Landslide

Hazard Profile

Landslides, mudslides and other debris flows can occur when a number of factors combine to create a specific set of conditions. Steep slopes alone do not indicate a landslide risk, although slides are unlikely to happen in an area with a slope less than 15 degrees or a 30% angle. The way in which the soil on the slope is stratified, or layered, and in what order those layers exist is the largest factor. If layers of loose soil, gravel, or other non-compact materials lay atop an impermeable surface such as clay or solid rock, those top layers are at risk of sliding due to a tremor, erosion, or during a heavy storm when they become saturated with water.

Because the Tulalip Reservation was once covered by glaciers that advanced and retreated many times during the various ice ages, many areas have stratified soil that creates a landslide risk. When the angle of a hillside or cliff edge coincides with the angle that the soil is layered, there is an extremely high risk of a slide. This may change drastically within a short distance, and thus landslide areas are often isolated pockets, rather than a continuous swath.

A hillside that was previously stable can become a landslide risk if the vegetation on it is removed, since root systems can act as a natural support. If the land around or above the slope is altered in such a way that stormwater runoff is increased, that can also add to landslide risks since the soil can become fully saturated in even a small rainstorm. Heavier water flows can also speed up erosion that changes the angle of the slope.

The most likely time for a landslide to occur is when the ground is almost or fully saturated, perhaps after steady rainfall for several weeks. In addition, an unstable slope can suddenly slide due to an earthquake, tsunami, or other major force or impact (e.g. the shockwave from an explosion).

Past Events

Landslides and mudflows in Snohomish County have previously occurred in conjunction with major storm systems. Heavy rains often overwhelm drainage systems, saturating soil and increasing runoff on steep slopes. One particular slide in January 1997 gave an idea of what a major slide on the Tulalip Reservation might look like, due to the similarity in slope and soil conditions. Fifty-feet of a cliffside property in Woodway gave way with enough force to knock a passing freight train into Puget Sound.

Location

There are four different types of landslides that can occur in the Puget Sound area:

- **High Bluff Peeloff**: Blocks of soil fall from high bluffs (commonly along the near-vertical cliffs of Puget Sound).
- **Groundwater Blowout**: Groundwater bursts out between the layers of permeable and impermeable soils.
- **Deep-Seated Landslides**: Deep sliding and slumping caused by groundwater pressures within a hillside.
- **Shallow Colluvial (Skin) Slides**: Shallow sliding of the surface of a hillside slope.

The shallow colluvial slide is the most common type of slide in the Puget Sound, which occurs in response to intense, short-duration storms. The largest and most destructive are deep-seated slides, although they are the least common. Most landslides occur in January, after rain during November and December has saturated the soil. Water is involved in nearly all cases; human influence was also identified in more than 80% of the reported slides.

Locations that experienced slides in the distant future are still considered potential hazard zones, because they can be reactivated by earthquakes or wet weather. Also, these dormant sites are more vulnerable to construction-triggered sliding because the ground has already been disturbed at some point in the past.

Recently the Tulalip Department of Natural Resources has mapped landslides and potentially unstable slopes along the coast from the northern reservation border down to Priest Point. To date this is the best available data regarding landslide hazards on Tulalip.

Frequency

The frequency of a landslide is related to the frequency of earthquakes, heavy rain, floods, and wildfires. On the Tulalip Reservation, landslides typically occur during and after major storms. The velocity of movement may range from a slow creep of centimeters per year to many meters per second, depending on slope angle, material and water content.

Severity

Landslides destroy property, infrastructure, transportation systems, and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about $1.5 billion.

Landslides, mudslides and debris flows during the 1996 Holiday Blast storm caused about $30-35 million in damage throughout Snohomish County, or half of all damage caused by the storm. The landslides also caused tens of millions of dollars of damage to road infrastructure. The actual amount of damage that occurred on the Tulalip Reservation is not known, but there were road washouts caused by landslides on Tulare Beach Road and on the unnamed cliffside private road that leads to Sunny Shores.

Warning Time

Mass movements can occur either very suddenly or slowly. It is possible to determine what areas are at risk within a certain timespan (e.g. areas at risk of slide in the next 10 years). The geology, vegetation, and amount of predicted precipitation for a given area inform these predictions. If these factors change significantly, for instance after a wildfire or major construction project, a reassessment of landslide zones may be required.

Secondary Hazards

Landslides can have many types of secondary effects. Landslides often block egress and ingress on roads, which can potentially isolate residents and businesses. Roadway blockages caused by landslides can affect commercial, public and private transportation, resulting in economic losses for businesses and the Tribe.

Other potential problems resulting from landslides are power and communication failures. Telephone or electrical poles near a slope that fails can be knocked over, breaking the lines. Landslides also have the potential of destabilizing the foundation of structures that may be costly to repair.

It is possible for landslides to affect environmental processes. Landslides can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

A major secondary hazard caused by landslides, especially along the coast or large lakes, is tsunamis. When debris from a landslide falls into a water body, such as Possession Sound, it creates a sloshing effect that generates a tsunami that can cause more damage than the landslide itself. One well-known incident was the landslide that occurred on Camano Head in the early 1800s. It killed nearly a hundred people, mostly women and children, and sent a tsunami southeast towards Hat Island, destroyed a village and killing others there. A similar event could affect the Tulalip Reservation, particularly Tulalip Bay and Priest Point.

Exposure Inventory

The Tulalip Reservation's main areas of exposure and vulnerability to landslides are to the homes located along the bluffs along Port Susan and Possession Sound. Using GIS, 2010 Snohomish County Assessor's parcel data was overlain onto the landslide hazard zones determined by the DNR and DCD studies, and a 50-foot buffer created around these zones.

There were no critical facilities identified in these zones; however, several residential parcels and portions of some roads fall within the hazard zone. If the roads are inaccessible after a slide, it may significantly hinder rescue and evacuation efforts, as these roads are the only route to these areas.

Vulnerability

The Tulalip Zoning Ordinance (Ordinance number 80) defines bluffs and steep slopes as Environmentally Sensitive Lands, where development should be regulated. These steep slopes are defined as "Slopes over 15% or otherwise subject to slope instability, potential landslide or significant erosion ".

For this study, the Tulalip Department of Natural Resources has mapped landslides and potentially unstable slopes along the coast from the northern border down to Mission Beach. Furthermore, the Tulalip Department of Community Development commissioned a study of unstable slopes above and below homes along Mission Beach. To date this is the best available data regarding landslide hazards on Tulalip.

The properties most vulnerable to landslides as of April 2006 are the houses located along the cliff at Hermosa Point, examples of which is shown in **Figures 11, 12 and 13**. Some are hanging over the edge of the rapidly eroding landslide-prone bluff. The ideal mitigation action would be to relocate or destroy the vulnerable homes.

Figure 11: Vulnerable Homes on Hermosa Point

Figure 12: Vulnerable Homes on Hermosa Point

Figure 13: Vulnerable Homes on Hermosa Point

Homes located along the bluffs on Potlatch Beach Road and Priest Point Drive are vulnerable to landslides.

The communities of Tulalip Shores, Tulare Beach, and Sunny Shores are extremely vulnerable to landslides. All three communities, but especially Tulare Beach and Sunny Shores, can become isolated by landslides blocking or washing out roads. These roads are Tulare Way, Port Susan Beach Road and Tulalip Shores Road. Much of Sunny Shore is located on a steep, winding private road that sees frequent landslides. Many homes here are perched on precariously steep slopes and are extremely vulnerable to landslides.

Mission Beach and Mission Beach Heights Road homes above and below the bluff are extremely vulnerable to landslides, as seen in **Figure 14.** In 2004, Tulalip Department of Community Development commissioned a study to assess the slopes at Mission Beach Heights, which found that:

> "...based on field observations, we have concluded that portions of the slope have a high risk of future landsliding. We encountered slide debris at several accessible locations at the toe of the slope. Exposed landslide scarps varying in heights were observed along most of the slope within the project area."

Figure 14: Mission Beach Heights

Loss Estimation

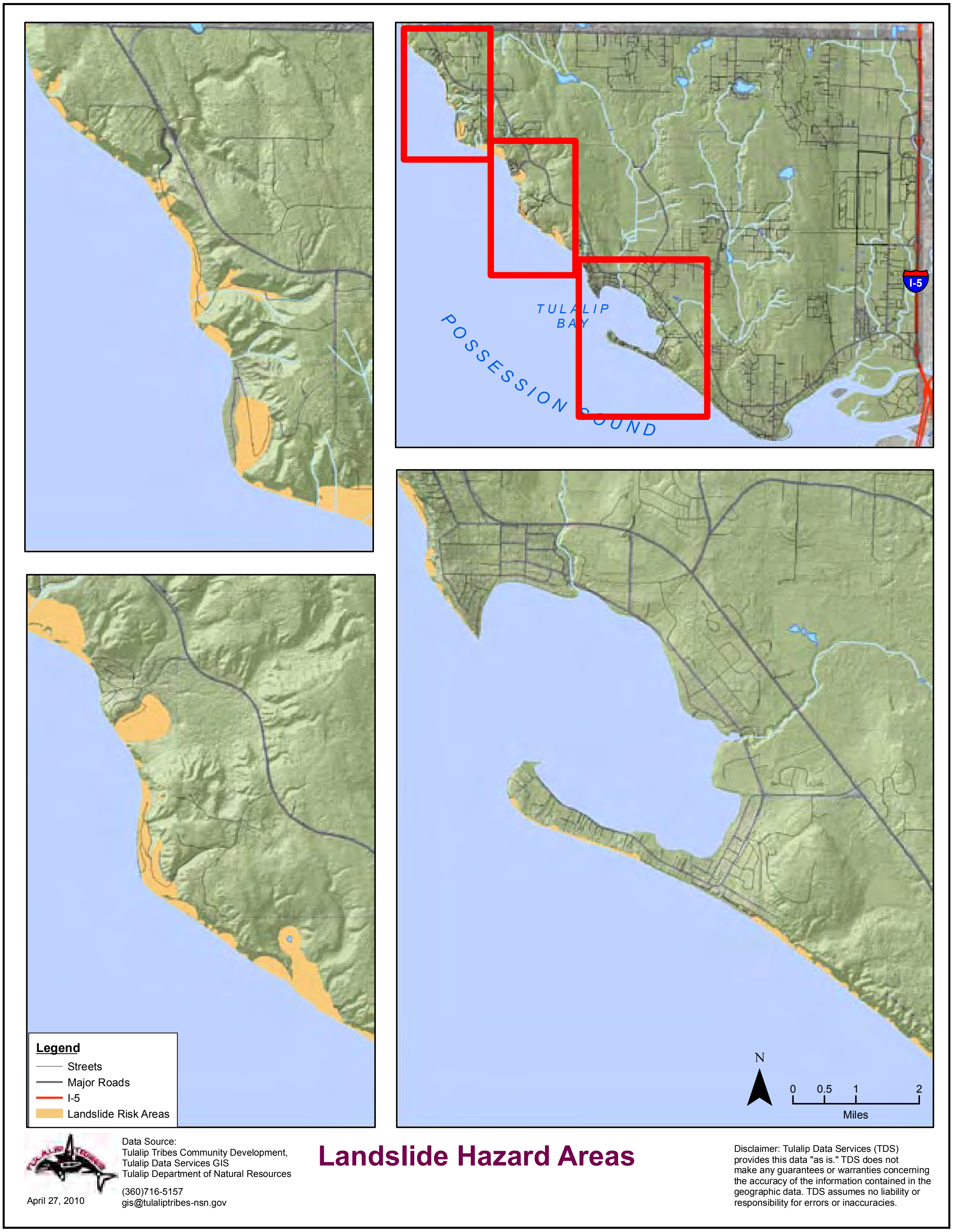
Currently there are no standards in place to estimate losses from landslides. Large landslides occur infrequently and tend to be very localized, damaging only one or a few homes. Nonetheless the damages can be high, and frequently homes are condemned after experiencing a landslide. The values used in this loss estimation are a hypothetical estimate of all potential damage. Its purpose is to come up with a value that can be used to compare with other hazards, in order to prioritize and focus mitigation efforts.

Assumptions

- Damage to buildings is estimated to be 55% of their value.
- Content loss is 10% of half the building value. Landslides typically destroy the structural integrity of the building, leading to condemnation, but hardly ever destroy the contents (clothes, televisions etc.) or injure people.

Landslide	Improvements			Land / Buildings		Contents			Daily Sales	
	Exposed		Damage	Exposed		Exposed		Damage		
Parcels	$54.6 M	11%	$30.0 M	$95.6 M	13%	$27.3 M	11%	$2.7 M		
Critical Buildings	0	0%	0	0	0%	0	0%	0	0	0%

Landslide	At Risk	% of Total
Population	4305	47%
Vulnerable Population	0	0%



Map 10: Landslide Hazard Areas

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Tsunami/Seiche

Hazard Profile

A tsunami is a series of high-energy waves of water that radiate outward from the epicenter of an earthquake like ripples on a pond. It is not a single large wave; the first wave will be followed a few minutes or a few hours later by several more waves, generally increasing in size over time. Tsunamis can travel at more than 600 miles per hour in the open ocean, traversing the entire Pacific Ocean in 20 to 25 hours. The 2004 Indian Ocean earthquake, also known as the Sumatra-Andaman earthquake, triggered a series of lethal tsunamis up to 100 feet high, killing over 200,000 people and devastating coastal communities in several countries.

> ***Seiche:*** *A seiche is a standing wave in an enclosed or partly enclosed body of water normally caused by earthquake activity. These events usually don't occur in proximity to the epicenter of a quake, but possibly hundreds of miles away due to the fact that the shock waves a distance away is of a lower frequency.*

The most recent disastrous tsunami occurred after the 2010 Chile subduction-zone earthquake, which caused localized destruction on the nearby coast and islands. Unusually high waves were recorded in Hawaii, Japan and the Puget Sound but caused no damage outside of South America.

Past Events

Within Puget Sound, no written records exist of damaging waves. However, verbal accounts among the Snohomish Tribe reported by Colin Tweddell in 1953 describe a great landslide-induced wave caused by the collapse of Camano Head at the south end of Camano Island sometime during the 1820s or 1830s. The slide itself buried a small village, and the resulting tsunami drowned "men and women, and some of the children" who may have been clamming on Hat (Gedney) Island, two miles to the south. Bathymetry between Camano Head and Hat Island could have contributed to the size and destructive power of the wave. The Tulalip Tribes consider this event a very tragic moment in their history and accordingly consider tsunami a major hazard.

Geologic evidence of tsunamis has been found at Cultus Bay on Whidbey Island and at West Point in Seattle. There was also a past event on Possession Beach on Whidbey Island that caused sloughing and a tsunami. Researchers believe these tsunami deposits are evidence of earthquake activity along the Seattle Fault or other shallow crustal Puget Sound faults. Research indicates that a tsunami affected the Snohomish River delta, possibly associated by a Seattle fault earthquake before 800 AD.

Puget Sound has experienced seiches in historical times. In 1891, an earthquake near Port Angeles caused an eight-foot seiche in Lake Washington. Seiches generated by the 1949 Queen Charlotte Islands earthquake were reported on Lake Union and Lake Washington. The 1964 Alaska earthquake created seiches on 14 inland bodies of water in Washington, including Lake Union.

Location

Tsunamis affecting Washington State may be caused by landslides or earthquakes of local origin, or by earthquakes at a considerable distance, such as from Alaska, South America or even Japan.

For the Tulalip Reservation, a tsunami will most likely be caused by a local earthquake or by a landslide along the bluffs or below the water surface. While a 70-foot wave was predicted in the 2004 plan, geologic records and the Washington State Geologist support a maximum wave height closer to thirty feet or less. This height is considered a worst-case scenario, such as a magnitude 9.1 Whidbey earthquake or a very large landslide. In most cases, a tsunami or seiche would be between 3-10 feet in height. The 30-foot tsunami height also takes into account the potential tsunami run up on shore. It was recently observed that the Indian Ocean and Chilean tsunamis traveled miles inland and to elevations above the actual wave height.

A 30-foot tsunami would affect low lying areas and communities on the Reservation, such as the Quil Ceda Creek watershed, Priest Point, Mission Beach, Tulalip Bay, Tulalip Shores, Spee-Bi-Dah, Tulare Beach, and Sunny Shores. The heaviest damage would be seen in those areas directly across open water, such as Mission Beach and Priest Point (see **Figure 15**). During an earthquake, seiches could also occur in the Reservation's lakes and ponds.

Figure 15: Priest Point

Frequency

Great earthquakes in the North Pacific or along the Pacific coast of South America that generate tsunamis occur at a rate of about six every 100 years. Local earthquakes and landslides that generate tsunamis occur more frequently, although a specific rate of occurrence has not been calculated yet.

Severity

Historically, tsunamis originating in the northern Pacific and along the west coast of South America have caused more damage on the west coast of the United States than tsunamis originating in Japan and the Southwest Pacific. For example, the 1960 Chile Earthquake generated a Pacific-wide tsunami that caused widespread death and destruction in Chile, Hawaii, and other areas in the Pacific. In contrast, the tsunami generated by the 1883 eruption of Krakatau Volcano in Indonesia and the 1886 tsunami on the Sunriku coast of Japan were not destructive outside their immediate locales.

Closer to the Northwest, a tsunami hit the Washington coast after the great 1964 Alaska earthquake; in places wave heights reached 15 feet. No deaths were reported in Washington but it caused $115,000 in damage. This same tsunami killed 11 people and caused $7.4 million damage in Crescent City, California.

Warning Time

Typical signs of a tsunami hazard are earthquakes and/or a sudden and unexpected rise or fall in coastal water. The large waves are often preceded by coastal flooding and followed by a quick recession of the water. Tsunamis are difficult to detect in the open ocean, with waves only one or two feet high. The tsunami's size and speed, as well as the coastal area's form and depth are factors that affect the impact of a tsunami; wave heights of fifty feet are not uncommon.

In general, scientists believe it requires an earthquake of at least a magnitude 7 to produce a tsunami. Seiches are usually earthquake-induced but typically do not occur close to the epicenter of an earthquake, but hundreds of miles away.

Tsunamis generated near Japan and Chile may take hours to reach Washington, while those generated off the Oregon/Washington coast may reach shore within 3 to 30 minutes. People in the way of a tsunami or seiche generated in Puget Sound may only have minutes to seconds to evacuate.

Secondary Hazards

Aside from the tremendous hydraulic force of the tsunami waves themselves, floating debris carried by a tsunami can endanger human lives and batter inland structures. Ships moored at piers and in harbors often are swamped and sunk or are left battered and stranded high on the shore. Breakwaters and piers collapse, sometimes because of scouring actions that sweep away their foundation material and sometimes because of the impact of the waves. Railroad yards and oil tanks situated near the waterfront are particularly vulnerable. Oil fires frequently result and are spread by the waves.

Fishing fleets and public utilities frequently receive the most severe damage, creating a major economic disruption and slowing the disaster recovery process.

Seiches create a "sloshing" effect on bodies of water. This primary effect can cause damage to moored boats, piers and facilities close to the water. Secondary problems, including landslides and floods, are related to accelerated water movements and elevated water levels. Damage to the Tulalip Bay Marina could have a serious effect on the Tulalip Tribes' economy.

Exposure Inventory

An inventory was made of all structures, population and critical facilities and infrastructure that are potentially exposed to the effects of a tsunami. Although past events indicate that a tsunami or seiche typically reach maximum heights of 10 feet, a 30-foot inundation zone was shown as a worst-case scenario. This elevation takes into account the run-up onto land caused by the force of the waves. Even if a tsunami or seiche does not reach this elevation, this area still serves as a critical location for evacuation and other planning purposes.

Major roads, such as Marine Drive and Interstate 5 (I-5) could be affected. Most property affected would be residential buildings and undeveloped parcels.

Population

The Elder Housing Center is located on the edge of Tulalip Bay in the tsunami risk area. Evacuation of this population would prove particularly difficult given the higher rates of disability and need for assistance. If a tsunami is generated locally, in the Puget Sound or off the coast, the short amount of evacuation time is a particular concern for this area. There are also several Tribal-owned buildings in the tsunami risk zone that are used for large events or have high visitor populations, such as the Quil Ceda Creek Casino, the Longhouse, the Boys and Girls Club and the Tribal Gym.

Vulnerability

The main vulnerability to tsunamis are areas, structures and people who live or work along low-lying areas along the coast. These include properties along Priest Point, Mission Beach, Tulalip Bay, Tulalip Shores, Spee-Bi-Dah (see **Figure 16)**, Tulare Beach, and Sunny Shores.

Figure 16: Spee-Bi-Dah

Many of the Tulalip Tribes' critical facilities, such as the health clinic, marina, tribal center and elder housing are located along Tulalip Bay, and are extremely vulnerable. Structures located along the I-5 corridor and Quil Ceda Creek watershed may experience some flooding, but are less vulnerable.

Loss Estimation

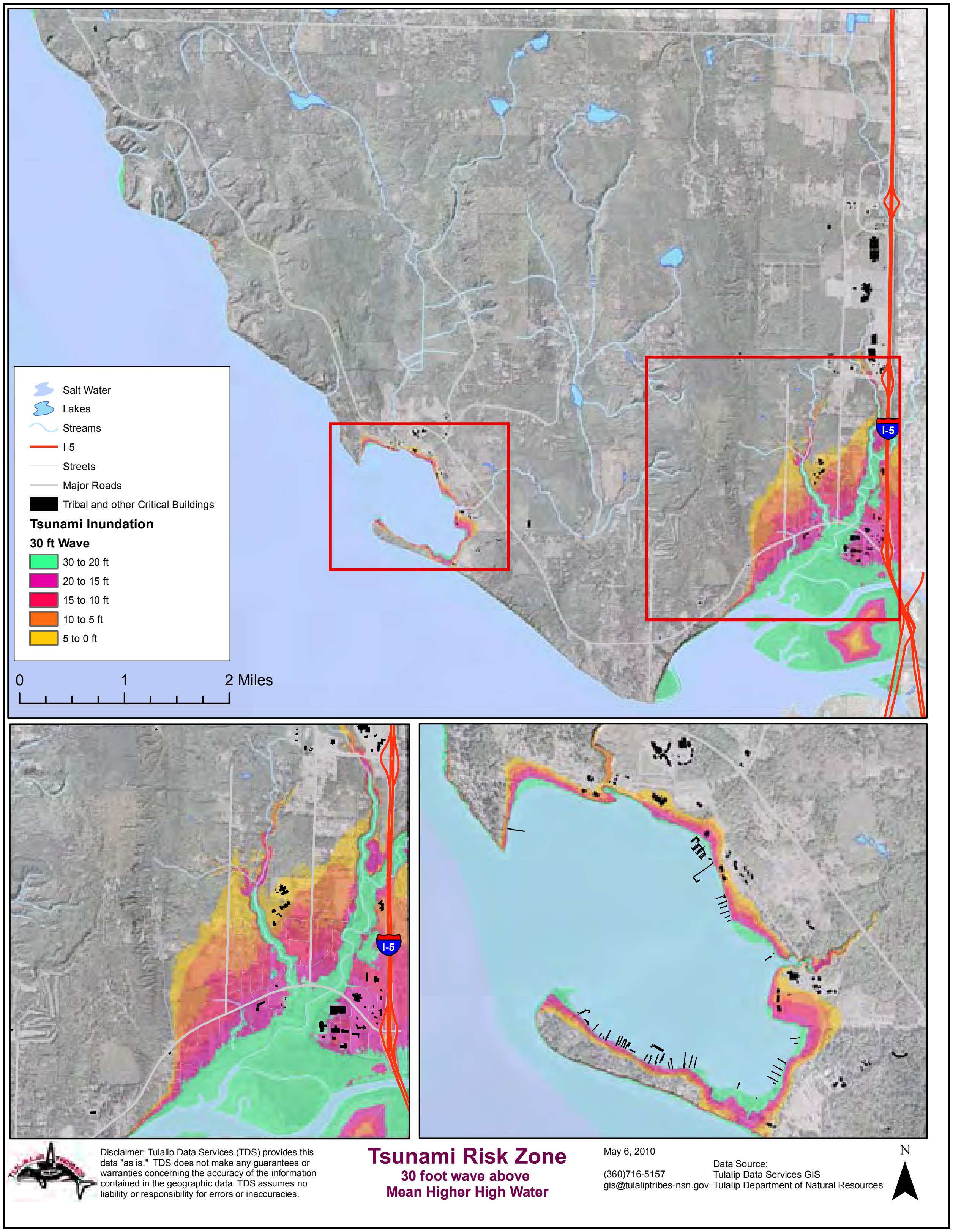
Currently there are no standards in place to estimate losses from tsunamis. In order to be able to compare the risks posed by all hazards, the values used in this loss estimation are a hypothetical estimate of *all* potential damage.

Assumptions

- Damage to buildings is estimated to be 50%
- Content loss is 50% of half the improvement value.

Tsunami	Improvements			Land / Buildings		Contents			Daily Sales	
	Exposed		Damage	Exposed		Exposed		Damage		
Parcels	$81.2 M	17%	$40.6 M	$216.1 M	29%	$40.6 M	17%	$20.3 M		
Critical Buildings	$122.2 M	36%	$61.1 M	50	32%	$136.5 M	39%	$68.2 M	$179 K	20%

Tsunami	At Risk	% of Total
Population	2180	24%
Vulnerable Population	138	13%



Map 11: Tsunami Hazard Area, 30 Foot Wave above Mean Higher High Water

Flood

Hazard Profile

The Tulalip Reservation does not experience the exposure to or severity of flooding typically found in the region or the rest of Snohomish County. While the Reservation is located along the coast and at the mouth of the Snohomish River, it is less exposed because the majority of the land is elevated on hills and bluffs above the floodplain.

The Reservation is drained by some small creeks that occasionally overflow, causing minor flooding. The Reservation can also experience coastal flooding from storm surges during severe weather. Some of the major infrastructure and critical facilities are located along the coast or on hydric soils in the low-lying flat areas along Quil Ceda Creek.

Past Events

The Tulalip Reservation does not have a well-documented history of flooding. This is due primarily to the fact that the Reservation is drained by small coastal creeks and does not have any significant development adjacent to the creeks.

The Upper Tulalip Creek Pond, used by the Tulalip Salmon Hatchery, is protected by a 70 year old dam that overtopped during the New Year's Day Storm of 1997. Approximately 400,000 Coho rearing in the pond were lost when the flood carried them over the dam and Totem Beach Road.

In 2000, blocked drainages caused significant street flooding. Firetrail Road flooded in three locations, from the overtopping of Cummings Lake and two washouts by small creeks crossing under the road.

Properties located along Priest Point have experienced 2-3 feet of flooding caused by the overflow of the Snohomish River and/or a strong storm surge. During the Super Bowl Storm of 2006, the Point was inundated by a combination of high tides and a strong storm surge, shown in **Figure 17**.

Figure 17: Priest Point Flooding, Super Bowl Storm, 2006

Location

There are three types of flooding that could affect the Tulalip Reservation: riverine flooding, storm surges and flash/surface flooding. The Tulalip Reservation does not yet participate in the National Flood Insurance Program, and therefore was excluded for study during the creation of FEMA Flood Insurance Rate Maps (FIRM), so 100- and 500- year floodplains are not defined. No flood maps have yet been created by Natural Resources or any other agency.

Riverine Flooding

Flood season begins in mid-November and continues to mid-February. Riverine flooding is usually preceded by a heavy, fresh snow in the mountains. If warm winds and heavy rainfall follows before the snow solidifies, a flood potential exists. It is rare for rain to cause flooding without these other elements being present.

High tides may prevent the usual discharge of river runoff into Puget Sound. The Reservation is least exposed to this type of flooding, as it is generally located above the floodplain of the Snohomish River. However, the marshy delta islands located near Ebey Slough and Steamboat Slough known as Big Flats can flood, as well as some of the marshy wetlands near the mouth of Quil Ceda Creek. Priest Point can be affected when heavy floods on the Snohomish River carry large amounts of silt and debris. The discharging flood can deposit this debris and silt along Priest Point, damaging bulkheads and property adjacent to the river mouth.

Storm Surges

Storm surges can affect a number of beachfront areas within the Tulalip Reservation. Generally, storm surges are caused by a combination of low atmospheric pressure and high winds. The effects of a storm surge include saltwater inundation and debris battering beachhead property. Property most often damaged by storm surge includes beachfront homes and businesses, bulkheads, marinas, docks and ferry terminals. The Super Bowl Storm of 2006 that damaged Priest Point is an example of this type of flooding.

Predicted sea level rise may make storm surge flooding more frequent or severe. The more intense storms predicted to occur due to global warming may cause increased damage or inundate higher elevations.

Flash Flooding and Surface Flooding

Flash floods occur within a few minutes to a few hours of excessive rainfall, a dam or levee failure, or a sudden release of water held by an ice or log jam. Most flood deaths are due to flash floods.

Flash flooding can occur on the small creeks located on the Reservation. These creeks include Tulalip Creek, Mission Creek and the Quil Ceda River. Creeks feeding Weallup Lake and Lake Agnes are known to overflow and sometimes washout Firetrail Road. The dam overtopping of Upper Tulalip Creek Lake in 1997 can be described as a flash flood.

In addition, urban flooding occurred during the Holiday Blast storm of December 1996 to January 1997 as a result of drainage systems that were incapable of carrying exceptional volumes of snowmelt and heavy rain runoff. As more of the Reservation's natural watershed is converted to human habitation and transportation systems, the urban flooding potential will continue to grow. In addition, sea level rise has prevented some of the existing outfalls from discharging stormwater during heavy rains. Sewer backups and urban flooding will become more common and severe as the tide level rises.

Frequency

The frequency of flooding on the Tulalip Reservation is similar to Snohomish County. Minor flooding can be experienced at least every year, especially during the fall and winter, while damaging flooding is experienced at least every 5 years.

Severity

While flooding in other areas of Snohomish County can be severe, flooding in Tulalip is generally minor. Roads can be made impassable or even washed-out by blocked culverts. Homes located on low-lying areas along the coast, such as Tulare Beach and Priest Point, can be damaged by storm surge and/or flooding from the Snohomish River.

During past events, 5 homes have made claims for damage from flooding. These claims totaled $37,000 for damage to buildings and $12,000 for damage to contents of buildings. The Tulalip Salmon Hatchery risks losing millions of dollars in fishing revenue if salmon fry are washed away.

Warning Time

The Tulalip Reservation is located at the mouth of the Snohomish River and would have several days advance warning of a riverine flood. Storm surges are harder to predict. Tulalip's location at the northern edge of the Convergence Zone creates the potential for unpredictable winds and severe weather to cause a massive storm surge that could damage low-lying waterfront properties.

Secondary Hazards

The major secondary hazards caused by flooding are landslides and erosion. Severe weather and flooding can saturate the soil, making it more susceptible to landslides. Flash flooding can cause erosion along streams, while storm surges can cause coastal erosion. Debris from flooding, such as logs, can also cause damage. Hazardous materials can also be transported by floodwaters.

National Flood Insurance Policies and Claims

The National Flood Insurance Program (NFIP) is administered by the Federal Emergency Management Agency (FEMA) and is intended to provide insurance to flood-prone properties. The Tulalip Tribes does not participate in the program, but Snohomish County does, and thus the Tulalip Reservation is covered. NFIP policies and claims serve as a good indicator of flood-prone properties and locations. Most people who take out a flood insurance policy have experienced flooding in the past. The Tulalip Reservation has 23 NFIP policies. During past flood events, 5 policyholders filed claims for flood damage.

Exposure Inventory

The Tulalip Reservation's main vulnerability to flooding is to properties located along the coast and the along mouth of the Snohomish River. For this exposure inventory, all properties located within 50 feet of the shore were inventoried. In addition, parcels and infrastructure within 50 feet of water bodies, such as streams, rivers and wetlands, and within 50 feet of hydric soils were included in the exposure inventory.

Some backup of water drainage during high tide, exacerbated by sea-level rise, has been reported by utilities managers. Waterlogging and basement seepage is also a possible risk for areas on hydric soils during the rainy season. These areas were included in the proximity map in order to identify those areas that may need special attention to storm drain clearance or encouragement to purchase flood insurance. While there is less estimated damage from these types of flooding, they are more likely to occur frequently in Tulalip than major riverine or coastal flooding.

Some parcels, whose property lines extend to the shore, may not necessarily have structures located along the shore.

Vulnerability

Properties located along the shore, especially low lying areas, are most vulnerable to coastal flooding. These include residential properties along Tulalip Bay, Tulare Beach and Priest Point. Due to low elevations, homes located along Tulare Beach and Priest Point are most vulnerable.

The Tulalip Salmon Hatchery is vulnerable to flooding. Any losses at the hatchery can have a negative impact on the fishing industry for the Tulalip Tribes and other fishermen.

Vulnerable roads include Firetrail Road, which has seen past washouts, and other main arterials whose drainages can get clogged. These roads include Quil Ceda Boulevard, Totem Beach Road and the intersection of 31st Ave and Marine Drive.

Loss Estimation

Flood loss estimates are based on damage curves developed by FEMA. These numbers do not represent the total estimated value a flood may cost, but rather a hypothetical estimate of all potential damage. Its purpose is to come up with a value that can be used to compare with other hazards, in order to prioritize and focus mitigation efforts.

Assumptions

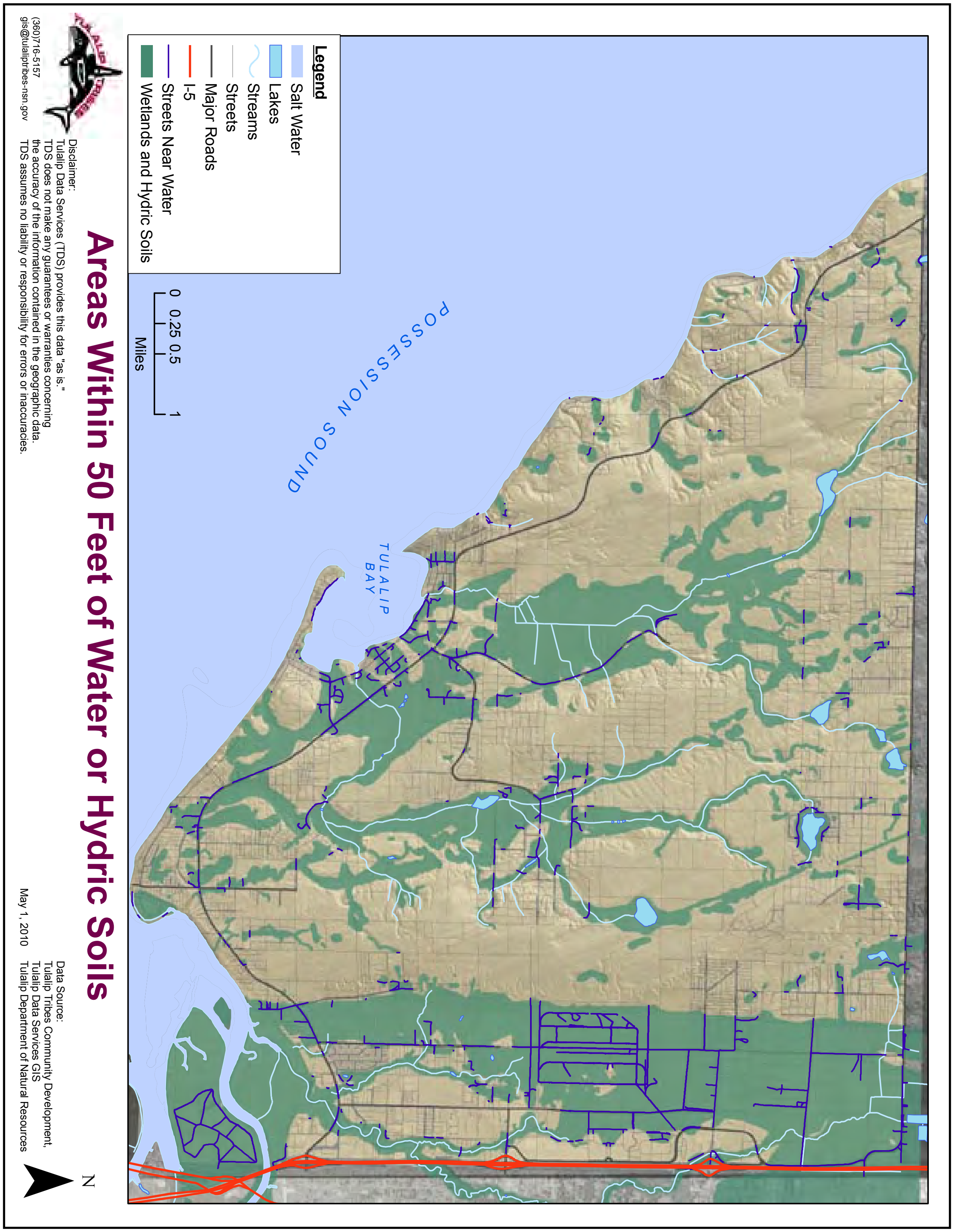
Flooding can reach depths of 3 feet. Exposed structures are assumed to be 1 story, no basement structures. Analysis of assessor's data found that 66% of structures exposed are 1 story, while 73% of structures have no improved basements.

Building damage estimates for these assumptions are 27% of improvement value. Building content damage estimates are 40.5% of half of the improvement value.

If flooding closed all access to Critical Buildings, the economic impact would result in a loss of $715,199 per day, or 81% of the estimated daily revenue of the Tribe.

Flood	Improvements			Land / Buildings		Contents			Daily Sales	
	Exposed		Damage	Exposed		Exposed		Damage		
Parcels	$59.3 M	12%	$16.0 M	$118.9 M	16%	$29.6 M	12%	$12.0 M		
Critical Buildings	$141.7 M	42%	$38.3 M	46	29%	$153.9 M	43%	$62.3 M	$715 K	81%

Flood	At Risk	% of Total
Population	2063	22%
Vulnerable Population	315	29%



Map 12: Areas Within 50 ft of Water or Hydric Soils

Wildland Fire

Wildland fires are fires caused by nature or humans that result in the uncontrolled destruction of forests, brush, field crops, grasslands, and real and personal property in non-urban areas.

Major, large-scale wildland fires are common east of the Cascades. In the Tulalip area, wildland fires are typically smaller due to the milder temperatures and heavy precipitation. There is some risk of a wildland fire starting in the heavily forested, sparsely populated inland area that could spread over a large area before being discovered. In addition, smaller wildland fires risk becoming interface fires, leaving some housing developments and critical buildings vulnerable. In some cases these areas are only accessible via a single road; if that road becomes impassable during a fire, evacuation may be difficult.

Hazard Profile

The wildland fire season in Washington usually begins in early July and typically culminates in late September; however, wildland fires have occurred in every month of the year. Drought, depth of snow pack, and local weather conditions can expand the length of the fire season.

People start most wildland fires; major causes include arson, recreational fires that get out of control, smokers' carelessness, debris burning, and children playing with fire.

Wildland fires usually are extinguished while less than one acre. A number of federal, state, county, city, and private agencies and private timber companies provide fire protection and firefighting services in Washington.

Factors that Influence Wildland Fire

A fire needs three elements in the right combination to start and grow – a heat source, fuel, and oxygen. How a fire behaves primarily depends on the characteristics of available fuel, weather conditions, and terrain.

Fuel

Lighter fuels such as grasses, leaves, and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs and trunks take longer to warm and ignite.

Weather

West of the Cascades, strong, dry east winds in late summer and early fall produce fire conditions. East wind events can persist up to 48 hours with wind speed reaching 60 miles per hour; these winds generally reach peak velocities during the night and early morning hours. These winds can be even stronger in the Convergence Zone, where the Tulalip Reservation is located.

Terrain

Topography influences the impact of weather conditions such as temperature, wind speed and direction; any potential barriers to fire spread, such as highways and lakes; and elevation and slope of land forms (i.e., fire spreads more easily as it moves uphill than downhill).

Past Events

Since 1970, the earliest year for which Department of Natural Resource (DNR) records are available, there have been 37 wildfires recorded on the Tulalip Reservation. These fires were all small, and it is not known at this time whether these fires caused any damage to property or infrastructure.

Location

Using the map of past events as an indicator, most wildfires could occur in the heavily forested areas and undeveloped lands near the bluffs in the northwest part of the Reservation. Many wildfires also have occurred in the undeveloped and heavily forested lands of the interior, particular in the hilly areas east of Marine Drive.

Frequency

Past events indicate that the Tulalip Reservation can expect usually at least one wildfire every year, although there were no fires in 2009. These will be small in size, and most likely will cause no or minor damage. Nonetheless the potential does exist for significant damage to structures and natural resources, such as timber, located in areas susceptible to fires, such as undeveloped timberlands and steep slopes.

Severity

As mentioned above, past events indicate that wildfires would not be severe on the Tulalip Reservation. In a worst-case scenario, a wildfire spread by heavy winds may damage residential structures and developments, particularly those located in the dense, heavily forested areas of the interior. On the other hand, ingress and egress to the interior lands is difficult, with only few maze-like trails accessing the timberlands.

Warning Time

After a wildfire is detected, it would only take minutes to at worst, hours to respond to a fire. Unless accompanied by very heavy winds, perhaps contributed by the weather conditions created in the Convergence Zone, sufficient time should be available to protect property and/or evacuate.

Secondary Hazards

Wildland fires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber. Wildland fires destroy transmission lines and contribute to flooding. Landslides can be a significant secondary hazard of wildfires. Wildfires strip slopes of vegetation, exposing them to greater amounts of rain and run-off. This in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a wildfire.

In addition to landslides, the following secondary effects are possible. Rehabilitation efforts after a fire occurs can reduce but cannot eliminate them:

- **Damaged Fisheries**: Critical trout fisheries throughout the west and salmon and steelhead fisheries in the Pacific Northwest can suffer from increased water temperatures, sedimentation, and changes in water quality and chemistry.

- **Soil Erosion**: The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- **Spread of Invasive Plant Species**: Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- **Disease and Insect Infestations**: Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- **Destroyed Endangered Species Habitat**: Catastrophic fires can have devastating consequences for endangered species.
- **Soil Sterilization**: Topsoil exposed to extreme heat can become water repellent, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

Exposure Inventory

Past events have shown that most fires occur in uninhabited areas. Furthermore, many of the lands where these wildfires occurred are Tribal Trust lands, and are used primarily for forestry or are maintained as Conservation lands. In order to come up with a general inventory to be used for planning purposes and the Loss Estimation, parcels within a 500-foot buffer of a past wildfire occurrence are considered more vulnerable.

Loss Estimation

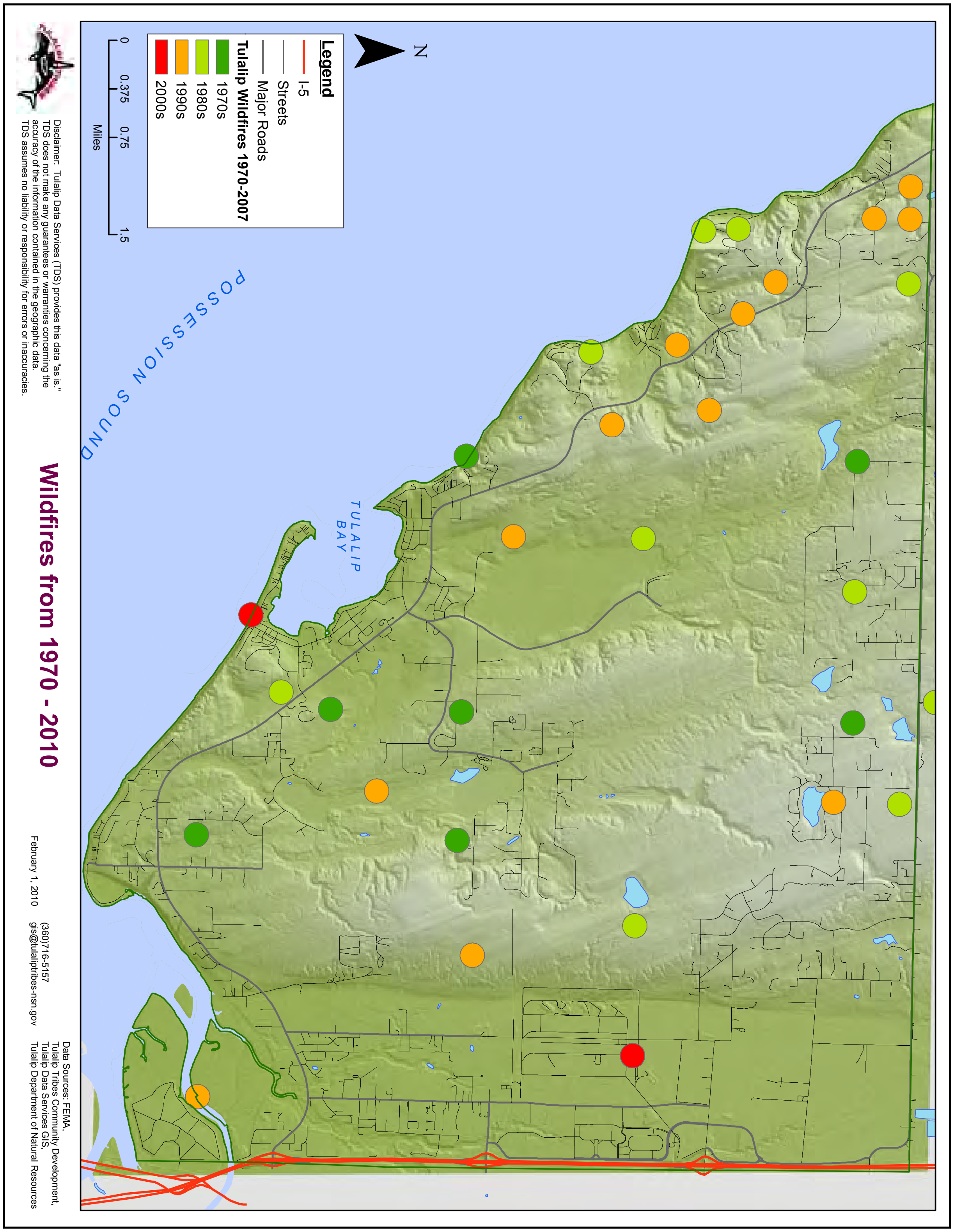
Wildfire loss estimates were based largely on the effects past wildfire events have had in the Puget Sound area. An estimate was based on projected damages that do not represent the total estimated value a wildfire may cost, but rather a hypothetical estimate of all potential damage.

Assumptions

- Wildfires will cause 10% damage to improvements and 5% damage to contents (which is estimated as half of improvement value)
- Wildfires will cause 10% damage to land

Wildfire	Improvements			Land / Buildings		Contents			Daily Sales	
	Exposed		Damage	Exposed		Exposed		Damage		
Parcels	$41.7 M	9%	$4.2 M	$162.0 M	22%	$20.9 M	9%	$1.0 M		
Critical Buildings	$5.0 M	2%	$503 K	4	3%	$5.0 M	1%	$252 K	0	0%

Wildfire	At Risk	% of Total
Population	1129	29%
Vulnerable Population	2	.2%



Map 13: Tulalip Wildfires since 1970

Additional Hazards

Heat Wave

While heat waves are fairly rare in the Pacific Northwest, the typically mild summers leave the residents particularly unprepared for extreme temperatures. Air conditioners are rare for most homes and businesses, leaving vulnerable populations at a higher risk of health complications or even death than in most areas of the country. The heat wave during the summer of 2009 lasted from July 26 to August 2, where the daily high temperatures ranged from 89 to 103 degrees Fahrenheit. July 29 was the hottest day in the Pacific Northwest since record keeping began in 1894.

Stores continuously sold out of fans, often within a few minutes of a shipment arriving. The elderly and those with breathing problems are typically the most at risk during a heat wave, and many elders in Tulalip live unaided in remote locations, sometimes without electricity or running water. Many are also low-income and cannot afford to purchase cooling units or air conditioning.

Heat waves are expected to become more common and more severe over time due to the effects of global warming. Mass shelters with air conditioning, food and water supplies may have to be activated during future heat waves to protect vulnerable populations.

Drought

While the Pacific Northwest, including Tulalip, are renowned for heavy precipitation and abundant water bodies, drought is a growing concern for planners and public utility operators. The summer months have significantly lower rainfall than the period between October and May. Occurring simultaneously with the 2009 heat wave, the Puget Sound area experienced its lowest rainfall in recorded history, with less than a quarter inch falling between May 20th to August 2nd (typical for this time period is nearly 3 inches).

A growing population, coupled with development that infringes on the aquifer's ability to recharge, could lead to water shortages in the near future. Many smaller municipalities purchase large quantities of drinking water from larger cities, risking increased rates or decreased supply as major cities continue to grow.

Higher overall temperatures and changing weather patterns are predicted impacts of climate change, and droughts are expected to become more common in the future. The Tulalip Tribes Comprehensive Land Use Plan has emphasized the use of Low-Impact Development (LID) in future development and mapped aquifer recharge locations for protection.

Pandemic

While the 2009-2010 H1N1 influenza pandemic never reached the levels of severity that some media outlets warned of, it was nonetheless a widespread, highly contagious illness that affected millions of Americans. Even those who were not hospitalized spent several days home sick from school or work, and costing businesses billions of dollars. In addition, it caused the deaths of 18,311 people worldwide, many of them children, pregnant women or those under 30.

While H1N1 had a lower death rate than regular seasonal influenza, the high rate of infection due to the delay in creation and distribution of vaccines compounded the annual flu season, overwhelming some hospitals and health clinics. During the first widespread phase, some schools were closed entirely to prevent the spread of infection and local colleges had clusters of over 2,000 cases within the first two weeks of classes.

Native American populations, similar to other minority groups, had higher rates of infection, hospitalization, and death than white populations. Although this mimics previous disease outbreaks, Tribal health clinics and officials who requested to be placed higher on the list to receive vaccines were denied, and supplies were distributed based solely on population size.

Future pandemic outbreaks may similarly strain Tribal resources and affect the economic vitality of the Tulalip Tribes. Educating the public about how to protect themselves from disease, prevent spreading the flu virus to others, and the steps to receive vaccination will be included in future educational outreach efforts by the Office of Emergency Management. Should the Health Clinic seek to establish a defined relationship with local hospitals to share resources during outbreaks and other mass casualty events, the OEM will support their efforts.

Hazardous Materials

Although not a natural hazard, hazardous materials can cause widespread damage to people, property, and the environment. Hazardous materials can be released by a hazard event, such as an earthquake, flood, or even by severe weather (for instance, a truck accident during an icy winter storm). Hazardous material spills may be the most deadly and dangerous secondary effect of natural hazards. That is why it is essential to identify all potential locations where hazardous materials may be spilled and what locations store hazardous materials on-site.

Initial review of Tier II facilities in Snohomish County (facilities and businesses that reported they contain hazardous materials) found the Tulalip Reservation did not have any. However, after discussions with Tribal officials, it was found that the Reservation had 5 major locations where hazardous materials are stored or sold:

- Home Depot
- Wal-Mart
- Suburban Propane
- Donna's Travel Plaza at the intersection of 116th and Interstate 5. This is the largest truck stop along the I-5 corridor located between Seattle and the Canadian border and routinely houses dozens of trucks containing hazardous materials. Any hazardous material spill could drain into the Quil Ceda Creek watershed.
- Tulalip Tribes Chevron Gas Station was recently opened a few blocks east of the Travel Plaza at 116th and 27th Ave NE. If underground storage tanks were somehow ruptured, a spill could enter the watershed and have negative environmental impacts. In addition, a gasoline spill may lead to an explosion or dangerous fire.

Additional vulnerabilities

- Interstate 5, the main thoroughfare between Canada and Mexico, makes up the eastern border of the Tulalip Reservation. Thousands of trucks containing hazardous materials travel this road along and through the Reservation every day, many of which stop at the truck stop mentioned above. The 2005 Hazardous Materials Commodity Flow

Assessment identified that at least 7% of all trucks traveling the corridor transport hazardous materials.

- The Tulalip Marina can also serve as a source for hazardous materials spills, particularly from diesel or gas used to fuel fishing and other boats.
- The Snohomish River, Possession Sound and Puget Sound can be a source for oil and other hazmat spills. See Section 4.9 Tulalip U&A.
- BNSF Railroad tracks that run north-south through Marysville, adjacent to Tulalip.
- The Backup Ammunition Storage Depot/ Boeing Test Site was located west of Quil Ceda Village and was used during World War II to store Mustard gas, tear gas, hydrogen cyanide and other materials. These chemical and conventional weapons were also used in training exercises at the site. It is not believed that any major stores of ammunition are to be found, but the Army Corps of Engineers is working with Tulalip Department of Special Projects to identify and clean up any hazardous materials that may be found.

Tulalip Usual and Accustomed Fishing Areas

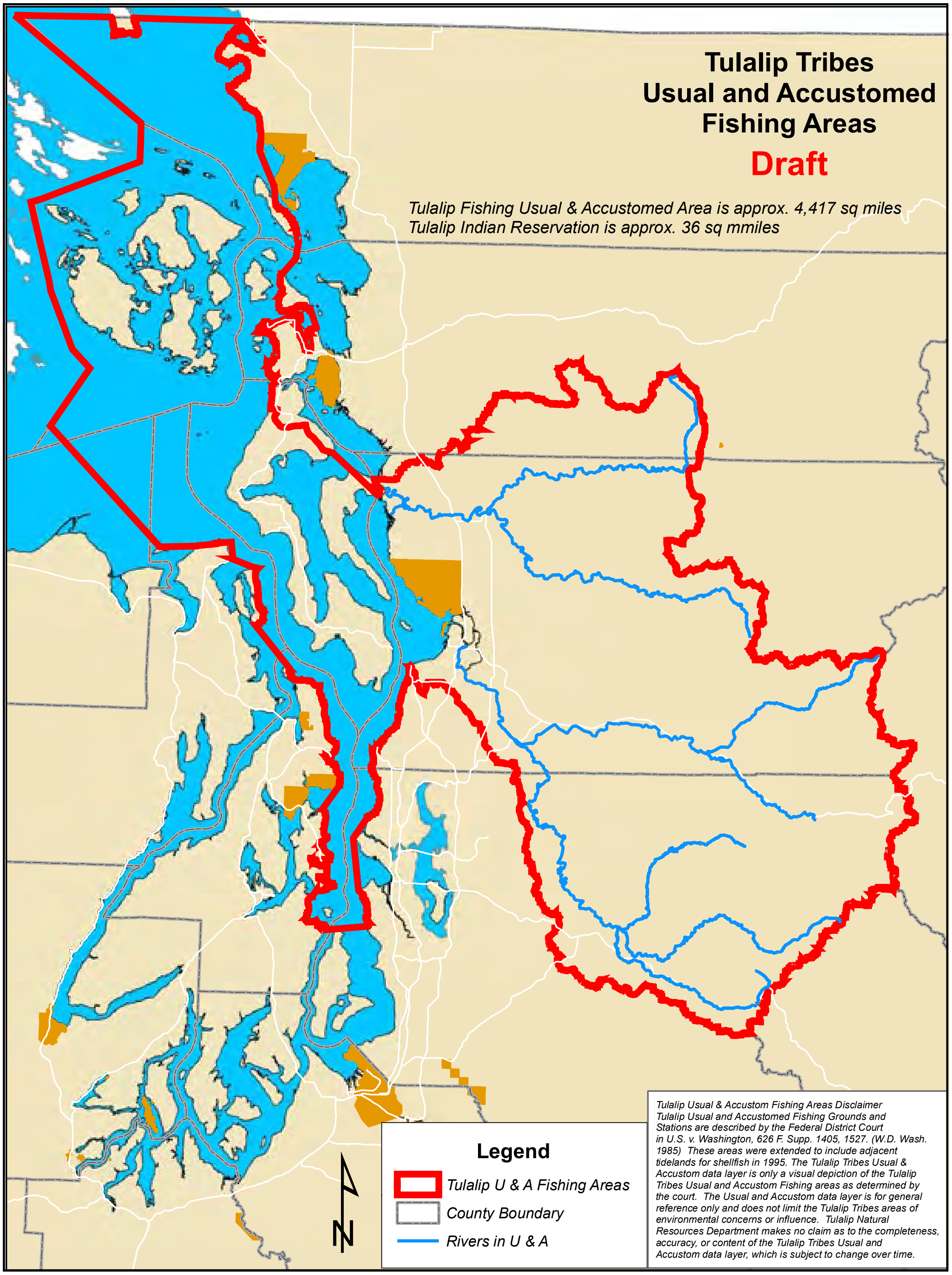
The Tulalip Tribes' Usual and Accustomed Fishing Areas (U&A) comprises approximately 4,417 square miles of Puget Sound and the Snoqualmie and Snohomish watersheds, as shown in **Map 14**. This U&A extends from the Canadian border south to the northern edge of Vashon Island.

Natural hazards can disrupt fisheries and can cause secondary hazards that can have far worse consequences that the natural hazard itself. Because the U&A is part of an ecosystem, an event anywhere within the ecosystem can have consequences downstream and/or many miles away.

Wildfires in the Cascade Mountains can increase vulnerability to landslides and mudflows that can disrupt fisheries and salmon spawning. The same can be said for flooding. Earthquakes can also cause landslides that can eventually disrupt fisheries. Flooding typically sends massive jams of logs downstream and eventually to the Snohomish River delta and other river deltas. These logjams then settle on to kelp beds and other salmon food habitats, eventually ruining their food source.

The main threat to the U&A is human-caused. Puget Sound is home to some of the largest ports on the West Coast and to numerous oil refineries. Numerous towns, ports and marinas line the coast. The potential for a major oil or other hazardous material spill is high. Whether spills are caused by human error, terrorism or by earthquakes, tsunamis or other natural hazard events, the effects are the same: severe pollution that kills plankton and eventually up the whole food chain to eagles, orcas and even humans. The economic effects to fisheries can be cataclysmic, especially to the Tulalip Tribes, who rely heavily on fishing as a way of life.

The Tulalip Tribes need to be a major partner in the effort to mitigate the effects of disasters on Puget Sound and in the watersheds.



Map 14: Usual and Accustomed Fishing Areas

Tribal Buildings, Critical Facilities and Infrastructure

Tulalip Data Services GIS department maintains a shapefile of large buildings on the Tulalip Reservation, including both Tribally-owned and private structures. It includes footprint data, building height, address, name and owner. The shapefile is currently being updated with information about each buildings capacity to serve as shelter-in-place, including whether or not there is a shower, kitchen or generator present. The next step is to add information regarding construction year and type, as well as other relevant information, to bring the data into compliance with HAZUS-MH software.

Shapefiles of water and sewer infrastructure are available as point and line data but do not include other attributes such as type of piping (e.g. brittle or ductile) needed for HAZUS-MH analysis. Adding this information to the shapefiles is another task for TDS, Utilities and Emergency Management.

Tribal Buildings

The shapefile identified the Tribe as owning 65 buildings. The Tribe maintain 41 buildings, including the Boys and Girls Club, which is leased by the Tribe from the Boys and Girls Club of America.

Critical Facilities and Infrastructure

Critical facilities and infrastructure are those that are critical to the health and welfare of the population. These become especially important after any hazard event occurs.

Critical facilities included for the Tulalip Reservation Hazard Mitigation Plan are as follows: police and fire stations, schools, and all tribal buildings including government buildings and housing. Essential facilities include buildings and businesses that are essential to the community's economy and/or safety after an event. These include the Tulalip Casino, Wal-Mart, Home Depot and other businesses that supply essential goods such as food and equipment. The contents of the Critical Buildings shapefile, including the square footage used to estimate replcement costs, contents and daily sales, is included in Appendix C.

Critical infrastructure includes the roads and bridges that provide ingress and egress and allow emergency vehicles access to those in need and the utilities that provide water, sewerage, electricity and communication services to the community.

Critical and essential facilities and infrastructure were identified through GIS analysis, and from interviews with Tribal officials.

Hazard Risk Rating

A risk rating has been completed for each of the major hazards described in this plan, and was based on the exposure inventory and loss estimation. For the purposes of this plan, the risk rating is a function of two factors. The first factor describes the probability that a hazard event will occur. The second factor describes the impact of the event. This is typically considered both in number of people affected and amount of dollar loss caused by the hazard event.

Community members were asked about their perception of risk of each hazard in the public survey. Those answers, in addition to details about the exposure and impact of each hazard, were presented to the Mitigation Planning Team, who then ranked each hazard depending on their perception of risk. Those rankings were then used by the team to rate the priority of Action Items that addressed each hazard.

Probability of Occurrence

The probability of occurrence of a hazard event provides an estimation of how often the event occurs. This is generally based on the past hazard events that have occurred in the area and the forecast of the event occurring in the future. **Table 11** shows how each hazard is then assigned a probability factor, which is based on yearly values of occurrence.

These are allotted as follows:

- High: Hazard event is likely to occur within 5 years
- Medium: Hazard event is likely to occur within 50 years
- Low: Hazard event is not likely to occur within 50 years

Probability of Hazards	
Hazard Event	**Probability**
Earthquake	Medium
Severe Weather	High
Landslides	Medium
Flooding	Medium
Wildland Fire	High
Tsunami/Seiche	Low

Table 11: Hazard Probability

Impact

The impact of each hazard was categorized by estimated exposure of large buildings, percentage of total water and sewer infrastructure located in the hazard zone, population and housing units at risk, and vulnerable population at risk. The totals of each were presented at the Mitigation Planning Team Hazard Ranking Meeting on April 14, 2010, in the following worksheet in **Figure 18.** As Heat Wave, Drought, Major Storm and Pandemic could potentially impact the entire reservation, their values were left blank. The results are summarized in **Table 12.**

Hazard Ranking Worksheet Tulalip Hazard Mitigation Plan Update 4/14/10

Name:

Hazard	% of Public	Occurrence	Amount at Risk							Ranking
	Worried/Very	*Frequency*	*% Buildings*	*% Street*	*% Pipe*	*% Utility*	*% Res*	*Population*	*% Vul Pop*	*High/Med/Low*
Drought	22%	Low								
Earthquake	69%	Medium	**68%**	**77%**	**74%**	**74%**	**62%**	**5710**	**69%**	
Flood	22%	Medium	**29%**	**30%**	**67%**	**26%**	**22%**	**2063**	**29%**	
Heat Wave	34%	Low								
Fire	43%	High								
Landslide	16%	Medium	**0%**	**1%**	**0%**	**0%**	**47%**	**4305**	**0%**	
Major Storm	63%	High								
Pandemic	36%	Low								
Tsunami	37%	Low	**34%**	**14%**	**12%**	**11%**	**24%**	**2180**	**13%**	

Figure 18: Hazard Ranking Worksheet

Hazard Ranking	Planning Team		Public	
	Rank	Votes	Rank	Votes
Major Storm	1	14	2	63%
Earthquake	2	13	1	69%
Pandemic	3	12	5	36%
Landslide	4	10	9	16%
Tsunami	5	8	4	37%
Flood	6	8	7	22%
Wildland Fire	7	8	3	43%
Heatwave	8	7	6	34%
Drought	9	6	7	22%

Table 12: Hazard Ranking Results

Although pandemic ranked in the top five for both the public and Mitigation Planning Team, no specific action items were identified to mitigate this hazard, other than including it in the Public Education Campaign. The Emergency Management Coordinator and Health Clinic will work together before the next update to identify any possible projects, based on the H1N1 experience and lessons learned in other locations.

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