SPR RESEARCH PROGRAM
SECOND-STAGE PROPOSAL SUMMARY

PROBLEM NUMBER AND TITLE

25-60: Resiliency through Proactive Design: Integration of Climate Change in Hydraulic Engineering

PROBLEM SUMMARY

Oregon's best available climate change projections predict more frequent and severe inland and coastal flooding, with 72% of total highway road miles potentially at high risk by 2050. Within these geographic areas where the projected increase of flooding is expected, ODOT has a substantial number of vulnerable assets including hundreds of scour critical bridges, thousands of culverts rated in poor or critical condition, and an unknown number of stream and riverbanks at risk of future destabilization. While ODOT's Hydraulic Engineers are responsible for the design of these hydraulic structures, **ODOT lacks standards for how to integrate future climate change projections in hydraulic design.** Multiple Global Climate Models (GCM) exist as do multiple methods for projecting precipitation, discharge, sea level rise, and design impacts—*and*—these methods vary by multiple geographic zones within Oregon and under certain site conditions. To ensure resiliency for hydraulic infrastructure statewide, research is needed to identify with confidence the most appropriate strategies for incorporating defensible climate projections in hydraulic design.

ODOT OBJECTIVES

- Produce clear decision support. Develop a decision-making framework and flowchart for designers that navigates when and how to incorporate climate change input for hydrologic and hydraulic design.
- Create time-saving tools. Develop user-friendly GIS tools for incorporating needed climate datasets.
- Enhance transparency. Develop criteria and tools for assessing quality and limitations of analysis.
- Implement data strategy. Catalog progress and build library of case studies to improve future work.
- Streamline and simplify processes. Develop site prioritization index and process to assess, inform, and implement a programmatic approach by hydrologic geographic regions.
- Share information widely. Provide workshop, guidance, tools, and process for evaluation and update.

BENEFITS

Predicted climate change will exacerbate hydrologic risks. Failing to consider these changing conditions in design may compromise the performance and resiliency of our transportation infrastructure, jeopardizing both lifeline route availability and everyday connectivity needs. Connectivity loss could then also result in isolation of vulnerable rural communities. Economically, to put ODOT's future challenges in perspective, a retrospective analysis of flooding impacts for maintenance costs totaled $23.4M between 2009-2021. Further impacting Oregon's economy, out of all travel delays between 2013-2021, ~half were attributed to flooding. With more frequent and severe flooding ODOT's maintenance costs and associated travel delays are likely to only increase in parallel without a proactive approach for resilient hydraulic design. This research will provide implementable guidance for **when and how to incorporate climate change into design,** furthering the OTP Policy EC.3.4 to "design transportation infrastructure for climate change and extreme weather resilience."

SCHEDULE, BUDGET AND AGENCY SUPPORT

Estimated Project Length: 42 months.
Estimated Project Budget: $445,000
ODOT Support: **Paul R. Wirfs (State Hydraulic Engineer), Paris Edwards (Climate Office Policy Lead), Ace Clark (District 13 Manager)**

FOR MORE INFORMATION

For additional detail, please see the complete STAGE 2 RESEARCH PROBLEM STATEMENT online at:
https://www.oregon.gov/odot/Programs/ResearchDocuments/25-60.pdf

SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2025

PROBLEM NUMBER AND TITLE

25-60: Resiliency through Proactive Design: Integration of Climate Change in Hydraulic Engineering

RESEARCH PROBLEM STATEMENT

Oregon's best available climate change projections predict more frequent and severe inland and coastal flooding, with 72% of total highway road miles potentially at high risk by 2050. Within these geographic areas where the projected increase of flooding is expected, ODOT has a substantial number of vulnerable assets including hundreds of scour critical bridges (Figure 1), thousands of culverts rated in poor or critical condition (Figure 2), and an unknown number of stream and riverbanks at risk of future destabilization (Figure 3). Failing to consider these changing conditions in design may compromise the performance and resiliency of our transportation infrastructure, jeopardizing both lifeline route availability and everyday connectivity needs. Connectivity loss could then result in isolation of vulnerable rural communities. Additionally, to put ODOT's future economic challenge in perspective, a retrospective analysis of inland flooding impacts for maintenance costs totaled $23.4M between 2009-2021. Further impacting Oregon's economy, out of all travel delays between 2013-2021, half were attributed to flooding (Figure 4). With more frequent and severe flooding ODOT's maintenance costs and associated travel delays are likely to only increase in parallel.

Figure 1: Ex. flooding impacting bridge (scour failure) during high intensity rainfall event (Rock Creek, OR206, 2017).

Figure 2: Ex. flooding and culvert failure during high intensity rainfall event (Hwy110 MP11,

Figure 3: Ex. flooding impacting road during high intensity rainfall event (embankment,

ODOT's Hydraulic Engineers are responsible for supporting the design of hydraulic structures, however ***<u>ODOT lacks standards for how to integrate future climate change projections in hydraulic design.</u>*** Recognizing the complexity and potential need to incorporate climate change data into hydrologic design, ODOT invested in a small research project to pilot the use of the recently published guidance document: "*NCHRP 15-61- Applying Climate Change Information to Hydrologic and Coastal Design of Transportation Infrastructure*." This pilot was part of a larger group effort with 7 other state DOTs that also piloted this new NCHRP manual. For ODOT, the findings from this larger effort included 1) more research, tools, and guidance are needed for full implementation, 2) the level of effort and resources needed will likely vary by project and might be high for more complex sites, and 3) a programmatic approach by corridor has precedent with other state DOTs and may be appropriate for ODOT given potential budget and resource constraints. This proposed research will identify and address critical data gaps, develop a framework for organizing hydrology data by geographic regions, and integrate this information with ODOT's Climate Hazard Risk Map as an updated WebGIS design tool for navigating the recommendation provided in the recent NCHRP 15-61 report. Note that while tempting, a sweeping approach to uniformly oversize all structures to accommodate future flows is not economically feasible and cannot guarantee future performance. Also, though the proposed design tool may provide a tailored approach by site location, prioritization of efforts will likely be needed due to economic constraints. To address this concern this research will also prepare a statewide programmatic approach that includes development of a prioritization matrix for incorporation of climate change input for hydrologic design.

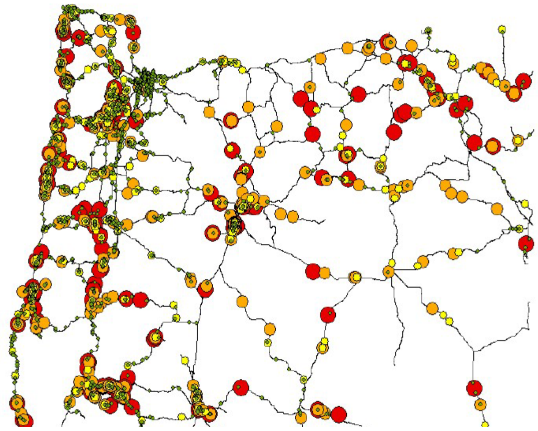

Figure 4: High water and flood related delays (2013-2021). Red circles 25-36 hours, Orange 13-24

RESEARCH OBJECTIVES

To bridge the current gap for incorporating climate change in hydrologic and hydraulic design, efficient and effective design tools, decision matrices, and a data strategy to identify and incorporate the best available datasets are needed. The goal of this research is to produce actionable deliverables for more confident and efficient incorporation of climate change into hydrologic design for our practitioners.

ODOT objectives include:

- <u>Produce clear decision support.</u> Develop a decision-making framework and flowchart for designers that navigates when and how to incorporate climate change input for hydrologic and hydraulic design.
- <u>Create time-saving tools.</u> Develop user-friendly GIS tools for incorporating needed climate datasets and tools.
- <u>Enhance transparency.</u> Develop criteria and tools for assessing quality and limitations of analysis.
- <u>Implement data strategy.</u> Catalog progress and build library of case studies to improve future work.
- <u>Streamline and simplify processes.</u> Develop site prioritization index and process to assess, inform, and implement a programmatic approach by hydrologic geographic regions.
- <u>Share information widely.</u> Provide workshop, guidance, tools, and process for evaluation and update as needed as relevant climate guidance and tools are updated.

WORK TASKS, COST ESTIMATE AND DURATION

Task 1: *Form Technical Advisory Committee (TAC).* For this project a subset of the TAC will also form a working group consisting of hydraulic engineers, water resource professionals, climate analysts and scientists, and academic partners. The working group will meet quarterly to discuss progress.
Task 2: Assessment of Data. Applicable, current climate data, databases, references (and limitations) will be identified, sorted, and a storage and retrieval protocol will be developed. Data gaps will also be identified.
Task 3: Case Studies. At least 4 case studies representatives of inland and coastal hydrology will be performed to supplement ODOT's Millport Slough Bridge pilot of NCHRP 15-61. These locations will represent coastal, cascade, the Willamette valley, central Oregon, and eastern Oregon watersheds. The purpose of this effort will be to identify data gaps, establish processes, estimate level of effort needed, and identify potential steps for standardization.
Task 4: Data Needs. In addition to available data, additional site specific or site type data will likely be needed. This task will cover this data acquisition (ex. geomorphological analysis of watershed).
Task 5: Tool Development. Based on findings and needs from Task 2 and Task 3, develop automated tools for data retrieval, processing, analysis, and storage. Tools will include GIS based tools and any GUI developed will be Python or Microsoft based and not require Admin privileges for access or distribution.
Task 6: Develop decision matrix. Using NCHRP 15-61 guidelines and findings from Task 3, develop decision matrix, protocols, design policies, and guidelines for implementation into the Hydraulic Engineering Manual.
Task 7: Assess Programmatic approach: A peer summit will be coordinated with other state DOTs that

successfully implemented climate change into their respective design processes. Following the peer summit and using the results from Tasks 2-7, assess the feasibility of a programmatic approach and deliver guidance.
Task 8: Communication of findings. In addition to a final report the findings from this research will be presented as workshop for ODOT's Regions. Relevant geospatial data will be integrated into ODOT platforms.
Key Deliverables: *Case Studies that can be leveraged to build a decision matrix, decision matrix and decision flowchart for designers based on select criteria (ex. project type, risk level, topology, etc.) informing when and how to incorporate climate change information for hydrologic and hydraulic design, GIS based tools for accessing climate data and project site specifics, protocols for data incorporation and interpretation, criteria for quality assessment, data strategy (including storage and retrieval), programmatic assessment, guidance document, workshop, expandable/searchable case study catalog, GIS data integrated into ODOT platforms.*
Estimated Project Length: 42 months.
Estimated Project Budget: $445,000

IMPLEMENTATION

Implementation of this research will be led by ODOT's Hydraulic Engineering Section. If this research is successful, elements of this research will be used to update ODOT's Hydraulic Manual. Workshops will be used to distribute the findings and assist with questions and concerns from the Regions and Maintenance Districts.

POTENTIAL BENEFITS

Climate change will introduce new hydrologic risks, such as sea level rise, changes in snowmelt, and changes in precipitation intensity, duration, and frequency. Failing to consider these changing risks compromises the performance and sustainability of existing and future transportation infrastructure. Incorporation of climate change considerations into the planning and design of transportation infrastructure will mitigate these potential risks and ensure that transportation infrastructure can continue to operate safely and effectively for Oregon, even in a changing climate. This research will provide implementable guidance for when and how to incorporate climate change into hydrologic and hydraulic design, including estimates on hours needed and level of effort recommended by location. To address the need identified from the OTP Policy EC.3.4 to "design transportation infrastructure for climate change and extreme weather resilience" products from this research are anticipated to be integrated into both the Hydraulic Manual as well as in design specifications such as temporary water management, bed material design, and scour mitigation.

PEOPLE

ODOT champion(s): **Paul R. Wirfs (State Hydraulic Engineer), Paris Edwards (Climate Office Policy Lead), Ace Clark (District 13 Manager)**, Lu Saechao (Senior Stormwater Hydraulic Engineer), Wesley Nickerman (Senior Bridge Hydraulic Engineer), Robert Trevis (Senior Culvert Hydraulic Engineer)
Problem Statement Contributors: Robert Trevis, Lu Saechao, Wesley Nickerman, Paul Wirfs, Ace Clark, Paris Edwards, Kira Glover-Cutter

STAFF REVIEW PAGE

Literature Check

TRID&RIP

☒ A review of TRID & RIP databases found no existing research that answers the research question

Technology & Data assessment

☐ No Identified T&D output

☒ At the end of this project, the implementing unit(s) within ODOT will need to coordinate the adoption of new technology or data in order to realize the full potential of this research.

Data will be incorporated in the Climate Hazard Risk Map and TransGIS. Database and any GUI developed will be Python or Microsoft based and not require Admin privileges for access or distribution. Databases that are not geospatial and Hydrologic or Hydraulic Engineering in nature will be owned and maintained by the Hydraulic Engineering Section.

Cross-agency stakeholders

- *Hydraulic Engineering Section*
- *Region Hydraulic Engineers*
- *Climate Office*
- *GIS for upload of Geospatial Data to TransGIS*