Floods

Introduction

In its most basic form, a flood is an accumulation of water over a normally dry area. When floods inundate areas where people live, work, and play, loss of life and property may result.

Tillamook County has an extensive history of flooding which is typically caused by large-scale weather systems generating prolonged rainfall or rain-on-snow events generating large amounts of runoff. The County also is subject to coastal flooding from high tides and wind-driven waves. While less common, potential also exists for flooding from tsunamis and channel migration. Flooding from tsunamis is discussed in the *Tsunamis* section.

The El Niño Southern Oscillation (ENSO) Cycle influences flooding. El Niño and La Niña are opposite phases of what is known as the El Niño-Southern Oscillation (ENSO) cycle. The ENSO cycle is a scientific term that describes the fluctuations in temperature between the ocean and atmosphere in the east-central Equatorial Pacific. La Niña is sometimes referred to as the cold phase of ENSO and El Niño as the warm phase of ENSO. These deviations from normal surface temperatures can have large-scale impacts not only on ocean processes, but also on global weather and climate. El Niño and La Niña episodes typically last nine to 12 months, but some prolonged events may last for years. They often begin to form between June and August, reach peak strength between December and April, and then decay between May and July of the following year. While their periodicity can be quite irregular, El Niño and La Niña events occur about every 3 to 5 years. Typically, El Niño occurs more frequently than La Niña. (Source: NOAA, *What are El Niño and La Niña?*, http://oceanservice.noaa.gov/facts/ninonina.html)

A measure of this cycle is the Southern Oscillation Index (SOI), which is “calculated from the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin, Australia.” The earliest systematic study of ENSO in the Northwest was Redmond and Koch (1991). The results were sufficiently strong that the authors suggested a cause-effect relationship between the SOI and Oregon weather. SOI values less than zero represent El Niño conditions, near zero values are average, and positive values represent La Niña conditions.

In Oregon El Niño impacts associated with these climate features generally include warmer winter temperatures and reduced precipitation with drought conditions in extreme events.

What Oregonians should especially plan for and monitor, however, is La Niña. During La Niña events, heavy rain arrives in Oregon from the western tropical Pacific, where ocean temperatures are well above normal, causing greater evaporation, more extensive clouds, and a greater push of clouds across the Pacific toward Oregon.

Types of Flooding

Riverine and coastal flooding are most the most common types of flooding in Tillamook County.

Riverine: Riverine flooding is caused by the passage of a larger quantity of water than can be contained within the normal stream channel. The increased stream flow is usually caused by heavy rainfall over a period of several days.

The most severe flooding conditions occur, however, when heavy rainfall is augmented by rapid snowmelt. These rain-on-snow events occur on mountain slopes within the low elevation snow zones of the Pacific Northwest. These events make more water available for runoff than does precipitation alone by melting the snowpack and by adding a small amount of condensate to the snowpack (van Heeswijk et al., 1996). If the ground is frozen, stream flow can be increased even more by the inability of the soil to absorb additional runoff.

There are two distinct periods of riverine flooding in Tillamook County — winter and late spring — with the most serious occurring December through February. The situation is especially severe when riverine flooding, caused by prolonged rain and melting snow, coincides with high tides and coastal storm surges. In short, the rivers back up and flood the lowlands. This type of flooding is especially troublesome in the Tillamook Bay area where homes and livestock can be isolated for several days. Several northern coastal rivers carry heavy silt loads that originated in areas burned during the "Tillamook Burn" fires (1933 to 1951) or from areas covered with volcanic ash during the Mount St. Helens eruption (1980). Consequently, some rivers actually may be elevated above local floodplains, which increases flood hazards. The costs and long-term benefits of dredging these rivers have not been determined.

Coastal: Coastal areas have additional flood hazards. Winds generated by tropical storms or intense off shore low-pressure systems can drive ocean water inland and cause significant flooding. The height of storm surge is dependent on the wind velocity, water depth and the length of open water (the fetch) over which the wind is flowing. Storm surges are also affected by the shape of the coastline and by the height of tides.

Flooding from wind-driven waves is common during the winter, during El Niño events, and when spring and perigean tides occur. The Federal Emergency Management Agency has identified and mapped coastal areas subject to direct wave action (V zones) and sand dune over-topping (AH and AO zones). Direct wave action was especially severe during the winter storm event of 1978 (Nestucca Spit), and the El Niño event of 1997-98. Significant beach and cliff erosion occurred during this period and a number of homes were destroyed. The following lessons were learned:

- Oregon coastal processes are complex and dynamic, sometimes eroding, sometimes accreting;
- Some sections of the Oregon coast are rising in relation to ocean levels, others remain fairly constant or are becoming lower (Komar 1992, 40-41);
- Primary frontal dunes provide protection from ocean storms;
- Sand spits are not permanent features; and
- Erosion rates vary and are dependent on several factors including storm duration and intensity, composition of sea cliff, time of year, and impact of human activities (e.g., altering the base of sea cliffs, interfering with the natural movement of beach sand).

Channel Migration: Channel migration is the process by which streams move laterally over time. It is typically a gradual phenomenon that takes place over many years due to natural processes of erosion and deposition. In some cases, usually associated with flood events, significant channel migration can happen rapidly. In high flood flow events stream channels can "avulse" and shift to occupy a completely new channel.

Areas most susceptible to channel migration are transitional zones where steep channels flow from foothills into broad, flat floodplains. The most common physiographic characteristics of a landscape prone to channel migration include moderate channel steepness, moderate to low channel confinement (i.e., valley broadness), and erodible geology.

Table XX. Types of Flooding Hazards Potentially Impacting Each Jurisdiction

Jurisdiction	Riverine Flooding	Coastal Flooding	Channel Migration
Unincorporated Tillamook County	✓	✓	✓
• Neskowin	✓	✓	
• Oceanside-Netarts			
• Pacific City	✓	✓	✓
Bay City	✓		
Garibaldi	✓		
Manzanita	✓		
Nehalem	✓		✓
Rockaway Beach	✓	✓	
Tillamook	✓		✓
Wheeler	✓		✓

Source:

Location and Extent of Flooding

The principal riverine flood sources in Tillamook County are the Kilchis, Miami, Nehalem, Nestucca, Tillamook, Trask, and Wilson Rivers, Three Rivers, and the Dogherty and Hoquarten Sloughs. All the rivers drain westward, eventually flowing into the Pacific Ocean. The Pacific Ocean is the source of coastal flooding.

Riverine: Floods are the most common and widely recognized of the hazards within Tillamook County. Flooding generally occurs quickly due to heavy concentrated rainfall. It can be confined to one river system or affect all 7 river systems within the County. Tidal changes coupled with high winds and/or snow accumulation at higher elevations has influence on the severity as well. Flood season is in effect from November 1 through March 31.

Many of the buildings built along the streams and the coast of unincorporated Tillamook County are exposed to the 100-year flood. In Neskowin, developed areas along Neskowin Creek, Kiwanda Creek, and the Pacific Ocean are exposed to the 100-year flood. The primary flood hazard in Pacific City is from the Nestucca River, though coastal flooding may occur. Several buildings inside the 1% flood zone are elevated above the estimated flood level. Central Pacific City is most affected by Nestucca River flooding.

Although some buildings in flood-prone areas have been elevated, greatly reducing overall flood risk, many buildings still can be impacted by floods. Nearly half of the buildings exposed to the 100-year flood in unincorporated Tillamook County and Neskowin, and nearly a quarter in Pacific City are estimated to be elevated above the predicted flood level. While the buildings themselves would not be damaged from flood, access to these buildings could be an issue.

The Cities of Nehalem, Rockaway Beach, and Tillamook are also subject to riverine flooding. Nehalem River flooding presents a particular hazard to structures in the City's low-lying business area. Floods from Rock Creek and other minor creeks cause damage to structures in low-lying areas of Rockaway Beach. The City of Tillamook lies between two major floodplains created by the Trask, Wilson, and Tillamook Rivers as well as many adjoining tributaries. Numerous buildings in the low-lying areas of the City of Tillamook are exposed to the 100-year flood. Rockaway Beach and the City of Tillamook have sustained significant damage from many floods, most recently during the December 2015 winter storms.

Although many buildings in these cities' flood-prone areas have been elevated, greatly reducing overall flood risk, many can still be impacted by floods. Nearly half of the buildings exposed to the 100-year flood in unincorporated Rockaway Beach and nearly a third in the City of Tillamook are estimated to be elevated above the predicted flood level. While the buildings themselves would not be damaged from flood, access to these buildings could be an issue.

Coastal: Coastal flooding regularly hammers low-lying areas of Neskowin and Rockaway Beach in particular, and to a lesser extent Pacific City. Rockaway Beach was particularly hard-hit during the December 2015 winter storms.

Channel Migration: In 2015, DOGAMI produced *Statewide Subbasin-Level Channel Migration Screening for Oregon*, a statewide study of susceptibility to channel migration. The Nehalem, Wilson, Trask, and Nestucca Rivers were studied. In general, where these rivers flow through lower elevations, their susceptibility for channel migration is greatest. More study is necessary to accurately determine the area within which their channels are likely to migrate over time and evaluate potential losses.

Exposure to flooding of any type is minimal in Oceanside-Netarts and the Cities of Bay City, Garibaldi, Manzanita, and Wheeler.

Insert map of principal flood sources.

Historically Significant Flood Events

Table XX. Historic Coastal Erosion and Flood Hazard Events in Tillamook County

Date	Location	Description
1931	Rockaway Beach	coastal damage from December storm
Oct–Dec. 1934	Rockaway Beach	coastal damage
Dec. 1935	Rockaway Beach	coastal damage
Jan. 1939	coastwide	severe gale; damage coastwide severe flooding due to breach of southern portion of Netarts spit
Jan. 1953	Rockaway Beach	70-ft dune retreat; one home removed
Dec. 1967	Netarts Spit	damage: coastwide State constructed wood bulkhead to protect foredune along 600 ft section (Cape Lookout State Park campground)
1997–98	Tillamook County	El Niño winter (second strongest on record); erosion: considerable
Jan–Mar. 1999	coastwide	five storms; coastal erosion extensive, including: • significant erosion (Neskowin, Netarts Spit, Oceanside, Rockaway beach) • overtopping and flooding (Cape Meares)
Dec. 2007	Tillamook County	wind storm
Dec. 2015	coastwide; most of western Oregon	severe winter storm; coastal erosion and coastal flooding

Sources: Schlicker et al. (1972, 1973); Stembridge (1975); Komar and McKinney (1977); Komar (1986, 1987, 1997, 1998); Allan et al. (2003, 2009), and many others; FEMA https://www.fema.gov/disaster/4258 accessed 09/2016; Julie Slevin, OEM, personal contact 09/162016.

Table XX. Historic Floods in Tillamook County

Date	Location	Description	Type of Flood
1813	NW Oregon	said to exceed "Great Flood" of 1861 (source: Native Americans)	unknown
Feb. 1890	coastal rivers	widespread flooding	rain on snow
Mar. 1931	western Oregon	extremely wet and mild; saturated ground	rain on snow
Dec. 1933	northern Oregon	intense warm rains; Clatskanie River set record	rain on snow
Dec. 1937	western Oregon	heavy coastal rain; large number of debris flows	rain on snow
Dec. 1953	western Oregon	heavy rain accompanied major windstorm; serious log hazards on Columbia	rain on snow
Dec. 1955	Columbia and coastal streams	series of storms; heavy, wet snow; many homes and roads damaged	rain on snow
Mar. 1964	coast and Columbia River estuary	Ocean flooding	tsunami
Dec. 1964	entire state	two storms; intense rain on frozen ground	rain on snow
Jan. 1972	northern coast	severe flooding and mudslides; 104 evacuated from Tillamook	rain on snow
Jan. 1974	western Oregon	series of storms with mild temperatures; large snowmelt; rapid runoff	rain on snow
Dec. 1978	coastal streams	Intense warm rain; widespread flooding	rain on snow
Feb. 1986	entire state	warm rain and melting snow; numerous homes evacuated	rain on snow
Feb. 1987	western Oregon	heavy rain; mudslides; flooded highways; damaged homes	rain on snow
Dec. 1989	Clatsop, Tillamook and Lincoln	warm Pacific storm system; high winds; fatalities; mudslides	rain on snow
Jan. 1990	W. Oregon	significant damage in Tillamook County; many streams had all-time records	rain on snow
Apr. 1991	Tillamook County	48-hour rainstorm. Wilson River 5 ft. above flood stage; businesses closed	rain on snow
Feb. 1996	NW Oregon	deep snow pack; warm temperatures; record-breaking rains	rain on snow
Nov. 1996	W. Oregon	record-breaking precipitation; flooding; landslides (FEMA-1149-DR-Oregon)	rain on snow
Nov. 2006	Tillamook County	heavy rains caused major flooding in Nehalem and Tillamook, causing $1 million in damage in Nehalem and $15 million in Tillamook	riverine
Dec. 2007	Tillamook County	heavy rains led to flooding in Tillamook along the Wilson River damaging businesses, homes, the railroad to the Port; county-wide damages total 26 million	riverine
Dec. 2008	Tillamook County	heavy rainfall caused flooding in downtown Tillamook; estimate of $3.8 million in damages throughout Tillamook County	riverine
Jan. 2012	Coos, Curry, Lincoln, and Tillamook Counties	a severe winter storm including flooding, landslides, and mudslides affected mostly the southern Oregon coastal counties	riverine
Sep. 2013	Tillamook County	heavy rain caused flooding at the Wilson River	riverine
Dec. 2015	W. Oregon	severe winter storm; Rockaway Beach flooded on the east side of Hwy 101 due to a combination of sand blocking outlets and high tides meeting large volumes of runoff from higher ground. The Hwy 101 corridor north of the City of Tillamook flooded causing a number of long-duration road closures. Previous mitigation projects minimized losses.	riverine

Source: Taylor and Hannan (1999), Source: Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://hvri.geog.sc.edu/SHELDUS/index.cfm?page=faq. National Climatic Data Center, Storm Events, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms; ; FEMA https://www.fema.gov/disaster/4258 accessed 09/2016; Julie Slevin, OEM, personal contact 09/16/2016; Chris Shirley, DLCD personal contact 09/16/2016.

Probability of Future Flooding

Flood risk or probability is generally expressed by frequency of occurrence and measured as the average recurrence interval of a flood of a given size and place. It is stated as the percent chance that a flood of a certain magnitude or greater will occur at a particular location in any given year.

FEMA's Flood Insurance Studies (FISs) Flood Insurance Rate Maps (FIRMs) are the most widely used indicators of the probability of flooding. FIRMs depict the inundation area of a flood with a 1% chance of occurring in any year (also known as "base flood" or "100-year flood") as well as inundation area of a flood with a 0.2% chance ("500-year flood), areas where the probability of flooding is unknown, and base flood elevations (BFEs) where they have been calculated. BFE is the projected depth of floodwater at the peak of a base flood, generally measured as feet above sea level. It is important to recognize that floods occur more frequently near the flooding source. Information regarding the probability of flooding at a given location in the regulated flood zones is provided by Flood Insurance Studies (FIS) for large watersheds. FEMA does not provide information about floods emanating from small watersheds (less than one square mile), or for floods caused by local drainage issues. Probabilities for these types of flood are, as a result, difficult to obtain.

Ocean storms can be expected every year. El Niño effects, which tend to raise ocean levels, occur about every 3 to 5 years (Taylor & Hannan, 1999). V (wave velocity) zones, depicted on FEMA's Flood Insurance Rate Maps, are areas subject to 100-year flood events. The Flood Insurance Rate Maps show areas vulnerable to wave action (V zones), as well as ponding and sheet-flow from waves over-topping dunes (AO and AH zones). Currently, DOGAMI is working with FEMA to update and remap FEMA coastal flood zones established for Oregon's coastal communities.

Communities participating in the NFIP are required to regulate development in Areas of Special Flood Hazard (1% chance), also known as the 100-year flood zone. The FIRMs are also used to rate required flood insurance policies on homes and businesses with federally-backed mortgages.

FEMA initially developed Flood Insurance Studies (FISs) and Flood Insurance Rate Maps (FIRMs) to administer the National Flood Insurance Program (NFIP) in Tillamook County in 1977 and 1978. The FIRMs for the Cities of Bay City, Garibaldi, and Wheeler have not been updated. The others have been updated, with the most recent update completed 12 years ago. FEMA is currently in the process of updating the FIS and FIRMs countywide. The Draft FIS and Draft FIRMs dated 2016, while currently unofficial, are the best available data and were used for this NHMP update. The Area of Special Flood Hazard (1% chance or 100-year flood zone) is basis of the flood exposure and loss analyses.

Table XX. Initial and Effective FIS and FIRM Dates

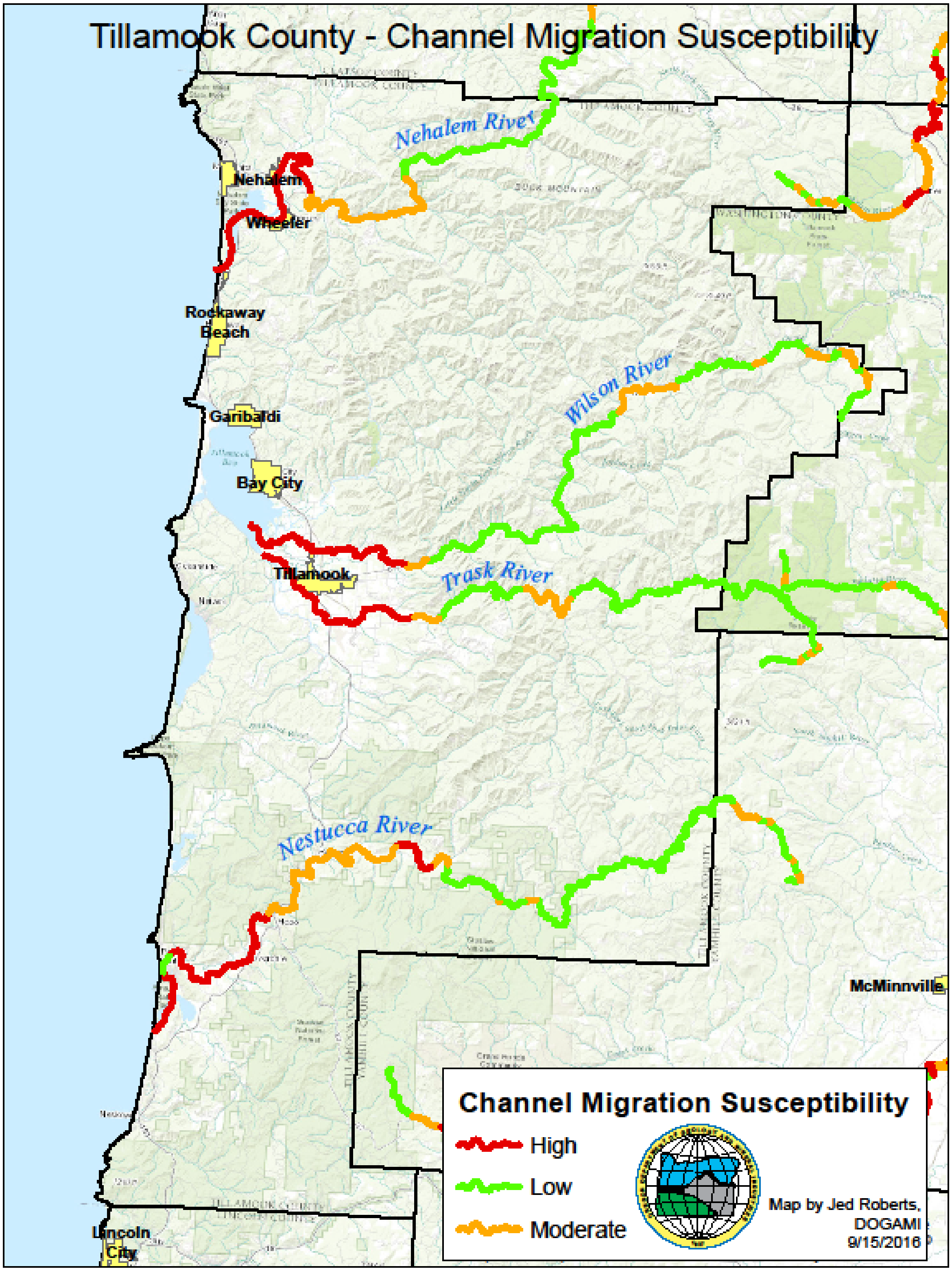
Jurisdiction	Initial FIRM Date	Effective FIS and FIRM
Unincorporated Tillamook County	8/1/1978	8/20/2002
Bay City	8/1/1978	8/1/1978
Garibaldi	8/1/1978	8/1/1978
Manzanita	5/1/1978	1/12/1982
Nehalem	4/3/1978	12/7/1982
Rockaway Beach	9/29/1978	10/12/1982
Tillamook	5/1/1978	4/16/2004
Wheeler	11/16/1977	11/16/1977

Source: FEMA database accessed September 16, 2016

Insert and discuss maps of flood-prone areas in each community.

Channel migration associated with flooding also can be identified with respect to a probability of migration over a period of 100 years. Historic aerial photos are catalogued to calculate past rates of migration which are then projected out to define a channel migration zone. Avulsion (i.e., channel shifting) zones, which are a component of the larger channel migration zone, are an exception to the migration rate approach. Areas of likely avulsion are identified by professional judgment of a fluvial geomorphologist, using high-resolution topographic data, aerial photos, and field observation.

Identification of channel migration susceptibility at the regional level is described in terms of low, moderate, and high relative probabilities. Probability is determined by assessing physiographic parameters of channel gradient, confinement, and pattern.



Insert discussion of the Southern Flow Corridor Project.

Insert graphics illustrating the Southern Flow Corridor Project.

Potential Effects of Climate Change

Recent studies make it clear that global ocean water levels are rising. Because Oregon's western edge is rising, the rates of sea level rise in Oregon are not as high as rates seen in other west coast locations, but they are rising. Flooding on the estuarine fringe is affected by ocean water levels — including tides and storm surges — in addition to freshwater inflow from the estuarine watershed.

Recent research also indicates that significant wave heights off Oregon are increasing. Increasing significant wave heights may be a factor in the observed increase of coastal flooding events in Oregon. During El Niño events, sea levels can rise up to about 1.5 feet (0.5 meters) higher over extended periods (seasons). Rising sea levels and increasing wave heights are both expected to increase coastal erosion and coastal flooding.

Extreme precipitation events have the potential to cause localized flooding due partly to inadequate capacity of storm drain systems. Flood events are expected to increase in number and magnitude. Areas thought to be outside the floodplain may begin to experience flooding.

Vulnerability to Flooding

Vulnerability expresses the impacts to people and the built environment anticipated from flooding.

Properties near the rivers that feed Tillamook Bay have experienced significant flood losses. In fact, the meaning of the term "100-year flood" was lost when repetitive flood events impacting the City of Tillamook and adjacent portions of Tillamook County exceeded the base flood elevation numerous times, including major flood events in 1996, 1998 and 1999, 2007, 2011, and most recently 2015. Many buildings – including those built before and after FIRMs were first developed – experienced repetitive flood losses along US-101 north of the City of Tillamook, many of which have been mitigated using FEMA post-disaster mitigation (HMGP) grants.

In general, the north coast is more vulnerable to riverine flood damage than the south coast because it is more densely populated and consequently contains much of the region's infrastructure. Physical location also makes a difference. For example, five rivers empty into Tillamook Bay, increasing risk from riverine flooding on the relatively flat valley floor.

Fortunately, unlike the East and Gulf coasts, only a few of Oregon's coastal developments are within FEMA-designated Velocity (V) zones. Information from the National Flood Insurance Program (NFIP) indicates that Lincoln and Tillamook Counties and their coastal cities account for nearly all of the V-zone flood policies and losses on the Oregon coast.

Coastal highways have always been problematic. Much of the problem is linked to local geology; some sections are more susceptible to wave action than others and require continuous maintenance. There is no practical solution outside of relocation of the highway.

Hazus-MH is a nationally applicable and standardized methodology that contains models for estimating potential losses from earthquakes, floods and hurricanes. Hazus-MH was developed by FEMA and uses Geographic Information Systems (GIS) technology to estimate physical, economic and social impacts of disasters (FEMA Hazus, 2015). Hazus-MH is used for mitigation and recovery, as well as preparedness and response. Government planners, GIS specialists, and emergency managers use Hazus-MH to estimate potential losses and then determine the most beneficial mitigation approaches to minimize them. Hazus-MH can be used in the risk assessment phase of the mitigation planning process, which is the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction and repeated damage (FEMA Hazus, 2015).

Loss Estimation and Exposure

Hazus-MH can be used in different modes depending on the level of detail required. Given the high spatial precision of the natural hazard data, DOGAMI chose the user-defined facility (UDF) mode. This mode makes loss estimations for individual buildings relative to their replacement cost, which DOGAMI then aggregates to the community level to report loss ratios.

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.

DOGAMI used Hazus-MH version 2.2, which was the latest version available at the outset of this risk assessment. Hazus-MH loss estimation results are shown in Table XX.

Exposure is the straightforward methodology of tallying 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. Exposure results are communicated in terms of total building value exposed rather than replacement cost, since the loss ratio is unknown. Exposure is used for landslide, tsunami, coastal erosion, and wildfire. For comparison with loss estimates, exposure is also used for the 1% annual chance flood. Exposure results are shown in Table XX.

Table XX. HAZUS-MH Loss Estimation Analysis Summary

HAZUS ANALYSIS SUMMARY										
Community	**Population**	**Potentially Displaced Residents**	**% Potentially Displaced Residents**	**Buildings**	**Damaged Buildings**	**Essential Facilities**	**Damaged Essential Facilities**	**Total Building Value ($)**	**Replacement Cost ($)**	**Loss Ratio (%)**
Unincorporated Tillamook County	13,364	578	4.3	15,015	1,055	17	1	1,282,436,000	9,517,000	0.70
• Neskowin	230	14	6.1	653	70	0	0	118,463,000	4,778,000	4.00
• Oceanside-Netarts	1,056	0	0.0	1,701	4	2	0	203,363,000	6,000	0.00
• Pacific City	947	170	18.0	1,707	320	1	1	212,062,000	3,063,000	1.40
Bay City	1,284	0	0.0	884	0	1	0	74,769,000	0	0.00
Garibaldi	779	0	0.0	755	17	3	0	64,331,000	61,000	0.09
Manzanita	599	0	0.0	1,523	0	1	0	259,780,000	0	0.00
Nehalem	267	7	2.6	260	33	2	1	24,887,000	259,000	1.00
Rockaway Beach	1,305	56	4.3	2,240	138	2	1	211,809,000	1,194,000	0.60
Tillamook	4,999	297	5.9	2,270	185	10	1	322,398,000	3,055,000	1.00
Wheeler	420	9	2.1	363	12	0	0	30,556,000	101,000	0.30
COUNTYWIDE	**25,250**	**1131**	**43.3**	**27,371**	**1,834**	**39**	**5**	**2,804,854,000**	**22,034,000**	**9.09**

Table XX. Exposure Analysis Summary

EXPOSURE ANALYSIS SUMMARY										
Community	**Population**	**Potentially Displaced Residents**	**% Potentially Displaced Residents**	**Buildings**	**Exposed Buildings**	**Essential Facilities**	**Exposed Essential Facilities**	**Total Building Value ($)**	**Building Value ($)**	**Exposure Ratio (%)**
Unincorporated Tillamook County	13,364	1,082	8.1	15,015	1,373	17	1	1,282,436,000	132,742,000	10.0
• Neskowin	230	38	17.0	653	136	0	0	118,463,000	39,637,000	33.0
• Oceanside-Netarts	1,056	4	0.4	1,701	49	2	0	203,363,000	9,362,000	4.6
• Pacific City	947	276	29.0	1,707	484	1	1	212,062,000	37,118,000	18.0
Bay City	1,284	5	0.4	884	7	1	0	74,769,000	562,000	0.8
Garibaldi	779	11	1.4	755	31	3	0	64,331,000	1,243,000	1.9
Manzanita	599	1	0.0	1,523	5	1	0	259,780,000	578,000	0.2
Nehalem	267	41	15.4	260	49	2	1	24,887,000	6,336.000	26.0
Rockaway Beach	1,305	157	12.0	2,240	356	2	1	211,809,000	28,591,000	13.0
Tillamook	4,999	529	11.0	2,270	275	10	1	322,398,000	35,124,000	11.0
Wheeler	420	9	2.1	363	12	0	0	30,556,000	917,000	3.0
COUNTYWIDE	**25,250**	**2,153**	**96.8**	**27,371**	**2,777**	**39**	**5**	**2,804,854,000**	**285,880,336**	**122**

National Flood Insurance Program (NFIP)

Structures built prior to issuance of the initial NFIP FIS and FIRMs are known as "pre-FIRM" structures. Their lowest floors are often below the BFE making them particularly susceptible to flooding. Those with lowest floors at least one foot below the BFE are called "minus rated" and are more vulnerable to flood damage. Table XX indicates a large number of flood insurance policies for pre-FIRM buildings in the County. Two-thirds of the structures are located in unincorporated Tillamook County and one-fifth are in Rockaway Beach, two of the places most susceptible to both riverine and coastal flooding in the County.

Table XX. NFIP Flood Insurance Policies

Jurisdiction	Number of Policies		Number of Policies by Building Type					
	Total Policies	Pre-FIRM Policies	Single-Family	2-4 Family	Other Residential	Non-Residential	Minus-Rated A Zone	Minus-Rated V-Zone
Unincorporated Tillamook County	1,537	660	1243	35	156	103	71	7
Bay City	14	7	14	0	0	0	1	0
Garibaldi	19	9	14	0	0	4	0	0
Manzanita	152	51	141	9	0	2	3	1
Nehalem	24	12	15	1	0	8	0	0
Rockaway Beach	415	197	256	29	118	12	35	7
Tillamook	112	57	67	4	4	37	2	0
Wheeler	6	5	4	0	0	2	0	0
TOTAL	2,279	998	1,754	78	278	168	112	15

Source: FEMA, August 22, 2016

Most of the NFIP insurance claims paid have been for flood damage in unincorporated Tillamook County and the City of Tillamook. Seventy-two percent and 65% respectively have been for damage to pre-FIRM structures. Countywide, 71% of all claims have been for damage to pre-FIRM structures. Although significantly fewer claims were paid for damage in the City of Tillamook than in unincorporated Tillamook County, the total amount paid was greater. The average amount paid per claim in unincorporated Tillamook County was $14,569, much less than the average $45,941 paid per claim in the City of Tillamook.

Table XX. NFIP Flood Insurance Claims

Jurisdiction	Insurance in Force ($)	Total # Paid Claims	# Pre-FIRM Paid Claims	# Post-FIRM Paid Claims	Total Paid ($)
Unincorporated Tillamook County	386,949,800	385	278	107	5,609,231
Bay City	3,677,400	1	1	0	4,145
Garibaldi	5,642,600	3	3	0	35,848
Manzanita	48,555,000	1	0	1	1,954
Nehalem	7,546,500	14	12	2	228,326
Rockaway Beach	87,290,900	44	32	12	621,057
Tillamook	31,774,200	174	113	61	7,993,652
Wheeler	925,100	1	1	0	62,616
TOTAL	**572,361,500**	**623**	**440**	**183**	**14,556,830**

Source: FEMA, August 22, 2016

Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. The Cities of Nehalem and Tillamook participate in CRS.

Insert map: General locations of claims paid

Repetitive Loss and Severe Repetitive Loss Properties

FEMA has identified 47 buildings in Tillamook County as repetitive loss (RL) properties. The NFIP defines a RL property as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period since 1978. At least two of the claims must be more than 10 days apart but within 10 years of each other. Or, the property must have incurred flood-related damage on 2 occasions, in which the cost of the repair, on average, equaled or exceeded 25% of the market value of the structure at the time of each such flood event.

Beyond identifying vulnerable buildings, the RL list provided by FEMA has value for hazard mitigation planning because the location of these buildings may indicate areas of persistent flood or drainage problems. The City of Tillamook is the only city in the state with RL buildings numbering in the double digits.

Severe repetitive loss (SRL) properties are a subset of RL properties. SRL properties:

1. Are covered under a contract for flood insurance made available under the NFIP; and
2. Have incurred flood related damage:
   a. for which four or more separate claims payments have been made under flood insurance coverage with the amount of each such claim exceeding $5,000, and with the cumulative amount of such claims payments exceeding $20,000; or
   b. for which at least two separate claims payments have been made under such coverage, with the cumulative amount of such claims exceeding the market value of the insured structure.

Table XX. NFIP Flood Insurance Claims

Jurisdiction	Repetitive Loss Buildings	Severe Repetitive Loss Buildings
Unincorporated Tillamook County	32	7
Bay City	0	0
Garibaldi	0	0
Manzanita	0	0
Nehalem	0	0
Rockaway Beach	2	0
Tillamook	13	5
Wheeler	0	0
TOTAL	**47**	**12**

Source: FEMA, August 22, 2016

State Vulnerability Assessment Methodology

Oregon does not have one standard method to assess risk across all hazards statewide. Experts from DLCD and DOGAMI together compiled and analyzed data and determined the best method or combination of methods to identify vulnerability and potential impacts of flooding for the following state assessment from the 2015 Oregon NHMP.

Knowledge derived from field experience, discussions with scientists, scientific publications, agency reports, and thesis dissertations were used to determine which communities are the most vulnerable to coastal hazards within Oregon. Tillamook County ranked #1 for vulnerability to coastal flooding in unincorporated Tillamook County at Neskowin, Tierra del Mar, Cape Meares, Twin Rocks, and also at Rockaway Beach.

Every Oregon County has suffered flood losses at one time or another. Some counties are more susceptible to both flood events and damages. To capture these differences in susceptibility DLCD created a countywide flood vulnerability index by compiling data from NOAA's Storm Events Database and from FEMA National Flood Insurance Program. Data were calculated statewide for the period 1978 through 2013 for five input datasets: number of events, structure and crop damage estimates in dollars and NFIP claims number and dollar amounts. The mean and standard deviation were calculated for each input. Then, each county was assigned a score ranging from 0 to 3 for each of these inputs according to Table XXTable .

Table XX. Scoring for Vulnerability Index

Score	Description
3	county data point is greater than 2.5 times standard deviation for the input data set
2	county data point is greater than 1.5 times standard deviation for the input data set
1	county data point is within standard deviation
0	no data reported

DLCD summed the scores for each of the five inputs to create a county-by-county vulnerability index. Since there were five input datasets, with a maximum score of three each, the maximum countywide score could be 15. The theoretical minimum score could be zero, but in fact all but one county had complete datasets, so the actual minimum score was four.

A vulnerability index value over 5 indicates that one or more input variables exceeded 1.5 times the confidence limit for that input, meaning that the value exceeds the average value for that input. A score over 6 indicates that at least one variable significantly exceeds average values. Tillamook County received a flood vulnerability score of 11 indicating that two or more input variables significantly exceeded average values for the State. In fact, Tillamook County's score was the highest in the state, indicating it is the county most vulnerable to flood losses statewide. Within the County, the City of Tillamook ranks in the four cities most vulnerable to flooding statewide as measured by number and dollar amount of NFIP claims paid (Oregon NHMP, 2015).

Local Risk Assessment Methodology

FEMA developed a hazard analysis methodology circa 1983, and gradually refined by OEM over the years. This "OEM Methodology" is used by communities throughout Oregon.

The methodology produces scores that range from 24 to 240. Vulnerability and probability are the two key components of the methodology. Vulnerability examines both typical and maximum credible events, and probability endeavors to reflect how physical changes in the jurisdiction and scientific research modify the historical record for each hazard. Vulnerability accounts for approximately 60% of the total score, and probability approximately 40%.

Conducting the hazard analysis described in this document is a useful early step in planning for hazard mitigation, response, and recovery. This method provides a sense of hazard priorities, or relative risk. It doesn't predict the occurrence of a particular hazard, but it does "quantify" the risk of one hazard compared with another. By doing this analysis, planning can first be focused where the risk is greatest.

Tillamook County executed this methodology in October 2015 considering probability of and vulnerability to floods throughout the county. The County rated probability high and vulnerability medium to high. The total score for flood was the highest of all the hazards considered and equal to the scores for winter storms, windstorms, and landslides.

Tillamook County and its cities executed the "OEM Methodology" again as an element of developing this risk assessment in September 2016. This time, Tillamook County considered only the rural areas of the county and the unincorporated urban communities of Neskowin, Oceanside-Netarts, and Pacific City. An assessment was also done by each city. The assessment is based on the knowledge and experience of local officials and subject matter experts. Insert statement about the results for floods here.

Table XX. Local Risk Assessment

Jurisdiction	Hazard	Hazard	Hazard	Hazard	Hazard	Hazard	Hazard	Hazard	Hazard
Unincorporated Tillamook County									
Neskowin									
Oceanside-Netarts									
Pacific City									
Bay City									
Garibaldi									
Manzanita									
Nehalem									
Rockaway Beach									
Tillamook									
Wheeler									

Source: Tillamook County Multi-Jurisdictional NHMP Update Steering Committee, September-October, 2016.