Guidebook for Tsunami Preparedness

in

Local Hazard Mitigation Planning

National Land Agency
Ministry of Agriculture, Forestry & Fisheries Structural Improvement Bureau
Fisheries Agency
Ministry of Transport
Japan Meteorological Agency
Ministry of Construction
Fire and Disaster Management Agency

CONTENTS

PREFACE

A Word on the Importance of this Handbook

The Japanese archipelago has suffered numerous tsunami attacks from ancient times. Countless Japanese have lost their lives or property as a result of tsunamis, most recently during the modern ear dating from the Meiji Period (1868-1912). Most notable among them were The Sanriku Tsunami of 1896, the Sanriku Tsunami of 1933, the Tokai Earthquake and Tsunami of 1944, the Chilean Earthquake and Tsunami of 1960, The Japan Sea Chubu Earthquake and Tsunami of 1983, and the 1993 Southeast Coastal Earthquake in Hokkaido.

Japan's hazard readiness has developed as a result of the lessons learned from the past. The coastal areas that have suffered much of the damage have been the most active in promoting preparedness, and especially in the wake of the Hanshin-Awaji Earthquake, local authorities nation-wide have begun a review of readiness policies and emergency planning.

Even with the sophisticated technology of today it remains difficult to predict where and when a tsunami will occur. When a tsunami is generated, the height and arrival time of the tsunami vary according to coastal configurations and the resulting types of damage complicate safety planning.

Furthermore, because Japan's historical tsunamis have yet to strike hit densely populated areas, readiness planning for coastal areas with large concentrations of people is essential task for planners. It is imperative, therefore, to coordinate and integrate efforts for effective preparedness, taking into account the particular hazards created by tsunamis.

This booklet intends to provide a plan of action and basic framework from which public safety officials will be able to increase community preparedness against the threats of tsunamis. Contained within are many proposals concerning tsunami readiness. However, it is recommended that local authorities bear in mind their community's unique topography and local circumstances when consulting this booklet. The general term "tsunami hazard mitigation plan" refers tsunami readiness as part of the overall local disaster planning.

The following contents are found in the booklet:

INTRODUCTION

Chapter 1 INTRODUCTION

1.1 The Purpose of Tsunami Hazard Planning

The purpose of tsunami hazard planning is to set forth and promote preparedness in everyday life to protect life and property in at-risk communities during a tsunami emergency.

More than 200 fatalities resulted from the Hokkaido Southwest Earthquake and Tsunami. On Okujiri Island, many residents, knowing that a tsunami generated by the Japan Sea Chubu Earthquake had caused fatalities ten years earlier, evacuated immediately to higher ground. Those who were late in evacuating died.

Some coasts are vulnerable to repeated tsunami attacks. Yet, humans too often fail to learn the lessons of the history. In addition to having substandard coastal defenses, when an earthquake-generated tsunami occurs, a lack of a defined tsunami policy leaves the community’s emergency response ambiguous or unclear. In addition, that tsunamis are uncommon contributes to complacency in society. Based on the situations described above, we can see the need for vigorous planning and promotion of awareness of the danger of tsunamis in order to protect ourselves.

Finally, in order put these measures in place, it is important that residents, users of coastal areas, private enterprise and the government reach a common understanding of preparedness, that is, in the face of tsunami hazards, individuals must protect themselves just as communities are responsible for their own protection.

1.2 **The Role of Tsunami Hazard Planning**

Tsunami Hazard Planning aims to protect citizens' lives and property by mitigating damage caused by tsunamis. It is an integral part of local hazard mitigation planning.

Tsunami Preparedness is one part of a comprehensive plan based on Emergency Law, which covers a broad range of local damage caused by earthquakes, wind and rain, volcanic eruptions, or snow. It is the basis from which local governments deal with disasters. This handbook describes a general plan for dealing with the unique hazards resulting from tsunamis. It discusses building and maintenance of defensive structures, conducting research on past emergencies, prevention, and emergency response.

Much remains to be learned about tsunamis. Their location and magnitude are difficult to predict. When a tsunami is generated in a local area, there is little warning time before it strikes. While the hard defensive structures such as tide gates embankments are important, the softer aspects, such as the establishment of evacuation areas and maintenance of evacuation routes, the system of communication and dissemination of information, are crucially important. Both facets must work in conjunction, and they form the basis of the readiness planning.

Other important factors that influence readiness planning are changes in the social environment and scientific research. These should be reflected in the planning, as well as local circumstances. Aim for local planning which adapts well to the overall plan and when necessary, review original plans and adopt appropriate measures. In conclusion, tsunami hazard planning is one part of local readiness, and both hard and soft aspects should be given consideration in the overall framework of a strong tsunami readiness policy.

1.3 Aims of Tsunami Readiness

Tsunami readiness plans consist of a broad range of measures. To keep damage at a minimum, plans make use of the natural topography and build defenses that take into account unique coastal features against a designed tsunami threat. There are three main areas covered by planning: defensive structures, civil planning based on tsunami readiness, and an emergency response system. All work together in a comprehensive plan of preparedness.

Defensive structures such as sea barriers serve as the basic method of mitigating the effects of the design tsunami and preventing it from directly coming inland. Such construction requires much planning and time. As they are being, built, some other potential hazards must be addressed. Important aspects of tsunami readiness and civil planning call for renovation of dilapidated buildings along coasts, reconstruction of or relocation of vital facilities to higher ground, evacuation system, warnings and communications system.

Potential Hazards

1) Construction of defenses requires time and a tsunami could occur before completion.
2) The tsunami could be a larger magnitude, overwhelming the defenses.
3) Other problems include protection of the environment and scenery, the multipurpose use of the coast, funding, purchase of land for defenses. Such factors affect the required construction time and crest height.

What we have learned from tsunami readiness in the past is that we must not only depend on physical defenses. In order to keep damage at a minimum, a combination of defenses, civil planning for tsunami, and a system of preparedness which collaborate in a comprehensive plan of preparedness is crucial.

Historical tsunamis are the basis of tsunami readiness planning. We have relatively accurate evidence, such as watermark heights. Of numerous tsunamis, the largest is selected, and its form the benchmark of a hypothetical design tsunami. In assessing the potential threat, recent scientific research on earthquakes which generate tsunamis along high-risk coasts, enables us to make projections of the largest possible tsunamis. These are compared with data of the largest past tsunamis. It is better to err on the side of safety, so the largest tsunami possible is most suitable for planning purposes.

Major earthquakes do not necessarily generate tsunamis. Various factors are at work, such as the location of epicenter and its magnitude, the depth of the quake, its direction and displacement of the fault. All these factors must be taken in account in configuring the magnitude of the design tsunami.

Here, defense structures refer to sea walls, tsunami breakwaters, tsunami tidegates, and river dikes. Tsunami readiness based on urban planning includes zoning restrictions, relocation to higher ground, renovation and reconstruction of dilapidated structures. These are planned measures taken to strengthen at-risk communities' preparedness.

Emergency readiness generally refers to the organizational structure and activity behind tsunami readiness, such as the warning system, establishing evacuation zones and routes, public educational programs, and protection of the fishing industry.

CHAPTER 2

DEVISING A TSUNAMI HAZARDMITIGATION PLAN

Chapter 2 Setting Up a Tsunami Hazard Mitigation Plan

2. 1 Procedures

Below are the procedures to be followed in setting up a tsunami hazard mitigation plan along coastal areas.

1. Basic Background Research
   1) Establishing the objectives of the research
   2) Assessment of damage from past earthquakes and tsunamis
   3) Assessment of current levels of tsunami preparedness
   4) Assessment of coastal areas

2. Creating the Design Tsunami and Estimating Damage

   1) The design tsunami
   2) Damage estimate
      (1) Selecting criteria according to coastal configuration
      (2) Estimate of inundation
      (3) Projection of the inundation area
      (4) Projection of the damage

3. Establishing preparedness tasks

4. Setting up the tsunami hazard mitigation plan

5. Implementation issue

This section describes the background research necessary in setting a tsunami hazard mitigation, including research items, issues for consideration, and procedures. It also contains information on devising a summary of existing readiness measures and a progress report on the implementation of safety measures.

1) Background Research

First, planners must have an understanding of coastal conditions (after a projection of inundation, specific coasts will focused on) which will be attacked by the design tsunami. An assessment of past tsunamis' characteristics and damage must be done. The potential danger of the tsunami is evaluated by taking in a number of critical factors. These include the coastal topography, use of the land, population, concentration of industry, resident attributes, progress of pre-planning, and other unique features of the area. Finally, the community's plans for building are taken into account, as well as the its future development.

2) The Design Tsunami

The design tsunami is based on data from the largest of past tsunamis, identified by relatively clear high watermarks. At the same time another projection is made using recent seismic data which predicts the generation of a tsunami along specific coasts. By comparing this information with the historical record, the largest possible hypothetical tsunami is generated and we are able to plan accordingly. Because earthquakes of the greatest magnitude do not necessarily generate the greatest tsunamis, the plan is evaluated further against a number of factors, such as the location of the earthquake's epicenter and any resulting change in the tsunami wave, the earthquake's magnitude, its depth and location, directivity, and displacement due to fault motion.

Regarding planning for defenses, estimation of the highest water levels is necessary, but that is in itself, insufficient. The estimated arrival time of the tsunami and evacuation time for people and ships and fishing boats must be taken into account as well.

3) The Damage Estimate

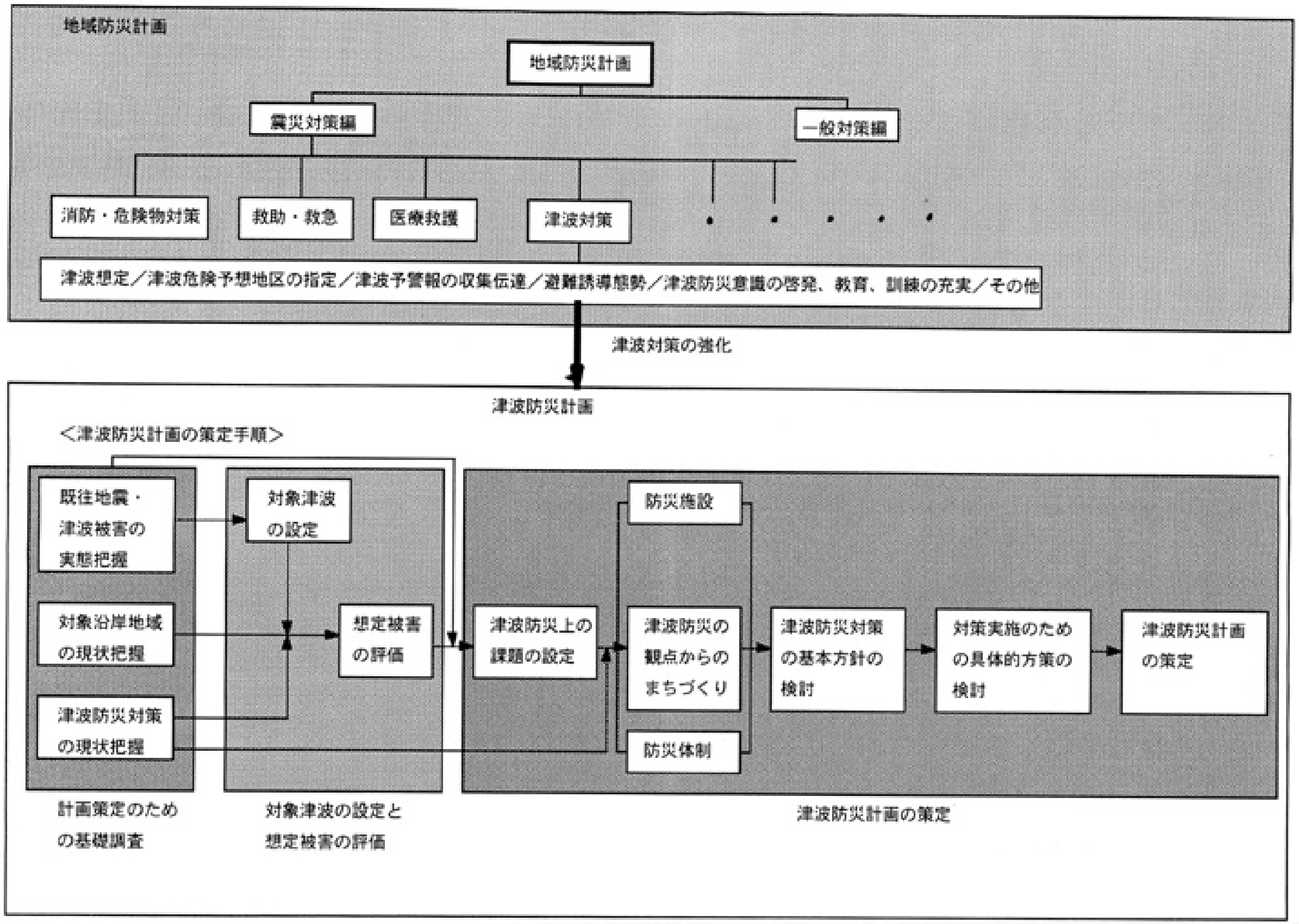
Once the area of inundation is projected, the parameters of the target coastal area are established. At the same time the area's vulnerability is assessed against the current state of defensive preparedness, and thus the damage estimate from the design tsunami, by type and scale of damage, is complete.

4) Preparedness Tasks

Following the research and damage estimate, the tasks which must be accomplished in order to complete preparedness are determined, including tsunami defensive structures, urban planning based on tsunami readiness, and organizational structure of the readiness system.

5) Setting up the Tsunami Hazard Mitigation Plan

As described above, a comprehensive plan depends on careful consideration of the three pillars of preparedness, i.e. defensive structures, urban planning based on tsunami readiness, and the organizational system of readiness. These must be measured against the area's readiness tasks, taking into account financial restraints, effectiveness of readiness measures, and their effects on the community's daily life. Finally, the measures adopted are prioritized according to urgency, importance, and feasibility. A specific plan for implementation is then drawn up based on the organization in place, methods available, scheduling, and funding.


地域防災計画
地域防災計画
震災対策編
一般対策編
消防・危険物対策
救助・救急
医療救護
津波対策
津波想定／津波危険予想地区の指定／津波予警報の収集伝達／避難誘導態勢／津波防災意識の啓発、教育、訓練の充実／その他
津波対策の強化
津波防災計画
＜津波防災計画の策定手順＞
既往地震・津波被害の実態把握
対象沿岸地域の現状把握
津波防災対策の現状把握
対象津波の設定
想定被害の評価
津波防災上の課題の設定
防災施設
津波防災の観点からのまちづくり
防災体制
津波防災対策の基本方針の検討
対策実施のための具体的方策の検討
津波防災計画の策定
計画策定のための基礎調査
対象津波の設定と想定被害の評価
津波防災計画の策定

2．2　Background Research

2.2.1　Focus of the Research

It is important to understand the unique features of each at-risk region. A survey must be conducted of the variance of coastal configuration, types of land usage, concentration of population and industry, percentage of elderly population, public attitudes and awareness toward tsunami preparedness, progress of plans underway, tasks and measures to be adopted. In addition to existing structures, it is also important is to clarify the future development of the community.

The background research should focus on the following:

(1) Socio-Economic Factors

Coastal regions are among the most important in terms of production and distribution of goods, housing, recreation activities whose varied purposes give rise to their multi-faceted development and usage.

Table 2-1 Use of Coastal Land and Points of Confirmation

Use of Coastal Land	Points of Confirmation
Sea & air ports, railways, and roads	○ Concentration of people and goods contribute to a risk of greater danger in the event of tsunami ○ Following a tsunami wave strike, paralysis of the transportation network has a great socio-economic effect ○Danger of human casualties is increased by number of passengers and visitors ○A lack of evacuation area for large vessels and tankers
Fishing harbors and fisheries	○The danger of collapse and fire is high in wooden housing and building developments, and they are especially vulnerable to tsunamis ○Basic living, especially at the local level, will be adversely affected ○ Safe evacuation sites (elevated platforms and evacuation buildings) are relatively few ○Evacuation areas for fishing vessels and equipment are few ○There is a danger of blockage of the port and obstacles in sailing routes caused by debris from fisheries, fishing equipment and nets.
Coastal manufacturing and energy storage	○ Increased danger of secondary damage caused by flow of dangerous materials or lumber ○Increased danger of large-scale fires in inland municipal areas ○Lack of sufficient evacuation areas for oil tankers and other large vessels ○Once a tsunami wave strikes it has a great socio-economic impact ○The environment could be polluted by leakage of dangerous chemicals
Developed areas such as commercial office buildings and residential	○ Concentration of people and goods contribute to a risk of greater danger in

districts	the event of tsunami ○ Increased danger of greater human casualties ○ Areas of concentrated housing or construction often have extremely narrow roads, which cause difficulty in event of evacuation ○Once a tsunami wave strikes it has a great socio-economic impact ○Tsunami runup can occur through inland water supply and sewage lines ○Hospitals and nursing care facilities are concentrated in one area, making it difficult to evacuate especially vulnerable people, such as patients and the elderly
Coastal parks, recreation and tourism facilities	○ Increased risk for casualties by the presence of outside visitors ○ Lack of awareness of designated evacuation areas ○Lack of sufficient evacuation areas
Agriculture and Forestry in Coastal Areas	○ Increased danger to agricultural production and damage to forests
Buried Waste Disposal	○Leads to environmental pollution
Undeveloped Coastlines	○Increased risk of casualties from fishing patrons

As the above information shows, the type and scale of damage caused by a tsunami depends greatly the unique features of the coastal region, its configuration, usage and urban development.
In addition to the above factors, the basic research must grasp the socio-economic circumstances of a particular area, and it must extract the particular defensive needs of the area. Finally, recreational visitors who fish, surf, or yacht must be accounted for just as the local residents are included in the mitigation measures.

(2) Effects of Topography

Tsunami damage is easily affected by topographical factors such as the coastal configuration (coastal line and the inland topography) and the sea floor topography. If the bay is v-shaped, there is a tendency that the concentration of the tsunami's energy is amplified and the water level throughout the bay is higher. At the outermost point of the cape and inland, the underwater topography's effect and the diffraction from the cape tend to concentrate and magnify the wave (increase of the tsunami by a concentrated effect). In addition, the more the crest wave of the tsunami approaches shallow water, the higher its water level tends to become (increase of the tsunami by shallow water effect). Furthermore, when the natural period and the periodicity of the tsunami are proximate, the water surface movement is reverberated by the tsunami, and the result is a higher water level in the bay (increase of the tsunami due to reverberation effect). Finally, in an extended shallow bay, the complicated interplay of nonlinear effects and diffusion can split a single tsunami wave into multiple waves (Soliton collisions). It is easy to predict the above by examining the topography of the coast. However, imprecise measurement of underwater topography makes difficult to judge the concentration of the tsunami.

Once the tsunami has breached the defenses, the area of inundation will be increased by low-lying flat land beyond the shore. Although cliffs and high ground that are easily accessed can be useful as refuge points during a tsunami, when flat or gentle hills are behind the shore, evacuation to such sites can be difficult.

Finally, when they are sufficiently high, roads behind the shoreline can serve as de facto levees. When a river or channel flows into to the ocean, there is a danger of tsunami runup from the mouth facing the ocean. The basic research must address possible effects of the topography on the tsunami, the evacuation, as well as man-made construction. Doing so will reveal the tasks that face safety planning.

Table 2-2 Topography and Potential Effects

Topography	Potential Effects
V-shaped bay	○The tsunami's energy is concentrated and the water level throughout the bay is higher
Tip of the cape	○Sea floor topography effects and cape diffraction amplify the force of the tsunami
Within the bay	○Reverberation effects can amplify the tsunami's force. A relatively short bay can amplify a local tsunami; a long bay can amplify a distant tsunami.
Ria shoreline	○A shoreline full of angles can result in some of the above effects.
Islands	○The waves are captured by the perimeters of the island and clockwise and counter-clockwise waves meet, raising the water level. Even when the rear of the island does not face the wave source, the above results in a higher water level.
Shallow continental shelf	○The water height of the tsunami is in inverse proportion to the fourth root of the water depth. The propagation velocity is also depends on the water depth, and the more shallow, the slower the speed. Accordingly, the tsunami tends to concentrate toward shallow water and amplification can occur.
Distant shoal	○In longer distant shoals, Soliton collisions can result, breaking up a single tsunami wave into multiple waves.
Inland topography	○If the inland topography is low, there can a deficiency of evacuation space. If there are cliffs or it is high ground, land can be used as evacuation areas if access roads are good.
Coastal roads	○If roads along the coast are of high enough, they can become effective levees.
Rivers and Water Channels	○There is a high risk of tsunami runup into the mouths of the rivers or channels that face the ocean.

（3） Assessing Current Levels of Preparedness

Many at-risk communities have learned from experiences such as the Sanriku tsunamis. They have embarked on and are actively engaged in a concrete and highly feasible plan of tsunami readiness. There are numerous other communities that have been struck by tsunamis in the past, but whose collective conscience about the dangers of tsunamis is becoming fainter.

Other communities that experienced tsunami attacks have developed or become urbanized, resulting in a complacency towards tsunami hazards. New generations of residents are unable or refuse to participate in drills and community-wide safety programs.

The background research must take these factors into account and define which tasks must be met by the readiness planning.

2．2．2　Damage Assessment from Past Tsunamis

By obtaining a clear understanding of the extent and causes of life and property damage (including secondary damage) of past earthquakes and tsunamis, we can develop a profile of the largest historical earthquake. This aids in creating the design tsunami, but also enables the danger of coastal areas to be assessed. It is important to incorporate new scientific research and updated land surveys. The latest seismology research on earthquake-free areas and earthquake periodicity should also be included.

To develop an accurate profile of past earthquakes and tsunamis, planners should consult other autonomies' local hazard mitigation programs, surveys and reports, historical records in local archives, and also consider conducting interviews with local historians or witnesses

Archives often describe the reconstruction efforts following earthquakes and we can learn much about the damage sustained through surveys and reports, historical accounts, and maps. Direct interviews with historians and witnesses are also valuable sources of information, but fewer witnesses are available for earthquakes which occurred long ago. Instead, information is often "legendary" and is not always reliable. Such accounts must always be compared with historical records and used in conjunction with each other. The survey should consist of the items listed in Table 2-3, which should be consulted during each stage of setting the plan.

General Description	Items	Purpose	Method of Inquiry
Characteristics of the earthquake	Epicenter & areas of no effect	Create the design tsunami and profile of largest earthquake-generated tsunami Determine the point of generation	Research of Archives ・Consult the Hazard Mitigation Plan of Local Autonomy ・Consult scholarly journals and articles of seismology ・Consult existing reports ・Confirm the seismic data
	Time, frequency, and periodicity		
	magnitude		
	epicenter fault line parameters (See Note no. 1)		
	Affected area		
	Generation of tsunami		
Tsunami Characteristics	Frequency of occurrence		Research Archives ・Consult scholarly journals and articles ・ Confirm the results of the tsunami data ・ Consult existing reports
	Amplification (wave form, periodicity, propagation velocity)		
	Refraction and resonance		
	Time of arrival following the earthquake	As above, including evacuation	
	Water level and high water mark	Determine the design tsunami Assessment of the largest past tsunami Projection of inundation and danger areas	As above
	Area of inundation (including water depth)		
	Amount of runup		
Human and property damage assessment (see Note No. 2)	Scale of the damage	Hazard assessment	Research archives ・ Consult scholarly journals and articles of seismology ・ Consult existing reports ・ Conduct interviews
	Characteristics of the damage		
	Causes		
	Reconstruction efforts (including emergency response and rebuilding)	Plan accordingly	

Table 2-3, Survey Items and their Purposes

Note No. 1: epicenter fault line parameters are determined by the position of the fault lines, depth, length, width, amount, and angle of displacement.

Note No. 2: Damage to life and property includes the following categories: 1) casualties, 2) housing, 3) coastal defense structures, 4) disruption of transportation (rail, road, and water), 5) essential services (water and sewage, electricity, gas, communication networks), 6) commerce and industry, 7) fishing and maritime industry, 8) agriculture, 9) forestry, 10) damage from fire and 11) damage to the land foundation

2.2.3 Assessing the Current State of the Tsunami Hazard Mitigation Program

The at-risk coastal area should undergo a thorough assessment of existing and planned defenses, including progress and review of those plans placed within the context of the tsunami hazard mitigation program. Plans for the future development should also be reviewed and clarified. Finally, areas struck by earthquakes and tsunamis should conduct a review of damage sustained and the subsequent reconstruction process.

To better understand the state of the hazard mitigation program, planners should conduct a systematic review of existing safety plans. These include plans of the defense structures and the port and fishing harbor. When necessary, public hearings with safety authorities or residents should be conducted. A survey of existing and planned coastal defenses should also be done. This includes bay and port defenses, fishing harbor defenses, including dikes, shoreline protection, breakwaters and parapet walls. The items to be reviewed are shown in Table 2-4, which should be referred to at each stage of the planning.

Table 2-4

General Area	Items	Purpose	Method of Inquiry
Defense structures	Process of construction	Assessment of danger of inundation Projection of the area of inundation Check for safety during evacuation Check for maintenance of defensive capability	Archive research ・ bay and harbor plans ・ construction plans ・ registers ・ Construction reports ・ On-site survey and other blueprints
	Rationale (within the context of the overall program)		
	Type of structure (dikes, shoreline protection, parapets)		
	Location		
	Basic structure		
	Date of Construction		
	Length		
	Crest height		
	Basic policy of construction		
	Installation of evacuation stairways		
	Method of natural water drainage		
	Type of beach in front of structure (include. post-construction alterations)		
	State of old dikes and other defenses		
	Progress of plans being implemented		
	Future development plans		

General Area	Items	Purpose	Method of Inquiry
Urban planning based on tsunami preparedness	Relocation to higher ground	Assessment of the danger of tsunamis	Review of documents, public hearings, and on-site survey
	Land usage, including bulwarking		
	Establishment of Anti-tsunami communities, buffer zones		
	Maintenance of tsunami tidegates, sluices and sluice gates, etc., and measures for on-duty personnel during emergencies		
	Future development plans		
Organizational System for dealing with Emergencies Evacuation measures	Issuing evacuation advisory and orders, communications systems, evacuation assistance (identify authorities and organizations responsible for)	Assessment of the evacuation system	Review of archives, public hearings
Preparation and maintenance of evacuation areas (temporary and evacuation sites for larger areas) and evacuation routes	Evacuation sites, designation of evacuation routes, distribution of evacuation sites, location of evacuation routes, topography and altitude of evacuation sites, evacuee capacity, evacuation areas (including their relationship to residential zones), evacuation site structures, readying the approach routes, road width, potential problem spots (bridges, tunnels, etc.)	Evaluation of the evacuation feasibility, sites, routes and safety	Review of Local Hazard Mitigation Program Land-use planning Public hearings On-site survey

General Area	Items	Purpose	Method of Inquiry
Tsunami warning system	Organization responsible (structure and authority) Warning System (recipients of the warning, method, channels (transmission and reception) and transmission time	Assessment of starting time for evacuation and feasibility of emergency measures	Review of Local Hazard Mitigation Program, etc. Public hearings
Emergency organizations	Report of Fire Department or volunteer fire dept. activities Chief and members' ages Location and distribution of fire departments and facilities, disaster readiness	Assessment of emergency capability and general public awareness of mitigation program	Review of Local Hazard Mitigation Program Public hearings

Educational programs	Promoting public awareness through television, radio and newspaper media Publishing in public information bulletins Placement of tsunami warning signs, boards, and memorials Commemorative events to promote tsunami hazard awareness Distribution of tsunami-related pamphlets Placement of evacuation route signs Distribution of evacuation manuals		
Tsunami Hazard Mitigation Program Drills	Drill contents Frequency of drills Degree of participation by local residents	Assessment of emergency capability	Public hearings
Other emergency measures	System for the collection and dissemination of information Securing roads and emergency relief delivery Distribution system for food, water and medical supplies Medical response system Rescue response system Fire-fighting Maritime evacuation Evacuation for ships, boats, and fishing vessels Working in conjunction with the greater area	Assessment of emergency capability	Review of Local Hazard Mitigation Program Public hearings

Regarding the Methods of Inquiry

Review the Written Records

Make use of the existing records, including bay and fishing plans, structural plans, and construction reports. Effective use should also be made of various local safety plans, such as local hazard mitigation programs and others.

Hold Public Hearings

In the development and implementation of a tsunami hazard mitigation program, public hearings play an extremely important role. Evaluations of community planning based on its community life, including residents' opinions regarding readiness, are vital to tsunami readiness planning. Individual and public gatherings should be used. Planners should take care to include members from all strata of society, such as younger generations, and not selectively choose people well-known or important figures in the community.

On-Site Surveys

Visiting the site itself is an indispensable part of planning. Planners should not solely rely on secondary sources such as records and hearings, but survey the terrain itself. Using data from past tsunamis, it is important to gain a complete understanding the land usage, location and usage of facilities, and the maintenance of defense structures.

2.2.4 Assessment of Coastal Areas

To accurately assess the risk of danger, it is necessary to understand the coast and in inland areas in three regards: 1) natural environment, 2) socio-economic structure, and 3) patterns of land-usage.

1) Natural Environment

It is necessary to determine the natural characteristics of the target areas, including topography, gradient, and depth of the sea-floor, sea conditions (sea level, esp. lunar month high tide average, ocean waves (winter wind waves) as well as the inland topography, including sea elevation.

In addition to making use of documentation such as scholarly journals, reports and archives, an on-site survey should be considered. Table 2-5 lists the items which should be covered at each stage of the planning.

Table 2-5 Research Items and Purpose

Category	Items	Purpose	Method of Inquiry
Shoreline	Sea-bottom topography	To project the area of inundation and understand the topographical effect on the tsunami	Consult written materials, including: nautical charts, Geographical Survey Institute, Urban planning maps, harbor construction plans, sounding data On-site survey
	Sea-bottom gradient		
	Depth		
	Shoreline topography		
	Sea Conditions (including sea level and waves)	Estimation of inundation	
Inland area	Topography	Predict the extent of tsunami damage	
	Sea-level	Evaluate the feasibility of evacuation	

2) Socio-Economic Factors

This information focuses on the attributes of the population, buildings, and economic activity of the community. Items include population, household distribution, household population, distribution of higher-risk population such as the elderly and disabled residents, and finally, the level of community awareness. Regarding buildings and structures, their earthquake resistance, size and date of construction must be determined. The type of business, number of employees and production output are other important factors.

To further clarify socio-economic factors, the national census, business establishment statistics, and public records should be consulted. When necessary, public hearings with residents and business managers can be held. Table 2-6 lists the items that should be covered at each stage of the planning.

Table 2-6 Research Items and Purpose

Category	Items	Purpose	Method of Inquiry
Demographics	Population, number and distribution of households	Projection of tsunami damage	Consult written materials, including: national census figures, public registers surveys of public attitudes and awareness Public hearings
	Ratio of elderly, children and other high-risk people	In addition to the above, evacuation feasibility, estimation of difficulty of evacuation, consideration of best response	
	Community lifestyles, awareness and attitudes toward hazard preparedness		
	Daytime and nighttime populations and their age distribution		
	Incoming and outgoing population		
Buildings and structures (See Note No. 1 below)	Structure	Projection of tsunami damage	Consult written materials, including: registers and housing statistics
	Size		
	Location		
	Years since construction		
	How the structure is being used	In addition to the above, evacuation feasibility	
Economic activity	Type of business	Projection of tsunami damage	Consult written materials, including: national census figures
	Facility holdings		
	Productive output of each facility		

	Number of employees at each facility	In addition to the above, evacuation feasibility	business establishment statistics Public hearings

Note No. 1:Types of construction include 1) houses, and 2) facilities for public and official use

3) Land Usage

The information to be investigated here are the conditions of coastal land and ground, urban form, location and distribution of city facilities. Also covered are land usage plans in action, development plans and most recent trends as well as long-term planning.

In order to understand the characteristics of land usage, urban development plans and local development plans should be consulted. When necessary, public hearing with developers and others should be held. Table 2-7 lists the items which should be covered at each stage of the planning.

Table 2-7 Research Items and Purpose

<table>
<tr><th>Category</th><th>Items</th><th>Purpose</th><th>Method of Inquiry</th></tr>
<tr><td>Land and Ground</td><td>Presence and state of land subsidence, land at zero sea level, reclaimed land, weathered land</td><td>Estimation of runup depth and duration of the damage</td><td rowspan="2">Consult written materials, including:
Urban development plans
Local development plans
Drawing plans
Facility registers

Public hearings
On-site surveys</td></tr>
<tr><td>Urban form</td><td>• Historical development of the city
• Land usage
• overcrowding and blockage
• green and undeveloped areas
• facilities housing dangerous materials and residential areas</td><td>Predict the extent of tsunami damage
Grasping potential causes of damage
Assessment of the possibility of increased damage</td></tr>
</table>

Urban facilities	State of port and harbor facilites • Transportation facilites and type of network • Lifeline facilities and type of network • Distribution of facilities with dangerous materials (factories, etc.) • Distribution of manufacturing facilities • Distribution of and capacity of train terminals or underground shopping centers • Distribution of tourist resources (including beaches, etc.) • Distribution of hospitals, nursing care facilities which house people at higher risk • Distribution of schools • Presence of rivers and channels	Predict the extent of tsunami damage Grasping potential causes of damage Assessment of the possibility of increased damage	
Urban and Local Development Planning	Review of plans being implemented (objective, contents, implementation time) and degree of completion	Predict the extent of tsunami damage	

2.3 Establishing the Design Tsunami and Estimation of Damage

2.3.1 Establishing the Design Tsunami

The tsunami hazard mitigation program is based on the assumption of the external force of a design tsunami. It is designed according to data from previous tsunamis where there is relatively precise data such as high water marks. Of these, the largest tsunami is selected and it forms the basis of the design tsunami. However, regarding specific local areas which, according to recent seismic research, will be possibly struck by an earthquake-generated tsunami, plans must incorporate more recent opinion in projecting the largest tsunami and compare it to the largest past tsunami data. Choose the safest possibility and base the design tsunami on the highest water level projections. There is no guarantee, however, that the largest earthquake will generate the largest tsunami. It remains important to take into account many factors such as the earthquake's scale, depth and location of the hypocenter, its directivity, displacement due to fault motion, as the design tsunami is developed.

In addition, it is necessary not only to estimate the tsunami's water level, but also its time of arrival, so as to formulate plans for evacuation of people, boats and ships easily affected by time constraints.

In the past, design tsunamis generally were based on the largest of past tsunamis, developed from relatively precise data of the readily available historical information.
More recently, projections of the largest possible oceanic earthquakes have incorporated theoretical advances such as geotectonics and the active fault model. Improvements more advanced seismic measuring technology has revealed "blank areas," gaps or areas unaffected by earthquakes, thereby making possible new projections not solely based on past data available. Local authorities are increasingly using such methods in the creation of design tsunamis.

As described above, this guide will focus on reliable data of the largest past tsunamis and incorporate new technology and opinion in making the design tsunami. From a comparison of these two, the guide will adopt the safest possible scenario by selection of the highest water level.

It must be remembered, however, that the largest earthquake may not necessarily generate the largest tsunami. In spite of being relatively small, a "tsunami-earthquake" could occur. Thus, evaluations of the earthquake's scale, depth and location of the hypocenter and the resulting tsunami's directivity, etc. should be part of the design tsunami.

Finally, apogean tsunamis (tsunamis generated from far away) must be accounted for. When records show that the coastal water level peak of an apogean tsunami was higher than that of the design tsunami, it becomes necessary to establish another earthquake in the design tsunami.

Regarding the evacuation of the people on the coast, ships and boats, key information is not the tsunami's water level, but its time of arrival, which is determined by the distance between the wave source and the coastline in question.

In order to determine the size and characteristics of past tsunamis and project the size of future earthquakes, planners should consult the "Pacific Earthquake & Tsunami Survey Report," published in 1996 by the Ministry of Construction, Ministry of Agriculture, Forestry and Fisheries, Fisheries Agency and the Ministry of Transport.

1) Amplification

In order to make an accurate projection of tsunami amplification, it is common these days to use active fault model to develop a numerical analysis of the tsunami which will be generated. In coastal areas where sufficient data is unavailable, the amplification of a past tsunami can be recreated by numerical analysis of wave height and propagation velocity over space and time. In areas recognized as vulnerable to a tsunami strike, more realistic projections can be made with the aid of specialists.

When drafting a hazard mitigation plan or developing a design tsunami, numerical analysis is an effective method but this technology is still in development stage. There are limits to the accuracy, cost and general applicability. At present, many questions remain concerning the accuracy of simulations of the wave source model, the form of the wave, form and amplitude of the leading wave, and river runup. As a result, although the numerical analysis of the tsunami can serve as a basis for a relative estimation, there are too many unsolved problems to make it an absolute estimation.

Caution should be exercised in the method of numerical analysis as follows:

(1) Use of the numerical analysis

a. Measuring the amplification of past tsunamis

After checking the recreation based on a comparison of past records and numerical results, it is possible to obtain unobserved results, for example, regarding the area of inundation or flow velocity (libration)

b. Predicting the Amplification

It is possible to predict the amplification created by current of future changes in the coastal features, such as breakwaters, sea walls, and reclaimed land. It is also possible to predict the effectiveness of defense structures. For general methods of carrying out a numerical analysis, planners should consult the "Manual for Predicting Tsunami Damage."

(2) Caution of Usage

a. Errors in the mathematical parameters

To make an accurate projection of a tsunami wavelength in time and space, it is necessary to establish as many equations as possible for each wave. Generally for each wavelength at least 20 and if possible 30 measurements should be carried out.

Furthermore, once the wave reaches shore, it is necessary to determine at least 50 points along the leading wave's wavelength (according to Iwasaki and Mano). For example, if the design tsunami's wavelength is 10 kilometers, to insure a minimum of numerical accuracy it is necessary to measure at least 200 meters.

Errors caused by linearity and non-linearity

When simulating the amplification, the non-linearity and wavenumber dispersiveness parameters of the physics model are important. Non-linearity is relative to wave height and depth of the water , and as the water becomes more shallow amplitude is increased, resulting in such effects as a forward tilt. The wavenumber dispersiveness, in relation to the ratio between depth and wavelength, can result in changes in the velocity depending on the wavelength.

As described, therefore, in waters exceeding a depth of 50 meters, linear wavelengths are employed. In shallower waters, non-linear wavelengths are used as standards in simulating the crest of the wave. It is necessary to consider the dispersiveness in simulating the runup in rivers and undulation.

Errors in initial conditions

Following an ordinary earthquake, we can say that change in the sea floor is the same as change in the mean sea level, and according to the hypocenter fault model, the amount of water level change in the water column determines the initial condition.

The starting point of the numerical analysis of the tsunami, the initial wave form, depends largely on setting of the hypocenter fault model. The setting of the model will affect the certainty of the calculation according which seismographer was used, which frequency band of the earthquake was used, whether only seismic information was used or if it was set in conjunction with high water marks. Such considerations must be accounted for in making numerical analyses of tsunamis.

Errors from submarine topography

The height of the tsunami increases as it approaches the shore (and the ocean floor becomes shallower). When a tsunami enters a v-shaped bay, its energy is increasingly concentrated, resulting in a steeper wave as it moves toward shore (amplification).

In the numerical analysis of the tsunami, the effect of underwater and shoreline topography on the steepness of the wave is automatically calculated. In the shallow depths, the precision of data is high; however, at greater depths, questionable data can easily result in errors.

Errors resulting from reverberation

Once the tsunami has breached the bay, the shape of the bay or port may contribute to the steepness of the wave. In performing the numerical analysis, the shape of even a small harbor must be accounted for.

Mathematical Error

Errors frequently occur during numerical analysis of tsunamis. In the differential equations, formulas for difference, the wavelength of the design tsunami and the inaccurate equations are often the causes.

Judgment Errors

The validity of wave height produced by mathematical formulae is compared with the observable data (the high water mark left from a tsunami strike), but when unreliable observed data is included, a numerical analysis becomes more difficult. It is preferable to make a general judgment and not focus too much on differences in local values.

2) Distant Tsunamis

Regarding distant (apogean) tsunamis, in and around Japan distant tsunamis registering high waves are infrequent. A lack of data makes it difficult to make a projection based on a statistical analysis of distant tsunamis. At present, among the distant tsunamis which have been observed, the greatest, judging from the scale of the earthquake itself, to have occurred in the Pacific Ocean is believed to be the Great Chile Earthquake of 1960. It is considered to be valid as a basis of the design tsunami.

2.3.2 Estimating Damage

The damage estimate is derived from the design tsunami. Its purpose is the protection of life and property. It is based on evaluations of damage caused by past tsunamis, the current use of land, the population, and agglomeration of industries of the at-risk community.

One of the basic principles in the promotion of the tsunami hazard mitigation program is the estimate of damage. In other words, in order to protect life and property from the damage caused by the design tsunami, the community's type and scale of damage must be projected so that the potential for danger can be estimated.

By doing so, not only are the assumptions underlying the program made clear, but the estimate will greatly affect the plan itself. In order to carry out the estimate, the current land-use, census and lifestyles of the population, and the agglomeration of buildings and industries, will be considered. The design tsunami's projected water level is derived from the numerical analysis and these results are examined and compared with the shore protection structures and the crest height of structures. Then, the estimate of the inundation will be an effective guide to the extent of danger. In cases when a more detailed study is required, the onshore runup calculation is used to estimate a community's inland area of inundation the final evaluation is based on this.

In coastal cities with ports, especially, floodgates and sea wall gates are usually kept open to facilitate access to the port and cargo handling. However, in the event of a tsunami, there is no guarantee that these will be able to be shut. Accordingly, to reduce the damage of flooding in low-lying inland areas, it is extremely important to estimate the flow of tsunami floodwater through these openings.

There remains much uncertainty in regard to the amplification of tsunamis. Further complicating an accurate assessment of the danger is that tsunamis cause secondary damage by floating debris, damage by chemicals such as oil, and fire. We must be aware that such conditions render the estimate a mere outline of the potential hazards.

1) Items to be used in the estimation of target areas

To evaluate the potential damage caused by the design tsunami, surveys with detail the characteristics of the target area should be conducted as in Table 2-8 below.

Table 2-8 Items & Standards of Evaluation

Contents	Items	Standards
Safe and smooth evacuation of residents and visitors (tourists, sun-bathers, fishermen, etc.)	○Evaluation of the safety of evacuation sites and routes	1. Distribution and time fluctuations of areas of inundation 2. Presence of safe evacuation sites a. designation and capacity of evacuation sites and routes b. presence of topographical and elevation-safe areas 3. Resident population figures 4. Areas where visitors are located, fluctuations by season and time of day 5. Location of elevated roads, bridges, tunnels, and other risk points during times of emergency
	○Comparison between the tsunami's time of arrival and the time required to evacuate from housing to evacuation sites	1. Starting time for residents' evacuation 2. History of hazard damage to the community, spread of safety education 3. Evacuation infrastructure a. outdoor speakers to issue tsunami warnings b. presence of signs indicating evacuation areas and routes, visibility at night c. distance from residences to evacuation sites 4. Topography and current road conditions a. check emergency stairways b. residents' walking speed during evacuation 5. Number of elderly and disabled a. traffic capacity for pedestrians and vehicles of evacuation routes

Protection of resident and public property	Assessment of indundation	1. Distribution of water levels and time fluctuations 2. Tsunami defense by shore protection structures a. type of construction, crest height, length, etc. b. plans for future construction 3. Sea conditions a. average lunar high tide, winter winds, etc.
	Potential for physical damage	1. Areas of inundations and time fluctuations 2. Agglomeration of facilities by type and function a. present use of land along the shore and coastal area and distribution of buildings b. accumulation of oil, lumber, etc. in ports and harbors

2) Estimation of Inundation

The estimation of inundation is made by comparing the maximum height of the tsunami along each shoreline with the crest height of shoreline protection structures .

(1) Establishing the maximum height of the tsunami

Along each shoreline, the maximum height of the tsunami has been established according to the numerical calculations of the design tsunami. As described previously, however, the analysis is not necessarily an absolute estimate and errors on the accuracy of the topographical approximation must be taken into account.

(2) Estimating Inundation

Due to the discrepancy in shoreline protective structures, in those areas without defense structures, it is extremely important to make an estimate of the danger of inundation for those areas most vulnerable.

In determining the risk of inundation, the average high tide during the lunar month (syzgy tide) is added the above (1) setting for the maximum tsunami wave height, and the worst-case scenario is hypothesized. Thus the maximum tsunami wave height for each shore is determined. The inundation estimate is then made by comparing this result with the crest height of the protective structures along the shore.

When the water marks of the greatest tsunami are clear, it is important to account for the difference between the values and the water mark values.

Note: When tsunami defense structures are built on the sea side of the water's edge, the risk of inundation is increased becuase the tsunami wave becomes steeper before reaching the structures.

(3) Estimate of Inundation when Flood Gates Cannot be Closed

The flood gates cannot be closed because 1) the arrival time of the tsunami is too short and 2) the frame is damaged by the earthquake. In such a case, inundation occurs even when the magnitude of the tsunami is not great. Therefore, the amount of flooding for each flood gate must be estimated.

3) Projecting the Area of Inundation

In order to evaluate the danger to the target coast, the design tsunami based on numerical analysis and the projected area of inundation are important. Using maps, creating a tsunami inundation projection map is effective.

(1) The importance of the Projection

Projecting the area of inundation for the target area is an extremely important part of the tsunami hazard mitigation program. Inundation data for recent tsunamis is relatively available. However, for tsunamis that occurred before the Meiji Period (1868-1912), there is practically no data. One of the most reliable sources of information are the high water marks of tsunamis.

However, high water marks are solely indicators of the extent of the inundation. They tell us little about the water level or spatial distribution of the flow velocity. Therefore, in assessing the danger, the area of inundation projected by the design tsunami is indispensable.

Recently, (local authorities) are increasingly making drafts for hazard mitigation plans which account for tsunamis generated by earthquakes . Not dependent on the presence of high water marks, inundation scenarios are essential. Once the areas of inundation have been determined, plans to protect life and property in these high-risk areas can be formulated.

(2) Method of Estimation

As stated previously, assessment of the dangers of tsunamis is possibly through a general framework of estimating the water level along the coast and through the projection of the inundation areas. However, when a detailed survey of population, the concentration of industry, the topography and characteristics of the inland areas is needed, numerical analysis of the tsunami (including runup calculations) is effective in estimating the area of inundation. The following are possible to be determined by numerical analysis.

Items for Projection

1) Tsunami coastal water level (including the maximum water level)
2) Time of arrival
3) Depth of inundation on land
4) Velocity increase at the edges of inundation areas

In historically vulnerable areas such as Tokyo and Osaka but for which no record of tsunami inundation exists, high water records make it possible to hypothesize tsunami inundation.

4) Estimating the Extent of Damage

Past tsunami damage is established by stating the relationship between the external force of the tsunami and the physical damage. That result can then forms a framework from which a projection can be made and the danger to the target area can be assessed.

(1) Tsunami Damage Estimate

Regarding damage caused by the tsunami, there are dynamic forces at work behind each cause. Pointing to representative factors of the process and extent of damage would desirable, but there is very little research to support this. Consequently, records of a tsunami’s high water level and the resulting damage are what are used. The greatness of the external force is determined by a detailed numerical analysis of the wave height.

Tsunami wave types differ with each wave. Depending on effects of the topography, the same tsunami wave can differ. This must be kept in mind as the assessment of the danger risk is made, and remember that this is producing an outline of potential damage.

(2) Feasibility of Evacuation

In developing the inundation scenario, the most important aspect of insuring the public’s safety is the warning and disaster evacuation system. In the evacuation plan, the design tsunami’s time of arrival gives a limited time for people to move smoothly and safely to refuge areas. Thus, great care must be taken in the selection of evacuation sites and routes. The first wave may not necessarily produce the highest runup and so safety plans could be required for a series of waves.

Reference: Devising an Evacuation Plan

1) Determining Evacuation Sites and Safety Zones

When residents must be evacuated from inundation areas, the availability of safety zones which can be used as evacuation sites - within walking distance - must be checked. Potential safety zones are hills over 10 meters elevation or open land outside the area of inundation that are safe from the threat of fire. In areas without such a safety zone, then it is necessary to consider using high builidings outside area of inundation.

2) Estimating the Evacuation Time

The time required for evacuees to move from the area of inundation to the safety zone must be calculated. The following must be accounted for in doing the calculation:

(1) A route which meets the necessary conditions and is the shortest route possible must be designated. When the safety zone borders a river or hills, it may be necessary to make a large detour. Narrow or dangerous points along the routs which could present obstacles during an escape must be accounted for.
(2) The time required to evacuate is set at human walking speed. For the sake of safety, it is preferable that the speed be adjusted to the pace of the elderly or disabled in areas where many such residents live.
(3) Evacuation time is calculated by the distance to the safety zone and the speed of the evacuees.

3) Comparison of the Tsunami Arrival Time

The feasibility of evacuation is evaluated by a comparison between the time required to escape to safety zones from the start of the evacuation and the tsunami's estimated time of arrival. The starting time for evacuation should be set based on the warning system and evacuation plan of the target area.

2.4 Identifying Tasks

Once the basic research and danger estimate have been carried out, the vulnerability of the target area is assessed and protective measures which should be adopted are identified.

Following the basic research and estimate of damage, the vulnerability and defensive capability of three areas is assessed: 1) defense structures, 2) city planning based on tsunami preparedness, and 3) the organizational system for dealing with emergencies. Based on their weaknesses, problem areas will be determined. Most importantly to remember is the use of underground facilities along the coastal plain, i.e. subterranean shopping areas, the underground or subway, and underground parking lots which are so prevalent. In urban areas, such considerations are vital to the planning.

Defense structures and city planning based on preparedness and the safety organization are three areas which must be seen in connection with the other, and the problem areas for a given target area that need to be addressed are given below.

Table 2-9 Items for Identifying Tasks

Category	Item	Considerations based on the current situation	Considerations from potential for danger
Defense structures	Construction and state of defense structures	1. Weakening of earthquake and tsunami resistance due to aging 2. Degree of aging according to structure maintenance 3. Installation of evacuation structures such as emergency stairways 4. Use of offshore defense structures 5. Installation of remote-controlled tsunami tidegates	Comparison of projected wave height and the crest height of defense structures
	Defense structures' resistance to earthquakes and tsunami force	1. Destruction of structures by earthquake 2. Destruction of structures by the tsunami (esp. the tide gates, etc.) 3. Destruction of the structure by breach of the wave, destruction caused by retreating waves or flow carrying or pulling objects out to sea	
	Changes in the tsunami caused by construction of defenses	1. Amplification increases wave altitude 2. Negative influence on nearby environment	
	Water discharge behind the sea walls	Lack of discharge mouths, consolidation of discharge channels Tide gates are too narrow resulting in lower discharge capacity	
	Influence on residents daily lives	Use of coastal areas by residents (production and daily life)	

	Construction standards for defense structures	Defense structures built for purposes other than tsunami safety	
	Maintenance of defense structures	Fortification and repair of damage, frequency of inspection	
Urban planning based on tsunami preparedness	Use of land inside and on the exterior of the levees	1. Accumulation of dangerous materials, location of facilities related to dangerous materials 2. Presence of lumber, vehicles, etc. which could be carried by the waves 3. Lack of evacuation sites and routes	1. Points of inundation and relationship to urban area 2. Distribution of water level in the inundation area and relationship to urban area
	Development of residential areas	1. Concentrations of aged housing, urban sprawl effect 2. Implementation of inflammable construction	
	Location and Structure of public facilities	1. Concentration and altitude of coastal hospitals, nursing homes, etc. with at-risk residents 2. Concentration and altitude of municipal buildings, fire & police departments along the coast 3. Concentration and altitude of schools along the coast	
	Construction of roads and railways	1. Location of stations and bus terminals with unknown number of patrons 2. Location of road and rail bridges which will be effected by tsunami river runup	

	Location and structure of communications and distribution centers	1. Possibility of runup in drinking water and sewage lines 2. Disruption of lifelines, i.e. flooding of transformers and pump stations	
	Location and structure of fishing facilities	Possibility of closing of the harbor and shipping lanes due to floating debris of fishing tools and fish farming materials	
	Use of tsunami control forests	Effectiveness against tsunamis	
Urban planning based on tsunami preparedness	Use of land at zero seal level	Lack of discharge mouths, consolidation of discharge channels Tide gates are too narrow resulting in lower discharge capacity	
	Use of reclaimed land and man-made islands	1. Potential damage to access roads to the mainland 2. Lack of evacuation sites and routes	
	Location and structure of port and harbor facilities	1. Blockage of shipping lanes by floating obstacles 2. Depletion of shipping ability due to destruction of port facilities	
	Location and structure of agricultural facilities, land improvement Handling of and evacuation of ships and boats	1. Danger of runup from water ducts 2. Lack of evacuation areas	
	Location and structure of businesses	Economic impact	

	Location and structure of manufacturing	Destruction of facilities, flood damage to production and negative impact on the economy	
	Location and structure of underground and other facilities where people gather	Potential increase of fatalities	1. Points of inundation and relationship to urban area 2. Distribution of water level in the inundation area and relationship to urban area
	Location and structure of recreation and leisure facilities	1. Potential increase of fatalities 2. Confusion during evacution for a lack of knowledge of evacuation sites	
	Location and structure of sites with dangerous materials	1. Potential for secondary damage caused by leakage 2. Lack of space for oil tankers to evacuate 3. environmental pollution	
	Use of underground facilities such as the subway, etc.	1. Potential increase of fatalities 2. Unprepared system for evacuation	
Organization for dealing with emergencies	Evacuation system for residents and fishermen	1. Distance between evacuation site and residential areas, route conditions and suitability of evacuation site 2. Distribution of elderly and disabled 3. Knowledge of evacuation site locations, level of safety awareness 4. Participation in evacuation drills	1. Time fluctuation of inundation area and possibility of escape 2. Tsunami time of arrival and possibility of escape

	Safety organizations	1. Level of community involvement 2. Number and activities of volunteer safety organizations, fire squadrons	
	Warning system	1. Faulty tsunami warning system 2. Installation of safety authorities' wireless communication system, outdoor speakers	
	Plans for beach patrons, etc.	1. Signs indicating routes to evacuation areas 2. Faulty tsunami warning system	
	Evacuation of port and ship employees	Lack of evacuation sites and routes	
	Closing flood gates	Installation of automatic or remote-controllable closing system	
	Protection of fishing	Lack of evacuation space for fishing boats	
	Safety Education	Public knowledge of evacuation sites, safety awareness	

2.5 Devising a Plan

The formulation of the tsunami hazard mitigation program is included as part of the local authority's hazard mitigation plan. Planners are responsible for determining content, organization, method, schedule and required funding.

In implementing the tsunami hazard mitigation program the most effective plan must be based on the local socio-economic conditions. In determining a suitable plan for a particular region, an overall effective plan which incorporates the three main areas of preparedness - the defense structures, city planning based on preparedness and the emergency organizational structure – will be based on the problems and tasks described in the previous section. Important in this regard are local fiscal conditions, effective defense measures, and the plan's effect on the community's daily life.

In carrying out the plan, the organization, methods for achieving the aims, time schedule, and funding need to be established and will be stated as part of the local hazard mitigation program. The method and schedule of achieving these aims will be evaluated with the economic feasibility, degree of urgency, necessity, and overall feasibility. In this way, local priorities can be established with higher priority goals being met first.

For long-term projects that require acquisition of land and extended period of construction, there should be a period of evaluation following the start of construction in which the progress is reevaluated. This is part of an incremental safety plan.

2.6 Problems During Implementation

Even when a program is already in place, it is in need of regular revision. As time passes the scope of damage changes, resulting from new patterns of usage of the coastal land, demographic, and social change.

In recent years, reclaimed land and man-made islands have resulted in a great expansion of coastal land use. Not only are there manufacturing and energy-related industries, but also multi-purpose usage of airports, recreation facilities, residential areas, and commercial centers.

In urban areas, the low birth rate and an increasingly aging of society have brought changes to the demographic structure. Large-scale housing complexes and more convenient transportation networks have caused a rapid growth in the coastal population and changes in urban society. For these reasons, as time passes from a program's implementation, the more its projections of damage resulting from a tsunami strike must reflect these changes.

With the increase in computer technology and advances in tsunami research, the tsunami's impact can be calculated more accurately through statistical analysis and thus should be updated on a regular basis, as should the mitigation program itself.

Chapter 3 Increasing Tsunami Preparedness

CHAPTER 3 INCREASING TSUNAMI PREPAREDNESS

3.1 Defense Structures

3.1.1. Introduction

The purpose of defense structures is to prevent the tsunami from striking land. They include the following:

(1) Sea walls
(2) Tsunami breakwaters
(3) Tsunami tidegates
(4) River dikes
(5) Others (Tsunami Control Forests, tsunami-resistant buildings)

Regarding defense structures, which directly prevent a breach of a tsunami, there are various structures such as sea walls; tsunami barriers, which are typically found at the entrance of a harbor; tsunami tidegates, constructed at the mouth of a river; and river dikes. (Note: sea walls are barriers designed to reduce the damage caused by high tides or tsunamis. River dikes are for mitigating effects of high tides in rivers. Breakwaters protect docks in fishing harbors and ports from the effects of waves).

Although tsunami control forests and tsunami-resistant buildings cannot completely prevent a tsunami breach, they have been effective in reducing the damaging effects of tsunamis, especially blocking floating debris. It remains difficult, however, to quantify their actual effectiveness, and they are based on the premise that the tsunami will breach the sea barriers. Their construction largely depends on civil planning, so they are mentioned as reference points.

a Sea Walls

Sea walls, which protect the coast from tsunamis striking land, are fundamental to tsunami preparedness. Their crest height should be determined by construction standards of the particular area in which they are built, but planners should bear in mind that a tsunami could still breach the walls and in that event, the effectiveness and safety of the levee walls must be taken into consideration.

b Tsunami breakwaters

Tsunami breakwaters alleviate rises of the water level within a designated area. They also are effective in altering tsunami wave reverberation. They are already in place at harbors for large vessels and are being built at various port entries such as at Kamaishi, Kuji, and Suzaki.

The effectiveness of tsunami breakwaters varies, depending on the shape of the bay, their location, the width of the mouth, and the variations of an incoming tsunami's cycle and wave height. It is necessary to bear in mind such factors when making a calculation or model simulation. At the same time, the reflection and reverberation effects within the breakwater effects on local areas must be accounted for in the planning.

c Tsunami tidegates

Tsunami tidegates are located at the estuaries of rivers. Their purpose is to prevent the tsunami waves from flowing up the rivers. There are many ways a tsunami wave affects a river, depending on the wave's power (strength), overflow, and external power. Thus a thorough review from a hydrology perspective is necessary. In past tsunamis, the tsunami tidegates sealed off flooding from tributaries, but as a result, reflective waves hit neighboring shores and the water level was increased. Planners must account for this during planning.

d River Dikes

By increasing the height of a river dike, the downstream dikes are set at a sufficient height to prevent surges in the river and thus stop overflow into a designated area.

Rivers are relatively susceptible to tsunami runup. Tsunamis move along shallow flat surfaces against the current and thus their wave formations become increasingly complex and the vibration width can become wider. The river dikes should be of a sufficient height to stop overflow, but a possible tsunami of unpredicted magnitude could still overflow. Thus, just as high sea-walls, the placement of a strengthened three-sided levee is necessary.

To avoid the increased cost of such a system, the construction of tsunami tidegates are common. However, in some cases where it is most beneficial to use the river system's topography as a buffer zone, constructing tsunami tidegates for all rivers is not necessarily the best method. In such a case, it must be remembered that drains in inundation areas remain vulnerable to tsunami runup.

e Others (Reference)

- Tsunami Control Forests

The ability of tsunami control forests to reduce a tsunami wave's energy remains, at present, unclear. There are, however, many historical examples of them stopping floating objects, and acting as a life preserver to people swept away by the tsunami, so they do have a safety role to play during a tsunami disaster. However, we should be aware that if the runup depth is over 4 meters, they have practically no beneficial effect.

- Tsunami-resistant Buildings

A row of buildings designed specifically to withstand a tsunami are placed at the waterfront and are effective for reducing the strength of the tsunami and preventing runup into the interior. It is also clear from studies that anti-tsunami buildings are effective at blocking floating objects such as boats, wood, houses, etc. Anti-tsunami buildings are an dually effective in that they allow usage of the coast and fishing and they have a safety function as well. They are described in more detail in Chapter 3, Tsunami Readiness and Civil Planning.

3.1.2 Construction Standards

Safety needs must be clarified for each at-risk area. Based on the damage estimate described in section 2.3, construction standards must now be drawn up. Standards will reflect the needs described from a detailed analysis of local situations and effective safety measures. In cases where patterns of land usage change, or new knowledge contributes to the understanding of tsunamis, it may be necessary to review and revise safety standards of construction. Finally, a balance must be sought between the mutual effects of construction in adjacent areas.

Defense structures form the base of the tsunami hazard mitigation program. Notwithstanding a higher guarantee of prevention from damage caused by tsunamis, the associated costs and time needed for construction are significant. Construction standards must reflect the safety needs of each area, which have been derived from damage estimates. Furthermore, its compatibility with civil planning and the organizational emergency system must be assessed. Defense structures and standards must reflect changes in patterns of land use and new knowledge of tsunamis and should be subject to revision.

(1) The tsunami mitigation hazard program is a response to a projected tsunami of the greatest magnitude. Construction standards of defensive structures are based on the local characteristics and measurements of their effectiveness. As part of a comprehensive plan including city planning based on preparedness and the emergency organization, there is no guarantee that construction standards match design tsunami requirements.

(2) Estimation of Damage

Priority areas are established based on damage estimates. In those areas, standards must be clearly stated as below. It is advised that other areas adopt similar standards.

(3) Construction standards are based on a comprehensive review of the following: a) structures in place and future construction plans, b) inland situation and future (environmental and social conditions), c) use of coastal land (production, daily life). Some cases may require an incremental approach due to safety effectiveness and economic factors.

(4) Levee free-boarding

When standards are being determined, it may be necessary to implement levee free-boarding. There is a possibility of uneven settlement, erosion of the foundation, drag forces, and the destruction of deteriorated facilities during an earthquake. Or, statistical error in the calculation of the wave height may occur. In such cases, there may be a need determine higher levee free-boards.

(5) A balance is needed between priority and adjacent areas as constructions could adversely affect the tsunami’s amplitude (rise in water level due to reflection and multiplication of waves from offshore structures).

3.1.3 Selecting Proper Defense Structures

The selection of defense structures should be based on the area conditions, present state of defense structures, construction cost and safety benefits. Defense structures may by used by themselves or in combinations with other types.

Defense structures have unique features and should be carefully selected depending on the land use, existing structures, cost, their effects, and whether stage construction can be carried out. Tide embankments and tsunami breakwaters can be used individually or in conjunction with each other. A great deal of land is required for the new construction or raising of tide embankments. Therefore, their use must be weighed against plans for future development of the area or land use.

In some areas, new construction could inconvenience use of the coast, block sunlight or air flow. Tsunami breakwaters can change the flow of the tidal current, affect water quality or fishing. Accordingly, careful attention to such problems must be given.

A more detailed guide to planning and building defense structures is found in “Guide to Coastal Protection Construction Standards .”

3.1.4 Earthquake and Tsunami-resistant Structures

1. Defense structures must be designed to withstand the force of the earthquake so as not to lose their safety function.

2. Great care must be taken in preventing destruction of the defense structure by collapse, erosion at their bases resulting from drag forces and retreating waves, or collison from floating objects such as ships or boats.

(1) In the wake of the Great Kobe Earthquake, shoreline structures are now being evaluated in terms of their earthquake-resistance. Measures to combat liquefaction are being considered. Anti-tsunami defense structures are designed to prevent inland inundation, and thus damage from the inertial force and liquefaction caused by an earthquake is unacceptable. Care must be taken in the design and fortification of tide- and sluicegates, which are susceptible to deformation by earthquake, possibly resulting in clogging or mechanical malfunction. There are reports of land subsidence following an earthquake. Accordingly, safety planning of defense structures should take the possibility of wider area subsidence into account.

(2) It is extremely difficult to accurately predict the magnitude and damage of tsunamis. Therefore, planners must be aware that their standards may be insufficient. Defense structures must at all costs serve their purpose and must be able to withstand a tsunami force greater than envisioned. Great care must be taken in preventing destruction of the embankment bodies by collapse, erosion resulting from drag forces and retreating waves. Water cushions should be in place for protection. Sliding or overturning resulting from disparate water levels on both sides of the levees and destruction by overflow of stone mounds within the harbor should be accounted for in the design stage.

3.1.5 Discharging Floodwater in the Protected Area

In areas protected by tsunami barriers, it is important to have a drainage plan.

(1) Flooding (or ponding) resulting from tsunami flooding across the defenses

(2) Flooding caused by rainfall

(1) There are cases when the tsunami waves will overflow the defenses. Although we can anticipate the reduction of flooding and of the tsunami's damaging force, the risk of further damage must be prevented by curtailing long-term ponding or flooding of protected areas within the levees.

(2) Lack of drains, consolidated drainage channels, and narrow drains are causes of insufficient drainage within the protected area. Flooding will occur in areas where rainwater is not immediately drained and in some areas, damage occurs every year. Installation of drains, drainage channels or pumping stations is necessary in the planning.

(3) When a tsunami attack occurs during a drainage period, it is necessary to discharge the reservoir of water within the channel with the tidegates closed. The same applies to cases when the tsunami breaches the tidegates and flooding has occurred.

3.1.6 Maintenance of Defense Structures

1. In order to prevent defense structures losing their defense capability from aging, full maintenance must be performed following construction.
2. Tidegates and inland lock gates are built according to local specifications. Defective parts will be repaired and their operation regularly inspected to insure they are fully operational at all times.

(1) As structures age, uneven settlement, consolidation settlement of the bank's filler, or sinking may result in a hollowing of the levee. The sand shore may regress or be lost, resulting in erosion of the core of the levee. Maintenance staff must conduct regular inspection and fortify and repair as necessary.

(2) During a tsunami attack, tidegates and inland lock gates play an important part of the tide embankment's role as a defense structure. They must be maintained fully operational at all times. The following are important points:

a. In cold climates, such as the Sanriku region, gates should be selected which can properly function even during freezing temperatures.
b. It is preferable to select gates which can be operated by remote control so as to avoid danger during a tsunami attack.
c. Smaller gates which are opened and closed by human power alone should be lightweight.
d. Gates should be maintained so that sediment does not prevent total closure.
e. Inspection for damage and full movement of sluicegates and inland lock gates should be conducted at least once a month. Damage should be repaired immediately.

3. 2 Urban Planning and Tsunami Preparedness

3.1.1 Outline

An outline for civil planning based on tsunami preparedness is given below. Such planning is based on the state of the area as detailed in the research. The planning for tsunami preparedness based on urban planning will be reflected in a number of plans, including land usage, public facilities, and transportation.

1 Promotion of land usage that is tsunami-resistant

1) Tsunami readiness in use of land and zoning laws

(1) Guidance for relocation to safer zones

- Guidance for established city areas (including relocation to higher ground)
- Promotion of appropriate land use during development of coastal land

(2) Introduction of anti-tsunami and buffer zones

(3) Construction and Protection of Safety Facilities

a Protection of Tsunami control forests

b Protection of old levees

2) Construction of important public facilities

3) Transportation facilities and other basic forms of community infrastructure

2 Increasing safety through proper use of land in coastal areas

1) General Planning

(1) Tsunami-resistant construction

(2) Dealing with dangerous materials

2) Increasing safety along the shoreline

(1) Residential districts

(2) Commercial districts

(3) Manufacturing and Shipping districts

3) Safety in Maritime Industries

4) Preservation of Lifeline Facilities

(1) Communications

(2) Distribution Centers

Urban planning for tsunami preparedness is based on the relocation of the most important facilities that protect life and property to areas safe from tsunami attack. In at-risk areas, it aims to reduce damage as much as possible through effective land use. The most drastic measures call for the relocation to higher ground as in past tsunami attacks.

It is, of course, extremely difficult and in many cases almost impossible to relocate residential homes and important facilities to safer locations. Therefore, medium and long-range planning based on safer use of land in at-risk areas should aim to reduce damage structurally (use of land and reinforced construction). Restrictions should be placed on at-risk areas to alleviate the concentration of structurally vulnerable buildings. New construction in these areas should be avoided.

In inland and coastal areas, however, construction needs depend on the usage and location for the promotion of business and commerce, as well as residential life. It is important, therefore, to promote tsunami safety based on the use of land that maintains a balance between the promotion of safety standards and function of land in each area.

Based on the above, construction in dangerous areas should be tsunami-resistant, which means that it does not only prevent damage to the structure itself, but also reduces the amount of damage inland. The inducement of such land usage is important also for effective evacuation and rescue efforts. Tsunami readiness should also play a role in the design and construction of the transportation network and public facilities.

Because tsunamis occur infrequently, planning should reflect the target area's future development and convenience of daily life. There is also the increased potential for new and unforeseen dangers caused by rapid changes in modern business and society. These dangers may not be reflected in records of past tsunamis. The location of dangerous substances and ways to deal with them present new challenges to tsunami preparedness.

3.2.2 Promoting Defensive Land-use

3.2.2.1 Zoning and Tsunami Hazard Mitigation

1) Inducement to use land in safe areas

(1) Land-use in urban areas

a. Relocation to higher elevation

The possibility for relocation to higher, safer ground should be considered when houses are located in areas expected to receive extensive damage.

Relocation to higher ground has been a part of reconstruction policies in the past and remains a viable though drastic, measure at present. The Land Agency has such a program through its Safety Relocation Program, initiated in December of 1972 under the eponymous law. It allows local authorities to relocate residents from designated danger areas to safer ones. This program is only carried out in "areas that have suffered a disaster or are designated as a danger zone." Therefore, in order to qualify for the government program, residential areas must be designated as a danger zone under the Basic Construction Law

b Planned Land-usage

Land use is promoted which reduces the extent of damage of a tsunami attack. In areas projected to be affected by a tsunami, current patterns of land usage, future development of the area, and the convenience of local residents must be taken into account.

The main task of urban planning based on tsunami readiness is to reduce the amount of damage as much as possible through appropriate land use. One measure is relocation, as above, but in areas where relocation is difficult, a policy of restricted land use is an effective alternative.

Policy measures should be based on the areas of inundation and projection of damage caused by the design tsunami, as discussed previously. The following are examples of land use restrictions under current law.

Danger Areas

The Basic Construction Law states, "Article 39: Areas which are at considerable risk of tsunamis, high tides, and flooding can be designated as danger areas. For safety precautions, housing and other construction may be restricted in danger areas.

The above allows local governments to declare danger areas and then proceed with a relocation program. Under the same provision, they also are able to promote tsunami-resistant construction and restrict building in the danger areas. Nagoya City is one such case. After designating a danger area, it placed residential and building restrictions an area over 6,000 hectares.

Zoning Restrictions on Residential Housing

According to Article 3 of the Restriction of Residential Housing Law "At the request of a prefectural government (or designated city), the Minister of Construction can designate an urban or suburban area that is at considerable risk as a Restricted Residential Area."

However, the law stipulates that "when the prefectural authorities request such a designation, they must first receive the mayor's agreement of the affected area." Based on the above, restrictions can be placed on at-risk areas and buffer zones to prevent reckless building.

(2) Appropriate Land Use during Development of the Coastline

In large metropolitan areas where the redevelopment of coastal land occurs, planning which promotes safety along the coast and increases the safety of inland areas is desirable.

2) Land Use Planning & Introduction of Anti-tsunami or Buffer Districts

> In at-risk coastal areas, anti-tsunami buildings and relocation are included in the urban planning and land-use planning. In addition, urban planning should include such measures as restriction on land use in areas which could serve as buffer districts.

When anti-tsunami buildings and evacuation buildings along the coast are planned, or when unused fields must be secured as part of the defense program, it is important to define the roles of such areas in the overall land use planning. By doing so, it is also important to seek a balance between use during daily life and that required during an emergency.

Here, land use which incorporates the concept of anti-tsunami districts or buffer districts should be reflected in the urban planning master plan as the vision for land use is developed. City planning should propose a guaranteed system and methods for making such land use a reality.

(1) Anti-Tsunami Districts

In land which is used behind the tide embankments, depending on the circumstances, can be designated as an anti-tsunami district. By constructing anti-tsunami buildings, the damage to the interior can be reduced. Research following the Sanriku Tsunami of 1933 reports that ferro-concrete houses and warehouses prevented the wooden houses behind them from being destroyed or carried off. This shows that strong structures weaken the tsunami force and also block large floating debris.

Effective examples such as the above can be incorporated in current planning. By designating high risk coastal areas as anti-tsunami districts, reinforcement of construction can be achieved. In such a case, a row of buildings can serve as a strengthened wall and is an effective way of reducing the amount of runup. The anti-tsunami buildings not only reduce overflow of the tsunami wave, but are effective in blocking lumber, boats and other dangerous floating debris from breaching the water’s edge.

As land use increases behind the tide embankments, and fishing warehouses or processing plants are adjacent to the tide embankments, their use as reinforced anti-tsunami buildings is important. It may be difficult to reinforce present structures, and therefore, new or reconstruction should be considered.

The same applies to future land use in other areas. It is necessary to restrict land use in dangerous areas, but for practical reasons it is necessary to have manufacturing or distribution facilities on the coast. In such cases, facilities should be reinforced as anti-tsunami and thus become an anti-tsunami district in the future.

(2) Buffer Districts

Areas that can absorb the force of the tsunami and which are not being used can be designated as a buffer district. They increase the safety in adjacent areas where usage is high. During a tsunami strike, defense structures at the water's edge cause reflection, which can increase the water level in adjacent area. This means the water that would normally flood on land becomes concentrated in the ocean. In such a case, land which can absorb the tsunami's power and which is unused can be designated as a buffer district. The buffer district can prevent a breach by a small or medium-sized tsunami, but absorbs a large tsunami. Thus, it contributes to the safety of neighboring areas which have heavier land use. Inland areas with no houses or is undeveloped is one way of dealing with such flooding. It can be used to absorb the runup of the tsunami and thus contribute to the safety of highly developed areas.

3) Protection and Construction of Safety Facilities

a Tsunami Control Forests

> Tsunami control forests are effective in the following regards. Existing forests should be protected and maintained.
> (1) Reduce damage to interior houses, etc.
> (2) Blockage of floating debris such as wood, ships, etc.

Regarding the Effectiveness of Tsunami Control Forests

The effectiveness of the forest depends on the size of the tsunami, size of the forest, the age and distribution of its main trees, and the density of undergrowth. Generally, a forest that is wide and well maintained is effective in reducing the flow velocity of the tsunami and also blocks floating debris. Finally, there are numerous examples of people saving themselves by grabbing hold of trees as the tsunami retreats.

Scarcity of land and clearing the forest for construction has led to cutting down the forests. However, in view of their role, the protection and maintenance of the forests is desirable.

On the other hand, forests have been ineffective against large tsunamis, so expectations must be kept in check in relation to control forests.

b Existing Levees

> If existing levees are deemed to be an effective defense structure, they should be maintained.

As defense structures are built, older structures tend to lose their safety function. However, a tsunami could overwhelm the new facilities, and when deemed effective, older defensive structures should be maintained as part of the overall defense.

3.2.2.2 Regarding Vital Public Facilities

The following points are important in the location and construction of public buildings such as the city hall, schools, hospitals, public halls, and parks.

(1) Inducement of proper land usage

(2) **Will be used as evacuation and rescue centers**

Public facilities play an important role and their location characterize the makeup of a given community. Judging the activity in the community and between the wider area, it is important to consider their placement in designing a community based on tsunami preparedness. They become centers for evacuation and rescue during a tsunami attack and so their placement in safe areas is necessary. When they are located in high danger areas, proper steps should be taken to ensure anti-tsunami construction.

In areas such Sanriku which have been attacked before, public facilities are often placed in safe locations. However, many at-risk areas may not be able to strategically locate their public facilities.

Schools and medical facilities are important in evacuation and rescue operations and therefore should be built in safe areas. When they are located far from residential areas, it is important to ensure that evacuation routes do not pass through hazardous areas.

Regarding facilities where many people gather that must be built at the water's edge, such as cargo loading or fishing cooperatives, their design must account for the high water level of the tsunami, i.e. height, structure and evacuation.

3.2.2.3 Transportation and Urban Infrastructure

In their role in building a community based on tsunami preparedness, the following points should be addressed regarding road and rail networks.

(1) inducement of proper land usage
(2) use as an evacuation route
(3) use as a emergency supply route

In addition, regarding the protection of maritime routes, planning should increase the safety of the port, which will be used as a center during rescue and reconstruction.

The following points are important regarding transportation networks, including main roads, local roads and railroads.

(1) Main Roads

Main roads, such as national and prefectural routes, are important in the transportation network and are critical as supply routes during an emergency. Accordingly, as much as possible, hazardous areas should be avoided. When it is unavoidable, the roads must be fortified against earthquakes and flooding. In an extreme case where the main road is inaccessible during a tsunami attack, an alternative network of detours must be in place for emergency transportation. These must also be constructed and fortified. There is a tendency for development along main roads. Main roads in safe areas then serve as an inducement to safe land usage. In cases where elevated roads and heavy traffic sever coastal areas, evacuation route measures must be in place.

(2) Local Roads

Like main roads, local roads must also be fortified. At the same time they must serve as escape routes. Accordingly, direct routes to higher ground are important. In order to promote safe use of land, it is necessary to build roads which connect ports with safe residential areas on high ground.

(3) Railroads

Railroads serve the same purposes as main roads and should therefore be built in safer areas. When they traverse hazardous areas, they should be properly foritified.

(4) Transportation Lines as Dual Levees

Some communities have the advantage of having two de facto levees by road and rail. In such circumstances, it is necessary to reinforce them by elevation of the roadbed and stone or concrete pitching of the embankment. The gap in the junction between embankment filling and wingwall of the concrete abutment is a weak point. Lightweight beams on railroad bridges are also susceptible to damage by floating debris.

(5) Maintaining Safety in a Port or Harbor

In areas which are vulnerable to being cut off from transport of emergency relief, such as those surrounded by mountains or peninsulas, the ability to ship emergency supplies by sea is vitally important. In such cases, so that the port or harbor can be used as a center for supply, rescue and reconstruction, they must be fortified against earthquakes. Attention must be given to the safety of anchored and sailing vessels as well as improving the function of the port and harbor as a relief center.

3.2.3 Coastal Facilities and Safe Land Use

3.2.3.1 General Considerations

1) Tsunami-proofing Construction

To prevent spills of dangerous chemicals or overturning by tsunami currents, it is suggested to reinforce buildings against tsunamis along the coast, especially in the inundation areas.

In the protected areas, there are usually houses, businesses, public buildings, fishery processing plants, etc., and petrol supply stations. On the ocean side of the embankment, there are fishing and recreation facilities. The fishing cooperative, fishery processing plant, and market should be tsunami-proofed by effective methods such as steel-framed reinforcement. Strong buildings at the water's edge have shielded buildings behind them in past tsunami attacks. Building restrictions that increase tsunami readiness can be implemented by local authorities according to the Basic Construction Law, as detailed earlier.

Hamanaka in Hokkaido and Nagoya City are two examples of local governments that have placed building restrictions in hazardous areas. Tokyo Prefecture offers incentive to raise floor heights in flood-prone areas by partially funding the cost. Areas frequently affected by tsunamis should investigate the possibility of placing restrictions and reinforcement of buildings in their communities.

2) Hazardous Materials

Hazardous materials can cause secondary damage during a tsunami attack. Accordingly, care should be taken to ensure they are protected and safely stored.

Tsunami waves often turn timber, fishing boats and equipment into projectiles. They are borne on the waves as they move inland and can destroy embankments, bridges, facilities and houses. In addition, spills of hazardous chemicals such as oil, gasoline, etc. can occur. One measure is to store such materials in tsunami-proofed warehouses, but volume and size are often too much for capacity. Little can be done in face of this situation. Improvements to timber yards are an immediate concern.

Regarding hazardous chemicals, storage should be done in safe areas when possible. Otherwise, storage tanks should be buried and steps to prevent spills should be taken in making them less susceptible to tsunamis. In the event of a spill, precautions for the safety of residents is important. Supplies and measures for the rapid recovery of spills or extinguishing fires should be stored and thought through. Management and public authorities in charge of hazard mitigation should cooperate during the design and construction phase of such facilities that will create a functioning system in an emergency.

3.2.3.2 Coastal Communities & Improving Safety

Coastal areas are an important part of the national life and productivity. Accordingly, higher concentration of population and industry occurs. It is important for tsunami readiness planners to use these characteristics to their advantage during planning stages. The characteristics of the following three areas will be discussed below:

(1) Residential areas
(2) Commercial districts
(3) Manufacturing and Distribution centers

(1) Improving safety in residential areas

In coastal regions where the nocturnal population is dense, it is important to stress the public's safety awareness and active participation in safety drills. Also key are environmental factors such as developing a community consensus about reconstruction of older buildings and the need for evacuation centers, etc.

（2） Improving safety in commercial districts

In metropolitan areas and tourist areas along the coast, large numbers of visitors gather to enjoy leisure activities. Developed in conjunction with local people, clear guiding systems for evacuation sites and routes must be in place for visitors. Management of large-capacity facilities must be encouraged to develop evacuation plans for customers.

(3) Improving Safety in Manufacturing & Distribution Centers

In ports and adjacent areas, plants and factories, warehouses and distribution facilities must be protected. Recently, underground transportation and changes in usage patterns of the waterfront have contributed to masses of people using coastal regions. Safety of these patrons must be considered. When the land faces a port with a lot of sea traffic, a tsunami would likely cause much damage by boats colliding or casting them on the shore. Appropriate safety measures can reduce such damage.

Furthermore, ports and harbors are vital during the emergency response following a tsunami. Steps should be taken to protect their vital functions from damage caused by carrying off of fishing equipment, spills, etc. Their use as an emergency center for relief supplies and emergency vessels should be strengthened through the readiness program. Finally, so that their vital role in safety preparedness is clear, involved parties should discuss emergency procedures, and draw up and sign written agreements on their usage during an emergency.

3.2.3.3 Ships and Boats

1) Safety Planning for Ships and Boats in Ports & Harbors

When a tsunami warning has been issued or the waters threatened, seagoing vessels are subject to the transmission, order or restrictions set by the Maritime Safety Agency. Port authorities must take appropriate measures as well to ensure the safety of the waters.

Regarding ports and harbors for which the Harbor Regulation Law is not applied, it is recommended that port authorities, ship and boat proprietors, and fishing cooperatives meet and agree on pre-planned safety measures.

The Niigata and Japan Sea Chubu Earthquake(s) generated tsunamis that carried away, sank, overturned, and grounded small craft such as pleasure boats, workboats, and tugboats.

When a tsunami warning is issued or danger is detected in a specific area, the Harbor Regulation Law (est. 1948) gives the harbormaster authority to issue warnings, orders and restrictions for offshore evacuation. In ports and harbors where the Harbor Regulation Law is not applied, however, it is recommended that port authorities, ship and boat proprietors, and fishing cooperatives meet and agree on pre-planned safety measures. The following points should be discussed:

(1) medium and large vessels will be evacuated to outside the port
(2) vessels which cannot be evacuated will be safely moored
(3) medium and large vessels will be withheld from entering the port

In those areas where a tsunami could affect coastal tankers, it is recommended that appropriate steps be taken in dealing with the proprietors of such vessels.

2) Fishing Boats

In the event of a tsunami attack on fishing boats, the protection of life is the focus of safety measures.

There are two main objectives in boat safety measures. First is the protection of property (the boat itself). Second is the prevention of secondary damage caused by a drifting vessel. In either case, during a tsunami attack, evacuation of fishing boats endangers those involved and this fact makes it impossible to draw up general guidelines for their evacuation.

When there are more than 10 hours before the arrival of a distant or local tsunami, it is preferable that fishing boats evacuate to deeper waters (circa 100 meters depth). In such cases it is imperative to pay close attention to estimated time of arrival issued by The Meteorological Agency. Fishing boats have escaped by opening passage routes through fish farming rafts.

If the arrival time is too short to escape, it is extremely dangerous to evacuate to offshore waters. Instead, a combination of loose mooring and loose anchorage can reduce the risk of drifting on land. There is no best method for boats that are being unloaded on land. If there is time, it is advised to lower the anchor outside the boat, making it more stationary during a tsunami strike. It is believed that keeping the mooring and anchor cables loose is effective in preventing them from being severed by the collision of the first wave or strain from buoyancy. Regarding the safety of fishing vessels, our lack of knowledge at present about the effects of amplification in and out of the harbor forces us to wait for future research.

Finally, for dealing with boats that have been grounded, especially on roads, it is important to consider the procedures and having the owners' agreement regarding their handling.

3.2.3.4 Protection of Marine Industries

1) Marine Industries Outside the Levees

The following points must be kept in mind regarding marine industries outside of the levees: (1) Location and use of maritime industry facilities (2) Anti-tsunami reinforcement to prevent erosion of defense structures (breakwaters, levees, coastal dikes) and the mooring

(1) Even though a coast may be defended by sea walls, marine facilities are normally built outside them (leaving them vulnerable to tsunamis). In addition to tsunami-proofing them, the first and second floors of such facilities should be designed to suffer minimal damage from flooding. When such facilities are built inside or outside the sea walls, reinforced construction turns them into anti-tsunami buildings, forming a protective barrier for buildings behind them.

(2) Other, non-defensive marine facilities should also be reinforced against earthquakes and tsunamis. Problems such as drainage and maintenance, and ageing should also be addressed. Harbor breakwaters and coastal dikes can be effective in reducing the force of small and medium-sized tsunamis.

2) Aquacultural Facilities

Although it is difficult to protects aquacultural facilities against tsunamis, the following points are important: (1) Use of Fishery Disaster Relief Program (2) Prevention of secondary damage

(1) At present, it is impossible to protect aquacultural facilities from tsunamis. It is recommended that victims make full use of such programs as the Fishery Disaster Relief Program. This program gives relief to small and medium fishing businesses which suffer unforeseen or extraordinary damage. It is organized as a credit union, and it aims at protecting and providing stability to small and medium-sized members of the fishing industry.

Its organization is diagrammed in Chart 3-1 below. The fishery credit union collects premiums and pays claims to the National Fishing Credit Union League. The national government also provides assistance and aids by paying part of the fisherman's premium.

There are four types of insurance schemes, depending on the type of maritime industry: fishing, fish farming, special types of aquaculture, and shellfish. Fish farming insurance provides assistance for "death or loss of fish from overflow, and damage to farming facilities."

Special Aquacultural Insurance provides assistance to compensate for "decreases in the selling price, production falls below standard levels, and damage to farming facilities."

(2) It is important to prevent secondary damage caused by farming materials, which could become projectiles much as boats or floating timber do. Though no such cases have been reported, steps should be taken to prevent farming debris from blocking the entrance to the port or obstructing passage routes.

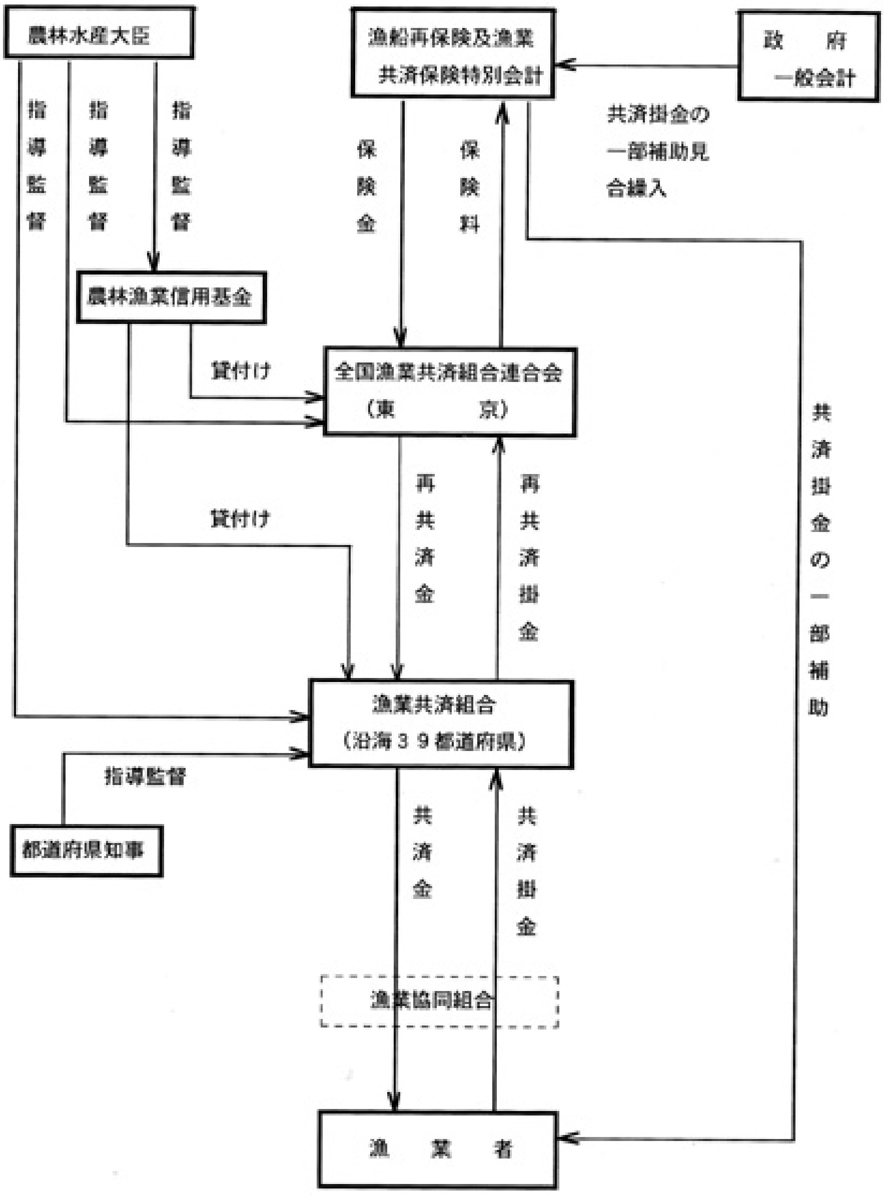


図３－１　　漁業災害補償制度の機構

Table 3-1 Types of Coverage by each Mutual Aid Association

Type of Association	Coverage available
Fishing	Assistance for financial shortfall resulting from low fishing catches
Fish Farming	Assistance for loss by the death or escape (overflow) and damage to farming equipment/facilities
Special Aquiculture	Assistance for loss of production, loss or damage to farming equipment/facilities
Fishing Gear	Assistance for loss of fishing gear during operation

3) Fishing Equipment

Safe handling of fishing equipment under normal conditions helps prevent it becoming debris during a tsunami attack.

Fishing equipment, disused vessels or drums can be left unattended to in ports. A large tsunami attack can turn such items into dangerous projectiles, causing damage to urban areas. In addition, there are cases of debris accumulation becoming an obstacle to the long-term functioning of the port. It is necessary, therefore, to properly deal with and dispose of fishing equipment.

3.2.3.5 Protection of Lifelines

1) Telecommunications

> **Telephone and communication facilities should be protected from a tsunami attack by placing them in a safe location and protecting their infrastructure.**

Telecommunication facilities play an important role during a tsunami attack. Care must be taken to protect cables and switchboards by placing them in safe location and building secure configurations. To protect communication channels, the most important facilities should not be build in high-risk areas. Communication facilities which are in hazardous areas should be placed underground or reinforced against tsunamis.

2) Utilities

> **Electric power and water supply utilities should be located in safe areas and their infrastructure protected.**

Just as telecommunications, electric utilities should be built in safe areas. Those in hazardous areas should be reinforced. Steps should be taken to ensure supply to evacuation and relief sites is secure during an emergency.

It is essential to guarantee a supply during an emergency. In evacuation and relief areas, potential water sources such as well water and swamp water must be considered. Communities that draw water from a river should be aware that damage to intake facilities from tsunami runup has been observed.

Regarding sewage, it is desirable to have a plan to prevent damage to terminal facilities located along the coast. There are cases when tsunami runup has gone through the outlet works into to sewage pipes and flooded urban areas. Measures to prevent runup through sewage outlets are necessary.

3.3 Disaster Organization

3.3.1 Outline

Organized disaster relief efforts are carried out on the basis of disaster law. This chapter focuses on issues related to organizational structure, as follows:

(1) Building Organizational Structure
- a Disaster headquarters and related organizations
- b Civil Defense

(2) Issuing Warnings and Communications
- a Monitoring tsunamis
- b Use of quantitative forecasting
- c Issuance of Warnings
- d Establishment and Protection of Communication Systems

(3) Evacuation
- a Evacuation of residents
- b Evacuation routes
- c Evacuation centers
- d Concern for the Sick, Elderly and Young
- e Safety for Visitors
- f Transportation

(4) Opening and Closing of Tidegates

(5) Educational Programs
- a Collection of data and education about past tsunamis
- b Safety Education
- c Making a Safety Manual
- d Safety bulletins

(6) Tsunami Readiness Drills

(7) Emergency Response
- a Emergency Organization
- b Mobilization of the Public
- c Establishment and Maintenance of Emergency Facilities

The Basic Disaster Law provides protection of national territory, life and property. The law contributes to social order and public welfare, and is the foundation of Japan's disaster prevention and relief program. To facilitate a comprehensive and planned administration of safety programs, the law provides for the formation of emergency organizations, clarifies authority, and establishes disaster mitigation programs.

(1) Basic Disaster Planning

The Central Emergency Board is commissioned by the Prime Minister, who serves as Chair, and is the basis of public administration of dealing with disasters and emergencies. Its policy includes the establishment of emergency organizations, promotion of disaster relief initiatives, expediting suitable reconstruction, promotion of scientific research related to disasters, and finally, administration of disaster programs, including policy directives for the develop of local disaster planning.

(2) Administration of Disaster Planning

Under the Basic Disaster Plan, the creation and implementation of safety programs is carried out by designated governmental authorities or public organizations. Careful consideration ensures that safety programs operate in coordination and naturally,

(3) Local Hazard Mitigation Planning

Regional and local autonomies are responsible for developing at the prefectural and city level. According the of the needs of the autonomy, the central government, local government and public organizations are responsible for making and administering disaster planning. Local planning is broader in scope and is based on deliberations by local disaster committees.

This chapter discusses existing disaster programs and introduces key items of tsunami preparedness related to disaster planning.

3.3.2 Organizational Structure

1) Outline

Establishing safety organizations promotes the overall tsunami hazard mitigation program.

The Basic Disaster Law establishes the organization of the hazard mitigation program. The Central Emergency Board is commissioned by the Prime Minister, who serves as Chair, and includes directors of designated government organizations. It deliberates on important safety issues and the overall safety program.

At the prefectural level, the governor heads, along with designated government authorities, police, fire and public entities, a regional commission. This commission determines safety plans at the regional level. Likewise, local authorities have a safety commission and it is the pivotal organization at the community level.

Finally, there are many organizations which are responsible for safety. Among them, there are 29 national government organizations, including the Cabinet Office, Agriculture, Forestry & Fisheries Ministry, and the Ministry of Construction. Japan Railways (JR)and Nippon Telephone and Telegraph (NTT) are among the 37 public entities designated.

2) Disaster Headquarters and Defense Organizations

When a tsunami warning is issued or a disaster has occurred, it is important to mobilize officials for the collection and dissemination of information and to orchestrate a rapid disaster response.

When a tsunami warning is issued or a disaster has occurred, rapid mobilization of officials is critical. A variety of situations must be accounted for concretely in the organization of the emergency system and dispatch of safety team.

Precise rules are necessary regarding the establishment and abolition of the Safety Headquarters, including its location and transfer of authority.

Regarding the role of the Safety Headquarters, clear rules are needed on the procedures to implement its decisions as well as measures to deal with command and control of safety units in the absence of their leaders. To insure smooth operations, the Headquarters should be established on the basis of local organizational structures. To avoid vertical division within the organization, those departments responsible for its operation should strengthen lateral checking mechanisms. There must be a clear division of labor which allows for the establishment and deployment of special teams.

Finally, depending on the circumstances, the mobile response of an on-site disaster headquarters may be necessary.

3) Civil Defense

Efforts should be made to build a civil defense organization.

During a disaster, community residents working together prevent further damage. They are an extremely important part of smooth relief efforts and from this perspective, efforts should be made to build up civil defense organizations.

It is necessary to create a favorable environment for civil defense, which includes, dissemination of information, construction of an emergency center, and regular practice of its activities.

In the event of a tsunami, a civil defense organization has the following roles:

1) although it is important to escape to higher ground or upper stories of solid buildings, assisting the sick, elderly or disabled to evacuation is one civil defense task.
2) increasing awareness of tsunami safety through disaster drills, etc. and educating about evacuation sites and routes.

3.3.3 Warning & Communications System

1) Monitoring of tsunamis

In order to better understand the effects of various coastal features on tsunamis, and to improve readiness, it is important to develop a system for monitoring tsunamis.

The National Meteorological Agency is making efforts to strengthen tsunami monitoring. However, the announced magnitude of the tsunami could be greater in some areas due to local conditions. As a result, a local system of gauging a tsunami affected by the particularities of the coast is important in developing inundation maps. The following three methods are available:

1) installation of tide gauges
2) a system for gathering information from local fishermen
3) installation of look-outs on high ground

It is also necessary to collect and store tsunami data.

2) Use of Quantitative Tsunami Forecasting

The National Meteorological Agency has adopted plans to introduce quantitative forecasting for tsunamis at the prefectural level. This valuable information forecasts the estimated height of a tsunami, which is effective as a basis of inundation maps.

The plans called for the introduction of quantitative forecasting in 1999. According to this method, the propagation and numerical model are calculated for an earthquake-generated tsunami. Then an exact estimate of the height of a tsunami for a given prefecture and the tsunami's time of arrival are estimated. This information enables safer evacuation and appropriate defensive measure to be taken.

Since this information applies to a wider area and is an average, effective planning uses this information in conjunction with data collected from various local shores. For more information on developing an inundation map and it usage, planners should refer to the *Manual for Tsunami Disaster Prediction*.

3) Warning System

The tsunami warning system should be rapid and accurate.

The Japan Meteorological Agency is required by law to forecast tsunamis. Their warnings are specifically divided into "tsunami watches" and "tsunami warnings." The flow of the warning system, from the Agency to the general public, is outlined in Chart 3-2 below.

The Agency headquarters and administered weather stations form the center for tsunami warnings. When an earthquake occurs, a tsunami forecast is issued, through the Fire and Disaster Management Agency, National Police Agency, prefectural governments, the Coast Guard, NTT, and Japan Broadcasting Association (NHK). At present, it takes 3-5 minutes for a warning to be issued.

However, following the Hokkaido Nansei Oki Earthquake in 1993, it is estimated that a tsunami over 10 meters was generated which struck Okujiri Island in 3-5 minutes. Several minutes are required to carry out a civilian evacuation and closing of the tidegates, so in the future, stringent efforts must be made to produce a more rapid and accurate warning system.

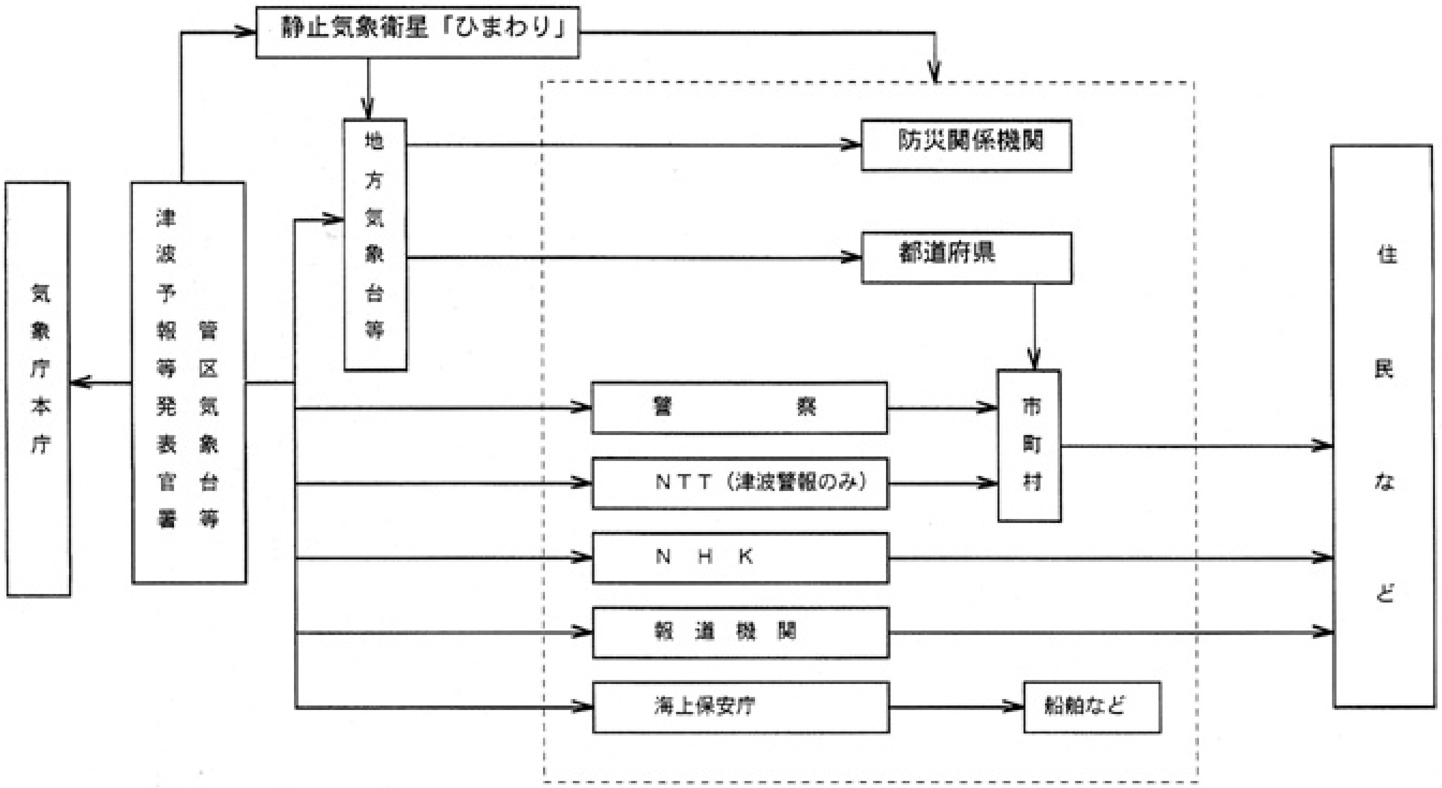
The following are issues that must be addressed:

1) is it possible for the warning to reach all households; are there areas which communication is difficult
2) are there areas where television and radio reception is impossible
3) are there areas which do not have cable broadcasting
4) are residents complacent about the threat of a tsunami; do they tend to ignore tsunami warnings
5) is it possible to warn fishing boats at sea

The above must be confirmed at the local level. Regarding tsunami warning systems, expansions of networks between the issuing source, mobile, and local wireless have bolstered the wireless warning system. Since 1994, the installation of receptors for the emergency information satellite system has made it possible to retrieve tsunami information from the central warning system.

In coastal areas next to urban centers or tourist and recreational areas, the warning system may not reach non-resident patrons, or their awareness of the dangers of tsunamis may be insufficient, possibly resulting in warnings going unheeded. In such areas, efforts to increase awareness and facilities for the distribution of safety information should be considered.

Finally, networks can be improved by installation of wireless communication between integral parts of community life such as city hall, schools, and hospitals.



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4) Building and Improving the Warning System

To reduce fatalities as much as possible, a rapid and accurate warning system is essential. The system for issuing watches and warnings should be strengthened and diversified.

In the past tsunami warnings were mainly transmitted by telephone. They were then increasingly transmitted on-line until 1994, when the emergency information satellite system was established using the stationary weather satellite Himawari, which enables tsunami information to be transmitted and received almost simultaneously as event occur.

In the future emergency communications systems should be strengthened not only through the wired system, but also through appropriate combinations of over technologies such as satellite and mobile communications.

3.3.4 Evacuation

1) Evacuation of Residents
2)

Local authorities should have a system in place for rapid and safe evacuation when an evacuation advisory is issued.

When a disaster occurs, or when a warning is issued which may necessitate an evacuation, the mayor issues an advisory or order to evacuate. In areas with no history of tsunamis, however, and even in areas that have been struck in the past such as Sanriku, public complacency and passage of time since the occurrence of a tsunami can negatively affect residents' willingness or speed to evacuate. To combat this, the promotion of awareness described in section 3.3.6 and practice of tsunami emergency drills in section 3.3.7 are important in building a system for rapid and safe evacuation. Finally, emergency actions undertaken should reflect the nature of the warning.

When a watch has been issued for a tsunami that has a wave height no more than a few centimeters, it is not necessary for residents on land to evacuate, except in the most vulnerable areas. In such a case the warning should be sufficient, but beach and fishing patrons should evacuate. It is also necessary to monitor sea conditions and prepare to close tidegates, etc.

In contrast to the above, when a tsunami warning is issued, on-land defensive measures are required. To develop an evacuation system, simulation methods and models are available (refer to The Ministry of Construction Architectural Research Report, No. 78).

There are cases, however, of an tsunami attack occurring only a few minutes after the earthquake. When a large tremor is felt, or when small tremors occur over an extended period, residents should not wait for a warning to be issued and must know evacuation is required. Such awareness can only be developed through educational programs.

Citizens are advised, "When you feel a strong earthquake, immediately leave the shore and evacuate to a safe area. Vessels should evacuate from the port." This forms the basis of tsunami awareness and should be stressed throughout educational programs.

What to Do in Case of a Tsunami

(General Public)

1. If you feel a strong earthquake (magnitude 4 or higher) or if the earthquake is weak but slow tremors continue for a long time, leave the shore immediately and evacuate to a safe area.
2. If a warning is issued but you did not feel an earthquake, leave the shore immediately and evacuate to a safe area.
3. Listen for accurate information from the radio, television, or soundtrucks.
4. If a tsunami watch has been issued, it is dangerous to continue swimming or fishing.
5. Tsunami waves attack repeatedly. Don't move until the warning is over.

2) Evacuation Routes

The following points are important in designing evacuation routes. (1) Selection of suitable routes (2) Sufficient road width (3) Marking of the evacuation routes (4) Installation of streetlamps (5) Notification to the public

The design of evacuation routes from residential districts must take into account the public's daily life, reduce time required for evacuation and ensure smooth evacuation. The following issues must be addressed.

(1) Is the selected route suitable?
(2) Is the road wide enough?
(3) Are there enough signs indicating the evacuation route?
(4) Have lights been installed for a night-time evacuation?
(5) Is the public sufficiently aware of the routes?

Lighting and clearly marked signs are especially important during a night-time evacuation. Emergency power sources for street lighting are effective during a power outage caused by the earthquake.

During a tsunami, rapid and safe evacuation is most important. The shortest and most direct route to a temporary evacuation site should be the highest priority. When the topography is unsuitable for such a route, agreement to use public property in the event of an emergency and installation of emergency stairways are measures that should be considered.

Finally, regarding the warning to visitors who may be unaware of area, the evacuation route sign system should be well-designed, standardized, and easy to understand. Signs which can be easily understood by non-Japanese speakers are recommended.

3) Evacuation Areas

Suitable areas for evacuation should be developed.

Evacuation areas should be designated as part of the local hazard mitigation plans. A safe area should be selected by its topography and elevation outside the inundation area projection as described in chapter 2. The evacuation site should have a sufficient capacity for the distribution and number of evacuated households, be accessible by the escape routes, and have a guidance system for evacuees. If the site is the gymnasium of an elementary or junior high school, then it should be checked for safety and withstanding earthquakes. There are three categories of evacuation areas: temporary evacuation sites, wider-area evacuation sites, and evacuation sites. Frequently used evacuation sites include elementary and junior highs, community halls, temples or shrines, kindergartens, and parks. During the Great Awaji-Hanshin Earthquake there were many cases of private property being used for evacuation. Depending on the land and local circumstances, residents and private enterprises should have an understanding about the use of high-rise buildings, etc. during an emergency.

In commercial districts where the daytime population is much greater than the nighttime, evacuation sites for non-residents must be established. The same applies for recreational and tourist areas.

In city centers and older housing districts, residents are usually well acquainted with evacuation areas. In comparison, residents in newer developments tend to be less aware. Therefore, local authorities should choose the location on its suitability and mark it clearly.

The area should be illuminated well enough to be seen at night from a distance, and emergency electric sources should be in place in the event of a power outage. Finally, food, blankets, and other supplies should be planned for and stored. Storage facilities should be constructed to house other emergency supplies as well.

(1) Temporary Evacuation Sites

Before escaping to the wider-area evacuation site, a temporary site is used for to collect evacuees and evaluate the circumstances. The site can offer some protection for evacuees and is used for forming up groups for further evacuation. It is a center for volunteer activity and is usually placed at a park, green tract of land, school grounds or apartment house commons.

(2) Wider-Area Evacuation Sites

Wider-area evacuation sites refer to parks or tracts of land that are large enough to protect evacuees from surrounding areas during a large earthquake, fire or tsunami.

(3) Evacuation Sites

Evacuation sites temporarily house and protect evacuees after their homes have been destroyed or threatened by earthquake or fire. Schools and community halls are commonly used.

4) Dealing with Vulnerable People

Measures must be adopted to ensure the safety of children, the elderly, and the sick during evacuation.

Residents at higher-risk such as children, the elderly, and the sick or disabled present different problems than normal adults during evacuation. Along the coasts, schools and kindergartens are frequently built on higher ground. When they have been designated as an evacuation site, the children, while school is in session, are safe. However, some schools are located within inundation areas of past tsunamis, and steps should be taken to relocate them to safer, higher ground. When children are not in school, building a spirit of mutual aid and neighborhood relations is a practical way to promote safety.

Regarding the elderly, though there are intermittent cases of family members evacuating them with a vehicle, building community relations are the best policy in the absence of a specific rule.

Hospitals and clinics are often located in higher, safer areas, but a number of clinics in lower areas remain susceptible to tsunami attack. In spite of this, medical staff and patients have no manual on evacuation procedures, nor have they conducted drills. Such circumstances must be rectified in the future.

5) Dealing with Visitors

Visitors, such as tourists, should be made aware of tsunami hazards and suitable evacuation measures should be developed.

Tourists and other visitors frequent the coasts, especially during the summer. Since these visitors generally have little knowledge or awareness about the dangers of tsunamis, communication systems along the beaches must be readied and awareness of evacuation procedures promoted through educational programs. In some remote areas, there are few residents and the beaches or camping grounds are left unprotected by defensive structures. Patrons should be informed of the dangers of tsunamis and what to do in case of an emergency. A warning system must be able to reach such people as well.

Some beaches and ports have wireless capability and loudspeakers installed to announce a warning to visitors and residents. Such examples should be referred to during the development of evacuation plans. At the same time, bed and breakfast inns and recreational facilities should be informed of evacuation routes and sites.

6) Transportation Issues

It is, in principle, prohibited to evacuate by automobile.

To ensure a safe and smooth evacuation, local hazard programs generally prohibit residents from evacuating by personal automobiles during any type of disaster. During a tsunami emergency, time is limited and fleeing vehicles not only clog the roads, they pose a threat to life. Therefore, evacuation by car is not generally allowed.

In a case of a distant tsunami, however, there may be sufficient time to escape by vehicle and thus is not necessary to prohibit it. Furthermore, even during a local tsunami event, in cases where roads and pedestrian evacuation routes do not intersect, prohibition of vehicle evacuation is not necessary.

3. 3. 5 Opening and Closing of Tidegates

> A system for rapidly closing tidegates during a tsunami threat should be devised.

The closing of tidegates is commonly a part of local tsunami mitigation planning. During a local tsunami, however, time of arrival may be too short before this can be accomplished. It is important to devise a system in which relevant authorities can close the tidegates immediately once a tsunami threat has been established. It is also important to have a plan for opening the gates once the threat has diminished.

3. 3. 6 Promoting Public Awareness

1) Collecting and presenting data from past tsunamis

> **Collection and presentation of data from past tsunamis involves the following activities:**
> **(1) Collecting assessments of damage**
> **(2) Construction and maintenance of public memorials and monuments**
> **(3) Marking inundation areas and high water marks**

(1) Collection of damage assessments

There are a number of activities which can be done. For example, interviews should be conducted with survivors and that information included in the local defense planning. Pamphlets or booklets which detail the damage and include survivors' accounts should be published. Finally, historical archives should be researched for tsunami-related information.

(2) Public memorials and monuments

In areas that have been struck by a tsunami, monuments are effective at promoting local residents and visitors' awareness. Maintenance is important. In the Sanriku region, dilapidated monuments are a problem. Repair, upkeep, and improvements such as adding explanatory panels or making the monument into a small park area can increase public awareness of tsunami hazards.

(3) Demarcation of inundation areas and high water marks

Clear marking of inundation areas and their high water marks are effective ways of promoting awareness and improving participation in the defense against tsunamis. Maps (used in pamphlets and display panels) and marks to indicate water level can be used.

2) Educational Programs

Improving public knowledge is an important part of safety education.

The legacy of past tsunamis forms the basis of public safety education. Personal accounts of experiences with tsunamis is a valuable part of safety education and should be included in social studies at elementary and junior high school. These accounts, combined with the latest scientific research and an understanding of the current state of preparedness are part of an organized and continued effort of safety education. Participation by local government and public organizations, such as community associations, youth and women's groups make the program more active.

3) Developing a Safety Manual

The public should be distributed safety manuals that are easily understood.

In addition to general knowledge about tsunamis, the public should know what to do in the event of an attack. A manual with simple explanations should be distributed among residents. The manual should include maps of evacuation sites and routes, as well as evacuation procedures and other pertinent information.

4) Public Awareness Programs

Sustaining and improving public awareness about tsunami safety can be achieved through public awareness programs.

Public awareness can be promoted through media channels or local venues. Television, radio, newspaper and magazines can reach broad audiences. Many public offices have regular publications that can be used to promote tsunami safety. Neighborhood associations have residential notice bulletins that are passed door to door. Existing memorials or monuments to past tsunami victims, or the construction of new ones, display panels and photographs at the local community hall or safety center are other ways to sustain and increase public awareness.

Public safety depends on cooperation between government and the public. As awareness decreases, safety measures become increasingly difficult to implement. Accordingly, planners should make use of local media sources and public venues, as follows:

(1) Media such as television, radio, newspapers, magazines, public bulletins and notices
(2) Permanent displays, memorials, tsunami museums
(3) Commemorative activities, symposia, guest speakers and lectures

3.3.7 Safety Drills

In order to reduce the amount of damage, the points in the text below should be kept in mind. Safety drills should include the following: (1) Tsunami monitoring drills (2) Transmission and relay of information drills (3) Drills to inform the public (4) Drills to inform unknown persons

Safety is achieved only by cooperation between the public and government. Tsunamis, however, occur so infrequently – once in several years or even decades – that safety precautions can be inhibited during the actual emergency. Regularly-staged public drills not only sustain and improve readiness, but reveal flaws or weaknesses in the current system. More accurate and rapid dissemination of information, appropriate evacuation measures, emergency response and mobilization are all areas that drills will be tested, as below:

(1) Monitoring of tsunamis
- Gain experience of tsunami monitoring
- Become accustomed to relaying monitoring orders and results

(2) Information-gathering
- Gain experience of starting up and switching to emergency utilities
- Becoming accustomed to tsunami forecast transmissions
- Gain experience of gathering information related to damage and the tsunami attack

(3) Communications system and informing the public
- Sound warning sirens
- Understand public information bulletins
- Confrim channels and time for the dissemination of public information
- Obtain information from public announcement vehicles or portable radio
- Measure reception area for wireless communication
- Drills with emergency broadcast systems
- Confirm contents and time for the dissemination of public information
- Relay to remote areas and children out of school

3.3.8 System of Response

1) Response Efforts

In the event of a tsunami attack, the response system must provide food, water, and medical supplies.

In the wake of a tsunami, the local emergency headquarters must be ready to respond in the following areas:

(1) Gathering and dissemination of disaster information
(2) Securing of roads and transportation network
(3) Distribution of food, water, and medical supplies
(4) Emergency medical treatment
(5) Rescue and relief operations
(6) Assess hygiene of affected area and prevent spread of disease
(7) Extinguish chemical or other fires
(8) Emergency rescue of stranded victims by plane or sea

The above response efforts are coordinated between the national, regional and local governments through the close cooperation between police, coast guard, medical personnel, and civil engineers. By performing joint drills, the safety response should operate smoothly.

2) Cooperation from the general public

Cooperation from the general public plays an important role in tsunami preparedness.

In the affected areas, rescue and response are required as follows:

(1) Drain water within the levees after the tsunami warning is removed
(2) Extinguish fires
(3) Aid and rescue of the injured and stranded
(4) Search for the missing
(5) Inform relief headquarters of the situation on the ground
(6) Alleviating public distress by dissemination of accurate information
(7) Nightwatches, fire protection, public safety and mutual aid
(8) Provide of drinking water, food and medical supplies
(9) Assessment of damage
(10) Protection of housing

As seen above, the rescue and relief efforts encompass a broad range of responsibilities. Assistance from neighboring, unaffected areas is extremely effective. Such a system can only be built through everyday activity and effort over an extended period of time.

3) Maintenance of Defensive Structures

Coastal defensive structures must be maintained by the appropriate authorities during normal times and emergency situations. In situations where defensive structures are managed by a number of entities, their mutual aid and cooperation ensures a standard response to tsunami hazards.

Coastal defensive structures are intended to protect life and property from the damaging effects of a tsunami. Accordingly, they cannot be allowed to become dilapidated. They must be inspected regularly and any deficiency must be reinforced or repaired.

Various entities may be responsible for their maintenance. When a standard response to a tsunami is required along a coast, authorities must work together to restore rapidly and completely the defensive capability. This is achieved by consolidating information gathering points and networking between the organizations.