One Map to Manage Risk, One Standard to Protect Underground Spaces

——Shenzhen's Exploration of Urban Flood Prevention and Climate Resilience under Extreme Rainfall

Abstract: Climate change is making extreme rainstorms more frequent and intense, increasing urban flood risks in high-density built-up areas. On 7 September 2023, Shenzhen experienced a record-breaking storm that exposed weak resilience at vulnerable points. Shenzhen responded by issuing China's first local standard for flood prevention in underground spaces, developing a unified Pluvial Flood Risk Map, coordinating cross-boundary river basin management, and using smart technologies to strengthen forecasting, early warning, scenario simulation and contingency planning. These measures offer lessons for strengthening urban flood management and climate resilience.

Keywords: extreme rainstorms; urban flooding; underground space waterlogging prevention; climate resilience

I Background

Shenzhen is a very crowded, fast-growing big city. Over the past few decades, natural ground has been steadily replaced by buildings, roads, and other hard surfaces, so that today roughly half the city is covered this way, compared to almost none a few decades ago. The city is also extremely dense in terms of both population and economic activity packed into each area of land.

In early September 2023, Shenzhen was hit by an intense, long-lasting rainstorm—known as the “9.7” storm—that dumped an unusually large amount of rain on the city over less than a day, with some districts, like Luohu, getting hit especially hard. Rain continued on and off over the following days, adding up to some of the heaviest rainfall totals the city has seen.

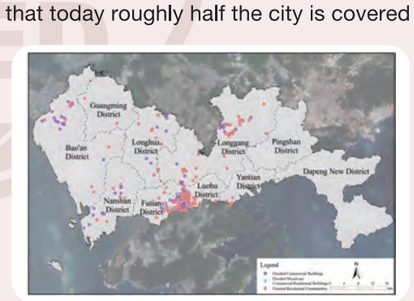


Figure 1. Map of flooded buildings in Shenzhen during the “9.7” storm

II Key Measures

(1) Using the Pluvial Flood Risk Map to Guide Infrastructure Siting and Underground Space Development

• Using observations from the “9.7” rainstorm and mathematical modelling, Shenzhen's water and emergency management authorities developed a citywide Pluvial Flood Risk Map and a risk register covering metro systems, underground commercial spaces, lifeline infrastructure, hospitals, schools, and other key facilities.

Risk management is differentiated across three levels:

• High-risk zones: Stringent controls require existing underground spaces and key facilities to undergo dedicated flood risk assessments and eliminate major hazards.

• Medium-risk zones: Measures focus on addressing weaknesses, optimising infrastructure siting and drainage systems, and strengthening monitoring and early-warning mechanisms.

• Low-risk zones: Routine management and preventive measures maintain baseline flood protection.

(2) First Technical Standard for Flood Prevention in Underground Spaces

• In April 2024, Shenzhen issued and implemented the Technical Guideline for Urban Underground Space Flooding Prevention. Guided by the principle of “prevention first, combining prevention, drainage, and rescue”, it covers planning, construction, operation and maintenance, and emergency response.

• It sets different flood-protection rules based on the type and risk of each facility. Underground spaces must be built to handle rare, severe flood events (the kind expected once every 100 years). Larger or critical sites—big underground malls, major hospitals, subway systems, and underground transit hubs—need custom flood-prevention designs.

• It also sets specific height rules for entrances: walkway entrances must sit at least 0.45 m above ground with 0.8 m barriers, while vehicle ramps need a reverse slope (at least 0.15 m) and 1.2 m barriers.

• Finally, it restricts where equipment can go and boosts emergency readiness: power rooms, transformers, and data centers in flood-risk areas can't be placed underground. Key underground sites must have monitoring systems linked to the city's data network, plus emergency response plans in place.

(3) Cross-boundary River Basin Management

• Shenzhen has incorporated improvements to the downstream Huizhou section of the Longgang River into regional flood-control coordination, removing 210,000 m³ of sediment along 5 km of its section. Huizhou is upgrading the Huiyang section of the Danshui River to a 50-year standard, with RMB 480 million in initial works completed in 2025. The people's congresses of Shenzhen and Huizhou conducted joint oversight to align upstream and downstream standards.



Figure 2. Schematic diagram of inconsistent upstream and downstream governance standards in the Longgang River Basin

(4) Smart Management of Urban Flooding

• After the disaster, Shenzhen's Emergency Management Bureau, Water Authority, and other relevant departments strengthened the dynamic updating of the Pluvial Flood Risk Map, improved forecast and early-warning dissemination, established risk-map-based scenario simulations, and revised emergency plans.

• Underground space water-level and alarm data connect to the municipal data platform, enabling map sharing and coordinated cross-departmental response.

III Lessons Learned

Shenzhen's experience shows that dedicated technical standards are essential to strengthen flood protection in high-density cities, resolving inconsistent standards and weak flood preparedness. The Pluvial Flood Risk Map should serve as a prerequisite for urban planning and construction, embedding risk assessment upfront and shifting flood governance from reactive emergency response to proactive prevention. River basin flood management requires integrated planning, cross-jurisdictional coordination, and aligned upstream and downstream flood-control and drainage standards to improve basin-wide disaster risk reduction.

Case provided by CCICED Scoping Study on Building a Climate-Adaptive Society and Carbon Market Expansion and Innovation