

A Briefing On

California Climate Change: Managing Risk & Uncertainty

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By Susan Lauer

Editor's Note:

This briefing paper on California climate change was produced by the Water Education Foundation to provide the public with a short overview of the key issues related to climate change and California water. The briefing paper is based on presentations from the “California Climate Change and Water Adaptation Summit” in Long Beach, which was held in mid-November 2008. The two-day event was sponsored by the California Department of Water Resources (DWR) and the Water Education Foundation.

The mission of the Foundation, a nonprofit organization, is to provide impartial coverage of water issues to lead to a broader understanding and resolution of water problems. Water issues can appear overwhelmingly complex and controversial. Through the Foundation, we try to open the door to understanding these issues so that people will be able to best manage and protect this precious resource. We believe that learning about climate change will help you determine what decisions should be made regarding these important issues.

For more information about this climate change summit, including access to speaker PowerPoint presentations, please click here: <http://www.watereducation.org/doc.asp?id=852&parentID=849>

– *Rita Schmidt Sudman*

Introduction

Climate change. Reports tout uncertainty and dire consequences for the future, yet in California, its impacts are already being felt on water resources – the availability, quality, flood management, ecosystem functions and distribution throughout the state.

Precipitation and runoff patterns are changing, meaning diminished snowpack in the Sierra Nevada mountains, and fluctuating and decreased flows in rivers throughout the state. Sea level rise along the coast and in the Sacramento-San Joaquin Delta is already measurable.

The changed future in terms of increasingly variable water supplies compels leaders to re-think how water agencies move forward and how water resources are used and managed. Extreme climatic events – from drought to floods – are expected to become more frequent, necessitating improvements in flood protection, drought preparedness and emergency response.

The bottom line is adaptation needs to happen now in order to avert problems in the future, agreed academics, scientists and water experts from state and local governments who gathered at the “California Climate Change and Water Adaptation Summit” in Long Beach in mid-November 2008. The two-day event was sponsored by the California Department of Water Resources (DWR) and Water Education Foundation.

“Climate change is real. Global warming is real,” said Lester Snow, director of DWR in his opening remarks. “We need to manage the reality of a changed climate. We need to adapt to changes in the pipeline.”

The ball is already rolling. Gov. Arnold Schwarzenegger issued an executive order on Nov. 14, 2008 to identify the state’s biggest vulnerabilities to rising sea levels and adopt an “adaptation strategy,” including asking the National Academy of Sciences to consult an independent panel of experts to forecast a range of likely scenarios along the coast through the end of the century. That panel would recommend ways to minimize damage to coastal roads, beaches, sewage and water treatment plants, wetlands and

marine life. Before the executive order, government water agency officials had been long working with other stakeholders to ascertain the risk and rethink how our water resources are managed.

It’s no easy task. Adapting California’s water management systems in response to climate change presents one of the most significant challenges of this century. “And it can’t be something we invest in after a disaster; we need to address it up front,” Snow said. “We need to act now.”



*Lester Snow,
Director of DWR*

Adaptation & Management

While there is much uncertainty associated with what the precise impacts of climate change might be, experts agreed that they will be significant alterations on water resources and the way we use those resources. Mitigating the impacts after they occur will not be effective. Once the damage is done, repairing the damage will be nearly impossible. Adaptation as soon as possible is the answer.

In summer 2008, the Western Governors’ Association (WGA) released a report, “The Next Steps Report,” that built upon its 2006 water sustainability report, providing more specifics for implementation of the sustainability report’s recommendations. The report noted that success will depend in large part on state initiative and innovation, because states oversee water planning, allocating and protecting water resources.

“But in the West, where the federal government is a substantial landowner and has a significant regulatory presence, the federal role is also critical. Cooperation among the states and the federal government continues to be

vital,” the report noted. “It will be paramount to move state and local government participation back into the process of federal decision making, before too much momentum has been built towards policy decisions.”

Better climate information to make sound decisions is paramount, said Jeanine Jones, interstate resources manager at DWR. “We have all these systems in place that were designed and are operated based on historical data. That’s no good under climate change. Old standards of practice are not good in the future.

“We need to be smarter about how we use the information,” Jones said. “We need to link water management with the academic and science and political.”

The WGA recommends that the federal government evaluate the performance of its structures – dams, reservoirs, etc. – in light of climate change. Additionally, the report urges evaluation of Corps reservoir flood rule curves to determine to what extent reservoir reoperation can contribute to adaptation.

In California, experts are focused on key areas. “Where are we most vulnerable to climate change right now? Temperature increase, precipitation changes and sea level rise,” said Tony Brunello, deputy secretary for energy and climate change at the California Natural Resources Agency. He noted the economic impact associated with climate change is estimated at trillions of dollars.

While progress is being made to ascertain the impacts, modeling changes year to year. A new set of scenarios due out in April 2009 will provide updated information for people at all levels of government and be included in the state’s Climate Adaptation Strategy (CAS). The CAS process will incorporate peer-reviewed scientific information gathered from scientists from around the world, funded largely by the California Energy Commission.

“There is lots of uncertainty, and research is fundamental,” Brunello said. “We need to tell the story. There are many ways to tell the story. And it is not finished once we are done.”



California leads the nation in thinking about climate policy, yet when it comes to water resources and management, a fragmented, complicated institutional structure and unresolved conflicts impedes adaptation to climate change. We haven’t done a good job with land use planning. And land use, water supply, fire control, public health are highly decentralized, said Michael Hanemann, Chancellor’s professor in the Agricultural and Resource Economics Department at the University of California, Berkeley.

“Getting our house in order now is the key precondition for effective adaptation,” he said. “Humans always adapt. The question is how well, quickly and comprehensively.

“The issue is less whether adaptation will or will not occur but, rather, how well organized or chaotic will it be?” he continued. “How promptly will it occur? How costly will it be when it does occur? How effective and comprehensive will it be in offsetting the climate induced changes?”

Hanemann stressed that the key to adaptation for water resources is risk management. That includes risk measurement, assessment and prediction, management and pricing.

“As it happens, water management agencies do a pretty poor job of risk management,” he said.

For example, they don’t measure or model risk in a *probabilistic* manner – considering probabilities of what may happen. Agencies use a historical hydrologic sequence even though this is a highly imperfect measure of risk, which almost certainly would understate the risk we face, even if there were no climate change.

“We don’t manage for risk. We don’t frame allocation in terms of risk sharing. We still try to manage for certainty,” Hanemann said.

He pointed to two looming issues. First, water transfers are seriously hindered. The idea that water could be sold as a commodity emerged in the late 1970s and came to the forefront during the 1987-1992 drought. Reallocating the available water on a supply-and-demand basis is viewed by proponents as the best financial, political and environmental means of accommodating an increase in population. Water transfers can occur among farmers, who use the bulk of the developed water supply, and between agricultural and urban users. The latter is encouraged by the high prices cities are willing to pay for water. The buying and transferring of water from the poorer rural areas to wealthier cities raises fear of third-party impacts.

Although water transfers have the potential to allocate water more efficiently, potential adverse impacts on third parties can occur. Fallowing of land and associated effects on farm workers are just two of the potential impacts of water transfers. Some fear that long-term

water transfers from farms to cities will hasten conversion of farmland for suburbs. Another problem can arise when farmers sell their surface water and continue to grow crops by substituting groundwater.

Because much of the water marketed would pass through the Sacramento-San Joaquin Delta – the heart of the water supply system – its facilities need to be improved to facilitate transfers. Additional sticking points are the allocation of water for environmental needs and environmental effects of actual water transfers.

A second major water issue, according to Hanemann, is pricing. In California water is underpriced and based on the historical cost of acquiring past supplies. For the future, pricing needs to anticipate actual supply and base cost on that. “The leadership of California will have to engage seriously with reform of water institutions if we are to deal successfully with the challenge of climate change,” he said.

“The mitigation response to climate change, or the reduction of greenhouse gas emissions that contribute to our changing climate, has received more international attention to date than adaptation. Now, there is a shift to an adaptation mindset,” noted the DWR white paper “Managing an Uncertain Future,” which discussed strategies for state and local water managers to improve the way they handle change. Many of the strategies will also help adapt the state’s water resources to accommodate non-climate demands including a growing population, ecosystem restoration and greater flood protection.

“As understanding of climate change improves, the challenge for California’s water community is to develop and implement strategies



*Michael Hanemann,
UC Berkeley*

that improve resiliency, reduce risk, and increase sustainability for water and flood management systems and the ecosystems upon which they depend,” the white paper noted.

Challenges of Climate Change

The “Managing an Uncertain Future,” white paper was blunt: “Adapting California’s water management systems in response to climate change presents one of the most significant challenges of this century.”

As temperatures rise, altered patterns of precipitations and runoff, and rising sea levels are challenging efforts to effectively manage water supplies, floods and the water quality. The trends of the last century – especially the increases in hydrological variability – will likely intensify this century, and abrupt changes in climate could also occur, the paper noted.

The Intergovernmental Panel on Climate Change (IPCC) notes that the western United States may be especially vulnerable to water shortages. While the existing system has some capacity to cope with climate variability, extreme weather events resulting in increased droughts and floods will strain that capacity to meet future needs.

Before climate change is even factored in, California is facing major challenges in how to distribute and share its water supply. Nearly 75 percent of the available water originates in the northern third of the state (north of Sacramento), while 80 percent of the demand occurs in the southern two-thirds of the state. The demand for water is highest during the dry summer months when there is little natural precipitation or snowmelt. California’s capricious climate also leads to extended periods of drought and major floods.

These basic problems have been remedied, in large part, by building one of the most complex and sophisticated flood control, water storage and transport systems in the world. An integrated system of federal, state and locally owned dams, reservoirs, pumping plants and aqueducts transports large portions of the state’s surface

water hundreds of miles to the Central Valley, Bay Area and Southern California. California’s rise to pre-eminence as the nation’s most populous state and the world’s eighth largest economy has depended in part on its ability to deliver water supplies where they are most needed by people.

But moving water over great distances has created intense regional rivalries. Water feuds historically have divided the state, pitting north against south, east against west and three major stakeholders (agricultural, urban and environmental) against one another. Intense disagreements persist over the manner in which California’s water resources are developed and managed.

Environmental groups and fish and wildlife biologists have argued for years that the health of California’s fish populations, riparian vegetation and wildlife have been sacrificed to ensure adequate water supplies for cities and farms. The conflict is especially acute in the Delta where large pumping plants in the south end of the Delta export water to the Central Valley Project and State Water Project.

“Historical hydrology has served as a guide to water supply and flood protection. However, due to climate change, the hydrology of the past is no longer a reliable guide to the future,” the white paper noted.

Sea Level Rise

Warming ocean water and melting continental ice sheets and glaciers will have an impact in California, both on coastal waters and inland. Climate warming projections, combined with recent global sea level rise estimates, suggest sea levels could increase by 1.6 feet (0.5 meters) by 2050 along California coastlines. By 2100 sea rise could be more than 3 feet (1 meter), according to Dan Cayan of Scripps Institution of Oceanography, UC San Diego, during the Climate Change and Water Adaptation Summit.

“It’s quite certain that temperatures will rise over the level we’ve seen in recorded history and likely the rate of sea rise will increase dramati-

cally,” Cayan said. “Not only in the open coast in California, but the (Sacramento-San Joaquin) Delta is also vulnerable.”

Some 116 square miles (300 square kilometers) is exposed to sea rise, signaling a real potential for problems. Most Delta lands are currently protected by levees and would be inundated if those levees fail or are overtopped.

The Delta is a 1,153-square-mile maze of islands and interconnected waterways located where the Sacramento and San Joaquin rivers converge and flow into San Francisco Bay. The system is composed of approximately 60,000 acres of waterways, 57,238 acres of which are navigable. Two-thirds of Californians get all or part of their drinking water from the Delta by virtue of local, state or federal water projects that export water to the San Francisco Bay area and central and southern California. The Delta also is the largest estuary on the West Coast, boasting hundreds of species of birds that travel along the Pacific Flyway and dozens of fish species including salmon and steelhead that migrate through the Delta on their journey to and from the ocean.

If Delta levees are overwhelmed, salt water could surge into the drinking water intakes in the south Delta, contaminating supplies for 25 million people in the Bay Area and Southern California.

Sea rise is caused in part by melting ice. The concern is that melting ice from Greenland and western Antarctica could cause sea levels to rise to levels that will flood low-lying cities and coastlines. The U.N.’s Intergovernmental Panel on Climate Change report released in 2007 estimated the sea level rise by 2100 could be from 0.2 to 0.8 meters. Already, some have questioned whether that estimate is too conservative.

“For ice, climate change is already here and it’s moving faster than we’ve expected,” said Walter Meier, research scientist at the National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Sciences at the University of Colorado, Boulder.

So why is the ice melting? It’s a phenomenon



known as the “ice-albedo feedback.” The change from sea ice to ice-free ocean is the largest surface contrast on earth as far as solar energy is concerned, and it substantially amplifies the initial greenhouse gas warming. Sea ice generally absorbs less than 40 percent of incoming solar energy, while an ice-free ocean surface absorbs more than 90 percent of incoming solar energy. The ice-albedo feedback is a cycle. Increased atmospheric temperature causes sea ice to melt. The water absorbs more solar energy and heats up, which in turn increases the atmospheric temperature. The increased temperature causes more sea ice to melt. And the cycle continues.

Meier called Greenland “the 800-pound gorilla” of climate change. If all the Greenland ice melted, it would be equivalent to about 20 feet in sea level rise.

“This 800-pound gorilla is a big gorilla. If [these] melt, things start to change,” he said. “In Greenland, things are already moving much faster than expected, and there’s a lot we don’t know about them.”

Jakobshavn Isbrae is the world’s fastest flowing glacier at about 20 meters per day. That speed has doubled in recent years, and the edge of the glacier has retreated dramatically since

1997. Jakobshavn Isbrae is not the only glacier melting; many Greenland outlet glaciers, which flow into larger valley glaciers, are accelerating, thinning, and retreating, according to Meier.

Indications are that within 10 to 15 years the planet could be on a course to an eventual 20-foot (6 meter) sea level rise even though the full impact of rising sea levels will not be felt for centuries: “Arctic sea ice is declining faster than models have predicted, and it is not unrealistic. If you proposed this to a group of scientists three years ago, you would have been laughed out of the room. No one is laughing now,” Meier said. “Even if the melt comes by 2030 or 2040, that’s something this generation will see.”

Flood Management

During heavy rains, large rivers as well as smaller streams and creeks can become dangerous. Hundreds of people have been killed and billions of dollars of damage done during floods in the past 50 years.

Upstream dams have done much to control flooding, but downstream levees are a big concern. In the Delta, flooding is not limited to winter storms. For example, on June 3, 2004, a bright, sunny day, a levee crumbled and sent surging river water into Upper and Lower Jones Tract west of Stockton. The levee was reconstructed and the water was ultimately pumped out of the island.

Numerous Delta islands are the result of a transformation from marsh to farmland and are situated actually below sea level and protected by levees built to create the agricultural land. As a result, these islands are vulnerable.

The California Bay-Delta Authority found a better than 60 percent chance that an earthquake or major flooding in the Sacramento Valley or San Joaquin River will cause multiple levees to fail simultaneously in the next half century.

Climate change further complicates flood control in California, impacting the timing



and magnitude of runoff and flooding patterns. Expected impacts include more precipitation falling as rain rather than snow, as well as an earlier melt to the winter snowpack.

More coastal floods, increasingly severe winter storms, rising sea levels and high tides are expected to cause more frequent and more severe flooding, erosion and damage to structures along the coast, according to the California Climate Change Center.

Development in floodplains – significant areas of risk – adds to the problem.

“We don’t talk about reducing flood risks, but managing flood risks. And it’s a tall order,” said Ken Kirby of Kirby Consulting Group in Davis. “No matter how much we spend, if people continue to live in floodplains, we will always be at risk. If you live in a floodplain, it’s not a matter of ‘if’ but ‘when.’”

The state has recognized and is working to address flood management challenges. The FloodSAFE Program is a statewide initiative to address the needs for increased flood protection and public safety. It builds upon the state’s ongoing flood management work, especially focusing on improving flood management systems, maintenance, system rehabilitation, effective emergency response and sustainable funding.

The program is high priority and with the voter approval of Proposition 84 and 1E bond funds, this program will proceed in two parts: near term actions to repair urgent flood infrastructure problems and planning to develop long-term solutions. “Integrated flood management is a very important piece of the plan,” Kirby said. “Flood waters respect no boundaries, so it’s important that we work together.”

Meanwhile, the U.S. Army Corps of Engineers (Corps) is gearing up for climate change impacts. “If there are federal dollars for flood damage reduction, then Corps has responsibility,” said Stu Townsley, chief of water management for the Sacramento District Office. “But Corps does not own water, just reservoir space.”

The Sierra Nevada provide most of the fresh water that flows down the state’s rivers and

ultimately to homes and farms.

Climate change is already changing the precipitation pattern in the Sierra. As more water falls as rain rather than snow, it poses difficulties for managers to store water for dry months of summer. That’s because rather than flowing into reservoirs during a long spring melt, runoff water

comes in concentrated, short deluges. In order to prevent flooding, reservoirs must release water more frequently – storing water until the end of the wet season would create an unsafe condition. Water supply shortages could develop not from a lack of water during a drought, but from an inability to store water when it is available.

Townsley noted that implications of climate change could mean reservoirs will need more flood control space. Alterations in operations might include changes in the timing of draw-downs, an earlier refill schedule and a forecast parameter that adds flexibility to release decisions.

In light of climate change, the development of water control plans and the scheduling of reservoir releases must be coordinated with appropriate agencies, or entities, as necessary to meet commitments made during the planning and design of the project. Additionally, Corps water control plans must be reviewed and adjusted, when possible, to meet changing local conditions.

“Why consider climate change? The Corps doesn’t go out and do things on its own. We need a local sponsor, someone who says they need the Corps help to do a project,” said Townsley.

At the state and local levels, legislation signed in 2007 will promote better planning to avoid



*Elissa Lynn,
DWR*

catastrophic flooding. The most extensive provisions apply to cities and counties in the Central Valley, including general plan revisions, zoning and subdivision ordinance revisions, new findings for permit approvals and setting the standard for 200-year urban protection. Cities and counties that don't act reasonably to minimize flood risk when approving new development may be liable for at least a portion of the cost if flood victims later sue the State to recover flooding damages, according to Terry Rivasplata, technical director for ICF Jones & Stokes.

"Foremost, the idea is to stop, think and do some adaptation and then go ahead," he said.

What's Around the Corner? Near-term Climate Variability

The past couple of years in California have been dry ones. Last year alone, precipitation was just 70 percent of seasonal average, reservoir storage was 73 percent of normal and end-of-season runoff was only 57 percent of average.

Just how dry has it been? In the Northern Sierra in 2008, it was the driest March through September in 88 years of record. Only 3.5 inches of rain fell, only 23 percent of normal. Statewide, it was the driest March through August in 114 years of record at just 31 percent of normal.

Water supplies are at "critical range for both Sacramento River and San Joaquin Valley with runoff at only 57 percent of normal for water year 2007-08" as of November 2008. "Can we make up for two dry years?" queried Elissa Lynn, senior meteorologist for California Department of Water Resources.

It will take a wet 2008-2009 water season. In fact, it would take a 95th percentile year to put reservoirs back to normal, according to Lynn. "As of early January, 2009, La Niña conditions appeared to be strengthening over the tropical Pacific Ocean; cooler equatorial sea surface temperatures," she said.

If La Niña does what it did last year when it was in place, there is the possibility that Northern California could see another spring drop-

off in precipitation. March and April, 2008 were virtually bone dry, eliminating about 20 percent of annual precipitation for the Northern Sierra.

"Not every La Niña has the same resulting weather, but the possibility of a third dry year exists, based on current ocean trends," Lynn said.

Saving Water in Drought Conditions

Gov. Schwarzenegger issued an Executive Order earlier this year to address the drought conditions and water resources. Among many other things, this order directed state agencies to develop a plan to achieve a 20 percent reduction in per capita water use statewide by 2020. With current urban use at 8.7 million acre-feet per year, a 20 percent reduction equals the savings of 1.74 million acre-feet per year.

Conservation is one of the key ways to provide water for Californians and protect and improve the Delta ecosystem. The "20% by 2020" approach is a seven-part plan that includes aggressive new goals for water conservation.

"Water use is expected to increase with population and with climate change. Water conservation serves to mitigate and adapt to climate change," said Manucher Alemi, chief of data services and program development branch, Office of Water Use Efficiency and Transfers at DWR.

Planning for the Future

Looking ahead to the 5th IPCC Assessment, the desire to incorporate better climate projections into climate change calculations is a great challenge, said Phil Duffy, scientific director, Palo Alto Office and Senior Research Scientist



*Phil Duffy,
Climate Central, Inc.*

for Climate Central, Inc., a nonpartisan source for climate information.

“Decision makers want detailed information and also information about uncertainty. Climate change modeling projections have limitations. A lot of uncertainty is scientific uncertainty, so we go to scenarios,” he said. “We are making progress but progress is slow. But the demand for more information has set the bar higher, and I am happy about that.”

One key for future success in adaptation is compiling information that can be used on the local and regional level. Water managers can use Integrated Regional Water Management planning approach (IRWM), a process that examines water supply management, conservation, and flood management in a holistic and interconnected manner.

Now, climate change uncertainty measures are finding their way into IRWM planning. This includes elements to increase diversification -- conservation, local water resources -- recycling and groundwater recovery -- and investigating analytical techniques and models for more accurate determination of climate change impacts on our water resources.

“The hydrograph has already changed, so we are behind the curve. Now the question is: How do we adapt?” said DWR Director Snow. “With integrated water management, we have been aggressive and have done a good job. But we’ve slacked off a bit. Now we understand: when we need to divert a unit of water, we need to make the best use of that unit.”

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