PACIFIC INSTITUTE

Diversifying Colorado's Water Portfolio

THE POTENTIAL FOR STORMWATER CAPTURE AND USE TO CONTRIBUTE TO A WATER RESILIENT FUTURE

Executive Summary

OCTOBER 2024

IN PARTNERSHIP WITH

WRIGHT WATER ENGINEERS, INC.

ONEWATER ECON

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ABOUT THE PACIFIC INSTITUTE

Founded in 1987, the Pacific Institute is a global water think tank that combines science-based thought leadership with active outreach to influence local, national, and international efforts in developing sustainable water policies. From working with Fortune 500 companies to frontline communities, our mission is to create and advance solutions to the world's most pressing water challenges. Since 2009, the Pacific Institute has also acted as co-secretariat for the CEO Water Mandate, a global commitment platform that mobilizes a critical mass of business leaders to address global water challenges through corporate water stewardship. For more information, visit pacinst.org

ABOUT WRIGHT WATER ENGINEERS, INC.

Founded in 1961, Wright Water Engineers is an employee-owned and operated, full-service water resources, environmental, and civil engineering firm based in Denver, Colorado, with outlying offices in Glenwood Springs and Durango. WWE's staff of approximately 50 people include professional engineers, hydrologists, scientists, biologists, chemists, geologists, and hydrogeologists. Areas of service include stormwater and drainage engineering, water rights, water conservation, watershed management, wildfire hydrology, water and wastewater system planning and design, wetlands, and water supply. For more about Wright Water Engineers, Inc., please visit wrightwater.com

ABOUT ONE WATER ECON

One Water Econ is a small economics consulting firm known for innovation and leadership within the water sector. We bring economic and policy expertise to help solve complex water sector challenges. One Water Econ's clients include water utilities, government agencies, research foundations, and nonprofit organizations. We routinely partner with engineers, scientists, and other multidisciplinary team members to provide a holistic approach to water resource management. Examples of our key services include benefit cost, triple bottom line, and economic impact analysis; ecosystem service valuation; market-based solutions for water resource management; affordability assessments; and analysis of water use and demand across sectors. For more about One Water Econ, please visit onewaterecon.com

ABOUT THE AUTHORS

Pacific Institute

Shannon Spurlock

Shannon Spurlock is a Senior Researcher at the Pacific Institute. Focusing on public policy & practice uptake, she develops and implements strategies for advancing policies and practices on priority topics for the organization, with a focus on scaling the integration of approaches with multiple benefits into public policy and planning. Prior to joining the Pacific Institute, Shannon ran a consulting business, where her projects included researching interagency collaboration among water utilities for the purpose of scaling water reuse and overseeing the development of a web-based tool that compared ratepayers' water rates across regions and utilities for the purpose of demonstrating affordability or lack thereof. Additionally, Shannon has extensive food systems experience and has led policy change at the local and state level. Shannon holds a bachelor's degree from the University of Colorado, Boulder and a master's degree in Nonprofit Management from Regis University.

Morgan Shimabuku

Morgan Shimabuku is a Senior Researcher at the Pacific Institute. She conducts research on a wide range of water management issues, including solutions to water equity and access challenges, benefits and trade-offs of water management strategies, and a universal approach for measuring water resilience at the basin scale. Prior to joining the Pacific Institute, Morgan was a senior program manager at an environmental nonprofit in Colorado where she ran residential and commercial water conservation program operations in partnership with municipal water providers. Previously, she worked as a scientist at a water resource consulting firm and supported the PacFish/InFish Biological Opinion Effectiveness Monitoring Program of the US Forest Service as a stream technician. Morgan received a bachelor's degree in Environmental Studies and Geology from Whitman College and a master's degree from the Department of Geography at the University of Colorado, Boulder, where she studied climate change, hydrochemical cycling, and snow hydrology at the Institute of Arctic and Alpine Research.

Jessica Dery

Jessica Dery is a Research Associate at the Pacific Institute. Her work addresses impediments and incentives for the use of recycled water in agriculture by merging science, policy, and outreach to promote communication and trust. Jessica has worked on a variety of interdisciplinary projects related to water quality and water reuse including agriculture and food safety, water treatment technologies, power generation, and public perception. Her experience includes conducting synthesis research, co-developing outreach products, and working directly with agriculture communities, utilities, and regulatory agencies. She received a bachelor's degree in Microbiology from Arizona State University and a master's degree in Soil, Water, and Environmental Science from the University of Arizona.

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Jane Clary

Jane Clary, Vice President and Principal Scientist at Wright Water Engineers, Inc., in Denver, CO, where she has worked for 31 years focusing on water quality, stormwater, watershed management and water conservation. She has co-authored multiple stormwater quality and water conservation manuals and guidance with entities such as the Water Research Foundation, the Mile High Flood District and the Green Industries of Colorado (GreenCO). Jane also served on the Colorado Water Quality Control Commission from 2017-2020. Jane holds a B.S. in Economics from Vanderbilt University and an M.S. in Environmental Science from the University of Colorado.

Natalie Collar

Natalie Collar, Senior Hydrologist at Wright Water Engineers, Inc. She has experience in statistical hydrology, disturbance hydrology, hydrologic and hydraulic modeling, meteorology, watershed mechanics, wetland science, stormwater management, and big data science. Natalie received a Ph.D. in Civil and Environmental Engineering from the Colorado School of Mines in 2022, and has M.S. (2015) and B.S. (2009) degrees from the University of California Santa Barbara in Watershed Science and Biology, respectively.

Rachel Pittinger

Rachel Pittinger, Senior Water Resources Engineer at Wright Water Engineers, Inc., in Denver, CO with over 20 years' experience working on projects related to water supply and planning, water rights investigation and valuation, water rights operation modeling, watershed modeling and planning, project funding, and technical evaluation related to water supply projects and construction management. She was formerly a project manager on water resources engineering and planning projects at the Colorado Water Conservation Board, where she oversaw numerous raw water supply and infrastructure projects. She is registered professional engineer in three states including Colorado, Wyoming and Utah.

One Water Econ

Janet Clements

Janet Clements, President of One Water Econ, has more than 20 years of experience in water resource economics and planning. She conducts benefit cost, triple bottom line, and economic impact analyses to inform water resource management decisions. Her areas of expertise include integrated water resource management, natural infrastructure, water sector funding and financing, and affordability of water services. Ms. Clements has conducted several studies for national water sector organizations and currently serves on EPA's Environmental Finance Advisory Board. Prior to attending graduate school, she was a water and natural resources planner in a rural California county. Ms. Clements holds a B.S. in Sustainable Resource Management from The Ohio State University and an M.S. in Agricultural and Natural Resource Economics from Colorado State University.

Jeff Odefey

Jeff Odefey, Director of Water Policy at One Water Econ, has over 20 years of experience leading multi-disciplinary efforts to promote integrated management of water resources through progressive regulation, sustainable financing, market-based mechanisms, and policy reforms. His work has focused on promoting green infrastructure, water conservation, conservation finance strategies and integrated water management as pathways to preserve and protect healthy waters and communities. Previously he served as a program director for American Rivers and as staff attorney for both Waterkeeper Alliance and Hudson Riverkeeper. He holds a B.A. in English and Art History from the University of Colorado, an M.A. from the University of Montana, and is a magna cum laude graduate of the Pace University School of Law.

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Additionally, over the course of more than a year, the Expert Review Panel generously and graciously provided critical input to guide and inform this project. The Project Team acknowledges the subject matter expertise shared by the Expert Review Panel. We are grateful for their time and insight. The Project Team takes full responsibility for the content of this report.

We thank the following individuals for their service on the Expert Review Panel:

- Stephen Barr, City of Littleton
- Joan Card, Culp & Kelly
- John Covert, Denver Trout Unlimited
- Dr. Ryan Gilliom, formerly of LRE Water
- Jens Jensen, Welborn Sullivan Meck & Tooley
- Frank Kinder, Northern Colorado Water Conservancy District
- Caroline Koch, WaterNow Alliance
- Cynthia Koehler, WaterNow Alliance
- Justin Mattingly, US Environmental Protection Agency
- Mark Mitisek, LRE Water
- Holly Piza, Mile High Flood District
- Dr. Sybil Sharvelle, Colorado State University
- Dave Smith, Water Innovation Services
- Dr. Katie Spahr, Denver Water
- Dr. Scott Struck, National Renewable Energy Laboratory
- Jessica Thrasher, Colorado State University
- Pat Wells, Northern Colorado Water Conservancy District
- Susan Wood, Regional Transportation District
- Jim Yahn, North Sterling Irrigation District
- Dr. Harry Zhang, The Water Research Foundation

The project team also gratefully acknowledges prior work on Sterling Ranch by Dr. Ryan Gilliom (formerly) and Mark Mitisek of LRE Water, which is referenced in this report.

Executive Summary

The 2023 Colorado Water Plan estimates that by 2050 there will be a municipal and industrial water supply gap of between 250,000 and 750,000 acre-feet per year (CWCB 2023). *Diversifying Colorado's Water Portfolio: The Potential for Stormwater Capture and Use to Contribute to a Water Resilient Future* seeks to advance understanding of the extent to which rainwater harvesting and stormwater capture in urban areas can fill this gap.

This project achieves this goal by 1) synthesizing Colorado water law as they relate to rainwater harvesting and stormwater capture and use, 2) quantifying the volumetric potential of rainwater harvesting and stormwater capture in urban areas across each of Colorado's eight river basins and the Denver metropolitan area, 3) identifying benefits associated with stormwater capture and use, 4) highlighting examples of urban stormwater capture and use projects in Colorado, 5) engaging and facilitating input from a diverse Expert Review Panel, and 6) preparing recommendations and suggesting next steps.

KEY FINDINGS

The project clarifies perennial questions about the role and potential of rainwater harvesting and stormwater capture and use to meet Colorado's water supply gap. For the first time, there is a baseline estimate of the volumetric and economic value for urban rainwater harvesting and stormwater capture and use in Colorado. This project answers questions about the scenarios in which rainwater harvesting and stormwater capture and use is currently allowed as well as the scales at which it may be most beneficial .

These findings are the result of extensive research, analysis, and collaboration with experts from Colorado and throughout the United States who served on the project's Expert Review Panel. The methodology used to calculate the volumetric potential of urban rainwater harvesting and stormwater capture and use was rigorously vetted and factors such as seasonality, elevation, and storm sequencing events informed these estimates.

ES Photo 1. Cistern at the CSU Spur Campus. *Source: Jane Clary*

As noted below in the findings, urban rainwater harvesting and stormwater capture and use are limited within Colorado's current legal (water rights) and regulatory frameworks. To highlight examples of how stormwater capture and use can be implemented within the existing water rights framework, the full report includes several case studies from Colorado, including the CSU Spur Campus where rainwater and stormwater runoff are captured and used on-site (ES Photo 1).

The key findings from this project include:

Colorado Water Law Surrounding Rainwater Harvesting and Stormwater Capture and Use

- Residential-scale rainwater harvesting (e.g., 110-gallon storage capacity) is allowed without a decreed water right. This regulation is consistent with Colorado water law that is based on the Prior Appropriation Doctrine and protects downstream water users from injury to their decreed water rights.

- Obtaining a water right for rainwater harvesting or stormwater capture and use beyond 110 gallons at a residential household in Colorado requires significant upfront legal and engineering costs on a project-specific basis, typically requiring an augmentation plan, purchase of replacement water for augmentation from a willing water provider, and ongoing engineering and legal costs for water rights accounting and filings with the State Engineer's Office.

- Only one rainwater harvesting pilot project has been applied for and approved in Colorado since legislation was passed in 2009. Deterrents for applying for pilot projects may include significant engineering and legal costs, intensive hydrologic monitoring requirements, dual infrastructure cost (to meet stormwater management requirements separately), and uncertainty about the likelihood of long-term success of a project as a reliable water supply.

- The concepts of Historic Natural Depletions and Regional Factors accepted for Colorado Water Conservation Board pilot projects open the door to broader rainwater harvesting and stormwater capture and use projects for new developments in Colorado. Nonetheless, the current legal, scientific, and engineering burden, along with uncertainty regarding success in water court, likely deter new developments from pursuing rainwater harvesting or stormwater capture and use beyond two 55-gallon rain barrels, unless no other water source is available, or a research/conservation objective motivates a pilot project. From a policy and water court process perspective, increased clarity on the likelihood of success in water court and minimum data requirements for success would be a helpful next step if broader implementation of stormwater capture and use projects is desired in Colorado.

- Stormwater management is allowed (and required) in Colorado for both flood control and stormwater quality purposes. This "stormwater management" is allowed outside of the concepts of rainwater harvesting and stormwater capture and use because the stormwater that is detained or infiltrated is not allowed to be put to a beneficial use.

Volumetric Potential of Rainwater Harvesting and Stormwater Capture and Use in Colorado

Based on analysis of several rainwater harvesting and stormwater capture and use scenarios, we find:

- For rainwater harvesting implemented at currently allowed 1–4-unit residential households in two 55-gallon rain barrels, and for a hypothetical rainwater harvesting scenario in 500-gallon cisterns at the same households, the potentially captured stormwater volumes by basin represent a small source of water for closing basin demand gaps. The volume of water from these two scenarios is generally on the order of less than 1% of residential outdoor water demand from 2015. This proportion may change, and improve, as outdoor landscapes become more sustainable and irrigation demand is reduced. Nonetheless, there are other potential benefits of rainwater harvesting at this scale that could make pursuing this strategy a beneficial endeavor.

- Stormwater runoff from existing impervious surfaces (e.g., rooftops, roads, parking lots) in Colorado's urban areas represents a substantial water source. However, this water that returns to streams through surface runoff or alluvial groundwater is not considered a "new water" source in over-appropriated basins because this water has essentially already been claimed for use under existing water rights filed in water court. Although there are some exceptions to this general statement, claiming the right to use this runoff would require site-specific water rights analysis, a plan for augmentation of out-of-priority depletions, and water court processes, or changes to existing water law. Nonetheless, these estimates suggest that larger scale stormwater capture could provide runoff volumes that could be used to meet a meaningful portion of outdoor residential water demand. Legal, economic, environmental, public health, and other site-specific constraints would need to be evaluated before pursuing stormwater capture and use at specific locations across the state.

- Based on hydrologic analysis completed as part of the Sterling Ranch pilot project, the concepts of Historic Natural Depletions and Regional Factors (Gilliom 2019) provide a framework for larger scale implementation of stormwater capture and use for new greenfield developments (e.g., neighborhood-scale). If these methods are adopted beyond the pilot project framework, there is potential for a new development to claim the right to capture and use a portion of the runoff from new impervious surfaces. For example, in the South Platte Basin, applying Regional Factors to hypothetical 10% and 25% increases in impervious area and using 10% to 25% capture rates for impervious area, the volumetric potential for urban stormwater runoff to serve as a "new water" source would be on the order of 3,100 to 19,600 AFY. More refined land development projections and Regional Factors in other river basins would be needed to improve this estimate or broaden it for use in other basins.

Valuing Rainwater Harvesting and Stormwater Capture and Use in Colorado

- This assessment of the economic value of rainwater harvesting and stormwater capture and use in Colorado focused on the avoided costs of providing potable water for outdoor landscape uses, the value of the water quality improvements associated with rainwater and stormwater capture, and the value of other associated benefits, such as reduced risk of property loss due to wildfire. Overall, the value of these benefits is constrained by the limited capture volumes permitted under current Colorado law that effectively restricts rainwater harvesting to residential properties with two 55-gallon rain barrels. Larger scale applications of stormwater would be required for economic viability along with water rights. Specific findings in the preceding section can be summarized as follows:

- In several regions of the United States (and internationally) rainwater harvesting and stormwater capture and use practices have demonstrated their ability to provide sufficient water to meet residential outdoor water demands, offsetting the need for water providers to provide potable water for this purpose. In some studies, these potable water offsets are significant.

- Although rainwater harvesting and stormwater capture and use have the potential to provide alternative or complementary sources of water supply in Colorado's urbanized areas, the 110-gallon residential capture volume currently allowed without water rights is insufficient to meaningfully contribute to overall water system resilience.

- When implemented at scale, rainwater harvesting has the potential to make more meaningful contributions to the overall water supply portfolio and conservation targets in some basins. This is particularly true for scenarios envisioning the possible offsets created by widespread adoption of 500-gallon or larger cisterns, which would require water rights under current water law.

- Captured rainwater can offset costs to residential water customers as well as retail water providers. Water providers can avoid energy, treatment, and infrastructure costs associated with delivering potable water for residential landscape irrigation. Legal limitations on stormwater capture and use in Colorado create unfavorable conditions for realizing these avoided cost benefits.

- As exemplified for the scenario examining the capture of runoff from 10% of impervious surfaces, neighborhood-, community-, or regional-scale stormwater capture can contribute to water supply reliability by creating additive or marginal sources of supply, creating flexibility and redundancy within the supply system. The analysis shows that allowing for greater capture volumes could meaningfully reduce the water supply gaps projected by several of the Basin Plans and associated economic impacts. However, larger scale infrastructure and storage would be needed to realize this potential.

- The rainwater harvesting practices reviewed in this report (i.e., the 110- and 500-gallon storage volumes) may have limited practical potential to reduce water quality impairments in Colorado's urbanized areas. Implementation challenges (e.g., reliance on homeowners to maintain practices) and relatively low capture volumes may prevent this benefit from being fully realized.

- Available evidence suggests that larger scale stormwater capture and use adoption will have greater benefits (relative to costs). As demonstrated by Sterling Ranch and other projects, capture in larger volume systems either at the site- or neighborhood-scale can provide sufficient volumes to meaningfully offset potable water demand, reduce water quality impacts, and potentially provide additional, high-value benefits.

Key Recommendations

To optimize the opportunity for urban rainwater harvesting and stormwater capture and use to contribute to the diversifying of Colorado's water portfolio, we offer a suite of 16 recommendations which fall into the following thematic areas:

- Build on existing legal pathways to allow stormwater and rainwater to meaningfully contribute to and diversify water portfolios.
- Provide guidance to land use planners and housing developers on how to include stormwater and rainwater as alternative water supplies to offset potable water use.
- Create the enabling conditions to advance stormwater capture and use and rainwater harvesting as strategies to contribute to more water-resilient communities.
- Conduct a more detailed assessment of the co-benefits of stormwater capture and use to identify targeted areas for implementation and potential co-funding partnerships.

Recommendations seek to advance the enabling conditions under which urban rainwater harvesting and stormwater capture and use will be able to meaningfully address Colorado's estimated municipal and industrial water gap, ultimately contributing to a more water resilient future for all those that live, work, and recreate in the Centennial State. To read the full report, **click here**.

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