

## **North Dakota Water Resources Research Institute (NDWRRI)**

### **2024-2025 Annual Report**

#### **History**

The NDWRRI was established in 1965 under the Water Resources Research Acts, administered through the US Geological Survey. It's part of the National Institutes for Water Resources, focusing on fostering new research, training future water resources professionals, exploring new ideas to address water issues, and disseminating research results. The institute emphasizes cooperation with colleges and regional organizations to solve water and land-related problems at state and regional levels. The NDWRRI is currently housed at the North Dakota State University in the Office of the Vice President for Research and Creative Activity.

#### **Mission**

The mission of the NDWRRI focuses on facilitating research to address water problems, support the education and training of future water resources professionals, explore innovative ideas related to water and its phenomena, and disseminate findings to water managers and the public. It aims to enhance statewide efforts in resolving water and related land issues through collaboration with colleges and regional organizations, promoting effective water management and sustainability efforts.

#### **Research**

The North Dakota Water Resources Research Institute (NDWRRI), part of the National Institutes for Water Resources, is committed to addressing North Dakota's critical water challenges through research, education, and collaboration. Established in 1965 and administered by the US Geological Survey under NDSU's Vice President for Research and Creative Activity, the NDWRRI funds Graduate Research Fellowships focused on priority issues set by the Advisory Board. Additionally, the Institute has developed a Water Resources Certificate Program for undergraduate students at NDSU, aiming to train future water professionals and encourage innovative solutions to water issues. During the 2024-2025 annual period, four undergraduate students at NDSU graduated with the addition of the Water Resources Certificate. Additionally, each year, the State Advisory Committee identifies research priorities and provides competitive fellowship opportunities to graduate students at NDSU and UND. These fellowships provide opportunities for students to address water-related topics, advance knowledge, and develop the skills needed to tackle regional water challenges. NDWRRI also promotes information exchange through seminars, conference participation, and its website and newsletter.

The NDWRRI is instrumental in developing a skilled workforce for water resources and addressing North Dakota's pressing water issues. By supporting graduate fellowships, the Institute drives impactful research with implications for water management, conservation, and policy. Through outreach initiatives such as a research seminar on outreach to Tribal Communities during the Spring of 2025 and the Water Resources Certificate program, the Institute enhances knowledge dissemination and strengthens state agency capabilities.

Collaborative NDWRRI-funded projects contribute to sustainable water management solutions, inform policy, and prepare students for careers in industry, government, and academia, ultimately benefitting North Dakota's communities and ecosystems.

Additionally, during the 2024-2025 year, the NDWRRI with support from the NDSU's Vice President for Research and Creative Activity maintained an active Faculty Water Fellows program. This program

supported four water faculty to pursue new state and region wide collaborations as well as the development of research proposals in key areas. The Faculty Fellows worked to develop a collaborative research proposal with Montana State University and the University of Wyoming for the National Science Foundation's R2I2 call (NSF R2I2: Sustainable water resource management and resilient response systems in the Upper Missouri Headwaters, Northern Great Plains Ecoregion). Further, during the Spring and Summer of '25, the faculty fellows worked to submit a statewide research project for the NSF ERISE program with collaborations at UND, Minot State University and a tribal college collaboration at the United Tribes Technical College. This project set to build a statewide social-ecological-environmental network for PFAS research.

## **Technology and Information Transfer**

The North Dakota Water Resources Research Institute (NDWRRI) is dedicated to advancing water resource knowledge and addressing critical issues in North Dakota through outreach and communication. Key initiatives include maintaining an updated website that serves as a hub for research, project updates, resources, events, and funding opportunities for the public and stakeholders. The institute publishes annual newsletters to spotlight research projects and the graduate research fellowship program.

The NDWRRI also sponsors events such a workshop titled "Building Bridges: Working with Tribal Nations & TCUs | Faculty Opportunities at the NDWRRI" and sponsored involvement at the South Dakota Student Water Conference as well as travel for presentations at the UCOWR/NIWR Conference in Minneapolis. Fellows and faculty are encouraged to share findings in peer-review journals and at various conferences. In August of 2024, the NDWRRI sponsored a full day conference on the North Dakota Water Diversion project bringing in panel speakers and community leaders to discuss the impact of the project.

During the Summer of 2024, Dr. Trung Le (Faculty Fellow) and his graduate student worked to restart a monthly water seminar series featuring speakers and presentations from water research leaders across the county and globe as well as graduate student fellowships who received research awards through the NDWRRI.

The Institute's LinkedIn page features semi-weekly posts and has attracted 640 follows as of December 2025. Further, the NDWRRI restructured the public facing website (June 2025), highlighting areas of expertise and initiatives as well as clearly presenting recordings of past seminars and information transfer.

The NDWRRI's outreach strengthens sustainable water management practices in North Dakota. By engaging diverse audiences through its digital and in-person efforts, the Institute disseminates essential research. The NDWRRI, during March 2025 identified three areas of expertise and contribution: 1) Water Management and Flow; 2) Clean Water and Environmental Threats; 3) Wildlife and Natural Resources. These areas of expertise highlight the work completed by faculty at both NDSU and UND as affiliated researchers with the NDWRRI. These activities build partnerships, support workforce development, and promote innovative water solutions, benefiting North Dakota's communities, ecosystems, and resources. NDWRRI ensures that water-related knowledge reaches those who can make a meaningful impact.

## **Education and Outreach**

Establishing education and outreach for the NDWRRI is essential for addressing water-related challenges and promoting sustainable practices in North Dakota. The NDWRRI Water Resources Certificate Program was launched in Fall of 2024 and featured four undergraduate students completing the program in Spring of 2025. This program provides specialized training to prepare students across majors for careers in water resources. The NDWRRI organized a seminar on best practices when collaborating with

Tribal Nations and TCUs during the Spring of 2025. This seminar invited faculty from NDSU and UND to discuss ways to include Tribal communities in research collaborations and projects. The NDWRRI has also encouraged affiliated faculty to collaborate with government, academia, industry, and communities, promoting innovative research and practical solutions through various events and campaigns. This includes participating in annual statewide Water Conferences and engaging with the ND USGS office personnel.

The NDWRRI communication staff manages public communications, the NDWRRI website, and LinkedIn activities. LinkedIn posts have shared the successes of NDWRRI affiliated faculty and students including links to conference presentations, posting of recorded seminars, and graduation announcements. The Water Faculty Fellows assist with outreach, including attending conferences, speaking with state leaders, and maintaining communication for policy recommendations and program development. The Fellows also document outreach outcomes, propose projects, and identify areas of need within the state for outreach and education. Faculty Fellows have also led seminars and workshops in topics such as an R workshop on Geospatial Data, further providing opportunities for education and professional development. During the Fall of 2025, the NDWRRI also restarted the Monthly Water Seminar providing educational opportunities and the dissemination of research outcomes.

### **Projects Funded in 2024-2025**

The NDWRRI has awarded nine projects for the 2024-2025 Graduate Research Fellowship program. The fellowships with the funding from the USGS 104b and the ND Department of Water Resources ranged from \$7,360 to \$14,832 and were for doctoral students (four new applications and five for renewals).

The students conducted water resources research at the North Dakota State University and the University of North Dakota. Fellows, their academic programs, university, faculty advisors, and research projects are:

**Name: Shirsa Mazumdar, Ph.D Student**

**Title:** Metal/Metal oxide-modified bio-based adsorbent for phosphate removal and recovery

**Program:** Civil, Construction, and Environmental Engineering, NDSU

**Advisor(s):** Achintya N. Bezbaruah

**Summary:** Efficient and cost-effective elimination of phosphates from aqueous solutions stands as a pivotal global concern. The proposed research will explore the viability of reclaiming phosphorus from agricultural runoff through adsorption using an adsorbent created from agricultural byproducts. The main objective will be met through a series of studies which is to synthesize, characterize, and study the adsorption properties of nanocellulose derived from agricultural waste such as wheat straw that has been thermally activated and modified with iron. Iron is preferred because of its robust affinity for phosphate, exceptional selectivity, expansive surface area, and chemical stability. Iron-modified nanocellulose could serve as a barrier on land or as filters to intercept phosphorus from reaching nearby water bodies. Subsequently, it could be utilized as a slow-release fertilizer when applied to the soil. This versatile feature of the adsorbent is deemed a significant contribution of this proposed study to the realm of phosphorus recovery.

**Name: Arvin Samadi Koucheksaraee, Ph.D Student**

**Title:** A Novel Hybrid Machine Learning Method for Streamflow Forecasting in Cold Regions

**Program:** Civil, Construction, and Environmental Engineering, NDSU

**Advisor(s):** Xuefeng Chu

**Summary:** Snowmelt plays a crucial role in the hydrologic systems of the northern United States, significantly impacting water supplies. Scholars are now engaged in the development of accurate models using machine learning (ML) models that comprehensively capture the intricate relationships of snowmelt, streamflow, and other related hydrologic processes. Although promising, the use of ML for streamflow prediction has been focused on rainfall-dominated watersheds. This study endeavors to develop a novel intelligent hybrid ML model for streamflow prediction in cold regions under the influence of snowmelt. This endeavor follows the identification of the most effective feature selection method between the cross-correlation and Baruta-SHAP methodologies, with a parallel focus on enhancing the input data architecture. The new modeling approach will be compared with other robust models to demonstrate its improvements in computational efficiency and accuracy. It will be tested in a watershed in North Dakota to highlight its broad implications in hydrology.

**Name:** Tiansong Qj, Ph.D Student

**Title:** Incorporating wetland characteristics in watershed-scale hydrologic modeling in depression-dominated areas

**Program:** Civil, Construction, and Environmental Engineering, NDSU

**Advisor(s):** Xuefeng Chu and Marinus L. Otte

**Summary:** This study will provide an integrated wetland-hydrology modeling framework, which can be used to address the problems of wetland loss and water quality deterioration in North Dakota (ND). Assessing the impacts of wetland restoration is crucial because of the significant role of wetlands in hydrologic processes. In semi-distributed hydrologic models, it is difficult to account for the impacts of wetlands on hydrologic processes, especially for depression-dominated watersheds with numerous wetlands in the Prairie Pothole Region. To address this issue, the concept of hydrologic response units (HRUs) used in the Soil and Water Assessment Tool will be employed and redefined by taking into account the spatial distributions of wetlands and their associated contributing areas. The redefined HRUs will be classified as (1) depressional HRUs and (2) regular HRUs. A new HRU-level wetland module will be developed to incorporate the influences of individual small wetlands for all depressional HRUs.

**Name:** Biraj Saha, Ph.D Student

**Title:** Per and polyfluoroalkyl substances (PFAS) leaching from yard waste compost

**Program:** Civil, Construction, and Environmental Engineering, NDSU

**Advisor(s):** Syeed Md Iskander

**Summary:** Per- and polyfluoroalkyl substances (PFAS), commonly referred to as "forever chemicals," are persistent organic pollutants that are widespread in the environment. Despite yard waste compost being widely recognized for its purity, the discovery of PFAS within it is unexpected and warrants thorough investigation to curtail the spread of PFAS through compost. This study is motivated by initial findings that suggest PFAS can migrate downwards through compost piles, driven by moisture. Therefore, our study aims to understand the dynamics of PFAS leaching from compost, considering both

its chemical properties and the impact of freeze-thaw cycles. We anticipate uncovering the mechanisms behind PFAS leaching, informed by the specific characteristics of PFAS and compost, as well as freeze-thaw processes. This knowledge is crucial for developing strategies to mitigate PFAS pollution in the environment.

**Name: Javad Souri, Ph.D Student**

**Title:** Turbulent characteristics in locations with potential ice jams

**Program:** Civil, Construction, and Environmental Engineering, NDSU

**Advisor(s):** Trung Le

**Summary:** Ice coverage of rivers is a common phenomenon in the northern hemisphere. The ice breakup situation stems from hydrodynamics of rivers under the ice-covered situation. This breakup might lead to the ice jam and its costs and damages motivate systematic research in three-dimensional flow structures in natural streams under ice coverage. This study examines Turbulent Kinetic Energy (TKE) and shear stress distribution as main characteristics of flow under relative bend curvature. We will perform field measurements on a meandering section of the Red River in Fargo, North Dakota, using the Acoustic Doppler Current Profiler (ADCP), SonTek M9, and Acoustic Doppler Velocimetry (ADV), SonTek FlowTracker2. In addition to contributing to understanding ice jam mechanisms, our research will lead to new theories regarding river ice.

**Name: Mohsin Uddin, Ph.D Student**

**Title:** Formation and Decay of Disinfection Byproducts (DBP) in Water Distribution Systems

**Program:** Civil, Construction, and Environmental Engineering, NDSU

**Advisor(s):** Jiale Xu

**Summary:** This project aims to investigate the formation and decay of disinfection byproducts (DBPs) within water distribution systems. DBPs are toxic chemicals generated from the reactions between disinfectants and natural organic matter during drinking water treatment, posing severe health risks. The impacts of key factors including pH, temperature, residence time, types of organic matters, pipe materials, and presence of metal ions ( $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Mg}^{2+}$ , and  $\text{Ca}^{2+}$ ) on DBP formation and decay in water were individually focused on previous studies. This proposed research will systematically investigate the mechanism of DBP formation and decay in water distribution systems under variable real-world environments and operating conditions. The findings will provide insights to better understand the cumulative effects of multiple factors, which will be useful for water regulatory agencies to optimize water treatment processes and mitigate potential health risks associated with DBP exposure.

**Name: Odunola Latifah Odofin, Ph.D Student**

**Title:** Biodegradation of Per- and Polyfluoroalkyl Substances (PFAS) in Water

**Program:** Chemical Engineering, UND

**Advisor(s):** Yun Ji

**Summary:** Per- and polyfluoroalkyl substances (PFAS) are a diverse group of emerging contaminants that pose a significant threat to water quality due to their persistence, bioaccumulation, and adverse health and environmental impacts. Conventional treatment methods are often expensive and ineffective in removing PFAS compounds from water sources, which highlights the need for sustainable remediation solutions. Microbial and enzymatic degradation offer promising avenues for cost-effective and environmentally friendly PFAS remediation. This proposal explores the potential of these biodegradation approaches for sustainable water treatment. We aim to identify microorganisms and enzymes capable of degrading PFAS compounds, optimize treatment processes, and evaluate the efficacy of biodegradation in large-scale water treatment applications. Additionally, factors influencing enzyme activity will be assessed to develop optimal conditions for enzymatic degradation. Through collaboration with experts in water treatment, analytical chemistry, and environmental science, this study will contribute to eco-friendly remediation strategies for mitigating PFAS contamination in water sources.

**Name: Mousa Almousa, Ph.D Student**

**Title:** Adsorption of Lithium from Bakken Oilfield-Produced Water Using Metal-Organic Framework (UiO-66) Impregnated in Activated Carbon.

**Program:** Civil Engineering, UND

**Advisor(s):** Yeo Howe Lim

**Summary:** Produced water in the Bakken oilfield has become a significant concern since oil and gas production growth has been substantial. Reusing produced water has become necessary since the treated water can be used for potable supplies, irrigation, deep well injection, and fracking, which improves profits and mitigates groundwater pollution. The total dissolved solids (TDS) in the ND Bakken formation are greater than 300g/l, which is much higher than the concentration of salt in seawater, therefore, an alternative approach for produced water disposal by the recovery of value-added elements of produced water is proposed. The produced water is known to contain traces of lithium. This study aims to selectively extract lithium metals from produced water by utilizing nanoparticles MOF (UiO-66) impregnated within activated carbon. The sustainable management of produced water could offer an economic opportunity for the US while promoting recycling and reuse practices, thereby decreasing freshwater usage in hydraulic fracturing.

**Name: Michael Rosati, Ph.D Student**

**Title:** Enhancing Water Quality Monitoring Through Regional Machine Learning Models

**Program:** Environmental Engineering, UND

**Advisor(s):** Yeo Howe Lim

**Summary:** Water quality monitoring is essential for safeguarding freshwater ecosystems and human health. This project aims to investigate the efficacy of regional machine learning models, trained on hyperspectral data collected across diverse geographical locations, in predicting phosphate concentrations compared to site-specific models. Leveraging hyperspectral remote sensing technology and machine learning algorithms, the study aims to develop predictive models capable of estimating phosphate concentrations in water bodies. By integrating spectral analysis, feature extraction, and machine learning techniques, the project seeks to identify informative spectral signatures associated with phosphate levels. The research will involve three main phases: data collection and preprocessing, model development and calibration, and model validation and performance analysis, with a primary emphasis on machine learning

techniques. The findings will contribute to advancing water quality monitoring practices and informing evidence-based management strategies for freshwater resources.

### **Peer Reviewed Publications and Conference Proceedings:**

Almoussa, Mousa, Ban H. Al-Tayyem, Mohamed E.A. Ali, Yeo Howe Lim, and Ali Alshami. (2025). Enhanced arsenic adsorption in groundwater using zirconium MOF-Modified granular activated carbon. *ACS ES&T Water*. 5(8): 4678-4691.

Almoussa, Mousa, Yeo Howe Lim, Mohammad AlMubaidin, Ali Alshami, Ban H. Al-Tayyem, Olusegun Tomomewo, & Houdaifa Khalifa. (2025). Comparative feasibility of lithium extraction technologies in US oilfields. *Desalination and Water Treatment*. 322.

Le, Trung, Javad Souri, Palmer Obembe. (2024). On the impact of channel curvature on flow characteristics of meandering bends. *American Geophysical Union Conference*. Washington, D.C. December 2024.

Qi, Tiansong (2024). An Enhanced Modeling Framework for Simulating Hydrologic Processes in a Depression-Dominated Watershed. *ND EPSCoR Annual Conference*. Bismark, ND. November 2024.

Saha, Biraj, Mohamed Ateia, Thabet Tolaymat, Sujan Fernando, Juby R. Varghese, Debasis Golui, Achintya N. Bexbaruah, Jiale Xu, Nirupam Aich, John Briest, & Syeed Md Iskander. (2024). The unique distribution pattern of PFAS in landfill organics. *Journal of Hazardous Materials*. 479.

Samadi-koucheksaraee, Arvin & Chu, Xuefeng. (2024). Development of a novel modeling framework based on weighted kernel extreme learning machine and ridge regression for streamflow forecasting. *Scientific Reports*. 14.

Samadi-koucheksaraee, Arvin (2024). Enhancing Streamflow Prediction through Advanced Preprocessing in Machine Learning Models. *Annual South Dakota Student Water Conference*. Brookings, SD. October 15, 2024

Samadi-koucheksaraee, Arvin (2024). Levering Machine Learning and TVF-EMD for Improved Streamflow Forecasting. *ND EPSCoR Annual Conference*. Bismark, ND. November 2024.

Souri, Javad, T. Le, L. Chamorro. (2025). Comparison of the hydrodynamics of open-surface and ice-covered rivers. *UCOWR/NIWR Annual Water Resources Conference*. Minneapolis, MN. June 2025.

Souri, Javad, S.C. Congress Surya, Michael Welch, Raja Jaladurgam, Prabal Singh, Trung Le.. (2024). Monitoring flow in velocities in small streams using drone imagery. *Annual South Dakota Student Water Conference*. Brookings, SD. October 15, 2024.

Souri, Javad, Berkay Koyuncu, Trung Le. (2024). Turbulent transfer of momentum in ice-covered rivers. *American Geophysical Union Conference*. Washington, D.C. December 2024.

## **Future Research Priorities**

The NDWRRI looks to continue future work in the areas of emerging contaminants like PFAS and infrastructure projects like the Fargo-Moorhead Flood Diversion Project. Additionally, NDWRRI affiliated faculty and students will continue to pursue research priorities surrounding water management and flow, clean water and environmental threats, and wildlife and natural resources to address key areas of necessity within ND communities.

## **NDWRRI Contact**

NDSU Department 4250 Water Resources Institute, PO Box 6050, 1735 NDSU Research Park Drive, Fargo, ND 58108-6050

Dr. Trung Le, Interim Director

Email: [trung.le@ndsu.edu](mailto:trung.le@ndsu.edu)

Website: <https://www.ndsu.edu/wrri>

LinkedIn: <https://www.linkedin.com/company/north-dakota-water-resources-research-institute/>