Overcoming Multi-Bind:

An Analysis of Water Supply Factors impacting the San Joaquin Valley in the State of California

(Continuity of Policies Applied to Critical Issues: Stock and Flow of Principles)

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Abstract

The intent of the study is to analyze intersecting systems which impact the supply and demand of water in the San Joaquin Valley of California. The systems germane to this effort include but are not limited to: geological, hydrological, meteorological, anthropological and political. Each system has been assessed to determine the eventual, net-effect on the supply of water. The intent was not to provide an exhaustive discussion of each discipline but to show how it affects the outcomes of water requirements and availability. The resultant policies implemented to control these various aspects of water were identified and determined to either adequately or inadequately provide solutions to issues formed from the negative impacts of the various systems.

This paper will begin to fill a void of scholarly data attempting to identify common and discreet issues within the body of water related policies. Conclusions should be considered by the various government agencies engaging in the processes of defining water-related management policies and contingency plans.

Introduction

The continuing water crisis in the state of California and in the Southwest of the United States is a symptom of an issue which is proving to have a much broader impact. As the human population has increased over the millennia, the growing scarcity of water has caused water shortage to become an urgent problem throughout the world (Kummu, et al, 2010). The recent drought in the Southwest of the USA brings home this reality that water shortage is no longer confined to the developing nations of the world. Studies by climate scientists indicate that, with the climate change now leaning heavily toward global warming, this drought may last for decades and even grow to a global disaster. Human ingenuity must be harnessed to devise and enable sustainable yet agile solutions.

The vision of this research has been to observe the past and present of five major systems which impact water in general but specifically the supply, distribution and demand. These separate systems act apart and interact as a whole whether in concert of as a cacophonous din.

When two factors present as conflicting priorities and requirements completing for attention there is a circumstance which confronts with a pair of undesirable actions; the proverbial no-win situation, also known as a double bind. In any paradigm as complex as water on a planet is, there is much more than a double bind; there is a multi-bind. Though there are other factors that have to do with water, with this paper the intent is only to look at five major factors. As the past and present context is considered the potential future is presumed.

The History

A. Geological

If one were to use a single word to describe the history of the San Joaquin Valley it would be best to call it tumultuous. Up until the Late Cretaceous–early Cenozoic period there was no such valley or the mountain ranges which now surround it (Henry, 2009). The valley originally formed as a Forearc basin as a result of tectonic interaction of the Pacific and North American plates. At the time the major fault consisted of the Pacific plate in subduction under the North American plate. This resulted in a wrinkling or buckling effect creating the various mountain ranges running north to south; those of this focus are the Sierra Nevada and the Coastal Range. The main interceding valley between these ranges being the San Joaquin. All this occurred well into the disassociation of Pangea, the super continent. Historical certainty would be virtually impossible for the preceding 4 billion plus years that followed the genesis of our planet.

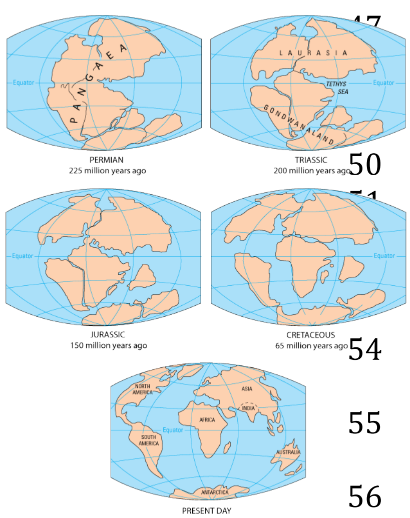

Figure 1 - Pangea, Gondwanaland, Laurasia and Tethys

Pangea, Gondwanaland, Laurasia and Tethys [Online image]. (2007-2008) Retrieved April 27, 2016 from http://earthguide.ucsd.edu/eoc/teachers/t_tectonics/p_pangaea2.html

The continuing movement of tectonic plates has affected the configuration of the state of California as it certainly has the whole of the earth. But the California Coastal range has seen the bulk of the local adjustments as a result of the various faults. The all too well known San Andreas has impacted the western border of the San Joaquin Valley as a result of its many temblors. Of minimal affect has been the Harlock Fault which intersects with the San Andreas in the Antelope Valley at the western most region of the Mojave Desert. This fault forms the Tehachapi Mountains, which border the southern extreme of the San Joaquin Valley.

Most of the major geological development of the San Joaquin predates the arrival of human inhabitants. The geological configuration was, at that time, essentially what it is today. The major changes have been the relative height of the land; at some locations this value has increased by as much as 4 meters in the last 1000 years. Much of this of late has been determined to be a result of subsidence due to ground water over use.

The graphic shows what was determined to be the location of the maximum subsidence in the United States identified by Joseph Poland of the United States Geological Survey. The subsidence from 1925 to 1977 alone was measured at 28 feet (Galloway, Jones & Ingebritsen 2000, p. 23).

Figure 2 - Subsidence in the San Joaquin (Galloway, Jones & Ingebritsen 2000, p. 23)

Humanity has built bridges over chasms, tunnels under the sea and hung communication devices above the sky, but in no way have we scratched the surface of what the forces of nature might unleash in the geological realm.

The indication from the historical geological evidence is that there are potential issues that could occur which either would provide a near panacea for water issues if subterranean reservoirs were then to be exposed or the pariah if the geological structure were to then impede the resourcing and delivery of water to the various points of use.

B. Meteorological

Climate has ever been a major factor in the struggles of humanity. It is estimated that we have lived through as many as nine glacial episodes in the preceding seven hundred millennia (Fagan, according to Ingram & Malamud-Roam, 2013). Between these glacial ages were periods simply known as interglacial (Ingram & Malamud-Roam, 2013, p.68).

The climate of the San Joaquin Valley has generally followed the global system of a dynamic paradigm; particularly that of North America and northern Europe. When the North American continent was covered with a sheet of ice so was what would become the San Joaquin Valley. As the North American climate warmed and the ice sheet melted much of what is now the United States of America became a lush tropical environment.

The latest thawing of a glacial period was about twenty thousand years ago. At the peak of that glacial cycle (known as the Glacial Maximum) a sheet of ice as much as two miles thick covered North America and northern Europe.

Analyses of various factors indicate that, since the end of the latest ice age, a trend of fluctuation between periods of significant precipitation and prolonged droughts. Tree ring analyses provided evidence of yearly states of climate and the trends show variations with wide differences in periodicity; over the period from the late sixteenth to

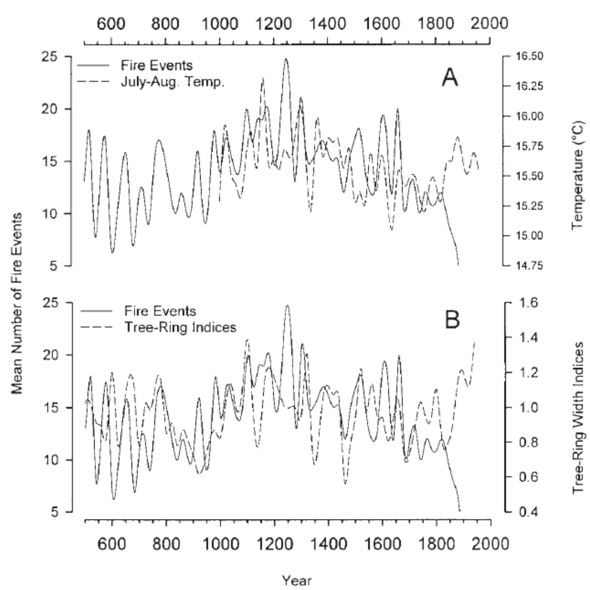

Figure 3 - Tree Ring Data Graph (Veblen, et al, 2013).

mid twentieth century BCE, droughts ranged from ten to sixty years (Veblen, et al, 2013). It can be seen in the rings where lower growth or the scars from a fire specifies an episode of drought.

As with the geological system that of the meteorological is difficult to assess with respect to the future. The exact cause(s) of the glacial periods and inter glacial periods cannot be absolutely identified. The basic principles at work which are component to these cyclic phenomena can be specified and measured; with these at present and the records of past changes templates have been developed with model the climate fluctuations. Thus, an estimation of future climatic events can be approximated. However, application of these models has not always been accurate enough to establish affirmative action for consequent issues; whether to deal with a prolonged drought or to collect and store excess run off in phases of greater moisture (Spada, et al, 2013).

C. Hydrological

As the San Joaquin Valley began to form the surrounding mountain ranges emptied their run-off therein eventually creating a lake. As with many such land formations the historical paradigm of a body of water developing, whether as a result of melting glaciers and simple mountain runoff, eventually leads to a marsh, meadow then forest. This process is as a result of the aging terrain and continued decrease in water shed as the ice sheet and glacial impact recedes.

At about the time that Europeans began to explore what is now the western United States, the San Joaquin Valley was essentially a series of lakes, swamps and bogs dissected by numerous rivers (Hundley, 2001, p.5).

The run-off from the Sierra Nevada and coastal ranges maintained the valley in a state very much a lake. During periods of drought the level subsided; in particularly long drought phases the valley would reach a condition which is essentially the same as is seen today, where the ground level experienced subsidence to an extreme degree.

The intersecting outcomes of the geological and meteorological systems provide the factors which generate the hydrological product. The basic character of these systems included an unreliable nature. Thus the course or flow of a river cannot be assumed to be available ad infinitum. Nor can it be expected that lakes or aquifers will ever be full.

D. Anthropological

The first human inhabitants of the San Joaquin Valley are believed to have arrived around 11,200 BCE. It is assumed that these pioneers came from the south since at the time the glaciers and snow of the Cascade and Sierra Nevada mount ranges would have made it impossible to come into the valley from the north (Fagan, 2004, p.3). These early inhabitants may have been members of the seafaring adventurers who first landed on the transverse coast of California; what is now Santa Barbara County. These were most likely of the Coastal Miwok tribe (Fagan, 2004, p.134). Up until the arrival of the Europeans the inhabitants of the San Joaquin Valley engaged mainly in hunting, fishing and foraging for fruits, nuts and other fodder that could be found growing in the wild. Eventually the concept of agriculture was discovered and implemented on a small scale at various small sub-tribal locations.

The various tribal units initially had little cause for hostility toward one another due to the ample supply of natural resource. As the environment began to grow more arid and the resulting decrease in resources, inter-tribal hostilities arose (Fagan, 2004, p.32). As the European invaders began to dominate the land, as well as the indigenous peoples, the strain on the natural resources began to engender strife; erupting into hostile disputes both between the various tribes and the European occupiers.

In the end the Europeans either forced the native population to migration to less desirable climes or into slavery (Johnston-Dodds, 2009, p.17). The eventual over utilization of the San Joaquin Valley in the most recent five hundred years has contributed to the extreme impact of the current drought.

E. Political

Since the conquest by Europeans of the Americas the administration of natural resources has become an issue. With the influx of Europeans intent upon building new lives in what was assumed to be a frontier, the land and it many natural resources, were taxed at a level never before seen by the indigenous population. Consequently efforts by the invaders were taken to control the natural bounty for themselves while limiting access to the local tribes.

The forced conversion by the indigenous tribes by the Spanish conquistadores associated priests subjected them to the rule of the Church. The royal land grants to wealthy or well connected Spanish immigrants gave the grant holder carte blanche in the use of natural resources on their property without regard for the needs of the tribes. Essentially the tribes were conquered and then subjected to all but slave labor. As grand and storied as the California missions are it cannot be forgotten that they were built by the blood, sweat and tears of a subjugated people (Haas, 1995).

Today the efforts to control water usage have seen limited success. After five years of drought a declared state of emergency has required the reduction of residential and business water use by at least twenty five percent. Failure to meet the standard incurs fines. In response the average decreased use has been over forty percent. Though this reduction is commendable it is questionable whether it will have any real effect on issues of water. Other than mandated usage reductions the political efforts have been focused on apportioning what little water is available (Thompson, 1993, p.)

II. The Systems

A. Geological

The geological system of planet earth consists of a stock and flow of matter and its mass which is evident in the discharge and exchange of energy seen in seismic movement and volcanic action. This system, though its impact on humanity, and the other inhabitants of the planet, is generally slow and subtle, it is nonetheless significant and on occasion catastrophic (Meadows & Wright, 2008).

Over the many millennia tectonic displacement has had the most affect on the planet in general and humanity in particular. The evolving attitude of tectonic plates has defined a dynamic trajectory of the many systems of watershed. Both surface and subsurface bodies of water are impacted by adjustments in the tectonic paradigm.

The geological system has been evolving for the last four billion years and can be expected to continue this process. The action of the evolving geological system has, and will continue, to define the boundaries of courses of watershed and bodies of water. Seismic activity can impact the flow of subsurface water sources. Pressure exerted on an aquifer might increase the volumetric flow rate for discreet springs and eventually causing water courses to change proportionally (Johnson, 2016).

In aggregate, the geological system, though its consequent functions are significant, would appear to have settled into a relative state of stationarity. Without cataclysmic geological system adjustments on a biblically epic level, the probability of momentous net results is not likely.

B. Meteorological

The Meteorological system of planet earth consists of a stock and flow of gasses, liquids and suspended particulate which resides in the atmosphere. Unlike that of the geological system this system’s impact on humanity, and the other inhabitants of the planet, is generally sudden and fickle, it is absolutely significant and on occasion catastrophic. This fickle nature makes the purveyors of meteorological prognostication the common butt of jokes about the weather. Yet this is the nature of climate in general and weather in particular. What the weather might have been in the past may assist in the estimation of what it could be in the future but it cannot be perfectly accurate. Still, there are marked variations in the patterns of the meteorological systems. The most drastic, yet long and drawn out, process of change can be seen in the transition from a glacial epoch to an inter-glacial period (Kleman et al, 2013, p. 2375)

The character of climate/meteorological system has been very much a victim of the intersecting systems. Even during a time about fifty three million years ago (the Early Eocene Climatic Optimum) was not invulnerable to the effects of green house gasses (Allegre, et al, 2005, p. 9). At that time the levels of carbon dioxide increased significantly as a result of methane released from vents in the ocean floor. Consequently average global temperatures increased to as much as 4.6 degrees above that of the present day.

C. Hydrological

The hydrological system of the planet consists of the stock and flow of water in any of the three phases, liquid, solid and gas. There is also a possibility for a fourth phase of water known as plasma. However, the presence of water in this state is rare (Abascal & Vega 2005).

The behavior of the hydrological system, as with that of geological and meteorological systems, is in a constant state of change. That is, it is never actually stable. Lakes may suddenly or slowly drain, rivers overrun their banks or run dry and subterranean aquifers dissipate. An astounding case in point is a resent discovery which came to light; that during many humid episodes in the late Quaternary there was a large river system running through the Western Sahara (Skonieczny, et al, 2015). Conversely, evidence shows that there were once rivers running where the oceans now meet the various continents; in particular the sediments and underwater geological terrain on the continental shelf of the pacific coast of California, there are clearly water courses and even waterfalls.

As each glacial period builds up the glaciers and ice sheets it is siphoning the water from every source via evaporation. The oceans obviously being the main source would sink to some four hundred feet below the current “sea level”. As the planet entered interglacial periods the ice sheets and glaciers melt and cause lakes to fill low lying areas and rivers where a difference in potential energy is present due to decreasing land elevation.

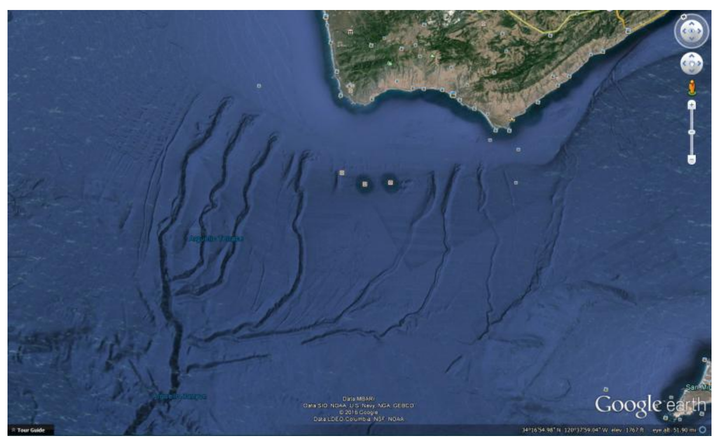

Figure 4 Water Courses - Point Conception, California (Google Earth)

D. Anthropological

Humanity has ever congregated, if for no other reason than, at least for mutual survival. These groupings at the foundation were simple organizational systems in the vein of the natural system model.

The basic unit of division was and tends to still be what has come to be known as the nuclear family. The grouping might take on many different forms throughout the ages and in different locations as they form and reform to meet the needs of each discreet set of challenges. As any unit grows the need to acquire resources consequently increases. In addition individuals would develop new skills and tools to deal with the evolving needs within a particular unit.

The utilization of natural resources would have become an issue as the unit of social division began to strain the supply. The most rudimentary purposes for water use being ingestion and cleaning.

As a system anthropological stock might be considered anything from raw population count to some measure of production. For the purpose of this study humanity would be a negative factor of flow in the equation of water issues. A higher population count would produce a greater demand on the water source(s) and thus a decreased over all water stock (Fagan, 2004, p.144).

E. Political

As the human social units grow it becomes apparent that there must be defined standards of behavior. Such standards would eventually be developed in application to natural resources. This would at least come about when it became evident that availability of those resources was beginning to decrease.

As the population of California increased and the dependency of much of the nation upon the bounty of the San Joaquin valley, the formerly plentiful supply of water from the various immediate sources has been depleted while the root sources have not kept up with the increased flow. Political elements in the San Joaquin valley, as well as those of the state of California at large, have attempted to reconcile this continuing deficit mainly by limiting water use for various purposes; specifically, personal/residential and industrial/agricultural.

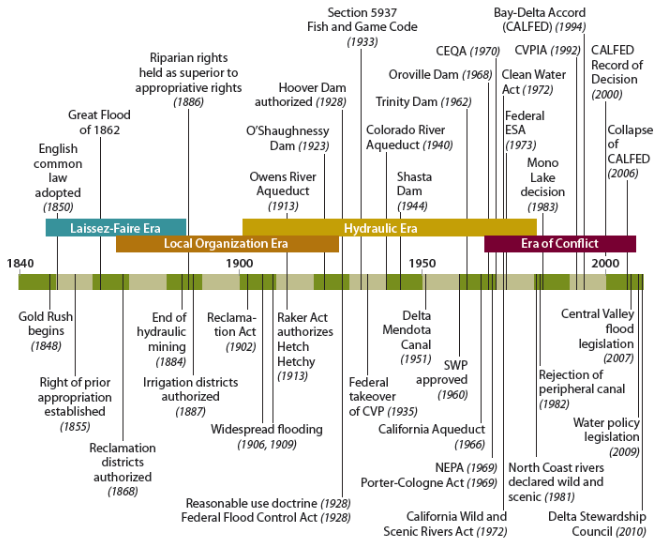

Figure 5 - Chronology of California Water Laws (Hanak et al 2011)

The earliest policies were directed at the indigenous tribal units. These prevented the tribes from living as they had for many generations. As with many other policies enacted at the federal level, these policies had the net effect of disenfranchising the tribes of their ancestral homelands; water being one of its many. The injustice brought upon the tribes essentially stole the land and its resources from them and gave it to the conquering European invaders (Johnston-Dodds, 2009).

Later policies began to address the occasional water supply issues brought on by droughts and over-use (Thompson, 1993, p. 674). Up to and including the 1960s saw a policy which was seen as a political-engineering approach; where ever there was a need for additional water supply the Federal government would build another water project (dam/reservoir, aquaduct, etc). These methods unfortunately lead to a significant level of environmental damage in addition to being economically costly. Since the 1970s, however the paradigm employed has been market based. This has been operated as if it were not but another capitalist venture. I was assumed that as demands grew that “the market” would grow and provide the need.

III. **The Potential** (future?)

A. Geological

The roots of the present are buried deep in the past (Stubbs as cited by Hutton, 1906). These realities portent a potential for a cataclysmic intersection of systems in nature upon which humanity has little if any impact, much less has control over. Even a slight shift in the tectonic pattern can alter meteorological and hydrological systems (Johnson, 2014). The process of hydraulic fracturing in the petroleum industry might be a consideration for application to extracting ground water. However, the concern would be for the sustainability as well as the potential for damage to the environment.

B. Meteorological

In locations where hurricanes are an annual worry, many families will have a small gasoline powered generator they keep for those occasions when the latest cyclonic episode leaves their home in a state not unlike that of one in nineteenth century South Eastern United States. Anticipatory preparation at any organizational level can provide a welcome respite from the impact of known hazards, whether an evacuation plan that reverses the flow of traffic on an interstate freeway to double the speed of egress.

Since the temper of the climate cannot be absolutely anticipated much less tamed it is unlikely that any reactionary effort will suffice to harness significant precipitation and store it for future use. Generally such efforts consist of damming rivers at points to create a lake or reservoir. This method has been in use for most of the last three millennia. Even those longest in operation can be seen to have had destructive results if nothing more than the elimination of habitat leaving innumerable species to move, adapt or go extinct.

C. Hydrological

Diverting the natural flow of water via human made ditches, gutters and aqueducts has been a method for controlling the flow and collection of water at least since the second millennia BCE. Simple analysis of water sources and demand should dictate the design of systems to collect and deliver water in such a manner as to minimize environmental impact. In addition it is only logical that the source be deemed sustainable or that the effort and resources expended to affect the water delivery be reasonably considered so as to ensure that a legacy operation not have wasted time and resources only to have the root source be exhausted.

The lessons learned from previous efforts must be a major factor in the equation which is employed to determine any course of action or expenditure of funds. The numerous dams now being dismantled are classic examples of discouraging failures. A favorite case in point is the Matilija dam near the Ojai Valley of California. Intended to provide water to the residents of the valley as well as minimize the impact of flooding into the Ventura river water shed, the lake that formed at the completion of the dame quickly silted to the point where there was barely four feet of water on top of the lake of mud. Not only has it never provided a drop of water to the intended customers, it has also caused a minor ecological disaster in that the silts that at one time ran down the Ventura river, providing stability to the beaches at the river's mouth, are now trapped behind the dam. Thus, the beaches, which were once the pride of Ventura (and a favorite of surfers) does not exist. It is now mostly gone, eroded away by the Pacific waves.

D. Anthropological

The people of the San Joaquin Valley are mainly involved with the industry of agriculture. These approximately 4 million people stand apart from most of the rest of the state in that the industries and occupations of the rest are more diverse. Thus, a dependency upon water for ones livelihood is not a primary consideration for the other 36 million people.

Unfortunately there has been a sense of "us and them" with the allocation of water resources, such that those in urban and suburban areas feel enmity toward the agriculture industry. When Governor Brown recently called for a reduction in water usage there were groups of residential customers who complained that the cuts did not impact the industrial use. The truth is that the order for reduced use did impact agriculture to the extent that many acres of crop lands which were once fruitful, now lie fallow and in many cases farmers have had to destroy withering trees of various types.

E. Political

The current drought, in its fifth year has driven the state to enlist local authorities to reach out to each other and plan to work in concert to preserve what little water resources that are available (SJVWIA, 2015). Still the thrust of policy effort is directed at usage; that is, the flow out of the overall water system is addressed but virtually no effort is made to identify and implement alternative water sources.

Conclusions and recommendations

The factors impacting sources of water and those which impact usage can be seen as various sub-systems of a singular system. And as each sub-system is altered, its impact on water supply and demand changes, whether to increase or decrease. Although there are certainly other factors which impact water availability and/or quality, these five (geological, meteorological, hydrological, anthropological and political) would seem to have the greatest impact. Others such as industrial and agricultural effluent, which impact availability and quality, are understood but have not been addressed specifically here due to their being a component of the anthropological system.

The evidence extant from the geological record is replete with details of our planet's history. This historical account proves beyond doubt that the planet has undergone significant change in the last four and a half billion years since it was slung off of its star, our sun (Allegre, et al, 2005). Most of that time was spend in a geological state similar to what it is now. The earth's crust had formed and was broken into the various tectonic plates; water was evident in subsurface aquifers and surface bodies ranging in size from small ponds to oceanic expanses covering much of the tectonic plates after about one hundred million years.

The meteorological condition of the planet has varied as it has (and is varying) in the current epoch but with the one significant difference being in the duration of the extremes. The coldest periods entailed episodes where precipitation was of biblical proportions and to the extent that as the temperatures plunged below the freezing point the planet was in a perpetual winter with sheets of ice developing, mostly at the North and South poles. The thickness of these sheets rival that of our current southern pole. During this period, in the northern hemisphere, an ice sheet extended over much of North America and Europe. These ages, commonly known interchangeably as "ice ages" or "glacial periods" were punctuated by relatively short epochs of warming trends known as "inter-glacial periods"; our current age is the latest of these following a glacial epoch which came to an end approximately twenty thousand years ago.

The hydrological condition of the area in question, has quickly reached a state of severe drought as a result of the aforementioned factors combined with the excessive water use by humanity. In only the last five hundred years there have been numerous periods of drought ranging in duration from 10 to 60 years (Veblen, et al, 2013). The only difference between those situations and that of our current state is that the population, and therefore demands on the natural hydrological systems, is many times greater. The estimated population of the Americas north of the Rio Grande, in pre-Columian time (<C.E. 1492), range from 900 thousand to 1.15 million. If one estimates a population of what is now California as approximately 12% of the total (based on California Population of 39,144,818 from 2015 census and a US population of 321,368,864 July 2015 estimate from CIA World Fact Book) the population of California would have been between approximately 110 and 140 thousand. This number would have placed a much lighter load on the water sources than the nearly 40 million of today. Thus the impact would have been minimal at worst (Lord, 1997, p. 69).

As previously mentioned, the values from the various sources indicated that the population of California, and therefore that of the San Joaquin Valley, has drastically altered the outcomes of the combined intersection of these separate systems which impact water supply and demand (Lord, 1997, p. 69). Thus the anthropological system has over the ages impacted the water context with a net negative value. Yet it is not mainly the population in the valley which are overtaxing the water supply, it is also the agricultural industry (DWR, 2008).

An intersection of the geological and meteorological systems of the planet can be seen in the formation of ruptures in the tectonic plates as well as the seams between them (Johnson, 2014). This volcanism causes changes in the climate locally and as in the case of the most powerful eruptions, global years long winters. These mini-glacial periods can have the effect of producing significant amounts of runoff from the additional snow fall and glaciations which replenishes the depleting aquifers. The expectation of these occurring at any time soon or in measure to offset the current drought condition, though possible, are so improbable as to be considered little more than childish and wistful dreams.

Since the planet has been operating in this manner for most of it existence it is probable that it will generally continue to behave this way. Thus, the fact that the glacial ice sheets of North America would melt during a period like the current, flooding the planes, and valley, carving river courses and canyons as the water finds its way to the sea or a landlocked body of water, then that is what most likely will happen in the future. The thinking that our observations from the records of the last few millennium can be trusted to predict the future is to assume that this brief moment in the history of the universe (Hawking, 1988), of perhaps ten thousand years, will remain in a stated of stationarity; that the cycles will always continue in the patterns which have been measured by humanity. Sadly, the larger view of our history tells us that stationarity is dead, or never really lived (Betancourt, et al, 2008).

Since there is little chance that humanity will be able to affect any changes on the major systems of the geological, meteorological or hydrological to produce more fresh water, it is incumbent upon leadership, in addition to the reduced usage, to move toward alternative sources and methods of providing fresh water for the planet. In this way the other two systems in question, anthropological and political, might devise a way forward that could provide for the needs of humanity as well as the rest of the planets flora and fauna.

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