Introduction: The Context for Western Water Policy and Planning

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ABSTRACT

Here we describe the context for water policy and planning in the western United States and the implications of natural climate variability and anthropogenic climate change for the region’s water resources. The questions related to water resource planning and policy development that face western water managers, policy makers and citizens are made more challenging by extreme droughts, floods and the likelihood of further changes in climate. This chapter discusses the purpose and focus of the book and provides an overview of its content and key messages.
I. Rationale and Purpose

As we wrapped up work on this book, drought and record warm temperatures had left California and the Pacific Northwest states grappling with the water resource impacts of paltry winter snowpacks, parched watersheds, and raging wildfires (California State Water Resources Control Board 2015; NOAA 2015a; NIDIS 2015). In California, the water content of the snowpack stood at 5% of normal on April 1, 2015 (California Department of Water Resources 2015), and low streamflow forecasts for the summer irrigation season prompted the Governor to declare a drought emergency. Shortly thereafter, the State Water Resources Control Board began mandating curtailment of surface water withdrawals from the state’s major rivers. As of June 12, curtailment orders on the Sacramento and San Joaquin Rivers extended to all water rights with priority dates junior to 1903, leaving those rights holders unable to draw upon their usual sources of supply. Elsewhere in 2015, a multi-year drought in Texas and Oklahoma gave way to torrential downpours and deadly flash flooding.

These extreme conditions provide stark reminders of the inherently variable climate of the Western region of the United States, and the challenges it poses for water policy and planning. Water resource professionals also are becoming increasingly aware of the fact that the range of high and low streamflows represented in the historical record provides an incomplete picture of the full range of natural variability and an inadequate guide to future hydroclimatic conditions. For example, it is now widely recognized that the Colorado River compact of 1922 allocated fixed amounts of water to the Upper and Lower Basins based on relatively short streamflow records that were not representative of long-term streamflows as revealed by paleoclimatic reconstructions, nor of likely future conditions.
Global climate change is already underway, and there is strong evidence that it is likely to alter patterns of water availability worldwide. The fact that nearly all major rivers in the western U.S. arise in snow-fed mountainous watersheds presents a distinct source of vulnerability due to temperature impacts alone (Cayan et al, Chapter 2 this volume). Warmer temperatures will inevitably alter the dynamics of snow accumulation and melting, leading to impairment of the natural water storage capacity of high-elevation catchments and alteration of seasonal river flow regimes (Adam et al 2009; Stewart 2009).

Although this volume documents the fact that a number of prominent water resources management agencies in the West are currently moving towards consideration of climate projections in formal planning, there is also abundant evidence that many present day water managers are repeating the fundamental mistakes made in the Colorado River Compact by assuming that 20th century climate variability is a reasonable proxy for 21st century conditions. The FERC licensing process is a notable example (Ray, Chapter 8 this volume) and FEMA flood maps that give information on eligibility for the federal flood insurance program are another (Zellmer and Klein, Chapter 19 this volume). Despite forward motion, there is a long way to go.

We have chosen to focus on the western U.S. in this book, because water is generally scarce relative to human uses in this region, and the control of water has played an important role in shaping its historical development and continued economic vitality. In defining the region, we rely on the tradition established by the 1902 federal Reclamation act (National Reclamation Act of 1902), which authorized federal support for the construction of irrigation projects in the 17 contiguous western states. In other words, our region of analysis includes the Great Plains states from the Dakotas southward to Texas, and the states westward to the Pacific Coast.
The impacts of climate change are expected to compound the many existing pressures on western water resources. These have grown as the region’s population has swelled – leading to transformation of the landscape, new water demands and shifting public views on how the resource should be managed. In many cases, growing demands are encountering diminishing or degraded sources of supply. For example, surface water supplies may be polluted, and groundwater resources may be pumped at unsustainable rates leading to declining aquifer levels, increasing pumping costs, and depletion of baseflows in interconnected surface streams. Furthermore, the cumulative ecological impacts of substantial water withdrawals and the region’s history of river basin engineering, have left many species in a fragile condition and less able to withstand episodes of drought and extreme high temperatures. A compelling argument can be made that the West’s major river basins and aquifers are now best understood as human-dominated systems (Richter et al, Chapter 5 this volume).

Assessment of the implications of climate variability and change for such systems requires attention to both their human and natural dimensions. More particularly, the dynamic interactions between these elements will determine the outcomes of any proposed changes in policy or infrastructure. Important points to recognize when considering options for improving the climate-resilience of the West’s water resource systems include the spatially complex patterns of water availability and demands; the large number of independent, but interconnected decision-makers; and the multitude of values at stake. There is no central water authority in any western state (and certainly none for the West as a whole), but rather a decentralized multi-layered system of water management by multiple entities including individuals, irrigation organizations, federal and state project operators, municipal water authorities, regional water management bodies, and drainage districts.
There is a wealth of available information on climate change and its implications for western hydrology and water management (e.g. Lewis 2003; Climatic Change 2004; Brekke et al 2009). There also is a growing literature providing advice on planning for adaptation to climate change in the face of considerable uncertainty (e.g. Lempert et al 2006; Wilby and Dessai 2010; WUCA 2010; Stakhiv 2011; Yates and Miller 2011). Much of this work focuses on planning problems relevant to small sets of well-defined decision makers, and thus fails to explore the complexity of real-world planning processes. The broader policy issues that climate change presents for balancing competing interests, sustaining societal benefits from water resources, and protecting ecological resources have been the subject of a separate literature, largely in law and policy science journals (e.g. Adler 2012; Craig 2010). Integration of these different spheres of knowledge will be important for the tasks of developing sound policies and effective planning processes.

Our purpose in writing this book is to help readers understand not only the challenges ahead, but also possible strategies for managing water-related risks, securing human well-being and protecting environmental resources in a variable and changing climate. This requires an accurate understanding of the starting point for adaptive actions –in other words, the existing physical, social and institutional features that will shape available options for responding to the combined impacts of human activities and climate change on water resources and flooding risks. It also requires a sound and well-informed approach for incorporating science information in water policy and planning deliberations.

Such an approach recognizes that science is not a static repository of “truth,” but rather an evolving process of systematic inquiry focused on gathering evidence to shed light on how systems work and what causes them to change. As such, uncertainties are an inherent part of the
process. Rather than seeing uncertainty as a reason for rejecting scientific input, citizens, policy makers and water resource professionals would do well to embrace uncertainty as a central aspect of the problems they seek to address. On the other side, science professionals can benefit by acquiring a realistic understanding of the motivations and considerations, apart from their own areas of expertise, that are important in driving policy and planning processes. Mutual understanding is needed between all parties engaged in making or informing water-related decisions in order to meet the challenges posed by an increasingly variable and changing climate. In this spirit, the topics covered in this volume were selected to provide a foundation for building a holistic and well-grounded understanding of the issues and context for future decision making regarding the West’s water resources.

II. Climate and Western Water

The West’s climate is highly variable in both time and space (Cayan et al, Chapter 2 this volume). Large scale moisture transport into the region is driven by ever-changing patterns in the exchange of heat, moisture and momentum between the atmosphere and oceans. Where that moisture falls as rain or snow depends heavily on the West’s complex topography. Mountain tops and westward-facing slopes capture much of the available moisture, leaving dry rain-shadow landscapes on the lee-side of the major mountain ranges. Within a short drive across any of the coastal and mountain states, one can witness the dramatic impacts of differences in temperature and precipitation regimes on vegetation and water availability.

The rivers that provide most of the West’s water arise in those well-watered mountainous areas. Their seasonal patterns of flow are shaped by the accumulation of snow over the winter season and its rapid release as meltwater over the course of the spring and early summer. Western water management infrastructure and water use practices are tuned to that regular seasonal cycle. In
essence, mountain snowpacks represent key water storage reservoirs – holding flows back in the winter when they might otherwise pose a flood risk and the water is not wanted for human uses, and releasing it to flow into the valleys just at the start of the irrigation season.

The warming anticipated from global climate change is likely to disrupt this long-established pattern. The loss of snowpack storage could spell reduced late summer streamflows, reduced water availability for irrigation and other human uses, and higher water temperatures. Those impacts would be especially likely in stream basins where there is little available natural or human-constructed storage capacity to capture and regulate earlier and possibly larger spring runoff.

Throughout history, human communities have adapted to differences in regional climates and their cultures, technologies and settlement patterns have been shaped by struggles to cope with climate variability, including extremes of droughts and floods. At present, we are entering an uncharted era in human experience with the global climate system. Rising atmospheric concentrations of carbon dioxide (CO₂) and other greenhouse gases are well documented (IPCC 2013; WMO 2014). As of 2015, the concentration of CO₂ in the global atmosphere stood in the neighborhood of 400 parts per million by volume (ppm), a level unprecedented in human history. Using ice core records to extend modern measurements back to 800 thousand years before present, researchers have found that CO₂ concentrations over that period fluctuated between roughly 170 and 300 ppm with low and high values corresponding respectively to glacial and interglacial periods (Jouzel et al 2007; Lüthi et al 2008; Scripps Institute of Oceanography 2015). To put this record in perspective, recall that there were no modern humans 800 thousand years ago – that was the era of ancestral humans *Homo erectus*. *Homo sapiens* did not emerge until about 200 thousand years ago (Smithsonian, 2015).
At the beginning of the industrial revolution in the mid-18th century, the concentration of CO₂ in the atmosphere was about 280 ppm, close to the mean level experienced during previous interglacial periods. Since 1750, human activities have released approximately 555(± 85) gigatons of carbon (GtC) into the atmosphere, of which about two-thirds was from fossil fuel burning and cement production and the remainder from deforestation and other land use changes. As a result, atmospheric CO₂ concentrations have increased by about 43% since pre-industrial times (IPCC, 2013). The sharp spike to modern levels occurred in the geologically very short period of two and a half centuries.

Continuing growth in CO₂ concentrations, together with rising concentrations of methane (CH₄), nitrous oxide (N₂O) and more powerful manufactured greenhouse gases such as halocarbons, have altered the Earth’s energy balance, leading to ongoing and expected future warming of ocean and land-surface temperatures. Changing large-scale atmospheric circulation patterns and acceleration of the hydrologic cycle are projected outcomes of global climate change.

There is abundant evidence that the measured changes in radiative forcing have already caused climate changes around the globe. Multiple independent research teams have recorded a 0.8°C increase in global average annual temperatures since the middle of the 19th century. As documented by the Intergovernmental Panel on Climate Change, each of the last three decades has been successively warmer at the Earth’s surface than any preceding decade since 1850. The oceans also have warmed, accounting for more than 90% of the net energy storage in the climate system between 1971 and 2010 (IPCC 2013).

Rising greenhouse gas concentrations will lead to changes throughout the climate system. For example, there may be a positive feedback to initial warming as shrinking snow and ice cover reduce the reflection of energy back to space. Another positive feedback comes from the fact that
warm air can hold more moisture than can cold air and atmospheric water vapor is itself a powerful greenhouse gas (NOAA 2015b). Global evaporation and precipitation will likely increase (Trenberth 2011), but there will be strong regional differences in the impacts on water availability as storm tracks shift in response to warming. Most climate model simulations project “…a poleward shift of the midlatitude storm tracks and equatorward contraction of convergence zones…” (Seager et al 2012, p. 3355). In the Northern hemisphere, such shifts are expected to concentrate greater precipitation in already wet far-northern areas and along the equator while fostering drier conditions in subtropical dry zones (around ±30° latitude) like northern Mexico and the U.S. Southwest. Many parts of the western U.S. fall in the transition zone between those projected trends, making projections of precipitation changes especially difficult. However, even with limited predictability of precipitation trends, the projected impacts of warmer temperatures on evaporation and transpiration provide considerable information about future water stress across the western U.S.

The important role of temperature in driving hydrologic change is illustrated in Figure 1.1, which shows projected changes by the mid-21st century in annual runoff and climatic water deficit (a measure of evaporative demand in excess of available soil moisture) in a high greenhouse gas emissions scenario. The mean changes as simulated by twenty climate models are shown only in areas where at least two-thirds of models agree on the sign of change. Note that annual runoff is projected to increase in a few areas where greater winter runoff would play a dominant role. However, even in those locations, moisture stress is projected to increase in response to the impacts of warming on evaporation and plant water use (Stephenson 1998).

The projected widespread increases in climatic water deficit are posited to contribute to an increased likelihood of wildfires and forest disturbance due to insect-outbreaks and drought-
induced mortality (e.g., Allen et al 2010). Such disturbances would further affect watershed hydrology, potentially leading to flashier runoff, higher stream temperatures and water quality degradation (Adams et al 2012; Luce et al 2012; Thompson et al 2013).

A point that is inadequately understood by the general public is the fact that both near-term climate and the climate of future decades will reflect the combined influences of natural variability and anthropogenic climate change. Seager and colleagues make the following argument. “There is a growing sense that a purely natural (i.e., uninfluenced by human activity) climate system no longer exists, and it is widely assumed that climate events like heat waves, stormy winters, droughts, and floods bear at least some imprint of human-induced climate change, rendering the term ‘natural climate variability’ a relic of the preindustrial age.” (Seager et al 2012, p.3356). This statement points to the difficulty of disentangling the separate influences of natural and human-forced processes in determining the observed sequence of climate conditions. This is a topic also discussed by Cayan et al (Chapter 2 this volume).

In the western U.S., where climate is innately highly variable, trends in weather patterns over typical planning horizons will be especially difficult to foresee. In short, the sequence of climate events over the next couple of decades is likely to be dominated by natural variability, but shaped by the underlying influence of anthropogenic climate change (Deser et al 2012a; b).

For example, natural temperature variability superimposed on increasing temperature trends due to climate change will likely result in periods of plateau (no trend) and rapid increases as the cycles of natural variability reinforce or oppose the long term trends. These expected patterns will likely be a source of confusion for the uninformed.
These facts suggest a need to focus on building resilience to a wide range of possible conditions together with flexibility to respond quickly to evolving weather events. It will be especially important to understand the full range of natural variability that may occur regardless of global climate change, and to incorporate that understanding into evaluation of planning options. Paleoclimate reconstructions, based on evidence from tree rings, geologic features and other information, are shedding considerable light on climate variability in this region prior to modern records. As described by Woodhouse et al (Chapter 9 this volume) methods for incorporating that information in water planning have been developed and are being used by some of the West’s water managers to improve the resilience of their systems.

III. Institutional Context

Fickle and unevenly distributed water resources have long posed challenges for human efforts to secure sustainable livelihoods in the western United States. Long before the 19th century influx of Euro-American settlers into the territories west of the Mississippi River, Native and Hispanic communities in the Southwest developed irrigation systems to allow farming in areas where crops otherwise could not succeed. Irrigation continues to be vitally important for western U.S. agriculture, accounting for most of the water consumed by human activities in the West.

The story of water planning and policy in the Western U.S. has revolved around efforts to solve problems posed by limited and highly variable water availability in a physically challenging environment. The West’s extensive present-day system of dams, levees and infrastructure for the transport and distribution of water are the outgrowth of more than a century and a half of such problem-solving. These efforts were often uncoordinated, involving decisions made at different points in time by a multitude of entities ranging from individual farmers and miners to state and federal government agencies.
Early water development projects were typically driven by narrowly defined objectives: for example, securing a reliable source of irrigation water to allow a family or larger community to survive, or shunting floodwaters away from an established community to prevent its destruction. Uncoordinated local solutions to specific local problems, however, frequently engendered new problems for other people, places and times. For example, levees to protect one community from flooding typically function simply to deposit the floodwaters farther downstream (Mount 1995). The West’s water institutions grew up as a parallel effort to resolve numerous conflicts between parties seeking to rely on the same water source, or to resolve incompatibilities between their proposed development projects. Competition for scarce water supplies and the adverse impacts on other parties of water diversions and stream channel modifications quickly led to disputes. These in turn, laid the early groundwork for the development of western water law and the evolution of administrative arrangements that now govern the management, use and development of western water resources. Prior appropriation was widely, although not exclusively, adopted as the principle for resolving conflicts over allocation of scarce and fleeting water supplies. It brought stability by clearly identifying who would or would not have the right to withdraw water from a river when flows were low. It also provided a strong incentive for late-comers to build reservoirs to secure their access to water when seasonal streamflows declined.

In the modern era, prior appropriation has many critics who point to it as having historically ignored the ecological and aesthetic value of natural streamflows, and as now locking water use into archaic patterns dominated by irrigated agriculture (Kenney 2005; Wilkinson, 1991). However, the doctrine has been modified in practice and there is evidence of flexibility (Tarlock 2001; Benson 2012). For example, the reservation of water for environmental purposes through instream flow provisions is a common, albeit fairly recent, addition to most western water codes.
Likewise, the movement of water to new and “higher” uses is authorized through the legal treatment of water rights as transferrable property. In both contexts, however, the promise is often greater than the reality.

The stunted evolution of water markets is particularly significant, as transactions costs can make otherwise viable transfers prohibitive. Transfers of water rights are regulated in various ways to prevent harm to other rights-holders, for example those relying on the return flows from an existing irrigation right. Such protections serve a useful purpose. However, the efficiency with which they are implemented varies dramatically from state to state depending on the quality of state record-keeping and the design of the review process. In some cases, documentation of actual water use is so poor that enforcement of water rights has occurred only when necessitated by drought, and then awkwardly (Wilson 2012; Lund et al 2014; Hanemann et al 2015). A proposed water transfer can provide a reason to review past uses and to update records, an essential step to marketing but a potentially costly and dangerous one for a water user whose rights have heretofore escaped serious governmental scrutiny.

In other settings, up-to-date records and well-developed administrative infrastructure already exist, allowing relatively efficient enforcement of water rights and providing adequate documentation to allow water markets to function without undue constraints (e.g. MacDonnell and Rice 2008; Jones and Cech 2009; Western Governors Association, 2012; Hansen et al 2014). But even in these situations, transfers can be discouraged by their high political costs, as the socioeconomic impacts to areas losing water can be significant (National Research Council, 1992).

Water management infrastructure and institutional arrangements for water allocation and mitigation of flood risks developed jointly over time in response to the region’s growth and
changing water demands. In recent decades, this complementary relationship between infrastructure expansion and the rules of management has become strained by concerns about the adverse impacts of dams, levees and water diversions on aquatic ecosystems and associated efforts to preserve the values that unimpaired watersheds can provide to the human community. The range of interests, values, and disciplines of participants in water decisions has expanded accordingly, increasingly transforming water management from a technical, engineering-driven exercise to a much more complicated endeavor.

In the Columbia River Basin in the Pacific Northwest, for example, the number of water management objectives that must be considered in developing new water management policies has expanded dramatically since the 1960s when the basin’s operating policies were first developed. Despite these expanding management concerns, the primary basis of the Columbia’s operating policies remains the Columbia River Treaty (CRT) (1964) which was (and remains) focused almost entirely on the conjunctive management of hydropower and flood control. Although the CRT is often cited as one of the most successful international water treaties in the world, the CRT does not address important impact pathways associated climate change, such as changes in seasonal hydropower generation (Hamlet et al 2010), evolving flood risks (Lee et al 2009; Tohver et al 2014), or the effects of intensifying low flows and warmer water temperatures on salmon populations (Mantua et al 2010). Although the need for change is readily apparent in the Columbia basin (Miles et al 2000), the social, legal, and political challenges that are tied to potential changes in the Columbia River Treaty are formidable, and the way forward is far from clear (Cosens et al, Chapter 10 this volume).

Legislation and formal administrative mandates and protocols are key aspects of the West’s water institutions, but the term “institutions” is a much broader concept. One definition was
provided by Nobel Laureate, Douglass North: “Institutions are the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)” (North 1991, p. 97). Thus, to understand the context for present-day water resource decision making, one may need to consider the informal customs and expectations of water users and managers in addition to the formal legal definitions of their rights and obligations.

Sound but generic advice on climate adaptation planning is available from several sources (e.g. National Research Council, 2009; Major and O’Grady 2010; NDWAC 2011). Key messages include the need to approach climate change adaptation as a risk management problem and the need to create flexibility. Somewhat less attention has been given to specifics about how to achieve these objectives in the context of ongoing planning processes that are often marked by conflicts between different stakeholder groups whose members are reluctant to let go of perceived entitlements and cherished preferred solutions.

Even among water management professionals it is common to find strong preferences for adherence to known strategies, reliance on observed records, and suspicion of model projections outside of the range of recent experience (Hamlet 2011). The prospect of continuing climate change and the growing likelihood of extreme droughts and floods belies the presumed security of such an approach. Following old strategies under rapidly changing conditions is likely to yield disappointing—and even dangerous results.

A very different planning perspective is needed to secure reliable water supplies, protect ecological resources and mitigate flood hazards when the underlying probability distribution of extreme climate conditions is not stable. The requisite perspective is one that seeks to understand
the implications of different plausible trajectories of changing water-related risks and growing pressures on resources; and one that fosters creative and proactive problem solving while avoiding unnecessary conflict and hardship. Also required are: 1) a willingness to embrace uncertainty by acknowledging our incomplete understanding of complicated water-dependent socioecological systems and our imperfect ability to predict their responses to climate-driven perturbations; and 2) a purposeful strategy of learning from the inevitable surprises that will come from limited understanding and predictability.

Armed with such a perspective, those engaged in water resource planning and flood hazard mitigation would be better able to participate in a long-term ongoing program of evaluating vulnerabilities, identifying robust response options, and taking action. A supportive policy environment is needed to facilitate such exploration and to ensure that planning processes are open but structured to facilitate constructive engagement of all relevant stakeholder communities. Examples of such processes, as well as the consequences of their absence, can be found in the material presented in this volume.

IV. Summary and Overview

We are confronting a reality of growing pressures on the West’s water resources. Potentially large physical changes in the region’s climate and hydrology coupled with limited predictability create new challenges for the ongoing need to make water policy and planning decisions. It is important to move beyond the near-term sectoral interests that have long dominated water planning, and to adopt a planning perspective focused on the long-term wellbeing of all citizens and the health of the environment on which that wellbeing depends. That will require taking into account the rapidly evolving climate system and its impacts on water resources systems. Decisions made now are likely to cast long shadows. That is, they will have enduring impacts
arising from the long life of water infrastructure and the lasting legacy of both water allocation decisions, and institutional innovations. In this setting, it is easy enough to caution policy makers and water planners to choose wisely, and to adopt strategies to respond to changing climate conditions. It is much more difficult to define what that means or how to make it happen.

We do not pretend that we have a recipe for efficient adaptation to prospective climate change. Although there have been success stories in many areas of the West (a number of them documented in this volume), there are no silver bullets or one size fits all solutions. Rather, we argue that it is important for anyone engaged in water policy discussions or analysis of water planning options to start with a realistic understanding of the values and interests at stake, how they relate to one another and what we do, do not and cannot know about the effects of any proposed action as affected by the West’s highly variable and changing climate.

The chapters in this volume identify many of the issues that will require policy attention or planning decisions in coming decades. It is clear that significant problems exist for western water management, even in the absence of anthropogenic climate change. It also is clear that anticipated climate change will worsen many of these problems and may foreclose some solution options. For example, past water development and land-use decisions have massively altered watersheds, streamflow regimes and aquatic habitats leading many species to the brink of extinction (Richter et al, Chapter 5 this volume). Recognition of the ecological values that have been lost has spurred restoration efforts, but it has proved difficult and expensive to undo the damage, and only limited stream-recovery success stories have been achieved thus far. The task will become increasingly daunting as summer streamflows decline and water temperatures rise in response to anthropogenic climate change. Furthermore, thresholds may be crossed beyond which even massive expenditures to acquire water for stream restoration may fail to preserve
species in their native habitats. However, that does not imply that preservation and restoration goals should be abandoned. It does imply that creative thinking and thorny negotiations will be needed to maintain a desirable balance between healthy aquatic ecosystems and out-of-stream water uses.

Groundwater management is another subject that will become more challenging in a changing climate. The practice of turning to groundwater use when surface water supplies are unavailable can be a sensible strategy for mitigating the impacts of short-duration droughts. Indeed, the economic impacts of the 2014-2015 California drought would have been more immediate and painful were it not for the ability of agricultural water users to sustain production by pumping groundwater (Howitt et al 2014). But when groundwater rights are poorly constrained, aquifer depletion may lead to long-term consequences for future water availability. That risk will escalate if climate change reduces summer streamflows. Attention to groundwater policies will be required, but the issues are complicated. For example, Fort (Chapter 3 this volume) notes that groundwater mining is an especially difficult problem because regulation has been historically lacking, and it is hard to define an appropriate balance between sustaining groundwater levels and allowing use when some aquifers are essentially non-renewable. Interactions between surface water and groundwater also present challenging issues for policy development, especially when a changing climate may alter the impacts of groundwater pumping on nearby streams, as discussed by Cech (Chapter 18 this volume).

Despite the magnitude of the challenges, however, we identify many reasons for optimism. The following chapters paint a picture of a policy environment that is complex and resistant to change, but not immutable. Old habits and ways of thinking are giving way to newer concerns about sustainability and protection of the public interest in healthy aquatic environments. New
processes are being tried that give voice to a broader range of interests and values in the
development of policy recommendations and proposals for infrastructure projects and
management strategies. While periods of water stress still inflame old conflicts, they also are
increasingly engendering new collaborative efforts to secure a sustainable and desirable water
future for communities, states and river basins. Adopting needed reforms, and at a pace sufficient
to meet rising challenges, is far from easy—but very few aspects of western water management
have ever been easy. The following pages offer a wealth of examples, insights, and
considerations to guide those efforts.
References


www.drought.gov


http://www.ncdc.noaa.gov/sotc/service/national/statewidetavgrank/201407-201506.gif


**List of Figures:**

**Figure 1.1:** Projected change in (a) annual runoff and (b) climatic water deficit as measured by the difference between potential evapotranspiration (PET) and actual evapotranspiration (AET) between mid-21st century (2040-2069) climate under a high emissions (RCP8.5) scenario and the late 20th century (1971-2000) climate as simulated by twenty climate models. RCP denotes a Representative Concentration Pathway as defined in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2013). [Figure courtesy of John Abatzoglou, a contributor to this volume].
Figure 1.1

Δ Runoff
2040-2069 minus 1971-2000, units: mm

Δ Climatic Water Deficit (PET minus AET)
2040-2069 minus 1971-2000, units: mm