# Chapter 5　Reconstruction of Homes and Cities

## Section 6　Coasts (seawalls, etc.) and rivers

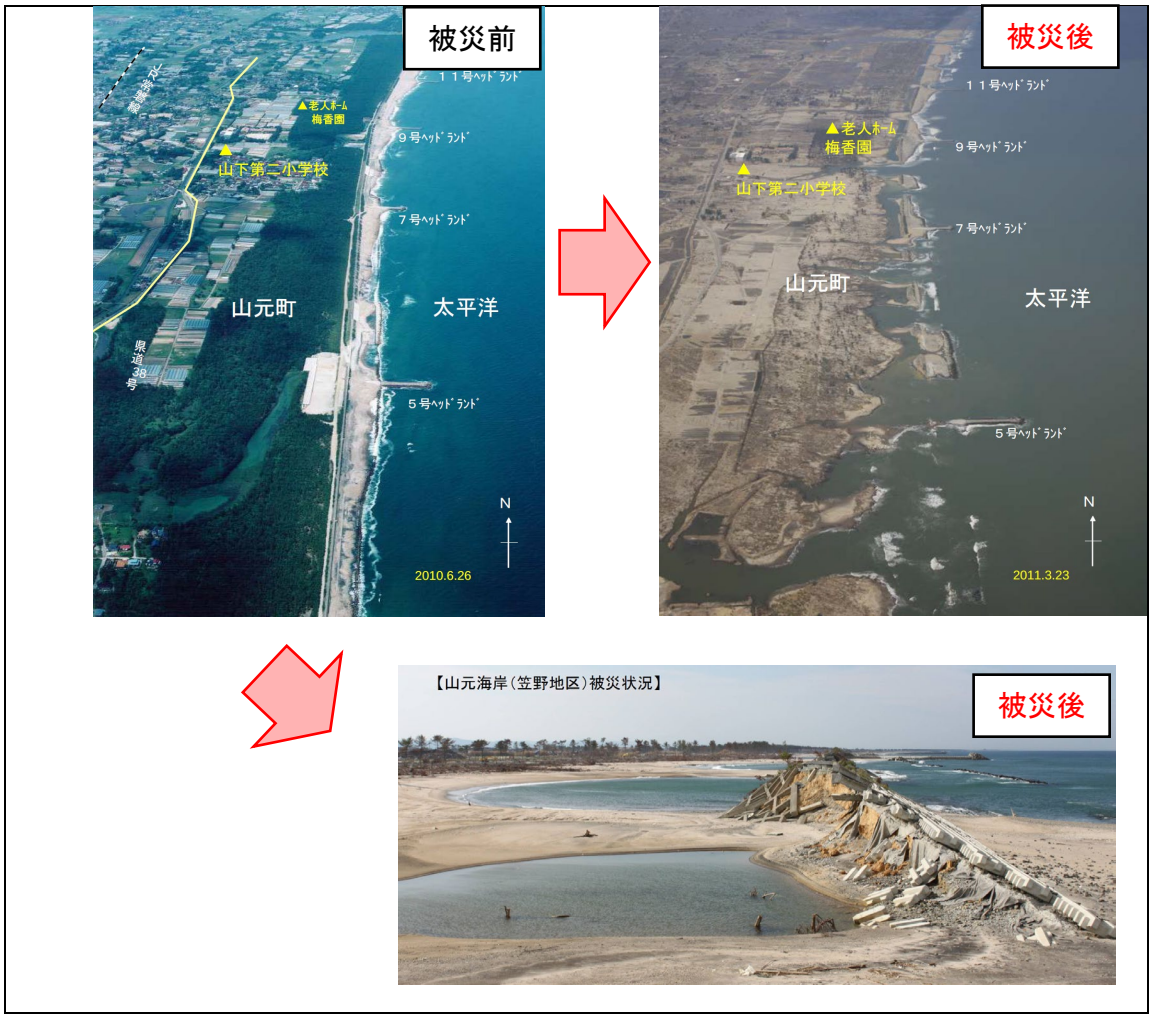
### 1. Overview of damage

#### (1)　Overview of damage on the coast

The tsunami generated by the earthquake washed away almost all coastal levees in the Tohoku region, and large inundation damage occurred in coastal areas. In the prefectures of Iwate, Miyagi, and Fukushima, which were hit particularly hard, 426 districts (about 190 km) out of 515 coastal districts (about 300 km of coastal levees and seawalls) were damaged; and the prefectures of Aomori, Ibaraki and Chiba, 43 districts out of 468 coastal districts were damaged.

On the Southern Sendai Coast (a 50 km section spanning from Sendai City in Miyagi Prefecture to the prefecture's border with Fukushima Prefecture), almost all coastal levees collapsed and were washed away, which left them beyond all recognition. In Rikuzentakata City, Iwate Prefecture, coastal levees collapsed, and flooding occurred over an area of approximately 13km$^2$, with approximately 90% of the urban area (approximately 2.9km$^2$) becoming flooded.

Figure 5-6-1　Damage situation on the Southern Sendai Coast




Source: Sendai River Office, Tohoku Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "Explanatory Materials Concerning the Restoration of Coastal Levees Along the Southern Sendai Coast"

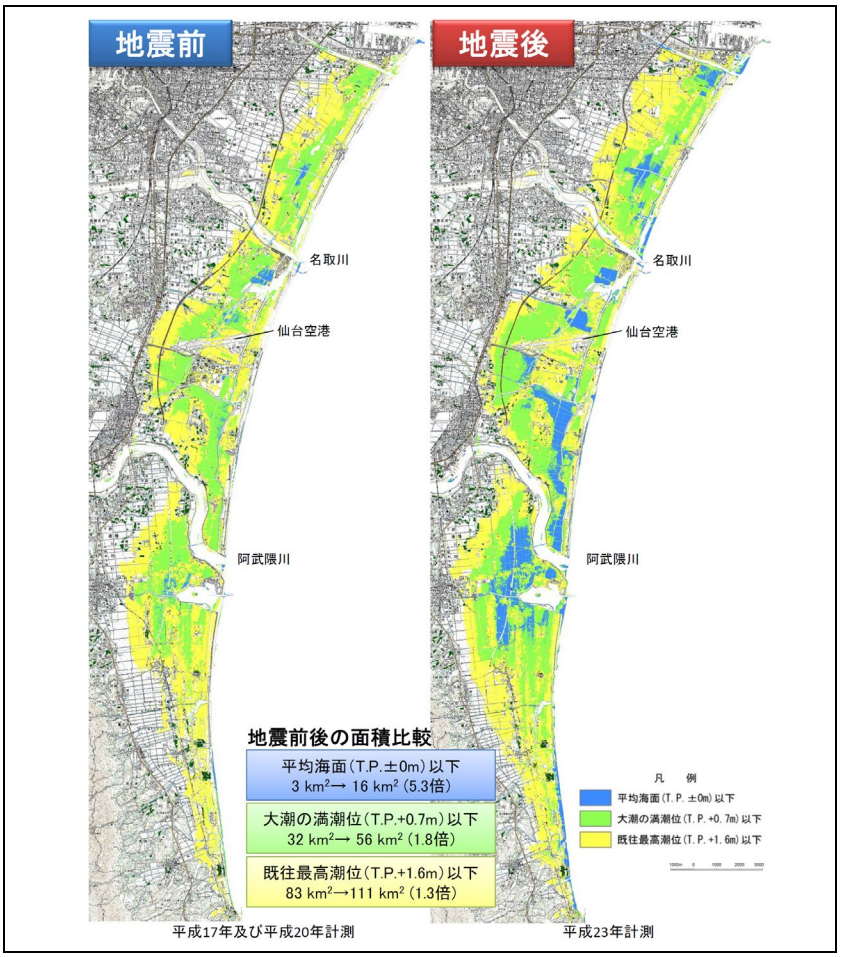
Figure 5-6-2 Damage situation on the Takada Coast in Iwate Prefecture


Source: Ministry of Land, Infrastructure, Transport and Tourism, "Trends in Coastal Administration"

Furthermore, the change in the Earth's crust associated with the massive earthquake caused land subsidence over a wide area, including the flatlands and coastal areas of the Sendai Plain. In the Sendai Plain, the area at or under the mean sea level became 5.3 times larger (post-earthquake area: 16 $km^2$), the area at or under the high tide level of the spring tide became 1.8 times larger (post-earthquake area: 56 $km^2$), and the area at or under the highest high-water level became 1.3 times larger (post-earthquake area: 111 $km^2$) in comparison to pre-earthquake levels.

This land subsidence, together with the destruction of coastal levees and erosion of sand dunes along the coast, which was caused by the tsunami, resulted in a significant deterioration of safety against spring tides, etc., and increased the risk of flooding and inundation in low-lying areas during heavy rain.

Figure 5-6-3 State of land subsidence on the Sendai Plain due to the Great East Japan Earthquake




Source: Ministry of Land, Infrastructure, Transport and Tourism, "Land Subsidence Caused by the Earthquake in the Sendai Plain" (April 28, 2011)

## (2) Overview of damage at rivers

In the rivers under the direct control of the national government, such as the Kitakami River and the Tone River, damage such as slippage and subsidence of levees occurred at 2,115 locations of 8 river systems due to the earthquake. There were 1,360 reports of damage to rivers managed by prefectural and municipal governments.

In addition, near the estuaries of the Kitakami River, Natori River, Abukuma River, etc., levees were overtopped by tsunami run-up and washed away houses.

As described above, river water and sea water flowed back into the inland areas due to damage to levees and blockage of drainage channels by debris, as well as the ground subsidence and damage inflicted upon drainage pump stations; and thus, the flooding continued over a wide area for a long period of time. As of March 13, two days after the earthquake, the inundated area was approximately 170 $km^2$ and the inundation volume was estimated to be 112 million $m^3$.

Figure 5-6-4 Examples of damaged river levees


Source: Ministry of Land, Infrastructure, Transport and Tourism Tohoku Regional Development Bureau, "Records of the Great East Japan Earthquake, the Securing of Lifesaving and Rescue Routes, and Restoration: Never Forget"

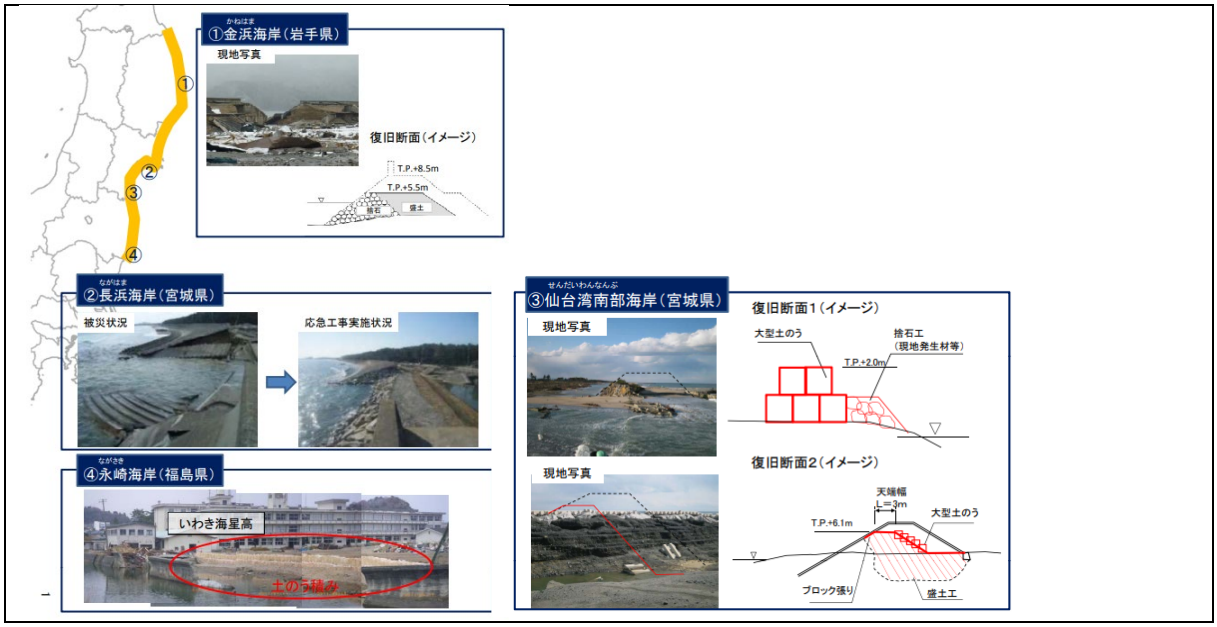
## 2. Emergency recovery

### (1) Emergency recovery on the coast

In emergency recovery on the coast, the national government, prefectures, municipalities, and related organizations coordinated and gave priority to the areas that were indispensable for the restoration and reconstruction of the region. Specifically, that includes villages where habitable dwellings remain, sections where public facilities and lifeline utilities that are essential for the restoration of daily life and reconstruction are located in inundated areas, and sections where, if closing construction were to not be carried out, seawater drainage would become an obstacle, hindering search operations, the disposal of rubble, the receiving of relief goods, and so on. In order to prevent these places from becoming flooded even at spring tide and high tide, closing measures were taken before the rainy season had begun by piling up sandbags and the creating embankments in coastal areas up to the high tide level.

In addition, reinforcement of the above countermeasures using locally generated materials, etc., was completed by the typhoon season, preventing secondary damage caused by storm surges and other such occurrences on about 50 km of the coast affected by the disaster.

Figure 5-6-5 Basic approach to disaster recovery of coastal levees experiencing destructive levels of damage (draft)




Source: Ministry of Land, Infrastructure, Transport and Tourism, "Reference Material 1: Second Meeting of the Coastal Tsunami Countermeasures Review Committee" (June 27, 2011)

### (2) Emergency recovery at rivers

#### 1) Emergency drainage measures

As mentioned above, as of March 13, the inundation caused by the tsunami covered approximately 170 km$^2$ with the estimated volume of inundation being 112 million m$^3$. The flooding was hindering the restoration activities for important infrastructure such as airports and roads, and activities conducted for the searching of missing persons. Therefore, the Ministry of Land, Infrastructure, Transport and Tourism set up a project team at the Ministry and the Tohoku Regional Development Bureau and gathered about 120 drainage pump vehicles owned by organizations such as the regional development bureaus found nationwide while also gathering disaster countermeasure vehicles such as lighting vehicles to carry out drainage work. In addition, the Ministry of Land, Infrastructure, Transport and Tourism dispatched liaison officers (local information liaison officers for disaster countermeasures) to various areas to support municipalities and established a system to directly receive requests for drainage, etc. In fact, there were requests for drainage from 67 locations in 16 municipalities in the three prefectures affected by the Tohoku earthquake, and prompt drainage work was performed by immediately dispatching drainage pump vehicles to each

municipality in accordance with the requests.

After that, in preparation for the full-scale flood season, drainage pump vehicles were continuously deployed in the coastal areas of Miyagi Prefecture as a countermeasure against inundation due to heavy rain and against flooding occurring due to spring tides, with operation taking place over a wide area and in a flexible manner.

Figure 5-6-6 Examples of the dispatch of drainage pump vehicles


Source: Ministry of Land, Infrastructure, Transport and Tourism Tohoku Regional Development Bureau, "Records of the Great East Japan Earthquake, the Securing of Lifesaving and Rescue Routes, and Restoration: Never Forget"

### 2) Preventing secondary damage resulting from storm surges, floods, etc., and emergency restoration of river levees

Immediately after the disaster, the national, prefectural, and municipal river administrators engaged in emergency recovery work such as sandbag piling to prevent secondary disasters, while carrying out emergency restoration work such as levee and block construction at 29 river levees that were particularly damaged.

For example, at the Kyukitakami River estuary, in order to reduce land subsidence caused by earthquakes and flooding at high tide which results from seawall damage, emergency measures were implemented using large sandbags, while raising existing facilities, building L-shaped retaining walls, and setting up temporary drainage basins to install drainage pumps.

At the estuary of the Kitakami River, 1,100 meters of the river levee, which was also used as a road, experienced outflow, which isolated the village from the outside and prohibited rescue activities. For this reason, the first priority was given to secure the road wide enough to allow one car to pass, and on March 14, two days after the start of the restoration work, temporary single-lane traffic was made possible. This enabled the operation of emergency vehicles and the transportation of emergency supplies, leading to support for disaster victims.

### 3) Countermeasures against elements such as liquefaction and cracks resulting from earthquake shaking

River levees located at inland areas saw cracks occurring due to the strong shaking of the earthquake and damage arose as a result of subsidence caused by liquefaction, etc. Therefore, in order to prevent the expansion of damage to levees, actions such as repairing of cracks (filling of cracks) and protection of levees with tarps (curing) were carried out immediately after the earthquake occurred.

After that, amidst a situation involving the concentration of restoration and reconstruction projects, the ground which caused the liquefaction was mended while planning stable securing of items such as sand and embankment materials through the sharing of information and cooperation with related organizations. At places such as the Eai River (Miyagi Prefecture), where the scale of damage was particularly significant, emergency embankments and large connecting blocks were constructed before the flood season. As a result of these efforts, emergency restoration

was completed downstream of the Eai Bridge in Osaki City in 17 days, which meant that the ability to travel there had been secured.

Figure 5-6-7 Example of emergency restoration work for river levees (Eai River in Osaki City, Miyagi Prefecture)


Source: Ministry of Land, Infrastructure, Transport and Tourism Tohoku Regional Development Bureau, "Records of the Great East Japan Earthquake, the Securing of Lifesaving and Rescue Routes, and Restoration: Never Forget"

## 3. Restoring and reconstructing

### (1) Development policy based on the Great East Japan Earthquake (coasts)

#### 1) Formulating a configuration method of design inundation depths

During the Great East Japan Earthquake, many coastal protection facilities and other such facilities were damaged by the tsunami, which was much larger than the height of tsunamis for which the designs accounted for at that time, resulting in severe damaged in the hinterland. For this reason, in September of 2011, the Central Disaster Management Council of the Cabinet Office presented a new concept of disaster mitigation for the largest class of tsunami (L2 tsunami), wherein damage would be minimized through multiple defenses combining both the development of structural and non-structural measures. Meanwhile, for tsunamis that occur with a relatively high frequency (L1 tsunami), it was decided to continue building items such as coastal levees based on viewpoints of protecting residents' property and stabilizing regional economic activities.

In coastal areas of Sanriku, tsunamis have occurred at intervals of approximately every 30 to 40 years, with examples being the Meiji Sanriku Tsunami in 1896, the Showa Sanriku Tsunami in 1933, and the Chile Earthquake Tsunami in 1960. Based on the above mindset, it was decided that coastal levees along the Sanriku coastal area should be designed not for the largest class of tsunami similar to that which occurred during the Great East Japan Earthquake (L2 tsunami), but for seismic tsunamis that occur once every 30 to 40 years (L1 tsunami).

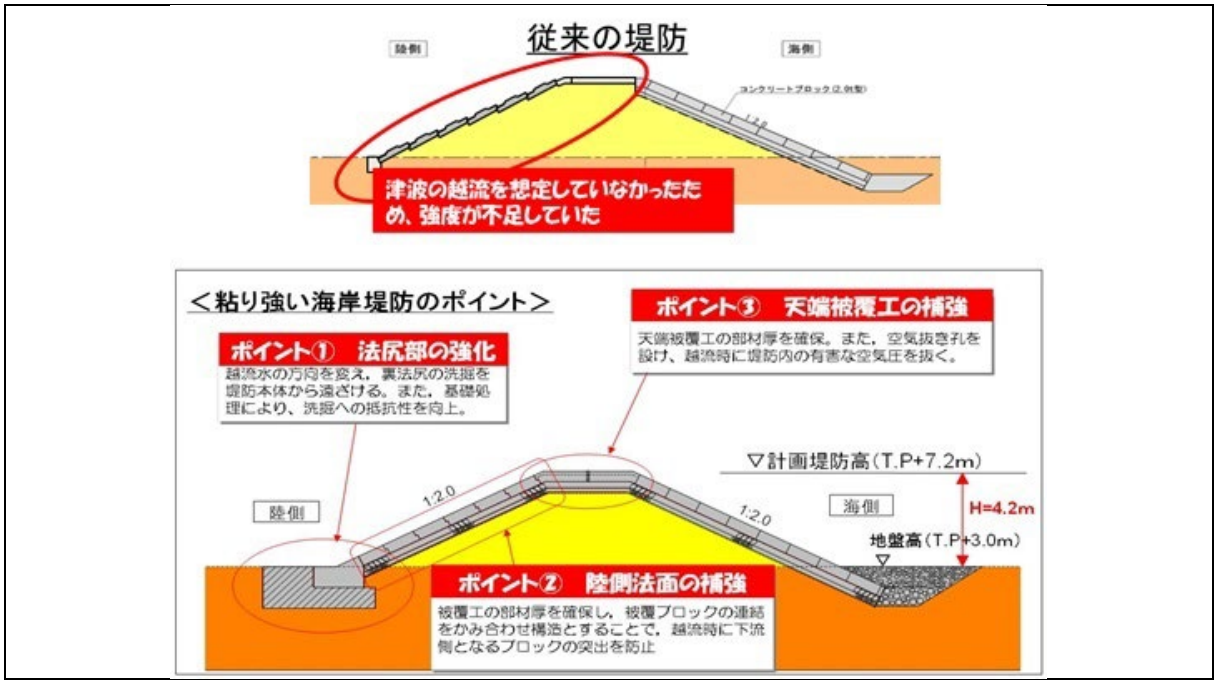
The heights of coastal levees in Japan are determined by taking into account the heights required in relation to the tsunami (design inundation depths) and heights required in relation to storm surges (design tide level + required height in relation to the design wave); and approximately 77% of coastal levees nationwide have been set up based on storm surges.

#### 2) Introducing structures that enable facilities to persistently demonstrate effectiveness

During the Great East Japan Earthquake, many facilities were damaged by the tsunami that overflowed at coastal levees and elsewhere, also causing serious damage to the hinterland. For this reason, in November of 2011, the ministries and agencies concerned with the coast (Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of Agriculture, Forestry and Fisheries), presented their basic mindset in terms of "tough structures" for facilities such as coastal levees, which was based on the recommendations of the Coastal Tsunami Countermeasures Review Committee. As a result of this, it was decided that structural measures would be taken to lengthen the time it takes, even if only slightly, for the destruction or collapse of the facilities to occur or reduce the possibility of them being completely destroyed, even if only slightly, in cases where the tsunami height ends up becoming higher than that of the design target and where water flows over the crowns of coastal levees as a result.

Specifically, the following three points were set: ① reinforcement of the toe of the slope to keep any scouring on the toe of the slope of the backside away from the main body of the levee or to prevent scouring from taking place, ② reinforcement of the landward slope to prevent the covering block on the downstream side from protruding during overflow, and ③ ensuring that there is a certain level of thickness in terms of the crown covering and that reinforcement of the crown coating to ensure that harmful air pressure found in the levee is released when overflow occurs.

Figure 5-6-8 Example of a coastal levee with a tough structure




Source: Ministry of Land, Infrastructure, Transport and Tourism, "4. Can Tsunamis be Prevented?"

### 3) Considering landscapes

It was important to consider the impact on the local landscape when urgently carrying out the restoration work for items such as coastal structures that were severely damaged by the Great East Japan Earthquake. For this reason, in November 2011, based on the discussions taking place at the "Landscape Study Group on the Restoration of Rivers and Coastal Structures," the Ministry of Land, Infrastructure, Transport and Tourism compiled information on concrete landscape-friendly methods for the restoration of rivers and coastal structures and formulated the "Guide for Landscape Consideration in the Restoration of Rivers and Coastal Structures."

This guide specifies elements such as "regionality," "ecosystems," and "sustainability" as items to be considered when considering landscapes and calls for action such as the devising of methods for slope treatment of levees and the active utilization of coastal forests and trees.

Based on this, for the coastal facility restoration project of the Southern Sendai Coast, the landscape consideration policy was established in consideration of "ecosystems," "visual landscapes," and "relationship with the region," developing a "green seawall" to serve as a model project. This has the embankment and vegetation being arranged so as to be integrated with the structure of the levee while at the same time having it function as a tough coastal levee.

Figure 5-6-9 Construction of a "green seawall" on the Southern Sendai Coast to serve as a model

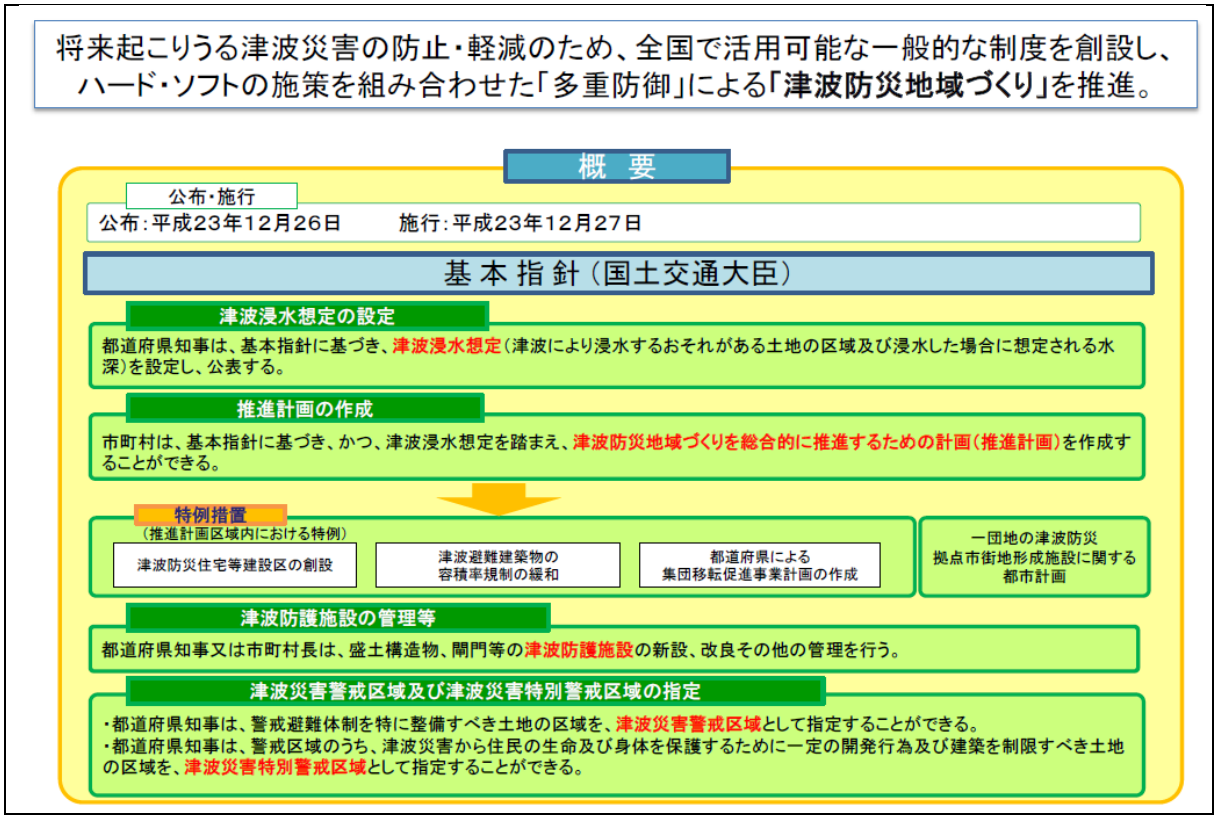

Source: National Association of Sea Coast, "2019 Practical Materials on Trends in Coastal Administration"

### 4) Enacting the Act on Development of Areas Resilient to Tsunami Disasters

After the Great East Japan Earthquake, based on various discussions taking place at the Central Disaster Management Council, the Great East Japan Earthquake Reconstruction Design Council, and so on, the Planning Subcommittee for the Council for the Improvement of Social Capital and the Traffic Policy Council made an urgent proposal on July 6, 2011, concerning “Approaches to Town Planning Which Incorporates Disaster Prevention in Relation to Tsunamis.” Based on the recognition that "there is no limit on disasters," these emergency recommendations stated that "human life comes first," even in the event of a tsunami of the largest class, and that "multiple defenses" using all structural and non-structural measures should be the basis of tsunami-related disaster prevention and mitigation measures.

In December 2011, the Act on Regional Development for Tsunami Disaster Prevention (Act No. 123 of 2011) was enacted to promote regional development that incorporates resilience in relation to tsunami disasters through "multiple defenses" by combining structural and non-structural measures based on the perspective of “disaster mitigation” and on the premise of “escaping” from the largest class of tsunamis.

Figure 5-6-10 Overview of the Act on Regional Development for Tsunami Disaster Prevention




Source: National Association of Sea Coast, "2019 Practical Materials on Trends in Coastal Administration"

### 5) Remote control and automation of floodgates and land locks

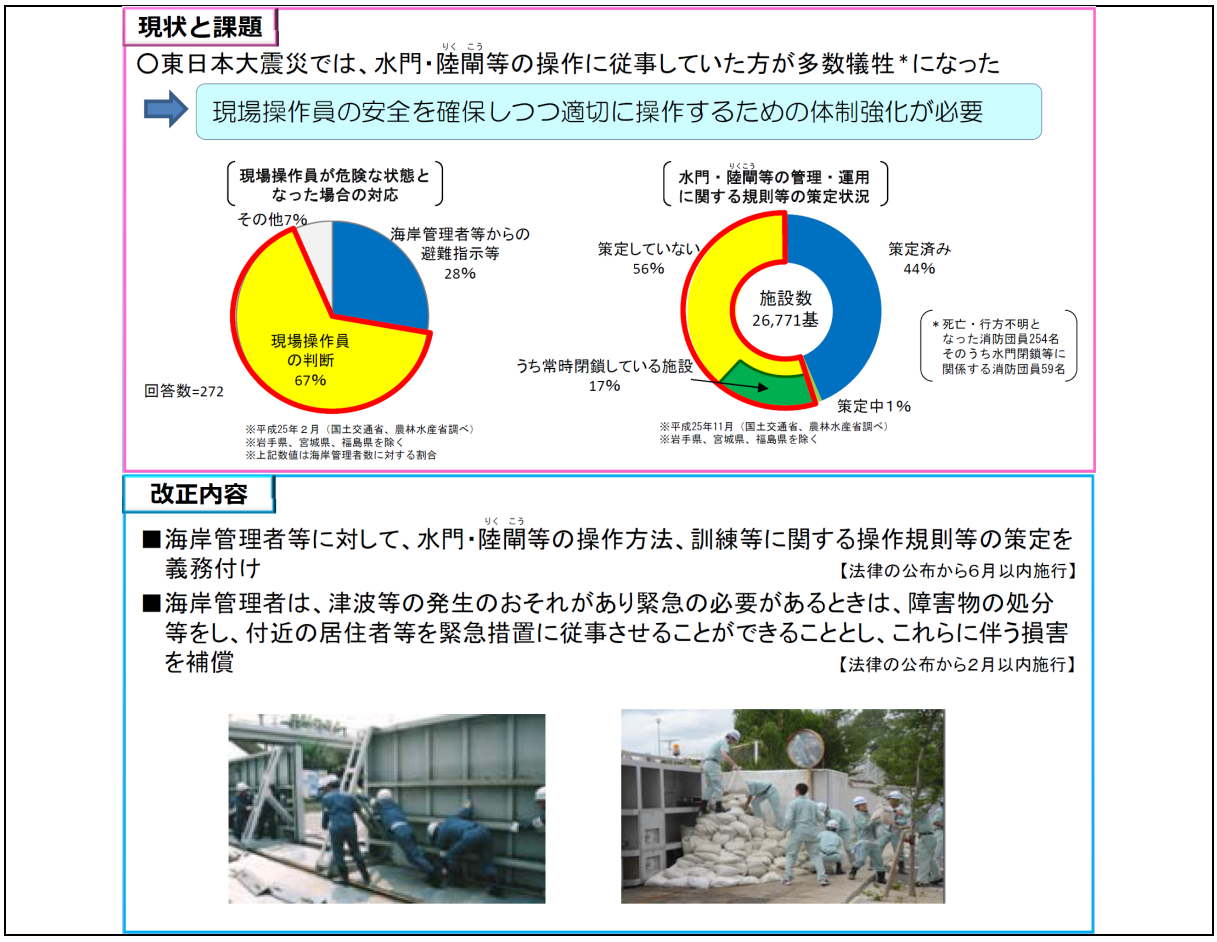
During the Great East Japan Earthquake, many people lost their lives after being swallowed by the tsunami while operating floodgates, etc. In light of this situation, in March 2012, the ministries and agencies concerned with the coast provided notifications to coast managers instructing them to establish management systems which ensure that the operation of floodgates, etc. undertaken in the event of a tsunami or storm surge, can take place in a manner which involves placing the top priority on ensuring the safety of those engaged in the operation of floodgates, etc. Furthermore, in order to implement the content of the notifications, the ministries and agencies concerned with the coast collected and organized various kinds of data and established the "Committee for Reviewing the Effective Management and Operation of Floodgates and Land Locks, etc." in January 2013; and the committee examined the revision of the "Guidelines for Management Systems of Floodgates and Locks in Tsunami and Storm Surge Measures" over the course of three meetings.

In June 2014, the Sea Coast Act (Act No. 101 of 1956) was amended to require that coast managers establish operating rules for facilities (operating regulations for managers other than coast managers) to ensure the safety of operators. Based on this, the ministries and agencies concerned with the coast established the "Committee for Reviewing the Safe and Appropriate Management and Operation of Floodgates, Land Locks, etc." in August 2014, and discussions were held in relation to the clarification of evacuation rules giving top priority to the safety of field operators and how management should be entrusted, with a review taking place which aimed at the revision of the guidelines in question. In addition, in December 2015, the "Review Committee on the Promotion of Safe and Appropriate Management and Operation of Floodgates, Land Locks and Other Such Items" was established to study measures for ensuring that the thorough implementation of operation and evacuation rules, etc. takes place by on-site operators, as well to consider templates for outsourcing contracts, etc., with the results of these study efforts being reflected on the content of the guidelines in question.

As a result, the guidelines in question state that automation and remote controls are necessary to quickly close floodgates, land locks, etc., in areas of high urgency where the estimated tsunami arrival time would only be a few minutes after the occurrence of an earthquake, and currently, from the viewpoint of ensuring the safety of operators,

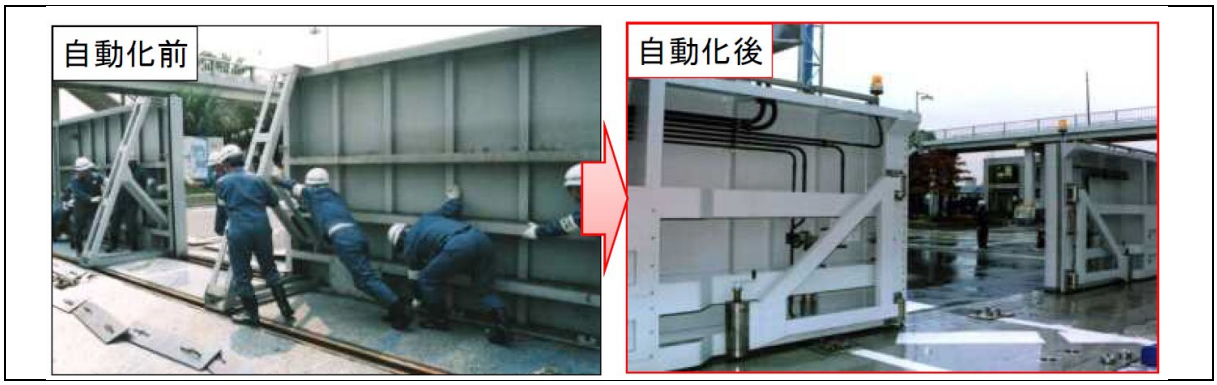
elements such as the consolidation and reorganization of facilities, having facilities closed all the time, and automation and remote controls, are all promoted as measures which are necessary.

Figure 5-6-11 Overview of the revision of the Coast Act



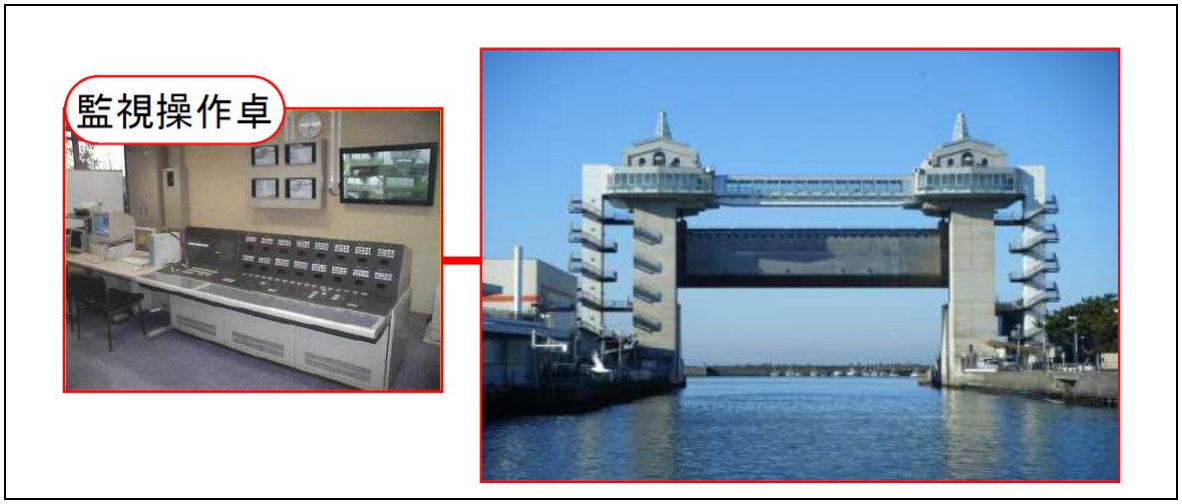

Source: Ministry of Agriculture, Forestry and Fisheries and the Ministry of Land, Infrastructure, Transport and Tourism, "'The Act for the Partial Revision of the Sea Coast Act' was Enacted at the 186th Ordinary Session of the Diet and Promulgated on June 11, 2014 (First Revision in 15 Years Since 1999)" (June 2014)

Figure 5-6-12 Conceptualization of land lock automation




Source: Ministry of Land, Infrastructure, Transport and Tourism, "Material 2: First Meeting of the Review Committee on the Promotion of Safe and Appropriate Management and Operation of Floodgates, Land Locks and Other Such Items" (December 2015)

Figure 5-6-13 Conceptualization of floodgate automation and remote control




Source: Ministry of Land, Infrastructure, Transport and Tourism, "Material 2: First Meeting of the Review Committee on the Promotion of Safe and Appropriate Management and Operation of Floodgates, Land Locks and Other Such Items" (December 2015)

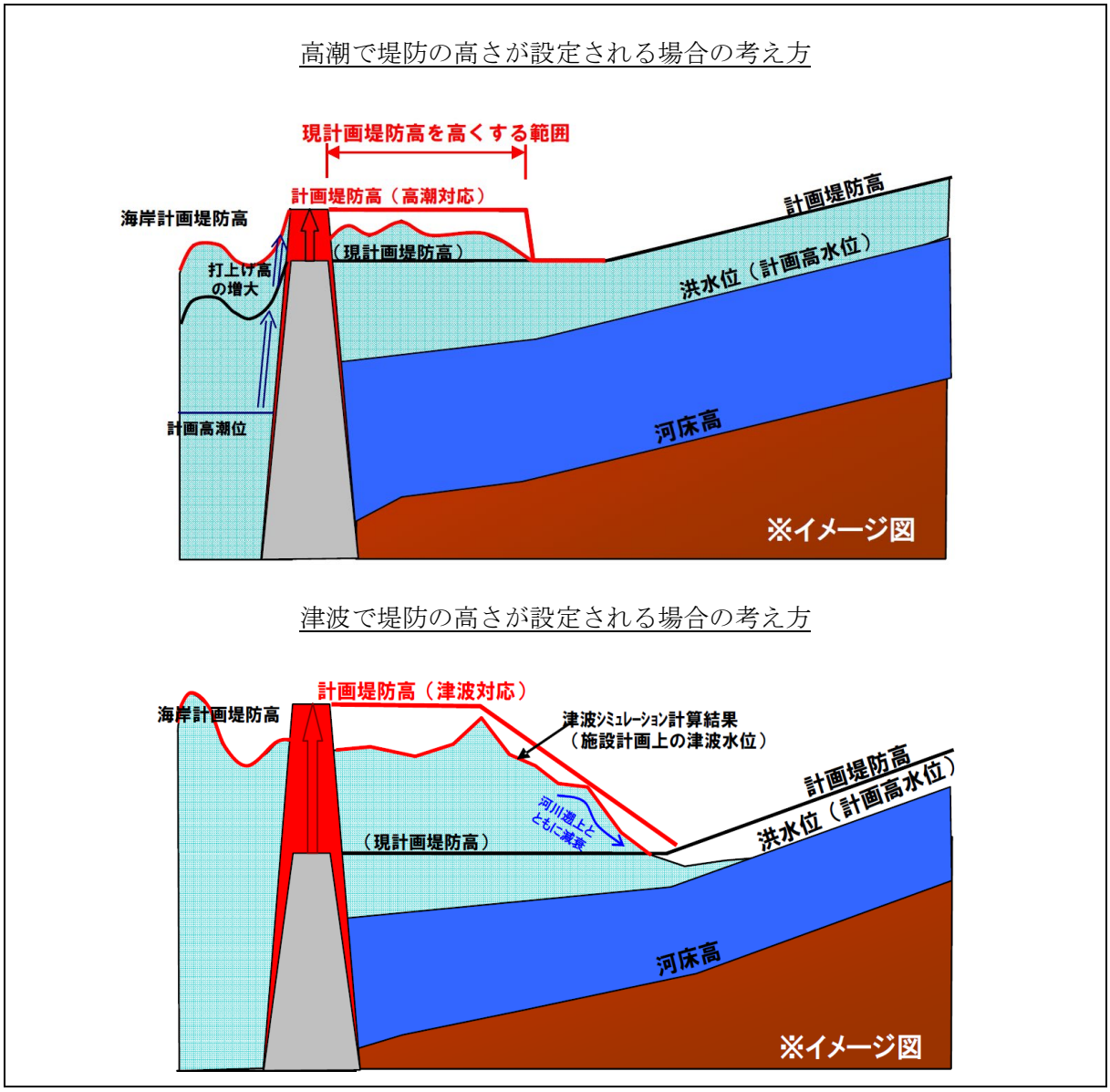
## (2) Development policy based on the Great East Japan Earthquake (rivers)

### 1) Setting river levee heights at estuaries

In preparation for the full-scale restoration of levees at estuaries, river administrators set levee heights so that they address the three external forces of floods, storm surges, and tsunamis (L1 tsunami) in order to match the heights of levees with new coastal levees to be constructed based on the previously described approach. At this time, river levees, etc. were improved so that they would be effective in combination with coastal levees in order to conform with the reconstruction plans of coastal municipalities.

In relation to the largest class of tsunami (L2 tsunami), it was decided to reduce damage by combining the development of structural elements with non-structural measures while at the same time implementing comprehensive damage reduction measures that are integrated with town planning that incorporates tsunami-related disaster prevention.

Figure 5-6-14 Setting river levee heights at estuaries




Source: Tohoku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "About the Setting of River Levee Heights (Draft)" (December 2011)



### 2) Introducing structures that enable facilities to persistently demonstrate effectiveness

In the same manner as the coastal levees mentioned earlier, at levees located near coastal levees found at the estuaries of rivers, "tough structures" were adopted which involves the covering of levees with concrete blocks, to allow for the extension of the time required, even if only slightly, for levees to break even in the event a huge tsunami exceeding design values were to arrive.

By adopting this structure, the time it would take for levees to break and collapse shall be lengthened, even if slightly, and the risk of levees being completely destroyed (and rendered to a state of complete outflow) shall be reduced.

The specific structure was determined based on the results of model experiments conducted by the National Institute for Land and Infrastructure Management (Ministry of Land, Infrastructure, Transport and Tourism), by confirming the following effects:

① Effects in terms of the prolonging of the lead time for evacuation by delaying the time taken until inundation
② Effects in terms of reducing inundation damage by reducing the inundation area and depth as a result of reducing the amount of inundation Effects in terms of reducing damage inflicted from the second wave onward
③ Effects in terms of the reduction of the risk of secondary disasters as rapid restoration becomes possible in cases where a facility is not completely destroyed but remains partially Effects in terms of the reduction of restoration costs

### 3) Remote control and automation of floodgates and land locks

In order to ensure that the functions of floodgates, etc. can be fully utilized at river levee sections where tsunami run-up is assumed to occur, it was decided that measures such as automation and remote controls are to be implemented in the same manner as coastal levees, etc., after making them earthquake-resistant.

### 4) Creating lively places in a manner which leverages waterfronts as symbols of reconstruction

When it comes to the town planning undertaken for the reconstruction taking place in the wake of the earthquake disaster, it was decided to form a lively waterside environment by coordinating efforts together with projects involving levees and undertake the preparation of things such as waterside revetments to increase the area's attractiveness as a waterside space and the preparation of passages to improve access to the waterside, and by creating a unified space where commercial facilities, exchange facilities, and other facilities are connected to river levees.

For example, in the Yuriage District River Town Development in Natori City, Miyagi Prefecture, which is located at the estuary of the Natori River and has long grown as a fishing port town in the suburbs of the Sendai metropolitan area, the waterfront space was set up so that it can be integrated with facilities such as commercial and exchange facilities that are connected to the waterfront space, in cooperation with the land readjustment project taking place behind the Natori River levee.

In the Ishinomaki District River Town Development taking place in Ishinomaki City, Miyagi Prefecture, based on the historical background which exists to the effect that the district has been developed as unified area consisting of a river, the sea, and a town since ancient times, the formation of a lively waterfront environment was planned by developing masonry-based revetments and waterfront terraces to improve the attractiveness of the waterfront spaces, by developing stairs and slopes to improve waterfront access, and by creating spaces in which facilities such as commercial and exchange facilities connected with waterfront spaces are integrated.

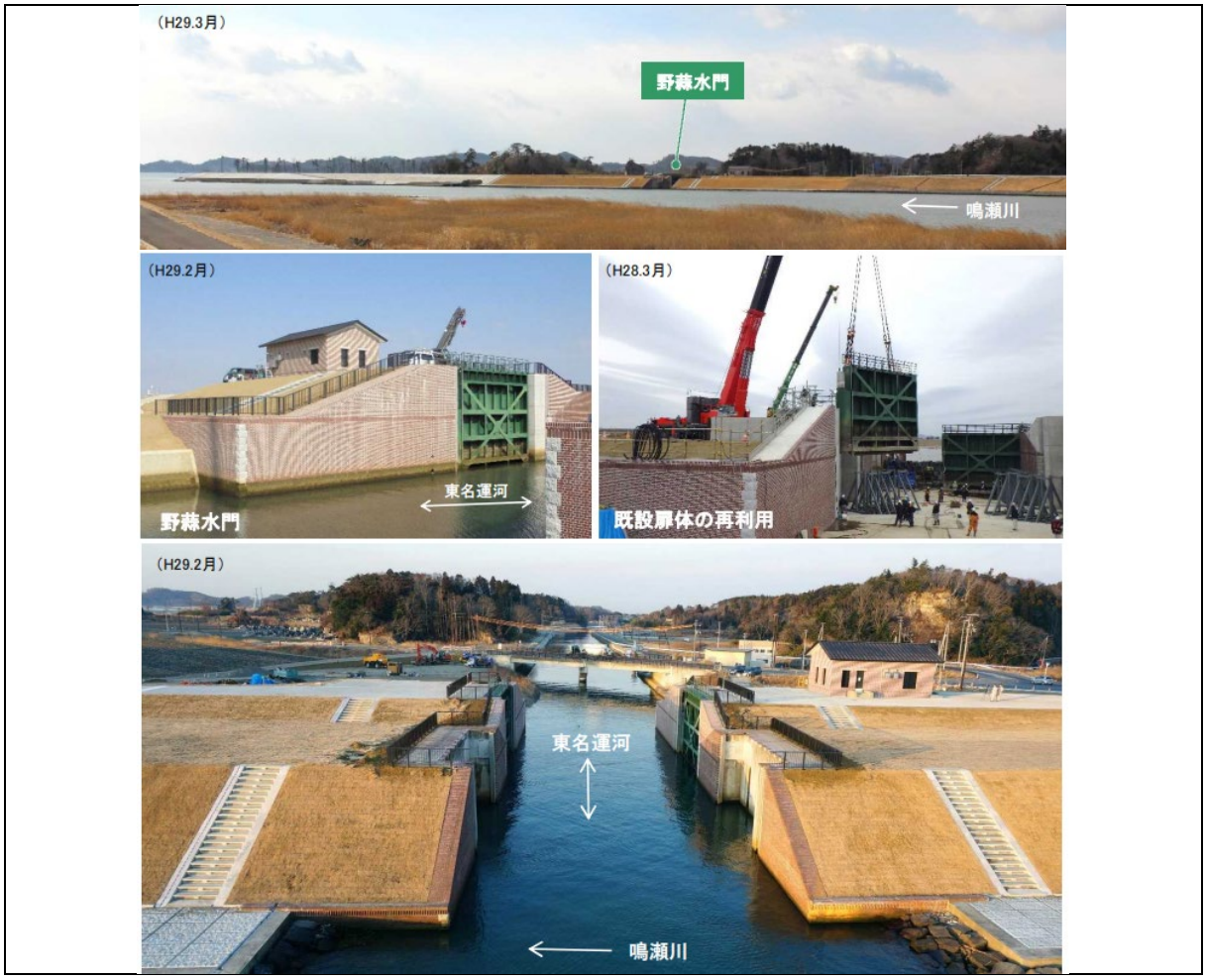
### 5) Considering landscapes

Review meetings were held in each region to discuss elements such as the basic policy in terms of landscapes, the design of levees and revetments, and the direction of the development of base districts. In conjunction with that, public comments, workshops, and other such actions were also carried out as appropriate.

In the central district of Ishinomaki City, in cooperation with the "Project for a Green Promenade at the Waterfront" and the "Kawamachi Exchange Center Project," efforts were made to create waterfront spaces that both create bustle and relaxation while giving consideration to the landscape by incorporating elements such as gradual slopes, stonework that is easy to sit on, and waterfront lighting.

The estuary of the Naruse River is located within the protected area of Matsushima, which is a Special Place of Scenic Beauty, and the architectural remains of the Nobiru Port Construction Project constructed during the Meiji era are also found there, meaning that there is special consideration required when it comes to the landscape. For this reason, a soil-covered revetment shape was adopted in consideration of harmony with the mountain range behind the river in the upstream section starting from around 0.4 km from the river mouth. In addition, mechanisms were devised so that the scenery would not be disturbed, such as by having the Nobiru Floodgate reuse the existing facilities and having the new floodgate to be constructed behind it be brick-lined.

Figure 5-6-15 Development at the Naruse River estuary




Source: KITAKAMIGAWA-KARYU RIVER OFFICE, Tohoku Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "Efforts Taking Place During the Nine Years After the Great East Japan Earthquake" (March 2020)

## (3) Coastal projects

### 1) Project overview

#### a. Efforts for acceleration

The Southern Sendai Coast, which is located in the southern part of Miyagi Prefecture, was hit by a massive tsunami with a height of more than 10 meters in some places, and a series of coastal levees located along the coast were completely or partially destroyed, resulting in a catastrophic situation. In response to an urgent request from the Governor of Miyagi Prefecture on March 30, 2011, the Tohoku Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism carried out restoration work on the damaged coastal levees in a unified manner on behalf of the prefecture. As a result, the restoration of coastal levees, etc. was completed at the end of FY2012 for sections where facilities essential for restoration and reconstruction of the area located behind those coastal levees, etc., such as the Sendai Airport and sewage treatment plants; and the restoration work for the remaining sections was completed at the end of FY2016.

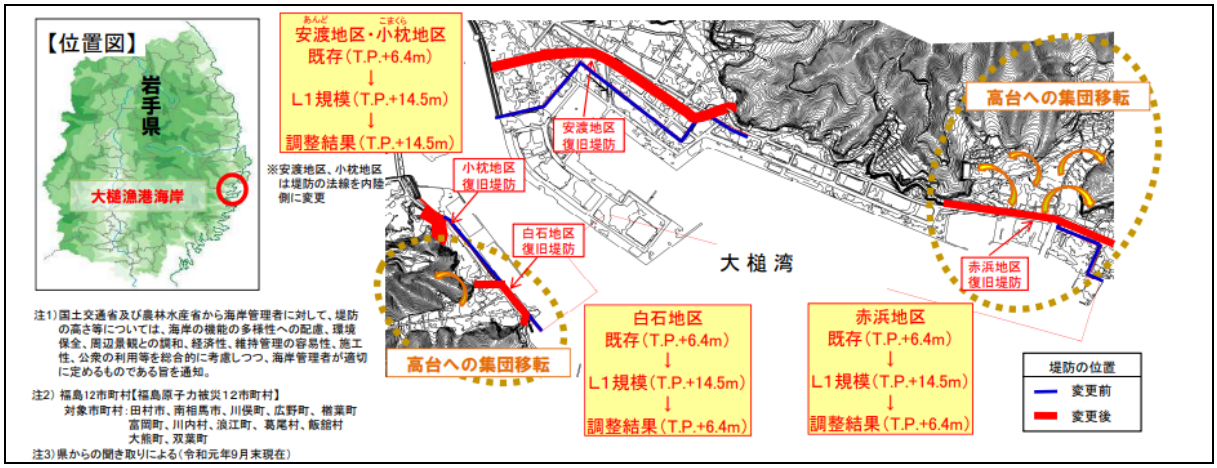
In addition, the relevant departments of the Ministry of Land, Infrastructure, Transport and Tourism Headquarters, which are in charge of measures for building tsunami-disaster-resistant communities, formed "Support Teams for the Building of Local Communities Resilient to Tsunami Disasters" and built a system where consultations and proposals could be provided all at one place in relation to necessary countermeasures. In cooperation with the Regional Development Bureau, support was provided to municipalities eager to develop tsunami-disaster-resistant areas, such as in the form of consultations and proposals concerning concrete countermeasures, in an effort to accelerate the progress of projects.

### b. State of development

In six disaster-stricken prefectures (Aomori Prefecture, Iwate Prefecture, Miyagi Prefecture, Fukushima Prefecture, Ibaraki Prefecture, and Chiba Prefecture), there were projects planned for 621 locations, and 590 projects, or about 95%, were completed by the end of March 2022. With respect to about 30% of the coastal levees found at 621 locations, action has been undertaken such as coordination with the town development going on behind the levees, and the projects are moving forward while at the same time there are readjustments being made such as those taking the form of the lowering of levee heights below the heights corresponding to tsunamis which occur relatively frequently (L1 tsunami), or changing of levee position.

For example, at the Otsuchi Fishing Port Coastal Akahama District and the Shiraishi District of Otsuchi Town, Iwate Prefecture, it was decided to keep the levees to be restored at their current heights based on the regional agreement that was in place in consideration of elements such as designations as a disaster risk areas and collective relocation to higher ground.

Figure 5-6-16 Example of lowered levee heights




Source: Ministry of Land, Infrastructure, Transport and Tourism, "Material 3: Second Meeting of the Committee for Coastal Protection Taking Place in Light of Climate Change" (December 9, 2019)

As mentioned above, on the Southern Sendai Coast, the "green seawall" was constructed as one form of tough coastal levee which took into consideration embankments that were integrated with the levee, and which took vegetation into consideration. Having restrictions on elements such as land and topography, construction locations were selected based on local opinions and based on the effects provided by the improvements being made. After carrying out a model project within a coastal section of approximately 100 meters (Iwanuma City, Miyagi Prefecture), approximately 1.0 kilometer of the project was completed by the end of March 2018.

### 2) Improvement effects

The main effects of coastal development projects include the avoidance of tsunami inundation, the reducing of tsunami run-up heights, and the delaying of tsunami overtopping time.

On the Southern Sendai Coast, coastal protection facilities featuring elements such as tough structures are being set up, and after they are completed, the area inundated by storm surges, waves and tsunamis is expected to be reduced by approximately 227 ha (from approximately 227 ha to 0 ha) within the Iwanuma Coastal District and by approximately 388 ha (from approximately 388 ha to 0ha) within the Yamamoto Coastal District.

Figure 5-6-17 Project for the Development of Coastal Protection Facilities Under Direct Jurisdiction for the Southern Sendai Coast (Iwanuma Coastal District)


Source: Ministry of Land, Infrastructure, Transport and Tourism Tohoku Regional Development Bureau, "[FY2021 Project Evaluation and Oversight Committee (3rd Meeting) Material] Coastal Project Re-evaluation: Project for the Development of Coastal Protection Facilities Under Direct Jurisdiction for the Southern Sendai Coast" (December 13, 2021)



## (4) River projects

### 1) Project overview

The restoration and reconstruction of river levees under the direct control of the national government was extended for about 48 km at the five estuaries of the Abukuma River, Natori River, Naruse River, Kyukitakami River, and Kitakami River.

Emergency measures were completed for the damaged levees by July 2011. In the implementation of this restoration, the levees of the necessary heights were built successively as tsunami countermeasures, etc., in accordance with plans such as the coastal levee improvement plans and the reconstruction plans formulated by municipalities, with the goal being to complete construction of all locations in about five years. In addition, with respect to the sections to be developed together in a unified manner with the town planning taking place, it was decided that the implementation was to be carried out while working to ensure that coordination takes place when it comes to town planning and levee development.

As a result, restoration and reconstruction works for the Kitakami River, Naruse River, Natori River and Abukuma River were completed by FY2017, and the work for the estuary of the Kyukitakami River was also completed by FY2021.

As of the end of March 2022, projects for river levees managed by prefectures and municipalities had been completed in 99%, or at 1,058 locations of the 1,070 planned locations.

### 2) Cooperation and support activities

Since March 13, two days after the earthquake, TEC-FORCES (Technical Emergency Control Forces) assembled in order within the jurisdiction of the Sendai River and National Route Office of the Ministry of Land, Infrastructure, Transport and Tourism, with members of the Kanto Regional Development Bureau, the Chubu Regional Development Bureau, and the Kyushu Regional Development Bureau providing technical support. In the implementation of river projects, external and internal works were carried out concerning damage investigation and disaster applications.

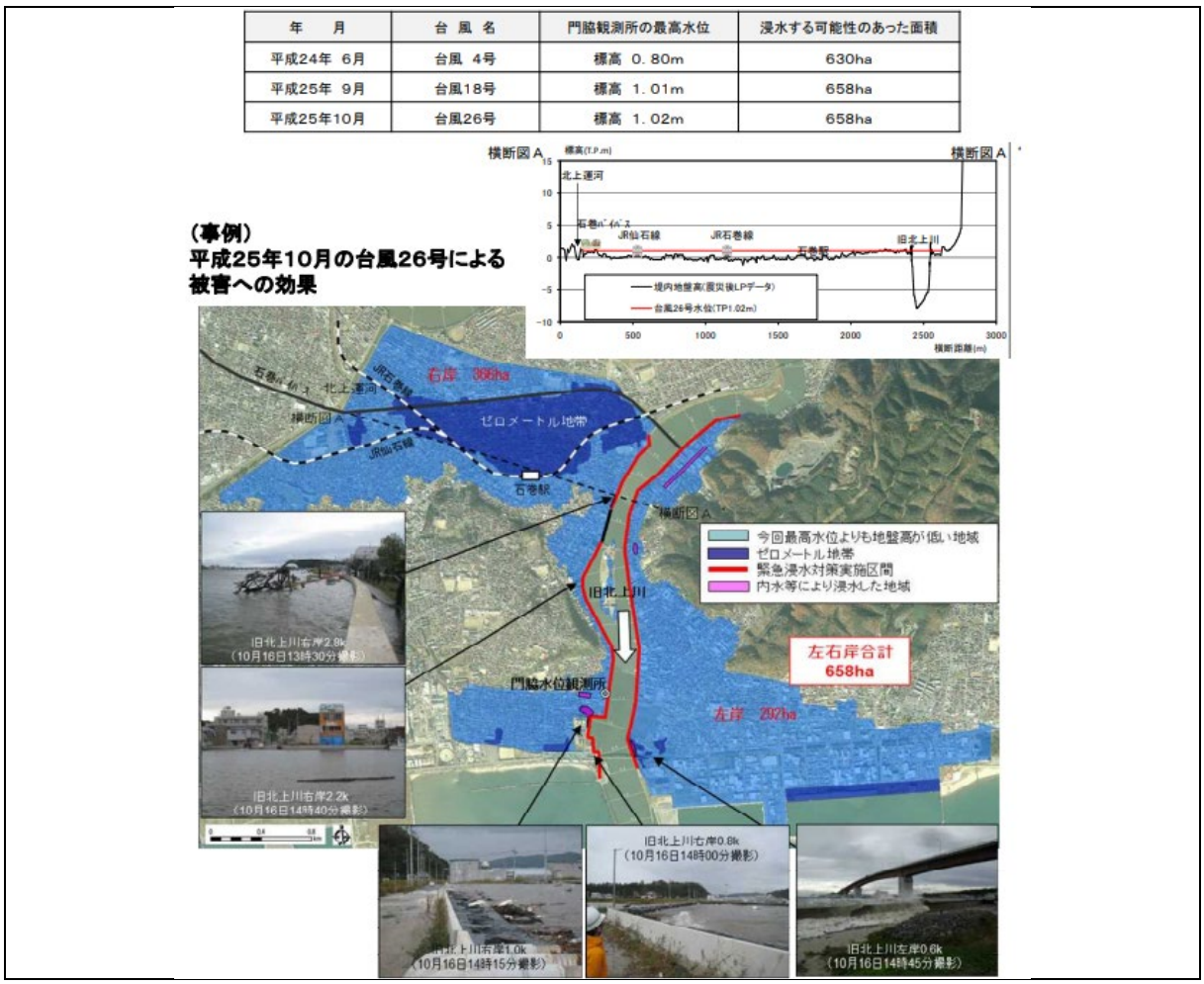
In addition, the Tohoku Regional Development Bureau set up a "Municipal Reconstruction Support Team" within the bureau, and the Sendai River and National Route Office played the role of a counterpart information desk for

reconstruction support. As a result, the various bureaus of the Ministry of Land, Infrastructure, Transport and Tourism and the Regional Development Bureaus worked together to study the issues faced by municipalities, and the Sendai River and National Route Office also provided information on reconstruction assistance.

### 3) Improvement effects

With respect to the Kyukitakami River, the risk of storm surge inundation at the estuary was higher than it had been before the Great East Japan Earthquake due to wide-area land subsidence caused by the earthquake, but storm surge damage and other such elements have been reduced through levee restoration and the implementation of pump drainage.

Figure 5-6-18 Reduction effects of storm surge damage caused by typhoons after the earthquake disaster




Source: KITAKAMIGAWA-KARYU RIVER OFFICE, Tohoku Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "Efforts Taking Place During the Nine Years After the Great East Japan Earthquake" (March 2020)

One of the effects of river levee restoration and reconstruction projects is the reduction of flood damage caused by tsunamis, etc. The planned height of T.P. + 7.2 m was secured in March 2017 for a series of sections of river levees at the estuary of the Abukuma River, and with the completion of the Shinhama Floodgate, a regional tsunami disaster prevention system was established that was integrated with the coastal levees of the Southern Sendai Coast. As a result, the inundated area of approximately 3,700 ha became 0 ha as a protective effect against a tsunami of approximately 7 m, which is equivalent to the height of the river levee.

The completion of levees at the estuary of the Kyukitakami River and on the Southern Sendai Coast also greatly improved the safety levels of flood control (tsunamis, storm surges, and floods). In addition, in conjunction with the levee construction, the national government, local governments, residents and others collaborated to create a lively place by utilizing the waterfront, creating a new exchange base serving as a symbol of reconstruction of the disaster-affected areas and thereby contributing to a significant increase in visitors to the area.

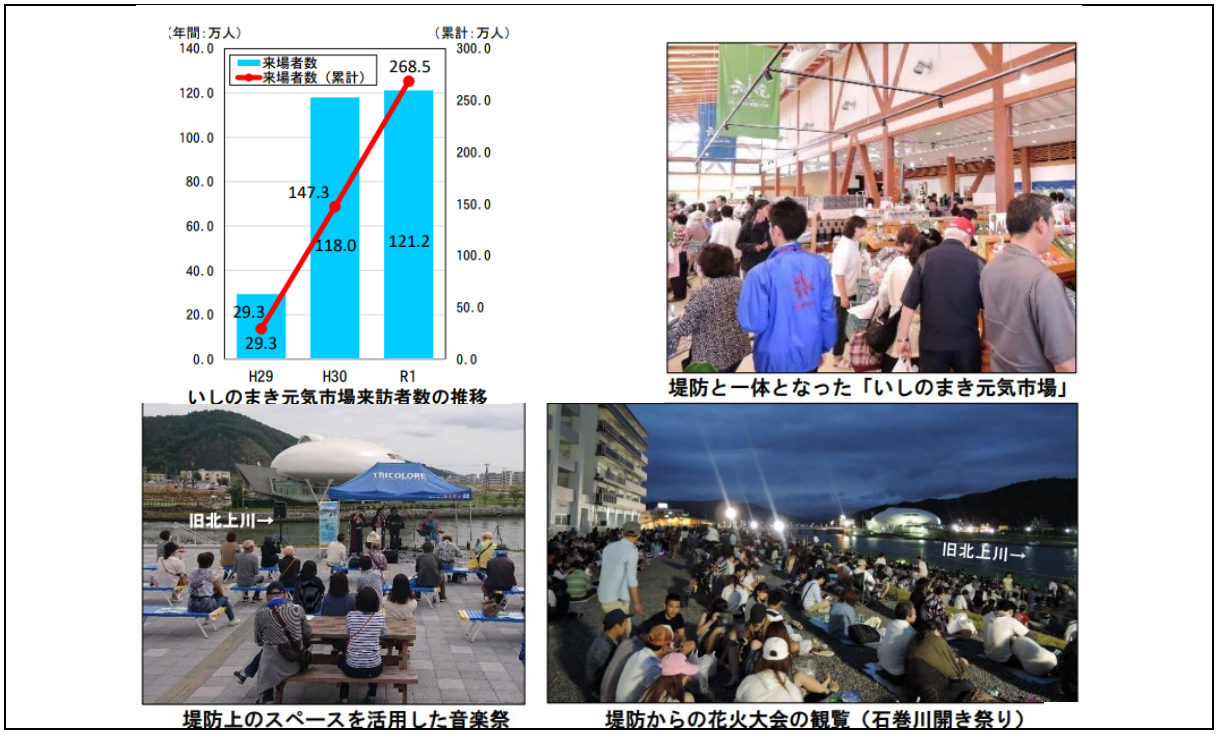
For the river town development of the Ishinomaki District at the estuary of the Kyukitakami River, the "Study Group for River Town Planning at the Estuary of the Kyukitakami River" was established as a place for the study of town planning and landscape consideration for the new levee construction, examining elements such as the basic policy for landscapes, the design of elements such as levees and revetments, and the direction to take in terms of the improvement of the base district. At the same time, the study group collected public comments and held workshops to obtain opinions from local residents and promote the development of waterside spaces where people can relax. In addition, in cooperation with the "Ishinomaki Waterfront Green Promenade Planning Council" (which started on July 2, 2012) established by Ishinomaki City, discussed items were reflected on the development effort such as building a promenade that would make use of levees and revetments to create a connection between the town behind them and the waterfront. In river town development taking place in the Ishinomaki District, an integrated space involving a terrace and a levee was partially completed in December 2016. The levee section, which was partially completed, was actively utilized for such events as the Ishinomaki River Opening Festival fireworks display, the Kitakami River Fair, and the MIZUBERING Ishinomaki event. Facility development as integrated space progressed with opening of the commercial facility Ishinomaki Genki Ichiba in June 2017, Kawamachi Multistory Parking Lot in November 2017, Transportation Square in June 2018 and Ishinomaki City Kawamachi Exchange Center in September 2018, serving as a base for tourist information and community activities.

It is thought that such a bustling waterside environment will continue to contribute to the reconstruction of the disaster-affected area as a symbol and as a new exchange hub.

Figure 5-6-19 Development of the green promenade at the Ishinomaki Waterfront


Source: KITAKAMIGAWA-KARYU RIVER OFFICE, Tohoku Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "Efforts Taking Place During the Nine Years After the Great East Japan Earthquake" (March 2020)

Figure 5-6-20 Effects of creating a lively place by improving the estuary of the Kyukitakami River




Source: Ministry of Land, Infrastructure, Transport and Tourism, "Reconstruction Acceleration Council (11th Meeting): Progress Status and Future Prospects in Terms of Restoration and Reconstruction (Material 1)" (December 20, 2020)

## 4. Issues that arose in project implementation and responses, etc.

### (1) Issues that arose in project implementation and responses

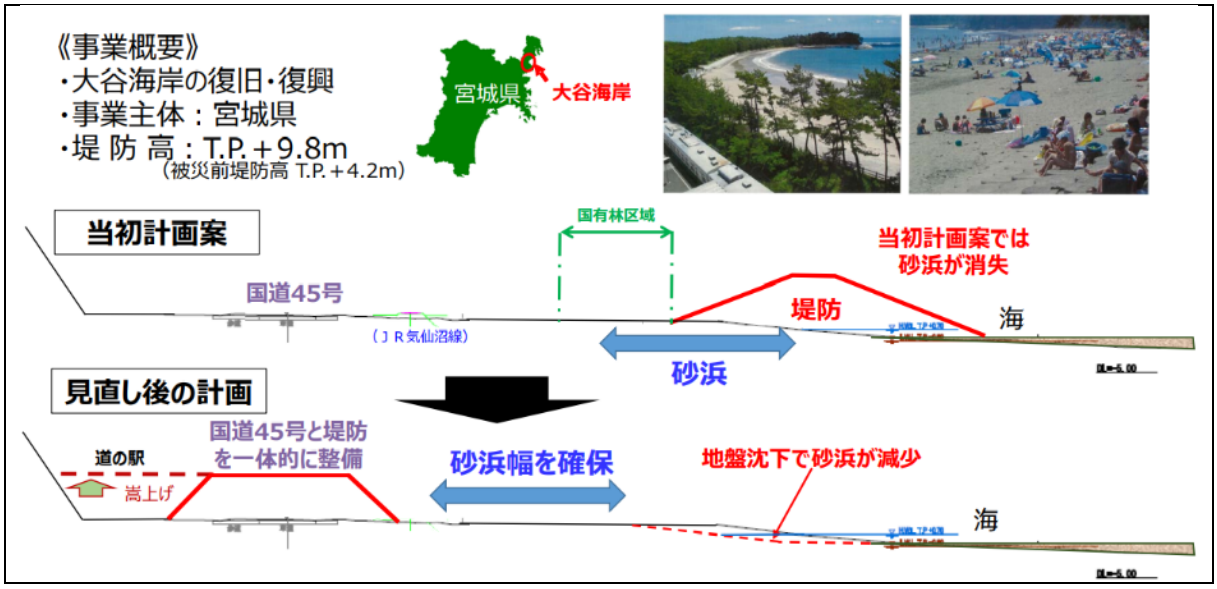
#### 1) Coasts

##### a. Example of the setback of a levee to preserve the beach (Otani Beach in Kesennuma City, Miyagi Prefecture)

Before the earthquake, the Otani Coast, with white sand and green pines, was a regional hub for tourism and exchanges visited by beachgoers.

When it came to restoration and reconstruction, the local community had requested that the elevation of elements such as the road found behind the levee take place together with the securing of the beach and the improvement of the levee, so Kesennuma City, Miyagi Prefecture, and the national government (Reconstruction Agency, the Ministry of Land, Infrastructure, Transport and Tourism, and the Forestry Agency at the Ministry of Agriculture, Forestry and Fisheries) along with other entities, examined the matters of the seawall and town planning. In July 2016, an agreement was reached on the seawall and the town development plan, and improvements were carried out which involved a combination of the setback of the levee position and the elevation of the road.

Figure 5-6-21 Case of the Otani Coast




Source: Ministry of Land, Infrastructure, Transport and Tourism, "1st Meeting of the Conference Concerning Regional Development Incorporating Tsunami Disaster Prevention and Beach Conservation (Material 3-1)" (September 6, 2017)

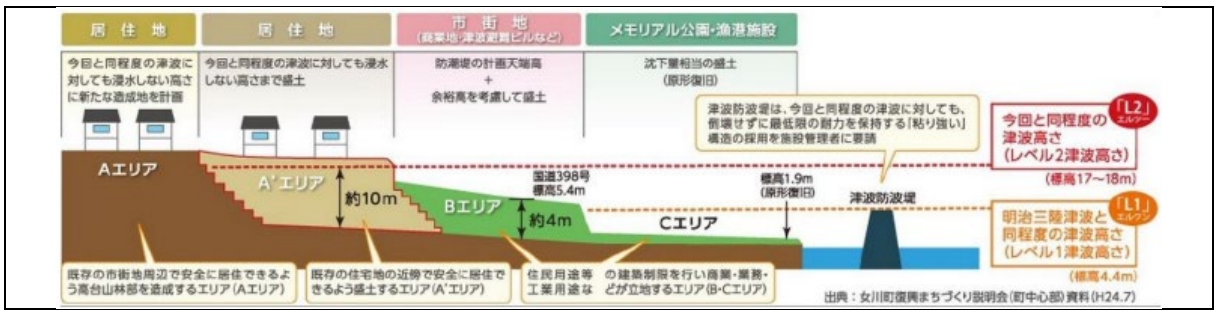


### b. Example of levee design which secures a view spanning from the city to the sea (Onagawa Town and the Uomachi in the inner bay area of Kesennuma City)

In Onagawa Town, it was quickly decided not to build a seawall as it would prevent people from being able to see the ocean. For that purpose, it was decided that ① tough breakwaters should be constructed offshore which would not collapse with tsunamis, ② land should be developed or filled at the height of an L2 tsunami or greater and that residential areas should be consolidated, and ③ low-lying areas damaged by the tsunami should be used as industrial sites, and that commercial areas where people gather in particular should have the ground level raised to the height of an L1 tsunami to construct evacuation buildings.

In Uomachi, which is found in the in the inner bay area of Kesennuma City, a flap-gate type (movable) levee with leeway equivalent to 1.0 m was adopted based on the levee height of T.P + 5.1 m, which meant that a view of the sea was secured by raising the height on the town side. The moveable levee was more expensive than other levees, but it was judged appropriate and adopted in consideration of the impact on the economy of the inner bay area, which is the central urban area. In addition, if the buildings on the town side were demolished all at once and the construction work for raising heights was to be completed, the reconstruction of the buildings would be delayed and the landowners would have to shoulder more burdens, so plans were carried out where the blocks of land to be raised was decided ahead of others and the land blocks where early rebuilding was desired would be collectively converted to one block of land.

Figure 5-6-22 Example of levee design which takes into consideration the landscape and natural environment (Onagawa Town)




Source: Hyogo Earthquake Memorial 21st Century Research Institute, "Collection of Lessons Learned and Know-how Gained from the Great East Japan Earthquake" (March 2021)

### c. Example of levee design which takes tourism into consideration (Minamimachi in the inner bay area of Kesennuma City and the Yuriage District of Natori City)

In Minamimachi in the inner bay area of Kesennuma City, waterfront facilities (public and commercial facilities) with panoramic views of the sea were combined with the seawall to make the seawall less conspicuous; and "Mukaeru," Minamimachi coast commercial facility, and "Umareru," Kesennuma City exchange plaza for the town, people, and work, were built along with Minamimachikaigan Kouen. From the town side, people can connect to the shopping facilities, restaurants, and parking lot on the first floor of the facility, and from the side facing the sea, the sloped green area and stairs lead them to the second floor of the facility; and there are five land locks that can be passed through, securing the traffic line between the side facing sea and the town side as much as possible.

In the Yuriage District of Natori City, a commercial facility called "Kawamachi Terasu Yuriage" was built on the side strip of the levee of the Natori River. There are 26 shops selling goods and which offer food and beverages, making for a space where visitors can enjoy meals while also enjoying the waterside.

Figure 5-6-23 Example of levee design which takes into consideration the landscape and natural environment (Kesennuma City)


Source: Hyogo Earthquake Memorial 21st Century Research Institute, "Collection of Lessons Learned and Know-how Gained from the Great East Japan Earthquake" (March 2021)

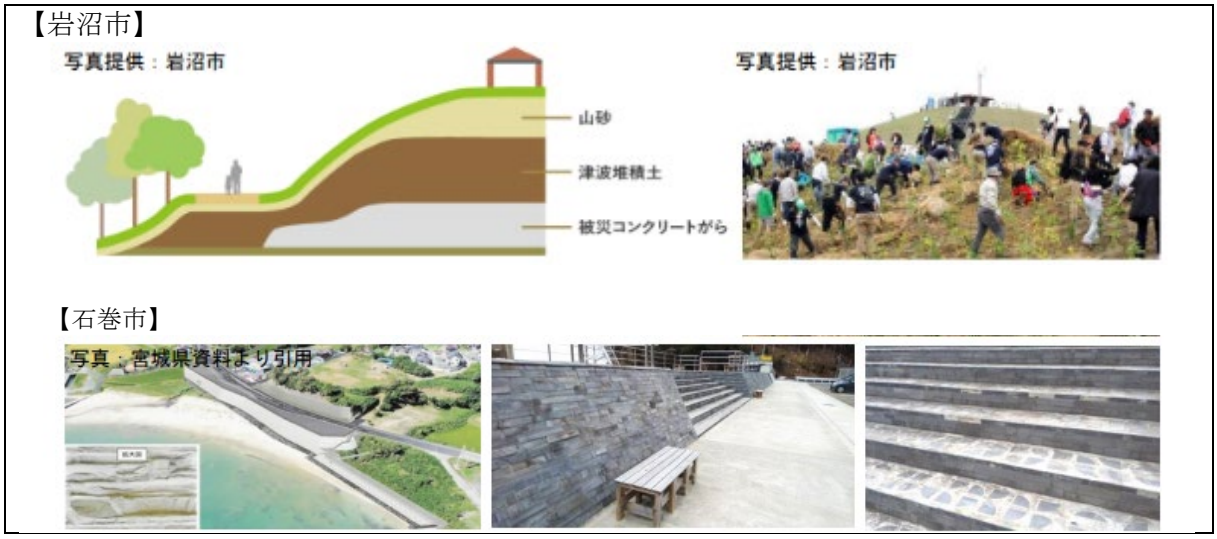
### d. Example of levee design which takes into consideration the landscape and natural environment (Hikado Fishing Port in Kesennuma City, Ogatsu-cho in Ishinomaki City, and Iwanuma City)

At Kesennuma City's Hikado Fishing Port, it was decided to raise the height of the national route (road) so that the sea can be seen from the national route located behind the levee, which was to take place together with embankment improvement undertaken with a goal of local tourism promotion and evacuation measures, with the decision being based on the opinions held by residents to the effect that the scenery itself is an asset of the region. In addition, it was decided to secure the beach as much as possible by installing a seawall on the old railway site. Furthermore, upon being provided with the advice of an environmental advisor, consideration was given to the natural environment not only in terms of design but also in terms of the construction plan, with an example being demonstrated by the fact that construction work was not carried out during the time when the geese would land and rest.

In the Namiita District of Ogatsu-cho in Ishinomaki City, genshoseki slates (a local specialty product) were placed on the surfaces of the levee, which usually tend to have an inorganic feel to them. Residents and volunteers also participated in the stone-laying work. Fan-shaped and crescent-shaped stones were placed on areas such as the stairs in the central part to express the local character.

In Iwanuma City, evacuation hills were built using disaster waste for the foundations, etc., and volunteers from all over the country planted trees on the slopes, forming "Green Levee." The Millenium Hope Hills constitutes one of the multiple defenses that attenuates the power of the tsunami and protects people, while being used as a place to pass down information concerning earthquake disasters and learn about disaster prevention.

Figure 5-6-24 Example of levee design which takes into consideration the landscape and natural environment (Iwanuma City and Ishinomaki City)




Source: Hyogo Earthquake Memorial 21st Century Research Institute, "Collection of Lessons Learned and Know-how Gained from the Great East Japan Earthquake" (March 2021)

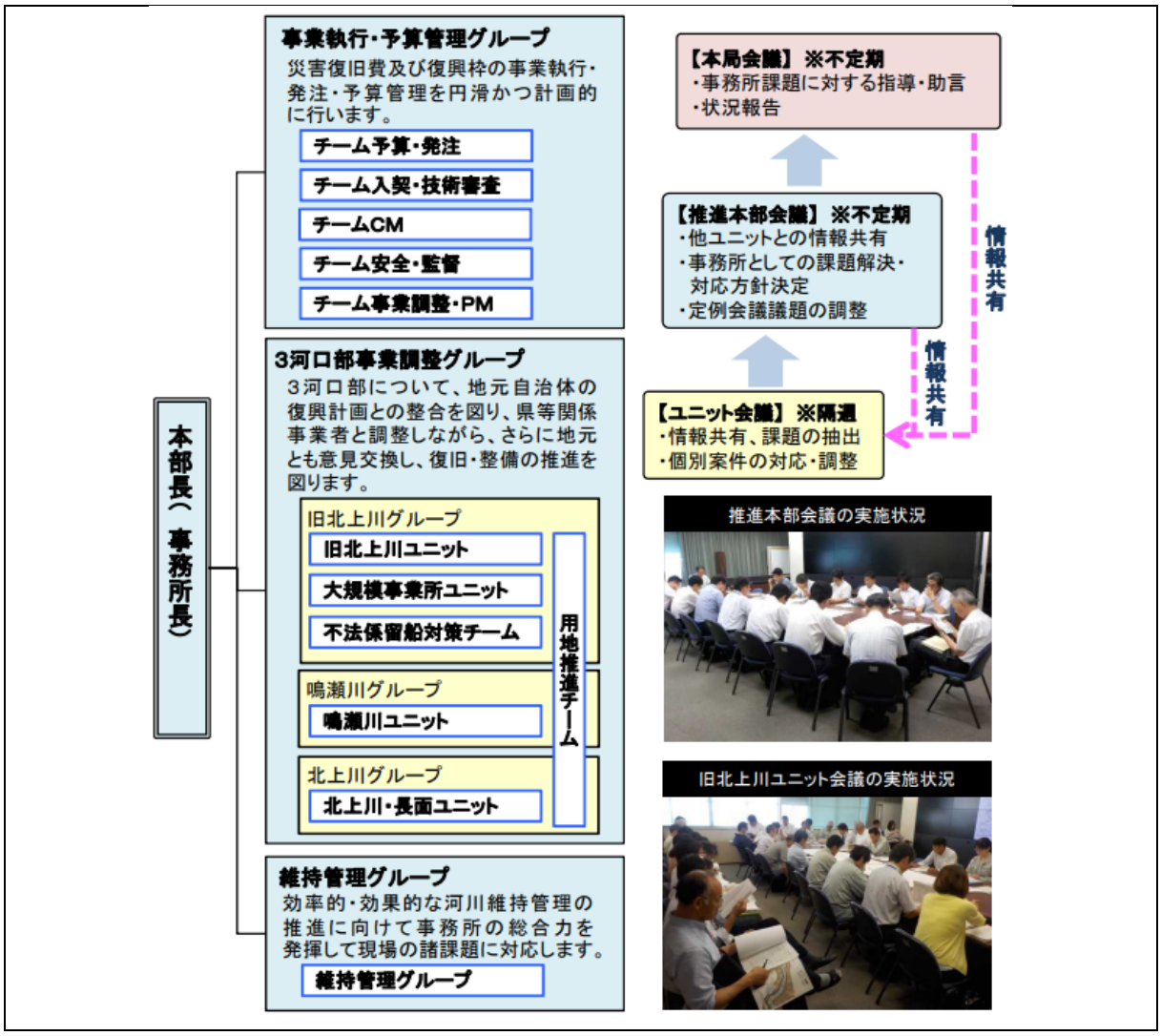


### 2) Rivers

#### a. Promoting project execution

In order to complete the early restoration and reconstruction projects of the Kitakami River, Kyukitakami River, and Naruse River estuaries, the KITAKAMIGAWA-KARYU RIVER OFFICE of the Ministry of Land, Infrastructure, Transport and Tourism, established the Headquarters for Promoting River Restoration and Maintenance after the Great East Japan Earthquake and tried promoting the projects by organizing units at each estuary.

Figure 5-6-25 Organization for the headquarters for promoting river restoration and maintenance after the Great East Japan Earthquake, at the KITAKAMIGAWA-KARYU RIVER OFFICE of the Ministry of Land, Infrastructure, Transport and Tourism




Source: KITAKAMIGAWA-KARYU RIVER OFFICE, Tohoku Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "Efforts Taking Place During the Nine Years After the Great East Japan Earthquake" (March 2020)

In addition, for the purpose of ensuring efficient project execution and proper execution and quality assurance of the construction related to restoration and reconstruction, PM[1] and CM[2] operations were managed in an integrated manner from the process spanning from project coordination to the supervision of construction.

### b. Strengthening information sharing and cooperation among administrative agencies

The "Council for Contact and Coordination in Relation to the Reconstruction and Disaster Prevention Base of the Ishinomaki and Higashimatsushima Districts" was organized in order to promote the efficient development of infrastructure while ensuring the safety and security of the region by sharing information among administrative bodies related to the development of infrastructures in Ishinomaki City and Higashimatsushima City that are related to areas such as rivers, coasts, ports, fishing ports, and sewerage systems. The council was greatly utilized in promoting restoration and reconstruction projects, including the development of levees at the estuary of the Kyukitakami River.

[1] Project Management (PM): Supervision of business execution that is undertaken in a manner involving the managing of the entire project in order to improve the efficiency of business execution.
[2] Construction Management (CM): Supervision of construction involving management for the purpose of ensuring the proper execution of contracts and quality.

Figure 5-6-26 Council for contact and coordination in relation to the reconstruction and disaster prevention base of the Ishinomaki and Higashimatsushima Districts


Source: KITAKAMIGAWA-KARYU RIVER OFFICE, Tohoku Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "Efforts Taking Place During the Nine Years After the Great East Japan Earthquake" (March 2020)

### c. Reducing heavy vehicle traffic on community roads

At the estuary of the Kitakami River, when the construction work reached its peak, construction vehicles frequently passed through narrow roads in the Yokokawa District. As such, securing the living environment and safety of the local residents in conjunction with the early recovery from the disaster did become an issue.

When the construction work at the estuary of the Kitakami River was carried out, the Tohoku Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism worked with Miyagi Prefecture, Ishinomaki City, etc., to prevent traffic accidents and to ensure the safety of local residents by diverting passage of large construction vehicles. As a result, approximately 60% of heavy-duty vehicles were switched over to passing construction vehicle detours, meaning that heavy-duty vehicle traffic on community roads was significantly reduced.

Figure 5-6-27 Setting up a detour for construction vehicles in the Yokokawa District


Source: KITAKAMIGAWA-KARYU RIVER OFFICE, Tohoku Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "Efforts Taking Place During the Nine Years After the Great East Japan Earthquake" (March 2020)

## (2) Lessons learned and know-how gained

### 1) Measures aimed at prompt emergency recovery

In order to start work involved in emergency recovery immediately after a disaster, important elements include the securing of materials and equipment for carrying out the work and the securing of traffic routes for construction vehicles.

In the Great East Japan Earthquake, success was achieved when it came to quickly preparing an environment for the commencement of construction by carrying out action such as setting up detours and installing emergency assembly bridges, making it possible to start emergency recovery work relatively early.

Based on these experiences, it would be desirable to assume in advance the occurrence of a large-scale disaster and secure the construction materials required for the construction of emergency temporary bridges and the materials and equipment required for traffic control and traffic guidance during normal times, while reviewing elements such as contract management for emergency recovery works, including emergency discretionary contracts.

### 2) Measures for the early restoration and reconstruction of coastal levees, etc.

In order to achieve the early restoration and reconstruction of facilities, it would be effective to have an integrated conceptualization of restoration measures for coastal protection facilities, river levees and urban areas starting from the stage before they are damaged by a tsunami or other such phenomena. It is thought that rapid restoration and reconstruction will be possible by conceptualizing how to restore urban areas after they are damaged by L1 and L2 tsunamis. Specific examples would be identifying who the landowners are in the target area, envisaging the range of objects to be protected, and examining elements such as mitigation measures against the division of the region and adverse effects on the natural environment caused by the construction of structures, etc.

Furthermore, in order to promote regional development which incorporates tsunami-related disaster prevention in restoration and reconstruction after the Great East Japan Earthquake, ministerial departments in charge of related measures at the Ministry of Land, Infrastructure, Transport and Tourism, formed teams and established a system where consultations and proposals for necessary countermeasures can be provided all at one place. Thus, having national and prefectural government organizations form teams to respond to various issues and having a system established whereby support can be flexibly provided to activities and projects in the region, is something that is considered important when it comes to the early progress of projects.

### 3) Building consensus for efforts such as the creation of good landscapes

In designing coastal levees for restoration and reconstruction after the Great East Japan Earthquake, the heights of levees were determined based on the water levels of design tsunamis (L1 tsunami), but there were actually many cases in which the heights of coastal levees, etc. were determined according to local conditions. At this time, it was important to build a consensus with local residents in order to install coastal levees which took into consideration not only the safety of the area but also elements such as the securing of the view from the city to the sea, consideration for the tourism industry and consideration for landscapes and the natural environment. There were cases such as those where a study committee was established that included relevant organizations in the region, and those in which public comments were collected and workshops were held, but in any case, it is thought that creating opportunities to hear the opinions of the people in the region and moving forward with projects while reflecting those opinions upon the contents of the projects was effective.

For example, Iwate Prefecture set up a committee without delay and has been conducting intensive discussions with the aim of determining the seawall development goal at an early stage, while discussing the heights of seawalls and plans in terms of urban planning by presenting many tsunami simulation cases in determining the seawall development goal in individual districts. In addition to the committee format, the prefectural government and municipalities have exchanged opinions more than 100 times to formulate flexible plans in coordination with local community development plans.

Various measures were taken in other areas also when it came to configuring the heights of coastal levees. In some severely damaged regions, there were strong assertions made to the effect that reconstruction plans with the possibility of flooding occurring again in the future could not be accepted, and in other regions, there were cases where conventional levee heights were requested after having accepted that flooding would occur, considering

better view of the sea from the inland side. In addition, there were also examples wherein the appropriate seawall heights were determined while searching through the use of simulation results based on new knowledge.

In any case, it is thought to be necessary to go about building consensus on a regional basis, taking into account elements such as the actual conditions of the affected regions and the changes in the states of mind of the residents after having been affected by a disaster.

### 4) Measures for the acquisition of land for the implementation of projects such as those involving coastal levees

In order to complete restoration and reconstruction projects as early as possible, it is important to accelerate the acquisition of land necessary for the projects, but significant damages resulting from tsunami in the Great East Japan Earthquake made it more difficult to undertake work such as the identification of landowners than would be the case for ordinary projects, and many problems arose when it came to the acquisition of land. In 2013, the Reconstruction Agency set up the Task Force for Accelerating Housing Reconstruction and Urban Reconstruction, which consisted of director-general level members from relevant ministries and agencies under the Minister for Reconstruction and established the Land Acceleration Support Team in 2014, which consisted of relevant ministries and agencies, to assist local governments in solving problems.

In terms of concrete measures, for cases where the landowner is known but is already deceased and the property has not been inherited (non-inheritance problem), efforts were made to reduce the burden placed on local governments by ① promoting the outsourcing of land acquisition work to entities such as compensation consultants and ② promoting the outsourcing of registration work to entities such as judicial scriveners and land and house investigators. In some areas such as the coastal areas of fishery settlements where there are many pieces of communal land, the number of heirs exceeded 100 even in cases where the owners were identified (communal land problem). It was decided that in such cases, the "Approved Regional Association System" would be used to acquire land quickly through the organization. In addition, the expedition of land acquisition was attempted by having family courts appoint absentee property administrators and having sales contracts concluded for cases where the owner of a piece of land is known but their whereabouts is not known and they cannot be said to be deceased (the problem of missing owners).

These efforts will likely serve as references in the future when land problems arise due to damage caused by elements such as tsunamis.

### 5) Passing on the idea of "multiple defenses"

As a result of the putting in place of coastal levees and other facilities, facilities have been developed in some areas which can be used as places to convey information on the power of the tsunami caused by the Great East Japan Earthquake and pass down information concerning earthquake disasters, and as places where people learn about disaster prevention. In the future, it will be necessary to ensure that the lessons learned from the earthquake disaster, including the concept of "multiple defenses," are handed down to the next generation by actively utilizing these facilities and carrying out action such as tsunami-related disaster prevention education and drills for disaster prevention and evacuation.

Volunteers from all over the country participated in the construction of the facilities, and the lessons of the earthquake are expected to be passed down also through such volunteer activities.