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Planning for Tsunami: Reducing Future Losses Through Mitigation

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Abstract. The National Tsunami Hazard Mitigation Program is a multi-faceted approach that encompasses tsunami identification, alert and warning systems and a comprehensive approach to tsunami risk reduction. This paper describes efforts to promote land use planning and development practices that reduce tsunami risk by local elected government and administrative officials. Seven Principles of Tsunami Risk Reduction are presented that range from risk assessment to site planning criteria.

Key words: land use planning, coastal development, tsunami risk mitigation

Abbreviations: FEMA – Federal Emergency Management Agency, IBC – International Building Code, NTHMP – National Tsunami Hazard Mitigation Program, UBC – Uniform Building Code

1. Introduction

Guiding development in areas subject to tsunami inundation poses severe problems for land use planners and regulators. In most coastal areas along the Pacific basin, the tsunami threat is uncertain, and in most areas the probability of occurrence and recurrence intervals are not known. Unlike the earthquake threat, winter storm surge threat or general threat of flood, where recurrence data is used for development decision making, the science of tsunami probability can be summarized as attempting to quantify a very low probability but extremely high impact threat.

Adding to the complex dynamic of tsunami mitigation efforts is the high value local governments place on their coastal environment, where the pressures for coastal access collide with private property rights, pressures for development in proximity to the surf line, and the necessary construction of water oriented recreation facilities in the areas at greatest risk. In most of the

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coastal states, it is the local government decision makers (city and county councils) that make land use and development decisions.

Faced with these conflicts, the National Tsunami Hazard Mitigation Program developed a strategy that utilizes techniques already incorporated into the broader and more "robust" efforts of coastal zone management, and planning procedures responsive to storm surge, coastal erosion, and coastal preservation, along with background and educational materials to introduce local officials to the tsunami threat. To implement this strategy, the National Tsunami Hazard Mitigation Program (NTHMP) retained a unique, interdisciplinary team of land use planners, engineers, building, and tsunami experts to combine their knowledge about the tsunami threat with their experience with local and state land use and development practices[1]. Drawing on tsunami modeling, land use regulation, architectural design, and site planning procedures, the team brought together a broad range of tools and approaches to address tsunami risks. This approach is incorporated as a comprehensive but simplified approach to tsunami mitigation in *Designing for Tsunamis: Seven Principles for Planning and Designing for Tsunami Hazards* (National Tsunami Hazard Mitigation Program, 2001; Figure 1)[2].

It is estimated that more than 900,000 people in 489 communities in the states of California, Oregon, Washington, Alaska, and Hawaii live in areas vulnerable to a 50-foot tsunami. Tsunami preparedness needs to address both mitigation and evacuation and response planning by local governments. While the danger from distant tsunamis can be communicated to coastal residents by NOAA's Tsunami Warning Centers, only mitigation and education can protect residents from tsunamis generated near their communities.

NTHMP recognized that planning for tsunamis will not be a high priority for most coastal communities, but by integrating the tsunami threat into other community mitigation and education efforts, the safety of coastal populations can be significantly increased.

Designing for Tsunamis is intended as a guide for local government elected officials and appointed planners, zoning officials, building officials, and those responsible for community development and redevelopment. It focuses mitigation through the use of land use and development policy, building design, and site planning. The guideline is a supplement to other publications developed by the NTHMP and the individual states that address emergency

[1]J. Laurence Mintier, Land Use Planning; L. Thomas Tobin, Coastal Engineering and Mitigation; Robert Olson, Government Mitigation Practices; Bruce Race, FAIA, Building Design and Site Planning; Jeanne Perkins, Mitigation; Daniel Jansenson, Architectural Design; James Russell, Building Codes and Regulation; Robert Wiegel, Coastal Engineering; Mark Legg, Geophysics and Tsunami Generation; Costas Synolakis, Tsunami Modeling and Mechanics.

[2]Designing for Tsunamis is supported by technical "white papers" prepared by the contributing author-experts.

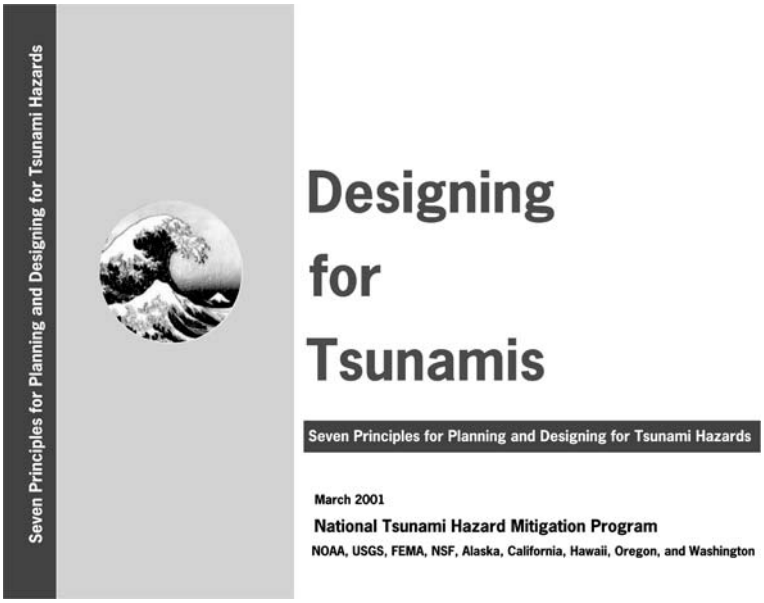

Figure 1. Designing for tsunamis: seven principles for planning and designing for tsunami hazards.

response and evacuation planning[3]. In preparing the guide, the authors reviewed the regulatory context for federal, state, and local planning and developed approaches that were consistent and compatible with local planning authorities. Based on their research, the authors identified the following seven basic principles for reducing a community's risk.

1.1. PRINCIPLE 1: KNOW YOUR COMMUNITY'S TSUNAMI RISK, HAZARD, VULNERABILITY, AND EXPOSURE

The foundation for local government planning and regulation is an objective and scientific assessment of the threat. This chapter outlines the nature of tsunamis, the differences between distant (tele-tsunami) and near-source tsunamis, the physics of tsunami wave propagation, the mechanisms of tsunami-caused damage, including flooding, velocity, and debris impact, and a brief history of damaging tsunamis in the Pacific Ocean.

Nearly 900,000 people are within the inundation of a 50-foot tsunami in the Pacific states. More than 152 communities in California with 590,000 residents are at risk, while 337 communities in Alaska, Hawaii, Oregon, and Washington are endangered. The guide outlines a methodology for

[3]For other NTHMP and state preparedness resources, see: http://www.pmel.noaa.gov/tsunami-hazard/links.htm.

identifying a community's risk, and recommends the use of tsunami specialists for preparing scenarios and loss studies. A tsunami scenario provides the basis for public education of the risk, constituency building for mitigation programs, and response and evacuation planning by emergency managers. An earthquake and tsunami scenario prepared for Humboldt and Del Norte counties in California is included in the guide to illustrate the content and uses of a scenario (California Geological Survey, 1995).

1.2. PRINCIPLE 2: AVOID NEW DEVELOPMENT IN TSUNAMI RUN-UP AREAS TO MINIMIZE FUTURE TSUNAMI LOSSES

A key to long-term reduction of community risk is the use of land use planning processes to guide future development. The objective is to reduce new development at risk so that future losses are minimized. Comprehensive plans, zoning ordinances and subdivision regulations can determine the location, density, types of development, and pattern of development in order to reduce risk. In coastal communities, these tools need to be reviewed to ensure that they address the tsunami risk. Where practical, use of open space setbacks, designation as low density, or recreation use or acquisition reduce potential losses. Subdivision and site planning regulations can be used to guide construction into less vulnerable locations in the inundation zones. While planning and zoning cannot prohibit coastal development, they can ensure that the type and location of permitted development is appropriate to the risk in the inundation zone. Since the opportunities for coastal development and risk mitigation vary with the local political and economic context, there is no one size plan to fit all coastal communities. The planning approach and acceptable level of risk will be determined in each community.

1.3. PRINCIPLE 3: LOCATE AND CONFIGURE NEW DEVELOPMENT THAT OCCURS IN TSUNAMI RUN-UP AREAS TO MINIMIZE FUTURE TSUNAMI LOSSES

The third principle emphasizes project review, site planning, and configuration of buildings to reduce their vulnerability to tsunami damage. The guide proposes the creation of a development review process that emphasizes the incorporation of mitigation techniques at project inception, an approach that ensures that new development incorporates a community's mitigation priorities. It is also considerably easier to reduce risk in the design of new developments than it is to retrofit existing developments that have ignored the tsunami threat. Mitigation approaches should incorporate site geology and topography to locate structures in areas not subject to inundation, design and elevation of buildings above projected flood levels, and attention to structural design to ensure that foundations and structures can withstand expected earthquake and tsunami forces. Site planning should also be used to slow and channel

inundation away from structures. There are numerous structural techniques identified in the Federal Emergency Management Agency's (FEMA) Coastal Construction Manual that are applicable to both storm surge and tsunami inundation (FEMA, 2002).

The guide includes a case study of the reconstruction of the city of Hilo, Hawaii, where devastating tsunamis in 1946 and 1960 prompted the formulation of a Downtown Development Plan to ensure that new development and redevelopment reduce future tsunami and flood losses.

1.4. PRINCIPLE 4: DESIGN AND CONSTRUCT NEW BUILDINGS TO MINIMIZE TSUNAMI DAMAGE

Where land use and site planning determine that structures are built in areas subject to tsunami inundation, construction techniques, building materials, enhanced engineering design, and building configuration can help to reduce property damage in future tsunamis.

The guide provides ''performance objectives'' for buildings in tsunami inundation zones, including location and configuration, elevation, structural and non-structural design standards, structural materials, and location of utilities. Also discussed are approaches for evaluating potential for tsunami damage against the criteria for performance.

Most local communities in the Pacific states have adopted the Uniform Building Code or the International Building Code prepared by the International Conference of Building Officials (ICBO).

Where the UBC or IBC is required, plan review and code enforcement is the responsibility of the local government, resulting in some variation in the quality of construction. While the UBC/IBC address fire, wind, earthquake, and flood design, there are no specific requirements for tsunami resistant construction. This places an additional responsibility on the designer and local code agency to ensure quality construction. The building code from the City and County of Honolulu and FEMA's Coastal Construction Manual provide guidance to architects and engineers in addressing tsunami forces.

Designing for Tsunamis points out that good design must be responsive to a community's needs, and should address codes and standards for a range of hazards, locally validated threat assessments, an objective determination of threat magnitudes, and a determination of a building's performance objectives by the owner, architect, and structural engineer.

1.5. PRINCIPLE 5: PROTECT EXISTING DEVELOPMENT FROM TSUNAMI LOSSES THROUGH REDEVELOPMENT, RETROFIT, AND LAND REUSE PLANS AND PROJECTS

As a community evolves, there are recurring opportunities to build mitigation into development and redevelopment plans. The guide outlines a process

that identifies opportunities for gradually improving community safety and resilience through identification of at-risk areas, evaluation of proposals for redevelopment, and the retrofit and reuse of existing structures. Options include the demolition of at-risk structures, providing financial incentives to encourage mitigation, adoption of special code requirements for the retrofit of structures in inundation zones, and the requirement for review of design by specifically qualified architects and structural engineers or peer review committees. The objective of each recommendation is to ensure that attention to the tsunami threat is addressed in planning and community redevelopment decision making.

1.6. PRINCIPLE 6: TAKE SPECIAL PRECAUTIONS IN LOCATING AND DESIGNING INFRASTRUCTURE AND CRITICAL FACILITIES TO MINIMIZE TSUNAMI DAMAGE

Critical infrastructure are those water and power utilities and facilities such as hospitals, fire and police stations that are essential to a community's safety. Loss of such facilities during an earthquake or tsunami event would leave a community helpless to respond, so decisions on their location and construction must be carefully considered. Since many utilities are private or owned by special districts, mitigation programs need to include participation by government, utility operators, and development interests.

The guide recommends the adoption of a comprehensive risk management policy that includes all stakeholders with interests in the coastal inundation zone. The objective of the policy should be the continued operation of critical infrastructure during and after earthquakes and tsunami events. New infrastructure should be designed and located to minimize future disruption. An inventory of existing facilities and risk assessment should provide the basis for on-going mitigation and risk reduction investments that relocate facilities out of harm's way, or strengthen existing facilities to withstand expected tsunami forces.

1.7. PRINCIPLE 7: PLAN FOR EVACUATION

Many existing communities lie within tsunami inundation zones. While decisions can now be made to limit future development at risk, mitigation and redevelopment actions will require decades of planning and investment to reduce the risk in existing communities. Developing local evacuation plans and procedures is therefore essential to protecting coastal residents from tsunami events. The guide discusses horizontal (out of buildings to high ground) and vertical (within buildings to upper floors) evacuation as options, depending on location and structure type, and provides a process for developing a plan and strategy for evacuation. Additional resources are

available in *Local Planning Guidance on Tsunami Response* published by the State of California (California Governor's Office of Emergency Services, 1998).

2. The Challenge

Land use and development decisions that will reduce losses from future tsunamis rest with local governments in most states. The challenge for the national and state programs is to provide local decision makers with credible data on the threat of tsunami, and cost effective tools for reducing risk, without the imposition of unreasonable constraints on coastal development.

The National Tsunami Hazard Mitigation Program recognizes that reducing future life loss and property damage can only be achieved by a long-term commitment to risk mitigation to eliminate the threat posed to our communities. Mitigation will take decades to accomplish, so the NTHMP has developed a comprehensive approach that bolsters mitigation achievements with advancements in the understanding of tsunami generation and propagation, improvements in tsunami detection, warning systems, modeling of tsunami effects, and in public education to protect coastal residents and reduce future losses.

The NTHMP also recognizes that reducing the risks posed by tsunami is not the responsibility of a single discipline, or that one solution will solve the problem in every jurisdiction. In some communities, risk reduction will be accomplished through land use planning and development regulation. In other communities, engineering structures may be a necessary "fix." *Planning for Tsunamis* provides a range of tools; the appropriateness of each will be determined at the local government, local political level.

Planning For Tsunamis was intended to be one tool in a package of resources for local government decision makers. This guide has been distributed to land use planning and development agencies in coastal communities subject to tsunami. It was intended to be a companion document to FEMA's Coastal Construction Manual in defining mitigation approaches to reduce risk. Implementation of the guide's risk reducing prescriptions will, however, ultimately depend on the availability of probabilistic risk assessments with the same credibility of flood, landslide, coastal storm inundation, and earthquake faulting; and the creation of a tsunami hazard regulatory framework that does not now exist in most states.

Planning For Tsunamis is the first step in a long-term commitment to tsunami risk reduction by the NTHMP. It has provided awareness of the threat to local decision makers and planners. Future initiatives should include dissemination of the guide through professional associations of planners and government councils, the development of regulatory tools to

implement risk reduction, and local workshops and training on implementation approaches.

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