

Research Stage 1 Problem Statement

PROPOSED TITLE: Developing cost-effective guidelines for resilient construction of culverts

1. Concisely describe the transportation issue (including problems, improvements, or untested solutions) that Oregon needs to research.

A significant factor influencing the long-term durability of concrete and metal culverts is the physicochemical properties of the soil around culverts and the culvert material. Typical physicochemical factors affecting degradation include pH, electrical conductivity, moisture sensitivity, displacement, and mineralogical composition of the substrate and the culvert material. In addition, extreme weather conditions such as excessive rain or freezing conditions can enhance the degradation rate. Advanced geotechnical and geochemical investigations can help monitor the varying physicochemical properties and enable the identification of critical factors driving the degradation. Therefore, monitoring and determining such physicochemical factors can help identify appropriate construction materials and subsequently improve the service life of the culverts.

2. What final product or information needs to be produced to enable this research to be implemented?

In this study, the factors driving the degradation of culverts will be determined using advanced laboratory investigation of soils collected from potential locations. The major research product is the improved evaluation and design guidelines, which will be implemented in ODOT's Hydraulic design manual. The revised guidelines can help mitigate delays associated with frequent maintenance and repair of culverts. Following review and approval by the ODOT Research and Hydraulic Engineering Section, this work will be used by ODOT engineers and their engineering consultants.

In addition, the laboratory investigation of this research will generate knowledge on the performance of soil around culverts under extreme weather conditions, which is critical to determine the long-term performance of the culverts. Specifically, (iii) a materials selection table keyed to soil pH/EC/mineralogy and exposure, (iv) field sampling protocol and lab methods appendix, and (v) a brief LCA/service-life memo. Additional research products include the increased confidence in selecting appropriate pipe zone backfill materials and developing a pipe backfill and compaction standard drawing for large culverts.

3. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

Name	Title	Email	Phone
Robert Trevis, P.E.	Senior Culvert Hydraulic Engineer	robert.e.trevis@odot.oregon.gov	503-871-7163
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4. Other comments:

The proposed research tasks are:

1. *Literature review*: Perform a literature review on factors influencing the degradation of culverts. Review the locations of aggressive soils (e.g., organic soils) and environments (e.g., coastal, desert alkaline, and other electrochemical environments) in Oregon.
2. *DOT/ industry survey*: Perform a DOT/industry survey to identify the state-of-practice for the construction and testing/treatment of backfill materials.
3. *Sample collection*: Collect soil samples from locations with damage (e.g., cracks and corrosion) to the culvert. Pore solution of the soil (e.g., suction lysimeters/Rhizon samplers) will also be periodically collected for monitoring the pH, Electrical conductivity, alkalinity, and chemical composition for a period of two years. The sites will be identified in collaboration with the ODOT research and culvert groups.
4. *Laboratory investigation*: Test soils before monitoring – what is the initial condition? Investigate the effect of extreme weather conditions on the soils around the culverts. This investigation focuses on developing pragmatic solutions (e.g., addition of Lime/cement-biochar mixture) to improve the long-term performance of the culvert.
5. *Revise existing guidelines*: Generate recommendations regarding the selection of appropriate backfill material and propose revisions to ODOT's Hydraulic design manual (Pipe Materials Chapter).
6. *Lifecycle Cost Analysis*: A short LCA/service-life memo quantifying embodied-GHG and deferred maintenance benefits from partial binder replacement and improved durability.
7. *Develop new guidelines*: Develop guidelines for developing a pipe backfill and compaction standard drawing for large culverts.
8. *Report*: Document findings and submit a final report.

5. State of Oregon Decision Making Lenses

State decision making lenses are a part of the state of Oregon's policy structure. State policy and federal policy are not always aligned. The state will prioritize research according to state policy, however ODOT may be required to skip prioritized proposals based on constraints placed on the use of federal funds. If state funds are available ODOT will attempt to fund prioritized research that is deemed ineligible for federal funding.

Please complete the following three sections. Your answers to these questions will be applied on a programmatic basis to support agency decisions. Answering yes to the questions below is not required. Resolving a narrowly focused technical research problem may meet agency needs without answering yes to any of the following questions. The ODOT Research Section will seek a balanced portfolio some projects will answer yes to one of the three categories below (e.g., climate, equity, and/ or safety) and other projects in a different category.

We are looking for an overall program balance and no one project is expected to balance all categories. Generally, a research problem statement is expected to be able to answer yes with clear and verifiable information in only one of the three categories below, some projects may be able to answer yes in two or even three categories. Some projects (i.e. needs focused on specific elements of infrastructure design), may have no 'yes' answers but may still be a high value research need.

Climate

Oregon recognizes the climate crisis and makes systemic changes to reduce emissions caused by travel. To that end, we seek research that reduces carbon emissions from construction activities and materials, and from maintenance equipment and operations. Oregon envisions a transportation system that is

resilient, this means a system that is durable in the face of seismic events and extreme weather to avoid negative impacts, withstand them or bounce back quickly to resume system function. We seek research that improves the ability of the transportation system to adapt or cope with more frequent and extreme weather events. This may include innovations in data and data sharing, construction materials and project design, communication, emergency planning and response, and more. Similarly, we seek research that avoids negative impacts on key habitats and ecosystems that can buffer or reduce damage to infrastructure and improve environmental conditions for wildlife and native vegetation. For definitions and details please review the equity vision, goals, and objectives of the [ODOT Strategic Action Plan](#) and [Oregon Transportation Plan](#).

5a. Will addressing the transportation issue identified as a need in Question 1 develop, or **validate methods for the estimation, measurement, or monitoring** of transportation generated greenhouse gases (GHG)?

☐ Yes

☒ No

☐ Unsure

5b. If climate or GHG is not the focus of this **transportation issue** identified in this problem statement, will the research apply a GHG analysis to transportation infrastructure, planning, operations, maintenance, or materials?

☒ Yes

☐ No

☐ Unsure

5c. Will addressing the **transportation issue** include development or testing of construction practices, methods, or materials to establish potential reductions in greenhouse gas emissions?

☒ Yes

☐ No

☐ Unsure

5d. Will solving the **transportation issue** in question 1 study or support the reduction of vehicle miles traveled and single occupancy vehicle travel or support transition to electric vehicles (or other types of zero emission vehicles) or low-carbon alternative fuels?

☐ Yes

☐ No

☒ Unsure

5e. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, or monitor, transportation system resilience in response to expected climate events, effects, or natural disasters in general?

☒ Yes

☐ No

☐ Unsure

5f. Will solving the **transportation issue** in question 1 lead to work that may result in better environmental conditions for wildlife and native vegetation?

☒ Yes

☐ No

☐ Unsure

5g. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

Acidic soils and waters near culverts lower pore-solution pH of cementitious materials and the soils around culverts. This accelerates the damage to cement and metal-based culverts, which reduces service life. We will assess a hybrid additive approach that uses locally sourced Douglas-fir biochar combined with limited lime or cement to increase and stabilize pH and strength, lessen acid-driven damage, while reducing binder use. Laboratory tests will measure pH buffering and acid-neutralization capacity,

corrosion risk (using electrochemical indicators and carbonation or acid exposure), and the mechanical and durability performance of repair mortars and pipe-zone backfills with and without biochar. We will also conduct a screening life cycle assessment to estimate reductions in embodied greenhouse gas emissions from partial binder replacement and longer service life. These results will support ODOT's climate and resilience goals by lowering embodied and maintenance emissions while improving performance during extreme weather.

Equity

Equity can have many dimensions and impacts relating to communities and transportation. It is important that problem statement proposals clearly explain the equity dimensions or impacts being examined. Oregon commits to social equity in the OTP, specifically to *improve access to safe and affordable transportation for all, recognizing the unmet mobility needs of people who have been systemically excluded and underserved. Create an equitable and transparent engagement and communications decision-making structure that builds public trust.* We seek research that studies elements of this goal or applies analysis to specific transportation topics to ensure the resulting research recommendation is consistent with agency equity goals. For definitions and details please review the equity vision, goals, and objectives of the [ODOT Strategic Action Plan](#) and [Oregon Transportation Plan](#).

5h. Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐ Yes

☒ No

☐ Unsure

5i. If the **transportation issue** is not focused on transportation equity, will the primary topic be assessed for equity benefits or impacts within the research project?

☒ Yes

☐ No

☐ Unsure

5j. Is the implementation of potential findings from this research likely to directly involve participation from an identified group that would benefit from an equitable process or outcome?

☐ Yes

☐ No

☒ Unsure

5k. Is the intended final product or information expected to support ODOT's equity efforts (Including but not limited to supporting one of the equity related objectives of the [ODOT's Strategic Action Plan](#) or [Oregon Transportation Plan](#)) ?

☐ Yes

☐ No

☒ Unsure

5l. If you answered yes to any of the equity questions above or can provide alternative details related to equity, please provide additional information:

We will identify potential sites based on the following options available on TransGIS.

1) ODOT identified priority routes -emergency/economy (TransGIS category: Projects & Needs Layer)

2) ODOT identified resilience corridors (TransGIS category: Planning & Climate)

3) ODOT Equity index (TransGIS category: Planning & Climate)

Safety

Research outcomes may include interventions and countermeasures to prevent or reduce the frequency of crashes or other causes of transportation-related injury or death; or may include measures to reduce severity of injury (including prevention of death) after a crash or other injurious event. For definitions and details please review the equity vision, goals, and objectives of the [ODOT Strategic Action Plan](#), [Oregon Transportation Safety Action Plan](#) and [Oregon Transportation Plan](#).

5m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☒ Yes

☐ No

☐ Unsure

5n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☐ Yes

☒ No

☐ Unsure

5o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☒ Yes

☐ No

☐ Unsure

5p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☐ Yes

☒ No

☐ Unsure

5q. Will solving the **transportation issue** support improving safety through **investing strategically**?

☒ Yes

☐ No

☐ Unsure

5r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

While this research does not directly prevent crashes or injuries, the outcomes enhance transportation safety by improving culvert reliability and resilience. A better understanding of soil–culvert interactions and material durability will reduce unexpected culvert failures. By minimizing emergency repairs and work-zone exposure, the project supports safer conditions for both workers and the traveling public and promotes long-term infrastructure resilience.

6. Corresponding Submitter's Contact Information: **[1 individual]**

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7. ODOT Sponsor Contact Information (Required if Submitter is not an ODOT employee)

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This form is not a grant application or contract document. Please do not include proprietary information on this form. Once this form is received ODOT may revise and publish the problem statement. If selected, ODOT will assign investigator(s) of the department's choosing to conduct research.