SPR RESEARCH PROGRAM
SECOND-STAGE PROPOSAL SUMMARY

PROBLEM NUMBER AND TITLE

26-56: Predicting High-Risk Locations and Cost-Effective Stormwater Runoff Treatment Strategies for Emerging Tire-Derived Contaminant 6PPD-Q

PROBLEM SUMMARY

The chemical 6PPD is added to tires to extend tire longevity by preventing tire-rubber from cracking and degrading. With tire wear and atmospheric ozone exposure 6PPD oxidizes to form the chemical 6PPD-quinone (6PPD-q), which has now been identified as a contributor to coho salmon mortality in highway stormwater runoff. While actual concentrations and subsequent impacts to Oregon's highway-adjacent waters remain uncertain, recent testing at ODOT's Stormwater Technology Testing Center (STTC) together with the recently published USGS reconnaissance efforts suggest the potential that road adjacent streams ***could*** contain runoff derived toxic levels of 6PPD-q. Further, a recently published, field validated 6PPD-q transport model indicates a positive association with increased traffic density that is comparable to some highway locations in Portland. Highway runoff monitoring by CalTrans confirms this observation of increasing concentration of 6PPD-q with increasing traffic density. However, multiple factors may influence 6PPD-Q runoff concentration including road classification and design, traffic composition, traffic speed, precipitation patterns and seasonality, land-use, road maintenance and sweeping, road surface characteristics, and perhaps most importantly DOT drainage infrastructure and stormwater treatment facilities.

ODOT OBJECTIVES

Clarity is needed to determine the degree to which ODOT needs to prepare for this emerging contaminant that threatens at least one species of Oregon's native migratory fish. The objectives of this work include:

1) Determine if and model where stormwater 6PPD-q concentrations may be problematic (focus on R1)
2) Evaluate the effectiveness of 6PPD-Q removal for ODOT stormwater facilities
3) Provide cost-conscious guidance with recommended treatment design and prioritization process

BENEFITS

Understanding the extent to which and where 6PPD-Q highway runoff poses a risk of contaminant contribution to adjacent water bodies will help inform drainage management and runoff treatment decisions. Evaluating the performance of existing stormwater management facilities may confirm that ODOT's current designs effectively reduce 6PPD-q without costly retrofits. This study may also reveal opportunities to modify soil mixes or minor design elements for improved efficiency and effectiveness. Most importantly, in addition to potentially providing data and tools for cost-effective management decisions, this research will provide community assurance and transparency that ODOT is taking a proactive approach for assessing this contaminant that is lethal at low concentrations to coho. Supporting coho salmon populations has ecological significance, cultural and tribal importance, legal significance for ODOT, and economic value to the state.

SCHEDULE, BUDGET AND AGENCY SUPPORT

Estimated Project Length: 42 months.
Estimated Project Budget: $495,000
ODOT Support: Paul Wirfs (State Hydraulic Engineer), John Raasch (State Environmental Manager), Patti Caswell (Maintenance Environmental Program 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/26-56

SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2026

PROBLEM NUMBER AND TITLE

<u>26-56:</u> Predicting High-Risk Locations and Cost-Effective Stormwater Runoff Treatment Strategies for Emerging Tire-Derived Contaminant 6PPD-Q

RESEARCH PROBLEM STATEMENT

The current method for extending tire longevity by preventing tire-rubber degradation includes the addition of the chemical additive 6PPD. With tire wear and atmospheric ozone exposure 6PPD oxidizes to form the chemical 6PPD-quinone (6PPD-q), which has now been identified as a contributor to coho salmon mortality in highway stormwater runoff [(1)]. 6PPD-q commonly enters surface waters through stormwater runoff from highways and other impervious surfaces. A recent multi-state USGS reconnaissance study measured baseline 6PPD and 6PPD-q concentrations at 94 sites across 15 states, including Oregon [(2,3)]. Stormwater and urbanized areas produced the highest detection frequencies and concentrations, with 6PPD-q values well exceeding the USEPA recently released non-binding screening levels of 11 ng/L [(1-3)].

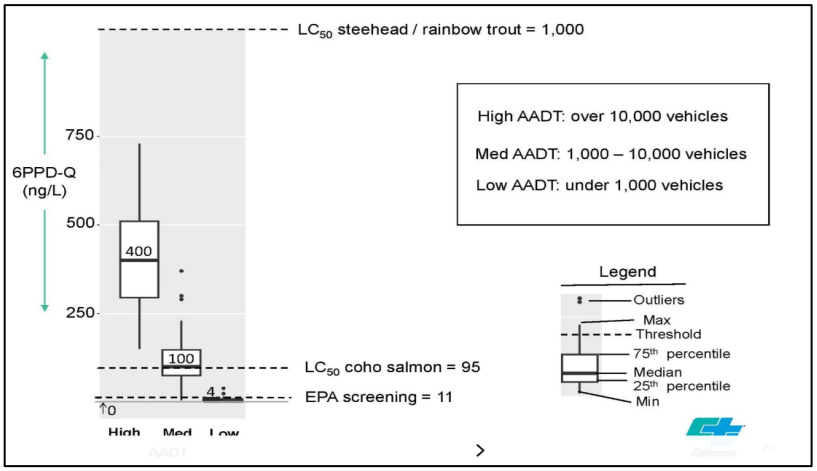

Figure 1: Stormwater 6PPD-q Increases w/ Traffic Volume. Graph on Left bars represent High, Med, Low AADT from 18 monitoring locations (CalTrans, Mavensnotebook.com/2025/01/07)

While actual concentrations and subsequent impacts to Oregon's highway-adjacent waters remain uncertain, recent testing at ODOT's Stormwater Technology Testing Center (STTC) [(4)] together with the recently published USGS reconnaissance efforts suggest the potential that road adjacent streams ***could*** contain runoff derived toxic levels of 6PPD-q. Further, a recently published, field validated 6PPD-q transport model indicates a positive association with increased traffic density [(5)] that is comparable to some highway locations in Portland. Highway runoff monitoring by CalTrans and King County Washington confirms this observation of increasing concentration of 6PPD-q with increasing traffic density (Figure 1) [(6,7)]. Of note, for the 18 monitoring stations in California spanning high to low AADT, runoff from low traffic roads consistently remained below the coho lethal concentration of 50% (LC50) of 95ng and the EPA screening value of 11ng.

Comprehensive state-wide continuous monitoring along the entirety of ODOT's network for 6PPD-Q highway runoff concentrations of concern is not feasible, neither is development of a fully predictive model built from extensive monitoring that accounts for all contributing variables. Multiple factors may influence 6PPD-Q runoff concentration including road classification and design, traffic composition, traffic speed, precipitation patterns and seasonality, land-use, road maintenance and sweeping, road surface characteristics, and perhaps most importantly DOT drainage infrastructure and stormwater treatment facilities. Of particular interest to ODOT, several stormwater best management practices (BMPs) have been identified with high potential for 6PPD-q removal that include the processes of infiltration, dispersion, and to an extent, biofiltration [(8)]. Specifically, this includes bioretention, infiltration basins and ponds, media filter drains, and compost-amended biofiltration, and other biofilters [(4,8)]. However, full field assessments of

performance during a PNW water year along highway networks is quite limited.

To narrow in on possible areas of interest for monitoring, mitigation, or prioritization and planning, both the state of Washington and the USGS have initiated independent mapping efforts [9,10]. The USGS will be releasing a sampling based 6PPD-q national scale hotspot map, estimated delivery by Fall 2025. Washington's efforts (Figure 2) to date have focused on a combined effort for mapping biological effects-based mapping and monitoring with four prime parameters of known concern and/or impact including: ecosystem characteristics, transportation characteristics, watershed characteristics, and waterbody characteristics.

In addition to sampling profile mapping and integrated parameter mapping, transport modeling may also be of value. For example, to simulate urban watershed fate and transport of 6PPD-q, the EPA applied their Visualizing Ecosystem Land Management Assessment (VELMA) ecohydrology tool [5]. The USGS in cooperation with the FHWA has also developed a planning-level modeling methodology called Stochastic Loading and Dilution Model (SELDM) that can simulate/estimate pollutant concentrations and loads [11]—which may be useful for predicting planning level estimates of 6PPD-q Total Maximum Daily Loads (TMDL) along highway corridors if prioritization is envisioned.

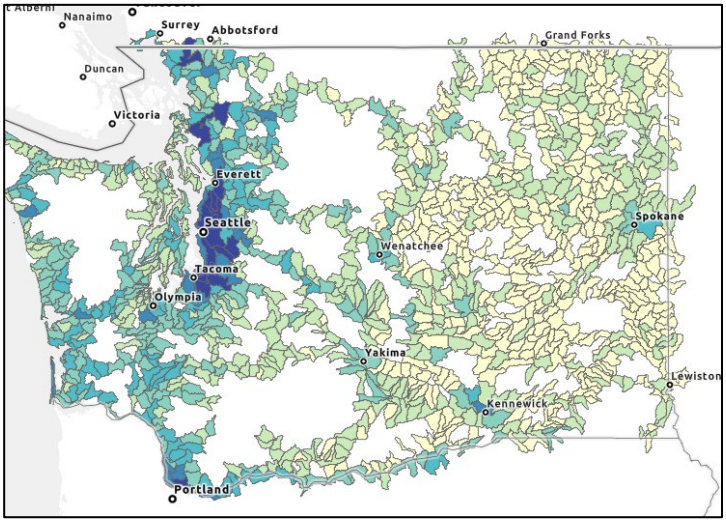

Figure 2: Biological Effects-Based Mapping and Monitoring. Biological Risk Vulnerability Mapping. Blue is highest, yellow is lowest risk/vulnerability (Washington Department of Ecology)

RESEARCH OBJECTIVES

Clarity is needed to determine the degree to which ODOT needs to prepare for this emerging contaminant that threatens at least one species of Oregon's native migratory fish. The objectives of this work include:

1) Determine if and model where stormwater 6PPD-q concentrations may be problematic (focus on R1)
2) Evaluate the effectiveness of 6PPD-Q removal for ODOT stormwater facilities
3) Provide cost-conscious guidance with recommended cost-effective treatment, design, planning, and prioritization process

WORK TASKS, COST ESTIMATE AND DURATION

Task 1: Technical Advisory Committee formation. An interdisciplinary, cross-agency, and inter-agency collaborative is envisioned for this research work.
Task 2: Targeted literature and data review that includes research in progress. It is quite possible that ODOT will co-opt an emerging methodology for rapid, cost-effective 6PPD-q field quantification, and this review should capture arguments for this approach [12].
Task 3: Development of research methodology and fieldwork methodology. Fieldwork will target those stormwater management facilities that have limited field assessment data that have also been identified as promising candidates for high-density traffic areas.
Task 4: Develop draft integrated interactive map for potential locations of interest that leverages sampling data and mapping methods [10]. Drafts of this map will inform fieldwork approach.
Task 5: Field assessment of up to two types of stormwater facilities of interest to the TAC and ODOT stormwater and maintenance teams. A comparison of USGS/EPA methodology vs fluorescent methods for quantification may be incorporated. If successful field plan will accommodate additional sampling.
Task 6: Corridor and/or site-based modeling for planning-level assessment and potentially prioritization

using already developed methods for TMDLs.
Task 7: Deliver finalized map and finalized modeling tool/methodology. Final map will include sampling data from Task 5 and any other ODOT or consultant associated with data available and shareable.
Task 8: Economic assessment for planning/prioritization for what is feasible at a corridor and site level.
Task 9: Communication and Final Deliverables. Workshops will be developed and delivered to a diverse audience for use of the delivered tools and communication of findings.

Key Deliverables: Online integrated planning-level highway network GIS map of areas of interest, field assessment and potential verification of up to two high potential BMPs, proof-of-concept corridor (or site-series) models, planning level economic assessment, cost-effective methodology and process recommendations, design considerations, workshops, final report, potential extended monitoring.

Estimated Project Length: 42 months.
Estimated Project Budget: $495,000

IMPLEMENTATION

The Research Coordinator will work closely with the TAC to develop operational mapping products and recommended processes. Workshops will be provided as the deliverables for this research roll-out. All deliverables will be planning-level tools to inform future decisions. The TAC will be comprised of these decision makers for ODOT's Hydraulic Engineering section, Environmental Section, Region 1, and importantly Maintenance.

POTENTIAL BENEFITS

The demonstrated toxicity of 6PPD-q for at least one listed threatened and endangered species and recent reports for toxic impacts to other aquatic species increases the likelihood that regulatory agencies will impose treatment requirements on Oregon highway projects. Statewide assessment of highway stormwater facility performance is not feasible. For starters, sampling and analysis costs for quantifying 6PPD-q are in the thousands per event per site and statewide stormwater facilities are in the tens of thousands. This research will enable an economically conscious, planning-level analysis of potential locations of interest for prioritization, monitoring, mitigation, modeling, or targeted research before investment. Specifically, an integrated mapping effort for honing-in on the most likely impacted areas will be delivered, followed by a recommended prioritization process, as well as several case studies of higher resolution modeling to determine monitoring need. These tools and guidance will provide a cost-effective, targeted approach for assessing 6PPD-q highway runoff contribution to receiving waters.

PEOPLE

ODOT champion(s): Paul Wirfs (State Hydraulic Engineer), John Raasch (State Environmental Manager), Patti Caswell (Maintenance Environmental Program Manager), Denis Reich (Region 1 Environmental Manager)

Problem Statement Contributors: Kira Glover-Cutter, Patti Caswell and Tom Loynes (page 1)

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(1) Williams T., Grant K., Madden E. (2023). What We Know: 6PPD and 6PPD-quinone. Interstate Technology Regulatory Council (ITRC).
(2) Lane, R. F., Smalling, K. L., Bradley, P. M., Greer, J. B., Gordon, S. E., Hansen, J. D., ... & Masoner, J. R. (2024). Tire-derived contaminants 6PPD and 6PPD-Q: Analysis, sample handling, and reconnaissance of United States stream exposures. Chemosphere, 363, 142830.
(3) Lane, R.F., Smalling, K.L., Bradley, P.M., Tush, D.L., Dietze, J.E., Greer, J.B., Hansen, J.D., Spanjer, A.R., Lucena, Z.N., Masoner, J.R., Stack, J.K., Sinclair, D.A., Johnson, A.G., Riskin, M.L., and Lambert, M.R., 2024, Concentrations of 6PPD and 6PPD-Quinone in a United States reconnaissance of stormwater, surface water, and groundwater, 2018-24: U.S.G.S. data release, https://doi.org/10.5066/P1A6RSGW.

(4) 2023-2024 Summary Report: 6PPD-1 in Highway Runoff and BMP Effectiveness: Seattle, Washington and Portland, Oregon. Prepared by Herrera.
(5) Halama, J. J., McKane, R. B., Barnhart, B. L., Pettus, P. P., Brookes, A. F., Adams, A. K., ... & Kolodziej, E. P. (2024). Watershed analysis of urban stormwater contaminant 6PPD-Quinone hotspots and stream concentrations using a process-based ecohydrological model. Frontiers in Environmental Science, 12, 1364673.
(6) https://mavensnotebook.com/2025/01/07/notebook-feature-from-roads-to-rivers-how-state-agencies-are-tackling-salmon-killing-tire-pollution/
(7) King County. 2024. The Relationship of 6PPD-q to Land Cover and Road Traffic. Prepared by Savannah Pasquan, Water and Land Resources Division. Seattle, Washington
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(9) USGS Communication February 28, 2025
(10) https://gis.ecology.wa.gov/portal/apps/storymaps/stories/53b11807ac124735b281872a514809b5
(11) Lantin A., Larsen L., Vyas A., Barrett M., Koryto K., Pechacek L. NCHRP Research Report 918. Approaches for Determining and Complying with TMDL Requirements Related to Roadway Stormwater Runoff. (2019).
(12) Hollman, K. V., Stack, M. E., Hoh, E., Sant, K. E., Harper, B., & Mladenov, N. (2025). Behavior of compounds leached from tire tread particles under simulated sunlight exposure. *Water Research*, *274*, 123060.

STAFF REVIEW PAGE

LITERATURE CHECK

TRID&RIP

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

ODOT DECISION LENSES

Climate: This work lead to work that may result in better environmental conditions for wildlife, specifically aquatic species, and especially coho salmon.

Equity: Salmon hold deep cultural significance for many Tribal Nations in Oregon, featuring prominently in traditions, diets, and ceremonies. Additionally, salmon-related commercial and recreational fisheries bolster Oregon's economy.

Safety: Depending on availability, there is an opportunity to proof-of-concept a new, low-cost method for detecting a proxy for 6PPD-q. If this works, this method will enable less personnel and reduced personnel time on ODOT ROW.

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.

CROSS-AGENCY IMPACTS

- List ODOT partners or impacted units. Paul Wirfs (State Hydraulic Engineer), John Raasch (State Environmental Manager), Patti Caswell (Maintenance Environmental Program Manager), Denis Reich (Region 1 Environmental Manager).