



# Columbia River Immersed Tube Tunnel





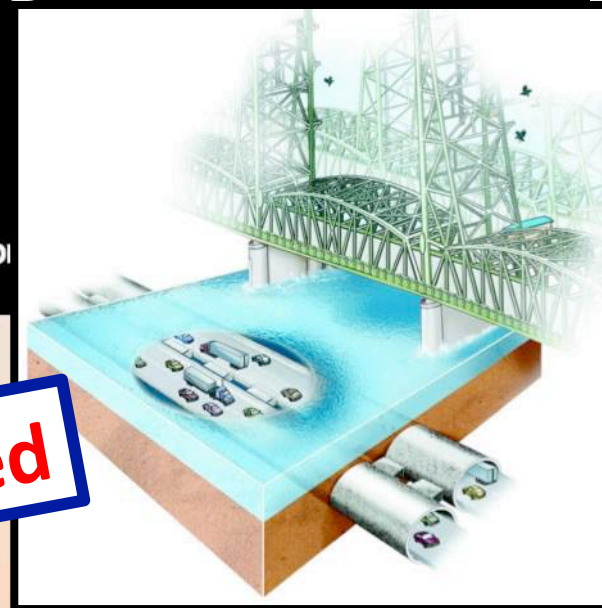
# Interstate Bridge Replacement River Crossing Alternatives Analyzed



Travis Brouwer  
Assistant Director

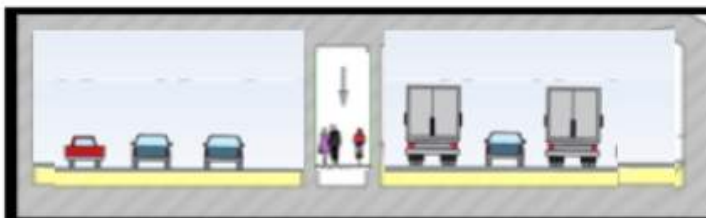


Washington State  
Department of Transportation



Deep Bored Tunnel **-Rejected**

Immersed Tube Tunnel **-Never Evaluated**



November 13, 2019

Deep Bored Tunnel

REJECTED

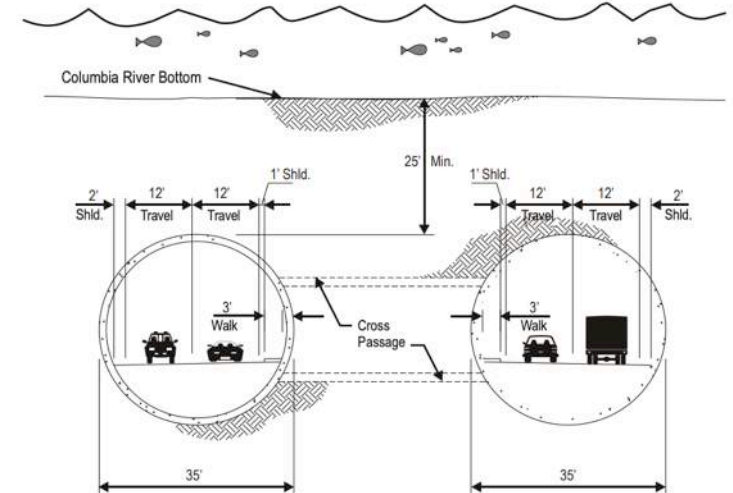
3.44 miles

Too long, small & costly

## Replacement Tunnel

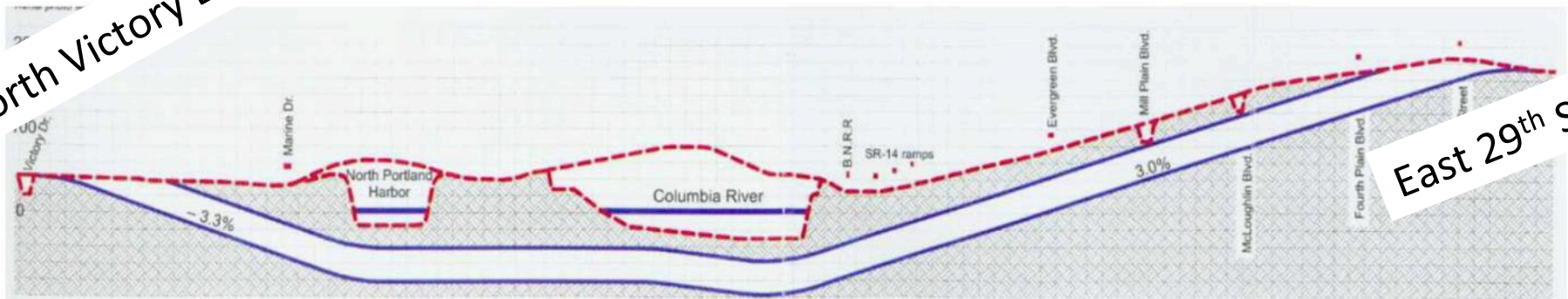
Does not satisfy Questions 1, 2, 3, and 5

- 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

North Victory Blvd.



East 29th St.



Immersed Tube

Time to evaluate

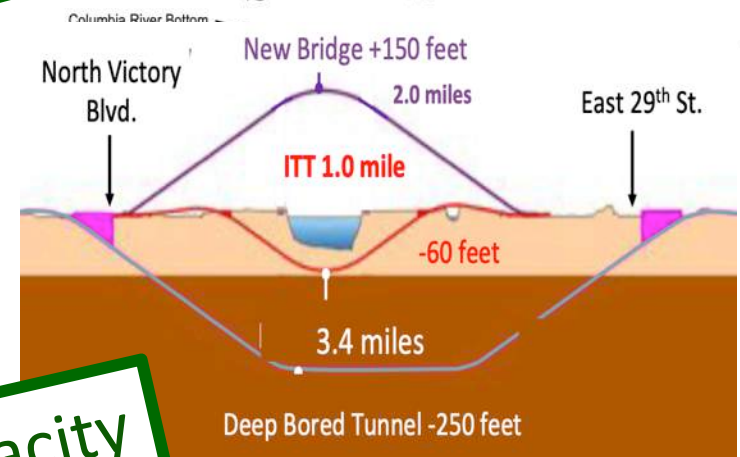
1 mile

Shortest Length & Grade

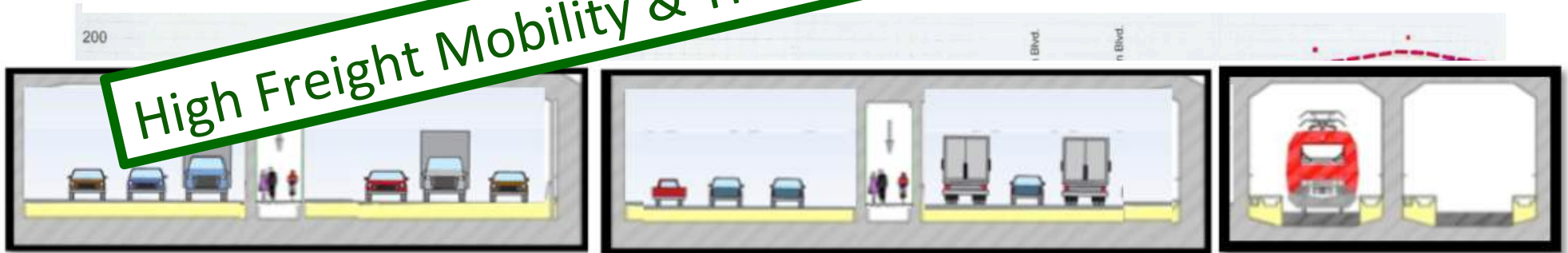
## Replacement Tunnel

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

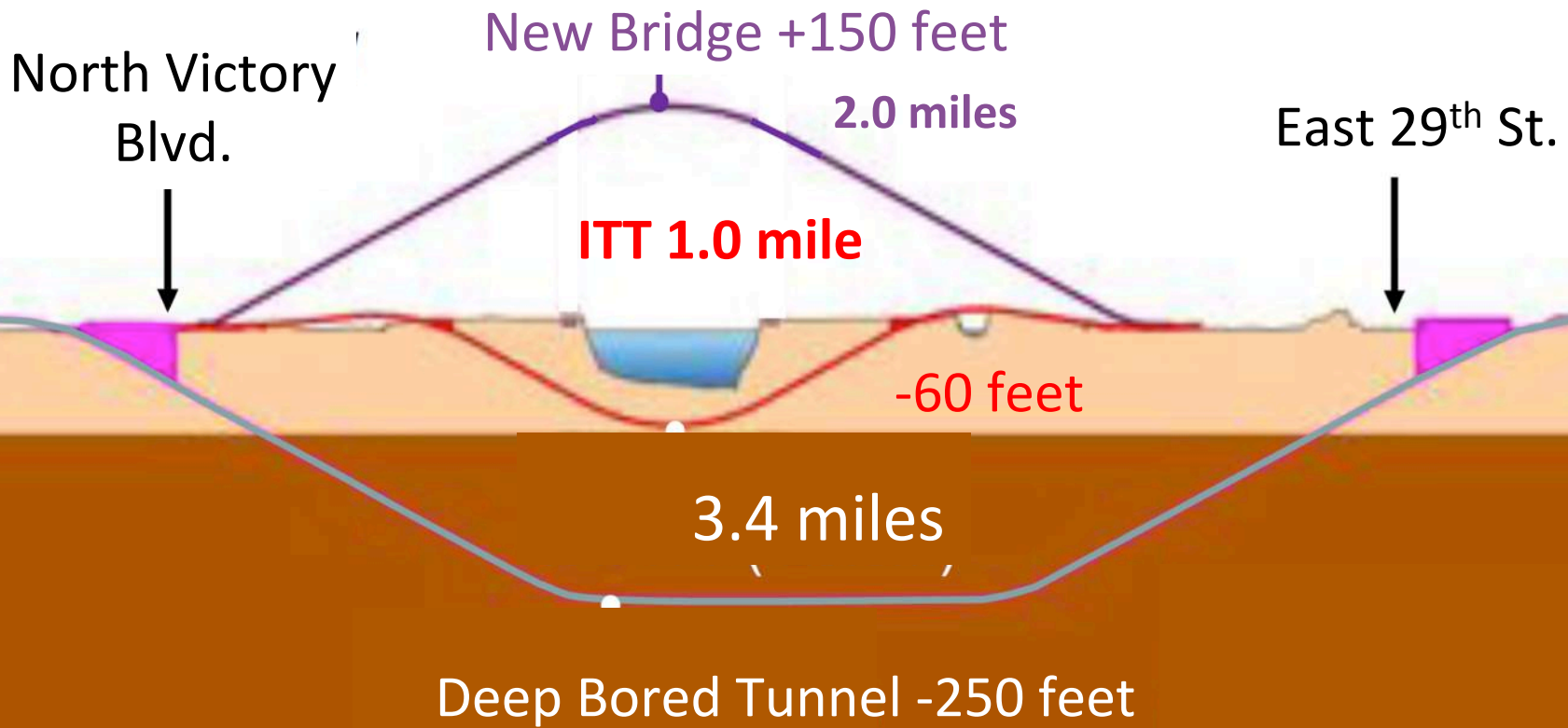


High Freight Mobility & Transit Capacity



# Immersed Tube Tunnel (ITT)

Shortest Length & Grade





# Immersed Tube Tunnel

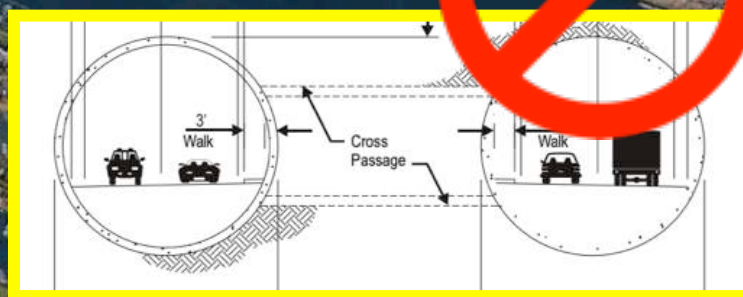


East 29<sup>th</sup> St.

Shortest Length & Grade

1.0 mile

3.44 miles



# Deep Bored Tunnel

North Victory Blvd.

Mor Furniture for Less

DSW Designer Shoe Warehouse

T.J. Maxx

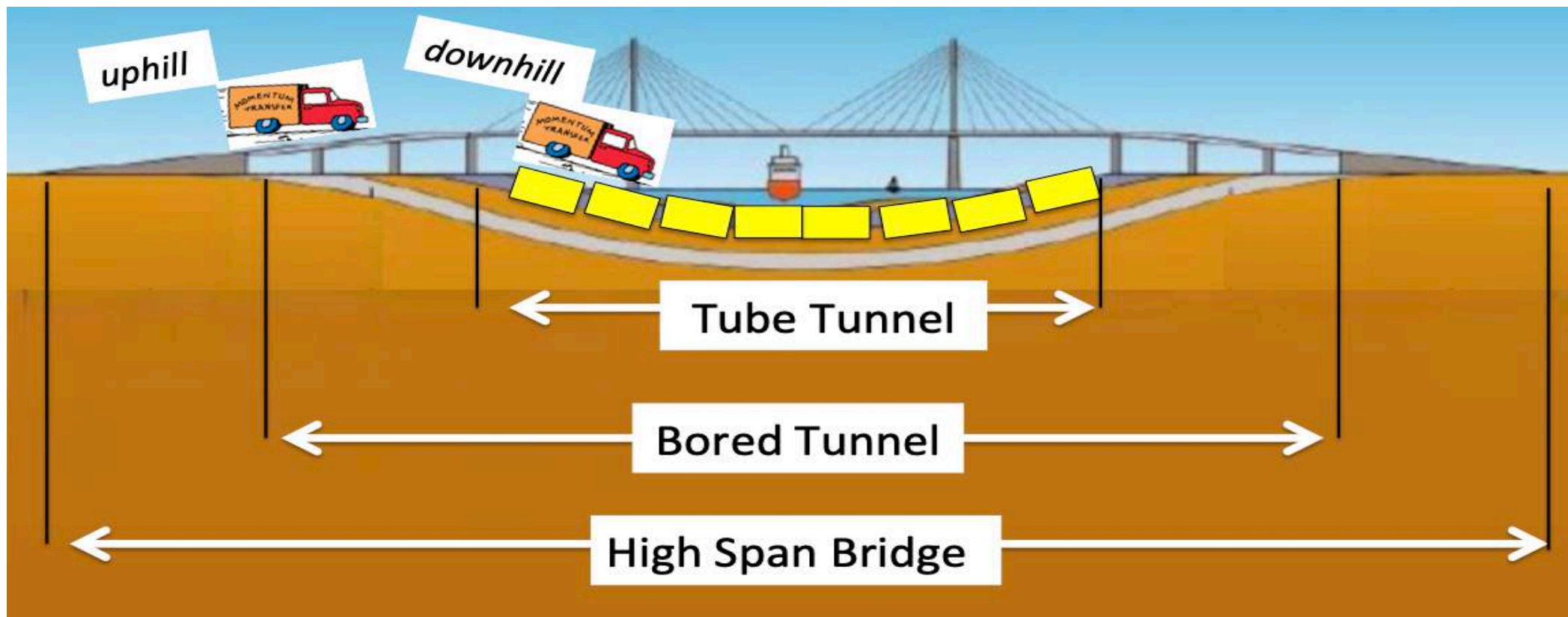
Hilton Vancouver  
Washington



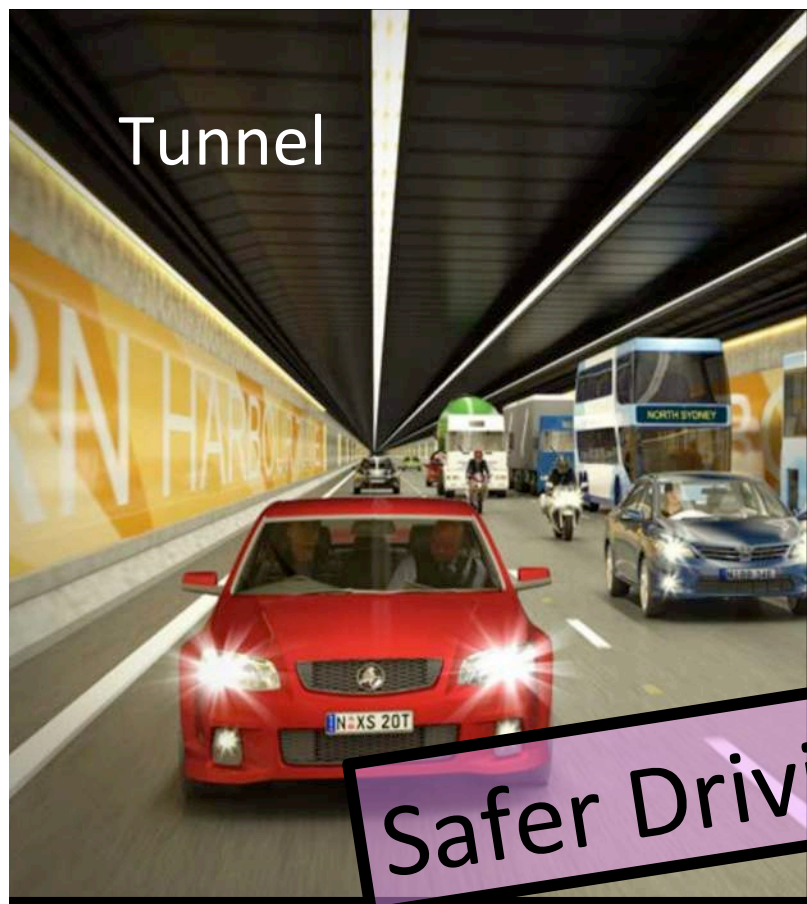
# Advantages of an Immersed Tube Tunnel



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



Safer Driving

Bridge  
fog, wind, rain & ice



KOIN 6 WEATHER  
**COLUMBUS DAY STORM**  
INFORMATION

**PEAK WIND GUST**

SOUTH 104 MPH  
(estimated)

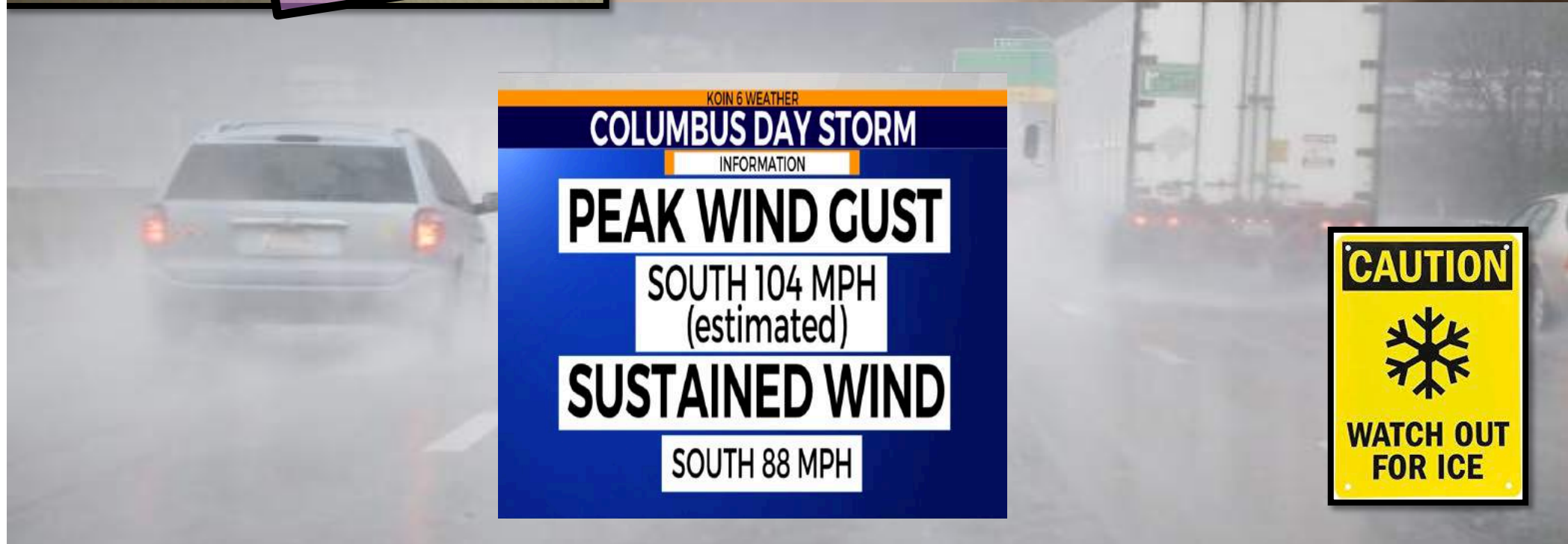
**SUSTAINED WIND**

SOUTH 88 MPH

**CAUTION**

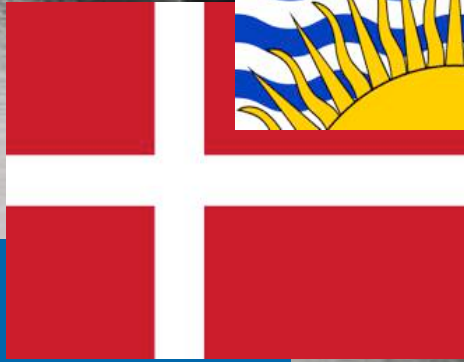


**WATCH OUT  
FOR ICE**

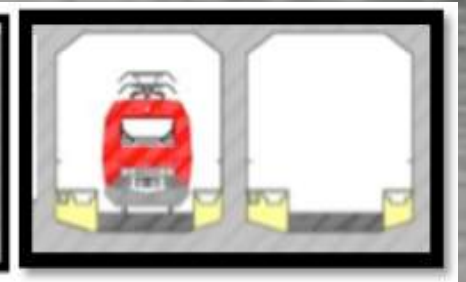
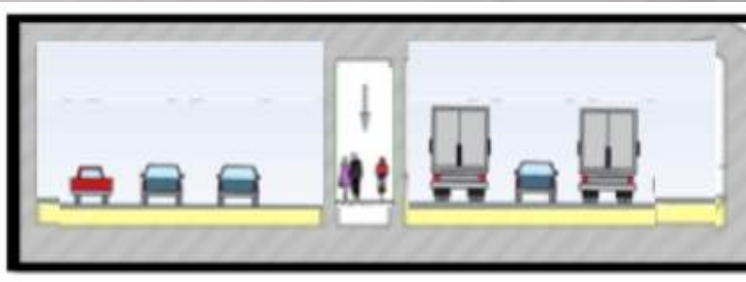
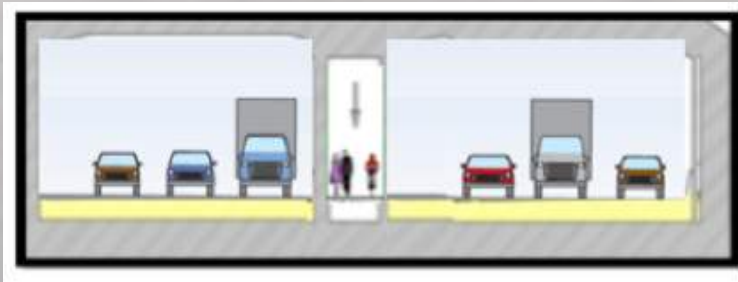




Ask our Canadian Neighbors  
& Scandinavian Cousins

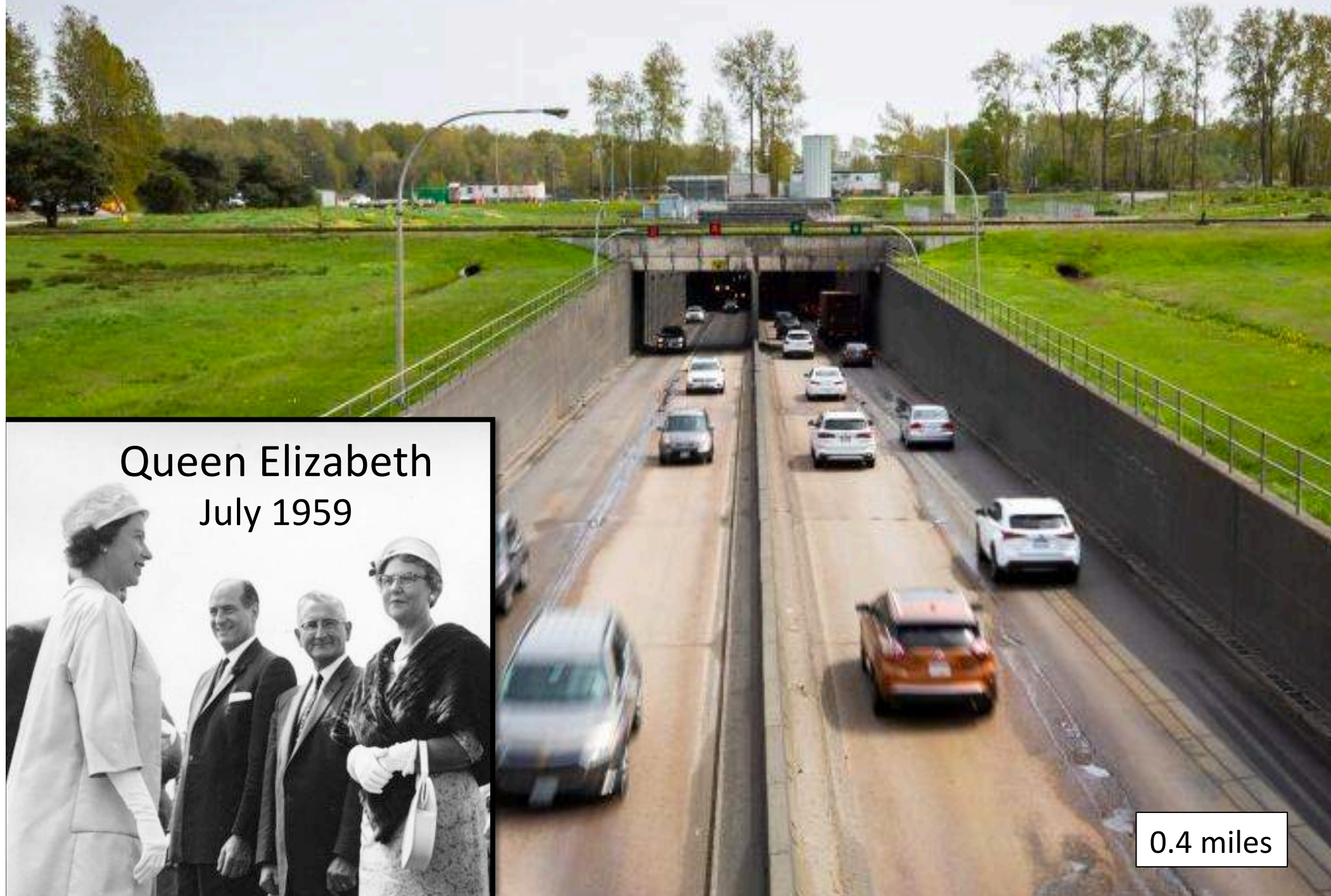


# Columbia River Immersed Tube Tunnel





# George Massey Tunnel 1959 - Fraser River

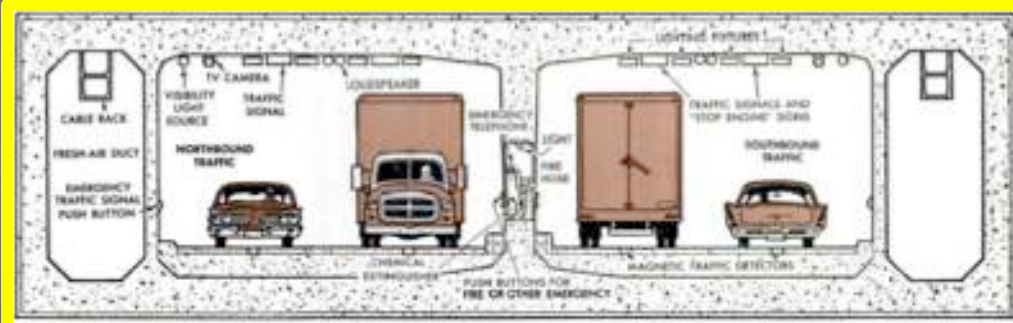


Queen Elizabeth  
July 1959

0.4 miles



# George Massey Tunnel 1959



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

Fraser River

2,064 ft.

Completed 1959 - 2 years & 2 months construction

\$29 million in 1959



Cut & cover tunnel approaches





bridge  
1917



3,000 ft.

Columbia  
River

Hayden  
Island

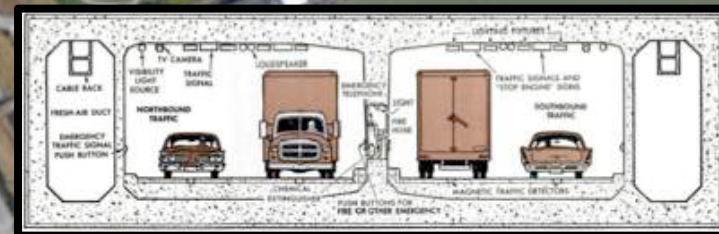
1,000 ft.

Very similar traffic, geography & geology

130,000 vehicles/day



tunnel  
1959



2,100 ft.

Fraser  
River

Deas  
Island

1,000 ft.

80,000 vehicles/day



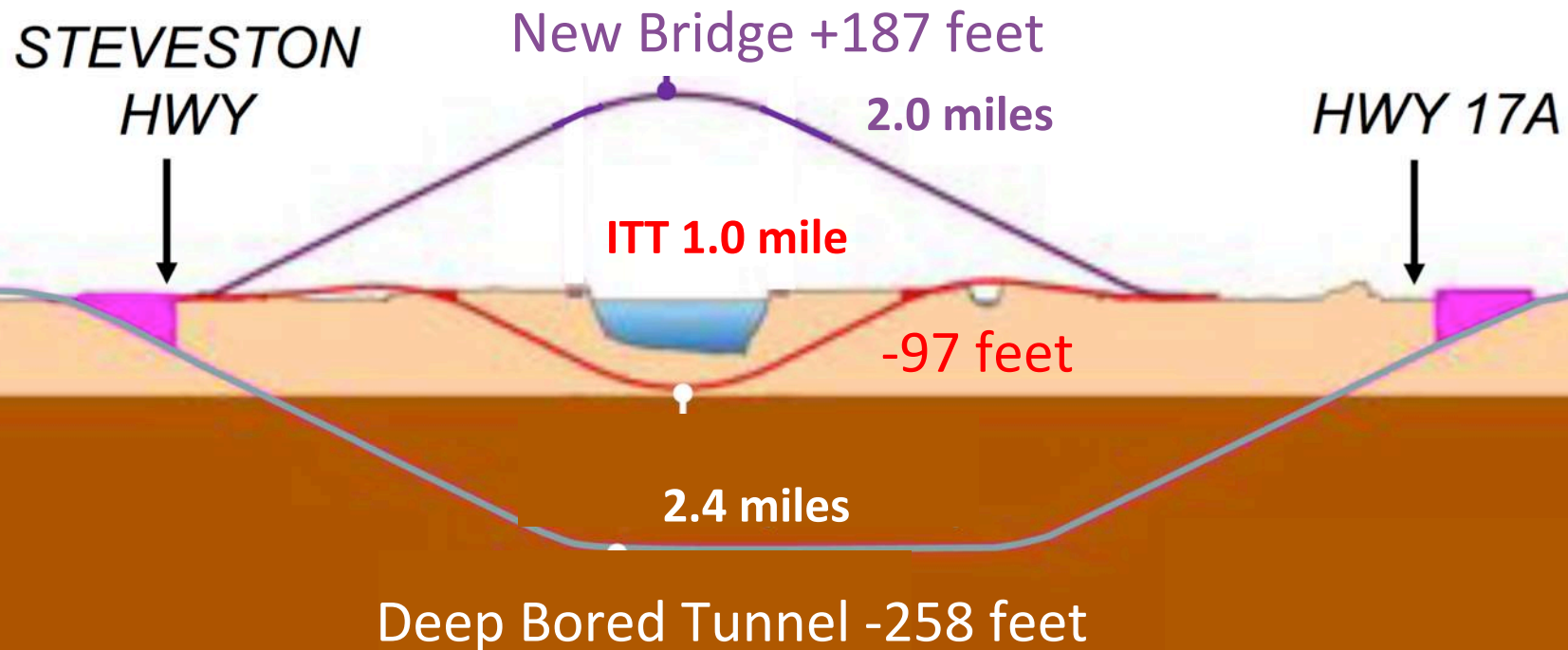
# George Massey Crossing Project

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

Selected

# Immersed Tube Tunnel (ITT)

Shortest vertical and horizontal distances



## New Fraser River Crossing





# THE VANCOUVER SUN

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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](https://bc.ctvnews.ca/8-lane-massey-tunnel-endorsed-by-metro-vancouver-board-of-directors-1.4666481)

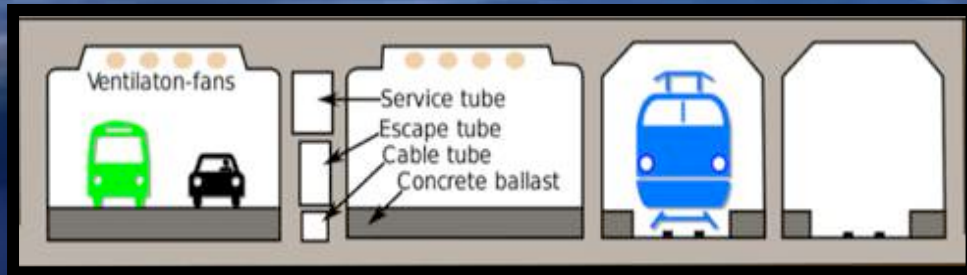
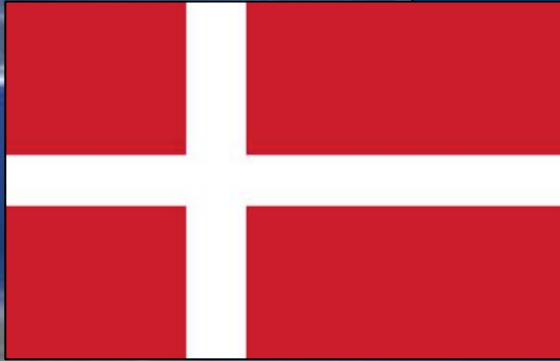
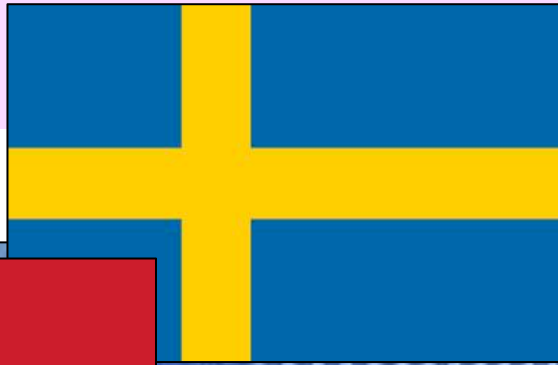


# Immersed Tube Tunnel Concept Design





# 1999 Øresund Immersed Tube Tunnel connects Sweden to Denmark



20 tubes x 577 ft.

2.2 miles  
\$745 Million

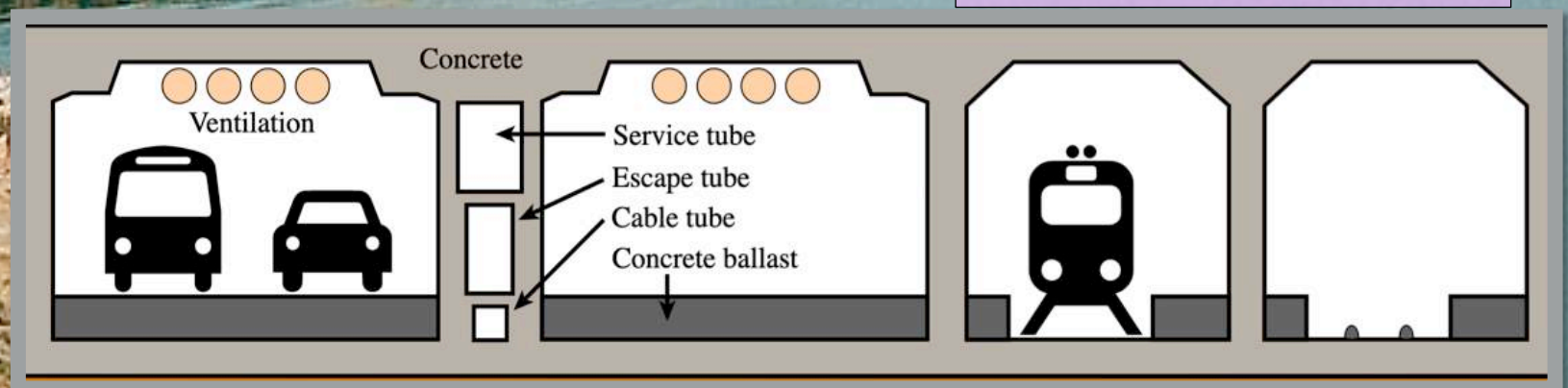


High-speed rail 125mph



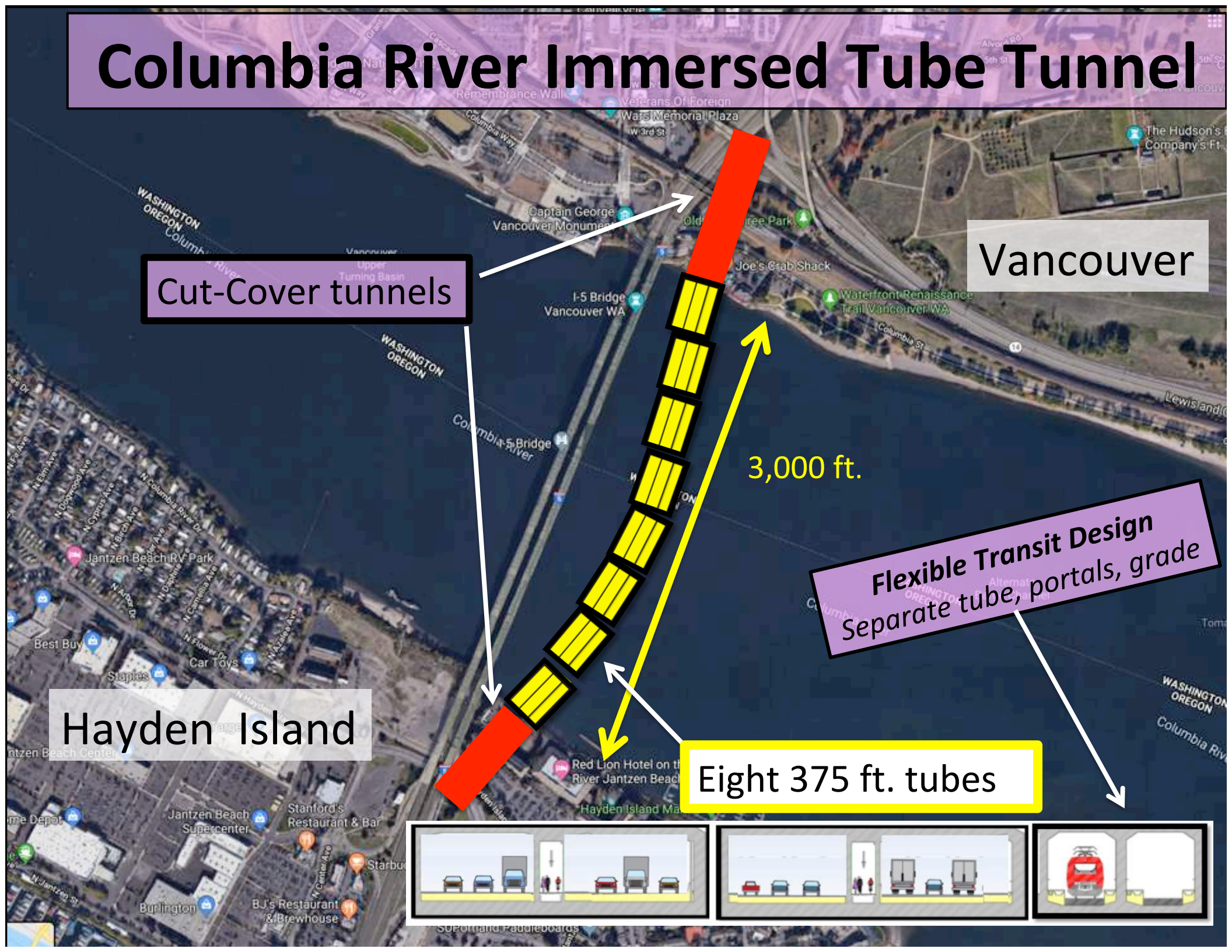
# Øresund Tunnel tube casting yard

Transit lanes





# Columbia River Immersed Tube Tunnel



Vancouver

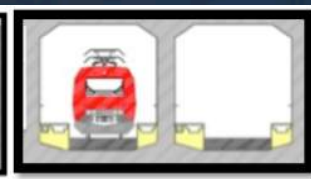
Cut-Cover tunnels

3,000 ft.

Flexible Transit Design  
Separate tube, portals, grade

Hayden Island

Eight 375 ft. tubes

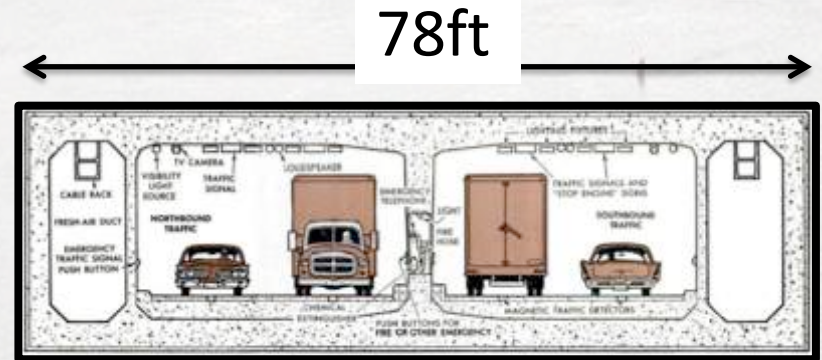




## 1959 George Massey – Fraser River

6 tubes x 344 ft. = 0.4 miles

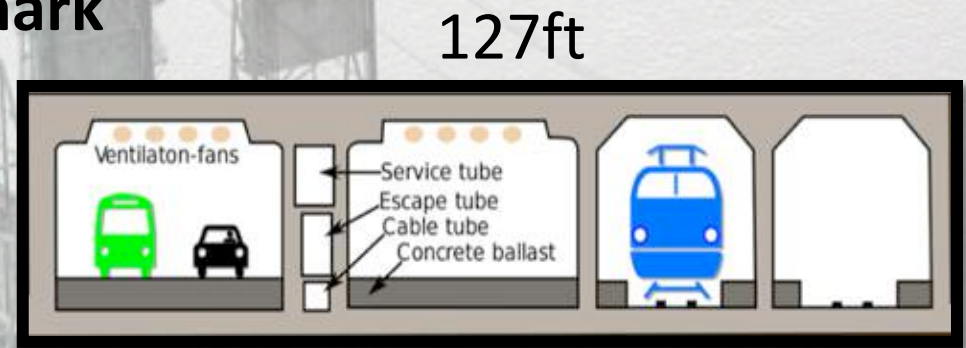
18,500 tons



## 1999 Øresund – Sweden to Denmark

20 tubes x 577 ft. = 2.2 miles

62,000 tons



## Columbia River

8 tube sections x 375 ft. = 0.6 miles

115ft



32,000 tons

115ft



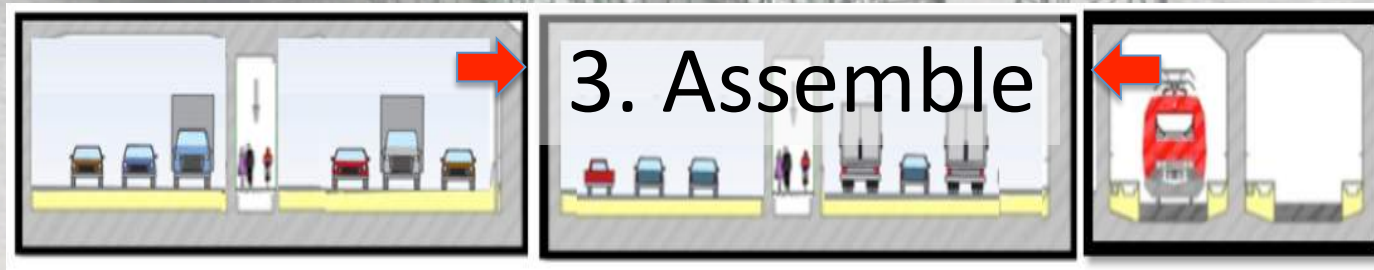
32,000 tons

45ft



13,000 tons





Immersed Tube





520

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

Aberdeen Casting Basin

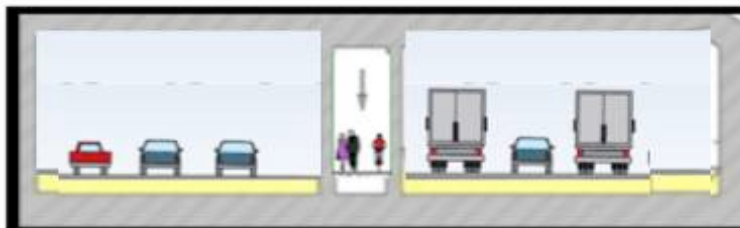
Columbia River Tube sections 375 ft.

115ft



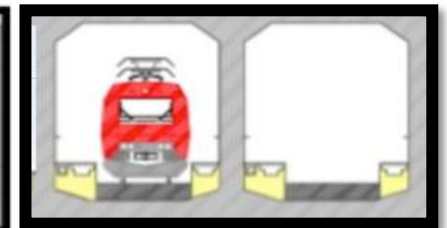
32,000 tons

115ft



32,000 tons

45ft



13,000 tons



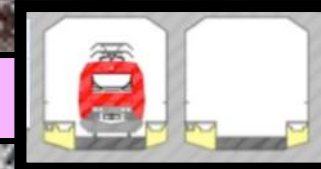
# Aberdeen Casting Basin

165 x 910 feet

Parallel tube construction



115 x 375



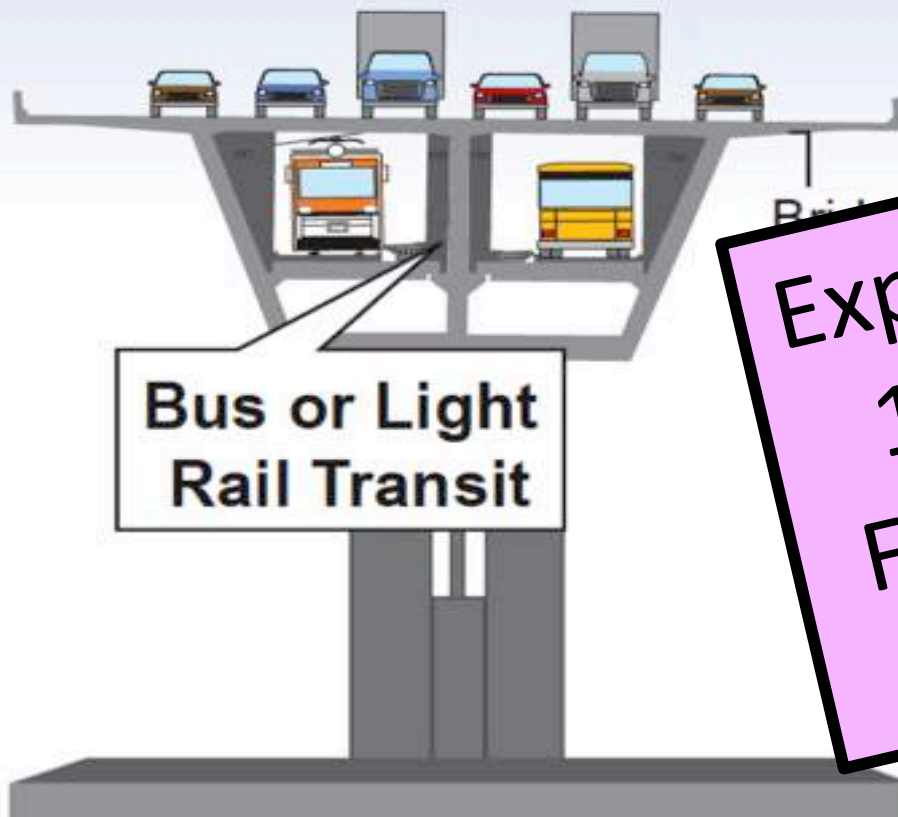
45 x 375



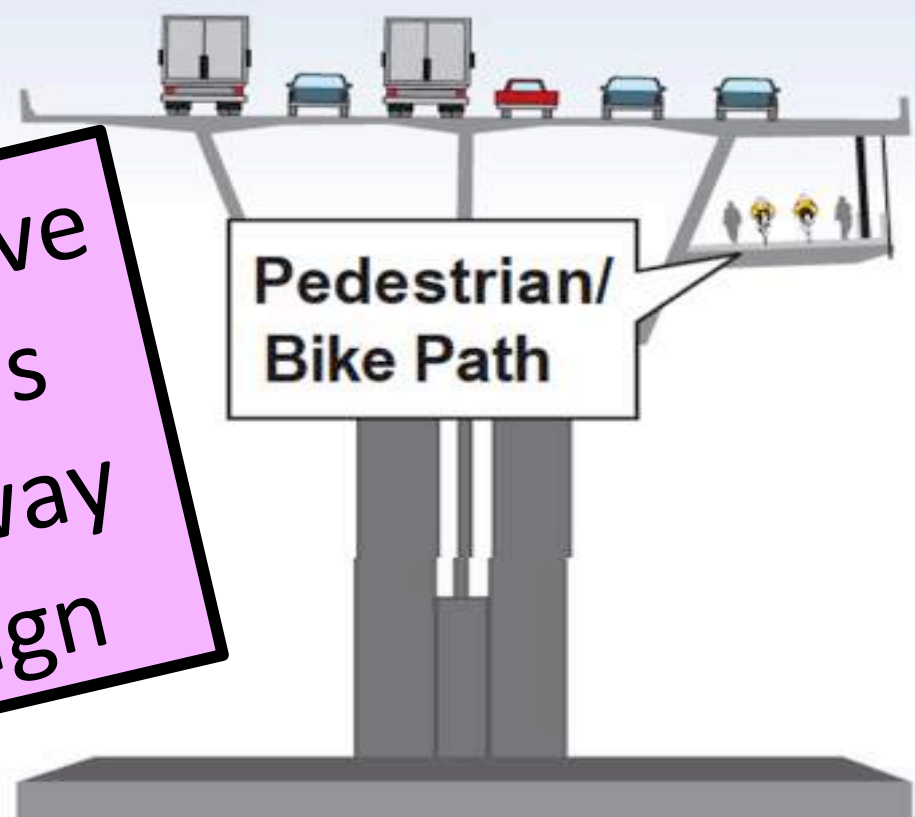
# Columbia River I-5 Bridge Planning Inventory



Southbound I-5

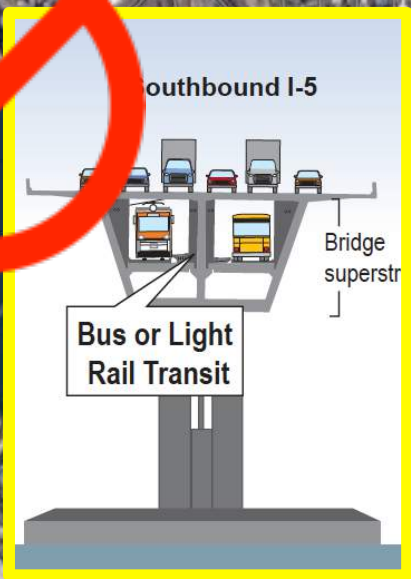
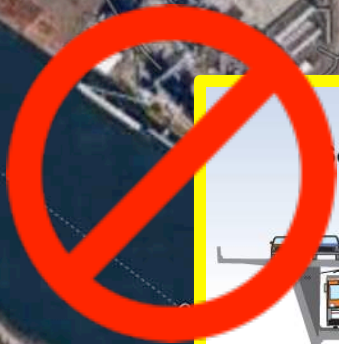


Northbound I-5



Expensive  
1960's  
Freeway  
Design



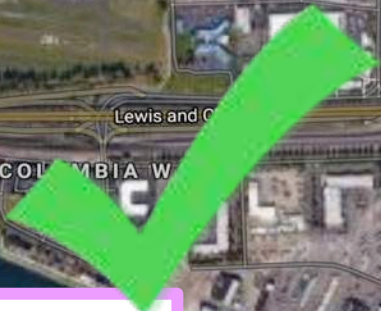


Bridge

1.7 miles

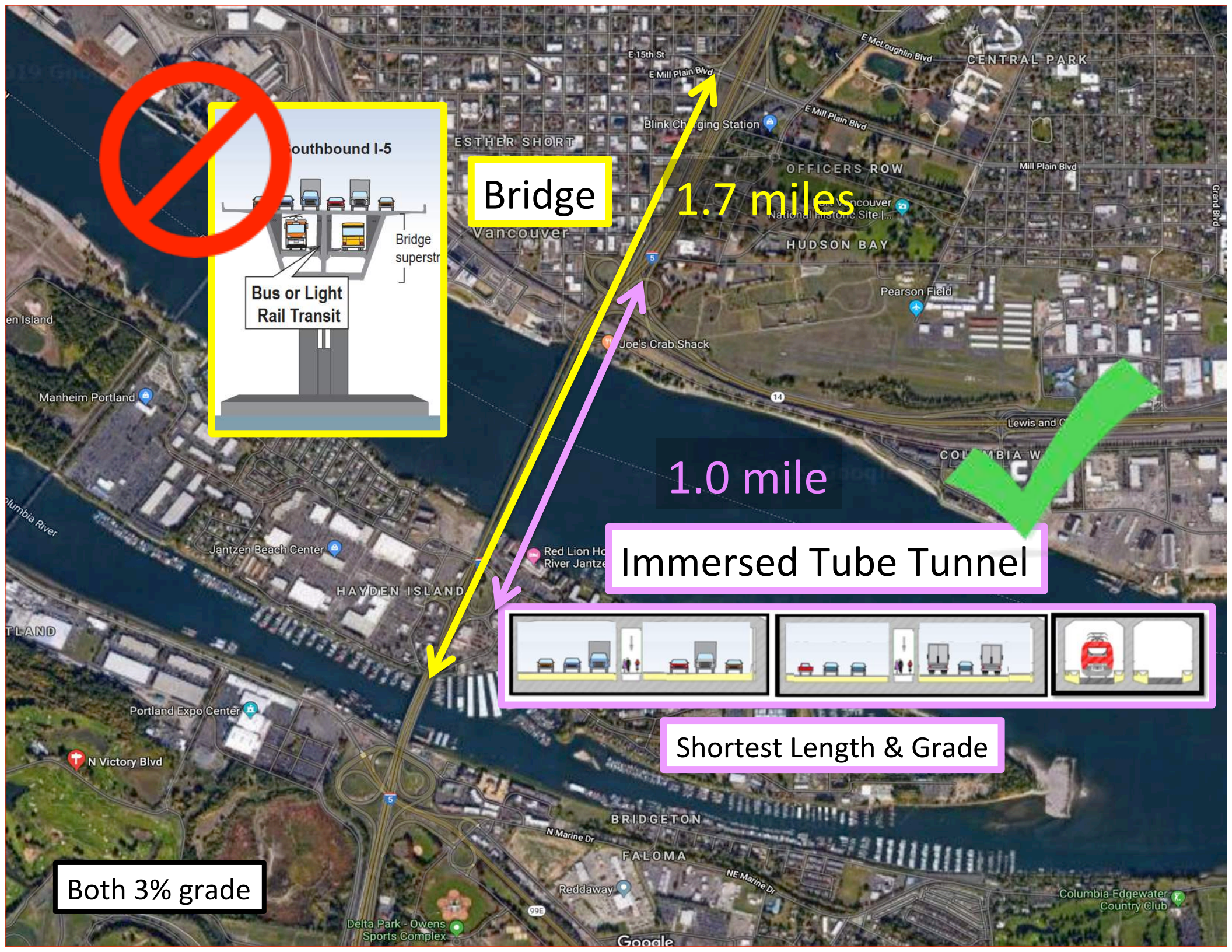
1.0 mile

Immersed Tube Tunnel

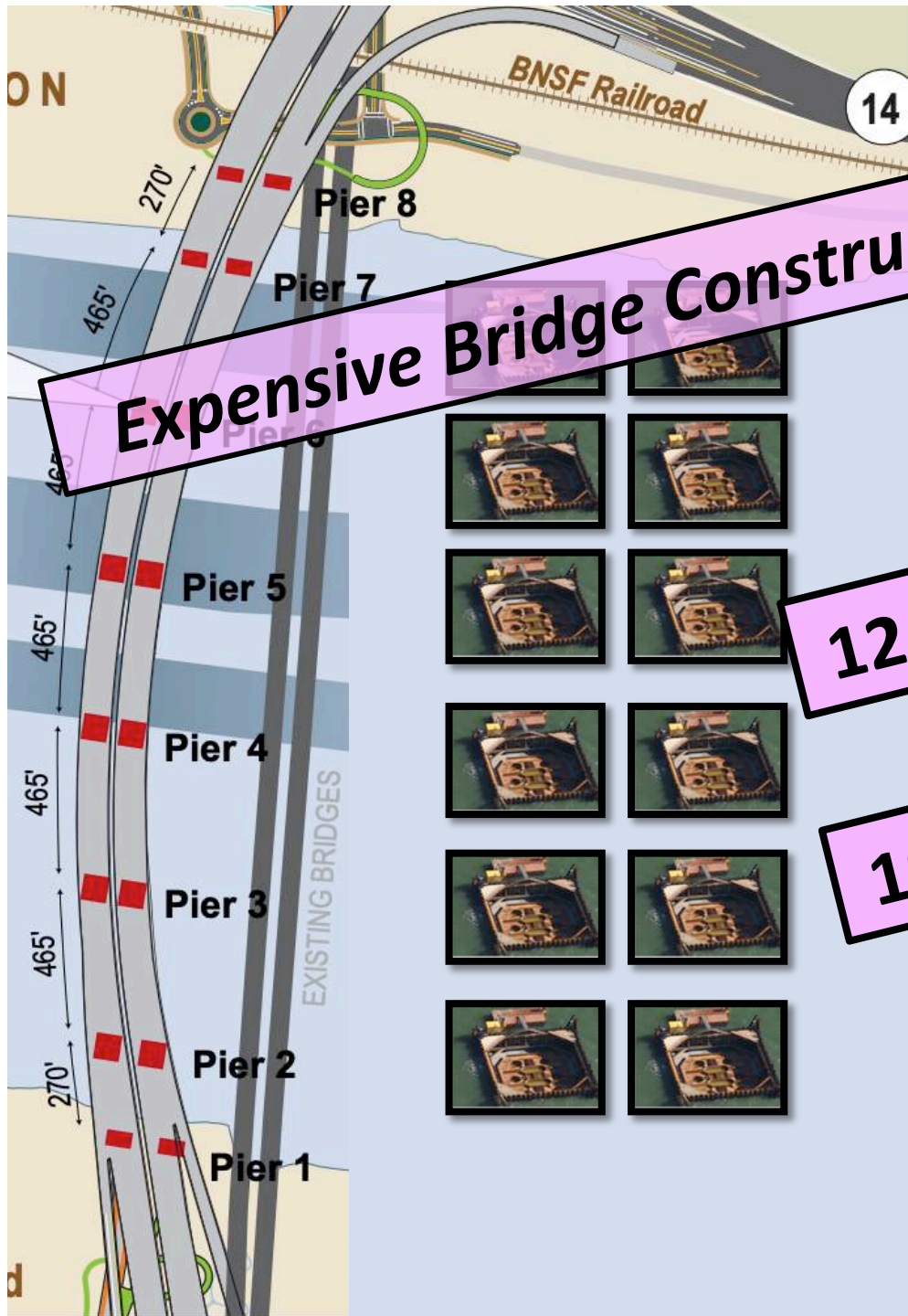


Shortest Length & Grade

Both 3% grade



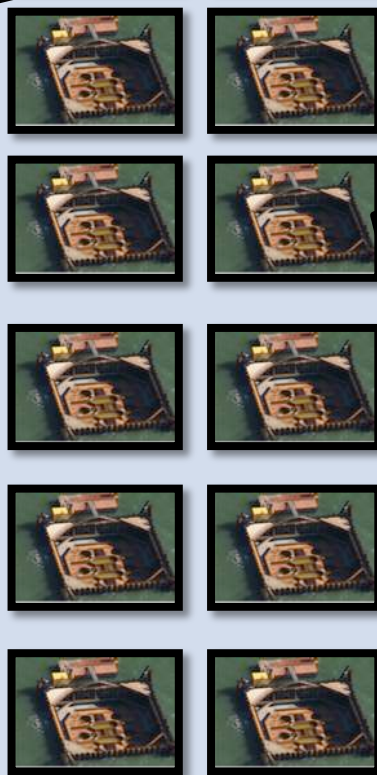




**Expensive Bridge Construction- 12 River Piers**



**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



**SAFETY  
FIRST**



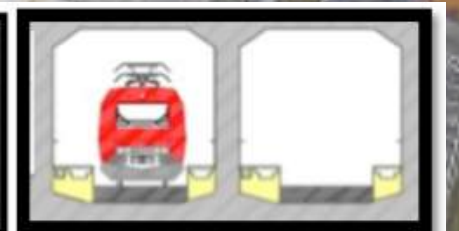
## ***SR 520 Pontoon***

***2009 bid - \$367.3 million***

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

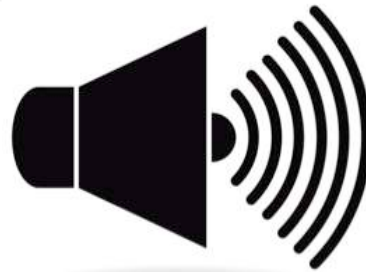
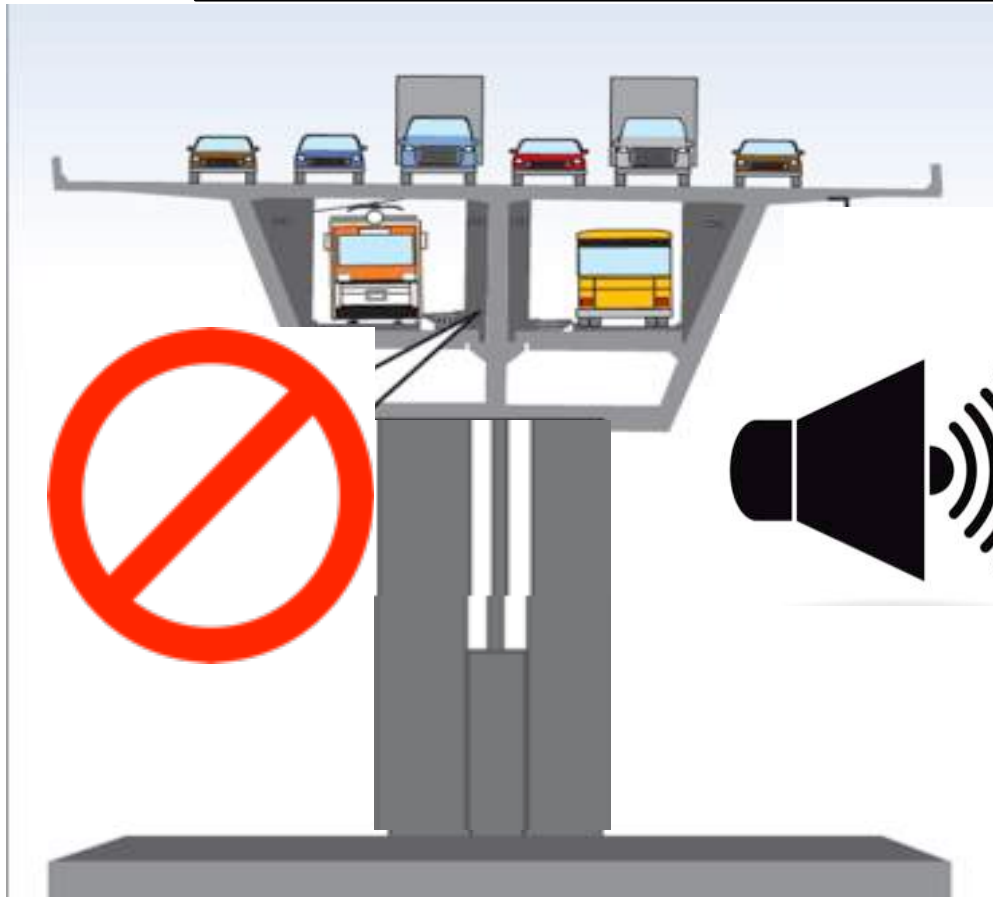


***Yard work is less expensive***

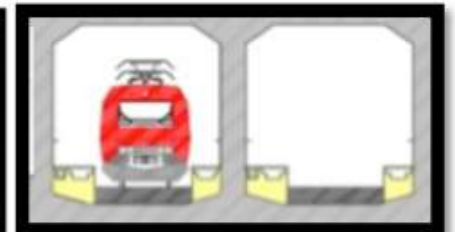
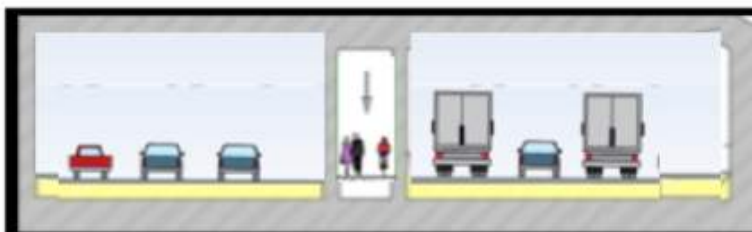




# Bridge Pollution = Noise + Visual + Shadow



Tunnel = No Pollution







# Columbia River I-5 bridge Planning Inventory



Navigation hazard



2002

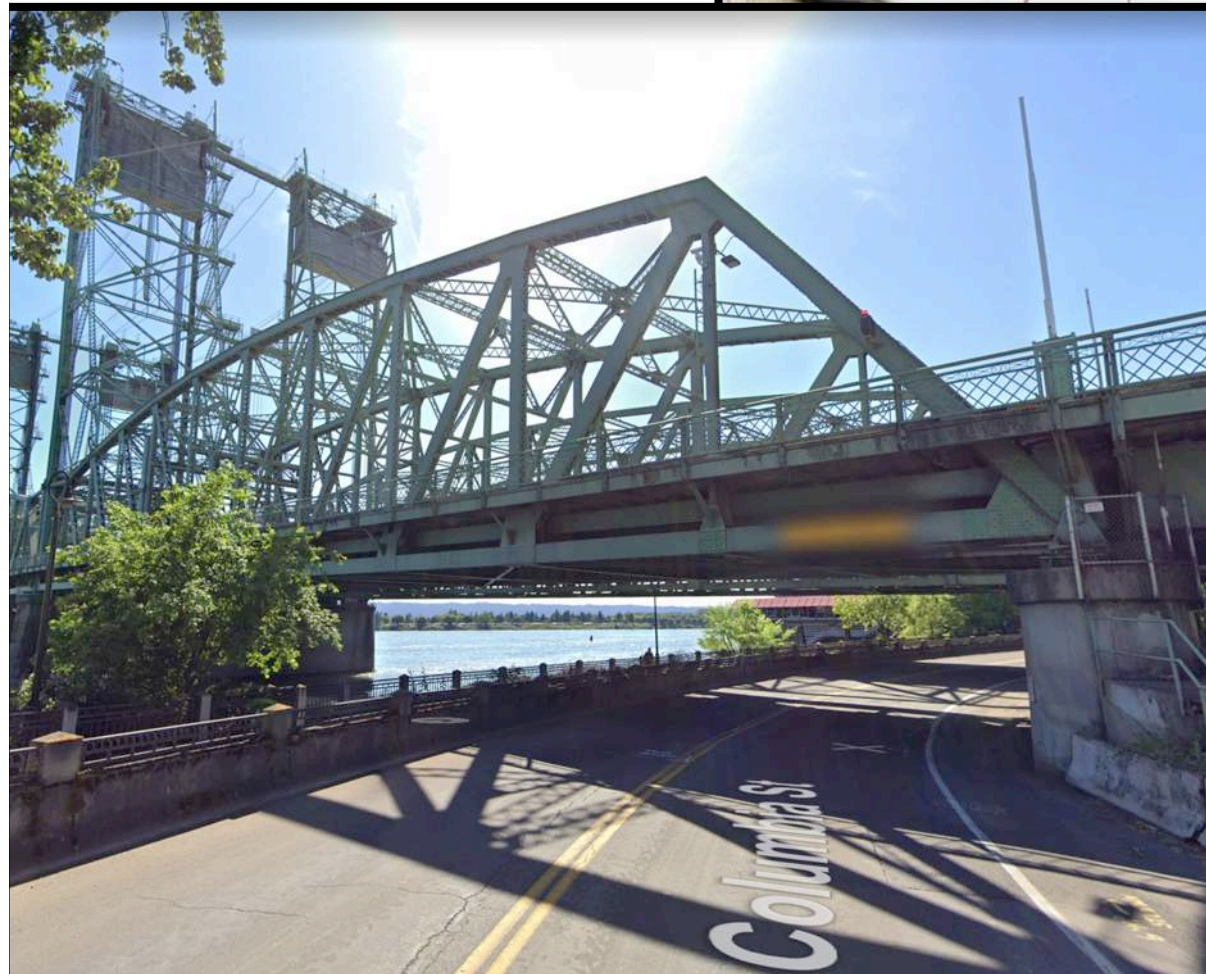


Columbia River \*barge tow

\*Barge KE = 14,000 ton @ 8mph



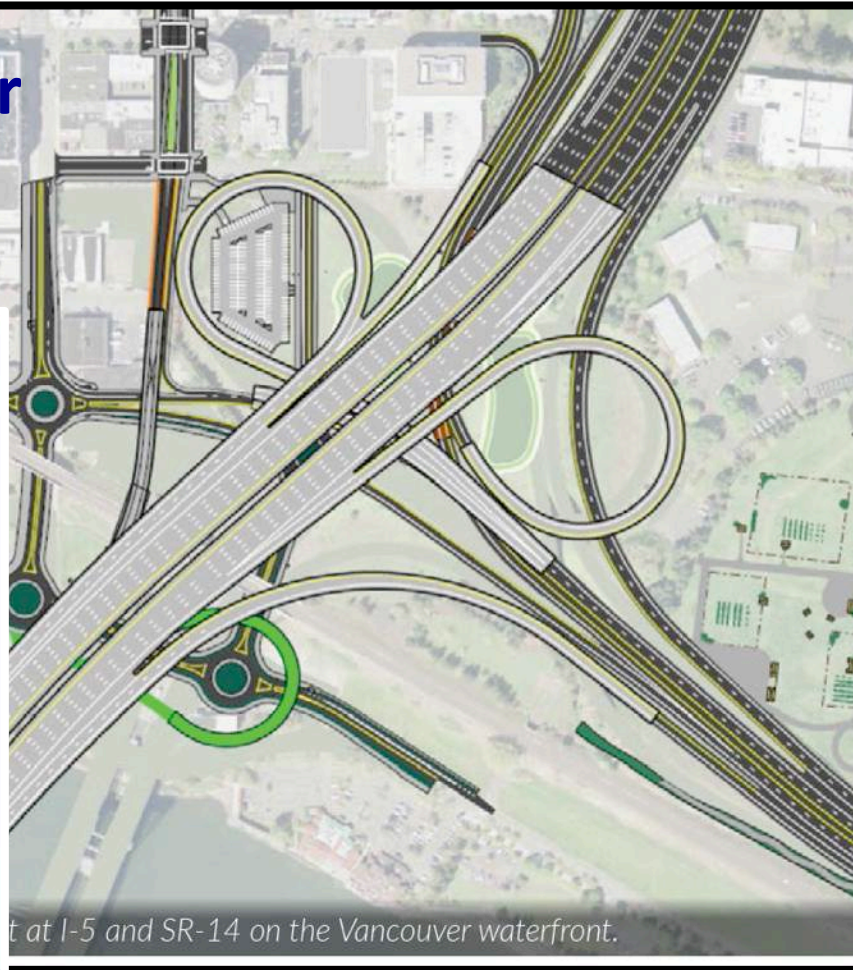
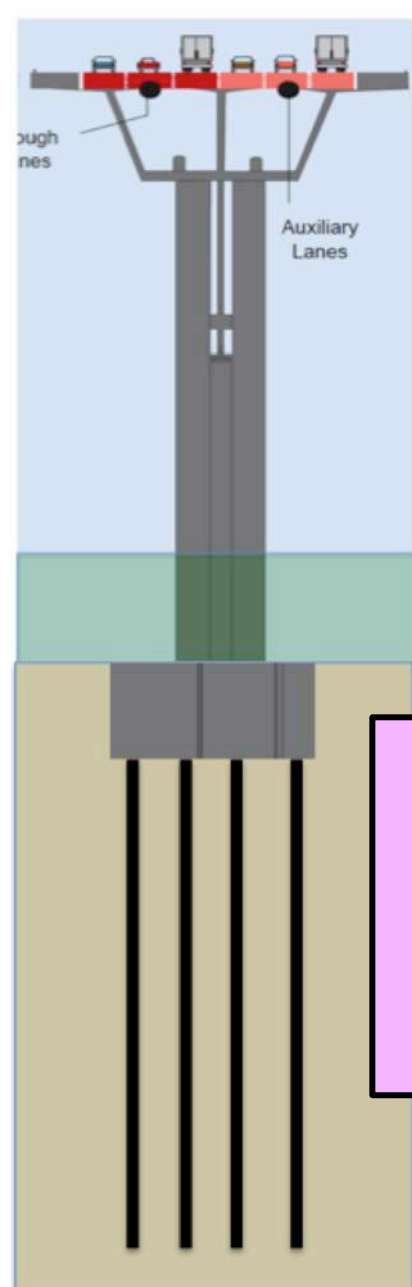
Columbia Street  
With 12 lane  
Bridge



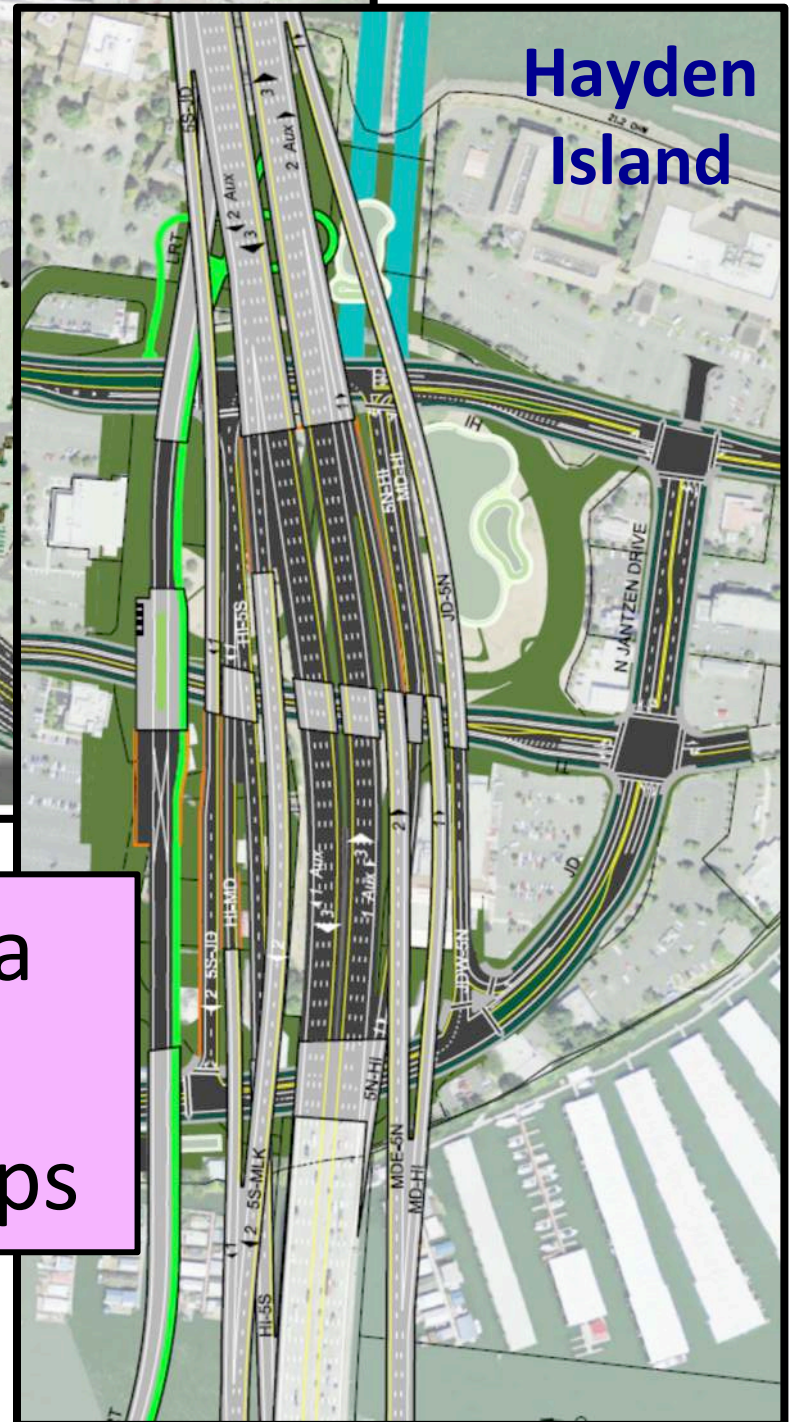
Current  
Columbia Street  
Vancouver, WA



# Vancouver



# Hayden Island



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



# View of Columbia River Immersed Tube Tunnel







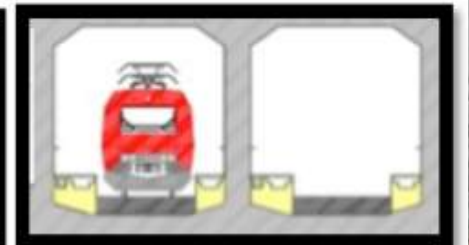
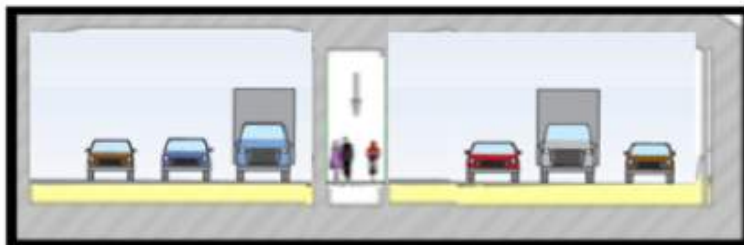


1<sup>st</sup> Goal

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

# Seismic Safety

Immersed Tube Tunnel



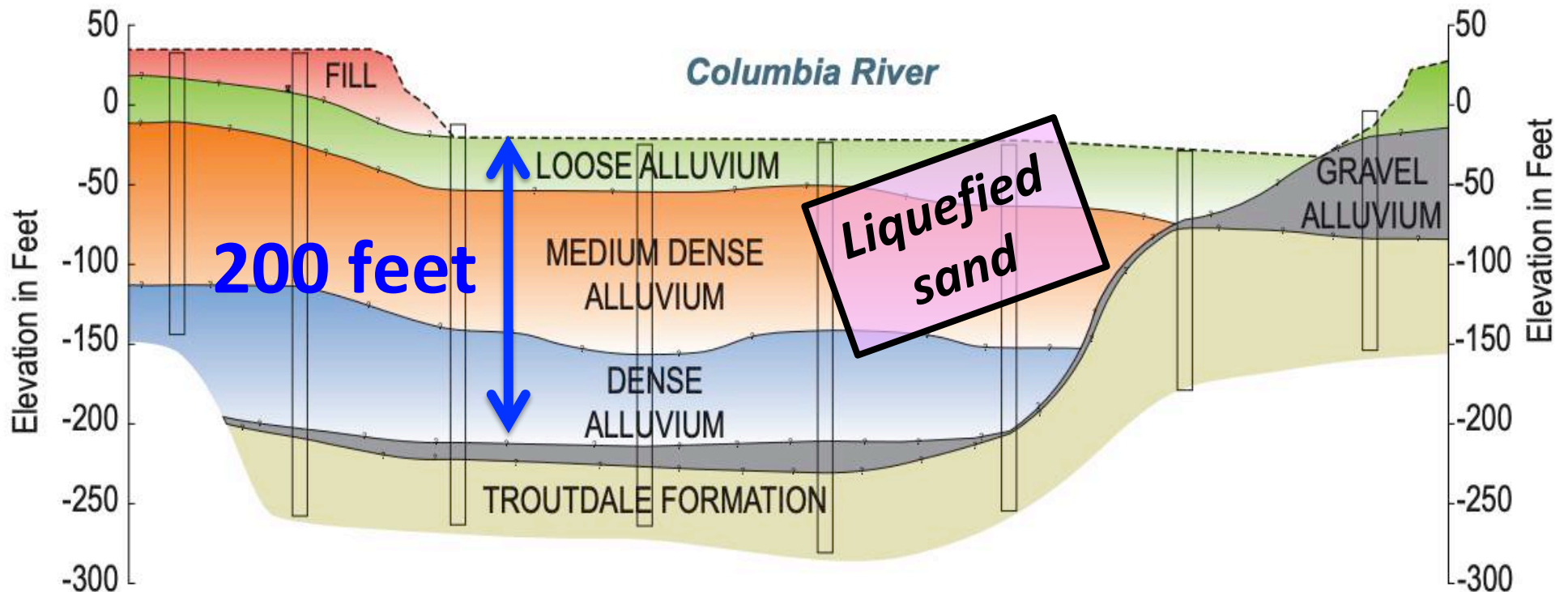


200 Feet of Liquid Sand

**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

Washington







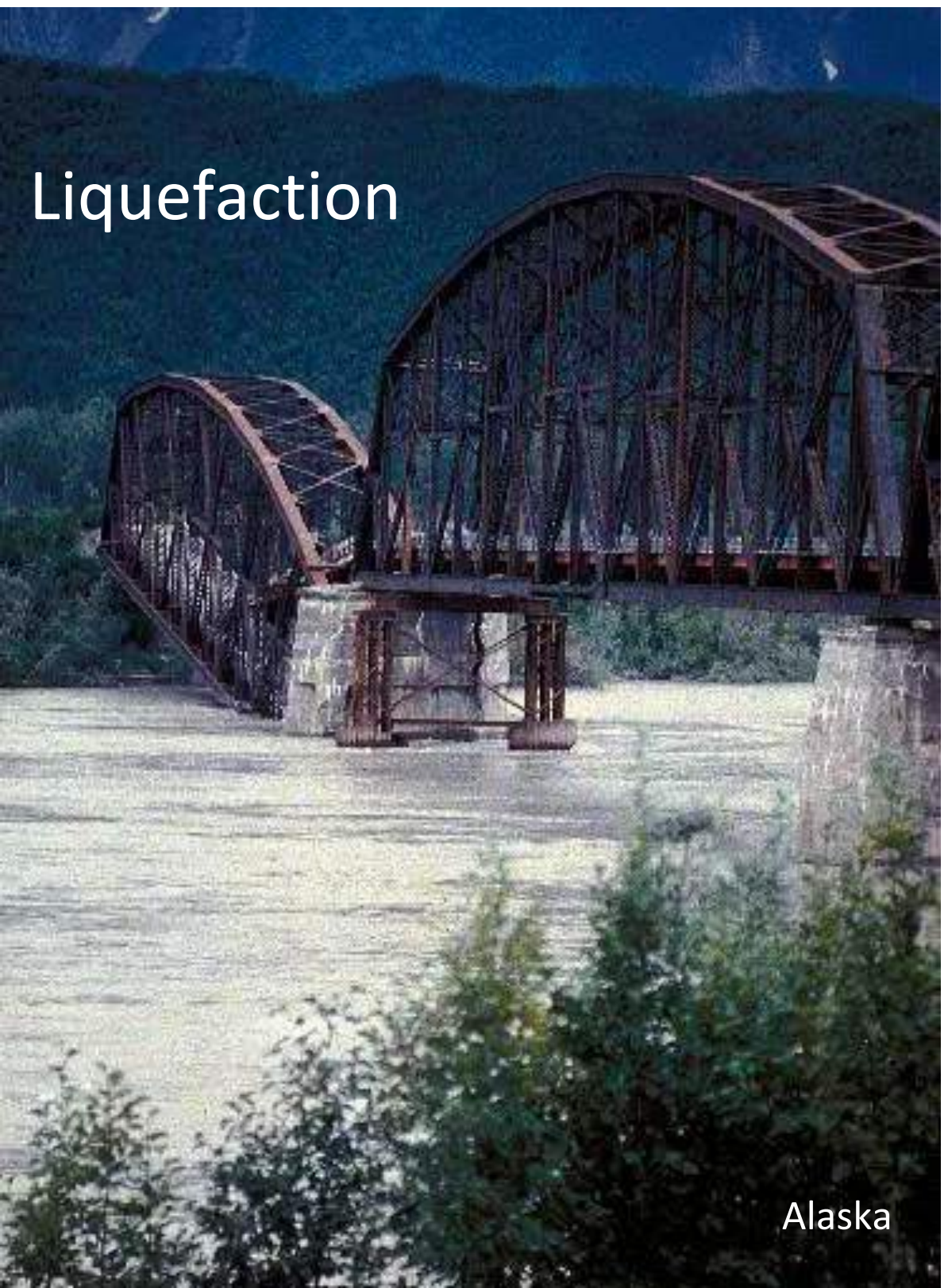
## Seismic Safety

## Liquefaction



This aerial photograph shows a multi-lane bridge that has completely collapsed into the water. The bridge deck is broken into several large sections that are partially submerged. In the background, a city with various buildings is visible on a hillside overlooking the water.

Japan



This photograph shows a large, dark steel arch bridge that has collapsed. The bridge's structure is heavily rusted and appears to be in a state of severe disrepair. It is situated in a river or bay, with a forested hillside in the background. The water in the foreground is calm, reflecting the surrounding environment.

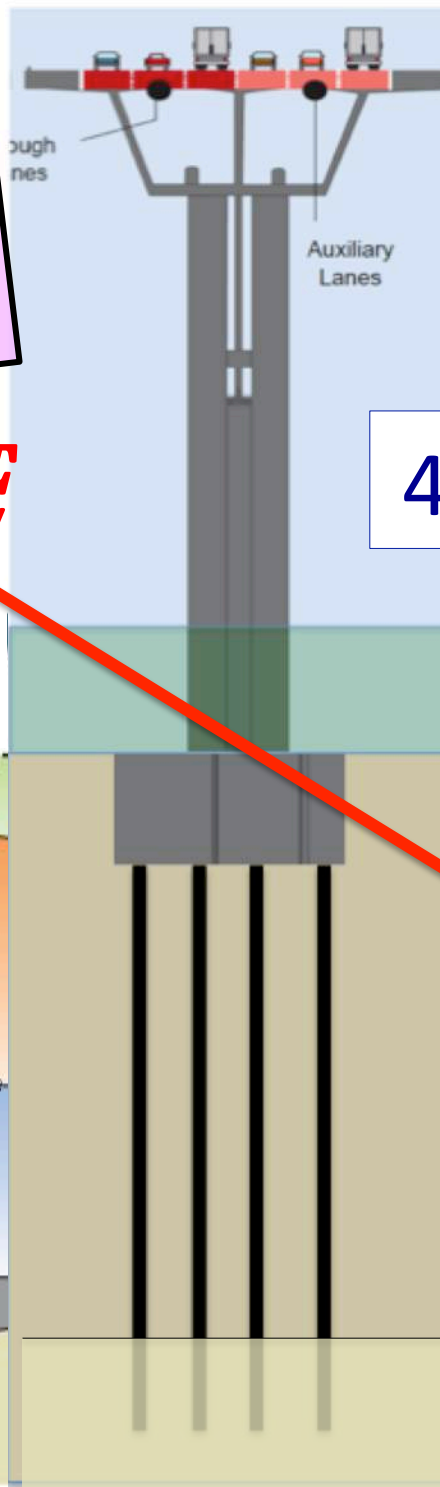
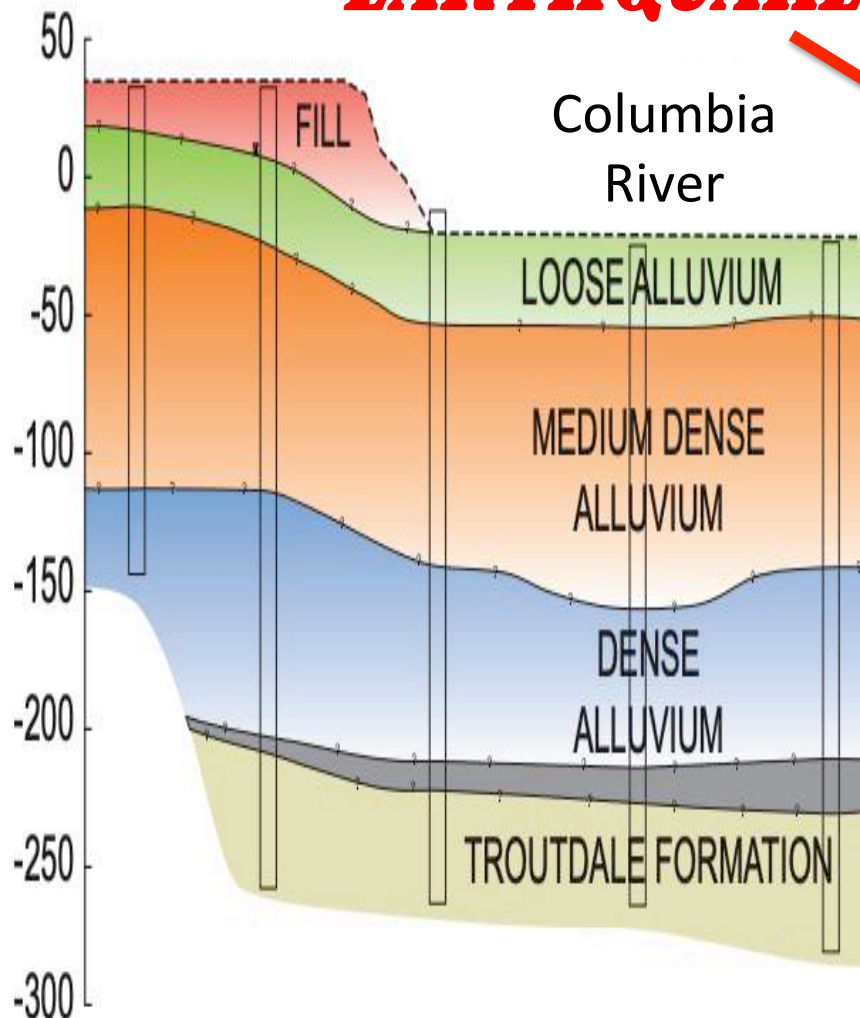
Alaska



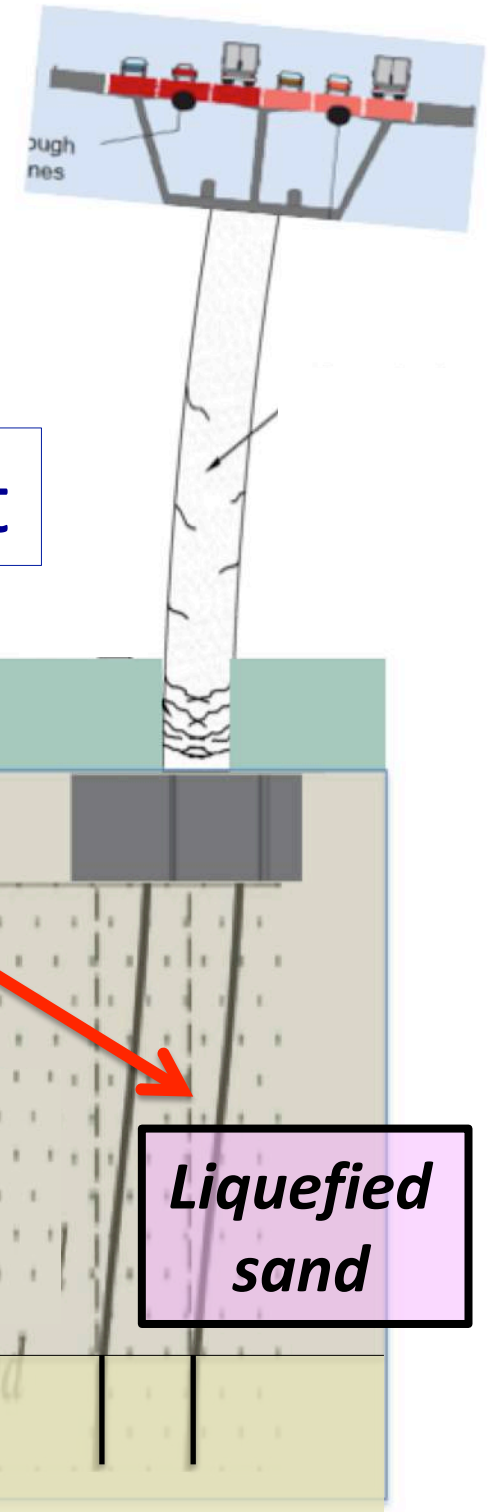
Seismic Safety

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

***EARTHQUAKE***



450ft



***Liquefied  
sand***



Seismic Safety

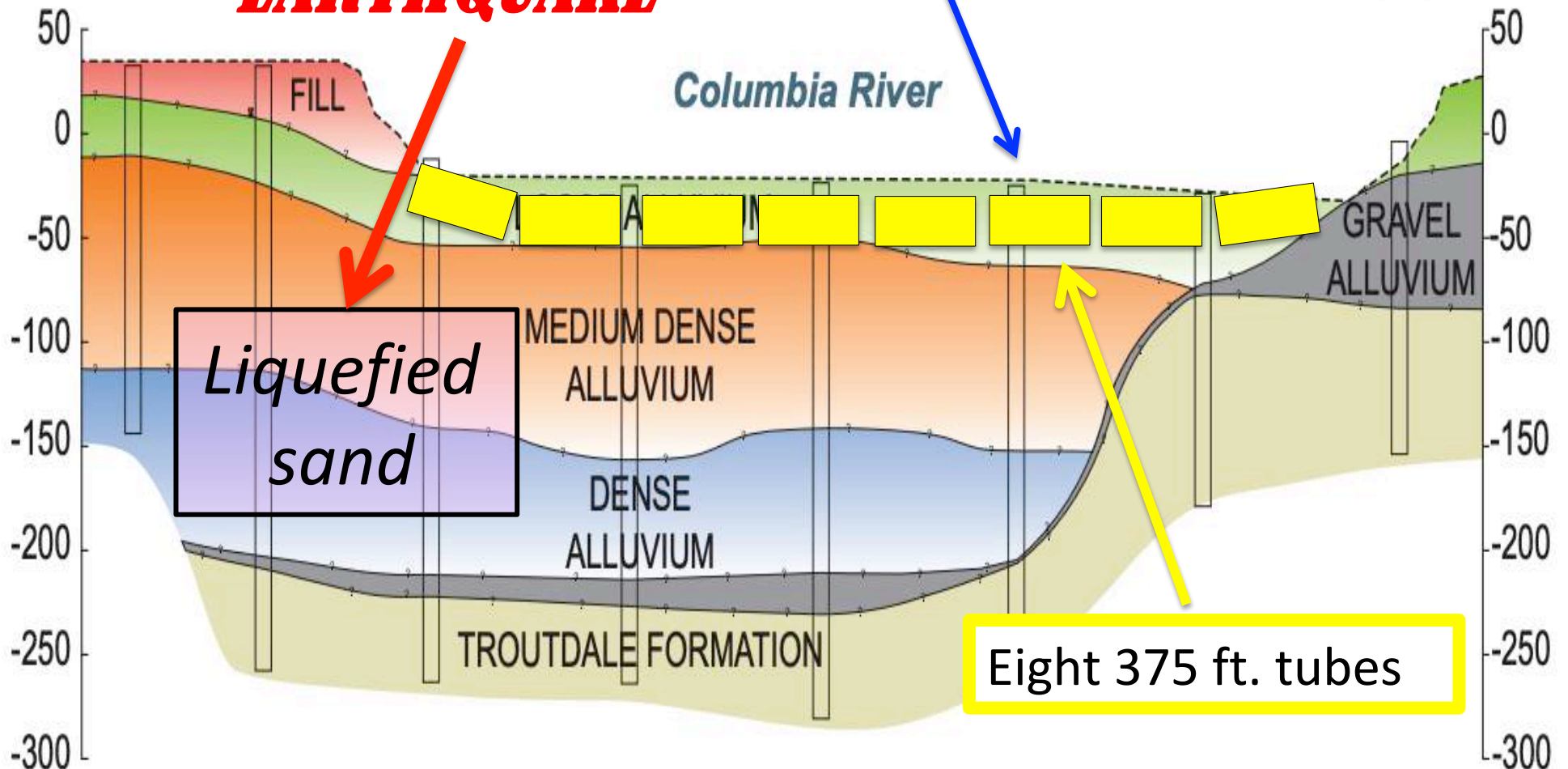


**Tunnel - Seismic resistant - neutral buoyancy**



*Neutral Buoyancy*

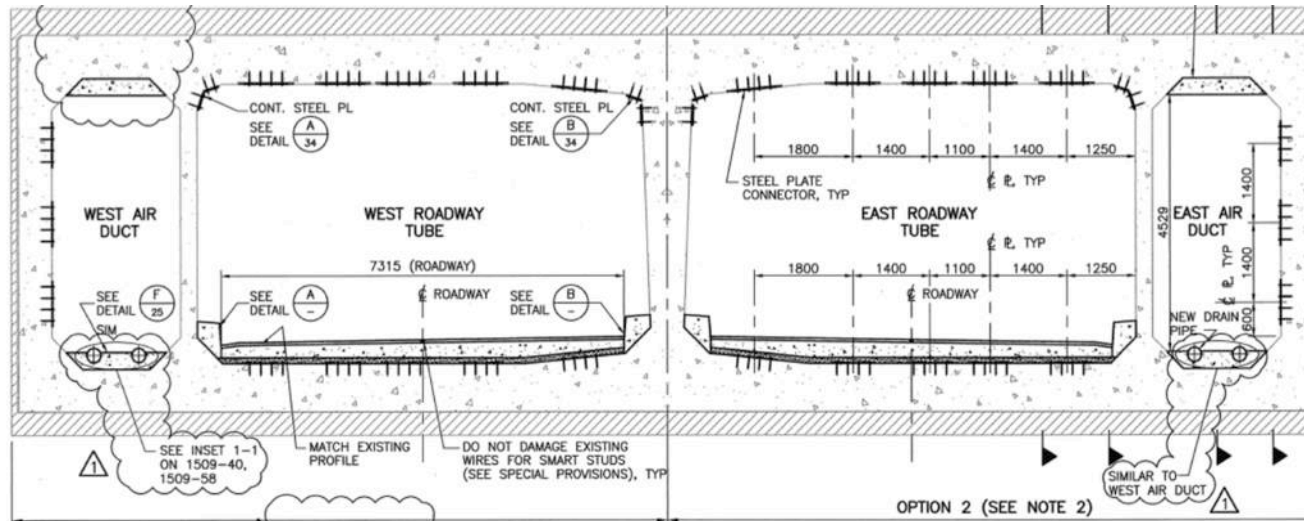
***EARTHQUAKE***





# George Massey Fraser River Crossing

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





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

**2<sup>nd</sup> & 3<sup>rd</sup> Goal**

## ***Immersed Tube Tunnel***

*Flexible number of lanes, tubes, portals, grades*







# 64 Immersed tube tunnels



International Database and Gallery of Structures



# Thank You



Bob Ortblad is a Civil Engineer & MBA.  
He teaches the history of infrastructure at the University of Washington  
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## References:

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

<https://canada.constructconnect.com/joc/news/infrastructure/2009/09/british-columbias-massey-tunnel-was-a-cutting-edge-endeavor-joc035191w#.Xd60l9Ct7x8.email>

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>

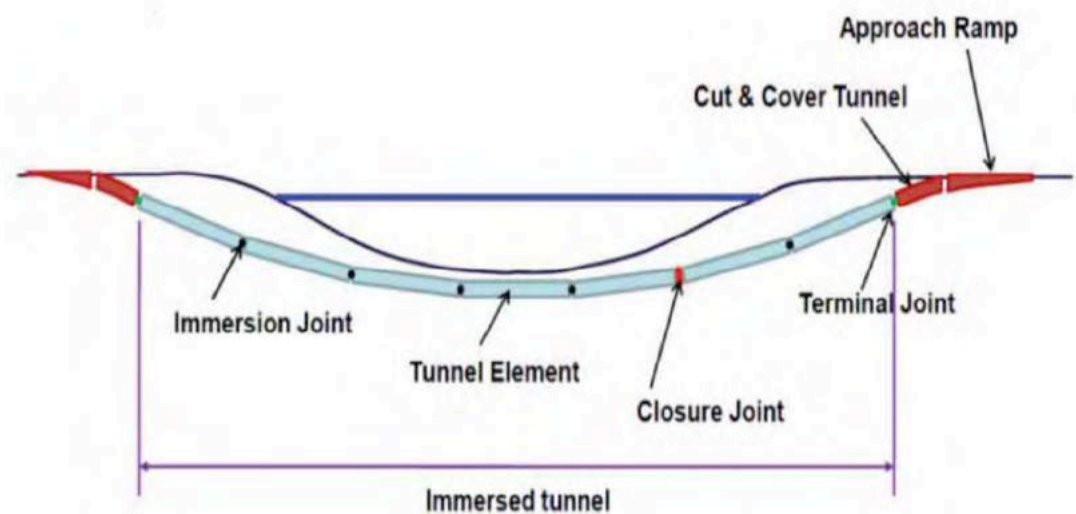
Sydney Harbour Tunnel

<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	Bjørsvika 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	Súdwest-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





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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).

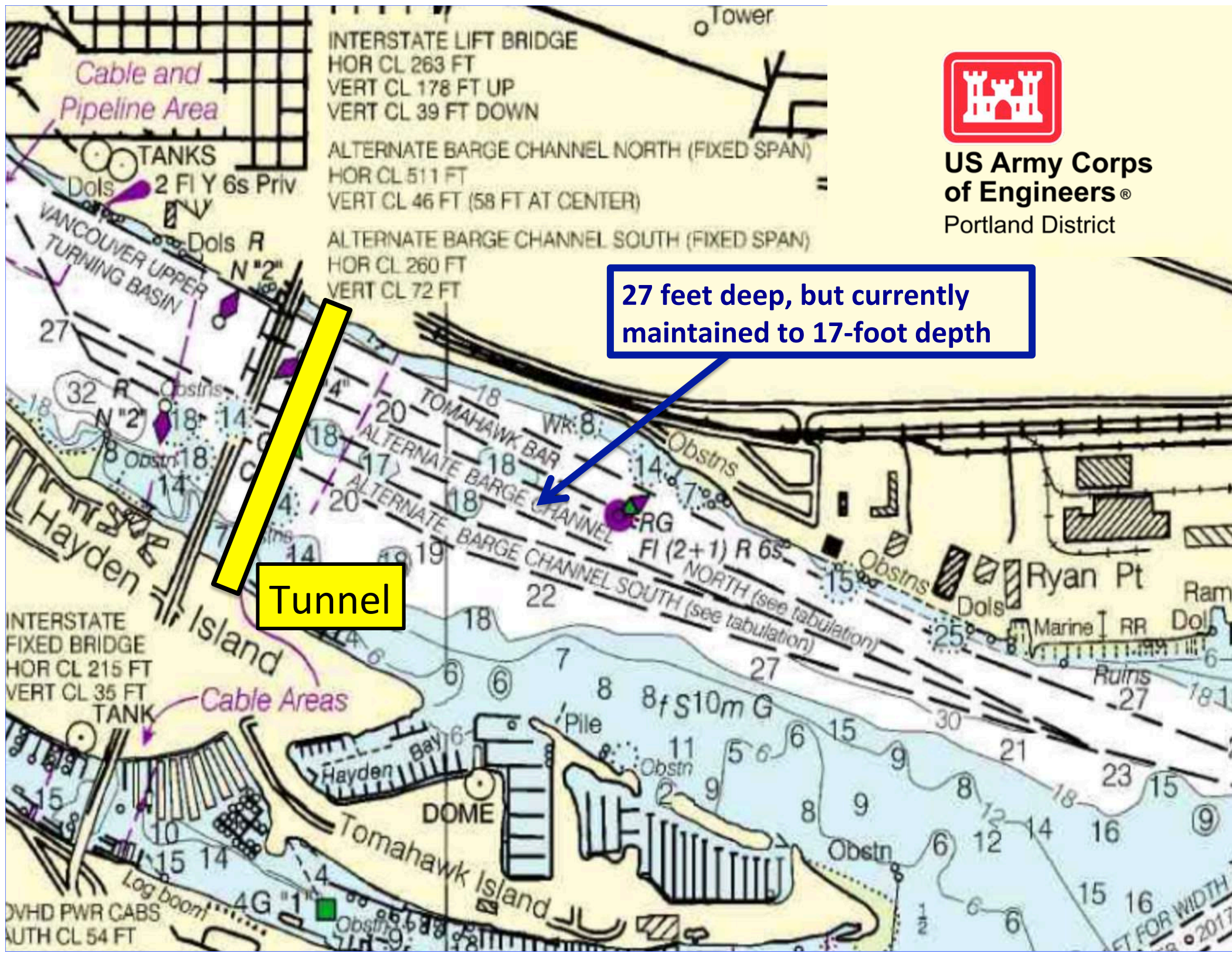
To keep the ports of Portland and Vancouver accessible to oceangoing ships, **every year the Corps dredges 6 million to 8 million cubic yards of sand** from the 107-mile shipping channel between Astoria and Vancouver

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.**





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INTERSTATE LIFT BRIDGE  
HOR CL 263 FT  
VERT CL 178 FT UP  
VERT CL 39 FT DOWN

ALTERNATE BARGE CHANNEL NORTH (FIXED SPAN)  
HOR CL 511 FT  
VERT CL 46 FT (58 FT AT CENTER)

ALTERNATE BARGE CHANNEL SOUTH (FIXED SPAN)  
HOR CL 260 FT  
VERT CL 72 FT

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

Tunnel



111 years old

1908

Burlington Northern Railroad Bridge 9.6

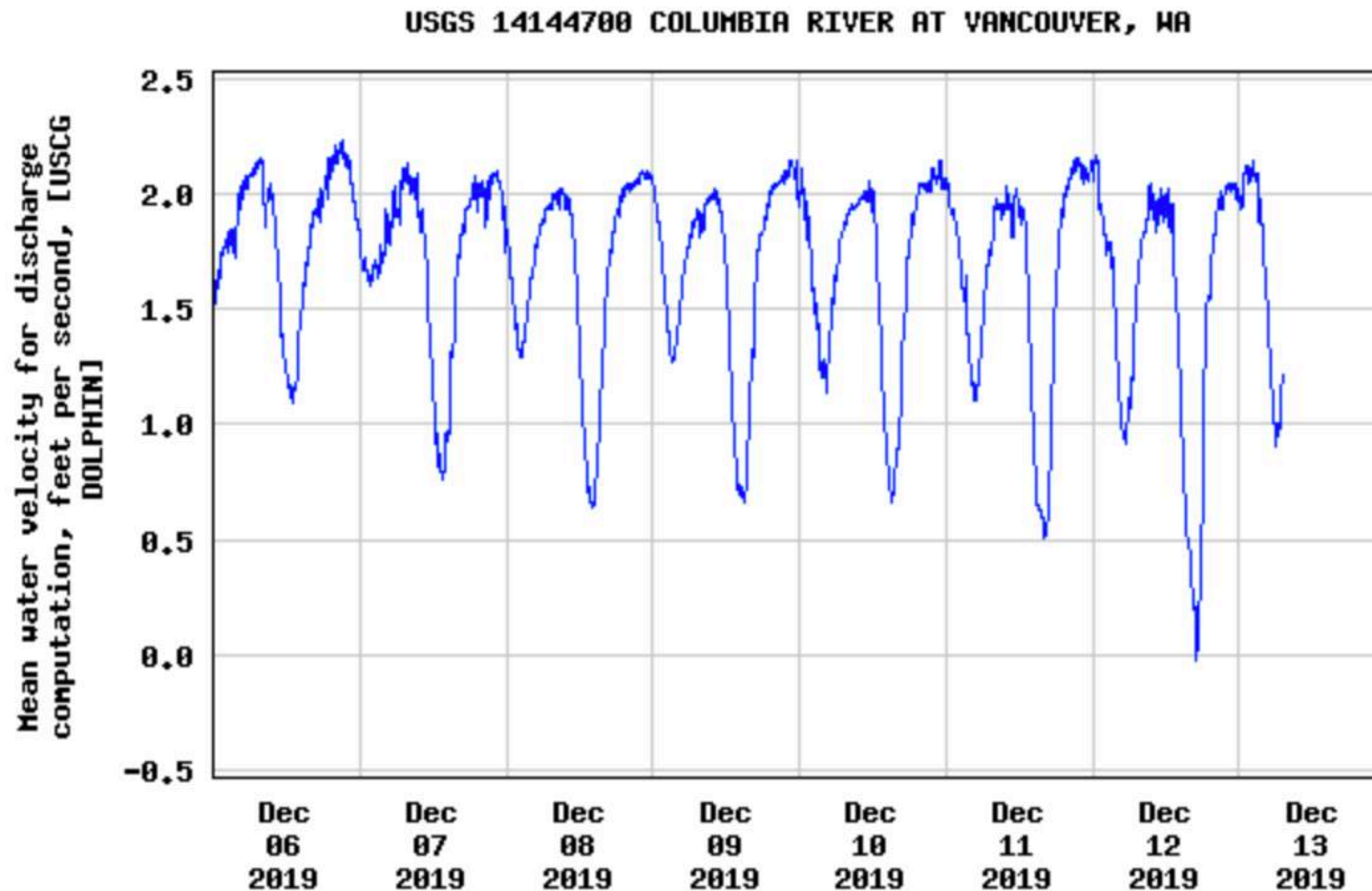




# Columbia River @ Vancouver, WA

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

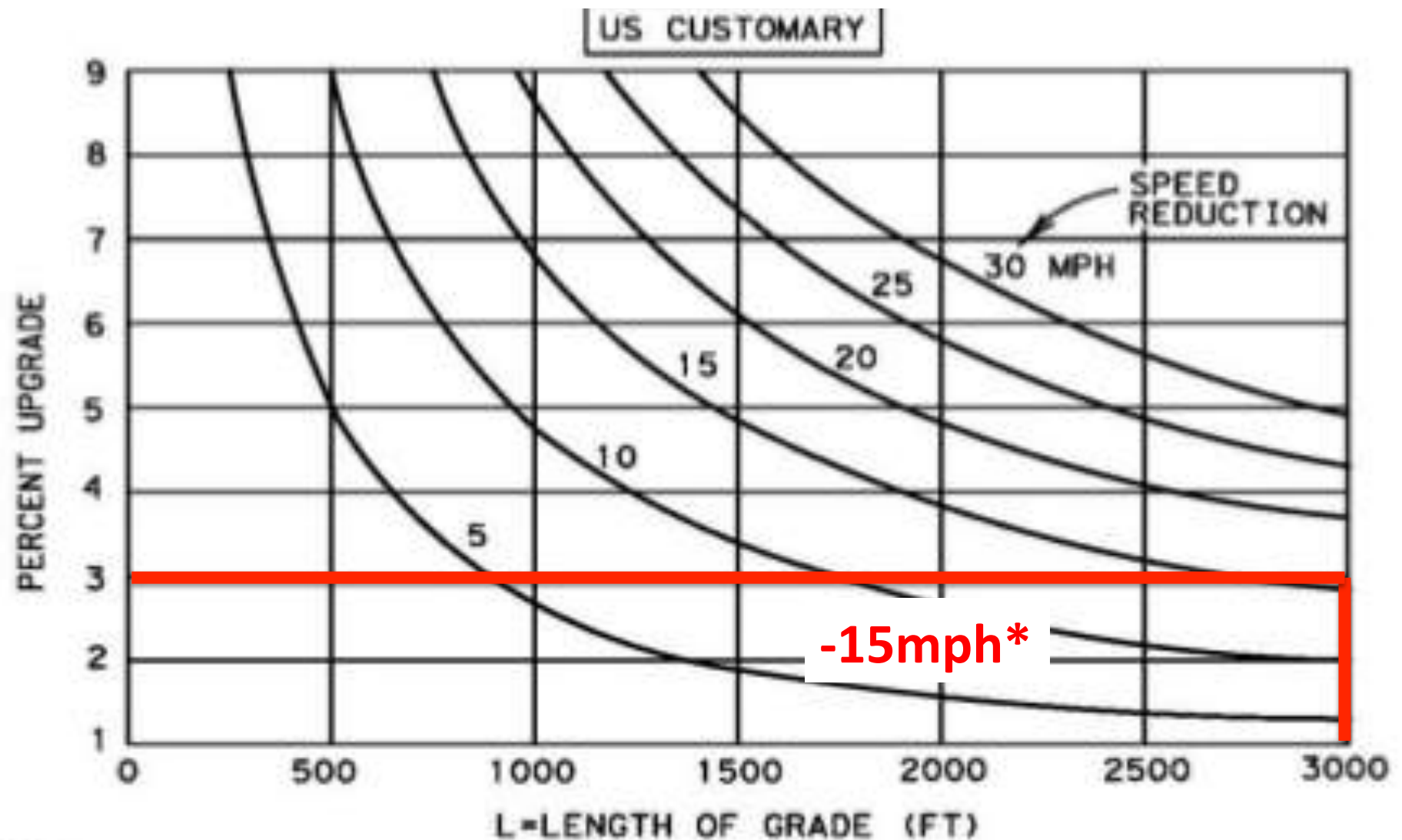
Most recent instantaneous value: 1.22 12-13-2019 07:05 PST



Max current  
2.2 = 1.5mph

Min current  
0.0 = 0.0mph





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

\*Heavy truck reduced speed

CRITICAL LENGTHS OF GRADE FOR DESIGN