Learning from Japan's Experience in Integrated Urban Flood Risk Management: A Series of Knowledge Notes

Appendix: Case Studies in Integrated Urban Flood Risk Management in Japan

This appendix provides a collection of case studies of flood risk management initiatives in Japan introduced within the series of Knowledge Notes on Japan's Experience in Integrated Urban Flood Risk Management, particularly Knowledge Notes 3 and 4.

The project costs of each case included in the appendix are converted into U.S. dollars ($) at the 2018 annual average exchange rate of $1 = ¥110, based on the yearly average currency exchange rate provided at https://www.irs.gov/individuals/international-taxpayers/yearly-average-currency-exchange-rates.

THE WORLD BANK IBRD • IDA | WORLD BANK GROUP
UFCOP Urban Floods Community of Practice
GFDRR Global Facility for Disaster Reduction and Recovery

©2019 The World Bank
International Bank for Reconstruction and Development
The World Bank Group
1818 H Street NW, Washington, DC 20433 USA
October 2019

DISCLAIMER

The report reflects information available up to June 30, 2019.

RIGHTS AND PERMISSIONS

CITATION

Please cite this series of knowledge notes and/or its individual elements as follows:
World Bank. 2019. "Learning from Japan's Experience in Integrated Urban Flood Risk Management: A Series of Knowledge Notes." World Bank, Washington, D.C.

World Bank. 2019. "Learning from Japan's Experience in Integrated Urban Flood Risk Management: A Series of Knowledge Notes—Knowledge Note 1: Assessing and Communicating Urban Flood Risk." World Bank, Washington, D.C.

World Bank. 2019. "Learning from Japan's Experience in Integrated Urban Flood Risk Management: A Series of Knowledge Notes—Knowledge Note 2: Planning and Prioritizing Urban Flood Risk Management Investments." World Bank, Washington, D.C.

World Bank. 2019. "Learning from Japan's Experience in Integrated Urban Flood Risk Management: A Series of Knowledge Notes—Knowledge Note 3: Designing and Implementing Urban Flood Risk Management Investments." World Bank, Washington, D.C.

World Bank. 2019. "Learning from Japan's Experience in Integrated Urban Flood Risk Management: A Series of Knowledge Notes—Knowledge Note 4: Operating and Maintaining Urban Flood Risk Management Investments." World Bank, Washington, D.C.

World Bank. 2019. "Learning from Japan's Experience in Integrated Urban Flood Risk Management: A Series of Knowledge Notes—Appendix: Case Studies in Integrated Urban Flood Risk Management in Japan." World Bank, Washington, D.C.

ACKNOWLEDGEMENTS

The four-part series "Learning from Japan's Experience in Integrated Urban Flood Risk Management: A Series of Knowledge Notes" and this appendix were prepared by a World Bank team led by Jolanta Kryspin-Watson, and comprising Shoko Takemoto, Zuzana Stanton-Geddes, Kenya Endo, and Masatsugu Takamatsu. Primary and secondary data gathering, and research, was conducted by Washington CORE and Yachiyo Engineering Co., Ltd. The four reports and their appendix benefited from additional research and contributions by Jia Wen Hoe, Sayaka Yoda, Toshihiro Sonoda, Alex Keeley, Tomoki Takebayashi, Thimali Thanuja Pathirana Batuwita Pathiranage, and Chinami Yamagami; and peer review by Vivien Deparday, Keiko Saito, Ryoji Takahashi, Bontje Marie Zangerling, Srinivasa Rao Podipireddy, Dixi Mengote-Quah, Dzung Huy Nguyen, and Camilo Lombana Cordoba. The team is also grateful for the support of Mika Iwasaki, Luis Tineo, Reiko Udagawa, and Haruko Nakamatsu.

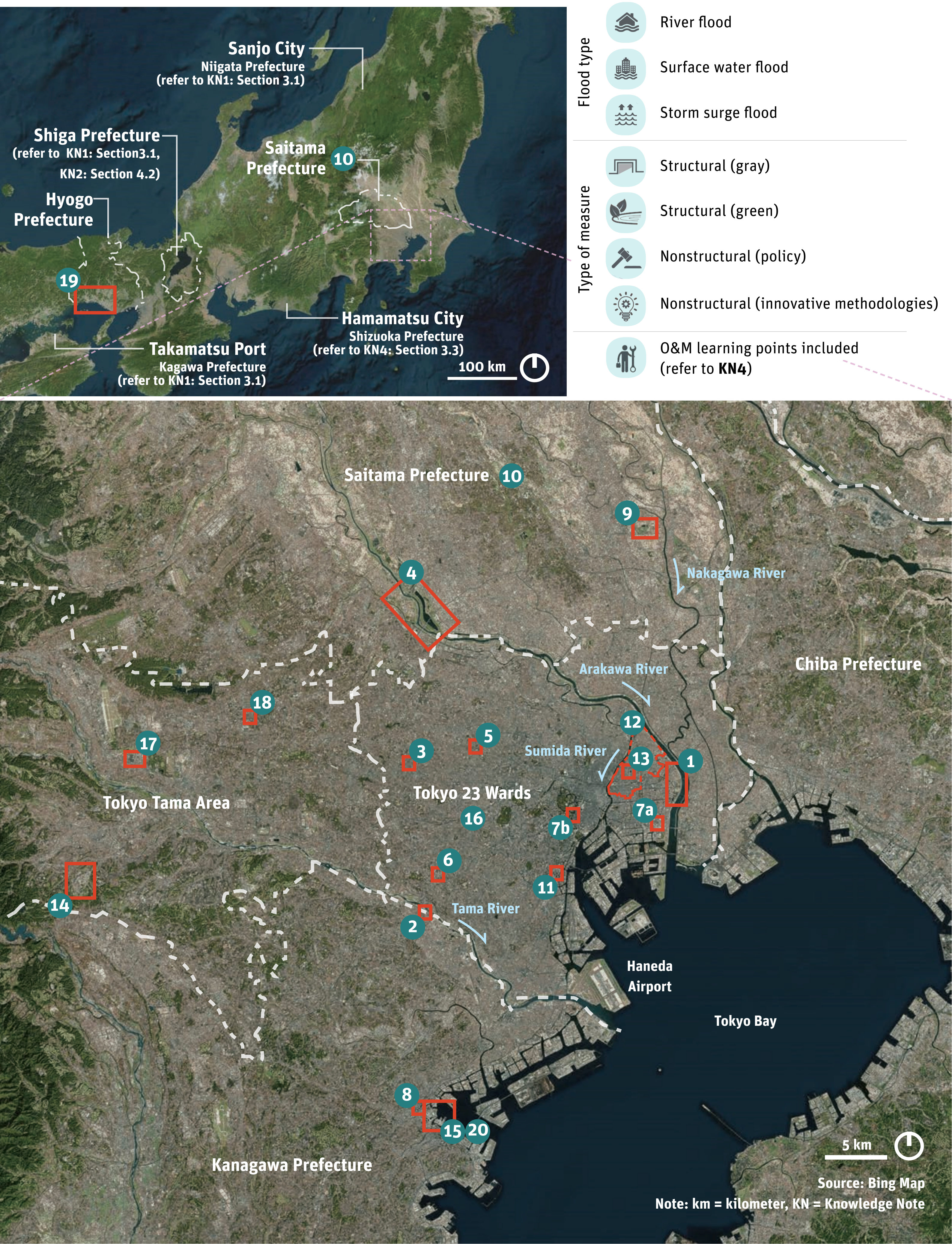
The Knowledge Notes were developed with valuable contributions and guidance from numerous Japanese professionals and experts on integrated urban flood risk management. These include Professor Hiroaki Furumai, the University of Tokyo; Arata Ichihashi, Tokyo Metropolitan Research Institute for Environmental Protection; Michiru Sasagawa, Rain City Support and People for Rainwater; Nobuyuki Tsuchiya, Japan Riverfront Research Center; Shinji Nishimura, Urban Renaissance Agency (UR); Keiji Takeda, UR; Mikio Ishiwatari, Japan International Cooperation Agency (JICA); Miki Inaoka, JICA; Tomoki Matsumura, Ministry of Land, Infrastructure, Transport and Tourism (MLIT); Akito Kinoshita, MLIT; Takuji Nakazato; Chikao Okuda, Tokyo Metropolitan Government; Professor Takanori Fukuoka, Tokyo University of Agriculture; Yorikazu Kitae, Development Bank of Japan (DBJ); Tomohiro Ishii, Yokohama City; Minato-Mirai 21 Promotion Division, Urban Development Bureau, Yokohama City; Environmental Planning Bureau, Yokohama City; and Shoji Takemoto, Kobe City.

Editorial services were provided by Fayre Makeig and Lisa Ferraro Parmelee. Kenya Endo designed the report.

The Knowledge Notes were prepared under the auspices of the Urban Floods Community of Practice (UFCOP). UFCOP is a global knowledge initiative led by the World Bank with support from the Global Facility for Disaster Reduction and Recovery (GFDRR) and others. The Knowledge Notes were developed with the financial support of the Japan–World Bank Program for Mainstreaming Disaster Risk Management in Developing Countries, which is financed by the Government of Japan and receives technical support from the World Bank Tokyo Disaster Risk Management Hub.

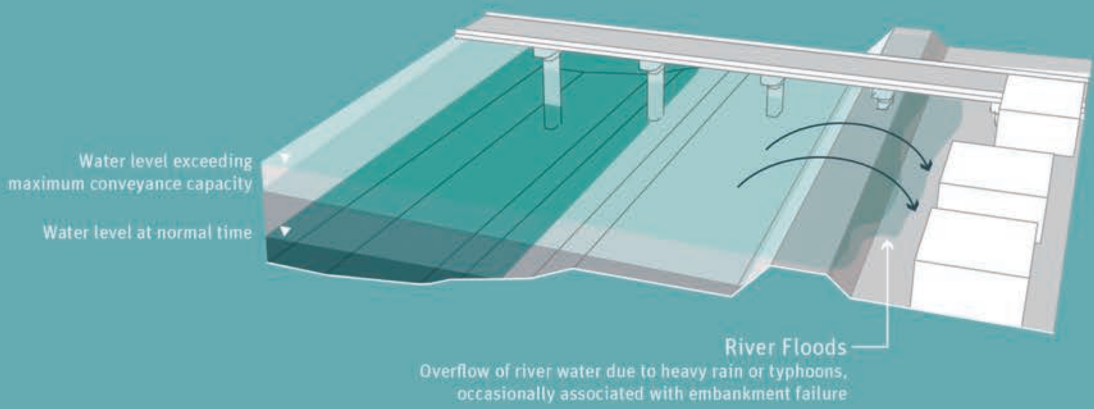
Cover Image: A view of the Hachioji Minamino District in Hachioji City, Tokyo. A new town development incorporates environmental conservation and flood mitigation measures along the Hyoei River.

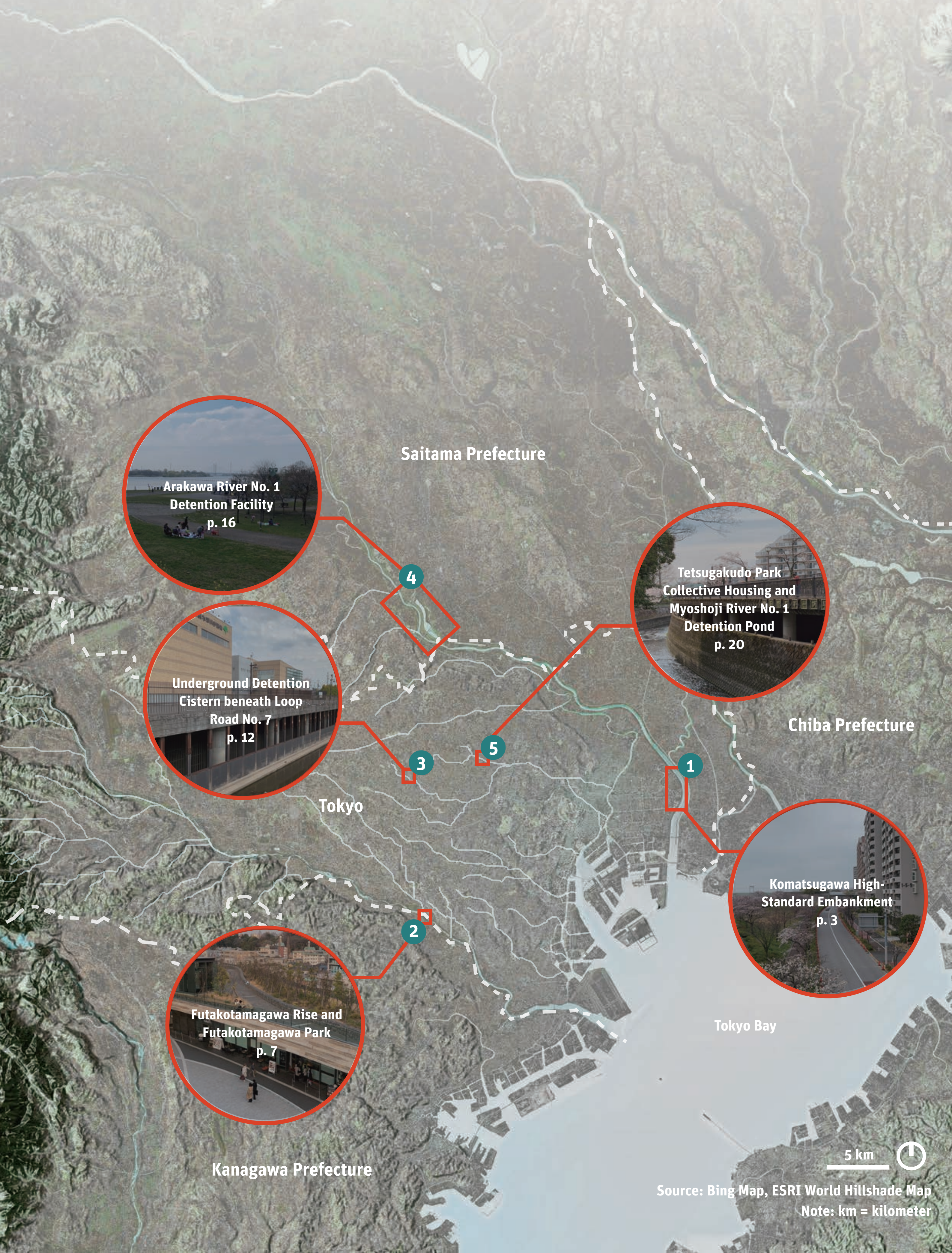
(Photo Credit: Kenya Endo)


Sanjo City
Niigata Prefecture
(refer to KN1: Section 3.1)
Shiga Prefecture
(refer to KN1: Section3.1,
KN2: Section 4.2)
Saitama
Prefecture
10
Hyogo
Prefecture
19
Takamatsu Port
Kagawa Prefecture
(refer to KN1: Section 3.1)
Hamamatsu City
Shizuoka Prefecture
(refer to KN4: Section 3.3)
100 km
Flood type
River flood
Surface water flood
Storm surge flood
Type of measure
Structural (gray)
Structural (green)
Nonstructural (policy)
Nonstructural (innovative methodologies)
O&M learning points included
(refer to KN4)
Saitama Prefecture
10
9
Nakagawa River
4
Arakawa River
Chiba Prefecture
18
12
17
3
5
Sumida River
13
1
Tokyo Tama Area
Tokyo 23 Wards
16
7b
7a
6
11
14
2
Tama River
Haneda
Airport
Tokyo Bay
8
15
20
Kanagawa Prefecture
5 km
Source: Bing Map
Note: km = kilometer, KN = Knowledge Note

List of Cases

River Floods





Source: Bing Map, ESRI World Hillshade Map
Note: km = kilometer

Case 1: Reducing River Flood Risk and Promoting Urban Redevelopment: Komatsugawa High-Standard Embankment

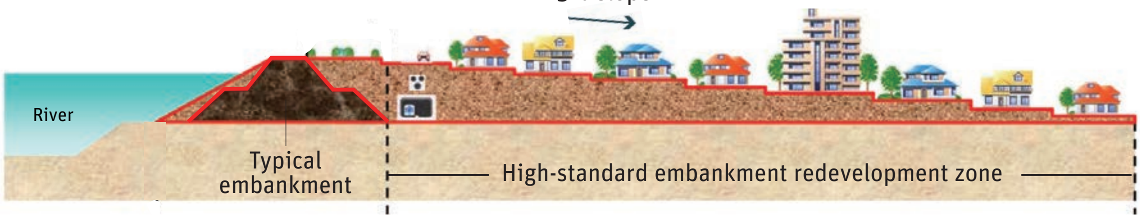
Location:	Komatsugawa District, Edogawa Ward, Tokyo
Site characteristics:	Dense urban area with high concentration of assets and population in the surrounding area
Flood management measure(s):	
Flood type	River
Management capacity	Designed to accommodate a maximum 1-in-200-year storm event
Type of measure(s)	Structural (gray): improvement of embankment
Relevant entities:	
Implementation	Embankment—national government (river administrator)
	Urban redevelopment zones—Tokyo Metropolitan Government (TMG)/Edogawa Ward and Urban Renaissance Agency (UR)[a]
Operation and maintenance (O&M)	Same as above
Finance	Same as above
Construction period:	1990–2015
Cost:	Construction cost: ¥48.8 billion ($444 million, as of 2011)[b]
Additional benefits and functions:	Urban redevelopment (residential, commercial, and industrial)
	Disaster risk management (provision of emergency evacuation sites during floods and earthquakes)[c]
Sources:	MLIT, n.d.(a), except where otherwise noted.
	a For more information, see www.toshiseibi.metro.tokyo.jp/bosai/sai_kai-kameido.pdf.
	b MLIT 2011.
	c Edogawa Ward 2006.

Context: Flood Risk and Significance of Area

Komatsugawa District is in **Edogawa Ward**, located in eastern Tokyo in the Koto Delta along the Arakawa River. The district's proximity to a large river, Arakawa, and its location below sea level exposes it to significant inundation risk. Its low elevation also means that, before the intervention, safe evacuation ground was not available for area residents in the event of floods. A flood impact analysis conducted in 2011 showed that if the Arakawa River were to overflow, the economic impact in Komatsugawa District could be up to ¥71 billion (US$645 million).[1]

In 1990, Edogawa Ward, in partnership with the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), initiated a project with the dual objectives of

1 For more information, see MLIT, Kanto Regional Office (2011).



3

reducing losses and damage to people and assets from flooding and establishing a safe site for evacuation during floods. A high concentration of population and assets in the surrounding areas, which are utilized for industrial, commercial, and residential purposes (Hashiguti, Hirabayashi, and Yamazaki 2009), strongly necessitated the implementation of a high-standard flood protection investment. Therefore, despite the high cost, lengthy construction time, and complicated relocation processes involved, the national and local governments together embarked on a project to establish a high-standard embankment with a design that aims to withstand a 1-in-200-year flood. This "super-levee" infrastructure was selected as the flood management approach in Komatsugawa District, as well as for other high-density and high-priority areas in the Tokyo Metropolitan Area facing similar flood risks and potential impacts.

Given its greater width and height as compared to traditional embankments, the design and construction of the super-levee was implemented jointly with an overall urban redevelopment project of Komatsugawa District.

Solution: Investment Design and Key Features

Investment Design

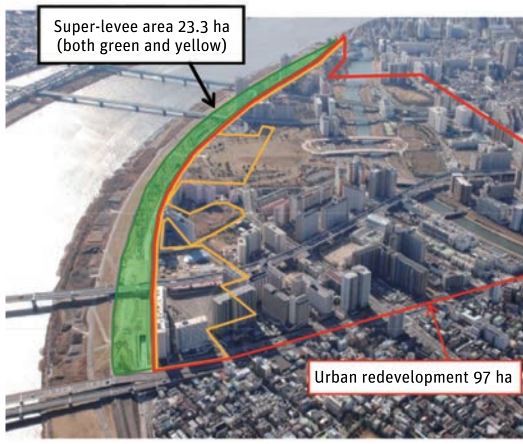
The high-standard embankment in Komatsugawa District is 2,380 meters (m) long, with a mean width of 97 m and an area of 23.3 hectares (ha) (MLIT n.d.[a]; Nakamura, Kato, and Shiozaki 2013). In addition to its utility for managing river flooding with up to 200-year return periods, it is used as a residential area, a public park that also serves as a disaster evacuation site, and a site for public facilities (a junior high school and a pumping station). Construction started in 1990 and was completed after 25 years in 2015. The total construction cost was an estimated ¥48.8 billion ($444 million). The many housing relocations and significant land compensation involved were some of the key challenges and reasons for the high cost and the long time required to build it.

As illustrated in **figure A1.3**, unlike a typical embankment, a high-standard embankment's sectional profile requires a large area for construction at the back side of the river to ensure structural stability. Komatsugawa's high-standard embankment project also included approximately 97 ha of urban redevelopment area, utilized for housing, commercial, and industrial purposes (MLIT n.d.[a]; **figure A1.6**).

Key Features

- **Coordination and partnership among the national government, local government, and developers:** To carry out this large-scale, high-cost, and complex flood management project in Komatsugawa District, sharing the responsibilities, costs, and risks of the project among various stakeholders was vital, as was ensuring their close coordination throughout the long period of project implementation. The national government (MLIT, which serves as the river administrator), the Tokyo Metropolitan Government (TMG)[2] and the local government (Edogawa Ward), and the housing developer (Edogawa Ward and the Urban Renaissance Agency, or UR)[3] jointly carried out the embankment design, construction, and urban redevelopment work. TMG, supported by the river administrator and UR, carried out the complex and time-consuming land readjustment work, the rezoning, and the establishment


4



5

Figure A1.1: Overall View of the Site

Photo Credit: Kenya Endo.

Figure A1.2: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A1.3: Conceptual Diagram of the High-Standard Embankment

Source: MLIT, Kanto Regional Office 2011.

Figure A1.4: Komatsugawa District before Development

Source: MLIT n.d.(a) (above); MLIT n.d.(b) (below).

Figure A1.5: Komatsugawa District after Development and Zoning

Source: MLIT n.d.(a). *Note*: ha = hectare.

Figure A1.6: Redeveloped Neighborhood Cityscape
Photo Credit: Kenya Endo.

of public facilities. Edogawa Ward led a process of building consensus among residents and promoting awareness of the necessity for a high-standard embankment in the region, which led to the residents' agreeing to temporary or permanent relocation.

- **Design of a multipurpose and multibenefit investment:** The high-standard embankment in Komatsugawa District was designed to serve three purposes: (i) to provide river flood protection; (ii) to provide a disaster evacuation site; and (iii) to provide attractive residential and commercial spaces with access to public amenities. Various planning and design innovations have enabled the single-investment project to generate multiple benefits. Based on the "Structure Decree on River Facility Management and Manual for River Works," established by the national government, the slope of the inner side of the embankment, for example, had to be within 3 percent so it would not be broken by excessive flooding. Furthermore, the structure of the embankment had to be resistant to earthquakes and available for residential development. The embankment's strong structure also allows it to function as an evacuation site.
- **Cost sharing and cost reduction measures among various stakeholders:** Given the involvement of the various stakeholders, different components of the Komatsugawa Embankment and redevelopment project were financed by different actors. In general, the embankment was financed by the river administrator and TMG's river development authorities. The urban redevelopment initiatives were financed mainly by TMG's Urban Development Department and UR. Costs for community consultations, consensus building, compensation (that is, partial compensation for temporary relocation, demolition and reconstruction of housing units, and so on), and tax incentives (such as reduction of the homeowner tax) were mainly covered by TMG. To lower the overall project cost, the river administrator decided to retain ownership of the site, essentially by not acquiring any land for the high-standard embankment. In other words, former residents were able to move back to the same location after rezoning and construction work were completed. Urban redevelopment of the site was effectively planned by TMG and initiated by the private sector with enhanced urban amenities, with some evidence of the land value increasing after the project.[4]
- **Remaining challenges:** The high cost, lengthy duration, and need for relocation over a large area remain key challenges in implementing a large-

2 Tokyo is a regional government encompassing 23 special wards, 26 cities, 5 towns, and 8 villages. However, reflecting the dense population, urban contiguity, and other realities of the 23 special ward area, a unique administrative system exists between the metropolitan government and the wards, which differs from the typical relationship between prefectures and municipalities. This system balances the need to maintain unified administration and control across the whole of the ward area and the need to have the local ward governments, which are nearer to the residents, handle everyday affairs. Specifically, in the 23 wards, the metropolitan government takes on some of the administrative responsibilities of a "city," such as water supply and sewerage services, and firefighting, to ensure the provision of uniform, efficient services, while the wards have the autonomy to independently handle affairs close to the lives of the residents such as welfare, education, and housing (TMG n.d.).

3 UR is a semipublic independent administrative institution and an agency responsible for Japanese housing.

4 A report by the Riverfront Research Institute (2006) found that the value of land in Komatsugawa District protected by the embankment increased at a higher rate (from ¥227,000/square meters [m^2] in 1996 to ¥304,000/m^2 in 2004, a 34 percent increase) than land in areas outside the embankment's protection (from ¥255,000/m^2 in 1996 to ¥299,000/m^2 in 2004, a 17 percent increase).

scale river embankment project. How to provide incentives strategically to the private sector to partner in such long-term initiatives remains a key challenge to further expanding and scaling up these initiatives. Building the slope of the inner side of the embankment, for example, requires large earthworks, as well as the simultaneous raising up of all utility and service infrastructure. This work can take up to two or three years for completion, and extended time for embankment construction will discourage the private sector's involvement in subsequent urban redevelopment (Hashiguti, Hirabayashi, and Yamazaki 2009).

Results: Multiple Benefits

The high-standard embankment project improved the disaster risk management capacity of the flood-prone Komatsugawa District and its surrounding area in the Koto Delta through the establishment of a structurally sound foundation able to withstand up to 1-in-200-year river floods. The embankment also created a new ward-wide evacuation hub in case of floods and other natural disasters (**figure A1.7**). Implemented jointly with a large-scale urban redevelopment project led by a housing development agency, the historically dense, disaster-prone neighborhood was transformed into an attractive living environment with improved safety and scenic views toward the Arakawa River, increasing property values in the area.

Figure A1.7: Evacuation Drills at Komatsugawa High-Standard Embankment
Source: MLIT, n.d.(b).

References

Edogawa Ward. 2006. "Edogawa Ward Basic Principles on Super Levee Implementation." https://www.city.edogawa.tokyo.jp/documents/8268/hoshin_all.pdf.

Hashiguti, Yumi, Rika Hirabayashi, and Motoya Yamazaki. 2009. "High-Standard Levee from Viewpoint of City Planning." *Reports of the City Planning Institute of Japan*, no. 7, February. https://www.cpij.or.jp/com/ac/reports/7-4_73.pdf.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism). 2011. "About the Project Scheme of the High Standard Embankment." July 25. http://www.mlit.go.jp/river/shinngikai_blog/koukikakuteibou/dai5kai/dai5kai_siryou1.pdf.

———. N.d.(a). "Arakawa Downstream River Office: Komatsugawa Super Embankment." Pamphlet, Ministry of Land, Infrastructure, Transport and Tourism.

———. N.d.(b). "High-Standard Embankment: Examples of Integrated Urban Development." Accessed February 13, 2019. http://www.mlit.go.jp/river/shinngikai_blog/koukikakuteibou/dai1kai/dai1kai_siryou3-2.pdf.

MLIT, Kanto Regional Office. 2011. "Arakawa High Standard Embankment Development Project (Komatsugawa District)." March 11. http://www.ktr.mlit.go.jp/ktr_content/content/000037867.pdf.

Nakamura, Hitoshi, Takaaki Kato, and Yuto Shiozaki. 2013. "Super Levees along the Arakawa River in Tokyo: Evaluation from the Viewpoint of Spatial Planning in a Low-Lying Area." International Conference on Flood Resilience—Experiences in Asia and Europe. September. http://icfr2013.ex.ac.uk/papers/A1_Nakamura.pdf.

Riverfront Research Institute. 2006. "Effects of Super-Levee Construction." *Riverfront Research Report*, no. 17, September. http://www.rfc.or.jp/rp/files/17-16.pdf.

TMG (Tokyo Metropolitan Government). N.d. "The Structure of the Tokyo Metropolitan Government (TMG)." http://www.metro.tokyo.jp/english/about/structure/structure04.html.

Case 2: Reducing River and Surface Water Flood Risk by Integrating Nature-Based Solutions within an Urban Redevelopment Project: **Futakotamagawa Rise and Futakotamagawa Park**

Location:	Futakotamagawa District is located in Setagaya Ward, Tokyo, approximately 15 kilometers (km) southeast of Tokyo's city center and adjacent to the large Tama River.
Site characteristics:	The area is mainly dense residential, but commercial buildings and offices are located near Futakotamagawa Station. It is prone to high flood risk due to its proximity to the Tama River, as well as urbanization and limited infiltration capacity.
Flood management measure(s):	
Flood type	River and surface water
Management capacity	Futakotamagawa Rise, including Futakotamagawa Park: River flooding: High-standard embankment designed to manage 1-in-100-year or 1-in-200-year flood events
	Surface water flooding: Detention—approximately 5,500 cubic meters (m^3) total (4,400 m^3 underground rainwater detention facility and 1,110 m^3 stormwater detention pond)[a]; infiltration—approximately 670 m^3 (through permeable pavers and infiltration trenches, etc.); greenery (natural infiltration)—approximately 1,300 m^3
Type of measure(s)	Futakotamagawa Rise: Structural rainwater harvesting and stormwater management measures (gray and green)
	Futakotamagawa Park: Structural rainwater harvesting and stormwater management measures (green) and high-standard embankment (gray)
Relevant entities:	
Implementation	Futakotamagawa Rise (11.2 hectares [ha]): Futakotamagawa East District Urban Redevelopment Association led by Tokyu Land Corporation and Tokyu Corporation in collaboration with TMG/Setagaya Ward
	Futakotamagawa Park (6.3 ha): Setagaya Ward in partnership with Tokyu Land Corporation and Tokyu Corporation, TMG, and MLIT (1,250 m of high-standard embankment)[b]
O&M	Futakotamagawa Rise: Tokyu Corporation
	Futakotamagawa Park: Setagaya Ward with residents
Finance	Futakotamagawa Rise: Tokyu Corporation with subsidies from TMG/Setagaya Ward
	Futakotamagawa Park: Park—TMG/Setagaya Ward; embankment—MLIT and TMG/Setagaya Ward
Construction period:	2007–15[b]
Cost:	Futakotamagawa Rise: Total cost of Futakotamagawa East Urban Redevelopment Project Phase 1 (8.1 ha out of 11.2 ha)—¥102.4 billion ($875 million)[b]
	Futakotamagawa Park: Park total—¥1.274 billion ($11.6 million), of which ¥40 million ($364,000) is for flood management measures[b]; embankment—unknown[c]

Additional benefits and functions:	Urban redevelopment: Housing and commercial development
	LEED ND (neighborhood development) Gold Certified
	Disaster risk management: Evacuation site, backup power generator, solar- and wind-powered streetlights, backup water source, emergency toilets, disaster preparedness equipment storage
	Environmental sustainability: Enhancement of biodiversity and mitigating of heat island effect; water recycling
Sources:	Nikkan Kogyo Shimbun 2017, except where otherwise noted.
	a Setagaya Ward 2013.
	b Bureau of Urban Development, TMG 2015.
	c The total national project cost for the high-performance embankment, 1987–2010, was reported as ¥693.6 billion, or $6.3 billion (Board of Audit of Japan 2012).

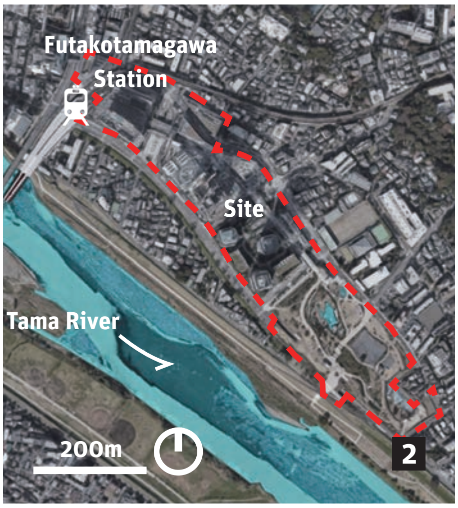


Figure A2.1: Overall View of the Site

Photo Credit: Kenya Endo.

Figure A2.2: Site Context

Source: Google Earth. *Note*: m = meter.

Context: Urban Redevelopment and Flood Risks

A gateway to western Tokyo, the upscale **Futakotamagawa** area is bounded by the Tama River and the Kokubunji cliff line. An expansion of residential neighborhoods there coincided with the growth of a commercial district surrounding Futakotamagawa Station, with major department stores opening in 1969. In the mid-1980s, however, vacancies in shopping arcades led to an economic decline on the east side of Futakotamagawa Station, resulting in underutilization of this high-value land with good access to the urban centers of Tokyo (MLIT, Kanto Regional Office 2001).

Furthermore, given its proximity to the Tama River, flood risk was also a concern in advancing further development in the area. During Typhoon Fitow (No. 9) in 2007, **Setagaya Ward** issued an evacuation advisory to 1,490 people and 740 households in the area, while MLIT and the ward stacked sandbags by the river, which prevented major inundations. With increasing risks of heavy rain and extreme weather events, there was a growing need for more robust flood management measures in the area (MLIT, Kanto Regional Office, n.d.).

Solution: Investment Design and Key Features

Investment Design

In light of this situation, in 2005, TMG approved the implementation of the 11.2 ha Futakotamagawa East District Category One Urban Redevelopment Project. Tokyu Corporation formed a redevelopment committee called the Futakotamagawa East District Urban Redevelopment Association (F-Inc. n.d.) to lead the implementation in two major phases, starting in 2007. Simultaneously, in conjunction and close coordination with this project, Setagaya Ward led the redevelopment of the connecting 6.3 ha area as the Futakotamagawa Park, which would also serve as a high-standard embankment against river flooding (**figure A2.3**).

The Futakotamagawa Rise project's key concept was "Water, Greenery, and Light," emphasizing the harmonization of nature and green features throughout the design of its office buildings, commercial facilities, hotels, and residential developments. Construction of the buildings and infrastructure of the project applied environmentally friendly methods, such as the installation of green roofs, solar panels, geothermal heat exchangers, and the use of recycled materials. Additionally, rainwater harvesting and recycling systems, as well as stormwater detention facilities, were integrated into the main building, and a number of eco-ponds and planting beds were installed (**figure A2.4**). The combination of urban

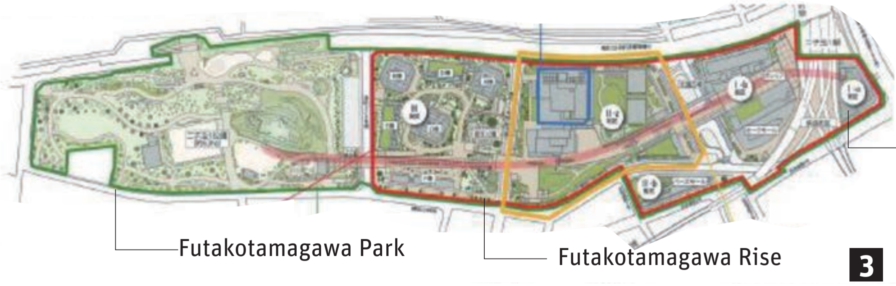


Figure A2.3: Overall Site Zoning

Source: Futakotamagawa Rise n.d.

Figure A2.4: Futakotamagawa Rise Retail Businesses and Roof Garden

Photo Credit: Kenya Endo.

redevelopment with flood risk mitigation presented some challenges, including the need for private investment, the regulatory burden, and the cost burden on redevelopment companies. The need for consensus among stakeholders and for sustainable operation and maintenance (O&M) after the redevelopment were also significant challenges.

The Futakotamagawa Park was developed as a public park by Setagaya Ward on a raised high-standard river flood embankment developed by MLIT (Board of Audit of Japan 2012). The park also has an underground rainwater detention pond, permeable pavers, and an infiltration trench, as well as a green space to manage stormwater overflow (**figures A2.5 and A2.6**).

Key Features

- **Integration of nature-based solutions:** The Futakotamagawa Rise project was awarded the world's first Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) gold certificate, based on its integration of various energy, environmental, and flood management benefits through both structural solutions, including gray and green solutions, and nonstructural solutions, including strong participation in the design, implementation, and O&M of the project.[5] The collective approach and seamless integration of both private and public development in one cohesive development project rather than individual smaller ones enabled the attainment of economic, environmental, and disaster risk management benefits, with less technical and financial burden, through role sharing among the various stakeholders.
- **Mechanisms for coordination and collaboration in multipurpose and multibenefit investments:** Various mechanisms were put into place to enable the different stakeholders to collaborate through a coordinated approach. To make it easier for the private developers—the Tokyu Land Corporation and Tokyu Corporation—to apply progressive disaster-resilient and environmentally sustainable construction methods and infrastructure design, Setagaya Ward and TMG relaxed their regulations on floor area ratio (FAR) and height limits on the proposed high-rise commercial, residential, and office buildings. Extensive consultation with the local residents by the Redevelopment Association, Setagaya Ward, and MLIT made possible the development of the high-standard embankment and the park. The public and private sectors, for example, spent several years in discussion with local residents to build consensus, and, as a result of this extensive dialogue, about 200 landowners joined the Redevelopment Association and offered their land for the redevelopment project under consensual terms. The active collaboration and engagement of the community continues to date, with various programs related to public awareness, environmental education,

5 LEED (Leadership in Energy & Environmental Design) is a green building certification system administered by the U.S. Green Building Council (USGBC). Among LEED certificates, LEED-ND (Urban Development) is awarded for environmental consideration, energy resource efficiency, and pedestrian-centered development. LEED-NC (New Buildings) is for environmental evaluation of new buildings, as well. For more information, see https://new.usgbc.org/.

green infrastructure, and flood risk management taking place regularly, with partial support from TMG and Setagaya Ward's community development and environmental subsidy programs (Bureau of Urban Development, TMG 2018).

- **Private and community participation in O&M:** Given the diverse stakeholders involved in the development and implementation of the Futakotamagawa Rise and Futakotamagawa Park development projects, the stakeholders were also able to share responsibility for O&M. As illustrated in **figure A2.7**, O&M, including for the flood management facilities within the Futakotamagawa Rise development, is shared among Tokyu Corporation, the developers, tenants, and citizens—for example, through the establishment of community-based environmental education groups. O&M for the Fukatotamagawa Park is led by Setagaya Ward. Additionally, the Futakotamagawa East District Urban Redevelopment Association is active in the O&M phase, organizing a number of town management activities that include O&M for structural measures, such as rainwater storage facilities, and nonstructural measures, to enhance livability.

Results: Establishment of Multipurpose Green and Resilient Commercial, Office, and Residential Development through Multi-stakeholder Collaboration

The **Futakotamagawa** Rise and Park development project illustrates how the private sector can be engaged in integrating flood risk management investments within redevelopment initiatives through a nature-based approach, which is still rare on a larger scale in Japan. Through partnership and close coordination in public sector priorities, such as urban redevelopment, environmental conservation, and river and surface flood management, the Futakotamagawa Rise example demonstrates that through joint planning and discussion, a comprehensive, cohesive, and creative approach to combining various public and private initiatives in close consultation with residents can result in a large-scale project with substantial economic, social, and environmental benefits, together with achieving flood management goals. The Futakotamagawa Rise project has been successful in terms of demonstrating that residents of Tokyo demand and value disaster-resilient and nature-based urban development. It was able, for example, to attract Rakuten, the largest e-commerce site in Japan and among the world's largest by sales, to locate its new global headquarters in Futakotamagawa Rise. This brought 10,000 new workers to the area.

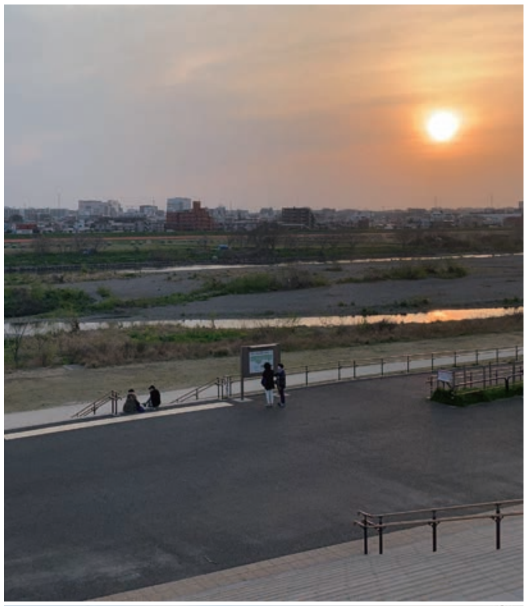


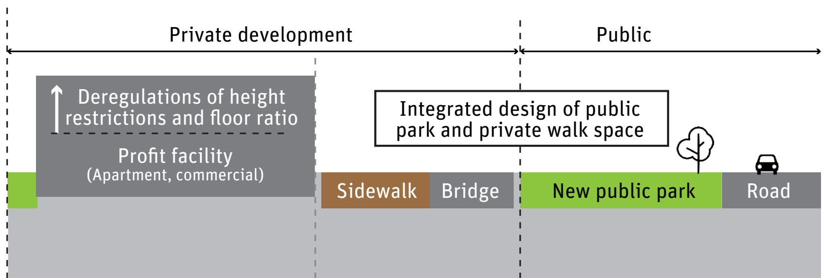
Figure A2.5: Futakotamagawa Park and Tama River and Landscape
Photo Credit: Kenya Endo.

Figure A2.6: Installation of Underground Rainwater Detention Pond beneath Futakotamagawa Park
Source: Nikkan Kogyo Shimbun 2017.

Figure A2.7: Cost Breakdown

Source: Development Bank of Japan 2019.

Note: MLIT = Ministry of Land, Infrastructure, Transport and Tourism; O&M = operation and maintenance; TMG = Tokyo Metropolitan Government.



Government: MLIT, TMG, and Setagaya Ward	Deregulation	Partially subsidizing O&M activities	Lead construction and O&M
Private developers and landowners: the members of the redevelopment association	Lead construction and O&M		Coordination
Tenants and community members	—	Participation in O&M activities	—

References

Board of Audit of Japan. 2012. "High-Standard Embankment Project: Results of Account Audit." January. http://report.jbaudit.go.jp/org/h23/YOUSEI2/2011-h23-6583-0.htm.

Bureau of Urban Development, TMG (Tokyo Metropolitan Government). 2015. "Futakotamagawa East Urban Redevelopment Project." July 31. http://www.toshiseibi.metro.tokyo.jp/cpproject/field/hutakotama/saikaihatsu81.html.

———. 2018. "Registration System of Town Development Organizations." April 16. http://www.toshiseibi.metro.tokyo.jp/seisaku/fop_town/syare03.htm.

Development Bank of Japan. 2019. "Re-framing the City through Green Infrastructure Finance: Experience from Japan." Presented at Integrated Urban Flood Risk Management Technical Deep Dive, Kobe City.

F-Inc. N.d. "Futakotamagawa Rise." Accessed February 13, 2019. http://www.f-inc.com/works/tokyu_dentetsu.html.

Futakotamagawa Rise. N.d. "About Futakotamagawa Rise." Accessed February 13, 2019. http://www.rise.sc/whatsrise/plan/.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism), Kanto Regional Office. 2001. "Tama River and Its Tributary Basic Master Plan." June. www.ktr.mlit.go.jp/ktr_content/content/000048377.pdf.

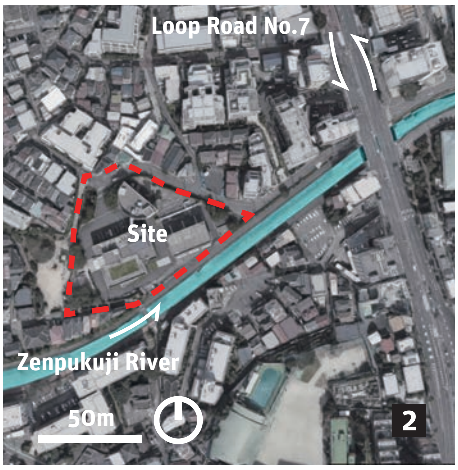
———. N.d. "Tama River Embankment Installation Project." Accessed February 13, 2019. http://www.ktr.mlit.go.jp/keihin/keihin00147.html.

Nikkan Kogyo Shimbun. 2017. "Preparation for Locally Heavy Rain—Controlling Stormwater Runoff and Efforts by Municipalities." June 19. https://www.nikkan.co.jp/articles/view/00432424/0/14756.

Setagaya Ward. 2013. "Setagaya Ward Futakotamagawa Park Basic Design." http://www.city.setagaya.lg.jp/kurashi/106/157/690/d00035487_d/fil/35487_4.pdf.

Case 3: Reducing River Flood Risk by Installing Underground Overflow Management Facilities: Underground Detention Cistern beneath Loop Road No. 7

Location:	Tokyo Metropolitan Area
Site characteristics:	Dense urban area with high concentration of assets and population in the surrounding area
Flood management measure(s):	
Flood type	River and surface water
Management capacity	Designed to accommodate a maximum rainfall target of 100 millimeters (mm)/hour.
Type of measure(s)	Structural (gray)
	Underground river overflow management facility
Relevant entities:	
Implementation	Bureau of Construction, TMG
O&M	Same as above[a]
Finance	Same as above
Construction period:	1st phase of the underground detention cistern beneath Loop Road No. 7: 1988–98 (Kanda River)
	2nd phase: 1995–2008 (Zenpukuji and Myoshoji rivers)
	3rd phase: 2016–25 (scheduled, Shakujii and Shirako rivers)
Cost:	Overall construction cost: Approximately ¥103 billion ($936 million)
	Phase 1: ¥54 billion; Phase 2: ¥49 billion[b]
Additional benefits and functions:	Not applicable
Sources:	Associated General Contractors of Tokyo n.d.; Bureau of Construction, TMG 2017; Nakano Ward 2013.
	a For more information, see Bureau of Construction, TMG n.d.(a).
	b MLIT, Kanto Regional Office 2005.



Context: Flood Risk and Urbanization

During Japan's period of fast economic growth, beginning in 1955, **the western wards of Tokyo** experienced rapid urbanization. In September 1958, Typhoon Ida caused 203 deaths and flooded 460,000 buildings, wreaking the greatest flood damage of the postwar era (Bureau of Construction, TMG n.d.[b]).[6] In response to the catastrophe, in the 1960s TMG's Bureau of Construction began to implement flood protection measures for small to medium-sized rivers to cope with rainfall above 50 millimeters (mm)/hour.

6 For more information, see Bureau of Construction, TMG n.d.(c).

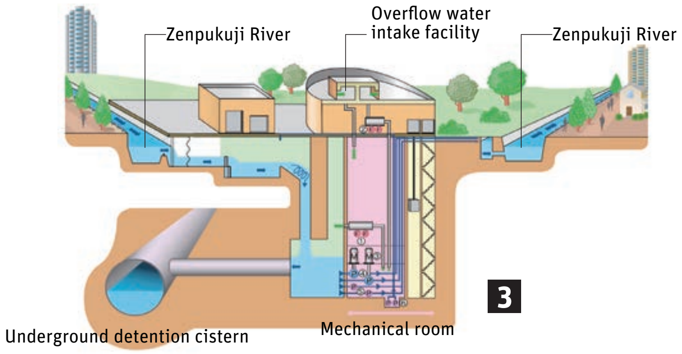


Figure A3.1: Overall View of the Site

Photo Credit: Kenya Endo.

Figure A3.2: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A3.3: Conceptual Diagram of the Facility

Source: Bureau of Construction, TMG 2016.

Figure A3.4: Underground Detention Facilities

Photo Credit: Kenya Endo.

In recent years, rainfall conditions have changed and the frequency of concentrated heavy downpours has increased, with rainfalls often exceeding 50 mm/hour. According to monitoring data from TMG for the past 30 years (1978–2007), heavy rainfall over short periods occurred over 30 percent more often in central Tokyo than in the surrounding areas. In response to this finding, TMG and ward and municipal governments collected rainfall data from 117 locations, and this investigation confirmed that the northwestern part of Tokyo in particular experienced frequent heavy rains exceeding 50 mm/hour (Yokoyama 2016).

Flood protection measures carried out by TMG's Bureau of Construction aimed mainly to enlarge the conveyance capacity of waterways by widening the river's sectional profile and excavating the riverbed. These approaches were often made impossible, however, by huge land acquisition costs or the presence of public infrastructure (such as subways). The local governments could choose from two other solutions: to build a detention pond upstream of the river for temporary storage of excessive stormwater or to construct a bypass channel to reduce the flow volume at bottlenecks (Associated General Contractors of Tokyo, n.d.). Considering the growing risk of flooding near this dense urban area with highly concentrated assets and population, it was crucial for the stakeholders to take measures that could be implemented within a short construction period, with little impact to the existing infrastructure and urban setting.

Solution: Investment Design and Key Features

Investment Design

To improve safety from flood risks quickly, TMG's Bureau of Construction built an underground detention cistern 4.5 kilometers (km) in length with a diameter of 12.5 m under Loop Road No. 7, 32–40 m below ground level (**figures A3.3** and **A3.4**). This facility was designed to deal with frequent flooding at the midstream of the Kanda, Zenpukuji, and Myoshoji rivers, an area that encompasses two western wards of Tokyo (Nakano and Suginami wards). It can store up to 540,000 cubic meters (m^3) of overflow water from the three rivers (**figure A3.5**).

Key Features

- **Achievement of cost and time savings through utilizing space under public roads:** The land acquisition cost for this project was not significant because the detention cistern was built right beneath a prefectural road, Loop Road No. 7, which is public land (Associated General Contractors of Tokyo n.d.). With the road running perpendicular to the three rivers (**figure A3.6**), the construction of a linear detention cistern also saved significant cost by having a single facility deal with three watersheds.
- **Use of a phased approach to construct large-scale flood management interventions as quickly as possible:** With a risk of flooding that might result in significant damage to the surrounding neighborhoods at any moment, early completion of mitigation measures was essential. To enhance flood management capacity as quickly as possible, the project was divided into two phases. Phase 1 consisted of the completion of a 2 km cistern and an intake facility for water from the Kanda River, with an overflow management

capacity of 240,000 m^3, which started operating in 1998. Phase 2 consisted of the remaining extent, which connected with the cistern built in phase 1 and started operating in 2008 (Bureau of Construction, TMG 2016). The next phase (phase 3) will extend the water management capacity even further. The Ring Road 7 Underground Regional Detention Cistern will be completed after connecting the current extent with the Shirako River Underground Detention Cistern, which is now under construction (**figure A3.6**). Once completed, the overall length of the cistern will be 13.1 km, with an overflow management capacity of 1.43 million m^3 (Associated General Contractors of Tokyo n.d.) from five rivers (adding the Shirako and Shakujii rivers), and it will be able to cope with heavy rainfall of up to 100 mm/hour.

Results: Increased Urban Flood Risk Management Capacity in Areas with Limited Space

With Phase 1 completed, the detention cistern began to demonstrate its flood management effects when it went into operation in 1998. By the end of February 2016, stormwater had flowed into the cistern from the three rivers 38 times, effectively mitigating flood damage along them (**figure A3.7**). Typhoon No. 11 in 1993 and Typhoon Ma-on (No. 22) in October 2004, for example, produced almost the same amount of rainfall, but the damage caused by the latter was significantly less than that caused by the former (**table A3.1**; Bureau of Construction, TMG 2016). Furthermore, the Ring Road 7 Underground Regional Detention Cistern is expected to increase flood management capacity and mitigate floods during concentrated heavy rains in the western wards, as well as their downstream neighborhoods.

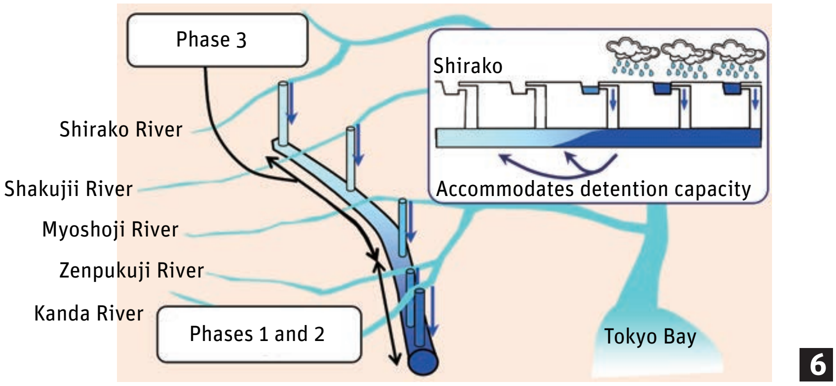


Figure A3.5: Flooding in 1993 by Typhoon 11; Water Intake and Situation in Nakano Ward
Source: Bureau of Construction, TMG 2016.

Figure A3.6: Relationship between Underground Detention Cistern and Five Rivers
Source: Bureau of Construction, TMG n.d.(d).

	Typhoon No.11 (Aug. 27, 1993)	Typhoon Ma-on No.22 (Oct. 9, 2004)
Total rainfall (hourly rainfall)	288 mm (47 mm/hour)	284 mm (57 mm/hour)
Flooded area	85 ha	4 ha
The number of flooded houses (inundation above the ground floor level/basement)	3,117 houses	46 houses

1

Table A3.1: Comparison between Typhoon No. 11 (1993) and Typhoon Ma-on (No. 22; 2004)

Source: Bureau of Construction, TMG 2016.
Note: ha = hectare; mm = millimeter.

References

Associated General Contractors of Tokyo. N.d. “Infrastructure Stock Effects.” Accessed February 13, 2019. http://token.or.jp/magazine/g201611.html.

Bureau of Construction, TMG (Tokyo Metropolitan Government). 2016. “Underground Detention Pond of Kanda River Loop Road No. 7.” Pamphlet, March. http://www.kensetsu.metro.tokyo.jp/content/000029010.pdf.

———. 2017. “About the Underground Detention Pond of Kanda River Loop Road No. 7.” March 9. http://www.metro.tokyo.jp/tosei/hodohappyo/press/2017/03/09/documents/07_01.pdf.

———. N.d.(a). “River Planning, Zoning, and River Restoration Areas.” http://www.kensetsu.metro.tokyo.jp/jigyo/river/jigyo/kuiki/kuiki.html.

———. N.d.(b). “Typhoon Ida Overall Damage (1958 September).” http://www.kensetsu.metro.tokyo.jp/suigai_kiroku/html/karino.htm.

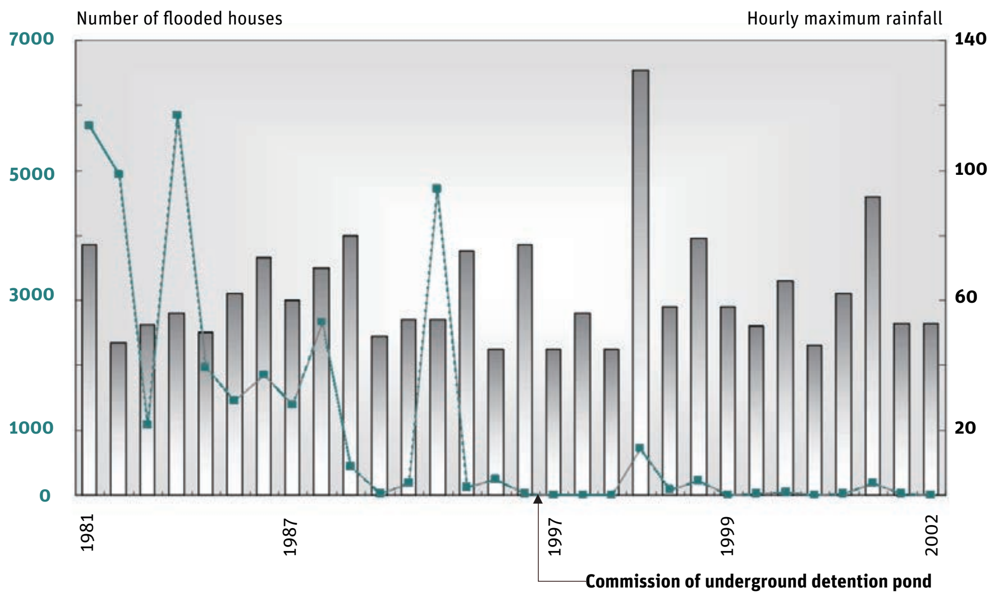
———. N.d.(c). “Historic Record of Flooding.” http://www.kensetsu.metro.tokyo.jp/suigai_kiroku/kako.htm.

———. N.d.(d). “River Development and Management.” http://www.kensetsu.metro.tokyo.jp/jimusho/sanken/kasen_seibi.html.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism), Kanto Regional Office. 2005. “Effects of Underground Detention Pond of Kanda River Loop Road No. 7.” February. http://www.ktr.mlit.go.jp/ktr_content/content/000001296.pdf.

Nakano Ward. 2013. “Urban River Development Plans.” August 23. http://www.city.tokyo-nakano.lg.jp/dept/502000/d004348.html.

Yokoyama, Hitoshi. 2016. “Actual Condition of Concentrated Torrential Rainfall and Its Adaptation in Tokyo.” August 7. http://www.airies.or.jp/attach.php/6a6f75726e616c5f6368696b79756b616e6b796f5f323031363131303231353037303132/save/0/0/21_2-10.pdf.



7

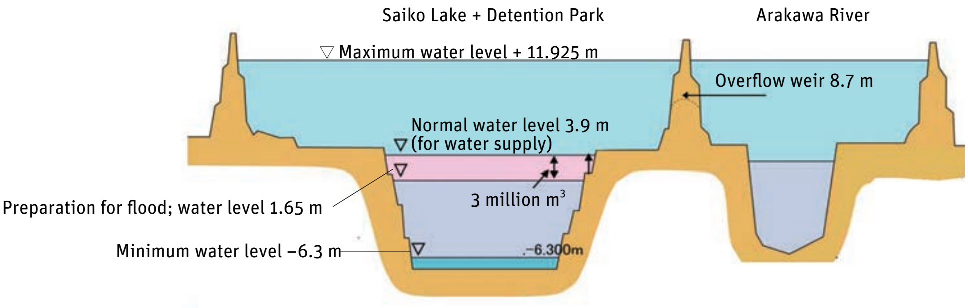
Figure A3.7: Maximum Rainfall and Number of Buildings Flooded by Kanda River, 1981–2002

Source: MLIT, Kanto Regional Office 2005.

1

Case 4: Reducing River Flood Risk by Installing a Multipurpose Detention Park and Reservoir: Arakawa River No. 1 Detention Facility

Location:	Saitama City, Saitama Prefecture
Site characteristics:	Urban area (commercial, residential, and public facilities) with low to medium density
Flood management measure(s):	
Flood type	River
Management capacity	Storage: 39 million m^3
	Water supply: Effective capacity 10.6 million m^3
	Treatment capacity: 302,400 m^3/day at advanced wastewater treatment facility[a]
	Arakawa No. 1 detention facility manages 850 cubic meters per second (m^3/s) water volume and is targeted to accommodate a maximum 1-in-200-year storm event[b]
Type of measure(s)	Structural (green)
	Detention park and reservoir
Relevant entities:	
Implementation	Detention facility, treatment plant, reservoir, and associated embankment—national government (river administrator)
	Park facilities (baseball field, jogging and cycling roads, barbeque pits)—Saitama, Toda, and Wako cities
O&M	Same as above
Finance	Same as above
Construction period:	Overall detention facility: 1974–2003
	Saiko Lake (reservoir): 1980–96
Cost:	Construction cost: ¥135.3 billion ($1.23 billion)
	O&M: ¥75.6 million ($687,000) annually (generated by taking the average between 2004 and 2009)[c]
Additional benefits and functions:	Water supply
	Recreational space (public park with sports field)
Sources:	MLIT, Kanto Regional Office 2016, except where otherwise noted.
	a For more details, see MLIT 2010.
	b MLIT 2010.
	c MLIT, Kanto Regional Office 2016.



2

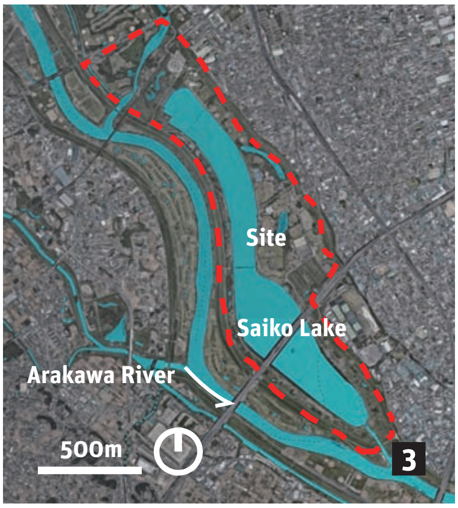


Figure A4.1: Overall View of the Site

Photo Credit: Kenya Endo.

Figure A4.2: Conceptual Diagram of Arakawa River No. 1 Detention Facility

Source: MLIT, Kanto Regional Office 2018.
Note: m = meter; m3 = cubic meter.

Figure A4.3: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A4.4: Sports Field

Photo Credit: Kenya Endo.

Figure A4.5: Urban Context

Photo Credit: Kenya Endo.

Context: Flood Risk

The Arakawa River is a Class A river[7] that flows from **Saitama Prefecture** to Tokyo. Currently, its watershed is shared by 9.7 million residents, and it serves as the region's main potable water supply. In 1947, the Arakawa River experienced a huge flood caused by Typhoon Kathleen that collapsed its embankment, killed 86 people, and damaged nearly 80,000 houses in Saitama Prefecture alone (MLIT, Kanto Regional Office n.d.). Given the socioeconomic damage caused by the devastating floods, as well as growing urbanization and the importance of protecting people and assets downstream, the Japanese government established a comprehensive Arakawa River Basic Construction Plan in 1965,[8] which included measures to install flood management dams upstream and detention facilities midstream, where land was still less developed (MLIT 2007).

In response to these renewed flood management plans, the national government, together with Saitama Prefecture,[9] initiated a project in 1973 to install the Arakawa River No. 1 Detention Facility (Furuichi 2018). The project also addressed the need to convert the region's water source from groundwater to river water, as rapid urbanization and population growth in Tokyo and Saitama Prefecture starting in the late 1950s had led to decreased groundwater levels and land subsidence, which had become a major social issue (MLIT 2015).

Solution: Investment Design and Key Features

Investment Design

Under these circumstances, MLIT began preparing a comprehensive development project for improvement of the Arakawa River in 1974. The construction of Saiko Lake (a 1.18 square kilometer [km^2] reservoir) and Arakawa River No. 1 Detention Park (a multipurpose 4.67 km^2 public park with a sports field and parking lots; **figure A4.4**) was completed in 1996 and 2003, respectively.[10] The storage capacity of the entire facility is 39 million m^3 (MLIT, Arakawa Upstream River Office n.d.[a]; Furuichi 2018). Since completion of the project, the site has served to store and supply sufficient water (**figures A4.6**) to the Tokyo Metropolitan Area and Saitama Prefecture, both of which used to suffer from frequent shortages (MLIT, Kanto Regional Office 2014; Nikkei 2016). The reservoir and park are managed by a number of local governments in the vicinity, including Saitama, Toda, and Wako (Toda City 2017; Wako City 2014).

Key Features

- **Designing a multipurpose and multibenefit investment:** The Detention Facility Utilization Plan was developed to implement proper maintenance and environmental conservation initiatives at the project site, based on discussion among a committee comprising experts and prefecture and city

7 Class A river systems are those designated by the MLIT minister as important for national land conservation or economic activities. Most Class A rivers have basin areas of 1,000 km^2 or more and are used for water supply and power generation.

8 For more details, see MLIT, Arakawa Upstream River Office n.d.(a) and MLIT, Kanto Regional Office 2007.

9 For more details, see MLIT, Kanto Regional Office 2007.

10 For more details, see MLIT, Arakawa Upstream River Office n.d.(b).

representatives. The plan divided the area into three zones: a nature conservation zone, a water park zone, and an outdoor activity zone. It called for both active use of the riverine environment and protection of the habitats of rare species, such as primrose (Primulaceae spp.).

- **Cost reduction through localizing cut-and-fill earthworks:** By jointly implementing the flood protection measures of the Arakawa River and the development of Saiko Lake, the project cost significantly less than it would have if the two had been carried out separately. About 7,660,000 m^3 of the soil that was excavated from the Saiko Lake development was reused for building embankments along the detention park, saving the ¥24 billion ($218 million) it would have cost to purchase and bring in soil from outside (MLIT, Arakawa Upstream River Office 2004).

Figure A4.6: Detention Facility under Normal and Flood Conditions
Source: MLIT, Kanto Regional Office 2018.

Results: Additional Benefits

Arakawa No. 1 Detention Facility has shown remarkable capacity for flood management and water supply. The administrator of the facility publishes a follow-up report every five years, which includes monitoring results pertaining to flood management effectiveness, volume of water supply, quality of water, sedimentation, and the status of the ecosystem and water resources in the reservoir. According to the report, during a flood in August 1999, the water level at the Keisei Oshiage Line Bridge—the lowest water-level monitoring point of the Arakawa River downstream—was 39 centimeters (cm) lower than during the previous flood. Without the development of upstream flood management facilities, the water level would have reached as high as 7 cm just below the bridge (MLIT, Arakawa Upstream River Office 2005). In addition to providing flood management benefits, Saiko Lake supplied approximately 40.5 million m^3 of water to the region over 195 days of water shortage between 2011 and 2016 (MLIT 2016).[11]

References

Furuichi, Hidenori. 2018. "100-Year History: Arakawa Upstream Renovation." June. http://www.jiti.co.jp/graph/page1806/0604k/index.htm.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism). 2007. "Water Resource of Japan—Chapter 8: Effective Use of Water Resource." http://www.mlit.go.jp/tochimizushigen/mizsei/hakusyo/H19/3-8.pdf.

———. 2010. "Arakawa Upstream River Improvement Project (Arakawa No. 1 Reservoir)." February 24. http://www.ktr.mlit.go.jp/honkyoku/kikaku/jigyohyoka/pdf/h21/05siryo/siryou1-9-1.pdf.

———. 2015. "Current Situation of the Use of Water." *In Basic Policy and Plans for River Improvement*. July 14. http://www.mlit.go.jp/river/basic_info/jigyo_keikaku/gaiyou/seibi/pdf/arakawa29-5-05.pdf.

———. 2016. *Periodic Report: Arakawa Reservoir General Development Facility.* December 21. http://www.ktr.mlit.go.jp/ktr_content/content/000667295.pdf.

11 For more details, see MLIT 2016.

MLIT, Arakawa Upstream River Office. 2004. "Construction of Arakawa River No. 1 Detention Pond (Monthly Construction, 04-08, p. 36)." Japan Construction Engineers Association. July. https://www.zenken.com/hypusyou/zenkensyou/h15/H15_zk_A/zk_15_a2_kasen03.pdf.

———. 2005. "Role and Mechanism of Detention Pond." Material for 12th meeting of the Council for Natural Regeneration in Arakawa Tarouemon District, November 6. http://www.ktr.mlit.go.jp/ktr_content/content/000030867.pdf.

———. N.d.(a). "Arakawa River Upper Stream 100-year History of River Improvement." http://www.ktr.mlit.go.jp/arajo/arajo00584.html.

———. N.d.(b). "The Role of Saiko Lake." http://www.ktr.mlit.go.jp/arajo/arajo00161.html.

MLIT, Kanto Regional Office. 2007. "Arakawa River Basic Plan for Construction and Development Basic Policy—Comparison Chart." February 27. http://www.mlit.go.jp/river/shinngikai_blog/shaseishin/kasenbunkakai/bunkakai/23/pdf/siryo5-1.pdf.

———. 2014. *Regarding the Utilization of Saiko Lake and Drowning (2012).* Report prepared by Jun Matsumoto. June. http://www.ktr.mlit.go.jp/ktr_content/content/000105728.pdf.

———. 2016. "Promotion of Advancement and Multipurpose Facilities." August. http://www.mlit.go.jp/common/001141415.pdf.

———. 2018. "Overview of Arakawa River No. 1 Detention Pond." May 18. http://www.ktr.mlit.go.jp/ktr_content/content/000700546.pdf.

———. N.d. "Typhoon Kathleen Overall Damage." http://www.ktr.mlit.go.jp/river/bousai/river_bousai00000006.html.

Nikkei. 2016. "What Kind of Lake Is Saiko Lake of Saitama?" November 26. https://style.nikkei.com/article/DGXKZO09946820V21C16A1L83000?channel=DF130120166109.

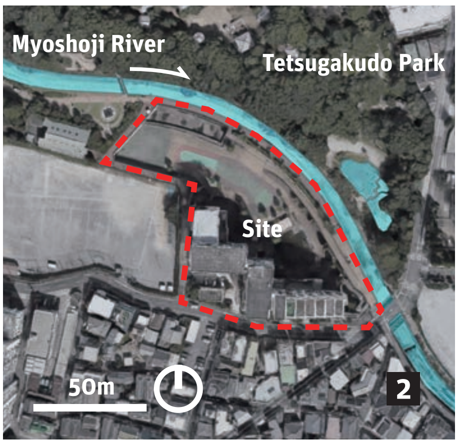
Toda City. 2017. "Toda City Information Portal." October 2. http://www.city.toda.saitama.jp/soshiki/213/siteikanrihyoukahyou.html.

Wako City. 2014. "Master Plan for Urban Development: Wako City." July 16. http://www.city.wako.lg.jp/home/toshikiban/toshikeikaku/masterplan.html.

1

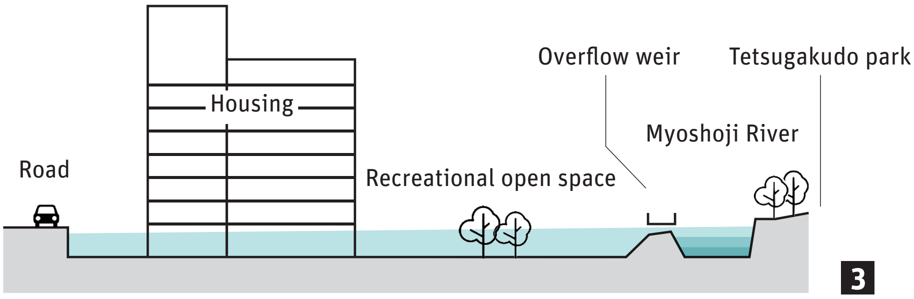
Case 5: Reducing River and Surface Water Flood Risk through Cost Sharing for O&M: Tetsugakudo Park Collective Housing and Myoshoji River No. 1 Detention Pond

Location:	The Myoshoji River between Shinjuku Ward and Nakano Ward in the Tokyo Metropolitan Area
Site characteristics:	Dense urban area with assets and population highly concentrated near residential, industrial, commercial, office, and public areas. A large plot of land became available when the factory relocated.
Flood management measure(s):	
Flood type	River and surface water
Management capacity	Tetsugakudo Park Collective Housing: 163 household development Myoshoji River No. 1 Detention Pond: 30,000 m^3 with management capacity of 50 mm/hour
	Park: 7,600 square meters (m^2) of permeable surface
Type of measure(s)	Structural (green and gray)
Relevant entities:	
Implementation	Tetsugakudo Park Collective Housing: Urban Renaissance Agency (UR)
	Myoshoji River No. 1 Detention Pond: TMG
	Park: Shinjuku and Nakano Ward
O&M	Same as above
Finance	Same as above
Construction period:	1984–87
Cost:	Total development cost: ¥10.4 billion ($94.5 million)[a]
Additional benefits and functions:	Increase in public recreation space
	Housing development
Sources:	UR 2018, except where otherwise noted.
	a UR n.d.



Context: Urban Development and Flood Risks

Rapid development over the years has made the Myoshoji River, which used to have fields and forests in its basin, into a typical urban river. With dense urban neighborhoods within its watershed, the river often overflows due to the immense volume of stormwater that flows into it during heavy rain (UR 2018). During the flood in 2005, for example, heavy rain damaged over 3,000 houses in **Suginami and Nakano wards** (Bureau of Construction, TMG 2015). The region was able to cope with about 30 mm/hour rainfall as of 1975, thanks to continuous flood mitigation efforts, but the amounts of torrential rainfall nowadays often exceed that capacity. In light of this, the river administrator had set as a goal for the immediate future the capacity to cope with 50 mm/hour rainfall; however, given that meeting that goal would drain water toward the downstream area, river



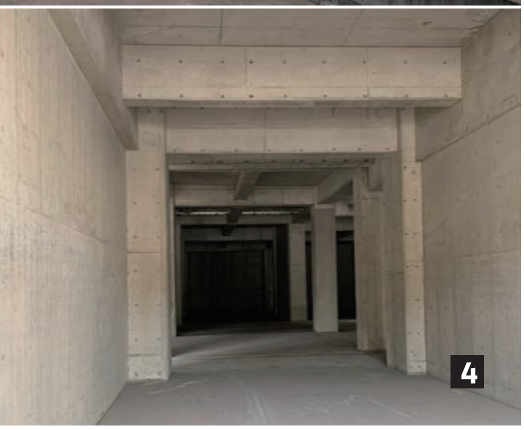


Figure A5.1: Overall View of the Site
Photo Credit: Kenya Endo.

Figure A5.2: Site Context
Source: Google Earth. Note: m = meter.

Figure A5.3: Conceptual Diagram of the Infrastructure
Source: Modified based on information from UR (2018).

Figure A5.4: Park and Pilotis Spaces at the Site
Photo Credit: Kenya Endo.

authorities of TMG have aimed to manage flood risks through the installation of detention ponds along the river, in conjunction with urban development initiatives.

Solution: Investment Design and Key Features

Investment Design

In response to new urban development and the increasing need for flood risk management, TMG, Shinjuku and Nakano wards, and the UR, a housing developer, launched a joint initiative in 1984. With a shared incentive to implement a project that would utilize land and reduce life-cycle costs effectively, TMG asked Nakano and Shinjuku wards and UR to collaborate on a multipurpose development that would combine residential development (led by UR) with the construction of aboveground detention ponds (led by TMG) and a public park (led by Shinjuku and Nakano wards). The total development area was to be approximately 11,000 m^2, with a water detention capacity of approximately 30,000 m^3 (**figure A5.3**).

TMG developed, along with the wards, the detention pond that improved the park, while UR facilitated development of a convenient and attractive housing development to ensure profitability of the overall development project. The collaboration of the four diverse stakeholders in the design implementation resulted in a multifunctional and multibenefit project.

The detention pond has two layers of water storage. As the water level of the Myoshoji River rises, the first storage layer takes surplus water flow into the middle of the detention pond. When the middle becomes full, surplus water then flows into the part that is used in normal times as park and pilotis spaces for the residential area (**figures A5.3** and **A5.4**). The detention pond can accommodate a rainfall of 30 mm/hour.

Key Features

- **Shared roles and responsibilities for implementation and O&M resulting in cost savings:** TMG tried to make use of the open space created after a factory relocation to install detention ponds, but the high price of the land presented a challenge. Furthermore, devoting the space solely to the purpose of water management represented an underutilization of this valuable land. In addition, the cost of the land made it difficult for the ward governments to finance the development costs on their own. Expanding the use of the land to other purposes, therefore, was important, as many people would have an interest in financing the construction (thus reducing the cost per investor), and O&M responsibilities could be shared among the stakeholders (UR 2018). To this end, TMG, Nakano and Shinjuku wards, and UR developed a management agreement that aimed to designate almost the entire development site as a "river area"; clarified who would manage the areas with multiple land use types; clarified the functions of the detention ponds and recreational park; and, last, stipulated that none of the four stakeholders would own the property rights or the exclusive usage rights to the river (UR 2018). As per this agreement, TMG and the two wards became responsible, respectively, for O&M of the detention ponds and the park. UR would be responsible for O&M of the piloti on the ground-floor level of the building and of the fence around it under normal circumstances. The agreement clearly stated that, after floods, the two wards would remove debris and mud from gutters and

Stakeholder	Land Cost Sharing	Land Use	Land Ownership
Tokyo Metropolitan Government	42%	Entire site (river area)	-
Nakano and Shinjuku Ward Authorities	33%	66%	50%
Urban Renaissance Agency	25%	Approximately 33% (entire site is subject to a floor area ratio)	50%

1

Table A5.1: Land Cost Sharing, Use, and Ownership by Stakeholders
Source: Based on UR (2018).

clean the fence. In addition, it was agreed that an administrator from UR would activate alarms for evacuation, if necessary. **Table A5.1** shows further cost- and role-sharing arrangements. As a result of these arrangements, costs were significantly reduced for the individual stakeholders, as compared to what they would have been had they implemented the project individually.

- **Effectiveness of governance and coordination mechanisms across city boundaries:** The location of the detention pond between Nakano and Shinjuku wards complicated its development and O&M management. To advance the development of collective housing and detention ponds, the two wards and UR reached an agreement that clearly defined in advance their duties and roles for sustainable construction and O&M, as described above.

Results: Large-Scale Flood Management Investment Enabled in High-Value Land

The investments in Tetsugakudo Park Collective Housing and Myoshoji River No. 1 Detention Pond have contributed significantly to flood management in the area. Records dating back to 1995, for example, show that the flood waters are managed within the park and the piloti spaces about twice a year, with a maximum depth of 230 cm. The detention pond has also repeatedly helped mitigate flood damage in the downstream area in central Tokyo (UR 2018).

Financing large-scale flood management facilities in urban centers with high-value land may be difficult if carried out by the public sector for public use alone. The case of Tetsugakudo Park Collective Housing and Myoshoji River No. 1 Detention Pond illustrates how partnership between local governments, as well as with a housing developer, to share the cost and responsibilities for implementation and O&M among the various stakeholders can enable the implementation of flood management facilities in high-value land areas in urban centers.

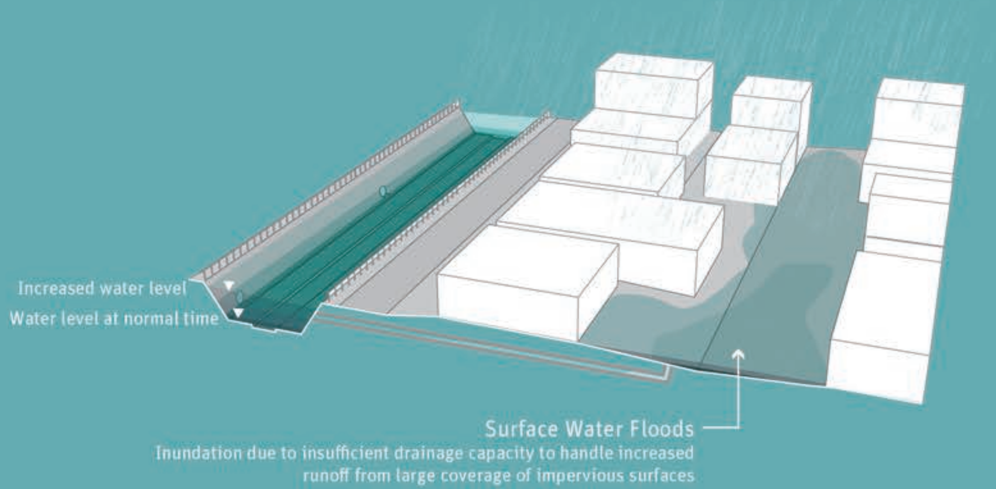
References

Bureau of Construction, TMG (Tokyo Metropolitan Government). 2015. "Special Urgent Project for Devastating Flood of Myoshoji and Zenpukuji Rivers." http://www.kensetsu.metro.tokyo.jp/jigyo/river/information/gekitoku/gekitoku.html.

UR (Urban Renaissance Agency). 2018. "Urban Development Runoff Mitigation System in Japan: Measures for Urban Rivers and Planning of Detention Ponds."

———. N.d. "Integrated Development of Detention Pond, Urban, and Housing in Japan."

Surface Water Floods



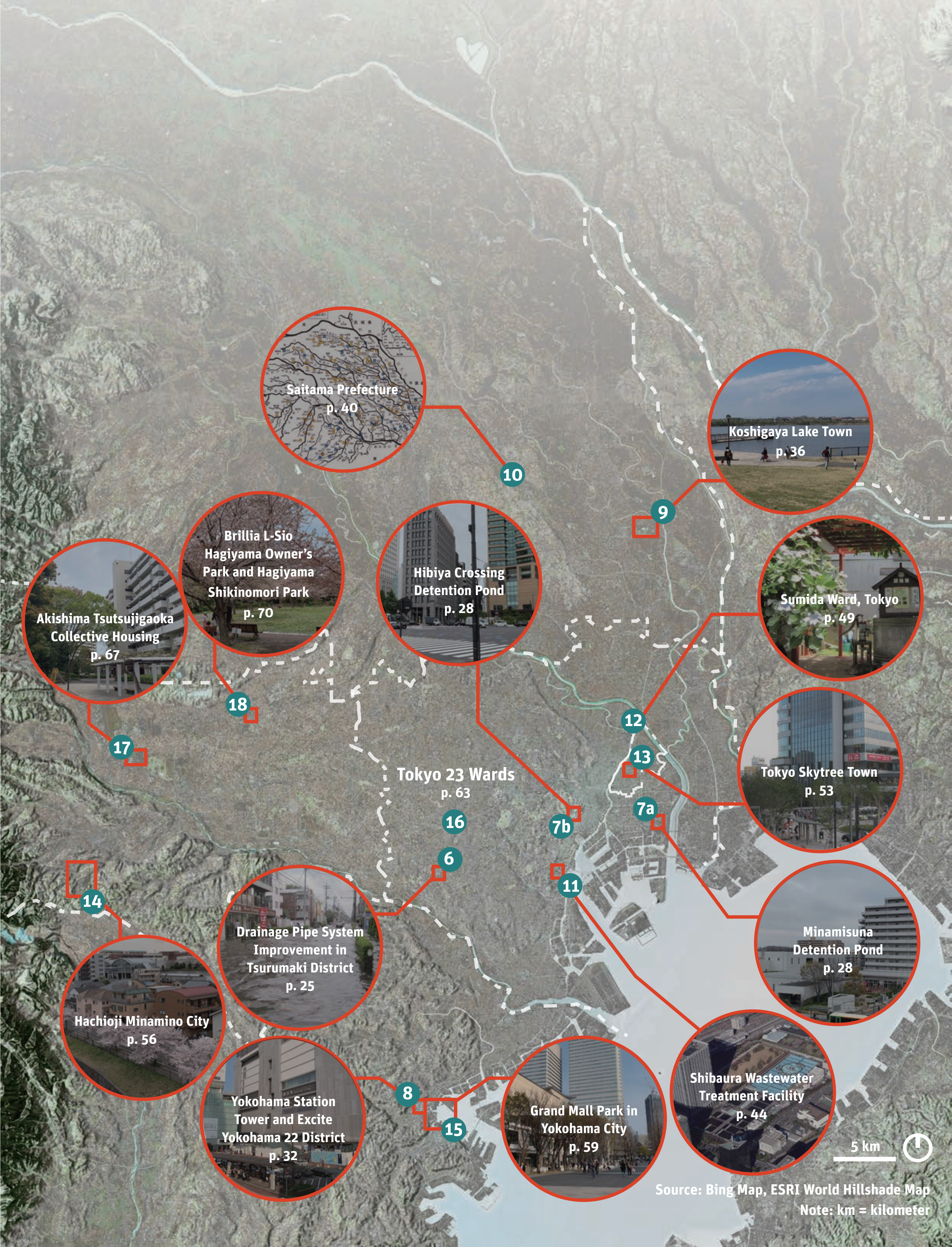

Saitama Prefecture
p. 40
10
Koshigaya Lake Town
p. 36
9
Brillia L-Sio
Hagiyama Owner's
Park and Hagiyama
Shikinomori Park
p. 70
Hibiya Crossing
Detention Pond
p. 28
Akishima Tsutsujigaoka
Collective Housing
p. 67
Sumida Ward, Tokyo
p. 49
18
17
12
13
Tokyo Skytree Town
p. 53
Tokyo 23 Wards
p. 63
7a
7b
16
6
11
14
Minamisuna
Detention Pond
p. 28
Drainage Pipe System
Improvement in
Tsurumaki District
p. 25
Hachioji Minamino City
p. 56
Shibaura Wastewater
Treatment Facility
p. 44
Yokohama Station
Tower and Excite
Yokohama 22 District
p. 32
8
15
Grand Mall Park in
Yokohama City
p. 59
5 km
Source: Bing Map, ESRI World Hillshade Map
Note: km = kilometer

Figure A6.1: Flooded Tsurumaki District on July 23, 2013
Source: Setagaya Ward 2016.

Case 6: Reducing Surface Water Flood Risk with an Underground Stormwater Management Facility: Drainage Pipe System Improvement, Tokyo

Location:	Along Jakuzuregawa River, which runs through Tsurumaki District, Setagaya Ward, and Kami-Meguro District, Meguro Ward, in central Tokyo
Site characteristics:	Located in a highly developed area in central Tokyo, with main railway stations and surrounded by thriving commercial areas
Flood management measure(s):	
Flood type	Surface water
Management capacity	Designed to accommodate maximum rainfall of 75 mm/hour
	Initial 2.8 km under Phase 1 estimated to have additional 42,000 m^3 storage capacity
Type of measure(s)	Structural (gray)
	Underground stormwater management facility (drainage pipe system)
Relevant entities:	
Implementation	Mainly the Sewerage Department of TMG with support from the Setagaya and Meguro ward governments
O&M	Same as above
Finance	Same as above
Construction period:	Phase 1 (initial 2.8 km): 2016–20[a]
	Phase 2 (remaining 4 km): To be determined
Cost:	Approximately ¥6.7 billion[b] ($61.3 million) for Phase 1
Additional benefits and functions:	Not applicable
Sources:	Bureau of Sewerage, TMG 2017.
	a Setagaya Ward 2016.
	b From bidding disclosure data available at http://oss.avantage.co.jp/bid/?p=536257; http://oss.avantage.co.jp/bid/?p=679307; http://oss.avantage.co.jp/bid/?p=310002.

Context: Urban Development and Flood Risk

The highly concentrated urban neighborhoods of Tokyo place great priority on saving people and assets from surface water floods. The massive network of existing infrastructure at the subsurface level (such as metro and utility lines), as well as dense built-up areas at the ground level, make structural (gray) measures with minimum impact to the existing urban settings the preferred approach.

Meguro and Setagaya wards are centrally located within the Tokyo Metropolitan Area, where houses and commercial developments are densely built and land values are high. With the financial and technical leadership of TMG, the two wards constructed a combined sewer and rain management system along the Jakuzuregawa River, 9.7 km in length (Watanabe 2015).

This system, which served as an exposed drainage channel until it was covered in 1955, drains stored water after a rainfall to lower the water level of the Meguro River. With rapid urban development, two additional water detention facilities (with storage capacity of 12,000 m³) were constructed.

Floods have been increasing in frequency and magnitude, however. During a concentrated heavy rain in July 2013, more than 60 buildings were inundated along the sewerage system.[12] **Figure A6.1**, for instance, shows flooding in Tsurumaki District on July 23 of that year, a result of a 66 mm/hour storm (Setagaya Ward 2016).

In response to such intense rainfall, TMG, together with central wards in Tokyo with high urbanization and flood risks, designated areas that urgently required improvement to and retrofitting of their flood management facilities to manage 75 mm/hour rainstorm events.[13] Flood management priority areas, including Setagaya and Meguro wards, were identified, based not only on their high flood risks and the density of their urban populations and assets, but also on the existence of flood management infrastructure that could be effectively upgraded. Among the characteristics of existing infrastructure in priority zones were (i) drainage systems laid not far below ground level, (ii) heavily urbanized neighborhoods in the surrounding areas, and (iii) valley-like conditions where a high volume of runoff came together all at once. These sites included Tsurumaki District in Setagaya Ward and Kami-Meguro District in Meguro Ward.

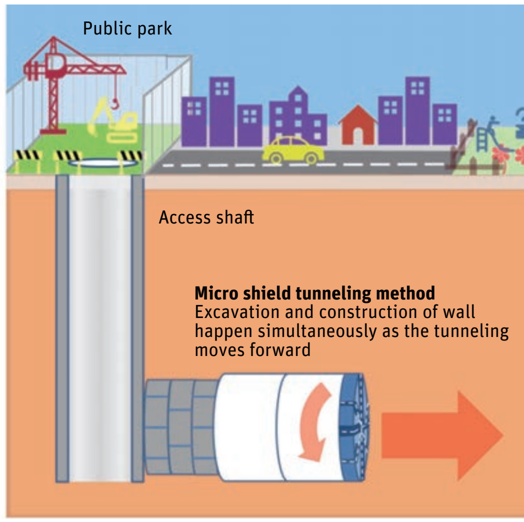
Solution: Investment Design and Key Features

Investment Design

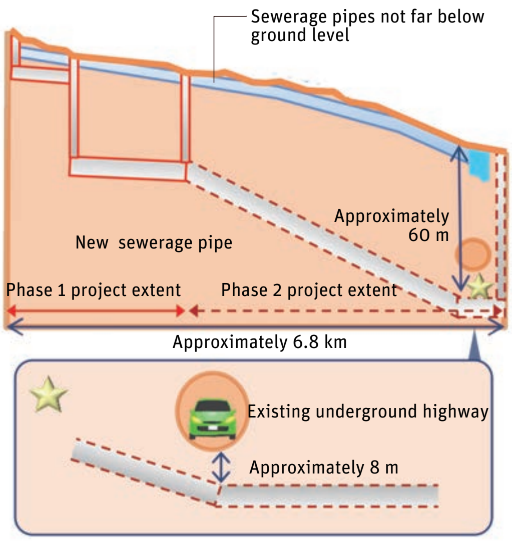
Construction of an additional channel underneath the original combined sewer and rain management system along the Jakuzuregawa River was initiated in 2017. The additional channel is approximately 5 m in diameter and 6.8 km long (Setagaya Ward 2016). The initial 2.8 km is estimated to have 42,000 m³ of additional storage capacity, which will contribute toward achieving TMG's target of managing intense storms with rainfall up to 75 mm/hour.

Key Features:

- **Little impact during underground construction work:** The "micro shield tunneling method" (see the conceptual diagram in **figure A6.2**) was utilized to construct additional water pipes running along the underground stormwater drainage system. In Tsurumaki's case, the new pipes were laid approximately 60 m below ground level (**figure A6.3**). In addition, access shafts for the construction work were placed in public parks, which minimized the impacts of noise, vibration, and dust on the surrounding neighborhoods. Given the low construction impact, TMG is able to construct two pipes simultaneously, which shortens the total construction time from the 6.5 years planned to 4.5 years.
- **Phased and modular construction process:** Extensive underground work often requires long periods to complete. In light of the urgent need to manage surface water as quickly as possible, TMG will implement the underground channel construction in three small segments (including two segments in Phase 1 that will be implemented simultaneously), from upstream to



2



3

Figure A6.2: Conceptual Diagram of Micro Shield Tunneling Method

Source: Bureau of Sewerage, TMG 2018.

Figure A6.3: Conceptual Diagram of Construction Work for New Sewerage Pipes at Tsurumaki District

Source: Bureau of Sewerage, TMG 2018.
Note: km = kilometer; m = meter.

12 For more information, see TMG (2015).
13 For more information, see TMG (2018).

downstream. As soon as construction of one segment is completed, the facilities can go into operation managing surface floods, without the need to wait for the entire project to be finished (Bureau of Sewerage, TMG 2018).

Results: Efficient Infrastructure Construction

The adoption of the micro shield tunneling method enabled efficient construction of the underground surface water management facility by shortening the construction time for the additional drainage pipes and making available the additional flood management capacity as quickly as possible. This was possible because the technological innovation allowed for the complex underground construction work to be carried out with minimal noise, shaking, and aboveground space, thus making possible the simultaneous construction of two segments of the pipes. Despite the high cost, highly dense urban centers with immediate flood management needs can benefit from this construction method, given the potential savings in time and disruption of existing economic, infrastructure, and social activities above- and belowground.

References

Bureau of Sewerage, TMG (Tokyo Metropolitan Government). 2017. "Tokyo Sewerage 2017." http://www.gesui.metro.tokyo.jp/business/kanko/kankou/2017tokyo/index.html.

———. 2018. "Protect Tokyo from Heavy Rain! Measures to Prevent Flooding of Sewer Systems." March. http://www.gesui.metro.tokyo.jp/living/pdf/shinsuitaisaku.pdf.

Setagaya Ward. 2016. "Announcement of Planning Change in Jakuzuregawa River Improvement Project." November 14. http://www.city.setagaya.lg.jp/kurashi/107/157/802/d00149982_d/fil/15.pdf.

TMG (Tokyo Metropolitan Government). 2015. "1-2-1 Construction Methodology of Sewerage System That Can Manage 75 mm/hour Rainfall." http://www.gesui.metro.tokyo.jp/business/pdf/1-2-1_2015.pdf.

———. 2018. "Zero Inundation, Safe, and Comfortable Sewerage System." http://www.gesui.metro.tokyo.jp/topics/shinsui_zero/.

Watanabe, Yusuke. 2015. "Methodology of Designing Sewerage System That Accommodates 75mm/hour Rainfall." http://www.gesui.metro.tokyo.jp/business/pdf/1-2-1_2015.pdf.

Case 7: Reducing Surface Water Flood Risk by Installing an Underground Stormwater Management Facility with Other Public Facilities: Minamisuna Detention Pond (7a) and Hibiya Crossing Detention Pond (7b)

Location:	Minamisuna and Hibiya are neighborhoods located in Koto and Chiyoda wards, respectively, in the Tokyo Metropolitan Area.
Site characteristics:	Minamisuna: Residential district; Hibiya: Central business district
Flood management measure(s):	
Flood type	Surface water
Management capacity	Minamisuna: Stormwater storage capacity of 25,000 m^3 (length 62 m × width 46 m × depth 9 m)[a]
	Hibiya: Stormwater storage capacity of 3,400 m^3 (width 9.9 m × length 47.7 m × depth 6.8 m)
Type of measure(s)	Structural (gray)
	Underground stormwater management facility (detention pond)
Relevant entities:	
Implementation	Minamisuna: Detention pond—Bureau of Sewerage, TMG with technical and financial support from MLIT; housing development—Tokyo Metropolitan Housing Supply Corporation; bicycle parking—Koto Ward
	Hibiya: Detention pond—Bureau of Sewerage, TMG with technical and financial support from MLIT; road upgrade—MLIT
O&M	Same as above
Finance	Same as above
Construction period:	Minamisuna: Detention pond began operation in 2006; overall Shinsuna Land Readjustment Project implemented 1997–2004[b]
	Hibiya: Detention pond construction: 2005–07; common tunnel construction in Hibiya started in 1987
Cost:	Minamisuna: Detention pond—approximately ¥10 billion ($85 million)[a]; Shinsuna Land Readjustment Project—approximately ¥16.8 billion ($152 million)[b]
	Hibiya: not available
Additional benefits and functions:	Minamisuna: 107 housing units, bicycle parking, parks, and other public amenities aboveground[c]
	Hibiya: Mitigation of heat island effect
Sources:	Kamata 2006, except where otherwise noted.
	a Bureau of Sewerage, TMG 2009.
	b Bureau of Urban Development, TMG 2004.
	c Tokyo Metropolitan Housing Supply Corporation, n.d.

Figure A7.1: Overall View of the Site: Minamisuna
Photo Credit: Kenya Endo.

Figure A7.2: Overall View of the Site: Hibiya Crossing
Photo Credit: Kenya Endo.

Figure A7.3: Minamisuna and Hibiya Site Contexts
Source: Google Earth. *Note*: m = meter.

Context: Urban Development and Flood Risk

Minamisuna District is located on reclaimed land below sea level in **Koto Ward**, Tokyo, and has historically suffered from severe flood damage to people and assets. Hibiya District is the heart of the central business district in Tokyo and the location of various highly valued structures and services. There, dense development with limited infiltration capacity has resulted in frequent inundation of the area around Hibiya Crossing, disrupting activities in the surrounding areas. During Typhoon Ma-on (No. 22) and Typhoon Tokage (No. 23) in October 2004, for example, serious flood damage to roads halted traffic in Hibiya Crossing and disabled the connectivity of this important transportation hub (**figure A7.4**).

In both districts, key public infrastructure facilities were in need of upgrading or under development, while the need to enhance their surface flood management capacities also increased. Minamisuna District is the location for Tokyo's second oldest sewerage management facility, which was established in 1930 as a pumping station (Chida 2012). Between 1997 and 2004, the Shinsuna Land Readjustment Project, a large urban redevelopment initiative, was implemented in the Shinsuna area, which includes Minamisuna, and a sewerage management infrastructure upgrade was implemented in conjunction with it (Bureau of Urban Development, TMG 2004). In Hibiya, as part of the national effort underway since 1963 to increase the construction and O&M efficiencies of underground infrastructure (such as electricity, water, communication, and sewerage systems), MLIT has been working to centralize such lifeline infrastructure through the construction of a common tunnel.[14] The work is considered especially important in high-density urban centers of the Tokyo metropolitan area, like Hibiya. Led by MLIT, construction of the common ditch, which is 6.7 m in diameter and 1,450 m long, started in Hibiya Crossing in 1989.

Solution: Investment Design and Key Features

Investment Design

As noted above, both underground surface flood management facilities in Minamisuna and Hibiya were constructed in conjunction with the development of another public facility as part of an initiative led by TMG's Bureau of Sewerage to meet its flood management goal of handling rainfall of 75 mm/hour in the central wards of Tokyo. In Minamisuna, MLIT constructed a detention pond 20 m belowground with a storage capacity of 25,000 m^3, with a public housing complex, public bicycle parking, and park developed aboveground as part of the larger urban Shinsuna Land Readjustment Project (**figures A7.5** and **A7.6**). In Hibiya, TMG, in partnership with MLIT, constructed a detention pond[15] with a storage capacity of 3,400 m^3 under a common lifeline infrastructure tunnel that runs beneath a national road (**figure A7.7**).

14 Also referred to as "Hibiya Common Ditch" (Kamata 2006).

15 Also called a "sewerage stormwater regulating reservoir" (Kamata 2006), but to maintain consistency in terminology throughout the Knowledge Notes, we refer to the facility in Hibiya Crossing as a detention pond.

Key Features

- **Cooperation with other public facilities and stakeholders:** When planned strategically, engagement of various stakeholders in designing and implementing urban flood management facilities can save significant time and cost. For construction of the detention pond in Minamisuna, the Bureau of Sewerage partnered with other urban development, environmental, and social development bureaus of TMG, as well as Koto Ward, to design the multiple-use development of the limited land area to maximize public amenities and functions. In Hibiya, MLIT and TMG's partnership is estimated to have reduced the cost of the detention pond by about 30 percent and the time to construct it by two years (Kamata 2006).
- **Layering belowground and aboveground benefits and use:** Development of flood management facilities in a high-density urban center requires efficient use of limited space, both above- and belowground, for flood management as well as for other benefits and uses. In Minamisuna, the belowground area is utilized for flood management, while the aboveground area hosts various public facilities, such as high-rise public housing, a public childcare center and park, and bicycle parking, providing various social and environmental benefits (Suido Sangyo Shimbun 2006). In Hibiya, collaboration between TMG and MLIT led to the utilization of the belowground space for development of a stormwater detention pond and tunnel to manage infrastructure utility lines centrally and the aboveground space for a national road. The water stored in the detention pond is also pumped up to a sprinkler system to water plants along the road, where the green vegetation serves as an important heat island mitigation mechanism during the summer (Kamata 2006).

Results: Cost Savings through Partnership

While underground stormwater management facilities can provide significant capacity for surface flood management, their construction and O&M can be extremely high, as can the opportunity cost to utilize valuable and limited space in high-density urban areas. The successful projects around the **Minamisuna** and **Hibiya** detention ponds demonstrate that, while the structural development of such large facilities can be extremely costly if done for a single purpose and by one institution, developing them in partnership can achieve significant savings through shared construction costs and responsibilities and/or reduced construction time.

4

5

Figure A7.4: Flooding in Hibiya, October 2003

Source: Kamata 2006.

Figure A7.5: The Minamisuna Neighborhood

Photo Credit: Kenya Endo.

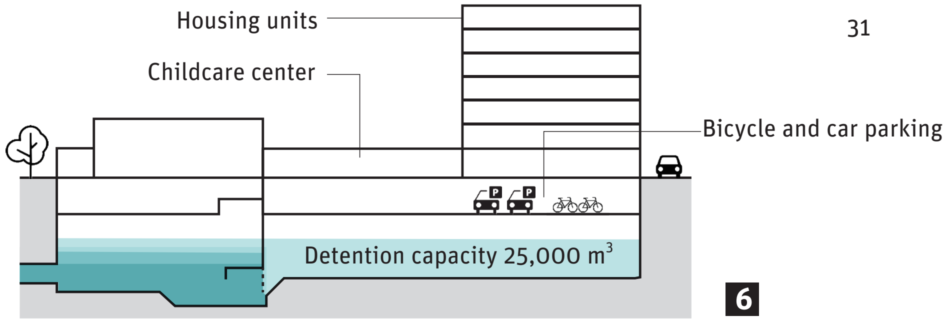


Figure A7.6: Conceptual Diagram of the Minamisuna Underground Stormwater Management Facility (Cistern)

Source: Developed based on information from MLIT (2006). *Note*: m^3 = cubic meter.

Figure A7.7: Conceptual Diagram of the Hibiya Underground Stormwater Management Facility (Cistern)

Source: Kamata 2006. *Note*: m^3 = cubic meter.

References

Bureau of Sewerage, TMG (Tokyo Metropolitan Government). 2009. "Technical Tour of Tokyo's Sewerage Facilities." http://www.envrisk.t.u-tokyo.ac.jp/udm/images/TechnicalTourGuide(Japanese).pdf.

Bureau of Urban Development, TMG. 2004. "Opening of New Mixed Urban Development in Shinsuna District." August 2. https://web.archive.org/web/20070824052633/http://www.metro.tokyo.jp/INET/OSHIRASE/2004/08/20e82300.htm.

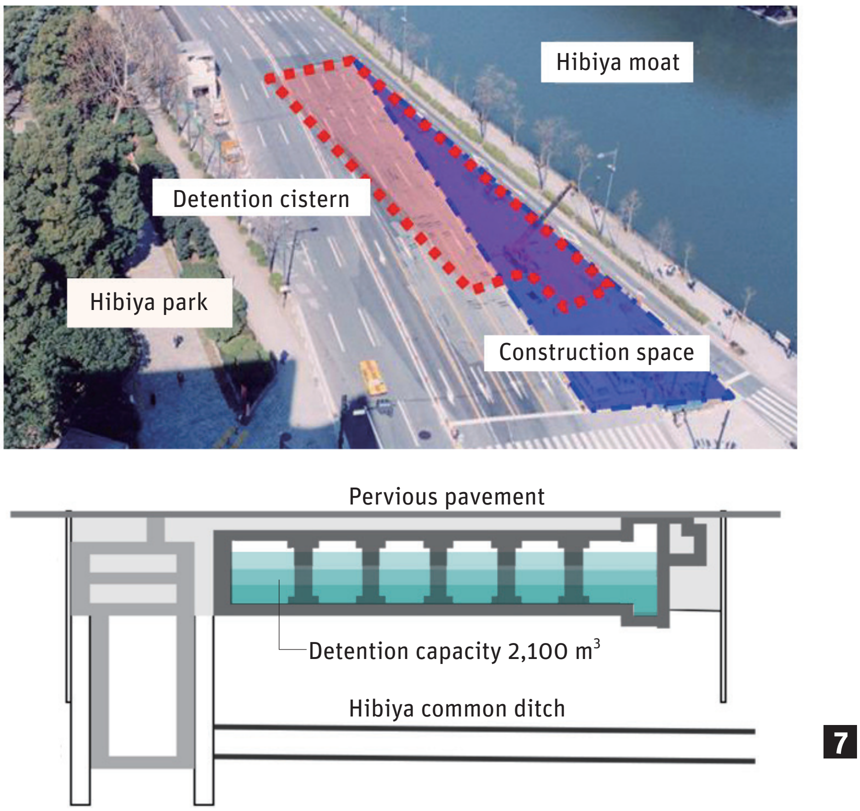
Chida, Shuichi. 2012. "Environmental Lecture Series 7: History of Sunamachi Wastewater Treatment Plant District." Japan Association of Drainage and Environment, Division of Night Soil, and Sewerage Research Group. http://sinyoken.sakura.ne.jp/caffee/cakaiwai023.pdf.

Kamata, Hiroshi. 2006. "Efficient Installation of Detention Pond in Cooperation with Another Development Project." June. http://www.gesui.metro.tokyo.jp/business/pdf/4-1-2_2006.pdf.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism). 2006. "Policy and Measures of Sewerage." June. http://www.mlit.go.jp/crd/city/sewerage/gyosei/keikaku3rd/03-3.pdf.

Suido Sangyo Shimbun. 2006. "Completion of Minamisuna Detention Pond." April 20. http://www.suidou.co.jp/060420.htm#060420-09.

Tokyo Metropolitan Housing Supply Corporation. N.d. "Kosha Heim Minamisuna." https://www.to-kousya.or.jp/opencms/export/sites/default/www_to-kousya_or_jp/chintai/campaign/forcom/pdf/koto_r02.pdf.



Case 8: Reducing Surface Water Flood Risk by Installing an Underground Stormwater Management Facility: **Yokohama Station Tower and Excite Yokohama 22 District**

Location:	Yokohama Station is located in Yokohama City, a highly concentrated urban area in Kanagawa Prefecture
Site characteristics:	A gateway to the city center, which 2.2 million people visit every day, the area features many commercial buildings. Around 2.2 million passengers pass through Yokohama Station in a day.
Flood management measure(s):	
Flood type	Surface water
Management capacity	Yokohama Station Tower underground detention cistern capacity: 170 m^3, contributing toward achievement of the citywide flood management target to accommodate rainfall of 82 mm/hour (1-in-50-year storm event). Current drainage facility achieves 60 mm/hour of storm water management. An additional 14 mm/hour to be initiated by Yokohama City's drainage capacity upgrade work. A further 8 mm/hour are to be achieved by public-private partnership efforts.
Type of measure(s)	Structural (gray) Underground stormwater management facility (cistern)
Relevant entities:	
Implementation	East Japan Railway Company (JR East) in partnership with Yokohama City
O&M	Same as above
Finance	Underground stormwater management facility—subsidies jointly provided by MLIT and Yokohama City to finance one-third of the total cost each, with JR East self-financing the remaining one-third.
Construction period:	2016–20 (scheduled)
Cost:	Construction cost for two Yokohama Station Tower buildings: ¥91.8 billion ($835 million) for a building 135 m tall with 26 stories and a building 31 m tall with 9 stories[a]
	Underground stormwater management facility—information not available
Additional benefits and functions:	Urban redevelopment Private sector engagement
Sources:	Tanigawa 2017; Climate Change Adaptation Information Platform 2018; Japan Skyscraper n.d., except where otherwise noted.
	a *Daily Engineering and Construction News* 2017.

Figure A8.1: Current View of Yokohama Station

Photo Credit: Kenya Endo.

Figure A8.2: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A8.3: Flood Damage in the Yokohama Station Area (Typhoon Ma-on in 2004)

Source: Ishii 2019.

Figure A8.4: Area Targeted by Excite Yokohama 22

Source: Urban Development Bureau, Yokohama City 2013.

Context: Surface Flood Risk at a Highly Urbanized Transportation Hub

The second-largest city in Japan with a population of 3.7 million, **Yokohama City** is adjacent to Tokyo, with easy access to Haneda International Airport. Yokohama Station, which functions as a hub station in the region, is used by approximately 2.2 million people per day and is a gateway to the Yokohama central business district. The station is, however, located in a lowland area close to Yokohama Bay and is surrounded by the Shintama and Katabira rivers; hence, the area risks serious flooding in the event of concentrated heavy rains.

The Katabira River, for instance, flows approximately 200 m south of the station, and its valley-like microtopography acts as a basin. When Typhoon Ma-on (with rain at a maximum intensity of 76.5 mm/hour) passed by in October 2004, the river overflowed and inundated 1,007 residential and commercial buildings in the vicinity (**figure A8.3**). Underground areas incurred significant damage as the water cascaded down to the basement-level shopping arcades, and the effects of the flooding on electrical facilities hindered evacuation procedures. Also presenting challenges to evacuation in the station and surrounding areas were aging buildings (vulnerable to earthquakes), a shortage of open space for evacuation, and a lack of risk communication and wayfinding measures that could effectively guide the public in case of emergency.

To manage the flood risks in the lower-lying area around Yokohama Station, water is drained to the surrounding rivers by three rainwater pumping stations and three small-scale pumping stations. These pumps can manage a storm with a 10-year return period, with rainfall intensity of approximately 60 mm/hour. Additionally, for districts located on high ground, gravity drainage is installed, designed for storms with 5-year return periods (approximately 50 mm/hour).

With the growing awareness of climate change and rising disaster risks,[16] Yokohama has taken a stepwise approach to increasing its flood management capacity. Combining the need for improving flood management with the implementation of a comprehensive redevelopment master vision, "Excite Yokohama 22," Yokohama City established a town development plan in 2009, focused on the integration of flood management measures with the town planning process in the 140 ha area highlighted in **figure A8.4**.

Solution: Investment Design and Key Features

Investment Design

The Excite Yokohama 22 town development plan defines a vision and guiding principles for the district's future (Urban Development Bureau, Yokohama City 2012). A key pillar is the importance of incorporating disaster prevention measures (against flooding, earthquake, and tsunami) comprehensively within the district's town planning process. For flood risk mitigation, the plan specifies that (i) private redevelopment projects more than 5,000 m^2 in area are required to install stormwater storage facilities that can handle more than 200 m^3 of excess stormwater; (ii) private and public sectors need to raise their ground-floor elevations to 3.1 m above sea level; and (iii) the target for Yokohama City's

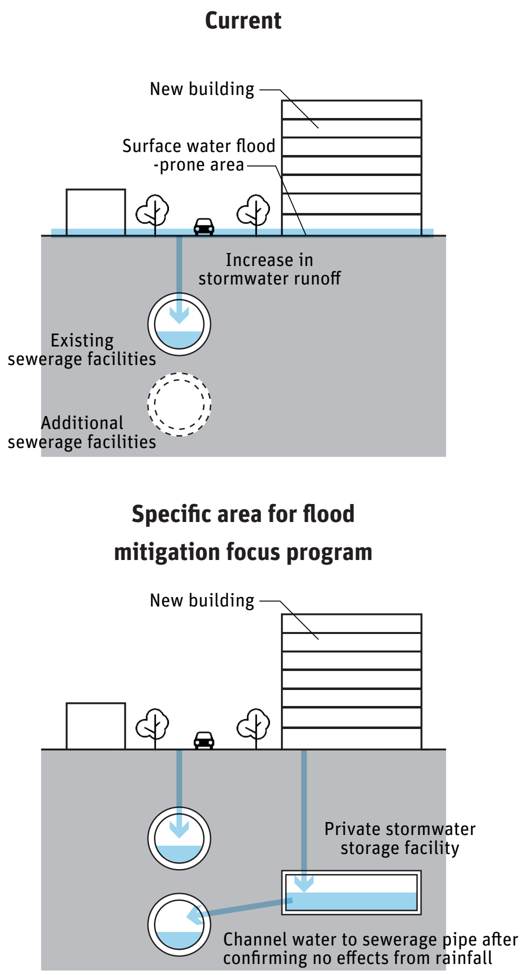
16 Since 1975, the overall frequency of rainfall above 50 mm/hour has increased by 30–40 percent (Ishii 2019).

sewerage and drainage capacity is to be increased to accommodate a rainfall of 74 mm/hour, equivalent to a 1-in-30-year rainfall event, through the laying of new drainage pipes deep underground and the installation of new pump facilities.

In addition to public sector efforts to enhance flood management capacity to this level, the city partnered with the private sector to manage up to 82 mm/hour or 1-in-50-year flood events in the central area near Yokohama Station. MLIT, Yokohama City, and private developers are collaborating on Yokohama Station Tower, a flagship project of this initiative that is expected to be completed in 2020. For it, a stormwater detention cistern with 170 m^3 capacity is under construction below basement level 3 of a mixed-use 26-story building (Climate Change Adaptation Information Platform 2018).

Key Features

- **A national policy enabling public-private partnership initiatives for installing stormwater management facilities:** MLIT designated Yokohama Station and its vicinity as the first "Flood Mitigation Focus Area" (a 30 ha site) in Japan. This new approach, established under the revision of the National Sewerage Law in July 2015, promotes the installation of stormwater storage facilities in large-scale private redevelopment projects through public-private partnerships (**figure A8.5**). The revision of the national act in 2015 led in turn to the revision of Yokohama City's bylaws in 2016, allowing for the first-ever designation of a flood damage control area in Japan in January 2017 and initiation of the collaborative Excite Yokohama 22 project in February 2017.
- **Cost-sharing among MLIT, Yokohama City, and private developers:** This policy obliges private developers to install and conduct O&M work on the stormwater storage facilities in their developments but at the same time enables them to receive subsidies for the work they do (for example, the construction of the underground cistern) from the national and local governments (Tanigawa 2017; MLIT 2016). Established in 2016, the subsidy program is available (i) to business operators conducting large-scale developments of 5,000 m^2 or more in area; and (ii) for the installation of 200 m^3 of management capacity per 1 ha of land area. For these projects, the private developers pay one-third of the total installation cost, with the remaining two-thirds subsidized by the national government and Yokohama City (one-third each). In addition to the subsidies, other incentives included tax reduction for installing larger storage capacity (300 m^3 or more; Ishii 2019).



5

Figure A8.5: Conceptual Diagram of Flood Mitigation Focus Area Program

Source: Modified based on information from MLIT (2016).

Results: Cost Savings through Partnership

Through the combined efforts of the public and private sectors, Yokohama City was able to meet the stormwater management target and lower the flood risks for its newly redeveloped site. The benefits for private developers were (i) subsidies offered by the national and city governments; (ii) enhanced mitigation of surface water flooding; (iii) potential increase in property value; and (iv) an opportunity to engage with the community as a form of corporate social responsibility. By providing financial incentives to the private developers for both installation and O&M works, Yokohama City was able, in return, to raise its stormwater management capacity goal in 2017 to 82 mm/hour, which is equivalent to a 1-in-

50-year rainfall.

References

Climate Change Adaptation Information Platform. 2018. “A Platform Vol. 9 Yokohama, Kanagawa.” April 18. http://www.adaptation-platform.nies.go.jp/articles/case_study/vol9_yokohama.html.

Daily Engineering and Construction News. 2017. “JR East/ Yokohama Nishiguchi Building.” *Daily Engineering and Construction News* 10 (24): 4.

Ishii, Tomohiro. 2019. “Yokohama Station Area Public-Private Partnership Flood Control.” April 25. Presentation slides describing the work of the Environmental Planning Bureau, City of Yokohama.

Japan Skyscraper. N.d. “Skyscrapers in Japan.” Accessed January 25, 2019. http://skyskysky.net/construction/202013.html.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism). 2016. “Countermeasures for Mitigating Inundation.” http://www.mlit.go.jp/hakusyo/mlit/h28/hakusho/h29/html/n2722c02.html.

Tanigawa, Hiroshi. 2017. “Subsidize Privately Installed Rainwater Storage Facility in Yokohama, as the First Case in Japan.” Nikkei Construction. February 3. https://project.nikkeibp.co.jp/atclppp/PPP/news/020200166/.

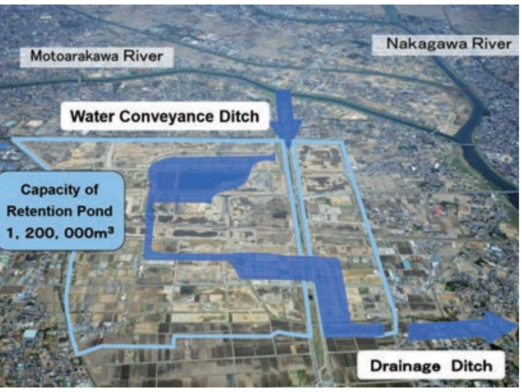
Urban Development Bureau, Yokohama City. 2012. “Yokohama Excite 22 Urban Development Guidelines.” https://www.city.yokohama.lg.jp/kurashi/machizukuri-kankyo/toshiseibi/toshin/excite22/unyo/field.files/0001_20180927.pdf.

———. 2013. “Yokohama Excite 22—Great Redevelopment Plan around Yokohama Station.” June. http://www.city.yokohama.lg.jp/toshi/tosai/excite/plan/ey22/.

1

Case 9: Reducing Surface Water and River Flood Risk by Integrating a Reservoir into Large-Scale Urban Development: Koshigaya Lake Town

Location:	Koshigaya City, Saitama Prefecture, which also serves as a suburb of Tokyo, approximately 20 km north of the Tokyo city center
Site characteristics:	A large-scale (225.6 ha) new town development site surrounded by a low-density urban area and agricultural lands
Flood management measure(s):	
Flood type	River and surface water
Management capacity	1.2 million m^3 of water detention capacity in 39.5 ha of an aboveground detention reservoir to temporarily manage rainwater that falls on-site but also to avoid river overflow by detaining rainwater flowing into the Nakagawa and Motoarakawa rivers.
	In a 61.5 mm/hour heavy rainfall event in 2009 in Koshigaya City, the reservoir effectively avoided inundation of the surrounding area.
Type of measure(s)	Structural (green)
	Reservoir
Relevant entities:	
Implementation	Urban Renaissance Agency (UR)
O&M	The reservoir and facilities associated with flood management arecomprehensively managed by Koshigaya City; park spaces surrounding the reservoir are managed by the city's tourism association
Finance	UR, Saitama Prefecture, MLIT
Construction period:	1999–2014
Cost:	Overall construction of reservoir and conduit: ¥51.6 billion ($469 million)
	Reservoir: ¥39.6 billion ($338 million) shared among UR (44 percent), MLIT (28 percent), and Saitama Prefecture (28 percent)
	Conduit: ¥12 billion ($103 million) by MLIT river administrators
	Overall Koshigaya Lake Town development: ¥80.6 billion ($733 million)
Additional benefits and functions:	Urban development, through development of new housing, commercial activities, and other public services
	Attractive living environment with access to a lake and associated water sports
	Community awareness and efforts toward disaster risk management and environmental conservation
Sources:	Koshiyaga City 2015b.



3

Figure A9.1: Overall View of the Site

Photo Credit: Kenya Endo.

Figure A9.2: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A9.3: Conceptual Diagram of the Reservoir and Its Relationship to the Larger Context

Source: Yoshimura 2016. *Note*: m^3 = cubic meter.

Context: Urban Development and Flood Risks

Since 2008, the **Koshigaya Lake Town** area has grown rapidly as a residential neighborhood with good access to major urban centers. Koshigaya Lake Town stands 20 km north of Tokyo's city center, on what used to be agricultural land adjacent to the Nakagawa River and the Motoarakawa River. Its vulnerability to frequent river floods left the site long undeveloped, despite its easy access from nearby large cities. For this reason, a new compact urban development project was initiated there in 1999 by combining flood mitigation measures with a housing development.

Solution: Investment Design and Key Features

Investment Design

Koshigaya Lake Town, a 225 ha urban development project led by the Urban Renaissance Agency (UR), was carried out from 1999 to 2014. The vision of creating an attractive living environment while mitigating flood risks was developed in collaboration with MLIT (as the national river administrator) and the Saitama prefectural government (as the local river administrator). The key intervention was the installation of a 39 ha detention reservoir within the development site to store water on occasions when the water level of the Motoarakawa River would increase, as well as when additional stormwater runoff would arise from the development of housing for 7,000 households, with a planned population of 22,400 (**figure A9.3**). A railway station was also opened in 2008.

The reservoir's water depth is normally set at 1–1.5 m, and this can increase up to a maximum of 5 m in heavy rainfall events. According to the hydraulic design, the shoreline of the reservoir and pedestrian walkways along the waterways are intended to flood; however, adjacent residential neighborhoods are not affected by the increase in water volume.

Key Features

- **Sharing of costs of reservoir construction:** As a joint venture to carry out both urban development and flood management, strategic roles and cost-sharing arrangements were made among UR, MLIT, and Saitama Prefecture. UR, as the developer, was made responsible for (i) land acquisition, (ii) management of any additional stormwater runoff arising from the new development, and (iii) construction and O&M of the new development site. MLIT and Saitama Prefecture, as the river authorities, became responsible for (i) land acquisition, (ii) management of river floods, and (iii) construction and O&M of the flood management facility. By combining the two initiatives, costs and responsibilities were shared, thus reducing the burden borne by individual stakeholders (UR 2018). MLIT and Saitama Prefecture, for example, proposed that UR handle excessive stormwater runoff from the new development, as well as water outside the development site that could cause river overflow. In return, MLIT and Saitama Prefecture would jointly bear the cost of reservoir installation, while UR led the construction of the larger-capacity reservoir. O&M responsibilities were also shared among the three parties. As a result, the developer (UR) bore 44 percent of the entire cost, while the two river administrators owed 28 percent each (UR 2018; **table A9.1**). Similar arrangements were made for land acquisition, with the project benefiting from public land readjustment measures by which private landowners provided parts of their land free for public use; this also reduced the overall project cost, as compared with implementing it as a private project. For UR, the partnership was beneficial, as it was able to ensure its newly developed site had lower flood risks, and its development project was environmentally friendly and livable.

- **Engagement of the developer in constructing and managing public facilities:** In general, a large-scale land readjustment initiative involves realignment of a great many public facilities, such as roads, parks, sewers, and rivers. In such cases, local governments face issues in terms of human and financial resources to deal with land acquisition, relocation, and so on. For the Koshigaya Lake Town development, a direct implementation system was used, in which UR, as the developer, led the redevelopment of public facilities, including the planning and construction of the public flood management facility (reservoir), with proper review and approval carried out by the government (UR 2007).

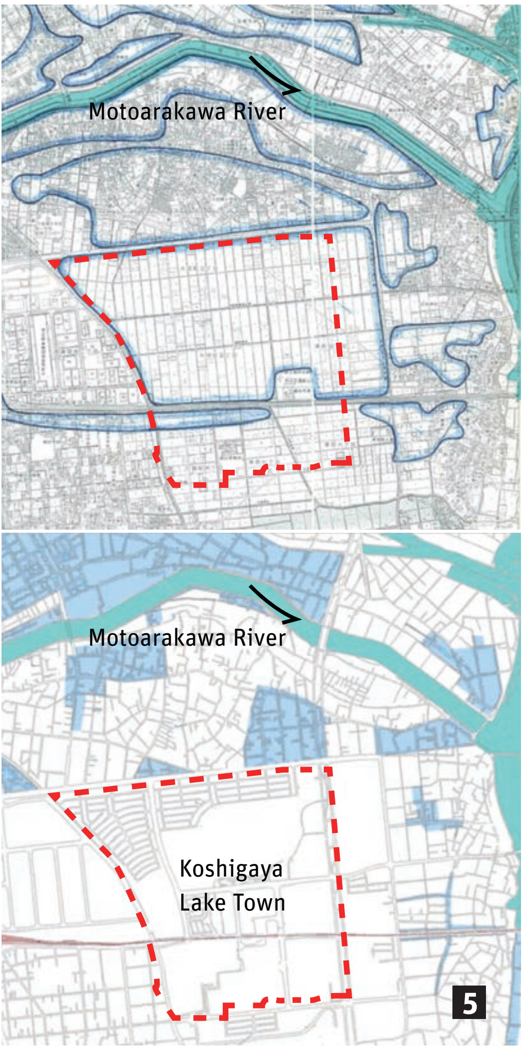
Results: Effective and Multipurpose Flood Management Investment through Joint Management

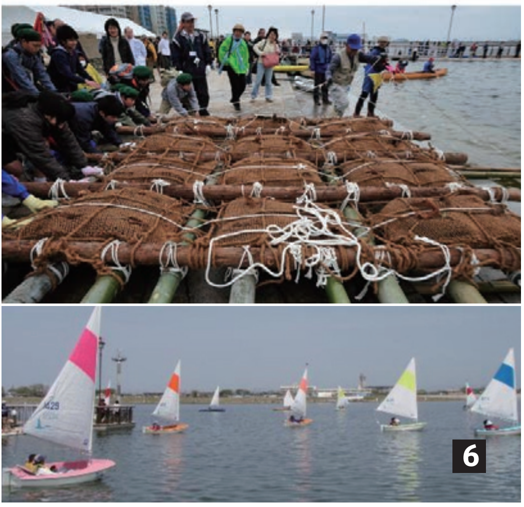
The collaboration among the public river administrators (MLIT and Saitama Prefecture) and the housing developer (UR) resulted in the development of one large reservoir facility to manage both river overflow and the additional stormwater generated by the development. Construction of large-scale aboveground flood management facilities can be extremely costly if done in isolation. This partnership arrangement to build a multipurpose flood management facility produced cost savings not only for construction but also for O&M by enabling cost and role sharing among the various parties involved.

The impact brought to the area by the establishment of this facility was significant. In 2015, when Typhoon Etau caused flood damage in the upper stream of the Motoarakawa River, the downstream area, including Koshigaya Lake Town, suffered no damage. A comparison with a 1991 event with equivalent rainfall intensity (shown in **figure A9.5**) demonstrates the impressive flood management achieved by the building of the reservoir (Koshiyaga City 2015a).

The success of the large-scale new urban development initiative at Koshigaya Lake Town was also owing to the strong collaboration among the public sector, the housing developer, and the community. The “Koshigaya Lake Town Hometown Project,” launched in 2007, organized various recreational events, disaster prevention drills, and voluntary activities using the park spaces and reservoirs (**figure A9.6**). The events successfully involved commercial providers, local governments, and resident associations in promoting the life of Koshigaya Lake Town. In 2014, the project became a nonprofit organization under the same name (UR 2009, 2018). With the community’s participation and enthusiasm, a high-quality, safe, and attractive living environment was generated.

Figure A9.4: The Lake Town Development: Shopping Mall and Residential Buildings
Photo Credit: Kenya Endo.





References

Koshigaya City. 2015a. "Inundation History of Koshigaya." November 10. http://www.city.koshigaya.saitama.jp/anzen_anshin/bosai/kasenchisui/kosigayanosinnsuizisseki.html.

———. 2015b. "Koshigaya Lake Town Designated Area Project." https://www.city.koshigaya.saitama.jp/kurashi_shisei/kurashi/sumai/reikutaun/laketown.html.

UR (Urban Renaissance Agency). 2007. "About the Enforcement Systems of Public Facilities by Urban Renaissance Agency." July. http://www.uraja.or.jp/town/system/2007/doc/20070702.pdf.

———. 2009. "Koshigaya Lake-Town-Unite the New Town Development & the Reservoir Construction." Urban Renaissance Agency.

———. 2018. "Urban River Measures and the Improvement of Large-Scale Reservoirs, Stormwater Runoff Control of Japan's Residential Development Areas." Urban Renaissance Agency.

Yoshimura, Hiroyuki. 2016. "Safe, Secure, and Enjoyable (KOSHIGAYA LAKE-TOWN), Urban Renaissance Agency." January 21. http://pubdocs.worldbank.org/en/454071453879343496/012116-qii-s4-hiroyuki-yoshimura.pdf.

	General Rule	Lake Town Rule
Runoff increase ..... A	Developer	Developer National government Local government
Flooding volume in the site ..... B		
Flooding volume outside of the site C		
Developer's share	$\frac{A+B}{A+B}$	$\frac{A+B}{2A+2B+C}$
River administrator's share	-	$\frac{A+B+C}{2A+2B+C}$
Basis of the concept	-Developments increase runoff and decrease water retention volume	-River administrators responsible to (A+B+C) -Developer responsible to (A+B)

1

Table A9.1: Mechanisms for Sharing the Costs and Responsibilities of Flood Management in Koshigaya Lake Town

Source: Yoshimura 2016.

Figure A9.5: Flooded Areas in 1991 and 2015

Source: Koshigaya City 2015a.
Note: Areas inundated by Typhoon No. 18 (1991) and Typhoon No. 18 (2015) are highlighted in blue.

Figure A9.6: Activities at Koshigaya Lake Town

Source: Yoshimura 2016.

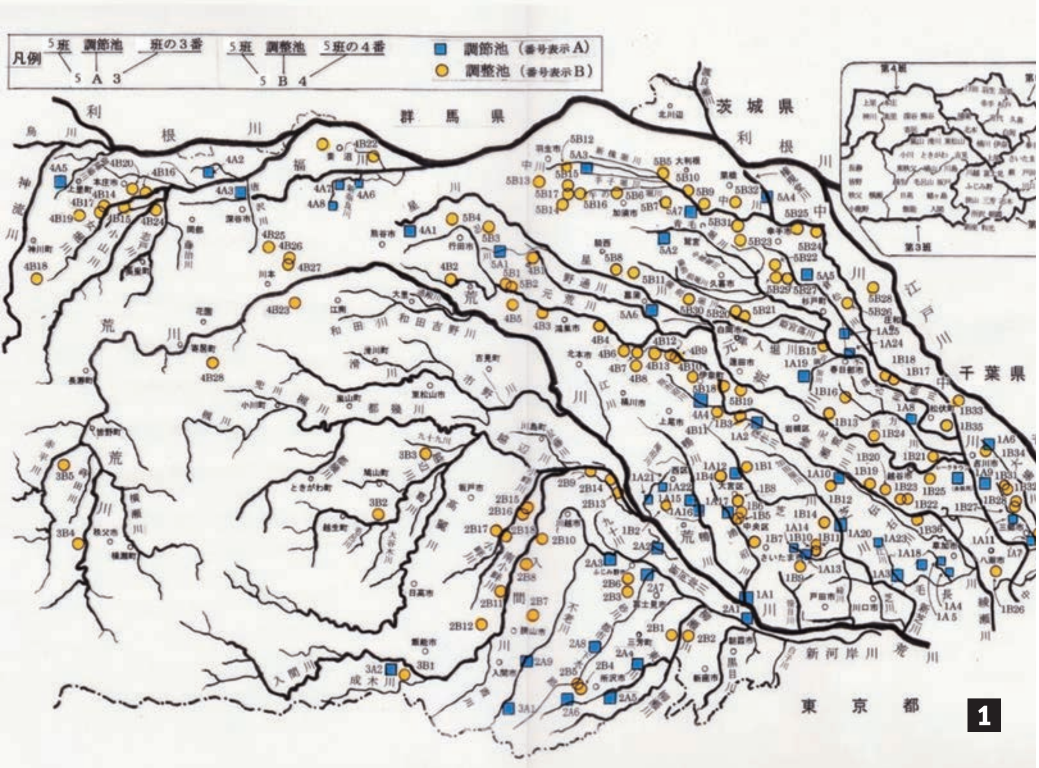


Figure A10.1: Schematic Illustration of Saitama Prefecture's Rivers, Detention Ponds, and Reservoirs

Source: Sainokawa Research Institute 2014.

Case 10: Reducing Surface Water and River Flood Risk by Implementing Reservoirs, Detention Ponds, and Parks: **Saitama Prefecture**

Location:	Saitama Prefecture
Site characteristics:	Saitama Prefecture, the fifth-largest prefecture in Japan by population (7.3 million), is located north of Tokyo. It has many major urban centers, including Saitama City (population 1.3 million) and Kawagoe City (350,000). The cities in Saitama Prefecture have high concentrations of population and assets, and remaining lands are mostly agricultural or hilly woodlands. Most of the rivers in Saitama Prefecture flow into Tokyo.
Flood management measure(s):	
Flood type	Surface water, river
Management capacity	For surface water flood management: Policy requires any urban development more than 1 ha in area to have a stormwater runoff management facility (ranging from 500 m^3/ha to 1,200 m^3/ha).[a]
	For river flood management: Combined storage capacity of all large-scale reservoirs, detention ponds, and parks exceeds 10.3 million m^3 in Saitama Prefecture.[a]
Type of measure(s)	Structural (gray and green)
	Reservoirs, detention ponds, and parks
	Nonstructural (policy)
Relevant entities:	
Implementation:	Large rivers: Mainly MLIT in collaboration with local governments
	Small and medium-sized rivers: Mainly local Saitama Prefecture authorities
	Watershed management: Private developers, property owners
O&M	Typically same as above
Finance	Typically same as above
Construction period:	Not applicable
Cost:	Saitama Prefecture's budget for Japanese FY2018 for flood management measures for concentrated and extreme rain, including investments for reservoirs, detention ponds, and parks, was reported as approximately ¥11.4 billion ($103 million).[b]
Additional benefits and functions:	Increase in public recreational spaces
	Environmental conservation and sustainability
	Urban (re)development
Sources:	Saitama Prefecture 2018b, except where otherwise noted.
	a Saitama Prefecture 2017.
	b Saitama Prefecture 2018a.

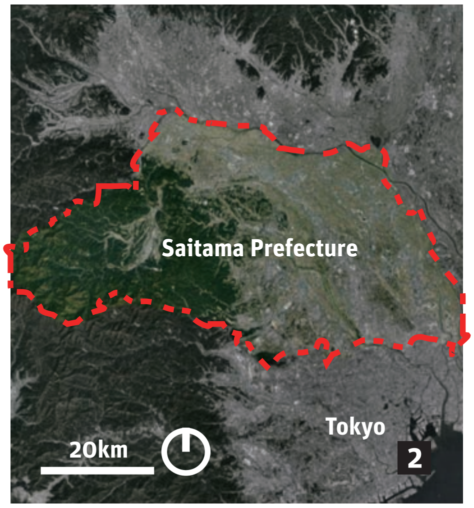


Figure A10.2: Site Context
Source: Google Earth. *Note*: km = kilometer.

Context: Flood Risk and Rapid Urbanization

The rapid economic growth that took place in Japan from 1955 led to the rapid urbanization of Tokyo's northern neighbor, **Saitama Prefecture**, beginning in the 1970s. To handle the resulting urban stormwater, most rivers in the prefecture, which were originally used for agricultural irrigation, were repurposed into drainage channels. This increased drainage demands for large rivers, such as the Tone and Arakawa rivers, as well as for most small and medium-sized rivers running throughout Saitama Prefecture, which did not have sufficient conveyance capacity to address the increased runoff. Although authorities initially planned to expand the rivers' conveyance capacity by widening them, this was difficult to do in Saitama Prefecture because most rivers flowed to downstream Tokyo, where limited land and its high costs made any further widening of the rivers impossible. In light of this situation, Saitama Prefecture's strategy for urban flood risk management involved taking (i) an integrated approach that combined river and rainwater management interventions with the participation of various stakeholders, including national and local governments and private developers, and (ii) a decentralized approach, implementing various types of interventions (in terms of size and function, such as reservoirs, detention ponds and parks, and so on). In this way, management of flood risks could be both centralized, by channeling stormwater generated in various locations to one consolidated site, and decentralized, by implementing smaller interventions in many places, normally near the locations where stormwater drainage needs would arise.

Solution: Investment Design and Key Features

Investment Design

By 2014, through Saitama Prefecture's integrated urban flood risk management (IUFRM) approach, more than 170 detention facilities with a capacity of over 10,000 m^3 had been installed in the prefecture through both private and public efforts. Of these, 51 were for the purpose of detaining water to avoid overflow into rivers, and 119 were to manage additional stormwater drainage from new developments (Saitama Prefecture 2018b).

Key Features

- **Integration of diverse approaches to flood risk management:** The 170 interventions implemented in Saitama Prefecture were diverse in type, size, and approach and included very large-scale interventions led by MLIT, such as the Watarase Reservoir, with detention capacity up to 26 million m^3 over an area of 4.5 km^2. Detention facilities whose development was led by Saitama Prefecture included multipurpose detention parks, which also served as public parks and athletic fields, with capacities ranging from 132,000 m^3 to 891,000 m^3; underground facilities with capacity around 10,000 m^3; and detention ponds and parks around rivers with capacities ranging from 1.1 million to 36 million m^3. City-led detention facilities were also often developed using a multistakeholder, multipurpose approach; examples included joint implementation with private housing developers. The management capacities of these facilities are normally under 100,000 m^3, with some facilities as large as 190,000 m^3 (Saitama Prefecture 2018b).

- **Engagement of private sector in sharing roles, costs, and responsibilities for flood management through policy instruments:** Additionally, Saitama Prefecture took a progressive approach by mandating that all new private development projects (commercial, residential, and so on) with an area of more than 1 ha install detention facilities. This approach built on the administrative *guidance* first released by the prefecture in 1968 under the national Urban Planning Act, which was then further advanced as a *requirement* under the ordinance enacted in 2006 (Saitama Prefecture 2018b).
- **Catalyzing of partnerships across sectors to establish multipurpose investments:** Many multifunction and multipurpose interventions, for both flood and non-flood times, emerged from a prefecture-wide effort to engage various sectors and stakeholders in the development of the flood management facilities. Many detention park and reservoir functions, for example, were utilized for agricultural lands, public recreational spaces, schoolyards and athletic fields, or natural biodiversity habitats. Many were developed with quasi-public and private green spaces adjacent to, or part of, new large housing developments by public and private developers. New shopping centers with lots of green, public amenities were also constructed. Thus, the flood management investments could deliver various additional benefits by increasing public amenities and livability, environmental conservation and sustainability, and economic development through the establishment of new or renovated housing and commercial developments.

Figure A10.3: Oyoshi, Yanagishima, and Yatsuka Detention Facilities in Saitama Prefecture

Source: Saitama Prefecture 2019.

Results: Multiple Stakeholders Sharing Roles, Costs, and Responsibility

The efforts led by the Saitama Prefecture's government illustrate how the public sector can promote flood management measures comprehensively in a region by implementing policy that makes them a requirement of urban development and by bringing together various stakeholders to share roles, costs, and responsibilities. This top-down policy-based approach, combined with a bottom-up approach that has enabled a variety of unique site-level interventions throughout the prefecture, has provided many examples of the diverse ways in which roles and responsibilities can be shared across stakeholders by incorporating various purposes and benefits besides flood management into interventions.

As a result, Saitama Prefecture has been able to implement an IUFRM approach on a large, prefecture-wide scale. Through close monitoring of the impact of its river and surface water flood management investments throughout the prefecture, Saitama has also been able to assess carefully the damage from flood events before and after interventions and has found significant reductions in the numbers of households and buildings inundated through several heavy rain events. During Typhoon Ma-on (No. 22) in 2004, for example, the storage of 5.4 million m^3 of stormwater in the prefecture's 21 large detention basins effectively prevented serious flood damage to downstream areas (Saitama Prefecture 2017).

References

Sainokawa Research Institute. 2014. "Function and Utilization of Detention Ponds in Saitama Prefecture." March. https://media.toriaez.jp/y1177/685180288122.pdf.

Saitama Prefecture. 2017. "Effects of River and Water Management Facilities." January 11. https://www.pref.saitama.lg.jp/a1007/kasen/kadoukouka.html.

———. 2018a. "Major Projects in FY2018 (H30) Budget." https://www.pref.saitama.lg.jp/a0103/documents/11_kendoseibi.pdf.

———. 2018b. "Ordinance for Installation of Stormwater Runoff Control Facility." December 17. https://www.pref.saitama.lg.jp/a1007/usuijyourei/usuiryuusyutu.html.

———. 2019. "Detention Ponds in Saitama Prefecture." May 22. https://www.pref.saitama.lg.jp/b1015/123tyousetutinoseibi.html.

1

Case 11: Reducing Surface Water Flood Risk by Enhancing a Sewerage Detention Facility in Collaboration with the Private Sector: Shibaura Wastewater Treatment Facility

Location:	Shinagawa Station, Minato Ward, Tokyo
Site characteristics:	Central business district, within a 10-minute walk of a large rail transportation hub, Shinagawa Station
Flood management measure(s):	
Flood type	Surface water
Management capacity	Maximum storage capacity of 76,000 m^3 of unprocessed stormwater and wastewater[a]
Type of measure(s)	Structural (gray)
	Sewerage management facility improvement with involvement of private sector
Relevant entities:	
Implementation	Underground combined sewer and stormwater detention facility: Bureau of Sewerage, TMG with technical and financial support from MLIT; construction by NTT Urban Development (bid winner)
	Urban redevelopment of 11,000 m^2 area above sewerage facility (30-year lease): Bureau of Urban Development, TMG with a group of private developers, including project owners—NTT Urban Development (NTT UD), Taisei Corporation, Hulic Co. Ltd., and Tokyo City Development Co. Ltd.; project designers—NTT Facilities, NTT UD, Taisei Corporation, and Nihon Suiko Sekkei Co. Ltd.; and, for construction—Taisei Corporation
O&M	NTT UD, Taisei Corporation, Hulic Co. Ltd., Tokyo City Development Co. Ltd., and Bureau of Sewerage, TMG
Finance	Underground combined sewer and stormwater detention facility—TMG
	Lease of aboveground land for 30 years—NTT UD
	Urban redevelopment of commercial building (Shinagawa Season Terrace) and park (Shibaura Chuo Park)—NTT UD, Taisei Corporation, Hulic Co., Ltd., and Tokyo City Development Co., Ltd.
Construction period:	2012–15[b]
Cost:	Construction of underground combined sewerage and stormwater detention facility: costs borne by TMG amount to ¥1.1 billion ($10 million) and by NTT UD, ¥7.7 billion ($70 million)
	Lease of aboveground land for 30 years: ¥86.4 billion ($785 million) (bid price by NTT UD)
	Construction of artificial ground above existing water treatment facility and park development: ¥780 million ($7.1 million) (borne by TMG)
	Aboveground construction cost: not available[c]
Additional benefits and functions:	Urban redevelopment
	Environmental benefits: prevention of untreated water overflow into river and sea, heat island mitigation, attraction of urban fauna and flora
	Tenancy fee income to TMG
Sources:	Bureau of Sewerage, TMG (n.d.), except where otherwise noted.
	a TMG n.d.
	b Taisei Corporation 2012.
	c All costs from Hashimoto (2015).

Figure A11.1: Overall View of the Site

Source: Bureau of Sewerage, TMG n.d.

Figure A11.2: Site Context

Source: Google Earth. *Note*: m = meter.

Context: Urban Development and Environmental Impacts from Floods

The Shibaura Wastewater Treatment Facility has been responsible for sewerage water treatment in Tokyo, including for the **Chiyoda, Chuo, and Minato wards**, since 1931. Beginning in 2012, renovation of the aging facility was undertaken in stages, with two objectives: (i) to mitigate the postflood environmental impact of the combined sewerage and drainage system, and (ii) to utilize the land where the facility is located, and effectively capture its high value.[17]

Combined sewerage and drainage system and its environmental impact

Because land is scarce in Tokyo, 82 percent of the city's wards historically have adopted a single conveyance channel for both sewerage and rainwater (Bureau of Sewerage, TMG 2015). When heavy rainfall exceeds the capacity of the wastewater treatment facilities, mixed sewer and stormwater overflows into rivers and the sea without proper treatment. The resulting water pollution and eutrophication can have a significant environmental impact (TMG 2017).

Capturing and utilizing high-value land

The Shibaura Wastewater Treatment Facility is located in Konan District, Minato Ward, a 10-minute walk from Shinagawa Station. The estimated value of the land near the station is four times the average in the Tokyo Metropolitan Area,[18] and, as it is host to a central station for the Linear Central Shinkansen (high-speed rail) and close to Haneda International Airport, the land value of the area is expected to continue to rise as its importance as a major transportation hub increases (Hashimoto 2015).

Establishing an urban identity as an environmentally friendly city

Under the district guidelines for community development around Shinagawa Station and Tamachi Station, formulated in 2007, a key priority under the MLIT-led initiative implemented in partnership with TMG was to develop a model for an environmentally friendly city. Water recycling and access (through the development of public parks, corridors, amenities integrating water design, and so on) were highlighted as key actions for implementation (TMG 2017). Accordingly, enhancing the environmental performance and value of the sewerage management plant as well as the surrounding area became an important agenda item within the redevelopment process.

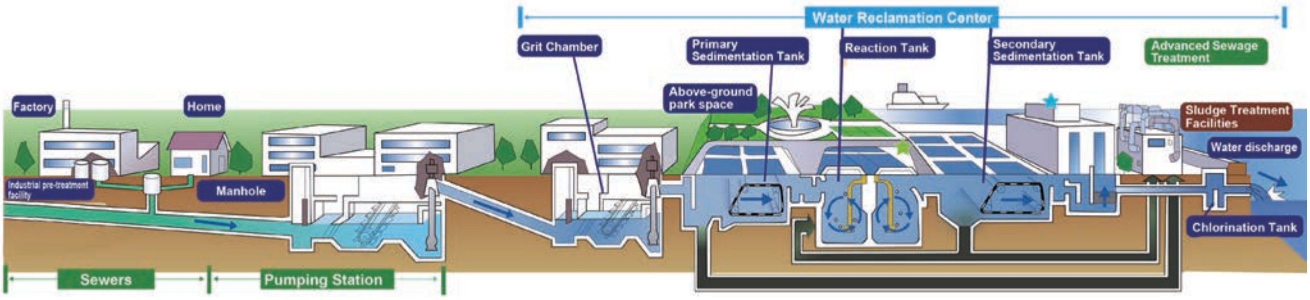
Solution: Investment Design and Key Features

Investment Design

The renovation of the Shibaura Wastewater Treatment Facility was implemented in

17 "Land value capture" is an approach to development that enables communities and/or governments to recover and reinvest increases in land value that result from public investment and other government actions. Also known as "value sharing," land value capture is rooted in the notion that public action should generate public benefit.

18 The average land price in 2019 was ¥1,096,445/m^2 (\$9,968/m^2), while the value in the area near Shinagawa Station was ¥4,494,000/m^2 (\$40,855/m^2), based on MLIT's land price publication; see http://www.land.mlit.go.jp/landPrice/AriaServlet?MOD=2&TYP=0).



3

conjunction with a large-scale, multi-stakeholder, urban redevelopment initiative that started in 2012. TMG, the owner of the 11,000 m^2 area occupied in large part by the Shibaura Wastewater Treatment Facility, tendered for a private sector firm that would redevelop the area under a 30-year lease agreement, as well as renovate the plant, and construct a combined sewerage and stormwater detention facility with a capacity of 76,000 m^3 underneath the developed land.[19]

In 2009, a consortium of private developers bid ¥7.7 billion ($70 million) for the construction of the underground detention facility and ¥86.4 billion ($785 million) for the lease for development. On the leased land, a 32-story commercial and office building (Shinagawa Season Terrace), as well as a publicly accessible park were developed. TMG is recovering the lease fee through a land-value capture mechanism, whereby the income generated through maintaining ownership and leasing 60 percent of the newly constructed building is retained by TMG. The generated income is utilized by TMG for O&M of the sewerage facility.

Shinagawa Season Terrace includes various innovative features, such as disaster resilience (with top-level seismic standard and resilience features so the building can serve as an evacuation hub in case of emergency), energy efficiency, water recycling, and an ecosystem-based design (Shinagawa Season Terrace n.d.).

Key Features

- **Utilization of new regulatory tools to enable multibenefit urban development:** According to the City Planning Act in Japan, development is highly restricted in areas where public urban facilities, such as roads, rivers, parks, and sewer pipes, are located (Real Estate Research Institute, Inc., n.d.). This has made integrating office building development with the renovation of the Shibaura Wastewater Treatment Facility challenging. The issue was solved by utilizing the new legislative concept called "vertical urban planning," which allows stakeholders to undertake redevelopment projects at multiple levels, regardless of overlapping public urban facilities beneath or above them. This project became the first wastewater treatment facility in Japan that applied the Multi-Level City Planning System under the City Planning Act (Bureau of Sewerage, TMG n.d.), providing a legal basis for this new multi-stakeholder and multipurpose redevelopment approach. The development proposal was divided in two main projects: (i) the underground public wastewater and stormwater treatment and detention facility; and (ii) the aboveground private sector–led commercial redevelopment. The proposals were reviewed jointly by TMG's Urban Planning Council and approved on three bases: (i) the need for renewal of the treatment facility; (ii) a request from neighboring community members for more public park spaces; and (iii) upcoming large-scale redevelopment projects around Shinagawa and Tamachi stations,

19 During heavy rain events, the detention facility holds the combined wastewater and stormwater to avoid releasing large volumes of untreated water into the nearby canal. Once a storm passes, the detained water is first treated at the wastewater facility and then released. However, during extreme heavy rain events, the combined wastewater and stormwater are released directly. The first flush at the beginning of a heavy rain event tends to have a higher concentration of sewerage compared to the flushes released at later stages. Thus, it is retained whenever possible.

4

Figure A11.3: Conceptual Diagram of the Shibaura Wastewater Treatment Facility
Source: Information provided by the Bureau of Sewerage, TMG.

Figure A11.4: Treatment Plant Interior and Facility Integrated with Decked Landscape Above
Photo Credit: Kenya Endo.

Figure A11.5: Public Greenery above the Treatment Facility
Photo Credit: Kenya Endo.

including the new high-speed rail development.

- **Financing of construction and O&M of flood management facilities through public-private partnership initiatives:** TMG collaborated with MLIT as well as a consortium of private sector firms to establish additional underground flood management capacity as part of a larger urban redevelopment project. This collaboration enabled TMG to share the expense of constructing an expensive underground facility, limiting its financial burden. Additionally, the annual income to TMG derived from adoption of a land-value capture and lease approach has defrayed the expense of O&M for the flood management facility, thus lowering its life-cycle cost. The engagement of the private sector to co-finance a flood management facility may be a cost-effective approach for constructing such facilities in other areas with high land values, such as Shinagawa.
- **Enhancement of environmental sustainability through flood management:** MLIT's and TMG's strong support for enhancing the sewerage management facility by establishing a new stormwater detention facility derived from the high priority they place on advancing the Shinagawa-Tamachi area as an environmentally friendly model city. Flood management and environmental sustainability investments are often mutually reinforcing, as avoiding storm and sewerage water overflow from floods can reduce risks not only of inundation but also of water pollution. Additionally, enhancing green space and biodiversity in the area can have the flood management benefits of increasing infiltration capacity and reducing inundation. Flood management and environmental sustainability also share common monitoring and evaluation processes to assess the impact of and benefits from investments, such as monitoring of water quality, odor, and other shared parameters (Tabuchi 2011).

Results: Multiple Benefits through Cost and Role Sharing with the Private Sector

TMG's efforts to engage the private sector consortium actively in the design and construction of the underground storm and sewerage water detention facility, as well as the aboveground urban redevelopment, enabled the creation of a cohesive, multipurpose, and attractive urban space, which would have been extremely difficult if these elements had been implemented by the public or private sector alone. In addition to its public benefits, such as flood management and environmental sustainability, the project resulted in the building of attractive commercial and office space, used by premier businesses and firms, and received recognition for its innovative green and resilient design.

This case illustrates how important it is for city governments to (i) plan and coordinate efforts proactively to utilize new legal systems and urban planning tools to make a project valuable and accessible to various stakeholders; (ii) explore ways in which flood management investments can be integrated within other key priorities and projects related to urban development and environmental sustainability promoted by various stakeholders, including the national government and the private sector; and (iii) consider creative ways to share roles and establish ownership, financing, and management responsibilities among a range of stakeholders.

References

Bureau of Sewerage, TMG (Tokyo Metropolitan Government). N.d. “Shibaura Wastewater Treatment Facility.” http://www.gesui.metro.tokyo.jp/living/tour/guide/sise-list/03-01/.

———. 2015. “Current Status and Issues (Management Plans 2016).” August. http://www.gesui.metro.tokyo.jp/business/pdf/gouryuukaizen2_01.pdf.

Hashimoto, Kaori. 2015. “Infrastructure Renovation at the Leased Upper Space of the Sewage Facility.” *Nikkei Architecture*, 9. https://project.nikkeibp.co.jp/atclppp/15/434169/082500036/.

Real Estate Research Institute, Inc. N.d. “About Urban Facilities.” Accessed February 13, 2019. https://www.athome.co.jp/contents/words/term_236/.

Shinagawa Season Terrace. N.d. “About Shinagawa Season Terrace.” https://shinagawa-st.jp/about/.

Tabuchi, Shinya. 2011. “Upper Utilization and Redevelopment Project of Shibaura Wastewater Treatment Facility.” December. http://www.gesui.metro.tokyo.jp/business/pdf/3-1-3_2011.pdf.

Taisei Corporation. 2012. “Notice: Launch of New Construction of Upper Part of Shibaura Wastewater Treatment Facility.” February 22. https://www.taisei.co.jp/about_us/wn/2012/120222_3577.html.

TMG (Tokyo Metropolitan Government). 2017. “Shinagawa Station and Tamachi Station Urban Development Guideline: Summary.” http://www.toshiseibi.metro.tokyo.jp/seisaku/shinagawa/topi045_8.pdf.

———. N.d. “Shibaura Wastewater Treatment Facility.” Accessed February 13, 2019. http://www.gesui.metro.tokyo.jp/living/tour/guide/sise-list/03-01/.

5

Case 12: Reducing Surface Water Flood Risk through Community-Based Rainwater Harvesting Systems: Sumida Ward, Tokyo

Location:	Sumida Ward, Tokyo
Site characteristics:	Sumida Ward is located in Eastern Tokyo. Most of its land is below sea level, with a high concentration of residential and commercial buildings. It is one of the most flood-prone areas within the Tokyo Metropolitan Area.
Flood management measure(s):	
Flood type	Surface water
Management capacity	Public rainwater harvesting system (RHS): 41 facilities; total storage volume—9,374 m^3; total collection area—62,462 m^2
	Private RHS—290 facilities; total storage volume—14,292 m^3; total collection area—145,032 m^2
	Community RHS (Rojison): 21 facilities; total storage volume—283 m^3
	Household RHS: Approximately 293 facilities; total storage volume—61 m^3 small tanks installed with subsidy program from Sumida Ward[a]
Type of measure(s)	Structural (gray)—including public, private, community, and household rainwater harvesting system (roof and underground/aboveground tanks and recycling system)
Relevant entities:	
Implementation	Public rainwater system (RS): Sumida Ward and TMG
	Private RS: Private facility owners
	Community RS: Community groups and nonprofit organizations
	Household RS: Homeowners/citizens
O&M	Same as above
Finance	Same as above, but with subsidies from Sumida Ward
Construction period:	Not applicable
Cost:	Community RS/Rojison (including water tank and hand pump): ¥2 million–¥9 million ($18,100–$81,800)/unit[a]
	Rainwater tank: Up to ¥100,000 ($900)[b] for 200-liter capacity of a household type, including installation cost
Additional benefits and functions:	Community revitalization
	Water recycling and drought management
	Increase in public awareness of disaster preparedness
Sources:	Sumida Ward 2018b, except where otherwise noted.
	a Sumida Ward 2008.
	b Rainwater Tank Consultation Room n.d.

Context: Urban Development and Flood Risks

Sumida Ward's location on low-lying land near the Sumida River exposes its high concentration of houses and office buildings to high flood risks. During the 1980s, urban flooding frequently occurred in the ward during heavy rains as low infiltration and drainage capacity resulted in inundated streets and buildings. At that time, impervious surfaces covered over 50 percent of Tokyo's 23 wards, while the rate for Sumida Ward was over 70 percent (Next Wisdom Foundation 2015). Additionally, enhancing Sumida Ward's infiltration capacity underground was difficult, given that most of its land is below sea level. With limited space to develop new, large-scale stormwater detention facilities aboveground, the ward relied heavily on publicly financed and developed high-cost gray infrastructure, such as underground drainage channels and detention facilities and pumps. Increasing flood risks and additional developments, however, created an urgent need to take further measures against surface water flooding in the area.

Solution: Investment Design and Key Features

Investment Design

To reduce increasing risks and damage from surface water flooding, Sumida Ward began a movement in 1982 to harvest, store, and utilize rainwater through public, private, and community efforts, based on the concept of an "urban dam." The collaboration enabled the installation of rainwater storage facilities in residential areas and public and private facilities distributed widely throughout the ward, providing a decentralized approach to surface flood management.

Sumida Ward installed rainwater systems in public buildings, each normally comprising a collection roof, an underground storage tank, and a recycling system to provide water for flushing toilets, watering plants, and similar uses. The ward also established a subsidy program in 1995, providing financial and technical support to encourage the installation of large, medium, and small tanks by the private sector, community groups, and households. The subsidy program is detailed in **table A12.1**.

One of the first installations of such a facility through this initiative was at the Sumo Wrestling Arena (**figure A12.3**), where the private Japan Sumo Wrestling Association constructed a 1,000-ton capacity rainwater storage tank in 1984. Since then, Sumida Ward has been promoting the installation of stormwater storage facilities in public buildings, community facilities, and residential areas to reduce flood risk, as well as to encourage the use of rainwater for toilet flushing and the irrigation of gardens and roadside greenery.

The "Rojison," a community-based rainwater utilization system, began operation in 1988 (**figures A12.4** and **A12.5**). A Rojison is an underground, community-owned, rainwater detention facility whose main function is to store rainwater for urban flood management and reuse the stored water for emergency situations; it is now at 21 locations throughout the ward. A Rojison collects rainwater from the roofs of residential buildings and stores it in its underground tank. Using a hand pump, citizens can withdraw the stored water to water gardens and wash roads, while Rojisons contribute to the ward's flood risk management measures.

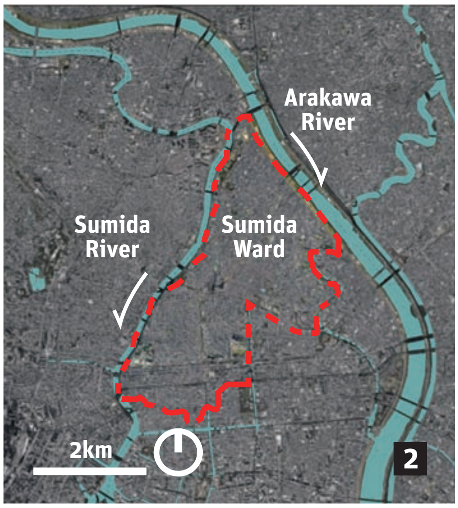


Figure A12.1: Image of Rojison (Community-Based Rainwater Utilization System)

Photo Credit: People for Rainwater (NPO).

Figure A12.2: Site Context

Source: Google Earth. *Note*: km = kilometer.

Figure A12.3: Sumo Wrestling Arena

Source: Sumida Ward 2016.

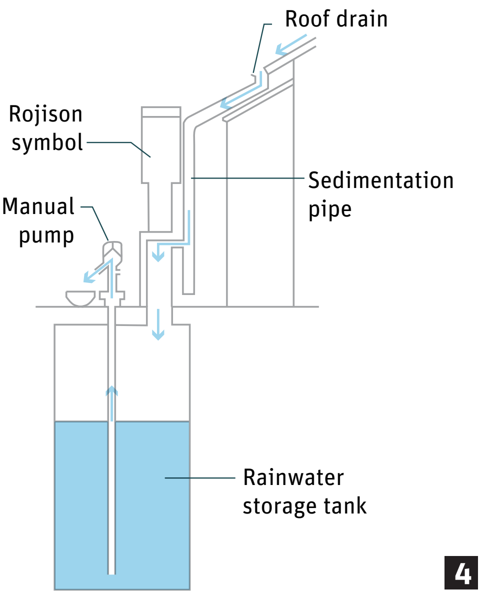


Figure A12.4: Sectional Diagram of a Rojison

Source: Modified based on information from Sumida Ward (2013).

Figure A12.5: Community Members Using Water from a Rojison

Photo Credit: People for Rainwater (NPO).

Key Features

- **Wardwide movement prompted by strong commitment and leadership of Sumida Ward staff:** The efforts of the staff of Sumida Ward in taking an alternative, community-based approach to flood risk management were instrumental in spurring the citywide efforts that have continued over the past three decades. In the early 1980s, the Sumida Ward staff and mayor, in light of the construction of the new Japan Sumo Wrestling Arena, approached and convinced the Sumo Wrestling Association to integrate a rainwater storage tank, while sharing the city's vision to install similar rainwater systems in all new public buildings throughout Sumida Ward. Furthermore, Sumida Ward advocated, both locally and globally, for the importance and significance of rainwater harvesting by hosting the Tokyo International Conference on Rainwater Utilization in 1994, initiating a subsidy program in 1995, establishing a Rainwater Utilization Ordinance in 2008 (Ministry of Internal Affairs and Communications 2015), and issuing the Sumida River Environment Declaration, which promotes rainwater utilization, in 2009. All of these efforts were also instrumental in raising the awareness of and support from residents and the private sector.
- **Community-based approach to rainwater system installation and O&M:** Civil society has also played a significant role in the implementation, scaling, and O&M of rainwater systems in Sumida Ward. After the 1994 international conference, a nonprofit organization, the Citizens Group to Promote Rainwater Utilization, was established, with the aim of supporting and promoting a bottom-up approach to rainwater storage and utilization. In addition to informing households and community groups about the ward's subsidy program and helping them get access to it, the organization provides information and technical support for O&M with other nonprofit organizations, such as People for Rainwater (Sumida Ward 2018b). Through this community-based approach, O&M for rainwater systems located in different places throughout Sumida Ward is led by residents who live near the facilities and conducted in cooperation with community groups, nonprofit organizations, and the ward (Next Wisdom Foundation 2015). Furthermore, in partnership with nonprofit organizations,[20] the government has promoted the technological development of water quality testing, water quality improvement, rainwater utilization, and rainwater storage and infiltration to extend these efforts throughout the ward, to the Tokyo Metropolitan Area, and to other urban areas in Japan.

Results: Widespread Implementation and O&M of Rainwater Management Systems through a Participatory and Multihazard Approach

While the rainwater harvesting capacity of each household may be small, the total contribution from household rainwater harvesting and storage systems toward reducing stormwater runoff becomes significant through a collective wardwide effort. In 2008, 21 Rojisons were installed in Sumida Ward (Sumida Ward 2018a);

20 See, for example, People for Rainwater (http://www.skywater.jp/aboutus#shiminnokai) and Rain City Support (https://amemachi.org/).

Tank Type	Description	Subsidy Amount	Maximum
Underground Storage Tank	The underground pit is used as a rainwater storage tank for large buildings, condominiums, etc. Stored water is used mainly for washing, toilets, and watering plants.	Subsidy amount per 1 m^3: ¥40,000 (US$363) times effective storage capacity (m^3)	Up to ¥1 million (US$90,909)
Mid-Size Storage Tank	Tank with storage capacity of 1 m^3 or more. Stored water is used mainly for washing, toilets, and watering plants.	Tanks made of fiber-reinforced plastic (FRP), stainless steel, or concrete: subsidy amount per cubic meter ¥120,000 (US$1,090) times effective storage capacity (m^3) Tanks made of high-density polyethylene: subsidy amount per cubic meter ¥45,000 (US$409) times effective storage capacity (m^3)	Up to ¥300,000 (US$2,727)
Small Storage Tank	Tank with storage capacity less than 1 m^3. Stored water is used mainly for watering plants.	50 percent of rainwater tank, including cost of construction.	Up to ¥40,000 (US$363)

Table A12.1: Types of Tanks and Subsidies
Source: Sumida Ward 2018a. *Note*: m^3 = cubic meter.

by March 2018, there were 645 facilities with a capacity of 24,010 m^3, equivalent to approximately 90 liters of rainwater per ward resident (Sumida Ward 2018b). Local residents and communities lead O&M of the rainwater harvesting and storage systems installed at the community level (Rojison), in their businesses, and in households. The community storage facility is often seen as a water resource by the surrounding residents and is often used for watering plants, gardens, and urban farms, in addition to serving an important role during times of disaster as a backup water supply and for firefighting, while the collective management of this community asset helps raise awareness and knowledge of local flood risks.[21] The firefighting benefits are particularly important for the neighborhoods in Sumida Ward, given its long history of managing fire risks. With their strong linkage to the community's needs and sociocultural context for disaster and water resource management, the efforts of Sumida Ward illustrate how initiatives in flood risk management led by residents and communities (including both implementation and O&M) can be supported and enhanced through various mechanisms and partnerships with the local government, including technical support, policy, and subsidies; the promotion of partnerships with the private sector; and so on.

References

Ministry of Internal Affairs and Communications. 2015. “Act on Promotion of Utilization of Rainwater.” http://elaws.e-gov.go.jp/search/elawsSearch/elaws_search/lsg0500/detail?lawId=426AC1000000017&openerCode=1.

Next Wisdom Foundation. 2015. “Sharing Sumida Ward Experience with the World: The Use of Rainwater.” June 22. http://nextwisdom.org/article/680/.

Rainwater Tank Consultation Room. N.d. “Rainwater Tank Consultation Room.” Accessed January 25, 2019. http://www.reasonable.jp/category/1685113.html.

Sumida Ward. 2008. “Types of Rojison.” April 17. http://www.city.sumida.lg.jp/kurashi/kankyou_hozen/amamizu/riyou/dounyuu_sisetu/amamizuriyou_sisetu/rozison.html.

———. 2013. “Rojison.” March 19. http://www.city.sumida.lg.jp/kurashi/kankyou_hozen/amamizu/riyou/rozison.html.

———. 2016. “History of Rainwater Use in Sumida Ward.” April 4. http://www.city.sumida.lg.jp/kurashi/kankyou_hozen/amamizu/riyou/rozison.html.

———. 2018a. “Overview of Rainwater Use Facility.” April 17. http://www.city.sumida.lg.jp/kurashi/kankyou_hozen/amamizu/riyou/dounyuu_sisetu/amamizuriyou_sisetu/rozison.html.

———. 2018b. “Overview of Rainwater Use Facility.” June 22. http://www.city.sumida.lg.jp/kurashi/kankyou_hozen/amamizu/riyou/dounyuu_sisetu/amamizu_riyouzisseki.html.

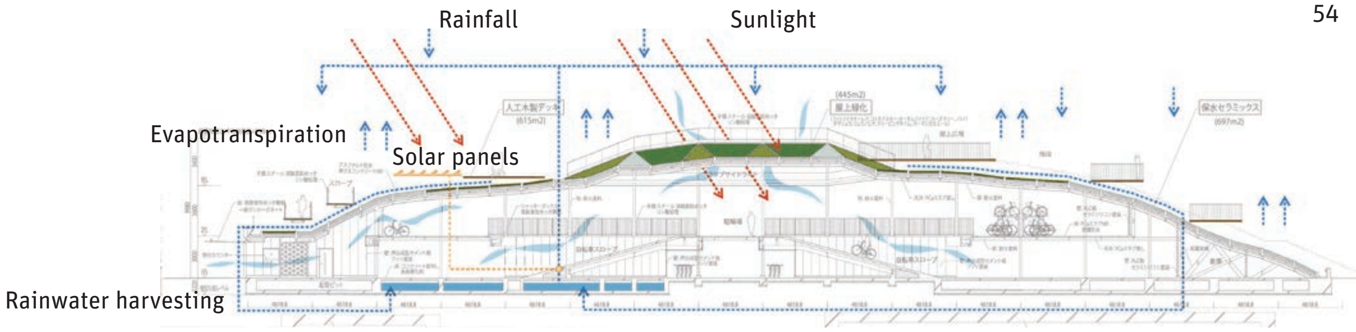
21 The stored water in the rainwater storage tanks needs to be drained before heavy rains to provide storage capacity.

Case 13: Reducing Surface Water Flood Risk by Implementing a Rainwater Harvesting Tank in a Private Urban Development: Tokyo Skytree Town

Location:	Tokyo Skytree Town, located in Sumida Ward between the Arakawa and Sumida rivers, Tokyo
Site characteristics:	The new redeveloped town includes the world's highest radiowave tower along with office, commercial, and recreational facilities, with a total site area of approximately 36,900 m^2. Much of Sumida Ward, which is located in Eastern Tokyo, is below sea level and contains a high concentration of residential and commercial buildings. It is one of the most flood-prone areas within the Tokyo Metropolitan Area.
Flood management measure(s):	
Flood type	Surface water
Management capacity	Rainwater harvesting tank capacity: 800 m^3
	Stormwater detention capacity: 1,830 m^3
Type of measure(s)	Structural (gray)
	Rainwater harvesting system (tank); underground stormwater management facility (cistern)
Relevant entities:	
Implementation	Tobu Railway Company, Tobu Tower Skytree Company
O&M	O&M: Same as above, with strong private sector contribution as part of corporate social responsibility
Finance	Same as above
Construction period:	2008–12
Cost:	Total development cost: ¥143 billion ($1.3 billion)
Additional benefits and functions:	Rainwater harvest and reuse
	Development with rich commercial facilities and thematic attractions that make it an attractive tourist destination
Sources:	Tsukahara 2012.

Context: Landmark Project in Area at High Risk for Flooding

With its low elevation and its location near the Sumida River, **Sumida Ward**, as described in **case 12**, is subject to high flood risks. The site where the Tokyo Skytree Town now stands was a large storage yard for Tobu Railway's freight trains until 1993. In 2006, the site was selected from among other candidates for development because of (i) the availability of extensive vacant land, (ii) consensus among local stakeholders, and (iii) proximity to other tourist destinations, such as Asakusa (Yamamoto 2012). The challenge was to incorporate rainwater and stormwater management schemes within the overall development site.



3

Solution: Investment Design and Key Features

Investment Design

Tokyo Skytree Town was constructed together with a broadcast tower, 634 m in height. The development consists of a high-rise office building, a large shopping mall, and thematic attractions, including an aquarium and planetarium, among others. The site, which is adjacent to two train stations (Oshiage and Tokyo Skytree stations), attracted over 50 million visitors in the first year (Nihon Keizai Shinbun 2013). As part of the development, a large rainwater harvesting tank (capacity 800 m^3) and an underground stormwater detention cistern (capacity 1,835 m^3) were installed. The development of Tokyo Skytree Town was initiated by the privately owned Tobu Railway Company in 2008, with a high potential for generating economic benefits by attracting both local and international visitors, as well as new business opportunities, to the surrounding areas (Horie 2012).

Key Features

- **Private developer's strong incentive to implement and manage a rainwater harvesting tank as part of its corporate social responsibility (CSR):** Although Sumida Ward has a subsidy scheme for rainwater harvesting and reuse, the private developer chose not to apply for it and instead self-sponsored the installation cost as part of its CSR activities. O&M for the facilities is conducted by the private developer as well, as part of its CSR activities to support the ward's mission of promoting rainwater reuse. Most rainfall on-site is collected strategically from the roofs and guided to the harvesting tank through downpipes. The harvested water is reused to cool buildings and solar panels, irrigate rooftop gardens, and flush toilets. In this way, the rainwater harvesting system has the potential to reduce the rate of water consumption by as much as 45 percent, which is greatly beneficial to the developer.
- **Large underground cistern to cope with stormwater runoff from the area:** In addition to the rainwater harvesting tank, a large underground stormwater detention cistern was implemented, given the region's high flood risk. In determining the size of the cistern, the developer chose to adopt a larger management capacity based on two criteria: a target specified by TMG's Bureau of Sewerage and the size of the land readjustment project. Tokyo Skytree Town development has become a flagship project that strongly echoes the ward's effort toward rainwater reuse, as well as addressing the local area's high risk of flooding. The private developer's proactive engagement in stormwater runoff management, reuse, and O&M was greatly appreciated by Sumida Ward.

Results: Installation of Flood Management Facilities Driven by High Potential for Economic Benefits

The Tokyo Skytree development is unique for the strong initiative taken by its private developer, whose efforts were driven by the high landmark profile of the site and the project's great economic attractiveness. Since the tower, buildings, and infrastructure were developed simultaneously, planning and installing related water management facilities together with them was more cost-effective than retrofitting or adding to an existing development. The project was aligned

4

Figure A13.1: Overall View of the Site

Photo Credit: Kenya Endo.

Figure A13.2: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A13.3: Rainwater Harvesting Tank and Renewable Energy Features Installed at Parking Building for 2,600 Bicycles in Front of Oshiage Station

Source: Modified based on information from the Institute for Building Environment and Energy Conservation (2019).

Note: The bicycle parking facility was built right next to Oshiage Station, and the project was led and implemented by Sumida Ward. Although much smaller in scale (4,048 m^2), the building was developed based on the same principle as the Tokyo Skytree Town project for rainwater storage and reuse. The building has an underground rainwater harvesting tank that collects rainwater from the roof and reuses it for irrigation and toilet flushing. Between the storage tank and the porous ceramic surface and vegetation that cover 65 percent of the roof, 100 percent of the rainwater received is recirculated within the building.

Figure A13.4: Tokyo Skytree Town Shopping Mall (Soramachi) and Urban Surroundings

Photo Credit: Kenya Endo.

5

Figure A13.5: Bicycle Parking Building
Source: Institute for Building Environment and Energy Conservation (2019).

with Sumida Ward's effort to promote rainwater storage and reuse, also taking into account the vulnerability of its geographical location to flood risk. The private developer's strong interest in CSR for implementation and O&M enabled Sumida Ward to achieve high flood management capacity within a very dense neighborhood.

References

Horie, Eiji. 2012. "Special Interview with Nezu, Yoshizumi, CEO Tobu Railway Co. Ltd." J-Money. March 23. https://j-money.jp/articles/20120427110814/.

Institute for Building Environment and Energy Conservation. 2019. "5th Sustainable Architecture Award, Honorable Mention—Oshiage Bicycle Parking Building." http://www.ibec.or.jp/hyosyou/building/5th/10.html.

Nihon Keizai Shinbun. 2013. "Tokyo Skytree Town, First Year Visitors Reach 50 Million." May 22. https://www.nikkei.com/article/DGXNASGF2106Z_S3A520C1MM0000/.

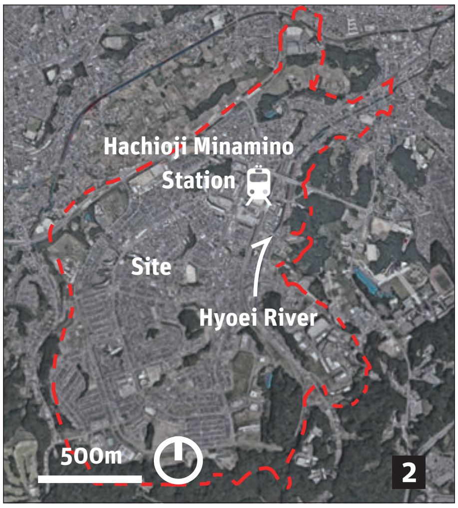
Tsukahara, Keiji. 2012. "Effort for Environmental Sustainability by Tokyo Skytree Town." *Journal of Hydrological Systems* 84 (40): 57–60.

Yamamoto, Hideki. 2012. "The History of Tokyo SkyTree Project." *Journal of the Institute of Electrical Installation Engineers of Japan* 32 (10): 717–20. October. https://www.jstage.jst.go.jp/article/ieiej/32/10/32_717/_pdf/-char/ja.


1

Case 14: Reducing Surface Water Flood Risk by Enhancing Pervious Surfaces and Detention Ponds in a New Town Development: **Hachioji Minamino City**

Location:	Hachioji Minamino District, Hachioji City, Tokyo, approximately 40 km west of the Tokyo city center
Site characteristics:	Residential area surrounded by low-density urban area and hilly woodlands
Flood management measure(s):	
Flood type	Surface water
Management capacity	Detention ponds (A and B): 126,000 m^3
	Infiltration system: Trench—7,753 m; pits—15,310 items; pervious pavers—163,387 m^2; gravel detention pools; above surface detention facilities—2,494 m^3 [a]
Type of measure(s)	Structural (green)
	Enhancing pervious surface
Relevant entities:	
Implementation	UR, Hachioji City/TMG
O&M	Same as above
Finance	Same as above
Construction period:	1986–97 (residents started to move in 1997)
Cost:	Total redevelopment cost (including flood management, urban development, and land readjustment projects): ¥256 billion ($2.3 billion)
Additional benefits and functions:	Urban development
	Environmental conservation
Sources:	UR 2009 and Suzuki 2014, except where otherwise noted.
	a UR n.d.



2

Context: Rapid Urbanization and Flood Risks

On the heels of rapid economic growth that began in Japan in 1955, Tokyo's suburbs gradually began to feel the pressures of rapid population growth and urban sprawl. Hachioji City, 40 km west of Tokyo central, experienced unorganized suburbanization in areas mostly covered by secondary forests, among hills and small scattered communities with little road access or public transportation. In need of a new urban development framework, Hachioji City worked with UR to come up with the Basic Development Vision in 1980 for the development of **Hachioji Minamino City** (UR 2009). A key concern highlighted in this vision was the increase in flood risks from the neighboring Hyoei River, as well as ecological impacts to its riverine environment, as the proliferation of pavements and built-up areas from the new town development was expected to reduce substantially

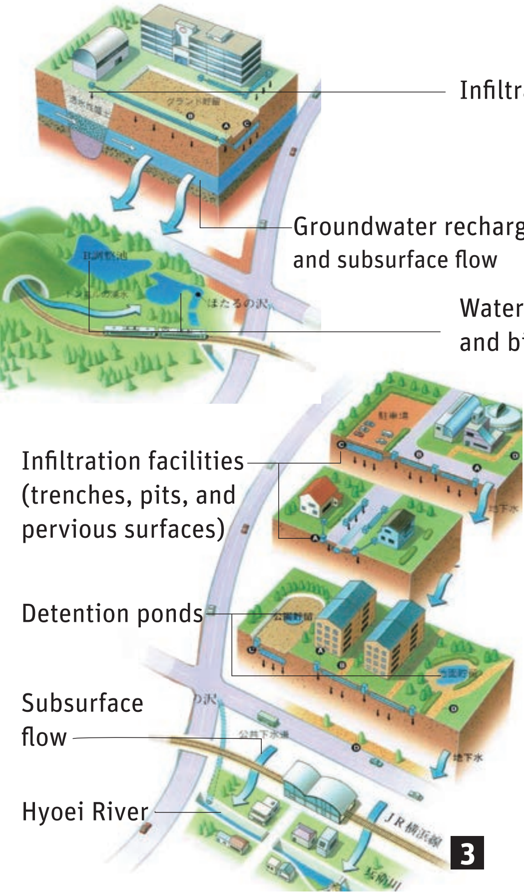


Figure A14.1: Overall View of the Site

Photo Credit: Kenya Endo.

Note: In the photo, the Hyoei River flows in front of the houses and the urban development is on the far side of it.

Figure A14.2: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A14.3: Conceptual Diagram of the Infiltration System

Source: UR 2009.

Figure A14.4: Hachioji Minamino City before and after the Development

Source: UR 2009.

the amount of stormwater infiltration. For this reason, a water circulation and restoration system (some of whose basic principles are illustrated in **figure A14.3**) was incorporated into the development framework to mitigate the risks, preserve ecological values, and create a livable residential community.

Solution: Investment Design and Key Features

Investment Design

Hachioji Minamino City, a 394.3 ha new town development and land readjustment project carried out between 1986 and 1997, transformed a hilly forest area into a residential neighborhood of 28,000 residents. Given the urgent need to develop this residential area for its growing population, Hachioji City had asked UR to conduct a development feasibility study, to which UR had responded with the Basic Development Vision, and this was then approved as the South Hachioji City Land Readjustment Project in 1985 (UR 2009).

Key Features

- **Enhancement of environmental conservation:** As part of a water circulation and restoration system, the flood management intervention led to several environmental benefits. Among them were (i) the enhancement of groundwater recharge, as well as recharge of the Hyoei River, through infiltration (that is, through the installation of trenches, pits, and pervious surfaces); and (ii) the development of detention ponds, creating a new watershed that has enhanced habitats and biodiversity (Suzuki 2014). A technical panel comprising Hachioji City Government, TMG, and the Ministry of Construction (now MLIT), as well as representatives from academia and the community, provided significant design input and guidance to reduce the negative impact of the development and ensure environmental conservation (Suzuki 2014).
- **Raising of awareness and support through combining a large-scale flood management project with household initiatives:** In conjunction with the large-scale urban development project, homeowners who moved into Hachioji Minamino City were encouraged to install stormwater infiltration facilities in their homes, supported by subsidies from Hachioji City. The promotion was led by the Hachioji City government, which covers 90 percent of the installation cost (up to ¥270,000 or $2,454) for the infiltration facility for each household (Hachioji City 2018).
- **Monitoring of the effectiveness of flood management facilities:** To gain an understanding of the impact and effectiveness of the flood management investment, UR, in partnership with Hachioji City, monitored rainfall and the water storage volume of the system over 17 years from 1996 to 2013. Two major groups of parameters were observed: “wet season parameters” (runoff rate, seasonal variation, and maximum runoff volume) and “dry season parameters” (maintaining of Hyoei River base flow volume during drought season). The observations showed the installed systems were highly effective in minimizing stormwater runoff during the “wet season” and mitigating drought during the “dry season” (Suzuki 2014). During the observation period, the flow peak of the Hyoei River never exceeded the design maximum flow of 60 m^3/s in a 1-in-3-year rainfall and 85 m^3/s in a 1-in-70-year rainfall (Suzuki 2014).

Results: Disaster-Resilient and Environmentally Friendly City

With various stakeholders collaborating on the development of the new Hachioji Minamino City, the measures to manage the increased risks of surface water flooding were integrated smoothly and strategically into other public and private priorities, such as drought risk management, environmental sustainability, and the creation of attractive new residential properties. The oversight provided by a technical panel that included members of academia, also allowed for environmental and biodiversity considerations to be integrated into the design of the project. Additionally, linking to an ongoing rainwater infiltration promotion campaign for homeowners led by Hachioji City not only increased the overall flood risk management capacity of the newly developed urban area but also raised awareness and enhanced the knowledge of community members regarding the issue of flooding in the area, as well as various types of solutions that could be implemented at both the large scale and household level. This cultivation of community awareness and support, combined with annual monitoring of the flood management effects of the installed system, has ensured until today the sustainability and continuity of these efforts in Hachioji Minamino City.

References

Hachioji City. 2018. “Subsidy Program for Installation of Stormwater Infilitration Facility.” May 11. https://www.city.hachioji.tokyo.jp/kurashi/life/002/004/005/p006591.html.

Suzuki, Yatsutsugu. 2014. “Study on Integrating Urban Development and Restoration of Hydrologic Cycle—Case Study of Hachioji Minamino Project.” Urban Renaissance Agency. https://www.ur-net.go.jp/lab/kiho159/159-05.pdf.

UR (Urban Renaissance Agency). 2009. “Town Planning with Environmental Symbiosis and Club Life.” September. https://www.ur-net.go.jp/urbandesign/project/nt2.html.

———. N.d. “Reflections on Implementing Rainwater Infiltration Facility: Case of Hachioji Minamino City.” https://www.ur-net.go.jp/info/topics/pdf/20140527hachiouji.pdf.

Case 15: Reducing Surface Water Flood Risk by Enhancing Pervious Surfaces: Grand Mall Park in Yokohama City

Location:	Grand Mall Park is located in Minato Mirai 21 (MM21) district, an urban development project in Yokohama City, Kanagawa Prefecture
Site characteristics:	MM21 district is developed on reclaimed land along Yokohama's waterfront. Various commercial facilities, high-rise office buildings, and tourist spots are placed around the harbor. Grand Mall Park, approximately 2.3 ha in size, is located in front of the Yokohama Museum of Art and includes the museum plaza.
Flood management measure(s):	
Flood type	Surface water
Management capacity	Rainwater retention capacity of single-sized crushed stones: 76 liters per m^3
Type of measure(s)	Structural (green)
	Enhancing pervious surface (green infrastructure)
Relevant entities:	
Implementation	Yokohama City
O&M	Same as above
Finance	Same as above
Construction period:	Construction: 1987–89
	Renovation work: 2015–17
Cost:	Approximately ¥1.8 billion ($16 million) budget for a 2.3 ha site, including the renovation of garden paths and facilities[a]
Additional benefits and functions:	Establishment of green spaces and public amenities
	Urban development
	Mitigation of heat island effect
Sources:	Chigira 2017, unless otherwise noted.
	a Yokohama City 2017.

Context: Urban and Flood Risk Contexts

The vision to develop a new urban center along **Yokohama City's** waterfront, the so-called **Minato Mirai 21** (MM21) project, was first conceptualized in 1965 in light of the rapid urbanization of the 1950s. The large-scale urban redevelopment of MM21 was initiated in 1983, with one of the aims of achieving environmental sustainability and disaster resilience, including the integration of measures for earthquakes, tsunamis, and coastal floods as a key element to inform the design and implementation of the overall MM21 Master Plan.

With the establishment of high-quality public spaces and key greenery aspects of the master plan, the original Grand Mall Park was partially completed in 1989 (Chigira 2017). As new commercial and residential buildings started gradually to increase in the surrounding areas, however, the original design and facilities of the park became outdated. In addition, increasing numbers of residents and tourists visiting the site necessitated the reestablishment of the park to meet the growing demand and accommodate users' needs, as well as to enhance the water circulation that had been disrupted over the years of development in the surrounding area. For these reasons, Yokohama City initiated the renovation of the Grand Mall Park in 2015 (Environmental Planning Bureau, Yokohama City 2015). A key feature introduced in the new design was vertical water circulation, which is derived from the concept of green infrastructure.

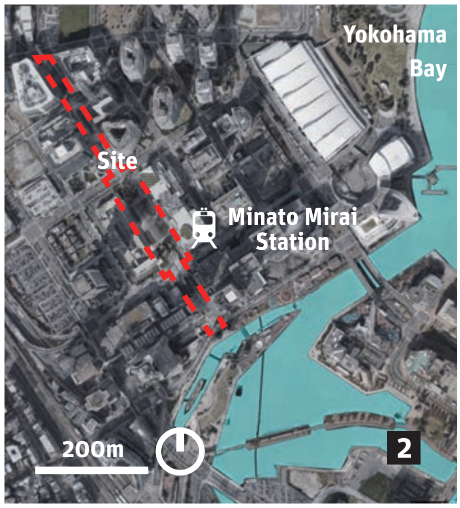
Solution: Investment Design and Key Features

Investment Design

Grand Mall Park is a green pedestrian axis 25 m in width that connects the station to the waterfront. The whole site of the park is 23,000 m^2 in area and it sits among commercial buildings, retail businesses, and museums (Environmental Planning Bureau, Yokohama City 2018). The park has a number of tall zelkova trees and unique street furniture with a sea waves feature (**figures A15.3** and **A15.4**); the concept of vertical water circulation is implemented at the level of the pavers and beneath them. A stormwater storage macadam lies beneath a 700 m pervious pavement and retains rainwater that comes through infiltration gutters, pervious pavements, and planting beds (Green Infrastructure Research Institute Association 2016).

Key Features

- **High-capability material for stormwater storage:** In contrast to standard single-sized crushed stones, rainwater storage macadam can promote the growth of tree roots and effectively store and release rainwater owing to its high water-absorbing ability and water-retentive function. The stormwater storage macadam used in Grand Mall Park has a 5 percent water retention capacity at the surface of the stone; hence, it retains 50 liters per cubic meter (L/m^3). Additionally, it is mixed with humus, which retains twice as much water (214 L/m^3) as general soils (108 L/m^3). The combination brings the water storage capacity beneath the paving of Grand Mall Park up to 76 L/m^3 (Chigira 2017). Before the renovation, stormwater from the park was drained through U-shaped gutters. Now, vertical water circulation contributes to the storage of stormwater runoff, some of which is then allowed to evaporate to



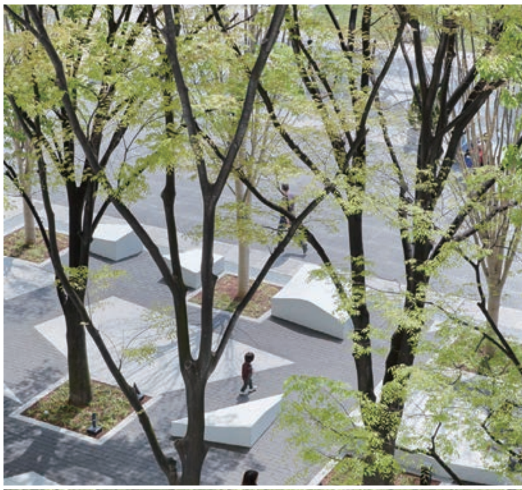
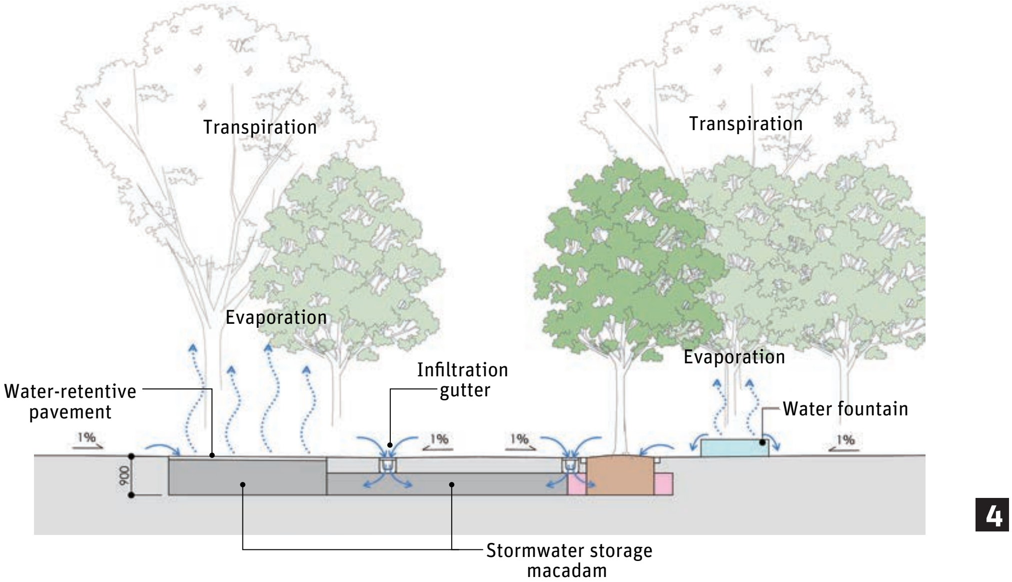


Figure A15.1: Overall View of the Site
Photo Credit: Forward Stroke Inc.

Figure A15.2: Site Context
Source: Google Earth. *Note*: m = meter.

Figure A15.3: The Grand Mall Landscape Design
Photo Credit: Forward Stroke Inc.



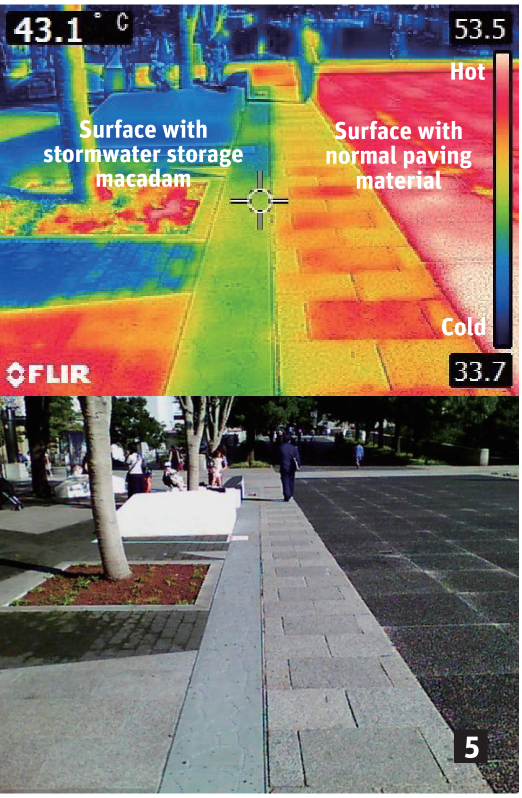


Figure A15.4: Conceptual Diagram of the Green Infrastructure and Hydraulic Cycle

Source: Based on information from Environmental Planning Bureau, Yokohama City (2018).

Figure A15.5: Demonstration of Heat Island Mitigation Effect

Source: Environmental Planning Bureau, Yokohama City (2018).

reduce the surrounding temperature and some of which is used by the trees to grow. With the planting of more trees and groundcover as part of the redevelopment, the proportion of green spaces at Grand Mall Park has increased from 34 percent to 46 percent (Manabe 2018).

- **Dual purpose of flood management and microclimate enhancement:** The park combines its stormwater management function, as described above, with enhancement of the microclimate for its visitors. In sunny conditions, the water stored in the macadam is slowly released back into the air through the pervious pavers as part of a natural evaporation system, and the temperature at the ground level drops. In other words, people sitting on the benches will feel cooler air at their feet, while enjoying the shade from the tree canopy above (Kida 2017).

Results: Both Stormwater Storage and Cooling Benefits

The landscape architect of Grand Mall Park chose a material that holds water in the subsurface layer and enhances stormwater detention capacity beneath the urban plaza. Although the amount of water each stone can hold is limited, the filling of up to 23,000 m^2 of space with such material collectively reduces the amount of runoff to a substantial degree. An additional unique feature of this material is that it releases water to the air in dry conditions, an effect that can be measured by gauging the microclimate of the plaza. When rainwater storage macadam was first introduced at Grand Mall Park in 2016, Yokohama City conducted a study to compare the effects with and without the material in the park. A thermography image produced by the analysis shows the outstanding effects that were observed (**figure A15.5**), with remarkable cooling indicated by the temperature right above the macadam.[22]

22 Detailed information is provided by Chigira (2017), Nojima et al. (2017a, 2017b), and Odagiri (2018).

References

Chigira, Yasuhiko. 2017. “Toward New Urban Development by Using Green Infrastructure—Case Study of Yokohama Grand Mall.” *Journal of the Japanese Society of the Revegetation Technology* 42 (3): 412–16. https://www.jstage.jst.go.jp/article/jjsrt/42/3/42_412/_pdf/-char/ja.

Environmental Planning Bureau, Yokohama City. 2015. “Grand Mall Park renewal construction will start.” Press release, April 30. https://www.city.yokohama.lg.jp/city-info/koho-kocho/press/kankyo/2015/20150430-020-21011.files/0001_20190611.pdf.

———. 2018. “Grand Mall Park Design Received Good Design Award 2018.” Press release, October 3. https://www.city.yokohama.lg.jp/city-info/koho-kocho/press/kankyo/2018/20181003-020-28247.files/0001_20190611.pdf.

Green Infrastructure Research Institute Association. 2016. “New Urban Development by Using Green Infrastructure”. http://green-infra.jp/. https://www.youtube.com/watch?v=nOTuLD_oxKE&feature=youtu.be.

Kida, Yukio. 2017. “Toward New Urban Development by Using Green Infrastructure—Construction Method of Green Infrastructure.” *Journal of the Japanese Society of the Revegetation Technology* 42 (3) 417–19. https://www.jstage.jst.go.jp/article/jjsrt/42/3/42_417/_pdf.

Manabe, Masahiko. 2018. “Resolving Urban Heavy Rain and Urban Heat Island by Turning Pavements and Buildings into Dams.” March 12. https://tech.nikkeibp.co.jp/atcl/nxt/column/18/00123/022100012/?ST=nxt_thmdm_avitation.

Nojima, Yoshiteru, Chigira Yasuhiko, Tsukui Atsushi, Masuda Munenori, Takeda Haruo, Kida Yukio and Fujisaki Kenichirou. 2017a. “Effect of rainwater storage and infiltration and micro-meteorology improvement by the installation of the base to store and infiltrate rainwater, an element technology of Green Infrastructure.” *Journal of the Japanese Society of the Revegetation Technology* 42 (3) 460–65. https://www.jstage.jst.go.jp/article/jjsrt/42/3/42_460/_pdf/-char/ja.

———. 2017b. “Effect of micrometeorology improvement by the installation of the base to store and infiltrate rainwater, an element technology of Green Infrastructure-result of manpower measurement-.” *Journal of the Japanese Society of the Revegetation Technology* 43 (1) 247–50. https://www.jstage.jst.go.jp/article/jjsrt/43/1/43_247/_pdf/-char/ja.

Odagiri, Kouji. 2018. “Grand Mall Park’s effect on thermal environment.” October 31. https://www.city.yokohama.lg.jp/kurashi/machizukuri-kankyo/kankyohozen/kansoku/science/shiryo/youshi.files/0100_20190304.pdf.

Yokohama City. 2017. “Social Infrastructure Comprehensive Development Plans (4th Revision).” August 22. http://www.city.yokohama.lg.jp/toshi/kikaku/koufukin/pdf/171020midorinohozennoyobikouennryokutijigyou.pdf.

Figure A16.1: Renewal of Sewer Pipes (before and after)
Source: Bureau of Finance, TMG n.d.

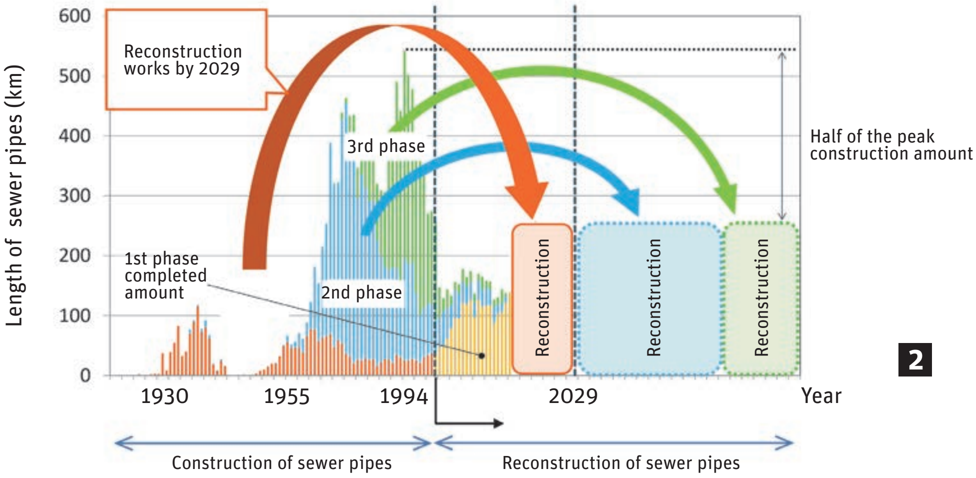
Case 16: Implementing Preventive O&M of Sewerage Facilities through Asset Management: Tokyo's Central Wards

Location:	Tokyo's 23 central wards, 621.5 km^2 in area and with a population of 9.5 million[a]
Site characteristics:	Dense urban areas with high concentrations of assets and population
Flood management measure(s):	
Flood type	Surface water
Management capacity	Based on the revised Tokyo Basic Policy for Heavy Rain Management 2014, the flood management target for sewerage facilities is set at 50 mm/hour. Areas with higher risk of surface water flooding, however, have an upgraded target of 75 mm/hour (refer to **Knowledge Note 2** and **case 6** in this appendix).
Type of measure(s)	Innovative methodologies for conducting sewerage facilities' O&M
Relevant entities:	
Implementation:	TMG
O&M:	Same as above
Finance:	TMG. MLIT offers subsidies for planning, inspection, and reconstruction work, based on the asset management method[b]
Construction period:	Not applicable
Cost:	Not available
Additional benefits and functions:	Seismic resilience
Sources:	Bureau of Sewerage, TMG (2016), except where otherwise noted.
	a Statistics of Tokyo 2019. b MLIT 2018.

Context: Aging Sewerage Facilities in Need of Upsizing to Accommodate Increasing Risk of Surface Water Flooding

Although **Tokyo's central area** is almost entirely connected to a centralized sewerage system managed by TMG, its age and size have presented a serious problem in the face of growing flood risks. Sewerage facilities in central Tokyo were established around 1955 as rapid urbanization and economic development were underway, and 100 percent connection was achieved in the central wards by 1994, with the total length of sewerage pipes having reached 16,000 km. Approximately 1,800 km of this extent, however, has already exceeded the end of its service life—an amount that will increase to 8,900 km in the next 20 years (Bureau of Sewerage, TMG 2016).

This is a critical concern for managing urban floods in Tokyo, given that 82 percent of its central wards have adopted combined sewerage systems. Sewerage facilities in most of central Tokyo are also responsible for draining stormwater to mitigate the risk of surface water flooding. In this highly urbanized environment, the trend of recent years toward increasingly intense rainfall imposes a growing risk of socioeconomic damage. As a basic requirement, there is an urgent need to upsize the conveyance



2

capacity of old sewerage pipes laid before 1986[23] to meet a 50 mm/hour rainfall target. In addition, districts identified as flood prone (refer to **case 6** in this appendix for more details) require further upsizing to accommodate 75 mm/hour storm events. The need to renew aging sewerage facilities can become an opportunity to upsize them at the same time as accomodating the most recent rainfall intensity targets.

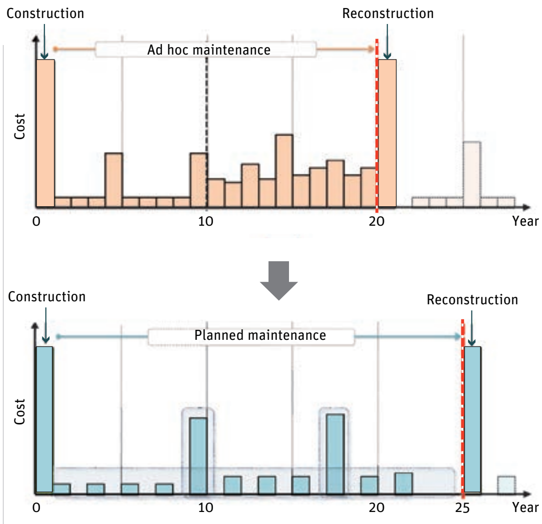
The most urgent need confronting TMG is to upgrade the many aging sewerage facilities that will reach the end of their service lives at almost at the same time (**figure A16.2**), and doing so at such a large scale is a challenge in itself. The challenge of carrying out this reconstruction work is further compounded by the high urban density of central Tokyo. Beneath any road in Tokyo, for example, various types of infrastructure, such as electricity grids and gas pipes, are installed in addition to sewerage pipes, which makes access to the pipes very difficult. As the impact of pipe reconstruction work on road traffic and economic activities must be kept to a minimum, keeping relevant administrators and local community members closely coordinated is essential and, in most cases, a time-consuming process. In addition, since sewerage and drainage functions cannot be stopped at any moment, bypass pipes must be laid before the reconstruction work commences, to ensure continuous flow of combined sewerage and stormwater. The same applies to pumping stations and wastewater treatment plants, as well, which drives the cost of reconstruction even higher.

Solution: Investment Design and Key Features

Investment Design

In light of these conditions and challenges, TMG, in partnership with MLIT, is working (i) to enhance O&M of existing sewerage infrastructure to extend its service life, as well as monitoring and repairing infrastructure, and (ii) to identify cost-effective ways to carry out reconstruction and expand the sewerage facilities in partnership with other sectors and stakeholders.

TMG enhanced O&M of the sewerage facilities by implementing a new asset management method, in accordance with MLIT's guidelines for asset management for public sewerage infrastructure. The method focuses on holistic, systemwide assessment and planning, rather than taking a facility-level approach (MLIT 2015). With a sewerage system as large as that in Tokyo, for example, conducting inspection and repair work for every facility on a regular basis is not feasible[24] because of constraints on human resources, time, and available budgets. An understanding of the current as well as the future state of the system as a whole



3

Figure A16.2: Schematic Asset Management Plan for the Sewer Pipes in Tokyo's 23 Central Wards

Source: Modified information based on Bureau of Sewerage, TMG (2016). *Note*: km = kilometer.

Figure A16.3: Comparison of Asset Management Method (bottom) with Conventional Method (top)

Source: Modified information based on Bureau of Sewerage, TMG (2016).

---

23 "Visions for Comprehensive Flood Management in TMG: Report 61 to the Governor of Tokyo," was published in July 1986, when the combined flood management target for river and sewerage improvement was set at managing 50 mm/hour rainfall (TMG 1986).

24 As specified in "Manuals for Developing O&M Plans of Sewer Pipes" (for more information, see MLIT n.d.), and "Guidelines for Sewerage O&M: 2014 Edition" (for more information, see Japan Sewer Collection System Maintenance Association n.d.), among others. According to these O&M manuals, annual inspection is suggested, for example, for sewer pipes and manholes that are 30 years old or more, while recommended once every three years for those that are newer.

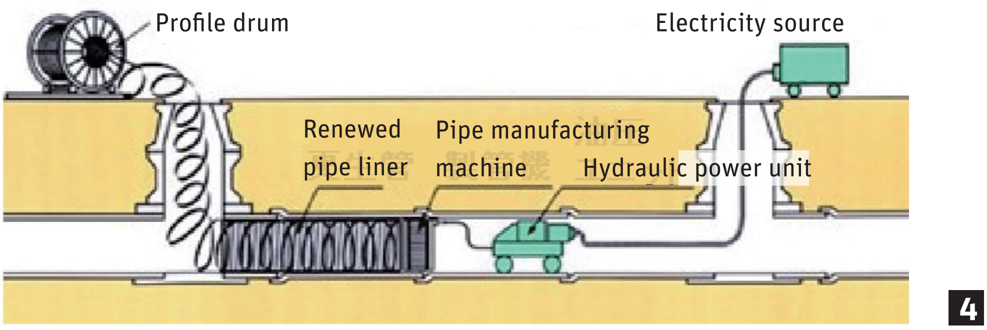


Figure A16.4: Schematic Illustration of Sewer Pipe SPR Rehabilitation Technology

Source: Modified information based on Bureau of Finance, TMG (n.d.).

will allow better prioritization of TMG's O&M action plan, through the avoidance of redundancy and unnecessary reconstruction work, and the prioritization of preventive O&M, such as repairs and anticorrosion treatments, to extend facility life as much as possible (**figure A16.3**).

With respect to cost- and time-effectiveness, TMG is implementing various solutions to enhance its aging sewerage facilities by (i) establishing a holistic framework to plan the entire process up front, taking into account the limited time and financial resources; (ii) clarifying priorities in terms of what actions (inspection, repair, or reconstruction) are to be taken where and when; (iii) combining the work with surface water flooding mitigation measures; and (iv) utilizing innovative technologies to expedite the process with minimal impact on the surrounding urban setting.

Key Features

- **Database development for a 16,000 km–long sewerage network:** TMG created a database for its sewerage system, recording the locations, depths, installation years, and types of pipes. This large set of geospatial information serves as the base for storing monitoring and inspection data, as well as information on planning the renewal of aging sewerage facilities (Morikawa 2018). By analyzing information collected through precise investigation of the deterioration level at each facility, for example, TMG can allocate specific amounts of time and costs required for reconstruction work and include them within its asset management plans. In 2005, TMG made part of this information available to the public through an online platform called SEMIS (Sewerage Mapping and Information System).
- **New technology for sewerage reconstruction:** To minimize disruption to sewerage services during the reconstruction process, various new technologies were developed in partnership with the private sector. The sewage pipe renewal (SPR) method, for example (schematically illustrated in **figure A16.4**), coats the inside of sewer pipes with materials made of vinyl chloride. The coating enhances structural stability against earthquakes and allows the continuous flow of wastewater and stormwater even during installation. Rehabilitation can take place without interfering with existing roads and infrastructure, resulting in a cost reduction of approximately 35 percent compared to conventional methods (MLIT 2014).[25] This Japanese private technology has been introduced to the global market as well and implemented in countries whose sewerage systems are subject to similar aging (Bureau of Sewerage, TMG 2015).

---

25 Compared to conventional reconstruction work, the SPR rehabilitation method can reduce costs by an average of ¥15.6 million ($142,000) per 30 m extension of underground sewerage pipe (width 1,670 mm x height 1,500 mm), a 35 percent cost reduction.

26 An economic life can be calculated based on when the annual average cost of facilities' installation and O&M combined becomes the lowest. Annual average cost can be calculated by dividing the total life-cycle cost (construction and O&M) by the duration of operation.

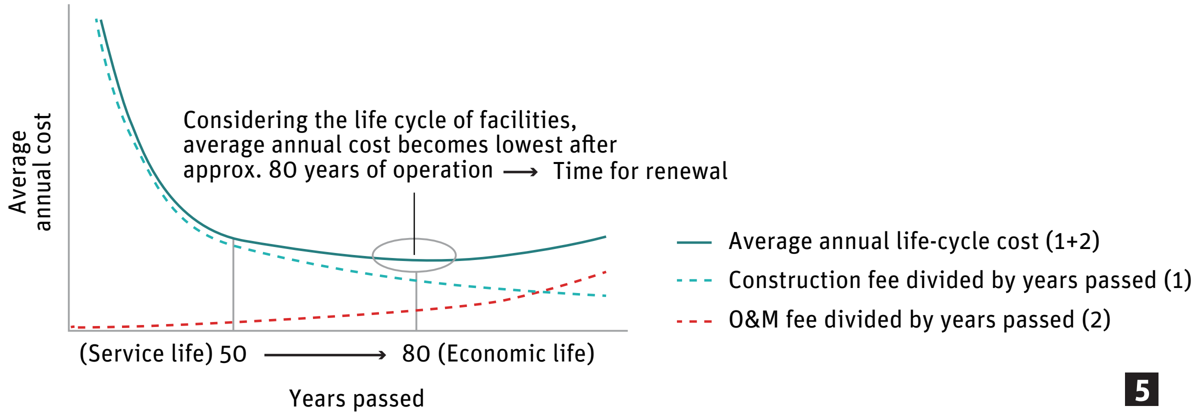


Figure A16.5: Asset Management Time Flow of Sewerage Pipes

Source: Modified information based on Morikawa (2018).
Note: O&M = operation and maintenance.

Results: Cost Savings from Extended Service Life

Through effective asset management, the service life of TMG's sewerage facilities has been extended by 30 years. Facilities whose service lives are normally 50 years were able to reach their economic lives[26] in approximately 80 years (Bureau of Sewerage, TMG 2016; see **figure A16.5**). Similarly, this approach has been applied to other kinds of facilities (such as pumping stations and wastewater treatment plants) and various types of equipment (such as mechanical and electric components) and has contributed to extending their economic lives through preventive repairs and reconstruction work.

The average annual life-cycle cost can potentially be reduced approximately 20 percent, from ¥290 million/year to ¥240 million/year, or $2.63 million/year to $2.18 million/year (Bureau of Sewerage, TMG 2016).

References

Bureau of Finance, TMG (Tokyo Metropolitan Government). N.d. *Tokyo Metropolitan Facilities and Infrastructure News*, no. 3. Accessed January 25, 2019. http://www.zaimu.metro.tokyo.jp/kouyu/toyu/tayori3.pdf.

Bureau of Sewerage, TMG. 2015. "Feature: Technological Capability of Tokyo Sewer Drawing Attention from Overseas Cities." http://www.gesui.metro.tokyo.jp/business/kanko/newstokyo/240/3/.

———. 2016. "Sewerage System Main Measurements for the Central 23 Wards." Accessed January 25, 2019. http://www.gesui.metro.tokyo.jp/business/pdf/02kubu_2016.pdf.

Bureau of Urban Development, TMG. N.d. "About Tokyo's Comprehensive Flood Management." http://www.toshiseibi.metro.tokyo.jp/kiban/kangae_3_1.htm.

Japan Sewer Collection System Maintenance Association. N.d. "Technical Manuals on Sewerage Facility O&M 2019." https://www.jascoma.com/doc/book/list/gijutu-r0110-manual.html.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism). 2014. "Sewerage System SPR Rehabilitation Technology Certified as Japanese Industrial Standard." Press release, July 25. http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20140725.pdf.

———. 2015. "Guidelines for Sewerage Facility Stock Management." November. http://www.mlit.go.jp/common/001110722.pdf.

———. 2018. "About Stock Management." http://www.mlit.go.jp/common/001280982.pdf.

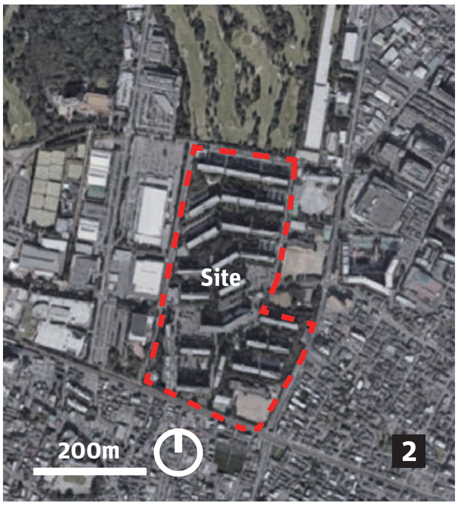
———. N.d. "Guidelines and Manuals for Sewerage O&M." http://www.mlit.go.jp/mizukokudo/sewerage/mizukokudo_sewerage_tk_000466.html.

Morikawa, Naoyuki. 2018. "Measures against Aging of Sewage Pipe." http://www.gesui.metro.tokyo.jp/business/pdf/4-1-1_jp_2018.pdf.

Statistics of Tokyo. 2019. "Tokyo's Statistics on Household and Population Based on Residential Census." March 25. http://www.toukei.metro.tokyo.jp/juukiy/jy-index.htm.

Case 17: Monitoring and Evaluating the Impact of Surface Water Flood Management: Akishima Tsutsujigaoka Collective Housing

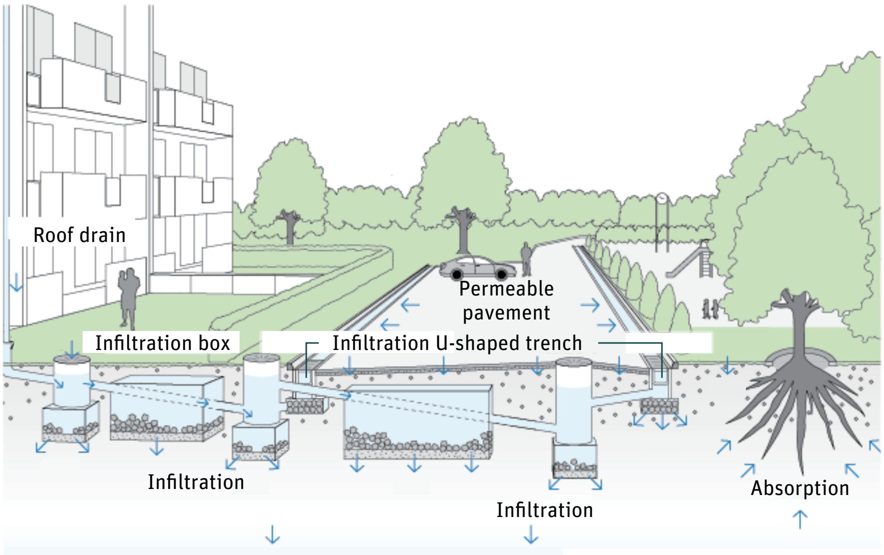
Location:	Akishima City, Tokyo, located 35 km west of the center of Tokyo
Site characteristics:	Urban area (commercial, residential, and public facilities) with low to medium density
Flood management measure(s):	
Flood type	Surface water
Management capacity	Not applicable
Type of measure(s)	Structural (gray and green)—enhancing stormwater infiltration
Relevant entities:	
Implementation	Urban Renaissance Agency (UR) and MLIT
O&M	UR, including long-term monitoring
Finance	UR
Construction period:	1977–81
Cost:	Not available
Additional benefits and functions:	Urban development (housing)
	Environmental conservation and sustainability
	Open space and public amenities
Sources:	Hayashi, Shimada, and Morikami 2002.



Context: Increasing Flood Risks Due to Urban Development

To address the substantial increase in stormwater runoff brought about by rapid urban development since the 1950s, more diversified methods were needed in **Akishima City** for urban flood risk management. Lack of data on the flood management effectiveness of new technologies and approaches presented a barrier, however, to the adoption of more multipurpose, nature-based solutions. In 1978, therefore, housing developer Urban Renaissance Agency (UR), under the direction of MLIT, embarked on an exploration of new ways to manage urban stormwater, with a particular focus on finding measures that could optimize the use of limited urban land while keeping the costs of construction and maintenance low.

Akishima Tsutsujigaoka Collective Housing, a 27.8 ha residential neighborhood that is home to 2,673 households (**figures A17.1**), was selected as the first pilot site for the joint initiative by UR and MLIT. A Committee for the Study of Stormwater Processing Systems within the Apartment Complex was established to test innovative stormwater management measures.



3

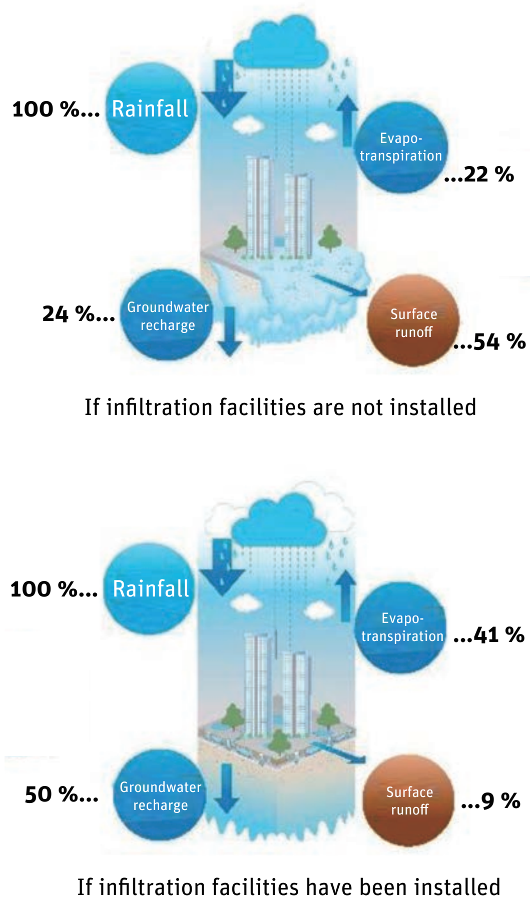
Solution: Investment Design and Key Features

Investment Design

The various new technologies and approaches tested included infiltration containers (49 items), an infiltration trench (494 m in length), an infiltration U-shaped gutter (143 m in length), and permeable pavement (3,580 m^2 in area; Hayashi, Shimada, and Morikami 2002). Using a stormwater infiltration system that combined all these technologies and approaches, UR initiated an effort to manage stormwater by imitating the natural process of the hydraulic cycle. Through this system, stormwater would infiltrate the subsurface level (**figures A17.3** and **A17.4**), which would not only minimize the amount of runoff that would flush immediately to the outside drainage system, but would also recharge the groundwater and return it back to the natural water cycle. This nature-based solution, as a result, would prevent the depletion of nearby rivers—another environmental challenge faced by rapidly urbanizing areas in Tokyo.

Key Features

- **Thorough assessment of site conditions and geology to inform intervention design:** The location of the stormwater infiltration interventions were determined based on a thorough site assessment, taking into consideration ground-level conditions, such as (i) underground water level, (ii) the permeability degree of topsoil, and (iii) the possibility of slope failure and groundwater pollution (MLIT 2010). The feasibility assessment clarified that the site is located above the mildest slope of the Tachikawa fluvial terrace, and groundwater exists approximately 10 m below the surface. The targeted layer for stormwater infiltration was the loamy layer or the layer of earth that was brought to the site during construction. The permeability coefficient of the loamy layer was within the range of 1.5×10^{-4} cm/s to 4.8×10^{-7} cm/s, according to laboratory testing, a range suitable for adequate water percolation (Hayashi, Shimada, and Morikami 2002).
- **Monitoring and evaluation of impacts over time:** A key objective of the pilot was to monitor and evaluate the flood management effectiveness of the stormwater infiltration system by gathering quantitative data. UR therefore carried out O&M and data gathering for more than 30 years, beginning in 1981 (Shouji 2014). Parameters recorded included rainfall and runoff (discharge) volume. A comparative analysis method was used to evaluate flood management effectiveness by monitoring the same parameters at a comparison study site within the property, 3.2 ha in area, that utilized conventional construction methods without any infiltration system (Hayashi, Shimada, and Morikami 2002).



4

Figure A17.1: Overall View of the Site
Photo Credit: Kenya Endo.

Figure A17.2: Site Context
Source: Google Earth. Note: m = meter.

Figure A17.3: Conceptual Diagram of the Infrastructure
Source: Based on information from UR (n.d.[a]).

Figure A17.4: Impact of Stormwater Infiltration System on Annual Water Balance
Source: UR n.d.(b).

Figure A17.5: Building Units and Surrounding Landscape and Parking Lots

Photo Credit: Kenya Endo.

Figure A17.6: Impact of the Stormwater Infiltration System of Akishima Tsutsujigaoka Collective Housing.

Source: UR n.d.(b).

Results: Substantiating Stormwater Management Effectiveness with Data

The 30 years of monitoring yielded clear evidence of the effectiveness of the stormwater infiltration system for surface flood management. Data showed that areas adopting the system reduced their stormwater runoff to one-quarter to one-fifth of the runoff of areas that did not install it (**figure A17.6**). UR has published the results of the long-term monitoring, as well as the outcomes of its follow-up surveys in 1992, 1995 (the 15-year anniversary of system implementation), 2002 (20-year anniversary), and 2012 (30-year anniversary; Shouji 2014). Based on this evidence of its efficacy, the system was installed at nearly 300 housing projects in Japan, across a total of 220 ha, between 1982 and 2002 (UR n.d.[a]).

The results of the Akishima Tsutsujigaoka Collective Housing pilot demonstrate the need for long-term monitoring and evaluation of the effectiveness of new technologies in managing urban flood risk, including both gray and green solutions, and showed the opportunity that can be created by good monitoring and evaluation in scaling such initiatives.

References

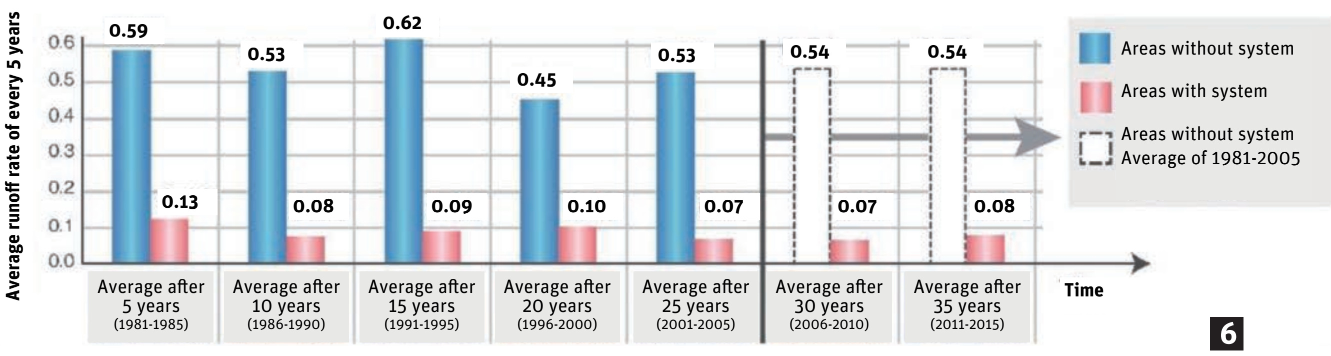
Hayashi, Ryotaro, Yoshikazu Shimada, and Yoshikazu Morikami. 2002. "Study on the Evaluation of Run-off Control Effect of Rainwater Infiltration System That Has Been Researched in Akisima-Tsutsujigaoka Heights Housing Complex Since 1981, over the Past 20 Years." https://www.jstage.jst.go.jp/article/proge1998/11/0/11_0_87/_pdf/-char/ja.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism). 2010. "Guidlelines for Promoting Rainwater Infiltration Facilities." April. https://www.mlit.go.jp/common/000113727.pdf.

Shouji, Hiroshi. 2014. *Towards a Multi-faceted Use of the Effect of Rain Water Circulation Brings—Study of Assessment Methods Such as the Effect of the Introduction of the Water Cycle Technology with a Focus on Rainwater Infiltration Method*. Seasonal research report of UR no. 158. https://www.ur-net.go.jp/lab/kiho158/158-04.pdf.

UR (Urban Renaissance Agency). N.d.(a). "Rainwater Underground Infiltration." Accessed February 16, 2019. https://www.ur-net.go.jp/rd_portal/architec/environment/environment_b01.html.

———. N.d.(b). "Rainwater Infiltration System by UR—For the Sound Water Cycle in Urban Areas." Information extracted from the brochure.



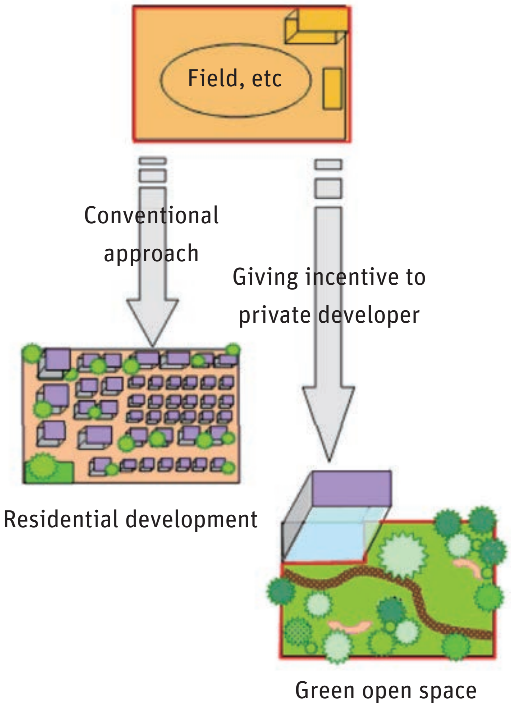
Case 18: Managing Surface Water Flood Risk through Private Sector Engagement:
Brillia L-Sio Hagiyama Owner's Park and Hagiyama Shikinomori Park

Location:	Higashimurayama City, Tokyo
Site characteristics:	Northern part of the Tama area with a population of approximately 150,000, 25 km west of central Tokyo. "Satoyama" (secondary woodlands) and green fields remain around the site.
Flood management measure(s):	
Flood type	Surface water
Management capacity	Not applicable
Type of measure(s)	Structural (green)
	Enhancement of pervious surfaces by increasing green spaces
Relevant entities:	
Implementation	Brillia L-Sio Hagiyama Owner's Park (14,899.77 m^2), including residential building for 184 households, and Hagiyama Shikinomori Park (TMG-certified private park, comprising 10,429.84 m^2 of Owner's Park area), implemented by Tokyo Tatemono Co. Ltd., and the Seibu Railway Co. Ltd. (private developers), with guidance from TMG
O&M	Brillia L-Sio Hagiyama Owner's Park: Tokyo Tatemono Amenity Support Co. Ltd.
	Hagiyama Shikinomori Park: Private developers and residents/landowners, in accordance with TMG's certified private park mechanism
Finance	Same as above
Construction period:	Completion date: July 30, 2009
Cost:	Not available
Additional benefits and functions:	Increase in public recreation space
	Environmental conservation and sustainability
	O&M of parks shared by community and private operator through participatory approach
	Disaster evacuation park and facilities established
Sources:	Real Estate Baseball Association 2009.

Context: Urban Development and Flood Risks

Higashimurayama City is exposed to flooding from neighboring small- to mid-sized rivers, as well as surface water flooding caused by heavy rain in the urban areas. The conservation of green fields and the creation of park lands are considered watershed countermeasures that mitigate stormwater runoff by increasing infiltration capacity.

A TMG-certified privately developed park system was initiated by TMG in 2006 in recognition of the growing need to establish green spaces and parks to increase urban infiltration capacity for surface flood management; reduce temperatures in



3

4

Figure A18.1: Overall View of the Site

Photo Credit: Kenya Endo.

Figure A18.2: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A18.3: Schematic Diagram of Privately Developed Park System

Source: Modified based on information from Bureau of Urban Development, TMG (2016).

Figure A18.4: The Park and Housing Blocks

Photo Credit: Kenya Endo.

cities during the summer and mitigate the urban heat island effect; enhance environmental conservation and sustainability; and create attractive living spaces for citizens. The high cost of land and maintenance, however, made it challenging to advance the development of new public parks and green spaces through public sector efforts alone.

Solution: Investment Design and Key Features

Investment Design

The first TMG-certified privately developed park was established in Higashimurayama City in 2009, in conjunction with a private housing development initiative by Tokyo Tatemono Co. Ltd. and the Seibu Railway Co. Ltd. Integration of the TMG-certified privately developed park within the development design enabled the newly established Brillia L-Sio Hagiyama Owner's Park (a private housing development with 184 new apartment units) and Hagiyama Shikinomori Park (a public park) to have 70 percent of their developed area (nearly 1 ha) as a green space, offering rich biodiversity while also functioning as a disaster evacuation park.

The TMG-certified privately developed park system enabled the private developers to integrate green areas into their designs under certain conditions: that they (i) would open certain portions of the site to the public; (ii) would carry out effective O&M, meeting accreditation criteria for disaster evacuation; (iii) would conduct O&M for at least 35 years; and (iv) would collectively manage all expenses. In turn, TMG would provide benefits to the developers, including such supporting measures as the deregulation of building codes in the park space and the reduction of the costs of land ownership (Bureau of Urban Development, TMG 2016). Furthermore, through this system, TMG would allow private developers to construct buildings, such as high-rise condominiums, in areas otherwise designated for parks and green spaces.

Additionally, the TMG-certified privately developed park system has provided an incentive to private land owners to participate in park maintenance by waiving property and urban planning taxes for 10 years and reducing inheritance taxes by 40 percent if the land is leased for more than 20 years.

Key Features

Private sector and community financing mechanism for urban green spaces: Utilization of the TMG-certified privately developed park system allowed for various incentives for private sector and community financing to establish and maintain new urban green spaces. TMG allowed height deregulation, for example, permitting apartment buildings to be as high as 34–35 m with 11 stories. The site's land right is owned by the apartment management association, which pays a monthly fee of ¥250,000 (roughly $2,200), or ¥1,400 ($12.70) per apartment unit, as the park maintenance fee, which is separate from the apartment maintenance fee. In addition, if the park is opened to the public for free, its property and city planning taxes are further reduced. The private enterprises own property rights over the park area and take care of the park's O&M as part of a 35-year contract with the apartment management association. TMG carries out O&M only of the public restrooms in the park.

A similar system in Japan, called the commercial enterprise management system (Park-PFI), also supports sustainable park O&M by enabling private sector financing and reducing the public sector's financial burden. This system allows private enterprises, such as restaurants and shops, to establish for-profit facilities inside parks. In return, the private enterprises hire individuals who carry out maintenance and repair work for the park facilities, including garden paths and plazas. This new O&M management method aims to increase the comfort and convenience of park visitors. In addition, the system improves the quality of urban parks by attracting private investment and, as a result, reducing the financial burden of O&M on the park administrator (MLIT 2018).

In addition, TMG utilizes the Tokyo Metropolitan Park Supporter Fund (Tokyo Metropolitan Park Association, n.d.). The fund collects donations from Tokyo citizens and is used for community events in the parks, such as traditional performing arts projects at Hamarikyu Gardens and concerts at Hibiya Park. Part of the profit generated from the cafe at the Komazawa Olympic Park also contributes to this fund.

Results: Private and Public Sector Partnership for a Multipurpose Urban Flood Risk Management Investment

The financing of parks and green spaces provides significant flood management, disaster risk management, and environmental sustainability benefits to cities. Financing the considerable life-cycle cost of these investments, however, can be difficult for the public sector to bear alone, particularly in urban areas with high land value. The utilization of the TMG-certified privately developed park system to develop and maintain the housing and park complex at **Higashimurayama City** is an example of how the private sector and landowners can be engaged and given incentive to share the financial and maintenance costs and responsibilities for the establishment of new, high-quality green spaces in urban areas. Such spaces serve multiple purposes and carry benefits including, but not limited to, flood risk management.

References

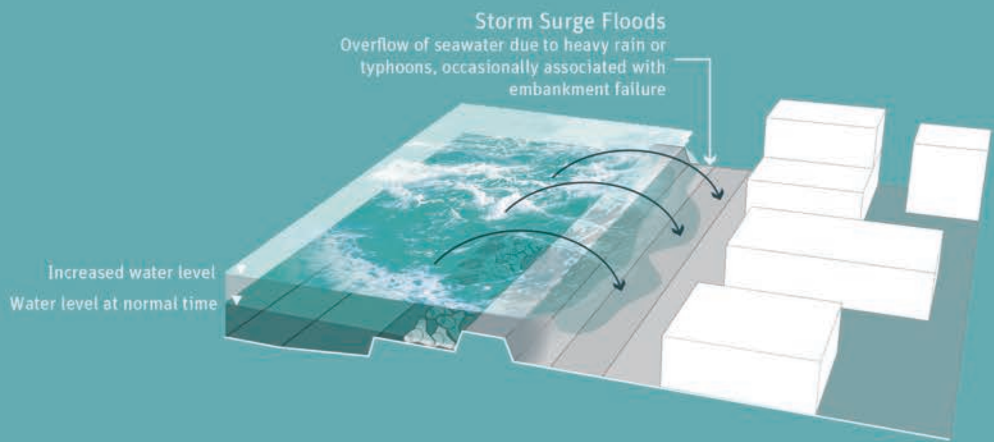
Bureau of Urban Development, TMG (Tokyo Metropolitan Government). 2016. "Introducing the Public Park System." http://www.toshiseibi.metro.tokyo.jp/kiban/kouen_1.htm.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism). 2018. "Guideline on Utilization of Park-PFI to Improve the Quality of the Urban Park." August 10. http://www.mlit.go.jp/common/001197545.pdf.

Real Estate Baseball Association. 2009. "First TMG-Certified Privately Developed Park: Hagiyama Shikinomori Park Opening Festival." October 5. https://www.dai3.co.jp/_old_hp/rbayakyu/21th/times/news265.htm.

Tokyo Metropolitan Park Association. N.d. "Tokyo Metropolitan Park Association." Accessed January 25, 2019. https://www.tokyo-park.or.jp/profile/supporter/index.html.

Storm Surge Floods




Port of Kobe
p. 75
Hyogo Prefecture
19
Takamatsu Port
Kagawa Prefecture
(refer to KN1: Section 3.1)
100 km
Saitama Prefecture
Chiba Prefecture
Tokyo
Minato Mirai 21 District in Yokohama City
p. 79
20
Kanagawa Prefecture
5 km
Source: Bing Map, ESRI World Hillshade Map
Note: km = kilometer, KN = Knowledge Note

Figure A19.1: Storm Surge Measures in Kobe,
—Iron Tide Gate, Flood Gate, and Pump Station

Source: Takemoto 2019.

Case 19: Managing Storm Surge Flooding by Enhancing Seawalls and Flood Gates: Port of Kobe

Location:	Kobe City, Hyogo Prefecture
Site characteristics:	High urban port city located on the north shore of Osaka Bay. Sixth-largest city in Japan with population around 1.5 million. Ports, industrial zones, and commercial and residential developments are densely located around the waterfront area.[a]
Flood management measure(s):	
Flood type	Storm surge flooding
Management capacity	Seawalls: Storm surge—designed to manage up to T.P.[b] + 2.80[c] (that is, to manage the worst typhoon events in history); tsunami—designed to manage up to M8[d] earthquake (projected Nankai Trough Earthquake level)
Type of measure(s)	Structural: 59.8 km of storm surge management measures at the Port of Kobe, including iron tide gate,
	pump stations, and flood gates
Relevant entities:	
Implementation	Port and Harbor Bureau, Kobe City Government
O&M	Same as above
Finance	Port and Harbor Bureau, Kobe City Government with support from MLIT
Construction period:	1965–2015
Cost:	Approximately ¥30 billion ($273 million)
Additional benefits and functions:	Seismic resilience and tsunami protection
Sources:	Kobe City n.d.(b), except where otherwise noted.
	a MLIT 2017.
	b Tokyo Peil (T.P.) datum corresponds to the mean sea level in Tokyo Bay.
	c Kobe City n.d.(a).
	d Japan Meteorological Agency Seismic Intensity Scale.

Context: Port Development and Flood Risks

As a major port city in Japan, **Kobe City** has its people and assets concentrated across the coastal area, where they are exposed to significant risks of coastal floods caused by storm surges and tsunamis. Kobe Port, opened in 1868, is a key hub of international and domestic marine transport. It provides vital support to Japanese and global industries and is one of the major international container hubs in the world.

Large portions of Kobe's coastlines are built on reclaimed land, and, historically, the city has experienced numerous devastating flood events from storm surges, including Typhoon Wilda (No. 20) and Typhoon Shirley (No. 23), which hit Kobe City in consecutive years (1964 and 1965) and affected more than 30,000 people (**figure A19.3**). More recently, in 2018, Typhoon Jebi (No. 21) brought maximum wind speeds of more than 45.3 m/sec, maximum hourly rainfall of 59 mm/hour, tides reaching a level of T.P.[27] + 2.33 m, and waves recorded at 4.72 m. Typhoon Jebi injured 5 people and damaged more than 300 houses (Hyogo Prefecture 2018). The Port of Kobe was severely affected, with 43 containers washed away and transportation networks and industrial zones disrupted by inundation.

To manage this significant risk of coastal floods, the Coastal Disaster Prevention Department of the Engineering Works and Disaster Prevention Division of the Kobe Ports and Harbors Office (i) works to manage coastal protection zones; (ii) plans, designs, and coordinates tsunami and storm surge protection projects throughout the city; (iii) monitors and maintains protection facilities; and (iv) comprehensively coordinates the office's activities for disaster prevention, shoreline measures, and other related matters.

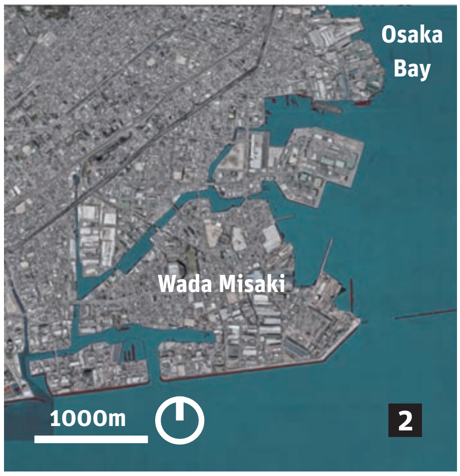


Figure A19.2: Site Context

Source: Google Earth. *Note*: m = meter.

Figure A19.3: Water-Covered Road and Riverbank Collapsed by Typhoon Shirley (No. 23) in 1965

Source: Takemoto 2019.

Solution: Investment Design and Key Features

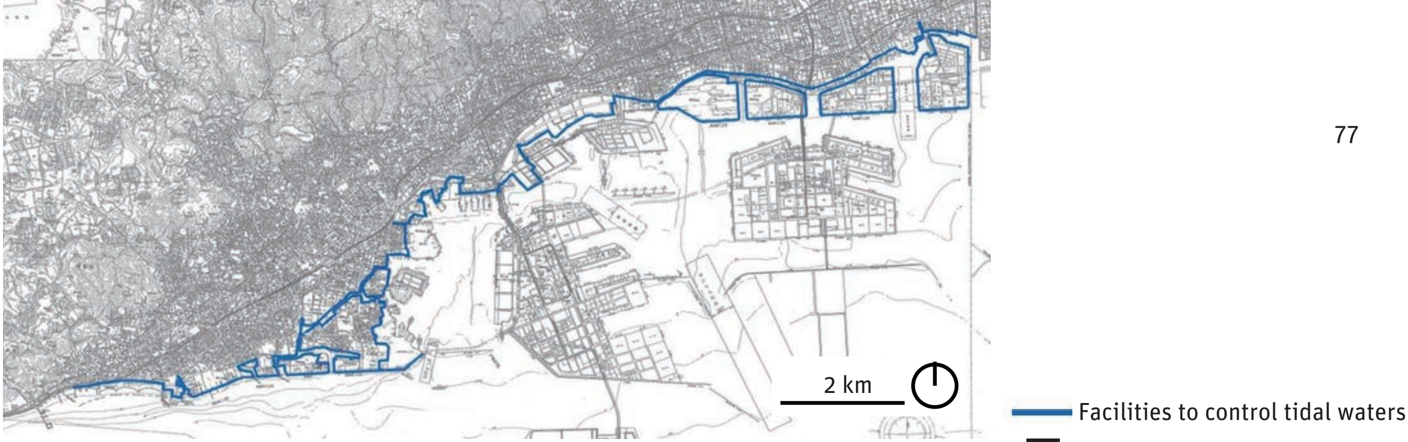
Investment Design

In response to the severe coastal flooding experiences of the 1960s, Kobe City has, since 1965, been implementing a Storm Surge Protection Project, investing for over five decades in flood management infrastructure across 59.8 km of the city's coastlines. Seawalls, iron tide gates, and pump stations have been set up in the coastal areas to prevent the overflow of seawater from storm surges (**figures A19.1** and **A19.4**).

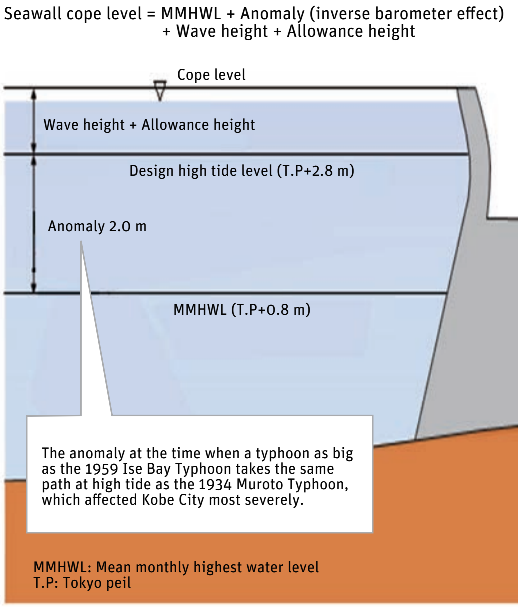
The design standard for the various types of infrastructure is to be able to manage a storm surge (typhoon) equal to that of the most severe events in history. For Kobe, these are the 1959 Ise Bay Typhoon, in terms of size (rain intensity, wind speed, and so on) and the 1934 Muroto Typhoon, in terms of tide level (influenced by the storm's path; **figure A19.5**).

These structural measures are combined with nonstructural measures, such as (i) strengthening the predisaster prevention system in areas of high flood risk by encouraging the development of business continuity plans; and (ii) improving the system for providing disaster prevention information to residents and workers in coastal areas by enhancing last-mile communication through loudspeakers and installing tide indicators and live cameras to share information in real time. The importance of such an integrated approach combining structural and nonstructural

27 Tokyo Peil (T.P.) datum corresponds to the mean sea level on Tokyo Bay.



4



5

Figure A19.4: The Storm Surge Protection Project 2-D Plan

Source: Takemoto 2019.

Figure A19.5: Design-Level Calculation of Seawalls Integrating Storm Surge Risks

Source: Takemoto 2019.
Note: m = meter; T.P. = Tokyo Peil datum which corresponds to the mean sea level on Tokyo Bay.

measures was borne out during the 2018 Typhoon Jebi event, and the city has since strengthened its efforts to encourage residents and workers to take predisaster prevention actions on their own.

Key Features

- **Incremental development and improvement:** Given the various types and the large extent of investments required to protect the port and city of Kobe from storm surge floods, the construction and improvement of structures has been incremental. This process is coupled with continuous review and improvement of the design of the structural measures, as well as the enhancement and implementation of nonstructural measures to address residual and unexpected risks. After Typhoon Jebi in 2018, for example, Kobe City, together with MLIT, the Japan Meteorological Agency, and experts from academia set up a committee to review the damage, draw lessons learned, and propose enhancements to the storm surge management measures for Kobe Port. Based on a thorough assessment of the damage, its causes, and bottlenecks in the post-Jebi review process, the committee proposed site-specific structural and nonstructural measures to enhance preparedness for future events. These included ground raising in targeted high-value areas, such as industrial yards; the fortification and raising of seawalls in targeted areas; enhancement of the installation of pumping facilities; review and improvement of evacuation sites and routes; improvement of disaster information communication systems; and review and improvement of the O&M of coastal embankments, among others (Kobe City 2019).
- **Use of innovative technology to ensure the safety of facility operators:** Kobe's coastal flood management measures are designed for both storm surge and tsunamis. The experience of large earthquakes, such as the Great Hanshin Awaji Earthquake in 1995 that affected Kobe and the Great East Japan Earthquake (GEJE) in 2011, has shown that enhancing not only the structure itself but also operational effectiveness and safety is key, particularly as the city prepares for a larger M8[28] Nankai Trough Earthquake. Quickly and safely closing the flood and tide gates is a critical concern. During the GEJE, more than 59 people reportedly died or went missing while attempting to close the gates (MLIT 2015). To tackle this issue, Kobe City has initiated the installation of a remote monitoring and operation system developed by NTT West that allows the flood and tide gates to be opened and closed from office computers and tablets and site conditions to be monitored in real time. The installation is expected to be completed at 15 sites by 2019 and scaled up throughout the coastal zone of Kobe, with completion of 167 sites by 2024. The city is also planning to implement systems that will automatically close the gates upon receiving early tsunami warnings (Nikkei BP Research Institute 2019).

28 Japan Meteorological Agency Seismic Intensity Scale.

Results: Mitigating Current and Future Flood and Disaster Risks and Preparing the Port and City of Kobe for Them

The storm surge management measures taken in Kobe provide an example of how cities can incrementally work toward mitigating their flood risks in densely urbanized coastal areas by integrating structural and nonstructural measures into their coastal infrastructure development plans and designs, constantly reviewing and enhancing approaches based on thorough reflection on disaster events, and adopting new technologies and solutions. This approach is effective for large-scale storm surge management measures that often require large amounts of space, time, and financing to implement.

References

Hyogo Prefecture. 2018. "Damage from Typhoon No 21 (Jebi)." As of November 1, 2018. https://web.pref.hyogo.lg.jp/kk03/documents/181101_08.pdf.

Kobe City. 2019. "Third Committee Meeting on Storm Surge Management Measures for Osaka Bay Port Area (Kobe Port Working Group)." http://www.city.kobe.lg.jp/information/committee/port/kentoukai-3.pdf.

———. N.d.(a). "Beware of Storm Surge!" http://www.city.kobe.lg.jp/safety/prevention/preparation/sand/img/H26-tsunami-kijis.pdf.

———. N.d.(b). "Realities and Measures against Tsunami and Fire." http://www.rokko-island.com/content/1100.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism). 2015. "The 4th Project Evaluation Committee. Document 8. A Draft Bill to Amend a Part of the Coast Act." http://www.mlit.go.jp/river/shinngikai_blog/shaseishin/kasenbunkakai/shouiinkai/r-jigyouhyouka/dai04kai/siryou8.pdf.

———. 2017. "List of Designated Cities." http://www.soumu.go.jp/main_sosiki/jichi_gyousei/bunken/shitei_toshi-ichiran.html#kome01.

Nikkei BP Research Institute. 2019. "Kobe City Introduces Remote Control and Monitoring System for Water Gates and Tide Iron Doors Using Tablets for Tsunami Countermeasures, in Partnership with NTT West." https://project.nikkeibp.co.jp/atclppp/PPP/news/122701005/.

Takemoto, Shoji. 2019. "Storm Surge Control Measures at the Port of Kobe." Kobe Ports and Harbors Office. Presented at Integrated Urban Flood Risk Management Technical Deep Dive, Kobe City.

Case 20: Reducing Storm Surge Flood Risk by Raising the Ground Level: **Minato Mirai 21 District in Yokohama City**

Location:	Minato Mirai 21 (MM21) district is a large, master-planned urban development project in Yokohama City, Kanagawa Prefecture.
Site characteristics:	Minato Mirai 21 district is developed on reclaimed land along Yokohama's waterfront. It serves as a central business district, with various commercial facilities, high-rise office buildings, and tourist spots placed around the harbor. It was developed to connect Yokohama's traditionally important areas with commercial centers of Kannai and the Yokohama Station area.
Flood management measure(s):	
Flood type	Storm surge
Management capacity	Coastal flood management measures in MM21 district, including storm surge floods, are designed based on inundation modeling from the Keichou Earthquake (which occurred in 1605, with an estimated magnitude of 8.5)[a]
Type of measure(s)	Structural (gray)—Ground raising
	Nonstructural—Signage of sea level and evacuation rights, tsunami early warning system, etc.
Relevant entities:	
Implementation	Land readjustment project (approximately 101.8 ha): Urban Renaissance Authority (UR)
	Land reclamation (approximately 73.9 ha): Yokohama City
	Construction of port area: MLIT and Yokohama City
	Construction of street, common tunnel for utility lines (approximately 7 km), sewerage construction, public parks and green space, waste treatment facility, etc.: Yokohama City in partnership with MLIT, UR, private sector, etc.
O&M	Same as above for infrastructure investments
Finance	Same as above
Construction period:	Land readjustment project—1983–2011[b]
Cost:	Estimated total construction and infrastructure investment cost: ¥2.625 trillion ($23.9 billion) from 1983 to 2016, including ¥1.52 trillion for building construction ($13.8 billion) and ¥530 billion for infrastructure construction ($4.8 billion)[b]
Additional benefits and functions:	Urban and economic development
	Establishment of green space and public amenities
	Seismic resilience
	Regional hub for disaster preparedness through establishment of decentralized off-grid energy infrastructure, etc.

Sources:	Urban Development Bureau, Yokohama City 2014, except where otherwise noted.
	a Crisis Management Office, Yokohama City 2013.
	b Some land readjustment projects are ongoing. More information is available in Urban Development Bureau, Yokohama City (2019a and 2019b).

Context: Reclaiming Land for Urban Development

Yokohama City has a long history of reclaiming land along the coast for use as rice fields and residential settlements, going back to the 1700s (Washiyama 2003). Because the inner part of Yokohama City is mostly hilly, ports and industrial factories were built extensively on reclaimed land along the city's waterfront (Yoshioka 2011). Rapid economic development in the 1950s led to the accumulation of population and assets, first in Tokyo and subsequently in Yokohama City. While the city experienced fast population growth and intensive housing development, however, core business units moved to Tokyo.

This led to the development of the **Minato Mirai 21** (MM21) district, starting in 1983, with the purposes of (i) enhancing the economic autonomy of Yokohama City by accumulating commercial enterprises and cultural facilities to attract citizens to work and live there; (ii) transforming previous land uses (for the shipping industry, including as cargo shipyards) into parks and socioculturally vibrant outdoor spaces; and (iii) creating a central business district for the region (Urban Development Bureau, Yokohama City 2014). The MM21 project aimed to connect Yokohama's traditionally important areas with commercial centers of Kannai and the Yokohama Station area.

Given its proximity to the coast, however, the MM21 district faced significant flood and disaster risks from tsunamis, storm surge floods, land subsidence, and soil liquefaction issues. The scale of the proposed project, with a total redevelopment area of 186 ha, housing for more than 10,000 residents, and offices for 190,000 workers, called for the application of both structural and nonstructural measures to ensure security for people living and working close to the bay (Urban Development Bureau, Yokohama City 2014).

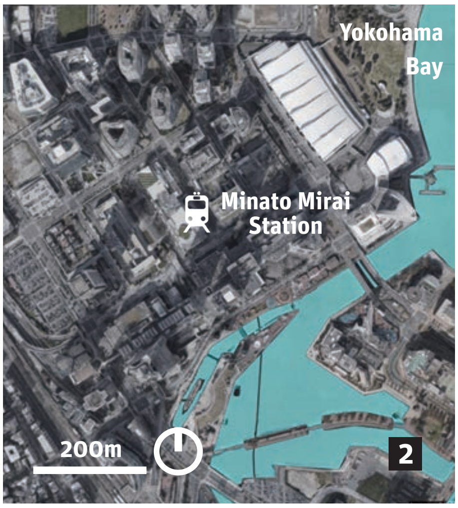


Figure A20.1: Overall View of the Site

Photo Credit: Kenya Endo.

Figure A20.2: Site Context

Source: Google Earth. *Note*: m = meter.

Solution: Investment Design and Key Features

Investment Design

Construction of the MM21 district project was initiated in 1983, based on the large-scale MM21 Master Plan for a 186 ha site along the waterfront of Yokohama. The various components of the development project included 87 ha of residential development, 42 ha for road and rail transportation, 46 ha for parks and green spaces, and 11 ha of port area (Association of Yokohama Minato Mirai 21 2016). The land readjustment project was carried out by the housing developer, Urban Renaissance Authority (UR) between 1983 and 2011, and the new railway station was completed in 2004.

The development project also included land reclamation of a 73.9 ha site, using a sand-drain method for ground stabilizing, and construction of utility corridors beneath arterial roads. Disaster risks, including earthquakes, tsunamis, and storm surge floods, were taken into consideration in the design and implementation of the land reclamation and development.

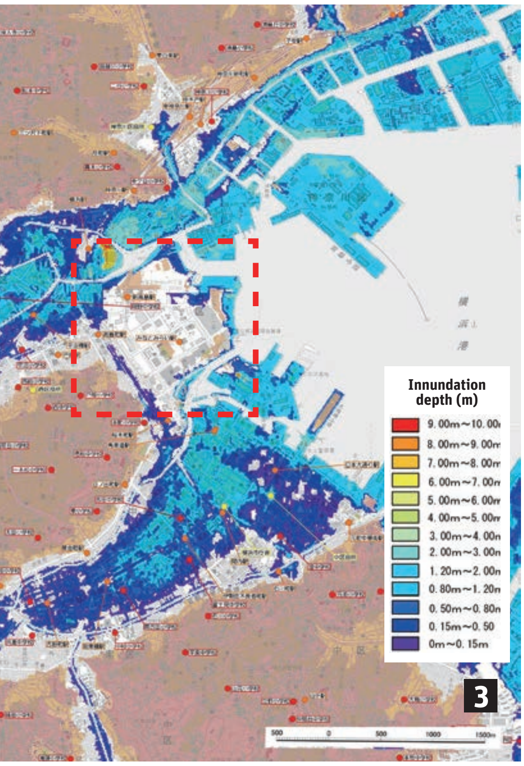


Figure A20.3: Tsunami Flooding Estimation Map

Source: Based on information from Crisis Management Office, Yokohama City (2013).
Note: m = meter.

As measures against tsunamis and storm surges, revetments along the coast were constructed to a height of 2.7–3.1 m above sea level, and residential development in the central districts of MM21 was limited to areas 3.1–5.0 m above sea level (Association of Yokohama Minato Mirai 21 n.d.[b]). These heights were based on inundation modeling from the Keichou Earthquake (which occurred in 1605, with an estimated magnitude of 8.5), as illustrated in the Tsunami Flooding Estimation Map published by Yokohama City (**figure A20.3**).

Key Features

- **Integration of disaster risks from the master planning phase:** From the beginning, the master plan outlined the importance of integrating disaster risk resilience into the basic land and infrastructure development of the MM21 district, particularly against earthquakes, tsunamis, and coastal floods from storm surges. Therefore, the land reclamation, land readjustments, and port development projects were designed and implemented in conjunction with the various disaster risk reduction and preparedness investments mentioned above. The early consideration and integration of risks enabled the development of large-scale, high-cost flood management infrastructure in a highly urbanized area.
- **Combination of hard and soft measures against coastal floods:** Various structural and nonstructural measures for disaster risk management were implemented in recognition of the high vulnerability of a site located on coastal reclaimed land. As described above, MM21 integrates hard measures to prevent and mitigate coastal floods, such as ground raising and coastal revetment construction, as well as soft measures, such as minimum sea level standards for residential development, early warning systems, evacuation signage and awareness raising, and so on (Association of Yokohama Minato Mirai 21 n.d.[c]). Additionally, community-led efforts, such as the Disaster Mitigation Focus Area Management Promotion Committee, established in partnership with the City of Yokohama, created various awareness programs and training sessions to promote safety and disaster resilience initiatives within MM21. The committee launched a program in 2017 that encourages community members and private business owners to offer shelter to people who might face difficulty returning to their homes during emergencies (Association of Yokohama Minato Mirai 21 2017).
- **Establishment of a mechanism to sustain stakeholder collaboration:** In 1984, to facilitate engagement of and coordination among various public, private, civil society, academic, and citizen stakeholders, a general incorporated association called Yokohama Minato Mirai 21 was established. The association took on the responsibility of leading the management of the new area in a cohesive and coordinated manner to ensure the development and sustainability of a livable, environmentally friendly, and culturally vibrant city. As a membership-based organization comprising land and building owners, facility operators, and public authorities, the Yokohama Minato Mirai 21 conducts various projects for the comprehensive management of the area, taking into account the interests of the district's various stakeholders, including the government, workers, companies, institutions, visitors, and citizens, and undertakes various city planning, environmental management,

and cultural promotion initiatives throughout the year. Disaster risk management is a key work area coordinated by the Yokohama Minato Mirai 21, and the association regularly shares information to enhance disaster risk awareness and preparedness of the various MM21 stakeholders (Association of Yokohama Minato Mirai 21 2017).

Results: Economically Vibrant, Disaster-Resilient, and Environmentally Sustainable Urban District

The case project demonstrates how structural and nonstructural storm surge flood measures can be integrated within large-scale coastal redevelopment projects from the design phase to implementation, and how significant economic, environmental, and social benefits can derive from these resilience measures. Despite the high cost and significant time required to develop the MM21 district and ensure its disaster risk resilience, Yokohama City reports significant economic benefits, including the full recovery of an estimated construction investment of ¥2.625 trillion ($23.9 billion) from 1983 until 2016. MM21 attracted more than 1,800 companies and 83 million annual visitors in 2018 alone and generated tax income of more than ¥14.5 billion ($132 million) for the city (Urban Development Bureau, Yokohama City 2019a).

Additionally, by creating an area resilient to seismic activity, tsunamis, and storm surge floods within the urban center of Yokohama, the city was able to enhance its overall disaster risk management capacity. Benefits include the provision of a new evacuation hub with access to disaster-resilient land; utilities, including a decentralized heating and cooling system; ports that can serve as logistics centers for emergency response operations; and an emergency drinking water supply with a storage capacity of 4,500 m^3, which can supply safe drinking water for 500,000 people for three days (Association of Yokohama Minato Mirai 21 n.d.[a]).

Placing a high value on green design, MM21 encouraged public and private investments in developing a green corridor connecting various interventions, such as green roofs and walls and the greening of publicly accessible open spaces, as well as the installation of permeable pavers with cooling effects to alleviate urban flood and heat island effects. Green buildings integrating solar and wind power were also promoted, in line with Yokohama's Environmental Future City initiative (Urban Development Bureau, Yokohama City n.d.).

As a result, despite the high cost of urban development, which is mostly incurred by land reclamation, the site has successfully revitalized the area through rich social and economic activities (**figures A20.4**).

Figure A20.4: Minato Mirai 21 District
Photo Credit: Kenya Endo.

References

Association of Yokohama Minato Mirai 21. 2016. "Minato Mirai 21 Information." https://www.ymm21.jp/upload/b3d5044f27dd40e5123a10738ea7fd93b72a4d4e.pdf.

———. 2017. "Redevelopment Plans for Urban Safety in the Minatomirai 21 Area." November. https://www.ymm21.jp/news/upload/fcb87714b6ab89d975300c62ba2bc65dc6426911.pdf.

———. N.d.(a). "Disaster Management." Accessed February 16, 2019. https://www.ymm21.jp/disa/disaster.html.

———. N.d.(b). "Measures against Storm Surge and Tsunami." Accessed February 16, 2019. https://www.ymm21.jp/disa/tsunami.html.

———. N.d.(c). "Minatomirai 21, a Disaster Resilient Town." April 20. Accessed February 17, 2019. https://www.ymm21.jp/news/rediscovery/21_30.php.

Crisis Management Office, Yokohama City. 2013. "Guideline for Tsunami Evacuation volume 3". March. https://www.city.yokohama.lg.jp/kurashi/bousai-kyukyu-bohan/bousai-saigai/map/tsunami/tsunami.files/0001_20180912.pdf.

Urban Development Bureau, Yokohama City. 2014. "Town Development of Yokohama Minatomirai 21 Area." Yokohama City. August 7. http://archive.city.yokohama.lg.jp/zaisei/toti/hoyutochi/mm21/img/ymm.pdf.

———. 2019a. "Minato Mirai 21 Project Overview." June 3. https://www.city.yokohama.lg.jp/kurashi/machizukuri-kankyo/toshiseibi/mm21/gaiyo.html.

———. 2019b. "Minatomirai 21 Infrastructural Development Current Status." March 12. Accessed February 16, 2019. http://www.city.yokohama.lg.jp/toshi/mm21/kiban/.

———. N.d. "Future City Initiative." http://future-city.jp/torikumi/yokohama/.

Washiyama, Ryutaro. 2003. "Exploring Landfill in Yokohama." July 20. http://www.washiyama.jp/sodegaura/nisiku-umetate.html.

Yoshioka, Machiko. 2011. "What Is the Future Landfill in Yokohama?" October 2. https://hamarepo.com/story.php?story_id=526.

UFCOP

Urban Floods Community of Practice is an umbrella program to share operational and technical experience and solutions for advancing an integrated approach to urban flood risk management, and leveraging expertise and knowledge of different stakeholders and practice groups and across the WBG. The program supports the development of an interactive space for collaboration and exchange on the subject, facilitating users' access to information and adaptation of knowledge to local conditions, and bringing together different stakeholders to enhance collective knowledge on integrated urban flood risk management.

World Bank Tokyo DRM Hub

The World Bank Tokyo Disaster Risk Management (DRM) Hub supports developing countries to mainstream DRM in national development planning and investment programs. As part of the Global Facility for Disaster Reduction and Recovery, the DRM Hub provides technical assistance grants and connects Japanese and global DRM expertise and solutions with World Bank teams and government officials. The DRM Hub was established in 2014 through the Japan-World Bank Program for Mainstreaming DRM in Developing Countries—a partnership between Japan's Ministry of Finance and the World Bank.

GFDRR

The Global Facility for Disaster Reduction and Recovery (GFDRR) is a global partnership that helps developing countries better understand and reduce their vulnerabilities to natural hazards and adapt to climate change. Working with over 400 local, national, regional, and international partners, GFDRR provides grant financing, technical assistance, training, and knowledge sharing activities to mainstream disaster and climate risk management in policies and strategies. Managed by the World Bank, GFDRR is supported by 36 countries and 10 international organizations.

Contact

World Bank Disaster Risk Management Hub, Tokyo
Phone: +81-3-3597-1320
Email: drmhubtokyo@worldbank.org
Website: www.worldbank.org/drmhubtokyo