



One Water 2100
Master Plan

Technical Memorandum
ONE WATER VISION AND SCENARIO
PLANNING
JANUARY 2022



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Executive Summary

Throughout history, water supply has been a challenge to all who live in the area that is currently called Tucson. Currently, the Central Arizona Project (CAP) provides a renewable source of water for a regional population of more than one million residents. However, this supply is increasingly uncertain due to long term drought and climate change. To address the challenge of providing water to a large city in the desert with limited water supply options, the City of Tucson has taken a proactive approach to water management.

The previous water master planning effort was written in 2004 and was titled “Water Plan: 2000-2050”. Since Water Plan: 2000-2050 was completed, there have been many changes in development patterns, water supplies, water demand, and water quality issues. Updates to were made to the plan in 2008 and 2012.

Water Plan 2000 - 2050 led to a change in water supply: Tucson reduced its reliance on pumping non-renewable groundwater and expanded beneficial use of renewable sources such as CAP water and reclaimed water. The Plan included the City’s first formal stakeholder engagement and scenario planning exercises. The commitment to stakeholder engagement continues with the One Water 2100 (1W2100) plan.

To ensure that the water supply remains secure through the year 2100 and beyond, Tucson has adopted a One Water approach to planning. One Water is an integrated approach to managing finite resources for long-term resilience and reliability. A distinguishing feature of this approach is the engagement of stakeholders and partners, particularly in visioning and scenario planning. The results from a One Water planning approach are unique to each individual community and can be applied at many different scales (e.g., regional or local) depending on the specific needs of the entity.

With guidance and support from Brown and Caldwell (BC), Tucson Water developed a One Water framework for 1W2100. This tailored approach for Tucson Water included vision and goal setting work with Mayor and Council and Tucson Water staff as well as a scenario planning effort with community stakeholders.

One Water Vision and Guiding Principles

Workshops, surveys, and one-on-one interviews with Tucson Water staff, City of Tucson staff and Mayor and Council led to creation of the following vision statement and guiding principles for Tucson Water.

Vision Statement:

One Water is Tucson’s commitment to:

- Resilience
- Equity
- Stewardship

- Quality of life

Guiding Principles:

1. Deliver water reliability through water supply diversification, conservation, and innovative improvements to infrastructure.
2. Build resilience by planning for climate change, leading mitigation efforts, and implementing collaborative and adaptive strategies that harness the water-energy nexus.
3. Enhance the community's quality of life by preserving and restoring riparian areas, increasing urban tree canopy, and supporting economic growth.
4. Achieve affordability, accessibility, and social justice by committing to fiscal responsibility and prioritizing equitable projects and programs.
5. Ensure public confidence with safe, high-quality water supplies and exceptional customer service that includes transparency and responsiveness.

Scenario Planning

Building on the vision statement and guiding principles, the project team consisting of BC and Tucson Water led a stakeholder group through a scenario planning process. These stakeholders represented various business, environmental, and other community groups within Tucson. From this exercise, the scenario planning stakeholders developed the following four strategies to protect against a variety of future scenarios involving changes in supply or demand:

- Reduce use of CAP water
- Increase reliance on reclaimed water to help offset reduced use of CAP water
- Do not abandon remediated groundwater, and even consider expanding it
- Incorporate rainwater/stormwater harvesting and onsite reuse into the long-term water plan

Generally, the above themes can be summarized as a recommendation to rebalance the supply portfolio through more use of locally controlled and distributed sources and deliberately less reliance on CAP water.

In addition to these direct actions related to the future portfolio of water supplies, the stakeholders recommended the following policies to guide Tucson Water:

- Develop and implement a consistent and effective public outreach and education campaign to disseminate messaging on water conservation and local water management strategies.
- Promote awareness of equity in the community to help avoid future conditions in which the economics of water in Tucson are unreasonably stratified and decisions difficult to implement.
- Remain involved in state and federal policy and regulatory discussions, both to help advocate and influence and to stay aware of pending changes.

- Consider the water-energy nexus as a key element of a sustainable water plan, with energy requirements and opportunities to reduce emissions through siting and renewable energy serving as important decision drivers.

This technical memorandum details the process and key conclusions of the One Water visioning and scenario planning efforts.

1 Introduction

1.1 Background

In 2004, Water Plan: 2000-2050 was published with a stated purpose “to initiate a dialog between Tucson Water and the community about the water resources challenges that must be addressed in the coming years.” In making this statement, Tucson Water reaffirmed its commitment to hearing the voice of the community on water issues. This commitment continues today through One Water 2100 (1W2100).

Since Water Plan: 2000-2050 was written in 2004, there have been many changes in development patterns, water supplies, water demand, and water quality issues. One noteworthy event was the economic recession of 2007-2009. During this period, development slowed and real estate values fell. This changed the trajectory of projected water demands throughout the Tucson Water service area. Updates to were made to the plan in 2008 and 2012.

Water Plan 2000 - 2050 led to an inflection point in Tucson water usage. Actions resulting from the plan shaped both the source of, and how, Tucson uses water. It also presented the results of the City’s first formal stakeholder engagement and scenario planning exercises. Not surprisingly, stakeholders identified drivers that, while different from today’s drivers in their details, share common themes.

For example, in 2004, a fundamental question existed regarding how to make use of Central Arizona Project (CAP) Water. While memories of the unsuccessful direct introduction of CAP water to the distribution system were fresh at the time, the dialog was fundamentally related to water quality, aesthetics, and sustainability – themes also identified in 1W2100 work.

A second key theme was related to renewable water. Between 1940 and 2000, water levels in Tucson’s central wellfield dropped nearly 200 feet. The planning and foresight of Water Plan 2004 reversed this trend (Figure 1-1) and changed the trajectory of groundwater use. Further, decisions made because of the 2004 plan led to the highly successful CAP recharge program that remains the cornerstone of Tucson’s sustainable water supply. The paths identified concerning renewable water were threefold: convert to pumping renewable groundwater (versus mining fossil groundwater), use wastewater effluent for potable purposes, and recharge the full allocation of CAP supply to the aquifer. The pathways established have been successful: data shows a rise in the central wellfield’s aquifer levels through 2020 (Figure 1-1), and the transition from fossil groundwater to renewable CAP supplies began following the publication of Water Plan 2004 (Figure 1-2). Groundwater recovered from CAP recharge areas (i.e., groundwater from renewable supplies) makes up the majority of the water supplied by Tucson Water. In addition, recognizing the interconnected nature of water, Tucson has invested in numerous projects that ensure a sustainable supply while improving the quality of life for area residents. For example, the Southeast Houghton Area Recharge Project (SHARP), which opened in 2020, provides 40 acres of desert landscape for walking and recreating while recharging more than 1 billion gallons of recycled water per year to the aquifer.

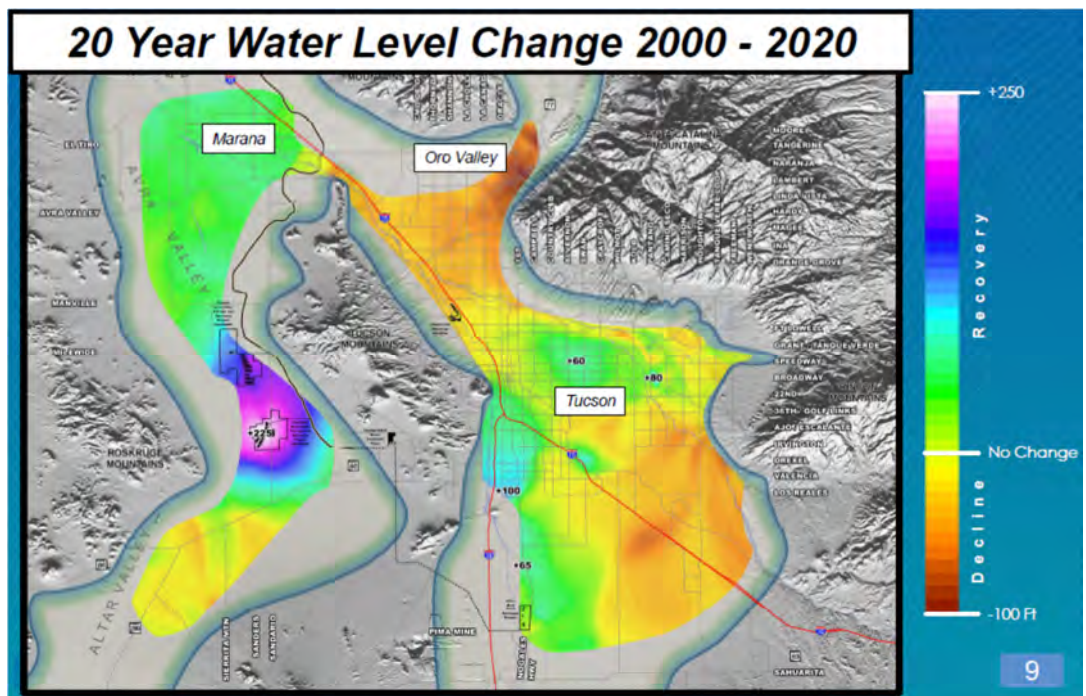


Figure 1-1. Illustration showing the increase in water levels in Tucson’s central wellfield and in recharge areas to the west of the city (Central Avra Valley Storage and Recovery Project [CAVSARP] and Southern Avra Valley Storage and Recovery Project [SAVSARP]) between 2000 and 2020.

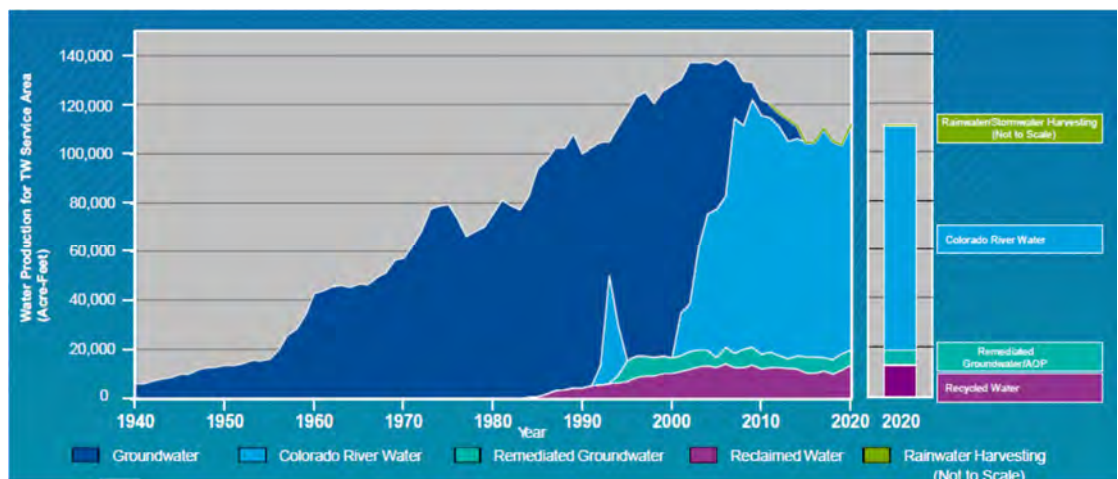


Figure 1-2. The arrival of CAP water in the late 1990s allowed the transition from non-renewable to renewable water sources – a key pathway identified in the Water Plan: 2000-2050.

Another concern identified in 2004 was land subsidence due to over-pumping of groundwater. While this issue is largely resolved in the central basin and in the Tucson Active Management Area, fissures resulting from over-pumping in rural areas surrounding Tucson have closed roads and damaged infrastructure. For this reason, the issue of land subsidence remains at the forefront of stakeholders' minds today.

The issues identified by stakeholders through the 1W2100 visioning exercise have common roots to those identified in 2004, but with contemporary twists. For example, the 1W2100 visioning and scenario planning work was conducted during some of the driest and hottest years in Tucson's history. A total of only 4.17 inches of rain fell throughout 2020, and the monsoon season was the driest on record. With this backdrop, risks to continuous high-quality water supply and uncertainty in demand trends were identified as key issues. Though the scenario planning work was conducted in 2021, a much wetter year on record, climate change and its impacts on the Colorado River and CAP allocations continued to be a primary concern. Climate change, underpinned by data showing that Tucson is the third fastest-warming city in the United States (Climate Central, 2019), together with recognition of the water-energy nexus, drove concern regarding climate from staff and the stakeholder groups. In addition, rather than a decision of how to use CAP water supplies, today's concerns relate to whether these supplies will remain viable in the long term with the watershed under a first-ever shortage declaration. Other top-of-mind issues include public education and equity awareness, conservation, water quality (particularly related to perfluoroalkyl substances [PFAS]), system resiliency, and governmental instability.

The following activities have all contributed to a positive water future for Tucson:

- Programs such as tiered water rates and education programs that encourage conservation
- Investment in stormwater and rainwater usage
- Regional collaborations and water-sharing agreements
- Maintain full CAP allocation through long-term storage buildup while reducing overall annual consumption

However, risks abound. Events that occurred during the 1W2100 scenario planning work and that influence key drivers and possible pathways include the declaration of shortage on the Colorado River, the shutdown of the Tucson Airport Remediation Project (TARP), and a global pandemic. Each of these events highlight uncertainty and the need for reliable, safe water.

Lake Mead was nearly full when Water Plan was released in 2004. Now, nearly 20 years later, significantly declining levels in Lake Mead are driving allocation changes and decisions. Figure 1-3 shows the projected level of Lake Mead, the sentinel reservoir, through 2023. The tiered Drought Contingency Plan, negotiated in 2019, places the burden of the initial reduction resulting from a shortage declaration on the agricultural industry. Tucson Water's allocation of water supplies are not reduced in their first two tiers, and the recharge of CAP at SAVSARP and CAVSARP will continue. Table 1-1 shows the trigger levels for Tucson Water. If drought persists and water levels reach tier

3, there will be a 14 percent reduction in Tucson’s water supply. Further, the management guidelines that govern water releases among basin states is set to expire in 2026. To prepare, Arizona is forming the Arizona Reconsultation Committee (ARC) to develop an Arizona perspective for reconsultation of the Colorado River Interim Guidelines. Renegotiation may result in a change to Tucson’s allocation even if drought eases. These events influence the scenario planning described herein.

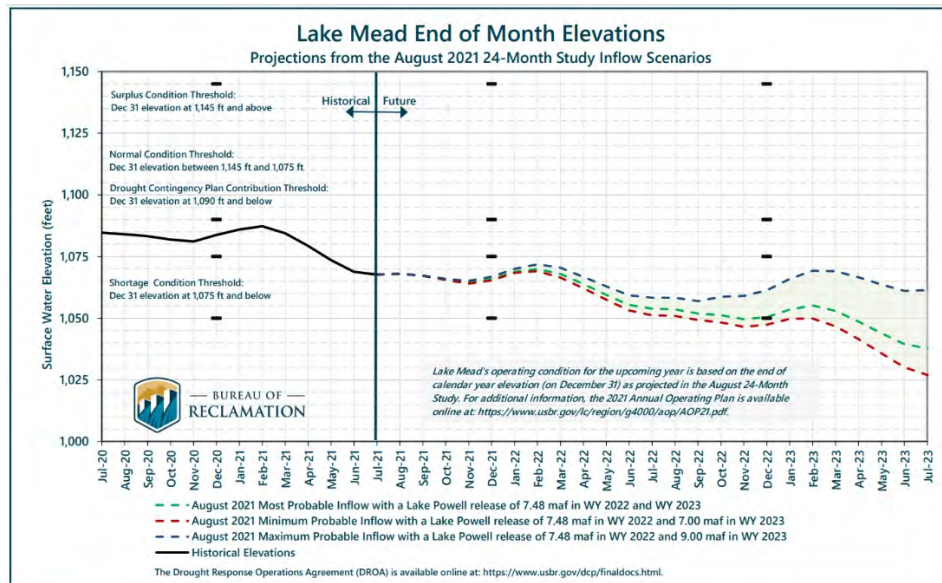


Figure 1-3. Projected Lake Mead water levels through July 2023.

Table 1-1. Summary of Colorado River shortage predictions and impacts to Tucson.

Shortage Tier	Lake Mead Level	Probability estimate (summarized)	Cuts to Tucson	Net CAP water available to Tucson (acre-feet)	2020 potable demand (acre-feet)	Amount CAP water stored based on 2020 demand (acre-feet)
1	< 1075'	>99% in 2022	0	144,191	96,179	48,012
2	< 1045'	~25-55% in 2023-2024	0	144,191	96,179	48,012
3	< 1025'	~20% in 2025	~14%	124,004	96,179	27,825

Generated by Tucson Water, source of predictions Bureau of Reclamation:
<https://www.usbr.gov/lc/region/g4000/riverops/crss-5year-projections.html>

In the second key event that occurred during the scenario planning work, Tucson stopped supplying TARP-treated water to the public due to increasing PFAS concentrations. This water supply, shown on Figure 1-2 as the teal “Remediated Water/AOP,” represented less than 10 percent of the overall supply; however, this water has now been removed from the potable supply. While the water will be diverted for discharge to the Santa Cruz River or for use in the reclaimed system, reliance on CAP or use of nonrenewable fossil groundwater will likely increase because of this event. For these and other reasons, uncertainties associated with water supply are key issues driving the development of 1W2100 and the scenario planning exercises described below.

The following sections summarize the results of the tasks, as well as foundational elements, planning approach, and visioning and scenario planning efforts to establish the framework for 1W2100.

1.2 One Water Overview

The One Water planning approach, originally documented in the Blueprint for One Water (WRF, 2017), involves first developing vision and guiding principles with key staff to establish direction for a comprehensive water plan. These principles are then used to engage public and community stakeholders to collect input to the process from their perspectives. To achieve these objectives, a One Water approach will include these elements:

- The mindset that all water has value
- A focus on multiple benefits
- Watershed-scale thinking and action
- Right-sized solutions
- Partnership for progress
- Inclusion and engagement of all

In short, One Water is an integrated planning and implementation approach to managing finite resources for long-term resilience and reliability. A distinguishing feature of the approach is the engagement of stakeholders and partners. The results from a One Water approach can take the form of a guiding framework, a document describing how to leverage existing plans, a scope defining prioritized water resource initiatives, or a combination thereof. The results are unique to each individual community and can be applied at many different scales (e.g., regional or local) depending on the specific needs of the entity. With guidance and support from Brown and Caldwell (BC), Tucson Water developed a unique One Water framework for 1W2100. The One Water planning approach, originally documented in the Blueprint for One Water (WRF, 2017), involves developing a One Water vision and guiding principles with key staff to establish direction for the plan, and engaging public and community stakeholders to provide valuable input and guidance to the process.

The City of Tucson’s overall planning effort, currently in progress, includes multiple components united under the umbrella of Plan Tucson. Other city-wide planning documents include the Climate Action and Adaptation Plan (2022), People, Communities, and Homes Investment Plan (P-CHIP, 2021), Move Tucson (2021), and 1W2100 (2021) will provide the basis for the general plan update. Mayor Romero’s office, Housing and Community Development, and the Department of Transportation and Mobility are using community wide stakeholder engagement practices to inform these plans. The 1W2100 Master Plan intends to provide a “comprehensive long-range plan to ensure the viability and quality of Tucson’s water supply for the next 80 years.” It is Tucson’s vision to incorporate environmental sustainability, social equity, and economic vitality through water in a way that is atypical of previous water plans. Community engagement is critical to the success of 1W2100.

1.3 Project Overview

The approach included two major tasks led by Brown and Caldwell with support from Tucson Water:

- Task 1: One Water Planning and Visioning (June 2019 - March 2020). The One Water approach starts with the collection of ideas from key internal stakeholders and process. Also, as part of Task 1, Tucson Water engaged city leadership including Mayor and Council and Tucson Water’s Director’s Office, and the Citizens’ Water Advisory Committee (CWAC). The approach benefits from developing internal champions through collaborative engagement of staff across all relevant departments within the organization. To accomplish this, Tucson Water identified staff throughout various City departments to participate in the One Water visioning process, including planning, engineering, conservation, environmental compliance, and hydrology. This team was engaged with a series of workshops, surveys, and one-on-one interviews. City leadership including Mayor and Council and Tucson Water’s Director’s Office, and the CWAC, were also engaged in workshops, surveys, and one-on-one interviews. Information collected from these two groups, leadership, and staff, was used in planning for the engagement of a broader community stakeholder group.
- Task 2: Scenario Planning (March 2020 – June 2021). In this task, the project team led the group of community-based stakeholders through a series of workshops and surveys to understand current supply and water system dynamics, then uncover system vulnerabilities, and finally identify robust solutions to achieve broad benefits over a range of potential future scenarios. Given the onset of the global pandemic caused by Covid-19, the original scenario planning process was paused for the remainder of 2020 and was re-envisioned as a virtual process in early 2021.

In all, these various participants provided feedback and guidance on the objectives, vision, and strategies for the 1W2100 integrated plan described herein.

To complete Task 2, BC and Tucson Water invited a diverse team of community representatives, business stakeholders, and local academics. Every effort was made to

incorporate viewpoints from various socio-economic groups. Table 1-2 is a list of the various organizations that were invited to participate in the 1W2100 scenario planning efforts. These organization cover a range of missions such as preserving the environment, promoting sustainable farming practices, enacting improvements in the neighborhood on issues, protecting and restoring watershed health, protecting public health, and many other beneficial causes. A single representative of each organization provided insight specific to their concerns and priorities.

Table 1-2. Organizations invited to participate in the stakeholder team. The stakeholders participated in a series of workshops in Task 2 to work through the scenario planning process.

Tucson Local Organizations
BKW Farms
Chicanos Por La Causa
Citizens' Water Advisory Council (CWAC)
Community Water Coalition
Menlo Park Neighborhood Association
Merchant's Garden/Pima County Food Alliance/AZ Farm Bureau
Metropolitan Pima Alliance
Pima Council on Aging
Pima County Consumer Health and Food Safety
Pima County Emergency Management
Pima County Office of Sustainability
Primer Pools and Spas
Sonoran Institute - Resilient Communities and Watersheds
Southern Arizona Homebuilders Association
Sunnyside School District
Sustainable Tucson
Tucson Electric Power
Tucson Residents for Responsive Government
UA - Public Health
Unified Community Advisory Board (UCAB) - AZ Dept of Environmental Quality
University of Arizona (UA) School of Architecture
Visit Tucson

2 Vision and Guiding Principles

As described above, One Water planning begins with the collection of key themes and values for developing the One Water vision and guiding principles (Task 1). During the workshops, surveys, and interviews, information and insight was collected on the current state of water in Tucson. This information assisted the project team in forming focus statements for the scenario planning exercises in Task 2.

2.1 Mayor and Council and CWAC Outcomes

The project team developed a survey for city leadership. Those surveyed included representatives from the Citizens' Water Advisory Committee (CWAC), the mayor's and City council offices. The objective of the survey was to understand, from the perspective of leadership, what are the top challenges the City of Tucson faces over the next 80 years. The questions in the survey began with broader questions on challenges the city faces (i.e., "what are the biggest challenges that Tucson is facing over the next 80 years?") then continued with focused on water-related challenges (i.e., "what are the top three challenges, related to water, that the city faces?") Responses to these two questions are summarized in Figures 2-1 and 2-2. Interestingly, while the first question was not specific to water, the top concern identified affects water supply: extreme weather and climate change. Further, other top issues raised including social inequality and education, also can be related to water. In the second question, the clear top three water challenges were demand management, water quality and water supply. These initial responses, paired with one-on-one interviews to further investigate the survey responses, revealed that Tucson leadership recognizes the challenges associated with an uncertain future particularly with threats to water supply, climate and changes in demand.

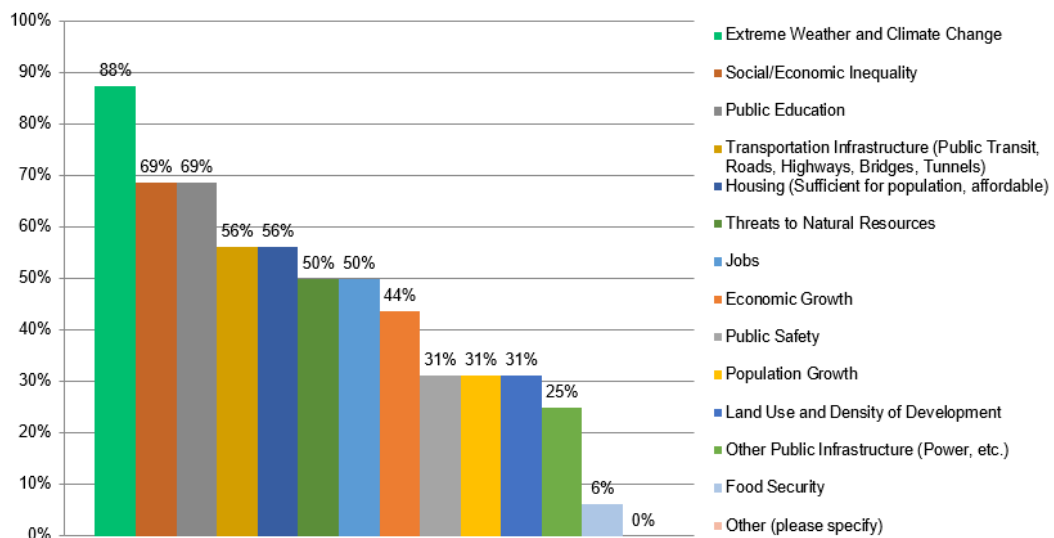


Figure 2-1. Survey responses to the question: what are the biggest challenges that Tucson is facing over the next 80 years?

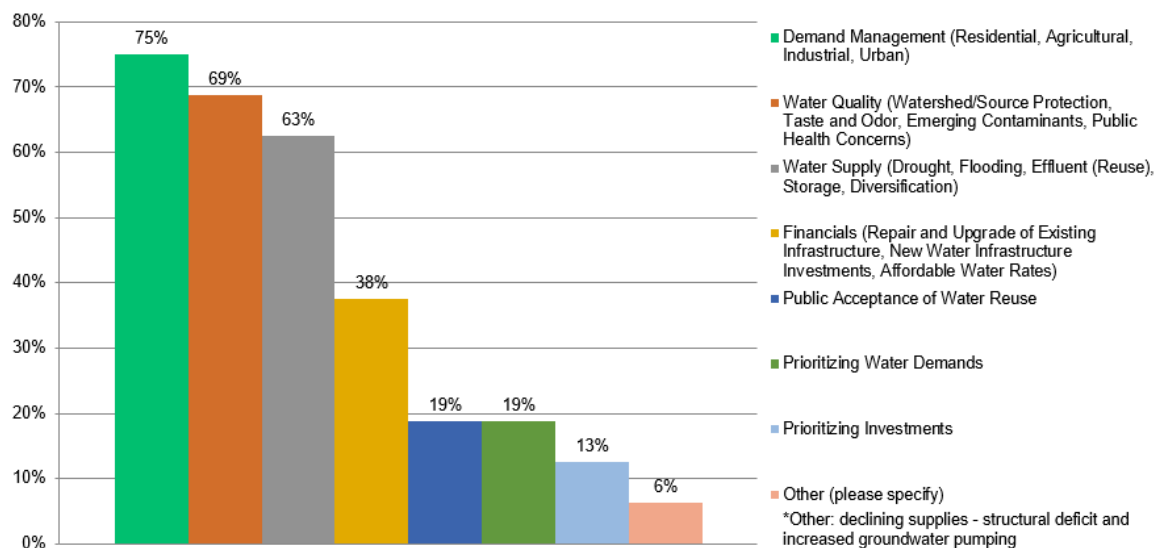


Figure 2-2. Survey responses to the question: what are the top three challenges that Tucson is facing related to water over the next 80 years?

BC’s one-on-one interviews with individual members from CWAC, City Council, and the mayor’s office helped decipher survey responses and dive deeper into specific concerns and key themes they would like considered in the One Water plan, vision, and guiding principles. These interviews were conducted over a two-day period from September 23-24, 2019 and included a total of 10 individual interviews. The interviews confirmed key themes identified by Tucson Water staff, including protecting quality of life, taking a One Water approach to resource management, equity, stormwater management, and climate change adaptation – elements that were echoed by community stakeholder participants and carried throughout the planning process. Notably, when asked how critical water is to sustaining Tucson’s vitality, 100 percent of participants responded with “Very Important.” The interviews also provided an opportunity to uncover issues specific to Tucson, including stormwater management, equity and water quality, which were presented as historic issues observed in the community. The interviewees listed specific outcomes they wanted to see out of 1W2100, which included climate resilience planning, adaptive planning, stakeholder involvement, the addressing of emerging contaminants, quality of life, and supply reliability.

The findings from the one-on-one interviews and surveys served as the foundation for establishing the One Water vision and guiding principles specific to Tucson Water and provided key issues to mitigate in 1W2100 and through the scenario planning process.

2.2 Tucson Water Staff Outcomes

In the first workshop, conducted in June 2019, roughly 30 staff members voted on the most important issues for One Water planning. Results from this exercise are provided in

Figure 2-3 below. The top issue concerning Tucson Water staff was quality of life, indicative of Tucson Water’s commitment to its community. Climate change adaptation, infrastructure, and water quality followed as top priorities.

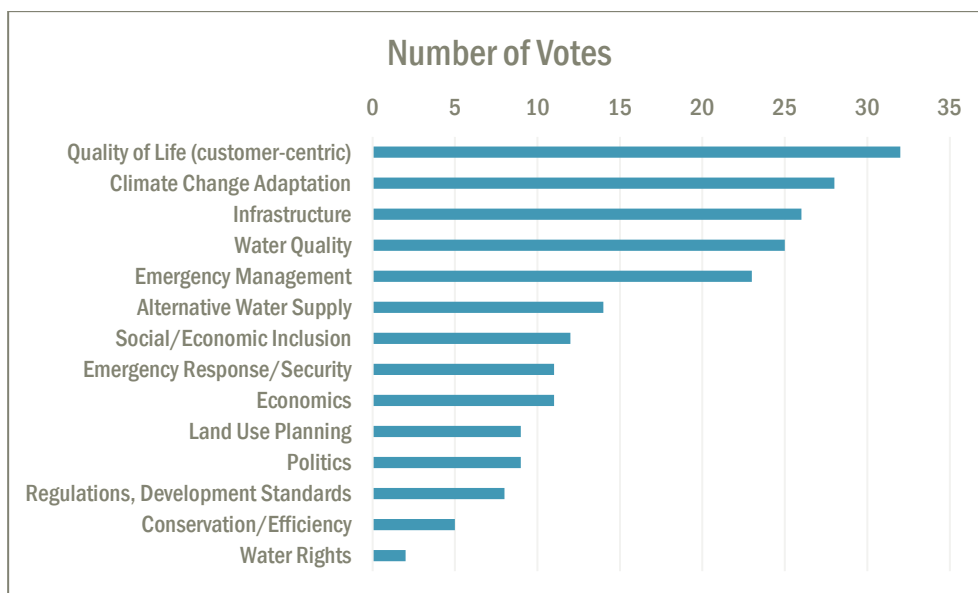


Figure 2-3. Results of City of Tucson Staff’s prioritization exercise regarding the relative importance of various issues as related to One Water planning

With the top four priorities – quality of life, climate change adaptation, infrastructure, and water quality—identified, staff broke into smaller groups to determine foundational or organizational issues, obstacles or opportunities for improvement, drivers behind the priorities, and associated stakeholders effected by the priorities.

In the second workshop, conducted in October 2019, participants were briefed on feedback received from Tucson water leadership, asked to review draft vision statements and guiding principles, and were introduced to the upcoming scenario planning effort. Tucson staff was in alignment with the responses received from city leadership on Tucson’s water challenges over the next 80 years which included demand management, water quality, water supply, financials. The group reviewed the draft One Water vision developed by BC and engaged in activity to customize their unique vision statement. Key words and phrases for the vision statement that resonated with staff included: collaboration, integrated, quality of life, resilience, adaptive, equity, stewardship and multi-beneficial. Regarding guiding principles, Staff participated in another activity to customize their One Water Guiding Principles. Six guiding-principle statements were written on posters and placed around the room. Staff broke into groups of three to four to circulate the room and review and comment on each guiding principle. Staff requested that words such as reinforce, enhance, and improve be removed from all statements as they imply a deficiency. Action words such as continue, commit, and provide were preferred. The results of workshop 2 provided the project team information from which to draft the vision statement and guiding principles.

One key takeaway from staff was the belief that, given actions taken over the previous 20 years and the fact that a significant amount of water has been banked in the aquifer, the future of water in Tucson is secure. This was a key result given that this group is intimately familiar with the current water scenario. This sentiment indicates that prior long-range plans and subsequent projects have created a sense of security around supply reliability despite mounting pressures and uncertainty. Additionally, some staff members acknowledged the bold leadership and vision from senior leadership within the organization who have clearly communicated the vision, priorities, and strategy. The purpose of 1W2100 is to ensure that water supply remains secure for the next 80 years and beyond.

2.3 Tucson Water Vision and Guiding Principles Development

With input from all the stakeholders in the planning process, the project team developed the following vision statement:

One Water is Tucson's commitment to:

- Resilience
- Equity
- Stewardship
- Quality of life

This statement encompasses many of the key themes uncovered through interviews with Mayor and Council. Tucson Water staff also developed the following guiding principles:

1. Deliver water reliability through water supply diversification, conservation, and innovative improvements to infrastructure.
2. Reinforce resiliency by planning for climate change, leading mitigation efforts, and implementing collaborative and adaptive strategies.
3. Enhance the community's quality of life by preserving and restoring riparian areas, increasing urban tree canopy, and supporting economic growth.
4. Achieve affordability, accessibility, and social justice by committing to fiscal responsibility and prioritizing equitable projects and programs.
5. Ensure public confidence with safe, high-quality water supplies and exceptional customer service that includes transparency and responsiveness.

The vision statement and guiding principles serve as the foundation of, and direction for, the 1W2100 plan and establishes Tucson Water's commitment to incorporating these themes throughout the planning process. Furthermore, these guiding principles may be used to inform Tucson Water's approach to water management going forward. They provide a foundation to reference as Tucson heads into an uncertain future and orients them to their core principles while they develop strategies to adapt to future issues. The One Water planning and visioning process also served as the launching point for the next phase of the One Water work with community stakeholders. A list of driving factors

and uncertainties was developed as identified by key staff through the workshops, surveys, and interviews. The list of driving factors was the first introduction to the community stakeholders to review, provide feedback, and begin their process of develop management strategies through scenario planning visioning as discussed in Section 3.

3 1W2100 Scenario Planning

3.1 Introduction

Scenario planning has been used by organizations for decades to help prepare for uncertain futures. It offers insight into plausible combinations of risk (uncertain factors and the significance of their potential impacts) that could emerge as future realities. Scenario planning provides a structured framework for organizations to identify factors that could influence their future, characterize the uncertainties associated with each factor, and determine how impactful each range of uncertainty could be. Within this framework, today’s decisions can be tested to see how resilient they may be to various combinations of the most impactful future uncertainties.

Figure 3-1 begins to illustrate the concept. The scenario planning effort takes a qualitative approach based on quantitative findings traditionally determined through modeling and/or planning studies. The qualitative approach in scenario planning includes developing scenarios to describe impactful uncertainties that create a structured space for planning, i.e., a framework of plausible future scenarios against which to test decisions. In this effort, the quantitative findings from the work completed by Jacobs Engineering, which included water use projection data, supported the qualitative scenario planning approach in which the summary from the work conducted was used to inform the stakeholders about the range of future outcomes to develop future narratives and risk mitigation strategies. The scenario planning approach taken in this work focuses on preparing for the most impactful plausible future.

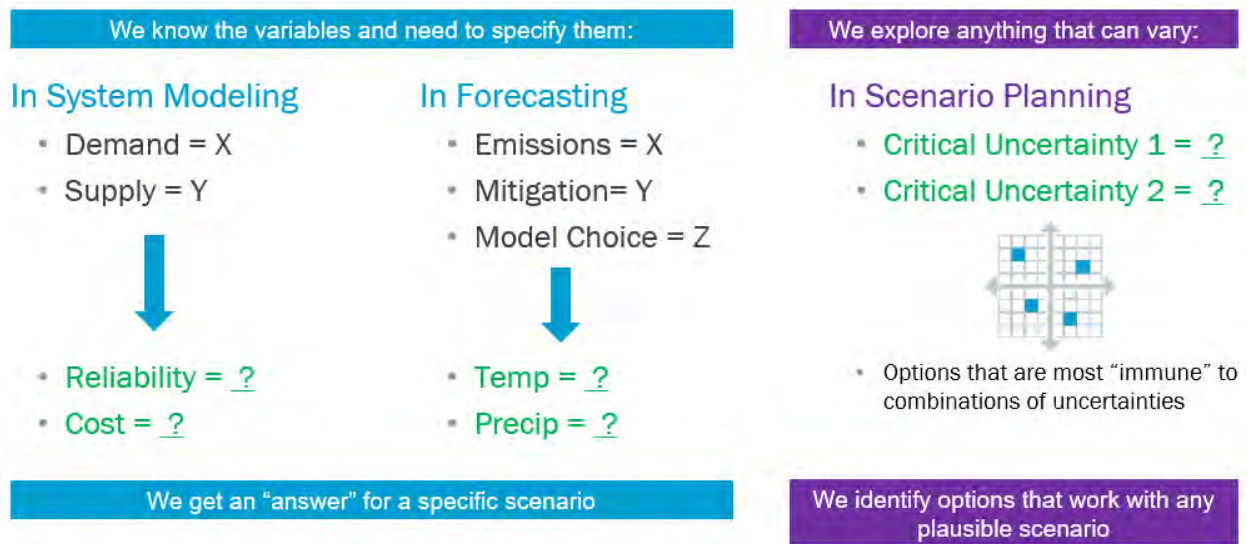


Figure 3-1. Traditional Planning and Scenario Planning

One useful way to visualize the philosophy of scenario planning is shown on Figure 3-2. Many traditional planning methods attempt to forecast future conditions either deterministically or probabilistically, and base decisions on the “most likely” future. Scenario planning acknowledges that beyond any probable future are a wide range of plausible futures, none considered any more probable than any other. In this context, the resilience of decisions made today can be tested against a range of plausible future condition to determine how durable they can be shown to be against the most critical uncertainties.

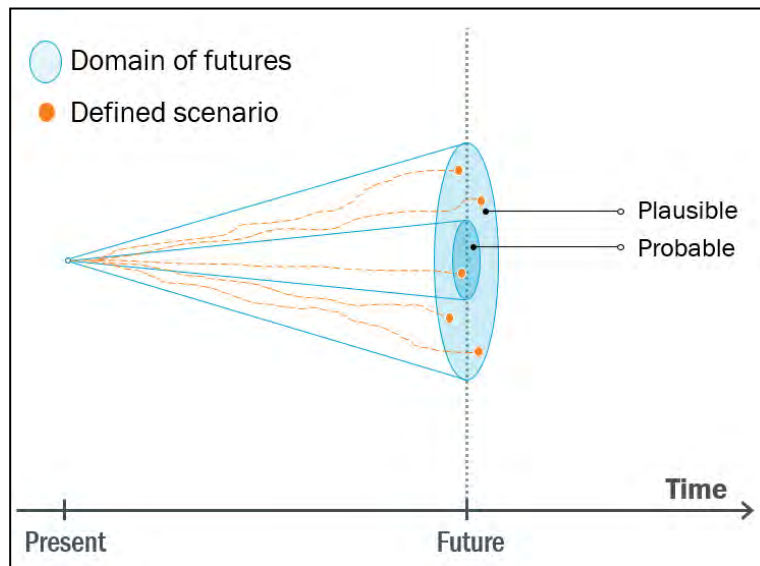


Figure 3-2. Plausible Future Scenarios Emphasized Over Probable

More specifically, scenario planning combines the most uncertain and most impactful future conditions (perhaps climate, economics, politics or institutional leadership, public health, demographics, etc.) and combines them across their full spectrum of possibilities in the form of 2 x 2 matrices to create four quadrants that describe plausible future conditions. Resource management or institutional strategy decisions are then formulated and tested in all four quadrants of uncertainty (all four “scenarios”), so that organizations are well-equipped to manage the most potentially impactful future conditions.

A useful analogy is asset management, where facilities are renewed based on the combined influence of likelihood and consequence of failure. The facilities that have the greatest probability of failure and the greatest impact in the event of a failure receive the greatest allocation of resources for improvements. In the scenario planning realm, we look at uncertainty and potential impacts of that uncertainty in much the same way to guide institutional decisions.

Figure 3-3 illustrates a typical process for scenario planning, in general terms. The remaining figures in this section illustrate the process in more detail. Tucson Water’s results for this same framework are included in Sections 3.3 - 3.4.



Figure 3-3. Standard Scenario Planning Process

The specific steps in scenario planning (generic):

- **Step 1:** Define the Focal Question: articulate the driving question that must be addressed.
- **Step 2:** Define factors, uncertainty, and criticality.
 - **Step 2a:** Brainstorm factors that could influence future conditions (drivers).
 - **Step 2b:** Group the factors by theme and rank based on uncertainty. “Uncertainty” is defined here as either a broad or narrow range of possible outcomes, without yet considering the consequences of each range.
 - **Step 2c:** Rank each group of factors by the criticality/impactfulness of its uncertainty. “Impactfulness” is defined as the potential consequences of experiencing either end of the spectrum of uncertainty.
- **Step 3:** Define plausible future conditions.
 - **Step 3a:** Combine the Factors with Highest Critical Uncertainty (Greatest Risks) into 2 X 2 Grids. The axes of each grid are defined as the extreme ranges of uncertainty, and do not necessarily need to be positive/negative.
 - **Step 3b:** Identify the most useful grid (or grids) for future planning. Note that this is an example only and does not reflect the specific drivers or axes defined by Tucson Water – See Section 3.3 – 3.4.
 - **Step 4a:** In narrative form, describe the 4 quadrants as equally plausible future scenarios. This is an example of a quadrant description from Tucson Water’s Scenario Planning Exercise:
 - Quadrant A: In a managed water use reality, we observe a decrease in demand resulting from intentional education, policies driving stewardship, and social equity programs. However, water use is tightly managed because

our reliance on limited water resources could or has resulted in a decrease in available supply, or unreliable quantities of water year to year.

The steps described above are illustrated in Appendix A Scenario Planning Process.

3.2 The Focal Question

The focal question for Tucson Water (step 1 in the process outlined above) is best expressed as the transition between a current state assessment and an outlook into the future:

“Through a diverse water supply portfolio and prudent storage of surplus CAP water, Tucson Water is well prepared for a severe drought in the Colorado River Basin in the near term. What adjustments to the supply portfolio and water management policies, both now and in the future, could help us provide the same confident assurance to all people of Tucson throughout the 21st Century?”

3.3 Critical Drivers and Uncertainties

The scenario planning stakeholder group met virtually on March 15, 2021 for the first of three workshops. During the first workshop they developed a list of uncertainties that could affect Tucson Water. The BC and Tucson Water staff team then developed categories to group the uncertainties listed into eight major driving factors. Table 3-1 summarizes the driving factors, and the specific uncertainties that comprise the categories, as developed with the stakeholders. This table represents the results of Steps 2a and a portion of 2b outlined above.

Table 3-1. Tucson Water Driving Factors and Uncertainty

Major Driving Factors	Uncertainties Identified by Stakeholders
Water Supply Changes	Threats to natural resources: CAP, water rights, water quality, the watershed and the Colorado River (induced by climate, political, or other human factors). Opportunities for green infrastructure (rainwater harvesting). Premise plumbing and effects on water quality. Environmental risks to riparian areas and stream recharge and how those affect the overall water system. Groundwater quality (contaminants of emerging concern and perfluorinated compounds).

Major Driving Factors	Uncertainties Identified by Stakeholders
Water Demand Changes	<p>Land use changes due to climate or zoning changes.</p> <p>Economic factors, such as availability/lack of availability of incentives for business and housing affordability.</p> <p>Population trends (significant and/or unplanned increase or decrease).</p> <p>Forms of transportation and incorporating green infrastructure opportunities to offset demand.</p> <p>Effects from water conservation.</p> <p>Potential for Tucson Water to acquire other service areas or remove service areas outside core area.</p>
System Resilience	<p>Water system reliability.</p> <p>Smart technologies.</p> <ul style="list-style-type: none"> • Cyber security threats • Possible efficiency improvements <p>Climate effects on infrastructure.</p> <p>Emergency planning and response.</p>
Community/Educational Factors	<p>Potential for public misinformation.</p> <p>Potential for widespread community engagement.</p> <p>Public acceptance and support (reclaimed water, resource dependency, etc.).</p>
Equity and Affordability	<p>Cost of service, affordability for all demographics.</p> <p>Realization of equity – understanding what it looks like and how it could be achieved.</p> <p>Stormwater and flooding impacts specifically observed in lower income areas.</p>
Government/ Policy/ Regulations	<p>Policy making on regional, state, and federal levels.</p> <p>Regulatory trends on all levels (local, state, and federal).</p> <p>State politics and decisions.</p> <p>Government instability.</p>
Water-Energy Nexus	<p>Ability to provide energy security, recognizing the energy future might be out of Tucson Water’s control.</p> <p>Incorporating redundancy for resilience.</p> <p>Ability to reduce carbon footprint.</p>
Economic Variability	<p>Change in workforce.</p> <p>Potential for youth flight due to climate effects.</p> <p>Changes in business connections to water service/ inability to incentivize business connections.</p> <p>Aging workforce and whether that leads to population increase or decrease.</p>

These eight prevailing factors were then ranked by stakeholders (on relative scales) based on their inherent uncertainty, and again on the impacts of that uncertainty, using the following guiding definitions:

- **Uncertainty:** The unknown range of affects a driver may have, whether positive or negative.
- **Potential Impact:** The criticality of uncertainty on the efficacy of decisions: Sometimes uncertainty matters and other times it may not.

Throughout the process, the analogy of a wedding plan was used to help clarify these definitions. If a wedding is planned for a Saturday, one might say that the weather for the Friday before the wedding and the Saturday of the wedding is equally uncertain, but only one of these uncertainties could impact the wedding. BC also used the analogy of asset management, in which total risk is a combined function of both the likelihood of failure (uncertainty) and the consequence of failure (potential impact). Together, uncertainty and potential impact of the uncertainty offer a profile on the risks posed by each driving factor.

Figures 3-4 and 3-5 illustrate how the stakeholders ranked the eight factors based on their relative uncertainty and potential impact (shown separately). Figure 3-6 combines the results using the average placement of each driver in the individual stakeholder lists and illustrates that the drivers identified range from high uncertainty with high impact to moderate uncertainty with low impact. These results completed steps 2b and 2c of the process outlined above and prepared the stakeholders for Step 3, in which they identified the most important drivers for the 1W2100 Plan and redefined them using some of the less-impactful drivers, as discussed in the following sections.

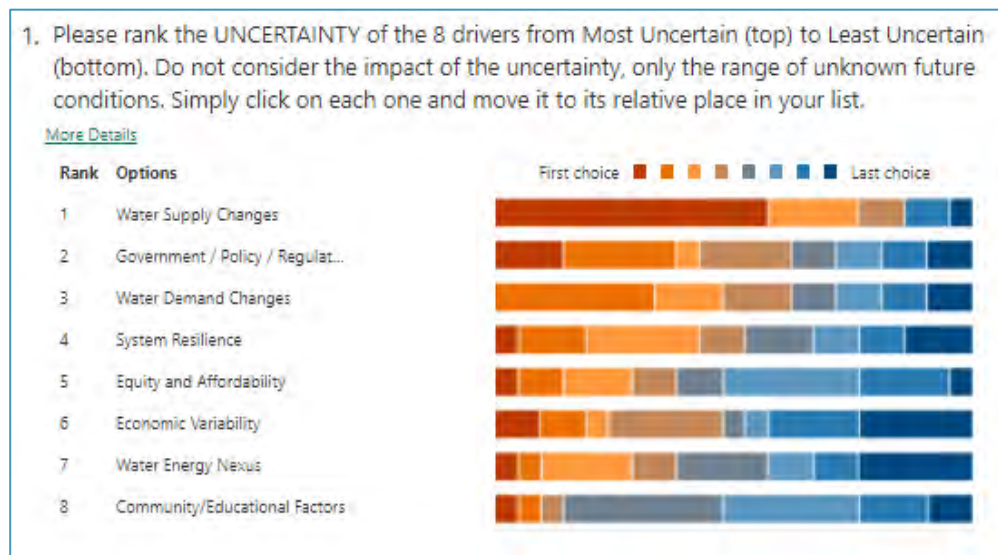


Figure 3-4. Stakeholder Survey Question and Results for Relative Uncertainty of Driving Factors

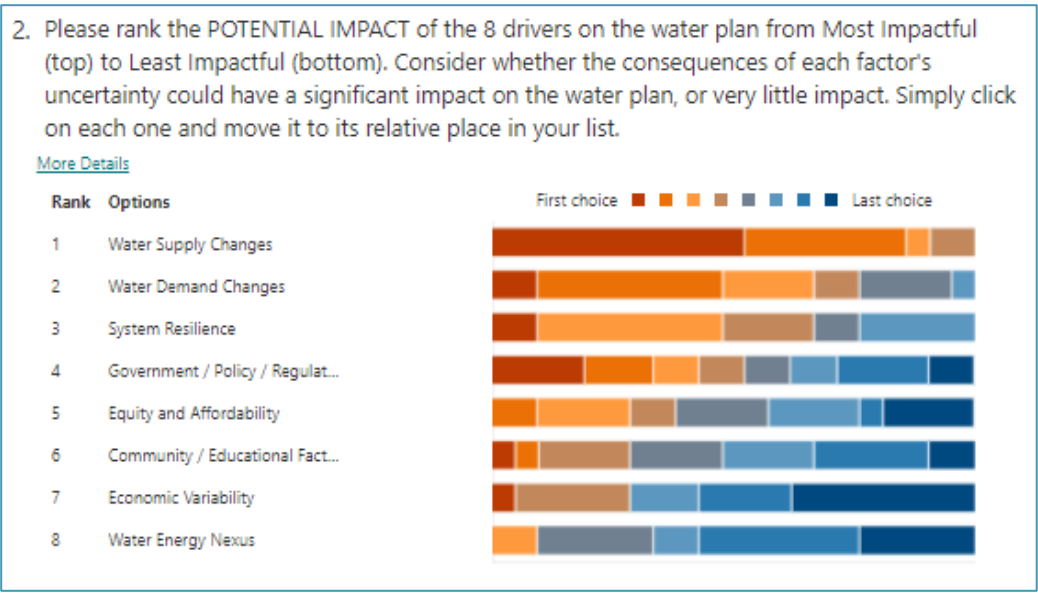


Figure 3-5. Stakeholder Survey Question and Results for Relative Potential Impact of Driving Factors

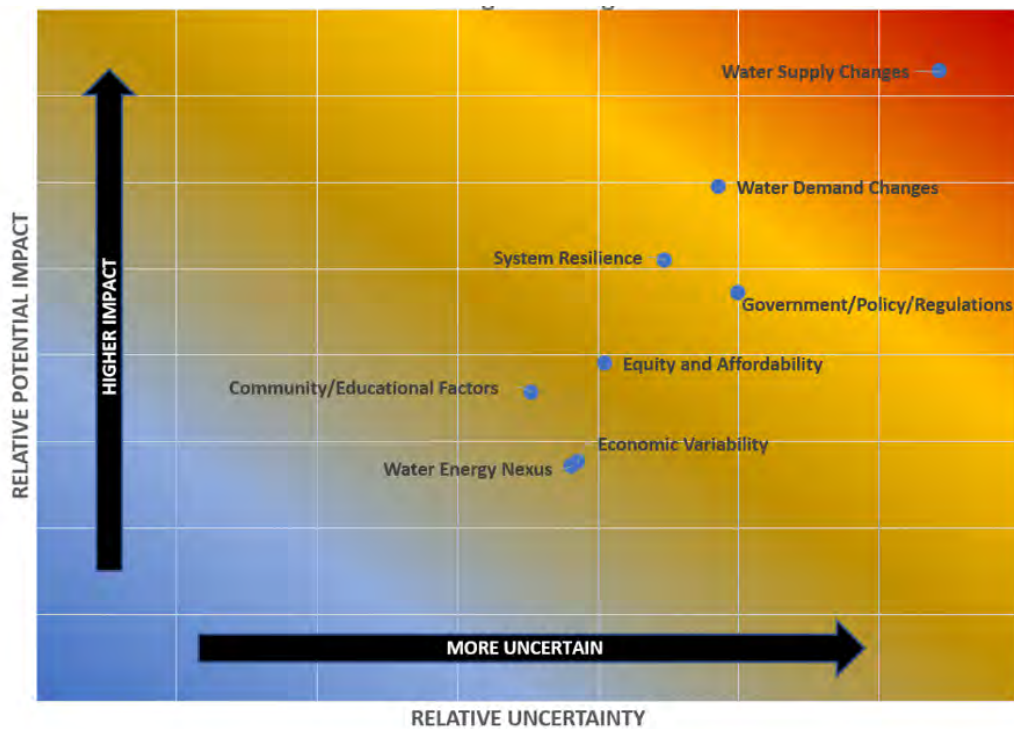


Figure 3-6. Average Stakeholder Results for Uncertainty and Impact of Driving Factors

3.4 Future Scenarios

As illustrated on Figure 3-7, stakeholders identified four of the eight driving factors as High Uncertainty / High Impact:

- Water supply changes
- Water demand changes
- System resilience
- Government/Policy/Regulations

In Step 3a outlined above, the group experimented with various combinations of these four drivers in the form of a 2 x 2 grid, in which each axis represented the full spectrum of uncertain outcomes for one of the two factors, and each quadrant, therefore, represented a future “scenario” based on the combinations of the two. Tucson Water’s stakeholders felt that it was important to also include some of the driving factors with less uncertainty or impact to help ensure that the future conditions explored in this exercise were broadly representative of their interests and concerns. Ultimately, four subgroups of the stakeholder committee were formed to explore four combinations of drivers, as outlined in Table 3-2, and highlighted in the left columns of Figure 3-7.

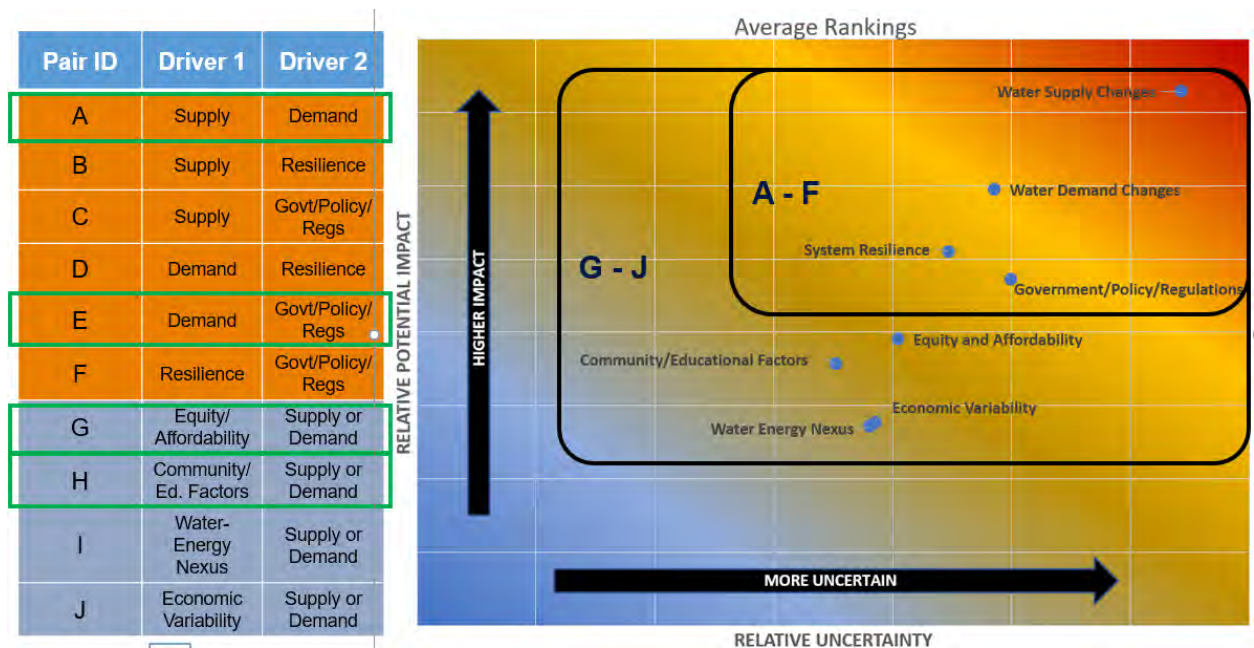


Figure 3-7. Groupings of Factors for Future Scenarios

Table 3-2. Selected Pairings of Driving Factors for Exploratory Scenario Definition

DRIVER 1	DRIVER 2
Water Supply Changes	Water Demand Changes
Water Demand Changes	Government/Policy/Regulations
Equity/Affordability	Supply or Demand (and/or)
Community/Education Factors	Supply or Demand

Each group created a 2 x 2 matrix as part of Step 3a and deliberated on combinations of their chosen drivers that create future conditions, or scenarios. Some instructive observations from these deliberations included:

- Each of the groups focused in some way on either water supply or water demand uncertainties, or both.
- Through discussion, the groups recognized that uncertainties in equity, affordability, education, and government/regulatory decisions were a “means” to arriving at future conditions in which supply and/or demand had experienced significant changes. As such, these driving factors were incorporated into the definition of the principal uncertainties of supply and demand and their associated scenarios in Step 4, to be discussed below.
- The groups recognized that the most common, most uncertain, and most potentially impactful uncertainties were those associated directly with future supply and future demand. Hence, as Step 3b, these two uncertainties were combined into the overarching matrix of four future scenarios around which alternative water management strategies were developed in Step 4, to be discussed below.

Figure 3-8 presents the governing matrix for the formulation of alternative water management strategies in Step 4. The first action in Step 4 was to develop narrative descriptions of each future scenario based on the plausible combination of supply and demand trends in each quadrant. Figure 3-8 illustrates the definition of the supply and demand axes, which incorporate previously identified and explored driving factors as key reasons why future conditions may develop. Figure 3-8 also includes the narrative description of each combination of supply and demand uncertainties, as developed by stakeholders who were asked to “imagine living in this quadrant in 50 years and explain what you observe.”

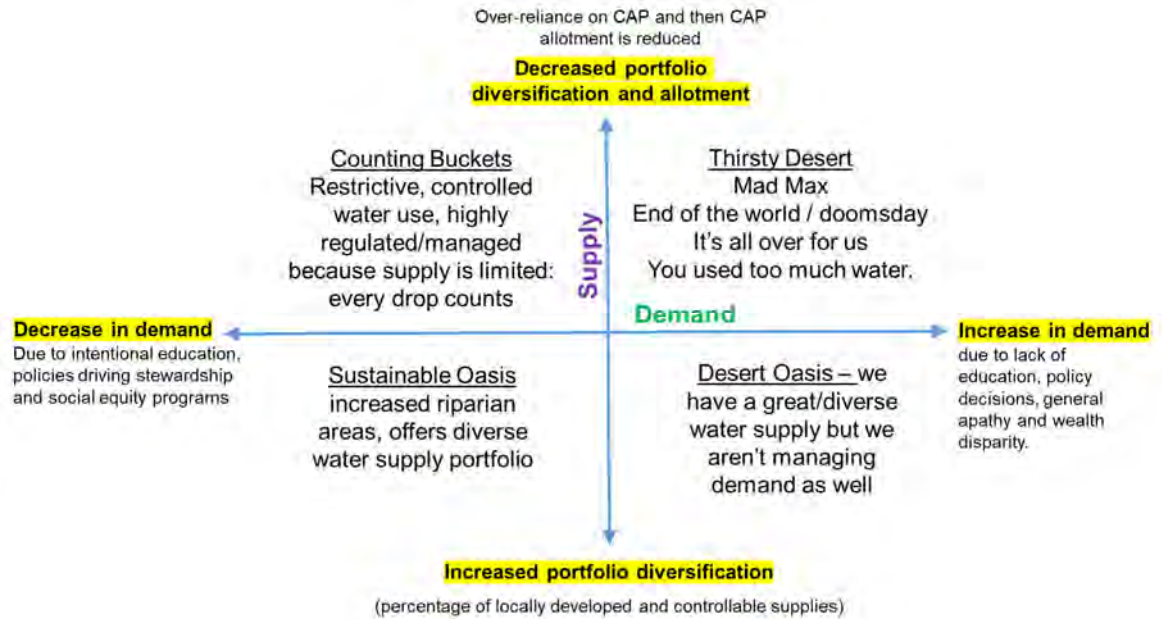


Figure 3-8. Plausible Future Scenarios

3.5 Conclusions: Stakeholder Findings and Recommended Water Management Strategies

As a final exercise (Step 4b), the stakeholders were asked to formulate approaches to either mitigate imagined circumstances associated with future scenarios, or to help avoid the circumstances from developing. Figure 3-9 illustrates how each of the four groups (each associated with one of the four scenario quadrants in Figure 3-8), approached this by discussing relative changes to current water supply portfolio allocations. Figure 3-9 illustrates the results of this discussion. The relative height of bars and the allocations within them do not represent numerical values. They are illustrations of the relative importance that different water supply types were given during each group’s discussion. The first bar on the left represents Tucson Water’s current, relative allocation of water supply sources. Each of the bars to the right present recommendations from the individual groups focused on specific future supply and demand scenarios.

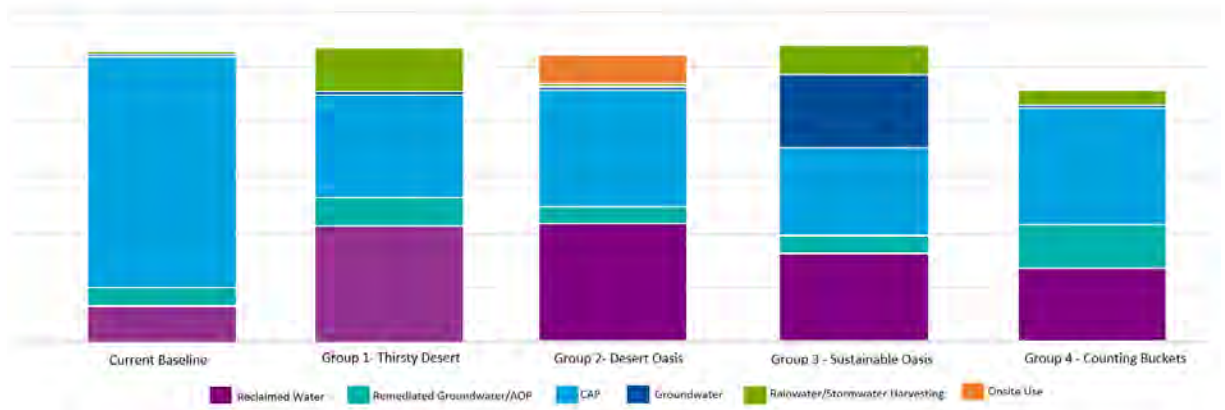


Figure 3-9. Testing Alternatives or Decisions Against Plausible Futures (RELATIVE CHANGES ONLY – Nonquantitative.)

All groups agreed on many recommendations, suggesting that certain decisions could be beneficial regardless of which supply and demand conditions emerge in the future. These universal recommendations build “immunity” to future uncertainty because they address uncertainties in each of the four scenario quadrants. The concluding recommendations from the stakeholder-driven scenario planning process are as follows:

- Tucson should plan on reducing reliance on CAP water through increased efficiency and conservation
- Increase on the use of reclaimed water to help offset reliance on CAP water, either moderately or significantly.
- Continue to treat or remediate groundwater
- Expand rainwater and stormwater harvesting
- Develop onsite reuse strategies

In general, these recommendations seek to increase the use of locally controlled and distributed water resources and decrease reliance on CAP water.

The stakeholders also recommended the following practices to be upheld in 1W2100:

- Develop and implement a consistent and effective public outreach and education campaign on water conservation and local water management strategies – this can help manage future uncertainty.
- Promote awareness of equity in the community to help avoid future conditions in which the economics of water in Tucson are unreasonably stratified and decisions difficult to implement, including policy and other water related decisions.
- Remain involved in state and federal policy and regulatory discussions
- Consider opportunities to reduce emissions in light of the water-energy nexus

4 References

Water Research Foundation (WRF). 2017. Blueprint for One Water. Denver, Colorado. Project 4660.

Climate Central. 2019. American Warming: The Fastest-Warming Cities and States in the U.S. Research Brief. April 17, 2019.

Appendix A. Scenario Planning Process

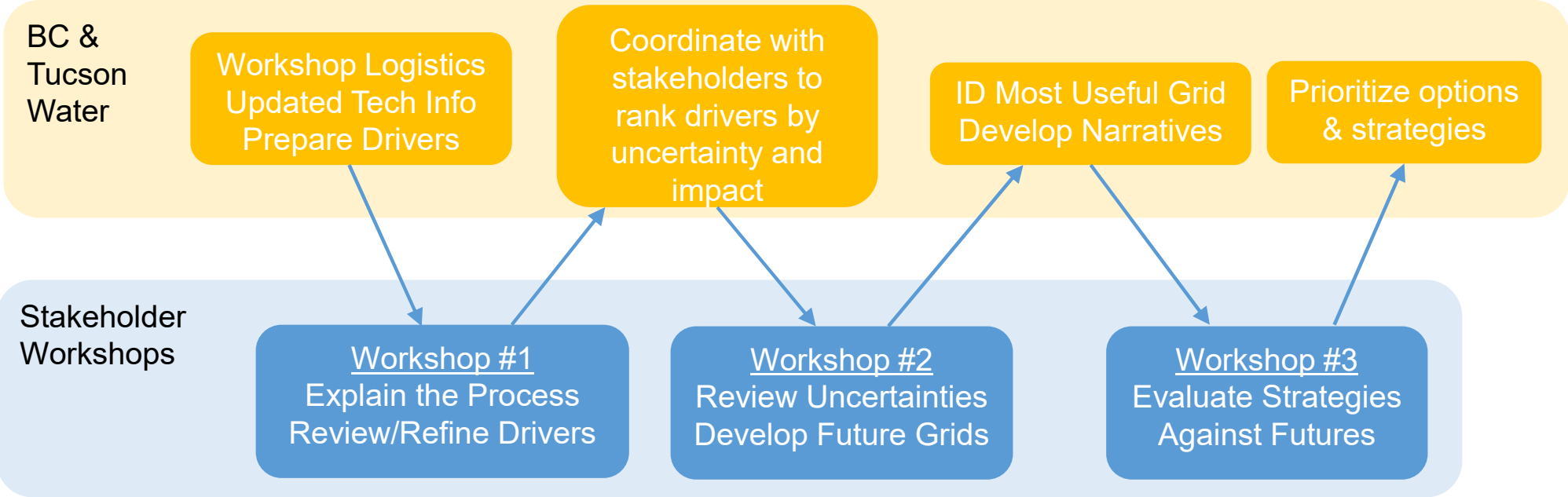




Scenario Planning

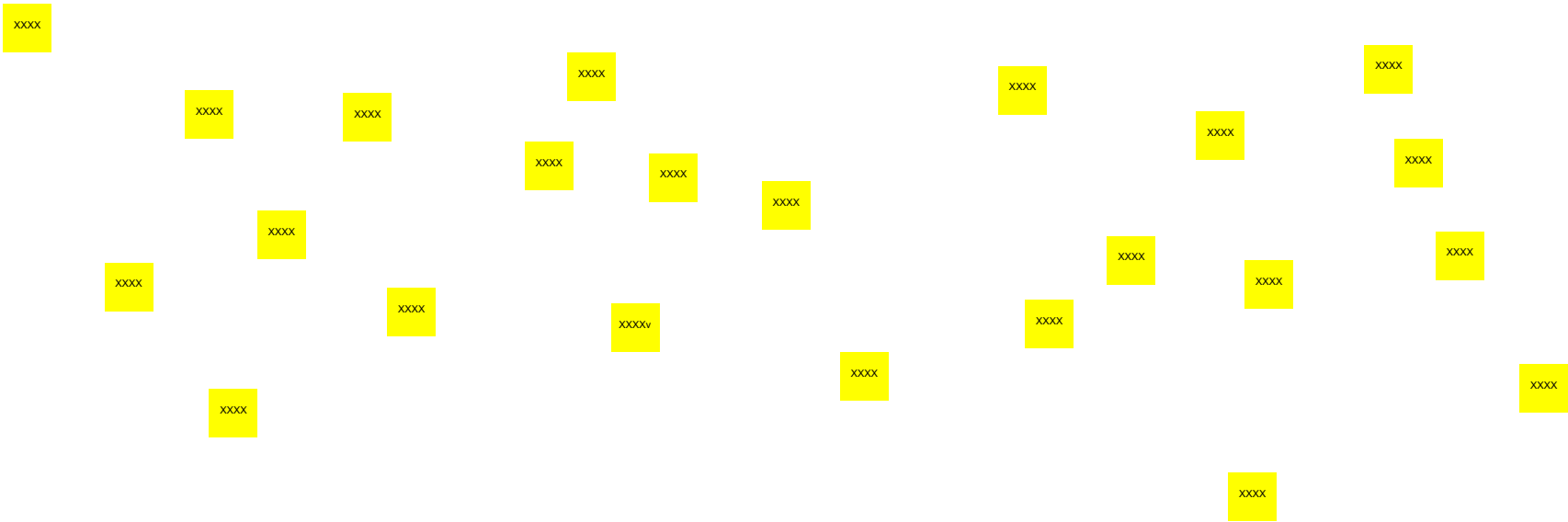
Putting it into action for Tucson Water

Your Role in Tucson Water's One Water Process: *Scenario Planning to Identify and Mitigate Uncertainties*



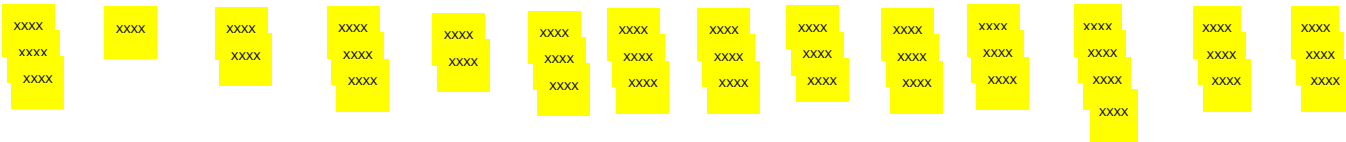
DRIVERS

Tucson Water brainstorms **driving factors** that are causing them to take action, and whose uncertainty could affect the efficacy of the plan



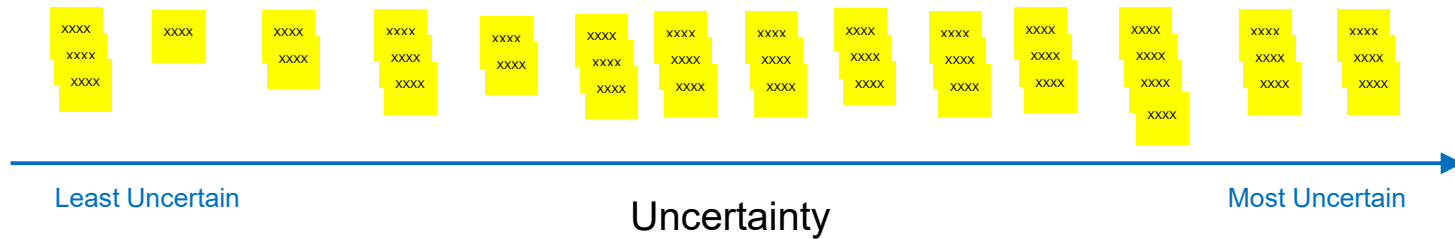
RELATED THEMES

We will help group the drivers into related themes



RELATIVE UNCERTAINTY OF THE DRIVERS

Stakeholders will refine the drivers and help rank them on their **uncertainty**

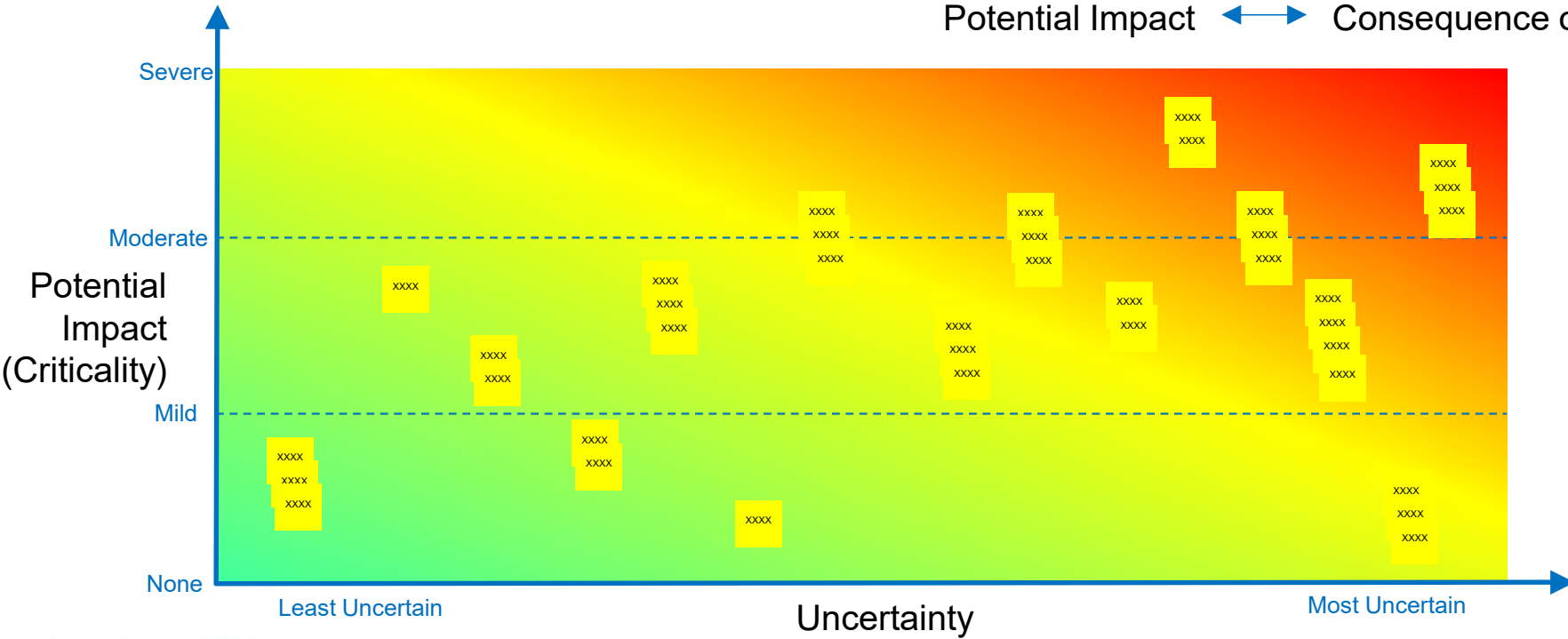


RELATIVE IMPACT OF THE UNCERTAINTY

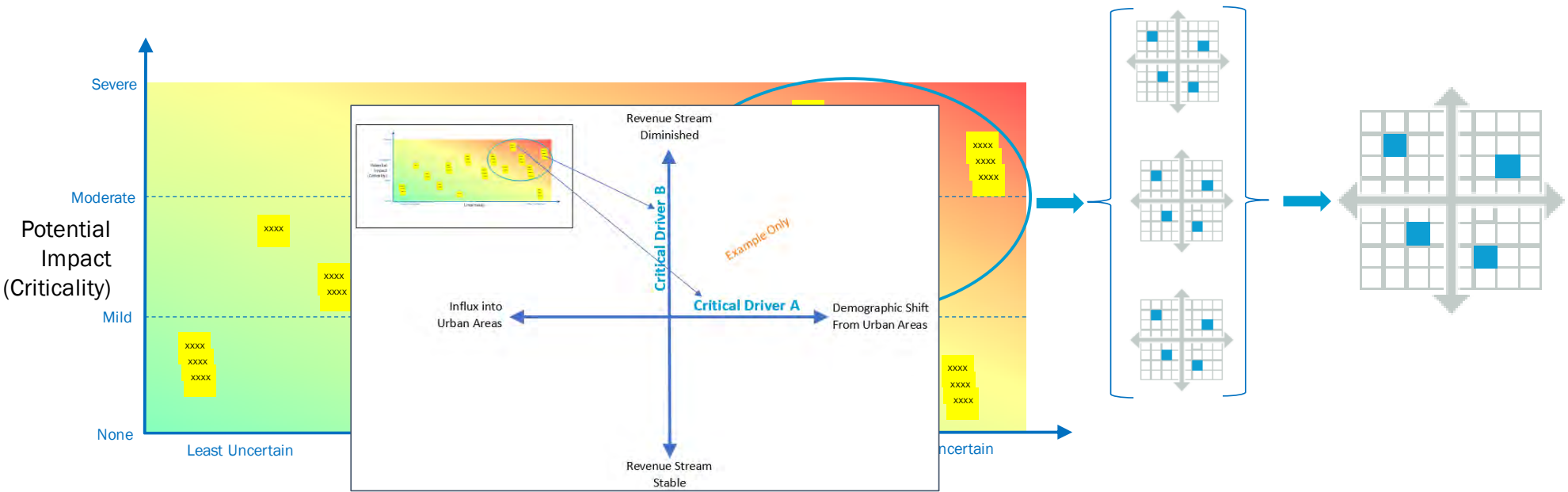
Stakeholders will help rank the drivers on their **impact**

We will borrow some philosophy from Asset Management:

Uncertainty ↔ Likelihood of Failure
 Potential Impact ↔ Consequence of Failure

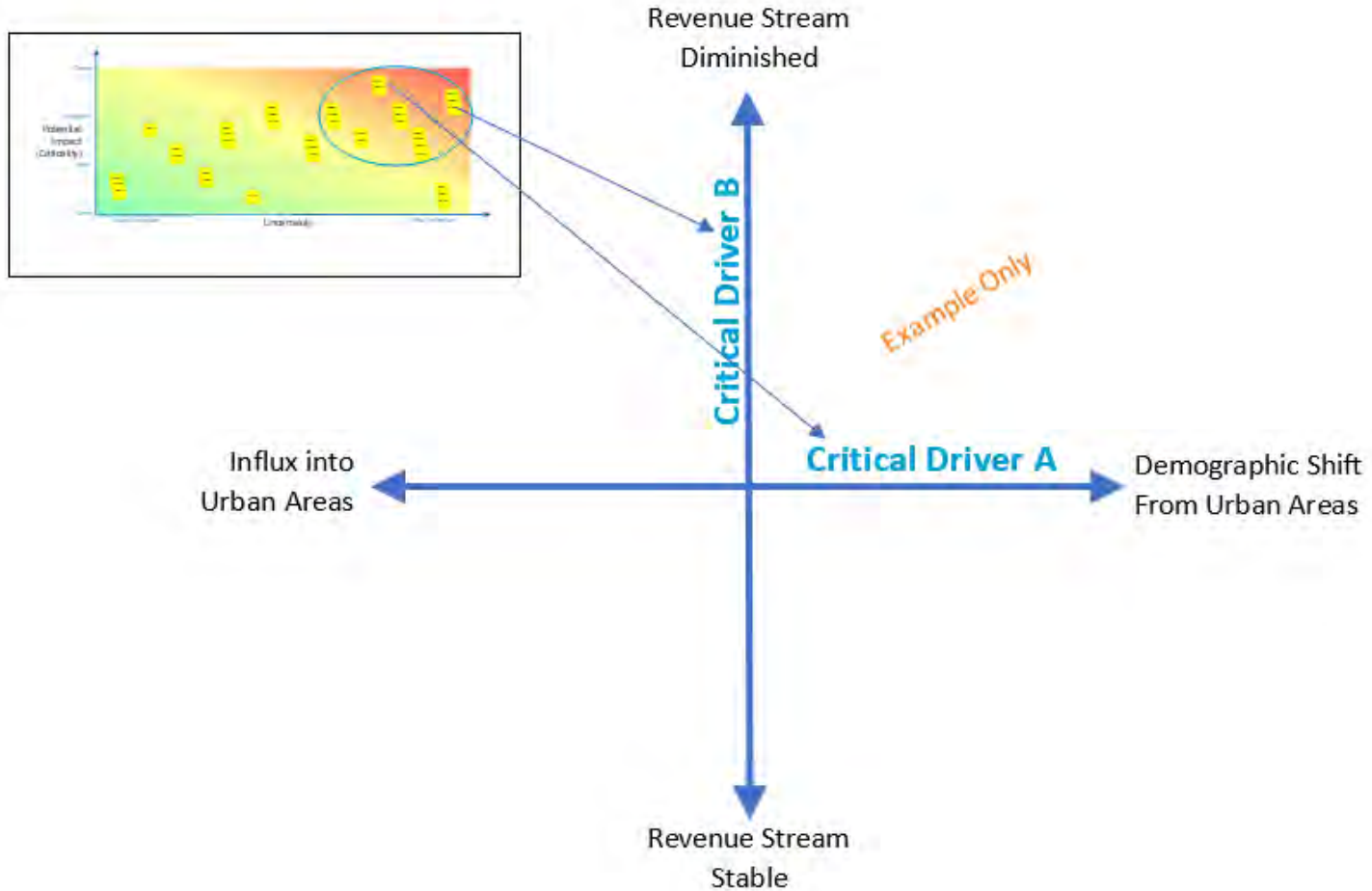


COMBINING THE MOST IMPACTFUL UNCERTAINTIES







Stakeholders will help develop grids of future risk and evaluate strategies to mitigate risk

Defining Plausible, High-Risk Futures



Testing Alternatives Against Plausible Futures

Alternatives	Quadrant A	Quadrant B	Quadrant C	Quadrant D
Alternative A				
Alternative B				
Alternative C				
Alternative D				

-  Extremely Satisfied
-  Satisfied
-  Dissatisfied
-  Extremely Dissatisfied