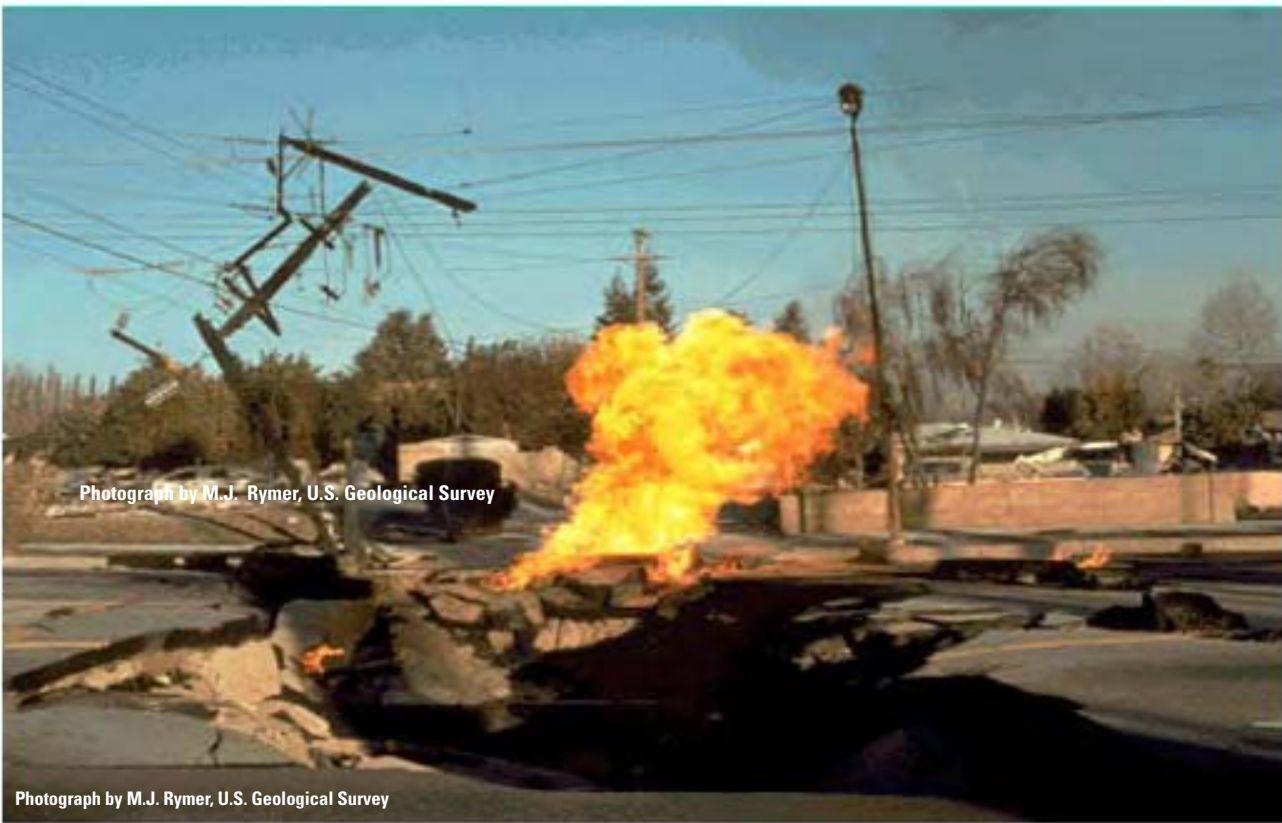


# **Increasing Resiliency to Natural Hazards: A Strategic Plan for the Multi-Hazards Demonstration Project in Southern California**



Open-File Report 2007-1255

**U.S. Department of the Interior  
U.S. Geological Survey**



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By Lucy Jones, Richard Bernknopf, Susan Cannon, Dale A. Cox, Len Gaydos, Jon Keeley, Monica Kohler, Homa Lee, Daniel Ponti, Stephanie Ross, Steven Schwarzbach, Michael Shulters, A. Wesley Ward, and Anne Wein

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**U.S. Department of the Interior**  
**U.S. Geological Survey**

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Suggested reference:

Jones, Lucy, Bernknopf, Richard, Cannon, Susan, Cox, D.A., Gaydos, Len, Keeley, Jon, Kohler, Monica, Lee, Homa, Ponti, Daniel, Ross, Stephanie, Schwarzbach, Steven, Shulters, Michael, Ward, A.W., and Wein, Anne, 2007, Increasing Resiliency to Natural Hazards—A Strategic Plan for the Multi-Hazards Demonstration Project in Southern California: U.S. Geological Survey Open-File Report 2007–1255.

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## Acronyms

ET	Earthquakes and Tsunamis
FD	Fire and Debris Flows
EROS	Earth Resources Observation System
FEMA	Federal Emergency Management Agency
FY	fiscal year
GIS	Geographic Information System
I-cubed	Integration and Implementation Interface
LIDAR	Light Detection And Ranging
MDHP	Multi-Hazards Demonstration Project
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Water Information System
SCCOOS	Southern California Coastal Ocean Observing System
SCEC	Southern California Earthquake Center
USGS	U.S. Geological Survey
WS	Winter Storm Events

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## Executive Summary

The U.S. Geological Survey (USGS) is initiating a new project designed to improve resiliency to natural hazards in southern California through the application of science to community decision making and emergency response. The Multi-Hazards Demonstration Project will assist the region's communities to reduce their risk from natural hazards by directing new and existing research towards the community's needs, improving monitoring technology, producing innovative products, and improving dissemination of the results. The natural hazards to be investigated in this project include coastal erosion, earthquakes, floods, landslides, tsunamis, and wildfires.

Americans are more at risk from natural hazards now than at any other time in our Nation's history. Southern California, in particular, has one of the Nation's highest potentials for extreme catastrophic losses due to natural hazards, with estimates of expected losses exceeding \$3 billion per year. These losses can only be reduced through the decisions of the southern California community itself. To be effective, these decisions must be guided by the best information about hazards, risk, and the cost-effectiveness of mitigation technologies. The USGS will work with collaborators to set the direction of the research and to create multi-hazard risk frameworks where communities can apply the results of scientific research to their decision-making processes. Partners include state, county, city, and public-lands government agencies, public and private utilities, companies with a significant impact and presence in southern California, academic researchers, the Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration (NOAA), and local emergency response agencies.

Prior to the writing of this strategic plan document, three strategic planning workshops were held in February and March 2006 at the USGS office in Pasadena to explore potential relationships. The goal of these planning sessions was to determine the external organizations' needs for mitigation efforts before potential natural hazard events, and response efforts during and after the event. On the basis of input from workshop participants, four priority areas were identified for future research to address. They are (1) helping decision makers design planning scenarios, (2) improving upon the mapping of multiple hazards in urban areas, (3) providing real-time information from monitoring networks, and (4) integrating information in a risk and decision-making analysis. Towards this end, short-term and out-year goals have been outlined with the priorities in mind.

First-year goals are (1) to engage the user community to establish the structures and processes for communications and interactions, (2) to develop a program to create scenarios of anticipated disasters, beginning in the first year with a scenario of a southern San Andreas earthquake that triggers secondary hazards, (3) to compile existing datasets of geospatial data, and (4) to target research efforts to support more complete and robust products in future years. Both the first-year and out-year goals have been formulated around a working-group structure that builds on existing research strengths within the USGS. The project is intended to demonstrate how developments in methodology and products can lead to improvement in our management of natural hazards in an urban environment for application across the Nation.

## Vision, Mission, and Objectives

### Vision

We envision a future in which the best science is used to improve resiliency to natural hazards by individuals and institutions in southern California.

### Mission

Our mission is to help communities reduce their vulnerability to natural hazards through the application of science and engineering to community planning and response. The project will be a new arena within the USGS for multi-disciplinary, collaborative work that will dramatically improve individual and community understanding of the risks from multiple hazards ever-present in southern California and that will empower the use of that information in making decisions to reduce losses.

### Objectives

The overarching objective of the Multi-Hazards Demonstration Project is to help communities reduce losses from natural hazards. We will do this by incorporating the expressed needs of southern California communities into natural-hazards science through new and existing research activities, producing innovative products, and improving dissemination of our results. The work will integrate multiple USGS research activities with the needs of external partners, such as emergency managers and land-use planners, to produce products and information that can be used to create more disaster-resilient communities. The long-term objectives are to

- Create a nucleation point that fosters two-way communication between scientists and disaster managers and area planners.
- Plan USGS research in concert with partners to further the goal of improved resiliency to natural hazards. This improved interaction will foster USGS' understanding of the needs for community decisions and will guide future USGS research.
- Initiate or expand real-time natural-hazard monitoring and warning systems.
- Provide easy access to new and existing hazards data, information, assessments, and models to facilitate integration and use by decision makers and researchers.

- Develop new research products and interactive tools that result in effective use of hazard, vulnerability, and risk maps and assessments. Integrate hazard products, and economic and social science research into decision-support resources that respond to community needs.
- Propose extensions of our methodology, products, and experience to other regions to build a robust Integrated Urban Hazards program for the Nation.

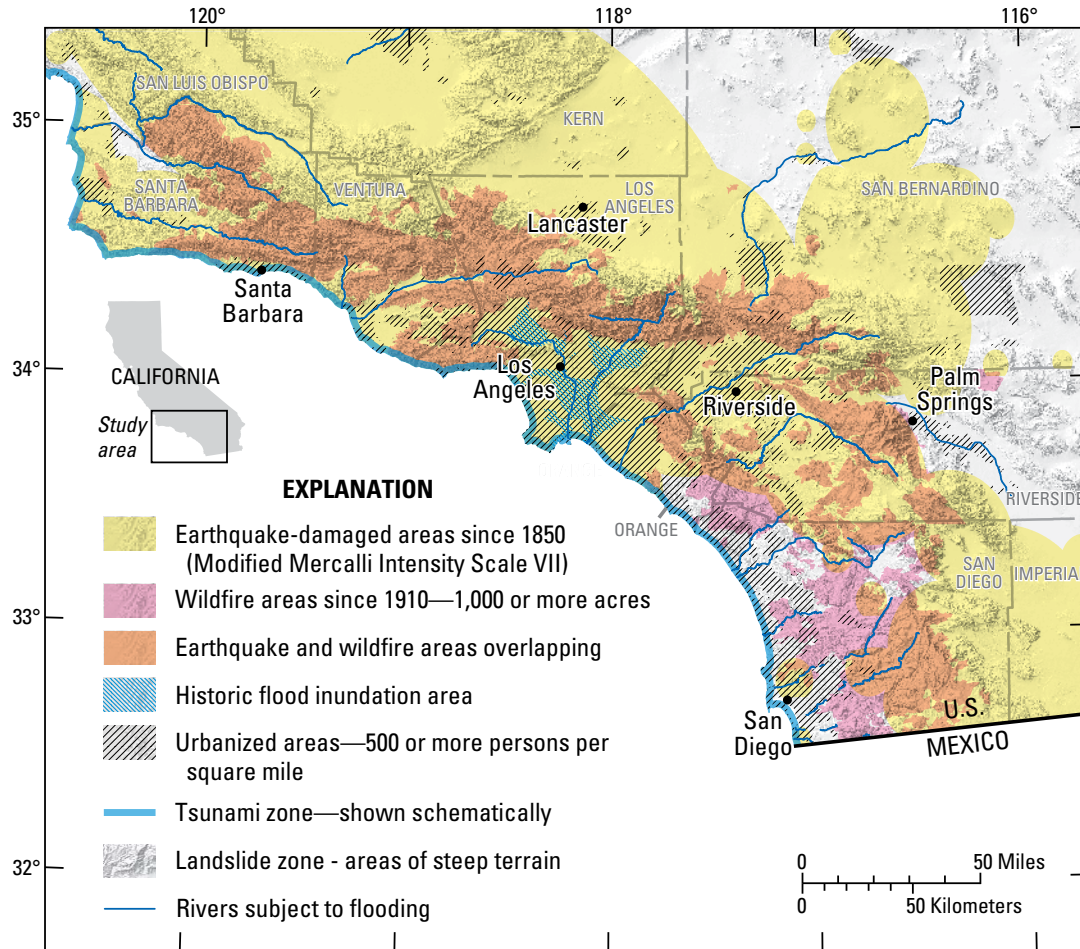
## Statement of Problem

Americans are more at risk from natural hazards now than at any other time in our Nation's history. In the United States each year, natural hazards cause hundreds of deaths and cost tens of billions of dollars in disaster aid, disruption of commerce, and destruction of homes and critical infrastructure. Although we have reduced the number of lives lost to many natural hazards, the economic cost of major disaster response and recovery continues to double or triple in constant dollars every decade. Southern California, in particular, has one of the Nation's highest potentials for extreme catastrophic losses due to natural hazards such as earthquakes, tsunamis, wildfires, landslides, coastal erosion, and floods. Estimates of expected losses from all these hazards in the eight counties of southern California exceed \$3 billion per year (fig. 1). These numbers are expected to increase as the present population of 23 million continues to grow at more than 10 percent per year.

These losses can only be reduced through actions of the southern California communities. To be effective, these actions must be guided by the best information about hazards, risk, and the cost-effectiveness of mitigation technologies. Long-term solutions require broad perspectives that recognize the inter-connectedness of urban communities and the natural environment.

USGS scientists must provide scientific information that is beneficial to society. Decision makers (for example, planners, policy makers, emergency response officials) in southern California know that scientific information is not being fully used in decisions about natural hazards. Factors that impede the use of scientific information include incompleteness, uncertainties, decentralized sources, non-standardization, presentation format, incomprehensibility to the layperson, misinterpretation, and inaccessibility of information.





**Figure 1.** Shaded relief map of southern California showing geographical extent and overlap of different hazards. The region of study will span the urban areas of southern California, including the Los Angeles and San Diego metropolitan areas, and extending north to Santa Barbara and Lancaster, south to the Mexico border, and east to Palm Springs.

Decisions to improve resiliency to natural hazards can be grouped into two sets of problems in two time frames: (1) emergency response to a natural hazard event as it happens, and (2) long-range planning for building resiliency to multiple and periodic natural hazards. The demand for and supply of scientific information for these problems takes place in a complex decision-making environment. The two problems have the following characteristics in common.

- Multiple natural hazards affect most regions, and the spatial extents of natural hazards often overlap, with initial hazards triggering secondary hazards.
- Natural hazards create multiple negative effects on social welfare including loss of life and injury, replacement costs of buildings and infrastructure, loss of function of critical facilities, service and infrastructure outages, business interruption, and a decrease in the quality of life.
- The severities of natural hazards vary greatly. Anticipated events, such as a 50-year flood or a Northridge-sized earthquake, are highly likely to occur during our planning horizon and fall within the knowledge and experience of at least some decision makers. The occurrence, magnitude, and impact of the most catastrophic events are much more uncertain and can break the entire social system. Standard mechanisms for loss evaluation and financial recovery will fail. Many losses are not replaceable and substantial public aid is necessary.
- Decision makers at different levels of government require different types of information at a wide range of spatial and temporal scales. The decision-making environment is dynamic and the decision makers need to be able to access the most recent information derived from scientific investigations that account for human and natural forces of change.
- Effective risk reduction options depend on resources that are subject to budget constraints and on personal or organizational preferences for acceptable levels of risk; the options thus need to be quantified by models and simulation studies.

## Project Principles

To accomplish our mission of applying the best science to improve disaster resiliency, we must

- Ensure that our research will be useful to communities.
- Conduct the best possible multidisciplinary scientific research.
- Work in partnership with communities to support them in using the research results.

Natural hazard information is useful when it is factored into decision-making about risk reduction strategies. USGS activities will increase our understanding of the framework of hazard possibilities, vulnerable environments, community responses, and associated risk reduction options. The vulnerable environment is in part created by humans, but is also natural—the soils, geology, hydrology, and ecology. Activities will be prioritized and carried out in order to fill gaps in the scientific knowledge base, which can help to improve resiliency. We aim to gain an understanding of the relations between human actions and environmental vulnerabilities and inform decision makers about possible risk reduction measures.

### Existing Hazards Research

The Multi-Hazards Demonstration Project is based on existing hazards research programs of the U.S. Geological Survey. The USGS role varies for the different hazards.

**Earthquakes.** The USGS has statutory responsibility to assess earthquake hazards for the Nation, monitor seismic activity and issue alerts, and conduct targeted research into earthquake processes and effects.

**Landslides.** The USGS has statutory responsibility to assess and issue warnings of landslide hazards for the Nation and conducts applied research in support of that responsibility.

**Floods.** The USGS has responsibility to monitor stream levels for use by NOAA in flood warnings and to conduct research on flood inundation and hydrology.

**Tsunamis.** The USGS assesses offshore geologic faults and landslides for tsunami generation potential, conducts research in tsunami generation, and provides global seismic data to NOAA for use in tsunami warnings and mitigation.

**Fires.** The USGS provides geospatial support to land-management agencies and conducts research in fire ecology and response of ecologic systems to fires.

**Coastal erosion.** The USGS conducts research in marine geology on susceptibility to coastal erosion.

Figure 2 shows the schematic relationships of the need for and flow of information in making decisions for risk reduction. Possible actions are shown in gold boxes and can take place either before or during and immediately after an event. The variables of the hazard system are shown in blue ovals. The hazard (for example, fire, earthquake, flood, etc.) has some probability of occurring with some magnitude, location, and other characteristics. It acts upon an environment with some susceptibility to the hazard. Most risk-reduction strategies are applied to this environment, such as compacting soils to reduce shaking, planting grass to stop erosion, or retrofitting buildings to prevent damage. The effect of each of these decisions on reducing losses can be determined through scientific study but also depends on the state of the environmental system. A second set of actions is undertaken during or after the event, such as fire fighting, and search and rescue. All of these elements affect each other and result in certain outcomes, shown in purple, of economic losses, casualties, and ecologic damage.

The decisions on the left side of the diagram are being made by different individuals and communities in southern California. The goal of the Multi-Hazards Demonstration Project is to understand the characteristics and relationships among the elements on the right so as to better predict the effects of the various risk reduction strategies and to communicate this information to those making the decisions. This information will provide critical support for improving strategies that will actively reduce losses. The elements and interdependencies will be captured in an *influence diagram* (modeled after that shown in figure 2) for each hazard that we are studying: earthquakes, tsunamis, wildfires, landslides, floods, and coastal erosion.

These hazards also are interdependent (table 1). An earthquake can immediately trigger fires, and a fire makes an area more susceptible to debris flows. Moreover, the risk-reduction strategy for one hazard may reduce or even aggravate some other hazard. The Multi-Hazards Demonstration Project proposes to investigate and communicate the relationships among the hazards, how they trigger each other, and how the risk reduction strategies interact.

To accomplish these multi-faceted tasks, the Multi-Hazards Demonstration Project will be organized around four working groups. Three of the groups—Earthquakes and Tsunamis (ET), Fire and Debris Flows (FD), and Winter Storm Events (WS)—will focus on the research of particular hazards and some of the interrelationships. The hazards have been grouped by the most direct connections among events. The fourth group, Integration and Implementation Interface (I-cubed), will support the interface with the community as well as develop the risk analysis model described schematically in the influence diagram (figure 2). This risk analysis model provides the backbone of the framework for conceptualizing the full range of activities of the Multi-Hazards Demonstration Project and its relationship to southern California decision making. As we move to concrete products that can actually be used, we can envision these as subsets of the bigger framework.

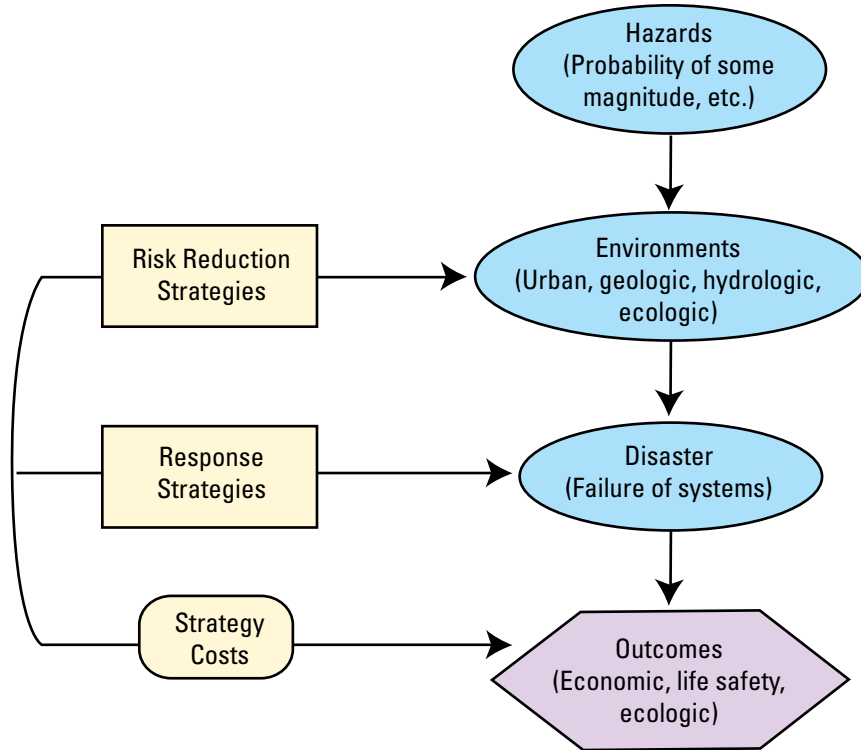


Figure 2. Guiding framework for the Multi-Hazards Demonstration Project.

Table 1. Secondary hazard triggering events.

	Earthquakes	Landslides and debris flows	Wildfires	Floods	Coastal erosion	Tsunamis
Secondary hazard effects	Landslides, tsunamis, fires (especially during wind season), floods from dam failures	Floods, tsunamis, coastal erosion	Floods and debris flows	Landslides and debris flows, spread of disease	Landslides, dangerous currents	Flooding, contamination, spread of disease, fires, coastal erosion

On the basis of input from external participants attending workshops during the winter of 2006, we have identified four initial priority areas for community support. These are our first-pass priorities and will be modified as necessary throughout the duration of the project. First is the integration of mapped hazards and expected consequences into risk and decision-making tools that individuals and communities can use to evaluate alternative actions. The development of analytical and numerical tools to access the information in this system will be a key aspect of the project framework.

Second is helping decision makers to develop planning scenarios and quantifying anticipated consequences of future events so they can do a better job of emergency preparedness and planning. These scenarios are needed for all the hazards

and need to convey the range of anticipated consequences, including the social and economic outcomes. This can be understood as one specific path through the influence diagram by setting the hazard probability to one for only one specific event.

Third is to improve upon the mapping of urban hazards. Maps are needed that specifically assess the probabilities of different hazard occurrence and their likely magnitude. For example: Is the threat to a given site greater for flooding or landslides? Where is earthquake shaking amplification most severe? These are a geographical representation of the upper part of the influence diagram, the hazard and environment susceptibility, for all the hazards.

Relationship of Working Groups to U.S. Geological Survey Science Centers and Programs		
Working group	Science centers of most participants	Primary funding programs
Integration and Implementation Interface	All science centers	All programs
Earthquakes and Tsunamis	Earthquake Hazards, Western Coastal and Marine	Earthquake Hazards, Coastal and Marine Geology
Fire and Debris Flows	Geologic Hazards, Western Ecologic Research Center, California Water Science Center, Earth Resources Observation System (EROS) Science Center	Landslide Hazards, Ecosystems, Geographic Analysis and Monitoring, Land Remote Sensing
Winter Storm Events	California Water Science Center, Geologic Hazards, Western Coastal and Marine	National Streamflow Information, Landslide Hazards, Geographic Analysis and Monitoring, Coastal and Marine Geology

The fourth priority is providing real-time information. For some hazards, knowing the ongoing processes can help mitigate the consequences. For instance, real-time debris-flow risk (determined from short-term rainfall prediction and geologic susceptibility) can be used to target evacuations. Near-real-time earthquake shaking maps can be used to guide rescue operations to the most heavily shaken areas. Participants also expressed the need for products that will allow them to postulate and evaluate choices for a risk-reduction strategy. This will be support for the response decision box in the influence diagram.

Activities are being designed with our existing and new partners to accelerate the development and dissemination of information. This will include working with partners from academic institutions to support research that will lead to future generations of tools that communities can use. We will also work with the earth observation networks of the USGS (seismic, geodetic, ground movement, stream gages, and land cover) and partners in southern California to ensure their continued and enhanced operations. We will work together to develop a new generation of monitoring products that provide greater situational awareness for emergency responders.

## First-Year Goals

Our goal is to provide hazards information in the form of concrete products needed to support communities in the decision-making process. The research needs for urban-hazard products are highly interdependent, as [table 1](#) illustrates, highlighting the need for cross-cutting research products and interactive analytical tools designed for decision makers' use. Our first-year and out-year goals incorporate these needs and are influenced by the two-way communication that continues to take place among scientists and between scientists and community decision makers. The working groups will have solidified during the first year, and we list them here to categorize the project activities. All four areas will require significant

integration of research across scientific disciplines and with community partners.

## Integration and Implementation Interface Working Group

**Scenario development.** The first round of strategic planning workshops with our user community highlighted a high-priority need for planning scenarios that can be used to devise hazard-response training exercises for their organizations. The community wants hazard information provided in a form that is accessible to and understandable by decision makers. During the first year, a scenario will be developed that describes the pre-event and post-event risks and probabilities associated with a southern San Andreas earthquake that triggers landslides (including one underwater) and a dam failure. The scenario will incorporate the general consequences associated with the potential impacts of a strong earthquake (for example, expected shaking intensity, secondary effects such as liquefaction and subsequent lateral spreading, and variations in site conditions based on soil type), landslide (for example, probability of initiation made on the basis of shaking intensity, rock type, slope steepness, and soil moisture conditions), and potential tsunami (probability based on landslide displacement characteristics and historical activity, impact on coastal communities from run-up height and inundation estimates). The potential area that can be inundated by flood waters released by a dam failure will be identified. Moreover, the scenario will demonstrate the effect on infrastructure such as highways, airports, railroads, marine facilities, communications, water supply and waste disposal, electrical power, natural gas, and petroleum fuels. A key element of the scenario will be software that can illustrate the levels of damage on the basis of structure types (for example, unreinforced masonry compared with steel moment frame), age of structure, and hazard-retrofitting history of structure. A related study, begun in 2006, will focus on the effect of an earthquake on water supplies and on how to use ground water to compensate.

**Community interface.** We will start a training program that will serve as a continuing process for helping communities use our products. The program will expand in FY 2008 to support the use of the new products that will be generated by this project. The information exchange will take place during scheduled workshops that will focus on developing effective mechanisms of communication between the decision makers and scientists before, during, and after hazard events. Two-way information exchange that guides the development of planning scenario content for use by the decision makers will take place during workshops and staff exchange programs. We aim to provide accurate and complete information to support those entities that provide outreach and education to the public and to promote interaction between users and scientific partners.

**Information management.** A large quantity of data has been accumulated for southern California for different purposes, in different formats, and for different geographical regions. We will be more efficient if we make use of all the existing pieces of relevant data. However, work is necessary to determine what data exist and how they may be useful. During the first year, we will focus on inventorying the data resources, determining both the needs and capabilities of researchers and partners, and developing a management plan for the most cost-effective information management strategy.

**Risk modeling.** We will initiate a risk-assessment methodology of multiple natural hazards in southern California that incorporates conditional (triggered secondary) hazard probabilities over a range of hazard magnitudes and severities. Probabilities of changes in land-cover, land-use, and demographics will be incorporated into model alternative futures for the communities. The work will involve the consolidation of hypotheses and empirical findings from the economic literature on risk reduction into a single decision framework. A key product will be the development of a tool to reveal decision-maker preferences regarding the key elements of the decision framework.

## Earthquakes and Tsunamis Working Group

**Southern San Andreas Fault.** The southern San Andreas Fault is recognized as southern California's most likely source of future great earthquakes, but the past history of great earthquakes and the rate at which strain is accumulating towards the next big earthquake is poorly understood. We will study the southern San Andreas Fault to improve the accuracy of hazard assessments of the region and to determine the likelihood of another large earthquake on this fault segment.

**Tsunami source.** We will move toward a probabilistic assessment of tsunami inundation in southern California by developing an improved understanding of local tsunami sources and the likely time history of their activity. We will re-examine all available geophysical and core data to improve upon our characterizations of tsunami sources and obtain better chronologic control on available core samples near faults and large landslides to better define history of activity and recurrence intervals.

**Microzonation.** Loose soils and basin deposits locally amplify seismic shaking and can be responsible for substantial damage. The fastest population growth in southern California is occurring in basins near the San Andreas Fault, including the San Bernardino, Coachella, and Antelope Valleys. We will compile existing data on these basins to develop a preliminary shaking amplification model and determine which data are needed to accurately quantify this risk.

## Fire and Debris Flows Working Group

**Fuel treatments on stability.** Soil erosion after large wildfires degrades both the ecologic and urban environments. We will evaluate how vegetation age and landscape fuels affect the rates of erosion following fires, using vegetation age, sediment, and remote imaging data.

**Vegetation-type conversions.** The shrublands of southern California have undergone significant change of vegetation type in the last century as human activity has brought exotic species to the ecosystems. We will begin the evaluation of the invasive species-fire cycle to determine what role conversion of ecosystems is playing in fire frequency.

**Post-fire debris-flow susceptibility.** The incidence of debris flows after fires is controlled by the topography and geology of the slope, the severity of the burning, and the intensity and duration of rainfall. Models to predict post-fire debris-flow probabilities, magnitudes, and potential inundation areas using measures of basin shape and materials, burn severity, and storm data will be modified and tested for the southern California environment.

**Post-fire erosion.** The southern California ecosystem is home to the greatest concentration of endangered species in the Nation. We will develop models and methods to map post-fire physical processes and effects on rare and endangered aquatic populations.

**Debris-flow warning system.** The results of the southern California models will be used to develop a flash-flood and debris-flow early warning system for release by NOAA for recently burned basins. The warning system will compare rainfall forecasts and rain-gage data with rainfall threshold conditions.

**Debris-flow inundation.** Identify areas susceptible to debris-flow inundation through a combination of empirical and modeling approaches to (1) identify likely source areas for debris-flow initiation, (2) estimate likely debris-flow volumes and peak discharges, and (3) determine areas likely to be inundated by debris flows. Debris-flow source-area identification will be a combined mapping and Geographic Information System (GIS) endeavor. Mapping of recent debris flows by field and remote sensing techniques will provide an empirical data base of debris-flow initiation locations that can be analyzed within a GIS to assess likely controlling factors such as topography (including slope, hill-slope curvature, and aspect), geology, soils, land-use, and recent disturbance history (such as fire).

## Winter Storm Events Working Group

**Gaging (streams, rain).** Install new stream and rain gages in southern California to improve flood and debris-flow forecasting, and real-time monitoring and warning capabilities. The gage locations are being selected with input from local water agencies and the National Weather Service to fill in gaps in the existing ALERT network. The gages will be constructed, instrumented, and operated to provide real-time streamflow information on the web during FY 2007 for access to all interested users.

**Flood frequency analysis.** Winter storms can produce significant flood runoff and debris flows from basins throughout Southern California. Distinguishing flood flows from debris flows is critical to the proper assessment of flood risk, but there is no USGS database for debris flows. A database for compiling and storing debris-flow data for USGS gaged sites, similar to the Peak Flow File for flood data, will be developed. Assessing flood risk also requires information about magnitude and probability of occurrence (frequency) of annual peak flood discharges. Long-term flood-discharge data are available for the analysis at more than 100 USGS stream gages in southern California, many of which provide flow information on a near real-time basis via the web. Flood-frequency characteristics will be revised and prepared for publication during FY 2007.

**Coastal erosion.** Severe winter storms have eroded seacoasts, leading to major economic losses. We will develop tools to assess coastal vulnerability to severe storm impact based on elevation and morphology data.

## Potential Out-Year Goals

We envision this project going in several productive directions depending on the fruitfulness of first-year pilot programs, community input, and funding. Setting priorities for these future research directions will be guided by the Planning and Steering Committees to take into account the research needs of partner agencies and decision makers.

## Integration and Implementation Interface Working Group

**Common database and urban hazard mapping.** An essential need voiced by the emergency response and planning communities during the Winter 2006 workshops was the need for trustworthy hazard data pulled together in one place and made easily accessible (“integrated data management”). As a result, a map product that will result from the research and cross-discipline projects will be a space-time GIS that has multiple layers including the extents, likelihoods, temporal aspects, and regional vulnerabilities of multiple hazards that can be used as input to an urban risk assessment in southern California. The goal of the GIS is to accept and

incorporate measurements from real-time monitoring networks and updated science products to assist in crises and longer term planning. A complete geotechnical database will serve as the starting point for long-term mitigation projects, short-term warning activities, hazard event emergency response, and post-event response and recovery. For example, this map product could allow end-users to conduct a geographical search of their scale of interest in order to investigate the level of risk associated with any one or multiple hazards at that location given the uncertainty of the information at the resolution of the location. Such information will improve the implementation of building codes, land-use planning decisions, and engineering design and retrofit decisions.

**Hazard scenarios.** We envision creating a suite of scenarios to support emergency planning for many disasters and to better manage mitigation activities. For the second year, we plan a scenario that will focus on a winter storm event that involves landslides, flooding, and coastal change. A key watershed will be selected with input from the southern California emergency managers to pilot a real-time flood-hazard modeling tool. An interactive, web-based user interface will be developed. Other earthquakes, wildfires, and combined disasters are also possible.

The third-year scenario will focus on the effects of wildfires, and subsequent floods and debris flows. The scenario will describe the consequences associated with the ignition of a fire in mountain steep lands; expected fire behavior based on vegetation type, condition, and landscape; and emergency response expectations based on transportation corridor and infrastructure impact. It will incorporate potential real-time tools to assess hazards posed by post-fire debris flows and floods to human infrastructure, wildlife, and aquatic habitats in the event of a subsequent winter storm. Risk will be evaluated in terms of probability, magnitude, and area of impact. The capabilities and limitations of existing warning systems for post-fire floods and debris flows will be illustrated.

**Risk analysis for decision making.** Our risk analysis work will create an environment for decision makers to assess alternative policies to improve the resiliency of southern California to multiple natural hazards. This work will take the form of an interactive simulation or game experiment embedded within a GIS that is informed by improved understanding of multiple hazards and interactions, quantification of the social and economic assets that are vulnerable, improved understanding of mitigation effectiveness, and lessons learned from work with our partners. We expect to develop tools that could be used to evaluate issues such as benefits and costs of risk-reduction options, relative roles of private insurance and government intervention, determination of acceptable risk, and scientific uncertainties for emergency response planning scenarios and long-term planning. These tools will provide an interactive approach for individual and institutional users to understand the risks and consequences of a range of multiple natural hazards and solutions. This effort also will examine how well our science products are serving or can serve decision makers and will help USGS scientists prioritize the development of future science products.

***Impact of natural disasters on endangered ecosystems.***

Leading conservation biologists rank the California Floristic Province, especially southern California, as one of the top 18 regions on the planet for biological diversity. Many species of plants and animals are found only in California, and many are threatened or endangered. Natural disasters, especially landslides and floods, can radically alter ecosystem habitats and put further strain on endangered populations. Moreover, our data have shown that roads and fuel breaks become barriers to movement within reserves for various sensitive species in southern California. This project will assess the population and genetic consequences of natural disasters and mitigation measures to prevent losses in disasters for several target species and predict what impacts the activities will have on these species under the future build-out scenarios. After different natural disasters, the USGS will carry out studies to understand the impact on different species.

***Impact of natural hazards on water supplies, ground water, and watershed stability.*** A disruption to water supplies in southern California is a dire threat to the economic viability and social well-being of the region. Different natural disasters pose different, but potentially significant, threats to the southern California water supply. Earthquakes on the San Andreas Fault can cut off all aqueducts carrying imported water to the region. Other earthquakes have the potential of disrupting water delivery systems. Wildfires can damage the shrubland ecosystems surrounding most urban environments in southern California that provide watershed cover. Sedimentation from debris flows and floods can impair water quality. We can analyze and compare the different threats to our water supply and evaluate the cost effectiveness of mitigable actions.

## **Earthquakes and Tsunamis Working Group**

***Earthquake-rupture chronology and slip rates for the southern San Andreas system in the last 2,000 years.*** The southern San Andreas Fault is recognized as southern California's most likely source of future great earthquakes, with 20 million people likely to be affected by such an event. Evidence is increasing that the fault has already exceeded the average time between great (magnitude about 8) events by more than 50 percent; however, recent geologic studies suggest that the hazard from this significant fault is uncertain by a factor of three. A systematic study of the earthquake history of the southernmost 550 kilometers of the fault through geologic studies (paleoseismology) to determine the rate of past events and how regularly they occurred will constrain the rate of earthquakes and the hazard of this catastrophic event.

***Time-dependent earthquake-hazard maps.*** The methodologies employed in producing the USGS national and urban seismic hazard maps assume the hazard does not change with time. However, the potential for an earthquake on a

fault increases with time from the last earthquake and may be modified by nearby conditions. Time-varying hazard maps are needed throughout the Nation. In addition, the occurrence of one earthquake makes another more likely. The USGS has developed significant capability in quantifying the increase in hazard likelihood and has a prototype product (daily earthquake hazard maps) that shows the chance of earthquake shaking in the next 24 hours.

***Earthquake site effects.*** Assessing the damage potential of earthquakes depends critically on local soil conditions and the structures of basins and valleys that can amplify the shaking from earthquakes. Three of the fastest growing areas of southern California are the Antelope Valley, the San Bernardino Valley, and the Coachella Valley—all valleys where site amplification could play a major role in increasing damage from big earthquakes. To better understand the nature of this risk, we must determine the subsurface structure of these basins. Seismic refraction techniques (such as used for oil exploration) will be used to determine the shape of the basins. This can then be modeled to understand which areas are most susceptible to resonance and other shaking amplification mechanisms. The same data will be useful in modeling ground-water systems to better understand local water resources in case a disaster cuts off outside water supplies.

***Mapping of Probabilistic earthquake-induced landslide hazards.*** Current hazard maps only provide a binary landslide susceptibility rating that does not provide a basis for prioritizing the risk or possible mitigable responses. Applied research is needed to determine what controls the relative likelihood of earthquake-induced landsliding, including the relative contributions of slope, bedrock geology, alluvial cover, and intensity, frequency, and duration of earthquake shaking in southern California. The results of this research could be combined with probabilistic earthquake hazard information to give a picture of the comparative likelihood of landsliding during earthquakes.

***Earthquake early warning.*** Most damage in earthquakes is caused by the shaking from seismic waves. These waves travel at the speed of sound in rocks from the fault that produces the earthquake, dying off with distance from the fault. In very large earthquakes, the fault can produce the shaking for many minutes and these waves can cause substantial damage even at great distances from the fault. Thus, in very large earthquakes it is possible to transmit (at the speed of light) the information that an earthquake is underway and receive that information at more distant sites before the earthquake waves themselves arrive. This type of system has recently been created in Japan and Mexico. Knowing that an earthquake will begin in 10-60 seconds can be used in automatic systems to reduce losses by actions such as securing hazardous materials, stopping trains, and shutting down nuclear reactors.

***Assessing the potential for local tsunamis from earthquake-induced offshore landslides and fault movement.***

Given the relative rarity of direct observations in any specific locale, the assessment of tsunami hazard potential depends on model formulations linking geologic processes and structures to tsunami generation, propagation, and impact. We know that past earthquakes have triggered offshore landslides that have in turn produced locally damaging tsunamis. A local tsunami that damages the Ports of Los Angeles and Long Beach and concentrated coastal developments will have major financial and social impact on the region. Research is needed to quantify the hazard magnitudes and likelihoods to better understand how large such a tsunami could be. Significant offshore bathymetric mapping has been completed in the last few years, but about one-third of the mainland slope has not been mapped using state-of-the-art technology. Quantification of the tsunami hazard needs a completion of the bathymetric mapping, assessment of the data to identify potentially tsunamic landslide deposits and active faults, determination of the ages of these landslides and time of most recent fault movement, modeling of the movement of these landslides, and modeling of associated tsunamis and synthesis of data within a probabilistic framework. These tsunami research and hazard assessment studies will be coordinated with partners in the Southern California Coastal Ocean Observing System (SCCOOS).

**Fire and Debris-Flow Working Group**

***Post-fire flood and debris-flow hazard assessment and early warning.*** Web-based tools to characterize post-fire debris-flow and flash-flood susceptibility, magnitude, and inundation area in response to storm rainfall conditions can be used to assess these potential hazards on a basin scale. Because the tools developed in this task will rely on data that are readily available both before and immediately after wildfires, they will be useful to land management agencies both in pre-fire planning and post-fire response. Application of the predictive models before the occurrence of wildfires can help identify sensitive drainage basins and thus direct forest restoration efforts. Rapid application of these tools post-fire will provide information necessary to provide warnings and to make effective and appropriate mitigation and planning decisions. Assessments of risks from post-fire floods and debris flows to human life and property, and to wildlife and aquatic habitats both immediately post-fire and over longer time periods can be used to create response plans.

***Evaluation of how pre-fire fuel manipulations affect watershed stability and subsequent downstream impacts.*** Shrubland ecosystems surround most urban environments in southern California and provide many important benefits to communities. One of the more critical values is as a watershed cover, and this ecosystem service becomes more apparent following wildfires when the vegetative cover has been temporarily eliminated. Twentieth-century urban expansion has used much of the desirable coastal plain real estate and forced

development ever closer to steep slopes in the surrounding mountain ranges, typically adjacent to federal lands. Increased potential for flooding, sudden debris flows, and erosion are factors that pose major hazards for these urban environments and affect natural resources. There are three areas where new research is needed: (1) Using several decades of sediment-production data in the Los Angeles Basin, coupled with past fire history data, we will analyze the extent to which vegetation-age and landscape-fuel mosaics can alter rates of erosion following fires; (2) We will relate remote-image algorithms using Landsat images to assess fire intensity to both real potential for sediment loss and vegetation recovery after fire; and (3) Debris-flow events have reduced or removed sensitive and endangered frogs and fish from entire watersheds. Understanding and predicting where these events will take place and what resources are at risk is a priority for managing the last remaining populations of these formerly widespread species and communities.

***Integrated approach to watershed risk assessment.*** We can apply an integrated approach to watershed risk assessment that examines all potential natural hazards expected to impact an area, and considers the spatial and temporal aspects of a hazard and the potential for interaction among hazards. Specific to the fire hazard, this approach will consider fuel loadings, effects of fuel treatment programs, pre-event long-term climatic conditions and rainfall regime, and potential resources at risk at the site of the hazard and downstream. The potential for deleterious effects on water resources including impacts on municipal water supplies, both surface and subsurface, will receive special attention.

***Impact of past fire activity on vegetation type conversion.*** Accelerated fire activity is responsible for major losses of natural shrubland ecosystems and replacement by non-native annual grasses and forbs. Type conversion has implications both for conservation and human safety through impacts to ecosystem functioning and fire regime. Loss of native shrublands greatly decreases the structural complexity of ecosystem communities and landscapes, and is responsible for the loss of critical components of the flora and fauna, including rare species and keystone species. When these shrublands are displaced by non-native grasslands, the functional types change from deeply rooted shrubs to shallow-rooted annuals, which alters the water-holding capacity and erosion potential of watersheds. This sometimes increases the potential for debris slides in the absence of other disturbances such as fire. These types of conversions also alter the risk of fires owing to the easily combustible nature of grasses relative to shrublands, often greatly extending the normal fire season. Two tasks are anticipated: The first task will take advantage of a 35-year remote imaging database (Landsat), which is capable of detecting vegetation changes at a relatively fine scale. Documenting the massive scale of past type conversion will be a critical first warning to future hazards. The second task will examine biodiversity and trophic response and recovery from landscape fires in San Diego. This five-year study addresses these presumed changes in flora and fauna to the vegetation



type conversion and takes advantage of extensive pre-fire USGS data.

***Assess effectiveness of pre-fire fuel management strategies on southern California fire behavior and reducing urban impacts from fire.*** California leads the Nation in fire losses. Since 1970, 12 of the Nation's 15 most destructive wildfires have occurred in California, costing the insurance industry \$4.8 billion, the most destructive being the southern California firestorms of October 2003. We will conduct an empirical study of how past fuel-manipulation projects in southern California have affected the progression of historical fires in the region. In addition, fire behavior models will be used to relate landscape patterns of fuels, topography, climate, and wind patterns to predictions of fire spread under different scenarios of fuel placement. This project also will include consideration of land planning scenarios of future build-out provided by urban growth models. The most useful product will be maps that distinguish important topographic fire corridors that are most likely to affect urban environments and placement of fuel treatments to minimize vulnerability of communities. This research will involve USGS researchers collaborating with land managers and scientists from the U.S. Forest Service and the U.S. Bureau of Land Management.

***Assess effectiveness of pre-fire fuel management strategies on southern California biodiversity and ecosystem stability.*** The impact of fuel treatments and fuel breaks to biodiversity and fragmentation within the remaining wildlands will be assessed with an emphasis on the recently formed Habitat Conservation Plans authorized by the Endangered Species Act. USGS data have shown that roads and fuel breaks become barriers to movement within reserves for various sensitive species in southern California. This project will assess the population and genetic consequences of these types of barriers for several target species and predict what impacts the fuel modifications will have on these species under the future build-out scenarios and how urban fire risk-reduction strategies can be successfully integrated into the reserve design for maintaining biodiversity in the region. This research will involve USGS researchers collaborating with other Department of the Interior scientists.

## Winter Storm Events Working Group

***Developing tools for predicting flooding and debris flows at ungaged sites.*** After flood-frequency information is updated at gaged sites, new predictive equations for estimation of flood magnitude and probability at ungaged sites in southern California will be developed using Generalized Least Squares regression techniques. Equations will be incorporated into a web-based program (StreamStats) that enables users to quickly obtain flood estimates at ungaged sites by simply clicking the site locations on a web map. Similar predictive

equations currently under development for estimating the probability of occurrence and volume of deposited material from debris flows also will be incorporated into the StreamStats program. Research will be initiated to understand and better determine risk in watersheds subject to both floods and debris flows (mixed-population analysis). As the risk from both processes becomes better understood, predictive methods in the StreamStats program will be modified as necessary to better convey the risk information. Insofar as possible, the StreamStats application for Southern California will be designed to provide flood and debris-flow risk information to local officials in easy-to-understand, non-technical terms.

***Real-time model predictions of coastal erosion and flooding.*** This will involve taking our short-term goal of generally assessing coastal vulnerability to erosion and flooding, and integrating these data into a fully operational, real-time coastal warning system. The web-based interface will feature a real-time model driven by the most up-to-date coastal conditions (specifically, wind, waves, and tides) with the product being an hourly hazard assessment of the southern California coastline. Using the state-of-the-art Delf3D integrated hydrodynamic and wave model and the most up-to-date topographic (specifically, Light Detection And Ranging - LIDAR) and bathymetric (specifically, multi-beam) data, this operational model will provide invaluable information to the full range of coastal users, particularly during the winter storm season. It will allow resources to be allocated in areas of greatest risk, and warnings to be issued to beachgoers where dangerous conditions exist. Development of this warning system will be closely coordinated with partners in the Southern California Coastal Ocean Observing System (SCCOOS).

***Rapid assessment of methods for characterizing and assessing errors in streamflow data.*** Many planning and design decisions are predicated on assumptions that streamflow data are complete and accurate. In fact there are multiple sources of error in streamflow records. A rapid and accurate method to estimate and evaluate these uncertainties is needed. The inherent difficulties of collecting streamflow records in southern California make it a prime area to design and develop methods for characterizing and assessing errors in flow measurements, instruments, and rating curves.

***Forcing mechanisms on changes in streamflow.*** Time series of streamflow records in many areas indicate decade-scale changes in flow volumes and flow duration curves. The frequency of extreme events may be changing. El Niño signals may offer an opportunity to predict some of these changes, and paleoflood techniques may offer a chance to document trends over long periods of time. Many basins in southern California have evolved from undisturbed to agricultural to urban in the last 50–100 years, and some stream-gaging stations have operated throughout these changes. These sites need to be studied to evaluate the impacts of changes in land use and regulation on flow statistics such as duration series and flood frequencies.

***Comprehensive assessment of landslide hazards and early warning.*** Although landslides often result in millions of dollars of damage, and even deaths, during rainy winters in southern California, no comprehensive evaluation of landslide hazards exists for the region. We propose the development and application of reliable and accurate landslide prediction tools that are appropriate to southern California. We will develop methods and models that use LIDAR and other high-resolution remotely sensed data to characterize landslide susceptibility or probability in response to seismic, climatic, or artificial disturbances. Physically based models of landslide processes can be coupled with methods for identifying the hydrologic precursors to landslide failure (either of large, deep-seated landslides or shallow landslides that generate debris flows), and with methods for real-time monitoring of hill-slope hydrologic conditions. Incorporation of quantitative precipitation forecasts and measurements into these models can result in spatially and temporally specific real-time warnings for landslides. Models that can be used to define potential areas that can be inundated by debris flows will be developed and integrated into the warning system. The improved hazard assessment approaches developed here will provide critical information on landslide occurrence at appropriate spatial and temporal scales to planners, decision makers, and emergency managers.

## Partnerships and Collaborations

An important feature of the project is that the USGS will work with partners and collaborators in southern California to apply the results of scientific research to loss reduction and to guide the direction of future research activities. Existing and new partnerships and activities will be designed with external input to accelerate the development and dissemination of information needed to create a disaster-resistant southern California. These collaborators will directly guide the research, resulting products, and implementation (fig. 3). The development of new partnerships and collaborations, as well as strengthening of existing partnerships and collaborations, is key to the project's success.

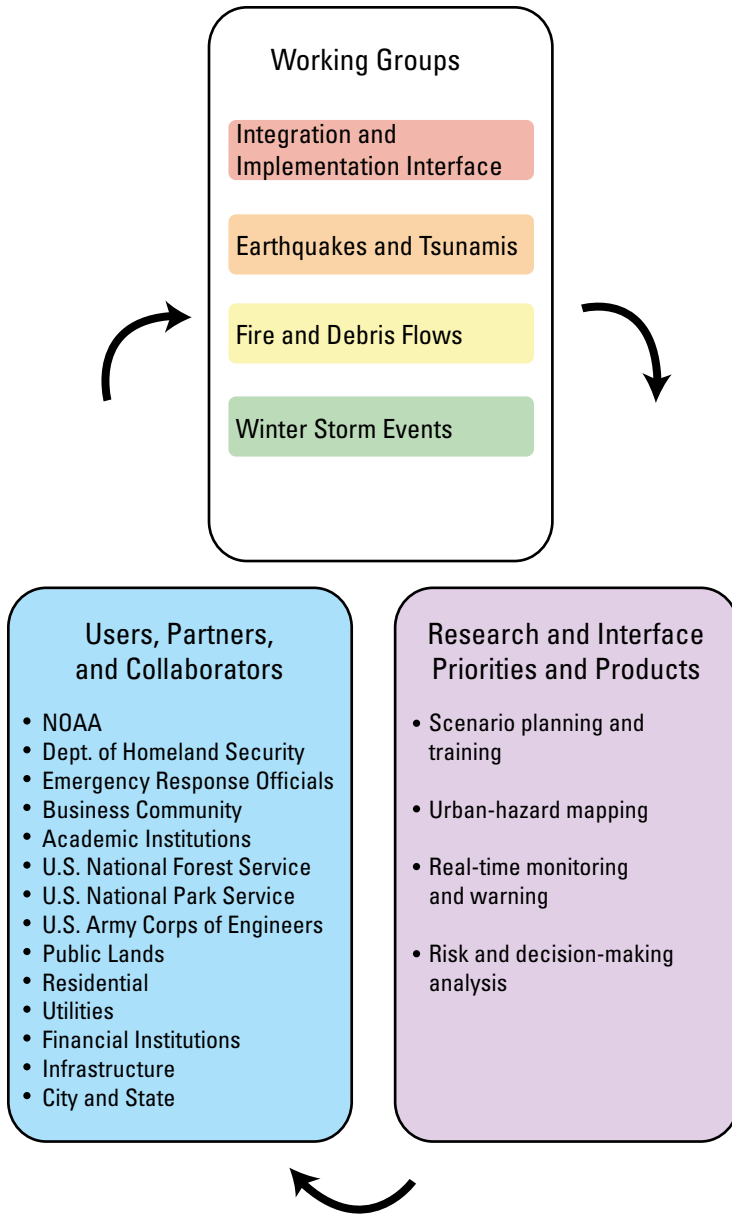
Prior to the writing of this strategic plan document, three strategic planning workshops were held in February and March 2006 at the USGS office in Pasadena to explore potential relationships. The goal of these planning sessions was to determine the external organizations' needs for mitigation efforts before potential natural hazard events, and response efforts during and after the event. Potential partners who were invited and who participated in these workshops included state, county, city, and public lands government agencies; public and private utilities; companies with a significant impact and presence in Southern California; FEMA; NOAA; and local emergency response agencies. Workshop participants' input was instrumental in developing the structure of the project and in developing short-term and long-term products and activities.

Many research projects will be conducted with appropriate partners. For instance, the study of the recurrence history of the Southern San Andreas Fault will be carried out with the Southern California Earthquake Center (SCEC) at the University of Southern California, and the debris flow early warning system is being created in cooperation with the National Weather Service. Significant resources of the project will be used to support training programs and other support mechanisms for the utilization of the southern California region.

## Governance

Management of the project will be by the MHDP Chief Scientist who will report to the USGS Regional Executive. The Chief Scientist will chair a Planning Committee of USGS scientists representing the four working groups. The Planning Committee will meet at least quarterly and will decide the level of effort for tasks and distribution of project funds following this Strategic Plan and guidance by an external Steering Committee. The Chief Scientist and members of the Planning Committee will ensure that priorities are maintained for the several USGS programs funding the work and that the needs of Program Coordinators for tracking progress and producing measurable results are met.

A Steering Committee will be formed to serve as an external advisory body for the project. The original Steering Committee will be drawn from existing cooperators and partners, identified by the Planning Committee. Future changes to the membership will be decided jointly by the Steering Committee itself and the Chief Scientist, with nominations from the Planning Committee. The Steering Committee will have up to ten members, and include representatives of local city, county, and State governments (including emergency managers and land-use planners), Federal agencies, and private sector partners. The purpose of the Steering Committee is to ensure that the project adheres to its original objectives summarized by the mission statement. The main tasks of the Steering Committee are to provide the project with guidance on objectives, and short-term and long-term goals, and to review progress and results on behalf of the southern California community. It will meet at least twice a year with the Chief Scientist and Planning Committee to evaluate how project activities have satisfied community needs. This discussion will include oversight of the coordination among disciplines, and the working relationships with decision makers and their involvement in the project. The Steering Committee will prioritize training and outreach activities and recommend modifications to the project based on feedback on the effectiveness and usefulness of research activities.



**Figure 3.** Relationships among the Southern California Multi-Hazards Demonstration Project working groups (MHDP), their research and interface priorities and products, and the end users, partners, and collaborators.

Each year the Steering Committee will discuss the long-term direction of the project in light of funding potential and will provide advice on changes to the project's strategic plan. The membership of the Steering Committee may change as the project matures, to reflect changes in the degree of exposure in business, government, and private sector communities. The Steering Committee will also provide advice on the implementation practices and management structure to make sure that it remains on target with the project's vision, mission, and objectives.

## **Metrics of Progress**

The measures of success of this project will require more than the success of its constitutive parts and more than success of the USGS. That is, the multi-hazards project will have been successful if planning for, reacting to and recovery after a natural hazard did not have a high impact on a community in terms of casualties, financial or capital loss, and environmental loss. However, such a metric is not directly measurable because it is external to the USGS and can only be assessed after the occurrence of an unpredictable natural event. The project will still use metrics to measure its progress and to determine whether research and technological development paths need to be expanded upon, modified, or abandoned altogether.

The elements of this project will be evaluated in two ways: under USGS program metrics that are already in place and identified in the budget process, and by their usefulness to multi-hazard products designed to increase community resilience. Formal metrics will be developed in consultation with the Steering Committee after it is formed.

All components of the project are also parts of USGS programs (for example, Earthquake Hazards Program, National Streamflow Information Program, etc.) and must fulfill the performance measures of those programs as submitted to Congress in the USGS budget. For FY 2007, these include

- Formal workshops or training provided to customers.
- Systematic analyses and investigations delivered to customers.
- County, or comparable jurisdiction, that has adopted improved building codes, land-use plans, emergency response plans, or other hazard mitigation measures based on USGS earthquake hazards information.
- Partnership formed to link scientific information and societal decisions.
- New stream gages reporting in NWIS Web (of the National Water Information System)

In addition, the activities in this project must contribute to the integrated goal of supporting the southern California population in disaster resiliency. All research products will be evaluated by their ability to contribute to the primary goals of the project (for example, risk and probability assessment, real-time monitoring and warning, economic and societal impact, and contribution to scenario plans). The basic-research projects will also be examined for their scientific rigor and the degree to which they complement ongoing research and interface activities. Other measures of progress will include the project's exposure in business, government, and private sector communities; the number of requests for information; how much and what kind of information is requested; how new materials have been used; increased, complementary communication with other response organizations; and the number and distribution of new partners who have become involved (and with whom the USGS has not previously been involved).

## Appendix A—FY 2007 Implementation Plan

To realize its objectives and accomplish its short-term goals, the Multi-Hazards Demonstration Project needs to encompass the full range of hazard activities in southern California without assuming control of all activities within each hazard area. Project-directed research will be carried out in coordination with existing research programs. However, the demonstration project will feature strong emphasis on implementation of science findings by the community. Project scientists will be fully engaged with the community in product development and training. Scientists will also formulate a unified planning process in which the research goals for all hazards are set together in consultation with the user community. Accountability and leadership, with funding tied to deliverables and milestones, will be the key to successful operation.

### Operational Structure

We will organize the Multi-Hazards Demonstration Project in Southern California around four research working groups: (1) Integration and Implementation Interface, (2) Earthquakes and Tsunamis, (3) Fire and Debris Flows, and (4) Winter Storm Events (including flooding, landslides, and coastal erosion). The research working groups do not have a one-to-one relationship with existing USGS programs or cost centers. Often several programs are involved.

Decisions regarding research priorities, new and existing partnership development, and budget will be made by the project's Chief Scientist, advised by a Planning Committee representing the programs involved. Both the Chief Scientist and the Planning Committee will ensure that the project meets objectives of this strategic plan and the needs of southern California as represented in the Steering Committee. Each member of the Planning Committee will be a senior scientist or Center Director representing one of the core activities. S/he will consult with the Program Coordinators whose funds are allocated to this activity. The Chief Scientist will report to the appropriate USGS Regional Executive. Lucy Jones will be the first Chief Scientist and report to Wes Ward.

Demonstration-project scientists will stay associated with their Cost Centers, which will provide facilities and supervision, and assess overhead. Overhead will follow the physical location (discipline housing) of the net expense.

### Future Research Priorities and Funding

The Chief Scientist and Planning Committee will meet once per quarter and will be responsible for deciding how the research money will be allocated based on research priorities and proposal/work plan submissions. They will interact with associated Team Chief Scientists who continue to have control over the day-to-day activities of the project-dedicated

researchers. These quarterly meetings will serve to communicate to the group the status of project-dedicated tasks, illustrate how research funds were used, where the discipline is going with the research, and to identify possible hurdles in the research or communicate the need for a task to be significantly modified or abandoned for lack of progress. The Planning Committee also has the task of keeping the Program Coordinators informed about present and future project activities.

The Chief Scientist will enter into agreements with Cost Centers to carry out the activities to support the strategic plan. The full budget of the project will exist in a virtual sense. Actual program dollars will go to tasks on projects within Cost Centers. The agreement between the Chief Scientist and the Cost Centers to fund work is revocable if the Cost Centers are not performing.

### Required Skills/Staffing

Project activities will be undertaken both by researchers who are expert in the individual hazards and by project support staff. The demonstration project will have a small number of full-time, cross-discipline members who provide shared functions to carry out the multi-hazard synthesis and interface with the user community. They will be assigned to a project administered by the California Water Science Center. These shared positions will be paid for as project expense. All participating programs will need to share in funding these shared positions.

Skills for the shared staff of the project team include training, science communication, Geographic Information Systems, database, and web development. Their expertise will be used to focus on

- Carrying out real-time data analysis and multi-hazard data synthesis by USGS researchers for response efforts.
- Supporting Geographic Information Systems (GIS) software.
- Developing and maintaining shared databases.
- Developing hardcopy and electronic cross-discipline interface materials (fact sheets, scenario publications, etc.).
- Carrying out multi-hazard data synthesis for mitigation and long-range planning.
- Establishing and maintaining partnerships and collaborations.
- Visiting partner organizations during scenario training exercise development, etc.
- Interacting with emergency response centers (Office of Emergency Services, businesses, and local government).

Other work that includes research and product development will be conducted by researchers in existing Cost Centers. In general, at least one scientist for each hazard discipline should be physically located in southern California to encourage interaction. The Team Chief Scientists and their Planning Committee representatives will negotiate with the project to develop a plan for research and development with appropriate milestones to assure completion. The Chief Scientist will have authority to terminate funding if project milestones are not met. The scientists provide the fundamental information that is used in the risk and decision-making assessments, as well as the scenario plans. The research component activities will encompass product development such as prognostic tools (specifically, predictive models); targeted science research with guidance from the user community, and interface- and graphical-tool development for effective data dissemination, as well as providing urgently needed information for users and partners. The highest priority staff will be those needed to create these products.

### **Core Physical Facility**

The project will consist of a physical central core that provides multi-hazard synthesis and interface with the user community, as well as links to the different research groups to support individual research projects. This physical central core will be located in the Los Angeles area and will house

the cross-discipline interface staff members and support staff. It will serve as the nucleation point for the community and external partners to interact with USGS staff and researchers. The core of the hazard synthesis, cross-discipline interface materials, partner exchange program, and emergency response center interaction work will be based out of the physical location. Most of the researchers will continue to work out of their current program offices.

### **Workshops**

A regular series of workshops will be scheduled with project scientists, project-dedicated staff members, and external partners. The objective will be to expand upon multi-hazard ideas first introduced during the February and March 2006 workshops for inclusion into research and cross-discipline interface activities. The workshops will be arranged around common themes (for example, land-use planning, or emergency response) and will serve to provide input to and guide multi-hazards research activities, as well as inform the external partners of new and existing hazards data and training resources. The workshops will also provide the opportunity to further in-house (either at the multi-hazards project offices or at the partner's work site) preparedness and scenario-training development.

## Appendix B—Proposed FY 2007 Funding Allocation

Funding for the project comes from many different programs in the USGS. The work will be carried out in a large number of cost centers. We outline the initial resources expected for first-year research and interface activities. In doing this, we organize by the four working groups that will oversee all of the project's work (table 2).

**Table 2.** Personnel and funding for the Multi-Hazards Demonstration Project (MHDP) in southern California—FY 2007.

[**Acronyms:** CAWSC, California Water Science Center; CMG, Coastal and Marine Geology Program; EHP, Earthquake Hazards Program, EHT, Earthquake Hazards Team; EGSC, Eastern Geographic Science Center; EROS, Earth Resources Observation System Science Center; GAM, Geographic Analysis and Mapping, GHT, Geologic Hazards Team, GIO, Geospatial Information Office; LHP, Landslide Hazards Program, LRS, Land Remote Sensing; MCGSC, Mid-Continent Geographic Science Center; NGP, National Geospatial Program; NRP, National Research Program (Water); NSIP, National Streamflow Information Program; NWIS, National Water Information System; OWRG, Office of Western Region Geology; OSW, Office of Surface Water; RMGSC, Rocky Mountain Geographic Science Center; SCEC, Southern California Earthquake Center; TFME, Terrestrial, Freshwater and Marine Ecosystems Program; WCMGT, Western Coastal and Marine Geology Team; WERC, Western Ecological Research Center; WGIO, Western Geospatial Information Office; WGSC, Western Geographic Science Center. (Every program will put 20 percent of new funds into a fund for shared activities described in Appendix A: Required Skills/Staffing)]

Working groups tasks	Participants and cost centers (Task leader in bold)	Funding FY 2007 program source
<b>Oversight and Management</b>	OWRG: Lucy Jones	\$140k MHDP
<b>Integration and Implementation Interface</b>		<b>EHP: \$387k; GAM: \$833k; NGP: \$500k; LHP: \$40k; CMG: \$40k; TFME: \$60k; NSIP: \$40K</b>
Scenario development:	CAWSC: <b>Lucy Jones</b> , new hire EHP: external contract	\$150k EHP, \$100k NGP; \$70k MHDP
Community interface	CAWSC: <b>Dale Cox</b> , new hire	\$140k NGP; \$100k MHDP
Information management	EHT: <b>Dan Ponti</b> , John Tinsley EGSC: Paul Hearn RMGSC: Sue Goplen WGIO: Robert Lugo, Carol Ostegern, Kevin Wood	\$167k EHP \$75k GAM \$20k GAM \$260k NGP
Risk modeling	WGSC: <b>Rich Bernknopf</b> , Anne Wein, Bill Labiosa, new hire EROS: Terry Sohl RMGSC: David Hester	\$425k GAM \$50k GAM \$203k GAM
<b>Earthquakes and Tsunamis</b>		<b>EHP: \$541k; CMG: \$180k</b>
Southern San Andreas Fault	EHT: <b>Ken Hudnut</b> , Tom Fumal, Katherine Kendrick, Gary Fuis External grant: SCEC	\$201k EHP \$240k EHP
Tsunami sources	WCMGT: <b>Homa Lee</b> , Eric Geist	\$180k CMG
Microzonation	EHT: <b>Dan Ponti</b> , John Tinsley, Sue Hough	\$100k EHP

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Working groups tasks	Participants and cost centers (Task leader in bold)	Funding FY 2007 program source
<b>Fire and Debris Flows</b>		<b>TFME: \$340k; GAM: \$65k; LHP: \$700k; NSIP: \$180k; LRS: \$50k</b>
Fuel treatments on stability	WERC: <b>Jon Keeley</b>	\$200k TFME
Vegetation type conversions	WERC: <b>Jon Keeley</b> , Robert Fisher	\$140k TFME
	WGSC: Cindy Wallace	\$20k GAM
Post-fire debris flow susceptibility	GHT: <b>Sue Cannon</b> , Joe Gartner, Dave Lidke, John Michael	\$200k LHP
	EROS: Susan Greenlee, Jeff Eidsenshink	
	MCGSC: Jeff Spooner	\$45k GAM, \$50k LRS
Post-fire erosion models	GHT: <b>Kevin Schmidt</b> , external contract	\$200k LHP
Debris flow warning system	GHT: <b>Jon Stock</b> , new hire	\$300k LHP
Debris flow inundation	CAWSC: <b>Chuck Parrett</b> Gerald Bawden	\$180K NSIP
<b>Winter Storm Events</b>		<b>CMG: \$180k; NSIP: \$390k; GAM \$82k</b>
Gaging (streams, rain)	CAWSC: <b>Jim Bowers</b>	\$230k NSIP
Flood frequency analysis	CAWSC: <b>Chuck Parrett</b> , NWIS,NRP Donna Knifong	\$160k NSIP,
	EROS: Jim Verdin	\$82k GAM
Coastal erosion	WCMGT: <b>Patrick Barnard</b>	\$180k CMG



## Appendix C—Potential Partners and Collaborators

The following is a list of organizations that are potential partners and collaborators drawn from the list of participants at the February and March 2006 workshops:

### *Organization*

California Coastal Commission  
California Department of Water Resources  
California Geological Survey  
California Seismic Safety Commission  
City of Los Angeles Emergency Preparedness  
California State University, Santa Barbara, Water Resources Institute  
Forest Service/Pacific Southwest Rescue Station—Forest Fire Laboratory, Riverside  
Homeland Security Advisory Council  
Leighton and Associates/Seismic Safety Commission  
Los Angeles Area Chamber of Commerce  
Los Angeles County – Office of Emergency Management  
Los Angeles County Building and Safety  
Los Angeles County, Department of Public Works Building and Safety  
National Park Service, Santa Monica Mountains  
Office of Rep. Jane Harmon  
San Bernardino County Office of Emergency Services  
Seismic Safety Commission  
State of California Office of Emergency Services  
U.S. Army Corps of Engineers  
U.S. Forest Service  
U.S. Forest Service Riverside Fire Lab  
University of California, Los Angeles, Department of Ecology and Evolutionary Biology  
Warner Brothers Studios



