State of Oregon
Oregon Department of Geology and Mineral Industries
Brad Avy, State Geologist

OPEN-FILE REPORT O-20-11

NATURAL HAZARD RISK REPORT FOR LINCOLN COUNTY, OREGON

INCLUDING THE CITIES OF LINCOLN CITY, DEPOE BAY, SILETZ, NEWPORT, TOLEDO, WALDPORT, AND YACHATS, AND THE CONFEDERATED TRIBES OF SILETZ INDIANS, AND THE UNINCORPORATED COMMUNITIES OF OTIS-ROSE LODGE, SALISHAN-LINCOLN BEACH, OTTER ROCK, SEAL ROCK-BAYSHORE, AND WAKONDA BEACH

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Cover photo: Indication of coastal erosion in Lincoln City, Oregon.

WHAT’S IN THIS REPORT?

This report describes the methods and results of a natural hazard risk assessment for Lincoln County communities. The risk assessment can help communities better plan for disaster.

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GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

See the digital publication folder for files.
Geodatabase is Esri® version 10.2 format. Metadata is embedded in the geodatabase and is also provided as separate .xml format files.

Lincoln_County_Risk_Report_Data.gdb

Feature dataset: Asset_Data
feature classes:
Building_footprints (polygons)
Communities (polygons)
UDF_points (points)

Raster data: Hazard_Data
FL_Depth_10yr
FL_Depth_50yr
FL_Depth_100yr
FL_Depth_500yr

Metadata in .xml file format:
Each dataset listed above has an associated, standalone .xml file containing metadata in the Federal Geographic Data Committee Content Standard for Digital Geospatial Metadata format

EXECUTIVE SUMMARY

This report was prepared for the communities of Lincoln County, Oregon, with funding provided by the Federal Emergency Management Agency (FEMA). It describes the methods and results of the natural hazard risk assessment performed in 2016-2018 by the Oregon Department of Geology and Mineral Industries (DOGAMI) within the study area. The purpose of this project is to provide communities within the study area a detailed risk assessment of the natural hazards that affect them to enable them to compare hazards and act to reduce their risk. The risk assessment contained in this project quantifies the impacts of natural hazards to these communities and enhances the decision-making process in planning for disaster.

We arrived at our findings and conclusions by completing three main tasks: compiling an asset database, identifying and using best available hazard data, and performing natural hazard risk assessment.

In the first task, we created a comprehensive asset database for the entire study area by synthesizing assessor data, U.S. Census information, Hazus-MH general building stock information, and building footprint data. This work resulted in a single dataset of building points and their associated building characteristics. With these data we were able to represent accurate spatial location and vulnerability on a building-by-building basis.

The second task was to identify and use the most current and appropriate hazard datasets for the study area. Most of the hazard datasets used in this report were created by DOGAMI; some were produced using high-resolution lidar topographic data. While not all the data sources used in the report are countywide, each hazard dataset was the best available at the time of writing.

In the third task, we performed the risk assessment using Esri® ArcGIS Desktop® software. We took two risk assessment approaches: (1) estimated loss (in dollars) to buildings from flood (recurrence intervals) and earthquake scenarios using FEMA Hazus®-MH methodology, and (2) calculated number of buildings, their value, and associated populations exposed to earthquake, flood, and tsunami inundation scenarios, or susceptible to varying levels of hazard from landslides, coastal erosion, and wildfire.

The findings and conclusions of this report show the potential impacts of hazards in communities within Lincoln County. A Cascadia Subduction Zone (CSZ) event (earthquake and tsunami) will cause extensive damage and losses throughout the county. Hazus-MH earthquake simulations illustrate the potential reduction in earthquake damage through seismic retrofits. Flooding is a threat for many communities in the study area, and we quantify the number of elevated structures that are less vulnerable to flood hazard. Our analysis shows that new landslide mapping based on improved methods and lidar information will increase the accuracy of future risk assessments. The risk from coastal erosion is high for many buildings along the open coast of Lincoln County. During the time of writing, the best available data show that wildfire risk is moderate for the overall study area. Our findings also indicate that most of the critical facilities in the study area are at high risk from a CSZ event (earthquake and tsunami). We also found that the two biggest causes of population displacement are a CSZ event (earthquake and tsunami) and landslide hazard. Lastly, we demonstrate that this risk assessment can be a valuable tool to local decision-makers.

Results were broken out for the following geographic areas:

- Unincorporated Lincoln County (rural)
- Community of Otter Rock
- Community of Seal Rock-Bayshore
- Confederated Tribes of Siletz Indians
- City of Lincoln City
- City of Siletz
- City of Waldport
- Community of Otis-Rose Lodge
- Community of Salishan-Lincoln Beach
- Community of Wakonda Beach
- City of Depoe Bay
- City of Newport
- City of Toledo
- City of Yachats

Selected Countywide Results

Total buildings: 42,052

Total estimated building value: $5.1 billion

Cascadia Subduction Zone (CSZ) Magnitude 9.0 Earthquake[a]

Red-tagged buildings[b]: 9,712

Yellow-tagged buildings[c]: 3,562

Loss estimate: $1.2 billion

Cascadia Subduction Zone Tsunami Inundation

Number of buildings exposed: 4,110

Exposed building value: $812 million

100-year Flood Scenario

Number of buildings damaged: 2,377

Loss estimate: $52 million

Landslide Exposure (High and Very High Susceptibility)

Number of buildings exposed: 12,894

Exposed building value: $1.4 billion

Coastal Erosion Exposure (Moderate Hazard)

Number of buildings exposed: 876

Exposed building value: $238 million

Wildfire Exposure (High Hazard)

Number of buildings exposed: 1,475

Exposed building value: $130 million

[a]Results reflect damages caused by earthquake to buildings outside of the tsunami zone. Earthquake and tsunami results combined estimate the total damages from a CSZ M9.0 event.

[b]Red-tagged buildings are considered to be uninhabitable due to complete damage.

[c]Yellow-tagged buildings are considered to be of limited habitability due to extensive damage.

1.0 INTRODUCTION

A natural hazard risk assessment analyzes how a hazard could affect the built environment, population, and local economy and identifies potential risk. In natural hazard mitigation planning, risk assessments are the basis for developing mitigation strategies and actions. A risk assessment enhances the decision-making process, so that steps can be taken to prepare for a potential hazard event.

This is the first natural hazard risk assessment analyzing individual buildings and resident population in Lincoln County. It is therefore the most detailed and comprehensive analysis to date of natural hazard risk and provides a comparative perspective never before available. In this report, we describe our assessment results, which quantify the various levels of risk that each hazard presents to Lincoln County communities.

The Oregon coast and Oregon Coast Range mountains are subject to several significant natural hazards, including riverine and coastal flooding, earthquake, tsunami, landslides, coastal erosion, and wildfire. This region of the state is moderately developed, mostly in the cities and unincorporated communities. Natural hazards that pose a potential threat to development results in risk. The primary goal of the risk assessment is to inform communities of their vulnerability and risk to natural hazards and to be a resource for risk reduction actions.

1.1 Purpose

The purpose of this project is to help communities in the study area better understand their risk and increase resilience to natural hazards that are present in their communities. This is accomplished by providing accurate, detailed, and best available information about these hazards and by measuring the number of people and buildings at risk.

The main objectives of this study are to:

- compile and/or create a database of critical facilities, tax assessor data, buildings, and population distribution data,
- incorporate and use existing data from previous geologic, hydrologic, and wildfire hazard studies,
- perform exposure and Hazus–based risk analysis, and
- share this report widely so that all interested parties have access to its information and data.

The body of this report describes the methods and results for these objectives. Two primary methods (Hazus-MH or exposure), depending on the type of hazard, were used to assess risk. We describe the methods for creating the building and population information used in this project. Results for each hazard type are reported on a countywide basis within each hazard section, and community based results are reported in detail in **Appendix A: Community Risk Profiles**. **Appendix B** contains detailed risk assessment tables. **Appendix C** is a more detailed explanation of the Hazus-MH methodology. **Appendix D** lists acronyms and definitions of terms used in this report. **Appendix E** contains tabloid-size maps showing county-wide hazard maps.

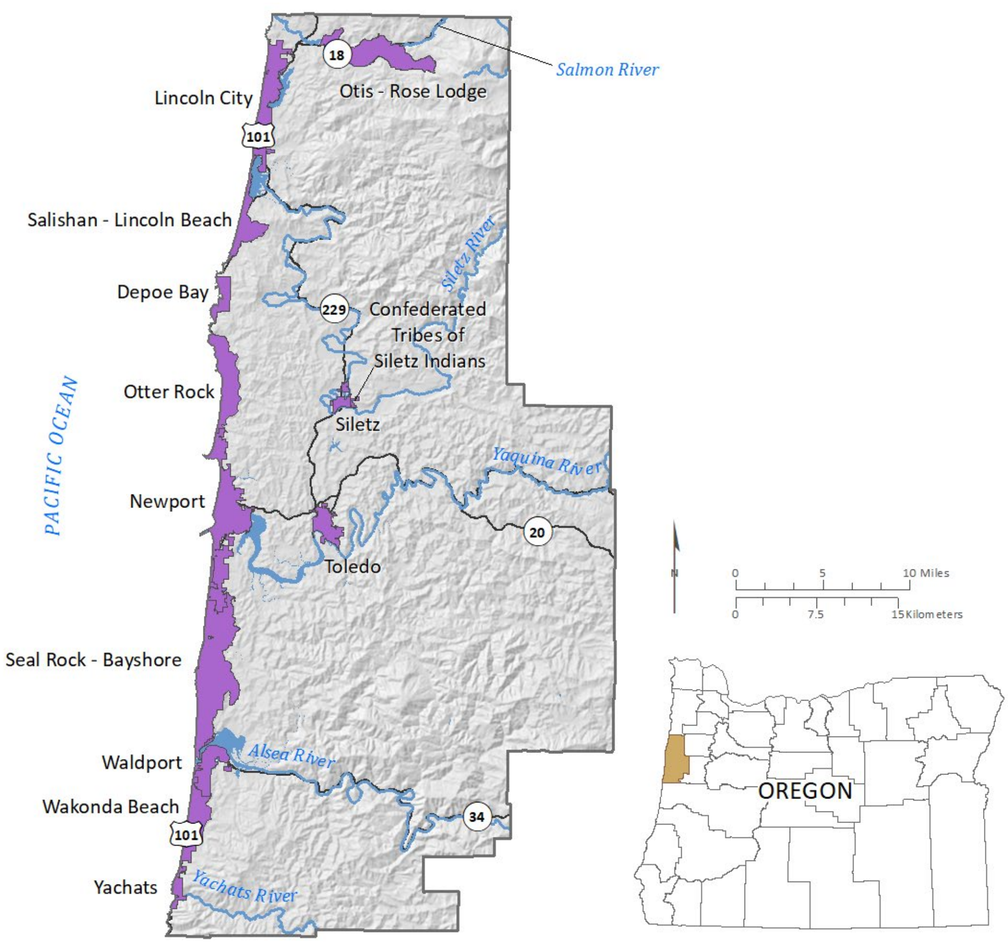
1.2 Study Area

The study area for this project is the entirety of Lincoln County, Oregon. Lincoln County is a coastal county located in the central coast part of the state and is bordered by Tillamook County on the north, Benton and Polk Counties on the east, Lane County on the south, and the Pacific Ocean on the west. The total area of Lincoln County is 993 square miles (2,572 square kilometers). A significant portion of the county is within the Siuslaw National Forest or is managed as industrial forest land.

The geography consists of rocky and irregular coastline and dune-backed beaches that form the county's western boundary, stretches of coastal lowlands, a coastal upland composed of headlands and low mountains, and a densely forested region with steep slopes that are prone to landslides.

The population of Lincoln County is 46,034 according to the 2010 U.S. Census Bureau (2010a). The county seat and county's largest community is the City of Newport. Most of the communities in the study, incorporated and unincorporated, are in the western portion of the county within a few miles of the Pacific Ocean. The incorporated communities are Depoe Bay, Lincoln City, Newport, Siletz, Toledo, Waldport, and Yachats (**Figure 1-1**). The unincorporated communities are Otis and Rose Lodge, Otter Rock, Salishan and Lincoln Beach, Seal Rock-Bayshore, and Wakonda Beach.

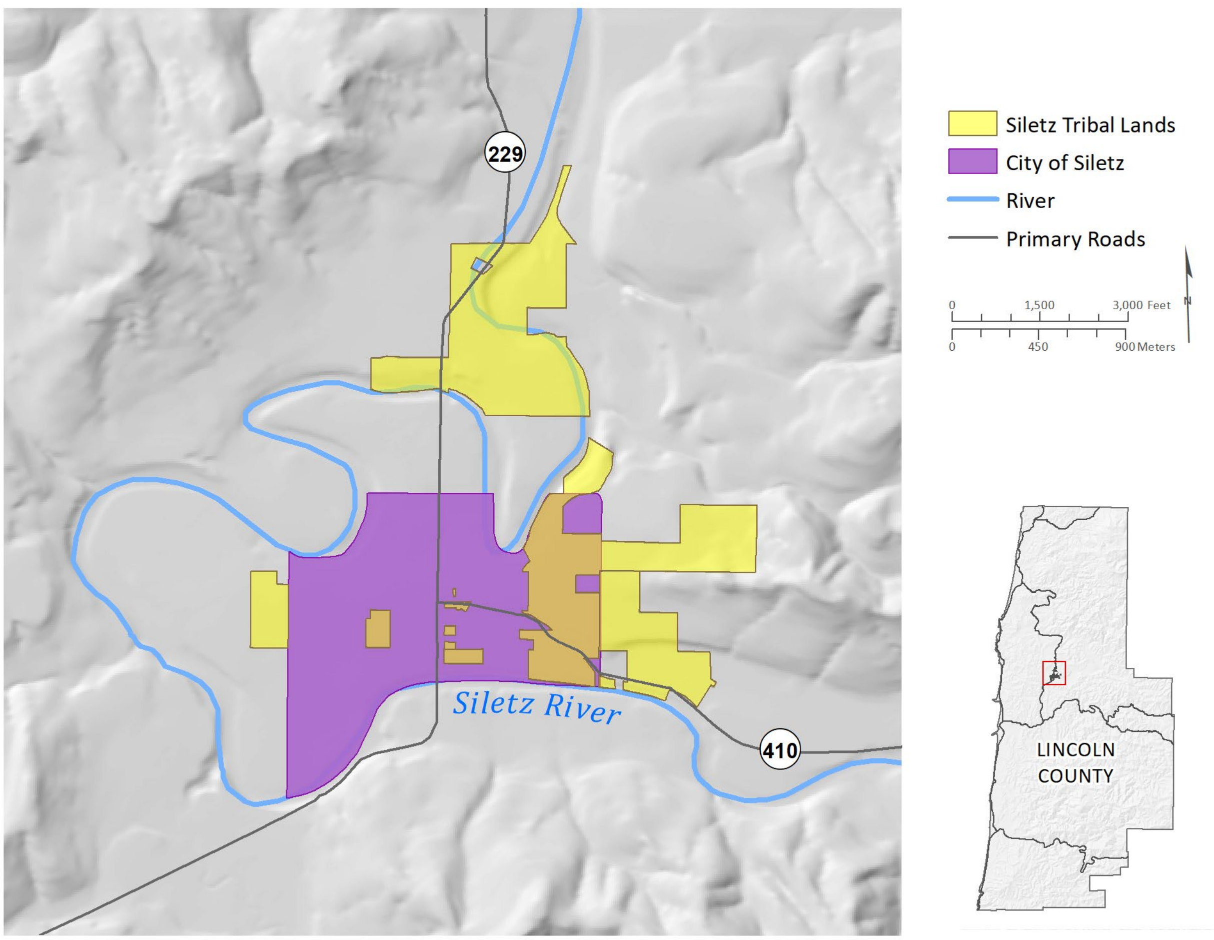
Figure 1-1. Study area: Lincoln County with communities in this study identified.



The Confederated Tribes of Siletz Indians ("Siletz Tribe") is a federally recognized tribe and community within the study area. The areas that comprise the tribal lands of the Siletz Tribe used in the analyses are made up of several non-contiguous areas within Lincoln County. The City of Siletz has tribal lands adjacent to and within it (**Figure 1-1)**. It is for this reason that areas within the City of Siletz that are Siletz tribal lands are included in total counts for buildings and population for the Siletz Tribe. No buildings or permanent residents are double counted in any of the individual hazard analyses. Results and analyses for the Siletz Tribe are for all areas considered tribal lands, including those within the incorporated boundary of the City of Siletz.

We selected the unincorporated communities based on population size and density, which makes them distinct from the rural unincorporated county jurisdiction. We based the boundaries of these unincorporated communities primarily on the 2010 census block areas.

Figure 1-2. City of Siletz and Siletz tribal lands overlapping boundaries.



1.3 Project Scope

For this risk assessment, we applied a quantitative approach to buildings and population. The decision to limit the project scope to buildings and population was driven by data availability, strengths and limitations of the risk assessment methodology, and funding availability. We did not analyze impacts to the local economy, land values, or the environment. Depending on the natural hazard, we used one of two methodologies: loss estimation or exposure. Loss estimation was modeled using methodology from Hazus®-MH (Hazards U.S., Multi-Hazard), a tool developed by FEMA for calculating damage to buildings from flood and earthquake. Exposure is a simpler methodology, where buildings are categorized based on their location relative to various hazard zones. To account for impacts on population (permanent residents only), 2010 U.S. Census data (U.S. Census Bureau, 2010a) were associated with residential buildings.

A critical component of this risk assessment is a countywide building inventory developed from building footprint data and the Lincoln County tax assessor database. The other key component is a suite of datasets that represent the currently best available science for a variety of natural hazards. The geologic hazard scenarios were selected by DOGAMI staff based on their expert knowledge of the datasets; most datasets are DOGAMI publications. In addition to geologic hazards, we included wildfire hazard in this risk assessment. The following is a list of the natural hazards and the risk assessment methodologies that were applied. See **Table 1-1** for data sources.

Cascadia Subduction Zone (CSZ) Earthquake and Tsunami Risk Assessment

- Hazus-MH loss estimation from a CSZ earthquake magnitude (M) 9.0 event (includes liquefaction and coseismic landslides)
- Exposure to five potential CSZ tsunami scenarios

Flood Risk Assessment

- Hazus-MH loss estimation to four riverine recurrence intervals (10%, 2%, 1%, 0.2% annual chance) and one coastal recurrence interval (1%)
- Exposure to 1% annual chance recurrence interval

Landslide Risk Assessment

- Exposure based on landslide susceptibility (low to very high)

Coastal Erosion Risk Assessment

- Exposure based on coastal erosion zones (none to high)

Wildfire Risk Assessment

- Exposure based on fire risk index (low to high)

Table 1-1. Hazard data sources for Lincoln County.

Hazard	Scenario or Classes	Scale/Level of Detail	Data Source
Earthquake (includes liquefaction and coseismic landslides)	CSZ M9.0	statewide	DOGAMI (Madin and Burns, 2013)
Tsunami	Local Source: Small (300 yr) Medium (425-525 yr) Large (650-800 yr) Extra Large (1,050-1,200 yr) Extra Extra Large (1,200 yr)	Oregon coast	DOGAMI (Priest and others, 2013)
Flood	Depth Grids: 10% (10-yr) 2% (50-yr) 1% (100-yr) 0.2% (500-yr)	Countywide	DOGAMI – derived from FEMA (2019) data, included in GIS data for this report
Landslide*	Susceptibility (Low, Moderate, High, Very High)	statewide	DOGAMI (Burns and others, 2016)
Coastal Erosion	Susceptibility (Not Exposed, Low, Moderate, High)	portions of the coast within Lincoln County	DOGAMI (Priest and Allan, 2004; Witter and others, 2007)
Wildfire	Risk (Low, Moderate, High)	regional (Western United States)	ODF (Sanborn Map Company, Inc., 2013)

CSZ M9.0 is Cascadia subduction zone magnitude 9 earthquake.

*Landslide data comprise a composite dataset where the level of detail varies greatly from place to place within the state. Refer to Section 3.4.1 or the report by Burns and others (2016) for more information.

1.4 Previous Studies

One previous risk assessment including Lincoln County has been conducted by DOGAMI. Wang and Clark (1999: DOGAMI Special Paper 29) ran two general level Hazus-MH earthquake analyses, a magnitude 8.5 CSZ earthquake and a 500-year probabilistic earthquake scenario, for the entire state of Oregon. In those analyses Lincoln County had a very high loss ratio relative to most counties in the state.

We did not compare the results of this project with the results of the previous study because of limited time and funding and differences in methodologies.

2.0 METHODS

2.1 Hazus-MH Loss Estimation

> ***Key Terms:***
> - *Loss estimation:* Damage that occurs to a building in an earthquake or flood scenario, as modeled with Hazus-MH methodology.
> - *Loss ratio:* Percentage of estimated loss relative to the total value.

"Hazus provides nationally applicable, standardized methodologies for estimating potential wind, flood, and earthquake losses on a regional basis. Hazus can be used to conduct loss estimation for floods and earthquakes […]. The multi-hazard Hazus is intended for use by local, state, and regional officials and consultants to assist mitigation planning and emergency response and recovery preparedness. For some hazards, Hazus can also be used to prepare real-time estimates of damages during or following a disaster" (FEMA, 2012a, p. 1-1).

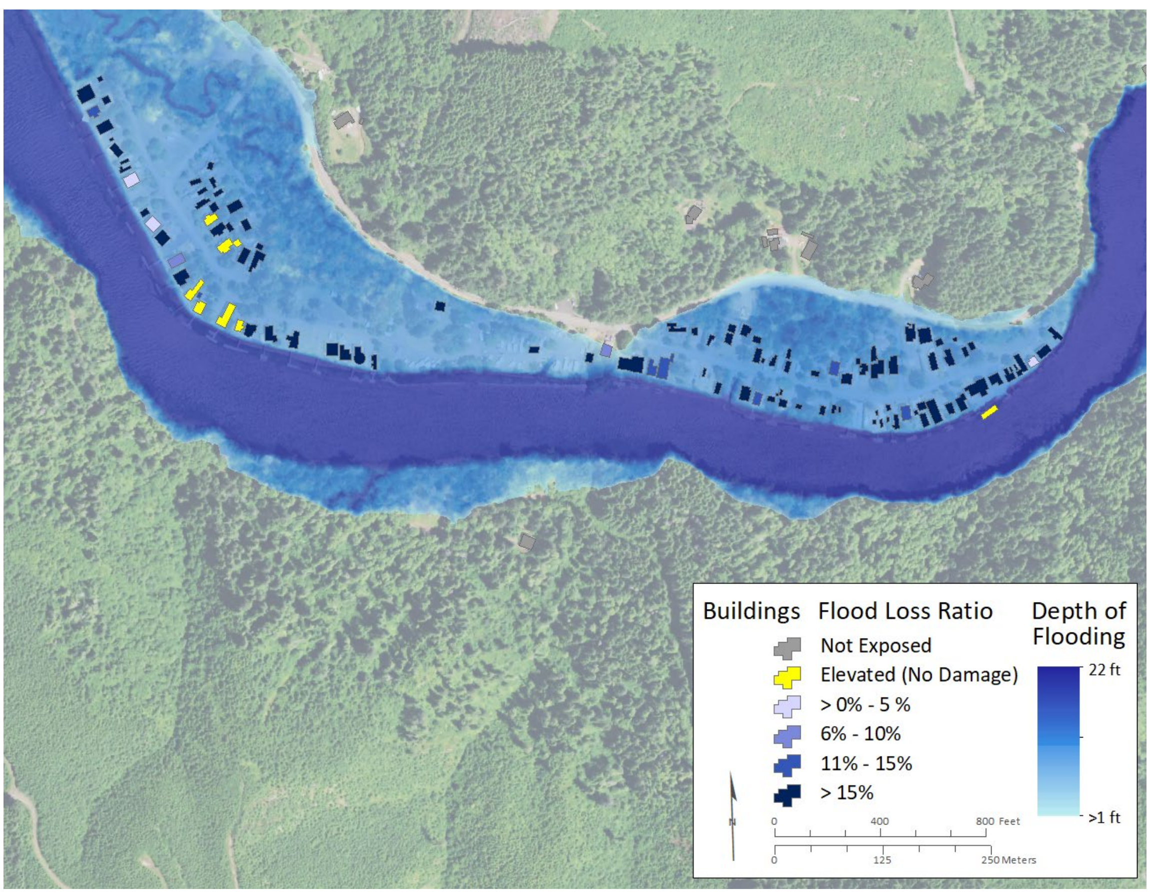
Hazus-MH can be used in different modes depending on the level of detail required. Given the high spatial precision of the building inventory data and quality of the natural hazard data, DOGAMI chose the user-defined facility (UDF) mode. This mode makes loss estimations for individual buildings relative to their "cost," which DOGAMI then aggregates to the community level to report loss ratios. Cost used in general building stock mode is associated with rebuilding using new materials, also known as replacement cost. Within the UDF mode, DOGAMI derived cost from the assessed value rather than replacement cost due to the accessibility and completeness of Lincoln County's assessor data.

The drawback of using the assessed value of buildings is that building values fluctuate based on the housing market from year to year, which is a different amount than how much it would cost to rebuild or repair buildings. Loss estimations based on replacement cost are closer to the cost of recovery from a flood or earthquake. For Hazus-MH analysis using cost derived from assessed value, the loss estimation provides a better picture on the impact to the county's tax revenue.

Damage functions are at the core of Hazus-MH. The damage functions stored within the Hazus-MH data model were developed and calibrated from the observed results of past disasters. Estimates of loss are made by intersecting building locations with natural hazard layers and applying damage functions based on the hazard severity and building characteristics. **Figure 2-1** illustrates the range of building loss estimates from Hazus-MH flood analysis.

DOGAMI used Hazus-MH version 3.0 (FEMA, 2015), which was the latest version available when we began this risk assessment.

Figure 2-1. 100-year flood zone and building loss estimates example in unincorporated Lincoln County (rural).



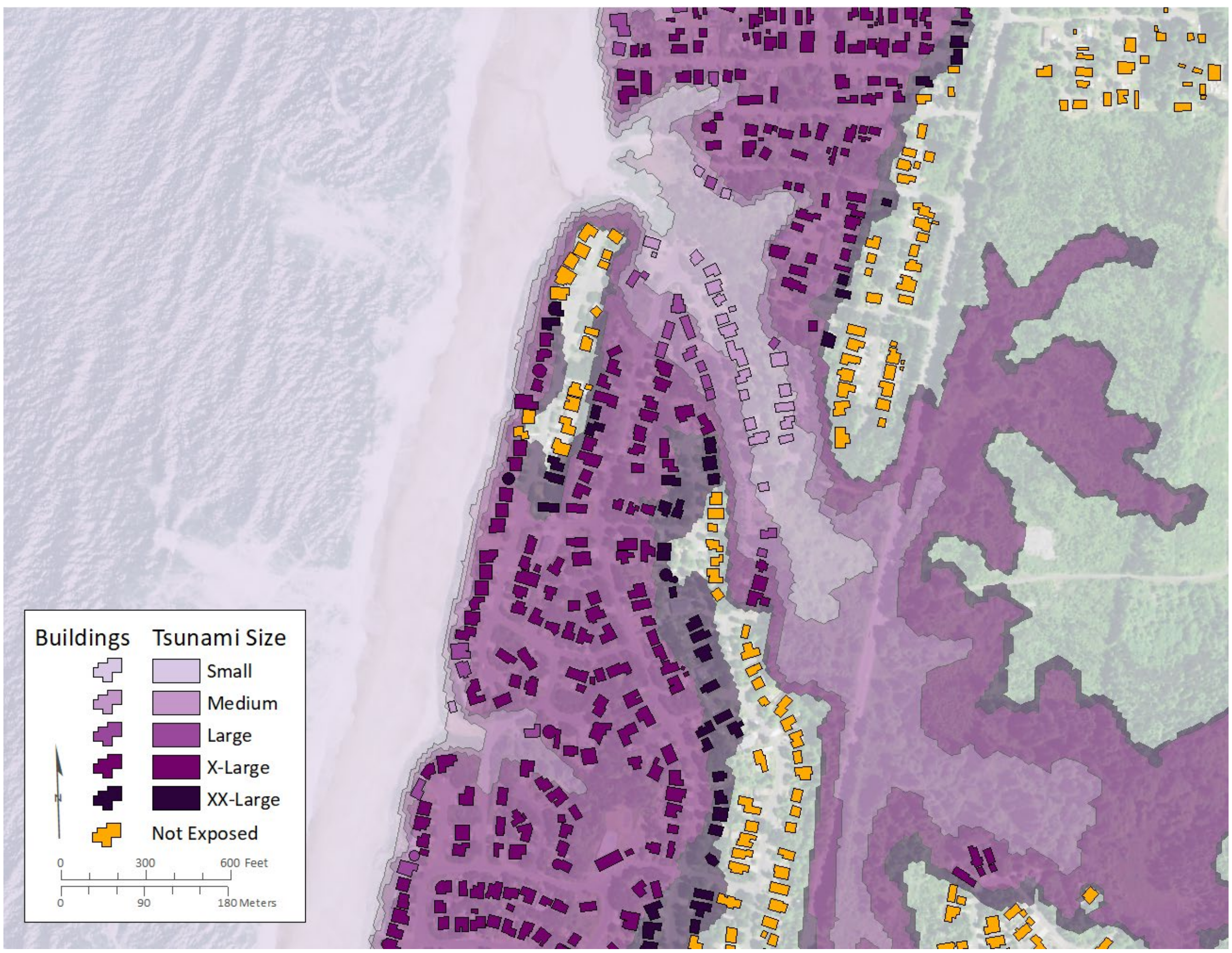
2.2 Exposure

> ***Key Terms:***
> - *Exposure:* Determination of whether a building is within or outside of a hazard zone. No loss estimation is modeled.
> - *Building value:* Total monetary value of a building. This term is used in the context of exposure.

Exposure methodology is calculating the buildings and population that are within a natural hazard zone. This is an alternative for natural hazards that do not have readily available damage functions and, therefore, loss estimation is not possible. It provides a way to easily quantify what is and what is not threatened. Exposure results are communicated in terms of total building value exposed, rather than a loss estimate because without a damage function a loss ratio cannot be calculated. For example, **Figure 2-2** shows buildings that are exposed to different tsunami scenarios.

Exposure is used for tsunami, landslide, coastal erosion, and wildfire to quantify buildings and residents at risk. For comparison with loss estimates, exposure is also used for the 1% annual chance flood.

Figure 2-2. Tsunami inundation scenarios and building exposure example in the community of Salishan-Lincoln Beach. Note that larger scenarios include the buildings of the smaller scenarios.



2.3 Building Inventory

A key piece of the risk assessment is the countywide building inventory. This inventory consists of all buildings larger than 500 square feet (152 square meters), as determined from existing building footprints or tax assessor data. **Figure 2-3** shows an example of building inventory occupancy types used in the Hazus-MH and exposure analyses in Lincoln County. See also Appendix B, **Detailed Risk Assessment Tables** and Appendix E, **Plate 1** and **Plate 2.**

To use the building inventory within the Hazus-MH methodology, we converted the building footprints to points and migrated them into a UDF database with standardized field names and attribute domains. The UDF database formatting allows for the correct damage function to be applied to each building. Hazus-MH version 2.1 technical manuals (FEMA, 2012b,c) provide references for acceptable field names, field types, and attributes. The fields and attributes used in the UDF database (including building seismic codes) are discussed in more detail in Appendix **C.2.2**.

Figure 2-3. Building occupancy types, portion of City of Lincoln City.

Table 2-1 shows the distribution of building count and value within the UDF database for Lincoln County. A table detailing the occupancy class distribution by community is included in **Appendix B: Detailed Risk Assessment Tables**.

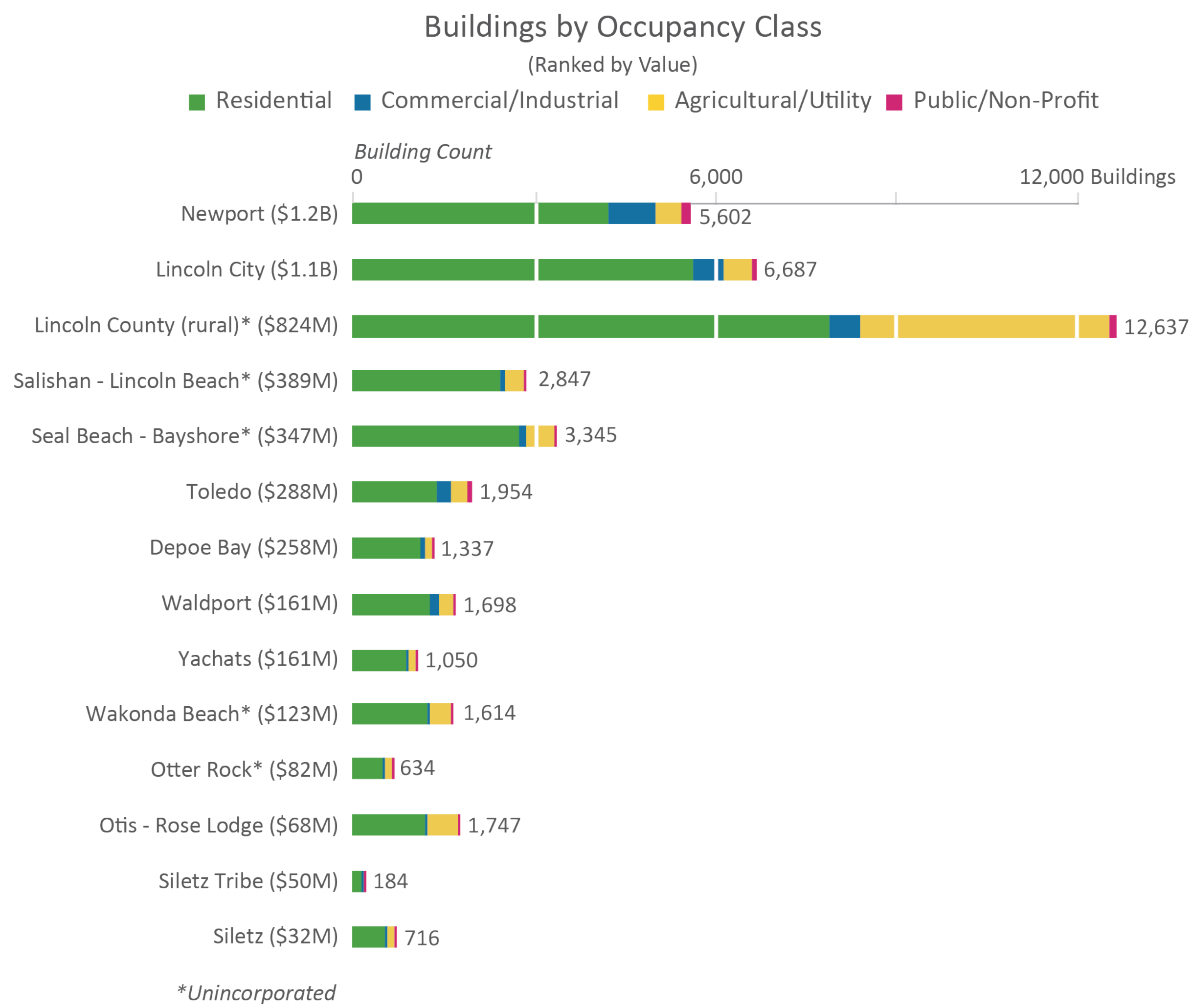
Table 2-1. Lincoln County building inventory.

Community	Total Number of Buildings	Percentage of Buildings of Lincoln County	Total Estimated Building Value ($)	Percentage of Building Value of Lincoln County
Unincorporated County (rural)	12,637	30%	824,038,000	16%
Otis - Rose Lodge	1,747	4.2%	67,662,000	1.3%
Otter Rock	634	1.5%	81,971,000	1.6%
Salishan - Lincoln Beach	2,847	6.8%	388,784,000	7.6%
Seal Rock - Bayshore	3,345	8.0%	347,085,000	6.8%
Wakonda Beach	1,614	3.8%	122,717,000	2.4%
Total Unincorporated County	22,824	54%	1,832,257,000	36%
Depoe Bay	1,337	3.2%	257,610,000	5.0%
Lincoln City	6,687	16%	1,086,802,000	21%
Newport	5,602	13%	1,243,095,000	24%
Siletz	716	1.7%	31,647,000	1%
Siletz Tribe	184	0%	49,797,000	1%
Toledo	1,954	5%	288,238,000	6%
Waldport	1,698	4%	161,309,000	3%
Yachats	1,050	2%	160,911,000	3%
Total Lincoln County	42,052	100%	5,111,666,000	100%

The building inventory was developed from several data sources and was refined for use in loss estimation and exposure analyses. A database of building footprints for a significant portion of Lincoln County was already available from a previous DOGAMI project (Priest and others, 2013). Building footprints in the database were digitized from high-resolution lidar collected in 2009 (North Coast project, Oregon Lidar Consortium; see http://www.oregongeology.org/lidar/collectinglidar.htm). The building footprints provide a spatial location and 2D representation of a structure. The total number of buildings within the study area was 42,052.

Lincoln County supplied assessor data that we formatted for use in the risk assessment. The assessor data contain an array of information about each improvement (i.e., building). Taxlot data, which contain property boundaries and other information regarding the property, were obtained from the county assessor and were used to link the buildings with assessor data. The linkage between the two datasets resulted in a database of UDF points that contain attributes for each building. These points are used in the risk assessment for both loss estimation and exposure analysis. **Figure 2-4** illustrates the building value and occupancy class across the communities of Lincoln County.

Figure 2-4. Community building value in Lincoln County by occupancy class.



Note that "Lincoln County (rural)" excludes incorporated communities, tribal lands, Otis-Rose Lodge, Otter Rock, Salishan-Lincoln Beach, Seal Rock-Bayshore, and Wakonda Beach.

We attributed critical facilities in the UDF database so they could be highlighted in the results. Critical facilities data came from the DOGAMI Statewide Seismic Needs Assessment (SSNA; Lewis, 2007). We updated the SSNA data by reviewing Google Maps™ data. The critical facilities we attributed include hospitals, schools, fire stations, police stations, emergency operations, and military facilities. In addition to these occupancy types, we considered other types based on local input or special considerations that are specific to the study area that would be essential during a natural hazard event, such as public works and water treatment facilities. Critical facilities are important to note because they play a crucial role in emergency response efforts. Communities with critical facilities that can function during and immediately after a natural disaster are more resilient than those with critical facilities inoperable after a disaster. **Table 2-2** shows the critical facilities on a community basis. Critical facilities are listed for each community (see **Appendix A: Community Risk Profiles**).

Table 2-2. Lincoln County critical facilities inventory.

	Hospital & Clinic		School		Police/Fire		Emergency Services		Military		Other*		Total	
Community	Count	Value ($)	Count	Value ($)	Count	Value ($)	Count	Value ($)	Count	Value ($)	Count	Value ($)	Count	Value ($)
(all dollar amounts in thousands)														
Unincorp. County (rural)	0	0	2	15,793	7	743	0	0	0	0	3	1,474	12	18,010
Otis - Rose Lodge	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Otter Rock	0	0	0	0	1	108	0	0	0	0	1	25	2	133
Salishan - Lincoln Beach	0	0	0	0	1	456	0	0	0	0	0	0	1	456
Seal Rock - Bayshore	0	0	0	0	1	213	0	0	0	0	1	1,035	2	1,248
Wakonda Beach	0	0	0	0	1	17	0	0	0	0	1	165	2	182
Total Unincorp. County	0	0	2	15,793	11	1,537	0	0	0	0	6	2,700	19	20,029
Depoe Bay	1	252	0	0	1	720	0	0	1	319	1	295	4	1,585
Lincoln City	3	19,444	3	13,854	4	4,482	0	0	0	0	1	2,284	11	40,063
Newport	1	3,534	4	29,705	4	3,547	1	791	1	751	5	23,972	16	62,300
Siletz	0	0	1	2,513	1	240	0	0	0	0	0	0	2	2,753
Siletz Tribe[1]	2	5,979	0	0	0	0	0	0	0	0	6	2,744	8	8,723
Toledo	1	378	2	9,968	2	2,185	0	0	1	294	1	396	7	13,221
Waldport	0	0	2	16,055	1	594	0	0	0	0	1	283	4	16,932
Yachats	0	0	0	0	1	241	0	0	0	0	0	0	1	241
Total Lincoln County	8	29,587	14	87,888	25	13,546	2	3,075	3	1,364	20	30,389	72	165,847

Note: Facilities with multiple buildings were consolidated into one building.

* Category includes buildings that are not traditional (emergency response) critical facilities but considered critical during an emergency based on input from local stakeholders (e.g., water treatment facilities or airports).

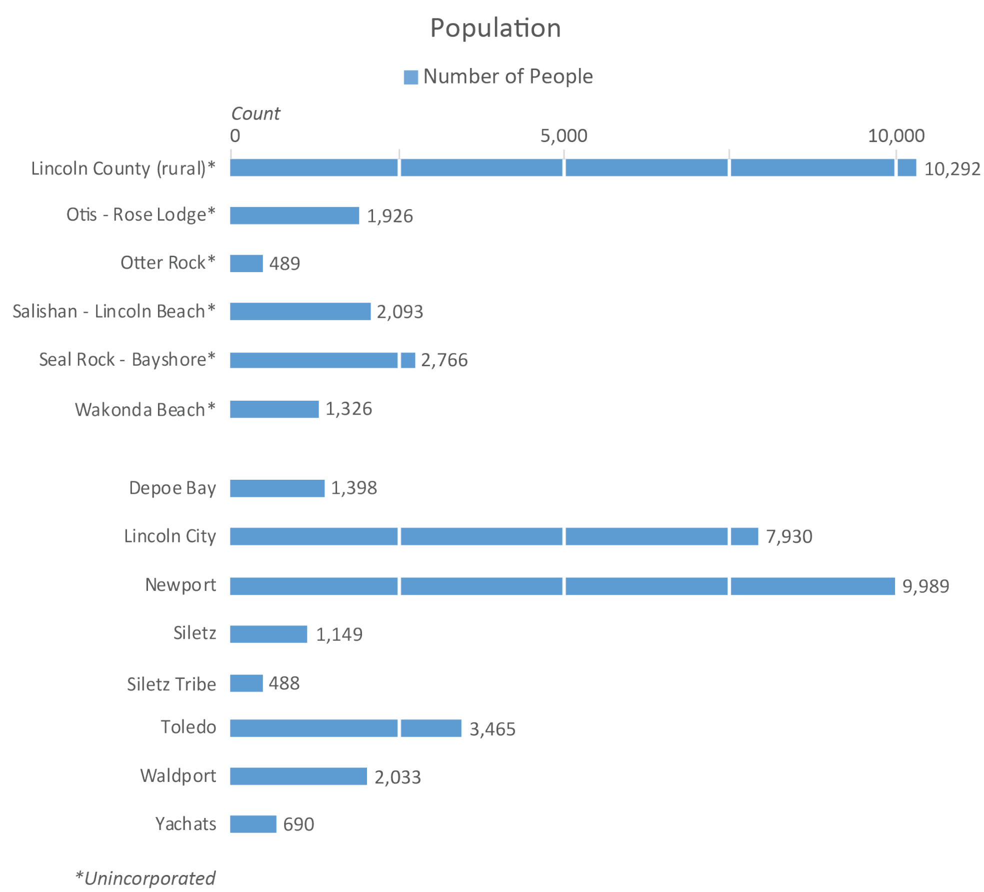
[1] Some of the critical facilities for the Siletz Tribe are located within the city limits of the City of Siletz.

2.4 Population

Within the UDF database, the population of permanent residents reported per census block was distributed among residential buildings and pro-rated based on square footage (**Figure 2-5**). We did not examine for this report the impacts from natural hazards to non-permanent populations (e.g., tourists), whose total numbers fluctuate seasonally. Due to lack of information within the assessor and census databases, the distribution includes vacation homes, which in many coastal communities make up some of the total residential building stock. From information reported in the 2010 U.S. Census, American FactFinder regarding vacation rentals within the coastal portion of the county and coastal communities, it is estimated that approximately 12% of residential buildings are vacation rentals in Lincoln County (U.S. Census Bureau, 2010b).

From the census data, DOGAMI analyzed the 46,034 residents within the study area could be affected by a natural hazard scenario. For each natural hazard, with the exception of the CSZ M9.0 earthquake scenario, a simple exposure analysis was used to find the number of potentially displaced residents within a hazard zone. For the CSZ M9.0 earthquake scenario the number of potentially displaced residents was based on a combination of residents exposed to tsunami and those in buildings estimated to be significantly damaged by the earthquake.

Figure 2-5. Population by Lincoln County community.



3.0 ASSESSMENT OVERVIEW AND RESULTS

This risk assessment considers six natural hazards (earthquake, tsunami, flood, landslide, coastal erosion, and wildfire) that pose a risk to Lincoln County. The assessment describes both localized vulnerabilities and the widespread challenges that impact all communities. The loss estimation and exposure results, as well as the rich dataset included with this report, can lead to greater understanding of the potential impact of disasters. Communities can use the results to update plans as part of the work toward becoming more resilient to future disasters.

3.1 Hazards and Countywide Results

In this section, results are presented for the entire study area. The study area includes all unincorporated areas, tribal lands, unincorporated communities, and cities within Lincoln County. Individual community results are in **Appendix A: Community Risk Profiles**.

Understanding the connection between Cascadia subduction zone earthquakes and tsunamis

During a large CSZ earthquake, the sudden uplift of the North American plate along the CSZ margin is likely to displace enough water to produce a tsunami that will have an impact along the Oregon coast. The proximity of the CSZ to the coastal areas of Oregon make them especially threatened by earthquakes and tsunamis (Madin and Burns, 2013).

Although we discuss CSZ earthquakes and tsunamis as separate hazards in this report, these hazards are closely associated. Their widespread effects and almost simultaneous occurrence present a challenge to planners.

3.2 Cascadia Subduction Zone Earthquake

An earthquake is a sudden movement of rock on each side of a fault in the earth's crust that abruptly releases strain accumulated over a long period of time. The movement along the fault produces waves of strong shaking that spread in all directions. If an earthquake occurs near populated areas, it may cause causalities, economic disruption, and extensive property damage (Madin and Burns, 2013).

Just off Oregon's coast, the Juan de Fuca tectonic plate slides under the North American plate. This area of interaction between the two plates is known as the Cascadia subduction zone (CSZ). The pressure and friction created by this convergent motion builds potential energy at the plate boundary until the overriding plate suddenly slips, releasing energy that manifests as strong shaking spread over a wide area. Earthquakes along the CSZ occur on average every 500 years and can be extremely large (Clague and others, 2000).

Two earthquake-induced hazards are liquefaction and landslides. Liquefaction occurs when saturated soils substantially lose bearing capacity due to ground shaking, causing the soil to behave like a liquid; this action can be a source of tremendous damage. Coseismic landslides are mass movement of rock, debris, or soil induced by ground shaking. All earthquake damages in this report include damages derived from both liquefaction and landslide factors.

Another risk factor associated with the CSZ event is co-seismic subsidence. According to Peterson and others (1997), a CSZ earthquake can result in coastal subsidence of up to 10 feet (1–3 meters). Low-lying developed areas near beaches and estuaries are most susceptible to this long-term hazard. A significant and permanent lowering of coastal terrain would expose buildings and infrastructure to tidal inundation in low-lying coastal areas that were formerly above high tide (Madin and Burns, 2013). Analysis of this potentially significant hazard is beyond the scope of this project.

3.2.1 Data sources

Most of the hazard data inputs for our Hazus-MH earthquake analysis were originally created for the 2012 Oregon Resilience Plan (ORP) for Cascadia Subduction Zone Earthquakes (Madin and Burns, 2013). In conducting their vulnerability assessment, the ORP seismic workgroup chose an earthquake scenario of M9.0 off the coast of Oregon along the subduction zone.

Hazus-MH offers two methods for estimating loss from earthquake, probabilistic and deterministic (FEMA, 2012b). A probabilistic scenario uses U.S. Geological Survey (USGS) National Seismic Hazard Maps, which are derived from seismic hazard curves calculated on a grid of sites across the United States that describe the annual frequency of exceeding a set of ground motions as a result of all possible earthquake sources (USGS, 2017). A deterministic scenario is based on a specific seismic event, which in this case is the CSZ M9.0 event. We selected the deterministic scenario method because the CSZ event is easily the highest seismic risk to this area (Clague and others, 2000). We used this method along with the UDF database so that loss estimates could be calculated on a building-by-building basis.

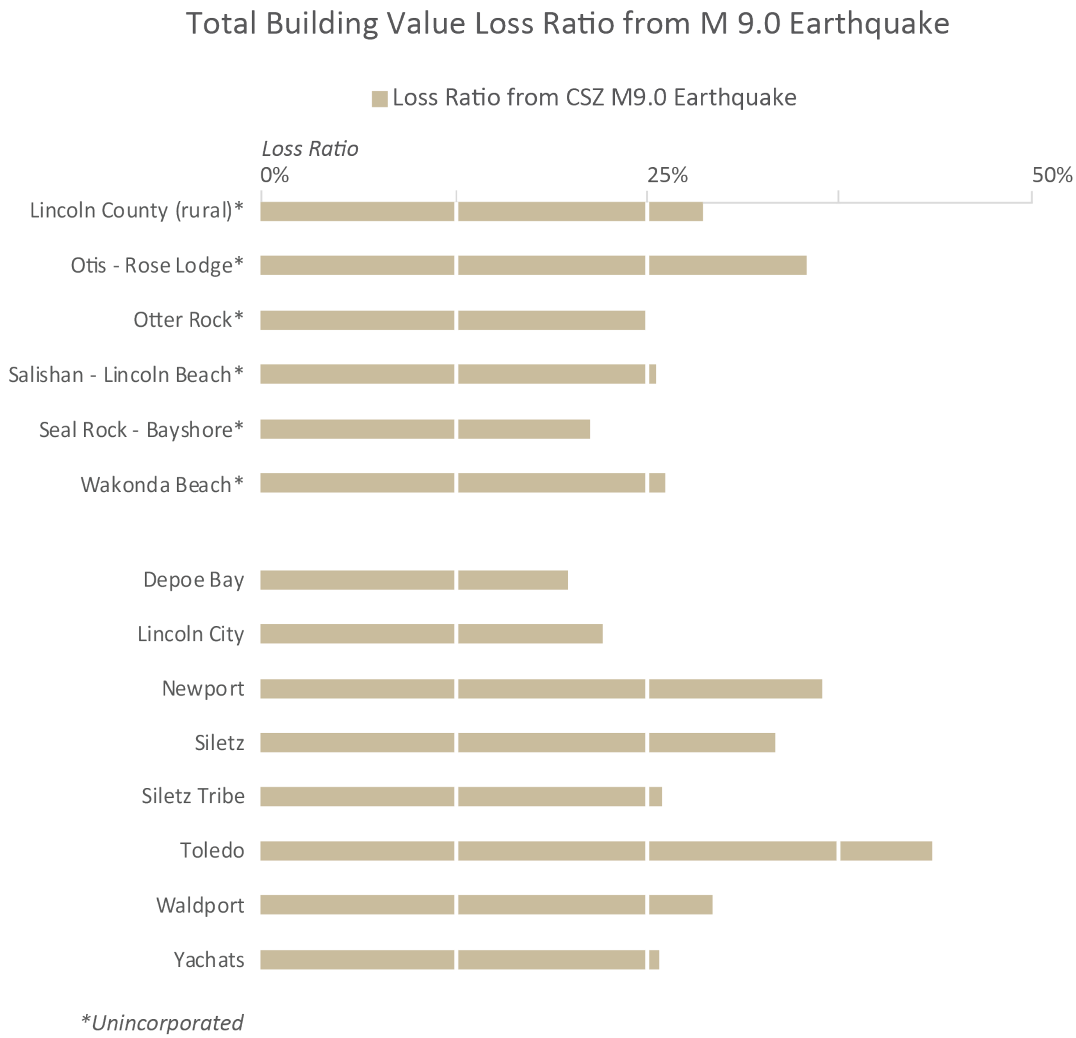
The following hazard layers used for our loss estimation are derived from work conducted by Madin and Burns (2013): National Earthquake Hazard Reduction Program (NEHRP) soil classification, peak ground acceleration (PGA), peak ground velocity (PGV), spectral acceleration at 1.0 second period and 0.3 second period (SA10 and SA03), and liquefaction susceptibility. We also used landslide susceptibility data derived from the work of Burns and others (2016). The liquefaction and landslide susceptibility layers together with PGA were used by the Hazus-MH tool to calculate permanent ground deformation and associated probability.

While the loss estimates and exposure results of the earthquake and tsunami presented in this report describe a singular CSZ scenario, the hazard data used in these analyses are the product of different sources that equate to a slightly different event magnitude. The Medium-sized tsunami scenario was modeled with a CSZ M8.9 earthquake (Priest and others, 2013). The earthquake bedrock ground motions from a M9.0 CSZ earthquake were produced by Arthur Frankel of the USGS (written communication, 2012) and then modified to include site class soil factors (Madin and Burns, 2013). While the tsunami scenario is associated with a specific amount of slip needed to generate a tsunami, the earthquake model is independent of slip with the earthquake energy distributed over the rupture zone. Irrespective of these differences, the two scenarios are comparable and are used in this report.

3.2.2 Countywide results

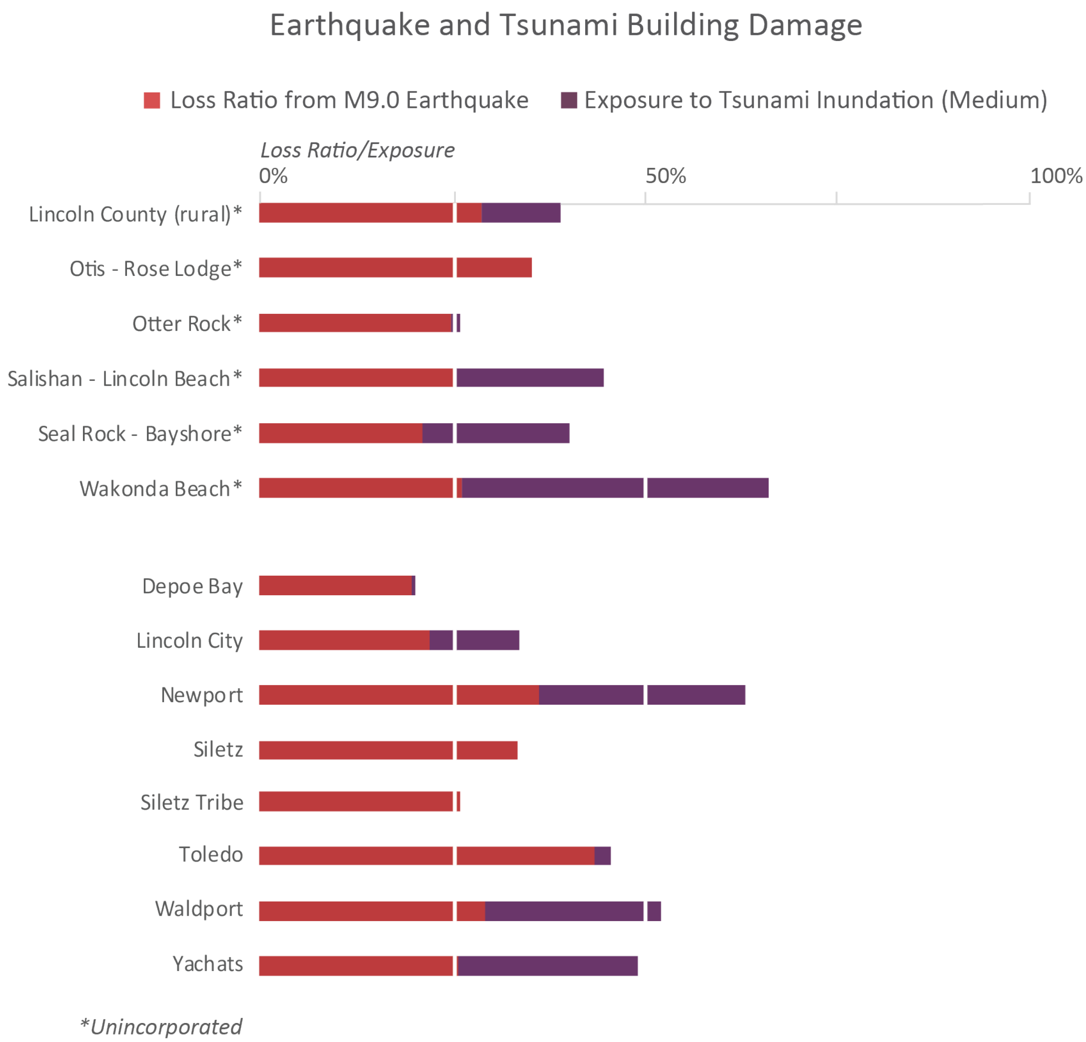
The CSZ event will produce severe ground shaking and ground failure, as well as a large and swift moving tsunami (Madin and Burns, 2013). Due to the nearly simultaneous timing of these two natural hazards, we have parsed loss estimate results to avoid double counting. That is, buildings within the (Medium-sized) tsunami zone are reported on the basis of exposure only, while buildings outside the tsunami zone are reported on the basis of Hazus-MH earthquake loss estimates. From recent tsunami events in Japan, Indonesia, and Chile, we assumed that tsunami losses to buildings are complete within the inundation area. Tsunami results are provided in the tsunami section (section 3.3). **Figure 3-1** shows the loss estimates by community for Lincoln County from a CSZ M9.0 event without the effects from tsunami.

Figure 3-1. Earthquake loss ratio by Lincoln County community.



Because an earthquake can affect a wide area, it is unlike other hazards in this report—every building in Lincoln County, to some degree, will be shaken by a CSZ M9.0 earthquake (see Appendix E, **Plate 3**). Hazus-MH loss estimates (see **Table B-2**) for each building are based on a formula where coefficients are multiplied by each of the five damage state percentages (none, low, moderate, extensive, and complete). These damage states are correlated to loss ratios that are then multiplied by the building dollar value to obtain a loss estimate (FEMA, 2012b). Loss estimates reported for earthquake are for buildings *outside* the (Medium-sized) tsunami inundation zone. **Figure 3-2** shows loss ratios from the CSZ event (both tsunami and earthquake) for the communities of Lincoln County.

Figure 3-2. CSZ M9.0 event loss ratio in Lincoln County, for both earthquake and tsunami inundation.



Note: Due to the nearly simultaneous timing of a Cascadia subduction zone earthquake and tsunami, loss estimate results have been parsed to avoid double counting. That is, buildings within the (Medium-sized) tsunami zone are reported on the basis of exposure only, while buildings outside the (Medium-sized) tsunami zone are reported on the basis of Hazus-MH earthquake loss estimates. Tsunami losses to buildings are assumed to be complete within the inundation area.

In keeping with earthquake damage reporting conventions, we used the ATC-20 post-earthquake building safety evaluation color-tagging system to represent damage states (Applied Technology Council, 2015). Red-tagged buildings correspond to a Hazus-MH damage state of "complete," which means the building is uninhabitable. Yellow-tagged buildings are in the "extensive" damage state, indicating limited habitability. The number of buildings in each damage state is based on an aggregation of probabilities per community and does not represent individual buildings (FEMA, 2012b).

Critical facilities were considered non-functioning if the Hazus-MH earthquake analysis showed that a building or complex of buildings had a greater than 50-percent chance of being at least moderately damaged (FEMA, 2012b). The number reported for non-functioning critical facilities is only for buildings outside the (Medium-sized) tsunami inundation zone.

The number of potentially displaced residents from the CSZ M9.0 earthquake was based on the formula: ([Number of Occupants] * [Probability of Complete Damage]) + (0.9 * [Number of Occupants] * [Probability of Extensive Damage]) (FEMA, 2012b). The probability of damage state was determined in the Hazus-MH earthquake analysis results. The number reported for potentially displaced residents is only for residences outside the (Medium-sized) tsunami inundation zone. Displaced residents due to a tsunami are discussed in the CSZ tsunami hazard section.

Lincoln countywide CSZ M9.0 earthquake results (not including buildings or population within the Medium-sized tsunami zone):

- Number of red-tagged buildings: 9,712
- Number of yellow-tagged buildings: 3,562
- Loss estimate: $1,171,005,000
- Loss ratio: 23%
- Non-functioning critical facilities: 52
- Potentially displaced population: 9,850

The results indicate that Lincoln County would incur significant losses (23%) due to a CSZ M9.0 earthquake. These results are strongly influenced by the overall average age of the building stock. This shows that the age of the building stock is one metric of earthquake vulnerability for a community. Seismic building codes were implemented in Oregon in the 1970s (Judson, 2012); nearly 75% of buildings in Lincoln County were built before modern seismic building code enforcement. Communities within Lincoln County that are composed of an older building stock are expected to experience more damage from earthquake than newer ones.

Moderate to high liquefaction zones exist throughout the county, which increases the risk from earthquake. Liquefaction could also present difficulties for evacuation from the subsequent tsunami, because liquefaction areas correspond closely with the most likely tsunami inundation zone (Priest and others, 2013). This factor, as well as the overall age of the building stock, along with the proximity of Lincoln County to the Cascadia subduction zone, results in high levels of damage.

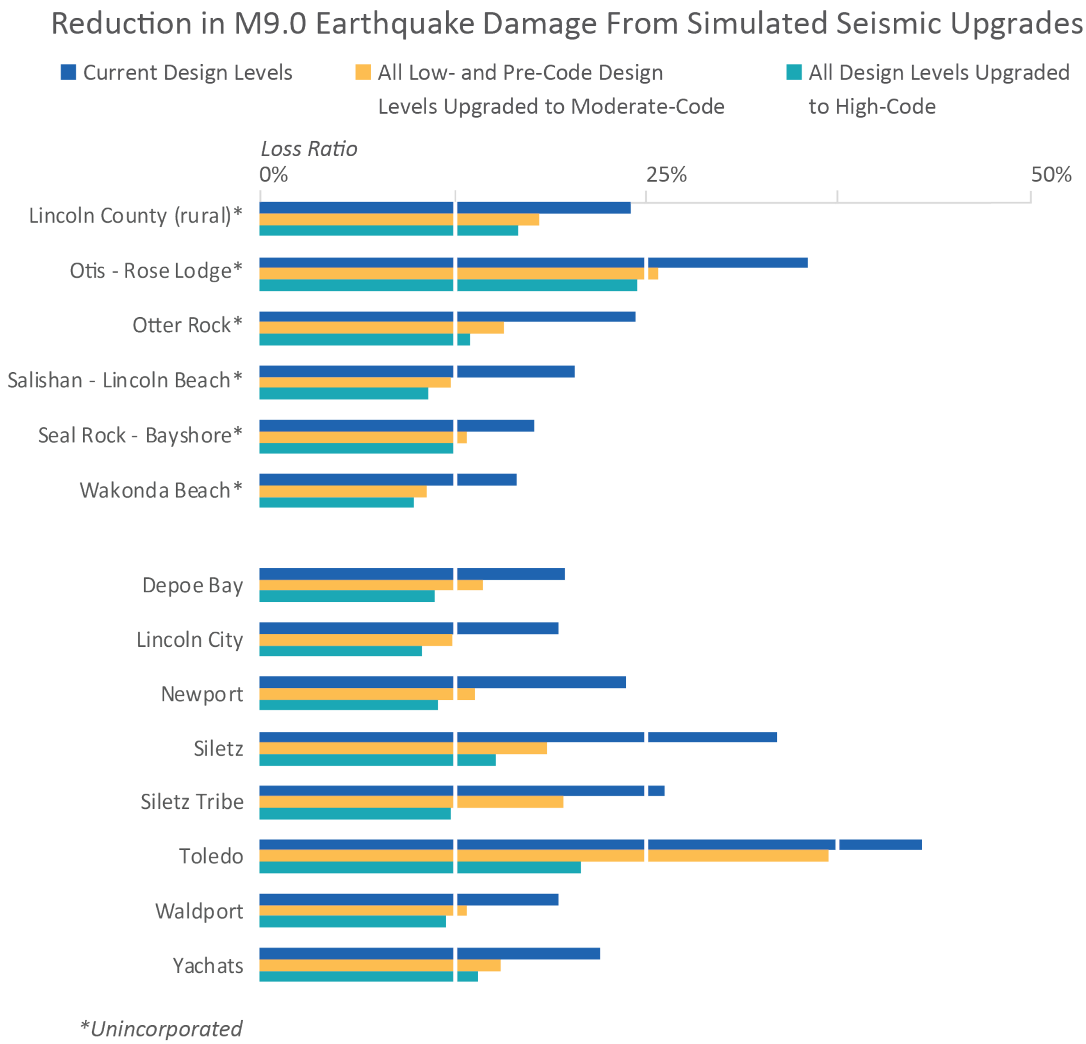
Although damage caused by coseismic landslides was not specifically looked at in this report, it likely contributes a significant amount of the estimated damage from the earthquake hazard in Lincoln County. Landslide exposure results show that 27% of buildings in Lincoln County are within a very high or high susceptibility zone. This indicates that a similar percentage of buildings would be damaged primarily from coseismic landslide rather than from earthquake shaking alone.

If buildings could be seismically retrofitted to moderate or high code standards, the impact of this event would be greatly reduced. In a simulation by DOGAMI, Hazus-MH earthquake analysis shows that loss estimates drop from 23% to 16%, when all buildings are upgraded to at least moderate code level. While retrofits can decrease earthquake vulnerability, for areas of high landslide or liquefaction, additional geotechnical mitigation may be necessary to have an effect on losses. **Figure 3-3** illustrates the reduction in loss estimates from a CSZ M9.0 earthquake through two simulations where all buildings are upgraded to moderate code standards or to high code standards. Communities that are mostly within the tsunami hazard zone may need additional tsunami mitigation to reduce vulnerability.

Key Terms:

- *Seismic retrofit:* Structural modification to a building that improves its resilience to earthquake.
- *Design level:* Hazus-MH terminology referring to the quality of a building's seismic building code (i. e. pre, low, moderate, and high). Refer to **Appendix C.2.3** for more information.

Figure 3-3. CSZ M9.0 earthquake loss ratio in Lincoln County, with simulated seismic building code upgrades.



Note: Loss estimates shown are for buildings outside the tsunami zone only and are reported on the basis of Hazus-MH earthquake loss estimates. Tsunami losses to buildings are assumed to be complete within the inundation area.

3.2.3 Areas of vulnerability or risk

We identified locations within the study area that are comparatively more vulnerable or at greater risk to CSZ M9.0 earthquake hazard:

- Although every building in Lincoln County will experience shaking from a CSZ earthquake, many of the buildings within the communities of Lincoln City, Salishan-Lincoln Beach, Newport, Seal Beach-Bayshore, and Waldport are located on soils with a high liquefaction potential, which increases the likelihood of substantial ground deformation and building damage, especially for areas close to the several estuaries within the study area.

> ***Key Terms:***
> - *Vulnerability:* Characteristics that make people or assets more susceptible to a natural hazard.
> - *Risk:* Probability multiplied by consequence; the degree of probability that a loss or injury may occur as a result of a natural hazard.

- Many buildings in the communities of Newport, Siletz, Toledo, and Otis-Rose Lodge are older and less likely to meet modern building design standards. Older buildings in these communities may be more vulnerable to substantial damage during an earthquake.
- Because of the liquefaction and landslides, these communities will likely be disconnected from other communities by severed transportation routes. With losses up to 44%, it is very important for a community's emergency services to be able to respond to emergencies within its own community.
- 52 (56 when including areas of tsunami inundation) of the 72 critical facilities in the study area are estimated to be non-functioning due to a CSZ earthquake.

3.3 Cascadia Subduction Zone Tsunami

Tsunamis are a natural hazard threat that exists for many communities along the Oregon coast. The tsunami addressed in this report is caused by the abrupt change in the seafloor accompanying an earthquake. In a megathrust earthquake, like the CSZ event, the sudden uplift of seafloor is converted into wave energy (Priest and others, 2013). Although not included in this report, other important processes that may trigger a tsunami include landslides that start below the water surface and landslides that enter a deep body of water from above the water surface (Witter and others, 2011). Tsunamis can travel thousands of miles across oceans, so that a particular coastal area may be susceptible to two different types of tsunami hazard (Priest and others, 2013):

- Tsunamis caused by distant sources and that travel across the ocean basin, and
- Tsunamis caused by local sources such as the CSZ and that occur immediately adjacent to a coast.

During a CSZ earthquake, the sudden uplift of a portion of the North American plate along the CSZ margin is likely to produce a tsunami that will have an impact along the Oregon coast. This locally generated tsunami poses a significant risk to low-lying coastal and estuarine developed areas in Lincoln County due to the limited warning time of an approaching tsunami. Tsunami inundation zone maps created by DOGAMI can serve as a tool for planning and mitigation efforts. We chose the "Medium" tsunami scenario shown on these maps to report the results of our analysis, because, according to Priest and others (2013), the Medium scenario tsunami is the most likely to occur from a CSZ event.

3.3.1 Data sources

The tsunami hazard data used in this report are from Priest and others (2013). Priest and others modeled areas of expected inundation from five local (CSZ) tsunami scenarios and two distant source scenarios and created a series of inundation maps. The distant source tsunami scenarios were not used in this report. The local tsunami scenarios used in this report for exposure analysis were CSZ "t-shirt" sizes of Small (Sm), Medium (M), Large (L), Extra Large (XL), and Extra Extra Large (XXL).

The slip deficit time intervals for each local source tsunami scenario is as follows (Priest and others, 2013):

- XXL 1,200 years
- XL 1,050–1,200 years
- L 650–800 years
- M 425–525 years
- Sm 300 years

The estimated recurrence rates are from Witter and others (2013) and are:

- XXL = unknown (not seen in 10,000-year record)
- XL = <1/10,000 = <0.01%
- L = 1/3,333 = 0.03%
- M = 1/1,000 = 0.1%
- Sm = 1/2,000 = 0.05%

For this risk assessment, DOGAMI compared the locations of buildings and critical facilities to the geographic extent of the local source tsunami inundation zones to assess the exposure for each community. The exposure results shown below are for the Medium scenario only (see **Table B-3** for all scenarios). The total dollar value of exposed buildings was summed for the study area and is reported below. We were also able to estimate the number of people at risk to tsunami hazard. See **Appendix B: Detailed Risk Assessment Tables** for cumulative multi-scenario analysis results.

3.3.2 Countywide results

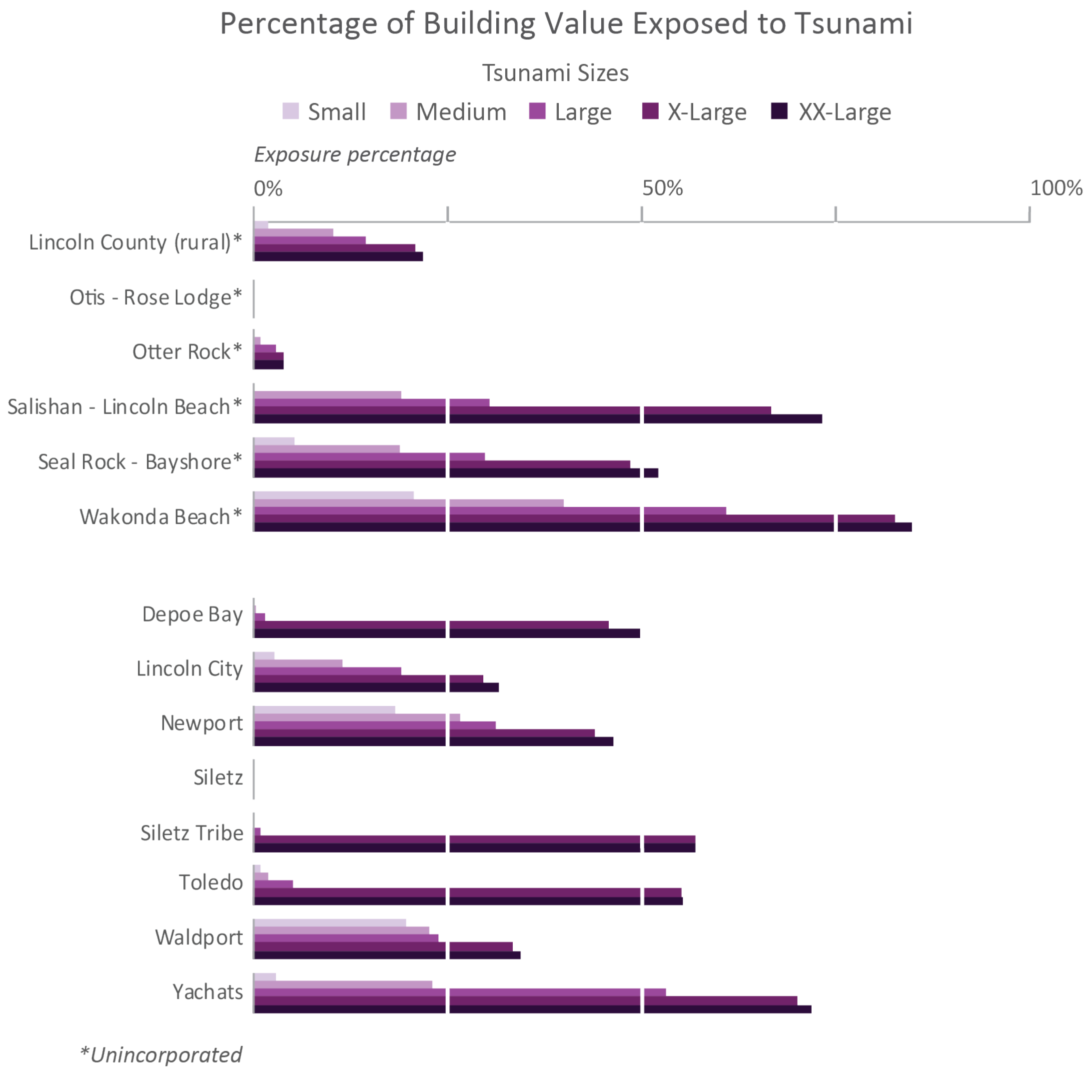
Because every community in this study is relatively near the Pacific Ocean, all communities would be affected by the largest of the DOGAMI calculated tsunami scenarios. However, the Medium-sized tsunami was chosen as the primary scenario for this report because that category represents areas that have the highest potential for losses. Most communities built along the open coast, bays, and estuaries will be impacted from a tsunami.

Lincoln countywide CSZ tsunami exposure (Medium-sized tsunami scenario):

- Number of buildings exposed: 4,110
- Exposure value: $812,270,000
- Percentage of exposure value: 16%
- Critical facilities exposed: 4
- Potentially displaced population: 2,949

The combination of earthquake and tsunami will have a significant impact to the entire coastal and estuarine portions of rural Lincoln County. Low-lying areas within coastal communities are predicted to be inundated by the Medium-sized tsunami scenario. Nearly a fifth of the county's buildings have exposure to tsunami inundation from the Medium-sized scenario (**Figure 3-4**). In some communities a high percentage of development is exposed to tsunami hazard. Nearly three thousand permanent residents could be impacted from a CSZ tsunami event and require medical and shelter services. Because there is high risk of tsunami along the entire coast and estuarine areas of Lincoln County, awareness is important for the emergency response immediately after the event and for future planning and mitigation efforts in these areas.

Figure 3-4. Tsunami inundation exposure by Lincoln County community.



3.3.3 Areas of vulnerability or risk

We identified locations within the study area that are comparatively more vulnerable or at greater risk to CSZ generated Medium-sized tsunami hazard:

- Residential areas built on the "Salishan Spit" in Salishan-Lincoln Beach are extremely vulnerable to tsunami hazard because evacuation to safe zones may be very difficult.
- Low-lying coastal areas and estuarine zones in Yachats, Wakonda Beach, Newport, and Lincoln City are vulnerable to tsunami hazard.

3.4 Flooding

In its most basic form, a flood is an accumulation of water over normally dry areas. Floods become hazardous to people and property when they inundate an area where development has occurred, causing losses. Floods are a frequently occurring natural hazard in Lincoln County and have the potential to create public health hazards and public safety concerns, close and damage major highways, destroy railways, damage structures, and cause major economic disruption. A typical method for determining flood risk is to identify the probability of flooding and the impacts of flooding. The probabilities calculated for flood hazard used in this report are 10%, 2%, 1%, and 0.2%, henceforth referred to as 10-year, 50-year, 100-year, and 500-year scenarios, respectively.

All the rivers in the county drain westward and, eventually, into the Pacific Ocean. The major rivers within the county are the Alsea, Salmon, Siletz, Yachats, and Yaquina. All the listed rivers are subject to flooding and can cause damage to buildings within the floodplain. Other flooding effects are due to coastal flooding from the Pacific Ocean for low-lying coastal developments and within Lincoln County's estuaries.

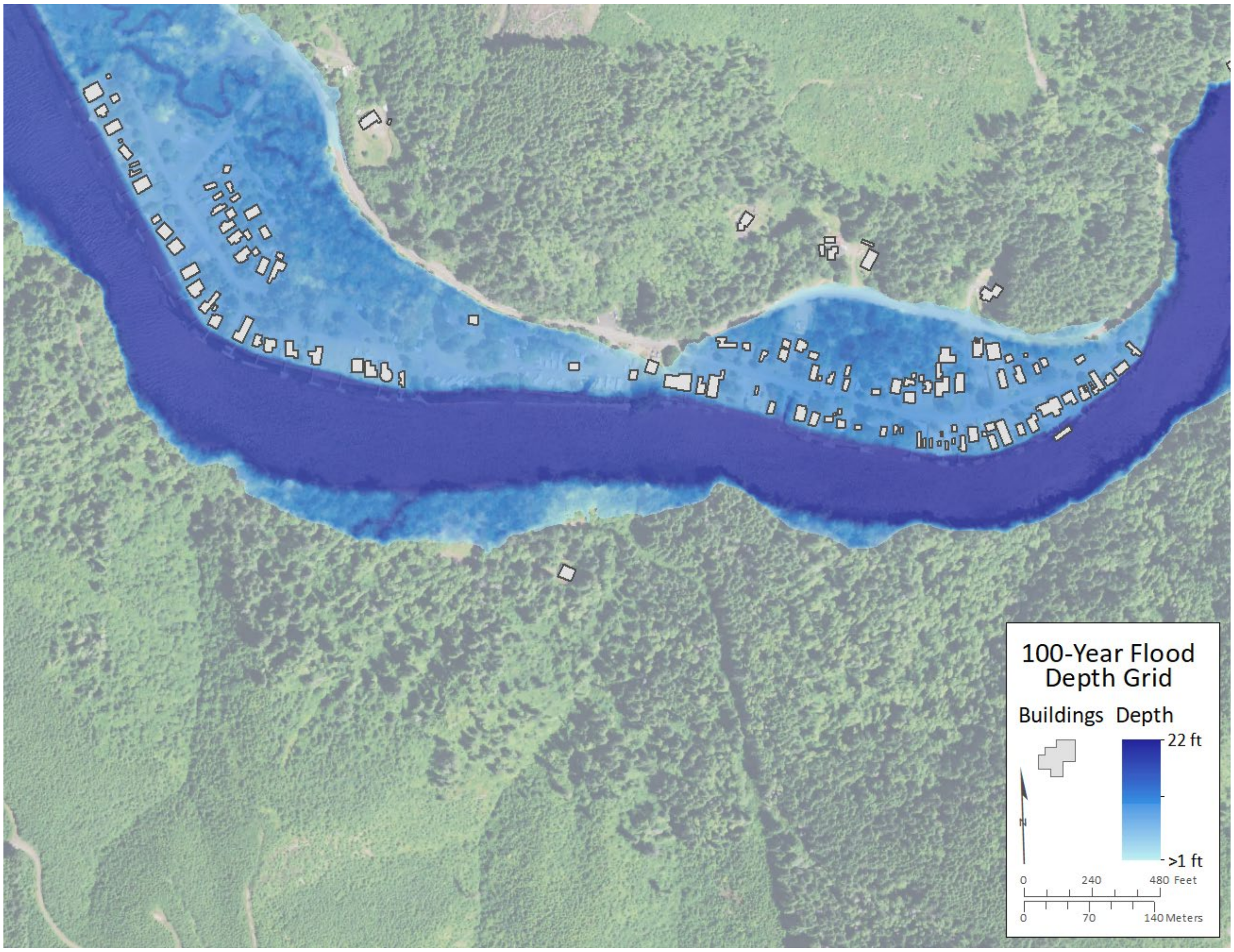
The ability to assess the probability of a flood, and the level of accuracy of that assessment is influenced by modeling methodology advancements, better knowledge, and longer periods of record for the stream or water body in question. The impacts of flooding are determined by adverse effects to human activities within the area and the natural and built environment. Examples of common mitigating activities are elevating structures above the expected level of flooding or removing the structure through FEMA's property acquisition ("buyout") program. Flood issues like flash flooding, ice jams, post-wildfire floods, and dam safety were not examined in this report.

3.4.1 Data sources

The Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) for Lincoln County were updated in 2017 (FEMA, 2019) and included a recently completed study of coastal flooding (Allan and others, 2015); these are the primary data sources for the flood risk assessment in this report. As of the completion of this report in 2018, the FIS and FIRMs were released as preliminary products. Between the period of completion of this report and publication of this report in 2020, the preliminary FEMA data were adopted in 2019 and currently represent the effective FIS and FIRM information. Further information regarding the National Flood Insurance Program (NFIP) can be found on the FEMA website: https://www.fema.gov/flood-insurance. These were the only flood data sources that DOGAMI used in the analysis, but flooding does occur in areas outside of the detail mapped areas.

Depth grids, developed by DOGAMI in 2015 to revise the Lincoln County FIRMs, were used in this risk assessment to determine the level to which buildings are impacted by flooding. Depth grids are raster GIS datasets in which each digital pixel value represents the depth of flooding at that location within the flood zone **(Figure 3-5)**. Though considered draft at the time of this analysis, the depth grid data are the best available flood hazard data. Depth grids for four flooding scenarios (10-, 50-, 100-, and 500-year) were used for loss estimations and, for comparative purposes, exposure analysis. The 100-year depth grid included coastal flood modeling that was not available for the other scenarios.

Figure 3-5. Flood depth grid example in unincorporated Lincoln County (rural).



Building loss estimates are determined in Hazus-MH by overlaying building data on a depth grid. Hazus-MH uses individual building information, specifically the first-floor height above ground and the presence of a basement, to calculate the loss ratio from a particular depth of flood.

For Lincoln County, occupancy type and basement presence attributes were available from the assessor database for most buildings. Where individual building information was not available from assessor data, we used oblique imagery and street level imagery to estimate these important building attributes. Only buildings in a flood zone or within 500 feet (152 meters) of a flood zone were examined closely to attribute buildings with more accurate information for first-floor height and basement presence. Because our analysis accounted for building first-floor height, buildings that have been elevated above the flood level were not given a loss estimate—but we did count residents in those structures as displaced. We did not look at the duration that residents would be displaced from their homes due to flooding. For information about structures exposed to flooding but not damaged, see the **Exposure analysis** section below.

3.4.2 Countywide results

For this risk assessment, we imported the countywide UDF data and depth grids into Hazus-MH and ran a flood analysis for each of the four flood scenarios (10-, 50-, 100-, and 500-year). We used the 100-year flood scenario as the primary scenario for reporting flood results (also see Appendix E. **Plate 5**). The 100-year flood has traditionally been used as a reference level for flooding and is the standard probability that FEMA uses for regulatory purposes (FEMA, 2013). See **Table B-4** for multi-scenario cumulative results.

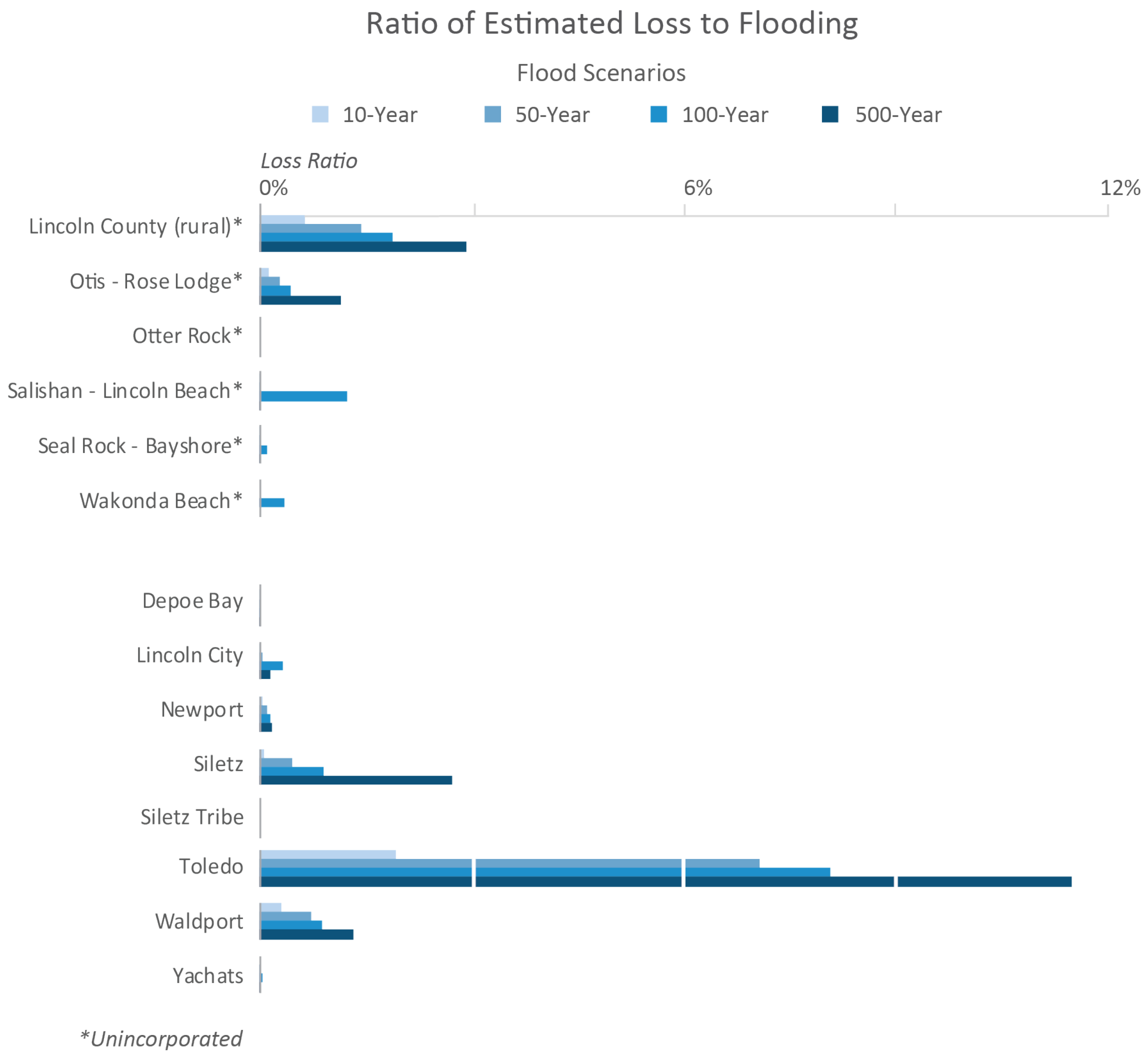
Lincoln countywide 100-year flood loss:

- Number of buildings damaged: 2,377
- Loss estimate: $52,251,000
- Loss ratio: 1%
- Damaged critical facilities: 3
- Potentially displaced population: 2,402

3.4.3 Hazus-MH analysis

The Hazus-MH loss estimate for the 100-year flood scenario for the entire county is over $50 million. Both riverine and coastal flooding have a significant impact on Lincoln County, especially within the floodplain and in low-lying coastal areas (**Figure 3-6**). The Georgia Pacific facilities comprises a significant portion of the overall flood losses for the City of Toledo. The Hazus-MH analysis also provides useful flood data on individual communities so that planners can identify problems and consider which mitigating activities will provide the greatest resilience to flooding.

Figure 3-6. Flood loss estimates by Lincoln County community.



Note: In addition to the four riverine flood scenarios, coastal flooding information is available for the 100-year flood scenario for portions of Lincoln County (rural), Lincoln City, Depoe Bay, Newport, Waldport, Yachats, Otter Rock, Salishan-Lincoln Beach, Seal Rock-Bayshore, and Wakonda Beach.

3.4.4 Exposure analysis

Separate from the Hazus-MH flood analysis, we did an exposure analysis by overlaying building locations on the 100-year flood extent. A significant number (8%) of Lincoln County's buildings were found to be within designated flood zones. By comparing the number of non-damaged buildings from Hazus-MH with exposed buildings in the flood zone, we estimated the number of buildings that could be elevated above the level of flooding. Of the 3,304 buildings that are exposed to flooding, we estimate that 927 are above the height of the 100-year flood. This evaluation also estimates that 2,403 residents might have mobility or access issues due to surrounding water. See appendix **Table B-5** for community-based results of flood exposure.

3.4.5 Areas of vulnerability or risk

We identified locations within the study area that are comparatively more vulnerable or at greater risk to flood hazard:

- The Port of Toledo and the Georgia Pacific manufacturing facility in the City of Toledo are highly vulnerable to flooding from the Yaquina River.
- Developed areas along the Siletz River in the unincorporated county and in Lincoln City are exposed to the 100-year flood.
- Many buildings in the low-lying business area of Waldport are particularly vulnerable to flooding. This area, along the riverbank, is subject to the 100-year flood due to the close proximity of the Alsea River. Mitigation actions, such as elevating buildings, have alleviated some problems.
- Coastal flooding threatens many residences in Wakonda Beach and Salishan-Lincoln Beach.

3.5 Landslide Susceptibility

Landslides are mass movements of rock, debris, or soil most commonly downhill. There are many different types of landslides in Oregon. In Lincoln County, the most common are debris flows and shallow- and deep-seated landslides. Landslides can occur in many sizes, at different depths, and with varying rates of movement. Generally, they are large, deep, and slow moving or small, shallow, and rapid. Some factors that influence landslide type are hillside slope, water content, and geology. Many triggers can cause a landslide: intense rainfall, earthquakes, or human-induced factors like excavation along a landslide toe or loading at the top. Landslides can cause severe damage to buildings and infrastructure. Fast-moving landslides may pose life safety risks and can occur throughout Oregon (Burns and others, 2016).

3.5.1 Data sources

The Statewide Landslide Information Layer for Oregon [SLIDO], release 3.2 [Burns and Watzig, 2014]) is an inventory of mapped landslides in the state of Oregon. SLIDO is a compilation of past studies; some studies were completed very recently using new technologies, like lidar-derived topography, and some studies were performed more than 50 years ago. Consequently, SLIDO data vary greatly in scale, scope, and focus and thus in accuracy and resolution across the state. Most of the landslide inventory mapping for Lincoln County was done in the early 1970s. Some lidar-based mapping was done in 2012 in a rural unincorporated area east of Toledo as part of a water quality evaluation.

Burns and others (2016) used SLIDO inventory data along with maps of generalized geology and slope to create a landslide susceptibility overview map of Oregon that shows zones of relative susceptibility: Very High, High, Moderate, and Low. SLIDO data directly define the Very High landslide susceptibility zone, while SLIDO data coupled with statistical results from generalized geology and slope maps define the other relative susceptibility zones (Burns and others, 2016). Statewide landslide susceptibility map data have the inherent limitations of SLIDO and of the generalized geology and slope maps used to create the map. Therefore, the statewide landslide susceptibility map varies significantly in quality across the state, depending on the quality of the input datasets. Another limitation is that susceptibility mapping does not include some aspects of landslide hazard, such as runout, where the momentum of the landslide can carry debris beyond the zone deemed to be a high hazard area.

We used the data from the statewide landslide susceptibility map (Burns and others, 2016) in this report to identify the general level of susceptibility of given area to landslide hazards, primarily shallow and deep landslides. We overlaid building and critical facilities data on landslide susceptibility zones to assess the exposure for each community (see **Table B-6**). The total dollar value of exposed buildings was summed for the study area and is reported below. We also estimated the number of people threatened by landslides. Land value losses due to landslides and potentially hazardous unmapped areas that may pose real risk to communities were not examined for this report.

3.5.2 Countywide results

All Lincoln County communities have some exposure to landslide hazard. Communities that developed in terrain with moderate to steep slopes or at the base of steep hillsides may be at risk to landslides. The Coast Range trends through much of Lincoln County, so much of the area is steep and landslide prone. The combination of rugged terrain, historically active landslides, large amounts of rainfall, and frequent large earthquakes make landslides a serious threat.

We combined high and very high susceptibility zones as the primary scenarios to provide a general sense of community risk for planning purposes (see Appendix E, **Plate 6**). It was useful to combine exposure for both susceptibility zones to accurately depict the level of landslide risk to communities. The high and very high susceptibility zones represent areas most prone to landslides and with the highest impact to the community.

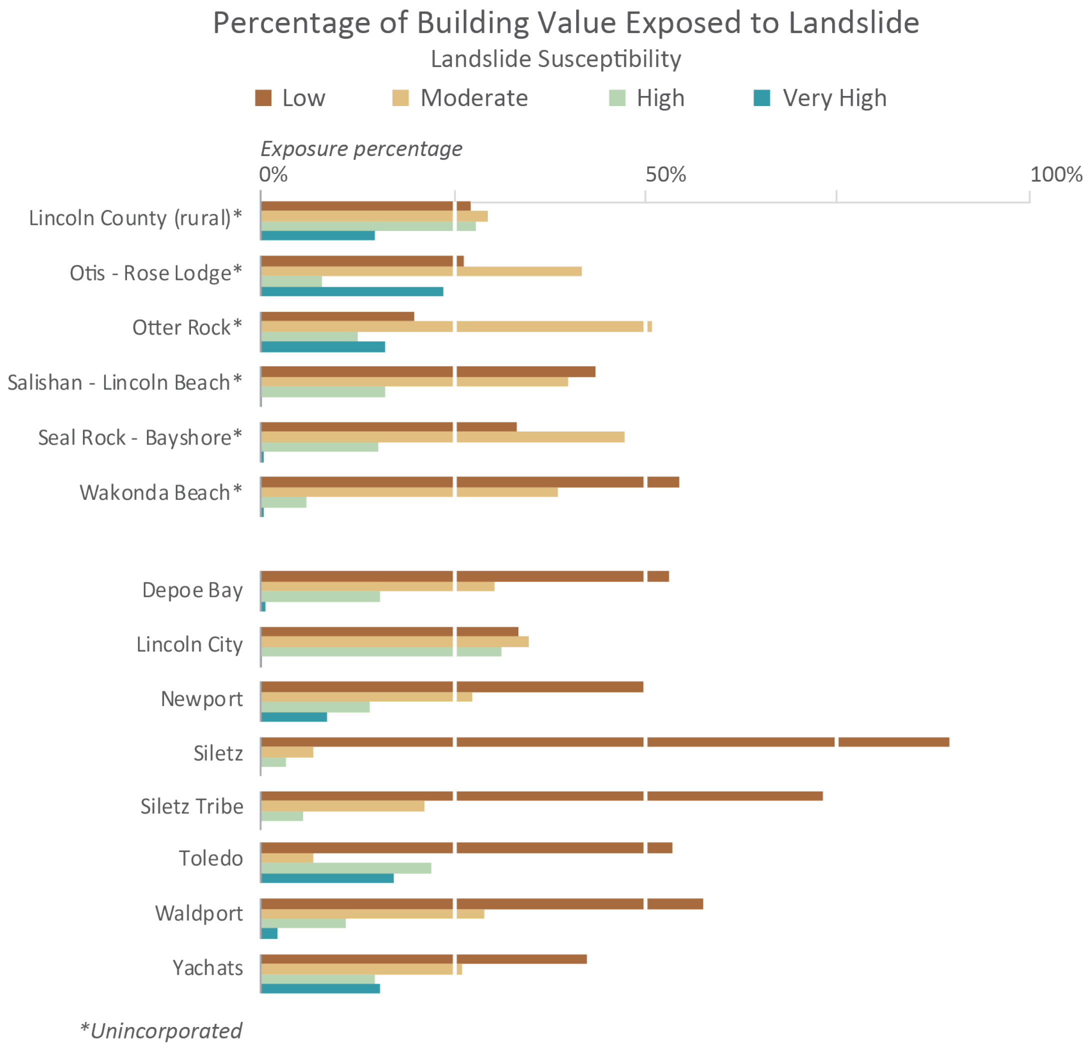
For this risk assessment we compared building locations to geographic extents of the landslide susceptibility zones (**Figure 3-7**). The exposure results shown below are for the high and very high susceptibility zones. See **Appendix B: Detailed Risk Assessment Tables** for multi-scenario analysis results.

Lincoln countywide landslide exposure (High and Very High susceptibility):

- Number of buildings: 12,894
- Exposure value: $1,383,822,000
- Percentage of exposure value: 27%
- Critical facilities exposed: 21
- Potentially displaced population: 14,886

The majority of buildings in Lincoln County corresponds to low and moderate susceptibility landslide zones. Still, approximately a quarter of the county's buildings have exposure to high or very high susceptibility to landslides. Landslide hazard is ubiquitous in a large percentage of undeveloped land and may present challenges for planning and mitigation efforts. Awareness of nearby areas of landslide hazard is beneficial to reducing risk for every community and rural area of the county.

Figure 3-7. Landslide susceptibility exposure by Lincoln County community.



3.5.3 Areas of vulnerability or risk

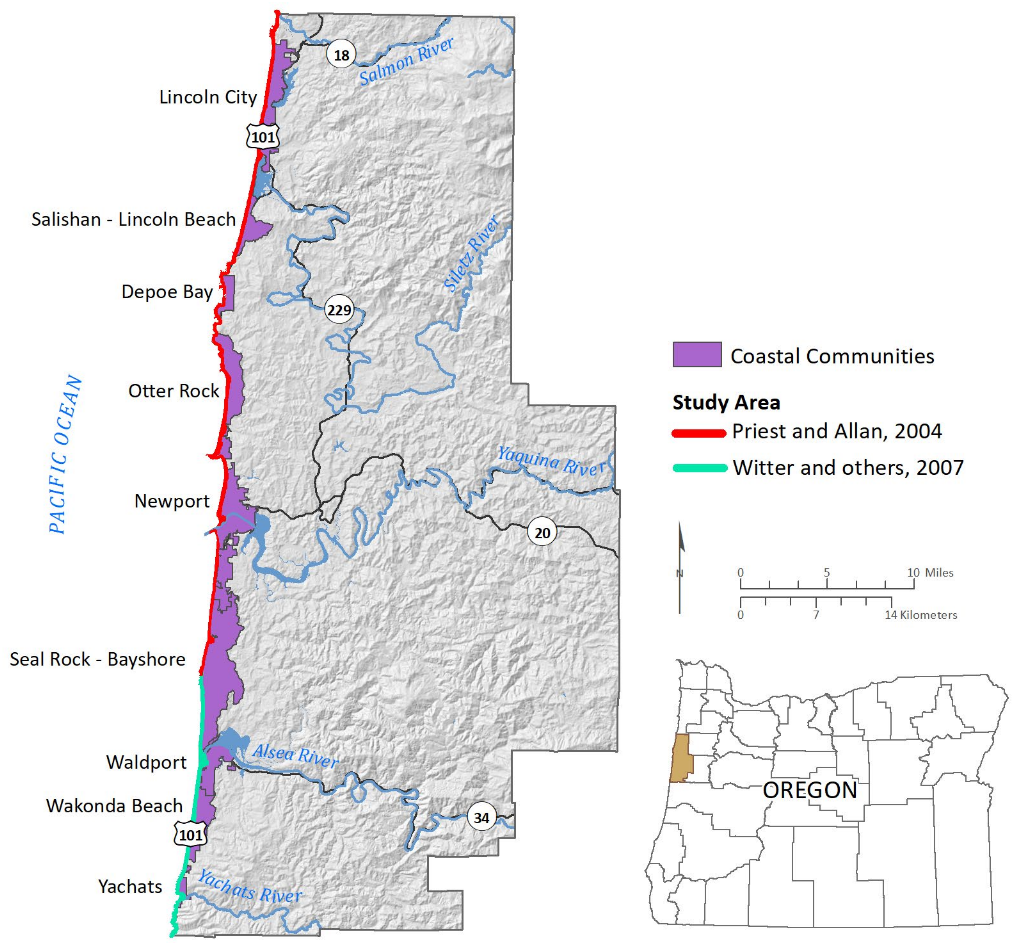
We identified locations within the study area that are comparatively more vulnerable or at greater risk to landslide hazard:

- Many residential buildings in the unincorporated county and the City of Newport, along the Yaquina River, are exposed to high and very high landslide hazard.
- An area mapped as very high susceptibility to landslides exists just to the east of the community of Seal Rock-Bayshore.
- Several places within the City of Toledo are exposed to very high landslide susceptibility. Nearly half of the buildings in the city, including all of its critical facilities, are threatened by landslide hazard.
- Nearly a quarter of the buildings in the community of Otis-Rose Lodge are exposed to very high landslide susceptibility.

3.6 Coastal Erosion

Erosion along the coast is a continuous process that occurs through a complex interaction of many geologic, atmospheric, and oceanic factors (including sea level rise). Beaches and dunes are highly susceptible to erosion, especially during large storms coupled with high ocean water levels. Coastal erosion is increasingly affecting people due to development near the beach or coastal bluffs. Typically, shoreline stabilization efforts using riprap are not an effective long-term mitigation (Stimely and Allan, 2014). Whether it is a gradual process or in the form of landslides, coastal erosion can cause loss of property. **Figure 3-8** shows the sections of coastline studied in two reports by Priest and Allan (2004) and Witter and others (2007) that may be subject to coastal erosion in Lincoln County.

Figure 3-8. Coastal erosion study area extents.



3.6.1 Data sources

Priest and Allan (2004) and Witter and others (2007) determined coastal erosion hazard zones for both dune-backed beaches and bluff-backed shorelines in Lincoln County. For dune-backed beaches, the reports delineated hazard zone boundaries based on rates of storm-induced erosion, sea level rise, and subsidence due to a CSZ event. The bluff-backed shoreline hazard zones were based on bluff retreat rates. In our assessment, both hazard zones were used to determine exposure to coastal erosion.

The hazard zones used to determine exposure are ranked as high, moderate, and low. A high hazard zone represents the most conservative erosion prediction, whereas the low hazard zone shows what would happen given a "worst-case scenario." The high hazard zone for dune-backed beaches was based on a large storm wave event coincident with a 3.3 ft storm surge. The high hazard zone for bluff-backed shorelines was based on only a relatively low mean rate of gradual erosion. The "active hazard zone" defined within the study was also included in the high hazard zone. The moderate hazard zone for dune-backed beaches was based on an extremely severe storm event coupled with a 5.6 ft storm surge and 1.3 ft sea level rise (SLR). The same zone for bluff-backed shorelines was based on an average amount of bluff retreat. The low hazard zone for dune-backed beaches was based on the same scenario as the moderate hazard but incorporating a 3.3 ft subsidence from a CSZ event. The low hazard for bluff-backed shorelines was based on a maximum bluff slope failure and gradual bluff retreat after 100 years (Priest and Allan, 2004; Witter and others, 2007).

We overlaid buildings and critical facilities on the coastal erosion hazard zones to assess the exposure for each community. The total dollar value of exposed buildings the study area is reported below. We also estimated the number of people threatened by coastal erosion. Land value losses due to coastal erosion were not examined for this project.

3.6.2 Countywide results

Coastal erosion, for obvious reasons, affects only communities and areas along the open coast of Lincoln County. Coastal communities in Lincoln County all have some level of exposure to coastal erosion. The steep nature of the dunes and bluffs adjacent to the ocean offers dramatic scenery but also contributes to coastal erosion hazards.

The moderate hazard category (5.6 ft storm surge and 1.3 ft SLR) was chosen as the primary scenario for this report because it fits best for long-term planning purposes: The moderate hazard zone represents an area of a reasonable level of probability with a high level of impact to a community.

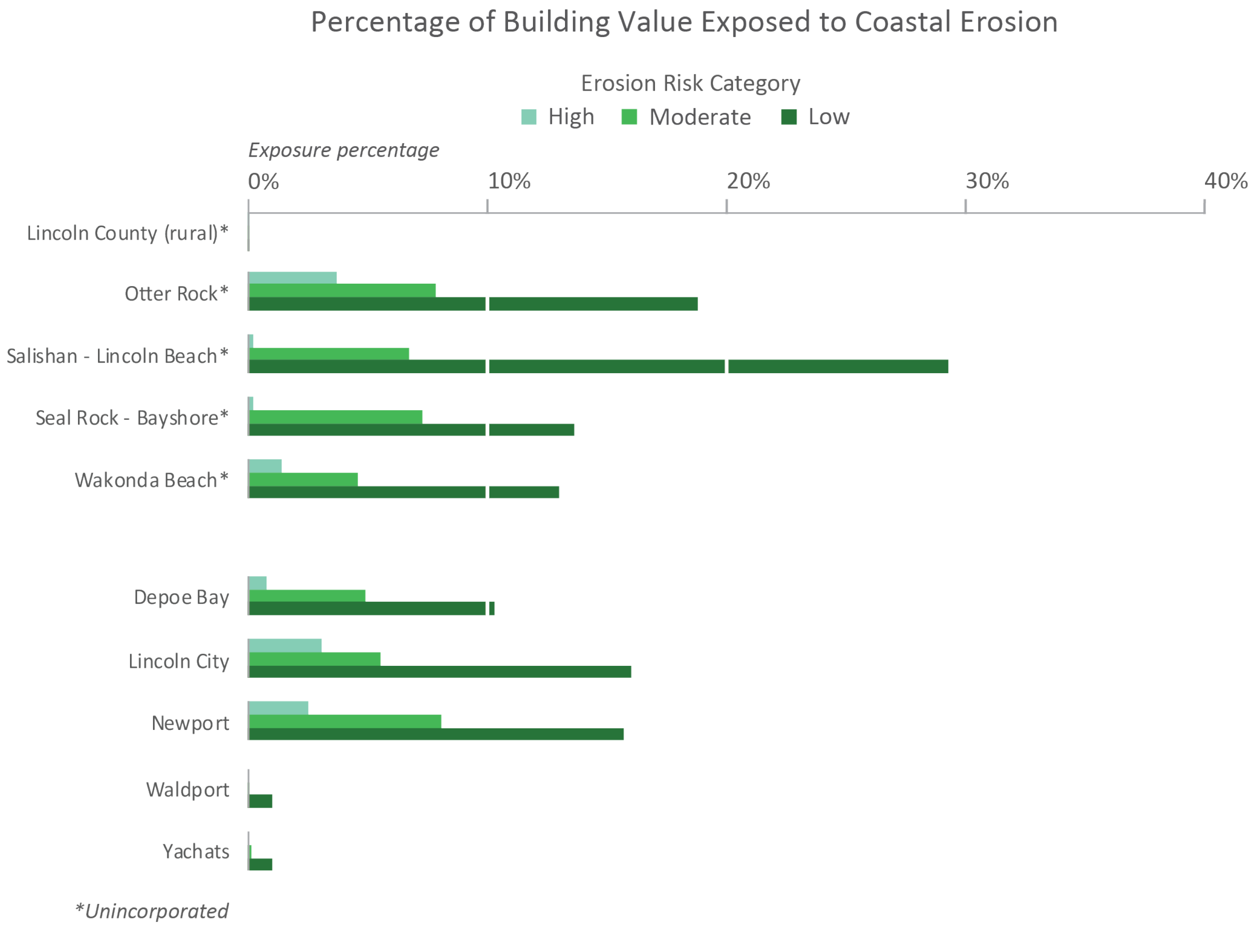
For this risk assessment, we limited the results of the exposure analysis to the communities included in the reports by Priest and Allan (2004) and Witter and others (2007), which are those communities along the coast with dune-backed beaches. The "percentage of exposure value" is the percentage of exposed building value relative to the total building value of the communities within the study areas. We did not include building value from communities outside the study areas in this calculation. See **Appendix B: Detailed Risk Assessment Tables** for multi-scenario analysis results.

Lincoln County coastal communities coastal erosion exposure (Moderate hazard):

- Number of buildings: 876
- Exposure value: $238,205,000
- Percentage of exposure value: 5.1%
- Critical facilities exposed: 0
- Potentially displaced population: 559

With the exceptions are Waldport and Yachats, most coastal communities and unincorporated areas of Lincoln County have a high level of exposure to coastal erosion. These threatened communities have between 5% to 8% of their overall building value exposed to moderate coastal erosion hazard. Awareness of this hazard is beneficial for reducing risk for future developments along Lincoln County's coastline. Long-term community plans that make allowance for coastal erosion encourage more resilience within the community. Figure 3-9 illustrates the distribution of losses due to coastal erosion with the different communities of Lincoln County.

Figure 3-9. Coastal erosion exposure by Lincoln County community.



Note: Beyond the designated communities, in unincorporated Lincoln County, building values total $75 million in areas of high coastal erosion hazard, $238 million in areas of moderate hazard, and $594 million in areas of low hazard.

3.6.3 Areas of vulnerability or risk

We identified locations within the study area that are comparatively more vulnerable or at greater risk to coastal erosion hazard:

- Almost every building built adjacent to the shoreline in Lincoln County has some exposure to coastal erosion. During times of high tide occurring along with powerful storms, the rate of erosion can greatly increase.
- Coastal erosion risk is particularly high for the communities of Newport and Otter Rock.

3.7 Wildfire

Wildfires are a natural part of the ecosystem in Oregon. However, wildfires can present a substantial hazard to life and property in growing communities, because communities often grow in the transition areas between developed areas and undeveloped areas, commonly called the wildland-urban interface (WUI) (Sanborn Map Company, Inc., 2013). The most common wildfire conditions include hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation). Once a fire has started, its behavior is influenced by numerous conditions, including fuel, topography, weather, drought, and development (Sanborn Map Company, Inc., 2013). Post-wildfire geologic hazards can also present risk. These usually include flooding, debris flows, and landslides. Post-wildfire geologic hazards were not evaluated in this project.

There is potential for losses due to WUI fires in Lincoln County. According to the Lincoln County NHMP, dozens of fires occur each year throughout Lincoln, Benton, Polk, and Yamhill counties, but the two most significant fires in Lincoln County both occurred in the mid-1800s (OPDR, 2015). In an effort to limit exposure to wildfire, the Lincoln County Comprehensive Plan provides guidance on reducing risk to wildfire (Lincoln County Planning Commission, 2009). Contact the Lincoln County Department of Planning and Development for specific requirements related to the county's comprehensive plan.

3.7.1 Data sources

The West Wide Wildfire Risk Assessment (WWA; Sanborn Map Company, 2013) is a comprehensive report that includes a database developed over the course of several years for 17 Western states and some Pacific Islands. The steward of this database in Oregon is the Oregon Department of Forestry (ODF). The database was created to assess the level of risk residents and structures have to wildfire. For this project, the Fire Risk Index (FRI) dataset, a dataset included in the WWA database, was used to measure the level of risk to communities in Lincoln County.

Using guidance from ODF, we categorized the FRI into low, moderate, and high hazard zones for the wildfire exposure analysis. The hazard zones are based on a combination of the impacts of wildfire (Fire Effects Index) and the probability of wildfire (Fire Threat Index). Both indices are the result of an integration of several input datasets. Broadly, the Fire Effects Index is based on potentially impacted assets and the difficulty of suppression. The components that make up the Fire Threat Index are fire occurrence, fire behavior, and fire suppression effectiveness (Sanborn Map Company, Inc., 2013).

We overlaid the buildings layer and critical facilities on each of the wildfire hazard zones to determine exposure. In certain areas no wildfire data is present which indicates areas that have minimal risk to wildfire hazard (see **Table B-8**). The total dollar value of exposed buildings the study area is reported below. We also estimated the number of people threatened by wildfire. Land value losses due to wildfire were not examined for this project.

3.7.2 Countywide results

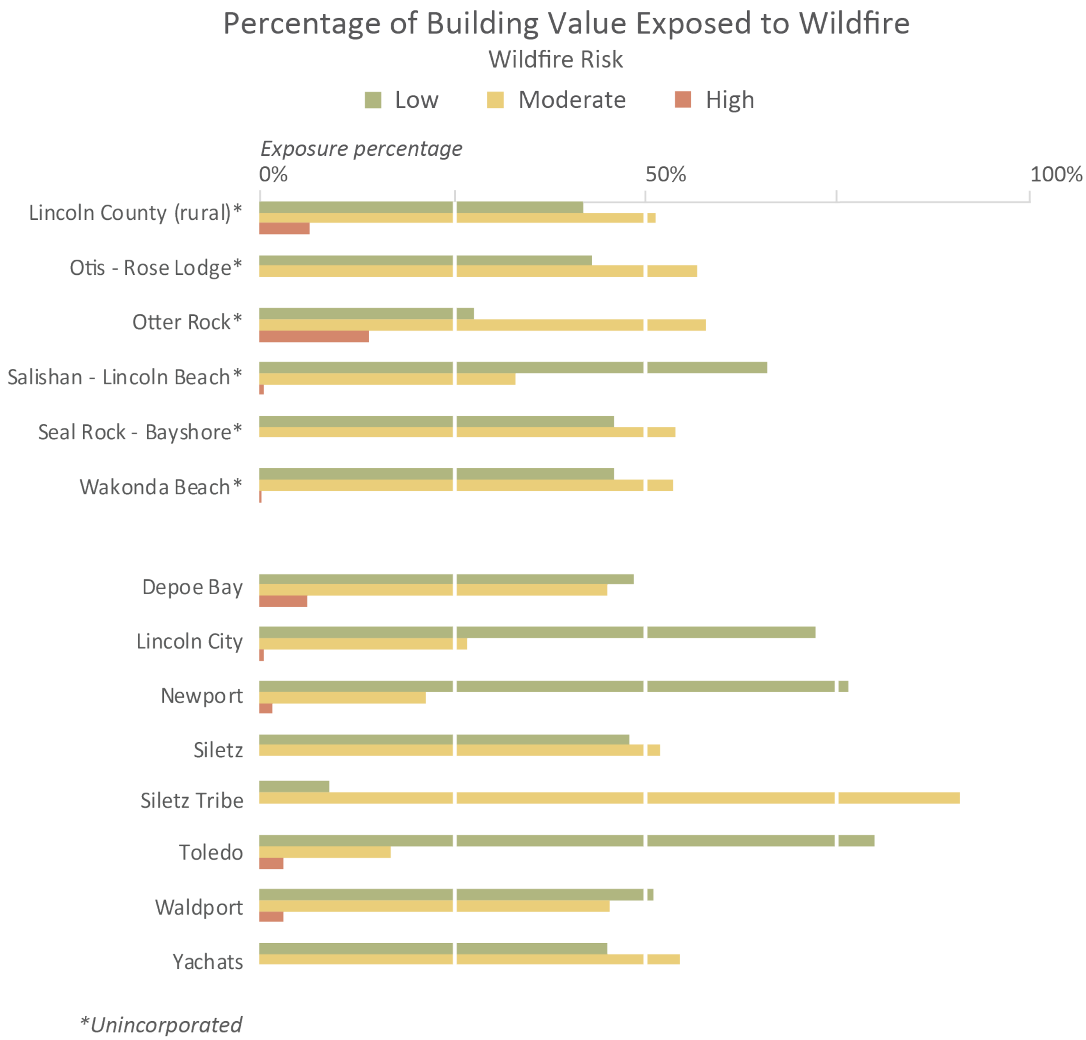
The high hazard category was chosen as the primary scenario for this report because that category represents areas that have the highest potential for losses. However, a large amount of loss would occur if the moderate hazard areas were to burn, as almost every community has ~30–60% of exposure to moderate wildfire hazard. Still, the focus of this section is on high hazard areas within Lincoln County to emphasize the areas where lives and property are most threatened.

Lincoln countywide wildfire exposure (High hazard):

- Number of buildings: 1,475
- Exposure value: $129,840,000
- Percentage of exposure value: 2.5%
- Critical facilities exposed: 5
- Potentially displaced population: 1,316

For this risk assessment, building locations were compared to the geographic extent of the wildfire hazard categories. We found that most communities in Lincoln County are not exposed to high wildfire hazard. The primary areas of exposure to this hazard are in the forested unincorporated areas of the county (see Appendix E, **Plate 7**). The community of Otter Rock and, to a certain extent, Depoe Bay are at a higher risk to wildfire than other communities in the county. **Figure 3-10** illustrates the distribution of losses due to wildfire with the different communities of Lincoln County. See **Appendix B: Detailed Risk Assessment Tables** for multi-scenario analysis results.

Figure 3-10. Wildfire hazard exposure by Lincoln County community.



3.7.3 Areas of vulnerability or risk

We identified locations within the study area that are comparatively more vulnerable or at greater risk to wildfire hazard:

- Wildfire risk is high for hundreds of homes in the forested areas in the eastern portion of unincorporated Lincoln County (rural).
- At the time of writing, the 2020 Echo Mountain is an active wildfire and has already burned a very large area in and around the communities of Otis and Rose Lodge. This wildfire was not specifically examined in this report, but areas near the burn will be at risk to indirect hazards such as post-wildfire debris flows, rock falls, and flash flooding.

4.0 CONCLUSIONS

The purpose of this study is to provide a better understanding of potential impacts from multiple natural hazards at the community scale. We accomplish this by using the latest natural hazard mapping and loss estimation tools to quantify expected damage to buildings and potential displacement of permanent residents. The comprehensive and fine-grained approach to the analysis provides new context for the county's risk reduction efforts. We note several important findings based on the results of this study:

- **Extensive overall damage and loses are expected from a Cascadia M9.0 earthquake and tsunami** – Due to its proximity to the CSZ, every community in Lincoln County will experience significant impact and disruption from a CSZ M9.0 earthquake event. Event impacts that were examined are limited to earthquake (including liquefaction and coseismic landslides) and tsunami. Results show that a CSZ M9.0 event will cause building losses of 30% to 50% across all communities. Some communities like Newport and Wakonda Beach can expect a high percentage of losses due to tsunami hazard. Other communities like the City of Toledo have little to no tsunami exposure but still will have high losses from earthquake alone. The high vulnerability of the building inventory (primarily because of the age of construction), the proximity to the CSZ event, and the amount of development within tsunami zones all contribute to the estimated levels of losses expected in the study area.
- **Retrofitting buildings to modern seismic building codes can reduce damages and losses from earthquake shaking** – Seismic building codes have a major influence on earthquake shaking damage estimated by Hazus-MH, a software tool developed by the Federal Emergency Management Agency (FEMA) for calculating loss from natural hazards. We examined potential loss reduction from seismic retrofits (modifications that improve building's seismic resilience) in simulations by using Hazus-MH building code "design level" attributes of pre, low, moderate, and high codes (FEMA, 2012b) in CSZ earthquake scenarios. The simulations were accomplished by upgrading every pre (non-existent) and low seismic code building to moderate seismic code levels in one scenario, and then by upgrading all buildings to high (current) code in another scenario. We found that retrofitting to at least moderate code was the most cost-effective mitigation strategy because the additional benefit from retrofitting to high code was minimal. In our simulation of upgrading buildings to at least moderate code, the estimated loss for the entire study area was reduced from 23% to 16%. We found further reduction in estimated loss in our simulation to 13% only by upgrading all buildings to high code. Some communities would see greater loss reduction than the county as a whole due to older building stock constructed at pre or low code seismic building code standards. An example is the City of Newport, where a significant loss reduction (from 24% to 14%) could occur by retrofitting all buildings to at least moderate code. This stands in contrast to a community with younger building stock, such as Depoe Bay, which would see loss reduction go from 20% to 14%. While seismic retrofits are an effective strategy for reducing earthquake shaking damage, it should be noted that earthquake-induced tsunami, landslide, and liquefaction hazards will also be present in some areas, and these hazards require different geotechnical mitigation strategies. Future research focused on tsunami, landslide, and liquefaction hazard specific risk assessments are areas needing a clear understanding of the hazard to inform local decision-makers.
- **Flooding is a recurrent problem for many communities in Lincoln County** – Many buildings within the floodplain are vulnerable to significant damage from flooding. At first glance, Hazus-MH flood loss estimates may give a false impression of risk because they show lower damages for

a community relative to other hazards we examined. This is due to the difference between loss estimation and exposure results, as well as the limited area impacted from flooding. Another consideration is that flood is one of the most frequently occurring natural hazard. An average of 12% loss was calculated when looking at just the buildings within the 100-year flood zone. The areas that are most vulnerable to flood hazard within the study are residential buildings along the Siletz River and developed portions of the City of Toledo along the river.

- **Elevating structures in the flood zone reduces vulnerability** – Flood exposure analysis was used in addition to Hazus-MH loss estimation to identify buildings that were not damaged but that were within the area expected to experience a 100-year flood. By using both analyses in this way, the number of elevated structures within the flood zone could be quantified. This showed possible mitigation needs in flood loss prevention and the effectiveness of past activities. For example, in the community of Lincoln City nearly half of the buildings exposed to flooding are elevated above the base flood elevation (BFE). Based on the number of buildings exposed to flooding, the Cities of Toledo and Siletz would benefit more from elevating buildings than other communities in the county.
- **New landslide mapping would increase the accuracy of future risk assessments** – The landslide hazard data used in this risk assessment were created before modern mapping technology; future risk assessments using lidar-derived landslide hazard data would provide more accurate results. Exposure analysis was used to assess the threat from landslide hazard. Landslide is a widespread hazard and is present for some communities within the county. The communities of Otis-Rose Lodge, Lincoln City, Toledo, and Yachats have areas that are exposed to high or very high landslide susceptibility.
- **Exposure analysis shows that most communities along the open coast are at risk to coastal erosion hazard -** Exposure analysis shows that nearly the entire developed coastline in Lincoln County is vulnerable to coastal erosion hazard. The communities of Newport and Otter Rock, for example, have approximately 8% of their total building value exposed to moderate coastal erosion hazard.
- **Wildfire risk is moderate for the overall study area** – Exposure analysis shows that buildings in the eastern part of the county are at high risk to wildfire hazard. High wildfire hazard is primarily limited to heavily forested rural areas and along both the Alsea and Yaquina Rivers. However, moderate wildfire hazard is present throughout the county and so is a potential threat for communities.
- **Most of the study area's critical facilities are at high risk to a CSZ earthquake and tsunami** – Critical facilities were identified and were specifically examined within this report. We have estimated that 78% of Lincoln County's 72 critical facilities will be non-functioning after a CSZ event. In comparison, 29% (21) of critical facilities are at risk to landslide hazard. A small number of critical facilities are at risk to flooding (3) and wildfire (5).
- **The two biggest causes of displacement to population are a CSZ event (earthquake and tsunami) and landslide** – Displacement of permanent residents from natural hazards was quantified within this report. We estimated that 30% of the population in the county to be displaced due to the combination of earthquake and tsunami. Landslide hazard is a potential threat to 32% of permanent residents and 5% are vulnerable to flood hazard. A small percentage of residents are at risk to displacement from wildfire and coastal erosion.
- **The results allow communities the ability to compare across hazards and prioritize their needs** – Each community within the study area was assessed for natural hazard exposure and

loss. This allowed for comparison of risk between communities and impacts from each natural hazard. In using Hazus-MH and exposure analysis, these results can assist in developing plans that address the concerns for those individual communities.

5.0 LIMITATIONS

There are several limitations to keep in mind when interpreting the results of this risk assessment.

- **Spatial and temporal variability of natural hazard occurrence** – Flood, landslide, coastal erosion, and wildfire are extremely unlikely to occur across the fully mapped extent of the hazard zones. For example, areas mapped in the 1% annual chance flood zone will be prone to flooding on occasion in certain watersheds during specific events, but not all at once throughout the entire county or even the entire community. While we report the overall impacts of a given hazard scenario, the losses from a single hazard event probably will not be as severe and widespread. An exception to this is earthquake ground-shaking, which is expected to impact the entire study area, and loss estimates for this hazard are based on a single event.
- **Loss estimation for individual buildings** – Hazus-MH is a model, not reality, which is an important factor when considering the loss ratio of an individual building. Hazus-MH does not provide a site-specific analysis. On-the-ground mitigation, such as elevation of buildings to avoid flood loss, has been only minimally captured. Also, due to a lack of building material information, assumptions were made about the distribution of wood, steel, and un-reinforced masonry buildings. Loss estimation is most insightful when individual building results are aggregated to the community level because it reduces the impact of data outliers.
- **Loss estimation versus exposure** – We recommend careful interpretation of exposure results. This is due to the spatial and temporal variability of natural hazards (described above) and the inability to perform loss estimations due to the lack of Hazus-MH damage functions. Exposure is reported in terms of total building value, which could imply a total loss of the buildings in a particular hazard zone, but this is not the case. Exposure is simply a calculation of the number of buildings and their value and does not make estimates about the level to which an individual building could be damaged. We note the tsunami hazard as a possible exception, given the extreme and widespread damage to buildings in recent events in Japan and Sumatra.
- **Population variability** – Many coastal communities in Lincoln County are popular vacation destinations, particularly during the summer. Our estimates of potentially displaced people rely on permanent populations published in the 2010 U.S. Census (U.S. Census Bureau, 2010b). As a result, we are underestimating the number of people that may be at risk to hazards, especially during periods of high temporary population.
- **Data accuracy and completeness** – Some datasets in our risk assessment had incomplete coverage or no high-resolution data within the study area. We used lower-resolution data to fill gaps where there was incomplete coverage or where high-resolution data were not available. Assumptions to amend areas of incomplete data coverage were made based on reasonable methods described within this report. However, we are aware that some uncertainty has been introduced from these data amendments at an individual building scale. At community-wide scales the effects of the uncertainties are slight. Data layers in which assumptions were made to fill gaps are building footprints, population, some attributes derived from the assessor database, and landslide susceptibility. Many of the datasets included known or suspected artifacts,

omissions and errors, identifying or repairing these problems was beyond the scope of the project and are areas needing additional research.

6.0 RECOMMENDATIONS

The following areas of research are needed to better understand hazards and reduce risk to natural hazard through mitigation planning. These research areas, while not comprehensive, touch on all phases of risk management and focus on awareness and preparation, planning, emergency response, mitigation funding opportunities, and hazard-specific risk reduction activities.

6.1 Awareness and Preparation

Awareness is crucial to lowering risk and lessening the impacts of natural hazards. When community members understand their risk and know the role that they play in preparedness, the community in general is a much safer place to live. Awareness and preparation not only reduce the initial impact from natural hazards, they also reduce the amount of recovery time for a community to bounce back from a disaster—this ability is commonly referred to as “resilience.”

This report is intended to provide local officials a comprehensive and authoritative profile of natural hazard risk to underpin their public outreach efforts.

Messaging can be tailored to stakeholder groups. For example, outreach to homeowners could focus on actions they can take to reduce risk to their property. The DOGAMI Homeowners Guide to Landslides (https://www.oregongeology.org/Landslide/ger_homeowners_guide_landslides.pdf) provides a variety of risk reduction options for homeowners who live in high landslide susceptibility areas. This guide is one of many existing resources. Agencies partnering with local officials in the development of additional effective resources could help reach a broader community and user groups.

6.2 Planning

Information presented here are available for local decision-makers in developing their local plans and help identify geohazards and associated risks to the community. The primary framework for accomplishing this is through the comprehensive planning process. The comprehensive plan sets the long-term trajectory of capital improvements, zoning, and urban growth boundary expansion, all of which are planning tools that can be used to reduce natural hazard risk.

Another framework is the natural hazard mitigation plan (NHMP) process. NHMP plans focus on characterizing natural hazard risk and identifying actions to reduce risk. Additionally, the information presented here can be a resource when updating the mitigation actions and inform the vulnerability assessment section of the NHMP plan.

While there are many similarities between this report and an NHMP, the hazards or critical facilities in the two reports can vary. Differences between the reports may be due to data availability or limited methodologies for specific hazards. The critical facilities considered in this report may not be identical to those listed in a typical NHMP due to the lack of damage functions in Hazus-MH for non-building structures and to different considerations about emergency response during and after a disaster.

6.3 Emergency Response

Critical facilities will play a major role during and immediately after a natural disaster. This study can help emergency managers identify vulnerable critical facilities and develop contingencies in their response plans. Additionally, detailed mapping of potentially displaced residents can be used to re-evaluate evacuation routes and identify vulnerable populations to target for early warning. At the time of writing, DOGAMI is producing a series of tsunami evacuation maps for recommended pedestrian travel speeds to reach tsunami evacuation zones. The product is called “Beat the Wave” and will be available soon for communities in Lincoln County.

The building database that accompanies this report presents many opportunities for future pre-disaster mitigation, emergency response, and community resilience improvements. Vulnerable areas can be identified and targeted for awareness campaigns. These campaigns can be aimed at pre-disaster mitigation through, for example, improvements of the structural connection of the frame to the foundation. Emergency response entities can benefit from the use of the building dataset through identification of potential hazards and populated buildings before and during a disaster. Both reduction of the magnitude of the disaster and increase in the response time contribute to a community’s overall resilience.

6.4 Mitigation Funding Opportunities

Several funding options are available to communities that are susceptible to natural hazards and have specific mitigation projects they wish to accomplish. State and federal funds are available for projects that demonstrate cost effective natural hazard risk reduction. The Oregon Office of Emergency Management (OEM) State Hazard Mitigation Officer (SHMO) can provide communities assistance in determining eligibility, finding mitigation grants, and navigating the mitigation grant application process.

At the time of writing this report, FEMA has two programs that assist with mitigation funding for natural hazards: Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM) Grant Program. FEMA also has a grant program specifically for flooding called Flood Mitigation Assistance (FMA). The SHMO can help with finding further opportunities for earthquake and tsunami assistance and funding.

6.5 Hazard-Specific Risk Reduction Actions

6.5.1 CSZ M9.0 Earthquake

- Evaluate critical facilities for seismic preparedness by identifying structural deficiencies and vulnerabilities to dependent systems (e.g., water, fuel, power).
- Evaluate vulnerabilities of critical facilities. We estimate that 78% of critical facilities (**Appendix A: Community Risk Profiles**) will be damaged by the CSZ event, which will have many direct and indirect negative effects on first-response and recovery efforts.
- Identify communities and buildings that would benefit from seismic upgrades.

6.5.2 Tsunami

- Use approved guides on preparing for tsunamis (e.g., DLCD guide on preparing for the CSZ tsunami) http://www.oregon.gov/LCD/OCMP/docs/Publications/TsunamiGuide20170130.pdf

- Evaluate the community evacuation plan, including consideration for viable vertical evacuation options.

6.5.3 Flood

- Map areas of potential flood water storage areas.
- Identify structures that have repeatedly flooded in the past and would be eligible for FEMA's "buyout" program.

6.5.4 Landslide

- Create modern landslide inventory and susceptibility maps.
- Monitor ground movement in high susceptibility areas.
- Consider land value losses due to landslide in future risk assessments.

6.5.5 Coastal erosion

- Monitor ground movement in high susceptible areas, especially during or after large storms.
- Monitor erosion control structures that are already in place.
- Identify critical facilities and infrastructure near high coastal erosion areas.
- Consider land value losses due to coastal erosion in future risk assessments.

6.5.6 Wildfire related to geologic hazards

- Evaluate post-wildfire geologic hazards including flood, debris flows, and landslides.

7.0 ACKNOWLEDGMENTS

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8.0 REFERENCES

Allan, J. C., Ruggiero, P., Cohn, N., Garcia, G., O'Brien, F. E., Serafin, K., Stimely, L. L., and Roberts, J. T., 2015, Coastal flood hazard study, Lincoln County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-15-06, 351 p. https://www.oregongeology.org/pubs/ofr/p-O-15-06.htm

Applied Technology Council, 2015, Rapid visual screening of buildings for potential seismic hazards: a handbook (3rd ed.): Redwood City, Calif., FEMA Publication 154. https://www.fema.gov/media-library-data/1426210695633-d9a280e72b32872161efab26a602283b/FEMAP-154_508.pdf

Bauer, J. M., Burns, W. J., and Madin, I. P., 2018, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-18-02, 96 p. https://www.oregongeology.org/pubs/ofr/p-O-18-02.htm

Burns, W. J., and Watzig, R. J., 2014, Statewide landslide information layer for Oregon, release 3 [SLIDO-3.0]: Oregon Department of Geology and Mineral Industries, 35 p., 1 pl., 1:750,000, geodatabase.

Burns, W. J., Mickelson, K. A., and Madin, I. P., 2016, Landslide susceptibility overview map of Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-16-02, 48 p. https://www.oregongeology.org/pubs/ofr/p-O-16-02.htm

Business Oregon, 2015, Oregon benefit-cost analysis tool for evaluation of seismic rehabilitation grant program applications: user's guide: Salem, Oreg., Infrastructure Finance Authority Division, 34 p. http://www.orinfrastructure.org/assets/apps/IFA/2015Oregon-SRGP/BCAusersGuideAppend.pdf

Clague, J. J., Atwater, B. F., Wang, K., Wang, Y., and Wong, I., (compilers), 2000, Penrose Conference 2000: Great Cascadia Earthquake Tricentennial: Oregon Department of Geology and Mineral Industries Special Paper 33, 156 p. https://www.oregongeology.org/pubs/sp/SP-33.pdf

Federal Emergency Management Agency, 2012a, Hazus®-MH 2.1 User manual, Flood model: Washington, D.C., 382 p. https://www.fema.gov/media-library-data/20130726-1820-25045-8814/hzmh2_1_fl_um.pdf

Federal Emergency Management Agency, 2012b, Hazus®-MH 2.1 Technical manual, Earthquake model: Washington, D.C., 718 p. https://www.fema.gov/media-library-data/20130726-1820-25045-6286/hzmh2_1_eq_tm.pdf

Federal Emergency Management Agency, 2012c, Hazus®-MH 2.1, Technical manual, Flood model: Washington, D.C., 569 p. https://www.fema.gov/media-library-data/20130726-1820-25045-8292/hzmh2_1_fl_tm.pdf

Federal Emergency Management Agency, 2013, NFIP flood studies and maps, unit 3 *in* Managing floodplain development through the National Flood Insurance Program (Home Study Course): Washington, D.C., 59 p. https://www.fema.gov/media-library-data/20130726-1535-20490-4172/unit3.pdf

Federal Emergency Management Agency, 2015, Hazus-MH software: FEMA's tool for estimating potential losses from natural disasters, version 3.0. https://www.fema.gov/media-library-data/1450218789512-a8b8b9976c9b2da6beb200555336004a/Hazus_3.0_USER_Release_Notes_v0.5.pdf

Federal Emergency Management Agency, 2019, Flood insurance study: Lincoln County, Oregon and incorporated areas: Washington D.C., Flood Insurance Study Number: 41041CV001B v. 1, 102 p. https://map1.msc.fema.gov/data/41/S/PDF/41041CV001B.pdf?LOC=d6d424b167952409eabc338441d39957

Judson, S., 2012, Earthquake design history: a summary of requirements in the State of Oregon: State of Oregon, Building Codes Division, Feb. 7, 2012, 7 p. http://www.oregon.gov/bcd/codes-stand/Documents/inform-2012-oregon-sesmic-codes-history.pdf

Lewis, D., 2007, Statewide seismic needs assessment: Implementation of Oregon 2005 Senate Bill 2 relating to public safety, earthquakes, and seismic rehabilitation of public buildings: Oregon Department of Geology and Mineral Industries Open-File Report O-07-02, 140 p. https://www.oregongeology.org/pubs/ofr/p-O-07-02.htm

Lincoln County Planning Commission, 2009, Lincoln County comprehensive plan and zoning code, Chapter 1, 145 p. https://scholarsbank.uoregon.edu/xmlui/handle/1794/9454

Madin, I. P., and Burns, W. J., 2013, Ground motion, ground deformation, tsunami inundation, coseismic subsidence, and damage potential maps for the 2012 Oregon Resilience Plan for Cascadia subduction zone earthquakes: Oregon Department of Geology and Mineral Industries Open-File Report O-13-06, 36 p. 38 pl., GIS data. https://www.oregongeology.org/pubs/ofr/p-O-13-06.htm

Oregon Building Codes Division, 2002, Oregon manufactured dwelling and park specialty code, 2002 ed.: Oregon Manufactured Housing Association and Oregon Building Codes Division, Department of Consumer and Business Services, 176 p. http://www.oregon.gov/bcd/codes-stand/Documents/md-2002-mdparks-code.pdf

Oregon Building Codes Division, 2010, 2010 Oregon manufactured dwelling installation specialty code: Department of Consumer and Business Services, Building Codes Division, 67 p. http://www.oregon.gov/bcd/codes-stand/Documents/md-2010omdisc-codebook.pdf

Oregon Partnership for Disaster Resilience, 2015, Lincoln County multi-jurisdictional natural hazards mitigation plan: Eugene, Oreg., University of Oregon, Community Service Center, 900 p. http://www.co.lincoln.or.us/sites/default/files/fileattachments/planning_amp_development/page/4161/lincoln_nhmp_2015.pdf

Peterson, C. D., Barnett, E. T., Briggs, G. G., Carver, G. A., Clague, J. J., and Darienzo, M. E., 1997, Estimates of coastal subsidence from great earthquakes in the Cascadia subduction zone, Vancouver Island, B.C., Washington, Oregon, and northernmost California: Oregon Department of Geology and Mineral Industries Open-File Report O-97-05, 44 p. https://www.oregongeology.org/pubs/ofr/O-97-05.pdf

Priest, G. R., and Allan, J. C., 2004, Evaluation of coastal erosion hazard zones along dune and bluff backed shorelines in Lincoln County Oregon: Cascade Head to Seal Rock - Technical report to Lincoln County: Oregon Department of Geology and Mineral Industries Open-File Report O-04-09, 188 p. https://www.oregongeology.org/pubs/ofr/O-04-09.zip

Priest, G. R., Witter, R. C., Zhang, Y. J., Wang, K., Goldfinger, C., Stimely, L. L., English, J. T., Pickner, S. P., Hughes, K. L. B., Wille, T. E., and Smith, R. L., 2013, Tsunami inundation scenarios for Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-13-19, 18 p., GIS data. https://www.oregongeology.org/pubs/ofr/p-O-13-19.htm

Sanborn Map Company, Inc., 2013, The West Wide Wildfire Risk Assessment, final report: report to Oregon Department of Forestry and others, March 31, 2013, 105 p. https://www.thewflc.org/sites/default/files/WWA_FinalReport_3-6-2016-1.pdf

Stimely, L., and Allan, J. C., 2014, Evaluation of erosion hazard zones for the dune-backed beaches of Tillamook County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-14-02, 113 p., geodatabase. http://www.oregongeology.org/pubs/ofr/p-O-14-02.htm

U.S. Census Bureau, 2010a, Master Address File/Topologically Integrated Geographic Encoding and Referencing system or database: Oregon census block. ftp://ftp2.census.gov/geo/tiger/TIGER2010BLKPOPHU/tabblock2010_41_pophu.zip

U.S. Census Bureau, 2010b, American FactFinder: Profile of General Population and Housing Characteristics: U.S. Census Bureau, accessed March 14, 2018. https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml

U.S. Geological Survey, 2017, Earthquake hazards 101 — the basics, web page. Retrieved from https://earthquake.usgs.gov/hazards/learn/basics.php

Wang, Y., and Clark, J. L., 1999, Earthquake damage in Oregon: Preliminary estimates of future earthquake losses: Oregon Department of Geology and Mineral Industries Special Paper 29, 59 p. https://www.oregongeology.org/pubs/sp/SP-29.pdf

Witter, R. C., Allan, J. C., and Priest, G. R., 2007, Evaluation of coastal erosion hazard zones along dune and bluff backed shorelines in Lincoln County, Oregon: Seal Rock to Cape Perpetua: Oregon Department of Geology and Mineral Industries Open-File Report O-07-03, 42 p. https://www.oregongeology.org/pubs/ofr/O-07-03.zip

Witter, R. C., Zhang, Y., Wang, K., Priest, G. R., Goldfinger, C., Stimely, L. L., English, J. T., and Ferro, P. A., 2011, Simulating tsunami inundation at Bandon, Coos County, Oregon, using hypothetical Cascadia and Alaska earthquake scenarios: Oregon Department of Geology and Mineral Industries Special Paper 43, 57 p. https://www.oregongeology.org/pubs/sp/p-SP-43.htm

Witter, R. C., Zhang, Y., Wang, K., Priest, G. R., Goldfinger, C., Stimely, L. L., English, J. T., and Ferro, P. A., 2013, Simulating tsunami inundation for a range of Cascadia megathrust earthquake scenarios at Bandon, Oregon, USA: Geosphere, v. 9, no. 6, 1783–1803. https://doi.org/10.1130/GES00899.1

9.0 APPENDICES

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APPENDIX A. COMMUNITY RISK PROFILES

A hazard analysis summary for each community is provided in this section to encourage ideas for natural hazard risk reduction. Increasing disaster preparedness, public hazards communication, and education, ensuring functionality of emergency services, and ensuring access to evacuation routes are actions that every community can take to reduce their risk. This appendix contains community specific data to provide an overview of the community and the level of risk from each natural hazard analyzed. In addition, for each community a list of critical facilities and assumed impact from individual hazards is provided.

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A.1 Unincorporated Lincoln County (Rural)

Table A-1. Unincorporated Lincoln County hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Unincorporated Lincoln County	10,292	12,637	12	824,038,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	963	9.4%	1,467	2	15,579,000	1.9%
*Earthquake**	*CSZ M9.0 Deterministic*	2,374	23%	4,386	9	197,815,000	24%
Earthquake (within Tsunami Zone)		151	1.5%	382	1	39,210,000	4.7%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	459	4.5%	808	1	84,583,000	10%
Tsunami	Senate Bill 379 Regulatory Line	466	4.5%	864	0	59,132,000	7.2%
Landslide	High and Very High Susceptibility	4,530	44%	5,135	3	354,114,000	43%
Coastal Erosion	Moderate Hazard	0	0.0%	2	0	197,000	0.0%
Wildfire	High Hazard	725	7.0%	915	3	53,619,000	6.5%

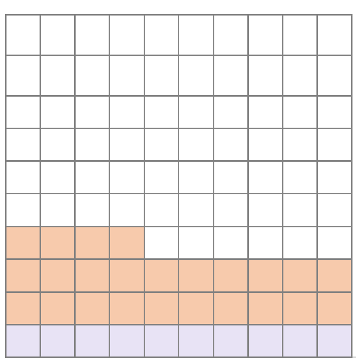
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-1.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-1. Unincorporated Lincoln County loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-2. Unincorporated Lincoln County critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
	Exposed	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**	**Exposed**
Central Oregon Coast Fire Station 7300	—	X	—	X	—	—
Central Oregon Coast Fire Station 7400	—	—	—	—	—	—
Eddyville Charter School	—	X	—	—	—	—
North Lincoln Fire Station 1200	—	X	—	—	—	—
North Lincoln Fire Station 1300	—	X	—	—	—	—
North Lincoln Fire Station 1700	X	X	—	—	X	—
Seal Rock Fire Station	—	X	—	—	—	—
Siletz Bay State Airport	—	X	—	—	X	—
Siletz Valley Fire Station 5300	—	—	—	—	—	—
Toledo High School	—	X	—	X	X	—
Toledo State Airport	X	X	X	—	—	—
Waldport Water Treatment Plant	—	X	—	X	—	—

A.2 Unincorporated Community of Otis-Rose Lodge

Table A-3. Unincorporated community of Otis-Rose Lodge hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Otis-Rose Lodge	1,926	1,747	0	67,662,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	127	6.6%	81	0	300,000	0.4%
*Earthquake**	*CSZ M9.0 Deterministic*	746	39%	871	0	23,949,000	35%
Earthquake (within Tsunami Zone)		0	0.0%	0	0	0	0.0%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	0	0.0%	0	0	0	0.0%
Tsunami	Senate Bill 379 Regulatory Line	0	0.0%	0	0	0	0.0%
Landslide	High and Very High Susceptibility	666	35%	602	0	21,495,000	32%
Coastal Erosion	Moderate Hazard	0	0.0%	0	0	0	0.0%
Wildfire	High Hazard	0	0.0%	0	0	0	0.0%

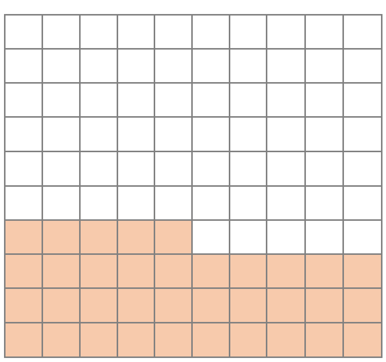
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-2.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-2. Unincorporated community of Otis-Rose Lodge loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Note: the unincorporated community of Otis-Rose Lodge has no identified critical facilities.

A.3 Unincorporated Community of Otter Rock

Table A-4. Unincorporated community of Otter Rock hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Otter Rock	489	634	2	81,971,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	0	0.0%	0	0	0	0.0%
*Earthquake**	*CSZ M9.0 Deterministic*	76	16%	202	1	19,891,000	24%
Earthquake (within Tsunami Zone)		5	0.9%	19	0	598,000	0.7%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	5	1.0%	22	0	829,000	1.0%
Tsunami	Senate Bill 379 Regulatory Line	6	1.2%	5	0	204,000	0.2%
Landslide	High and Very High Susceptibility	105	21%	168	0	23,648,000	29%
Coastal Erosion	Moderate Hazard	26	5.3%	55	0	6,469,000	7.9%
Wildfire	High Hazard	101	21%	133	0	11,658,000	14%

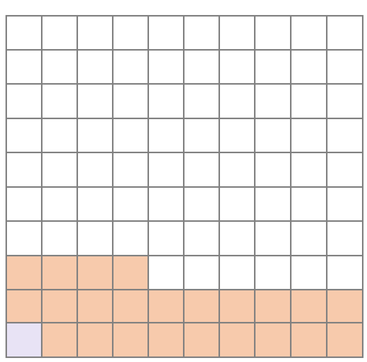
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-3.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-3. Unincorporated community of Otter Rock loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-5. Unincorporated community of Otter Rock critical facilities.

	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**	**Exposed**
Beverly Beach Water District	—	—	—	—	—	—
Depoe Bay Fire Station 2400	—	X	—	—	—	—

A.4 Unincorporated Community of Salishan-Lincoln Beach

Table A-6. Unincorporated community of Salishan-Lincoln Beach hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Salishan-Lincoln Beach	2,093	2,847	1	388,784,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	83	4.0%	66	0	4,838,000	1.2%
*Earthquake**	*CSZ M9.0 Deterministic*	465	22%	866	0	78,921,000	20%
Earthquake (within Tsunami Zone)		31	1.5%	52	0	20,370,000	5.2%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	118	5.7%	227	0	74,194,000	19%
Tsunami	Senate Bill 379 Regulatory Line	172	8.2%	367	0	79,451,000	20%
Landslide	High and Very High Susceptibility	256	12%	369	0	63,765,000	16%
Coastal Erosion	Moderate Hazard	39	1.8%	102	0	26,168,000	6.7%
Wildfire	High Hazard	42	2.0%	38	0	2,885,000	0.7%

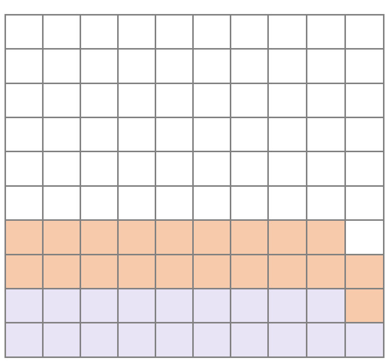
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-4.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" the level of flooding (base flood elevation).

Figure A-4. Unincorporated community of Salishan-Lincoln loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-7. Unincorporated community of Salishan-Lincoln critical facilities.

	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**	**Exposed**
Depoe Bay Fire Station 2200	—	—	—	—	—	—

A.5 Unincorporated Community of Seal Rock-Bayshore

Table A-8. Unincorporated Community of Seal Rock-Bayshore hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Seal Rock-Bayshore	2,766	3,345	2	347,085,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	43	1.6%	17	0	372,000	0.1%
*Earthquake**	*CSZ M9.0 Deterministic*	546	20%	968	0	61,629,000	18%
Earthquake (within Tsunami Zone)		44	1.6%	86	0	12,237,000	3.5%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	289	11%	450	0	65,926,000	19%
Tsunami	Senate Bill 379 Regulatory Line	309	11%	476	0	67,481,000	19%
Landslide	High and Very High Susceptibility	364	13%	445	1	55,334,000	16%
Coastal Erosion	Moderate Hazard	105	3.8%	155	0	25,329,000	7.3%
Wildfire	High Hazard	0	0.0%	0	0	0	0.0%

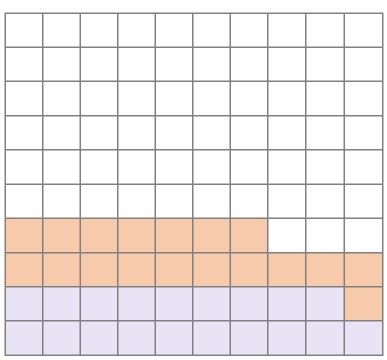
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-5.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-5. Unincorporated Community of Seal Rock-Bayshore loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-9. Unincorporated Community of Seal Rock-Bayshore critical facilities.

	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**	**Exposed**
Bayshore Station	—	—	—	—	—	—
Seal Rock Water District	—	—	—	X	—	—

A.6 Unincorporated Community of Wakonda Beach

Table A-10. Unincorporated Community of Wakonda Beach hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Wakonda Beach	1,326	1,614	2	122,717,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	41	3.1%	29	0	442,000	0.4%
*Earthquake**	*CSZ M9.0 Deterministic*	307	23%	414	2	20,339,000	17%
Earthquake (within Tsunami Zone)		70	5.3%	144	0	11,827,000	9.6%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	268	20%	506	0	49,025,000	40%
Tsunami	Senate Bill 379 Regulatory Line	350	26%	497	1	52,060,000	42%
Landslide	High and Very High Susceptibility	112	8.4%	108	1	7,879,000	6.4%
Coastal Erosion	Moderate Hazard	16	1.2%	44	0	5,629,000	4.6%
Wildfire	High Hazard	7	0.5%	5	0	292,000	0.2%

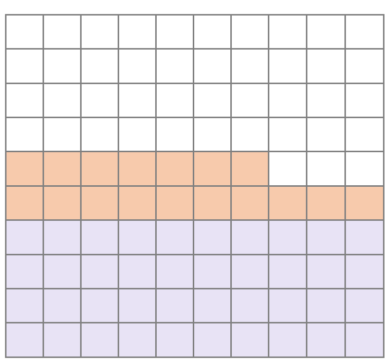
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-6.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Figure A-6. Unincorporated Community of Wakonda Beach loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-11. Unincorporated Community of Wakonda Beach critical facilities.

	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**	**Exposed**
Wakonda Beach Airport	—	X	—	—	—	—
Yachats Fire Station	—	X	—	X	—	—

A.7 Confederated Tribes of Siletz Indians

Table A-12. Confederated Tribes of Siletz Indians hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Confederated Tribes of Siletz Indians	488	184	8	49,797,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	0	0.0%	0	0	0	0.0%
*Earthquake**	*CSZ M9.0 Deterministic*	184	38%	86	6	13,013,000	26%
Earthquake (within Tsunami Zone)		0	0.0%	0	0	0	0.0%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	0	0.0%	0	0	0	0.0%
Tsunami	Senate Bill 379 Regulatory Line	0	0.0%	2	0	28,287,000	57%
Landslide	High and Very High Susceptibility	80	16%	21	0	2,746,000	5.5%
Coastal Erosion	Moderate Hazard	0	0.0%	0	0	0	0.0%
Wildfire	High Hazard	0	0.0%	0	0	0	0.0%

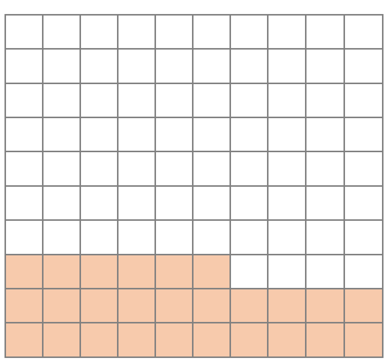
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-7.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-7. Confederated Tribes of Siletz Indians loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-13. Confederated Tribes of Siletz Indians critical facilities.

Critical Facilities by Community*	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
	Exposed	>50% Prob.	Exposed	Exposed	Exposed	Exposed
CTSI Administration Building	—	—	—	—	—	—
CTSI Annex STEDCO Building	—	X	—	—	—	—
CTSI Community Center	—	X	—	—	—	—
CTSI Cultural Center	—	X	—	—	—	—
Public Works Shop	—	X	—	—	—	—
Siletz Community Health Clinic	—	—	—	—	—	—
Siletz Indian Health Clinic	—	X	—	—	—	—
USDA Food Distribution Center	—	X	—	—	—	—

*Some of the listed critical facilities for the Confederated Tribes of Siletz Indians are located within the city limits of the City of Siletz.

A.8 City of Depoe Bay

Table A-14. City of Depoe Bay hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Depoe Bay	1,398	1,337	4	257,610,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	1	0.0%	2	0	20,000	0.0%
*Earthquake**	*CSZ M9.0 Deterministic*	269	19%	427	3	50,750,000	20%
Earthquake (within Tsunami Zone)		2	0.2%	9	1	370,000	0.1%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	8	0.5%	13	1	1,177,000	0.5%
Tsunami	Senate Bill 379 Regulatory Line	9	0.6%	20	0	3,818,000	1.5%
Landslide	High and Very High Susceptibility	348	25%	319	2	42,048,000	16%
Coastal Erosion	Moderate Hazard	45	3.2%	64	0	12,820,000	5.0%
Wildfire	High Hazard	21	1.5%	32	0	16,336,000	6.3%

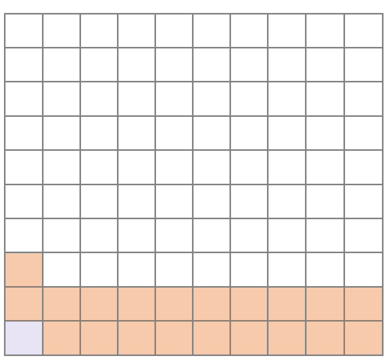
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-8.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Figure A-8. City of Depoe Bay loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-15. City of Depoe Bay critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance Exposed	Earthquake Moderate to Complete Damage >50% Prob.	Tsunami CSZ M9.0 – Medium Exposed	Landslide High and Very High Susceptibility Exposed	Wildfire High Hazard Exposed	Coastal Erosion Moderate Hazard Exposed
Depoe Bay City Hall	—	X	—	—	—	—
Depoe Bay Fire Station 2300	—	X	—	X	—	—
Samaritan Depoe Bay Clinic	—	X	—	—	—	—
U.S. Coast Guard Depoe Bay Station	—	X	X	X	—	—

A.9 City of Lincoln City

Table A-16. City of Lincoln City hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Lincoln City	7,930	6,687	11	1,086,802,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	505	6.4%	249	0	3,648,000	0.3%
*Earthquake**	CSZ M9.0 Deterministic	1,029	13%	1,350	6	209,653,000	19%
Earthquake *(within Tsunami Zone)*		201	2.5%	271	0	31,377,000	2.9%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	923	12%	899	0	125,896,000	12%
Tsunami	Senate Bill 379 Regulatory Line	1,097	14%	1,121	0	176,978,000	16%
Landslide	High and Very High Susceptibility	2,758	35%	2,180	3	343,400,000	32%
Coastal Erosion	Moderate Hazard	65	0.8%	184	0	60,436,000	5.6%
Wildfire	High Hazard	89	1.1%	75	1	8,049,000	0.7%

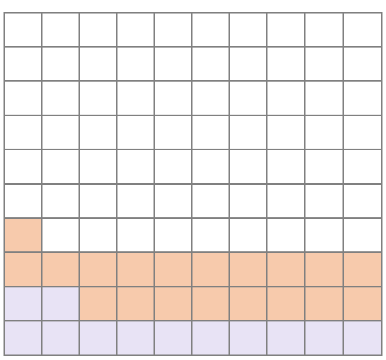
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-9.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Figure A-9. City of Lincoln City loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-17. City of Lincoln City critical facilities.

	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**	**Exposed**
Lincoln City City Hall	—	X	—	—	—	—
Lincoln City Police Department	—	X	—	X	—	—
North Lincoln Fire Station 1400	—	—	—	X	—	—
North Lincoln Fire Station 1500	—	—	—	—	—	—
North Lincoln Fire Station 1600	—	—	—	—	—	—
Oceanlake Elementary School	—	X	—	X	—	—
Samaritan Coastal Clinic	—	—	—	—	—	—
Samaritan North Lincoln Hospital	—	X	—	—	X	—
Samaritan Women's Health Center	—	—	—	—	—	—
Taft Elementary School	—	X	—	—	—	—
Taft High School	—	X	—	—	—	—

A.10 City of Newport

Table A-18. City of Newport hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Newport	9,989	5,602	16	1,243,095,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	10	0.1%	13	0	1,973,000	0.2%
*Earthquake**	*CSZ M9.0 Deterministic*	2,122	21%	1,902	15	294,327,000	24%
Earthquake (within Tsunami Zone)		73	0.7%	186	1	158,074,000	13%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	271	2.7%	436	1	330,953,000	27%
Tsunami	Senate Bill 379 Regulatory Line	217	2.2%	348	1	291,629,000	24%
Landslide	High and Very High Susceptibility	2,417	24%	1,453	4	283,580,000	23%
Coastal Erosion	Moderate Hazard	260	2.6%	264	0	100,712,000	8.1%
Wildfire	High Hazard	94	0.9%	81	1	22,783,000	1.8%

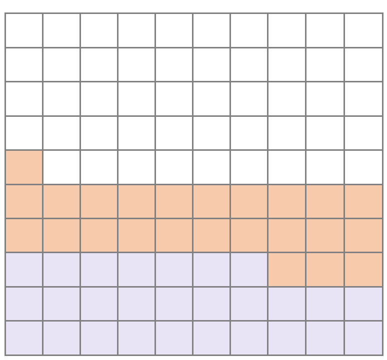
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-10.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-10. City of Newport loss ratio from Cascadia subduction zone event.



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† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami (tsunami damage negligible for this community).

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-19. City of Newport critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
	Exposed	>50% Prob.	Exposed	Exposed	Exposed	Exposed
City of Newport Public Works	—	X	—	X	—	—
Lincoln County Public Works	—	X	—	—	—	—
Lincoln County Sheriff's Office	—	X	—	—	—	—
Newport Fire Station 1	—	X	—	—	—	—
Newport Fire Station 3400	—	X	—	X	—	—
Newport High School	—	X	—	—	—	—
Newport Middle School	—	X	—	—	—	—
Newport Municipal Airport	—	X	—	X	—	—
Newport Police Department	—	X	—	-	—	—
Newport Water Treatment Plant	—	X	—	X	—	—
Oregon National Guard Armory	—	X	—	—	—	—
Oregon State Police Newport	—	X	—	—	X	—
Port of Newport	—	X	X	—	—	—
Sam Case Elementary School	—	X	—	—	—	—
Samaritan Pacific Communities Hospital	—	X	—	—	—	—
Yaquina View Elementary School	—	X	—	—	—	—

A.11 City of Siletz

Table A-20. City of Siletz hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Siletz	1,149	716	2	31,647,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	77	6.7%	44	0	289,000	0.9%
*Earthquake**	*CSZ M9.0 Deterministic*	328	28.5%	322	2	10,591,000	33%
Earthquake (within Tsunami Zone)		0	0.0%	0	0	0	0.0%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	0	0.0%	0	0	0	0.0%
Tsunami	Senate Bill 379 Regulatory Line	0	0.0%	0	0	0	0.0%
Landslide	High and Very High Susceptibility	26	2.2%	20	0	1,075,000	3.4%
Coastal Erosion	Moderate Hazard	0	0.0%	0	0	0	0.0%
Wildfire	High Hazard	0	0.0%	0	0	0	0.0%

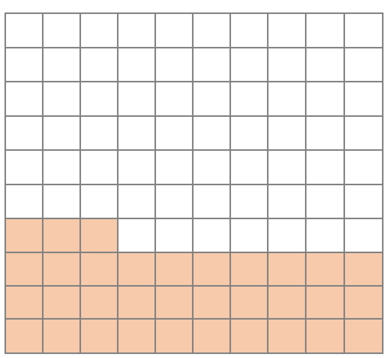
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-11.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-11. City of Siletz loss ratio from Cascadia subduction zone event.



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† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami (tsunami damage negligible for this community).

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-21. City of Siletz critical facilities.

	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**	**Exposed**
Siletz Valley Fire Station 52	—	X	—	—	—	—
Siletz Valley School	—	X	—	—	—	—

A.12 City of Toledo

Table A-22. City of Toledo hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Toledo	3,465	1,954	7	288,238,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	87	2.5%	151	1	23,272,000	8.1%
*Earthquake**	*CSZ M9.0 Deterministic*	898	26%	770	*6*	123,401,000	43%
Earthquake (within Tsunami Zone)		4	0.1%	40	0	2,264,000	0.8%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	15	0.4%	60	0	5,754,000	2.0%
Tsunami	Senate Bill 379 Regulatory Line	10	0.3%	22	0	1,277,000	0.4%
Landslide	High and Very High Susceptibility	2,739	79%	1,528	7	113,948,000	40%
Coastal Erosion	Moderate Hazard	0	0.0%	0	0	0	0.0%
Wildfire	High Hazard	169	4.9%	120	0	8,976,000	3.1%

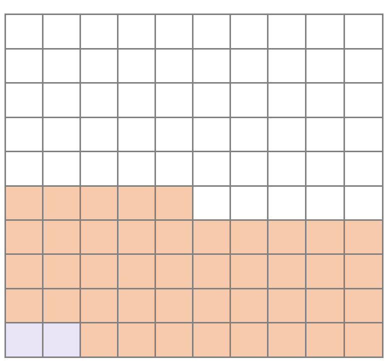
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-12.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-12. City of Toledo loss ratio from Cascadia subduction zone event.



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† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami (tsunami damage negligible for this community).

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-23. City of Toledo critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance Exposed	Earthquake Moderate to Complete Damage >50% Prob.	Tsunami CSZ M9.0 – Medium Exposed	Landslide High and Very High Susceptibility Exposed	Wildfire High Hazard Exposed	Coastal Erosion Moderate Hazard Exposed
Olalla Center for Children and Families	—	X	—	X	—	—
Port of Toledo	—	X	—	X	—	—
Samaritan Toledo Clinic	—	—	—	X	—	—
Toledo Elementary - Arcadia	—	X	—	X	—	—
Toledo Elementary School	—	X	—	X	—	—
Toledo Fire and Rescue Station 41	—	X	—	X	—	—
Toledo Police Department	X	X	—	X	—	—

A.13 City of Waldport

Table A-24. City of Waldport hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Waldport	2,033	1,698	4	161,309,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	452	22%	251	0	1,438,000	0.9%
*Earthquake**	*CSZ M9.0 Deterministic*	381	19%	421	1	31,228,000	19%
Earthquake (within Tsunami Zone)		205	10%	306	1	16,078,000	10%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	508	25%	520	1	36,666,000	23%
Tsunami	Senate Bill 379 Regulatory Line	518	26%	526	1	37,495,000	23%
Landslide	High and Very High Susceptibility	260	13%	224	0	21,613,000	13%
Coastal Erosion	Moderate Hazard	1	0.0%	2	0	121,000	0.1%
Wildfire	High Hazard	67	3.3%	76	0	5,243,000	3.3%

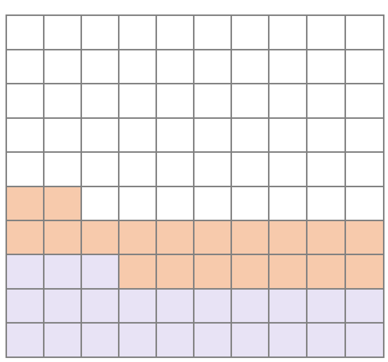
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-13.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-13. City of Waldport loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami (tsunami damage negligible for this community).

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-25. City of Waldport critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance Exposed	Earthquake Moderate to Complete Damage >50% Prob.	Tsunami CSZ M9.0 – Medium Exposed	Landslide High and Very High Susceptibility Exposed	Wildfire High Hazard Exposed	Coastal Erosion Moderate Hazard Exposed
Central Oregon Coast Fire Station 7200	—	X	X	—	—	—
Crestview Heights School	—	X	—	—	—	—
Waldport High School	—	—	—	—	—	—
Waldport Public Works Department	—	—	—	—	—	—

A.14 City of Yachats

Table A-26. City of Yachats hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Yachats	690	1,050	1	160,911,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	13	1.9%	7	0	81,000	0.1%
*Earthquake**	*CSZ M9.0 Deterministic*	125	18%	289	1	35,498,000	22%
Earthquake (within Tsunami Zone)		6	0.9%	32	0	6,089,000	3.8%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Percent of Exposure
Tsunami	*CSZ M9.0 – Medium*	85	12%	169	0	37,266,000	23%
Tsunami	Senate Bill 379 Regulatory Line	215	31%	408	0	67,112,000	42%
Landslide	High and Very High Susceptibility	225	33%	322	0	49,175,000	31%
Coastal Erosion	Moderate Hazard	2	0.3%	4	0	325,000	0.2%
Wildfire	High Hazard	0	0.0%	0	0	0	0.0%

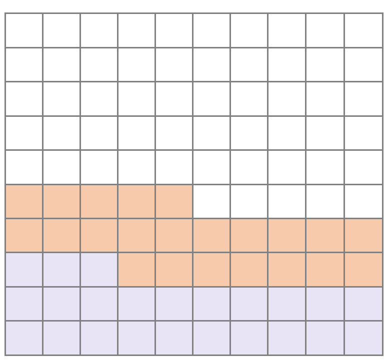
*Earthquake losses were calculated for buildings outside of Medium tsunami zone.

Rows with italicized text and shaded background indicate results should be considered in tandem as they are expected to occur within minutes of one another. Colors correspond to colors in Figure A-14.

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Figure A-14. City of Yachats loss ratio from Cascadia subduction zone event.



Each cell represents 1% of building value, so the grid represents 100% of total building value. The magnitude 9.0 CSZ event is predicted to simultaneously produce a damaging earthquake and tsunami. Hazus-MH modeling for loss ratio is available only for earthquake. Buildings with exposure to the tsunami inundation zone are assumed to be completely damaged, which would be 100% loss ratio. To avoid double counting of buildings, the earthquake loss ratio was calculated only for buildings outside of the tsunami zone.

† Each cell represents approximately 1% of building value.

= Estimated losses due to tsunami.

= Estimated losses due to earthquake (outside of tsunami zone).

Table A-27. City of Yachats critical facilities.

	Flood 1% Annual Chance	Earthquake Moderate to Complete Damage	Tsunami CSZ M9.0 – Medium	Landslide High and Very High Susceptibility	Wildfire High Hazard	Coastal Erosion Moderate Hazard
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**	**Exposed**
Yachats Fire Station and South Lincoln Ambulance Service	—	X	—	—	—	—

APPENDIX B. DETAILED RISK ASSESSMENT TABLES

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Table B-1. Lincoln County building inventory.

(all dollar amounts in thousands)

Community	Residential			Commercial and Industrial			Agricultural			Public and Non-Profit			All Buildings			
	Number of Buildings	Building Value ($)	Building Value per Community Total	Number of Buildings	Building Value ($)	Building Value per Community Total	Number of Buildings	Building Value ($)	Building Value per Community Total	Number of Buildings	Building Value ($)	Building Value per Community Total	Number of Buildings	Number of Buildings per County Total	Building Value ($)	Building Value per County Total
Unincorp. County (rural)	7,906	631,261	77%	518	70,737	8.6%	4,120	90,158	11%	93	31,882	3.9%	12,637	30%	824,038	16%
Otis - Rose Lodge	1,187	58,554	87%	45	2,615	3.9%	512	6,439	10%	3	54	0.1%	1,747	4.2%	67,662	1.3%
Otter Rock	506	76,865	94%	26	2,666	3.3%	97	2,221	3%	5	219	0.3%	634	1.5%	81,971	1.6%
Salishan - Lincoln Beach	2,424	369,588	95%	82	10,539	2.7%	333	7,619	2%	8	1,038	0.3%	2,847	6.8%	388,784	7.6%
Seal Rock - Bayshore	2,769	324,323	93%	92	10,617	3%	479	10,204	2.9%	5	1,940	0.6%	3,345	8.0%	347,085	6.8%
Wakonda Beach	1,221	113,222	92%	46	2,560	2.1%	346	6,919	6%	1	17	0.0%	1,614	3.8%	122,717	2.4%
Total Unincorp. County	16,013	1,573,813	86%	809	99,734	5.4%	5,887	123,561	7%	115	35,149	2%	22,824	54%	1,832,257	36%
Depoe Bay	1,107	240,446	93%	101	12,815	5%	121	2,415	0.9%	8	1,933	1%	1,337	3.2%	257,610	5.0%
Lincoln City	5,653	872,800	80%	509	157,146	14%	443	10,325	1%	82	46,531	4%	6,687	16%	1,086,802	21%
Newport	4,239	756,284	61%	758	336,121	27%	445	14,764	1%	160	135,926	11%	5,602	13%	1,243,095	24%
Siletz	543	22,453	71%	33	3,060	10%	119	1,511	5%	21	4,623	14.6%	716	1.7%	31,647	0.6%
Siletz Tribe	156	13,633	27%	7	35,882	72%	20	262	0.5%	1	20	0%	184	0%	49,797	1%
Toledo	1,399	90,504	31%	235	171,689	60%	278	4,347	2%	42	21,698	7.5%	1,954	5%	288,238	6%
Waldport	1,258	114,481	71%	171	19,798	12%	233	3,779	2%	36	23,251	14%	1,698	4%	161,309	3%
Yachats	875	145,015	90%	60	7,092	4%	104	2,984	2%	11	5,821	4%	1,050	2%	160,911	3%
Total Lincoln County	31,243	3,829,428	75%	2,683	843,337	16%	7,650	163,949	3%	476	274,951	5%	42,052	100%	5,111,666	100%

Table B-2. Cascadia subduction zone earthquake loss estimates.

(all dollar amounts in thousands)

			Total Earthquake Damage*		Earthquake Damage outside of Medium Tsunami Zone							
			Buildings Damaged		Buildings Damaged				Building Design Level Upgraded to at Least Moderate Code			
Community	Total Number of Buildings	Total Estimated Building Value ($)	Sum of Economic Loss	Loss Ratio	Yellow-Tagged Buildings	Red-Tagged Buildings	Sum of Economic Loss	Loss Ratio	Yellow-Tagged Buildings	Red-Tagged Buildings	Sum of Economic Loss	Loss Ratio
Unincorp. County (rural)	12,637	824,038	237,025	29%	1,113	3,273	197,815	24%	1,093	2,038	148,809	18%
Otis - Rose Lodge	1,747	67,662	23,949	35%	162	710	23,949	35%	259	418	17,430	26%
Otter Rock	634	81,971	20,489	25%	49	153	19,891	24%	57	85	12,971	16%
Salishan - Lincoln Beach	2,847	388,784	99,292	26%	232	635	78,921	20%	336	323	48,026	12%
Seal Rock - Bayshore	3,345	347,085	73,866	21%	216	752	61,629	18%	361	393	46,375	13%
Wakonda Beach	1,614	122,717	32,165	26%	90	323	20,339	17%	168	144	13,219	11%
Total Unincorp. County	22,824	1,832,257	486,785	27%	1,861	5,845	402,544	22%	2,274	3,400	286,829	16%
Depoe Bay	1,337	257,610	51,121	20%	123	304	50,750	20%	140	158	37,226	14%
Lincoln City	6,687	1,086,802	241,029	22%	473	877	209,653	19%	279	602	135,326	12%
Newport	5,602	1,243,095	452,401	36%	669	1,234	294,327	24%	500	653	172,323	14%
Siletz	716	31,647	10,591	33%	83	239	10,591	33%	151	81	5,887	19%
Siletz Tribe	184	49,797	13,013	26%	23	63	13,013	26%	42	21	9,756	20%
Toledo	1,954	288,238	125,665	44%	185	585	123,401	43%	139	431	106,017	37%
Waldport	1,698	161,309	47,306	29%	84	337	31,228	19%	161	170	21,588	13%
Yachats	1,050	160,911	41,587	26%	61	228	35,498	22%	62	149	25,003	16%
Total Lincoln County	42,052	5,111,666	1,469,499	29%	3,562	9,712	1,171,005	23%	3,750	5,666	799,956	16%

*All losses calculated from earthquake inside or outside of Medium-sized tsunami zone.

Table B-3. Tsunami exposure.

(all dollar amounts in thousands)

			Small (Low Severity)			Medium (Moderate Severity)			Large (High Severity)			X Large (Very High Severity)			XX Large (Extreme Severity)		
Community	Total Number of Buildings	Total Estimated Building Value ($)	Number of Buildings	Building Value ($)	Percent of Building Value Exposed	Number of Buildings	Building Value ($)	Percent of Building Value Exposed	Number of Buildings	Building Value ($)	Percent of Building Value Exposed	Number of Buildings	Building Value ($)	Percent of Building Value Exposed	Number of Buildings	Building Value ($)	Percent of Building Value Exposed
Unincorp. County (rural)	12,637	824,038	355	15,800	1.9%	808	84,583	10%	1,367	118,969	14%	2,156	171,267	21%	2,289	180,026	22%
Otis - Rose Lodge	1,747	67,662	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0%	0	0	0.0%
Otter Rock	634	81,971	2	75	0.1%	22	829	1.0%	27	2,392	2.9%	41	3,255	4.0%	42	3,320	4.1%
Salishan - Lincoln Beach	2,847	388,784	2	127	0.0%	227	74,194	19%	463	118,556	31%	1510	258,525	66%	1,723	284,264	73%
Seal Rock - Bayshore	3,345	347,085	165	18,929	5.5%	450	65,926	19%	771	103,403	30%	1292	168,594	49%	1,376	180,717	52%
Wakonda Beach	1,614	122,717	205	25,490	20.8%	506	49,025	40%	825	74,722	61%	1316	101,228	82%	1,359	103,841	85%
Total Unincorp. County	22,824	1,832,257	729	60,421	3.3%	2,013	274,557	15%	3,453	418,042	23%	6,315	702,869	38%	6,789	752,168	41%
Depoe Bay	1,337	257,610	7	394	0.2%	13	1,177	0.5%	31	4,022	1.6%	302	117,504	46%	364	128,874	50%
Lincoln City	6,687	1,086,802	304	29,513	2.7%	899	125,896	12%	1,274	208,280	19%	2041	322,050	30%	2,168	343,849	32%
Newport	5,602	1,243,095	245	227,220	18%	436	330,953	27%	558	388,222	31%	847	545,330	44%	923	574,998	46%
Siletz	716	31,647	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%
Siletz Tribe	184	49,797	0	0	0.0%	0	0	0.0%	1	487	1.0%	2	28,287	57%	2	28,287	57%
Toledo	1,954	288,238	38	2,715	0.9%	60	5,754	2.0%	107	14,815	5.1%	184	158,786	55%	192	159,141	55%
Waldport	1,698	161,309	374	31,604	20%	520	36,666	23%	547	38,506	24%	694	53,962	33%	705	55,554	34%
Yachats	1,050	160,911	50	4,835	3.0%	169	37,266	23%	545	85,305	53%	733	112,498	70%	756	115,443	72%
Total Lincoln County	42,052	5,111,666	1,747	356,701	7%	4,110	812,270	16%	6,516	1,157,678	23%	11118	2,041,284	40%	11,899	2,158,314	42%

Table B-4. Flood loss estimates.

			(all dollar amounts in thousands)											
			10% (10-yr)			**2% (50-yr)**			**1% (100-yr)***			**0.2% (500-yr)**		
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**Number of Buildings**	**Loss Estimate**	**Loss Ratio**	**Number of Buildings**	**Loss Estimate**	**Loss Ratio**	**Number of Buildings**	**Loss Estimate**	**Loss Ratio**	**Number of Buildings**	**Loss Estimate**	**Loss Ratio**
Unincorp. County (rural)	12,637	824,038	780	5,234	0.6%	1,290	11,891	1.4%	1,467	15,579	1.9%	1,744	24,174	2.9%
Otis - Rose Lodge	1,747	67,662	20	86	0.1%	48	192	0.3%	81	300	0.4%	135	784	1.2%
Otter Rock	634	81,971	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%
Salishan - Lincoln Beach	2,847	388,784	2	17	0.0%	5	33	0.0%	66	4,838	1.2%	8	76	0.0%
Seal Rock - Bayshore	3,345	347,085	1	3	0.0%	1	4	0.0%	17	372	0.1%	13	89	0.0%
Wakonda Beach	1,614	122,717	0	0	0.0%	0	0	0.0%	29	442	0.4%	0	0	0.0%
Total Unincorp. County	22,824	1,832,257	803	5,339	0.3%	1,344	12,120	0.7%	1,660	21,531	1.2%	1,900	25,123	1.4%
Depoe Bay	1,337	257,610	1	7	0.0%	1	9	0.0%	2	20	0.0%	1	10	0.0%
Lincoln City	6,687	1,086,802	95	247	0.0%	182	581	0.1%	249	3,648	0.3%	336	1,609	0.1%
Newport	5,602	1,243,095	5	478	0.0%	7	1,303	0.1%	13	1,973	0.2%	12	2,238	0.2%
Siletz	716	31,647	1	23	0.1%	22	147	0.5%	44	289	0.9%	62	864	2.7%
Siletz Tribe	184	49,797	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%
Toledo	1,954	288,238	103	5,573	1.9%	140	20,355	7.1%	151	23,272	8.1%	176	33,100	11.5%
Waldport	1,698	161,309	148	522	0.3%	232	1,195	0.7%	251	1,438	0.9%	337	2,155	1.3%
Yachats	1,050	160,911	0	0	0.0%	1	0	0.0%	7	81	0.1%	8	32	0.0%
Total Lincoln County	42,052	5,111,666	1,156	12,189	0.2%	1,929	35,709	0.7%	2,377	52,251	1.0%	2,832	65,131	1.3%

*1% results include coastal flooding source.

Table B-5. Flood exposure.

			1% (100-yr)*				
Community	**Total Number of Buildings**	**Total Population**	**Potentially Displaced Residents from Flood Exposure**	**% Potentially Displaced Residents from Flood Exposure**	**Number of Flood Exposed Buildings**	**% of Flood Exposed Buildings**	**Number of Flood Exposed Buildings Without Damage**
Unincorp. County (rural)	12,637	10,293	963	9.4%	1,750	13.8%	283
Otis - Rose Lodge	1,747	1,926	127	6.6%	125	7.2%	44
Otter Rock	634	489	0	0.0%	0	0.0%	0
Salishan - Lincoln Beach	2,847	2,093	83	4.0%	124	4.4%	58
Seal Rock - Bayshore	3,345	2,766	43	1.6%	63	1.9%	46
Wakonda Beach	1,614	1,326	41	3.1%	97	6.0%	68
Total Unincorp. County	22,824	18,892	1,258	6.7%	2,159	9.5%	499
Depoe Bay	1,337	1,398	1	0%	4	0%	2
Lincoln City	6,687	7,930	505	6%	465	7%	216
Newport	5,602	9,989	10	0%	28	0%	15
Siletz	716	1,149	77	7%	57	8%	13
Siletz Tribe	184	488	0	0%	0	0%	0
Toledo	1,954	3,465	87	3%	163	8%	12
Waldport	1,698	2,033	452	22%	409	24%	158
Yachats	1,050	690	13	2%	19	2%	12
Total Lincoln County	42,052	46,034	2,403	5%	3,304	8%	927

*1% results include coastal flooding source.

Table B-6. Landslide exposure.

(all dollar amounts in thousands)

Community	Total Number of Buildings	Total Estimated Building Value ($)	Very High Susceptibility			High Susceptibility			Moderate Susceptibility		
			Number of Buildings	Building Value ($)	Percent of Building Value Exposed	Number of Buildings	Building Value ($)	Percent of Building Value Exposed	Number of Buildings	Building Value ($)	Percent of Building Value Exposed
Unincorp. County (rural)	12,637	824,038	1,894	122,402	14.9%	3,241	231,712	28.1%	4,060	244,314	30%
Otis - Rose Lodge	1,747	67,662	489	16,127	23.8%	113	5,368	7.9%	694	28,223	42%
Otter Rock	634	81,971	59	13,295	16%	109	10,353	12.6%	237	41,822	51%
Salishan - Lincoln Beach	2,847	388,784	5	721	0.2%	364	63,044	16.2%	1,069	155,399	40%
Seal Rock - Bayshore	3,345	347,085	14	1,826	0.5%	431	53,509	15.4%	1,600	164,217	47%
Wakonda Beach	1,614	122,717	10	578	0%	98	7,301	5.9%	640	47,418	39%
Total Unincorp. County	22,824	1,832,257	2,471	154,950	8.5%	4,356	371,287	20.3%	8,300	681,392	37%
Depoe Bay	1,337	257,610	16	1,888	0.7%	303	40,160	15.6%	550	78,358	30%
Lincoln City	6,687	1,086,802	22	3,416	0%	2,158	339,985	31.3%	2,514	378,454	35%
Newport	5,602	1,243,095	447	107,675	8.7%	1,006	175,905	14.2%	1,637	341,777	27%
Siletz	716	31,647	0	0	0.0%	20	1,075	3.4%	57	2,215	7%
Siletz Tribe	184	49,797	0	0	0.0%	21	2,746	5.5%	70	10,582	21%
Toledo	1,954	288,238	608	50,046	17.4%	920	63,903	22.2%	328	19,740	7%
Waldport	1,698	161,309	14	3,749	2.3%	210	17,863	11.1%	460	46,824	29.0%
Yachats	1,050	160,911	179	25,122	15.6%	143	24,053	14.9%	310	42,113	26.2%
Total Lincoln County	42,052	5,111,666	3,757	346,845	6.8%	9,137	1,036,977	20.3%	14,226	1,601,454	31.3%

Table B-7. Coastal erosion exposure.

(all dollar amounts in thousands)

Community*	Total Number of Buildings	Total Estimated Building Value ($)	High Hazard			Moderate Hazard			Low Hazard		
			Number of Buildings	Building Value ($)	Percent of Building Value Exposed	Number of Buildings	Building Value ($)	Percent of Building Value Exposed	Number of Buildings	Building Value ($)	Percent of Building Value Exposed
Unincorp. County (rural)	12,637	824,038	1	9	0.0%	2	197	0.0%	9	696	0.1%
Otter Rock	634	81,971	18	3,048	3.7%	55	6,469	7.9%	152	15,479	19%
Salishan - Lincoln Beach	2,847	388,784	6	1,086	0.3%	102	26,168	6.7%	320	114,090	29%
Seal Rock - Bayshore	3,345	347,085	7	883	0.3%	155	25,329	7.3%	271	47,376	14%
Wakonda Beach	1,614	122,717	9	1,744	1.4%	44	5,629	4.6%	115	15,978	13%
Total Unincorp. County	21,077	1,764,596	41	6,770	0.4%	358	63,792	3.6%	867	193,619	11%
Depoe Bay	1,337	257,610	10	2,161	0.8%	64	12,820	5.0%	112	26,662	10%
Lincoln City	6,687	1,086,802	22	33,756	3.1%	184	60,436	5.6%	394	174,737	16%
Newport	5,602	1,243,095	75	32,111	2.6%	264	100,712	8.1%	559	196,029	16%
Waldport	1,698	161,309	0	0	0.0%	2	121	0.1%	13	1,648	1.0%
Yachats	1,050	160,911	0	0	0.0%	4	325	0.2%	12	1,716	1.1%
Total Lincoln County*	37,451	4,674,322	148	74,798	1.6%	876	238,205	5.1%	1,957	594,411	13%

*Does not include non-coastal communities (these communities do not factor into total amounts and percentages).

Table B-8. Wildfire exposure.

			(all dollar amounts in thousands)					
			High Hazard			**Moderate Hazard**		
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**Number of Buildings**	**Building Value ($)**	**Percent of Building Value Exposed**	**Number of Buildings**	**Building Value ($)**	**Percent of Building Value Exposed**
Unincorp. County (rural)	12,633	824,009	915	53,619	7%	6,821	424,100	51%
Otis - Rose Lodge	1,747	67,662	0	0	0%	928	38,478	56.9%
Otter Rock	634	81,971	133	11,658	14%	287	47,449	58%
Salishan - Lincoln Beach	2,847	388,784	38	2,885	1%	1,163	129,897	33%
Seal Rock - Bayshore	3,345	347,085	0	0	0.0%	2,011	187,068	54%
Wakonda Beach	1,614	122,717	5	292	0%	994	66,049	54%
Total Unincorp. County	22,824	1,832,257	1,091	68,453	3.7%	12,204	893,041	49%
Depoe Bay	1,337	257,610	32	16,336	6%	597	116,251	45.1%
Lincoln City	6,687	1,086,802	75	8,049	1%	1,822	293,564	27%
Newport	5,602	1,243,095	81	22,783	1.8%	1,131	270,007	22%
Siletz	716	31,647	0	0	0.0%	359	16,423	52%
Siletz Tribe	184	49,797	0	0	0.0%	166	45,265	91%
Toledo	1,954	288,238	120	8,976	3%	643	49,299	17%
Waldport	1,698	161,309	76	5,243	3.3%	666	73,549	45.6%
Yachats	1,050	160,911	0	0	0.0%	570	87,964	54.7%
Total Lincoln County	42,052	5,111,666	1,475	129,840	2.5%	18,158	1,845,363	36.1%

APPENDIX C. HAZUS-MH METHODOLOGY

C.1 Software

We performed all loss estimations using Hazus®-MH 3.0 and ArcGIS® Desktop® 10.2.2.

C.2 User-Defined Facilities (UDF) Database

We compiled a UDF database for all buildings in Lincoln County for use in both flood and earthquake modules of Hazus-MH. We used the Lincoln County assessor database (acquired in 2015) to determine which taxlots had improvements (i.e., buildings) and how many building points should be included in the UDF database.

C.2.1 Locating buildings points

We used the existing DOGAMI dataset of building footprints (unpublished) to help precisely locate the centroid of each building. Where the building footprint dataset lacked coverage in the eastern portion of the county, we used the centroid of the taxlot; for taxlots larger than 10 acres the building centroid was corrected by using orthoimagery. Extra effort was spent to locate building points along the 1% and 0.2% annual chance inundation fringe. For buildings partially within the inundation zone, we moved the building point to the centroid of the portion of the building within the inundation zone. We used an iterative approach to further refine locations of building points for the flood module by generating results, reviewing the highest value buildings, and moving the building point over a representative elevation on the lidar digital elevation model to ensure an accurate first-floor height.

C.2.2 Attributing building points

We populated the required attributes for Hazus-MH through a variety of approaches. We used the Lincoln County assessor database wherever possible, but in many cases that database did not provide the necessary information. The following is list of attributes and their sources:

- **Longitude** and **Latitude** – Location information that provides Hazus-MH the x and y positions of the UDF point. This allows for an overlay to occur between the UDF point and the flood or earthquake input data layers. The hazard model uses this spatial overlay to determine the correct hazard risk level that will be applied to the UDF point. The format of the attribute must be in decimal degrees. A simple geometric calculation using GIS software is done on the point to derive this value.
- **Occupancy class** – An alphanumeric attribute that indicates the use of the UDF (e.g., "RES1" is a single-family dwelling). The alphanumeric code is composed of seven broad occupancy types (RES = residential, COM = commercial, IND = industrial, AGR = agricultural, GOV = public, REL = non-profit/religious, EDU = education) and various suffixes that indicate more specific types. This code determines the damage function to be used for flood analysis. It is also used to attribute the Building Type field, discussed below, for the earthquake analysis. The code was interpreted from "Stat Class" or "Description" data found in the Lincoln County assessor database. Where data were not available, the default value of RES1 was applied throughout.
- **Cost** – The cost of an individual UDF. Loss ratio is derived from this value. The value was obtained from the Lincoln County assessor database. Where not available, cost was based on the square

footage of the building footprint or from the square footage found in the Lincoln County assessor database. When multiple UDFs occupied a single taxlot, the overall cost of the taxlot was distributed to the UDFs based on square footage.

- **Year built** – The year of construction that is used to attribute the **Building design level** field for the earthquake analysis (see "Building Design" below). The year a UDF was built is obtained from Lincoln County assessor database. Where not available the year of "1900" was applied (7.8% of the UDFs).
- **Square feet** – The size of the UDF is used to pro-rate the total improvement value for taxlots with multiple UDFs. The value distribution method will ensure that UDFs with the highest square footage will be the most expensive on a given taxlot. This value is also used to pro-rate the **Number of people** field for Residential UDFs within a census block. The value was obtained from DOGAMI's building footprints; where (RES) footprints were not available, we used the Lincoln County assessor database.
- **Number of stories** – The number of stories for an individual UDF, along with **Occupancy class**, determines the applied damage function for flood analysis. The value was obtained from the Lincoln County assessor database where available. For UDFs without assessor information for number of stories that are within the flood zone, closer inspection using the Google Street View™ mapping service or available oblique imagery was used for attribution.
- **Foundation type** – The UDF foundation type correlates with **First floor height** values in feet (see Table 3.11 in the Hazus-MH Technical Manual for the Flood Model [FEMA Hazus-MH, 2012c]). It also functions within the flood model by indicating if a basement exists or not. UDFs with a basement have a different damage function from UDFs that do not have one. The value was obtained from the Lincoln County assessor database where available. For UDFs without assessor information for basements that are within the flood zone, closer inspection using Google Street View™ mapping service or available oblique imagery was used to ascertain basement presence.
- **First floor height** – The height in feet above grade for the lowest habitable floor. The height is factored during the depth of flooding analysis. The value is used directly by Hazus-MH: Hazus-MH overlays a UDF location on a depth grid and by using the **First floor height** determines the level of flooding occurring to a building. The **First floor height** is derived from the **Foundation type** attribute (Lincoln County assessor data) or observation via oblique imagery or the Google Street View™ mapping service.
- **Building type** – This attribute determines the construction material and structural integrity of an individual UDF. It is used by Hazus-MH to estimate earthquake losses by determining which damage function will be applied. This information was not in the Lincoln County assessor data, so instead Building type was derived from a statistical distribution based on **Occupancy class**.
- **Building design level** – This attribute determines the seismic building code for an individual UDF. It is used by Hazus-MH for estimating earthquake losses by determining which damage function will be applied. (see "Seismic Building Codes" section below for more informatio*n*). This information is derived from the **Year built** attribute (Lincoln Assessor) and state seismic Building Code benchmark years.
- **Number of people** – The estimated number of permanent residents living within an individual residential structure. It is used in the post-analysis phase to determine the number of people affected by a given hazard. This attribute is derived from the default Hazus-MH database (U.S. Census Bureau, 2010a) of population per census block and distributed across residential UDFs.

- **Community** – The community that a UDF is within. These areas are used in the post-analysis for reporting results. The communities were based on incorporated area boundaries; unincorporated community areas were based on building density.

C.2.3 Seismic building codes

Oregon initially adopted seismic building codes in the mid-1970s (Judson, 2012). The established benchmark years of code enforcement are used in determining a "design level" for individual buildings. The design level attributes (pre code, low code, moderate code, and high code) are used in the Hazus-MH earthquake model to determine what damage functions are applied to a given building (FEMA, 2012b). The year built or the year of the most recent seismic retrofit are the main considerations for an individual design level attribute. Seismic retrofitting information for structures would be ideal for this analysis but was not available for Lincoln County. **Table C-1** outlines the benchmark years that apply to buildings within Lincoln County.

Table C-1. Lincoln County seismic design level benchmark years.

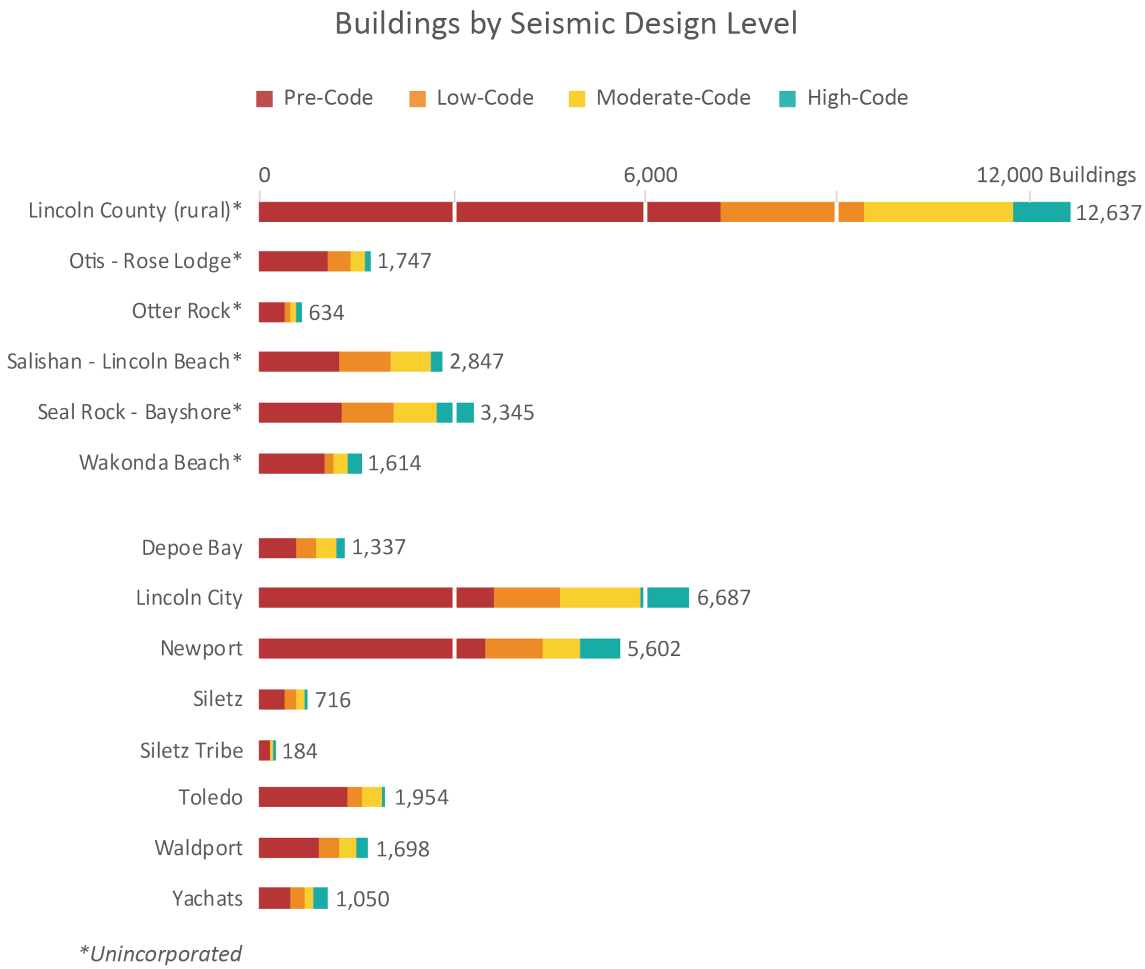
Building Type	Year Built	Design Level	Basis
Single-Family Dwelling (includes Duplexes)	prior to 1976 1976–1991 1992–2003 2004–2016	Pre Code Low Code Moderate Code High Code	Interpretation of Judson (Judson, 2012)
Manufactured Housing	prior to 2003 2003–2010	Pre Code Low Code	Interpretation of OR BCD 2002 Manufactured Dwelling Special Codes (Oregon Building Codes Division, 2002)
	2011–2016	Moderate Code	Interpretation of OR BCD 2010 Manufactured Dwelling Special Codes Update (Oregon Building Codes Division, 2010)
All other buildings	prior to 1976 1976–1990 1991–2016	Pre Code Low Code Moderate Code	Business Oregon 2014-0311 Oregon Benefit-Cost Analysis Tool, p. 24 (Business Oregon, 2015)

Table C-2 and corresponding **Figure C-1** illustrate the current state of seismic building codes for the county.

Table C-2. Seismic design level in Lincoln County.

Community	Total Number of Buildings	Pre Code		Low Code		Moderate Code		High Code	
		Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings
Unincorp. County (rural)	12,637	7,199	57%	2,206	17%	2,318	18%	914	7.2%
Otis - Rose Lodge	1,747	1,078	62%	322	18.4%	256	14.7%	91	5.2%
Otter Rock	634	381	60%	89	14%	97	15%	67	10.6%
Salishan - Lincoln Beach	2,847	1,246	44%	788	28%	636	22%	177	6.2%
Seal Rock - Bayshore	3,345	1,282	38%	804	24.0%	660	19.7%	599	17.9%
Wakonda Beach	1,614	1,008	62%	147	9%	231	14%	228	14.1%
Total Unincorp. County	22,824	12,194	53%	4,356	19.1%	4,198	18.4%	2,076	9.1%
Depoe Bay	1,337	566	42%	294	22%	316	24%	161	12.0%
Lincoln City	6,687	3,664	55%	1,020	15%	1,252	19%	751	11.2%
Newport	5,602	3,516	63%	872	15.6%	601	11%	613	11%
Siletz	716	402	56%	180	25.1%	110	15.4%	24	3.4%
Siletz Tribe	184	164	89%	13	7.1%	6	3.3%	1	0.5%
Toledo	1,954	1,385	71%	226	11.6%	285	15%	58	3.0%
Waldport	1,698	932	55%	308	18%	277	16%	181	11%
Yachats	1,050	490	47%	200	19%	158	15%	202	19%
Total Lincoln County	42,052	23,313	55%	7,469	18%	7,203	17%	4,067	10%

Figure C-1. Seismic design level by Lincoln County community.



C.3 Flood Hazard Data

DOGAMI developed flood hazard data in 2015 for a revision of the Lincoln County FEMA Flood Insurance Study (FEMA, 2019). The hazard data were based on some previous flood studies and new riverine and coastal hydrologic and hydraulic analyses. For riverine areas, the flood elevations for the 10-, 50-, 100-, and 500-year events for each stream cross-section were used to develop depth of flooding raster datasets or "depth grids." For coastal zones and other stillwater flood areas, a 100-year stillwater elevation was used to create the depth grid.

A countywide, 2-meter (~6.5 foot), lidar-based depth grid was developed for each of the 10-, 50-, 100-, and 500-year annual chance flood events. The depth grids were imported into Hazus-MH for determining the depth of flooding for areas within the FEMA flood zones.

Once the UDF database was developed into a Hazus-compliant format, the Hazus-MH methodology was applied using a Python (programming language) script developed by DOGAMI. The analysis was then run for a given flood event, and the script cross-referenced a UDF location with the depth grid to find the depth of flooding. The script then applied a specific damage function, based on a UDF's Occupancy Class [OccCls], which was used to determine the loss ratio for a given amount of flood depth, relative to the UDF's first-floor height.

C.4 Earthquake Hazard Data

Several data layers were used for the deterministic analysis conducted for this report. Data layers created for the Oregon Resilience Plan (ORP; Madin and Burns, 2013) provided most of the earthquake inputs for the CSZ magnitude 9.0 event modeled in Hazus-MH. Liquefaction susceptibility data came directly from the ORP, but site ground motion data (PGA: peak ground acceleration; PGV: peak ground velocity; SA10 and SA03: spectral acceleration at 1.0 second period and 0.3 second period) were derived from NEHRP site class soil data. The GIS procedure used to amplify the site ground motion data from NEHRP soil data are described in Appendix B of Bauer and others (2018): Site Ground Motion and Ground Deformation Map Development. The landslide susceptibility data from the ORP were replaced with newer and more accurate data (Burns and others, 2016).

The hazard layers were formatted for use in a Python script developed by DOGAMI to apply the Hazus-MH methodology. The earthquake hazard datasets used in the analysis were: ground motion data (PGA, PGV, SA03, and SA10), a landslide susceptibility map, and liquefaction susceptibility map. Permanent ground deformation (PGD) for landslide and liquefaction were both calculated using Hazus-MH methodology for each of the susceptibility maps. In addition to the earthquake data layers, Hazus-MH requires a water table parameter for PGD due to liquefaction. As water table data were unavailable, we set the water table value to a depth of 5 feet (1.5 meters).

A deterministic method for a CSZ M9.0 event was deemed the most likely and impactful earthquake scenario for Lincoln County. Past work has shown that probabilistic models of a 500-year event for this area are roughly the same as the CSZ M9.0 event.

During the Hazus-MH earthquake analysis, each UDF was analyzed given its site-specific parameters (ground motion and ground deformation) and evaluated for loss, expressed as a probability of a damage state. Specific damage functions based on Building type and Building design level were used to calculate the damage states given the site-specific parameters for each UDF. The output provided probabilities of the five damage states (None, Slight, Moderate, Extensive, Complete) from which losses in dollar amounts were derived.

C.5 Post-Analysis Quality Control

Ensuring the quality of the results from Hazus-MH flood and earthquake modules is an essential part of the process. A primary characteristic of the process is that it is iterative. A UDF database without errors is highly unlikely, so this part of the process is intended to limit and reduce the influence these errors have on the final outcome. Before applying the Hazus-MH methodology, closely examining the top 10 largest area UDFs and the top 10 most expensive UDFs is advisable. Special consideration can also be given to critical facilities due to their importance to communities.

Identifying, verifying, and correcting (if needed) the outliers in the results is the most efficient way to improve the UDF database. This can be done by sorting the results based on the loss estimates and closely scrutinizing the top 10 to 15 records. If corrections are made, then subsequent iterations are necessary. We continued checking the "loss leaders" until no more corrections were needed.

Finding anomalies and investigating possible sources of error are crucial in making corrections to the data. A wide range of corrections might be required to produce a better outcome. For example, floating homes may need to have a first-floor height adjustment or a UDF point position might need to be moved due to issues with the depth grid. Incorrect basement or occupancy type attribution could be the cause of a problem. Commonly, inconsistencies between assessor data and taxlot geometry can be the source of an error. These are just a few of the many types of problems addressed in the quality control process.

APPENDIX D. ACRONYMS AND DEFINITIONS

D.1 Acronyms

CRS	Community Rating System
CSZ	Cascadia subduction zone
DLCD	Oregon Department of Land Conservation and Development
DOGAMI	Department of Geology and Mineral Industries (State of Oregon)
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FRI	Fire Risk Index
GIS	Geographic Information System
NFIP	National Flood Insurance Program
NHMP	Natural hazard mitigation plan
NOAA	National Oceanic and Atmospheric Administration
ODF	Oregon Department of Forestry
OEM	Oregon Emergency Management
OFR	Open-File Report
OPDR	Oregon Partnership for Disaster Resilience
PGA	Peak ground acceleration
PGD	Permanent ground deformation
PGV	Peak ground velocity
RFPD	Rural Fire Protection District
Risk MAP	Risk Mapping, Assessment, and Planning
SHMO	State Hazard Mitigation Officer
SLIDO	State Landslide Information Layer for Oregon
SLR	Sea level rise
UDF	User-defined facilities
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WUI	Wildland-urban interface
WWA	West Wide Wildfire Risk Assessment

D.2 Definitions

1% annual chance flood – The flood elevation that has a 1-percent chance of being equaled or exceeded each year. Sometimes referred to as the 100-year flood.

0.2% annual chance flood – The flood elevation that has a 0.2-percent chance of being equaled or exceeded each year. Sometimes referred to as the 500-year flood.

Base flood elevation (BFE) – Elevation of the 1-percent-annual-chance flood. This elevation is the basis of the insurance and floodplain management requirements of the NFIP.

Critical facilities – Facilities that, if damaged, would present an immediate threat to life, public health, and safety. As categorized in HAZUS-MH, critical facilities include hospitals, emergency operations centers, police stations, fire stations and schools.

Exposure – Determination of whether a building is within or outside of a hazard zone. No loss estimation is modeled.

Flood Insurance Rate Map (FIRM) – An official map of a community, on which FEMA has delineated both the SFHAs and the risk premium zones applicable to the community.

Flood Insurance Study (FIS) – Contains an examination, evaluation, and determination of the flood hazards of a community and, if appropriate, the corresponding water-surface elevations.

Hazus-MH – A GIS-based risk assessment methodology and software application created by FEMA and the National Institute of Building Sciences for analyzing potential losses from floods, hurricane winds, and earthquakes.

Lidar – A remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. Lidar is popularly used as a technology to make high-resolution maps.

Liquefaction – Describes a phenomenon whereby a saturated soil substantially loses strength and stiffness in response to an applied stress, usually an earthquake, causing it to behave like liquid.

Loss Ratio – The expression of loss as a fraction of the value of the local inventory (total value/loss).

Magnitude – A scale used by seismologists to measure the size of earthquakes in terms of energy released.

Risk – Probability multiplied by consequence; the degree of probability that a loss or injury may occur as a result of a natural hazard. Sometimes referred to as vulnerability.

Risk MAP – The vision of this FEMA strategy is to work collaboratively with State, local, and tribal entities to deliver quality flood data that increases public awareness and leads to action that reduces risk to life and property.

Riverine – Of or produced by a river. Riverine floodplains have readily identifiable channels.

Susceptibility – Degree of proneness to natural hazards that is determined based on physical characteristics that are present.

Vulnerability – Characteristics that make people or assets more susceptible to a natural hazard.

APPENDIX E. MAP PLATES

See appendix folder for individual map PDFs.

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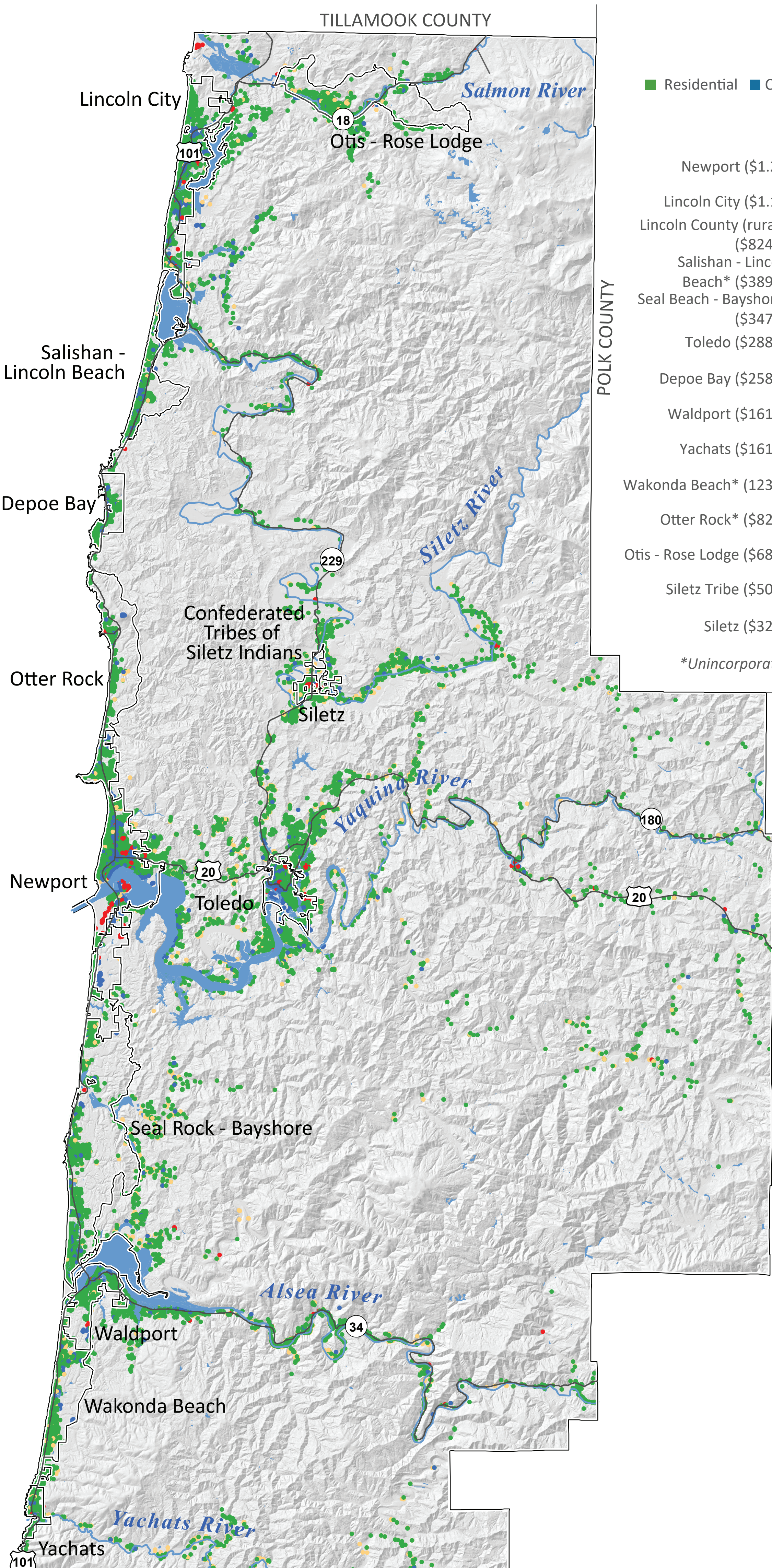
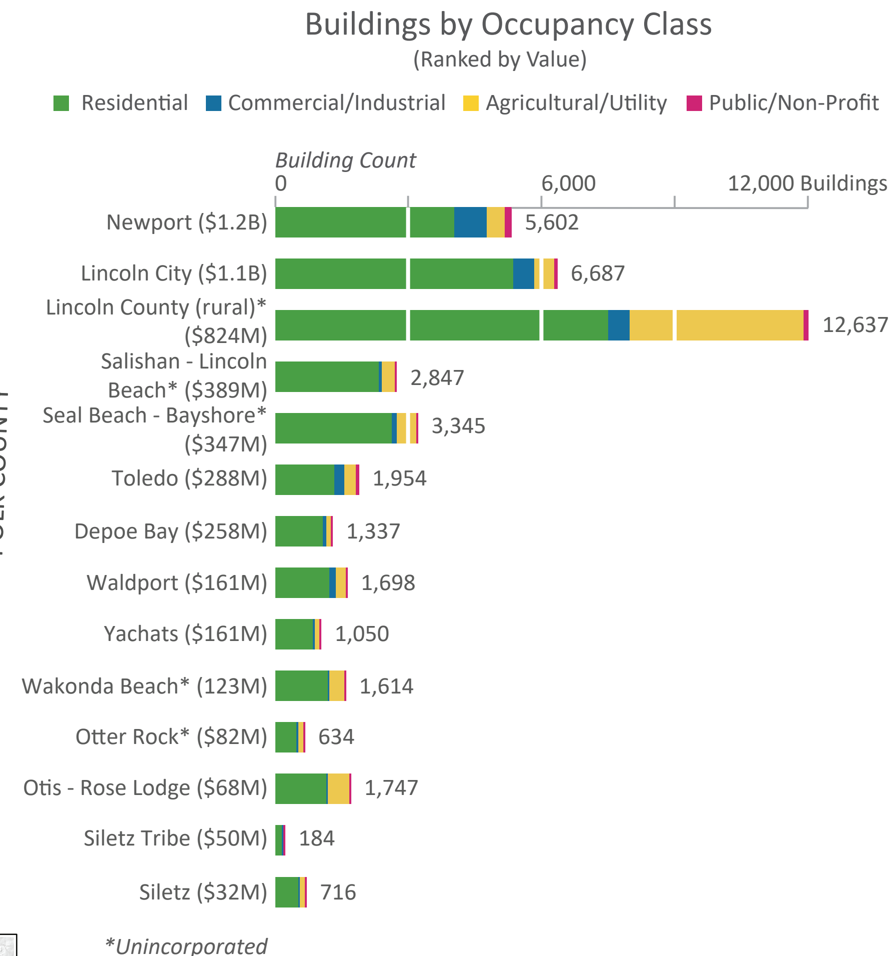
PLATE 1

Building Distribution Map of Lincoln County, Oregon





Building Occupancy

- Agricultural / Utility
- Commercial & Industrial
- Public & Non Profit
- Residential

Data Sources:
Building footprints: Oregon Department of Geology and Mineral Industries (2010)
Roads: Oregon Department of Transportation (2014)
Place names: U.S. Geological Survey Geograpic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: U.S. Geological Survey and Oregon Lidar Consortium (2012)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CS6

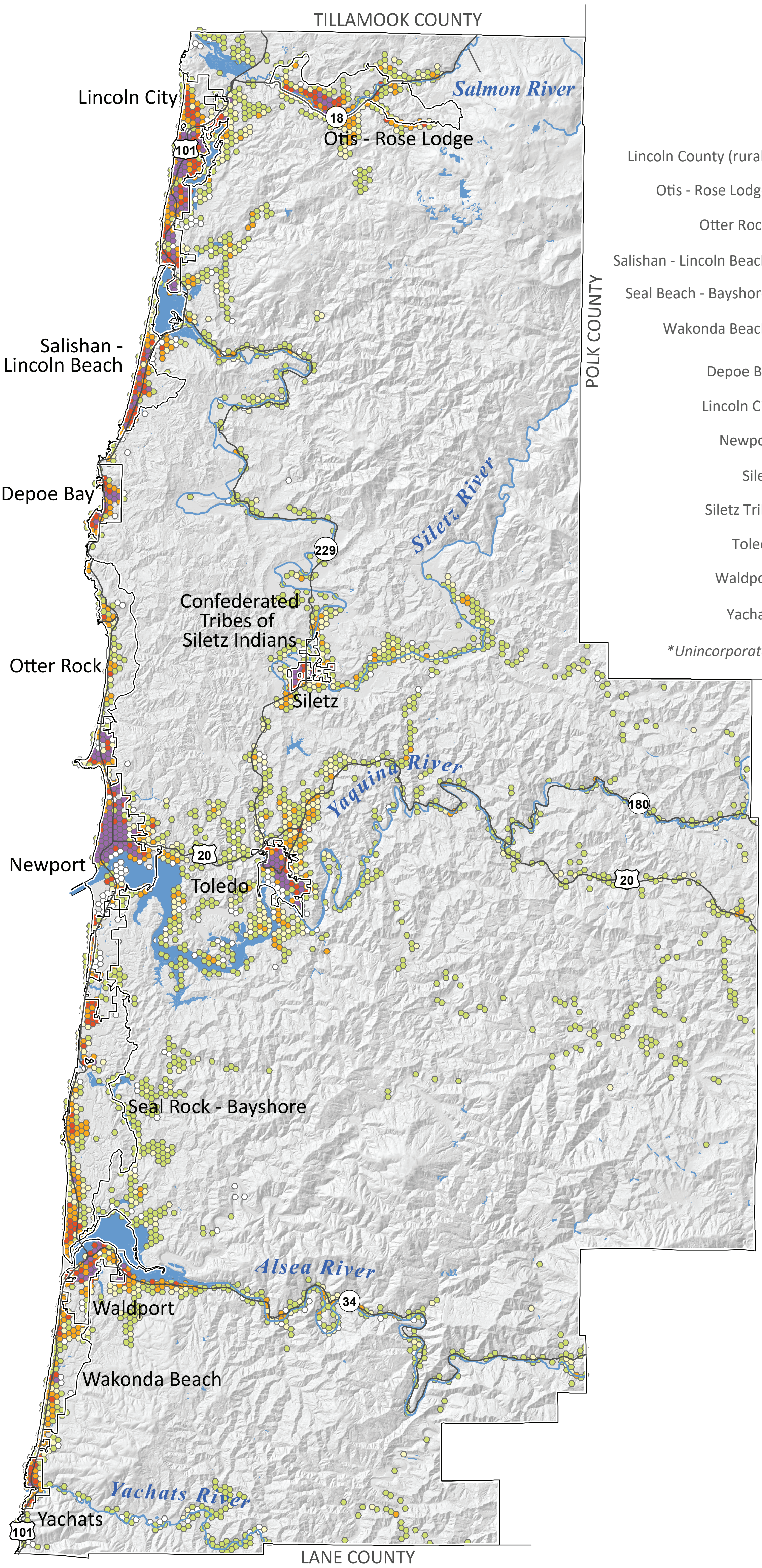
Cartography by: Lowell H. Anthony, 2018

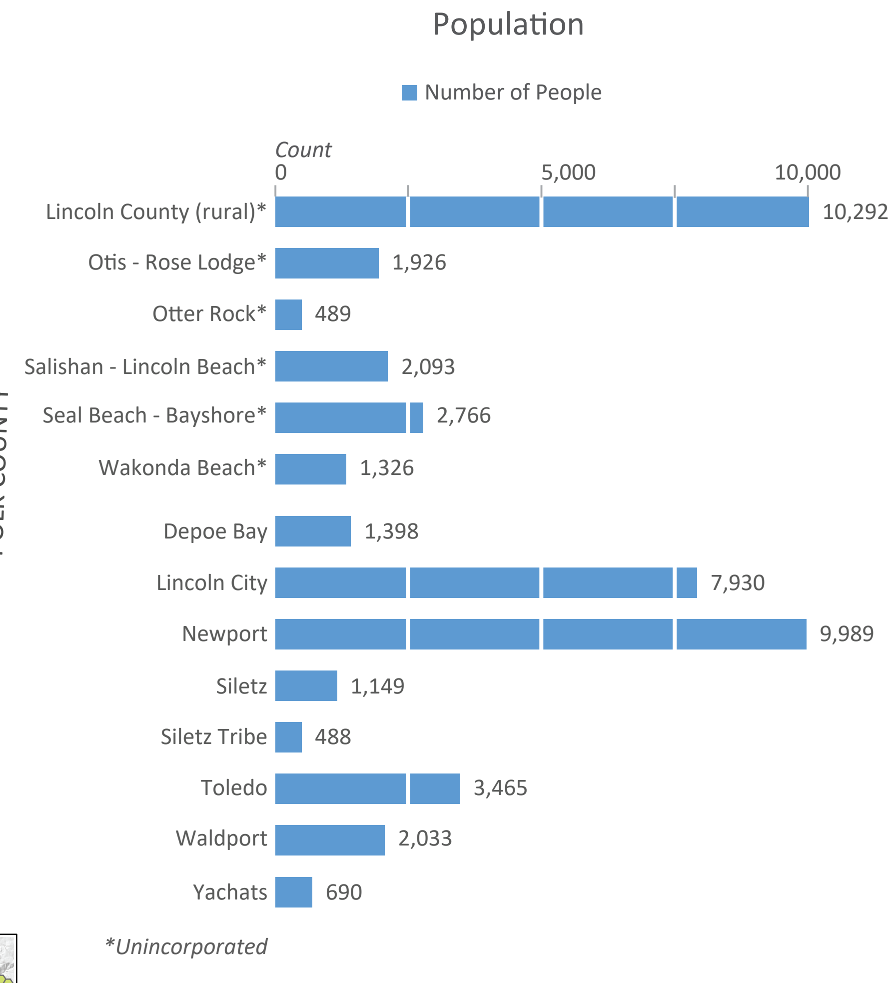
Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication cannot substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from the results shown in the publication. See the accompanying text report for more details on the limitations of the methods and data used to prepare this publication.

N
0 1.5 3 Miles
0 3 6 Kilometers

PLATE 2

Population Density Map of Lincoln County, Oregon





People per 20 acres

- Building(s) present no permanent residents
- 0 - 10
- 11 - 20
- 21 - 40
- 41 - 80
- 81 +

This map is an overview map and not intended to provide details at the community scale. The GIS data that is published with the Lincoln County Natural Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Data Sources:
Population data: U.S. Census (2010)
Roads: Oregon Department of Transportation (2014)
Place names: U.S. Geological Survey Geograpic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: U.S. Geological Survey and Oregon Lidar Consortium (2012)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CS6

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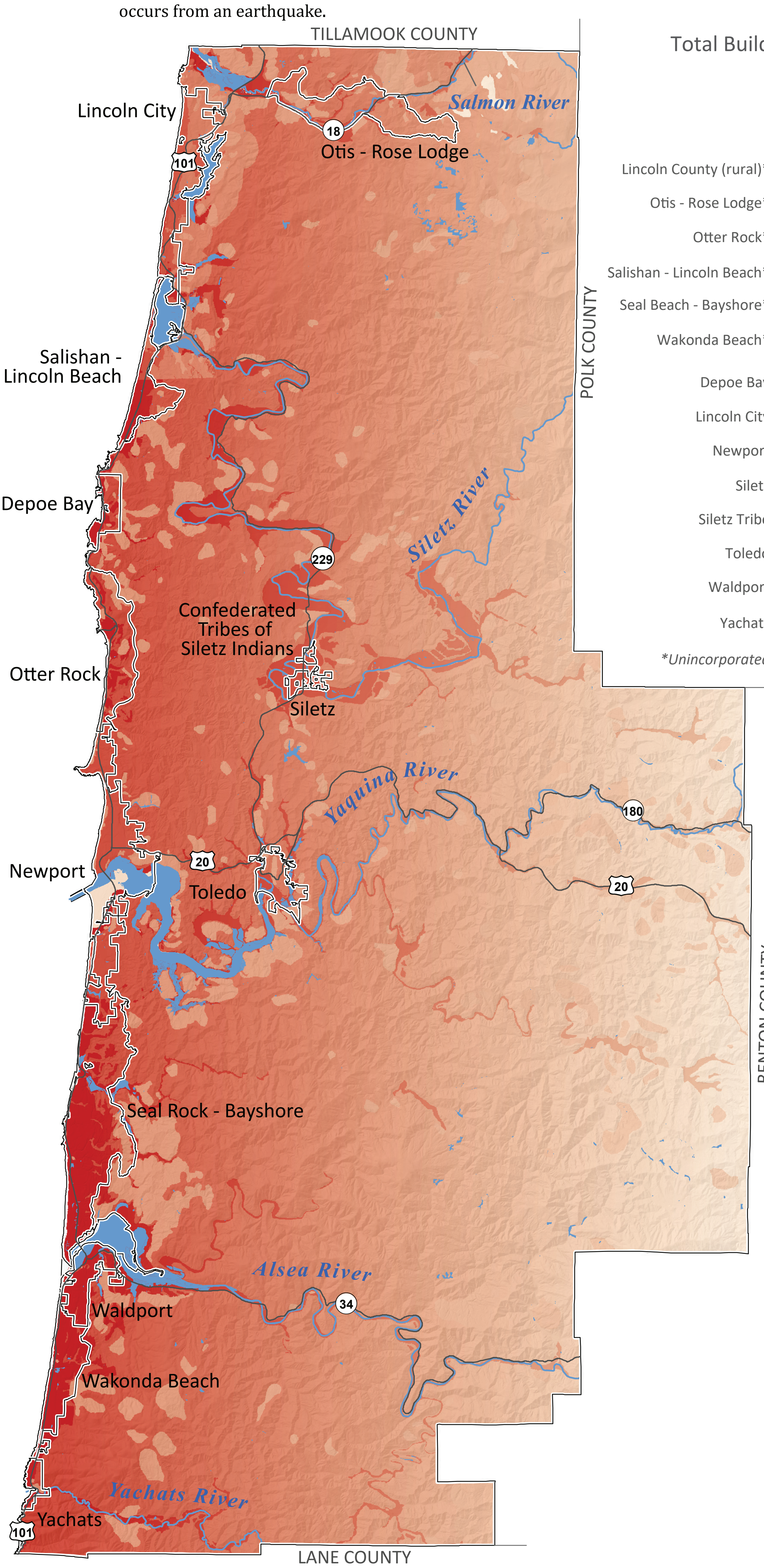
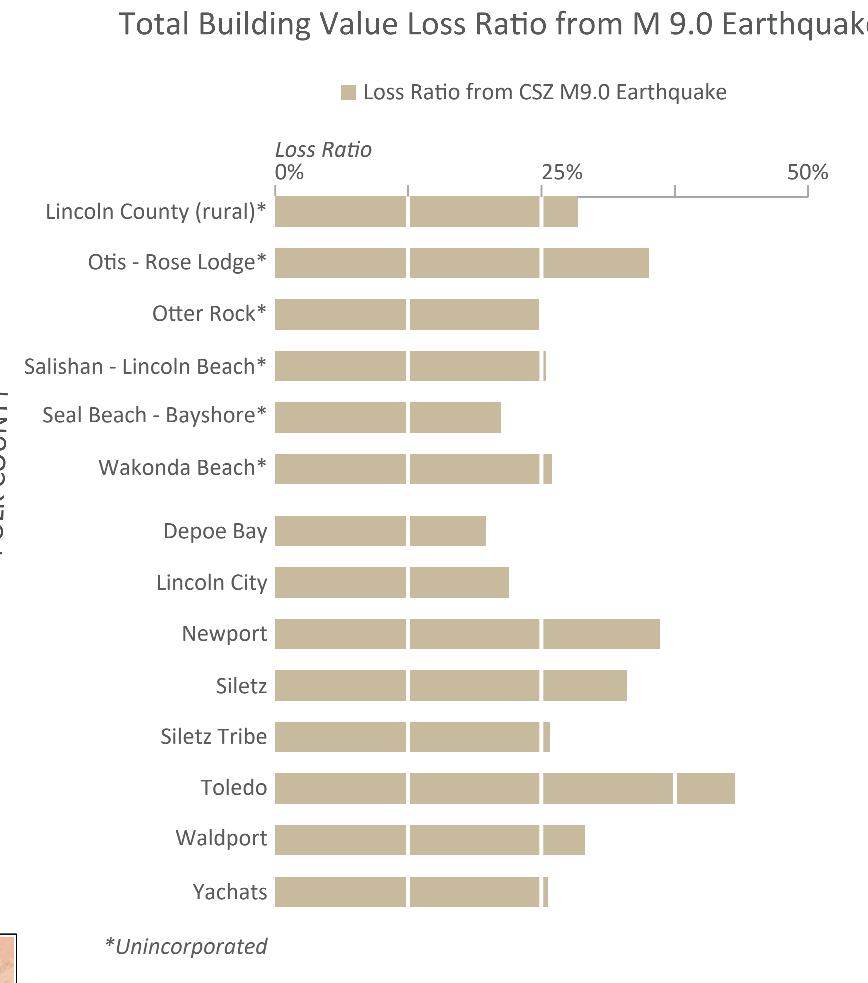
N
0 1.5 3 Miles
0 3 6 Kilometers

PLATE 3

M9.0 CSZ Earthquake Shaking Map of Lincoln County, Oregon

Peak Ground Acceleration (PGA) is the maximum acceleration in a given location or rather how hard the ground is shaking during an earthquake. It is one measurement of ground motion, which is closely associated with the level of damage that occurs from an earthquake.





Earthquake Peak Ground Acceleration

(Correlated Modified Mercalli Scale)

Very Strong — Severe

This map is an overview map and not intended to provide details at the community scale. The GIS data that is published with the Lincoln County Natural Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Data Sources:
Earthquake peak ground acceleration: Madin and Burns (2013)
Roads: Oregon Department of Transportation (2014)
Place names: U.S. Geological Survey Geograpic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: U.S. Geological Survey and Oregon Lidar Consortium (2012)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CS6

Cartography by: Lowell H. Anthony, 2018

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N
0 1.5 3 Miles
0 3 6 Kilometers

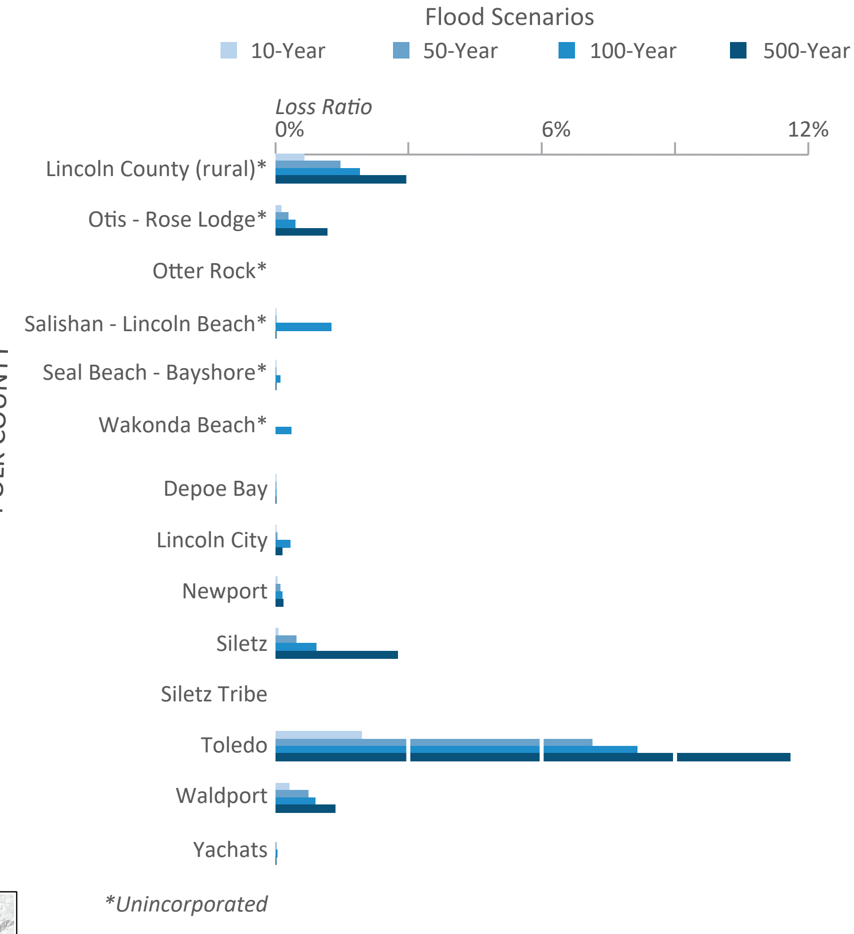
PLATE 4

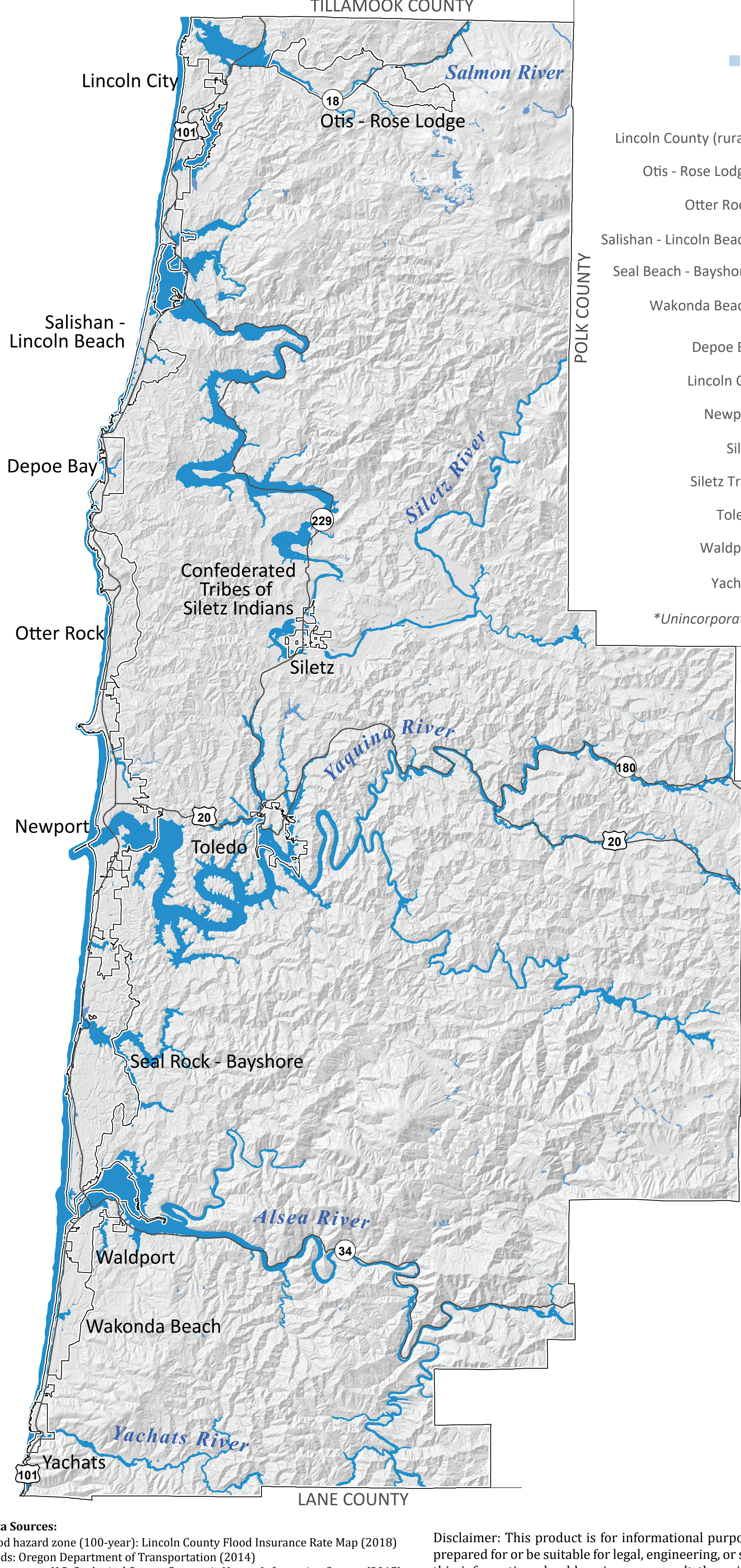
Flood Hazard Map of Lincoln County, Oregon

Study Location Map

The flood hazard data show areas expected to be inundated during a 100-year flood event. Flooding sources include riverine. Areas are consistent with the regulatory flood zones depicted in Lincoln County's Digital Flood Insurance Rate Maps.

Ratio of Estimated Loss to Flooding





Flood Hazard Zone

100-Year Flood (1% annual chance)

This map is an overview map and not intended to provide details at the community scale. The GIS data that is published with the Lincoln County Natural Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Data Sources:

Flood hazard zone (100-year): Lincoln County Flood Insurance Rate Map (2018)
Roads: Oregon Department of Transportation (2014)
Place names: U.S. Geological Survey Geograpic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: U.S. Geological Survey and Oregon Lidar Consortium (2012)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CS6

Cartography by: Lowell H. Anthony, 2018

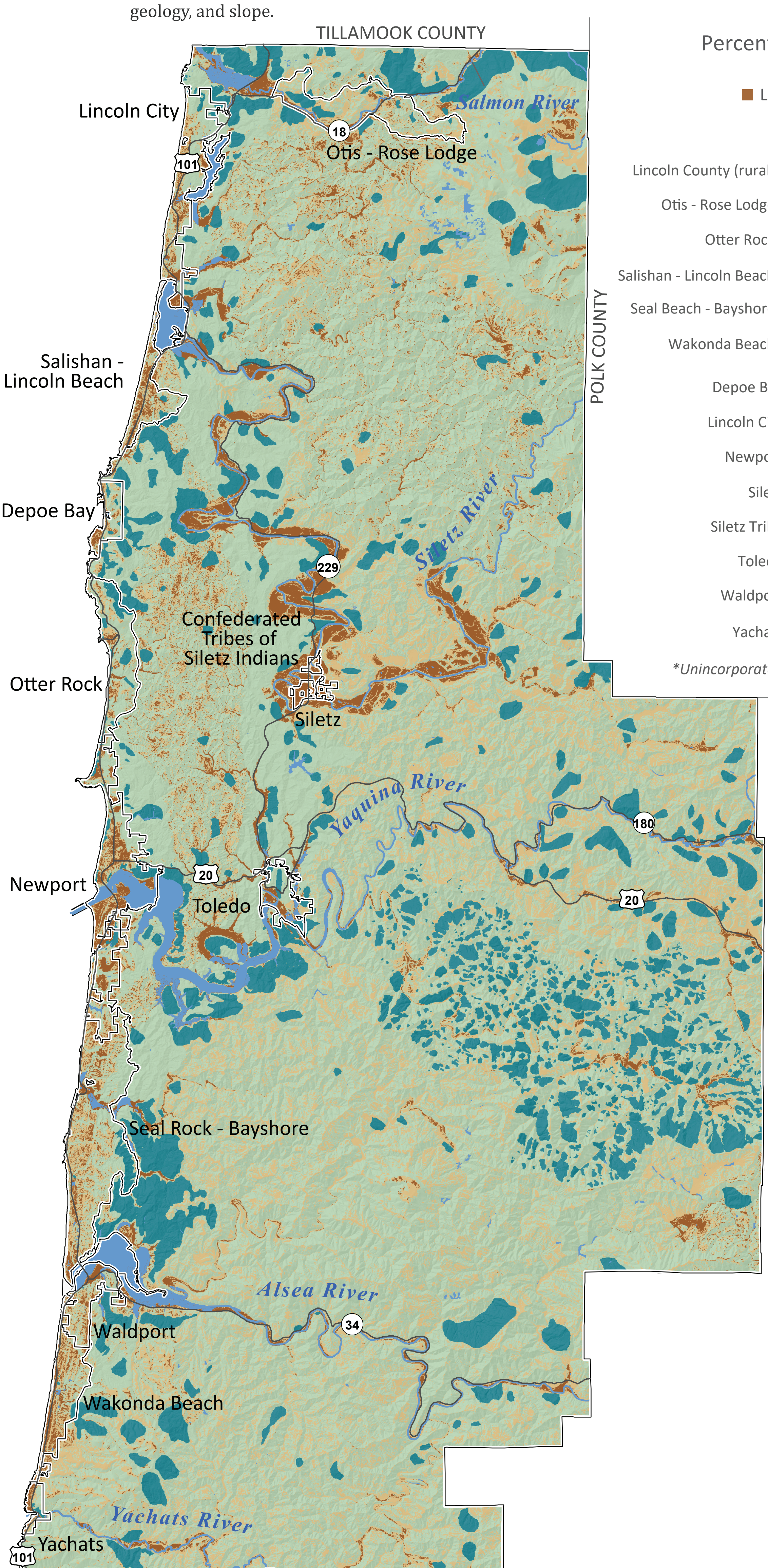
Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication cannot substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from the results shown in the publication. See the accompanying text report for more details on the limitations of the methods and data used to prepare this publication.

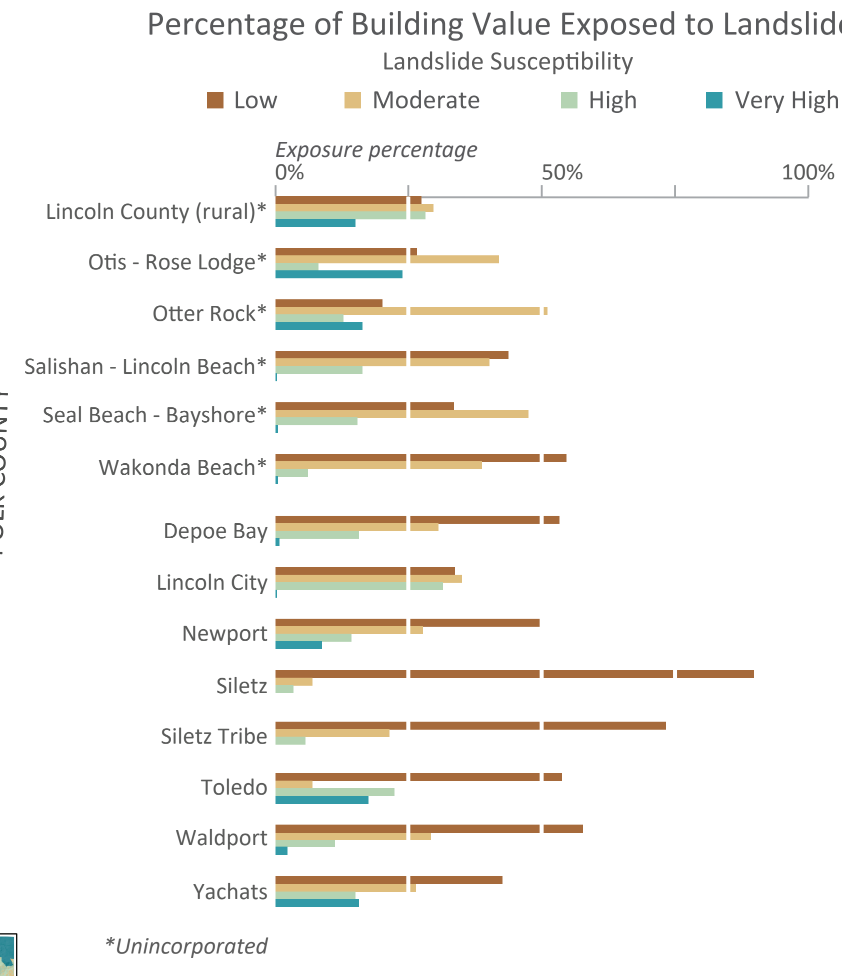
N 0 1.5 3 Miles
0 3 6 Kilometers

PLATE 5

Landslide Susceptibility Map of Lincoln County, Oregon

Landslide susceptibility is categorized as Low, Moderate, High, and Very High which describes the general level of susceptibility to landslide hazard. The dataset is an aggregation of three primary sources: landslide inventory (SLIDO), generalized geology, and slope.





Landslide Susceptibility

- Low
- Moderate
- High
- Very High

This map is an overview map and not intended to provide details at the community scale. The GIS data that is published with the Lincoln County Natural Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Data Sources:
Landslide susceptibility: Oregon Department of Geology, Burns and others (2016)
Roads: Oregon Department of Transportation (2014)
Place names: U.S. Geological Survey Geograpic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: U.S. Geological Survey and Oregon Lidar Consortium (2012)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CS6

Cartography by: Lowell H. Anthony, 2018

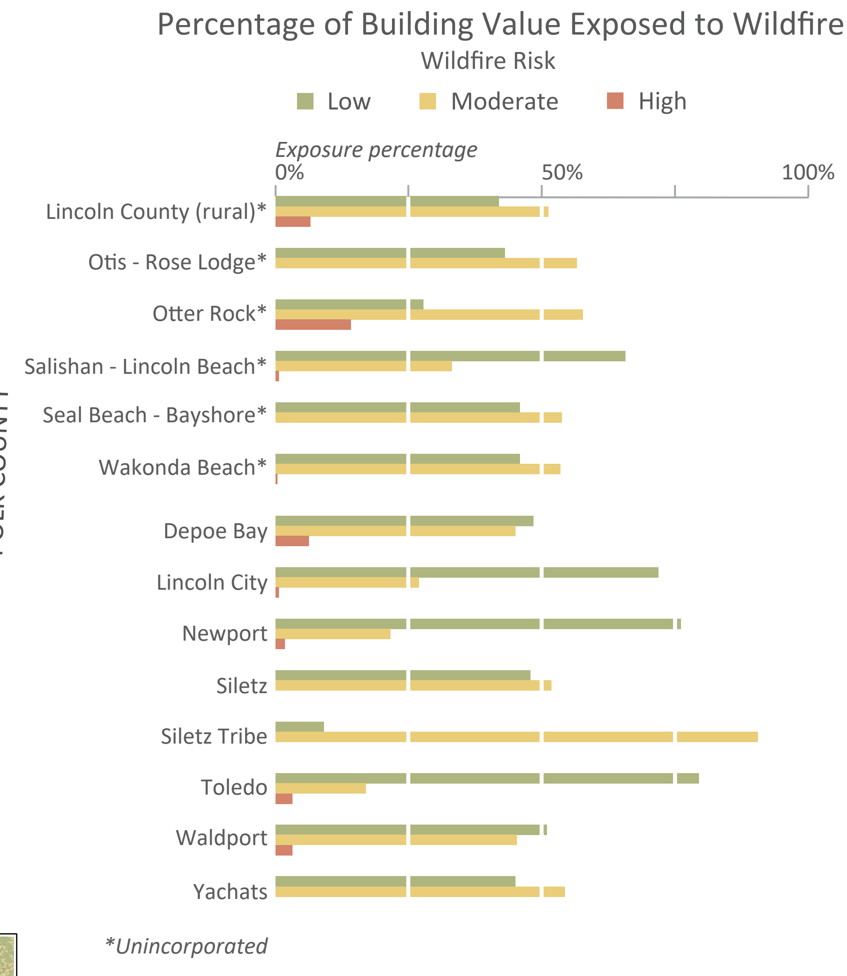
Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication cannot substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from the results shown in the publication. See the accompanying text report for more details on the limitations of the methods and data used to prepare this publication.

N
0 1.5 3 Miles
0 3 6 Kilometers

PLATE 6

Wildfire Risk Map of Lincoln County, Oregon

Wildfire Risk is categorized as Low, Moderate, and High and indicates the level of risk a location has to wildfire hazard. The Wildfire Risk data layer (Fire Risk Index) is derived from a combination of the Fire Threat Index (fire history and behavior) and the Fire Effects Index (infrastructure and assets).



Wildfire Risk

- Low
- Moderate
- High

This map is an overview map and not intended to provide details at the community scale. The GIS data that is published with the Lincoln County Natural Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Data Sources:
Wildfire risk data: Oregon Department of Forestry, Sanborn Map Company, Inc. (2013)
Roads: Oregon Department of Transportation (2014)
Place names: U.S. Geological Survey Geograpic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: U.S. Geological Survey and Oregon Lidar Consortium (2012)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CS6

Cartography by: Lowell H. Anthony, 2018

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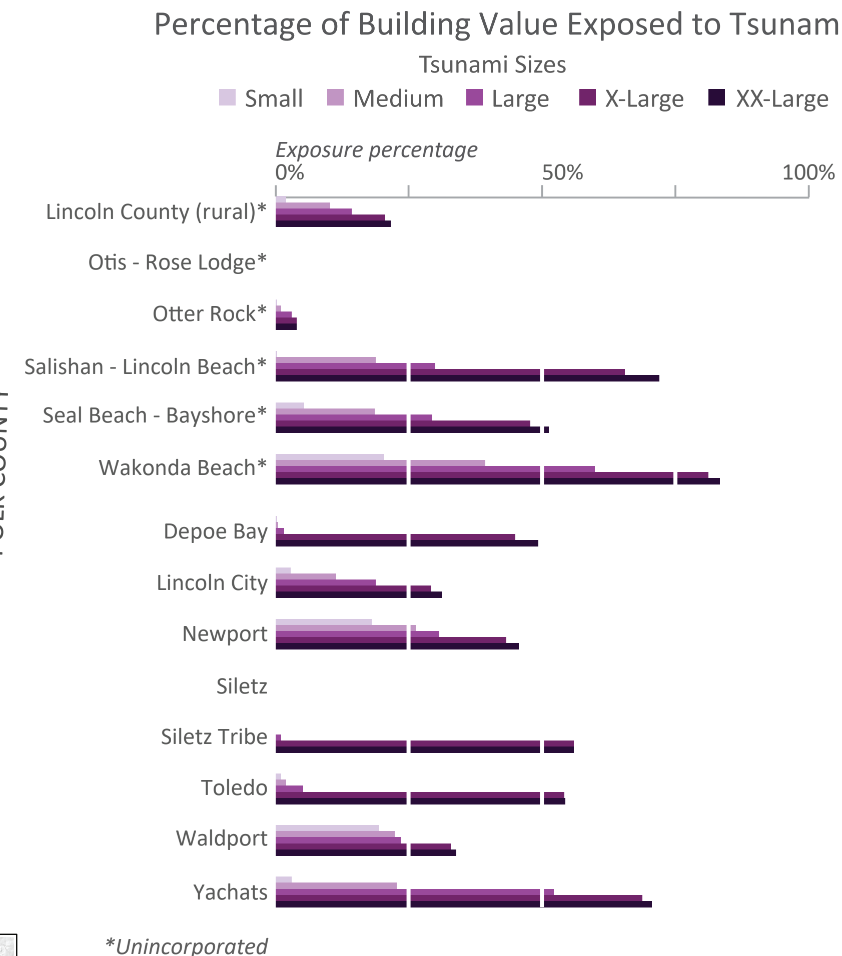
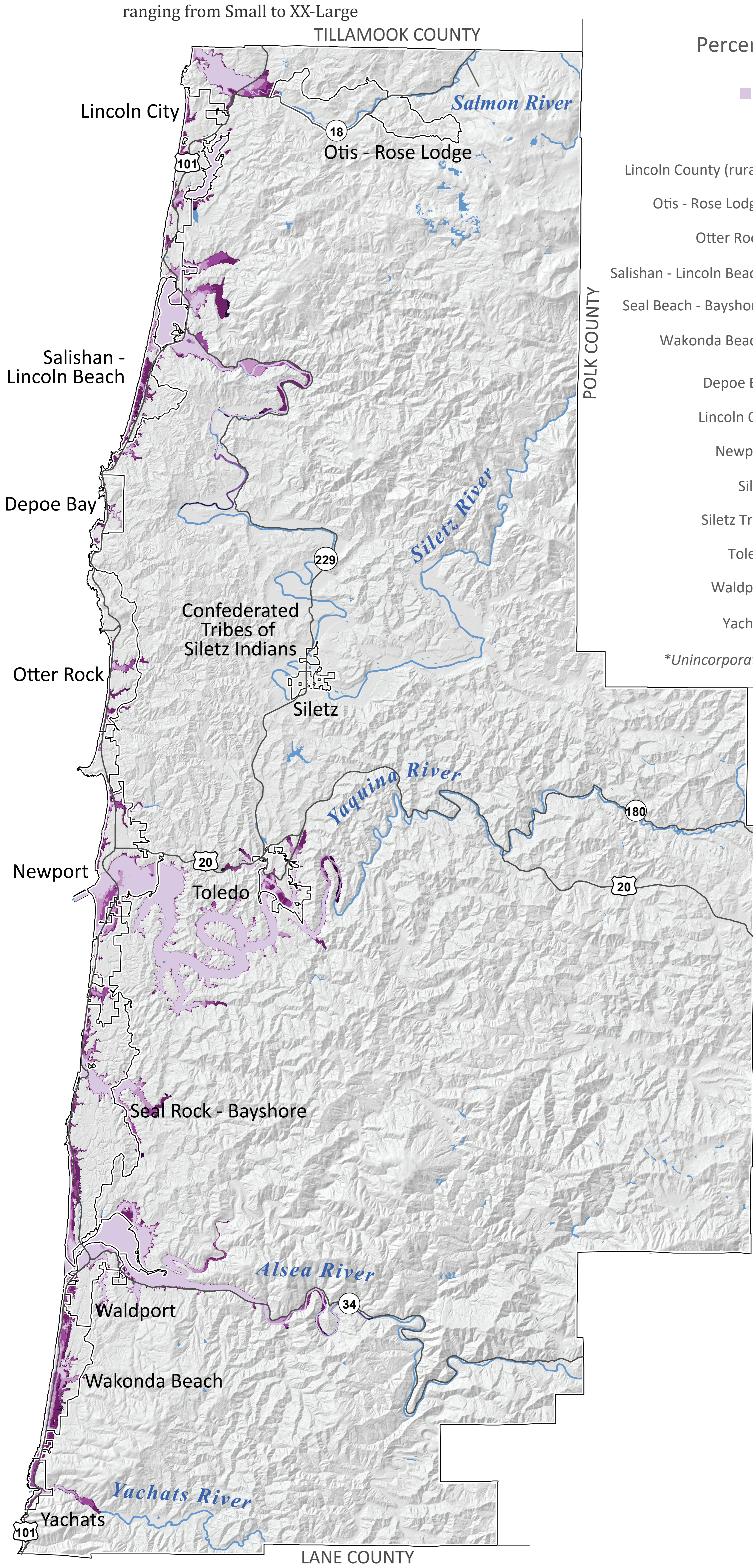
N
0 1.5 3 Miles
0 3 6 Kilometers

PLATE 7

Tsunami Inundation Map of Lincoln County, Oregon

The tsunami hazard data show areas of expected innundation from several local tsunami scenarios produced from a magnitude 9.0 CSZ earthqauke. The scenarios were categorized based on "t-shirt" sizes, ranging from Small to XX-Large





Tsunami Hazard Zone

- Small
- Medium
- Large
- X-Large
- XX-Large

This map is an overview map and not intended to provide details at the community scale. The GIS data that is published with the Lincoln County Natural Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Data Sources:
Tsunami hazard zones: Oregon Department of Geology, Priest and others (2013)
Roads: Oregon Department of Transportation (2014)
Place names: U.S. Geological Survey Geograpic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: U.S. Geological Survey and Oregon Lidar Consortium (2012)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CS6

Cartography by: Lowell H. Anthony, 2018

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N
0 1.5 3 Miles
0 3 6 Kilometers