EXECUTIVE SUMMARY

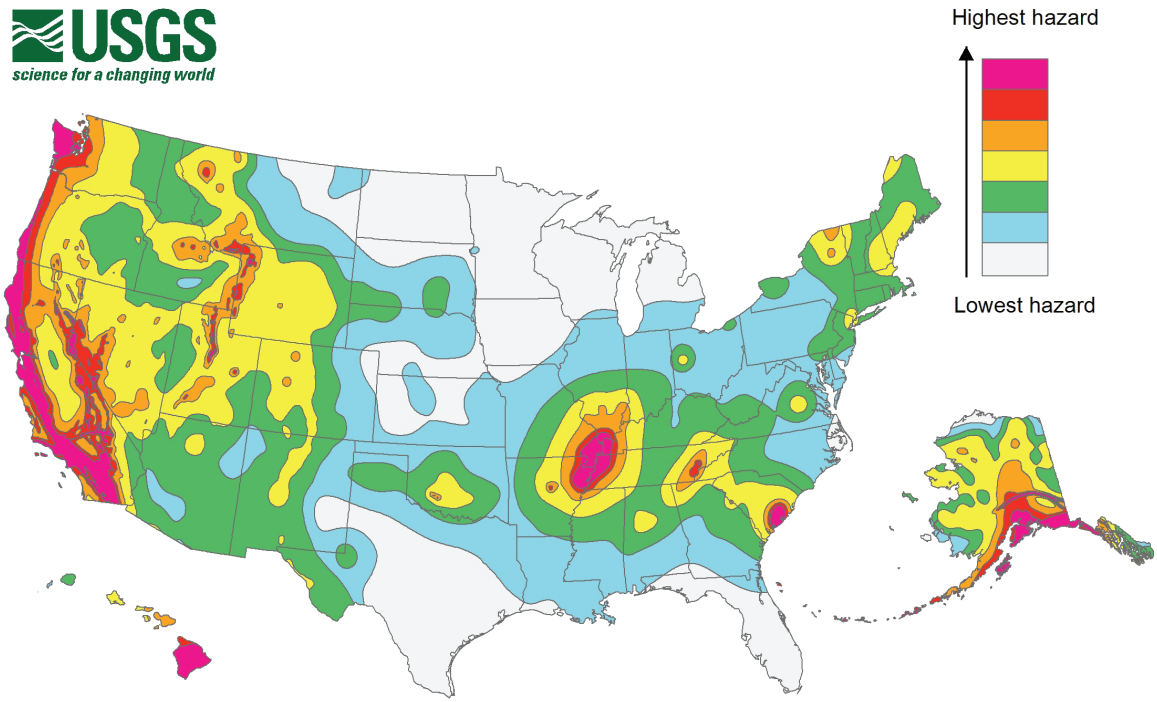
Looking towards the Pacific Ocean from Ocean Shores. Photo Credit: UW Project Team

Why a Manual?: To reduce Washington State's huge tsunami risk.

Washington State has the second-highest earthquake risk in the United States. Western Washington has several active faults that impact communities along its coastlines. The Cascadia Subduction Zone (CSZ), just off the Pacific Ocean coastline, runs from Northern California up to Canada and is capable of generating a magnitude 9 earthquake. Earthquakes are a major source for tsunamis in Washington State. A local CSZ tsunami will leave some coastal communities with as little as 15 to 20 minutes to evacuate and is estimated to cause over 8,000 fatalities. Distant tsunamis, coming from as far away as Alaska and Japan, allow for significantly more warning time.

Coastal communities that lack sufficient natural or artificial high ground are particularly vulnerable. Residents, employees, and visitors will have limited time to evacuate to safety. For at-risk communities, tsunami vertical evacuation structures are a way to save lives. Evacuation structures are designed to withstand an earthquake, aftershocks, liquefaction, and multiple tsunami waves. They can be included as part of a new building or be a standalone tower or berm. Evacuation structures have performed successfully in Japan and have also been built in New Zealand. In 2016, the Ocosta Elementary School was completed with an evacuation area above the gymnasium. This school, located near Westport, Washington, is the first tsunami vertical evacuation structure to be built in North America.

Communities on Washington State's Pacific Ocean coastline have limited resources. Unlike California and Oregon, Washington State's major ports, infrastructure and associated funding resources are concentrated in the Puget Sound and along the Columbia River and not along the Washington coast. Tsunami vertical evacuation structures are complex and relatively new. Building these high-performance structures requires a variety of partners and expertise. Communities also have to administer a robust public engagement process to build support, plan, and determine funding options. Given all these factors, Washington State Emergency Management Division (EMD) felt that it was important to provide coastal communities with a manual that could help them navigate this process and protect their communities.



Earthquake Hazard Map. Image Credit: USGS

Manual Layout

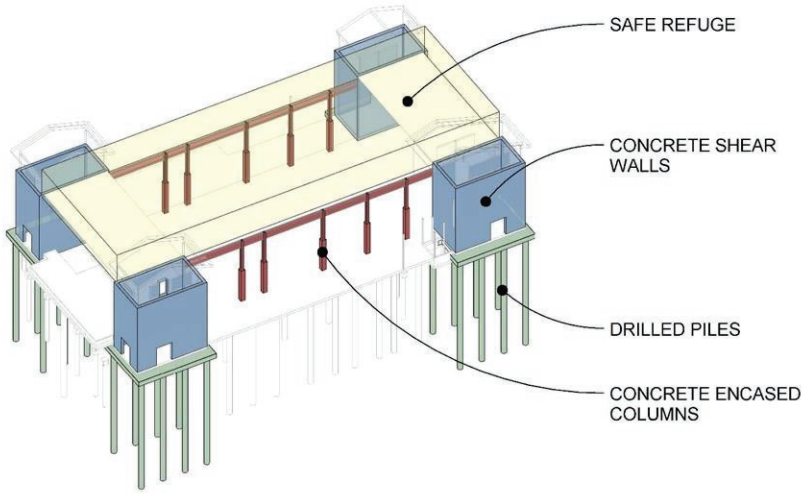
Chapter 1 contains the core of this report and describes the 7 Phase Process. This process lays out the various steps that communities should follow to plan, design and construct tsunami vertical evacuation structures. Some of the phases, like community engagement, continue throughout the entire process. Other phases, such as funding, occur during a specific period in the process. The other chapters and appendices are referenced throughout the 7 Phase Process. They are intended as "deeper dives" to fill in important details and provide background information.

The following are the 7 Phases:

- Phase 1: Involve Emergency Management Partners
- Phase 2: Assess Tsunami Risks and Current Evacuation Options
- Phase 3: Engage the Community
- Phase 4: Identify and Evaluate Potential Sites
- Phase 5: Develop a Funding Plan with Alternatives
- Phase 6: Assemble Project Team, Complete Design, and Confirm Budget
- Phase 7: Construct, Complete, and Operate

Chapters 2 and 3 describe the various roles of those involved in planning, design, and construction of evacuation structures. These projects are complex, clarifying the various roles and responsibilities can help communities to know who is involved and when to involve them in the process. The roles described include community leaders, stakeholder committee members, emergency managers, tsunami modelers, geologists, geotechnical engineers, structural engineers, and architects. Chapter 3 also provides an in-depth explanation of tsunami models and building codes.

Chapter 4 provides various bulleted planning guides. One guide is a distilled version of the 7 Phase Process while other guides describe consideration about structure type and design. Also included, is an explanation of the original *Project Safe Haven* planning process that was used to identify potential evacuation structure sites for several coastal communities. In addition, there is a guide for how to respond to and prepare for a tsunami. Communities can make use of these guides during various parts of the process.



Ocosta Elementary School auditorium with roof top tsunami refuge structural design. Rendering Credit: Degenkolb Engineers

Chapter 5 describes a variety of funding, regulatory and planning options. Although grants are one source of funding, the ones available are competitive and do not cover all the project costs. Local funds will be needed and can be raised through a variety of funding mechanisms. In addition, planning can help to prioritize, incentivize and mandate evacuation structures. Other approaches that support coastal community resilience are also described in this chapter.

Chapter 6 outlines five recommendations that can assist coastal communities in building tsunami vertical evacuation structures. The first three recommendations are broader in scope and involve advocacy and overall planning efforts. The last two recommendations are aimed at helping to reduce project costs and provide needed project management support. The recommendations are as follows:

- R1: Develop a Coastal Alliance Network
- R2: Integrate Tsunami and Seismic Risk into all Planning Efforts
- R3: Support Tsunami Risk Reduction and Continuity Planning
- R4: Develop Approaches that Reduce Project Costs
- R5: Provide Vertical Evacuation Structure Project Management Assistance

Lastly, this report provides five appendices with important background information. Appendices A, B, and C document interviews and public meetings that are the research foundation for this manual. Appendix A outlines the interviewing process, who participated in it and a selection of findings from the interviews. Appendix B includes agendas and survey findings from the public meetings conducted in the cities of Ocean

Shores and Aberdeen. Tsunami experts made presentations and the audience asked questions. Audience members also filled out survey cards. Appendix C was prepared by a research team from New Zealand that conducted a series of interviews with Washington State coastal residents. Appendix D provides a host of valuable resources for communities including key contact information, reports and articles. Appendix E is a glossary.

Tsunami Evacuation Route sign. Photo Credit: EMD

A Continuum of Efforts

Many individuals and organizations have contributed to helping make coastal communities more resilient to tsunamis. These efforts go back decades and include the growing research in mapping of earthquake faults and the modeling of seismic and tsunami hazards. The National Tsunami Hazard Mitigation Program (NTHMP) provided funding for this report and other efforts to support community preparedness. The Federal Emergency Management Agency (FEMA) awards grants for tsunami structures and publishes reports, like FEMA 646, that provide guidance on vertical evacuation structures. The National Oceanic Atmospheric Administration (NOAA) and the University of Washington (UW) develop tsunami models, and the United States Geological Survey (USGS) generates research on tsunami evacuation models. The Washington State Emergency Management Division (EMD) works closely with coastal communities to support preparedness, response, recovery and mitigation efforts, including the construction of tsunami vertical evacuation structures. The Department of Natural Resources (DNR) provides tsunami inundation maps and assists with pedestrian evacuation mapping. *Project Safe Haven*, the first effort to help communities plan for evacuation structures, was an effort of various organizations already listed and the UW Institute of Hazards Mitigation and Planning. County and local emergency managers, local leaders, engineers, designers, planners, residents and others have all made critical contributions.

Washington State places a priority on community resilience. The Resilient Washington Subcabinet Project Team and EMD produced the *2017 Resilient Washington Subcabinet Report: Findings and Recommendations* that states as Recommendation #9: "Improve life safety in communities at risk for local tsunamis." This manual fits into the continuum of these many and diverse efforts.