**PROJECT TITLE: Timing is everything: When is groundwater in MN recharged?**

**I. PROJECT STATEMENT**

Shallow groundwater is essential to the state of Minnesota, where, in addition to maintaining streamflow during dry periods, it is used for municipal and agricultural purposes. Despite its importance, we do not understand *when and how much precipitation* makes it into groundwater in our state, particularly in the northern regions. It is generally thought that most groundwater recharge in Minnesota occurs during spring snowmelt, after the ground thaws but before the growing season. One implication of this assumption is that warm winters might lead to reduced snowpack volume and thus reduced groundwater recharge. However, we suspect that a second ‘window of opportunity’ for recharge in the **autumn**, after leaf-off but before the ground freezes, is comparable in importance. This autumn recharge may be critical in maintaining groundwater reservoirs during warm or dry winters where spring recharge is reduced. Understanding the timing and amount of groundwater recharge is vitally important for managing these precious stores, especially during periods of extreme drought and flooding.

Our specific objectives are to:

1. Develop a network of research sites to measure precipitation, soil, and groundwater across the state.
2. Observe the timing and magnitude of groundwater recharge (spring, summer, or fall) at the different sites and identify the weather and soil conditions that influence the timing of recharge.
3. Develop and improve upon models for estimating groundwater recharge, with a focus on capturing the interplay between soil characteristics (i.e., moisture and temperature) and groundwater infiltration.

Almost three-quarters of Minnesotans rely on groundwater for drinking water, resulting in over 700 million gallons of water withdrawn per day.

* **The Challenge:** Groundwater overuse is of particular concern in the NE, SE, and Metro portions of the state. The sensitivity of groundwater recharge to seasonal soil conditions is not well understood.
* **The Issue:** We need the most scientifically sound models of groundwater recharge to predict aquifer response to climate conditions and thus ensure acceptable withdrawal rates.
* **The Opportunity:** Current groundwater models—including those embedded within climate models—are lacking in verifiable field-data about the timing and magnitude of recharge in the cold climate of Minnesota. Our monitoring network would provide missing field data that will be synthesized to improve these models, ensuring that they accurately represent physical processes controlling recharge.

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1:** *Establish a network of research sites distributed across the state*

We will establish a network of five research sites across different climatic regions in the state. Where possible, we will overlap our sites with established field-based research sites, thereby leveraging existing facilities and avoiding costly duplication of efforts. We will add to their monitoring with any missing components. At each site we will aim to monitor weather conditions, soil moisture/temperature at various depths, groundwater, and streamflow. These data will be collected using continuously deployed sensors over a period of three full field seasons (May 2021 - November 2023). Additionally, we will characterize the overlying vegetation, topography, and predominant soils at each study site. Lastly, we will collect water samples periodically from precipitation, soil, groundwater, and streams to better understand water movement and fluxes throughout the system.

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| **Outcome** | **Completion Date** |  |
| *1. Identification of five research sites across the state* | *December 2020* |  |
| *2. Installation of monitoring equipment and site-level assessment* | *June 2021* | **ENRTF BUDGET:** |
| *3. Characterization of site topography, soils, and vegetation* | *September 2021* | **$456,639** |
| *4. Periodic collection of water samples for stable isotope analysis* | *November 2024* |  |
| *5. Continuous monitoring of weather and hydrology at each site* | *November 2024* |  |

**Activity 2:** *Synthesis of data and model assessment and development*

Current approaches to estimating groundwater recharge in MN rely heavily on the interpretation of stream hydrographs. While these methods are time efficient and require minimal environmental data, they are underpinned by simplifying assumptions that may not hold in our cold climates. Our proposed monitoring network will pair direct field observations of water movement and storage, allowing us to assess the validity of current recharge estimates. We will use our data to refine existing models of recharge that will allow for interfacing with climate-models.

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| **Outcome** | **Completion Date** |  |
| *1. Compilation of data that will be publically available* | *June 2024* |  |
| *2. Quantify the amount of groundwater recharge across the sites* | *June 2024* | **ENRTF BUDGET:** |
| *3. Determine the timing of groundwater recharge at each site* | *June 2024* | **$63,525** |
| *4. Refine existing groundwater models* | *June 2024* |  |
| *5. Disseminate results via publications and presentations* | *October 2024* |  |

**III. PROJECT PARTNERS:**

**A. Partners receiving ENRTF funding**

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| **Name** | **Title** | **Affiliation** | **Role** |
| **Dr. Salli Dymond** | **Assistant Professor** | **UMN-Duluth** | **Lead PI** |
| **Dr. John B. Swenson** | **Associate Professor** | **UMN-Duluth** | **Co-PI** |

**B. Partners NOT receiving ENRTF funding**

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| **Name** | **Title** | **Affiliation** | **Role** |
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**IV. LONG-TERM- IMPLEMENTATION AND FUNDING:** This project will provide data to determine the timing and amount of groundwater recharge across different portions of the state. We will use the field-data to update existing groundwater recharge models to help the DNR better manage the state’s groundwater resources. We will keep our sensors deployed at the existing sites, which have the potential to collect long-term data. This project directly addresses two LCCMR priorities for the 2020 funding cycle: A. Foundational Natural Resource Data and Information, and B. Water Resources.

**V. TIME LINE REQUIREMENTS:** We request funding for three full field seasons plus an additional 9 months to complete analyses and writing (July 1, 2020 - June 30, 2024). Three field seasons will increase the likelihood of capturing a wider range of thermal and hydrologic conditions and thus allow us to gain more physical insight into the feedbacks and history dependence that control the timing of groundwater recharge.