Stormwater Control Measures for Tokyo

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1. Introduction

Tokyo has been steadily moving forward with construction of trunk sewers, pumping stations and other infrastructure so that the sewer system can handle rainfalls of 50 millimetres per hour.

However, in recent years there has been an increase in the frequency of localized intense rainfalls greatly in excess of 50 millimetres per hour. A review of data from the 117 precipitation stations in Tokyo show that in 1990 only a dozen or more places recorded hourly rainfall of more than 50 millimetres; in 2005, this number grew to 66. (Fig. 1)

On September 4, 2005, a torrential downpour of more than 100 millimetres per hour inundated the western part of Tokyo's Ward area. More than 5000 households suffered flood damage, the subway system and expressway interchanges were temporarily closed, and urban functions and the lives of citizens were seriously affected. Given the ongoing trend to effectively use urban space by building subways and underground shopping complexes as well as an increase in the number of owners building homes with basement/semi-basement rooms or parking spaces, measures to protect against such intense rainfalls became a topic of rapid interest.

2. Basic Policy for Tokyo’s intense rainfall

Tokyo Metropolitan Government instituted its Basic Policy for Intense Rainfalls in August 2007. The policy has three core goals: to protect lives during flood disasters, to secure indispensable urban functions during inundations and to reduce property damage caused by flooding. The policy strikes a balance between implementing measures to protect against the intense rainfalls seen in recent years and remaining compatible with previous plans.

The long-term (30-year) plan for whole area of Tokyo is to:

1. Eliminate flood damage during rainfalls of up to 60 millimetres per hour.
2. Protect to the maximum extent possible against above-floor flooding and underground flooding during rainfalls of up to 75 millimetres per hour.
3. Secure lives and safety during past maximum levels of rainfall.

Within the next 10 years, the following measures will be applied in priority areas/zones:

1. Protect to the maximum extent possible against above-floor flooding and underground flooding during rainfalls of up to 55 millimetres per hour.
2. Secure lives and safety during past maximum levels of rainfall.

3. Steps being taken under the Basic Policy for Intense Rainfall

The most fundamental measure is to improve river and sewage facilities to eliminate flooding from rainfalls of up to 50 mm per hour. Another measure is to construct retention facilities to reduce flood damage in areas where serious flood damage can be expected.

To accomplish the entire policy for whole area of Tokyo requires a great deal of time and money. An effective and efficient way to move forward with efforts is through a 10-year plan that identifies rainfall characteristics and vulnerability to flooding, selecting priority areas at the watershed, zone and facility level and accelerating the implementation of measures.

After 10 years, these priority areas will be protected to the maximum extent possible against above-floor flooding and underground flooding during rainfalls of up to 55 millimetres per hour. Of these 55 millimetres, approximately 5 millimetres will be handled through watershed measures such as infiltration inlets, while the other 50 millimetres will go through the sewage system. (Fig. 2)

In addition, sewer facilities in places highly susceptible to flood damage (such as locations with underground shopping complexes) will be upgraded to handle rainfalls with an intensity exceeding 50 millimetres per hour. (Fig. 3)

4. Effective measures that consider geographical characteristics

(1) Stormwater runoff models

Runoff from heavy rainfalls flows down hills and into lower area, rapidly raising water levels around rivers and making it difficult for sewers to discharge stormwater. Moreover, flooding can easily occur in drainage area where trunk sewers are at a shallow depth, as heavy rains raise the water level in the trunk sewer so branch sewers have difficulty discharging stormwater into the trunk sewer. (Fig. 4)

Therefore, sewer design methods that use rainfall runoff analysis, which take into account detailed geographical characteristics, should be considered for implementation in addition to the current rational methods of design. The use of runoff models allows appropriate measures to be taken for construction of relief sewer and increase sewer diameter.

Moreover, by verifying such runoff models, the focus on traditional output-based programs for increasing stormwater flow capacity will shift to outcome-based programs, which are seen as an effective way of reducing flood damage. (Fig. 5)

(2) Verify the effectiveness of measures against intense rainfall

At least one year after the completion of improvements in a given zone, we carry out a follow-up evaluation by comparing the reduction in flood damage against actual rainfall.

Two methods are used to analyze project effects:

(a) A before-and-after comparison of rainfall and the occurrence of flood damage.
(b) Simulation using a design rainfall (50 mm/h) to provide a comparison of the flooded area before and after the project.

In places where projects have been completed, a before-and-after comparison of flood damages according to the amount of rainfall is carried out in addition to an evaluation by simulation.

Looking at the example of the Naka-Ochiai area of Shinjuku ward, there were 47 cases of flood damage during nine intense rainfalls between 1993 and 2000. After the completion of the project which employs measures such as increasing sewer pipe diameters and looping sewers, no flooding damage occurred in 2002 and 2003 even though there were four intense rainfalls during this period. (Fig. 6)
Incidences of flood damage were also reduced in other zones where similar measures were implemented.

5. Ongoing and future efforts

(1) Strengthening risk communication

Given the increased frequency of rainfalls over 50 millimetres per hour, there are limits to what can be done in terms of improving river and sewage facilities in order to reduce flood damage. From the perspective of individuals being able to help themselves and others, it is also crucial that we be able to transmit vital information, report changes to evacuation procedures and communicate other important matters when rainfall will exceed the capacity of rivers and sewers.

We have been strengthening risk communications with metropolitan residents so they can protect themselves against flooding. We also provide flood risks maps (Fig. 7) and trunk sewer water level information to each ward to support disaster-prevention activities and early evacuation efforts. We are also developing a low-cost optical fiber system that can be used in manholes to gauge water levels, and will expand the number of locations to which that information is delivered.

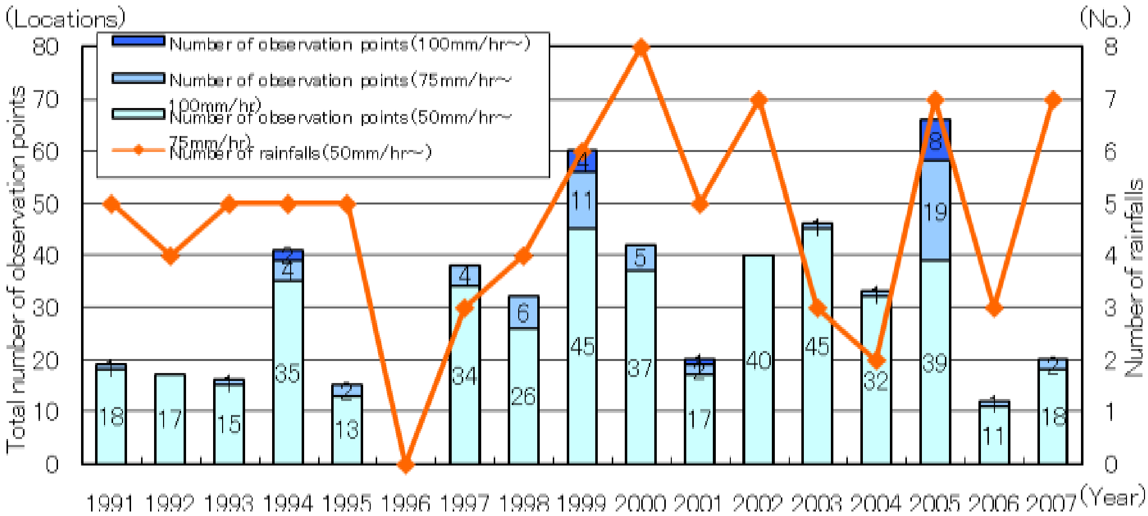
The Bureau of Sewerage also runs Tokyo Amesh (Fig. 8), an online rainfall information system that can be accessed through a computer or cellular phone. The system is very popular and is accessed 15.7 million times annually. We are also working with neighboring cities and prefectures to share precipitation radar data in order to provide more accurate rainfall information, thus providing better service to our customers.

(2) Early-stage reduction of flood damage

Ensuring the ability of Tokyo to withstand disasters is of the utmost importance to protect the lives and property of its citizens and to strengthen the urban functions and advanced technologies that keep the metropolis internationally competitive.

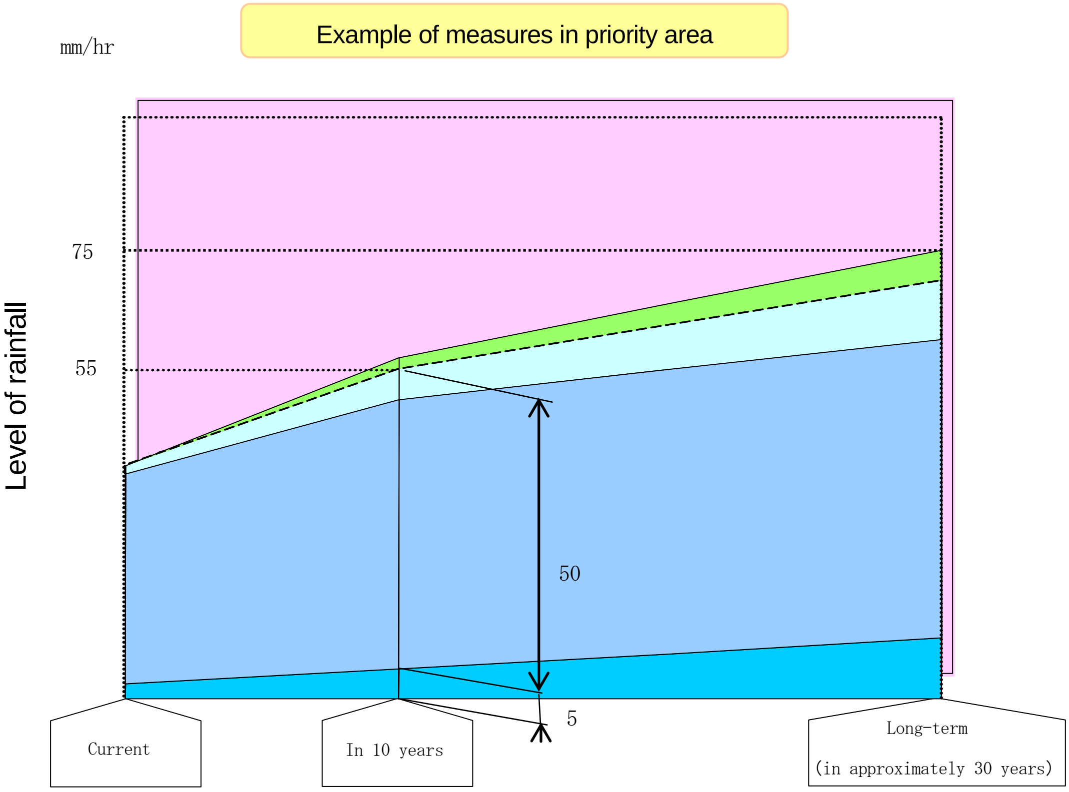
We expect that localized intense rains with an intensity of more than 50 millimetres per hour will continue to occur regularly due to the effects of global warming and the heat island phenomenon. Tokyo's Basic Policy for Intense Rainfall aims to realize an urban environment that can effectively deals with flooding through individual, mutual and public action. Since the role of drainage facilities and retention facilities play a large part in the plan, it is necessary to steadily implement the improvement of such facilities.

While keeping the goals of the long-term plan in sight, we are working to realize the 10-year plan for priority zones by focusing efforts on improving trunks sewers and pumping stations, which are the core infrastructures in flood prevention programs, while coordinating with the River division and City Planning division on matters of urban development.



Source : Tokyo Metropolitan Construction Bureau *Flood Records*

Figure 1.　Frequency of intense rainfalls in Tokyo over 50mm per hour



Legend

- Strengthen evacuation measures : provision of information on intense rainfalls, etc
- House and community planning : raised floor construction, flood boards, etc
- River and sewerage improvements (retention facilities) : detention reservoirs, regulating reservoirs, etc
- River and sewerage improvements (drainage facilities) : bank protection, sewer improvement, etc
- Watershed measures : infiltration inlets, conservation of green area

Figure 2. Role-sharing of measures

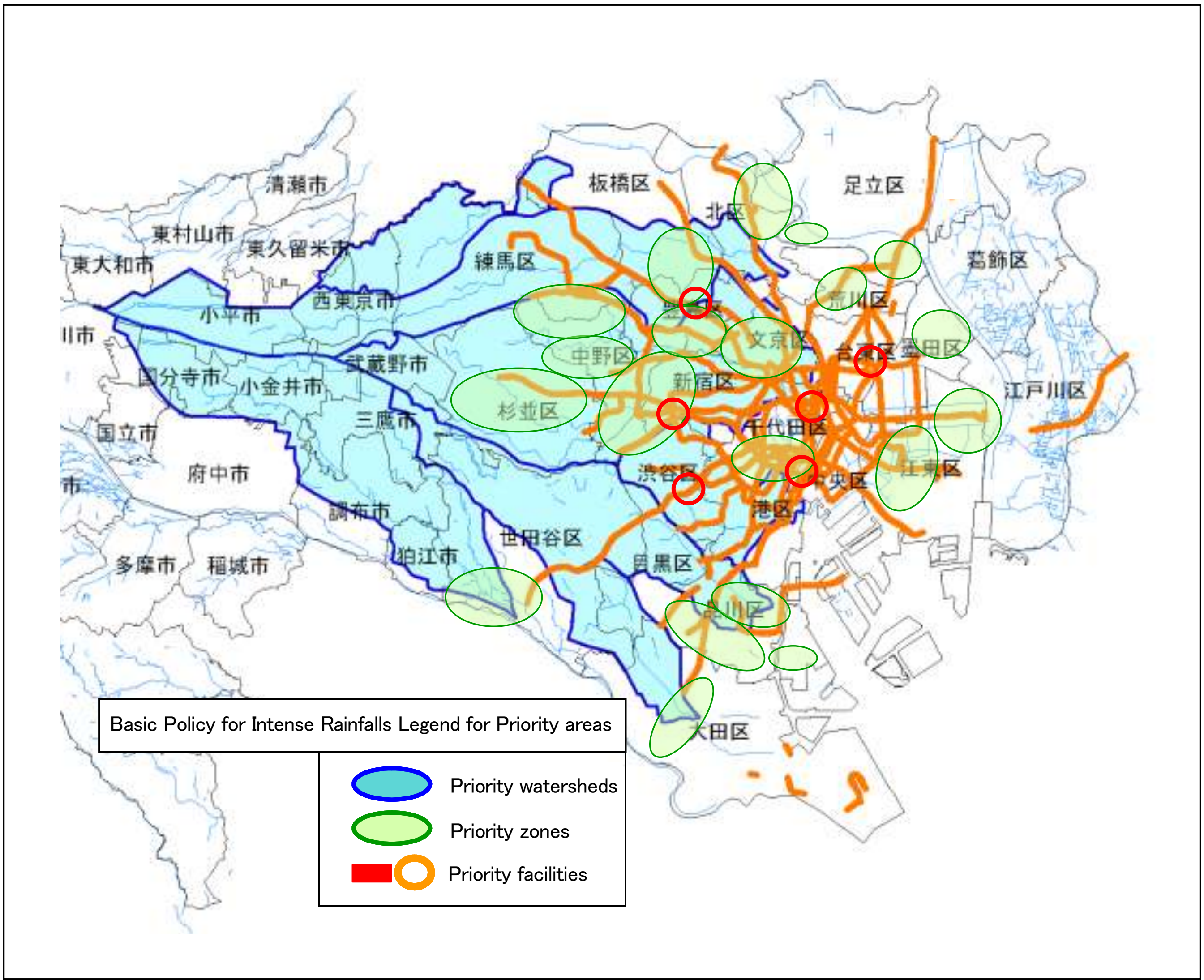


Figure３.　Map of priority areas for the Basic Policy for Intense Rainfalls

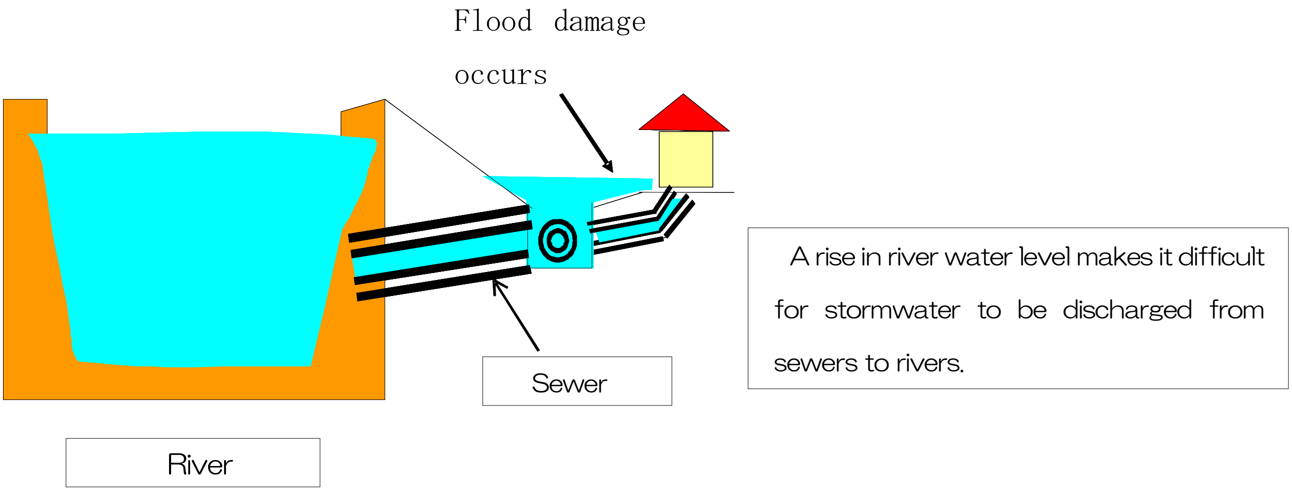
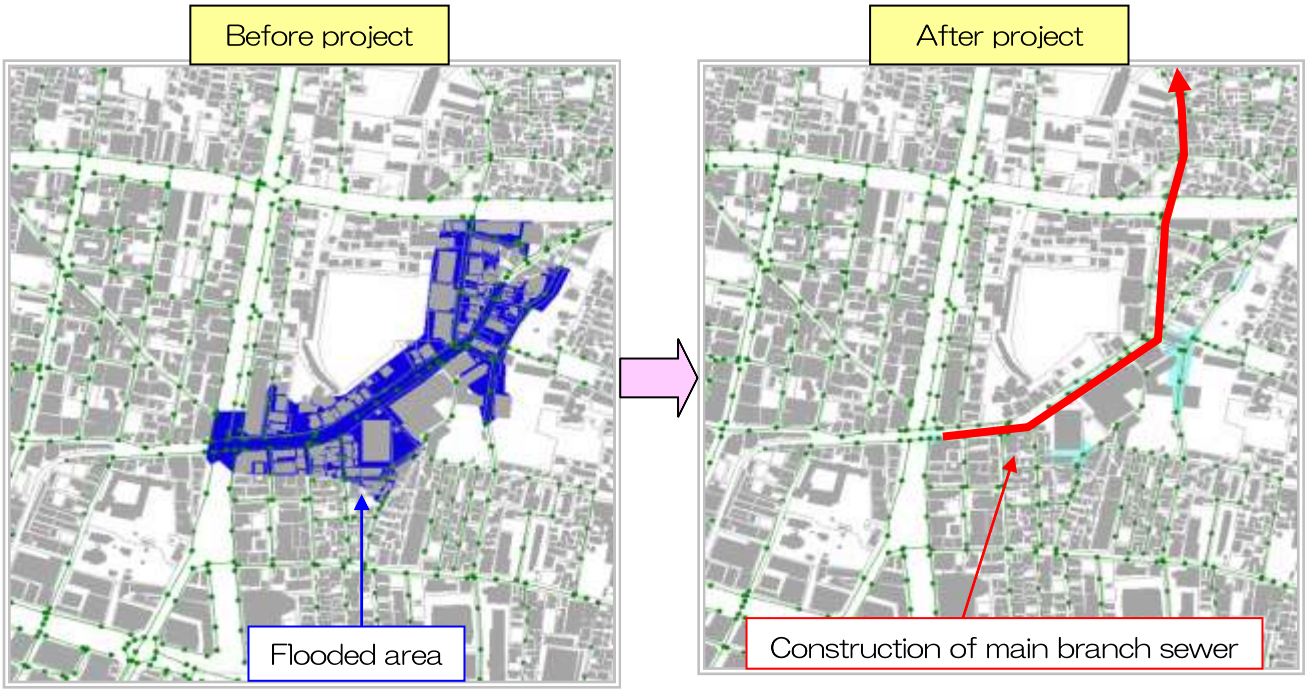


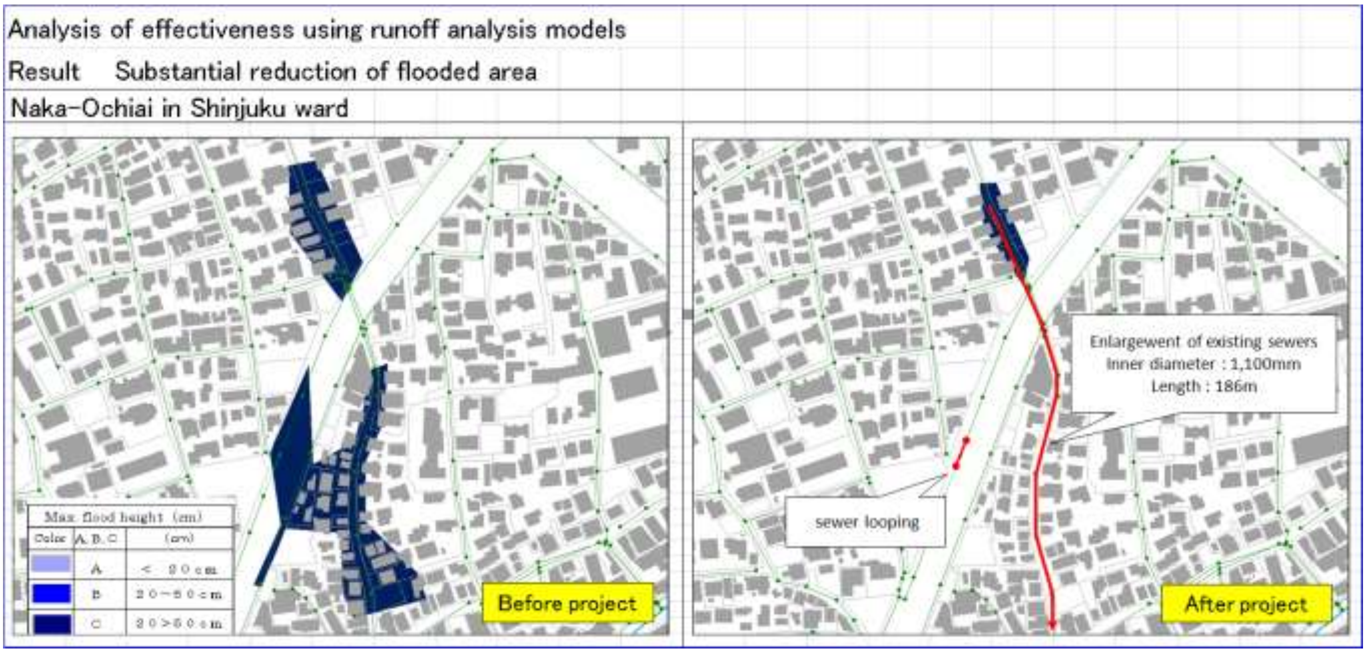
Figure4. Illustration of flood damage resulting from increased river water levels.



Max. depth of flooding (cm)	< 20 cm	20 – 50 cm	> 50 cm

Figure５. Prior evaluation of project by runoff analysis model

(Shinjuku and Toyama areas, Shinjuku City)



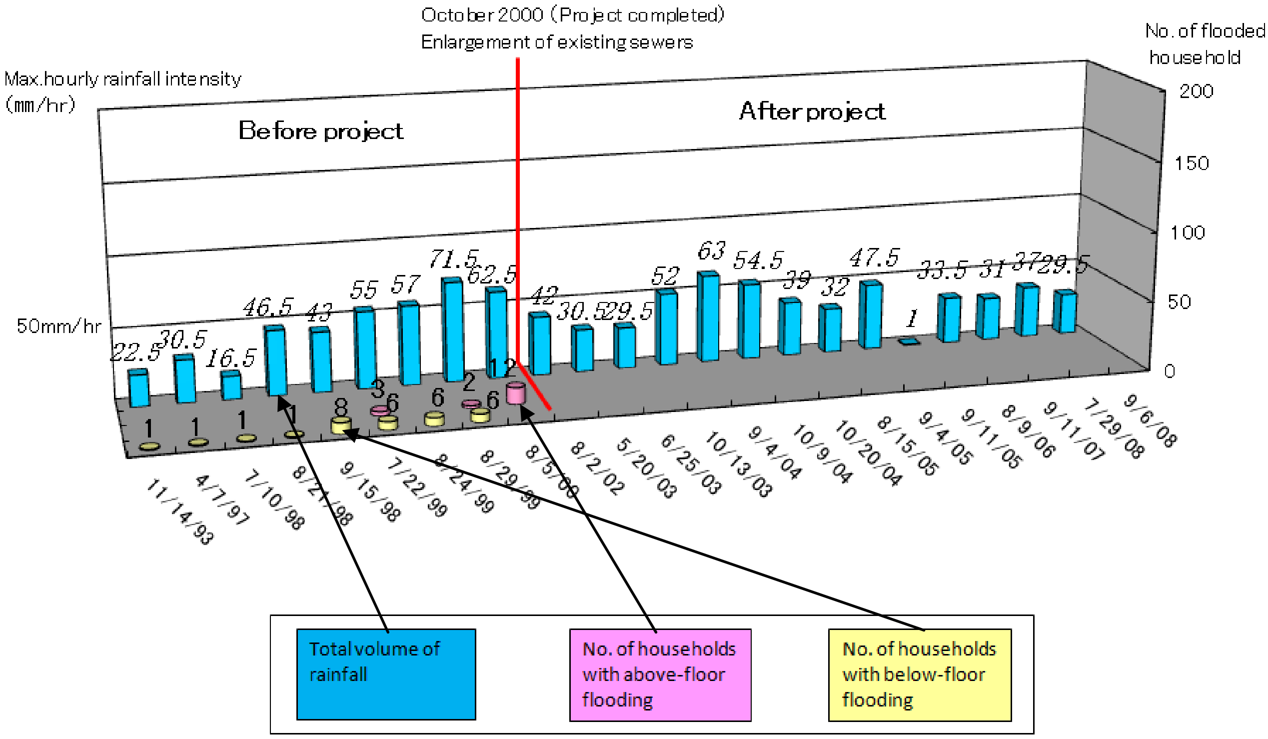


Figure 6. Verification of effects with runoff analysis models

(Naka-Ochiai area, Shinjuku City)

Figure7.　Expected flood area for the Kanda River watershed

http://tokyo-ame.jwa.or.jp/

Figure8. Tokyo Amesh online rainfall information system.