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Climate Crisis is Straining the Colorado River's Complex Policy Architecture

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The Policy Architecture of the Colorado River Basin

Conversations about policies on the Colorado River Basin (CRB) invariably lead to criticism of the antiquated nature of the [1922 Colorado River Compact](#) and its overestimate of future water flows. However, the 1922 compact is just one of a suite of water-sharing agreements, court decrees, and treaties that dictate how CRB water is shared among seven states, Mexico, a myriad of sovereign tribes, and the environment. These policies are referred to as the Law of the River.

The CRB states faced a problem in the early 1900s. Southern states, especially California, had begun developing agriculture and wanted infrastructure for flood control and irrigation. The passage of the [Reclamation Act](#) and creation of the Bureau of Reclamation in 1902 provided the means by which the infrastructure could be built. However, Congress would not approve any spending until states in the CRB reached an agreement on the division of the CRB's water. Eventually, the 1922 Colorado River Compact was created (Meyers, 1966).

The negotiators of the 1922 compact were concerned with ensuring that each state received enough water to meet their interests (MacDonnell, 2023; Hundley, 2009). Given that states in the CRB's south were developing agricultural systems faster than states in the north were, the northern states feared that southern states would win the right to use most of the water, depriving them of water. This was a legitimate concern because in 1922 the Supreme Court ruled in *Wyoming v. Colorado* that prior appropriation was the method by which interstate streams would be divided (Meyers, 1966).

To get around this, the CRB was divided into two subbasins—an Upper Basin (consisting of Utah, New Mexico, Colorado, and Wyoming) and a Lower Basin (consisting of Nevada, Arizona, and California)—with

each subbasin nominally allocated 7.5 million acre-feet (MAF) of water. A separate clause in the 1922 compact granted the Lower Basin the right to use an additional 1 MAF of water beyond the 7.5 MAF they were granted by the previous provision. This was an overpromising of wet water supplies, which only worsened later as the water needs of tribes were recognized and Mexico negotiated a right to a share of the river (MacDonnell, 2023).

Since most of the water in the CRB originates in Upper Basin mountains, Lower Basin states feared that much of the water would be used upstream. Two additional provisions were added that said that the Upper Basin states must not use so much water as to cause the flow of river to fall below 75 MAF over 10 years (an average of 7.5 MAF per year), thereby ensuring water would always make it to the Lower Basin (MacDonnell, 2023). For much of the CRB's history, this provision has been interpreted as constraining the Upper Basin to the amount of water left in the river after 7.5 MAF has been set aside for the Lower Basin (MacDonnell, Getches, and Hugenberg, 1995). As discussed in more detail below, climate change impacts lead some to challenge this interpretation. Another provision ensured that Upper Basin states could not withhold water from the Lower Basin states and that the Lower Basin states could not require the delivery of water that they did not need.

In 1928, the [Boulder Canyon Project Act](#) was passed, fulfilling the federal government's promise to provide funding for the Hoover Dam for flood control and hydropower and the All-American Canal for Southern California irrigation. The legislation also delineated how Lower Basin states were to share their 7.5 MAF, with Nevada granted 0.3 MAF, Arizona 2.8 MAF, and California 4.4 MAF.

Arizona did not ratify the 1922 compact for several years. In that time, California secured contracts to more water than they were allotted in the Boulder Canyon Project Act (Meyers, 1966). Fearing that California would

win the right to a wealth of water from the yet-to-be-constructed Lake Mead and leave Arizona with little water, Arizona eventually ratified the 1922 compact and sued to settle their water apportionment. The litigation led to a 1964 Supreme Court ruling known as [Arizona v. California](#), in which the court established that California could not use more than 4.4 MAF and that tributaries in the Lower Basin (like the Gila River) could be used without counting toward a state's Colorado River allocation (Meyers, 1966).

Before significant diversion altered its flows, the Colorado River entered the Sea of Cortez and supported a vibrant estuary, as documented in *A Sand County Almanac*, where Leopold canoed the river's terminus in Mexico near the Gulf of California (Leopold, 1949). Yet Mexico's claims to the river were not quantified in the 1922 compact. Rather, the 1922 compact framers put in a placeholder provision for a possible future allocation for Mexico. Eventually, a [1944 treaty](#) quantified Mexico's allotment at 1.5 MAF of water.

One other group of water users was largely left out of the 1922 compact: Native American tribes. In 1908, the Supreme Court issued a ruling in [Winters v. United States](#), determining that federally recognized tribes with an established reservation had a right to the amount of water that was needed for irrigation and other purposes. These so called "Winters rights" are federally reserved rights that usually hold seniority dates of either time immemorial or of the date that the tribe's reservation was established, often predating the 1922 compact. Generally, tribes hold the most senior rights in the CRB (U.S. Bureau of Reclamation and Ten Tribes Partnership, 2018).

Although this ruling was handed down long before the 1922 compact, tribes were not invited to participate substantively in the 1922 negotiations or for many decades afterward when subsequent water-sharing agreements were crafted. As a result, tribes and their water claims were not part of the river's governing framework, making it difficult for tribes to access the water to which they have been entitled (Robison et al., 2018). If a tribe wishes to turn their promised rights into real water, they have to go through a complex negotiating process, potentially including litigation, to quantify the exact amount of water to which they are entitled. Some tribes have done this, but others have not or have been only partially successful (Guarnio et al., 2021). The 30 tribes in the CRB collectively hold recognized diversionary rights to 3.2 MAF, but 12 tribes have unresolved water right claims to at least 400,000 acre-feet more (Guarnio et al., 2021).

In 1948 the Upper Basin states settled the question of how they should divide their water by opting to split their share on a percentage basis. The 1948 [Upper Colorado River Basin Compact](#) granted Colorado the right to 51.75%, Utah 23%, Wyoming 14%, and New Mexico

11.25% of the Upper Basin's available water, after 7.5 MAF were delivered to the Lower Basin. The 1948 compact also outlined a scheme for how Upper Basin states would need to reduce their water use in the event that delivery volumes to the Lower Basin were below the 1922 compact's provision of allowing 75 MAF to flow to the Lower Basin every 10 years. This provision is known as curtailment and is being more frequently discussed in both basins today (Robison, 2016b).

Environmental interests were also ignored in the formation of the Law of the River, meaning that instream flows—water kept in a river for the benefit of the environment—were not considered. Environmental protections of water flows in the CRB came relatively late in its more than 102 year history, and a litany of environmental impacts occurred in that time including inundating aquatic habitat under dams and reservoirs, dewatering of the river's delta, endangerment of native plant and animal species, introduction of invasive species, alterations to the river's natural flow regime, loss of riparian areas, and others.

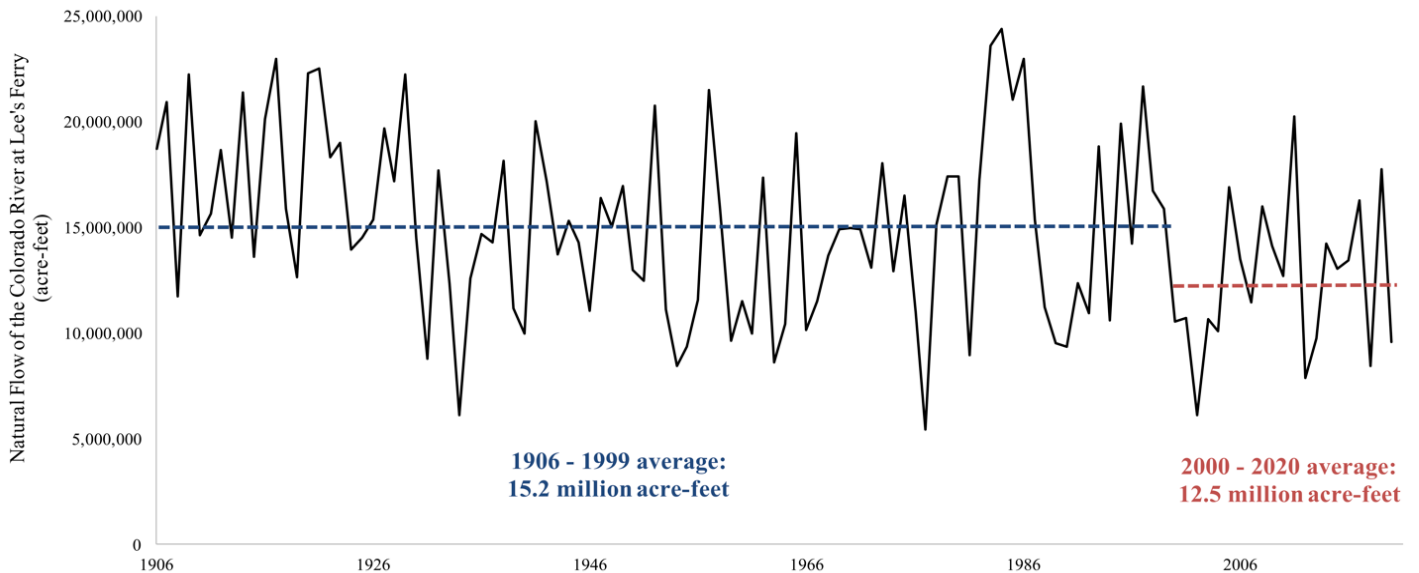
Today, there is still no basin-wide mandate for instream flows, and the majority of water for environmental flows is a result of the Endangered Species Act (ESA), which dedicates small amounts of water to certain areas of the CRB that have been identified as "critical habitat" for endangered species (Shaner, 2004). Most of the ESA activities in the CRB are implemented by four different programs: The Upper Colorado River Endangered Fish Recovery Program, the San Juan River Basin Recovery Implementation Recovery Program, a program run by Grand Canyon National Park, and the Lower Colorado Multi-Species Conservation Program. In addition, when permitting processes take place to build new infrastructure or diversions, or modify existing operations, the Fish and Wildlife Service is generally consulted.

Twentieth-Century Policy Architecture Straining under Twenty-First-Century Global Pressures

The Law of the River was not designed to address the twenty-first-century problem of climate change impacts and economic and population growth. Many of the CRB's policies were devised before scientists began measuring atmospheric concentrations of CO₂, much less forecasting future flows in the CRB (United Nations, 2007). Yet, rapidly developing climate change impacts are affecting farms, cities, tribes, and ecosystems across the CRB, often faster than institutions are capable of addressing (Kenney et al., 2011).

Some seventh-eighths of the water in the Colorado River Basin originates from just one-eighth of the landmass in the headwater mountains of Utah, Colorado, and Wyoming, where snowpacks act as the largest reservoir in the CRB. Snowmelt runoff constitutes the majority of

Figure 1. Natural Flow of the Colorado River, Twentieth Century versus Twenty-First Century



Source: U.S. Bureau of Reclamation (2023b).

water flows in the CRB, which is why rising air temperatures that reduce snowpacks are reducing water flows (Lukas and Payton, 2020). This can be seen by comparing average Colorado River flows from the twentieth century to those in the twenty-first century. As Figure 1 shows, flows in the first quarter of the twenty-first century are roughly 20% lower than they were in the twentieth century, a phenomenon that is in part due to warming temperatures (Udall and Overpeck, 2017; Woodhouse et al., 2016; Milly and Dunne, 2020).

Additional studies have indicated that the CRB is transitioning to a hotter, drier climate in a long-term process called aridification (Overpeck and Udall, 2020), and that the CRB is currently experiencing its worst drought in 1,200 years (Williams, Cook, and Smerdon, 2022).

The rapid pace of flow declines stands in contrast to the glacial pace of decision making in the CRB. With the benefit of hindsight, we are able to see that many of the actions taken in the first quarter of the twenty-first century to address low river flows did not go far enough, requiring states to renegotiate agreements multiple times, as demonstrated by the 2007 Interim Guidelines.

Following a series of low water years in the early 2000s, the federal government spurred the CRB states to create a new agreement to prevent water levels in the country's two largest reservoirs (Lake Powell and Lake Mead) from falling to low levels (Grant, 2008). The 2007 Interim Guidelines required Lower Basin states to reduce water use by set amounts when water levels in Lake Mead fell to certain thresholds. The guidelines last through 2026 (Grant, 2008).

By the early 2010s, it became clear that the 2007 Interim Guidelines did not go far enough to address the ever-

worsening conditions in the CRB and additional cuts were needed to ensure that neither Lake Powell nor Lake Mead fell to catastrophically low levels before 2026. The Drought Contingency Plans (DCPs) were enacted in 2019, which bolster the 2007 Interim Guidelines by adding additional water cuts to Lower Basin states. The DCPs also authorized additional actions like releasing emergency water from upstream reservoirs and reducing downstream deliveries from Lake Powell (Stern, Sheikh, and Hite, 2023). Yet, like the original guidelines, the DCPs underestimated just how low river flows would get; a few years later the CRB once again found itself facing a crisis.

In 2022, the Commissioner of the Bureau of Reclamation (USBR) told a congressional committee that the CRB states needed to cut a one-time amount of 2–4 MAF of water to prevent reservoir collapse prior to 2026 (U.S. Congress, 2022). If water levels in Lake Powell approached the minimum hydropower generation levels, downstream water deliveries would be threatened. The testimony sparked a new round of negotiations among the CRB states, which lasted through the winter of 2023. Fortunately, an above-average winter in 2023 provided some breathing room to finalize negotiations. Eventually, the process resulted in another update to the 2007 Interim Guidelines in the form of a supplemental environmental impact statement, in which the Lower Basin states anticipate collectively cutting 0.75 MAF of additional water each year from 2023 to 2026. While these cuts have not been formally allocated among the Lower Basin states, the USBR indicates that Arizona is expected to cut approximately 0.28 MAF, Nevada 0.07 MAF, and California 0.4 MAF per year (U.S. Bureau of Reclamation, 2024a). The USBR finalized this process with a record of decision adopting the above-stated plan (U.S. Bureau of Reclamation, 2024b).

In a similar way, other important tools used by the USBR to manage the Colorado River also lag behind the rapid pace of river flow declines. For instance, the USBR periodically creates a hydrologic determination, or an official estimate of how much water is available for Upper Basin states to share. The last time the USBR created a hydrologic determination was in 2007, based on data exclusively from the twentieth century, before climate change impacts had significantly shrunk river flows (U.S. Bureau of Reclamation, 2007).

With the benefit of hindsight, we can see that the tools water managers created to manage low river flows—the 2007 Interim Guidelines, the 2019 DCPs, and the hydrologic determination—persistently lagged behind the rapid pace of climate change impacts. This is the result of a number of problems in CRB decision making, including an underestimation of the severity of future flow declines and political complexities posed by the sometimes-opposing agendas of the Upper Basin, Lower Basin, federal government, and other key actors. This has forced negotiators back to the table for lengthy talks to develop ad hoc agreements, focusing states’ resources on short term problems rather than long-term plans.

At the end of 2026, the 2007 Interim Guidelines will expire and the CRB will need to implement new long-term plans. The USBR has initiated a National Environmental Policy Act process to permit these new plans, and they hope to release a draft environmental impact statement (DEIS) in December of 2024 (U.S. Bureau of Reclamation, 2023a). This is a similar but separate process from the one described before, which focuses on plans through (but not extending past) 2026. The USBR has asked representatives from the CRB states to agree on and submit one alternative so it can be included in the DEIS. The Upper Basin (Mitchell et al., 2024), Lower Basin (Buschatzke, Entsminger, and Hamby, 2024), and a consortium of conservation groups have all submitted plans to the USBR (National Audubon Society et al., 2024). Both basins plan to continue negotiations until an agreement is reached.

These new plans will set the course for the CRB for the next several decades. The USBR and states would be wise to learn from the 2007 Interim Guideline process and create plans for very low river flows to avoid reconvening in a few years to renegotiate the plan again.

The Biggest Challenges Facing the Colorado River in the Future

Failure to plan for a river with much less water is a major problem in the CRB today. Arguably the most important question to ask when considering the CRB’s future is how low Colorado River flows are going to get. A series of studies have provided estimates forecasting a 10%–40% decline in river flows from various twentieth-century baselines (Lukas and Payton, 2020). Table 1 ties these projected flow declines to actual water volumes in the Colorado River.

In reviewing these estimates, it is important to keep in mind that average flows in the CRB in the twenty-first century are already roughly 20% lower than they were in the twentieth century. Therefore, estimates that flows will only decline 10%–15% are likely outdated. As two scientists put it, “The emerging reality is that climate change is already depleting Colorado River water supplies at the upper end of the range suggested by previously published projections” (Udall and Overpeck, 2017, pages 2404-2405).

As warming in the CRB continues, average natural Colorado River flows could drop as low as 9–11 MAF, less than the 17.5 MAF allocated in the 1922 compact and the roughly 13.3 MAF of total water used in the CRB (Stern, Sheikh, and Hite, 2023). Attempting to deal with this hydrologic change with existing twentieth-century policies and practices is proving to be problematic.

Take, for example, the classic interpretation of Article III(d) of the 1922 compact. For most of the CRB’s history, this provision was interpreted as requiring the Upper Basin to deliver 75 MAF of water every 10 years to the Lower Basin, leaving the Upper Basin the

Table 1. Estimates of Colorado River Flow Declines in the Twenty-First Century

Percent Reduction in the Natural Flow of the Colorado River from Twentieth-Century Average as Measured at Lee Ferry	Corresponding Natural Flow of the Colorado River at Lee Ferry (MAF)
10% decrease	13.7
15% decrease	12.9
20% decrease	12.2
25% decrease	11.4
30% decrease	10.6
35% decrease	9.9
40% decrease	9.1

Source: Lukas and Payton (2020).

“leftovers” and forcing them to bear the burden of reduced flows (Robison, 2016a). CRB scholars have argued that this is an untenable situation, and that interpretation of this provision needs to change to reflect the new hydrologic reality imposed by climate change. A different reading of Article III(d)—one that doesn’t impose a delivery obligation on the Upper Basin but requires them to “not deplete” too much water—could relieve some of the climate change burden from the Upper Basin’s shoulders (Castle and Fleck, 2019).

Additionally, many tribes in the CRB have been absorbing water shortages de facto since they face barriers that prevent them from developing their full water rights, despite having seniority (Becker et al., 2022). Collectively, tribes in the CRB are currently using a fraction of their reserved rights, which total 3+ MAF. If all these rights were put to use, water use in the CRB would even further outstrip available supply (Guarnio et al., 2021). Many of the CRB’s drought responses have succeeded because of tribal nonuse. This cannot be a cornerstone of future plans.

Further, the CRB looks different today than it did in 1922. Las Vegas, for example, has undergone a transformation from small town to booming metropolis, but Nevada is allotted little water from the river. Simultaneously, Utah is allowed three times as much water but has a similar population to Nevada. Is the twentieth-century allocation structure still serving the twenty-first-century CRB, or are more dramatic changes needed?

Old practices and Law of the River interpretations struggle to keep up with twenty-first-century challenges, requiring the reinterpretation of policies or creation of new ones. Fortunately, a new tool can speed the creation and testing of policies to help the CRB address its challenges. Researchers at the University of California Riverside have created a HEM-CRB that can

help stakeholders test the impact their policy ideas would have on the hydrology and economy of the CRB and identify previously unseen trade-offs (Crespo et al., 2023). The HEM-CRB is a flexible tool capable of analyzing the performance of existing CRB policies (e.g., voluntary and/or compensated cuts by specific users) and new approaches (e.g., water markets, proportional sharing, social planner allocation). The model can also account for environmental flows, tribal water rights, and other frequently overlooked factors.

While the HEM-CRB does not change the structure of the decision-making process in the CRB—negotiations are largely left to nonelected representatives of the CRB states and residents of those states have little democratic accountability over their representative—it can indirectly influence this process in a few key ways. The HEM-CRB can provide new information to decision makers about the likely impact of proposed policies and changes to the policies that could make them more effective. This could help negotiators further refine their plans, identify previously unseen opportunities, and ultimately craft deals that create more beneficial and durable outcomes for the CRB. Additionally, the HEM-CRB can help stakeholders obtain better information on the effect of various policy proposals, helping them understand how negotiators’ proposals will impact them. The HEM-CRB will also create a “sandbox” where stakeholders can create and test their own ideas, expanding the pool of possible solutions.

Although the HEM-CRB might not directly change the structure of the highly insular decision-making structure in the CRB, it can improve transparency by providing excluded stakeholders better information about their representative’s proposals. Also, if representatives take advantage of the HEM-CRB’s ability to robustly analyze and identify solutions, they will be better equipped to adapt twentieth-century policies to twenty-first-century challenges.

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