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TSUNAMI PROTECTION FOR ROYAL CANADIAN NAVY ASSETS

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AIM

1. The aim of this service paper is to examine the dangers posed by the Cascadia Subduction Zone and the Juan de Fuca Plate on Canada's Pacific Fleet, and to propose specific recommendations for Tsunami protection. Such measures will ensure fleet survivability after an impending natural catastrophe so to ensure emergency response and global deployment capability in an era of increased international tensions.

INTRODUCTION

2. CFB Esquimalt, home of the Canadian Pacific Naval Fleet was initially established in eighteen-fifty-five as a Royal Naval Dockyard, and, in nineteen-ten, was inherited by the Royal Canadian Navy. Today, CFB Esquimalt employs some eight-thousand sailors and civilian personnel.[1] A fleet of fifteen commissioned warships and submarines are housed within the confines of Esquimalt Dockyard along with Fleet Diving Unit Pacific, the commercially operated Esquimalt Graving Dock, Songhees / Esquimalt First Nations communities and many other homes close to sea level. At first glance, it is easy to see why ancestors may have chosen the location given that it is accessible to the open ocean, but not fully exposed to it. The location is tucked away at the northwest corner of Constance Bank, bound by natural breakwater features, protected on three sides by land, and appears protected by wave propagation from the open ocean entering at Neah Bay on the west end of the Strait of Juan de Fuca (see map at annex A).

3. Since the late nineteen-eighties, studies have been undertaken to ascertain the potential danger imposed by the Cascadia Subduction Zone (or Cascadia Fault). Scientists from around the globe suggest that the fault has been building pressure for many hundreds of years.[2] Its geographic makeup is similar to, if not more concerning that others which have caused recent catastrophic damage around the globe. As recent as twenty-twenty-one, studies are increasingly pointing to a much greater threat to Esquimalt Harbour than even Victoria Harbour just three kilometers away.[3] To prevent such catastrophic outcomes from occurring within Esquimalt Harbour, mitigation measures are highly recommended, particularly in the wake of costly and ongoing, Esquimalt Dockyard infrastructure upgrades and fleet vessel recapitalization projects.[4] Billions in recent expenditures will remain exposed in the small harbour that is expected to endure the most tsunami damage beyond the Strait of Juan de Fuca, unless risk

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[1] "Maritime Forces Pacific," , accessed 9 Feb 2023, https://www.canada.ca/en/navy/corporate/our-organization/structure/marpac.html.

[2] "Odds are about 1-in-3 that Mega-Earthquake Will Hit Pacific Northwest in Next 50 Years," , accessed 10 Feb, 2024, https://www.sciencedaily.com/releases/2010/05/100524121250.htm.

[3] "Capital Region Coastal Flood Inundation Mapping Project Summary," , accessed 9 Feb, 2024, p.15 https://www.crd.bc.ca/docs/default-source/climate-action-pdf/reports/2020-sea-level-mapping-project/coastal-flood-inundation-mapping-project-summary.pdf.

[4] "A/B Jetty Recapitalization," , accessed 10 Feb, 2024, https://www.dcc-cdc.gc.ca/projects/project-esquimalt.

mitigations measures are undertaken. It is not a question of if such a tragedy will take place, but only when, the West Coast experiences its next megathrust earthquake.

DISCUSSION

4. Off of the West Coast of Vancouver Island and the United States northwest, a geophysical phenomenon that has only been well known and intently studied since the mid-1980s, continues to unfold. The Cascadia Subduction Zone, consisting of two plates of the earths crust, the Juan the Fuca Plate and the North American Plate, converge just one hundred nautical miles west of the entrance to the Strait of Juan the Fuca (see annex B figure 1). These two plates border the much larger Ring of Fire, defined as the perimeter of Pacific Plate that lies beneath the Pacific Ocean. This Pacific Plate is said to be responsible for nearly ninety percent of the world's earthquake and tsunami activities.[5] Increasing risk of seismic activity even further along the pacific northwest, is the existence of the Juan the Fuca Ridge, which is a mid-ocean seismic spreading center just to the west of the Cascadia Subduction Zone. This ridge, which continuously separates from the Pacific Plate through volcanic activity, is known to apply additional eastward pressure to the Cascadia Subduction Zone.[6]

5. Over the last seventy-five years, there has been three intraslab (or deep) earthquakes along the Cascadia Faultline; the 1949 Olympia earthquake, the 1993 Scotts Mills earthquake, and in 2001 Nisqually earthquake, all of which measured in magnitude of 5.6 thru to 6.7 and caused minimal casualties. These types of earthquakes occur, not below the ocean, but rather below mainland at great depths often exceeding fifty kilometers (see annex B, image 2, deep earthquakes). Earthquakes of this scale, occur, on average once every thirty years, with the last occurring in 2001. Episodic Tremors and Slip (ETS) describe the near constant minor tremors recorded along the various faults. Monitored and measured by Natural Resources Canada, ETS groupings occur roughly every fifteen month and are rarely cause for concern.[7] The event with the most cause for concern is that of the megathrust earthquake. According to scientists, there is now a forty-percent probability of a magnitude eight earthquake striking Canadas West Coast in the next forty-five years, with a ten-percent probability of that earthquake being magnitude nine or higher.[8]

6. The past two decades have yielded two megathrust earthquakes that together claimed the lives of a quarter-million people. The boxing day earthquake in the Indian Ocean (227,898 lives) and Tohoku earthquake in Japan (22,312 lives) were magnitude nine-point-three and nine-point-one respectively, and both were undersea megathrust

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[5] "Plate Tectonics and the Ring of Fire." accessed 12 Feb 2024, https://education.nationalgeographic.org/resource/plate-tectonics-ring-fire/.

[6] "Scientists Map Source of Northwest's Next Big Quake." accessed 17 Feb 2024, https://www.universityofcalifornia.edu/news/scientists-map-source-northwests-next-big-quake.

[7] "Episodic Tremor and Slip." accessed 17 Nov 2024, https://www.earthquakescanada.nrcan.gc.ca/pprs-pprp/pubs/GF-GI/GEOFACT_ETS_e.pdf.

[8] "Dams, Risk, and the Cascadia Subduction Zone: A USAC Perspective." United States Army Corps of Engineers, , accessed 19 Feb, 2023, https://www.youtube.com/watch?v=WyYqQjgzOpM.

earthquakes. The two tragedies took place relatively close to their respective coastlines and produced significant tsunamis that devastated local communities and other villages, some of which experienced death tools over two-thousand kilometers from the epicenter.[9] The number of casualties in Japan were far less than those of the Boxing Day Earthquake owing to nearly one-hundred years of intense preparations by the Japanese people including the creation of barriers as early as the mid-twentieth century. Given that Canada and the United States have only begun considering earthquake proofing measures in the nineteen-eighties, experts assess that the west coast of North America is nowhere near as prepared to handle a magnitude nine, or even a magnitude eight earthquake. It is anticipated that such an event would prove catastrophic for the entirety of the Pacific Northwest, with tens of thousands likely to die while hundreds of bridges and buildings topple along the one-thousand-kilometer subduction zone from southern Oregon to Northern Vancouver Island.

7. The last recorded Vancouver Island megathrust earthquake was a nine-point-two magnitude and resulting tsunami, which took place in the year 1700. Megathrust earthquakes generally share the same subduction zone characteristics. The Indian Ocean / Sumatra disaster was the result of the subduction of two minor plates with that of Japan being a slip of two major plates. For the Cascadia subduction zone, two major plates, with a booster, as detailed in paragraph four, interact to create compression in a transition zone that is held back by a locked zone (see annex B).[10] The compression zone off of Vancouver Island has been building resistant energy for some three-hundred-twenty-five years, and the energy will someday be released. On average, depending on timeline horizon, Cascadia megathrust earthquakes occur between every two-hundred-fifty to five-hundred years. Simple math demonstrates how the previously cited forty percent chance over the next forty-five years has been calculated. Once the North American Plate slips over top of the Juan de Fuca Plate, the earthquake will be felt near instantaneously for hundreds of miles, whereas the associated under-ocean fluvial waves will work their way through the water column and start their surface wave journeys to adjacent shorelines in both directions. Concerned with such eventuality, Joint Task Force Pacific had been planning for the inevitable.

8. Codenamed Contingency Plan (CONPLAN) PANORAMA, Joint Task Force Pacific has been planning for a response to a catastrophic earthquake in British Columbia for nearly two decades. The twelve February 2014 version of the CONPLAN generally accepted, that the next megathrust event along the Cascadia Fault is likely to destabilize the Pacific Fleet, its resources, and its personnel. The document calls on external leadership (C2) to render assistance due to the likely absence of local resources. It also recognizes that soldiers and sailors will likely first ensure the safety of family members before assisting with the greater effort and may very well find it impossible to report to work due to the disaster’s effects on infrastructure. The document all but admits defeat,

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[9] "The 2004 Tsunami Wiped Away Towns with ‘Mind-Boggling’ Destruction." accessed 9 Feb 2024, https://www.history.com/news/deadliest-tsunami-2004-indian-ocean.

[10] "The Mega Earthquake that may Someday Wipe Seattle Off of the Map." accessed 9 Feb 2023, https://inhabitat.com/a-mega-earthquake-could-be-coming-that-will-wipe-seattle-off-the-map/.

and that notion is arguably justified if nothing is done before hand to improve the likely outcome. One area for improvement within the document itself, may be in the accounting for time. While the shaking from the magnitude nine earthquake will cause devastation for a known (felt) duration, the resulting tsunami would not reach the shores of Esquimalt harbour for some seventy-five to ninety minutes thereafter.[11] The tsunami may also very well flood CFB Esquimalt, flooding workspaces such as the Regional Joint Operations watch floor, and preventing sailors from returning to their vessels. (see annex D).

9. Water propagation resulting from megathrust earthquake tsunamis often defy logic. Assessed on its own, the location of Esquimalt Harbour would seem rather insignificant compared to the rest of the Saanich Peninsula, which may point to the reasons for early first nations settlements. The underwater topography and shallowing around Fisgard Lighthouse and throughout Esquimalt Harbour however, makes the harbour far more susceptible to significant damage than though just a decade ago. Water propagation from open ocean, through the Strait of Juan de Fuca and around a ninety-degree elbow at Race Rocks on the southern tip of Vancouver Island do little to provide relief to Esquimalt Harbour users. Faced with a magnitude nine earthquake, Esquimalt Harbour is expected to first experience a significant drawback (also known as drawdown) of up to two meters,[12] which is the process of water leaving a shoreline or harbour to supply an approaching surge with water as it grows in intensity until reaching the shore (see picture at annex F). The second stage is that of inundation, which will most certainly involve several aggressive wave segments of debris fields sloshing over the period of several hours. This inundation, modelled in the 2015 CRD report, estimated a rise in water levels by up to 3.5 meters,[13] but that projection was revised to over a 4.5-meters in the 2021 CRD report (see annex E).[14] The third and final stage is that of a post tsunami drawback. All stages of the tsunami will result in negative effects on Fleet infrastructure, ashore and moored in and around Esquimalt Harbour unless mitigations take place.

10. The only way to prevent damage, would the creation of a harbour barrier. An earthquake proof, mechanical barrier would all but ensure the ability to sail the West Coast fleet after a tsunami disaster, something that is not known to be a part of existing planning or conversation. To combat ocean effects created by coastal earthquake activity, Japan is taking to such drastic means to protect its shores. While concurrently moving the majority of their low-lying cities to higher elevations, Japan is building tsunami barriers. One such government sponsored megaproject is currently underway along the northeast coastline, where a fourteen-meter tall wall is set to stretch over four hundred kilometers (see images at annex G). Mixed reviews by those who oppose the project include such arguments as loss of ocean view, cost to project to protect largely rice fields in the wake of tragedy, and finally, the effects on marine life and fisheries resulting from the elimination of mountain runoff. Given previously mentioned study projections, a

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[11] "Modelling of Potential Tsunami Inundation Limits and Run-Up,." last modified 14 June 23, p.23 https://www.crd.bc.ca/docs/default-source/news-pdf/2013/modelling-of-potential-tsunami-inundation-limits-and-run-up-report-.pdf.
[12] AECOM, "Modelling of Inundation Limits.", p. 19
[13] AECOM, "Modelling of Inundation Limits.", p. 27
[14] WESTMAR, "Capital Region Coastal Flood Inundation Mapping Project Summary," p. 16

mechanized tsunami wall of only eight meters in height, stretching the 0.87-kilometer entrance with reinforcement along other low-lying areas, may be sufficient to save the West Coast fleet and dockyard facilities.

11. Unlike on the East Coast where tidal ranges of 10 meters occur on a regular basis, the available depth of Esquimalt Harbour cannot not accommodate rapid, large tidal ranges. Taking the potential maximum figures from all reports, a two-meter drawdown may lead to a six-point-five-meter surge.[15] Results may include bottoming of vessels and breaking of vessel lines, that would be far too difficult to manage during a water deluge. Outside of fending off tsunami phases with a mechanical tsunami barrier, a second and more advanced sort of ocean barrier at the entrance to the harbour would also have the ability to protect the fleet against future ice melt sea water rise and the potential for lowering of land after the release of tectonic plate pressure. This more advanced, and certainly more expensive solution is that of a lock system, similar to that in Incheon South Korea (see annex H). The Incheon inner harbour lock system, ensures the static height of the waters surface while the outside of the lock endures tidal heights of up to ten meters. A similarly constructed lock with some tsunami proofing could act as two stage protection for Esquimalt Harbour while simultaneously protecting it from potential tidal range heights associated with global warming.

CONCLUSION

12. Despite the acceptance of its fate in Contingency Plan PANORAMA, Canada possesses the ability to take bold actions to protect its rejuvenating West Coast fleet from a magnitude nine earthquake and associated tsunami threat. With the Royal Canadian Navy existing largely in two locations in the country, the next West Coast natural disaster has the potential to reduce the fleet by 50% within a matter of minutes if mitigation measures are not pursued. Japan, on the other hand, has made significant progress in protecting four hundred kilometers of what is mostly vegetation, rice fields, and the odd fishing villages. Canada must look to Japan for their expertise and agree to significantly reduce the risk of creating a disabled fleet, or in a more strategic manner, consider adopting a lock system that could protect the harbour, its people, and its businesses from future sea water level threats.

13. The vulnerability of Esquimalt harbour and the pacific fleet is not limited to the physical actions of mother nature. Many United States major naval bases and coastlines are also susceptible to significant damage during a megathrust tsunami, meaning that reliance on assistance from the south is unlikely. With both Canada, and the US forced to respond domestically to what may amount to the largest ever military operation, there will be far less capacity to continue overseas missions. Some great powers may already have this particular disaster on their radar as a condition to advance with their own wartime priorities. Should this be the case, the construction of sea barrier at the entrance to Esquimalt harbour may also act as a strategic deterrence, advertising to neutral and

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[15] Gonzalez, Frank, Randall LeVeque and Loyce Adams, Tsunami Hazard Assessment of the Strait of Juan De FucaWashington State Emergency Management Division,[2015]). p.80

enemy states that Canada will have the ability defend national and international interests, come “Hell or High Water.”

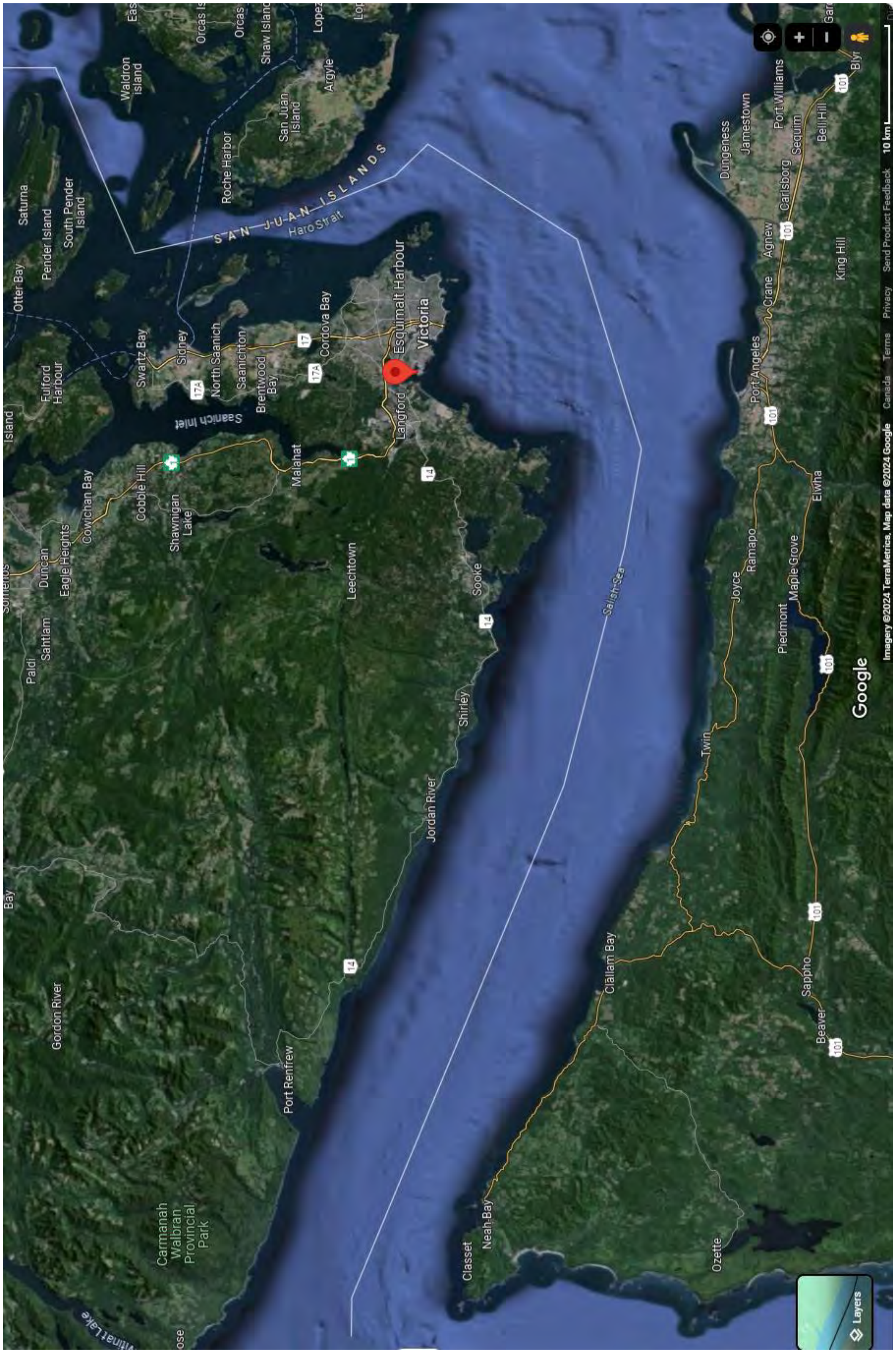
RECOMMENDATIONS

14. Although further research is required to ascertain the need for a either a lock, or a tsunami barrier at the entrance of Esquimalt Harbour, the research and potential investment may well we worth the expense. At just 0.87 kilometers wide, a tsunami proof barrier may prove worthy investment, saving 50% of Canada’s Naval Fleet, First Nations Communities and low-lying homes at the harbour’s edge. Done correctly, Esquimalt dockyard could even turn out to be a safe haven in the event of such a disaster.

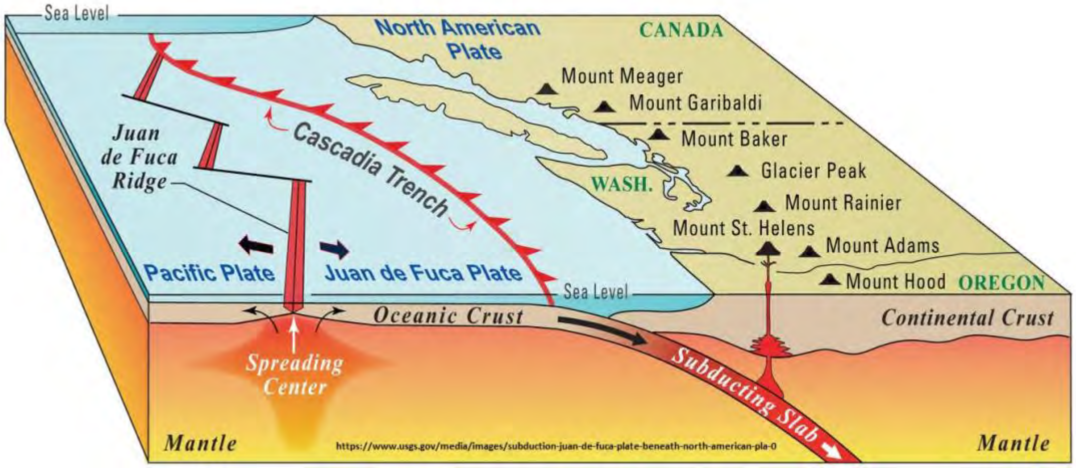
15. Greater study into structure possibilities, specific to countering the effects of magnitude 8-9 earthquakes, in Esquimalt Harbour, must be undertaken. From the analysis of existing infrastructure, it is recommended that the navy initiate steps to protect its fleet from the Cascadia Subduction Zone megathrust earthquake. In deciding to invest in a barrier or lock, the Navy will be able to fend off the immediate dangers and be ready to provide initial support to the tens of thousands in need while also being able to maintain an international presence. The time to figure out what to do to reduce the effects of a major tsunami or a megathrust earthquake is not after it happens, particularly given the scientifically justified forty percent chance of this disaster taking place in the next half-century.

Annexes: A - Map of Strait of Juan de Fuca
B - Subduction of the Juan de Fuca Plate beneath the North American Plate
C - Cascadia Locked and Transition Zones
D - Tsunami Hazard Zone for Esquimalt Harbour based on CRD 2021 Tsunami Inundation Mapping Report
E - Esquimalt Harbour maximum surface elevation for a magnitude 8-9 earthquake
F - Beach spectators during the drawback phase of the 2004 Boxing Day Tsunami
G - Japans Northeast 14 Meter Wall
H - Incheon South Korea Inner Port & Lock System

Annex: A (Map of Strait of Juan de Fuca)

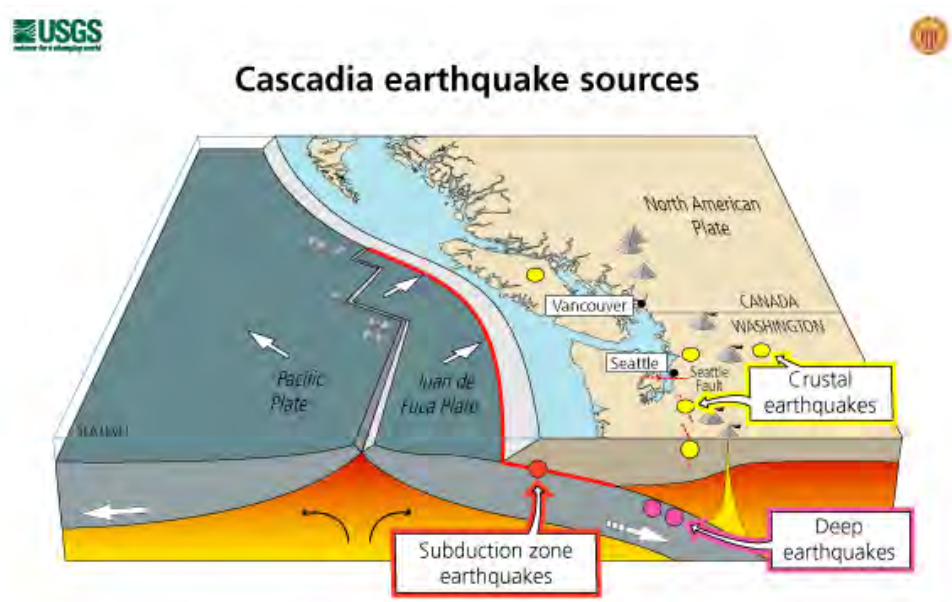


Annex: B (Subduction of the Juan de Fuca Plate beneath the North American Plate)



https://www.usgs.gov/media/images/subduction-juan-de-fuca-plate-beneath-north-american-pla-0

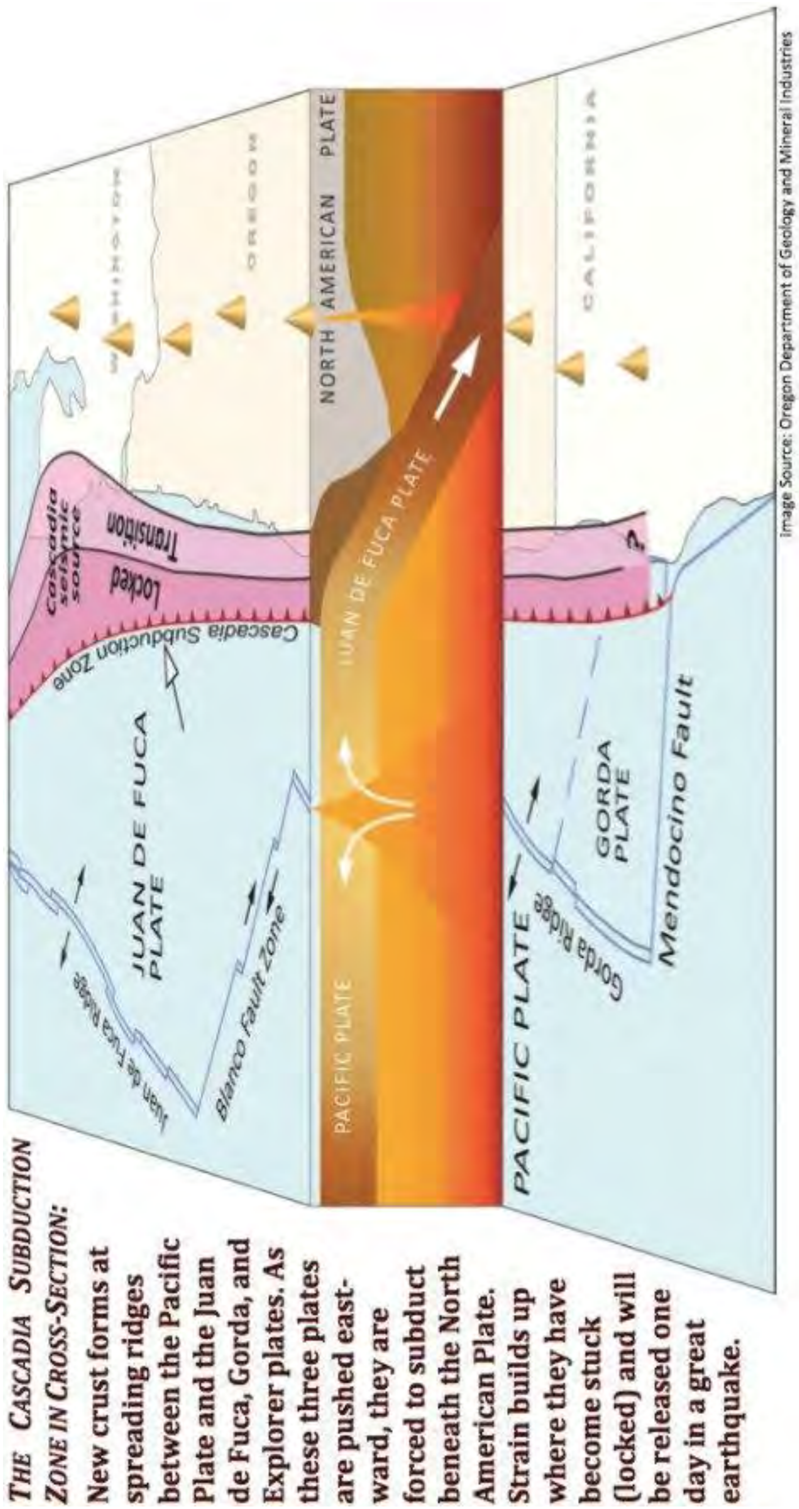
Figure 2 (Cascadia Deep Earthquakes and Recurrence Intervals)



Source	Maximum Size	Recurrence Interval	Major Past Earthquakes (Year)
Subduction Zone	M 9	500-600 yr	1700
Deep Juan de Fuca plate	M 7+	30-50 yr	1949, 1965, 2001
Crustal faults	M 7+	Hundreds of yr?	900, 1872

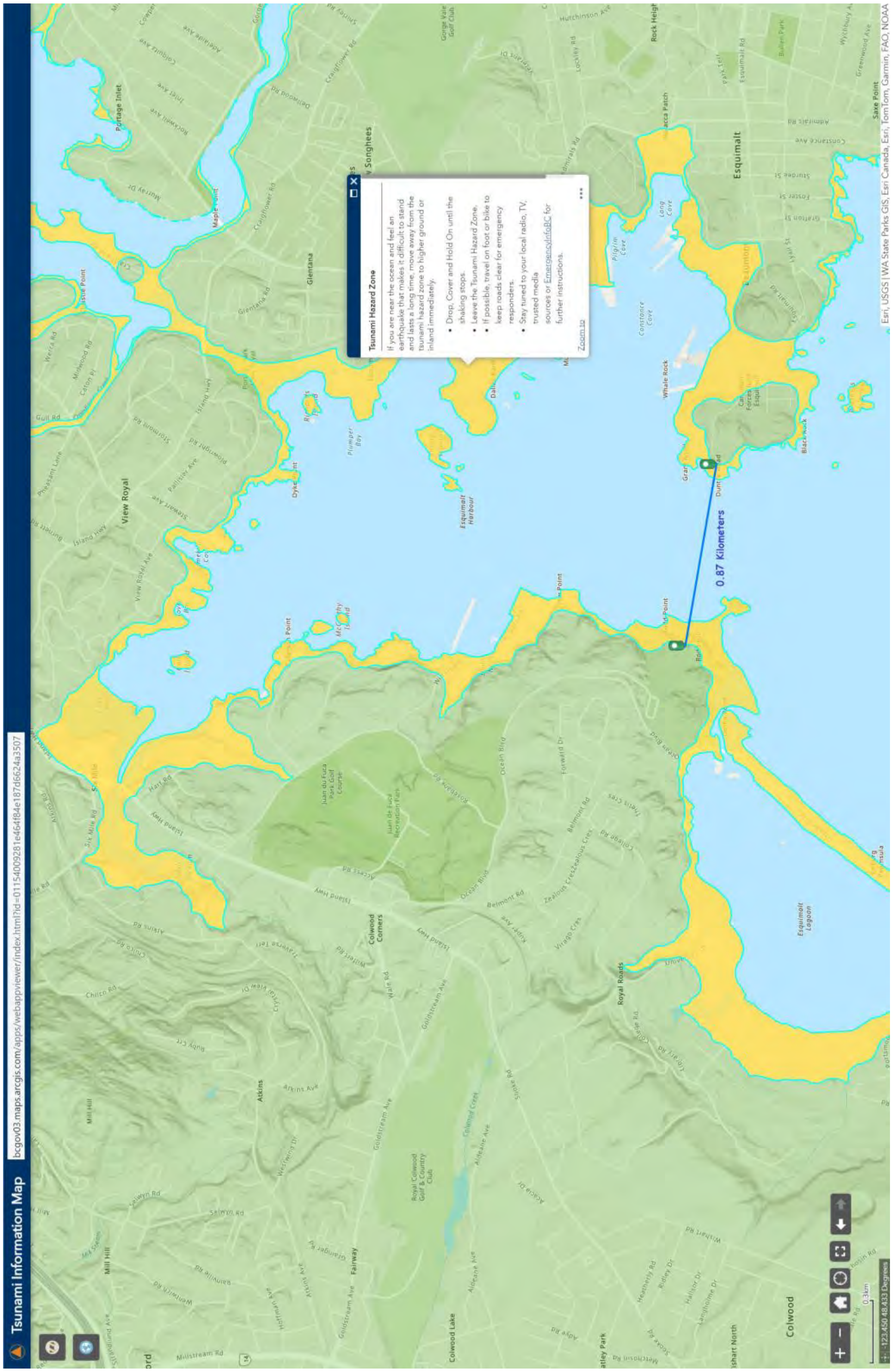
https://environment.uw.edu/news/2019/11/world-tsunami-awareness-day-what-are-the-risks-and-how-can-we-prepare/

Annex: C (Cascadia Locked and Transition Zones)

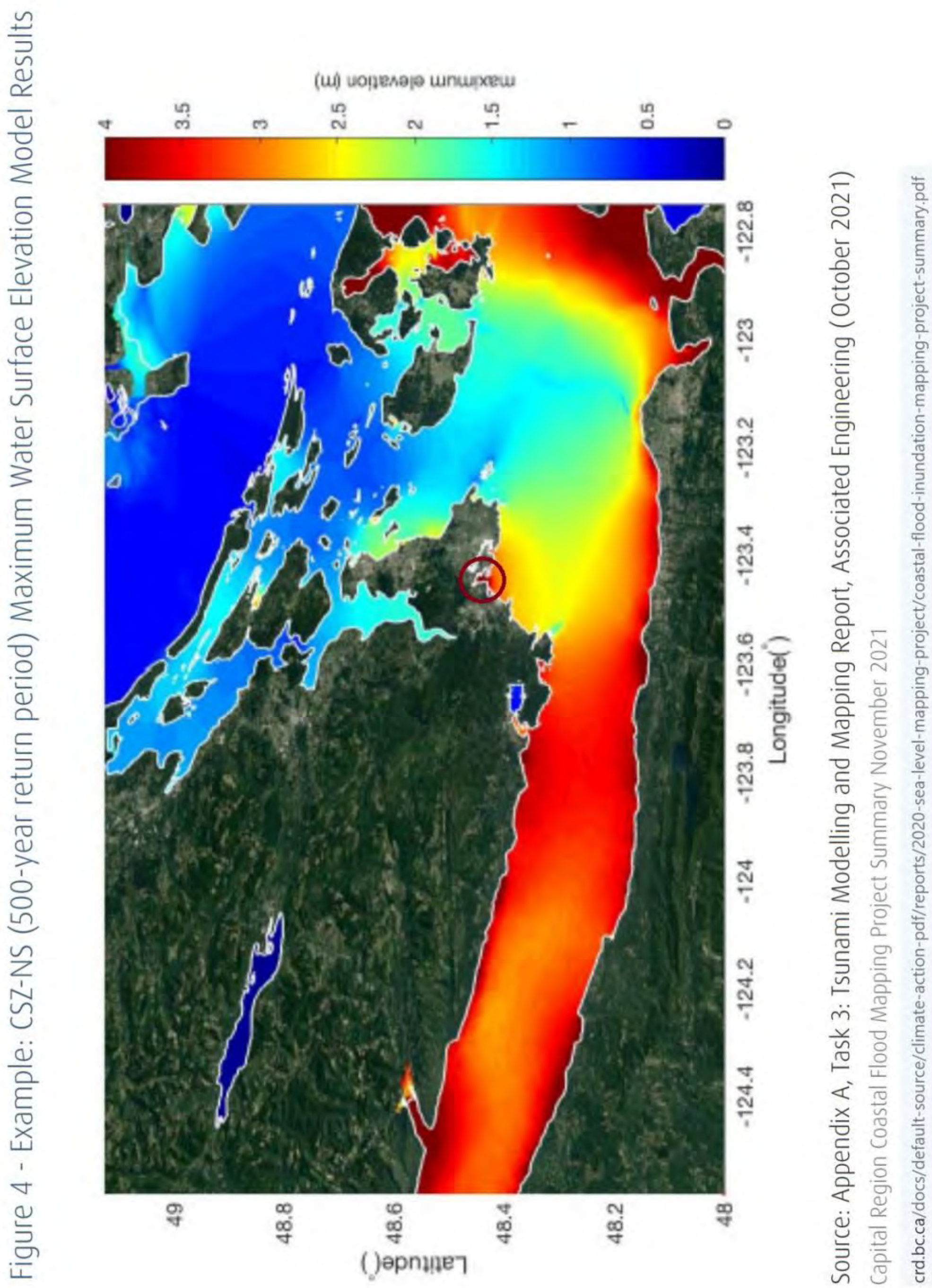


https://inhabitat.com/a-mega-earthquake-could-be-coming-that-will-wipe-seattle-off-the-map/cascadia-subduction-zone-cross-section/

Annex: D (Tsunami Hazard Zone for Esquimalt Harbour based on CRD 2021 Tsunami inundation mapping report)



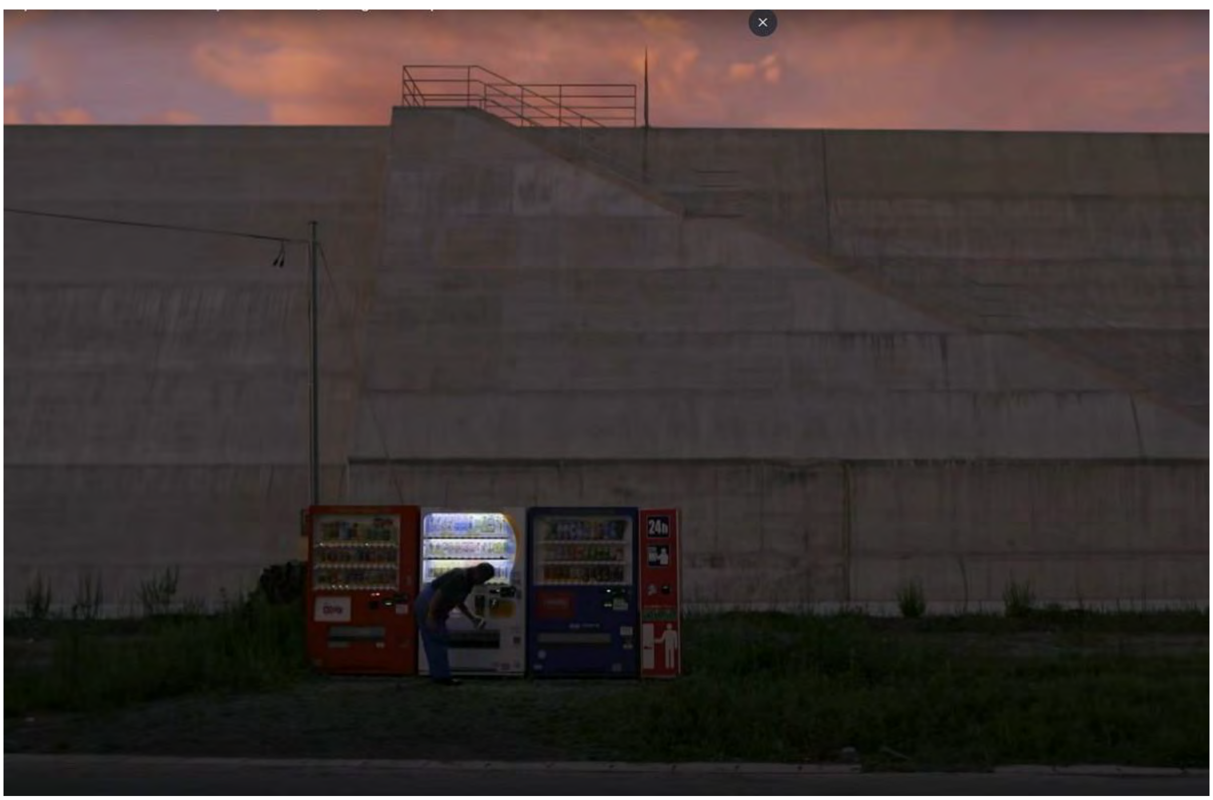
Annex: E (Esquimalt Harbour Maximum Surface Elevation for a magnitude 8-9)



Annex: F (Beach spectators during the drawback phase of the 2004 Boxing Day tsunami)

https://w2.weather.gov/jetstream/tsu_inundation

Annex: G (Japan's Northeast 14-Meter Wall)



Annex: H (Incheon, South Korea: Inner Port & Lock System)

https://incheon.mof.go.kr/en/board.do?menuIdx=1820&bbsIdx=38734

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