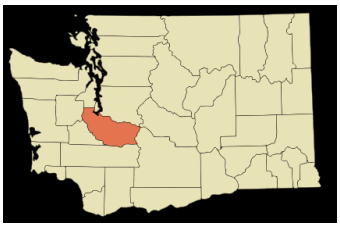
Hazard Mitigation Best Practices

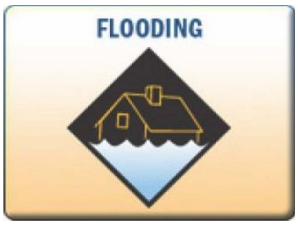
A compilation of the Hazard Mitigation Best Practices in the State

This section serves as a review of some best practices in hazard mitigation and as a guide for all types of organizations in their hazard mitigation planning and actions. These best practice summaries can trigger ideas for future mitigation projects as well as provide handout material for public relations campaigns or public meetings to gain support for hazard mitigation activities. There is a wide range of project scopes included to show that smaller organizations can get involved even with limited budgets. Private organizations and individual homeowners can conduct hazard mitigation activities outside of any Federal, State, or Locally funded project, and at very reasonable costs and efforts. As hazard-prone as Washington State is, all residents and organizations should be practicing hazard mitigation.

Various types of hazard mitigation projects are listed below (click on the types to hyperlink to those projects within this document).

Additionally, FEMA maintains a best practice portfolio searchable by state and hazard. Washington State has 30 records when accessed in December 2012 for projects started in 1989 through 2008. See Public and Private Sector Best Practice Stories for All Activity/Project Types at http://www.fema.gov/mitigationbp/.





Washington State Hazard Mitigation Best Practices

Pierce County Carbon River Acquisitions

Unincorporated Pierce County, WA – The Carbon River starts at the end of the Carbon Glacier, which flows down the north side of Mount Rainier. To the east of the City of Orting, the river meanders along a steep slope and is subject to normal channel migration (meander bend) as well as abrupt migration (avulsion) from landslides. In response to the flooding in 2006 and Presidentially Declared Disasters 1671 and 1682, Pierce County proposed to purchase and remove homes along this part of the Carbon River. The restoration of the area to its natural state offered life sustaining, ecological, and financial benefits. Additionally, the County has

View from acquired properties across the river from the landslide area. As these slopes become saturated during periods of significant rainfall, large landslides can fall into the river's channel thereby causing it to migrate towards the properties. Structural techniques (levees) placed near the River's normal edge have been largely ineffective against preventing the channel migration and protection during significant flooding events.

received Flood Control Assistance Account Program (FCAAP) grants from the State Department of Ecology to conduct acquisition projects in the area. The County utilized funds from its Surface Water Management Fees to provide the local matching share requirement of these grants.

As part of the grant conditions, the County agreed to maintain the properties as open space in perpetuity by recording deed restrictions on the properties. Removing the homes allowed for increased floodplain storage capacity. However, difficulties included homeowners deciding not to sell their properties after the grants were awarded or the property changed ownership and the bank would not sell the foreclosed property.

Quick Facts

Total Project Estimated Cost: **$2,794,323** (estimated)

Primary Activity/Project: **Acquisition/Buyouts**

Funding: **HMGP (FEMA-Federal), FCAAP (State), Surface Water Management Fees (Local)**

Before the Acquisition – Home is subject future flooding and channel migration

After the Acquisition and Demolition – The property contributes to natural and beneficial floodplain function

Note: This summary was created by Wes Nims, Washington State EMD Hazard Mitigation Grant Program Coordinator and reviewed and edited by Randy Brake, Surface Water Management Engineer, Pierce County Public Works and Utilities - Surface Water Management.

HMGP GRANT FUNDED PROJECT
WASHINGTON STATE HAZUS-MH DATABASE ENHANCEMENT PROJECT

Original Author: Ray Cakir, DNR-DGER Minor
Edits: Wes Nims and Beverly O'Dea, WA EMD
April 9, 2010

The following is a recap of a data-enhancement project initiated by WA EMD, funded through a FEMA HMGP Grant, and contracted with Washington State Department of Natural Resources. The purpose to this project was to enhance the data sets available for local jurisdictions' use as they conduct their risk assessment and determine dollar losses of essential/critical facilities. The below is a description of the processes undertaken to complete the project, as well as information on future projects to continue enhancing the information. The project lead for EMD was Cathy Walker, GIS Analyst for the Washington Military Department.

The Washington State Military Department Emergency Management Division (EMD) subcontracted the Washington State HAZUS-MH (Multi Hazard) Database Enhancement Project (called HAZUSWA) to the Washington State Department of Natural Resources (WA-DNR), Division of Geology and Earth Resources (DGER), to enhance the database for accurate earthquake and flood modeling studies in Washington.

In order to manage the project work flow and allow for monitoring of progress, DGER established a SharePoint site, which allowed for collecting, sorting, querying, searching source data, and tracking each dataset history through the HAZUS database enhancement process. Workflow generally consisted of the following steps:

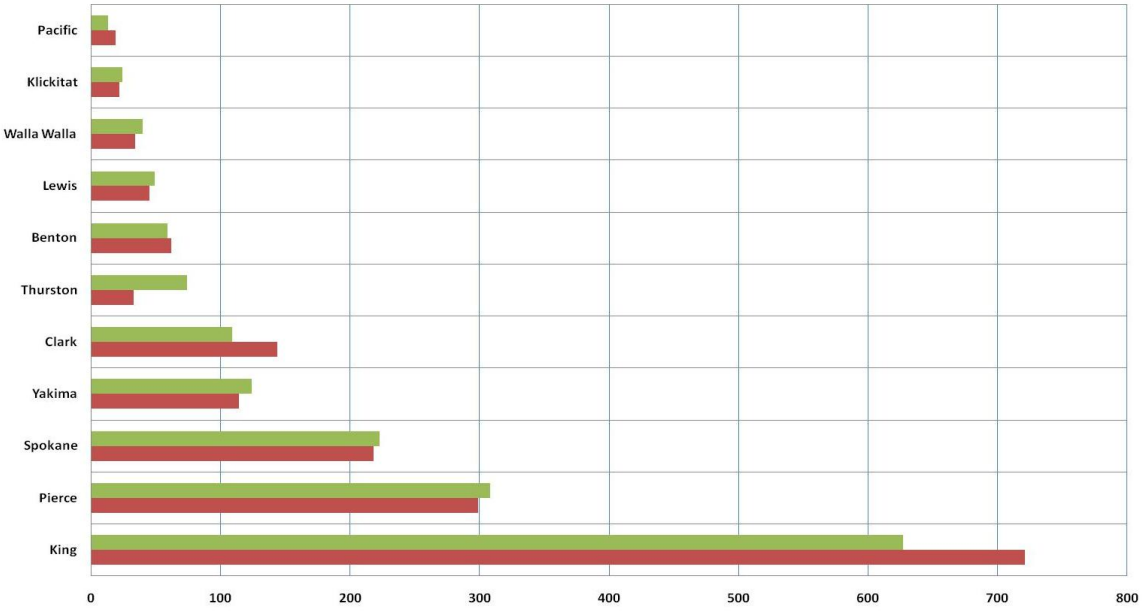
1) Contact source data agencies/companies (county, state, and national agencies or companies). Record all source data contact agency/person information and relevant URL addresses on the HAZUSWA external SharePoint site.
2) Receive the data (record all sour data type and contact information).
3) Perform quality assurance/quality control (QA/QC) on data based on file arrangement (Excel-Access table, ESRI shape, geodatabase, etc.); convert projection to the Geographical Coordinate System (GCS) and NAD83 datum (the standard coordinate system for HAZUS-MH), complete location check in ArcMap (using DNR orthophotos, ESRI orthophotos, and street database) and Google Map, and attribute completeness check based on required attributes for each entity of the HAZUS database.
4) Update processed data through the Comprehensive Data Management System (CDMS); complete field checks (character lengths, field names, consistency in number/text field, etc.); populate new attributes, which are a) facility classification (for example, UtlClass, TSclass and Efclass are used as designated fields for the utility systems, transportation systems, and essential facilities, respectively) based on the HAZUS descriptions in the facility-analysis classification tables, b) newly generated latitude and longitudes in decimal degrees, and c) state designation field.

DGER had approximately 5-7 individuals working on this project throughout the 10-month period. DGER contacted all Washington state county GIS and EMD offices, documenting all communication on SharePoint. In all, 315 datasets were collected, either directly or indirectly, related to the HAZUS-MH database. The data was then sorted, reprojected (to the HAZUS projection), and DGER edited the 166 relevant datasets for location quality (10% random check). Location quality checks were followed by preparations of data completeness reports for all these datasets, including attribute comparisons between the HAZUS and QA/QC'd source data. We then quantified all field information matched between the two entities as a percentage (earthquake- and flood-specific field checks were excluded). Also, DNGR gave information about the availability of the source metadata and what was changed and edited on the source data, and other information such as paths for the

available supplementary data and our personal comments about the processed source data. All 166 datasets have been finalized and are ready to be used for the CDMS update procedure. We completed QA/QC on all received data, including essential facilities (EF), transportation systems (TS), and high potential loss facilities (HPLF).

There is currently 69 QA/QC'd updated source datasets on the HAZUS database through the CDMS. Other QA/QC'd datasets can also be updated using the CDMS, depending on the CDMS-required data format (point) and data quality for the HAZUS earthquake or flood modeling purposes. The updated data through the CDMS have demonstrated both increments and decrements in number of records for the existing level 1 datasets. Comparison by EMD's GIS Analyst of the HAZUS-MH MR4 data to that collected demonstrates a better quality and more accurate representation of each dataset updated. For example, when comparing bridge data from HAZUS to the collected data, HAZUS data includes bridges which, when cross-checked with orthoimagery, are not located on roads or crossing tributaries (in some cases represented in the middle of an empty field), versus local data which is more accurately reported.

Suggested Follow-up Action:
While this project propelled the state forward significantly with respect to the accuracy of the various datasets, Figures 1 and 2 below demonstrate data still lacking when, for instance, counting the number of schools received from counties. Figure 2 shows that up to 80 percent of the HAZUS attribute information required for schools can be available for the selected counties. Our preliminary work on several counties shows that in 1 to 2 months, DGER can gather the missing school information that is not available in data received from counties. This effort can be combined with assessors' data update and later all results given to the counties to further update and complete their datasets. We also suggest that the Washington State Office of the Superintendent of Public Instruction (OSPI) can take the lead in collecting some of the HAZUS-required school information (such as year built, number of floors, etc.).



	King	Pierce	Spokane	Yakima	Clark	Thurston	Benton	Lewis	Walla Walla	Klickitat	Pacific
Level 2	627	308	223	124	109	74	59	49	40	24	13
Level 1	721	299	218	114	144	33	62	45	34	22	19

Figure 1. Increments and decrements in number of schools for level 1 versus level 2 essential-facility school data.

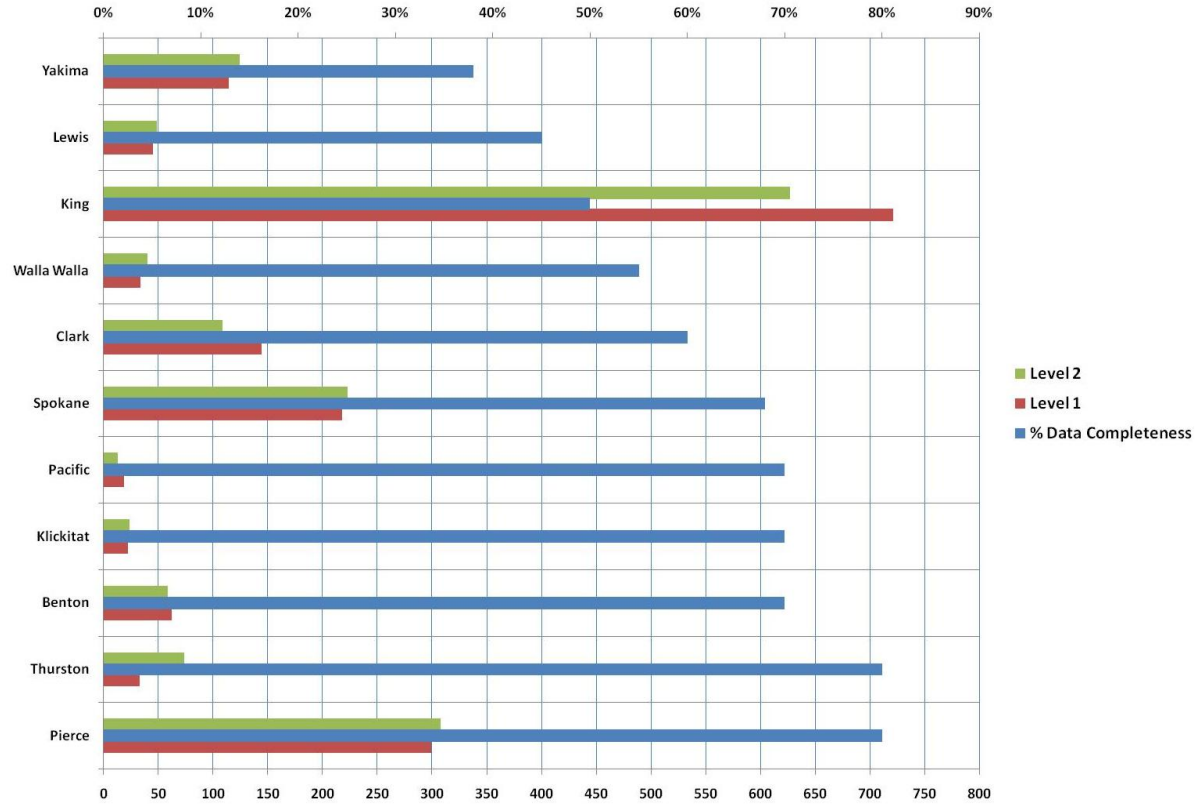
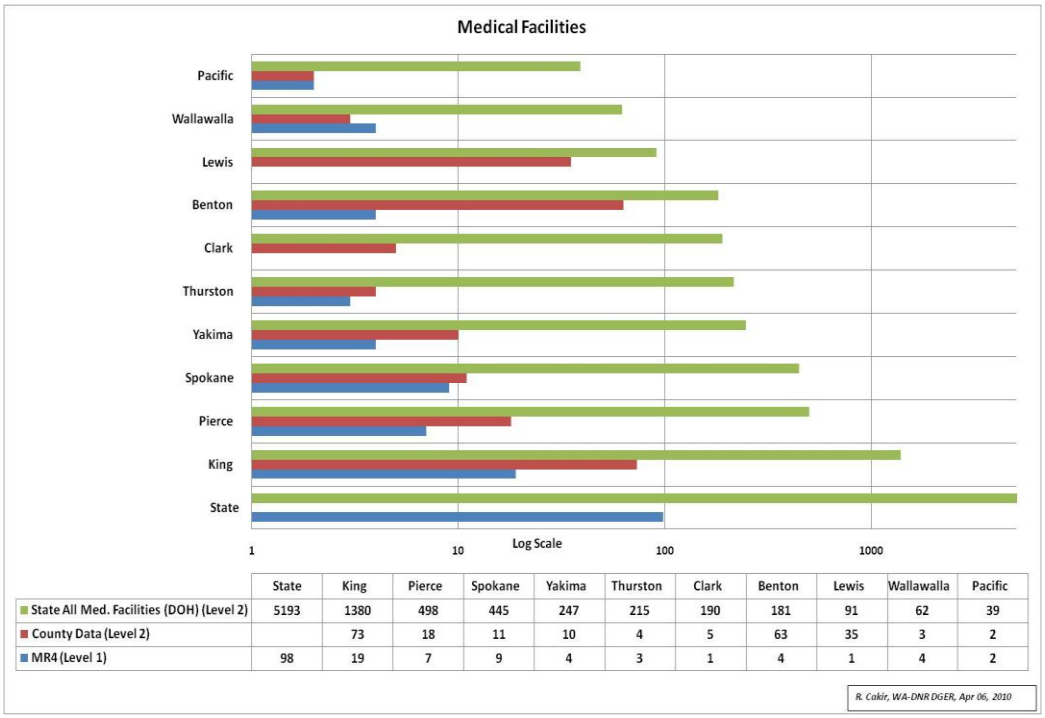


Figure 2. Increments and decrements in number of schools between level 1 and level 2 data, and percent completeness for the main HAZUS attributes (excluding the flood and earthquake specific information).

All medical facilities data available through the Washington State Department of Health (DOH) was added. This additional dataset increased data on medical facilities 10 to 20 times more than previously reported (including county and HAZUS level 1) (Figure 3). We found that police and fire facilities were more accurate in county data received (Figure 4).

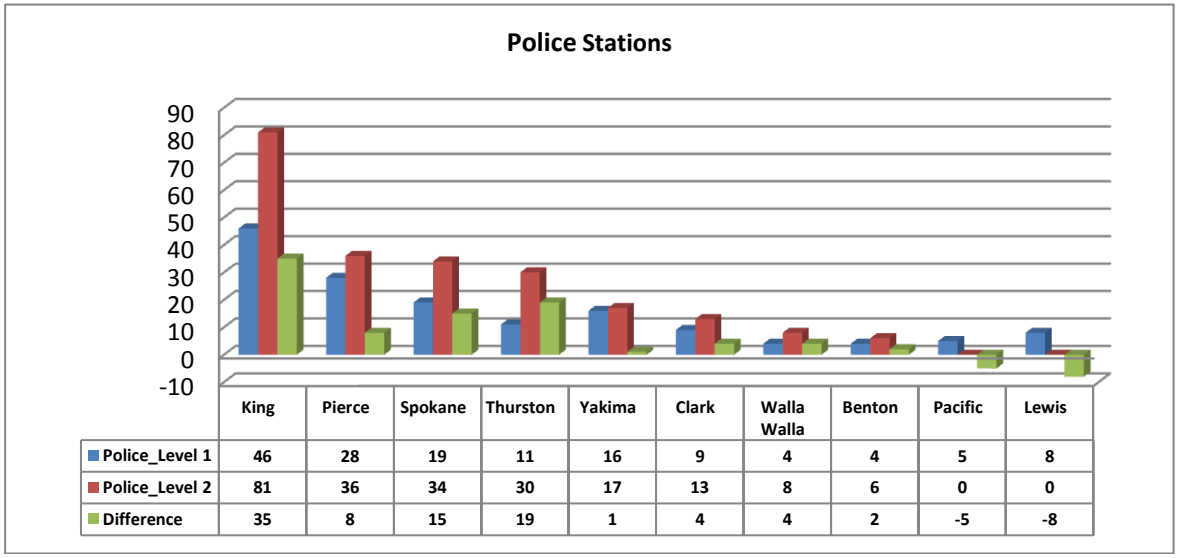
This project demonstrates that

1) More collaborative efforts should be done, between the EMD and DGER, to further enhance the HAZUS-MH database for Washington State.
2) Some essential facilities are significantly improved with new data updated through the CDMS, such as statewide medical facilities and fires stations for highly populated counties.
3) Statewide data for dams are most up to date information and have been considerably improved (including state and federal government regulated ones).
4) Data collection and editing work require a well-designed project management and team working environment and regular meetings, discussions, information sharing among and outside the project members.
5) SharePoint makes all project data and information and work flow easily manageable.
6) Attribute completions of the school data can go up to 80%, this can be done in 1-2 months in the DGER with experienced staff.
7) HAZUS-MH model tests should be run based on the newly updated data for the selected counties.

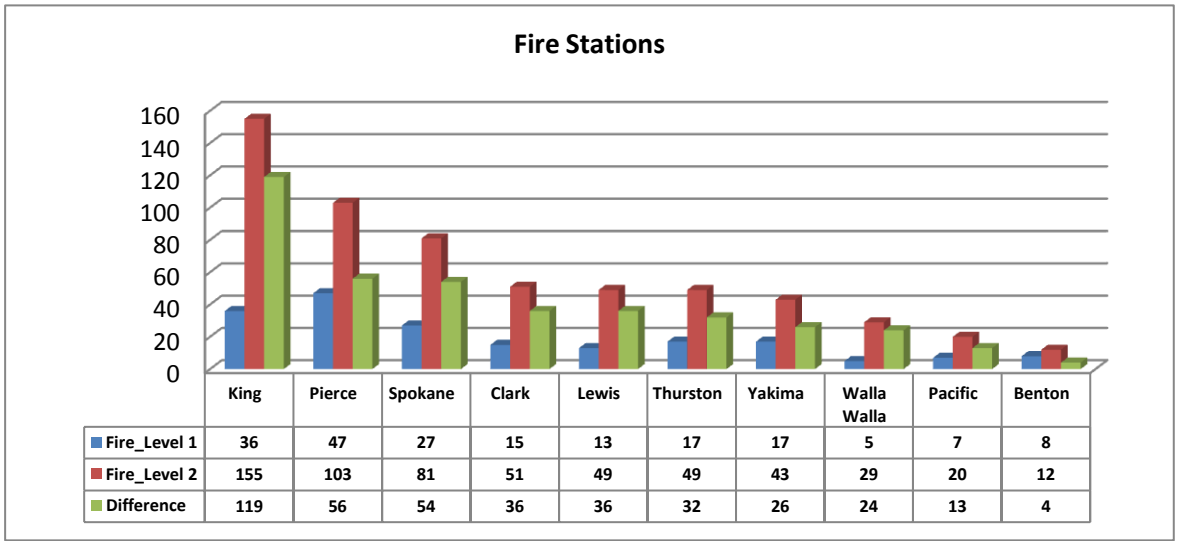


	State	King	Pierce	Spokane	Yakima	Thurston	Clark	Benton	Lewis	Wallawalla	Pacific
State All Med. Facilities (DOH) (Level 2)	5193	1380	498	445	247	215	190	181	91	62	39
County Data (Level 2)		73	18	11	10	4	5	63	35	3	2
MR4 (Level 1)	98	19	7	9	4	3	1	4	1	4	2

Figure 3. Medical facilities showing significant improvement after using the statewide DOH data.



	King	Pierce	Spokane	Thurston	Yakima	Clark	Walla Walla	Benton	Pacific	Lewis
Police_Level 1	46	28	19	11	16	9	4	4	5	8
Police_Level 2	81	36	34	30	17	13	8	6	0	0
Difference	35	8	15	19	1	4	4	2	-5	-8



	King	Pierce	Spokane	Clark	Lewis	Thurston	Yakima	Walla Walla	Pacific	Benton
Fire_Level 1	36	47	27	15	13	17	17	5	7	8
Fire_Level 2	155	103	81	51	49	49	43	29	20	12
Difference	119	56	54	36	36	32	26	24	13	4

Figure 4. HAZUS Level 1 and Level 2 comparison for the police and fire stations of counties that sent the data.

Washington State
Office of the
Insurance Commissioner

Insurance and catastrophes: Protecting consumers in the event of an emergency - *January 2009*

HB1564/SB5417
HB1565/SB5416
HB1566/SB5669

What these bills will do

The Insurance Commissioner is proposing three separate bills that together will help protect consumers in the event of an emergency.

Background

2007 floods led to $45 million in insurance claims

Large-scale catastrophes, such as floods, earthquakes, windstorms, wild fires and volcanic eruptions, can happen throughout our state and the effects can be devastating. Washington was struck by a major windstorm in 2006 and experienced historic flooding in both 2007 and 2009. The 2007 floods alone resulted in 1,044 claims and claims payments of nearly $45 million.

These events remind us that in a few short hours, homes can be destroyed, infrastructure ravaged, and power, telephone and mail service can be interrupted for long periods of time. Families and businesses are displaced, leaving them struggling to accomplish the most basic tasks of early recovery.

Insurers may be located in areas where emergencies occur, but are not currently required to have a plan that addresses state and local emergencies.

The problem

Less than 8% of flood victims had flood insurance

Flood insurance: Flood insurance is not required outside certain federally designated flood zones and many people outside these areas don't know that flooding isn't covered under standard homeowners insurance policies.

This was illustrated in the aftermath of the 2007 flood, when less than 8 percent of people in affected areas had flood insurance. Too many citizens are exposed to devastating and unnecessary personal financial risk. This also creates a strain on other disaster assistance resources.

People can lose coverage or have to pay out of pocket if they are displaced

Displacement: Insurance is vital to recovery in the event of a natural disaster. However, such disasters can cause sudden and widespread coverage issues. For example, disruption of mail delivery or receipt could mean lost renewal notices or billing statements, resulting in cancellation of coverage. Or, if a family has to relocate, they may need to see doctors outside of their insurance network, and end up having unexpected and significant out-of-pocket expenses.

Most insurers do the right thing and choose to be flexible in times of emergency. For example, the Commissioner requested that insurers not cancel or non-renew policies for victims of the 2007 floods for a given time period – and they showed exemplary

If insurers aren't prepared, consumers could suffer

cooperation. However, we had no way to know if all insurers had received the message and couldn't offer consumers the reassurance they were seeking. Additionally, insurers had to manually override automated systems that, because of the lack of pre-existing guidelines, could not be programmed to anticipate the need for the moratorium.

Emergency preparedness: Not all insurance companies have plans in place to make sure they are ready for a disaster. Lack of a contingency plan and reliable back-up records could disrupt service and prevent claims payments in the event of an emergency.

The solution

These bills would:

- **Educate consumers about flood insurance**
- **Protect consumers from unfair cancellation and costs**
- **Require insurers to be prepared**

These bills would establish legal protections for consumers and predictability for insurers in the wake of future disasters. Specifically they would:

- Require insurers to inform consumers that property insurance does not cover flood damage and to tell them about the National Flood Insurance Program. Information would be provided in writing at policy inception and annually thereafter.
- Allow the Commissioner to require insurers to make reasonable exceptions, such as grace periods for payments and access to out-of-network medical care, in the event of an emergency. Authority would be limited to the insurance of people within the geographic area defined in the Governor's declaration.
- Expand insurers' emergency-preparedness requirements to include state and local emergencies and require domestic insurers to maintain a continuity plan in case a local, state or national emergency disrupts business operations.

Contact: Drew Bouton - Legislative Liaison - 360-725-7101 - DrewB@oic.wa.gov

Hazard Mitigation Grant Applications Best Practices

Benefit-Cost Analysis

All projects (except the acquisition of substantially damaged structures) submitted for FEMA Hazard Mitigation Grants must have a benefit-cost ratio (BCR) of greater than one. The FEMA approved benefit-cost analysis (BCA) software is used to determine the BCR and requires adequate training and experience to utilize it effectively. Even though FEMA and the State try to provide BCA training and technical support to local jurisdictions, inevitably, some still struggle to produce credible BCAs. Therefore, in some cases, it may be more efficient for a local jurisdiction to hire a contractor with experience in utilizing the FEMA BCA software to generate the BCA for a given project application. There are several jurisdictions that follow this process. As long as the local jurisdiction designates the anticipated contractor costs in the budget as pre-award costs, the costs can be reimbursed if the project is ultimately awarded and funded by FEMA. A credible BCA contractor can provide invaluable experience in atypical projects, including acquisition projects involving channel migration and landslides as well as utility or infrastructure retrofit projects where loss of service values can factor into the BCA.

Scope of Work and Complying with the Feasibility and Effectiveness Requirement

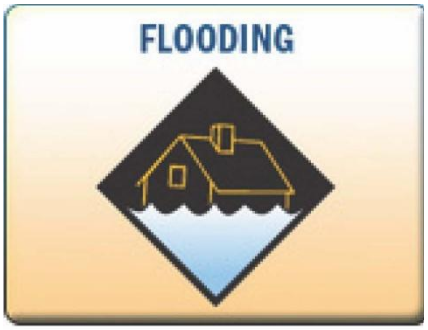
All projects must include a detailed Scope of Work (SOW) that provides detailed information about the project, including documentation that shows how the project conforms to acceptable engineering practices and that the project will mitigate the indentified risk. Some applications submitted in the past have included weak SOWs and the State could not determine if the project was feasible or would be effective in addressing the hazard. FEMA's website provides links to sample SOWs for the major project types. See the section entitled *Engineering Case Studies by Project Type* near the bottom of the following site:
www.fema.gov/government/grant/hma/grant_resources.shtm#Engineering Case Studies by Project Type

Public Involvement

It is very important that the local jurisdiction follow the requirements for public involvement as they are outlined in the State's guidance for the specific hazard mitigation grant for which the jurisdiction is applying. For projects that are located in or might affect floodplains or wetlands, these requirements are mandated by Executive Order 11988, Floodplain Management, which requires public involvement in any Federal action that might affect floodplains or wetlands. The State EMD has generally required public involvement for any type of hazard mitigation project, not just those affecting floodplains or wetlands. This ensures that the public has ample opportunity to be made aware of any proposed hazard mitigation activity and provide input to the alternative development and selection process. Furthermore, it helps build community support for hazard mitigation and potentially generate interest in hazard mitigation on an individual level.

FEMA

Snohomish County Chatham Acres Acquisition



Chatham Acres, WA - A flood in December 1999 caused major damage to Chatham Acres, a small community located on the North Fork Stillaguamish River. In a process known as avulsion, the river abandoned its existing path and cut an entirely new 200-foot wide, 800-foot long channel through Chatham Acres before rejoining its original course.

As the river's path changed its course, one home was washed away. Fortunately the house was unoccupied at the time and no one was hurt. Ten other residences in the area, however, were immediately threatened by the avulsion. Something needed to be done to prevent additional damages or destruction of the homes by flooding or further migration of the river.

Most of the homes in Chatham Acres had been constructed in the 1930s, before the implementation of Flood Insurance Rate Maps (FIRMs). Unknowingly, the homes were built within the Stillaguamish River's floodway.

In response to the immediate problem, the Chatham Acres Homeowner's Association (CAHA) applied for and received approval to construct a section of rip-rap along the affected shore.

It became clear early in the project that the rip-rap would suffice only as a temporary solution. Soon after it was in place, three more flood events caused the loss of an additional 50 feet of riverbank. The river had also begun to erode the shoreline behind the rip-rap.

In addition to the ongoing erosion at the site of the 1999 event, an even larger threat was developing 650 feet upstream from the rip-rap location. The Stillaguamish River appeared to be changing course and would likely enter Placid Creek, a parallel stream to the Stillaguamish, which would lead to even greater and more damaging avulsion throughout the area.

In June 2002, an application was filed for the FEMA Hazard Mitigation Grant Program (HMGP) requesting funding for the purchase and demolition of the Chatham Acres homes. The proposed removal of the residences and restoration of the area to its natural state offered life sustaining, ecological, and financial benefits.

The most important advantage to the acquisition approach was safeguarding the lives and property of those in the endangered area. With the residences gone, not only would the immediate threat be resolved, but any potential problems arising from future flooding and avulsion would be removed as well.

The County agreed as part of accepting the grant to never develop anything on the property and put restrictive easements on the property title to ensure this. Another major reason the acquisition strategy was selected was due to its favorable effect on the area's ecology.

Quick Facts

Sector:
Public

Cost:
$1,899,000.00 (Actual)

Primary Activity/Project:
Acquisition/Buyouts

Primary Funding:
Hazard Mitigation Grant Program (HMGP)

During the course of the project, some positive developments occurred. While assessing the properties for the demolitions, the contractor determined that much of the house material could be recycled for future use. When calculating the value of the reclaimed material, in comparison with the originally quoted figure the demolitions would cost, a significant savings resulted. Additionally, two of the homes designated as historic were saved and relocated prior to the scheduled destruction.

FEMA

Community Park Creation from Acquisitions Prevents Future Flood Damage

Skagit County, WA – After 34 homes on the west side of the Skagit River, opposite downtown Mount Vernon, were severely damaged in the 1996 floods, city officials concluded it was time to take aggressive steps to prevent this kind of damage in the future.

In partnership with the Washington State Division of Emergency Management and FEMA, the City of Mount Vernon acquired 34 flood-prone properties. The designated homes were then demolished (or moved), and the entire site was combined to form an enlarged community park.

The acquisition totaled approximately $2,375,000, financed from the post-disaster Federal Hazard Mitigation Grant Program (HMGP). Substantial though the grant was, its total amount pales in comparison to the cost of replacing and repairing the homes that stood there.

During the 2003 flooding, the entire park was under water again. But, this time there were no homes to repair or replace, and no people to evacuate or rescue. After the water receded, all that needed doing was some minor cleanup.

Quick Facts

Sector: **Public**

Cost: **$2,375,000 (Estimated)**

Primary Activity/Project:
Acquisition/Buyouts

Primary Funding:
Hazard Mitigation Grant Program (HMGP)

The City of Mount Vernon saved itself from serious flooding, thanks to thousands of citizens who filled and stacked sandbags to protect the downtown area, and to city planners who took steps to minimize future damage after the 1995-96 floods.

FEMA

Acquisitions and Elevations: Letting the River Flow Freely in WA

Mason County, WA - The Skokomish River valley experiences wide spread flooding several times each year as heavy rains and mountain snow runoff swell the river outside of its banks.

"The Skoke," as it is commonly called, drains nearly 250 square miles of the mountainous Olympic Peninsula into the Hood Canal region of South Puget Sound. County officials were aware of several areas in particular that suffered frequent and severe flooding, but 12 homes along East Bourgault Road incurred the most significant flood losses. Damages to homes along East Bourgault Road alone had exceeded $300,000 in recent years.

Residents whose homes flooded at least once a year, and who often were forced to evacuate their homes 3 to 4 times each flood season, desired relief. Ten of the 12 homeowners had expressed an interest in participating in an acquisition project. So in 1991, the County applied for and was awarded Hazard Mitigation Grant Program (HMGP) funding to begin buying out some of the homes.

Quick Facts

Sector: **Private**

Cost: **$2,264,849 (Actual)**

Primary Activity/Project:
Acquisition/Buyouts

Primary Funding:
Hazard Mitigation Grant Program (HMGP)

In December 1996, the County adopted a Comprehensive Flood Hazard Management Plan that outlined several recommendations for mitigating flood losses in the Skokomish River Valley. The success of the initial round of acquisitions along East Bourgault Road, which included six homes, created public support for more buyouts. The County applied for additional HMGP funds, and was twice awarded additional funds to acquire, and perhaps elevate where appropriate, more homes along East Bourgault Road as well as Skokomish Valley Road, the second priority area for mitigation.

Mason County was awarded a total of $1,510,077 in HMGP (Federal share) for its non-structural mitigation effort. The remaining $754,772 was funded by the State of Washington and through local government and private resources.

To date, the County has completed the purchase of 13 homes and approximately 75 acres of floodplain. Officials expect to fund the acquisition or elevation of at least seven more properties in 1999.

Site visits since the project was implemented have proven that it has been hugely successful. The Skoke now flows across East Bourgault Road without causing damage where homes once stood. The project as a whole is expected to save approximately $1.50 in avoided damages for each $1 spent.

FEMA

Higher and Higher: Life Above the Waters

Lewis County, WA - Over the past three decades, Washington State has experienced numerous record floods resulting in widespread destruction of property and tragic loss of life. These events have demonstrated the necessity of building stronger, safer, and smarter to protect the people, homes, and businesses in flood affected areas.

Retrofitting existing structures or designing new buildings to be disaster resistant can significantly reduce the threat of future damage and lower long-term financial risk. While staying out of the path of potential floodwater is the best choice for avoiding danger, this is not always an option. In such situations, the next best choice is to be above it. Following the flooding of 1996, Bob and Loyann Munyan, residents of the flood-prone City of Centralia in Lewis County, were approached by a neighbor with information about a home elevation program. The Federal Emergency Management Agency (FEMA) had available funding through the Hazard Mitigation Grant Program (HMGP). The HMGP provides 75 percent funding for approved projects, which frequently include home elevations or relocations, while the State, Local governments, and often homeowners themselves, contribute the balance. Grants are applied for by local communities working in partnership with the State and FEMA.

Quick Facts

Year: **1996**

Sector: **Private**

Cost: **Amount Not Available**

Primary Activity/Project:
Elevation, Structural

Primary Funding:
Hazard Mitigation Grant Program (HMGP)

"We added our name to the list," said Loyann Munyan, "and we were told we had been approved for a 100 percent grant to raise the house."

The Munyans elevated their home 5 feet, 10 inches above its previous height, bringing their floor level one foot higher than expected maximum flood levels for their community. Without the grant, they were informed that the elevation would have cost approximately $30,000.

During the December 1st flooding of 2007, record setting storms brought water to within seven inches of their front door.

In the nearby City of Chehalis, schoolteacher Kevin Fields watched the waters rise on December 1st, but felt confident that his house would remain safe, even while the homes of his neighbors began to flood. Like the Munyans, Mr. Fields' home had been inundated during the 1996 floods. The previous owner, tired of the repeated cycle of flood damage and repair, decided to sell. He bought the home with the intention of elevating it.

"The City wanted me to elevate at least four feet," said Mr. Fields. "That would have been one foot above the 1996 flood levels. I went four feet higher than that and elevated a full eight feet."

Given his expertise and easy access to equipment and materials, the cost of the elevation was less than $10,000. According to Mr. Fields, since the elevation, there have been at least a dozen floods in his neighborhood. Though typical water levels in the area only reach ankle to knee deep, this would still be sufficient to flood the first floor of a ground level home.

FEMA

Snoqualmie Home High and Dry

King County, WA - The Snoqualmie River pays periodic visits to the historic neighborhoods of the former mill town of Snoqualmie, Washington. In eight major floods since 1990, the river delivered muddy water and misery to the homes and lives of hundreds of residents. In each of these events water covered most of the floor of the Snoqualmie Valley.

Brian Tate bought his Snoqualmie home in 1988 and became all too familiar with major flood damage during the big event of 1990. The water was just under the flooring in 1995, 2003, and 2005, but he suffered big losses again in 2006. “It doesn’t matter much if it’s three inches above the floor, or three feet. The damage is done,” said Brian.

In recent years, homeowners like Brian decided they’d had enough of the depressing ritual of throwing out much of what they own, cleaning the rest, then drying out and rebuilding. It was time to take action. So he and several neighbors decided to accept the offer of help from King County’s Structural Elevation Program, which coordinates resources to raise houses out of harm’s way.

Brian found that it takes a lot of time and effort to complete a home elevation project. Funding came, in part, from a Federal Emergency Management Agency (FEMA) Flood Mitigation Assistance Program grant. The King County River Improvement Fund provided additional money. Because Brian’s home had been declared “substantially damaged” (damage was more than 50 percent of the value of the structure) it was eligible for an Increased Cost of Compliance (ICC) insurance benefit as part of his National Flood Insurance Program (NFIP) coverage. Brian also contributed to the cost of the elevation project and related improvements to his home.

Quick Facts

Year:
2006

Sector:
Public/Private Partnership

Cost:
Amount Not Available

Primary Activity/Project:
Elevation, Structural

Primary Funding:
Flood Mitigation Assistance (FMA)

After the funding was in place, a great deal of effort went into planning the elevation project, getting the required permits, negotiating with a contractor, and finally lifting and modifying the building and its foundation. Miraculously, the project was completed just before January 7th, 2009, when the mighty Snoqualmie flooded once again, causing Kimball Creek to flow backwards into Brian’s yard and under the house.

The King County Flood Warning Program had provided most residents with enough time to move their belongings from the storage areas beneath their elevated homes and to drive their cars to high ground. “In general, things went better than I had expected,” said Brian. A tour through the neighborhoods of Snoqualmie shows how determined people can rise up to secure a safe and affordable future.

FEMA

"Noah's Ark" A First Person Account

Quick Facts

Sector:
Private

Cost:
$140,000.00 (Estimated)

Primary Activity/Project:
Elevation, Structural

Primary Funding:
Homeowner

Woodland, WA - "On February 8, 1996, my family and I faced the most difficult challenge of our lives. We were forced to leave our home because of water rising from the Columbia and Lewis Rivers. Water was entering through our front door. What followed was five days of 5 feet of water in our home. Almost everything was destroyed. This was a bit of a shock as we do not live on either river. However, we do live in the floodplain, which by the way never floods (or so we were told). We carried structure but not content insurance so as we sat in our tiny, 20 foot borrowed trailer, and I tried to figure out what to do.

"We were given a lot of literature from government agencies and I, through my tears, read and highlighted everything. I went to meetings and asked questions of city officials, who were no help at all. Finally, someone shoved a video tape in my hands just to shut me up and make me go away. The video tape was "Mitigation Success Stories in the State of Washington," a video jointly developed by FEMA Region X and Washington State agencies, including the State Emergency Management Division and Department of Ecology.

"For the first time in weeks, I felt there was hope. You see, everyone just said rebuild the house, don't worry; it [flooding] will never happen again. But no one could assure me it wouldn't happen again. So, armed with my video and moving on very shaky ground, I insisted we explore the possibility of raising the house on its foundation. My husband thought I was crazy, and so did every other lending institution in the area.

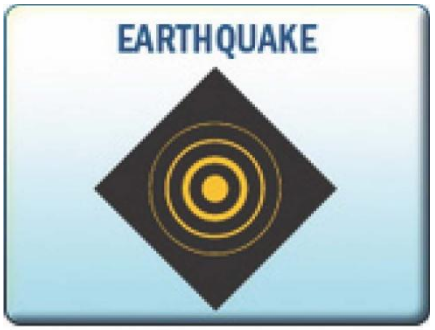
"I started with the insurance settlement and used it to raise the house on its foundation. After that, things got a little scary as I had no idea how we were going to complete the project. We purchased a 5th-wheel travel trailer and moved it onto the site just to keep our sanity. If it hadn't been for the Small Business Administration and the generosity of my husband's Credit Union we might still be in that travel trailer. However, we had help from a lot of other people. The Christmas of 1998 marks our second year in this home that is 8 feet on the foundation and 4 feet above the flood plain. I must also mention how grateful I am to the wonderful contractor whom I hired to complete the work, Darryl Manue of Woodland Homeworks. When the rest said that's impossible, stupid, and why would you want to spend that much money, Darryl said yes, it can be done. Our home went from a simple 3 bedroom, 2 bath, 2,000 square foot home to a 4 bedroom, 3 bath, 2,400 square foot home with many features required to meet flood code and a few tricks of our own.

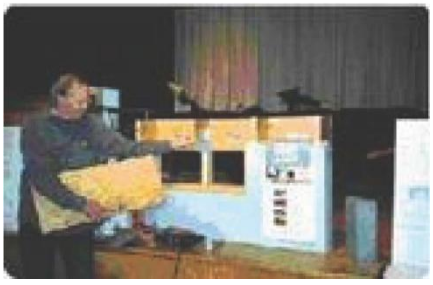
"There is so much more to this story. We are one of two families in this town to raise our house on the foundation. There is so much denial in this area. We have not faced major flooding since 1996, however the Lewis River jumped to flood stage today and the weather box we have lets us know about flood warnings and watches on a regular basis. I don't ever remember having to worry about flooding and now it seems to be with us all the time. Our flood insurance has been reduced to $300 for three years."

Cowlitz County, Washington

FEMA

Home Earthquake Retrofit Program Keeping Homes and Neighborhoods Secure





Seattle, WA – The Phinney Neighborhood Association (PNA) is a very proactive community group located in the City of Seattle. For many years the organization has sponsored programs and activities that have built a strong sense of community.

Following the Loma Prieta earthquake of 1989, program director Roger Faris and members of the PNA realized that the earthquake hazard they faced in Seattle was as great as that in California. They decided to incorporate an earthquake safety program into the existing Well Home Program. In 1998, the City of Seattle was selected as one of the sites to receive disaster mitigation funds under the Project Impact initiative. The funding was used to develop the "Home Retrofit Program," a comprehensive program to reinforce a typical Pacific Northwest home's ability to withstand earthquake movement.

Home Retrofit Program is a partnership between Seattle's Department of Design, Construction and Land Use, the University of Washington, PNA, Washington Mutual, Bank of America, and the Office of Housing. Each partner has contributed critical elements which make the program successful for the average homeowner. Specific items include plans for home retrofit projects; streamlined processes for obtaining building permits; professional training for builders and contractors; special retrofit loan products; grants for low-to moderate-income homeowners; and a tool lending library. The program is offered as a training workshop and scheduled through PNA.

A unique feature of the program is the tool lending library. "Half of doing any job well is having the right tool," states Faris. PNA members can borrow tools for a modest weekly tool maintenance fee, and in some cases, at no cost. Having the right tools readily available for homeowners' use provides additional incentive for retrofitting homes.

When the Nisqually Earthquake struck the Seattle area in February of 2001, the Phinney neighborhood experienced severe shaking. Following the quake, Faris received many phone calls from “graduates” stating how secure they felt because they had retrofitted their homes.

Previous earthquake damages have resulted in an average cost for home repair of $30,000, plus the cost of a licensed contractor at about $3,000. Homeowners' cost to do the work themselves averages $1,000.

Quick Facts

Sector:
Private

Cost:
$1,000.00 (Estimated)

Primary Activity/Project:
Retrofitting, Non-structural

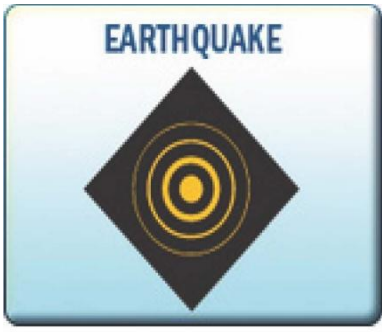
Primary Funding:
Homeowner

The Home Earthquake Retrofit Program offers the following benefits: safer homes to protect lives and property; lower repair costs; less damage to utility connections, which reduces fire hazard; availability of home retrofit loans; and an greater opportunity to obtain earthquake insurance.

King County, Washington

FEMA

Historic Home Retrofit Preventing Earthquake Damage



Poulsbo, WA - In late 1998, Doris Chapot purchased a two-story Cape Cod-style home built in 1902. For years it served as the First Lutheran Church parsonage. In 1940, the parsonage was moved to its present location. It was set on posts and concrete pier blocks, but nothing more was done to ensure its safety from earthquake damage.

At the time of purchase, a building inspector suggested that Chapot have an earthquake retrofit done to ensure positive connections among beams, posts, and pier blocks. Forty piers were braced with a gusset system that included a two-foot, triangle-shaped plywood tying the posts to the concrete pier. All of the posts around the perimeter were tied together in the front and the back with 2-foot by 6-foot posts, and nails were strategically placed. Because pier blocks were different shapes, bendable metal connections were used for attaching the posts.

The retrofit project was completed on February 26, 2001. On February 28, a large 6.8 magnitude earthquake, with the epicenter located in the Nisqually Basin in western Washington State, caused an estimated $2 billion in damages. Movement was felt as far north as Vancouver, British Columbia, and as far west as Salt Lake City, Utah. Chapot was on the second floor during the earthquake. "I've been through many earthquakes during my lifetime and the house rode beautifully." After a careful inspection under the house, no damage was detected. "Not one thing in the house fell or broke! It feels so good to be safe!"

Kitsap County, Washington

Quick Facts

Sector:
Private

Cost:
$3,312.00 (Actual)

Primary Activity/Project:
Retrofitting, Structural

Primary Funding:
Private funds

FEMA

Non-Structural Mitigation: Cost Effective Way of Preventing Damage

Olympia, WA - On February 28, 2001, Mrs. Mallinger was at home when she felt shaking and realized that there was an earthquake. During the two phases of the earthquake, books, glassware, CDs, pottery and some pictures fell. The power and water to her home did not shut down but the telephone was out of service. When Mrs. Mallinger was able to check her home more thoroughly, she found that the shaking had been severe enough to cause a ceiling light fixture in the garage to fall, and new cracks in the foundation.

The Mallingers water heater was several years old and needed to be replaced. During installation, earthquake strapping was recommended by the installer. The Mallingers agreed, and flexible gas lines were installed and metal strapping was used to secure the water heater to the wall studs.

Four years after the securing of the water heater, the Olympia area was shaken by a 6.8 magnitude earthquake. The shaking was severe enough at this house to cause items to fall from shelves, a ceiling light fixture to fall, and the foundation to crack. The simple preventative action taken to secure the water heater, at a cost of about $10, protected a home valued at $250,000 from fire. The Mallingers also have earthquake insurance.

Quick Facts

Sector:
Public

Cost:
$10.00 (Actual)

Primary Activity/Project:
Retrofitting, Non-structural

Primary Funding:
Private funds

Knowing that the water heater strapping prevented the chance of fire gave the Mallingers great peace of mind. As a result, they recommended to their neighborhood homeowners' association that all homes in the neighborhood secure their water heaters. This initiative will further protect the community and create a greater level of survivability in the event of future earthquakes.

Thurston County, Washington

FEMA

Boeing Retrofits Hardware Systems Safeguarding Against Earthquakes

Seattle, WA - Deep inside the earth's crust, pressures are building that eventually will result in an earthquake of epic proportions. Deep inside Boeing, a few good people are busily tying everything down. One of them, Doug Marsh, became a believer after the Kobe, Japan, earthquake in 1995. He vividly remembers seeing film footage of workers freezing at the onset of the tremors- only reacting as equipment started falling all around them.

Having been in the Northwest during the 1965 Seattle earthquake, Marsh knew that 30 years was long enough for most people to get pretty relaxed about a potentially large-scale earthquake. "When I started talking about seismic mitigation in 1999, most people treated the subject without any particular sense of urgency," he said. "To the company's credit, a disaster preparedness audit had just been completed that showed the need for more earthquake preparation."

Quick Facts

Sector:
Private

Cost:
$1,500,000.00 (Estimated)

Primary Activity/Project:
Retrofitting, Non-structural

Primary Funding:
Business Owner

Steve Guzek, senior manager of Computing Disaster Preparedness in SSG Information Technology Services, saw the connection to his then-new organization immediately. "After that audit, I became convinced that seismic mitigation was going to be a critical part of any serious company-wide disaster preparedness program," Guzek said. Guzek drew Marsh into his group. Marsh immediately began working with Boeing organizations to develop seismic mitigation plans for their computing assets.

Fortunately, by the time Seattle got it's rolling wake-up call in February 2001, Marsh and Davis had completed the installation of nearly 1,200 seismic isolation platforms and had made almost 1,000 machines virtually quakeproof. As a testament to their work, none of the machines that they retrofitted failed in the Nisqually shaker. Working with the vendors who make the server isolation hardware, Marsh helped develop a number of new methods for installation and upgrade that operators can perform while the server is online. In fact, the step-by-step processes that the Computing Disaster Preparedness group wrote to accompany them have become the industry standard for seismic mitigation procedures. "Boeing has become something of an industry bellwether in terms of seismic preparation," Guzek said. "But as we move further and further from the last significant quake, it is human nature to focus on other things. Organizations are less likely to put seismic preparation at the top of their 'to-do' list... "Until the ground moves again."

King County, Washington

FEMA

Businesses Increase Involvement in Earthquake Mitigation

The State of Washington - What do Starbucks Corporation, the Boeing Company, and the Friday Harbor Flower Shop have in common? All are businesses, all are located near Seattle, and all are taking an active role in keeping their employees safe and making their businesses more disaster resistant from earthquakes and other hazards.

The Cascadia Region Earthquake Workgroup (CREW) is a non-profit action group on a mission. In 1996, the scientific community established CREW to promote awareness of seismic risk among businesses and emergency managers. The Nisqually earthquake in February 2001 provided CREW and its partners with an important opportunity to assess lessons learned and to take additional steps to mitigate against damage from future earthquakes. Since the Nisqually earthquake, CREW has sponsored conferences and held forums to showcase both successes and failures during the Nisqually earthquake, and how to apply those lessons learned to a variety of other hazards, including man-made hazards.

Quick Facts

Sector:
Private

Cost:
Not Available

Primary Activity/Project:
Training

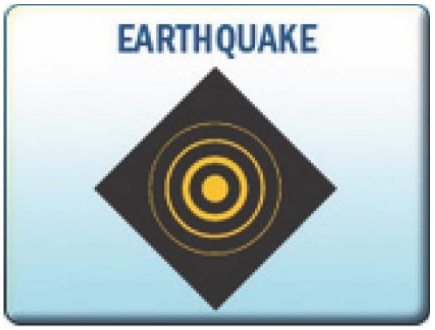
Primary Funding:
Non-Profit Organization

In April 2003, CREW will release a 20-minute video directed at small- and medium-sized businesses. Using the lessons learned from Nisqually, the message of the video is “protect your people, your buildings, and your business.” The video, which highlights the work of Starbucks, Boeing, and the Friday Harbor Flower Shop, will be distributed along with a tool kit developed in partnership with the Institute for Business and Home Safety. CREW also plans to meet with the Seattle Chamber of Commerce and other Chambers of Commerce to establish coordinating centers with businesses, and will continue to sponsor its series of business forums.

State-wide, Washington

FEMA

Police Department Seismic Retrofit: Strengthening a Critical Facility



Seattle, Washington - Early in the 1990s, the City of Seattle, Washington, decided to do an overall survey to determine the weaknesses and integrity of several older buildings. One of the worst identified was a police station that had been built in 1926, and purchased as is by the city in 1985 with an appraisal value of $2.3 million.

A project to strengthen and seismically retrofit the building began in August of 1995 and was completed in January of 1998. Capital Improvement funds paid for the approximate $957,000 retrofit program.

Diagonal bracing was done on the east and north walls of the basement and the first and second floor. One major brace was run through the middle of the building while extra members were strategically placed throughout each floor. Certain walls were reinforced with fiberglass and epoxy. In the basement, micro piles were driven into the footings, and additional diagonal and vertical braces were installed to carry the load should the building rock. Steel angles connected the floors and walls.

A new emergency generator system was installed using bolted footings with springs that allow for earthquake movement without disruption of service. Many member supports added additional strength to the eight bays of trusses lined in a series across the roof. Windows throughout the building were covered with safety film. "This was a difficult job that took over a year to complete," Robert Snyder, City Architect and Engineer for the project said. "The police department remained active throughout the retrofit."

The southwest corner of the building had always been a weak spot. When a 6.8 magnitude earthquake struck the Puget Sound Region of western Washington, the integrity of that corner, which is also an exit stairway, was seriously compromised. Temporary steel braces were added to secure the walls, as well as vertical reinforcements bolted through from the outside.

After the earthquake, no one throughout the police department experienced even non-structural damage. "Some phone books fell over, and some file drawers came open," was all one secretary could report. There were a few cracks in the safety covered windows, that would have shattered had the film not been applied. On the roof, the scupper shifted, causing leakage though the seams and into the interior of the building. The City of Seattle had the foresight to retrofit, save people from serious injury and possible death, and save the historic and valuable 75-year-old building from total destruction.

King County, Washington

Quick Facts

Sector:
Public

Cost:
$957,000.00 (Estimated)

Primary Activity/Project:
Retrofitting, Non-Structural

Primary Funding:
Local Sources

FEMA

Public School Retrofit Program Efforts Prompted By Parents and Staff

Lake Washington, WA - It was April 29, 1965, when the last major earthquake struck western Washington State. While aware of the possibility of another event, locals had been lax in their efforts to take action. With population growth over the years, and the building of more schools in the Lake Washington School District, parents and district staff members began vocalizing their concern about the risk of earthquake and what would happen to their children in such an event.

Quick Facts

Sector:
Public

Cost:
$6,000,000.00 (Estimated)

Primary Activity/Project:
Retrofitting, Non-structural

Primary Funding:
Local Sources

In early 1992, local engineers assessed the safety of the school buildings. Since schools did not have a lot of money, local funds would be used, and a plan was developed. The plan would determine the cost to complete structural and non-structural projects for seismic retrofit.

The school district including Kirkland, Redmond and parts of King County imposed a construction levy on the 1992 general election ballot to raise funds for seismic upgrades, a safety program, and also an Americans with Disabilities Act (ADA) program. A two year levy was initiated in 1996 and a four year levy in 1998 with total funds, for retrofit alone, in the amount of about $6 million. Structural and non-structural retrofitting has been done.

On February 28, 2001, mitigation and safety measures in the Lake Washington School District were tested when a strong 6.8 earthquake struck the Nisqually Basin and Puget Sound area of western Washington. Most of the schools in the district are built on a liquefaction zone which caused the ground to "roll like jelly," said Forrest Miller, Director of Support Services for the School System. "The buildings were all tested and nothing failed. The only thing that fell was one light fixture in the oldest building which was built in 1952."

There are several successes to this story. Mr. Miller stated he is "so impressed with the people in this district who got things done!" Because of their vision and perseverance, lives as well as millions of dollars were saved. Due to their on-going safety drills, the children and teachers were well trained, and were actually training the adults on what to do.

Custodians and other appropriate employees have received the Applied Technology Council (ATC) Training, which teaches rapid visual assessment of interior structures. Immediate inspection can be done after an incident, which, in this case was instrumental in allowing classes to resume with minimal loss of time. Teachers and other school employees were tested beforehand to determine responsibility during earthquake and fire drills so every student would be accounted for and in their pre-decided location.

The benefits are many. There are 25,000 students in the Lake Washington School District, which is the fifth largest in the state of Washington. There was no loss of life or injury, and 40 buildings in the district were saved by either new construction or seismic retrofit. To construct a new school building today would cost at least $36 million, and to find temporary housing for classrooms in case of damages would have cost thousands.

King County, Washington

FEMA

Water Storage Tank Seismic Retrofit

Mercer Island, WA - Mercer Island in Lake Washington is a busy community with a population of 22,000 and high median income. Located east of Seattle, it is accessed only by the Interstate 90 floating bridge. The islanders are totally dependent on two above-ground steel water reservoirs, four million gallon capacity each, as their main water source. This water supply is also essential for fire fighting.

The City of Mercer Island recognized that there was a potential life safety problem due to the fact that the island is in an earthquake hazard area. Should the tanks fail due to an earthquake, 12 homes, schools, a church and several public buildings situated downstream would be inundated. The Island would lose the primary water supply and the water flow would cover I-90, the main transportation corridor.

The City of Mercer Island applied for and was granted funding through the Hazard Mitigation Grant Program (HMGP) for seismic restraints and structural improvements of the reservoirs and pump station. The pump station pressurizes all the water through a system of pipes to deliver it to the upper end of the island. Because of this critical function, an automatic generator was installed and large pieces of equipment and cabinets were bracketed to the walls. The pump station was also completely structurally retrofitted. The project was completed in March 2000.

Quick Facts

Sector:
Public

Cost:
$1,386,281.00 (Actual)

Primary Activity/Project:
Retrofitting, Structural

Primary Funding:
Hazard Mitigation Grant Program (HMGP)

On February 28, 2001, a 6.8 magnitude earthquake struck the Puget Sound Region. Mercer Island sustained a great deal of shaking. Those located close to the reservoirs during the earthquake say that the water in the reservoirs "sloshed for an hour." The water tanks "rode" through the earthquake with minimal to no damage and performed the way the retrofit was designed. Power went out throughout the island but the automatic generator came on maintained the function of the pumps. Overall, the power was out for over six hours. Subsequent engineering inspection has determined that there is no threat of collapse. The timely mitigation project eliminated danger to the homes and structures as well as protecting the water supply. Minimally, the project saved over $9 million in home replacement costs.

King County, Washington

FEMA

Critical Waterline Seismic Retrofit Success

Lacey, WA - Holmes Island lies within the waters of beautiful Long Lake in western Washington State. Less than 30 homes are on the island, with only one road and bridge for access and one pipeline for its water source. That waterline follows along Holmes Island Road and across the bridge.

In the summer of 1995, a project was undertaken by the City of Lacey, Public Works Department. Approximately 200 feet of pipeline were replaced on each side of the bridge and across totaling 450 foot. Flexible joints were designed to rotate, extend, retract and twist. Connections were high density 8-inch sleeved polyethylene water main pipes that were run through 10 inch steel pipes for extra protection. The total cost for this project, funded through the Water Utility Funds for Capital Improvement, was $162,000.

In the event of an earthquake, these pipes move along with the bridge and avoid rupturing, which would cause loss of water to the island and thousands of dollars in repair. "It would cost $4,000 for one coupling alone," states Mark Russell, Design and Construction Manager for the City of Lacey, Public Works Department. "A temporary system would cost $15,000 to $20,000."

Quick Facts

Sector:
Public

Cost:
$162,000.00 (Actual)

Primary Activity/Project:
Retrofitting, Structural

Primary Funding:
Local Sources

The Holmes Island Bridge and waterline were tested on February 28, 2001, when a strong 6.8 earthquake struck the Puget Sound Region of Western Washington.

Approaches to the bridge slumped 6 to12 inches, and bridge supports were pulled away from the banks. The ground all along the road moved at least that much. The water main pipes dropped 8 inches. Because of the flexible expansion capability of the waterline under the road, no pipes were broken and water supply was never compromised.

The City of Lacey is currently seeking $50,000 in Federal funds to replace a portion of the waterline that is out of alignment from the earthquake. Had the city not planned ahead, they could have spent up to $20,000 for a temporary "fix" and still would have to spend the $162,000 or more dollars for a new pipeline. More importantly, the residents of Holmes Island did not lose their water source, and now have reassured confidence that their lives will not be compromised from loss of water.

Thurston County, Washington

FEMA

High Marks for Accuracy: Tracking Flood Levels in Lewis County

Quick Facts

Year: **2007**

Sector: **Public**

Cost: **Amount Not Available**

Primary Activity/Project:
Hazard Identification

Primary Funding:
Cooperative Technical Partners (CTP)

Lewis County, WA - Lewis County, Washington has a long history of damaging floods originating from three major rivers (the Chehalis, Cowlitz, and Nisqually) as well as numerous tributaries, including the Newaukum and Skookumchuck Rivers.

"Past floods have really taught us a lesson," said Martin Roy, a senior engineer and surveyor for the Lewis County Department of Public Works.

On December 1st, 2007 Lewis County was again inundated by a flood of record proportions. This time, the Chehalis River overflowed its banks and poured huge amounts of water into the streets and structures of several Lewis County communities. Water levels were recorded as high as nearly ten feet above the Chehalis' normal flood stage in some areas.

Having learned the lesson from delays in previous floods, Martin Roy and his team did not hesitate to act. "The flood occurred on a Monday," said Mr. Roy. "On Tuesday afternoon, as the water was still receding, we were out marking peak water elevations."

The procedure to capture water elevation data is initially simple. A series of points are marked throughout an impacted community. These can take the form of marks made on walls, nails driven into telephone poles, and other similar methods of indicating how high the water actually reached. At each point, a Global Positioning Satellite (GPS) reading is taken and a description of the area and marking is noted.

After durable markings are placed and catalogued, surveyors can return at a later date to determine the elevation of the high water marks using precise instruments.

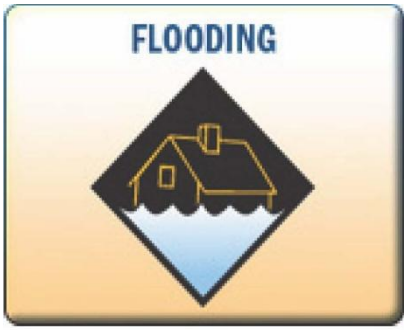
Previously, high water mark collection in Lewis County was funded by matching grants provided by the Washington Department of Ecology's Flood Control Assistance Account Program (FCAAP), resulting from a channel migration study. This year the Department of Ecology is assisting directly in the high water marks study with the contribution of equipment and personnel.

"We're teaming up with the Cities, the State's Department of Ecology, and the Federal Emergency Management Agency (FEMA) to complete the collection of elevations," said Matt Hyatt, Lewis County's Geographic Information System (GIS) Manager. "Our GIS Division is acting as the central location for collecting and distributing the maps and information that will aid in the planning effort. Once all the elevations have been surveyed by the different agencies, we'll compile them into a single map which will demonstrate the extent and depth of the inundation area, and assist analysis by the flood engineers and specialists to better understand the exact nature of this event."

Having such data improves the quality and accuracy of flood hazard mapping, flood insurance studies, and flood risk analysis. Greater detail in high water mark tracking assists in the approval and success of grant applications and helps with prioritization of elevation and acquisition projects.

FEMA

Water on the wrong side of the levee?



Snohomish County, WA - Severe flooding in western Washington State in early January 2009, brought on by heavy rainfall and warm temperatures that melted December's snow, posed the first test for the flood drainage gates installed 15 months earlier in the levee along the lower Stillaguamish River ("Old Stilly") south of Stanwood. The floodgates passed that test with "flying colors," according to Max Albert of the Stillaguamish Flood Control District (SFCD). Albert was referring to how quickly – in about half the time as during previous floods – that floodwaters trapped behind the levee drained through the gates and off Marine Drive and the Burlington Northern Santa Fe (BNSF) railroad tracks.

The Stillaguamish River floods approximately every three years, with overbank flows and extensive inundation of the floodplain. Floodwaters that overtop the north bank of the Stillaguamish below Silvana naturally flow northwesterly down the valley toward Stanwood. Historically, these floodwaters drained back to the river through Irvine Slough, a wide natural floodway and the shortest distance to saltwater. As development in Stanwood and the lower part of the river basin proceeded, however, obstructions to flow in this floodway reduced its capacity and the efficiency with which the slough could carry water back to the river. Millions of cubic feet of floodwaters, trapped between the north valley wall and the river levees, backed up the valley south of Stanwood. Water levels rose rapidly, commonly by more than three feet per hour, and after the flood crest the water drained out slowly over a period of several days.

The trapped floodwaters had several effects, ranging from inconvenience to costly damages, including extended closures of the BNSF railway line and Marine Drive, which is traveled by more than 5,000 vehicles each day; recurring damage and potential failure of city and SFCD levees; saturation of agricultural fields; stranding of salmon; and prolonged isolation of residents, posing risks to health and safety.

Quick Facts

Sector:
Public

Cost:
$155,000.00 (Estimated)

Primary Activity/Project:
Flood Control

Primary Funding:
Hazard Mitigation Grant Program (HMGP)

The SFCD, which maintains the levees and drainage systems in a 6,000-acre area of the lower valley between Silvana and Stanwood, was formed in 1992. In 2005, in an effort to eliminate or at least lessen the effects of future floods, the SFCD proposed construction of a flood drainage gate in the existing levee of the Stillaguamish River Old Channel near Stanwood. With a grant from the Federal Emergency Management Agency (FEMA), $30,000 from the City of Stanwood, and technical assistance from Snohomish County, the SFCD built the "Old Stilly Gate" in September 2007. The "gate" consists of a 130-foot-long concrete section, with 10, 5-foot by 10-foot, top-hinged hatches installed within the levee. A riprap (large angular rock) apron protects the levee bank on the discharge (river) side. The floodgate is self-actuating: If the water level behind the levee is higher than the river, the hatches open and water drains to the river. If the river is higher than the water behind the levee, the hatches close to prevent flooding from the river.

FEMA

Puyallup River Levee Rehabilitation Project

Pierce County, WA - Since the early 1900s, approximately 90 miles of levees have been built in the Puyallup River system, which includes the Puyallup, Carbon, and White Rivers. Levee construction began in the lower reach of the Puyallup River and progressed sporadically upstream, with the levees on the upper Puyallup and Carbon Rivers completed in the late 1950s.

Although the levees were built primarily to control inundation of agricultural fields, the flood protection afforded by the levees allowed human occupation and development of the floodplain. That protection was compromised over time, however, as maintenance lapsed and sections of the levees were damaged or destroyed by flooding and resulting erosion.

In 1996, a flood on the Puyallup damaged several homes along the river a few miles upstream from the city of Orting, damaged or destroyed several hundred feet of a levee, and threatened Orville Road, an important local roadway. That event triggered efforts by the U.S. Army Corps of Engineers (USACE), in close cooperation with Pierce County, the Washington Department of Fish and Wildlife (WDFW), and the Puyallup Tribal Nation to develop a plan to address the flood damages and lessen the risk of future damages along the river. The focus was the reach upstream from the city of Orting.

Quick Facts

Sector: **Public**

Cost: **Amount Not Available**

Primary Activity/Project:
Flood Control

Primary Funding:
Hazard Mitigation Grant Program (HMGP)

The plan proposed creating a system of new setback levees and bank protection measures. In 1997, 10,000 feet of new setback levee were constructed, 1,000 feet of existing levee were repaired, and 2,600 feet of the riverbank were “hardened” against erosion.

The acquisition of properties, removal or repair of old levees, and the construction of new levees was made possible by a combination of funding from several sources including the State’s Flood Control Assistance Account Program (FCAAP) and FEMA’s Hazard Mitigation Grant Program (HMGP). The work on the levees and floodplain restoration measures were funded by a special appropriation to the Corps’ Seattle District.

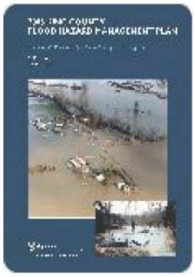
The presence of the original levees at the river’s edge resulted in the isolation of the floodplain from the main channel of the river. The erosion of parts of the levee system in the reach of the river upstream from Orting in the floods of 1996, and the removal of the remaining sections and of an old agricultural levee, restored the natural connection between river and floodplain.

The reconnection of the Puyallup River with about 125 acres of its natural floodplain had two positive consequences. First, it allowed the river more room to spread out and dissipate energy during future flood flows. Since completion of the project in 1997, the levees have worked as designed. In fact, during the floods 2003 and 2006, they greatly mitigated the flood impact to the area protected by the project.

The project also restored the access to salmon of approximately 2,000 feet of the channel of a tributary to the Puyallup, and within a few days of completion of the work, chum salmon were seen entering the small stream for the first time in many years.

FEMA

2006 King County Flood Hazard Management Plan



King County, WA - The State of Washington has considerable experience in dealing with disasters. The most frequently occurring and costly natural hazard in Washington is flooding. Like many Washington communities, King County is subject to a wide range of flood hazards.

With six major river systems traversing the region and many other bodies of water all subject to the random acts of nature, the residents of King County face the frequent risk of inundation from rising flood waters. In addition, many of King County's rivers and tributaries are subject to channel migration resulting in the potential for more damaging and dangerous flood events.

Recognizing the ever-present and changing hazards facing their residents, King County officials have taken significant steps to reduce the effects of flooding. In 1993, the County adopted a Flood Hazard Reduction Plan. That document was updated in 2006.

This pro-active planning effort has already helped King County. Looking at examples in the Cedar River, just one of the six major river basins, there are many mitigation projects, both completed and underway, that reduce future vulnerability. This river has sustained many flood events over the years. In response to this flooding, more than 65 flood protection facilities have been constructed in the basin since 1960. Most of these take the form of levees and revetments, yet few if any provide protection to a 100-year flood level.

Many of the proposed projects listed in the Cedar River section of the County's 2006 Plan specifically address the need for greater protection than what is currently provided by the many levees and other flood control structures that have been installed along the course of the river over time. Solutions are wide ranging – some take the form of buyouts, while others involve setting back the levees or removing them entirely.

According to the Plan, their presence causes an impediment to floodwater and natural floodplain processes throughout the reach, affecting both the adjacent public infrastructure and the local natural resources. The Plan calls for the additional acquisition of properties on both banks and moving the levees back from their present locations, consequently opening up the floodplain and allowing the river's natural processes to reestablish themselves.

Flooding in the November 2006 event had widely different effects in the numerous basins throughout King County. While the Snoqualmie River experienced the highest flood of record, Cedar River sustained only moderate flooding.

Quick Facts

Sector:
Public

Cost:
Amount Not Available

Primary Activity/Project:
Floodplain Management

Primary Funding:
State sources

For King County the outcome was clear: in areas where efforts have been taken to address and reduce flood risks, those actions have worked. Damage in King County during the November 2006 flood was minimized through ongoing implementation of the County's comprehensive flood plans.

Both the 1993 Flood Hazard Reduction Plan and the 2006 Flood Hazard Management Plan were funded, in part, through 50 percent cost share grants from the Washington Department of Ecology's Flood Control Assistance Account Program (FCAAP). In developing the 2006 update, the County utilized its own staff and resources as well as a thorough public participation process.

FEMA

Low Impact Development for Flood Control

Seattle, WA - The 2nd Avenue Street Edge Alternative (SEA) Street project was a pilot project undertaken by Seattle Public Utilities to redesign an entire 660-foot block with a number of Low Impact Development (LID) techniques. The goals were to reduce stormwater runoff and to provide a more "livable" community.

Throughout the design and construction process, Seattle Public Utilities worked collaboratively with street residents to develop the final street design. The design reduced imperviousness, included retrofits of bioswales (landscape elements intended to remove silt and pollution from surface runoff water) to treat and manage stormwater, and added 100 evergreen trees and 1,100 shrubs.

Conventional curbs and gutters were replaced with bioswales in the rights-of-way on both sides of the street, and the street width was reduced from 25 feet to 14 feet. The final constructed design reduced imperviousness, or resistance, by more than 18 percent.

The costs for the LID retrofit were compared with the estimated costs of a conventional street retrofit. Managing stormwater with LID techniques resulted in a cost savings of 29 percent. Also, the reduction in street width and sidewalks reduced paving costs by 49 percent.

For this site, the environmental performance has been even more significant than the cost savings. Hydrologic monitoring of the project indicates a 99 percent reduction in total potential surface runoff, and runoff has not been recorded at the site since December 2002, a period that included the highest-ever 24-hour recorded rainfall at Seattle-Tacoma Airport. The site is retaining more than the original design estimate of 0.75 inch of rain.

King County, Washington

Quick Facts

Sector:
Public

Cost:
Amount Not Available

Primary Activity/Project:
Flood Control

Primary Funding:
Local sources

FEMA

Moo-ving On Up: Critter Pads Keep Farm Animals Safe From Floods

Duvall, WA - When flood impacts a farm community, there are many challenges and complications. Not only must residents get themselves out of harm's way, but they also must protect their livestock, secure farm equipment and supplies, and deal with many other issues.

Jason Roetcisoender's family has owned their 120-acre farm in Duvall, Washington since the 1920s. Throughout that time, there have been numerous floods that have impacted their home and property. In a flood in 1975, while the farm was run by Jason's father, they lost 32 cows. In Duvall's flood-of-record in 1990, the family lost 120 animals to high water.

"After the flood in 1990, Washington State and King County approved emergency permitting for the installation of critter pads," said Mr. Roetcisoender. "The local farmers, including my father, went to them to try to find a solution to the flooding, and that was one of the remedies they came up with."

A critter pad, or livestock flood sanctuary mound, is an area where approved fill material is used to raise the ground above the Base Flood Elevation (BFE). When flooding occurs, farmers move their livestock onto the pads to keep the animals out of the water's reach. Critter pads require special permitting and must be specifically designed to ensure they have a negligible impact on the floodplain. They also may not be built within the boundaries of a river's floodway.

Since the Roetcisoenders completed their critter pad in 1991, they have had to use it on three occasions, including the November flood of 2006. In that November 2006 incident, Mr. Roetcisoender was able to move over 300 head of cattle onto the pad and keep them safe. They also filled two of the family's trucks with feed and drove them up onto the pad to be safe and easily accessible.

Quick Facts

Sector:
Private

Cost:
Amount Not Available

Primary Activity/Project:
Elevation, Structural

Primary Funding:
Homeowner

In the nearby Town of Carnation, Michelle Blakely has a 33-acre farm where she grows organic vegetables and fruits, and raises chickens, cows, pigs, and turkeys. When they purchased the farm two years ago, a critter pad was already in place, built by the previous owner. According to Mrs. Blakely, the pad was part of the incentive to acquire the land.

Unfortunately, in 2006, when the waters rose during the November flood, despite being above the BFE, it turned out the pad was not high enough. Upon returning to their home following a mandatory evacuation, the Blakelys found that all their chickens and turkeys were gone.

The Blakelys suffered significant financial damage to their farm from the 2006 flood, a good portion of it in poultry losses. Not wanting to go through this again, they decided to raise the critter pad even higher. They purchased permitted fill, rented a bulldozer, and raised the pad almost three feet.

When the floodwaters came again in December of 2007, the Blakelys felt they were ready. Working fast, the Blakelys managed to relocate their birds from coops on different areas of their property to the elevated pad, even as rising waters surrounded them. If the chickens and turkeys had not been moved to the critter pad, they would have been lost. This time, the Blakelys managed to save almost 1,500 birds from floodwaters.

National Fire Plan Success Story

Two Lakes Fuels Reduction Project
Tonasket Ranger District, Okanogan-Wenatchee Forest
National Fire Plan - Fuels Reduction 2008

The Two Lakes Fuels Reduction Project was the first planning completed on the Tonasket Ranger District, Okanogan-Wenatchee National Forests under the Healthy Forest Restoration Act. Two Lakes is located near Lost and Bonaparte Lakes, about 18 miles east of Tonasket, Washington. Adjacent to a roadless area, it is a heavily used recreation area featuring: two major lakes, two campgrounds, three organization camps, a group of summer residences, a resort located on Washington State land, and three housing developments on private land. Interagency and community involvement were key to the progress of this project. Special use permit holders, community members, and interest groups actively collaborated in the development of the Two Lakes Project. Following no objections, the project is now being implemented.

Representatives of Boy Scouts of America joined District employees to assist with fuels treatment.

The project will reduce hazardous fuels in the wildland urban interface around Lost and Bonaparte Lakes. The forest consists of large dry ponderosa pines, western larch, and Douglas fir with many small trees encroaching. These small, overcrowded trees are competing for nutrients, water, and sunlight, weakening them and making the trees more susceptible to insects or disease. The dense forests are a significant fire hazard, threatening the general area, and the larger trees.

The fuels treatments in Two Lakes are intended to provide additional defensible spaces around the recreation and residential areas as identified in the 2004 Havillah Community Wildfire Protection Plan. Treatment includes approximately 2,500 acres of commercially thinned trees, producing 7.94 million board feet of timber; 3,600 acres of ladder fuels treatment and thinning, and approximately 3,600 acres of treatment using prescribed fire.

"This collaborative project has helped restore healthy ecosystem functions while reducing the threat from wildland fire and building upon positive interactions with community members," said District Ranger Mark Morris.

Forest Service interpreters are working closely with the Tonasket Kiwanis Club to develop an interpretive sign near their youth camp, Camp Tokawani, explaining the Two Lakes project. In addition, showing their appreciation, the Boy Scouts camp on Bonaparte Lake recently sent a thank you letter to the Forest Supervisor stating their gratitude for the wildfire risk reduction, and for the collaborative process used.

Contact: Mark Morris, Tonasket District Ranger, Okanogan-Wenatchee National Forest; (509) 486-5110, msmorris@fs.fed.us. NOTE: This article was taken from the following website: www.forestsandrangelands.gov/success/stories/2008/nfp_2008_wa_fs_trd_ownf_fuelsreduction.shtml

HAZUS User of the Year!

2009 2nd Quarter

Congratulations to Cathy Walker, the 2009 2nd Quarter HAZUS User of the Year. Walker is a GIS analyst at the State of Washington Military Department, Information Technology (IT) Division, Geographic Information Systems (GIS) Section. She has been a HAZUS-MH user and champion for many years and recently assumed leadership of the Washington HAZUS User Group (WAHUG). Her involvement has helped jump-start the WAHUG and brought new excitement and enthusiasm into the group.

Since working with the Washington Emergency Management Division and now for the IT Division of the Washington Military Department, Walker has had the opportunity to conduct HAZUS-MH analysis for both the flood and earthquake hazards. The reports generated from these HAZUS-MH analyses have been used at other state agencies within the state of Washington to determine the risk and vulnerability of buildings considered critical to the operation of these agencies. In addition, Walker has had the opportunity to provide HAZUS-MH analysis in support of the Regional Catastrophic Planning Team efforts currently in progress for the Puget Sound region. Walker has a certificate in GIS and Spatial Modeling from the University of Washington-Tacoma and is pursuing a Master of Science degree in Geographic Information Science from the University of Denver.

Walker conducted outreach for the last year in the state of Washington to those potentially interested in using HAZUS-MH to perform risk analysis and vulnerability assessments as part of their local disaster preparedness planning. Walker has organized these current and potential HAZUS-MH users, created outreach materials, arranged resources at the state level, and conducted meetings to renew interest in expanding the use of HAZUS-MH in the state of Washington. In addition, the increased concern for flooding in western portions of the state has increased the demand for HAZUS-MH risk and vulnerability assessments.

The WAHUG is interested in HAZUS-MH training and collaborations between public and private entities. Walker hopes to participate in the HAZUS-MH Train the Trainer Program in the coming years as a way to meet the needs of the WAHUG. Walker's long-range goals for the WAHUG include bringing speakers and HAZUS-MH experts to WAHUG meetings and continuing to provide technical support to HAZUS-MH users via on-site visits and by telephone. Walker plans to hold WAHUG meetings bi-monthly and looks forward to offering formal and informal training sessions at these meetings.

Cathy Walker's motivation and enthusiasm for HAZUS-MH and her leadership of the Washington HAZUS User Group make her an outstanding HAZUS-MH champion. FEMA is proud to recognize Cathy Walker as the 2009 2nd Quarter HAZUS User of the Year.

Congratulations!

FEMA

Washington State Department of Transportation

January 2010

WSDOT's Unstable Slope Management Program

The Problem

The Washington State Department of Transportation manages 7,048 miles of highway facilities that traverse widely varying terrains with complex geologic landforms. Unstable slopes, which include landslides, rock falls, and debris flows of all sizes, can impact highways when they fail. Failure of unstable slopes poses a potential safety risk to the traveling public and adversely affects regional commerce when resulting highway closures occur.

Washington State Department of Transportation • WSDOT's Unstable Slope Management Program

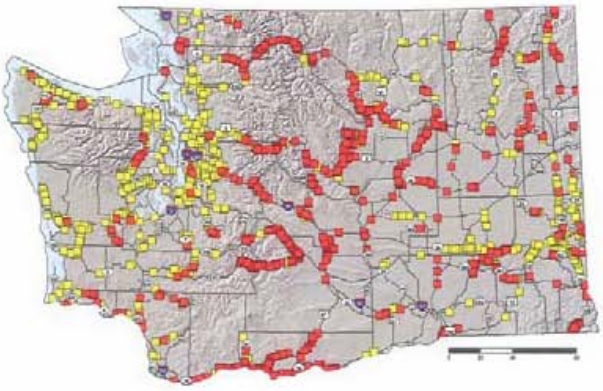
WSDOT's Unstable Slope Management Program

How We Manage Unstable Slopes

Prior to 1995, unstable slopes were stabilized reactively after they had failed. To address unstable slope issues with a proactive approach, a budget category in the Highway Preservation Program for Unstable Slopes was established in 1995. The target investment level for this category in the highway system was estimated at approximately $300 million over 10 biennia. WSDOT developed the Unstable Slope Management System (USMS) to provide a methodology to rationally evaluate known unstable slopes within the WSDOT highway system. The method focuses on balancing hazard and risk in prioritizing slopes for the allocation of funds for proactive stabilization efforts.

WSDOT regional offices in collaboration with Headquarters Geotechnical Division did the initial identification of unstable slopes. This resulted in a baseline inventory of over 2,500 sites. These known slopes are scored using a numerical rating system based on eleven criteria that identify the hazard and measure the potential risk factors to the highway facility if a slope fails. Based on the numerical rating system, a site may have a score ranging from 33 (lowest) to 891 (highest), with higher numbers representing a greater risk to the highway facility at that location. Table 1 identifies the rating factors. Since the inception of the USMS, the number of slopes in the inventory has increased to about 3,100. Detailed numerical ratings have been completed for almost all known unstable slopes statewide. Figure 1 identifies unstable slopes along state routes in Washington State.

Figure 1: Unstable Slopes along State Routes in Washington State



Data Source: Unstable Slope Management System (USMS)
Date: 11/23/2005

The next part of the process is for geotechnical specialists with expertise in slope stability to provide a description of the slope stability problem and to develop conceptual slope mitigation designs and cost estimates. A simple benefit-cost analysis compares the cost of a 24-hour traffic delay and the maintenance costs over twenty years to the costs to mitigate the slope hazard. Based on this approximate benefit-cost comparison, sites with a ratio of 1 or greater are placed on a prioritized list of slopes to be programmed for remediation. Currently, WSDOT prioritizes and programs remediation for unstable slopes that have a numerical rating of 350 or greater along interstate highways, principal arterials, and other highway facilities with traffic volumes of 5,000 vehicles a day or greater, and a benefit-cost ratio of 1.0 or greater. Conceptual designs and cost estimates have been completed on 433 moderate to high-hazard unstable slopes as part of the ongoing prioritization process. Figure 2 identifies mitigated slopes along state routes in Washington State.

Processes Leading to Slope Instability

Slope instability is a category of natural hazard that refers to the movement of a soil or rock mass under the influence of gravity. Rock falls occur on both natural and excavated slopes. Causes of rock falls include a combination of natural processes and man-made influences, acting singly or in combination, to dislodge discrete blocks of rock. Usually planes of weakness termed "discontinuities" physically divide the rock mass into an assemblage of blocks.

Landslides are a category of natural hazards that involve the down slope movement of soil materials under the influence of gravity. Soil slope failures generally fall into two categories: 1) deep seated rotational failures or translational slides and 2) shallower debris flows and slides. Generally, rotational-type slope failures occur more slowly than debris flows and slides, which can occur rapidly. Landslide mechanisms involve either an increase in driving forces or a reduction of resisting forces (i.e., increased water pressure or loss of shear strength of the soil).

Distinction between Hazard and Risk

It is important to understand the terms "*hazard*" and "*risk*". Rock fall or soil slope failures are geologic processes categorized as natural hazards. These natural processes include landslides, debris avalanches, slope creep, soil piping, snow avalanches and so on. These events occur in nature and have done so since the geologic evolution of landforms began. In some cases, the activities of humans can influence the occurrence of natural hazard events. A reference to a high hazard means that there is a high likelihood an event will occur.

Risk refers to the consequences of a natural hazard event if it occurs. It is easy to envision an event that has absolutely no consequence in terms of human activity, for example a snow avalanche in the remote mountains. The same natural hazard perched above a ski resort would represent a significant risk.

The hazards that most interest WSDOT are those that have both a high likelihood of occurrence and a high likelihood of causing damage, injuries, death or severe economic impacts. Applied to highway slopes, it is necessary to assess both the degree of hazard in terms of the rock or soil becoming dislodged from the slope and the potential damage (risk) it could inflict based on its energy, probable trajectory and the likelihood of something vulnerable being in its path.

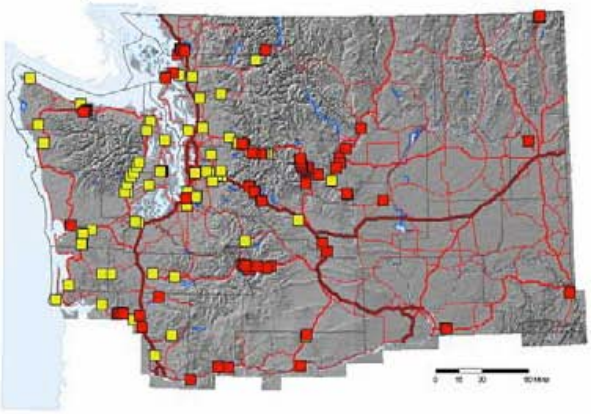
WSDOT's Unstable Slope Management Program

Table 1: USMS Rating Criteria

Category	Points = 3	Points = 9	Points = 27	Points = 81
Problem Type: Soil	Cut or Fill slope erosion	Settlement or piping	Slow moving landslides	Rapid landslides or debris flow
Problem Type: Rock	Minor rockfall Good catchment	Moderate rockfall Fair catchment	Major rockfall Limited catchment	Major rockfall No catchment
Average Daily Traffic	< 5,000	5,000 to 20,000	20,000 to 40,000	> 40,000
Decision Sight Distance	Adequate sight distance	Moderate sight distance	Limited sight distance	Very limited sight distance
Impact of Failure on Roadway	< 50 Feet	50 to 200 Feet	200 to 500 Feet	> 500 Feet
Roadway Impedence	Shoulder only	1/2 Roadway	3/4 Roadway	Full Roadway
Average Vehicle Risk	< 25% of the time	25% to 50% of the time	50% to 75% of the time	> 75% of the time
Pavement Damage	Minor - not noticeable	Moderate - driver must slow	Severe - driver must stop	Extreme - not traversable
Failure Frequency	No failures in last 5 years	One failure in last 5 years	One failure each year	More than one failure
Annual Maintenance Costs	< $5,000 per year	$5,000 to $10,000 per year	$10,000 to $50,000 per year	> $50,000 per year
Economic Factor	No detours required	Short detours < 3 Miles	Long detours > 3 Miles	Sole access - no detours
Accidents in Last 10 Years	0 to 1	2 to 3	4 to 5	> 5

WSDOT's Unstable Slope management program is a proactive, infrastructure- preservation program that seeks to cost-effectively reduce the risk of moderate- to high-hazard unstable slopes from adversely impacting our highest priority state highway facilities. The mitigation objective is to achieve long-term risk reduction. Therefore, the mitigation must either be a permanent solution or provide a reasonable performance life (>20 years).

Figure 2: Mitigated Slopes along State Routes in Washington State



Mitigated Rockfall Mitigated Landslide/Debris Flows

Data Source: Unstable Slope Management System (USMS)
Date: 12/08/2009

Under the existing USMS procedures, a slope that qualifies for stabilization receives a comprehensive (i.e., 20-year design life) treatment. In other words, stabilization is all or nothing at a given site. In some cases, a minimal amount of slope treatment can remediate a large component of the risk at a given site, for example, hand scaling of a rock slope. As part of the program WSDOT has also developed a risk reduction strategy that complements the current full slope stabilization program. On an annual basis WSDOT Geotechnical Division and regional personnel jointly determine the sites that will be included in this risk reduction strategy. An allocation of $1.5 million has been made available for risk reduction for each biennium beginning in 2007. This is in addition to the $20 million earmarked each biennium for programmed sites on the comprehensive slopes stabilization program.

Managing Risk

Between 1995 and 2009, WSDOT spent approximately $165 million on stabilizing more than 83 moderate to high-hazard programmed unstable slopes. In addition, the department spent another $208 million on unforeseen emergency slope corrections, for a total investment in unstable slopes of $26.6 million per year.

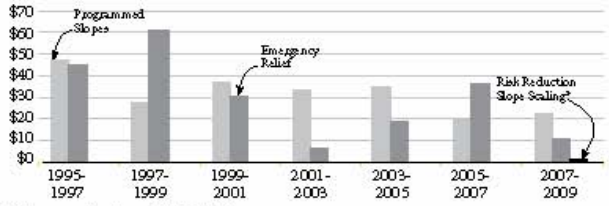
The Department's funding of non-dedicated dollars for the Highway Construction Program has decreased from approximately $1400 million in 2001-2003 to $650 million in 2009-2011. This reduction in non-dedicated State and Federal funds has made it essential for WSDOT to evaluate the performance of its highway system and determine how that performance will change in the future as a result of different investment alternatives.

In 2004, the Department began evaluating how the highway system was performing and developed a 10-year Asset Management Plan to identify the investment levels necessary for building the 2005-2007 Highway Preservation Program. At that time, the Department estimated that it would take an additional $100 million over the next 10 years to retrofit the currently identified high- and moderate-risk slopes. The evaluation recognized that emergency work, including slope failures, would probably continue, and WSDOT has set aside state funding to match federal emergency relief dollars and state declared emergencies. These funds are in addition to the $100 million for the planned unstable slope retrofit work.

Figure 3 shows the dollars spent on programmed and emergency unstable slopes projects from 1995 to 2009.

Figure 3: Unstable Slopes Projects - Actual Expenditures Emergency Relief vs. Programmed Project

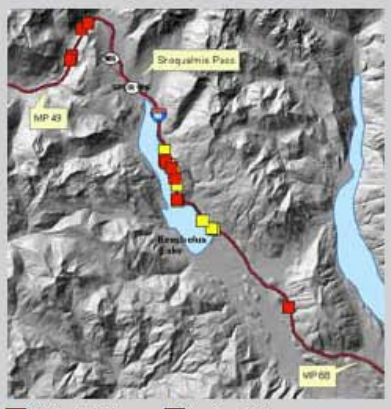
Dollars in thousands



* New program implemented in 2007-2009
Source: WSDOT Capital Program Development and Management

WSDOT's Unstable Slope Management Program

I-90 Snoqualmie Pass Corridor – Milepost 49 to Milepost 68



Mitigated Slopes Deferred Slopes

Map Source: Unstable Slope Management System (USMS)
Date: 12/04/2009

Scaling at Snoqualmie Pass.

Snoqualmie Pass.

Interstate 90, a multi-lane facility between MP 49 and MP 68, carries 30,500 vehicles per day across Snoqualmie Pass. It is the most heavily used east-west crossing of the Cascade Mountains, serving large volumes of recreational, business and freight traffic. Over 25% of the traffic is trucks bound for local, national and international markets.

The highway passes through widely varying geology and mountainous terrain requiring highway cuts in bedrock, some approaching 100 feet in height. The exposed geology has naturally occurring planes of weaknesses that often create a potential risk of rockslides and rockfalls. In the 1960s and 1970s, wide ditch catchments and concrete barriers were typically employed to minimize the risk of rockfall reaching the traveled lanes.

Ongoing unstable slope scoping work conducted by WSDOT's Geotechnical Division, including a 2006 reassessment of unstable slopes in the corridor, has identified 19 high priority unstable slopes along this portion of I-90. Seventeen of these unstable slopes are rockfall areas, one is a landslide area and one is a settlement area.

Of these identified high priority unstable slopes 11 have been mitigated since 1995. Mitigation has included the removal of approximately 75,000 cubic yards of loose unstable rock from the slopes, the installation of approximately 14,000 linear feet of rock bolts and rock dowels, and the installation of approximately 224,000 square feet of wire mesh and cable net slope protection. The total project cost for this rock slope stabilization work was $10.6 million.

A major highway improvement project planned for I-90 east of the Snoqualmie Pass summit in the late 1990s caused WSDOT to defer eight of the high priority slopes located between MP 49 and MP 68 from active consideration for mitigation in the Unstable Slopes Preservation Sub-program (P3). The proposed improvement project *I-90 Snoqualmie Pass East* will either stabilize these unstable slopes or realign the highway away from these hazards. In 2005, the legislature provided major funding for construction of two phases of the project. These reconstruction projects, *Hyak Snowshed Vicinity* and *Snowshed to Keechelus Dam* between MP 55 and MP 60 will stabilize existing rock cuts and landslides in conjunction with highway widening and realignment work to reduce the hazards associated with the deferred unstable slopes. These projects will begin construction in the spring of 2010 and 2011, respectively.

Risk Reduction Rock Slope Scaling

In 2007, WSDOT initiated the Risk Reduction Rock Slope Scaling Program. The intent of this program is to reduce risk of rockfall along state highways. Risk reduction rock slope scaling entails the removal of loose unstable rock from a rock slope with the use of hand tools, such as scaling bars, hydraulic wedges, air pillows and in some cases with the use of mechanical equipment. These techniques can significantly reduce the likelihood of rockfall from reaching the highway where geologic site conditions make this type of work feasible.

The WSDOT Geotechnical Division works directly with the Region Maintenance and Materials Engineer's offices to identify the locations of rock slopes where risk reduction scaling would be beneficial. Typically these slopes have chronic rockfall problems with rocks reaching the highway numerous times during the year

Scaling.

WSDOT's Unstable Slope Management Program

US 12 MP 146.

US Highway 12 – Milepost 138 to 167

Over White Pass US 12 is a two-lane principal arterial, one of three year-round passes that cross the Cascade Mountains. The narrow highway crosses below steep rock slopes and has long sections with limited site distance. Existing ditch and shoulder widths are limited in width and provide very limited catchment for rockfall. The highway carries an average of 3,240 vehicles per day, with trucks comprising approximately 27%.

Because of the large number of problematic rockfall areas located along the White Pass corridor, a focused rockfall corridor study was completed in 2003. The work entailed a check of the numerical rating for each slope, a detailed description of the slope instability/failure mechanism, a conceptual stabilization design and estimated quantities, and a cost estimate to mitigate the slope. WSDOT maintenance personnel provided information on frequency and size of rockfall or landslide events. Benefit-cost analyses were completed for each of these slopes to determine if they were cost effective to mitigate. As a result of this study, 153 unstable slopes have been identified and numerically rated along this corridor. Of these, 36 unstable slopes were identified as high risk slopes with a chronic history of rockfall, and two soil slopes were identified as having a high risk of landslide/debris flow activity.

Mitigated Slopes

Map Source: Unstable Slope Management System (USMS)
Date: 12/03/2009

Of the 38 identified high risk unstable slopes, 23 have been mitigated to date. These unstable slope mitigation projects included removal of approximately 19,600 cubic yards of loose unstable rock, installation of 7,000 linear feet of rock bolts and rock dowels for rockslope reinforcement, and installation of 257,000 square feet of wire mesh and cable net slope protection. The total project cost for this rock slope stabilization work was $9.1 million. Additional slope stabilization work is planned to address the remaining high risk unstable slopes. This stabilization work, which removes loose unstable material and prevents rockfall from reaching the highway, has significantly reduced the risk of highway closures and has improved safety for the traveling public.

and requiring multiple maintenance callouts to clear the highway of rockfall debris. These efforts have resulted in an extensive statewide list of candidate rock slopes that would benefit from rock slope scaling.

WSDOT engineering geologists assess the site conditions at each of the candidate slopes and determine the feasibility of rock slope scaling and whether or not rock slope scaling can effectively reduce the rockfall risk. These slopes are then rated utilizing a simple rating system based on eight criteria as shown in Table 2. The resulting total score is used to prioritize slopes for risk reduction scaling.

Table 2: Risk Reduction Rating Criteria

Category	Points = 3	Points = 9	Points = 27	Points = 81
Slope Height	< 25 ft.	25 to 50 ft.	50 to 75 ft.	> 75 ft.
Ditch Effectiveness	Good catchment	Moderate catchment	Limited catchment	No catchment
Total Roadway Width	< 40 ft.	32 ft.	24 ft.	< 24 ft.
Rockfall History	Few falls	Occasional falls	Many falls	Constant falls
Number of Maintenance Calls per Year	< 1	1 to 3	4 to 5	> 5
Rockfall Block Size	< 1 ft.	1 to 2 ft.	2 to 3 ft.	> 3 ft.
Volume of Rockfall per Year	< 3 cyd.	3 to cyd.	6 to 10 cyd.	> 10 cyd.
Average Daily Traffic	< 500	500 to 2,750	2,751-5,000	> 5,000

During the 2007-2009 biennium, 31 high priority rock slopes were identified as candidates for risk reduction scaling. Based on a biennial budget of $1.5 million, eight slopes on SR 2, 7, 20, 21, and 261 have been successfully scaled. An additional 44 slopes have been identified across the state and another $1.5 million has been allocated for risk reduction rock slope scaling in the 2009-2011 biennium.

Scaling.

WSDOT's Unstable Slope Management Program

Tumwater Canyon.

Tumwater Canyon Rock Slopes Stabilization

US Highway 2, between MP 90.5 and MP 99, is in a narrow, steep-sided river valley known as Tumwater Canyon. Traffic volumes in the canyon average approximately 5,000 vehicles per day, with trucks comprising 15% of that volume. Rockfall-related incidents along this section of highway have been a significant concern because of the unfavorable geology, limited sight distance on the tight curves, very narrow shoulders and limited ditch capacity for rockfall catchment.

As part of the P3 Unstable Slope Program engineering geologists with the Geotechnical Division worked with Regional Maintenance staff to identify 14 unstable slopes where the risk of rockfall was high and the potential impacts from a rockslope failure could be significant. Conceptual designs were developed to mitigate these rockslopes. Rockslope mitigation included the use of scaling, rock dowels, rock bolts, fiber-reinforced shotcrete, wire mesh and cable nets. Project costs were prepared by the region and the slopes were prioritized for mitigation based on the calculated benefit/cost ratios.

The six highest priority slopes were programmed for mitigation beginning in 1995. These slope mitigation projects removed approximately 99,000 cubic yards of loose unstable rock from the slopes, installed 6,000 linear feet of rock bolts and dowels for rockslope reinforcement, and installed 99,000 square feet of wire mesh and cable net slope protection. The total project cost for this rockslope stabilization work was $1.9 million.

Mitigated Slopes

Map Source: Unstable Slope Management System (USMS)
Date: 12/04/2009

These slope mitigation projects have had a significant impact by reducing the number of rockfall related incidents in this corridor by approximately 80%. Two additional unstable slope projects in the canyon are currently in the final design phase and the slopes are scheduled for mitigation in 2010-11.

Midway Curve MP 65.

Midway Curves I-90 Project

Three unstable rock slopes, at approximately MP 66 in the Midway Curve area near Easton were identified for mitigation in the January 2006 I-90 unstable slope reassessment report to Governor Gregoire, following two major rockslides on Snoqualmie Pass in the fall of 2005. The bedrock exposed in the three existing cut slopes was highly fractured with large overhangs, and contained wide differentially weathered fault zones, and structurally controlled wedge blocks that dipped unfavorably toward the highway.

Rockzilla at work.

The western and middle rock slopes, which exceed 100 feet in height, were mitigated by extensive mechanical and hand scaling of approximately 45,000 cubic yards of loose unstable rock from the slopes, installing approximately 5,000 linear feet of tensioned rock bolts and untensioned rock dowels, and draping the slopes with approximately 141,000 square feet of wire mesh and cable net slope protection. The eastern slope was mitigated by flattening the slope, excavating a wider ditch and constructing a low concrete barrier wall. The total project cost for this rock slope stabilization work was approximately $6.6 million.

Three factors enabled the Department to successfully complete the $5 million unstable slope mitigation project in a single construction season in time for the winter travel season. They used digital imaging technology to accurately map and characterize the rock slopes under winter conditions, construction of a Mechanically Stabilized Earth wall to create a temporary detour during construction enabling crews to work with minimal traffic disruption, and large-volume mechanical scaling to remove loose rocks quickly and safely.

The American Council of Engineering Companies presented WSDOT and their consultants the Gold Award for "Social, Economic, and Sustainable Design Considerations" and the Silver Award for "Originality or Innovative Application of New or Existing Techniques" for the I-90 Snoqualmie Pass MP 66 rock slope mitigation project.

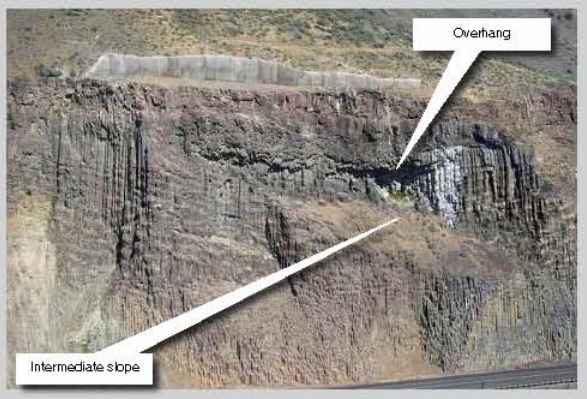
WSDOT's Unstable Slope Management Program

SR 28 Rock Island Slope Stabilization

This rockfall site near Wenatchee is located along SR 28, just south of Rock Island Dam between MP 11.83 and MP 11.96. The two lane highway and a heavily used rail line are situated between a high basalt cliff and the Columbia River. The near vertical, 300-foot high unstable slope has an irregular slope configuration. It has an overhang with a moderately sloping intermediate bench approximately 130 feet above the highway. The average daily traffic through this section of highway is approximately 7,600 vehicles, 18% of which are trucks. WSDOT Maintenance personnel reported that three to four rockfall events occur every year, involving blocks 1 to 2 feet in size that reach the highway shoulders and travelled lanes, with smaller sized rockfall occurring more frequently.

The slope stabilization project removed 3,100 cubic yards of loose unstable rock from the slope. This was accomplished by the use of pry bars, pneumatic pillows, and hydraulic jacks operated by workers suspended from climbing ropes. Approximately 225,000 square feet of ring nets and wire mesh slope protection were draped on the slope to catch and contain rockfall so it would not enter the highway. The ring nets and wire mesh were lifted into place by a crane working from an upslope bench and the highway. The ring nets and wire mesh slope protection panels were seamed together by workmen suspended from climbing ropes.

The project provided WSDOT the opportunity to compare the attributes and performance of ring nets to more commonly used cable nets. WSDOT was able to secure Federal Experimental Feature status and funding for the project. Performance of the ring nets will be evaluated annually for the next five years. The final cost of the completed unstable slope mitigation project was approximately $3.89 million.



Solutions to Meet the Current Need to Reduce Public Risk

Present funding is for $25 million per biennium (projected to 2015) for planned work in the unstable slope management program. In preparing for the biennial budget development process, the Department reviews its current Asset Management Plan for unstable slope needs, adjusting it for the accomplishments of the past two years, adding any new needs, and evaluating the benefits of accelerating the rate at which unstable slope risks are addressed.

Some factors in this evaluation are the hardships for the public with travel delays, detours, and potential affect to local businesses, and the availability of having qualified contractors and workers to perform the work. WSDOT has identified the projects for the 09-11 biennium, and has developed the preliminary program through the 11-15 biennium. There will be continued scoping to identify needs and projects for the future biennia.

Future Needs

The Department has successfully mitigated over 228 high-risk unstable slopes over the last 15 years. However, more work remains to be done. Our goal is to mitigate all identified high and moderate risk unstable slopes on interstate highways, principal arterials and other roadways with moderate to high traffic volumes by 2020. At the same time, the Department will continue to conduct rock slope scaling as an interim measure on highway corridors with a high incidence of rockfall.

Geotechnical analysis and design of mitigation measures for 35 more high-risk unstable slopes is currently underway. Preliminary engineering to develop conceptual mitigation proposals and cost estimates for 64 moderate-risk slopes was begun in 2009. Additional engineering work to refine mitigation designs and improve cost estimates for theses unstable slopes is needed to ensure that we can continue to manage risk through an aggressive construction program. Sustained funding at the current $25 million per biennium level for unstable slope mitigation and $1.5 million per biennium level for rock slope scaling is needed to ensure that these goals can be met.

For more information

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Common Types of Unstable Slopes

Landslide – The vertical and horizontal displacement of a soil mass, under the influence of gravity, within a slope or embankment. Generally landslides can be divided into two categories based on failure geometry. Those landslide categories are circular and sliding block failures. The rate of movement of landslides can vary from very slow moving to very rapid.

Debris Flow – A rapidly moving fluid mass of rock fragments, soil, water, and organic material with more than half of the particles being larger than sand size. Generally debris flows occur on steep slopes or in gullies and can travel long distances. Typically, debris flows result from unusually high rainfall, or rain on snow events.

Rockfall – The fall of newly detached segments of bedrock of any size from a cliff or steep slope. The rockfall descends mostly through the air by free fall, bouncing, or rolling. Movements are very rapid to extremely rapid, and may not be preceded by minor movements.

10-01-0001

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