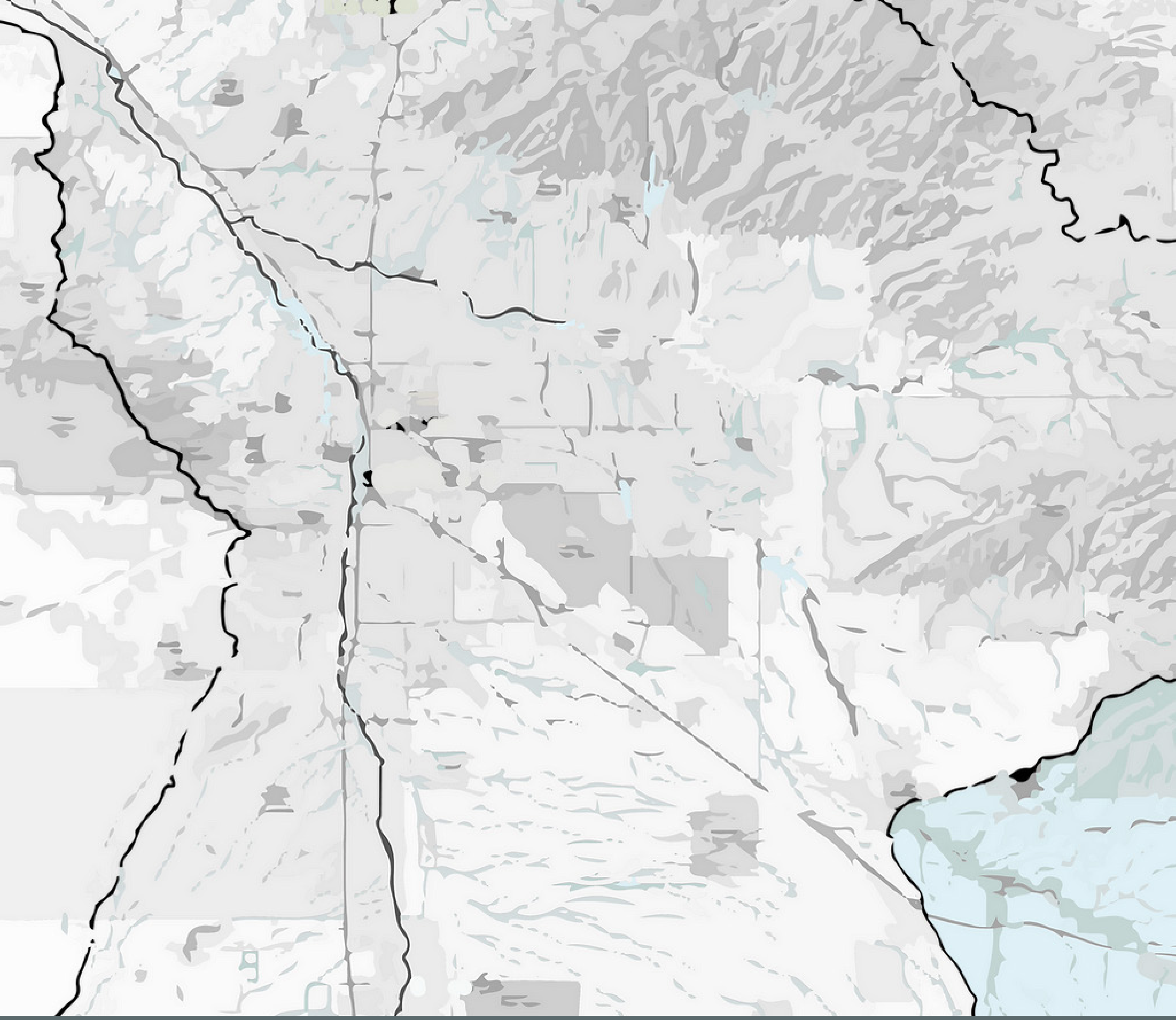

Advancing a Net Zero Urban Water Future in the US Southwest

Governance and Policy Challenges and Future Needs

Monsoon Cloud Dropping Rain | *Photo by Brian Anderson | WRRC 2022 Photo Contest Winner*

Introduction

This policy brief synthesizes the findings from a three-day workshop held at University of Arizona in April 2023, focused on identifying the governance and policy challenges to a NZUW future in the Southwest US. The workshop involved water managers, non-governmental organizations, and academics from across the Southwest, and was part of a four-year National Science Foundation Research Coordination Network (RCN) grant under the Dynamic and Integrated Socio-Environmental Systems (DISES) Program. The ultimate purpose of this DISES-RCN is to define and examine the viability and value of pursuing a NZUW approach in arid and semi-arid urban scenarios of Albuquerque, Denver, Los Angeles, and Tucson, all serviced by the Colorado River. A NZUW approach meets the needs of a given community with a locally available and sustainable water supply, without detriment to interconnected systems or long-term water supply *(1)*. It is an integrative approach that uses progressive targets and a quantitative assessment framework to adapt to challenges created by multiple drivers of change in the urban water system.

The findings detailed in this policy brief have been published in a recent *ACS ES&T Water* article titled "Advancing a Net Zero Urban Water Future in the United States Southwest: Governance and Policy Challenges and Future Needs" *(2)*.

This RCN is spearheaded by the University of Arizona, Colorado School of Mines, Colorado State University, University of New Mexico, and University of California Los Angeles, in collaboration with Tucson Water, Denver Water, Albuquerque Bernalillo County Water Utility Authority, and Los Angeles Department of Water and Power. The NZUW research network aims to improve the sustainability, resilience, and adaptation of urban water systems impacted by the Colorado river crisis and the recent reductions in their water allocations imposed by the Bureau of Reclamation *(3)*.

Award Number : 2206132

University of Arizona College of Architecture, Planning, and Landscape Architecture Underwood Garden | *Photo by Mamta Popat / Arizona Daily Star*

Context of the Problem: Defining Governance and Policy

Various drivers of change, such as climate change, population growth, and economic development, are producing stresses on and within urban water systems. Innovation that integrates natural, social, and built systems through a lens of equity are required to adapt to these changes. To engage with the NZUW framework, several terms must first be defined. Water governance is "the range of political, organizational and administrative processes through which community interests are articulated, their input is incorporated, decisions are made and implemented, and decision-makers are held accountable" *(4)*.

Governance refers to the framework of customs, regulations, and laws, as well as the engagement processes between the public and private sectors and civil society *(5)*. Policies are the "mechanisms that support different levels of water management" *(6)*. Ultimately, moving toward a net zero balance between urban water supply and demand will require an understanding of and updates to governance and policy across the Colorado River Basin and within cities in the Southwest specifically.

Key Areas of Governance and Policy Challenges for a Future NZUW Balance Across the Colorado River Basin

There are myriad challenges to reaching NZUW balances in the Southwest. The first workshop of this eight workshop series of DISES-RCN identified five main areas of governance and policy challenges for achieving NZUW balances for cities across Southwest: (1) accounting for diversified water sources and sinks; (2) planning, design, and operations; (3) monitoring and enforcement; (4) coordinating between multiple agencies and sectors; and (5) addressing equity and justice in the NZUW transition.

1. Incorporating and Accounting for Diversified Water Sources and Sinks

Several urban water sources are important contributors to NZUW approaches, including stormwater, rainwater, graywater, and recycled treated wastewater. The practice of stormwater and rainwater harvesting are gaining increasing attention, however, governance and policy challenges must be addressed that can be characterized as 1) regulatory (e.g. timing of release following collection, legally appropriate uses, water rights issues, accounting for groundwater and surface water return flow); 2) technological; 3) siting complications (e.g. identification of potential capture areas); 4) development of integrated water management benefits; 5) inherent variability in availability; and 6) water quality concerns (e.g. E. colie. Coli, pathogens, or PFAS, required treatment levels).

Wastewater reclamation and reuse also provides opportunities to meet demands, particularly in arid regions, via landscape and agricultural irrigation, industrial and environmental uses, aquifer recharge, non-potable urban uses, and indirect or direct potable reuse *(7,8)*. However, widespread adoption of Direct Potable Reuse (DPR) faces several governance and policy challenges including 1) providing reliable treatment of reclaimed water to meet stringent water-quality requirements for potable reuse; 2) gaining public acceptance; 3) evolving regulations in most states; and 4) project costs and regulation related to a growing list of emerging contaminants. To encourage and facilitate adoption of DPR and other forms of water reuse, the EPA's Water Reuse Action Plan aims to align federal, state, local, and tribal policies and programs *(8,9)*.

Graywater technologies at the household scale are not consistently allowed in states across the Colorado River Basin, as some states require graywater to be treated and returned to the river for delivery to downstream users. Graywater reuse is therefore complicated as its use may violate the return requirements in interstate regulations *(10,11)*.

Green infrastructure (GI) is an essential component of a water management plan if a city is to achieve a NZUW balance without detriment to interconnected natural systems while also meeting stormwater runoff regulations and maintain livable cities. Despite strong interest in GI, many regulatory and policy challenges exist that serve as barriers to implementation including those noted above related to water rights, timing of release, and acknowledgement of groundwater-surface water connectivity. Additionally, stormwater management in many cities lacks dedicated revenue and/or dedicated utilities to fund, plan, and implement GI projects. Scales of GI (on-site to municipal) are also important to consider when designing policies, as scale highly influences costs, water volumes captured, and the specific nature of co-benefits provided by GI practices.

The water supply for cities relying on water from the Colorado River is dictated by a set of complex and fragmented water rights, which presents a host of challenges to NZUW accounting and transition to a NZUW goal.

Understanding how regulatory constraints are coupled with quantities of water needed to meet urban demand and water rights obligations complicates advancements of NZUW, particularly in light of policy goals to ensure equitable water quality and quantity.

Additionally, the river compacts across the Southwest have historically attempted to ensure the water from the Colorado River is not captured by upstream users to the detriment of downstream water rights holders. Furthermore, approaches to policy development and strategy implementation are strongly fragmented across cities in the Colorado River Basin. Factors such as water rights, return flow credits, and Compact obligations for discharges should be considered holistically across the Colorado River Basin to design a more systematic and quantifiable approach that allows cities to meet their municipal and basin-wide water demands.

The lack of clear accounting for surface and groundwater interactions and movement along the Colorado River system provides substantial complications in developing policies focused on holistic water management that recognize connections and interactions between water sources. This is particularly important to consider to achieve NZUW systems where accounting for water is core to incentivizing implementation. For example, the ability to account for stormwater returned to groundwater via GI and other methods for deep infiltration, and then obtain credits for that returned water, could enable more efficient and flexible use of different water sources via trading mechanisms to achieve NZUW, particularly in areas where accounting for return flows or infiltration is necessary to get credit.

2. Planning, Design, and Operations

A better understanding of the impacts of climate change, including more regionally specific models, can improve current and future policy and governance of urban water resources. Climatic variability that exists both spatially (e.g., across cities, within cities) and temporally (across seasons) also highlight the need for flexible policies that regulate rainwater and stormwater capture. Additionally, climate change amplifies variability in precipitation distribution and quantity, which influences the design and effectiveness of multiple systems, such as GI *(12,13)*, and influences temperatures that can impact water usage within urban regions (e.g. irrigation), particularly during extreme heat events. This inherent variability and uncertainty in precipitation and end-use demands creates challenges when designing policies across a broad region, and highlights the need for flexible and adaptive design decisions to ensure long-term reliability.

Reaching a NZUW goal requires the planning of future operations and capital improvements. Thus, NZUW requires modeling that simultaneously evaluates both future water demands and local water supply potential. On the demand side, continued investments in water use efficiency that reduce consumption and overall demand is critical. On the local supply side, the potential for stormwater capture and use, groundwater recharge, water reuse, graywater management, and local diversions should be evaluated to understand the fiscal and managerial implications of these potential investments.

Advocating for governmental investment in new urban water sources can be challenging when only traditional metrics are considered *(14)*. For example, the inability to measure and value multiple benefits associated with alternative water sources, such as GI practices *(15,16)*, can lead to low investment in these approaches. Additionally, accounting procedures within water agencies need to be updated to support continued investments beyond the status quo. For example, when agencies compare costs for existing and new infrastructure, these approaches often fail to incorporate future costs of existing infrastructure with cost increases related to upgrades and maintenance, which makes investments in new alternatives appear less attractive (*17,18)*.

3. Monitoring and Enforcement

Beyond the political will to enforce policy, there is a monetary cost associated with monitoring efforts, including personnel time to maintain and support the integration of new water sources, which require a designated funding stream. Technologies (e.g., automated metering, in-pipe water quality monitoring, remote sensing monitoring) may help in some areas, but the challenge will remain that clear lines of regulatory responsibility, as well as long-term funding to monitor indicators and to enforce policies by those responsible, needs to be granted alongside new water policies and investments.

One critical challenge in NZUW is obtaining more precise water usage data at spatial and temporal scales to support both design and operations. Comprehensive metering of urban water inputs and outputs is critical to a NZUW future as diversified sources of water are brought into the functioning of the urban water system.

4. Coordinating between Multiple Agencies and Sectors

The current regulatory landscape that provides guidance on the implementation and operation of alternative water sources are slowly changing though national, state and local efforts *(19)*, yet still remain largely uncoordinated *(20)*. Specifically, coordination among local, state and national agencies can assist in technology rollouts and implementation through efficient approvals and regulations. Additionally, the interaction between the water delivery system, stormwater management, and the wastewater system is an important area that needs coordination, particularly based on a quantitative approach to urban water management.

5. Addressing Equity and Justice in the NZUW Transition

From an equity perspective, one of the most important aspects of NZUW is to ensure that all customers receive the same quality and affordability of water at the tap. Water quality is a contentious issue as contaminants can be difficult and /or costly to remove, regardless of source, and communities. In less wealthy communities, affordability becomes an important barrier to equity, since the burden of water purification infrastructure makes water utility bills more expensive, and thus water could be underutilized to meet basic health and welfare needs *(21)*. Without proactive planning, the NZUW transition may exacerbate the existing water inequities in communities with less resources.

Another issue with moving toward NZUW involves outdoor irrigation and landscaping, often accounting for half of municipal urban water use *(22,23)*. The trees and vegetation growing in many areas of the Southwestern US are largely non-native species and have higher water requirements *(24)*. Because outdoor water use is a consumptive water use, for urban areas to maintain outdoor vegetation under NZUW, landscaping will need to survive with little to no supplemental irrigation, implying a major transformation in some cities toward native plants and landscape and streets designed to optimize passive stormwater harvesting.

There are both centralized and decentralized solutions to move toward NZUW. NZUW is an approach geared toward societal benefit, but there may be unintended unequal distribution of infrastructure impacts, and/or costs, especially in the timing of the transition *(25)*. Thus it is, and will be, important to consider the impacts across scales (city, neighborhood, resident) as the urban water system is updated and to insure already underserved communities are treated equitably.

City Specific Application Examples

To understand the concrete implications of these five areas of challenges in governance and policy in the NZUW transition, we investigate four case study cities: Albuquerque, Denver, Los Angeles, and Tucson. Each of these four cities is connected to the Colorado River system yet has a diversity of other local and imported water sources included in its supply portfolio.

Table 1 provides the general characteristics of these cities and outlines their current water sources to understand the implications of a NZUW goal. **Table 2** summarizes how the challenges from the proceeding section cut across these four case study cities.

Shared top priority needs across the four cities include:
- Support potable water reuse (through development of advanced treatment technologies, public engagement efforts, and establishing regulations for DPR and IPR)
- Create coordination among national, state and local agencies on implementation and operation of alternative local water sources
- Address equity and justice of all stakeholders in urban water planning
- Develop and incentivize water conservation plans to reduce indoor and outdoor water consumption
- Make aquifer storage and recovery projects easier and economical to pursue

University of Arizona ENR2 Green Roof and Rooftop Photovoltaic (PV)+ Project | *Photo by Rashi Bhushan*

Conclusion and Insights

The Colorado River supplies over 40 million people in the Southwest with their daily water supply and is neither able to meet current demands nor fulfill past agreements. As cities in the Southwest reconsider their dependence on imported water, NZUW is an important framework to comprehensively understand urban water supply and demand balances across natural, built, and social systems. Transitioning to a NZUW future where cities thrive within local water supplies will require considerable modifications to governance and policy across the Southwest and its cities specifically. This policy brief outlines the governance and policy challenges across five key areas: accounting for diversified water sources and sinks; planning, design, and operation; monitoring and enforcement; coordinating between multiple agencies and sectors; and addressing equity and justice in the NZUW transition. These challenges are reflected in four case study cities: Albuquerque, Denver, Los Angeles, and Tucson. Across these cities, the policies needed to move toward a NZUW future in the Southwest are related to: supporting DPR and IPR; creating coordination among national, state and local agencies on implementation and operation of alternative local water sources; addressing equity and justice of all stakeholders in urban water planning; developing and incentivizing water conservation plans to reduce indoor and outdoor water consumption; and making aquifer storage and recovery projects easier and economical to pursue.

An NZUW transition in the Southwest has considerable challenges but is possible. As NZUW is meant to be a progressive target, the transition toward this future will be gradual and dependent on comprehensive urban water system modeling (encompassing natural, built, and social systems) and accurate data for decision-support to move toward a net zero balance. Governance and policy will provide a critical framework and process to guide this transition and will need to address equity and justice concerns. Although these changes are heavy lifts, unless they are made, more inequalities will result within cities and across cities in the Southwest that are built upon a foundation of water rights from an over allocated Colorado River.

Havasu Creek | *Photo by Dave Wilson | WRRC 2022 Photo Contest Winner*

Table 1: Summary of Characteristics of the Case Study Cities[a]

	Albuquerque[b]	Denver	Los Angeles	Tucson
Population	0.56 million	0.72 million	3.9 million	0.54 million
Area	188.95 sq miles	154.7 sq miles	502 sq miles	241.33 sq miles
Main Local Water Source	Groundwater and surface water	Surface water	Groundwater and surface water	Groundwater
Imported Water Source(s)	Colorado River via the San Juan-Chama Project	Colorado River (infrastructure used to divert river to Denver)	Los Angeles Aqueduct, California State Water Project, and Colorado River water (via Metropolitan Water District)	Central Arizona Project (Colorado River) via the Central Arizona Project canal and lift stations
Annual Rainfall[c]	8.84 inches	15.85 inches	14.3 inches	10.76 inches
Total annual water use (city boundary)	27 billion gallons (Water Authority)	30 billion gallons (Denver Water)	160 billion gallons (LADWP)	28 billion gallons (Tucson Water)
Total annual water use (utility boundary)	29 billion gallons (Water Authority)	60 billion gallons (Denver Water)	160 billion gallons (LADWP)	28 billion gallons (Tucson Water)
% Imported water (volume)	80% (31 billion gallons)	46% (13.8 billion gallons)	89% (142 billion gallons)	84% (23.8 billion gallons)
% dependence on Colorado River water	80%	46%	6%	84%
Residential per capita water use	80 GPCD (Water Authority)	96 GPCD (Denver Water)	112 GPCD (LADWP)	76 GPCD (Tucson Water)
City location within Colorado River Basin	Adjacent	Inline	Terminus	Terminus with water rights junior to California

[a]Water use numbers were calculated by the different utilities and not as a part of this study; therefore, there may be differences in how the numbers were calculated. Information was obtained for Albuquerque from the Water Authority based on the 2023 Annual Operating Plan for the period from April 1, 2023, through March 31, 2024; for Denver from https://www.denverwater.org/your-water/water-supply-and-planning/water-use; for Los Angeles from https://ladwp-jtti.s3.us-west-2.amazonaws.com/wp-content/uploads/sites/3/2021/10/04152431/2020-2021_Facts_and_Figures_Digital_final.pdf; and for Tucson from https://www.ewra.net/wuj/pdf/WUJ_2021_28_01.pdf.

[b]Albuquerque's dependence on Colorado River water changes from year to year and is dependent on conditions in the Rio Grande River; the numbers in this table represent 2023 conditions.

[c]The numbers represent the average annual precipitation derived from the 30-year Climate Normal (1991–2020), sourced from National Oceanic and Atmospheric Administration (NOAA).

Table 2: Five areas of governance and policy challenges toward a NZUW future across the four case study cities

(Note: Members from water utilities for the four case study cities were asked to select five policy priorities to transition to a NZUW future.)

Priority Level: Very Low or None | Low or Minor | Moderate | High | Very High

Policy Needs Toward a NZUW Future	Priority for Each City			
a. Accounting For Diversified Water Sources and Sinks	**ABQ**	**DEN**	**LA**	**TUS**
1. Expanded system of water accounting for new sources and diversified and sustainable uses for urban water	Low or Minor	Very Low or None	Very Low or None	Very Low or None
2. Metering of private wells to understand its actual water balance	High	Very Low or None	Very Low or None	Very Low or None
3. Make aquifer storage and recovery projects easier and economical to pursue	Very High	Moderate	Very High	Low or Minor
4. Allow use of graywater at household scale	Very Low or None	Very Low or None	Low or Minor	Very Low or None
5. Legal changes to limitations on holding stormwater	Very Low or None	Low or Minor	Low or Minor	High
6. Increase funding to build more alternative water projects (rainwater capture projects, reclaimed water and brackish water systems, SCU, and GI projects)	High	High	High	High
7. Design systematic approaches to quantify water recharged through GI measures	Very Low or None	Low or Minor	Very Low or None	Very Low or None
8. Create clear policies that incorporate surface-groundwater interactions	Low or Minor	Very Low or None	Moderate	High
9. Develop and incentivize water conservation plans to reduce indoor and outdoor water consumption with climate-appropriate landscapes, including shading from built structures and a vibrant urban tree canopy to promote cooling	Very High	Very High	Very High	Very High
b. Planning, Design, and Operations	**ABQ**	**DEN**	**LA**	**TUS**
10. Improve planning, designing and implementation of GI with considerations for climate variability, water quality, water accounting, and water rights.	Very Low or None	Moderate	Low or Minor	Low or Minor
11. Secure improved forecasts of urban water supply and demands for accurate urban water planning	High	High	Moderate	Low or Minor
12. Support DPR and IPR (through development of advanced treatment technologies, public engagement, and establishing state regulations)	Very High	Very High	High	Very High
13. Develop funding sources to adequately pay for new alternative water supplies	Very High	High	Very High	Very High
14. Ensure full-cost accounting of water supply sources to ensure relatable comparisons of the annualized unit costs of supply for existing and new sources given likely future contributors of inflation, regulations, and energy prices.	Low or Minor	Low or Minor	Very Low or None	Low or Minor

Policy Needs Toward a NZUW Future	Priority for Each City			
c. Monitoring and Enforcement	**ABQ**	**DEN**	**LA**	**TUS**
15. Increase capacity to measure and manage how water is used				
16. Enable comprehensive metering of urban water inputs and outputs for alternative water sources				
17. Develop efficient monitoring and accounting practices for GI and groundwater-surface water interactions across the Basin				
18. Invest in hiring and training of staff to allocate and distribute water to users in accordance with the law				
19. Train staff and stakeholders in alternative water projects to safeguard public health				
d. Coordination between Multiple Agencies and Sectors	**ABQ**	**DEN**	**LA**	**TUS**
20. Increase coordination between different water management sectors to enable a quantitative approach to urban water management				
21. Increase coordination across cities in the river basin for a more coordinated, robust and regulated GI implementation				
22. Create coordination among national, state and local agencies on implementation and operation of alternative local water sources				
23. Develop a clear vision of NZUW goals, including timeline, coordinated across the Colorado River Basin				
e. Addressing Equity and Justice in the NZUW Transition	**ABQ**	**DEN**	**LA**	**TUS**
24. Ensure representation, participation and accountability of all stakeholders for urban water planning				
25. Ensure all users have access to same quality and affordability of basic water need				
26. Build equity while planning access and distribution of GI and other centralized and decentralized water project benefits				
27. Establish more progressive water pricing				
28. Increase funding capacity to help lower-income communities have equitable access to water				

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