

Introduction

The Oregon Department of Geology and Mineral Industries (DOGAMI) has been identifying and mapping the tsunami inundation hazard along the Oregon coast since 1994. Oregon, DOGAMI manages the National Tsunami Hazard Mitigation Program, which has been administered by the National Oceanic and Atmospheric Administration (NOAA) since 1995. DOGAMI's work is designed to help cities, counties, and other sites in coastal areas reduce the potential for disastrous tsunami-related consequences by understanding and mitigating the geologic hazard. Using federal funding awarded by NOAA, DOGAMI has developed a new generation of tsunami inundation maps to help residents and visitors along the entire Oregon coast prepare for the next Cascadia Subduction Zone (CSZ) earthquake and tsunami.

The CSZ is the tectonic plate boundary between the North American Plate and the Juan de Fuca Plate (Figure 1). These plates are converging at a rate of about 1.5 inches per year, but the movement is not smooth and continuous. Rather, the plates lock in place, and unreleased energy builds up over time. At intervals, this accumulated energy is violently released in the form of a megathrust earthquake rupture, where the North American Plate suddenly slips westward over the Juan de Fuca Plate. This rupture causes a vertical displacement of water that creates a tsunami (Figure 2). Similar rupture processes and tsunamis have occurred elsewhere on the planet where subduction zones exist; for example, offshore Chile in 1960 and 2010, offshore Alaska in 1964, near Sumatra in 2004, and offshore Japan in March 2011.

CSZ Frequency: Comprehensive research of the offshore geologic record indicates that at least 19 major ruptures of the full length of the CSZ have occurred off the Oregon coast over the past 10,000 years (Figure 3). All 19 of these full-rupture CSZ events were likely magnitude 8.9 to 9.2 earthquakes (Witter and others, 2011). The most recent CSZ event happened approximately 300 years ago on January 26, 1700. Sand deposits carried onshore and left by the 1700 event have been found 1.2 miles inland, older tsunami sand deposits have also been discovered in estuaries 6 miles inland. As shown in Figure 3, the range in time between these 19 events varies from 110 to 150 years with a median time interval of 490 years. In 2008 the United States Geological Survey (USGS) released the results of a study announcing that the probability of a magnitude 9.0 CSZ earthquake occurring over the next 30 years is 10% and that such earthquakes occur about every 500 years (WGCEP, 2008).

CSZ Model Specifications: The sizes of the earthquake and its resultant tsunami are primarily driven by the amount and geometry of the slip that takes place when the North American Plate snaps westward over the Juan de Fuca Plate during a CSZ event. DOGAMI has modeled a wide range of earthquake and tsunami sizes that take into account different fault geometries that could amplify the amount of seawater displacement and increase tsunami inundation. Seismic geophysical profiles show that there may be a steep slip fault running nearly parallel to the CSZ but closer to the Oregon coastline (Figure 1). The effect of this slip fault moving during a full-rupture CSZ event would be an increase in the amount of vertical displacement of the Pacific Ocean, resulting in an increase of the tsunami inundation onshore.

Cascadia Subduction Zone Setting

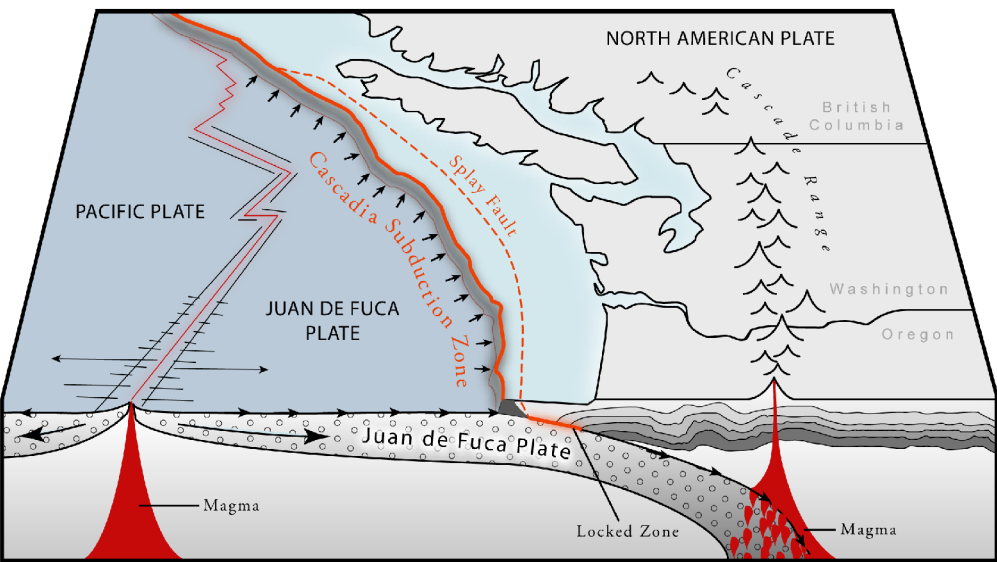
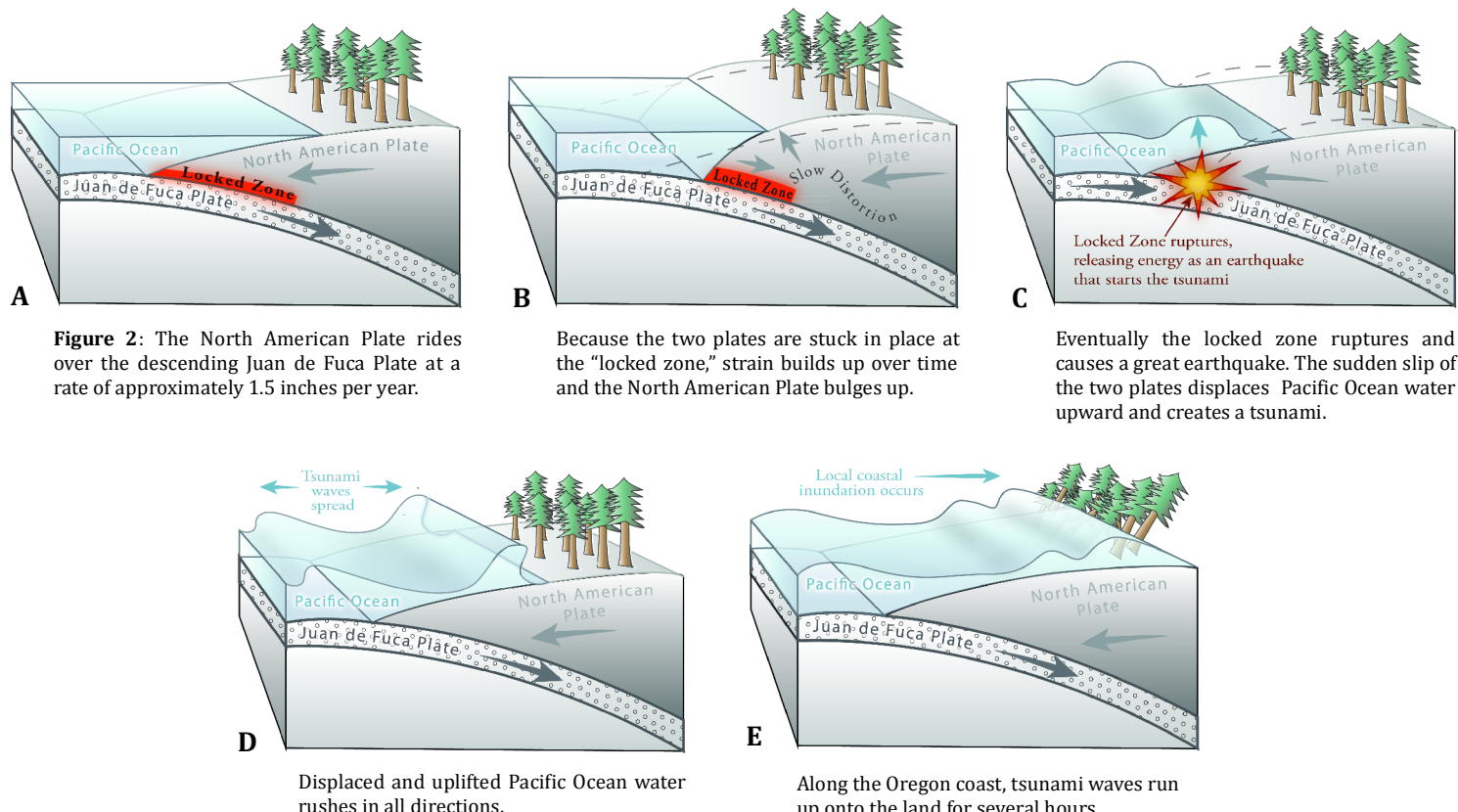


Figure 1: This block diagram depicts the tectonic setting of the region. See Figure 2 for the sequence of events that occur during a Cascadia Subduction Zone megathrust earthquake and tsunami.

How Tsunamis Occur



Occurrence and Relative Size of Cascadia Subduction Zone Megathrust Earthquakes

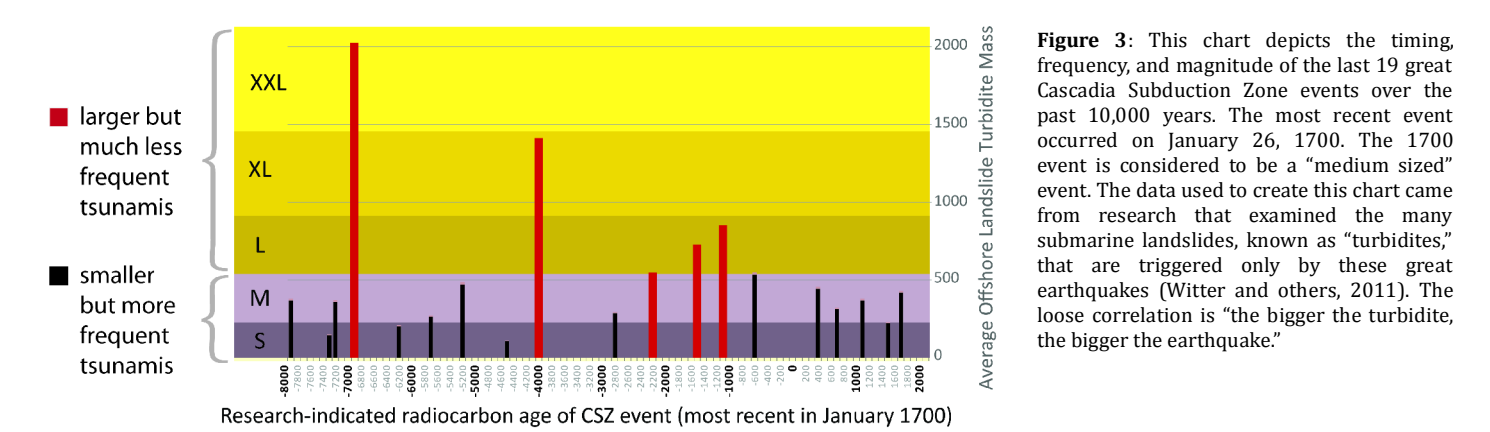


Figure 3: This chart depicts the timing, frequency, and magnitude of the last 19 great Cascadia Subduction Zone events over the past 10,000 years. The most recent event occurred on January 26, 1700. The 1700 event is considered to be a "medium sized" event. The data used to create this chart came from research that examined the many volcanic islands, known as "bathtub" that are triggered only by these great earthquakes (Witter and others, 2011). The loose correlation is "the bigger the earthquake, the bigger the bathtub."

Buildings within Tsunami Inundation Zones

Entire Map Area		Unincorporated Areas	
Total Buildings	169	Total Buildings	169
Buildings within Tsunami Zones*			
Small	2	2	2
Medium	5	5	5
Large	8	8	8
Extra Large	19	19	19
Extra Extra Large	19	19	19

Percent of Buildings within Tsunami Zones		Percent of Buildings within Tsunami Zones	
Small	1.2%	1.2%	1.2%
Medium	3.0%	3.0%	3.0%
Large	4.7%	4.7%	4.7%
Extra Large	11.2%	11.2%	11.2%
Extra Extra Large	11.2%	11.2%	11.2%

*Building counts shown are based on polygon centroids and are cumulative within the map area.

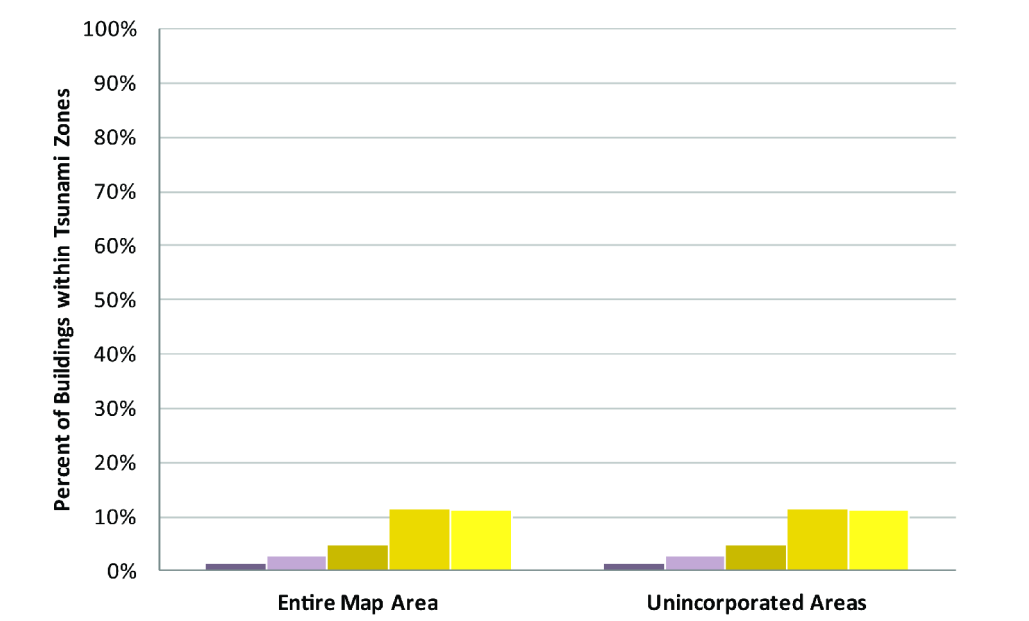
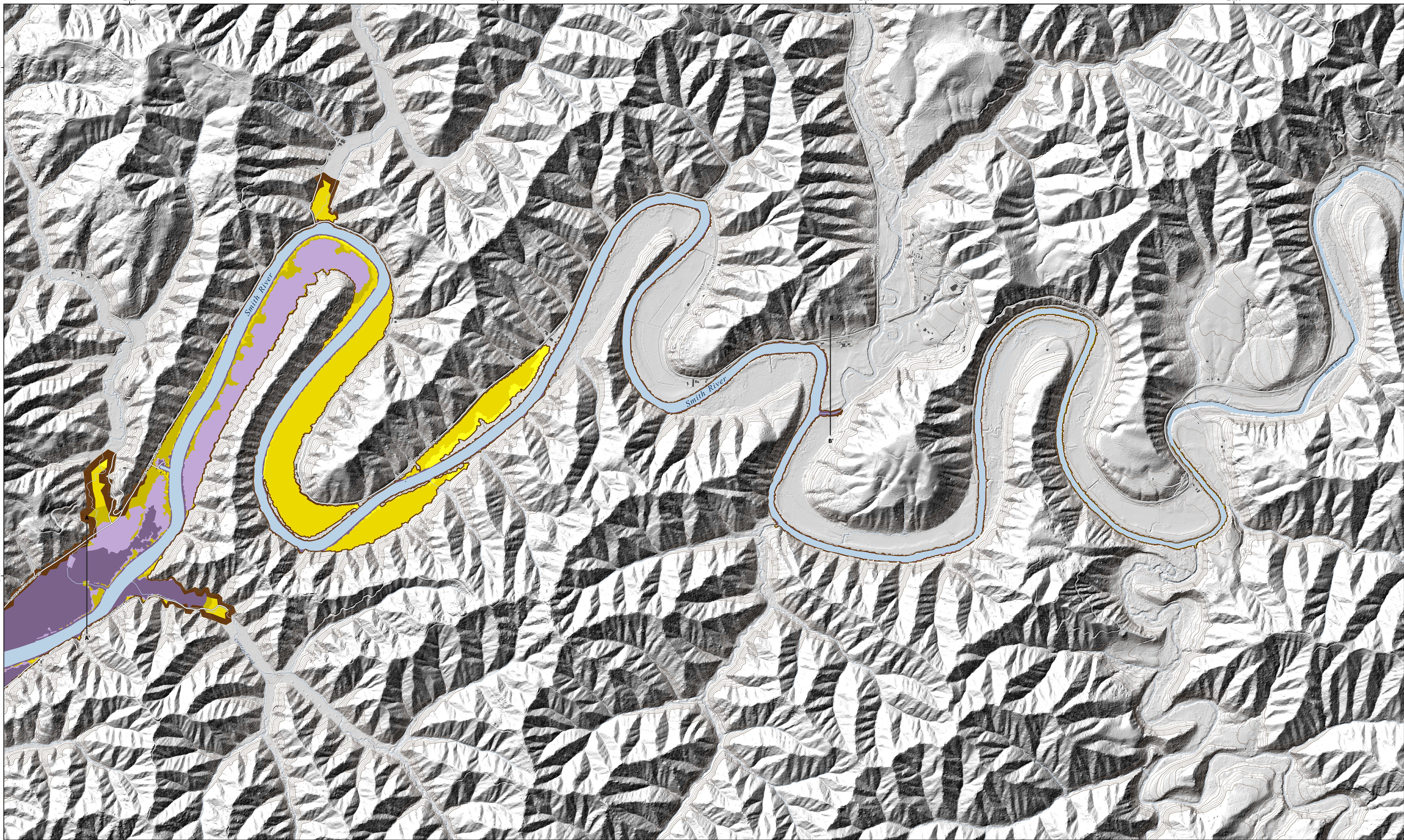


Figure 4: The table and chart show the number of buildings inundated for each "Tsunami T-shirt scenario" for cities and unincorporated portions of the map.

Local Source (Cascadia Subduction Zone) Tsunami Inundation Map Sulphur Springs, Oregon

2013



Estimated Tsunami Wave Height through Time for Simulated Gauge Station

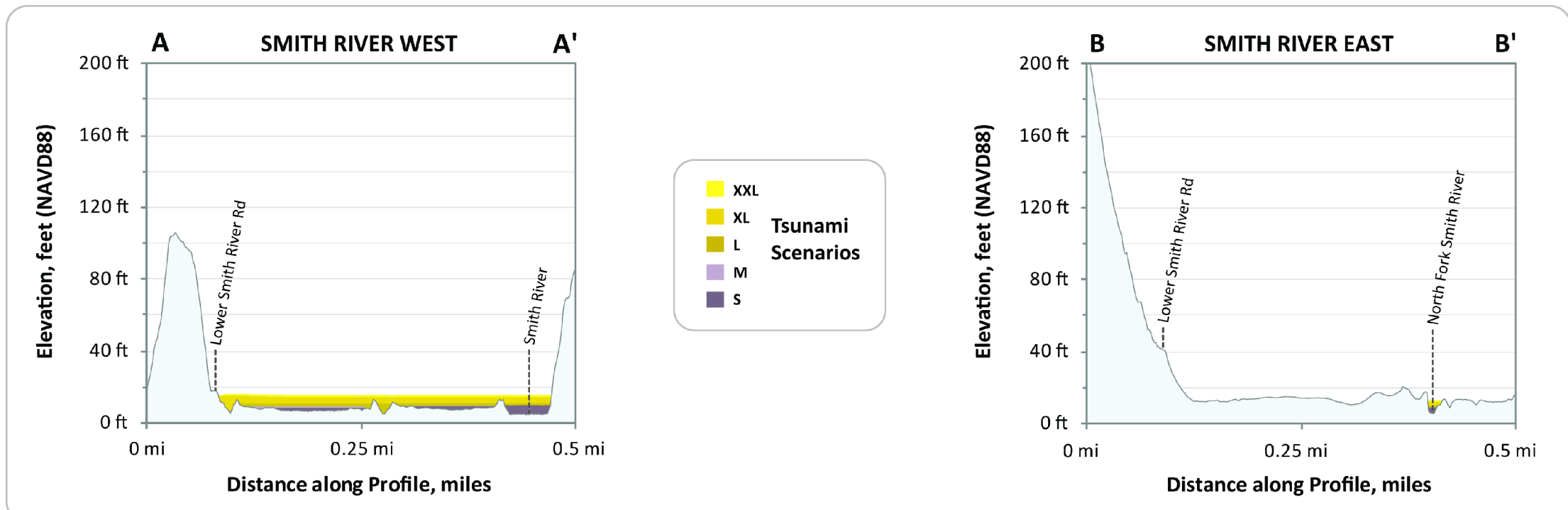


Figure 5: This chart depicts the tsunami waves as they arrive at the selected reference point (simulated gauge station). It shows the change in wave heights for all the tsunami scenarios over an 8-hour period. The starting wave elevation (0.0 hour) takes into account the local land subsidence or uplift caused by the earthquake. Wave heights vary through time, and the first wave will not necessarily be the largest as waves interfere and reflect off local topography and bathymetry. Any absence of data indicates periods for which tsunami inundation has not yet reached or has receded from the station location and dry land is exposed.

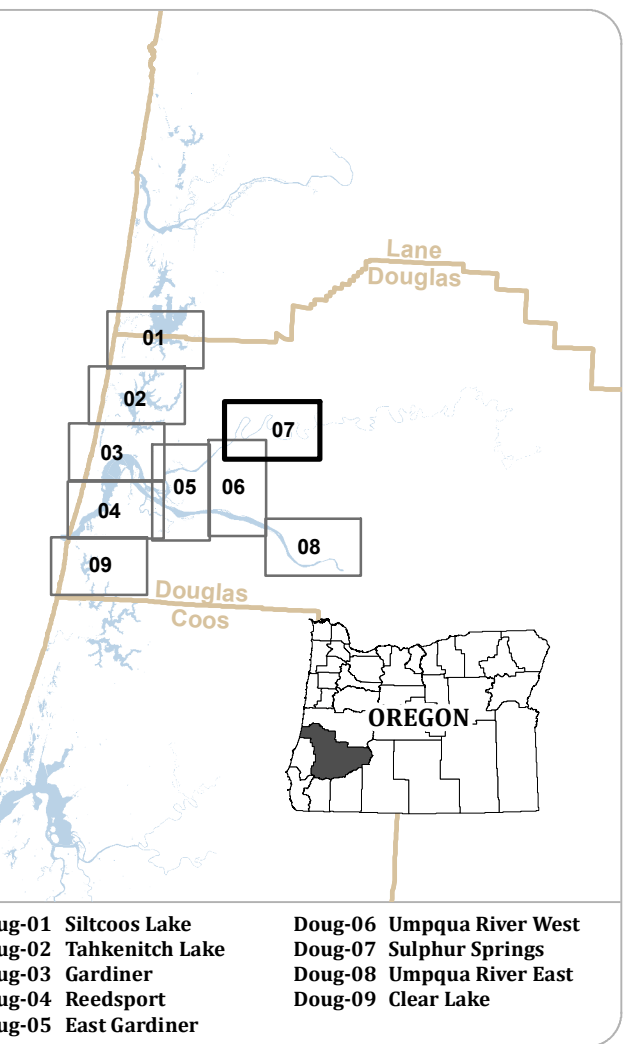
Maximum Wave Elevation Profiles

Legend

Earthquake Size	Average Slip Range (ft)	Maximum Slip Range (ft)	Time to Accumulate Slip (yrs)	Earthquake Magnitude
XXL	59 to 72	118 to 144	1,200	~9.1
XL	56 to 72	115 to 144	1,050 to 1,200	~9.1
L	36 to 49	72 to 98	650 to 800	~9.0
M	23 to 39	46 to 62	425 to 525	~8.9
S	13 to 16	30 to 36	300	~8.7

Urban Growth Boundary	Fire Station
Building Footprint	Police Station
Simulated Gauge Station	School
Profile Location	Hospital/Urgent Care Clinic
Senate Bill 379 Line	U.S. Highway
State Park	State Highway
Elevation Contour (25 ft intervals up to 200 ft)	Improved Road

Tsunami Inundation Map Index



Data References

Source Data:
This map is based on hydrodynamic tsunami modeling by Joseph Zhang, Oregon Health and Science University, Portland, Oregon. Model data inputs were created by John T. English and George R. Priest, Department of Geology and Mineral Industries (DOGAMI), Portland, Oregon.
Hydrologic data, contours, critical facilities, and building footprints were provided by DOGAMI. Senate Bill 379 line data were provided by Rachel L. Smith and Sean C. Pickner, DOGAMI, in 2011 (GIS file not in press, 2012).
Urban growth boundaries (2011) were provided by the Oregon Department of Land Conservation and Development (DLCD).
Transportation data (2012) provided by Douglas County, Oregon, and used by DOGAMI to improve the spatial accuracy of the features or to add newly constructed roads not present in the original data layer.
Lidar data are from DOGAMI Lidar Data Quadangles (2009-43224-Sulphur River Flood Plain, LQ-2009-43123-06-Sulphur River, LQ-2009-43124-05-Sulphur, and LQ-2009-43125-04-Sulphur River).
Coordinate System: Oregon Statewide Lambert Conformal Conic, Unit: International Feet, Horizontal Datum: NAD 1983 BARS, Vertical Datum: NAVD 1983, Graticule shown with geographic coordinates (Latitude/Longitude).
Software: Esri ArcGIS 10.1, Microsoft Excel®, and Adobe Illustrator®.
Editing:
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