Geologic Hazards: Reducing Oregon's Losses

Special Paper 32

A SUMMARY OF SPECIAL PAPER 31:
MITIGATING GEOLOGIC HAZARDS IN OREGON:
A TECHNICAL REFERENCE MANUAL

By

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Oregon Department of Geology and Mineral Industries

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This publication is a summary of the Oregon Department of Geology and Mineral Industries' *Special Paper 31: Mitigating geologic hazards in Oregon:A technical reference manual,* which contains more complete information about natural hazards in Oregon and how to mitigate them.

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and
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STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
John D. Beaulieu, State Geologist

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Floods are one of Oregon's most common natural disasters, affecting homes, businesses, farms, roads and railroads.

Executive summary

The science of geology tells us that natural disasters of the future will exceed those that we have experienced in our brief written history.

Oregon has a variety of geologic hazards including landslides, debris flows, floods, earthquakes, volcanoes, tsunamis, and erosion.

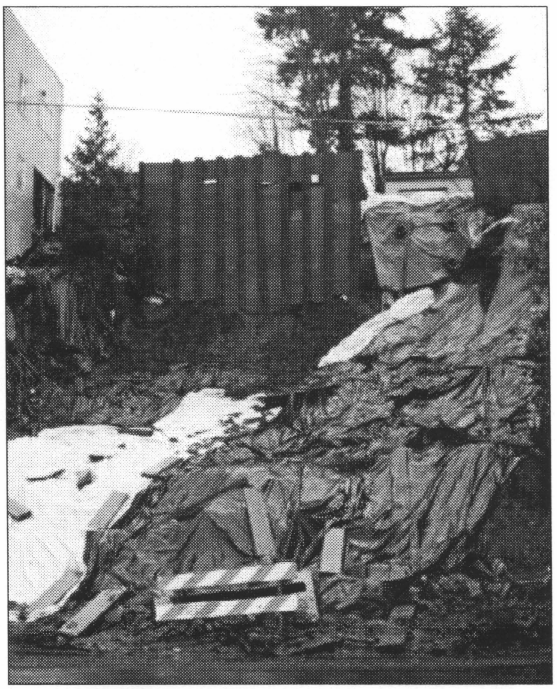
The risks posed by these hazards can be managed so that the benefits achieved are acceptable in terms of costs. The keys to managing the risk are having enough information about the hazard and taking the proper steps in risk reduction.

Reducing risks from geologic hazards involves several steps. These are:

- Properly characterizing the hazard;
- Building a team to develop strategies;
- Considering a range of strategies to address the risk;
- Choosing the appropriate strategies from a broad range of choices;
- Permanent integration of the strategies to assure ongoing success.

Community efforts that do not include each of these steps may not be fully effective. There may be adequate information about a hazard, but unacceptable strategies are proposed. Alternatively, strategies may be acceptable, but may not be effective, because the hazard was not fully understood. Other reasons why strategies may be ineffective are:

- Strategies may develop good information about hazards but do not link to risk reduction actions.
- Strategies may include actions reducing risk but not adequately characterize the hazards.
- Strategies may place the burden fully on local government without benefit of technology transfer or proper technical information from sources better able to provide scientific and technical information.
- Strategies may place the emphasis on interaction and process but not on understanding the hazard or finding the most effective risk reduction methods.



Landslides are a common problem throughout Oregon. This 1996 landslide in Portland's West Hills directly affected at least four lots and two roads. The major damage occurred to the house located across the street from the slide.

In Oregon, there are many opportunities to reduce risks from geologic hazards. Land use statutes and goals, building code regulations, construction practice manuals, public education, and voluntary actions have equally important roles in risk reduction.

A firm basis for action includes:
- **Characterizing the hazard**
- **Using a carefully selected team**
- **Considering a range of strategies**
- **Selecting the best strategy**
- **Institutionalizing the strategy**

Processes for implementing risk reduction may include rule development, comprehensive plans, periodic review of plans, ordinance development, public education, or other strategies by a variety of agencies.

The focus of this manual is to present the hazards and insights and information on how they can best be understood and managed from a technical and a risk-management point of view. It includes basic elements that should be present in any effective regulatory or decision making process.

Why a technical reference manual?

Oregon has among the widest variety of significant geologic hazards of any state in the union.

Demographics are increasing the risk of natural hazards to Oregonians as development is increasingly being carried out on more hazardous land than in the past. With proper information, it is possible to manage the risks posed by these geologic hazards.

In spite of efforts to manage risks, some actions are ineffective at reducing damage from geologic hazards. There are many reasons, including:

- The hazards are unrecognized or poorly understood;
- The full range of choices for risk reduction is not fully appreciated;
- The issue is so diverse and involves so many participants that the process simply bogs down and dies out;
- The community chooses to handle the hazard on a case-by-case basis rather than develop a comprehensive strategy;
- Legal jeopardy may not be well understood.

It is common for those who find themselves dealing with hazards to enter into the arena with:

- Incomplete knowledge of their task;
- Lack of understanding of all the hazards they need to consider;
- Lack of awareness of all the choices that exist and the tradeoffs associated with each;
- Lack of awareness of the total geographic area in need of policy.

It is important to point out that risk reduction strategies may not totally eliminate the hazard, but rather may be better viewed as attempts to effectively manage the risk.

Among other information, the appendices to this manual summarize the geologic hazards of Oregon, provide perspectives on how the geologic view of the hazard may differ from the view provided by history alone, and list several general strategies that might be pursued in the reduction of risk from hazards.

This manual is a summary of "A summary of risk reduction of geologic hazards: A technical reference manual for Oregon (Special Paper 31)." See that publication for more information on each section of this manual.

The effects of flooding do not end when the water recedes. Cleanup and rebuilding may take months; in some cases, structures, properties, or even neighborhoods must be abandoned. Flood control measures must be carefully planned so they do not cause more problems downstream.

Recognize that geologic hazards are a growing problem

Reduction of risk from geologic hazards is of increasing concern to communities in Oregon for a variety of reasons.

- Oregon is a state with a wide range of geologic hazards with significant impacts.
- Demographics are pushing development into higher hazard types of terrain.
- Recent legal actions are better defining the responsibilities and liabilities of communities, developers, and landowners.
- Regardless of the overall average risk for the state, the specific site where a disaster occurs is catastrophic for the victims, so reasonable steps to manage the risk are expected.

If the community does too little to manage risk, unnecessary losses will occur; if they do too much to control risk they may invite legal actions based on the "takings" doctrine. The challenge is to forge a strategy that optimizes the benefits of effective governance while minimizing the negatives. Key components are risk reduction, avoidance or management of liability issues, and sensitivity to cost issues.

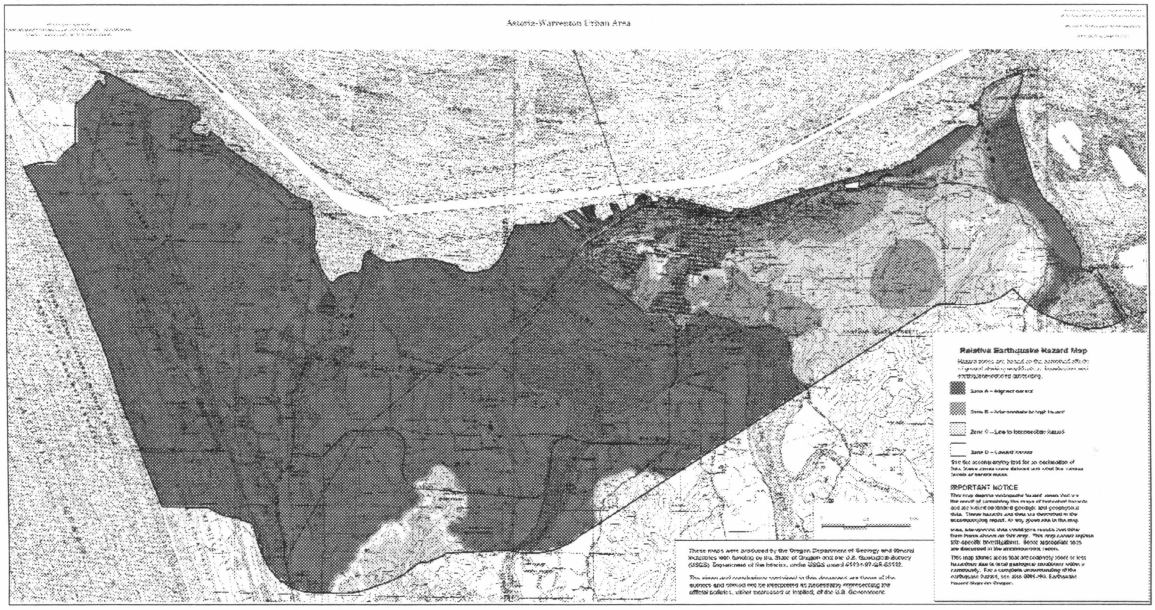
Properly characterize the hazards

For a geologic hazard to be properly mitigated the hazard first must be characterized. This involves a determination of what the hazard is, where the hazard is, how bad it is, and how often it might become a problem.

Delineation (where the hazard is) is just part of characterization. There may also be a need to evaluate the interplay of the specific hazard against other hazards. Sometimes a proposed solution for one hazard simply aggravates another hazard. Multi-hazard analysis is recommended where more than one hazard exists.

In states like Oregon we deal with many kinds of geologic hazards, including landslides, debris flows, floods, earthquake ground response, volcanic hazards, tsunamis, and erosion. For each of these hazards, our historic record of losses only tells part of the story, given the shortness of the record. Available information on hazards certainly should be consulted, but in many instances, available information alone may not be adequate.

Proper characterization of the hazard enables us to understand the extent, magnitude, frequency, and causes of the hazard in a manner adequate to develop and implement risk management strategies. Where hazards are found to be minimal, the community might be better served to place its energies elsewhere. Where hazards are significant, carefully selected strategies of risk reduction are in order.



Ground response maps are one tool to characterize earthquakes. The maps show how the ground will respond to earthquakes in terms of amplification, liquefaction, and landslides. These maps, like the one above for Astoria-Warrenton, must be used in conjunction with bedrock shaking maps and a risk assessment before a community can completely understand its risk.

Many structures were built before our current understanding of coastal processes. Efforts to stop erosion can be costly and may trigger unexpected behavior on adjacent coastline property.

Create a team of stakeholders

Risk reduction is the interest of a wide range of stakeholders. A properly selected team of participants must be constructed to address the risk. For small and simple hazards, the team of stakeholders may be small, strategic, even informal. For large and difficult hazards, more formal and larger arrangements are advised, with a larger array of stakeholders.

In large and difficult hazard situations, risk reduction can be the responsibility of the Building Codes official, planner, public, roads department, property owners, realtors, emergency management system, and others. Actions taken by each can help to manage the risk, though no one party by itself manages all the possible risks.

In areas of lesser hazard, the team may be much smaller, limited to a few key persons. Public interest and participation will vary with public knowledge of the hazard and with the potential impacts of the hazard.

The role of the scientist and engineer is to provide expertise so that considered options are also feasible. However, science provides means to characterize the hazard but does not dictate the final policy choices.

Project Impact, a new national initiative sponsored by the Federal Emergency Management Agency (FEMA), is one of many efforts that can be used at the local level to bring together citizens, government, and the private sector to minimize losses before the next disaster occurs. Partnering efforts, regardless of scale, can be a successful means of risk reduction.

Know the specific reason for the strategy

Strategies to address geologic hazards can be many and varied. Because strategies inevitably involve tradeoffs, it is important to clearly define the reason for the strategy or policy before decisions are made.

For example, a hazard line for coastal erosion designed for possible future insurance purposes may not be the line desired by planners who are trying to avoid all losses.

A key element then, to the development of hazard risk reduction policy, is a clear recognition of the desired outcome of the policy. These outcomes should be itemized, so the success of the policy can be measured after implementation.

Strategies are community specific

Selecting risk management strategies involves balancing of the amount of risk, the benefits and the liabilities of each possible action, and the values of the community. Given the variability of conditions, community values, economic considerations, and other factors, it is clear that strategies need to be developed ***locally,*** based on a clear characterization of the local hazard.

The emphasis should be on making decisions that are tailored to a jurisdiction rather than adopting preexisting language from another location, or from a "model ordinance." At the same time, reviewing a well-developed ordinance from an analogous area can provide a good starting point in the development of a community-specific regulation or ordinance.

Select from a range of strategies

Knowing the full range of available mitigation actions is helpful when choosing acceptable strategies.

Equally as important as characterizing the hazard is the decision process by which a community decides to deal with the hazard. For a given hazard, there are many paths to risk reduction. In general, strategies may include but are not limited to

- Simple or complex ordinances (zoning, subdivision, development codes);
- Building code provisions;
- Continuing public education efforts;
- Incentives or disincentives, such as tax credits;
- Revised construction and design manuals for lifelines; and
- Coordinating efforts when jurisdictions abut one another in a hazard zone.

The selection of effective local strategies depends on the nature and the degree of the hazard. It depends on the needs and wants of the community and on the desired or acceptable level of investment that might apply to the solution. It also depends on the level of risk and the level of regulation or restraint on property use that the community is willing to accept.

These discussions can take place locally, regionally, or at the state level, depending on jurisdiction. The Oregon Department of Geology and Mineral Industries has responsibility to provide information on geologic hazards.

Particularly in a state like Oregon, where hazards are so varied and pervasive, it is important to understand that the potential solutions to the problems posed by the hazards are as varied as the hazards and the communities themselves.

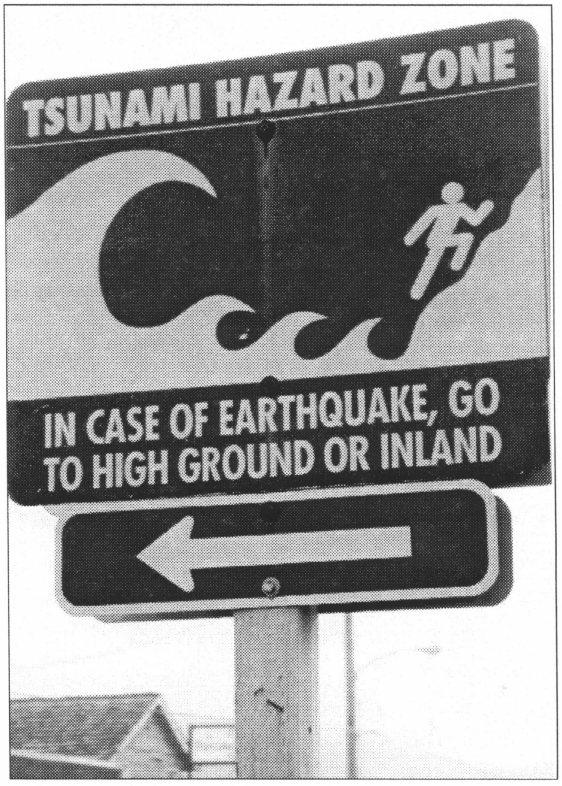
Make the strategy permanent

The selected risk reduction strategy must be put into place permanently, so that the effort continues after those who were initially involved are no longer available for implementation. This is called institutionalizing the strategy.

This may include adoption of

- Planning ordinances;
- Building code revisions;
- Training efforts;
- Public information strategies including publications or signs;
- Programs on storm water management and erosion control;
- Emergency plan chapters;
- Revising construction and design manuals;
- Revising manuals for road construction; and
- Education projects directed toward increasing public awareness of the hazard.

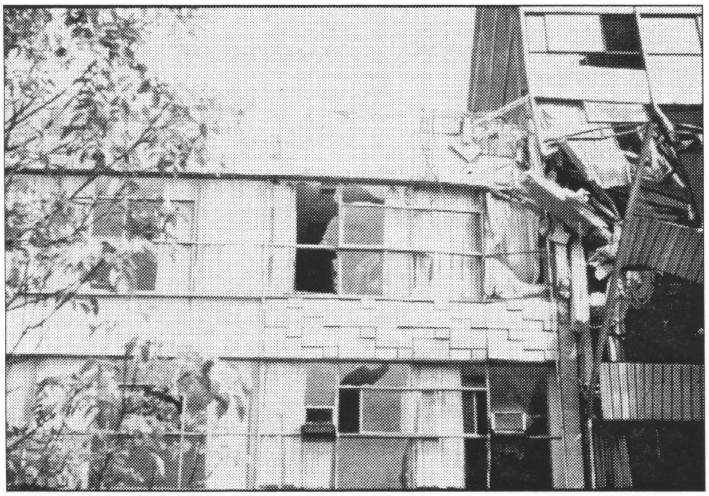
Depending on the strategy adopted, the lead responsibility for reducing the risk may fall to a planner, a building code regulator, an emergency manager, a scientist, a member of the private sector, or some other member of the risk reduction team.



Coastal communities are preparing their residents and tourists for the next inevitable tsunami. A variety of methods are being used, from general information about tsunamis to detailed evacuation routes, including this sign in Rockaway Beach, Tillamook County.

Proceed with perspective

A firm basis for action includes hazard characterization, team effort, consideration of a range of strategies, selection of the best strategies, and careful selection of the method of institutionalizing policy through implementation.



Few buildings completely collapse in an earthquake. Cost-effective mitigation activities can focus on well-understood potential problems. For example, an important stress point is where two buildings of different heights intersect. Photo courtesy of National Geophysical Data Center.

A jurisdiction may be willing to proceed toward the formulation of strategies, but the information base or the resource base may not be adequate to justify moving ahead.

A minimal effort of risk reduction from geologic hazards should

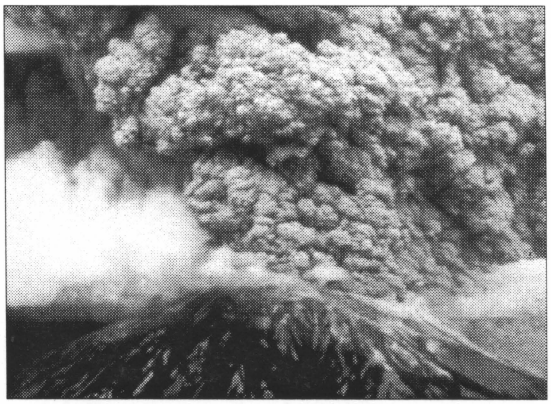
- Properly characterize the hazards;
- Address multi-hazard issues;
- Involve a team of stakeholders, including the public;
- Address an array of choices for risk reduction;
- Select a choice and make the choice permanent; and
- Demonstrate a reasonable chance of success based on scientific principles.

This array of defined steps collectively removes many of the uncertainties that poorly thought-out efforts bring with them. For hazard situations of limited impact, scaled-down efforts are justified, but the key components should still be considered.

Using this process can optimize the prospects of properly managing the hazard and minimize the chance of pursuing ineffective strategies. It can engage stakeholders and educate the public. Further, the rigor, balance, and objectiveness of the process can minimize exposure to future lawsuits arising from perceived arbitrariness or unacceptable work.

Finally, as communities develop and deal with geologic hazards, they generally discover that simple and general strategies may work at first, but more focused efforts that address specific local conditions and issues work better through time. This is particularly true where communities expand into new areas with greater hazard potential. Development often intensifies through time in a given area, leading to increased hazard potential as a result of alterations to the natural terrain.

Where a city and a county or two cities abut one another and share a common hazard situation, they may wish to cooperate in a broad strategy of risk reduction.



Though volcanic eruptions are the most spectacular geologic hazard, there is typically plenty of warning and well-defined danger zones for Oregon's volcanoes. Photo courtesy of National Geophysical Data Center.

Appendix 1. The diversity of geologic hazards in Oregon

Oregon displays great variety of geologic settings, geologic hazards, types of development, and potential losses from geologic hazards. Efforts at geologic hazard risk reduction in the state vary depending on setting, cause, rock type, general geology, current land use practices, future land use, and numerous other factors.

High rainfall and saturated ground contributes to floods, landslides, erosion, and increased earthquake damage. Road closures due to landslides are common in the winter in many places in Oregon.

- Earthquakes are generated from three locations: the shallow crust, the Cascadia subduction zone fault off the coast of Oregon, and the subducting slab under the crust. Predicted losses in the future for Oregon indicate hundreds or thousands of lives lost on the average every 500 years and $65 million damage as an annualized average.
- Landslides are generally related to various combinations of slope, rock, type, and climate. In general, moderate-slope slumps and steep-slope debris torrents dominate recent discussions. Losses for Oregon generally average less than one or two lives per year and $1 million to $10 million per year.
- Coastal erosion generally averages a few inches per year, but may be up to several hundred feet in one year in sandy areas. Rates vary elsewhere for certain kinds of high slope settings and other specialized situations. Major causes are sea level rise, cyclic climatic activity, and unstable landforms. Progressive losses over the years have destroyed all or parts of many communities and roads along the Oregon Coast.
- Volcanic hazards are infrequent but can be extreme in their consequences. In Oregon, ash fall, localized lava flows, and extensive debris flows down major river channels are the most likely threats.
- Tsunamis are large waves caused by undersea earthquakes or landslides. Oregon is threatened both by tsunamis from distant sources and tsunamis generated by activity on the Cascadia subduction zone. Deaths from a large tsunami along the Oregon coast could easily be in the range of 5,000 during times of high beach use, if proper public education has not been effectively institutionalized.
- Flooding in Oregon includes lowland flooding of major stream valleys and torrential floods down more restricted valley channels cut into the mountains. Deaths are rare, but in one event, Oregon experienced the third-largest fatality total of any flood in the nation since 1900. Economic losses have topped hundreds of millions of dollars in some recent floods.
- Stream bank erosion is a hazard which has gained more prominence as fish survival has become a higher priority for the state. Other issues include stability of construction in areas of severe erosion, long-term migration of channels, and land use. Major stream bank erosion occurs where major streams leave mountainous areas and pass through transition reaches where sediment loads are highly variable relative to the capacity of the stream to move them.

Appendix 2. Selected geologic disaster events in Oregon

Event	Frequency	Geologic causes and description
"100-Year" floods in Tillamook	More than 5 since 1970	• Geology and slope inhibit upland infiltration • Channels convey water very rapidly • Gravel modifies stream cross sections • Numerous rivers enter the valley
Large flood at Lake Oswego, 1996	>100 years	• Unusual geologic channel produces unusual flood potential • Headwater dam was insufficient for large flood events • Construction occupies ancient flood plain • Rain-on-snow weather pattern
Disastrous debris flows in Columbia River Gorge	50–100 years	• Unique geology dictates disastrous debris flows keyed to intense rainfall • Community and lifelines are located on low, flat ground constructed by debris flows
Flood/debris torrents in minor drainages	100 years +	• Intense storms coupled with minor channels and natural channel debris or culture-related channel debris • Historic losses of 247 lives at Heppner, 50 lives at Mitchell, 4 lives near Roseburg in 1996, $10 million in Ashland 1996
Large landslides at The Dalles	Ongoing until mitigated	• $150 million real estate threatened prior to mitigation in mid-1980s • Geology dictates slip surfaces beneath parts of the city • Irrigation aggravated slide potential
Potential loss of Portland water supply	100 years	• Distant water supply requires overland pipes across unstable terrain • Pipelines cross active landslides and occupy prehistoric volcanic debris channel from Mount Hood • Landslide damage to pipe in 1998 • Geologic analysis in 1973 spurred construction of a backup water-supply well field closer to town
Coastal erosion	Ongoing	• Rates dictated by geology, type of slide, climate and oceanography • Losses include parts of Newport, Bay Ocean, numerous parts of other communities • Episodic rates very high in sandy terrain (several hundred feet in some seasons)
Future crustal or intraslab earthquake	100–300 years	• Actual risk is greater than that implied by brief historic record • Construction practice historically lagged behind appropriate requirements until recently • Shift to Zone 3 in western Oregon (1991) addressed requirements for new construction
Subduction zone earthquake	300–600 years	• Locked subduction zone ruptures in one or several closely spaced events with magnitude range of 8.0-9.0 impacting all of western Oregon • Shift to Zone 3 (1994) and Zone 4 (south coast 1998) addresses new construction
Tsunami at Seaside and other coastal communities	300–600 years	• Tsunamis from subduction events repeat on Oregon coast • Susceptible to distant tsunamis (from Alaska, 1964) • Communities are located on low-lying ground • Mitigation includes selective building restrictions, evacuation routing, and public education

Appendix 3. Damage from geologic hazards in Oregon

Geologic hazard	Prehistoric impacts	Historic impacts	Future impacts based on geologic understanding
Landslide	Large scale landslides have formed large landforms and have blocked numerous rivers to form lakes as at Loon Lake, Triangle Lake, and Bonneville.	$150 million in threatened real estate at The Dalles in 1980s; 8 deaths in Douglas County in 1974; 8 deaths in several events in Oregon in 1996; tens of millions of damage per year.	Greater losses in the future in urban or developed areas owing to demographic trends for growth into less stable areas and increasing general population pressures on the land.
Chronic coastal erosion	Several miles of coastal retreat in many areas in past 10,000 years coupled with sea level rise. Short term erosion of sandy areas can be extreme.	Loss of all or parts of numerous developments in communities including Bay Ocean, Cape Meares, Newport, Lincoln City and others (The Capes).	Coastal retreat varies from a few inches per year to a foot per year on the average, depending on geology and oceanography and can be gradual or sporadic with large periods of no loss.
Flood/ debris torrents	Geologic evidence of a variety of floods of variable statistical sizes for all drainages. Debris torrents very common in much steep terrain.	18 deaths in Vanport Flood in 1948. Over 50 deaths in Mitchell in an event prior to 1900s and 247 deaths at Heppner on June 14, 1903, from a debris torrent originating in Balm Fork Canyon	Future flooding is inevitable as seen recently in Tillamook, Prineville, etc., but impacts are mitigated by present dam system and by National Flood Insurance program.
Earthquake	Large-scale Cascadia earthquakes of magnitude 8.5–9.0 for coastal Oregon with additional extensive damage related to ground response and tsunami.	A magnitude 5.5 to 6.0 earthquake in Oregon with damage in the tens of millions of dollars as at Scotts Mills and Klamath Falls in 1993.	Large scale Cascadia earthquakes of magnitude 8.5–9.0 for western Oregon with additional extensive damage related to tsunami. Risk varies with ground response and building type.
Tsunami	Numerous coastal villages of Native Americans destroyed or impacted as seen in archeological record, inferred from geologic record and heard in myth record.	4 deaths from the Alaska tsunami in 1964 plus considerable damage in various communities including Seaside, Florence, and Cannon Beach.	Cascadia subduction zone tsunamis will yield considerable damage; mitigation strategies focusing on critical and essential buildings, evacuation, and public education.
Volcanic	Volcanic activity is, varied, widespread and continuing to present day, but sometimes with prolonged dormancy periods for any given volcano. Numerous native American legends; Old Maid Flat-Sandy River hot mudflow event in 1780s.	Only a few small events in Oregon including minor eruptive activity at Mount Hood in the 1800s and a few deaths there related to gas emissions in the Crater Rock area; Mount St. Helens in Washington erupted in 1980 with a large lateral blast, killing 57 people.	Varied with major hazard to lifelines and inhabitants of key drainage areas such as the Sandy River drainage; events have low frequency of occurrence and are generally preceded with precursors adequate to trigger evacuations.

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Appendix 3. Damage from geologic hazards in Oregon (continued)

GEOLOGIC HAZARD	PREHISTORIC IMPACTS	HISTORIC IMPACTS	FUTURE IMPACTS BASED ON GEOLOGIC UNDERSTANDING
STREAMBANK EROSION	Strong evidence of large-scale stream migration in flood plains of most major streams, particularly those of the major streams entering valleys from mountainous areas.	Much of the historic areas of stream-bank erosion were addressed with levee construction in earlier decades; the shortcomings of this approach as a universal strategy are seen in the scattered levees now far from streams.	Areas of increasing need for attention involve the interplay of residential development, stream instability, ecological concerns, lifeline stability, and channel modification through dredging or nearby aggregate mining.

Planning offices should not be viewed as the key lead agency in the reduction of risk for all hazards, or as responsible for the reduction of all risk from geologic hazards. Specifically note that in the above table, lives were lost in landslides in Douglas County in circumstances not under the control of a planning office. In the 1996 event at Hubbard Creek, the homes were not authorized, and no building permits were obtained for them. In the 1974 event, deaths involved repair crews working in inclement weather.

Appendix 4. Specific hazard characterization

GEOLOGIC HAZARD	CHARACTERIZATION	COMMENTS
EARTHQUAKE	Bedrock shaking map	Shows how much bedrock shakes in the general case; complete for Oregon; undergoing minor adjustments periodically. Used for broad seismic zoning policy.
	Ground response map	Shows how unconsolidated geologic material above bedrock modifies bedrock shaking beneath a building; generally conducted at the community level; most larger communities of western Oregon are complete. Used for prioritizing efforts.
	Site specific study	Shows shaking potential at a site based on a site study; required for many larger and more critical structures. Used for specific engineering decisions.
	FEMA 154 of buildings	Sidewalk review of structures to generally suggest statistically how they might behave in an earthquake. Used to prioritize buildings for further study.
	FEMA 178 of building	Structural review of a building from the inside by a qualified professional to define how it probably will behave in an earthquake and to identify recommended upgrade.
	FEMA 273 of building	Innovative analysis of a building to show ways in which it might be rehabilitated to meet stated standards in a stated earthquake.
LANDSLIDE	Regional landslide map	General map showing general landslide distribution inferred from general features and geology; used for general policy development and to identify target areas for more detailed mapping.
	Subdivision or local landslide map	Local landslide map keyed to extent of local development such as a subdivision; needed to manage non site specific causes of slides such as regional drainage, cumulative runoff, cumulative erosion, and problems associated with lifelines such as roads and buried utility lines.
	Site-specific map	Site-specific map used to manage or regulate hazard and risk unique to the site; site specific studies alone do not always address cumulative problems.
COASTAL EROSION	Regional coastal erosion map	General map showing general distribution and rate of coastal erosion inferred from general features, historic data and geology; used for general policy development and to identify areas in need of more detailed study.
	Littoral cell erosion map	Map characterizing erosion and deposition within a littoral cell and based on understanding of the geologic processes in the littoral cell; for bedrock reaches geologic processes and landslides are key components; for sandy reaches and spits; storm driven events and wave models may receive emphasis.
	Site-specific study	Site-specific map used to manage problems unique to the site; site specific studies alone do not always address cumulative problems.

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Appendix 4. Specific hazard characterization (continued)

GEOLOGIC HAZARD	CHARACTERIZATION	COMMENTS
VOLCANIC ACTIVITY	Ash zone map	Specifies probable ash falls around a volcano and considers wind directions, eruption size, and proximity to the vent.
	Debris torrent map	Specifies probable extent of diverse volcanic debris that can flow down valleys from a volcano. Based on prior volcanic behavior and surrounding topography.
	Specialized map	Considered specialized features associated with the volcano such as existing lakes or unusual prior activity such as lateral blasts.
TSUNAMI	Coast-wide general tsunami map	General map published by DOGAMI and formally adopted by the Governing Board to implement SB 379 (1995) (for selected new construction under building codes regulations) based on simple computer model and general geologic evidence; depicts general distribution of the average tsunami.
	Modeled bay tsunami map	Tsunami map for a single bay based on complex computer model of water behavior combined with all available field data; can be adopted by DOGAMI as a SB 379 map by action of the Governing Board.
	Community evacuation map	A version of the Modeled Bay Map, which is given more conservative distributions of the tsunami for increased safety because it guides simple evacuation rather than regulates some selected buildings under the building codes regulations.
	Site-specific tsunami map	DOGAMI can grant exceptions to the restrictions on selected new construction in the tsunami inundation zone defined by the SB 379 maps. Such exceptions may rely on site-specific tsunami inundation maps.
FLOOD	National flood maps	Maps issued by the Federal Emergency Management Agency to implement the National Flood Insurance Program. Maps are probabilistic and subdivide flood areas into zones of varying risk; quality of maps is under ongoing discussion. Maps do not include tsunami zones as such or torrential channel floods.
	Other flood maps	Other types of flood maps depict channels subject to torrential or flash floods, tsunami zone of various types, lowland flooding of nonprobabilistic nature, or specific flood events.
STREAM BANK EROSION	Stream erosion maps	These maps are rare and there is no standardized approach. For the proper management of floodplains maps are needed which show areas of progressive stream bank erosion, areas of deposition, areas of prior channel change, reaches of rivers with unstable channels and areas of probable future overflow in floods.

Appendix 5. Multi-hazard relationships

	Flood	Slide	Tsunami	Ground response
Slide	• Actions to avoid slides may pose flood problems and vice versa. • Drainage controls may aggravate flooding, water quality or sliding.			
Tsunami	• The two differ in terms of size, flows of water, hazard; cannot treat the same. • Regulations for tsunamis are building specific.	• Avoidance of tsunami zone may introduce slide hazards that need to be addressed at alternative locations. Slide avoidance should not drive development into tsunami zone.		
Ground response	• Structure strategies for floods may aggravate ground response risk. Strategies for ground response may conflict with flood strategies.	• The two are compatible. However, earthquake-induced landslides are not the only kinds of slides to address.	• Styles of construction to avoid tsunami developed in quake deficient areas may not be appropriate for quake threatened areas.	
Coastal erosion	• No readily apparent problems. • Flood control structures locally can starve beaches in the long term.	• The two are compatible. • Avoiding coastal erosion with structures can promote erosion and sliding elsewhere.	• Removal of logs to avoid battering rams conflicts with leaving of logs to forestall storm driven erosion.	• No apparent conflicts at this time.

Appendix 6. Geologic hazard risk reduction by state and local agencies

Agency	Role and strengths	Conditions inviting partnerships
OEM Office of Emergency Management	• Conduit for federal funding after a disaster • Close coordination with local contacts • Broad responsibilities in disaster response and interest and activity in risk reduction • New focus on development of regional mitigation plans and multi-objective initiatives	• Emphasis is primarily on post-disaster response. • Little geotechnical expertise internally. • Focus of some federal recovery programs may emphasize restoration of public facilities and assistance to individual homeowners at the expense of proactive regional strategies
DLCD Department of Land Conservation and Development	• Oversee planning on community or area basis • Oversee Goal 7 (natural hazards) and Goal 17 (beaches and shore lands) • Oversight of federally funded Coastal Zone Management Program	• Focus is regional or community-wide and not building specific • Little geotechnical expertise within the agency • Goal 7 efforts for many communities in the state are weak on adequate hazard characterization
DOF Department of Forestry	• Extensive field-based knowledge of debris torrent risk in mountainous areas and forest lands • Agency lead on debris-flow warning system	• Small size of staff dedicated to geologic hazards • Incomplete linkages to many agencies and communities needing expertise
Local Cities and Counties	• Central role regarding local concerns • Must live with the solutions at local level • Unique access to some federal funding programs	• Insufficient technical background • Lack of proper hazard characterization. • Possible pressure of local politics
BCD Building Codes Division	• Building specific approach suited to hazards • Site-specific reports required for seismic hazard • Restrictions on use of earthquake-damaged buildings • Exemptions to building classifications relative to tsunami zone restrictions	• Treatment of variable nonstatic or offsite ground conditions is weak • Major focus is building specific and not regional or community-wide. • No specific authorities for seismic rehabilitation of preexisting structures
DOGAMI Department of Geology and Mineral Industries	• Centralized source of information on geologic hazards for the state of Oregon • Partnership style and community approach • Strong public education commitment and program	• Small size of staff • Incomplete linkages to many agencies and communities needing expertise • Specific lead roles for some aspects of risk reduction assigned to other agencies

Appendix 7. Range of strategies to reduce risk

This section provides a generic summary of various techniques of risk reduction that have been tried for various hazards from place to place in Oregon. Depending on the nature of the hazard, level of risk, financial considerations, and standards any one of these techniques has been found to be the best approach at one time or another at a given location or another.

A particular strategy that works in one place may not work in another. This is particularly true in Oregon, where conditions of geology, climate, culture, and cost vary from place to place. Accordingly, flexibility in approaches is one of the core messages of this reference manual.

Here we encounter a key point in the reduction of risk from threats as complex as geologic hazards. An understanding of the range of options and their respective proper applications is a requirement for proper strategy development. Effective risk reduction requires an understanding of the choices.

There are tradeoffs involved for all mitigation options. The less rigorous strategies bring with them the possible risks of not properly addressing issues of public safety, health, or welfare. Yet in situations involving little risk and less intensive development, implementation of less rigorous strategies may be appropriate.

The more restrictive strategies may bring with them the risks of higher costs, and possibly unacceptable limits on personal property freedoms. Yet choices of this type sometimes are judged as best for the community.

For any selected strategy, ongoing communication within the team and with the scientists should assure that the action reasonably reduces real risk while it balances considerations of cost, economics, safety, resource protection, personal rights, and liability issues.

Choices should also work in terms of natural processes. The challenge is to select options that balance losses against gains in a manner acceptable to the community.

The format of the following table is designed to assist the reader.

- The various options for risk reduction are listed in general order of increasing regulation or effort. Risks of high hazard and frequent occurrence generally are more properly addressed with options near the end of the listing. Hazards of low frequency or impact are more appropriately addressed with options at the front of the listing.
- The first column breaks the larger listing into major categories.

Appendix 7. Range of strategies to reduce risk — Table

General action	Specific strategy	Likely lead agency	Examples and comments
Do nothing about geologic hazards	Actively or passively ignore the possibility of the presence of hazards	Any	It is possible to administratively overlook hazards or ignore their presence leaving their treatment to routine operations. If risk is low doing nothing formal at the governmental level may result in no adverse consequences. Proper characterization of the hazards assists in judging the adequacy of this option.
	Misplace hazards reports or fail to distribute them effectively	Any	Good hazard information sometimes does not find its way to the user owing to other priorities. This is not acceptable practice, but has been allowed to happen in several jurisdictions. Sometimes hazard reports are presented in such a technical manner or are so poorly presented that they are misplaced or overlooked simply because their content is not fully appreciated.
	Assign low priority to hazards actions; go on to other problems	Any	Various hazards can be regarded as too low in priority to warrant consideration. Hazards of vague impact or long time frames may be treated in this fashion. Risk based decisions are acceptable; if defined risk is low, the need to mitigate is also low. If low priority is assigned it should be done based on objective analysis and not simply on a lack of appreciation of the issues that might be present.
Develop only general ideas about geologic hazards	Develop vague reports for policy offices with no specific action track	Any	General discussion of hazards can appear in reports without leading to any particular insights or actions. Awareness is served, but risk reduction is not accomplished. Generalized discussions of hazards are common in any of a variety of planning documents. Often the information does not appear to lead to any decisions one way or the other. Regardless of the degree of generality, it is important that the information be channeled to a discrete decision, even if the decision for the time being is to do nothing more. Where no decision is linked to the information, progress towards risk reduction has not occurred.
	Provide vague language in planning documents or other policy documents that might lead to action eventually	Any	Planning documents can state a concern for hazards, but can fall short of actual action plans to do anything about them. Planning documents can recommend action by others, but follow-through may not be provided. An example is a general treatment of a hazard in a comprehensive planning document that does not lead to a discrete action to reduce risk. General policy language in a planning document represents work undone, but does provide the benefit of defining a start point for further policy discussions.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Develop general maps that mention the risk of geologic hazards	Adopt small-scale maps with general information to focus attention into some areas	Planning office	This approach serves to flag areas of concern in terms of future development. By itself it does not accomplish risk reduction, but coupled with the focusing of further work in hazardous areas, it sets into play a process that can accomplish risk reduction. Such general portrayals may prompt individual actions later for risk reduction in target areas or may eventually serve as the basis for policy action by the community. For areas of only long-term future concerns such maps may be valid ways to flag areas of need of greater attention in the future when demographics are more demanding. Maps of this sort may be of greater value to counties than to communities with greater developmental pressures. They can be appropriate for depicting large scale hazards of low frequency, such as some volcanic hazards.
	Develop narratives in planning documents with nonspecific observations and place into policy documents to keep the issue alive	Planning office	It is common to find general hazard discussions in planning documents that describe hazards and lay out future options for treatment. Depending on the use of the document, this approach may be an appropriate step toward increasing governmental awareness or formulating action at a later time. Areas not under development pressure may be properly served for a while with this kind of flagging, for example.
	Adopt or distribute borrowed regulatory text from other areas. For example, ordinances from one city are sometimes adopted by another	Planning office	In an attempt to fix the problem this approach is sometimes pursued. It includes the notion that ordinances can be imported verbatim from other areas. In areas of diverse geologic conditions such as Oregon, this approach is usually unwise and is not as effective as ordinance development based on characterization of the hazard area in question. In general it is necessary to characterize the hazard at the location in question before effective mitigation can be implemented. However, general language in ordinances from analogous areas often can provide a useful starting point for developing an ordinance somewhere else.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Develop good geologic hazard maps that focus on the specific hazard for the specific area	Develop large-scale maps of hazard areas and adopt specific requirements aimed at tying information to property documents. Included are recordation on deeds and waiver requirements	Planning office	Larger scale maps that properly depict the hazard, its variations, and its causes can be useful tools in formulating mitigation strategies appropriate for the area in question. The key is in finding the proper balance of effort, expense, and rigor among involved parties. In much of the northwest we have learned, for example, that hazard depictions at a 1:24,000 scale in communities are not adequate to properly characterize the hazard and to prescribe effective strategies for risk reduction. As larger and larger scales are pursued it is important that the distinction between a policy map at one scale not be blurred with site-specific maps intended for individual parcels. It is also important to appreciate that site-specific maps alone generally do not solve hazards of a regional nature.
	Develop or require specific characterization and remediation for the site in question	Planning office	Site-specific studies address factors and impacts at the site and are appropriate for hazards that are limited in distribution to specific sites. However such studies may overlook regional factors and causes that may also be at play. This approach works for small hazards, but is inadequate for regionally driven hazards (which are handled below). Site specific studies and risk reduction often must be integrated with more regional strategies to effectively mitigate hazard risk in areas of regional hazards like large landslides. This also is particularly true with coastal erosion issues, where the behavior of littoral cells must be appreciated to solve local coastal erosion issues.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Provide public education to forearm those making decisions in the hazard area *(continued on next page)*	Require disclosure statements in specified situations. This approach appears to serve the buyer, but may be difficult to formulate and may overlook other aspects of the hazard	Local or state government at policy level	The idea is to not allow owners to pass properties of risk on unsuspecting buyers. Requirements to disclose information should focus on information of a site-specific nature since the overall context is site specific. This particular approach may be reasonable in its administration, if it is focused on areas for which reasonable chances of risk have been predetermined. Otherwise it can be burdensome on areas with no risk.
	Require recordation of eminent hazard areas for discovery in title search activities	Local or state government at policy level	This is a specialized category of disclosure in which key areas are properly recorded so that they surface in title searches prior to closing of sales. Regional hazards of proper characterization can be handled in this way provided the payoff justifies the administrative investment. A disadvantage is that record keeping may be sufficiently inefficient that properties that are properly mitigated eventually will still show up as hazard threatened in a title search.
	Prepare and distribute publications or other releases of the hazard information	Any	Public education is a viable strategy where numerous members of the public may be involved and other options are not effective. For example, warning signs are a proper choice along cliffs, in tsunami danger zones, in areas of dangerous surf, or in some landslide areas. This approach relies on the "buyer beware" or "visitor beware" principle and provides reasonable prospects of the buyer or visitor being informed. It also provides information to officials needing to know about hazards before making decisions. Proper information can guide a variety of proactive policy discussions.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Provide public education to forearm those making decisions in the hazard area *(continued from previous page)*	Provide for realistic and reliable warning systems	Emergency management or Any	For specific areas of fairly frequent high impact hazards this mechanism provides mainly for public safety. It addresses lives rather than property. Owing to high investment and maintenance factors this strategy generally is limited in application to areas of very high risk. Tsunami hazards threaten transient populations and lend themselves to signing along beaches for general public warning and for warning sirens in at-risk communities for evacuation. On a broader scale Oregon has implemented a statewide warning system based on existing communication systems and identification of threshold rainfall events. In some areas of the world mechanical warning systems are designed to function near the bottom of extremely hazardous debris avalanche channels.
	Public education	Any	An agency with knowledge of the hazard can develop strategies of focused outreach to assure that major players and the public know what the problem is and are assisted in finding ways to address it. The effort can focus the general public in an area of hazard or can rely on focused communications with particular interest groups or stakeholders. Clear decisions regarding whether to pursue general or focused efforts should be made to better assure effectiveness. Techniques for outreach should strategically address the characteristics of the target audience. For example, the use of signs along beaches for tsunamis recognized that the use of signs at the location of the hazard is clearly an effective way to meet a transient and changing population (beach users and tourists). Team efforts can be effective, such as the landslide brochure development, which was part of the Governor's debris avalanche strategy. For tsunamis, a wide array of outreach products are available including bookmarks, brochures, informative mugs, and videos.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Facilitate voluntary mitigation with specific opportunities *(continued on next page)*	Provide for land trades or land purchases to remove those at risk	Local or state government at policy level	Communities such as Astoria have engaged in land trades in which hazardous ground traded from the private sector to minimize their losses in exchange for other land. The community then uses the land for preferred community uses such as parks. Key ingredients are an extreme desire for the public to have access to a solution plus the availability for land to trade by the community. This technique has been used to solve other land use problems.
	Provide for insurance, either through government or through private sector	Local or state government at policy level	As with the flood insurance program these programs spread the risk, but also are keyed to efforts to reduce the risk, by requiring reasonable mitigation by participants. This technique requires a intensive administration and is most appropriate where risk is complex, widespread and of large size, and where occupation of the hazard area seems necessary (i.e., earthquakes). For complex hazards of difficult characterization and many causes (some of which can be self-induced), such as landslides, insurance makes less sense. As people learn of the hazard those not at risk choose not to participate, thus rendering shared risk not viable.
	Develop incentive programs leading to self-initiated mitigation of the specified risk	Local or state government at policy level	To reduce some risks, tax credits may be appropriate. Generally this is true if the induced mitigation through private action adds up to a major public benefit in the long run. Seismic rehabilitation of selected buildings is a candidate for this kind of strategy.
	Remove development incentives in areas of geologic risk	Local or state government at policy level	Various governmental programs involve general incentives such as cost breaks for infrastructure and tax incentives. These can be structured with appropriate limitations so that they do not apply in areas of known unacceptable geologic hazards. For example, tax breaks for new industrial development can be structured to not apply in flood plains.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Facilitate voluntary mitigation with specific opportunities *(continued from previous page)*	Provide for engineered solutions through disaster-based reconstruction	Emergency management or Any	After losses have occurred at a site reconstruction using engineered solutions to the problem might be appropriate where relocation is not possible and where expense is justified by the results; such things as rehabilitation of bridges damaged in a flood or an earthquake fall into this category. For a large slide in The Dalles in the middle 1980s, slide drainage of groundwater was implemented because the city was already in place and it provided a much more acceptable solution than moving the threatened buildings. The geology was permissive of a dewatering solution. In other communities such as Kelso, Washington, the geology renders dewatering to be not feasible.
	Develop partnerships of impacted audiences including self-funded improvement districts to provide creative mitigation	Local or state government at policy level or Neighborhood group	For some regional hazards the most effective solution is to promote private sector efforts toward team problem solving. Such an effort may be characterized by recognition of a common specific goal, proper information in advance, and creative thinking. Tactics may include taxing districts with funding aimed at effective solutions. This approach may be needed in hazard areas where existing development precludes many of the other options. Littoral cells, regional landslides, and large stream erosion areas lend themselves to this kind of strategy. Some communities in other states have formed Geologic Hazard Abatement Districts under the general guidance of state law.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Require mandatory mitigation of geologic hazards *(continued on next page)*	Develop restrictions through zoning	Planning office	Where land use zones can effectively address the causes of the risk in a manner acceptable to the users, this approach may provide much of the risk reduction. Approaches such as this lend themselves to regionally driven geologic hazards such as large, relatively active landslides. Alternatively, in Oregon earthquake ground response for technical reasons does not lend itself to risk reduction through direct zoning action, because within zones of given hazard it is the building type that most determines the risk, and not the zone itself.
	Develop building code controls that specifically address the hazard	Building codes	Some hazards do not lend themselves to the tools of land use zone regulation, but can be addressed in the manner of construction of buildings. Seismic codes for buildings are an example. Ground response data can guide or influence requirements for specific buildings. Also, prevention of slides that might be caused by site preparation can be avoided through implementation of grading codes. General grading codes do not, however, directly address hazards posed by larger preexisting slides or geologic materials of uniquely unstable slope characteristics.
	Adopt grading ordinances, hillside development regulations, subdivision ordinances, etc., which are keyed to the characterization of the hazard. Also included here might be some geologic hazard abatement districts.	Planning office	Specialized regulations focused on the risk areas and the causes of the risk can provide the basis for ongoing management strategies to mitigate the risk long-term, as land use evolves in the area of concern. Examples include: limits to grading, conformance to topography, setbacks, open space, clustering, lot size and shape, vegetation, road layout, and road engineering. In general, one factor that simply must be addressed in these strategies is proper management of storm runoff. In slide-prone terrain, piecemeal approaches to the runoff problem inevitably lead to slide problems at least on a local basis. Many such slides can be avoided with proper runoff management.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Require mandatory mitigation of geologic hazards *(continued from previous page)*	Construct protective structures in areas of particularly high risk	Local or state government at policy level	Where cost of the hazard greatly exceeds cost of the structures engineered solutions may be justified. A full range of possible solutions for each hazard is available; considerations of cost generally limit the number of realistic choices, if any, for a specific problem. Examples include walls to divert debris avalanches, for example. On a larger scale flood protection dams and levees are other examples. Increasingly the side effects of hard solutions are being evaluated in terms of impacts on watershed values. Yet another example is rip rap along coastlines. Here various policies may prohibit use of rip rap in given situations. Also, technically sound evaluations of the long- term effect of rip rap on the property in question and the rest of the littoral cell must support the decision to riprap, or the solution will only be temporary.
	Require engineered solutions in the actual construction of the building	Building codes	Involves requiring the private sector to spend the money for risk reduction as part of the construction or improvement of the structure. On a building-specific basis, seismic zones currently define a wide range of required engineering solutions. In future years, requirements may be more directly linked to modeled probabilistic earthquake activity rather than formally defined zones. Specialty requirements can be developed for construction in tsunami zones. For non-inhabited structures a variety of regulations or handbooks provide engineering requirements for power plants, dams, substations and other structures. Proper design presumes proper understanding of the risk. In Oregon the State Geology Department (DOGAMI) peer reviews the field based geologic hazard findings upon which engineering designs are based.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Implement prohibitions against construction in areas of geologic hazard	Prohibit some new construction with specified exemptions for certain situations that simply are not workable	Building codes	For some really hazardous areas prohibitions of some types of construction are viewed as necessary. Exemptions are designed to balance other considerations or circumstances. The tsunami restrictions for certain kinds of critical and special occupancy structures along the coast are a good example. To the extent the requirements focus on certain kinds of buildings only, and do not otherwise control activities in the hazard zone, the regulatory arm that is most appropriate is Building Codes, according to wording of the statute.
	Prohibit new construction with exceptions for facilities that can demonstrate lower than anticipated hazard or risk	Building codes or Planning office	For some really hazardous areas prohibitions of some types of construction are viewed as necessary. Exceptions can be provided where risk is addressed in other ways or where further analysis shows that an exception is justified through better understanding of the hazard. The tsunami restrictions along the Oregon coast are a good example. Where most kinds of buildings are restricted, the planning office probably is most suited to the task. Where only a few kinds of very specific buildings are involved a Building Codes approach may make more sense.
	Prohibition without exemptions or exceptions	Planning office	Simple prohibition of construction is an option for really serious situations. Examples are rare. Here the focus is on the region rather than selected buildings; regulation by the planning office makes the most sense. In Crescent City, California, much of the area destroyed by the 1964 tsunami is now dedicated to parks and greenway rather than construction. Some landslide areas and coastal erosion areas in Oregon probably should either be set off limits for construction or should require very intensive mediation. Some properly delineated debris torrent channels should be off limits to construction.

Appendix 7. Range of strategies to reduce risk — Table (continued)

General action	Specific strategy	Likely lead agency	Examples and comments
Provide for retroactive actions for preexisting structures in areas of geologic hazards	Provide for rehabilitation of selected structures or classes of structures, using passive triggers	Local or state government at policy level	This strategy addresses risk in structures that are in place when the hazard is recognized. Prioritized seismic rehabilitation can be an example. Cost benefit is a primary consideration. Rehabilitation can be keyed to passive triggers or otherwise prompted. Good information on ground response, building-type inventory (using FEMA 154, 178, or 273 for example), and probabilistic risk can assist the community in making decisions regarding the value of rehabilitation programs. Portland has codified such a program. Remediation of buildings in flood plains or slide areas might also be required as a condition of financial assistance after a disaster.
	Provide for rehabilitation of structures or classes of structures with mandated active triggers	Local or state government at policy level	This strategy addresses risk in structures that are in place when the hazard is recognized. Prioritized seismic rehabilitation can be an example. Cost benefit is a primary consideration. Active triggers apply to more serious situations. Good information on the hazard, building inventory, and probabilistic risk can assist the community in making decision regarding the value of rehabilitation programs. Mandated triggers should be reserved for the more serious threats to human safety.
	Require removal of structures from high risk areas	Local or state government at policy level	This approach is used where imminent destruction is anticipated; homes have been removed from landslide areas, for example, as noted above. In the option described here the emphasis is on mandatory action as opposed to voluntary or incentive driven removal. Good information on the hazard, building inventory, and probabilistic risk can assist the community in making decision regarding the value of removal programs. This particular course of action is pursued only very rarely. Structures that have received repeated disaster assistance from public funds are sometimes discussed in connection with this concept.

Appendix 8: Questions

The following questions can help to identify institutional impediments:

1. Is the jurisdiction that is characterizing the hazard satisfied with only characterization, or is it reaching out to policy persons to help promote the understanding that is also needed for effective risk reduction?
2. Since Mother Nature speaks indirectly through scientific principles and natural events, it is important that the policy person be listening to the interpreters (geologists, engineers, etc.) to better understand the hazard before deciding how to deal with it. Are experts being consulted to determine the probable effectiveness of proposed strategies?
3. Since Mother Nature does not go to meetings, have policy makers solicited timely advice from the interpreters during policy development? Or have they structured policy meetings to focus solely on the positions of "stakeholders" and forgotten that Mother Nature controls the ultimate outcome?
4. Because Mother Nature may complicate the situation with the presence of multiple hazards, has consideration been made of how a solution for one hazard may aggravate another hazard? Often the solution proposed for one hazard may aggravate another hazard. Have policy makers tapped ongoing input from experts to assure that corrective actions do not actually add to overall risk?
5. In efforts to follow clear procedures, have policy makers successfully linked characterization, conversation, and risk reduction in decision-making or have they built procedural walls between them? For example, in funding opportunities, are communities expected to adopt policy in the absence of requisite hazard characterization?
6. Is the jurisdiction that is characterizing the hazard providing opportunities to communicate with the community and the risk reduction team? Or are schedule and budget more restrictive and dictate termination of involvement by scientists once the map is made, but before policy decisions begin to be made?
7. Do the funding sources for risk reduction prescribe funding criteria that connect the four components of success (characterization, team effort, strategy selection, and institutionalization) or do their criteria unnecessarily eliminate one or more of these while promoting the others?
8. Does the community that is attempting to reduce risk develop strategies keyed to local conditions or does it merely import regulations developed elsewhere under a different set of circumstances?
9. In pursuit of the goal to reduce risk for a community, are those involved systematically identifying all significant hazards or are they content to pursue just those hazards that are readily apparent to the public?
10. Have communities dealing with hazards fallen in the trap of simply "delineating hazards" and asking for "site-specific studies" later? Or are they attempting to characterize the hazard (where it is, how bad it is, how often it occurs, and how human activities change these answers), then asking for more of the right kind of information so that more effective policies and strategies can be formulated?
11. Does each jurisdiction, according to its own specialized interests, consider itself the leader? Or does it recognize and proceed with the conviction that science, building codes, response planning, technical information, and local values are all parts of a broader team effort involving unique contributions, ongoing communication and teamwork?

A case study using the principles in this manual can be found in *A summary of risk reduction of geologic hazards: A technical reference manual for Oregon (Special Paper 31).* The City of Salem, Marion County and Polk County worked together to mitigate landslide hazards in the Salem Hills.