Interstate BRIDGE Replacement Program

DRAFT Bridge Design Options Technical Report

April 2023

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Bridge Design Options Technical Report

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ACRONYMS AND ABBREVIATIONS

BMP	best management practice
CIA	contributing impervious area
EMF	electric and magnetic fields
FHWA	Federal Highway Administration
GHG	greenhouse gas
I-5	Interstate 5
IBR	Interstate Bridge Replacement
LPA	Locally Preferred Alternative
LRT	light rail transit
NB	northbound
NEPA	National Environmental Policy Act
ODOT	Oregon Department of Transportation
SB	southbound
SEIS	Supplemental Environmental Impact Statement
sq ft	square feet
WSDOT	Washington Department of Transportation

1. INTRODUCTION

The Interstate Bridge Replacement (IBR) program would replace the aging Interstate Bridge across the Columbia River with a modern, seismically resilient multimodal structure, and the program would construct infrastructure improvements along a 5-mile stretch of the Interstate 5 (I-5) corridor in Portland, Oregon, and Vancouver, Washington. Through a collaborative process with the federal lead agencies—the Federal Highway Administration (FHWA) and the Federal Transit Administration—and the local and regional agencies sponsoring the IBR program, a Modified Locally Preferred Alternative (LPA) has been developed. The Modified LPA is a modification of the LPA that was selected for the Columbia River Crossing Project, which completed the NEPA process with a signed Record of Decision (ROD) in 2011 and two re-evaluations that were completed in 2012 and 2013. The IBR program's Modified LPA is evaluated in the Supplemental Environmental Impact Statement (SEIS).

A component of the Modified LPA is a new pair of Columbia River bridges, which would be built west (downstream) of the existing bridges. The bridge type identified for the Modified LPA is a double-deck fixed-span bridge; it is described in Chapter 2. There are two additional design options for bridge configuration: single-level fixed-span bridges, and single-level bridges with movable spans. This technical memorandum evaluates the impacts and benefits to the environment that would result from the Modified LPA and the two bridge design options. This analysis supplements discipline-specific technical reports, which evaluate the Modified LPA with double-deck fixed-span bridges. A comparative analysis across all environmental disciplines is provided. For consistency in this analysis, the Modified LPA and each of the bridge design options are assumed to have one auxiliary lane across the Columbia River bridges.

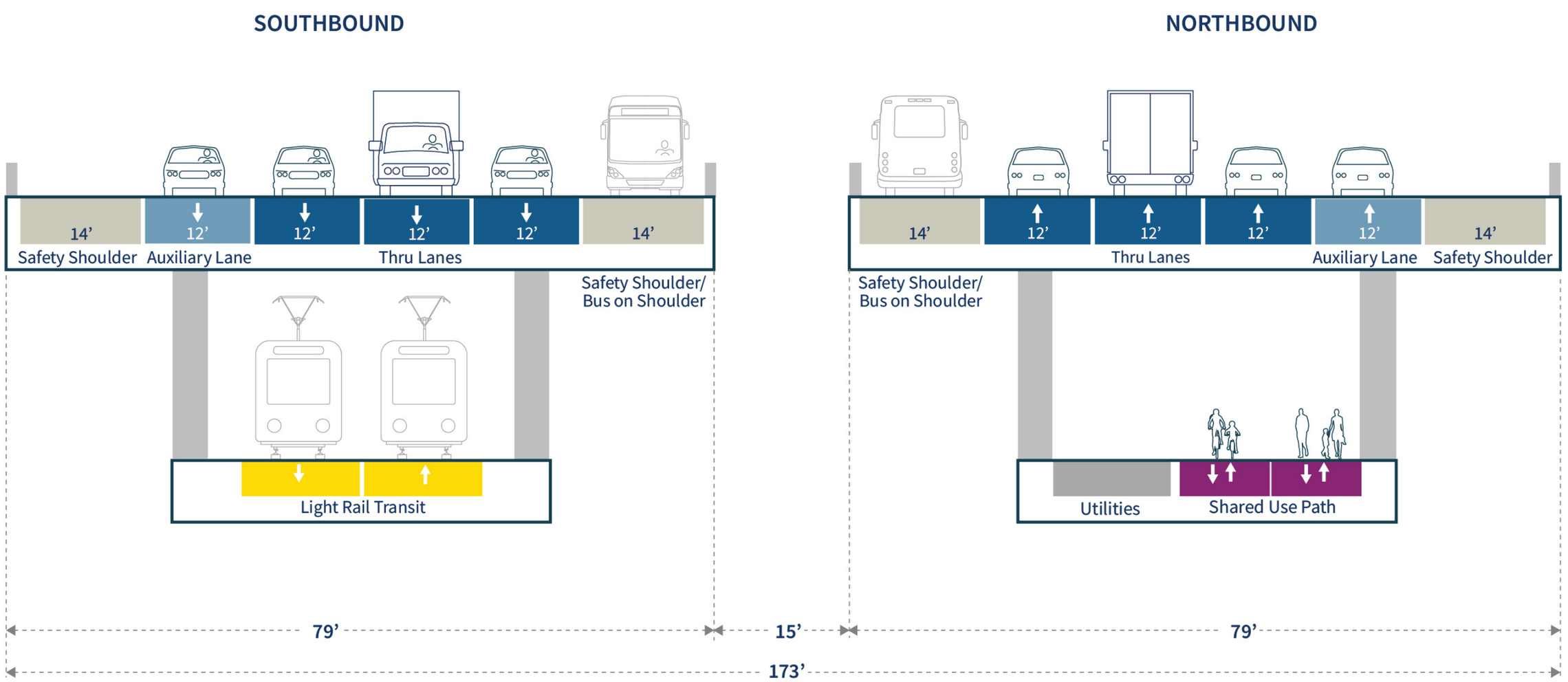
2. BRIDGE CONFIGURATIONS

The following sections describe the assumptions and features for the Modified LPA and each of the bridge design options. Following the descriptions, Table 2-1 provides a side-by-side comparison of the bridge design options.

2.1 Modified LPA – Double-Deck Fixed-Span Bridge

Under the Modified LPA, the existing parallel I-5 bridges that cross over the Columbia River would be replaced by two new parallel bridges, which would be located west of the existing bridges. The new eastern bridge would accommodate northbound highway traffic on the upper level with a bicycle and pedestrian path and utilities underneath. The new western bridge would carry southbound traffic on the upper level and two-way light rail tracks below. Whereas the existing bridges each have only three lanes with no shoulders, each of the two new bridges would be wide enough to accommodate three through lanes, one auxiliary lane, and shoulders on both sides of the traveled way. Lanes and shoulders would be built to full design standards. Figure 2-1 is a cross section of the two proposed parallel double-deck bridges.

1 Figure 2-1. Cross Section of the Double-Deck Bridge (Modified LPA)



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The existing Interstate Bridge has nine in-water pier sets, whereas each of the new Columbia River bridges would be built on six pairs of in-water piers, plus multiple piers on land. Each in-water pier set would be supported by a foundation of approximately twelve 10-foot-diameter drilled shafts; each group of shafts would be tied together with a concrete pile cap measuring approximately 50 by 80 feet at the water line. Columns or pier walls would rise from the pile caps and connect to the superstructures of the bridges (see Figure 2-2. As with the existing bridges, the new Columbia River bridges would provide three navigation channels: a primary channel and two barge channels (see Figure 2-3). However, the primary navigation channel in the Modified LPA would be swapped with the existing main barge channel; the new primary navigation channel would be closer to the center of the river than its current location. The current location is near the Vancouver shoreline where the existing lift spans are located. Each of the three navigation channels would be 400 feet wide (this width includes a 300-foot congressionally or USACE-authorized channel plus a 50-foot channel maintenance buffer on each side of the authorized channel). The new Columbia River bridges would provide approximately 116 feet of vertical navigation clearance for river traffic using the primary navigation channel. This height would not impede takeoffs and landings by aircraft using Pearson Field or Portland International Airport to the east. The new Columbia River bridges under the Modified LPA would not include movable spans. Figure 2-3 compares the profile and clearance of the new Columbia River bridges under the Modified LPA with the profile of the existing Interstate Bridge shown in the background.

Figure 2-2. Bridge Foundation Concept

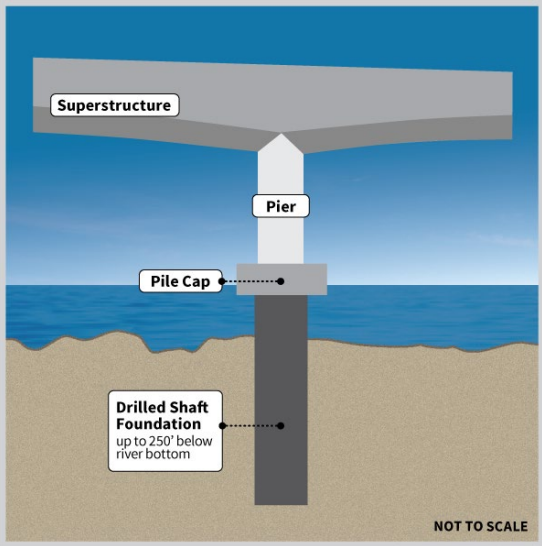
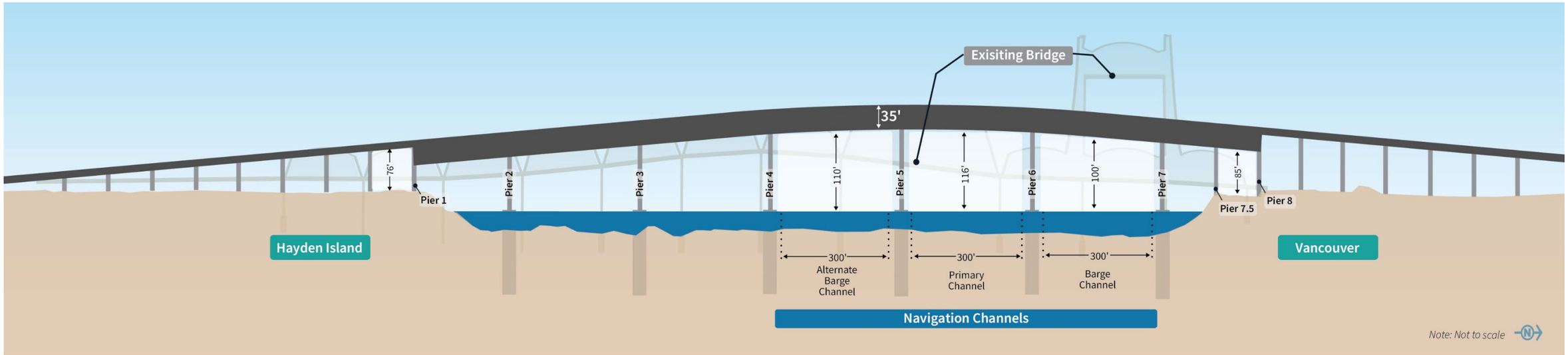


Figure 2-3. Profile and Vertical Navigation Clearance of the Proposed Columbia River Bridges



2.2 Design Options

2.2.1 Single-Level Fixed-Span Bridges

The single-level fixed-span bridges design option would have two side-by-side, single-level steel or concrete haunched girder[1] bridges; an example is shown in Figure 2-4. Similar to the Modified LPA, the single-level fixed-span bridges would provide 116 feet of vertical navigation clearance over the primary navigation channel and 400 feet of horizontal navigation clearance at the primary navigation channel and barge channels. The I-5 highway, light rail tracks, and the shared-use path would be on the same level across the two bridges. There would be the same number of in-water piers for the single-level fixed-span bridges design option as for the Modified LPA. Figure 2-5 shows a typical cross section of the single-level fixed-span bridges design option.

Figure 2-4. Haunched Girder Bridge

2.2.2 Single-Level Movable-Span Bridges

The single-level movable-span bridges design option would have two side-by-side, single-level steel haunched girder bridges with constant-depth (not haunched) movable lift spans between Piers 5 and 6. The single-level movable-span bridges would provide 89 feet of vertical navigation clearance over the primary navigation channel when the movable lift spans are in the closed position.

[1] A haunched girder is one whose depth varies along its length. The bridge type is not yet determined but this bridge type is representative for a single-level fixed-span bridge for environmental analysis purposes only.

In the open position, the single-level movable-span bridges would provide 178 feet of vertical navigation clearance. Similar to the Modified LPA, this design option would provide 400 feet of horizontal navigation clearance at the primary navigation channel and two barge channels. The I-5 highway, light rail tracks, and the shared-use path would be on the same level across the two bridges. There would be the same number of in-water piers for this design option as for the Modified LPA. The size of the pile caps would be the same as for the fixed-span options for in-water Piers 2, 3, 4, and 7. The size of the pile caps for Piers 5 and 6 would be 50 feet by 312 feet to accommodate the equipment that operates the movable lift spans. The cross section of the single-level movable-span design option is shown on Figure 2-6. The cross section of the movable spans is shown in the top image, and the cross section of the fixed spans is shown in the bottom image.

1 Figure 2-5. Cross Section of the Single-Level Fixed-Span Bridges Design Option

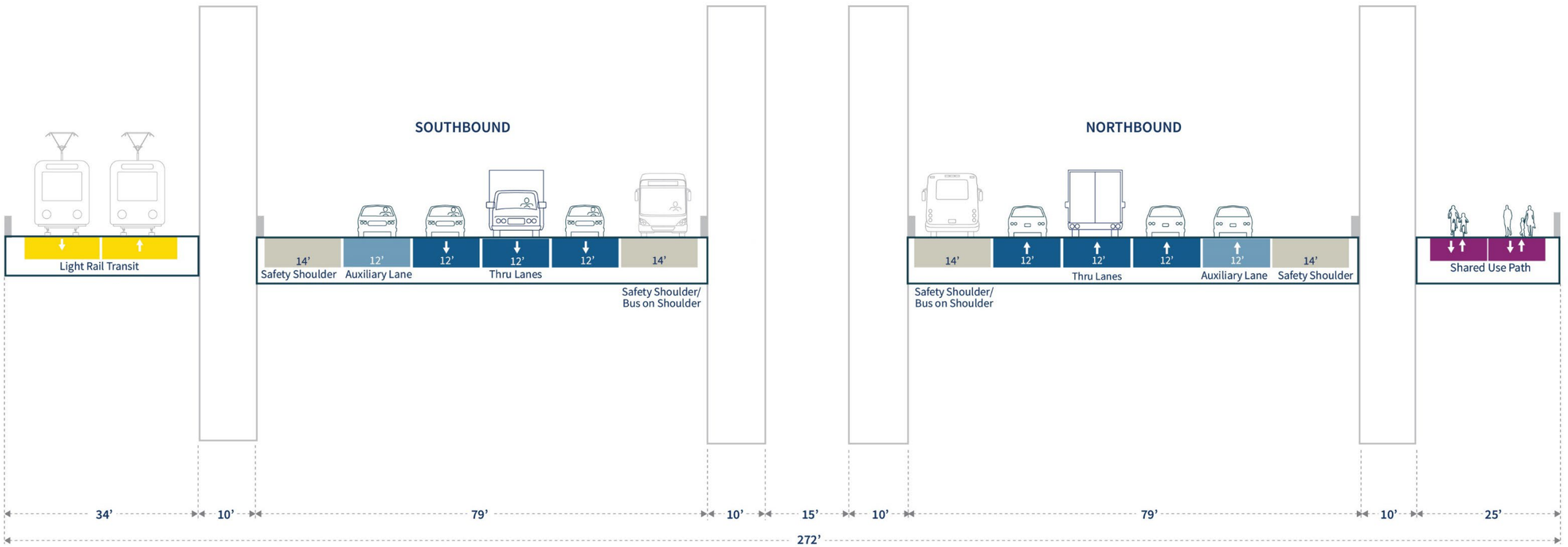


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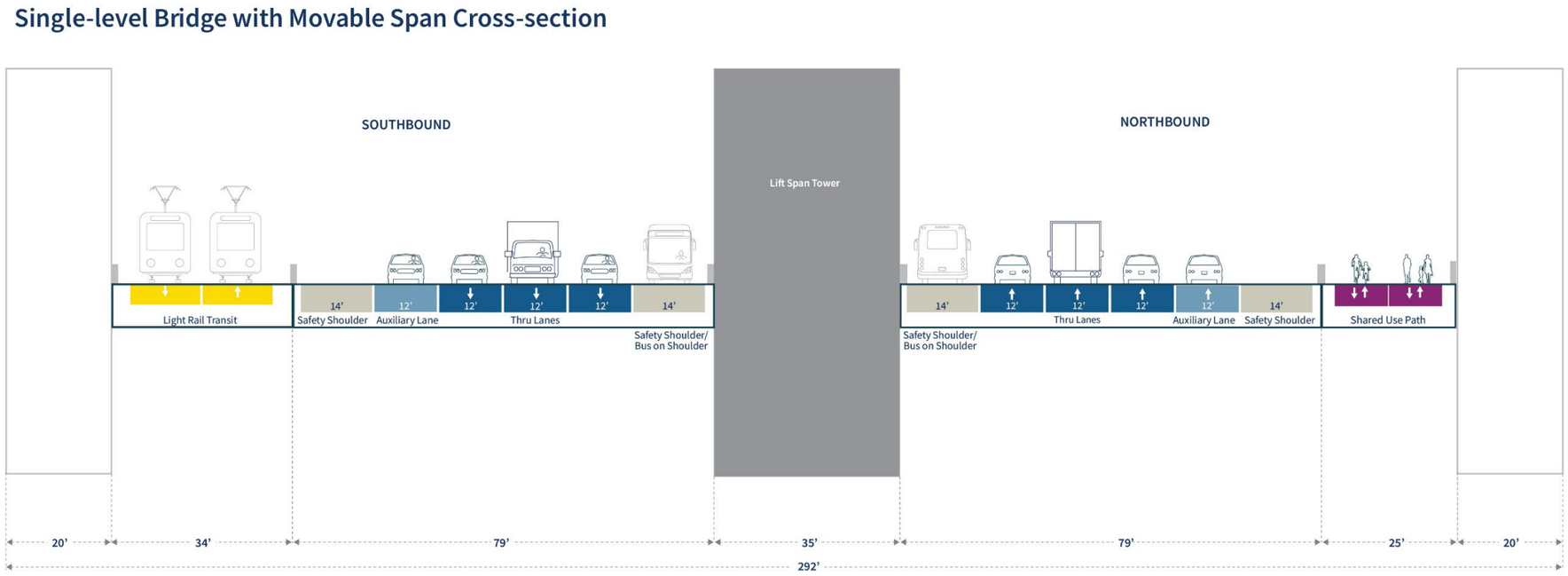
Figure 2-6. Cross Sections of the Single-Level Movable-Span Bridges Design Option



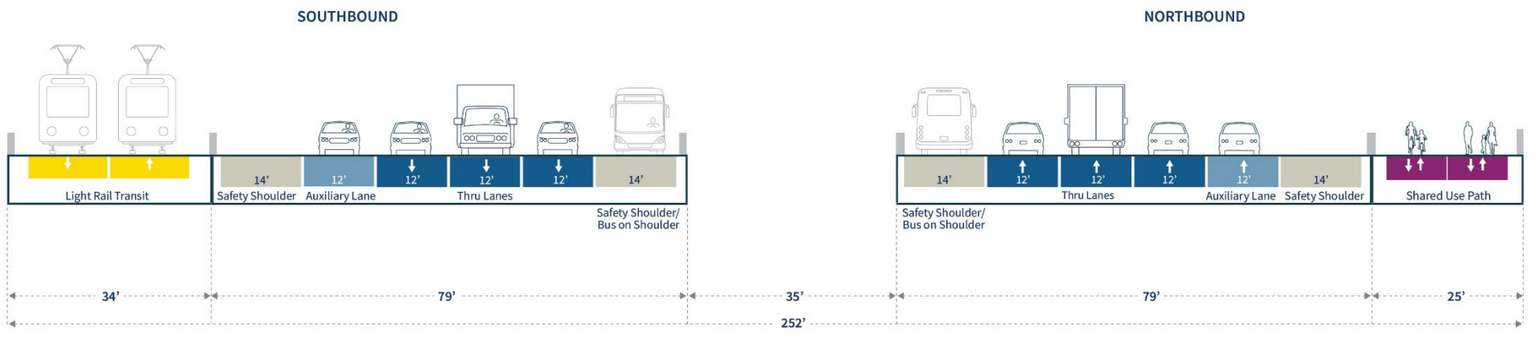


Table 2-1. Summary of Bridge Design Options

	Modified LPA (Double-Deck Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Bridge type	Double-deck truss.	Single-level, haunched concrete or steel girders, extradosed or finback.	Single-level, haunched steel girders (for fixed spans) with constant-depth steel girder movable span.
Number of bridges	2	2	2
Movable-span type	N/A	N/A	Vertical lift span with counterweights.
Movable-span location	N/A	N/A	Between Piers 5 and 6.
Lift opening restrictions	N/A	N/A	Assume potential for future rules that would be determined by USCG (beyond the assumed No-Build bridge restrictions for peak AM and PM highway travel periods).[1] Typical opening durations are assumed to be 12 minutes for the purposes of impact analysis, but would ultimately depend on various operational considerations related to vessel traffic and river conditions.
Out-to-out width	173 feet total width 79 feet (SB) 79 feet (NB)	272 feet total width 113 feet (SB) 104 feet (NB)	292 feet at the movable span 252 feet at the fixed span 113 feet SB fixed span 104 feet NB fixed span
In-water work seasons	Up to seven (five for construction and up to two for demolition)	Up to 7 (5 for construction and up to 2 for demolition)	Up to 7 (5 for construction and up to 2 for demolition)
Vertical clearance at primary navigation channel	116 feet	116 feet	89 feet when closed 178 feet when open
Horizontal clearance for all navigation channels	400 feet	400 feet	400 feet
Approximate tower height	N/A	N/A	243 feet

	Modified LPA (Double-Deck Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Span length between Piers 5 and 6	450 feet	450 feet	450 feet
Number of in-water piers	6 per bridge (12 total)	6 per bridge (12 total)	6 per bridge (12 total)
Pile cap sizes and numbers	50 feet by 80 feet	Single-level steel or concrete girder: 50 feet by 110 feet NB and 50 feet by 120 feet SB. Single-level extradosed or finback (with cantilevered deck): 50 feet by 228 feet.	Piers 2, 3, 4, and 7: 50 feet wide by 110 feet long NB, 50 feet by 113 feet SB (two independent pile caps at each pier, one for NB and one for SB). Piers 5 and 6: 50 feet wide by 312 feet long (one combined footing at each location to house tower/equipment for the lift span).
Transit location	Below highway on SB bridge.	West of highway on SB bridge.	West of highway on SB bridge.
Shared-use path location	Below highway on NB bridge.	East of highway on NB bridge.	East of highway on NB bridge.

1 The No-Build Alternative assumes existing conditions that restrict bridge openings during weekday peak periods (Monday through Friday 6:30 a.m. to 9:00 a.m.; 2:30 p.m. to 6:00 p.m., excluding federal holidays). With the movable-span option, the Draft SEIS analysis estimates the potential frequency for openings for vessels requiring clearance greater than the closed position. While potential additional opening time restrictions beyond No-Build are not yet known and would be determined by the U.S. Coast Guard through its regulatory processes, the Draft SEIS characterizes the typical transportation impacts of an opening at non-peak time periods, such as evenings or weekends. The overall analysis considers the frequency of openings and the time periods where openings could be allowed. Potential mitigation measures will be identified in consultation with the U.S. Coast Guard to support more details on specific additional time periods when openings could be further restricted; this information and updated analysis would be incorporated in subsequent drafts of this technical report and in the SEIS.

NB = northbound; SB = southbound; USCG = U.S. Coast Guard

3. ENVIRONMENTAL IMPACTS AND BENEFITS FOR BRIDGE OPTIONS

For each environmental resource area, Table 3-1 summarizes the impacts and benefits of the Modified LPA with a double-deck fixed-span bridge and the two bridge design options compared to the No-Build Alternative. For the purposes of this analysis, all bridge option scenarios include one auxiliary lane in each direction, the C Street ramps at the SR 14 interchange, and a centered I-5 alignment in downtown Vancouver. These impacts are based on conceptual design and are subject to change. Unless otherwise noted, the temporary impacts would be the same for the Modified LPA and each of the design options.

Table 3-1. Comparison of Environmental Impacts and Benefits for Bridge Design Options

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Transportation	**Highway Traffic and Local Connections**			
	• Traffic congestion would continue to worsen, and the existing bridge would remain a bottleneck. • Highway traffic would continue to be affected by bridge lifts. • The frequency and duration of bridge lifts is expected to be similar to existing conditions, which averaged 260 bridge lifts per year between 2015 to 2019. This includes an average of 153 lifts per year for vessels and 98 lifts per year for maintenance. • The lack of shoulders on the bridge (2 feet) would continue to impact traffic congestion and safety concerns. • Existing grades are approximately 5% and would not change with the No-Build Alternative. • Existing maximum height is approximately 90 feet. • The crash rate during bridge lifts/traffic stoppages is three to four times higher than during normal operating conditions. • Crash rates on I-5, including across the Interstate Bridge, are expected to increase compared to existing conditions due to increased congestion. • Lacks seismic resiliency.	• Includes wider shoulders (14 feet) and improved geometry, allowing improved traffic operations and safety compared to the No-Build Alternative. • The maximum grade is 4% on the Washington side and 3.8% on the Oregon side of the bridge. The bridge profile is higher than the No-Build Alternative at approximately 163 feet maximum. The increased bridge height over the water increases the length of the steeper grades, so all users must climb over a longer distance to get over the peak, as compared to No-Build. However, these factors would reduce the effect of the grade climb on active transportation and heavy vehicles (freight and buses). • Crash rates on I-5, including across the Columbia River bridges, are expected to be reduced compared to the No-Build Alternative because of improved roadway geometry (vertical and horizontal improvements), added acceleration and deceleration length for vehicles to merge/diverge/weave, added shoulders, and the removal of bridge lifts as the Modifies LPA does not include a movable span. • Increased seismic resiliency.	Similar to the Modified LPA, except: • The maximum grade is 3% over the Columbia River and 1.5% over the Vancouver waterfront and BNSF railroad on the Washington side, and 3% on the Oregon side of the bridge. • Lower profile height than under the Modified LPA at approximately 135 feet maximum, which would improve ramp geometry. Profile would be similar to that of the lower deck in the Modified LPA. • Lower bridge height over the water decreases the length of the steeper grades so all users have a shorter climb distance to get over the peak. This would be beneficial for users when compared to the Modified LPA.	Similar to the single-level fixed-span bridges, except: • The maximum grade is 4% on the Washington side and 1% on the Oregon side of the bridge. Lower profile height at approximately 120 feet maximum, but still higher than the No-Build Alternative. • Impacts traffic operations due to the bridge lifts. • Similar to the No-Build Alternative, periodic bridge lifts would continue. However, the number of lifts would be reduced with approximately 60 lifts per year for marine vessels. This estimate is based on averages from 2012 to 2022 and known and estimated vessel heights. • It is estimated that there would be 12 lifts per year for maintenance, which is fewer than the No-Build Alternative. Additional lifts would be required for training purposes. • Similar to the No-Build Alternative, daytime bridge lifts could impact traffic congestion for an hour or more; nighttime bridge lifts would have less impact on traffic congestion. • Similar to the No-Build Alternative, the crash rate is expected to be three to four times higher during a bridge lift than during normal operating conditions. However, since the total number of lifts per year would be fewer than the No-Build Alternative, the total number of crashes would also be lower.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
	High-Capacity Transit			
	• Bus transit would continue to be affected by traffic congestion, which would increase over time. • Bus transit would be delayed by bridge lifts.	• Bus operations would be similar to those described under highway traffic and local connections (above). • New light rail transit (LRT) service between Portland and Vancouver would be provided on the lower level of the southbound bridge and could cross the bridge without interruption. • LRT design speed would be 30 miles per hour (mph) approaching Waterfront Station. Operating speed would be lower. • The location on the lower deck requires primary emergency response access from the ends of the bridges, which would result in slower response times than the No-Build, but times would remain in the acceptable range.	Similar to the Modified LPA, except: • Single-level bridge design would improve LRT track geometry allowing higher travel speeds (55 mph design speed approaching Waterfront Station) and additional transit station location options at the Hayden Island Station and Waterfront Station compared to the Modified LPA. • Single-level bridge would improve transit emergency response due to same-level access for all modes, similar to No-Build.	Similar to the single-level fixed-span bridges, except: • LRT service would be subject to interruption by bridge lifts unless openings were restricted to nighttime only. • LRT speed over the bridge would be reduced due to movable joints on the rails, but design speed would be similar (55 mph).
	Active Transportation/User Experience			
	• Active transportation users of the shared-use path would continue to be subject to narrow widths (4 feet), limited sightlines, poor connections, and proximity to traffic. • Active transportation users would continue to experience delays during bridge lifts. • Bridge height (approximately 90 feet) and grades (approximately 5%) would not change.	• Would improve active transportation compared to the No-Build Alternative by adding a wider shared-use path (approximately 25 feet total for two-way path) and eliminating delays from bridge openings. • Users of the path would experience less exposure to pollutants from vehicle exhaust and would receive more protection from the elements than under the No-Build Alternative due to the shared-use path positioning on the lower deck. • Reduced visibility of the path from the vehicle lanes would result in active transportation users not experiencing the safety benefit from visibility from highway users, as compared to the No-Build Alternative. • Emergency response times to shared-use path incidents may be slower than under No-Build condition because active transportation users would be on the lower level. • Increased bridge height at 160 feet would require increased length of steeper grades (3.8% to 4%) as compared to the No-Build Alternative, thus reducing ease of access due to longer climb distance to surpass the peak.	Similar to the Modified LPA, except: • Users would experience similar exposure to pollutants from vehicle exhaust as with the No-Build Alternative and would continue to be exposed to the elements. • Users would experience the same level of security as with the No-Build Alternative due to visibility from the highway lanes. • Emergency response times to shared-use path incidents could improve compared to the Modified LPA. All facilities being located on a single level allows access from the highway lanes, similar to the No-Build Alternative.	Similar to the single-level fixed-span bridges, except: • Users and emergency responders would continue to experience delays during bridge lifts, similar to No-Build, but there would be fewer lifts overall. • Slightly reduced bridge height but would require steeper grades than with the No-Build Alternative, reducing ease of access.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Aviation and Navigation	**Aviation**			
	The historical hazard to aviation from the lift-span towers of the Interstate Bridge would be maintained.	• Main bridge structures would not encroach into Part 77[2] airspace at Pearson Airfield, unlike with the No-Build Alternative. • Would require some special (shorter) street lighting and signage to avoid Part 77 airspace at Pearson Airfield, unlike No-Build. • Improved (less steep) estimated departure climb gradient of 427ft/NM required to clear the bridge compared to No-Build (650ft/NM). • Wildlife in and around airports is a hazard to aviation. Consolidated structural elements would reduce the areas on which birds can land and roost, compared to the existing truss bridges, which use many small structural elements.	Similar to the Modified LPA, except: • For the extradosed and finback types, Pier 7 would likely penetrate into Part 77 airspace at Pearson Airfield. The haunched girder type may have furniture intrusions. • Would not require special street lighting and signage to avoid Part 77 airspace at Pearson Airfield.	Similar to the single-level fixed-span bridges, except that the lift-span towers would penetrate the Part 77 airspace at Pearson Airfield, as with the No-Build Alternative.
	Navigation			
	• River navigation would continue to be impacted by bridge lift timing limitations, the need for the S-curve maneuver, the reduced horizontal clearance in the primary channel from the authorized navigation channel width (263 feet), and in the event of an earthquake, the seismic deficiencies of the North Portland Harbor bridge and Interstate Bridge. • The bridge provides 178 feet of vertical navigation clearance when the lift span is in the open position. In the closed position, the bridge provides 38 feet (primary channel), 58 feet (barge channel), and 72 feet (alternate barge channel) of vertical navigation clearance.	• Reduced navigation clearance of 116 feet compared to 178 feet for the No-Build Alternative. Some current river users may be limited in future activities or require modifications to operations or vessels. • The length of the Vancouver Upper Turning Basin would be reduced. • Horizontal clearance would be increased in the primary navigation channel from 263 feet between bridge piers to 400 feet. • Decreased navigation complexity due to the primary navigation channel moving south compared to the No-Build Alternative, resulting in safer conditions for navigation. • The distance between the BNSF bridge and the I-5 bridge would be reduced, slightly reducing the available distance for vessels to align with the openings of the two bridges. • Bridge Pier 7 may impact vessel use of Terminal 1 at the Port of Vancouver.	Similar to the Modified LPA, except that the reduction in the Vancouver Upper Turning Basin would be shortened along with a similar reduction in distance between the I-5 bridge and the BNSF bridge.	Similar to the single-level fixed-span bridges, except: • Would provide 178 feet of vertical navigation clearance in the open position (as required by the USCG); this is similar to the No-Build Alternative. • Would provide higher vertical navigation clearance in the closed position (89 feet) as compared to the No-Build Alternative (72 feet). • Decreased navigation complexity due to the primary navigation channel moving south compared to the No-Build Alternative, resulting in safer conditions for navigation. • Movable-span operations, and thus river navigation operations, may need to be restricted to nighttime openings to minimize impacts to vehicle traffic and transit operations. This may be more restricted than under the No-Build Alternative.

[2] Code of Federal Regulations (CFR) Part 77 (often referred to as "Part 77") is the standard by which obstructions in navigable airspace are determined. Any object that penetrates the Part 77 surfaces may be deemed a hazard to aviation.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Property Acquisitions and Displacements	**Acquisitions**			
	No temporary or permanent easements, acquisitions, or encroachments.	Parcels that would require acquisition: • 45 full • 131 partial/subsurface Land uses that would be displaced: • 43 single-family residences • 35 commercial businesses • 2 public facilities	Same as the Modified LPA.	Same as the Modified LPA.
	Roadway Footprint Impacts			
	Maintains existing deck footprint (329,000 sq ft).	• Would require aerial encroachment over the planned Port of Vancouver public market development. • The elevated transit structure would be constructed near the planned Port of Vancouver Block B development. • Larger deck footprint than with the No-Build Alternative (455,550 sq ft).	Similar to the Modified LPA, except: • Additional aerial encroachment over the public market development. • Reduced clearance between elevated transit structure and Block B. • Larger deck footprint (491,180 sq ft).	Similar to the single-level fixed-span bridges.
Land Use	• No building or land use displacements would occur. • Existing land uses served by the structure, as well as interstate commerce and daily commute patterns, would remain vulnerable to high levels of congestion, unsafe conditions, and potential earthquake-induced failure. • Traffic congestion related to bridge lifts would impair freight movement and reduce area productivity, which may have indirect impacts on land use plans and goals.	• Would displace the Hurley Building (commercial office use) in Vancouver. • Would not lead to changes in existing land use patterns, zoning designations, or comprehensive land use plans.	Same as the Modified LPA.	Same as the Modified LPA.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Economic Activity	• No short-term benefits or impacts, or changes associated with construction activities. • Existing bottlenecks and congestion would increase. • Freight reliability would decrease as congestion spreads beyond the peak hour into times when trucks tend to travel. • Congestion at the Interstate Bridge would increase the cost of congestion delay to trucks. • Operation hours for taller vessels would continue to be restricted to off-peak hours.	• Higher minimum bridge clearance would allow most vessels to pass without lift span delays and timing restrictions, which would provide more flexibility in operating schedules and increased operation hours for taller vessels. This would benefit marine commerce. • Reduced maximum navigation clearance could have economic impacts to the four vessels/users that would no longer pass beneath the bridge; these impacts would be mitigated. • Improved travel times for vehicles crossing the river due to lack of bridge lifts. This benefits the trucking industry by reducing labor costs, improving safety, potentially improving vehicle operating costs, and reducing scheduling uncertainty. • Improved freight access resulting from the Modified LPA would reinforce existing economic growth and development. The Modified LPA would support this growth by reducing the roadway congestion experienced by freight and other vehicles going to and from the two cities. • New transit connections in downtown Vancouver would improve travel time, accessibility, and broaden the pool of labor available. • Improved travel times and reduced congestion would also likely broaden the labor pool available to businesses along the I-5 corridor. • Would result in both positive and negative temporary impacts, which include negative impacts from reduced business visibility, travel delays and congestion, and benefits from increased employment and spending in the construction industry.	Similar to the Modified LPA, except that the lower maximum height and reduced highway grade would benefit freight vehicle speed.	Similar to the single-level fixed-span bridges, except: • Bridge lifts would continue to cause delays and congestion for vehicles, freight, transit, and active transportation users. • Movable-span operations, and thus river navigation operations, may need to be restricted to nighttime openings to minimize impacts to vehicle traffic and transit operations. This may be more restricted than the No-Build Alternative. This could impact marine commerce by restricting movement to certain time periods for large vessels. • Lower bridge height would allow less traffic to pass without the delays associated with the bridge openings.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Neighborhoods	• Existing neighborhoods, community facilities, and social resources would not be impacted. • Neighborhoods would not benefit from reduced congestion, improved multimodal mobility, or potentially improved access to employment opportunities.	• Transit service would be improved by the addition of LRT. Residents of adjacent neighborhoods would benefit from increased access. • Changes to intersection operations in the study area would not be anticipated to impact neighborhood cohesion. • Hayden Island would experience both positive and negative changes to neighborhood cohesion including negative impacts from visual changes (larger scale than existing bridge) and residential and business displacements, as well as benefits from changes to access and circulation. • Temporary construction impacts including travel delay and congestion, air quality reduction, and noise could negatively impact neighborhood quality and cohesion in all neighborhoods adjacent to the corridor. • Travel conditions and delay would not be expected to reduce neighborhood cohesion. Most intersections would operate similar to or better than with the No-Build Alternative.	Similar to the Modified LPA, except: • Less constrained LRT profile and better transit alignment geometry would provide additional transit station location options at the Vancouver Waterfront Station and on Hayden Island. This would provide more opportunities to maintain or improve neighborhood cohesion. • Potential to improve Waterfront Station access and connection to development would benefit neighborhood cohesion.	Similar to the Modified LPA, except: • Decreased LRT profile elevation and grade could improve access and connections to the Vancouver Waterfront Station for transit vehicles and users. This could maintain or improve neighborhood cohesion. • Bridge lifts would impact vehicles and transit by causing backups which reduce reliability for all modes using the bridge. This would impact neighborhood cohesion.
Environmental Justice (EJ)	EJ populations would not benefit from reduced congestion, the extension and improvement of high-capacity transit, or improved active transportation accessibility.	• Compared to the No-Build Alternative, the Modified LPA would benefit EJ populations by improving air quality and providing investments in high-capacity transit, station area improvements, and active transportation improvements. Transit and active transportation improvements would improve access to jobs and services for EJ populations. • Tolling implemented on the new Columbia River bridges would result in low-income populations spending a proportionately greater share of household income and household expense on transportation to pay tolls than the general population. • The mitigation strategies included in the EJ analysis assume that future implementation of an IBR tolling program would include a low-income and/or equitable tolling policy to offset these disproportionate effects on EJ populations. • Preliminary determination of no disproportionately high and adverse effects on EJ populations.	Similar to the Modified LPA.	Similar to the Modified LPA, except that the movable-span option would result in additional travel delay for transit and active transportation users crossing the Columbia River. Disturbances to transit and active transportation could impact low-income and minority populations more than the general population. However, no disproportionately high and adverse effect on EJ populations is anticipated (per FHWA and USDOT guidance), given that the impacts would be the same for all populations traveling through the study area.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Equity	Equity priority communities would not benefit from reduced congestion, the extension and improvement of high-capacity transit, or improved active transportation accessibility.	• Addresses the program's Mobility & Accessibility equity objective. • Transit, active transportation, and drive-time improvements would provide benefits for equity priority communities by improving access to jobs and services. The program and transit agency partners can take steps to ensure that certain equity priority communities (i.e., BIPOC[3] and people under age 25) benefit as much or more than the general population by optimizing transit connections to high-capacity transit. • Hayden Island—where an above-average concentration of older adults and people with disabilities live, and where many lower-wage jobs are located—would be affected by bridge construction in relation to noise, air quality, temporary visual quality and aesthetic impacts, and transportation (traffic detours and road closures). Residential displacement would occur to accommodate the program footprint. • Downtown Vancouver—where an above-average concentration of low-income households, older adults, and people with disabilities live—would be affected by bridge construction in relation to temporary noise and air quality impacts, temporary visual quality and aesthetic impacts, traffic detours and road closures, and temporary closures of east-west bicycle and pedestrian connections. Commercial displacement would occur to accommodate the program footprint. • Bridge tolling may disproportionately impact lower-income drivers, many of whom belong to other equity priority communities. A more detailed equity analysis depends on the details of the yet-to-be-determined tolling program structure.	Same as the Modified LPA.	Similar to the Modified LPA, except that there would be additional travel delay for transit and active transportation users crossing the Columbia River due to the movable span. Disturbances to transit and active transportation could impact equity priority communities more than the general population—in particular BIPOC, low-income, and people with disabilities—due to their greater reliance on modes besides driving.

[3] Black, Indigenous, and People of Color

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Public Services	• Continued delay and disruption to emergency response times due to bridge lifts, and substandard shoulders limit emergency response vehicles' ability to circumvent traffic. • Congestion impacts limit the ability for emergency response to reach the bridge in both directions during both peak periods. • Bicycle/pedestrian path located adjacent to highway provides emergency vehicles with direct access to bike/pedestrian incidents.	• Emergency response times to transit and shared-use path incidents could be slower compared to the No-Build Alternative as a result of their location on the lower bridge deck, which would require primary emergency response to enter from the ends of the bridges. • Congestion would be reduced as compared to the No-Build Alternative, which would benefit emergency response vehicles' ability to access the bridge. Emergency response could use the shoulder to bypass congestion, which is not an option with the No-Build Alternative. • Emergency response delays from bridge lifts and accidents would be reduced compared to the No-Build Alternative.	Similar to the Modified LPA, except that emergency response times to transit and shared-use path incidents could improve compared to the Modified LPA. All facilities being located on a single level allows access from the highway lanes, similar to the No-Build Alternative.	Similar to the single-level fixed-span bridges, except that delays and disruptions to emergency response as under the No-Build Alternative would continue due to bridge lifts, but with less frequency.
Utilities	No impact to utilities or the levels of service provided, except in the event of a catastrophic earthquake.	• Utilities that would need to be relocated due to construction of the new bridges include the following: ➢ Communication cables across Hayden Island and southbound Interstate Bridge. ➢ Underwater communication and power cables. ➢ Communication infrastructure, a sewage lift station and force main, and a critical high-pressure gas line between the SR 14 interchange and the Columbia River. • Depending on the type of bridge foundations used, a sewage lift station on Columbia Street in Vancouver could require a full relocation.	Same as the Modified LPA.	Same as the Modified LPA.
Parks and Recreation	**Permanent Acquisition of Park Land (square feet)**			
	No permanent acquisition of park land.	• Old Apple Tree Park – 3,480 • Fort Vancouver National Historic Reserve – 40,984 • Fort Vancouver National Historic Site – 18,255 • Columbia River Renaissance Trail – 1,007 • Lewis & Clark National Historic Trail – 173 • Lower Columbia River Water Trail – 173 • Discovery Historic Loop Trail – 2,759	Similar to the Modified LPA, except: • Fort Vancouver National Historic Reserve – 43,538 • Fort Vancouver National Historic Site – 19,017 • Lewis & Clark National Historic Trail – 275 • Lower Columbia River Water Trail – 275	Similar to the single-level fixed-span bridges option.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
	Temporary Disturbance of Park Land (sq ft)			
	No temporary disturbance of park land.	• Old Apple Tree Park – 7,171 • Fort Vancouver National Historic Reserve – 91,580 • Fort Vancouver National Historic Site – 43,378 • Fort Vancouver Waterfront Park – 845 • Vancouver Landing at Terminal One – 1,521 • Columbia River Renaissance Trail – 229 • Lewis & Clark National Historic Trail – 2,004 • Lower Columbia River Water Trail – 2,004 • Discovery Historic Loop Trail – 2,030	Same as the Modified LPA, except: • Fort Vancouver National Historic Reserve – 93,446 • Fort Vancouver National Historic Site – 42,616 • Lewis & Clark National Historic Trail – 1,905 • Lower Columbia River Water Trail – 1,905	Similar to the single-level fixed-span bridges option.
Historic and Archaeological Resources	• No impact to archaeological resources because there would be no ground disturbance. • No impact to cultural and historic resources because there would be no demolition or construction activities. • The original 1917 span of the bridge would be retained.	Conclusions regarding the Modified LPA's effects on archaeology, cultural, and historic resources are pending.	Pending.	Pending.
Visual Quality and Aesthetics	No changes to visual quality or aesthetics.	• Adds new visual elements such as revised interchanges and on/off-ramps, bridge structures over North Portland Harbor and the Columbia River, expanded roadways, retaining walls, sound walls, signage, and lighting. • New Columbia River bridges would be higher in elevation and greater in mass because of the double deck and therefore more visible to surrounding areas. • Visual impacts would be neutral for many viewers because existing vegetation and land cover would block views; however, some viewers with direct views in the Vancouver Downtown, Columbia River, and Columbia Slough landscape units would have more exposure to changes in bridge, highway, and transit infrastructure that could reduce visual quality. • No substantial structural elements would extend above the bridge deck, such as the green steel lattice structure or lift span on the existing Interstate Bridge. This would maximize views above the bridge deck to the surrounding landscape. • Overall, the Modified LPA would be larger in scale than the features of the existing I-5 area and would contrast with the existing visual environment for adjacent viewers. Visual impacts would be adverse for some viewers.	Similar to the Modified LPA, except: • The wider single-level bridges would provide more bridge architectural opportunities such as the potential to use finback or extradosed designs; however, additional visual mass and height associated with these designs would likely increase visual impacts for neighbors and travelers. • The roadway would be wider than with the No-Build Alternative and the Modified LPA and would move transportation elements closer to nearby viewers; however, it would have a slimmer vertical profile than the Modified LPA and would further open views under and between bridge elements. • Viewers close to or under the Columbia River Bridges may benefit from this design option, but viewers in most areas would have similar or greater visual impacts as with the Modified LPA due to the increased bridge width. • Overall, adverse effects on visual quality would increase.	Similar to the Modified LPA, except: • There would be permanent visual impacts; the lift towers would protrude into the skyline for areas in Vancouver, Fort Vancouver, and toward and from Hayden Island. • Movable-span structures would increase the visual weight of the bridge. • Overall, adverse visual impacts would increase.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Air Quality	• The frequency and duration of bridge lifts is expected to be similar to existing conditions, resulting in similar levels of air quality pollutants due to vehicular idling during bridge openings.	• Reduction in air quality pollutants due to the elimination of bridge openings, which reduces the amount of vehicular idling. • Steeper grade than the No-Build Alternative; would increase operational emissions.	Similar to the Modified LPA, except that there would be fewer operational emissions due to the reduced profile grade of the bridges (approximately 29 feet lower height and 1% lower grade). The lower roadway deck would reduce the steepness of the bridge, which in turn reduces acceleration and braking of vehicles crossing the bridges and results in fewer emissions.	Similar to the single-level fixed-span bridges, except that there would be Increased air quality pollutants due to vehicular idling during bridge openings, but there would be fewer bridge openings than with the No-Build Alternative.
Noise and Vibration	At noise-sensitive locations near the Interstate Bridge, the No-Build Alternative would have highway noise impacts at one more location than existing conditions.	• The Modified LPA would have highway noise impacts at 14 more locations than with the No-Build Alternative. The 14 additional noise impact locations' noise levels would exceed the substantial increase threshold of 10 dBA over existing noise levels. Proposed highway noise mitigation does not reduce the number of impacts at these locations. • The Modified LPA would have moderate noise impacts at five more locations related to transit operations than with the No-Build Alternative. With proposed transit mitigation, the Modified LPA would have no transit noise impacts. • Shared-use path users would have less exposure to noise from highway vehicles than under the No-Build Alternative because the path would be on the bridge's lower deck. • Temporary and intermittent construction noise and vibration would occur with the Modified LPA that would not occur with the No-Build Alternative.	Similar to the Modified LPA, except: • This option would result in more highway noise impacts than the Modified LPA with a slight increase in highway noise impacts east and west of the bridge. Additional impacts would be due to the wider bridge span (99 feet wider) and lower roadway deck (30 feet lower). • This option could result in more noise impacts west of the bridge related to LRT operations due to the westward shift in the LRT alignment and increase in LRT speed due to improved geometry. • Shared-use path users would have more exposure to noise from highway vehicles than with the Modified LPA. Exposure would be similar to that experienced under No-Build Alternative conditions.	Similar to the single-level fixed-span bridges.
Energy and GHG	• The frequency and duration of bridge lifts is expected to be similar to existing conditions, resulting in similar levels of GHG emissions due to vehicular idling during bridge openings. • GHG emissions due to the electricity required to raise and lower the bridge.	• Bridge construction is material-intensive, resulting in GHG emissions from the manufacture and transport of construction materials. • More energy consumption and operational GHG emissions due to steeper grade than existing Interstate Bridge. • Lower energy consumption and GHG emissions from eliminating the need for bridge lifts.	Similar to the Modified LPA, except that there would be fewer operational emissions than with the Modified LPA due to the reduced profile grade of the new Columbia River bridges (approximately 29 feet lower height).	Similar to the single-level fixed-span bridges, except: • Increased air quality pollutant and GHG emissions due to vehicular idling during bridge openings. • Increased energy consumption and GHG emissions due to the electricity required to raise and lower the bridge.
Electric and Magnetic Fields	The would be no EMF impact.	• No additional human exposure to EMF as a result of the extension of LRT, and associated substation facilities, into downtown Vancouver.	Same as the Modified LPA.	Same as the Modified LPA.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Water Quality and Hydrology	**Long-Term Impacts**			
	• Existing impervious surface area would remain untreated, which would allow for the continued release of stormwater with a degraded quality into study area's receiving waters. • No change in existing conditions.	• The installation of piers within the Columbia River would encroach upon the river's 100-year floodplain. • The 0.0001% increase in impervious surface area in the Lower Columbia River watershed is not expected to measurably affect base flows in the river. • The Modified LPA would increase the total contributing impervious area (CIA) in the study area by 20.8 acres; however, it would increase the treated CIA by 171.8 acres compared to the No-Build Alternative. This would decrease roadway-derived pollutants, and overall, have a beneficial long-term effect on the water quality of receiving waters.	The footprint would differ from that of the Modified LPA. However, given the similarity of construction activities and BMPs, all long-term effects for this option would be similar to those of the Modified LPA (see Table 1).	Same as the single-level fixed-span bridges.
	Temporary Impacts			
	There would be no construction-related temporary impacts.	• The Modified LPA's anticipated temporary effects on hydrology, including placing obstructions in the water column and altering groundwater flows during depressed roadway construction, would be minor due to the large size of the waterways, particularly the Columbia River. • The Modified LPA would avoid potential water quality impacts, such as construction-related turbidity and hazardous material spills, through implementation of BMPs to ensure protection of the waterways.	The footprint would differ from that of the Modified LPA. However, given the similarity of construction activities and BMPs, all temporary effects for this option would be similar to those of the Modified LPA.	Same as the single-level fixed-span bridges.
Wetlands and Jurisdictional Waters	**Long-Term Impacts**			
	Untreated stormwater would continue to discharge into wetlands and waters.	Approximately 0.22 acres of in-water fill would be required to construct the proposed bridge foundations, and approximately 0.66 acres of in-water fill would be removed through the removal of the existing bridge foundations, resulting in a net restoration of approximately 0.44 acres of benthic habitat.	Similar to the Modified LPA, except that there would be a larger permanent benthic footprint (see Table 1) and less net benthic restoration.	Similar to the single-level fixed span bridges, except that there would be a larger permanent benthic footprint (see Table 1) and less net benthic restoration.
	Temporary Impacts			
	There would be no construction-related temporary impacts.	Temporary benthic impacts and overwater coverage would occur during construction (from temporary work bridges and platforms, temporary piles, barges, and cofferdams) that would not occur under the No-Build Alternative.	Similar to the Modified LPA, except that there would be more benthic in-water area temporarily displaced by pilings or within cofferdams.	Similar to the single-level fixed-span bridges, except that there would be more benthic in-water area temporarily displaced by pilings or within cofferdams.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Ecosystems	**Long-Term Impacts**			
	• Stormwater would enter surface water untreated, continuing to impair water quality. • Regular, intermittent maintenance activities would have potential to disturb aquatic and terrestrial species and habitats and nesting birds. • No seismic upgrades could result in the Interstate Bridge failing or collapsing during a catastrophic event such as a major earthquake, affecting fish and wildlife in the immediate vicinity of the bridges and aquatic habitats upstream and downstream.	• Approximately 0.22 acres of benthic habitat displacement required to construct the bridge foundations and approximately 0.66 acres of benthic habitat would be restored by the removal of the existing bridge foundations, for a net restoration of approximately 0.44 acres. • Approximately 0.14 acres of shading at the water surface from drilled shaft caps for the replacement bridges. • Increased CIA by approximately 20.8 acres compared to the No-Build Alternative. Treatment would be provided for all new, existing, and replaced CIA, most of which is currently untreated. This would result in a substantial net improvement in water quality compared to the No-Build Alternative. • Permanent impacts would occur to terrestrial habitats and vegetation, including: ➢ Approximately 0.79 acres of riparian buffer in Washington (including a 0.15-acre impact to Biodiversity Area). ➢ Approximately 0.05 acres of wetland buffer in Washington. ➢ Approximately 0.58 acres of wetland in Oregon. ➢ Approximately 1.12 acres of area designated as "High" value riparian/wildlife habitat, and approximately 6.20 acres of area designated as "Medium" value riparian/wildlife habitat in Oregon.	Similar to the Modified LPA, except: • Larger permanent benthic footprint (see Table 1) and less net benthic restoration. • Greater amount of total overwater coverage. • Larger drilled shaft caps and more water surface-level shading.	Similar to the single-level fixed-span bridges, except: • Larger permanent benthic footprint (see Table 1) and less net benthic restoration. • Greater amount of total overwater coverage. • Larger drilled shaft caps and more water surface-level shading.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
	Temporary Impacts			
	There would be no construction-related temporary impacts.	Temporary construction-related impacts that would not occur under the No-Build Alternative include: • Benthic impacts and overwater coverage during construction (from temporary work bridges and platforms, temporary piles, barges, and cofferdams). • Impacts associated with fish salvage operations during construction. • Impacts to water quality. • Underwater and terrestrial noise. • Overwater lighting. • Changes in avian predation pressure on juvenile salmonids. Temporary impacts to sensitive terrestrial habitats and vegetation, including: • Impacts to approximately 1.15 acres riparian buffer in Washington (including 2.87-acre impact to Biodiversity Area). • Impacts to approximately 0.03 acres of oak woodland habitat in Washington. • Impacts to approximately 1.19 acres of riparian buffer habitat in Washington. • Impacts to approximately 2.56 acres of wetland in Oregon. • Impacts to approximately 4.60 acres of area designated as "High" value riparian/wildlife habitat, and approximately 5.70 acres of area designated as "Medium" value riparian/wildlife habitat in Oregon.	Similar to the Modified LPA, except: • More benthic in-water area temporarily displaced by pilings or within cofferdams (see Table 1). • More overwater area temporarily shaded by work bridges, platforms, and barges.	Similar to the single-level fixed-span bridges, except: • More benthic in-water area temporarily displaced by pilings or within cofferdams (see Table 1). • More overwater area temporarily shaded by work bridges, platforms, and barges.
Geology and Groundwater	• No structural improvements to address seismic resiliency. • No stormwater treatment for pollutants in roadway runoff could further degrade groundwater quality.	• Improved effectiveness of surface runoff water handling and treatment would help protect surface and groundwater quality. • The new Columbia River bridges would be designed to be more resilient to a seismic event.	Same as the Modified LPA.	Similar to the single-level fixed-span bridges, except that this option would require more substantial river piers and pier foundations to support the span because the movable parts are more sensitive to foundation settlement.
Hazardous Materials	There would be no demolition or construction and as such no impacts to hazardous materials related to in-water excavation for bridge foundations.	In-water excavation for bridge foundations could unearth or dislodge hazardous materials in river sediments. These sediments could adversely affect aquatic resources.	Same as the Modified LPA.	This option would require increased in-water work due to the larger bridge foundations (see Table 1), increasing the likelihood of impacts to potential hazardous materials in river sediments compared to the Modified LPA. This could also result in a greater potential for additional negative impacts to aquatic resources.

Resource Area	No-Build Alternative	Modified LPA (Double-Deck Fixed-Span Bridges)	Single-Level Fixed-Span Bridges	Single-Level Movable-Span Bridges
Climate	• The frequency and duration of bridge lifts is expected to be similar to existing conditions, resulting in similar levels of air quality pollutant and GHG emissions due to vehicular idling during bridge openings. • Increased GHG emissions due to the electricity required to raise and lower the bridge. • No GHG emissions related to manufacture and transport of construction materials.	• Greenhouse gas emissions would be reduced due to the elimination of bridge openings, which would reduce the amount of vehicular idling. • Bridge construction is material-intensive, resulting in GHG emissions from the manufacture and transport of construction materials. • Operational emissions would increase due to the steeper grade of the double-deck bridge compared to the existing bridge.	Similar to the Modified LPA, except: • Fewer operational emissions than the Modified LPA due to reduced profile grade of the new Columbia River bridges (approximately 29 feet lower height). • Shallower grade may attract more active transportation users.	Similar to the single-level fixed-span bridges, except: • Increased air quality pollutant and greenhouse gas emissions due to vehicular idling during bridge openings. • Increased GHG emissions due to the electricity required to raise and lower the bridge.
Cumulative Effects	When combined with past, present, and foreseeable future actions, retaining the existing bridge would not have any solely beneficial cumulative effects on a particular resource. Retaining the existing bridge would contribute to adverse cumulative effects for the following resources: • Air quality • Climate • Economics • Ecosystems • Energy and GHG emissions • Geology and groundwater • Hazardous materials • Transportation • Water quality and hydrology Retaining the existing bridge would contribute to both adverse and beneficial cumulative effects for the following resources: • Navigation • Noise and vibration	When combined with past, present, and foreseeable future actions, the cumulative effects of double-deck fixed-span bridges would be beneficial for the following resources: • Air quality • Climate • Economics • Ecosystems • Energy and GHG emissions • Geology and groundwater • Hazardous materials • Transportation • Water quality and hydrology When combined with past, present, and foreseeable future actions, the cumulative effects of double-deck fixed-span bridges may be adverse for the following resources: • Noise and vibration When combined with past, present, and foreseeable future actions, the cumulative effects of double-deck fixed-span bridges may be both adverse and beneficial for the following resources: • Navigation • Visual and aesthetic resources Note: Conclusions regarding the Modified LPA's cumulative effects on archaeology, cultural, and historic resources are pending.	Similar to the Modified LPA, except that there would be minor differences in resource impacts (as identified above), but none of the differences would change the cumulative effects conclusions.	Same as the single-level fixed-span bridges.

BMP = best management practice; CIA = contributing impervious area; EMF = electric and magnetic fields; GHG = greenhouse gas; LRT = light rail transit; sq ft = square feet