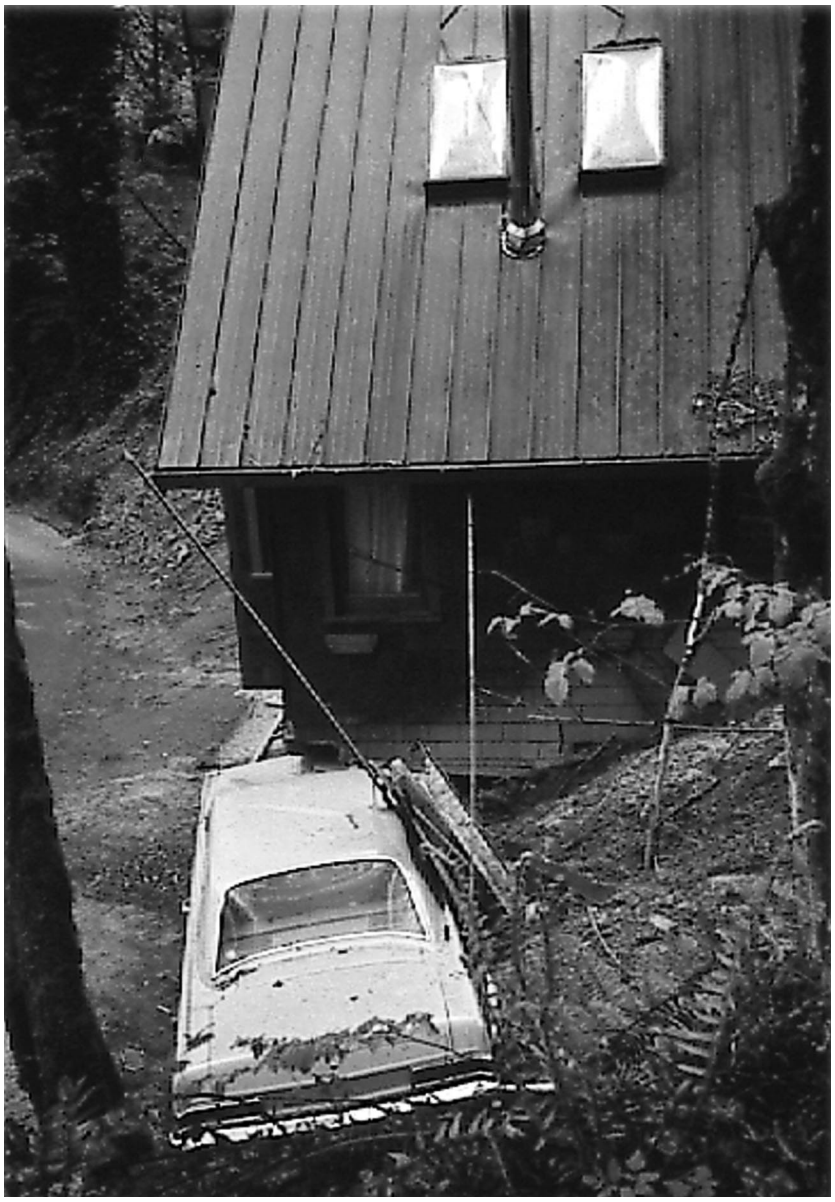
Special Paper 31
Mitigating Geologic Hazards in Oregon: A Technical Reference Manual



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SPECIAL PAPER 31

Mitigating Geologic Hazards in Oregon: A Technical Reference Manual

by

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and

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In cooperation with:

City of Salem

Marion County

Polk County

Oregon Emergency Management

Federal Emergency Management Agency

1999

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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Executive summary

With proper information, the risks posed by geologic hazards can be managed so that benefits gained by strategies to reduce risk are acceptable in terms of costs. The keys to risk management are to have enough information about the hazard and to take the proper steps in risk reduction.

Reducing risks from geologic hazards includes several steps. These are

- Properly characterizing the hazard;
- Constructing a team to develop strategies;
- Considering a range of strategies to address the risk;
- Making an informed selection of strategies from a broad range of choices; and
- Permanently integrating the strategies to assure ongoing success.

Community efforts may not be fully effective if they do not fit into this broad effort reaching from characterization to integrating strategies. Available information may be adequate, but devised strategies may not be acceptable. Alternatively, strategies may be acceptable, but may not be effective in actually reducing risk, because the hazard was poorly characterized.

Risk reduction strategies can fail for many reasons, including the following:

- Strategies that develop good information about hazards but are not linked to risk reduction actions will not be effective.
- Strategies that demand actions for risk reduction but do not include adequate characterization of the hazards may not be successful, cost-effective, or useful.
- Strategies that 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 will often be unsuccessful.
- Strategies that place the emphasis on interaction and process but not on the acquisition of substantive information or proper discovery of the most effective strategies will be ineffective.

The general information provided here describes how hazards can be effectively handled. The strategies are sufficiently general to fit into the context of most regulatory or public-education schemes. The manual does not to describe a preferred regulatory decision-making process or provide extensive information on such processes. Instead, it describes the basic elements that should be present in any effective regulatory process or decision-making process.

In Oregon, there are many opportunities to reduce risks from geologic hazards. A comprehensive framework of land use statutes and goals guide planning for a wide range of considerations, including some strategies to reduce risk from hazards. In addition, building code regulations, manuals for construction practice, public education, and voluntary actions have their equally important respective roles in reducing risk from geologic hazards.

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

The focus of this manual is to present insights and information on how hazards can best be understood and managed, from a technical and a risk-management point of view. It does not focus on procedural elements of various agencies or on the mechanics of how they make their respective decisions.

The general process described here is not intended to replace or compete with any preexisting policy framework for any given jurisdiction. Rather, the process described here can be adapted to fit preexisting procedures or schedules.

Why a technical reference manual?

Oregon has among the widest variety of significant geologic hazards of any state in the union. A broad base of readily available information about the hazards that occur in Oregon and about the strategies that are available for risk management can be useful. It can provide the policy maker with a needed perspective and background to guide proper selection of necessary actions for a community.

Demographics show an increase in the risk to Oregonians, as development becomes more intense and moves onto more hazardous land. With proper information it is possible to realistically manage the risks posed by these natural hazards.

The diversity of geologic hazards in Oregon is summarized in Appendix 1, and significant events for various kinds of hazards are summarized in Appendix 2. The science of geology tells us that events of the future will exceed those that we have experienced in our brief history of occupation to date, as is shown in ***Appendix 3****.*

Reduction of risk from geologic hazards is frequently not achieved. There can be many reasons for this, including the following:

- The hazards are unrecognized or poorly understood.
- The risk posed by a hazard is not understood.
- The full range of choices for risk reduction is not fully investigated.
- There is the notion that the scientist who defines the hazard is also the one prescribing the solution.
- The process for establishing a risk reduction strategy is ill defined.
- The issue is so diverse and involves so many stakeholders or participants that the process simply bogs down.
- Those charged with reducing risk are uncomfortable asserting a policy position because of a lack of information, interagency support, or documentation.
- The community has not specifically defined the purpose of its policy, leading to a lack of clear direction or to the inability to make clear tradeoffs toward specific policies.
- The community does not view the hazard as a problem and chooses to handle it on a case-by-case basis rather than develop a community-wide strategy.
- Legal jeopardy may not be well understood.

In simple terms, 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 they may actually have and the tradeoffs associated with each; and
- 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 may be better viewed as attempts to effectively manage the risk. The goal of this manual is to help provide much of the general technical information and perspective needed to effectively reduce risk in Oregon.

The intent is not to advocate any particular set of solutions or pathways to develop them. Simply stated, part of what is needed is the right information of the right kinds in the hands of the right people at the right times.

This manual summarizes the geologic hazards of Oregon. It provides perspectives on how the geologic view of the hazard may differ from the view provided by history alone. It lists numerous general strategies that might be pursued in the reducing of risk from hazards. Communities need to choose which strategy or strategies best suit their needs; information provided here may help them to do that.

This manual includes an illustration of how characterization, team selection, risk-reduction strategy selection, and institutionalization of choices actually worked in a case example involving the Salem area. The project was a landslide risk-reduction strategy process used by the City of Salem, Oregon, and bordering Marion County in the Salem Hills; and Polk County in the Eola Hills (Appendix 22).

General lessons learned in the Salem area can be applied to geologic hazards in general in other parts of the state. The main messages of this manual can also be applied in other states even though regulatory schemes or risk reduction schemes may differ from those in Oregon.

How to use this manual

This manual is designed for reference by a variety of audiences varying from general to technical and from policy-oriented to research-oriented. It is not necessary to read the entire manual. Instead, it is designed so users can locate facts or specific discussions in which they are interested.

Each appendix can be used by itself, without first reading the complete manual before it. Those with general interests will benefit most from this general text that precedes the appen-

dices. Specialists will find helpful additional information in the appendices. Key appendices are noted in the text where they seem particularly relevant.

Recognize that geologic hazards are a growing problem

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

First, Oregon is a state with a wide range of geologic hazards of potentially significant impact.

Second, demographic trends are pushing development into higher hazard types of terrain.

Third, recent legal actions are defining the responsibilities and liabilities of communities, developers, and landowners better.

Fourth, regardless of the overall average risk for the state from any given hazard, the specific impact where disasters occur is catastrophic for the victims, so reasonable steps to manage the risk are expected.

*The relative magnitude of the risk is addressed in **Appendix 4.***

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 geologic hazards

For a geologic hazard to be properly mitigated, the hazard must first be characterized. This is a determination of what the hazard is, where the hazard is, how bad it is, and how often it might become a problem. Note that this is a broader consideration than simply "delineation" of the hazard, which is the operative term in some older discussions.

Delineation (where the hazard is) is just part of characterization. There may also be a need to evaluate the interplay of the specific hazard with other hazards. Sometimes a proposed solution for one hazard simply aggravates another hazard. Multi-hazard analysis (Appendix 6) is therefore recommended where more than one hazard exists.

*The characterization of geologic hazards is discussed further in **Appendix 5** and the issues related to multiple hazards at the same location is analyzed in **Appendix 6.***

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 (Appendix 3). Available information on hazards should be consulted, but in many instances, available information alone may not be adequate. There may be a need to develop additional information.

Knowledge of geology helps to provide a complete perspective on the severity of the hazard. By developing this kind of information in addition to historic information, we better position ourselves to make good judgments about how much or what kinds of risk-reduction strategies to pursue.

Proper characterization of the hazard (Appendix 5) enables us to understand the extent, magnitude, 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 by focussing its energies elsewhere. Where hazards are significant, carefully selected strategies of risk reduction are in order. With proper characterization, the community can determine where within the community strategies are needed and where they are not needed.

Realistic risk reduction involves recognition that a range of actions is possible (Appendix 17). Possible actions range from the minimal no-action approach to the maximum safety approach of total prohibition of activity in high hazard areas. A range of creative solutions may be applicable to specific situations.

Create an equitable team of stakeholders

Risk reduction is the proper and shared interest of a range of stakeholders. A properly selected team of participants must be constructed to address the risk (Appendix 8). It is not solely the planner or any other single individual who alone reduces risk. For small and simple hazards, the team of stakeholders may be small, strategic, and even informal. For large and difficult hazards, more formal and larger arrangements are advised.

*The creation of the Project Management Team is discussed in **Appendix 8** and its role in the risk reduction process in **Appendix 9.***

On large and difficult hazard situations, risk reduction can be the responsibility of many entities, including officials from building codes, planning, roads department, and emergency management; members of the public, property owners, realtors, and others (Appendix 8). Actions taken by each can help to manage the risk, though none by itself manages all the possible risks. Development of a risk reduction strategy involves coordination of the respective efforts of each.

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. Standardized approaches toward creation of the team of stakeholders may not make sense everywhere (Appendix 7).

***Appendix 7** includes a discussion of the proper level of effort to invest in characterizing hazards, which varies considerably with degree of hazard and degree of exposure.*

New partnering initiatives can show considerable promise for reducing the risk of particularly significant hazards. Project Impact, a new national initiative sponsored by the Federal Emergency Management Agency (FEMA) for example, is one of many efforts that can be implemented 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 successful, if they properly address the basic principles forwarded in this document.

*The role of state and federal agencies is treated in **Appendix 10.** The strengths and limitations of state agencies in Oregon are displayed in **Appendix 11.** This discussion can serve as the starting point in the construction of effective statewide governmental partnerships aimed at a disaster resistant state.*

*Key legislative responsibilities are presented for the Oregon Department of Geology and Mineral Industries **(Appendices 12 and 13),** the Office of Emergency Management **(Appendix 14),** local government under the provisions of Goal 7 **(Appendix 15)** and the Building Codes Division **(Appendix 16).***

Know the specific reason for the strategy

Strategies or policies to address risk from geologic hazards can be many and varied. Because strategies inevitably involve tradeoffs, it is important to clearly define the reason for the strategy before making decisions. The specific reason for the strategy can influence tradeoff selection and the manner in which the hazard is characterized.

For example, if the desire is to characterize hazards to develop insurance premiums, the end result will be a statement of statistical losses which will then be translated into premiums to cover the losses. But if the desire is to characterize hazards as a basis for policies to avoid losses, a more conservative line will be drawn. This may involve restrictions through land use planning processes. In the former, insurance-based case, the goal is met if losses are handled actuarially, but in the second case the goal is to minimize or entirely avoid losses.

Various interests may approach hazards differently, given their differing objectives and goals (i.e., management of cost sharing vs. total elimination of risk). That is why a method of hazard treatment by one entity may not satisfy the needs of another.

In Oregon, 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 to the development of hazard risk reduction policy, therefore, is a clear recognition of the desired outcome of the policy when applied.

Characterizations of a hazard by one party for one purpose may not meet the needs of another party for another purpose.

Strategies are community specific

Management of risk from geologic hazards involves recognition that selection of risk management strategies involves community-based 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 in Oregon, it is clear that strategies may 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. At the same time, general reference to well-developed ordinance language from an analogous area certainly can provide a good starting point for a community in the development of a community-specific regulation or ordinance.

It must be recognized, however, that cursory review and adoption of an imported "model ordinance" for any given hazard generally may not be effective in reducing risk. In complex areas like much of Oregon, it is often necessary to modify model ordinances to meet local conditions.

In pursuing risk reduction from geologic hazards, a community may benefit from the general treatment of geologic hazards already addressed in part by existing statute, goal, or rule at the state level. For example, statewide land use planning goals and federal regulations prescribe conditions for participation in the National Flood Insurance Program. Another example is the limitation that Goals 17 and 18 place on mitigation of coastal hazards. Finally, the state Building Code rules prescribe the levels of seismic risk that will be accommodated in new construction and the kinds of site-specific reports required for certain kinds of structures.

Select from a range of strategies

Knowledge of the full conceptual range of available mitigation actions is helpful in focusing on acceptable strategies for a particular community or situation.

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.

*Respective general responsibilities of selected state agencies are summarized briefly in **Appendices 10 and 11.** Some of the individual responsibilities for some major state agencies are summarized for easy reference **(Appendices 14, 15, and 16).***

The specific strategy selected by one community may be different from that selected by another, owing to differences in the magnitude of the hazard, the frequency of the hazard, the interplay of the one hazard with other hazards, or the institutional settings of the respective communities. Often cost-benefit considerations drive the final selection.

*A full range of strategies used historically for various hazards at various locations in Oregon is provided in **Appendix 17.***

Where jurisdictions abut one another in a hazard zone, coordinated efforts are desirable. In a state with the diversity of Oregon, it is appropriate to pursue geologic hazard risk reduction with an open and flexible approach that looks at a range of options.

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 the community is willing to accept.

These discussions can take place locally, regionally, or at the state level, depending on jurisdiction. As noted above, statewide frameworks may

already guide many of these discussions in a general way. The Oregon Department of Geology and Mineral Industries (DOGAMI) has responsibility to provide information on geologic hazards (Appendices 12 and 13).

In a community where a few problems have occurred but no legal actions have been taken, a strategy of little action may be acceptable in the short term. In a similar community with a significant hazard but a history of legal proceedings against the city or other parties, more rigorous management of the risk may be chosen as the appropriate course of action.

The general pattern of risk reduction strategies in use in Oregon is described generally in ***Appendix 18.***

The geology and land use may be the same in both cases. But the approach of the community will be different. The role of the geologist is to characterize the hazard, inform the participants, and provide technical support.

It cannot be emphasized enough that where significant geologic hazards are present, the process of characterizing them is separate from selecting options to deal with the 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 communities themselves.

In pursuing a final selection of a strategy to deal with a hazard, a community policy team may have difficulty making the final decision. Cost-benefit analyses of the various options are often helpful at this stage. For example, if a city or county is having trouble deciding what to do with a slide-plagued rural road, it might consider the options of reroute, road closure, or engineered correction. Cost estimates for each relative to the value of the road can assist in making a final selection. Other considerations may also dictate the selection. For example, the road might be critical for emergency services, so road closure would not be an option.

Make the strategy permanent

The selected risk reduction strategy must be put into place permanently, so the effort continues past the participation of those who were initially involved This is called "institutionalization."

This responsibility may fall on any of a wide range of agencies as shown in ***Appendix17*** *and discussed in* ***Appendix 19.***

Institutionalization may include adoption of

- Planning ordinances;
- Building code revisions;
- Training efforts;
- Public information strategies, including publications or signs;
- Storm water management and erosion control programs;
- Emergency plan chapters;
- Revisions to construction and design manuals;
- Revisions to manuals for road construction;
- Other efforts 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 any other member of the risk reduction team. In some cases, several persons will assume a role in a coordinated effort. The challenge is to follow through to completion and meet the chosen goal.

Proceed with perspective

A jurisdiction may be willing to dicuss strategies but does not have an information base or resource base to move ahead with any measure of confidence and reliability.

Regulations and requirements bring with them legal considerations. These are discussed in ***Appendix 20.***

For hazards warranting considerable effort, the process and information provided here provides a firm basis for action. This includes hazard characterization, team effort, consideration of a

range of strategies, selection of the best strategies, and careful selection of the method of establishing permanence through implementation.

Oregon is a challenging state, but also has many unique resources to direct at the challenge as described in ***Appendix 21.***

A minimal effort of risk reduction from geologic hazards should

- Properly characterize the hazards;
- Address multi-hazard issues;
- Involve a properly constructed team including the public;
- Address an array of choices for risk reduction;
- Select a choice, make the choice permanent; and
- Demonstrate reasonable chances of success in the eyes of science.

These steps remove 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 through time often intensifies in a given area, leading to increased hazard potential as the natural terrain is altered.

The level of effort to be expended in each of these components varies greatly with circumstance as discussed in ***Appendix 7.***

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.

A very large series of scenarios could be displayed to provide a complete set of examples to show how strategies become institutionalized once they are selected. This is not necessary. The key point is that once a strategy is selected, it is incumbent on the lead agency or agencies to put it into place permanently in the most effective manner that is available and that is politically feasible.

Considering the Salem example of working to reduce the risk of landslides provides a detailed and instructive record of how a community addressed a geologic hazard using the principles of this manual.

The landslide risk reduction effort in Salem, Marion, and Polk Counties is an instructive example of how the information and guidance of this manual can assist in reducing risk from geologic hazards. The effort is summarized in ***Appendix 22.***

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. Included are wide varieties of landslides, earthquakes, coastal erosion, volcanoes, tsunamis, and floods. 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.

A brief look at some of the hazards in the following list illustrates the wide variety of hazards and shows the close relationship of the hazards to the geology. It is little wonder that in a geologically diverse and active state like Oregon knowledge of the geology and emphasis on flexibility are keys to understanding and reducing the risk presented by the hazards.

Although it is not the purpose of this manual to exhaustively review the technical aspects of geologic hazards in Oregon, they are briefly summarized here for clarity.

- Earthquakes are of three types; those associated with shallow crustal faults, those associated with the subduction-zone fault off the coast of Oregon, and those associated with very deep displacements on the lower crustal slab. Modeled losses in the future for Oregon indicate hundreds or thousands of lives lost on the average every 500 years and a total of $65,000,000 in damage as an annualized average..
- Landslides are of many types and 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–$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. For Oregon, moderate ash fall, localized lava flows, and extensive debris flows down major river channels are the most likely threats in long-term planning scenarios. The eruption of Mount St. Helens took 57 lives in neighboring Washington State in 1980.
- Tsunamis are large waves caused by severe displacement of the sea floor, generally through earthquake activity. Local sliding under the ocean may greatly increase the size of predicted tsunamis. Oregon is threatened both by tsunamis from distant sources and those from activity on the nearby subduction zone. Losses of lives from a large tsunami along the Oregon coast could easily be in the range of 5,000 lives 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 instance Oregon experienced the third largest flood fatality total of any flood in the nation since 1900 (247 in 1903; see Appendix 3). Economic losses have topped hundreds of millions of dollars in some recent floods.
- Stream-bank erosion is a hazard that has gained increasing importance, as understanding of and priority for fish survival achieve prominence. 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 annual and long-term sediment loads are highly variable relative to the capacity of the stream to move them uniformly.

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.

(Continued on next page)

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. The total magnitude of geologic hazard risks in Oregon

The magnitude of geologic hazards for Oregon is far greater than our limited historic frame of reference might suggest. Our limited time of observation is not a complete measure of the kinds and magnitudes of hazards that might occur. Here in Oregon, written history is less than two hundred years old.

For Oregon, the annualized loss of life probably can be estimated at one to two for landslides, earthquakes or floods. Property losses probably range in the tens of millions for landslides and floods. The very general fatality figures for floods and landslides are based on the short historical record. In addition, flood losses have totaled hundreds of millions of dollars in extreme single events in recent years.

For earthquakes, estimated annualized losses are approximately $65 million per year, using currently available computer models and data. For other hazards such as tsunamis and volcanoes, any calculations at this time would involve fairly general estimates of fairly infrequent events and would be highly speculative.

Losses from natural hazards in Oregon are very significant. However, they may not appear large on an annualized basis. To facilitate risk comparisons, losses are often viewed on a per-year basis in some statistical approaches. This technique works fairly well where losses are evenly distributed geographically and do not vary much from year to year.

In contrast to a consideration of annualized losses, however, a consideration of actual losses for even a modestly sized hazard in a specific event at a given location is impressive. Also, the very large size of some of the less frequent future disasters demand attention. This is true even though statistical treatments leading to annualized losses may not appear troublesome. Measures to avoid or reduce these events of loss and suffering are expected for natural hazards of highly variable annual magnitude and often very local occurrence.

Further, increasing population and demographic shifts are often directed towards increasingly hazardous areas of the state. Early development occurred in floodplains and more recent development is occupying steeper terrain. The estimated losses noted above that rely on historic patterns or current patterns of occupancy are therefore understatements of future risk.

In general it is unrealistic to seek absolute safety from geologic hazards. As communities attempt to do what is reasonable and responsible questions arise regarding exactly how much risk they may be dealing with for any particular hazard. This information is useful for deciding a realistic course of risk reduction.

Appendix 5. Specific hazard characterization

Characterization

Reducing geologic hazard risks requires that the geologic hazard be properly characterized. Historically, discussions related to this issue in Oregon have focused on the "delineation" of the hazard. Drawing a line around the hazard was generally treated as adequate. Once the line was drawn, the management technique often was simply to require site-specific reports prior to individual developments inside the line.

The first key to reducing risk from geologic hazards, therefore, is to proceed from a proper characterization of the hazards. In addition to understanding the distribution of the hazard, proper characterization involves a determination of the frequency, the potential impacts, the causes, and sometimes the variability of the hazard from place to place. It is becoming increasingly clear that management of "known hazards" is not adequate for risk reduction. Communities are becoming increasingly surprised by the occurrence of geologic hazard events about which they had no prior knowledge.

Currently, DOGAMI is mandated by statute as shown in Appendix 13 to develop information about hazards so that they become known.

Types of Studies

Techniques of characterization can be arrayed according to degree of effort or relative cost. At the start are library searches, general map analyses, aerial photographic studies, and Geographic Information System manipulations.

Numerous kinds of maps of varying resolution have been developed for the various kinds of geologic hazards that occur in Oregon. These are summarized in the following table.

Regional characterizations of hazards can be used to guide broad policy development for risk reduction. In addition, site-specific studies can be mandated to assure adequate characterization before construction.

There is also the growing recognition that subdivisions and other multi-site proposals for development may need area-specific geologic hazard assessments. These can address collective impacts of multi-site development such as collective runoff, collective drainage modification, collective erosion, and other impacts not specifically originating at any given site. They may also address off-site conditions that may be hazardous to the site in question.

More intensive techniques include field mapping, geophysical data collection, drilling, sampling, and others. Proposed development often requires field investigation of some kind in addition to the less expensive and more general office-based efforts.

Map Scale and Content

A commonly misunderstood aspect of hazard characterization is the assumption of an ideal map scale. The scale of hazard maps needed to implement given strategies varies. A broad policy option that requires further studies in some areas but eliminates other areas from further consideration may have a relatively small scale (1:24,000 or smaller). The necessary scale for mandated studies in follow-through target areas may be larger. Emergency managers, for example, may be properly served with one scale, while planners with activities keyed to specific site decisions may be better served with another.

The scale needed to characterize different kinds of hazards also varies. Regional maps are often needed to address regional issues. In spite of increased detail available in site-specific maps, such maps often do not capture regional hazards.

For example, in coastal areas, there is increasing discussion of littoral cell management to address the close regional aspects of erosion and deposition effecting adjoining properties along a given beach. Regional maps are needed to capture littoral processes. In inland areas, intermediate-scale regional maps also are often needed to capture broader hazard aspects of hillsides such as drainage. The same is true of some areas slated for subdivisions and of stream corridors. The unique place of hazard maps of intermediate scope and scale is shown in the table at the end of this section.

It is not a cost-effective expectation to have the entire state mapped on a site-specific basis for all hazards. It is also not necessary. With an array of risk reduction strategies to choose from, it is possible to match general map scale with the general level of detail implicit in the policy. For example,

where societal needs mandate detail for decisions specific to given parcels, large-scale maps may be needed. For other areas subject to broader policy schemes, more general maps of smaller scale may suffice.

Earthquake hazard maps and risk reduction avenues provide a particularly instructive example:

- For earthquakes, a series of studies of progressively greater cost and focus is available. Bedrock shaking is characterized at the state or regional level. Ground response is dependent on soil types, thickness, and water content and is best characterized at the community level. These studies are complete for much of Oregon. In this context, soil type does not refer to agricultural soils mapping, but rather soils mapping for ground response for earthquake shaking. Successive characterizations of hazards can be made toward an understanding of the specific locations of the earthquake hazards in terms that can guide cost-effective mitigation.
- Building type also is important for risk to property or to life in an earthquake. The Federal Emergency Management Agency (FEMA) issues publications to guide the evaluation of buildings. Using FEMA Publication 154, a community can briefly evaluate all buildings for general rating or prioritizing in terms of earthquake risk. FEMA Publication 178 can be used to define more clearly the rehabilitation that might be considered for a given building selected for more consideration. FEMA Publication 273 provides techniques for developing strategies for given types of construction for predetermined levels of safety, such as life safety. Working with all of these tools, a community can fashion a focused effort to reduce earthquake risk.

A key overriding point in a more general sense is that there are many kinds of studies, many levels of effort, and many strategies of risk reduction that may be appropriate for any given hazard. The table at the end of this section summarizes the kinds of maps that have been prepared for various hazards in various parts of Oregon. Each serves its intended audience; yet there is a variety of scales and of technical content for the maps of any given hazard.

Other Considerations

A close working relationship with a qualified expert can be most essential for a community trying to discover the risk reduction strategies that best meet its needs. With well-placed advice, a community can properly address the array of risk reduction strategies that makes sense to the community but that also actually work.

Appendix 17 summarizes a general array of risk reduction strategies that applies in general to any kind of geologic hazard.

The Oregon Department of Geology and Mineral Industries (DOGAMI) is charged with characterizing hazards in a general way (Appendix 13). In prioritizing its efforts, the agency generally considers severity of the hazard and relative size of the impacted population in terms of life safety and economic impact. Other agencies also have roles in hazard characterization, particularly in certain circumstances involving the safety of their respective operations or holdings.

While the private sector tends to focus on characterizations for individual clients, it often relies on the more general products of state government to help assure efficiency, correctness, and cost effectiveness. Government agencies may archive reports completed by the private sector for the purposes of public information. Cooperation between government agencies and between government and the private sector can help to assure accuracy and high quality of reports.

Where various parties work together, the public is also well served. For example, access to funding by one agency might be linked to ability to perform studies by another, all for the service of a third party such as local government, which might be responsible for the public safety. Advisory groups and management teams as discussed in the introductory text can help bring these parties together.

Registration of professions and adoption of report guidelines can also help to assure quality control. In Oregon, the Board of Geologist Examiners registers geologists and engineering geologists and has adopted guidelines for the content of engineering geology reports conducted in the state.

Provisions for peer review of reports can help to assure quality control as well. Effective and affordable systems of peer review require close cooperation between local and state agencies, the community and its consultant, and professional associations. Close coordination between those making the regional hazard assessments, subdivision assessments, and site-specific assessments can help to assure maximum effectiveness and accuracy of each. Systems of peer review can include local mandates supplemented by peer-review teams or oversight for particularly critical issues by overview bodies or even state agencies.

Table Appendix 5. 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.

(Continued on next page)

Table Appendix 5. 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 6. Multi-hazard considerations

Geologic hazards do not always occur in isolation from one another. It is not uncommon in Oregon for two or more geologic hazards to occur together. Part of a hazard characterization, therefore, may include the development of an understanding of more than one hazard at or near a given location.

Care must also be taken to assure that the selected mitigation for one hazard does not increase risk exposure from another. A systematic review of selected options for the various hazards may be needed.

An example is the need to manage runoff in slide-prone areas. Routing runoff to avoid aggravating slides in hillside subdivisions is crucial. Yet, the increased runoff in key drainage areas within and below the subdivision can become a safety hazard or an environmental hazard in itself. With proper location and design of runoff management systems it is possible to control the slide hazard while keeping problems associated with increased runoff within acceptable levels. For urban areas, associated erosion and stream water quality is also becoming an increasing concern.

Where more than one hazard presents significant risk, a range of options for risk reduction may need to be pursued. In the ideal case, there is no incompatibility of proposed solutions for each hazard. Where conflicts between risk reduction options are present, clear information about the nature of each hazard generally is needed to formulate workable solutions. This includes information on hazard frequencies under natural and altered conditions, potential hazard impacts, and the specific causes of the hazards.

In other situations, the reduction of risk from one hazard may simply be viewed as a matter of choosing mitigation for one hazard over another.

An example is the choice that is sometimes made between erecting structures on stilts to avoid floods. Elevated construction may alleviate the flood hazard but may increase the risk of damage from less frequent earthquakes. Where earthquakes are known to be infrequent and small, the choice for stilts may make sense. Where earthquakes are more frequent and larger, the use of stilts may not make sense. In either case, foresight may provide proper judgment in addressing mitigation for both hazards. Sufficient hazard characterization is needed to guide the proper and practical choice for a community. Sufficient information might also guide specific design development or siting decisions that properly addresses both hazards.

In all cases where more than one significant geologic hazard is present, proper characterization of the hazards in terms of magnitude, frequency, aggravating factors, and impacts is key to developing and selecting appropriate risk reduction strategies.

Actions taken to manage water quality through runoff management can aggravate landslide conditions. Also, diversions of runoff to local streams can increase flood potential downstream in urban environments. Based on proper characterization of the landslide risk and proper modeling of the runoff potential, it is possible to develop strategies for both concerns that are keyed to the specific situation. Foresight is needed regarding the potential problems and proper development of a workable strategy. Commonly this is a condition of development placed on the developer.

The following table plots the intersections of hazards that may interact with each other at a given location and states some of the conflicts that might exist between the hazards. For any given site, an experienced professional may be needed to perform on-site evaluations and to construct a complete list of issues in need of evaluation.

Table Appendix 6. Multi-hazard considerations

	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 7. Appropriate level of effort

A key consideration for any community in the development of risk reduction strategies for geologic hazards is the level of effort that is most desirable. Consideration of magnitude of losses in terms of lives or economics on an annualized or event-based perspective is appropriate. Proper characterization can provide the necessary information. For some communities, a brief survey and continuation of current practices may be adequate. For others long-term intensive efforts including public participation might be more appropriate.

The cost of adequate characterizations is an important consideration and can be an obstacle to their completion. The public is best served where prior studies are available in the public record and are, therefore, retrievable in routine library searches, on the Internet, or for sale in readily identifiable outlets.

Some general principles can be stated to scope the appropriate level of effort:

1. The community should consider a range of possible hazards rather than just hazards about which given individuals have prior knowledge.
2. Level of effort can be scaled to level of risk. This is not the same as scaling effort to the level of immediately available resources.
3. For each hazard, the analysis should reasonably address the entire extent of the community, ideally extending at least to the current urban growth boundary.
4. The level of effort between hazards or from place to place for a given hazard can vary as a matter of professional judgement and prudence.
5. Hazards of significance for urbanizing areas require some level of field investigation in addition to library searches and Geographic Information System analysis.
6. The effort should involve a policy team to address strategies in a manner open to the public.
7. The effort can be guided by the "prudent person" principle. (Would a normally prudent person without a vested interest, using reasonable effort and using reasonably available information arrive at substantially the same conclusions?)
8. Treatments of a given hazard may vary from community to community, given the high degree of variability of hazards in Oregon.
9. The level of effort should be determined by considerations of risk and not necessarily by levels of readily available funding. Creativity, support of relevant programs, and partnerships can eventually bring available resources more into line with the actual need.

In any given community, as development patterns change through time, the relative need for any given strategy may also change or need to be changed. What worked well under one set of conditions in the past may not work well under different conditions in the future.

Of significance here is the general willingness of society to focus risk reduction efforts on certain levels of risk for a fairly narrow band of occurrence. Events with greater than 500 to a few thousand years recurrence generally do not attract much attention for most kinds of construction. In general, occurrences of less than one in 1,000 years fail to generate public interest. Hazards of a seasonal nature (storms), 100-year occurrence (100-year floods), or even 500 years (the frame of reference for earthquake construction regulations) generate interest only if the impact is high enough. It is a general observation that the public generally is not interested in any kinds of hazards having very low probabilities of occurrence. Threats of asteroid impacts are the province of Hollywood, not City Hall.

Within this pattern, this reference manual emphasizes that proper characterization of hazards in terms of intensity and frequency can help communities to decide where to place their efforts in reducing risk from geologic hazards. To the extent that the community wants to know frequency of occurrence (as a prelude to a decision whether or not to mitigate), a characterization study is needed. Without characterizing the study area there can be no basis for stating the potential frequency of occurrence that can be expected for any given hazard.

Risk reduction from geologic hazards generally requires concerted efforts to form effective and properly focused partnerships. These partnerships may require the engagement of new agencies or groups to be successful. Accordingly, team formation and team effort is given emphasis in the procedures recommended in this publication.

Where lawsuits are common regarding geologic hazards, the cost of proactive risk reduction is generally far less than the cost of settlements for future cases. Where nothing is known of a potential hazard one way or the other, a qualified expert should be retained to perform a reconnaissance level study, at a minimum.

Regardless of the level of effort that is selected, most agencies operate with review cycles for their regulations, ordinances, or instruction manuals. Coordinating activities described in this book with pre-existing cycles of decision making can greatly reduce the apparent workload involved in achieving reduction of risk from hazards.

Appendix 8. Team membership

In efforts to achieve actual risk reduction a common question simply is: "Who is supposed to decide what to do about the hazard, once it has been adequately characterized?" The answer varies depending on the nature of the hazard, the causes of the hazard, the organiztion of government in the community, the working relationships between agencies, and the relationships between agencies, the private sector and the public.

The identity of the most appropriate party to take the lead varies.

The size of the project management team will also vary with circumstance. Some efforts will be large; others will be streamlined. Establishment of a team should not be approached rigidly. Focus should be on prudently engaging key stakeholders and assuring public input along the way. Routine procedures for public involvement, open meetings, and open records generally address these issues.

Areas of truly large hazard efforts for risk reduction can best be accomplished with a team that systematically addresses options, preferences, costs, and probable benefits. The team generally will need to interact with scientists to understand the interplay of the hazard with various options and to respond to questions. For areas of lesser hazard or risk, streamlined versions of teams described in this discussion may be acceptable.

To properly consider options for risk reduction, a large hazard team with expertise and responsibilities spanning the full range of options generally may be needed. In constructing the team, it is not appropriate to assume that hazard risk reduction is the sole responsibility of the planner, or to assume that all geologic hazard risk reduction can be encompassed, for example, in the comprehensive plan.

As a function of the significance of the risk and the size of the effort, team members, therefore, might include any or all of the following:

1. Scientists knowledgeable about the hazards;
2. Building code officials to take the lead on building-specific solutions;
3. Planners to take the lead on regional, more general strategies, particularly development and resource protection strategies;
4. Emergency responders to lay the groundwork for emergency response or to provide communication networks with local officials;
5. Local officials involved in making the decisions for their respective areas;
6. Lifeline representatives (roads, water, sewer, power, phone);
7. Realtors, insurance, financial institutions;
8. Members of the public, neighborhood associations/groups;
9. Appropriate risk management officials;
10. Others, including developers, builders, construction trades;
11. Public-private facility and utility providers; and
12. Special-interest groups such as watershed councils or resource protection groups.

Appendix 9. Roles of the strategy selection team

The role of the Strategy Advisory Team is to address strategies for risk reduction. It may also function more broadly as a Project Management Team with responsibilities to provide for hazard characterization, to receive the hazard characterizations, and to lead community consideration of the full range of possible risk reduction options. Their role is to define the preferred course of action and to pursue effective institutionalization and implementation. If the role includes oversight of the characterization, the specific needs of the community are better addressed in the design, scope, and emphasis of the characterization effort.

The level of effort expended by the Project Management Team can be scaled to the level of risk that is being addressed. (See also Appendix 8.)

Specific responsibilities of the team might include

- Grant management and oversight of characterization;
- Work plan development for the overall effort;
- Periodic meetings;
- Provision of opportunities for public outreach and input;
- Review of current mitigation efforts;
- Coordination with stakeholders;
- Coordination with state agencies;
- Selection of risk reduction strategies.

Success should be viewed in terms of a team effort by many entities. It is important to understand the general strong points and weak points of the main team members. Key to success is the linking of strong points to the point of discrete actions selected by the community. Each participant has a key role, and no participant can play lead for all the roles.

The role of the scientist and engineer is to speak for Mother Nature in the discussions, so that options that are considered are also feasible. Science, which provides for the characterization of the hazard, does not dictate the final choices, however.

The scientist fulfills the role of technical advisor as the policy persons learn about the hazards, present options, ask questions, and eventually settle on preferred methods of risk reduction for the community. These methods might include a mix of public education, emergency planning, land use decisions, building code requirements, guidance for road construction, alterations of natural terrain, and restrictions on storm water drainage.

Appendix 10. The role of state and federal agencies

The services of several key state agencies can be of assistance to local communities as they select and implement risk reduction strategies for geologic hazards. Keys among these are

1. Office of Emergency Management (OEM), primarily with major responsibilities for disaster mitigation, preparedness, response, and recovery and the administration of federal funds after a major disaster declaration;
2. Department of Land Conservation and Development, with major responsibilities for planning-based hazard management including the implementation of Goal 7 (geologic hazards), the implementation of Goal 18 (beaches and dunes), and oversight of the State's federally funded Coastal Zone Management Program, with attention given to coastal hazard policy, hazard assessments and hazard mitigation;
3. Building Codes Division and local counterparts, particularly with major responsibilities for construction and for some hazards that are building-specific in their occurrence; also included are provisions for expansive soils, management of buildings after damage in an earthquake, and classification of buildings possibly coming under the purview of tsunami zone restrictions; and
4. Oregon Department of Geology and Mineral Industries (DOGAMI), with major responsibilities for geologic hazard characterization, public education, the development of partnerships aimed at reducing risk, and exceptions (based on science-based refinement of tsunami inundation zone delineation) to state-mandated tsunami zone restrictions.

In general, unless the Legislature acts or a state agency exercises an assigned responsibility, it is ultimately local communities that must develop the strategies and policies for reducing significant risk from geologic hazards. Partnerships involving federal agencies, the general public, the private sector, and state and local government are needed. State agencies can serve several key service functions. These include

1. Pursuing statewide policy in situations that warrant such an approach. Included, for example, are provisions in state building codes or the development of Goal 7 in the land use planning process;
2. Providing technology information transfer through automated information exchange, information outlets, guidebooks such as this one, or workshops;
3. Providing long-range efforts of benefit statewide through strategic planning for agency programs;
4. Developing objective lists of communities in terms of risk exposure to guide expenditure of limited funds;
5. Establishing a policy framework for treatment of hazards statewide;
6. Providing broad public education for given hazards such as the public education efforts for tsunamis by DOGAMI and OEM, or the previous joint development of the debris flow warning system after the losses of 1996 and 1997;
7. Providing technical expertise and capacity in the characterization of hazards or in the translation of hazard data to policy; and
8. Providing access or reference to relevant literature in respective areas of expertise.

Involvement of many agencies in hazard mitigation is positive when the agencies coordinate their respective efforts and individually focus on tasks most related to their respective strong points or assigned responsibilities. The key concept underlying these specialized responsibilities is that the agencies form and function as a team having broad capabilities to pursue a disaster resistant state for Oregonians.

Numerous federal agencies maintain programs aimed at geologic hazards. The Federal Emergency Management Agency (FEMA), for example, oversees a wide variety of hazard-related programs including the National Flood Insurance Program and Project Impact. FEMA also provides relief after a presidential declaration of a natural disaster.

The US Geological Survey (USGS) develops broad information about numerous geologic haz-

ards. Land management agencies like the Bureau of Land Management and the USDA Forest Service deal with hazards on the lands they manage. The U.S. Corps of Engineers and the U.S. Bureau of Reclamation consider flood management in the operation of dams.

Creative partnerships are generally required to produce an effective delivery system. Local government, state government, and the federal government must strive to maintain existing effective partnerships. Among these are the Governor's Interagency Hazard Mitigation Team and some activities of the Community Solutions Team. In addition, new partnerships may be needed to better bring the benefits of appropriate federal efforts to local communities wherever necessary.

In addition, the process must draw upon the resources and interests of the private sector. Insurance companies, banks, charitable organizations, private trusts, and other public-interest groups often can amplify messages, provide assistance, assume responsibilities, and implement strategies as well as government can. Opportunities for creative cooperative ventures should be aggressively sought on all scales from local dissemination of simple information to national consideration of legislation such as hazard insurance.

Appendix 11. 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 12. Coordination of DOGAMI with other state agencies having major geologic hazard responsibilities

AGENCY	DOGAM ROLE
OEM **OFFICE OF EMERGENCY MANAGEMENT**	• Assist during disaster response; includes technical advice at command center • Provide information about hazards and coordinate closely related activities at the staff level • Promote proactive risk reduction based on information and community-wide approach
DLCD **DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT**	• Work with communities through broad-based group of stakeholders with attention on requirements of Goal 7 and State Agency Coordination Agreement • Assist efforts for Goal 7 process improvement upon request • Develop joint efforts to prepare and distribute community-based hazard maps
DOF **DEPARTMENT OF FORESTRY**	• Coordinate with DOF for landslide related activities on forested land • Participate in cooperative efforts for landslide warning system • Add agency data on landslides around communities and provide proper technology transfer to rural communities
LOCAL **CITIES AND COUNTIES** **WATERSHED COUNCILS** **SOIL & WATER CONSERVATION DISTRICTS**	• Prepare and distribute hazard characterizations for communities at risk from geologic hazards • Provide public education and work with local advisory groups as they develop policies and strategies to deal with significant geologic hazards· • Lead multi-hazard efforts where appropriate and where necessary • Provide limited peer review of selected geotechnical reports • Provide consultation for proposed structures in the tsunami inundation zone
BCD **BUILDING CODES DIVISION**	• Provide input into the development or revisions of structural codes and rules as appropriate; input is focused on that aspect of the revisions that relate to the geologic hazards • Provide geologic hazard information upon request or as needed for agency to perform its role • Assist in staff training exercises for geologic-hazard-related topics • Assist or promote building inventories for the purpose of assessing exposure to seismic risk • Coordinate efforts to administer the statutory restrictions on selected construction in the tsunami inundation zone

Appendix 13. Selected statutes of the Oregon Department of Geology and Mineral Industries

516.010 Definitions. *As used in this chapter*

(6) "Geologic hazard" means a geologic condition that is a potential danger to life and property, which includes but is not limited to earthquake, landslide, flooding, erosion, expansive soil, fault displacement, volcanic eruption, and subsidence.

516.030 Duties of the Department. *The State Department of Geology and Mineral Industries shall: ...*

(3) Initiate, carry out, or administer studies and programs that will, in cooperation with universities, federal, state, and local government agencies, reduce the loss of life and property by understanding and mitigating geological hazards. These studies and programs may include but need not be limited to: ...

(6) Statewide hazard assessment, including identification and mapping of geologic hazards, estimation of their potential consequences and likelihood of occurrence and monitoring and assessment of potentially hazardous geologic activity....

For responsibilities, see Appendix 4. Statutes ORS 455.446 and 455.447 detail the department's tasks in the context of statutes relating to building codes.

Where geologic hazards are significant, individuals and local governments commonly seek experience and expertise at the state level. This is not the only option. Assistance can also be sought from private companies or from the federal government. States with strong geologic surveys generally see the state agency being asked to conduct such functions as conducting peer reviews, providing published information, monitoring hazard situations, providing technical assistance, conducting hazards inventories, and providing advice on demand.

In Colorado, the Colorado Geologic Survey is charged with peer reviewing all site-specific geotechnical reports. In California, many county offices have hired professionals for that purpose. Situations vary from state to state. In Oregon, DOGAMI has a central role in the management of risk from geologic hazards. Whereas the land use planning process mandates that proper attention be paid to geologic hazards, state law directs DOGAMI to provide information on the hazards and to pursue joint efforts to accomplish risk reduction. The Strategic Plan defines major efforts in six-year time frames and the statute prescribes general responsibilities.

Appendix 14. Selected statutes of the [Oregon] Office of Emergency Management

401.015 Statement of policy and purpose.
(1) The general purpose of ORS 401.015 to 401.105, 401.260 to 401.325 and 401.355 to 401.580 is to reduce the vulnerability of the State of Oregon to loss of life, injury to persons or property, and human suffering and financial loss resulting from emergencies and to provide for recovery and relief assistance for the victims of such occurrences.

(2) It is declared to be the policy and intent of the Legislative Assembly that preparations for emergencies and governmental responsibility for responding to emergencies be placed at the local government level. The state shall prepare for emergencies, but shall not assume authority or responsibility for responding to such an event unless the appropriate response is beyond the capability of the city and county in which it occurs, the city or county fails to act, or the emergency involves two or more counties. [1983 c.586 s.1]

401.020 [Amended by 1975 c.379 s.8; repealed by 1983 c.586 s.49]

401.025 Definitions for ORS 401.015 to 401.580.
As used in ORS 401.015 to 401.105, 401.260 to 401.325 and 401.355 to 401.580, unless the context requires otherwise:

(4) "Emergency" includes any man-made or natural event or circumstance causing or threatening loss of life, injury to person or property, human suffering or financial loss, and includes, but is not limited to, fire, explosion, flood, severe weather, drought, earthquake, volcanic activity, spills or releases of oil or hazardous material as defined in ORS 466.605, contamination, utility or transportation emergencies, disease, blight, infestation, crisis influx of migrants unmanageable by the county, civil disturbance, riot, sabotage, and war.

(5) "Emergency management agency" means an organization created and authorized under ORS 401.015 to 401.105, 401.260 to 401.325 and 401.355 to 401.580 by the state, county or city to provide for and assure the conduct and coordination of functions for comprehensive emergency program management.

(6) "Emergency program management" includes all the tasks and activities necessary to provide, support, and maintain the ability of the emergency services system to prevent or reduce the impact of emergency or disaster conditions which includes, but is not limited to, coordinating development of plans, procedures, policies, fiscal management, coordination with nongovernmental agencies and organizations, providing for a coordinated communications and alert and notification network and a public information system, personnel training and development, and implementation of exercises to routinely test the emergency services system.

(8) "Emergency service agency" means an organization within a local government which performs essential services for the public's benefit prior to, during or following an emergency. This includes, but is not limited to, organizational units within local governments, such as law enforcement, fire control, health, medical and sanitation services, public works and engineering, public information, and communications.

(10) "Emergency services" includes those activities provided by state and local government agencies with emergency operational responsibilities to prepare for and carry out any activity to prevent, minimize, respond to, or recover from an emergency. These activities include, without limitation, coordination, preparedness planning, training, interagency liaison, fire fighting, oil or hazardous material spill or release cleanup as defined in ORS 466.605, law enforcement, medical, health and sanitation services, engineering and public works, search and rescue activities, warning and public information, damage assessment, administration and fiscal management, and those measures defined as "civil defense" in section 3 of the Act of January 12, 1951, P.L. 81-920 (50 U.S.C. 2252).

(16) "Oregon emergency management plan" means the state emergency preparedness operations and management plan. The Office of Emergency Management is responsible for coordinating emergency planning with government agencies and private organizations, preparing the plan for the Governor's signature, and maintaining and updating the plan as necessary.

401.260 Office of Emergency Management; director; employees.

(1) The Emergency Management Division that has operated under this chapter is continued as the Office of Emergency Management within the Department of State Police and is made the emergency management agency for the State of Oregon. The office shall be under the supervision of a director appointed by the Superintendent of State Police with the approval of the Governor. The appointee shall serve at the pleasure of the superintendent, shall not be subject to the State Personnel Relations Law, and shall be qualified by education, training and experience in the emergency management profession. The office shall be responsible administratively to the superintendent, shall retain direct access to the Governor and shall simultaneously notify the Governor and the superintendent of all emergencies.

(2) The Superintendent of State Police, with the approval of the Governor, may employ, subject to the applicable provisions of the State Personnel Relations Law, such personnel as are necessary to carry out the purposes of ORS 401.015 to 401.105, 401.260 to 401.325, 401.355 to 401.580 and 401.710 to 401.790, and shall fix their compensation in accordance with the compensation plan for classified employees and make expenditures within the appropriation therefor or from other funds made available to the office for purposes of emergency program management.

(3) The continued mission of the Office of Emergency Management is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in this chapter by planning, preparing, and providing for the prevention, mitigation, and management of emergencies or disasters that present a threat to the lives and property of citizens of and visitors to the State of Oregon. [1983 c.586 s.10; 1993 c.187 s.4]

401.270 Duties of director.

The Director of the Office of Emergency Management shall be responsible for coordinating and facilitating emergency planning, preparedness, response, and recovery activities with the state and local emergency services agencies and organizations, and shall, with the approval of the Superintendent of State Police or as directed by the Governor:

(1) Make rules that are necessary and proper for the administration of ORS 401.015 to 401.105, 401.260 to 401.325 and 401.355 to 401.580;

(2) Coordinate the activities of all public and private organizations specifically related to providing emergency services within this state;

(3) Maintain a cooperative liaison with emergency management agencies and organizations of local governments, other states, and the Federal Government;

(4) Have such additional authority, duties and responsibilities authorized by ORS 401.015 to 401.105, 401.260 to 401.325 and 401.355 to 401.580 or as may be directed by the Governor;

(5) Administer grants relating to emergency program management and emergency services for the state;

(6) Provide for and staff a State Emergency Operations Center to aid the Governor and the Office of Emergency Management in the performance of duties under ORS 401.015 to 401.105, 401.260 to 401.325 and 401.355 to 401.580;

(7) Serve as the Governor's authorized representative for coordination of certain response activities and managing the recovery process;

(8) Establish training and professional standards for local emergency program management personnel;

(9) Establish task forces and advisory groups to assist the office in achieving mandated responsibilities; and

(10) Enforce compliance requirements of federal and state agencies for receiving funds and conducting designated emergency functions. [1983 c.586 s.11; 1993 c.187 s.5]

Appendix 15. Department of Land Conservation and Development Goal 7, regarding areas subject to natural disasters and hazards

Goal 7: To protect life and property from natural disasters and hazards.

Developments subject to damage or that could result in loss of life shall not be planned nor located in known areas of natural disasters and hazards without appropriate safeguards. Plans shall be based on an inventory of known areas of natural disaster and hazards.

Areas of Natural Disasters and Hazards — are areas that are subject to natural events that are known to result in death or endanger the works of man, such as stream flooding, ocean flooding, ground water, erosion and deposition, landslides, earthquakes, weak foundation soils, and other hazards unique to local or regional areas.

GUIDELINES

PLANNING

1. Areas subject to natural hazards should be evaluated as to the degree of hazard present. Proposed developments should be keyed to the degree of hazard and to the limitations on use imposed by such hazard in the planning areas.
2. In planning for floodplain areas, uses that will not require protection through dams, dikes and levies should be preferred over uses that will require such protection.
3. Low density and open space uses that are least subject to loss of life or property damage such as open storage, forestry, agriculture and recreation should be preferred in floodplains, especially the floodway portion. The floodway portion should be given special attention to avoid development that is likely to cause an impediment to the flow of floodwaters.
4. Plans taking into account known areas of natural disasters and hazards should consider, as a major determinant, the carrying capacity of the air, land, and water resources of the planning area. The land conservation and development actions provided for by such plans should not exceed the carrying capacity of such resources.
5. Planning for known areas of natural disasters and hazards should include an evaluation of the beneficial impact on natural resources and the environment from letting such events naturally reoccur.

IMPLEMENTATION

1. Cities and counties not already eligible should qualify for inclusion in the National Flood Insurance Program, provided under the National Flood Insurance Act of 1968 (Public Law 90-448). The Act requires that development in flood-prone areas be appropriate to the probability of flood damage, and the danger to human life. The Flood Disaster Protection Act of 1973 (P.L. 93-234) and other pertinent federal and state programs should be considered. The United States Department of Housing and Urban Development should identify all flood and mud-slide prone cities and counties in Oregon, and priority should be given to the completion of flood rate maps for such areas.
2. When locating developments in areas of known natural hazards, the density or intensity of the development should be limited by the degree of the natural hazard.
3. When regulatory programs and engineering projects are being considered, the impacts of each should be considered.
4. Natural hazards that could result from new developments, such as runoff from paving projects and soil slippage due to weak foundation soils, should be considered, evaluated and provided for.

Appendix 16. Selected statutes of the Building Codes Division

455.020 Purpose; scope of application.

(1) This chapter is enacted to enable the Director of the Department of Consumer and Business Services to promulgate a state building code to govern the construction, reconstruction, alteration and repair of buildings and other structures and the installation of mechanical devices and equipment therein, and to require the correction of unsafe conditions caused by earthquakes in existing buildings. The state building code shall establish uniform performance standards providing reasonable safeguards for health, safety, welfare, comfort, and security of the residents of this state who are occupants and users of buildings, and will provide for the use of modern methods, devices, materials, techniques and practicable maximum energy conservation.

(2) The regulations adopted pursuant to this chapter shall include structural standards; standards for the installation and use of mechanical, heating and ventilating devices and equipment; and standards for prefabricated structures; and shall, subject to ORS 455.210 (1) to (5), prescribe reasonable fees for the issuance of building permits and similar documents, inspections and plan review services by the Department of Consumer and Business Services.

(3) This chapter does not affect the statutory jurisdiction and authority of the Workers' Compensation Board, under ORS chapter 654, to promulgate occupational safety and health standards relating to places of employment, and to administer and enforce all state laws, regulations, rules, standards and lawful orders requiring places of employment to be safe and healthful.

(4) This chapter and any specialty code does not limit the authority of a municipality to enact regulations providing for local administration of the state building code; local appeal boards; fees and other charges; abatement of nuisances and dangerous buildings; enforcement through penalties, stop-work orders or other means; or minimum health, sanitation and safety standards for governing the use of structures for housing, except where the power of municipalities to enact any such regulations is expressly withheld by statute. Pursuant to the regulation of dangerous buildings, a municipality may adopt seismic rehabilitation plans that provide for phased completion of repairs that are designed to provide improved life safety but that may be less than the standards for new buildings. [Formerly 456.755; 1991 c.227 s.2; 1991 c.310 s.2; 1995 c.304 s.1; 1995 c.400 s.5]

455.446 Construction of certain facilities and structures in tsunami inundation zone prohibited; establishment of zone; exceptions.

(1)(a) New essential facilities described in ORS 455.447 (1)(a)(A), (B) and (G) and new special occupancy structures described in ORS 455.447 (1)(e)(B), (C) and (E) shall not be constructed in the tsunami inundation zone established under paragraph (c) of this subsection. The provisions of this paragraph apply to buildings with a capacity greater than 50 individuals for every public, private or parochial school through secondary level and child care centers.

(b) The State Department of Geology and Mineral Industries shall establish the parameters of the area of expected tsunami inundation based on scientific evidence that may include geologic field data and tsunami modeling.

(c) The governing board of the State Department of Geology and Mineral Industries, by rule, shall determine the tsunami inundation zone based on the parameters established by the department. The board shall adopt the zone as determined by the department under paragraph (b) of this subsection except as modified by the board under paragraph (d) of this subsection.

(d) The board may grant exceptions to restrictions in the tsunami inundation zone established under paragraph (c) of this subsection after public hearing and a determination by the board that the applicant has demonstrated that the safety of building occupants will be ensured to the maximum reasonable extent:

(A) By addressing the relative risks within the zone.

(B) By balancing competing interests and other considerations.

(C) By considering mitigative construction strategies.

(D) By considering mitigative terrain modification.

(e) The provisions of paragraph (a) of this subsection do not apply:

(A) To fire or police stations where there is a need for strategic location; and

(B) To public schools if there is a need for the school to be within the boundaries of a school district and this cannot otherwise be accomplished.

(f) All materials supporting an application for an exception to the tsunami inundation zone are public records under ORS 192.005 to 192.170 and shall be retained in the library of the department for periods of time determined by its governing board.

(g) The applicant for an exception to the tsunami inundation zone established under paragraph (c) of this subsection shall pay any costs for department review of the application and the costs, if any, of the approval process.

(2) The definitions in ORS 455.447 apply to this section.

(3) The provisions of this section do not apply to water-dependent and water-related facilities, including but not limited to docks, wharves, piers and marinas.

(4) Decisions made under this section are not land use decisions under ORS 197.015 (10). [1995 c.617 s.2]

Note: 455.446 was enacted into law by the Legislative Assembly but was not added to or made a part of ORS chapter 455 or any series therein by legislative action. See Preface to Oregon Revised Statutes for further explanation.

455.447 Regulation of certain structures vulnerable to earthquakes and tsunamis.

(1) As used in this section, unless the context requires otherwise:

(a) "Essential facility" means:

(A) Hospitals and other medical facilities having surgery and emergency treatment areas;

(B) Fire and police stations;

(C) Tanks or other structures containing, housing or supporting water or fire-suppression materials or equipment required for the protection of essential or hazardous facilities or special occupancy structures;

(D) Emergency vehicle shelters and garages;

(E) Structures and equipment in emergency-preparedness centers;

(F) Standby power generating equipment for essential facilities; and

(G) Structures and equipment in government communication centers and other facilities required for emergency response.

(b) "Hazardous facility" means structures housing, supporting or containing sufficient quantities of toxic or explosive substances to be of danger to the safety of the public if released.

(c) "Major structure" means a building over six stories in height with an aggregate floor area of 60,000 square feet or more, every building over 10 stories in height and parking structures as determined by Department of Consumer and Business Services rule.

(d) "Seismic hazard" means a geologic condition that is a potential danger to life and property, which includes but is not limited to earthquake, landslide, liquefaction, tsunami inundation, fault displacement, and subsidence.

(e) "Special occupancy structure" means:

(A) Covered structures whose primary occupancy is public assembly with a capacity greater than 300 persons;

(B) Buildings with a capacity greater than 250 individuals for every public, private or parochial school through secondary level or child care centers;

(C) Buildings for colleges or adult education schools with a capacity greater than 500 persons;

(D) Medical facilities with 50 or more resident, incapacitated patients not included in subparagraphs (A) to (C) of this paragraph;

(E) Jails and detention facilities; and

(F) All structures and occupancies with a capacity greater than 5,000 persons.

(2) The Department of Consumer and Business Services shall consult with the Seismic Safety

Policy Advisory Commission and the State Department of Geology and Mineral Industries prior to adopting rules. Thereafter, the Department of Consumer and Business Services may adopt rules as set forth in ORS 183.325 to 183.410 to amend the state building code to:

(a) Require new building sites for essential facilities, hazardous facilities, major structures and special occupancy structures to be evaluated on a site-specific basis for vulnerability to seismic geologic hazards.

(b) Require a program for the installation of strong motions accelerographs in or near selected major buildings.

(c) Provide for the review of geologic and engineering reports for seismic design of new buildings of large size, high occupancy, or critical use.

(d) Provide for filing of noninterpretive seismic data from site evaluation in a manner accessible to the public.

(3) For the purpose of defraying the cost of applying the regulations in subsection (2) of this section, there is hereby imposed a surcharge in the amount of one percent of the total fees collected under the structural and mechanical specialty codes for essential facilities, hazardous facilities, major structures, and special occupancy structures, which fees shall be retained by the jurisdiction enforcing the particular specialty code as provided in ORS 455.150.

(4) Developers of new essential facilities, hazardous facilities and major structures described in subsection (1)(a)(E), (b) and (c) of this section and new special occupancy structures described in subsection (1)(e)(A), (D) and (F) of this section that are located in an identified tsunami inundation zone shall consult with the State Department of Geology and Mineral Industries for assistance in determining the impact of possible tsunamis on the proposed development and for assistance in preparing methods to mitigate risk at the site of a potential tsunami. Consultation shall take place prior to submittal of design plans to the building official for final approval. [1991 c.956 s.12; 1995 c.79 s.229; 1995 c.617 s.1]

Note: 455.447 was added to and made a part of 455.010 to 455.740 by legislative action but was not added to any smaller series therein. See Preface to Oregon Revised Statutes for further explanation.

455.448 Entry and inspection of earthquake-damaged structures; warrant enforcement; order to vacate; rehabilitation of historic structures.

(1) For the purposes of enforcement of this chapter the building inspector or any person appointed by the Department of Consumer and Business Services, after showing official identification and, if necessary, a warrant issued to the building owner or agent of the owner under subsection (2) of this section, may:

(a) Enter, at reasonable times, any property that is known to be damaged, or for which there are reasonable grounds to believe that the structure has been damaged, as a result of an earthquake.

(b) Inspect, at reasonable times, within reasonable limits and in a reasonable manner property that is known to be damaged, or for which there are reasonable grounds to believe that the structure has been damaged, as a result of an earthquake.

(2) If entry is refused, the building inspector or any duly appointed representative of the Department of Consumer and Business Services may appear before any magistrate empowered to issue warrants and request such magistrate to issue an inspection warrant, directing it to any peace officer, as defined in ORS 161.015 to enter the described property to remove any person or obstacle and assist the building inspector or representative of the department inspecting the property in any way necessary to complete the inspection. [Formerly 401.537]

Note: 455.448 and 455.449 were added to and made a part of 455.010 to 455.740 by legislative action but were not added to any smaller series therein. See Preface to Oregon Revised Statutes for further explanation.

455.449 Unsafe condition resulting from earthquake damage; abatement of nuisance.

(1) All buildings or portions thereof which are determined after inspection by a building inspector or a representative of the Department of Consumer and Business Services to be in unsafe condition as a result of earthquake damage may be declared to be a public nuisance and shall be abated by repair, rehabilitation, demolition, or removal in accordance with the procedure specified by rules adopted by the agency.

(2) Any building declared to be in unsafe condition under subsection (1) of this section shall be made to comply with one of the following:

(a) The building shall be repaired in accordance with the current building code or other current code applicable to the type of substandard conditions requiring repair;

(b) The building shall be demolished if the owner of the building consents; or

(c) The building may be vacated, secured, and maintained against entry if the building does not constitute an immediate danger to the life, limb, property or safety of the public.

(3) If the building or structure is in such condition as to make it immediately dangerous to the life, limb, property, or safety of the public or its occupants, the Department of Consumer and Business Services or representative of the department shall order it to be vacated.

(4) If the structure, in whole or in part, is listed on or is eligible for listing on the National Register of Historic Places, established and maintained under the National Historic Preservation Act of 1966 (P.L. 89-665), or, if the National Register of Historic Places ceases accepting nominations, is approved for listing on an Oregon register of historic places, or is a locally designated landmark protected by ordinance against demolition without due process, alternative compliance with the provisions of subsection (2)(a) and (c) of this section shall be allowed if the repaired or rehabilitated building is no more hazardous than it would be if repaired or rehabilitated in accordance with (2)(a) of this section. [Formerly 401.539]

Note: See note under 455.448.

Appendix 17. 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 in Oregon. Depending on the nature of the hazard, level of risk, financial considerations, and local standards, these techniques have been found to be the best approach at one time or another at specific locations in the state.

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 reducing 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 in 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 balancing 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.

Table Appendix 17. Range of strategies to reduce risk

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.

(Continued on next page)

Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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.

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Table Appendix 17. Range of strategies to reduce risk (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 18. General patterns of geologic hazard risk reduction in Oregon

A variety of strategies has been used to address geologic hazards in various parts of Oregon. For any given hazard, different strategies have been tried from place to place. For any given location, the approach that is best for one hazard may be inappropriate for another. In Oregon the diversity of hazards is such that flexibility in approaches is recommended, and more than one hazard may need to be addressed in any given location. In Oregon, there presently is no hazard with a complete risk reduction program statewide.

Historically, Oregon communities often have been forced to approach geologic hazards without sufficient attention toward characterization. With the risks increasing over time, an effort is needed to develop better strategies. In 1989, DOGAMI was assigned responsibility for hazard mitigation and was directed to pursue cooperative methods of meeting its goals. The Agency Strategic Plan plots the course of action and the emerging performance measures provide a means of tracking progress.

For significant hazards, doing too little may involve failure to address threats to public safety, including lives; public health, including lifeline systems; and public welfare, including insurance losses, buyer victimization, and governmental liability. Likewise, requiring too much may involve high costs; unacceptable economic tradeoffs, including loss of investment opportunity; and possibly unacceptable limits to personal freedoms (takings). The challenge recognized in all jurisdictions that have seriously attempted to reduce the risk from geologic hazards is that there is a need to balance these considerations.

Some strategies displayed in Appendix 17 are rarely used, but have been successful in their particular niche. These include recordation, prohibitions on certain kinds of construction with exceptions, removal of structures, land trades, specific incentives, and public/private partnerships to address specific problems. Where successful, these unusual efforts are focused by sufficient information and are driven by extreme circumstances. An historic example of public partnership is the risk reduction of landslides in The Dalles in the 1980s. There, partnering of efforts by government (which creatively identified the problem and secured funding), and the private sector (which performed a detailed site-specific study and actually drilled the wells) reduced the risk through the construction of four drainage wells above the slide area.

Some strategies or approaches are common. These include general hazard mapping without clear policy guidance, general narrative development in planning documents, large-scale mapping, and general reliance on site-specific reports. For areas of increasing loss owing to demographic trends, the provision of general public information alone may no longer be adequate. Further, for many situations generic site-specific reports may not address the off-site regional factors or unusual specific factors on the site.

Appendix 19. Risk reduction not limited to the role of any single agency or jurisdiction

Many agencies and jurisdictions provide key capabilities aimed at reducing risk to geologic hazards as shown on the table in **Appendix 11.** At the same time each agency exhibits practical limits to its capabilities and cannot be expected to do everything.

A key to effectively reducing risk from geologic hazards is to recognize that the best strategy or strategies reside with different agencies at different locations or for different solutions. No single agency is designed to handle all hazards or situations.

Yet, often when a hazard is identified, it can be observed that a particular agency senses the need to mitigate within the scope of its authorities. Thus, for example, planning agencies may be seen pursuing zoning models to solve ground response problems that are revealed on earthquake risk maps. Yet the hazard portrayed on the map and the design and content of the map may be more appropriately addressed primarily by Building Code regulations on a building-specific basis.

Alternatively, one may observe Building Code agencies feeling the need to advance their interests outside the design of buildings to increasingly address ground conditions beyond the footprint of the building addressed in Building Code regulations. Within the scope of regional hazards, the concern may be more appropriately handled in the planning environment through zoning overlays.

Each agency or entity with a major role in risk reduction brings to the table particular strong points. They also bring limitations that suggest that partnering may be in order in some cases or that another agency or entity might be better suited to assume the lead in certain areas.

For effective reduction of risk to significant geologic hazards statewide a team effort is needed to recognize and to use the strengths of each agency as they work together. This is particularly true in a state like Oregon with such a diversity of hazards and such a range of specifics within each hazard.

For specific hazard risk reduction for areas in a state, the team concept also is valuable as summarized in **Appendices 8 and 9**. The level of effort varies with circumstance as discussed in **Appendix 7**.

Appendix 20. Legal considerations

Consideration of possible legal actions by affected parties might also be factored into the evaluation of any option that is being considered. For example, extremely restrictive choices for risk reduction might bring with them lawsuits based on a perceived "takings." The community might judge this to be acceptable risk in some cases. However, a knowledgeable community might also take additional care in the structuring of the preferred risk reduction strategy to minimize exposure.

Actions by public entities are sometimes challenged by lawsuit for any of a variety of alleged losses incurred by the public. Likewise, members of the public may also sue each other over alleged losses resulting from hazardous events. The proper structuring and proper wording of risk reduction measures in rule, manual, ordinance or order should be pursued with full benefit of legal counsel.

The specific legal context for differing jurisdictions may vary slightly, but general patterns are also discernible. For example, inaction or the less aggressive of the possible risk reduction strategies may be leave the community subject to lawsuit if parties experience avoidable losses in the event of a geologic hazard disaster. This might be for "negligence", "liability" or possibly failure to effectively deal with "nuisances".

On the other hand, the more restrictive actions may be subject to lawsuit on the grounds of a property "takings". Scenarios can become even more complex as one considers tort law, specific situations particular to any given situation, and the full array of involved parties from homeowners, realtors, consultants, government agencies and employees of government agencies.

The purpose of this section is to provide a general alert to the reader of the kinds of legal issues that surround geologic hazards. It is not our intent to provide legal advice. For those wishing more precise information, this appendix very briefly summarizes selected court opinions relative to legal issues surrounding geologic hazards.

The Joint Interim Task Force on Landslides and Public Safety created pursuant to SB1211 (1997) developed the list (October 7, 1998). Those wishing actual legal advice should consult an attorney. The listing of cases provided here is reproduced exactly as it was developed by the Task Force and can provide a starting reference point for legal counsel, once it is selected.

Table Appendix 20. Legal considerations
Selected case law relative to geologic hazards

Hubbard v. Olsen-Roe Transfer Co., 224P.636, 110 Or. 618 (1924)	"Act of God" excuses failure to perform a duty but does not exclude circumstances produced by human agency.
Nettleton v. James, 319 P.2d 879, 212 Or. 375 (1958)	When a landslide occurs on a landowner's property and that landowner did nothing to contribute to the landslide, the damage caused is considered an "unavoidable accident" because it occurred without the negligence of the landowner.
Marvin v. Champion Int'l. Corp., No. 97CV0318CC (Or. Cir. Ct. January 24, 1997)	Argues strict liability; negligence in clear-cutting a dangerous slope.
Fazzolari v. Portland School District, 734 P.2d 1326, 1336, 303 Or.1.17 (1987)	In order to bring a negligence claim in Oregon, the plaintiff must show that the defendant's conduct unreasonably created a foreseeable risk (foreseeability) and that this foreseeable risk caused an injury to the plaintiff (causation).
Slogowski v. Lyness, 927 P.2d 587, 589, 324 Or. 436, 441 (1996)	Foreseeability in Oregon requires (1) that defendant's conduct caused a foreseeable risk of harm, (2) that the risk is to an interest of kind that the law prohibits against negligent invasion, (3) that the defendant's conduct was unreasonable in light of the risk.
Schweiger v. Solbeck, 191 Or. 454, 572, P.2d 200 (1951)	Defendant was held liable for damage to property caused by a debris slide originating from the defendant's logging operation (permitting slash and other logging debris to collect in a steep ravine above the plaintiff's property).
Union Pacific Railroad Co. v. Vale, Oregon Irrigation District, 253 F. Supp. 251 (D. Or. 1966)	Under Oregon law, the defendant was liable for damage to the plaintiff's railroad tracks caused by a landslide created by seepage from the defendant's irrigation canal.
Hamilton v. State and City of Astoria, 42 Or. Ap. 821,601 P.2d 822 (1979)	Neither the State nor city was negligent under *res ipsa loquitur* for property damage caused by a landslide triggered by flooding from a manhole because neither entity had exclusive control over the city storm drain.
McLane v. Northwest Natural Gas Co., 255 Or. 324, 328, 467 P.2d 635, 637 (1970)	Strict liability attaches if an activity is abnormally dangerous and carries an inherent risk of injury to others. An activity is abnormally dangerous if it is "extraordinary, exceptional, or unusual." Considering the locality in which it is carried on; when there is a risk of grave harm from such abnormality, and when the risk cannot be eliminated by the exercise of reasonable care.
Nicolai v. Day, Restatement of Torts, 520	The Court (Oregon) adopted elements contained in the Restatement as necessary to establish strict criteria.

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Table Appendix 20. Legal considerations (continued)

Selected case law relative to geologic hazards

Burkett v. Freedom Arms, 704 P.2d 118, 119, 299 Or. 551, 577	Oregon Courts use Restatement elements as guides, not as strict criteria.
Koos v. Ross, 293 Or. 670, 678, 652 P.2d 1255, 160-1261 (1982), citing McLane, 255 Or. At 329, 467 P.2d 638	Whether the danger (presented by an activity) is so great as to give rise to strict liability depends both on the probability and the magnitude of the threatened harm. If the consequences of a mishap are potentially lethal or highly destructive of health and property, a slight likelihood that they will occur suffices, even if the harm in the actual occurrences is less severe.
Union Pacific Railroad Co. v. Vale, Oregon Irrigation District, 253 F. Supp. 258 (D. Or 1966)Also see: *Laurance v. Tucker,* 160 Or. 474, 85 P.2d 374 (1939); *Boulevard Drainage System v. Gordon,* 91 Or. 240, 177 P. 956 (1919); *Stephens v. City of Eugene,* 90 Or. 167, 175 P. 855 (1918); and *Esson v. Wattier,* 25 Or. 7, 34 P. 756 (1893)	... any interference with lawful possession of property is an act which will entitle the injured party to complain in tort and that "this is true even though the act may be done accidentally, or in good faith, or under justifiable error." The actor need only set in motion the chain of events that results in tress pass.
Raymond v. Southern Pacific Co., 259 Or. 629, 633, 488 P.2d 460, 462 (1971)	Claims alleging nuisance and seeking to enjoin timber harvesting that may cause landslides presently are not valid in Oregon. Unlike claims in tort or trespass, nuisance law is proactive, allowing a plaintiff to seek an injunction of defendant's activities that unreasonably interfere with plaintiff's use and enjoyment of her land. Oregon Courts have never recognized such a claim on steep slopes.
York v. Stallings, 217 Or. 13, 22, 341 P.2d 529, 534, (1958)	Oregon Supreme Court: ... in determining the existence of a nuisance, the nature of the industry involved is considered. "Timber and logging is a primary industry and its operations are not to be enjoined without substantial reasons." (Finding codified in Oregon legislation in 1995).
Henricks v. State, 678 P.2d 759, 67 Or. App. 453 (1984) (parole boards); *Penland v. Redwood Sanitary Sewer Service District,* 934 P.2d 434 at 440, 146 Or. App. 255 (Pr. Sup. Ct. 1997) (sanitation districts); *Brungardt v. Barton,* 685 P.2d 1021, 1023, 69 Or. App. 440 (1984)	Oregon Tort Claims Act Legal Challenges - Arguments: When determining whether an action is within the scope of employment, Oregon Courts look at (1) whether the act is the kind the person was employed to do; (2) whether the act occurred within an authorized time and space; (3) whether the act was at least in part to serve the employer. An act by a public body employee is outside the scope of employment if it involves malfeasance, or willful or wanton neglect of duty.
Penland v. Redwood Sanitary Sewer Service District, 146 Or. App. At 234, 934 P.2d at 440; *Hendricks v. State* 678 P.2d at 760 (1984); *Brennen v. City of Eugene,* 591 P.2d 719, 285 Or. 401 (1979)	"Routine decisions made by employees in the course of their day-to-day activities, even though the decision involves a choice among two or more courses of action" is not an exercise of immune discretion. Therefore, discretion does not include issuing a license when the issuer need only compare facts.

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Table Appendix 20. Legal considerations (continued)

Selected case law relative to geologic hazards

Neher v. Cartier, 879 P.2d 156 at 158, 319 Or. 417 at 422 (1994)	Constitutional grant of immunity held unconstitutional by the Oregon Supreme Court considering that worker's compensation is not a "substantial remedy" in this wrongful death suit. The Court was careful to preserve the legislature's ability to grant immunity to employees, so long as a tort plaintiff still had a substantial remedy.
Nollan v. California Coastal Commission, 483 U.S. 825 (1987)	Takings issue: All regulation must substantially advance a legitimate state interest. If the legislation does not do so, then a taking occurs and compensation for even temporary takings are required.
Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419 (1982) Also see: Queenside Hills Realty Co. v. Saxl, 328 U.S. 80, 66 S. Ct. 850 (1946) (fire regulation)	Interference with owner's right to exclude others from the property by placing a commercial cable box on the owner's apartment building was a taking that required compensation. This does not alter the state's ability to enforce or require compliance with building codes.
Lucas v. South Carolina Coastal Commission, 112 S. Ct. 2886 (1992)	Asks if the proscribed use is a nuisance under state common law. If it is considered a nuisance, then the use was never part of the property owner's right to begin with and therefore no taking occurs regardless of the hardship to the property owner.
Raymond v. Southern Pacific Co., 259 Or. 629, 633 (1972)	A private nuisance is the invasion by a neighbor of an "individual's interests in the use and enjoyment of land."
Stevens v. The City of Cannon Beach, 317 Or. 131 (1993)	Oregon Supreme Court determined that dry sands of Oregon's beaches had always been free to access by the public at large. Therefore restriction on a landowner's ability to build on beach front property was not considered a taking.
Keystone Bituminous Coal Assn. v. DeBenedictis, 480 U.S. 470 (1987)	Takings multifactor balancing test: (1) Economic impact of the regulation on the claimant; (2) interference with the owner's reasonable investment backed expectations; (3) the character of the government action.
Mugler v. Kansas, 123 U.S. 623, 665 (1887)	" ... all property in this country is held under the implied obligation that the owner's use of it shall not be injurious to the community."
Dolan v. City of Tigard, 114 S. Ct. 2309 (1994)	Related to city taking, final Supreme Court Opinion (5-4): "Undoubtedly the prevention of flooding along Fanno Creek and the reduction of traffic congestion in the central business district qualify as the type of legitimate public purposes we have upheld ... It seems equally obvious that a nexus exists between preventing flooding along Fanno Creek and limiting development within the Creek's 100 year flood plain."

Appendix 21. Oregon as a laboratory for approaching geologic hazards

Oregon has as great an array of significant geologic hazards as any other state. The magnitude of any given hazard may be greater in other states, but the array of hazards is as broad as, or broader than, that in any other state. In addition, Oregon possesses a wealth of legislative and administrative approaches toward reducing risk from geologic hazards.

Oregon is a good learning ground for discovering more effective ways to reduce the risk of geologic hazards. We note for example:

- The Oregon Department of Geology and Mineral Industries (DOGAMI) is directed by state statute to form partnerships to provide prerather than post-risk reduction from geologic hazards, based on information before the fact. Included are landslides and earthquakes.
- Close working relationships exist between DOGAMI, other state agencies, and local governments in geologic hazard matters involving planning. Results can easily be transferred to other jurisdictions in Oregon for their use.
- Close working relationship of DOGAMI with the Office of Emergency Management (OEM) on the state level allows close coordination with disaster preparedness and mitigation efforts, disaster-related funding opportunities, and related hazard mitigation planning activities in that agency.
- Oregon's statewide land use law overseen by the Department of Land Conservation and Development (DLCD) addresses geologic hazards and landslides in a general, yet uniform fashion from border to border, under the oversight of the Land Conservation and Development Commission (LCDC).
- Coordination of many hazard-related activities is made possible through the efforts of the Interagency Hazard Mitigation Team (IHMT), staffed by the Oregon Emergency Management division (OEM) of the State Police Department.
- Oregon state agencies have developed close working relationships with federal counterparts, including the U.S. Geological Survey, (USGS), the Federal Emergency Management Agency (FEMA), and the National Oceanic and Atmospheric Administration (NOAA).

Appendix 22. Salem area as a case study

INTRODUCTION

The experiences of the City of Salem, Marion County, and Polk County in dealing with landslide risk provide a good case example for demonstrating how communities and jurisdictions can work to reduce the risk from geologic hazards. Although the following discussion deals with landslides in parts of South and West Salem, it is best viewed in a more general sense.

By studying this example, general lessons can be learned about how communities can deal with all kinds of geologic hazards. It is a description of how a community used such information as collected in this manual to develop a strategy to reduce risk from geologic hazards. The specific issue was landslides, but the general theme was hazard risk reduction.

The slide area as initially delineated involved parts of the community of Salem and part of Marion County. The slide area was very large, and development potential was great. Accordingly an aggressive approach was needed. Sliding varied considerably from place to place, but the scale of the hazard lent itself to meaningful mapping at reasonable cost. Variation in slide potential across the mapped area suggested that flexible management strategies could vary from place to place. Lawsuits were in place, and more were contemplated in the future.

Both jurisdictions began participation early, in a team effort that also involved funding assistance by the Federal Emergency Management Agency (FEMA) and the Office of Emergency Management (OEM) and technical assistance by the Oregon Department of Geology and Mineral Industries (DOGAMI). Polk County was included later, as slides in West Salem became a concern. One of the early challenges in the effort was the need to accommodate different levels of development pressure in the urban (Salem) and nonurban (Marion and Polk Counties) areas, while still laying the groundwork for coordinated strategies in the long term.

Interrelated topics of resource management were involved. Included were river erosion at the base of a historic slide area and preexisting plans for groundwater or surface water storage above the slide. The land under study has been of prime interest for future residential development due to its suburban location and earlier platting for development.

GENERAL SETTING

The South Salem Hills and the Eola Hills comprise large, landslide prone areas that were attractive as a pilot study area for risk reduction from geologic hazards for a variety of reasons:

- The areas are largely undeveloped. A greater range of risk management solutions were available before development than would be after development occurs.
- The areas are attractive to future developments and, therefore, are in greater need of risk reduction strategies than if no development or limited development were likely to occur.
- The areas consist of a large landslide mass and lend themselves better to study on a regional scale than a small, site-specific hazard area would.
- The character of the susceptibility for landslides in the study areas varies considerably and invites segmented characterization of the slides. This, in turn, invites consideration of a variety of risk reduction strategies to address the various levels of hazard risk.
- Segmented characterization provides the opportunity to consider developing different sets of requirements from place to place, depending on the degree or level of susceptibility to hazard.
- Varying degrees of regulation may allow optimizing the use of these valuable areas while still prudently addressing the risks posed by landslides.
- The slide masses lie partly in the City of Salem and partly in Marion and Polk Counties. This provides an opportunity to demonstrate how local jurisdictions can work together towards consistent and coordinated management of risks posed by regional geologic hazards.
- The landslide risk relates to other geologic hazards and lends itself to development of a multi-hazard risk reduction strategy.

PROJECT INITIATION

Funding was secured from FEMA Presidential declared disaster funds provided to the state after the floods and landslides of February 1996. OEM, with responsibilities for hazard preparedness, mitigation, response, and recovery plus coordination with FEMA, played a key role in contract development. OEM was particularly helpful in translating the objectives of the project into terms that would match the procedural and threshold requirements for project tasks and matching efforts required by FEMA.

The initial scope of the project focused on the hills in South Salem, where previous landslide evidence raised questions as to the suitability of this area for further development. Risk management and legal concerns were high at the outset owing to the potential for lawsuits and a real awareness of possible public safety issues.

The size of the South and West Salem slide areas and the many manifestations of recent movement at some sites make the area one of significant concern. For that reason a rigorous approach to the issue as conducted in this study was appropriate, particularly after the events of 1996. Prior to that, more general studies had been conducted. Until recently, the need for more refined work was not immediately apparent to the nongeologist.

CHARACTERIZATION OF THE SALEM AREA LANDSLIDES

The large south Salem landslide area addressed by this study comprises parts of a large bedrock fold. The tilt of the bedrock to the south and to the west of South Salem facilitates sliding. Over geologic time the meandering Willamette River has impinged on various parts of the growing fold. This activity, coupled with clay soils overlying basalt bedrock, produced a variety of landforms of varying instability, resulting in landslides. Variations in the details and age of these events have produced the various segments of the region that now display varying degrees of instability. Minor undercutting still occurs to the west, where the river still impinges on the slope.

The failures include blocks of basalt separating from intact bedrock and riding down the slope over prolonged periods of geologic time. In areas of more ancient sliding, erosion has obscured and removed much of the older slide debris. For these areas, remaining slide potential is much less than for areas of more recent slides.

DOGAMI contracted to provide the hazard characterization, technology transfer services, and technical assistance that might be needed for institutionalization of the selected strategies.

Hazard characterization was subsequently contracted out to the private sector following the competitive bid procedures established for the State of Oregon through the Department of Administrative Services. In the contracting the following themes were emphasized:

- Reliance on state-of-the-art knowledge and information on the local geology, knowing that the nature and distribution of the rock types controlled the details of the slide and the water budgets that drove the slide.
- Division of the slide into segments, so development strategies can address actual conditions on the ground.
- Linking of the various segments to suggested kinds of strategies that would be most likely to reduce risk to acceptable levels while maintaining the maximum prudent flexibility in terms of future uses of the land.

At higher elevations of the Salem Hills in South Salem and the Eola Hills in West Salem, deeply weathered soils have formed above the Columbia River basalt. Under natural conditions, there is little sliding, and without careful study the slopes might erroneously be deemed stable. However, under conditions of subdivision development, minor displacements can occur on this apparently stable terrain that can be very significant to structures placed upon them. Small slides that would otherwise be undetectable or of little interest under natural conditions can damage or destroy roads and houses. The subtleties of the slide areas underscore the need for communities to approach hazards on a community-wide basis. To do less is to risk failure to detect the hazards.

A supplemental funding cycle was needed to secure additional funding to better address and characterize sliding in West Salem. Included in an effort to secure the needed funds were initial interagency communications, applications, approvals, and dispersal. Revisions to work schedules and subcontracts followed. Clearly, funding for a project of citywide scope from the

beginning would have been desirable. A hazard characterization effort for a community ideally should be conducted on the entire community.

The actual procedure for characterizing the landslides is the subject of other publications. Sources of information for this project came from both the public and private sectors. Field investigation was included, as was the use of aerial photo interpretation. For urban and urbanizing areas, cursory examination of topographic maps is not adequate for characterizing risk. Actual field examination and data collection are required. Accordingly, efforts based solely on GIS, which rely on topographic data from maps, are not adequate.

For this investigation, consultation with geologic experts and use of the best available geologic maps was also a requirement. Rock characteristics control the slides and geologic maps best provide the information needed to understand the geology. Geophysics and drilling were not used in this project. Budget did not allow this level of rigor, but it might be warranted at other locations and in other situations. In addition, the intended purpose of the map to guide broad policy did not require that level of investment at this time. The benefits of these costly types of investigations are best reserved for smaller scale studies, such as subdivision-based or site-based geotechnical investigations where needed.

MULTI-HAZARD CONSIDERATIONS FOR THE SALEM LANDSLIDE EXAMPLE

Several geologic hazard issues associated with landslides needed to be considered. Water was the prime trigger for the 1990s landslide activity. Accordingly, the management of storm water runoff—so as not to aggravate the potential for landslides—is crucial to reducing both the hazard and risks of the hazard occurrence.

Existing proposals to store water above the slide mass either at the surface or in the subsurface were carefully evaluated to assure water would not find its way through the subsurface to the slide areas. An understanding of the detailed geology was key to successfully addressing this consideration. The nature and distribution of the rocks defines the underground (subsurface) drainage systems that might be available to natural groundwater in the area.

Earthquakes can also induce landslides. The technology to thoroughly evaluate the potential of earthquake induced sliding is in its infancy for deep-seated slides on moderate slopes, such as those involved in much of this investigation area. In a general way, this hazard was mapped for part of the city by DOGAMI in a previous study (GMS–105). Earthquake-induced landslide efforts in the study area were coordinated with this investigation to the extent that they were able to provide information toward characterizing the degree of hazard within the study area.

Finally, undercutting by the Willamette River in South Salem was the original cause of the landslide. Accordingly, attention needed to be given to those parts of the slide where the Willamette River still impinges on the slope in the west part of the South Salem study area. Given the control of the river by dams and the reduction of flood erosion, the threat of this factor is more remote than in the past. Nonetheless, it warranted consideration in the analyses.

TEAM SELECTION

The project represents a collaborative effort by Salem, Marion County, Polk County, DOGAMI, and OEM. At the local level, broad-based advisory teams were formed to review and direct actions by local government.

Technical Advisory Committee (TAC)

In a separate funding effort, the City of Salem sought and received funding to address natural hazard situations and mitigation measures through preparation of a Hazard Mitigation Plan (HMP), assisted by a Hazard Plan Technical Advisory Committee. The goal of the general effort for the city is to minimize future natural hazard impacts and the level of risk to the community through a strong public education component. The plan to be developed by the group is intended ultimately to include all types of hazards: flooding, landslides, earthquakes, wind, volcanic eruption, hazardous material spills, and others.

Development of the plan in this effort is to allow the city to participate and receive funds through the Hazard Mitigation Grant Program (HMGP), the federally funded effort for the purpose of hazard mitigation activities administered by FEMA.

At the state level this effort is also addressed by Goal 7 of the state land use planning program,

administered by the Department of Land Conservation and Development. This goal addresses "Areas Subject to Natural Disasters and Hazards". At the state level other major agencies involved in risk reduction for geologic hazards include DOGAMI (hazard characterization and partnerships for risk reduction), OEM (hazard response and coordination with FEMA), and the Building Codes Division (building-specific regulations).

The flood component of the HMP was to be developed by the Salem Public Works Department as part of the Storm-Water Master Plan. A Storm-Water Master Plan Survey Committee was formed to provide policy direction on development of the plan and implementation strategies.

The purpose of the Hazard Mitigation Plan, therefore, was to

- Assess the ongoing mitigation activities in the community;
- Evaluate additional mitigation measures that should be undertaken; and
- Outline a strategy to implement mitigation projects and activities.

The Technical Advisory Committee (TAC) was established to advise the City on development of the Plan. (Each jurisdiction must develop separate plans to receive funds for this specific activity from the Hazard Mitigation Grant Program) The TAC was also established to provide copies of resources available from the agencies and any regulations that may be applicable to planning for and regulating hazards. Finally, the TAC was also to discuss the progress of work toward identifying existing and potential hazards, hazard planning objectives, and possible mitigation measures.

The TAC began meeting in March 1998. It consisted of staff from the City Planning and Public Works Departments responsible for implementation of the plan and representatives from other agencies that dealt with emergency management services. Members were: Fire, Police, Risk Management, Planning, Public Works, Parks, OEM, DOGAMI, City Manager, City of Keizer, Salem/Keizer School District, Mid-Willamette Valley Council of Governments, County personnel for emergency management, fire districts, and others.

It was clear that landslide efforts in the project under discussion here would provide meaningful information for the broader and geographically larger efforts of the more general Hazard Mitigation Plan to be formulated under a separate concurrent initiative.

Landslide Hazard Advisory Committee (LHAC)

The landslide component of the Hazard Mitigation Plan was handled as a separate element to be incorporated into the Plan. A new advisory committee was formed. This approach would capitalize on the extra effort that was going to go into landslides and would allow more focused discussion. An effort aimed at the many aspects of all hazards simply would not be able to provide specific details and recommendations on the landslide effort in the context of all the other demands on the larger Hazard Mitigation Plan effort.

Development of this component involved formulation of a specific Landslide Hazard Advisory Committee formed in October of 1998. It consisted of a broad spectrum of public and private interests. The members included an engineering geologist, civil engineer, the Marion-Polk Building Industry Association, the Salem Chamber of Commerce, Northwest Natural, three neighborhood associations, the Farm Bureau, the Parks and Recreation Advisory Board, the Marion County Planning Commission, the Salem Planning Commission, Polk County Community Development Department and two watershed councils. Staff for the Advisory Committee included personnel from the City of Salem, Marion and Polk Counties, and the Oregon Department of Geology and Mineral Industries (DOGAMI).

This committee first set priorities on a preferred method to aproach the issue and advised the City and County to use hillside development regulations and/or ordinances and other risk reduction strategies to deal with potential landslide and debris flow hazards. The committee met monthly from November 1998 to June1999 and from October 1999 to January 2000. The committee first heard from experts about the hazards in question and then advised the City and County staff on which types of concepts

should be built into the proposed risk reduction strategies, including possible ordinances. Considerations included staff review of the adequacy and shortcomings of existing regulations, review of strategies used in similar situations by other communities in three states, and development of effective hillside ordinances to accommodate the risk.

City and County staff then developed draft language with LHAC input to fine-tune the ordinances. Resulting language included definitions, applicability, exemptions, geotechnical reports requirements, review requirements, and enforcement, among others. A major result was the development of "Graduated Response Tables" as a part of the draft ordinances. Future development sites will be rated by the sum of scores on three factors: (1) slope conditions, (2) physiographic conditions (determined from published maps), and (3) type of activity proposed. Scores will be low on flat terrain, areas mapped as low-hazard, and proposals for single-family dwellings or accessory structures. Moderate scores will be given to moderate slopes, areas mapped as moderate-hazard, and proposals for multiple-family dwellings and partitions. High scores will be given to proposals on steep slopes, areas mapped as high-hazard, and proposals for grading, subdivisions, schools, hospitals, commercial or industrial buildings. Differing levels of geotechnical reports will be required, depending upon the sum of the scores. Requirements for construction will be based in part upon the recommendations in the reports.

After the Committee completed its work and draft language had been written, the planning staff of the City and County moved ahead toward the public hearing and ordinance adoption process in the first half of 2000.

Appendix 23. Concluding 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?