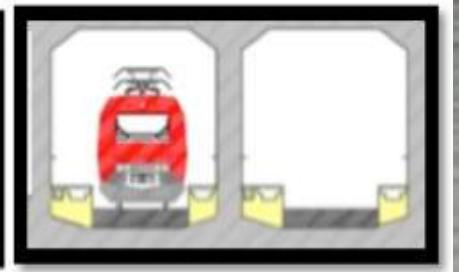
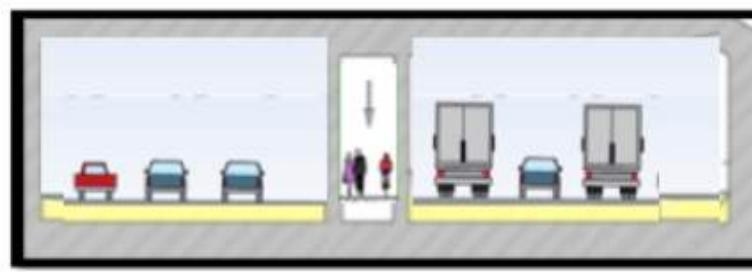
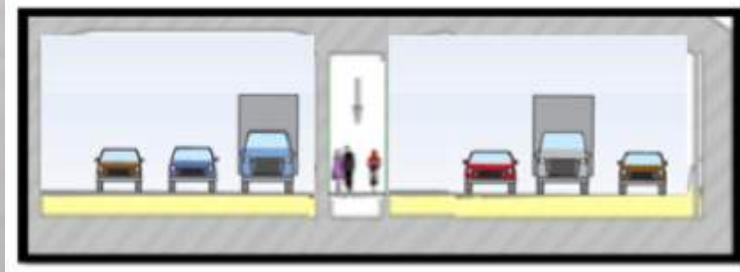




Columbia River Immersed Tube Tunnel



Interstate Bridge Replacement River Crossing Alternatives Analyzed



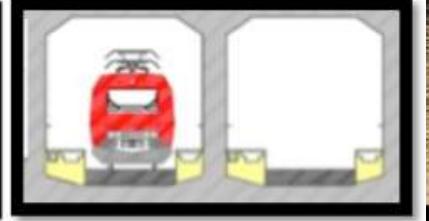
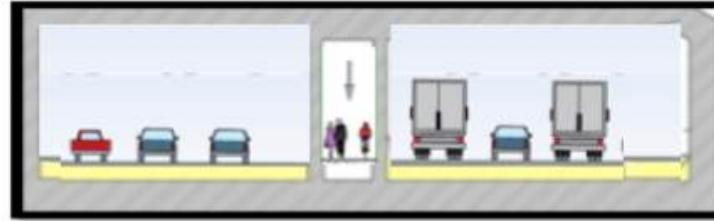
Travis Brouwer
Assistant Director



Washington State
Department of Transpor



Immersed Tube Tunnel -Never Evaluated



November 13, 2019

Deep Bored Tunnel

REJECTED

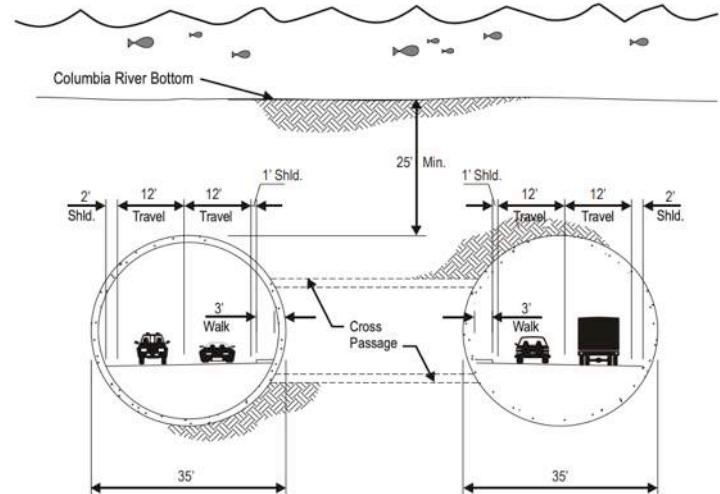
3.44 miles

Too long, small & costly

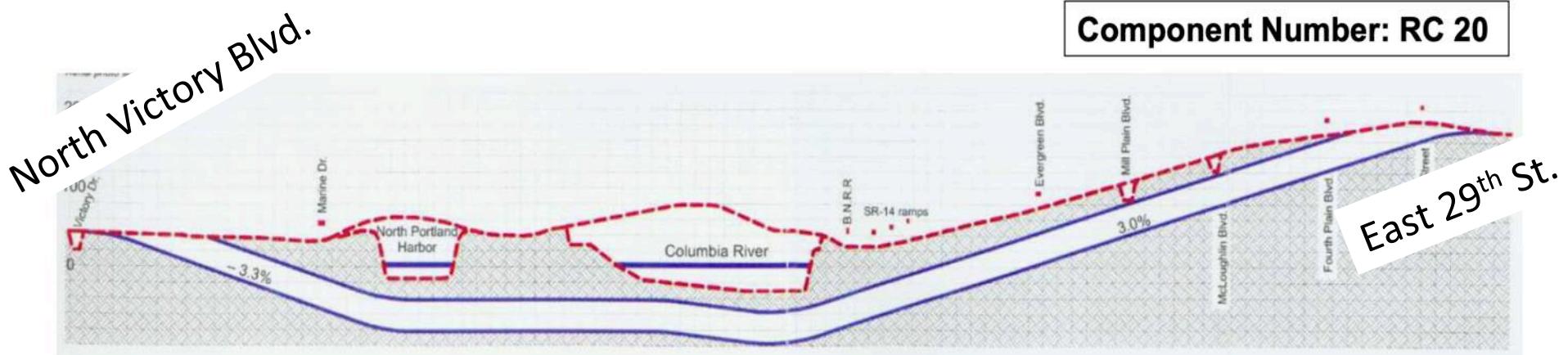
Replacement Tunnel

Does not satisfy Questions 1, 2, 3, and 5

- Q1 & 3 – Does not serve I-5 commuter and truck freight trips within the project area
- Q2 – Does not provide service to key transit markets in downtown Vancouver, Hayden Island, and North Portland
- Q5 – Does not improve bicycle/pedestrian facilities



Component Number: RC 20



Immersed Tube

Time to evaluate

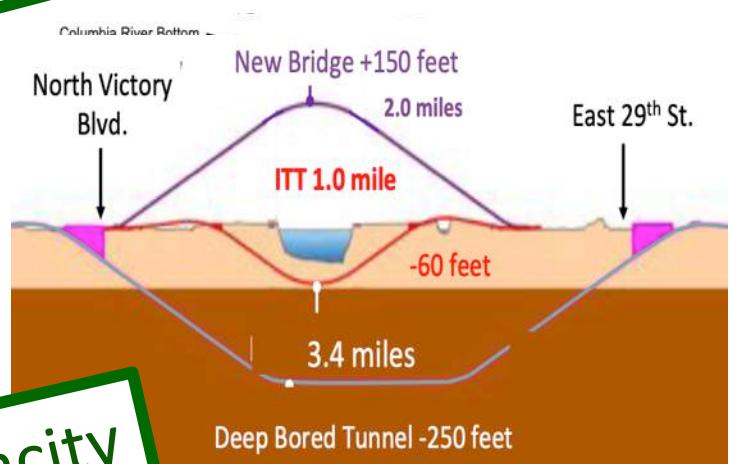
1 mile

Shortest Length & Grade

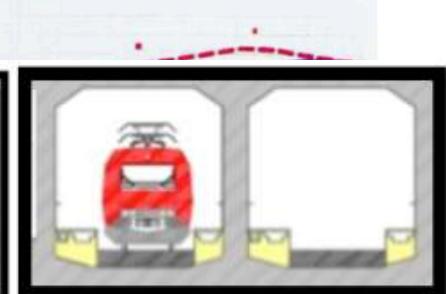
Replacement Tunnel

Does ~~not~~ satisfy Questions 1, 2, 3, and 5

- Q1 & 3 – Does ~~not~~ serve I-5 commuter and truck freight trips within the project area
- Q2 – Does ~~not~~ provide service to key transit markets in downtown Vancouver, Hayden Island, and North Portland
- Q5 – Does ~~not~~ improve bicycle/pedestrian facilities

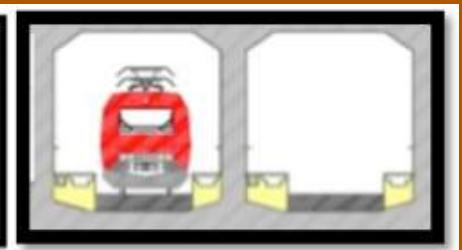
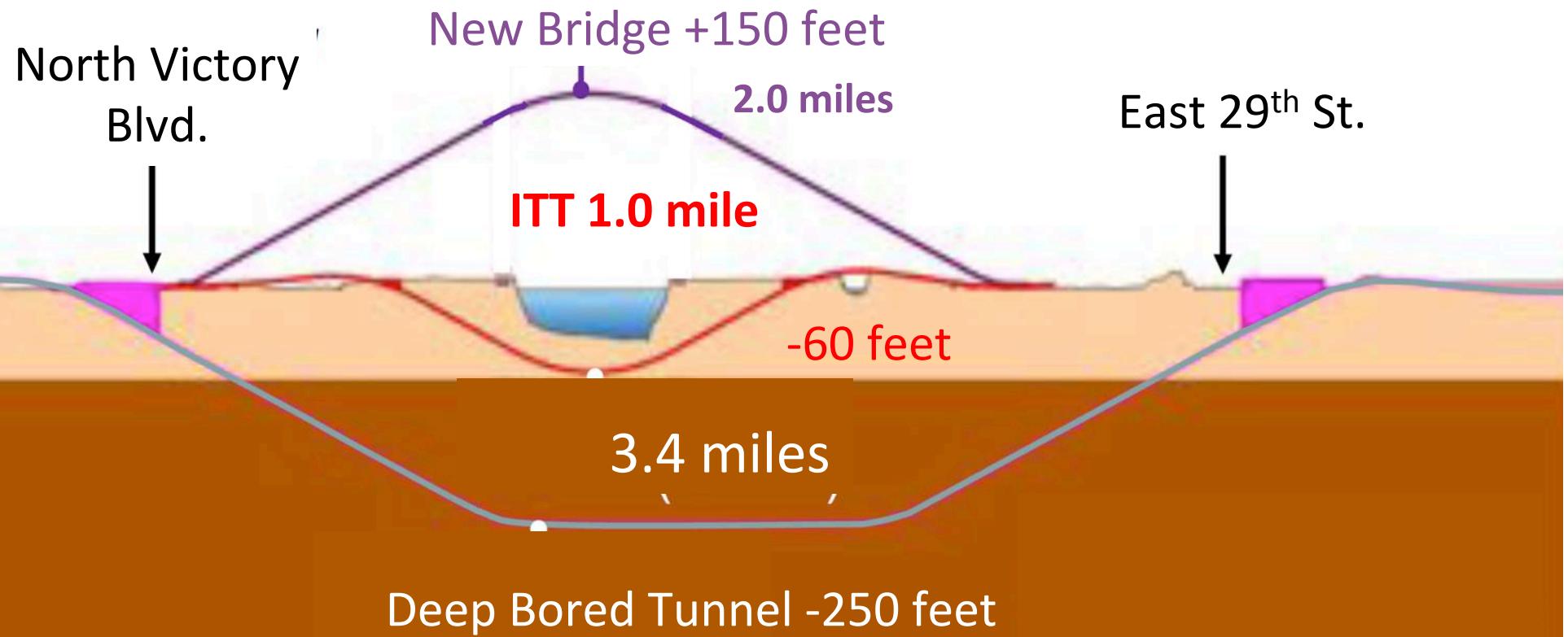


High Freight Mobility & Transit Capacity

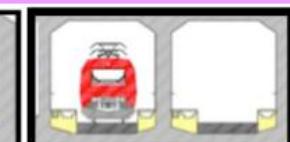


Immersed Tube Tunnel (ITT)

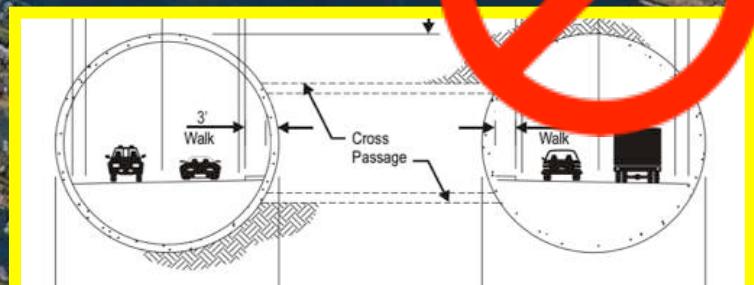
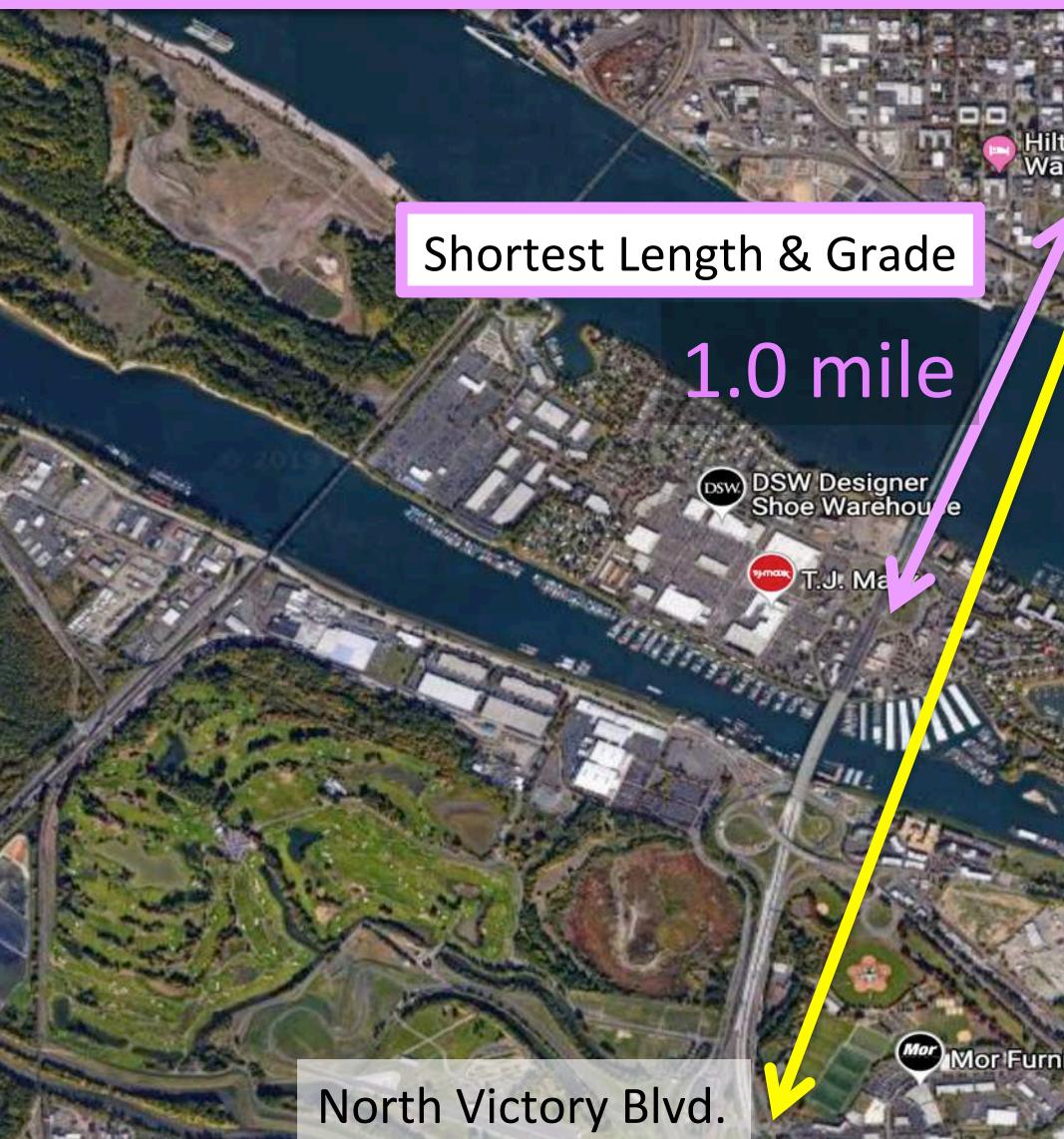
Shortest Length & Grade



Immersed Tube Tunnel



East 29th St.



Advantages of an Immersed Tube Tunnel



Immersed tubes can be placed immediately beneath the river allowing approach to be shorter and flatter, connecting current on & off ramps

Initial downhill grade giving uphill momentum for trucks, short dip vs. long bridge climb

Air & Water traffic clearances & No River Piers

Suitable for poor soil condition & High earthquake resistance

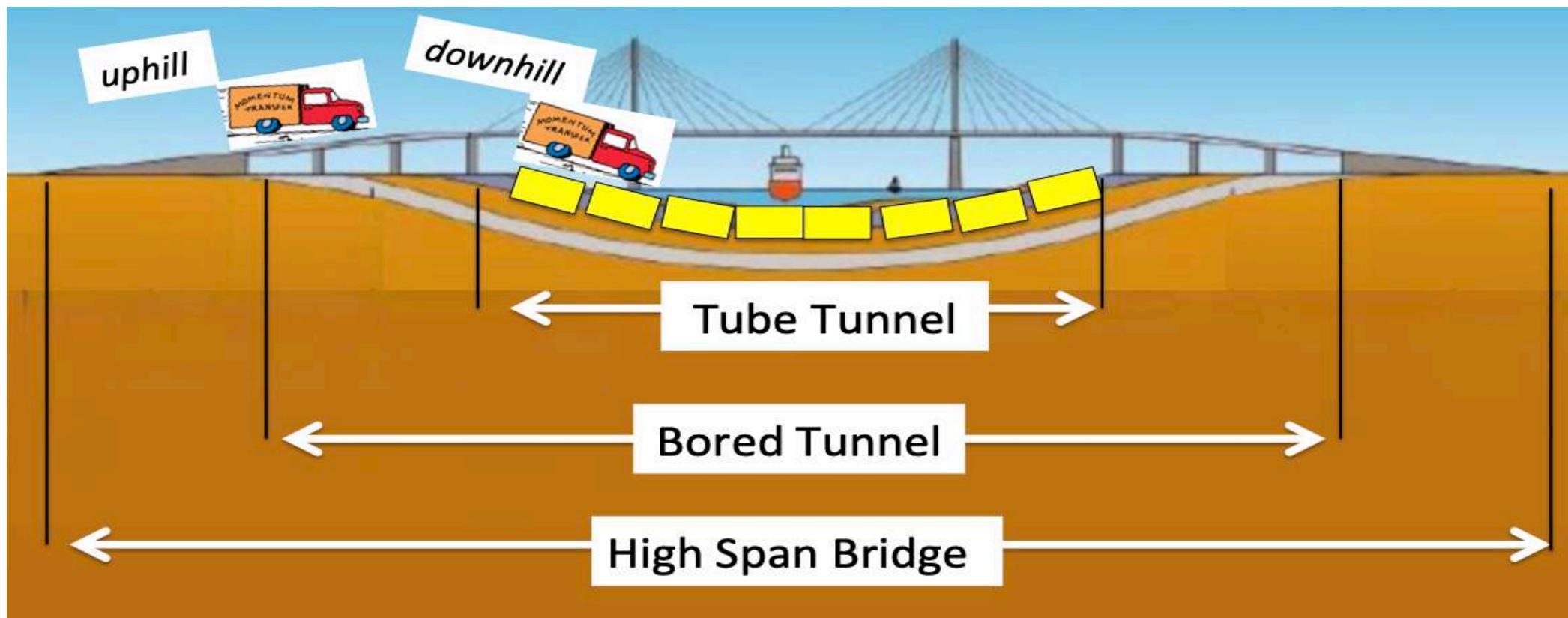
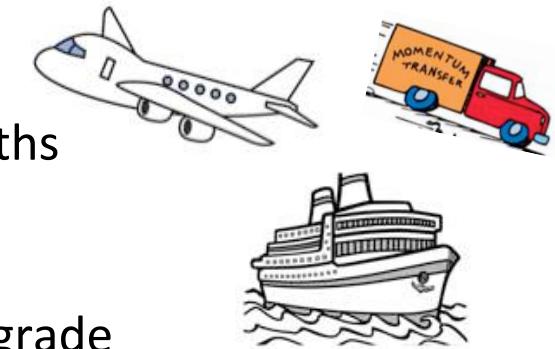
Parallel tube construction, Fraser River tubes installed in 5 months

No temporary cofferdams to disrupt shipping

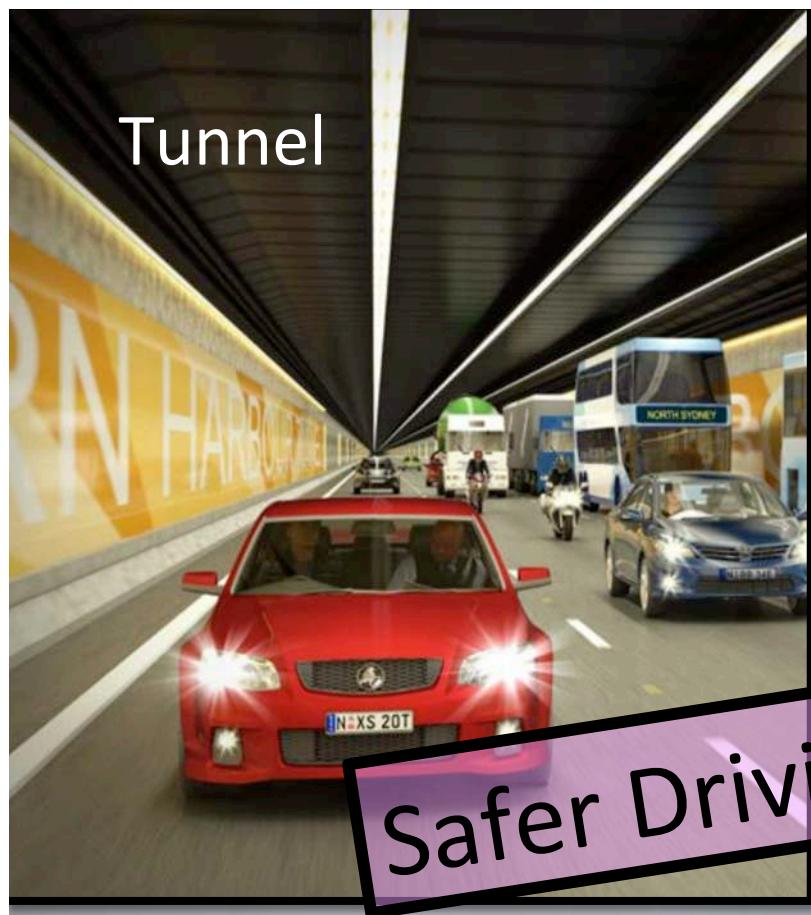
Safer in yard construction vs. dangerous in river construction

Flexible transit design – possible separate transit tube, portals, grade

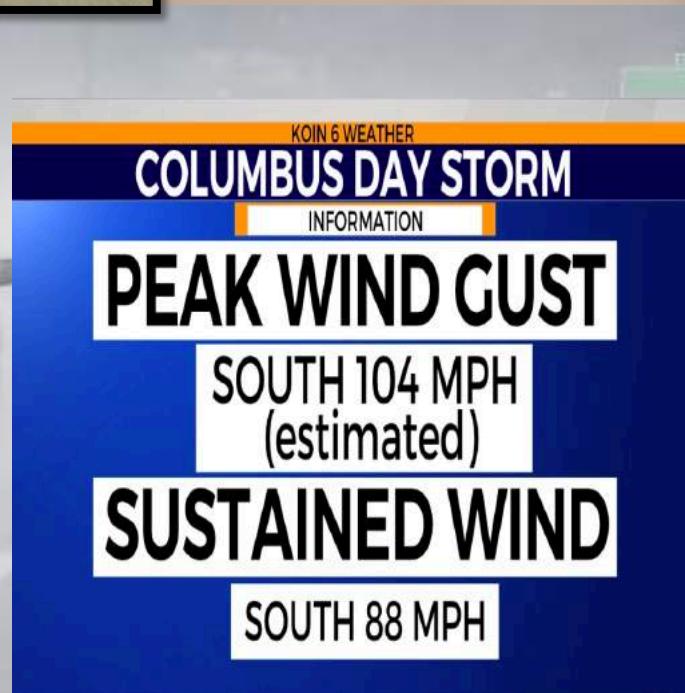
Aberdeen SR 520 pontoon casting yard



Tunnel



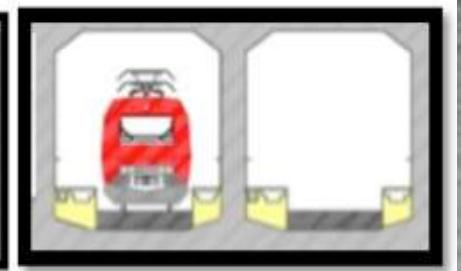
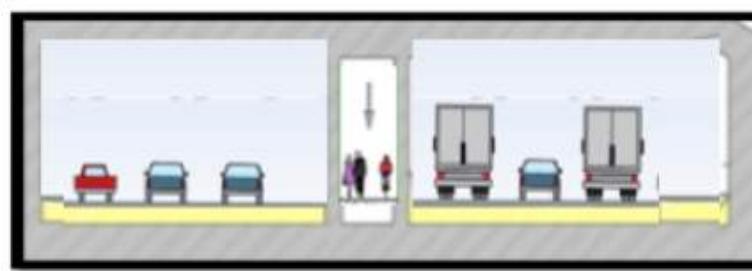
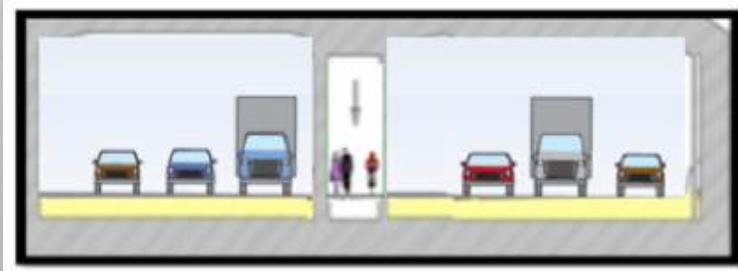
Bridge
fog, wind, rain & ice



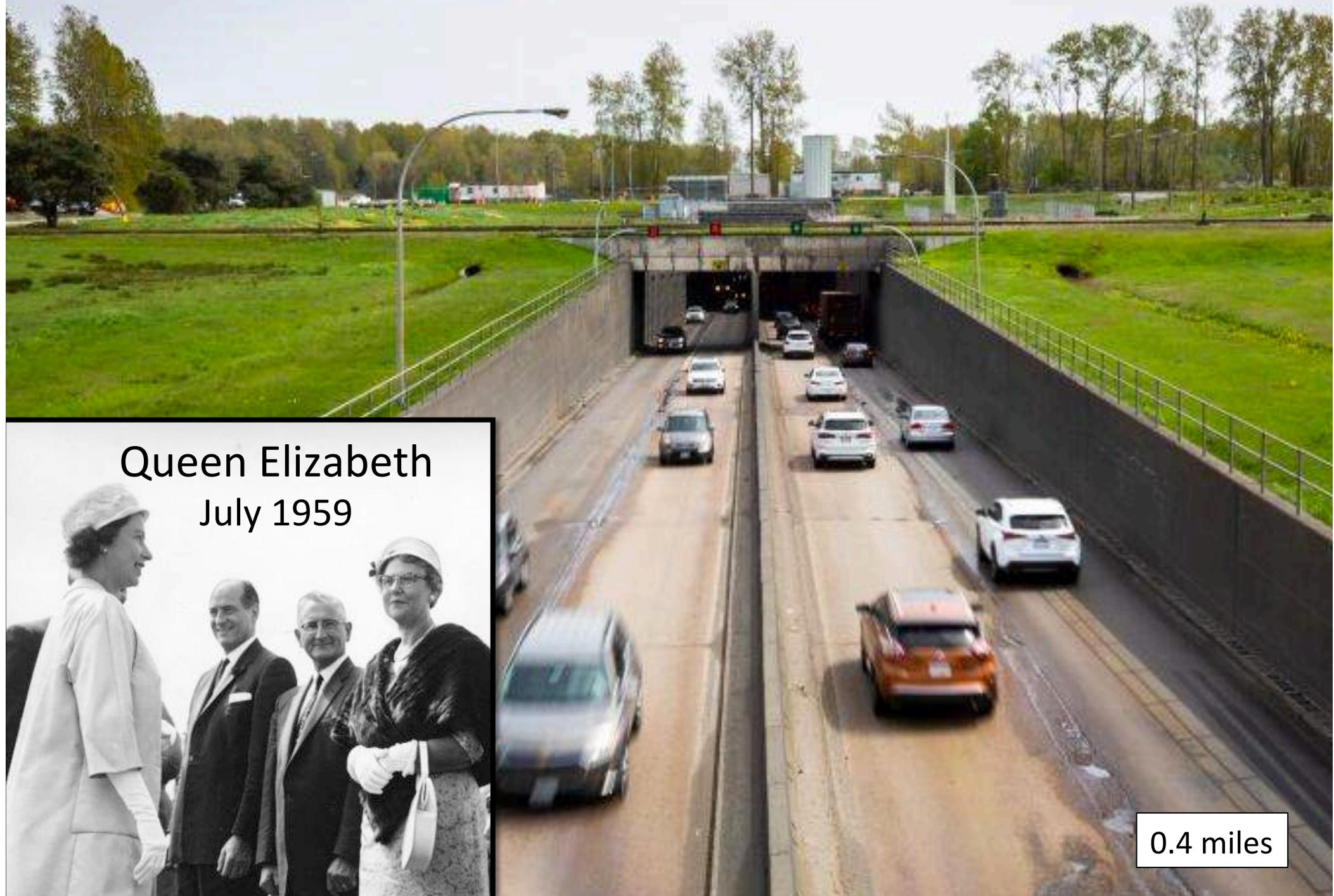


Ask our Canadian Neighbors
& Scandinavian Cousins

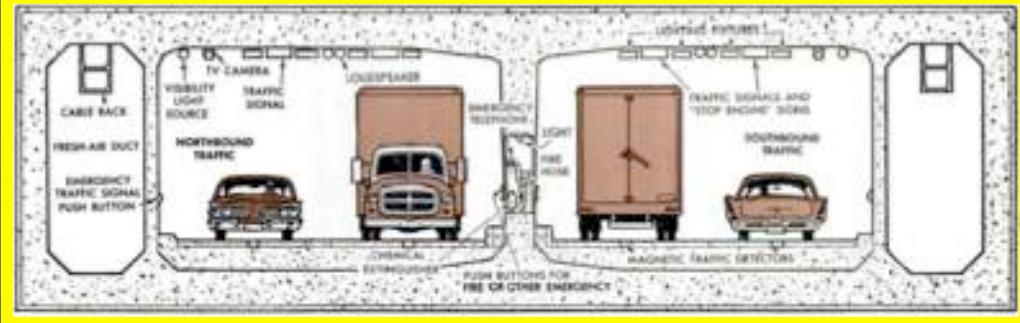
Columbia River Immersed Tube Tunnel



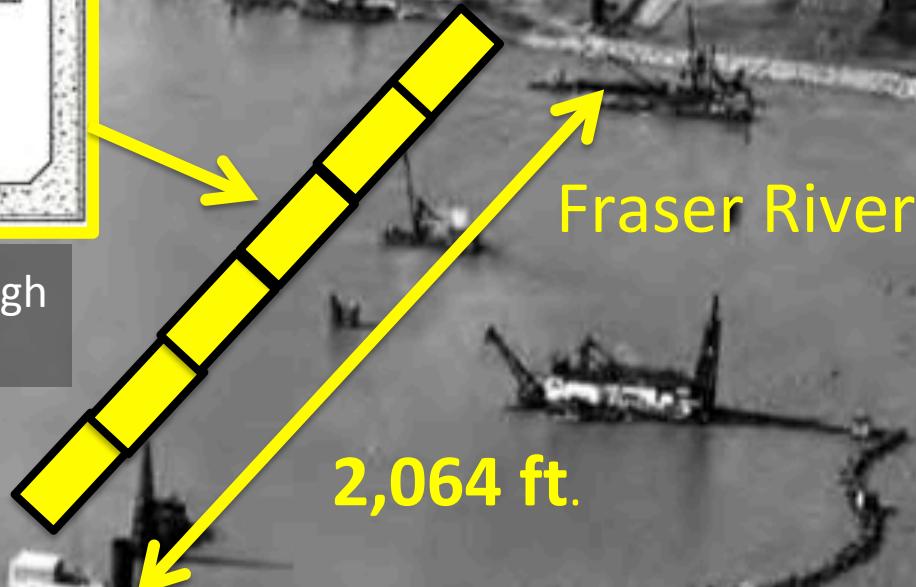
George Massey Tunnel 1959 - Fraser River



George Massey Tunnel 1959



Six sections - 344 ft. long 78 ft. wide 24 feet high
Installed in five months



Competed 1959 - 2 years & 2 months construction

\$29 million in 1959



Cut & cover tunnel approaches



bridge
1917



3,000 ft.

Hayden
Island

Columbia
River

1,000 ft.

2,100 ft.

Fraser
River

Deas
Island

1,000 ft.

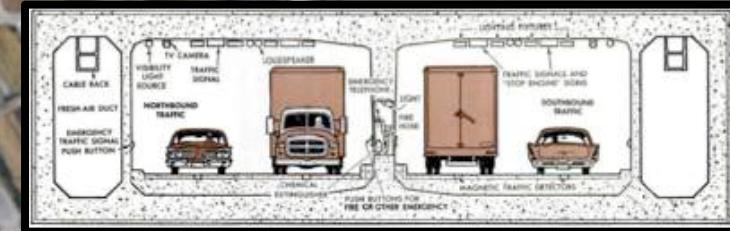
Very similar traffic, geography & geology

130,000 vehicles/day

80,000 vehicles/day



tunnel
1959





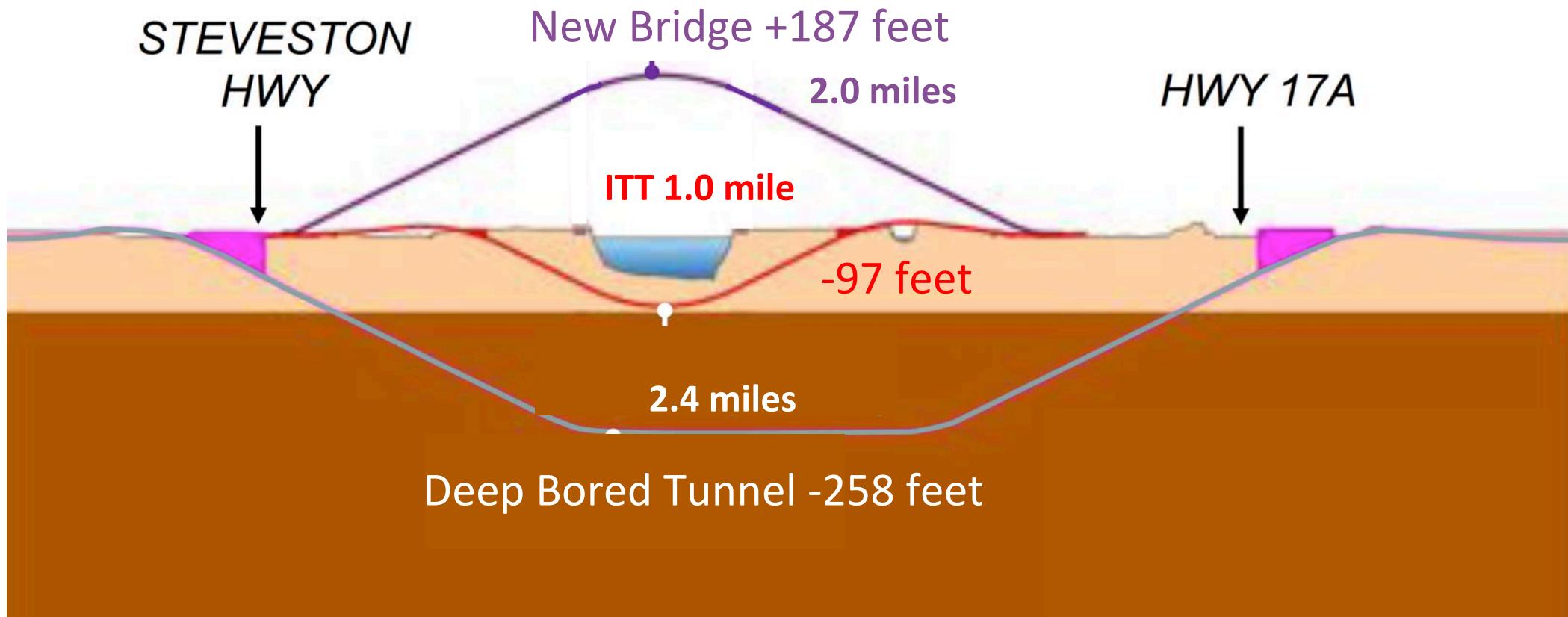
George Massey Crossing Project

Option	Bore Tunnel	Immersed Tube	Long-span Bridge
Environment Impacts	<ul style="list-style-type: none">• Sinkhole potential• ALR• Ground densification	<ul style="list-style-type: none">• In-river construction	<ul style="list-style-type: none">• Noise, visual and shade
Est. Schedule	<ul style="list-style-type: none">• EA• Construction <ul style="list-style-type: none">• 3 yr• 7 yr	<ul style="list-style-type: none">• 3 yr• 5 yr	<ul style="list-style-type: none">• 2 yr• 5 yr
Construction Risk	<ul style="list-style-type: none">• High	<ul style="list-style-type: none">• Medium	<ul style="list-style-type: none">• Low
High level cost estimate	<ul style="list-style-type: none">• Approx. 3 times cost of ITT/bridge	<ul style="list-style-type: none">• Comparable cost to bridge	<ul style="list-style-type: none">• Comparable cost to ITT

Selected

Immersed Tube Tunnel (ITT)

Shortest vertical and horizontal distances



New Fraser River Crossing



Ministry of
Transportation
and Infrastructure

THE VANCOUVER SUN

Oct 17, 2019

In a unanimous vote, Metro Vancouver's finance and inter-government committee has backed a task force's recommendation to replace the aging George Massey crossing with a new **eight-lane immersed-tube tunnel**. It would have six lanes for regular traffic and two dedicated to transit.



8-lane Massey Tunnel endorsed by
Metro Vancouver board of directors
<https://bc.ctvnews.ca/8-lane-massey-tunnel-endorsed-by-metro-vancouver-board-of-directors-1.4666481>



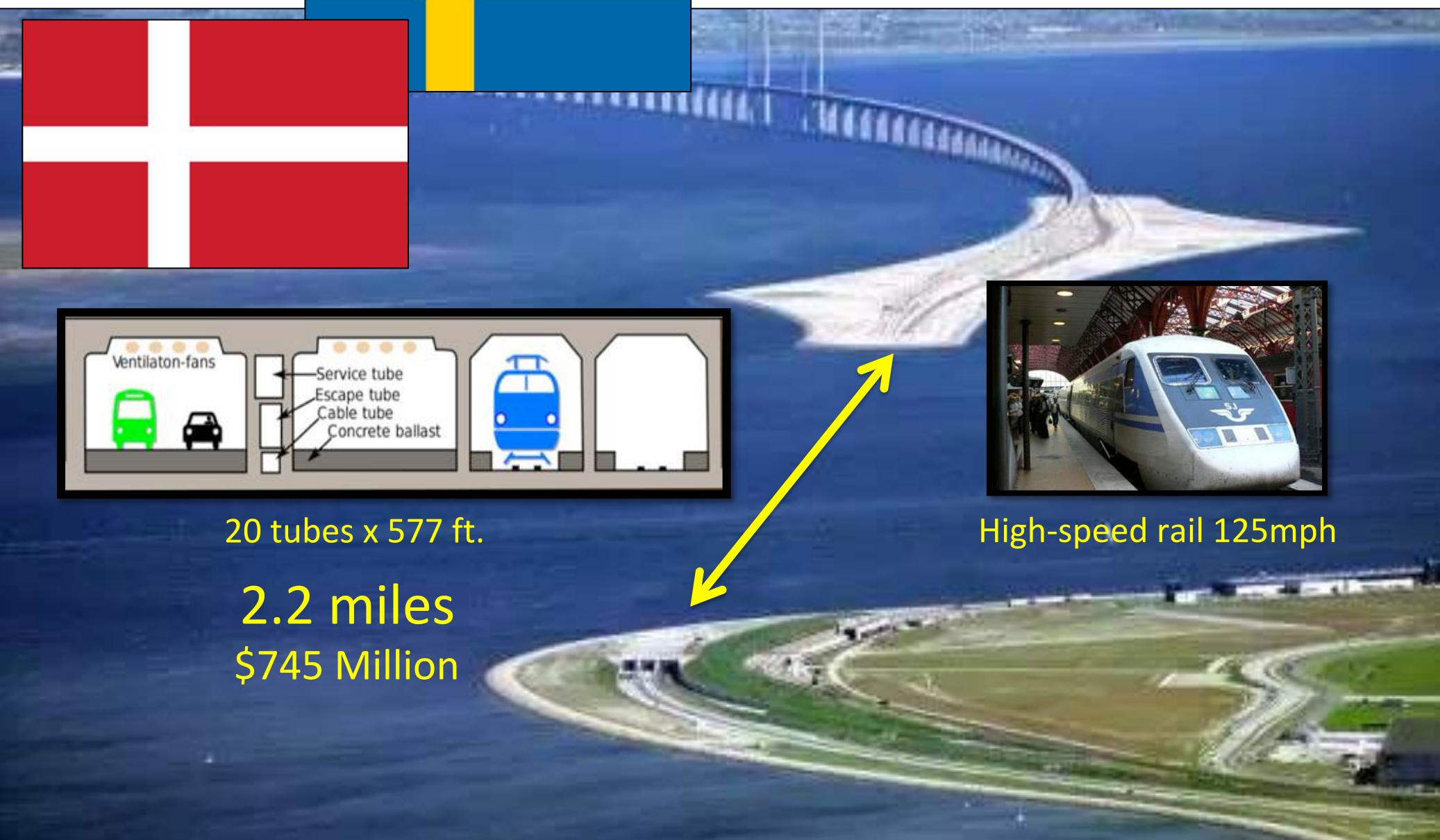
Ministry of
Transportation
and Infrastructure



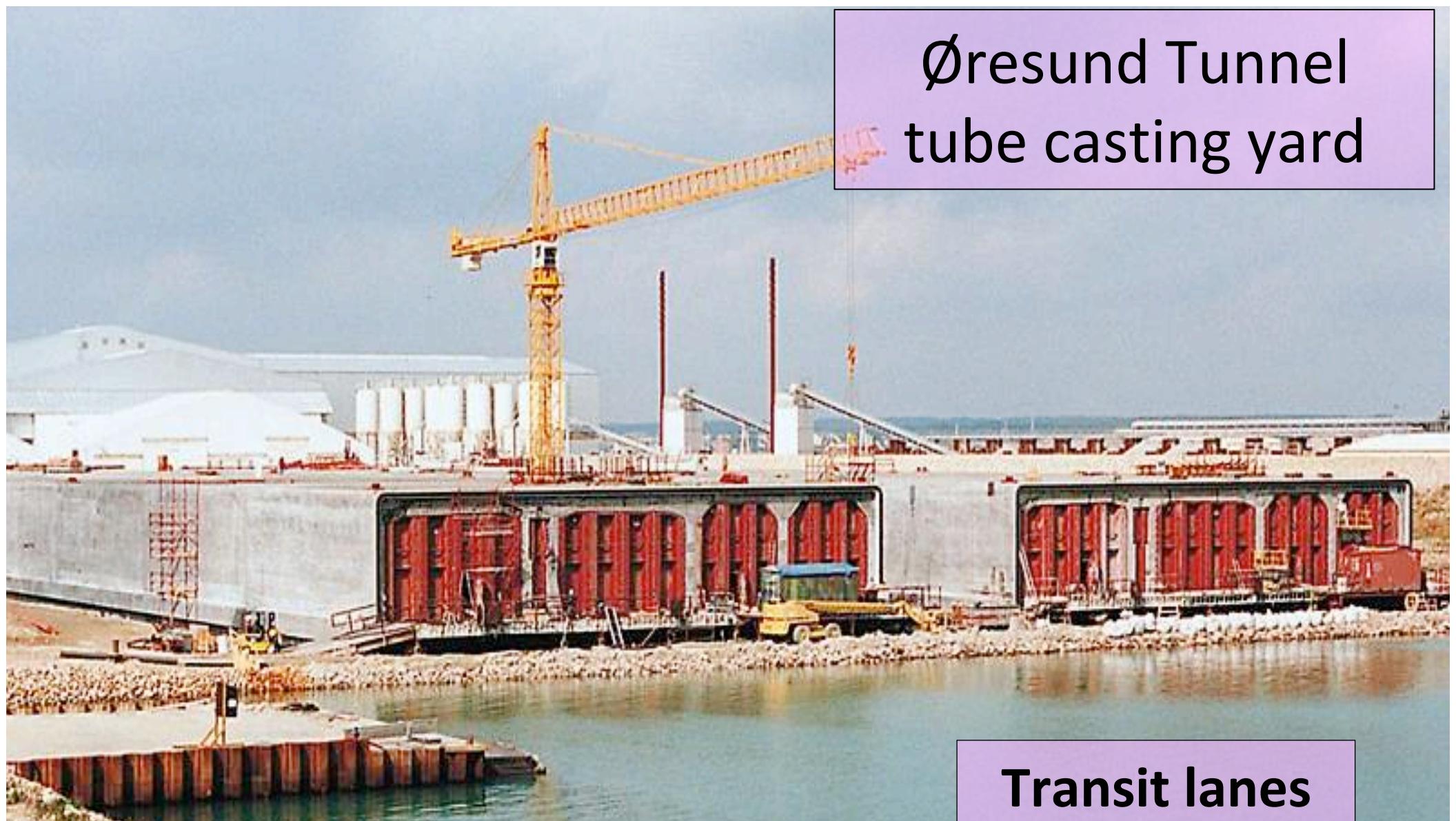
Immersed Tube Tunnel Concept Design



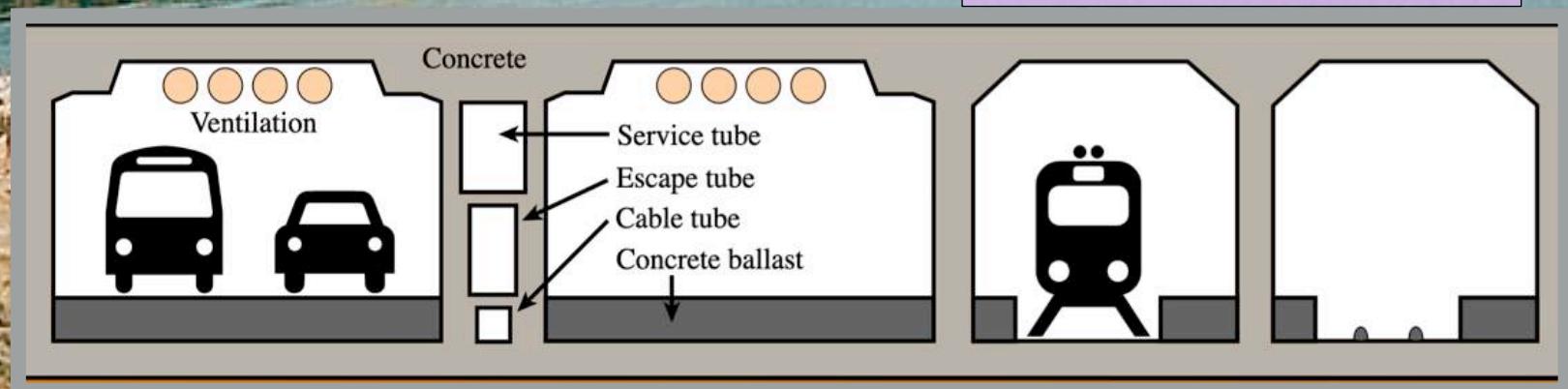
1999 Øresund Immersed Tube Tunnel connects Sweden to Denmark



Øresund Tunnel tube casting yard



Transit lanes



Columbia River Immersed Tube Tunnel

Cut-Cover tunnels

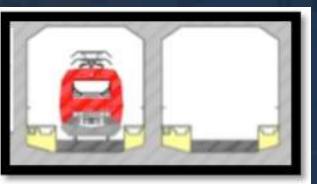
Vancouver

3,000 ft.

Flexible Transit Design

Separate tube, portals, grade

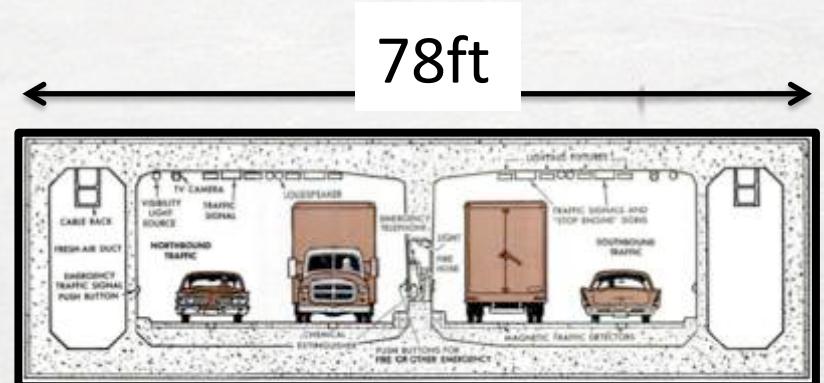
Eight 375 ft. tubes



1959 George Massey – Fraser River

6 tubes x 344 ft. = 0.4 miles

18,500 tons

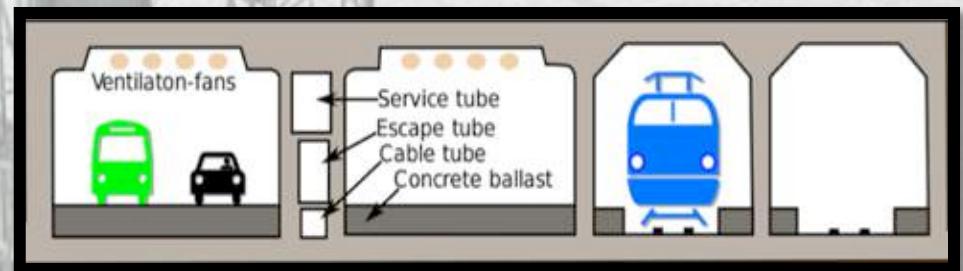


1999 Øresund – Sweden to Denmark

20 tubes x 577 ft. = 2.2 miles

62,000 tons

127ft



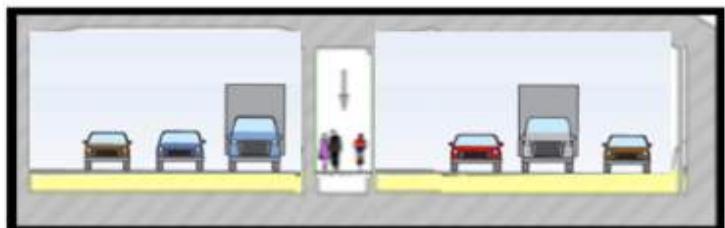
Columbia River

8 tube sections x 375 ft. = 0.6 miles

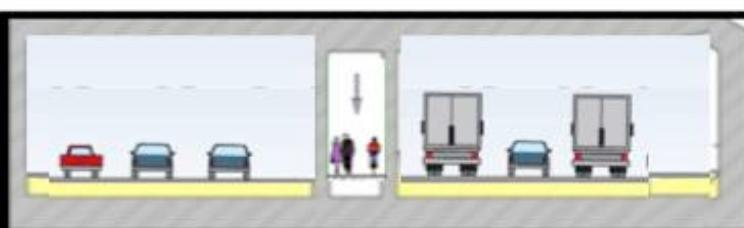
115ft

115ft

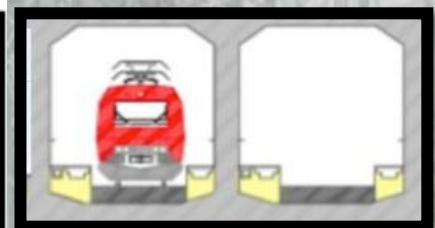
45ft



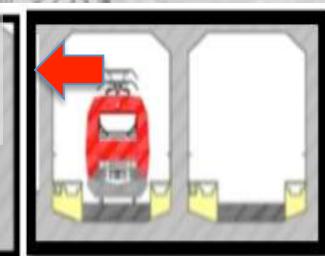
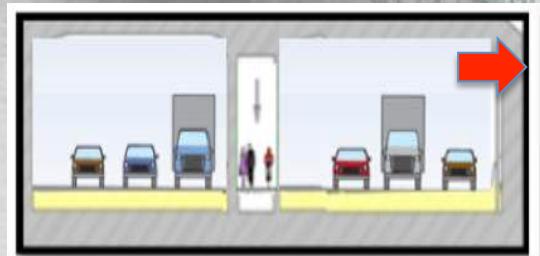
32,000 tons



32,000 tons



13,000 tons



520

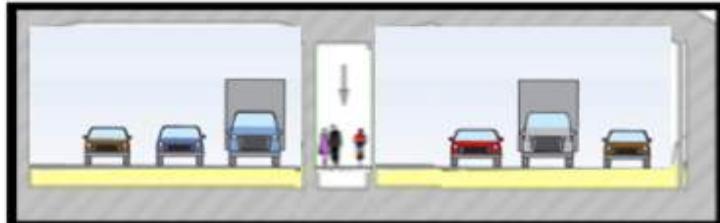
Pontoons 360 x 75 ft. x 28 ft.
11,000 tons

Aberdeen Casting Basin



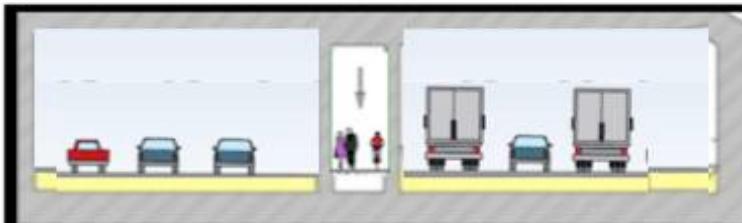
Columbia River Tube sections 375 ft.

115ft



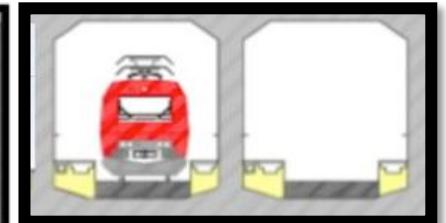
32,000 tons

115ft



32,000 tons

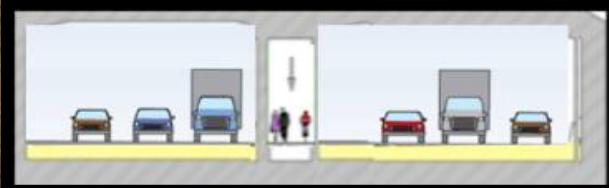
45ft



13,000 tons

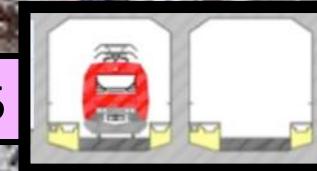
Aberdeen Casting Basin 165 x 910 feet

Parallel tube construction



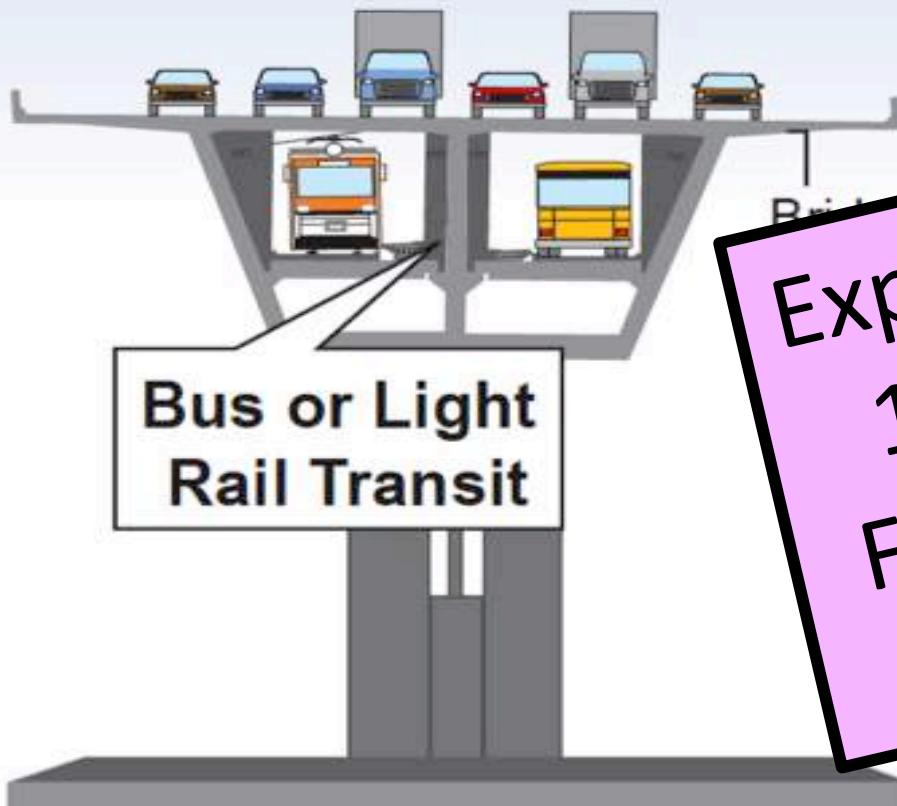
115 x 375

45 x 375

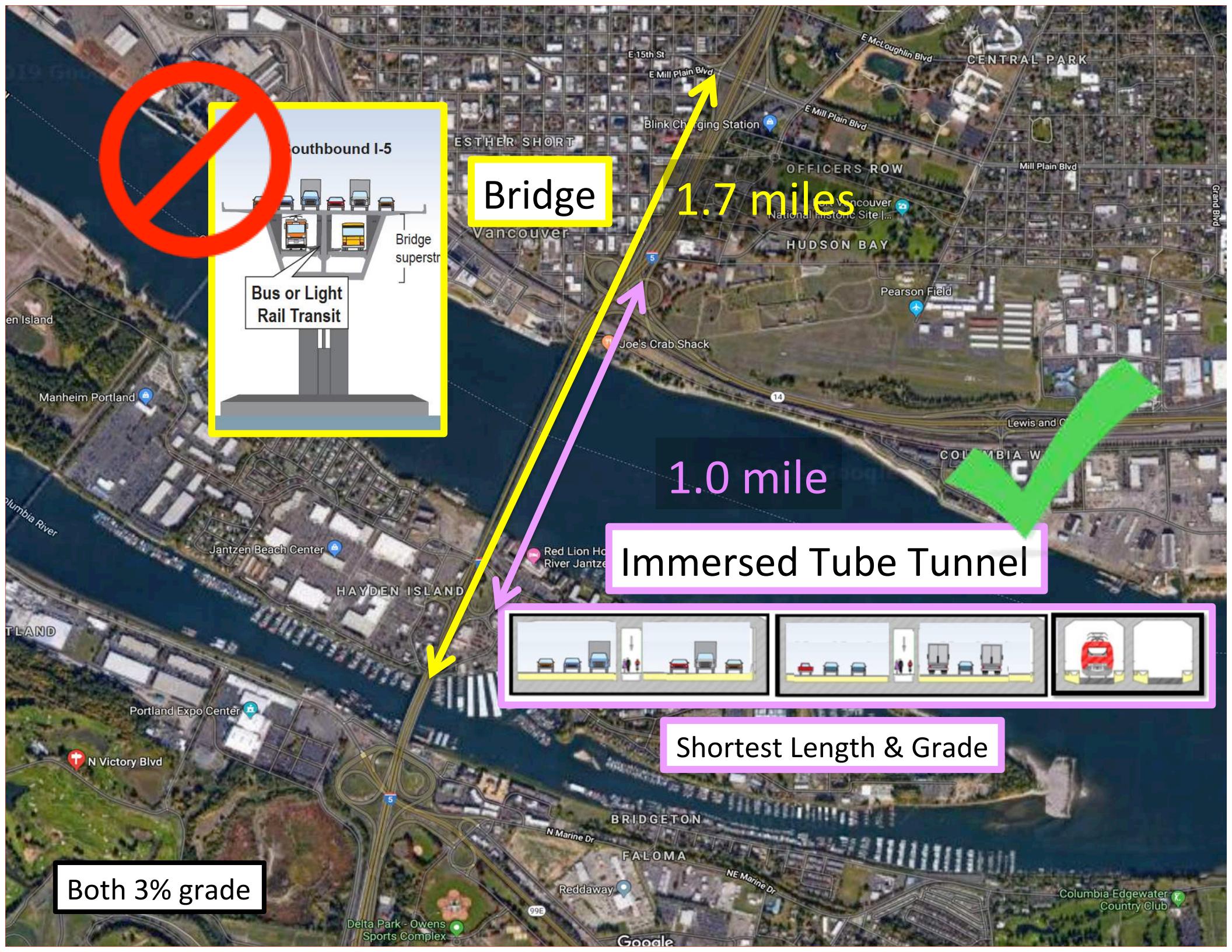


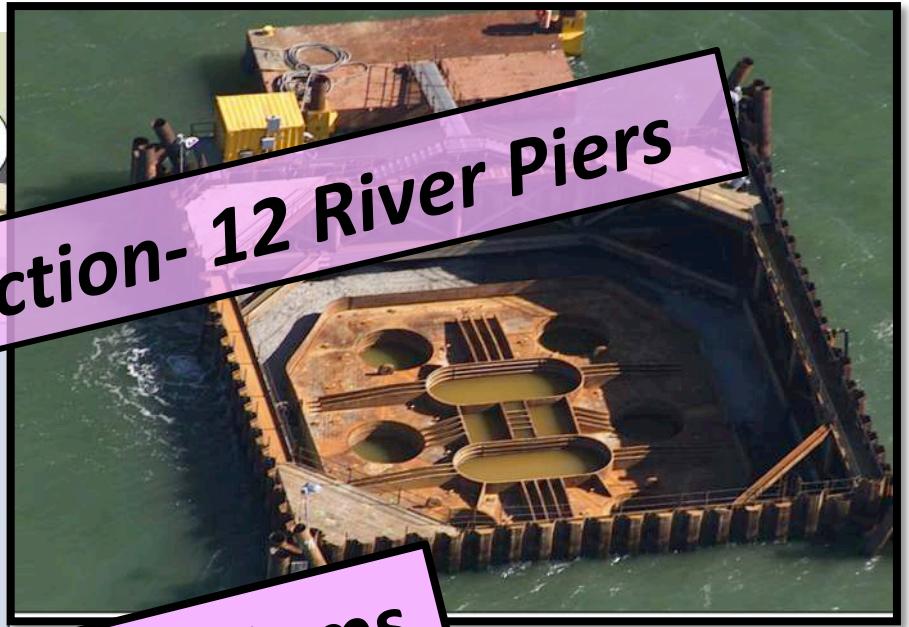
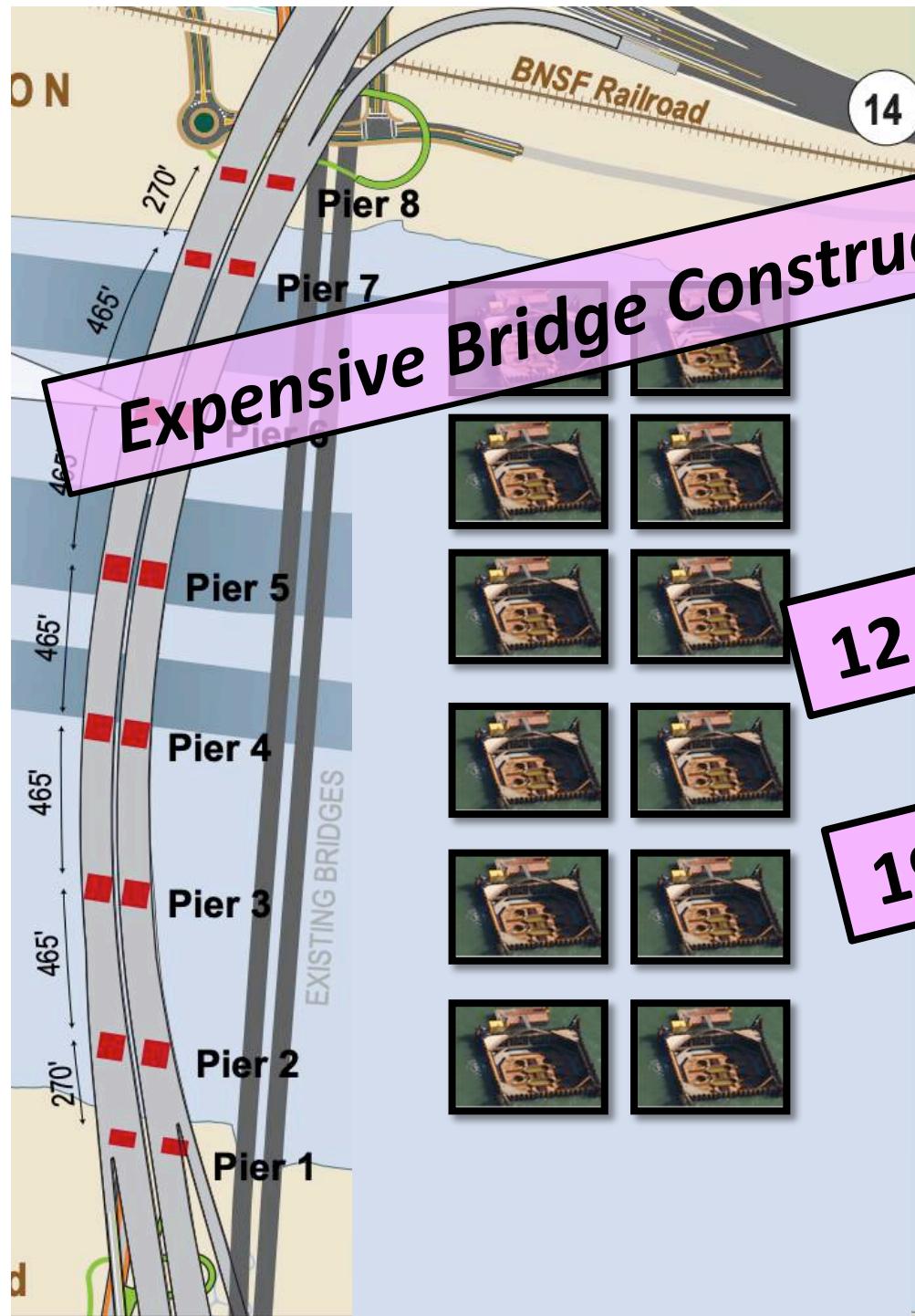
Report to the Washington State Legislature

Columbia River I-5 Bridge Planning Inventory

**Southbound I-5****Northbound I-5**

Expensive
1960's
Freeway
Design





12 Cofferdams

192 drilled shafts





In River work is dangerous*



Expensive marine cranes



*WA workers compensation
in river rate \$4.93/hr.

Casting Yard - Aberdeen, WA

Land based cranes



Yard work is safer

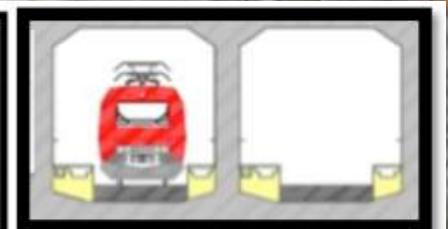


SR 520 Pontoons
2009 bid - \$367.3 million

Kiewit-General's bid was \$180 million less than WSDOT's estimate.



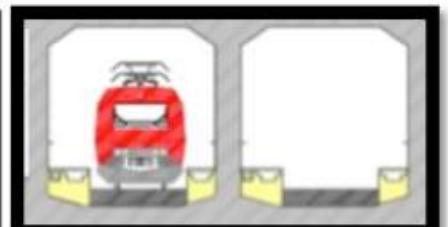
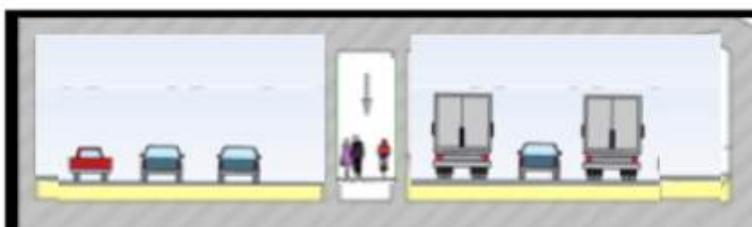
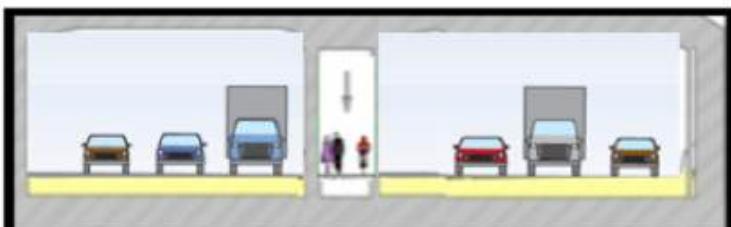
Yard work is less expensive



Bridge Pollution = Noise + Visual + Shadow

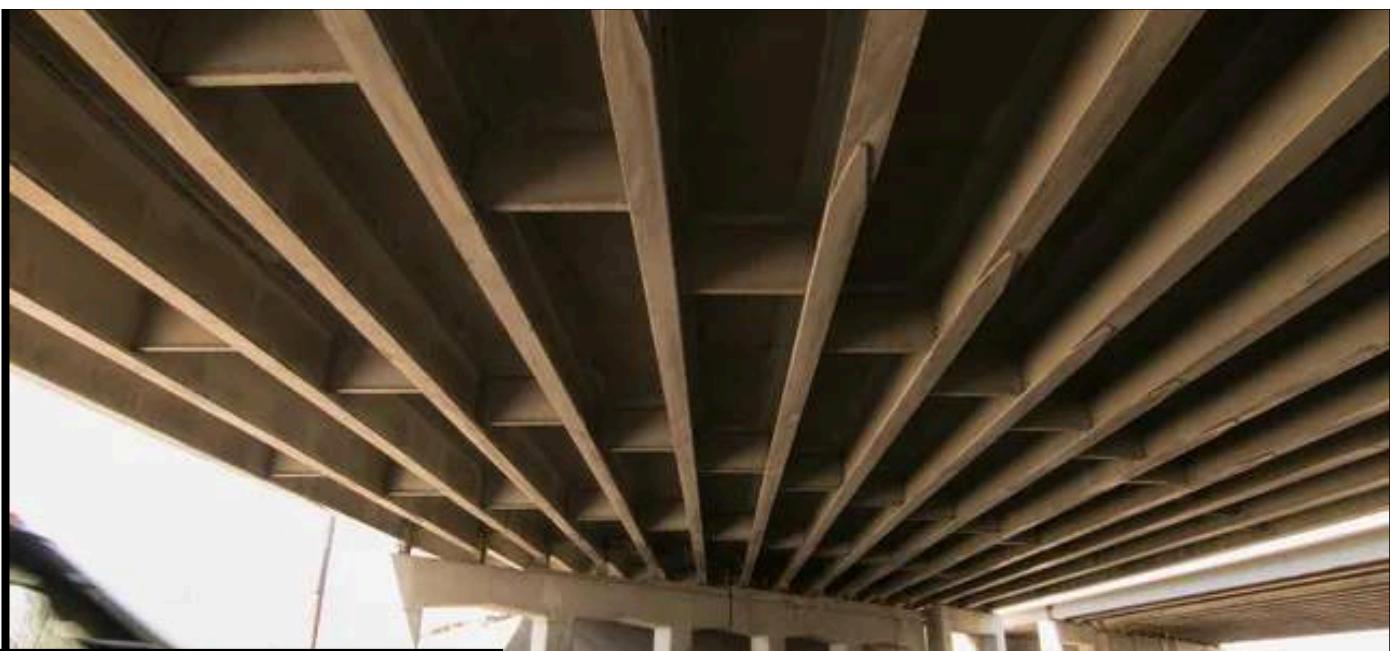


Tunnel = No Pollution



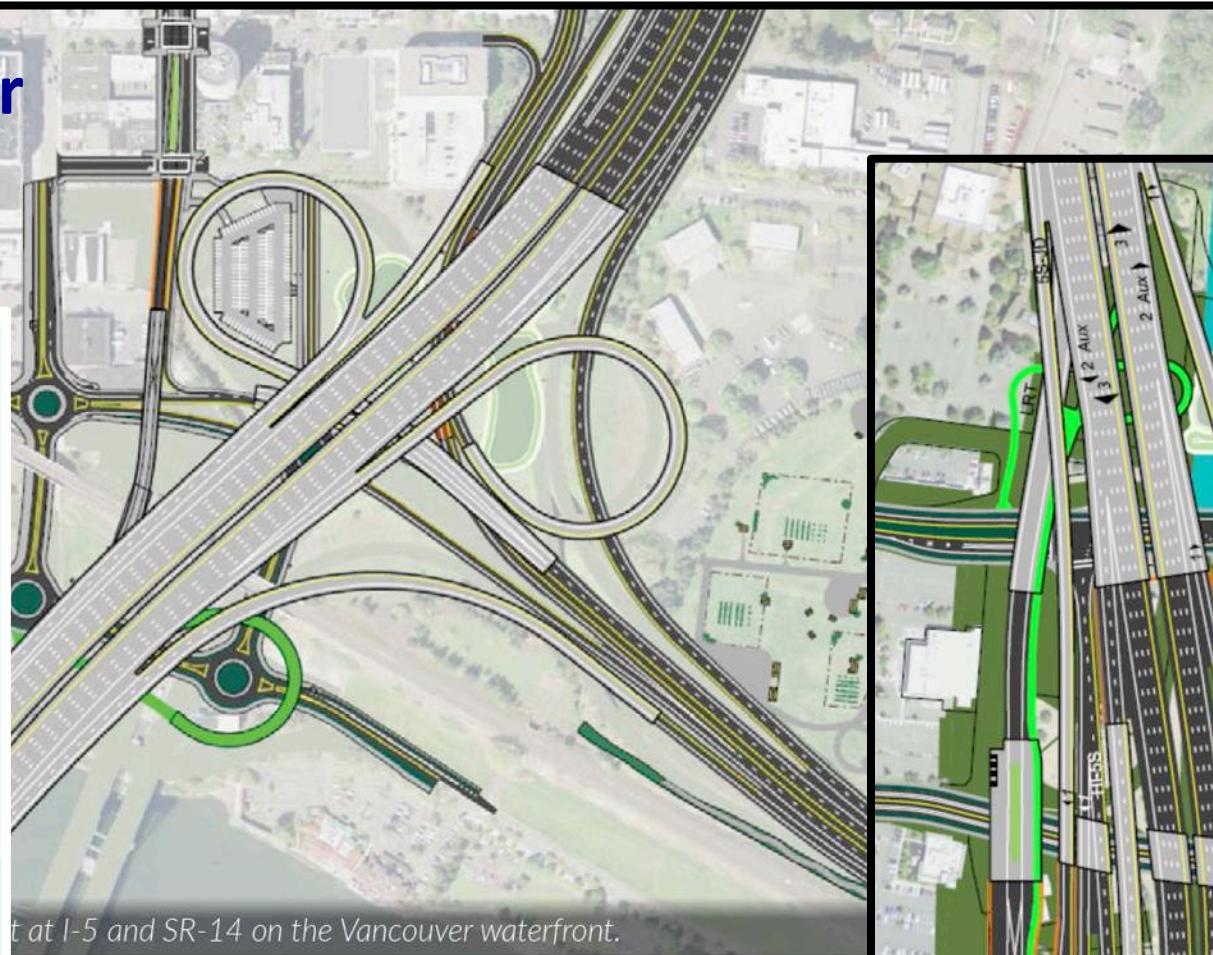
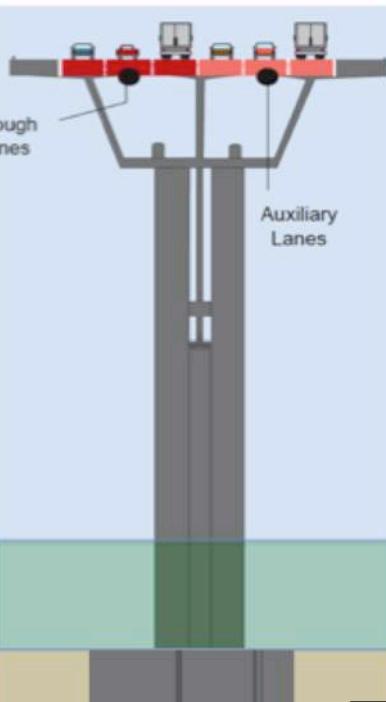


Columbia Street
With 12 lane
Bridge

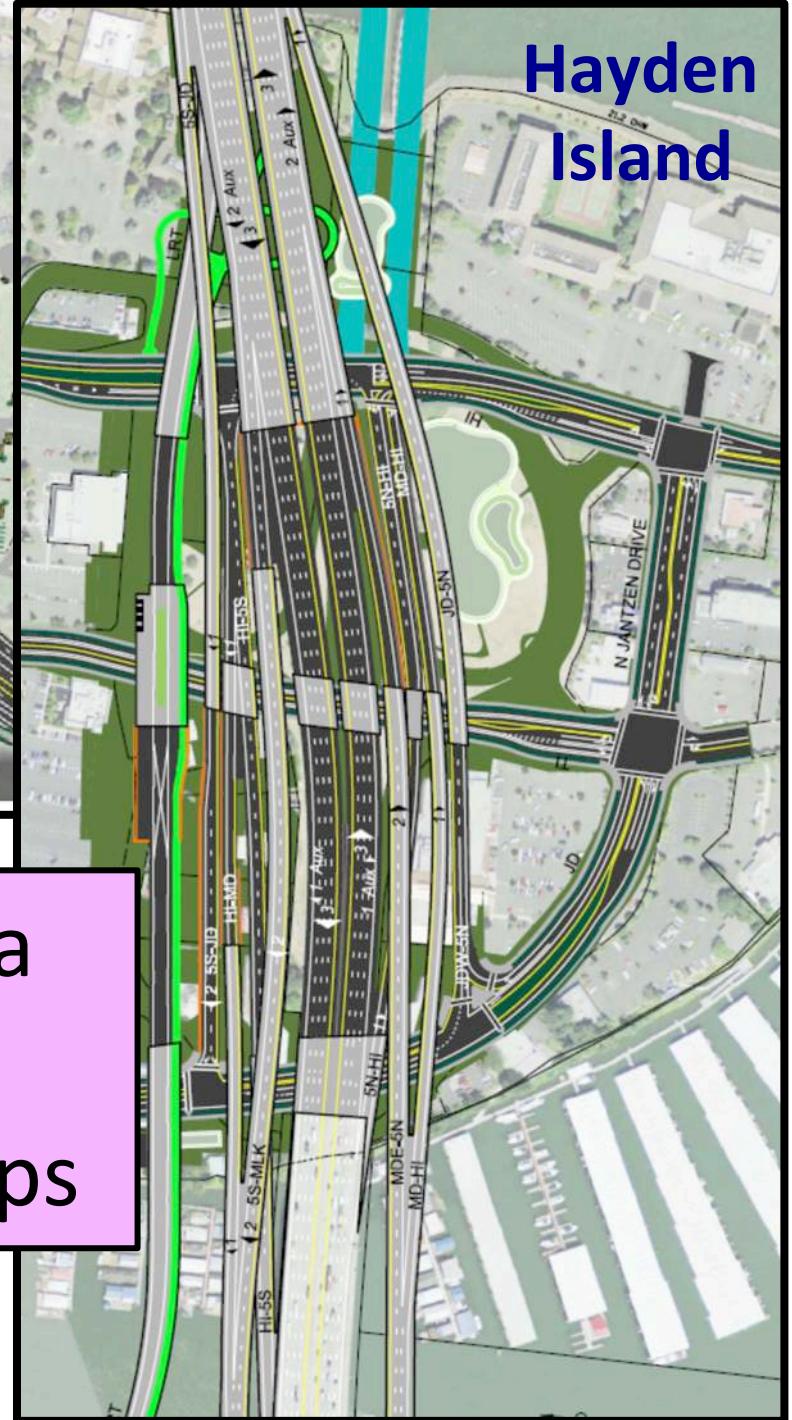


Current
Columbia Street
Vancouver, WA

Vancouver

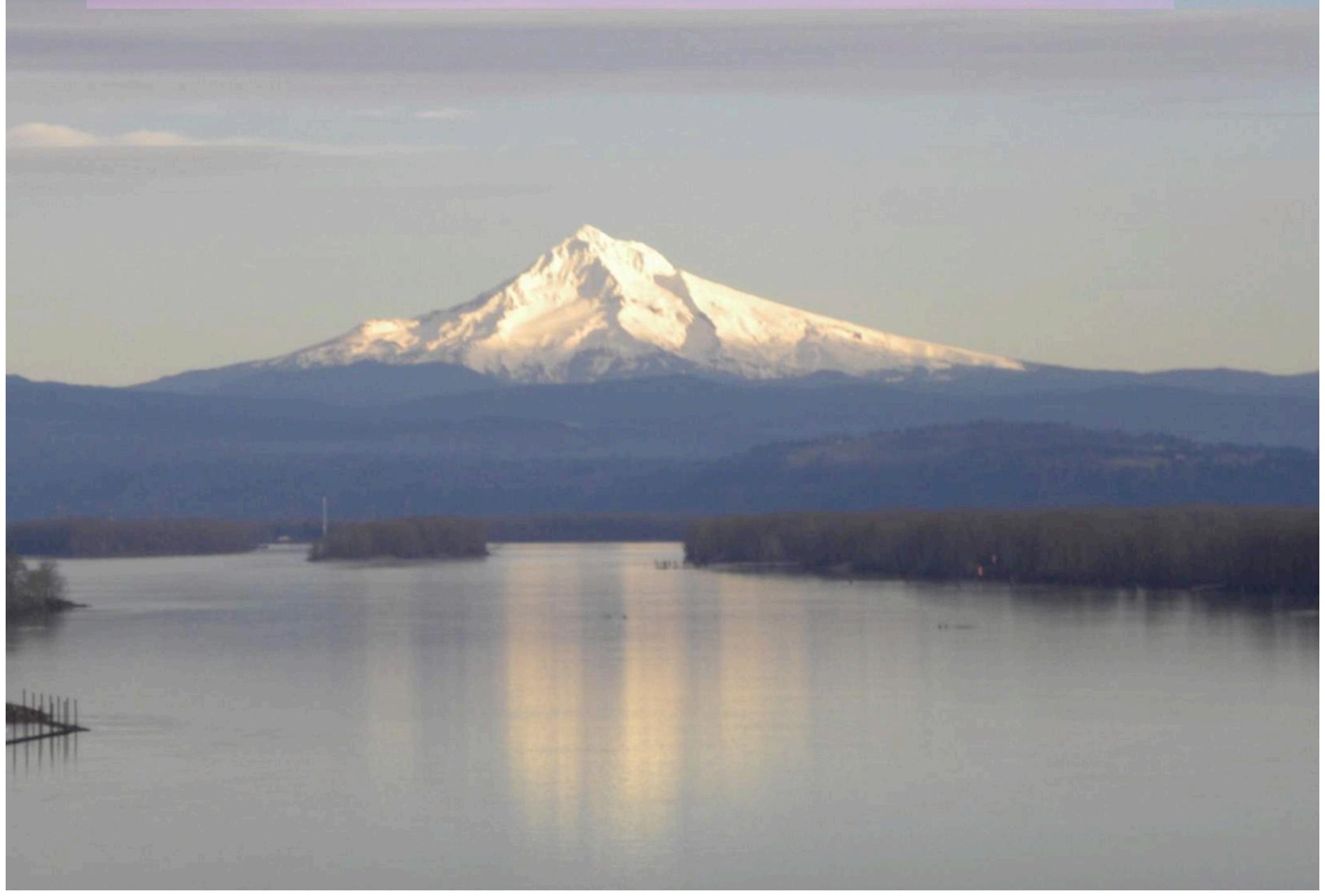


Hayden Island



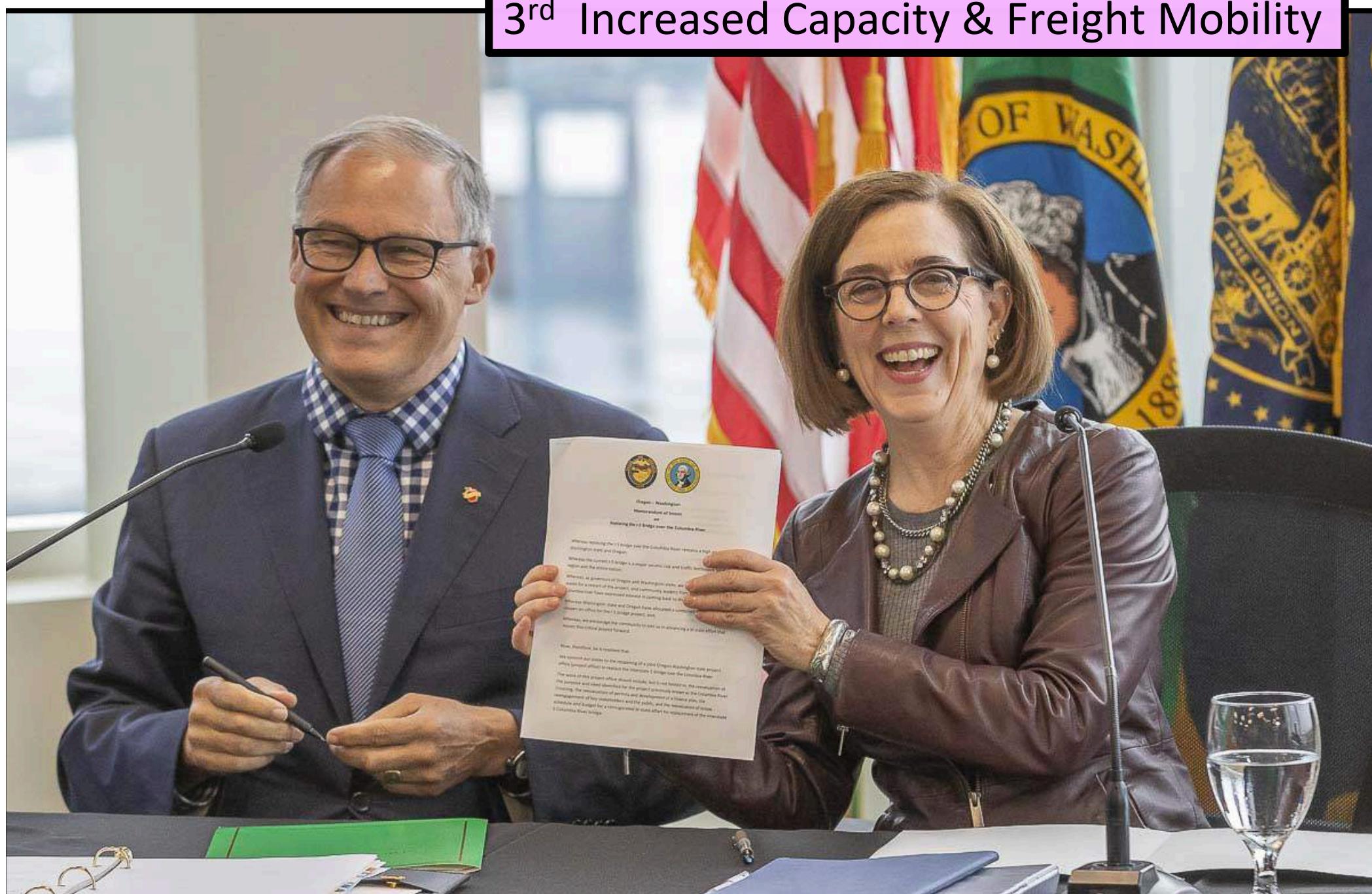
High Bridge creates a
concrete stew of
swirling on & off-ramps

View of Columbia River Immersed Tube Tunnel



Agreed goals:

- 1st Seismic safety
- 2nd High Capacity Transit
- 3rd Increased Capacity & Freight Mobility

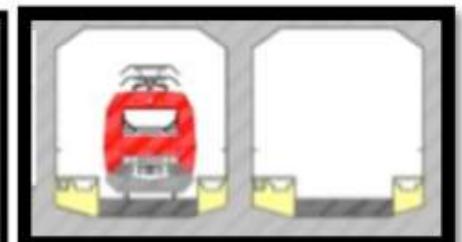
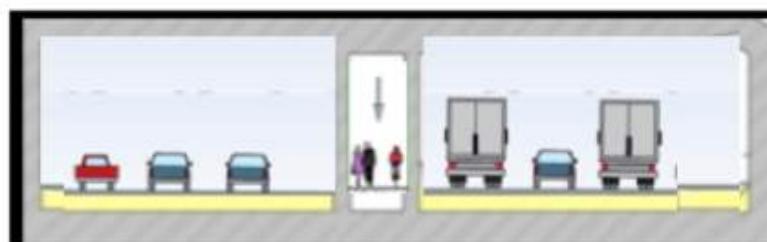
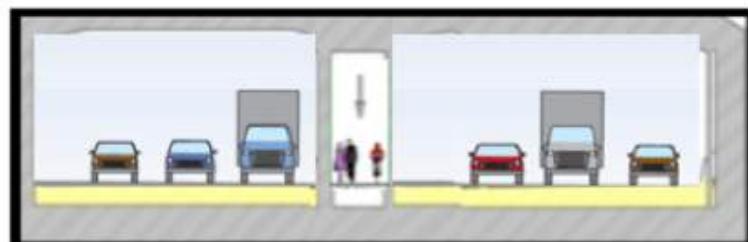


1st Goal

- 1st Seismic safety
- 2nd High Capacity Transit
- 3rd Increased Capacity & Freight Mobility

Seismic Safety

Immersed Tube Tunnel

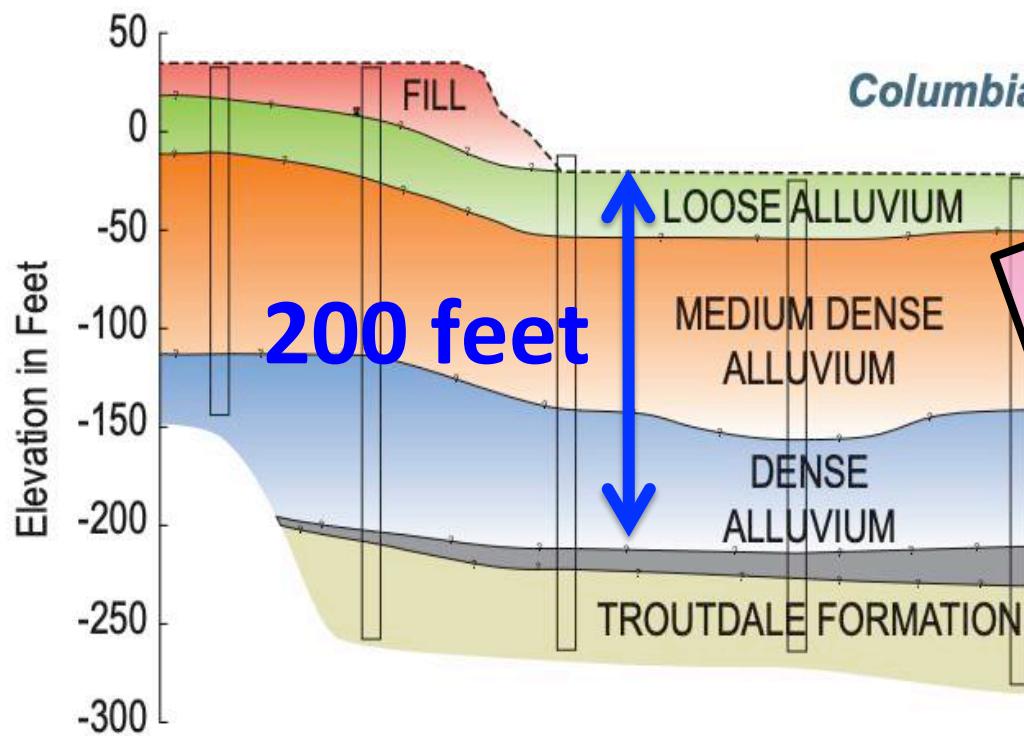




200 Feet of Liquid Sand

EARTHQUAKE RISK: The Interstate Bridge pilings sit in sandy river soils which could behave like liquid during an earthquake, causing the bridge to fail.

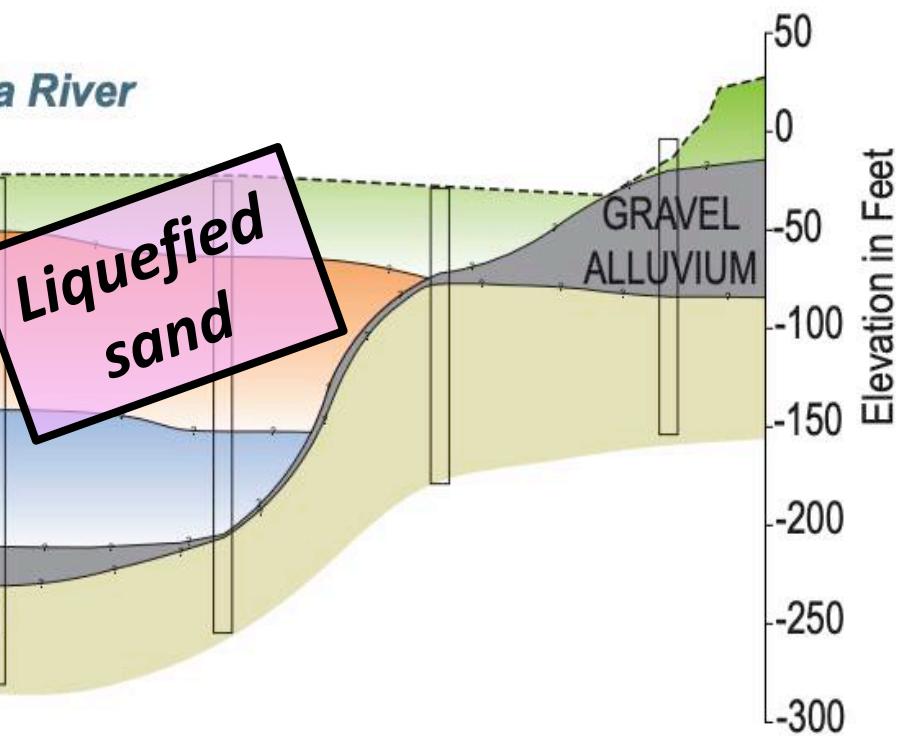
Oregon



Columbia River

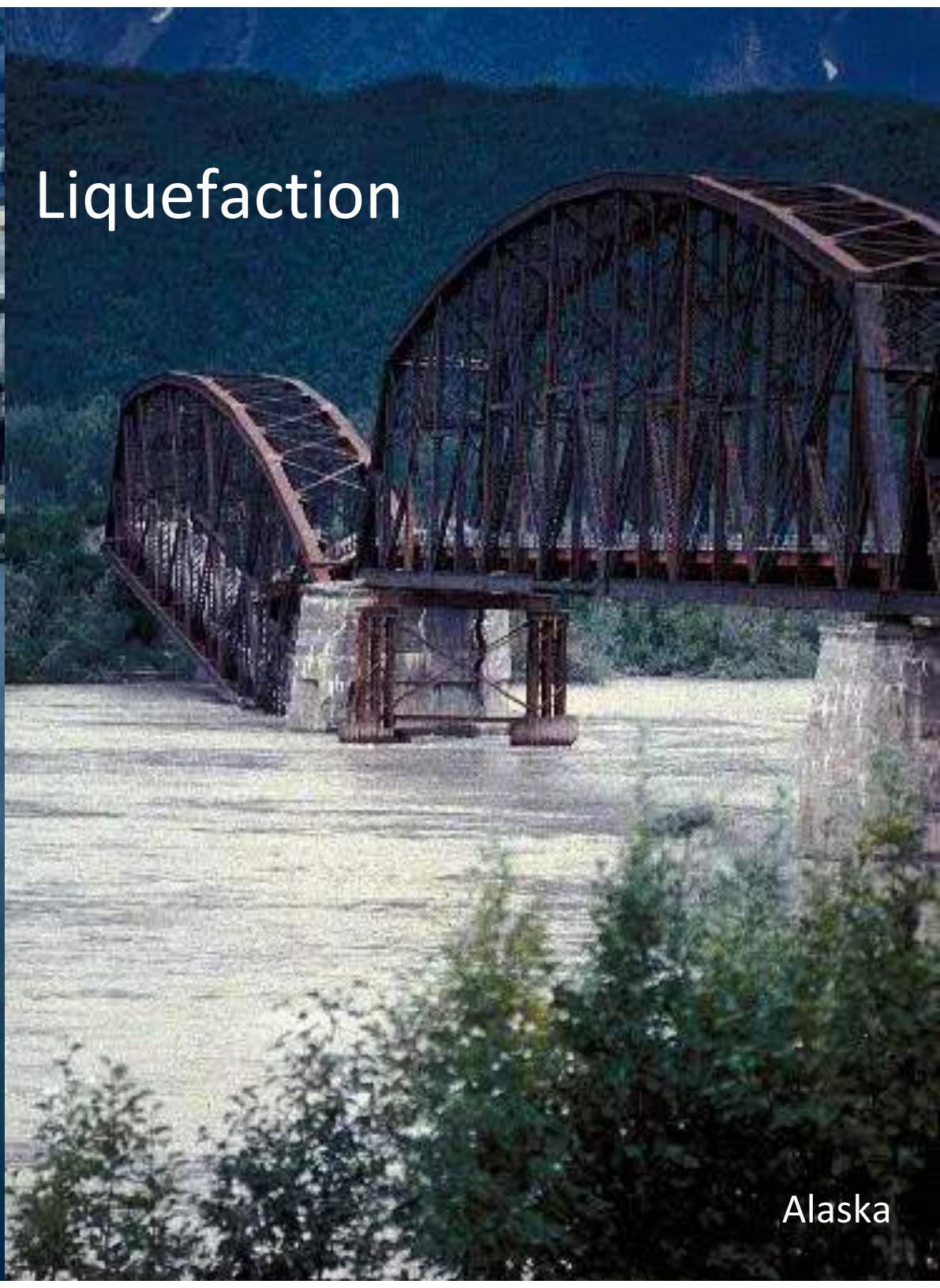
Liquefied
sand

Washington





Japan



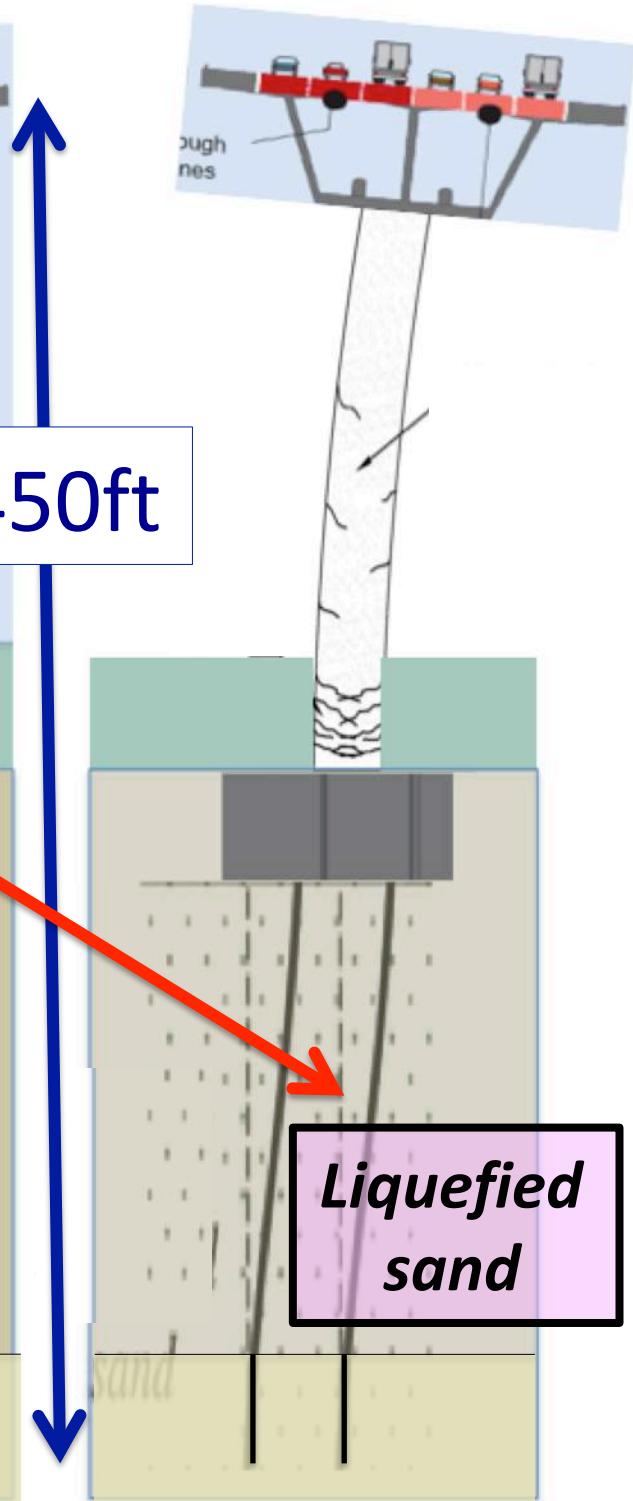
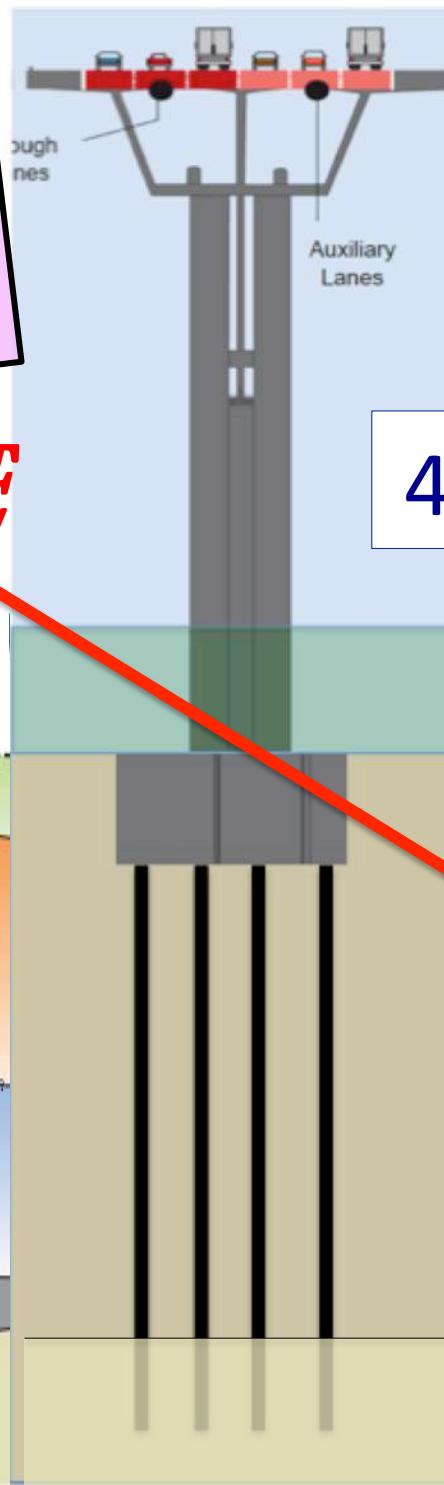
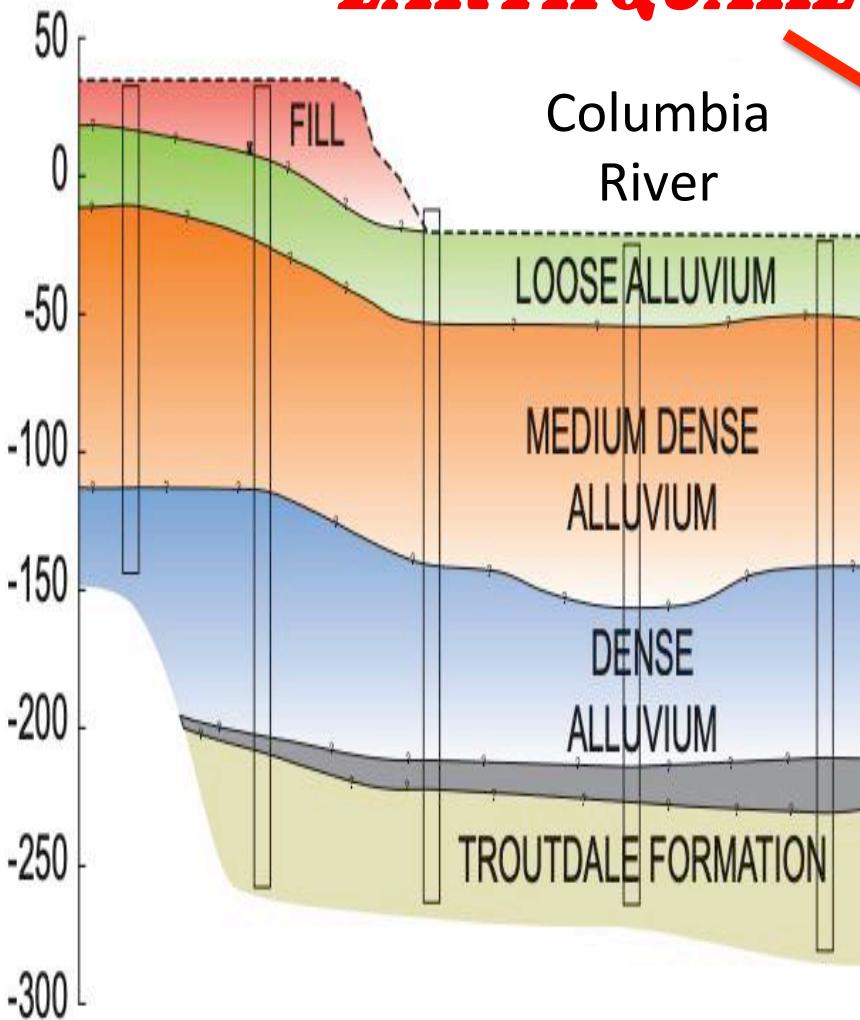
Alaska

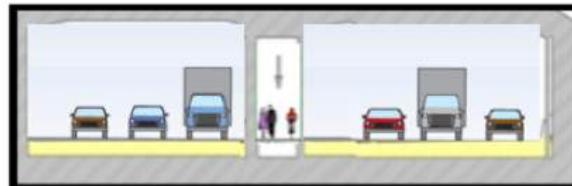
Liquefaction



**Bridge - Seismic risk
450ft. to solid ground**

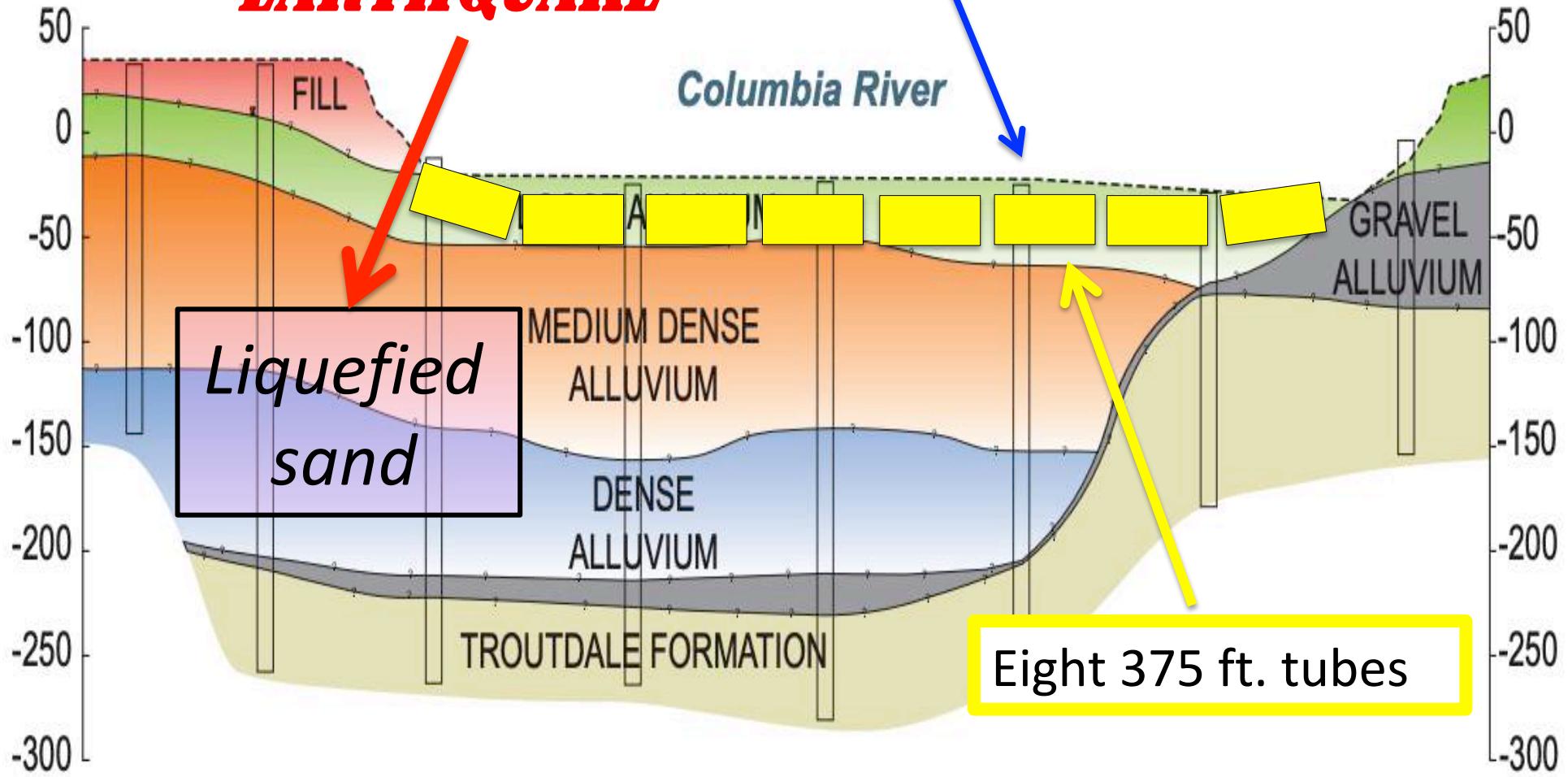
EARTHQUAKE





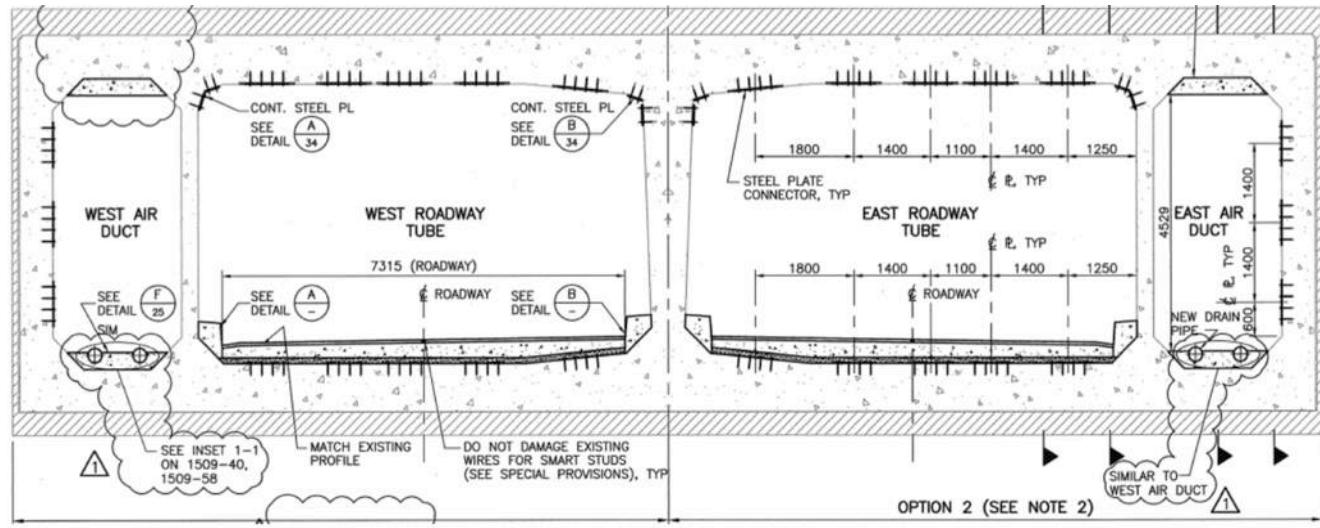
Tunnel - Seismic resistant – neutral buoyancy

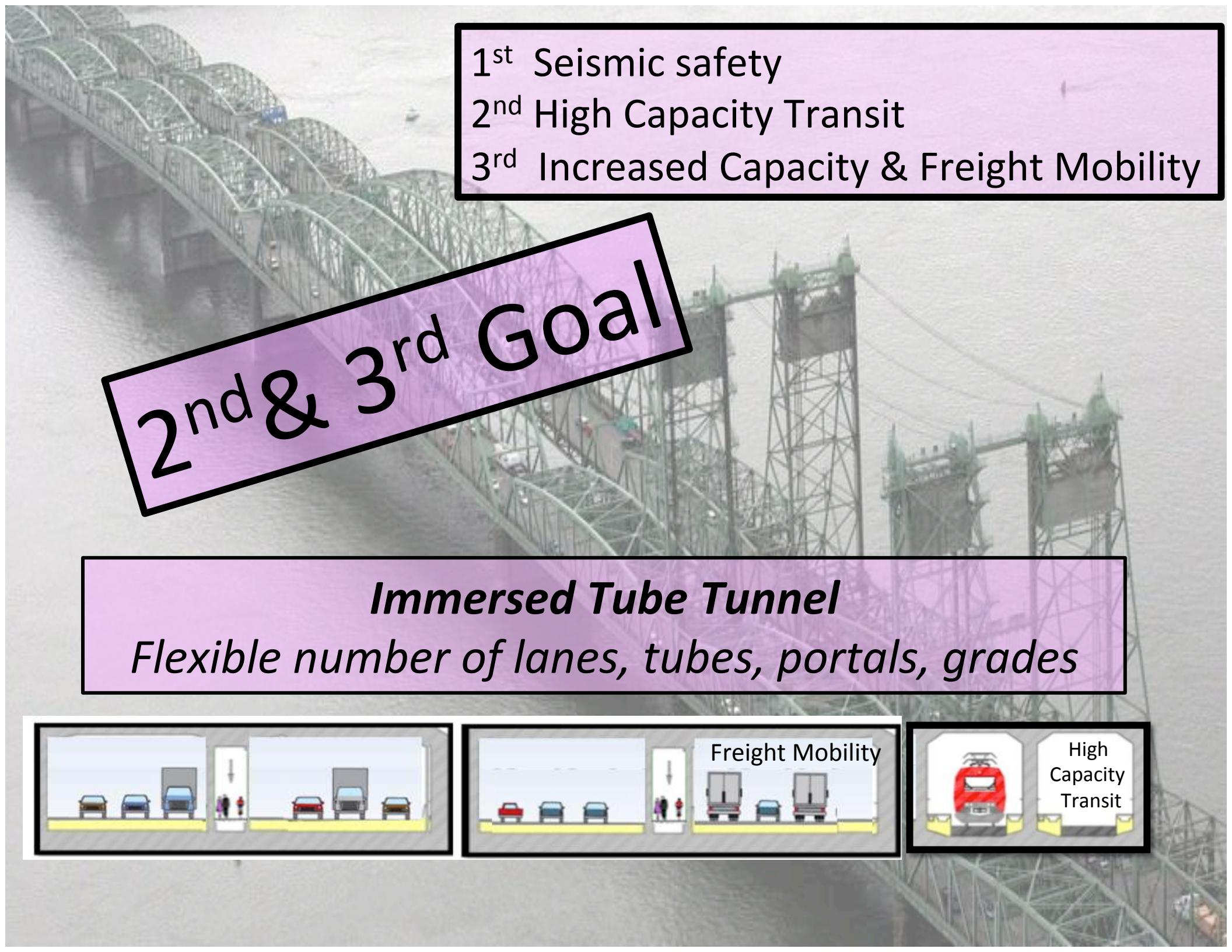
EARTHQUAKE



George Massey Fraser River Crossing

2006 Seismic retrofit of **1959 immersed tube tunnel**
Designed for 275-year earthquake

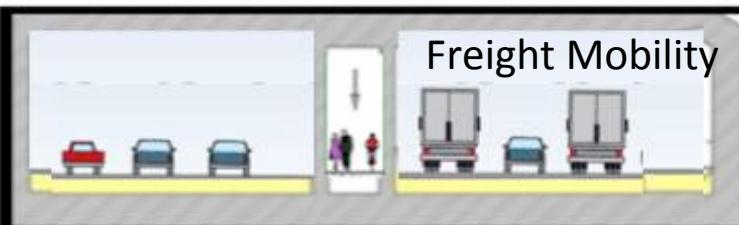
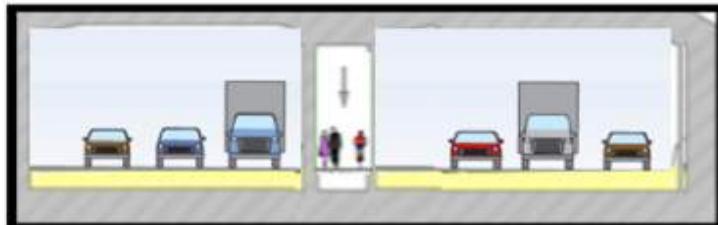




- 1st Seismic safety
- 2nd High Capacity Transit
- 3rd Increased Capacity & Freight Mobility

2nd & 3rd Goal

Immersed Tube Tunnel
Flexible number of lanes, tubes, portals, grades



Malmo to Copenhagen
2000



Hong Kong to Macao
2018



Richmond to Vancouver

1959



Proven Solution

Baltimore
1999



Detroit

1910



Sydney
1992

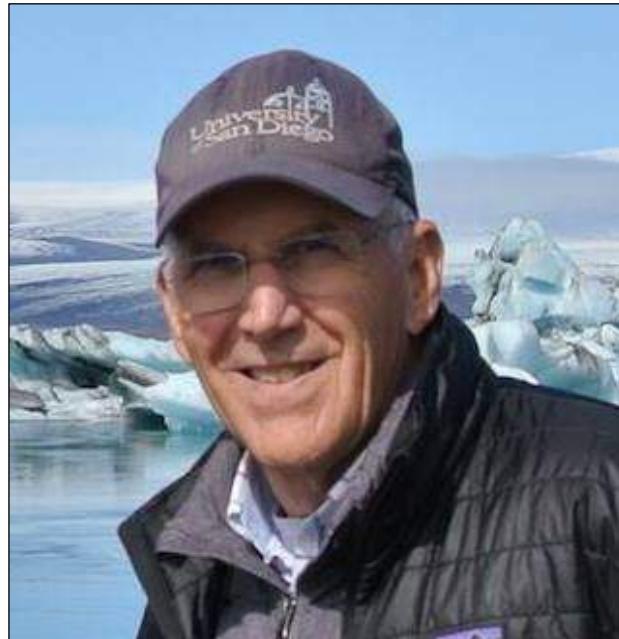


64 Immersed tube tunnels



International Database and Gallery of Structures

Thank You



TRUSS ME
I AM
CIVIL ENGINEER



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References:

British Columbia's Massey Tunnel was a cutting-edge endeavor

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Construction of the George Massey Tunnel 1957-59

<https://www.youtube.com/watch?v=A1igKk8eK0M>

In a unanimous vote, Metro Vancouver's finance and inter-government committee has backed a task force's recommendation to replace the aging George Massey crossing with a new eight-lane immersed-tube tunnel.

<https://vancouversun.com/news/local-news/task-force-recommends-new-eight-lane-tube-to-replace-massey-tunnel>

George Massey Crossing Project – Mayors' Task Force Oct. 2, 2019

<https://engage.gov.bc.ca/app/uploads/sites/52/2019/10/GMC-Project-Presentation-at-Task-Force-Meeting-Oct-2.pdf>

Crossing the Oresund

<https://data.oresundsbron.com/cms/download/Crossing%20the%20%C3%98resund.pdf>

WSDOT – Columbia River I-5 Bridge Planning Inventory - Dec 2007

<https://www.wsdot.wa.gov/accountability/ssb5806/>

Immersed Tube Tunnel – railsystem.net

<http://www.railsystem.net/immersed-tube-tunnel/>

Trelleborg - How to build an immersed tunnel

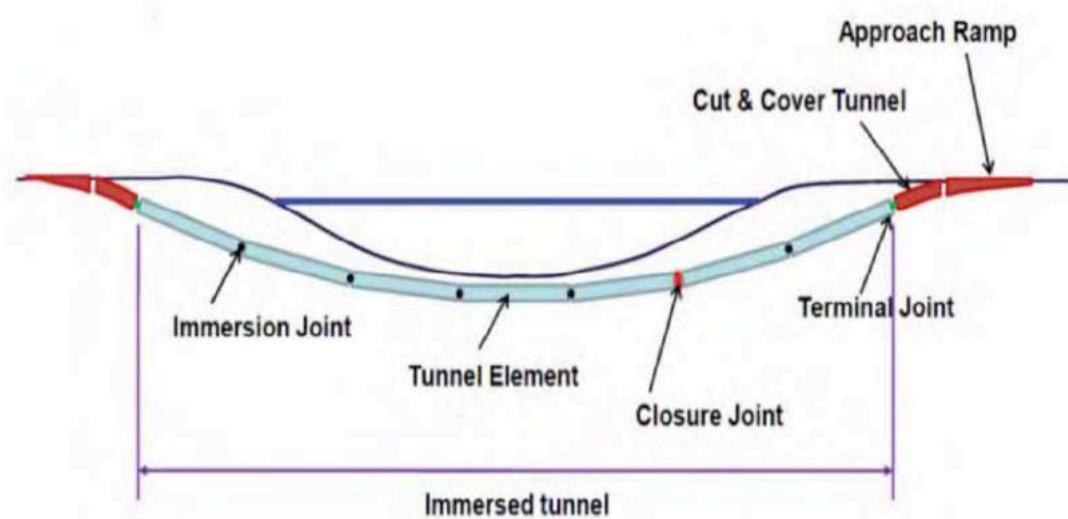
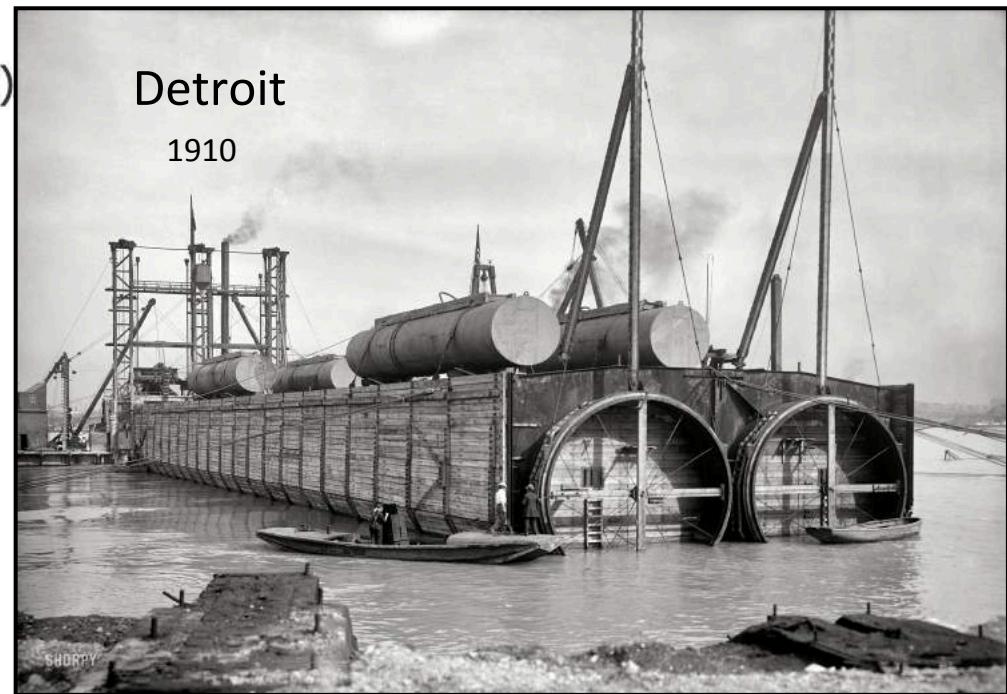
<https://www.youtube.com/watch?v=2Xkyyc9PIQA>

Sydney Harbour Tunnel

<https://www.youtube.com/watch?v=576ydM8rPCw>

Immersed Tube Tunnel Projects

1. Michigan Central Railroad (first tunnel in 1910)
2. Marmaray (world's deepest immersed tunnel)
3. Cross-Harbour Tunnel
4. Eastern Harbour Crossing
5. Sha Tin to Central Link
6. Tsuen Wan Line
7. Western Harbour Crossing
8. Busan-Geoje Fixed Link
9. Tokyo Bay Aqua-Line
10. Detroit-Windsor Tunnel
11. George Massey Tunnel
12. Louis-Hippolyte Lafontaine Bridge-Tunnel
13. 63rd Street Tunnel
14. Baltimore Harbor Tunnel
15. Chesapeake Bay Bridge-Tunnel
16. Detroit-Windsor Tunnel
17. Downtown Tunnel
18. East Side Access
19. Fort McHenry Tunnel
20. Hampton Roads Bridge-Tunnel
21. Midtown Tunnel (Virginia)
22. Monitor-Merrimac Memorial Bridge-Tunnel
23. Posey and Webster Street tubes
24. Ted Williams Tunnel
25. Transbay Tube
26. Sydney Harbour Tunnel



64 Immersed tube tunnels

#	Name	Year	Location
1	63rd Street Tunnel	1989	New York (NY) 
2	Baytown Tunnel	1953	Baytown (TX)  - La Porte (TX) 
3	Beneluxtunnel	1967	Rotterdam 
4	Beneluxtunnel	2002	Rotterdam 
5	Beveren Tunnel	1969	Beveren 
6	Bjørvika Tunnel	2010	Oslo 
7	Botlek Road Tunnel	1980	Rotterdam 
8	Coen Tunnel	1966	Amsterdam 
9	Conwy Tunnel	1991	Conwy (GB-WLS) 
10	Dordtsche Kil Tunnel	2004	Dordrecht  - Binnenmaas 
11	Drechtunnel	1977	Zwijndrecht  - Dordrecht 
12	Dublin Port Tunnel	2006	Dublin 
13	Eastern Harbour Crossing	1989	Hong Kong 
14	Elbe Tunnel (1st to 3rd Tubes)	1975	Hamburg (HH) 
15	Ems Tunnel	1989	Leer (Ostfriesland) (NI) 
16	Fort McHenry Tunnel	1985	Baltimore (MD) 
17	Fort Point Channel Tunnel		Boston (MA) 
18	Frans Tijmans Tunnel	1967	Antwerp 
19	Galamadammen Aqueduct	2007	Koudum 
20	George Massey Tunnel	1959	Delta (BC)  - Richmond (BC) 
21	Harderwijk Aquaduct	2003	Harderwijk 
22	Havana Bay Tunnel	1958	Havana 
23	IJtunnel	1968	Amsterdam 
24	Jack Lynch Tunnel	1999	Cork 
25	Limerick Tunnel	2010	Limerick 
26	Lingding-Tonggu Channel Tunnel	2018	Zhuhai 
27	Louis Hippolyte Lafontaine Tunnel	1967	Montreal (QC) 
28	Luntou Tunnel		Guangzhou 
29	Maas Tunnel	1942	Rotterdam 
30	Marieholm Tunnel	2020	Gothenborg 
31	Marmaray Tunnel	2013	Istanbul 
32	Medway Tunnel	1996	Chatham (GB-ENG)  - Strood (GB-ENG) 

33	Melocheville Tunnel	1957	Beauharnois (QC)  - Salaberry-de-Valleyfield (QC) 
34	Midtown Tunnel	1962	Norfolk (VA)  - Portsmouth (VA) 
35	Noord Tunnel	1992	South Holland 
36	North-South Corridor Cross Harbour Tunnels	2020	Hong Kong 
37	Oude Maas Tunnel	2006	Zwijndrecht  - Binnenmaas 
38	Øresund Tunnel	2000	Malmö  - Copenhagen 
39	Piet Heintunnel	1997	Amsterdam 
40	Posey Tube	1928	Oakland (CA)  - Alameda (CA) 
41	Preveza-Aktio Tunnel	2002	Preveza 
42	Prinses Margriet aquaduct	1978	Südwest-Fryslân 
43	Schiphol Tunnel	1986	Amsterdam  - Leiden 
44	Second Midtown Tunnel	2016	Norfolk (VA)  - Portsmouth (VA) 
45	Second Tyne Tunnel	2011	Newcastle upon Tyne (GB-ENG) 
46	Sydney Harbour Tunnel	1992	Sydney (NSW)  - Kirribilli (NSW) 
47	Ted Williams Tunnel	1996	Boston (MA) 
48	Thomassen Tunnel	2003	Rotterdam 
49	Tingstadstunneln	1968	Gothenborg 
50	Transbay Tube	1974	San Francisco (CA)  - Oakland (CA) 
51	Traversée sous-fluviale de Météor	1998	Paris (75) 
52	Tunnel du Vieux Port de Bastia	1979	Bastia (2B) 
53	Tunnel du Vieux-Port	1967	Marseilles (13) 
54	Velsen Road Tunnel	1957	Velsen 
55	Warnow Tunnel	2003	Rostock (MV) 
56	Washburn Tunnel	1950	Houston (TX) 
57	Webster Street Tube	1963	Oakland (CA)  - Alameda (CA) 
58	Western Harbour Rail Tunnel	1997	Hong Kong 
59	Western Harbour Tunnel	1997	Hong Kong 
60	Westerschelde Tunnel	2003	Terneuzen  - Nieuwdorp 
61	Wijkertunnel	1996	Beverwijk 
62	Willemsspoortunnel	1993	Rotterdam 
63	Yongjiang Tunnel	1995	Ningbo 
64	Zhujiang River Tunnel	1993	Guangzhou 



**US Army Corps
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Portland District

Today, the authorized Columbia River **between Vancouver, Wash. and The Dalles, Ore.** project includes a deep-draft navigation channel and pile dike structures which stabilize the channel. The 300-foot-wide navigation channel is authorized to be **27 feet deep, but currently maintained to 17-foot depth**, considered adequate for current users (primarily tug and barge traffic).

To keep the ports of Portland and Vancouver accessible to oceangoing ships, **every year the Corps dredges 6 million to 8 million cubic yards of sand** from the 107-mile shipping channel between Astoria and Vancouver

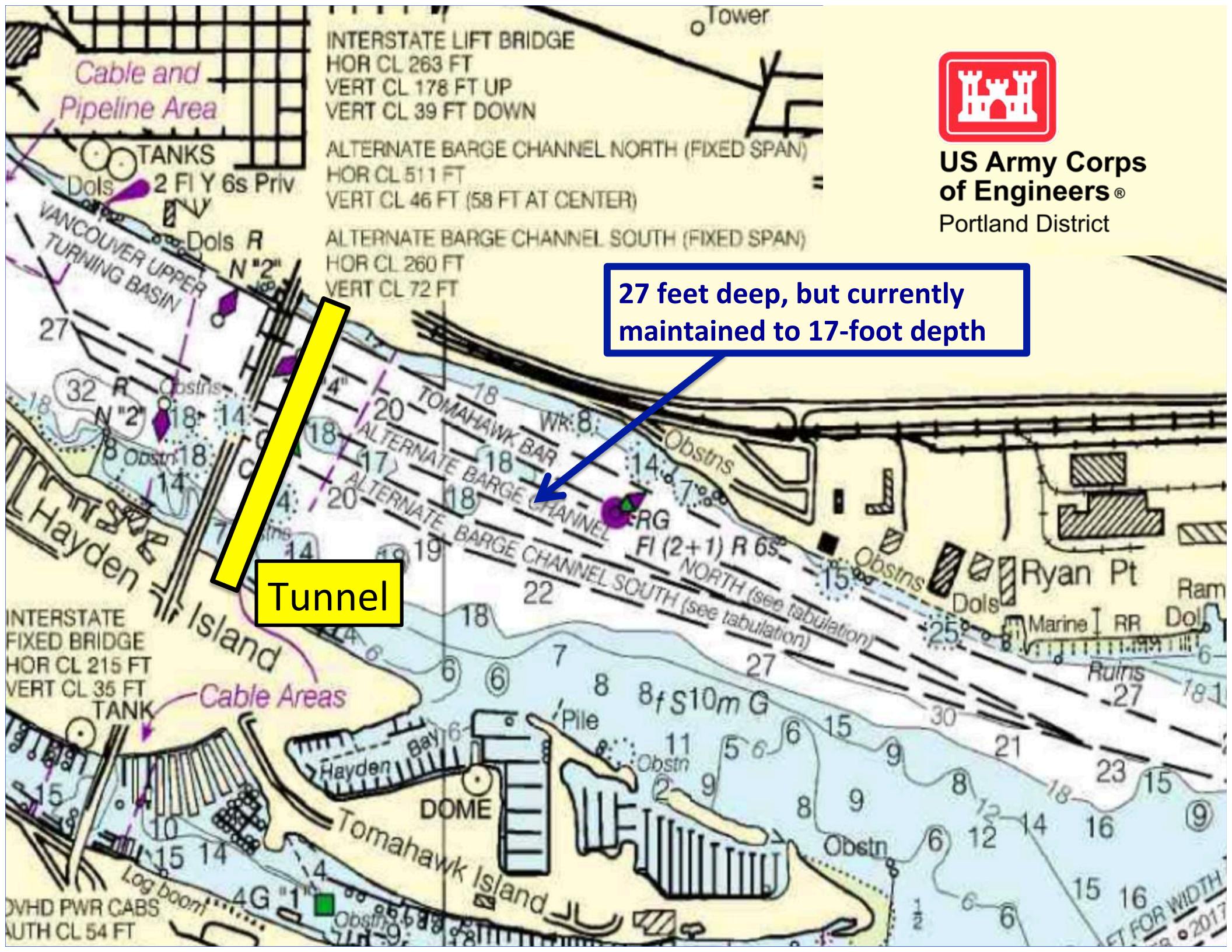
The Corps is drafting a new plan in conjunction with the ports of Portland, Vancouver, Woodland, Kalama and Longview. A big part of that work is figuring out where to put up to **160 million cubic yards of sand over the next 20 years.**



US Army Corps of Engineers® Portland District

27 feet deep, but currently maintained to 17-foot depth

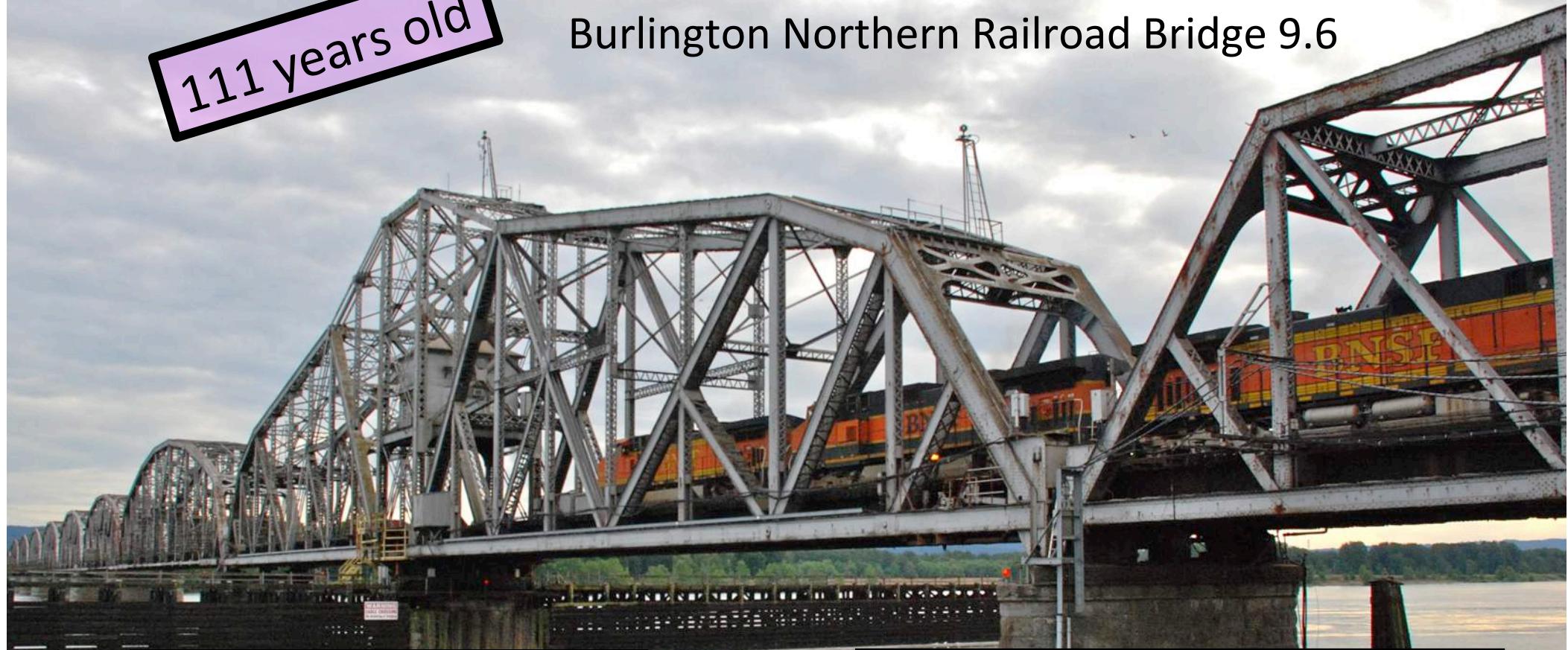
Tunnel



111 years old

1908

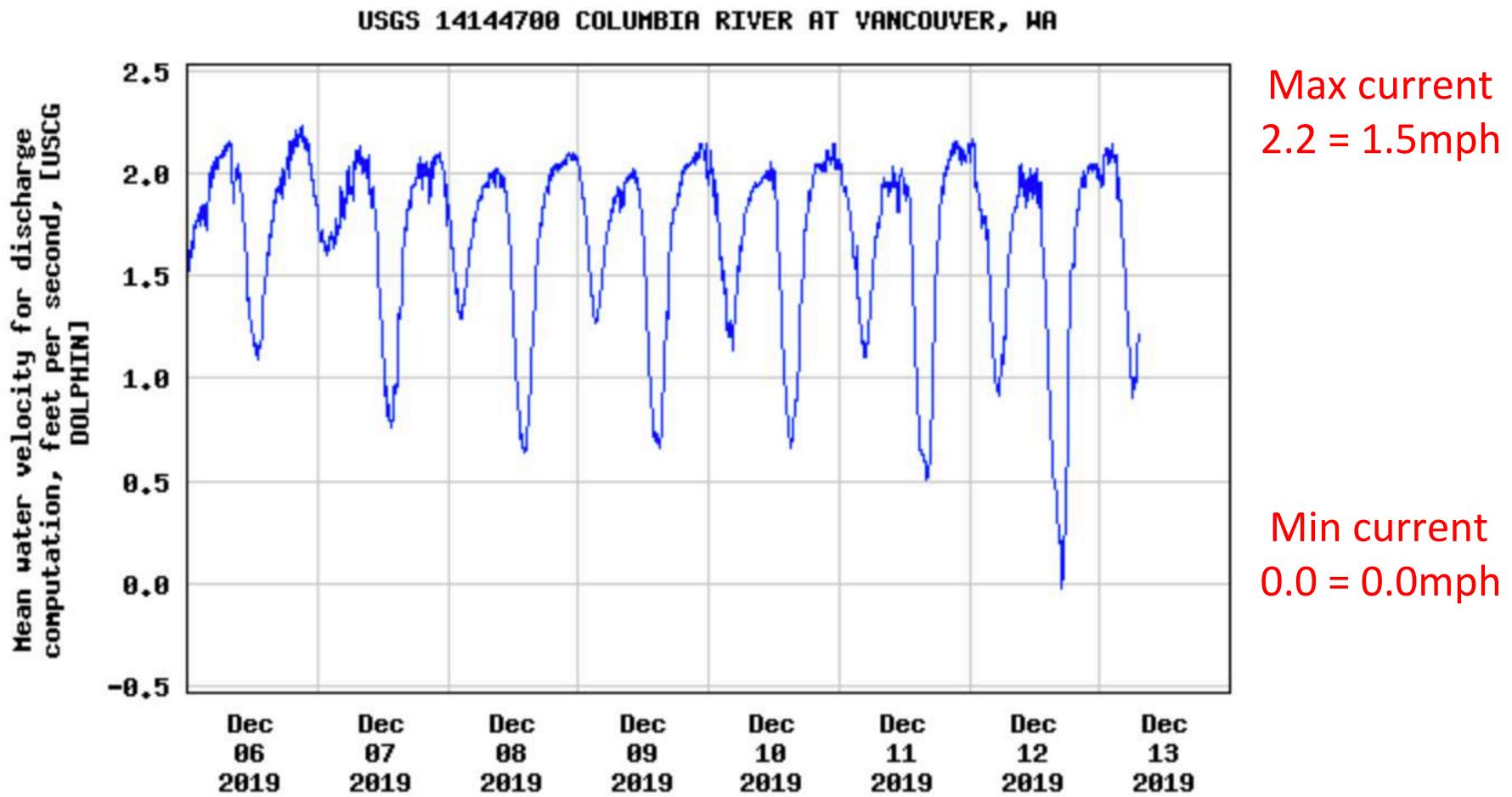
Burlington Northern Railroad Bridge 9.6

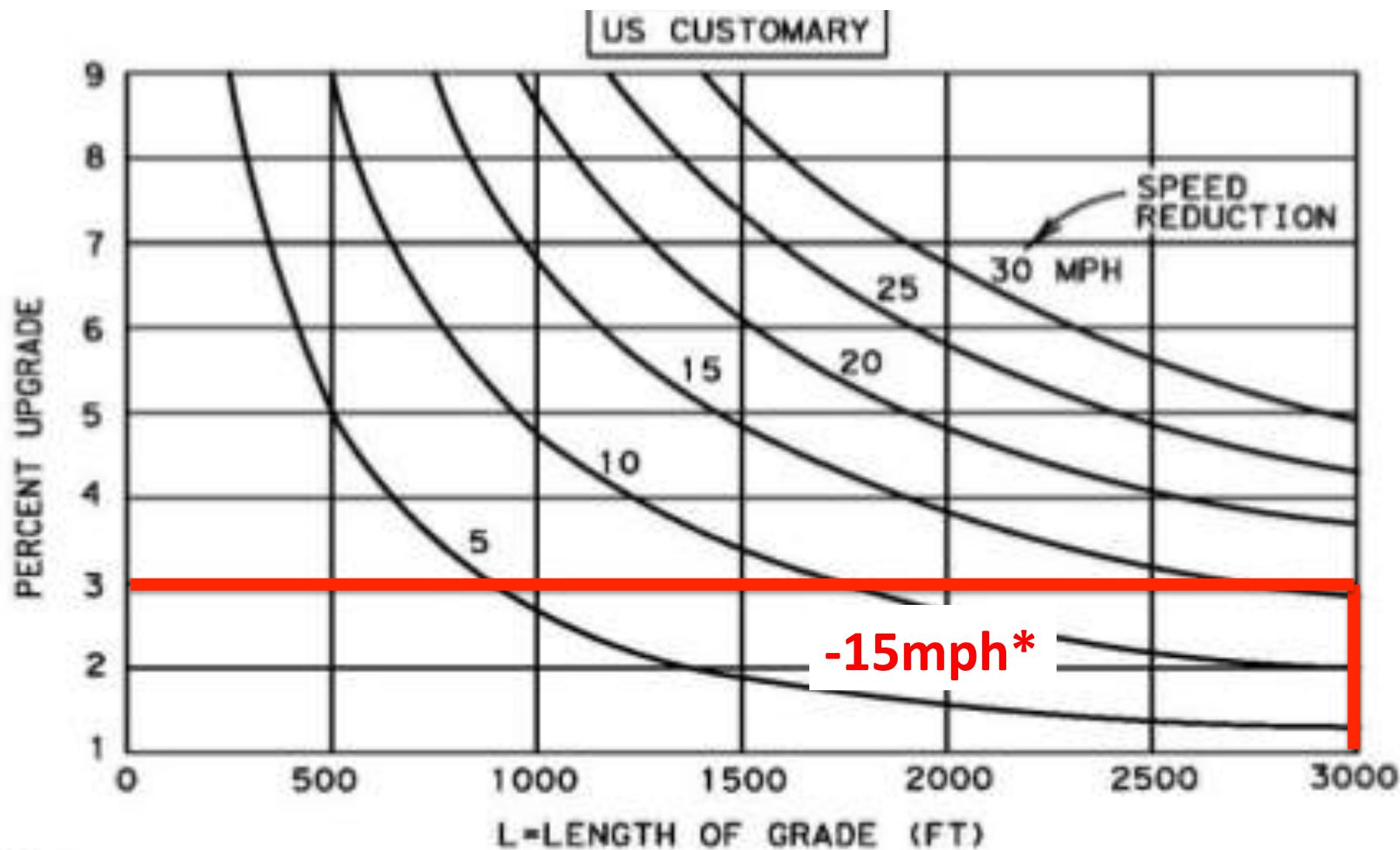


Columbia River @ Vancouver, WA

Mean water velocity for discharge computation, feet per second, Upstream,

Most recent instantaneous value: 1.22 12-13-2019 07:05 PST





Note:

Assumed typical heavy truck of
200 lb/hp; Entering Speed=70 mph

***Heavy truck reduced speed**

CRITICAL LENGTHS OF GRADE FOR DESIGN