Appendix H

David Jones' Drought Analysis Shared Vision Model

EL NIÑO, PDO, CLIMATIC CYCLES, AND DROUGHT IN THE SIERRA NEVADA

DAVID L JONES

Examination of American River hydrographic data for the 20th century shows that 3 distinctive cycles of 20- to 30-year duration occurred: an early cycle characterized by declining stream flow, a mid-century cycle of about average stream flow, and a late century cycle dominated by alternating periods of flooding and drought. These long-term cycles are readily apparent through inspection of five-year moving averages or generation of polynomial trend lines. Frequency data show that drought conditions prevailed during about 35 percent of the past century, but distribution of drought was not random. The early cycle had much more persistent and long-lived drought than the later cycles, which were characterized by short, intermittent droughts that rarely lasted more than two years.

In 1997, climatologists at the University of Washington discovered the basis for these climatic cycles. Using NASA satellite data, they demonstrated that ocean temperatures in the Northern Pacific Ocean oscillated between warm and cool conditions over twenty to thirty year time periods. These oscillations are term the Pacific Decadal Oscillation (PDO), and they have their counterpart in the North Atlantic Ocean which is named the NAO. Rainfall patterns along the Pacific Coast correlate with the PDO, in that coastal areas from central California northward receive more precipitation during the cool cycles and Southern California and Arizona receive more rainfall during the warm cycles.

These patterns are influenced by El Niño – La Niña oscillations which involve tropical Pacific Ocean waters along the Equator, stretching from eastern Asia to the coast of Peru. These oscillations, termed EN/SO, fluctuate more rapidly than does the PDO, and appear to have most effect on our weather conditions and rainfall during periods when PDO is warm. El Niño events tend to deliver large volumes of rain from tropical storms that arrive early in the rainy season. Because of this, they tend to melt the existing snow pack and augment stream runoff with resulting flooding of downstream areas.

Tree ring studies are useful for analyzing past climatic conditions for time periods that predate acquisition of instrumental weather data. Such studies show that drought in past centuries was more severe and of much longer duration than any drought experienced during the past century. It appears that the 20th century had more abundant rainfall than any other century back to at least 1600, and that it had the most strongly negative (cool) PDO during this time period. Intensity of PDO appears to vary over a 120 year time period, so we now may be leaving an extended period of exceptionally cool ocean waters.

In summary, drought is not a random event, but is a normal product of the interaction of multivariate factors, including ocean temperature, sea-surface atmospheric pressure, wind direction and velocity, and, perhaps, variation in irradiance of the Sun. The recognition of PDO and EN/SO cycles permit for the first time estimates to be made of future climatic conditions for longer periods of time (years to decades) than had heretofore been possible. Droughts of long duration appear to be a normal attribute of these cycles, so planning for severe drought protection should demand as high a priority as that afforded flood protect, for the economic consequences of extended drought far outweigh those of local floods.

Historical rainfall patterns of western El Dorado County for the past 100 years can be summarized by recognizing that we had a period of declining rainfall followed by 30 years of normal rainfall, with the remaining part of the century characterized by “boom or bust” highly variable conditions. Tree ring data substantiate a similar cyclical pattern extending back to 1600, but with longer periods of drought. This record impels us to consider long-term drought to part of the normal pattern, and we must begin to plan for such emergencies. Additional upstream storage is required is we are to provide even minimal levels of drought protection. This need is strongly amplified by El Dorado County’s lack of groundwater storage sites. Unlike the counties within the Great Valley, we have no unified water table or aquifers sufficient to serve as storage sites, so surface water sites must be developed.

David L. Jones
Professor emeritus, Department of Geology and Geophysics, UC Berkeley
ED: BS, Yale, 1952; PhD, Stanford, 1956
USGS, 1955-1985
UC Berkeley, 1985-1996; current, Pres. Lava Cap Winery

THE SHARED VISION MODEL (SVM) ANALYSIS

The El Dorado County Western Slope Drought Analysis presents the key outcomes of the first phase of drought analysis effort including: a consensus-based, collaborative stakeholder process, the development of a Shared Vision Model (SVM), and input from a team of veteran experts. The second phase of the drought analysis will establish drought preparedness plans for each of the purveyors participating in this study. Phase 2 is expected to be completed by mid 2007. Agencies involved with this drought planning analysis are the El Dorado County Water Agency (EDCWA), El Dorado Irrigation District (EID), Georgetown Divide Public Utility District (GDPUD), Grizzly Flats Community Services District (GFCSD) and the City of Placerville. These stakeholders participated in the analysis by serving as Drought Advisory Committee members.

The drought analysis incorporates water purveyor supply constraints, stakeholder needs and concerns, future water demands, and possible long-term climate change into a Shared Vision Model (SVM). The Microsoft© Excel based SVM was built with stakeholders as a framework for creating a dynamic, consensus-based view of each purveyor’s water system. The SVM uses drought simulation to translate the science of drought into practical solutions for water purveyors. The SVM computer drought simulator includes analysis of historical runoff hydrology, reservoir storage capacities under current operating rules, water demand projected through year 2030, and additional new water supply that could offset predicted water shortfalls.

The project’s overall goal is to provide the tools necessary to complete individual preparedness plans and the response plans unique to each of the purveyors. The Shared Vision Model Conclusions Summary are based on the following assumptions:

- Purveyor historical record: GDPUD (1966-1980), GFCSD (1911-1987), EID (1922-2004)
- Design drought conditions refer to 1976, 1977, 1977 (repeated) hydrology
- Reliability refers to the volume of water supplied divided by volume demanded in the simulation period (historical or design drought). This value is weighted so that a month with a small shortfall does NOT count as much as a month with a large shortfall.
- Shortfall refers to the amount of water demand a purveyor cannot supply. Average shortfall is the average value of all months with shortfall; months with no shortfall are not included. For example, if two months out of 36 months have shortfalls and one month’s shortfall is 10 acre feet, the other 20 acre feet, the average shortfall is 15 acre feet. (This note is important when it seems

as though average shortfalls should decrease; they may not for instance when reliability increases due to fewer months of shortfalls being averaged)

- All the following scenarios assume purveyor contracts in place as of January 2005. These also incorporate each purveyor's drought plan including drought indicators and triggers (i.e. EID's Sly Park monthly volume matrix).

Source: *El Dorado County Western Slope Drought Analysis - Phase I Report and February 5, 2007 SVM*.

CLIMATE CHANGE FACTORS

Projections of future climate change are represented by changes in seasonal river flow patterns. This assumes lessening amounts of water stored in snow pack, reductions in average annual precipitation amounts, and an increase in the extent and frequency of drought. In order to incorporate the potential for climate change, various climate scenario factors were applied to each purveyor's actual hydrological record as well as the design drought scenario, base 1976, 1977, 1977 (repeated) hydrology. These factors shown in Tables **10-1**, **10-2**, **10-3**, and **10-4** represent the relationship between actual hydrology and four types of shifts in projected hydrologic runoff conditions. These shifts are based on regionally derived scenarios developed by Dr. Jay Lund and his research analysis team at UC Davis. These are the same data sets used in the forecasting tools for the Department of Water Resources, Bulletin 160: California Water Plan and the California Energy Commission Climate Change Report (Vicuna, 2005). Dr. Lund's information for American River watershed inflows to Folsom Lake under four different scenarios was used to index the runoff hydrology and reflect the possible impact due to climate change. The four scenarios consist of (1) HCM 2050 Scenario, a warmer and wetter climate in year 2050, (2) PCM 2050 Scenario, a cooler and drier climate by year 2050, (3) HCM 2100 Scenario, a warmer and wetter climate by year 2100, and (4) PCM 2100 Scenario, a cooler and drier climate year 2100. PCM 2100 Scenario represents the potential "worst case" climate change scenario for drought. Additional information on how these climate change scenarios were created is provided in the Appendix E of the April 2006 *El Dorado County Western Slope Drought Analysis - Phase I Report*.

SVM MODELED SCENARIOS (AS OF JANUARY 31, 2007)

Current Conditions (Default Conditions)

This scenario consists of:

- 2004 demands;
- Contracts (*including current water shortage contingency policies*) in place as of January 2005;
- Operating rules for surface supplies as defined for 2005; and
- Historical hydrologic record conditions (no climate change).

TABLE 10-1
CURRENT CONDITIONS (DEFAULT CONDITIONS)

	Historical record		**Design drought**	
	Reliability	**Average Shortfall (AF/mo)**	**Reliability**	**Average Shortfall (AF/mo)**
GDPUD	100%	0	100%	0
GFCSD	98.12%	4	82.25%	9
EID	99.74%	113	100%	0

2030 without Action

This scenario consists of:

- Projected 2030 demands;
- Contracts (*including water shortage contingency policies*) in place as of January 2005;
- Operating rules for surface supplies as defined for 2005; and
- Historical hydrologic record conditions (no climate change).

TABLE 10-2
2030 WITHOUT ACTION

	Historical record		**Design drought**	
	Reliability	**Average Shortfall (AF/mo)**	**Reliability**	**Average Shortfall (AF/mo)**
GDPUD	80%	1,970	64%	1,258
GFCSD	90.72%	14	80.55%	11
EID	95.01%	791	80%	2,368

2030 With Action

This scenario consists of:

- Projected 2030 demands;
- Contracts (*including water shortage contingency policies*) in place as of January 2005;
- Operating rules for surface supplies as defined for 2005;
- Historical hydrologic record conditions (no climate change); and
- Modeled water efficiency projects planned to reduce water demands. Water efficiency projects refer to water conservation and water loss reduction measures for EID; using their existing well for GFCSD; and water conservation for GDPUD.

2030 WITH ACTION

	Historical record		Design drought	
	Reliability	**Average Shortfall (AF/mo)**	**Reliability**	**Average Shortfall (AF/mo)**
GDPUD	81%	1,858	67%	1,266
GFCSD	91.53%	14	80.55%	11
EID	95.82%	756	83%	2,032

2030 with Action and Climate Change

This scenario consists of:

- Projected 2030 demands;
- Contracts (*including water shortage contingency policies*) currently in place as of January 2005;
- Operating rules for surface supplies as defined for 2005;
- Modeled water efficiency projects planned to reduce water demands. Water efficiency projects refer to water conservation and water loss reduction measures for EID; using their existing well for GFCSD; and water conservation for GDPUD; and
- Worst case cooler and drier "Climate Scenario - PCM 2100" hydrologic conditions enacted.

2030 WITH ACTION AND CLIMATE CHANGE

	Historical record		Design drought	
	Reliability	**Average Shortfall (AF/mo)**	**Reliability**	**Average Shortfall (AF/mo)**
GDPUD	66%	1,928	58%	987*
GFCSD	86.14%	14	68.63%	10*
EID	95%	742*	78%	2,355

* Average shortfall values decrease with climate change due to a longer more moderate drought duration (additional months with more moderate shortfall amounts are being averaged). For example for GDPUD's future with action scenario under design drought conditions, the average drought duration was 6.5 months. The average duration extended to 9.5 months with the cooler and drier PCM 2100 climate change conditions.

By 2030 under the cooler and drier PCM2100 climate scenario water supplies will be reduced by 11% for EID, 19% for GFCSD, and 28% for GDPUD.

10.5.5 SUMMARY OF THE DROUGHT EFFECTS ON CLIMATE CHANGE

Independent of climate change, the SVM derived tables presented previously demonstrate that demand cutbacks (as adopted in each purveyors water shortage contingency plans) and conservation efforts alone will not decrease drought shortfall magnitudes. A few examples of the effects of enacted drought mitigation measures under projected 2030 demands are summarized below.

- EID can ALMOST completely mitigate projected 2030 shortfalls under design drought conditions and historical hydrological flow patterns with Scenario C action summarized above and (1) PL101-514 and the White Rock Diversion Project (92% reliability in a design drought), or (2) PL101-514, groundwater banking and Alder Creek Reservoir (94% reliability in the design drought).

- GDPUD can expect shortfalls about 5% of the time, with a drought being called and policies enacted almost 50% of time under Scenario C actions and Rubicon River 1B UARP PL101-514 enacted in design drought conditions.

- GFCSD can ALMOST completely mitigate design drought conditions (97.8% reliability) with the use of a 350 AF off-stream storage reservoir that is half full at the beginning of the drought. Under historical record-based conditions and the use of an off-stream reservoir the system reliability is 99.7%.