REQUEST FOR PROPOSALS (RFP)

Adaptive Control Frameworks to Unlock Full-Scale BNR Potential (RFP 5424)

Date Posted
September 8, 2026

Due Date
Proposals must be received by 3:00 pm Mountain Time on Monday, October 26, 2026.

WRF Project Contact
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Project Sponsors
This project is funded by The Water Research Foundation (WRF) as part of WRF's Research Priority Program.

Project Objectives

- Identify and categorize the dominant failure modes of current aeration and process control implementations under real-world operating conditions.
- Develop guidance on data and instrumentation requirements for utilities to support adaptive control, including the characterization of existing sensor infrastructure and the use of soft sensors where hard sensors are limited.
- Develop practical adaptive control frameworks and implementation guidance that utilities can deploy without dependence on proprietary black-box tools or specialized data science expertise, including hybrid approaches that augment conventional controls with data-driven models (e.g., artificial intelligence (AI)/machine learning (ML), digital twins) for variable flow and concentration conditions.
- Benchmark control performance against biological capacity indicators across multiple full-scale facilities to quantify the gap between achievable and realized biological nutrient removal (BNR) performance.

Budget
Applicants may request up to $300,000 in WRF funds for this project.

Background and Project Rationale
The water sector routinely invests in capital-intensive solutions such as additional aeration capacity, supplemental carbon systems, and tertiary filtration to address BNR shortfalls that may fundamentally be problems with control execution, not biological potential. Variable conditions such as influent flow, temperature, carbon availability, and wastewater strength

impact BNR performance. Additional factors such as pH or alkalinity can result in less-than-optimal performance compared to full BNR capabilities as well. Prior WRF research has advanced the science of BNR process fundamentals and control strategy development, but a critical gap remains, which is understanding why adaptive control strategies fail in practice and how to design control frameworks that are robust to the conditions that cause failure. For example, aeration control strategies such as ammonia-based aeration control (ABAC) and ammonia vs. nitrate (AvN) are widely implemented but frequently fail under variable influent loading or temperature swings, causing operators to override automation and revert to manual control, negating the intended performance and efficiency gains. This project directly targets that execution gap.

Adaptive control in wastewater treatment uses digitalization, AI/ML, and sensors to automatically adjust plant operations and stabilize treatment performance in real-time. This dynamic approach can offset the negative impacts from unpredictable rainfall surges and temperature-driven changes in biological activity due to extreme weather events and a changing climate. This approach can also help stabilize treatment performance through inherent variability in secondary influent characteristics, such as carbon-to-nitrogen ratios or alkalinity. The geographic regions of focus in this study will be the United States and Canada.

In summary, this project will advance adaptive control strategies to improve reliability, reduce energy waste, improve nutrient removal performance, and prevent misdiagnosis of process limitations in BNR systems. Establishing data-driven approaches could confer significant cost savings and improve performance without requiring capital-intensive solutions. In addition, an adaptive control framework can help unlock the full potential of nutrient removal, including under extreme weather events, for a holistic solution.

Research Approach

This RFP is intentionally flexible in the research approach to encourage creativity and originality from proposers. Proposers should describe how they will conduct the research to meet the objectives listed above. The following approach is intended as a starting point.

- **Failure-Mode Characterization:** Analyze operational data and records from partner utilities to identify and categorize dominant failure modes in full-scale BNR aeration control implementations (ABAC, AvN, cascade dissolved oxygen [DO], low DO BNR, feed-forward), flow and step-feed control implementations, and/or solids inventory management (wasting control, return activated sludge [RAS] control, secondary clarifier performance).
- **Sensor Infrastructure Inventory and Data Quality Assessment:** Characterize existing online sensor coverage, sensor and instrumentation reliability, sensor maintenance, calibration schedules, data accessibility, and data use across partner facilities. Identify sensor gaps through targeted spot sampling. Evaluate the contribution of instrument reliability, maintenance/calibration practices, sensor drift, sample conditioning, and communication failures to control performance limitations and adaptive control failure modes.
- **Soft Sensor Development and Validation:** Develop and validate soft sensors using hard sensor data to ground truth. These should be designed to function within existing

infrastructure (e.g., no new sensor installation will be required). Develop practical guidance on how and when to use soft sensors to address BNR limitations. Evaluate long-term robustness, maintenance requirements, and retraining needs for soft sensor applications under changing process and seasonal conditions.

- **Adaptive Control Framework Development:** Develop hybrid control frameworks (rule-based logic augmented by AI/ML) for variable flow and loading conditions, with implementation guidance utilities can use without proprietary tools or specialized data science expertise. Discuss the current state of open-source control systems and what truly non-proprietary software and hardware systems may look like for utilities.
- **Operator Adoption and Organizational Readiness:** Evaluate the organizational, operational, and human-factor barriers to adaptive control implementation and develop guidance to improve operator confidence for long-term use of automated control systems.
- **Multi-Facility Benchmarking:** Benchmark realized control performance against biological capacity indicators across partner facilities to validate the control frameworks. Assess applicability of adaptive control framework across a range of treatment process configurations and facility sizes. Support quantification of benefits for business case development. Quantify the gap between realized performance/capacity without adaptive control versus performance/capacity potential with adaptive control (e.g., nutrient removal performance, aeration energy consumption, chemical consumption, process stability, compliance risk, deferral of capital expenditure).

Expected Deliverables

Expected deliverables from this project include:

- Comprehensive literature review including WRF's research studies.
- Utility-facing implementation guidance covering both instrumentation and controller sections, for example, controller selection, sensor infrastructure, tuning, sensor calibration requirements, operator training, and maintenance requirements, designed without proprietary dependencies, and system integration. The following components need to be included in the guidance document.
    - Decision framework for utilities to assess whether control limitations (vs. biological or capacity constraints) are the primary barrier to BNR performance.
    - Failure-mode catalog for common BNR control strategies with root-cause analysis.
- Multi-facility dataset quantifying the gap between BNR capacity and realized performance.
    - Utility case studies that span broad geographic regions in the United States and Canada.
- Outreach, e.g., webcasts and public outreach materials such as conference presentations.
- Submission of one open access peer-reviewed journal paper.

Communication Plan

Please review WRF's *Project Deliverable Guidelines* for information on preparing a communication plan. Conference presentations, webcasts, peer-reviewed publication submissions, and other forms of project information dissemination are encouraged.

Project Duration
The anticipated period of performance for this project is 24 months from the contract start date.

References and Resources
The following list includes examples of research reports, tools, and other resources that may be helpful to proposers.

- Clark, D. L., T. Stober, M. Falk, H. Holmberg, P. Vanrolleghem. 2023. *Holistic Approach to Improved Nutrient Management.* Project 4974. Denver, CO: The Water Research Foundation. https://www.waterrf.org/research/projects/holistic-approach-improved-nutrient-management.
- Johnson, B. R., C. Yang, J. Registe et. al. 2024. *Development of Hybrid Digital Twins for Predictive Nutrient Control*. Project 5121. Denver, CO: The Water Research Foundation. https://www.waterrf.org/research/projects/development-hybrid-digital-twins-predictive-nutrient-control.
- Liu, T., G. T. Daigger, and X. Li. 2026. Wastewater Management under Global Climate Change Conditions. *ACS Environmental Au.* Perspective (May 17, 2026). https://doi.org/10.1021/acsenvironau.6c00097.
- Neethling, JB, M. Falk, and E. Evans. 2023. *Guidelines for Optimizing Nutrient Removal Plant Performance.* Project 4973. Denver, CO: The Water Research Foundation. https://www.waterrf.org/research/projects/guidelines-optimizing-nutrient-removal-plant-performance.
- Thompson, K., S. Sinha, R. Dadiala, A. Vishwakarma, and C. Dermody. 2025. *Designing Sensor Networks and Locations on an Urban Sewershed Scale with Big Data Management and Analytics.* Project 4797. Denver, CO: The Water Research Foundation. https://www.waterrf.org/research/projects/designing-sensor-networks-and-locations-urban-sewershed-scale-big-data-management.

Proposal Evaluation Criteria
The following criteria will be used to evaluate proposals:

- Understanding the Problem and Responsiveness to RFP (maximum 20 points)
- Technical and Scientific Merit (maximum 30 points)
- Qualifications, Capabilities, and Management (maximum 20 points)
- Communication Plan, Deliverables, and Applicability (maximum 15 points)
- Budget and Schedule (maximum 15 points)

PROPOSAL PREPARATION INSTRUCTIONS

Proposals submitted in response to this RFP must be prepared in accordance with WRF's *Guidelines for Research Priority Program Proposals*. The guidelines include instructions on technical aspects, financial statements, indirect costs, and administrative requirements that the applicant must follow when preparing a proposal.

Proposals that include the production of web- or software-based tools, such as websites, spreadsheets, databases, etc., must follow the criteria outlined for web tools presented in the *Technology Deliverables Guidance*.

Eligibility to Submit Proposals
Proposals will be accepted from both U.S.-based and non-U.S.-based entities, including educational institutions, research organizations, governmental agencies, consultants, or other for-profit entities.

WRF's Board of Directors has established a *Timeliness Policy* that addresses researchers' adherence to the project schedule. Researchers who are late on any ongoing WRF-sponsored studies without approved no-cost extensions are not eligible to be named participants in any proposals. Direct any questions about eligibility to the WRF Project Contact listed at the top of this RFP.

Administrative, Cost, and Audit Standards
WRF's research program standards for administrative, cost, and audit compliance are based upon, and comply with, Office of Management and Budget (OMB) Uniform Grants Guidance (UGG), 2 CFR Part 200 Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards, and 48 CFR 31.2 Contracts with Commercial Organizations. These standards are referenced in WRF's *Guidelines for Research Priority Program Proposals* and include specific guidelines outlining the requirements for indirect cost negotiation agreements, financial statements and the Statement of Direct Labor, Fringe Benefits, and General Overhead. Well in advance of preparing the proposal, your research and financial staff should review the detailed instructions included in WRF's *Guidelines for Research Priority Program Proposals*.

Budget and Funding Information
The maximum funding available from WRF for this project is $300,000. The applicant must contribute additional resources equivalent to at least 33% of the project award. For example, if an applicant requests $100,000 from WRF, an additional $33,000 or more must be contributed by the applicant. Acceptable forms of applicant contribution include cost share, applicant in-kind, or third-party in-kind that comply with 2 CFR Part 200.306 cost sharing or matching. The applicant may elect to contribute more than 33% to the project, but the maximum WRF funding available remains fixed at $300,000. Proposals that do not meet the minimum 33% of the project award will not be accepted. Consult the *Instructions for Budget Preparation* on the Outbound Grants page for more information and definitions of terms.

Period of Performance
It is WRF's policy to negotiate a reasonable schedule for each research project. Once this schedule is established, WRF and its sub-recipients are contractually obligated to adhere to it. Under WRF's *No-Cost Extension Policy*, a project schedule cannot be extended more than nine months beyond the original contracted schedule, regardless of the number of extensions granted.

Utility and Organization Participation
WRF encourages participation from water utilities and other organizations in WRF research. Participation can occur in a variety of ways, including direct participation, in-kind contributions, or in-kind services. To facilitate their participation, WRF has provided contact information for utilities and other organizations that have indicated an interest in this research. Proposers are responsible for negotiating utility and organization participation in their proposals. The listed utilities and organizations are under no obligation to participate, and the proposer is not obligated to include them in their proposal.

Application Procedure and Deadline
Proposals are accepted exclusively through WRF's Portal, and they must be fully submitted before 3:00 pm Mountain Time on Monday, October 26, 2026.

To learn how to submit a proposal for this RFP, please visit www.waterrf.org/proposals and follow the instructions on the page.

Questions to clarify the intent of this RFP and WRF's administrative, cost, and financial requirements may be addressed to the WRF project contact, Dr. Harry Zhang at 571.384.2098 or hzhang@waterrf.org. Questions about how to submit proposals through WRF's Portal should be directed to WRF's Customer Care Form.