

A R T I C L E S

How to Take Climate Change Into Account: A Guidance Document for Judges Adjudicating Water Disputes

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Editors' Summary

This report is intended for use by federal, state, and administrative judges who are confronted with a legal dispute involving a water resource that is alleged to be impacted by climate change. It may be useful as well for attorneys litigating or experts working on water adjudications. The purpose of this document is to summarize the manner in which climate change may impact rights and frameworks established under state and federal law concerning water resources and to anticipate the issues that water-related climate claims will pose to legal decisionmakers. This report arose out of the November 11-12, 2009, workshop, "Water Law and Climate Change," held in Reno, Nevada, and sponsored by the National Judicial College and Dividing the Waters, a nonprofit organization of federal and state water adjudicators. *No judge who attended the workshop has reviewed or approved of the content of this document. This document does not reflect the personal opinion of any individual judge.*

Water management and the resolution of water disputes have long relied on a simple and fundamental assumption: the past is a way to understand the present and to predict the future. Thus, for example, water allocation decisions—whether made by states in negotiating an interstate compact or by courts quantifying reserved rights—were made based on the historic record of water supply availability.

Climate change undermines the basic premise in water disputes that the past is a fair predictor of the future. Climate change is already affecting some hydrological regimes, and, in the future, such effects will increase.¹ Decisions that depend on projections of what may occur in the future present courts with a greater degree of uncertainty than they faced in the past.

Climate change issues are being raised and increasingly considered in water litigation and in environmental policy more generally. This document notes the escalating importance for water management of the "climate change/hydrologic cycle" link and sketches implications for courts. The general problem climate change presents to courts in water disputes is how to deal with decisionmaking in light of greater uncertainty. The report surveys several tools judges can use to understand the new science of climate change, and some of the options for resolving water disputes in ways that reflect a more rapidly changing and uncertain world.

Many courts are already deciding issues related to climate change. In fact, climate change has been considered in dozens of cases handed down by federal and state courts. Several of the most significant cases thus far involve actions to compel federal agencies to regulate or consider the emissions of greenhouse gas (GHG) emissions under existing environmental laws. Of these cases, *Massachusetts v. EPA*² is the most important. A second important line of cases seeks to compel

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1. Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change (IPCC), IPCC Secretariat, Geneva, 210 pp. (Bryson Bates et al. eds., 2008).
2. 549 U.S. 497, 37 ELR 20075 (2007).

federal agency action with respect to climate change through assessment of climate change impacts under the National Environmental Policy Act (NEPA).³ In a third set of cases, courts are being asked to hold large emitters of GHGs liable for their contribution to climate change. Thus, for instance, states and environmental organizations are seeking equitable relief and, in some cases, damages, from large coal-fired electrical generators, automobile manufacturers, and energy companies under theories of public nuisance, trespass, and negligence.⁴

The issue of the impact of climate change on water cases is different from the litigation seeking to compel an agency to address climate change under an existing statutory or regulatory scheme. In water disputes, courts are frequently called upon to decide claims that potentially turn upon acceptance or rejection of projections of the impacts of climate change upon the natural environment.

Massachusetts v. EPA

In *Massachusetts v. EPA*, the U.S. Supreme Court upheld the standing of Massachusetts and other states to challenge the failure of the U.S. Environmental Protection Agency (EPA) to regulate greenhouse gas (GHG) emissions from motor vehicles and went on to hold that the Clean Air Act regulates GHGs as air pollutants. As a result of this decision, EPA is moving forward on several fronts to regulate GHG emissions from motor vehicles and stationary sources.¹

1. See, e.g., U.S. EPA, Reconsideration of Interpretation of Regulations That Determine Pollutants Covered by Clean Air Act Permitting Programs, Final Rule, 75 Fed. Reg. 17004 (Apr. 2, 2010); Prevention of Significant Deterioration and Tailoring Rule, 75 Fed. Reg. 31514 (June 3, 2010); Endangerment and Cause and Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, Final Rule, 74 Fed. Reg. 66496 (Dec. 15, 2009); Mandatory Reporting of Greenhouse Gases, 74 Fed. Reg. 56260 (Oct. 30, 2009).

It is precisely these questions of impact that will arise with increasing frequency in water disputes. Courts are already

3. 42 U.S.C. §§4321-4370f, ELR STAT. NEPA §§2-209. *Center for Biological Diversity v. Nat'l Highway Transp. Safety Admin.*, 506 F.3d 506, 37 ELR 20281 (9th Cir. 2007) (agency violated NEPA by failing to assess climate change-related impacts from new fuel efficiency standards); *Nw. Envtl. Advocates v. Nat'l Marine Fisheries*, 460 F.3d 1125, 37 ELR 20176 (9th Cir. 2006) (NEPA challenge to Columbia River dredging plan based upon failure to analyze impacts attributable to climate change); *Mayo Found. v. Surface Transp. Bd.*, 472 F.3d 545, 37 ELR 20006 (8th Cir. 2006) (supplemental environmental impact statement on rail extension project adequate under NEPA, despite failure to consider climate change impacts of project).

4. *Connecticut v. Am. Elec. Power*, 582 F.3d 309, 39 ELR 20215 (2d Cir. 2009) (reversing district court dismissal of states' suit against power plant owners and thereby clearing the way for a trial on states' public nuisance claims); *People ex rel. Brown v. General Motors*, 2007 WL 2726871 (N.D. Cal. 2007) (dismissing, on political question grounds, state lawsuit against car manufacturers for contributing to public nuisance of global warming); *Native Village of Kivalina v. ExxonMobil Corp.*, 663 F. Supp. 2d 863, 39 ELR 20236 (N.D. Cal. 2009) (dismissing, on political question and standing grounds, action of Native Alaskan Village against oil companies for damages based upon common-law liability claims).

beginning to grapple with such questions. The most prominent example is the current litigation over the impact of major water diversion projects in California upon various threatened and endangered aquatic species. In two separate written opinions by Judge Oliver Wanger of the U.S. District Court for the Eastern District of California, the court enjoined the water projects based upon a determination that the federal agencies involved had failed to consider and incorporate the scientific evidence indicating that climate change may impose significant changes to the hydrologic systems subject to the diversion projects.⁵

In *Natural Resources Defense Council v. Kempthorne*, Judge Wanger found:

the [FWS Biological Assessment] projects future project impacts in explicit reliance on seventy-two years of historical records. In effect, the Biological Assessment assumes that neither climate nor hydrology will change. This assumption is not supportable. . . .

At least half a dozen models predict warming in the western United States of several degrees Celsius over the next 100 years (Redmond, 2003). Such sophisticated regional climate models must be considered as part of the FWS' consideration of the best available scientific data.⁶

I. Understanding Climate Science

The earth's climate is changing in a manner that is outside the parameters established by natural variability.⁷ This conclusion stems from the wide number of ways the climate system is changing, and the fact that observed increases in temperature over the last several decades cannot be explained by any known natural mechanism.⁸

The earth's climate varies naturally on all time scales, from seasons to millennia. Much of this variability is caused by known agents, such as changes in the earth's orbit that explain the comings and goings of ice ages, or the much smaller influences of variable sun and volcanic eruptions. Variations internal to the earth's climate system are also important, particularly on the interannual to decadal time scales important to human decisionmaking. The best examples are the global-scale influences of the El Niño-Southern Oscillation system of the tropical Pacific, as well as variations in ocean conditions in the North Atlantic that affect the climate.

Since the 19th century, almost all areas of the earth's lower atmosphere and oceans have warmed significantly.⁹ The warming in the ocean is now detectable to great depths,

5. *Natural Resources Defense Council v. Kempthorne*, 506 F. Supp. 2d 322, 367-68, 37 ELR 20305 (E.D. Cal. 2007).

6. *Id.*

7. See IPCC, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Susan Solomon et al. eds., 2007).

8. *Id.*

9. *Id.*; THOMAS R. KARL ET AL., GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES (2009), available at <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/full-report>.

The California Delta Litigation

Two cases—*Natural Resources Defense Council v. Kempthorne* and *Pacific Coast Federation of Fishermen's Association v. Gutierrez*—shine a spotlight on what is destined to be a growing number of cases asking courts to determine the effects of climate change upon the rights of litigants in water disputes. The cases concern the adequacy of the federal government's measures to protect a tiny endangered fish species, the Delta smelt, from harms resulting from California's planned water diversion projects.

The Water Projects

Enormous batteries of pumps on the edge of the California Delta feed the federal Central Valley Project and the State Water Project. Those two projects, in turn, push water south to over 1.2 million acres of farmland and more than 25 million people, primarily in Los Angeles and San Diego. The Delta's ecosystem is a critical link in California salmon's annual spawning runs, and is home to more than 120 species of fish, including the smelt.

Kempthorne

In 2005, a coalition of sport fishing and environmental organizations challenged the Biological Opinion (BiOp) prepared by the U.S. Fish and Wildlife Service (FWS) on the impacts of several large federal and state water diversion projects upon the continued existence of the Delta smelt, a threatened species under the federal Endangered Species Act (ESA).¹ In its BiOp, the FWS found that the diversion projects would not jeopardize the continued existence of the Delta smelt, nor would it adversely affect the smelt's critical habitat.

In a May 2007 decision, Judge Oliver Wanger of the U.S. District Court Judge for the Eastern District of California held the BiOp inadequate under the ESA for several reasons, among them that the FWS had “. . . failed to utilize the best available scientific information by not addressing the issue of climate change.”²

The BiOp's conclusions were based in part upon the assumption that the hydrology of the Delta will follow historical patterns. To the contrary, Judge Wanger found in *Kempthorne* that “[t]he best scientific data available today establishes that global climate change is occurring and will affect western hydrology” and hence that reliance upon such historical records rendered the BiOp's conclusions arbitrary and capricious.³

Gutierrez

In a related case, a coalition of fishing and environmental organizations and an Indian tribe challenged the adequacy of a 2004 BiOp rendered by the National Marine Fisheries Service (NMFS) with respect to the potential adverse impacts of the same California water projects upon various salmonid species. As in *Kempthorne*, the federal agencies in *Gutierrez* concluded that the effects of the proposed water projects were unlikely to jeopardize the continued existence of the endangered salmonid species.

In May 2008, however, Judge Oliver Wanger remanded the 2004 BiOp back to the NMFS and the Bureau of Reclamation, ruling that the BiOp was deficient in many respects.⁴ Similar to the basis of his decision in *Kempthorne*, Judge Wanger found that the agencies had failed to address, adequately explain, and analyze the effects of global climate change upon the hydrology of northern California rivers, and hence had failed to incorporate the best available science in its determination that the survival of the salmonid species would not be jeopardized by the water projects.

Despite the readily available scientific data demonstrating that warmer temperatures attributable to climate change are projected to lead to major reductions in the Sierra snowpack and decreases in summer stream flow, the court found that “[t]he BiOp does not discuss this global climate change data or mention that NMFS, at a minimum, considered this data.”⁵ Instead, the court continued, explaining the basis for its decision to remand the BiOp:

the BiOp relies on past hydrology and temperature models that assume the historical monthly temperature, hydrologic, and climatic conditions experienced from 1922 through 1994 will continue for 25 years through the duration of the [water project operations at issue].⁶

Recent Developments

To implement his decisions in *Kempthorne* and *Gutierrez*, Judge Wanger imposed a temporary injunction upon deliveries of water from northern California (the Sacramento-San Joaquin Delta) to the Central Valley and southern California. This dramatic decision cut off 30% of the deliveries to the State Water Project and the Central Valley Project. This outcome highlights the legal implications of an agency's failure to “take climate change into account” in water rights adjudications.

Since Judge Wanger issued his opinions in *Kempthorne* and *Gutierrez*, new BiOps have been prepared for both the Delta smelt and the salmonids. Both were based on biological assessments that used scenarios to provide a basis for the projected climate change implications for the water projects at issue. The scenarios chosen were sensitive to a range of future climate and sea-level impacts that are projected to occur during the 20-year consultation horizon of the proposed action. The scenarios added climate change effects to a base model that incorporated the environmental impacts of the full build-out of the project in 2030.

Both biological assessments conclude that:

[T]he impact of climate change in the future introduces greater uncertainty into the way in which water is managed in California. The historic hydrologic pattern represented by [hydrologic modeling based upon the past 82 years of record] can no longer be solely relied upon to forecast the future. Precipitation and runoff patterns are changing, creating increased uncertainty for ecosystem functions.

1. 16 U.S.C. §§1531-1544, ELR STAT. ESA §§2-18.

2. *Id.*; *Pacific Coast Fed'n of Fishermen's Ass'ns v. Gutierrez*, 606 F. Supp. 2d 1122, 1183 (E.D. Cal. 2008) (emphasis added).

3. *Id.*

4. *Gutierrez*, 606 F. Supp. 2d at 1183.

5. *Id.* at 1184.

6. *Id.*

and global sea level has risen in a manner consistent with ocean expansion due to warming, as well as the global melting of alpine glaciers. The warming atmosphere is now holding more water vapor, sea ice retreat in the Arctic has been unprecedented, and even the large polar ice sheets are now losing mass at an increasing rate.¹⁰

The climate science research community has also become much more confident that the bulk of the climate changes being observed today are due to human-caused increases in GHG concentrations in the lower atmosphere. Carbon dioxide emissions due to fossil fuel combustion are the biggest driver of anthropogenic climate change,¹¹ but a host of other GHGs are also contributing. Confidence in the primacy of GHG increases in causing the observed climate change of the last 150 years stems from a range of climate system observations and statistical tests, as well as from well-established climate theory.¹²

No other known source of changes in the global climate, such as changes in the earth's orbit, volcanic particles in the atmosphere that cause cooling, or solar variability, can explain the global to continental-scale patterns of climate change that have been observed, nor the pattern of observed warming up in the atmosphere. The confidence in the primacy of human causation has increased steadily since the 1980s, when human-caused climate change first became a widespread concern.¹³

Average global temperatures have risen about 1.5 °F since 1900, and some portions of the United States have warmed significantly more than this amount.¹⁴ Because climate change of the future is unlike any of the past, we must rely on numerical climate models to project the climates of the future. These models are representations of the real-world climate system, and they perform well in simulating many aspects of our climate in the past.

Even given the general utility of these models, and the fact that different models agree on many general aspects of future climate, e.g., that the entire earth will stay warm long after GHG concentrations are stabilized in the atmosphere, it is important to note that they will never agree completely. This is because models use different data sources and are designed and calibrated to represent different components of the global climate system in different ways.

Variation across even well-grounded models constitutes uncertainty that must be considered when estimating the potential impacts of future climate change. Another important source of uncertainty is our inability to anticipate human actions of the future, and in particular, to anticipate future anthropogenic GHG emissions. Given these uncertainties,

the globe is expected to warm an additional 2 to 11.5 °F by the end of the century.¹⁵

The evidence of warming is already observable in parts of the United States, and an increasing range of future hydrologic changes are predicted with confidence.¹⁶ Substantial changes to the water cycle are expected as the planet warms, because the movement of water in the atmosphere and oceans is one of the primary mechanisms for the redistribution of heat around the planet. Continued warming is very likely and is expected to reduce late-season snowpack.¹⁷ Loss of snowpack will change the seasonality and volume of flow in rivers that receive important annual contributions from snow.¹⁸ The warming is also exacerbating the drought in the western United States, leading to greater impacts on vegetation than would have occurred in the absence of warming.¹⁹

There has already been a northward movement of winter storm-tracks that was projected to dry the Southwest United States, and this drying is expected to continue into the future.²⁰ Projected precipitation declines may lead to a drying across much of the southern United States in winter and spring,²¹ and nearly all of the United States in summer,²² although confidence in these projections outside the Southwest is not as high.

Climate science has made important strides in modeling regional aspects of climate change, in addition to the more widely recognized advances in simulating continental to global climate change.²³ This advance in regional-scale modeling has created the opportunity to refine our understanding of how climate change may affect river basins, and this work will be put forward in water-related cases in courts. Notwithstanding improvements in regional hydrologic models that incorporate climate effects, separating "climate effects" from the background of substantial natural variability remains challenging.

When dealing with climate change, it is critical to remember that whereas past climate impacts were dominated by natural climate variability, the future may be much more the product of human-caused climate change trends superimposed upon natural seasonal- to interdecadal-scale climate variability. Thus, each year may not be warmer than the preceding year, and substantial natural climate anomalies, such as severe drought, will still occur with little or no warning.

II. Implications of Climate Change for Water Management

Water managers are beginning to grapple with the changes in water quantity, quality, and seasonality that are occurring

10. IPCC, *supra* note 7.

11. *Id.*

12. KARL ET AL., *supra* note 9.

13. Hervé Le Treut et al., *Historical Overview of Climate Change Science* (2007), in *CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE* (Susan Solomon et al. eds., 2007); KARL ET AL. *supra* note 9.

14. KARL ET AL., *supra* note 9, at 27.

15. KARL ET AL., *supra* note 9, at 24.

16. *Id.*

17. *Id.* at 33.

18. *Id.*

19. *Id.* at 41.

20. *Id.* at 24.

21. *Id.* at 124.

22. *Id.*

23. *Id.*

The Scientific Consensus With Regard to Human-Induced Climate Change

Jonathan Overpeck, Marc Miller & Diana Liverman, *Global Climate Change as A Local Phenomenon*, in NAVIGATING CLIMATE CHANGE IN A FEDERAL SYSTEM (Schlager, Engel & Rider, Eds. forthcoming 2011)

Whereas there is still considerable *political* debate concerning the reality of climate change, the *climate science research community* is confident in their assertions that climate change is already happening, that it is driven mostly by human activities (e.g., the burning of fossil fuels), and that it will continue to become more significant with time.

There will always be scientific debate about the details of climate change, but this type of debate—in scientific journals, emails or elsewhere—is intrinsic to science and does nothing to diminish scientific confidence in the reality of climate change as an environmental issue that must be taken seriously. The vast bulk of the scientific literature relating to climate change is not policy prescriptive, but rather forms a foundation of knowledge to be used by the public and decisionmakers in efforts to deal with climate change.

While the popular perception is that climate change emerged as a topic of concern only in the new millennium, the reality of climate change has been suspected for over 100 years,¹ and major scientific reports of the last several decades have expressed increasing confidence that human-caused climate change is detectable and likely to be substantial in the future in the absence of efforts to curb greenhouse gas (GHG) emissions.²

The most recent report of the World Meteorological Organization, United Nations Intergovernmental Panel on Climate Change (IPCC) was the strongest report yet on the seriousness of the climate change issue. The U.S. National Academy of Sciences has weighed in similarly in several recent study reports,³ and these are also supported by multiple major climate change reports published by both the G.W. Bush and Obama Administrations.⁴

What are the biggest uncertainties with respect to future climate change?

As with all science, there are uncertainties with respect to climate change science. The most important concern how much climate change will occur in a given region, of what type, and by when.

A primary reason for this uncertainty is the inability to predict future human actions, particularly as they relate to GHG emissions. Additional uncertainty exists because global climate models do not agree on some details of what will happen in the future for a given estimate of GHG emissions. Nonetheless, the current scientific state-of-the-art is sufficient for informed decisionmaking with respect to climate change mitigation and adaptation.

Does the recent slowing of global warming mean the problem is going away?

Absolutely not. Climate change is about the changes that will occur over decades, not in any year or even 10 years. Climates of the future will be the result of human-caused GHG emissions, but also other smaller climate influences like variations in the sun, volcanic eruptions, and processes internal to the earth's climate system like El Niño or deep-ocean circulation. As a result, there are multiple periods in the last 150 years of inexorable warming where the rate of warming either was faster or slower than the average of the whole period. The fact remains that the earth has warmed about 0.8 °C since the Industrial Period began, and the last decade is the warmest of the entire period.⁵

1. Hervé Le Treut et al., *Historical Overview of Climate Change Science* (2007), in CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Susan Solomon et al. eds., 2007).

2. *Id.*

3. U.S. NATIONAL RESEARCH COUNCIL, *ECOLOGICAL IMPACTS OF CLIMATE CHANGE* (National Academy Press 2008); U.S. NATIONAL RESEARCH COUNCIL, *AMERICA'S CLIMATE CHOICES: ADVANCING THE SCIENCE OF CLIMATE CHANGE* (National Academy Press 2010).

4. U.S. CLIMATE SCIENCE PROGRAM, *SCIENTIFIC ASSESSMENT OF THE EFFECTS OF GLOBAL CHANGE ON THE UNITED STATES: A REPORT OF THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES NATIONAL SCIENCE AND*

TECHNOLOGY COUNCIL (2008); U.S. CLIMATE SCIENCE PROGRAM, *WEATHER AND CLIMATE EXTREMES IN A CHANGING CLIMATE. REGIONS OF FOCUS: NORTH AMERICA, HAWAII, CARIBBEAN, AND U.S. PACIFIC ISLANDS. A REPORT BY THE U.S. CLIMATE CHANGE SCIENCE PROGRAM AND THE SUBCOMMITTEE ON GLOBAL CHANGE RESEARCH* (Thomas R. Karl et al. eds., 2008); THOMAS R. KARL ET AL., *GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES* (2009), available at <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/full-report>.

5. IPCC, *CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE* (Susan Solomon et al. eds., 2007); KARL ET AL., *supra* note 4.

as a result of climate changes.²⁴ Judges should be familiar with the strategies available to water managers to deal with these changes, so that they can anticipate the types of issues that may arise in water disputes. The following section discusses the projections by the scientific community that are most critical for water managers and some of the advantages

and disadvantages of various adaptation strategies that water managers may adopt in response to such projections.

The most recent findings of the International Panel on Climate Change (IPCC) include some important messages for the water managers in the United States, especially those governing water resources in the West. For example, the

24. JOSEPH BARSUGLI ET AL., *OPTIONS FOR IMPROVING CLIMATE MODELING TO ASSIST WATER UTILITY PLANNING FOR CLIMATE CHANGE* (2010); EDWARD MEANS III ET AL., *DECISION SUPPORT PLANNING METHODS: INCORPORATING CLIMATE CHANGE UNCERTAINTIES INTO WATER PLANNING* (2010).

Water Terminology

Groundwater: water below the land surface that is stored in spaces between rock and soil particles. It originates from precipitation and surface water that moves through the soil into the saturated zone.

Aquifer: an underground, porous, water-bearing rock formation or group of formations. The porous rock is sufficiently saturated such that the aquifer can yield water to wells and springs.

Recharge: process by which water is added to the aquifer through downward movement from the surface to the groundwater.

Managed Basin: an intensely regulated and monitored watershed.

Evapotranspiration: the sum of evaporation and transpiration. Evaporation is the loss of water from a surface to the atmosphere, and transpiration is the loss of water from plants to the atmosphere. Evapotranspiration is an important part of the water cycle and accounts for a significant loss of water from a watershed. The rate of evapotranspiration is affected by many factors, including temperature, humidity, wind speed, and water availability.

most recent IPCC report states that “[p]rojected warming in the western mountains by the mid-21st century is very likely to cause large decreases in snowpack, earlier snow melt, more winter rain events, increased peak winter flows and flooding, and reduced summer flows.”²⁵ This message is supported by more recent work.²⁶

Another important message is that because of the dramatic impact of rising temperatures on both the supply and the demand for water, drought will be a more major concern in the future, even in areas that may have an increase in total precipitation. In some cases, the increase in total precipitation is expected to come from extreme flooding events, so the additional water supplies may cause more damage than benefit.

As noted by the IPCC, climate change is projected to result in decreases to the total amount of water that is stored in snowpack in many regions, and increases in the amount of precipitation that falls as rain instead of snow. This effect will be most visible at the lower elevations where snowpack currently exists. Earlier runoff will likely occur in most snowmelt-dominated basins due to warming temperatures, with a corresponding decrease in late-season flows. The impacts of this change may be different in “managed basins” that have reservoirs to manage the flows and where, therefore, timing

can be a less significant issue. Finally, warmer air temperatures will mean warmer water in rivers and reservoirs.

Climate change may also affect water quality through multiple mechanisms. These include an increase in the concentration of pollutants that can result from a reduction in total flows, an increase in nonpoint source contamination, which occurs as a result of flooding during extreme events, and higher water temperatures.²⁷ The latter leads to reduced oxygen availability and other chemical and biological changes.

Increasing salinity of water supplies is a particular concern, because of sea-level rise and resulting saltwater intrusion in coastal areas, because recycling water through municipal, agricultural, and industrial reuse systems concentrates salt, because warming temperatures will increase evaporation, and because new more saline sources of water, including brackish groundwater, will need to be tapped as other water sources decline in availability.

Emerging Issues for Climate and Water

Though climate change science informs impacts on water supplies in many categories, it would be useful to know more about the following questions:

- What are the implications of changes in seasonality of runoff and increased evapotranspiration on groundwater recharge?
- What temporal and spatial changes will occur in demand and supply?
- How will the reuse of municipal effluent, desalination, and changes in energy costs affect the availability of water supplies for existing uses and for the environment?
- How will increases in fire frequency, bark beetle infestations, invasive species, vegetation transformations, and other large-scale ecosystem impacts affect the hydrologic cycle?
- How will ecosystem impacts and land use by humans affect water supply via the entrainment of soil-derived dust into the atmosphere and onto mountain snowpack?
- Most water delivery and treatment systems are extremely energy-intensive. For example, 20% of the total electrical energy in California is used to pump and treat water. How will carbon management alternatives, such as cap-and-trade programs, affect the economics of water supply and choices about new sources?

These and other questions will continue to perplex water managers.

25. IPCC, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION, AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (M.L. Parry et al. eds., 2007).

26. KARL ET AL., *supra* note 9.

27. KARL ET AL., *supra* note 9; IPCC, *supra* note 7.

The management implications of assessing climate change will vary from one basin to another. For example, in a watershed where groundwater recharge is dependent on surface water flows, changes in surface water availability could have a big impact. In other groundwater basins, there is little recharge, and such basins may see few impacts from climate change.

There are long-term lags in some regions between changes in the climate system and changes in water levels or surface flows. For example, there are cases where river flows are dependent on groundwater recharge that may occur hundreds of miles from where the water is initially discharged into a river. In these cases, the impacts of a change in the climate system may not be observable for decades or even centuries.

Historically, when surface water supplies decline, people have turned to groundwater to offset the shortage. This is of concern for two reasons—an increase in demand may well coincide with a decrease in supply of groundwater in much of the Southwest and Midwest. Though very little is known about the potential impacts of climate change on groundwater aquifers, it is generally accepted that increases in temperature and changes in precipitation patterns will change the surface flows that support aquifer recharge. Recharge of aquifers is affected by the volume and timing of surface flows, but also by changes in the amount of water that is lost to evaporation and water used by plants.²⁸

In many states, the surface water and groundwater are not managed conjunctively, so a switch from surface to groundwater supply may have consequences that are outside the jurisdiction of agencies and courts. This disconnect between the legal system and the hydrologic surface and groundwater systems already causes significant management and environmental problems.²⁹ These problems will be exacerbated in the context of climate change. Conjunctive management of surface and groundwater is already a major topic of management in the western states, and its significance is likely to increase as interstate and international disputes increase.³⁰

There are many ways to adapt behavior that will lessen the impacts of climate change. The most obvious adaptation tool is reducing consumption, so that there is less demand on the system. Conservation has a number of positive impacts, especially because it generally reduces energy use at the same time (energy to pump, treat, and deliver water is embedded in every gallon that is used). Conservation also has costs, including the question of who should bear those costs. There may also be some surprising negative externalities from con-

servation, since water previously “wasted” does in some cases support habitat or downstream water users.³¹

Integrating land use planning with water supply availability (both under current and future conditions) is another tool for adaptation, as are harvesting rainwater, underground water storage and recovery, and “banking” water to support instream flows during dry years. Municipal water reuse will be an important part of the water supply portfolio in many regions.³²

However, in traditional water rights disputes, there is little incentive to conserve water for the future; the dominant method for short-term adaptation has been to reduce access to water resources when a shortage occurs. More flexible water rights are possible, and can contribute to adaptation. Water rights can be established that are conditional on water supply availability, or incorporate dry-year options to purchase or lease agricultural water rights to provide a buffer for water use in cities. Another flexible water rights approach is to divide a regional water supply into unit shares (percentage allocations of a total water supply) to allow for ongoing and built-in flexibility in managing water supplies when there are large fluctuations in availability.

III. How Climate Change May Impact Water Cases

How might climate change impact cases pending before a state or federal judge?

Judges are responsible for reviewing and approving settlements in major river basins and sub-basins that will endure for decades. Climate change may affect both the projections of water availability and the uncertainty in projections being made by the litigants in these disputes. Judges may be asked to resolve disputes between parties about the effects that climate change may or may not have on water supplies, water quality, endangered species, and other environmental disputes. Judges may be required to evaluate requests to change or augment the amount of water that water rights holders are claiming in prior appropriation or riparian water systems. The following subsections describe in greater detail the manner in which climate change impacts can arise in legal disputes.

A. Water Allocation Decisions

The issue of climate change is likely to arise in cases where parties face changes in water availability, as well as changes in demand. For example, climate change effects on the seasonality of flows may result in an altered pattern of flows that

28. Katharine Jacobs, *Sustainability and River Restoration in the Colorado River Basin: A Climate Perspective*, in PROCEEDINGS OF THE COLORADO RIVER BASIN SCIENCE AND RESOURCE MANAGEMENT SYMPOSIUM (Ted S. Melis et al. eds., 2009).
 29. ROBERT GLENNON, *WATER FOLLIES: GROUNDWATER PUMPING AND THE FATE OF AMERICA'S FRESH WATERS* (2002).
 30. Katharine Jacobs, *Groundwater Management Issues and Innovations in Arizona*, in POLICY AND STRATEGIC BEHAVIOR IN WATER RESOURCE MANAGEMENT (Ariel Dinar & José Albiac eds., 2009).

31. Gregg Garfin et al., *Climate Change Adaptation Lessons From the Land of Dry Heat*, in PLANNING FOR AN UNCERTAIN FUTURE—MONITORING, INTEGRATION, AND ADAPTATION. PROCEEDINGS OF THE THIRD INTERAGENCY CONFERENCE ON RESEARCH IN THE WATERSHEDS: U.S. GEOLOGICAL SURVEY SCIENTIFIC INVESTIGATIONS REPORT 2009-5049, 292 (Richard M.T. Webb & Darius J. Semmens eds., 2009).
 32. Gregg Garfin et al., *Beyond Brainstorming: Exploring Climate Change Adaptation Strategies*, 89 EOS TRANSACTIONS AM. GEOPHYSICAL UNION 227 (June 18, 2008).

adversely affects existing water rights holders.³³ Agricultural users in particular may find that they no longer have an irrigation supply at the time when irrigation is necessary.

Claims for irrigation water may be exacerbated by changes in the length of the growing season associated with warming. Irrigation water may be needed earlier than it has been in the past. Affected users may seek a modification of their right to allow diversion at an earlier time, or request to store the water for use later in the season. When the time period in which the agricultural user can take water is fixed in a decree, there may be a request to modify that decree. If a permit is modified by an administrative agency to allow the changes that the agricultural user seeks, other affected users may object.

Urban development and its associated water needs may also be affected by climate change. Increasing temperatures will increase the demand for water, as well as decrease supply—and so this argument may be used in the context of urban areas seeking new water sources. They may, for example, seek permits to import groundwater from other basins. If these permits are granted without taking the impacts of climate change into account, the water supplies in the adjacent basin may be overallocated, resulting in environmental damage or impacts on other water rights holders.

Parties proposing diversions that would have been historically possible may face challenges by parties countering with climate models that indicate historical data can no longer be relied on. New appropriations should provide a court with the opportunity to consider new information from climate models, but changes in existing water rights may also need to take climate change into account.³⁴

Climate change can also be raised in cases where questions of federal law are implicated, such as in endangered species cases, as in the California Delta litigation, or in federal reserved water rights cases. When the United States withdraws land from the public domain, reserving them for a federal purpose, it implicitly reserves then-unappropriated waters needed to accomplish the purpose of the reservation. Climate change has the potential to affect water supplies such that there will no longer be the quantity of water needed to accomplish the purposes of the reservation. If the government seeks a quantification of the reserved right, it may introduce evidence of climate change, arguing for a greater right than would be needed in the absence of climate change impacts.

B. Water Quality-Related Disputes

Climate change can also be implicated in cases where there is an issue regarding water quality. For example, in *Kemphorne*, the Biological Opinion being challenged pointed to reduced water quality from agricultural runoff, effluent discharge, and boat effluent as reasons for the Delta smelt's decline.³⁵

The Biological Opinion (BiOp) included provisions to supply water to protect the smelt and meet water quality standards.³⁶ However, as discussed above, the court in *Kemphorne* held that the BiOp failed to consider the possible effects of climate change on the smelt's habitat.³⁷

Water quality impacts from climate change include increased temperature and its associated reductions in dissolved oxygen. In addition, impacts on water quantity from climate change are related to water quality because of the potential for pollutants, including those from agricultural runoff and effluent discharge, to become concentrated in times of low flows. Sea-level rise, another concern from climate change, can also lead to salt-water intrusion into freshwater supplies. Finally, increases in heavy downpours are a robust prediction of climate change and are already being observed throughout the United States. Such extreme events are strongly associated with increases in sediment and pathogens.³⁸

Issues of water quantity, water quality, and water timing frequently arise in the context of NEPA and analogous state provisions. A significant proportion of federal actions that trigger NEPA review are either water projects or have a significant water component. Increasing recognition of the role of water in providing both direct and indirect ecosystem services has been recognized in NEPA guidance.³⁹ Recognition of the concept of ecosystem services throughout water adjudications may be highlighted by the added uncertainty and complexity introduced through climate change.

IV. Climate Change Impacts and Legal Decisionmaking

The following considerations impact the manner in which the issue of climate change will arise in legal disputes and the tools available to a judge when attempting to resolve a case in a manner that takes climate change into account.

A. The Demise of the Presumption of "Stationarity"

Traditionally, parties to water-related disputes have used estimates of the past availability of water to project the availability of water in the future. Now, however, as a result of climate change, the past as the most reasonable predictor of the future for water supply is in serious doubt. Some courts are beginning to realize this. For example, in the Delta smelt litigation discussed above, the court held the federal government resource agencies' BiOps inadequate, due to their reliance upon historic water levels to project future water availability. The court ruled that this reliance was arbitrary and capricious, in view of the climate change data and models. It is reasonable to predict that precisely this situation will confront an increasing number of courts in the

33. DOUGLAS KENNEY ET AL., *THE IMPACT OF EARLIER SPRING SNOWMELT ON WATER RIGHTS AND ADMINISTRATION: A PRELIMINARY OVERVIEW OF ISSUES AND CIRCUMSTANCES IN THE WESTERN STATES* (2010), available at http://www.colorado.edu/western_water_law/docs/WRCC_Complete_Draft_090308.pdf.

34. *Id.*

35. *Natural Resources Defense Council v. Kemphorne*, 506 F. Supp. 2d 322, 335, 37 ELR 20305 (2007).

36. *Id.* at 358.

37. *Id.* at 370.

38. KARL ET AL., *supra* note 9; IPCC, *supra* note 7.

39. U.S. EPA, *CONSIDERING ECOLOGICAL PROCESSES IN ENVIRONMENTAL IMPACT ASSESSMENTS* (July 1999). See generally J.B. RUHL ET AL., *THE LAW AND POLICY OF ECOSYSTEM SERVICES* (2007).

Water Disputes and NEPA

NEPA provides the basic federal process for illuminating the environmental costs and benefits of “proposals for legislation and other major Federal actions significantly affecting the quality of the human environment.”¹

The essential tools of NEPA are notice, assessment, input, and a record of decision. Notice of the proposed action must be given to relevant federal, state, and local agencies and the public. Assessment requires that the agency make a set of tiered judgments, including whether the proposed action is subject to “categorical exclusion,” “scoping” of issues that should inform an initial environmental assessment (EA), the determination in an EA whether a proposed action is a “major Federal action significantly affecting the quality of the human environment” and therefore requiring a full environmental impact statement (EIS), and the production of EISs. Input includes comment by government (federal agency, state, tribal, and local) and the public.

While the overwhelming consensus is that NEPA is primarily a procedural statute—meaning that it is a statute that requires that identification of environmental impacts and alternatives to the proposed action, but not any particular outcome—the statute and its implementing regulations require a Record of Decision (ROD) after the initial steps of notice, assessment, and input are complete. In the ROD, the agency must identify the alternatives it considered, whether it adopted all practicable means to avoid or minimize harm and if not, why not.²

Federal actions include not only actions by federal agencies, but many actions by state, local, and private actors that are funded, permitted, or regulated by federal agencies. A substantial proportion of the federal actions that trigger EISs directly involve water projects.³

The impact of climate change on water quantity, water quality, and water timing has far-reaching implications for NEPA analyses. Changes to water resources resulting from climate change may require the reconsideration of categorical exclusions, may elevate more actions to a level of “significance” calling for the preparation of a full-blown EIS, may require for greater attention to water impacts in EAs and EISs, and may lead to more frequent mitigation and monitoring measures in RODs.

States have parallel statutory schemes that may trigger additional environmental analysis. The impacts of climate change on water resources may have similar ramifications for the analyses conducted under state “mini-NEPAs.”⁴

1. 42 U.S.C. §4332(C).

2. 40 C.F.R. §1505.2.

3. See U.S. EPA List of EISs since 2004, <http://www.epa.gov/compliance/nepa/index.html>; see also Necessity and sufficiency of environmental impact statements under §102(2)(c) of National Environmental Policy Act of 1969 (42 U.S.C.A. §4332(2)(c)) in cases involving water and waterworks projects, 67 A.L.R. Fed. 54. Many other federal projects include impacts on water in the factors considered in EISs, EAs, and mitigation and monitoring plans.

4. See Katherine M. Baldwin, *NEPA and CEQA: Effective Legal Frameworks for Compelling Consideration of Adaptation to Climate Change*, 82 S. CAL. L. REV. 769 (2009); Madeline June Kass, *Little NEPAs Take On Climate Goliath*, 23 NAT. RESOURCES & ENV'T 40 (2008).

context of water rights cases. Courts will be unable to rely upon “what has been” when projecting water availability in the future.

Another way of saying this is that the concept of “stationarity,” long a fundamental assumption underlying water management in the United States, is now dead.⁴⁰ The concept of stationarity is based on the premise that the random variability of a water system, e.g., flow in a river, is such that its statistical properties, e.g., mean, variance, extremes, autocorrelation, and so on, do not vary with time. Given this assumption of stationarity, projections of future river flow could be bounded by knowledge of how the river had varied in the past, for example as determined by stream gauges. The use of hydrologic data developed in the last 100 years to manage water supplies and control floods has persevered, even as human and natural changes to river systems altered the dynamics of these systems, and even as tree-ring studies challenged the envelope of variability defined by stream gauges (suggesting a larger range of natural variability over larger periods of time).

The potential effects of climate change on river hydrology, however, call into question the assumption that flow is a stationary process. Continued reliance on the past envelope of variability for anticipating future river flow may be misleading. Parties that continue to present historical data as a foundation for decisions about the future are likely to be countered by climate change models that question the validity of such an approach. Judges will be confronted by the need to assess competing claims about the future, with some claims based on measured, but perhaps suspect, data based upon the historical record, and the other claims based on the output of a climate-driven model.

B. Judicial Decisionmaking Under Uncertainty

Projections of future climate involve multiple layers of uncertainty from multiple sources. While some of these uncertainties can be reduced through the collection of more data and advances in climate science, many uncertainties will remain. For example, scientists can generate higher quality observations, improve our ability to downscale global models to regional scales, improve our understanding of existing variability caused by ocean-atmosphere interactions, and do better at linking specific future atmospheric concentrations of GHGs with more exact global and regional increases in temperature.

On the other hand, the uncertainties associated with future GHG emissions trajectories and the uncertainties associated with how climate change will affect random natural year-to-year and decade-to-decade climate and hydrological variability are unlikely to be substantially

40. P.C.D. (Chris Milly et al., *Stationarity Is Dead: Whither Water Management?*, 319 Sci. 573 (2008)). See also Robin Kundis Craig, “Stationarity Is Dead”—Long Live Transformation: Five Principles for Climate Change Adaptation Law, 34 HARV. ENVTL. L. REV. 9 (2010).

reduced. The traditional approach of using the historic record to bound the uncertainty associated with natural variability will be increasingly inappropriate as the climate system changes in the 21st century.

Consequently, the impact that the incorporation of climate change effects will have upon water adjudications will turn in large part upon how these uncertainties are resolved in the context of existing legal rules and frameworks. The sections below discuss two legal frameworks that will have important implications for how judges in water cases take climate change into account: the admissibility of scientific evidence concerning climate change; and the presumptions affecting a judge's resolution of issues turning on scientific uncertainty.

C. Procurement, Admissibility, and Use of Expert Testimony on Climate Science

Climate science is a field of highly developed expertise, and as in other subjects that depend on complex data and extensive training, not all witnesses who may claim to be experts will agree with each other. Hence, any water case in which the issue of climate change science has been raised is likely to involve numerous perspectives and challenges. As a result, judges must navigate issues related to expert testimony on climate science.

The first and most fundamental issue is whether judges are comfortable leaving the determination of what expert testimony will be considered in the case to the parties, or whether judges will seek to exert some control over this body of evidence. Most importantly, under Rule 706 of the *Federal Rules of Evidence*, federal judges can appoint their own experts or experts nominated by the parties. This is also true under the rules applicable in many states. Although this option is rarely exercised, judges might find that the unfamiliar nature of climate science motivates them to exert a higher degree of control over the expert testimony presented. Appointment of experts under Rule 706 is not the judge's only option, however. Judges might also consider the appointment of a Special Master to help with the assessment of expert testimony.

Whether or not judges take an active role in selecting experts who will testify regarding climate science, they will still be required to scrutinize the testimony of experts to ensure that it meets the standard of reliability applicable in his or her jurisdiction. In federal court, this means the testimony must meet the four-part test enunciated in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*⁴¹ This test puts the judge

in the role of the "gatekeeper," responsible for determining whether the testimony is based upon a legitimate scientific methodology and is otherwise reliable. Although water rights is a matter of state law, many water disputes in which the effects of climate change are an important aspect are likely to end up in federal court. This is because such cases may include claims under federal environmental statutes, such as the Endangered Species Act (ESA), NEPA, the Clean Water Act,⁴² and others.

For cases adjudicated solely under state law, the standard applicable to the admissibility of evidence related to the impacts of climate change will depend upon the state. Many states explicitly use the *Daubert* standard or a test that is substantially similar.⁴³ Other states employ the *Daubert* factors, but have never overruled the earlier *Frye* test, which calls for a judge to screen out all expert testimony that is not considered reliable within the relevant scientific community.⁴⁴ Some states continue to rely on the *Frye* test,⁴⁵ and still others employ their own unique screening test.⁴⁶

Water dispute cases are more likely to be bench trials, as opposed to jury trials. Consequently, judges might be expected to apply the applicable admissibility screen less stringently, because they will not be concerned about protecting the jury from exposure to misleading expert testimony. Nevertheless, judges will have to maneuver through a thicket of difficult considerations when applying *Daubert* or the alternative test applicable under state law.

The list of issues that could arise in the context of determining the admissibility of climate change science is daunting. Many judges may wish to delegate these admissibility issues to a Special Master, if possible.

Importantly, administrative judges are unlikely to be confronted by the difficulties of applying *Daubert*, *Frye*, and other admissibility tests to climate change evidence. Although some commentators have urged agencies to scrutinize scientific evidence according to the *Daubert* factors,⁴⁷ thus far, this call has gone largely unheeded. Instead, the reliability of scientific evidence is scrutinized in the administrative context under the applicable rule of administrative procedure. Hence, in federal agencies (and in the parallel rules that apply in most state agencies), admissibility issues will be subsumed under the procedural requirements applicable to administrative rulemakings and adjudications. In adjudications, the evidence considered by the agency must be

42. 33 U.S.C. §§1251-1387, ELR STAT. FWPCA §§101-607.

43. These states are Alaska, Arkansas, Colorado, Connecticut, Delaware, Idaho, Indiana, Iowa, Kentucky, Louisiana, Maine, Michigan, Mississippi, Montana, Nebraska, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, West Virginia, and Wyoming. 90 A.L.R. 453.

44. These states are: Alabama, Hawaii, Massachusetts, Nevada, New Hampshire, and New Jersey. *Id.*

45. Arizona, California, the District of Columbia, Florida, Illinois, Kansas, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New York, North Dakota, Pennsylvania, and Washington. *Id.*

46. These states are: Georgia, Utah, Virginia, and Wisconsin. *Id.*

47. See Alan Charles Raul & Julie Zampa Dwyer, "Regulatory Daubert": A Proposal to Enhance Judicial Review of Agency Science by Incorporating Daubert Principles Into Administrative Law, 66 LAW & CONTEMP. PROBS. 7, 8 (2003).

41. *Daubert v. Merrell Dow Pharm., Inc.* 509 U.S. 579, 23 ELR 20979 (1993). Under *Daubert*, the judge is to exercise a "gatekeeping" role to ensure that the basis of the expert's testimony is "scientific" knowledge. To help him or her with this task, the Court suggested the judge determine: (1) whether the scientific theory or technique has been tested empirically; (2) whether a theory or technique had been subjected to peer review and publication; (3) whether there exists and are maintained standards controlling the technique's operation; and (4) whether the theory or technique is generally accepted (the *Frye* test). Subsequently, the Court has held that the *Daubert* factors apply to all expert testimony based on "technical" or "other specialized" knowledge. See also *Kumho Tire Co., Ltd., v. Carmichael*, 526 U.S. 137, 141, 29 ELR 20638 (1999) (applying the *Daubert* factors to the expert testimony of a tire failure analyst).

Daubert and Climate Change Experts

Courts will need to consider the following issues in deciding which experts and what testimony to allow. These considerations include:

- Validating the climate science that forms the basis of the expert's testimony.
 - (a) Important—and relevant—tools of climate science come in the form of climate models. Climate models are based upon knowledge of how the climate system works, as well as observed data, and they are often a required basis for “predicting” or “projecting” future climate states or changes. *Daubert* asks whether the scientific method used has been “tested” and whether it has a known rate of error. How is this to be applied to climate models, where projections of future conditions are expressed as probabilities of the likelihood of future conditions? Climate scientists routinely “test” (some use the terms “validate” or “evaluate”) their models by determining how well they are able to simulate known climate states or changes that occurred in the past. In some instances, this may be sufficient to meet the first prong of the *Daubert* test, while in others, more extensive testing and documentation of the model may be necessary.
- Given that climate scientists often work with more than a dozen climate models simultaneously, what must a judge do to ensure that the experts' testimony is based upon a reliable method? Is it necessary that a judge determine whether each climate model has been “tested” against past data? Is it instead sufficient that the majority of models generally agree with each other? In some cases, model agreement may not be a reliable metric of model reliability.
- Validating any extrapolations from climate models.
 - (b) For instance, the most valuable testimony may consist of expert opinions based on “downscaling” the output of global climate models, often by means of regional models that use this global model output, either directly or indirectly, as input to project regional impacts. These regional models are tested (or validated) in the same way as the climate models, i.e., based on the ability to replicate the past, and, thus, face the same *Daubert* challenges. The downscaling process itself may introduce additional sources of uncertainty that may need to be examined.
- Evaluating the reliability of the experts' interpretation of underlying or separate climate data.
 - (c) For instance, climate experts are finding that the distribution of temperature increases that result from today's climate models reveal that there may be higher than normal probability that actual temperature increases could be well in excess of the mean temperature increase projected by the models. Climate experts may disagree about the extent of the range of temperature increases. Or, as in the California Delta cases, the parties may argue about the interpretations of the studies used to “update” the hydrology models to incorporate climate change into environmental scenarios.
 - (d) Climate science may be relevant in a case only to the extent climate change is affecting another system, such as regional water hydrologic system. For example, a party may rely upon climate science to argue that the quantity of available surface water supplies will decrease. Thus, this party may wish to present the expert testimony of a hydrologist testifying as to the implications of climate model output that is used as input to a hydrologic model. It seems reasonable that to the extent that the climate model output is at issue, a climate scientist is the appropriate expert, whereas, if the question is one of interpreting the implications of this output for a given watershed or the direct use of this output in a regional model, a hydrologist would be the more appropriate expert.

The last prong of the *Daubert* test and the entirety of the *Frye* test asks whether the scientific basis of the expert's testimony is “generally accepted” within the relevant community of scientists. Climate change science is continually improving. The newest climate models are much more accurate than older models. Yet, the techniques incorporated into the newer models may not have been around long enough to be “generally accepted” within the climate change science community. Will the *Frye* test applied in its entirety in some states (or as an aspect of the *Daubert* test) result in the exclusion of the best climate science available? And again, what is the relevant “community” of scientists when the testimony may involve layers of different fields of scientific expertise as discussed in the above bullet?

reliable, probative, and substantial.⁴⁸ In rulemakings, interested persons must be given notice and an opportunity to respond to an agency's proposed rule.⁴⁹ Some courts require that the agency disclose the scientific data upon which the agency relied.⁵⁰ With respect to all rulemakings, the agency's decision must not be arbitrary.⁵¹

The procurement and admissibility of climate science evidence does not exhaust the list of issues that will arise in a case concerning the impacts of climate change upon a water resource. Assuming evidence of climate change impacts is admitted into evidence in a given case, the judge may still be faced with difficult issues concerning the weight to be accorded such evidence. This task is all the more significant in bench trials, where it is not shared with a jury. Where the public is potentially affected by the actions at issue in the case, judges may be faced with the question of whether to apply a precautionary approach to the weight-of-the-evidence question. Application of a precautionary standard might entail the court shifting, to those advocating an action or policy change with respect to the water resource at issue, the burden of proof that the given action or policy is not harmful. This might be considered an application of the precautionary principle as applied in environmental law. This principle provides a framework for decisionmaking where the science concerning the impacts of particular actions are uncertain. According to the framework, the decisionmaker shifts the burden of proving the harmlessness of a particular behavior upon the advocate of the given behavior.⁵²

V. Options and Limitations for More Flexible and Adaptable Decisions

The implications of increased uncertainty and changing conditions in the future will affect disputes over water rights (quantity, quality, and source). As a general matter, courts, and at least most claimants seek finality. Judges and parties seeking to resolve water cases have recognized the importance of flexibility in various contexts, but the new concerns about stationarity increases the need for flexibility.⁵³ Many historical water disputes have been long, drawn-out proceedings, and have remained on the dockets of particular judges for literally decades. The need to get the best fit between the science of climate change and the water resources at issue will require greater flexibility or "feedback" into judicial resolution of water cases. Admittedly, these options come with costs.

One option available is to delay resolution while additional information is gathered. Another option is to appoint a Special Master to monitor changing conditions in water dis-

putes. Often, those special masters report back to the court, either on a set schedule, when various triggers occur, when the Special Master deems it necessary, or on a request by a party. In either situation, the case remains on the docket of the court.

Not all resolutions that account for uncertainty and anticipated change require ongoing administration by courts or by their agents (such as Special Masters). Judicial orders can incorporate triggers to initiate different allocation schemes based on changing water supply or water quality conditions. Another approach is to allocate water rights based on a percentage of actual supplies rather than fixed volume allocations. A further approach is to require replenishment of overdrafted aquifers within a time period, or establish flexible accounting mechanisms to allow users to "pay back" the system using credits that have been accrued in previous years. Judicial orders can set conditional water rights, such as "stepped" allocations with triggers for later action (either allowing or disallowing a given use) based on actual snow-pack or flow or water quality readings, changes in demand or reservoir levels, or the impact on an endangered species. Where the law allows—or where parties are willing to do so—orders can mandate the integration of surface and groundwater (sometimes referred to as "conjunctive management"). One form of conditional rights can turn on "wet," "normal," and "dry" years, with different allocations for each condition.

Delay in resolving water rights issues can be very costly to the parties, but often this delay is justified. In some circumstances, delay may increase risks and cause economic hardship, but in other cases, it may result in better decisions that ultimately reduce costs.

One approach to uncertainty and changing conditions is to establish a framework for "adaptive management."⁵⁴ The idea of adaptive management, developed originally for use by administrators of public lands and natural resources and now widely incorporated in resource management, may have some relevance to the resolution of water cases. Adaptive management has been suggested as an appropriate response to changing water supply conditions, but monitoring and evaluation components must be carefully specified from the outset to be successful.

Adaptive management involves clear articulation of assumptions and goals, making interim decisions, and then monitoring carefully to adjust the decisions in light of new scientific information. Adaptive management works from several premises that are consistent with climate change: (1) decisions are made acknowledging incomplete knowledge, varying degrees of uncertainty, and different risks of error; (2) changing conditions and unforeseeable circumstances will make even wise management or judicial decisions less wise; and (3) management can be set up to propose "hypotheses" rather than "solutions" and to incorporate mea-

48. Administrative Procedure Act (APA), 5 U.S.C. §556(d) (2006).

49. APA, §553.

50. See *United States v. Nova Scotia Food Products*, 568 F.2d 240, 252 (2d Cir. 1977).

51. *Id.* at 253.

52. ARIE TROUWBORST, *EVOLUTION AND STATUS OF THE PRECAUTIONARY PRINCIPLE IN INTERNATIONAL LAW* 7-31 (Daniel Bondansky & David Freestone eds., 2002).

53. Casey Brown, *The End of Reliability*, J. WATER RESOURCES PLAN. & MGMT., 143-45 (2010).

54. See BARRIERS AND BRIDGES TO THE RENEWAL OF ECOSYSTEMS AND INSTITUTIONS (Gunderson, Holling & Light eds., 1995); PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS (Gunderson & Holling eds., 2002); BRIAN WALKER & DAVID SALT, *RESILIENCE THINKING: SUSTAINING ECOSYSTEMS AND PEOPLE IN A CHANGING WORLD* (2006).

surement and feedback to test and change those hypotheses on an ongoing basis.

Successful adaptive management, like new ideas for the proportional allocation of water rights, have additional costs in administration over traditional water rights and water management. Economists and lawyers have long recognized that new property rights (and the mechanisms for enforcing those rights) come into existence when the benefits of those rights outweigh the costs.⁵⁵

The increasing uncertainty of the impacts of climate on water rights and the corresponding complexity in water adjudication may justify the costs of monitoring, analysis, and management required to implement such systems. But the barriers to new kinds of water rights and administration are not just economic. Such dynamic systems can be in tension with the culture of existing water systems, users, and agencies that have long been used to prescribed rules, fixed allocations, and less discretionary authority.

Why not rely on the inherent ordering and allocation of much western water law (in the form of prior appropriation doctrine) and on the interest of parties to return to court if circumstances change? The answer to that question is that courts have a general obligation to resolve disputes in ways that will allow for settled expectations, and that minimize predictable future disputes. The consequences of non-stationarity and increased uncertainty are that judicial decisions that seem more certain are not, and that decisions that incorporate variability in supply, adaptation, and uncertainty are more likely to succeed, and to reduce later disputes.

VI. Conclusion

This Article approaches the concept of “taking climate change into account” from a variety of perspectives—including climate science, water management, and law. The intent has been to frame this issue more clearly and to provide some judicial options in thinking about

55. Harold Demsetz, *Towards a Theory of Property Rights*, 57 AMER. ECON. REV. 347 (1967); Terry L. Anderson & Peter J. Hill, *The Evolution of Property Rights: A Study of the American West*, 18 J. LAW & ECON. 163 (1975).

Climate Emerges in Two Major Water Disputes

Climate Change and the Colorado River

The environmental impact statement prepared for the 2007 agreement between the Colorado River Compact's seven basin states on shortage sharing and cooperative management of Lakes Mead and Powell is arguably the first significant assessment of the climate change implications of a water quantity-related judicial determination. In response to this EIS, the parties to the Colorado River Compact adopted “Interim Guidelines,” a major amendment to dozens of laws, court findings, and operating agreements that collectively make up the “Law of the River.” The EIS, developed by the Bureau of Reclamation with numerous partners, contains an appendix developed by a broad array of hydrologists, modelers, and tree-ring experts. “Appendix U” discusses recent climate trends, potential impacts of climate change on the flows of the Colorado, additional historical variability beyond that represented in the 100-year gage record generated through an analysis of tree-ring records at Lees Ferry dating to 762 A.D., and provides guidance for the incorporation of additional climate science into future studies. Although this is not a quantitative analysis, it is a significant step toward a future where climate change will need to be “taken into account” in state and federal water decisions.

*Republican River Compact: Kansas v. Nebraska and Colorado*¹

Many states do not manage their surface and groundwater together. As a result, pressure on water supplies resulting from climate change is leading to greater groundwater withdrawals and increased conflicts between water rights holders over the impacts of these withdrawals. An example of such a conflict is the action brought by Kansas against Nebraska for violation of the 1943 Republican River Compact. In May 1998, Kansas filed a complaint in the U.S. Supreme Court, claiming that Nebraska had violated the Republican River Compact by allowing the unimpeded development of thousands of wells in an aquifer hydraulically connected to the Republican River and its tributaries. Colorado was joined in the lawsuit because the headwaters of the Republican River are located in Colorado, and because it is a party to the Republican River Compact.

Nebraska denied Kansas' allegations and filed a motion to dismiss the case on the premise that the compact did not specifically mention groundwater. Kansas argued that while groundwater was not mentioned in the compact, it was part of the Republican River system and, therefore, subject to the compact. Colorado argued for the inclusion of alluvial groundwater (occurring in association with streambeds), but not wells located on the tablelands that pump from the Ogallala aquifer.

After a hearing, the Special Master denied Nebraska's motion and concluded that groundwater must be included within the allocation and consumptive use computations in the compact. This decision motivated the states to mediate their dispute. Their final agreement, approved by the Supreme Court in May 2003, contains a waiver of claims, a moratorium on new wells, compact administration mechanisms, a dispute resolution system, and the development of a hydrologic model to administer compact compliance. Although, at the time it was constructed, the model did not account for climate change, it did depend upon a great deal of climate data. To determine compliance in any year, data for the previous five years must be considered. The settlement has had the effect of encouraging conversations between the state parties about the impacts of climate change.

1. U.S. Supreme Court, Original Matter 126 (May 19, 2003).

how to approach climate-related testimony in court cases and ways to incorporate more adaptive approaches into water rights decisions.

The challenges associated with incorporating climate change into decision processes are not going to go away—in fact, as impacts accelerate, it is almost certain that these issues will become more central to water rights and water management processes. The decisions by Judge Wanger in

the Bay-Delta litigation are widely viewed as “watershed events,” both because they forced the issue of considering climate change in endangered species decisions and because the injunction that was issued as a remedy has had such substantial impacts on water users in California. Clearly, this is not the last major case where “taking climate change into account” will have significant economic and environmental consequences.