The development of modern river management in Japan[1]

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This article is aimed at providing an overview of the general development of modern river management in Japan. In addition to institutional development, the improvement in the Tone River, one of the most important rivers in Japan, will be described as a specific case. The following content of this article will justify the selection of the river.

A hydrological comparison between rivers in Japan and in the Netherlands[2]

The territory of Japan consists of four large and other small islands. About seventy percent of the total land area of Japan is contained in steep mountains, therefore rivers are very short and steep compared with great rivers in large continents. In contrast, the average annual precipitation in Japan is about 1,750 mm, well over twice the average in the Netherlands. The water from precipitation collects in rivers and reaches the sea in a short time period. Thus, the maximal discharge in those rivers is generally large in comparison to their size, while it lasts only a short time.

The average monthly precipitation shows a yearly cycle. A considerable portion of precipitation occurs during the rainy season from June to the beginning of July as well as during the typhoon season around September. In addition, meltwater flows out from snowfields on mountains in April and May. Generally speaking, the dry seasons are from December to March in winter and from the middle of July to the end of August in summer. One of the difficulties in the Japanese water management consists in the fact that both overflow and shortage of water should be taken into account in summer.

Wet rice culture, the most important in Japanese agriculture, requires an abundance of water for irrigation. Contrary to the Netherlands where the great rivers supply water constantly even in the dry seasons, drought in summer can be serious in some regions in Japan. On the other hand, paddy fields are drained for harvest. Before the advent of powered pumping drainage of the fields occurred only by gravity. The climate is less favorable for wind power utilization in Japan than in the region on the North Sea.

River and water management in the pre-modern period

In the Edo period (1603-1867), river works were conducted under the control of the shogunate. Flood control in that time depended primarily on local countermeasures. For example, embankments protecting the land of the *Shōgun* were made higher than those of other lords [*daimyos*] on the other side of the river who were forbidden to raise the embankments. In some cases, embankments were built around settlements, being quite removed from the river in expectation of inundation. Along the river embankments a few overflow points were planned in advance and wood zones were formed in order to reduce the impetus of the overflow. Furthermore, inhabitants of flood-prone regions had provisions for the worst such as evacuation mounds [*mizuka*], elevated shelters [*mizuya*] and emergency boats.[3]

1 I thank Professor G. P. van de Ven for offering me the occasion to write this paper as well as for his constant support and encouragement. Professor A. Porsius and Bart van de Ven have read this paper and provided valuable comments. The Heiwa Nakajima Foundation gave financial support to my study in the Netherlands. And, finally, I am grateful to Maarten Slooves for drawing the maps.

2 River Bureau, Ministry of Construction Japan (supervised.), *The River Law with commentary by article* (Tokyo 1999), E-vii; Y. Takahashi, *Kasen kōgaku* [River engineering] (Tokyo 1990), 281-290; K. Noma, 'Suiri no tōsei ni tsuite [On the control of water utilization]', *Suiri to Doboku* 9 (1936) 10, 11-24.

3 *The River Law*, E-i-E-ii; T. Ōkuma, *Kōzui to chisui no kasen-shi* [Floods and water management in the history of rivers] (Tokyo 1988).

The beginning of the modern water management in Japan[4]

Modern water management in Japan began during the Meiji period (1868-1912) when a number of Dutch civil engineers were invited to this country. In 1872 the chief engineer, Cornelis van Doorn, placed the first water gauges in Japan at *Sakai-machi* by the Tone River and *Kema* by the Yodo River. The visiting engineers made plans for the improvement of rivers and harbours throughout Japan.

Activities of the Dutch engineers are often characterized as river improvement with a view to navigability [*teisui kōji*].[5] At the beginning of the modern period, the Japanese government made an enthusiastic effort to increase production and to foster industries under the slogan 'a rich nation, strong soldiers'. During that period, inland navigation was of the greatest importance as a means of transportation. Therefore the central government actively took the initiative to improve rivers for navigation, while flood protection was deemed to be a task of local governments.[6]

This situation gradually changed after the advent of the railways. After the first rail line between Tokyo and Yokohama was laid, a network of railways quickly formed. The government constantly and strongly supported this enterprise. By the end of the Meiji period, the total length of the railway system reached approximately 11,000 kilometers. However, railway expansion undermined the position of inland river navigation which was dependent on the weather and the condition of low water. The center of gravity in transportation shifted from inland navigation to travel by rail.

Contrarily, demand for flood protection developed against the background of the progress of reclamation of marshy areas. In addition, in the early and middle Meiji period, floods frequented many parts of Japan. When the Imperial Diet was inaugurated in 1890, a large number of requests for flood protection were submitted.

In 1896, the River Law, the fundamental law concerning the public works for river improvement, was finally enacted. The law required local governments to assume the primary responsibility for river works and maintenance as before, but it also stipulated that the national government should undertake a river improvement project in cases in which the project had interprefectural effects or if the difficulty or the cost exceeded the capacity of the local government concerned. The result was that the central government launched actively into works for flood protection. Directly after the enactment of the River Law, flood protection works for three of the principal rivers in Japan began under the direct control of the Ministry of Interior.

Furthermore, fourteen years later, following a nationwide flood in 1910, the Emergency Flood Control Committee was formed by an Imperial order. The committee framed a First-phase Flood Control Plan and recommended increasing the number of rivers to be improved through national projects to sixty-five.

The Tone River in the pre-modern era[7]

The Tone River, or *Bandō Tarō*, is one of the greatest rivers in Japan, running through the Kanto plain (Fig. 1). The plain, where Tokyo is located, is the largest in Japan. The total surface area of the Kanto plain is 32,000 km^2, only slightly smaller than the total surface area of the Netherlands (36,000 km^2) (Fig. 1).

Presently, the mainstream of the Tone River flows from the mountainous inland to the far north of Tokyo into the Pacific Ocean at Chōshi, Chiba. The river basin amounts to 16,000 km^2, the largest in Japan. However, it was not so from the outset. Historical documents indicate that, prior to the modern era, the main river flowed into the Tokyo Bay (Fig. 2).

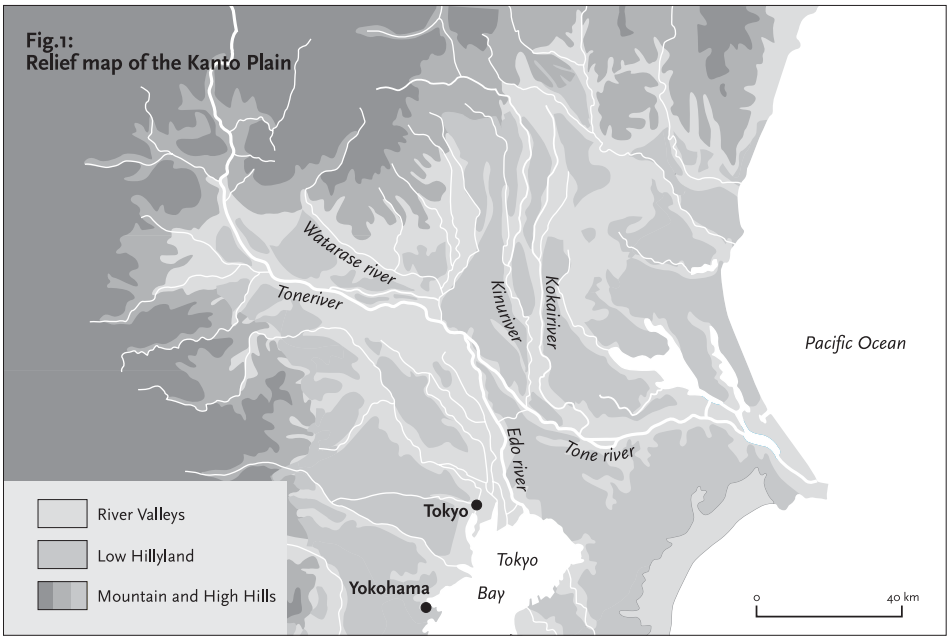
Since Tokugawa Ieyasu moved in 1590 to Edo (presently Tokyo) and there later in 1603 established his shogunate, the Tone River underwent various artificial modifications.

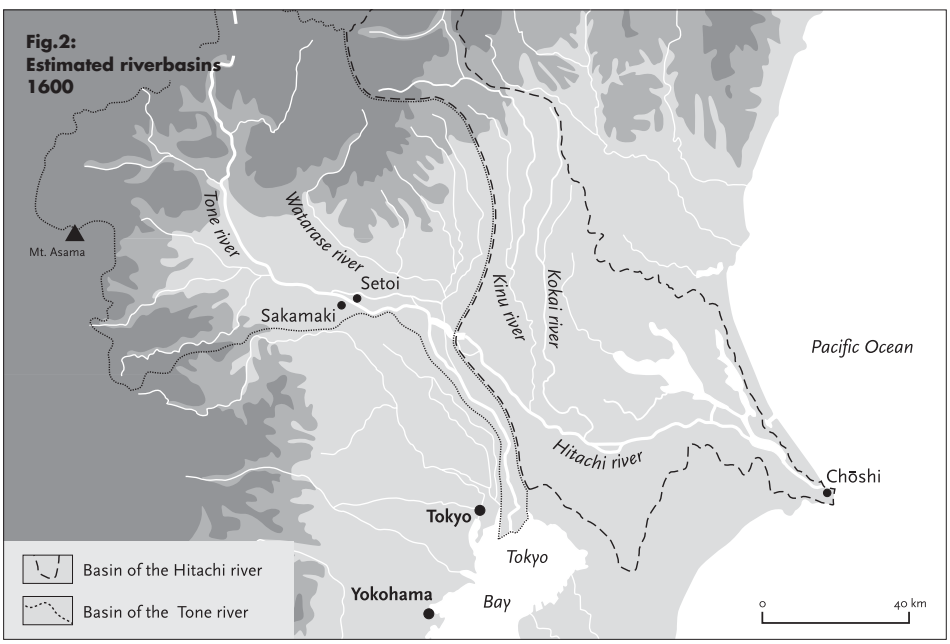
4 *The River Law*; L.A. van Gasteren et al. (eds.), *In een Japanse stroomversnelling. Berichten van Nederlandse watermannen - rijswerkers, ingenieurs, werkbazen - 1872-1903* (Amsterdam/Zutphen 2000); T. Ōkuma, *Tonegawa Chisui no Hensen to Suigai* [Changes and Damages in the History of the Water Management of the Tone River] (Tokyo 1981); Ōkuma, *Kōzui to chisui no kasen-shi*.

5 Customarily in Japan, water management [*chisui*] is divided into two parts, water management in a narrow sense, i.e. that for flood protection, and water utilization [*risui*]. The latter comprises works for irrigation, drinking-water supply, inland navigation etc. In particular, works intended for improvement of inland navigation are called 'low-water works [*teisui kōji*]'. Conversely, works for flood protection are called 'high-water works [*kōsui kōji*]'.

6 It was not explicitly determined, but a widely accepted custom at that time. Cf. Tonegawa Hyakunen-shi Henshū Iinkai [the editorial committee for the centenary history of the Tone River], *Tonegawa Hyakunen-shi* [the centenary history of the Tone River] (Tokyo 1987), 524, note 1.

7 Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 1-106; ibid., *Kōzui to chisui no kasen-shi*, 106-120; H. Koide, *Nihon no Kasen Kenkyu* [Studies on the rivers in Japan] (Tokyo 1972), 8-93.



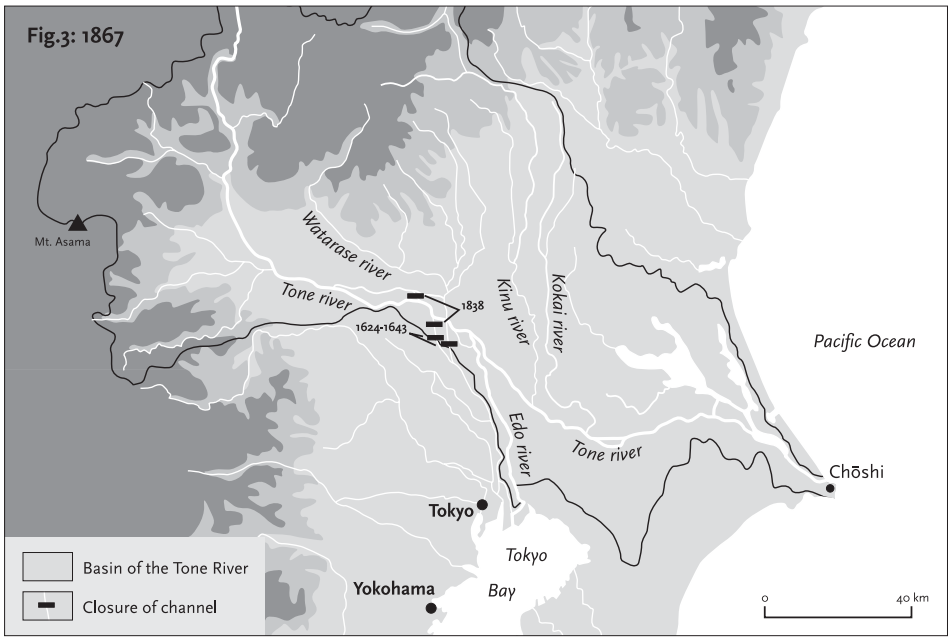


Finally, by cutting a new channel, it was connected to another river called Hitachi River that originally belonged to a different basin. Although the precise purpose of this great earthwork is not yet known with certainty, it is very likely that promotion of inland navigation was initially aimed at improving the transportation of commodities from the hinterland to Edo. For Edo, then no more than an underdeveloped fishing port, it was *sine qua non* to grow into an important economic center comparable to older cities in western Japan such as Kyoto and Osaka.[8]

Thus, a system of waterways came into existence that connected the northeast area of Japan to the Kanto region. A navigation route from the basin of the Kitakami River to the basin of the Tone River via Chōshi was established. The route was connected to Edo via the Edo River, a large branch of the Tone River that splits off about forty kilometers to the north of Edo and flows into the Tokyo Bay to the east of the city. The Tone River served as the trunk of that network throughout the Edo period (1603-1867).

The principle of water management in the Tone River at that time was established by the Ina family who served the Tokugawa shogunate. In order to mitigate flooding they

8 In the traditional historiography of the Tone River, it has been supposed that the purpose of this shift, the so-called *Tonegawa Tosen* [the displacement of the Tone River to the East], was to protect Edo against the floodwater. H. Koide (1972) was the first who cast doubt on this supposition. T. Ōkuma argues that possibly the initial purpose was the improvement of the inland navigation. Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 38-50.



adopted soft measures that tolerated inundations to some extent. For example, they left a bottleneck between *Sakamaki* and *Setoi* in the upper Tone River so that flooding and overflow from the river channel would be hindered there. Thus, the discharge in the middle and lower stream is supposed to have been limited considerably. The *Sakamaki-Setoi* bottleneck can justly be regarded as the pivotal anti-flooding measure of the Inas. This system seems to have functioned reasonably during the early and middle stages of the Edo period.

The situation changed drastically in the end of the eighteenth century. In 1783, Mount Asama erupted and the descent of volcanic ash caused the riverbed to rise along the Tone River. Thereafter, inundations occurred more frequently all over the river region. The system implemented by the Inas was disturbed. At approximately that time, groynes were constructed at the upper mouth of the Edo River. The purpose of this construction was supposedly the protection of Edo against the floodwater of the Tone River. Because of complaints from the inhabitants upstream, a convention was established that the river breadth at that point should be kept at least about 32.7 m. From then on it appeared that more water began to flow into the lower Tone River by flooding and embankments there burst more frequently. Since then, the course of the management of the Tone River kept varying until the end of the Tokugawa shogunate (Fig. 3).

The beginning of the modern era of river improvement in the Tone River

As mentioned previously, Dutch engineers were engaged with the Tone River since just after their arrival. Following the establishment of the water gauge at *Sakai-machi*, Isaac Lindo, a graduate of the Koninklijke Militaire Academie te Breda, took the level along the Tone River and established the original bench-mark for Japanese topographic maps. On the basis of this survey, he submitted a report in 1873, in which he proposed to return the floodwater of the Tone River to the Tokyo Bay, making the Edo River the mainstream.[9]

However, thirteen years later, when another Dutch engineer, Anthonie Rouwenhorst Mulder, drew up a master plan for the Tone River, the idea to expand the Edo River was relegated to the background. Mulder states three objectives in his plan, namely, improvement of navigability, flood protection and reclamation of marshes. Concerning the first two points, he suggested the regularization of the river breadths. Although he proposed to remove the groynes at the upper mouth of the Edo River, the premise of

9 Van Gasteren, *In een Japanse stroomversnelling*, 153; Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 109-111; I. Lindo, 'Rindo Nihon chisui no setsu [a report on water management in Japan by Lindo]', in: the Tokyo Branch Office of Bureau of Civil Works, the Ministry of Interior, *Tonegawa kaishū enkaku kō* [a historical outline of the improvement of the Tone River] (Tokyo 1928). The original report in Dutch by Lindo was supposedly lost with other documents concerning the improvement of the Tone River in the great earthquake in 1923.

his plan was that the distribution of floodwater between the Tone River and the Edo River should not be altered. This stipulation was probably consistent with the opinion of the concerned Japanese officials that Mulder would meet. Among other things, it is remarkable that Mulder recommended leaving a number of ponds along the lower Tone River intact as retarding basins.[10]

Mulder's plan, although it was a rather rough outline and left much unsubstantiated, presented a scheme to improve the entire Tone River from the upper stream to the estuary. According to this plan, the improvements would be implemented during the period from 1887 to 1905 on a budget of ¥4,077,215.657.[11] In the work actually executed, it appears that emphasis was placed on maintenance of the minor bed and the navigation channel.[12]

In the meantime, contrary to Lindo's former proposal, the groynes at the upper mouth of the Edo River were reinforced and the river breadth at that point was considerably narrowed. While the breadth seems to have been 47 to 55 meter at the end of the Edo period, it was reduced to about 16 meter as a result of a series of constructions during the Meiji period in 1875, 1884, 1885, 1896 and 1898, respectively. Although contemporary sources suggest that this reinforcement was performed by initiatives from the Dutch engineers, it is implausible on grounds of their reports cited above.[13]

In the same period as the improvements according to Mulder's plan proceeded, floods repeatedly struck the area along the Tone River. The dissatisfaction of the inhabitants took the form of fierce criticism against the so-called 'Dutch techniques'. After the enactment of the River Law, improvements according to Mulder's plan were discontinued in 1899 so that a new project, aimed principally at flood protection, was launched in the following year.[14]

The First Improvement Work of the Tone River, 1900-1930

Instead of the plans of Lindo and Mulder, Japanese successors adopted a large-scale dredging and embanking scheme over the entire reach of the Tone River. The Tonegawa Kaishū Kōji [the Improvement Work of the Tone River] began in 1900 (Fig. 4). In that plan, the design-flood discharge was fixed at 3750 m^3/s in the upper stream. At this design-flood discharge, flooding was estimated to occur a few times during every ten years. For the Edo River, a discharge of approximately 970 m^3/s was assigned and the idea to direct the main floodwater to the Edo River totally disappeared. Conversely, marshes along the lower stream should be separated by sluices from the mainstream in order to prevent backwater. Consequently, all floodwater should now be disposed within the river channel. The period of construction was divided into three terms. In the first (1900-1909) and second (1907-1930) terms, primarily improvement of the lower stream was performed. During the third term (1910-1930), construction occurred in the middle and upper streams.[15]

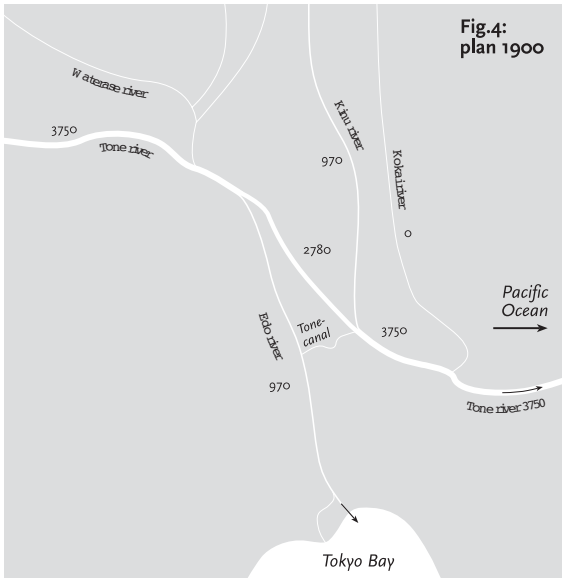
However, on the 8th of August 1910, ten years after the work began, the Tone River was struck by a huge, unprecedented flood. The largest discharge in the upper stream was estimated at 7000 m^3/s, nearly twice the design-flood discharge of the improvements under construction. The plan was revised and the design-flood discharge was increased to 5570 m^3/s (Fig. 5). The increment was to be coped with as follows. Firstly, because construction for the first term was already completed and that for the second term had already begun, a great deal of the increased discharge would be diverted to the Edo River. The assigned discharge was augmented from 970 to 2230 m^3/s. Secondly, it was proposed to make the cross-section of the river as large as possible. Alterations during the third term were realized by (1) constructing retarding areas, (2) leaving the old river channel intact as much as possible such that the breadth between old embankments was wider than the standard, and (3) increasing the freeboard of dykes. The completed sections of the first and the second terms were managed only by raising dykes.[16]

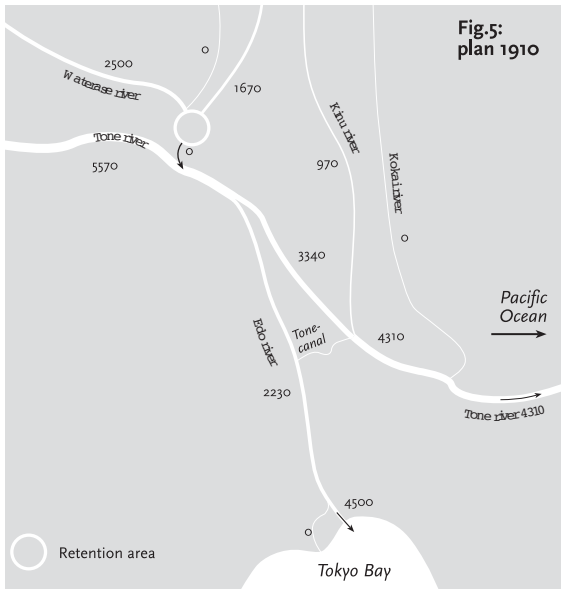
10 A.Th.L. Rouwenhorst Mulder, 'Tonegawa (Tsumanuma yori umi ni itaru) kaishū keikakusho [an improvement plan for the Tone River from Tsumanuma to the sea]', reproduced in: R. Kurihara, 'Tonegawa chisui-shi [the history of water management in the Tone River], no. 13, 14', *Kasen* (June-July 1957), 51-61; 50-57; Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 114-120. As for an overview of Mulder's activities in Japan, see Van Gasteren, *In een Japanse stroomversnelling*, 290-311.

11 The Japanese government then issued the 1-yen silver coin for payment in international trade. The coin had almost the same weight and the same fineness as the Mexican silver dollar that was frequently used for foreign trade in North and South America and East Asia. The 1-yen silver coin was used for inland trade as well. Although there were also bank notes for yen, it is not until 1885 that they became generally convertible into the silver coins. See Van Gasteren, *In een Japanse stroomversnelling*, 170.

12 *Tonegawa kaishū enkaku kō* (1928), 32; [S. Kondō?], 'Tonegawa Kōsui Kōji Keikaku Ikensho [advice on the plan for flood protection in the Tone River]', reproduced in: R. Kurihara, 'Tonegawa chisui-shi [the history of water management in the Tone River], no. 17, 18', *Kasen* (December 1957-January 1958), 55-64; 44-56, there December 57; Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 117.

13 At that time, pollution of the basin of the Watarase River, an upper branch of the Tone River, produced a serious environmental problem. It was caused by toxic drainage from a mine at *Ashio* and absorbed public attention. Ōkuma suspects that the government was afraid that the polluted river water would enter Tokyo. Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 123-129; *Tonegawa kaishū enkaku kō*





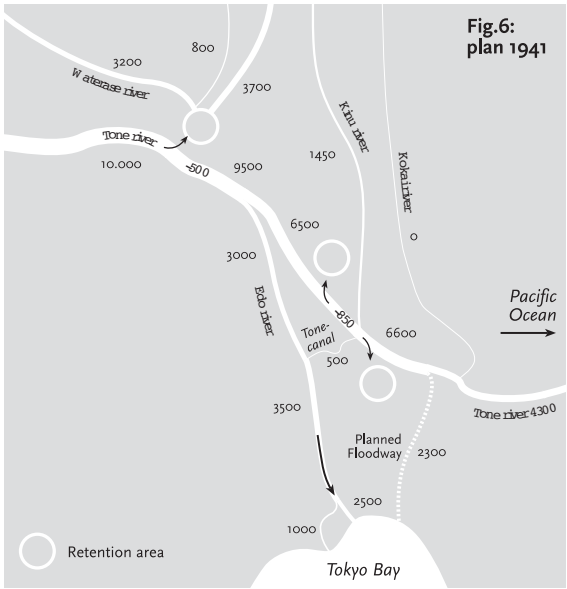
Thus, continuous embankments were built from upstream to downstream along the Tone River. What is remarkable is that the *Sakamaki-Setoi* bottleneck was broadened and its retarding function was lost. Although new retarding areas were provided, their capacity does not appear to have been comparable to the old bottleneck. In addition, while dischargeability in the upper stream was improved, that in the lower stream was not increased in proportion. Although the Edo River should receive the excess according to the plan, actual inflow was considerably limited by structures such as weirs and locks that replaced the old groynes. The disproportion between the upper and lower streams appeared not long after the completion of the improvement work.[17]

The Second Plan for the Improvement of the Tone River

During the period from 1935 to 1941, enormous floods visited the basin of the Tone River that tested the just accomplished improvement works. During the flood on the 26th of September 1935, brought by two successive typhoons, the discharge in the upper stream was estimated at more than 10,000 m³/s. Although the embankments along the main river escaped bursting, thanks to protecting activities, dykes along one tributary, the Kokai River, were broken in many places due to the backwater. Additionally, the high water level in the main river that lasted for many hours seriously hindered drainage from lakes and marshes along the lower stream and the surrounding areas remained under water for more than a month. Thus, weaknesses in the measures taken against flooding in the lower stream were revealed.[18]

In response to this disaster, the *Tonegawa Chisui Senmon Iinkai* [the Special Committee for Water Management in the Tone River] was organized in order to establish a fundamental plan for flood protection. The main concern of the committee was to implement reinforcing measures in the sections previously improved during the first and the second terms of the former improvement work in which the freeboard of the embankments had not been increased while the retarding capacity had diminished by closing the marshes and lakes. The committee fixed the design-flood discharge at 10,000 m³/s and examined six draft plans. Raising dikes generally along the lower stream was considered to be infeasible for reasons including the weakness of the ground, the long duration of the high water level and the difficulty in draining the inner basin. The centerpiece of the plan that the committee finally adopted was the excavation of a floodway that would discharge

(1928), 29.
14 Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 129-136.
15 *Tonegawa kaishū enkaku kō* (1928), 35-36; [S. Kondō?], 'Tonegawa Kōsui Kōji Keikaku Ikensho'; the Tokyo Branch Office of Bureau of Civil Works, the Ministry of Interior, *Tonegawa kaishū kōji gaiyō* [synopsis of the improvement works for the Tone River] (Tokyo 1928), 6-7; Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 137-152.
16 Meanwhile, a large retarding basin was set up at the confluence of the Watarase River to the Tone River in order to prevent the influx of polluted flood discharge from the former to the latter, by compulsory purchase of Yanaka village. At the great cost of the village the basin was going to play a very important role in the management of the Tone River thereafter. M. Tominaga, 'Sanada sensei to Tonegawa kaishū kōji [Dr. Sanada and the improvement works for the Tone River]', *Kasen* (June 1960), 29-38; Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 152-158.
17 Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 158-173.
18 Ōkuma, *Kōzui to chisui no kasen-shi*, 168-170.



2,500 m³/s from *Fusa* on the Tone River directly into the Tokyo Bay. Expansion of the Edo River was discarded on grounds of its relatively high estimated costs. The opportunity to restore the Tone River to its original watercourse was missed again.[19]

Just after the committee proposed the abovementioned plan, however, there was another move brought about from a different direction; it was a plan to utilize the Watarase retarding basin as a reservoir for the water supply in Tokyo. In this case, it would not be far from using that reservoir for flood retention. The retarding basin was projected to be capable of regulating 1,000 m³/s of the maximal discharge of the Tone River with the addition of some adequate facilities. Furthermore, if the overall discharge in the Edo River and the lower Tone River could be increased slightly, the discharge in the planned floodway would reduce to 1,000 m³/s. That discharge was considered to be small enough to be coped with by alternative measures. Thus, there emerged a plan to construct a flood control dam at *Ikari*, upstream of the Kinu River, instead of the floodway. Considering that the costs for the floodway had been underestimated, the plan for the dam was likely to be more economical. Yet, for various reasons, a decision was not reached. Not until two typhoons played havoc in 1938 was a definitive plan determined. The plan, the *Tonegawa Zoho Keikaku* [the Supplementary Plan for the Tone River], arranged to be executed since 1939, subsequently underwent minor modifications as a result of another typhoon in 1941.[20]

According to this plan, the design-flood discharge of 10,000 m³/s should be reduced by 500 m³/s due to the Watarase reservoir (Fig. 6). The Edo River should assimilate 3,000 m³/s. The Tone Canal, constructed in 1890 as a shortcut of the navigation route according to the design by Mulder, was to be adapted for use as a diversion channel in order to direct 500 m³/s to the lower Edo River. The effective discharge from the Kinu River was to be maintained at 1,480 m³/s by two dams at *Ikari* and *Kawamata*. Two reservoirs near the mouth of the Kinu River should retain a total of 850 m³/s. The mouth of the Kokai River should be shifted downstream and its discharge was not to affect that in the main stream of the Tone River. As for the core of the entire plan, the discharge flowing through the Tonegawa Floodway was determined to be 2,300 m³/s.[21]

The *Tonegawa Zoho Keikaku* marked a new epoch in the history of the improvement of the Tone River. While the preceding plan was intended only for flooding that occurred several times per decade, the *Tonegawa Zoho Keikaku* established a thorough and integrated plan for flood protection in the entire Tone River for the first time, raising the design-flood discharge to 10,000 m³/s. The plan promised a real beginning of flood protection

19 Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 206-223. Later it was evident that the initial estimation for the floodway had been too low. It was corrected from ¥39.1 million in 1938 to ¥133.3 million in 1943. Ōkuma suggests the possibility that the expansion of the Edo River might be less expensive, even if inflation at that time was taken into account.

20 Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 223-225. In fact, the *Ikari* dam had already been planned around 1923 as a part of the improvement work for the Kinu River and came into effect in 1926. However, it was stopped in 1933 because of a couple of faults found in the dam site, together with a limited budget. See M. Tominaga 'Ikari entei fukkatsu ni tsuite [On the revival of the *Ikari* dam]', *Kasen* (January 1957), 2-23.

21 M. Tominaga, 'Tonegawa ni okeru jūyō kadai [The important tasks in the Tone River]', *Kasen*, April, June, July 1966: 15-26, 30-39, 31-44; Ōkuma, *Kōzui to chisui no kasen-shi*, 168-173.

in the Tone River comparable to those in other major Japanese rivers. However, this plan was never accomplished primarily due to the outbreak of World War II.[22]

The Introduction of the Concept of Kasui Tōsei [River Water Control]

In the meantime, the emphasis in water management works shifted slightly. After inland navigation diminished, the most important user of river water was the agricultural sector. By the end of the Edo period, the minimal discharge during the dry seasons had nearly been exhausted in most of the rivers in Japan for use in irrigation canals. Customary water rights were acknowledged.[23]

However, as the industrialization of Japan increased, demands for power generation or industrial use increased. Additionally, growing megalopolises, especially Tokyo, were about to drink up their own reservoirs. This tendency was enhanced during World War I when Japan evolved into a modern industrial nation, taking advantage of the vacuum that occurred in the supply for markets in East Asia because of the war. Subsequently, conflicts occurred among the various users of water.[24]

Thus, the idea of *Kasui Tōsei* was born. Primarily, administrators and engineers of the Ministry of Interior were advocates for the idea. They introduced the concept of flood control by storing floodwater in dammed reservoirs and attempted to reconcile flood protection with other interests. The construction of multipurpose dams would serve them best. They were deeply influenced by similar projects in Europe and in the United States. Among others, activities of the Tennessee Valley Authority (TVA) made a great impression on the protagonists of River Water Control. Simultaneously, in order to adapt other projects to the Japanese situation, theories of earthquake-resistant design were also developed.[25]

In 1938, the cabinet finally established the *Kasui Tōsei Iinkai* [the Committee for the Control of River Water]. Under the lead of the Ministry of Interior, projects for that purpose were planned for seventeen large rivers, although most of them were not accomplished under the unfavorable circumstances during World War II.[26]

The Appearance of Large-scale Multipurpose Dams[27]

The construction of large-scale dams was realized after the defeat of Japanese militarism. After the war, the General Headquarters of the U.S. Occupation Forces (GHQ) supervised all affairs concerning the economy, the society and the politics in Japan. Within the GHQ existed a Natural Resources Section of which the technical adviser was Professor Edward A. Ackerman of Chicago University. Subsequently to the termination of the war, Ackerman remained in Japan for more than one year and studied natural resources in Japan and their uses. Finally, he made a comprehensive report concerning the resources in Japan. He also suggested that without colonies Japanese industry would recover to its status before the war only if its own natural resources were used efficiently. Emphasis was placed on the development of water resources.

Under the auspices of the GHQ, the *Keizai Antei Honbu* [the Economic Stabilization Board, *Anpon*] was established in 1946. After disorganization of the Ministry of Interior, the *Anpon* assumed the task of administering national development plans. The *Shigen Iinkai* [the Resources Board] was attached to the *Anpon*. That board was modeled after the National Resources Planning Board of the U.S. government that was established by President Franklin Roosevelt in order to promote New Deal policies. In 1950, the Comprehensive National Land Development Law was enacted in which comprehensive development of rivers played a central role.

From the latter half of the 1950s to the 1960s, a large number of multipurpose dams

22 Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 246-250.
23 Ōkuma, *Kōzui to chisui no kasen-shi*, 183.
24 *The River Law*, E-iii; I. Yamauchi (ed.), *Kasen sōgo kaihatsu to suiri gyōsei* [the comprehensive development of rivers and administration of water] (Tokyo 1962), 11-13.
25 I. Yamauchi, *Kasen sōgo kaihatsu to suiri gyōsei*, 18-24; N. Mononobe, 'Chosuiyō jūryoku entei no tokusei narabini sono gōriteki sekkei hōhō [Properties of the gravity dam for water reservation and the method for its rational design]', *Doboku-gakkai-shi* [Journal of the Society of Civil Engineers] 11 (1925), 995-1157; *ibid.* 'Chosui ni yoru chisui oyobi risui ni tsuite [On the water management and water utilization by means of water reservation]', *Suiri to Doboku* 1 (1928) 1, 55-60.
26 I. Yamauchi, *Kasen sōgo kaihatsu to suiri gyōsei*, 24-51; S. Matsuura, 'River Controle Projects before the World War II and the Social Background', *Nihon dobokushi kenkyū happyōkai ronbunshū* [Papers of the Research Meeting on the Civil Engineering History in Japan] 5 (1985), 187-195.
27 I. Yamauchi, *Kasen sōgo kaihatsu to suiri gyōsei*; Y. Kawakami, 'A Historical Study on the Transition of the National Planning Policy before the Comprehensive National Land Development Act', *Dobokushi kenkyū* [Historical studies in civil engineering] 15 (1995), 61-70; Y. Takahashi *Gendai Nihon doboku-shi* (1990), 149-155.

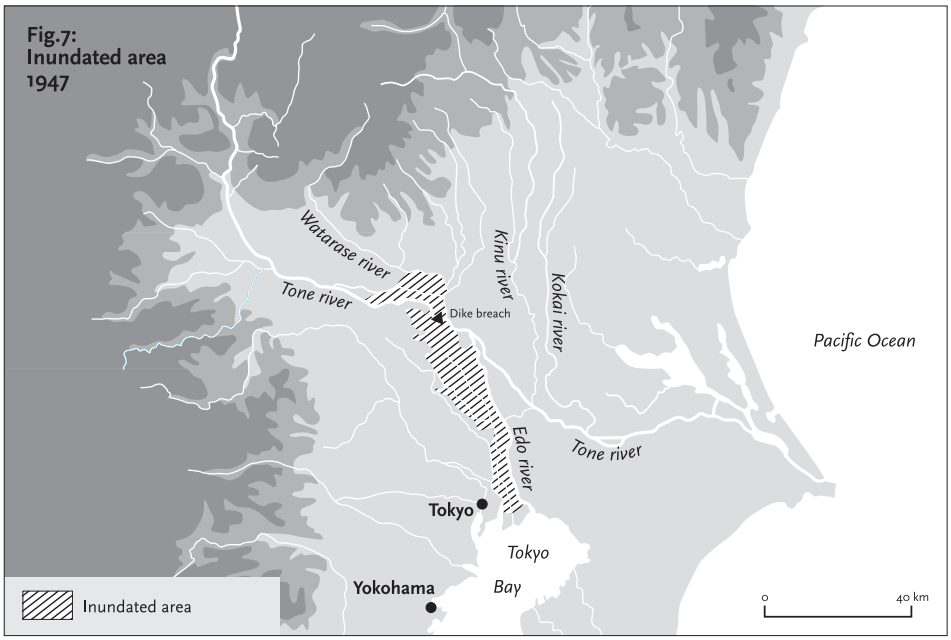


Fig.7: Inundated area 1947

were constructed in the upper streams of the important rivers in Japan. Fifty-eight large-scale dams, higher than 30 meter, were constructed in 1946-1955, 174 in 1956-1965 and 199 in 1966-1975. The emphasis of the development was initially placed on electric power, then shifted to water resources. In order to meet new demands for river management, the River Law was totally revised in 1964 for the first time since its enactment in 1896. The appearance of large-scale multipurpose dams is characteristic of river water management in Japan in the latter half of the twentieth century.

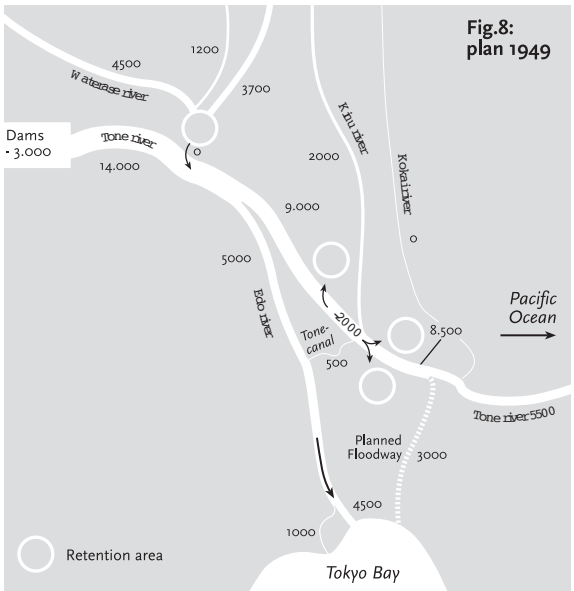
The Third Plan for the improvement of the Tone River using multipurpose dams[28]

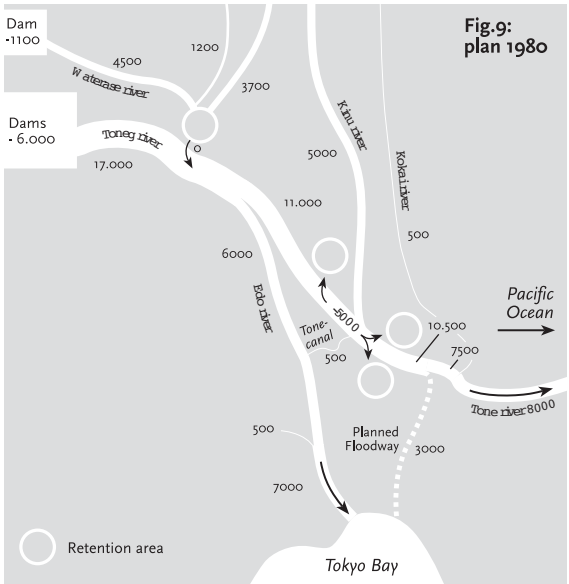
Meanwhile, in 1947, two years after the defeat of Japan in World War II, a gigantic typhoon named *Kathleen* struck Japan and an unprecedented flood struck the Tone River once again. The maximal discharge in the upper river was estimated at 17,000 m³/s. This cipher is astonishing, considering that the design discharge of the Rhine, which has a drainage basin more than ten times as large as that of the Tone River, is determined to be 15,000 m³/s at Lobith. At that time, dykes burst near Kurihashi and the floodwater flowed through the eastern section of Saitama prefecture to inundate two wards of the Tokyo Metropolitan Government (Fig. 7). Because of this inundation, 7.5 percent of the population of Tokyo, i.e. about 380,000 inhabitants, suffered damage.

Thus, the *Tonegawa Kaitei Kaishū Keikaku* [the Revised Plan for the Improvement of the Tone River] was designed (Fig. 8). A number of multipurpose dams were projected to play an important role. The basic flood discharge was determined on the basis of the estimated discharge of 17,000 m³/s, of which 3,000 m³/s should be stored by dams in the upper tributaries. Of this plan, construction of multipurpose dams proceeded steadily, whereas the construction of the Tonegawa Floodway failed to materialize.

The plan was revised again in 1980 in response to the estimated increase in the maximal flood discharge (Fig. 9). In that plan, the design-flood discharge was augmented to 22,000 m³/s. In order to meet the increased discharge, the assignment of flow to the Edo River was augmented by 1,000 m³/s and the capacity of the upper dams was to be increased to 6,000 m³/s. However, specific sites for new dams were not established. Additionally, no indication exists that construction of the Tonegawa Floodway is about to begin whereas the planned site has now grown into a densely built-up zone.[29]

28 Ōkuma, *Tonegawa Chisui no Hensen to Suigai*, 251-308; G.P. van de Ven (ed.), *Man-made lowlands. History of water management and land reclamation in the Netherlands* (Utrecht 2004), 292-293.
29 Ōkuma, *Kōzui to chisui no kasen-shi*, 175-180.





Reaction against Channel-centered Water Management and Reflection on the River Environment[30]

While the construction of multipurpose dams was steadily ongoing, a number of problems emerged that were rooted in the conventional methods of modern river improvements used since the Meiji period. Although the multipurpose dam was introduced as a new element, the principle of river improvement remained to discharge all floodwater into the river channel by regularizing the river breadth and raising embankments. The premise was that no floodwater should flow out of the channel while virtually no measures were considered against extreme floods larger than the design flood.

However, a trend appeared in which peak flooding increased as the improvement of the river channel proceeded. Some experts considered this phenomenon to be a consequence of the improved dischargeability of the channel and the reduced inundation. Increased peak flooding presented a potentially fatal dilemma to modern river improvement. If current principles were maintained, the projects for raising dykes and expanding the channel would be endless. Concomitantly, rapid urbanization altered the form and distribution of land utilization in the river basin, which resulted in changes in flood runoff patterns that instigated new types of inundation in urban areas. In the 1970s, embankments successively burst along important rivers, such as the Tama River (1974), the Ishikari River (1975) and the Nagara River (1976). The number of cases increased in which flood victims accused the river administrator.

Under these circumstances, the Minister of Construction consulted the River Council in 1976 after the burst in the Nagara River, caused by a disastrous typhoon, No. 17. The following year, the Council submitted an *Interim Report on Policies for Comprehensive Flood Control Measures*. In this report, they proposed measures such as restraints on flood and sediment discharge in the river as well as maintenance of the retention and detention functions of river basins in addition to conventional improvement works on the river channel. This report is considered to have marked a turning point from flood control centered on the improvement of the river channel to water management in the entire river basin.

In addition, measures against extreme floods that exceed the design flood level were also introduced, on the basis of the River Council's 1987 report titled *Recommendations on Policies for Protection from Extreme Floods*, in order to protect urban areas in which property and important business functions are concentrated. One example of the new measures

30 Y. Takahashi, *Kokudo no henbō to suigai* [Changes in the Japanese landscape and flood damages] (Tokyo 1971); ibid. *Toshi to mizu* [City and water] (Tokyo 1988); Ōkuma, *Kōzui to chisui no kasen-shi*, 232-256; H. Matsuzaki and N. Tamai, 'A Study on Historical transition of the River Environment Administration and Proposal to Nature-Oriented River Works', *Dobokushi kenkyū* [Historical studies in civil engineering] 17 (1997), 543-550; *the River Law*, E-v-vi; N. Sato, 'Revision of River Law and the Future River Administration', *Doboku-gakkai-shi* [Journal of the Society of Civil Engineers] 82 November (1997), 38-40.

is the so-called 'high-standard levees'. These are embankments that have an enormously wide levee crown. In so doing, they reinforce the resistance against overflow, while areas created on the crown can be used as sites for various urban facilities.

Meanwhile, various river-related problems, such as water pollution, raised consciousness of the river environment. In 1980, the *Kasen kankyō kanri kihon keikaku* [the basic plan for river environment administration] was established, followed by the *Kasen kankyō kanri no arikata ni tsuite no tōshin* [the report on the desirable method of river environment administration] in the next year. On the basis of these reports, administrative plans for the preservation of the river environment were framed and model projects were initiated. In 1990, the *Tashizengata kawazukuri suishin ni tsuite no tsūtatsu* [the notification on the promotion of creating close-to-nature rivers] was published.[31]

In 1996, the River Council submitted a report titled *21 seiki no shakai wo tenbōshita kongo no kasenseibi no kihonteki hōkō ni tsuite* [on the basic direction of future river improvement with a view to 21st-century society]. On the basis of this report, the following year the River Law was revised for the second time. The revised River Law embraced the consequences of the developments since 1964.

The major alterations are summarized as follows. Firstly, 'improvement and reservation of the river environment' was added to the goals of the Law. Secondly, the planning scheme for river management was revised and the river management plan was roughly divided into two constituents, the Fundamental River Management Policy and the River Improvement Plan. While the former is an abstract, long-term plan determined from the scientific and technological point of view, the latter is a concrete, short-term plan that reflected opinions of local communities. In addition to opinions of local inhabitants, the input of experts other than river engineers can be sought. Thirdly, in recognition of the traditional technique of forming woods along the embankments in order to prevent bursting due to overflow, the river administrator is entitled to form and maintain 'fluvial wood zones' as river administration facilities. The revised Law can be considered to be a step in the direction of departure from channel-centered river management.

Concluding Remarks

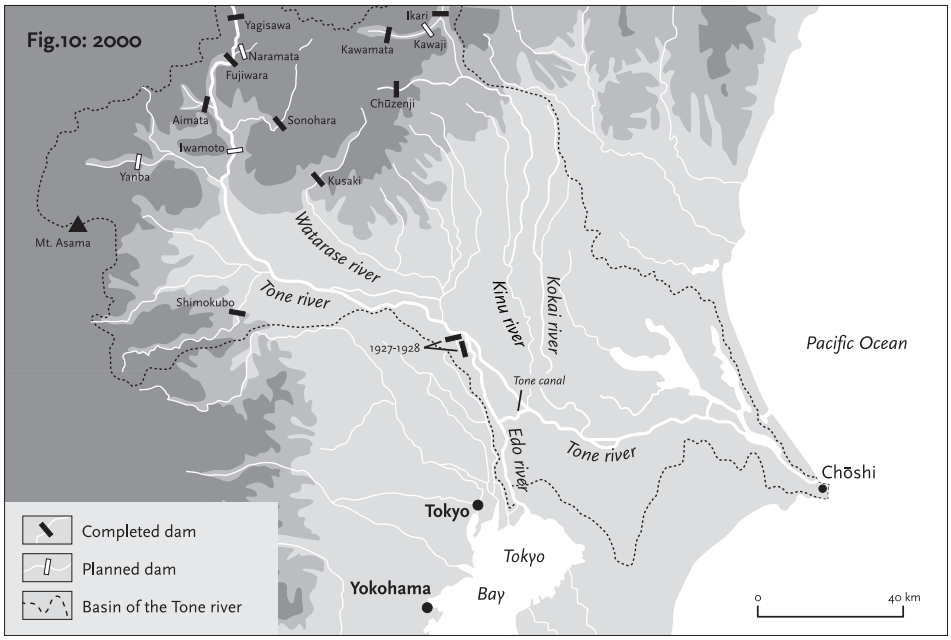
Since the beginning of the modern period, river management in Japan has been performed under the influence of diverse interests. Sometimes conflicts in river management are described as those between *chisui* versus *risui*, or security versus benefit. However, it seems more suitable to say that security has always existed as the primary goal of river management while its phenotypes were under the influence of the then prevailing interests. Thus, continuous embankments were a technological expression in a period when interest in reclamation and wet rice culture prevailed, whereas flood protection using multipurpose dams was a product of the necessity to coordinate a variety of new interests in a modern industrialized society.

Currently, the circumstances of rivers are changing again. Agriculture has declined. Hydroelectric generation has decreased in importance due to the development of alternative energy sources and water consumption in the industry has been economized using new techniques. The growth of the urban population is reaching a ceiling. Revision of the River Law reflected the new situation.

The ideal adopted in the new River Law has already had certain consequences. There are measures against extreme floods ongoing in relatively small rivers in urban areas such as making small retentions of parks or constructing underground reservoirs. In addition, so-called 'close-to-nature' river improvement is continuing on several minor rivers.

Nonetheless, profound revision of plans for great rivers has not yet appeared. For example, although difficulties are evident for the construction of dams and the floodway in the plan for the Tone River, no alternative has been adopted yet (Fig. 10).

31 *Tashizengata kawazukuri* [creating close-to-nature rivers] is a translation of *Naturnaher Wasserbau*.



After the first decade since the revision of the River Law in 1997, it is still unclear if the revised Law will bring about a fundamental reorganisation in the river management as a genuine turning point in the history of the modern river management in Japan. The course of water management still seems to be fluctuating between the old principle and the new ideal.