Oregon Department of Transportation

Research Stage 1 Problem Statement

Number 26-11 – "Develop Planning Level Subsurface Data Tool for Reduction in Project Costs, Quick Emergency Evaluation, and Provision of Extrapolated Data for Rural Service Areas"

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

State geologists and geotechnical engineers are often forced to make important decisions about planning, guidance, and maintenance with sparse data. For example, subsurface material properties will entirely dictate the performance of a variety of geostructures during earthquakes, severe weather events, or simply regular service; however, these subsurface material properties are largely unconstrained, even at a project level. This lack of data on material properties is due to: (1) challenges associated with archiving and digitizing subsurface data from past projects; (2) expense, access issues, and trafic impacts of drilling and subsurface exploration; and (3) challenges in interpolating or extrapolating subsurface properties to scales of relevance for planning.

Through creation of the GOSEP (Georeferenced Oregon Soil Engineering Properties) database, we have digitized ***over 6,000 geolocated borings*** from ODOT and others and are developing tools for interpolating subsurface data at geospatial scales relevant to ODOT planning. We seek to leverage prior Cascadia Lifelines Program (CLiP, of which ODOT is a partner) support of GOSEP to: (1) continue to serve as a living database for curation and archival of subsurface data from ODOT and other partners; (2) expand upon tools which enable ODOT professionals to extract interpolated subsurface material properties data and groundwater levels at sites of interest; (3) create databases of material properties and variability at spatial scales relevant to ODOT (e.g., by watershed or geologic unit); (4) expand extrapolations to particularly relevant, but data sparse, regions (e.g. mountainous terrain) through integration of other available or reproducible datasets; and (5) expand the database to incorporate other relevant ODOT subsurface assets (e.g. piezometer data, inclinometer data, CPT soundings). These data will provide ODOT planners and designers with planning-level insight to subsurface material and groundwater properties for new projects, maintenance and repair, scoping projects, landslide mitigation, and other applications – all with increased certainty relative to *ad hoc* geologic interpolations. As ODOT professionals are increasingly tasked with doing more with less resources, planning-level tools of this nature can streamline scoping of ODOT service projects and provide valuable data for emergency projects where timely subsurface investigation is infeasible.

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

All of ODOT's assets exist on or beneath the ground. The design, construction, maintenance, and repair of these assets requires *a priori* knowledge of soil material properties, which is often widely unavailable. This results in designs that may be over- or under-conservative, causing added expense in the form of construction or maintenance, respectively. In addition to the further costs of performing data-sparse designs or scoping projects, unconservative design may result in repairs that impede the traveling public and incur added expenses in the form of road closures, construction, and employee time. By building upon the GOSEP database to develop data-driven geospatial, interactive tools to infer estimated subsurface

material properties (and their uncertainties) based on curated, digitized borehole information, we provide a pathway for ODOT professionals to better constrain subsurface conditions at project planning stages or emergency repairs. We aim to expand the range and accuracy of these interpolations with other subsurface datasets from ODOT, such as inclinometers, piezometers, and *in-situ* testing data, as well as other datasets that infill sparse areas of coverage (e.g., landslide inventories and metadata, USDA soil information, SoilGrids250). Further, we aim to create geospatial unit-specific distributions in relevant material properties that provide first-order data relevant to ODOT projects. Data produced from these tools will be of relevance to numerous critical ODOT functions that require information about subsurface conditions, including seismic hazard analyses, slope instability, material stockpiling and scoping, construction planning, repair of existing infrastructure, and more.

We have digitized and archived several thousand boreholes from ODOT and other Oregon agencies, all searchable in the current GOSEP webGIS platform, funded through CLiP in one-year phases. As a part of this work we have developed an interactive ***digital drill rig*** that uses advanced, innovative geostatistical techniques to interpolate and weight existing borehole data at locations of interest to provide estimated subsurface standard penetration test (SPT) profiles in regions of modestly dense borehole data. SPT blow counts are well-correlated with a variety of material properties, including important design inputs like strength, density, and stifness. GOSEP is developed to a point where it is readily available to be customized into an ODOT-specific suite of innovative tools for subsurface data curation, but these advancements require more direct ODOT geoprofessional involvement and a longer timeframe of support than that currently ofered by the CLiP program. CLiP generally supports exploratory research – this prior exploratory research has landed GOSEP at a stage where it is functioning well and has great potential for expanded utility. That is, we seek to enhance and refine these analyses and tools with supplementary datasets, including CPT data, categorical information relating to soil/rock classification, and other datasets, such as landslide inventory metadata (e.g. products from SPR786 and SPR808), USDA soil survey data, the Unstable Slopes Database, SoilGrids250 (a machine-learning-based map of near-surface soil textural properties), and any other materials datasets that ODOT is able to provide (e.g., laboratory data). We also aim to leverage novel machine learning algorithms to enhance extrapolation and interpolation capabilities.

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.

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4. Decision making lenses

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 diferent 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 high value research need.

Equity

Equity can have many dimensions and impacts relating to communities, and transportation. It is important that problem statement proposals clearly explain in what capacities are equity dimensions or impacts being examined within problem statements. It is a goal of the OTP to "Improve access to safe and afordable 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". Proposed research may have the intent of studying elements of this goal or apply analysis to specific transportation topics to ensure the resulting research recommendations is consistent with our equity goals. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4a Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐Yes ☒No ☐Unsure

4b 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

4c 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

4d Is the intended final product or information expected to support ODOT's equity eforts (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

4e If you answered yes to any of the equity questions above or can provide alternative details related to equity, please provide additional information:

Climate

Oregon recognizes the climate crisis and makes systemic changes to reduce emissions caused by travel. Every mile driven in Oregon is powered by a clean source of fuel. We seek research that supports

construction and maintenance operations are carbon neutral and investments in mobility that support travel by low and no emission modes. While every research project may not result in a reduction in emissions, transportation investments overall support emission reductions to achieve state goals. Oregon envisions a transportation system that is resilient in the face of seismic and climate events and impacts to the degradation of the natural environment are reduced. Our vision includes a transportation infrastructure is built in a way that avoids impacts on key habitat and results in better 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.

4f. 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 gasses (GHG)?

☐Yes ☒No ☐Unsure

4g. 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

4h. 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

4i. Will the 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

4j. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, monitor, transportation system resilience in response to expected climate events, efects, or natural disasters in general?

☒Yes ☐No ☐Unsure

4k. Will the 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

4l. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

Through the proposed research we seek to improve both the quality and quantity of data available to ODOT design engineers. The engineers can leverage this information to improve transportation system resilience in the face of climate change and other natural disasters.

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.

4m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☐Yes ☒No ☐Unsure

4n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☐Yes ☒No ☐Unsure

4o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☐Yes ☒No ☐Unsure

4p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☐Yes ☒No ☐Unsure

4q. Will solving the **transportation issue** support improving safety through **investing strategically**?

☐Yes ☒No ☐Unsure

4r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

5. Other comments:

The following tasks are envisioned for this research, which will leverage research products from SPR786, SPR808, and CLiP-funded endeavors:

Task 1: Review current approaches for characterizing material property data at large geospatial scales, and investigate added geostatistical techniques for interpolating, extrapolating and weighting three-dimensional subsurface data with particular emphasis on techniques that leverage data whose spatial distribution is linear (e.g., along a roadway) since that is consistent with much of the data currently owned by ODOT.

Task 2: Compile additional datasets in sparse regions that enable further extrapolation of subsurface data, including back-analyzed landslide inventory information, SoilGrids250, OWRD well logs, USDA soil survey data, and added borings from CLiP partners.

Task 3: Develop relationships between statewide data and data from regions of dense subsurface investigation through geostatistical and/or machine learning techniques. Enable extrapolation of constrained subsurface material properties (and their uncertainties) to data-sparse regions.

Task 4: Expand GOSEP to display newly interpolated datasets through further development of the ***digital drill rig*** tool to enable function in data sparse regions to yield estimates of subsurface strength, density, shear wave velocity and other relevant properties.

Task 5: Develop and provide the ODOT-specialized GOSEP+ tool as either a Windows 11 program, a web-based service, or a documented Jupyter notebook. The exact format will be determined at the beginning of the project in consultation with ODOT research, engineering, and information technology staf.

Task 6: Provide recommendations for tool use, directions for borehole data uploads, and host a workshop outlining tool application for ODOT use.

6. Corresponding Submitter's Contact Information:

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