Exhibit D

Research Project Requirement Template

Nature-Based Solutions (NBS) for Climate Resilient Culverts

Recipient/Grant (Contract) Number: 69A3552348306 (CY1-OSU-UARK-01)

Center Name: Southern Plains Transportation Center (SPTC)

Research Priority: Improving the Durability and Extending the Life of Transportation

Principal Investigator(s): Jaime Schussler, Oklahoma State University; Norb Delatte, Oklahoma State University; Andrew Braham, University of Arkansas

Project Partners: Oklahoma State University and University of Arkansas

Research Project Funding: Oklahoma State University: $75,000 (Federal) and $80,124 (Match); University of Arkansas: $72,934 (Federal) and $72,931 (Match)

Proposed Start and End Date: 10/1/2023 to 9/30/2024

Project Description: Culvert design must consider structural design, hydraulic design, environmental and site consideration, joint performance, and service life. The design service lives (DSL) of culverts range between 15-20 years; however, most U.S. DOTs DSL are currently 50-75 years. Climate change has resulted in increased storm frequency and intensity, leading to increased stormwater runoff and sediment yields; however, the rigidity of the culverts has not allowed the conveyance to adapt. Downstream implications include flooding, washouts, and damages leading to costly emergency repairs. This has altered stream behavior and disproportionately affected aquatic species. Research in the Northwest has shown that culverts disrupt natural movement patterns, which impact local ecosystems. The main objective of this research is to identify culvert characteristics that lead to vulnerability under climate change and develop nature-based solutions (NBS) for culverts through partnerships.

The following study tasks are proposed to meet the above objective: Task 1: engaging the Oklahoma and Arkansas DOTs to determine current practices in culvert design, inspection, and maintenance and facilitate data sharing amongst stakeholders; Task 2: creating Excel and GIS databases with the collected culvert data that includes attribute data such as installation year, location, application (e.g., stream crossing, drainage channel), culvert material, size, and design flow, as available; Task 3: conducting site visits to verify the information in the databases and assess the feasibility for NBS in the catchment; Task 4: developing a vulnerability framework and risk prioritization tool; Task 5: creating fact sheets on potential NBS and resources for retrofitting existing culverts; and Task 6: final reporting and recommendations for future work. Future work may include the following: (a) expansion of databases to additional jurisdictions; (b) performance under climate projections; (c) NBS to minimize the need for critical repair of culverts; and (d) experimental catchments with NBS.

US DOT Priorities: The findings from NBS for Climate Resilient Culverts are anticipated to contribute to SPTC's strategic goals by providing better planning tools for (a) climate-resilient infrastructure, (b) resource allocation, and (c) identification of cost-sharing opportunities, and align with U.S. DOT's Climate and Sustainability, Transformation, and Safety Strategic Goals. DEI initiatives for the *NBS for Climate Resilient Culverts* project will be actively pursued through research participation, outreach, and workforce development efforts in Oklahoma and Arkansas. Specifically, the project will engage women, including the principal investigator, contributing to the USDOT's mission of increasing participation in

transportation. Project findings will be disseminated through LTAP training courses and contribute to outreach activities that provide underrepresented undergraduate students with opportunities to engage in research projects through meetings, presentations, workshops, and field trips. These efforts will foster the inclusion of diverse people, which will positively impact the future transportation sector. This project will touch on all U.S. DOT Strategic goals, but the specific KPIs addressed include: (a) contribution to resilience improvement plans, (b) research and deployment of approaches not currently deployed in the transportation system, (c) increase the diversity of applicants for mission-critical occupations.

Outputs: The anticipated outputs of this project include: (a) GIS and Excel databases of culverts in Oklahoma and Arkansas; (b) framework to categorize culvert risk under climate change; (c) Excel-based tool to prioritize culvert maintenance and NBS; (d) fact sheets on culvert maintenance, replacement, and cost-sharing opportunities for upstream alternatives that prioritize NBS to improve culvert resilience under climate; (e) LTAP/ TTAP course on NBS culvert resilience; and (f) student conference posters/presentations at university and DOT sponsored research symposiums and national conferences, such as TRB.

Outcomes/Impacts: The developed databases will serve as centralized repositories of information on existing culverts in Oklahoma and Arkansas that can be easily expanded into additional jurisdictions. Framework and prioritization tools will allow culvert vulnerability to be assessed according to a unified metric. The developed databases and tools will equip transportation planners to make well-informed decisions related to NBS for culvert resiliency. An LTAP/TTAP course offering will provide training on the developed tools to transportation planners, increase awareness, and encourage the adoption of NBS to mitigate climate impacts on culvert design. Additionally, this project includes graduate, undergraduate, and summer camp students and will contribute to the next generation of transportation professionals.

Final Research Report: