Plan area.

Table 4-21. Passenger vehicle energy consumption in the Plan area

Mode	2011 daily vehicle miles traveled	2011 daily energy consumption (million Btu)
On-road vehicles (including autos, light trucks, medium trucks, and heavy trucks)	79,435,205	539,368

Table 4-22. Total 2011 energy consumption in the Plan area

Mode	2011 daily energy consumption (million Btu)	Percentage of total daily energy consumption
Transit energy consumption	2,383	0.4
On-road vehicles (including autos, light trucks, medium trucks, and heavy trucks)	539,368	99.6
Total	541,751	100

4.6.2 Long-term impacts

Current Plan Alternative

The Current Plan Alternative includes light rail, commuter rail, and regional express bus/BRT, as described in Section 2.3. Table 4-23 summarizes the projected daily operational energy demand in the year 2040 for the 2040 ST2 buildout, the Current Plan Alternative and the Potential Plan Modifications Alternative. Energy consumption rates (including the MOVES model) do not take into account recent and likely future updates to EPA's fuel economy standards. Other state and federal legislation could also reduce future energy consumption rates. As such, actual future energy consumption for commuter rail, buses, and on-road vehicles (including autos, light trucks, medium trucks, and heavy trucks) could be lower.

As compared to the 2040 ST2 buildout, daily Sound Transit commuter rail, light rail, and regional express bus/BRT energy consumption would increase under the Current Plan Alternative if all elements of the alternative are implemented. Because passenger vehicles account for the majority of energy consumed by daily transportation, total daily energy consumed would decrease slightly with the Current Plan Alternative, as compared to the 2040 ST2 buildout.

Table 4-23. Estimated 2040 daily transportation energy consumption in the Plan area

Mode	2040 ST2 buildout		2040 Current Plan Alternative		2040 Potential Plan Modifications Alternative	
	Vehicle miles traveled	Energy consumption (million Btu)	Vehicle miles traveled	Energy consumption (million Btu)	Vehicle miles traveled	Energy consumption (million Btu)
Light rail transit	17,900	1,156	38,100	2,461	80,510	5,200
Commuter rail[1]	1,400	129	1,680	155	2,380	220
Regional express bus/ BRT[1]	43,400	1,637	73,100	2,757	60,500	2,282
Non-transit on-road vehicles[1]	99,865,404	560,264	99,033,864	555,648	98,264,900	551,335
Total	99,928,104	563,186	99,146,744	561,021	98,408,290	559,037

[1] The energy calculations do not take into account recent and likely future updates to EPA's fuel economy and emission standards. Other state and federal legislation also could reduce future energy consumption rates. As such, actual 2040 energy consumption could be lower.

Sound Transit published a Sustainability Plan in 2011 that builds on the Sustainability Initiative that the Sound Transit Board adopted in 2007 and which is included in the Current Plan Alternative. According to the Sustainability Plan, Sound Transit will integrate efficient operating practices at existing and new facilities, use energy-saving equipment to reduce energy demand, and maximize intermodal transit connections to reduce automobile vehicle miles traveled. Implementation of the Sustainability Plan will further reduce energy consumption.

Potential Plan Modifications Alternative

As compared to the 2040 ST2 buildout, daily Sound Transit commuter rail, light rail, and regional express bus/BRT energy consumption would increase under the Potential Plan Modifications Alternative if all elements of the alternative were implemented. Because passenger vehicles account for the majority of energy consumed by daily transportation, total daily energy consumed would decrease slightly with the Potential Plan Modifications Alternative as compared to the 2040 ST2 buildout.

As compared to the Current Plan Alternative, annual Sound Transit commuter rail and light rail energy consumption would increase under the Potential Plan Modifications Alternative if all elements of the alternative were implemented. Daily energy consumption for Sound Transit regional express buses/BRT, however, would decline as compared to the Current Plan Alternative. Because passenger vehicles account for the majority of energy consumed by daily transportation, total daily energy consumed would decrease slightly with the

Potential Plan Modifications Alternative as compared to the Current Plan Alternative because more trips would be shifted from personal vehicles to transit. The Potential Plan Modifications Alternative would also include the Sound Transit Sustainability Plan, which would further reduce energy consumption.

4.6.3 Construction impacts

During construction, energy would be consumed by heavy equipment, such as graders, excavators, loaders, cranes, cement kilns, concrete trucks, haul trucks, compressors, generators, and, possibly, tunnel boring machines. No unusual energy demands are expected. Increases in fuel and electricity consumption for construction of elements of the Current Plan Alternative or the Potential Plan Modifications Alternative could impact energy resources or fuel availability.

Energy used during construction and in the manufacture of construction materials would be irretrievable. However, construction of the Current Plan Alternative and the Potential Plan Modifications Alternative would not adversely affect the continued availability of energy because the scale of usage for construction is negligible when compared to energy consumption in Washington State, the United States, or globally.

4.6.4 Potential mitigation measures

No mitigation measures are needed, as the Current Plan Alternative and the Potential Plan Modifications Alternative would reduce regional energy consumption. Increases in electrical consumption would not be substantial in terms of regional consumption. Either alternative would also include the Sound Transit Sustainability Plan and its associated reductions in energy consumption, both long-term and during construction.

4.6.5 Significant unavoidable adverse impacts

Over the long term, significant unavoidable adverse impacts to energy resources are not expected from the Current Plan Alternative or the Potential Plan Modifications Alternative.

4.7 Environmental health

This section describes potential impacts and mitigation for the Current Plan Alternative and the Potential Plan Modifications Alternative on areas of environmental health in the Plan area. Environmental health topics reviewed include risks of potential releases to the environment affecting public health, such as toxic or hazardous materials, major hazardous waste sites, and electromagnetic fields (EMF).[1] This section also includes a qualitative discussion of the relationship between transportation and health. Additional resources that involve environmental health topics described in this Final SEIS include air quality (Section 4.2) and noise (Section 4.3).

For this plan-level Final SEIS, the potential impacts are qualitatively described based on broadly defined corridor locations. For analysis purposes, the study area for these study corridors

Hazardous materials

Hazardous materials are generally described as wastes that could pose risks to human health and the environment.

Categories of hazardous materials

- Hazardous waste
- Dangerous waste
- Hazardous substances
- Toxic substances

[1] Risk of explosion (WAC 917 11-444(2)(a)(ii)) is not analyzed because the Current Plan Alternative and the Potential Plan Modifications Alternative would not have explosion risks.

varies in width by mode for consistency with Sound Transit project-level environmental documents, as described in the introduction of this chapter. While the number of high-risk hazardous materials sites within each study corridor is provided, it does not represent the number of sites that would be impacted if a corridor were implemented. The number of high-risk hazardous materials sites affected, the anticipated level of potential impacts, and measures to avoid and minimize impacts would be determined during future project-level planning and environmental reviews.

4.7.1 Regulatory environment

The use, storage, transport, and disposal of hazardous materials have been regulated for decades through federal, state, and local policies and regulations, such as the following:

Federal

- Comprehensive Environmental Response, Compensation, and Liability Act
- Superfund Amendments and Reauthorization Act
- Resource Conservation and Recovery Act
- Toxic Substances Control Act
- Occupational Safety and Health Act
- Clean Air Act
- Clean Water Act

State

- Model Toxics Control Act Cleanup Regulation
- Dangerous Waste Regulations
- Solid Waste Regulations
- Water Pollution Control Act
- Washington Industrial Safety and Health Act

Although there are no regulatory requirements or exposure limits for EMFs, these fields can result in electromagnetic interference, which can cause disruptions and possibly malfunctions in sensitive equipment.

4.7.2 Affected environment

Hazardous materials

Past and current development and zoning along many of the study corridors raises the likelihood of encountering hazardous materials. The disturbance or release of hazardous materials during construction could pose risks to human health and the environment resulting in the need for contamination control or cleanup. Contaminants could also migrate from sites located outside the study corridors; however, hazardous materials contained within the study corridors or close to the study corridors are most likely to pose a risk.

Regulatory records reviewed include the Ecology Model Toxics Control Act (MTCA) Hazardous Site List (HSL) and the EPA National Priority List (NPL) to identify hazardous materials sites with chemical releases that pose the greatest risk within the study corridors. Available GIS data were also compiled to create a database of hazardous materials sites that pose the largest risk. A map and list of these sites can be found in Appendix E.

Developed areas surrounding the study corridors include numerous sites with localized or low-level contamination that pose little, if any, risk. The reviewed records include known contaminated or cleaned-up sites; other sites with unknown contamination could exist within the study corridors.

Common sources of hazardous materials and types

- Automotive maintenance and fueling stations (gasoline, diesel fuel, paints, solvents, and oils)
- Dry cleaners and chemical labs (solvents)
- Lumber mills (preservatives, heavy metals)
- Railroad yards (fuels, oils, solvents)
- Landfills (methane gas, leachate)
- Machine shops (solvents)
- Electrical parts manufacturers (solvents, PCBs)

Electromagnetic fields

EMFs are produced during typical operation of electric power lines and electric devices such as home appliances, the use of automobiles, and the operation of sensitive electronics in hospitals and laboratories. Many of the common electrically powered components of transit systems such as wayside power lines, substations, and overhead catenary for trolley buses, streetcars, and light rail facilities also produce EMFs. The strength of EMFs decreases rapidly with distance from the source. EMFs are present throughout existing infrastructure in developed study corridors, and a slight increase in the presence of EMFs is expected with future transportation improvements.

EMFs

Electric or magnetic fields, also referred to as electromagnetic fields or EMFs, are produced through the use of electricity.

The National Institute of Environmental Health Sciences has concluded that for most health outcomes there is no evidence that EMF exposures have adverse effects (NIEHS 2002). In addition, the World Health Organization (1998) survey of available data concluded: "There is little confirmed experimental evidence that extremely low frequency magnetic fields can affect human physiology and behavior at field strengths found in the home or environment."

Human health and physical activity

Transportation infrastructure can affect human health and physical activity. Air quality, noise, integration with bicycle and pedestrian facilities, and the presence of hazardous materials and EMFs can all affect human health and/or physical activity. The discussion of human health and physical activity generally describes effects from the Current Plan Alternative and the Potential Plan Modifications Alternative and references other report sections that provide additional details for related elements, such as air quality and noise.

4.7.3 Long-term impacts

Hazardous materials

The Current Plan Alternative and the Potential Plan Modifications Alternative could increase the hazardous materials used during operation and the frequency of accidental spills as a result of the increase in the number of facilities. The long-term operation and maintenance of transportation-related facilities could involve the use, storage, transport, and disposal of a variety of vehicle fuels, lubricants, batteries, and solvents. Maintenance and storage facilities required to maintain vehicle fleets would include substantial quantities of these materials. All

hazardous wastes resulting from operation of the Current Plan Alternative or the Potential Plan Modifications Alternative would follow proper handling and disposal of regulated materials.

A long-term benefit could result from the removal and proper disposal of hazardous materials prior to and during construction. Removing these materials would have a positive impact on air and water quality, soils, and sediments and would eliminate future potential public health hazards and liability risks. Transit improvements could also improve vehicular traffic operations, thereby reducing the risk of accidents, including those involving the release of harmful materials into the environment.

Electromagnetic fields

The Current Plan Alternative and the Potential Plan Modifications Alternative could increase EMFs and stray currents. Stray currents flowing from electrical systems to buried pipe or cable and back to the traction power substation from conducting utility lines could also occur from the Current Plan Alternative and the Potential Plan Modifications Alternative. Long-term EMF impacts to sensitive electronics in medical and research facilities could occur from the interaction of electrically powered train cars with overhead catenary wires, power transmission lines, and traction power systems located in close proximity to these facilities. Research laboratories at the University of Washington are one example of highly sensitive facilities. Medical and research facilities that use sensitive electronics are concentrated in the study corridors located in Seattle, Bellevue, Redmond, Kent, and Issaquah for the Current Plan Alternative. Such study corridors under the Potential Plan Modifications Alternative include additional medical and research facilities in Seattle, Everett, Edmonds, Kent, Tacoma, Puyallup, and Lakewood.

EMF impacts at medical and research facilities would be limited to those areas located in close proximity to electrical components of the facility, which could include wayside power lines, substations, and overhead catenary for trolley buses, streetcars, and light rail. To minimize this issue, Sound Transit would coordinate with the entities that own and operate these facilities for the development of any corridor.

No conclusive evidence shows that EMFs create adverse human health effects. Long-term human health impacts resulting from EMFs associated with the Current Plan Alternative or the Potential Plan Modifications Alternative are not expected.

Human health and physical activity

Air pollutants contribute to reductions in air quality and health conditions such as lung cancer, cardiovascular disease, asthma, and other respiratory problems linked to poor quality of life and premature mortality. In general, decreasing commute times and promoting alternative modes of transportation—other than automobiles and trucks—could decrease air pollution (UCLA-HIA 2014). Refer also to Section 4.2. Human health effects related to high levels of noise include hearing loss, cardiovascular effects, mental health, quality of life, and increased stress from loss of sleep. The Current Plan Alternative and the Potential Plan Modifications Alternative could slightly increase overall noise levels in some locations. Refer also to Section 4.3. All potential transit modes in the Current Plan Alternative and the Potential Plan Modifications Alternative

An increase in transit services is statistically linked to benefits in human health and physical activity.

could provide long-term benefits to human health and the environment if previously contaminated properties are permanently cleaned up and existing contamination is properly removed.

The Current Plan Alternative and the Potential Plan Modifications Alternative could have long-term benefits on human health and physical activity because an increase in transit services is statistically linked to benefits in human health and physical activity (Stokes 2008). A lack of physical activity can cause a variety of health concerns, including obesity, mortality, cardiovascular disease, diabetes, cancer, hypertension, bone and joint diseases, and mental health (UCLA-HIA 2014). The Current Plan Alternative and the Potential Plan Modifications Alternative offer transportation options that could encourage more physical activity for users, such as:

- Transit-oriented development could result in more walkable communities to maintain healthier lifestyles by providing improved access to goods, services, and outdoor recreation opportunities that can be accessed by walking or bicycling.
- Supporting facilities that would add, improve, or connect to bicycle and pedestrian facilities could increase physical activity and provide opportunities to improve health.

The Current Plan Alternative and the Potential Plan Modifications Alternative could increase health and physical activity for transit users, particularly those within bicycling or walking distance of stations. The average transit user in North America spends 19 minutes a day actively walking, which is three times the average for the population as a whole (Litman 2010). The Potential Plan Modifications Alternative could increase the number of study corridors with transit service, but the long-term benefits within each study corridor would be similar to those for the Current Plan Alternative.

Additional opportunities for physical activity could occur, particularly for those accessing light rail by walking or bicycling. An analysis of 2001 National Household Travel Survey data for transit users finds that walking to and from transit helps inactive persons attain a significant portion of the recommended minimum daily exercise they need; 29 percent of respondents get 30 minutes or more of exercise a day from walking to and from transit (Besser 2005). Using mass transit and improving traffic control and pedestrian facilities could also lead to safety improvements.

Sound Transit's Bicycle Policy encourages bicycle access to its facilities and services and, with its local and transit partners, promotes bicycle access through its public information materials. Sound Transit provides bicycle access at stations and on transit vehicles, and bicycle racks and lockers at stations. The Current Plan Alternative and the Potential Plan Modifications Alternative could improve safety conditions by improving non-motorized access routes to mass transit stations and traffic controls in the vicinity of stations, thereby reducing the number of injuries and deaths caused by vehicle accidents with pedestrians and bicycles.

Current Plan Alternative

Table 4-24 lists all NPL sites and the MTCA HSL sites with Washington Ranking Method (WARM) ranking of 1 that are located within the study areas for corridors included in the Current Plan Alternative. These numbers do not represent an estimate of the number of resources that would be affected if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors. Figure 4-27 and Figure 4-28 show the locations of these sites in relation to the Current Plan Alternative corridors. Numerous low risk sites, such as car washes and markets with low-levels of soil contamination, are not shown in Figure 4-27 and Figure 4-28, but are located along corridors included in the Current Plan Alternative. The potential impacts of the Current Plan Alternative are described by mode below.

MTCA HSL sites are priority sites planned for cleanup using state funds that have been assessed and ranked using the Washington Ranking Method. WARM ranking is required by WAC 173-340-330 and updated twice a year.

Light rail

Development of light rail corridors would typically require property acquisition for rights-of-way and light rail facilities, including stations and park-and-ride facilities. Operation and maintenance facilities could release contaminants into the environment during operation. However, all hazardous wastes generated from light rail operations would follow applicable regulations for the proper handling and disposal of regulated materials.

"High-risk sites" are the total number of NPL and MTCA 1 sites within 1 mile of a study corridor. High-risk sites could be substantially contaminated and could create liability for Sound Transit during construction or operation. High-risk sites can be listed on one or both government databases; therefore, the number of high-risk sites provided is approximate.

As shown in Table 4-24, the potential light rail extension corridor between downtown Seattle and Ballard (corridor F) has the highest number of total high-risk sites (a total of 8) within the 1-mile-wide study area. This corridor is also one of the shortest corridors, which means it has a higher density of sites than the other corridors. Depending on the location, nature, and transport of contaminants, tunneling or other ground-disturbing activities in corridor F could encounter substantial contaminated soils that would require treatment and disposal. The remaining light rail corridors have between 0 and 2 sites that could pose a contamination risk.

Approximately five medical and research facilities located in the study corridors of the Current Plan Alternative use sensitive electronics that could be affected by EMF. These facilities are located in one or more of the following study corridors: A, C, D, E, F, or G. Corridor G terminates at the University of Washington, which has several EMF-sensitive research facilities. EMF impacts at medical and research facilities would be limited to those areas located in close proximity to electrical components of the facility, which could include wayside power lines, substations, and overhead catenary.

Table 4-24. High-risk hazardous materials sites for Current Plan Alternative study corridors

ID	Current Plan Alternative study corridor location	Approximate length of corridor (miles)	Number of NPL sites[1]	Number of MTCA 1 sites[1]
Potential rail extensions, assumed light rail: 1-mile-wide study area				
A	Tacoma to Federal Way	10	1	1
B	Burien to Renton	8	1	1
C[2]	Bellevue to Issaquah along I-90	10	0	1
D	Renton to Lynnwood along I-405	28	1	0
E	Renton to Woodinville along Eastside Rail Corridor	22	1	0
F[2]	Downtown Seattle to Ballard	6	0	8
G[2]	Ballard to UW	4	0	0
H	Lynnwood to Everett	13	0	2
Total high-risk hazardous materials sites within potential light rail extension study corridors[3]			2	13
Potential rail extensions, assumed commuter rail: quarter-mile-wide study area				
I	DuPont to Lakewood	8	0	1
J	Renton to Woodinville along Eastside Rail Corridor	22	0	0
Total high-risk hazardous materials sites within potential commuter rail extension study corridors[3]			0	1
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail/quarter-mile-wide study area if BRT				
K[2]	UW to Redmond via SR 520	13	Light rail: 0 BRT: 0	Light rail: 3 BRT: 0
L	Northgate to Bothell	9	Light rail: 0 BRT: 0	Light rail: 2 BRT: 2
Total high-risk hazardous materials sites within high-capacity transit study corridors[3]			Light rail: 0 BRT: 0	Light rail: 5 BRT: 2
Bus rapid transit (BRT): quarter-mile-wide study area				
M	Federal Way to DuPont along I-5	25	1	1
N	Renton to Puyallup along SR 167	21	0	0
O	Bellevue to Issaquah along I-90	10	0	0
P	Renton to Woodinville along Eastside Rail Corridor	22	0	0
Q	Renton to Lynnwood along I-405	28	0	0
R	Seattle to Everett along SR 99	27	0	1
S	Lynnwood to Everett along I-5	13	0	1
Regional express bus				
T-Y	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS	—	—	—
Total high-risk hazardous materials sites within bus study corridors[3]			1	3

Sources: U.S. Environmental Protection Agency 2014; Ecology 2014

NPL = National Priorities List; MTCA 1 = Model Toxics Control Act Hazardous Sites List sites with a WARM ranking of 1.

[1] These numbers do not represent an estimate of the number of resource areas that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

[3] Numbers include resource areas where only a portion of the resource is within the study corridor. Some resource areas may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.

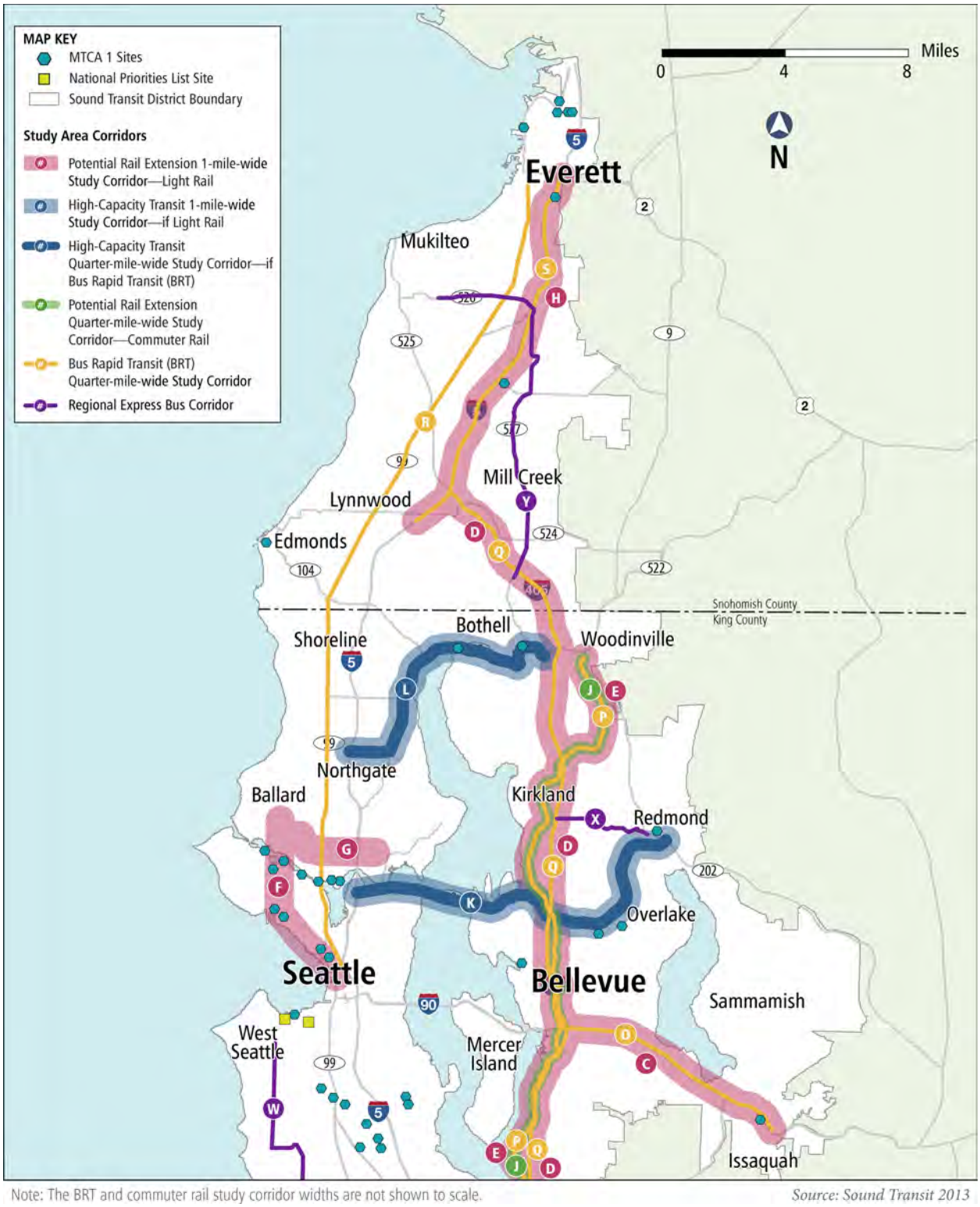
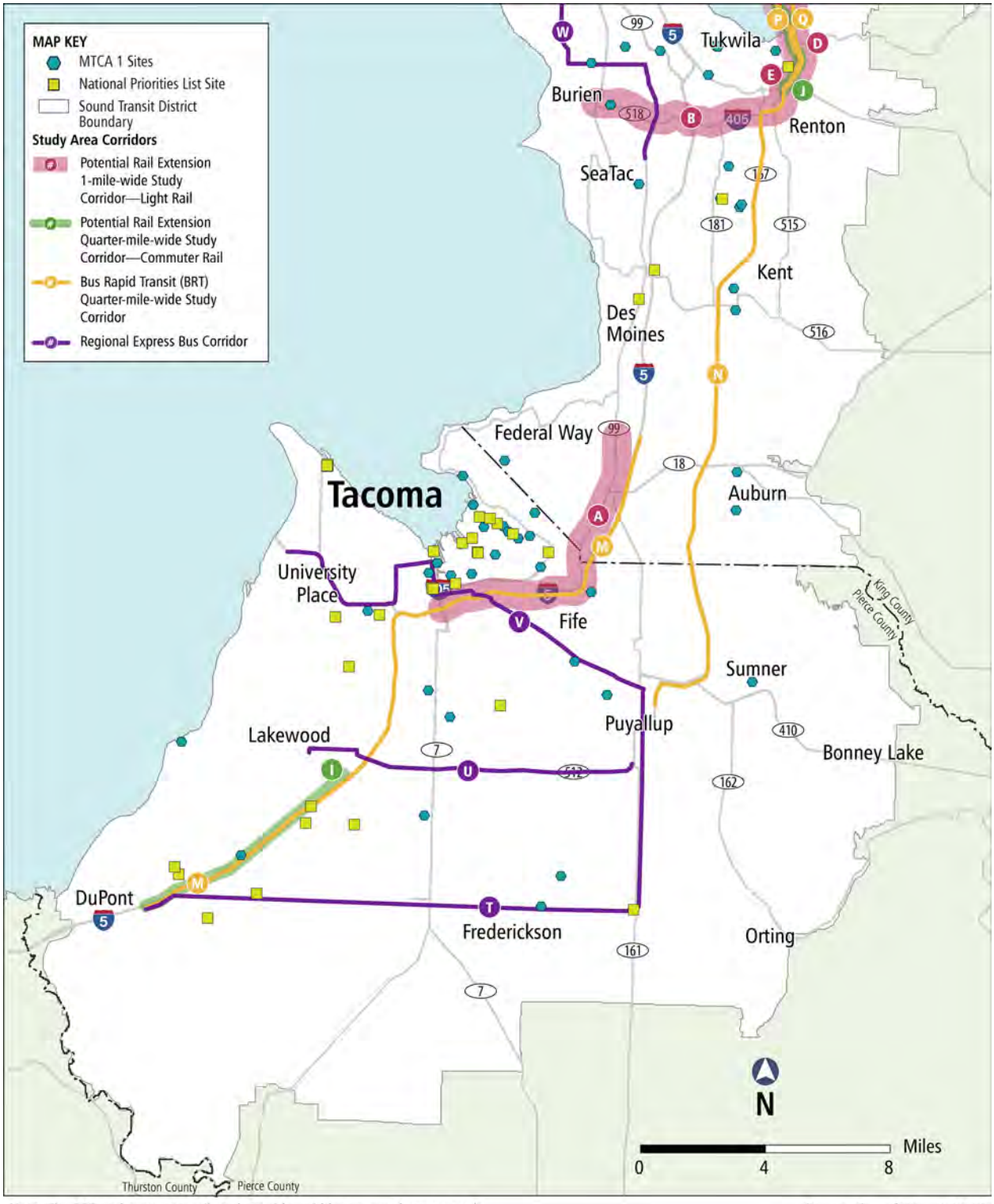


Figure 4-27. High-risk hazardous materials sites for Current Plan Alternative study corridors—north



Note: The BRT and commuter rail study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-28. High-risk hazardous materials sites for Current Plan Alternative study corridors—south

Commuter rail

Impacts of commuter rail are similar to those previously described for light rail but could also include spillage of diesel fuel. Generally, commuter rail would be expanded in existing rail corridors, which have an increased potential for prior contamination. Similar to light rail, all hazardous wastes resulting from commuter rail operations and maintenance facilities would follow applicable regulations for the proper handling and disposal of regulated materials.

One high-risk site was identified within the one-quarter-mile-wide study area for commuter rail between DuPont and Lakewood (corridor I); the Eastside Rail Corridor has none. In general, because commuter rail service would operate within existing rail corridors, there would be a low potential for disturbance of contaminated soils except where new track, infill stations, or other support facilities could be constructed.

Regional express bus/bus rapid transit

Impacts during operation could occur in regional express bus and BRT corridors similar to those described for light rail but could also include spillage of diesel fuel for diesel-powered buses. Similar to light rail, all hazardous wastes resulting from regional express bus and BRT operations, including associated maintenance bases, would follow applicable regulations for the proper handling and disposal of regulated materials.

Four high-risk sites were identified within the one-quarter–mile-wide study corridor for the BRT corridors included in the Current Plan Alternative. The BRT corridor from Federal Way to DuPont (corridor M) has two sites, the largest number of high-risk sites within the BRT study corridors.

High-capacity transit (mode not specified)

Study corridors K and L could be selected as either light rail or BRT corridors. For light rail, study corridor K from UW to Redmond via SR 520 contains three high-risk sites within the 1-mile study area, and study corridor L from Northgate to Bothell includes two high-risk sites near Redmond and Bothell.

If BRT, two high-risk sites were identified within the study area for corridor L, primarily near Redmond and Bothell.

If selected as light rail, Current Plan Alternative HCT corridors K and L would include three medical and research facilities that use sensitive electronics that could be affected by EMF. Study corridor K includes the University of Washington campus, which has several EMF-sensitive research facilities.

Potential Plan Modifications Alternative

Table 4-25 lists all NPL or Federal (Superfund) Cleanup sites and MTCA HSL sites with WARM ranking of 1 located within the Potential Plan Modifications Alternative study corridors. These numbers do not represent an estimate of the number of resources that would be affected if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors. Figure 4-29 and Figure 4-30 show the location of each site in relation to Potential Plan Modifications Alternative study corridors. Numerous low-risk sites, which are not shown in Table 4-25, Figure 4-29, and Figure 4-30, are located along study corridors included in the Potential Plan Modifications Alternative.

Table 4-25. High-risk hazardous materials sites for Potential Plan Modifications Alternative study corridors

ID	Potential Plan Modifications Alternative study corridor location	Approximate length of corridor (miles)	Number of NPL sites[1]	Number of MTCA 1 sites[1]
Potential rail extension, assume light rail: 1-mile-wide study area				
1	Downtown Seattle to Magnolia/Ballard to Shoreline Community College	12	0	8
2[2]	Downtown Seattle to West Seattle/Burien	13	0	2
3	Ballard to Everett Station via Shoreline Community College, Aurora Village, Lynnwood	24	0	0
4	Everett to North Everett	2	0	0
5	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	1	2
6	DuPont to downtown Tacoma via Lakewood, Tacoma Mall	16	7	2
7	Puyallup/Sumner to Renton via SR 167	21	0	3
8	Downtown Seattle along Madison Street	3	0	1
9	Tukwila to SODO via Duwamish industrial area	11	0	2
10	North Kirkland or University of Washington Bothell to Northgate via SR 522	13	0	2
11	Ballard to Bothell via Northgate	13	0	2
12	Mill Creek, connecting to Eastside Rail Corridor	8	0	0
13	Lynnwood to Everett, serving Southwest Everett Industrial Center (Paine Field and Boeing)	7	0	1
14[2]	UW to Sand Point to Kirkland to Redmond	10	0	1
15	Downtown Tacoma to Tacoma Community College	3	0	0
16	Tacoma Mall to University Place	6	1	0
17	Steilacoom to Ruston via University Place	12	4	1
18	Issaquah to Issaquah Highlands	2	0	0
Total high-risk hazardous materials sites within light rail study corridors[3]			12	22
Potential rail extension, assume commuter rail: 1-mile-wide study area new track/quarter-mile-wide study area existing track				
19	Puyallup/Sumner to Orting	8	0	0
20	Lakewood to Parkland	3	0	0
21	Tacoma to Frederickson	10	0	0
Total high-risk hazardous materials sites within commuter rail study corridors[3]			0	0

Table 4-25. High-risk hazardous materials sites for Potential Plan Modifications Alternative study corridors (continued)

ID	Potential Plan Modifications Alternative study corridor location	Approximate length of corridor (miles)	Number of NPL sites[1]	Number of MTCA 1 sites[1]
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail/quarter-mile-wide study area if BRT				
22	Downtown Tacoma to Parkland	8	Light rail: 2 BRT: 0	Light rail: 1 BRT: 1
23	Tukwila Sounder station to downtown Seattle via Sea-Tac Airport, Burien, West Seattle	15	Light rail: 0 BRT: 0	Light rail: 2 BRT: 1
24	Downtown Seattle to Edmonds via Ballard, Shoreline Community College	19	Light rail: 0 BRT: 0	Light rail: 8 BRT: 2
25	West Seattle to Ballard via Central District, Queen Anne	14	Light rail: 0 BRT: 0	Light rail: 7 BRT: 1
26	Edmonds to Lynnwood Link	5	Light rail: 0 BRT: 0	Light rail: 1 BRT: 0
Total high-risk hazardous materials sites within high-capacity study corridors[3]			Light rail: 2 BRT: 0	Light rail: 9 BRT: 3
Bus rapid transit (BRT): quarter-mile-wide study area				
27	Puyallup vicinity, notably along Meridian Avenue	6	0	0
28	Issaquah to Issaquah Highlands	2	0	0
29	Kent to Sea-Tac Airport	11	0	0
30[4]	Downtown Seattle along Madison Street	—	—	—
Regional express bus/BRT (mode not specified): quarter-mile-wide study area				
31	Issaquah Highlands to Overlake via Sammamish, Redmond	14	0	0
32	Tacoma to Bellevue	34	0	0
33	Puyallup to downtown Seattle via Kent, Rainier Valley	35	0	2
34	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	1	2
35	Tacoma to Frederickson	13	0	1
Regional express bus				
36-47	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS	—	—	—
Total high-risk hazardous materials sites within bus study corridors[3]			1	4

Sources: U.S. Environmental Protection Agency 2014; Ecology 2014

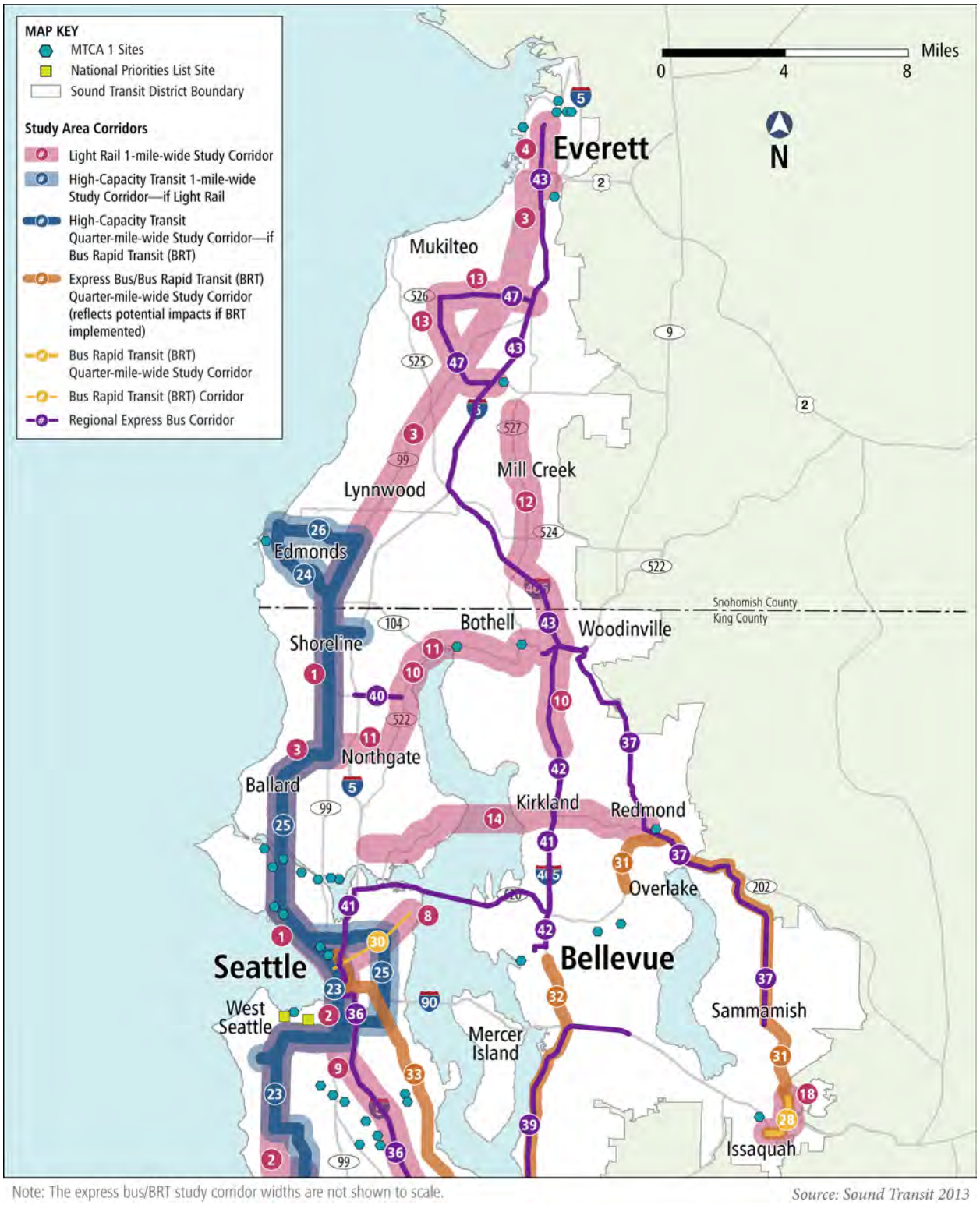
NPL = National Priorities List; MTCA 1 = Model Toxics Control Act Hazardous Sites List sites with a WARM ranking of 1

[1] These numbers do not represent an estimate of the number of resource areas that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

[3] Numbers include resource areas where only a portion of the resource is within the study corridor. Some resource areas may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.

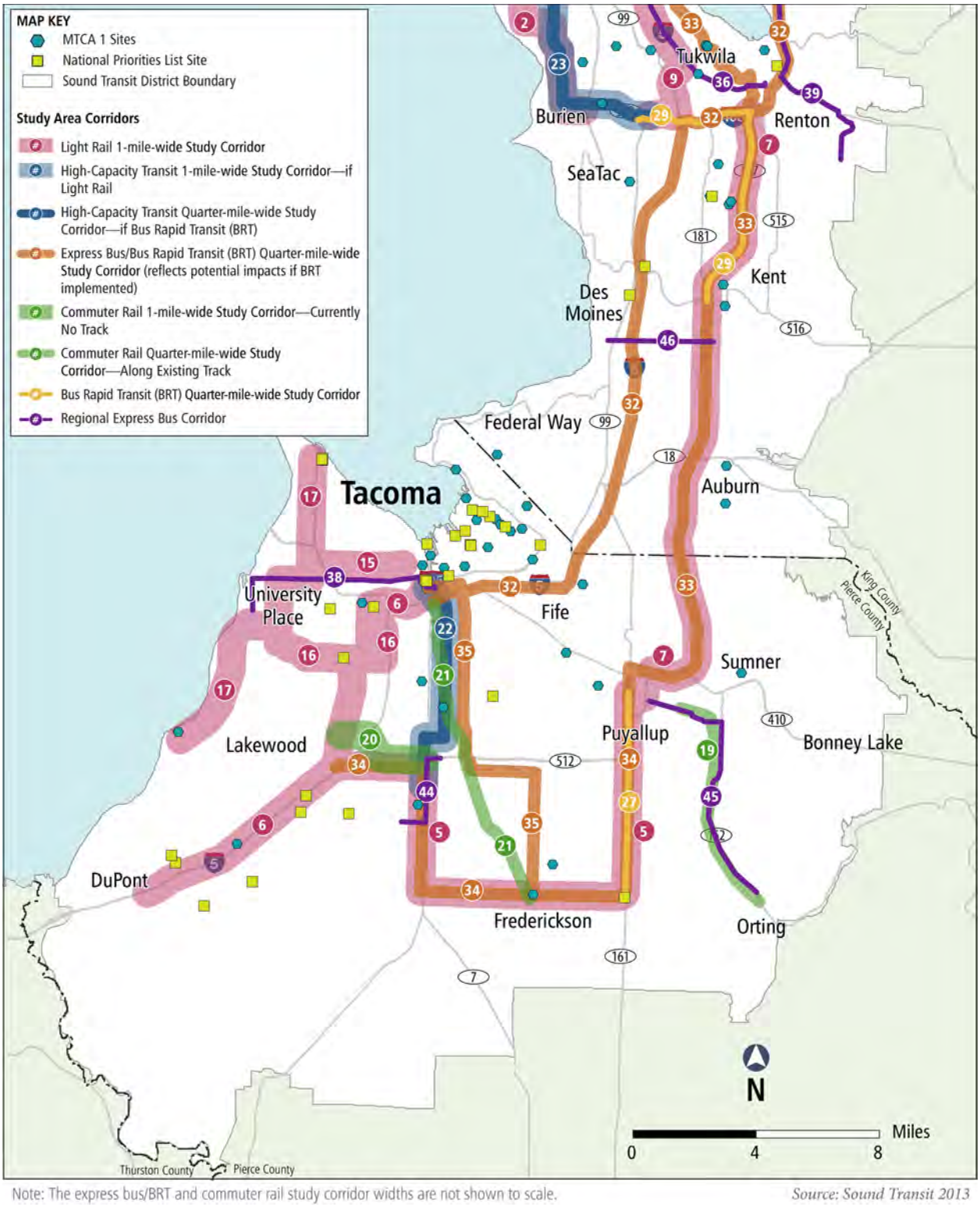
[4] Corridor 30 is BRT but would use existing roadway facilities in this location so was not analyzed using GIS.



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-29. High-risk hazardous materials sites for Potential Plan Modifications Alternative study corridors—north



Note: The express bus/BRT and commuter rail study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-30. High-risk hazardous materials sites for Potential Plan Modifications Alternative study corridors—south

The Potential Plan Modifications Alternative would have similar impacts as those described for the Current Plan Alternative. However, because of the additional corridors in the Potential Plan Modifications Alternative, the impacts and benefits could be greater than those in the Current Plan Alternative. More detailed information regarding potential long-term impacts of the Potential Plan Modifications Alternative is provided below.

Light rail

Similar to the Current Plan Alternative, development of light rail corridors would typically require property acquisition for rights-of-way and light rail facilities, including stations and park-and-ride facilities. Operation and maintenance facilities could release contaminants into the environment during operation. However, all hazardous wastes generated from light rail operations would follow applicable regulations for the proper handling and disposal of regulated materials.

As shown in Table 4-25, study areas for corridors 1, 6 and 17 have the largest number of total high-risk sites within the 1-mile-wide light rail study area. Corridor 17 could intersect the former Asarco Smelter, an area that may have been contaminated with heavy metals. Corridors 2 and 14, each of which has one identified high-risk site, could include potential tunnel sections.

Approximately 20 medical and research facilities located in the study corridors of the Potential Plan Modifications Alternative use sensitive electronics that could be affected by EMF. The greatest numbers of facilities are in corridors 2 and 8. EMF impacts at medical and research facilities would be limited to those areas located in close proximity to electrical components of the facility, which could include wayside power lines, sub-stations, and overhead catenary.

Commuter rail

No commuter rail corridors in the Potential Plan Modifications Alternative included any high-risk sites within their study areas.

Regional express bus/bus rapid transit

Impacts during operation could occur in regional express bus and BRT corridors similar to those described for light rail but could also include spillage of diesel fuel for diesel-powered buses. Similar to light rail, all hazardous wastes resulting from regional express bus and BRT operations, including associated maintenance bases, would follow applicable regulations for the proper handling and disposal of regulated materials.

The BRT corridor from Lakewood to Puyallup via Spanaway, Fredrickson, and South Hill (corridor 34) has three high-risk sites within the one-quarter-mile-wide study corridor, the largest number of high-risk sites within the BRT study corridors for the Potential Plan Modifications Alternative.

Streetcar

Streetcar facilities would generally have impacts similar to those described for light rail. However, impacts could occur to a lesser extent because of the smaller scale of disturbance required for streetcar facilities. Streetcar facilities generally have a smaller footprint than light rail facilities. In addition, the depth of disturbance required is generally shallower than that for light rail, thereby lessening the likelihood of encountering high-

risk sites; however, the potential exists for impacts similar to those described for light rail.

High-capacity transit (mode not specified)

Corridors 22 through 26 could be selected as either light rail or BRT corridors. For light rail, study areas for corridors 24 and 25 contain the majority of high-risk sites because of their proximity to areas with historical industrial use in the vicinity of Interbay and the ship canal. The study areas for these same corridors, if implemented as BRT, could have less risk associated with hazardous materials sites.

If selected as light rail, Potential Plan Modifications Alternative HCT corridors 22 through 26 would include approximately 10 medical and research facilities that use sensitive electronics that could be affected by EMF.

4.7.4 Construction impacts

Current Plan Alternative

Construction impacts in areas of hazardous materials contamination could have an adverse effect on environmental health, particularly in areas in close proximity to construction sites. Activities such as grading, excavation, and trenching could result in exposure to hazardous materials and the release of contaminants to soil, groundwater, and surface waters. These activities could include work in a variety of areas that have obvious signs of contamination (such as large industrial areas or existing railroad lines) and in areas with no visible signs of contamination (such as vacant land) where encountering unknown contamination is possible.

The study corridors include many areas where roadways or rail lines are present, including existing transit corridors where additional stations, park and ride lots, or support facilities would be built. Contamination is common on, and adjacent to, existing transportation facilities because of a long history of hazardous materials use, transport, and storage. Depending on the nature of the contaminants in the soil and subsurface, contaminated media could migrate to nearby properties and water sources, farther extending the range of construction impacts. If contaminated areas are encountered during construction, protocols would be followed for proper handling and disposal of all regulated materials.

Construction could negatively impact human health through exposure to the release of contaminants during construction, particularly near construction activities. Persons living near construction activities could be exposed through skin contact, ingestion, or inhalation of soil particles, dust, or vapors. With appropriate working conditions in place, these human health risks would be low.

Construction of light rail facilities could result in impacts similar to those previously described. Impacts could vary for at-grade, elevated, and belowground construction. Facilities requiring tunneling or elevated structures with deep foundations could have higher construction impacts compared to at-grade facilities because construction activity could encounter more subsurface materials in developed study corridors. Cut-and-cover tunnel construction would disturb large quantities of near-surface soils compared to bored tunnel construction, which only includes surface disturbance at the portals, stations, and vent structures. Because most soil contamination is near the surface, cut-and-cover construction

would have a higher risk of encountering contaminated soils than bored tunnel construction. Supporting facilities could require property acquisition outside of available rights-of-way. Due diligence would be taken to confirm environmental conditions prior to any property acquisition or easement.

Impacts could occur with commuter rail projects because existing rail yards and tracks generally have a history of hazardous materials use, transport, and spills; however, because commuter rail would largely use existing tracks with fewer new tracks, stations, and support facilities, the magnitude of construction disturbance would be less than for light rail. Impacts would be similar to those described previously. Corridor 20 does not include prior rail use or identified high-risk sites; therefore, the potential to encounter contamination would be less in that corridor.

Regional express bus operating on existing facilities would have fewer construction-related impacts. Impacts from construction of BRT requiring new facilities, including lanes, ramps, park-and-ride lots, or maintenance facilities, would be similar to those described previously. In cases where BRT routes would not require additional rights-of-way, there would be no construction-related impacts.

No impacts from EMF on nearby sensitive facilities are expected during construction.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar construction risks and impacts as those described for the Current Plan Alternative. However, because of the additional corridors in the Potential Plan Modifications Alternative, impacts could be greater than those of the Current Plan Alternative. As a result, overall construction-related risks and temporary impacts would be slightly greater for the Potential Plan Modifications Alternative. Construction impacts by mode are similar to those described for the Current Plan Alternative.

The Potential Plan Modifications Alternative also includes streetcar as a transit mode. Higher concentrations of contaminated sites are present in urbanized areas where streetcars would be located. Most streetcar construction would occur at shallower depths than projects requiring tunneling or aerial structures. Construction impacts would be similar to those described previously.

4.7.5 Potential mitigation measures

The Current Plan Alternative and the Potential Plan Modifications Alternative would adhere to all applicable regulations regarding hazardous materials handling and spill response during construction and long-term operation. Overall, the alternatives could have an overall beneficial impact on environmental health because of regional air quality improvement and the likelihood of increased physical activity among transit patrons. There are also mitigation measures related to air quality (Section 4.2.5), noise (Section 4.3.5), and traffic safety within the transportation discussion (Chapter 3). No impacts related to EMF from light rail on nearby sensitive facilities are expected; however, modified traction-power delivery designs are expected to be able to mitigate any impacts that could occur. Standard design measures would protect utilities and structures from stray current.

The following measures would be taken to avoid long-term adverse impacts to environmental health:

- Identify contaminated sites during project level planning, environmental review, and design
- Avoid large areas of contamination that pose the greatest risk to human health and the environment as practical
- Perform environmental due diligence for all property acquisitions

The following measures would be taken to avoid adverse impacts to environmental health during construction:

- Implement all applicable BMPs
- Prepare project-specific hazardous materials management plans for contaminated sites during project planning

4.7.6 Significant unavoidable adverse impacts

Significant adverse impacts can be mitigated or avoided for most plan elements under the Current Plan Alternative and the Potential Plan Modifications Alternative. However, some impacts could occur in some study corridors.

4.8 Visual quality and aesthetics

This section describes the visual and aesthetic character of the Plan area and potential impacts and mitigation for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, potential impacts for these alternatives are qualitatively described based on broadly defined corridor locations.

4.8.1 Regulatory environment

Within the Plan area, counties and cities have adopted plans, policies, and regulations that govern the design and aesthetic characteristics of their communities as well as support the preservation of views from and within those communities.

The comprehensive plans of some local jurisdictions contain policies that protect views of specific natural and built features; discourage light, glare, and light blockage; and list parks, shorelines, schoolyards, street ends, and other specific locations that receive special visual protection. Other local jurisdictions address the visual character of their communities in more general terms within planning documents. In addition to those policies specified in comprehensive plans, many communities also adopt design guidelines to specify certain architectural standards in specific districts. Whether general or specific, comprehensive plan policies and provisions ultimately translate into land use regulations that control the type, height, and bulk of individual projects throughout the Plan area.

4.8.2 Affected environment

The natural beauty of the central Puget Sound region and a visually diverse built environment make up the unique visual character of the Plan area. Several elements are considered in defining the visual quality and aesthetic character of the Plan area, including:

- **Landforms**—Types, gradients, scale
- **Vegetation**—Types, size and maturity, continuity
- **Land uses**—Size, scale (apparent size in relation to actual size), character of associated buildings and ancillary site uses
- **Transportation facilities**—Types, sizes, scale, directional orientation
- **Overhead structures, utilities, and lighting**—Types, sizes, scale
- **Open space**—Types (including parks, reserves, greenbelts, undeveloped land), extent, continuity
- **Viewpoints and views to visual resources**—Natural resources, farm landscapes, historic structures, dramatic downtown skylines
- **Streetscapes and urban design**—Pavement types (roadway, bike lanes, crosswalks, sidewalks), median design, street trees, street furniture, light fixtures

Natural features

Visible to the east are the Cascade Mountains with Mt. Baker to the northeast and Mt. Rainier to the southeast while the Olympic Mountains are visible to the west (Figure 4-31). Important water views include Puget Sound, Commencement Bay, Elliott Bay, Possession Sound, and Lake Washington, as well as other lakes and streams. These mountain and water views are picturesque and valuable and visible from many points in the Plan area, including urban and suburban settings.

Other natural features, such as river valleys, bodies of water, underdeveloped wooded areas, floodplains, and wetlands, provide portions of this area with a natural appearance. These natural views also provide visual interest when paired with rural development and waterfront land uses and water or marine activities, such as boating, fishing, ferries, cruise ships, and shipping.

Bodies of water

- Puget Sound
- Lake Union
- Lake Stevens
- Lake Washington
- Lake Sammamish
- Ship Canal
- Puyallup River
- Duwamish River
- Green River
- White River
- Cedar River
- Sammamish River
- Snohomish River

Urban environment

Urban portions of the Plan area are diverse in scale, magnitude, height, and overall character. Generally, the visual character of the Plan area's urban environment is described by:

- **Iconic structures—**The Space Needle, sports stadiums, large event venues, and bridges. Skyline views are created by high-rise buildings in downtown Everett, Seattle, Bellevue, and Tacoma.
- **Public plazas, civic facilities, and public areas—**Small-scale parks in business cores with large linear parks located along shorelines and near urban neighborhoods or on the outskirts of urban areas.

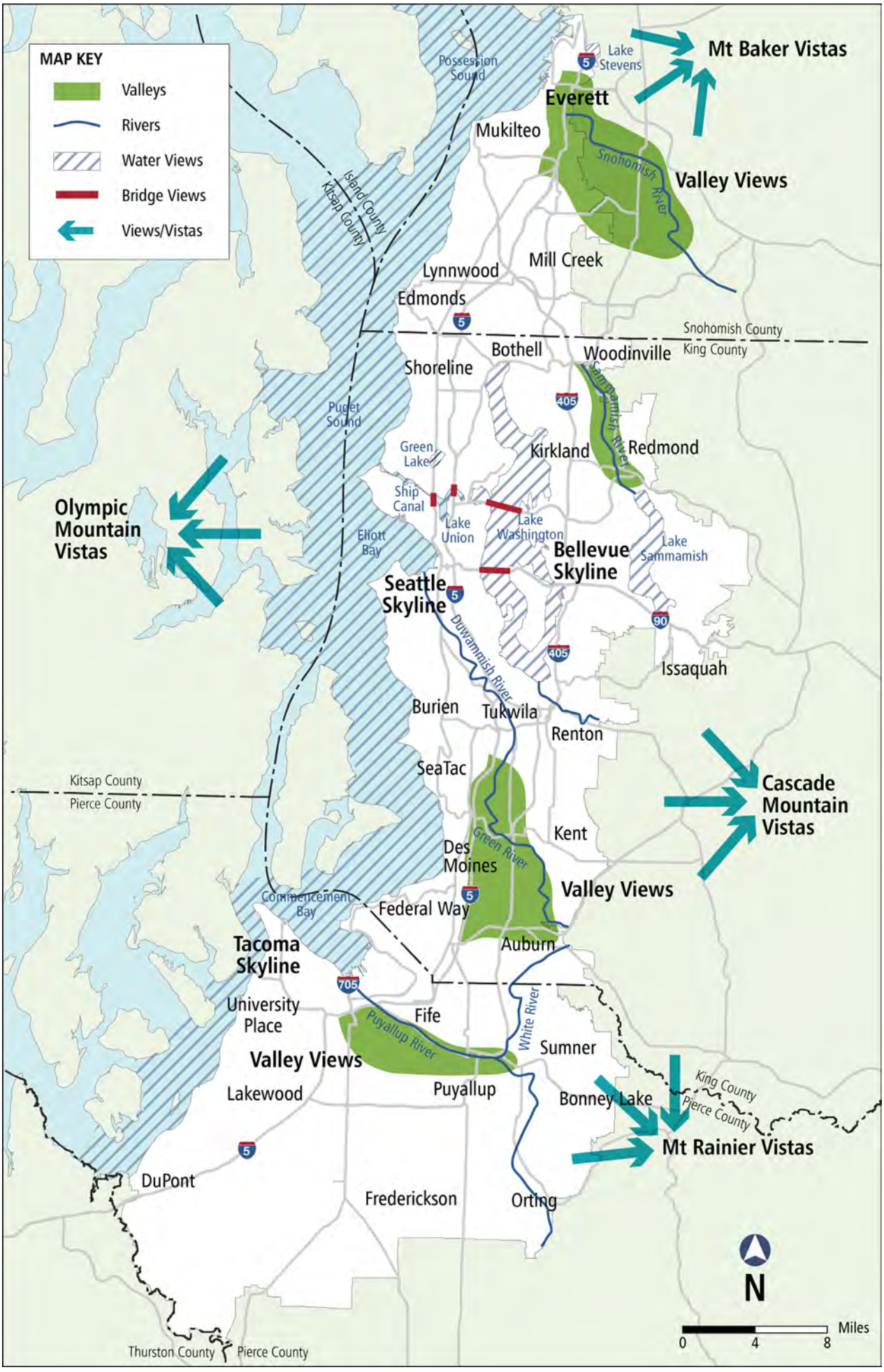


Figure 4-31. Visual resources in and around the Plan area

- **Industrial land uses—**Shipping, manufacturing, and warehouses prevalent along parts of the waterfront in Everett, Seattle, and Tacoma. Associated structures include low-rise industrial buildings and mid-rise commercial buildings as well as large expanses of pavement.
- **Numerous urban neighborhoods—**Single-family residences generally developed in the 19th and early- to mid-20th centuries with the highest intensity development generally along the I-5 corridor through Snohomish, King, and Pierce Counties. The intensity of development tends to decrease on leaving central Puget Sound.
- **Transportation-related infrastructure—**Roadways, on-ramps, retaining walls, overhead lines, stations, operation and maintenance facilities, rail lines, park-and-ride facilities, parking garages, and signage.

Urban environment

The urban environment is characterized by higher density development in comparison to the areas surrounding it.

Suburban environment

The suburban environment is characterized by smaller to mid-range cities located throughout the Plan area, such as Edmonds, Kirkland, Des Moines, Kent, and Auburn.

Suburban environment

Generally, the visual and aesthetic character of the Plan area's suburban environment is described by the following:

- **Town centers—**Relatively small street grids, small- to moderate-scale buildings, including mixed-use and multi-family land uses, and a pedestrian-friendly environment.
- **Retail and commercial development—**Emphasis on automobile-oriented retail commercial development. Commercial structures include medium- to large-scale retail malls, small- to medium-scale commercial and retail strip development, and office parks. Typically, structures tend to be no more than three or four stories.
- **Single-family neighborhoods—**Single-family residences located on or near ridge tops and desirable natural features. Multifamily developments tend to be located closer to arterials, highways, and commercial centers.
- **Numerous landscaped public parks and open spaces—**Residential landscapes, broad and mostly open landscapes typical of business parks, nature reserves, and street trees.
- **Transportation infrastructure—**Extensive system of arterial roads and highways, park-and-ride facilities, transit centers and stations, bus stops, and commuter and light rail lines and stations.

Agricultural environment

Agricultural areas, such as the Green, Puyallup, and Snohomish River valleys, include farming and grazing activities as well as low-intensity commercial uses. The agricultural environment is generally open areas with a very low density of development, rural architecture, and occasional historic structures.

Viewer groups

Visual experience depends of the perspective of the viewers as well as the quality of the landscape. Viewer groups performing different activities have different sensitivities and visual awareness. Regular viewers of a landscape are more sensitive than infrequent viewers.

Viewer groups for a transit system include passengers; residential neighbors; recreational users of parks, beaches, and paths; adjacent commercial users; and drivers and users of other transportation facilities.

4.8.3 Long-term impacts

Under both the Current Plan Alternative and the Potential Plan Modifications Alternative there is the potential for long-term impacts to the existing visual quality of the Plan area. Both alternatives could add features (such as walls, stations, at-grade or elevated guideways, infill stations, operation and maintenance facilities, park-and-ride facilities, and other structures) or alter or remove some of the visible features that compose the current visual setting of the Plan area. The magnitude of these impacts would vary depending on the nature of existing land uses, the proximity of proposed transit improvements to sensitive views and viewer groups, and the incorporation of potential measures to avoid or mitigate potential negative effects that would impact visual resources, design, or aesthetics. In general, new transportation facilities constructed in existing transportation corridors are less likely to negatively affect visual resources than those built in new corridors.

The visual sensitivity of land uses in the Plan area varies greatly, for example:

Neighborhoods with single-family homes, parks, cemeteries, and schools and hospitals with open space campuses would be more sensitive to bulk, height, increases of scale, and visual change than mixed-use areas with larger multi-story residential buildings and commercial or industrial uses.

The following visual quality impacts could result regardless of alternative or mode. However, the degree to which they affect the visual environment would vary depending on the intensity of the change and the sensitivity to those changes.

- **Guideways, transit centers, and stations—**These structures, along with associated platforms, canopies, lighting, and related facilities, could affect the views and visual character of some areas depending on their placement. Visual impacts would be higher if structures were placed in residential neighborhoods, natural areas, and open spaces while they would be lower if located along freeways and arterials, at existing park-and-ride facilities, and in activity centers. Lighting in these facilities could also contribute to higher levels of light and glare.
- **Park-and-ride facilities—**Park-and-ride facilities consist of large amounts of pavement either at grade or in a parking structure, which could contrast with the existing views and visual character of adjacent land uses. Lighting in these parking facilities could also result in higher levels of light and glare.
- **Additional rights-of-way—**New or widened rail corridors, roads, or other public rights-of-way could increase the visual presence of the transportation facility and reduce visual buffers between transportation infrastructure and adjacent land uses. Depending on the location, the introduction of transportation facilities could remove or alter existing features (including landscape features and structures) and views, which could result in a substantial impact.
- **Supporting facilities—**These could include, but are not limited to, added structures, vent shafts, power substations, tunnel portals, and operations and maintenance facilities. The addition of these elements could obstruct or clutter views, and (depending on the location and existing land uses) result in substantial changes to the existing visual

character. Additional property could be required for supporting facilities, resulting in the addition or removal of structures and existing vegetation.

Current Plan Alternative

Potential mode-specific long-term impacts of the Current Plan Alternative on the visual quality of the Plan area are presented below.

Light rail

Light rail could introduce several new visual elements that could impact the visual quality in portions of the Plan area. Light rail would require additional transportation infrastructure, such as stations, park-and-ride facilities, and supporting facilities (vent shafts, power stations, and operation and maintenance facilities). All these elements would have similar visual effects as those previously described for all modes.

Other elements of light rail include overhead power lines or catenary and the potential for either at-grade, elevated, or below-grade alignments, and structures. Elevated guideways, structures, and portals would be more visually prominent compared to at-grade or below-grade sections as they could alter near or long-range views and also have greater effects on light and shadow characteristics of nearby land uses.

Overhead catenary

A catenary is a system of overhead wires used to supply electricity to a train, streetcar, or light rail vehicle.

Generally, the impacts of light rail on visual quality in the Plan area could be considered low in locations where the light rail corridors would be close to major transportation facilities that already feature a high level of transportation activity, such as I-5, SR 99, SR 520, I-90, and I-405. The degree of visual quality impacts could be higher where light rail parallels arterials, particularly where residential uses occur and especially in the case of elevated guideways and structures, which are visible from greater distances and may cast shadows in addition to their visual presence. Built elements of light rail support facilities, such as maintenance facilities, could have similar impacts.

All of the light rail corridors for the Current Plan Alternative may include sensitive view areas. However, the impacts are generally expected to be low depending on the vertical profile of a corridor and the surrounding land uses; impacts to viewers of the system would be particularly low if any portion of a corridor were to be constructed in a tunnel, as the only aboveground features for a tunneled corridor would be at-grade station entrances, vent structures, and portals. Tunnels generally have minimal visual interest for passengers but can provide opportunities for art or visual variety if they make up a short section within a longer corridor. Study corridors C, F, and G include potential tunnels in parts of the corridors.

The light rail extension from Tacoma to Federal Way (study corridor A), which extends beyond the corridors currently in development by Sound Transit, is primarily in a developed transportation corridor with limited visual sensitivity. Light rail along the Eastside Rail Corridor (study corridor E) could result in an increased visual presence of a transportation facility. The Eastside Rail Corridor includes sensitive view areas with mountain, Lake Washington, and valley views. Service along the Eastside Rail Corridor would provide passengers with scenic views, although this corridor is in close proximity to I-405. Light rail could also enhance certain aspects of the quality of the visual setting

in portions of the Plan area, particularly regarding streetscapes and urban design. Streets supporting new light rail stations and trackways could have improved sidewalks, landscaping, lighting, and public art.

Commuter rail

Commuter rail would generally operate along established rail corridors and would not represent a substantial change in the visual environment, with the exception of additional support facilities or infill stations. Under the Current Plan Alternative, commuter rail service could include service extensions, additional or modified rail stations, and improved station facilities. This could require additional track and associated rights-of-way and the addition of structures, including supporting facilities, and would have similar visual effects as those described for supporting facilities for all modes.

The commuter rail extension from DuPont to Lakewood (study corridor I) would be in an existing operating rail corridor, much of it parallel to I-5; therefore, introducing the commuter rail service would generally have limited visual impact. The Renton-to-Woodinville rail extension (study corridor J), along the Eastside Rail Corridor, could result in an increased visual presence of the transportation facility. The Eastside Rail Corridor includes sensitive view areas with mountain, Lake Washington, and valley views. Service along the Eastside Rail Corridor would provide passengers with scenic views, although this corridor is in close proximity to I-405.

Regional express bus/bus rapid transit

Regional express bus/BRT systems operate in a variety of rights-of-way, including dedicated busways, on HOV lanes, and BRT running on arterials partly or fully outside general traffic lanes. Additional regional express bus routes using existing facilities where buses currently operate would have little potential to generate additional impacts, and BRT has the flexibility to mix these approaches within a given corridor. Since these systems generally operate on existing transportation infrastructure, the potential for visual quality impacts resulting from their continued or increased use is considered low.

New capital projects in the Current Plan Alternative, including HOV direct access ramps, transit stations, park-and-ride facilities, and rider amenities, would have similar visual effects as those described for all modes under the Current Plan Alternative.

The BRT corridors from Bellevue to Issaquah (study corridor O) and Seattle to Everett along SR 99 (study corridor R) would have water views. The BRT corridor from Renton to Woodinville along the Eastside Rail Corridor (study corridor P) could result in an increased visual presence of the transportation facility. The Eastside Rail Corridor includes sensitive view areas with mountain, Lake Washington, and valley views. Bus service along the Eastside Rail Corridor would provide passengers with scenic views, although this corridor is in close proximity to I-405; the BRT corridor from Renton to Lynnwood along I-405 (study corridor Q) would share many of the visual aspects as study corridor P.

High-capacity transit (mode not specified)

Study corridors K and L, both HCT corridors, could be selected as either light rail or BRT corridors. Both corridor K from the UW to Redmond via SR 520 crossing Lake Washington and corridor L from Northgate to Bothell along Lake Washington have sensitive view areas. If selected as light rail, the impacts generally would be similar to those described for the other light rail corridors. Study corridor K could include a potential short tunnel west of Lake Washington where the system would not be visible to viewers along that portion of the corridor. The visual experience for passengers would be similar to that described for tunnels in the other light rail corridors.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar impacts as those described for the Current Plan Alternative. However, because of the additional corridors in the Potential Plan Modifications Alternative, the visual impacts could be greater than those in the Current Plan Alternative.

Light rail

New light rail corridors proposed as part of the Potential Plan Modifications Alternative could require additional rights-of-way and structures. This could create greater visual impacts. All of the light rail corridors for the Potential Plan Modifications Alternative could include sensitive view areas. For example, study corridor 2 between downtown Seattle, West Seattle, and Burien and study corridor 8 from downtown Seattle east via Madison include views of Lake Washington or Puget Sound. Other corridors include views of the Kent Valley (such as study corridor 7 from Puyallup/Sumner to Renton via SR 167), city skylines (such as study corridor 1 from downtown Seattle to Magnolia/ Ballard and Shoreline Community College and corridor 15 from downtown Tacoma to Tacoma Community College), or more distant views of Mt. Rainier or the Cascades. All of these are in proximity to existing transportation corridors. Study corridor 12, Mill Creek connecting to the Eastside Rail Corridor, would be a new facility and, therefore, could have a greater visual change. Study corridor 14 crosses unbroken water views of Lake Washington. A bridge crossing would introduce a substantial new visual element in the corridor; the impact would be reduced if the crossing is in a tunnel. Study corridor 2 also includes potential tunnels in part of the corridor.

Similar to the Current Plan Alternative, the Potential Plan Modifications Alternative could enhance certain aspects of the quality of the visual setting in portions of the Plan area, particularly regarding streetscapes and urban design. Streets supporting new light rail stations and trackways could have improved sidewalks, landscaping, lighting, and public art. The increase in corridors offers a greater opportunity for these improvements.

Commuter rail

Commuter rail would include adding express tracks, new stations, and access improvements. However, similar to the Current Plan Alternative, the addition of commuter rail generally would not represent a substantial change in the visual environment, except for study corridor 20 where there are no existing tracks or rail service. Commuter rail support facilities, such as stations, park-and-ride facilities, and maintenance facilities,

would add new visual elements that could have similar impacts as light rail support facilities. The addition of commuter rail from Puyallup to Orting (study corridor 19), Lakewood to Parkland (study corridor 20), and Tacoma to Fredrickson (study corridor 21) would occur in areas where distant mountain views are sometimes visible.

Regional express bus/bus rapid transit

New regional express bus/BRT routes are included as part of the Potential Plan Modifications Alternative and would generally not result in any additional visual impacts beyond those described above for the Current Plan Alternative. Additional regional express bus routes using existing facilities where buses currently operate would have little potential to generate additional impacts. Some routes would operate in areas with water, valley, or mountain views, offering passengers scenic views. Service to Titlow Beach (study corridor 38) would provide water views. Several corridors in the Kent Valley would provide valley views (study corridors 32, 29, 33, and 46). Intermittent mountain views would be available from many corridors in the Plan area, but Mt. Rainier views would be prominent from corridors 27, 34, and 45 in the southeast portion of the Plan area.

Streetcar

Potential streetcar lines as part of the Potential Plan Modifications Alternative would require additional transportation infrastructure, such as stations and platforms, an overhead catenary system, and new or expanded maintenance facilities. With the exception of the Eastside Rail Corridor, the relatively small scale of these systems combined with the urban visual environment they are located within would result in minimal visual impacts. However, the degree of visual quality impacts could be higher if catenary is added where there are currently few or no existing overhead wires, particularly in open or natural landscapes or where residential uses occur.

High-capacity transit (mode not specified)

Study corridors 22 through 26, all HCT corridors, could be selected as either light rail or BRT corridors. The HCT corridors from downtown Seattle to Edmonds via Ballard and Shoreline Community College (study corridor 24) and Edmonds to Lynnwood Link (corridor 26) could include views of Puget Sound. The HCT corridors between the Tukwila Sounder Station to downtown Seattle (study corridor 23) and between West Seattle and Ballard (study corridor 25) would include views of Elliott Bay. If selected as light rail, the impacts generally would be similar to those described for the other light rail corridors. Similarly, if selected for BRT, visual impacts would be similar to those described for other BRT routes with similar characteristics.

4.8.4 Construction impacts

Both the Current Plan Alternative and the Potential Plan Modifications Alternative could result in temporary construction impacts to the existing visual quality and aesthetics of the Plan area.

Current Plan Alternative

Construction impacts would vary by the types of construction needed for different projects; however, the visual impacts would be similar in nature. Because bus and commuter rail modes would largely use existing roadways or tracks, their construction would be less

extensive, resulting in less temporary visual impact than light rail or some BRT facilities that require construction of an exclusive guideway. Overall, construction of structures, including elevated guideways, bridges, and parking garages, would have the greatest construction impacts on visual quality. Construction of bored tunnels would require staging areas initially, but would be primarily underground, and any potential for impacts on visual quality would be very low. Construction of cut-and-cover tunnels would include large areas of disturbance along the length of the tunnel and would be more visually intrusive. Although construction impacts could last for several years, they are generally considered temporary. Impacts to visual quality for all modes could include the following:

- Site clearing and demolition could remove mature trees, ground cover, and existing structures and affect either a linear corridor or a specific site. This could contribute to reduced visual quality of the immediate area during construction.
- Reduced unity of the visual environment and increased visual clutter could result from construction activities, staging areas, detours or temporary roadways, lighting, signage, heavy equipment, trailers, fences, temporary noise shielding, and material storage.
- Light and glare impacts on adjacent areas could occur when nighttime construction occurs.

Potential Plan Modifications Alternative

Impacts of the Potential Plan Modifications Alternative to visual quality during construction would be similar to those described for the Current Plan Alternative. However, the Potential Plan Modifications Alternative could involve additional construction activity in the region because of the additional corridors under consideration. As a result, overall temporary impacts to visual quality could be slightly greater for the Potential Plan Modifications Alternative.

4.8.5 Potential mitigation measures

Elements of the Current Plan Alternative and the Potential Plan Modifications Alternative would be designed to avoid or minimize potential adverse effects as practical. Where avoidance is not practical, mitigation measures to reduce or minimize adverse long-term impacts on visual quality could include the following:

- Avoid or reduce the need to acquire and clear new rights-of-way, either through route modification or selection
- Incorporate aesthetic considerations in the design of various project elements using interdisciplinary design teams
- Integrate facilities(particularly stations) with existing plans, including area redevelopment plans
- Design stations and transit centers to be compatible with their surroundings
- Minimize the bulk, elevation, or height of elevated guideways and structures to limit their visibility and reduce shadows
- Minimize impacts to viewpoints, parks, view corridors, and scenic routes

- Preserve existing vegetation, when practicable, and minimize clearing of mature trees
- Plant appropriate vegetation in and adjoining the rights-of-way to replace existing street trees and greenbelts and to provide screening for sensitive visual resources and viewers
- Use source shielding in exterior lighting at stations and ancillary facilities (such as maintenance bases and park-and-ride facilities) to ensure that light sources (such as bulbs) are not directly visible from residential areas, streets, and highways and to limit spillover light and glare in possible residential areas

Mitigation measures to reduce or minimize adverse temporary construction impacts on visual quality include the following:

- Minimize clearing for construction and construction-related activities
- Reduce temporary construction light and glare impacts by shielding and aiming light sources downward to avoid light spillover
- Screen views of construction equipment and materials from sensitive viewers as practical
- Restore landscaping disturbed by construction-related activities after completion of work

4.8.6 Significant unavoidable adverse impacts

Significant adverse impacts to visual quality can be mitigated or avoided for most plan elements under the Current Plan Alternative and the Potential Plan Modifications Alternative. However, unavoidable impacts could include obstructing or altering scenic views or being out of scale with the surroundings in some areas.

4.9 Land use

This section describes existing and planned land use in the Plan area and potential impacts and mitigation for the Current Plan Alternative and the Potential Plan Modifications Alternative. Additional information on existing and planned land uses in each jurisdiction is summarized in Appendix F. For this plan-level Final SEIS, potential impacts for the alternatives are qualitatively described based on broadly defined corridor locations. Project-specific impacts and potential measures to avoid and minimize impacts would be determined during future project-level planning and environmental reviews.

The Current Plan Alternative and the Potential Plan Modifications Alternative both assume the same amount of regional growth in population and employment from 2010 to 2040—approximately 1 million additional people, approximately 1 million additional jobs, and approximately one-half million new households.

4.9.1 Regulatory environment

The Plan area was created by the Snohomish, King, and Pierce County Councils under authority provided by the State Legislature in the 1990 High-Capacity Transportation Act (Chapter 81.104 RCW).

Specifically in its Regional Transportation Planning Section (RCW 81.104.080), the HCT Act states:

> Where applicable, regional transportation plans and local comprehensive plans shall address the relationship between urban growth and an effective high capacity transportation system plan, and provide for cooperation between local jurisdictions and transit agencies. …
>
> (2) Interlocal agreements between transit authorities, cities, and counties shall set forth conditions for assuring land uses compatible with development of high capacity transportation systems. These include developing sufficient land use densities through local actions in high capacity transportation corridors and near passenger stations, preserving transit rights-of-way, and protecting the region's environmental quality. The implementation program for high capacity transportation systems shall favor cities and counties with supportive land use plans. …
>
> (3) Interlocal agreements shall be consistent with state planning goals as set forth in Chapter 36.70A RCW. Agreements shall also include plans for concentrated employment centers, mixed-use development, and housing densities that support high capacity transportation systems.

1990 High-Capacity Transportation Act

The HCT Act strongly links HCT planning and implementation to the Growth Management Act (Chapter 36.70A RCW).

The Washington State Grown Management Act (GMA) (Chapter 36.70A RCW) provides a comprehensive framework for managing growth and identifying needed transportation and infrastructure improvements to support and serve changes in land use. Under the GMA, counties are required to designate Urban Growth Areas (UGA), and all cities must be located within an UGA. UGAs include cities and surrounding lands plus urban villages in unincorporated areas. Land use plans within the UGAs must be appropriate in size, intensity, and character to accommodate most growth projected for a 20-year planning period.

In 2008, the PSRC General Assembly adopted *VISION 2040* as the region's strategy for addressing anticipated population and employment growth through 2040 and *Transportation 2040* to guide the region's long-range transportation planning. *VISION 2040* is the growth management, environmental, and transportation strategy for the central Puget Sound region. The *VISION 2040* report states:

> …. Land use, economic, and transportation decisions will be integrated in a manner that supports a healthy environment, addresses global climate change, achieves social equity, and is attentive to the needs of future generations.

Puget Sound Regional Council (PSRC)

The region's federally designated metropolitan planning organization covering the four-county area, including Snohomish, King, and Pierce Counties, all located within the Plan area, and Kitsap County on the Olympic Peninsula, which is not within the Plan area.

VISION 2040, Transportation 2040, county-wide planning policies, and county and local comprehensive plans reflect GMA mandates that ensure consistency between regional and local plans. At the county level, land use in the central Puget Sound region is managed through comprehensive plans which, under the GMA, must designate a UGA or areas and adopt county-wide planning policies. Comprehensive plans prepared by each jurisdiction guide development at the local level. Land use management is accomplished through each jurisdiction's development regulations and programs.

Under the GMA, local and regional plans are required to be consistent with each other. Appendix F summarizes relevant state, regional, and municipal land use plans, policies, and legislation, particularly as they relate to transit. The appendix also includes a broad assessment of the relative consistency of the Current Plan Alternative and the Potential Plan Modifications Alternatives with those plans.

Transit-oriented development

Transit-oriented development (TOD) is a land-development pattern that integrates transit and land use such that transit stations contribute to the vitality and livability of surrounding neighborhoods while the land development patterns near transit stations maximize ridership on the system. Sound Transit is committed to assessing TOD potential as one of the decision factors at all stages of project development, beginning with long-range planning.

TOD Program Strategic Plan priorities

- Directly influence regional land use
- Shape station area plans by preserving options
- Implement TOD projects or development partnerships

Sound Transit's TOD program was established by its Board in 2000; the TOD policies on which it was based were subsequently updated by Board Resolution 2012-24, the "Transit-Oriented Development (TOD) Policy."

The policy directs Sound Transit to assess TOD early in system planning and throughout all phases of transit project development, construction, and operations. The policy also ensures that evaluation criteria for transit plan alternatives include TOD measures. In support of this policy, Sound Transit's Transit-Oriented Development Strategic Plan (2014c) guides the analysis, creation, implementation, and monitoring of TOD projects. The program addresses the importance of inter-agency, intra-agency, and public collaboration and support in achieving Sound Transit's TOD policies.

While TOD is only one of the many elements that influence station locations and designs, the TOD work can affect the options being developed in a specific corridor.

4.9.2 Affected environment

Population, households, and employment

The Sound Transit district, referred to as the Plan area, is roughly aligned with the UGAs in Snohomish, King, and Pierce Counties; although unlike some UGAs, it contains no "gaps" or "unconnected" areas. Because the GMA requires all cities to be within a UGA, the UGAs contain cities outside the contiguous metropolitan area, for example Snohomish, North Bend, and Enumclaw.

Population in the Plan area grew overall since 2000, despite the recent recession. Historic and forecasted population within the Plan area is shown in Table 4-26 and on Figure 4-32. Approximately 2.8 million people lived within the Plan area in 2010, an increase of 11 percent since 2000. The Plan area's population increased every year between 2000 and 2010, but the rate of growth slowed substantially since the recession in the second half of the decade. Population growth rates have increased slightly and are expected to continue to increase going forward. By 2040, the population of the Plan area is expected to reach approximately 3.8 million, an increase of about 34 percent over 2010. Snohomish and Pierce Counties are expected to experience the greatest percentage increase in population, at 45 percent and 42 percent, respectively. King County will continue to have the largest absolute population. The average annual growth rate for population in the Plan area is about 1.0 to 1.1 percent.

Approximately 2.8 million people lived within the Plan area in 2010, an increase of 11 percent since 2000. By 2040, the population of the Plan area is expected to reach approximately 3.8 million, an increase of about 34 percent over 2010.

Table 4-26. Total population 2000 to 2010 and growth forecasts, 2010 to 2040

Sound Transit District within county	2000	2010	2040 forecast	Actual growth 2000–2010	Forecasted growth 2010–2040
Snohomish	366,900	418,300	604,600	14%	45%
King	1,556,200	1,716,300	2,216,600	10%	29%
Pierce	594,400	671,400	592,000	13%	42%
Total	**2,517,500**	**2,806,100**	**3,773,200**	**11%**	**34%**

Source: PSRC 2013a, 2013b

The 2040 values are based on PSRC 2035 land use forecasts extrapolated to 2040.

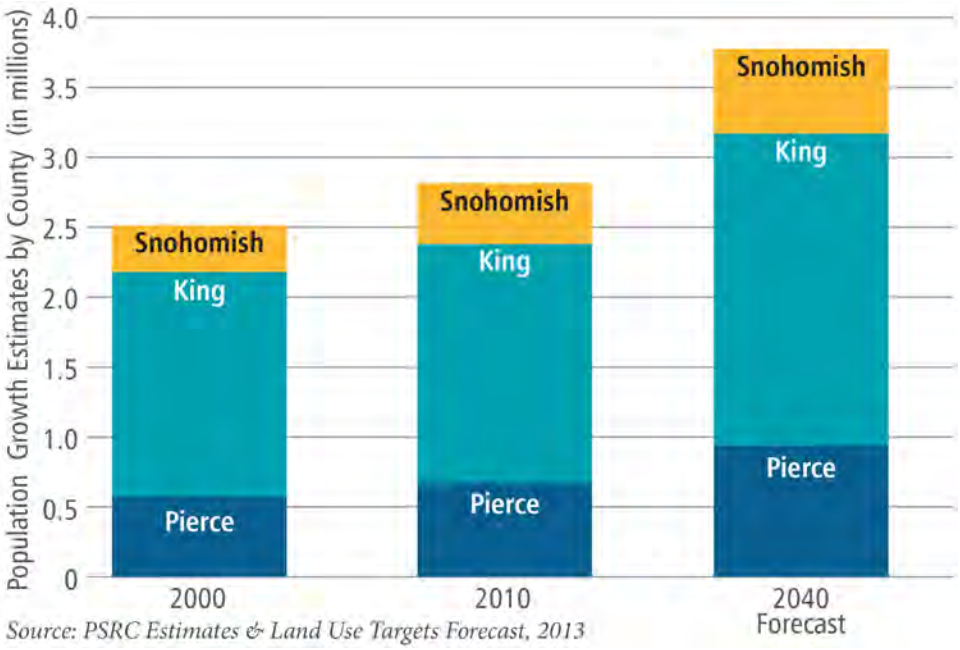


Figure 4-32. Population growth

Households within the Plan area increased by 12 percent between 2000 and 2010, with a forecasted increase of 44 percent by 2040, which would be an increase of approximately 14 to 15 percent per decade (Table 4-27 and Figure 4-33). The average annual growth rate for households in the Plan area is about 1.1 to 1.2 percent. The changes in the last decade represent a considerable slowing in household formation compared to the decade between 1990 and 2000, when total households within the Plan area increased by 17 percent.

Table 4-27. Total households 2000 to 2010 and growth forecasts, 2010 to 2040

Sound Transit District within county	2000	2010	2040 forecast	Actual growth 2000–2010	Forecasted growth 2010–2040
Snohomish	141,400	163,400	245,500	16%	50%
King	648,000	711,300	985,400	10%	39%
Pierce	223,000	255,000	399,800	14%	57%
Total	**1,012,400**	**1,129,700**	**1,630,700**	**12%**	**44%**

Source: PSRC 2013a, 2013b

The 2040 values are based on PSRC 2035 land use forecasts extrapolated to 2040.

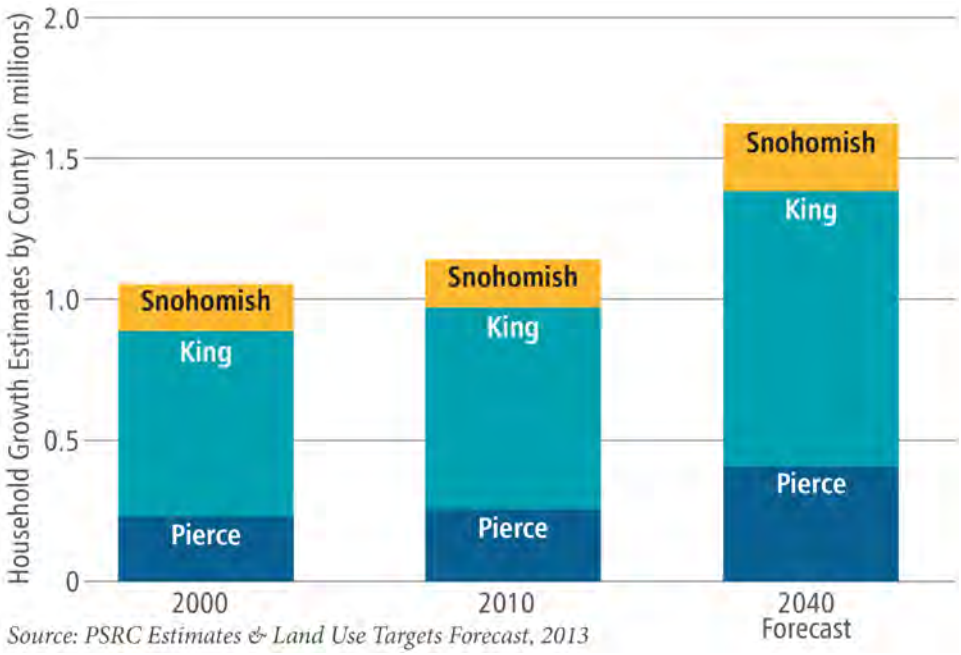


Figure 4-33. Household growth

During the recent recession, Plan area employment declined slightly. Between 2000 and 2010, employment within the overall Plan area declined by approximately 1 percent to 1.6 million (Table 4-28 and Figure 4-34). Over this period, employment increased in Pierce County (14 percent) and Snohomish County (8 percent), but decreased 5 percent in King County which resulted in an overall decrease for the Plan area. In 2000, Pierce and Snohomish County accounted for only 26 percent of all jobs in the Plan area, with King County accounting for the remaining 74 percent. Because of the different rates of growth/loss, by 2010 Snohomish and Pierce Counties accounted for a combined 29 percent of the Plan area's employment.

Employment growth is expected to outpace population. Employment growth within the Plan area for 2000–2030 had previously been forecast to be 45 percent, while the current forecast for 2010–2040 is 62 percent, which represents an average annual growth rate for employment at about 1.6 percent.

Table 4-28. Total employment 2000 to 2010 and growth forecasts, 2010 to 2040

Sound Transit District within county	2000	2010	2040 forecast	Actual growth 2000–2010	Forecasted growth 2010–2040
Snohomish	166,900	179,800	309,700	8%	72%
King	1,161,800	1,098,600	1,721,500	-5%	57%
Pierce	242,200	275,700	486,300	14%	76%
Total	**1,570,900**	**1,554,000**	**2,517,500**	**-1%**	**62%**

Source: PSRC 2013a, 2013b

The 2040 values are based on PSRC 2035 land use forecasts extrapolated to 2040.

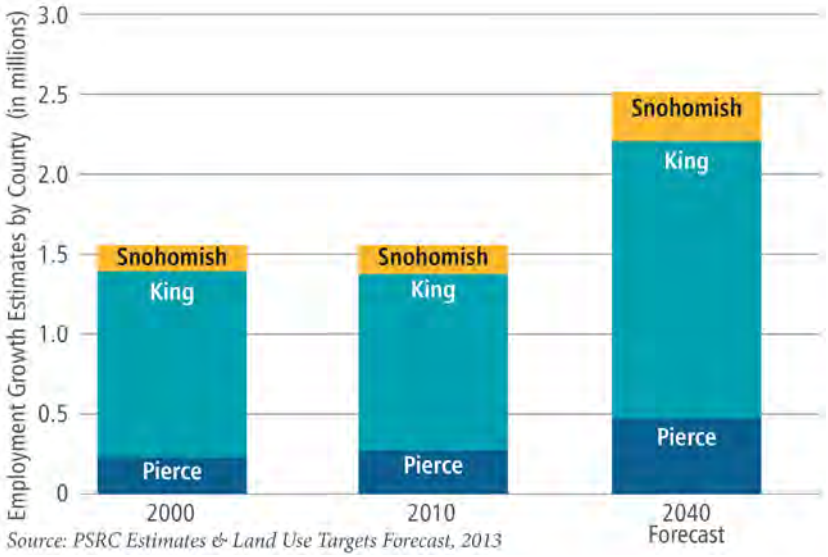


Figure 4-34. Employment growth

The economy in the central Puget Sound region is expected to remain strongly linked to the high-technology sector, including information technology, aerospace, and life sciences and global health. The sectors that currently account for the largest share of the region's jobs include business services, wholesale and retail, government (including military), information technology, tourism, health services, and aerospace.

Regional growth centers and land use

The regional growth strategy in *VISION 2040* supports concentrating growth in more than two dozen regionally designated growth centers that will serve as hubs for regional transportation and as focal points of higher-density population and employment. These centers, designated by PSRC, will support mixed-use development with jobs, retail, services, and housing. The regional growth centers in the Plan area (as of time of printing) are shown in Figure 4-35. *VISION 2040* also designates Manufacturing and Industrial Centers (MIC). The MICs within the Plan area are also shown on Figure 4-35.

Transportation 2040, built on the foundation of *VISION 2040*, outlines a long-term template for how the region should invest in transportation to support the region's expected growth. This plan relies on coordinated land use and transportation planning as a key element in achieving its goals.

The land use characteristics of the portions of the three counties within the Plan area are described in the following section and are shown on Figure 4-36 through Figure 4-38. Given its size, King County is divided into North King County, East King County, and South King County for discussion purposes in this section.

Snohomish County

The portion of Snohomish County within the Plan area is bordered by the Snohomish/King County line to the south, Puget Sound to the west, Everett to the north, and, to the east, along a line roughly aligned with the city limits of Everett, Mill Creek, and the northern part of Bothell (which straddles two counties), along with the unincorporated areas in between. Cities include Bothell, Brier, Edmonds, Everett, Lynnwood, Mill Creek, Mountlake Terrace, Mukilteo, and Woodway.

The Paine Field/Boeing MIC is located in the City of Everett and unincorporated Snohomish County. The MIC is comprised of land in both unincorporated Snohomish County and the incorporated southwest Everett area; of the nearly 4,300 acres within the MIC, 2,834 acres are within the City of Everett while 1,443 acres are in the unincorporated area of Snohomish County. Industrial/commercial land on the eastern edge of Mukilteo borders the airport. Industrial businesses supporting the Boeing Company have made this area a major employment center in Snohomish County and the state.

Commercial and multifamily development clusters are located along SR 99 through the entire area, passing through Edmonds, Lynnwood, and Everett; with other concentrations in downtown Lynnwood along I-5, downtown Everett, Everett Mall at the convergence of I-5 and SR 99, and along I-405 from Bothell north to Mill Creek.

VISION 2040 goal

... to focus population and employment growth in urban areas in a way that improves transportation efficiency; increases the use of transit, biking, and walking; and improves the balance between jobs and housing.

Regional growth strategy

... to better align job and housing locations, resulting in shorter commutes and reduced emissions.

Transportation 2040 programs and projects

... to increase local transit service by more than 100 percent in peak periods and over 80 percent in off-peak periods.

Regional growth centers

Regional growth centers are designated areas of high-intensity residential and employment development. They are most typically located in the historic downtowns or other major activity areas of the region's five Metropolitan Cities and in Core Cities. Regional growth centers serve as a primary framework for regional transportation and economic development planning.

Manufacturing and industrial centers

Existing employment areas with intensive, concentrated manufacturing and industrial land uses.

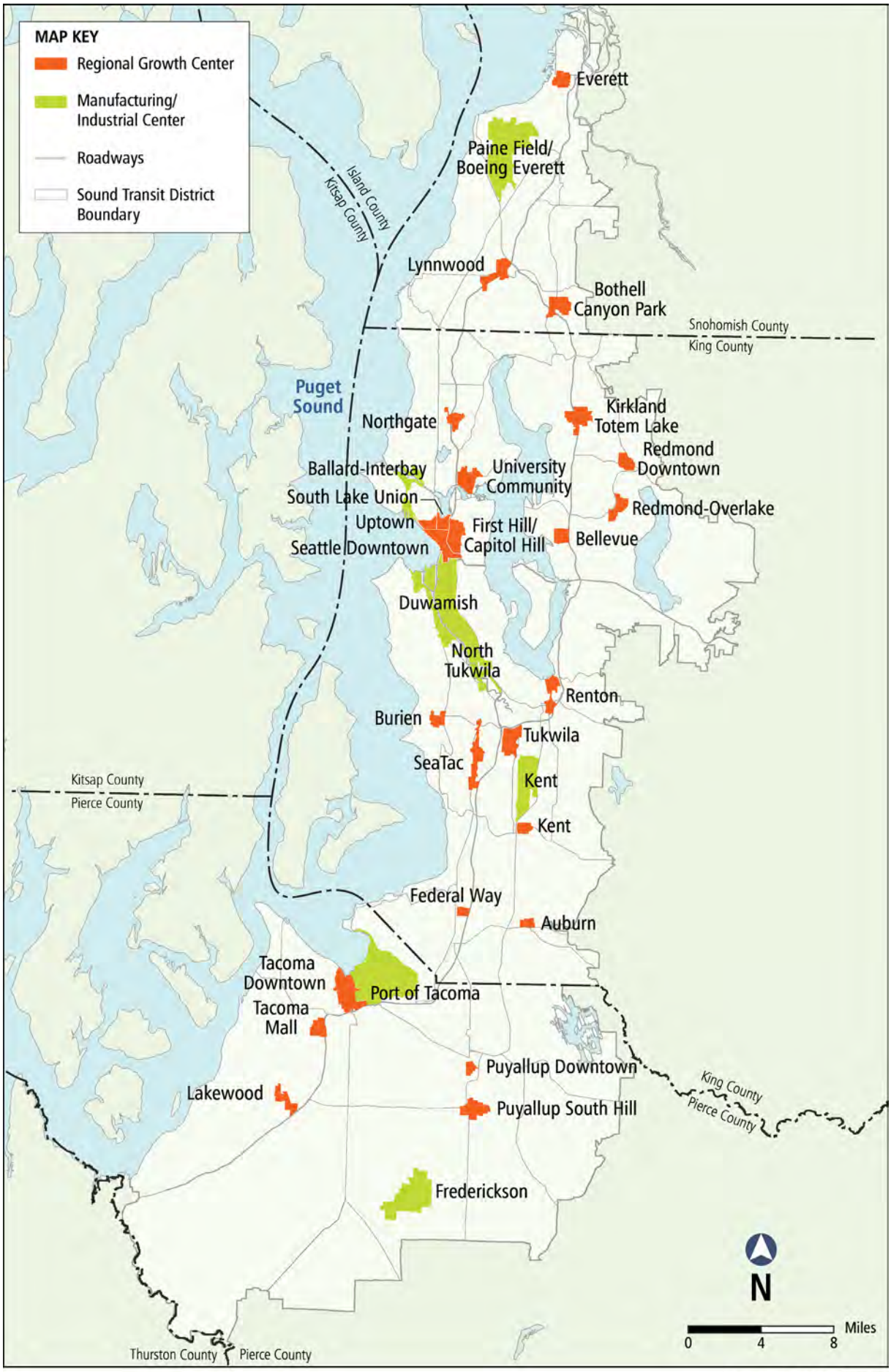
Snohomish County *VISION 2040* designated ...

... growth centers within the Plan area:

- Everett
- Lynnwood
- Bothell/Canyon Park

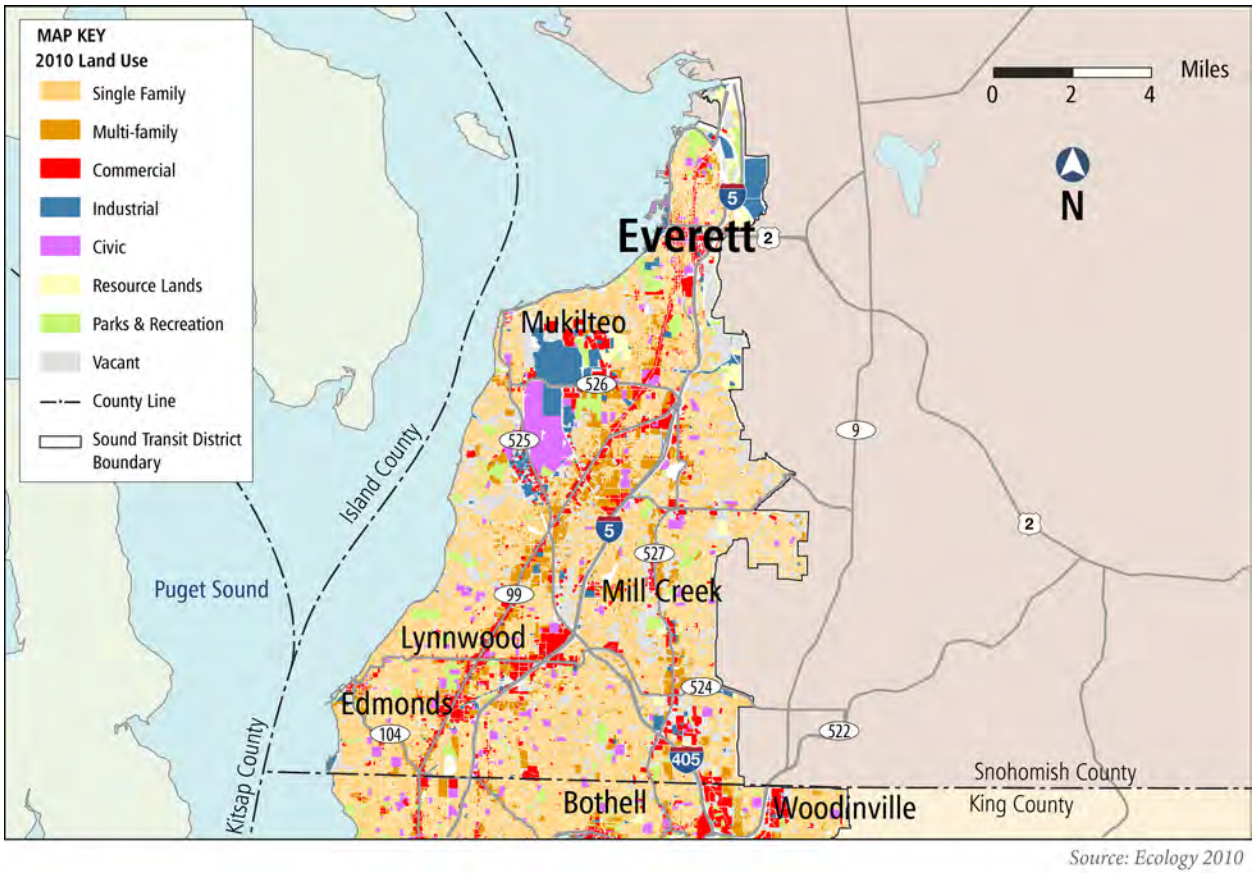
... manufacturing/industrial center within the Plan area:

- Paine Field/Boeing Everett



Source: PSRC 2014b

Figure 4-35. Regional growth centers and manufacturing and industrial centers within the Plan area



Source: Ecology 2010

Figure 4-36. Land uses in the Plan area—Snohomish County

Away from highway/arterial corridors, the predominant land use in the area is single-family residential. Unincorporated areas of Snohomish County are expected to remain predominantly low density single-family, served by commercial development on SR 99 and other minor highways and arterials.

North King County *VISION 2040* designated ...

... regional growth centers within the Plan area:

- Northgate
- University Community (around the University of Washington)
- Uptown (Lower Queen Anne)
- Seattle Downtown
- First Hill/Capitol Hill
- South Lake Union

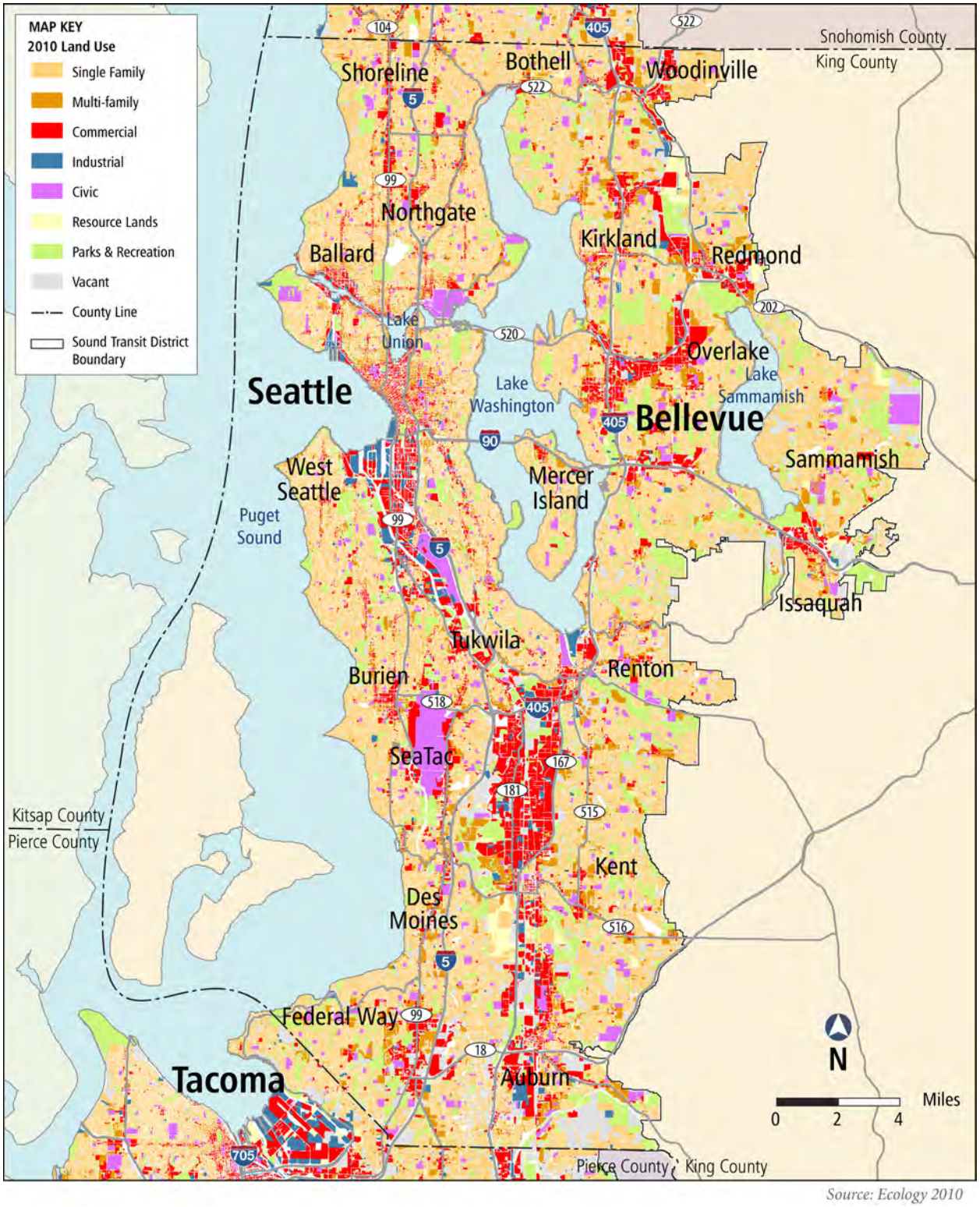
... manufacturing/industrial centers within the Plan area:

- Ballard/Interbay
- Duwamish

North King County

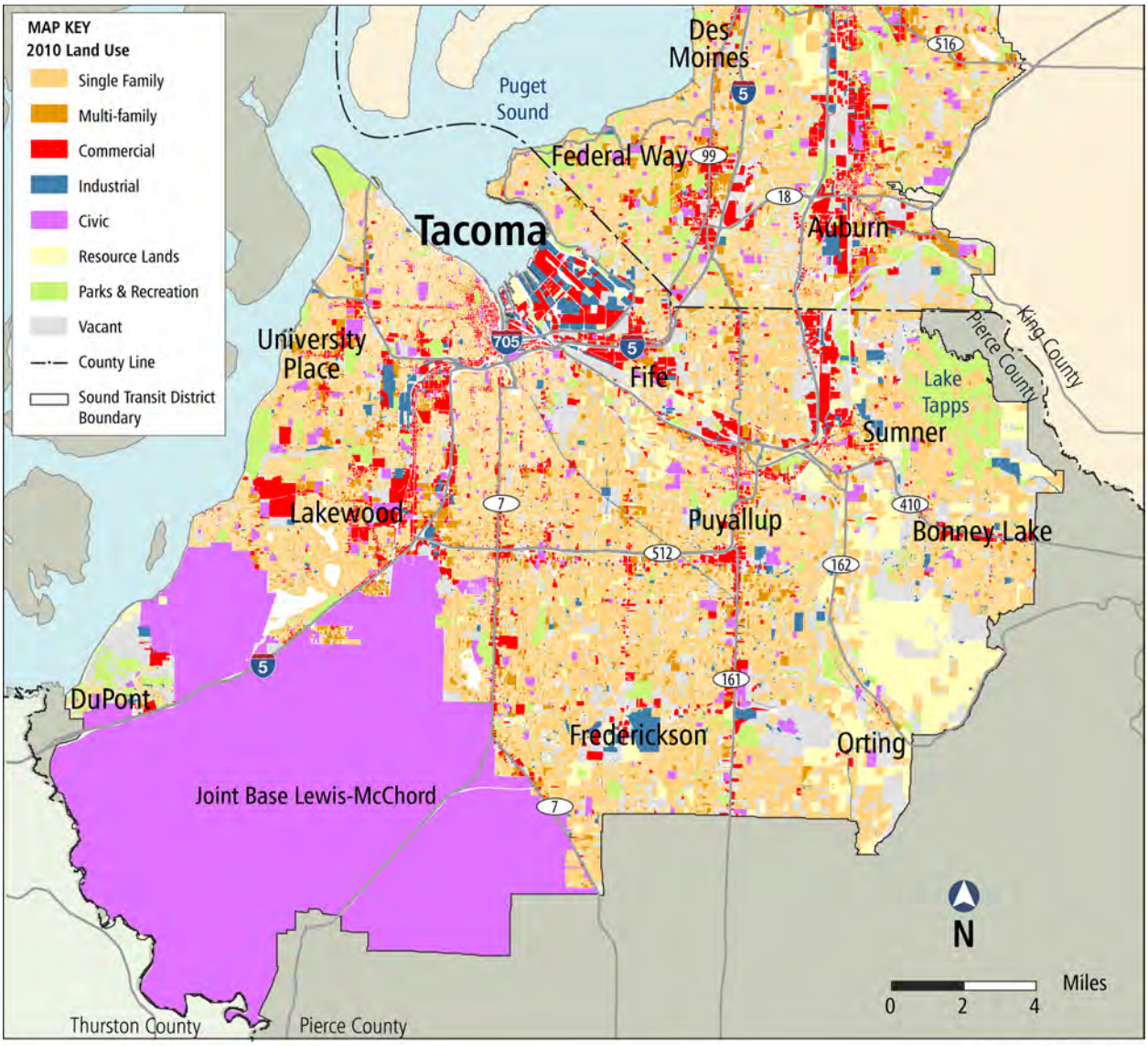
The northern portion of King County within the Plan area is bordered by the Snohomish/King County line to the north, the eastern city limits of Lake Forest Park and Lake Washington to the east, the southern city limits of Seattle to the south, and Puget Sound to the west. The area comprises the incorporated cities of Lake Forest Park, Seattle, and Shoreline.

Lake Forest Park, on the north shore of Lake Washington, is almost entirely single-family residential, with a small commercial area serving its residents. The city of Shoreline is bisected by SR 99, an auto-oriented commercial corridor zoned almost entirely for commercial/mixed-use, with a Town Center District along approximately a third of its length. I-5 runs through the city east of SR 99, bordered primarily by residential uses. There are small pockets of high density residential zoning scattered elsewhere in the city, which is otherwise primarily low density residential development.



Source: Ecology 2010

Figure 4-37. Land uses in the Plan area—King County



Source: Ecology 2010

Figure 4-38. Land uses in the Plan area—Pierce County

The remainder of North King County is the City of Seattle, the largest city in the state. Industrial land in the city is clustered along the waterfronts, including Puget Sound, the Lake Washington Ship Canal, and the Duwamish River. Downtown Seattle comprises a mix of commercial, office, industrial/warehouse, and multifamily residential uses; currently more than 200,000 people work in downtown Seattle. Since the easing of the recent recession, development of denser mixed-use neighborhoods has accelerated in Seattle, particularly in downtown, First Hill/Capitol Hill, around the University of Washington, and in Northgate, Ballard, West Seattle, and areas of southeast Seattle.

East King County

The portion of East King County within the Plan area is bordered by the King/Snohomish County Line to the north, Lake Washington to the west, and the southern city limits of Renton to the south, and includes Mercer Island. This area contains the cities of Woodinville, Redmond, Bellevue, Kirkland, Sammamish, Issaquah, Mercer Island, Newcastle, and Renton, as well as the towns/villages of Yarrow Point, Hunts Point, Medina, and Beaux Arts Village. Only a small area within East King County is unincorporated.

East King County *VISION 2040* designated ...

... regional growth centers within the Plan area:

- Kirkland-Totem Lake
- Redmond Downtown
- Redmond-Overlake
- Renton
- Bellevue
- Issaquah (City preparing application to submit to PSRC)

Land uses in this area include dispersed commercial, office, and industrial development surrounded by suburban low-density housing. Particularly in suburban city centers, east King County also includes a substantial amount of mixed-use and multi-family land uses. Bellevue and Redmond are major employment and commercial centers, with the highest-density office and residential development in the area and several high-technology-based companies; the Microsoft Company is a major employer. Kirkland comprises moderate-density commercial and office land uses and a mix of low- and medium-density residential uses. Renton includes low- to medium-density industrial, residential, and automobile-oriented commercial development. The Boeing Company is a major employer in Renton. Costco World Headquarters in Issaquah is a major employer in East King County. Costco also has plans to expand office and retail space in the Central Issaquah Area.

Bothell, Woodinville, Juanita, Totem Lake, Factoria, Issaquah, and the Bel-Red area in Bellevue include major retail and office uses. In Bellevue, the Overlake Hospital area and the I-90/Eastgate corridor to the east comprise single-family residences and moderate-density commercial and industrial development. Issaquah comprises low- and medium-density residential neighborhoods with commercial and retail areas concentrated along the I-90 corridor, as well as higher density development in the Issaquah Highlands. The I-90 corridor through Mercer Island is comprised primarily of single and multifamily residences with commercial and office uses concentrated in downtown Mercer Island.

South King County

The portion of South King County within the Plan area runs from the southern city limits of Burien, SeaTac, and Tukwila on the north, to Federal Way and Pacific on the south, and from Puget Sound on the west to an eastern boundary that includes Auburn and Kent. South King County also contains sizeable areas of unincorporated land between Federal Way and Auburn on the east side of I-5. The area contains the cities of Burien, SeaTac, Tukwila, Normandy Park, Des Moines, Kent, Auburn, Federal Way, Algona, and Pacific.

Seattle-Tacoma International Airport, in the city of SeaTac, is surrounded by supportive uses such as light industrial, parking, and motels/hotels. Other land uses in the City of SeaTac include

South King County *VISION 2040* designated ...

... regional growth centers within the Plan area:

- Auburn
- Burien
- SeaTac
- Tukwila
- Federal Way
- Kent

... manufacturing/industrial center within the Plan area:

- North Tukwila—which adjoins the Duwamish Manufacturing/Industrial Center in Seattle
- Kent

multifamily and single-family housing, served by retail/commercial primarily along SR 99. The Tukwila regional growth center contains a mix of high-intensity retail, commercial, industrial, and office uses; the center's primary focus is Southcenter Shopping Mall. Tukwila recently adopted a subarea plan for this urban center with new development regulations calling for more urban development, transit-oriented development, and new design guidelines that will help transition Southcenter from a suburban commercial area to a more vibrant mixed-use urban center. The Kent MIC is currently about 57 percent warehousing and 13 percent industrial, with primarily one-story buildings. The Tukwila MIC is an important center of industrial activity, especially for the aerospace sector.

Burien, Normandy Park, and Des Moines contain primarily single-family neighborhoods with some multifamily, plus commercial areas serving local residents. The Muckleshoot Reservation is located in South King County, and a portion of the reservation is within the Plan area. The City of Auburn extends onto reservation land.

Pierce County

The portion of Pierce County within the Plan area is bounded on the north by the cities of Tacoma, Milton, and Fife, on the south by DuPont and Joint Base Lewis-McChord, and from Puget Sound on the west to an eastern boundary that takes in Orting, Bonney Lake, and Sumner. A large part of southern Pierce County is unincorporated. The area contains the cities of Tacoma, Fife, Milton, Edgewood, Sumner, Bonney Lake, Puyallup, Orting, Fircrest, University Place, and Steilacoom. The Puyallup Reservation, associated with the Puyallup Tribe of Indians, is located in the Tacoma area. Parts of six cities extend onto reservation land, including Tacoma, Fife, Puyallup, Edgewood, Milton, and a small portion of Federal Way. In addition, I-5 traverses the Puyallup Reservation.

Pierce County *VISION 2040* designated ...

... regional growth centers within the Plan area:

- Tacoma Downtown
- Tacoma Mall
- Lakewood
- Puyallup Downtown
- Puyallup South Hill
- University Place (pending designation)

... manufacturing/industrial centers within the Plan area:

- Port of Tacoma
- Frederickson

Downtown Tacoma comprises relatively high-density office and residential development and a substantial number of retail uses. It also contains industrial areas to the north and south, including the Port of Tacoma. Downtown Tacoma is a governmental and financial center and contains a University of Washington branch campus. The Tacoma Mall is a regional shopping center that, together with surrounding neighborhoods, comprise the Tacoma Mall Mixed-Use Center.

Southwest of Tacoma, University Place contains commercial and multifamily areas along Mildred Street, 27th Street, and Bridgeport Way, which contains a high density of population and employment.

Located between Tacoma and DuPont, Joint Base Lewis-McChord and Madigan General Hospital are major employers. Frederickson, an unincorporated area at the southern edge of the Plan area, is zoned for heavy manufacturing; Boeing has a fabrication plant there.

Sumner, Puyallup, and the Tacoma Tideflats comprise low- to medium-density industrial, residential, and automobile-oriented commercial uses. Downtown Puyallup is

currently primarily in commercial, single- and multifamily uses; Puyallup South Hill is home to South Hill Mall, auto-oriented retail, both "big box" and lower density, and single- and multifamily residential uses.

4.9.3 Long-term impacts

Long-term impacts common to both alternatives

Both alternatives would be consistent with regional goals that address growth. The regional growth strategy involves focusing the majority of the region's growth into currently designated urban areas. In *VISION 2040*, designated regional growth centers and other center types are the focal points of activities within urban areas and will be connected to other centers by high-capacity transit. *Transportation 2040* guidelines recognize the importance of a network of facilities for biking, walking, and taking transit to and within regional growth centers.

The Current Plan Alternative and the Potential Plan Modifications Alternative would improve transit service to regional growth centers. Transit projects would provide mobility options and would help achieve higher land use densities in urban centers, particularly near stations. Both alternatives would generally be consistent with state, regional, county, and municipal land use plans, policies, and legislation. Appendix F includes a broad assessment of the relative consistency of the Current Plan Alternative and the Potential Plan Modifications Alternative with state, regional, county, and municipal land use plans, policies, and legislation. Sound Transit facilities are defined as essential public facilities under the GMA, and no local comprehensive plan or development regulation may preclude the siting of essential public facilities.

Region-wide current population and employment goals would be achievable under both the Current Plan Alternative and the Potential Plan Modifications Alternative. The Current Plan Alternative and the Potential Plan Modifications Alternative would continue development and expansion of high-capacity transit corridors and support growth patterns and concentrations at a regional scale; therefore, generally the interaction of regional growth and transportation at the broad scale would not impact population, employment, or housing.

The influence of different transit modes on development potential in the region would vary depending upon transit operations, corridor characteristics, and government support with codes, incentives, and infrastructure to achieve transit-supportive development and direct access to transit connections. The timing, intensity, and location of specific land use benefits and impacts of transit projects and programs would be determined during project-level planning and environmental review. Regional long-term benefits of the Current Plan Alternative and the Potential Plan Modifications Alternative would include the following:

- Implementation of the regional growth centers strategy by connecting centers and corridor areas with high levels of population and employment
- Increased access to employment, housing, and services due to increased transit and connections
- Support local development of compact, mixed-use communities that help limit urban sprawl

- Less dependence on automobile travel and greater transit- and pedestrian-oriented development activity

Without supportive land use policy, plans, and codes, these benefits from transit projects may not be fully realized. In industrial and manufacturing areas, activities attracted to transit station areas could potentially displace existing land uses. Increased demand for parking near stations and increased traffic from connecting local transit and pick-ups or drop-offs can also have impacts on nearby activities. These potential impacts can be avoided or minimized by integrating land use planning with long-range transit planning and maintaining consistent development policies and codes.

The Current Plan Alternative and the Potential Plan Modifications Alternative could have long-term impacts to land use, such as property acquisitions, displacements, and land use conversion to a transportation use. The degree of such impacts would depend on the mode, location, and type of facilities required, as well as the density of surrounding residential, industrial, or commercial development. Any property acquisition would convert existing land uses to public rights-of-way for the construction and operation of the system. Property acquisitions are expected to comprise a small percentage of commercial, industrial, and residential land uses at a community or regional level and would not directly alter land use patterns. Generally most corridors follow existing transportation corridors. Depending on the mode and the conditions adjacent to the transportation corridor, some of the elements of the alternatives may occur within the existing right-of-way. In areas where there is partial acquisition or construction staging, the land could be restored to its previous land use or redeveloped to a use allowed under the zoning. This would further reduce the amount of land converted to public rights-of-way.

Current Plan Alternative

Under the Current Plan Alternative, *Sound Move* and ST2 would be completed and the HCT system would continue to expand as envisioned in the current Long-Range Plan in support of the region's adopted growth and land use strategy. The Current Plan Alternative would serve and connect regional growth centers and focus growth within the boundaries of the UGAs. The Current Plan Alternative would enable local jurisdictions to meet their planned land use and density objectives and accommodate the projected population and employment growth within currently planned urban growth areas.

Light rail

Under the Current Plan Alternative, light rail connections would be added to regional growth centers and manufacturing industrial centers. The Current Plan Alternative includes potential light rail extensions and connections between and through the Everett, Lynnwood, Bothell Canyon Park, Seattle Northgate, Kirkland Totem Lake, Seattle's University Community, Seattle downtown, Redmond downtown, Redmond Overlake, Bellevue downtown, Renton, Burien, SeaTac, Tukwila, Federal Way, and Tacoma downtown regional growth centers:

- Tacoma and Federal Way (corridor A)
- Burien and Renton (corridor B)
- Renton and Lynnwood along I-405 (corridor D)

- Renton and Woodinville along the Eastside Rail Corridor (corridor E)
- Lynnwood and Everett (corridor H)
- UW to Redmond via SR 520 (corridor I)
- Northgate to Bothell (corridor J)

Light rail also would provide connections between the Ballard-Interbay MIC and the Seattle downtown and Seattle's University Community regional growth centers:

- Downtown Seattle and Ballard (corridor F)
- Ballard and the UW (corridor G)

The potential light rail connection between Bellevue and Issaquah (corridor C) would connect the Bellevue regional growth center with Issaquah, which is not currently a PSRC-designated regional growth center. However, central Issaquah is designated as an Urban Center in the King County Countywide Planning Policies. The City of Issaquah is also actively in the process of seeking designation from PSRC as a Regional Growth Center.

Additional support facilities along these extensions would include stations, park-and-ride facilities, traction power substations, maintenance facilities, and pedestrian and bicycle access. Additional stations, park-and-ride facilities, or maintenance facilities could also be developed as infill along existing light rail lines.

In densely populated urban areas, light rail could result in a relatively high number of property acquisitions, but in those areas with the highest potential for impacts, tunneling could be considered. For example, tunneling may be considered in some segments of the Bellevue to Issaquah corridor (corridor C), Ballard to UW corridor (corridor G), and downtown Seattle to Ballard corridor (corridor F).

Potential changes in land use as a result of the Current Plan Alternative would be influenced by existing development patterns, supportive land use and development policies, local community and business support, and market forces. Local jurisdictions would determine the actual permitted densities and types of land uses in station areas. In most cases, private interests would determine actual development projects; in other cases, projects could be public or public-private partnerships.

Because light rail typically operates in an exclusive right-of-way, light rail offers better long-term travel time reliability than modes without exclusive rights-of-way, such as regional express bus or streetcar. Therefore, depending on the surrounding land uses and supportive infrastructure, light rail could attract greater ridership and stimulate more transit-oriented development and economic activity than modes without exclusive rights-of-way. In addition, light rail could be designed to tie more closely into community land uses than commuter rail, which generally is limited to existing rail right-of-way.

Redevelopment and infill near transit stations is more likely if:

- Local plans and policies encourage compact, transit-supportive development
- Mixed-use, pedestrian-oriented land use patterns surround stations
- Vacant or underused land is available for development or redevelopment
- Sizable parcels can be assembled for development or redevelopment
- Station access is supported by connectivity of streets, sidewalks, and bicycle facilities
- Convenient access is provided to multiple transit connections

Light rail would require some property acquisition for track and support facilities, such as stations and park-and-ride facilities, traction power substations, or maintenance facilities. New development, redevelopment, or infill surrounding transit stations could replace some dispersed automobile-oriented land uses.

The greatest changes in land use patterns could occur in station areas. Businesses in the vicinity of transit stations would benefit from improved accessibility for their employees and customers. Overall, greater transit and pedestrian-friendly development activity would be anticipated. Transit-oriented development could be incorporated into new transit projects or subsequent in-fill projects on properties at or adjacent to stations. Station areas that have fewer existing transit-oriented characteristics that support regional growth centers could develop later than areas where those characteristics exist or are planned by local jurisdictions.

Maintenance facilities would need large areas for rail car storage, maintenance, and operations. The scale of these facilities and their related activities could conflict with other uses or plans, particularly if residential or mixed-use activities were predominant. In general, these facilities would be most consistent with industrially zoned areas and least compatible with residential areas or compact urban centers. However, modern maintenance facilities can be designed and operated to be relatively unobtrusive.

Commuter rail

Similar to light rail in the Current Plan Alternative, commuter rail is consistent with the goals of the Regional Growth Strategy. Service between Seattle and Pierce County would be extended 9 miles south from Lakewood to DuPont (corridor I), connecting the DuPont community with Lakewood, which is a regional growth center. Commuter rail would also extend from Renton to Woodinville along the Eastside Rail Corridor (corridor J). Corridor J would include commuter rail connections between the regional growth centers in Renton, Bellevue, and Kirkland Totem Lake. Associated support facilities would include stations, maintenance facilities, park-and-ride facilities, and access facilities, such as pedestrian bridges. These types of facilities could also be provided along the existing commuter rail line.

Although new commuter rail lines would use existing freight or passenger rail corridors, right-of-way easements or property acquisitions may be needed to accommodate rail improvements along corridors where commuter rail is already operating. Such improvements could include new or expanded track sections, maintenance facilities, and storage or passing tracks.

In general, land use impacts are expected to be minor, since most of these corridors currently support rail-related uses, such as freight or Amtrak service. Land use impacts at station areas, park-and-ride facilities, and maintenance facilities would be similar to those described for light rail. However, because commuter rail is generally limited to existing rail right-of-way, commuter rail might not tie into community land uses as closely as would light rail.

Regional express bus/bus rapid transit

BRT and regional express bus would support the region's adopted growth and land use strategy. The Current Plan Alternative includes BRT and regional bus service that would connect to regional centers, manufacturing industrial centers, and other communities, creating an integrated system of transit services. BRT would provide connections between and through the Lynnwood, Bothell Canyon Park, Seattle Northgate, Kirkland Totem Lake, Seattle University Community, Seattle South Lake Union, Seattle uptown, Seattle downtown, Redmond downtown, Redmond Overlake, Bellevue downtown, Renton, and Puyallup downtown regional growth centers with the following corridors:

- Renton and Puyallup along SR 167 (corridor N)
- Renton and Woodinville along the Eastside Rail Corridor (corridor P)
- Renton and Lynnwood along I-405 (corridor Q)
- Seattle and Everett along SR 99 (corridor R)
- Lynnwood and Everett along I-5 (corridor S)
- UW to Redmond via SR 520 (corridor K)
- Northgate to Bothell via SR 522 (corridor L)

Several BRT corridors include connections between regional growth centers and smaller communities. These include the Federal Way regional growth center and the Bellevue downtown regional growth center:

- Federal Way and DuPont along I-5 (corridor M)
- Bellevue and Issaquah[2] along I-90 (corridor O)

Where dedicated guideways, frequent service, and supportive land use patterns exist, land use impacts of BRT could be similar to those of light rail if BRT were implemented in the form of buses operating in exclusive guideways. If lanes were added to existing roadways such as SR 99, which has dense development close to the roadway, impacts to residential, commercial, or other land uses could occur. Increased transit accessibility could increase the function of centers by improving access to jobs and housing choices. BRT in mixed traffic or in semi-exclusive facilities (including in HOV facilities) is expected to have fewer land use impacts than BRT in exclusive guideways.

Regional express bus, which operates on existing roadways, could include additional corridors. The Current Plan Alternative includes regional bus connections between several regional growth centers:

- Redmond to Kirkland (corridor X)
- Puyallup to Lakewood (corridor U)
- Puyallup to Tacoma (corridor V)

[2] The City of Issaquah is in the process of applying to become a new regional growth center in accordance with PSRC's Designation Procedures for New Regional Growth and Manufacturing Industrial Centers (2011).

Corridor V would continue to University Place, which is actively in the process of seeking designation from PSRC as a Regional Growth Center. Connections also include links between the regional growth centers of Puyallup, SeaTac, Bothell, and Mill Creek and other communities:

- Puyallup to DuPont via Cross Base Highway (corridor T)
- SeaTac to West Seattle (corridor W)
- North Bothell to Mill Creek to Mukilteo (corridor Y)

Additional support facilities, depending on the mode selected, could include maintenance facilities and park-and-ride facilities. The land use impacts of BRT in exclusive guideways would be similar to those of light rail due to some of the more permanent infrastructure improvements, whereas regional express bus would use the existing roadway system. Either mode could require additional or expanded maintenance facilities.

High-capacity transit (mode not specified)

UW to Redmond via SR 520 (corridor K) and Northgate to Bothell via SR 522 (corridor L) could be selected as either light rail or BRT corridors. Both corridors would connect to regional growth centers, and impacts would be similar to those described for the other corridors of the same mode.

Potential Plan Modifications Alternative

Similar to the Current Plan Alternative, the Potential Plan Modifications Alternative would support the region's adopted growth and land use strategy by adding transit beyond what is currently planned. However, the Potential Plan Modifications Alternative would add direct connections between more locations, as well as to several areas that are not regional growth centers. In addition, some corridors would add higher capacity services, such as light rail, where lower capacity services, such as bus, would otherwise operate.

Generally, impacts would be similar within each corridor and mode as the Current Plan Alternative, but more corridors would be impacted. Expanded transit access to regional growth centers under the Potential Plan Modifications Alternative could serve population, employment, and development in centers above the levels of the Current Plan Alternative, although the timing, intensity, and location of development and infill are unknown. The Potential Plan Modifications Alternative would increase the ability of local jurisdictions to achieve growth targets and implement local plans, including subarea plans. The extent to which these additional benefits are achieved is dependent upon how many of the corridors included in the Potential Plan Modifications Alternative are incorporated into the Long-Range Plan as part of the update process.

The only communities that would receive service from Sound Transit under the Potential Plan Modifications Alternative that would not receive it under the Current Plan Alternative are Orting, Ruston, and Steilacoom; of these only Orting is currently without transit service provided by a local operator.

The Potential Plan Modifications Alternative could connect to more locations, result in more redevelopment, and have more property effects than the Current Plan Alternative. As a result, the Potential Plan Modifications Alternative could increase the opportunities to

support implementation of PSRC's *VISION 2040* and the Growing Transit Communities Strategies. It could also better support the local land use plans of more communities. The extent to which these additional benefits are achieved is dependent upon how many of the corridors included in the Potential Plan Modifications Alternative are incorporated into the Long-Range Plan as part of the update process.

Light rail

Similar to the Current Plan Alternative, the Potential Plan Modifications Alternative would add light rail connections to regional centers, manufacturing industrial centers, and smaller communities. However, these connections would expand light rail beyond that of the Current Plan Alternative and provide increased connectivity within the region.

If all corridors were implemented under the Potential Plan Modifications Alternative, they would provide light rail connections to regional growth centers not served by light rail in the Current Plan Alternative, including Kent, Auburn, Tacoma Mall, Lakewood, Puyallup downtown, and Puyallup South Hill. The Potential Plan Modifications Alternative also would provide light rail connections to MICs not served in the Current Plan Alternative, including Paine Field/Southwest Everett, Frederickson, and Kent. The Potential Plan Modifications Alternative includes light rail extensions and connections between:

- Downtown Seattle, Magnolia/Ballard and Shoreline Community College (corridor 1)
- Downtown Seattle, West Seattle, and Burien (corridor 2); this corridor includes potential tunnel sections
- Ballard and Everett Station via Shoreline Community College, Aurora Village, Lynnwood (corridor 3)
- Everett and North Everett (corridor 4)
- Lakewood, Spanaway, Frederickson, South Hill and Puyallup (corridor 5)
- DuPont and downtown Tacoma via Lakewood, Tacoma Mall (corridor 6)
- Puyallup/Sumner and Renton via SR 167 (corridor 7)
- Downtown Seattle along Madison Street (corridor 8)
- Tukwila and SODO via Duwamish industrial area (corridor 9)
- North Kirkland or University of Washington Bothell and Northgate via SR 522 (corridor 10)
- Ballard and Bothell via Northgate (corridor 11)
- Mill Creek and Bothell, connecting to Eastside Rail Corridor (corridor 12)

- Lynnwood and Everett serving Southwest Everett Industrial Center (Paine Field and Boeing) (corridor 13)
- UW to Sand Point to Kirkland to Redmond (corridor 14), including potential tunnel sections
- Downtown Tacoma to Tacoma Community College (corridor 15)
- Tacoma Mall to University Place (corridor 16)
- Steilacoom to Ruston via University Place (corridor 17)
- Issaquah to Issaquah Highlands (corridor 18)

Several of the centers that would be served by new light rail connections, such as DuPont, Sumner, and Mill Creek, are not designated by the PSRC as regional growth centers or MICs. However, light rail service would add connectivity within the UGA beyond the connectivity provided by the Current Plan Alternative. Additional support facilities would include stations, park-and-ride facilities, traction power substations, maintenance facilities, and pedestrian and bicycle access.

Similar to light rail under the Current Plan Alternative, the greatest changes in land use could occur in station areas. Changes to land use also could occur in corridors that require additional rights-of-way for transit facilities. For example, if light rail requires additional right-of-way but development occurs up to the existing roadway, acquisitions may be required. Segments of dense, urban corridors could be affected, such as Ballard to Everett via Aurora Village (corridor 3) and downtown Seattle to East Seattle via Madison Street (corridor 8). In some cases, tunnels may be considered to minimize impacts.

Commuter rail

Commuter rail service would be further expanded. The Potential Plan Modifications Alternative includes commuter rail extensions between:

- Puyallup/Sumner and Orting (corridor 19)
- Lakewood and Parkland (new track) (corridor 20)
- Tacoma and Frederickson (corridor 21)

Service to the regional growth centers of Puyallup, Lakewood, and Tacoma, and to the Frederickson MIC would be consistent with the Regional Growth Strategy.

Orting and Parkland, which is an unincorporated suburb of Tacoma, are within the UGA but are not designated urban growth centers. Similar to the discussion of commuter rail impacts for the Current Plan Alternative, land use impacts are expected to be minor, since most of these corridors currently support rail-related uses. However, in relatively small communities with a low population density, such as Orting, the addition of a rail station or support facilities could be associated with land use changes that are not necessarily consistent with community goals. A commuter rail line from Lakewood to Parkland (corridor 20) is currently not consistent with the City of Lakewood's Comprehensive Plan. This is also true for the portion of light rail corridor 5 in the same area.

Furthermore, if corridor 20 (or a section of corridor 5) were to traverse the McChord Field Clear Zone, transportation facilities may not be compatible in that location.

Additional support facilities would include stations, park-and-ride facilities, maintenance facilities, and pedestrian and bicycle access. Site selection and operation of these facilities would take into account local land use policies, plans, and goals.

Regional express bus/bus rapid transit

BRT and regional express bus would support the region's adopted growth and land use strategy. The Potential Plan Modifications Alternative includes BRT and regional bus service that would connect to regional centers, manufacturing industrial centers, and other communities. Together, the Current Plan and the Potential Plan Modifications Alternatives would provide BRT service to most of the regional growth centers in the Plan area. For the Potential Plan Modifications Alternative, BRT service could further improve connections between a number of regional growth centers and MICs, including Tukwila and bus routes in the vicinity of Puyallup, notably along Meridian (roadway widening).

The Potential Plan Modifications Alternative includes additional corridors that would provide the following regional bus connections:

- Puyallup vicinity, notably along Meridian Avenue (corridor 27)
- Issaquah to Issaquah Highlands (corridor 28)
- Kent and Sea-Tac Airport (corridor 29)
- Downtown Seattle along Madison Street (corridor 30)
- Issaquah Highlands and Overlake via Sammamish, Redmond (corridor 31)
- Tacoma and Bellevue (corridor 32)
- Puyallup to downtown Seattle via Kent, Rainier Valley (corridor 33)
- Lakewood to Spanaway to Fredrickson to South Hill Puyallup (corridor 34)
- Tacoma to Fredrickson (corridor 35)
- Renton and downtown Seattle (corridor 36)
- University of Washington Bothell to Sammamish via Redmond (corridor 37)
- University Place to Titlow Beach to downtown Tacoma (corridor 38)
- Renton (Fairwood) to Eastgate via Factoria (corridor 39)
- 145th Street from I‑5 to SR 522 (corridor 40)
- North Kirkland to downtown Seattle via SR 520 (corridor 41)
- Woodinville-to-Bellevue (corridor 42)
- Woodinville-to-Everett (corridor 43)
- Connection to Joint Base Lewis-McChord (corridor 44)
- Puyallup/Sumner to Orting (corridor 45)
- Kent to Kent-Des Moines Station (corridor 46)
- Lynnwood to Everett, serving Southwest Everett Industrial Center (Paine Field, Boeing) (corridor 47)

New regional express bus service typically not typically require additional rights-of-way and therefore direct impacts to adjacent land uses, if any, would be minor. In Shoreline,

any improvements required along 145th Street for the implementation of corridor 40 would be consistent with the City of Shoreline's Route Development Plan which is currently under development. If 145th Street is widened to accommodate buses, the impacts to adjacent land uses would be similar to those impacts described for BRT in other corridors through densely developed areas.

Additional support facilities could include stations, platforms, or bus stops; park-and-ride facilities; ramps; maintenance facilities; and pedestrian and bicycle access. Site selection and operation of these facilities would take into account local land use policies, plans, and goals.

Streetcar

Potential streetcar service is considered in areas within the City of Seattle, as well as parts of Lynnwood, Edmonds, Everett, the Paine Field vicinity, and the Eastside Rail Corridor. Streetcars would operate in existing rights-of-way and would travel through and connect regional growth centers to urban villages and neighborhood business districts (all intended locations of high-density mixed-use development and growth).

Streetcars have some similar characteristics to at-grade light rail, but like most bus transit, they generally do not operate in exclusive rights-of-way, and instead operate within mixed traffic. Compared to light rail, stations and platforms can be smaller. Therefore, the development impacts could be fewer as compared to a light rail operating at-grade due to a smaller footprint.

Because streetcars would operate in existing rights-of-way, there would be few or no property acquisitions, with the exception of maintenance and storage facilities.

High-capacity transit (mode not specified)

Several HCT corridors include connections between regional growth centers and smaller communities, supporting the region's adopted growth and land use strategy. These include the regional growth centers of Tukwila, Burien, downtown Seattle, and Ballard–Interbay:

- Downtown Tacoma to Parkland (corridor 22)
- Tukwila Sounder station to downtown Seattle via Sea-Tac Airport, Burien, and West Seattle (corridor 23)
- Downtown Seattle and Edmonds via Ballard, Shoreline Community College (corridor 24)
- West Seattle and Ballard via Central District, Queen Anne (corridor 25)
- Edmonds to Lynnwood Link (corridor 26)

The impacts for each mode would be similar to those described above as part of the light rail and BRT sections. Where dedicated guideways, frequent service, and supportive land use patterns exist, land use impacts for light rail and BRT would be similar if BRT would operate in exclusive guideways. If BRT lanes were added to existing roadways, such as SR 99, impacts to residential, commercial, or other land uses could occur.

Additional support facilities, depending on the mode selected, could include stations, park-and-ride facilities, traction power substations, maintenance facilities, and pedestrian and bicycle access.

4.9.4 Construction impacts

Current Plan Alternative

Temporary land use impacts could occur as a result of construction easements and staging areas. Construction could also temporarily affect nearby land uses. Temporary construction impacts would include disruption of local traffic patterns and access to residences and businesses; increased traffic congestion; and increased noise, vibration, and dust. While implementation can last multiple years, heavy civil construction, which is the most disruptive, would only occur during a portion of the overall construction period. Regional express bus facilities or BRT could require substantially less construction time, as would commuter rail on existing tracks. Those corridors and modes with elevated and at-grade facilities involving the development of new or substantially expanded rights-of-way, such as light rail, would be expected to have higher impacts than those within existing rights-of-way or those that include belowground segments. Although some businesses could experience hardship during construction, this would not affect the land use type unless the property became vacant.

Sites would be needed to stage construction activities, load and unload trucks, store equipment and materials, and allow for parking of construction workers. Where possible, depending on the scale of the construction at a specific location, construction staging could be located on property proposed for use by that mode, but other sites along a corridor could be used where the area is not sufficient. Corridors and modes that include belowground segments could have fewer construction impacts if mined, except at stations and portals, whereas cut-and-cover construction would have greater impacts to adjacent uses.

Potential Plan Modifications Alternative

Generally impacts would be similar within each corridor and mode as the Current Plan Alternative, although the magnitude of the impacts would be greater because of the larger amount of construction activity. Temporary construction impacts would include disruption of local traffic patterns and access to residences and businesses; increased traffic congestion; and increased noise, vibration, and dust. However, the potential for greater land use impacts could increase because of the broader scope of actions across a wider geography.

4.9.5 Potential mitigation measures

The Current Plan Alternative and the Potential Plan Modifications Alternative could have long-term impacts to land use, such as property acquisitions, displacements, and land use conversion to a transportation use. In general, implementation of transit in any of the corridors would emphasize design, planning, and engineering to avoid or minimize impacts, including displacements. Where property acquisition and displacements would be unavoidable, Sound Transit would provide relocation assistance and advisory services. The relocation program would follow Sound Transit's Real Property Acquisition and Relocation Policy, Procedures, and Guidelines. Sound Transit would comply with state law (Chapter 8.26 RCW and Chapter 468-100 WAC) and federal law (42 USC 4601–4655 and 49 CFR 24) when acquiring real property and relocating residents and businesses. Under this

policy, relocation experts would explain all relocation benefits available to displaced individuals and businesses.

Although all disturbances to adjacent land uses during construction cannot be avoided, construction impacts are not expected to cause substantial changes in land use and specific mitigation related to land use is not required. Mitigation measures related to construction impacts are discussed in representative sections of this Final SEIS (e.g., Air Quality, Noise and Vibration, Transportation, Visual Quality and Aesthetic Resources, Parks and Recreation, and Public Services and Utilities Sections).

4.9.6 Significant unavoidable adverse impacts

Significant unavoidable adverse land use impacts are not expected. However, unavoidable land use impacts could occur in some corridors and with some modes. Permanent land use changes could occur where displacements and land acquisition are necessary for implementation under either the Current Plan Alternative or the Potential Plan Modifications Alternative.

4.10 Public services and utilities

This section describes types of existing public services and utilities in the Plan area and potential impacts and mitigation for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, potential impacts for these alternatives are qualitatively described based on broadly defined corridor locations. The actual number of public services and utilities affected, the anticipated level of potential impact, and measures to avoid and minimize impacts would be determined during future project-level planning and environmental reviews.

4.10.1 Affected environment

Public services and utilities in the Plan area include fire protection and police services, schools, health and emergency services (including hospitals), postal services, solid waste, sanitary sewer, storm drainage, and water supply. There are also natural gas lines, petroleum and steam pipelines, telecommunications systems, and electric utilities.

Each of the counties in the Plan area has a solid waste division to implement its Solid Waste Management Plan. This plan covers all aspects of waste management, from curbside collections and recycling to long-term monitoring of landfills. Sanitary and storm sewer service in the Plan area is provided by cities, counties, special purpose districts, and tribal nations. Most collection systems are within roadway rights-of-way, connecting to major treatment plants located throughout the region. Water is supplied by either public or private providers. Public water sources include municipalities and water districts. Private water systems are usually located in non-urbanized areas. Many of the major water supply distribution lines, particularly in urban communities, are located underground within roadway rights-of-way.

Utility providers within the Plan area include municipal agencies, public utility districts, and private companies. In addition to public or municipal utility providers, such as cities with water or sewer utilities, there are electrical power, natural gas, and telecommunications service providers. A Puget Sound Energy natural gas power plant is located near Fredrickson, southeast of Tacoma, in the vicinity of 176th Street E. There is a petroleum product

pipeline located along the eastern portion of the Plan area; it traverses the Plan area from the vicinity of Redmond to approximately Bellevue and again from the vicinity of Renton to approximately Spanaway. King County Wastewater Treatment Division's Eastside Interceptor runs along the majority of the Eastside Rail Corridor.

Some natural gas inter/intrastate pipelines are also located in the Plan area. The Olympic Pipeline traverses the eastern side of the Plan area in the vicinity of Sammamish and reenters the Plan area in the vicinity of Auburn to approximately Spanaway. The Olympic Pipeline is a 400-mile-long interstate pipeline system that includes 12-inch, 14-inch, 16-inch, and 20-inch pipelines. The pipeline runs along a 299-mile corridor from Blaine, Washington, to Portland, Oregon. The system transports gasoline, diesel, and jet fuel. Two east-west natural gas pipelines are located in the Plan area—one in the vicinity of 180th Street SE to approximately the northern junction of I-5 and I-405 in Lynnwood and the other in the vicinity of Maple Valley Highway in Renton.

Two major (345 kilovolts (kV) or more) high voltage electric transmission lines are located in the Plan area. One line is in the vicinity of Renton, running approximately east–west to the junction of I-405 and SR 167 in the Plan area. The other is a 500-kV line that runs east–west across the Plan area from Federal Way, crossing I-5 in the S. 320th Street vicinity, to Covington; this same alignment also contains a 230-kV electric transmission line.

The following additional lower voltage lines also are located in the Plan area:

- 115-kV line crossing I-5 slightly north of SR 526 in the vicinity of Everett.
- 230-kV line located near Redmond in the vicinity of Willows Run Golf Club.
- 115-kV line running east-west through Tukwila.
- 230-kV line (Talbot-O'Brien) ending near the vicinity of the junction of I-405 and SR 167, running southeast out of the Plan area.
- 230-kV line entering the Plan area in the vicinity of Auburn at SR 18 and traveling southwest until it reaches Kersey Way SE, where it straightens out and runs south until reaching SR 410 and runs southwest again until it reaches the vicinity of SR 7 in Spanaway where it runs straight south out of the Plan area. Two lines (one of which is 230 kV and the voltage of the other is unlisted) branch off of the original 230-kV line in the vicinity of 176th Street SE in South Tacoma. These two lines run generally north across SR 512 to Pipeline Road E.

Emergency services include fire, safety, and police services, which are provided by cities, counties, and special purpose districts throughout the Plan area and by the State Highway Patrol. Individual jurisdictions may have their own police and fire departments or may contract with other jurisdictions, such as adjacent cities or their county, to provide the services.

Major hospitals are located in the Plan area, with the highest concentrations found within the major metropolitan cities of Seattle, Bellevue, Tacoma, and Everett. Each county also provides a variety of non-hospital social services and health care facilities.

Public schools and school districts provide primary and secondary education from grades K-12. School districts range in geographic coverage from large districts encompassing several cities or areas of counties to districts that occur largely within a single city. Many school districts use a combination of transportation services for their students, operating school bus fleets on designated routes typically for grade school children. In areas where public transit is unavailable, school bus routes also serve higher grade levels. In addition to public schools, private and post-secondary schools are located within the Plan area.

4.10.2 Long-term impacts

Current Plan Alternative

The Current Plan Alternative would continue to increase mobility within the Plan area by providing people with additional transportation services and options. This increased mobility would lead to increased access to services such as medical and educational facilities, libraries, post offices, community centers, and social service centers that would benefit public service providers. However, access to specific public services and the movement of police, fire, or emergency medical services could be limited if new rights-of-way restrict access to particular areas or if traffic to park-and-ride facilities and stations substantially increases levels of congestion. (See Chapter 3 for more information on the effects of the alternatives on the transportation network, including local streets.) Overall, long-term impacts on utility services and systems are expected to be minimal.

None of the Current Plan Alternative corridors are in the vicinity of the natural gas power plant near Frederickson. In addition, while some of the improvements in the Current Plan Alternative would use electricity, consumption of these resources is not expected to impact operation of this facility.

Light rail

Corridors that include exclusive or partially exclusive new at-grade rights-of-way for light rail would have the highest potential to affect existing access and circulation. Elevated light rail would have a lower potential to affect access and circulation. Below-ground light rail would only affect access and circulation at surface facilities, such as access areas to belowground stations and portal areas where an underground light rail facility might surface.

Where light rail vehicles cross surface streets at-grade, operations could increase the potential for accidents with pedestrians or other vehicles, including buses, personal vehicles, and bicycles. These at-grade street crossings could also affect emergency and incident response routes or times. Increased congestion at station areas and park-and-ride facilities could also affect response times. Light rail improvements in areas of at-grade street crossings would include design considerations to minimize such impacts through measures such as signage and signal prioritization. Mitigation measures are discussed further in Section 4.10.4.

Additional police and security staff could be needed to monitor existing and proposed stations, park-and-ride facilities, and other areas to protect people and property. Sound Transit operates its own security force within its facilities.

Quality-of-life crimes, including vandalism, drunkenness, and panhandling, and property crimes account for more than 90 percent of transit facility crimes, with violent crimes accounting for most of the remaining crimes. Crimes are more likely to occur at a station than in a light rail vehicle, and stations with park-and-ride facilities have more potential for crime than stations without parking. Different types of station access (stairs, escalators, or elevators) do not necessarily influence criminal activity, but their design and location can be a factor if the station access provides places where criminals can act without being observed by others. Any new stations would include numerous features to address security issues, which are discussed further in Section 4.10.4.

It is not anticipated that light rail and its supporting facilities would substantially increase demand for solid waste services.

Light rail could conflict with existing utilities. The potential for conflicts occurs wherever a light rail alignment or associated feature would cross, run under, or limit access to an existing utility, such as electric lines, water, stormwater, or sewer lines, and telecommunications (cable and fiber optic) utilities. Utility conflicts would be addressed by avoiding the conflict or by relocating the utility; as a result, no long-term impacts to utilities are expected.

Major disruptions in utility service also would be unlikely as a result of light rail operations or maintenance. If there were a major disruption during light rail operations or maintenance, transit users could be affected (e.g., a light rail vehicle could become inoperable and would need to be evacuated), but Sound Transit's design standards ensure that plans would be in place to address any potential impacts as a result of such disruptions and other concerns.

The operation of light rail facilities would place a demand on electrical utilities because the light rail system would draw power from the regional electrical power grid. However, the power demands of the light rail system should not impact the ability of electrical utilities to meet overall demand in their service areas. The potential exists that electrical utilities could require upgrades to support the operation of light rail facilities. Tunnels for light rail facilities would require more electricity, and longer corridors would require more electricity than shorter ones. To distribute power along the corridor, traction power substations would provide power to the overhead contact system that powers the light rail vehicles. These substations would be powered by electric lines connected to the nearest power pole. Without control measures, a portion of the electrical current flowing through the light rail vehicles could stray into a buried pipe or cable, then flow along conducting utility lines in the ground back to the traction power substation. To avoid this issue, Sound Transit would coordinate control measures with entities that own and operate the utility lines that could be affected and select BMPs appropriate for the circumstances.

For the Current Plan Alternative, no light rail corridors cross the petroleum product pipeline located along the eastern portion of the Plan area; it traverses the Plan area from the vicinity of Redmond to approximately Bellevue and again from the vicinity of Renton to approximately Spanaway. Corridors D and H cross natural gas inter/intrastate pipelines. The Current Plan Alternative is not expected to impact the petroleum product

pipeline or the natural gas pipelines. Once verified, the pipelines could be avoided or relocated. The electric transmission line in the vicinity of Renton does not cross any of the corridors in the Current Plan Alternative; therefore, there is no potential for impacts to that line. The transmission line in the vicinity of Federal Way crosses corridor B. Corridor B could be elevated, however, so the final design would account for the transmission line's location to ensure there would be no impacts to the line and that the clearance requirements and compatible uses are met.

Commuter rail

The Current Plan Alternative contains two commuter rail corridors and both would be accommodated within existing rail rights-of-way. These corridors would have a moderate potential for adverse impacts to public services and utilities because there is existing rail service along these tracks. Where these at-grade commuter rail corridors cross surface streets, an increase in rail operations along these existing tracks could increase the potential for accidents with pedestrians or other vehicles, including buses, personal vehicles, and bicycles; this potential currently exists, but with additional trains using these tracks, the potential could increase. An increase in rail operations along these existing tracks could result in more frequent at-grade street crossings that could also affect emergency and incident response routes or times. Commuter rail improvements in areas of at-grade street crossings would include design considerations to minimize impacts to the extent possible through measures such as signage and signal prioritization. Increased congestion at station areas and park-and-ride facilities also could affect response times.

In the Current Plan Alternative, no commuter rail corridors cross the petroleum product pipeline or the natural gas inter/intrastate pipelines or the electric transmission lines; therefore, these facilities would not be affected.

Similar to light rail, additional police and security staff could be needed to monitor stations, parking facilities, and other areas to protect people and property. Sound Transit operates its own security force within its facilities, and its system principles and guidelines are designed to ensure safety and security throughout the commuter rail system.

Regional express bus/bus rapid transit

Additional regional express bus routes using existing facilities where buses currently operate would have little potential to generate additional impacts. BRT facilities could impact public services and utilities. Where regional express or BRT facilities would be accommodated within existing freeway rights-of-way, the potential for impacts would be low. Vehicles already travel along these roadways, and additional buses are not likely to impact utilities or public services. In the case of BRT that would operate on a dedicated lane, it could be necessary to construct an additional lane in each direction. This construction would likely require grading and other improvements that could impact utilities, as discussed in Section 4.10.3.

In the Current Plan Alternative, corridor N crosses the petroleum product pipeline roughly in the vicinity of Edgewood, and corridors N, P, Q, and S cross natural gas inter/intrastate pipelines. However, impacts to these utilities are not expected. Once

verified, the pipelines could be avoided or relocated. The 115-kV transmission line in the vicinity of Everett crosses corridor S. The two transmission lines in the vicinity of Federal Way cross corridors M and N. These BRT corridors could require roadway widening, although this is not expected to impact an overhead transmission line unless the widening conflicts with associated towers or utility poles.

High-capacity transit (mode not specified)

Corridors K and L, both HCT corridors, could be selected as light rail or BRT corridors. If so, the impacts generally would be similar to those described for the other light rail or BRT corridors. However, neither of these corridors crosses the petroleum product pipeline, the natural gas inter/intrastate pipelines, or are in the vicinity of any of the electric transmission lines.

Potential Plan Modifications Alternative

Long-term impacts resulting from the Potential Plan Modifications Alternative would be similar to impacts associated with the Current Plan Alternative by mode as described above.

The Potential Plan Modifications Alternative would not impact the natural gas power plant in the vicinity of Fredrickson; corridors 5, 21, and 34 are near the natural gas power plant, which is roughly southeast of the intersection of 128th Street East and Canyon Road East. Corridors 18 and 28 are near a petroleum pipeline but would not likely result in any direct effects to the pipeline or service. During future project-level design and environmental review, major utilities would be avoided to the extent practicable. In addition, while some of the improvements in the Potential Plan Modifications Alternative would use electricity, impacts to the operation of the power plant are not expected.

Light rail

Impacts to public services and utilities from light rail would be similar to those described in the Current Plan Alternative. However, because the Potential Plan Modifications Alternative has a broader scope of potential actions across a broader geographic area, this could result in greater overall impacts.

In the Potential Plan Modifications Alternative, corridors 5 and 7 cross the petroleum product pipeline and corridors 5, 7, and 12 cross natural gas inter/intrastate pipelines. However, impacts to these pipelines are not expected. Once verified, the pipelines would be avoided or relocated. The electric transmission line in the vicinity of Renton does not cross any of the corridors in the Potential Plan Modifications Alternative so there is no potential for impacts to that line. The transmission line in the vicinity of Federal Way crosses corridor 7. Two of the 230-kV lines in the southern portion of the Plan area cross corridor 5 twice. Corridor 7 could be elevated, so the final design would account for the transmission line to ensure there would be no impacts to the line and that the clearance and compatible use requirements would be met.

Commuter rail

Impacts to public services and utilities from new commuter rail corridors would be similar to those described in the Current Plan Alternative. The Potential Plan Modifications Alternative contains three commuter rail corridors, two of which would be accommodated within existing rail rights-of-way.

In the Potential Plan Modifications Alternative, corridor 21 crosses the petroleum product pipeline and corridor 19 crosses natural gas inter/intrastate pipelines. However, impacts to these pipelines are not expected because there are existing tracks along these corridors. In addition, once verified, the pipelines could be avoided or relocated, if necessary. Corridor 21 is crossed by four electric transmission lines—three 230-kV lines and one of unknown voltage. This commuter rail corridor would operate on existing tracks on which rail currently operates; therefore, impacts to the transmission lines are not expected.

Regional express bus/bus rapid transit

Impacts to public services and utilities from BRT and regional express bus in the Potential Plan Modifications Alternative would be similar to those described for the Current Plan Alternative.

Corridor 33 crosses the petroleum product pipeline and corridor 27 and 34 cross natural gas inter/intrastate pipelines. However, impacts to these pipelines are not expected. Once verified, the pipelines could be avoided or relocated. The transmission lines in the vicinity of Federal Way cross corridors 32 and 33, and corridor 27 is crossed by two 230-kV lines in the southern portion of the Plan area. These BRT corridors could require roadway widening, although this is not expected to impact an overhead transmission line unless the widening conflicts with associated towers or utility poles.

Streetcar

Corridors that include exclusive or partially exclusive new rights-of-way for streetcar operations could affect existing access and circulation. Where streetcar facilities would cross streets, operations could increase the potential for accidents with pedestrians or other vehicles, including buses, personal vehicles, and bicycles. Streetcar improvements at street crossings would include design considerations to minimize the potential for such impacts through measures such as signage and signal prioritization. These street crossings could also affect emergency and incident response routes or times. However, Sound Transit would coordinate with service providers to mitigate such potential effects.

Impacts to utilities for streetcar facilities would be similar to those described for light rail. Streetcar operations would also draw power from the regional electrical power grid. Utility lines that cross streets, both above and below ground, could be relocated. Because streetcar facilities would be entirely at-grade, there is a greater potential for these corridors to require utility relocations than for light rail. Streetcars, like light rail, would use traction power substations to provide power to the overhead contact system that powers the streetcar. As a result, streetcars have a similar potential to impact utilities in regard to stray current. However, this issue would be considered during final design, and control measures, BMPs, and coordination with utility providers would minimize potential impacts.

High-capacity transit (mode not specified)

Corridors 22 through 26 could be selected as either light rail or BRT corridors. The impacts generally would be similar to those described for the other corridors of the same mode. None of these corridors cross the petroleum product pipeline, the natural gas inter/intrastate pipelines, or are in the vicinity of any of the electric transmission lines.

4.10.3 Construction impacts

Current Plan Alternative

Traffic rerouting, lane closures, and construction traffic could affect emergency response times and travel times or routes for public service vehicles during construction periods, particularly at stations or construction sites. This could require emergency responders to alter their response routes or it could increase their response times.

Construction could have short-term impacts on some public services. Access to public services near construction sites could be temporarily impeded by traffic restrictions, displacement of parking or loading areas, road closures for construction and utility relocation, or other factors. Some services could require permanent relocation, although the magnitude of this impact would be determined during project-level planning and review. Public services could also be affected by the disruption of utility services due to outages. Emergency vehicles could be temporarily impeded along or across roadways directly involved in construction or on adjacent roadways as a result of increased congestion. Additional police support could be required to direct and control traffic during construction in areas with high traffic volumes. Construction would also generate waste, which would require solid waste disposal services. The magnitude of the disposal services required would depend on the amount of construction.

Construction impacts would vary by alternative and could require relocation of existing utilities, although major utilities would be avoided to the extent practicable. Some electrical utilities could require upgrades to facilities and equipment or expansions in their service areas in order to provide service to light rail and streetcar corridors. The design of some underground utilities near belowground corridors and stations could be modified. Portions of corridors C, F, G, and K could be constructed in either cut-and-cover or bored tunnels, and the potential for conflicts with underground utilities would be greater in those areas. Bored tunnels are generally deeper than cut-and-cover tunnels; therefore, they would have less potential to affect underground utilities than cut-and-cover tunnels. Some utility relocations and modifications could temporarily disrupt service, although these disruptions would be minimized by the provision of temporary connections during construction. Outages for switchovers to temporary connections would be scheduled and announced. Disruption or reduction of water for emergency fire services would not be allowed. Construction could also unintentionally disrupt water, electrical, communications, or other utility services, although such unplanned disruptions would likely be minor. Major disruptions in utility service would be unlikely because construction activities would be coordinated with utility providers; the locations of utilities would be determined during preconstruction; and proper construction techniques would be used to avoid such impacts.

Cut-and-cover construction of belowground corridors and stations would generate greater impacts to belowground utilities, such as those that are piped or buried.

Construction of elevated light rail requires deep foundations for columns, and construction of at-grade light rail and roadway widening for BRT improvements requires in-street work. Therefore, construction of light rail or BRT has the potential to result in the types of impacts described above. Overhead utilities could be affected by the construction and

placement of elevated guideways and require relocation. Commuter rail and regional express bus improvements would have fewer construction impacts to utilities because they would largely occur in existing rail and street rights-of-way.

Potential Plan Modifications Alternative

Construction impacts would be similar to those described for the Current Plan Alternative. However, the Potential Plan Modifications Alternative, because of its broader scope of potential actions across a broader geographic area, could result in greater overall impacts.

Potential long-term impacts would depend on the specific transit improvements. Construction impacts to utilities would be comparatively higher with the introduction of new light-rail corridors not included in the Current Plan Alternative. Impacts would also be higher for light rail in corridors identified as being otherwise developed for regional express bus because light rail would require construction as described above while regional express bus would operate on existing roadways. Construction of at-grade light rail and streetcars generally requires the relocation of utilities to avoid future conflicts. Portions of corridors 2 and 14 could be constructed in a tunnel, and the potential for conflicts with underground utilities could be greater in those areas depending on whether they would be constructed as a bored tunnel or a cut-and-cover tunnel.

4.10.4 Potential mitigation measures

Public services and utilities would be studied further during project-level planning and environmental review, and some impacts could be avoided by adjusting alignments and profiles. Street closures, detours, or other temporary restrictions of street capacity would be reviewed by local jurisdictions and affected emergency services to minimize the effect on service levels. Permanent access changes for emergency service providers could be incorporated to preserve standards of service. Facility design and construction would comply with all federal, state, and local standards and would be coordinated with emergency service providers. Potential mitigation measures for impacts on solid waste services could include minimizing waste generation, promoting recycling at rail and transit stations, recycling waste generated by construction and operation, and using recycled materials and products during construction.

Pre-construction activities would include potholing and surveys to identify utility locations as well as outreach to inform customers of potential service disruptions. Construction would be closely coordinated with affected utilities, and plans would be developed to prevent or offset unexpected or emergency shutdowns. Applicable code requirements would be followed for engineering design of utilities and relocations for all utility work. Policies would also be followed related to advanced notices of changes in operations or service levels during construction activities.

During final design, Sound Transit would investigate methods of reducing energy use during light rail operations and construction as part of its Sustainability Plan and agency-wide sustainability efforts. Sound Transit adopted a Sustainability Initiative in 2007 that promotes energy efficiency, minimizes waste, and implements more energy-efficient alternatives than current practices. According to the initiative, Sound Transit will integrate efficient operating practices at existing and new facilities, use energy-saving equipment to reduce energy demand, and maximize intermodal transit connections to reduce automobile usage.

Crime prevention measures would be analyzed at the project level and would be developed in coordination with local jurisdictions. Final designs would incorporate Crime Prevention Through Environmental Design principles. These principles, in association with other security features of the light rail system and the presence of security personnel, would deter criminal activity and generally make transportation facilities safer and more secure.

Crime Prevention through Environmental Design (CPTED)

CPTED is an approach to deterring criminal behavior through environmental design that implements strategies that rely on the ability to influence the decisions that precede criminal acts.

Sound Transit's design standards directly address emergency access throughout transportation facilities and evacuation of passengers, if needed. The standards also include many principles and guidelines designed to ensure safety and security throughout transportation systems, such as design requirements for lighting, unobstructed views, pedestrian safety, elevators and escalators, public plazas, patron information centers, public telephones, call-for-aid stations, emergency management panels, security cameras, vandalism deterrents, public address systems, radio communications, and alarms. In addition, transportation vehicle operators receive emergency response training. Lastly, Sound Transit police, police from local jurisdictions, and Sound Transit security personnel regularly patrol all transportation facilities; Sound Transit develops emergency response and safety and security plans and programs in cooperation with local jurisdictions.

4.10.5 Significant unavoidable adverse impacts

Significant unavoidable adverse impacts to public services and utilities are not expected with either the Current Plan Alternative or the Potential Plan Modifications Alternative.

4.11 Parks and recreation

This section describes existing parks and recreation facilities in the Plan area and potential impacts and mitigation for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, potential impacts for these alternatives are qualitatively described based on broadly defined corridor locations. For analysis purposes, the study area for these corridors varies in width by mode as described in the introduction to this chapter. While the number of parks and recreation resources within each study area are provided, it does not represent the number of resources that would be impacted if a corridor were implemented. The number of parks and recreation facilities affected, the anticipated level of potential impacts, and measures to avoid and minimize impacts would be determined during future project-level planning and environmental reviews.

4.11.1 Regulatory environment

Since the mid-1960s, federal transportation policy has reflected an effort to preserve the beauty and integrity of publicly owned parks and recreation areas, waterfowl and wildlife refuges, and historic sites considered to have national, state, or local significance. Section 4(f) refers to the original section within the U.S. Department of Transportation Act of 1966 that established the requirement for consideration of parks and recreational lands, wildlife and waterfowl refuges, and historic sites of federal, state, or local significance in transportation project development. The law (49 USC 303 and 23 USC 138) is implemented by the FTA

through 23 CFR 774. Section 4(f) coordination and analysis would occur during future project-level planning and environmental reviews.

In addition, when federal funds granted through Section 6(f) of the Land and Water Conservation Act (administered through the Washington State Recreation and Conservation Funding Board on behalf of the National Park Service) have been used to acquire or develop recreational facilities in a project's study area, all practical alternatives to the project element that would affect that facility must be evaluated or, if no practical alternative exists, replacement lands of equal value must be identified. This state funding agency also administers other grants, referred to as "RCO," that are subject to similar requirements for conversion as Section 6(f) without requiring approval from the National Park Service.

4.11.2 Affected environment

Publically available GIS data were compiled to create a database of public parks and recreation facilities in the Plan area. The parks and recreation facilities in the GIS database, which exceed 1,300, include a wide variety of open space areas, sports fields, trails, and water-oriented facilities. A list of parks and recreation facilities within the Plan area is included in Appendix G.

Geographic information systems data sources

- Snohomish County
- King County
- Pierce County
- City of Everett
- City of Mountlake Terrace
- City of Redmond
- City of Lake Forest Park

Except for the school district play areas (that are available for public use during non-school hours), parks and recreation facilities are generally owned or maintained by the parks and recreation departments of the cities in the Plan area. Snohomish, King, and Pierce Counties, Washington State, UW, and the Port of Seattle also own and maintain such facilities in the Plan area.

A few of the existing parks and recreation facilities noted in Table G-1 (Appendix G) are part of the Olmsted Plan for Seattle's parks, boulevards, and playgrounds. As can be seen in the figures of this section, the Plan area contains a wealth of parks and recreation facilities.

Some parks in the corridor study areas may be considered noise-sensitive, particularly those that are used for passive recreation. Most parks, however, including those used primarily for active recreation, would not be considered noise-sensitive.

4.11.3 Long-term impacts

Long-term impacts to parks and recreation facilities could occur from direct or indirect uses of park property. A direct use occurs when land is permanently incorporated into a transportation facility through acquisition of all or part of a park property. Direct uses can also include reducing available parking as well as permanent maintenance easements. The potential for direct impacts from property acquisition are dependent on the amount of additional rights-of-way typically required for a particular transit mode and the degree to which impacts to parks and recreation facilities can be avoided in a corridor. Some corridors can be constrained by dense development or other sensitive resources that affect the degree to which either avoidance or minimization measures are practicable and reasonable.

In the case of indirect effects, the impact is not related to acquisition of park property but rather a result of being close enough to a park or recreation facility so as to severely impact important features, activities, or attributes associated with the park or recreation facility and to substantially impair it. Depending on the uses of a park, indirect effects could include noise impacts if the park is noise sensitive. Other indirect effects could include access restrictions (for either automobiles or pedestrians), vegetation removal, or, in cases where scenic qualities are considered important features, changes to the visual setting or obstructing a scenic view.

Given the high density of parks and recreation facilities in King County, transportation improvements in this county generally have a higher likelihood of impacting parks and recreation facilities, regardless of mode.

Both alternatives under consideration could require acquisition of all or a portion of a park or recreation facility in a new corridor where transportation uses had been less intensive or did not exist, for expansion of an existing corridor, or for infill facilities. Many light rail, commuter rail, or BRT projects would require additional property for rights-of-way, although to varying degrees. Although parks and recreation facilities would be avoided to the extent practical during the planning process, use of these properties or other direct impacts could occur, particularly when other physical constraints limit alternatives.

Transit infrastructure (e.g., light rail guideways or expanded roadway facilities) could also physically separate parks and recreation facilities from neighborhoods, thereby reducing accessibility. However, by improving regional mobility, both alternatives could increase accessibility to parks and recreation facilities for transit users, particularly those within walking distance of stations. Both alternatives could also provide offsetting benefits by helping to reduce the need for parking because transit could improve access to some park and recreation facilities. Both alternatives could also result in indirect effects, such as those described above, but the degree to which those effects would impact a park or recreation facility would depend on the nature and intended use of the park or recreation facility.

Current Plan Alternative

The potential impacts of the Current Plan Alternative are described below by mode. Table 4-29 shows the number of parks and recreation facilities within the study area for each of the corridors included in the Current Plan Alternative. The locations of these resources are shown in Figure 4-39 and Figure 4-40. The numbers shown in Table 4-29 do not represent an estimate of the number of parks and recreation facilities that would be impacted if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors.

Light rail

Development of light rail in some of the corridors could require property acquisition for rights-of-way, both for the guideway and support facilities. Light rail stations with park-and-ride facilities in suburban environments on average require approximately 2 to 8 acres of land. Although parks and recreation facilities would typically be avoided during the planning process, use of these properties or other direct impacts could occur, particularly when additional physical constraints limit alternatives.

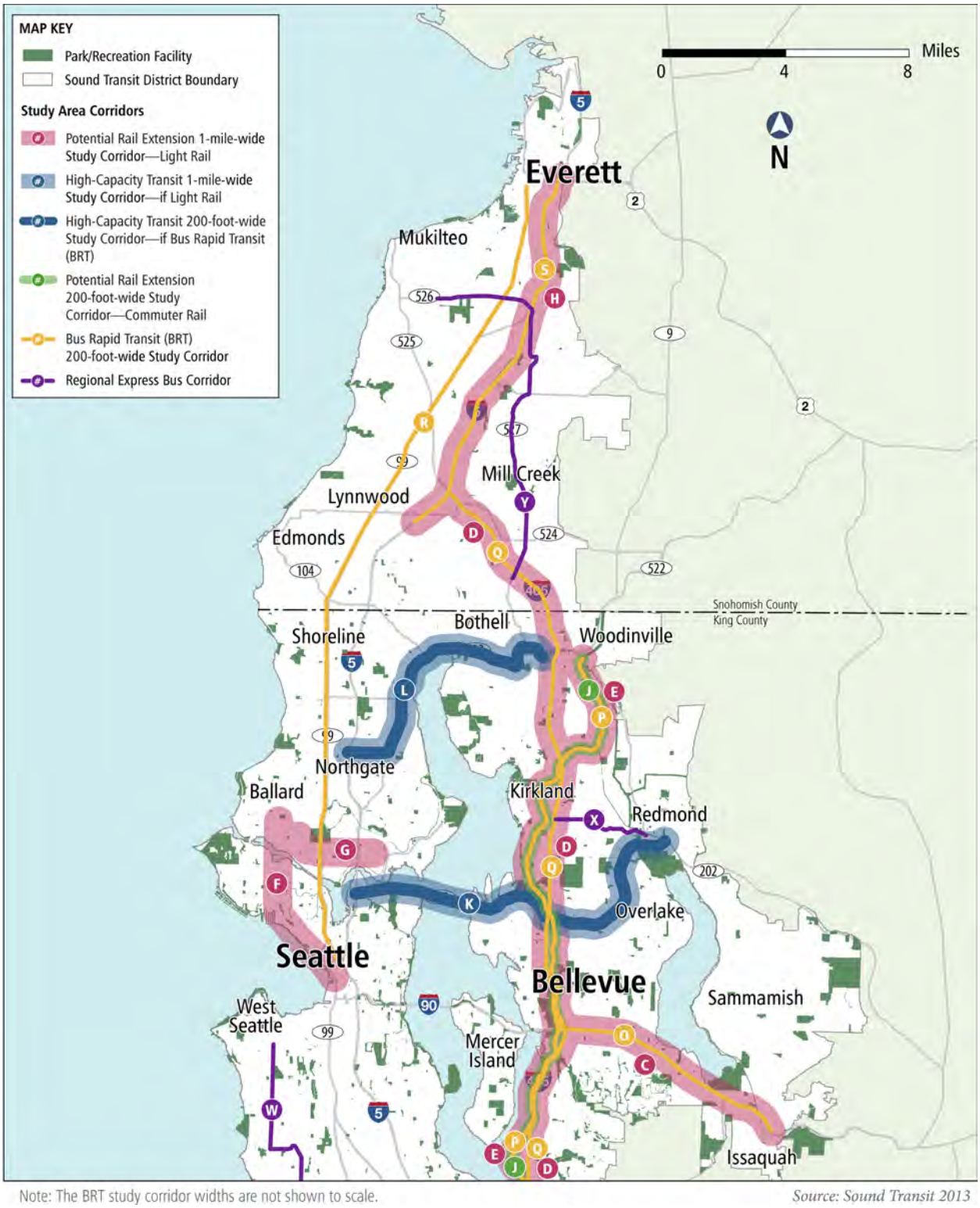
Table 4-29. Parks and recreation facilities for Current Plan Alternative study corridors

ID	Current Plan Alternative study corridor location	Approximate length of corridor (miles)	Number of parks and recreation facilities[1]
Potential rail extensions, assumed light rail: 1-mile-wide study area			
A	Tacoma to Federal Way	10	18
B	Burien to Renton	8	32
C[2]	Bellevue to Issaquah along I-90	10	27
D	Renton to Lynnwood along I-405	28	63
E	Renton to Woodinville along Eastside Rail Corridor	22	62
F[2]	Downtown Seattle to Ballard	6	44
G[2]	Ballard to UW	4	24
H	Lynnwood to Everett	13	20
Total parks and recreation facilities within potential light rail extensions study corridors[3]			222
Potential rail extensions, assumed commuter rail: 200-foot-wide study area			
I	DuPont to Lakewood	8	1
J	Renton to Woodinville along Eastside Rail Corridor	22	11
Total parks and recreation facilities within potential commuter rail extensions study corridors[3]			12
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail/200-foot-wide study area if BRT			
K[2]	UW to Redmond via SR 520	13	Light rail: 60 BRT: 14
L	Northgate to Bothell	9	Light rail: 33 BRT: 9
Total parks and recreation facilities within high-capacity transit study corridors[3]			Light rail: 91 BRT: 22
Bus rapid transit (BRT): 200-foot-wide study area			
M	Federal Way to DuPont along I-5	25	0
N	Renton to Puyallup along SR 167	21	1
O	Bellevue to Issaquah along I-90	10	3
P	Renton to Woodinville along Eastside Rail Corridor	22	11
Q	Renton to Lynnwood along I-405	28	3
R	Seattle to Everett along SR 99	27	8
S	Lynnwood to Everett along I-5	13	1
Regional express bus			
T-Y	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS	—	—
Total parks and recreation facilities within bus study corridors[3]			24

[1] These numbers do not represent an estimate of the number of resource areas that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

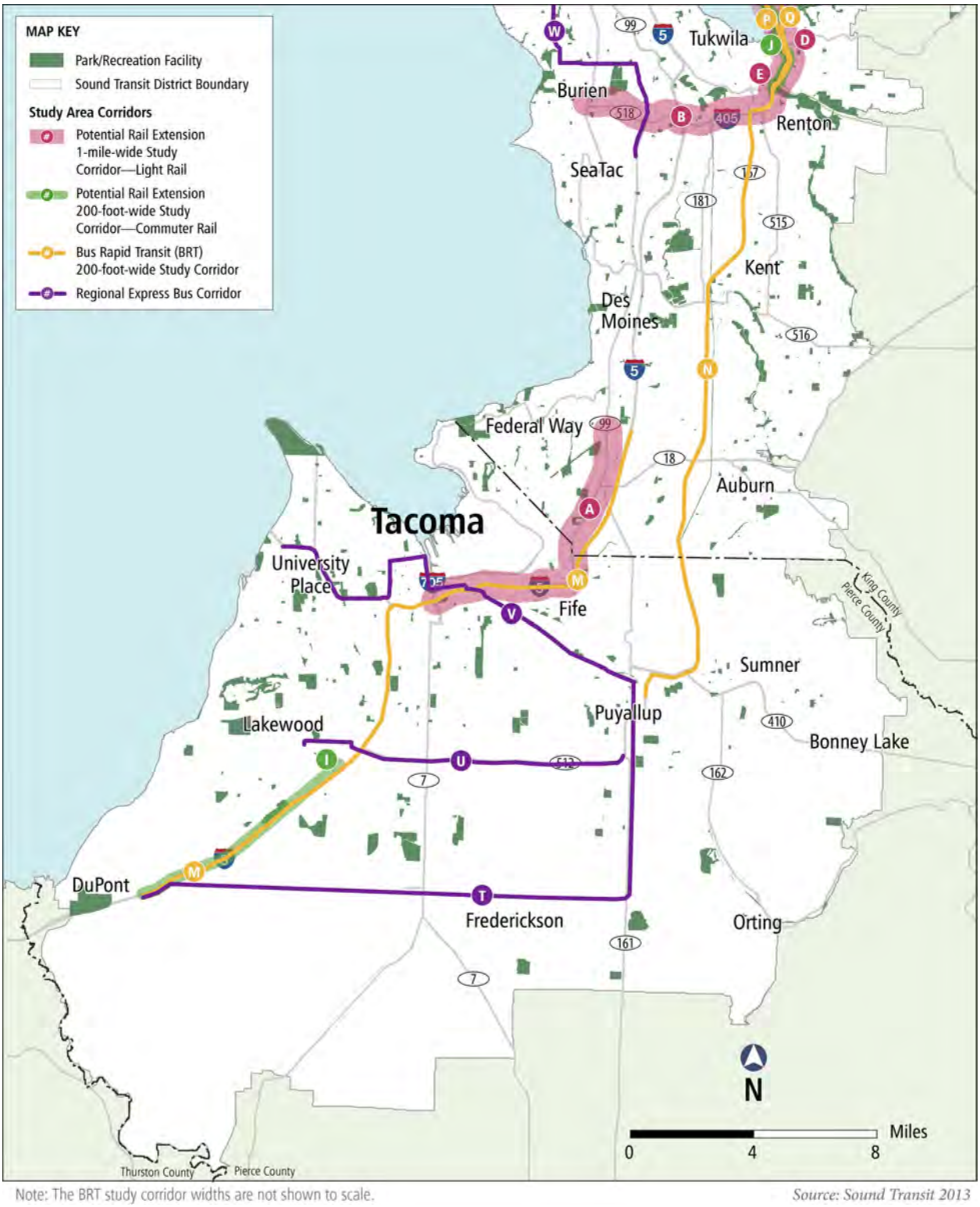
[3] Numbers include resource areas where only a portion of the resource is within the study corridor. Some resource areas may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-39. Parks and recreation facilities for Current Plan Alternative study corridors—north



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-40. Parks and recreation facilities for Current Plan Alternative study corridors—south

In Snohomish County, parks and recreation facilities in the study area for corridor H include Martha Lake Park, McCollum Pioneer Park, and the Interurban Trail. Parks in King County include Lake Sammamish State Park (corridor C), North SeaTac Park, and the adjacent Sunset Playfield (corridor B). Corridors D and E are extremely close in proximity and length, and share roughly 40 of the approximately 60 parks and recreation facilities in their study corridors, including Gateway Park, Heronfield Wetlands, Liberty Park, Newcastle Beach Park, and Watershed Park, all of which are located in King County. In Pierce County, the study area for corridor A includes Celebration Park, Hylebos Wetlands, and West Hylebos Wetlands Park. Along with corridors D and E, the study area for corridor F contains a fairly high number of parks and recreation facilities with just over 40. Study area for corridors A and H contain the fewest, with about 20 each. Corridors F and G contain particularly high concentrations of parks and recreation facilities given their relatively short lengths of 6 and 4 miles, respectively. This is likely because these corridors are located in King County, which has a high density of parks and recreation facilities.

Light rail could increase noise levels and elevated structures could create a visual barrier that could change views from and within some parks and recreation facilities, as described earlier. Portions of corridors C, F, and G could be constructed in cut-and-cover or bored tunnels, which would avoid park impacts in those areas. In addition, many parks and recreation facilities could potentially be avoided during project-level planning and preliminary engineering for light rail alignments.

Light rail infrastructure and support facilities, such as stations, park-and-ride facilities, and maintenance facilities, could also have similar impacts.

Commuter rail

Two commuter rail corridors are included in the Current Plan Alternative. The Tacoma Country and Golf Club occurs in the study area for corridor I. The study area for corridor J contains approximately 10 parks and recreation facilities, including the Sammamish River Trail Site and Newcastle Beach Park. Because commuter rail generally would use existing tracks, there would be a low potential for right-of-way acquisition. In addition, it is unlikely there would be a substantial increase in noise levels or visual effects as a result of the use of existing tracks.

Regional express bus/bus rapid transit

Additional regional express bus routes using existing facilities where buses currently operate would have little potential to generate additional impacts. For those BRT corridors where additional rights-of-way would be required for new dedicated bus lanes, there could be impacts to parks and recreation facilities similar in nature to light rail. Although impacts to parks and recreation facilities would typically be avoided in the planning process, use of these properties or other direct impacts could occur, particularly when other physical constraints limit alternatives. However, given the rather small numbers of parks and recreation facilities found within the study area for these corridors, the impacts to parks and recreation facilities as a result of right-of-way acquisition is expected to be low. Corridors P and R contain 11 and 8 parks and recreation facilities, respectively; all other BRT study corridors contain 3 or less.

Increased traffic or noise, or changes to the surrounding visual environment, could affect parks and recreation facilities near these corridors, but BRT corridors are generally adjacent to existing roadways so these impacts are expected to be low.

For those regional express or BRT corridors where no additional rights-of-way would be required, signal improvements and other infrastructure at intersections or arterials could add visual elements, which could change views to or from parks and recreation facilities.

High-capacity transit (mode not specified)

Corridors K and L could be selected as either light rail or BRT corridors. Light rail study areas for corridors K and L contain 60 and 33 parks and recreation facilities, respectively, while the smaller study areas for BRT corridors contain 14 and 9. Many parks and recreation facilities do not directly abut an adjacent highway, which explains the fairly substantial decrease in the amount of parks and recreation facilities in the study corridors between light rail and BRT.

Corridors K and L are both in King County and are located near parks and recreation facilities. Study corridor L is in the vicinity of Swamp Creek Park, Sammamish River Park and Sammamish River Trail Site, Blyth Park, and the Park at Bothell Landing. Corridor K crosses the Washington Park Arboretum and is in the vicinity of Fairweather Nature Preserve, Yarrow Bay Wetlands, Wetherill Nature Preserve, and the Viewpoint Park in Bellevue. In Redmond, study corridor K is in the vicinity of the Town Center Open Space, Heron Rookery Park, and Rotary Park. If selected as light rail, a portion of corridor K could be constructed in a cut-and-cover or bored tunnel, which would avoid park impacts in that area. In general, it is anticipated that project-level planning and preliminary engineering for light rail alignments in both corridors could avoid most parks and recreation facilities.

Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar impacts as those described for the Current Plan Alternative. However, because of the additional corridors in this alternative, the impacts to parks and recreation facilities could be greater than those in the Current Plan Alternative.

Table 4-30 shows the number of parks and recreation facilities within the study area for each of the corridors included in the Potential Plan Modifications Alternative. The locations of these resources are shown in Figure 4-41 and Figure 4-42. The numbers shown in Table 4-30 do not represent an estimate of the number of parks and recreation facilities that would be impacted if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors.

Similar to the Current Plan Alternative, some parks and recreation facilities could experience direct impacts as a result of property acquisition, particularly when physical constraints limit other options. In addition, indirect effects could occur. However, impacts to parks and recreation facilities would be avoided to the extent practical in the subsequent project-level planning and environmental review process.

Table 4-30. Parks and recreation facilities for Potential Plan Modifications Alternative study corridors

ID	Potential Plan Modifications Alternative study corridor location	Approximate length of corridor (miles)	Number of parks and recreation facilities[1]
Potential rail extensions, assumed light rail: 1-mile-wide study area			
1	Downtown Seattle to Magnolia/Ballard to Shoreline Community College	12	59
2[2]	Downtown Seattle to West Seattle/Burien	13	57
3	Ballard to Everett Station via Shoreline Community College, Aurora Village, Lynnwood	24	30
4	Everett to North Everett	2	6
5	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	12
6	DuPont to downtown Tacoma via Lakewood, Tacoma Mall	16	19
7	Puyallup/Sumner to Renton via SR 167	21	29
8	Downtown Seattle along Madison Street	3	38
9	Tukwila to SODO via Duwamish industrial area	11	27
10	North Kirkland or University of Washington Bothell to Northgate via SR 522	13	42
11	Ballard to Bothell via Northgate	13	43
12	Mill Creek, connecting to Eastside Rail Corridor	8	11
13	Lynnwood to Everett, serving Southwest Everett Industrial Center (Paine Field and Boeing)	7	8
14[2]	UW to Sand Point to Kirkland to Redmond	10	50
15	Downtown Tacoma to Tacoma Community College	3	12
16	Tacoma Mall to University Place	6	9
17	Steilacoom to Ruston via University Place	12	20
18	Issaquah to Issaquah Highlands	2	5
Total parks and recreation facilities within light rail study corridors[3]			355
Potential rail extensions, assumed commuter rail: 1-mile-wide study area new track/200-foot-wide study area existing track			
19	Puyallup/Sumner to Orting	8	4
20	Lakewood to Parkland	3	0
21	Tacoma to Frederickson	10	1
Total parks and recreation facilities within commuter rail study corridors[3]			5

Table 4-30. Parks and recreation facilities for Potential Plan Modifications Alternative study corridors (continued)

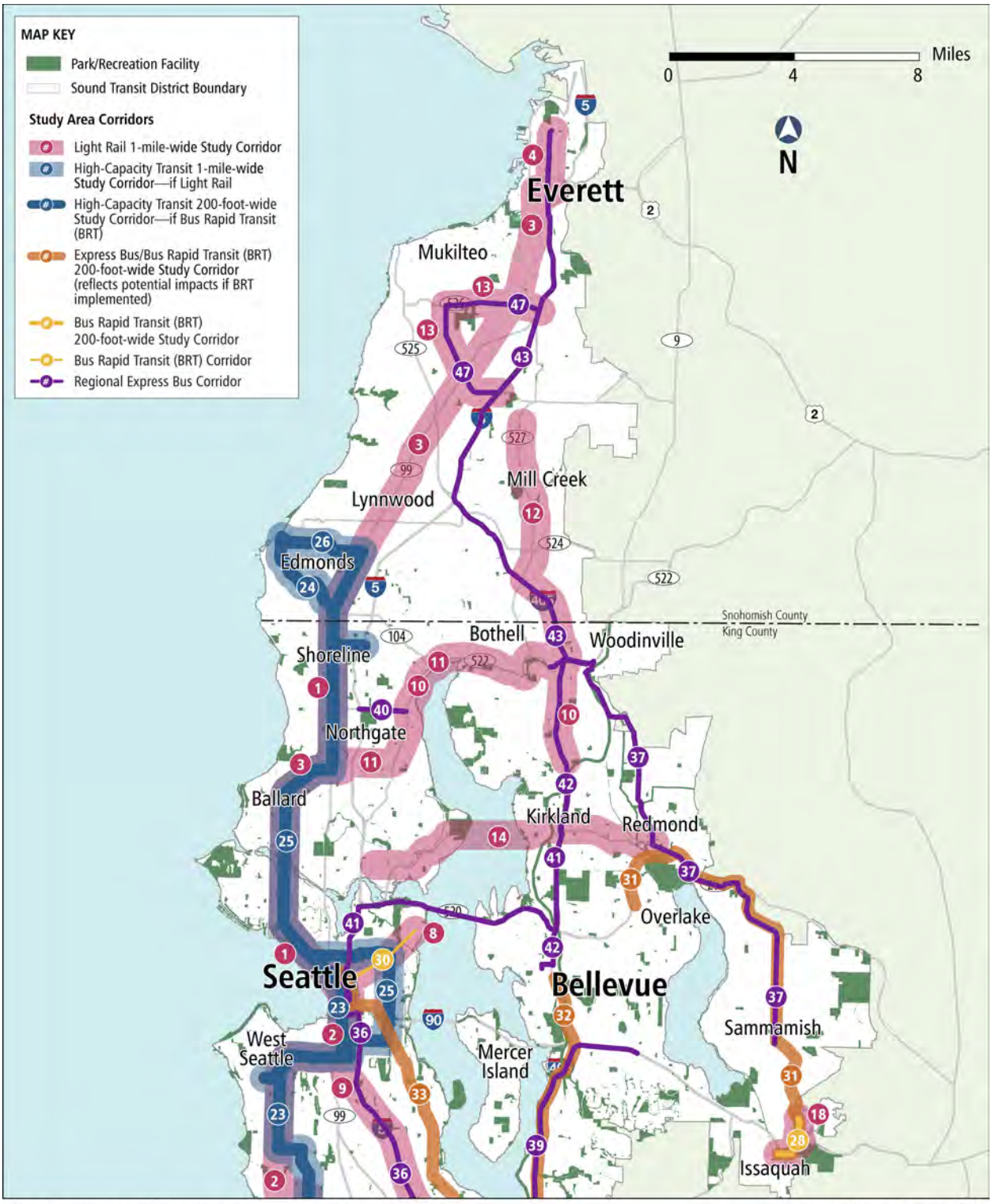
ID	Potential Plan Modifications Alternative study corridor location	Approximate length of corridor (miles)	Number of parks and recreation facilities[1]
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail/200-foot-wide study area if BRT			
22	Downtown Tacoma to Parkland	8	Light rail: 7 BRT: 2
23	Tukwila Sounder station to downtown Seattle via Sea-Tac Airport, Burien, West Seattle	15	Light rail: 56 BRT: 4
24	Downtown Seattle to Edmonds via Ballard, Shoreline Community College	19	Light rail: 62 BRT: 5
25	West Seattle to Ballard via Central District, Queen Anne	14	Light rail: 103 BRT: 15
26	Edmonds to Lynnwood Link	5	Light rail: 5 BRT: 0
Total parks and recreation facilities within high-capacity transit study corridors[3]			Light rail: 171 BRT: 23
Bus rapid transit (BRT): 200-foot-wide study area			
27	Puyallup vicinity, notably along Meridian Avenue	6	1
28	Issaquah to Issaquah Highlands	2	1
29	Kent to Sea-Tac Airport	11	2
30[4]	Downtown Seattle along Madison Street	—	—
Regional express bus/BRT (mode not specified): 200-foot-wide study area			
31	Issaquah Highlands to Overlake via Sammamish, Redmond	14	7
32	Tacoma to Bellevue	34	4
33	Puyallup to downtown Seattle via Kent, Rainier Valley	35	14
34	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	2
35	Tacoma to Frederickson	13	2
Regional express bus			
36-47	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS	—	—
Total parks and recreation facilities within bus study corridors[3]			30

[1] These numbers do not represent an estimate of the number of resource areas that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

[3] Numbers include resource areas where only a portion of the resource is within the study corridor. Some resource areas may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.

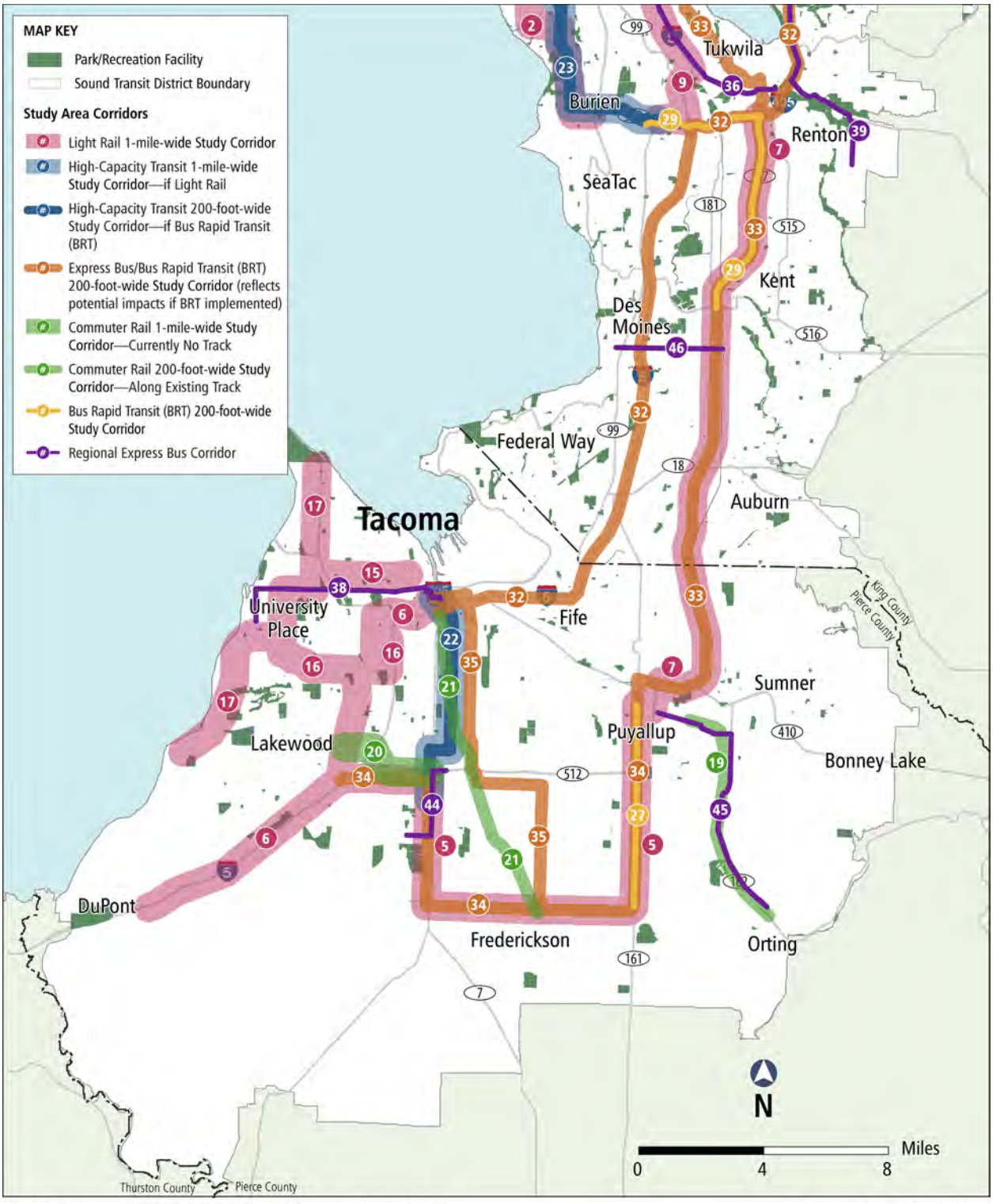
[4] Corridor 30 is BRT and is assumed to use existing roadway facilities in this location so was not analyzed using GIS. Impacts to parks could occur in this corridor but they are not expected to be significant.



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-41. Parks and recreation facilities for Potential Plan Modifications Alternative study corridors—north



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-42. Parks and recreation facilities for Potential Plan Modifications Alternative study corridors—south

Light rail

Similar to the Current Plan Alternative, some light rail corridors could require additional property for rights-of-way, including for stations, park-and-ride facilities, and additional support facilities. Although impacts to parks and recreation facilities would typically be avoided in the planning process, use of these properties or other direct impacts could occur, particularly when other physical constraints limit alternatives. The light rail study areas for corridors 1, 2, 10, 11, and 14 each contain more than 40 parks or recreation facilities. Looking at the number of parks and recreation facilities per mile, corridor 8, downtown Seattle along Madison Street, has the greatest density of parks and recreation facilities. This is likely because these corridors are located in King County, which has a high density of park and recreation facilities. Corridor 14 also crosses one of the largest parks in the region, Warren G. Magnuson Park.

In the northern portion of the Plan area, some parks and recreation facilities that are in the vicinity of light rail corridors include North Creek (corridor 12), Walter Hall Park and Golf Course (corridor 13), and Kasch Memorial Park (corridor 13). In King County, parks and recreation facilities that occur in study areas for light rail corridors include Sammamish River Park and Sammamish River Trail Site (corridor 10), Swamp Creek Park (corridor 10), Blyth Park (corridor 10), Warren G. Magnuson Park (corridor 14), Marymoor Park (corridor 14), Grass Lawn Community Park (corridor 14), and Camp Long (corridor 2). In the southern portion of the Plan area, light rail study areas include parks and recreation facilities such as Point Defiance Park (corridor 17), Chambers Creek Park (corridor 6) and Tacoma Country and Golf Club (corridor 6). A portion of corridors 2 and 14 could be constructed as cut-and-cover or bored tunnel, which would avoid impacts to parks and recreation facilities in those areas. Many parks and recreation facilities could potentially be avoided during project-level planning and preliminary engineering for light rail corridor alignments.

Light rail infrastructure and support facilities, such as stations, park-and-ride facilities, and maintenance facilities, could have similar impacts.

Commuter rail

Commuter rail impacts are expected to be minimal because commuter rail corridors would generally run on existing tracks that may only require minor improvements or adjustments. Corridor 20 is the exception because there are no existing tracks that could be used; it was therefore evaluated using a larger study area. However, no parks or recreation facilities are located in the study area for corridor 20. Commuter rail corridors could require control and communications systems or stations that could change views to or from some parks and recreation facilities. However, the three commuter rail corridors in the Potential Plan Modifications Alternative are located in Pierce County in areas of relatively low density for parks and recreation facilities. Of these three corridors, the study area for corridor 19 contains the most parks—a total of four. It is expected that impacts to parks and recreation facilities from commuter rail in the Potential Plan Modifications Alternative would be low.

Regional express bus/bus rapid transit

Impacts on parks and recreation facilities from regional express bus or BRT corridors are similar to those described for the Current Plan Alternative. Additional regional express bus routes using existing facilities where buses currently operate would have little potential to generate additional impacts. For those BRT corridors where additional rights-of-way would be required for new dedicated bus lanes, impacts to parks and recreation facilities would be similar in nature to light rail. There could be increased traffic or noise, or changes to the surrounding visual environment, that could affect parks and recreation facilities near these corridors; however, BRT corridors are generally adjacent to existing roadways so these impacts are expected to be low.

For those non-dedicated BRT corridors where no additional rights-of-way would be required, signal improvements and other infrastructure at intersections or arterials could add visual elements, which could change views to or from parks and recreation facilities.

Streetcar

In general, streetcars would generally be in existing rights-of-way and would have similar impacts on parks and recreation facilities as those described for regional express bus. A streetcar in the Eastside Rail Corridor could have similar park impacts as BRT or light rail in the ERC as described for the Current Plan Alternative.

High-capacity transit (mode not specified)

Study corridors 22 through 26 could be selected as either light rail or BRT corridors. The impacts to parks and recreational resources generally would be similar to those described for the other corridors for the selected mode. The light rail study areas for corridors 23 and 24 contain similar numbers of parks and recreation facilities, with 56 and 62, respectively; the same holds true for the BRT study areas, which contain four and five parks and recreation facilities, respectively. The wider light rail study area for corridor 25 contains the highest number of parks and recreation facilities, with 103; the narrower BRT study area for the same corridor has 15. Many parks and recreation facilities do not directly abut adjacent highways, which explains the fairly substantial decrease in the amount of parks and recreation facilities in the study corridors between light rail and BRT. In general, parks and recreation facilities could likely be avoided by the final light rail corridor alignments.

Three of the HCT corridors are primarily located in King County in areas of relatively concentrated parks and recreation facilities, which results in their having the greatest potential for impacts. Denny Park and Miller Playfield are located in the northern area of these corridors; Sam Smith Park, the Amy Yee Tennis Center, and Jefferson Park Golf Course are in the central vicinity; and Salmon Creek Ravine, Camp Long, and North SeaTac Park and the adjacent Sunset Playfield are in the southern area of these corridors.

4.11.4 Construction impacts

Current Plan Alternative

Construction impacts could occur at parks and recreation facilities located near construction of transit-related improvements. Impacts from construction could include temporary trail detours, temporary restrictions on park access and public use, street closings and traffic detours, increased noise and vibration from heavy equipment, dust, and soil being tracked onto paved surfaces. Construction equipment and lighting, stockpiled materials, demolition, clearing, dust, and general clutter could temporarily affect park access and usability. In some cases, construction of new or expanded transportation corridors, stations, and access facilities could require use of park and recreation facilities for staging areas or other construction activities.

Impacts would vary for at-grade, elevated and belowground tunnel construction. Elevated and at-grade light rail, commuter rail, and BRT would have higher construction impacts on parks and recreation facilities compared to belowground tunnel construction because construction activity would be at-grade or above ground near the park or recreation facility. Belowground bored tunnels are generally deep and often lower in elevation than cut-and-cover tunnels, which are generally shallower. Cut-and-cover tunnels would include large areas of disturbance along the length of the tunnel, while bored tunnels would limit disturbance to the portal, shaft, and station areas. Portions of corridors C, F, G, and K could be constructed in tunnels.

Construction of light rail would likely have the highest potential for impacts to parks and recreation facilities. This is because of the overall length and location of these corridors. In addition, construction of light rail would be more extensive given the scale and large footprint of such facilities and the amount of earthwork and general disturbance to the surrounding area during work activities.

Construction of commuter rail generally would have a low potential for impacts to parks and recreation facilities due to the use of existing tracks with minor improvements.

Construction of BRT that would operate in exclusive rights-of-way could require construction of an additional lane in each direction along existing roadways. In new right-of-way, BRT would have impacts similar to those of light rail. Construction of BRT that would use existing facilities would have a low potential for impacts to parks and recreation facilities because of the small number of parks and recreation facilities in the study corridors. The greatest construction activity would be required where roadway widening is needed to accommodate BRT that requires construction of two new bus-dedicated lanes in each direction.

Specific construction impacts and the number of parks and recreation facilities affected would be evaluated during future project-level planning and environmental review.

Potential Plan Modifications Alternative

Construction impacts of the Potential Plan Modifications Alternative to parks and recreation facilities would be similar to those described for the Current Plan Alternative. However, the Potential Plan Modifications Alternative could involve additional construction activity in the region because of the additional corridors under consideration. As a result, overall temporary construction impacts to parks and recreation facilities could be slightly greater. Portions of corridors 2 and 14 could be constructed in a tunnel and could have similar impacts as those described above for tunnel construction. Construction impacts of commuter rail facilities would be similar to those described above. One commuter rail study corridor (17) does not currently have tracks and therefore would require a greater degree of construction; however, there are no parks or recreation facilities in this study corridor.

4.11.5 Potential mitigation measures

In general, impacts to parks and recreation facilities would be avoided or mitigated to the extent reasonable and practicable under the Current Plan Alternative and the Potential Plan Modifications Alternative. For affected park resources, Sound Transit would coordinate with the agency or jurisdiction that owns each resource in order to develop design measures and construction plans that would minimize potential long-term and temporary construction impacts. Mitigation could include restoration of disturbed parks and open space to pre-project conditions or park enhancement. Restoration could include landscaping, paths, vehicle access, parking, and other built features of the park or recreation facility. If acquisition of parks and recreation facilities is necessary, replacement parkland and comparable facilities could be provided in a new location or compensation provided to the resource owner. Such mitigation would be required for any parks that used Land and Water Conservation funds.

Mitigation for construction-period impacts typically includes the following:

- Maintaining access during temporary road, parking, and trail closures
- Conducting outreach to the public and providing signage with information on temporary closures and detours and the duration and type of temporary impacts
- Coordinate with owners and operators to minimize impacts and accommodate the continued use and enjoyment of affected parks and recreation facilities (e.g. construction would be coordinated to avoid major events)

Many of the mitigation measures identified in this Final SEIS for other resources (air quality, visual and aesthetics, noise and vibration, and transportation) would also reduce potential long-term and construction impacts on park and recreation facilities.

4.11.6 Significant unavoidable adverse impacts

Significant adverse impacts to parks and recreation facilities can be mitigated or avoided for most plan elements under the Current Plan Alternative and the Potential Plan Modifications Alternative. However, the unavoidable use of parks and recreation facilities or other impacts could occur in some corridors and with some modes, particularly when other physical constraints limit alternatives.

4.12 Historic and cultural resources

This section describes existing historic and cultural resources in the Plan area and potential impacts and mitigation measures for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, the potential impacts are qualitatively described based on broadly defined corridor locations. For analysis purposes, the study area for these study corridors varies in width depending on mode, as described in the introduction to this chapter. While the number of historic properties and cultural resources within the study area for each corridor is provided, it does not represent the number of properties or resources that would be impacted if a corridor were implemented. The actual number of historic properties, cultural resources, and traditional cultural properties affected, the anticipated level of potential impacts, and avoidance and minimization measures would be determined during future project-level planning and environmental reviews.

4.12.1 Regulatory environment

Historic sites are regulated by federal, state, and local laws as summarized below. Project development could require consultation with many entities including local governments, local landmark/historic commissions, tribes, and other consulting parties. Compliance with federal and state laws, and with local historic preservation ordinances, would be evaluated during future project-level planning and environmental review. Those efforts would include consultation with the Advisory Council on Historic Preservation (ACHP); the Washington State Department of Archaeology and Historic Preservation (DAHP), which is led by the State Historic Preservation Officer; federal lead agencies such as FTA; affected Native American tribes; local landmark/historic commissions; affected local governments; the public; and other consulting parties.

Federal

Section 106 of the National Historic Preservation Act requires Federal agencies to consider the effect of their undertakings on historic or cultural properties. Section 106 sets guidelines for protecting historic properties, which are defined as any prehistoric or historic districts, sites, buildings, structures, or objects included in, or eligible for inclusion in, the National Register of Historic Places (NRHP). The process for complying with Section 106 requirements is outlined in 36 CFR 800. The consultation process would occur during future project-level environmental reviews in accordance with Section 106.

NRHP listing criteria

Resources on the National Register are:

- At least 50 years old
- Retain important character-defining features from the past
- Have an association with events, activities, developments, or people that were significant in the past

As discussed in Section 4.11.1, Section 4(f) of the Department of Transportation Act of 1966, as amended (16 USC 470, 49 USC 303, and 23 USC 138), also protects historic sites that are in, or eligible for inclusion in, the NRHP.

Federal law also includes regulations specific to Native American resources:

- American Indian Religious Freedom Act of 1978 (42 USC 1996)
- Executive Order 13007 (access to or ceremonial use of sacred sites by Indian religious practitioners)

The Archaeological Resources Protection Act of 1979 (16 USC 470aa-mm) applies to archaeological sites on tribal and non-tribal lands, which are managed under the federal government.

State and local

At the state level, RCW 27.34.200 and Chapter 25-12 WAC protect historic properties, which are defined as structures, sites, districts, buildings, and objects of historic, archaeological, architectural, and cultural significance. DAHP maintains the Washington Heritage Register (WHR), which includes properties that for various reasons—usually relocation or incompatible alterations—do not meet the higher standards for NRHP designation.

Revised Code of Washington

- Indian Graves and Records (Chapter 27.44 RCW) protects Indian burials
- Archaeological Sites and Resources (Chapter 27.53 RCW) protects archaeological sites
- Confidentiality of Information (Chapter 76.09 RCW) provides for the confidentiality of these sites

Many local governments maintain local historic registers. Although criteria for listing vary among jurisdictions, they are generally similar to those used for the NRHP. However, the level of protection provided by these regulations varies considerably. In some cases, the local historic preservation board or commission must approve demolition of a local landmark or changes to its exterior. Some jurisdictions have designated local historic districts, and any alterations of buildings or elements in the district must be reviewed and approved by the appropriate board.

These jurisdictions within the Plan area have local historic preservation programs:

- Snohomish County
- King County
- Pierce County
- City of Bothell
- City of Edmonds
- City of Everett
- City of Lakewood
- City of Lynnwood
- City of Seattle
- Town of Steilacoom
- City of Tacoma

A number of cities in King County have established historic preservation programs through interlocal agreements with the county. These programs incorporate the county's preservation ordinance, and each city has a landmarks commission that designates historic resources within the city. The cities within the Plan area that have these agreements with King County are Auburn, Burien, Des Moines, Issaquah, Kenmore, Kent, Kirkland, Newcastle, Redmond, Sammamish, Shoreline, Tukwila, and Woodinville.

4.12.2 Affected environment

Architectural historic properties and districts in the Plan area that are listed in the NRHP were identified through DAHP's historic properties database. Also identified were several properties designated as National Historic Landmarks. DAHP also maintains records of traditional cultural properties and archaeological sites that have been listed on the Washington State Archaeological Site Inventory. Site-specific information about these properties is exempt from public disclosure under state law (RCW 42.56.300) to prevent looting and vandalism.

Appendix H includes maps and a list of the NRHP-listed historic properties and historic districts in the Plan area. The majority of properties are concentrated in the major urban areas of Seattle, Tacoma, and Everett. Future project-level planning and environmental reviews would include surveys of potentially affected areas, as necessary, to identify potential historic properties and determine their NRHP eligibility status.

Architectural historic properties

Architectural historic properties reflect the history of the region. The historic era dates back to the early 1790s when the first contact between Native American tribes and European explorers took place. Euro-American settlement in Puget Sound began in the 1850s. Early activities were primarily logging, fishing, and agriculture. Trade and industry increased dramatically in the late 19th century, particularly after the arrival of the transcontinental railroad (1873 in Tacoma, 1893 in Seattle) and after the Klondike Gold Rush began in 1897. This sparked a population and development boon throughout the Puget Sound region. Few intact remnants of mid-19th century settlement remain. However, many resources from the late 19th century through the mid-20th century remain, and numerous historic properties and districts are listed in or are eligible for listing in the NRHP, the WHR, and local registers.

Archaeological sites

Archaeological sites can be found anywhere, in forests, rural areas, or cities; on beaches or mountain tops, beneath buildings, or even underwater. They can be on public land, tribal reservations, or private property. They may be accidently uncovered during construction projects or discovered during carefully planned systematic surveys by archaeologists.

On the Washington coast and along major rivers, Native American people lived in villages with an economy based on the harvesting and storage of salmon, which arrived in dense, predictable runs. Prehistoric archaeological sites include shell middens, open sites or campsites, pictographs and petroglyphs, caves or rockshelters, wet sites, culturally modified trees, and burial sites or cemeteries.

Most prehistoric sites in the Plan area reflect cultural uses by hunter-fisher-gatherer groups that occupied the Puget Sound region beginning around 11,000 years ago. Such uses include villages, camps, and sites for food gathering, and other seasonal activities. These sites tend to be near watercourses and shoreline areas. Low-bank saltwater shorelines, particularly near freshwater stream and river confluences, are particularly likely to have sustained human occupation. For example, in King County approximately half of the state-registered prehistoric archaeological sites lie within 200 feet of waters of statewide significance (see Appendix C for waters bodies and shorelines of statewide significance in the Plan area). Native Americans also used the

Historic landmarks

Nationally significant historic places designated by the Secretary of the Interior because they possess exceptional value or quality in illustrating or interpreting the heritage of the United States. Just over 2,500 historic places bear this national distinction.

Historic or cultural resource

Any site, building, structure object, district, traditional cultural place, or cultural landscape that has historical significance at the local, state, or federal level that is listed in or eligible for listing in the NRHP, including buildings, districts, sites, structures, or objects.

Archaeological resource

An artifact, feature, or site that helps in understanding the human past. Past activities can include prehistoric, historic, and contemporary activities.

Shell middens

Villages, campsites, or shellfish processing areas composed of a dark, organically rich soil with shells or shell fragments, artifacts, and fire-cracked rock. These sites are found along saltwater shorelines of western Washington.

mountains and forests for a variety of resources that include game, plants, and raw materials, such as stone, wood, and wool (DAHP 2003).

More recent archaeological sites in the region, often referred to as historic archaeological sites, include military and homestead sites, and logging, mining, and railroad-related features. While physical evidence of these sites aboveground has largely been destroyed by ground-disturbing activities, such as development and natural forces, belowground remnants may still exist.

In Washington State, more than 28,000 archaeological sites, districts, and cemeteries have been inventoried; over 2,000 of these are located in Snohomish, King, and Pierce Counties (DAHP 2011).

Traditional cultural properties

Traditional cultural properties are properties associated with cultural practices or beliefs of a living community that are (1) rooted in that community's history and (2) important in maintaining the continuing cultural identity of the community. In the Plan area, traditional cultural properties are primarily associated with Native American groups. Federally and non-federally recognized tribes can identify traditional cultural properties. Numerous traditional cultural properties and sites occur throughout the state. However, similar to archeological historic properties, site-specific information about these properties is exempt from public disclosure under state law (RCW 42.56.300). During future project-level planning, consultation with DAHP and Native American groups would be conducted to determine the location of any potentially affected traditional cultural properties.

4.12.3 Long-term impacts

For purposes of Section 106, an adverse effect may be found when the undertaking alters, either directly or indirectly, any of the characteristics that qualify the property for inclusion on the NRHP in a manner that diminishes its historic integrity. Long-term and permanent adverse effects to historic properties can include the following:

- Physical destruction of, or permanent damage to, all or part of a historic property
- The introduction of visual, atmospheric, or audible elements that permanently diminish the integrity of the property's significant historic features
- Permanent changes to elements of the property's setting that contribute to its historic significance, including relocation of the property to a new setting
- Alteration of a property, including restoration or rehabilitation, that is not consistent with the Secretary of Interior's Standards for the Rehabilitation of Historic Properties

These types of effects to historic properties are possible within any of the study corridors. However, they are more likely to occur in urban areas where the concentration of architectural historic properties is highest.

Current Plan Alternative

The Current Plan Alternative could result in long-term impacts to historic properties, historic districts, archaeological sites, and traditional cultural properties. Table 4-31 shows the number of NRHP-listed architectural historic properties and historic districts within the study areas for the corridors being analyzed for the Current Plan Alternative. The locations of these resources are shown in Figure 4-43 and Figure 4-44. The numbers shown in Table 4-31 do not represent an estimate of the number of architectural historic properties that would be impacted if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors. Potential effects to architectural historic properties for each type of mode are described below. Numerous archaeological and traditional cultural properties and sites occur throughout the state. However, site-specific information about these properties is exempt from public disclosure under state law (RCW 42.56.300). During future project-level planning, consultation with DAHP and Native American groups would be conducted to determine the location of any potentially affected properties.

Light rail

New elevated guideways, tunnels, stations, and support facilities associated with light rail corridors, if located in new rights-of-way, could adversely affect architectural historic properties if those properties cannot be avoided and would need to be demolished or altered. Similar impacts could also occur in locations of new infill stations, park-and-ride facilities, and operations and maintenance facilities for light rail.

Operation of light rail, particularly at-grade or elevated, could cause adverse noise, vibration, or visual effects to some architectural historic properties. These same effects could also occur as a result of the light rail guideway, new stations, or other support facilities, such as park-and-ride facilities and maintenance facilities.

These types of effects are more likely to occur in urban areas with development constraints that limit avoidance measures, in areas with relatively higher densities of historic properties, and along transportation corridors where additional right-of-way is required. This is particularly true in portions of the corridors between downtown Seattle and Northgate and near downtown Tacoma. The study area for corridor F (downtown Seattle to Ballard) has a very high concentration of NRHP-listed historic properties—a total of 70. Portions of other corridors tend to have fewer historic properties and are generally located farther from the urban core. It should be noted that portions of corridors C, F, and G potentially contain tunnels, which could lower potential long-term impacts to aboveground historic properties.

Archaeological sites and traditional cultural properties could also be permanently impacted by the placement of tunnels or structures, such as piers to support elevated rail lines. Although light rail tunnels are at depths below where archaeological sites are typically found, some light rail alignments and portals could require cut-and-cover construction techniques that could impact archaeological sites. Other ground-disturbing activities associated with new stations, park-and-ride facilities, or other support facilities could also impact these sites.

Table 4-31. NRHP-listed architectural historic properties and districts for Current Plan Alternative study corridors

ID	Current Plan Alternative study corridor location	Length of corridor (miles)	Number of architectural historic properties and districts[1]
Potential rail extensions, assumed light rail: 1-mile-wide study area			
A	Tacoma to Federal Way	10	5
B	Burien to Renton	8	0
C[2]	Bellevue to Issaquah along I-90	10	3
D	Renton to Lynnwood along I-405	28	5
E	Renton to Woodinville along Eastside Rail Corridor	22	2
F[2]	Downtown Seattle to Ballard	6	70
G[2]	Ballard to UW	4	13
H	Lynnwood to Everett	13	3
Total architectural historic properties and districts within potential light rail extension study corridors[3]			98
Potential rail extensions, assumed commuter rail: 200-foot-wide study area			
I	DuPont to Lakewood	8	0
J	Renton to Woodinville along Eastside Rail Corridor	22	0
Total architectural historic properties and districts within potential commuter rail extension study corridors[3]			0
High-capacity transit (HCT): 1-mile-wide study area if light rail/200-foot-wide study area if BRT			
K[2]	UW to Redmond via SR 520	13	Light rail: 9 BRT: 0
L	Northgate to Bothell	9	Light rail: 7 BRT: 0
Total architectural historic properties and districts within high-capacity transit study corridors[3]			Light rail: 16 BRT: 0
Bus rapid transit (BRT): 200-foot-wide study area			
M	Federal Way to DuPont along I-5	25	0
N	Renton to Puyallup along SR 167	21	0
O	Bellevue to Issaquah along I-90	10	0
P	Renton to Woodinville along Eastside Rail Corridor	22	0
Q	Renton to Lynnwood along I-405	28	0
R	Seattle to Everett along SR 99	27	3
S	Lynnwood to Everett along I-5	13	0
Regional express bus			
T-Y	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS	—	—
Total architectural historic properties and districts within bus study corridors[3]			3

[1] These numbers do not represent an estimate of the number of resource areas that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

[3] Numbers include resource areas where only a portion of the resource is within the study corridor. Some resource areas may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.

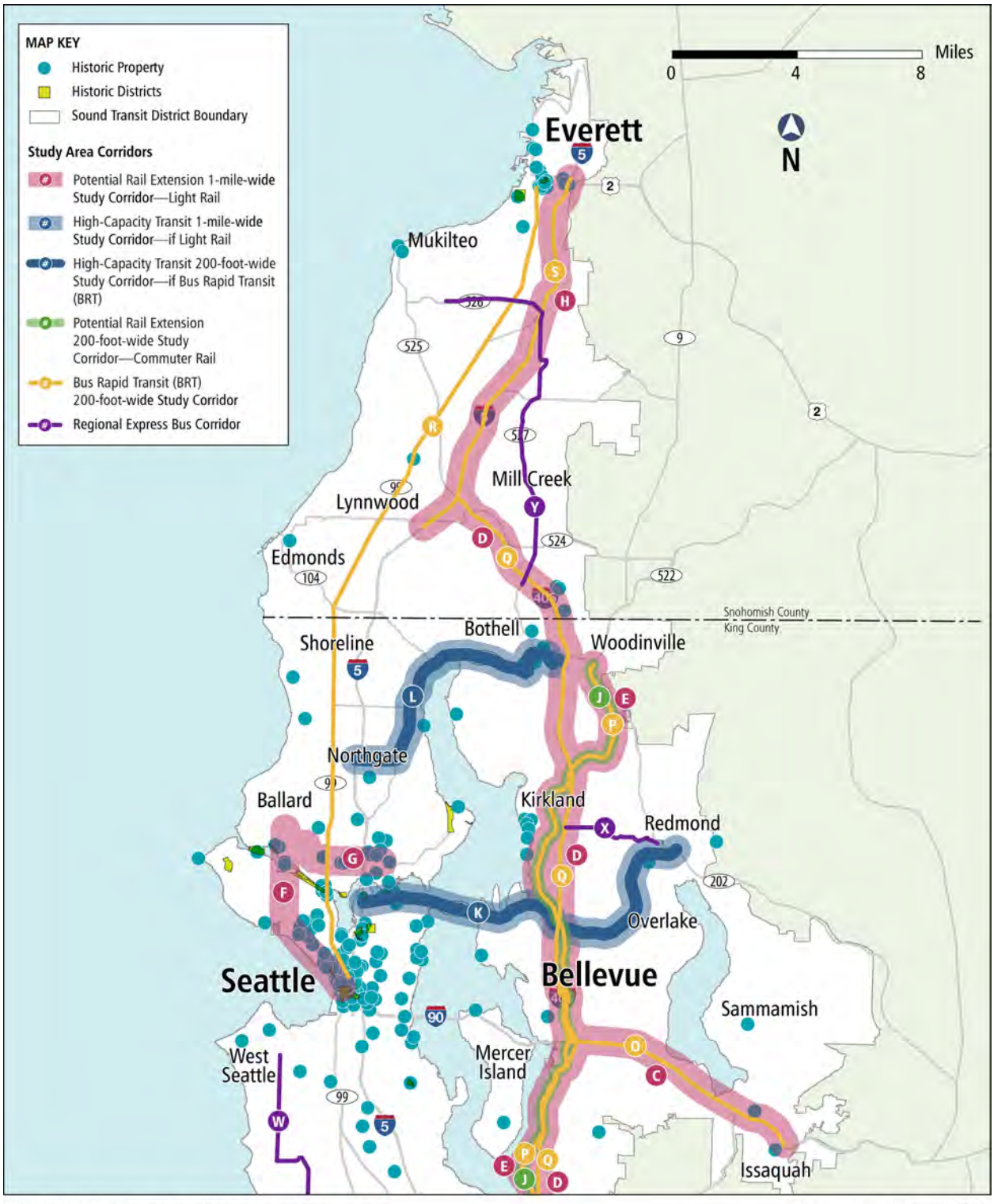
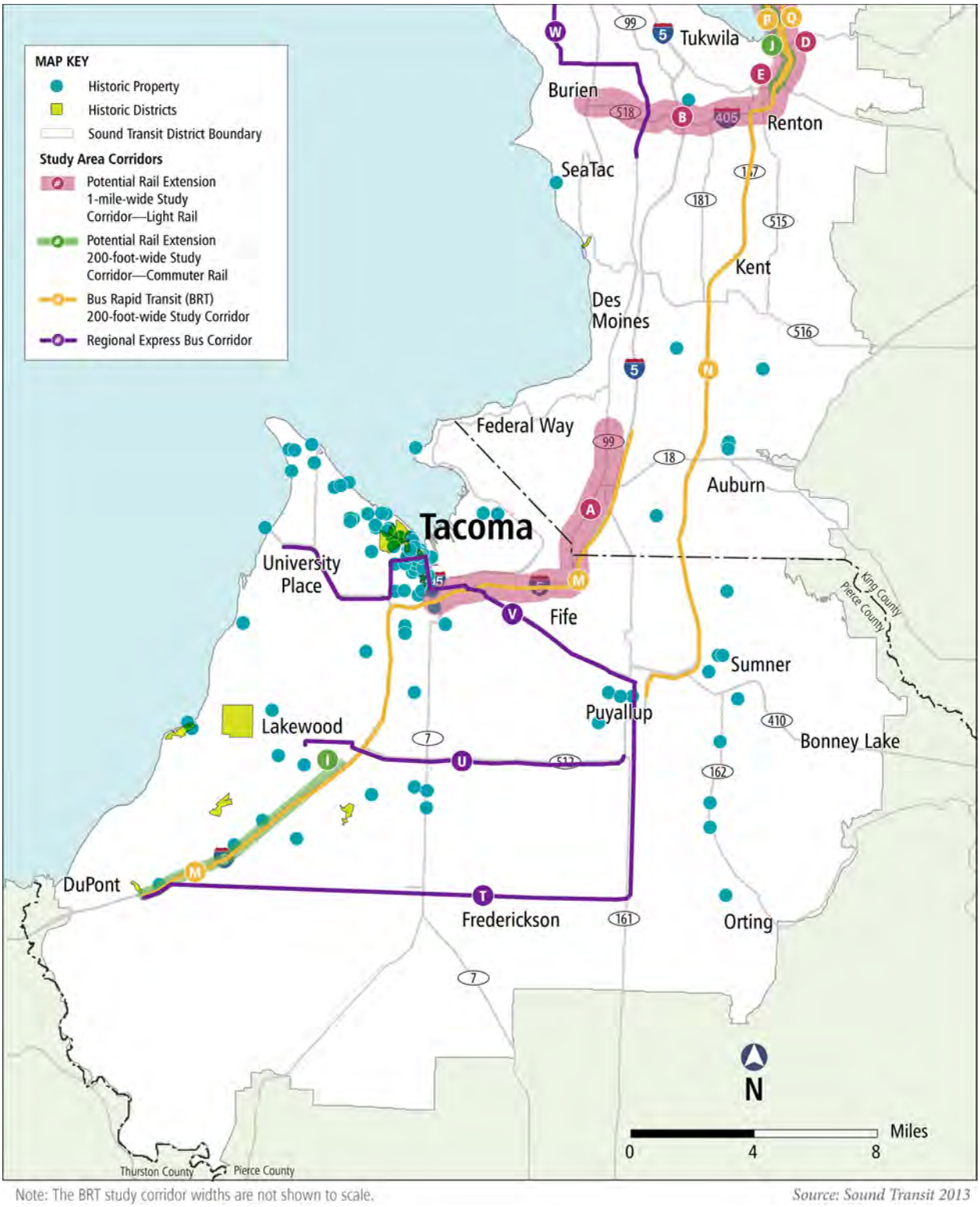


Figure 4-43. NRHP-listed architectural historic properties and districts for Current Plan Alternative study corridors—north



Note: The BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-44. NRHP-listed architectural historic properties and districts for Current Plan Alternative study corridors—south

Commuter rail

The study areas for corridors I and J contain no NRHP-listed architectural historic properties or districts. These commuter rail corridors could include new storage tracks, stations, park-and-ride facilities, and service facilities. Similar to light rail, the presence of new stations or support facilities could have adverse visual, noise, or vibration effects to adjacent historic properties if any were identified in the future during project-level reviews.

In addition to these two corridors, new track, infill stations, and service facilities could be added to existing commuter rail to increase service. Because commuter rail generally would use existing tracks, there is little potential for commuter rail to directly impact historic properties, except where additional rights-of-way may be needed.

Construction of additional storage tracks, new and infill stations, and related facilities, such as park-and-ride facilities and storage and maintenance yards along commuter rail corridors could impact either existing or newly identified archaeological sites or traditional cultural properties.

Regional express bus/bus rapid transit

Additional regional express service and BRT would be mainly at-grade either on or along existing roadways. Elevated, belowground, and bridge segments could occur in some areas. Where buses are operating on existing roadways, potential impacts to architectural historic or archaeological properties would be limited to new access ramps or HOV lane improvements, bus stops, transit centers, park and ride facilities, and maintenance facilities. For these types of associated facilities, effects on historic properties would be similar to support facilities associated with light rail or commuter rail. In addition to potential direct effects from property acquisitions, these support facilities could cause noise effects to some historic properties. These types of impacts would be more likely to occur in urban areas with relatively high densities of historic properties.

For lane-exclusive BRT, adding a lane on each side of an existing roadway could impact architectural or archaeological historic properties to a greater extent than use of an existing roadway. Three architectural historic properties have been identified in the study area for corridor R, Seattle to Everett along SR 99. Although a small number of architectural historic properties are located in BRT corridor study areas, additional properties could be determined eligible for the NRHP during project-level review. Archaeological properties could be affected depending on the level of earthwork required for roadway widening and any potential utility relocation.

High-capacity transit (mode not specified)

Study corridors K and L could be selected as either light rail or BRT corridors. The impacts generally would be similar to those described for the other corridors for each mode. The study areas for light rail corridors K and L contain 9 and 7 historic properties, respectively. Portions of corridor K, if implemented as light rail, could include tunnels, which could lower potential long-term impacts to aboveground historic properties in those sections.

No architectural historic properties or districts are within the BRT study areas. However, additional historic properties and archaeological resources eligible for the NRHP could be identified during project-level review. Potential Plan Modifications Alternative

The Potential Plan Modifications Alternative would have similar impacts as the Current Plan Alternative. However, as a result of the additional corridors in the Potential Plan Modifications Alternative, the architectural historic, archaeological, and traditional cultural property impacts could be greater than those in the Current Plan Alternative. Table 4-32 shows the number of NRHP-listed architectural historic properties and historic districts within the study areas for the corridors being analyzed for the Potential Plan Modifications Alternative. The locations of these resources are shown in Figure 4-45 and Figure 4-46. Similar to the Current Plan Alternative, the numbers shown in Table 4-32 do not represent an estimate of the number of architectural historic properties and historic districts that would be impacted if a corridor were implemented. They may, however, indicate the relative concentration of resources near various corridors. Potential effects for architectural and archeological properties for each type of mode are described below.

Light rail

Study areas for corridors 1, 2, 4, 8, and 15, located throughout Seattle, Everett, and downtown Tacoma, contain particularly high concentrations of NRHP-listed architectural historic properties. In particular, corridor 8 through Seattle along Madison Street has one the highest concentration of resources of all corridors and could, therefore, result in the greatest impacts. Similar to the Current Plan Alternative, the greatest potential for effects on historic properties is in more urban areas. Similar to the Current Plan Alternative, operation of light rail, particularly at-grade or elevated, could cause adverse noise, vibration, or visual effects to some architectural historic properties. Direct impacts could also occur as a result of alteration or demolition of historic properties. Archaeological sites could be permanently impacted by ground-disturbing activities, including the placement of tunnels or structures, such as piers, to support elevated rail lines. Portions of corridors 2 and 14 could include tunnels, which could avoid potential long-term impacts to above-ground historic properties.

Similar to the Current Plan Alternative, the same impacts described above and other ground-disturbing activities could occur during development of the light rail guideway, stations, park-and-ride facilities, operation and maintenance facilities, and additional support facilities.

In addition, impacts could also occur for new infill stations, park-and-ride facilities, and operations and maintenance facilities along light rail corridors that are already in operation or in the project development process.

Although impacts to historic properties would be avoided to the extent practical during future project-level planning and environmental reviews, adverse effects could occur, particularly when other physical constraints limit avoidance options.

Table 4-32. NRHP- listed architectural historic properties and districts for Potential Plan Modifications Alternative study corridors

ID	Potential Plan Modifications Alternative study corridor locations	Length of corridor (miles)	Number of architectural historic properties and districts[1]
Potential rail extensions, assumed light rail: 1-mile-wide study area			
1	Downtown Seattle to Magnolia/Ballard to Shoreline Community College	12	71
2[2]	Downtown Seattle to West Seattle/Burien	13	66
3	Ballard to Everett Station via Shoreline Community College, Aurora Village, Lynnwood	24	15
4	Everett to North Everett	2	13
5	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	5
6	DuPont to downtown Tacoma via Lakewood, Tacoma Mall	16	15
7	Puyallup/Sumner to Renton via SR 167	21	1
8	Downtown Seattle along Madison Street	3	63
9	Tukwila to SODO via Duwamish industrial area	11	35
10	North Kirkland or University of Washington Bothell to Northgate via SR 522	13	7
11	Ballard to Bothell via Northgate	3	7
12	Mill Creek, connecting to Eastside Rail Corridor	8	5
13	Lynnwood to Everett, serving Southwest Everett Industrial Center (Paine Field and Boeing)	7	0
14[2]	UW to Sand Point to Kirkland to Redmond	10	16
15	Downtown Tacoma to Tacoma Community College	3	18
16	Tacoma Mall to University Place	6	1
17	Steilacoom to Ruston via University Place	12	8
18	Issaquah to Issaquah Highlands	2	1
Total architectural historic properties and districts within light rail study corridors[3]			186
Potential rail extensions, assumed commuter rail: 1-mile-wide study area new track/200-foot-wide study area existing track			
19	Puyallup/Sumner to Orting	8	0
20	Lakewood to Parkland	3	0
21	Tacoma to Frederickson	10	1
Total architectural historic properties and districts within commuter rail study corridors[3]			1

Table 4-32. NRHP- listed architectural historic properties and districts for Potential Plan Modifications Alternative study corridors (continued)

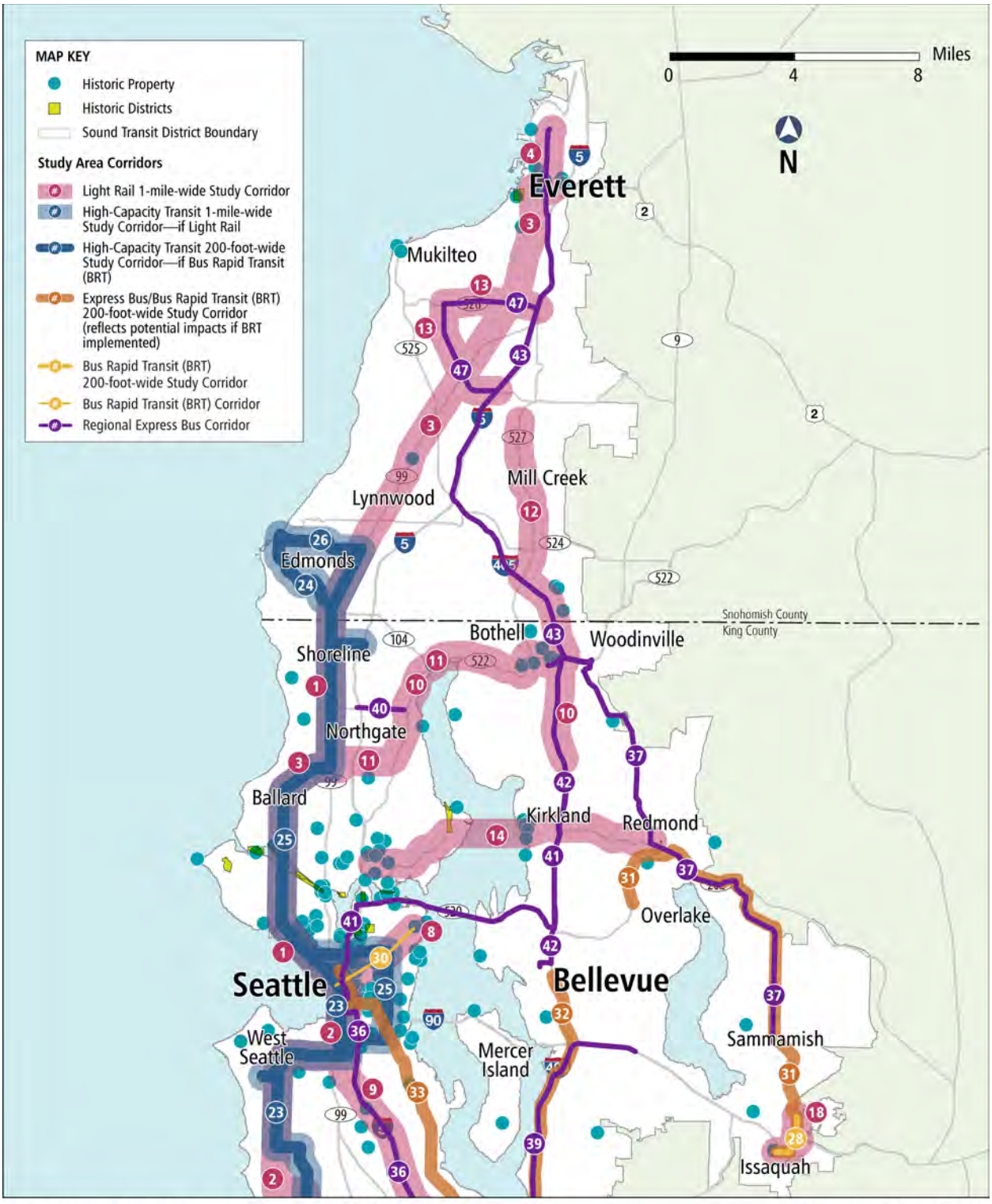
ID	Potential Plan Modifications Alternative study corridor locations	Length of corridor (miles)	Number of architectural historic properties and districts[1]
High-capacity transit (HCT) (mode not specified): 1-mile-wide study area if light rail/200-foot-wide study area if BRT			
22	Downtown Tacoma to Parkland	8	Light rail: 12 BRT: 1
23	Tukwila Sounder station to downtown Seattle via Sea-Tac Airport, Burien, West Seattle	15	Light rail: 66 BRT: 5
24	Downtown Seattle to Edmonds via Ballard, Shoreline Community College	19	Light rail: 75 BRT: 13
25	West Seattle to Ballard via Central District, Queen Anne	14	Light rail: 49 BRT: 2
26	Edmonds to Lynnwood Link	5	Light rail: 1 BRT: 0
Total architectural historic properties and districts within high-capacity transit study corridors[3]			Light rail: 113 BRT: 18
Bus rapid transit (BRT): 200-foot-wide study area			
27	Puyallup vicinity, notably along Meridian Avenue	6	0
28	Issaquah to Issaquah Highlands	2	0
29	Kent to Sea-Tac Airport	11	0
30[4]	Downtown Seattle along Madison Street	—	—
Regional express bus/BRT (mode not specified): 200-foot-wide study area			
31	Issaquah Highlands to Overlake via Sammamish, Redmond	14	0
32	Tacoma to Bellevue	34	0
33	Puyallup to downtown Seattle via Kent, Rainier Valley	35	5
34	Lakewood to Spanaway to Frederickson to South Hill to Puyallup	20	0
35	Tacoma to Frederickson	13	0
Regional express bus			
36-47	These routes would use existing facilities and were treated as potential service changes so were not analyzed using GIS	—	—
Total architectural historic properties and districts within bus study corridors[3]			5

[1] These numbers do not represent an estimate of the number of resource areas that would be impacted; however, they may indicate the relative concentration of resources near various corridors.

[2] Portions of these corridors could be constructed in tunnels.

[3] Numbers include resource areas where only a portion of the resource is within the study corridor. Some resource areas may be within more than one study corridor; therefore, the number of resources within each study corridor may be greater than the total for all study corridors combined.

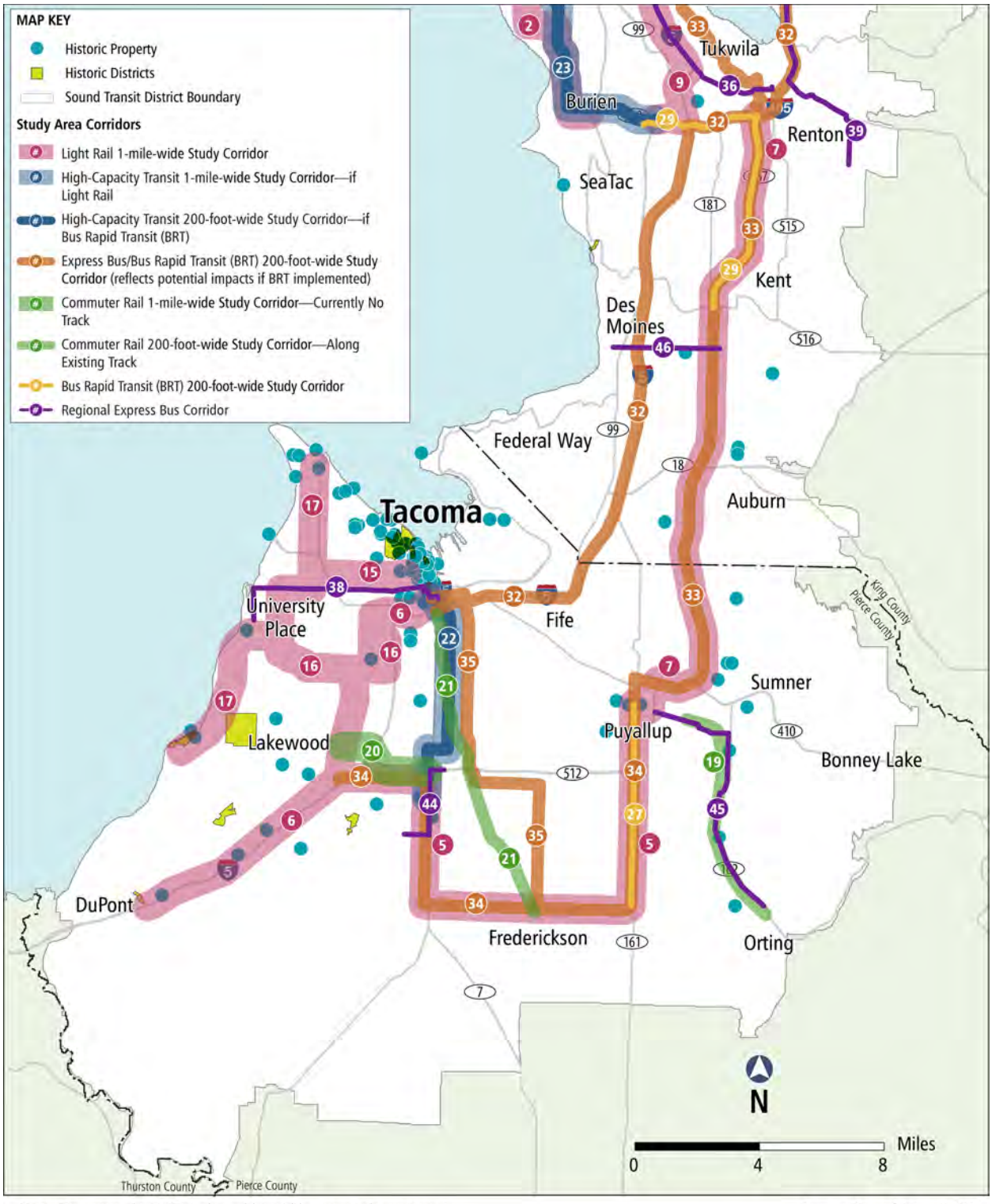
[4] Corridor 30 is BRT and is assumed to use existing roadway facilities in this location so was not analyzed using GIS. Impacts to historic resources could occur in this corridor but they are not expected to be significant.



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-45. NRHP-listed architectural historic properties and districts for Potential Plan Modifications Alternative study corridors—north



Note: The express bus/BRT study corridor widths are not shown to scale.

Source: Sound Transit 2013

Figure 4-46. NRHP- listed architectural historic properties and districts for Potential Plan Modifications Alternative study corridors—south

Commuter rail

Study areas for new commuter rail corridors 19 and 20 have no NRHP-listed architectural historic properties, and corridor 21 has only one. However, additional NRHP-eligible properties could be identified during future project-level planning and environmental review.

Similar to the Current Plan Alternative, these corridors could include new tracks, stations, park-and-ride facilities, and service facilities that could have long-term impacts to historic properties. Since commuter rail generally would use existing tracks, it is less likely to directly impact architectural historic properties or historic districts than light rail, except where additional right-of-way is needed for new commuter rail stations and infill stations. Similar to light rail, the presence of new tracks, stations, or support facilities could result in visual effects on architectural historic properties.

In addition, ground-disturbing activities used for the construction of additional storage tracks, stations, and related facilities, such as park-and-ride facilities, could permanently impact archaeological sites.

Regional express bus/bus rapid transit

No NRHP-listed architectural historic properties have been identified in the regional express or BRT study areas. However, if NRHP-eligible properties were identified during future project-level planning and environmental review, potential impacts would be assessed and avoidance and minimization measures would be determined.

Similar to the Current Plan Alternative, BRT would be mainly at-grade either on or along existing roadway corridors. Elevated, belowground, and bridge segments could occur in some areas.

For lane-exclusive BRT, adding an additional lane on each side of an existing roadway could impact unidentified architectural or archaeological historic properties. Archaeological historic properties could be impacted depending on the level of earthwork required for roadway widening and any potential utility relocation.

Similar to BRT located in existing lanes, regional express bus service is not expected to directly impact architectural or archaeological historic properties. Associated facilities, such as bus bases, park-and-ride facilities, and transit centers for BRT and regional express bus service, would have similar impacts to architectural historic properties as support facilities associated with light rail or commuter rail.

The addition of new lanes, direct access ramps, transit centers, park-and-ride facilities, and grade or barrier separation could result in noise or visual effects to some historic properties. These types of impacts are more likely to occur in urban areas with relatively high densities of historic properties.

Streetcar

Although streetcars generally run in existing rights-of-way, the potential for effects related to noise, vibration, and visual setting of adjacent historic properties could be similar to light rail that operates in existing roadway rights-of-way. Ground-disturbing activities would be less because large structures are typically not needed for streetcars.

High-capacity transit (mode not specified)

Corridors 22 through 26 could be selected as either light rail or BRT corridors. Impacts generally would be similar to those described for the other corridors for the mode selected. If selected for light rail, the wider study area for corridors 23, 24, and 25 would include relatively high concentrations of architectural historic properties. If selected for BRT, relatively minor impacts to architectural historic properties are expected.

4.12.4 Construction impacts

This section discusses potential impacts to historic properties that could occur during construction and are more temporary in nature. These impacts could range from relatively minor nuisances to potential adverse effects. Examples of such impacts include the following:

- Temporary encroachment on historic properties for construction staging
- Pile driving, tunneling, excavation, or other construction activities that cause permanent damage
- Temporary access restrictions
- Temporary noise, visual, vibration, or localized air impacts
- Unanticipated discovery of archaeological resources

Current Plan Alternative

Construction activities could disturb archaeological sites and alter, damage, or remove other historic properties. Clearing and grading in advance of construction could result in the discovery of unrecorded archaeological sites or artifacts that were not previously identified. Impacts to archaeological sites or architectural historic properties would be most likely to occur in urban areas with relatively high densities of historic properties, as well as older rail and roadway corridors where proximity to historic resources is likely to be greater, such as study corridor F (downtown Seattle to Ballard).

Impacts would vary for at-grade, elevated, and different types of belowground construction. Elevated and at-grade light rail, commuter rail, and BRT would have greater construction impacts on architectural historic properties because construction activity would be generally at-grade or above ground near historic properties. Belowground construction using cut-and-cover or boring tunneling methods and surface construction at portals and stations from mined tunnels also could impact historic properties; corridors C, F, G, and K contain potential tunnels in portions of the corridors. In addition, mined construction could cause vibration or settlement-related damage to historic properties and could affect the location and context of belowground archaeological resources.

Construction of light rail likely has the greatest potential to impact historic properties because of the relatively large scale of such projects and the amount of ground disturbance. This is particularly true in urban areas such as Seattle, Tacoma, and Everett where there is a higher concentration of historic properties. Light rail in suburban areas would most likely have fewer impacts on historic properties.

Construction of commuter rail generally would have a lower potential for impacts to historic properties due to the use of existing tracks with limited new right-of-way requirements and

the low number of properties within these corridors. New support facilities or infill stations could increase potential impacts.

Construction of BRT that would operate in exclusive rights-of-way could require construction of an additional lane in each direction along existing roadways. BRT that would require new facilities would have impacts similar to those of light rail. Construction of BRT that would use existing facilities would have a low potential for impacts to historic properties because fewer new facilities would need to be constructed and historic resources are less likely to be disturbed.

Specific construction impacts and the number of historic properties affected would be evaluated during future project-level planning and environmental review.

Potential Plan Modifications Alternative

Construction impacts to historic properties would be similar to those described for the Current Plan Alternative. However, the Potential Plan Modifications Alternative could involve additional construction activity in the region because of the additional corridors under consideration. As a result, overall temporary impacts to historic properties could be slightly greater for the Potential Plan Modifications Alternative. However, within each study corridor the number of previously recorded architectural historic properties varies as previously described.

Belowground construction using cut-and-cover or boring tunneling methods and surface construction at portals and stations from mined tunnels also could impact historic properties; corridors 2 and 14 contain potential tunnels in portions of the corridors.

Construction impacts of commuter rail facilities would be similar to those described for the Current Plan Alternative. One commuter rail study corridor (20) does not currently have tracks so it would require a greater degree of construction; there are no NRHP-listed architectural historic properties in this corridor.

4.12.5 Potential mitigation measures

Where impacts to historic, archaeological, or traditional cultural properties cannot be avoided, appropriate mitigation measures would be determined during project-level planning and environmental review in consultation with the lead federal agencies, DAHP, Native American tribes, local landmarks/historic commissions, affected local governments, the public, and other consulting parties.

Architectural historic properties

If architectural historic properties are identified during project-level planning, efforts would be made to relocate the proposed alignment or support facilities to avoid impacts. If facilities cannot be relocated, potential mitigation measures to avoid or minimize impacts could include the following:

- Design facilities to be compatible with historic buildings or districts.
- Modify construction methods and schedules to avoid or limit construction-related impacts (noise, dust, emissions, vibration, restricted access, and traffic congestion).

- If no alternative to relocation or demolition exists, document architectural historic properties to the standards agreed upon by the lead agencies, DAHP, local governments, and other interested parties as appropriate. Prepare interpretive information regarding the affected resource and make it available to the public.
- Conduct all rehabilitation or relocation work in accordance with the Secretary of Interior's Standards for Rehabilitation of Historic Properties or other agreed-upon standards.

Archaeological sites

Mitigation for archaeological sites could involve the following:

- Review records, DAHP's statewide archaeological predictive model, and conduct field reconnaissance to determine the location of sites during project-level environmental review.
- Monitor, and in some cases conduct subsurface testing in, high probability areas, such as those near lakes, rivers, and shorelines or historically sensitive areas. In consultation with the lead agencies, DAHP, Native American Tribes, and other consulting parties as appropriate, prepare an Archaeological Resources Monitoring and Treatment Plan or Unanticipated Discovery Plan to guide monitoring during construction.
- Excavate significant archaeological sites to recover data that could contribute important information. If sites are discovered and found to be ineligible for inclusion in national, state, or local registers, no data recovery is typically required.

4.12.6 Significant unavoidable adverse impacts

Significant adverse impacts to historic and cultural resources can often be mitigated or avoided for most plan elements under the Current Plan Alternative and the Potential Plan Modifications Alternative. However, unavoidable adverse impacts to historic and cultural resources could occur in some corridors and with some modes.

4.13 Cumulative impacts

This section describes the cumulative impacts for the Current Plan Alternative and the Potential Plan Modifications Alternative. For this plan-level Final SEIS, potential cumulative impacts for these alternatives are qualitatively described based on broadly defined corridor locations. Project-level impacts and potential measures to avoid and minimize impacts would be determined during future project-level planning and environmental reviews.

What are cumulative impacts?

Cumulative impacts are the impacts of a proposed action taken with other past, present, and reasonably foreseeable future actions.

A cumulative impacts assessment considers the overall changes in the environment due to past, present, and reasonably foreseeable future actions regardless of what party undertakes the actions. Cumulative impacts can result from individually minor, but collectively substantial, actions occurring over time. For the Long-Range Plan Update SEIS, the cumulative impact assessment is building on the impacts identified for the Current Plan Alternative and the Potential Plan Modifications Alternative in the preceding sections of Chapter 4. Refer to Chapter 3, Transportation, for a detailed

description of the cumulative impacts of the Current Plan Alternative and the Potential Plan Modifications Alternative on the transportation system. For each element of the environment discussed in Chapter 4, this cumulative impacts section discusses the impacts of the Current Plan Alternative and the Potential Plan Modifications Alternative within the context of the impacts of other past, present, and future activities within the region.

The long-range expansion of the regional transit system is occurring in the midst of, and in support of, the larger trend of urbanization and growth in the Puget Sound region and beyond. This growth includes the continued development of the region's cities (including urbanized Snohomish, King, and Pierce Counties) as well as transportation and other public infrastructure improvements needed to support growing population and employment levels and increased economic activity. Some areas of the environment are also affected by past and present actions that extend well beyond the plan area. For example, environmental areas such as air quality, ecosystems, water, or transportation can be impacted by activities originating well beyond central Puget Sound.

Much of the growth in the last several decades has been guided by the coordinated regional growth management strategy developed by PSRC and its predecessor, the Puget Sound Council of Governments. The most current growth management strategy, *VISION 2040* and its accompanying regional transportation plan, *Transportation 2040*, describe the expected population and employment growth patterns in the region through the year 2040, as well as the major transportation facilities that would be developed. These regional growth management strategies have emphasized higher levels of density within regional growth centers and development within designated urban growth centers, as well as transportation strategies that create multimodal corridors to help reduce reliance on the automobile.

Appendix I lists the reasonably foreseeable major transportation improvements identified as fully or partially funded in the current regional transportation plan. This list includes projects being planned or implemented by WSDOT (such as SR 99/Alaskan Way, SR 520, SR 167, SR 522, I-5, and I-405); by Sound Transit itself (the remaining projects funded by *Sound Move* or ST2, which are already assumed in the current Long-Range Plan); by other transit agencies such as Community Transit, Metro, and Pierce Transit; and various transportation improvement projects by cities, counties, and ports in the region.

Section 4.9 reviews the population and employment growth projected through the year 2040, and also describes the expected pattern of growth, including the regional centers where much of the new growth would be focused.

Within that larger regional context of continued growth and development, many other projects and actions by public or private parties are expected to occur in the coming decades. These include land development projects, often the result of private planning and investments. Similarly, the region has many environmental management restoration and preservation programs and projects ranging from floodplain management to waterfront recovery, stream channel daylighting to sediment cleanup, and air quality management. These more localized specific activities and developments usually occur under shorter time frames than the Long-Range Plan Update, and they are not centrally planned and managed. A comprehensive listing of all such activities through 2040 is not possible. However, it is reasonable to assume that these types of land development actions, including some

environmental programs, will occur throughout the Plan area through both public and private proposals; moreover, they would have the potential to alter aspects of the environment.

The Current Plan Alternative has limited areas where it could result in cumulatively greater impacts when combined with other past or future actions by others. For most of the areas of the environment (as discussed further below), Sound Transit's mitigation measures and other standard environmental commitments would reduce the potential for unavoidable adverse impacts. Therefore, the Current Plan Alternative would not have many areas where it would increase cumulative impacts, and in most cases such impacts would be localized.

The differences in the cumulative impacts for the Current Plan Alternative and the Potential Plan Modifications Alternative would be relatively minor when considered on a regional scale. Within a historic context, considering past actions and urban development, along with other present and reasonably foreseeable future actions, the change in cumulative impacts would also be minor. The differences would be mostly at a local level because the Potential Plan Modifications Alternative includes more activities in more locations than the Current Plan Alternative, and its geographic scope is larger. Both alternatives would offer environmental benefits. These benefits, combined with other regional plans and projects to help manage growth in a more sustainable manner, could result in greater cumulative benefits because they would help to reduce vehicle trips and urban sprawl.

4.13.1 Earth

Surface geology in some areas of the Puget Sound region has been substantially altered through filling and regrading activities. These alterations were conducted for the development of major cities; the construction of large transportation facilities such as I-5; the Lake Washington Ship Canal; the ports of Seattle, Tacoma, and Everett; and major airports such as Paine Field and Sea-Tac Airport. Fewer major projects at that scale are expected in the future, but some projects and developments could affect localized geologic conditions.

As noted in Section 4.1, significant unavoidable adverse earth impacts due to the Current Plan Alternative or the Potential Plan Modifications Alternative are not expected. The primary types of impacts identified for the Current Plan Alternative and the Potential Plan Modifications Alternative were related to landslide, steep slope, seismic, and other geologic hazard areas—risks that could largely be managed by appropriate design measures. Typical construction impacts included erosion, settlement, and soils removal. Similar types of geologic risks impacts would be expected for other types of future developments and actions. These other current and future activities would be subject to local permits and building standards; therefore, unavoidable adverse impacts would be limited. Overall cumulative impacts would be minor.

4.13.2 Air quality

Although motor vehicles are a major source of air quality pollution, pollution is created from a broad range of other sources, including industrial facilities, aircraft, marine vessels, home heating, power plants, or agriculture. Natural sources or events such as wildfires can also contribute to pollution. Since the passage of the federal Clean Air Act in 1970, substantial progress has been made in reducing air pollutant emissions from motor vehicles and other sources. However, continued population and employment growth has been increasing the

number of pollution sources and likely will continue to do so; in addition, greenhouse gas emissions will continue to be a primary global concern.

Section 4.2 concludes that no adverse regional air quality impacts are expected for the Current Plan Alternative or the Potential Plan Modifications Alternative; both alternatives could reduce vehicle trips and related pollutant emissions, which would benefit air quality. Some localized impacts on air quality could occur, but these could be mitigated. Construction activities for the Current Plan Alternative and the Potential Plan Modifications Alternative could increase air quality pollution in the short term, but mitigation measures could be implemented.

4.13.3 Noise and vibration

The level of noise and vibration due to human activity in the region has been growing concurrent with population increases for more than 100 years; this trend is expected to continue to increase. Transportation (ranging from motor vehicles to airplanes, trains, and ships) is a major noise source, as are industrial activities and construction. Cumulative impacts for noise are expected to be similar for the Current Plan Alternative and the Potential Plan Modifications Alternative; however, the geographical area of impact would increase due to the additional scope of the corridors in the Potential Plan Modifications Alternative.

Most noise and vibration due to transit operations would be reduced through mitigation (Section 4.3). Therefore, the increases in cumulative impacts with the Current Plan Alternative or the Potential Plan Modifications Alternative would be low, although some areas may have increased noise levels over time as other developments occur and as surrounding traffic grows. In addition, temporary construction impacts may be unavoidable in some locations. In localized areas, the construction of projects by others in the same time period could increase the cumulative duration and intensity of construction noise and vibration impacts.

4.13.4 Water quality and hydrology

Water resources within the Plan area have been affected by past actions due to urban development or earlier agricultural and resource extraction activities (such as logging and mining) that occurred with settlement. Recent regulations and water resource management programs have helped to avoid and mitigate impacts from new development.

As described in Section 4.4, the Current Plan Alternative or the Potential Plan Modifications Alternative would avoid or minimize water quality and hydrology impacts by complying with regulations, plans, and policies that have been established to protect water quality during construction and operation. The Current Plan Alternative or the Potential Plan Modifications Alternative, when combined with other projects in the region (which also would be subject to surface-water management regulations), would have a low potential to increase cumulative impacts on water quality and hydrology. However, they could contribute to an overall trend that removes natural cover and increases impervious surfaces. While some modes, such as light rail transit, have non-pollutant generating guideways, the corridors have facilities such as parking lots, new roadways for access, or bus or shared use facilities that could be pollutant-generating surfaces.

To minimize potential increases in cumulative impacts, Sound Transit would continue to integrate Low Impact Development approaches in its projects, seek opportunities to provide replacement vegetation where feasible, and, as practical, develop its facilities to not preclude future restoration of streams or other water bodies that were affected by past actions.

4.13.5 Ecosystems

In much of the Plan area, ecosystems have been altered to varying degrees, particularly where urban development has been concentrated (Section 4.5). This includes most of the major water bodies in the Plan area, as well as the largely forested ecosystems that originally dominated the landscape. Much of the Plan area has been substantially modified, and the remaining habitats are fragmented and impaired, although many still support native and nonnative fish, wildlife, and plant species adapted to the urban environment. Of particular ecological concern are the threatened, endangered, or candidate species affected by many past actions, often as a result of lost and degraded habitat.

Within the Plan area, further development is expected to continue into the future. Environmental protections for critical areas, permitting, and growth management policies, if correctly implemented, would help minimize cumulative impacts on ecosystems, particularly compared to earlier developments occurring before these protections and policies were in place. In addition, the Current Plan Alternative or the Potential Plan Modifications Alternative helps support more compact development in urban centers and decreases pressures for sprawl, including on the fringes of the region where much of the remaining higher quality habitat is in place. Still, the plan alternatives, when combined with these other future actions, could result in higher levels of cumulative impacts on ecosystems during operation and construction. However, mitigation measures, along with natural resource permit conditions and Sound Transit's environmental protection commitments, would help to keep incremental increases in impacts low.

As noted under water quality and hydrology above, Sound Transit could help offset potential increased cumulative impacts by avoiding and minimizing ecosystem impacts and restoring or replacing impacted habitat and vegetation. For example, Sound Transit's Sustainability Initiative includes a commitment to achieve a "no net loss" in wetlands and other ecosystem functions and acreage. Sound Transit would also implement low impact development approaches and BMPs for construction, as well as for its permanent facilities and operations.

4.13.6 Energy

Energy consumption in the region, nationally, and worldwide has increased as population, employment, and related economic activity and development have increased. These trends are expected to continue. Long-term, significant unavoidable adverse impacts on energy resources are not expected for the Current Plan Alternative or the Potential Plan Modifications Alternative. As noted in Section 4.6, their long-term impact on regional energy consumption due to transportation activities would be positive because they would reduce overall transportation energy consumption, leaving them with a low potential for increased cumulative impacts when taken with other actions.

Construction activities related to the Current Plan Alternative and the Potential Plan Modifications Alternative would consume energy. However, the Current Plan Alternative or the Potential Plan Modifications Alternative, along with other continued development within the

region, would not adversely affect the continued availability of energy. Energy production in Washington, the United States, and globally reflects continued expectations for increased population and employment growth and related urban infrastructure, including programs such as the regional transit system.

4.13.7 Environmental health

The Plan area has a large number of contaminated sites due to past uses, and the Plan area continues to have ongoing activities that involve the production and use of contaminated materials. Increasingly strict regulations, cleanup programs, and improved management practices have slowed the rate of contamination and helped address areas with past contamination.

As noted in Section 4.7, the Current Plan Alternative or the Potential Plan Modifications Alternative would not create adverse impacts due to hazardous materials or have other impacts on human health or physical activity; therefore, the additional cumulative impacts would be low to positive. Light rail and some other system elements involve electrical systems that generate electromagnetic fields, similar to or lower than fields created through other urban features and activities, and EMF levels would remain well below what is considered hazardous. Contaminated sites in corridors associated with both alternatives could be encountered, but these sites could be avoided or managed to reduce risk to humans and the environment. Corridors that require acquisition of past contaminated sites could also result in a positive cumulative impact because such sites might not be otherwise remediated.

Under the Current Plan Alternative or the Potential Plan Modifications Alternative, an expanded regional transit system, in conjunction with other regional and local plans and projects, would increase long-term benefits to human health. They would create an urban environment that increases transit access and service, encourages more active lifestyles, and helps reduce the negative impacts of higher levels of automobile use.

4.13.8 Visual quality and aesthetics

The visual character of the Plan area has changed due to development, which has altered landscapes and replaced natural features with manmade ones. Either the Current Plan Alternative or the Potential Plan Modifications Alternative would continue to alter visual conditions by removing existing natural features or previous developments and adding features such as walls, stations, transit guideways, and transit vehicles. Many of the corridors follow existing transportation corridors that are already visually prominent, and the additional transit facilities could increase their scale.

Because the transit improvements from the alternatives are intended to link activity centers, they are likely to be near other planned transportation and land use development projects. In some cases, the plan elements along with other concurrent development projects could increase a trend toward larger buildings, greater visual scale, and greater density. However, the mitigation measures identified in Section 4.8 would be employed to further minimize cumulative adverse impacts.

Construction activities involve temporary periods with higher levels of visual impacts, and if multiple projects are being constructed in the same vicinity, the cumulative impacts could by higher. However, for either long-term or construction period actions, coordinated planning

with other developments, local jurisdictions, and the public could help further reduce the potential for higher impacts and improve visual continuity and harmony in the developed areas, with opportunities for shared or combined green spaces, unified design elements, or other visual amenities.

4.13.9 Land use

The land use analysis in Section 4.9 is inherently cumulative because it anticipates the population and employment growth expected regionally; moreover, the Current Plan Alternative and the Potential Plan Modifications Alternative support the plans and policies established through coordinated regional, county, and local jurisdictional comprehensive planning processes, which would be a benefit. The increased mobility and transportation service expected with the plan alternatives would help support the higher land use densities expected in urban centers and other activity areas and corridors, which is consistent with regional and local land use plans.

Land use would have local impacts, such as property acquisitions; in some corridors, these acquisitions would add to the impacts of past or future acquisitions for other transportation facilities. Other conversions of existing land uses could occur cumulatively as other projects, including private developments, develop vacant land or underutilized sites and structures. However, private development would be subject to the conditions established under a local jurisdiction's adopted plans, policies, and regulations. Construction impacts on adjacent land uses could also be cumulatively higher in areas where other projects have major construction activities nearby.

Cumulative impacts on land use would be relatively minor and localized in the areas where the Potential Plan Modifications Alternative involves corridors, facilities, and programs not included in the Current Plan Alternative. Regionally, the potential for increased adverse cumulative land use impacts would be relatively low for either alternative given the scale of other past, present, and reasonably foreseeable future developments. Improved high-capacity transit systems would support the goals, objectives, and policies of these plans for managing population and employment growth by increasing transportation choices.

4.13.10 Public services and utilities

As regional population has increased (Section 4.10), the demand for public services and utilities has also increased. No significant unavoidable adverse impacts on public services or utilities are expected with either the Current Plan Alternative or the Potential Plan Modifications Alternative. The potential for increased cumulative impacts from the Current Plan Alternative or the Potential Plan Modifications Alternative would be low when compared with the longer term increases in demand for public services and utilities due to population and employment growth regionally. Construction activities may alter the location of some utilities and services, but generally utilities and services would continue to be maintained during construction, minimizing impacts. Other public infrastructure projects would likely apply similar mitigation measures during operation and construction as Sound Transit would under both alternatives. In addition, other types of development would be governed by local comprehensive plans and related concurrency requirements, which tie development approvals to the ability to provide supporting public services and utilities.

4.13.11 Parks and recreation

Parks and recreation facilities are also experiencing higher levels of use as the region grows. Most local comprehensive plans call for protecting existing parks and recreation facilities and developing new ones to meet community needs. However, continued development throughout the region is reducing the amount of land available for such facilities.

As noted in Section 4.11, cumulative impacts on parks could occur in areas where either the Current Plan Alternative or the Potential Plan Modifications Alternative is near other public or private developments. In these areas, nearby parks and recreation facilities are likely to experience an increase in cumulative impacts from noise, traffic, and construction activities, including visual change. However, the Current Plan Alternative and the Potential Plan Modifications Alternative could also provide offsetting benefits by helping to reduce the need for parking because transit could improve access to some park and recreation facilities. Both the Current Plan Alternative and the Potential Plan Modifications Alternative also provide opportunities to incorporate complementing facilities such as improved bicycle, pedestrian, or trail links to parks and recreation facilities.

4.13.12 Historic resources

Past developments have affected archaeological and historic resources in the central Puget Sound region. Section 4.12 notes that impacts on historic properties, including archaeological sites, are a possibility from operation or construction along either the Current Plan Alternative or the Potential Plan Modifications Alternative corridors, and mitigation would avoid or minimize impacts. The potential for cumulative impacts would increase because other public and private urban developments could remove or alter other historic properties. Archaeological sites could be affected by other projects as well as land developments.

4.13.13 Mitigation for cumulative impacts

For all the environmental areas identified above, Sound Transit's environmental mitigation measures for the direct and indirect impacts of the Current Plan Alternative or the Potential Plan Modifications Alternative discussed in Sections 4.1 through 4.12 would help reduce the potential for increases in cumulative impacts considering the impacts of other past, present, or reasonably foreseeable future actions. To avoid other potential sources of cumulative impacts, Sound Transit would coordinate with other parties developing projects or with other actions that might coincide in location or in time with the development of any of the Long-Range Plan corridors or programs. This coordination would be particularly beneficial for construction-period activities, which are a primary area of impacts stemming from the plan alternatives.

In addition, Sound Transit could also work with agencies responsible for resource management to identify further measures to help offset the potential for higher cumulative impacts in areas where they may occur. For example, to offset potential ecosystem impacts in areas where multiple projects by Sound Transit and others might be occurring, Sound Transit could participate in programs for mitigation banking for wetlands or ecosystem function replacement.

4.13.14 Significant unavoidable adverse impacts

Although most of the impacts of the alternatives could be mitigated below the level of significance for most environmental topic areas, some areas of significant impacts could remain even after mitigation. For example, construction impacts could involve significant impacts that may not be avoidable or fully mitigated, and which could have greater duration or intensity when combined with other actions. Other areas of potentially significant cumulative impacts are the loss of historic or archaeological resources, increases in noise or vibration, the loss or alteration of specific ecosystem features (although Sound Transit's no net loss policies would provide compensatory mitigation), and visual impacts.