Texas Department of Transportation

UNIVERSITY OF TEXAS ARLINGTON

PROJECT SUMMARY REPORT

0-7201: Hydrologic Approaches to Playa Lakes, Areas of Significant Karst Geology, and Arid Regions

Background

Maintaining Karst terrains, playa lakes, and arid regions are significant features of the Texas landscape and are found in various parts of the state. The hydrology of these regions is complex and can vary depending on a variety of factors including climate, soil characteristics, and land use which pose several challenges in the hydrologic design of infrastructure for the Texas Department of Transportation (TxDOT). As the population continues to grow, there is an increasing demand for transportation infrastructure to support the state's growing needs. Providing guidance and standards of practice is an essential function of TxDOT to ensure that reliable transportation infrastructure is developed and maintained across the state. Understanding the hydrological processes in these unique regions is essential for sustainable development of infrastructures in the state. still much to be learned about the hydrologic behavior of playa lakes, karstic areas, and arid regions. In absence of consistent, scientifically-based standards for hydrologic design of transportation infrastructures in these regions, designers consider the specific conditions in each region and adopt design measures and management strategies based on their judgment. The project proposed to perform a literature search using national and international sources, conduct surveys and interviews to collect information on the state of knowledge and practices from state DOTs and international transportation agencies, create a project web-based repository to compile all reference materials to promote knowledge-sharing and facilitate collaboration with other agencies and researchers, synthesize the literature search and the results from surveys and interviews, and develop recommendations for future research, ultimately leading to more effective and sustainable transportation infrastructures. By taking this comprehensive approach, the TxDOT can better understand the hydrological behavior of these regions and make informed decisions toward developing hydrological design guidance and standards of practice for these areas.

What the Researchers Did

The research team conducted a thorough literature review to provide an overview of the state of knowledge regarding hydrological practices in playa lakes, arid zones, and karst terrains. This involved reviewing a wide range of sources, including drainage design manuals from state departments of transportation, publications from the Federal Highway Administration (FHWA), stormwater design guidelines from various states, cities, and international sources, as well as over 300 research studies published in scientific journals and presented at conferences. The review revealed that while many studies have focused on these regions, few address the specific hydrological challenges these environments pose to infrastructure design.

To further evaluate current practices, a survey was conducted with 76 experts from 30 state Departments of Transportation (DOTs), 13 university faculty members, 12 consultants, and 21 other agencies (federal, state, city, and local). The survey received 24 responses, providing valuable insights into the effectiveness of existing guidelines and hydrological modeling approaches. Additionally, follow-up interviews with 2 selected participants, including representatives from DOTs in Kansas, Minnesota, New Mexico, and Virginia, as well as other experts, provided deeper insights into current practices.

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What They Found

Based on the results of the literature review, survey, and interviews, the project team compiled and synthesized current knowledge and practices regarding hydrologic approaches for playa lakes, karst terrains, and arid regions. Using a comprehensive methodology, the team aimed to improve understanding of hydrological behavior in these unique environments, providing a foundation for more informed decision-making in the development of hydrological design guidance and standards of practice. Key findings and challenges identified include:

Playa Lakes: Playa lakes are characterized by highly variable and unpredictable hydrology, including flash flooding, erosion, sedimentation, and complex interactions between infiltration, evaporation, and sediment dynamics. The lack of data further complicates accurate hydrological modeling in these areas. Existing methods, such as the Rational Method and the NRCS Curve Number method, fail to capture the complexities of playa lake systems, particularly the interactions between surface and subsurface water flows, sediment mobilization, and rapid changes in hydrological conditions.

Karst Regions: Karst terrains present challenges due to their unpredictable subsurface water flow, rapid infiltration, and the potential for sinkhole formation. These factors render traditional hydrological methods inadequate, necessitating the use of more advanced techniques. Data acquisition in karst regions is particularly difficult, complicating accurate hydrological analysis. While FHWA recommends several standard and empirical methods for estimating runoff in karst areas, these methods are site-specific and often fail to account for the complex subterranean interactions, leading to inaccurate predictions of peak flows and flood extents.

Arid Zones: Arid regions face challenges due to limited rainfall, high evaporation rates, and scarce water resources, which contribute to flash floods and soil erosion. Traditional hydrological models, such as NRSC Curve Number method, which are often designed for more humid climates, fail to accurately represent the conditions in arid zones. Without modifications, these models lead to inaccurate flood predictions and potentially inadequate infrastructure design. Tailored approaches that account for the specific hydrological dynamics of arid zones are essential for improving the reliability and resilience of infrastructure.

What This Means

This study underscores the critical need for customized approaches to water resource management and infrastructure design in complex environments such as playa lakes, arid regions, and karst landscapes. It highlights significant challenges in predicting rainfall-runoff and managing flood risks in these diverse regions, emphasizing the importance of region-specific solutions and further research. The intricate hydrological processes unique to these environments demand a deeper understanding that extends beyond traditional methodologies.

The study also advocates for refining current design standards to better address the distinctive characteristics of these landscapes. Such advancements are essential for improving infrastructure design and creating more resilient transportation networks capable of withstanding the challenges posed by Texas' complex and dynamic environments.

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