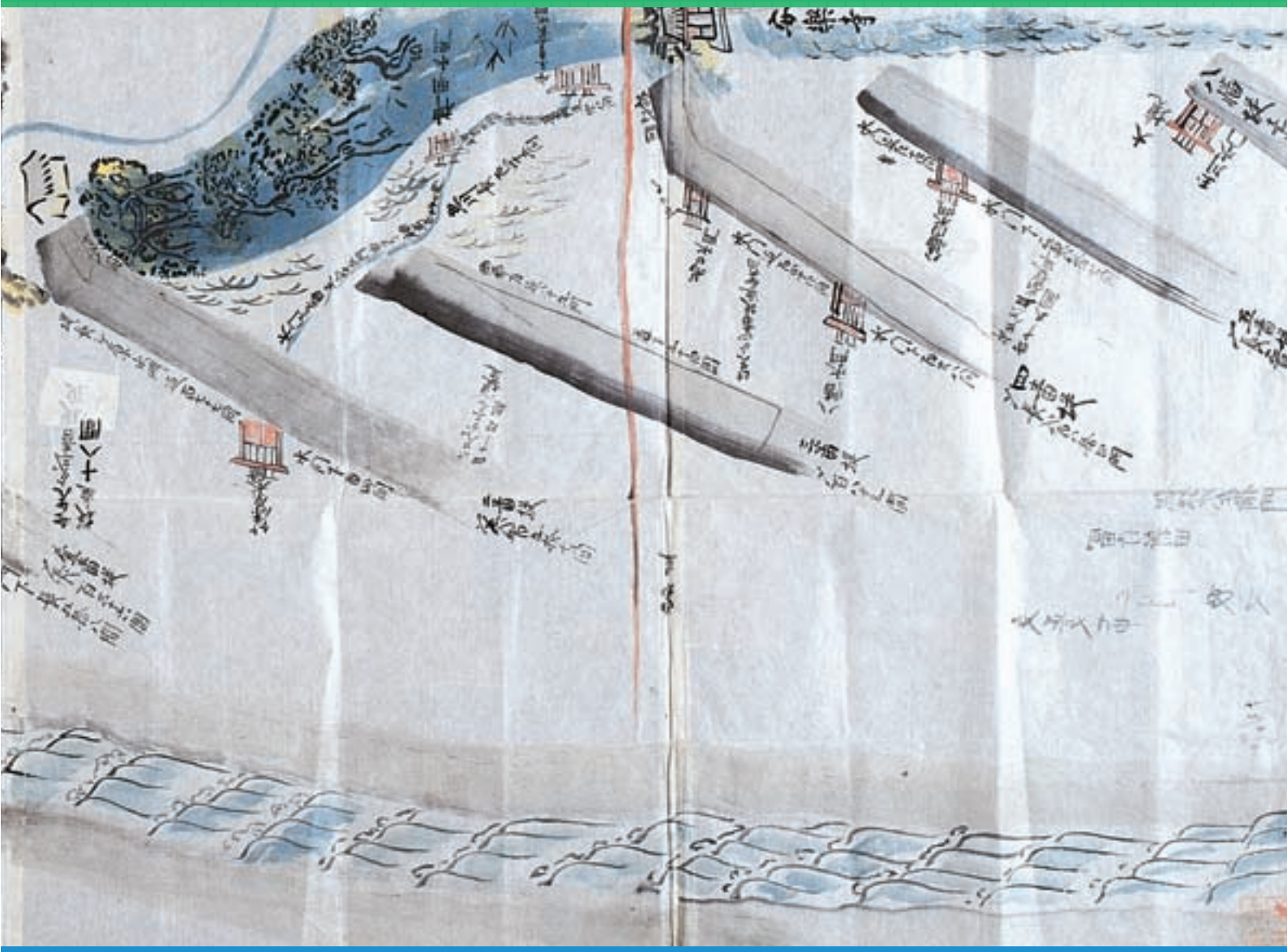
Flood control study from the past history

Information about Fuji river Flood Control

- Shingen Embankment
- Manriki Forest
- Karigane Embankment



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There are various flood control facilities along Fuji river, and there are many facilities or methods which can be referred for other steep rivers in Japan. These facilities exist at different locations such as in the river flow or near the river bank. Their sizes vary from a tall and strong embankment which is easily found to a small water barricade such as Gyuwaku hidden in a ordinary field.

All of them are important flood control facilities which protect people who live near the river during flood disasters.

This small booklet was published to announce our ancestors' precious idea and efforts for Fuji river flood control. Among various flood control facilities along Fuji river, three locations of “Shingen Embankment”, “Manriki Forest”, and “Karigane Embankment” are introduced in this booklet to help you understand Fuji river.

“Shingen Embankment” is located in the west side of the Kofu basin. It is told that Shingen Takeda, a famous war lord in warring state, constructed it, and it is called by that name honoring his achievement.

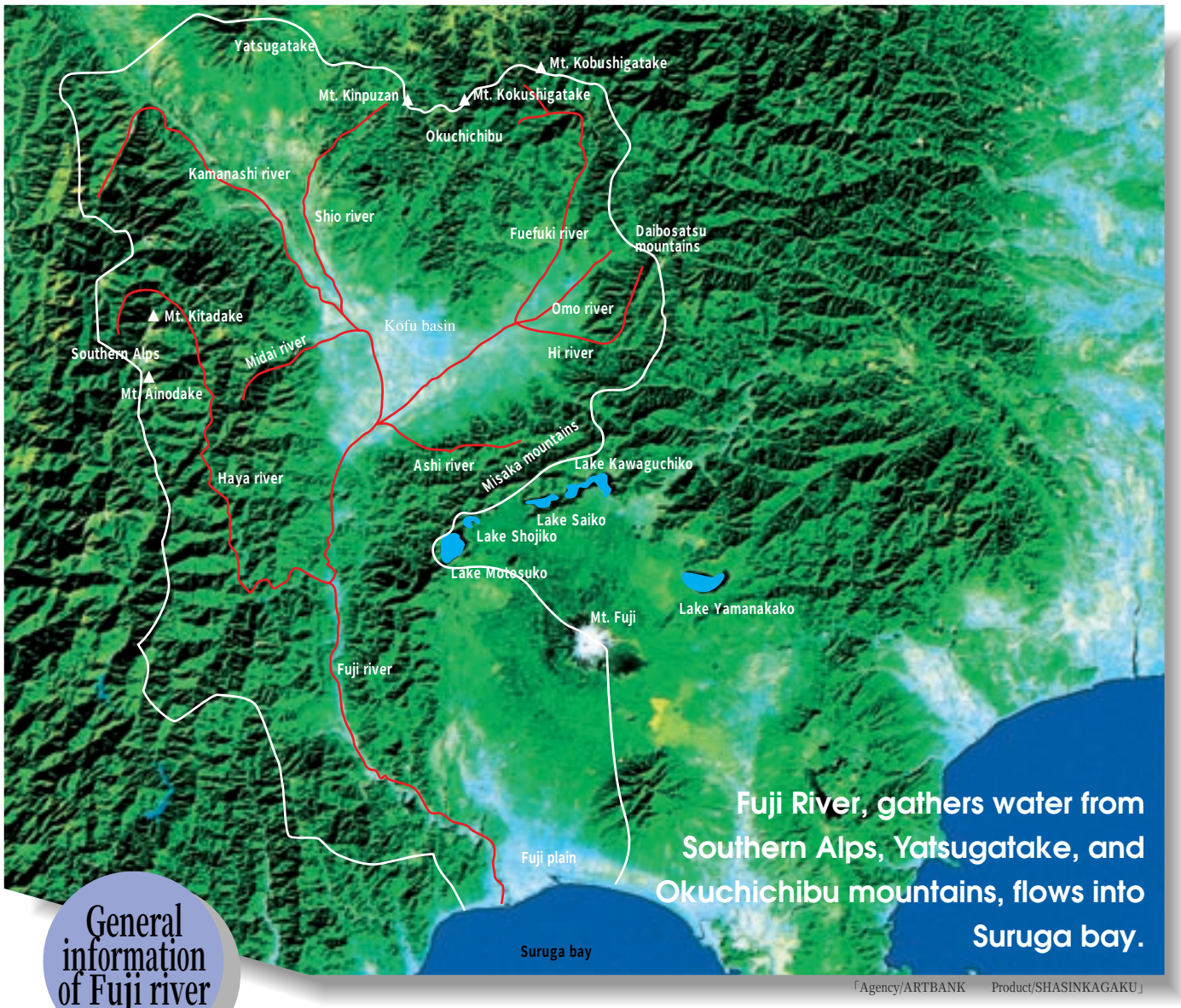
“Manriki Forest” is located in the east of the Kofu basin to prevent a flood of Fuefuki river. This is a flood prevention forest where covered by dense and large pine trees. It is told that the origin of the name, “Manriki”, has the wish of making a strong bank with all people's united power.

“Karigane Embankment” is located in Fuji city in Shizuoka prefecture of Fuji river (lower area). The name is called because the shape of the facility looks like wild geese flying in the sky. This is a very unique shape embankment.

We believe that in every flood control facilities, you will see the wonderfulness of the flood control techniques achieved by our ancestors. Please try to get good understandings about Fuji river flood control history related with those facilities and people's knowledge who involved.

Our ancestors joined their knowledge, invention, and technique for Fuji river flood control.

Fuji River System Area



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General information of Fuji river

A large river in Japan Islands

Fuji river is located nearly in the central area in Japan. The river water, originates from the Southern Alps which is called Japanese high peaks, flows into Suruga bay at Pacific Ocean side.

The river covers three prefectures, Nagano, Yamanashi, and Shizuoka, and its river area reaches to approximately 3,990km^2, which is one of the largest river in Japan.

The weather is greatly different by regions. Reviewing the annual precipitation, as compared to Kofu, which precipitation is lower of approximately 1,100mm, Nanbu (Nanbu town, Yamanashi prefecture) in the midstream and Yoshiwara (Fuji city, Shizuoka prefecture) in the downstream are zones with a lot of rain of approximately 2,500mm and 2,000mm respectively.

The geographical features in the river area are steep, and 90% of the area is covered by the mountains. There are many mountains in the river area, such as the highest mountain in Japan, Mt. Fuji, the second highest Mt. Kitadake and the forth highest Mt. Ainodake with over 3,000 m peaks in Southern Alps in the west side, and Mt. Yatsugatake and Chichibu mountains include Mt. Kobushigatake, Mt. Kinpuzan, and Mt. Kokushigatake with over 2,000 m peaks in the north side.

The geological features are very complex and fragile. This is because a giant dislocation called “Itoi river-Shizuoka Tectonic line” runs under in north and south direction also there are many other dislocations run through and across the area. As a result, there are many collapsed areas. The collapsed rocks and sands carried by the river water accumulate at gentle flow areas. Then alluvial fan areas and rivers with its riverbed higher than the surrounding areas were created.

In the alluvial fan areas formed in Fuji river (Kamanashi river), there are urban areas in the basin. Kofu city, which is the prefectural capital of Yamanashi prefecture, Minami-Alps city, Fuefuki city, Kai city, and Yamanashi city are located in the upstream area. The midstream area is dotted with cities such as Minobu Town and Nanbu Town, etc. on top of a river terrace.

To protect these urban areas from being damaged by flood, the flood control work was important then, and it is now as well.

Running to the south through Kofu basin toward Suruga bay...
Fuji river as one of three steep rivers in Japan

The upper area of Fuji river is called Kamanashi river. It originates from the west side of Mt. Nokogiridake of Southern Alps at the boarder between Yamanashi and Nagano prefectures. On the other hand, the largest branch river called Fuefuki river originates from the southeast side of Mt. Kobushigatake in Chichibu mountains.

If we trace the river flow from the origin to the river mouth, it as follows. Inui river from the origin, Mt. Nokogiridake, running to the north, changes its direction sharply to the southeast at the merge point with Tachiba river, flows between mountains to Nirasaki city, merging with Shio river and Midai river, enters into Kofu basin. Then it flows to the south at the west side of the basin, merging with Fuefuki river at the south side edge of the basin, and changes its flow to the southwest direction. The river continues to flow down forming the valley in the mountains and merges with Haya river, which has 514 km^2 of the river area, in Minobu town. Finally, it reaches to Fuji city, runs at the west side of the alluvial fan area of Fuji plain, then flows into Suruga bay.

Fuji river is surrounded by steep mountains such as Mt. Fuji and Southern Alps, and its river slope is so steep that it is ranked in one of the "three most rapid streams in Japan" along with Mogami river and Kuma river. The Fgure-1 shows the comparison of river slopes between Fuji river and other rivers. From this result, you will see that Fuji river has a very steep river slope.

At the upper area of Fuji river Southen Alps at the left, Mt. Yatsugatake at the right.
The left side river is Kamanashi river (Fuji river), Nirasaki city central area at the middle.

Fast requirement for river preparation

Furthermore, the length of the main river is 128 km along Fuji river from the origin to the river mouth. The length of the largest branch, Fuefuki river, is 54.2 km. Fuji river is one of the first class river, so the national government basically manages the river. Under the river law, the area where the government directly manages the river preparation and other related issues is called "the area excluded from the specified area." Normally, this area is called "direct managed area."

The total length of the direct managed area is 122.1 km along Fuji river, and banks are fixed in order to protect from the damage by the flood. The detail is indicated in the table-1. If we report the river bank preparation condition in the direct managed area, the total length of the river bank is 240.6 km, and 71.8 km has been completed according to the plan. It is only about 41% of the total plan. Table-2 shows the status of the river bank completion.

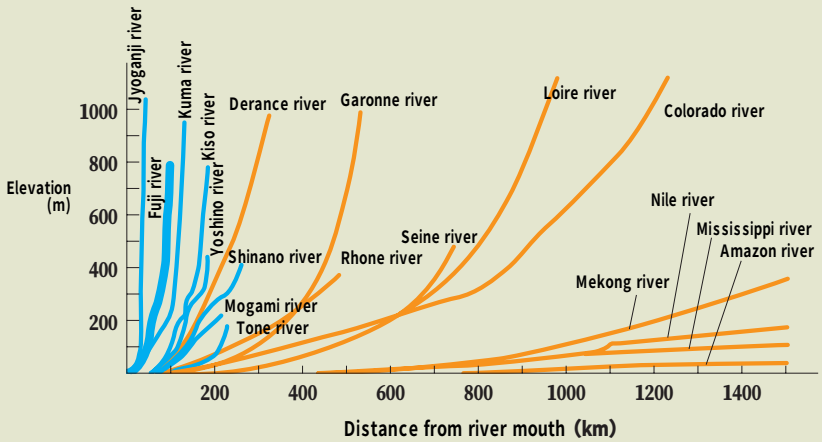
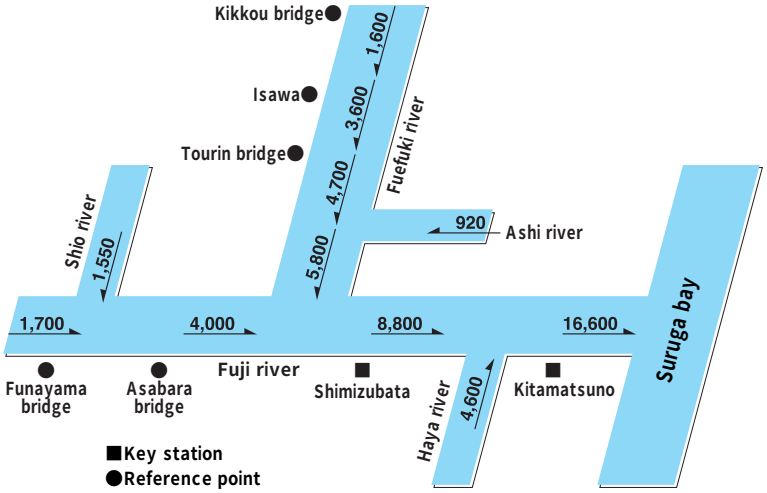


Figure-1. River bed slope comparison between Fuji river and other rivers.

River	Main river Branch river	Main river 2nd branch river	River length km	
			Direct managed section	Main river length
Fuji river			122.1	
	Fuji river (Main river)		85.0	128.0
	Haya river		3.0	71.0
	Fuefuki river		31.3	
		Fuefuki river (Main river)	(28.0)	54.2
		Nigori river	(0.4)	12.6
		Hirusawa river	(0.3)	8.1
		Gowari river	(0.1)	5.0
		Omo river	(1.5)	20.9
		Hi river	(1.0)	24.3
	Midai river		1.8	19.0
	Shio river		1.0	37.2

Table-1. River length along Fuji river area. (Direct managed area.)

図-2. Figure-2. Flow amount distribution at Fuji River (m³/s)



River	Fuji River
Total river bank length (km)	240.6
Total completed river bank length (km)	68.1
Temporary river bank length (km)	76.6
Unstarted river bank length (km)	29.2
Mountain section length (km)	66.7

Table-2. Preparation report at Fuji River updated Mar. 2004.

Fuji river has the third Design flood discharge in Japan

"Planned amount for river preparation" to flow the high volume of water safely without flooding has been set for each river. This flow amount is called "disign flood discharge." This amount is decided for each river according to the river design plan.

The current plan of Fuji river was updated in 1974. Figure-2 is called the flow amount distribution at Fuji river, indicating the flow amount at each location and river. According to the figure, disign flood discharge at Kitamatsuno near from the river mouth is 16,600 m³/s, this is the third largest amount in Japan.

The probability to occur this estimated large flow amount is 1/100 - 1/150 years.

	Shimizu bata	Kitamatsuno
Typhoon No.18, Mar, 1991	3,223	12,396
Typhoon No.10, Aug, 1982	(6,800)	(14,300)
Typhoon No.7, Aug, 1959	5,712	(9,000)

(m³/S)

Table-3. Significant floods in the past and max. flow at major locations.
( ) shows estimated values.

Constantly changing flow amount

The flow amount of the river always changes. The average flow amount in a day is called "daily average flow amount," indicated by m³/s. People in the past also investigated the river flow condition and flow amount before they constructed river banks and other facilities. In present days, it is very important to figure the flow amount which is constantly changing. Table-3 shows the average flow amount in the last ten years. (The maximum flow amount is the actual maximum flow recorded in the last ten years.)

History of the Fuji River Flood Control

This presents the major events related with Fuji river flood control from the 9th century to the 20th century.

825 The river in the Kai country flooded. An officer reported to the Emperor.
927 An embankment completed and its amount reported to the Ministry of Taxation.
1542 A severe flood at Fuji river, system Kamanashi river, and Midai river.
Lord Shingen Takeda started the flood control project since this flood.
1560 Lord Shingen Takeda completed the Shingenembankment in Ryuo.
1583 Fuefuki river flooded and damaged the Manriki embankment.
The embankment was reinforced with tree plantation.
1621 An embankment construction started at Kagoshita village.
1674 Karigane embankment completed.
1896 The river law established.
1907 Fuji river flooded. Fuefuki river flow direction changed.
1921 The government established a branch office for Fuji river flood control.
1935 Fuji river flooded.
1945 The World War II ended.
1959 Fuji river flooded.
1964 The river law updated completely.
1966 Fuji river Construction Basic Plan established.
The estimated large flow amount decided.
1974 Fuji river Construction Basic Plan updated.
The estimated large flow amount increased.
1982 Fuji river flooded.
1990 Fuji river Embankment Management Basic Plan established.
1995 River Channel Preparation project completed.

Major facility in the west side of Kofu basin flood control

Shingen Embankment

Kai city, Yamanashi Prefecture (Kamanashi River)

Shingen Embankment, protecting Kofu basin from flood disasters.

The upstream of Fuji river is called Kamanashi river. Therefore, the local information board writes “Fuji river (Kamanashi river).” This location is called the nose of Ryuo, entering into Kofu basin. At the little above, a branch river, Midai river, merges from the right, and another branch, Shio river, merges from the left at the same location. The estimated large flow amount at the merge point is 4,000 m³/s and the riverbed slope is as steep as 1/135. The flat area in Kofu basin consists of multiple alluvial fan areas created by several rivers. Among those, the majority of area was created by Kamanashi river. The nose of Ryuo is located at the center of alluvial fan, in other words it is at the top location of the fan area. The rivers on alluvial fan area flows relatively freely under natural condition. Because both Kamanashi river and Midai river are flow over the alluvial fan areas, the merge points in Kai City and Hatta village are faced with high danger of potential flood disasters. These locations are very important to prevent flood disasters. (Refer to figure-3.)

Shingen embankment stabilizes the river channel of Midai river and prevents the river from damaging Kamanashi river. In addition, it has the role to stabilize the river channel so that the main river may not be flooded in the center of the Kofu basin. The facilities, which construct Shingen embankment are designed so that the effectiveness of flood control improves synthetically by making full use of the river construction method of the right method at right place.

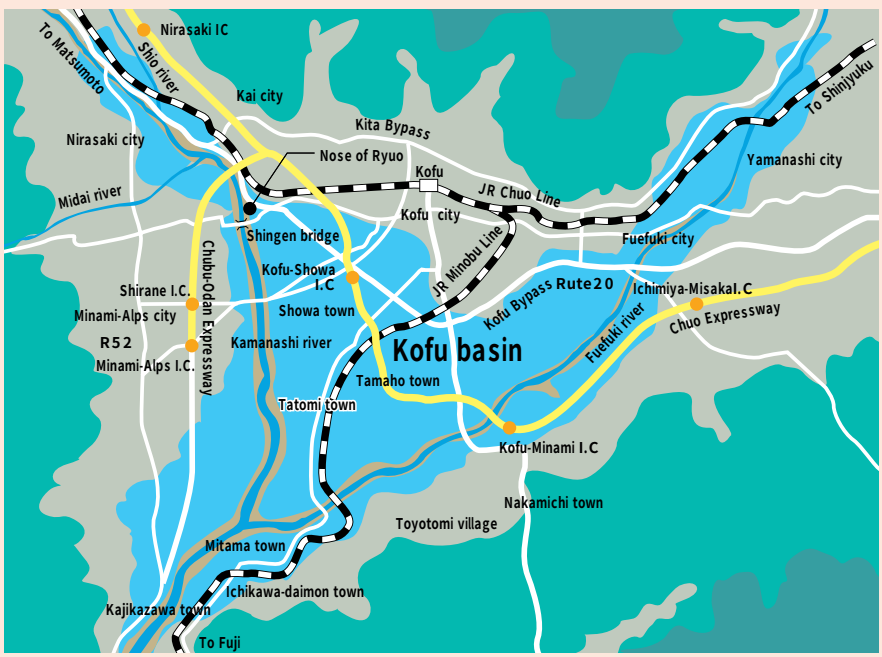


Figure-3 Flood area requires protection in Kofu basin.

Name of Midai River and Flood Control History

It is necessary to prepare flood control facilities such as embankments and water controls at Kamanashi river and Midai river for peaceful living and agricultural activities in Kofu basin. Therefore, many efforts at those locations has been done in early days. The historical record at Sengen shrine wrote that there was a massive disaster around Kamanashi river and Midai river in Kai country in 825. The governor, Akitsu Bunya reported to the Emperor. The Emperor sent a messenger to establish Sanjya shrine for flood control. It is said that the name of Midai river is called so because of the messenger from the Emperor. The damage record in 825 indicated that there were already established agricultural and housing properties.

The flood-fighting festival called " Omiyuki-san, " which still inherited in present days, started in that age.

We can understand that people lived in the basin tried lots of efforts to protect their lives and properties from flood disasters according to the various records of the shrines and local stories.

Midai river, originating from Koma mountains, merges into Kamanashi river.

The God for flood control in Kofu basin at Sanjya shrine.

Shingen embankment still protect people in Kofu basin.

Shingen embankment

Large zelkova trees at Shingen embankment tell its long history.

Shingen Embankment now

Not only in Yamanashi, there are several embankments called Shingen embankment in the mid central and Kanto area where Lord Takeda expanded their control; however, the most famous embankment is Shingen embankment located in Kai city. This embankment at Ryuo still protects the Kofu basin area from flood disasters. There is 20 - 30 m high cliff where the hills from the nose of Ryuo contacts with Kamanashi river.

This cliff is called Takaiwa, actually, this landscape is also a part of Lord Shingen's flood control plan. Although the present embankment is different form the original formation constructed by Lord Shingen, the many of the techniques used follow the special techniques in Koshu style. If we introduce some of those structures of the embankment, there are embankments, projected flow controls, water flow controls in series formation, river banks, reinforced riverbed, plantation between the embankments, and Takaiwa as the natural landscape. Please refer to the figure-4 as you read the following explanation.

The embankment at ❶ touches to the mountain side at K-186 around the left bank of Koshozuka, then constructed toward the lower stream. The projected bank ❷ constructed with parallel to the main embankment. The most upper projected bank touches to the mountain at K-187, extended about 400 m toward the lower stream. Next, another projected bank ❸ touches to the main embankment at K-184, extended about 400 m toward the lower stream. The next projected bank ❹ also touches to the main embankment at K-182, extended about 1,300 m toward the lower stream. This section has double banks structure of the projected bank and the main embankment. The opening is constructed at the lower end of the projected bank at ❺.

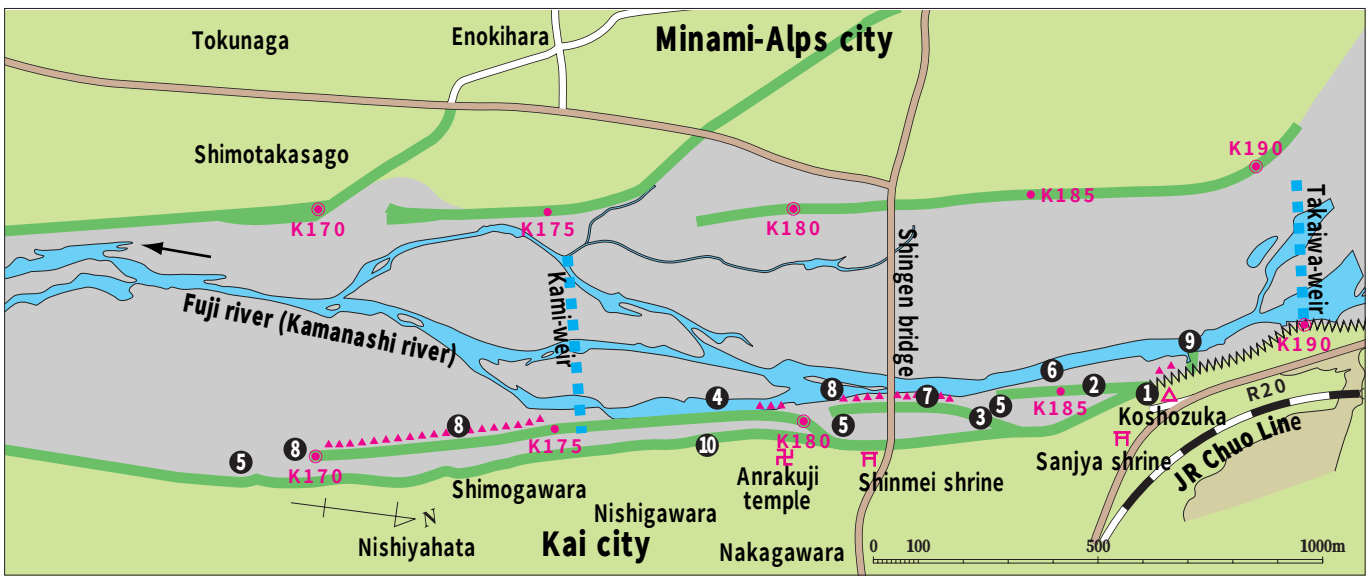


Figure-4 Present condition of Shingen embankment.

Residential and agricultural area

In other words, the technique of Geese formation by Koshu style is used.

The surface of the embankments and projected banks are covered with stones ❻, and water side of the embankment is reinforced with concrete blocks ❼ for excavation protection. These blocks are not seen under normal condition.

There are flow control called " Seigyu " ❽ units placed in series submerged in the water flow in front of the embankments. Furthermore, there is a projected flow control bank ❾ with tortoise-shell style attaches to Takaiwa above the contact with the main embankment. The flow control structures such as the projection and Seigyu are features found in the Koshu style techniques. The idea of Lord Shingen still exists in these days.

The most distinguish feature of the Shingen embankment is trees consists of zelkova ❿ for flood prevention. Those trees are standing for several hundreds years to protect us from driftwood, earth and sands. The wonderful zelkova trees give us beautiful scenes throughout four seasons.

The area between the banks are covered with grass as a part of river environment preparation plan. Many people are visiting for recreational activities.

Seigyu and concrete made surface covers are applied in the present days.

It offers recreational and relaxed moment to people.

Lord Shingen Takeda, the origin of flood control in Japan

From the past, " the person, who control water, also rule the country. " The success in flood control was the key for the stable country especially in Kai where there is little flat lands.

Lord Shingen Takeda with his age of 19 years old became the leader of Kai in 1541. The records said there were several flood disasters during 10 years forward and backward when he became the leader. The important information in the country was kept in secret during Sengoku period.

The flood control projects were important information in the area, so the plans and construction must be performed under strict secret. The flood control techniques were assumed as high technological issues in those days, those were never announced to the public. Only spies could get those secret information. However, his idea about flood control was so superb, then it became known to other countries. His method of flood control was called " Koshu Flood Control Method " in Edo period, it is recognized as the origin of the flood control technology in Japan. You will be able understand the this method which was kept in secret during Sengoku period as you read.

Large flood control project over 20 years

The reason of the construction was assumed because of a large flood disaster at Kamanashi river and Midai river in 1542. The construction said to be completed in 1560 according to the ancient written record about taxation as shown in photo-1. It was a large construction project which took about 20 years. This project was performed in a large size and with well-prepared plans. Figure-5 indicates the general information about this big construction event. The explanation will be following.

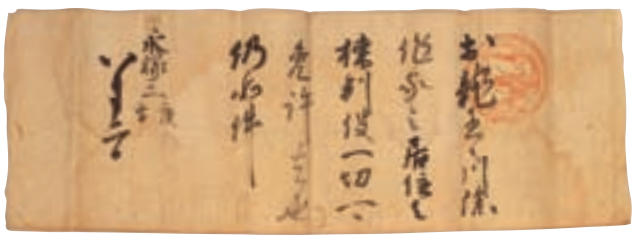


Photo-1 Sentence on a taxation record implies the completion of Shingen embankment.
* Owned by Hosaka family in Kai city

Old diagram shows the modification of stone stack at Midai river.
* Owned by Tsukiyama district in Minami-Alps city

Plan concerns both Midai river and Kamanashi river

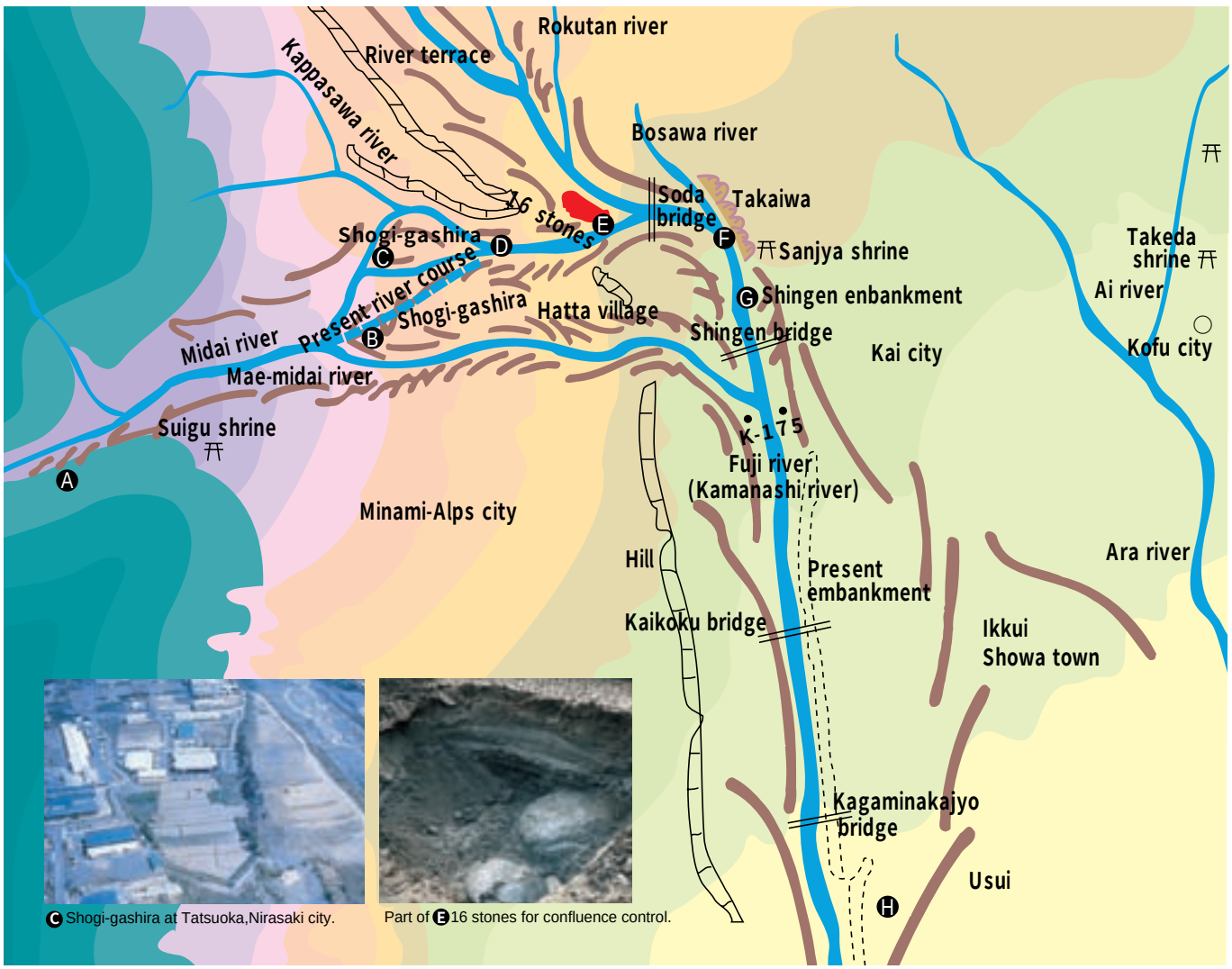
It is necessary to control Kamanashi river flow to protect Kofu basin from flood disasters, and to achieve this condition, it is necessary to control a branch, Midai river, first. Midai river, originating from the fragile area in Koma mountains and carrying a huge amount of earth and sands, formed an alluvial fan area with 4 km in radius. It flows faster over the alluvial fan area with 1/60 of average slope.

Midai river used to merge into the right side of Kamanashi river at K-175 during Lord Shingen period. The present Shinmeigawa position is same during that period. If Fast flowing Midai river with huge amount of earth and sands merges into Kamanashi river at this point, The force would push Kamanashi river toward the central area in Kofu basin. This was very dangerous condition regarding flood control. The experience from the disaster in 1542, he thought it was necessary to concern both Kamanashi river and Midai river as a pair for stable development of Kofu basin and stable land application. However, to promote this modification, there were following issues to be solved.

Ⓐ Stone stack to control Midai river.

1. Construction of rigid embankment to stop flooding.
2. Reduction of flow energy in case of heavy rain to protect the embankment.
3. Stable plan to reduce the influence of Midai river over Kamanashi river.
4. Treatment plan for sedimentation from Kamanashi river and Midai river.
5. Promotion method to announce the importance of flood control and to maintain function of the facilities.

There were many problems to solve the above issues.



Ⓒ Shogi-gashira at Tatsuoka,Nirasaki city.

Part of Ⓔ16 stones for confluence control.

Figure-5 Flood control diagram at Fuji river (Kamanashi river) and Midai river.
(There were two streams of Midaigawa until the disaster in Meiji 29.)

Lord Shingen took the following steps to solve those issues. Please refer to figure-5 as you read the explanation. First, to stabilize the passage of Midai river, a large size " stone stack " at Ⓐ (Tsukuyama, Minami-Alps city) in figure-5 to suppress the raged flow at the top of the alluvial fan area. Then, " Shogi-gashira " at Ⓑ (Arino, Minami-Alps city) and Ⓒ (Tatsuoka, Nirasaki city) were constructed to reduce the force of the current by dividing the flow, and Ⓓ (near Horikiri bridge) was excavated according to the divided flow as a pass to guide the flow to Kamanashi river. In addition, 16 large stones were placed at Ⓔ (Misada, Nirasaki city) to adjust the merging flow with Kamanashi river, and directed the main river flow toward Takaiwa at Ⓕ. Then at the area near the nose of Ryuo, Shingen embankment was constructed. Projected banks were placed to reduce the direct hit of flood water for double preparation. In case flood water went over the embankment Ⓖ, he constructed openings to guide the flood flow back to the main river at Ⓗ, Ikkui and Usui locations.

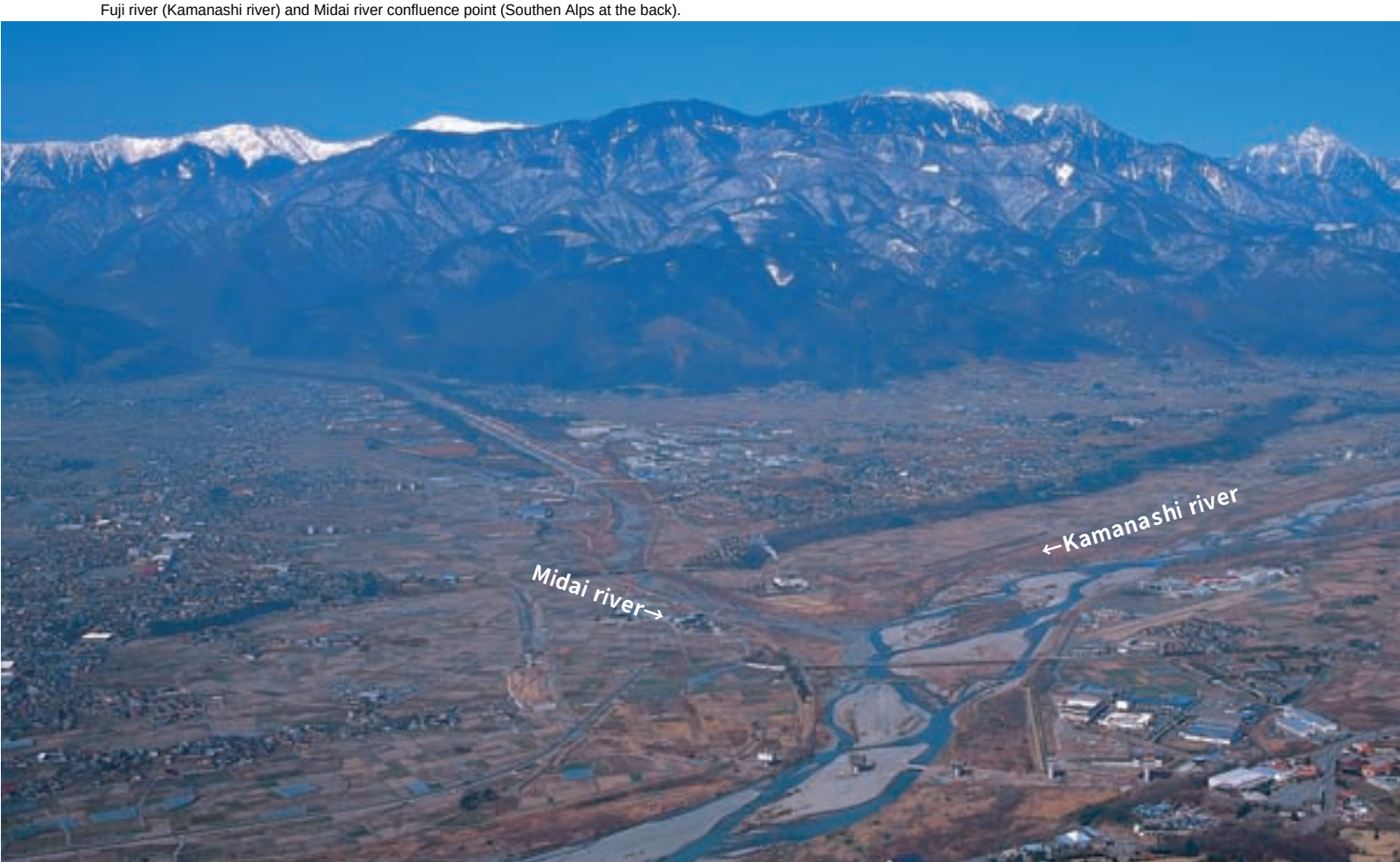
To keep and maintain the constructed facilities permanently, Lord Shingen set up " Ryuo river lodge " and ordered the people who live there to maintain the facilities including the embankment. At the same time, he exempted them from tax to win the hearts of the people. Also he promoted the traditional festival called " Omiyuki-san, " that people carried a portable shrine from Sengen shrine in Ichimiya-cho, Fuefuki city to Sanjya shrine where Shingen embankment locates, to announce the importance of the flood control issue.

The tradition continues to the present days, the flood prevention festival, Omiyuki-san will be scheduled on April 15 every year.

Fuji river (Kamanashi river) flows toward Takaiwa.

Omiyuki-san festival with unique foot step.

Fuji river (Kamanashi river) and Midai river confluence point (Southen Alps at the back).



Major facility in the east side of Kofu basin flood control

Manriki Forest

Yamanashi city, Yamanashi prefecture. (Fuefuki river)

Three of the most frequent disaster locations and Manriki forest

Fuefuki river reaches to Kofu basin at Sashide, Yamanashi city. This location was famous for its beautiful scenery and known since people in Heian period made a poem which described the river at Sashide area.

Manriki forest is located at directly lower area from Sashide. This is a highest point on the alluvial fan area formed by Fuefuki river, it was called one of the three of the most frequent flood disaster locations in Kai country. In present days, this area is a still important location for flood control in the east side of Kofu basin. There are Yamanashi city Shotokuji, Fuefuki city, and Kofu city Kawadacho located at the lower area from Manriki forest. The estimated large flow amount is 1,600 m^3/s and the average river slope is 1/60 which is a very steep river. Manriki forest is a flood control facility which consists of flood prevention trees and open levee.

The river basin near Fuefuki river used to be the center of the government management with the capital town in Nara and Heian periods. The names of area in Fuefuki city, such as Kou and Teramoto, show the evidence in the historical truth for above activities. The Fuefuki river area is an important in present Yamanashi prefecture. From agricultural point of view, fruit production amount of grapes and peaches is the top in Japan. Also wine production is ranked as the top in Japan.

The function of Manriki forest is to guide the flood water back to Fuefuki river at the embankment opening by blocking the carried earth and sands and driftwood with dense pine trees. Although the name, “Manriki,” appeared in the record during Nanbokucho period, it was heard that the name came from a wish to construct a strong river bank by joining the forces of ten thousands people. Manriki forest is well prepared as a river park and is a symbol of Yamanashi city.

Manriki Forest Now

Dense Manriki forest is located at the location where Fuefuki river is out from the mountain area and reaches to Kofu basin. The forest like Manriki is called a flood prevention forest, this is a famous flood control facility in Japan. Fuefuki river with a steep slope, carrying a lot of earth and sands, has changed its flow route many times since the past. During the flood disaster in 1907, it changed the flow direction near Isawa-cho, Fuefuki city.

Figure-6 indicates the present condition of the forest. The flood control facility like Manriki forest consists of trees for flood prevention, constructed objects such as embankment, river bank, and water control, and natural landscapes such as Tonoyama and Shishiiwa rocks. First of all, regarding embankments and river banks, ❶ is the upper banks. ❷ is the lower banks. ❸ is the low height stone constructed banks. ❹ is the former stone stacked embankment (Geese shape embankment). Those seem to be constructed after the disaster in 1583. Next, regarding the forest which is the main facility. Red pine trees with their diameter more than 60 cm located at ❺, there are about 500 trees in total. ❻ overlaps with the tree area, it is a retarding basin with approximately 13.5 ha. There is an opening of the river banks at ❼. Regarding flow control, there is water control of Sashide at ❽. This structure belongs to tortoise-shell style. There are concrete block foundations at ❾. As natural landscapes, there are Tonoyama at ❿ and its cliff at Sashide, and Shishiiwa rock (Manrikigaoka) at ⓫.

Analyzing the flood control method with those structures, First, the flood main flow is reflected by the flow control of Sashide at ❽ to the center of the river. The embankments at ❶ and ❷ and river banks will guide the flood water to the lower area. The low height river bank with stones at ❸ and concrete block foundations at ❾ will protect from excavation. If the flood water goes over the banks, the forest of red pine trees will protect the houses and fields by blocking earth and sands and driftwood. If the flood water enters into the embankment area, the flood energy is already reduced so the damage should be able to be kept in minimum level. If possible, the flood water should be blocked by the trees and guided back to Fuefuki river through the open levee at ❼.

Manriki forest will continue its function to protect our peaceful living from flood water.

Sashide stream known since Heian period.

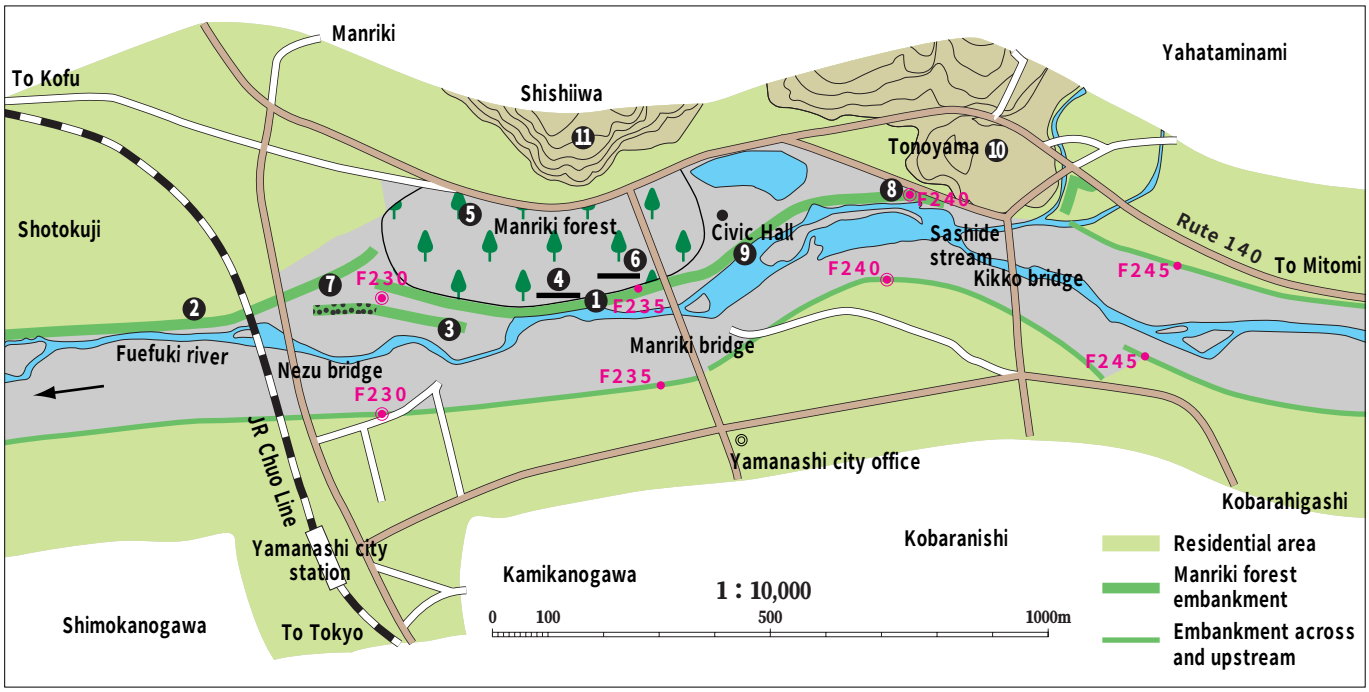


Figure-6. Manriki Forest present layout.

Manriki forest along Fuefuki river, a protection at the east side of Kofu basin. Okuchichibu mountains at behind.

Manriki Forest constructed by the efforts in the past

The name " Manriki " appeared as " Koshuji Manrikiken " in the document during the Nanbokucho period. The area near Fuefuki river was the political center in the early Yamanashi prefecture. Manriki seemed to be included in the Yamanashi area during Nara period. As we stated in the previous page, There was the capital called Kou in the past period. There was a flood control facility at Manriki area in the early age because Manriki area was the most suitable location to protect the capital from flood disasters. The historical record in 1583 indicates there was a flood disaster that damaged the embankment at Sashide and the flood water reached to the twenty one villages. During that period, Lord Tokugawa controlled the area. This record shows there were already some embankments constructed before.

The river construction near Manriki area was done after the huge disaster in 1583. The record indicated that the embankment with about 5.4 m high and 32.4 m long was constructed between the first point at Sashide and Semata, also trees were planted. There were several flood disasters in 1644, 1689, and 1713 during Edo period, but the damage was not so serious because of the embankments and tress. If you walk through Manriki forest, you will find some marks which made by the river water flow. There used to be festivals for flood prevention sponsored by the Yamanashi Oka shrine and Miwa shrine at Kaininomiya. Manriki forest has been well maintained through several hundreds years by the people live close.

Large forest prevents debris flows

The department of engineering at Yamanashi university studied about the flood control effects of Manriki forest and related facilities using a model. The result is shown in figure-7. The experimental results were conducted using the estimated large flow amount with 1,600 m^3/s and exceeded flow amount with 2,300 m^3/s. How much of earth and sands can be blocked by the pine trees? Where does it accumulate? What is the effect of the embankment? What is the geographical meanings of the facilities? What is the overall structural effect? If you observe figure-7 with these questions, it will be very obvious about the well designed flood control effect. As results, earth and sands accumulates evenly in the forest. This is because of a large area with 15 ha and trees planted over a flat ground.

In addition, half of the flood water follows toward the embankment opening, effects which reduce the flood damage can be highly expected. Remarkably, we should pay attention to the roles of Tonoyama at the natural hill in the west

side, the cliff at Sashide, and Shishiiwa rock at Manriki mountain. During a huge water flow which exceeds the estimated flow amount, the rapid flow will go straight in front of Tonoyama, then be reflected by Shishiiwa rock, and return from the opening. These location arrangement might be decided as they observe the flood in 1583.

Manriki forest is a large area. Trees consists of mainly red pines and other broad-leaved trees. The area includes birds and other species habitats, irrigation channels with pleasant water sounds. These natural and active ecological system is located near the central of Yamanashi city. This is an ideal location that can offer people with pleasant moment. A low height embankment that is constructed with actual large size stones found near the river is named as "stone embankment." This multi-natural style river bank was first constructed in Japan.

Manriki forest is an important facility of the new era where people can realize the flood control history and get relaxed moment with close to the river and water.

Manriki Forest is a flood control forest consists of red pine trees.

Manriki Forest can be also a park.

Stone stacked bank in the past.

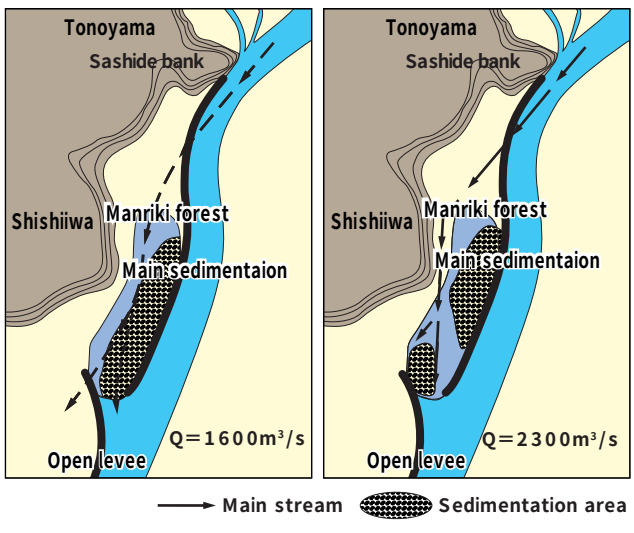


Figure-7 Study diagram about flood control effect.

Open levee. (A stream offers pleasant moment.)

Completed by 3 generation of Furugori family

Karigane Embankment

Fuji city, Shizuoka prefecture. (Fuji river)

As a guardian protects a large Fuji plain

Fuji river reaches to the plain field at the area between Iwamoto, Fuji city and Kijima, Fujikawa town. This flat area used to be called as Kashima-gosengoku. Fuji plain is an alluvial fan created by Fuji river. This alluvial fan area with its center at Iwamoto is gently tilting toward Suruga bay. Its slope is 1/230, the radius is about 7 km, and the arc length is about 10 km.

Fuji river flows over this plain area, the left side is Fuji city and the right side is Fuji river town and Kanbara town. About 380,000 people live in the area, the base for paper manufacturing and aluminum refining which are the leading industry in Japan, and it's also an important location for transportation.

This area was also an important location for transportation during Heian period. There is a record in 864 which described this location. In these days, there are six bridges go over, such as Tokaido Shinkansen, Tomei Express way, Tokaido Line, Rute 1, and Suikankyo bridge, etc. If there is any flood at Fuji river, the damage is against not only people in the area but also the nationwide. Refer to figure-8.

The facility that leads a high amount of flow from Fuji river under control and protects against flood disasters is called Karigane embankment. The name came from an image of flying geese in the sky if we observe the embankment from a higher location. It has been about 330 years since its completion. It continues to protect Fuji plain area which was called Kashimaso before, keep people's living, properties, main industries, and transportation routes safely. The flood control secret of Karigane embankment is found the unique design.

Karigane Embankment Now

Karigane embankment is located at the location when Fuji river reaches to the flat area. The estimated large flow amount is 16,600 m³/s and the river slope is 1/230, this amount is ranked at the 3rd in Japan. Karigane embankment has various methods to an increased volume of water flow in the river area There might be more other methods which we don't recognize yet. Please see the present features one by one.

Karigane embankment consists of several constructed structures and natural landscape. If we categorize the into major groups,

1. Embankment 2. Projected flow control
3. Gyuwaku flow control 4. Natural landscape

there are total of four groups. Figure-9 shows the present Karigane embankment. Please refer to this figure wile you read the following explanation.

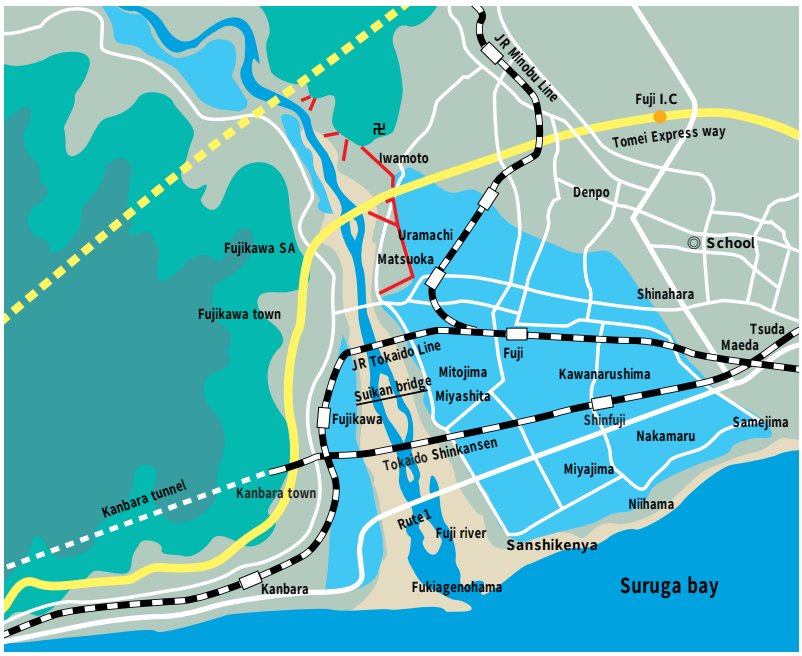


Figure-8 Flood area requires protection at Fujikawa lower area.

Karigane embankment
Flood area

First, regarding embankments, ❶ is the main bank of Karigane embankment. ❷ is the leading bank which called 90 ken embankment. Regarding projected flow controls, those belong to tortoise-shell types. ❸ is the new 1st projected flow control, ❹ is the 1st projected flow control, ❺ is the 2nd projected flow control, and ❻ is the 3rd projected flow control. As the structures belong to projected banks, there are Bizen embankment at ❼, Shinbizen embankment at ❽, and Yanagi embankment at ❾. Next, regarding Gyuwaku flow controls, there concrete middle size Seigyu flow controls at ❿. As the landscapes used for flood control, there are the rock of Iwamotoyama at ⓫, the Suijin rock at ⓬, and Amagafuchi cliff on the other side at ⓭. In addition, as the gods who control water gathering the local people's reliance and respects, there are Gosho shrine at ⓮ and Suijinja at ⓯.

This Karigane embankment completed in the early Edo period, by efforts, tremendous cost, and 50 years of period offered by the three generations of the local clan , Furugori family who worked as the officer of Suruga area.

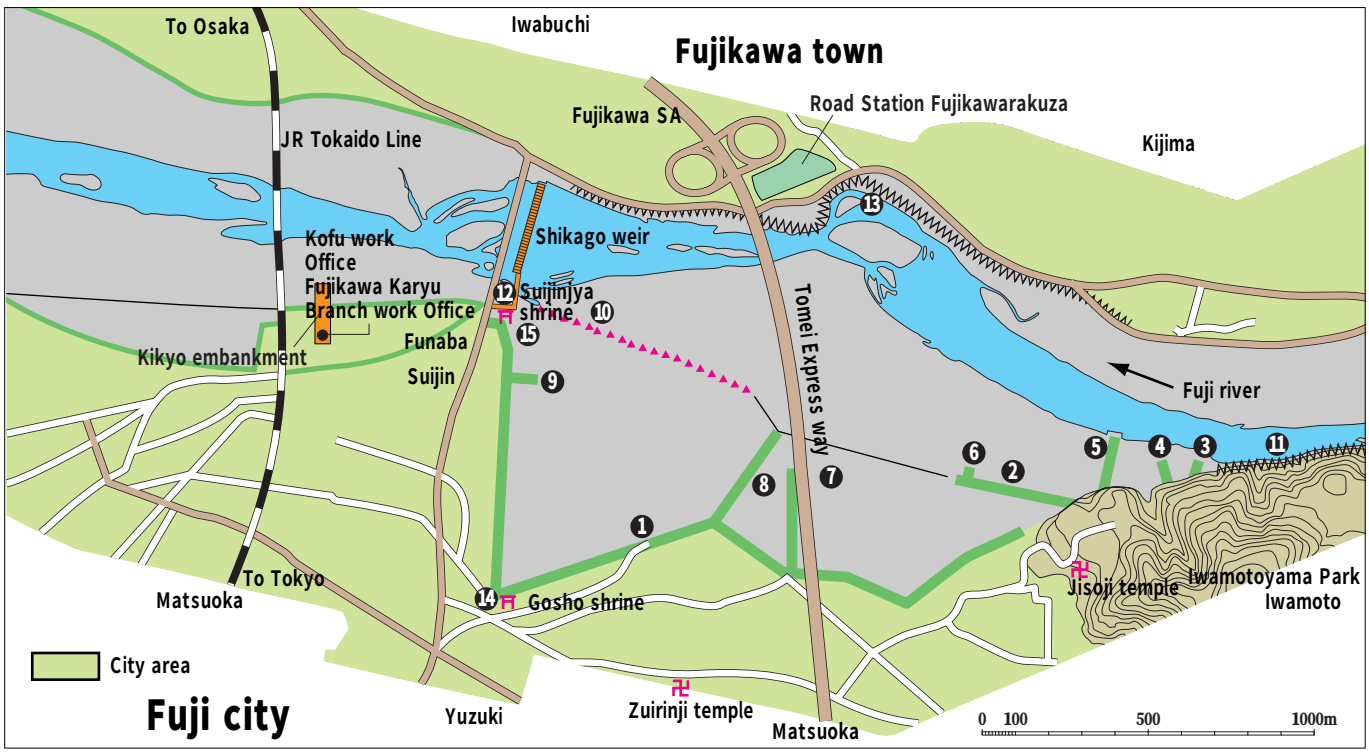


Figure-9 Present Karigane Embankment.

Furugori clan control expanded to Kashimaso

In 1279, during Kamakura period, a nun went across Fuji river. She wrote on her diary said " After sun rise, the morning was really cold at Fuji river. I went over 15 streams. "

In those days, Fuji river seemed to be divided into many streams. This area was called Kashimaso in the past. During Sengoku to Edo period, agricultural fields had been reclaimed by the clans lived near. Furugori from Sutsuso Nakasato was one of those clans.

The ancestors of Furugori clan reclaimed the area near Matsuoka, Fuji city, and originated Kagoshita village around in 1555. During Sengoku period, there were three dominant lords, Imagawa in Suruga, Takeda in Kai, and Hojyo in Sagami, who competed their powers. This area was ruled by various clans. Edo Shogunate was established in 1603, it was about 50 years later after Furugori clan started to reclaim the land. the development in Kashimaso was promoted but there were many flood disasters occurred.

Karigane Embankment construction started initially by Shigetaka

Shigetaka who was the head of Furugori clan started the construction in 1621 to protect the in Kagoshita village from flood disasters. Later, he was appointed as deputy governor by Surugahan. His son, Shigemasa, also continued the father's will to make efforts to control flood disasters. Sigemasa worked not only to prevent disasters but also to expand the irrigation channel for agriculture in 1640. His clan's income increased to 1100 koku units because of his achievement. However, a massive flood disaster in 1660 destroyed the all agricultural fields that Furugori clan reclaimed through the past 100 years. Shigemasa tried to start a new construction but he passed away without completing his goal with the age of 66 years old. His will was inherited by his son, Shigetoshi.

Furugori clan tomb at Zuirinji temple.

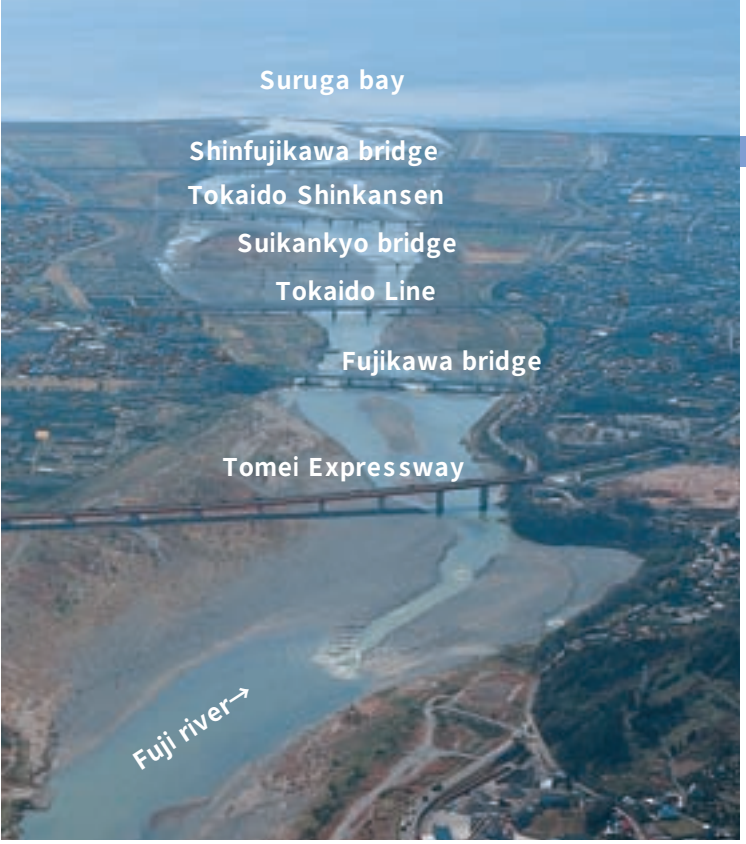
Karigane Embankment, resembling to Geece flying in the sky, Fuji river mouth and Suruga bay.

Third generation, Shigetoshi, completed Karigane Embankment

Inheriting his grandfather's and father's flood control technology, Shigetoshi also referred to the technology of Takeda clan in Kai with some advice of the monk at Tanrinji temple, trying to improve flood control plans which endure against massive disasters. In 1667, he started a big construction that never tried before.

So far, the flow of Fuji river mainly separated into the east and west at the Suijin rock and formed small streams. By constructing an embankment between Iwamoto and Suijin rock to close the east streams, he tried to merge Fuji river flow into one at the west side. Only embankment was not enough to control Fuji river's fast flow, projected flow controls with tortoise-shell structure, Iwamoto 1st and 2nd, to bounce the water flow, extended Bizen embankment to reduce the water energy were constructed. The area from Suijin rock to Iwamoto and surrounded with the bank was used as a reservoir. With those complex effects, his plan tried to protect Fuji plain and Kashimaso from flood disasters. This construction was completed in 1674. Since then for 330 years, the area is still well protected by Karigane embankment.

Spring scene at willow embankment.



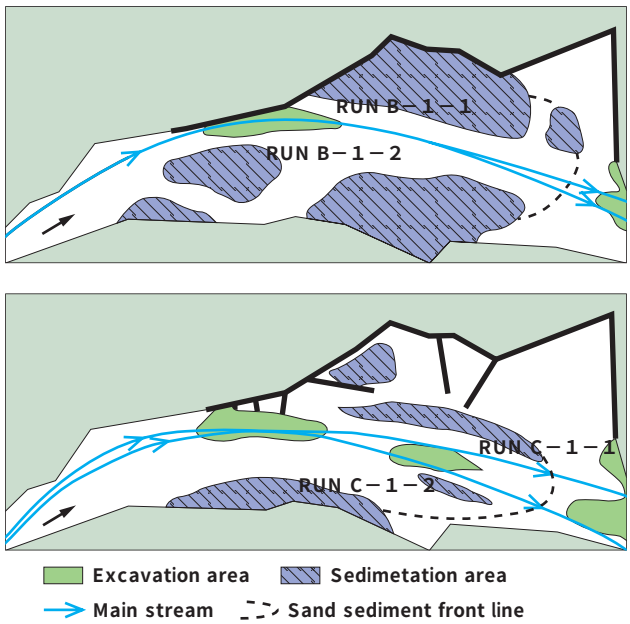


Figure-10 Study diagram about water control effects.

Studying the flood control technology at Karigane embankment

Why is the shape of the embankment resemble to Geece flying in the sky? Figure-10 indicates the experimental result by the department of engineering at Yamanashi university to study the technology using the estimated large flow amount. As a result, the direction of the main flow can be guided to the river center without accumulation of earth and sands by the effects of projection at Iwamoto and Bizen embankment. The shape of embankments, the angle of Bizen embankment, and projection at Iwamoto are so ideal to control flood flow. (Refer to figure-9.)

Things we should not forget is a pious history about Gosho shrine. Even an embankment was completed, it was soon destroyed. A story says that a 1,000th person who crossed Fuji river was sacrificed as a victim to the god. Since then the embankment was not destroyed any more. Gosho shrine was dedicated to the victim's spirit.

Recent investigation indicated that there is an active Fuji river dislocation near the area. It got active with about 150 years cycle. This dislocation is able to move 150 cm in vertical direction. When the giant earthquake occurred in 1937, The record at the Kofu construction office indicates there was a collapse at the embankment.

1st, 2nd, and 3rd projected flow control are located near Mt. Iwamoto at the North edge of Karigane embankment.

Epilogue

We have observed "Shingen embankment," "Manriki forest," and "Karigane embankment" as treasures along Fuji river. These facilities made by our ancestors are still control and protect us from flood disasters. Normally these are very quietly standing.

The future flood control might need to improve according to our new era. We would like you to get close to Fuji river, and please put your opinions, impression, and suggestion.

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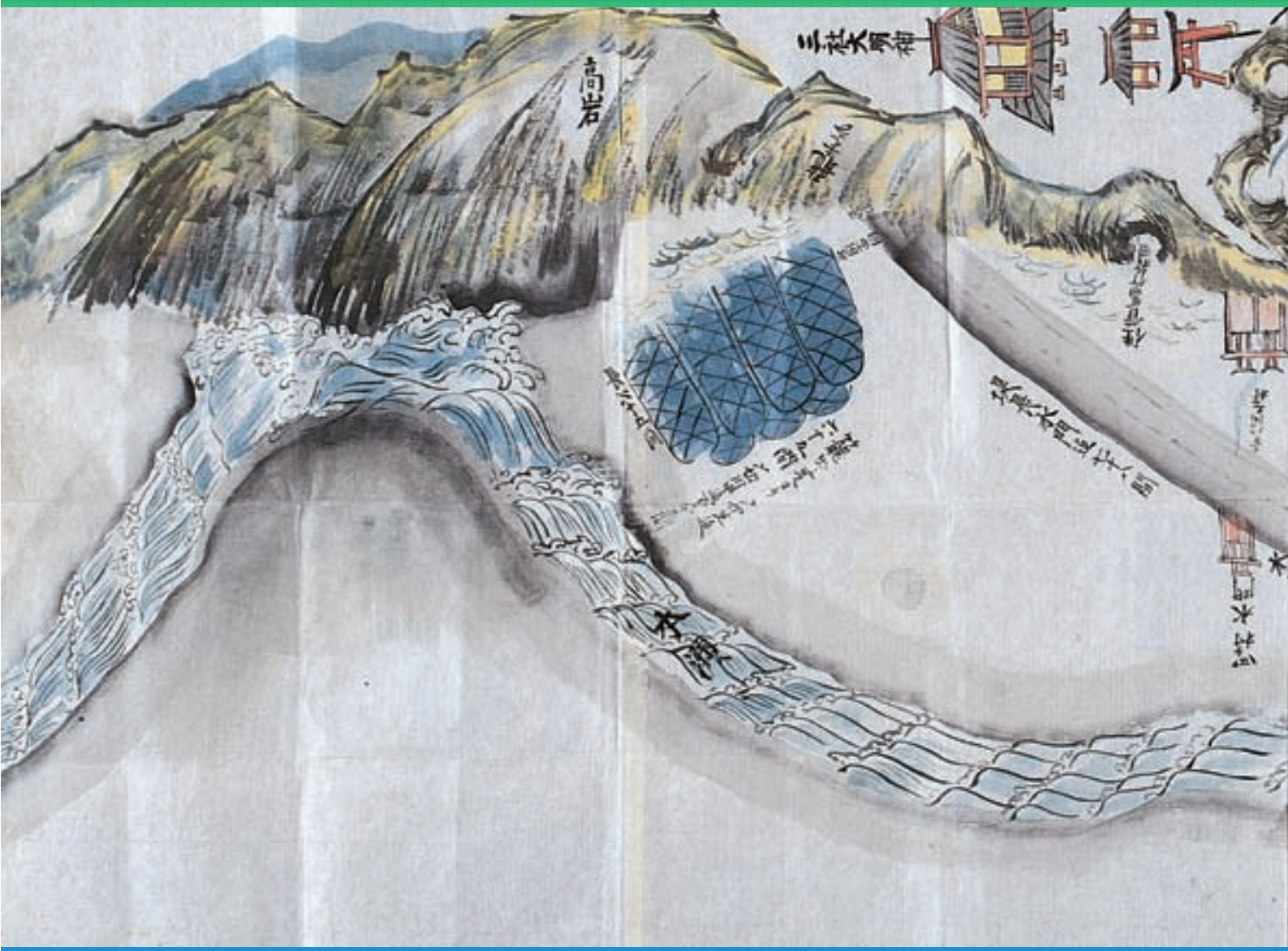
FUJI RIVER'S FLOOD CONTROL



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