# Study of Sewerage Systems for Climate Change Adaptation

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**1. Introduction**

Climate change has resulted in a growing trend of more severe and frequent water-related disasters. The Working Group II report in the IPCC's Sixth Assessment warns that anthropogenic climate change is linked to a rise in both the frequency and intensity of extreme weather events. These events lead to extensive negative impacts, causing damage to both nature and humanity beyond what natural climate change would entail. In 2021, legislation (2021 Law No. 31) was passed to partially amend the Act on Countermeasures against Flood Damage of Specified Rivers Running Across Cities. The law, hereinafter referred to as "the Watershed Flood Preparedness Law," aims to enhance flood preparedness within watersheds by fostering collaboration among stakeholders to counteract the heightened risk of floods due to increased rainfall.

The Water Quality Control Department is conducting investigations and research of sewage systems designed to protect cities from flooding in response to recent legislative developments. This paper presents some of these investigations and research findings.

**2. Study and research of flood control measures within urban areas.**

2.1 Providing support for the development of mid- to long-term stormwater plans.

In the Watershed Flood Preparedness Law, the sewage work plan included a new section specifying the rainfall threshold, which serves as an indicator to initiate flood damage prevention activities. This threshold is hereinafter referred to as "design rainfall." The Comprehensive Stormwater Management Plan[1] outlines fundamental aspects of stormwater management, such as areas where flood control through sewage systems is necessary, targeted preparation standards, and a gradual facility construction policy. This plan also defines the design rainfall. To ensure consistency between the Comprehensive Stormwater Management Plan and the operation plan under Article 4 of the Sewerage Act (1958, Law number 79), we decided to incorporate the design rainfall into the operation plan (Figure 1).

The design rainfall, established to address climate change, was initially determined by multiplying the current design rainfall with region-specific rainfall change multipliers.[2] However, it is necessary to review the adequacy of the current design rainfall to avoid it being excessive or insufficient. To comprehensively understand the process of creating design rainfall in local governments, we investigated how they develop the design rainfall intensity formula and the rainfall data used in its creation. Most local governments followed the Sewage Facility Planning and Design Guideline, 2019 Edition, when creating the design rainfall intensity formula. However, a few of them used rainfall data from recent years to set the design rainfall. These data might have already been influenced by climate change. To calculate design rainfall, it is necessary to utilize rainfall data from a period that can be deemed regular.[1] Therefore, we intend to confirm that the rainfall data used are from a regular timeframe. Additionally, we plan to reevaluate the approach to designing sewage facilities to adapt to climate change.

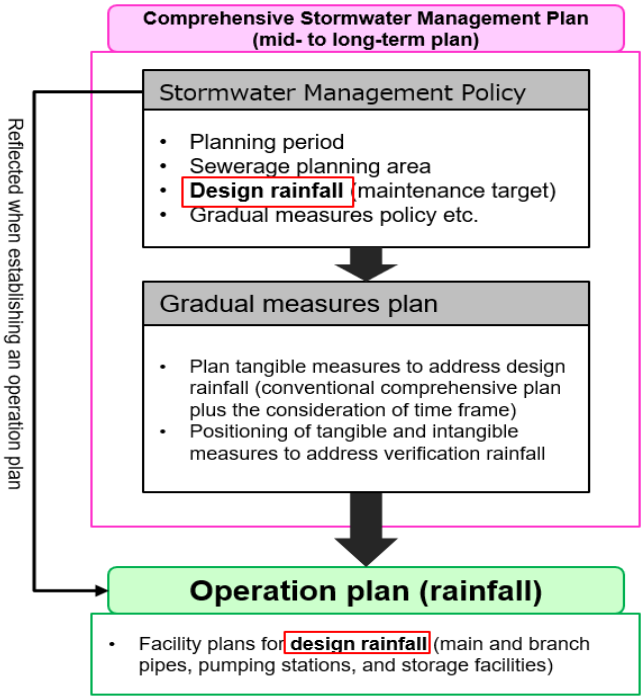


**Figure 1. Relationship between the Comprehensive Stormwater Management Plan and the operation plan[1]**

2.2 Study of safety measures for sewage pipeline manhole covers

Sewage pipe manhole covers frequently lift or break during heavy rainfall. These incidents pose risks to public health and road traffic safety. Even when a large amount of stormwater flows into sewage facilities, they must remain undamaged, and their functionality must be ensured. Hence, we examined how local governments are dealing with situations where sewage pipes were damaged during heavy rainfall. Our study also involved reviewing the existing literature, considering the aspects of structural mechanics, and conducting analyses using a runoff analysis model.

Through our investigation and study, we discovered that in areas with heavy traffic from large vehicles, manhole covers are prone to being pushed down too much into the receiving frame. To mitigate this, it is advisable to use next-generation pressure relief covers designed for easy internal pressure release or to employ lattice-type covers in these areas. Moreover, such factors as the spacing between manholes, the size of air holes on the covers, pipe diameter, and the amount of air sealed inside the pipes significantly impact the level of risk. Additionally, we developed a simplified risk level judgment chart (example) that quantifies the risk level of each manhole based on the estimated internal pressure in pipes in the event of manhole damage. Furthermore, we created a safety priority site matrix and a draft of the manhole cover safety examination flow.

The current draft of the sewage manhole safety guideline[3] does not fully account for the complexity of hydraulic phenomena during heavy rainfall or the quantitative risks arising from variations in local situations. We thus encourage local governments to use our investigation and research[4] as a reference for implementing prioritized safety measures and effectively preventing manhole damage.

## 3. Exploring emergency restoration methods for sewage treatment plants

We drafted the Approach to Sewage Discharge and Treatment During Disasters,[5] drawing from lessons learned from the Great East Japan Earthquake. In this draft, we outlined the process of selecting temporary treatment methods, defining target water quality, and specifying the timeline for achieving these targets during the emergency restoration stage after sewage treatment plants are damaged by earthquakes or tsunamis, causing a loss of functionality.

Typhoon Hagibis, which struck the eastern part of Japan in 2019, resulted in river flooding and inundation of sewage treatment plants at 17 locations. These treatment plants lost their functionality and were unable to process sewage. During the rainfall disaster, there was minimal damage to sewage pipelines and other civil structures. As a result, sewage continued to flow into the treatment plants from undamaged areas. Additionally, floodwater entered sewage treatment plants through sewage pipes. These characteristics differed from the damage typically faced during earthquakes or tsunamis. Therefore, in collaboration with the Public Works Research Institute (PWRI), we proposed effective emergency restoration measures for sewage treatment plants damaged by flooding. We recommended methods to identify the factors hindering disinfection, implemented as an emergency measure, and suggested a method to monitor the generation of disinfection by-products, as well as efficient sewage treatment and disinfection methods along with emergency measures for early restoration. These emergency response strategies were developed through on-site inspections and testing at the Disaster Risk Management Experimental Facility located in the Ibaraki Prefecture Kasumigaura Sewage Treatment Center (Figure 2). We would like to reflect the findings in the draft Disaster Concept.

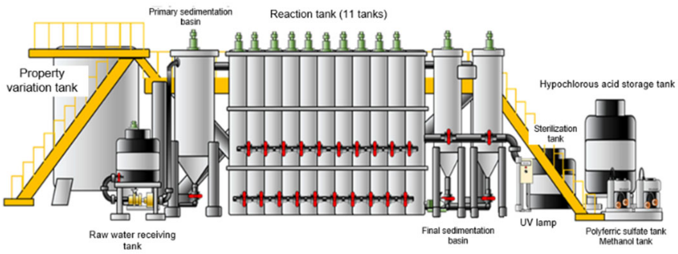


**Figure 2. Disaster Risk Management Experimental Facility**

(Normal water inflow: 24 $m^3$/day, Maximum water inflow: 48 $m^3$/day)

## 4. Conclusion (future activities etc.)

To ensure effective watershed flood control, it is crucial to develop infrastructure through initiatives like the Five-Year Plan to Accelerate Measures for National Resilience. Additionally, conducting an investigation and research to implement intangible measures effectively is also essential. The Water Quality Control Department has been working on predicting flooding using simulations and researching ICT/AI-based solutions as part of the Breakthrough by Dynamic Approach in Sewage High Technology Project Initiative.[6] We are committed to continuing our efforts in discovering effective ways to utilize new technologies. We will also proceed with our research in utilizing existing sewerage systems and evaluating the effectiveness of green infrastructures, such as stormwater infiltration facilities.

Local governments serve as sewage administrators, and their city size, financial resources, and technical capabilities can vary. Taking these factors into account and adopting a wide-area and comprehensive perspective as a nation, we aim to continue our research to support the planning, drafting, and implementation of sewage technical policies, contributing to the construction of a safe and resilient nation.

**☞For more information:**

1) Sewerage and Wastewater Management Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure and Transport: Comprehensive Stormwater Management Plan Establishment Guideline (draft). November 2021
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