Impacts of Managing Water in a Closed Basin: A Study of the Walker River Basin, Nevada, USA

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ABSTRACT

Throughout much of the world, many ecological problems have arisen in watersheds where a significant portion of stream flows are diverted to support agriculture production. Within endorheic watersheds (watersheds whose terminus is a terminal lake) these problems are magnified due to the cumulative effect that reduced stream flows have on the condition of the lake at the stream's terminus. Within an endorheic watershed, any diversion of stream flows will cause an imbalance in the terminal lake's water balance, causing the lake to transition to a new equilibrium level that has a smaller volume and surface area. However, the total mass of Total Dissolved Solids within the lake will continue to grow; resulting in a significant increase in the lake's TDS concentration over time. The ecological consequences of increased TDS concentrations can be as limited as the intermittent disruption of productive fisheries, or as drastic as a complete collapse of a lake's ecosystem. A watershed where increasing TDS concentrations have reached critical levels is the Walker Lake watershed, located on the eastern slope of the central Sierra Nevada range in Nevada, USA. The watershed has an area of 10,400 sq. km, with average annual headwater flows and stream flow diversions of 376 million m^3/yr and 370 million m^3/yr, respectively. These diversions have resulted in the volume of Walker Lake decreasing from 11.1 billion m^3 in 1882 to less than 2.0 billion m^3 at the present time. The resulting rise in TDS concentration has been from 2,560 mg/l in 1882 to nearly 15,000 mg/l at the current time. Changes in water management practices over the last century, as well as climate change, have contributed to this problem in varying degrees. These changes include the construction of reservoirs in the 1920s, the pumpage of shallow groundwater for irrigation in the 1960s and the implementation of high efficiency agricultural practices in the 1980s. This paper will examine the impacts that each of these actions, along with changes in the region's climate, has had on stream flow in the Walker River, and ultimately the TDS concentration in Walker Lake.

1 INTRODUCTION

While the Great Basin encompasses a relatively large portion of the western United States its water resources are some of the sparsest in the nation. This lack of water obviously poses a challenge to water resource managers within this region. What in many cases has not been as obvious is the management challenge posed by the very nature of the movement of water within these endorheic watersheds. That is, water does not flow through the basin, but rather moves within the basin and accumulates at the basin's lowest point, often referred to as its sink. Thus, a basin's sink becomes the memory of all of the activities that impacted the basin's water resources over its history. Within these basins there are only two methods for water to leave the basin: the first being through the diversion of water out of the drainage; and the second being through the evaporation or transpiration of water from within the basin. The impacts to the environmental condition of these sinks due to the diversion of waters out of a closed basin have been relatively well documented and understood, with Mono Lake and Owens Lake serving as examples of the extreme environmental harm that can occur (e.g. see *Cadillac Desert,* Reisner 1986). However, for many closed basins, the impact of in-basin water diversions on the environmental conditions of its sink is now being just being fully realized. This is particularly the case for those basins where the sinks are either playa or deep-water terminal lakes. One such basin is the Walker Lake basin in northwestern Nevada, where the cumulative impacts of over a century of water resources management activities has resulted in Walker Lake reaching a critical environmental threshold.

2 BACKGROUND

Nearly a century ago, policy makers, and the general public, considered lakes at the terminus of rivers within closed basins to have little to no value. This attitude was exemplified by U.S. Senator Newlands of Nevada (one of the original sponsors of legislation to create the US Reclamation Service) who considered these lakes only purpose being to "slake the great thirst of the desert sun." Hence, it is not surprising that water resources management within the Great Basin originally focused on controlling and diverting as much water as practicable for irrigated agriculture, with little thought given to the resulting long-term impacts to the lakes and wetlands that were fed by drainage in these basins. However, within the last several decades, due to changes in societal values and an increased role that indigenous populations have played in guiding water resources management policies, reversing the environmental degradation caused to these playa and terminal lakes has become the latest water resources management challenge. For example, the possible extinction of the Cui-ui (an omnivorous lake sucker endemic only to Pyramid Lake and the lower Truckee River) in Pyramid Lake (fed by the Truckee River) has led to the complete overall of the management of the Truckee and Lower Carson River systems. In addition, the continuing decline in the water level of Walker Lake, along with its increase in concentration of total dissolved solids (TDS) concentration has prompted the initiation of extensive studies whose purposes are to determine the best approach to take to stabilize Walker Lake's environmental condition. During both of these efforts, a number of ideas have emerged that proposed a suite of water resources management tools that can be used to solve Walker Lake's problem. Many of these water resource management tools are those that were developed to address environmental problems in non-endorheic basins (those where rivers do not flow to a terminal lake). From a surficial look, many of these tools appeared to show great promise. However, through a more systematic analysis it was determined that these water resources management tools did not have a great deal of applicability to helping resolve an endorheic basins water resources management challenges. In many cases, if employed, these tools would cause even greater harm to the environmental condition of Walker Lake. To best understand why these conventional water resources management tools hold so little value for reversing Walker Lake's environmental problems, both an understanding of the integrated hydrologic, environmental and human history in the Walker basin is necessary as well as the development of an integrated understanding of its basin scale hydrology.

3 PHYSICAL SETTING

Walker Lake is a terminal deep-water lake located in Northwestern Nevada within the Eastern Drainage of the Sierra Nevada Range (see Figure 1). The drainage area of the Walker Lake basin is approximately 11,110 square km and contains five distinct irrigated agricultural regions through which the Walker River and its tributaries flow. These regions are referred to as the Bridgeport Valley, Antelope Valley, Smith Valley, Mason Valley and the Schurz Area. The Walker River basin's climate is characterized by relatively cold winters and warm summers. The mean annual precipitation throughout the basin ranges from 200 mm in the lower elevations at the eastern portion of the watershed to over 1,000 mm at the higher elevations in the western portion of the watershed, near the crest of the central Sierra. The majority of rainfall occurs from late October through early May, primarily in the form of snow at the higher elevations, and a mixture of rainfall and snow in the lower elevations. The flow in the Walker River is governed by this seasonal cycle of precipitation, with stream flows being the highest in late spring, fed by snowmelt from the higher elevations and lowest in early fall.

The earliest irrigation rights on the Walker River date back to 1859 and belong to the Walker River Indian Reservation. The 1902 decision known as Decree 731 provides the basis for present day water priorities in the Walker River basin (Kersten, 1961). Since Decree 731 did not include water rights for several tributaries, Decree C-125 was later established in 1936. It regulated the use of surface water for irrigation but did not include any provisions for groundwater allocation. Decree C-125 also established water rights for the headwaters of the East and West Walker Rivers, lands downstream, and storage rights for the two main reservoirs in the Walker Lake basin, Bridgeport (located on the East Walker tributary) and Topaz Reservoir (located on the West Walker tributary. However, Decree C-125 did not establish storage water rights for Weber Reservoir (located on the main Walker River just upstream of Walker Lake).

The largest user of water within the basin is irrigated agriculture. Since the mid-1800s, farming, ranching and agriculture have been a component of the Walker River Basin economy. Annual revenues for Lyon County (where Smith and Mason Valleys are located) are between $40-50 million per year, making it the most important agricultural area in the State of Nevada (Horton, 1996). The principal irrigated crops are pasture, alfalfa and grains; there are smaller acreages of onions, garlic and potatoes. Historically, irrigation in these regions has been supplied primarily through the diversion of surface waters of the Walker River and its tributaries. Within the last half-century, however, these surface diversions have been supplemented with groundwater pumpage, primarily in the Smith and Mason Valleys.

The total area of land within the Walker River basin with deeded water rights is approximately 450.2 square km (Pahl 1998). However, surface water is over-appropriated in the Walker River system. During an average snowpack year (when snowpack equals 100% of normal), only 84% of agricultural rights can be satisfied and it requires a year of 130% of normal snowpack to provide enough water to satisfy the full allocation of diversions to water right holders within the basin. Thus, from year to year the amount of irrigated acreage is highly dependent on the basin's hydrologic condition, with the irrigated acreage fluctuating a great deal. Within the last two decades the irrigated acreage in the basin has ranged from a low of approximately 202.2 square km in 1992 to a high of 305.5 square km in 1995 (Tracy and Minor, 2001).

At the present time, environmental and recreational water uses are also important in the basin, especially at Walker Lake. The upper forks of the West and East Walker Rivers are very popular fishing areas. The California Department of Fish and Game stocks the area with rainbow, brown and brook trout. In addition, fishing is prevalent at Topaz and Bridgeport Reservoirs. The Artesia Lake (Smith Valley area) and Mason Valley Wildlife Management Areas provide waterfowl habitat and hunting access. Walker Lake is the primary recreation destination for the lower watershed, offering summer and winter fishing, boating and water skiing (Walker River Atlas, 1992). Water quality is a particular concern for the fate of the Lahontan cutthroat trout (Oncorhynchus clarki henshawi), a federally listed threatened species. The Nevada Division of Wildlife began stocking Walker Lake with strains of Lahontan Cutthroat trout in the late 1940's and early 1950's. A number of studies have been undertaken since this time to determine what levels of TDS cause trout mortality and how the survival of stocked trout could be improved. These studies generally concur that complete mortality of Lahontan cutthroat trout occurs at TDS concentrations over 16,000 mg/l (Vinyard and Dickerson 1996, Taylor 1972) and that TDS concentrations over 10,000 mg/l cause negative physiological effects (Galat et al. 1983). In addition, elevated TDS levels affected the survival of species in the Walker Lake food web, such as zooplankton and tui chub (Galat et al. 1983). In 1994, a water quality analysis conducted by the USGS found TDS concentrations in Walker Lake to be approximately 13,400 mg/L (Clary et al., 1995). Between 1985 and 1996 the climate in the Walker Lake basin was relatively wet, leading to a decrease in the Lake TDS by 1998 to approximately 10,600 mg/L (Langsdale 2001). Subsequently, the western Great Basin has experienced a sustained period of normal or below normal precipitation. This has resulted in numerous years of flows into Walker Lake that are well below those needed to balance the Lake's evaporation rate. Thus, at the current time, Walker Lake's TDS concentration has risen to over 15,000 mg/l (Langsdale 2001).

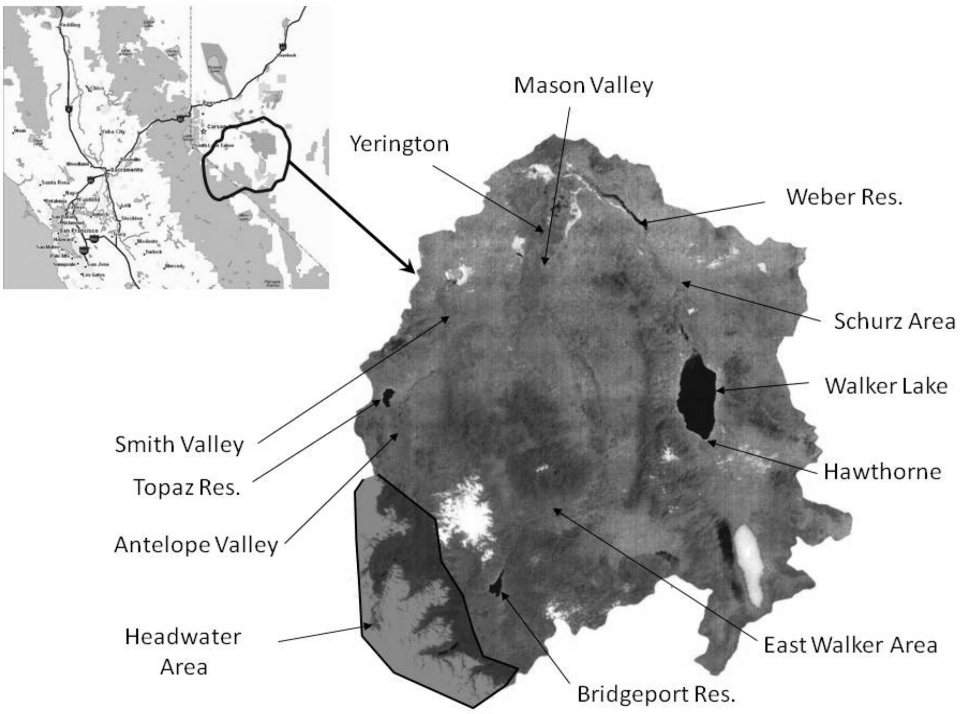


Fig. 1 A Birds Eye View of the Walker River Basin (Land-Sat Image Acquired July of 1995)

4 HYDRO-HISTORY OF THE WALKER RIVER BASIN

There have been a variety of changes to the Walker River basin's hydrologic regime since the first diversions of water from the Walker River occurred over 150 years ago. A complete listing of these disturbances, both large and small, can be seen in Horton (1996). However, in terms of their impacts on the condition of Walker Lake there have been 3 significant alterations to the Walker River Basin's Hydrologic Regime. Figure 2 presents a timeline of these events and the resulting impacts to Walker Lake's volume and TDS concentration.

4.1 Initiation of Diversions

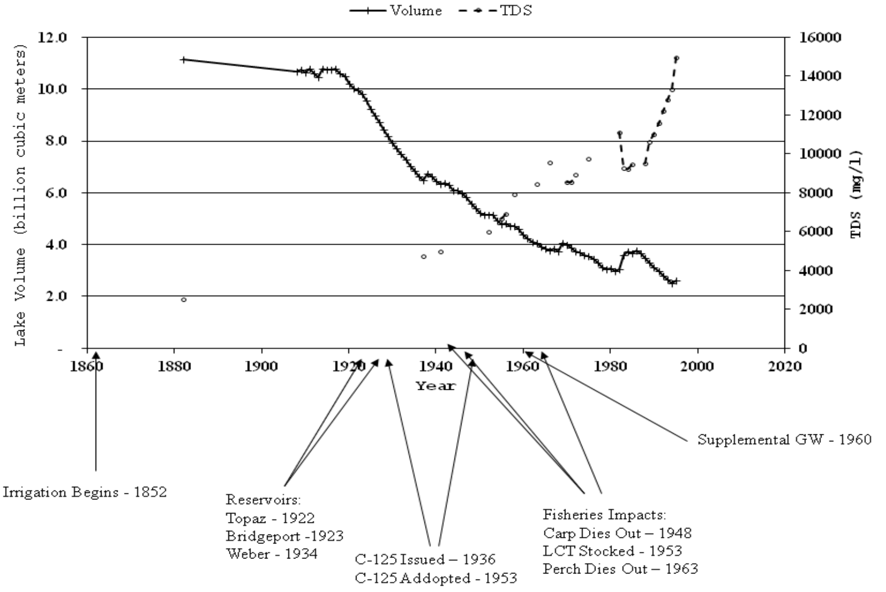
As can be seen in Figure 2, the first significant change within the Walker River basin occurred in 1852, with the initiation of diversions from the Walker River. From 1852 to the early 1900s, diversions on the Walker River continued to increase, to the point that for average years, the demand for diverted water could not be met. These diversions had an impact on Walker Lake, and created an imbalance in Walker Lake's hydrology, to where there was approximately 6.20 million m^3 more evaporation from the Lake than inflow of water to the Lake. As can be seen in Figure 2, during this period the average volume of water in Walker Lake decreased from about 11.2 billion m^3 in 1882 to approximately 8.68 billion m^3 in 1920, with a corresponding rise in the TDS concentration from approximately 2,600 mg/l in 1882 to 3,300 mg/l in 1920. Climatic conditions with the basin were such that crops could easily be grown into early September. However, with no upstream flow controls, flows in the Walker River tapered off to base flow conditions by late July for most years.

4.2 Reservoir Construction

To help allow for an extended irrigation period in the Smith and Mason Valleys, two reservoirs were constructed, with construction being completed in 1922 on Topaz Reservoir and 1923 on Bridgeport Reservoir. Topaz reservoir is an off channel storage reservoir on the West Fork of the Walker River with an active storage capacity of 74.4 million m^3. Bridgeport reservoir is an inline reservoir on the East Fork of the Walker River that has an active storage capacity of approximately 53.9 million m^3. In addition, to help manage irrigation on the Walker River Paiute Reservation, Weber reservoir was constructed in 1934. The initial capacity of Weber Reservoir was about 13.6 million m^3, but due to sedimentation, the current capacity is close to 11.2 million m^3. These reservoirs allowed for an extended irrigation season in the downstream Smith and Mason Valleys. However, this extended irrigation season was at the expense of conditions within Walker Lake. During the period from 1920 to the early 1960s, Walker Lake's volume went from approximately 8.68 billion m^3 to 3.72 billion m^3, which translates into an average yearly hydrologic imbalance of 124 million m^3 per year, which is over double the hydrologic imbalance that existed during the previous 40 years. Also during this period, the Carp population within Walker Lake died out in 1948 and the Sacramento Perch population died out in 1963 due to increased salinity levels that rose from 3,300 mg/l in 1920 to approximately 9,000 mg/l in 1965. In addition, in 1953 a lake stocking program began for the Lahontan Cutthroat trout to aid in sustaining its population in Walker Lake. It is hypothesized that this stocking program was due more to barriers being placed in the LCTs spawning runs than the increased TDS concentration in Walker Lake. Also during this period, Decree C-125 (described above) was issued in 1936 and adopted in 1953.

4.3 Supplemental Groundwater Pumpage

Even with the construction of reservoirs within the basin, during extended periods of drought many irrigators could not receive their water rights allocations due a lack of flow in the Walker River. Thus, in the early 1960s, the State Engineer of Nevada allowed for the development of groundwater rights within the Smith and Mason Valleys that were designated as supplemental to the water rights holder's surface water rights. This allowed decree water right holders to use groundwater to make up their full water right duty on their water-righted lands if flows in the Walker River were insufficient to meet their decreed rights. This in essence ensured decreed water right holders that applied for supplemental groundwater rights that their full water right allocation would be met each year. However, these groundwater rights were for alluvial aquifers within the Smith and Mason valley that are relatively well connected to Walker River and its tributaries (Meyers et al. 2002). Hence, much of the groundwater used to supplement surface water diversions is at the expense of future surface water flows. During the period from 1964 (the first year where it is estimated that extensive groundwater pumpage occurred) to the current time, Walker Lake's volume has decreased from approximately 3.72 billion m^3 to just less than 2.48 billion m^3. In addition, its TDS concentration has risen from about 9,000 mg/l, to its current level of over 15,000 mg/l.



Irrigation Begins - 1852

Reservoirs:
Topaz - 1922
Bridgeport -1923
Weber - 1934

C-125 Issued – 1936
C-125 Addopted - 1953

Fisheries Impacts:
Carp Dies Out – 1948
LCT Stocked - 1953
Perch Dies Out – 1963

Supplemental GW - 1960

Fig. 2 A Chronology of the Impacts of Water Management Infrastructure on Walker Lake

4.4 Current Setting

As noted above, the hydrologic condition within the Walker Lake basin has changed quite a bit within the last 150 years. Thus, "long-term" average conditions are not the best baseline to use to compare alternative water management scenarios against. Rather, the best baseline condition for comparison purposes is the current estimates of the hydrologic, ecologic and economic conditions within the basin.

At the current time, the best estimate of the annual average availability of water resources within the Walker River basin is approximately 635 million m^3 per year, which includes the estimated groundwater pumpage within the basin, and approximately 699 million m^3 per year is consumptively used within the basin. At the current time there is a net water deficit of over 62 million m^3 per year, which accounts for the continuing decrease in Walker Lake's volume. This decrease in volume is due to a net loss of water from Walker Lake, where the amount of water evaporated from the lake's surface is greater than the inflow of water to the lake from the Walker River, small streams that flow directly into the lake, and direct precipitation on the lake's surface. Thus, there is a corresponding rise in the TDS concentration within the Lake over time. At the current time, this net hydrologic imbalance results in a long-term average increase in the Lake's TDS concentration of approximately 170 mg/l/year. However, during dry periods the yearly increase in TDS concentration can be as high as 600 mg/l, and during wetter periods the TDS concentration has decreased, as was the case in the wetter periods of 1983-1984 and 1995-1998. In addition, an "average" water year in the basin does not translate into an average flow year into Walker Lake. Due to the Walker River basin having more decreed water rights than average flow, an average flow year typically results in Walker Lake receiving less than half of the water needed to balance it evaporation. Only when inflows exceed 150% of normal does the lake receive enough water to balance its evaporative losses. Thus, during "average" water years with the basin, Walker Lake's TDS will typically increase by 300 to 400 mg/l.

5 WATER RESOURCES MANAGEMENT OPTIONS IN THE WALKER RIVER BASIN

Due to the continuing degradation of Walker Lake, a number of water management strategies have been proposed, with the intent of improving the water quality within Walker Lake. To help evaluate the impact of these strategies, an model developed by Langsdale (2001) was employed to predict the impact on flows of the Walker River into Walker Lake, and ultimately the lake's TDS.

5.1 Increasing Water Use Efficiency

One management tool that has proved useful in helping improve instream flows in many rivers is through the increase in the water use efficiency. At the field scale, water use efficiency is defined as the ratio of water consumed by a crop to maintain its growth, to the amount of water used to irrigate a crop. When applied at a watershed scale, improvements in water use efficiency not only include improvements in water management at the field scale, but also reductions in diversion canal losses and diversion structure operations. Within the Walker River basin, the watershed scale irrigation efficiency varies with the amount of flow in the river. Higher flow years yield lower efficiencies and lower flow years yield higher efficiencies. Overall though, the average basin water use efficiency, defined by the ratio of water consumed for its intended purpose versus the amount of water diverted or pumped, is approximately 70%. This estimate excludes the Bridgeport Valley area where diversion records have not been kept, hence making it difficult to estimate the Valley's water use efficiency. In terms of its impacts on Walker Lake, higher water use efficiencies would be detrimental. The reasons for this are a mixture of the nature of water flow in a closed basin and the fact that there are more water rights appropriated within the Walker River basin than there is flow. For the most part within the basin, inefficiencies in water result in return flows back to the Walker River, either through surface runoff, or more commonly via a ground water flow pathway. Return flows that occur via surface runoff are considered part of the natural flow of the Walker River, and thus are appropriated to according to rule of the river. Return flows that occur via a groundwater flow pathway typically return to the river near the end, or after the irrigation season (late September through January). Decree C-125 only allows for diversions from the Walker River until the end of October. Thus, any return flows that migrate to the river after October flow to Walker Lake. If water use efficiencies were increased within the basin, these return flows would decrease, and thus reduce the overall flow to Walker Lake. In addition, since the Walker River decree provides for 50% more water rights than the average flow in the river, any water left within the Walker River due to decreased diversions from higher water use efficiency strategies would be made available to the more junior water rights holders, not Walker Lake. Thus, implementing strategies for increased water use efficiencies within the basin would, on average: (1) Increase the amount of irrigated land within the Walker River basin; (2) slightly increase the agricultural production and hence the agricultural output for the basin; and (3) decrease flows to Walker Lake and hence hasten its demise. Therefore increased water use efficiency would not be an appropriate tool in aiding improvements in Walker Lake's future condition.

5.2 Water Banking

A second management tool that has been used to help improve instream flows is the use of water banking. Water banking in terms of its use in the Walker River basin would be the storage of decreed water rights, either in a reservoir or aquifer, for use at a later time in the irrigation season. This would allow decreed water right holders to choose to have their instream flow water rights stored in either Bridgeport or Topaz Reservoir and released at a later time in the irrigation season. Implementing a water bank within the Walker River basin would allow decreed water rights holders to bank their water in upstream reservoirs for later release to Walker Lake. However, holding the water upstream in a reservoir could entail additional losses due to seepage through the holding dams (which would be considered part of the natural flow of the river) or increased evaporative losses from the reservoirs. In addition, banking the water behind an upstream reservoir would simply delay Walker Lake from receiving water that it needs to maintain its ecological function. Thus, it would be more effective to allow the water right holders to send their water directly to Walker Lake, which would be considered a direct purchase of water as opposed to water banking. Therefore, water banking would also not be an appropriate tool for aiding in the stabilization and restoration of Walker Lake.

5.3 Enhanced Flow Controls

A third tool that has obviously been used extensively within the Western United States to help manage stream flows is through the construction of either on or off channel reservoirs. This tool has primarily been used to aid in managing water diversions from rivers. However this tool is increasingly being used to help develop stream flow environments that are of benefits to downstream riparian ecologies. Within the Walker River basin several locations have been identified where a reservoir could be constructed to increase the water holding capacity of the basin. In particular, a reservoir with up to 112 million m^3 of capacity located in the Hoye Canyon area (just upstream of the Smith Valley) has been proposed in the past. Increasing the water storage capacity within the Walker River basin would allow water managers greater flexibility in controlling river flows during the year. However, this would not lead to an increase in the availability of water within the basin. In addition, since any new reservoir would result in an increase in the consumptive losses of water from the basin (through increased evaporation from an increase in open water surface area) this would result in the reduction of future flows to Walker Lake. Even if water storage rights were established for such a reservoir that would be dedicated to Walker Lake through the transfer of decreed flow rights, for the reasons given above, it would be better for the environmental condition of the Lake if the decreed rights were transferred directly to Walker Lake. Thus, enhanced flow controls are also not appropriate tools for aiding in the stabilization and restoration of Walker Lake.

5.4 Conjunctive Groundwater Use

A fourth tool that has been used in many areas to help improve instream flows is the conjunctive use of groundwater to supplement surface water flows. This is especially true in areas where groundwater resources can be pumped from shallow alluvial aquifers that underlie the stream courses. As discussed earlier, groundwater resources in the Smith and Mason Valleys have been used to enhance the ability of decreed water right holders for receiving their full water right during average and dry hydrologic years. This approach has obviously been of great benefit to water users within the basin, particularly in the Smith and Mason Valleys. However, it has come at the expense of flow in the Walker River below these valleys. In Tracy et al. (2001) a water balance for Walker River inflows, recorded stream diversions and outflow past the irrigated areas of the basin was calculated for the periods of 1942 to 1963 (prior to supplemental groundwater rights) and 1963 to 1998 (after supplemental groundwater rights were in place). For nearly the same average stream diversions for both periods, the estimated ungaged inflow to Walker Lake had decreased by over 37.2 million m^3 per year. This reduction in inflow is a direct result of the lowering of the water table in the alluvial aquifers in Smith and Mason Valley, which caused an increase in exfiltration of water from the streams that served to recharge these aquifers. This analysis suggests that any additional groundwater pumpage would further decrease these contributions to flow within the basin, and hence be detrimental to Walker Lake, and not be an appropriate tool to aid in its stabilization.

5.5 Riparian Corridor Improvements

A fifth tool that has been used in some areas to attempt to improve stream flows is through the improvement of riparian corridors, either through the eradication of invasive vegetation or through the restoration of stream channel function. Within the lower Walker River, below the Wabuska Gage, there are several reaches of river where the channel is badly eroded or braided, and associated with these river reaches are areas where Tamarisk is fairly extensive. It is thought removing the Tamarisk from these areas and stabilizing the stream banks will yield water savings, which can then be passed on to Walker Lake.

5.6 Water Importation

Another approach that has been used to help aid stream flows is through the importation of water to the basin. This is not at all an unfamiliar concept in Sierran basins, with water being diverted out of the Truckee River basin to the American River basin and the Carson River basin, and the diversion of water out of the Mono basin, into the Owens basin, and out of the Owens basin to Southern California. Even within the Walker basin, there is a small diversion of water into the Owens basin that is used for agricultural purposes. However, all of the basins that are adjacent to the Walker River basin, and the basins adjacent to these, are fully appropriated. Thus, it can be assumed that there will not be water available from basins where it would be practical to import it to the Walker River basin. Hence, within the Walker River basin, and for all of the western Great Basin drainages, water importation would not be a practical solution.

5.7 Water Purchase

The final tool that is available to improve stream flows is through the purchase of water from water rights holders. This can be accomplished using a number of approaches, including: payments to fallow land so that the water right holder does not divert water; lease of a water right from year to year that allows the water right lessee to transfer the amount and timing of the right for a different purpose within the basin; and purchase of a water right that allows the water rights purchaser to transfer the amount and timing of the right to another location and beneficial use within the basin. Under Western Water law, all of these approaches have to be applied in a manner in which junior water rights holders would suffer no harm.

6 CONCLUSIONS

The uniqueness of water management in a closed basin requires a rethinking of the tools that are useful to solve the problem. Closed basins don’t have the advantage of having a short memory. In open basins, many of the water management challenges for both environmental and agricultural uses relate to surviving extreme conditions, in particular drought. However, once the extreme period has passed, and near-normal conditions proceed, conditions in the watershed have a chance to return to some level of normality. This in essence creates a need to develop suites of tools that are useful in dealing with extremes. The situation for closed basins is quite different. Since the basin's water resources only exit through evaporation or export, the impact of water resource decisions made at any time are cumulative on the terminal lakes. That is, cubic meter of water that is consumed through crop production, municipal use or consumption along the riparian corridor is an cubic meter of water that is lost to the lake forever. Thus, the tools that are employed to manage water within these basins must reflect this condition. This eliminates the use of any tool that simply alters the timing of flows within the basin, as these have no long-lasting impact on the condition of the terminal lakes. Only tools that lead to true reductions in consumption (not diversion) of waters, or true additions of water (not changes in point of extraction) are of use in managing waters within these basins for benefit of the terminal lakes. This suggests that ultimately the only long-term solution for Walker Lake will be the reduction of the consumptive use of water within the basin, which in turn suggests that the only tools that will prove useful in the long run will only be Water Marketing and Water Rights Purchase.

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