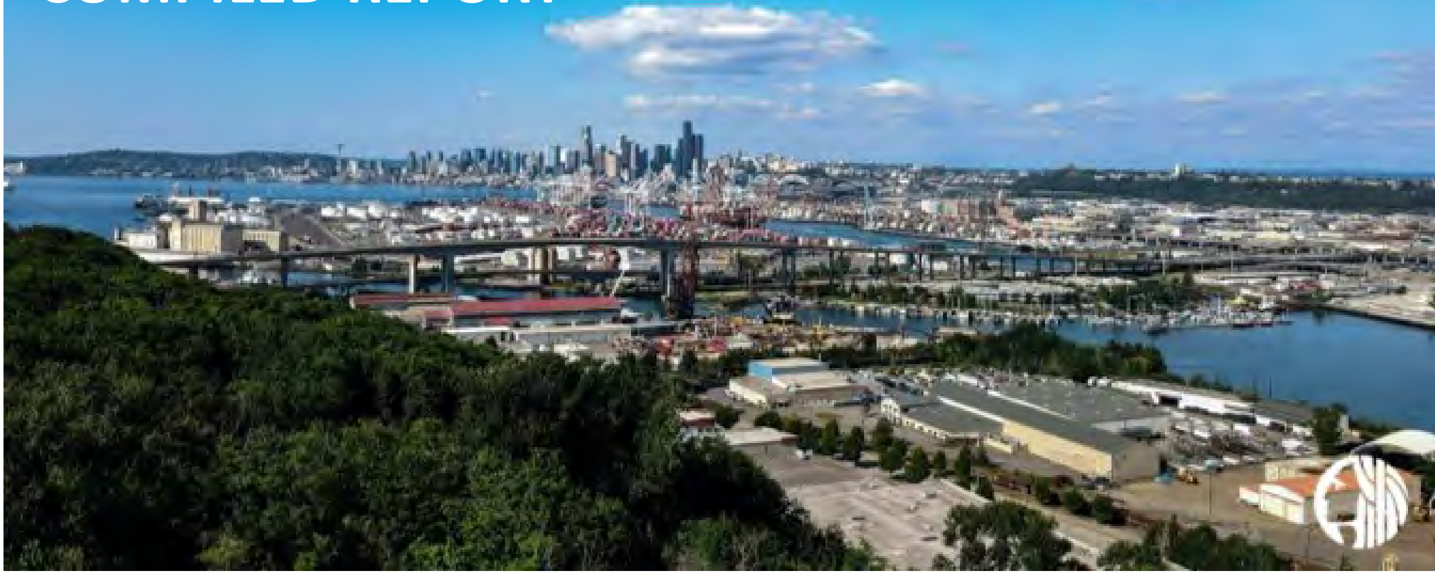
WEST SEATTLE HIGH BRIDGE (WSHB) LONG-TERM REPLACEMENT PLANNING COMPILED REPORT



City of Seattle, December 2021

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WSHB LONG-TERM REPLACEMENT PLANNING EXECUTIVE SUMMARY

In March 2020, the City of Seattle closed the West Seattle Bridge to protect public safety due to the accelerated growth of new and existing structural cracks on the West Seattle High Bridge (WSHB), which is the portion of the West Seattle Bridge that crosses the west channel of the Duwamish Waterway, as illustrated in Figure ES-1.

The West Seattle Bridge has historically been the City's most used bridge, carrying an average of over 100,000 people every day. The closure has caused major traffic disruptions in West Seattle, nearby neighborhoods, and in Seattle as a whole. The WSHB is currently being repaired to address the structural deficiency and restore the bridge to service.

Understanding the repaired structure will eventually need to be replaced to maintain regional mobility, the City has undertaken a long-term planning process to identify potential replacement concepts. The planning team that undertook this study consisted of Seattle Department of Transportation (SDOT) staff and a consultant team, in consultation with SDOT subject matter experts and partner agency representatives. This long-term planning assumes the existing bridge will be repaired and open to traffic to the greatest extent possible at the time of replacement.

1. Corridor Overview

The WSHB is a portion of the longer West Seattle Bridge, which is the primary east-west route for accessing West Seattle, the portion of the City located west of the Duwamish Waterway. The WSHB and surrounding facilities in the corridor are illustrated on Figure ES-1.

Figure ES-1. WSHB Context

WSHB LONG-TERM REPLACEMENT PLANNING EXECUTIVE SUMMARY

West Seattle, the part of the City to the west of the WSHB, is known for its marine setting and distinct neighborhoods, which include Admiral, Alki, Arbor Heights, Delridge, Fauntleroy, Morgan, and West Seattle Junction. The areas served by the West Seattle Bridge also include the western portions of the Duwamish Manufacturing and Industrial Center (MIC), one of two designated MICs in Seattle, as identified by the Puget Sound Regional Council (PSRC) and the City. The land uses immediately under the bridge are mostly transportation, port, and industrial, but there are residential and neighborhood commercial areas to the south and west. The lower Spokane Street Bridge is located just north of the WSHB. The next nearest Duwamish Waterway crossing is more than 3 miles to the south.

The WSHB is located in or near several environmentally critical areas, including the Duwamish Waterway itself. There are seismic (liquefaction) hazard areas, steep slopes, landslide hazard areas, and flood zones, and four superfund sites in the area. The Duwamish Waterway is critical habitat for Green River Chinook and Steelhead species that are protected under the Endangered Species Act, and several tribes have traditional and accustomed fishing rights.

2. Purpose and Need for Replacement

The purpose and need for a WSHB replacement is:

> To maintain the long-term transportation capacity, safety, mobility, and access needed for efficient travel across the Duwamish Waterway between West Seattle, the Duwamish Valley, and the region, while also:

- Providing for the needs of navigation on the Duwamish Waterway and supporting the maritime, intermodal shipping, and industrial activities of the Port of Seattle, Northwest Seaport Alliance, and the Duwamish Manufacturing and Industrial Center.
- Creating greater racial and social equity by avoiding impacts and seeking benefits to nearby communities, the natural and built environments, the economy, and transportation.
- Maintaining effective mobility functions on the local and regional transportation system, including the west channel of the Duwamish Waterway, both long term and during the construction of a crossing replacement.

Based on the long-term need to preserve and enhance mobility for the larger corridor between West Seattle and I-5, additional needs to be considered in future potential planning at the corridor level include:

- Provide a safe and resilient Duwamish Waterway crossing that is compatible with future corridor developments.
- Maintain essential public infrastructure connecting West Seattle to the region, allowing the corridor to avoid long-term closures and to withstand natural disasters, such as a major seismic event, flooding, or inundation related to the corridor's location within the Cascadian Subduction Zone and near the Puget Sound.
- Efficiently accommodate future multimodal transportation demand for cross-Duwamish Waterway trips between West Seattle and the local and regional transportation system, as West Seattle and the region continue to add people, jobs, and economic activity in the coming decades.

The purpose and need for the WSHB replacement is further discussed in Appendix A, Purpose and Need Memorandum.

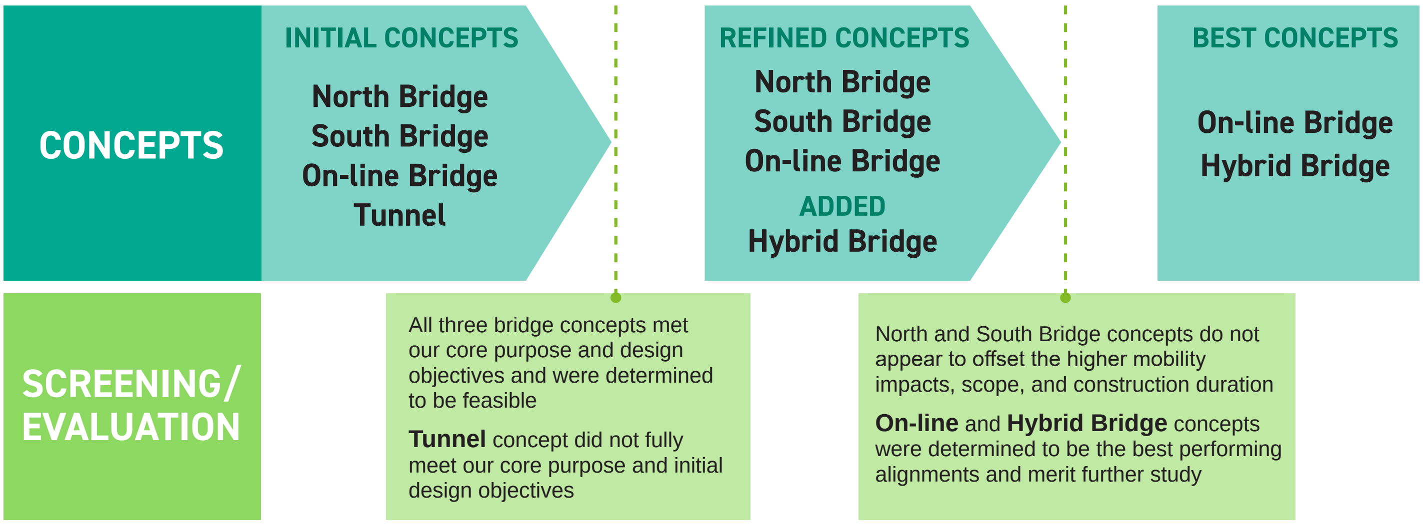
WSHB LONG-TERM REPLACEMENT PLANNING EXECUTIVE SUMMARY

3. Process Overview

The WSHB long-term planning effort developed its findings using a multistep planning, conceptual design, and analysis process, along with coordination with stakeholders. This process is summarized in Figure ES-2.

The first step in the WSHB long-term replacement planning process was developing a core purpose that focused on the replacement of the WSHB before the end of its service life. The planning team identified four representative concepts to screen for feasibility: three bridge concepts, including a North Bridge Concept, a South Bridge Concept, and an On-Line Bridge Concept; and a Tunnel Concept to the south of the WSHB.

Figure ES-2. WSHB Long-Term Replacement Planning Process Overview

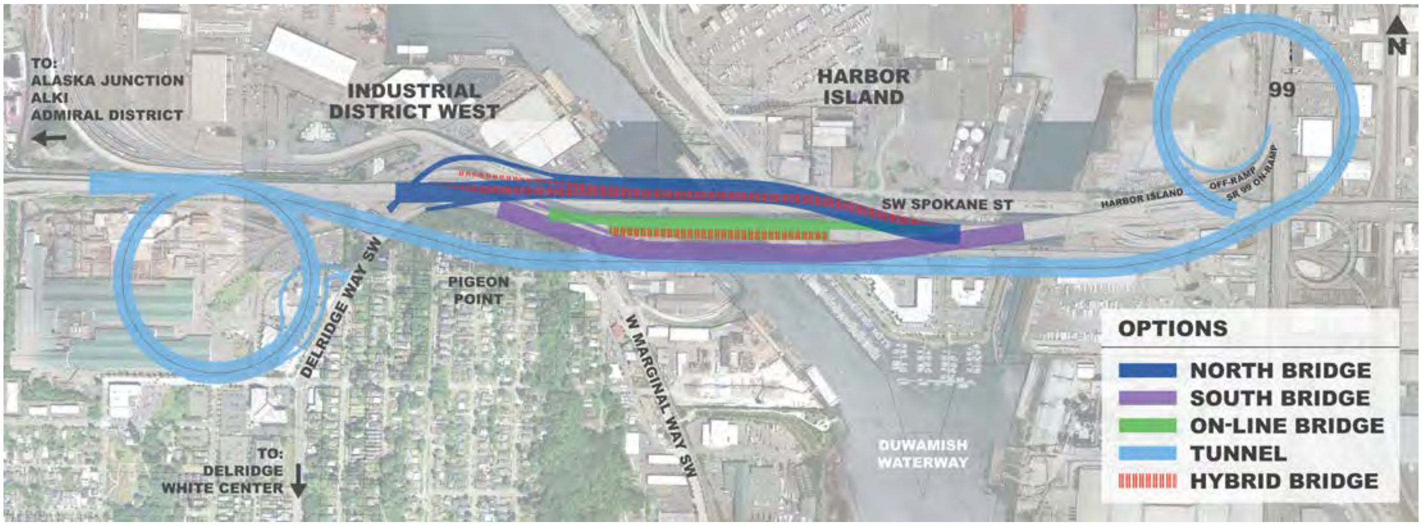


Through the feasibility screening, all of the bridge concepts were found to meet the core purpose and need of the project and were able to meet the primary design objectives. All of the bridge concepts had termini that limited replacement to the area between Delridge to the west and Harbor Island to the east. The Tunnel Concept, although technically feasible at a reduced design speed, would be the least able to replace the connections and functional services of the WSHB. The scope and scale of the Tunnel Concept would far exceed the three bridge concepts, including in terms of length, the extent of major changes to other facilities in the corridor, and in construction duration. Based on those initial feasibility findings, the planning team did not conduct additional design or construction definition for the tunnel.

Following the feasibility screening, the planning team reviewed the three representative bridge concepts to identify areas where the concepts could be improved. The team developed a new concept, the Hybrid Bridge Concept that combined the North and On-Line bridge concepts. Those four bridge concepts then underwent a more detailed evaluation that allowed the concepts to be compared across several categories, including mobility, construction challenges, construction duration, environmental impacts, racial and social equity, and order of magnitude costs. The tunnel concept was also evaluated but did not undergo further engineering detail or refinement, based on the findings from the feasibility screening showing that it had lower mobility performance and much higher magnitude scope and construction challenges. The four bridge concepts that underwent further evaluation, along with a representative Tunnel Concept, are shown in Figure ES-3.

WSHB LONG-TERM REPLACEMENT PLANNING EXECUTIVE SUMMARY

Figure ES-3. WSHB Representative Concepts



4. Key Findings

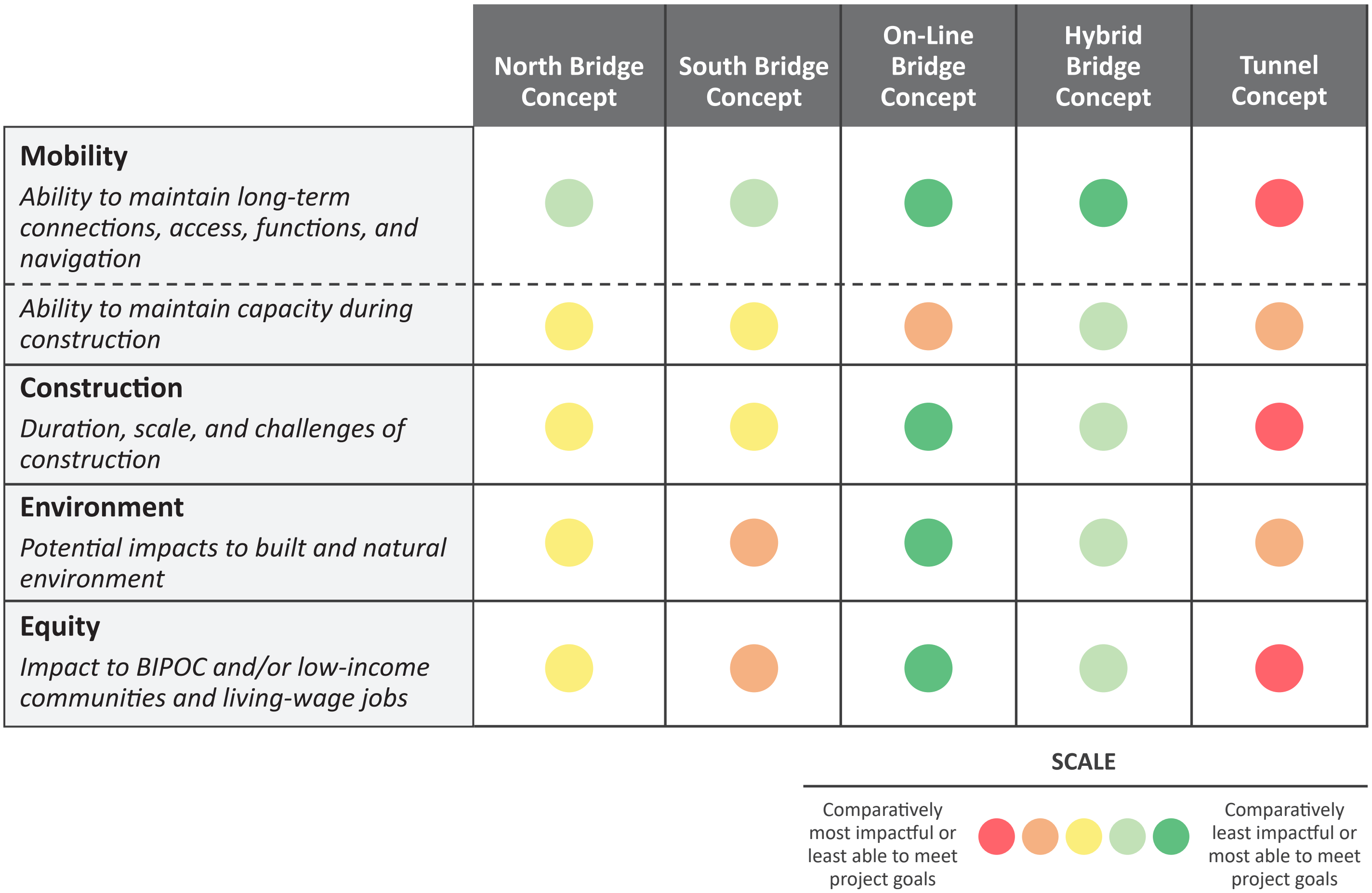
The planning team found the WSHB could be effectively replaced with a new bridge between Delridge Way and Harbor Island, allowing mobility to continue during construction and avoiding the need to reconstruct larger sections of the West Seattle Bridge or nearby ramps. The planning team also found:

- The On-Line and Hybrid bridge concepts best fulfilled the project purpose and need with solutions that remained primarily in the City's existing right-of-way.
- With any of the concepts, the future replacement of the WSHB would be a major capital project with a high degree of technical challenges and complexity.
- All of the concepts would reduce traffic capacity for several years during construction.
- The Hybrid Bridge Concept was the only concept that would maintain up to three lanes in each direction throughout construction (the repaired bridge has four eastbound, three westbound), compared to lengthier periods with two lanes each way for the other concepts.
- The Tunnel Concept did not warrant further detailed study, considering its poor performance compared to the other WSHB replacement concepts.

Figure ES-4 summarizes the general evaluation findings of the long-term replacement planning concepts, highlighting the primary differences in their performance.

WSHB LONG-TERM REPLACEMENT PLANNING EXECUTIVE SUMMARY

Figure ES-4. Summary of Concept Evaluation



5. Future Considerations

Beyond the key findings regarding the location and scale of a potential WSHB replacement project, the planning team also identified implementation considerations for any future project, including:

- For any WSHB replacement, it could take 14 to 20 years to deliver a project, and potentially longer if a replacement project is to be phased with other project actions in the area, such as a project involving the adjacent Spokane Street Bridge.
- Any future WSHB replacement will be a major capital project investment for the region, with a potential cost likely approaching or exceeding $1 billion in current dollars.
- To maximize the potential for funding a future project of such importance to the region, a placeholder for the WSHB replacement in the region's long-range Regional Transportation Plan would support a pro-active funding strategy for seeking federal, state, regional and other funding well ahead of the need for replacement.

FINAL REPORT
1. Project Overview

To protect public safety, the high span of the West Seattle Bridge (the West Seattle High Bridge or WSHB) over the west channel of the Duwamish Waterway was closed in 2020 and is being repaired to address a structural deficiency and restore the bridge to service. Understanding the repaired structure will eventually need to be replaced, the City has undertaken a long-term planning process to identify potential replacement concepts. The planning team that undertook this study consisted of Seattle Department of Transportation (SDOT) staff and a consultant team, in consultation with SDOT subject matter experts and partner agency representatives. This long-term planning assumes the existing bridge will be repaired and open to traffic to the greatest extent possible at the time of replacement.

Prior to the 2020 closure, the West Seattle Bridge transported an average of over 100,000 people a day, including 17,000 bus riders and substantial volumes of vehicles carrying freight and goods. Stabilization of the bridge began in 2020, and the bridge is anticipated to reopen in 2022. Although only the WSHB was damaged, the WSHB closure removed traffic from the West Seattle Bridge between SR 99 on the east to Fauntleroy Way SW in West Seattle. The WSHB study area, including the West Seattle Bridge and the WSHB, is illustrated on Figure 1-1 and the WSHB profile is illustrated in Figure 1-2.

KEY TERMS FOR THIS REPORT:

West Seattle High Bridge (WSHB)
The portion of the larger West Seattle Bridge that crosses the west channel of the Duwamish Waterway (see Figure 1-1)

West Seattle Bridge
The continuous elevated facility that crosses both channels of the Duwamish Waterway, generally located between Highway 99 from the Spokane Street Viaduct and Fauntleroy Way SW (see Figure 1-1)

Spokane Street Corridor
Used synonymously with **"WSHB Replacement Study Area"** throughout this report, consists of the broader corridor surrounding the West Seattle Bridge between I-5 and West Seattle, including at-grade and elevated facilities, i.e., Spokane Street Viaduct, Spokane Street, Fauntleroy Way SW, etc. (see Figure 1-1)

Figure 1-1. WSHB Replacement Study Area

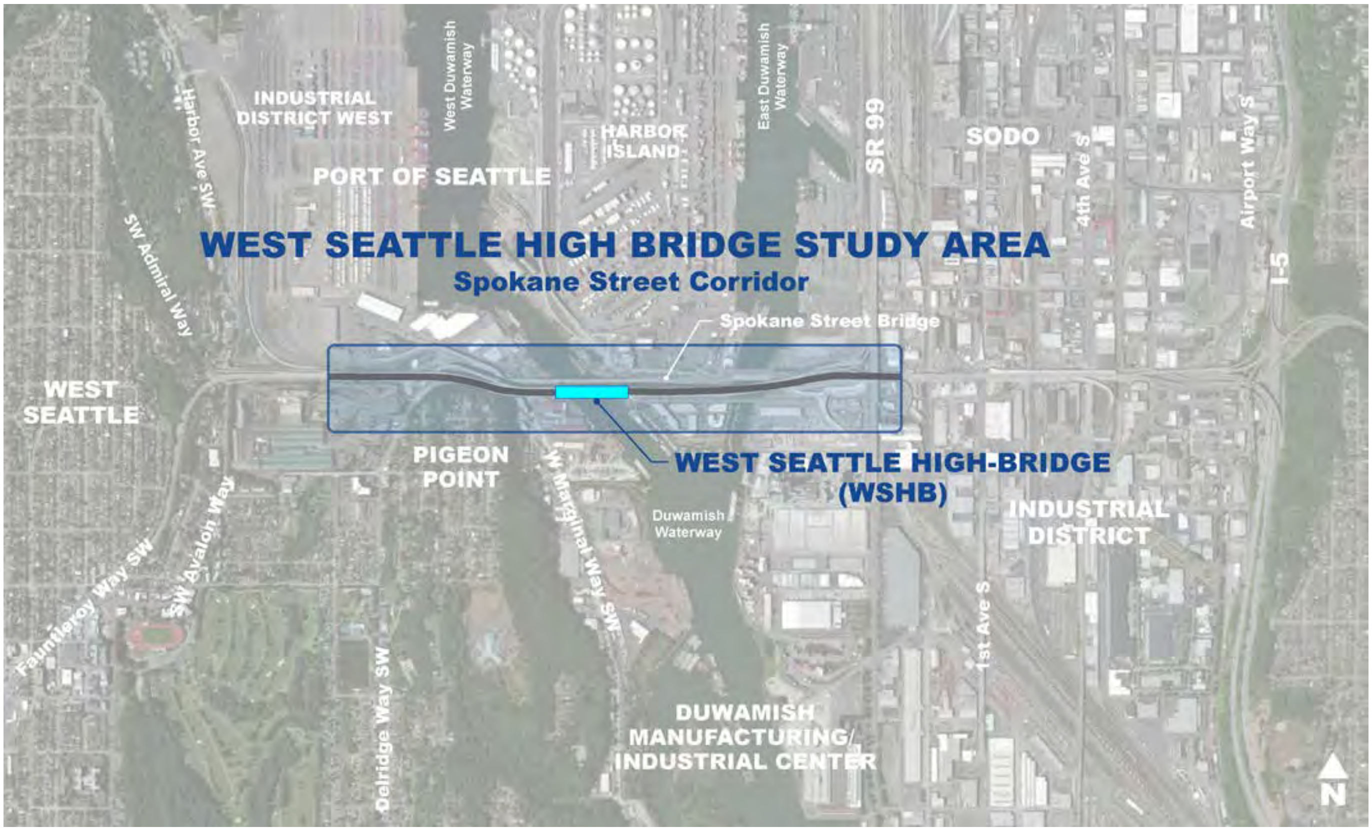
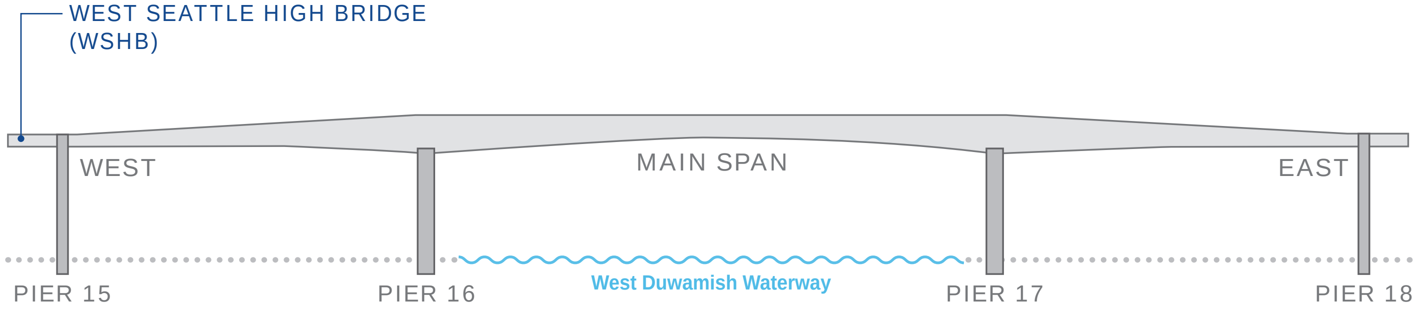


Figure 1-2. WSHB Profile



Prior to the closure, the West Seattle Bridge was the primary facility connecting West Seattle to the rest of Seattle and the regional roadway network, including I-5 and SR 99. The WSHB crosses the west channel of the Duwamish Waterway, a major navigable channel supporting maritime and industrial businesses.

Figure 1-3. West Duwamish Waterway Navigable Channel Under WSHB (Looking south, from simulation)

Additional information and photos of the corridor are in Appendix H.

Current Closure

The 2020 closure highlights the extraordinary importance of the WSHB. During the closure, all vehicles must use alternative routes that are less direct and have limited capacity. The closure of the bridge and the resulting traffic restrictions, detours, congestion, and cut-through traffic has greatly impacted travel between West Seattle, the Port of Seattle and the region. It has affected travel in the Duwamish Valley industrial areas and neighborhoods between downtown Seattle and Tukwila. This in turn altered economic activity, environmental conditions, and quality of life throughout West Seattle and the Duwamish Valley. There have been impacts to some of Seattle’s most diverse and historically underserved neighborhoods, several of which are located south of the bridge, as are similarly diverse neighborhoods in unincorporated areas of King County.

The City's Reconnect West Seattle program is responding to the unexpected closure of the WSHB and its impacts to West Seattle and the nearby Duwamish Valley communities. The "Reconnect West Seattle Implementation Plan", developed through a community-led process, identifies neighborhood mitigation strategies, mobility planning, and community involvement.

Study Area Characteristics

West Seattle is located west of the Duwamish Waterway, and the West Seattle Bridge is its primary east-west route. West Seattle is known for its marine setting and distinct neighborhoods, which include Admiral, Alki, Arbor Heights, Delridge, Fauntleroy, Morgan, and West Seattle Junction.

West Seattle also includes the western portions of the Duwamish Manufacturing and Industrial Center (MIC), one of two designated MICs in the City, as identified by both Puget Sound Regional Council (PSRC) and the City. MICs are designated as locations for more intensive industrial activity, and they are key parts of the regional growth strategy set forth by PSRC and the City. The Duwamish MIC supports close to 60,000 jobs and an estimated 12.7 percent of the City's employment across manufacturing, construction, and other important industries. The Duwamish MIC serves as a critical trade and transportation hub, including for the Port of Seattle (the Port), and includes Harbor Island, a key freight terminal for the Port, and the Northwest Seaport Alliance. Several BNSF rail lines run through the Spokane Street Corridor, and a moveable BNSF Bridge crosses the west channel of the Duwamish Waterway just south of the WSHB, shown on Figure 1-4.

Figure 1-4. BNSF Bridge

A major Seattle City Light transmission line runs just north of the Spokane Street Bridge (low bridge), which is located just north of the WSHB, as shown in Figure 1-5.

Figure 1-5. Seattle City Light Transmission Line

Transportation and Future Growth

The West Seattle Bridge, long the busiest city-owned roadway in Seattle, rivals I-5 and I-90 for total trips served per day. For more than a century, the corridor has been the primary route for daily commutes, commercial and freight trips, transit, and general-purpose travel between West Seattle and the region. From West Seattle to I-5, the bridge allows east-west traffic to travel above the crossings of multiple north-south arterials as well as the major rail lines serving both freight and passenger travel through the Duwamish Valley.

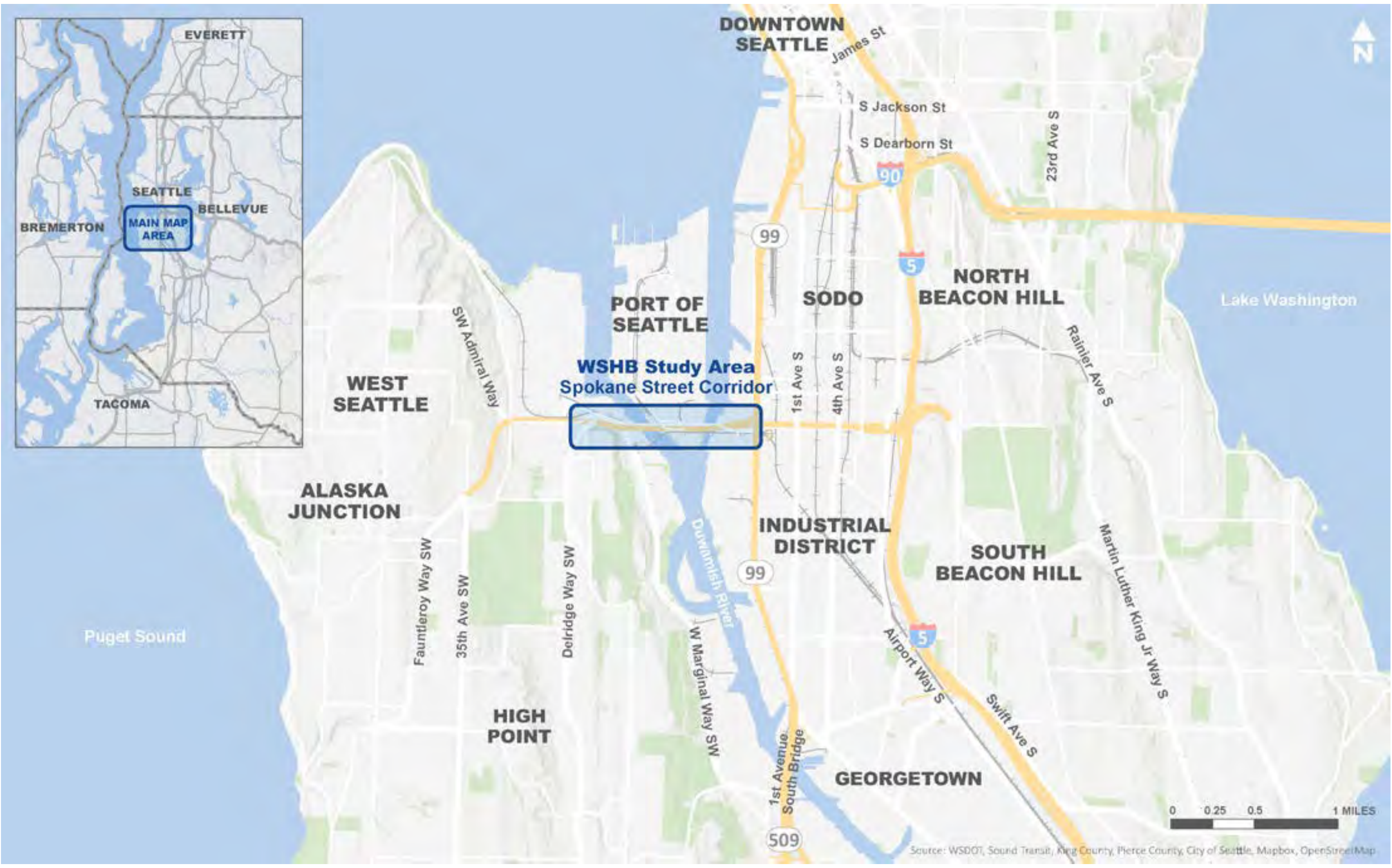
During closure of the West Seattle Bridge, the Spokane Street Bridge has been limited to priority traffic, such as emergency vehicles and transit. The Spokane Street Bridge is shown in Figure 1-6. The Spokane Street Bridge is operated from a control tower located between the WSHB and the Spokane Street Bridge, on the west bank of the west channel of the Duwamish Waterway, shown on Figure 1-7.

Figure 1-6. Spokane Street Bridge (Low Bridge)

Figure 1-7. Spokane Street Bridge Control Tower

Besides the Spokane Street Bridge, the nearest Duwamish Waterway crossing to the WSHB is the 1st Avenue South Bridge located more than 3 miles to the south. The 1st Avenue South Bridge and the broader context of the Duwamish Waterway crossings are illustrated on Figure 1-8.

Figure 1-8. WSHB Transportation and Growth Context



According to PSRC, by 2040 Seattle will add about 135,000 people and about 150,000 jobs within the city. Over half of the population growth—and over a quarter of the added jobs—is anticipated to occur in the area surrounding the West Seattle Bridge and west into West Seattle. The increases in population and employment will also increase the demand for travel, with the potential to impact congestion, even with the expansion of high-capacity transit to serve West Seattle.

Environmental Conditions and Land Use

The WSHB is in or near several environmentally critical areas, including seismic hazard areas, steep slopes, flood zones and landslide hazard areas. The Duwamish Waterway and nearby greenbelts are wildlife corridors. This includes Pigeon Point, a park and natural area to the west. The West Seattle Bridge and its foundations are in a "liquefaction zone" that extends to either side of both the west and east channels of the Duwamish Waterway.

Four Superfund sites are in the vicinity (the Lower Duwamish Waterway, just south of the West Seattle Bridge; the Lockheed West Seattle site, north of the bridge at the mouth of the west waterway; Harbor Island, north of the bridge between the east and west channels of the Duwamish Waterway; and the Pacific Sound Resources Wykoff site, north of the bridge, just west of the Lower Duwamish Waterway site). In addition, at least three Natural Resource Damage (NRD) sites are in the WSHB study area.

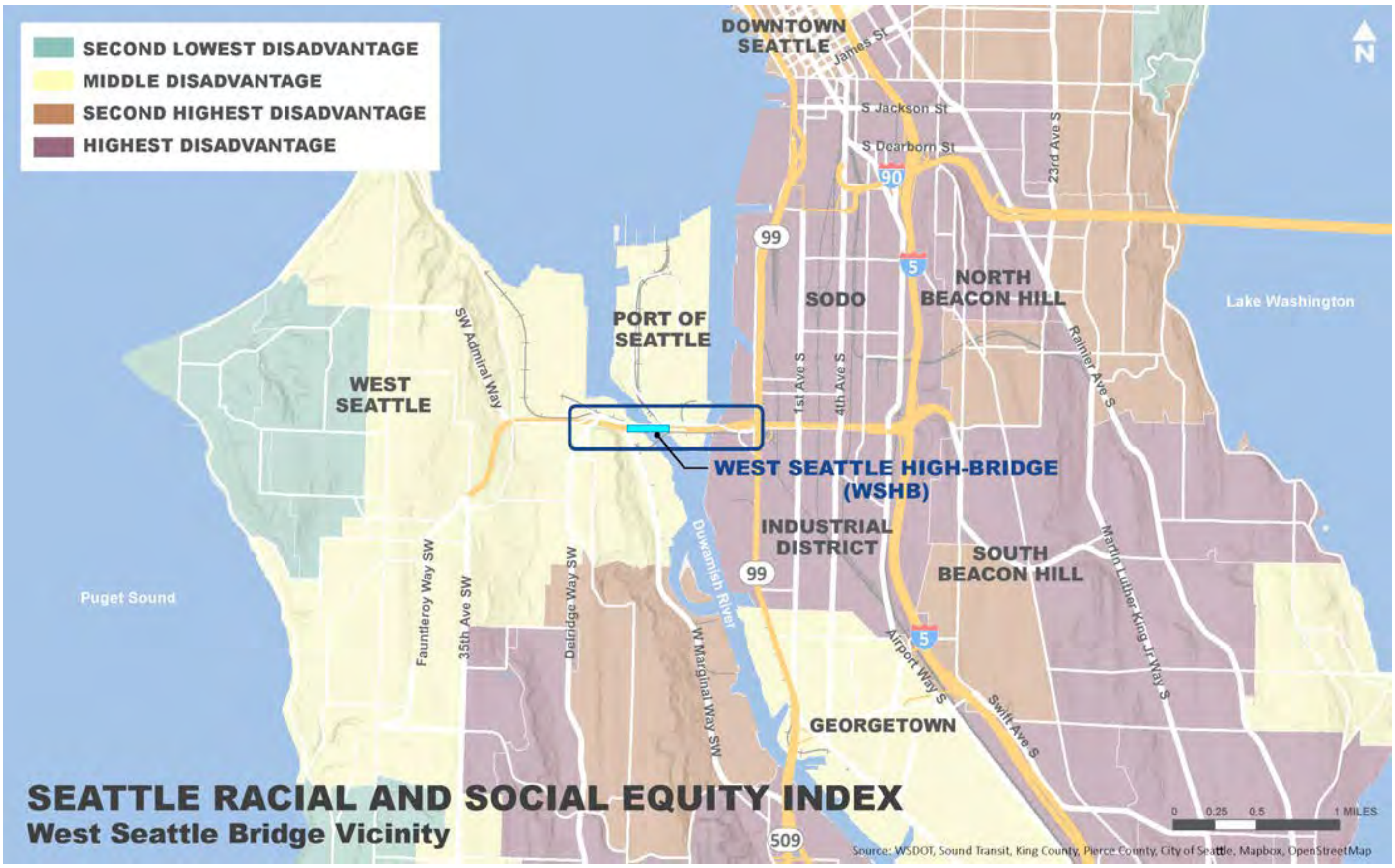
While the land uses adjacent to the bridge are mostly transportation, port, and industrial, there are residential and neighborhood commercial areas to south and west.

Diversity in West Seattle and Duwamish Valley Communities

Many of the neighborhoods in West Seattle are demographically similar to the City overall, but the percentage of residents who are black, indigenous, or people of color (BIPOC) is higher in the Delridge neighborhood. The areas east of the Duwamish Waterway are less populated but have a higher percentage of BIPOC residents as well.

The City's Race and Social Equity Index combines information on race, ethnicity, and related demographics, with data on socioeconomic and health disadvantages to identify where priority populations make up relatively large proportions of neighborhood residents. The City's Race and Social Equity Index in the area surrounding the West Seattle Bridge is shown on Figure 1-9. Much of West Seattle is in the middle and highest disadvantage index ranges, including areas surrounding the WSHB, with neighborhoods to the east and south in the highest disadvantage indexes, including communities along the WSHB closure detour routes.

Figure 1-9. City's Race and Social Equity Index



2. Replacement Planning Overview

The current repairs to the WSHB are intended to allow the West Seattle Bridge to be reopened, but the WSHB will eventually need to be replaced before the end of the high span's service life.

This section of the report describes the WSHB long-term replacement planning, including:

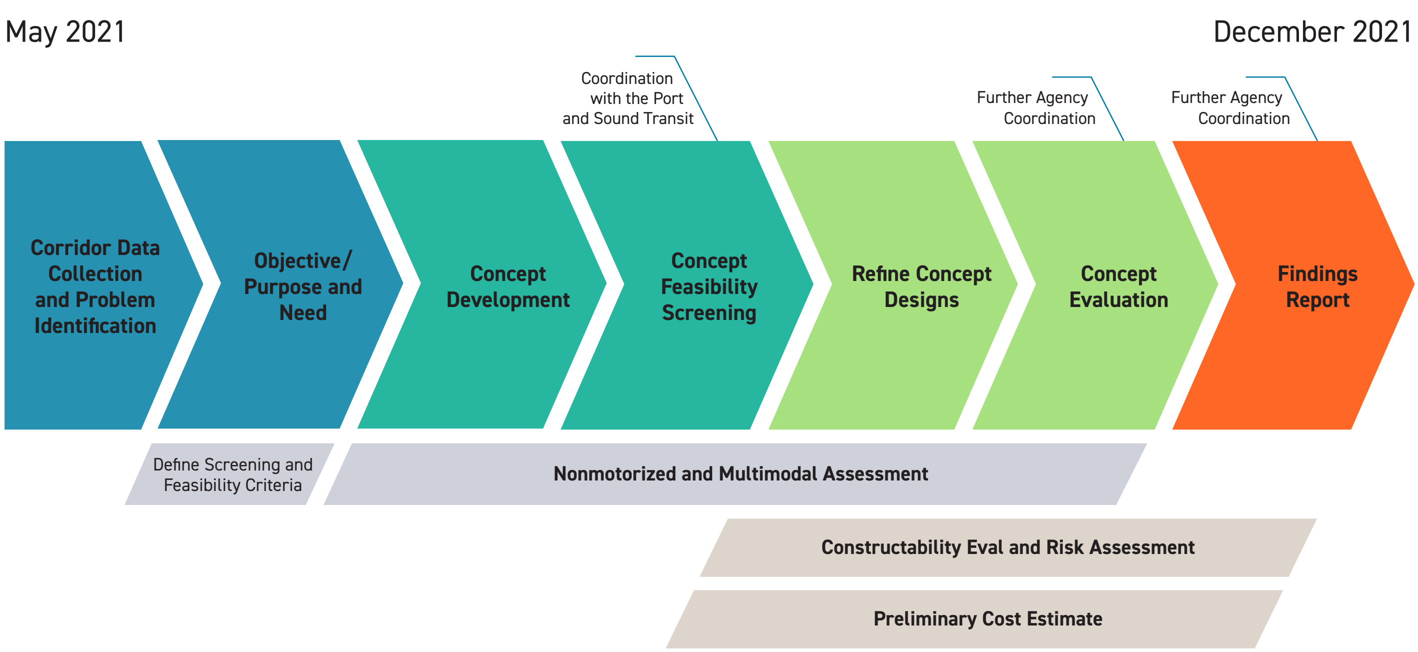
- The process used for this long-term planning effort.
- The development of potential concepts for replacement.
- The purpose and need for the eventual replacement of the WSHB.
- Key findings of the initial feasibility screening and concept evaluation of potential replacement concepts.
- An assessment of potential improvements for nonmotorized travel.
- Future considerations related to WSHB replacement planning.

REPORT CONTENTS:

2.1. Planning Process

The WSHB long-term planning was a strategic corridor assessment focused on identifying the scale and location of a future project to eventually replace the repaired WSHB. It began in early 2021 and combined high level planning, conceptual design, and multidisciplinary analysis. Figure 2-1 illustrates the general framework for the planning and its key steps.

Figure 2-1. Planning Process



2.2. Purpose and Need for a Replacement

This study began by defining the core purpose for a future replacement project, focusing on the need to replace the crossing of the west channel of the Duwamish Waterway before the WSHB reached the end of its service life. The planning team then further developed the purpose and need for a future replacement, considering not just the service life issues of the WSHB but the underlying importance of a durable crossing.

The replacement project is needed to maintain the long-term transportation capacity, safety, mobility, and access needed for efficient travel across the Duwamish Waterway between West Seattle, the Duwamish Valley, and the region while:

- Providing for the needs of navigation on the Duwamish Waterway and supporting the maritime, intermodal shipping, and industrial activities of the Port of Seattle, Northwest Seaport Alliance, and the Duwamish Manufacturing and Industrial Center.
- Creating greater racial and social equity by avoiding impacts and seeking benefits to nearby communities, the natural and built environments, the economy, and transportation.
- Maintaining effective mobility functions on the local and regional transportation system, including the west channel of the Duwamish Waterway, during and after the construction of a crossing replacement.

Beyond the need to replace the WSHB replacement before the end of its service life, the planning team identified a broader set of needs related to the larger Spokane Street Corridor between West Seattle, SR 99 and I-5. In this larger corridor context, the future replacement should:

- Provide a safe and resilient Duwamish Waterway crossing that helps maintain the essential public infrastructure connecting West Seattle to the region, allowing the corridor to avoid long-term closures and to withstand natural disasters such as a major seismic event, flooding, or inundation related to the corridor's location within the Cascadian Subduction Zone and near the Puget Sound.
- Allow the region to efficiently accommodate future multimodal transportation demand for cross-Duwamish Waterway trips between West Seattle and the local and regional transportation system, as West Seattle and the region continue to add people, jobs, and economic activity in the coming decades.

Additional background on the purpose and need for a long-term replacement project is in the Purpose and Need Memorandum developed during the planning process (Appendix A).

2.3. Concept Development

To further the guide the development of potential concepts, the planning team developed the following implementation and design objectives reflecting the purpose and need. Concepts were to have the ability to:

- Maintain transportation service on the repaired WSHB while a replacement was being constructed.
- Maintain navigation on the Duwamish Waterway during and after construction, while avoiding major in-water construction.
- Practicably allow for construction of a new bridge and demolition of the WSHB.
- Maintain long term transportation service equivalent to the WSHB, with designs that provided:
  - » The existing roadway width.
  - » The existing design speed (45 mph).
  - » Acceptable grades and vertical curves.
  - » Existing horizontal and vertical navigational clearances.
  - » Existing access/egress points.

Based on the above and considering existing conditions in this tightly developed and constrained area, the planning team developed four primary groups of concepts: bridges aligned to the North, to the South, and in the same location as the existing WSHB (On-Line), as well as tunnel concepts. The team produced several variations of each concept, as shown in Appendix B, Concept Development Summary.

The planning team then held workshops with both consultant and SDOT subject matter experts to select a “representative” version for each of the four groups of concepts to undergo initial feasibility screening. The selection of each representative concept was guided by how well each concept met the core purpose for a replacement and achieved the base implementation and design objectives. The team then assessed the relative ability of the concepts to achieve the design objectives without unnecessarily increasing a future project’s scope, impacts, construction challenges, or creating adverse effects to other facilities or connections. The representative North Bridge Concept, South Bridge Concept, On-Line Bridge Concept, and Tunnel Concept are shown on Figures 2-2 through 2-5.

Figure 2-2. North Bridge Concept

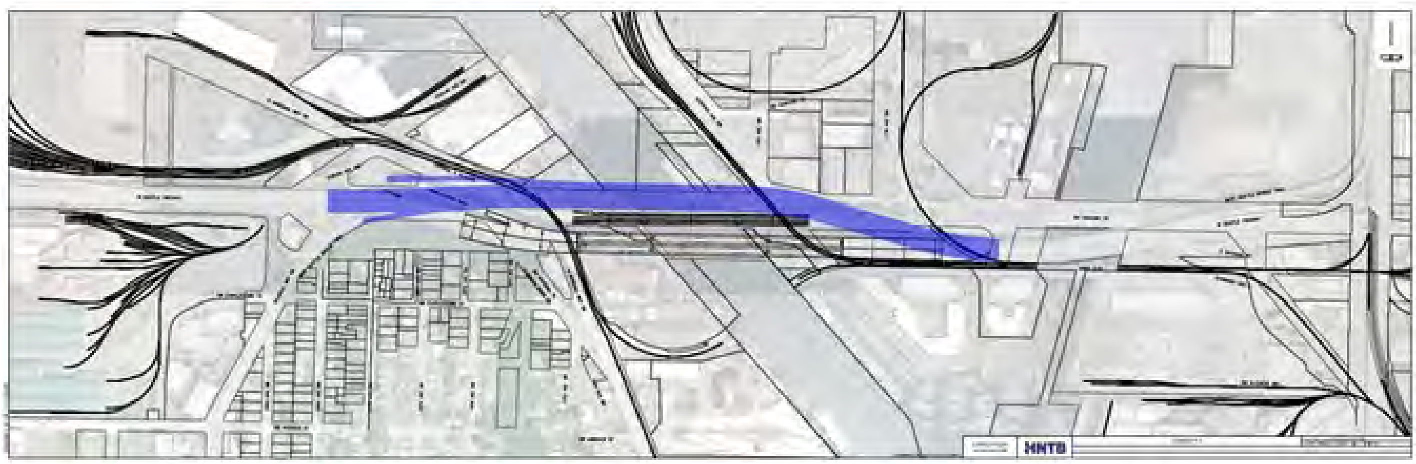


Figure 2-3. South Bridge Concept

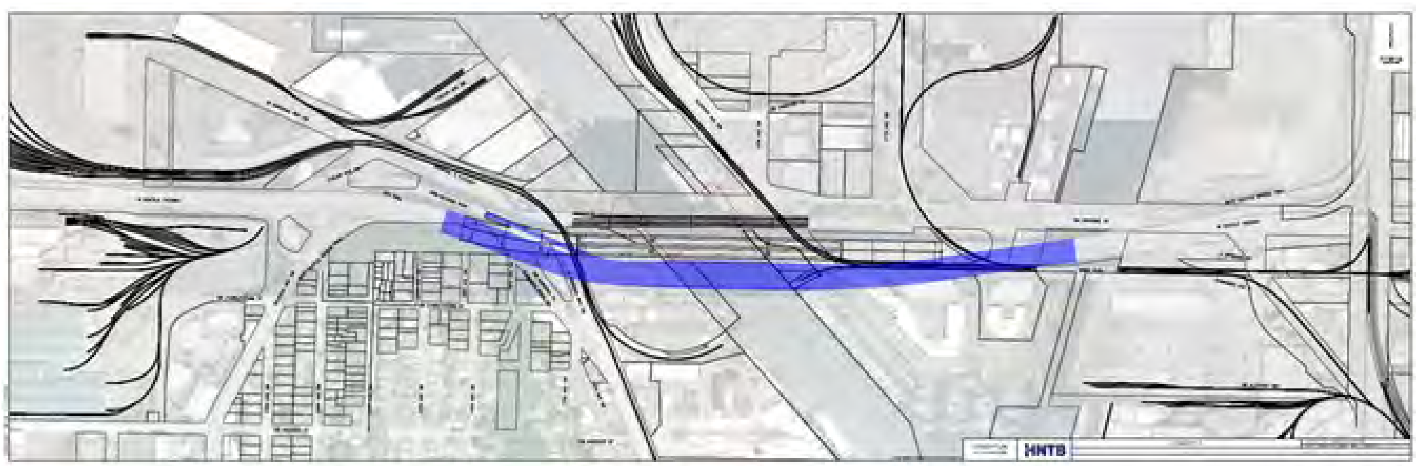


Figure 2-4. On-Line Bridge Concept

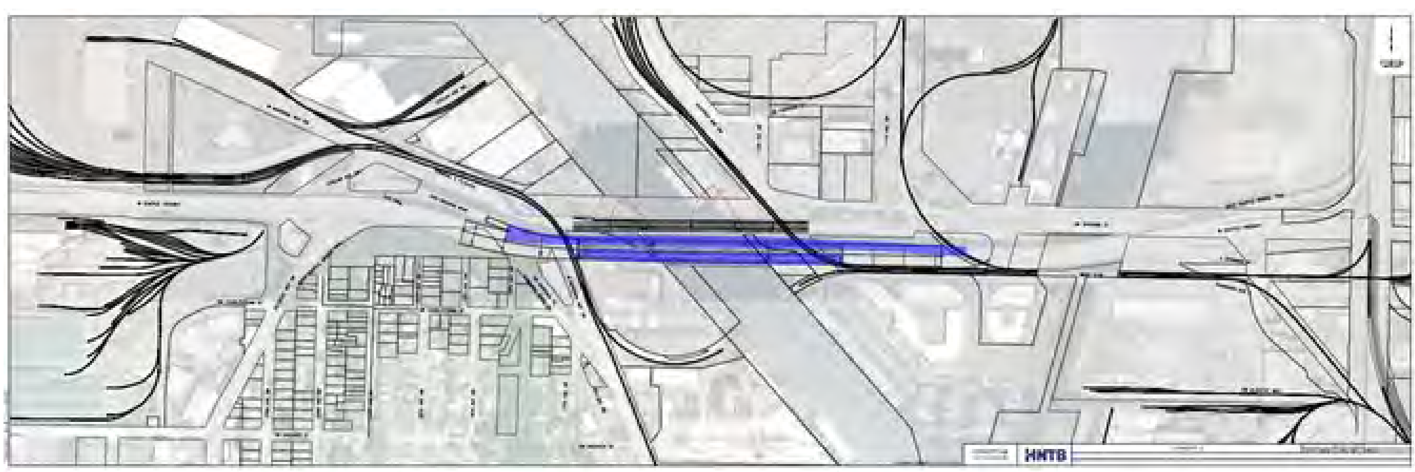


Figure 2-5. Tunnel Concept

These four representative concepts were then further assessed for their feasibility and relative advantages and disadvantages, as described in Section 3. Additional background information on the development of the representative concepts is attached as Appendix B.

3. Concept Feasibility Screening

3.1. Screening Criteria

Once the planning team had developed the four representative concepts, the next step was to establish screening criteria, covering the following two primary categories for assessing the ability of concepts to effectively meet the purpose and need for a replacement crossing:

- Implementation and Design – Ability to meet primary replacement objectives, particularly the ability to maintain mobility and capacity during construction and long term.
- Construction – Relative differences in construction phasing, duration, and difficulty.

Within those two categories, the planning team used qualitative sub-measures to evaluate the degree to which replacement concepts satisfied the design and construction objectives. For example, for design, this screening considered whether each concept would maintain the connections and functional services provided by the repaired WSHB, whether it would meet design standards for a 45-mph facility, and whether it would avoid navigational impacts. For construction, this screening defined initial construction and demolition phasing approaches, and then estimated the total duration and extent of construction. At this early phase of concept planning, the approximate duration and extent of construction were high-level estimates used to identify substantial differences between concepts.

FEASIBILITY SCREENING CRITERIA:

Maintain connections and functional services?

Meet design standards for a 45 mph facility?

Maintain long-term navigation envelope?

Duration and extent of construction?

Other considerations: *mobility effects, environmental issues, and conflicts with regional facilities*

This feasibility screening also included the preliminary identification of potential environmental impacts (primarily the need for additional right-of-way) and conflicts with existing or planned infrastructure, such as Port of Seattle facilities or Sound Transit's West Seattle Link Extension project. Although those considerations were not necessarily feasibility criteria, the preliminary identification of potential environmental impacts and infrastructure conflicts was included to highlight major challenges and differences between the concepts being evaluated.

The initial feasibility screening was also designed to inform the refinement of concepts that appeared promising, including potential opportunities for combined or hybrid options.

3.2. Key Findings of Feasibility Screening

Based on the initial feasibility screening, all of the bridge concepts met the core purpose and need of the project, met overall design objectives, and had termini that limit the replacements to those that begin near Delridge on the west and end on Harbor Island to the east. All of the bridge concepts, including the North and South bridge concepts that are fully off line, would maintain travel during construction but would need to reduce capacity to varying degrees.

In general, the On-Line Bridge Concept would meet the primary replacement design objectives with the smallest footprint and would be more likely to have the least construction impacts, assuming demolition and construction phasing are feasible. The feasibility screening showed that the On-line Bridge Concept may be faster and would have approximately the same impacts to mobility during construction as the North and South bridge concepts due to complex tie-in work that would be required for those off-line alignments. More detailed study during refinement would be needed to confirm the approach and related design and construction needs.

Both the North and South bridge concepts appeared to be feasible and may be capable of being modified to reduce some of the potential impacts identified in this preliminary screening. They both have a larger construction footprint and larger scope than the On-Line Bridge Concept and would have more impacts due to the new right-of-way areas that a replacement would occupy.

Although the Tunnel Concept appeared to be technically feasible at a reduced design speed, this concept was the least able to replace the connections and functional services of the repaired WSHB and would have the greatest construction and environmental impacts. The Tunnel was not able to meet the 45 mph design speed, would involve more complicated construction techniques through challenging soil, and would require more temporary and permanent use of land outside the City's existing right-of-way. The Tunnel would not be able to maintain all of the existing access points and would include challenging grades and site distance issues at each terminus. In addition, the scale of the Tunnel Concept, at 14,000 feet of new infrastructure, would far exceed the scale of the other three bridge concepts and would take longer to construct.

The Concept Feasibility Screening Memorandum is attached as Appendix D and the key findings are summarized in Table 3-1.

Table 3-1. Feasibility Screening Summary

	North Bridge Concept	South Bridge Concept	On-Line Bridge Concept	Tunnel Concept
	Located north of both the WSHB and the Spokane Street Bridge, from just past Pigeon Point to the west and before the east channel of the Duwamish Waterway to the east	Located south of the WSHB, between Pigeon Point to the west and near the west side of the east channel of the Duwamish Waterway to the east	Located generally in the same location as the WSHB, extending slightly farther north, but still south of the low bridge control tower, with a slightly wider cross section than the existing bridge	Located just south of the WSHB, with helix access points on either side of the Duwamish Waterway
Design				
Would it maintain connections and functional services?	Yes	Yes	Yes	No
Would it meet design standards for a 45-mph facility?	Yes	Yes	Yes	No
Would it avoid navigational impacts?	Yes, except for impacts during construction and demolition May have negative impacts to Spokane Street Bridge operations and navigation	Yes, except for impacts during construction and demolition Avoiding navigational impacts could be more challenging due to need to avoid BNSF Bridge approach	Yes, except for impacts during construction and demolition	Yes, except for impacts during construction and demolition
Construction				
How much would capacity be reduced and for how long?	No reduction on WSHB, but capacity would be reduced to 4 lanes (2 in each direction) for approximately 3–4 years at tie-in locations at both ends	No reduction on WSHB, but capacity would be reduced to 4 lanes (2 in each direction) for approximately 3–4 years at tie-in locations at both ends	Reduced to 4 lanes (2 in each direction) for the duration of construction (approximately 4 years)	No reduction on WSHB but capacity would be reduced to 4 lanes (2 in each direction) or closed at times during construction at tie-in locations at both ends
Approximately how long would construction and demolition take?	At least 6 years*	At least 7 years*	At least 4 years*	At least 8–10 years*
How much new infrastructure would be constructed?	3,400 linear feet	3,300 linear feet	2,300 linear feet	14,000 linear feet

* Note that following the feasibility screening, the anticipated duration of construction was modified and extended based on additional constructability review, described in Section 4.

4. Concept Evaluation

Following the feasibility screening, five concepts were further defined and evaluated following the feasibility screening, based on early conceptual definitions of the location, general profile, and features of these representative concepts. The team also further assessed potential design, construction and demolition approaches for the concepts, including potential bridge types and foundation requirements.

The concepts evaluated are shown on Figure 4-1. More detailed descriptions and figures for each concept are in Appendix C.

Each of the concept definitions generally reflect the standard geometric requirements and the general vertical and horizontal alignment for a replacement facility, establishing the general location, footprint, and scale of a future replacement project. The planning study did not involve the more detailed design and permitting studies that would ultimately be needed for a formal project. For instance, the study did not involve detailed structural engineering studies of bridge type, size, and location, as well as other more detailed civil, geotechnical and structural engineering, or detailed definition of the demolition program needed.

CONCEPTS EVALUATED

North Bridge Concept
Refined to reduce grade of Delridge ramp following feasibility screening

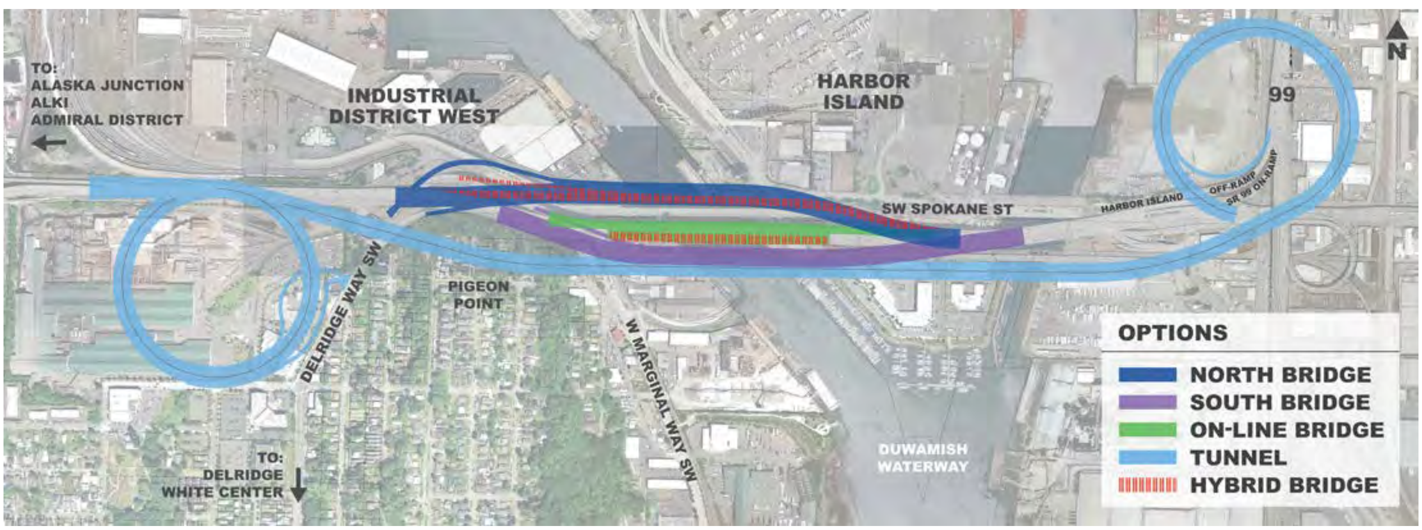
South Bridge Concept
No additional refinement

On-Line Bridge Concept
Refined to be located within existing right-of-way

Tunnel Concept
No additional refinement

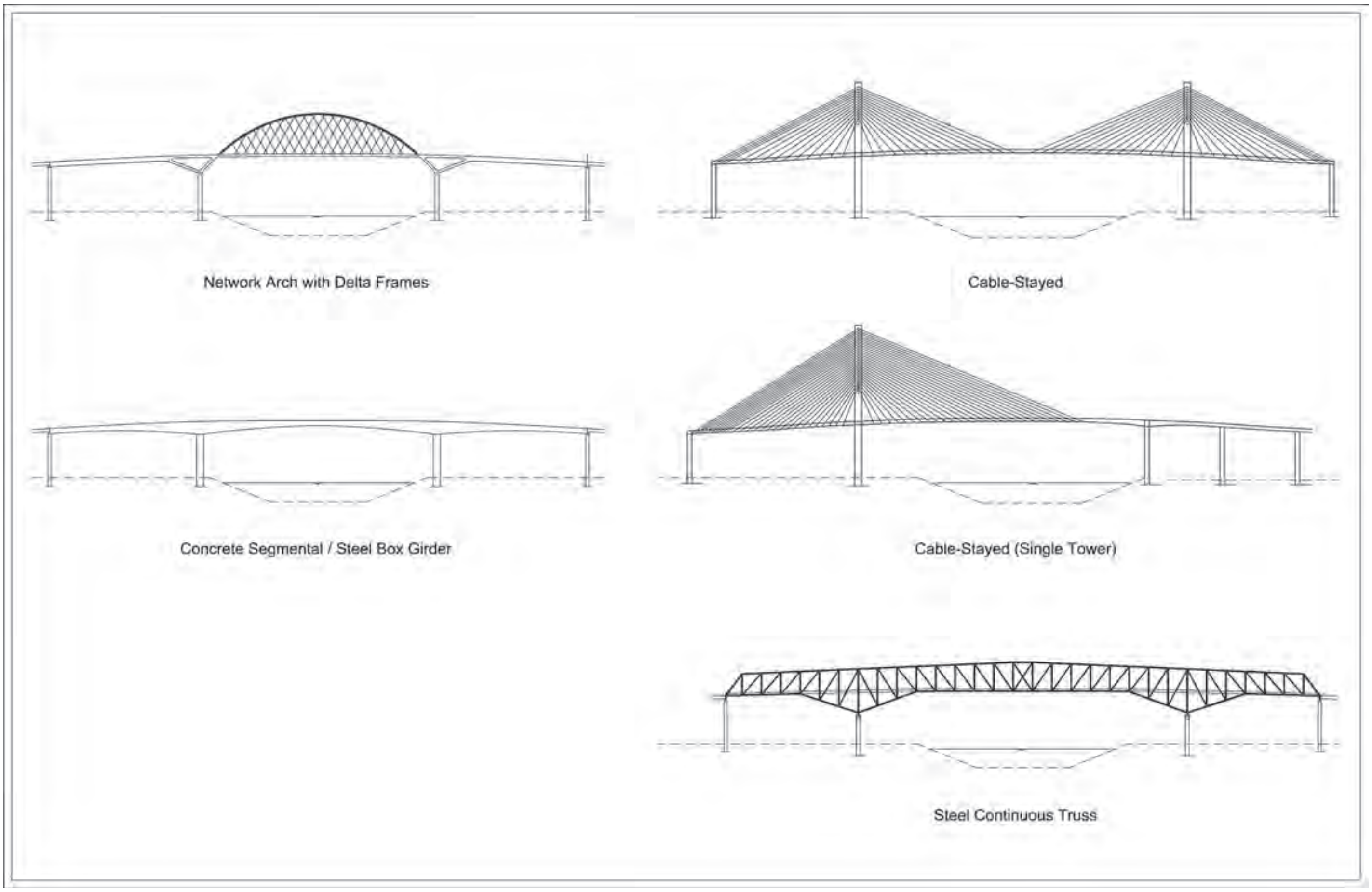
Hybrid Bridge Concept
New concept combining North Bridge and On-Line Bridge concepts

Figure 4-1. Concepts Evaluated



For this more detailed concept evaluation, the planning team identified potential bridge types that could be feasible in each location. This helped evaluate how potential bridge types could affect the activities and duration of construction, the staging areas and techniques needed, the level of effects, and costs. The potential bridge types considered are illustrated on Figure 4-2. They include network arches with delta frames, concrete segmental/steel box girder, steel continuous truss, cable-stayed and single-tower cable-stayed. The concept evaluation considered where bridge type would affect the project impacts.

Figure 4-2. Potential Bridge Types



4.1. Evaluation Criteria

Table 4-1 defines the criteria used to evaluate the four bridge concepts and the Tunnel Concept.

Table 4-1. Evaluation Criteria

Evaluation Criteria	Measures of Comparative Differences
Capacity and Mobility	
Note: None of the bridge concepts being evaluated would alter long-term overall capacity or permanently close access points to the West Seattle Bridge. While the measures below consider both permanent and construction effects, much of the emphasis is on construction effects that are different between concepts.	
Automobile Traffic	Changes to access and circulation
	Maintenance of traffic during construction
Transit	Effects on transit service, access, or operations during construction
Freight	Changes to access, circulation, congestion, or affecting freight routes or rail facilities during construction
Nonmotorized	Construction period impacts to nonmotorized travel
Navigation	Changes or restrictions to navigation during construction
Safety/Design Impacts	Improvements or impacts to sight distances, slope, access points, or other features
Construction Activities	
Construction Challenges	Relative risk and complexity of construction approach needed, including third-party approvals
Scope of Construction	Duration and phases of construction, time requirements
Scale of Construction	Linear feet of new/demolished infrastructure
Environment	
Effects on the Natural Environment	Proximity/impacts to critical areas such as shorelines, steep slopes, ESA species, wetlands, streams, or other natural habitat areas
Effects on the Built Environment	Extent of new right-of-way needed; permanent and construction
	Estimated level of property impacts (residential, commercial, other) and related displacements
	Conflicts with utilities
Parks and Cultural Resources	Effects on historic, archaeological, or parks resources, or properties with cultural associations
Equity	
Community Impacts	Temporary or permanent impacts to BIPOC, low-income, or other underserved populations, including through noise, visual, air quality, community separation, service disruptions, or changes in access and congestion (travel times)
Business, Job Opportunities, and Access	Loss of or impacts to businesses with living-wage jobs or impacts to access to jobs

Along with the concept evaluation criteria, the planning team also considered the estimated rough order of magnitude (ROM) costs for each concept for comparative purposes only. The ROM costs could change based on detailed design choices, site conditions and construction approaches, including for demolition of the repaired WSHB. Additional information on the ROM for capital costs and how those estimates were determined is in Appendix G.

4.2. Description of the Concepts Evaluated

4.2.1. North Bridge Concept

The North Bridge Concept, shown in Figure 4-3 and further detailed in Appendix C, would be north of both the WSHB and the Spokane Street Bridge. It would rebuild portions of the Delridge ramps and would rejoin the existing West Seattle Bridge, just past Pigeon Point to the west and before the east channel of the Duwamish Waterway to the east. It would be approximately the same width as the existing WSHB. Following the feasibility screening of the North Bridge Concept, the westbound approach to the Delridge off-ramp was slightly modified to reduce the grade by modifying the geometry and extending the tie-in point to the south.

Construction of the North Bridge Concept would begin by constructing a new eastbound and westbound crossing of the west channel of the Duwamish Waterway, north of the existing WSHB and the Spokane Street Bridge, and constructing a new portion of the westbound off-ramp to Delridge. Next, the north half of the existing approaches to the WSHB would be demolished and reconstructed to connect to the new WSHB. Then, the remainder of the new westbound Delridge ramp and temporary access from eastbound Delridge would be constructed, followed by demolition and reconstruction of the south half of the approaches to connect to the new WSHB, completing the tie-ins. Feasible bridge types for the North Bridge Concept include network arches with delta frames, segmental concrete box or steel box girder, or single-tower cable-stayed.

Figure 4-3. Conceptual Drawing of North Bridge Concept

4.2.2. South Bridge Concept

The South Bridge Concept, shown on Figure 4-4 and further detailed in Appendix C, is located south of the existing WSHB. It would rebuild portions of the Delridge off-ramp and would rejoin the West Seattle Bridge at Pigeon Point to the west and near the west side of the east channel of the Duwamish Waterway to the east. It would extend the Delridge off-ramp but would not affect the on-ramp.

Construction of the South Bridge Concept would begin by constructing a new eastbound and westbound crossing of the west channel of the Duwamish Waterway, to the south of the existing WSHB. Next, the south half of the existing approach to the WSHB would be demolished and reconstructed to connect to the new bridge. Then, the north half of the existing approaches to the WSHB would be demolished and reconstructed to complete the new tie-ins. Finally, the WSHB would be demolished, and the new westbound off-ramp to Delridge would be constructed. Feasible bridge types for the South Bridge Concept include network arches with delta frames or single-tower cable-stayed.

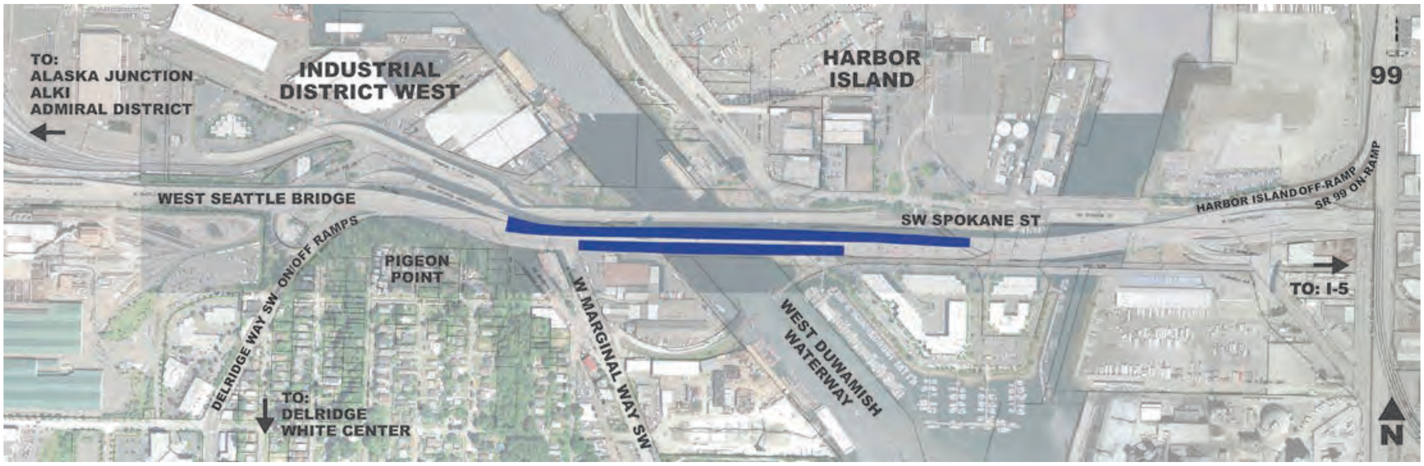
Figure 4-4. Conceptual Drawing of South Bridge Concept

4.2.3. On-Line Concept

The On-Line Bridge Concept, shown in Figure 4-5 and further detailed in Appendix C, is located generally in the same location as the existing WSHB, with the westbound lanes shifted closer to the Spokane Street Bridge control tower. The existing eastbound alignment would be maintained. The concept's total cross section would be slightly wider than the existing bridge.

The assumed construction approach for the Refined On-Line Bridge Concept would begin with demolition of the north (westbound) half of the existing WSHB and part of the approaches, followed by construction of the new westbound main bridge and then the westbound tie-ins at either end. Once the new westbound main bridge and tie-ins are completed, the south half of the existing WSHB and part of the approaches to the main bridge would be demolished, and a new eastbound main bridge would be constructed. Lastly, the eastbound tie-ins at either end of the main bridge would be constructed. Construction could take 6 to 8 years, depending on bridge type and whether it would be constructed on repurposed foundations or new foundations. Feasible bridge types for the On-Line Bridge Concept include network arches with delta frames, segmental concrete box or steel box girder, single-tower cable-stayed, cable-stayed, or steel continuous truss.

Figure 4-5. Conceptual Drawing of On-Line Concept

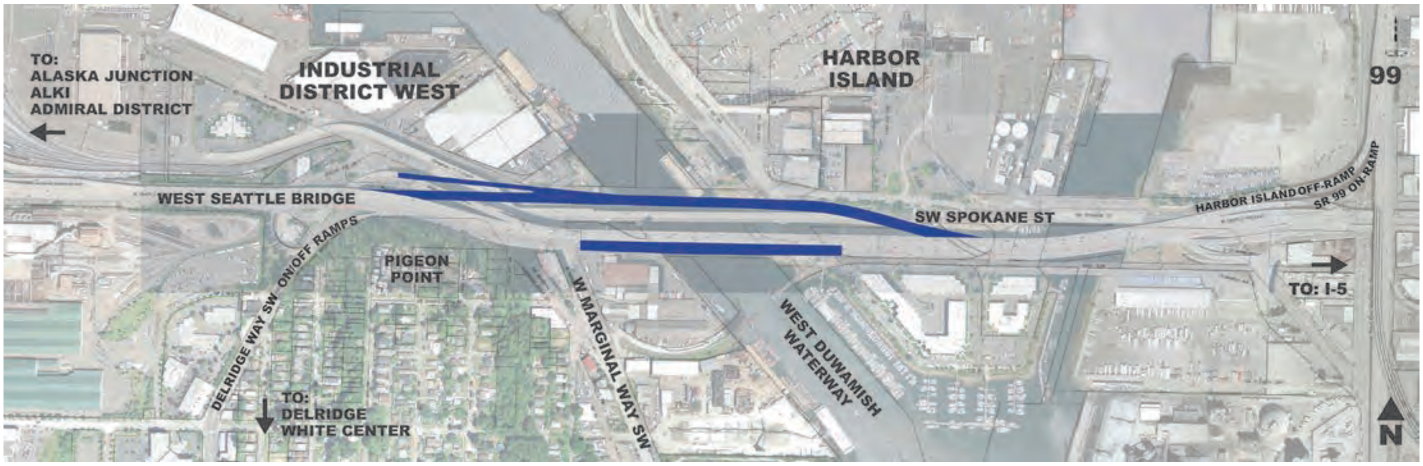


4.2.4. Hybrid Bridge Concept

The Hybrid Bridge Concept combines elements of the North Bridge Concept and the On Line Bridge Concept. The concept is shown on Figure 4-6 and further detailed in Appendix C. This concept still stays largely within the existing right-of-way but has the ability to maintain up to three lanes of traffic in each direction during construction.

Construction of the Hybrid Bridge Concept would begin with the construction of a new westbound main bridge to the north of the existing WSHB and then the tie-ins at either end of the new bridge, followed by the demolition of the south half of the existing WSHB and part of the approaches. Next, a new eastbound main bridge, followed by tie-ins at either end, would be constructed, followed by the demolition of the north half of the existing WSHB and part of the approaches. Although reductions in capacity would be minimized, construction sequencing required to maintain access to Delridge would limit concurrent construction activities and likely extend the duration of construction. Feasible bridge types for the Hybrid Bridge Concept include network arches with delta frames, single-tower cable-stayed, cable-stayed, and steel continuous truss.

Figure 4-6. Conceptual Drawing of the Hybrid Bridge Concept



4.2.5. Tunnel Concept

The Tunnel Concept did not perform well in the initial feasibility assessment and no further engineering study or refinement was performed. However, the planning team selected a representative tunnel concept to show the potential performance of a tunnel across a broader range of evaluation criteria, shown in Figure 4-7. The design and construction approach details of the Tunnel Concept were not developed to the same level as the bridge concepts, but the full range of evaluation criteria were still applied to supplement the feasibility screening findings and provide a comparison to the bridge concepts.

The representative concept is a tunnel located just south of the existing WSHB, with helix access points on either side of the west channel of the Duwamish Waterway. In addition to the basic footprint assumption shown below, one or more tunnel ventilation and emergency access/egress facilities and other maintenance facilities would be required. The tunnel concept would require reconstructing all ramps and access points between Avalon Way and SR 99, including portions of the SR 99/West Seattle Bridge interchange, but these were not advanced in more detail beyond the initial feasibility assessment. A more complex program for sequencing and maintenance of traffic would also be needed, given the tunnel tie-ins near the SR 99 interchange system and the Delridge and Avalon ramp connections. The conceptual drawings that provide the basis for this concept are attached in Appendix C.

Detailed construction phasing was not evaluated for the Tunnel.

Figure 4-7. Conceptual Drawing of the Tunnel Concept

4.3. Key Findings of the Concept Evaluation

Table 4-2 summarizes the key findings of the concept evaluation across the major categories of criteria, with additional detail on all criteria in Appendix E, Concept Evaluation. The Tunnel Concept is included in the tables for comparative purposes but is shown in grey to indicated that the design concept, as well as the key findings regarding the tunnel, were developed at a less detailed level than for the other concepts because the feasibility screening found that it would be less effective in meeting the purpose and need for a replacement to the WSHB.

Based on the concept evaluation, the On-Line and Hybrid bridge concepts would perform as well or better than the other potential concepts across most measures. The Tunnel Concept had the lowest performance across all criteria. A summary of the major differences in the concepts, as well as broader study findings, is in Section 5.

Table 4-2. Summary of Key Concept Evaluation Findings

	Refined North Bridge Concept	South Bridge Concept	Refined On-Line Bridge Concept	Hybrid Bridge Concept	Tunnel Concept
	Located north of both the WSHB and the Spokane Street Bridge from just past Pigeon Point to the west and before the east channel of the Duwamish Waterway to the east; refined to maintain existing grade at the Delridge ramps	Located south of the WSHB, between Pigeon Point to the west and near the west side of the east channel of the Duwamish Waterway to the east	Located generally in the same location as the existing WSHB, extending slightly farther north, but still south of the low bridge control tower, with a slightly wider cross section than the existing bridge; refined by moving the new westbound structure slightly north of the existing bridge, followed by a new eastbound structure	A new westbound structure would be built slightly north of the WSHB, and a new eastbound structure would follow the existing eastbound lanes of the WSHB, except slightly wider	Located just south of the WSHB, with helix access points on either side of the Duwamish Waterway
Capacity and Mobility					
Would the completed replacement WSHB maintain connections and functional services?	Yes, long-term access and circulation would be equivalent to the existing bridge	Yes, long-term access and circulation would be equivalent to the existing bridge	Yes, long-term access and circulation would be equivalent to the existing bridge	Yes, long-term access and circulation would be equivalent to the existing bridge	No, access and circulation would be substantially altered compared to the existing bridge, speeds would be slower, and travel times would be longer
Would the project impact navigation?	No permanent impacts to navigation May temporarily restrict navigation during construction. Proximity to Spokane Street low bridge could be challenging	No permanent impacts to navigation May temporarily restrict navigation during construction. Proximity to the BNSF Bridge could be challenging	No permanent impacts to navigation May temporarily restrict navigation during construction	No permanent impacts to navigation May temporarily restrict navigation during construction	No permanent impacts to navigation Temporary impacts to navigation may occur, depending on construction technique
How much would capacity be reduced during construction and for how long?	Capacity would be reduced to 2 lanes in each direction for at least 3–4 years during tie-in construction Closure of Delridge ramps during some phases of construction Some night and weekend closures of surface streets	Capacity would be reduced to 2 lanes in each direction for at least 2–3 years during tie-in construction	Capacity would be reduced to 2 lanes in each direction for the duration of construction	No reduction of capacity for all or most of construction (would maintain up to 3 lanes in each direction) Capacity could be reduced to 5 lanes for some phases of construction Weekend closures at westbound tie-in affecting Delridge Some night and weekend closures of surface streets	Capacity would be maintained on the WSHB, but would be interrupted and reduced at times during construction at tie-in locations at both ends
Would the project impact the corridor or adjacent facilities?	Port access facilities (including the Terminal 5 Flyover and Terminal 18) and BNSF rail facilities for Harbor Island and Terminal 18 would be impacted	Potential construction impacts to BNSF Bridge and direct conflict with Sound Transit's Preferred Alternative DUW-1a and Alternative DUW-1b, in the Pigeon Point area	No direct conflict, but construction would occur over BNSF rail lines, and there may be construction staging conflicts with Sound Transit's DEIS Preferred Alternative (DUW-1a) and DUW-1b	No direct conflicts, but construction would occur near the Spokane Street Bridge, and there may be construction staging conflicts with Sound Transit's DEIS Preferred Alternative (DUW-1a) and DUW-1b	The SR 99 interchange to the east and to Fauntleroy and Delridge connections to the west would need to be reconfigured Potential conflicts with Sound Transit DEIS alternatives, both long term and during construction, including conflicts with the western helix and potentially with Sound Transit foundations to the east of the crossing to SR 99, affecting Sound Transit's DEIS Preferred Alternative (DUW-1a) and DUW-1b

	Refined North Bridge Concept	South Bridge Concept	Refined On-Line Bridge Concept	Hybrid Bridge Concept	Tunnel Concept
Construction					
Approximately how long would construction and demolition take?	At least 8-10 years	At least 8-10 years	At least 6-8 years	At least 6.5-8.5 years	At least 10 years
How much new infrastructure would be constructed?	~ 3,400 linear feet	~ 3,300 linear feet	~ 1,700 linear feet eastbound ~ 2,300 linear feet westbound	~ 1,700 linear feet eastbound ~ 3,300 linear feet westbound	~ 14,000 linear feet
Major construction challenges?	Longer span would limit bridge type options Proximity to low bridge and BNSF Construction over live traffic Limited space to place columns for tie-in structures	Longer span would limit bridge type options Proximity to BNSF and Sound Transit alignments to the south would make construction challenging	Maintenance of traffic relies on temporary seismic retrofit to existing bridge foundations to allow for phased construction Construction would occur in very close proximity to low bridge and BNSF, as well as Sound Transit alignments to the south (Preferred Alternative DUW-1a and Alternative DUW-1b) in the Pigeon Point area	Longer span would limit bridge type options Construction would occur in very close proximity to low bridge and BNSF, as well as Sound Transit alignments to the south (Preferred Alternative DUW-1a and Alternative DUW-1b) in the Pigeon Point area	Extensive property acquisition needs Tunneling through poor soil, through fill and under waterways Higher potential for archaeological resources Locating construction staging, storage, and haul access for spoils and construction materials Locating emergency access and tunnel ventilation systems Potential conflicts with Sound Transit alignments to the south (Preferred Alternative DUW-1a and Alternative DUW-1b)
Environment					
Would the project impact environmentally critical areas or species?	Minor construction impacts possible; no permanent impacts	Yes, minor construction impacts possible and permanent impacts to Pigeon Point (steep slope, critical habitat)	No permanent impacts other than minor potential impact to Pigeon Point (steep slope, critical habitat)	Minor construction impacts possible; no permanent impacts	Yes, construction impacts likely and potential permanent impacts to Pigeon Point (steep slope, critical habitat) and the Duwamish Waterway
Would the project conflict with existing utilities?	Yes, would conflict with City transmission lines	No conflicts identified	No conflicts identified	Yes, minor conflict with City transmission lines	Yes
Equity					
Would low- or living-wage jobs be impacted?	Yes	Yes	No permanent impacts but some temporary construction impacts	Yes, but fewer than North and South bridges	Yes
Would the project impact BIPOC or low-income communities?	No direct impacts to housing or facilities associated with BIPOC or low-income communities, but potential impacts due to impacts to employers with living-wage jobs, including reduced access to Port enterprises	No direct impacts to housing or facilities associated with BIPOC or low-income communities, but some potential impacts due to impacts to employers with living-wage jobs, including reduced access to Port enterprises	No direct impacts to housing or facilities associated with BIPOC or low-income communities	No direct impacts to housing or facilities associated with BIPOC or low-income communities, but potential impacts due to impacts to employers with living-wage jobs, including reduced access to Port enterprises	Loss and change to access to the corridor, loss of employment opportunities, loss of housing, and the magnitude and length of major construction period affecting a large area would impact BIPOC and low-income communities

Additional detailed information on the Concept Evaluation is attached as Appendix E.

5. Key Findings of the West Seattle High Bridge Replacement Planning Study

5.1. Findings on the Location and Scope of a Future Replacement Project

Before it reaches the end of its remaining service life, the WSHB can be effectively replaced with a replacement high span bridge project built within the City's existing right-of-way while still allowing transportation service to continue in the corridor during construction. The scope of the replacement project could be limited to the areas between Delridge Way and Harbor Island.

KEY FINDINGS – The WSHB can be replaced...

- Within City right-of-way
- Between Harbor Island and Delridge Way
- While maintaining some mobility during construction
- Without precluding broader corridor improvements

By focusing on the core purpose for replacing the WSHB before the end of its service life, the study found viable solutions to avoid triggering larger, corridor-wide actions and impacts, such as those that might require rebuilding the structures over the east channel of the Duwamish Waterway, reconstructing the SR 99 interchange, or building a tunnel between SR 99 and Admiral Way. While larger corridor improvements might still be implemented as related projects, they would not necessarily be directly connected to the City's future actions to replace the WSHB before the end of its service life.

Based on the replacement study, the two concepts that performed the best were the On-Line Bridge Concept (rebuilt bridge on the existing alignment) and the Hybrid Bridge Concept (an eastbound bridge built on the WSHB existing alignment with a westbound bridge to the north). Both concepts have better performance in terms of limiting the footprint of the project within existing right-of-way, reduced impacts, shorter construction duration, and lower cost compared to concepts realigning the bridge entirely to the north or south. Additional information about the estimated ROM difference in cost is attached in Appendix G. While all concepts offered generally the same long-term mobility performance (matching the current WSHB capacity), the Hybrid Bridge Concept offered better mobility during construction than the On-Line, North, or South bridge concepts.

With all of the concepts, the future replacement of the WSHB remains a major capital project with a high degree of technical challenges and complexity. Construction alone could require at least 6 years due to the challenges of maintaining mobility on the highway, on roadways and rail facilities below, and without obstructing navigational uses on the Duwamish Waterway. Prior to construction, further planning, design, and environmental permitting and funding efforts could range from 4 to 8 years, depending on the project details.

A very high-level representation of the key findings from the concept evaluation is illustrated in Figure 5-1.

Figure 5-1. Summary of WSHB Long-Term Replacement Concept Evaluation Findings

	North Bridge Concept	South Bridge Concept	On-Line Bridge Concept	Hybrid Bridge Concept	Tunnel Concept
Mobility *Ability to maintain long-term connections, access, functions, and navigation*	Light green	Light green	Green	Green	Red
Ability to maintain capacity during construction	Yellow	Yellow	Orange	Light green	Orange
Construction *Duration, scale, and challenges of construction*	Yellow	Yellow	Green	Light green	Red
Environment *Potential impacts to built and natural environment*	Yellow	Orange	Green	Light green	Orange
Equity *Impact to BIPOC and/or low-income communities and living-wage jobs*	Yellow	Orange	Green	Light green	Red

SCALE

Comparatively most impactful or least able to meet project goals — Red, Orange, Yellow, Light green, Green — Comparatively least impactful or most able to meet project goals

5.2. What Were the Major Differences between the Concepts?

With all of the concepts, the study found it will be particularly challenging to replace the WSHB crossing on a major elevated corridor while maintaining transportation service. All of the concepts would have periods of several years when traffic capacity would be reduced during construction, compared to the existing bridge.

The Hybrid Bridge Concept was the only concept that would be able to maintain up to three lanes each way throughout construction. This is because it would add new bridge capacity while using the existing structure in alternating phases to keep moving traffic.

The major differences across the concepts were found in construction period capacity and mobility, coupled with the higher costs and impacts of replacing the crossing on an entirely new alignment, compared to staying within City right-of-way.

The North and South bridge concepts could build much of a replacement bridge in new right-of-way without affecting the existing WSHB, but the replacement bridge would still need to be reconnected to the existing bridge

PRIMARY DIFFERENTIATORS:

- Ability to maintain capacity and mobility throughout construction
- Amount of new right-of-way required and related impacts
- Construction challenges

at either end of the new structure, referred to as the “approaches” or the “tie ins.” The study found this would require reducing traffic to two lanes each way for several years in order to integrate the new highway structures with the existing. Overall, the higher costs, impacts, and risks that came with the North and South bridge concepts did not come with any advantages over the On-Line and the Hybrid bridge concepts. In addition, the North or South bridge concepts would need to use land beyond the City’s current control, which also made those off-line concepts more subject to change over time in this dynamic seaport area and could increase costs, impacts, and complexity for a future replacement project.

The advantages of the On-line and Hybrid bridge concepts, beyond the differences in mobility during construction, are largely related to the ability to build the replacement project mostly within the City’s current right-of-way. Replacing the WSHB within existing right-of-way would avoid costs, risks, and impacts, including to the adjacent water-dependent marine uses and other facilities such as the BNSF Railway bridge or the Port of Seattle. For most of the evaluation measures, the On-Line and Hybrid bridge concepts performed similarly. However, with the On-Line Bridge Concept, construction-period capacity would be reduced to two lanes each way for most of the approximately 6 years needed for construction, whereas the Hybrid Bridge Concept would allow up to three lanes each way throughout construction. If the impacts of constrained mobility can be mitigated, there are potentially off-setting advantages for the On-Line Bridge Concept because it offers the lowest cost and the least impacts of all the concepts.

As noted above, the Hybrid Bridge Concept’s major advantage is a sequencing plan that could maintain up to three lanes each way throughout construction. This also offers more flexibility in project implementation. If implemented as a single, continuous project, the Hybrid Bridge Concept would take about the same time to construct as the On-Line Bridge Concept (at least 6 to 7 years). The difference in ROM costs and impacts would be more than for the On-Line Bridge Concept because the concept still involves constructing a new bridge to the north.

With the On-Line Bridge Concept, the replacement bridge would be built generally where it is today, although design details such as bridge type, foundations, and long-term seismic design standards still remain to be determined. For the Hybrid Bridge Concept, there is more flexibility to shift the eastbound and westbound alignments within the City’s right-of-of way, based on other goals and priorities in the immediate area. For example, the selection of a specific alignment for the westbound or the eastbound lanes could be influenced by factors such as the long-term needs of the Spokane Street Bridge and its future retrofitting or replacement. The Hybrid Bridge Concept could also be modified and/or phased to improve other area connections or avoid conflicts with future changes in surface infrastructure or environmentally critical steep slopes near Pigeon Point. Section 6 describes such potential future design considerations.

The evaluation measures used to assess the representative concepts were largely designed to help identify the major differences that would affect the likely scope, location, and ability to implement a future WSHB replacement project. While the Hybrid and the On-line bridge concepts clearly emerged as the most promising concepts, more detailed study would be needed to confirm potential advantages and differences that could affect the City’s future project decisions. This includes phasing and funding tradeoffs, the type or types of bridges to be used, their construction techniques, specific alignment details, and the future design standards that may apply.

5.3. Other Related Corridor Needs

When the replacement planning study began, the planning team reviewed other potential problems or needs that could substantially affect the long-term solutions needed for a WSHB replacement. The team considered whether or not there were additional capacity, operational, or facility issues on the WSHB or in connecting parts of the West Seattle Bridge or the larger Spokane Street Corridor that could affect the problem statement underlying the purpose and need for a WSHB replacement.

At this broad, corridor-assessment level, the team reviewed whether replacement concepts for the WSHB could preclude the ability of the City or others to take action to address concerns for other parts of the corridor. This includes actions to improve safety and mobility, implement related projects, improve environmental conditions, or address potential race and social equity issues. (Note that major conflicts with other facilities, such as the Spokane Street Bridge, the BNSF Bridge, and future Sound Transit bridges, were already being considered in the concept development and evaluation steps described in Sections 2 and 3 of this report.) The sections below summarize the study findings regarding corridor-level issues and the replacement concepts considered.

5.3.1. Long-Term Transportation Needs

The areas served by the corridor are projected to continue to gain jobs, population, and economic activity in the coming decades, which could increase long-term transportation demand. Prior to the WSHB emergency closure and the COVID-19 pandemic, the West Seattle Bridge (including the WSHB) was chronically congested. The WSHB has the same functional capacity as the connecting sections of the West Seattle Bridge, and the corridor has long experienced congestion and delays at the SR 99 interchange and I-5, particularly at peak periods. Long-range plans at the City or regional level do not currently propose major capacity expansions for the corridor, I-5, or SR 99.

The replacement planning found viable concepts to replace the WSHB without affecting long-term operations in connecting parts of the corridor. Therefore, additional study of future multimodal operational needs and conditions on and adjacent to the WSHB was not necessary at this time.

The On-Line and Hybrid bridge concepts would not preclude other operational improvements or modifications as part of an eventual replacement, but any such change in operations would likely involve more detailed assessments of connections across the larger surrounding corridor. Currently, there are unprecedented disruptions in travel behavior presented by the COVID-19 pandemic and technological changes, making future travel demand unusually difficult to predict. Sound Transit's proposed extension of high-capacity transit to West Seattle will also notably alter travel behavior and conditions. For these reasons, the planning team recommended that the City defer detailed demand and operational studies for the WSHB replacement, and instead conduct them later in a subsequent phases of replacement planning and design, closer to when the WSHB replacement would be needed.

5.3.2. Nonmotorized Planning

Bicycle and pedestrian trips in the corridor are currently made via the Spokane Street Bridge and have not been allowed on the West Seattle Bridge, including on the WSHB. The planning team reviewed whether a future WSHB should be designed to accommodate nonmotorized trips (see Appendix F). The current volumes of nonmotorized trips on the Spokane Street Bridge and connecting paths rank the corridor as one of the busiest in the City and future demand is expected to grow. The study compared opportunities for improving current facilities along the existing route to a potential new nonmotorized facility implemented in coordination with the future WSHB replacement. The assessment assumed a nonmotorized facility running parallel to the replaced portion of the WSHB with separate structures connecting to the existing nonmotorized network at ground level and did not consider reallocating lanes on the WSHB for nonmotorized use.

The study found that adding a new nonmotorized facility via the WSHB replacement project would require major investments beyond the anticipated limits of the current replacement concepts and would have extended steep grades that would present more challenges for compliance with the standards of the Americans with Disabilities Act. Given the assumptions of this study, the planning team determined there is currently no compelling reason to require a nonmotorized facility on a high bridge structure if the surface route continues to provide an alternative. Future planning work for the WSHB will revisit whether a nonmotorized facility on a high bridge structure becomes appropriate given any additional information or changes to conditions in the Spokane Street Corridor.

6. Future Considerations

In addition to the key findings, this long-term replacement study also identified several broader questions and observations about the corridor, which are summarized in this Section 6.

6.1. Study Limitations

As a long-range planning study intended to help frame the location and scope of a future WSHB crossing replacement project, this study did not involve the more extensive design, environmental, public involvement, agency coordination, and funding analysis that would ultimately be needed to define and deliver a future project with a defined construction timeline. For this reason, representative concepts, rather than a more extensive alternatives analysis, were used to compare the requirements, constraints, and advantages for facilities in a range of locations. Section 2 described the key design and performance objectives for a WSHB replacement. The planning team did not explore or evaluate all feasible design choices that could be available, including formally determining bridge types and construction methods.

This study was guided by the City's determination that the replacement timeframe would be around 2060. The timing of the replacement project would consider the actual service life of the WSHB as well as other factors such as funding, future design, environmental and permitting requirements, and decisions about other facilities, such as the Spokane Street Bridge.

The replacement planning study was highly focused on the needs of the WSHB and the general definition of a future replacement project, especially its scope and location. The study did not immediately try to solve all long-term needs in connecting facilities or the larger corridor. For instance, the study did not consider in detail the service life of the approaches, including the east Duwamish Waterway crossing. As the entire corridor reaches the end of its service life, or as the City considers other factors such as corridor resiliency and long-term state of good repair, there may be the need to improve other portions of the West Seattle Bridge or other facilities. This could introduce new opportunities and constraints, and it could affect overall implementation and funding timelines. However, these other factors are unlikely to change the study's findings about the advantages of maximizing the value of the City's existing right-of-way, the importance of maintaining mobility during construction, and the need to minimize impacts to adjacent communities and the environment in West Seattle and the Duwamish Valley.

6.2. Corridor Future Compatibility

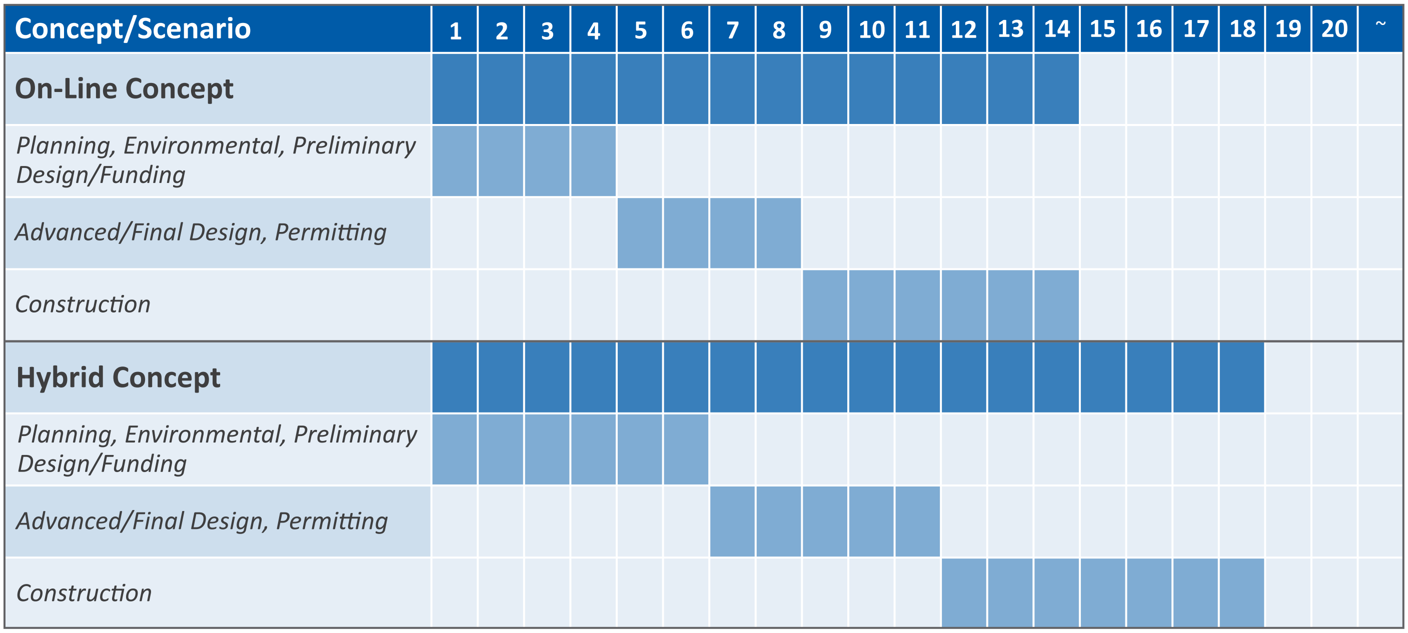
In addition to identifying concepts that would replace the mobility provided by the WSHB, the long-term planning study reviewed how other projects or the broader mobility needs for the corridor could affect a future WSHB replacement project. This could include actions focused on improving conditions for a given mode, such as freight, or to address conditions on facilities beyond the limits of the replacement project.

The Spokane Street Bridge will also eventually need major rehabilitation or replacement. The needs for the Spokane Street Bridge could affect future decisions about WSHB replacement design and implementation. This would be particularly important if the replacement for a Spokane Street Bridge necessitates a full closure of that bridge during construction, or if the lower bridge replacement involves a shift in alignment. Particularly with the Hybrid Bridge Concept, there are potential design and phasing variations that could help minimize the mobility impacts of a lower bridge closure.

6.3. Project Development Steps and Timelines

For any WSHB replacement, it could take 14 to 20 years to deliver a project, and potentially longer if a replacement project is to be phased with other project actions in the area, such as a project involving the adjacent Spokane Street Bridge. At a minimum, implementation actions would need to begin at least 8 years in advance of the construction period, including securing funding for each step of implementation. A general illustration of potential planning, project development and delivery timelines for the On-Line and Hybrid bridge concepts is shown on Figure 6-1.

Figure 6-1. General Planning, Project Development, and Delivery Timelines (in years)



The City has had successful experience with other similar projects that have been advanced and developed as part of a coordinated program of actions, such as the Waterfront Seattle program and the Mercer Corridor program. The Washington State Department of Transportation used similar program strategies to address the needs of SR 520, the Alaskan Way Viaduct, I-405 and others. The setting, needs, and opportunities for the West Seattle Bridge are similarly complex to these examples. The areas and facilities immediately adjacent to WSHB alone also may require a more comprehensive assessment to ensure long-term compatibility of the replacement and to maximize the benefits of overall future public investments in the area. The timeline for developing the strategic visions that guided the implementation similar complex programs have varied, but, overall, the guiding plans have been in place well before individual project development actions started.

6.4. Funding and Implementation Strategies

In addition to being a vital transportation link, the West Seattle Bridge is critically important to the local, state, and national economies, as well as to international trade. These qualities create a substantial array of strategies for the City to pursue for project and corridor development. There are strategies that focus on the WSHB alone, as well as strategies highlighting larger corridor issues or the corridor's services for a major port/industrial area of state and national significance. The 2021 Infrastructure Investment and Jobs Act expanded the range of federal grant programs for major highway corridor projects with direct ties to freight, jobs, commerce, resiliency, racial equity and environmental justice. Those grants are available for different stages of corridor or project development, from planning to design to construction, and they encourage "bundling" of related projects to streamline implementation. They also can leverage locally generated funds, state funds, interagency partnerships, and public/private partnerships. Although an implementation date has not been defined for the WSHB replacement, a "placeholder" replacement project in the region's long-range Regional Transportation Plan (RTP) managed by PSRC, increases the eligibility of the project for an array of federal funding opportunities. The City should work with PSRC to either include the project as part of an RTP amendment or as part of the next RTP update.

6.5. Construction Period Mobility Needs

Although the On-Line and the Hybrid bridge concepts offer the City a choice between having potentially two lanes versus up to three lanes of capacity each way during construction, a variety of other mobility factors could affect the larger mobility impacts of the future choice, which in turn may affect nearer term corridor and area mobility management strategies. The discussions below identify some of these considerations but do not address fiscal, racial and social equity, detailed traffic, or other environmental effects of construction period capacity reductions.

6.5.1. Sound Transit West Seattle Link in Place and Operating

Operation of the West Seattle Link light rail, which is anticipated to begin in 2032, will provide additional mobility to West Seattle, both in terms of person-carrying capacity as well as better reliability and quality of service for transit riders. Longer term, that additional mobility may translate into less traffic on the WSHB, or at least lower levels of future growth in vehicle trips, which could lessen the effects of multiple years of reduced capacity during reconstruction. As the On-Line Bridge Concept would only allow for two lanes in each direction, an operational light rail may influence decision-making on a Hybrid or On-Line replacement.

Another consideration related to the future West Seattle Link light rail is its potential to hinder or complicate construction access for WSHB demolition and replacement. While any impacts to WSHB reconstruction activities would be highly dependent upon Sound Transit's final alignment, typology, and operational requirements, constructability impacts could also influence decision-making about the Hybrid or On-Line bridge concepts.

6.5.2. Other Mobility Factors Affecting Construction-Period and Long-Term Mobility Needs

In addition to the potential for light rail to affect long-term corridor mobility needs, or if light rail is not in operation before a WSHB replacement begins construction, the City's strategies for managing mobility needs during construction and longer term would be shaped by the potential effects of other strategies to manage travel demand and traffic. This includes possible future choices the City or the region could consider, involving tolling or other transportation pricing. Whether changes in the cost of travel occurs at regional or corridor levels, this could still affect travel volumes, travel route preferences, and the time and mode of travel that travelers may choose in the Spokane Street Corridor and areawide. Mobility could also be affected by the level of investments in infrastructure, services, or technologies that provide alternatives to driving.

Changes in the transportation services provided by other facilities in the area can also affect WSHB construction mobility management decisions. If capacity or service is reduced on one of the other facilities serving cross-Duwamish trips, such as the 1st Avenue South Bridge, the Spokane Street Bridge, the BNSF Bridge or the South Park Bridge, the impacts of lower capacity on the West Seattle Bridge would be more acute. The Spokane Street Bridge and the BNSF Bridge, the primary facilities serving the Port and adjacent industrial areas, would have the greatest impact to corridor mobility. However, shifts or reduction in capacity or service of the 1st Avenue South Bridge and the South Park Bridge would have an effect, as would any changes to the limited number of other routes or facilities serving travel from West Seattle.

6.6. Corridor-Level Compatibility

The study's findings identified the On-Line and Hybrid bridge concepts as the best performing for a WSHB replacement. For the actual selection of a future replacement project, a wider set of factors would need to be considered. This includes further study of implementation, design, construction, and long-term needs in the corridor and for other modes, including freight and nonmotorized travel. The bridge type of a future WSHB may be influenced by the Sound Transit light rail bridge type, especially if the light rail project overall is a high and prominent structure extending well beyond the Duwamish Waterway crossing. Similarly, as noted earlier, the Spokane Street Bridge replacement strategy may also affect WSHB replacement.

As the bridges in the corridor approach the end of their service life, more detailed technical studies would support future decision-making: project-level design refinements for both the Hybrid and On-Line bridge concepts could initially focus on completing type, size, and location studies, with more detailed assessments of approaches, helping to identify the most cost-effective and constructable strategy. The On-Line Bridge Concept would also involve further study of new substructures compared to reuse of the existing foundations. The potential reuse of existing foundations could also affect the Hybrid Bridge Concept. Further evaluation of foundation assumptions, constructing new or reusing existing, will be required for both the On-Line and Hybrid bridge concepts, especially considering any updates to seismic standards and ground conditions.

APPENDIX A

Purpose and Need Memorandum

MEMORANDUM

DATE:	September 30, 2021
TO:	Wes Ducey and Elisabeth Wooton
FROM:	Daryl Wendle and Erin Ferguson, Parametrix; HNTB Team
SUBJECT:	West Seattle High Bridge Long-Term Replacement Planning - Draft Initial Purpose and Need
CC:	Ted Zoli, Paul Huston, and Diana Giraldo, HNTB

This memorandum presents an initial draft purpose and need for a long-term replacement for the high bridge segment of the West Seattle Bridge (often referred to as the high bridge, West Seattle High Bridge or WSHB). This initial purpose and need statement describes why the high bridge must be replaced, and is the basis for the development and evaluation of potential replacement solutions.

Background

The West Seattle Bridge is an essential east-west elevated facility connecting West Seattle to the rest of Seattle and the regional roadway network, including I-5 and SR 99. The bridge is a part of a broader corridor, collectively referred to as the Spokane Street Corridor, that includes connected facilities such as the Spokane Street Viaduct and the Fauntleroy Expressway, as well as adjacent lower facilities such as Spokane Street and the Spokane Street Bridge (also referred to as the "low bridge"). The West Seattle Bridge setting is illustrated in Figure 1. Figure 2 shows the bridge relative to the city and regional roadways.

The high bridge crosses the west waterway of the Duwamish River and is the only fixed span crossing (non-moveable) over the navigable waterway. Aside from the two-lane Spokane Street Bridge directly below and north of the high bridge, the 1st Avenue South Bridge, nearly 3 miles south, is the next closest crossing of the Duwamish River. With a population approaching 100,000 and growing, West Seattle is the only major district of Seattle that relies primarily on a single corridor to directly connect to the center of the city. The West Seattle Bridge is the most direct and highest capacity route connecting West Seattle to I-5 and the regional highway system. There are major impacts whenever there is a reduction or elimination of transportation capacity on the bridge.

The west waterway of the Duwamish River provides a large vessel/deep draft navigation route between the Puget Sound and the Port of Seattle's major maritime shipping terminals, other facilities operated by the Northwest Seaport Alliance, and properties in the Duwamish Manufacturing/Industrial Center to the south. This area is an economic powerhouse, home to nearly 70,000 jobs and contributing up to 30% of the business and sales tax revenue raised within the city.

In March 2020, the City of Seattle closed the high bridge in the interest of public safety, due to the accelerated growth of new and existing structural cracks. Prior to the closure, the bridge transported an average of over 100,000 vehicles a day, including 17,000 bus riders and substantial volumes of vehicles carrying freight and goods. Stabilization of the bridge began in 2020 and the bridge is anticipated to reopen in mid-2022. The closure of the high bridge required closure of the full West Seattle Bridge, from SR 99 on the east to Fauntleroy Way SW in West Seattle. During the closure, all vehicles must use alternative routes that are less direct, have capacity limits, or both. The closure of the bridge and the resulting traffic restrictions, detours, congestion, and cut-through traffic has impacted travel in West Seattle, the Port of Seattle, and in the industrial areas and neighborhoods between downtown Seattle and Tukwila. It has degraded economic activity, environmental conditions, and quality of life throughout West Seattle and the Duwamish Valley, including the diverse communities located primarily in Seattle neighborhoods to the south of the bridge and in unincorporated areas of King County.

As the busiest city-owned roadway in Seattle, the West Seattle Bridge rivals I-5 and I-90 for total trips served per day. For more than a century, the corridor has been the primary route for daily commutes, commercial and freight trips, transit, and general purpose travel between West Seattle and the region. From West Seattle to I-5, the bridge allows east-west traffic to travel above the crossings of multiple north-south arterials as well as the major rail lines serving both freight and passenger travel through the Duwamish Valley.

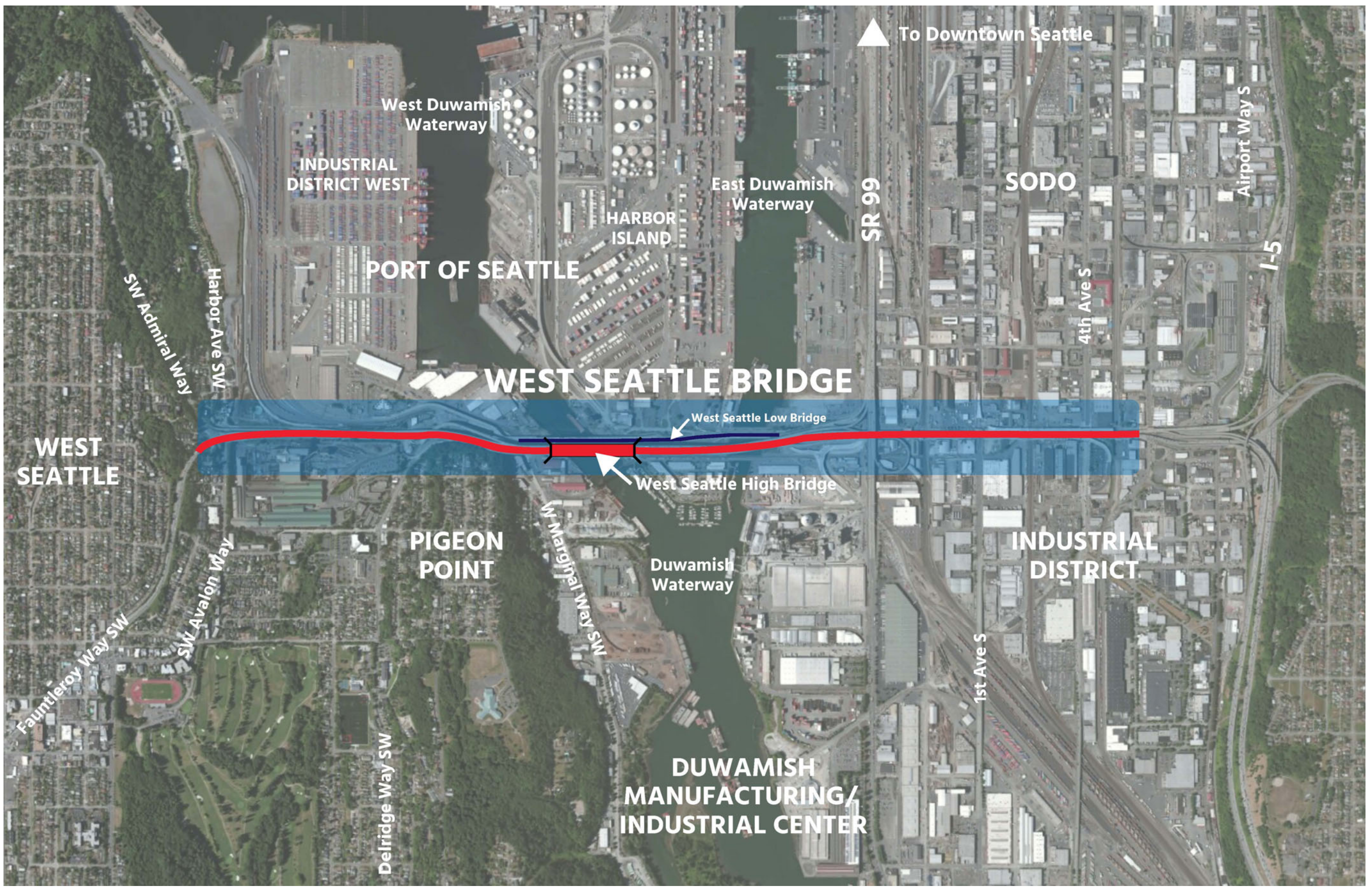


Figure 1: West Seattle High Bridge Local Setting

Purpose and Need for a Replacement Duwamish River Crossing

The current repairs to the high bridge are intended to allow the West Seattle Bridge to be reopened, but the crossing of the Duwamish River will eventually need to be replaced before the end of the high span's service life.

- The purpose of a replacement crossing is to maintain the long-term transportation capacity, safety, mobility, and access needed for efficient travel across the Duwamish River between West Seattle, the Duwamish Valley, and the region, while:
  - Providing for the needs of navigation on the Duwamish River and supporting the maritime, intermodal shipping and industrial activities of the Port of Seattle, Northwest Seaport Alliance, and the Duwamish Manufacturing and Industrial Center;
  - Creating greater racial and social equity by avoiding impacts and seeking benefits to nearby communities, the natural and built environments, the economy, and transportation; and
  - Maintaining effective mobility functions on the local and regional transportation system, including the west channel of the Duwamish River, during the construction of a crossing replacement.

Figure 2: West Seattle Bridge Regional Setting

Based on the long-term need to preserve and enhance mobility for the larger corridor between West Seattle and I-5, additional needs as part of planning a future replacement crossing could include:

- To provide a safe and resilient Duwamish River crossing and maintain essential public infrastructure connecting West Seattle to the region, the corridor must be able to avoid long term closures and to withstand natural disasters, such as a major seismic event, flooding, or inundation related to the corridor's location within the Cascadian Subduction Zone and near the Puget Sound.

- As West Seattle and the region continue to add people, jobs and economic activity in the coming decades, the corridor must allow the region to efficiently accommodate future multimodal transportation demand for cross-Duwamish River trips between West Seattle and the local and regional transportation system.

Importance of the West Seattle Bridge

For more than a century, an east-west corridor located generally along Spokane Street has been a critical transportation link between the West Seattle peninsula and greater Seattle. The existing West Seattle High Bridge was built in 1984, six years after one of the two draw spans of the prior 1924 twin bascule bridges was damaged by a large freighter. Then, as now, the closure affected transportation, the economy, and the communities in the area. Even before that incident and partial corridor closure, the City of Seattle and other entities in the region had for decades discussed plans for a more reliable roadway crossing of the Duwamish River that did not require stopping traffic to allow large maritime vessels to pass on the river. Funding for a West Seattle Freeway with a high bridge was part of the Forward Thrust ballot measure in 1968.

In addition to serving the dense multi-use neighborhoods of West Seattle, the West Seattle Bridge is where the waterborne, rail, truck, and airborne freight shipping modes converge for the Port of Seattle and the Duwamish Manufacturing/Industrial Center. The Port of Seattle facilities along the Duwamish River and Elliott Bay constitute one of the largest U.S. west coast international ports, and the Duwamish Manufacturing/Industrial Center is at the heart of the larger industrial and jobs center south of downtown, from Seattle to Tukwila.

The small number of routes available to serve east west trips across the Duwamish Valley reflects the natural steep topography of the valley and the barrier posed by the Duwamish River itself, with the West Seattle peninsula to the west and Beacon Hill to the east. As the region has developed over time, railroads, the Port of Seattle and related shipping, industrial and manufacturing developments; natural preserves; neighborhoods; and transportation infrastructure have continued to constrain the area available for new or replaced transportation capacity.

General Traffic. Prior to its closure, the West Seattle Bridge typically carried over 100,000 vehicles, and an estimated 130,000 people, each day. Due to its heavy use, the elevated roadway regularly experienced congestion and delay, particularly at peak morning and evening travel periods. Congestion also was aggravated by weaving movements between the multiple on- and off-ramps for the bridge (Figure 3). During AM and PM peak periods, when traffic volumes were greater than the facilities' design capacities, traffic queues could stretch from the bridge back to Fauntleroy Way SW and Admiral Way in the AM peak periods, and back to SR 99 and I-5 during the PM peak periods. Key congestion points included the interchange ramps for SR 99 and I-5, and the ramps to and from Harbor Island (heavily used by freight trucks). Both I-5 and SR 99 are regularly congested themselves, even before they receive traffic from the West Seattle Bridge. Traffic volumes and demand had been consistently high and growing up to the bridge closure and the COVID-19 pandemic. Disruptions anywhere along the West Seattle Bridge from Fauntleroy Way to I-5 can cause severe and long-lasting delays for travelers. Over 25% of daily trips on the West Seattle Bridge were to and from SR 99, and over 60% were to or from I-5.

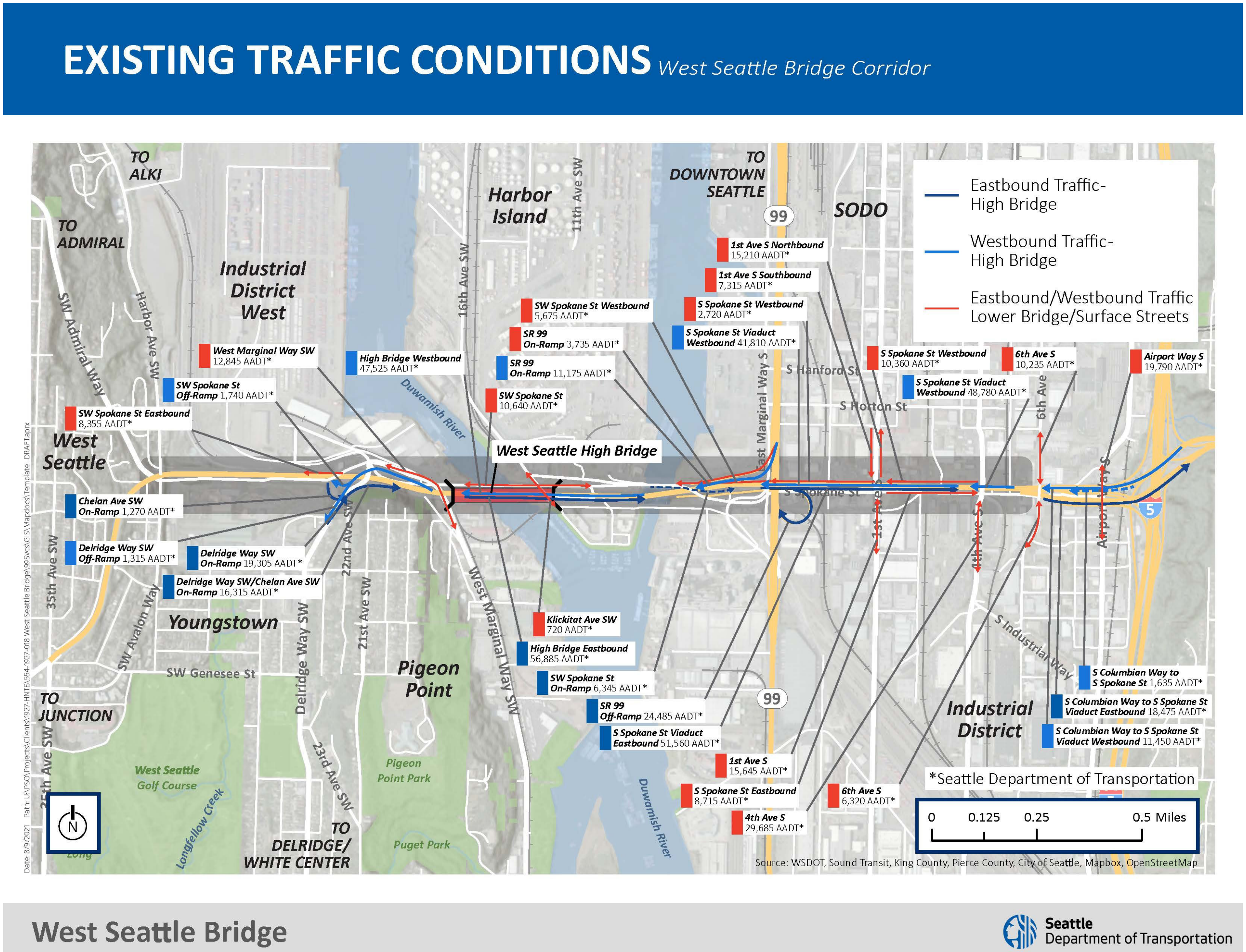


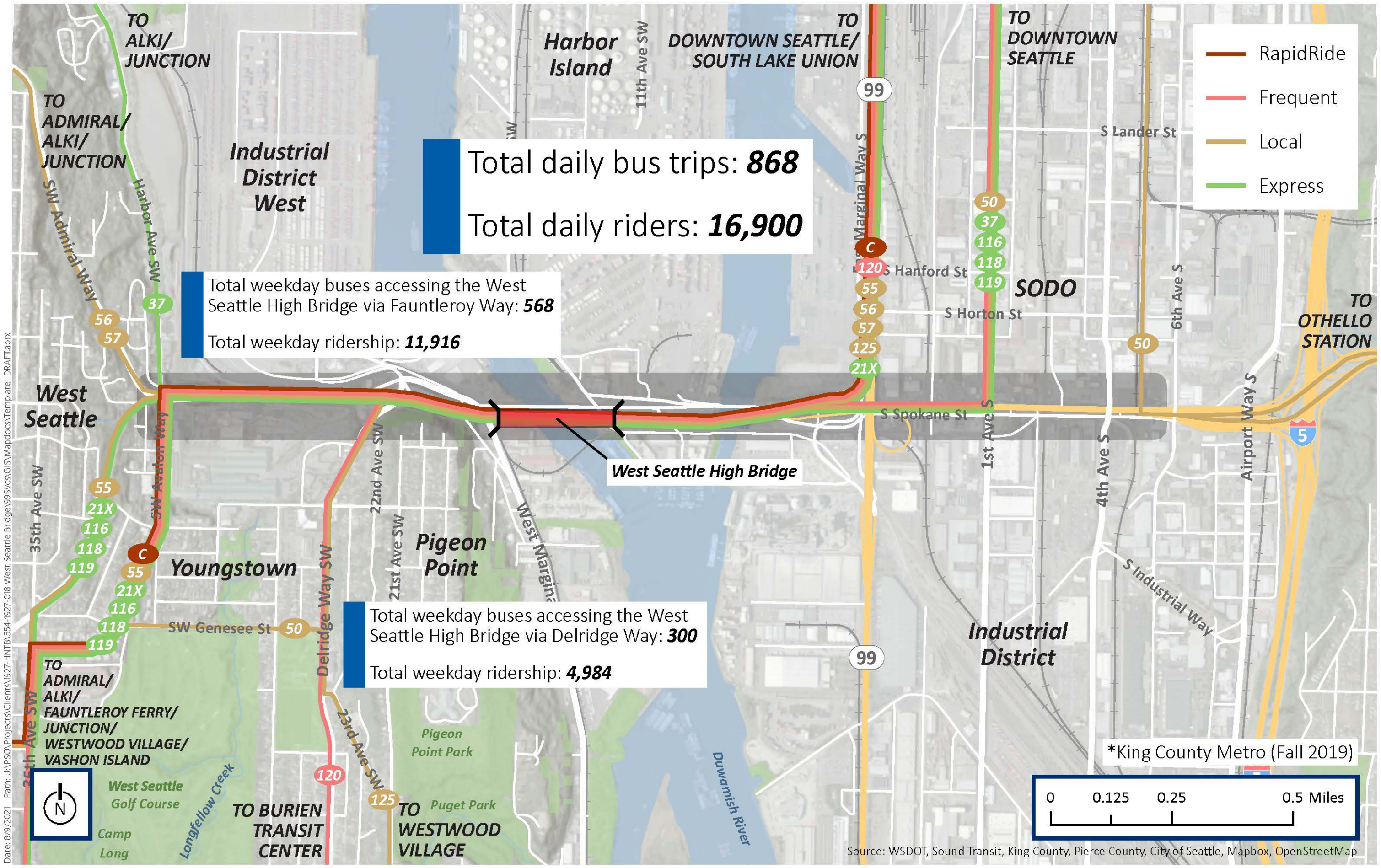
Figure 3: Estimated Average Daily Traffic Volumes and Key Access Points to the West Seattle Bridge (prior to closure)

Non-Motorized Travel. Currently, the West Seattle Bridge does not allow bicyclists or pedestrians, which are currently served by facilities on and along Spokane Street and the Spokane Street Bridge. Prior to the COVID-19 pandemic, the volume of non-motorized trips on these facilities were among the highest in the region, with over 320,000 trips annually and more than 1,000 trips per day. Even during the pandemic, usage remained high, at over 800 trips daily.

Transit. The West Seattle Bridge is a key link in one of the city's busiest transit corridors. Prior to the bridge closure, 13 King County Metro or Sound Transit bus routes used the bridge, including Regional Express, RapidRide, Frequent, Peak Only Express, and Local service routes. Those routes consisted of 868 daily bus trips, serving over 17,000 riders. Although there are bus only lanes and ramps in sections, delays related to congestion have affected travel times and reliability for transit trips. During the AM peak period, some delays are associated with traveling from Avalon Way to the bus-only lanes, and during the PM peak, some delays are related to the SR 99 ramps, due to the lack of westbound, bus-only facilities. Major features of transit service in the corridor, including across the West Seattle High Bridge, is illustrated on Figure 4. During the bridge closure, most buses have been rerouted to the Spokane Street Bridge, a slower, less reliable, and more circuitous route with overloaded connections.

Sound Transit is planning an extension of light rail to serve West Seattle, with a target date of 2031 to begin operations. Some of the bus routes using the West Seattle Bridge could be reprogrammed to serve planned light rail stations, which may reduce but not eliminate the number of bus routes on the bridge in the future.

EXISTING TRANSIT CONDITIONS *West Seattle Bridge Corridor*

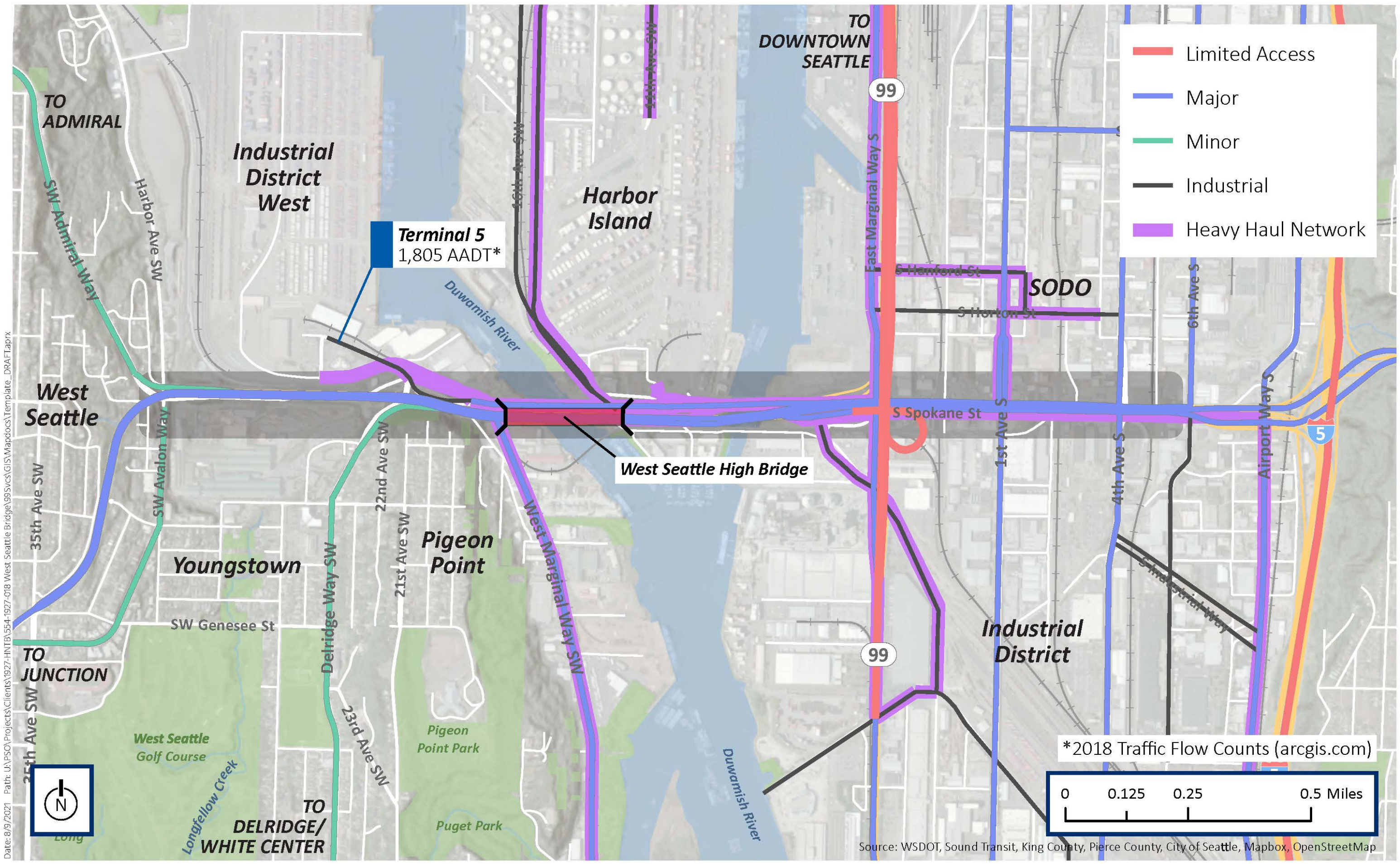


West Seattle Bridge Seattle Department of Transportation

Figure 3: Transit Service on the West Seattle Bridge (2019)

Freight. The West Seattle Bridge is part of a major freight route connecting I-5 and SR 99 to the Port of Seattle; the Duwamish Manufacturing/Industrial Center; and locations throughout West Seattle. It serves about 15,000 freight trips daily, with about 10,000 trips destined to Harbor Island and the industrial areas, and 5,000 trips continuing to other locations in West Seattle (as of 2016). The major freight truck routes through the corridor are illustrated on Figure 4. The Seattle Freight Master Plan identifies both the West Seattle Bridge and South Spokane Street as locations with severe traffic conditions affecting goods movement throughout the city and identifies them as two of the locations within the city with the greatest need for improvements to better accommodate freight traffic.

EXISTING FREIGHT ROUTES AND FACILITIES *West Seattle Bridge Corridor*



West Seattle Bridge

Seattle Department of Transportation

Figure 4: Freight Truck Routes and Estimated Volumes through West Seattle Bridge Corridor (2018)

Need for a Resilient, Reliable Corridor

The closure of the WSHB has highlighted how essential the larger West Seattle Bridge is to travel, mobility, and the economic vitality of West Seattle, Seattle as a whole, the region, and the state. The vital transportation and economic significance of the bridge as vital infrastructure is heightened by the presence of the Port of Seattle and the industrial/manufacturing enterprises in the Duwamish Valley, centers of national and international trade, commerce, and employment. While the current closure is because of the structural deficiencies of the high bridge, any other partial or full closures of the West Seattle Bridge, the city's longest elevated roadway, would have similar negative mobility, economic, environmental and racial equity effects.

West of I-5, there are currently only four crossings of the Duwamish River into Seattle, including the currently closed West Seattle Bridge. The Spokane Street moveable bridge (sometimes referred to as the "low or swing bridge"), located directly north of the high bridge, has only two travel lanes and is heavily used for Port-related traffic to Harbor Island. It also carries the Duwamish River's only pedestrian and bicycle crossing available within 3 miles. The 1st Avenue South Bridge and the South Park Bridge are located to the south. Both are moveable bridges serving primarily north-south trips, and they and the arterials connected to them were already at capacity before the West Seattle Bridge was closed. During the high bridge closure period, the Spokane Street Bridge has been limited to freight, public transit, emergency vehicles, and nonmotorized travel.

With the closure of the West Seattle Bridge, travel conditions have substantially worsened and spread in duration, and include lengthy detours. This has greatly affected general mobility, human health and environmental conditions, and the economy for local neighborhoods and businesses throughout the Duwamish Valley and West Seattle, including in the South Park, Georgetown, High Point and White Center areas. These areas are among the most racially diverse in the region and have higher proportions of low income households and Black, Indigenous, and People of Color (BIPOC) communities than Seattle as a whole. For the Port of Seattle and the Duwamish Manufacturing/Industrial Center, as well as the industrial/commercial areas of SODO (South of Downtown) and the eastern and southern Duwamish Valley, the lost mobility and increased traffic and congestion from detoured traffic has impacted basic economic functions. Workers have faced difficult and lengthy commutes to get to and from their jobs, and the Port and area enterprises face both cost and operational hardships as they try to move goods and provide services through a gridlocked area.

The West Seattle Bridge is located in one of the most seismically vulnerable regions in the United States, known as the Cascadian Subduction Zone, where the pressures of huge, overlapping, tectonic plates deep underground periodically release and cause major earthquakes. The Nisqually Earthquake of 2001 was one of the most recently prominent earthquakes, and it revealed the vulnerability of structures that were not built to withstand high magnitude seismic events. In some areas, particularly areas that have been artificially filled, the shaking from an earthquake is magnified and the soil loses stability, causing structural failures. Much of the area crossed by the Spokane Street Corridor, from I-5 west through the industrial area in the Duwamish Valley, are former tideflats that were filled. Harbor Island was also created by filling. Much of the West Seattle High Bridge and its ramps and approaches were built in 1984, and seismic standards for such structures and their foundations are now more strict to prevent catastrophic structural failures. Other elevated sections of the West Seattle Bridge are older and have elements that either do not meet current seismic standards or will need rehabilitation or replacement to maintain their service life in the coming decades. Due to the lack of effective alternative routes, future closures or restrictions anywhere in the corridor would cause the types of impacts being faced today, increasing the cumulative effects on the area.

The closure of the West Seattle Bridge has clearly shown that the lack of alternative routes and "resiliency" in the corridor has major impacts on general traffic, transit, and freight movement to and from West Seattle and the region as a whole. Alternative routes from West Seattle to I-5 have added an average of 14 to 20 minutes to the typical commute and have separated West Seattle businesses from their customers and employees. The impacts of the current closure may be higher as transportation patterns return to pre-pandemic conditions, and as regional growth continues.

Finally, while commute patterns have shifted during the COVID-19 pandemic, primarily for workers with jobs that can be accomplished remotely, general transportation demand in the Spokane Street Corridor is expected to continue growing along with increased population and employment. According to the Puget Sound Regional Council, Seattle expects an increase of 20 percent in population and 25 percent in employment between 2015 and 2040, which would add about 135,000 people and about 150,000 jobs to the city. Approximately 11% of that population growth and 7% of the anticipated job growth is anticipated to occur in the area surrounding the bridge and west into West Seattle. These increases in population and employment are expected to add to already congested corridor conditions, even with the expansion of high capacity transit to serve West Seattle.

Although the current repairs are intended to return the existing bridge to service, a long-term strategy for the replacement of the West Seattle High Bridge and to maintain safe and effective travel on the facilities connecting to the bridge is needed to prevent additional interruptions to travel, economic activity and quality of life in this critical corridor, in the areas it serves, and in the communities affected by closures and detours.

APPENDIX B

Concept Development and Refinement Background Information

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES
719 2ND AVENUE, SUITE 200 | SEATTLE, WA 98104 | P 206.394.3700

WSHB CONCEPT DEVELOPMENT

The development of potential concepts for the long-term replacement of the West Seattle High Bridge (WSHB) is based on initial framework planning done by SDOT and the HNTB team to establish a core purpose for the replacement, and a list of assumptions, preferences, and outstanding questions to be addressed. The core purpose used for the concepts and background information supporting it is further discussed in a separate memo for the Purpose and Need.

DRAFT ASSUMPTIONS TO GUIDE DESIGN OBJECTIVES AND INITIAL CONCEPTS	PREFERENCES	OUTSTANDING/RELATED QUESTIONS
Maintain current bridge height and place no new piers or structures in the navigational channel (maintain existing navigation envelope)	No new piers in water (West or East Duwamish)	Near-term and long-term purpose of the project
Maintain same capacity (post-construction)	Consider future low bridge replacement	Location and scale of facility
Height and width (approx. the same as existing, 100 ft.)	Compatibility with ST preferred alternative	Approach to nonmotorized
Design to current standards/maintain existing	Seismic design	Future capacity needs after Sound Transit is implemented, approach to transit on the bridge
Lane Number (assume same as existing for traffic analysis and leave open for their use)	Planning for critical link to resiliency corridor	One bridge or two (East and West)
Design Speed – remain consistent with the rest of the West Seattle Bridge and assume current 45 mph	Freight movement (ideally 12 ft lanes, 10 ft outer shoulders, 8 ft inside)	One or two bridges (parallel for resiliency)
Access - ability to provide existing access to the Port (especially with Tunnel)		Coordination with ST re location/size
Design Vehicle - lane width/freight		Capacity during construction (full or partial)
Maintain standard clearances from BNSF or other existing rail lines		Vehicle Weight
Maintain low-bridge access to Port		Design details (demo plan, representative ramps/facility design)
Leverage existing infrastructure to the extent feasible		Traffic Analysis
Critical seismic performance		

The HNTB team initially developed 12 potential concepts and variations to replace the cross-Duwamish functions of the West Seattle High Bridge (WSHB). Those concepts were based on addressing the following problem statement:

> The high span of the West Seattle Bridge over the west channel of the Duwamish River is being repaired to address a structural deficiency and return the bridge to service, but the crossing will eventually need to be replaced.

And on the initial core purpose of long-term replacement of the WSHB:

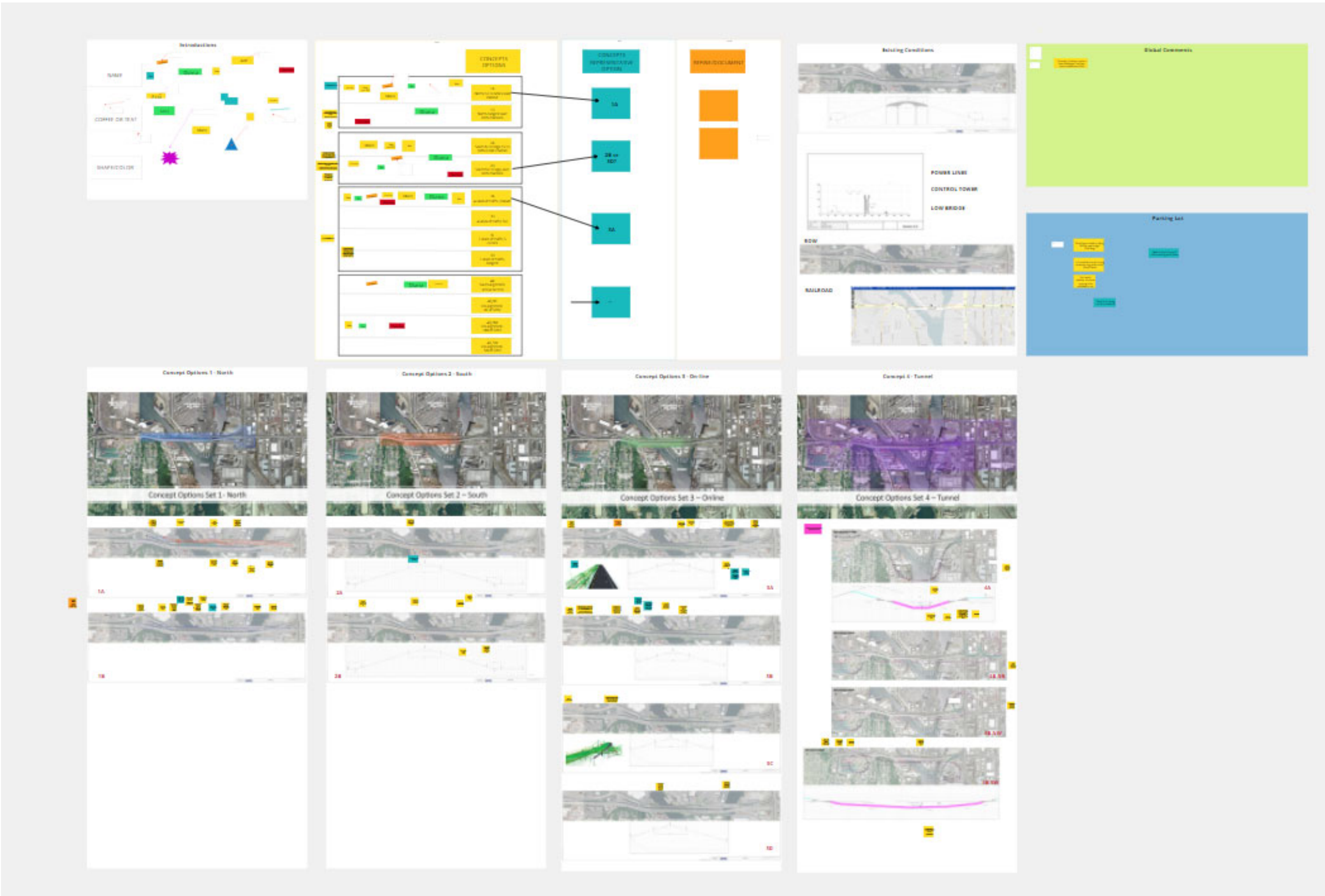
> Replace the West Duwamish River crossing to maintain long term capacity, safety, mobility and access for West Seattle and the region.

Additional long term needs or objectives for the West Seattle Bridge, the east-west corridor it is in, or the surrounding system, including nonmotorized, transit, freight, capacity, and resiliency. The study continued to investigate these related needs, but they were not expected to alter the core need for a crossing replacement.

SDOT and the HNTB team held an initial Concept Workshop on June 7, 2021. The purpose of Concept Workshop No. 1 was to review 12 potential WSHB replacement concepts and select four representative concepts to advance for feasibility screening: one to the North, one to the South, one On-line (in the same location as the existing/repaired bridge), and a Tunnel.

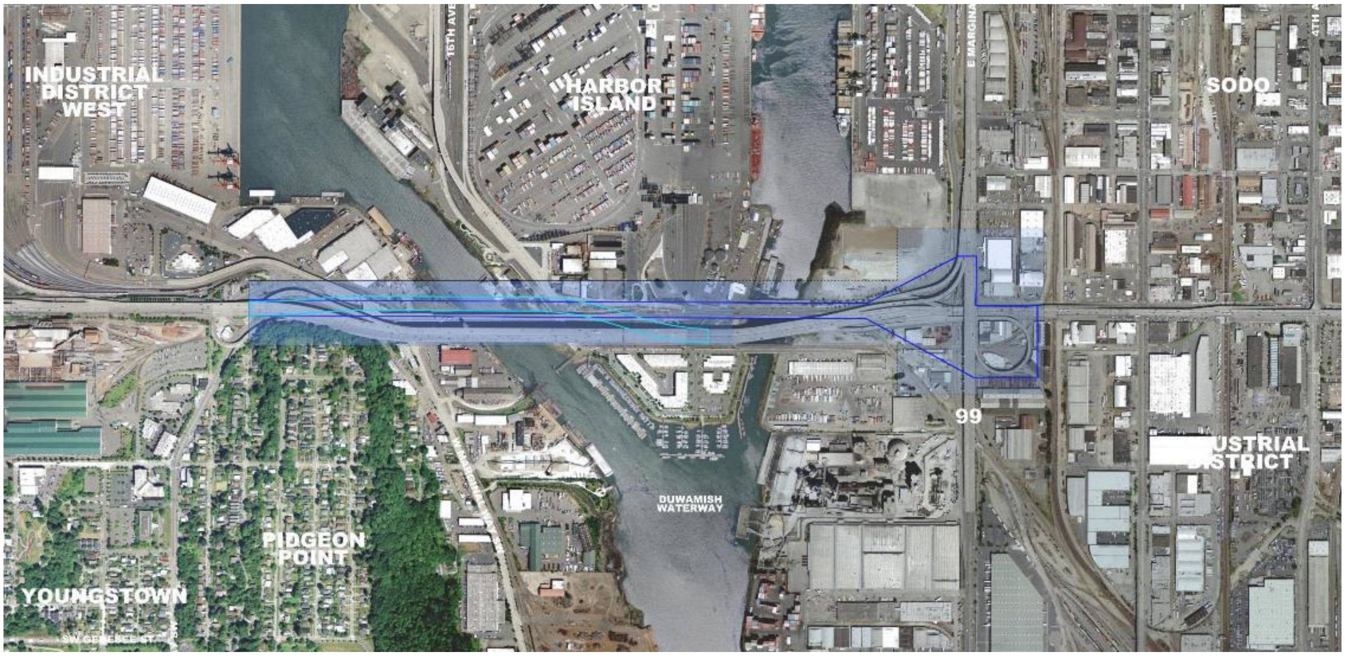
The HNTB team used an online collaboration tool, Conceptboard, to review and elicit input from the internal consultant and SDOT client teams. A snapshot of the Conceptboard for Concept Workshop No. 1 is shown below:

Concept Workshop No. 1 - Conceptboard

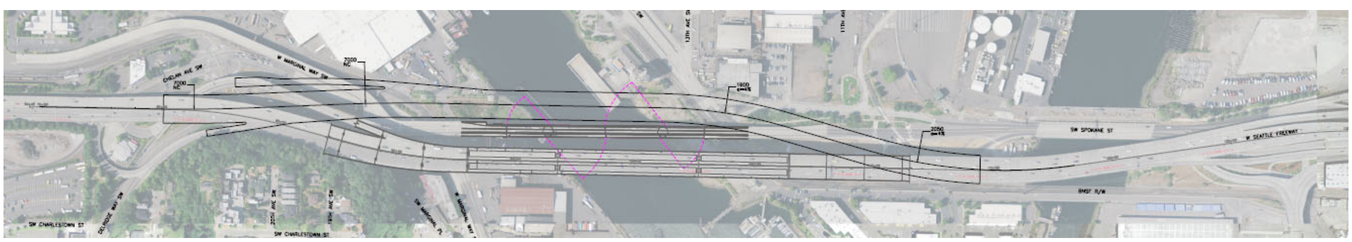


As shown on the Conceptboard, 2 North Concepts, 2 South Concepts, 4 On-line Concepts, and 4 Tunnel Concepts were considered, and the input received on each potential concept is described below.

SET 1: NORTH CONCEPTS



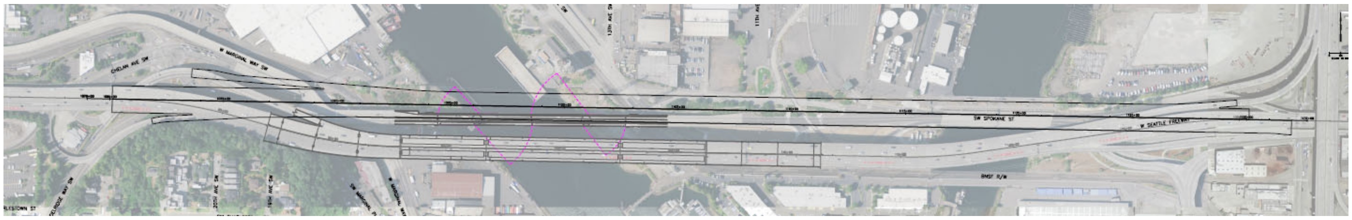
Concept 1A:



Summary of Input on Concept 1A:

- It would be challenging to maintain an acceptable slope at connecting ramps (especially those that connect to freight routes like the Chelan 5-Way)
- Location limits viable bridge types
- Key issue would be to keep the existing bridge open as long as possible
- Potential conflict with electric transmission line
- Would introduce a new curve (although it meets standards, not ideal)
- Potential conflicts with BNSF (appears to be enough space, but would require coordination)
- Potential impacts to Port operations and future plans
- Based on the assumption that east Duwamish crossing has a very long useful life, which may be a big assumption
- Could consider whether a combination of 1A and 1B is better

Concept 1B:



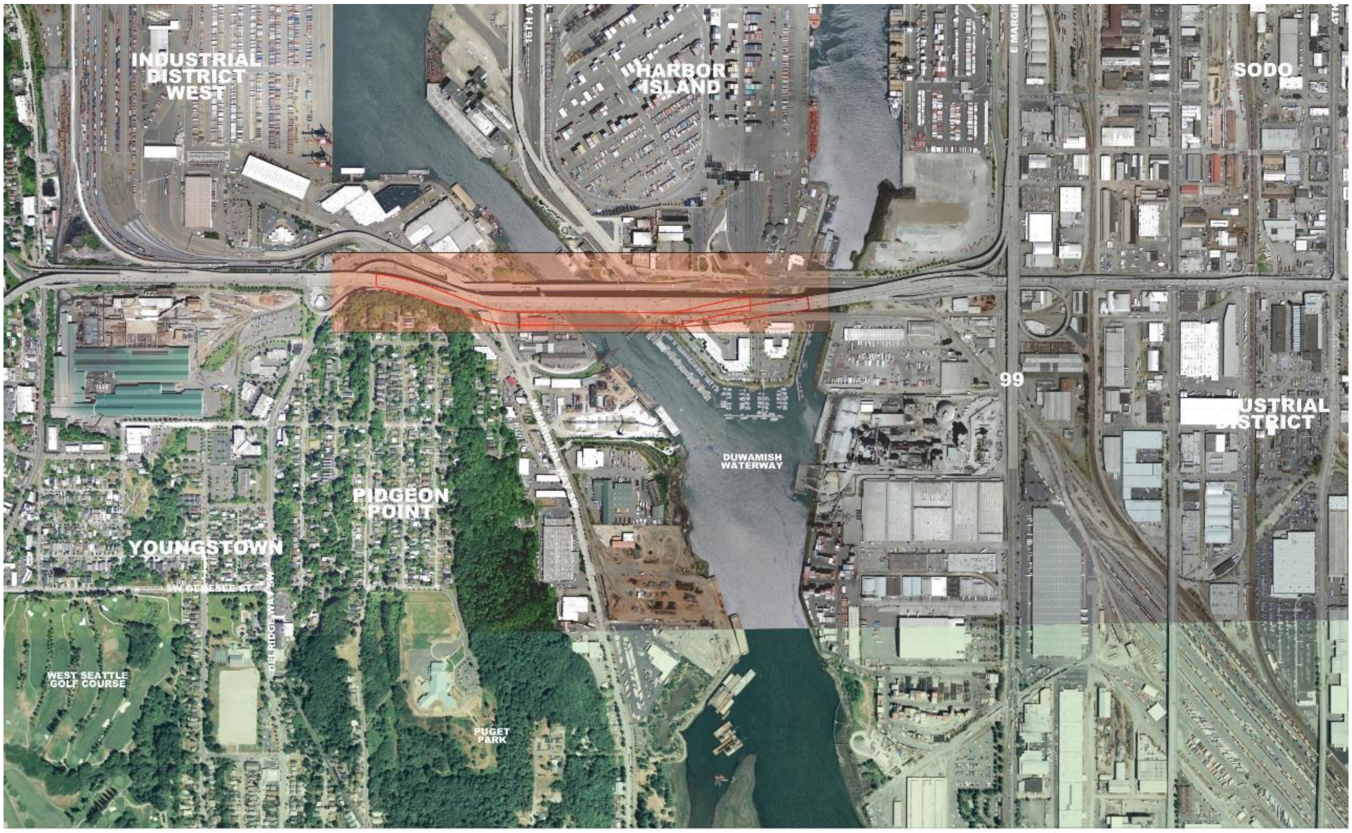
Summary of Input on Concept 1B:

- Need to address closing access during construction (at Delridge Ramp)
- Would conflict with Spokane Street Swing Bridge
- Construction and maintenance of traffic during construction would be challenging
- Could be some impacts of construction over the Spokane Street Swing Bridge
- May be outside of existing ROW
- Would support numerous bridge types
- Makes future deep foundations for the structure below possible
- Would likely require realignment of Spokane Street
- 1B becomes a bigger project beyond current project

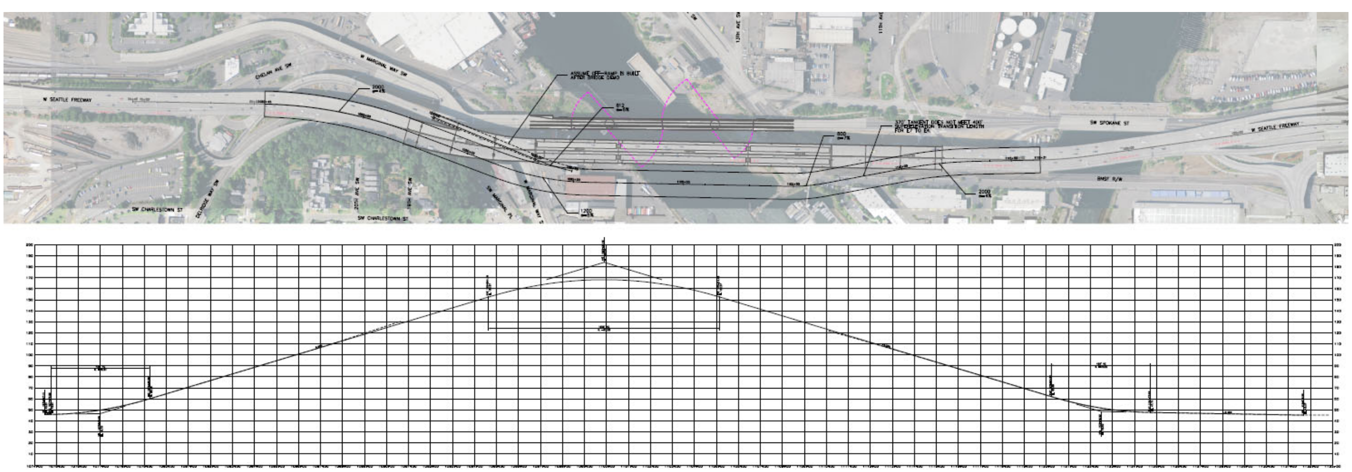
Selection of Representative North Concept – 1A

There was consensus that both North Concepts appeared to be feasible, but the workshop attendees selected Concept 1A as the representative North Alignment. In addition to the input above, the primary rationale for selecting Concept 1A was that it has the smallest workable footprint.

SET 2: SOUTH CONCEPTS



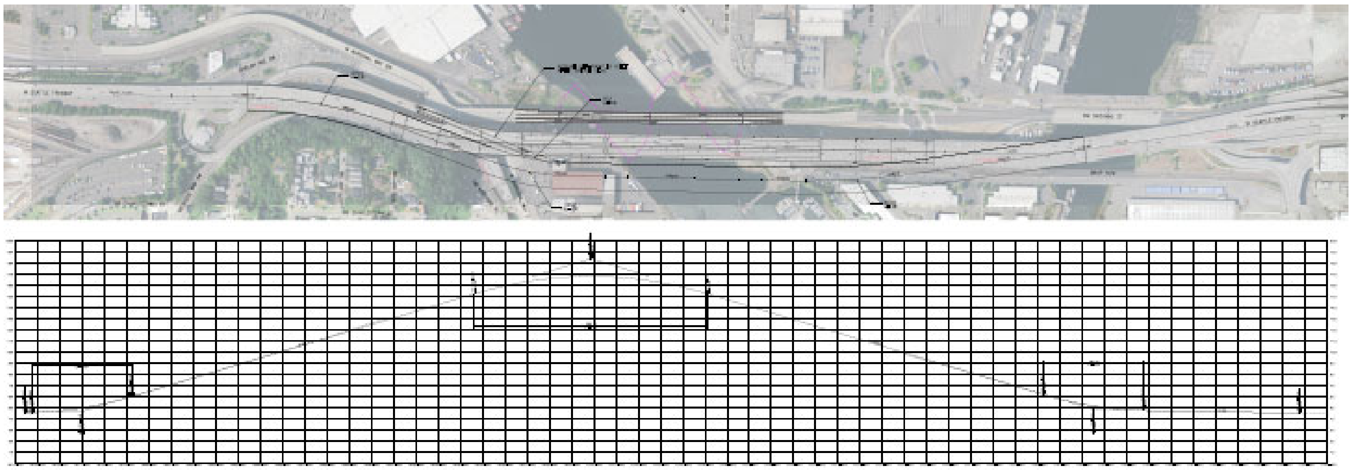
Concept 2A



Summary of Input on Concept 2A:

- Limits choice of bridge type
- May require something in the water
- Impacts Pigeon Point (land stability (peet))

Concept 2B:



Summary of Input on Concept 2B:

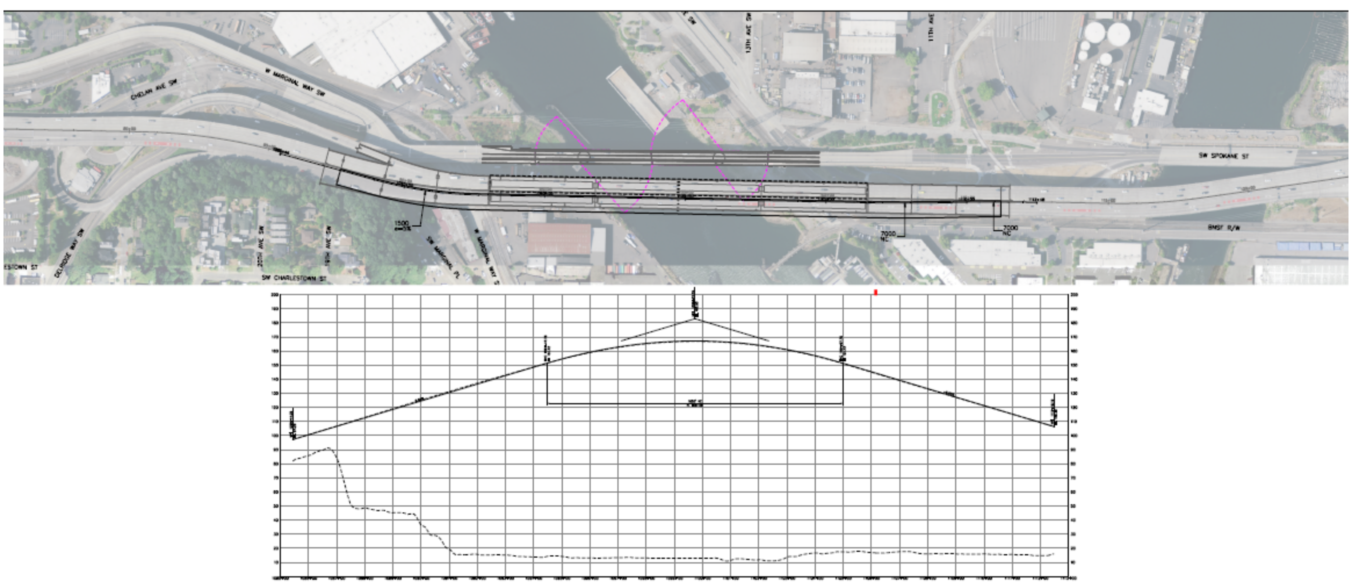
- Same west end geometry as 2A.
- Benefit to going as narrow as possible to the South
- Challenge avoiding the BNSF bridge (same as 2A but also hits another property on Harbor Island)
- Better alignment than 2A

Selection of Representative South Concept:

Both South Concepts appear to pose more challenges than the North Concepts and the workshop participants were divided almost equally on their preference for Concepts 2A or 2B. There was some discussion of selecting the southern-most on-line concept rather than one of these two concepts fully to the south, but the ultimate decision was to select Concept 2B as representative for the South Alignment. In addition to the input above, one rationale for selecting a representative South Concept was to help differentiate once there is more certainty around where Sound Transit's project will be.

SET 3: ON-LINE CONCEPTS

Concept 3A:

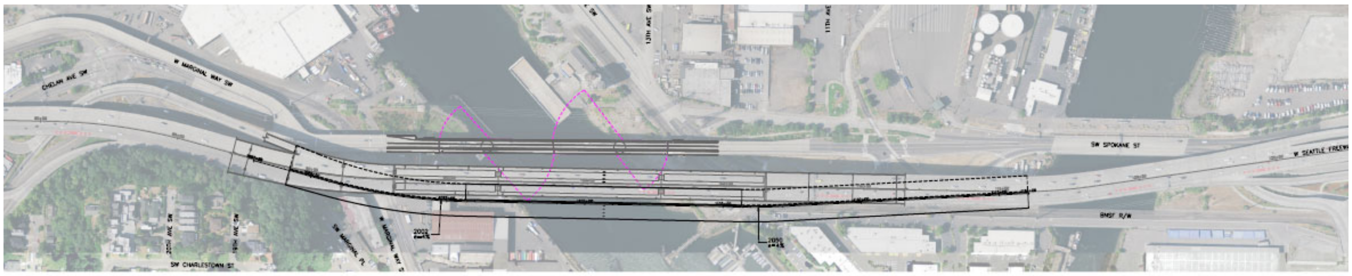


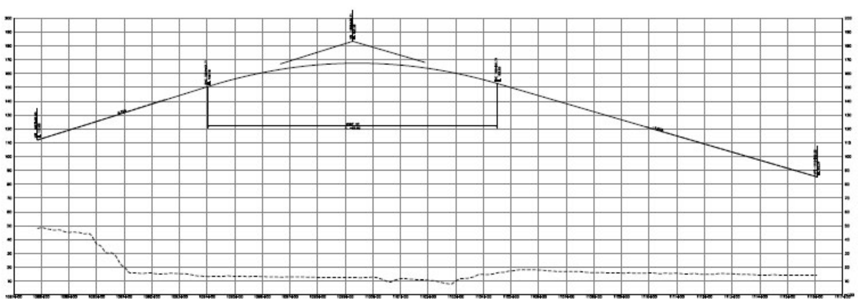
Summary of Input on Concept 3A:

- Maintains 2 lanes each direction for duration of construction
- Right on top of existing bridge
- Based on assumption that half can be demolished while the other half maintains traffic.

- Concept 3A has the smallest footprint of all the On-line concepts
- Would need to be two structures
- Would require a longer span to stay out of water
- Least impacts, easiest to accomplish, but reduces to 2 lanes and assumes partial demolition
- Construction staging would require that the remaining portion of bridge would be stable.
- Initial design was to avoid the low Spokane Street Swing Bridge

Concept 3B:

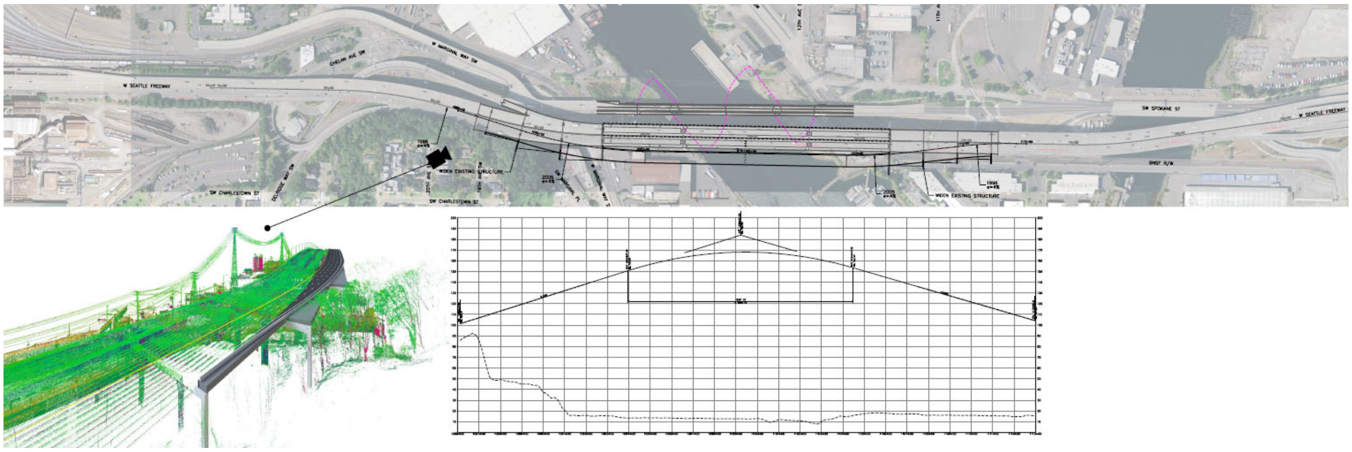




Summary of Input on Concept 3B:

- Maintains 2 lanes each direction for duration of construction
- Right on top of existing bridge
- Located further South than 3A and would allow construction of full bridge, except tie ins once traffic is switched to new bridge
- Intent was to minimize construction impacts, but may not actually benefit due reduction in traffic capacity at tie-ins
- Based on the assumption that half the bridge would be demolished and the other half would maintain traffic (compared to Concept 2A and 2B, which assumes full bridge stays)
- May be able to avoid conflict with BNSF
- Span is much longer than existing
- Makes sense to have two structures

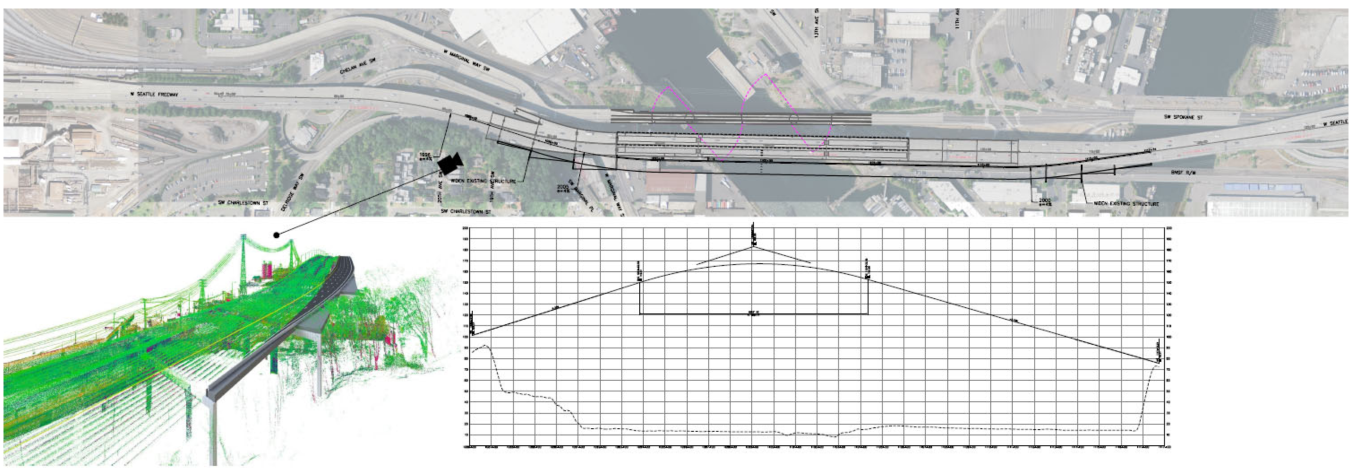
Concept 3C:



Summary of Input on Concept 3C:

- Would maintain 7 lanes of traffic
- Would not impact existing bridge during construction of new eastbound bridge since the new structure would be offline

Concept 3D:



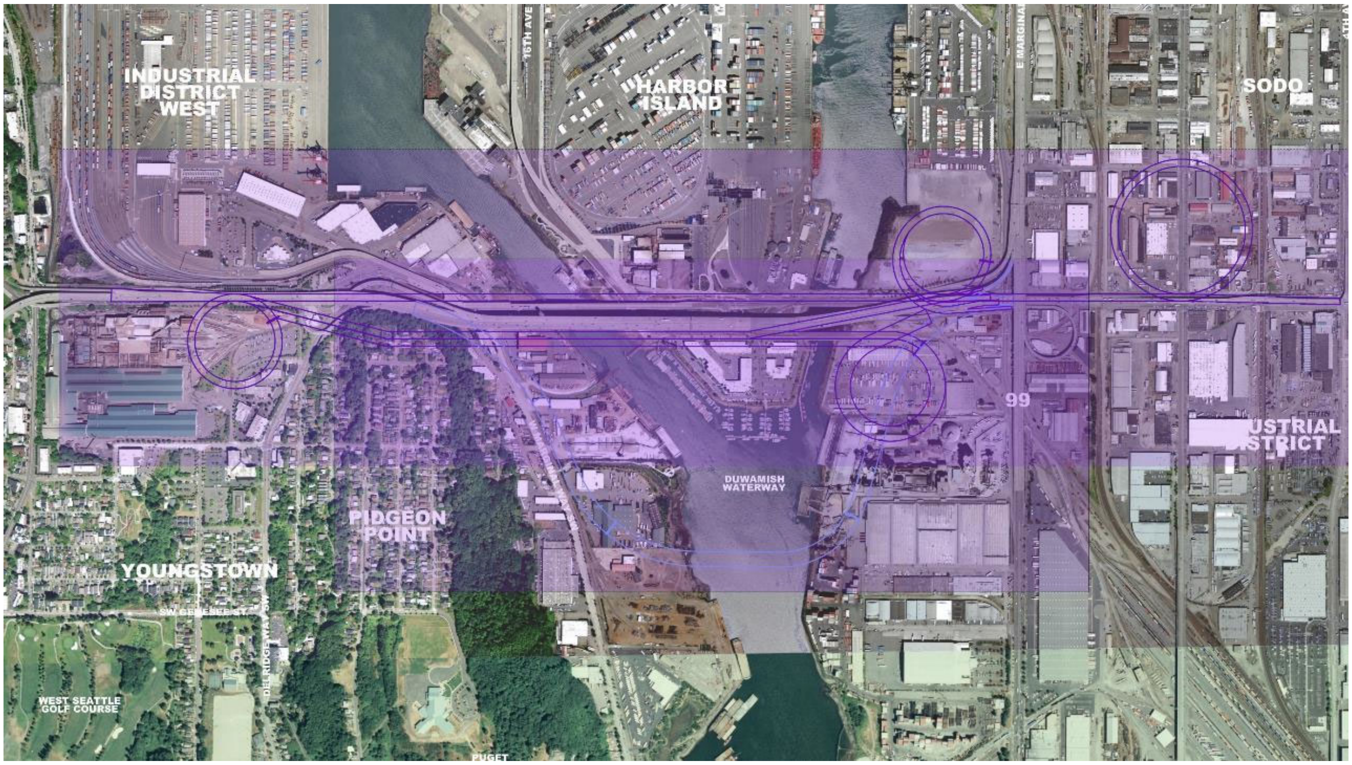
Summary of Input on Concept 3D:

- Same concept but on tangent with the East approach (more ideal roadway design)
- Could potentially limit impacts by squeezing in
- Does not look like you could do it to the north

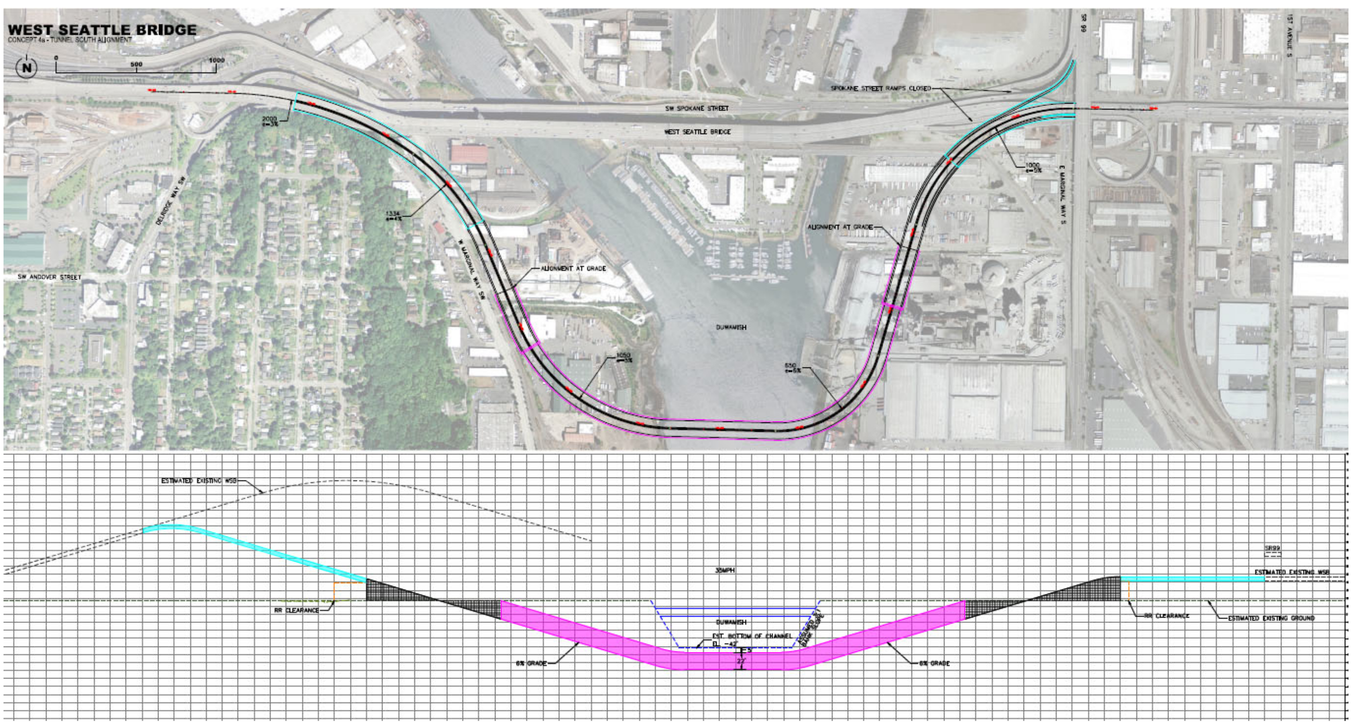
Selection of Representative On-line Concept:

The workshop participants were unanimous in selecting Concept 3A as the representative On-Line Concept. The participants shared a general sentiment that the On-line Concept was a promising concept with potentially fewer impacts than the North or South concepts. Concepts 3C and 3D were both identified as improvements over Concepts 2A and 2B, so although not selected for feasibility screening, were identified as concepts to consider revisiting as we learn more.

SET 4: TUNNEL CONCEPTS



Concept 4A:

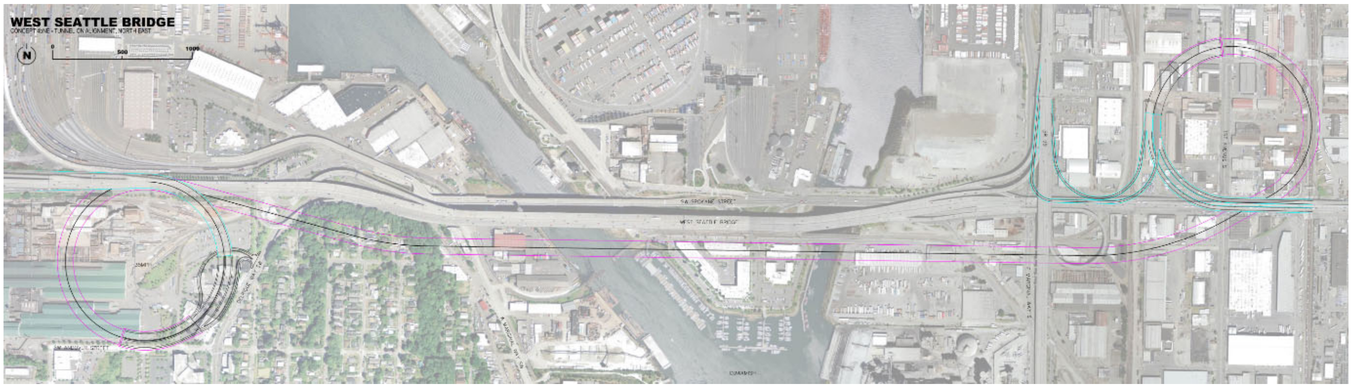


Summary of Input on Concept 4A:

- Does not meet 45 mph
- Very big on-land impact

- To maintain longitudinal tie-ins would be pushed far to the South
- 6% grade not ideal
- May need to be deeper or require complex/difficult construction techniques (armored lid)

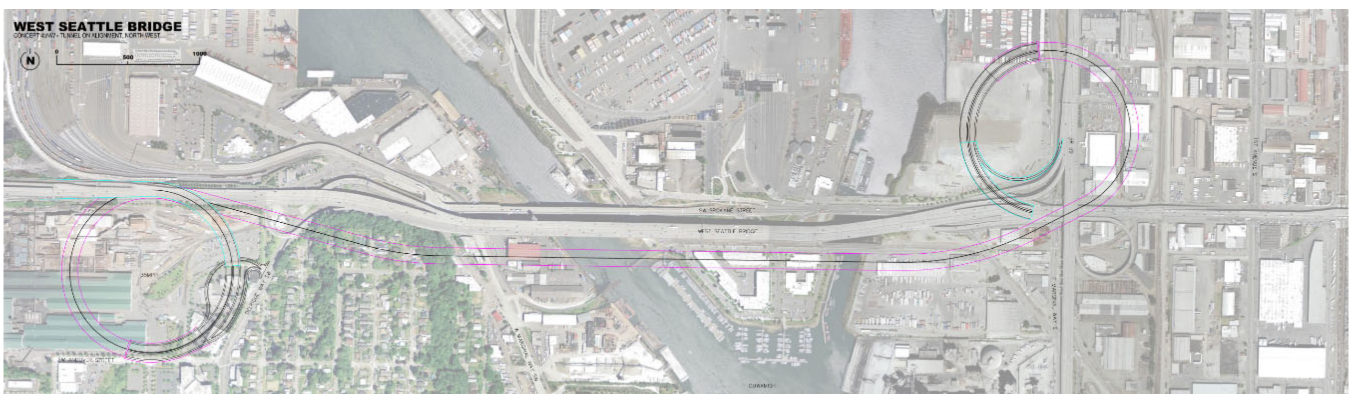
Concept 4B_NE:



Summary of Input on Concept 4BNE:

- Does not meet 45 mph
- Would require the use of a helix to access
- Very big on-land impacts/property acquisition
- Would impact connection at 99

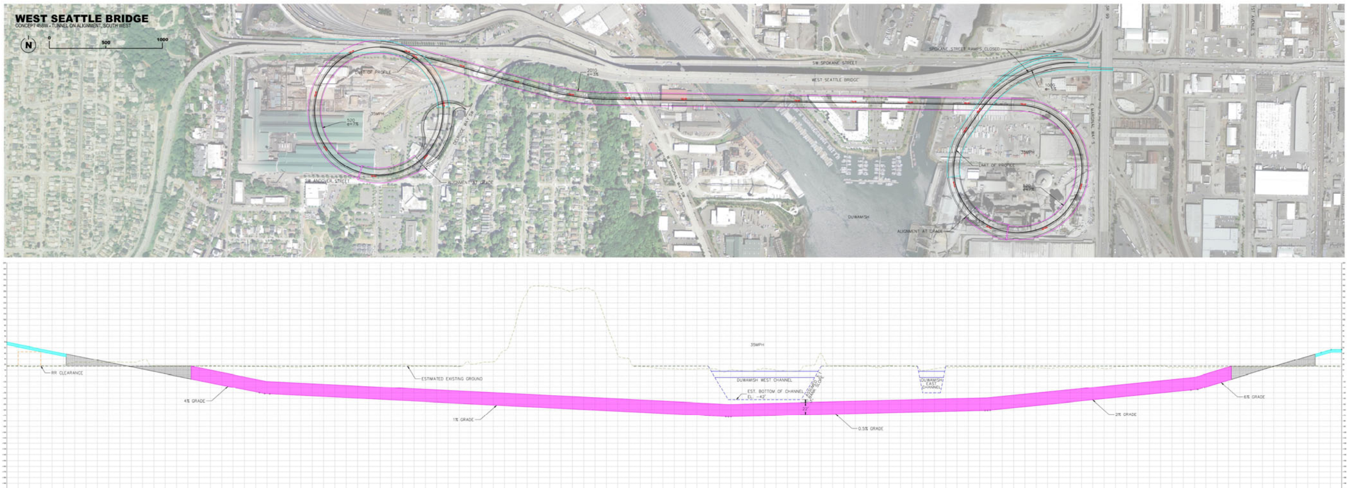
Concept 4B_NW:



Summary of Input on Concept 4BNW:

- Does not meet 45 mph
- Very big on-land impacts/property acquisition
- Would require use/acquisition of port property at east helix
- Less impact at connection at 99, depending on construction method

Concept 4B_SW:



Summary of Input on Concept 4BSW:

- Does not meet 45 mph
- May be able to design without a helix on the west side
- Constructability and connection to Delridge is an outstanding question
- Very big on-land impacts/property acquisition
- Conflicts with BNSF

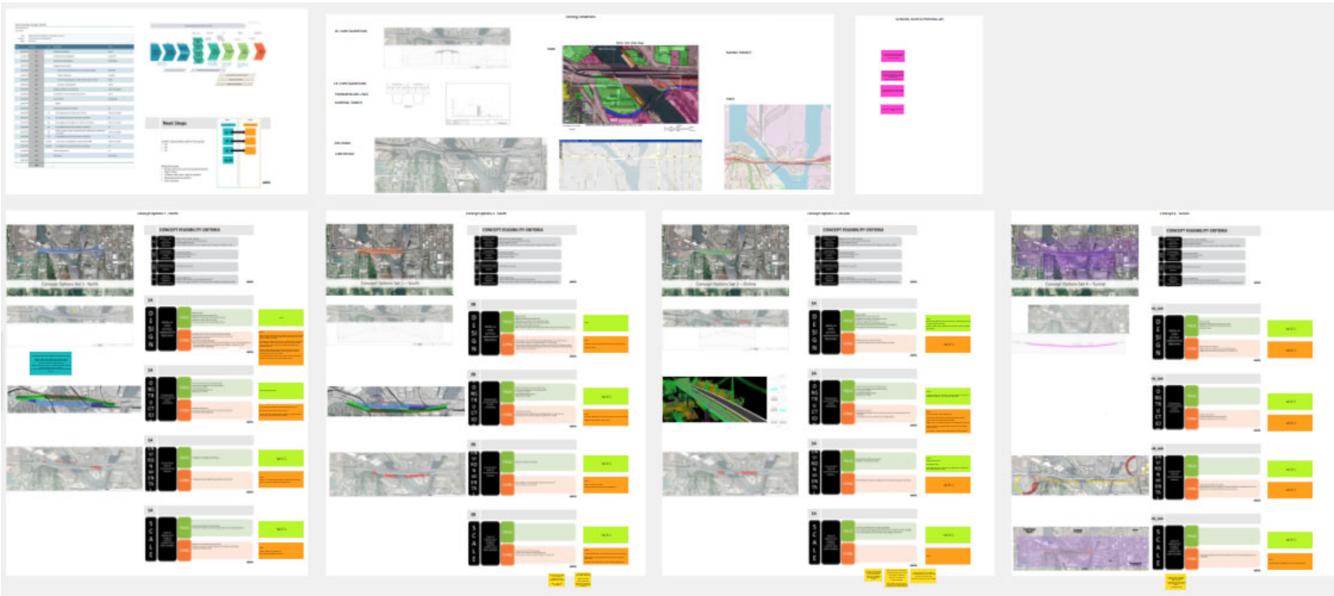
Selection of a Representative Tunnel Concept:

The workshop participants all agreed that although all of the Tunnel Concepts were potentially feasible, the potential conflicts and impacts were much greater than the bridge concept and that the scope of the project would exceed the need. Workshop participants were relatively split between selecting Concept 4A and Concept 4B_NW as the representative Concept, but ultimately selected Concept 4B_NW.

Summary of Concept Workshop No. 1

The outcome of Concept Workshop No. 1 was the identification or confirmation of potential benefits and challenges associated with each of the 12 potential concepts and to select the following representative concepts to carry through to an initial feasibility screening: 1A – North, 2B – South, and 3A – On-line, and 4B_NW – Tunnel.

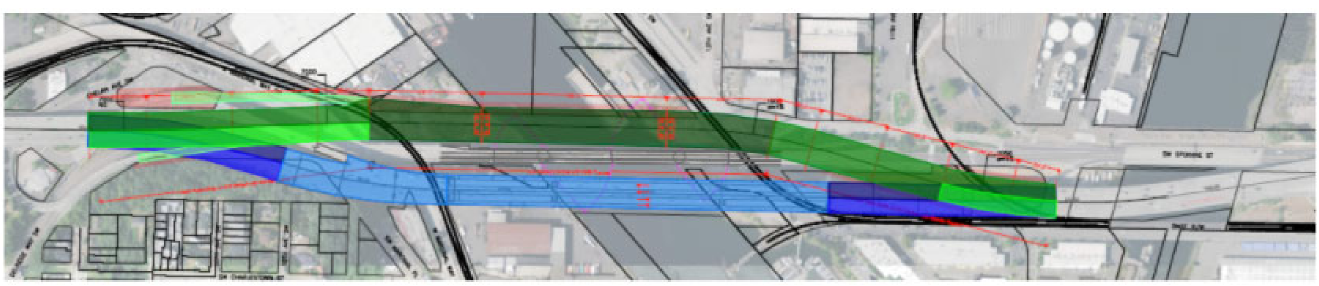
Concept Workshop No. 2 – Conceptboard



After selecting the four representative concepts, SDOT and the HNTB team held a second Concept Workshop where the four representative concepts were vetted by SDOT Subject Matter Experts (SMEs), who reviewed the findings of Concept Workshop No. 1 and confirmed the decision to carry the four representative concepts through feasibility screening. The SME's also helped identify additional potential benefits and challenges of each of the representative concepts.

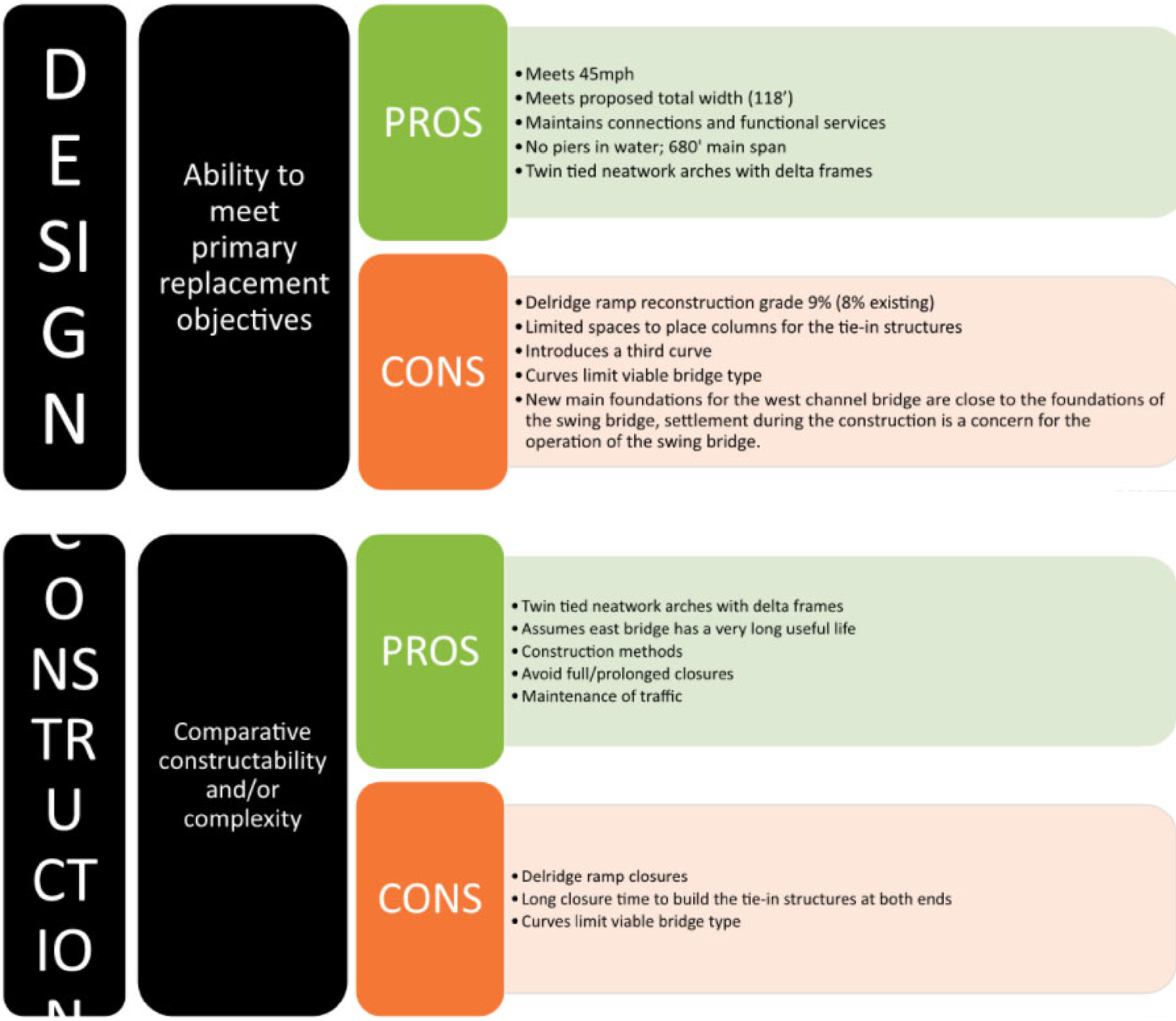
At Concept Workshop No. 2, the HNTB team also introduced draft initial concept feasibility criteria, including Design, Construction, Environmental, and Scale. The Workshop attendees were asked to help identify the pros and cons related to each criteria, which helped both with development of the concepts and to inform the initial feasibility screening findings.

Concept 1A – North:



Summary of Consideration of Concept 1A:

SDOT and the HNTB team presented the following notes on the design for consideration of Concept 1A:

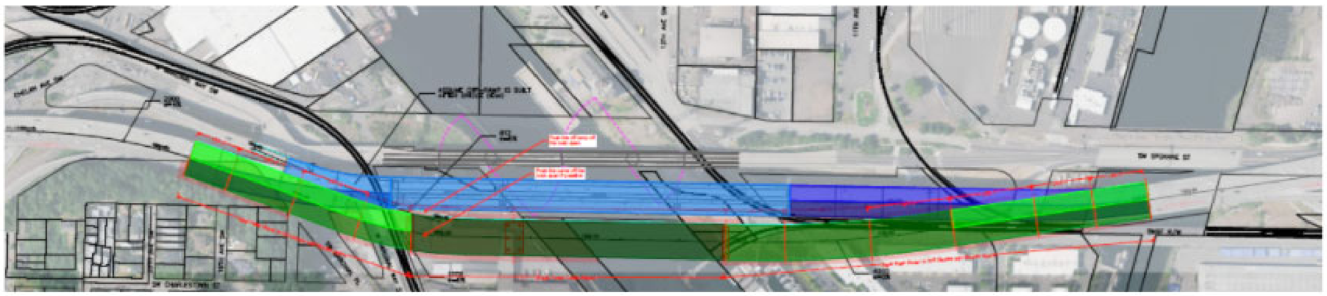


Workshop participants generally agreed with the pros and cons the HNTB team had identified, but also provided the following input:

- The Port of Seattle has concerns about any alignment to the north
- Construction over active traffic could pose a risk
- There could be benefit to pushing an alignment farther north by lengthening Delridge ramp, could include a direct connection to the Port that would be valuable
- Would need to consider the operation and maintenance needs of the swing bridge
- Large vehicle access must be maintained
- Challenging to improve grade at Delridge ramp
- Would need room for inspection access and a strategy for inspections for the entire crossing
- T5 Flyover (a port structure under Marginal Way) access must be maintained, including clearance for over-size loads. Changes planned in the next 3-4 years will increase the importance there.
- Concept 1A allows for several feasible bridge types
- Would require a lot of staging based on overlap with existing structure.

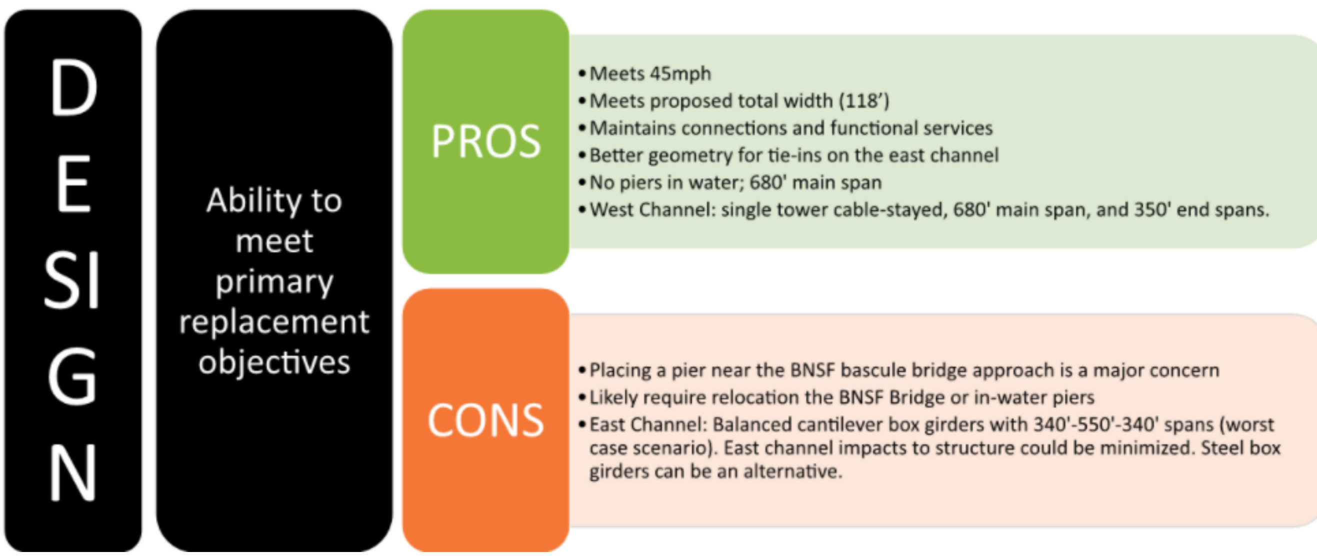
- On the west side, crane placement would be a challenge (not enough footprint on the ground, so unique construction techniques may be required).
- Potential conflict with ST.

Concept 2B – South



Summary of Consideration of Concept 2B:

SDOT and the HNTB team presented the following design notes for consideration of Concept 2B:

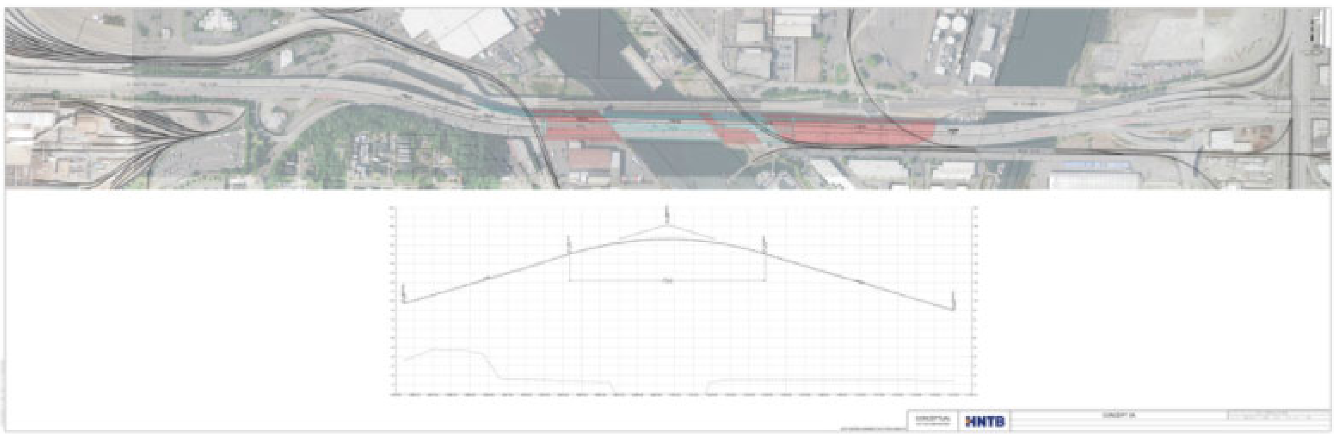


CONSTRUCTION	Comparative constructability and/or complexity	PROS	• Twin tied neatwork arches with delta frames • Assumes east bridge has a very long useful life • Construction methods • Avoid full/prolonged closures • Maintenance of traffic
		CONS	• Delridge ramp closures • Placing a pier near the BNSF bascule bridge approach is a major concern • Long closure time to build a significant length of tie-in viaduct
ENVIRONMENTAL	Comparative level of environmental impacts	PROS	• Updates to existing aerial leases
		CONS	• New significant permanent right-of-way needs to the south • New aerial leases over Railroad
SCALE	Scale of replacement program needed/ conflicts with other facilities	PROS	
		CONS	• Impact to Sound Transit future plans • Conflicts with regional facilities (ST, Railroad) • Likely require relocation the BNSF Bridge or in-water piers.

Workshop participants generally agreed with the design notes and pros and cons the HNTB team had identified, but also provided the following input:

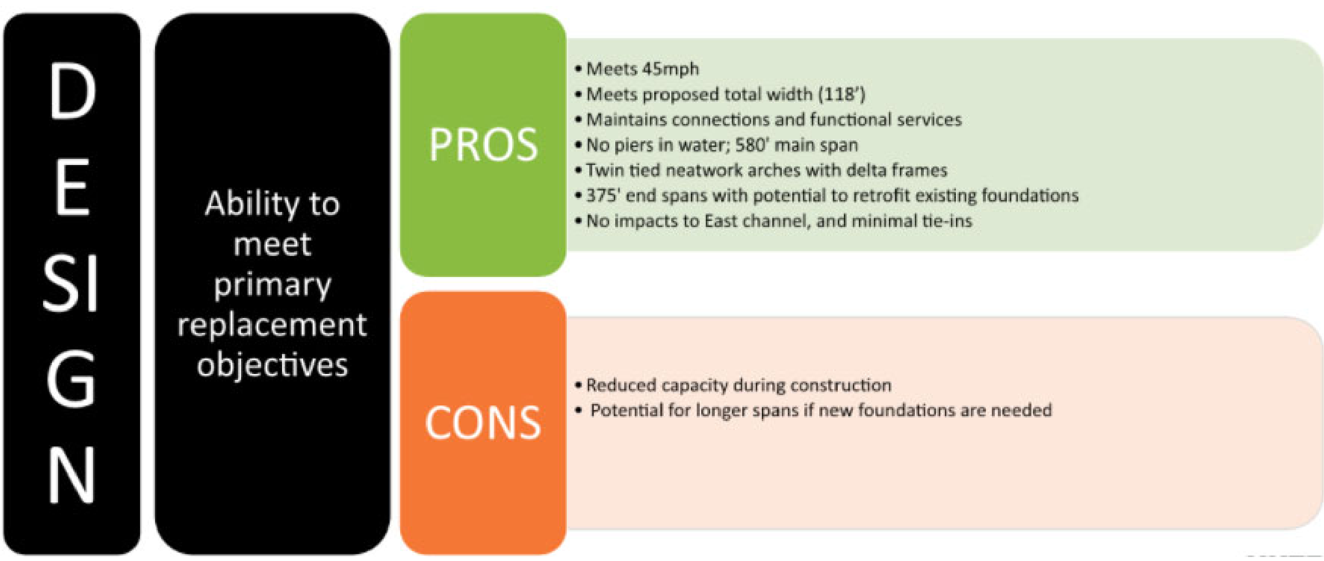
- Would be challenging to locate pier outside water (feasible, but challenging)
- Main span is longer than other concepts
- Concept 2B would impact Pigeon Point
- Moving north makes things slightly less complicated
- Could keep traffic moving but not at full capacity; reduced capacity will be for a long duration
- Very close in proximity to the BNSF Bridge; Conflict with BNSF appears unavoidable
- In-water work could likely be avoided

Concept 3A – On-Line



Summary of Consideration of Concept 3A:

SDOT and the HNTB team presented the following information for consideration of Concept 3A:



CONSTRUCTION	Comparative constructability and/or complexity	PROS	• Twin tied neatwork arches with delta frames • Assumes east bridge has a very long useful life • Construction methods • Avoid full/prolonged closures • Maintenance of traffic
		CONS	• Delridge ramp closures • Building new foundations near the existing foundations with battered piles will be challenging • The phased construction eliminates some bridge options
ENVIRONMENTAL	Comparative level of environmental impacts	PROS	• No permanent right-of-way needs • Updates to existing aerial leases
		CONS	• TCEs needed for temporary stablization work during the phased construction.
SCALE	Scale of replacement program needed/ conflicts with other facilities	PROS	• Limits of replacement to west waterway • No conflicts with regional facilities (ST, Port, Railroad, Lower Bridge) • Can still avoid the control tower even going to the north
		CONS	

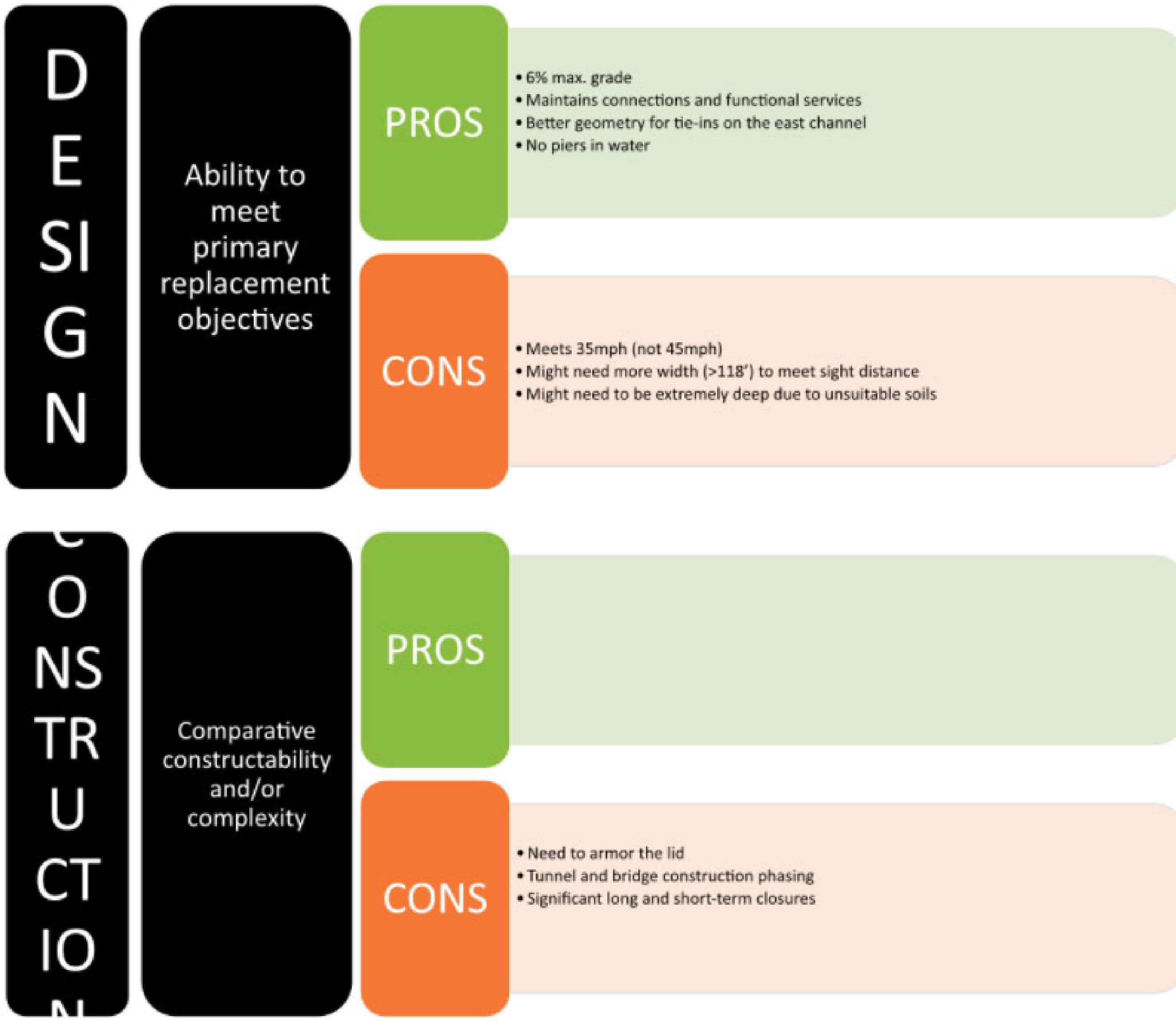
Workshop participants generally agreed with the pros and cons the HNTB team had identified, but also provided the following input:

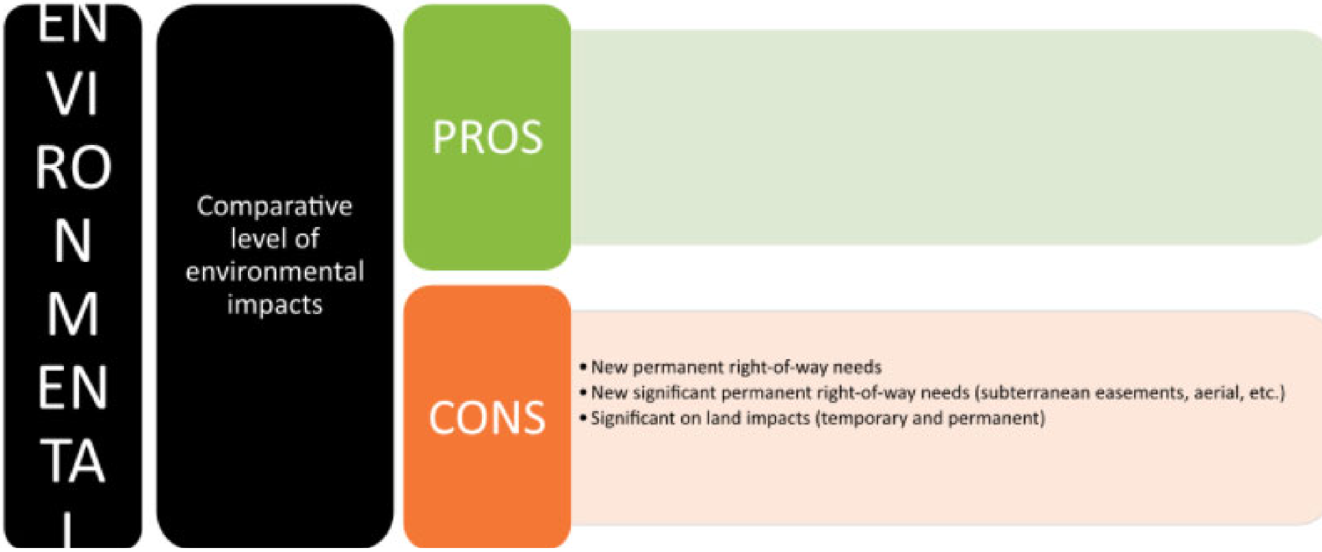
- Whatever complexities we have from the main-span are mitigated by lack of conflicts related to tie-ins.
- Easier to reliably maintain traffic through construction, better connectivity with Delridge
- Noted relatively flat curve
- Would impact fewer spans
- Would maintain Delridge and 2 lanes each way; difference from other concepts is that this also includes the main span
- On-line concepts are based on the assumption that SDOT could maintain traffic on a partially demolished bridge
- Existing bridge would need to meet certain standards and require temporary support (could be challenging/expensive)
- Would be constructed as two separate bridges, which would allow shorter span lengths
- 18 feet between structures could be used for maintenance, allow for different bridge types, and provide space for inspection
- Some concern whether there was enough space to the north, particularly for construction and demo
- Question whether transit would be maintained
- A twin bridge might work but would be much longer and taller
- Would have very close clearance to the control tower, but would fit

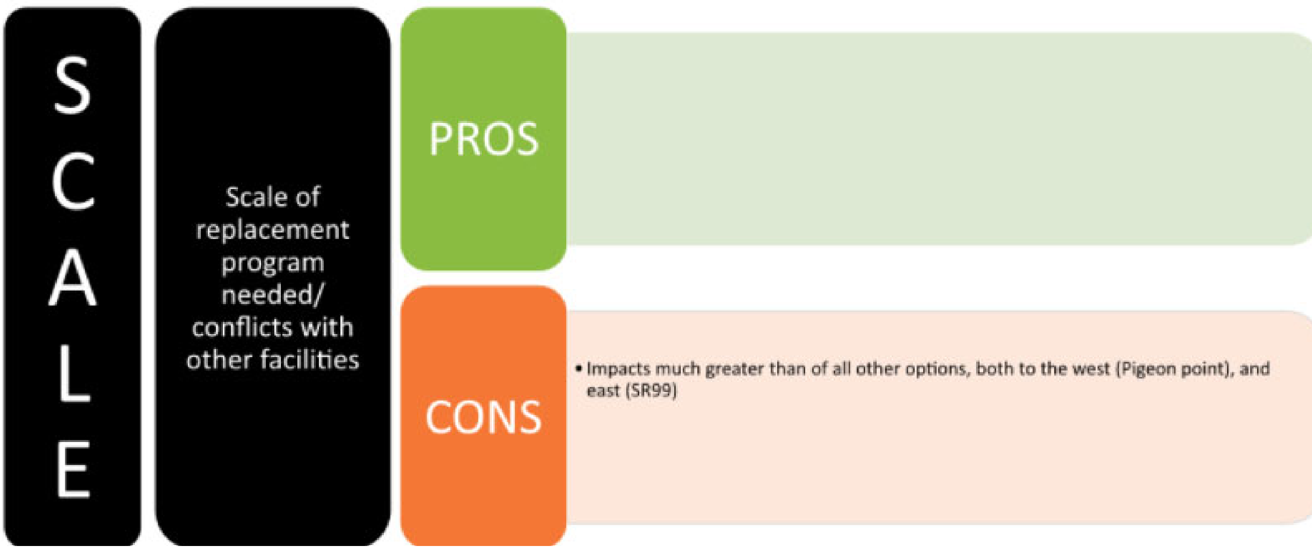
Concept 4b_NW – Tunnel

Summary of Consideration of Concept 4B_NW:

SDOT and the HNTB team presented the following information for consideration of Concept 4B_NW:







Workshop participants generally agreed with the pros and cons the HNTB team had identified, but also provided the following input:

- Would likely be two separate tunnels, maybe some cut and cover sections, potentially stacked
- You would have to decommission the rest of the bridge

General Comments

The following additional comments, concerns and questions were noted during Concept Workshop No. 2:

- Any in-water work would need to occur outside of navigation channel, preferably no in-water work (Risks = Tribe interests, ESA consultation, etc.)
- All options will have some reduction in capacity during tie-in, even if totally offline.
- Pigeon Point – will SDOT be required to make improvements on the West just because it has slope stability issues?
- Looks like we are trying to minimize impacts, which is a good thing.
- Other online concepts quickly become hybrids – could go back to them, but this allows the best comparison

- All concepts assume an 18 ft separation
- How do we balance trade-off in risk? For example, impacts to BNSF v. in-water work?

Subsequent Steps in Concept Development

Following Concept Workshop No. 2, SDOT and the HNTB team reviewed the items discussed during both Concept Workshops and finalized the representative concept designs. Concurrent with concept development SDOT and HNTB have continued to develop the purpose and need for the project, developed feasibility screening criteria, began consideration of potential nonmotorized connections and a joint rail/road structure, and used those representative concepts to do an initial feasibility screening. Following that initial screening, SDOT and the HNTB team will consider whether any of the representative concepts could be refined to minimize or reduce the impacts identified and may develop new or modified concepts for further evaluation

APPENDIX C

Conceptual Drawings for Evaluation

WSHB LONG-TERM REPLACEMENT PLANNING

North Bridge Concept

CONCEPTUAL
NOT FOR CONSTRUCTION

HNTB

CONCEPT 1

WSHB LONG-TERM REPLACEMENT PLANNING

South Bridge Concept

NOTE: EXISTING ALIGNMENT DATA FROM AS-BUILTS

CONCEPTUAL
NOT FOR CONSTRUCTION

HNTB

CONCEPT 2

PLOTTED BY: $$USERNAME$$
DATE: $$$$DATE$$$ TIME: $TIME$

WSHB LONG-TERM REPLACEMENT PLANNING

On-Line Bridge Concept

NOTE: EXISTING ALIGNMENT DATA FROM AS-BUILTS

CONCEPTUAL
NOT FOR CONSTRUCTION

HNTB

CONCEPT 3

PLOTTED BY: $$USERNAME$$
DATE: $$$$DATE$$$ TIME: $TIME$

WSHB LONG-TERM REPLACEMENT PLANNING

Hybrid Bridge Concept

NOTE: EXISTING ALIGNMENT DATA FROM AS-BUILTS

CONCEPTUAL
NOT FOR CONSTRUCTION

HNTB

CONCEPT 13

PLOTTED BY: $$USERNAME$$
DATE: $$$$DATE$$$ TIME: $TIME$

CONCEPTUAL
NOT FOR CONSTRUCTION

HNTB

PLOTTED BY: $$USERNAME$$
DATE: $$$$DATE$$$ TIME: $TIME$

APPENDIX D

Concept Feasibility Screening Memorandum

CONCEPT FEASIBILITY SCREENING MEMORANDUM

West Seattle Bridge Long-Term Replacement Planning – Task 5

August 10, 2021

PREPARED FOR

Seattle Department of Transportation

PREPARED BY

Daryl Wendle, Erin Ferguson,
Diana Giraldo, and David Gerla,
HNTB Team

CONCEPT FEASIBILITY SCREENING MEMORANDUM

Introduction

To protect public safety, the high span of the West Seattle High Bridge (WSHB) over the west channel of the Duwamish River was closed in 2020 and is being repaired to address a structural deficiency and restore the bridge to service. To maintain regional mobility, the crossing will need to be replaced while the repaired structure is still functioning. To develop potential replacement solutions and screen them for feasibility, SDOT developed an initial purpose statement and design objectives for a future replacement.

The core purpose of a replacement for the Duwamish River crossing is to maintain long term capacity, safety, mobility, and access for West Seattle and the region.

The primary design objectives for a long-term solution are to:

- Replace the connections and functions of the West Seattle High Bridge
- Maintain the navigation clearances of the bridge
- Meet current minimum design standards for a 45-mph roadway
- Maintain mobility for the crossing during the construction period of the replacement, avoiding full or prolonged closures of the crossing

To help determine the location of potential replacements and screen them for their ability to meet the core purpose of the project, SDOT developed four representative concepts:

- Concept 1, a North Alignment
- Concept 2, a South Alignment
- Concept 3, an On-Line Alignment
- Concept 4, a Tunnel

Background information on the development of those concepts is attached to this memo as Attachment A.

Based on the core purpose, SDOT also established two primary categories for assessing feasibility and screening concepts.

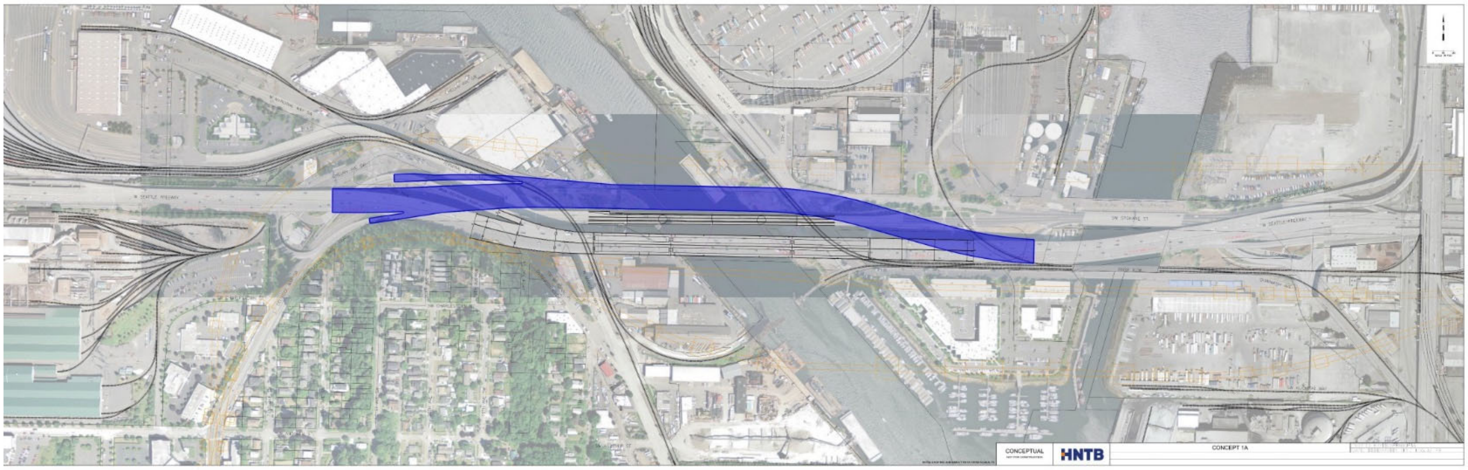
- Design – Ability to meet primary replacement design objectives
- Construction – Relative differences in construction phasing, duration, and difficulty

Within those two categories, SDOT used qualitative sub-measures to evaluate the degree to which replacement concepts would be able to meet design and construction objectives. For example, for Design, this initial screening considered whether each concept would maintain the connections and functional services of the WSHB, whether it would meet design standards for a 45-mph facility, and whether it would avoid navigational impacts. For construction, this initial screening considered the total duration and extent of construction. At this early concept phase of planning, the approximate duration and extent of construction are high level estimates and would need further design and construction detail. The high level estimates used here are primarily meant to identify substantial differences between concepts.

This feasibility screening also includes the preliminary identification of potential environmental impacts (primarily the need for additional right-of-way) and conflicts with existing or planned infrastructure, such as Port of Seattle facilities or Sound Transit's West Seattle Link Extension Project. Although there are not necessarily feasibility criteria, the preliminary identification of potential environmental impacts and infrastructure conflicts is included to highlight major challenges and differences between the concepts being evaluated.

This initial screening information is also designed to inform the refinement of concepts that appear promising, including potential opportunities for hybrid options. Following this feasibility screening, more detailed evaluation criteria with comparative scales will be established in coordination with SDOT and used to evaluate the differences between the remaining, refined, and/or new concepts.

North Alignment – Concept 1



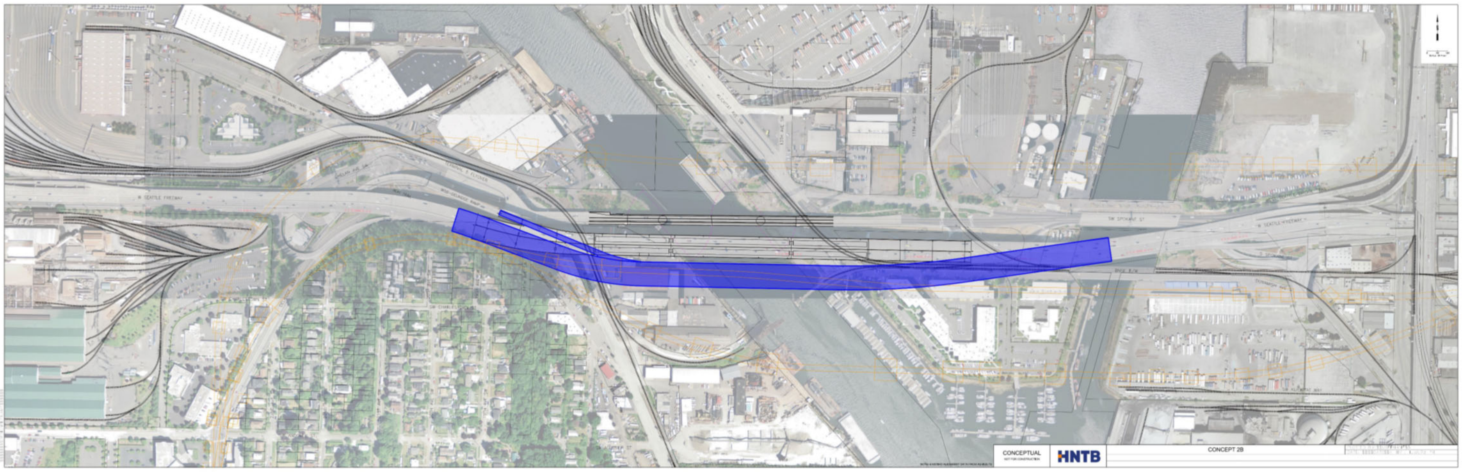
Concept Description

The North Alignment (Concept 1) is located north of both the WSHB and the Spokane Street Low Bridge. It would rebuild portions of the Delridge ramps and would rejoin the existing West Seattle Freeway just past Pigeon Point to the west, and before the east channel of the Duwamish River to the east.

Screening Criteria	Findings
Design Ability to meet primary replacement design objectives	
Maintain connections and functional services	• Yes, the North Alignment would maintain the connections and functional services provided by the WSHB. • Connecting sections to the Delridge on and off ramps would be realigned but would still provide the same connections.
Meet design standards for a 45-mph facility	• Yes, the North Alignment would meet design standards for a 45-mph facility, including at the reconfigured connections at the east and west ends of the replaced bridge.
Avoid navigational impacts/maintain long term navigation envelope	• The navigation envelope through the west channel of the Duwamish River would be maintained, with no piers located in water. • The North Alignment would maintain at least the same height above the navigation channel and at least the same width as the existing WSBH. • There would be some temporary impacts to navigation during construction of the new bridge and the demolition of the existing bridge, including potential negative impacts to the Spokane Street low bridge.
Qualitative assessment of potential mobility effects (predicted effect on corridor congestion, reliability, or safety, including steeper grades at access/egress ramps or connection/tie in points)	• The North Alignment would realign the Delridge ramps, with challenging grades (For example, the reconstructed grade of the Delridge off-ramp could be approximately 9% compared to 8% existing, without additional refinement). The grade plus a tighter curve for the off-ramp could affect traffic operations, including for heavier vehicles such as trucks and transit vehicles. • The realignment on the west side would straighten an existing curve, improving sight distance. • On the east side it would introduce an S-curve, prior to the east channel crossing. The addition of a curve, combined with the grades needed to maintain a high bridge crossing, could affect traffic operations.

Screening Criteria	Findings
Construction Relative differences in construction phasing, duration, or difficulty	
Total Duration and Extent of Construction	• All existing lanes of travel could be maintained as a new bridge is being built in a fully separate alignment north of the repaired span. However, at the tie-in locations at both ends, the general construction phasing approach for this concept assumes reduced capacity to two lanes in each direction for approximately 3-4 years. • Construction for the full replacement and demolition is estimated to be up to six years. • Full closures of the Delridge ramps could also be needed for part of this time. • The North Alignment would be north of the Spokane Street low bridge but could overlap the moveable bridge opening zone, creating some additional challenges for construction. • An additional 3,400 feet of new infrastructure would be constructed.
Environmental Notes	
General summary of environmental issues noted	• The North alignment would require new permanent transportation right-of-way to the north of the repaired WSHB. Many of these areas involve transportation uses rather than industrial or manufacturing uses, but it could affect marine land uses and docks within the Port of Seattle. • During construction, additional areas would be needed for staging based on proximity to the repaired WSHB, including at the areas needed for the tie in locations, for demolition of the repaired WSHB, for foundations, and for general staging.
Infrastructure Conflict Notes	
Conflicts with regional facilities (Port of Seattle, Railroad, lower bridge and trail/Spokane Street) or Sound Transit plans	• During construction, there may be impacts to Port of Seattle access as well as some areas with waterside operations. The design would need to provide adequate clearance for the Port's T5 flyover, which accommodates oversize truck loads. • The North Alignment may conflict with operations the Spokane Street swing bridge.

South Alignment — Concept 2



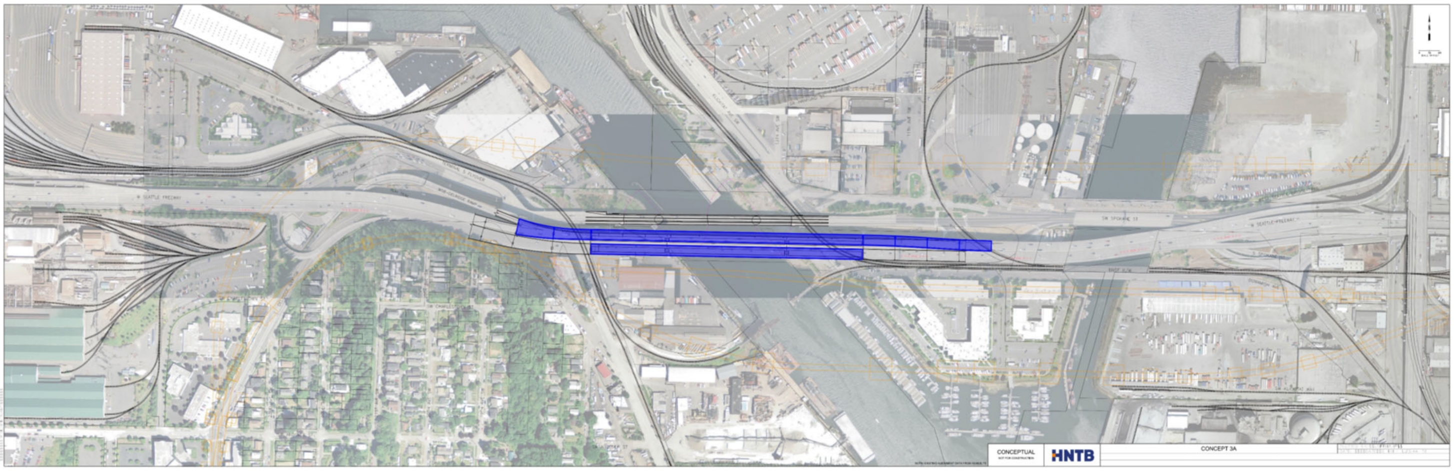
Concept Description

The South Alignment (Concept 2) is located south of the WSHB. It would rebuild portions of the Delridge ramps and would rejoin the West Seattle Freeway at Pigeon Point to the west and near the west side of the east channel of the Duwamish River to the east. It would extend the Delridge off-ramp but would not affect the on-ramp.

Screening Criteria	Findings
Design Ability to meet primary replacement design objectives	
Maintain connections and functional services	• Yes, the South Alignment would still allow the same connections and functional services provided by the WSHB.
Meet design standards for a 45-mph facility	• Yes, the South Alignment would meet design standards for a 45-mph facility, including at the reconfigured connections at the east and west ends of the replaced bridge.
Avoid navigational impacts/maintain long term navigation envelope	• The navigation envelope through the west channel of the Duwamish River would be maintained, with no piers located in water, although staying out of the water would be challenging and could be necessary to avoid impacts to BNSF bridge approach. • The South Alignment would maintain at least the same height above the navigation channel and width as the repaired WSHB. • There would be some impacts to navigation during construction of the new bridge and the demolition of the existing bridge.
Qualitative assessment of potential mobility Effects (predicted effect on corridor congestion, reliability, or safety, including steeper grades at access/egress ramps or connection/tie-in points)	• The South Alignment would introduce a new curve at the tie-in at the east side of the WSHB and would include a tighter curve at the tie-in to the west. The addition of curves, combined with the grades needed to maintain a high bridge crossing, could affect traffic operations.
Construction Relative differences in construction phasing, duration, or difficulty	
Total Duration and Extent of Construction	• All existing lanes of travel on the high bridge could be maintained while a new bridge is built in a fully separate alignment south of the repaired span. However, at the tie-in locations at both ends, the general construction phasing approach assumes the need to reduce capacity to two lanes in each direction for approximately 3-4 years. • Full closure of the Delridge off-ramp could be required, but no closure would be needed for the Delridge on-ramp. • Construction for the full replacement and demolition is generally estimated to be approximately 7 years. • An additional 3,300 feet of new infrastructure would be constructed.

Screening Criteria	Findings
Environmental Notes	
General summary of environmental issues noted	• The South Alignment would impact the Pigeon Point area and related greenbelt where natural areas and steep slopes are present. • New permanent right-of-way to the south of the repaired WSHB would be required, potentially affecting freight and industrial businesses west of the Duwamish and on Harbor Island, including a portion of a marina. Construction staging areas would also be needed. • A new aerial lease over BNSF tracks and the BNSF bridge would be required, with the potential to restrict train traffic during construction.
Infrastructure Conflict Notes	
Conflicts with regional facilities (Port of Seattle, Railroad, lower bridge and trail/Spokane Street) or Sound Transit plans	• A pier may be needed near the BNSF bascule bridge approach, which may require relocation of the BNSF bridge or the location of pier(s) in water. • The South Alignment would overlap with Sound Transit alternatives DUW-1a and 1b, particularly approaching Pigeon Point.

On-Line Alignment – Concept 3



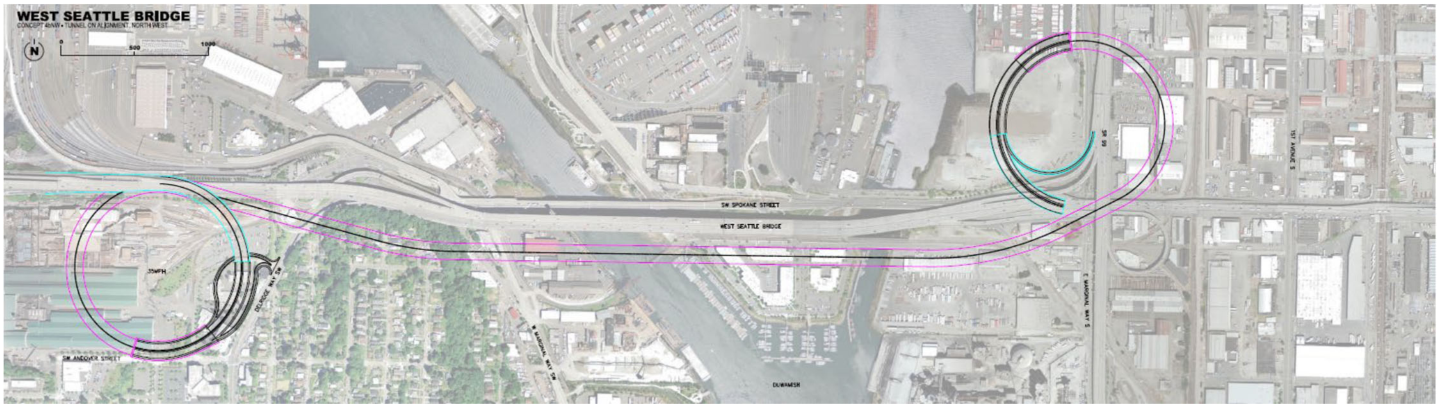
Concept Description

The On-Line Alignment (Concept 3) is located generally in the same location as the existing WSHB, extending slightly farther north, but still south of the low bridge control tower, with a slightly wider cross section than the existing bridge

Screening Criteria	Findings
Design Ability to meet primary replacement design objectives	
Maintain connections and functional services	• Yes, the On-line Alignment would maintain the connections and functional services provided by the WSHB.
Meet design standards for a 45-mph facility	• Yes, the On-line Alignment would meet design standards for a 45-mph facility, including at reconfigured connections at the east and west ends of the replaced bridge.
Avoid navigational impacts/maintain long term navigation envelope	• The navigation envelope through the west channel of the Duwamish River would be maintained, with no piers located in water. • The On-line Alignment would maintain at least the same height above the navigation channel and width as the repaired WSHB. • There would be some impacts to navigation during construction of the new bridge and demolition of the existing bridge, which would occur in two phases.
Qualitative assessment of potential mobility Effects (predicted effect on corridor congestion, reliability, or safety, including steeper grades at access/egress ramps or connection/tie-in points)	• Because the On-line Alignment is essentially in the same location as the repaired bridge, there would be very few to no potential effects that could worsen long term mobility.

Screening Criteria	Findings
Construction Relative differences in construction phasing, duration, or difficulty	
Total Duration and Extent of Construction	• The On-line Alignment could maintain reduced capacity (four lanes of travel, two in each direction) for the duration of construction. • The ability to maintain traffic and access is based on the assumption that a portion of the repaired bridge could be demolished while the remaining portion would continue to be operational throughout construction, with shorter-term closures required for shifts in traffic during phasing and ultimately for the construction of tie-ins to the east and west of the replaced span. More detailed study of the repaired facility would be needed to confirm the viability of this approach. • Construction of the full replacement is generally estimated to be approximately 4 years. • Demolition activities for the repaired span would be phased to intersperse with periods for new bridge construction. • Reconstruction of the Delridge ramps would be limited. • An additional 2,300 feet of new infrastructure would be constructed.
Environmental Notes	
General summary of environmental issues noted	• The On-line Alignment would have limited new permanent right-of-way needs but the replacement would still need construction staging areas as well as buffers on either side of the rebuilt facilities.
Infrastructure Conflict Notes	
Conflicts with regional facilities (Port of Seattle, Railroad, lower bridge and trail/Spokane Street) or Sound Transit plans	• The On-Line Alignment could conflict with regional facilities, including the Port of Seattle, the proposed alignments of Sound Transit, the facilities of the Railroad, or the Spokane Street low bridge.

Tunnel Alignment – Concept 4



Concept Description

The Tunnel Alignment (Concept 4) is a tunnel located just south of the existing WSHB, with helix access points on either side of the Duwamish River. It would require reconstructing all ramps and access points between Avalon Way and SR 99, including portions of the SR 99/West Seattle Freeway interchange.

Screening Criteria	Findings
Design Ability to meet primary replacement design objectives	
Maintain connections and functional services	• The Tunnel Alignment would partly maintain a crossing of the Duwamish River, but would modify all other existing connections and functional services on both the west and east sides, such as the existing connections to Spokane Street, Delridge Way, SW Admiral Way, and SR 99. • Mobility would be reduced due to longer distance, slower travel times, extended grades, and curves and grades at all connection points, including the SR 99 interchange and Delridge ramps.
Meet design standards for a 45-mph facility	• No, the Tunnel Alignment cannot meet design standards for a 45-mph facility due to the slopes and curves required to descend below the Duwamish River within a relatively short distance from major access/connection points such as the SR 99 freeway or the Delridge ramps. • The Tunnel would only meet standards for a 35-mph facility.
Avoid navigational impacts/maintain long term navigation envelope	• The navigation envelope through the Duwamish navigational channel would be maintained, with no piers located in water. • The Tunnel Alignment may require an armored lid because the west channel is maintained through dredging and there is also the potential for accidental impacts from passing vessels or their anchors. • There would be impacts to navigation during demolition of the repaired bridge, and potentially during tunnel construction.
Qualitative assessment of potential mobility Effects (predicted effect on corridor congestion, reliability, or safety, steeper grades at access/egress ramps or connection/tie-in points)	• The Tunnel Alignment would have fewer or modified access points, lower design speeds, and longer travel times, due to the additional length of the tunnel concept and its helixes, which would all reduce mobility compared to the repaired West Seattle Bridge, including for trips to and from I-5. • The added curves and steeper slopes with the Tunnel Alignment would also affect operations, including for trucks or buses, and could increase the potential for traffic incidents. • The Tunnel Alignment may require greater width to meet sight distance, to provide for incident response, or to meet other safety requirements.

Screening Criteria	Findings
Construction Relative differences in construction phasing, duration, or difficulty	
Total Duration and Extent of Construction	• The Tunnel Alignment could maintain traffic and access on the repaired bridge, but capacity is likely to be reduced or closed at times due to impacts at tie-in points. • Construction and staging would be challenging near tie-ins and may require closure of additional facilities, such as Spokane Street. • Overall construction would be a minimum of 8 to 10 years. • The Tunnel Alignment would include the construction of up to 14,000 feet of new infrastructure.
Environmental Notes	
General summary of environmental issues noted	• The Tunnel Alignment would require the acquisition of a large amount of new permanent right-of-way, extending well beyond the footprint of the existing WSHB. This could impact natural areas, including Pigeon Point. • The Tunnel Alignment could require a larger area of impacts to existing land uses, both temporary and permanent, converting existing residential, commercial, and industrial properties to right-of-way use. This could include impacts to a major steel mill and a Port of Seattle property that would both be difficult to relocate, potentially resulting in the loss of a major employer providing living wage jobs. • Higher potential for prolonged construction impacts because in addition to extensive tunnel spoils removal and hauling needs, it would require the decommissioning and demolishing of the West Seattle Bridge and connecting sections of the West Seattle Freeway to at least SR 99.
Infrastructure Conflict Notes	
Conflicts with regional facilities (Port of Seattle, Railroad, lower bridge and trail/Spokane Street) or Sound Transit plans	• The Tunnel Alignment would conflict with regional facilities, including the Port of Seattle facilities, Sound Transit alignments, and BNSF. • The access ramp on the west side of the Tunnel Alignment would conflict with Sound Transit's proposed Delridge Stations.

Summary of Concept Feasibility Screening Findings

All of the bridge concepts meet the core purpose and need of the project, meet overall design objectives, and have termini that limit the replacements to begin near Delridge on the west and end on Harbor Island to the east. All of the bridge concepts, including the North and South alignments that are fully off-line, would maintain travel during construction but would need to reduce capacity.

In general, the On-Line Alignment (Concept 3) meets the primary replacement design objectives with the smallest footprint and is more likely to have the least construction impacts, assuming demolition and construction phasing is feasible. The feasibility screening showed that the On-line Alignment may be faster and would have approximately the same impacts to mobility during construction as the North and the South alignments, due to complex tie-in work that would be required for those off-line alignments. More detailed study during refinement would be needed to confirm the approach and related design and construction needs.

Both the North Alignment (Concept 1) and the South Alignment (Concept 2) appear to be feasible and may be capable of being modified to reduce some of the potential impacts identified in this screening. They both have a larger construction footprint and larger scope than Concept 1 and would have more impacts due to the new right of way areas that a replacement would occupy.

Although the Tunnel Alignment (Concept 4) appears to be technically feasible at a reduced design speed, this concept is the least able to replace the connections and functional services of the repaired West Seattle High Bridge and would have the greatest construction and environmental impacts. The scale of the Tunnel Alignment, at 14,000 feet of new infrastructure, far exceeds the scale of the other three bridge concepts and would take longer to construct.

See Table 1 for a summary of the feasibility screening key findings. These findings will inform the potential refinement of concepts for further evaluation. Based on these initial findings, SDOT will consider whether refinement to any of the representative concepts could address any of the issues identified in this feasibility screening, including:

- Provide additional mobility during construction?
- Reduce duration of construction impacts?
- Avoid conflicts with Sound Transit?
- Avoid conflicts with BNSF?
- Avoid conflicts with the Port of Seattle?
- Minimize impacts to operation of the Spokane Street Swing Bridge?
- Improve grades at Delridge Ramp(s)?
- Reduce right-of-way acquisition needs?
- Reduce environmental impacts?
- Reduce equity impacts or increase benefits?

Table 1. Concept Feasibility Screening – Summary of Key Findings

	North Alignment (Concept 1)	South Alignment (Concept 2)	On-Line Alignment (Concept 3)	Tunnel (Concept 4)
	Located north of both the WSHB and the Spokane Street Low Bridge from just past Pigeon Point to the west and before the east channel of the Duwamish River to the east.	Located south of the WSHB between Pigeon Point to the west and near the west side of the east channel of the Duwamish River to the east.	Located generally in the same location as the WSHB, extending slightly farther north, but still south of the low bridge control tower, with a slightly wider cross section than the existing bridge.	Located just south of the WSHB, with helix access points on either side of the Duwamish River.
Design				
Would it maintain connections and functional services?	Yes.	Yes.	Yes.	No.
Would it meet design standards for a 45 mph facility?	Yes.	Yes.	Yes.	No.
Would it avoid navigational impacts?	Yes, except for impacts during construction and demolition. May have negative impacts to swing bridge operations and navigation.	Yes, except for impacts during construction and demolition. Avoiding navigational impacts could be more challenging due to need to avoid BNSF bridge approach.	Yes, except for impacts during construction and demolition.	Yes, except for impacts during construction and demolition.
Construction				
How much would capacity be reduced and for how long?	No reduction on WSHB, but capacity would be reduced to 4 lanes (2 in each direction) for approximately 3-4 years at tie-in locations at both ends.	No reduction on WSHB, but capacity would be reduced to 4 lanes (2 in each direction) for approximately 3-4 years at tie-in locations at both ends.	Reduced to 4 lanes (2 in each direction) for the duration of construction (approximately 4 years).	No reduction on WSHB, but capacity would be reduced to 4 lanes (2 in each direction) or closed at times during construction at tie-in locations at both ends.
Approximately how long would construction and demolition take?	6 years	7 years	4 years	8-10 years
How much new infrastructure would be constructed?	3,400 feet	3,300 feet	2,300 feet	14,000 feet

APPENDIX E

Concept Evaluation Memorandum

WEST SEATTLE HIGH BRIDGE (WSHB) LONG-TERM REPLACEMENT PLANNING

Concept Evaluation

December 2021

PREPARED FOR

Department of Transportation
City of Seattle

PREPARED BY

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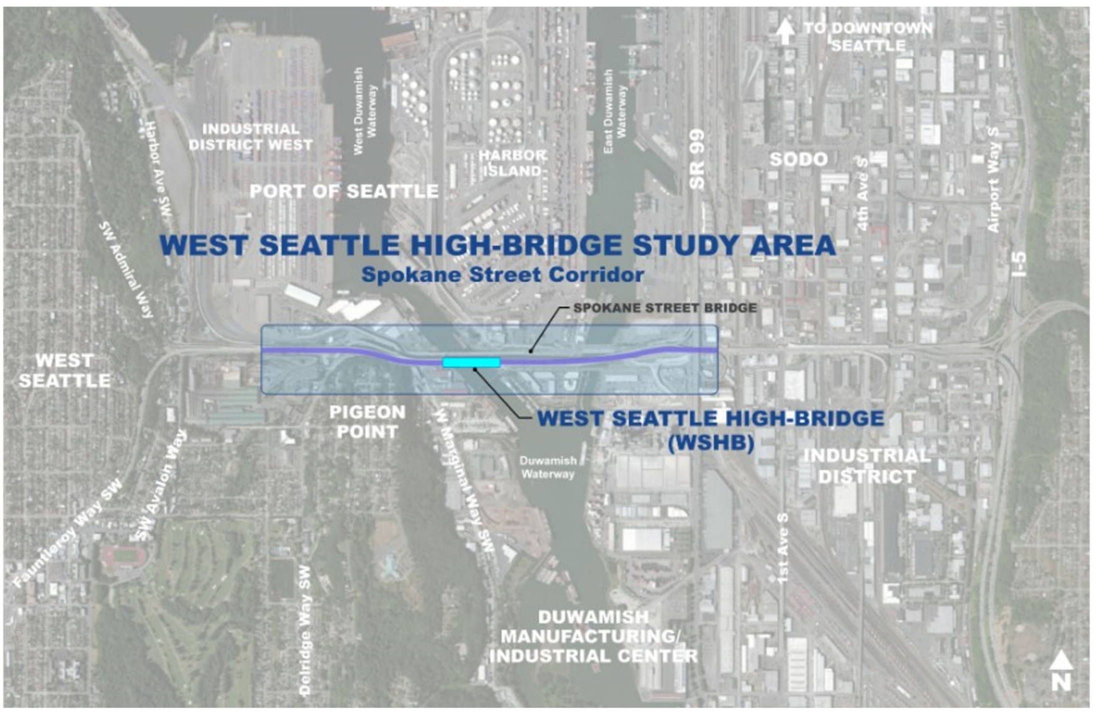
1. INTRODUCTION

To protect public safety, the high span of the West Seattle Bridge (the West Seattle High Bridge or WSHB) over the west channel of the Duwamish Waterway was closed in 2020. It is now being repaired to address a structural deficiency and restore the bridge to service. Understanding that the repaired structure will eventually need to be replaced to maintain regional mobility, the City has undertaken a long-term planning exercise to identify potential replacement options. The planning team that undertook this study consisted of Seattle Department of Transportation (SDOT) staff and a consultant team, in consultation with SDOT subject matter experts and partner agency representatives. This long-term planning assumes the existing bridge will be repaired and open to traffic to the greatest extent possible at the time of replacement.

The project vicinity, including areas referenced throughout this evaluation, is shown in Figure 1.

Figure 1 – Project Vicinity



The core purpose of a replacement for the WSHB is to maintain long-term capacity, safety, mobility, and access for West Seattle and the region.

The primary design objectives for a long-term solution to meet this purpose are to:

- Replace the connections and functions of the WSHB
- Maintain the navigation clearances of the bridge
- Meet current minimum design standards for a 45-mile per hour (mph) roadway
- Maintain mobility for the crossing during the construction period of the replacement, avoiding full or prolonged closures of the crossing

The Purpose and Need Memorandum with a fuller description was prepared and attached to the WSHB Long-Term Planning Compiled Report as Appendix A.

The first step in the long-term replacement planning process was to develop initial representative concepts to meet the core purpose of a replacement project. The planning team identified the following four representative concepts:

- Concept 1, a North Bridge Concept
- Concept 2, a South Bridge Concept
- Concept 3, an On-Line Bridge Concept
- Concept 4, a Tunnel Concept

The planning team assessed the feasibility of these initial concepts based primarily on design (the ability to meet primary design objectives) and construction (the relative differences in construction phasing, duration, and difficulty). For example, the feasibility screening considered whether each concept would maintain the connections and functional services of the WSHB, whether it would meet design standards for a 45-mph facility, whether it would avoid navigational impacts, and what the high-level estimates of the total duration and extent of construction for each of the four concepts are. The feasibility screening also included the preliminary identification of potential environmental impacts (primarily the need for additional right-of-way) and conflicts with existing or planned infrastructure, such as Port of Seattle facilities or Sound Transit's West Seattle Link Extension Project, intended to highlight major challenges and differences between the concepts.

The feasibility screening found that all of the bridge concepts would meet the core purpose and need of the project, meet overall design objectives, and have termini that would begin near Delridge on the west and end on Harbor Island to the east. All of the bridge concepts, including the North and South bridge concepts that are fully off line, would maintain travel during construction but would require periods of reduced capacity.

The On-Line Bridge Concept (Concept 3) met the primary replacement design objectives with the smallest footprint. The feasibility screening showed that the smaller size of the On-line Bridge Concept would limit environmental impacts, may be faster to construct, and would allow two lanes of traffic each way to be maintained during construction.

Both the North Bridge Concept (Concept 1) and the South Bridge Concept (Concept 2) met the primary replacement design objectives. They both have a larger scope and construction footprint than the On-Line Bridge Concept. Both could maintain travel across the river during construction, although they would need to close lanes to connect the new bridge structure to the east and west sections of West Seattle Bridge.

The Tunnel Concept (Concept 4) did not initially meet the primary replacement design objectives for a facility that would replace the connections and equivalent services provided by the existing WSHB, but it still could be technically feasible at a reduced design speed. The scale of the replacement was found to be several times greater than the other concepts, both in terms of size as well as construction complexity. Based on these findings, no additional design refinement was developed for the Tunnel Concept.

Following the feasibility screening, the planning team identified the concepts to carry forward for further development and evaluation. The refinement effort involved additional design and engineering assessments, focusing on constructability and engineering risk and construction reviews of the concepts. It also included the development of a "Hybrid Bridge Concept" (Concept 13), combining two of the initial concepts (the North and On-Line bridge concepts). A larger set of evaluation criteria was established, covering capacity and mobility, construction, environment, and equity. The planning team also began considering the potential rough order of magnitude (ROM) costs for the concepts, but cost was not a criterion in this evaluation.

2. CONCEPTS EVALUATED

In total, four bridge concepts were further defined and evaluated following the feasibility screening, based on early conceptual definitions of the location, general profile, and features of these representative concepts. The tunnel concept was also evaluated but did not undergo further engineering detail or refinement, based on the findings from the feasibility screening showing that it had lower mobility performance and much higher magnitude scope and construction challenges.

The five concepts evaluated:

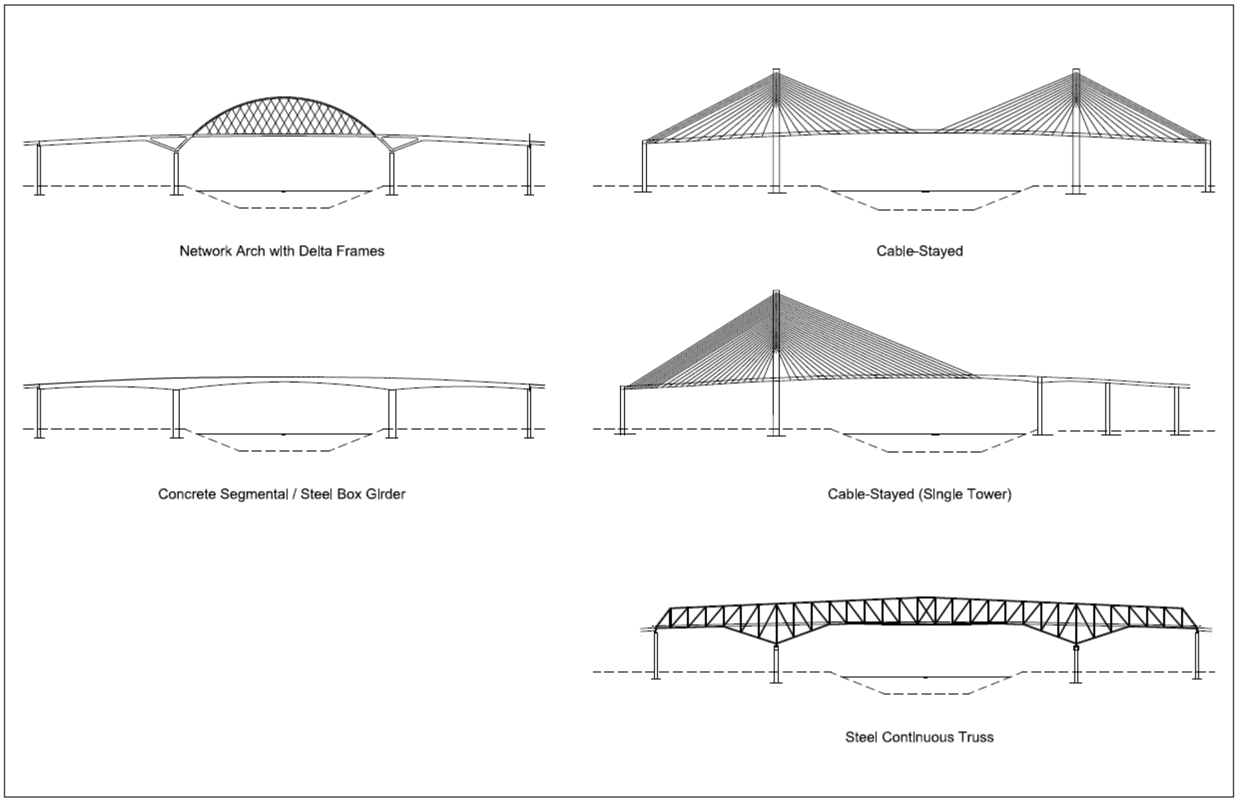
- North Bridge Concept (Concept 1, refined to reduce grade of Delridge ramp)
- South Bridge Concept (Concept 2)
- On-Line Bridge Concept (Concept 3, refined to be located within existing right-of way)
- Tunnel Concept (Concept 4)
- Hybrid Bridge Concept (Concept 13, new concept combining North Bridge and On-Line Bridge concepts)

Figures and a description of each concept are described in Section 4 below. Larger conceptual drawings are attached to the WSHB Long-Term Planning Compiled Report as Appendix C.

Each of the concept definitions generally reflect the standard geometric requirements and the general vertical and horizontal alignment for a replacement bridge, establishing a preliminary alignment and scale of a future replacement project. Other more detailed engineering design and studies would still be needed to develop a specific replacement project, including more detailed structural engineering studies of bridge type, size, and location, as well as geotechnical and structural engineering, drainage, or demolition of the existing spans.

For this evaluation, however, the planning team identified potential bridge types that could be feasible in each location and could affect the performance of a given concept as they were comparatively evaluated. For example, potential bridge type could affect the duration of construction, staging areas and techniques needed, the level of effects, and costs. The potential bridge types that could be used to replace the WSHB are illustrated on Figure 2. They include network arches with delta frames, concrete segmental/steel box girder, steel continuous truss, cable-stayed, and single tower cable-stayed. Throughout this evaluation, where it is understood that the bridge type would affect the project impacts, that difference is noted.

Figure 2 – Potential Bridge Types



3. EVALUATION CRITERIA

The following evaluation criteria, shown in Table 2, were used to further evaluate the four bridge concepts and the Tunnel Concept.

Table 2 – Evaluation Criteria

Evaluation Criteria	Measures of Comparative Differences
Capacity and Mobility	
Note: None of the bridge concepts being evaluated would alter long-term overall capacity or permanently close access points to the West Seattle Bridge (WSB). While the measures below consider both permanent and construction effects, much of the emphasis is on construction effects that are different between concepts.	
Automobile Traffic	Changes to access and circulation
	Maintenance of traffic during construction
Transit	Effects on transit service, access, or operations during construction
Freight	Changes to access, circulation, congestion, or affecting freight routes or rail facilities during construction
Nonmotorized	Construction period impacts to nonmotorized travel
Navigation	Changes or restrictions to navigation during construction
Safety/Design Impacts	Improvements or impacts to sight distances, slope, access points, or other features
Corridor and Adjacent Facilities	Opportunity or need for improvement to corridor or adjacent facilities (functional or structural)
Construction Activities	
Construction Challenges	Relative risk and complexity of construction approach needed, including third-party approvals
Scope of Construction	Duration and phases of construction, time requirements
Scale of Construction	Linear feet of new /demolished infrastructure
Environment	
Effects on the Natural Environment	Proximity/impacts to critical areas such as shorelines, steep slopes, ESA species, wetlands, streams, or other natural habitat areas
Effects on the Built Environment	Extent of new right-of-way needed; permanent and construction
	Estimated level of property impacts (residential, commercial, other) and related displacements
	Conflicts with utilities
Parks and Cultural Resources	Effects on historic, archaeological, or parks resources, or properties with cultural associations
Equity	
Community Impacts	Temporary or permanent impacts to BIPOC, low-income, or other underserved populations, including through noise, visual, air quality, community separation, service disruptions, or changes in access and congestion (travel times)
Business, Job Opportunities, and Access	Loss of, or impacts to, businesses with living-wage jobs or impacts to access to jobs

4. CONCEPT EVALUATION

4.1. Concept 1 – North Bridge Concept

The North Bridge Concept (Concept 1), shown in Figure 3, would be located north of both the WSHB and the Spokane Street Bridge. It would rebuild portions of the Delridge ramps and would rejoin the existing West Seattle Bridge, just past Pigeon Point to the west and before the east channel of the Duwamish Waterway to the east. It would be approximately the same width as the existing WSHB. Following the initial feasibility screening of the North Bridge Concept, the westbound approach to the Delridge off-ramp was slightly modified to reduce the grade by modifying the geometry and extending the tie-in point to the south.

Construction of the North Bridge Concept would begin by constructing a new crossing of the west channel of the Duwamish River, north of the existing WSHB and the swing bridge, and constructing a new portion of the westbound off-ramp to Delridge. Next, the north half of the existing approaches to the WSHB would be demolished and reconstructed to connect to the new WSHB. Then, the remainder of the new westbound Delridge ramp and temporary access from eastbound Delridge would be constructed, followed by demolition and reconstruction of the south half of the approaches to connect to the new WSHB, completing the tie-ins. During construction, capacity on the existing WSHB would be reduced to two lanes in each direction (four lanes total). Feasible bridge types for the North Bridge Concept include network arches with delta frames, segmental concrete box or steel box girder, or single-tower cable-stayed.

The construction and staging for the North Bridge Concept is summarized in Table 3, and Table 4 summarizes the evaluation of the North Bridge Concept.

Table 3 – Potential Construction and Staging Scenario for North Bridge Concept (Concept 1)

Stage	North Bridge Concept - Construction Staging and Activities	Year																No of Open Lanes Each Direction
		0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	
1	Construct Main Span and majority of tie-ins on both sides	■	■	■	■	■	■	■										3
	Switch traffic to new EB Bridge							🚗										2
2	Demolish WB approach and complete tie-ins								■	■	■	■						2
3	Demolish EB west shore and complete tie-in on both ends												■	■	■			2
	Switch all traffic to new Bridge														🚗			3
4	Construct ramps and complete all construction activities															■		3
5	Demolish the exiting main bridge																■	3

Note: *Assumes network arches and delta frames. A segmental box girder and cable stayed-bridge type would take approximately 1-2 years longer. Numerous other construction/staging scenarios are possible.*

Figure 3 – Conceptual Drawing of North Bridge Concept

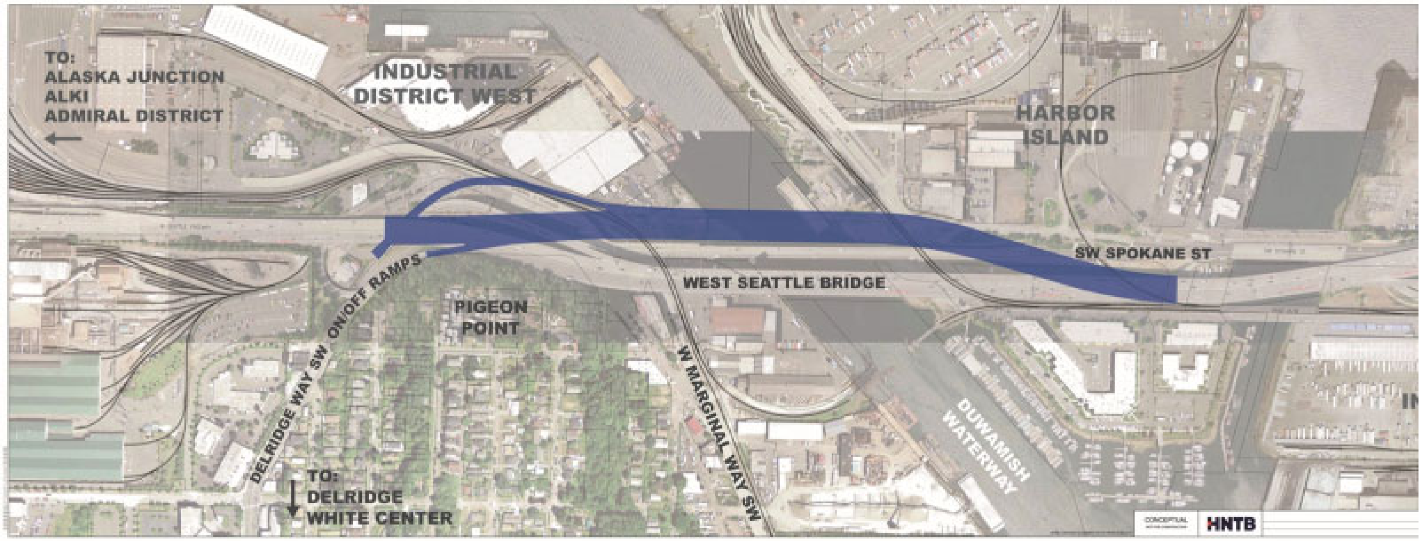


Table 4 – North Bridge Concept Evaluation Summary

NORTH BRIDGE CONCEPT (CONCEPT 1)		
Evaluation Criteria	**Measures of Comparative Differences**	**Effect**
Capacity and Mobility		
Automobile Traffic	Access/circulation	• No substantive long-term change to access and circulation compared to existing bridge
	Maintenance of traffic	• Maintains existing capacity across the WSHB during construction of the new main span bridge • Reduced to 2 lanes of traffic in each direction during construction of tie-ins (approximately 3–4 years) • Night/weekend closures of several surface streets likely required to complete bridge work overhead • Some traffic control/maintenance (e.g., rolling closures, flagging, nights/weekends closures, etc.) on the Terminal 5 Flyover likely required to complete bridge work overhead • Delridge westbound off-ramp access closed to complete tie-ins of reconstructed portions; some reconstruction of the eastbound on-ramp would also be needed
Transit	Effects on service, access, or operations	• Potential for transit-only lanes on the WSHB to be removed during construction; keeping the transit lane would require closure of a general-purpose lane

Table 4 – North Bridge Concept Evaluation Summary (continued)

NORTH BRIDGE CONCEPT (CONCEPT 1)		
Evaluation Criteria	Measures of Comparative Differences	Effect
Freight	Effects on freight or rail facilities	• Construction would occur above and on Port property as well as on City right-of-way, potentially constraining access to Harbor Island/Terminal 18 and Terminal 5 roadway facilities as well as rail lines on Harbor Island and to Terminals 5 and 18 • Construction period capacity reductions on WSB would also affect freight by increasing congestion and delays
Nonmotorized	Nonmotorized travel	• Potential temporary closures or detours to nonmotorized facilities located on lower Spokane Street bridge both east and west of the west channel of the Duwamish Waterway and West Seattle Bridge Trail near Delridge Way SW
Navigation	Navigation restrictions	• The North Bridge Concept would not have any permanent impact to navigation • Impacts to navigation during construction would vary based on bridge type, but all bridge types may require the closure of the navigation channel for short periods of time (from multiple hours-long closures to a few days long closures) and some bridge types would restrict vertical clearance during periods of construction • The network arch with delta frames and steel box girder bridge types would require a complete closure of the navigation channel for up to a few days for the float-in operation and installation for each of the two bridge sections over the channel • All other potential bridge types would require channel closure during multiple, shorter stages of lifting and erecting operations • The segmental box girder and cable-stayed bridge types would reduce the vertical navigation clearance during installation of falsework over the west channel, which could take up to 18 months. • Vertical clearance would not be reduced during construction with other potential bridge types
Safety/Design Impacts	Design deviations affecting safety	• Would add a new S-curve, which would be allowed but increases safety concerns
Corridor and Adjacent Facilities	Effects to adjacent transportation facilities	• Large foundation construction in vicinity of the Spokane Street Bridge • Potential for construction period conflicts or constraints to Port access facilities, including access to Terminal 5 (T5 Flyover) and

Table 4 – North Bridge Concept Evaluation Summary (continued)

NORTH BRIDGE CONCEPT (CONCEPT 1)		
Evaluation Criteria	Measures of Comparative Differences	Effect
		Terminal 18, as well as to BNSF rail facilities for Harbor Island and Terminal 18
Construction Activities		
Construction Challenges	Construction risk/complexity	• Constructing a new WSHB near the Spokane Street Bridge imposes logistic construction challenges and safety risks, particularly given the sensitivity of lower swing bridge machinery and operations • BNSF lines on both ends of the new main spans impose schedule, permitting, and design risks • Building the approach tie-in structures on either end over the live traffic from WSB and Spokane Street is a safety risk, and phased construction of the tie-in structures imposes additional schedule and safety risks • There is limited room to place the columns for the tie-in structures; longer spans and/or steel structures instead of prestressed girders would likely be needed, and it's a potential cost-escalation and schedule risk • The foundations may require ground improvement that would enlarge the environmental footprint
Scope of Construction	Duration	• At least 8–10 years of construction, conducted in phases
Scale of Construction	Linear feet or new/removed infrastructure	• 3,400 linear feet
Environment		
Effects on the Natural Environment	Effects to critical areas or species	• Portions of the North Bridge would be located in designated environmentally critical Geologic Hazard Areas (a liquefaction-prone area, a steep slope erosion hazard area, and landslide-prone areas), a flood-prone area, and Fish and Wildlife Habitat Conservation Areas (including the Duwamish Waterway and Pigeon Point) • Also crosses over the Bernice White natural resource mitigation site, with the potential to place columns within the site
Effects on the Built Environment	Right-of-way requirements/long term and construction	• Requires additional right-of-way to the north of the existing bridge, including some Port of Seattle properties
	Property impact types and displacements	• Port of Seattle property on the west side of the Duwamish and Lehigh Northwest Cement to the east would be impacted, potentially involving displacement or reconfiguration of the uses

Table 4 – North Bridge Concept Evaluation Summary (continued)

NORTH BRIDGE CONCEPT (CONCEPT 1)		
Evaluation Criteria	Measures of Comparative Differences	Effect
	Conflicts with utilities	• Conflict with major Seattle City Light transmission lines that run to the north of the existing bridge • The lines would need to be relocated prior to foundation construction for this concept
Parks and Cultural Resources	Effects on properties with cultural associations or parks resources	• No impacts anticipated
Equity		
Community Impacts	Effects to BIPOC or low-income populations	• No direct effects to housing or community facilities associated with BIPOC or low-income populations, although reduced capacity during construction may affect mobility for BIPOC or low-income populations. For extended periods, there would be slower travel through the corridor as well as more congestion on alternative routes
Business, Job Opportunities, and Access	Effects on businesses with living-wage jobs or impacts to access to jobs	• Could affect the operations of Lehigh Northwest Cement and Port of Seattle on the east shore and Island Tug and Barge on the west shore • Transportation constraints during construction could affect access to jobs and the operations of maritime and industrial businesses in the Port area

4.2. Concept 2 – South Bridge Concept

The South Bridge Concept (Concept 2), shown in Figure 4, is located south of the existing WSHB. It would rebuild portions of the Delridge off-ramp and would rejoin the West Seattle Bridge at Pigeon Point to the west and near the west side of the east channel of the Duwamish Waterway to the east. It would extend the Delridge off-ramp but would not affect the on-ramp.

Construction of the South Bridge Concept would begin by constructing a new crossing of the west channel of the Duwamish River to the south of the existing WSHB. Next, the south half of the existing approach to the WSHB would be demolished and reconstructed to connect to the new bridge. Then, the north half of the existing approaches to the WSHB would be demolished and reconstructed to complete the new tie-ins. Finally, the WSHB would be demolished and the new westbound off-ramp to Delridge would be constructed. During construction, capacity of the West Seattle Bridge would be reduced to two lanes in each direction (four lanes total) and westbound access to Delridge would be temporarily closed. Feasible bridge types for the South Bridge Concept include network arches with delta frames or single-tower cable-stayed.

The construction and staging for the South Bridge Concept is summarized in Table 5, and Table 6 summarizes the evaluation of the South Bridge Concept.

Table 5 – Potential Construction and Staging Scenario for South Bridge Concept (Concept 2)

Stage	South Bridge Concept - Construction Staging and Activities	Year																No of Open Lanes Each Direction
		0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	
1	Construct Main Span and majority of tie-ins on both sides																	3
	Switch traffic to new EB Bridge																	2
2	Demolish WB approach and complete tie-ins																	2
3	Demolish EB west shore and complete tie-in on both ends																	2
	Switch all traffic to new Bridge																	3
4	Demolish the exiting main bridge																	3

Note: *Assumes a single-tower cable stayed bridge. Network arches with delta frames would take 1-2 years longer due to additional construction challenges. Numerous other construction/staging scenarios are possible.*

Figure 4 – Conceptual Drawing of South Bridge Concept

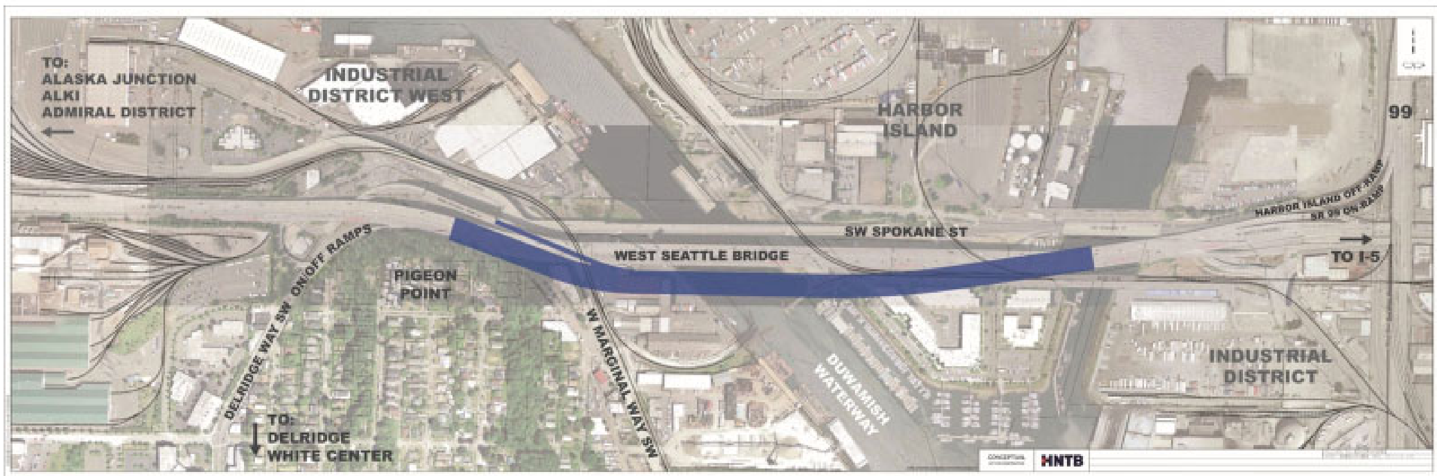


Table 6 – South Bridge Concept Evaluation Summary

SOUTH BRIDGE CONCEPT (CONCEPT 2)		
Evaluation Criteria	Measures of Comparative Differences	Effect
Capacity and Mobility		
Automobile Traffic	Access/circulation	• No substantive long-term change to access and circulation from existing bridge
	Maintenance of traffic	• Maintains existing capacity across the WSHB during construction of the new main span bridge • Reduced to 2 lanes of traffic in each direction during construction of tie-ins to existing structure (approximately 2–3 years) • Westbound access to Delridge closed during portion of WSHB demolition and reconstruction of the Delridge ramp • Night/weekend closures of West Marginal Way SW likely required to complete bridge work overhead
Transit	Effects on service, access, or operations	• Potential for transit-only lanes on the WSHB to be removed during construction; keeping the transit

Table 6 – South Bridge Concept Evaluation Summary (continued)

SOUTH BRIDGE CONCEPT (CONCEPT 2)		
Evaluation Criteria	Measures of Comparative Differences	Effect
		lane would require closure of a general-purpose lane
Freight	Effects on freight or rail facilities	• Potential construction impacts to the BNSF moveable bridge located to the south of the WSHB (Bridge No. 36.8) • Construction would also occur over and adjacent to rail lines serving Harbor Island and Terminal 5 • Construction period capacity reductions on WSB would also affect freight by increasing congestion and delays
Nonmotorized	Nonmotorized travel	• Potential temporary closure or detour of West Seattle Bridge Trail near West Marginal Way SW • Conflict with planned protected bike lanes on West Marginal Way SW, connecting the Duwamish Trail to the WSB
Navigation	Navigation restrictions	• The South Bridge Concept would not have any permanent impact to navigation • Impacts to navigation during construction would vary based on bridge type, but all bridge types may require the closure of the navigation channel for short periods of time (from multiple hours-long closures to a few days long closures) and some bridge types would restrict vertical clearance during periods of construction • A network arch with delta frames would require a complete closure of the navigation channel for up to a few days for the float-in operation and installation for each of the two bridge sections over the channel • All other potential bridge types would require channel closure during multiple, shorter stages of lifting and erecting operations • The cable-stayed bridge types would reduce the vertical navigation clearance during installation of falsework over the west channel, which could take up to 18 months • Vertical clearance would not be reduced during construction with other potential bridge types
Safety/Design Impacts	Design deviations affecting safety	• No design deviations anticipated
Corridor and Adjacent Facilities	Effects to adjacent transportation facilities	• Construction activity conflicts with BNSF existing bridge and could pose constraints on BNSF options to replace it • Direct alignment conflict with Sound Transit's DEIS Preferred Alignment (DUW-1a)

Table 6 – South Bridge Concept Evaluation Summary (continued)

SOUTH BRIDGE CONCEPT (CONCEPT 2)		
Evaluation Criteria	Measures of Comparative Differences	Effect
		• Construction staging conflicts with the Sound Transit Preferred Alternative DUW-1a from the bridge section to Pigeon Point and with both the Preferred Alternative and Alternative DUW-1b in the Pigeon Point area
Construction Activities		
Construction Challenges	Construction risk/complexity	• Constructing the new main span bridge near BNSF Bridge imposes logistic construction challenges and safety risks • The new main pier on the west shore will be very close to the BNSF Bridge approach structure that is supported on short, battered piles. Construction of the new bridge piers may cause settlement of the BNSF structure. Costly mitigation measure, such as relocating the BNSF Bridge, may be needed • BNSF lines on both ends of the new bridge impose schedule, permitting, and design risks, especially on the east shore where the tie-in structure will go almost parallel to the BNSF lines for the entire length of the tie-in structure • The west tie-in structure would extend to Pigeon Point, where slope instability poses cost and schedule risks • The Sound Transit DEIS Preferred Alternative (DUW-1a) and this concept directly conflict because their footprints overlap. The Sound Transit DEIS Alternative DUW-1b, which would be south of the concept, could significantly complicate construction, including crane activities, but they do not directly overlap • Foundations may require ground improvement that would enlarge the environmental footprint
Scope of Construction	Duration	• At least 8-10 years of construction, conducted in phases
Scale of Construction	Linear feet of new/removed infrastructure	• 3,300 linear feet
Environment		
Effects on the Natural Environment	Effects to critical areas or species	• Small portions of the South Bridge Concept to the west would be located in designated environmentally critical Geologic Hazard Areas (liquefaction-prone area, steep slope erosion hazard area, and landslide-prone areas) • The South Bridge Concept would be in a designated environmentally critical flood-prone area and a Fish and Wildlife Habitat Conservation Area (the Duwamish Waterway) • Would impact priority habitat (biodiversity area) and steep slope at Pigeon Point

Table 6 – South Bridge Concept Evaluation Summary (continued)

SOUTH BRIDGE CONCEPT (CONCEPT 2)		
Evaluation Criteria	Measures of Comparative Differences	Effect
		• The South Bridge Concept would also be located partially in the Lower Duwamish Waterway Source Control Area and the Harbor Island Superfund Site
Effects on the Built Environment	Right-of-way requirements/long term and construction	• Additional right-of-way would be required south of the existing bridge
	Property impact types and displacements	• Potential impacts to Riverside Mill/United Motor Freight, undeveloped Seattle Parks land, BNSF right-of-way (aerial; Harbor Island - under existing bridge)
	Conflicts with utilities	• No conflicts identified
Parks and Cultural Resources	Effects on properties with cultural associations or parks resources	• Potential impacts to Pigeon Point Park, part of the West Duwamish Greenbelt

Table 6 – South Bridge Concept Evaluation Summary (continued)

SOUTH BRIDGE CONCEPT (CONCEPT 2)		
Evaluation Criteria	Measures of Comparative Differences	Effect
Equity		
Community Impacts	Effects to BIPOC or low-income populations	• No direct effects to housing or community facilities associated with BIPOC or low-income populations, although reduced capacity during construction may affect mobility for BIPOC or low income populations. For extended periods, there would be slower travel through the corridor as well as more congestion on alternative routes
Business, Job Opportunities, and Access	Effects on businesses with living-wage jobs, or impacts to access to jobs	• Could eliminate living-wage jobs at industrial/manufacturing businesses south of the existing WSHB, including the Port of Seattle to the east • Access to jobs would be impacted during construction (delay, detours, etc.)

4.3. Concept 3 –On-Line Bridge Concept

The On-Line Bridge Concept (Concept 3), shown in Figure 5, is located generally in the same location as the existing WSHB and proposes a new westbound structure slightly north of the existing one but still south of the Spokane Street Bridge control tower. (Early versions of the On-Line Bridge Concept proposed a new eastbound structure slightly south of the existing WSHB. With this refined On-Line Bridge Concept, the existing eastbound alignment would be maintained, with a total cross section slightly wider than the existing bridge.)

The assumed construction approach for the On-Line Bridge Concept would begin with demolition of the north half of the existing WSHB and part of the approaches, followed by construction of the westbound main bridge and then the westbound tie-ins at either end. Once the new westbound main bridge and tie-ins are completed, the south half of the existing WSHB and part of the approaches to the main bridge would be demolished, and a new eastbound main bridge would be constructed. Lastly, the eastbound tie-ins at either end of the main bridge would be constructed. Construction could take 6 to 8 years, depending on bridge type and whether it was constructed on repurposed foundations or new foundations. Feasible bridge types for the On-Line Bridge Concept include network arches with delta frames, segmental concrete box or steel box girder, single-tower cable-stayed, cable-stayed, or steel continuous truss.

The construction and staging approaches for the On-Line Bridge Concept are summarized in Table 7. Table 8 summarizes the evaluation of the On-Line Bridge Concept.

Table 7 – Potential Construction and Staging Scenario for the On-Line Bridge Concept

Stage	On-Line Bridge Concept - Construction Staging and Activities	Year																No of Open Lanes Each Direction
		0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	
	Switch all traffic to south half of existing bridge																	2
1	Demolish north half existing bridge and part approaches																	2
2	Construct W Main Span																	2
3	Construct WB E Tie-In and W Tie-In																	2
	Switch all traffic to WB Bridge																	2
4	Demolish south half existing bridge and part approaches																	2
5	Construct EB Main Span																	2
6	Construct EB E Tie-In and W Tie-In																	2
	Open EB Bridge and switch traffic																	3

Note: *Assumes network arches and delta frames. A segmental box girder and cable stayed-bridge type would take approximately 1-2 years longer. Numerous other construction/staging scenarios are possible.*

Figure 5 – Conceptual Drawing of On-Line Bridge Concept

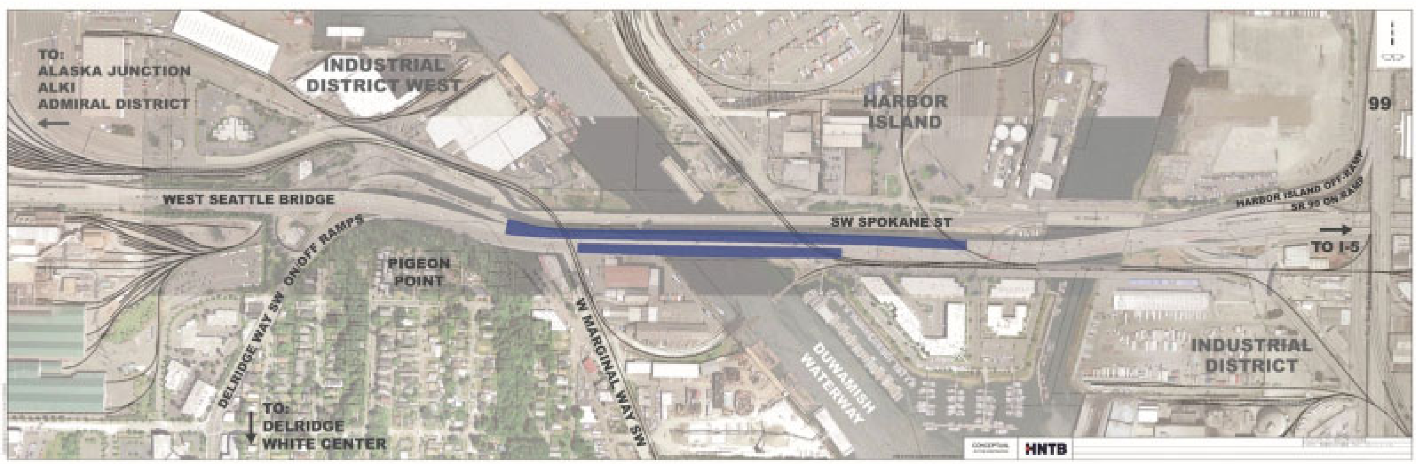


Table 8 – On-Line Bridge Concept Evaluation Summary

ON-LINE BRIDGE CONCEPT (CONCEPT 3)		
Evaluation Criteria	Measures of Comparative Differences	Effect
Capacity and Mobility		
Automobile Traffic	Access/circulation	• No substantive long-term change to access and circulation from existing bridge
	Maintenance of traffic	• Two lanes of traffic would be open in each direction for the duration of construction
Transit	Effects on service, access, or operations	• Potential for transit-only lanes on the WSHB to be removed during construction; keeping the transit lane would require closure of a general-purpose lane
Freight	Effects on freight or rail facilities	• No direct long-term impacts.

Table 8 – On-Line Bridge Concept Evaluation Summary (continued)

ON-LINE BRIDGE CONCEPT (CONCEPT 3)		
Evaluation Criteria	Measures of Comparative Differences	Effect
		• Reduced capacity on WSB during construction would affect freight traffic with additional congestion and delays. • Replacement of the bridge would be above rail lines serving the Port, including Harbor Island and Terminals 5 and 18
Nonmotorized	Nonmotorized travel	• Potential temporary closure or detour of West Seattle Bridge Trail near West Marginal Way SW during demolition
Navigation	Navigation restrictions	• The On-Line Bridge Concept would not have any permanent impact to navigation • Impacts to navigation during construction would vary based on bridge type, but all bridge types may require the closure of the navigation channel for short periods of time (from multiple hours-long closures to a few days long closures) and some bridge types would restrict vertical clearance during periods of construction • The network arch with delta frames, steel continuous truss, and steel box girder bridge types would require a complete closure of the navigation channel for up to a few days for the float-in operation and installation for each of the two bridge sections over the channel • All other potential bridge types would require channel closure during multiple, shorter stages of lifting and erecting operations • The cable-stayed and concrete segmental box girder bridge types would reduce the vertical navigational clearance during installation of falsework over the west channel, which could take up to 18 months • Vertical clearance would not be reduced during construction with other potential bridge types
Safety/Design Impacts	Design deviations affecting safety	• None
Corridor and Adjacent Facilities	Effects to adjacent transportation facilities	• No direct conflicts • Construction would be above BNSF rail lines serving the Port of Seattle • Potential construction staging conflicts with Sound Transit's DEIS Preferred Alternative (DUW-1a) and DUW-1b
Construction Activities		
Construction Challenges	Construction risk/complexity	• Demolishing one-half of the bridge under live traffic on the other half of the bridge poses some technical challenges and will require median barrier removal and the use of temporary barriers

Table 8 – On-Line Bridge Concept Evaluation Summary (continued)

ON-LINE BRIDGE CONCEPT (CONCEPT 3)		
Evaluation Criteria	Measures of Comparative Differences	Effect
		• The remaining one-half bridge may require interim rehabilitation for seismic design to be used as an independent structure to carry live traffic, which has potential design, implementation, and cost risks • Temporary supports could be required for demolition of the existing bridge; potential reuse of these temporary piers could be considered for new bridge construction • Repurposing or rebuilding the existing foundations would enable shorter spans and more feasible bridge types, but rehabilitating the existing foundations would be challenging because of the battered piles and existing ground improvement • Constructing the new main span bridge near BNSF Bridge carries construction challenges and safety risks, although there is more separation than with the South Bridge Concept • The existing BNSF Bridge is settlement sensitive such that construction of the new bridge piers may impact movable bridge operations • BNSF lines on both ends of the new bridge impose schedule, permitting, and design risks • The west tie-in structure will encroach to Pigeon Point where slope stability is potentially a cost and schedule risk • The foundations may require ground improvements, which could enlarge the environmental footprint • The Sound Transit DEIS Preferred Alternative (DUW-1a) and this concept do not directly conflict because their footprints are separate, but the presence of DUW-1a near the current bridge and its foundations could complicate construction and demolition, including crane activities or foundation work
Scope of Construction	Duration	• At least 6–8 years of total construction time (at least 6 for network arch, longer for other bridge types), with construction conducted in phases to maintain traffic
Scale of Construction	Linear feet of new/removed infrastructure	• 1,700 linear feet eastbound • 2,300 linear feet westbound
Environment		
Effects on the Natural Environment	Effects to critical areas or species	• Potential to encroach upon steep slope at Pigeon Point where the new tie-ins are constructed • Portions of the On-Line Bridge Concept would be located in designated environmentally critical Geologic Hazard Areas (liquefaction-prone area, steep slope erosion hazard area, and landslide-prone areas), a flood-prone area, and Fish and Wildlife

Table 8 – On-Line Bridge Concept Evaluation Summary (continued)

ON-LINE BRIDGE CONCEPT (CONCEPT 3)		
Evaluation Criteria	Measures of Comparative Differences	Effect
		Habitat Conservation Areas (including the Duwamish River and Pigeon Point) • Would be located partially in the Lower Duwamish Waterway Source Control Area and the Harbor Island Superfund Site
Effects on the Built Environment	Right-of-way requirements/long term and construction	• No permanent acquisition of right-of-way would be required • Temporary easements for construction staging would be needed
	Property impact types and displacements	• Riverside Mill (potential aerial easement) • Potential displacement related to temporary support required for demolition of existing bridge
	Conflicts with utilities	• No conflicts identified
Parks and Cultural Resources	Effects on properties with cultural associations or parks resources	• Potential impacts to Pigeon Point Park, part of the West Duwamish Greenbelt • No permanent effects on cultural resources
Equity		
Community Impacts	Effects to BIPOC or low-income populations	• No direct effects to housing or community facilities associated with BIPOC or low-income populations, although reduced capacity during construction may affect mobility for BIPOC or low income populations. For extended periods, there would be slower travel through the corridor as well as more congestion on alternative routes
Business, Job Opportunities, and Access	Effects on businesses with living-wage jobs, or impacts to access to jobs	• No permanent effects on businesses with living-wage jobs • Access to jobs would be impacted during construction (delay, detours, etc.)

4.4. Concept 13 – Hybrid Bridge Concept

The Hybrid Bridge Concept (Concept 13), shown in Figure 6, is a combination of the North Bridge Concept (Concept 1) and the On-Line Bridge Concept (Concept 3), intended to utilize existing right-of-way and maintain up to three lanes of traffic in each direction during the construction.

Construction of the Hybrid Bridge Concept would begin with the construction of a new westbound main bridge to the north of the existing WSHB, then the tie-ins at either end of the new bridge, followed by the demolition of the south half of the existing WSHB and part of the approaches. Next, a new eastbound main bridge, followed by tie-ins at either end, would be constructed, followed by the demolition of the north half of the existing WSHB and part of the approaches. Up to three lanes of traffic would be open in each direction for the duration of construction. Construction sequencing required to maintain access to Delridge would limit some concurrent construction activities, somewhat extending the duration of construction. Feasible bridge types for the Hybrid Bridge Concept include network arches with delta frames, single-tower cable-stayed, cable-stayed, and steel continuous truss.

The construction and staging for the Hybrid Bridge Concept is summarized in Table 9 and Table 10 summarizes the evaluation of the Hybrid Concept.

Table 9 – Potential Construction and Staging Scenario for Hybrid Bridge Concept (Concept 13)

Stage	Hybrid Bridge Concept - Construction Staging and Activities	Year																No of Open Lanes Each Direction
		0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	
1	Construct WB Main Span																	3
2	Construct WB E Tie-In and W Tie-In																	3
	Open WB Bridge to traffic and switch existing EB onto north half of existing bridge																	3
3	Demolish south half existing bridge and part approaches																	3
4	Construct EB Main Span																	3
5	Construct EB E Tie-In and W Tie-In																	3
	Open EB Bridge to EB traffic																	3
6	Demolish north half of existing and part approaches																	3

Note: *Assumes network arches and delta frames. A segmental box girder and cable stayed-bridge type would take approximately 1-2 years longer. Numerous other construction/staging scenarios are possible.*

Figure 6 – Conceptual Drawing of the Hybrid Bridge Concept

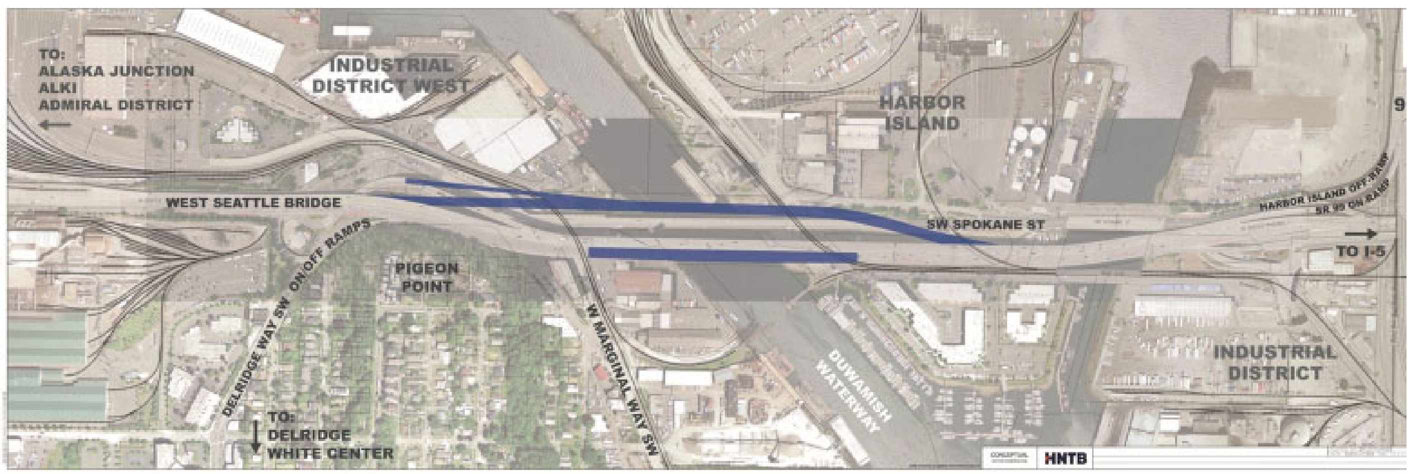


Table 10 – Hybrid Bridge Concept Evaluation Summary

HYBRID BRIDGE CONCEPT (CONCEPT 13)		
Evaluation Criteria	Measures of Comparative Differences	Effect
Capacity and Mobility		
Automobile Traffic	Access/circulation	• No substantive long-term change to access and circulation from existing bridge
	Maintenance of traffic	• Up to three lanes of traffic would be open in each direction for the majority of the construction period, with potentially two 6-week periods with 3 lanes/2 lanes or other configurations • Night/weekend closures of several surface streets likely required to complete bridge work overhead • Some traffic control/maintenance (e.g., rolling closures and flagging) on the Terminal 5 Flyover likely required to complete bridge work overhead • Weekend closure of westbound access to Delridge required to construct tie-in
Transit	Effects on service, access, or operations	• Potential for transit-only lanes on the WSHB to be removed during construction; keeping the transit lane would require closure of a general-purpose lane
Freight	Effects on freight or rail facilities	• No direct long-term impacts • Reduced capacity on WSB during construction would affect freight traffic with additional congestion and delays • Replacement of the bridge with two separate spans would place construction above rail lines serving the Port, including Harbor Island and Terminals 5 and 18 • The new north bridge would have construction above and adjacent to access roads to Terminals 5 and 18
Nonmotorized	Nonmotorized travel	• Potential temporary closure or detour of West Seattle Bridge Trail near SW Manning Street
Navigation	Navigation restrictions	• The Hybrid Bridge Concept would not have any permanent impact to navigation • Impacts to navigation during construction would vary based on bridge type, but all bridge types may require the closure of the navigation channel for short periods of time (from multiple hours-long closures to a few days long closures) and some bridge types would restrict vertical clearance during periods of construction • The network arch with delta frames, steel continuous truss, and steel box girder bridge types would require a complete closure of the navigation channel for up to a few days for the float-in operation and installation for each of the two bridge sections over the channel • All other potential bridge types would require channel closure during multiple, shorter stages of lifting and erecting operations • The cable-stayed and concrete segmental box girder bridge types would reduce the vertical navigation clearance

Table 10 – Hybrid Bridge Concept Evaluation Summary (continued)

HYBRID BRIDGE CONCEPT (CONCEPT 13)		
		during installation of falsework over the channel, which could take up to 18 months • Vertical clearance would not be reduced during construction with other potential bridge types
Safety/Design Impacts	Design deviations affecting safety	• None anticipated
Corridor and Adjacent Facilities	Effects to adjacent transportation facilities	• New bridge foundation construction in the vicinity of the Spokane Street swing bridge pivot and rest piers. Given displacement sensitivity of swing bridge machinery and operations, this represents enhanced risk for this alignment • Potential conflicts or constraints to Port access facilities during construction, including access to Terminal 5 (T5 Flyover) and Terminal 18, as well as to BNSF rail facilities for Harbor Island and Terminal 18 • Potential construction staging conflicts with Sound Transit's DEIS Preferred Alternative DUW-1a and DUW-1b
Construction Activities		
Construction Challenges	Construction risk/complexity	• Demolishing one half of the bridge under live traffic on the other half of the bridge is a safety risk with many logistic challenges • The remaining one-half bridge would likely require rehabilitation for seismic design to be used as an independent structure to carry live traffic, which has potential design, safety, and cost risks • Constructing the new eastbound main span bridge near the BNSF Bridge imposes logistical construction challenges and safety risks • Repurposing or rebuilding the existing foundations would enable shorter spans and more feasible bridge types for the new eastbound bridge, but rehabilitating existing foundations would be challenging because of the battered piles and existing ground improvement • Temporary supports would be required for demolition of the existing bridge; potential reuse of these temporary piers could be considered for new bridge construction • The new main pier for the eastbound bridge on the west shore will be close to the BNSF Bridge approach structure that is supported on short, battered piles. Construction of the new bridge piers may cause settlement of the BNSF structure • Constructing the new westbound main span bridge near the Spokane Street low bridge imposes logistical construction challenges and safety risks • BNSF lines on both ends of the new westbound main spans impose schedule, permitting, and design risks • Building the approach tie-in structures on either end over the live traffic from WSB and Spokane Street is a safety risk

Table 10 – Hybrid Bridge Concept Evaluation Summary (continued)

HYBRID BRIDGE CONCEPT (CONCEPT 13)		
		• There are limited locations to place the columns for the tie-in structures, so longer spans and/or steel structures instead of PS girders would likely be needed, which would be a potential cost escalation risk. The foundations may require ground improvement that will enlarge the environmental footprint • The Sound Transit DEIS Preferred Alternative (DUW-1a) and this concept do not directly conflict because their footprints are separate, but new foundations for a cable-stayed or single -tower cable-stayed bridge type would be close to the DUW-1a alignment and could complicate bridge construction and demolition, including crane activities or foundation work. To the west of the bridge, where connecting elevated sections may need improvements, Sound Transit DEIS Alternative DUW-1b could pose construction period conflicts as well
Scope of Construction	Duration	• At least 6.5–8.5 years
Scale of Construction	Linear feet of new/removed infrastructure	• 3,300 linear feet (westbound) • 1,700 linear feet (eastbound)
Environment		
Effects on the Natural Environment	Effects to critical areas or species	• Crosses over the Bernice White Place natural resource mitigation site, with the potential to place columns within the site • Portions of the Hybrid Bridge Concept would be located in designated environmentally critical Geologic Hazard Areas (liquefaction-prone area, steep slope erosion hazard area, and landslide-prone areas), a flood-prone area, and Fish and Wildlife Habitat Conservation Areas (including the Duwamish River and Pigeon Point) • Would be located partially in the Lower Duwamish Waterway Source Control Area and the Harbor Island Superfund Site
Effects on the Built Environment	Right-of-way requirements/long term and construction	• Limited new permanent right-of-way needs • Temporary easements for construction staging would be needed
	Property impact types and displacements	• Riverside Mill (potential need for aerial easement) • Potential displacement related to temporary support required for demolition of existing bridge
	Conflicts with utilities	• The Hybrid Bridge Concept may conflict with Seattle City Light transmission lines to the north
Parks and Cultural Resources	Effects on properties with cultural associations or parks resources	• No impacts anticipated
Equity		
Community Impacts	Effects to BIPOC or low-income populations	• No direct effects to housing or community facilities associated with BIPOC or low-income populations, although reduced capacity during construction may affect mobility for BIPOC or low-income populations. For

Table 10 – Hybrid Bridge Concept Evaluation Summary (continued)

HYBRID BRIDGE CONCEPT (CONCEPT 13)		
		extended periods, there would be slower travel through the corridor as well as more congestion on alternative routes
Business, Job Opportunities, and Access	Effects on businesses with living-wage jobs or impacts to access to jobs	• No direct impacts to properties or jobs, but a north bridge in the City right-of-way would be adjacent to existing enterprises, with the potential to temporarily impact their operations • Access to jobs would be impacted during construction (delay, detours, etc. due to the bridge being constructed over access routes)

4.5. Concept 4 - Tunnel Concept

The Tunnel Concept (Concept 4), shown in Figure 7, did not perform well in the initial feasibility assessment, and no further engineering study or refinement was performed. However, the planning team used a representative Tunnel Concept to predict the potential performance of a tunnel across a broader range of evaluation criteria in this concept evaluation. The representative concept is a tunnel located just south of the existing WSHB, with helix access points on either side of the west channel of the Duwamish Waterway. In addition to the basic footprint assumption shown above, one or more tunnel ventilation and emergency access/egress facilities and other maintenance facilities would be required. The Tunnel Concept would also require reconstructing all ramps and access points between Avalon Way and SR 99, including portions of the SR 99/West Seattle Bridge interchange, but these details were not advanced beyond the initial feasibility assessment. A more complex program for sequencing and maintenance of traffic would also be needed, given the tunnel tie-ins near the SR 99 interchange system and the Delridge and Avalon ramp connections.

Detailed construction phasing was not evaluated for the Tunnel. Table 11 summarizes the evaluation of the Tunnel Concept.

Figure 7 – Conceptual Drawing of the Tunnel Concept

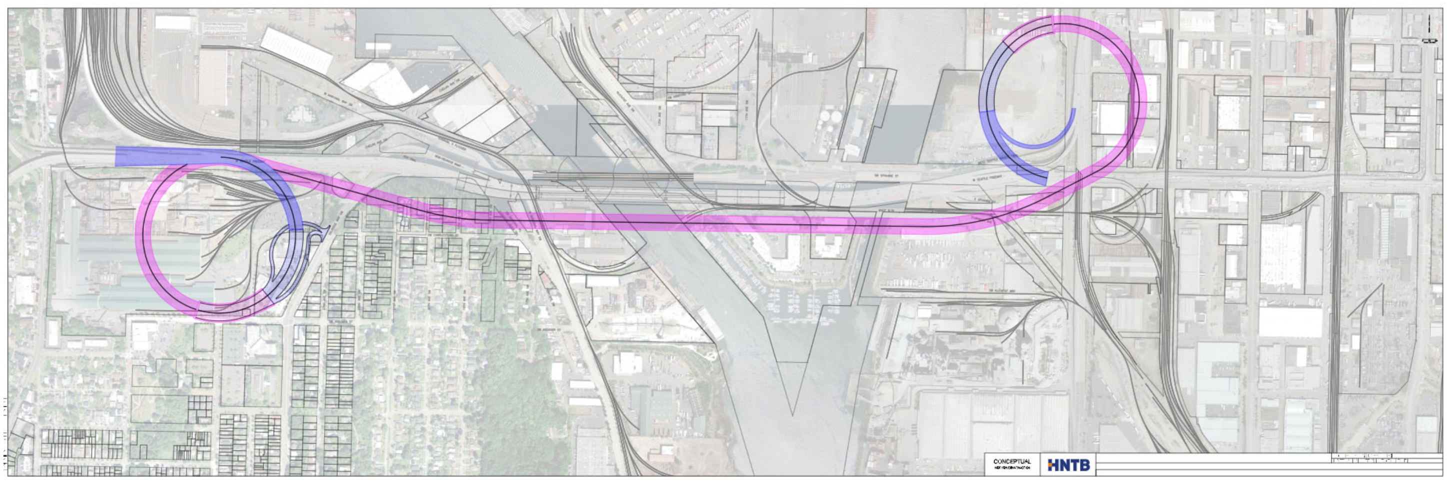


Table 11 – Tunnel Concept Evaluation Summary

TUNNEL CONCEPT		
Evaluation Criteria	Measures of Comparative Differences	Effect
Capacity and Mobility		
Automobile Traffic	Access/circulation	• Access and circulation would be substantially altered compared to the existing bridge due to revision of multiple ramp and access points, and a longer route with reduced speeds • A crossing of the Duwamish River would be maintained, but access to the facility would be reduced compared to existing • The completed tunnel would require slower speeds and increase the distance between the connecting points and, therefore, create longer travel times
	Maintenance of traffic	• Traffic could be maintained on the WSHB but would be interrupted and reduced during the challenging tie-in work at both ends, particularly considering the SR 99 interchange
Transit	Effects on service, access, or operations	• Transit-only lanes across the WSHB would be maintained through construction but would be impacted/closed at tie-in points to the west and east
Freight	Effects on freight or rail facilities	• Some existing freight access routes to the corridor would be affected during construction, and some may be permanently altered or consolidated • Access to and from WSB and Spokane Street and Harbor Island could also be affected during construction and potentially reconfigured long term • Some freight (such as flammable materials) may not be allowed to travel through the tunnel, requiring the use of an alternate route
Nonmotorized	Nonmotorized travel	• Existing multiuse trail may need to be rerouted due to conflicts with the new structure at the east and west tie-in locations • Conflict with planned protected bike lane/multiuse path on East Marginal Way S between S Atlantic St and Spokane Street
Navigation	Navigation restrictions	• Maintains long-term navigation, but temporary impacts during construction may still occur, especially if construction under the Duwamish Waterway cannot be conducted without in-water construction or vessel restrictions
Safety/Design Impacts	Design deviations affecting safety	• Tighter curves and increased slopes in multiple locations would restrict sight distances and may increase safety concerns • Potential need to restrict hazardous materials transport within the tunnel to protect public safety
Corridor and Adjacent Facilities	Effects to adjacent transportation facilities	• The tunnel would require the reconfiguration of the SR 99 interchange to the east and to Fauntleroy and Delridge connections to the west

Table 11 – Tunnel Concept Evaluation Summary (continued)

TUNNEL CONCEPT		
Evaluation Criteria	Measures of Comparative Differences	Effect
		• Potential conflicts with Sound Transit DEIS alternatives both long term and during construction, including due to the western helix, and potentially with Sound Transit foundations to the east of the crossing to SR 99, affecting Sound Transit's DEIS Preferred Alternative (DUW-1a) and DUW-1b
Construction Activities		
Construction Challenges	Construction risk/complexity	• Tunneling through poor soil and fill, including under waterways • Extensive property acquisition needs • Prolonged construction impacts (spoils removal, hauling, decommissioning, and demolition) • Staging and construction period access for tunneling equipment, materials, and spoils removal in developed areas. • Potential to encounter buried archaeological deposits in former tideflats • Challenges in siting tunnel ventilation and emergency access facilities
Scope of Construction	Duration	• At least 10 years
Scale of Construction	Linear feet of new/removed infrastructure	• 14,000 linear feet
Environment		
Effects on the Natural Environment	Effects to critical areas or species	• Potential to impact Pigeon Point Park natural area • Located in an environmentally critical designated liquefaction-prone area and flood-prone area
Effects on the Built Environment	Right-of-way requirements/long term and construction	• A large amount of new right-of-way would be required in areas that are already developed for other uses. • Tunnel ventilation and emergency access facilities at ground level would increase the extent of property needed
	Property impact types and displacements	• Port of Seattle property (at 2917 East Marginal Way S) • Nucor Steel • Frye Commerce Center • Delridge Villas/Ounces Taproom and Beer Garden • Skylark Café and Club • Warehouse properties
	Conflicts with utilities	• Potential conflict with underground utilities; may not impact above-ground transmission lines
Parks and Cultural Resources	Effects on properties with cultural associations or parks resources	• Potential impacts to Pigeon Point Park, part of the Duwamish Greenbelt • Tunneling through areas with higher potential to hold archaeological deposits
Equity		
Community Impacts	Effects to BIPOC or low-income populations	• Greater potential to reduce access to the corridor from BIPOC or low-income areas

Table 11 – Tunnel Concept Evaluation Summary (continued)

TUNNEL CONCEPT		
Evaluation Criteria	Measures of Comparative Differences	Effect
		• More impacts to communities along haul routes over the extended construction period • Potential air quality impacts from tunnel ventilation could affect BIPOC or low-income populations
Business, Job Opportunities, and Access	Effects on businesses with living-wage jobs or impacts to access to jobs	• Greatest effect on businesses because of extended construction timeline, amount of property affected, and disruptions to corridor access and circulation • Potential loss of living-wage jobs at industrial and port-related enterprises that would be difficult to relocate if displaced

5. SUMMARY OF KEY FINDINGS

Graphic representation of the comparative results of the concept evaluation is shown in Figure 8, which indicates areas where there were notable differences in the performance of the concepts in the major groups of criteria. Table 12 describes these differences in more detail in comparison across the concepts. The Tunnel Concept is included in the tables for comparative purposes, but is shown in grey to indicate that the design concept, as well as the key findings regarding the tunnel, were developed at a less detailed level than for the other concepts because the feasibility screening found that it would be less effective in meeting the purpose and need for a replacement to the WSHB.

Figure 8 – Summary of Concept Evaluation Findings

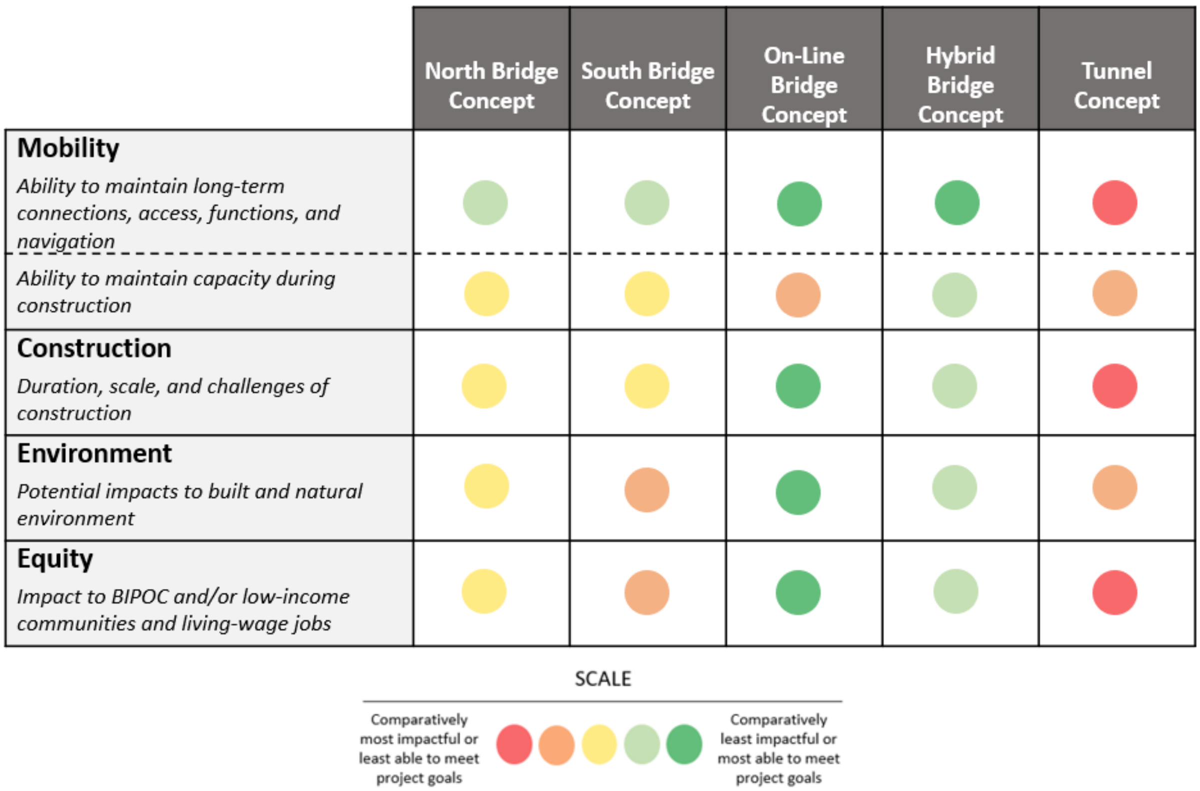


Table 12 – Summary of Key Concept Evaluation Findings

	North Bridge Concept	South Bridge Concept	On-Line Bridge Concept	Hybrid Bridge Concept	Tunnel Concept
	Located north of both the WSHB and the Spokane Street Bridge, from just past Pigeon Point to the west and before the east channel of the Duwamish Waterway to the east; refined to maintain existing grade at the Delridge ramps.	Located south of the WSHB, between Pigeon Point to the west and near the west side of the east channel of the Duwamish Waterway to the east.	Located generally in the same location as the existing WSHB, extending slightly farther north, but still south of the low bridge control tower, with a slightly wider cross section than the existing bridge; refined by moving the new westbound structure slightly north of the existing bridge, followed by a new eastbound structure.	A new westbound structure would be built slightly north of the WSHB, and a new eastbound structure would follow the existing eastbound lanes of the WSHB, except slightly wider.	Located just south of the WSHB, with helix access points on either side of the Duwamish Waterway
Capacity and Mobility					
Would the completed replacement WSHB maintain connections and functional services?	Yes, long-term access and circulation would be equivalent to the existing bridge	Yes, long-term access and circulation would be equivalent to the existing bridge	Yes, long-term access and circulation would be equivalent to the existing bridge	Yes, long-term access and circulation would be equivalent to the existing bridge	No, access and circulation would be substantially altered compared to the existing bridge, speeds would be slower, and travel times would be longer
Would the project impact navigation?	No permanent impacts to navigation May restrict navigation for short periods of time during construction. Proximity to low bridge could be challenging	No permanent impacts to navigation May restrict navigation for short periods of time during construction. Proximity to the BNSF Bridge could be challenging	No permanent impacts to navigation May restrict navigation for short periods of time during construction	No permanent impacts to navigation May restrict navigation for short periods of time during construction	No permanent impacts to navigation Temporary impacts to navigation may occur, depending on construction technique
How much would capacity be reduced during construction and for how long?	Capacity would be reduced to 2 lanes in each direction for at least 3–4 years during tie-in construction Closure of Delridge ramps during some phases of construction Some night and weekend closures of surface streets	Capacity would be reduced to 2 lanes in each direction for at least 2–3 years during tie-in construction	Capacity would be reduced to 2 lanes in each direction for the duration of construction	No reduction of capacity for all or most of construction (would maintain up to 3 lanes in each direction) Capacity could be reduced to 5 lanes for some phases of construction Weekend closures at westbound tie-in affecting Delridge Some night and weekend closures of surface streets	Capacity would be maintained on the WSHB, but would be interrupted and reduced at times during construction at tie-in locations at both ends

Table 12 – Summary of Key Concept Evaluation Findings (continued)

Would the project impact the corridor or adjacent facilities?	Port access facilities (including the Terminal 5 Flyover and Terminal 18) and BNSF rail facilities for Harbor Island and Terminal 18 would be impacted	Potential construction impacts to BNSF Bridge and direct conflict with Sound Transit's Preferred Alternative DUW-1a and Alternative DUW-1b in the Pigeon Point area	No direct conflict, but construction would occur over BNSF rail lines, and there may be construction staging conflicts with Sound Transit's DEIS Preferred Alternative (DUW-1a) and DUW-1b	No direct conflicts, but construction would occur near the Spokane Street Bridge, and there may be construction staging conflicts with Sound Transit's DEIS Preferred Alternative (DUW-1a) and DUW-1b	The SR 99 interchange to the east and to Fauntleroy and the Delridge connections to the west would need to be reconfigured Potential conflicts with Sound Transit DEIS alternatives, both long term and during construction, including conflicts with the western helix and potentially with Sound Transit foundations to the east of the crossing to SR 99, affecting Sound Transit's DEIS Preferred Alternative (DUW-1a) and DUW-1b
Construction					
Approximately how long would construction and demolition take?	At least 8-10 years	At least 8-10 years	At least 6-8 years	At least 6.5-8.5 years	At least 10 years
How much new infrastructure would be constructed?	~ 3,400 linear feet	~ 3,300 linear feet	~ 1,700 linear feet eastbound ~ 2,300 linear feet westbound	~ 1,700 linear feet eastbound ~ 3,300 linear feet westbound	~ 14,000 linear feet
Major construction challenges?	Longer span would limit bridge type options Proximity to low bridge and BNSF Construction over live traffic Limited space to place columns for tie-in structures	Longer span would limit bridge type options Proximity to BNSF and Sound Transit alignments to the south would make construction challenging	Maintenance of traffic relies on temporary seismic retrofit to existing bridge foundations to allow for phased construction Construction would occur in very close proximity to low bridge and BNSF, as well as Sound Transit alignments to the south (Preferred Alternative DUW-1a and Alternative DUW-1b) in the Pigeon Point area	Longer span would limit bridge type options Construction would occur in very close proximity to low bridge and BNSF, as well as Sound Transit alignments to the south (Preferred Alternative DUW-1a and Alternative DUW-1b) in the Pigeon Point area	Extensive property acquisition needs Tunneling through poor soil, through fill, and under waterways Higher potential for archaeological resources Locating construction staging, storage, and haul access for spoils and construction materials Locating emergency access and tunnel ventilation systems Potential conflicts with Sound Transit alignments to the south (Preferred Alternative DUW-1a and Alternative DUW-1b)

Table 12 – Summary of Key Concept Evaluation Findings (continued)

Environment					
Would the project impact environmentally critical areas or species?	Minor construction impacts possible; no permanent impacts	Yes, minor construction impacts possible and permanent impacts to Pigeon Point (steep slope, critical habitat)	No permanent impacts other than minor potential impact to Pigeon Point (steep slope, critical habitat)	No permanent impacts, but some minor construction impacts.	Yes, construction impacts likely and potential permanent impacts to Pigeon Point (steep slope, critical habitat) and the Duwamish Waterway
Would the project conflict with existing utilities?	Yes, would conflict with City transmission lines	No conflicts identified	No conflicts identified	Yes, minor conflict with City transmission lines	Yes
Equity					
Would low- or living-wage jobs be impacted?	Yes	Yes	No permanent impacts but some temporary construction impacts	Yes, but fewer than North and South bridges	Yes
Would the project impact BIPOC or low-income communities?	No direct impacts to housing or facilities associated with BIPOC or low-income communities, but potential impacts due to impacts to employers with living-wage jobs, including reduced access to Port enterprises	No direct impacts to housing or facilities associated with BIPOC or low-income communities, but some potential impacts due to impacts to employers with living-wage jobs, including reduced access to Port enterprises	No direct impacts to housing or facilities associated with BIPOC or low-income communities	No direct impacts to housing or facilities associated with BIPOC or low-income communities, but potential impacts due to impacts to employers with living-wage jobs, including reduced access to Port enterprises	Loss and change to access to the corridor, loss of employment opportunities, loss of housing, and the magnitude and length of major construction period affecting a large area would impact BIPOC and low-income communities

APPENDIX F

Nonmotorized Assessment

WEST SEATTLE HIGH BRIDGE LONG-TERM REPLACEMENT PLANNING

Nonmotorized Evaluation
White Paper

December 2021

PREPARED FOR

Seattle Department of Transportation

PREPARED BY

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INTRODUCTION

To protect public safety, the West Seattle Bridge (often referred to as the high bridge, West Seattle High Bridge or WSHB) over the west channel of the Duwamish Waterway was closed in 2020 due to the accelerated growth of new and existing structural cracks. Repairs began in 2020 and the bridge is anticipated to reopen in mid-2022, but the WSHB will eventually need to be replaced. This white paper supports a planning effort underway to evaluate and determine the long-term replacement strategy for the WSHB.

This document summarizes analysis related to nonmotorized facilities in the Spokane Street Corridor, attempting to answer the following questions:

(1) Based on the City's West Seattle High Bridge Replacement planning, has a need for additional nonmotorized capacity in this corridor been identified?

(2) If there is a need, is the need great enough to warrant a new or upgraded facility?

(3) If the need warrants a new or improved facility, which corridor and what infrastructure (e.g., high or low facilities) could best serve this need?

Lastly, this document summarizes potential approaches to providing nonmotorized facilities across the Duwamish Waterway, including potential benefits and trade-offs of each approach. Figure 1 shows the existing bridge and its setting, along with existing nonmotorized facilities.

West Seattle High Bridge Replacement Planning

The West Seattle High Bridge Replacement Planning effort is evaluating potential long-term replacement solutions. The core purpose of a future replacement for the Duwamish Waterway crossing is to maintain long-term capacity, safety, mobility and access for West Seattle and the region.

The primary design objectives for a long-term solution are to:

- Replace the connections and functions of the West Seattle High Bridge
- Maintain the navigation clearances of the bridge
- Meet current minimum design standards for a 45-mph freeway
- Maintain mobility for the crossing during the construction period of the replacement, avoiding full or prolonged closures of the crossing

The City of Seattle (SDOT) developed and evaluated five representative concepts:

- North Bridge Alignment (Concept 1)
- South Bridge Alignment (Concept 2)
- On-Line Bridge Alignment (Concept 3)
- Hybrid Bridge Alignment (Concept 13 – combination of On-Line and North Alignments)
- Tunnel (Concept 4)

Based on the evaluation, the City found the most advantages with the On-Line Bridge Alignment (Concept 3) and the Hybrid Bridge Alignment (Concept 13), both of which remain largely in the City's existing Spokane Street Corridor transportation right-of-way and can be implemented within a project area that lies between Delridge Way SW and Harbor Island. For more information on the concepts, see the West Seattle High Bridge Draft

Concept Evaluation Memo (Attachment E). The nonmotorized evaluation builds on the evaluation findings, primarily for the definition of the new infrastructure needed for a future high bridge span replacement project.

EXISTING CONDITIONS

Below the WSHB, the Alki Trail and West Seattle Bridge Trail provide a nonmotorized connection between West Seattle and SODO across the Duwamish River via the lower Spokane Street bridge. As described in the City of Seattle's Bicycle Master Plan (BMP), this nonmotorized corridor is part of the Citywide Network, which is intended to not only provide short-distance connections to neighborhood destinations but also to provide an all ages and abilities connection to destinations throughout the City. This nonmotorized corridor is also identified in the BMP as part of the Regional Bicycle Network. Regional bicycle connections are critical to achieving growth targets for increased bicycle travel because they provide connections to neighboring jurisdictions and other regional destinations. The Alki Trail and West Seattle Bridge Trail are the only Citywide Network connection between the West Seattle peninsula and the remainder of Seattle. The nearest alternative crossings of the Duwamish River are located more than 3 miles to south, via the 1st Avenue South Bridge or the South Park Bridge at 16th Avenue S. Additionally, the 1st Avenue South Bridge is included as part of the Local Connector Network rather than the Citywide Network, indicating that it is not intended to be a primary route for regional nonmotorized connections.

As shown on Figure 1, there are multiple bicycle corridors connecting to the Alki Trail and West Seattle Bridge Trail that provide access to and from other West Seattle neighborhoods, including Alki, Admiral, the Junction, Delridge, and White Center. The facility types for these connections range from neighborhood greenways to protected bicycle lanes. However, many of these facilities do not provide complete connections to the neighborhood centers they are intended to serve. The bicycle lanes on Delridge Way SW[1] currently terminate near the Delridge Community Center and the protected bicycle lanes on SW Avalon Way terminate at Fauntleroy Way SW.

The West Seattle Bridge Trail also provides access for pedestrians across the Duwamish Waterway. The corridor is not included in the City's Pedestrian Master Plan (PMP) as a priority investment corridor. Priority investment corridors were identified in the 2017 PMP as priorities for pedestrian investments because they provide access to schools and frequent transit stops and are likely to be locations where people most need to walk in the city. The Spokane Street Corridor is mostly surrounded by industrial lands, and while the corridor can be walked, there are fewer intermediate destinations. There are nearby roadways to the West Seattle Bridge Trail that are included in the priority investment corridors, including portions of SW Admiral Way. The PMP also identifies arterial street segments where infrastructure modifications appear likely to make streets even safer for pedestrians. In the study area, several streets have been identified as priorities for safety improvements, including portions of the Alki Trail beneath the WSHB, SW Avalon Way, SW Admiral Way, and Delridge Way SW.

The City of Seattle's Vision Zero Bicycle and Pedestrian Safety Analysis also identified priority locations for safety improvements to avoid and/or address pedestrian and bicycle crashes with vehicles. There are several locations along the West Seattle Bridge Trail, including at Delridge Way SW, SW Spokane Street, and Chelan Avenue SW, that are identified as priority locations for preventing bicycle crashes with vehicles.

[1] Bicycle facilities on Delridge Way SW are being built as part of the RapidRide H Line improvements. A southbound protected bicycle lane will be constructed on Delridge Way SW between SW Juneau Street and SW Cambridge Street.

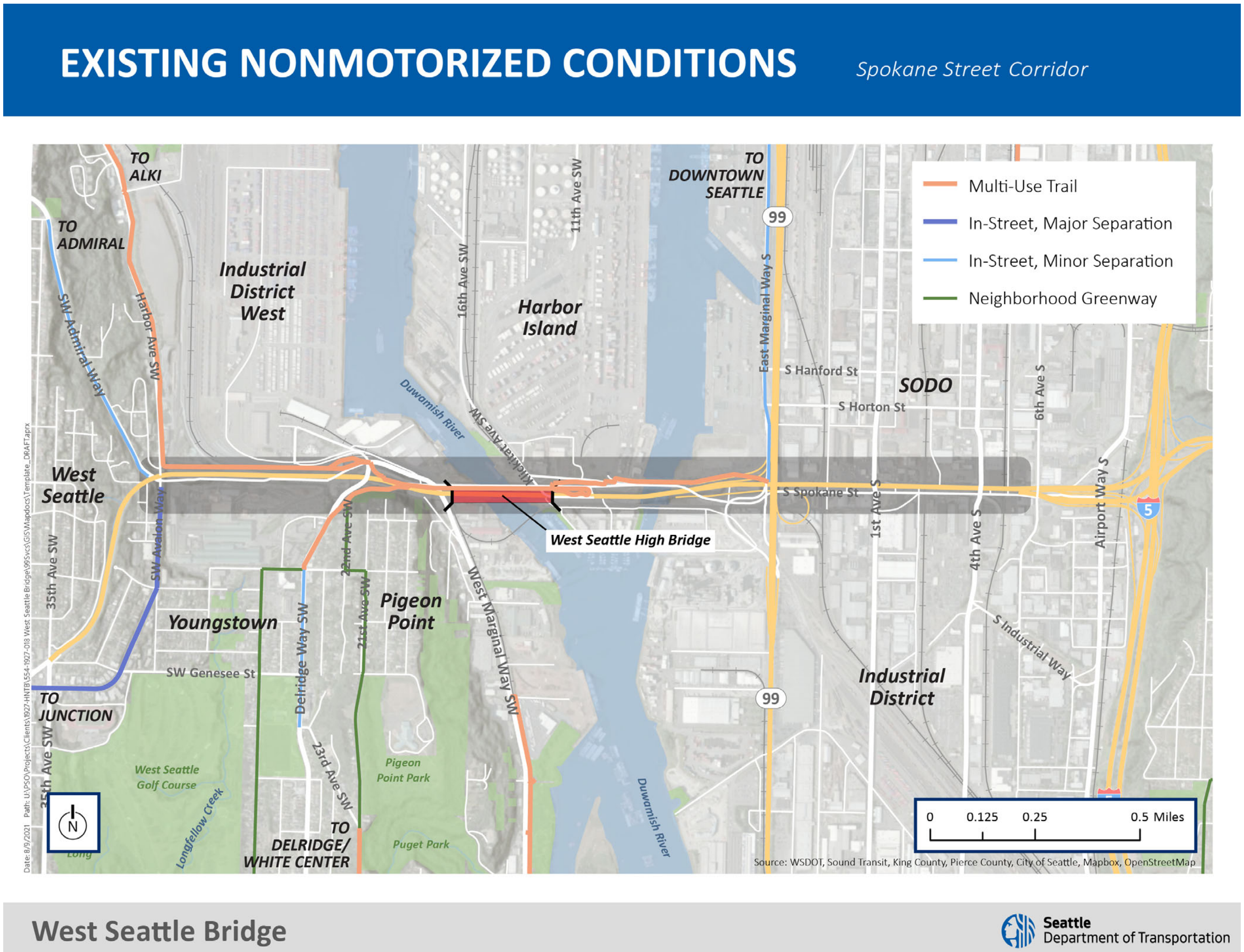

Figure 1. Existing Nonmotorized Conditions

Pre-Pandemic Conditions

In 2019, approximately 321,270 bicycles crossed the West Seattle Bridge Trail, with approximately 1,025 people biking traveling across the bridge every weekday[2]. The volume of users across the West Seattle Bridge Trail is comparable to other regional trails, as described in Table 1.

[2] https://www.seattle.gov/transportation/projects-and-programs/programs/bike-program/bike-counters/spokane-bike-counters

Table 1. Bicycle Volumes Across the West Seattle Bridge Trail and Other Regional Trails

Facility Name	Average Annual Bicycle Trips	Average Daily Bicycle Trips
West Seattle Bridge Trail	321,270 (2019)[3]	1,025 (2019)
SR 520 Trail	~300,000 (2018)[4]	
Burke Gilman Trail at 9th Ave NW		1,080-1,720 (2015)[5]
Burke Gilman Trail at 70th Ave NE		1,015 (2019)[6]
I-90 Trail near Bellevue		500-577 (2015)[7]
Fremont Bridge Trail		3,811 (2019)[8]

Currently, the West Seattle Bridge Trail is approximately 8- to 12-feet in width. With volumes at levels identified in Table 1, the facility is just meeting or falling below minimum standards for shared-use paths.[9] A width of 12 to 14 feet with 2-foot shoulders is recommended based on user volumes. Other design considerations may be recommended to reduce user speeds and encourage separation of user types on portions of the trail with steeper grades.

During the Covid-19 pandemic, bicycle trips across the corridor decreased to approximately 285,380 annual bicycle trips (2020) and 800 average weekday bicycle trips. This relatively low drop in demand, despite lower travel levels regionally, indicates the importance of this corridor for nonmotorized travel and as a viable alternative to vehicular trips.

Bicycle level of traffic stress (BLTS) measures how comfortable people riding bikes feel when bicycling on a facility. The BLTS methodology assigns a numerical stress level to streets and trails based on attributes like traffic speed, traffic volume, number of lanes, frequency of parking turnover, ease of intersection crossings, and others. The City of Seattle completed a BLTS analysis as part of the BMP effort. Several of the existing facilities that are intended to be all ages and abilities have higher BLTS scores, meaning that they are high-stress facilities. This includes the facilities on SW Admiral Way and Delridge Way SW.

Sidewalks are present in most locations near the Spokane Street Corridor; however, the condition of sidewalks and curb ramps may require improvement or repair to be compatible with Americans with Disabilities Act (ADA) standards.

The Reconnect West Seattle (RWS) process has also identified intersections and connections to the West Seattle Bridge Trail that may benefit from safety and comfort improvements. This includes the intersections at Avalon Way, Chelan Avenue SW/West Marginal Way SW/Delridge Way SW, and East Marginal Way S as well as the crossing of the West Seattle Bridge Trail and the SW Spokane Street to SW Klickitat Avenue slip lane[10]. RWS will install an on-street two-way Protected Bicycle Lane (PBL) on W Marginal Way to connect the West Seattle Bridge Trail with the Duwamish River Trail in the summer/fall of 2022 after the high bridge reopens to traffic. RWS has also undertaken trail and bicycle lane maintenance by clearing vegetation, repairing pavement, and re-striping.

3 https://www.seattle.gov/transportation/projects-and-programs/programs/bike-program/bike-counters/spokane-bike-counters
4 https://wsdot.wa.gov/Projects/SR520Bridge/About/sr-520-trail.htm
5 Burke Gilman Trail Missing Link Final EIS Transportation Discipline Report
6 https://data.seattle.gov/Transportation/Burke-Gilman-Trail-north-of-NE-70th-St-Bicycle-and/2z5v-ecg8
7 https://bellevuewa.gov/sites/default/files/media/pdf_document/Ped%20Bike%20Count%20Report%202015.pdf
8 https://www.seattle.gov/transportation/projects-and-programs/programs/bike-program/bike-counters/fremont-bike-counters
9 https://wsdot.wa.gov/publications/manuals/fulltext/M22-01/1515.pdf
10 http://www.seattle.gov/Documents/Departments/SDOT/BridgeStairsProgram/West%20Seattle%20Bridge/ReconnectWS_Implementation_Plan%20(002).pdf

Projected (2040) Conditions

The City of Seattle BMP, published in 2014, identifies the 20-year vision for the bicycle network in the City. The long-term BMP vision includes recommended Citywide Network facilities (Citywide Network is intended to be an all ages and abilities network) on SW Admiral Way, SW Avalon Way (which has been constructed to Fauntleroy Way SW), Delridge Way SW, West Marginal Way, East Marginal Way, and S Spokane Street east of E Marginal Way as shown on Figure 2. There is currently no timeline for funding or completion of the full BMP Vision. The City completes an annual 5-year implementation plan that identifies near-term actions. Planned near-term improvements include improvements to the neighborhood greenway on 21st Avenue SW and the protected bicycle lanes on West Marginal Way S. No other improvements are currently identified for the Spokane Street corridor.

Volumes in the Spokane Street Corridor would be expected to grow from existing conditions based on the anticipated population and employment growth in the West Seattle area. According to the Puget Sound Regional Council (PSRC), Seattle expects an increase of 20 percent in population and 25 percent in employment between 2015 and 2040, which would add about 135,000 people and about 150,000 jobs to the City. Over half of the City's expected population growth as well as over a quarter of the City's job growth between 2015 and 2040 is anticipated to occur in the area surrounding the bridge and west into West Seattle. This level of population and employment growth would be expected to increase the nonmotorized travel demand on facilities in the Spokane Street corridor.

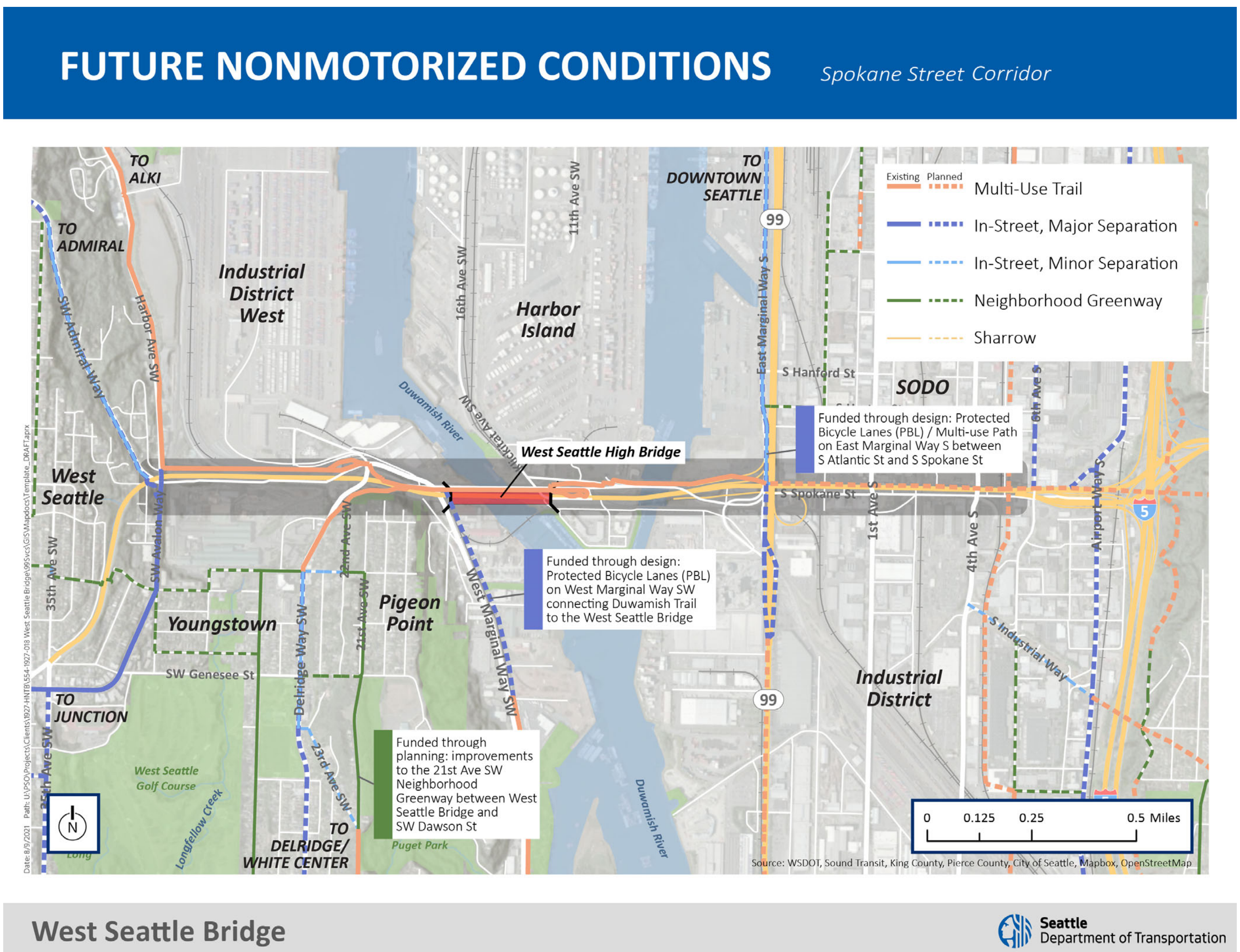

Figure 2. Future Nonmotorized Conditions

Issues and Needs

Issues impacting nonmotorized travel in the Spokane Street Corridor include the following:

- The high volume of nonmotorized use today is substantial, even without facilities at regional trail standards, which indicate a high demand for nonmotorized trips, especially for people biking; with expected future population and employment growth, volumes are expected to grow and would put additional strain on facilities where travel capacity is limited
- The West Seattle Bridge Trail narrows in several locations, including across the low bridge and where the trail curves near SW Spokane Street/Klickitat Avenue SW following the east approach of the lower Spokane Street bridge, creating conflicts between trail users
- There is a lack of adequate holding or refuge areas at many locations where nonmotorized users must wait to cross an arterial or to wait while the bridge opens
- There is a need for improved wayfinding (striping, signage) on the Spokane Street Corridor for people walking and biking, particularly in locations where nonmotorized users are traversing intersections and crossings
- In addition to conflicts between trail users in narrow locations, there are multiple major arterial crossings, including in areas with heavy freight traffic, that present conflicts between modes and potential blind spots
- The lower Spokane Street bridge openings for maritime traffic delay trail users, with no alternative routes available within nearly 3 miles

POTENTIAL INVESTMENT STRATEGIES

Potential improvements to nonmotorized access in the Spokane Street Corridor fall into two primary investment strategies:

1. Partner with the WSHB long-term replacement project to provide a new nonmotorized facility that is at regional trail standards
2. Implement a program of improvements to the existing network generally consistent with the Seattle BMP for this corridor, consisting of local improvements to a surface corridor that uses the lower Spokane Street bridge but improves conditions to meet the regional trail standards for east-west trips crossing the Duwamish Waterway

Analysis Assumptions and Bridge Facility Considerations

This analysis of nonmotorized facilities in the Spokane Street Corridor used the following assumptions when developing and evaluating potential investment strategies:

- The lower Spokane Street bridge will continue to provide nonmotorized access across the Duwamish Waterway
- The removal and/or reallocation of travel lanes on the WSHB or connections to the WSHB were not considered
- Localized design constraints or right-of-way availability were not considered
- The bridge height required to meet the navigational clearance for the WSHB dictates the ability to meet ADA compliant grades along a nonmotorized facility for the portion that traverses the high bridge.

Additionally, Table 2 summarizes bridge facility considerations that influence each of the investment strategies. The grades on the east bridge approach for the Lower Spokane Street Bridge and both approaches for the WSHB are not ADA compliant (approaches exceed a 5 percent grade). However, the length of the bridge approaches for the Lower Spokane Street Bridge are much shorter than the lengths of the WSHB approaches, meaning that nonmotorized users would be required to traverse at grades exceeding 5 percent for shorter distances when using the Lower Spokane Street Bridge.

Table 2. Bridge Facility Considerations in the Spokane Street Corridor

	Lower Spokane Street Bridge	WSHB – Hybrid Concept*
Grade (slope) along West Approach of Bridge	4.55%	6%
Distance of the West Approach of the Bridge	~100 feet	~1,600 feet
Grade (slope) along East Approach of Bridge	7.00%	6%
Distance of East Approach of the Bridge	~65 feet	~1,000 feet

* There is additional length of high bridge structure that has a grade of between approximately 3 and 5 percent. The steepest portion of the WSHB is summarized in the table.

Nonmotorized Facility via the WSHB Replacement

One potential approach would be to provide a nonmotorized facility, likely a shared-use path, that would connect to the WSHB replacement structure and use that structure to cross the Duwamish Waterway. There are multiple locations where a connection from existing nonmotorized routes could be made to a high bridge facility, but all would require additional infrastructure to reach the high bridge replacement section. Locations where a connection to a high bridge facility could be achieved with an ADA-compatible grade of 5 percent were evaluated further and are summarized on Figure 3. It should be noted that the potential routes that were reviewed as part of this investment strategy considered the direct path between the high bridge structure and the at-grade location (i.e., the distance is the minimum distance of additional infrastructure needed to reach a high bridge structure). In many cases, longer connections would be needed based on localized constraints, including other infrastructure and right-of-way availability. A list of the locations and potential routes evaluated is included as an attachment to this document.

Figure 4 summarizes the potential lengths of additional ramp or other infrastructure needed for each of the routes that could accomplish a 5 percent grade. Potential connections would be between 0.07 miles and 0.38 miles in length, at minimum. For analysis purposes, a set of representative routes were selected to identify the potential scope of the new nonmotorized structures needed to access the high bridge crossing (using the Hybrid Span Replacement Concept as representing the length of the high bridge concept). These are shown on Figures 5 through 9. Based on these representative connections, the minimum length of additional structures needed to accommodate nonmotorized access beyond the assumed footprint of the Hybrid Concept would be between approximately 0.6 and 1.2 miles.

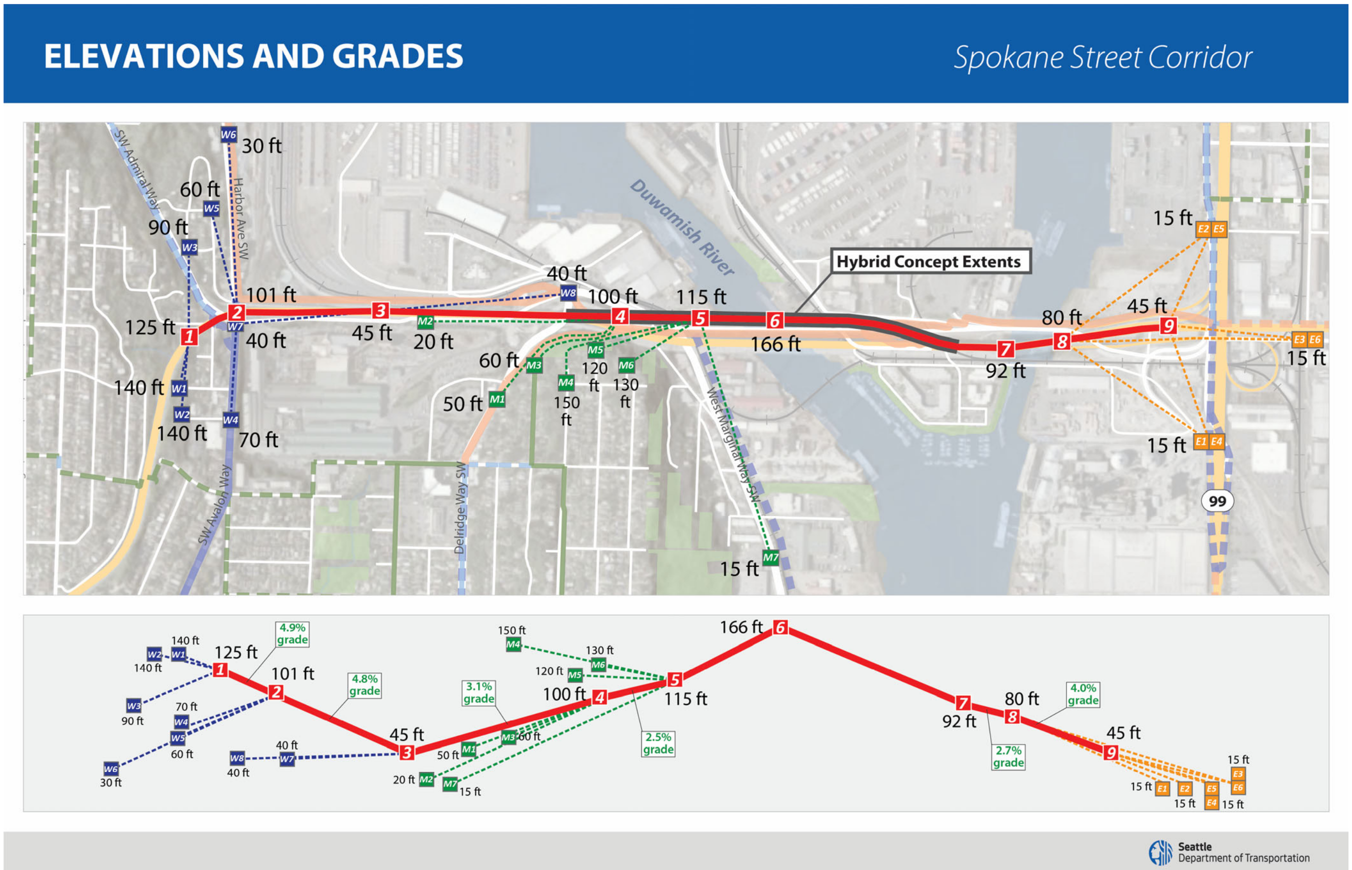

Figure 3. Elevations in the Spokane Street Corridor

POTENTIAL RAMP CONSIDERATIONS *Spokane Street Corridor*

	Description	Elevation Change	Min. Distance	Grade
W1 → 1	SW Charlestown St	140 ft to 125 ft	0.07 mi	4.3%
W2 → 1	SW Bradford St	140 ft to 125 ft	0.11 mi	2.7%
W3 → 1	SW Hinds St & 31st Ave SW	90 ft to 125 ft	0.14 mi	4.6%
W4 → 2	SW Bradford St & SW Avalon Way	70 ft to 101 ft	0.15 mi	3.8%
W5 → 2	SW City View St & 30th Ave SW	60 ft to 101 ft	0.16 mi	4.7%
W6 → 2	Harbor Ave SW	30 ft to 101 ft	0.27 mi	4.9%
W7 → 3	SW Spokane St/ SW Admiral Way & SW Avalon Way/ Harbor Ave SW	40 ft to 45 ft	0.20 mi	0.5%
W8 → 3	SW Spokane St & Delridge Way SW	40 ft to 45 ft	0.28 mi	0.3%
M1 → 4	Delridge Way SW & 23rd Ave SW	50 ft to 100 ft	0.23 mi	4.0%
M2 → 4	SW Spokane St	20 ft to 100 ft	0.30 mi	5.0%
M3 → 4	22nd Ave SW	60 ft to 100 ft	0.17 mi	4.4%
M4 → 5	SW Charlestown St & 21st Ave SW	150 ft to 115 ft	0.27 mi	2.4%
M5 → 5	20th Ave SW	120 ft to 115 ft	0.17 mi	0.6%
M6 → 5	19th Ave SW	130 ft to 115 ft	0.13 mi	2.1%
M7 → 5	W Marginal Way SW	15 ft to 115 ft	0.38 mi	5.0%
E1 → 8	Duwamish Ave S & E Marginal Way S	15 ft to 80 ft	0.26 mi	4.8%
E2 → 8	S Hinds St & E Marginal Way S	15 ft to 80 ft	0.29 mi	4.3%
E3 → 8	S Spokane St & Colorado Ave S	15 ft to 80 ft	0.38 mi	3.3%
E4 → 9	Duwamish Ave S & E Marginal Way S	15 ft to 45 ft	0.18 mi	3.2%
E5 → 9	S Hinds St & E Marginal Way S	15 ft to 45 ft	0.17 mi	3.4%
E6 → 9	S Spokane St & Colorado Ave S	15 ft to 45 ft	0.21 mi	2.7%

Seattle Department of Transportation

Figure 4. Potential Ramp Considerations to Access an Elevated Structure

ELEVATIONS AND GRADES

Spokane Street Corridor

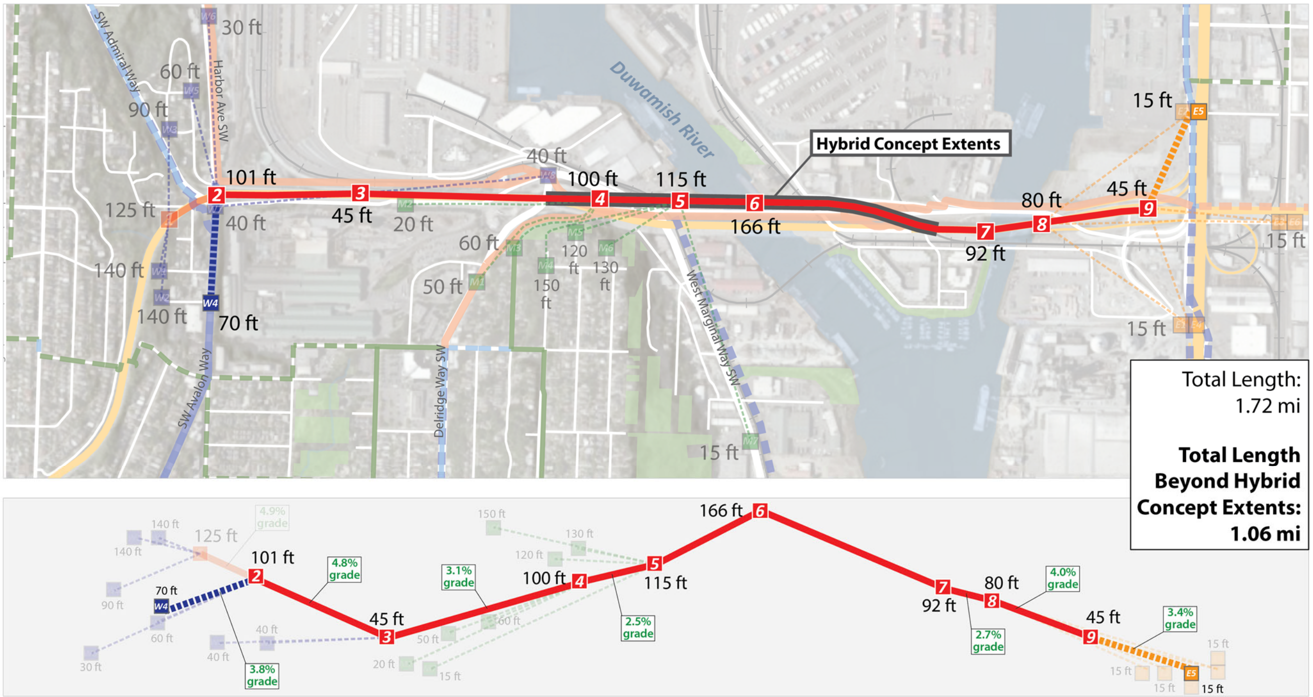

Figure 5. Representative Route W4 to E5

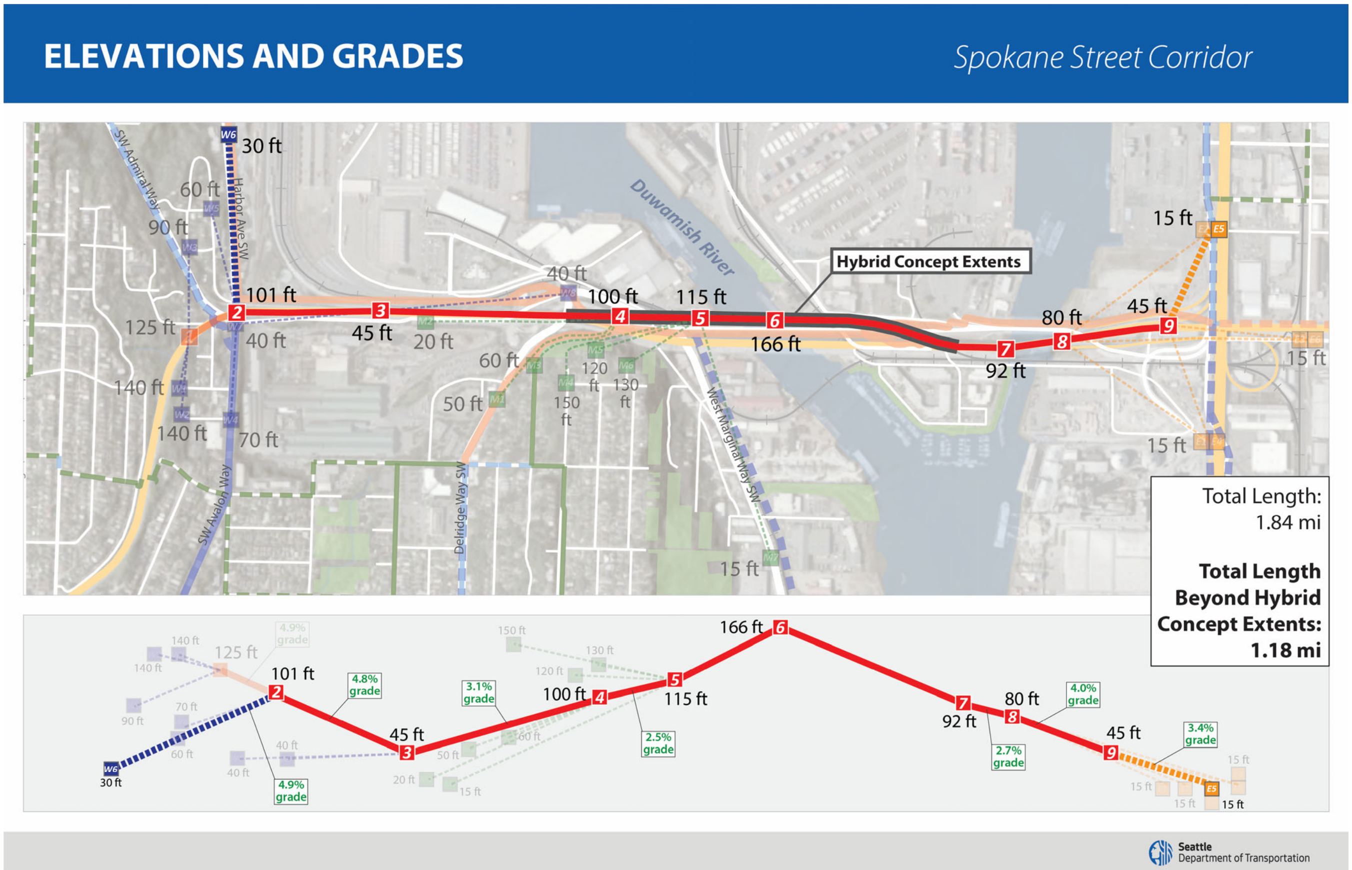

Figure 6. Representative Route W6 to E5

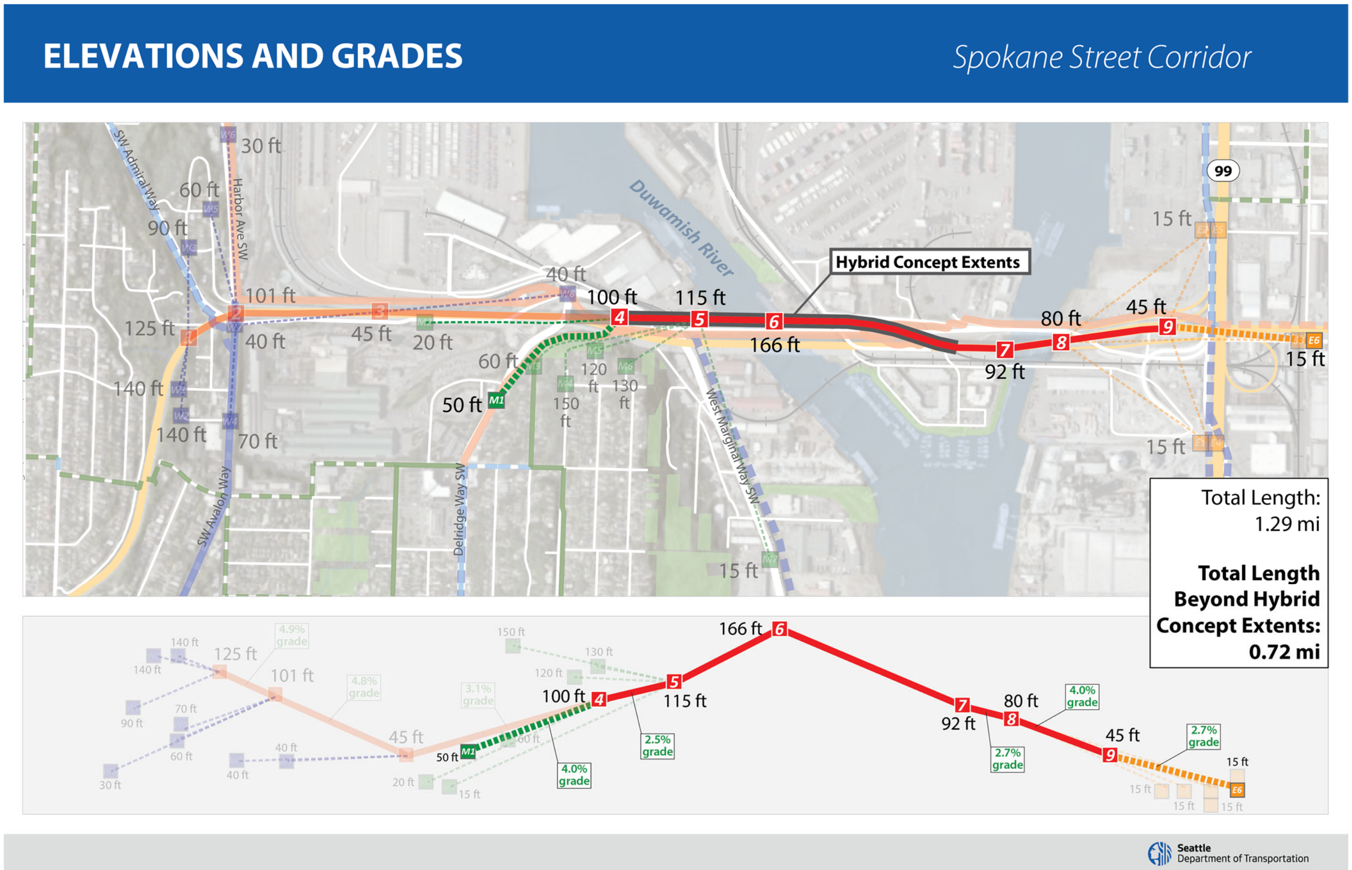

Figure 7. Representative Route M1 to E6

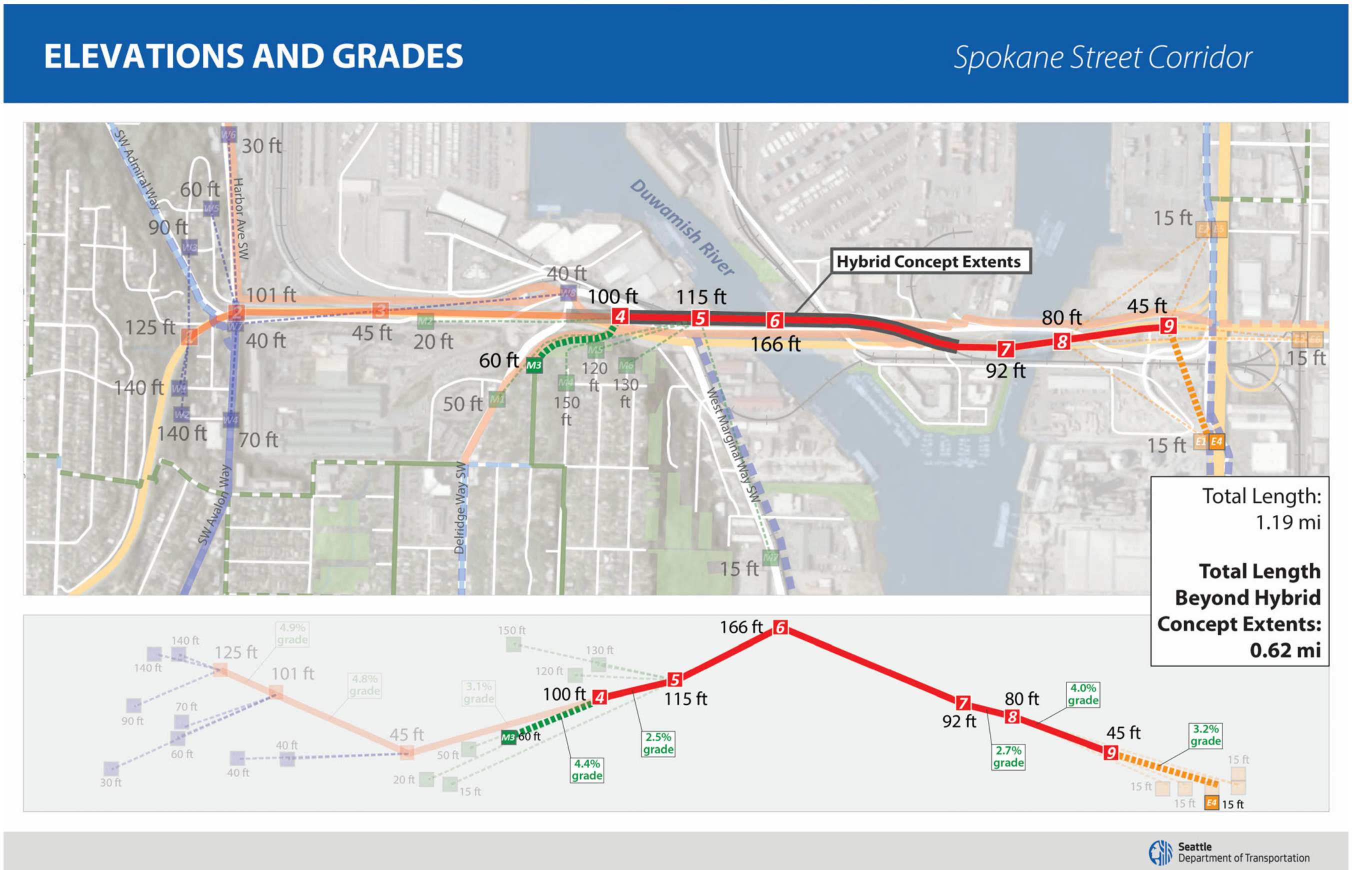

Figure 8. Representative Route M3 to E4

ELEVATIONS AND GRADES

Spokane Street Corridor

Figure 9. Representative Route M7 to E4

These representative connecting facilities have not been conceptually designed and are shown here to help estimate the extent of additional infrastructure needed to make a complete connection using the high bridge. However, the following factors would influence the feasibility and complexity of a potential nonmotorized facility on the high bridge:

- Grades and ability to accommodate an ADA-compatible structure. This may require longer ramps or other types of access infrastructure to allow nonmotorized users to access the structure, which otherwise may not be able to meet recommended grades under ADA
- Need to expand the scope and area of construction of a WSHB replacement project to accommodate a nonmotorized facility and the need to construct adjacent elevated paths or other nonmotorized facility
- Need to grade-separate a nonmotorized pathway from any ramps a pathway might need to cross and provide adequate separation from travel lanes on the WSHB
- Limited availability of right of way/space in the areas surrounding the bridge
- Access to the structure could require longer ramps or routes to meet grades needed for a connection to adjacent at-grade facilities
- Potential safety concerns related to long downgrades and the potential for high user speeds and severe collisions between bicycle and pedestrian users
- Ability to capture nonmotorized users depending on comfort, ability, and willingness to ascend to a high structure
- Consideration of interaction between a new nonmotorized facility and existing nonmotorized corridors
- Consideration of equitable access for users from various communities
- Concerns for maintaining safety and security for users, and additional potential infrastructure needed on a high bridge to monitor for safety and discourage or prevent falls from the bridge.

Programmatic Improvements to Existing Facilities

As an alternative to a nonmotorized facility on the WSHB replacement, SDOT could also consider programmatic improvements to existing facilities in the Spokane Street Corridor, consistent with the goals of the Seattle BMP. This would include improvements to the West Seattle Bridge Trail serving east-west trips between West Seattle and other regional facilities as well as improvements to facilities serving nonmotorized trips to the existing corridor.

Improvements could include:

- Widening the existing multiuse path through the Spokane Street Corridor, if feasible, or adding an adjacent path to separate directional movements
- Various safety improvements, such as potential realignment of the existing multiuse path in some locations (such as near SW Manning Street), crossing upgrades and/or grade separation, striping, and traffic calming
- Intersection upgrades, which could include the intersections of Avalon Way/SW Spokane Street, Chelan Avenue SW/West Marginal Way SW/Delridge Way SW, and East Marginal Way S/SW Spokane Street as well as the crossing of the West Seattle Bridge Trail at the SW Spokane Street to SW Klickitat Avenue slip lane that provides access Harbor Island for freight

Comparison of Investment Strategies

The potential trade-offs and benefits of each investment strategy are summarized in Table 3.

Table 3. Comparison of Approaches to Nonmotorized Travel in Spokane Street Corridor

	Nonmotorized Facility via the WSHB Replacement	Programmatic Improvements to Existing Facilities
Benefits	• Ability to provide facility that meets regional trail standards • Potential ability to be a signature facility with unique experience and views for those able to navigate to and cross a high bridge facility • Removes delay for nonmotorized users due to bridge openings for those able to navigate to and cross a high bridge facility • Removes multiple at-grade crossings for those able to navigate to and cross a high bridge facility	• Can be accomplished incrementally and over time • Flexibility in total cost based on improvements selected • Corridor and connections to the corridor would be familiar to users • Minimizes grade changes for users, increasing accessibility • Easier connections to more nonmotorized facilities that allow for more equitable access • More design flexibility to make improvements
Trade-Offs	• May not be feasible to meet ADA standards without adjusting grade of high bridge (which would change scope and scale of all replacement concepts) • Would likely offer only limited connections to existing nonmotorized facilities, which could impact equitable access • Would notably expand scope for a WSHB replacement concept and require at least 0.6 to more than 1.0 mile of additional elevated structure • Nonmotorized improvements would not occur until a future undetermined date when the repaired spans and path connections are fully complete • High and extended grade could discourage some users and result in high bicycle speeds, safety concerns, and inequitable access • High elevation at bridge may require additional safety and security measures or infrastructure	• May not be feasible to widen some existing facilities to meet regional trail standards or to implement some higher cost treatments, such as crossing grade separations • Interaction between nonmotorized users and freight would likely continue unless grade separated treatments are developed • Nonmotorized users would continue to be delayed by bridge openings • Coordination with improvements to the lower Spokane Street bridge would be required

Key Findings and Recommendations

Given the assumptions of this study, there is currently no compelling reason to require a nonmotorized facility on a high bridge structure if the surface route continues to provide an alternative. Future planning work for the WSHB will revisit whether a nonmotorized facility on a high bridge structure becomes appropriate given any additional information or changes to conditions in the Spokane Street Corridor. The key findings and recommendations of the nonmotorized evaluation are summarized below:

- The historic and existing nonmotorized trip volumes along the corridor make it one of the busiest nonmotorized routes in the region, and demand is anticipated to grow
- The level of existing and anticipated nonmotorized travel in the corridor is high and warrants improvements to facilities in the corridor
- The existing corridor facilities used for nonmotorized travel have capacity limitations and do not meet the typical standards for a major nonmotorized corridors, such as comfort, wayfinding, ease of use, and safety
- A new, nonmotorized facility via the WSHB would require major investments beyond the anticipated limits of the current replacement concepts which are focused on the main span and side spans

- Extended steep grades required for a high bridge route would present more challenges for ADA compliance
- Extended steep grades on a high bridge route could create safety challenges and would require special design considerations to prevent crashes
- A new high bridge route would not eliminate the need for improvements to the existing surface/lower bridge corridor
- Programmatic improvements would allow for more flexibility to implement improvements nearer term, over time, and with greater consideration of equity and cost-benefit
- Programmatic improvements may also provide more opportunities to partner with other projects or actions, such as with the future lower Spokane Street Bridge improvements, including reconfigured street connections
- A high bridge route is unlikely to match the benefits and equitable access of a surface-based route and is unlikely to meet ADA requirements
- The cost and scale of constructing a new high bridge route is likely to be several orders of magnitude greater than implementing improvements to the existing surface-based route

APPENDIX G

Rough Order of Magnitude (ROM) Cost Summary

APPENDIX G - Rough Order of Magnitude (ROM) Cost Summary

As part of long-term replacement planning for the WSHB, the planning team developed a Rough Order of Magnitude (ROM) cost estimate, commensurate with the level of conceptual design for the following concepts:

- Concept 1A – North Bridge Concept
- Concept 2B – South Bridge Concept
- Concept 3A - On-line Bridge Concept
- Concept 4B – Tunnel Concept
- Concept 13 – Hybrid Bridge Concept

The ROM costs for all the concepts are reported in ranges (shown on the table below). The objective of this summary is to provide a general overview of the major categories included, assumptions, and some of the considerations used to develop the quantities, entries, or percentages for the different items. The ROM cost estimate for the Tunnel Concept is the least certain given the minimal design that was done for that concept.

<u>Major categories included</u>
The methodology for determining the ROM cost estimates focused on general assumptions and unit prices using previous actual construction bids based on contractor experience, for the most significant items in the estimate categories. Quantities were approximate and not reviewed in detail, apart from general discussion of the methodology for deriving the values. A simplified spreadsheet template was developed to estimate ROM costs and it included the following sections for major categories:

- Structures were based on estimated rough quantities.
- Earthwork, Drainage, Maintenance of Traffic (MOT), Traffic Items, Minor Items, Pavement, and Mobilization were estimated in percentages of applicable sections.
- Professional Services, Project Development Costs, and Project Management or Owner construction costs were also estimated as percentages.
- Owner construction costs include sales tax, construction engineering, raw cost of affected utility towers, and project-specific obligations.

<u>Assumptions</u>
The primary assumptions for calculating the ROM cost estimates were:

- Construction cost includes 40% contingency.
- Design build was the assumed delivery method for all concepts.
- “Construction” cost refers to Total Project Cost, which includes Planning, Environmental, Construction, Construction Management and Project Administration.
- All the costs assume new foundations.
- Utility impacts or relocations (including transmission lines) were not estimated and are not part of the cost estimate ranges, but an estimated cost for unavoidable impacts to transmission line towers were included.
- Slope stabilization, ground improvement, and seismic retrofit measures are not included in the cost estimate ranges. If needed, slope stabilization could affect foundation design and cost.
- ROM ranges are given in 2021 dollars, so escalation is not taken into account due to timeline uncertainty.
- Operation and maintenance costs were not included.

<u>Additional Considerations</u>
Other considerations used to define ranges, percentages, premiums, etc., are listed here:

- Location and constructability were a limiting factor for bridge typology. Variability of ROM cost ranges by concept is primarily due to varying feasibility of bridge type. For example, the On-Line and Hybrid concepts show a wider ROM cost range because there are more bridge types available for those concepts, while the span lengths and constraints for the South Concept don't allow for many types of bridges to be feasible, and therefore the ranges are not as wide.

- Estimated costs and assumptions for Right of Way (ROW) were vetted with SDOT and included separately. The difference in magnitude of ROW impacts is a significant differentiator between the concepts.

Preliminary Cost Estimate Ranges (in millions)[1]

	North Bridge Concept	South Bridge Concept	On-Line Bridge Concept	Hybrid Bridge Concept	Tunnel Concept [2]
Construction	$1,170-$1,650	$1,075-$1,270	$725-$1,040	$825-$1,245	at least x4
ROW	$15	$245	$3	$3	$925
Total	$1,185-$1,665	$1,320-$1,515	$730-$1,045	$830-$1,250	at least x5

Notes:

1. Preliminary cost estimate ranges are intended to show rough order of magnitude (ROM) for the representative concepts in 2021 dollars and incorporate the range in cost of feasible bridge types for each concept.
2. The tunnel concept was not advanced beyond the initial feasibility screening, so this preliminary ROM cost represents the magnitude difference between the bridge concepts and a tunnel option.

Risk Assessment

In addition to the assumptions listed above, results in this summary reflect the current project planning, but not potential future risk management. A risk register development and risk management were outside the current scope of this task.

Formal identification, definition, and characterization of specific risks and opportunities to the project cost and schedule were not performed as part of the long-term replacement planning. However, throughout concept development, screening, evaluation, and ROM estimating, the team was able to document the observations below, related to risk and opportunities. There are factors and risks that would apply differently to certain concepts, and some of those are also listed below:

- Utility relocation would affect mainly the North Concept.
- Higher risks related to ROW would be experienced by the North and South bridge concepts and the Tunnel Concept. One of the main advantages that the Online and Hybrid concepts have is that there is no need for permanent fee acquisitions.
- Risk of funding and funding-related delays were not observed as construction funding is assumed to be available as-needed. During the time of this report, a Federal infrastructure bill was passed, which could translate into funding opportunities for this important corridor that would be prudent to look at.
- The results represent a "snapshot in time" as of the date of the deliverable (December 2021), and do not reflect future risk management efforts that may be undertaken by SDOT.
- Cost risks due to escalation and delays in construction would be higher for the North and South bridge concepts and the Tunnel Concept due to their longer durations. Year of Expenditure (YOE) costs would normally be inflated to the mid-point of construction, so the longer the duration, the higher the cost and risk. For this exercise, ROM costs are given in 2021 dollars.
- Risk of increased total cost for the Tunnel Concept is high due to its significant length compared to all other concepts, and the level of detail used for the ROM estimate. The tunnel concept was not reviewed for constructability or staging, and there was no information on soil conditions for its entire length. Costs and durations were reviewed, discussed, and adjusted, where the team concluded it to be appropriate.
- Due to the nature of this corridor, some common risks should be evaluated once the long-term planning for replacement resumes, as follows:
    - Uncertain market conditions / competition for a design-build contract
    - Extraordinary commodity price increase (i.e., steel)

- Changed seismic design criteria
- Tribal non-concurrence on concepts
- Unanticipated hazmat issues
- Challenge to environmental clearance or other legal challenge (NEPA/SEPA)
- Unanticipated utilities encountered
- Coordination with adjacent businesses during construction
- Zoning, Land Use, and Real Estate price changes

APPENDIX H

Site Visit Report

APPENDIX H – WSHB SITE VISIT REPORT

BERNICE WHITE PLACE

Off from West Marginal Way SW, Seattle WA 98106

Bernice White Place is located under the lower West Seattle Bridge off from West Marginal Way SW, adjacent to the Riverside Mill, it does not have a standard address. There are 3-4 parking spots for visitors that can also be used for people who plan to use the bike/walking path that is on the bridge and surrounding area. There is an access gate into the mill for authorized vehicles only.

Under the bridge, viewing the parking area and mill.

Under bridge access area to Riverside Mill.

View towards the low bridge control tower, from the stairs leading to the low-bridge bike/ped path.

The area itself is a small, fenced area of greenery and water with a sign dedicating the location and giving the history of Tribal Elder Bernice White.

Sign commemorating Bernice White and the surrounding green area.

RIVERSIDE MILL AND SURROUNDING AREA

3800 West Marginal Way SW, Seattle, WA 98106

The Riverside Mill is located within an area that stretches under and around the West Seattle Bridge structure, equipment and buildings are located directly under and close to supporting columns of the Bridge as well. There is one access gate for the mill located under the bridge but the main entrance for it and other industrial buildings in the area is about a block south of the bridge underpass.

View into Riverside Mill showing columns from the High Bridge.

View towards West Marginal Way SW from above the Riverside Mill

Riverside Mill (and other industrial areas) access road.

On the east side of West Marginal Way (directly across from Riverside Mill) there is a privately owned building with no public access, the warehouse for Global Diving, and some residential buildings that are likely low-income.

View of Riverside Mill and private building across the street.


View of residential areas near Riverside Mill

OUNCES TAPROOM & SKYLARK CAFÉ AND CLUB

3809 Delridge Way SW, Seattle, WA 98106 & 3803 Delridge Way SW, Seattle, WA 98106

Ounces Taproom and the Skylark Café and Club are located on the same block directly across from the Harbor Island onramp for the West Seattle Bridge. There is a sidewalk that runs in front of both businesses. Both have small, separate parking lots. There are some older commercial buildings that don't look currently occupied and a few occupied residential houses across the street.

Harbor Island and I-5/Highway 99 North on-ramp.

Commercial and residential buildings across from Skylarks and Ounces.

Ounces Taproom is a primarily outdoor beer garden space, with a small indoor area primarily for drink pick up with limited seating.

Ounces Taproom outdoor seating.

The Skylark Café is primarily an indoor space, with limited outdoor seating, it is primarily a bar and entertainment venue, with most of its business in the evening/late night.

The Skylark Café and Club building.

FRYE COMMERCE CENTER

2414 SW Andover St, Seattle, WA 98106

The Frye Commerce Center is comprised of a wide variety of businesses, such as a dog daycare, bank, a children's daycare center, and a theater supply store. There are multiple buildings spread over a large area of property interconnected with parking lots. The Frye Commerce Center is adjacent to Nucor Steel.

PNTA, a theater supply store in the Frye Commerce Center.

Wonder Dogs, dog daycare, and a graphics and signing business.

Waterfront Federal Credit Union and ATM.

NUCOR STEEL SEATTLE

2424 SW Andover St, Seattle, WA 98106

Nucor Steel Seattle is a large steel fabricator, it shares an access road off from Andover St. with Frye Commerce Center. While visiting the site at around 11:00am there was very heavy traffic made up of mostly semi-sized trucks going into Nucor Steel. Although I couldn’t access the property it did seem to house both industrial and office space, with two entrances available as well.

Truck entrance into Nucor Steel.

Additional parking and signage for Nucor Steel.

PIDGEON POINT NEIGHBORHOOD

Pidgeon Point is a community that overlooks the West Seattle Bridge and surrounding industrial area. The houses are a mix of older and new single-family homes, and a few new townhomes.

View of mixed newer and older homes in Pidgeon Point neighborhood.

View of older single-family homes in Pidgeon Point.

View of new single-family homes in Pidgeon Point.

The community seems very close knit, with a sign welcoming others, and listing upcoming evens as one drives into the neighborhood. There is also a neighborhood web page with history, events, and links to the neighborhood Facebook group and email list. There are no obvious or scenic views of the bridge from the street but may be from some of the taller homes.

View towards the West Seattle Bridge from Pidgeon Point.

TERMINAL 18 PARK

3401 Klickitat Ave SW, Seattle, WA 98134

Terminal 18 Park is located on the east side of the West Seattle Bridge. It's a very small park with parking for about 6 cars available, a sculpture, and a few seating areas, one of which is covered.

Terminal 18 Park seating areas and sculpture.


Part of the Terminal 18 Park parking area.

At the time I visited (around 12:00pm on a Friday) it was empty. There were two other cars, but no one else in the immediate area. The park was neat and well maintained, but a foul, fish smell was present. There were a few places that would be easy access for people fishing from shore, and views of the Bridge, the river, and surrounding industrial areas.


View of tugboats across from Terminal 18 Park.

View of industrial area adjacent to Terminal 18 Park.


View of West Seattle Bridge from Terminal 18 Park.