WATER IN THE GREAT BASIN

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ABSTRACT

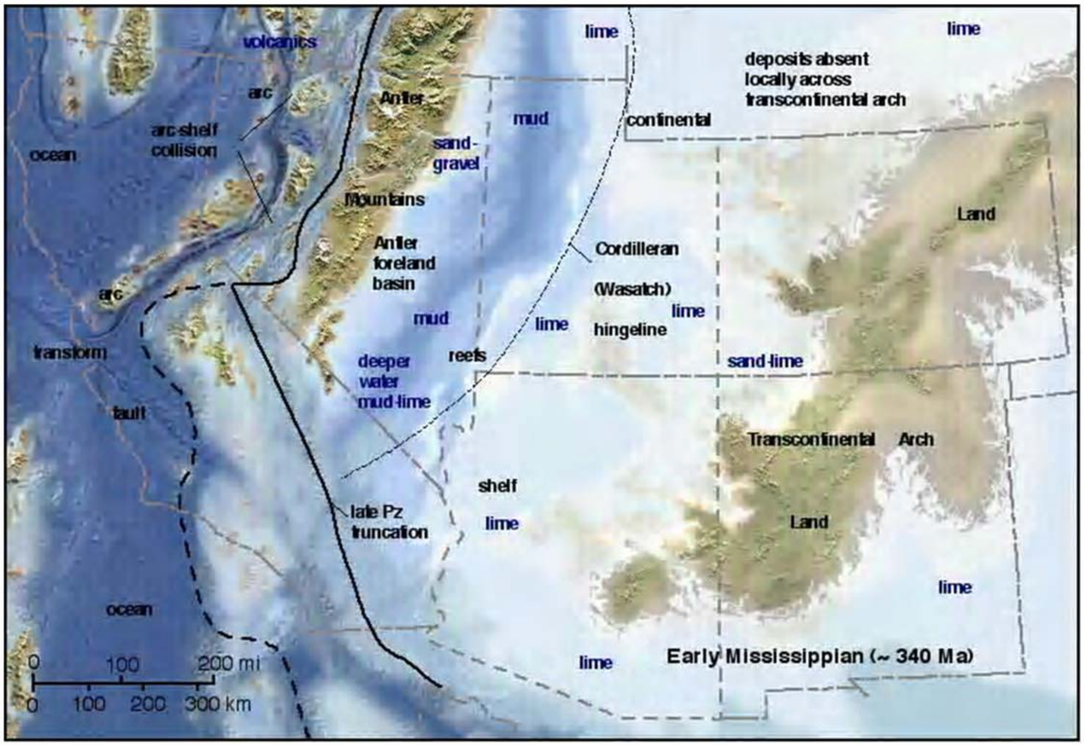
Throughout history, water has played a pivotal part in the formation of many geological regions. The Great Basin is no exception. This paper discusses briefly the roles water has played in its formation and how water is present there today. The paper then continues on to discuss the role human interaction has played with the Great Basin region's water resources. In the past two centuries the human population in the Great Basin and the United States Southwest in general has exploded to levels the region had never dreamt of seeing. As the population has grown, so has the demand for water. Only in the past half century or so have the possible environmental effects of the harvesting of the area's water to support the human population began to be considered at all, and also researched. The cities of Las Vegas and Los Angeles provide two interesting examples showing how water needs can exceed the area's natural water resources, the potential harmful effects of importing water from another area, and how humans begin to look for alternatives once these detrimental effects are realized.

FORMATION

ANCIENT SEAS

Long before the Great Basin or any of the mountains that surround it had formed, the western edge of the United States sat underneath an ocean. As the North American plate moved westward, it slowly accumulated sediments off the ocean floor and pieces of continental crust from other smaller plates called *terranes* that increased its size. Around three hundred-forty million years ago a terrane called the Antler Arc collided with the North American plate's continental crust and created mountains near where the Great Basin would someday in the distant future stand. (Blakey, 2006) This Antler Orogeny's range was eventually brought down by erosion and tectonics and the sea returned. It was not until around two hundred million years ago that land again rose above the waves.

The waters left their geological footprint upon the west. Over the hundreds of millions of years sediments and decaying organisms piled up on the ocean floor. As the layers thickened, pressure on the lower sediments, along with certain chemicals in the seawater, would metamorphose them into rock. Along with any igneous materials resulting from the subduction



Antler Orogeny (Blakey)

zone this layer of sedimentary rock is now estimated to be around thirteen miles thick (Hill, 2006). In the mountains of the Basin and Range region, most older rocks are these sedimentary rocks—sandstone, limestone, and shale—or some altered form of them.

ICE THE SCULPTOR

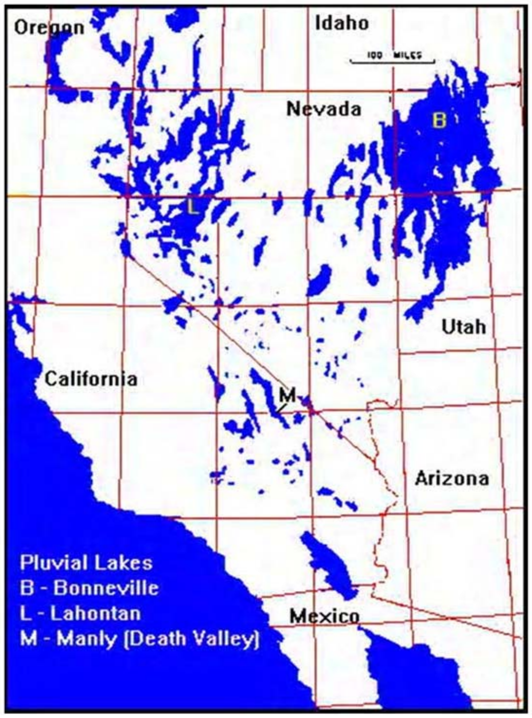
As much as water has the power to form the sedimentary rocks that make up a significant portion of the mountains of the western United States, so it has the power to cut these mountains down. Water erosion is a very noteworthy force, but for now the focus is on ice. Rivers of ice may seem to be a contradictory term, but glaciers do indeed flow, if slowly. As they crawl along, their immense weight and pressure lets the glaciers carve away the stone around them.

There have been many ice ages throughout time; the most recent one peaked around eighteen thousand years ago. Ice sheets reached down from the poles to almost as far south as the Ohio River in the Midwest (http://en.wikipedia.org/wiki/Wisconsinian_Glaciation, 2008). Much of the Sierra Nevada was covered in its own glaciers, scraping out the u-shaped valleys with hanging waterfalls and all the other features typical of glaciation, forever changing the face of the west.

PLUVIAL LAKES

When the ice receded around ten thousand years ago it left behind more than just the scars it etched into the rock. In cirques, basins, and other general low points large amounts of water sat as another testament to the enormity of the glaciers. These *pluvial lakes* filled many basins within the great basin, including Death Valley, with giant lakes. To put the amount of water in perspective, Lake Bonneville was around three hundred meters deep at its crest and covered hundreds of miles (Dutch, 1999). Over time the climate changed for the drier and these glacial lakes disappeared.

Pluvial Lakes of the Great Basin Region (Dutch)



Pluvial Lakes (Dutch, 1999)

THE GREAT BASIN WATERSHED

"The Great Basin is not a single basin, but rather a series of contiguous watersheds" (http://en.wikipedia.org/wiki/Great_Basin, 2008). It is a grouping of watersheds sitting within the Basin and Range province that all share one thing: precipitation that falls inside their boundaries does not drain to the ocean. The mountainous topography of the region creates barriers to water flow to either the Pacific or the Gulf of Mexico while the generally low amounts of precipitation received allow most water to either evaporate or sink into the groundwater. This makes the Great Basin what is called an *interior drainage*.

The Great Basin (USDA FS)

These interior drainage systems create unique bodies of water called *saline lakes*. At the end of an individual watershed there is either a saline lake or salt flats. If precipitation in the area is higher than the evaporation potential, meaning more precipitation falls than evaporates, there will be a lake. Since there are no outlets from these lakes, as water evaporates it leaves behind the minerals it was holding. Over time these minerals, of which salt is almost inevitably one, collect in the lake, making it saline. Salt flats gain their minerals in the same process, but more water evaporates than falls, so no lake is present. As pluvial lakes in the Great Basin slowly dried up and disappeared, they left enormous volumes of minerals behind. Lake Bonneville left behind the famous Bonneville Salt Flats and the Great Salt Lake, Lake Manly dried to create Badwater Salt Flats in Death Valley (Dutch 1999), and numerous other flats and saline lakes mark where the ancient glacial lakes once stood.

GENERAL CLIMATE AND ECOSYSTEMS

The Great Basin region is fairly arid, with a very large portion of it classified as a desert. The technical definition of a desert is an area that receives less than 250 mm (10 in) of precipitation annually. This is due in large part to the rain shadow effect of mountain ranges in between the Great Basin and the Pacific Ocean. Most of the precipitation the Great Basin does receive falls as snow on the mountains in winter, while summer thunderstorms typically make up the rest. Because of the large amount of topographical relief in Basin and Range type areas a fairly wide variety of flora and fauna are supported. In some of the more arid regions wildlife and vegetation is much scarcer. In these regions when rain does come, it creates violent flash floods as the soil cannot absorb much water. These short bursts of precipitation work on the landscape with strong erosive forces, creating slot canyons, washes, and similar forms.

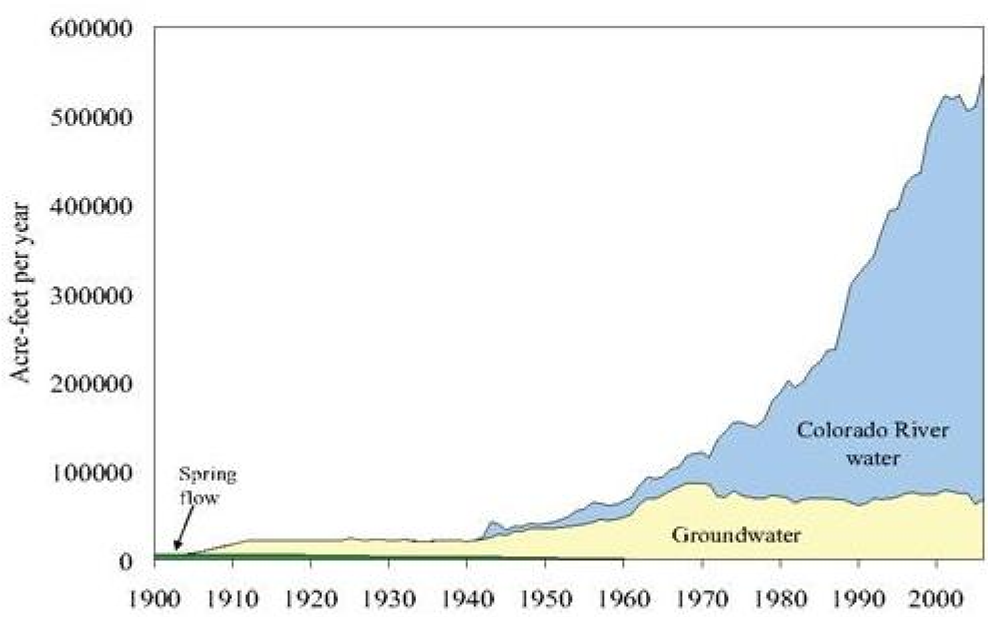
Groundwater in the Great Basin varies in its availability. USGS surveyors tracking groundwater depths in various places in Nevada found depths of up to almost nine hundred feet and down to around four. Even two measurements within the same county, White Pine, showed four hundred feet of difference. Faults due to continental extension provide methods for deep seated groundwater to reach the surface in places, creating springs or oases in the typical north-south orientation.

THE HUMAN FACTOR

LAS VEGAS

Founded in 1911, Las Vegas had been a stopover for traders going through the region for water. Las Vegas is Spanish for “fertile meadows,” and the area was covered in them. Shallow aquifers and wells brought groundwater to the surface that supported the vegetation. By the advent of World War Two, twenty thousand acre feet of water were being pumped out of the aquifers each year. At this point the water table began to drop; water was being mined faster than it could be replenished. A pipeline was constructed that diverted some water from Lake Mead to the city, but groundwater was still the primary source. Larger projects diverting water continued to be created, but the population of Las Vegas was rocketing upward at unpredicted levels. By the last quarter of the century, water usage was at critical levels, and the city continued to grow. At this point conservation became a necessity, finding other options for bringing in water was no longer adequate. In 1991 the Southern Nevada Water Authority (SNWA) was founded and began initiatives for conserving water. Now Las Vegas continues to search for method to both conserve water and augment its use of the Colorado River. (SNWA Water Resource Plan 2008: Chapter 1: A Brief History of Water in Southern Nevada, 2008)

Figure 9. Water Use By Source, 2007



SNWA, 2008

THE MEADOWS

Had Las Vegas not began to use water diverted from the Colorado River as its primary source there may have been more changes than just deeper wells being needed. Around 2006 Brown University began gathering sixteen years of data to perform a study on the effects of changing groundwater depths on vegetation in Owens Valley, California. Owens Valley is considered an alkali meadow ecosystem, where vegetation depends on very shallow groundwater, similar to Las Vegas. Using satellite records to determine plant cover and records on depth-to-water and precipitation the four geologists (Craine, Elmore, Manning, and Mustard) were able to draw their conclusions. They determined that vegetation in this ecosystem reacted more depending on changes in groundwater levels, not in precipitation levels. If the depth to water level exceeded around two and a half meters the amount of plant cover became much more correlated with the precipitation levels as opposed to further drops in the water level.

This shows that the average maximum root depth of plants in these meadow type ecosystems is around two and a half meters. If the water levels drop below this the plants now have to rely on precipitation, making plant cover much more seasonally variable. This also destroys the vegetations ability to weather a drought by depending on the aquifers. When this drop in water levels occurs, if it persists, the species of vegetation begins to change. Plants with deeper root systems and annuals that do not depend on groundwater start to replace the native flora.

In the area observed several groundwater wells were being pumped to supply nearby towns with water. Results showed that the areas nearest the wells had more significant drops in water levels compared to any drops in other areas. During droughts pumping levels general increase as less water is available from other sources. This could easily create a viscous cycle that would destroy the native meadow flora as groundwater levels would drop most during droughts, when drops in groundwater are most harmful to vegetation. Had Las Vegas not started relying on water diversion instead of groundwater pumping the natural plants of the area may have lost all chance of survival. This change in vegetation may have already occurred and has not been observed or noted, or irrigation and watering of plants could present a confounding variable, giving the natural vegetation an artificial crutch to allow it to continue living. (Elmore, Manning, Mustard, Craine, 2006)

LOS ANGELES

In her UCLA Symposium speech, Martha Davis commented on Southern California's obsession with water, saying. "Not that we aren't preoccupied with the issue of future water supplies for a good reason. In the LA Basin alone, we have approximately 6% of California's habitable land but only .06% of the State's stream flow -- yet we hold over 45% of the State's population"(Davis, 1998). The City of Angels has been hard at work to correct that for a long time. Since around the beginning of the twentieth century Los Angeles has been reaching outward for more water, exceeding its own supplies. The Owens Valley Aqueduct in 1913, two hundred thirty-eight miles, and it has been expanded three times afterwards, reaching now into Mono Basin. The Boulder Dam Act around 1915 tapped water from the Colorado River with a four hundred mile aqueduct. The State Water Project in the 1950's brought water from Northern California. Only in the 1970's did the harsh environmental blowback of these projects start to be realized. Owens Valley and Mono Lake are the two best examples, and will be discussed later. And it was not until a severe drought at the beginning of the Nineties that the L.A. government began imposing conservation laws like water rationing. In 1998, when Davis gave her speech, the water use levels were the same as they had been around 1980, even though the city had gained almost a third of its own population from then. As the population continues to grow, more methods of conservation are being and need to continue to be developed.

OWENS LAKE

Owens Lake was a saline lake in the Owens Valley in southern California near the town of Keeler. Keeler once was home to several thousand residents and a center of local trade due to nearby mines. When Los Angeles began diverting the streams that fed Owens Lake in 1913 the lake's waters began dropping drastically. By the 1920's the lake was entirely dry. A giant salt flat was left behind. The high levels of minerals in the lake created alkali dust. On windy days this dust is kicked up creating noxious clouds that are harmful enough that many of the very few—under a hundred—residents that remained in Keeler are dying from lung cancer. In recent decades legal action was taken against Los Angeles and an air quality settlement was made instituting programs that are trying to mitigate the dust problems and eventually at least partially restore the lake. (http://en.wikipedia.org/wiki/Owens_Lake)

MONO LAKE

Mono Lake underwent a similar process to Owens Lake, except that action was taken in its protection long before it dried up, but not before the decreased water level had increased the lake's salinity to levels dangerous to its ecosystem. The hypersaline lake is an incredibly unique environment, as it is a vital nesting ground to several species of birds, and provides a stopover point for migratory birds because it contains an incredible abundance of food for them, namely brine shrimp and alkali flies. The specific species of brine shrimp is endemic to Mono Lake, though other similar species exist in other saline environments. Many unique features of volcanism and various results of other geological forces—such as tufa towers—give the lake its wonderful individuality, and helped spur locals into action to preserve the lake. After much litigation the Mono Lake Committee and the Los Angeles Department of Water and Power managed to work out compromises that allow some of the diverted stream water to flow into the lake. The lake's decline was halted and the level is rising and will continue to do so until it reaches the agreed upon 6,392 feet above sea level. (http://en.wikipedia.org/wiki/Mono_lake)

CONCLUSION

Water has played a vital role in the Great Basin region of the United States since its infancy. Even now it continues to shape the area geologically and ecologically. There are many more issues that water is focal too than are presented in this paper. The extent of this influence is only matched by the extent of man's influence over them. What has taken eons to form and develop could be destroyed by less than a century's carelessness. Methods of water usage need to be well researched and environmental side effects considered before they are implemented. If humans fail to recognize that they owe this kind of care to the Earth they must at least acknowledge that such carelessness might easily be their own undoing.

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IMAGE: *“Great Basin Map.”* USDA Forest Service. 13 May 2008. 12 June 2008 <http://www.fs.fed.us/rm/boise/research/gis/maps/GreatBasinMap.jpg>

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IMAGE: *Figure 9. Water Use by Source, 2007*.“SNWA Water Resource Plan 2008: Chapter 1 - A Brief History of Water in Southern Nevada.” Southern Nevada Water Authority. 2008. 12 June 2008 <http://www.snwa.com/html/wr_resource_plan.html>

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