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Urban Water System Modeling and Simulation Tools to Evaluate Infrastructure Resilience

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ABSTRACT: Water supply and distribution systems are critical to sustaining life and economic activity throughout the world. In the United States, there are more than 53,000 publically or privately owned potable water systems, with nearly a million miles of pipe networks. There are many threats that could result in service disruption to these systems, both human-caused and natural. For example, across the nation, water infrastructure assets have exceeded their expected design life, increasing the risk of failure. Failures in drinking-water infrastructure can result in water disruptions, impede emergency response, and damage other essential infrastructure systems. In extreme situations, failing infrastructure or drought could cause water system pressure loss, resulting in unsanitary conditions and increasing the risk of public health issues. Policy makers must develop strategies to manage, plan, and protect these systems, while also maintaining natural resources. To adequately inform policy, researchers must understand the complete infrastructure system and its behavior to adequately assess system vulnerability, reliability, and resilience.

Researchers at Los Alamos National Laboratory (LANL) have developed tools to aid in the evaluation of urban water distribution system resilience relative to a multitude of failure mechanisms. These tools model and simulate water system networks, and provide a testbed to evaluate potential disruptions and identify system-critical components. The relative importance of system-critical components, and, thereby, system-level resilience, depends largely on metrics researchers use to evaluate the functionality of the water system and consequences of water service disruption. Common metrics within the resilience framework include system characteristics—both in terms of pressure and ability to meet required demands—and cascading effects on population, with an estimated outage area, economic impact, and impact to other critical infrastructure that depend on water for operation.

LANL has used these tools extensively in support of homeland security infrastructure projects, including pre-planned urban and regional water infrastructure resilience studies, electric power/water system interdependency analyses, and cyber-physical resilience studies, in addition to infrastructure analysis support during national level emergencies. This talk will describe these tools and discuss ongoing research and development relative to water distribution system optimization and expansion planning.

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