SUB-SECTION 4M.7

PUYALLUP TRIBE ALL HAZARD MITIGATION PLAN
SEVERE WEATHER HAZARD[1]

Table of Contents

Identification Description

Definition[2]

Severe weather includes a variety of meteorological phenomena that are detrimental to citizens and or infrastructure in the County. These atmospheric disturbances are usually characterized by strong winds frequently combined with rain, snow, sleet, hail, ice, thunder, and lightning. This definition includes unusual weather disturbances such as tornadoes or waterspouts, which appear infrequently in Pierce County. In addition, any heavy fall of snow or rain might be considered a severe storm in its own right. Secondary hazards or impacts that can result from severe storms include flooding, (see Flood Hazard Chapter of the HIRA) landslides (see Landslide Hazard Chapter of the HIRA), power outages (see Energy Emergency Hazard Chapter of the HIRA), and closed transportation routes limiting emergency response, pollution, and environmental damage (see Transportation Accidents Hazard Chapter of the HIRA).

For the purpose of this sub-section this plan will not cover rain storms. Since the primary hazards that occur from heavy rain are flooding, landslides and erosion; the effects of rain will be covered in the chapters on flooding and landslides.

Types

Hail

Hail storms occur when freezing water in thunderstorm clouds accumulates in layers around an icy core. Hail can cause damage by battering crops, structures, automobiles and transportation systems. While Pierce County does get occasional hail storms, they seldom include hail stones large enough to cause major damage. However, when hailstones are large,[3] especially when combined with high winds, damage can be extensive.

Ice Storms

Ice storms occur when rain falls out of the warm, moist upper layer of atmosphere into a below-freezing, drier layer near the ground. The rain freezes on contact with the cold ground and other surfaces. It accumulates on exposed surfaces such as trees, roads, houses, power lines, etc. The accumulated weight of this ice, especially when accompanied by wind, can cause damage to trees and utility wires. Ice storms are usually of short duration from several minutes to a few hours. However, the danger left behind will last until a rising temperature allows for thawing.

Snowstorms

Snowstorms or blizzards, which are snowstorms accompanied by high wind and/or poor visibility, occur occasionally in the County. A snowstorm including warmer moist air from the Pacific Ocean, overrunning existing cold subfreezing air, could continue to drop snow for several days.

Tornadoes

Tornadoes are the most violent weather phenomenon known. Their funnel shaped clouds rotate at speeds up to 300 miles per hour or more, and large ones may affect areas from one-quarter to three-quarters of a mile or more in width, see Table 4.9-1. They may travel for some distance although seldom more than 15 miles. Tornadoes are produced by strong thunderstorms. Such thunderstorms can also produce large hail, heavy rain and strong sustained winds over a larger geographic area.

Windstorms

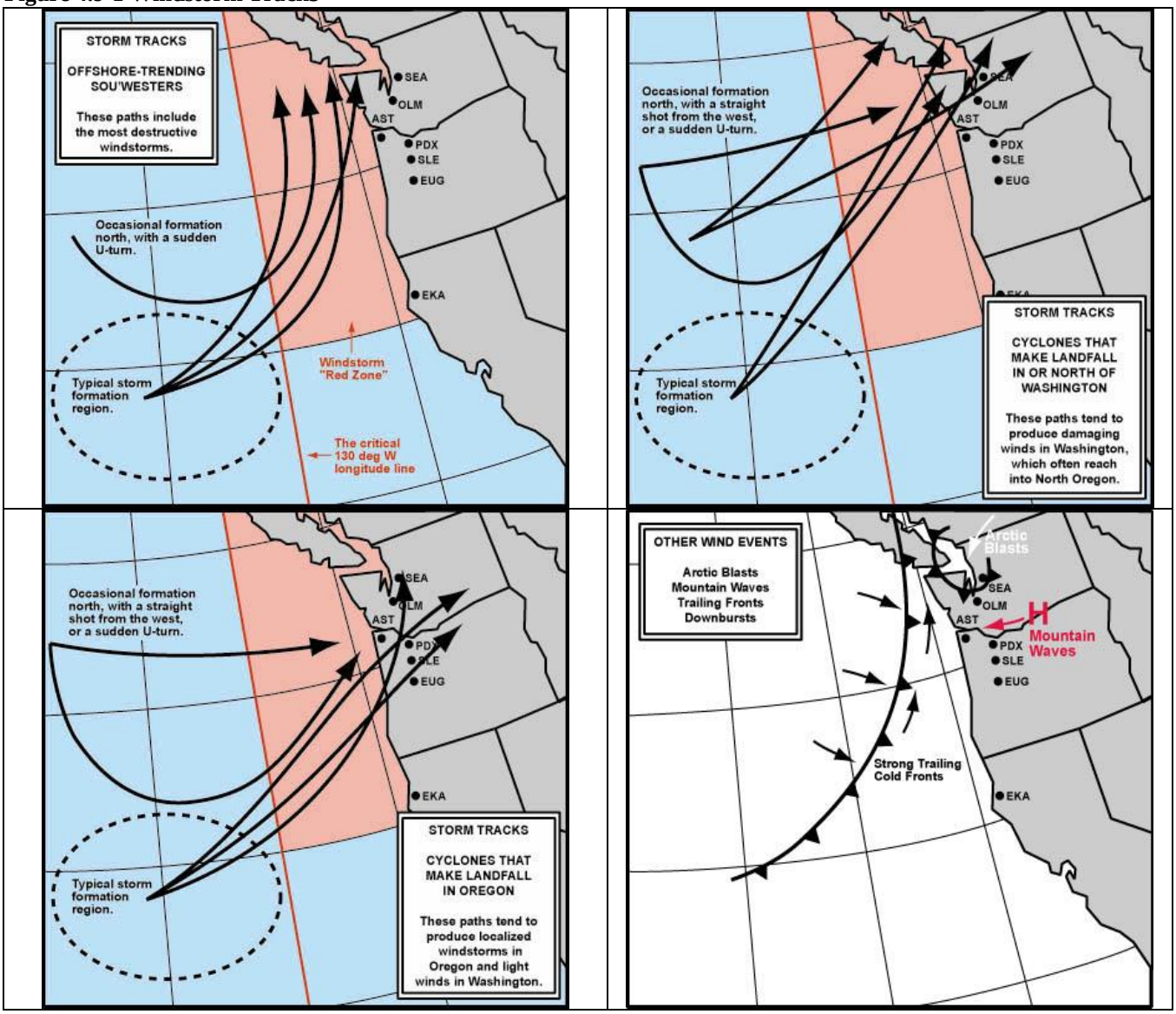
There are four main types of windstorm tracks that impact the Pacific Northwest and Pierce County as identified in Figure 4.9-1. From these systems two basic windstorm patterns have emerged that impact Pierce County. These are the south-wind event and the east-wind event; see maps Map 4.9-1 and Map 4.9-2. The Planning Area can expect some wind related problems on an annual basis, although the majority of those do not cause extensive damage. The East Wind events and South Wind events outlined below are the typical windstorms in the Planning Area that cause damage. Wind speeds vary and are noted on the maps and the following occurrences table. South-wind events are generally large scale events that affect large portions of not only Pierce County, but also most of Western Washington and possibly Western Oregon. In occasional cases, they may even affect areas as far south as Northern California. South-wind events, due to funneling effects, can reach up to 100 mph in confined areas such as the Tacoma Narrows. In contrast, east-wind events are more limited. High pressure on the east side of the Cascade Mountain Range creates airflow over the peaks and passes, and through the funneling effect of the valleys, the wind increases dramatically in speed. As it descends these valleys and then exits into the lowlands around Enumclaw and Buckley, the wind can pick up enough speed to damage buildings, rip down power lines, and destroy fences. Once it leaves the proximity of the foothills the wind tends to die down rapidly causing little damage to the rest of the County.

Table 4.9-1 Fujita Tornado Damage Scale[4]

SCALE	WIND EST. (MPH)	TYPICAL DAMAGE
F0	65-85	**Minor damage.** Peels surface off some roofs, some damage to gutters or siding, branches broken off trees; shallow- rooted trees pushed over.
EF1	86-110	**Moderate damage.** Roofs severely stripped, mobile homes overturned or badly damaged, loss of exterior doors; windows and other glass broken.
EF2	111-135	**Considerable damage.** Roofs torn off well-constructed houses; foundations of frame homes shifted, mobile homes completely destroyed, large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	**Severe damage.** Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	**Extreme damage to near total destruction.** Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200	**Massive damage.** Strong frame houses leveled off foundations and swept away; steel-reinforced concrete structures critical damaged; high rise buildings have severe structural deformation. Incredible phenomena will occur.

While these are the primary wind events to cause damage within the County, they are not the only problem. A strong north wind event combined with a higher than normal tide can cause coastal flooding along the County shorelines and can push extra water into the lower reaches of the Puyallup River.
Localized geographic conditions can exacerbate the problem, causing an increase in wind intensity. Ridges, valleys, mountains, and even large buildings can redirect wind flow and cause local variations in damage.

Figure 4.9-1 Windstorm Tracks[5]



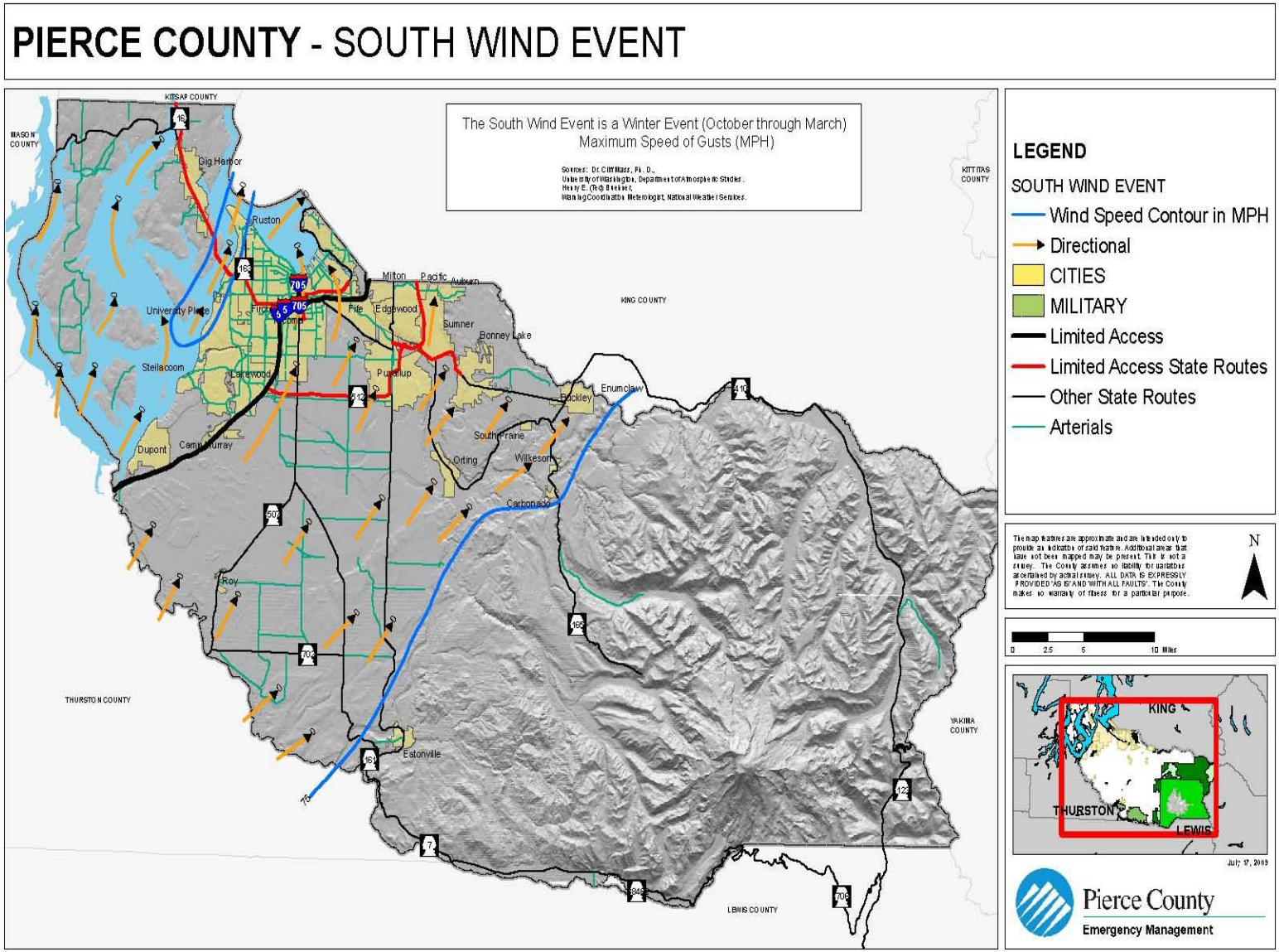
Profile

Location and Extent

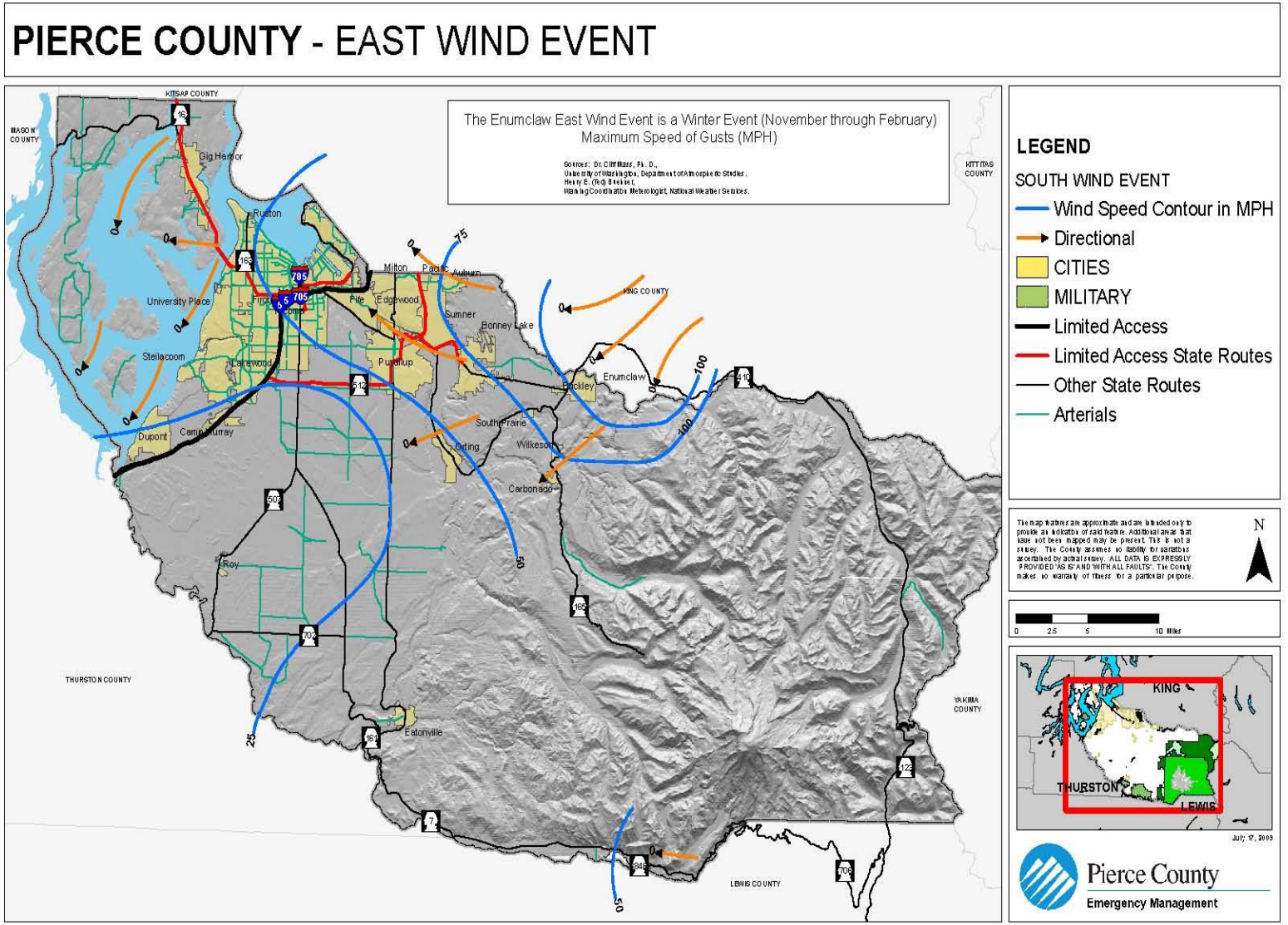
Severe weather of all types directly and indirectly affects the entire Planning Area. Due to variations in geographic location and elevation, certain areas of the Planning Area are more vulnerable to certain types of severe weather, including: windstorm, snowstorm, and ice storm. Storms can cause school closures and government office closures when roads are deemed dangerous or when power outages occur. There are no defined thresholds for these actions and the decision for any closures is left to the discretion of the Tribal Government. All response activities-whether to contract fire services, tribal law enforcement, maintenance, etc.-are conducted on an as-needed basis.

Maps are currently available that depict wind events. Maps 4.9-1 and 4.9-2 show the severe windstorm hazard for the broader Pierce County area the Planning Area as depicted in South Wind Event and the East Wind Event. Maps 4.9-3 and 4.9-4 show the wind severe storm hazard for the Planning Area as depicted in the South Wind Event and East Wind Event. Each type of wind storms directly and indirectly affects all of the planning Area. The maps show Pierce County and the Planning Area, and the extent of severe windstorms with predominant wind direction.

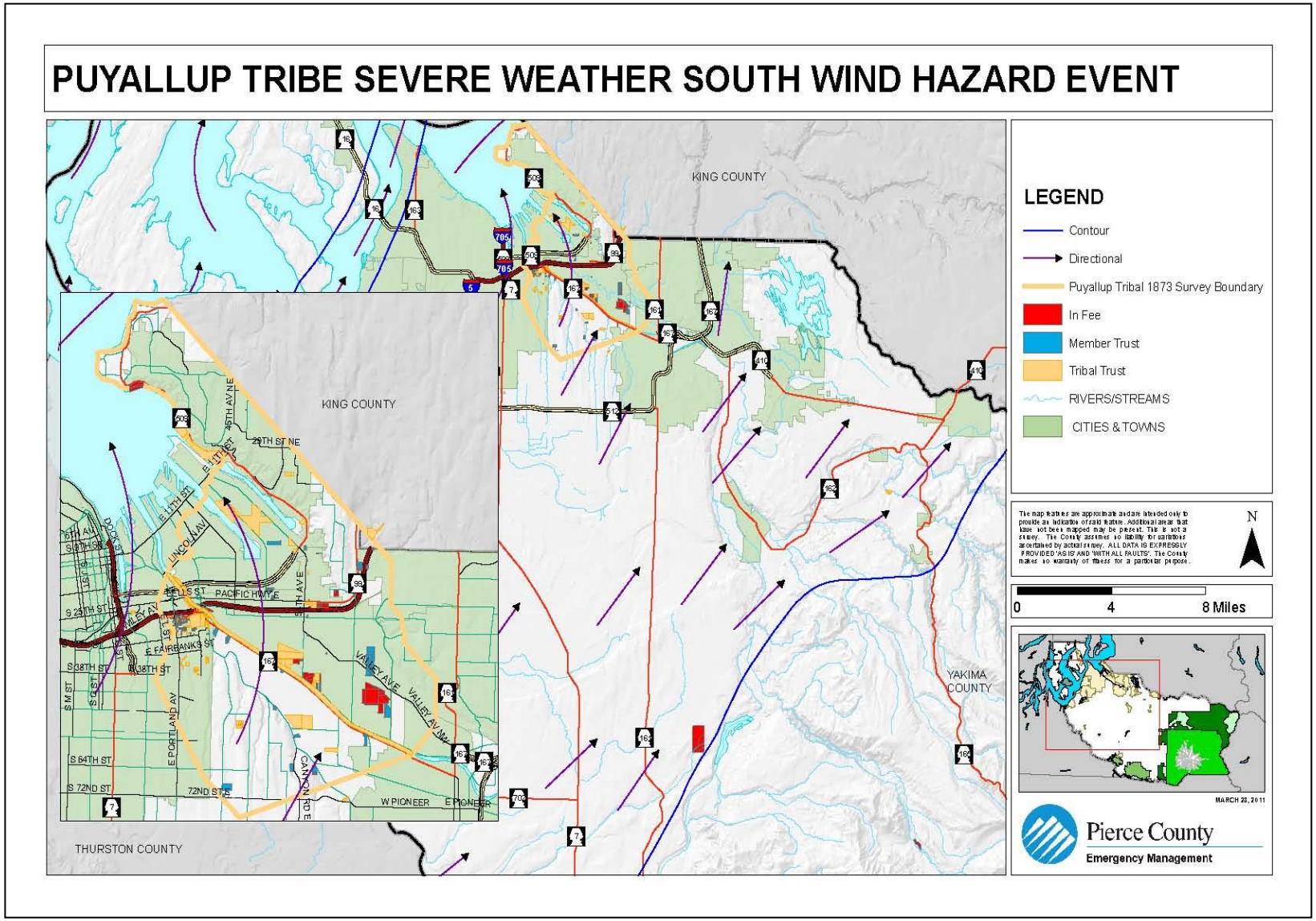
Map 4.9-1 Pierce County Severe Weather Wind Hazard—South-Wind Event[6]



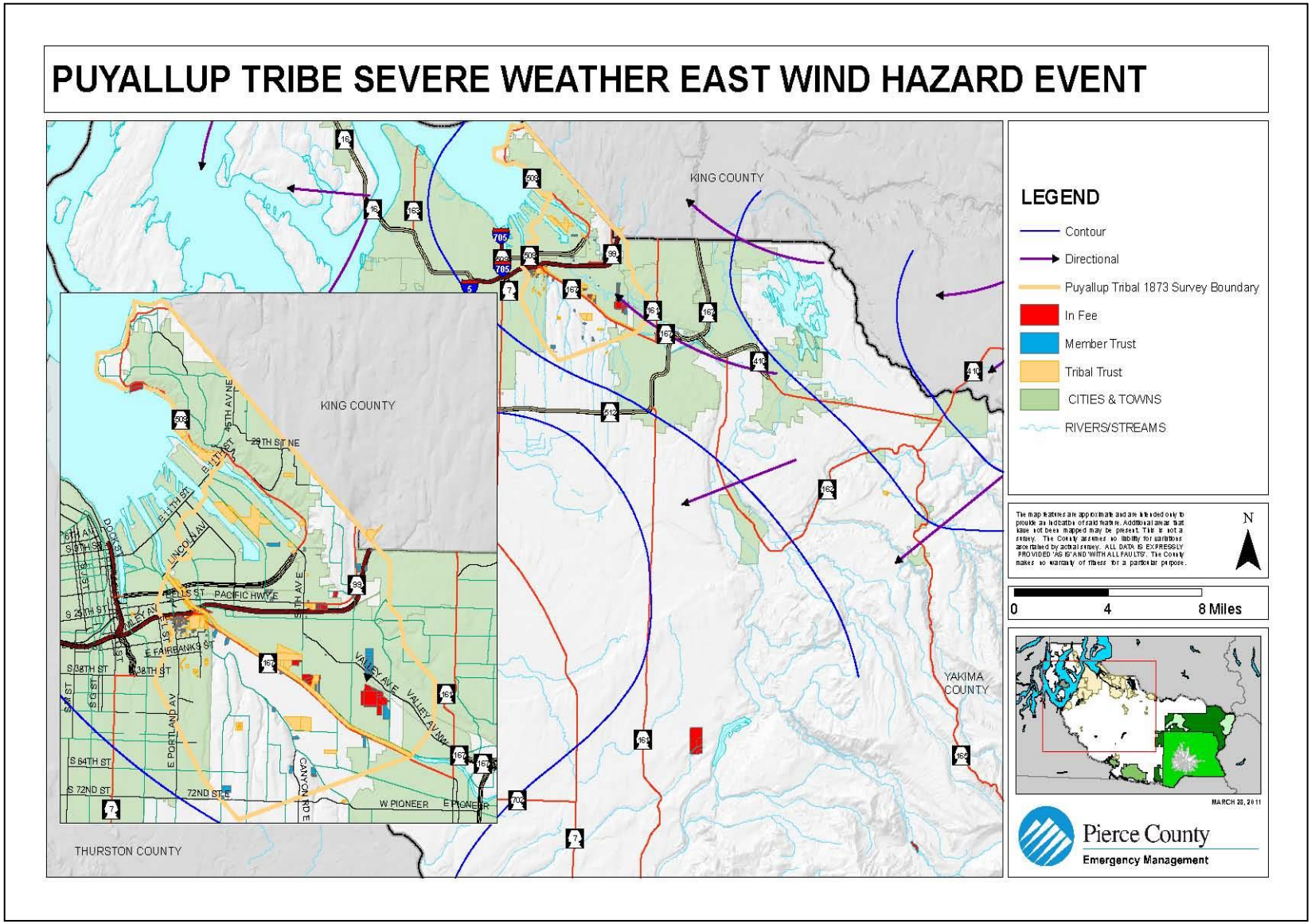
Map 4.9-2 Pierce County Severe Weather Wind Hazard—East Wind-Event[7]



Map 4.9-3 Puyallup Tribe of Indians Severe Weather Wind Hazard—South Wind-Event



Map 4.9-4 Puyallup Tribe of Indians Severe Weather Wind Hazard—East Wind-Event



Occurrences

Historically, over the years Pierce County and the Planning Area has had a number of instances of severe weather. While not all of these have caused major long-term problems, they all have disrupted people's day-to-day activities and posed a burden, especially on the poor and elderly. Table 4.9-2 lists some of the other notable severe storms (weather) in Pierce County and the Planning Area.

Table 4.9-2 Notable Severe Weather in Pierce County

DATE	DESCRIPTION
HAIL	
June 2007	National Weather Service has a report of hail between ¾" and 1" in the Cascades of eastern Pierce County. While hail has been a regular addition to thunderstorms in the Puget Sound basin, and have caused minor damage, there are no major hail storms that have had hail large enough in the populated areas to cause enough damage for a major declaration.
ICE STORMS	
December 1996-February 1997 (Federal Disaster #1159)	A series of winter storms delivered snow, freezing rain, warm rain and wind to the west coast producing floods, snow and ice damage, and landslides.
SNOWSTORMS	
January 14-23, 2012 (Federal Disaster #4056)	'Snowmageddon' resulted in heavy snow and local high winds, causing damage of more than $32 million.
December 12, 2008 – January 5, 2009 (Federal Disaster/Emergency #1825)	A cold snap with multiple days of snow closed roads and eventually a record snow event was declared with a snow emergency declared for the County.
November 27, 2006	Up to six inches fell throughout the County, followed by two days of sub freezing temperatures.
January 9-10, 2006	Up to seven inches fell throughout the County, followed by two days of sub freezing temperatures.
January 2004	Successive snowfalls and freezing causes EOC activation and closure of Pierce County government due to severe weather conditions. 5.5 inches recorded in Tacoma, up to 12 inches recorded in southern areas of County.
November 19-21, 1996 (Federal Disaster #1152)	Up to 12 inches of snow, knocking out power, causing road, school, and business closures.
November 17, 1985	A snowstorm combined with a cold spell lasted for over a week causing power outages, traffic congestion, broken pipes, and all-around havoc with the normal day-to-day business of the County.
February 1980	Significant snowfall.
January 9, 1980	Up to15 inches of snow fell throughout the County.
January 1972	Snowing in the County with drifts up to four feet. Winds with the snow were clocked at 25 mph.

November 21,1960	Up to seven inches of snow fell throughout the County, knocking out power.
March 5, 1960	Up to seven inches of snow fell throughout the County.
January 16, 1950	Tacoma had drifts up to 12 feet. Economic loss in the County ran into millions of dollars.
February 1, 1916	From two to four feet of snow fell throughout Western Washington.
TORNADOES	
October 11, 2014	Waterspout off Anderson Island in South Puget Sound never hit land and lasted for a couple of minutes.
April 27, 2014	A tornado (EF0), maximum width of 25 yards, touched down in Eatonville for less than a minute. Estimated peak wind speed was 75 mph.
September 6, 2009	A tornado (F1-high end) touched down at Lake Tapps and continued in a NE direction for 9.6 miles with winds from 100-110 mph.
February 19, 2007	A funnel cloud was reported near Orting. It did not touch down.
June 18, 2002	A funnel cloud was recorded in the Gig Harbor area. It did not touch down.
September 27 2001	This F1 tornado began as a funnel cloud over the Puyallup Valley and then moving to the NE touched down in the Bonney Lake area.
May 31, 1997	A tornado (F1) touched down in south Tacoma near the Tacoma Mall, damaging a church, power lines, and few other buildings.
June 23, 1996	A tornado (F0) touched down in north Tacoma running north into Ruston, damaging some homes, downing a number of trees and breaking power lines.
September 24, 1981	A tornado touched down at Gray Field on Ft. Lewis.
June 12, 1978	A tornado touched down in E. Tacoma and at Ft. Lewis.
October 5, 1899[8]	A tornado devastated a tract of land from 300 to 600 yards wide from Mossy Rock and Osborne in Lewis County to Orting. The storm was strong enough to uproot old growth forest.
WINDSTORMS	
January 7, 2007	Windstorm came into Washington causing minor damage in Pierce County but major damage to isolated counties such as Chelan County.
December 14, 2006 (Federal Disaster #1682) Hanukkah Eve Windstorm of 2006	South-wind event, serious damages throughout Western Washington. Over 1,500,000 people were without power, some as long as 10 days. Major tree and electrical damage.
November 12-15, 2006	Damaging winds up to 86 mph on coast and 60 mph around western interior. Power was out to over 100,000.
February 17, 2006	East-wind event, localized to Pierce County, produced sustained winds of 40-50mph for 18hrs, knocking down trees and power lines and causing over $4,000,000 in public damage alone in the County.
December 25, 2005	Christmas Day Gale had winds of 40+ mph recorded at a number of weather stations in Pierce and other counties in W. Washington
December 2003	East-wind event causes downed trees, power outages, and damage to property in Buckley, Eatonville, Bonney Lake and surrounding areas. Sustained winds of 60 mph and gusts up to 80 mph.

December 1995	Windstorms starting in Northern California generated winds in excess of 100 mph, and continued to the north into Canada causing three states, including Washington, to issue disaster proclamations.
March 1995	Windstorms created multiple power-outages and downed trees.
January 1993 (Federal Disaster #981)	Inauguration Day Storm.
November 1981	High winds in Western Washington.
October 1962 (Federal Disaster #137)	Columbus Day Storm recorded winds up to 88 mph in Pierce County. This was less than in some other areas. Maximum wind speed in other areas reached as high as 150 mph. Strongest recorded windstorm in Pierce County History causing extensive damage throughout the County.
November 1958	High winds in Western Washington.
November 7, 1940	Tacoma Narrows Bridge blown down.

Recurrence Rate

Based on the previous history of severe weather that has impacted Pierce County and information from the National Weather Service[9] it was determined the probability of recurrence for the severe storms hazard in Pierce County to be a five years or less occurrence.

Hail

To date (2016) the various hail storms in the County have caused limited damage to some of Pierce County's agricultural products. The only reported hail storm with hail large enough to have caused extensive damage in the past was located in the Cascades. Minor hail storms which do not cause major damage happen on almost a yearly basis somewhere in the County. Since large hail is such a rare occurrence it is listed as a 100 year or less occurrence.

Ice Storms

The record shows only a single significant ice storm in the past 100 years. It was therefore determined the probability of recurrence as 100 years or fewer occurrences.

Snowstorms

Table 4.9-1 lists 13 significant snowstorms in the past 100 years. Taking this as an average it was determined that snowstorms of consequence happen as a 10 year or less occurrence.

Tornadoes

While not as frequent as windstorms, there have been seven recorded tornadoes in the past 120 years. Given this frequency, it was determined the probability of recurrence as 20 years or less.

Windstorms

Wind has played a prominent role in the history of emergencies and disasters impacting communities within Pierce County. Major events, see Table 4.9-1, have occurred 13 times during the past 70 years and caused millions of dollars worth of damage. Pierce County can expect some wind-related problems on an annual basis, although few of these cause extensive damage. Based on the historical frequency of large windstorms it was determined the probability of recurrence as 10 years or less.

Impacts

As can be seen above, the impacts from severe weather can be largely dependent on the type of incident. Since the severe weather can range from snowstorms to tornadoes each one is factored out in this section.

Health and Safety of Persons in the Affected Area at the Time of the Incident

Hail

Over the years, hail has not been a major factor in Pierce County. While injury and even death to people and animals that are in the wrong spot at the wrong time can occur, the size of hail that impacts Pierce County is usually too small to cause injury or death. While the damage to crops, cars and other items out in the weather can be dramatic, direct impacts to people in the affected areas of Pierce County are usually limited to minor stings and bruises. However, should a hailstorm with large hail stones occur, individuals could be injured and in rare instances killed.

Ice Storms

Direct impacts on the general public from ice storms can include cold related injuries like hypothermia, or injury and death from accidents. Accidents can occur either through falls due to ice on walkways or on the ground, or auto accidents due to the ice on the roads. In addition, overloading on trees or utility wires can cause limbs or wires to break. These can fall either on individuals, automobiles, or homes causing damage or traumatic injuries or in the case of downed utility wires fires could start or individuals could be electrocuted.

Figure 4.9-2 Snowstorm 01/2004 Downtown Tacoma

Individuals on home based life support systems could be adversely impacted by the power outages if they do not have a backup power system.

A combination of cold and lack of power will force many people to find alternate ways of cooking and heating. Those who attempt to cook or heat with barbecue grills or hibachis run the risk of carbon monoxide poisoning.

Snowstorms

Direct impacts on the general public from snowstorms can include cold related injuries like hypothermia or frostbite. This can be especially prevalent in the older population and those who lose heat and power for extended periods of time.

Access to normal businesses, health facilities, government offices, etc. can all be compromised due to snow; see Figure 4.9-2. In many cases the hills and slopes of many of the roads and streets restricts individuals' movements. This remains the case until such time as road crews are able to either plow or sand the roads and streets.

There is an increase in injuries and deaths from accidents and in some cases increases in heart attacks from individuals attempting to shovel snow away from walkways and driveways.

Depending on the depth of the snow, the length of time it stays around, and the number of downed tree limbs, or trees in lines, road closures could isolate some individuals; possibly for days.

Individuals on home based life support systems could be adversely impacted by the power outages if they do not have a backup power system.

A combination of cold and lack of power forces many people to find alternate ways of cooking and heating. Those who attempt to cook or heat with barbecue grills or hibachis run the risk of carbon monoxide poisoning.

Tornadoes

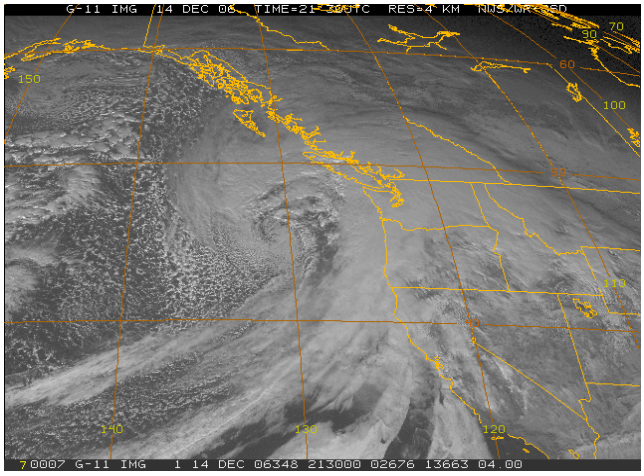
Most tornadoes that have historically impacted Pierce County have been rather small. The exception is the October 1899 tornado. The results of any tornado can be devastating to those caught in one. However the number of people injured or killed and the number of houses, businesses, community facilities, etc. destroyed or damaged varies dramatically depending on the size of the tornado, where it touches down, and how long it is in contact with the ground.
Members of the community caught in a tornado can expect that many of them could have major injuries or be killed by the tornado. Flying debris and collapsing buildings are the main cause of injury and death.

Windstorms

Windstorms are one of the emergencies that impact all of Pierce County on a regular basis. Some are much more damaging than others. For those like the Hanukkah Eve Windstorm of 2006, see Figure 4.9-3[10], the impact on the public can be very severe.

Individuals can be hit by flying debris or falling limbs and trees. During past windstorms cars have been crushed and houses split by falling trees. Individuals can suffer injury or death. Downed wires have been known to electrocute individuals, as happened in Gig Harbor in the Hanukkah Eve Windstorm of 2006.

Figure 4.9-3 Satellite Image -Hanukkah Eve Windstorm



Large numbers of power lines down, combined with trees and limbs on roads can keep fire, medical and law enforcement personnel from responding to individual incidents. During heavy wind first responders may have to wait until the wind abates before being able to respond to calls.

Individuals on home based life support systems without a backup power system could be adversely impacted by the power outages.

With power outages sometimes lasting for days there are individuals who attempt to cook or heat their homes with a barbecue or hibachi. For these individuals and families the buildup of carbon monoxide can be fatal.

Health and Safety of Personnel Responding to the Incident

Hail

First Responders have very similar safety and health concerns to those of the general public regarding hail. While injury and even death to people and animals that are in the wrong place at the wrong time can occur, the size of hail that impacts Pierce County is usually too small to cause major damage. Hail storms here will result in first responders seeking shelter for the short period of time the hail is falling. There should not be any different result for the first responders than for the general public. Just as the general public's injuries are usually limited to minor stings and bruises, so are the first responders'.

Ice Storms

First Responders can expect similar injuries as the general public. These could include cold related injuries like hypothermia, or injury and death from accidents. Accidents can occur either through falls due to ice on walkways or on the ground, or in response vehicles due to the icy roads. In addition over loading on trees, utility wires etc. can cause breaking of limbs or wires to fall either on individuals, automobiles, or buildings causing damage or traumatic injuries. In the case of downed utility wires fires could start or

individuals could be electrocuted. Road crews will have to be careful of downed lines and work in conjunction with utility workers to open roads.

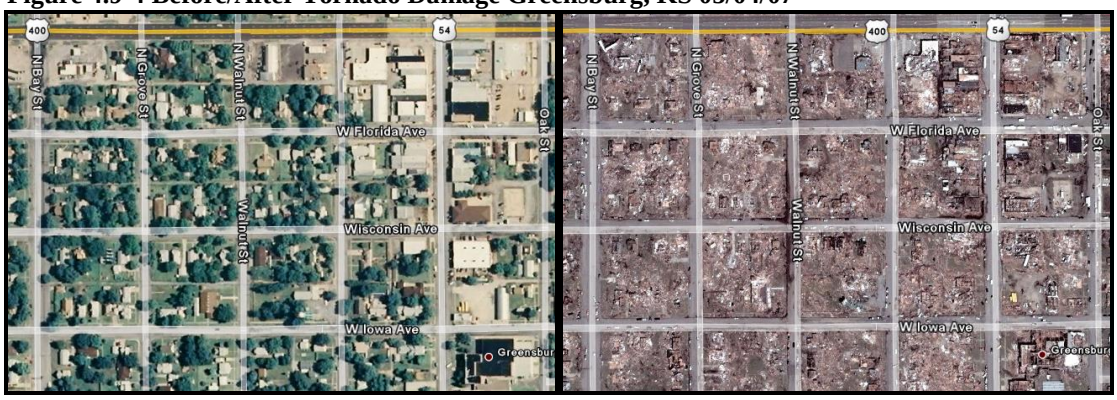
Snowstorms

First responders operating in the hazardous environment of a snowstorm, have the potential to get cold related injuries if they are not adequately protected from the elements. Due to the amount of time spent on snow covered roads responding to storm related problems, they also have a potential for traffic accidents.

Tornadoes

During the actual tornado itself, responders are like any other citizen. They are as likely as anybody else to be injured or killed by the storm. The Greensburg Kansas tornado, see Figure 4.9-4, gives a good impression of what can happen as a tornado passes through a community. Once the tornado has passed however, they will enter the area where the damage has occurred. With a large tornado this puts them in a hazardous area. They could be exposed to live electric wires, hazardous chemicals, and unstable debris.

Figure 4.9-4 Before/After Tornado Damage Greensburg, KS 05/04/07[11]



Windstorms

First responders will be putting themselves in harms way throughout windstorm incidents. They can be hit by flying debris or falling limbs and trees as well as coming in contact with downed power lines. Their response vehicles have been crushed and over the years there are the occasional injuries. In the aftermath of the windstorm, first responders by the nature of their work are putting themselves in harm's way by clearing roads, restringing wire, and cutting trees.

Continuity of Operations and Delivery of Services

Hail

Hail has not traditionally caused more than the most minor slowdown of any public services within the boundaries of Pierce County. Due to the shortness of the normal hailstorm and the small size of the normal hailstones it is not expected to disrupt any

organizations continuity of operations or the delivery of services to the public for more than a short period of time. Should there be an increase in size of the hail stones and an increase in the length of the storms then damage might begin to appear on equipment, facilities and people.

Ice Storms

While ice storms themselves tend to last only a few hours at the most, the after affects can last for days. The actual problem with iced roads, falling branches, and other types of damage will continue until the temperature warms enough for the ice to melt. In a situation where the temperature remains below freezing for a long period of time there may be continuity of operations problems for some local jurisdictions or agencies. The inability of agencies with small staff to staff their operations if roads are closed due to ice or downed power lines could cause their operations to lapse for short periods. For most jurisdictions however, the closing of roads and the related damage will slow down rather than actually stop normal operations.

An ice storm can slow down and in some cases halt the delivery of services over the entire County and for any jurisdictions or agencies located within its borders. The loss of power from the breaking of lines has in the past, and will again, affect thousands of customers. Ice coated streets do not allow the normal movement of emergency vehicles of any type within their normal response times, so the delivery of all types of services will be slower than normal or even non-existent until such time as the streets are once again passable. Delivery of services will rapidly improve once the temperature warms and the ice begins to melt.

Snowstorms

Normal amounts of snow in the populated portions of Pierce County have a limited effect on the continuity of operations of most agencies or jurisdictions in the County. Most, if not all, are able to maintain operations of some sort through the few inches of snow that is normal in the County. Figure 4.9-5[12] shows a typical quantity of snow for Pierce County.

Figure 4.9-5 Public Works Responds 2005 Snowstorm

A snowstorm equivalent to the January 16, 1950 storm that had drifts up to 12-feet deep in the Tacoma area would inhibit movement enough that some organizations would be totally unable to operate. Such a storm could shut down the entire County, and depending on the ensuing temperatures governmental agencies, schools, businesses and services might be shut down for days.

Snow covered streets do not allow the normal movement of vehicles of any type. For light snow there could be minor slowdowns in the delivery of services. For heavy snow,

jurisdictions and agencies could all get behind in their normal operations. With a very heavy snow fall, especially when combined with wind, the delivery of all types of services will be slower than normal or even non-existent until such time as the streets are once again passable. Delivery of services will rapidly improve once the temperatures have risen and the roads have been plowed and are open to traffic. Even with the roads opening up, the electric utilities could take several days to get all the lines back up in all the outlaying areas of the County.

Tornadoes

A small tornado touching down in Pierce County should not impact the continuity of operations for any of its larger jurisdictions. It is possible that a small tornado could directly damage the only response capability or administrative office of a very small agency or jurisdiction. In that case, their continuity of operations would be impacted until they were able to get assistance from a neighboring jurisdiction. This is, however, unlikely.

A very large tornado on the scale of the one in 1899, could damage or destroy a large area to the extent that a large proportion of a jurisdiction's capability, either physically or administratively may limit its continuity of operations. That could either physically or administratively limit its continuity of operations. Having the administrative offices destroyed, possibly along with the staff being injured or killed, would make the normal day-to-day operations difficult to maintain. Combining this with broken pipes in the destroyed buildings, phone and electric lines down, streets covered with debris and possible fires from broken gas lines would increase the difficulty of maintaining the continuity of operations.

Within the area directly impacted by the tornado the delivery of services is directly related to the size of the tornado. Small tornadoes will have little to no effect on service delivery, while a large one, because of the amount of damage done, could totally take out service delivery to the impact area. This would include blocking roads, and breaking gas, water and electric lines. Within the damaged area it would take time to rebuild the damaged homes and businesses and begin to reconnect them to the damaged utilities.

Due to the localized nature of the tornado, the delivery of services to the rest of the County should be minimally impacted. The main exception to this could be electric. The damage to the power infrastructure could have a direct affect on surrounding neighborhoods, businesses, and jurisdictions, all of which could experience power outages over a very broad area, until such time as the power companies can make repairs and restore services.

Windstorms

Operations for most if not all of the agencies or jurisdictions in Pierce County should be able to continue, albeit at a reduced level in some cases. Damage to the administration, infrastructure and a reduction in response are very possible consequences of a major windstorm. However, its operational structure would probably not entirely shut down for

any jurisdiction in the County. Damage to administrative facilities and operational equipment would put various organizations in a bind in so far as maintaining their normal support to the public, but would not totally shut down their operations.

The impacts to the delivery of services could impact the entire County or in some cases, only a portion of it. This is largely dependent on the type of windstorm.

An east-wind event, see Map 4.9-2 Pierce County Severe Storm Wind Hazard – East-Wind Event, with very strong winds will usually only impact the eastern portions of the County. The force of the wind decreases rapidly over distance. Wind speeds that can hit 100 mph in Buckley will be 50 mph or less by the time it gets to the western portion of the County. In a case like this there could be some loss of ability by local jurisdictions in the eastern portions of the County to deliver adequate services to the community. With heavy winds there could be extensive debris on the roads, broken lines and if some buildings are damaged, there could be broken water or gas pipes.

With a south-wind event, see Map 4.9-1, essentially the entire populated area of the County will be impacted. This is equivalent to the Columbus Day windstorm of 1962 or the Hanukkah Eve Windstorm of 2006. In these two cases, there was major damage to the trees and power-lines. Many roads were totally closed, see Figure 4.9-7, and some people were without power for over 10 days. In situations like this the local jurisdiction is not capable of maintaining an adequate delivery of services. In order to bring the services back up to their normal level, they will possibly have to staff the recovery operations for weeks.

Property, Facilities, and Infrastructure

Hail

Large hailstones can damage property, facilities and some infrastructure like electrical transformers, etc. However in Pierce County the size of hail that has fallen historically has caused minimal damage, if at all, to any of the jurisdictions' facilities or infrastructure in Pierce County.

Ice Storms

Ice storms can cause damage to public and private property, jurisdictions' facilities and local infrastructure. Overloaded tree limbs breaking off and landing on cars, buildings, and equipment can cause significant damage. Overloaded wires can break causing fires. Ice on roofs adding extra weight can cause damage, especially on lightly built structures. A 50-foot conifer can accumulate as much as 99,000 lbs of ice during a storm[13], and when combined with wind may topple causing much more damage than it would have otherwise.

Snowstorms

Typical Pierce County snowfall of a couple of inches does not normally cause much damage to the facilities, property, or infrastructure, around the County. A snowstorm slows down traffic and causes an increase in traffic accidents, but little more. In contrast, an unusually heavy storm like the January 16, 1950 storm could cause extensive damage to facilities, equipment and infrastructure. In a case like this, power lines could come down, equipment could be damaged, and facilities could have extensive damage from excessive weight on roofs.

Tornadoes

Depending on the track and size of the tornado, it could devastate facilities and infrastructure. The last few tornadoes to strike Pierce County have been relatively small and have not caused appreciable damage to the facilities or infrastructure of any jurisdiction in the County. If a tornado the size of the Greensburg Kansas tornado of May 4, 2007, see Figure 4.9-4, were to strike one of the towns or other jurisdictions in the County they would have extensive damage to their property, facilities and the jurisdictions infrastructure. Descriptions of the 1899 tornado to hit Pierce and Lewis counties appear to put it in the same category. That tornado destroyed old growth forest with trees up to four feet in diameter and left a path of destruction 300 to 600 yards wide and 50 miles long. A repeat of that event passing through the populated portions of the County could destroy or damage some major pieces of infrastructure in addition to family homes and businesses.

Windstorms

The impacts to facilities, property and infrastructure include downed power lines, closed roads, see Figure 4.9-6[14], damaged or destroyed equipment and facilities can be extensive from major windstorms.

Figure 4.9-6 Downed Power Pole 02/2006 Windstorm

Power can be out to portions of the County for over a week after a major windstorm. This means that traffic lights will be out at crossings and emergency facilities without generator backup will not be able to function. Having many roads covered with debris like the one in Figure 4.9-7 would virtually shut the County down.

Strong wave action from windstorms can erode coastal areas with railroad tracks and roads built in some cases right up to the water's edge.

Response vehicles and facilities may have trees or branches fall on them. Blowing

debris, such as parts of roofs, fences, metal signs, and even sand can all cause damage to property and equipment.

The Environment

Hail

Environmental impacts are some of the more serious effects resulting from hailstorms in Pierce County. Hail tends to cause extensive damage to crops and other plants. It can abrade or tear leaves; break stalks, stems or branches; destroy blossoms; and bruise fruit. All this will cause short term environmental damage. However, due to the normally small size of hail in Pierce County, this damage is short-term seldom lasting more than one year.

Ice Storms

Ice storms cause environmental damage by placing an excess amount of weight on plants that can break the limbs off large trees, crush small shrubs and injure or kill animals. Conifers are a little more resilient to the effects of the ice than are deciduous trees and can accumulate large quantities of ice. When combined with wind however they then can topple with considerable force.

Icing can further damage plants by sealing the leaves, stems and buds from the air, suffocating these parts. When the ice sheet covering the ground persists for a lengthy period it can also suffocate some plant species.

Animals that are used to snow cannot dig through the ice as they would snow to reach their normal food supply and so starve. Some become encased in ice themselves and die[15].

With enough time the environment will regain its normal vitality, but depending on the amount of damage done it could take from a few months to several years.

Snowstorms

Light snowstorms have very little impact on the environment. The plants and animals that are endemic to Pierce County are used to this type of winter weather. With a heavy snowfall, broken limbs from trees will be one of the most visible signs of damage. If the snow remains deep for an extended period of time, some large animals being unable in deep snow to cover enough terrain to find food may starve to death. Regardless of the initial damage done by the storm, the scars on the environment will disappear; usually in a matter of months.

Tornadoes

Tornadoes by their very nature can destroy everything in their path. The 1899 tornado, according to news reports, cut a 300 to 600 yard swath through forest ripping up trees

four feet in diameter. A repeat of a tornado of that size could cause even more environmental damage today. In 1899 it tore through forest and farms. While the environment suffered the loss of many trees it began to repair itself immediately and eventually the vegetation and forest recovered.

The environment that the tornado would travel through has changed considerably. Forests have been logged and are now in at least their second if not third re-growth. Instead of a few farms spread apart you have a modern metropolitan area. A tornado that touches down in the wrong area could destroy oil storage tanks, and hundreds of other hazardous chemical storage sites. All the material, especially hazardous materials that are transported on the highway system or through the port by ship or rail would be at risk of being spilled. Many of these could cause drastic, long-term environmental damage possibly lasting for many decades. Spills into the rivers or Commencement Bay could decimate fish populations for years.

Windstorms

The impacts include downed trees and limbs. In some cases entire stands of trees can blow down in a single windstorm, see Figure 4.9-7.[16]. A single tree falling at any one point is a very minor environmental problem that will have very little impact depending on the location. However a full stand of trees all falling together leaves a scar that will take decades to re-grow. Loss of forest increases erosion and increased erosion leads to more silt in the rivers. Fallen trees can block streams or cause log jams on rivers that can cause the water to back up with possible flood consequences.

Along coastal areas strong winds, especially when combined with high tides can erode beaches. The wave action can undercut hillsides that extend down to the water increasing the possibility of landslides.

Wind damage to homes, businesses or industry can cause further environmental damage through the release of hazardous chemicals. Natural gas lines can be broken leading to fire. Very strong winds can tip over trucks or cause the driver to have an accident leading to a spill. Depending on the quantity and type of chemical the spills will be more or less damaging.

Figure 4.9-7 County Road December 2006 Windstorm

Economic and Financial Condition

Hail

Economic impacts from hail, even the relatively small hail that occasionally falls here in Pierce County can be dramatic. With portions of the Puyallup Valley still being farmed from Orting to Sumner and Fife there is a high potential for damage to crops if there is a hailstorm at the right time of year. Other types of economic damage may come about if the hailstones are large enough to damage cars, equipment being used outside and building exteriors.

Ice Storms

The economic or financial impact of an ice storm can be extensive. Damage to facilities due to the weight of the ice can be in the millions of dollars. Closed roads and power outages either due to ice and debris on the road, downed power lines, or damage to electrical power facilities will cause closure of businesses. This can lead to lost revenue for the business and lost income for employees. Damage to homes and personal property can also be high, leading to increased debt for the individual family.

Snowstorms

Most snowstorms to strike Pierce County have a very limited impact on the local economy. They are more of a short-term inconvenience than anything else, melting off in a few hours or a day. However, a major storm that knocks out electricity; closes roads, schools and businesses could have a major impact on the local economy. The inability of retail outlets to maintain a certain level of commerce, restock, and in some cases lose stock from either damage from the cold or exceeding expiration dates on perishables could cost them millions of dollars. When employers close their business even for a few days the ripple effects include not just lost goods but lost wages for employees. With lost wages, the employee becomes unable to pay his/her bills. If this goes on for very long, the lost wages make it difficult for the worker to pay the normal day-to-day bills that arrive in the mail much less support the retail economy.

Tornadoes

A small tornado hitting the unpopulated areas of Pierce County would have negligible economic or financial consequences for the jurisdictions in the County.

In contrast, a large tornado moving through an industrial area, a populated area, or an area with a concentration of businesses could devastate the local economy. This would be especially true if a large number of businesses or the industrial base of the County were affected. Homes and some businesses could be rebuilt and be up and running within a year or so. Larger scale projects like malls or the port industrial complex could take many years to rebuild and re-staff.

Windstorms

The economic and financial aspects of a windstorm can be extensive. Local damage to homes and businesses can run into the millions of dollars. When business or industry is damaged there can be extensive loss of employment. This leads to individuals and

families not being able to make their bill payments, including rent or house payments. People unable to work will need assistance which puts a burden on the taxpayer. If the situation does not resolve itself the jurisdiction could eventually have some people leave the area.

Coastal erosion through wind damage can cause transportation problems. The under-cutting of roads along the coast, the damage to bridges from high-wind coastal flooding and the erosion leading to landslides are all problems that could affect the local economies throughout Pierce County's coastal areas.
Another area is agricultural damage. This includes the lumber industry. Lumber can react differently than the other agricultural products of Pierce County. Damage to most crops from a windstorm might take a year or more to recover. With the lumber industry a large timber blow-down might be salvageable. While this could keep the loggers employed and the company in a good financial condition initially, they will have to jump right into replanting the area to allow a harvest in a few decades.

Public Confidence in the Jurisdiction's Governance

Hail

Hailstorms should not cause any loss of confidence in any of the jurisdictions in Pierce County. However, depending on the quantity of damage to agricultural resources and the ability of State and Federal agencies to quickly assist with their recovery, there could be some loss of confidence in them.

Ice Storms

The reputation of local jurisdictions and agencies in the wake of an ice storm is partly dependent on the weather itself. A heavy ice storm that maintains below freezing temperatures for a long period of time will continue to tax local resources throughout that period. Citizens will become more adamant in demanding relief from power outages and other storm related problems. In contrast an ice storm that does its damage and then melts quickly allowing for a rapid recovery will not damage the confidence of citizens in the local jurisdictions or agencies.

Snowstorms

Small snowstorms will have little if any impact on the citizens' confidence in local agencies or jurisdictions. With large storms depositing a great deal of snow throughout Pierce County, two factors will affect peoples' perceptions on the competency of the local jurisdiction. The first is how fast the roads are brought back to being passable and the second is how quickly their electricity is returned. If these two things are brought back to normal quickly, confidence in the local entity will be high. If, on the other hand, things are slow and the perception develops that not enough is being done, then confidence in the local jurisdiction will falter and it will develop a reputation for either incompetence or not caring about the citizens it serves.

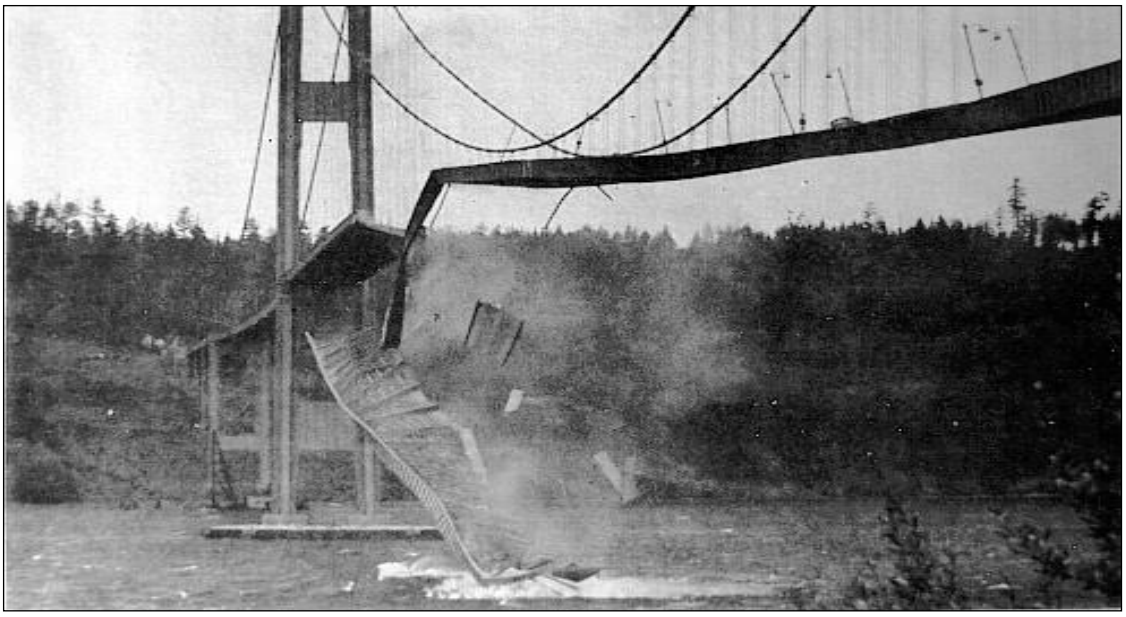
Tornadoes

In the wake of a tornado the confidence in any individual entity will be based on how quickly it responds to the needs of the affected community. People know that tornadoes are extremely damaging and there are not many of them that actually form in Pierce County.

A tornado by its very nature is more localized in its damage. Rather than being a County-wide phenomenon, the path of destruction will be well defined. Any jurisdiction directly impacted by the wind should be able to begin recovery operations immediately. If assistance is needed, and it hasn't been for the last few tornadoes, it would be available from nearby agencies and jurisdictions on short notice.

If the perception, real or not, is that any agency or jurisdiction is not responsive to the needs of the community affected by this incident, then there will be a decrease in confidence in that organization. If, on the other hand, the entities involved act quickly to get the community back on its feet, its reputation should not be hurt.

Figure 4.9-8 Tacoma Narrows Bridge – November 7, 1940 Windstorm[17]



Windstorms

The Hanukkah Eve Windstorm of 2006 impacted all of Western Washington and provides a good example of the results that can be achieved when communities pull together to resolve problems that arise. It can be used as a template to gauge the public reaction to the work that government entities do in attempting to bring the community back to normal.

Initially the public is very supportive of the actions of first responders. However, as time goes on and there are still pockets of homes or businesses without electricity or phone service, people will begin to lose faith in the abilities of the local entity. They begin to wonder why they do not have services and other people do. Eventually they begin to feel that the local jurisdiction has either forgotten about them or that they are considered to not be important enough to warrant a quick response. If a jurisdiction cannot overcome these fears then they can escalate into confrontations between individuals and those working to restore services.

Vulnerability

Areas in the Cascade foothills receive a great deal more snow than the lowlands. If snow were an annual winter problem, local infrastructure and services would be much better prepared to handle it. A contributing factor is that the snow that falls in the lowlands usually has a higher water content and easily creates ice when driven on.[18]

The Planning Area, having a temperate climate, can experience a dramatic change in road conditions within this short difference in elevation. This means that with winter temperatures hovering around freezing, roads wet with melting snow or rain during the day can become iced overnight, causing transportation problems.[19]

The general effects of most severe storms are immobility and loss of utilities. Transportation routes can become blocked, travelers and commuters can get stranded, and families can be separated. Additionally, because electrical lines are damaged, other utilities such as telephones (cellular and landlines), natural gas, and water and sewer systems can become inoperable. Physical damage to homes and facilities can occur from wind damage and accumulation of snow, ice, and hail can occur from accompanying winds. Even a small accumulation of snow can wreak havoc on transportation systems due to lack of clearing equipment and lack of experienced bad-weather drivers. There is the possibility for injury or death in traffic accidents associated with icy streets. There is an increase in hypothermia deaths, especially among the elderly. The number of house fires sometimes increases as people try to heat their houses with non-traditional methods. There can also be an increase in the number of asphyxiation victims due to the use of hibachis or barbecues in the house for heating or cooking when the power is off. Frequently, there is economic loss to businesses, not just from damage, but also from loss of business and school closures.[20]

Planning Area

The Planning Team determined the Planning Area has a medium vulnerability to the severe storms hazard because of the following factors: the impacted area, the construction type of most structures, type of severe storms, and past occurrences. Depending on construction type, the effects of a storm can be varied for each structure. There is potential for moderate economic losses and a health/safety risk for up to 25% of the population. As the area continues to develop, the impacts of severe storms such as road closures and downed power lines will affect a greater number of people and facilities.

In the entire Planning Area, over 16,000 acres are vulnerable to the severe storms hazards identified by the Planning Team. The total damage to the Planning Area could equal approximately $8 billion (the assessed value of all parcels in the Planning Area).

For Tribal Trust parcels located in the Planning Area, all 485 parcels are vulnerable to severe storms hazard. The total estimated losses to these parcels would equal $300,329,200.

Resource Directory

Regional

- **Pierce County Department of Emergency Management**
  http://www.co.pierce.wa.us/PC/Abtus/ourorg/dem/abtusdem.htm

- **Seattle Office of the National Weather Service**
  www.wrh.noaa.gov/seattle

- **Western Regional Climate Center**
  http://www.wrcc.dri.edu

- **Office of the Washington State Climatologist**
  http://www.climate.washington.edu/

- **"The Storm King"**
  http://www.ocs.orst.edu/storm_king_site/

National

- **ASCE Wind Speed Maps**
  http://www.pubs.asce.org/

- **Coastal zone management programs by state**
  http://coastalmanagement.noaa.gov/

- **Extreme Heat Fact Sheet**
  http://www.fema.gov/hazard/heat/index.shtm

- **National Severe Weather Laboratory estimates the likelihood of severe thunderstorm hazards in the United States.**
  http://www.nssl.noaa.gov/hazard

- **National Weather Service Climate Prediction Center**
  http://www.cpc.ncep.noaa.gov

ENDNOTES

[1] Background and specific information for entire Pierce County Landslide Section provided through consultation with landslide hazard expert, Tim Walsh, Washington State Department of Natural Resources.
[2] This entire section has been modified from PC HIVA, Storms Section, September 5, 2002, pp.41-45.
http://www.co.pierce.wa.us/xml/abtus/ourorg/dem/HIVAWEB.pdf
[3] The largest hailstone in US history was a 7" wide chunk of ice slightly smaller than a soccer ball. It is referenced in National Geographic News on August 4, 2003, http://news.nationalgeographic.com/news/2003/08/0804_030804_largesthailstone.html In contrast the heaviest hailstone recorded comes from northern India on March 10, 1939 and weighed 7.5 lbs. It is referenced on the Multi-Community Environmental Storms Observatory website at http://www.mcwar.org/articles/hail.pdf
[4] Developed in 1971 by T. Theodore Fujita of the University of Chicago, NOAA Storm Prediction Center, http://www.spc.noaa.gov/faq/tornado/f-scale.html
[5] The Storm King, Windstorm Events Roughly Broken Down by Track Type, http://www.ocs.orst.edu/storm_king_site/index.html
[6] South Wind Event, Pierce County Planning and Land Services ,Map developed by Karen Truman with assistance from Ted Buehner with National Weather Service, 2002.
[7] East Wind Event, Pierce County Planning and Land Services ,Map developed by Karen Truman with assistance from Ted Buehner with National Weather Service, 2002.
[8] A tornado in the West, Special to the NY Times, Published October 9th, 1899. http://query.nytimes.com/mem/archive-free/pdf?_r=1&res=9B06EFDB173DE433A2575AC0A9669D94689ED7CF&oref=slogin
[9] Phone conversation with Ted Buehner of the National Weather Service, NOAA, Department of Commerce, Seattle office, March 6, 2008.
[10] NOAA Satellite Photo of Hanukkah windstorm approaching the Washington Coast, 12/13/06.
[11] Photos from before and after of Greensburg Kansas, Google Earth and May 2007 CATF3 photo
[12] Photo from Pierce County Road Operations.
[13] Ice Storms: Hazardous Beauty, Keith C. Heidorn, PhD, The Weather Doctor, December 2001, http://www.islandnet.com/~see/weather/elements/icestorm.htm
[14] Photo by Luke Meyers, Aftermath of February 2006 Windstorm.
[15] Ice Storms: Hazardous Beauty, Keith C. Heidorn, PhD, The Weather Doctor, December 2001, http://www.islandnet.com/~see/weather/elements/icestorm.htm
[16] Photo from Pierce County Public Works Road Operations, December 14, 2006.
[17] *Bridge midsection crashing into the waters of the Tacoma Narrows, November 7, 1940. Bashford and Thompson Photo. PH Coll. 290.36 University of Washington Libraries. Manuscripts, Special Collections, University Archives Division.
[18] *Ibid*, p. 3-5.
[19] *Ibid*, p. 3-5.
[20] *Ibid*, p. 3-5.

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