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Senator Jeff Golden,
Chair Senator Fred Girod,
Vice-Chair Senate Committee on Natural Resources
State Capital Salem, OR 97301

02-03-2023

RE: Testimony for Bill SB 455 - Relating to the Development of a Recharge Testing Program in Oregon

Submitted Via Electronic Submission to Senate Committee on Natural Resources by Dr. Salini Sasidharan, Oregon State University

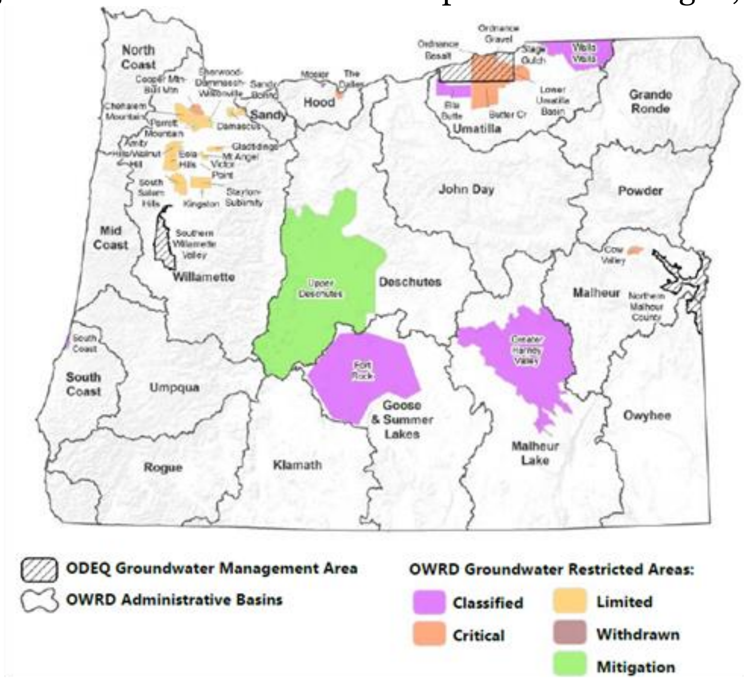
Position - Neutral

Dear Chair Golden, Vice-Chair Girod, and Members of the Committee:

My name is Salini Sasidharan, I am an Assistant Professor/ Sustainable Groundwater Management Engineer at the Department of Biological and Ecological Engineering, Oregon State University (OSU). I perform research at the Sustainable Groundwater Quantity and Quality Innovation Lab. My position at OSU was part of State Legislative action, and Water Cluster hire to address critical water management issues in the state, region, nation, and globe, improve natural resource management, achieve agricultural competitiveness and resilience through interactions with the state and regions many stakeholders while maintaining key ecosystem services in our landscapes. In addition, I also act as the elected Chair for the Lower Umatilla Groundwater Management Area (LUBGWMA) Committee. I would like to take a Neutral Position on Bill SB455, and I would like to share my experience with Managed Aquifer Recharge.

While groundwater accounts for approximately 97 percent of all liquid freshwater on earth, it is being hidden from our view, creating a cascade of challenges for its sustainable use and protection. The result is that groundwater quantity and quality management is almost universally neglected until the human and economic costs become too obvious to ignore. When groundwater is compromised, the consequences for human health, agriculture, and the economy are far-reaching and can span generations. Moreover, as water variability increases with human-induced water shortages, climate change and/or natural climate and earth cycles, groundwater's importance as a water source will increase.

Oregon is geographically and climatically diverse and experiencing environmental challenges. As a result, many groundwater resources are compromised in Oregon, which led to the declaration of three Groundwater Management Areas (GWMA) and 22 designated Groundwater Administrative Areas (GAA) in Oregon (Figure 1). In some areas, reductions in groundwater use coupled with artificial recharge have led to water level recovery or stabilization. However, intensive groundwater withdrawals could contribute to the depletion of streams, land subsidence, irreversible reduction of storage area, drying up of pumping wells, increased cost of deep aquifer pumping, exacerbated seawater intrusion at the coastal basin, disconnected stream-aquifer systems, and compromised groundwater quality.



We could manage these precious water resources by employing innovative management and engineering tools. In Sustainable Groundwater Quantity and Quality Innovation Lab at OSU, we focus on research for building a climate-resilient water resource management by designing innovative managed aquifer recharge (MAR) or artificial recharge through systems such as drywell. MAR is a cross-cutting technology that intentionally diverts, transports, stores, infiltrates, and recharges excess conventional and unconventional water into aquifers during a wet period for subsequent recovery during dry periods. MAR has been expanding in popularity to improve groundwater resources because of its low implementation cost, evaporation loss compared to surface reservoirs, and ability to infiltrate large volumes of water. MAR can be accomplished through infiltration basins, aquifer storage and recovery (ASR), aquifer storage, transfer, and recovery (ASTR), flooding land (Flood-MAR), flooding agricultural land (Ag-MAR), and vadose zone recharge (drywell). In addition, MAR provides the following additional benefits. 1) increase summer baseflows, 2) deliver cool groundwater return flows to maintain cold-water fisheries, 3) urban stormwater management, 4) flood mitigation, 5) reduce surface water pollution, 6) act as a hydraulic barrier for seawater intrusion, 7) dilute contaminated groundwater, and 8) generate electric power using regenerative drive technology.

I have ten years of experience working on various MAR practices worldwide, including CSIRO Australia (during my Ph.D. at Flinders University, Australia), a pioneer of ASR and ASTR technology worldwide. In the past six years, during my Postdoc at the University of California, Riverside, I have been working on several grants provided by EPA and USDA-NIFA on MAR projects in California, especially on drywell-MAR and Ag-MAR to mitigate the groundwater depletion issues in

Oregon State University

Southern California and Central Valley to help with California's Sustainable Groundwater Management Act (SGMA). This research will help to improve groundwater quantity and quality, compensate for climate change, secure water supply, manage saltwater intrusion, restore groundwater and stream water exchange, mitigate flooding, and provide ecosystem functions.

Since I joined OSU my experience in Oregon related to MAR has been excellent. My involvement as a Chair of LUBGWMA Committee has given me many opportunities to explore MAR opportunities at Eastern Oregon to help mitigate both water quality and water quantity issues in the region. I have received several fundings to perform research on MAR, and several federal and state funding opportunities are currently under review.

The multidisciplinary research at my Sustainable Groundwater Quantity and Quality Innovation Lab includes the following research topic related to MAR

- Development of pretreatment for source water and posttreatment for recovered water for various MAR systems
- Subsurface and groundwater modeling for MAR
- Site-specific comparison of various MAR techniques
- Alternative water for groundwater recharge, such as recycled wastewater
- Use of geophysical tools for site characterization

I believe Managed Aquifer Recharge success stories are making the "invisible" resource of groundwater increasingly "visible" and have been proven to produce a wealth of benefits from integrated management of a wide range of conventional and unconventional water resources, paving the way for global adoption to achieve sustainable development goals for water. However, I would like to highlight that time is of the essence. Therefore, a state action plan focusing on region-based research studies, piolet scale demonstration funding, support for large-scale implementation, and regulatory framework on water quantity, quality, water rights, and water banking and recovery for various Managed Aquifer Recharge are crucial for accelerated success and achieving climate resilience and groundwater sustainability. I have added the Water Resources IMPACT article that I wrote on Managed Aquifer Recharge for further information on MAR.

Thank you so much for the opportunity to represent Oregon State University,

Salini Sasidharan |Ph.D.
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Department of Biological & Ecological Engineering
College of Agricultural Sciences | **Oregon State University**

WATER RESOURCES

IMPACT

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FEATURE

Managed Aquifer Recharge: Making the Invisible Visible and Beyond

Salini Sasidharan

CLIMATE CHANGE IS PRIMARILY A WATER CRISIS.

Climate change alters weather patterns, leading to extreme weather events, unpredictable water availability, water scarcity, and water contamination. Humans, animals, plants, ecosystems, and other living forms feel its impacts through worsening floods, rising sea levels, shrinking ice fields, wildfires, and droughts. As a result, millions are impacted daily and are at risk.

When we talk about climate change, we often picture drying lakes and rivers, low water levels in reservoirs, and dried-out agricultural fields and wetlands. However, many water resources are largely hidden from view. For example, groundwater, a crucial freshwater source for humanity, is found underground in aquifers—porous rock or sediment saturated with water. It is underneath our feet and invisible, everywhere and nowhereat once. But this "invisible" resource can help fight climate change, and we cannot afford to wait. As the world spotlights groundwater by "making the invisible visible" on behalf of the UN, a promising and innovative approach to sustainable groundwater management and resilience—managed aquifer recharge (MAR)—is gaining fame.

> *Two-thirds of the Earth is covered by water, yet less than one percent of the world's freshwater is accessible for use. Groundwater is the largest component (about 70%) of accessible freshwater.*

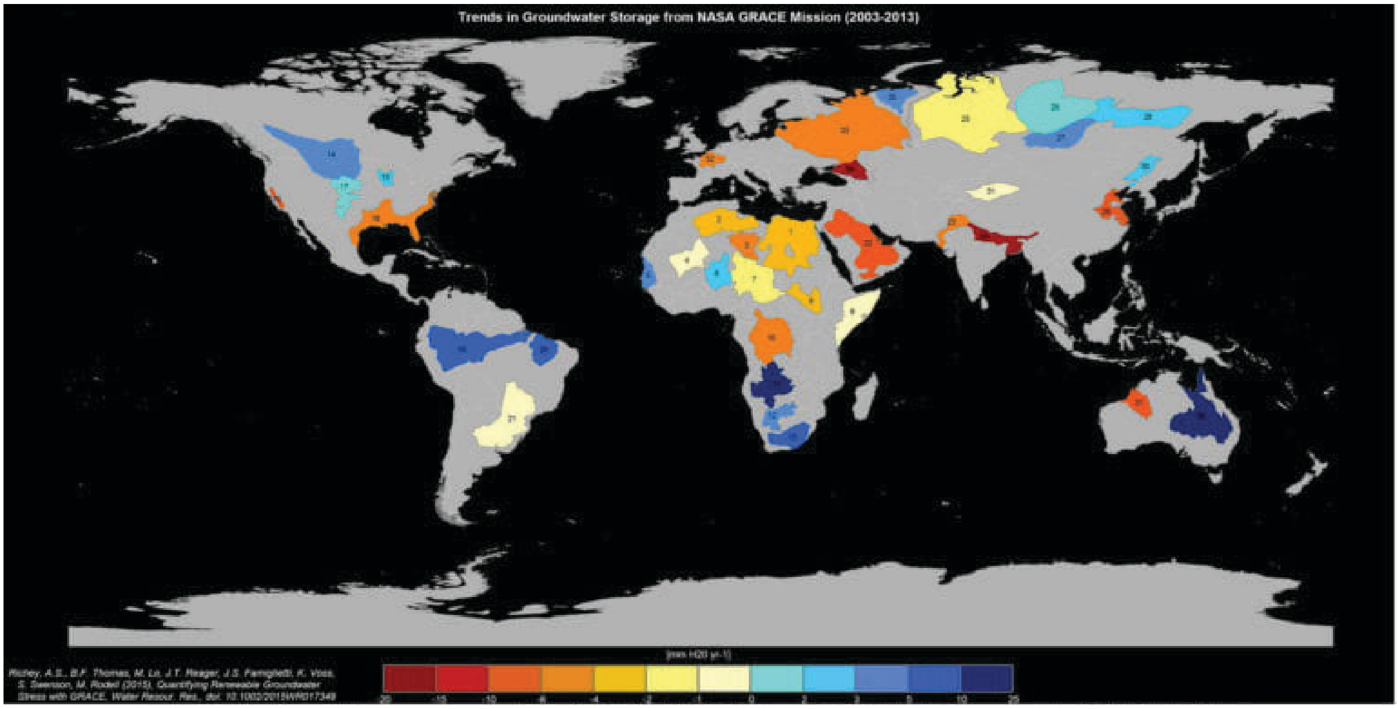
Groundwater: An Invisible Resource

Because groundwater is an "invisible" resource, it remains little understood and undervalued. Two-thirds of the Earth is covered by water, yet less than 1% of the world's freshwater is accessible for human use. Groundwater is the largest component (about 70%) of accessible freshwater. The amount of water stored in groundwater systems or aquifers is greater than that of all rivers, lakes, and the largest human-made reservoirs combined. Groundwater resources supply nearly half the world's drinking water and support the agricultural activities that provide food for billions of people. But that is not all: various industrial processes use groundwater, including data centers, livestock, energy, mining, oil and gas, engineering, construction, and manufacturing facilities.

Despite its crucial role, the general public and most decision makers know and understand very little about groundwater. But this is changing. As groundwater becomes an increasingly important resource worldwide, more people than ever are learning about its value and functions. Views about how groundwater systems are linked with other systems are changing accordingly. An important piece of this puzzle is the problem of groundwater depletion.

Groundwater Depletion: A Global Problem

Groundwater depletion is often defined as long-term water-level declines caused by continuous groundwater pumping. Many areas of the United States and other parts of the world are experiencing groundwater depletion. According to the U.S. Geological Survey (USGS), the water stored in the ground can be compared to money kept in a savings bank account. If you withdraw money faster than you deposit new money, you will eventually start having account-supply problems and deplete your savings intended



Underground aquifers are less susceptible to the effects of climate change than surface water reservoirs. But as NASA's data indicates, many aquifers are being depleted faster than they can be recharged. Yellow, orange, and red indicate aquifers that are experiencing a net loss of water. Source: University of California Irvine/National Aeronautics and Space Administration (NASA).

for emergency use. Most aquifers take thousands of years to refill, relying on snowmelt and rain to quench depleted reservoirs. But with climate change and drought pressuring arid communities, agriculture, and energy grids, reliance on groundwater is increasing. This means that aquifers are being drained faster than natural systems can replenish them, and the ramifications are far-reaching. Intensive groundwater withdrawals can lead to a host of problems: depletion of streams, land subsidence, irreversible reduction of storage area, drying up of pumping wells, increased cost of pumping from deep aquifers, aggravated seawater intrusion at the coastal basin, disconnected stream-aquifer systems, compromised groundwater quality, and the formation of sinkholes.

Additionally, groundwater depletion spells major economic losses in groundwater-irrigated agriculture. For example, California's Central Valley is one of the most productive agricultural regions in the world. More than 250 different crops are grown there, with an estimated value exceeding $17 billion per year. This multi-billion-dollar agricultural industry relies almost entirely on irrigation. If water supplies in the region are depleted—through climate change or poor management of groundwater resources—a loss of productivity and profit is not far behind.

Securing water availability, safeguarding groundwater-related environmental values, and sustainably managing groundwater resources are vital to the health of the environment, the economy, and society. If managed intelligently and sustainably at individual points of withdrawal (such as farms, irrigation districts, or industrial facilities), groundwater has significant untapped potential to serve as a potent source of climate resilience in uncertain years and decades. The rising global temperature, population, and need for more productive agricultural land reduce the effectiveness of water storage in surface reservoirs due to high evaporative loss, displacement of people, loss of high-quality agricultural land, changes in downstream flow patterns, and adverse impacts on aquatic fish populations. Therefore, managing water storage in aquifers is an increasingly appealing alternative. Unlike surface reservoirs, groundwater is naturally insulated from surface evaporation and therefore protected—to some degree, at least—from climate change impacts. Storage in aquifers can be accomplished using practices with minimal impacts on land use and human displacement. In the face of climate change, sustainable use of "hidden" groundwater requires the strategic and creative use of existing techniques such as managed aquifer recharge.

Making the Invisible Visible

The concept of purposeful underground water storage known as managed aquifer recharge (MAR) has been around for more than a century. But it has been gaining renewed attention and fresh prominence since the late 20th century as our worldwide climate crisis has intensified. MAR is the intentional diversion, transport, storage, infiltration, and recharge of excess surface water (snowmelt, streamflow, floodwater, stormwater) and other excess water (recycled wastewater, desalinated ocean water, and water from dewatering mining activity) into aquifers during a wet period for subsequent recovery during dry periods or for the environmental benefit. MAR can be accomplished through a variety of approaches such as infiltration basins; aquifer storage and recovery (ASR); aquifer storage, transfer, and recovery (ASTR); flooding of land (Flood-MAR); flooding of agricultural land (AgMAR); and vadose zone infiltration devices like drywells.

Managing Aquifer Recharge: A Showcase for Resilience and Sustainability, a new book edited by Yan Zheng, Andrew Ross, Karen Villholth, and Peter Dillon, presents real-life examples of MAR from around the world. The book details how people have collaborated, from the village to the state level, to improve the quantity and quality of water supplies and buffer them against drought and emergencies. MAR has been proven to produce a wealth of benefits from integrated management of a wide range of conventional and unconventional water resources, paving the way for global adoption to achieve sustainable development goals for water. These MAR success stories are making the "invisible" resource of groundwater increasingly visible.

Managed Aquifer Recharge in Agricultural Regions

The 2014 Sustainable Groundwater Management Act in California requires groundwater basins with significant overdraft, land subsidence, seawater intrusion, water-quality degradation, or groundwater pumping-induced reduction in streamflow to develop sustainable groundwater management practices. Among these practices is agricultural managed aquifer recharge (AgMAR or FloodMAR), which can include winter irrigations in various forms, recharge through unlined canals and set-aside land (recharge basins), in lieu recharge, and other forms. This innovative method takes advantage of large sections of agricultural land to recharge winter runoff not stored or used before ocean discharge, and has gained popularity in California. AgMAR utilizes in-place irrigation infrastructure to recharge excess water and replenish aquifers at large scales without changing land use. It can be practiced over broad agricultural regions due to connectivity with rivers and infrastructure used to deliver water for irrigation. Typically, however, there will be only a short period when crops are not grown in agricultural fields or are not under pre-growing preparation, depending on the crop type. Therefore, agricultural fields provide only a time-limited opportunity for MAR operation and can miss the opportunity to capture, flood, and recharge water during some seasons.

Another approach that is gaining prominence in the United States and beyond is drywell-MAR. A drywell is a vadose zone infiltration system. Drywells (vadose zone injection wells) are commonly used as low-impact development practices to capture urban stormwater

As surface water reservoirs come under threat from climate change, AgMAR and drywell-MAR sites, such as this one in Fresno, California, are playing an increasingly visible role in water resource management. Sources: Travis Pacheco and Salini Sasidharan.

runoff. Drywell-MAR has a small footprint and is, therefore, a great solution where land availability is scarce. In contrast to AgMAR, drywells have minimal evaporation losses, and subsurface heterogeneity can enhance infiltration and recharge from drywells. Because of this, drywell-MAR is increasingly popular as an alternative or conjunctive MAR technology for AgMAR when poor surface soil or low permeable clay layers are present at shallow depths.

A Journey with Hurdles

As with any innovation, there are still hurdles to the widespread implementation of MAR. Further investigations into aquifer storage capacity and efficiency will be necessary to enable siting and design of projects. These must be coupled with water-quality evaluation and assessment of environmental and infrastructure impacts. Management of groundwater quantity and quality will also require cooperation among government agencies. While the policy dimensions are relatively simple for short-term storage, water banking for drought relief requires agreed-on water-sharing plans and honoring of water entitlements. Community engagement may take time. Enrique Fernández Escalante and coauthors recently reviewed 22 regulations, guidelines, or MAR site operation rules to construct the monitored and intentional recharge (MIR) conceptual model. A vision for a successful MAR project relies on careful regional and site planning.

Furthermore, there are other limits as well. MAR is not suitable for all locations—it is useful only in areas with sufficient surface water resources or alternative water that could be used for recharge. Ultimately, MAR must be placed in a larger context, recognizing that it is one approach in a broader portfolio of methods necessary for managing sustainable quantities and groundwater qualities for generations to come. ■

Salini Sasidharan is an assistant professor and sustainable groundwater management engineer at the Department of Biological and Ecological Engineering, Oregon State University. She is an expert in managed aquifer recharge with a special focus on integrated water quality and quantity with ecological and environmental engineering approaches for vadose zone MAR such as drywell-MAR.

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