River Crossing Option Comparison

EXECUTIVE SUMMARY

The Interstate Bridge Replacement (IBR) program will replace the existing Interstate Bridge crossing the Columbia River between Vancouver, Washington, and Portland, Oregon. As part of the planning process the IBR program must define the type of river crossing that will replace the existing bridges early in the design phase in order to study the impacts and benefits and advance the permit process.

The IBR program prepared the *River Crossing Options Comparison* report to provide context for the replacement crossing, and the IBR program's reasoning for the recommended bridge configuration and height. The report includes a summary of existing and future conditions such as environmental and cultural resources, navigation and aviation needs, and sea-level rise. The report also summarizes the advantages and disadvantages of the following seven river crossing options as it relates to key program elements and considerations.

1. Immersed tube tunnel (ITT)
2. Bored tunnel
3. Lift span bridge
4. Bascule bridge
5. Swing bridge
6. High-level fixed bridge
7. Mid-level fixed bridge

Based on technical evaluations, public outreach, and discussions with partner agencies, the IBR program recommends a fixed-span bridge with 116 feet of vertical navigation clearance. The rationale and analysis summarized in the report demonstrates that the identified option provides the best replacement river crossing for the community and region. A fixed bridge with 116 feet of vertical clearance is a solution that balances the needs of all users and modes of transportation, including freight and personal vehicles, transit, active transportation, aviation, and river users. This river crossing option has the best ability to meet the IBR program's Purpose and Need statement, meet the community's values and priorities, minimize environmental impacts, contributes to achieving climate and equity goals and program desired outcomes, and will use conventional design and construction methods, contributing to a lower cost.

Table 1 provides a summary of the considerations associated with each river crossing option. The table is color coded and provides a symbol to indicate if a consideration is an advantage (green, with a "+" symbol), disadvantage (red, with a "-" symbol), or neutral (yellow, with a "•" symbol).

Table 1. River Crossing Option Comparison

Consideration	Bored Tunnel	Immersed Tube Tunnel	Lift Span	Bascule Span	Swing Span	High-level Fixed	Mid-level Fixed
Active Transportation/SUP	– **Safety concerns** due to enclosed SUP for over 1 mile (e.g., no "eyes on the path, emergency egress, fire and life safety) – **Missed direct connectivity** from the SUP on the river crossing to local trails on both sides of the river (e.g., Renaissance Trail, Marine Drive Trail) + Opportunities to **improve connectivity** between existing trails on the Washington shore and potential for more park space along the river due to removal of existing I-5 connections		– **Delay to SUP users** during a bridge opening; **no suitable detour route** is available + Lower bridge elevation would be a **benefit for path users** (reduced grades would **increase ease of access and operability** of the SUP)			– Active transportation connections to Hayden Island and Vancouver waterfront **would be challenging** due to height above ground	+ Connections to existing grade at Hayden Island and Vancouver waterfront **can be achieved with ramps**
Aviation	+ **No penetration** in Pearson airspace		– Lift span towers would **permanently penetrate** Pearson airspace	• Leaves would **temporarily penetrate** Pearson airspace when open	+ **No penetration** in Pearson airspace	– **Permanent penetration** into Pearson airspace	• **Likely penetration** of lights and signs into Pearson airspace
Columbia River Navigation	+ **Unlimited** horizontal and vertical navigation clearances + **Compatible** with existing navigation channels + **Eliminates navigation hazards** (e.g., bridge piers, bridge deck) in/over the river		+ Provides **178 feet or unlimited vertical clearance** for navigation – **Openings required** to accommodate tall vessels/cargo – **Lower vertical clearance** (in the closed position) than that provided by the fixed span bridge – Movable span operations and thus river navigation operations would likely need to be **restricted to specific days and/or times** to minimize impacts to vehicle traffic and transit operations • Primary navigation channel would be **moved south** • Requires **400 feet** of horizontal clearance per the USACE			+ **No change in vertical clearance** • Primary navigation channel would be **moved south** to the bridge profile high point	• Would accommodate a vertical clearance **up to 116 feet** for navigation • Would **reduce** navigation clearances as they exist today • Primary navigation channel would be **moved south** to the bridge profile high point – **Mitigation** for 4 vessels/users is proposed (reported approximately 70 trips/year)[a]

<table>
<tr><th>Consideration</th><th>Bored Tunnel</th><th>Immersed Tube Tunnel</th><th>Lift Span</th><th>Bascule Span</th><th>Swing Span</th><th>High-level Fixed</th><th>Mid-level Fixed</th></tr>
<tr><td rowspan="2">Construction Considerations</td><td rowspan="2">– Requires significant, challenging launching pits for the tunnel boring machine(s) (TBM(s))
– Requires a record or near-record diameter TBM for vehicular tunnel bores</td><td rowspan="2">– Requires unconventional and complex below-grade construction to accommodate interchange connections consisting of cut and cover tunnels with large temporary excavations. This would make construction impractical
– Construction would require negotiation and approval of a permit from BNSF to construct over/under/through their ROW; it is unlikely that BNSF would accept interruptions of their operations, and therefore construction would likely require the program construct a temporary alternative route; there is no readily available route</td><td colspan="3">• Extended construction schedule (approximately 1 to 2 years) due to in-water work, equipment, and specialized workforce required</td><td colspan="2" rowspan="2">+ Conventional construction methods and risks</td></tr>
<tr><td>--</td><td>• Additional schedule extension with third bridge configuration</td><td>--</td></tr>
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Consideration	Bored Tunnel	Immersed Tube Tunnel	Lift Span	Bascule Span	Swing Span	High-level Fixed	Mid-level Fixed
Cost Considerations	– Due to the significant disadvantages of a bored tunnel (e.g., would eliminate five interchanges), a conceptual cost estimate was not developed. However, it is certain that a bored tunnel would be **more expensive than an ITT** (due to such factors as increased construction method costs, significantly increased tunnel length, and increased construction risk mitigation)	– Total tunnel cost (from grade to grade): **$3 billion**	– Construction cost of two 450-foot lift spans: $500 million – Total bridge cost (Pier 1-8): **$930 million**	Three bridge option: – Construction cost of three 400-foot single-level bascule spans: $600 million – Total bridge cost (Pier 1-8): **$1.03 billion** Two bridge option: – Construction cost of two 400-foot double-deck bascule spans: $550 million – Total bridge cost: **$980 million**	– Construction cost of two 550-foot swing spans: $800 million – Total bridge cost (Pier 1-8): **$1.23 billion**	• The work completed for CRC and supported by the IBR program suggested **higher costs** for a higher fixed span bridge. This is, in part, due to the changes that would occur at each land side connection, accounting for differences in interchanges, transit stations, and active transportation connections.	+ Construction cost of two 450-foot fixed spans: $70 million + Total bridge cost: **$500 million**
Environmental Considerations	+ **Eliminates over-water shading** impacts to fish and marine habitat. While a bored tunnel would go under the river, thus reducing/avoiding impacts to the river, an ITT would require dredging the river bottom – **see below for impacts specific to an ITT** + **Potential to reuse riverfront properties**/land above the tunnel + **Removes the bridge from the viewshed**, which benefits historic properties, parks and trails, and other resources – Construction **noise, vibration, and congestion** impacts to businesses – **Impacts to neighborhoods and parks/recreation** due to tunnel portals and local connections – Utilities would require **substantial relocations** – **Impacts on local communities and neighborhoods** from construction of the cut and cover sections, tunnel portals and local connections, including displacement		– **Increased air quality pollutant and greenhouse gas emissions** due to vehicular idling during a bridge opening – **Increased in-water work** due to size of foundations would increase impacts to biological resources, hazardous materials, and historic structures and archaeological resources – **Challenging stormwater containment** due to the bridge joints that allow the movable span to function			+ **Smaller aquatic footprint** compared to tunnels and movable span bridges + **Less in-water work/structures** than tunnel options + **Smaller pier foundations** compared to movable span bridges	

Consideration	Bored Tunnel	Immersed Tube Tunnel	Lift Span	Bascule Span	Swing Span	High-level Fixed	Mid-level Fixed
	of businesses and residences and neighborhood isolation						
	+ Construction could **avoid impacts to aquatic** plants, fish, and other marine animals/plants by boring below the river bottom	– **In-water trenching and dredging would disturb the river bottom** across the entire width of the Columbia River, including the riverbanks (in-water excavation would require approximately 4 million cubic yards of material) – Disturbance of the river bottom and nearshore habitat **would require mitigation** – Dredged material would need to be placed in an in-water or upland site and **may require special handling** if contaminated materials are found – **In-water construction** would impact aquatic plants, fish, amphibians, marine mammals, and birds (including ESA-listed species) – **Concerns for cultural resources** along the shoreline and underwater; could impact Fort Vancouver and Old Apple Tree Park; size and volume of excavation and vibration could disturb or permanently impact resources	– **Permanent visual impacts** due to lift towers	– **Additional displacement of benthic habitat** with third bridge configuration; additional over-water shading with third bridge configuration – **Visual impact** during bridge opening	– **Increased land use and development impacts** due to downstream location of bridge (due to construction considerations)	– Sustained 4% grade would result in **increased greenhouse gas emissions** – Sustained 4% grade would create **noise impacts** due to the use of Jake brakes for freight vehicles on the descent – **New visual impacts** to/from Fort Vancouver and to/from Hayden Island	+ Shorter sustained 4% grade would result **in less greenhouse gas emissions** than high-level fixed + Shorter sustained 4% grade would result in **less noise** impacts than high-level fixed. + Would have **less viewshed impacts** than a high-level bridge

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		– Disturbance and suspension of **potentially contaminated materials in the river**; large excavation of contaminated soil on land may exceed capacity of existing disposal locations					
Geotechnical Considerations	– **Control of ground loss** during tunneling, particularly under the river – **Groundwater control and water tightness** in temporary excavations (e.g., launch pits) and permanent underground structures (e.g., stations) – **Balancing incorporation of ground improvements** for ground strengthening and liquefaction mitigation with tunnel profile depth to mitigate against tunnel buoyancy	– **Ground improvement may be required** to improve the soils of the river bottom above, below and around the ITT, which contributes to **high construction schedule and cost risks**	• **Requires more substantial river piers and pier foundations** to support the span as compared to a fixed span (movable parts are more sensitive to foundation settlement) to ensure smooth operation over its lifetime			+ **Smaller** piers and foundations than a movable span	+ **Smaller** piers and foundations than movable span or a high-level fixed
High-Capacity Transit	– An underground station could result in **high costs and construction risks** due to ground conditions near the river		– **Reduced** train speed over bridge – **Interruptions to operations** during a bridge opening throughout 18-mile service network, unless openings are restricted to nighttime only – **Extensive maintenance** to keep communications, power and track operable + Opportunity to decrease the profile elevation and grade could **improve connections** to the Vancouver Waterfront station for transit vehicles and transit patrons			+ **Avoids impacts** to transit operations related to a movable span – Station locations (Hayden Island, downtown Vancouver) would be	• Station location on Hayden Island would be a **typical** elevated station, one level up

Consideration	Bored Tunnel	Immersed Tube Tunnel	Lift Span	Bascule Span	Swing Span	High-level Fixed	Mid-level Fixed
						very elevated, which would make **fire and life safety more challenging**	• Station in downtown Vancouver would be elevated **but more reasonably able to accommodate fire and life safety**
Highway Traffic	– Due to missed connections (**loss of five interchanges**), large volumes of traffic would be **rerouted through local streets** to access I-5	– Due to missed connections (**loss of two interchanges**), large volumes of traffic would be **rerouted through local streets** to access I-5	– The cycle time for a bridge opening would be **20 to 30 minutes** – Daytime bridge lifts **could impact traffic volumes** for an hour or more; nighttime bridge lifts would not impact traffic volumes for multiple hours a day – To reduce congestion and improve mobility, movable span operations would **likely need to be restricted** to specific days and/or times + Reduced length of grade of the lower profile **would benefit freight and other vehicles** that might be affected by the lower speeds caused by steeper grades			+ **Avoids traffic safety impacts** related to a movable span	
			--	+ **Fastest cycle time** to open and close the bridge resulting in less congestion	--	– Sustained 4% grade would **slow down freight** – Due to missed connections at **two interchanges**, large volumes of traffic would be **rerouted through local streets** to access I-5	+ Shorter sustained 4% grade would have a **lesser impact on freight speed**
Highway/Local Connections	– **Eliminates five I-5 interchanges**. This would result in a loss of access to local streets and require modification to the SR 14 corridor	– **Eliminates two I-5 interchanges.** This would result in a loss of access to local streets and require modification to the SR 14 corridor	+ **Maintains** local highway and street connections + Reduced grades would **increase the ease of ramp connections**, primarily on the Hayden Island end of the bridge – **Retains** existing interchange locations			– **Missed** local connections (would touch down at Marine Drive and at Mill Plain) – Would **eliminate two I-5 interchanges** (Hayden Island, SR 14/Downton Vancouver)	+ **Maintains** local highway and street connections – **Retains** existing interchange locations
Operational Considerations	– Requires a **full-time staffed operations center** for monitoring the mechanical, electrical, traffic control systems, and security		– More likely to result in **misalignment or damage** from a seismic event – **Requires a bridge operator** on site			+ **Does not require** on-site or specialized operation staff	

Consideration	Bored Tunnel	Immersed Tube Tunnel	Lift Span	Bascule Span	Swing Span	High-level Fixed	Mid-level Fixed
	– Requires **additional and different systems requirements** (fixed firefighting systems; mechanical ventilation systems [jet fans]; standpipe system; tunnel thermal protection systems; drainage systems; traffic monitoring systems; security systems)		– Requires **additional maintenance** associated with mechanical and electrical systems				
Safety	– Requires **extensive fire and life safety systems** would be required – Requires **additional and different** safety requirements (fixed firefighting systems; mechanical ventilation systems [jet fans]; standpipe system; tunnel thermal protection systems; drainage systems; traffic monitoring systems; security systems) – Fire prevention and ventilation **difficult at abrupt changes** in geometry – **Hazardous materials are not typically permitted** in tunnels (would require approval at the state level) – Safety concerns due to **enclosed tunnel with two points of access** (e.g., potential delays in emergency response, road blockage due to a collision)		– Crash rate is expected to be **3 to 4 times higher during a bridge lift** than during normal operating conditions			+ **Avoids traffic safety impacts** related to a movable span	
Structural Considerations	– Requires **more rigorous design efforts** and specialty contractors		– Requires **more rigorous design efforts** and specialty contractors			+ **Traditional** major complex bridge design delivery	
			– Towers up to **60 feet taller** than vertical clearance required – Counterweights in the towers would **require additional seismic design** considerations to mitigate earthquake impacts	– Would be **one of the largest** double-leaf bascule spans in the world – Potential for **operational problems** due to span imbalance, keeping counterweight pit dry, and center locks issues – Must **resist seismic and wind loading** to a greater extent than	– Would be **one of the largest** movable spans of its type in the world – **More machinery** than a bascule or vertical lift bridge: an end-centering device and end-lifting devices • Low profile and **does not require** expensive counterweights		

Consideration	Bored Tunnel	Immersed Tube Tunnel	Lift Span	Bascule Span	Swing Span	High-level Fixed	Mid-level Fixed
				other movable span options	• **Less massive piers** than a bascule or vertical lift bridge		

[a] During the CRC Project, mitigation agreements were negotiated with the four impacted users that were unable to modify operations (such as accepting an air gap of less than 10 feet) in order to transit a bridge height of 116 feet. Three upstream fabricators entered into mitigation agreements with the program. The anticipated mitigation agreements would have resulted in payments to the companies that would be used by the companies at their business direction and control. Payments were never made because the project was stopped. The remaining vessel owner made a decision to terminate negotiations that involved a payment to compensate the owner for vessel modifications, and an agreement was never finalized.